



UNIVERSITY OF CALCUTTA

Notification No. CSR/13/2023

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 11.07.2023 approved the Syllabi of the under mentioned subjects for semester wise Four-year (Honours & Honours with Research) / Three-year (Multidisciplinary) programme of U.G. courses of studies, as applicable under CCF,2022 . under this University, as laid down in the accompanying pamphlet.

Name of Subject:

1. Anthropology
2. BBA
3. Bengali
4. BFAD
5. Bio Chemistry
6. Botany
7. Chemistry
8. Commerce
9. Economics
10. Education
11. English
- ✓ 12. Geology
13. Hindi
14. History, Islamic History & Culture
15. Home Science
16. Human Rights
17. Journalism & Mass Communication
18. Mathematics
19. Microbiology (Honours)
20. Molecular Biology
21. Philosophy
22. Physiology
23. Political Science
24. Psychology
25. Social Science
26. Sociology
27. Urdu
28. Women's Studies
29. Zoology

The above shall be effective from the academic session 2023-2024.

SENATE HOUSE

KOLKATA-700 073


12/7/2023
Prof. (Dr.) Debasis Das

Registrar

Syllabus for B.Sc Geology

NEP System (2020)
Curriculum & Credit Framework

Eight Semester (Four Year) Hons. / Hons. (with
research)

Six semester Minor

Six semester (Three year) MDC

University of Calcutta

Course Structure (4 year Hons.)

Sem.	PaperCode	Theory	Practical	Credit	
Sem.1	GELA-DSC-100-Th	Introduction to Earth System Science (50)		2	4
	GELA-DSC-100-P		Study of hand specimens of minerals and rocks (50)	2	
	GELA-SEC-100	Field Studies-1 (100).		4	4
Sem.2	GELA-DSC-200-Th	Mineral Science (50)		2	4
	GELA-DSC-200-P		Crystallography, Study of minerals under microscope (50)	2	
Sem.3	GELA -DSC-300-Th	Structural Geology-1 (50)		2	4
	GELA -DSC-300-P		Graphical and stereographic methods. Study of Geological Maps-1. (50)	2	
	GELA-DSC-310-Th	Sedimentology (50)		2	4
	GELA -DSC-310-P		Study of sedimentary rocks under microscope and graphical presentations (50)	2	
	GELA -SEC-300	Field Studies-2 (100)		4	4
	GEL-IDC-100-Th	Earth System Science (50)		2	3
	GEL-IDC-100-P		Earth System Science (25)	1	
Sem.4	GELA-DSC-400-Th	Igneous Petrology (50)		2	4
	GELA-DSC-400-P		Study of igneous rocks under microscope(50)	2	

	GELA-DSC-410-Th	Geochemistry and Economic Geology (75)		3		4
	GELA-DSC-410-P		Ore Microscopy (25)		1	
	GELA -DSC-420-Th	Metamorphic Petrology (50)		2		4
	GELA -DSC-420-P		Study of metamorphic rocks under microscope, ACF-AKF plots (50)		2	
	GELA -DSC-430-Th	Palaeontology-1 (50)		2		4
	GELA -DSC-430-P		Macro palaeontology (50)		2	
Sem.5	GELA-DSC-500-Th	Geotectonics and Geomorphology (75)		3		4
	GELA-DSC-500-P		Field Studies-3. (25)		1	
	GELA-DSC-510-Th	Principles of Stratigraphy (25), Indian Stratigraphy (50)		3		4
	GELA-DSC-510-Tu		Tutorial (25)		1	
	GELA-DSC-520-Th	Fuel Geology (50)		2		4
	GELA-DSC-520-P		Fuel Geology (50)		2	
	GELA-DSC-530-Th	Hydrogeology (50)		2		4
	GELA-DSC-530-P		Hydrogeology (50)		2	
Sem.6	GELA-DSC-600-Th	Structural Geology-2 (50)		2		4
	GELA-DSC-600-P		Study of Geological Maps-2. Completion of outcrops (50)		2	
	GELA-DSC-610-Th	Remote Sensing and GIS (50)		2		4
	GELA-DSC-610-P		Remote Sensing and GIS (50)		2	

	GELA-DSC-620-Th	Engineering Geology (50)		2		4
	GELA-DSC-620-P		Engineering Geology (50)		2	
	GELA-SI-100	Summer Internship (100)		3		3
Sem.7	GELA-DSC-700-Th	Exploration Geology (50)		2		4
	GELA-DSC-700-P		Exploration Geology (50)		2	
	GELA-DSC-710-Th	Geophysics (50)		2		4
	GELA-DSC-710-P		Geophysics and Application of Statistics in Geology (50)		2	
	GELA-DSC-720-Th	Environmental Geology and Marine Geology (75),		3		4
	GELA-DSC-720-P		Tutorial (25)		1	
	GELA-DSC-730-Th	Palaeontology-2 (50)		2		4
	GELA-DSC-730-P		Micropaleontology, Ichnology (50)		2	
	GELA-DSC-740	Earth Science Colloquium (100)		4		4
Sem.8	GELA-DSC-800-Th	Climatology and Planetary Geology (75)		3		4
	GELA-DSC-800-P		Tutorial. (25)		1	
	GELA-DSC-810-Th	Analytical Techniques in EarthSciences (50)		2		4
	GELA-DSC-810-P		Computer Application in Geology (50)		2	
	GELA-DSC-820-Th	Grand Viva (100)		4		4
	GELA-DSC-830-Th	Dissertation Thesis (150)		6		8

	GELA-DSC-830-P		Dissertation Viva(50)		2	
	GELA-DSC-840-Th	Pedology and Natural Hazards (75)		3		4
	GELA-DSC-840-Tu		Tutorial. (25)		1	
	GELA-DSC-850-Th	Watershed Management and Medical Geology (75)		3		4
	GELA-DSC-850-Tu		Tutorial (25)		1	

GEL-IDC-Th	Earth System Science (50)		2		3
GEL-IDC-Tu		Tutorial (25)		1	

Course Structure (Minor)

Sem.	PaperCode	Theory	Practical	Credit	
Sem.1/ Sem.3	GELG-100-Th	Introduction to Earth SystemScience (50)		2	4
	GELG-100-P		Study of hand specimens of minerals androcks (50)	2	
Sem.2/ Sem.4	GELG-200-Th	Mineral Science (50)		2	4
	GELG-200-P		Crystallography, Study of minerals under microscope (50)	2	
Sem.5	GELG-500-Th	Structural Geology-1 (50)		2	4
	GELG-500-P		Graphical and stereographic methods.Study of Geological Maps-1. (50)	2	

Sem.6	GELG-600-Th	Igneous Petrology (50)		2	4
	GELG-600-P		Study of igneous rocks under microscope(50)	2	

Course Structure (MDC)

Sem.	PaperCode	Theory	Practical	Credit	
Sem.1	GELG/GELM-100-Th	Introduction to Earth SystemScience (50)		2	4
	GELG/GELM-100-P		Study of hand specimens of minerals androcks (50)	2	
Sem.2	GELG/GELM-200-Th	Mineral Science (50)		2	4
	GELG/GELM-200-P		Crystallography, Study of minerals under microscope (50)	2	
Sem.3	GELG/GELM-300-Th	Structural Geology-1 (50)		2	4
	GELG/GELM-300-P		Graphical and stereographic methods.Study of Geological Maps-1. (50)	2	
Sem.4	GELG/GELM-400-Th	Sedimentology (50)		2	4
	GELG/GELM-400-P		Study of sedimentary rocks under microscope and graphical presentations (50)	2	
Sem.5	GELG/GELM-500-Th	Igneous Petrology (50)		2	4
	GELG/GELM-500-P		Study of igneous rocks under microscope(50)	2	
	GELG/GELM-510-Th	Geochemistry and Economic Geology (75)		3	4
	GELG/GELM-510-P		Ore Microscopy (25)	1	

Sem.6	GELG/GELM-600-Th	Metamorphic Petrology (50)		2		4
	GELG/GELM--600-P		Study of metamorphic rocks under microscope, ACF-AKF plots (50)		2	
	GELG/GELM-610-Th	Palaeontology-1 (50)		2		4
	GELG/GELM-610-P		Macro palaeontology (50)		2	

