Since 1919

NATIONAL COLLEGE *(AUTONOMOUS)*

(Nationally Re-Accredited at "A+" Level by NAAC with CGPA of 3.61)

Recognized as a College with Potential for Excellence by UGC

Tiruchirappalli- 620001

Since 1961

POST GRADUATE AND RESEARCH DEPARTMENT OF GEOLOGY

Scheme & Syllabus for M.Sc., Applied Geology
Outcome Based Education System (OBES)
Applicable to the candidates admitted
from the academic year 2022-2023 onwards

POST GRADUATE AND RESEARCH DEPARTMENT OF GEOLOGY

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Vision

- To transform the Department into one of the best learning centres for Geology in the State and the country

Mission

- To educate and impart training to students towards providing effective geology work force
- To impart knowledge and skills towards developing sustainable solutions for various geological problems relating to the society
- To enhance the performance of the students in competitive examinations such as IIT-JAM, GATE, CSIR-NET, SET, UPSC, TNPSC, etc.
- To invite distinguished geologists and geoscientists of various government and private sectors for special lectures

Programme structure

Category	No of courses	Total Credits
Core Course (T+P)	15	70
Elective Course	05	20
Total	20	90

Programme Outcomes (POs):

- The programme outcomes relating to M.Sc. Degree programme include:

PO1	Enrich their knowledge on the fundamental concepts, principles and processes in the programme and its various important branches and its linkages with related disciplines.
PO2	Imparting field-based knowledge to make the learning process interesting and to provide a complete knowledge of the programme and its courses.
PO3	Imparting knowledge on acquiring practical knowledge on various fields of the programme using laboratory exercises.
PO4	Imparting technical, analytical, creative and problem-solving skills relating to the programme.
PO5	Moulding the students to become professionals / entrepreneurs and, self-employed in various fields of the programme and its various related fields.
PO6	Orienting the students towards taking up research in various fields of the programme.
PO7	Recognise and appreciate the importance of the programme and its application in academic, industrial, environmental and social contexts.
PO8	Making every student to be a socially responsible citizen.

Programme Specific Outcome (PSO)

The student graduating with the **M.Sc. Applied Geology** Degree would have acquired knowledge on:

PSO1	Earth's origin, structure, materials and history along with processes and landforms associated with various geomorphic agents.
PSO2	The linkages with other related discipline such as Geography, Environmental sciences, Physics, Chemistry, Mathematics, Life sciences, Remote Sensing, Information Technology.
PSO3	Geological history of the Earth including the life forms and geological events in a temporal frame work.
PSO4	Endogenetic and Exogenetic processes of the Earth.
PS05	Various skills such as identification of crystals, minerals, rocks, ores, fossils in hand specimens and microscope.
PSO6	Using instruments in field and lab, interpreting topographic maps, geologic maps, constructing cross-sections and visualising in 3D.
PSO7	Various structural features on the stress associate with them.
PSO8	Understanding the pathways, fluxes, and influence of water and other fluids at Earth's surface and in the subsurface. Explore, Identify, interpret and exploit different types of economic deposits in surface and subsurface. Also to explore and exploit economic minerals and materials in surface and subsurface.
PSO9	Improving the presentation skills of our students especially related to complex geologic concepts.
PSO10	Investigating skills, both individually and as a team towards solving Geology related problems.
PSO11	Present thrust areas and emerging fields in research relating to various fields of Geology.
PSO12	Skills to become professionals/ entrepreneurs / self employed in various fields of Geology.
PSO13	Enlighten their knowledge on higher learning programmes.
PSO14	Social responsibilities and obligations.

Scheme of Examination

(Applicable to the candidates admitted from the academic year 2022-2023)

SEMESTER	Course	Course Code	Course Title	Instructional Hours / Week	Credit	Exam Hours	Marks			
							Internal	External		Total
								Oral	Theory	
I	CC – I	P22GY1	Stratigraphy	5	5	3	25	0	75	100
	CC – II	P22GY2	Palaeontology	5	5	3	25	0	75	100
	CC – III	P22GY3	Advanced Crystallography and Mineralogy	5	5	3	25	0	75	100
	CC – IV	P22GY4P	**Practical I** – Palaeontology, Advanced Crystallography and Mineralogy	10	4	4	25	5	70	100
	EC – I	P22GY5E	Elective I	5	4	3	25	0	75	100
				30	**23**					**500**
II	CC – V	P22GY6	Igneous and Metamorphic Petrology	5	5	3	25	0	75	100
	CC – VI	P22GY7	Sedimentary Petrology and Sedimentology	5	5	3	25	0	75	100
	CC – VII	P22GY8	Geomorphology	5	5	3	25	0	75	100
	CC – VIII	P22GY9P	**Practical II** – Petrology, Engineering Geology & Mining Geology	10	4	4	25	5	70	100
	EC – II	P22GY10E	Elective II	5	4	3	25	0	75	100
				30	**23**					**500**
III	CC – IX	P22GY11	Hydrogeology	5	5	3	25	0	75	100
	CC – X	P22GY12	Economic Geology and Mineral Economics	5	5	3	25	0	75	100
	CC – XI	P22GY13P	**Practical III** – Economic Geology, Hydrogeology and Geoexploration	10	4	4	25	5	70	100
	EC – III	P22GY14E	Elective III	5	4	3	25	0	75	100
	EC – IV	P22GY15E	Elective IV	5	4	3	25	0	75	100
				30	**22**					**500**
IV	CC – XII	P22GY16	Geotectonics and Structural Geology	5	5	3	25	0	75	100
	CC – XIII	P22GY17P	**Practical IV** – Structural Geology, Remote Sensing and GIS	8	4	4	25	5	70	100
	CC – XIV	P22GY18P	**Practical V –** Geoinstrumentation and Geostatistics	6	4	3	25	5	70	100
	EC – V	P22GY19E	Elective V	5	4	-	25	0	75	100
	CC – XV	P22GY20P	Dissertation	6	5	-	75	25	0	100
				30	**22**					**500**
Total					**90**					**2000**

Note: Geological field instructional tour is mandatory for all the students of M.Sc. Applied Geology Programme. It will be organized in the even semesters. Students should submit the tour report which will be considered for evaluating the internal marks of the practical examination of the last semester.

ELECTIVE COURSES		
EC – I	P22GY5E1	Environmental Geology and Marine Geology
	P22GY5E2	Climate Change Studies
EC – II	P22GY10E1	Engineering Geology, Mining Geology and Ore Dressing
	P22GY10E2	Geotechnics
EC – III	P22GY14E1	Geoexploration
	P22GY14E2	Isotope Geology
EC – IV	P22GY15E1	Fuel Geology
	P22GY15E2	Instrumentation Techniques in Geology
EC – V	P22GY18E1	Remote Sensing and GIS
	P22GY18E2	Remote Sensing Applications in Geosciences

MAPPING OF PROGRAMME SPECIFIC OUTCOMES (PSO) WITH COURSE OUTCOMES (CO)

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10	PSO11	PSO12	PSO13	PSO14
CC1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC2	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
CC3	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
CC4	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓
CC5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC8	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
CC9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC11	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC12	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC13	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
CC14	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CC15	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5E1	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
5E2	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓
10E1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10E2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
14E1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
14E2	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
15E1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15E2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19E1	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
19E2	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

CO - Course Outcome, CC-Core Course, EC-Elective Course, SBE- Skill Based Elective, PSO-Programme Specific Outcome.

MAPPING OF COURSE OUTCOMES (CO) REVISED BLOOM'S TAXONOMY (BT)

CO/BT	K1	K2	K3	K4	K5	K6
CC1	✓	✓	✓	✓	✓	✓
CC2	✓	✓	✓	✓	✓	✓
CC3	✓	✓	✓	✓	✓	✓
CC4	✓	✓	✓	✓	✓	✓
CC5	✓	✓	✓	✓	✓	✓
CC6	✓	✓	✓	✓	✓	✓
CC7	✓	✓	✓	✓	✓	✓
CC8	✓	✓	✓	✓	✓	✓
CC9	✓	✓	✓	✓	✓	✓
CC10	✓	✓	✓	✓	✓	✓
CC11	✓	✓	✓	✓	✓	✓
CC12	✓	✓	✓	✓	✓	✓
CC13	✓	✓	✓	✓	✓	✓
CC14	✓	✓	✓	✓	✓	✓
CC15	✓	✓	✓	✓	✓	✓
5EC1	✓	✓	✓	✓	✓	✓
5EC2	✓	✓	✓	✓	✓	✓
10EC1	✓	✓	✓	✓	✓	✓
10EC2	✓	✓	✓	✓	✓	✓
14EC1	✓	✓	✓	✓	✓	✓
14EC2	✓	✓	✓	✓	✓	✓
15EC1	✓	✓	✓	✓	✓	✓
15EC2	✓	✓	✓	✓	✓	✓
19EC1	✓	✓	✓	✓	✓	✓
19EC2	✓	✓	✓	✓	✓	✓

CO – Course Outcome, CC-Core Course, EC-Elective Course, SBE- Skill Based Elective.
BT-Bloom's Taxonomy, K1-Remember, K2- Understand, K3-Apply, K4-Analyse, K5-Evaluate, K6- Create.

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
I	P22GY1	Core Course – I STRATIGRAPHY	5	25	75	100

Course Objectives

To impart knowledge on

- Stratigraphic Scale, Principles of Stratigraphy and Correlation
- Precambrian (Archaean and Proterozoic) Stratigraphy of India
- Phanerozoic (Palaeozoic, Mesozoic and Cenozoic) Stratigraphy of India
- Economic and paleontological importance of the stratigraphic formations of India.
- Stratigraphy of Tamil Nadu and Pondicherry region

Unit 1: Principles of Stratigraphy – Concept of lithostratigraphy, Chronostratigraphy, Biostratigraphy, Chemostratigraphy – Stratigraphic nomenclature: global level and India – International Chronostratigraphic Chart: Stratotypes, Global Boundary Stratotype Sections and Points (GSSP) – Methods of stratigraphic correlation – Homotaxis and contemporaneity – Facies concept in Stratigraphy: Walther's law – Outline of Earth's climatic history – Imperfections in geological records – Major Stratigraphic Divisions of India – Applications of stratigraphy.

Unit 2: Stratigraphy of Indian Archaean granites, Greenstone belts, Geological evolution of Archaean nuclei (DharwarCraton, Bastar, Singhbhum, Aravalli and Bundelkhand) – Economic Importance of the Indian Archaeans - Proterozoic Mobile Belts: Eastern Ghats Mobile Belt, Southern Granulite Terrain, Central Indian Tectonic Zone, Aravalli-Delhi Belt, North Singhbhum Mobile Belt. Proterozoic (Purana) sedimentary basins: Cuddapah and Vindhyan Super Groups – Economic Importance of the Indian Proterozoic formations

Unit 3: Stratigraphy, fossils and economic importance of: Cambrian of Salt Range – Permo-Carboniferous of Salt Range – GondwanaSupergroup - Triassic of Spiti, Jurassic of Kutch, Narmada Valley and Cretaceous of Trichinopoly and Deccan traps

Unit 4: Stratigraphy, fossils and economic importance of: Assam – Bengal basins –Garhwal-Shimla Himalayas – Siwalik Super Group and Indo-Gangetic Alluvium – Overview of Himalayan Geology and Quaternary stratigraphy of India – Age problem pertaining to Saline series and Deccan traps – Boundary problem pertaining to Precambrian/Cambrian, Permian/Triassic, Cretaceous/Tertiary and, Neogene/Quaternary formations of India.

Unit 5: Geology of Tamilnadu and Pondicherry**:**Outline of structure and tectonics – Stratigraphy and economic importance of:Sathyamangalam Group, Layered Mafic and Ultrabasic Complexes – Peninsular Gneissic Complex: Kolar Group, Khondalite and Charnockite Group –Migmatite Complex – Alkaline Complexes (Older) – Mafic dykes – Alkali-Syenite-Carbonatite Complexes (Younger) – Ultra basics / basics (Younger), Granite (Younger). Salient features of Palaeozoic, Mesozoic and Cenozoic Sediments.

Text Books

1. Geological Society of India (2006). Geology and Mineral Resources of the States of India, Part VI - Tamil Nadu and Pondicherry, GSI Misc. Publn. No. 30, GSI Operation: Tamil Nadu, Kerala & Pondicherry (Government of India), Chennai.
2. Krishnan, M. S (1982). Geology of India and Burma, CBS Publishers & Distributors, Delhi.

3. Subramanian, K. S. and T. A. Selvan (2001). Geology of Tamil Nadu and Pondicherry, Geological Society of India, Bangalore, 192p.
4. Ravindrakumar (1988). Fundamentals of Historical Geology and Stratigraphy of India, Wiley Eastern Ltd., New Delhi.
5. Wadia, D. N (1998). Geology of India, Tata McGraw Hill, India.

Reference Books

1. Boggs, S (2001). Principles of Sedimentology and Stratigraphy, Prentice Hall,
2. Brenner, R. E and T. R.McHargue (1988). Integrative Stratigraphy: Concepts and Applications, Prentice Hall.
3. Doyle, P and M. R. Bennett (1996). Unlocking the Stratigraphic Record, John Wiley and Sons.
4. Geological Society of India (1990). Stratigraphic Boundary Problems in India, Memoir 16, ISSN No: 0016-7622, Geological Society of India, Bangalore, 116p.
5. Hedberg, H. D (2008). International Stratigraphic Guide – A Guide to Stratigraphic Classification, Terminology and Usage, John Wiley & Sons, New York.
6. Miall, A. D (1997). The Geology of Stratigraphic Sequence,Springer-Verlag.
7. Michael E. Brookfield (2004). Principles of Stratigraphy, Wiley Blackwell Publishing.
8. Naqvi, S. M and J. J. W. Rogers (1987). Precambrian Geology of India, Oxford University Press.
9. Ramakrishnan, M and R. Vaidhyanadhan (2008). Geology of India, Vols. I & II, Geological Society of India, Bangalore.
10. Robert, M. S (1989). Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
11. Weller, A. K (1958). Principles of Stratigraphy, Asia Publishing House.

