ANNAMALAI UNIVERSITY

407 - M.Sc. GEOLOGY

Programme Structure and Scheme of Examination (under CBCS)
(Applicable to the candidates admitted from the academic year 2022 -2023onwards)

Course Code	Study Components & Course Title	Hours/Week	Credit	Maximum Marks		
				CIA	ESE	Total
	SEMESTER – I					
22PGEOC11	Core Course - I : Structural Geology and Tectonics	4	4	25	75	100
22PGEOC12	Core Course - II : Mineralogy and Mineral Optics	4	4	25	75	100
22PGEOC13	Core Course – III : Stratigraphy and Geomorphology	4	4	25	75	100
22PGEOP14	Core Practical – I : Structural Geology, Mineralogy and Mineral optics	12	4	40	60	100
22PGEOE15	Core Elective – I	3	3	25	75	100
22PGEOO16	Open Elective – I :	3	3	25	75	100
	Total	**30**	**22**			**600**
	SEMESTER – II					
22PGEOC21	Core Course – IV : Economic Geology and Mineral Economics	4	4	25	75	100
22PGEOC22	Core Course – V : Hydrogeology	4	4	25	75	100
22PGEOC23	Core Course – VI : Remote Sensing and Digital Image Processing	4	4	25	75	100
22PGEOP24	Core Practical – II : Economic Geology, Remote Sensing, DIP and Hydrogeology.	12	4	40	60	100
22PGEOE25	Core Elective – II :	4	4	25	75	100
22PHUMR27	**Compulsory Course: Human Rights**	2	2	25	75	100
	Total	**30**	**22**			**600**

List of Core Electives (Choose 1 out of 3 in each Semester)

Semester	Course Code	Course Title	H/W	C	CIA	ESE	Total
I	22PGEOE15-1	Gemmology	3	3	25	75	100
	22PGEOE15-2	Meteorology and Climate change	3	3	25	75	100
	22PGEOE15-3	Medical Geology	3	3	25	75	100
II	22PGEOE25-1	Environmental Geosciences and Disaster Management	4	4	25	75	100
	22PGEOE25-2	Digital Cartography	4	4	25	75	100
	22PGEOE25-3	Introduction to Geological Software	4	4	25	75	100

List of Open Electives (Choose 1 out of 3 in each Semester)

Semester	Course Code	Course Title	H/W	C	CIA	ESE	Total
I	22PGEOO16-1	Environmental geosciences	3	3	25	75	100
	22PGEOO16-2	Geohazards	3	3	25	75	100
	22PGEOO16-3	Medical Geology	3	3	25	75	100

SEMESTER - I CORE – I	22PGEOC11: STRUCTURAL GEOLOGY AND TECTONICS	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To learn about the mechanical properties of rocks.
2. Explain how rocks respond to those stresses by brittle deformation, or by fracturing, and the types of joints and faults.
3. To understand the ductile deformation of folds its processes and mechanisms, and the types of foliations and lineations.
4. To acquire relevant knowledge of boudinage, shear zones, and salt tectonites.
5. To understand the concepts of earth tectonics, mechanism of plate movements, and various theories of plate tectonics.

Unit 1

Deformation: Definition - Components of deformation. *Strain*: Homogeneous and heterogeneous deformation – One, two, and three-dimensional strain - The strain ellipsoid. Uniaxial strain (compaction) - Pure shear and coaxial deformations - Simple shear - Progressive deformation and flow parameters -Steady-state deformation - Incremental deformation. *Stress*: Definitions, magnitudes, and units – Causes and components - Stress on a surface - Stress at a point - The stress tensor (matrix)- Mohr circle and diagram.

Unit 2

Fracture: Brittle deformation mechanisms - Types of fractures - Failure and fracture criteria - Fracture termination and interaction. *Joints*: Definition and characteristics - Kinematics and stress. *Faults:* Fault anatomy - Types of Faults - Recognition of Faults - Characteristics of Normal Faults - Shape and Displacement of Normal Faults - Kinematic Models of Normal Fault, reverse faults, and strike-slip faults -Contractional faults - Thrust faults - Ramps, thrusts, and folds - Extensional regimes: Extensional faults. Fault systems - Low-angle faults and core complexes - Ramp-flat-ramp geometries - Rifting - Half-grabens and accommodation -Strike-slip faults - Transfer, Transform, and Transcurrent faults.

Unit 3

Folds: Folding processes – folding mechanisms - homogeneous flattening, Folding of multilayer - Formation of Kinking and Chevron folds. Fold in shear zones - Folding at shallow crustal depths. *Foliation and cleavage:* Basic concepts and types of foliation. Cleavage development and types. *Lineation* and its types. Lineation is related to plastic deformation, brittle regime and kinematics.

Unit 4

Boudinage: Boudinage and pinch-and-swell structures - Geometry, viscosity, and strain -Asymmetric boudinage and rotation - Foliation boudinage - Boudinage and the strain-ellipse.

Shear zones and Mylonites: Definition: Shear zone - The ideal plastic shear zone -Adding pure shear to a simple shear zone - Non-plane strain shear zones. Mylonites and kinematic indicators.

Salt tectonics and halokinesis - Salt properties and rheology - Salt diapirism, salt geometry and the flow of salt - Rising diapirs: processes - Diapirism in strike-slip settings - Salt collapse by karstification - Salt décollements.

Unit 5

Plate tectonics: Concept of plate and plate movements, nature of convergent, divergent, and conservative plate margins. Plate tectonics in relation to igneous, sedimentary and metamorphic processes and mineralization. Triple junctions, aulocogens, plume theory, island arcs. Nature and origin of earth's magnetic field. Evolution of Himalaya and Himalayan tectonics.

C0URSE OUTCOMES

At the end of the course, the student will be able to

1. Complete knowledge about stress and strain.
2. Gain knowledge about the genesis of fractures and faults.
3. Ability to understand the processes and mechanisms of folds, and types of foliations and lineations.
4. Understand the geometry and structures of boudinage, shear zones, and salt tectonics.
5. Understand the concept of plate tectonics and plate movements.

