M.Sc., Applied Geology and Geomatics

SYLLABUS

(With effect from June 2024 Onwards)

Centre for Applied Geology
Gandhigram Rural Institute (Deemed to be University)
Gandhigram – 624 302 Tamilnadu

CENTRE FOR APPLIED GEOLOGY

VISION: To create space, Spatial and Geosciences-based Rural Development Models and Plans. The branch of Geology is one of the vital disciplines for comprehensive, holistic and Sustainable Rural Development. The Centre for Applied Geology has been created to achieve this ambition/goal.

MISSIONS:

Using geological technologies in earth and space system studies, the following academic programmes for a B.Sc. Geology (Hons) and M.Sc. Applied Geology and Geomatics, as well as Research and Extension programs, are envisaged independently and interdependently with various departments of GRI-DU.

MISSION:1 Rural Natural Resources Inventory and Management: Mineral, Water, Hydrocarbon and Geothermal Resources inventory and creation of natural resources based rural development plans.

MISSION:2 Rural Water Management: Specific Studies to bring out village-wise / taluk-wise water management plans, including surface water potential, water quality pollution due to rock-water interaction and anthropogenic activities with the rejuvenation of defunct water bodies inventory, modelling of Groundwater, Artificial recharge techniques, etc.

MISSION:3 Rural Geo-Energy Management: Geo-Energy Resources inventory & Planning like Oil and Gas, Coal, radioactive and geothermal energy.

MISSION:4 Geological Eco system-based development plans: Creation of Rural development plans based on geomorphic provinces like river systems, coastal systems, arid systems, etc.

MISSION:5 Natural Disaster Vulnerability Mapping and Management Models: Earthquakes, Landslides, Floods, Tsunamis and other disaster prediction and prevention plans for rural areas.

MISSION:6 Creation of Spatial Decision Support Systems for the development of rural areas.

ELIGIBILITY: A Pass in B.Sc., Geology / Applied Geology or its equivalent.

Program Outcome (PO)

PO 1: Become a professional in Geology and apply the principles to the needs of the Employer/ Institution /Enterprise/ Society.

PO 2: Familiarize with advanced analytical skills in Geology and its applications

PO 3: Apply the information learned to critically assess a wide range of ideas, complex problems and issues related to Geology.

PO4: Integrate, evaluate and understand the ideologies involved in different domains of Geology

PO5: Able to use skills and modern technical tools in the field of Geology and Geomatics

PO6: Describe the processes and outcomes of the studies undertaken in Geology

PO7: Formulate research methods and analyze complex problems to reach sustainable development goals.

Programme Specific Outcome (PSO)

PSO 1: Apply the knowledge of Geology in the multidisciplinary domains.

PSO 2: Solve the complex problems in the field of geology with an understanding of the societal, legal and cultural impacts of the solution.

PSO 3: Use research-based knowledge and research methods including analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PSO 4: Understand the impact of Geology in societal and environmental contexts, and Describe the knowledge of and need for sustainable development.

PSO 5: Communicate effectively with the scientific community and with the society such that, being able to comprehend, write effective reports and make clear documentation, make effective presentations.

SCHEME OF EXAMINATIONS
FIRST SEMESTER

Course Code	Paper Title	C	Hours			CFA	ESE	Total
			L/T	P	E			
24GEOP0101	Physical Geology and Geomorphology	3	3	-	3	40	60	100
24GEOP0102	Structural Geology, Geotectonics and Palaeontology	4	4	-	3	40	60	100
24GEOP0103	Stratigraphy and Indian Geology	4	4	-	3	40	60	100
24GEOP0104	Crystallography, Mineralogy and Gemology	4	4	-	3	40	60	100
24GEOP0105	Remote Sensing and GPS	3	3	-	3	40	60	100
24GEOP0106	Crystallography and Mineralogy - Practical I	2	-	4	3	60	40	100
24GEOP0107	Structural Geology, Palaeontology and Remote sensing - Practical II	2	-	4	3	60	40	100
24GTPP0001	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			
24GEOP0208	Igneous and Metamorphic Petrology	4	3	-	3	40	60	100
24GEOP0209	Economic Geology and Ore Dressing	3	3	-	3	40	60	100
24GEOP0210	Environmental Geology and Natural Disaster Management	3	3	-	3	40	60	100
24GEOP0211	Digital Image Processing	4	4		3	40	60	100
24GEOP02G (1/2/3/4)	Elective Generic	4	4	-	3	40	60	100
24GEOP0212	Igneous and Metamorphic Petrology and Economic Geology - Practical III	2	-	4	3	60	40	100
24GEOP0213	Digital Image Processing - Practical IV	2	-	4	3	60	40	100
24ENGP00C1	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			
24GEOP0314	Sedimentary Petrology and Marine Geology	3	3	-	3	40	60	100
24GEOP0315	Geophysics and Geochemistry	4	4	-	3	40	60	100
24GEOP0316	Meteorology and Climatology	3	3	-	3	40	60	100
24GEOP03D (1/2/3)	Elective Discipline Centric	4	4	-	3	40	60	100
24GEOP0317	Geophysics, Geochemistry and Sedimentology - Practical - V	2	-	4	4	60	40	100
24GEOP0318	Geographic Information System and GPS –Practical VI	2	-	4	4	60	40	100
24GEOP03M (1/2)	Modular Course	2	2	-	-	50	-	50
24EXNP03V1	Village Placement Programme	2	-	-	-	50	-	50
24GEOP03F1	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			
24GEOP0419	Petroleum, Coal, and Geothermal Resources	3	3	-	3	40	60	100
24GEOP0420	Mining Geology and Engineering Geology	3	3		3	40	60	100
24GEOP0421	Hydrogeology	4	4	-	3	40	60	100
24GEOP0422	Hydrogeology Practical - VII	2	-	4	4	60	40	100
24GEOP04M (1/2)	Modular Course	2	2	-	-	50	-	50
	Human Value and Professional Ethics	2	2	-	-	50	-	50
24GEOP0423	Dissertation	6		-		75	75*+50**	200
	Total	**22**						

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

Electives Discipline Centric
24GEOP03D1 - Experimental Petrology
24GEOP03D2 - Advanced Ore Geology
24GEOP03D3 - Geographic Information System
Modular Courses
24GEOP03M1 – Medical Geology
24GEOP03M2 – Micro-palaeontology
24GEOP04M1 – Geostatistics
24GEOP04M2 - Advanced Hydrogeology
Value Added Course
Introduction of Geological Software's
Field Geology and Topographical Maps Reading

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 Discipline Centric					4			
Modular Course					2		2	
Extension / Field Study					2			
Total	**22**		**22**		**22**		**22**	

Semester – I

Course Code & Title	**24GEOP0101** **PHYSICAL GEOLOGY AND GEOMORPHOLOGY**		
Class	M. Sc. Applied Geology and Geomatics	Semester	I
Cognitive Level	K-1 K-2 K-3		
Course Objectives	**The Course aims** • To learn the Origin of the Earth, Interior structure of Earth, atmosphere, Hydrosphere, Lithosphere, and various geological processes acting on Earth, • To understand the natural processes which act on the earth's surface and the landforms, • To build knowledge about the landforms formed due to tectonic activity, • To Describe the Coastal geomorphic features and their associated landforms, • 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. Modern on planetary origin. **Age of the Earth -** Direct and Indirect Methods. **Earth's Atmosphere, Hydrosphere, Lithosphere and their Constituents. Interior of the Earth with Major and Minor Seismic Discontinuities. Isostasy, Continental Drift, Paleomagnetism, Earth's gravity and magnetic fields. Concept of Geoid and spheroid. Indian Geomorphology. Rock Cycle.**	12
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.**	12
III	**Earthquakes** - Origin, Classification, Causes of Earthquake Seismology, Earthquake Measurement Scales – Magnitude and Intensity Scale. **Mobile belts in peninsular India. Fluvial Geomorphology -** Stream Erosion, Stream Transportation and Deposition, Features of Stream Erosion, Depositional Landforms, **Drainage Systems,** Types of Streams and Stages of Valley Development.	12
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.	12
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.	12

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. *http://shaileshchaure.com/Notes/GEOMCON.pdf*
2. *https://www.nap.edu/read/12700/chapter/3#17*
3. *https://www.usu.edu/geo/liddell/oceans/oc-ppts/ocpptxt_10.pdf*
4. http://www.geo.hunter.cuny.edu/~fbuon/GEOL_231/Lectures/Volcanic%20Landforms.pdf.
5. http://www.geo.hunter.cuny.edu/~fbuon/GEOL_231/Lectures/Coastal%20Geomorphology.pdf
6. *http://library.iigm.res.in:8080/jspui/bitstream/123456789/465/1/AnandSP_RajaramM_IAGR Memoir-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, 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.