Course Outcomes

On completion of the course the students would have acquired a comprehensive knowledge on

- Stratigraphic Scale, Principles of Stratigraphy and Correlation
- Precambrian (Archaean and Proterozoic) Stratigraphy of India
- Phanerozoic (Palaeozoic, Mesozoic and Cenozoic) Stratigraphy of India
- Economic and paleontological importance of the stratigraphic formations of India.
- Stratigraphy of Tamil Nadu and Pondicherry region

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
I	P22GY2	Core Course – III PALAEONTOLOGY	5	25	75	100

Course Objectives

To impart knowledge on

- Fossils – their types and modes of preservation, evolution of life through time and, classification of organisms
- Evolution of vertebrates and invertebrates through geologic time, their morphology and important vertebrate and invertebrate fossils of India
- Microfossils, micropaleontological techniques, morphology of foraminifera and ostracods, evolution of plant life through ages and, important plant fossils in Indian Stratigraphy
- Applications of Palaeontology

Unit 1: Concepts of Paleontology: Fossils: types of fossils, nature and modes of preservation of fossils – Taphonomic processes: death, preburial and post burial changes of organisms – Evolution of life through geological time scale – Paleontology and evolution: Macroevolution and Microevolution, Punctuated equilibrium and phyletic gradualism – Classification of organisms: concept of species and binomial nomenclature – Outline on stromatolites, Ediacaran fauna and Largerstatten

Unit 2: Vertebrate Paleontology: Evolution of vertebrates through geologic time – Devonian fishes –Mesozoic reptiles – Evolutionary trend of Horse, Elephant and Man – Important vertebrate fossils in Indian Stratigraphy.

Unit 3: Invertebrate Paleontology: Evolution of invertebrates through ages – Morphology, evolution and stratigraphic importance of Corals, Graptolites, Trilobites, Brachiopods and Ammonites – Important invertebrate fossils in Indian Stratigraphy.

Unit 4: Micropaleontology: Microfossils and their types – Micropaleontological techniques: Separation of microfossils – General morphology of foraminifera and ostracoda – **Paleobotany:** Evolution of plants through ages – Gondwana flora and their stratigraphic significance – Outline on dinoflagellates, spores and pollens – Important plant fossils in Indian Stratigraphy.

Unit 5: Applications of Palaeontology: Uses of paleontological data in paleoecology, palaeoclimate, paleogeography, paleogeophysics, evolutionary studies correlation and biostratigraphy – Radiocarbon dating of fossils – Oxygen and carbon isotope studies of microfossils and their applications – Applications of microfossils in environmental interpretation, petroleum exploration and marine geological studies.

Text Books

1. Bignot, G (1985). Elements of Micropalaeontology, Graham Trotman.
2. Clarkson, E and N.K. Clarkson (1998). Invertebrate Palaeontology & Evolution, Wiley-Blackwell.
3. Doyle, P (1996). Understanding Fossils: An Introduction to Invertebrate Palaeontology, John Wiley & Sons Ltd.
4. Jain P.C and M.S. Anatharaman (2018). An Introduction to Paleontology, Vishal Publications.
5. Raup, D.M and S.M Stanley (1985). Principles of Paleontology, CBS Publications.
6. Saraswati P. K and M.S. Srinivasan (2016). Micropaleontology - Principles and Applications, Springer International Publishing.
7. Sreepat Jain (2017). Fundamentals of Invertebrate Palaeontology, Springer.
8. Woods, H (1959). Invertebrate Palaeontology, Cambridge.

Reference Books

1. Armstrong Howard, A and D. B. Martin (2005). Microfossils, Blackwell Publishing.
2. Benton, M. J (2015). Vertebrate Palaeontology and Evolution (IV Edition), Wiley-Blackwell.
3. Colbert, E.M (1960). Evolution of the Vertebrates, Wiley Eastern.
4. Easton, W. H (1960). Invertebrate Paleontology, Harper's Geoscience Series,
5. Hag, B.U and A. Boersma (1978). Introduction to Marine Micropalaeontology. Elsevier, Netherlands, 376p.
6. Moore, R.C., Lalieker, C.D and A.G. Fischer (1952). Invertebrate Fossils, McGraw Hill.
7. Prothero, D. R (2007). Evolution - What the Fossils Say and Why it Matters? Columbia University Press,
8. Reed Wicander and J. S. Monroe (2007). Historical Geology: Evolution of Earth and Life through Time (VI Edition), Brooks / Cole, Cengage Learning.
9. Romer, A.S (1960). Vertebrate Palaeontology, Chicago Press.
10. Shrock, R.R and W.H Twenhofel (1953). Principles of Invertebrate Palaeontology, Arnold Publications.

Course Outcomes

On completion of the course the students would have acquired knowledge on

- Fossils – their types and modes of preservation, evolution of life through time and, classification of organisms
- Evolution of vertebrates and invertebrates through geologic time, their morphology and important vertebrate and invertebrate fossils of India
- Microfossils, micropaleontological techniques, morphology of foraminifera and ostracods, evolution of plant life through ages and, important plant fossils in Indian Stratigraphy
- Applications of Palaeontology

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
I	P22GY3	**Core Course – III** **ADVANCED CRYSTALLOGRAPHY AND MINERALOGY**	5	25	75	100

Course Objectives

To impart knowledge on

- Crystallographic projections and notations, application of XRD and space lattices
- Construction and uses of nicol prism, optical indicatrix of uniaxial and biaxial minerals and, determination of refractive indices of minerals
- Parts and functioning of polarising microscope, optical accessories, optical properties of uniaxial and biaxial minerals, determination of optic sign, optic axial angle and sign of elongation
- Optical properties, physical properties and paragenesis of Quartz, Feldspar, Feldspathoid, Zeolite group minerals and. Garnet, Epidote, Spinel, and Alumino-silicates
- Optical properties, physical properties and paragenesis of Olivine, Pyroxene, Amphibole, Mica, Chlorite, Halide and clay minerals

Unit 1: Advanced crystallography: Derivation of 32 Crystal classes and their symmetry projections – Hermann mauguin notation – Spherical, Stereographic and Gnomonic projections of crystals belonging to normal classes – 14 Bravais space lattices – X-ray Crystallography: Derivation of Bragg's law and its applications, Powder diffraction method, Powder diffractometer – Monochromatic radiations – Debye-scherrer method - Space lattice-unit cell-motif-point group-space group. Concepts of crystal field theory and mineralogical spectroscopy. Stoichiometry – atomic substitution in minerals. Lattice defects (point, line and planar)

Unit 2: Optical mineralogy: Polarization – double refraction in calcite – Nicol prism. Orthoscopic and conoscopic study of minerals - Ray velocity surface of Uniaxial and biaxial minerals, Optic axis - primary and secondary optic axes – Indicatrix: uniaxial and biaxial minerals - Interference figure, sign of elongation, optic sign. Methods of determination of refractive indices of minerals

Unit 3: Polarizing Microscope and Its Accessories - Quartz wedge, mica plate, gypsum plate, berek compensator, micrometer ocular and their uses. Optical Properties of uniaxial and biaxial minerals – Mineral orientation, dispersion, pleochroic scheme, birefringence, twinning, extinction angle, determination of optic sign using interference figures, sign of elongation and optic axial angle, optical anomalies and irregularities in minerals. U stage techniques for determination of anorthite content and twin laws in plagioclase

Unit 4: Descriptive mineralogy: mineral properties **-** Isomorphism, polymorphism, pseudomorphism, exsolution, order and disorder relations, fluorescence in minerals, Thermoluminescence study and its significance - metamict state, staining techniques and micro chemical tests. Structural classification of silicate minerals and their compositional variations – Optical properties, physical properties and paragenesis of the following mineral groups: Olivine Group, pyroxene group, amphibole group, mica group, chlorite group, halide groups and clay minerals.

Unit 5: Optical properties, physical properties and paragenesis of the following mineral groups: Quartz, Feldspar, Feldspathoid and Zeolites groups - Garnet Group, Epidote group, Spinel group, Alumino-silicates, Optical

properties, physical properties and paragenesis of the following minerals: zircon, sphene, topaz, staurolite, beryl, cordierite, tourmaline, wollastonite , apatite, fluorite, corundum and calcite.

Text Books

1. Berry, L.G and B. Mason (2019). Elements of Mineralogy (2nd eBook Edition), CBS Publishers and Distributors, New Delhi.
2. Dana, F.S (1955). A Text Book of Mineralogy, Asia publishing House, Wiley.
3. Mason, Band L.G. Berry (2004). Elements of Mineralogy (II Edition), CBS Publishers, 561p
4. Phillips, P.C (1956). An Introduction to Crystallography, Longmans Green & Co.
5. Read, H.H (1974). Rutley's Elements of Mineralogy, Thomas Murby& Co.
6. Winchell, A.N (1968). Elements of Optical Mineralogy, Wiley Eastern Pvt. Ltd.

Reference Books:

1. CornelisKlen and Cornelius S. Hurlbut (1985). Manual of Minerology, John Wiley &Sons
2. Deer, W.A., Howoe, R.A and J. Zuessman (1966). An Introduction of the Rock Forming Minerals, Longmans.
3. Dyar, M and M.E. Gunter (2007). Mineralogy and Optical Mineralogy, Mineralogical Society of America, 705p.
4. Gribble, C.D and A.J. Hall (1985). A Practical Introduction to Optical Mineralogy, Springer, 252p.
5. Kerr, P.F (1959). Optical Mineralogy, McGraw Hill, New York, 442p.
6. Nesse, W.D (1991). Introduction to Optical Mineralogy, Oxford University Press, Oxford, 335p.
7. Wade, F.A and R.B. Mattox (1960). Elements of Crystallography and Mineralogy, Harper & Bros.

Course Outcomes

On completion of the course the student would have gained knowledge on

- Crystallographic projections and notations, application of XRD and space lattices
- Construction and uses of nicol prism, optical indicatrix of uniaxial and biaxial minerals and, determination of refractive indices of minerals
- Parts and functioning of polarising microscope, optical accessories, optical properties of uniaxial and biaxial minerals, determination of optic sign, optic axial angle and sign of elongation
- Optical properties, physical properties and paragenesis of Quartz, Feldspar, Feldspathoid, Zeolite group minerals and. Garnet, Epidote, Spinel, and Alumino-silicates
- Optical properties, physical properties and paragenesis of Olivine, Pyroxene, Amphibole, Mica, Chlorite, Halide and clay minerals

Semester	Course Code	Course Title	Credit	Marks			
				Internal	Oral	External	Total
I	P22GY4P	Core Course – IV PRACTICAL 1 PALAEONTOLOGY, ADVANCED CRYSTALLOGRAPHY AND MINERALOGY	4	25	5	70	100

Course Objectives

To impart knowledge on

- The morphological characters and evolutionary characters of marine invertebrates, foraminifera and osctracods and, plant fossils
- Stereographic and gnomonic projections of natural crystals, symmetry projections of 32 classes, measurement of interfacial angle using contact goniometer
- Identification of minerals using physical and optical properties of minerals, determination of optical vibration directions, dichroic and pleochroic schemes, sign of elongation, optic sign, optic axial angle by Mallard's method

A. Palaeontology:

Megascopic study of corals, Graptolites, Trilobites, Brachiopods, Cephalopods and Echinoderms with special reference to their evolutionary characters – Study of plant fossils – Microscopic study of some foraminifera and ostracoda.

B. Crystallography:

Stereographic and Gnomonic projections of natural crystals of normal classes -symmetry projections of 32 classes - calculation of crystal elements to test the knowledge of application of tangent relation - Anharmonic ratio, Napier's theorem and equation of the normal - Use of contact goniometer in measuring interfacial angles.

C. Mineralogy:

Megascopic and microscopic study of important rock forming silicates –Determination of optical vibration directions, dichroic and pleochroic schemes, sign of elongation, optic sign of uniaxial and biaxial minerals

Course Outcomes

On completion of the course students would have gained practical knowledge on

- The morphological characters and evolutionary characters of marine invertebrates, foraminifera and osctracods and, plant fossils
- Stereographic and gnomonic projections of natural crystals, symmetry projections of 32 classes, measurement of interfacial angle using contact goniometer
- Identification of minerals using physical and optical properties of minerals, determination of optical vibration directions, dichroic and pleochroic schemes, sign of elongation, optic sign, optic axial angle by Mallard's method

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
I	P22GY5E1	Elective Course – I ENVIRONMENTAL GEOLOGY AND MARINE GEOLOGY	4	25	75	100

Course Objectives

To impart knowledge on

- Basic concepts of Environmental Geology, Earth in space and time, mass extinction events, energy sources of disasters, strategies for reducing hazards of earthquake and volcanic activity
- River flooding, mass movements, soil erosion, their hazards, mitigation measures and the role of Geology in it, environmental impacts of mining activities, hydropower projects, disposal of nuclear waste.
- Hazards of coastal areas, mitigation measures and, the role of geology in it, impacts of human activities in coral reef, marine and estuarine environments, water pollution, global climatic changes, desertification and urbanisation
- Physical properties and chemistry of ocean water, ocean circulation and influencing factors, tectonic domains of ocean floor, formation of oceanic crust and, sea level changes
- Oceanic sediments – their deposition, distribution and geochronology, origin of ocean basins, marine mineral resources, marine pollution, laws of sea, EEZ and SEZ

Unit 1: Basic concepts of Environmental Geology – Outline of Earth in space and time – Mass extinctions through geologic time – Energy sources of disasters: internal and external sources – Earthquakes: hazards of earthquakes, strategies for their reduction and the role of geology –Volcanic activity: hazards of volcanic activity, strategies for their reduction and the role of geology.

Unit 2: River flooding: factors governing flood severity, hazards of flooding, strategies for their reduction and the role of geology – Mass movement: factors influencing slope stability, types and hazards of mass movement, strategies for their reduction and the role of geology – Soil erosion: factors influencing soil erosion, hazards of soil erosion, strategies for their reduction and role of geology – Environmental impacts of mining activities, hydropower projects, disposal of nuclear wastes.