Text Books

1. Badgley.P.C. (1965), Structural and Tectonic Principles, Harper International, New York.
2. Billing, M.P.(1972).Structural Geology, Prentice-Hall.
3. Condie, K.C.,(1976).Plate tectonics and Crustal evolution.
4. Davis,G.H., 1984.Structural Geology of Rocks and Regions. John Wiley & Sons.
5. Haakon Fossen, 2010. Structural Geology, Cambridge University Press.
6. Hill. E.S. (1972), Elements of Structural Geology, John Wiley, New York
7. Hobbs, B.E., Means, W.D. and Williams, P.F. John Wiley, (1976) An outline of structural geology,
8. Paor, D. (1996). Structural Geology and Personal Computer, Pergamon,

Supplementary Readings

1. Park, R.G., (1983). Foundations of Structural Geology, Blackie and Sons Ltd.
2. Soumyajit Mukherjee, (2019) Techtonics and Structural Geology – Indian Context. 1st ed. Springer Geology.
3. Twiss, Robert J., and Moores, Eldridge M., (2007). Structural geology, W.H.Freeman, and Company, New York., p.742
4. Windley, B.F.,(1976).The Evolving Continents. John Wiley and, New York.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	1	3
CO2	2	1	3	2	2
CO3	3	2	1	2	3
CO4	3	1	2	3	2
CO5	3	1	2	2	3

SEMESTER - I CORE – II	22PGEOC12: MINERALOGY AND MINERAL OPTICS	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To Understand the Concepts in Mineralogy and Crystallography.
2. Study of physical, chemical and optical properties of minerals.
3. The classification of crystals into systems and classes.
4. To learn the techniques of X- ray diffraction pattern and their interpretation.
5. To get familiarities with U-Stage methods of determination of optic axial angle.

Unit 1

Transformation of minerals- polymorphism, polytypism and polysomatism, Solid solution and exsolution. Isomorphism, atomic substitution- exsolution-order, disorder relations- polymorphism, pseudomorphism. Fluorescence in minerals. Metamict stage- staining techniques and microchemical test.

Unit 2

Optic axes, optic axial angle measurements- optic orientation. Conoscopic characters of uniaxial and biaxial minerals. Dispersion in crystals- optic anomalies.

Unit 3

Rock and Ore forming minerals: Structure, P-T stabilities, paragenesis and mode of alteration of silicates, oxides, carbonates, phosphates, sulphates and halides.

Unit 4

Symmetry elements, translation, rotation, reflection, inversion, screw and glide-point groups and crystal classes. Derivation of 32 crystal classes based on Schoenflies notation. Correspondence between Schoenflies and international notation. Bravies lattices and their derivation. An outline of space groups.

Unit 5

Optical anomalies-Outlines of U-Stage methods of determination of optic axial angle. Anorthite content and twin laws of plagioclase feldspar, and orientation of cleavage and twin planes. Irregularities of crystal-Concept of Crystal field theory and mineralogical spectroscopy.

COURSE OUTCOMES

1. Students will get insight into the mechanism & formation of minerals under different conditions as their special features.
2. Understand the optical properties of minerals.
3. Understand the para genesis of minerals.
4. Gain knowledge on how X-rays are useful in mineralogical studies.
5. Students get knowledge on various methods of optic axis angle determination.

Text Books

1. Buerger, M.J.1956 Elements of Crystallography, John Wiley and sons,
2. Dana, E.S.1935 A Text Book of Mineralogy, John Wiley & Sons,
3. Ernest, E.Walhstrom, 1960, Optional Crystallography, John Wiley & Sons,
4. Mitra,S.1994, Fundamentals of Optical, Spectroscopic and X-ray Mineralogy, available at S.R.Technico Book House, Ashok RajPath, Patna.
5. Aretas N. Ndimofor (2018) The fundamentals of Crystallography and Mineralogy. Spears Media Press.

Supplementary Readings

1. American mineralogist special volume son Mineralogy.
2. Azaroff, L. V. and Buerger, M. J. 1959, The powder method,, Mc Graw Hill Book Co.,
3. Babu, S. K. and D. K. Sinha, Practical Manual of Crystal Optics, CBS Publihsers & Distributors.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	2	1
CO2	3	2	1	3	2
CO3	1	3	2	1	3
CO4	2	3	1	1	2
CO5	2	3	1	2	3

SEMESTER - I CORE – III	22PGEOC13: STRATIGRAPHY AND GEOMORPHOLOGY	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To familiarise withthe basic principles and the concepts of stratigraphy and stratigraphic divisions of India.
2. Students are able to know different stratigraphical systems and geological events of India.
3. Can understand the mineral wealth of India.
4. Able to know the theoretical concepts of engineering science
5. Able to know the fundamentals and concepts of geomorphology, tectonics, erosional and depositional landforms, Earth's various Exogenetic and Endogenetic processes.

Unit 1

Principles of stratigraphy: the laws of order of superposition. Law of Uniformitarianism, Correlation, Standard stratigraphic scale and Indian Geologic Time scale. Imperfections in the geological record.Geological divisions, Stratigraphic classification and Nomenclature. Stratigraphic Units: Homotaxis.Physiographic divisions of India: Peninsular India, Indo-Gangetic alluvial plains, Extra Peninsular India

Unit 2

Precambrian Stratigraphy: Archaeans of Dharwar, Archaeans of Tamilnadu, Mineral Wealth of Archaeans of India, Stratigraphy and Mineral Wealth of Puranas, Life during Precambrian. Palaeozoic Stratigraphy: Distribution of Palaeozoic rocks in India, Palaeozoic rocks of Peninsular India,

Unit 3

Mesozoic Stratigraphy: Gondwana formations of India, Gondwana formations of Tamilnadu, Triassic of Spiti, Jurassic of Kutch, Cretaceous of Tiruchirapalli& Pondicherry, Deccan traps, age of the Deccan traps.Cenozoic Stratigraphy: Geological events during Cenozoic era in India, the rise of Himalayas, the stratigraphy of Siwalik system, Tertiary rocks of Assam, Tertiary rocks of Tamilnadu, Mineral wealth of Tertiary rocks of India:

Unit 4

Definition of Geomorphology.Principles and laws of geomorphology.Concept of weathering and erosion cycle; Physical, chemical and biological weathering.Erosional and Depositional landforms.Fluvial process: Types of drainage pattern, Fluviallandforms, Types of Deltas and River basins in India; Aeolian process as a geomorphic agent. Aeolian landforms. Types of glaciers. Landforms in glaciated regions.

Unit 5

Agents of geomorphic processes – Volcanism, Gravity, glaciers, wind, rivers, tides, waves, currents. Endogenetic and Exogenetic Processes. Classification of mountains, types of volcanoes. Volcanic landforms. Isostasy, Classification of coastlines, Depositional and erosional coast lines. Coastal and marine landforms. Major geomorphological divisions of India,

COURSE OUTCOME

1. Being able to apply the principles of stratigraphy and the physiopgraphical divisions of India.
2. Students are able to recognize mineral wealth and life of Purana periods.
3. Capable of knowing the geological events during the Cenozoic era in India and the rise of the Himalayas.
4. Understand the basic knowledge that includes weathering and erosion cycle.
5. Students understand the agents of geomorphic processes and volcanic landforms.