Paper – GELA -DSC-100-Th
GELG/GELM-100-Th
Introduction to Earth System Science
(Full Marks – 50)

1. **Earth Systems Science:** Definitions and Scope.
2. **Elementary ideas on solar system:** terrestrial and Jovian planets. Origin of the solar system, nebular hypothesis, formation of planets. Layered structure of Earth, differentiation of Earth's core, mantle and crust, formation of Earth's oceans and atmosphere. Earth as a system of interacting components- solid earth, atmosphere, hydrosphere, biosphere.
3. **History of development of geological thoughts,** Catastrophism, Neptunism, Plutonism, Uniformitarianism, law of superposition, law of faunal succession, law of original horizontality and law of cross-cutting relation. Contribution of Werner, Hutton, Smith and Lyell.
4. **Earth's materials: Minerals.** Definition of minerals. Chemical classification of minerals: native elements, oxides, sulphides, carbonates, sulphates, phosphates, silicates (a few examples from each class). Chemical compositions and physical properties of some common rock forming minerals and ore minerals (those mentioned in the Unit 1 of the practical paper: GELA-DSC-100-P).
5. **Earth's materials: Rocks.** Rocks as mineral assemblages, rock texture.
Igneous rocks, acid, intermediate, mafic and ultramafic rocks. Petrography of granite, granodiorite, pegmatite, rhyolite, syenite, trachyte, diorite, andesite, gabbro, dolerite, basalt, peridotite.
Sedimentary rocks, clastic and non-clastic. Petrography of conglomerate, sandstone, siltstone, shale, limestone,
Metamorphic rocks, foliated, non-foliated. Petrography of slate, phyllite, schist, gneiss, quartzite, marble.
6. **Structure of geologic bodies.** Deformation of rocks. Primary and secondary structures: definitions, brief outlines, and examples.
Stratum: formation, group and bed, volcanic flows.
Attitudes of linear and planar structures: strike and dip, plunge and pitch.
Definitions, brief descriptions and labelled diagrams of the following structures:
 - Folds: antiform, synform, neutral fold, anticline, syncline.
 - Fractures: joints, and faults. Normal, reverse, and strike slip faults.
 - Foliations and lineations.

7. **Earth's internal processes:** Magmatism, and Metamorphism. Volcanoes and volcanism, products of volcanic eruption, eruptive styles, volcanic belts, recent volcanism in India.
8. **Earthquakes:** causes, elastic rebound theory, focus and epicentre, intensity and magnitude. Seismic waves, seismograms, travel-time curves for seismic waves, seismic discontinuities, locating epicentre, and determining magnitude. Earthquake belts. Effects of earthquakes, seismic zones of India.
9. **Internal Constitution of Earth** – evidences from seismic waves, meteorites, and others. Compositional layers: crust, mantle and core, their sublayers and bounding discontinuities. Rheological layers: lithosphere, asthenosphere, mesosphere.
10. **Heat flow:** Basic concepts, geothermal gradient. Heat flow anomalies. Hotspot and mantle plume.
11. **Elementary idea of theory of plate tectonics.** Plates and plate boundaries, relative motion of plates. Present day configuration of plates.
12. **Earth's surface processes.** Weathering, erosion, mass wasting; bed rock, regolith, soil, soil profile. Erosion, transportation and deposition by wind, river, glacier, groundwater and ocean. Common landforms related to action of wind, river, glacier; coastal landform. Ice ages, evidence and causes. Oceanic and atmospheric circulation patterns.
13. **Age of the Earth.** Principles of determination of relative ages of rock bodies and geologic events. Absolute ages of rocks and minerals, fundamental principles of radiometric dating. Geologic Time Scale up to the level of Eras and Periods.
14. **The fossil records.** Fossils as evidence of past life. Modes of preservation of fossils. Uses of fossils.
15. **Gravity and gravity anomaly on Earth:** Bouguer and Free-air anomaly. Concept of isostasy and compensation, hypotheses of Airy and Pratt

Paper – GELA -DSC-100-P

GELG/GELM-100-P

Introduction to Earth System Science

(Full Marks – 50)

Practical: Study of Minerals and Rocks in Hand Specimens

Unit 1. Study of common minerals in hand specimens (20 Marks)

Silicates: garnet, beryl, sillimanite, kyanite, staurolite, tourmaline, talc, chlorite, biotite, pyroxene, amphibole, muscovite, feldspar, quartz (different varieties), jasper, agate.

Other minerals: pyrite, chalcopyrite, galena, sphalerite, calcite, aragonite, dolomite, malachite, magnetite, haematite, psilomelane and pyrolusite, bauxite, apatite, graphite, barite and gypsum.

Unit 2. Study of common igneous, metamorphic and sedimentary rocks in hand specimens (30 Marks)

Granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosite, peridotite, pyroxenite, basalt, andesite, trachyte, rhyolite and pegmatite.

Conglomerate, sandstone, shale, limestone, dolomite, and ironstone.

Slate, phyllite, schist, gneiss, amphibolite and marble.

Reference Books

- Dasgupta, A. 2013, An introduction to Earth Science, World Press
- Duff, P. M. D. and Duff, D. (Eds.) (1993). Holmes' principles of physical geology.
- Emiliani, C. (1992). Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
- Gross, M. G. (1977). Oceanography: A view of the earth.
- Gross, M. G. (1977). Oceanography: A view of the earth. Englewood Cliffs, N.J., Prentice-Hall.
- Grotzinger, J., Jordan, T.H., Press, F and Siever, R. (2007). Understanding Earth (Fifth Edition). W. H. Freeman and company, New York. Other editions of this book may also be consulted.
- Klein, C. (2007). Manual of Mineral Science. 23rd Edition. J. Wiley and Sons. (For unit 4)
- Lutgens, F. K., Tarbuck, E. J., and Tasa, D. (2016). Essentials of Geology. 13th Edition. Pearson Education, Inc. Other editions of this book may also be consulted.
- Marshak, S: Essentials of geology, w. w. Norton & company
- Patwardhan, A. M., 1999. The Dynamic Earth System. Prentice Hall.
- Tarback, E. J. and Lutgens, F.K. (2006). Earth Science. Pearson Prentice Hall, New Jersey.
- Taylor and Francis. Emiliani, C. (1992). Planet Earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.

Paper – GELA-SEC-100

Field Studies – 1

(Full Marks – 100)

12-days fieldwork. Introductory fieldwork for reconnaissance geological survey of an area. Reading of topographic maps and use of geological field equipment. Report writing.

Field should be carried out in and around following areas:

Maithan, Purulia, Biharinath, Saltora and Malbazar-Darjeeling areas of West Bengal, Jabalpur area of M.P., Chandipur-Balasore area of Odisha, Arialur- Uttatur-Salem-Chennai of Tamil Nadu.

Paper – GELA -DSC-200-Th

GELG/GELM-200-Th

Mineral Science

(Full Marks – 50)

Unit 1: Crystallography

Concept of crystal and crystalline matter. Internal order in crystal.

Crystal structure; elementary ideas about crystal morphology in relation to internal structures.

Crystal parameters and indices; form and zone.

Stereographic projection of crystal faces, Crystal symmetry, classification of crystals into systems. Internal order in crystals. Lattice theory, Unit cells, and 32 point groups. Introduction to space groups.

Twinning in crystals. Laws of twinning, Twin laws for quartz and feldspar.

Unit 2: Atomic arrangements and Mineral structure

Arrangement of atoms and ions in the minerals.

Different types of bonding in minerals.

Co-ordination principle, ionic radius and coordination number. Pauling's rules.

Short range and long range order – definitions and brief descriptions.

Basic concepts of solid solutions, polymorphism (with descriptions of polymorphs of C, SiO₂, Al₂SiO₅, CaCO₃, and K-Feldspar), polytypism, isomorphism and pseudomorphism of minerals.

Arrangement of [SiO₄]⁴⁻ tetrahedra in the silicate sub-classes: nesosilicate, sorosilicate, inosilicate (single and double chain), cyclosilicate, phyllosilicate and tectosilicate.

Internal structures of three silicate minerals groups: pyroxene, amphibole, and mica.