Unit 3: Coastal hazards (coastal erosion, coastal flooding, sea water intrusion): strategies for their reduction and the role of geology – Impacts of human activities in coral reef, marine, estuarine environments – Global climate change: causes and effects – Surface and groundwater pollution – Desertification: causes and effects – Impacts of urbanization.

Unit 4: Marine Geology: Concepts and principles – Physical properties of ocean water – General oceanic circulation of water and factors affecting it – Formation of bottom waters – Major water masses of the world's oceans – Chemistry of ocean water – Morphologic and tectonic domains of the ocean floor –Structure, composition and mechanism of the formation of oceanic crust – Hydrothermal vents – Ocean margins and their significance – Sea level processes and eustatic changes.

Unit 5: Factors controlling deposition and distribution of oceanic sediments – Geochronology of oceanic sediments – Diagenetic changes in oxic and anoxic environments – Origin of ocean basins - Marine mineral resources – Tectonism and marine deposits – Marine pollution: pollutants in the marine environment, causes and remedial measures – Law of the Sea, EEZ and SEZ.

Text Books

1. Keller, E.A (2012). Introduction to Environmental Geology (V Edition), Pearson Prentice Hall, New York, 705p.
2. Montgomery, C.W (2019). Environmental Geology (IX Edition), McGraw-Hill Pub., New York, 576p.
3. Valdiya, K.S (1987). Environmental Geology – Indian Context, Tata McGraw Hill Publications, New Delhi, 583p.
4. Duff, D (1993). Holmes' Principles of Physical Geology (IV Edition), Chapman & Hall, London.
5. Kind, A.H (1979). Introduction to Marine Geology and Geomorphology, Edward Arnold.
6. Kennett, J.P (1982). Marine Geology. Prentice Hall, London.

Reference Books

1. Bhatt, J.J (1994). Oceanography: Exploring the Planet Ocean. D. Van. Nostrand Company, New York.
2. DeWet, A., Menking, K and D. Merritts (2014). Environmental Geology: An Earth Systems Approach, Macmillan Learning, 500p.
3. Foley, D., McKenzie, G.D and R.O. Utgard (2009). Investigations in Environmental Geology (III Edition), Pearson Prentice-Hall, 288p.
4. Gross, M.G (1977). Oceanography: A View of the Earth, Prentice Hall.
5. Jin Erickson (2002). Environmental Geology, Facts on File, Inc., New York, 310p.
6. Kerth. S (1996). Ocean Science, John Wiley & Sons Inc. New York.
7. Kuenen, Philip (1950). Marine Geology, Wiley.
8. LaMoreaux, J.W (2019). Environmental Geology, Springer Science+Business Media, LLC, part of Springer Nature, New York, 472p. (New)
9. McConnell, R.L and D.C Abel (2015). Environmental Geology Today, Jones and Bartlett Learning, Burlington, 844p.
10. Reichard, J.S (2011). Environmental Geology, McGraw Hill, New York, 545p.
11. Seibold, E and W. H. (1982). The Sea Floor. Springer-Verlag, Berlin.
12. Shepard, F. P (1994). Submarine Geology, Harper and Row Publ. New York.
13. Turekian, K.K (1968). Oceans, Prentice Hall

Course Outcomes

On completion of the course the students would have acquired a comprehensive knowledge about

- Basic concepts of Environmental Geology, Earth in space and time, mass extinction events, energy sources of disasters, strategies for reducing hazards of earthquake and volcanic activity
- River flooding, mass movements, soil erosion, their hazards, mitigation measures and the role of Geology in it, environmental impacts of mining activities, hydropower projects, disposal of nuclear waste.
- Hazards of coastal areas, mitigation measures and, the role of geology in it, impacts of human activities in coral reef, marine and estuarine environments, water pollution, global climatic changes, desertification and urbanisation
- Physical properties and chemistry of ocean water, ocean circulation and influencing factors, tectonic domains of ocean floor, formation of oceanic crust and, sea level changes
- Oceanic sediments – their deposition, distribution and geochronology, origin of ocean basins, marine mineral resources, marine pollution, laws of sea, EEZ and SEZ

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
I	P22GY5E2	Elective Course – I CLIMATE CHANGE STUDIES	4	25	75	100

Course Objectives:

To impart knowledge on

- Earth's radiation balance, latitudinal and seasonal variation of climatic parameters, Earth's atmosphere, global ocean circulation, classification of current climates
- Earth's energy imbalance and energy flow and climatic processes
- Paleoclimatology and multidisciplinary approach in deducing Paleoclimate
- Important aspects of natural climatic changes and anthropogenic changes

Unit 1: Fundamentals of Climate: Solar spectrum and Earth's radiation balance; latitudinal and seasonal variation of temperature, pressure, air density, humidity – Constitution and stratification of the Earth's atmosphere –Global ocean circulation– Water cycle –Classification of current climates: Koppen's and Thornthwaite's scheme of classification

Unit 2: Climate Processes: Earth's energy imbalance and energy flow - Radiative forcing - Rising Temperature - Solar irradiance – Greenhouse effect – Carbon-dioxide and carbon - Climate forcing, and climate feedbacks – Earth's atmosphere – Earth's land surface – The world ocean –Cryosphere and melting ice - Ocean-Atmosphere Interface – Land-Atmosphere iterface.

Unit 3: Paleoclimatology: Principles of Paleoclimatology – Causes of climate change – Multidisciplinary approach in Paleoclimatology – Proxies of palaeoclimate–Paleo-atmospheres: Ice-core Record – Paleo-sea level: Sediment core record – Biological concepts in Paleoclimatology

Unit 4: Natural Climate Change: Orbital climate change and geologic evidence –Millennial-scale climate change, Holocene climate change, Centennial climate change and Decadal climate change – Inter annual climate change in the Tropics: ENSO – Ice core record of climate change: glacial, interglacial climate and climate proxies from ice cores - Sea-level change: historical sea-level and evidence for Sea-Level Change – Role of volcanoes in climate change.

Unit 5: Anthropogenic Climate Change: Human activities impacting the climate system –Fossil fuel, atmospheric change, land use – Ocean acidification – Rising sea level – Melting glaciers – More violent storms – Deforestation – Desertification – Species migration and extinctions – Changing seasons and disruption of life cycles – Projections of future climate – Intergovernmental Panel on Climate Change and Summary of the latest assessment report.

Text Books

1. Mcilveen, J.F.R (1992). Fundamentals of Weather and Climate, Springer-Science Business Media.
2. Ralph J. C (2001). Climate Change Science,National Research Council, Washington, D.C.
3. Thomas Farmer, G (2015). Modern Climate Change Science: An Overview of Today's Climate Change Science, Springer, New York.
4. Trevor Letcher (2009). Climate Change, Elsevier Science.

Reference books:

1. AsheemSrivastav (2019). The Science and Impact of Climate Change, Springer Singapore.
2. FátimaAlves, Walter Leal Filho and UlissesAzeiteiro (2018). Theory and Practice of Climate Adaptation, Springer International Publishing.
3. James Rodger Fleming (1998). Historical Perspectives on Climate Change, Oxford University Press.
4. Lamb,H. H (2006). Climate: Present, Past and Future: Volume 1 - Fundamentals and Climate Now, Routledge (Taylor &Francis Group).
5. Michael D. Mastrandrea, Stephen H. Schneider (2010). Preparing for Climate Change, The MIT Press.
6. Thomas M. Cronin (1999). Principles of Paleoclimatology, Columbia University Press, New York.

Course Outcomes

On completion of the course the student would have acquired a comprehensive knowledge on

- Earth's radiation balance, latitudinal and seasonal variation of climatic parameters, Earth's atmosphere, global ocean circulation, classification of current climates
- Earth's energy imbalance and energy flow and climatic processes
- Paleoclimatology and multidisciplinary approach in deducing Paleoclimate
- Important aspects of natural climatic changes and anthropogenic changes

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
II	P22GY6	Core Course – V IGNEOUS AND METAMORPHIC PETROLOGY	5	25	75	100

Course Objectives

To impart knowledge on

- Forms, structures and textures, classification of igneous rocks, types of magma, their generation, physical properties
- Bowen's reaction series, crystallisation of unary, binary and ternary magma, trace elements and REE and their applications in igneous petrology
- Igneous rocks and plate tectonic settings, petrogenetic aspects of important rock suites of India
- Types of metamorphism, metamorphic structures and textures, metamorphic zones, grades and facies, chemographic diagrams and, plate tectonic significance of metamorphism
- Equilibrium concepts in thermodynamics, metamorphism of pelitic, mafic and impure carbonate rocks, study of common metamorphic rocks

Unit 1: Forms of igneous rocks – Structures and textures of igneous rocks – Classification of igneous rocks – Outline on the generation of magma – Types of magma and their chemical composition – Physical properties of magma – Magma ascent and magma diversity: magmatic differentiation, assimilation, fractional crystallization and liquid immiscibility.

Unit 2: Elementary thermodynamics: Laws of thermodynamics, Gibb's Phase rule and Lever Rule and their application to igneous petrogenesis – Bowen's reaction series – Crystallization of unary magma: SiO_2 system – Crystallization of binary magma: simple eutectic (Albite-Silica), solid solution (Forsterite-Fayalite) and incongruent melting (Forsterite-Silica) – Crystallization of ternary magma: Diopside-Forsterite-Silica melt systems, Diopside-Albite–Anorthite melt systems and Anorthite–Forsterite–Silica melt systems – Role of volatiles in crystallization – Trace elements and their application in fractional crystallization – REE distribution in rocks and their application to igneous systems.

Unit 3: Igneous rocks and plate tectonic settings: igneous rocks at divergent boundary (mid-oceanic ridges, rift valleys), igneous rocks at convergent boundary (subduction zones), igneous rocks in intraplate (above hotspots, continental flood basalt and large igneous provinces) – Outline on the petrogenetic aspects of important rock suites of India: Deccan basalts, granites (granitoids), layered intrusive complexes, anorthosites, carbonatites, komatiites, syenites, kimberlites, lamprophyres, and ophiolites.

Unit 4: Metamorphism: controls, limits and agents – Types of metamorphism – Short notes on metamorphism of partial melting, metasomatism, anataxis and palingensis – Metamorphic structures and textures – Mineralogical changes due to metamorphism: zones, grades and facies – Chemographic diagrams: ACF, AKF, AFM – Plate tectonic significance of metamorphism: Pressure Temperature Time (P-T-t) paths and metamorphic facies series.

Unit 5: Equilibrium concepts in thermodynamics: enthalpy, entropy, Gibb's free energy, chemical potential and equilibrium – Gibb's phase rule and Claussius-Clapeyron equation –Geothermobarometer – Metamorphism of pelitic, mafic and impure carbonate rocks – Brief study on common metamorphic rocks: slate, phyllite, schist, gneiss, amphibolite, eclogite, granulite, khondalite, migmatite, marble, quartzite.

Text books:

1. Best, M.G (1993). Igneous and Metamorphic Petrology, CBS Publishers and Distributors.
2. Ehlers E.G (1999). Petrology: Igneous Sedimentary & Metamorphic, CBS Publishers and Distributors.

3. Hatch R. H and A.K. Wells (2003.) Petrology of the Igneous Rocks, CBS Publishers and Distributors.
4. Haldar S. K and Tisljar Josip (2014). Introduction to Mineralogy and Petrology, Elsevier.
5. Turner, F.J and J. Verhoogen (1960). Igneous and Metamorphic Petrology, McGraw Hill.
6. Tyrrell, G.W (1963). Principles of Petrology, Asia Publishing House.
7. Winter J.D (2014). Igneous and Metamorphic Petrology, Prentice Hall.

Reference books:

1. Antony Hall (1992). Igneous Petrology, ELBS.
2. Frost, B. R and D.C Frost (2014). Essentials of Igneous and Metamorphic Petrology, Cambridge University Press, New York.
3. Gautham Sen (2014). Petrology, Springer Publications.
4. McKenzie W.S., Donaldson, C.H and C. Guilford (1982). Atlas of Igneous Rocks and their Textures, Longman.
5. McBirney, A.R (1994). Igneous Petrology, CBS Publishers and Distributors.
6. Morse, S.A (1980). Basalts and Phase Diagrams, Springer Verlag.
7. Phillipots R. Anthony and Cornelis Klein (2017). Earth Materials: Introduction to Mineralogy and Petrology, Cambridge University Press,
8. Raymond, L. A (2001). Petrology: The Study of Igneous, Sedimentary and Metamorphic Rocks, McGraw Hill.
9. Winkler, H.G.F (1967). Petrogenesis of Metamorphic Rocks, Springer and Verlag.

Course Outcomes

On the completion of the course the student would have acquired knowledge on

- Forms, structures and textures, classification of igneous rocks, types of magma, their generation, physical properties
- Bowen's reaction series, crystallisation of unary, binary and ternary magma, trace elements and REE and their applications in igneous petrology
- Igneous rocks and plate tectonic settings, petrogenetic aspects of important rock suites of India
- Types of metamorphism, metamorphic structures and textures, metamorphic zones, grades and facies, chemographic diagrams and, plate tectonic significance of metamorphism
- Equilibrium concepts in thermodynamics, metamorphism of pelitic, mafic and impure carbonate rocks, study of common metamorphic rocks

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
II	P22GY7	Core Course – VI SEDIMENTARY PETROLOGY AND SEDIMENTOLOGY	5	25	75	100

Course Objectives

To impart knowledge on

- Textures and structures, and classification of sedimentary rocks,
- Techniques in Sedimentology, graphical representation of sediment size analysis data and their interpretation, applications of trace elements, REE and stable isotopes towards solving sedimentological problems
- Sedimentary facies and products
- Plate tectonics and sedimentation, classification and description of sedimentary basins, and formation of basins
- Sedimentary basin analysis

Unit 1: Sedimentation – Textures and structures of sedimentary rocks – Classification and composition of sedimentary rocks – Study of residual deposits: terra rosa, clay with flint, laterite, bauxite, residual clays – Study of clastic rocks: rudaceous (Conglomerate and Breccia), arenaceous (Sandstone and its classification), volcano-clastic deposits, siltstones, mudstones – Study of non-clastic rocks (limestones and dolomites, siliceous deposits, ferruginous deposits, carbonaceous deposits, phosphatic deposits, evaporites).