24GEOP0101 PHYSICAL GEOLOGY AND GEOMORPHOLOGY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M	S	S	S		S		S	M	S	S
CO2	S	S				S	M	S	S	S		S
CO3	S	M	S	M	S	M	S	S	M	S	S	S
CO4	S	S	M	S	M	S	S					S
CO5	S	S	S	M	S		M	S	S	M	S	S

Course Code & Title	**24GEOP0102** **STRUCTURAL GEOLOGY, GEOTECTONICS, AND PALAEONTOLOGY**
Class	M. Sc. Applied Geology and Geomatics **Semester** I
Cognitive Level	K-1 K-2 K-3
Course Objectives	**The Course aims** • To introduce students to the concepts of stress and strain, as well as deformation and types of folds. • To gain knowledge of the origin, mechanism, and characteristics of various types of faults and joints • To describe Continental drift, plate tectonics, and Himalayan orogeny in detail. • To know the past life and Applications of fossils in age determination and correlation. • To study the Application of micro-palaeontology 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 and criteria for failure of rocks - types of stress ellipsoid and their geological significance - strain analyses of naturally deformed rocks.** Cleavage and Schistosity: slaty cleavage or schistosity, 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.** 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. Distinction between F1 and F2 folds.	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*****:**; Joints and shear fractures - brittle and ductile shear zones - Classification of joints and extension fractures. ***Geometry and mechanics of development of Foliation, Lineation and its type*****s**. **Unconformity:** Introduction - Kinds of Unconformities - Recognition of Unconformities. Significance in Stratigraphy - Distinguishing Faults from Unconformities - Diapirs and Salt Domes. Structural analyses: - kinematic and dynamic analysis of deformation	12

III	**Geotectonics:** Tectonic features of the Earth - Fabric elements and classification; S-C fabric;L-, L-S-, and S-tectonic fabrics. Continental drift, Implications of heat flow; The nature of convection in the mantle; convection in the mantle and their evidence; Mantle Plumes. Seafloor spreading - Plate Tectonics – Rock magnetism and its origin -polarity reversals -polar wandering. Elements of Tectonism - Characteristics of Plates - World Plates - Plate Boundaries - **Plate Tectonics and Mineral Deposits**– 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, concepts of taphonomy – 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 –– Invertebrate**; –** Paleoecology – Paleobiogeography- Palynology**; Palaeontology:** Morphology, Evolutionary Trends, Stratigraphic importance and application of ***Trilobites - Graptolites – Corals – Brachiopods – Cephalopods, Pelecepods.*** *Ediacara fauna*	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. Gondwana plant fossils and their significance. **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. *http://geologylearn.blogspot.com/2015/08/deformation-mechanisms-and.html*
2. *http://www.yourarticlelibrary.com/geology/rocks/rock-cleavage-meaning-types-and-importance-geology/91506*

3. *https://flexiblelearning.auckland.ac.nz/rocks_minerals/rocks/schist.html*
4. *https://www.britannica.com/science/foliation-geology*
5. *http://geologylearn.blogspot.com/2015/08/folding-mechanisms-and-processes.html*
6. *http://eqseis.geosc.psu.edu/~cammon/HTML/Classes/IntroQuakes/Notes/faults.html*
7. *http://www.indiana.edu/~geol105b/images/gaia_chapter_6/unconformities.html*
8. *http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000448GO/P000596/M018266/ET/1482317287MAINTEXT.pdf*
9. *https://sciencing.com/types-fossil-preservation-5413212.html*
10. *http://osp.mans.edu.eg/abuzied/MicroPalaeontology.html.*
11. https://www.ias.ac.in/article/fulltext/reso/004/07/0042-0048
12. 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.

24GEOP0102 **STRUCTURAL GEOLOGY, GEOTECTONICS, AND PALAEONTOLOGY**												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	L	L	M				S	M	M		L
CO2	S			M	M	L	M	S	M	M	M	
CO3	S			M	M		M	S		M	M	
CO4	S		M		M			S	M	M	M	
CO5	S	L	M	M	M			S		M	M	

Course Code	**24GEOP0103**	Semester
Course Title	**STRATIGRAPHY AND INDIAN GEOLOGY**	**I**

Cognitive Level

K – 1
K – 2
K – 3

Course Objectives

The Course aims

- To introduce the basic principles of stratigraphy, its classification,
- Geologic timescale and various types of correlation.
- To Learn the origin and significance of Indian Stratigraphy
- To Gain knowledge about the Cambrian, Gondwana, and Cretaceous systems.
- To Understand the structure of the Krishna-Godavari basin, the Siwalik System and Deccan traps
- To describe in detail the boundary and age problem

Unit	Content	Lectures
I	**Stratigraphy:** Principles and Classification of Stratigraphy – Litho, Bio, Chrono, Magneto stratigraphy and their applications – Elements of – Cyclo-stratigraphy, Allo, Pedo, Chemo and Seismic Stratigraphy. Basic ideas of **Sequence stratigraphy** and Quaternary Stratigraphy. Bouma sequence – Geological Time Scale and Indian Time Scale, facies and facies changes – break in records - Paleogeography and life of each period. Principles of Correlation. Code of stratigraphic nomenclature. Strato types and its requirements.	**12**
II	**Indian Stratigraphy: Archaean Group:** Dharwar province - Southern Granulite Terrain, Bastar Craton – Singhbhum Craton – Bundelkhand Craton, Aravalli - Precambrian cratons and mobile belts of India and Proterozoic Basins – Delhi Orogenic Belt – Eastern Ghats Mobile Belt. **Proterozoic Group:** Cuddapah Basin – Vindhyan Basin – Bhima Basin**.**	**12**
III	**Paleozoic Group:** Paleozoic rocks of salt range – Paleozoic rocks of Kashmir – Paleozoic rocks of Spiti – Paleozoic rocks of peninsula. **Gondwana super Group:** Lower Gondwana System – upper Gondwana system – the constant Gondwana. **Upper Carboniferous and Permian System – Mesozoic Group:** Triassic system – Jurassic system Cretaceous system.	**12**
IV	**Deccan Traps**: Distribution - Classification - Structure – Geological Succession – Inter-Trappean and Intra-Trappean beds- Bagh Beds – Origin-Economic importance - Lameta beds - Age and Economic importance**. Cenozoic Group:** Rise of Himalayas – Siwalik system – Cenozoic rocks of Assam – Cenozoic rocks of peninsula. Pleistocene – Holocene system, Quaternary glaciations, - Eocene, Oligocene and Lower Miocene systems.	**12**
V	**Boundary and Age Problems**: K-T boundary problem, Precambrian – Cambrian boundary problem, 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.	**12**

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. *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*

24GEOP0103 STRATIGRAPHY AND INDIAN GEOLOGY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S	L	S		L	M	L	M		M	L
CO2	S	S	L	M			S			M	M	L
CO3	S	S	L	M			M		S	S	M	L
CO4	S	S	L	M			M			M	M	L
CO5	S	S		M	L		L	L			M	L

Course Code	**24GEOP0104**	Semester
Course Title	**CRYSTALLOGRAPHY, MINERALOGY AND GEMOLOGY**	**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 characteristic 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	**Mineralogy:** An Introduction of Mineral and Mineraloid **Chemistry of minerals:** Crystal chemistry – bonding – chemical classification of Minerals – structures of silicates – Atomic Substitution and Solid solution in Minerals isostructuralism – isotypism and Isomorphism, Polymorphism and Polytypism – Pseudomorphism - 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**
III	Alteration products, paragenesis, and modes of occurrence of the following rock form silicates. **Neso silicates:** Olivine group, Garnet group – **Sorosilicate:** Epidote group – Beryl. **Ring Silicates:** Tourmaline – Benitoite – **Chain Silicates:** Pyroxene group – Amphibole group – **Sheet Silicates:** Mica group- Chlorite group - **Tectosilicates:** Quartz – Feldspar group – Feldspathoid group - Zeolite and Scapolite groups. Clay and Spinel Group	**12**
IV	**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. **Transmitted Light Crystallography:** Polarised light – Refractive index – isotropy – biaxial indicatrix triaxial ellipsoid – uniaxial indicatrix – interference colours and	**12**