Text Books

1. Krishnan M.S. (2003) - Geology of India and Burma, 6th Edition, CBS.
2. Wadia D.N. (1953)– Geology of India, TATA McGraw – Hill.
3. Ravindrakumar K.R.- Stratigraphy of India.
4. Thurnbury, W. D.: Principles of Geomorphology
5. Worcester, P. G.: A test book of Geomorphology
6. Savinder Singh: Geomorphology

Supplementary Readings

1. Pascoe, E.H.(1968) A manual of the Geology India and Burma, Govt of India
2. Holmes, A.: Principles of Physical Geology
3. Strahler, A.: Physical Geography.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	1	2
CO2	1	2	3	1	2
CO3	3	2	1	3	2
CO4	1	1	2	2	3
CO5	3	3	2	1	3

SEMESTER - I CORE PRACTICAL - I	22PGEOP14: STRUCTURAL GEOLOGY, MINERALOGY AND MINERAL OPTICS	CREDITS: 11 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. They will be trained for the field measurement techniques like true dip, apparent dip, and estimation of the thickness of the beds.
2. To study structural analysis using stereographic projection.
3. To be familiar with megascopic identification of minerals.
4. To be familiar with microscopic identification of minerals.
5. To gain knowledge on the various determinative optical mineralogical features.

Exercise/ Practise

Structural geology

1. Calculation of True dip and apparent dip.
2. Estimation of Thickness of beds.
3. Methods of representing physiographic features on geological and contour maps.
4. Interpretation of geological and contour maps.
5. Elementary structural analysis with the use of stereographic methods

Mineralogy and Mineral Optics

1. Megascopic identification of: Tourmaline, Topaz, Beryl, Zircon, Rutile, Apatite. Calcite, Gypsum. Metamorphic minerals: Garnet, Cordierite, Kyanite, Sillimanite, Andalusite, Sphene, Staurolite, Chondrodite.
2. Microscopic study of: Tourmaline, Topaz, Beryl, Zircon, Rutile, Apatite. Calcite, Gypsum.
3. Metamorphic minerals: Garnet, Cordierite, Kyanite, Sillimanite, Andalusite, Sphene, Staurolite, Chondrodite.
4. Mineral calculations for the following group of minerals-Feldspars, Pyroxenes, Amphiboles, Olivine, Micas and Garnets
5. Determination of plagioclase orientation in thin section and its Anorthite content from extinction angle measurements.
6. Pleochroic scheme
7. Optic signs of uniaxial and biaxial minerals.
8. Stereographic projections of crystals of Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic and Triclinic systems.
9. Goniometric measurement of interfacial angles.

COURSE OUTCOMES

1. The students will have practical experience in the measurement of Geometry of geological formation and understand the mapping of the geological features.
2. Students able to prepare stereomodels.
3. Students become familiar with identifying minerals in thin sections.
4. Can perform mineral calculations for mineral groups.
5. Students able to determine Goniometric measurement of interfacial angles.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	1	3	2	3	2
CO2	3	2	1	2	3
CO3	2	3	2	1	3
CO4	1	3	2	2	2
CO5	3	2	1	3	2

SEMESTER - I CORE ELECTIVE - I	22PGEOE15 - 1: GEMMOLOGY	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To know about the scope, definition and descriptions of natural and artificial gemstones.
2. To know the physical and crystallographic properties of the gemstones.
3. Understanding the optical properties of gemstones.
4. Able to know the techniques and instruments employed in gemological laboratories.
5. To know the cutting and carving methods of precious and semiprecious stones.

Unit 1

Scope and importance of gemmology. Definition of a gem. Descriptions of gemstones, minerals and rocks. Formation of minerals. Difference between gemstones and minerals. Natural gems (minerals, rocks, non-minerals, organic materials). Artificial stones (imitations, composites and synthetics).

Unit 2

Physical properties: Hardness and durability. Mohs' scale, cleavage, parting, fracture, specific gravity and its determination (hydrostatic and heavy liquids). Other properties (thermal, electrical, etc,.). Crystallographic property**:** Nature of crystals, Crystalline and amorphous materials, polycrystalline materials, crystal systems, symmetry, crystal habit and twinning.

Unit 3

Optic property: Nature of light. Visible spectrum. Reflection and refraction (laws). Single and double refraction. Optic properties of gemstones. Refractive index. Total internal reflection. Dispersion. Refractometer (principles and use). RI determination on isotropic and anisotropic stones. Birefringence determination. Optic sign determination. Polarized light. Polariscope, principles and use. Absorption of light. Absorption spectrum.Spectroscope, principles and use.

Unit 4

Basic Techniques employed in Gemmological Laboratories: X-radiography, UV-VIS, FTIR-spectroscopy, Raman-spectroscopy, EX-XRF, LIBS, Diamond view. Gemmological Instruments and Units of Measurement

Unit 5

Fashioning of Gemstones: Cutting and carving, Basic techniques, Different types and shapes of cut, Brilliant cut. Inclusions: Their importance in gemology and their physical, morphological and genetic classification. Inclusions and its impact on gemstones.

COURSE OUTCOMES

1. Students gain knowledge of identification of natural and synthetic gemstones.
2. Students able to identify the physical properties of gemstones.
3. Ability to understand the optical properties and its significance of precious and semi-precious stones.
4. Gain knowledge of the instruments applied for gemological studies,
5. Students gain knowledge on cutting and shaping of gem stones.

Text books

1. Arthur Holmes, (1992) Principles of Physical Geology, Edited by Duff. P. 4th Ed. Chapman and Hall, London.
2. Radhakrishnan, V. (1996) General Geology V.V.P Publishers, Tuticorin.
3. Charles C. Plummer, Diane H. Carlson and Lisa Hammersley (2016) Physical Geology, 15th edition, McGraw Hill Education, New York.
4. Miller, (1949) An Introduction to Physical Geology, East-West Press Ltd.,
5. Spencer, E.V (1962), Basic concepts of physical Geology, Oxford & IBH,
6. Charles Fletcher (2014) Physical Geology: The sciences of Earth, 2nded. Willey.
7. Mohapatra, G.B. (2014) Text book of Geology. CBS edn.

Supplementary readings

1. Don Leet, and Sheldon Judson, (1960) Physical Geology, Prentice Hall & Co.,
2. Gorshkov,G, G and A.Yakushova,A (1967). Physical Geology, Mir Publishers, Moscow.
3. Wyllie, P.J (1971) The Dynamic Earth, John Wiley and Sons.
4. Vincent S. Cronin and Dennis Tasa (2018) Physical Geology. Pearson Publishers, New York. 15th edition.
5. Jain Sreepat (2014) Fundamentals of Physical Geology. Springer Nature India Pvt. Ltd. New Delhi

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	3	2
CO2	1	3	2	2	3
CO3	3	2	1	1	1
CO4	2	1	3	1	3
CO5	3	2	1	3	2

SEMESTER - I CORE ELECTIVE - I	22PGEOE15 - 2: METEOROLOGY AND CLIMATE CHANGE	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To understand the basic concept of atmospheric science.
2. To understand the atmospheric impact on climatic conditions and weather patterns.
3. Application of remote sensing on understanding atmospheric science and the weather forecast.
4. Students learn tropical meteorology.
5. Able to understand the importance of climate change and its impacts.