Unit 2: Techniques in Sedimentology – Collection and analysis of field data – Mechanical analysis of sediments – Graphical representation of size analysis data – Statistical parameters and their geological significance – Microscopical techniques – Cathodoluminesence – X–ray diffraction – Scanning electron microscope – Application of trace element, rare earth element and stable isotope geochemistry to sedimentological problems – Heavy minerals and their significance – Provenance of sediments – Sedimentary differentiation – Lithification and diagenesis.

Unit 3: Sedimentary facies and products: Non-marine continental, continental margin, oceanic facies – Non marine environments: Desert, fluvial, lake and glacial-environments, climaticsignificance of red beds – Transitionalenvironments :coastalcurrents, estuarine, deltas, shore fans, barrier complexes and pertidal complexes – Marine environments – Continental shelf, slope and rise – Climaticsignificance of carbonates.

Unit 4: Concept of plate tectonics and sedimentation – Classification and description of basins: down-warp basins, rift basins, interior basins, foreland basins, subduction basins, pull apart basins, delta type basins, composite basins – Basin formation: basins in compressional zones, strike slip zones, transform fault zones – Geosynclines: stratigraphy and sedimentation – Lateral relationships and correlation of sedimentary strata.

Unit 5: Basin analysis: Basin and its lithic fill, palaeoslope, palaeocurrent, palaeo-fluvial channels and depositional environment – Diagnostic and maturation, sediment chemistry, basin evolution and tectonics – Sequence stratigraphy: para-sequence sets and stacking patterns: progradational stacking, aggradational stacking, retrogradational stacking – Depositional sequence: Low-stand System Tract (LST), Transgressive System Tract (TST), High-stand system Tract (HST) – Sequence boundary, transgressive surface, maximum flooding surface – A note on applications of Chemo-stratigraphy.

Text Books

1. Petijohn, F.J (2002). Sedimentary Rocks (III Edition), CBS Publishers & Distributors.
2. Prothero, D. R and Schwab, F (2003). Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy, W. H. Freeman.
3. Tucker, M.E (2001).Sedimentary Petrology, Blackwell Science.
4. Williams, H., Turner, F.J and C.M Billbert (1954). Petrography, Freeman

Reference Books

1. Bayly, B (1968). Introduction to Petrology, Prentice Hall.
2. Bhattacharyya, C. Chakraborty (2000). Analysis of Sedimentary Successions, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi
3. Blum, M.D., Marriot, S.B and F. Leclair (2005). Fluvial Sedimentology, Blackwell Publishing, London
4. Hsu, K.J (2004). Physics of Sedimentology (II Edition), Springer Verlag, London
5. Krumbein, W.C. and L.L. Sloss (1951). Stratigraphy and Sedimentation, Freeman.
6. Michael McLane (1995). Sedimentology, Oxford University Press, London
7. Sam Boggs (2000). Principles of Sedimentology and Stratigraphy, Pearson USA

Course Outcomes

On completion of the course students would have acquired knowledge about the

- Textures and structures, and classification of sedimentary rocks,
- Techniques in Sedimentology, graphical representation of sediment size analysis data and their interpretation, applications of trace elements, REE and stable isotopes towards solving sedimentological problems
- Sedimentary facies and products
- Plate tectonics and sedimentation, classification and description of sedimentary basins, and formation of basins
- Sedimentary basin analysis

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
II	P22GY8	Core Course – VII GEOMORPHOLOGY	5	25	75	100

Unit - 1: Geomorphology – Introduction

Fundamental concepts of geomorphology – Fundamental driving forces of landform formation: internal and external forces – Energy balance of the Earth's surface processes – Physiography of the Earth – Outline of geomorphic processes: exogenous and endogenous processes – Applications of Geomorphology

Unit - 2: Weathering, Soil and Drainage

Weathering: types and products, factors affecting rates of weathering, landforms formed by weathering, applications – Soils: soil development process, factors affecting soil production, soil profiles, soil classification, soils and landscapes,– Erosion, transportation and deposition of Earth materials – Hill slopes: processes, climatic influence on slope processes, slope morphology, and slope evolution, applications – Drainage: patterns, evolution, quantitative analysis.

Unit - 3: Fluvial, Glacial, Groundwater, Aeolian Geomorphology

Fluvial Geomorphology: fluvial processes and landforms, applications of fluvial geomorphology – Glacial Geomorphology: glacial processes and landforms, applications – Groundwater Geomorphology: processes, landforms, and applications – Aeolian Geomorphology: aeolian processes, landforms, applications

Unit - 4: Tectonic and Volcanic Geomorphology, Landforms related to rock type and structure

Tectonic Geomorphology: tectonic processes, landforms and landscape response to tectonics, markers of tectonic geomorphology, applications – Volcanic Geomorphology: volcanic landscapes, processes of volcanic landform evolution, applications – Landforms related to rock type and structure - Outline on impact craters – Anthropogenic activities and landforms

Unit - 5: Coastal, Marine, Climatic Geomorphology and Geomorphology of India

Coastal Geomorphology: coastal processes and landforms, applications – Shorelines: classification of shorelines and their evolution – Marine Geomorphology: marine processes and landforms, applications – Climatic Geomorphology: records of changing climate cycles, Koppen climate classification, climate related landform and processes, landscape response to climate, landscape controls on climate, applications – Major geomorphic features of India: coastal, peninsula and extra peninsula – River basins of India

Text Books

1. Dayal, P (2010). A Text Book of Geomorphology, Rajesh Publications, New Delhi, 730p.
2. Kale, V and Gupta, A. (2018). Introduction to Geomorphology, Universities Press, Orient Black Swan Pub., Chennai, 278p.
3. Kale, V. (2014). Landscapes and Landforms of India, Springer Netherlands, 271p.
4. Plummer, C.C., Carlson, D.H and Hammersley, L. (2016). Physical Geology (15th Edition), McGraw-Hill Education, New York, 595p.
5. Savindra Singh (2018). Geomorphology, PrayagPustakBhawan, Allahabad
6. Sharma, H.S. (2010). Geomorphology in India, PrayagPustakBhawan, Allahabad, 563p.
7. Siddhartha, K. (2018). The Earth's Dynamic Surface: A Book of Geomorphology (Paperback), Books Wagon Pub., 588p.
8. Thornbury, W.D. (2018). Principles of Geomorphology (3rd Edition), New Age International Publishers, New Delhi, 614p.

9. Vaidyanathan, R. (2002). Geomorphology of the Indian Subcontinent, Published by the Indian Society of Remote Sensing, 29p.

Reference Books

1. Adrian Harvey. (2012). Introducing Geomorphology: A Guide to Landforms and Processes, Dunedin Academic Press Ltd., Edinburgh, 124p.
2. Ahnert, F. (1998). Introduction to Geomorphology, Routledge Publishers, New Delhi, 360p.
3. Bierman, P.R and Montgomery, D.R. (2014). Key Concepts in Geomorphology, W. H. Freeman and Company Publishers, New York, 494p.
4. Burbank, D.W and Anderson, R.S. (2008). Tectonic Geomorphology, Blackwell Science Ltd., Oxford, U.K, 274p.
5. Gutierrez, M. (2005). Developments in Earth Surface Processes: Climatic Geomorphology, Elsevier Pub., Amsterdam, 760p.
6. Rugget, R.J. (2017). Fundamentals of Geomorphology (Fourth Edition), Routledge Pub., Oxon, 543p.
7. Summerfield, M A. (1991).Global Geomorphology, Pearson Educational, for Prentice Hall, London, 537p.
8. Tarbuck, E.J and Lutgens, F.K. (2014). Earth – An Introduction to Physical Geology, Pearson Education, Inc. New York, 904p.
9. Thompson, G.R and Turk, J (1997). Introduction to Physical Geology (2nd Edition), Brooks/Cole Publishers, California, 300p.

Semester	Course Code	Course Title	Credit	Marks			
				Internal	Oral	External	Total
II	P22GY9P	Core Course – VIII PRACTICAL 2 PETROLOGY, ENGINEERING GEOLOGY AND MINING GEOLOGY	4	25	5	70	100

Course Objectives:

To impart knowledge on

- The identification of igneous rocks from their megascopic and optical characteristics, CIPW Norm calculation, problems relating to Niggli values and Niggli basis, variation diagrams
- The identification of sedimentary rocks from their megascopic and optical characteristics, Mechanical analysis of sediments and statistical studies of grain size data
- The identification of metamorphic rocks from their megascopic and optical characteristics, interpretation of ACF, AKF and AFM diagrams
- Determination of engineering properties of various geological materials and skills in engineering geological works and problems
- Ore reserve estimation

A. Petrology

i) Igneous Petrology

- Megascopic and microscopic study of igneous rocks
- Problems relating to C.I.P.W. Norm
- Harker's diagram and Niggli variation diagram
- Problems relating to Niggli values and Niggli basis
- Von Wulff plots and variation diagrams

ii) Sedimentary Petrology

- Megascopic and microscopic study of sedimentary rocks
- Mechanical analysis of sediments and statistical studies of grain size data

iii) Metamorphic Petrology

- Megascopic and microscopic study of metamorphic rocks.
- ACF, AKF and AFM diagrams

B. Engineering Geology

- Determination of engineering properties of various geological materialsand skills in engineering geological works and problems.

C. Mining Geology

- Problems relating to evaluation of ore reserves.

Course Outcomes

On completion of the course the student would have gained practical knowledge on

- The identification of igneous rocks from their megascopic and optical characteristics, CIPW Norm calculation, problems relating to Niggli values and Niggli basis, variation diagrams
- The identification of sedimentary rocks from their megascopic and optical characteristics, Mechanical analysis of sediments and statistical studies of grain size data
- The identification of metamorphic rocks from their megascopic and optical characteristics, interpretation of ACF, AKF and AFM diagrams
- Determination of engineering properties of various geological materialsand skills in engineering geological works and problems
- Ore reserve estimation

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
II	P22GY10E1	**Elective Course – 2** **ENGINEERING GEOLOGY, MINING GEOLOGY AND ORE DRESSING**	4	25	75	100

Course Objectives:

To impart knowledge on

- Engineering properties of rocks and soils, geological investigations pertaining to the construction of highways, railways, airfields/runways, bridges and buildings, mitigation of mass movements
- Geological investigations for dams and reservoirs, tunnels, coastal structures, construction of harbours and docks
- Types of sampling, methods of drilling, geological logging, ore reserve estimation
- Alluvial mining, opencast mining, underground mining, coal mining techniques
- Ore dressing techniques.

Unit 1: **Engineering Geology:** Elementary concepts of Rock Mechanics and Soil Mechanics – Engineering properties of rocks and soils – Geological reconnaissance, site investigation, characterization and problems related to civil engineering projects – Outlines on Standard Penetration Test (SPT), Seismic Cone Penetration Test (SCPT) and Core Recovery (CR) – Overview on Rock Quality Designation (RQD) and Rock Mass Rating (RMR) – Geotechnical Report (GTR) – Geologic considerations of construction Materials – Geological investigations pertaining to the construction of Roads/Highways, Railways(rail tracks), Airfields/Runways, Bridges and Buildings – A note on seismic design of buildings – Geological and geotechnical investigations for the mitigation strategies of mass-movements with special emphasis on landslides – Causes of hill-slope instability – Slope stability – Outline on geosynthetics.

Unit 2: Geological investigations for dams and reservoirs – Spill way problems and reservoir problems – Geological investigations preceding tunneling or excavation, problems relating to tunneling or excavation in hard and soft grounds – Geological investigations pertaining to coastal protection structures – Geotechnical investigations pertaining to the construction of harbour and docks –Important Engineering Geological case studies.

Unit 3: **Mining Geology:** Mining terms and their descriptions – Sampling: principles and types of sampling - Drilling: types of drills and methods of drilling – Geological logging - Explosives and blasting methods - Rock excavations: haulage, shafts and shaft sinking –Ore reserve estimation: assaying and evaluation of ore bodies and their extensions – Factors controlling the choice of various mining methods – Outline of Mines and Minerals Act of India.

Unit 4: Mining Methods: Alluvial mining: panning, sluicing, hydraulicking, drift mining and dredging – Opencast mining and mine machinery pertaining to it(power shovel, bucket wheel excavator, conveyor and spreader) – Underground mining: Stopping (open stopes, supported stopes, shrinkage stopes) and caving (top slicing, sub level caving and block caving) – Underground coal mining methods: Room and pillar method, long wall (advancing & retreating) method, pillar robbing, hydraulicking, power source roofing – Strip mining of coal – Hazards and mitigation of mining hazards.

Unit 5: Ore Dressing: Physical and chemical properties of minerals as applied to mineral dressing – Comminution: crushing and crushers (Jaw crushers, gyratory crushers and stamping) – Grinding and grinding mill (ball mill, rod mill and pebble mill) – Size separation: screening and screen separators (grizzly, trammel, vibratory, gyratory), sieve scale, grizzlie, vibrating screens – Settling, free settling hindered settling, gravity concentration –

Classification and classifiers (hydraulic, spiral, hydrocyclone) – Concentration: leaching, ore sorting, gravity concentration (panning, jig, spiral concentrator, shaking table, multigravity separator), magnetic separation, electrostatic separation, dense medium separation (flotation), dewatering (sedimentation, filtration, thermal dying) – Floatation: principle and application, frothing, collecting, and dispersing agents, floatation machines, practice and filtration.