Unit 3: Crystal Optics

Nature of light and optical behaviour of crystals.

Introduction to petrological microscope.

Theory of light propagation in isotropic, uniaxial, and biaxial crystals.

Study of refractive indices, Becke test, twinkling effects, and pleochroism of minerals.

Principles of orthoscopic and conosopic studies of minerals under optical microscope.

Unit 4: Principles of X- ray powder methods.

Bragg Equation and its application, X –ray camera: diffractogram, procedure for identification of minerals from x-ray powder diagram, use of internal standards. Brief outline of EPMA, XRD and SEM.

Unit 5: Fundamentals of Crystal Field Theory.

Concept of stabilization energy. Application of crystal field Theory in determining mineral structure.

Paper – GELA-DSC-200-P

GELG/GELM-200-P

Mineral Science

(Full Marks – 50)

Study of the symmetry of crystals. Stereographic projection of crystals.

Derivation of structural formulae based on composition: Pyroxene and Amphibole (on the basis of total FeO).

Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite, chlorite, epidote, kyanite, sillimanite, tourmaline, zircon, sphene, zoisite, apatite.

Determination of scheme of pleochroism and extinction angles of hornblende.

Reference Books

- Blackburn W. H. and W. H. Dennen. Principles of mineralogy. Dubuque, IA: Wm. C. Brown Publishers. 1993)
- Buerger M. Elementary Crystallography. The MIT Press (May 15, 1978)
- Dana, E.S. and Ford, W.E., (2002) A textbook of Mineralogy (Reprints).
- Deer, W. A., Howie, R. A., and Zussman, J. (1996). An Introduction to Rock-Forming Minerals. Prentice Hall.
- Haldar, S.K., 2014, Introduction to Mineralogy and Petrology, Elsevier
- Kerr, B.F., (1995) Optical Mineralogy 5th Ed. McGraw Hill, New York.
- Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley and Sons.
- Nesse, W. D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- Nesse, W. D. (2017). Introduction to Mineralogy (Third Edition). Oxford University Press.
- Perkins, D. (2015). Mineralogy (Third Edition). Pearson Education.
- Putnis, A. (1992). Introduction to Mineral Sciences. Cambridge University Press.

- Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy – Concepts and Methods. Text Book Series, Geological Society of India, Bangalore
- Rutley's Elements of Mineralogy. Springer; 27th edition (November 30, 1988)
- Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.

Paper – GELA -DSC-300-Th

GELG-500-Th

GELM-300-Th

Structural Geology – 1

(Full Marks – 50)

Unit 1. Introductory Concepts: Geological structures and structural elements. Scales of observation of structures. Penetrative and non-penetrative structural elements. Definitions of geometric, kinematic and dynamic analysis of structures. Definitions and brief descriptions: primary, penecontemporaneous, and secondary structures. Application of primary structures in structural geology.

Attitudes of linear and planar structural elements: plunge and pitch, strike and dip. Representation of planes and lines in stereographic and equal area projection diagrams. Outcrops of planes on horizontal and uneven surfaces. Outlier and inlier.

Unit 2. Folds: Geometry of a fold: Fold axis, hinge line, inflection line, axial surface, median surface and enveloping surface, fold wavelength and amplitude.

Classification of folds based on direction of convexity, younging direction of beds, fold shape, orientation of fold axis and axial plane. Equal area projection diagrams of different types of folds. Concept of π and β plots. Fleuty's classification of folds, Ramsay's classification of folds (1967). Outcrop patterns of folded rock units on horizontal and sloping surfaces. Relation between major folds and minor folds and their relations.

Unit 3. Foliations and Lineations: Primary and secondary foliation. Morphological features of secondary foliation, morphological classification of rock cleavage. Relation of secondary foliations with major folds.

Types of lineation, and their geometrical relation to folds.

Unit 4. Brittle deformation structures: Joint sets and joint systems, relation of joints to folds. Faults: translational and rotational faults, slip and separation; nomenclature of faults based on geometrical relation of faults to affected strata, slip and separation.

Effects of faults on outcrop of strata.

Horst and graben, autochthon, allochthon, nappe, window and klippe.

Criteria for recognition of faults.

Unit 5. Unconformity: types of unconformity, criteria for distinguishing unconformity from faults and intrusive contacts.

Paper – GELA-DSC-300-P

GELG-500-P

GELM-300-P

Structural Geology – 1

(Full Marks – 50)

Unit – 1. Graphical and stereographic methods

Graphical solution of simple true dip-apparent dip problems, determination of attitudes of homoclinal strata from vertical bore hole data.

Stereographic projection of planes and lines. Solution of simple structural problems using a stereographic net, e.g., true dip-apparent dip problems, determination of plunge and pitch of lines.

Determination of the structural elements of cylindrical folds using stereonet.

Determination of slip and separation of faults using graphical and/or stereographic methods.

Unit – 2. Study of Geological Maps – 1

Study of geological maps of horizontal and uneven topographic surfaces, showing homoclinal strata and/or unconformity.

Study of geological maps showing faulted homoclinal strata on horizontal topography.

Reference Books

- Billings, M. P. (1987). Structural Geology, 4th edition. Prentice-Hall.
- Davis, G. H., Reynolds, S. J., and Kluth, C. F. (2012). Structural Geology of Rocks and Region. 3rd Edition. John Wiley & Sons, Inc.
- Fossen, H. (2016). Structural Geology. Second Edition. Cambridge University Press.
- Lisle, R. J. and Leyshon, P. R. (2004) Stereographic projection techniques for structural geologists and civil engineers. Second Edition. Cambridge University Press.
- Marshak, S. and Mitra, G. (1988). Basic Methods in Structural Geology. Prentice Hall.
- Phillips, F. C. (1973). The use of stereographic projection in structural geology. Hodder.
- Ragan, D. M. (2009). Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
- Twiss, R. J. and Moores, E. M. (2007) Structural Geology. Second Edition. W. H. Freeman and Company.

Paper – GELA -DSC-310-Th

GELM-400-Th

Sedimentology

(Full Marks – 50)

Unit 1: Introduction to Sedimentology

Scope of sedimentology, origin of sediments, classification of sedimentary rocks based on composition and texture.

Unit 2: Granulometry: Textural parameters of clastic sediments

Grain size: concept of size and scale; particle shape and fabric; sedimentary textures. grain size analyses and environmental connotations.

Unit 3: Basic Hydraulics and Sedimentary Structures: sediment transport mechanism

Fluid flow: flow rheology, fluid gravity flow, sediment gravity flow, flow regime, laminar and turbulent flow, particle entrainment in fluid flow.

Mass flow: types and products.

Sedimentary structure: primary and penecontemporaneous deformation structures, biogenic structures.

Paleocurrent analysis: data acquisition, methodology, different palaeocurrent patterns.

Unit 4: Sedimentary rocks

Siliciclastic rocks: components and classification(s) of conglomerates, sandstones, mudrocks.

General introduction to carbonate rocks, BIF, chert;

Components and classifications of limestone, dolomite and dolomitisation.

Unit 5: Sedimentary environments

Classification, sedimentary facies.

Facies analysis: Principles, facies models and environmental reconstructions of principal siliciclastic environments in continental (aeolian, glacial, fluvial, lacustrine), transitional (deltaic, tidal flat, barrier beach) and marine realm (clastic shelf, deep marine). Carbonate depositional system.

Unit 6: Diagenesis

Concepts of diagenesis

Stages of diagenesis: diagenetic changes in sand and carbonate deposits, lithification.

Unit 7: Basin analysis

Classification and formation mechanism of major basin types.

Paper – GELA -DSC-310-P

GELM- 400-P

Sedimentology – Practical

(Full Marks – 50)

Analysis of Directional data: Palaeocurrent data, Trend data.

Statistical analysis of particle size distribution.

Petrographic study of clastic and non-clastic rocks in thin sections under microscope and interpretation of possible depositional environment.