Unit 1

Principles of Meteorology - The Atmosphere - Origin of the Earth's Atmosphere, Composition of the Atmosphere, Vertical Structure of the Atmosphere, Ozone Layer, Upper Atmosphere. Earth Sun relationships – Equinoxes, solstices, perihelion and Aphelion, Causes of seasons. Radiation: Basic Laws - Rayleigh and Mie scattering, Multiple scattering. Seasonal and latitudinal variation of insolation. Emission and Absorption of Terrestrial Radiation, Radiation windows. Greenhouse effect, Tropical convection.

Unit 2

Cloud classification, Condensation Nuclei, Growth of Cloud drops and ice-crystals, Precipitation Mechanisms, Findeisen process, coalescence process - Precipitation of warm and mixed clouds, Artificial precipitation, type of precipitation, fog, Hail suppression. Basic equations and fundamental forces: Pressure, Gradient, Centripetal and Coriolis forces, Ekman spiral and transport, Langmuir circulation, scale analysis, geostrophic and gradient wind, Atmospheric turbulence, Continuity equation in Cartesian and Isobaric co-ordinates.

Unit 3

General circulation and climate model – east west circulation in tropics – Climate variability and forcing; Low frequency variability, MJO Madden-Julian oscillation), ENSO, QBO (quasi-biennial oscillation) and Sunspot cycles. Basic principles of general circulation modeling, Ocean – atmosphere couple model, Grid-point and Spectral (GCMs). Role of the ocean in climate Modeling, Inter-annual variability of ocean fields and its Relationship with Monsoon.

Unit 4

Tropical Meteorology: Trade wind inversion, ITCZ, Cyclones – Tropical, extra tropical and anticyclones. Monsoon through tropical cyclones, SW and NE monsoons, Indian monsoon, jet stream, Western disturbances, and severe local convective systems in India. Withdrawal, Break active and Weak monsoons and their prediction. Air masses and fronts: Sources, Origin and Classification of Air masses, Fronts, frontogenesis, Parcel wind.

Unit 5

Concept of weather, climate and weather-climate differences, Climate Classification - Köppen's and Thornthwaite's. Climate change and Global warming. Indian climatology – four seasons. Meteorological Satellites – Polar orbiting and Geostationary Satellites, Visible and Infrared radiometers, Multiscanner radiometers; Identification of Synoptic systems, Fog and Sandstorms, Determination of Cyclones, Estimation of SST, Cloud Temperatures, Winds and Rainfall, Temperature and Humidity.

COURSE OUTCOMES

1. The students will gain knowledge about atmospheric science,
2. They will understand the importance of the atmosphere and its role in climatic condition and weather patterns.
3. They will know about the application of remote sensing for weather forecasting.
4. Students get familiarity with cyclonic studies.
5. Able to know the meteorological satellites, Polar orbiting and Geostationary Satellites, Fog and Sandstorms.

Text Books

1. Bar Charts, (2012). Meteorology (Quick Study: Academic).
2. Donald Ahrens C, (2008), Meteorology Today: An Introduction to Weather, Climate, and the Environment. Study Guide/Workbook.
3. Frank R. Spellman , (2012). The Handbook of Meteorology.
4. Frederick K. Lutgens, Edward J. Tarbuck, Dennis Tasa , (2009) The Atmosphere: An Introduction to Meteorology (11th Edition).
5. Frederick K. Lutgens,, Edward J. Tarbuck, Dennis Tasa, (2012) The Atmosphere: An Introduction to Meteorology (12th Edition).
6. Steven A. Ackerman,Meteorology, John A. Knox, (2011) Third Edition.
7. Storm Dunlop, (2003). The Weather Identification Handbook: The Ultimate Guide for Weather Watchers.
8. Sverre Petterssen, (2008) Introduction to Meteorology.

Supplementary reading:

1. Donald Ahrens C, (2011) Essentials of Meteorology: An Invitation to the Atmosphere.
2. Donald Ahrens. C. (2008) Essentials of Meteorology.
3. James R. Holton, (2004). An Introduction to Dynamic Meteorology (International Geophysics).
4. Roland B. Stull, (1988). An Introduction to Boundary Layer Meteorology (Atmospheric Sciences Library).
5. Roland B. Stull, (1999). Meteorology for Scientists and Engineers.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	2
CO2	2	3	2	2	3
CO3	3	2	2	1	3
CO4	2	1	3	2	3
CO5	3	3	2	3	2

SEMESTER - I CORE ELECTIVE - I	22PGEOE15 - 3: MEDICAL GEOLOGY	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. The course is designed to introduce the basic concepts of medical geology.
2. Students are able to the interaction between the abundance of elements and isotopes, and the health of humans and plants.
3. The course provides a basic understanding of trace elements' geogenic and anthropogenic distribution and their toxic effects on human health.
4. Capable of understanding water-related diseases.
5. Understand the basic knowledge that includes environmental toxicology and environmental epidemiology.

Unit 1

General characteristics of tropical, subtropical environments, arid zone, seasonally dry tropics and sub-tropics, humid tropics, and sub-tropics zone and mountainous zone.

Unit 2

Medical Geology- Perspectives and Prospects, Public Health and Geological Processes: An Overview of a Fundamental Relationship. Environmental Biology-Natural Distribution and Abundance of Elements, Anthropogenic Sources, Uptake of Elements on Chemical and Biological Perspective and its functions.

Unit 3

Volcanic Emissions and Health, Radon in Air and Water, Arsenic in Groundwater and the Environment, Fluoride in Natural Waters, Water Hardness and Health Effects, Bioavailability of Elements in Soil, Selenium Deficiency and Toxicity in the Environment, Soils and Iodine Deficiency.

Unit 4

Geospatial analysis as a tool in epidemiology; health hazards associated with volcanic eruptions; global dust flux and respiratory problems; impacts of radon, arsenic, selenium, mercury, iodine, and uranium on physiological function; carcinogenic associations with coal and fibrous minerals; geological effects on animal health, and geophagy (human ingestion of soil materials as a dietary supplement).

Unit 5

Environmental Toxicology, Environmental Epidemiology, Environmental Medicine, Environmental Pathology, Speciation of Trace Elements. Mineralogy of Bones, Inorganic and Organic Geochemistry Techniques, Histochemical and Microprobe Analysis in Medical Geology.

COURSE OUTCOMES

1. On completion of the course the student will be able to understand the distribution of trace elements and their cyclic movement through the abiotic-biotic environment.
2. Students are able to understand the Public Health and Geological Processes:
3. Students able to solve iodine deficiency of soils
4. Can assess the geological effects on animal health, and geophagy.
5. Students can do Histochemical and Microprobe analysis in Medical Geology.