Text Books

1. Arogyaswamy, R.N.P (1986). Courses in Mining Geology, Oxford & IBH Publishing Co., New Delhi.
2. Bell, F. G (1983). Fundamentals of Engineering Geology, Butterworths.
3. Blyth, F. G H. and M. H. De Freitas (1984). Geology for Engineers (VII Edition), Elsevier.
4. Haldar, S.K (2018). Mineral Exploration Principles and Applications, Elsevier, Oxford, 377p.
5. Krynine, D. P and W.R. Judd (2018). Principles of Engineering Geology and Geotechnics, CBS Publishers and Distributors Pvt. Ltd., New Delhi.
6. McKinstry, H. E (2000). Mining Geology, Asia Publishing House.
7. Pandey, V. K and A. Mishra (2017). Handbook of Engineering Geology, CBS Publishers and Distributors Pvt. Ltd., New Delhi.
8. Parbin Singh (2013). Engineering Geology, S. K. Kataria& Sons.
9. Taggart, A.E (1964). Elements of Ore Dressing, Wiley.
10. Venkat Reddy, D (2010). Engineering Geology, VikasPubl. House Pvt. Ltd., New Delhi.

Reference Books

1. Abzalov, M (2016). Applied Mining Geology, Springer International Publishing, 443p.
2. Das, B. M and K. Shoban (2017). Principles Geotechnical Engineering(IX Edition), Cengage Learning, 784p.
3. Donald, P. C (2017). Geotechnical Engineering: Principles and Practices (II Edition), Pearson Education, 808p.
4. Gokhale, K.V.G.K and D.M.Rao (1981). Experiments in Engineering Geology, Tata McGraw Hill, 142p.
5. Joseph, E. B (1984). Physical and Geotechnical Properties of Soils (II Edition), McGraw-Hill Inc., US, 576p.
6. Maslov, N. N (1987). Basic Engineering Geology and Soil Mechanics, Mir Publishers, Moscow.
7. Murthy, V.N.S (2018). Soil Mechanics and Foundation Engineering, CBS Publishers and Distributors Pvt. Ltd., New Delhi.
8. Ries, H and T.L.Watson (2011). Elements of Engineering Geology. John Wiley & Sons.
9. Singh, A and P.Rastogi (2006). Modern Geotechnical Engineering (III Edition), CBS Publishers and Distributors Pvt. Ltd., New Delhi, 846p.
10. Thamus, P.J (1979). An Introduction to Mining, Methun.
11. Stanton, R.L (1972). Ore Petrology, McGraw Hill.

Course Outcomes

After the completion of the course students would have gained knowledge about

- Engineering properties of rocks and soils, geological investigations pertaining to the construction of highways, railways, airfields/runways, bridges and buildings, mitigation of mass movements.
- Geological investigations for dams and reservoirs, tunnels, coastal structures, construction of harbours and docks.
- Types of sampling, methods of drilling, geological logging, ore reserve estimation.
- Alluvial mining, opencast mining, underground mining, coal mining techniques.
- Ore dressing techniques.

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
II	P22GY10E2	Elective Course – 2 GEOTECHNICS	4	25	75	100

Course Objectives:

- To make the learners understand the basicsof geotechnics and soil/rock mechanics.
- To initiate acquaintance on the site selection for various civil engineering structures.
- To learn the geotechnical investigations pertaining to their construction.
- To understand the natural hazards, site suitability analysis and mitigation strategies.
- To acquaint the geotechnical skills through case studies.

Unit 1:Introduction to Geotechnics(Geotechnical Engineering) – Formation of the Quaternary soil layers – Soils of Geological past – Review on Indian bedrocks – Soil properties: soil components and classification – Structure of soils – Mechanics of materials: stress and strain under conditions of tension, compression and shear – Elastic, plastic and time-dependent material – Multi-axis stress state – Conditions of failure – Soil Mechanics: soil stress and deformation – Tension in the soil-water system: total pressure, pore pressure and effective pressure – Soil compression – Soil shear and failure - Soil composition – The consolidation process – Soil's carrying capacity – Soil pressure – Soil slope stability – Rock mechanics*:* Rock strength and deformation properties – Rock mechanics calculations - Rock classification.

Unit 2: Geological reconnaissance, site investigation, characterization and problems related to Civil Engineering projects – Geotechnical Report (GTR) – Laboratory and field geotechnical tests: Applications of Geophysical (electrical) methods in Geotechnical investigations or Civil Engineering problems – Ground investigations – Penetration tests: Standard Penetration Test (SPT) and Seismic Cone Penetration Test (SCPT) – Drilling, Sampling (Bore Holes and Trial Bits) - Core Recovery (CR) – Logging, Bore-Log Report and Data Interpretation – Rock Quality Designation (RQD) – Bienawiski's Rock Mass Rating (RMR).

Unit 3: Construction materials: Geologic considerations and physical characteristics of building stones, concrete aggregates and rail road ballasts – Outline on Geosynthetics – Types of foundations and safe bearing capacity – Environmental considerations related to Civil Engineering Projects – Geological investigations pertaining to the development of roads/highways, airfields, bridges and buildings.

Unit 4: Dams and Reservoirs:Types of dams, geological investigations for dams and reservoirs – Dam foundation, construction, problems and remedial measures – Spill way problems and reservoir problems. Tunnels/Excavation sites: Geological investigations preceding tunneling or excavation – Problems relating to tunneling or excavation in hard and soft grounds– Coastal Structures: Geotechnical investigations pertaining to the construction of harbour and docks.

Unit 5: Natural hazards or geological causes for the failures of engineering structures and mitigation strategies – Geological and geotechnical investigations for the areas prone to mass movements with special emphasis on landslides – Causes of hill-slope Instability – Slope stability– Geological investigations pertaining to coastal protection, structures for control or preventive measures of coastal erosion and other impacts – A note on earthquake-resistant structures – Impacts of climate change on Engineering Geology and mitigation measures – Important Engineering Geological case studies.

Text Books

1. Das, B. M and K. Shoban (2017). Principles Geotechnical Engineering (XI Edition), Cengage Learning, 784p.
2. Pandey, V. K and A. Mishra (2017). Handbook of Engineering Geology, CBS Publishers and Distributors Pvt. Ltd., New Delhi.
3. Parbin Singh (2013). Engineering Geology, S. K. Kataria& Sons
4. Sivakugan N and Das, B. M (2014). Geotechnical Engineering: A Practical Problem Solving Approach, Cengage Publisher, Eureka Series.
5. Gokhale, K.V.G.K and D. M.Rao (1981). Experiments in Engineering Geology, Tata McGraw-Hill, 142p.

Reference Books

1. Bell, F. G (1983). Fundamentals of Engineering Geology, Butterworths.
2. Blyth, F. G. H and M. H. De Freitas (1984). Geology for Engineers (VII Edition), Elsevier.
3. Coduto, D. P., Yeung, M. R and W. A. Kitch (2010). Geotechnical Engineering: Principles and Practices (II Edition), Prentice Hall.
4. Harrison, J. P and J. A. Hudson (2001). Engineering Rock Mechanics: Part 2: Illustrative Worked Examples, Pergamon Publishers.
5. Hudson, J. A and J. P. Harrison (2000). Engineering Rock Mechanics: An Introduction to the Principles, Pergamon Publishers.
6. Krynine, D. P and W. R. Judd (2018). Principles of Engineering Geology and Geotechnics, CBS Publishers and Distributors Pvt. Ltd., New Delhi.
7. Maslov, N. N (1987). Basic Engineering Geology and Soil Mechanics, Mir Publishers, Moscow.
8. Murthy, V. N. S (2018). Soil Mechanics and Foundation Engineering, CBS Publishers and Distributors Pvt. Ltd., New Delhi.
9. Richard Bassett (2011). A Guide to Field Instrumentation in Geotechnics: Principles, Installation and Reading, CRC Press, 232p.
10. Ries, H. and T. L. Watson (2011). Elements of Engineering Geology. John Wiley & Sons.
11. Robert W. Day(2012). Geotechnical Engineers Portable Handbook (II Edition), McGraw-Hill Education, 1088p.
12. RuwanAbeyRajapakse(2015). Geotechnical Engineering Calculations and Rules of Thumb (II Edition), Butterworth-Heinemann, 457p.
13. Steve Hencher (2012). Practical Engineering Geology (Applied Geotechnics), CRC Press, 464p.
14. Venkat Reddy, D (2010). Engineering Geology, VikasPubl. House Pvt. Ltd., New Delhi.
15. Vutukuri, V. S., Lama, R. D and S. S. Saluja (1974). Handbook of Mechanical Properties of Rocks (Vol. 1,2,3& 4), Trans./Tech. S. A., Switzerland.

Course Outcomes

After the completion of the course students will be able to:

- Understand the concepts of Geotechnics as Soil Mechanics and Rock Mechanics.
- Ascertain the engineering properties and performance of rocks and soils.
- Apply the knowledge in petrology, structural analyses and field geology for site suitability study.
- Relate the geological and geotechnical skills in the construction of civil engineering structures.
- Recognize the natural hazards or geological causes for the failures of engineering structures and mitigation strategies.

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
III	P22GY11	Core Course – IX HYDROGEOLOGY	5	25	75	100

Course Objectives:

To impart knowledge on

- Hydrologic cycle, vertical distribution of groundwater, hydrologic properties of aquifers, groundwater occurrence in various rocks
- Groundwater movement, groundwater fluctuations and, impacts of global climatic change on groundwater
- Construction of wells and well hydraulics
- Surface and subsurface investigation methods for groundwater exploration, groundwater management and groundwater regime in India
- Graphical representation of hydrochemical data and interpretation, drinking water quality standards of WHO and BIS, groundwater contamination, and groundwater scenario in Tamil Nadu

Unit 1: Occurrence and Distribution of Groundwater: Origin of water on Earth – Hydrological cycle – Genesis of groundwater – Vertical distribution of groundwater – Hydrologic properties of aquifers – Geologic formations as aquifers: porosity, permeability and hydraulic conductivity and their ranges in representative rocks – Groundwater occurrence in igneous rocks, sedimentary rocks, metamorphic rocks, consolidated and unconsolidated sediments – Natural and artificial discharge of groundwater: springs, hot springs, geysers, water wells, and artesian wells.

Unit 2: Groundwater Movement and Groundwater Levels: Darcy's Law: experimental verification and validity; Darcy's Law in homogenous, heterogenous, isotropic and anisotropic media – Reynold's number and Bernoulli equation – Field and laboratory determination of hydraulic conductivity – Groundwater flow: rates, direction, dispersion and diffusion – Flow line and flow nets – Groundwater table mapping and Groundwater potential zonation – Groundwater fluctuations: causes and effects – Impacts of global climatic change on groundwater.

Unit 3: Water Wells and Well Hydraulics: Water wells: shallow wells and deep wells – Construction of a well: well drilling and well completion – Well development through pumping, bridging, surging with air, back washing, acidizing – Protection of well through sealing – Pumping test: Theis's method, Theim's method, Copper-Jacob's method, Chow's method – Well flow near aquifer boundaries.

Unit 4: Groundwater Exploration and Management: Geomorphological, structural and biological indicators of Groundwater – Surface investigation methods of groundwater: remote sensing, electrical resistivity – Sub surface investigation methods of groundwater; test drilling, resistivity logging – Managing groundwater resources: estimation of groundwater recharge and discharge, groundwater budget, residence time concept – Artificial recharge methods – Groundwater basin investigations and management practices – Groundwater regime in India.

Unit V: Groundwater Quality: Groundwater composition and units of expression, mass-balance calculations – Rock water interaction: chemical equilibrium, free energy, redox reactions and cation/anion exchanges – Graphic representation of chemical data – Latest drinking water quality standards of WHO and BIS – Outline of irrigation water quality standards – Groundwater quality contamination – Sea-water intrusion: causes, effects and their control – Groundwater issues due to urbanization; solid and liquid waste disposal and plume migration models – Application of isotopes (H, C, O) in groundwater – Groundwater scenario in Tamil Nadu.

Text Books

1. Todd, D.K (2005).Groundwater Hydrology, Wiley India Pvt. Ltd., New Delhi.
2. Gokhale, N.W (2009). All about Water, CBS Publishers, New Delhi.
3. Raghunath, H.M (2007). Groundwater, Wiley Eastern Limited, New Delhi.
4. Ramakrishnan, S (1998). Groundwater, KJ Graphs Arts, Chennai.
5. Saxena,R. N. and Gupta, D. C (2017). Elements of Hydrology and Groundwater, PHI Learning Private limited, New Delhi.

Reference Books

1. Fetter, C.W (2007). Applied Hydrogeology, CBS Publishers, New Delhi.
2. Hamid Rizvi, S.M (2015). Geomorphology and Hydrogeology, Kalyani Publishers New Delhi.
3. Sankar Kumar Nath (2000). Geophysical Prospecting for Groundwater, Oxford and IBH, New Delhi.
4. Sathya Prakash Garg (1993). Groundwater and Tube Wells, Oxford University Press, New York.

Course Outcomes

On completion of the course the student would have gained knowledge on

- Hydrologic cycle, vertical distribution of groundwater, hydrologic properties of aquifers, groundwater occurrence in various rocks.
- Groundwater movement, groundwater fluctuations and, impacts of global climatic change on groundwater.
- Construction of wells and well hydraulics.
- Surface and subsurface investigation methods for groundwater exploration, groundwater management and groundwater regime in India.
- Graphical representation of hydrochemical data and interpretation, drinking water quality standards of WHO and BIS, groundwater contamination, and groundwater scenario in Tamil Nadu.

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
III	P22GY12	Core Course – X ECONOMIC GEOLOGY AND MINERAL ECONOMICS	5	25	75	100

To impart knowledge on

- The important processes of formation of mineral deposits
- Classification of mineral deposits, controls of ore localisation, metallogenetic epochs and provinces, plate tectonics and ore genesis, geologic thermometry and geobarometry, geological and geochemical modeling of ore deposits.
- The mode of occurrence, distribution in India, origin and uses of ore deposits such as asbestos, barite, bauxite, chromite, copper, gold, iron, lead and zinc, manganese. Magnesiteandplacers
- Mines and Mineral legislation of India, India's National Mineral Policy, Mineral conservation and substitution.
- Ore microscope and study of ore minerals, microchemical techniques, ore textures and paragenesis

Unit 1: Economic Geology: Processes of formation of mineral deposits: Magmatic concentration, Sublimation, Contact metasomatism, Hydrothermal (Cavity, filling and replacement), Sedimentation, Evaporation, Residual and Mechanical Concentration, Oxidation and Supergene Enrichment and Metamorphism.