	Newton's scale - fast and slow components, and order determination – Interference figures – Pleochroic scheme – Extension angle and its types – Birefringence. Optical accessories like mica, gypsum and quartz plates – Determination of Optic sign: uniaxial and biaxial minerals- Absorption of light by minerals.	
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 in India	**12**

Text Books:

1. Berry Mason, L.G., (1985) Mineralogy, W.H. Freeman &Co.
2. Gribble, C. D., Rutley's., (1988) Elements of Mineralogy. CBS, New Delhi.
3. Gribble, C.D., Hall, A.J., (1985) Optical Mineralogy Principles & Practice. George Allen and Unwin, London
4. Ford, W.E., (1988) Dana's Textbook of Mineralogy. Wiley. New Delhi. (Reprint).
5. Read, P.G., (2005) Gemmology, Butterworth-Heineman

Reference Books:

1. Parbin Singh, B., (2005) A Textbook of Engineering and General Geology, S. K. Kataria & Sons, Delhi.
2. Perkins & Dexter., (2010) Mineralogy (3rd Edition) Prentice Hall.
3. Kerr B.F, (1995) Optical Mineralogy. McGraw Hill, 5th Edition, New York.
4. Deer, W. A., Howie, R. A. & Zussman., (2013) An Introduction to Rock Forming Minerals, Third Edition, ELBS, Ed.
5. Revelli Phillips, W.M. & Dana. T. Griffen., (2004) Optical Mineralogy-The Non- Opaque Minerals, CBS publishers & Distributors, New Delhi.
6. Walhstrom, E.E., (1979) Optical Crystallography, John Wiley & Sons.
7. Mike Howard & Darcy Howard, (1998) Introduction to Crystallography and Mineral Crystal Systems, Rock hounding Arkansas.

Web Resources:

1. https://www.britannica.com/science/isometric-system
2. http://www.mineralogy4kids.org/all--crystals/crystal-systems/tetragonal-system
3. https://uwaterloo.ca/earth-sciences-museum/resources/crystal-shapes/hexagonal-crystal-system
4. https://www.britannica.com/science/orthorhombic-system
5. https://uwaterloo.ca/earth-sciences-museum/resources/crystal-shapes/monoclinic-crystal-system
6. http://www.chem.wisc.edu/~danny/interactive/triclinic/
7. http://www.tulane.edu/~sanelson/eens211/#Lecture%20Notes
8. http://jaeger.earthsci.unimelb.edu.au/msandifo/Teaching/Mineralogy2/mineralogy.pdf
9. http://epgp.inflibnet.ac.in/ahl.php?csrno=448
10. https://www.researchgate.net/publication/221923612_An_Introduction_to_Mineralogy
11. http://www.minsocam.org/msa/openaccess_publications/McNamee_Gunter_Lab_Manual.pdf

24GEOP0104 CRYSTALLOGRAPHY, MINERALOGY AND GEMOLOGY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M		M	M			S				
CO2	S	M		M	M		M	S		S	L	S
CO3	S			S	M		M	S	L			
CO4	S			M	L			S				
CO5	S	M		S	S		M	S			L	S

Course Code & Title	**24GEOP0105** **REMOTE SENSING AND GPS**
Class	M. Sc. Applied Geology and Geomatics — Semester I
Cognitive Level	K-1 K-2 K-3
Course Objectives	**The Course aims** • To understand the principles of remote sensing and the key elements of interpretation, • To know in detail how the Electromagnetic Spectrum is related to Remote sensing. • To introduce the satellites, their orbits, their sensors, and their characteristics. • To explain the types of remote sensing and data interpretation • 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. ***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	12
II	***The Nature of Electromagnetic Radiation (EMR)*****-** electromagnetic spectrum, energy- frequency-wavelength relationship, Blackbody and its related laws: Stefan-Boltzmann Law, Wien's Law, Planck's Radiation Law & Kirchoff's law electromagnetic energy and its interactions in the atmosphere: Absorption, Scattering & Atmospheric windows and with terrain features. ~~Wave Model~~, Types of Reflection, Spectral reflectance curve	12
III	**Satellites and Sensors- Platforms- Satellite Orbits:** Geostationary, Sun-synchronous, LEO, MEO, GTO and Lagrange points. **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.	12
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**	12
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.	12

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

24GEOP0105 REMOTE SENSING AND GPS												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	L		M	S	M		M	M	L	S		
CO2		M		M	S			M		S	M	
CO3	M			S	M		M	L		M		
CO4	S	M		S	S			M	M	S		
CO5		M			S		M		M	M		

Course Code & Title	**24GEOP0106** **CRYSTALLOGRAPHY AND MINERALOGY PRACTICAL – I**
Class	M. Sc. Applied Geology and Geomatics
Semester	I
Cognitive Level	K-1 K-2 K-3
Course Objectives	The Course aims • To identify various crystal models • To derive the Millerian Signs • To determine the optical properties of minerals • To discriminate the structural formulae for various mineral groups. • 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, and 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, and 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.

24GEOP0106 CRYSTALLOGRAPHY AND MINERALOGY PRACTICAL – I												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S		M	L			S		M	L	
CO2	S	S		M	M			S		M	M	
CO3	S	S		M				S		M	L	
CO4	S	S		M	L			S		M	L	
CO5	S	S		M	L			S		S	L	L

Course Code & Title	**24GEOP0107** **STRUCTURAL GEOLOGY, PALAEONTOLOGY AND REMOTE SENSING - PRACTICAL - II**

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

Cognitive Level

K-1

K-2

K-3

Course Objectives

The Course aims

- To identify the megascopic features and the morphological characteristics of Fossils.
- To determine the geological structures through cross-sections.
- To identify the True dip, apparent dip, and thickness of Beds.
- To visually interpret the images using stereoscopes
- Interpret the lithology, structure, geomorphology, and 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. Lithology through satellite data
5. Structure through satellite data
6. Geomorphology through satellite data
7. Land use and Land cover through satellite data

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

24GEOP0107 STRUCTURAL GEOLOGY, PALAEONTOLOGY AND REMOTE SENSING - PRACTICAL - II												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S			S		L	M	M		M		
CO2	S	S		S						L		
CO3	S	S	M	S	S	M				S	S	
CO4	S	S	S	S	S	L	M	S		S	S	
CO5	S	S	M	S	S	L	M	S		S	S	

Semester – II

Course Code & Title	**24GEOP0208** **IGNEOUS AND METAMORPHIC PETROLOGY**

Class	M. Sc. Applied Geology and Geomatics	Semester	II

Cognitive Level

K-1

K-2

K-3

Course Objectives

The Course aims

- To learn the composition of Magma, crystallization of magma
- To understand the classification of Igneous rocks
- To gain knowledge of the petrography of various types of Igneous rocks.
- To know the formation and different facies of Metamorphism
- To describe the petrography of metamorphic rocks.

Unit	Content	Lectures
I	**Igneous Petrology**: Composition and Constitution of Magmas – Phase rule **Stages of Consolidation of Magma**, Bowen's Reaction Principle – 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). **Diversity of Igneous rocks** – Partial Fusion, Differentiation and Assimilation.	12
II	**Forms, Structure and Texture of Igneous Rocks. Classification of Igneous rocks** – Chemical classification - Silica saturation and Alumina saturation, Mineralogical Classification, Textural Classification, CIPW Norm, 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	**Distinguished Petrographic Characteristics (Texture, mineralogy, classification, occurrence and origin)** - Granites, Basalt, Anorthosites, Pegmatites, Lamprophyres, Carbonatites, and Kimberlite. **Igneous rocks at Continental margins:** The Ophiolite suite, Calc alkaline and Tholeilite group of rocks.	12
IV	**Metamorphic Petrology:** Definition, Agents and Types of Metamorphism, the 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. 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 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. *http://en.wikipedia.org/wiki/Igneous_petrology*
2. *http://www.tulane.edu/~sanelson/eens212/intro&textures.htm*
3. *http://ericfdiaz.wordpress.com/an-introduction-to-igneous-petrology*
4. *Krishikosh.egranth.ac.in/bitstream/1/2023720/1/BPT9862pdf.*
5. *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 metamorphic petrology.
CO5: Assess the Petrography, nomenclature, classification and petrogenesis of important metamorphic rocks.