Reference Books

- Allen, J.R.L. (1985). Principles of Physical Sedimentology. George Allen and Unwin, London.
- Boggs, S. Jr. (2010). Principles of Sedimentology and Stratigraphy. 4th Ed. Pearson Prentice Hall.
- Collinson, J. D. and Thompson, D. B. (1988). Sedimentary structures. Unwin- Hyman, London.
- Collinson, J., Mountney, N., Thompson, D., Sedimentary Structures, Terra Publishing, 3rd Ed., 2006
- Folk, R. L. (1974). Petrology of Sedimentary Rock. Hemphill Publishing Company, Austin, Texas.
- Nichols, G. (2009). Sedimentology and Stratigraphy. Second Edition. Wiley Blackwell.
- Prothero, D. R. and Schwab, F. (2004). Sedimentary geology. Macmillan.
- Selley, R.C., Applied sedimentology, 2nd Edn., Academic Press, 2000
- Tucker, M. E. (2001). Sedimentary Petrology, Third Edition Blackwell Science.

Paper – GELA -SEC-300

Field Studies – 2

(Full Marks – 100)

12-day fieldwork for lithological and structural mapping of a deformed rock terrain and sedimentological studies in the same area (with low grade metasedimentary rocks preserving sedimentary structures) or of adjoining area.

Fieldwork should be carried out in and around following areas:

Ramtek-Mansar area of Maharashtra, Ajmer, Nathdwara-Kankrouli, Bewar and Jahazpur areas of Rajasthan, Ghatshila-Galudih area of Jharkhand and Chitradurga area of Karnataka.

Paper – GELA -DSC-400-Th

GELG-600-Th

GELM-500-Th

Igneous Petrology

(Full Marks – 50)

Unit 1: Introduction to Igneous Petrology

Modes of magma generation in the crust and upper mantle.

Physical properties of magma – temperature, viscosity, density and volatile content. Modes of emplacement of igneous rocks: volcanic, hypabyssal, and plutonic.

Unit 2: Forms of Igneous rock bodies

Mode of occurrence of igneous rocks.

Forms and structures of igneous rock bodies.

Unit 3: Texture and Microstructure of Igneous rocks

Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of igneous minerals.

Description of the following textures and microstructures with their occurrence in different rocks – panidiomorphic, hypidiomorphic, allotriomorphic, porphyritic, vitrophyric, poikilitic, ophitic, sub-ophitic, intergranular, intersertal, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona and kelpitic rims, perthitic, myrmekitic, variolitic, speherulitic and spinifex, vesicular, amygdaloidal, flow structures such as pilotaxitic and trachytic.

Unit 4: Classification of Igneous rocks and Petrographic Description

Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical, associational and tectonic.

Norm and mode. Standard classification schemes – Shand, Hatch and Wells, and IUGS. TAS diagram for volcanic rocks. Outline of CIPW classification.

Composition and texture and Indian occurrence of important igneous rocks: granite, pegmatite, syenite, monzonite, diorite, norite, gabbro, anorthosite, dolerite, pyroxenites, peridotite, lamprophyres, carbonatite, rhyolite, andesite, dacite, basalt, komatiite.

Pyroclastic rocks.

Unit 5: Chemical Petrology

Major, minor, trace and REE; Variation diagrams and its use in magmatic evolution. Concept of K_d , and D .

Unit 6: Phase Diagrams

Phase rule and its application to eutectic, peritectic and solid solution system. Phase equilibria in the following binary and ternary systems, and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite, albite – orthoclase, diopside – albite – anorthite, anorthite – forsterite – silica, quartz – albite – anorthite, forsterite – diopside – silica and nepheline – kalsilite – silica.

Bowen's reaction principle.

Unit 7: Petrogenesis of Igneous rocks

Magmatic processes; crystal settling in magma, magma convection, crystal mush theory, igneous cumulates, magmatic differentiation and diversity of igneous rocks, assimilation and fractional crystallisation.

Petrogenesis of common igneous rocks: granite, basalt, anorthosite, alkaline rocks, carbonatite and ultramafic rocks.

Unit 8: Magmatism

Fundamental ideas of magmatism in different tectonics settings, mantle convection.

Mantle melting, melt-mantle interaction and magmatic evolution in various geodynamic settings.

Mid Ocean Ridge Basalt (MORB) and Island Arc Basalt (IAB).

Large Igneous Provinces, mantle plumes and related magmatism with special emphasis on Deccan Trap.

Brief idea on physical volcanology, criteria for identification of several volcanic flows, distinct zones within a flow, common volcanic structures, pyroclasts.

General idea on layered complex, salient features of Stillwater, Skaergaard and Bushveld complexes.

Ophiolites: genesis, emplacement and classification

Paper – GELA -DSC-400-P

GELG-600-P

GELM -500-P

Igneous Petrology

(Full Marks – 50)

Study of important igneous rocks in thin sections: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosite, dunite, peridotite, pyroxenite, basalt, andesite, trachyte, rhyolite, dacite.

Plotting of mode in IUGS classification of igneous rocks (Streckeisen diagram).

Calculation of CIPW norms of silica-oversaturated and undersaturated igneous rocks, use of those normative data to interpret crystallization history.

Use of variation diagram to quantify magmatic crystallization. Determination of igneous rock suite using variation diagrams.

Quantitative modelling of partial melting and fractional crystallization using K_d and D .

Reference Books

- Best, Myron G. (2001). *Igneous and Metamorphic Petrology*. Cox, K. G. and Bell, J. D. (1979). *The Interpretation of Igneous Rocks*. Springer/Chapman and Hall. Bose M. K. (1997). *Igneous Petrology*.
- Blatt H., Tracy R.J. and Owens B.E. (2006) *Petrology – Igneous, sedimentary and metamorphic rocks* (3rd Edition), W.H. Freeman and Company, New York.
- Bose, M.K., 1997: *Igneous Petrology*. The World Press Pvt. Ltd. 568 p.
- Cox, K. G., Bell, J. D. and Pankhurst, R. J. *The Interpretation of Igneous Rocks*. Unwin Hyman, 1979
- Ehlers, WG, and Blatt, H.(1987) *Petrology, Igneous, Sedimentary and Metamorphic rocks*, CBS Publishers
- Frost B. R. and Frost C. D (2014). *Essentials of Igneous and Metamorphic Petrology*. Cambridge University Press.
- Hall, A. *Igneous Petrology*, 2nd Edn., Longman, 1996
- Hatch F.H., Wells A.K and Wells M.K. (1984) *Petrology of the igneous rocks*. CBS Publishers, 551p.
- McBirney, A. R. *Igneous Petrology*, 3rd Edn., Jones & Bartlett, 2006
- Middlemost, E. A. K. *Magmas and Magmatic Rocks*. Longman, 1985
- Perchuk, L.L. and Kushiro, I.1991: *Physical Chemistry of Magmas*-Springer Verlag
- Philpotts, A. and Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
- Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
- Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering
- Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
- Sen, G. 2014, *Petrology: Principles and Practice*, Springer.
- Turner F.J and Verhoogen J. (1960) *Igneous and Metamorphic Petrology*, McGraw- Hill.
- Winter, J. D. (2014). *Principles of igneous and metamorphic petrology*. Pearson.

Paper – GELA -DSC-410-Th

GELM-510-Th

Geochemistry and Economic Geology

(Full Marks – 75)

Group-A

Elements of Geochemistry

(Full Marks – 35)

Unit 1: Origin of Solar System: Origin of Solar System; Nucleosynthesis; Origin and evolution of the Earth; Origin of the Earth's crust.

Definition, age, importance of study; classification and its basis, mineralogical characteristics and contrast with terrestrial mineralogy, broad chemical characteristics, brief outline on origin.

Unit 2: Layered Structure of Earth and Geochemistry: Chemical Composition of the Earth as three-layer structures.

Composition of crust, mantle and core.

Unit 3: Aqueous Geochemistry: Abundance of elements in river and ocean water, constancy of elemental composition of ocean water

Concept of ionic and redox potential and pH

Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations.

Factors controlling chemical sedimentation.

Unit 4: Geochemical Classification of Elements: Goldschmidt's Rule; Behaviour of elements during magmatic crystallization.

Unit 5: The atmosphere: structure and composition of atmosphere; geochemical cycle of nitrogen. The evolution of atmosphere; constancy of atmospheric composition; Formation and destruction of ozone layer, Ozone hole.