Unit 2: Classification of mineral deposits – Controls of ore localization: structural, stratigraphic, physical and chemical controls – Metallogenetic epochs and provinces – Plate tectonics and ore genesis – Geologic thermometry – Geobarometry – Stable and radiogenic isotopes of ores and the host rocks – Geological and Geochemical modeling of ore deposits.

Unit 3: Study of the following ore deposits with regard to their mode of occurrence, distribution in India, origin and uses; Asbestos, Barite, Bauxite, Chromite, Copper, Gold, Iron, Lead and Zinc, Manganese. Magnesite, Placer minerals.

Unit 4: Mineral Economics: definition and scope – Significance of minerals in National economy, peculiarities inherent in mineral industry – Tenor, grade and specifications for minerals – Mines and Mineral Legislation of India – India's National Mineral Policy – Strategic, critical and essential minerals with reference to India – Mineral conservation and substitution.

Unit 5: Ore Microscopy:Construction of ore microscope – Polishing and mounting of ores – Micro hardness: procedure for its determination and factors affecting it – Study of optical properties of ore minerals: colour, reflectivity, bi-reflectance, isotropism, anisotropism, polarization colours, rotation properties, internal reflections and relation sense – Instrumentation and methods of determination of reflectivity – Polarization figures of isotropic and anisotropic ore minerals – Microchemical techniques – Ore textures and paragenesis – Applications of ore microscopy.

Text Books

1. Bateman, A.M (1995). Economic Mineral Deposits, Willey.
2. Deb, S (1980). Industrial Minerals and Rocks of India, Allied.
3. Gokhale, K.V.G.K. and T.C. Rao (1978). Ore Deposits of India, their Distribution and Processing, Thomson Press.

4. Sinha, R.K (2019). Mineral Economics, CBS Publishers, New Delhi
5. Tiwari, S.K (2019). Ore Geology, Economic Minerals and Mineral Economics, Atlantic Pub.

Reference Books

1. Cameron, E.N (1961). Ore Microscopy, Wiley.
2. Coggin, B.J and A.K Dey (1995). India's Mineral Wealth, Isha Books.
3. Craig, J.R and D.J. Vaughan (1995). Ore Microscopy and Ore Petrography (II Edition), John Willey& Sons Lindgren, W (1993). Mineral Deposits, McGraw Hill.
4. Park, C.F and R.A Macdiarmid (1970). Ore Deposits, Freeman.
5. Stanton, R.L (1972). Ore Petrology, McGraw Hill.

Course Outcomes

On completion of the course students would have acquired a comprehensive knowledge about

- The important processes of formation of mineral deposits
- Classification of mineral deposits, controls of ore localisation, metallogenetic epochs and provinces, plate tectonics and ore genesis, geologic thermometry and geobarometry, geological and geochemical modeling of ore deposits.
- The mode of occurrence, distribution in India, origin and uses of ore deposits such as asbestos, barite, bauxite, chromite, copper, gold, iron, lead and zinc, manganese. Magnesite and placers
- Mines and Mineral legislation of India, India's National Mineral Policy, Mineral conservation and substitution.
- Ore microscope and study of ore minerals, microchemical techniques, ore textures and paragenesis

Semester	Course Code	Course Title	Credit	Marks			
				Internal	Oral	External	Total
III	P22GY13P	Core Course – XI PRACTICAL 3 ECONOMIC GEOLOGY, HYDROGEOLOGY AND GEOEXPLORATION	4	25	5	70	100

Course Objectives:

To impart knowledge on

- The identification of ore minerals based on physical and optical properties.
- Analysis of rainfall data, hydrologic data interpretation, pumping test data interpretation, plotting of hydrochemical data and interpretation
- Interpretation of geologic maps.
- Interpretation of geophysical data
- Geochemical analysis and Interpretation of geochemical data
- Interpretation of well logging data.

1. Economic Geology

- Megascopic identification of important ore minerals.

2. Ore Microscopy

- Identification of ore minerals using ore microscope.

3.Geoexploration

- Interpretation of geological maps
- Interpretation of geophysical data
- Interpretation of geochemical data
- Interpretation of well logging data

Course Outcomes

On completion of the course, students would have acquired practical knowledge on

- The identification of ore minerals based on physical and optical properties
- Analysis of rainfall data, hydrologic data interpretation, pumping test data interpretation, plotting of hydrochemical data and interpretation
- Interpretation of geologic maps.
- Interpretation of geophysical data.
- The analytical, calculation and interpretation techniques for geochemical methods of exploration
- Interpretation of well logging data.

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
III	P22GY14E1	Elective Course – 3 GEOEXPLORATION	4	25	75	100

Course Objectives:

To impart knowledge on

- The principles of geological exploration, guides to ore search and field geology.
- Geophysical exploration methods such as electrical, seismic, electromagnetic and well-logging techniques
- Geophysical exploration methods such as magnetic, radioactive and gravity methods
- The principles of geochemistry, geochemical dispersion and mobility.
- Sampling and analytical techniques for geo- and biogeo-chemical methods of exploration.

Unit 1: Geological Exploration: Stages of exploration – Scope, objectives and methods of prospecting, regional exploration and detailed exploration – Criteria controlling the choice of sites for geological prospecting – Marginal information of toposheets and study of field equipments – Field documentation and basic field procedures – Sampling (pitting, trenching, drilling), assaying and ore reserve estimation techniques – Categorization of ore reserves – Outline on exploratory mining – Ore controls as guides: mineralogical, structural, stratigraphical and geomorphological guides to ore search- Geological methods of surface and sub-surface exploration on different scales.

Unit 2: Geophysical Exploration: Outline on geophysical methods of exploration – Electrical methods: resistivity, self-potential and induced polarization methods, their principles, field procedures, instruments used, applications and limitations – Magnetic method: magnetic properties of rocks and minerals, Earth's magnetic field, regional and local anomalies, instruments used in exploration, procedures in field survey, interpretation of data, applications –Electromagnetic method: principles, instruments used, field procedures, interpretation of data, and applications, outline on magneto-telluric technique – Well logging techniques and their applications

Unit 3: Gravitational method: Earth's gravitational field, geoid, principles, instruments used in exploration, field procedures, corrections, interpretation of data, applications and limitations – Seismic method: seismic refraction and reflection methods – principles, field procedures (data acquisition), data processing, data interpretation, and applications – Radioactive method: Radioactive decay, radioactivity in rocks and minerals, instruments used in exploration, procedures in field survey, interpretation of data, applications

Unit 4:Geochemical Exploration: Origin of elements and abundance of elements in the earth's crust – Classification of elements: major, minor, trace and rare earth elements - Principles of geochemical prospecting: Geochemical cycle, geochemical environments, geochemical dispersion, geochemical mobility, geochemical anomalies and path finder elements –Geochemical survey: reconnaissance surveys and detailed surveys - Stages of a geochemical survey: planning, sampling, analysis, geochemical map, anomaly and interpretation.

Unit 5: Methods of Geochemical survey: lithogeochemical surveys, hydrogeochemical surveys, pedogeochemical surveys (stream sediments, lake sediments, glacial sediments, heavy minerals) - Biogeochemical exploration: principles, sampling, chemical analysis and interpretation of anomalies – Geobotanical indicators for mineral prospecting - Applications of Geochemistry in mineral exploration.

Text Books

1. Bateman, A. M (1995). Economic Mineral Deposits, Willey.
2. DhanaRaju, R (2009). Handbook of Mineral Exploration and Ore Petrology: Techniques and Applications, Geological Society of India, 494p.

3. Mason, B and C. B. Moore (1982). Principles of Geochemistry (IV Edition), John Wiley & Sons, 344p.
4. Misra, K. C (2012). Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.
5. Misra, K. C (2012). Understanding Mineral Deposits, Kluwer Academic Publishers, 860p.
6. Ramachandra Rao, M. B (1975). Outlines of Geophysical Prospecting: A Manual for Geologists, Prasaranga, University of Mysore, Mysore, 403p.
7. Sharma, P.V (2004). Geophysical Methods in Geology, Elsevier Inc.

Reference Books

1. Burger, H. R (1992). Exploration Geophysics of the Shallow Subsurface, Prentice Hall.
2. Dobrin, M. B (2001). Introduction to Geophysical Prospecting, McGraw Hill Inc.
3. Edwards, R and K. Atkinson (2013). Ore Deposits Geology and its Influence on Mineral Exploration, Springer.
4. Ginzburg, I. I (2013). Principles of Geochemical Prospecting: Techniques of Prospecting for Non-Ferrous Ores and Rare Metals, International Series of Monographs on Earth Sciences, Volume 3, Pergamon.
5. Govett, G. J. S (2013). Hand Book of Exploration Geochemistry, Elsevier Science, 461p.
6. Kearey, P. and M Brooks (1989). An Introduction to Geophysical Exploration, English Language Book Society / Blackwell Scientific Publications, 296p.
7. Kovalevsky, A. L (1987). Biogeochemical Exploration for Mineral Deposits, VNU Science Press, Utrecht, The Netherlands.
8. Kuzvart, M. andMBohmer (1986). Prospecting and Exploration of Mineral Deposits, Elsevier Science Ltd., 508p.
9. Levinson, A.A (1976). Introduction to Exploration Geochemistry, Applied Publication Co., Calgary.
10. Lowrie, W (1997). Fundamentals of Geophysics, Cambridge Low Price.
11. Marjoribanks, R (2010). Geological Methods in Mineral Exploration and Mining (II Edition), Springer,253p.
12. Moon, C. J., Whateley, M. K. G. and A. M. Evans (2006). Introduction to Mineral Exploration (II Edition), 481p.
13. Raman, P. K (1989). Principles and Practices of Mineral Exploration: A Professional Manual, Geological Society of India, 120p.
14. William, W. M (2014). Isotope Geochemistry, Wiley.

Course Outcomes:

After the completion of the course students would have acquired a comprehensive knowledge about

- The principles of geological exploration, guides to ore search and field geology.
- Geophysical exploration methods such as electrical, seismic, electromagnetic and well-logging techniques
- Geophysical exploration methods such as magnetic, radioactive and gravity methods
- The principles of geochemistry, biogeochemistry, geochemical dispersion and mobility.
- The sampling, analytical and interpretation techniques for geo- and biogeo- chemical methods of exploration.

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
III	P22GY14E2	Elective Course – 3 ISOTOPE GEOLOGY	4	25	75	100

Course Objectives:

To impart knowledge on

- The basic concepts of Isotope Geology, radioactivity and radioactive decay
- Stable isotopes in different spheres of the Earth
- Effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems, unstable nuclides in Earth
- Isotope Geology of Sr, Nd, Pb and Ar, and their applications
- Analytical techniques in Isotope Geology

Unit 1: Introduction to isotopes and nuclear systematic: Discovery of radioactivity, stable and radiogenic isotopes – Introduction to isotope geology –Nuclear structure, atomic weights, nuclear stability and abundance – Theory and mechanism of decay, particles emitted, positron, negatron and alpha decay – Equations of radioactive decay and radiogenic growth.

Unit 2: Fundamentals of stable isotope geochemistry – Oxygen and Hhydrogen isotopes in the hydrosphere, atmosphere and lithosphere – Stable isotopes of carbon, nitrogen and sulphur– Fractionation of stable isotopes – Carbon isotopes in the Earth's reservoirs –Sulphur isotopes and their applications in ore geology.

Unit 3: Effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems – Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types; their decay schemes – Radioactive elements as major elements, minor elements and trace elements and their geochemical behaviour.

Unit 4: Geochronology – Isotope Geology of Sr, Nd, Pb and Ar, and their applications – Applications of stable isotopes in geothermometry and geobarometry– Isotopes in mineral exploration, petroleum exploration, paleo-climate evaluation, health and environmental aspects –Cosmogenic nuclides and their applications.

Unit 5: Introduction to analytical techniques and mass spectrometry – Mass spectrometer: instrumentation, chemical separation, isotope dilution and ratio analysis – Methods of dating: Isochron method, model/mineral ages, Ffission track, ^{40}Ar-^{39}Ar, U and Th disequilibrium, choncordia method, ^{14}C, Be and Al – Interpretation and geological significance of ages – Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks and in evolution of ocean, crust and mantle.

Text Books

1. Faure, G (1986). Principles of Isotope Geology (II Edition), John Wiley & Sons, New York.
2. Faure, G and T. M. Mensing (2005). Isotopes: Principles and Applications (III Edition), John Wiley & Sons, New York.
3. Sharp Zachary (2006). Principles of Stable Isotope Geochemistry, Prentice Hall

Reference Books

1. Dickin, A. P (1995). Radiogenic Isotope Geology, Cambridge University Press, Cambridge.
2. Faure, G and J.L. Powell (1972). Strontium Isotope Geology. Springer Verlag, 188p.

3. Hoefs, J (1987). Stable Isotope Geochemistry (III Edition). Springer-Verlag, Berlin.
4. Rollinson, H. R (1993). Using Geochemical Data: Evaluation, Presentation, Interpretation, Longman, Harlow.
5. William, W.M (2014). Isotope Geochemistry, Wiley

Course Outcomes

On completion of the course the students would have acquired a comprehensive knowledge about

- The basic concepts of Isotope Geology, radioactivity and radioactive decay
- Stable isotopes in different spheres of the Earth
- Effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems, unstable nuclides in Earth
- Isotope Geology of Sr, Nd, Pb and Ar, and their applications
- Analytical techniques in Isotope Geology

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
III	P22GY15E1	Elective Course – 4 FUEL GEOLOGY	4	25	75	100

Course Objectives

To impart knowledge on

- The origin of coal, sedimentology of coal bearing strata, coal formation in space and time and petrography
- Physical properties and chemical composition, classification of coal, underground coal gasification, distribution of coal deposits in India
- Origin of petroleum, reservoir rocks, reservoir traps, global oil belts, petroliferous basins of India
- Prospecting for oil and gas, micropaleontology in petroleum exploration, oil and gas reserve estimation, RIG drilling procedures, mudlogging concepts and utilities, oil recovery techniques, oil policy of India
- Exploration of radioactive minerals, productive horizons of atomic minerals in India, geothermal energy and its sources in India

Unit 1: Coal Geology: Origin of coal: peat formation and its environments, biochemical peatification, geochemical coalification, causes of coalification, coal maturity and diagenesis – Post depositional changes of coal seams – Coal Geology: sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams – Coal formation in geological space and time – Petrography of coal: lithotypes, micro-lithotypes and macerals and their applications.