Text Books

1. C.B. Dissanayake and R.Chandrajith (2009), *Introduction to Medical Geology*, Springer, London
2. H.Catherine, W.Skinner, Antony R. Berger, (2003), *Geology and Health*: Closing gap, Oxford Univ. press, New York.
3. K.S. Valdiya (2004), *Geology, environment, Society*, University Press (India), Hyderabad.
4. Lawrence K. Wang, Jiaping Paul Chen, Yung-Tse Hung, Nazih K. Shammas (2009), *Heavy Metals in the Environment*, CRS Press, Taylor & Francis Group, Boca Raton, FL
5. M.M. Komatica, (2004), *Medical Geology*, Vol.2, *Effects of the geological environment on Human health*, Elsevier, U.K.

Supplementary readings

1. Olle Selinus, Brian Alloway, José A. Centeno, Robert B. Finkelman, Ron Fuge, Ulf Lindh, Pauline Smedley (Ed). (2005) Essentials of Medical Geology: Impacts of the Natural Environment on Public Health. Elsevier Academic Press, London
2. C. B. Dissanayake and Rohana Chandrajith, (2020). Introduction To Medical Geology: Focus on tropical environments, Springer Nature
3. Losif F.Volfson(2010),Medical Geology: Current Status and Perspectives. Russian Geological Society (ROSGEO) Publisher. Moscow.
4. Scott S. Olson, (1999), *International Environmental Standards* Handbook, CRC Press, London.
5. William N.Rom, (2012), *Environmental Policy and Public Health - Air Pollution, Global Climate Change, and Wilderness*, John Wiley & Sons, Inc. Published by Jossey-Bass A Wiley Imprint. UK.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	2	2
CO2	2	1	3	2	3
CO3	2	3	3	1	2
CO4	3	2	1	2	3
CO5	1	3	1	2	3

SEMESTER - II CORE – IV	22PGEOC21: ECONOMIC GEOLOGY AND MINERAL ECONOMICS	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. Emphasizing understanding the various ore-forming processes and ore genesis of metallic and non-metallic minerals.
2. They gain good geological knowledge on the occurrences of ore deposits in India and in the world.
3. Capable of orebody exploration techniques, sample collection and reserve estimation methods.
4. Being able to apply geological knowledge for mineral excavation and understand technology-based mining.
5. Understanding the complete operational knowledge related to the field of mining

Unit 1

Classification of mineral deposits. Major ore forming processes: magmatic, hydrothermal, sedimentary and metamorphic processes; distribution of mineral deposits; crustal evolution and metallogenesis; metallogeny through time; plate tectonics and ore deposits.

Unit 2

Study of following metallic mineral deposits, with special reference to their mineralogy, genesis, uses and distribution in India. Gold, copper, aluminium, iron, manganese, chromium, lead and zinc. Study of important non-metallic industrial minerals: origin, occurrences, distribution in India and industrial uses. asbestos, mica, barytes, ceramic minerals, building stones, cement raw materials, mineral pigments. Refractory materials, abrasive minerals and fertilizer minerals.

Unit 3

Methods of investigation of ore bodies. Different stages of prospecting. Rock sampling techniques. Ore reserve estimation methods and UNFC. Introduction to mining. Classification of mining methods. Mine development. Surface mining methods – rock drilling methods and types of drills. Mine explosives - bench parameters and mine haulage.

Unit 4

Important terms and definitions associated with subsurface mining: Shaft, adit, chute, winze, raise, stope, drift, crosscut, gallery, mine support and ventilation. Classification of subsurface mining methods. Underground mine layout – unit and auxiliary operations. Outline of underground coal mining methods. Underground mine machineries. Role of geologists in mining industry.

Unit 5

Prominent mines and minerals legislations of India. Preparation of mine plans and mining schemes. EIA report preparation. Mine accidents and miner's diseases.Mineral economics and its concept. Strategic, critical and essential minerals. National mineral policies - mineral taxation. India's mineral production - factors affecting mineral price - price of major minerals, export and import of in India.

COURSE OUTCOMES

1. Students can understand the various mineral deposits and their origin and association.
2. Understand the various types of mineral deposits that are economically valuable.
3. They can explore mineral deposits for economic purposes.
4. Students can recognize economic viable minerals by using exploration techniques.
5. Able to apply geological knowledge in mineral exploitation.

Text Books

1. Brown, C. and Dey, A.K.1955. Indian Mineral Wealth. Oxford Univ.
2. Gokhale, K.V.G.K. and Rao, T.C., 1983. Ore Deposits of India. East West Press Pvt. Ltd.
3. Jense, M.L. and Bateman A.M., 1981. Economic Mineral Deposits. John Wiley and Sons.
4. Krishnnaswamy, S., 1979. India's Minerals Resources. Oxford and IBH Publ.
5. Deb, S., 1980. Industrial minerals and Rocks of India. Allied Publishers Pvt. Ltd.
6. Umeshwar Prasad, 2003. Economic Geology. CBS Publishers and distributers.
7. Sharma, Nand Ram, K.V.S., 1972. Introduction to India's Economic Minerals, Dhanbad.
8. Petrology and Economic Geology Best, Myron G. 2002. Igneous and Metamorphic Petrology, Blackwell Science.
9. Mookherjee, A. 2000. Ore Genesis-A Holistic Approach, Allied Publisher.
10. Anthony M. Evans, Ore Geology and Industrial Minerals: An Introduction - Wiley India Pvt. Ltd.

Supplementary readings

1. Edward A. Keller. 2008. Introduction to Environmental Geology, Pearson Prentice Hall.
2. Howard L. Hartman and Jan M. Mutmansky. 2002. Introductory Mining Engineering. Wiley India Pvt. Ltd
3. Swapan K. Haldar. 2018. Mineral Exploration: Principles and Applications. 2nd Edn., Elsevier.

4. Bruce A Kennedy . 1990. Surface Mining. Society for Mining, Metallurgy, and Exploration (SME) Mining Engineering Handbook.
5. William A. Hustrulid, W. A. Hustrulid, Richard L. Bullock. 2001. Underground Mining Methods.Society for Mining, Metallurgy, and Exploration (SME) Mining Engineering Handbook.
6. Chatterjee, K. K. 2007. Uses of Metals and Metallic Minerals. New Age International Publications.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	2	3
CO2	3	2	1	3	2
CO3	1	3	2	2	3
CO4	3	2	1	3	2
CO5	2	3	2	1	3

SEMESTER - II CORE – V	22PGEOC22: HYDROGEOLOGY	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To learn the fundamental components of the hydrological cycle and distribution of fresh and saltwater of the Earth.
2. To impart theoretical, practical and field knowledge pertaining to the Hydrogeological domain.
3. To understand the physical, chemical and biological characteristics of water with special emphasis on pollution and contamination.
4. Understand the relationship in between water and rock interaction and saltwater intrusion and its remedial measures in the coastal aquifers.
5. An ability to ethical, social, healthy and sustainable consumption of water resources.