24GEOP0208 IGNEOUS AND METAMORPHIC PETROLOGY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S					M	L	L	S	L		
CO2	S	L			L	M	M	S	S	M		
CO3	S	L	L		M	M	M	S	S	M	L	S
CO4	S				M	M	L	L	S	L		
CO5	S	M	L		L	M	M	S	S	M	L	S

Course Code & Title	**24GEOP0209** **ECONOMIC GEOLOGY AND ORE DRESSING**

Class	M. Sc. Applied Geology and Geomatics	Semester	II

Cognitive Level	K-1 K-2 K-3
Course Objectives	The Course aims • To Understand the process of formation of ore deposits and classification of various mineral deposits • To Study the Geological setting, characteristics, and genesis of Ore deposits • To Study Ore mineral textures and their paragenesis • To Learn the various mining methods and prospecting methods • To Acquire knowledge on the mineral dressing

Unit	Content	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 Metallogenic Provinces - Geological Thermometry and barometry for Ore minerals. Application of fluid inclusion study and stable isotope geochemistry in understanding ore forming processes	12
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- VMS and SEDEX type 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.	12
III	**Geological setting, characteristics, and genesis of** Molybdenum, Tantalum, Cobalt, Chromium, Cadmium and Titanium Minerals used in **refractory, fertilizer, ceramic, cement, glass and paint industries**; minerals used as abrasive, filler; building stones - **Ore grade and Reserve**, assessment of grade, reserve estimation.	12
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. Marine mineral resources and Law of Sea. **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 effects, Skarns, Framboids or Framboidal**. Paragenesis: Shape, Relict, Colloform Banding, Growth zoning, Cross-Cutting relationship, Twinning, Exsolution, Replacement, Fluorescence.**	12

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**.**	12

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

24GEOP0209 ECONOMIC GEOLOGY AND ORE DRESSING												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M	L	M	M		M	S	M	S	M	M
CO2	S				M	L	L	S		S	M	
CO3	S	S		S	M	M	M	S	S	S	M	M
CO4	S	S		S	M	M	M	S	M	M	M	M
CO5	S	L			L			S		L		

Course Code &Title	**24GEOP0210** **ENVIRONMENTAL GEOLOGY AND NATURAL DISASTER MANAGEMENT**		
Class	**M. Sc. Applied Geology and Geomatics**	**Semester**	**II**
Cognitive Level	K-1 K-2 K-3		
Course Objectives	**The Course aims** • To know the basic concepts, Importance of Environmental geology and various types of natural resources and problems. To Study the Energy, Land and Air resources and their related problems • To understand the concepts of various disasters, their classification, causes and impacts. • To Acquire knowledge about the approaches to Disaster risk reduction and various disaster management cell		

Unit	Content	Lectures
I	**Environmental Geology:** Basic concepts of environmental geology, Ecology and biodiversity; Global changes in the ecosystem and climate; global warming and its causes; anthropological impacts on the natural environment. Impact of use of energy and land on the environment. Exploitation and conservation of mineral and other natural resources. Planet Earth, environment and its types, scope and importance of environmental geology - Biogeochemical cycles; Atmospheric CO2 fluctuations throughout the geological history; impacts of circulations in atmosphere and oceans on climate. Environmental Protection Acts in India. Environmental impacts (EIA) due to mining and mineral processing. Applications of environmental geology in environmental protection/management; conservation and restoration of land. **Natural Resources:** types of resources (based on origin and 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.	12
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, **Atmospheric Disturbances: Cyclones and Anticyclones) Causes, Effects and Control Measures. Pollution:** Water pollution, Air pollution, mine pollution, mine waste handling, transportation and dumping**.**	12

III	**Introduction to Disaster:** Definitions and Concepts of 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.	12
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- definition, causes, types and effects; Hailstorms- definition, formation, characters, effects and mitigations. Tornadoes- definition, formation, characters, effects and mitigations	12
V	**Approaches to Disaster Risk Reduction**: Disaster Management Cycle, Phases of Disaster Cycle. Culture of Safety, Prevention, mitigation and Preparedness - Disaster management in India – NDMA, NIDM, SDMA. Role of Technology in Disaster Management	12

Text Books:

1. Jonathan Turk and Graham R. Thompson, Environmental Geoscience: Saunders College Division, 2000.
2. Davis, N., (1976), Environmental Geosciences, John Wiley and Sons, New York.,
3. Keith, L. H., (1996), Principles of Environmental Sampling. ACS Professional Reference book, Amer. Chem. Soc., Washington DCSubramanian, V., (2002), A Textbook in Environmental Science, Narosa Publishing House, New Delhi
4. Savindra Singh, (2015) Environmental Geography, Pravalika Publications, Allahabad.
5. Keller, E.A., (2010) Environmental Geology: CBS Publisher, New Delhi
6. Valdiya, K.S., (2005) Geology Environment and Society. Universities Press,
7. Bryant, E., (2008) Natural Hazard. Camb. Univ. Press.

Reference Books:

1. Bennett, M. R. & Doyle, P., (1997), Environmental Geology: Geology and The Human Environment, Wiley India
2. Detwler, T.R., (1971), Man's Impact on Environment, McGraw Hill Environmental Geology: Ecology, Resource and Hazard Management
3. Chouhan, T.S.& Joshi, K.N., (1996) Applied Remote Sensing and Photo Interpretation, VigyanPrakashan,
4. Savindra Singh, (2020) Oceanography, Pravalika Publications, Allahabad

Web Resources:

1. *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*

4http://www.geo.unibe.ch/unibe/portal/fak_naturwis/e_geowiss/a_igeo/content/e42577/e42580/e454184/e454188/RWIforbeginnersA5-ERZ2_ger.pdf

5. *http://wwwnaweb.iaea.org/napc/ih/documents/global_cycle/vol%20IV/IV_Ch4.pdf*
6. *https://www.conserve-energy-future.com/causes-and-effects-ofenvironmental-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-anagementhandbook.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 should be 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

24GEOP0210 ENVIRONMENTAL GEOLOGY AND NATURAL DISASTER MANAGEMENT												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M	S			L	M	S	M	M		M
CO2	S	S	M	S	M	M		S	M	S		
CO3	S	M				M	M	S		S	M	
CO4	S	S	L	S	S		M	S	S	S		
CO5	S	S		L		M	M	S	S	M	M	L

Course Code & Title	**24GEOP0211** **DIGITAL IMAGE PROCESSING**

Class	M. Sc. Applied Geology and Geomatics	Semester	II
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To understand the basic principles of Image Processing • To learn the various image processing techniques • To gain knowledge on Image Transformation. • To know types of Image classification techniques. • To describe the computer and Android applications in the field of geology		

Unit	Content	Lectures
I	**Digital Image Processing**: Introduction, 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. Resampling and Interpolation **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/Rationing. PC transformation. Fourier transformation**. Image Fusion:** Multiplicative Fusion, PCA transform fusion, HIS transform fusion. **Image Classification: The Classification Stage.** Supervised and Unsupervised classification	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 Software;** 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. *http://148.206.53.84/tesiuami/S_pdfs/Remote%20Sensing%20Digital%20Image%20Analysis.pdf*
2. *http://www.wamis.org/agm/pubs/agm8/Paper-5.pdf*
3. *http://www.fao.org/3/a-i0304e.pdf*
4. *https://think-asia.org/bitstream/handle/11540/5035/disaster-management-handbook.pdf?sequence=1*
5. *http://www.untagsmd.ac.id/files/Perpustakaan_Digital_1/DISASTER%20MANAGEMENT%20Disaster%20Management%20Handbook.pdf*
6. *https://think-asia.org/bitstream/handle/11540/5035/disaster-management-handbook.pdf?sequence=1*
7. *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

24GEOP0211 DIGITAL IMAGE PROCESSING												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S	L	M		M		S	M		M	
CO2	S		L		M		L	S		M		L
CO3	S	S		S		M			M			M
CO4	S	S	L	M		M		S	S	S		M
CO5		M	S	L			L	S		M	M	

Course Code & Title	**24GEOP0212** **IGNEOUS AND METAMORPHIC PETROLOGY AND ECONOMIC GEOLOGY – PRACTICAL - III**		
Class	M. Sc. Applied Geology and Geomatics	Semester	II
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To Differentiate the megascopic properties of igneous, sedimentary and metamorphic rocks • To Discriminate the petrographic properties of rocks microscopically • To study the optical properties of ore minerals • 'To Identify the economic minerals in hand specimen • 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 the 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.