Unit 6: Isotope Geology: Stable and radioactive isotopes, cosmogenic isotopes, stable and Radiogenic isotope geochemistry, principles and methods of radioactive dating; Application of isotopes in Geology.

Unit 7: Chemical Geodynamics: Chemical evidence for mantle heterogeneity, Lead paradox, DUPAL anomaly.

Unit 8: Geochemical cycle: Geochemical cycles of Oxygen, Nitrogen, Carbon and Sulphur

Group – B: Economic Geology

(Full Marks – 40)

Unit 1: Ores and Gangues

Ores, protore, gangue minerals, tenor, grade and lodes. Hypogene and supergene ore deposits, epigenetic and syngenetic mineral deposits; mineral beneficiation. Resources and reserves-economic and academic definitions.

Unit 2: Ore – Classification, Types and Genesis

Concordant and discordant ore bodies.

Endogenous processes: magmatic concentration, skarns, greisens, and hydrothermal deposits.

Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits.

Unit 3: Mineral deposits in Space and Time

Mineral deposits and their litho-tectonic environments.

Metallogenic provinces and epochs.

Unit 4: Ore texture

Types of ore texture, sequence of temperature of formation of ore minerals, ore solid solution, complexing and ore deposition

Unit 5: Ore grade and Reserve

Assessment of ore grade and reserve, reserve estimation.

Unit 6: Metallic and Nonmetallic Deposits of India

Important deposits of India including atomic minerals: study of geologic set up, mode of occurrence, mineralogy and genesis of the following ore deposits in India: iron ore in Singhbhum and Karnataka, Manganese of Central India, copper of Malanjkhand, lead-zinc of Zawar area, uranium of Singhbhum.

Non-metallic and industrial rocks and minerals in India.

Introduction to gemmology.

Unit 7: Mineral Economics

Resource management concept, mineral economics, present status of resources, resource development and future sources.

Paper – GELA-DSC-410-P

GELM-510-P
Ore Microscopy
(Full Marks – 25)

Ore microscopy: Identification of ore minerals under microscope (common oxides and sulphides).

Mineral identification, Mineral association, Broad textural features, Paragenesis.

Reference Books

Group – A

- Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
- Dickins, A. P., Radiogenic Isotope Geology. Cambridge University Press, 1995
- Faure, G., 1986: Principles of Isotope Geology-John Wiley
- Faure, Gunter and Teresa M. Mensing (2004). Isotopes Principles and Applications. Wiley India Pvt. Ltd
- Geyh, M. A. and Schleicher, H., Absolute age determination. Springer, 1990
- Govett, G.J.S. (Ed.), 1983: Handbook of Exploration Geochemistry-Elsevier
- Henderson, P., 1987: Inorganic Geochemistry-Pergamon Press.
- Hoefs, J., Stable Isotope Geochemistry, 3rd Edn. Springer-Verlag, 1987
- Krauskopf, K.B., 1967: Introduction to Geochemistry-McGraw Hill
- Longman U.K. Faure, G., Principles of Isotope Geology, 2nd Edn. John Wiley & Sons, 1986
- Marshal, C.P. and Fairbridge, R.W., 1999: Encyclopaedia of Geochemistry-Kluwer Academic
- Mason, B. (1986). Principles of Geochemistry. 3rd Edition, Wiley, New York.
- Mason, B. and Moore, C.B., 1991: Introduction to Geochemistry-Wiley Eastern
- Misra, K.C. 2012, Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.
- Nordstrom, D.K. and Munoz, J.L., 1986: Geochemical Thermodynamics-Blackwell
- Rollinson, H. (2007). Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific and Technical.
- Sharp Zachary (2006). Principles of Stable Isotope Geochemistry. Prentice Hall
- Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers
- Walther, J. V. (2009). Essentials of geochemistry. Jones and Bartlett Publishers.
- White, M. William (2014). Isotope Geochemistry. Wiley – Blackwell

Group – B

- Arndt, Nicholas and Ganino, Clément 2012, Metals and Society – An Introduction to Economic Geology – Springer, Heidelberg, 160pp.
- Bateman, A.M. and Jensen, M.L. (1990). Economic Mineral Deposits. John Wiley.
- Deb, S. (1980). Industrial minerals and rocks of India. Allied Publishers.

- Evans, A.M. (1993). Ore Geology and Industrial minerals. An Introduction. (Third Edition). Blackwell Publishing.
- Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, TataMcGraw-Hill, New Delhi.
- Guilbert, John M. and Charles Frederick Park (2007) The Geology of Ore Deposits, Waveland Press
- Krishnaswamy, S. (1979) India's mineral resources. Oxford & IBH
- Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
- McDonald, I. Boyce A.J., Butler I.B., Herrington R.J. and Polys D.A. (Eds), 2005, Mineral Deposits and Earth Evolution –The Geological Society of London. 269pp.
- McQueen, K K.G. Ore Deposit Types and their Primary Expressions –CRC LEME, Australian National University, Canberra, ACT 0200 and School of REHS, University of Canberra, ACT 2601. 14p.
- Mookherjee, A. (1999): Ore Genesis – A Holistic Approach. Allied Publishers Ltd., New Delhi, India. 657p.
- Ore Microscopy and Ore Petrography – J.R. Craig and D.J. Vauhan, 1994. John Wiley and Sons, 434pp.
- Piranjo, F. 2012. Hydrothermal Mineral Deposits: Principles and Fundamental Concepts for the Exploration Geologist – Springer Science & Business Media, 709pp.
- Prasad, U. (2006) Economic Geology: Economic Mineral Deposits. CBS Pub.
- Ridley, J. (2013): Ore Deposit Geology. Cambridge University Press, UK. P398.
- Robb, Lawrence 2005, Introduction to Ore Forming Processes –Blackwell Publishing Company, Victoria, 373pp.
- Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.
- Sawkins, F.J. 2013. Metal deposits in relation to plate tectonics –Springer Science & Business Media, 461pp.
- Stanton, R. L. (1972). Ore Petrology. McGraw-Hill , 713pp.
- Tarling, D.H. 1981. Economic Geology and Geotectonics – John Wiley and Sons, 213pp.
- Tiwari, S.K. (2010) Ore Geology, Economic Minerals and Mineral Economics, Atlantic Publishers & Distributors (P) Limited

Paper – GELA -DSC-420-Th

GELM-600-Th

Metamorphic Petrology

(Full Marks – 50)

Unit 1: Metamorphism: Controls and Types

Definition of metamorphism. Factors controlling metamorphism, Types of metamorphism – contact, regional, fault zone metamorphism, impact metamorphism.

Progressive and retrogressive metamorphism.

Unit 2: Metamorphic Facies and Grades. Metamorphic Structures and Textures

Index minerals, metamorphic zones and isograds.

Concept of metamorphic facies and grade; Facies series.

Unit 3: Structures and Textures of Metamorphic Rocks

Structure and texture; relationship between metamorphism and deformation.

Unit 4: Metamorphic Equilibrium

Stable mineral assemblages.

Closed and open system.

Composition-paragenesis diagrams. ACF, AKF and AFM diagrams.

Unit 5: Fundamentals of thermodynamics used in Geological system

Phase rule, metamorphic reactions and phase equilibria in metamorphic rocks. Metamorphic phase equilibria calculation: geothermometry and geobarometry. Phase diagrams, Schreinemaker's bundle and petrogenetic grid for metamorphic assemblages in various grades of metamorphism. Graphical representation of various mineral assemblages in different P-T conditions.

Unit 6: Progressive Metamorphism

Metamorphism of Mafic, Pelitic and Calcareous Rocks.

Progressive and retrogressive metamorphism.

Prograde and retrograde metamorphic minerals reactions.

Unit 7: Migmatites and their origin

Migmatites, its origin and evidence.

Metamorphic differentiation.

Unit 8: Metasomatism

Metasomatism, Alkali metasomatism

Unit 9: Metamorphic rock associations and Plate Tectonic settings

Heat flow and metamorphism; Paired Metamorphic belt, Schematic diagrams to illustrate the origin of paired metamorphic belts. Time-scale of metamorphism and implications on thermal history. Temperature-time histories in metamorphic rocks. Metamorphic P-T-t paths and tectonic evolution. Thermal modelling and metamorphic facies series. Different types of metamorphic facies and their tectonic setting.