Unit 1

Hydrogeology: Hydrologic cycle and its components, Origin and age of groundwater, Occurrence of groundwater, Global distribution of fresh water. Vertical distribution of groundwater. Aquifers: Types of aquifers. Springs: Types of springs. Hydrologic properties of rocks: Porosity, Permeability, Specific yield, Specific retention, Hydraulic conductivity, Transmissivity and Storage coefficient.

Unit 2

Groundwater movements: Subsurface movement, Base flow, Effluent flow and influent flow. Darcy's law, Reynold's number, Laminar flow and turbulence flow. Water level fluctuation: Water table and Piezometric surface and its fluctuations.Pumping test: objective, layout of the test and its measurement.

Unit 3

Water well technology: Well types, drilling methods, construction of well, design of well, development and maintenance of wells. Artificial recharge of groundwater: Concept and methods. Saline water intrusion in aquifers: Salinewater intrusion, Ghyben–Herzberg's relationship between fresh and saline water, Prevention and control of saltwater intrusion in the coastal aquifers.

Unit 4

Groundwater quality: Chemical composition of groundwater, major cations and anions, trace elements and their sources. Water quality measurements: physical, chemical and biological parameters. Graphical representation of hydrochemical data: Piper's facies analysis. Groundwater contaminations and Pollutions: Problems related to arsenic and fluoride contamination, radioisotopes in hydrogeological studies. Trace element and health hazards, Impact of urbanization. Hydrogeochemical provinces of India.

Unit 5

Groundwater exploration techniques: Surface investigation of groundwater - Geologic method, electrical resistivity method, seismic method, gravity and magnetic method. Subsurface investigation of groundwater: test drilling, water level measurements. Application of Geophysical logging in Groundwater exploration.Groundwater provinces of India.

COURSE OUTCOMES

1. Capable of understanding the impact of water conservation methods in a regional and national contexts.
2. An ability to understand the importance of groundwater augmentation strategies.
3. To perform socio economic analysis to evaluate the intangible benefits of artificial structures.
4. Formulate and solve deterministic and optimization models for water resources.
5. To get familiarization of principles and applications of various groundwater exploration techniques.

Text Books

1. Alley, W.M., (1993), Regional Groundwater Quality-VNR, New York
2. Davies, S.N. and De Wiest, D.R., (1966), Hydrogeology-John Wiley& sons, Inc, New York,463p.
3. Fetter, C.W., (1990), Applied Hydrogeology-McGraw Hill, Publisher, New Delhi.
4. Freeze, R.A. and John,A., (1979), Groundwater, Cherry, Prentice Hall,Inc,604p.
5. Handa.O.P (1984), Groundwater Drilling, Oxford & I.B.H. Publishing Co.
6. Hem J.D.,(1970), Study and interpretation of the chemical characteristics of Water
7. Hiscock,K.,(2005), Hydrogeology, Principles and Practice, Blackwell Publishing,389p.
8. Karanth, K.R., (1987), Groundwater Assessment, Development and Management-Tata, McGraw Hill New Delhi 720p.
9. Kazmann, (1973), Modern Hydrology, Harper and sons Publishers, New Delhi.
10. Manning,J.C.,(2007),Applied Principles of Hydrology, CBS Publishers and Distributers, ,New Delhi.
11. Raghunath, H.M., (2007), Groundwater 3rd edition,New Age International Publishers,520p.

Suplementary Readings

1. Reddy and Rami,J.P.,(2008), A Textbook of Hydrology, University Science Press, Bangalore.
2. Schwartz,F.W and Zhang,H.,(2003), Fundamentals of groundwater, John Wiley& sons, Inc, New York,583p.
3. Shaw,E.M., (1994), Hydrology in Practice,3rd edition, Chapman and Hall,London,569p.
4. Subramaniam, V., (2000), Water-Kingston Publ. London.
5. Todd, D.K., (1980), Groundwater Hydrology-John Wiley & sons publishers, New York,535p.
6. Tolman.C. (1972), Groundwater, McGraw Hill Book Company.
7. Walton.W.C. (1970). Groundwater Resource Evaluation, McGraw Hill Book Company.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	3
CO2	3	1	2	2	3
CO3	2	2	3	1	3
CO4	1	3	1	3	2
CO5	2	1	3	2	3

SEMESTER - II CORE – VI	22PGEOC23: REMOTE SENSING AND DIGITAL IMAGE PROCESSING	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To know about the fundamental concept, principles of thermal, microwave remote sensing, and interaction with earth surface features.
2. To understand the principles and calibration techniques of LIDAR and Hyperspectral remote sensing classification techniques.
3. To gain knowledge on digital image data formats, image distortions, and corrections.
4. To know different types of image enhancement techniques, filtering, and band rationing.
5. To become familiar with image classification techniques, accuracy assessment, and image analysis.

Unit 1

Fundamentals of Thermal Remote Sensing - Thermal radiation principles, thermal interaction behavior of terrain elements, thermal sensors and specifications. Interpretation of thermal image. Passive Microwave Remote Sensing - Introduction - Basic physics and spectral characteristics of RADAR waves, microwave radiometers - Emission laws - interaction with earth features, applications. Active Microwave Remote Sensing - RADAR operation and measurements - SLAR - Imaging Geometry - Resolution Concepts, SAR - Concepts - Doppler principle, Interaction with Earth surface and vegetation.

Unit 2

LIDAR Remote Sensing: Introduction - Characteristics of laser, Principle of LiDAR, laser interaction with objects. *Hyperspectral Remote Sensing:* Hyperspectral Imaging: Hyperspectral concepts, data collection systems, calibration techniques, data processing techniques and preprocessing, Spectral mixture analysis, Spectral Matching, and Classification techniques.

Unit 3

Digital Image Processing: Introduction- Data Formats: BIP, BIL, BSQ, and GeoTIFF -. Image distortions – Image corrections- Radiometric distortions and their corrections - Geometric distortions and corrections: Image to Map, Image to Image registration, and Ground Control Points –Atmospheric correction. Resampling methods.

Unit 4

Image Enhancement: Introduction - Contrast enhancement methods: Linear & Non-linear - Gray-Level Thresholding - Density Slicing - Histogram equalization - Histogram Normalization. Filtering techniques: Convolution filtering, Sobel and Laplatian, Edge detection filter, High and low pass filtering. Band rationing.

Unit 5

Image classification techniques: Supervised and Unsupervised classification – Classification Accuracy Assessment: Concepts - Sources of errors - Error matrix analysis: User's, Producers accuracies and Kappa statistics.Image Analysis: Pattern recognition, Shape analysis, Textural and contextual analysis.

COURSE OUTCOMES

1. The student will be exposed to the fundamental concepts of thermal and microwave remote sensing techniques and interact with the earth's surface materials.
2. Ability to understand the LiDAR, and hyperspectral remote sensing techniques and their classification techniques.
3. Gain the knowledge of different types of digital data formats and rectify the various corrections using image processing techniques.
4. Understand the concept of image enhancement techniques.
5. Acquire the knowledge of image classifications and different types of error matrix analysis.