24GEOP0212 IGNEOUS AND METAMORPHIC PETROLOGY AND ECONOMIC GEOLOGY – PRACTICAL - III												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S					M	L	L	S	L		S
CO2	S	L			L	M	M	S	S	M		S
CO3	S	L	L					S		M	L	
CO4	S				M	M	L	L		L		
CO5	S	M	L		L			S	S	M	L	S

Course Code & Title	**24GEOP0213** **DIGITAL IMAGE PROCESSING - PRACTICAL - IV**		
Class	M. Sc. Applied Geology and Geomatics	Semester	II

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 and Generation of Class Statistics.
18. Generation of Digital terrain model from contours and break lines
19. Generation of Contours from DEM
20. Generation of Slope and Aspect
21. Generation of Line of Sight
22. AOI based Clip/subset of imageries
23. Atmospheric Correction
24. Exploring the basic principles of geological software.
    a. Rockworks
    b. Igepet
    c. Surfer
    d. Aquachem
    e. Petroplot
25. 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.
CO5: To apply mobile technology in geological mapping

24GEOP0213 DIGITAL IMAGE PROCESSING - PRACTICAL - IV												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	L		L	M		L	S		L	M	
CO2	S	S	L	S	S	M		S	S	S	M	
CO3	S	S		S	S	S	L	S	S	M		M
CO4	S	S	L	S	M		L	S	M	M		L
CO5	S	S	L	S	M	L		S		M		L

Semester – III

Course Code & Title	**24GEOP0314** **SEDIMENTARY PETROLOGY AND MARINE GEOLOGY**

Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 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.	9
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.	9
III	**Outline on Grain size analysis**: Heavy mineral analysis, Clay mineral analysis and palaeo environmental studies. **Grain size determination:** sample preparation, direct measurements, dry and wet sieving. Grain size analysis and graphical representation. Provenance of sedimentary rocks.	9
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.	9
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. Marine pollution, pathways, resilence time, pollutants in the marine environment. Methods of measuring properties of the sea.	9

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. *www.usouthal.edu/geology/haywick/GY402/402-pp1.pdf.*
2. *https://www.lib.utexas.edu/geo/folkready/entirefolkpdf.pdf.*
3. *http://ocean.stanford.edu/courses/bomc/chem/lecture_14.pdf*
4. *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.

24GEOP0314
SEDIMENTARY PETROLOGY AND MARINE GEOLOGY

CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S	S	S		S	S	S	S	S	S	S
CO2	M	M	S	S	M		S			S	S	S
CO3	S	M	S	M	M	S	S	M	S	M	M	M
CO4	S	M	S	S	S	M	M	S		M	S	S
CO5	S	S	S		S	M	M	S	S	S	S	M

Course Code & Title	**24GEOP0315** **GEOPHYSICS AND GEOCHEMISTRY**		
Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To know the gravity and radiometric method of exploration • To learn the magnetic and electromagnetic methods of exploration • To describe the electric method of exploration and its interpretation and analysis techniques. • To gain knowledge of the seismic method of exploration • 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. Determination of shape and depth of ore bodies. Advantages and Limitations of gravity method of prospecting. GRACE mission ***Radioactive Methods***: Introduction - Ground Radiometric survey - Radioactive decay and Types: Beta Decay – Positron Decay – Electron Capture 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.	12
II	**Magnetic Methods**: Principle– Magnetic Susceptibility - Earth's Magnetism - Magnetism of rocks and minerals: Induced and remnant magnetism. Magnetic materials and Magnetic domains: 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. Airborne geophysical surveys – 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.**	12
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 – Background potentials – Mineralization potential — Field equipment -** non-polarizable electrodes - The potentiometer - Electric millivoltmeter. **Field procedure** - Interpretation - Applications. **Induced Polarization Methods:** Principle -	12

	Polarization types: Membrane or electrolytic polarization – Electrode polarization -– 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 - Operational methods: Fan shooting, Arc shooting and Profile shooting - Reduction of data – Travel time curves for single homogenous and heterogenetic layers - Interpretation -Determination of attitude and depth of formations. 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.	12
V	**Introduction to geochemistry** – Periodic table - distribution of elements in rocks and soils. Chemical composition and characteristics of atmosphere – lithosphere - hydrosphere; geochemical cycles. Meteorite types and composition**. Goldschmidt's classification of elements;** **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 **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.	12

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. *https://www.school-for-champions.com/astronomy/earth.htm#.WxddcO6FO70*
2. *https://geoinfo.nmt.edu/geoscience/projects/astronauts/gravity_method.html*
3. *http://www.geol-amu.org/notes/b8-4-4.htm*
4. *https://www.michigan.gov/documents/deq/GIMDL-USGSINF672R6_302983_7.pdf*
5. *http://www.geol-amu.org/notes/b8-3-6.html*
6. *https://csegrecorder.com/articles/view/magnetic-and-gravity-methods-in-mineral-exploration*
7. *http://rallen.berkeley.edu/teaching/F04_GEO594_IntroAppGeophys/Lectures/L05.pdf*
8. *http://crack.seismo.unr.edu/ftp/pub/louie/class/492/data/2011/gph492_all_files_2011/AppliedGeophysics_Telf ord/AppliedGPH_MagneticMethods.pdf*

9. *https://sites.ualberta.ca/~unsworth/UA-classes/223/notes223/223D1-2009.pdf*
10. *http://www.engr.uconn.edu/~lanbo/G228378Lect0510EM1.pdf*
11. *https://www.kau.edu.sa/Files/0003035/Subjects/EM(1).pdf*
12. *http://shodhganga.inflibnet.ac.in/bitstream/10603/65005/8/08_chapter%201.pdf*
13. *http://www.tomoquest.com/attachments/File/EEG_Electrical_Surveying_SP.pdf*
14. *http://en.geophysik.at/index.php/methods/seismic-methods*
15. *http://www.geosearches.com/seismic.php*
16. *http://www.subsurfacesurveys.com/pdf/Methods.pdf*
17. *http://www.mdru.ubc.ca/home/resources/seg/seg_talks/Ray_Lett_Notes.pd*
18. *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 procedures, and application of magnetic and electromagnetic methods for geological studies.

CO3: Evaluate the basic principles, field procedures, and application of electrical and radioactive methods for geological studies.

CO4: Assess the basic principles, field procedure, and application of refraction and reflection methods for geological studies.