Unit 2: Physical properties of coal – Chemical composition of coal – Chemical analysis of coal: proximate and ultimate analysis – Classification of coal: Indian classification and International classifications (I.S.O. classification) – Classification of coal in terms of rank, grade and type – Outline of underground coal gasification, coal as an oil prone rock, coal as a liquid fuel – Geological and geographical distribution of coal and lignite deposits of India – Outline of Coal Bed Methane (CBM).

Unit 3: Petroleum Geology: Petroleum:constituents and composition – Origin of petroleum: organic and inorganic, evidences in their favour and against – Formation and migration of petroleum – Reservoir rocks: porosity and permeability – Reservoir traps: structural, stratigraphic and combination traps – Oilfield fluids: water, oil and gas – Applied stratigraphy – facies, sequence and depositional environment – An outline of oil belts of the world and India – Sedimentary basins of India – Petroliferous basins of India – Geology of productive oilfields of India.

Unit 4: Prospecting methods for oil and gas: geological, geophysical (seismic) and geochemical methods – Micropaleontology in petroleum exploration – Oil and gas reserve estimation – Proved, probable and possible reserves – Deterministic methods – Drilling and logging procedures – Drilling RIG: components, concepts and operational procedures – Electrologs: principles, procedures and interpretation – Mudlogging units: basic concepts and utilities – Reservoir studies: principles – Oil recovery: enhanced oil recovery techniques (chemical methods, miscible methods, thermal method – Petroleum management and economics – Oil shale – Gas hydrates - Oil policy of India.

Unit 5: Atomic Energy: Concept of atomic energy – Nuclear fuel cycle – Radioactive minerals: mineralogy, chemistry, geological characteristics, mode of occurrence, genesis and association of major types of atomic minerals in nature – Classification and applications of uranium deposits – metallogenic epochs and provinces of uranium mineralisation – Methods of exploration for atomic minerals – Productive geological horizons of atomic minerals in India – Lithium: uses and occurrences in India –Geothermal energy: Principles of utilization of Earth's heat – Types of geothermal source – Applications of geothermal sources – Exploration of geothermal sources –

Geothermal sources in India- Future scenario of geothermal energy in India - Prospects of non-conventional fuel in India.

Text Books

1. Aswathanarayana, U (1985). Principles of Nuclear Geology, Oxford Press.
2. Chandra, D., Singh, R.M and M. P. Singh (2000). Textbook of Coal (Indian Context), Tara Book Agency, Varanasi.
3. Chandrasekharam, D (2005). Geothermal Energy Resources of India: Past and the Present, World Geothermal Congress - 2005, pp.1-9.
4. Dhana Raju, R (2005). Radioactive Minerals, Economic Geology series, Geological Society of India, 65p.
5. Holson, G. D and E. N. Tiratso (1985). Introduction to Petroleum Geology, Gulf Publishing, Houston, Texas.
6. Larry Thomas (2013). Coal Geology, John Wiley & Sons.
7. Levorsen, T (1999). Geology of Petroleum (II Edition), CBS Publishers and Distributors, Delhi
8. Saxena, V. K (2004). Geothermal Resources of India, Allied Publishers Pvt. Ltd.
9. Selley, R.C (1998). Elements of Petroleum Geology, Academic press.

Reference Books

1. Boyle, R.W (1982). Geochemical Prospecting for Thorium and Uranium Deposits, Elsevier.
2. Brown, J. C and A. K. Dey (1975). Mineral and Nuclear Fuels of the Indian Subcontinent and Burma, A guide to the Study of the Coal, Oil, Natural Gas, Uranium, and Thorium Resources of the area. India, 533p.
3. Cataldi, R and M. C. S. Arrriaga (2020). History of Geothermal Energy in the World to the 20th Century, ThinkGeoEnergy, Iceland.
4. Dahlkamp, F.J (1993). Uranium Ore Deposits, Springer Verlag.
5. Doveton, J.H (1994). Geological Log Interpretation, SEPM, Tulsa.
6. Isabel Suárez-Ruiz and John C. Crelling (2008). Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press.
7. Henry, G (1994). Geophysics of Sedimentary Basins, Technip, Rue Ginoux, Paris.
8. Lewis, D. W and D. McConchie (1994). Analytical Sedimentology, Chapman & Hall, New York.
9. North,F.K (1985). Petroleum Geology, Allen Unwin.
10. Pohl Walter (2011). Economic Geology: Principles and Practice: Metals, Minerals, Coal and Hydrocarbons - Introduction to Formation and Sustainable Exploitation of Mineral Deposits, John Wiley & Sons.
11. Singh, M.P (1998). Coal and Organic Petrology, Hindustan Publishing Corporation, New Delhi.
12. Sircar, A. and K. Yadav (2019). Harnessing Geothermal Energy Applications in India, Technology Publications, 200p.
13. Ravi Shankar Guha, S. K., Seth, N. N., Muthuraman, K., Pitale, U. L., Jangi, B. L., Prakash, G., Bandopadhyay, A. K and R. K. Sinha (1991). Geothermal Atlas of India, Special Publication No.19, GSI, 144p.
14. Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and R. Teichmuller (1982). Stach's Textbook of Coal Petrology, GebruderBorntraeger, Stuttgart.
15. Yates, M (1980). Earth Power: The Story of Geothermal Energy, Abingdon Publishers.

Course Outcomes

On completion of the course students would have acquired knowledge about

- Origin of coal, sedimentology of coal bearing strata, coal formation in space and time and petrography of coal.
- Physical properties and chemical composition, classification of coal, underground coal gasification, distribution of coal deposits in India
- Origin of petroleum, reservoir rocks, reservoir traps, global oil belts, petroliferous basins of India.
- Prospecting for oil and gas, micropaleontology in petroleum exploration, oil and gas reserve estimation, RIG drilling procedures, mudlogging concepts and utilities, oil recovery techniques, oil policy of India.
- The principles, geological characteristics, types, applications, exploration techniques and Indian occurrences of atomic minerals and geothermal energy resources.

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
III	P22GY15E2	Elective Course – 4 INSTRUMENTATION TECHNIQUES IN GEOLOGY	4	25	75	100

Course Objectives:

To impart knowledge on

- Sample preparation for geochemical analysis, instruments used for geochemical analysis such as AAS, ICP-AES, XRF, GSMS, ICP-MS, SSMS, AMS, TIMS and SIMS
- Principles, applications and limitations of SEM, EPMA, NAA, LC, TLC and HPLC
- Principles and applications of instruments used for Crystallography and Mineralogy
- Principles, types, field procedures and applications of the instruments used for geophysical survey

Unit 1: Geochemical analysis: Qualitative analysis and quantitative analysis – Sampling and sample preparation – Dissolution procedures for geologic samples - Principles, applications and limitations of the following instruments: Atomic Absorption Spectrometry (AAS), Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES), X-Ray Fluorescence Spectrometry (XRF).

Unit 2: Principles, applications and limitations of the following instruments: Gas Source Mass Spectrometry (GSMS), Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), Spark Source Mass Spectrometry (SSMS), Accelerator Mass Spectrometry (AMS), Thermal Ionisation Mass Spectrometry (TIMS), Secondary Ion Mass Spectrometry (SIMS).

Unit 3: Principles, applications and limitations of the following instruments: Scanning Electron Microscope (SEM), Electron Probe Microanalysis (EPMA), Neutron Activation Analysis (NAA), Liquid Chromatography (LC), Thin Layer Chromatography (TLC), High Performance Liquid Chromatography (HPLC).

Unit 4: Principles and applications of the following instruments used for crystallography and mineralogy: X-Ray Diffraction, Reflectance and Emission Spectroscopy, Thermal Emission Spectroscopy, Mossbauer Spectroscopy, Laser Raman Spectroscopy.

Unit 5: Principles, types, field procedure and application of the instruments used for the following geophysical surveying techniques: Gravity methods, Magnetic methods, Seismic methods, Resistivity methods and Radioactivity methods

Text Books

1. Douglas A. Skoog, James Holler, F., Stanley and R. Crouch (2016). Principles of Instrumental Analysis (VII Edition), Cengage Learning
2. Francis Rouessac, and AnnickRouessac (2007). Chemical Analysis - Modern Instrumentation Methods and Techniques, Wiley.
3. Robinson, E.S. and C. Coruh (2002). Basic Exploration Geophysics, John Wiley.
4. The Lord Energlyn and L. Brealey (1971). Analytical Geochemistry, Academic Press, Elsevier.
5. Ramachandra Rao, M. B (1975). Outlines of Geophysical Prospecting - A manual for Geologist, Prasaranga, University of Mysore, Mysore.

Reference Books

1. Baedecker, P. A (1987). Methods for Geochemical Analysis. U.S. Geological Survey bulletin
2. Dobrin, M. B (2001). Introduction to Geophysical Prospecting, McGraw Hill Inc.
3. Keare, P and M. Brooks (1999). An Introduction to Geophysical Exploration, Blackwell Scientific Publications.
4. Potts, P.J (1995). Microprobe Techniques in the Earth Sciences, Mineralogical Society (Great Britain) Chapman & Hall.
5. Robin Gill (2014). Modern Analytical Geochemistry - An Introduction to Quantitative Chemical Analysis Techniques for Earth, Environmental and Materials Scientists, Routledge.

Course Outcomes

On completion of the course students would have acquired a comprehensive knowledge about

- Sample preparation for geochemical analysis, instruments used for geochemical analysis such as AAS, ICP-AES, XRF, GSMS, ICP-MS, SSMS, AMS, TIMS and SIMS
- Principles, applications and limitations of SEM, EPMA, NAA, LC, TLC and HPLC
- Principles and applications of instruments used for Crystallography and Mineralogy
- Principles, types, field procedures and applications of the instruments used for geophysical survey

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
IV	P22GY16	Core Course – XII GEOTECTONICS AND STRUCTURAL GEOLOGY	5	25	75	100

Course Objectives:

To impart knowledge on

- Structure of Earth's interior, including geophysical properties such as gravity, magnetism, thermal variations, seismicity and volcanic activity.
- Plate tectonics, continental drift, seafloor spreading and, structural and tectonic features of India, and geodynamics of Indian plate
- Concept of stress and strain, behaviour of rocks and minerals under stress and deformation mechanism
- Nomenclature, classification, mechanics and structural analysis of faults, joints, unconformities, folds and, petrofabric analysis

Unit 1: Concepts of seismology and Earth's internal structure – Interplate and intraplate seismicity – Earth's gravitational field, principles of geodesy, concept of geoid and spheroid, Isostasy – Geomagnetism, polarity reversals, polar wandering, and paleomagnetism – Thermal structure of the Earth, heat flow and thermodynamics of lithosphere, mantle and core, volcanism and volcanic zones – Radioactivity, radioactive isotopes and their applications –Overview on geosynclines.

Unit 2: Theory of plate tectonics, tectonic features along plate boundaries: shield areas, mobile zones, rift valleys, mid-oceanic ridges, triple junctions, submarine canyons and Island arcs, relationship of plate tectonics with seismicity, volcanism and mountain building – Continental drift theory and supportive evidences – Concept of supercontinent, their assembly and breakup – Concept of seafloor spreading and supportive evidences – Structural and tectonic features of India – Geodynamics of Indian plate – Outline of Himalayan orogeny – Overview on Quaternary tectonics and neotectonics.

Unit 3: Concept of stress and strain, stress-strain relationships for elastic, plastic and viscous materials – Behaviour of rocks and minerals under stress – Measurement of strain in deformed rocks – Rheological properties of rocks – Deformation mechanism – Role of fluids in deformation processes – deformation at microscale, superposed deformation – Kinematic and dynamic analysis of deformation – Various states of stress and their representation by Mohr circles – Stereographic projections of structural elements.

Unit 4: Fault: Nomenclature and classification, recognition criteria, mechanics and causes of faulting – Structural analysis of faults – Fault-related folding – Geometry and mechanics of shear zones – Joints: classifications of joints, modes of representation of joints – Unconformities: types, recognition, significance, distinction from faults and their use in dating structural events – Gravity induced structures.

Unit 5: Fold: Nomenclature, classification, recognition, and mechanics of folding – Structural analysis of folds – Deformation of linear structures by flexural slip folding and shear folding; superimposed folding, type 1, 2 and 3 interference patterns – Fabrics: foliations, lineations, cleavage, schistosity, gneissose structure, mullions and boudinage: their description, geometry and relation to major structures – Petro fabric analysis: petro fabric diagrams and their interpretation – Classification and characteristics of Tectonites, L- L-S-, and S- tectonic fabrics.

Text Books:

1. Allan Cox (1973). Plate Tectonics, Freeman & Co.
2. Belosov, V. V (1962). Basic Problems in Geotectonics, McGraw Hill.

3. Billings, M. P (1974). Structural Geology, Prentice-Hall, Inc., New Jersey, USA.
4. Bloom, A. L (2004). General Geology, V.V.P. Press.
5. Ghosh, S. K (1993). Structural Geology: Fundamental and Modern Developments, Pergamon Press.
6. Gokhale, N.W (2019). Theory of Structural Geology, CBS Publishers.
7. Hobbs, B. E., Means, W. D. and Williams, P. F (1976). An Outline of Structural Geology, John Wiley & Sons Inc., New York, Wiley.
8. Valdiya, K. S (1984). Aspects of Tectonics – Focus on South Central Asia, Tata McGraw-Hill.