Text Books

1. Fawaz T Ulaby, Richard K Moore and Adrian K Fung, Microwave Remote Sensing active and passive, Vol. 1, 2 and 3 Addison – Wesley Publication company. 1981, 1982, and 1986.
2. Robert M HaralickadSimmonet, Image processing for remote sensing 1983.
3. Travett J W (1986). Imaging Radar for Resources surveys, Chapman and Hall, London.
4. Lillisand,T.M&R.W.Kiefer.(2008). Remote sensing and Image Interpretation, John Wiley and Sons Inc.
5. Gupta R.P (2014). Remote Sensing Geology, Springer.

Supplementary Readings

1. Sabins F F (2007). Remote Sensing: Principles and Interpretation, W H Freeman And Company.
2. Curran,P.B. (1985).Principles of Remote Sensing. ELBS. London.
3. John R Jensen (2017). Introductory Digital Image Processing: A Remote Sensing Perspective, Pearson.
4. Robert A. Schowengerdt (1997). Remote sensing Models and methods for image processing, Academic Press

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	2	3	3	1	3
CO2	1	1	3	1	3
CO3	3	2	3	2	3
CO4	3	3	2	3	2
CO5	3	2	1	2	3

SEMESTER - II CORE PRACTICAL - II	22PGEOP24: ECONOMIC GEOLOGY, REMOTE SENSING & DIP AND HYDROGEOLOGY	CREDITS: 12 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To know the non metallic minerals and their industrial applications, distribution and occurrence and to know the method of ore reserve estimation.
2. To learn Remote sensing and digital image processing.
3. To familiarize water quality, samples have been collected from the field and estimate physical, chemical and biological parameters using different analytical techniques.
4. To know the relationship among the different ions data obtained from the hydrogeology laboratory and projected graphically.
5. Understand water quality and its suitability for domestic, irrigational and industrial purposes, the data have been compared and correlated with BIS and WHO standards.

Exercise/ Practise

Economic Geology

1. Computation of ore reserves from sampling data
2. Estimation of ore reserves by traditional methods:
    i. Included area method
    ii. Extended area method
    iii. Triangle method
    iv. Polygonal method and cross section method.
3. Computation of ore reserves from maps

Satellite Remote Sensing

1. Different satellite data products
2. Marginal Information
3. Geological Mapping – Igneous, Metamorphic and Sedimentary Rocks, Lineament Mapping, Structural Mapping.
4. Geomorphological Mapping – denudational, fluvial and coastal geomorphology
5. Water Resource – Surface water mapping, snow cover mapping, drainage pattern
6. Interpretation of Thermal Scanner Imagery

Digital Image Processing

1. Starting ERDAS imagine, and explore the viewer interface
2. Identifying image statistics, data format and Histogram
3. Determination of Contrast Difference, Contrast Ratio and Image Quality
4. Measuring Tools
5. Band Combination
6. Spatial Enhancement
7. Supervised Classification

Hydrogeology

1. Calculation of rainfall by the arithmetric method.
2. Determination of catchment area by Theissen polygon method and calculation of rainfall
3. Determination of catchment area by Isohyetal method and calculation of rainfall
4. Calculation of Specific yield and transmissibility from the given data.
5. Diagrammatic representation of hydrochemical data: bar, circular radial, multivariate Schoeller diagram, Stiffs diagram, horizontal and vertical scale diagram
6. Calculation of Water quality parameters SAR, TH, NCH, TDS, EC, pH and interpretation for various uses.
7. Pumping test: time drawdown and time recovery tests and evaluation of aquifer parameters.
8. Identification of groundwater zones from resistivity data.

COURSE OUTCOMES

1. Students will gain knowledge on ore reserve estimation.
2. Students will know the field map projection techniques using GPS .
3. They will know to interpret GPS and GIS data.
4. Gain training in the chemical analysis of water.
5. They will be able to estimate of water resource potential.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	3
CO2	2	1	3	2	3
CO3	3	2	2	3	3
CO4	2	3	3	2	1
CO5	2	3	3	2	3

SEMESTER - II CORE ELECTIVE - II	22PGEOE25 - 1: ENVIRONMENTAL GEOSCIENCES AND DISASTER MANAGEMENT	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To understand the principles of environmental geology.
2. To know the types of Environmental hazards & disasters.
3. To gain knowledge on different pollution aspects.
4. Be familiar with the different environmental issues and management.
5. To know about the emerging approaches in Disaster Reduction and Management.

Unit 1

Definition, Principles and scope of Environmental Geoscience: Earth, Man and components of Environment, Ecosystem, Pathways in Ecosystems. Renewable and non-renewable resources- types of alternative renewable energy sources- their advantages. Natural hazards – Endogenic: Tectonism, Volcanoes, Earthquakes, landslides. Exogenic: atmospheric hazards, cyclones, lightning, hailstorms, drought, cold waves, heat waves, floods.

Unit 2

Assessing geological hazards and risks, types of hazards earthquakes, volcanic eruptions, floods, subsidence, landslides, hazards of oceans, and whether-preventive and precautionary measures. Environmental impacts of mining, surface blasting, etc. Impact assessment of mining; dumping of ores; mine waste and fly ash

Unit 3

Environmental Pollution - definition, causes and concepts, sources of pollution-nature of pollutants- Concept of acid rain, greenhouse effect, EI-Nino, La-Nino, ozone depletion. Deforestation and erosion, global warming and climatic change concepts. Natural and anthropogenic sources of air pollution, water pollution sources and consequences of water pollution, soil/land pollution and their interactions with soil components, Sources of marine pollution and its control, causes, effect, and control of solid waste. Effects of pollutants on human beings, plants, animals, and climate.

Unit 4

Reclamation & Management of wastelands. Solid Waste Management Plan, Waste minimization technologies, Hazardous Waste Management. Indian environmental laws related to Water, Air and Forest conservation. Environmental Impact Assessment (EIA), general guidelines for the preparation of environmental impact statement (EIS), scope and types of Environmental Audit. Environmental Management Plan (EMP). Environmental Ethics. Environmental Education (EE)

Unit 5

Introduction: Disaster-Definition, Factors, Significance. Hazard and Disaster; Terminology in Disaster Management (vulnerability, risk, capacity building). Disaster Management Concepts: Elements of disaster management, Scope and objectives of disaster management, Approaches to disaster management, Disaster Management Cycle, its phases, and significance of disaster profile and vulnerability scenario of India. Disaster management policy, National and State Bodies for Disaster Management, Early Warming Systems

COURSE OUTCOMES

1. To help the learners to understand and address the connection between the atmosphere, ecology, ecosystem, and problems in the environment
2. The students will gain knowledge on the interaction between human activities and the atmosphere, ocean, and the solid Earth
3. Understand the different environmental pollution, its causes, and remedies in which where we live
4. The learners will understand the issues related to different geo hazards or hazard
5. They will gain knowledge of the disaster management plan and methods