CO5: Describe the basic principles of Exploration Geochemistry

24GEOP0315 GEOPHYSICS AND GEOCHEMISTRY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M	L	M	S		M	S	M	M	M	L
CO2	S	M		M	S	L	L	S	M	M	M	
CO3	S	M		M	S	M	M	S	M	M	M	L
CO4	S	M		M	S	M	M	S	M	M	M	L
CO5	S	M		M	S			S	M	M	M	

Course Code	24GEOP0316	Semester
Course Title	**METEOROLOGY AND CLIMATOLOGY**	**III**
Cognitive Level	K – 1 K – 2 K – 3	
Course Objectives	**The Course aims** • To Understand the atmospheric composition and its layer details • To Study circulation characteristics of the atmosphere • To assess the cyclones and their factors • To Learn the precipitation and its characteristics • To Acquire knowledge of climatology basics	

Unit	Content	Lectures
I	**Meteorology** and **Climatology** – Scales in climatology **Atmosphere:** Composition and structure of the atmosphere, Layered structure of the atmosphere, Insolation and distribution of Insolation – Earth's radiation balance - Heat Budget, heating and cooling of temperature, Temperature distribution, Air pressure – Pressure gradient and pressure variations, Atmospheric pressure patterns and Pressure belts.	**9**
II	**General Circulation and Climate Modelling:** Zonally symmetric circulations, meridional circulation models – Zonally asymmetric features of general circulation; – Thermal circulation on a rotating Earth. Circulation patterns. Wind: Fundamental forces affecting wind, Surface wind systems, Atmospheric circulation patterns and wind Belts.	**9**
III	**Ocean Circulation** – El Nino – Southern Oscillation Events **east-west circulations in tropics**: MJO Madden-Julian oscillation), ENSO, QBO (quasi-biennial oscillation) and sunspot cycles. Concepts of ocean-atmosphere coupled models - Cyclones and Anticyclones. Local winds – Land Breeze and Sea Breeze, Mountain Breeze and Valley Breeze.	**9**
IV	Clouds and Precipitation: Formation and classification of clouds, Precipitation – Ice crystal theory and Collision-Coalescence theory - Forms of precipitation, types of precipitation, Distribution of precipitation, Intensity of precipitation, Artificial precipitation.	**9**
V	Monsoon – Concepts of the origin of monsoon, Asian monsoon and Indian monsoon, climatic significance of monsoon, Economic importance of monsoon. Atmospheric Stability and Instability – humidity - Thunderstorms - **Fronts:** General frontal characteristics - frontogenesis and frontolysis – Classification of fronts – principal zones of frontogenesis - Water balance. Air masses, Jet streams, tropical cyclones, Classification of climates – Koppen's and Thornthwaite's scheme of classification. Climate change.	**9**

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.

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/*

24GEOP0316 METEOROLOGY AND CLIMATOLOGY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	L					L	M			M	
CO2	S	M					M	M		M	S	
CO3	S	S		L			M	M	L		S	L
CO4	S	S	M				M	M		M	S	
CO5	S	S	M				M	M	L	M	S	L

Course Code & Title	**24GEOPO317** **GEOPHYSICAL, GEOCHEMISTRY AND SEDIMENTOLOGY - PRACTICAL V**		
Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 K-3		
Course Objectives	**The Course aims** • To Analyze and interpret the resistivity data using the Wenner method and Schlumberger method • To Interpret the structures using Gravity and seismic data • To Process, analyze and interpret the geochemical data • To Identify the Megascopic and microscopic properties of Sedimentary rocks • 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

24GEOP0317 **GEOPHYSICS, GEOCHEMISTRY AND SEDIMENTOLOGY – PRACTICAL - V**												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S		S	S			S	M	M		
CO2	S	S		S	S		S	S	M	M		
CO3	S	S		S	S		S	S	M	M		
CO4	S	S		S	S		M	S	M	M		
CO5	S	S		S	S		M	S	M	M		

Course Code & Title	**24GEOPO318** **GEOGRAPHIC INFORMATION SYSTEM AND GPS- PRACTICAL-VI**
Class	M. Sc Geology and Geomatics Semester III
Cognitive Level	K-1 K-2 K-3
Course Objectives	**The Course aims** • To learn to handle the fundamental tools of ArcGIS software • To Gain detailed knowledge in map registration, GDB creation and Digitization • To Compute the various Conversion and overlay techniques • To-Do the Mosaicking, DEM generation and Classification processes

Contents

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

24GEOP0318 GEOGRAPHIC INFORMATION SYSTEM AND GPS- PRACTICAL- VI												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S			S		L	S			M	
CO2	S	S		M	S			S	M	M	M	
CO3	S	S	L	M	S	L		S		M	M	L
CO4	M	M	L	S	S			S	M		M	
CO5	S	S			S			S			M	

Semester – IV

Course Code &Title	**21GEOP419** **PETROLEUM, COAL AND GEOTHERMAL RESOURCES**

Class	**M. Sc. Applied Geology and Geomatics**	**Semester**	**IV**
Cognitive Level	K-1 K-2 K-3		
Course Objectives	**The Course aims** • To Describe the origin and mode of formation of hydrocarbon • To Learn the geological conditions favouring the formation of hydrocarbon • To Know the mode of occurrence of petroleum and the concept of atomic fuel • To Understand the origin, properties, classification, and distribution of coal • To Gain knowledge of the various geothermal resources and geochemical guides		

Unit	Content	Lectures
I	**Petroleum Geology**: Introduction to petroleum geology and its economic strength. Physical and chemical properties; transformation of organic matter into kerogen: **Origin and Theories:** Organic and Inorganic Processes; **Environment of Oil Formation:** Sedimentary Basins – Onshore and Offshore; **Migration of Petroleum:** Porosity, Permeability mechanism, pattern and barriers. Physical and chemical characteristics of crude oil.	12
II	***Mode of Occurrence of Petroleum:*** Surface and subsurface occurrence of petroleum and gas. Entrapment of oil: types and mechanism, Origin of oil, source rock and maturation. Reservoir rocks, fluids and cap rocks Petroleum Methods of petroleum exploration. Concepts of petrophysics, Petroliferous basins of India; geology of the productive oil and gas fields of India; Provinces **Atomic Fuel:** Concept of atomic energy. Mode of occurrence and association of atomic minerals in nature **Global Distribution of Petroleum Reserves- *Petroliferous Basins of India*. *Well, Logging,*** Mudlogging methods and usage in oil companies. Wireline logs, different types of wireline logs Identification of major minerals like oil and gas (Hydrocarbons), Coal.	12
III	**Coal Geology:** Origin of coal, Physical Properties, Chemical Composition; Classification of Coal: Indian and International classifications of coal, Rank and Grade. Indian coal deposits Distribution of Gondwana and Tertiary coal fields of India. Lithologic characteristics 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 the generation of methane in coal beds, coal as a reservoir and coalbed methane exploration. Coal carbonization (coke manufacture), coal	12

	gasification and coal hydrogenation. Gas hydrates and Coal bed methane, Petroliferous basins of India	
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. Nuclear and non-conventional energy resources**	
V	**Geothermal Resources** – Introduction to geothermal energy, geothermal resources and reservoirs. Various Types, Availability, Size, Distribution-Recovery; Geothermal Energy for Power Generation, Environmental Effects of Geothermal Energy 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; Design of Geothermal Boreholes, Borehole Thermal Energy Storage Systems.	12

Text Books:

1. Levorsen, A.I., (1985) Geology of Petroleum, Second Edition, CBS Publishers and Distributors, Delhi.
2. Basic petroleum geology by Peter K. Link Oil & Gas Consultants International; 3rd edition (January 1, 2007)
3. Introduction to Petroleum Geology Hardcover – 31 January 1985 by George Douglas Hobson and E.N. Tiratsoo
4. Larry Thomas, (2012) Coal geology, Wiley India Pvt. Ltd.
5. Dickson, M.H., and Fanelli, M., (2013) Geothermal energy utilization and technology, 1st Edition, Routledge- CRC press
6. Geothermal Exploration – Global Strategies and Applications, Colin Harvey, Graeme Beardsmore. Inga Moeck and Horst Rüter, IGA Academy Books, 2016
7. Geologic Fundamentals of Geothermal Energy - By David R. Boden (2017)
8. Geothermal Energy- From Theoretical Models to Exploration and Development- Authors:Ingrid Stober, Kurt Bucher (2021)

Reference Books:

1. Brown, A. R., (1986) Interpretation of Three-Dimensional Seismic Data, American Association of Petroleum Geologists, USA.
2. Coal and Organic Petrology by M.P. Singh
3. Aswathanarayana, U., (1985) Principles of Nuclear Geology. NBT. Delhi.
4. Paine, D.P., (1986) Aerial photography and image interpretation for resource management, Wiley and Sons, New York.
5. Rao, D.P., (1999) Remote Sensing for Earth Resources, Second Edition, Association of Exploration Geophysicist, Hyderabad.
6. Chandra, D., and Singh, R M., (2000) Textbook of coal geology (Indian context) Tara Book Agency, Varanasi.
7. Glassley, W.E. Geothermal Energy. Second Edition. CRC Press. 2015. [WG]
8. Rosen, M.A. and Koohi-Fayegh, S. Geothermal Energy. Sustainable Heating and Cooling Using the Ground. 2017.