Regional occurrence and tectonic significance of metamorphic rocks: metamorphism along convergent plate margins, in continent-continent collisions, in rifting terrains and sea floor metamorphism.

Paper – GELA -DSC-420-P

GELM-600-P

Metamorphic Petrology Practical

(Full Marks – 50)

- Textural and mineralogical study of following metamorphic rocks in thin sections: slate, schists (pelitic and mafic), gneiss, amphibolite, charnockite, khondalite, mafic granulite, eclogite, calc-silicates, marble, high Mg-Al granulites.
- Interpretation of metamorphic textures with reference to time relations between the phases of deformation and recrystallization of minerals such as chloritoid, garnet, staurolite, kyanite and magnetite.
- Interpretation of protolith, grade and facies; important reaction texture under microscope.
- Graphical plots of metamorphic mineral assemblages using chemographic diagrams (ACF and AKF and AFM).
- Estimation of Pressure and Temperature from important models of Geothermobarometry: Garnet-biotite, Garnet-Orthopyroxene, Garnet-Clinopyroxene, Hornblende-Plagioclase, Garnet-Orthopyroxene-Plagioclase-Quartz, Garnet-Sillimanite-Biotite-Quartz methods.

Reference Books

- Best, M.G., 2003, *Igneous and Metamorphic Petrology*, Blackwell.
- Bucher, K. and Frey, M. 1994: *Petrogenesis of Metamorphic Rocks*-Springer Verlag
- Frost, B.R. and Frost, C.D. 2019, *Essentials of Igneous and Metamorphic Petrology*, Cambridge University Press.
- Kornprobst, Jacques 2002, *Metamorphic Rocks and Their Geodynamic Significance*, Springer.
- Kretz, R., 1994: *Metamorphic Crystallization*-John Wiley
- Mason, R., (1978) *Petrology of Metamorphic Rocks*. CBS Publ.
- Philpotts, A. and Ague, J. (2009). *Principles of igneous and metamorphic petrology*. Cambridge University Press.
- Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
- Rollinson, H. R. (2014). *Using geochemical data: evaluation, presentation, interpretation*. Routledge.
- Sharma, Ram S. (2016) *Metamorphic Petrology Concepts and Methods*. Text Book Series, Geological Society of India, Bangalore
- Spear F. S. (1993). *Metamorphic phase equilibria and Pressure-Temperature-Time paths*. Mineralogical Society of America. Monograph.
- Turner, F.J., 1990: *Metamorphic Petrology*, McGraw Hill, New York.
- Winkler, H.G.C., (1967) *Petrogenesis of Metamorphic Rocks*. Narosa Publ.

- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.

Paper – GELA -DSC-430-Th

GELM-610-Th

Palaeontology – 1

(Full Marks – 50)

Unit 1: Fossilization and fossil record

Nature and importance of fossil record; Fossilization processes and modes of preservation

Unit 2: Taxonomy and Species concept

Species concept with special reference to palaeontology, Taxonomic hierarchy. Theory of organic evolution interpreted from fossil record

Introduction to ecology and palaeoecology with case studies. Fossils as a window to the evolution of ecosystems.

Taphonomic principles with case studies.

Unit 3: Invertebrates

Hard part morphology of Mollusca, Brachiopoda, Trilobita and Echinoidea.

Significance of ammonoids in Mesozoic biostratigraphy and their paleobiogeographic implications.

Functional adaptation of Bivalvia.

Origin of invertebrates and major steps in their evolution.

Unit 4. Palaeobotany and Introduction to Gondwana Flora

Plant diversity through time; flowering versus non-flowering plants; palynology as a tool; Gondwana flora and importance

Unit 5: Application of fossils

Biozones, index fossils, correlation.

Role of fossils in sequence stratigraphy.

Fossils in paleoenvironmental analysis.

Paleobiogeography, biogeographic provinces, dispersals and barriers.

Paper – GELA -DSC-430-P

GELM-610-P

Palaeontology – 1

(Full Marks – 50)

Study of fossils showing different modes of preservation

Hard part morphology of the following invertebrates: Bivalves, Gastropods, Cephalopods, Brachiopods, Trilobites, Echinoids (Identification at the generic level).

Morphology of spores and pollens.

Elementary exercise on functional morphology of bivalves.

Reference Books

- Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.
- Benton, Michael J. and Harper, David A. T. 2009. Introduction to Palaeobiology and the Fossil Record. Wiley-Blackwell, John Wiley & Sons, Ltd.
- Black, Rhona M. (1989) The Elements of Paleontology, Cambridge University Press
- Brechley, P. J., and Harper, D. A. T. 1998. Palaeoecology: Ecosystems, Environments and Evolution. Chapman and Hall.
- Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
- Clarkson, E.N.K. (2013) Invertebrate paleontology and Evolution, Blackwell Science
- Dasgupta, Amal 2005. Introduction to Paleontology, The world Press Private Limited, Kolkata.
- Davies, Morley (2008) An Introduction to Palaeontology, Read Books.
- Doyle, Peter (1996) Understanding Fossils: An Introduction to Invertebrate Palaeontology, Wiley
- Enay, Raymond (2012) Paleontology of Invertebrates, Springer-Verlag.
- Foote, Michael and Miller, Arnold I. 2006. Principles of paleontology (3rd edition) W.H. Freeman
- Goldring, Roland (2014) Field Palaeontology, Routledge
- Jackson, Patrick Wyse (2019) Introducing Paleontology: A Guide to Ancient Life, Dunedin Academic Press Ltd.
- Jain, P.C. and Anantharaman, M.S, 2016. Paleontology (Palaeobiology). Evolution and Animal Distribution, Vishal Publications.
- Jain, Sreepat 2017. Fundamentals of Invertebrate Paleontology Macrofossils. This Springer imprint is published by Springer Nature.
- Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
- Moore, R.C., Lalicker, C.G., Fischer, A.G, 2004: Invertebrate fossils. McGraw, Hill, Book Co.
- Pojeta, John Jr. and Springer, Dale A. 2001. Evolution and Fossil Record. American Geological Institute, The Paleontological Society. Printing: CLB Printing
- Prothero, Donald R., 2004. Bringing Fossils to Life: An Introduction to Paleobiology, 2nd edition, McGraw Hill, Higher Education.
- Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology

- Shah, S.K. (2013). Elements of Palaeontology. Text-book Series in Geological Sciences for Graduate Students, Geological Society of India.
- Shrock, R.R. & Twenhoffel, W.H., 2002. Principles of Invertebrate Paleontology. CBS Publ.
- Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
- Stearn, C.W. & Carroll, R.L, 1989: Palaeontology-the Record of Life-John Wiley
- Willis, K.J. & McElwain, J.C. 2002. The evolution of plants Oxford University Press
- Woods H, 1982. Paleontology Invertebrate. CBS Publications and distributors.

Paper – GELA-DSC-500-Th
Geotectonics and Geomorphology
 (Full Marks – 75)

Group – A: Geotectonics

Unit 1: Introduction to Physiographic Divisions of Earth

Crustal types: oceanic, transitional and continental crusts.

Islands, mountains belts and continental margins, ocean basins

Shield, platforms, and cratons.

Concepts of orogens.

Unit 2: Internal constituent of Earth

Compositional and Rheological layers of Earth. Concept of lithosphere and asthenosphere. Mantle dynamics.

Unit 3: Historical Perspectives

Wegener's Continental drift hypothesis and its evidences. Continental position in the past.

Sea-floor spreading hypothesis and its evidences. Magnetic time scale. Palaeomagnetism. Vine-Mathews' hypothesis.

Polar-wandering.

Wilson cycle.

Unit 4: Plate Tectonic Theory

Plates: physical character of plates. Distribution of plates in the Earth; macro and micro plates.

Plate boundaries: types, character, Identification of boundaries. Motion along plate boundaries.

Triple points. Kinematics of plate motion. Rate of plate motion. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults, aulacogens, ophiolites.

Magmatism in oceanic ridges and in subduction zones.

Concept of hot spot and plumes.

Driving mechanisms of plates. Plate tectonics and mantle convection.