Reference Books:

1. Condie, K. C. (1989). Plate Tectonics and Crustal Evolution (III Edition), Pergamon Press.
2. Davis, G.H (1984). Structural Geology of Rocks and Regions, John Wiley & Sons.
3. De Sitter, U (1956). Structural Geology, McGraw Hill.
4. Turcotte, D. L and Schubert, G (2014). Geodynamics, Cambridge University Press.
5. Fossen, H (2010). Structural Geology, Cambridge University Press.
6. Kearey, P., Klepeis, K. A and Vine, F. J (2009). Global Tectonics (III Edition), Wiley-Blackwell.
7. Keller, E. A and Pinter, N (2001). Active Tectonics (II Edition), Pearson Publications.
8. Pollard, D. D and Fletcher, R. C (2005). Fundamentals of Structural Geology, Cambridge University Press.
9. Ragan, D. M (2009). Structural Geology - An Introduction to Geometrical Techniques (IV Edition), Cambridge University Press.
10. Ramsay, J. G (1967). Folding and Fracturing of Rocks, McGraw Hill.
11. Robert J. T and E. M. Moores (2006). Structural Geology (II Edition), W. H. Freeman Publishers.
12. Rowland, S. M., Duebendorfer, E. M and Schiefelbein, I. M (2007). Structural Analysis and Synthesis: Laboratory Course in Structural Geology (III Edition), Wiley-Blackwell.

Course Outcomes

At the end of the course students would have acquired knowledge on

- Earth's interior, including its structure and geophysical properties such as gravity, magnetism, thermal variations and, seismicity and volcanic activity.
- Plate tectonics, continental drift, seafloor spreading and, structural and tectonic features of India, and geodynamics of Indian plate
- Concept of stress and strain, behaviour of rocks and minerals under stress and deformation mechanism
- Nomenclature, classification, mechanics and structural analysis of faults, joints, unconformities, folds and, petrofabric analysis

Semester	Course Code	Course Title	Credit	Marks			
				Internal	Oral	External	Total
IV	P22GY17P	Core Course – XIII PRACTICAL 4 STRUCTURAL GEOLOGY, REMOTE SENSING AND GIS	4	25	5	70	100

Course Objectives:

To impart knowledge on

- The interpretation of complex geological maps, solving structural geology problems using stereographic projection techniques, estimating depth and thickness of geological formations, attitude of tabular bodies and interpretation of lithological data from inclined boreholes, estimation of distance and attitude of geological formations using trigonometric functions in three point problems.
- To impart knowledge on photogrammetry, annotation of aerial photographs and satellite images, interpretation of Remote Sensing data for geological applications.
- To impart practical knowledge right from data input, georeferencing, digital data analysis, to lay out of map.

1. Structural Geology Problems and Structural Geology Map interpretation

Interpretation of complex geological maps, study of field geological maps – Problems relating to depth, thickness and three point problem – Use of stereographic projection in Structural Geology problems – Borehole problems involving determination of attitude of tabular bodies and interpretation of lithological data from inclined boreholes, preparation of Latitudinal vertical sections

2. Remote Sensing and GIS

Elementary exercises relating to photogrammetry: determination of scale, flying height, areal extent, flight planning measures – Annotation of aerial photographs – Stereovision test – Orientation of aerial photographs for interpretation using mirror stereoscope – Annotation of IRS satellite image – Visual interpretation of lithology, geological structures (Including lineaments), landforms, drainage network and land use / land cover from aerial photographs and satellite images.

GIS: Georeferencing – Digitization – Creation of vector layer – Creation of raster layer – Map analysis: Buffer analysis, union / intersection – Map lay out

Course Outcomes

On completion of the course students would have gained practical knowledge on

- The interpretation of complex geological maps, solving structural geology problems using stereographic projection techniques, estimating depth and thickness of geological formations, attitude of tabular bodies and interpretation of lithological data from inclined boreholes, estimation of distance and attitude of geological formations using trigonometric functions in three point problems.
- To impart knowledge on photogrammetry, annotation of aerial photographs and satellite images, interpretation of Remote Sensing data for geological applications.
- To impart practical knowledge right from data input, georeferencing, digital data analysis, to lay out of map.

Semester	Course Code	Course Title	Credit	Marks			
				Internal	Oral	External	Total
IV	**P22GY18P**	**Core Course – XV PRACTICAL 5 GEOINSTRUMENTATION AND GEOSTATISTICS**	**4**	**25**	**5**	**70**	**100**

Course Objectives

To impart knowledge on

- Various instruments used in geological research
- SPSS software and its utility in various branches of geology

Geo instrumentation Experiments

- Sieve shaker- Grain size analysis
- Thin section machine – Preparation of Thin- and polished-sections
- Resistivity meter / MT machine – Resistivity survey and interpretation
- RTK GPS – GPS survey and Mapping
- Total station – Determination of heights and distance
- Total station - Determination of area
- Total station - Traversing
- Auto levelling – Determination of heights
- Plane table - Traversing

Geostatistics

- Interpretation of grain size analysis using Statistical software
- Ore reserve calculation using Statistical software
- Correlation of groundwater quality using Statistical software
- Factor analysis using Statistical software
- Cluster analysis using Statistical software

Basic concepts, working principles and demonstration of operating techniques in the lab for the following instruments:

- Atomic Absorption Spectroscopy (AAS)
- Scanning Electron Microscope (SEM)
- X- Ray Diffraction (XRD)
- Particle size analyser
- Micro Vickers Hardness

Course Outcomes

On completion of the course students would have gained practical knowledge on

- Various instruments used in geological research
- SPSS software and its utility in various branches of geology

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
IV	P22GY19E1	Elective Course – 5 REMOTE SENSING AND GIS	4	25	75	100

Course Objectives

To impart knowledge on

- The principles, latest developments and applications of both Aerial and Satellite Remote Sensing in Geology
- The principles, latest developments and applications of GIS and GNSS

Unit 1: Fundamentals of Remote Sensing: Processes and elements of electromagnetic Remote Sensing – Electromagnetic spectrum and its components – Energy sources and radiation principles — Energy interaction with Earth's atmosphere – Energy interaction with the earth's surface features – Spectral reflectance curve of vegetation, soil and water – Data acquisition, receiving and recording – Outline of thermal, microwave and LIDAR Remote Sensing

Unit 2: Aerial Remote Sensing: Types of aerial photographs – Photographic scale and causes for its variation – Flight planning procedures – Outline of parallax, relief displacement and vertical exaggeration – Stereoscopes: lens and mirror stereoscopes – Mosaics: types their construction – Annotation of aerial photographs – Principles of photointerpretation – Outline of digital photogrammetry

Unit 3: Satellite Remote Sensing: Types of satellites – Scanning systems and detectors: across-track and along-track scanning systems –Sensor resolution and their types –Sensor characteristics of LANDSAT, SPOT, IRS series of satellites – Outline of high resolution satellites and Hyperspectral Remote Sensing – Indian space programme: past, present and future – Image interpretation: visual and digital interpretation techniques – Outline of Digital Image Processing techniques

Unit 4: Remote Sensing Applications in Geology: Lithological mapping – Structural mapping – Mineral exploration – Groundwater exploration – geomorphic mapping – Land use / land cover mapping – seismic zonation – Landslide zonation – Flood zonation – Soil erosion zonation – Pollution studies

Unit 5: Geographic Information System (GIS) and Global Navigation Satellite System (GNSS):

GIS: Components – Data structure – Types of Data: raster and vector – Data conversion (Vector to Raster and Raster to Vector) – Spatial data input processes and devices – Entry of non-spatial data – Linking of spatial and non-spatial data – Data verification – Data correction – Data interpolation – Data analysis – Surface modelling – DEM and DTM – Data output – Data quality, errors and their sources – Application of GIS in Geological studies – GNSSS: basic concept, structure, applications.

Text Books

1. Allum, J.A.E (1978). Photogeology and Regional Mapping, Pergamon Press Ltd., Oxford
2. Anji Reddy, M (2001). Textbook of Remote Sensing and GIS, BSP PS Publications, New Delhi
3. Gupta, R.P (2008). Remote Sensing Geology, II Edition, Springer Pub., New Delhi

4. Lillesand, T.M., Kiefer, R.W and Chhipman, J.W (2017). Remote Sensing and Image Interpretation, VI Edition, John Wiley& Sons Inc., New Delhi
5. Miller, V.C (1961). Photogeology. McGraw-Hill Publishers, New York
6. Narayan, L.R.A (1999). Remote sensing and its application. Universities Press Ltd., Hyderabad
7. Pandey, S.N (1987). Principles and applications of photogeology. Wiley Eastern Ltd., New Delhi
8. Rampal, K.K (1999). Handbook of Aerial Photography and Interpretation. Concept Publishers Company, New Delhi
9. Sabins, F.F (1997). Remote Sensing principles and interpretation, III Edition, W.H. Freeman & Company, Publishers, New York
10. Prithvish Nag and S. Sengupta (2008). Introduction to Geographical Information System. Concept Publishing Company, New Delhi
11. Chang, K (2006). Introduction to Geographic Information Systems. Tata McGraw Hill Pub. Co. Ltd., New Delhi
12. Tor Bernhardsen (2009). Geographic Information Systems: An Introduction, John Wiley & Sons Inc., Student Edition, New Delhi
13. Gupta, R.K (2011). Geographic Information System: Fundamentals and Applications. Arise Publishers, New Delhi

Reference Books

1. Barrett, E.C and C.F. Curtis (1982). Introduction to Environmental Remote Sensing. Chapman & Hall Publishers, New York.
2. Bruno Marcolongo and Franco Mantovam (1997). Photogeology – Remote Sensing Applications in Earth Sciences, Oxford & IBH Publishers Co. Pvt. Ltd., New Delhi
3. Curran, P (1988). Principles of Remote Sensing. Corgman Publishers, London
4. Siegal, B.S and R. Gillespie (1980). Remote Sensing in Geology, John Wiley & Sons, New York
5. Jean Yves Scanvic (1997). Aerospatial Remote Sensing in Geology. Oxford & IBH Publishers Co. Pvt. Ltd.
6. Heywood, I., Cornelius, S and S. Carver (2010). An Introduction to Geographic Information Systems, III Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi
7. Lo, C.P and A.K.W. Yeung (2007). Concepts and Techniques of Geographic Information Systems. Prentice-Hall India Pvt. Ltd., New Delhi

Course Outcomes

- The principles, latest developments and applications of both Aerial and Satellite Remote Sensing in Geology
- The principles, latest developments and applications of GIS and GNSS

Semester	Course Code	Course Title	Credit	Marks		
				Internal	External	Total
IV	P22GY19E2	Elective Course – 5 REMOTE SENSING APPLICATIONS IN GEOSCIENCES	4	25	75	100

Course Objectives

To impart knowledge on

- The applications of Remote Sensing for studies pertaining to geologic studies, geomorphic mapping, water resources, land use / land cover analysis, coastal applications and, natural disasters

Unit 1: Remote Sensing Applications in Geology: Spectral properties of rocks and minerals, elemental composition and spectra of rocks and minerals, physical properties and spectra, optimal spectral windows – Mapping of rock types – Mapping of geological structures: folds, faults, fractures / lineaments – Mineral exploration – Land and water degradation due to mining activity.

Unit 2: Remote Sensing Applications for Geomorphic Mapping: Mapping of Structural landforms – Denudational landforms – Fluvial landforms – Aeolian landforms – Coastal landforms – Drainage networks and patterns.

Unit 3: Remote Sensing Applications for Water Resource Studies and Land Use/ Land cover Analysis: Mapping and monitoring of surface water bodies – Monitoring of quality of surface water bodies – Groundwater potential zonation mapping in unconsolidated and hard rock areas - Land Use/ Land cover Analyses: Remote Sensing Applications in: Land use/Land cover classification system of USGS and NRSC – Mapping of land use/ land cover classes.

Unit 4: Remote Sensing Applications for Natural Disaster Studies: Mapping of flood prone and, flood affected areas – Mapping of earthquake prone and, earthquake affected areas – Mapping of volcanic eruption prone areas – Mapping of landslide prone areas, and landslide affected areas – Mapping of soil erosion prone areas.

Unit 5: Remote Sensing Applications for Coastal Applications: Mapping of erosion prone areas – Shoreline change analysis – Coastal wetland mapping – Oil spill mapping – Mapping of coral reef habitat – Mapping of mangrove habitats.

Text Books

1. Lillesand, T.M., Kiefer, R.W and Chhipman, J.W. 2015. Remote Sensing and Image Interpretation (VII Edition), John Wiley & Sons Inc., New Delhi, 708p.
2. Gupta, R.P (2008). Remote Sensing Geology (II Edition), Springer Pub., New Delhi
3. Boris Escalante-Ramirez (2012). Remote Sensing – Applications, InTech Pub., Croatia, 516p.

Reference Books

1. Bruno Marcolongo and Franco Mantovam (1997). Photogeology – Remote Sensing Applications in Earth Sciences, Oxford & IBH Publishers Co. Pvt. Ltd., New Delhi
2. Sabins, F.F (2007). Remote Sensing Principles and Interpretation (III Edition), Waveland Pr. Inc., 512p.
3. Wang, Y (2010). Remote Sensing of Coastal Environments. CRC Press, Taylor & Francis Group, 423p.

Course Outcomes

On completion of the course the student would have gained knowledge on

- The applications of Remote Sensing for studies pertaining to geologic studies, geomorphic mapping, water resources, land use / land cover analysis, coastal applications and, natural disasters

Semester	Course Code	Course Title	Credit	Marks		
				Internal	Oral (External)	Total
IV	P22GY20P	Core Course – XIV DISSERTATION	6	75*	25**	100

*** Evaluation for 75 marks (internal) would be done by the candidate's dissertation supervisor. It would be based on the**

i) Plan of the dissertation work

ii) Candidate's individual initiative for the completion of the dissertation

iii) Execution of the plan by the candidate

**** Evaluation for the 25 marks (Oral) would be done by the external examiner. It would be based on candidate's performance in the Viva-voce**