Web Resources:

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

8. https://geology.com/rocks/coal.shtml
https://www.vsb.cz/e-vyuka/en/subject/541-0580/04

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.

24GEOP0419 PETROLEUM, COAL AND GEOTHERMAL RESOURCES												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M		L				M		L	M	
CO2	S	M	L	L	M	S	L	M	S	L	M	M
CO3	S	M		L		S		M	S	L	M	
CO4	S	S	L	L	M	S	L	M		L	M	M
CO5	S	M	L	L	M	S	L	M	S	L	M	M

Course Code & Title	**24GEOP0420** **MINING GEOLOGY AND ENGINEERING GEOLOGY**

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

Unit	Content	Lectures
I	**Mining Geology:** Introduction to Mining - Prospecting and Sampling, Trenching, Pitting, Exploratory Drilling. **Classification of Mining methods -** Alluvial Mining, Opencast Mining or Quarrying, Underground Mining. **Mining terminologies**: Exploitation, Shaft, Hanging wall, Adit, Drive, Level, Crosscut, Tunnel, Raise, Winze, Ore bin, Chute, Stope. **Excavations and its types**. **Drilling:** Percussion drills, Rotary drills, Miscellaneous drilling methods. **Explosives**: Low explosives, High explosives, sheathed explosives, permitted explosives, Liquid oxygen, AN/FO and Slurry types.	12
II	**Alluvial mining:** Pan and batea, Rocker, Longtom, Sluicing, Derrick and cableway, Hydraulicking, Drift mining, Dredging. **Opencast mining:** Loading by hand, Loading by machines, Glory hole, Kaolin mining. **Underground mining:** Open stopes, Overhand stopping, Caving methods. **Coal mining methods:** Board & Pillar method, Longwall Advancing, Longwall Retreating, Horizon Mining, Underground Hydraulic Mining, Strip Mining. **Sampling and its types**.	12
III	**Ore dressing**: Crushing, Grinding, Sizing, Classification, Air sizing, Electrical Precipitation of dust, **Concentration -** Washing and scrubbing, Gigging, Tabling, Vanners, Floatation, Magnetic separation, Electrostatic separation. **Role of geologist in the mining industry, Environmental impacts by mining industries and reclamation techniques, Mining legislations, 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. 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, Brief 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.	12
	Text Books	

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 Publishers & 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. *https://iasmania.com/mineral-resources-india-iron-coal-aluminium-copper-lead-zinc/*
2. *http://www.aadnc-aandc.gc.ca/eng/1100100028056/1100100028058*
3. *https://everydayoil.wordpress.com/2012/11/16/different-types-of-drilling-and-its-breif-description/*
4. *http://www.cienciaviva.pt/img/upload/Introduction%20to%20mining.pdf.*
5. *https://www.americangeosciences.org/critical-issues/faq/what-are-main-mining-methods*
6. *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 about the Underground mining methods.
CO3: Analyze the role of Geologists in the mining sector
CO4: Discuss the Engineering Properties of rocks
CO5: Study of Geological consideration of the construction of dams, reservoirs and tunnels

24GEOP0420 MINING GEOLOGY AND ENGINEERING GEOLOGY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S	L	M	L	M		S		M	S	S
CO2	S	S		M	S	L	L	S	M	L	M	
CO3	S	S		M	S	M	M	S	M	M		
CO4	S	S	M	S	S	S	S	S	S	M	M	L
CO5	M				S			M				

Course Code & Title	**24GEOP0421** **HYDROGEOLOGY**

Class	M. Sc. Applied Geology and Geomatics	Semester	IV

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

Course Objectives:

The Course aims

- To Describe the hydrological properties of rocks
- To illustrate the physical parameters of water quality standards
- To Understand the concept of groundwater basins
- To Know the engineering properties of rocks
- 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 – Water witching.	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. **Seawater Intrusion** – Ghyben-Herzbergrelation – Freshwater – saltwater relation in Oceanic Island – Control of seawater Intrusion – Groundwater recharge, Karst Terranes.	12
V	**Pumping Tests**: Dupuit's equilibrium formula for unconfined and confined aquifers – Thiem's equilibrium formula for unconfined and confined aquifers. **Natural and artificial recharge** – Quality of recharging water – Recharge rate – Methods of artificial recharge. Water Purification – Settings – Coagulation – Fluorination – Defluorination – Disinfection – Deuteration – Groundwater Basins of Tamil Nadu.	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 purification methods.

24GEOP0421 HYDROGEOLOGY												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S	M	M			M	M	S	L		M
CO2	S	M	M	M	M		M	M	S	L		M
CO3	S	M	M	L	M		M	M	S	M	L	M
CO4	S	M	M	L	M		M	S	S	L	L	
CO5	S	M	M	L	M		M	S	S	M	L	M

Course Code & Title	**24GEOP0422** **HYDROGEOLOGY - PRACTICAL VII**

Class	M. Sc. Applied Geology and Geomatics	Semester	IV

Cognitive Level	K-1 K-2 K-3
Course Objectives	The Course aims • To Analyze and interpret the resistivity data using the Wenner method and Schlumberger method • To Interpret the hydrological properties of rocks • To Process, analyze and rainfall data • To explore the water quality • 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) Thiessen 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. Piper Trilinear Diagram and its Interpretation

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
CO3: Analyze the rainfall data
CO4: Interpret the hydrogeochemical properties of surface and sub-surface

24GEOP0422 HYDROGEOLOGY - PRACTICAL VII												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	S	S	M	S	M	M	S	M	M	M	L
CO2	S	S	S	M	S	M	L	S	M	M	M	M
CO3	S	S	S	M	S	M	L	S	M	M	M	L
CO4	S	S	S	M	S	M	M	S	M	M	M	S
CO5	S	S	S	M	S	M	M	S	M	S	M	S

Course Code & Title	**24GEOP0423** **DISSERTATION**		
Class	M. Sc. Applied Geology and Geomatics	Semester	IV
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The students are allowed to work in various domains of geology and will undergo the practice of collecting, processing, analyzing, and interpreting the data to bring out new results.		

DISCIPLINE CENTRIC COURSES

Course Code & Title	**24GEOP03D1** **EXPERIMENTAL PETROLOGY (ELECTIVE_DISCIPLINE CENTRIC)**		
Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To understand the principles of Experimental petrology • To learn the process involved in thermodynamics. • To evaluate thermodynamic data using Raoult's Law and Henny's law • To calibrate the geothermometers and Geobarometers from the experimental thermodynamic data • 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 **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

24GEOP03D1 EXPERIMENTAL PETROLOGY (ELECTIVE_DISCIPLINE CENTRIC)												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M			L			M				M
CO2	S	M						M		M	L	
CO3	S	L	L				L	M		M		S
CO4	S	L		M				M				L
CO5	S	M		M			L	L			L	

Course Code & Title	**24GEOP03D2** **ADVANCED ORE PETROLOGY** **(ELECTIVE_DISCIPLINE CENTRIC)**		
Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To Understand the modern concepts of ore genesis • To Study in detail the ore isotopes • To Acquire knowledge of the ore deposits • To Learn the plate tectonic and the related ore genesis • 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

24GEOP03D2 ADVANCED ORE GEOLOGY (ELECTIVE_DISCIPLINE CENTRIC)												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S											
CO2	S	M		M	S							
CO3	S			M			L	M	L		M	
CO4	S	M		L				M		L		
CO5	S		L	M	S	L	M	L				M

Course Code & Title	**24GEOP03D3 GEOGRAPHIC INFORMATION SYSTEM (ELECTIVE_DISCIPLINE CENTRIC)**		
Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To Provide the basic principles and components of GIS • To Learn the different types of Spatial and non-spatial data • To know the basic concepts of data quality and data problems • To integrate and analyze the data. • 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: 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

24GEOP03D3
GEOGRAPHIC INFORMATION SYSTEM
(ELECTIVE_DISCIPLINE CENTRIC)

CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M			S		L	S	L		M	
CO2	S	M	L	M	S			S	M	M		
CO3	S	S		M	S	L		S		M	M	L
CO4	S			M	S		L	S	M			
CO5	S	S		M	S	L		S	M	M	M	

MODULAR COURSES

Course Code & Title	**24GEOP03M1** **MEDICAL GEOLOGY (MODULAR COURSE)**		
Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To know the basic principles and concepts of medical geology • To learn in detail the Geological impacts of trace elements in nutrition • 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 and 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.