Unit 5: Plate Tectonic Explanation of Major Physiographic Features of Earth

Alpine-Himalayan chain, Andes mountains, Japan Arc, Mid-Atlantic Ridge, African Rift, Narmada Graben, San Andreas Fault.

Unit 6: Plate Tectonics: Past and Present

Supercontinents and their breakup and assembly. Assembly and breakup of Pangaea. Other supercontinents.

Group – B: Geomorphology

Unit 1: Introduction

Introduction to geomorphology; relationship between the landforms and the properties of earth material and different kind of processes. Endogenic and exogenic processes.

Unit 2

Geoid, topography, hypsometry, major morphological features of the earth surface. Large scale topography – plate tectonics overview.

Unit 3

Surficial processes and geomorphology; weathering and associated landforms. Landforms produced by glacial, periglacial processes, fluvial processes, aeolian processes, coastal processes. Landforms associated with igneous activities.

Unit 4

Endogenic-exogenic interactions; rates of uplift and denudation; tectonics and drainage development; sea-level change; long-term landscape development. Landform dating techniques.

Paper – GELA-DSC-500-P

Fieldwork

(Full Marks – 25)

7-day fieldwork related to mine visit (iron ore/base metal/coal). Local surface geology and hydrogeology.

Fieldwork may be carried out in and around following areas.

Metallic deposits of Rajasthan, Zawar Area, Pur-Banera belt, Khetri Area; Gondwana coal fields; iron, copper and uranium ores of Singhbhum region; Manganese deposits of Central India; Iron ore deposits of Odisha.

Reference Books

- Alien, P.A., 1997. *Earth Surface Processes*, Blackwell publishing.
- Bridge, J.S. and Demicco, R.V., 2008. *Earth Surface Processes, Landforms and Sediment Deposits*, Cambridge University Press.

- Burbank D.W. and Anderson R.S. 2011, Tectonic geomorphology, Wiley
- Condie K.C. 2013, Plate Tectonics & Crustal Evolution
- Condie, K.C. 2016, Earth as an Evolving Planetary System. Elsevier, Amsterdam. ISBN: 978-0-12-803689-1
- Duff, P. M. D., & Duff, D. (Eds.). 1993. Holmes' principles of physical geology. Taylor & Francis.
- Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
- Esterbrook, D.J., 1992. *Surface Processes and Landforms*, MacMillan Publ. Kale, V.S. and Gupta A 2001 *Intoduction to Geomorphology*, Orient Longman Ltd.
- Hugget; 2016. Fundamentals of Geomorphology by Taylor and Francis.
- Kale, V.S. and Gupta, A., 2001. Introduction to Geomorphology. Orient Longman Ltd.
- Keary, P. and Vine, F.J., 1997. Global Tectonics. Blackwell and crustal evolution. Butterworth-Heinemann.
- Leeder, M. and Perez-Arlucea M 2005 Physical processes in earth and environmental sciences, Blackwell publishing.
- Moores, E and Twiss. R.J., 1995. Tectonics. Freeman.
- Patwardhan, A. M., 1999. The Dynamic Earth System. Prentice Hall.
- Summerfield, M.A., 2000. Geomorphology and Global tectonic. Springer Verlag.
- Summerfield M A 1991Globe *Geomorphology* Prentice Hall.
- Thornbury, W.D. 2002. Principles of Geomorphology. CBS Publ. New Delhi.
- Valdia, K.S., 1988. Dynamic Himalaya. Universities Press, Hyderabad.
- Wllcock, P.R., Iverson R M (2003) Prediction in geomorphology ' AGU Publication.

Paper – GELA-DSC-510-Th

Principles of Stratigraphy & Stratigraphy of India

(Full Marks – 75)

Group –A

Principles of Stratigraphy

(Full Marks – 25)

Unit 1: Preliminary Ideas of Stratigraphic Units

Litho-, bio- and chronostratigraphic units.

Stratigraphic correlation.

Introductory concepts of chemostratigraphy, seismic stratigraphy, sequence stratigraphy, and magnetostratigraphy

Unit 2: Code of stratigraphic nomenclature

International Stratigraphic Code – development of a standardized stratigraphic nomenclature.

Concepts of Stratotypes. Global Boundary Stratotype Section and Point (GSSP).

Unit 3: Facies concept in stratigraphy, Walther's Law of Facies.

Unit 4: Paleogeography:

Concept of paleogeographic reconstruction.

Group –B

Stratigraphy of India

(Full Marks – 50)

Unit 1: Physiographic and tectonic subdivisions of India

Brief introduction to the physiographic and tectonic subdivisions of India.

Unit 2: Precambrian Stratigraphy of India

Introduction to Indian Shield

Concept of Archean nuclei of India

Geologic evolution of the following Precambrian terrains in terms of sedimentation, structure, magmatism, metamorphism, and geochronology: Dharwar, Singhbhum, Rajasthan, and Central India

Introduction to the Proterozoic basins of India.

Geology of Vindhyan and Cuddapah basins

Unit 3: Phanerozoic Stratigraphy of India

Palaeozoic Succession of Kashmir and its correlatives from Spiti Stratigraphy.

Stratigraphy of Gondwana basins.

Triassic successions of Spiti, Jurassic of Kutch, Cretaceous successions of Cauvery basins

Cenozoic stratigraphy of India: Kutch basin, Siwalik successions, Assam and Andaman basins and Bengal Basin

Unit 4: Volcanic provinces of India

Deccan, Rajmahal, Sylhet Trap

Unit 5: Stratigraphic boundaries

Important Stratigraphic boundaries in India: Precambrian-Cambrian boundary, Permian-Triassic boundary, Cretaceous-Paleogene boundary

Paper – GELA-DSC-510-Tutorial

(Full Marks – 25)

Reference Books

- Boggs, S., Jr. (1987) Principles of Sedimentology and Stratigraphy, Meril Publishing.
- Dasgupta, A. 2010, Phanerozoic Stratigraphy of India, World Press, Kolkata.
- Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
- Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
- Lemon, R.L. (1990) Principles of Stratigraphy, Meril Publishing.
- Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
- Ravindra Kumar (1985) Fundamentals of Historical Geology and Stratigraphy of India, John Wiley.
- Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.

Paper – GELA-DSC-520-Th

Fuel Geology

(Full Marks – 50)

Unit 1: Coal

Definition and origin of Coal; Condition of formation of coal.

Basic classification of coal: ASTM and Indian classification.

Fundamentals of Coal Petrology – Introduction to lithotypes, microlithotypes and macerals in coal.

Proximate and Ultimate analysis, optical properties of coal.

Correlation of coal seams. Industrial utilization of coal. Coal resources of India. Estimation and categorization of coal resources.

Unit 2: Petroleum

Chemical composition and physical properties of crudes in nature

Origin of petroleum

Reservoir rocks: general attributes

Classification of reservoir rocks – clastic and chemical.

Hydrocarbon traps: definition, anticlinal theory and trap theory.

Classification of hydrocarbon traps – structural, stratigraphic and combination.

Time of trap formation and time of hydrocarbon accumulation.

Cap rocks – definition and general properties.

Well logging

Petroliferous basins of India

Unit 3: Nuclear Fuel

Geochemistry of U and Th, geochemical abundance of radioactivity in crustal rocks, important minerals, types of U and Th deposits, nuclear raw material resources of India, usage of nuclear energy.

Unit 4: Other fuels

Coal Bed Methane (CBM), Gas Hydrate

Global and Indian scenario. Oil shale – a brief overview.

Unit 5: Renewable Energy

Brief introduction to potential alternative (renewable) energy sources such as geothermal energy, solar, wind, wave, tidal, biofuel/biodiesel, etc.

Paper – GELA-DSC-520-P

Fuel Geology

(Full Marks – 50)

Study of hand specimens of coal

Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks). Reserve estimation of coal.

Codification of Indian coal.

Petroleum Interpretation of seismic section. Interpretation of well-logs and VSP data.

Calculation of formation-pressures. Estimation of oil and gas reserves.