Text Books

1. Lal. D.S Climatology, Published by Sharda Pustak Bhawan, New Delhi
2. Harsh .K. Gupta (2003), *Disaster Management*, University Press, New Delhi.
3. Ignacimuthu.S, (1998), *Environmental Awareness and Protection*, Phoenix Publishing House Pvt. Ltd., New Delhi
4. R.B Singh(Ed) (2000), *Disaster Management*, Rawat Publication, New Delhi.
5. Upendra Kumar Sinha, (1986), *Ganga-Pollution & Health Hazard*, Inter-India publication, New Delhi.
6. Sharma.R.K., Gagandeep sharma, (2016) *Natural Disaster*, APH Publications New Delhi.
7. Vaidyanathan.S (2011), *An introduction to disaster management*. IKON books, new Delhi

Supplementary reading

1. Keller.E.A, (1978), *Environmental Geology*, 4th Ed, A. Charles E.Merrill Pub. Co., A. Bell & Howell Co., London,
2. Lawrence Lundgren, (1986), *Environmental Geology*, Prentice-Hall, New Delhi.
3. Strahler.A.N and Strahler.A.H. (1973), *Environmental Geosciences*, Wiley International Edition, UK.
4. Thomas D. Schneid and Larry Collins, (2001), *Disaster management and preparedness*: Occupational safety and health guide series, CRC Press, Lucknow.
5. Valdiya, K.S., (1987), *Environmental Geology, Indian context*, Tata Mc Graw Hill. Bombay.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	1	3
CO2	2	3	1	3	2
CO3	1	1	3	2	3
CO4	3	2	3	2	1
CO5	2	3	2	1	3

SEMESTER - II CORE ELECTIVE - II	22PGEOE25 - 2: DIGITAL CARTOGRAPHY	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To understand the principles, roles and representations of cartography
2. To practice the use of digital cartographic modules in the creative design process
3. To learn the transformation of maps to required projection and geodetic sytems.
4. To gain knowledge and practice skills in cartographic design, representation and production in a GIS environment
5. To understand the application of cartographic software and its uses.

Unit 1

Definition, scope and concepts of Digital cartography. Characteristics of Map.Categories of maps.Methods of mapping, relief maps, thematic maps.Trends in Digital Cartography – Live Maps.

Unit 2

Scale of maps. Use of Maps to establish spatial relationships among selected phenomena of interest, analysis and synthesis.

Unit 3

Geodesy, Spheroid, Geoid, Map projection, Properties and uses of projection. classification principles of construction of common projections, cylindrical, conical, azimuthal and globular projections. Projections used in Survey of India topographic sheets.

Unit 4

Ground Survey and positioning, Remote sensing, census and sampling, Geographical Information System (GIS) - data processing, image processing, digital database generation, Geographic and cartographic database, basic Statistical processing, design of colour and pattern, typography and lettering of the map.

Unit 5

Digital Compilation, Processing and generalizing of geographic data, Simplification and Classification, computer assisted cartographic processes, symbolization, mapping with point, line and area symbols-Portraying the land surface form..

COURSE OUTCOMES

After the completion of the course, the student will be able to understand:

1. The concepts, elements and components for the preparation of Digital maps.
2. The methods to create digital maps in various formats as per the requirement and purpose.
3. The use of GIS software to produce accurate, appropriate, convincing and creative maps and graphics.
4. The use of digital cartographic methods for exploring, evaluating, confirming and presenting geospatial relationships.
5. The efficiency of digital cartography and effectiveness in preparing maps that are conveying messages easily with comfortable presentations for the users.

Text Books

1. Campbell, J. 1984. Introductory Cartography, Printers Hall Englewood Cliffs, N.J.
2. Dent B.D, 1985. Principles of Thematic Map Design, Addision Wesley Pub. Company. 398p.
3. Monmonier, M.A, 1982. Computer Assisted Cartography - Principles and Prospects, Prentice Hall, Englewood Cliffs, NJ.
4. Robinson A.H, Morrison J.L, Mucehreke P.C, and Kummer A.J. 1995. Elements of Cartography, John Willey & Sons, 6th Edition.

Supplementary Readings

1. Gretchen N. Peterson. 2009.GIS Cartography-A Guide to Effective Map Design, CRC Press ,Taylor& Francis Group, London, 215p.
2. Markus Jobst Ed. 2011. Preservation in Digital Cartography, Springer, NY.
3. Department of Economic and Social Affairs
4. Statistics Division, 2000. Handbook on geographic information systems and digital mapping. UN, NY.
5. Marina De LimaEd. 2017. Handbook of Cartography. Academic Pages, USA.317p.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	1	3	2	3	2
CO2	2	3	1	3	1
CO3	3	2	1	1	3
CO4	2	1	3	3	2
CO5	3	1	2	1	3

SEMESTER - II CORE ELECTIVE - II	22PGEOE25 - 3: INTRODUCTION TO GEOLOGICAL SOFTWARE	CREDITS: 4 HOURS: 4 / WEEK

COURSE OBJECTIVES

1. To understand the computer software for geological studies.
2. To understand the application of geological related software.
3. To understand applications of the software used in the interpretation of the geological data on the map.
4. To know about the statistical software used in the geological field.
5. To know about the Interpretation of data in suitable software related to the field.

Unit 1

Interpretation and analysis of Geological data using MS-office, IGPET, WATEQ4F

Unit 2

Applications, Principles of data input, processing and interpretation in software like PHREEQC and MODFLOW

Unit 3

ArcGIS, Map info for spatial analysis and integration of complex geological and geophysical data. ERDAS IMAGINE as image-processing tools for analyzing remotely sensed data.

Unit 4

Overview of geostatistical analysis using the statistical package SPSS, Graphical analytical packages like Surfer and RockWorks for both 2-D surfaces.

Unit 5

Data Interpretation: Toposheets, Aerial photographs, Satellite imageries. Interpretation of Meteorology data: rainfall, temperature, wind, humidity; Interpretation of borehole logs, litho log, SP log, Resistivity log, Gamma log, neutron log.

COURSE OUTCOMES

1. Gain knowledge of computer software in geology.
2. Students will know the application of geological related software.
3. Students gain knowledge about interpreting the data on map.
4. Students have knowledge about uses of statistical software in geology.
5. Gain the knowledge of applications and interpretation of computer software.

Text Books

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

Supplementary readings

1. ERDAS: IMAGE 2018, Version 16.5(V 16.5.0.82)
2. PHREEQC Ver.1: Ground water & pollution, II Edition: A.A. Balkana. Publication, Leiden.
3. The Parkhurst,D.L.,1995,user's guide to PHREEQC.

OUTCOME MAPPING

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	3	2
CO2	2	2	1	2	3
CO3	2	3	3	2	1
CO4	3	2	3	1	2
CO5	3	2	1	2	3