24GEOP03M1 MEDICAL GEOLOGY (MODULAR COURSE)												
CO/PO	PO							PSO				
	1	2	3	4	5	6	7	1	2	3	4	5
CO1	S	M			S		L	S	L		M	
CO2	S	M	L	M	S			S	M	M		

Course Code &Title	24GEOP03M2 MICROPALAEONTOLOGY (MODULAR COURSE)		
Class	M. Sc. Applied Geology and Geomatics	Semester	III
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To Learn the sampling methods as well as the processing techniques • To Interpret and rebuild the paleoenvironments using microfossils • 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 bio-chronostratigraphy, 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

24GEOP03M2 MICROPALAEONTOLOGY (MODULAR COURSE)											
PO							PSO				
1	2	3	4	5	6	7	1	2	3	4	5
S	M			S		L	S	L		M	
S	M	L	M	S			S	M	M		

Course Code &Title	**24GEOP04M1** **GEOSTATISTICS (MODULAR COURSE)**		
Class	M. Sc. Applied Geology and Geomatics	Semester	IV
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To introduce the advanced and applied aspects of Mathematical Geology. • To understand the Concepts of Geostatic and concepts of data distribution in space • To learn the concepts of correlation, exploratory spatial data analysis and interpolation		

Unit	Content	Lectures
I	**Geostatistics:** Meaning, Definition, Scope and History of Geostatistics, **Spatial data**- Characteristics & Types: Point pattern, continuous surfaces, Area with counts and aggregate rates, Terms in Spatial Analysis - 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. **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.	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. Anisotropies, Kriging, Relationship between Experimental side and Theoretical Side, **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

24GEOP04M1 GEOSTATISTICS (MODULAR COURSE)											
PO							PSO				
1	2	3	4	5	6	7	1	2	3	4	5
S	M			S		L	S	L		M	
S	M	L	M	S			S	M	M		

Course Code & Title	**24GEOP04M2** **ADVANCED HYDROGEOLOGY (MODULAR COURSE)**		
Class	M. Sc. Applied Geology and Geomatics	Semester	IV
Cognitive Level	K-1 K-2 K-3		
Course Objectives	The Course aims • To Introduce the basic phenomena of hydrogeology and its advances. • To Understand the concepts of the hydrologic cycle • To Interpret the role of geologic structures in identifying the potential zones of groundwater • To Describe the Characteristics of groundwater in arid, semi-arid coastal as well as alluvial regions • 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 the 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

24GEOP04M2 ADVANCED HYDROGEOLOGY (MODULAR COURSE)											
PO							PSO				
1	2	3	4	5	6	7	1	2	3	4	5
S	M			S		L	S	L		M	
S	M	L	M	S			S	M	M		

Value Added Course

FIELD GEOLOGY AND TOPOGRAPHICAL MAPS READING

Cognitive Level	K – 1 K – 2 K – 3
Course Objectives	**The Course aims** • Introduce the Field geological techniques, • To Examine the topographic maps and • .

Unit	Content	Lectures
I	**Introduction:** basic equipment and Supplies – Clinometer, Brenton compass and their uses – **Field identifications** of Rocks and Minerals, Structures, Stratigraphic sequences and Geomorphic features. Specimens and Samples – Fossils and Biogenic Structures. **Basic field observations.** Location - Soils and vegetation- measuring distances - Compass and tape traversing - Determination of slopes and gradients- Measuring difference in elevation. Field sketches and Drawings – Field photographs. Fieldwork Report Writing.	**10**
II	**Basic Concepts:** - Topographical Map – Map Scale – Representation of Map Scale – Indexing Topographical Maps**. Reading Topographical Maps**: Symbols and Colours – Marginal Information – Map Scale – Map Orientation. **Identifying Features on Topographical Maps:** Physical Features – Man-made and Cultural Features. **Interpretation of Topographical Map:** Identification of Marginal Information – Interpreting Physical Features – Interpreting Man made Features. **Field mapping:** Orientation of Map – Locating Position – Measuring Distance – Interpreting Contours – Interpreting Man-made Features - Constructing a Topographical Profile**.**	**10**

Text Books:

1. Mathur S.M. (2010) Guide to Field Geology, PHI Learning Private Limited, New Delhi, 24-33p.
2. Coe, A.L. (2010) Geological Field Techniques. Blackwell Publishing Ltd., United Kingdom
3. Lahee, F.H. (2002) Field Geology, First Indian Edition. CBS Publishers and Distributors Pvt. Ltd, New Delhi.

Reference Books:

1. Lisle, R.J., Brabham, P.J. and Barnes, J.W. (2001) Basic Geological Mapping, Fifth Edition. John Wiley and Sons Ltd, UK.
2. Greenly, E. and Williams, H. (1993) Methods of Geological Surveying, Thomas Mur by Publishers, London.
3. Field Geology, Block 3, Physical and Structural Geology, (BGYCT-131), IGNOU, New Delhi

Web resources:

1. https://orkustofnun.is/gogn/unu-gtp-sc/UNU-GTP-SC-11-04.pdf
2. https://geographyfieldwork.com/GeologyFieldworkRiskAssessments.htm
3. http://files.meetup.com/824870/Basic%20Land%20Navigation,%20Chapter%204%20%20June,%202007.pdf.

4. http://training.nwcg.gov/pre-courses/s290/S-290%20Student%20CD/Map%20and%20Compass.pdf.

FIELD GEOLOGY AND TOPOGRAPHICAL MAPS READING (Value Added Course)											
PO							PSO				
1	2	3	4	5	6	7	1	2	3	4	5
S	M			S		L	S	L		M	
S	M	L	M	S			S	M	M		

Value Added Course

INTRODUCTION OF GEOLOGICAL SOFTWARE

Cognitive Level	K – 1 K – 2 K – 3
Course Objectives	**The Course aims** • To Prepare the Mineral resource maps of Tamil Nadu • To Create the shear zone and blocks of Tamil Nadu •

Unit	Content	Lectures
I	Interpretation and analysis of Geological data using IGPET, WATEQ4F. Applications, Principles of data input, processing, and interpretation in software like PHREEQC, MODFLOW, Aquachem and Petroplot. Overview of geostatistical analysis using statistical package SPSS, Graphical analytical packages like Surfer and Rock Works for both 2-D surfaces.	**10**
II	**Mobile Applications:** Field data collection using Field Move Clino – GEO5 Data Collector **Geological Field Guides**: Smart Geology -Mineral Guide - Petrologic - Geological time scale – Rocklogger – Rockd – Relief Maps-3D GPS. Interpretation of field areas and distance using Locus GIS – Geo Area - Google Earth.	**10**

Text Books:

1. Wen-Hsing Chaing & Wolgang Kinzelbach "User Manual for Processing MODFLOW", windows version 4.0,1996.
2. Sharon L. Qi, Jennifer B. Sieverling using ArcInfo to facilitate numerical modelling of groundwater flow,1997.
3. Hill Mc (1992) MODFLOW – A computer program for estimating parameters of a transient, 3-D, Ground flow model using nonlinear regression, U.S. Geological Survey, open-file report – 91-484.

Reference Books:

1. PHREEQC Ver.1: Groundwater & pollution, II Edition: A.A. Balkana. Publication, Leiden. The Parkhurst, D.L.,1995, user's guide to PHREEQC
2. Groundwater Assessment Development and Management, Karanth.K.R. (1987) Tata McGraw Hill Publishing Company, Ltd.
3. Pine, J.C, Natural Hazards Analysis: Reducing the Impact of Disasters, CRC Press, Taylor and Francis Group(2009).
4. Smith K, Environmental Hazards: Assessing Risk and Reducing Disaster Routledge Press (2001)
5. Mobile play store

Web resources:

1. https://en.wikipedia.org/wiki/Moral_agency

2. https://en.wikipedia.org/wiki/Moral_rights
3. https://en.wikipedia.org/wiki/Moral_skepticism
4. https://www.nrlc.org/
5. https://en.wikipedia.org/wiki/Haleigh_Poutre

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