Reference Books

- Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.
- Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
- Boyle, R.W., 1982: Geochemical Prospecting for Thorium and Uranium Deposits-Elsevier
- Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House. Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
- Chandra, D., Singh, R.M. and Singh, M.P., 2000: Textbook of Coal (Indian Context)-Tara Book Agency, Varanasi.
- Dahlkamp, F.J., 1993: Uranium Ore Deposits-Springer Verlag
- Durrance, E.M., 1986: Radioactivity in Geology. Principles and Application-Ellis Hoorwood
- Holson, G.D. and Tiratsoo, E.N., 1985: Introduction to Petroleum Geology-Gulf Publ. Houston, Texas
- Selley, R.C., 1998: Elements of Petroleum Geology-Academic Press

- Singh, M.P., (Ed.), 1998: Coal and Organic Petrology-Hindustan Publ. Corp., New Delhi
- Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M. and Teichmuller, R., 1982: Stach's Text Book of Coal Petrology- Gebruder Borntraeger, Stuttgart
- Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence-Springer Verlag

Paper – GELA-DSC-530-Th

Hydrogeology

(Full Marks – 50)

- Introduction to Hydrogeology; Scope and Socio-economic Relevance; Water Use Pattern.
- Concepts of water balance studies, recharge and discharge areas; Groundwater Contours
- Hydrologic cycle – Definition and scope, components of hydrologic cycle: precipitation, evapotranspiration, run-off, percolation, infiltration, base-flow. Surface water-groundwater interaction.
- Geologic factors governing groundwater occurrence and movement. Sea water ingressión.
- Distribution and Classification of Sub-surface water; Classification of Water Bearing Formations
- Water Table and Piezometric/Potentiometric Surface; Groundwater level fluctuations and environmental influences; Impact of Climate Change on Groundwater
- Hydrological properties of aquifers: porosity, void ratio, permeability, specific yield, specific retention, storage coefficient, hydraulic conductivity, transmissivity, hydraulic diffusivity, groundwater velocity, Isotropy and Anisotropy, Homogeneity and Heterogeneity.
- Theory of groundwater flow: Groundwater flow and Solute Transport – Laminar flow, Turbulent flow, Radial flow; Darcy's law and its applications and Validity, Reynold's number, Flow lines and Equipotential lines, Confined and Unconfined Flows, Drawdown and Cone of Depression; Hydraulic Head; concepts of Dupuit-Thiem, Jacob's and Theis Equations
- Groundwater quality: Physical and Chemical parameters of groundwater, Pollution indicators, Water Quality Interpretation; Water Quality Standards; Water Facies Diagrams
- Groundwater Exploration: Geophysical methods
- Hydrostratigraphic units; Groundwater provinces of India. Groundwater Budget; Groundwater resources of India – its future.
- Groundwater Exploitation and Management; Conjunctive use; Rainwater harvesting and artificial recharge of groundwater

Paper – GELA-DSC-530-P

Hydrogeology

(Full Marks – 50)

- Water potential zones of India (map study)
- Grain size analyses in relation to groundwater studies
- Drawing of Groundwater Contours from Depth to Water Table
- Simple numerical problems related to determination of porosity, void ratio, saturation percentage, bulk density, water content
- Calculation of Effective Porosity, Groundwater Velocity and Travel Time
- Simple numerical problems related to determination of Permeability in field and laboratory
- Numerical problems on Groundwater storage in terms of Specific Yield and Specific Retention
- Graphical representation of chemical quality data in water classification diagrams.

Reference Books

- Alley, W.M., 1993: Regional Ground Water Quality-VNR, New York
- Davie, Tim. 2008, Fundamentals of Hydrology. 2nd Ed. Routledge.
- Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
- Fetter, C. W. Jr. 2014, Applied Hydrogeology by Pearson Education Limited, 4th ed.
- Fetter, C.W., 2014, Applied Hydrogeology, Pearson Education Limited, Fourth edition.
- Freeze, R.A. & Cherry, J.A., 1979: Ground Water-Prentice Hall
- Hiscock, Kevin M. and Bense, Victor F. 2014, Hydrogeology: Principles and Practice, 2nd Ed., Wiley Blackwell.
- Hydrology: Principles, Analysis, and Design by H. M. Raghunath. New Age International Publishers, 2006, Revised Second edition.
- Introduction to Hydrology by Warren Viessman Jr. and Gary Lewis. Prentice-Hall, 2003, Fifth edition.
- Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd
- Raghunath, H. M., 1990. Groundwater. Wiley Eastern Ltd.
- Sharp, John M. Jr. 2007. A Glossary of Hydrogeological Terms by Department of Geological Sciences, The University of Texas.
- Singhal B. B. S. and Gupta R. K., 2010, Applied hydrogeology of fractured rocks.
- Subramaniam, V., 2000. Water-Kingston Publ. London.
- Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
- Zektser, Igor S. and Everett, Lorne G. (Editors). 2004. Groundwater Resources of the World and Their Use, UNESCO.

Paper – GELA-DSC-600-Th

Structural Geology – 2

(Full Marks – 50)

Unit 1. Stress

Concept of stress, normal stress, shear stress, principal axes of stress, planes of maximum shear stress. 2D and 3D stress. Stress ellipsoid. Mohr circle of stress.

Unit 2. Strain

Displacement and strain, longitudinal and shear strain, principal axes of strain, homogeneous and inhomogeneous strain, rotational and irrotational strain, pure shear and simple shear, strain ellipse and strain ellipsoid. Vorticity. Flinn's plot.

Technique of strain measurement in 2D – Fry & Wellman's method, R_f - ϕ , Mohr diagram.

Unit 3. Rheology

Factors controlling deformation behaviour of rocks – confining pressure, temperature, time, solution. Brittle and ductile deformation. Creep of rocks, intracrystalline plastic deformation. Creep laws – Nabarro–Herring creep; Coble creep, dislocation creep.

Unit 4. Folding Mechanism

Concepts orthogonal flexure, flexural slip and flexural flow, passive shear. Buckling, bending and volume loss folding, geometrical characteristics of the folds formed by these three mechanisms. Fault-related folding.

Unit 5. Superposed Deformation

Basic concepts of superposed deformation for passive shear folds and buckle folds. Interference patterns in superposed folding, deformation of older planar and linear structures, geometry of new structures.

Unit 6. Fracturing and Faulting of rocks

Brittle deformation mechanisms, three types of fracture.

Failure and fracture criteria, Tensile, Mohr-Coulomb envelope, von Mises envelope, Griffith's model.

Anderson's classification of faults. Fault formation in non-porous and porous rocks. Fault growth and seismicity.

Unit 7. Shear zone

Basic concepts, shear zone rocks, common mesoscopic and microscopic structures in shear zones; origin of sheath/eye fold; subsidiary fault and fracture geometries, shear sense indicators.

Strain model of shear zone.

Unit 8. Fold and thrust belt

Brief descriptions of thrust system, thrust sheet, leading and trailing edges of thrust sheet, forelimb and backlimb. Emergent thrusts, blind thrusts, window and klippe, geometry of thrusts, flats and ramps, cutoff.

Definition of fold-thrust belts, detachment fault or décollement, imbricate structure or imbricate fan, duplex structure, forethrust and backthrust. Basic ideas on tectonic setting of fold-thrust belts.

Unit-9 Grain-scale deformation

Factors that control grain-scale deformation. Processes of grain-scale deformation: Dissolution precipitation, point defects, line defects, twinning, deformation kinking, recrystallisation (bulging, subgrain rotation, grain boundary migration).

Paper – GELA-DSC-600-P Structural Geology – 2 (Practical) (Full Marks – 50)

Simple pole rotation problems using stereograms.

Interpretation of simple geological maps showing unconformities, folded and faulted strata.

Completion of outcrops of homoclinal strata and unconformities on horizontal and uneven topography.

Completion of outcrops of folded and faulted strata on horizontal topography.

Basic problems of cross-section balancing of deformed strata.

Strain analysis (Fry method).

Reference Books

- Billings, M. P. (1987). Structural Geology, 4th edition. Prentice-Hall.
- Davis, G. H., Reynolds, S. J., and Kluth, C. F. (2012). Structural Geology of Rocks and Region. 3rd Edition. John Wiley & Sons, Inc.
- Fossen, H. (2016). Structural Geology. Second Edition. Cambridge University Press.
- Lisle, R. J. and Leyshon, P. R. (2004) Stereographic projection techniques for structural geologists and civil engineers. Second Edition. Cambridge University Press.
- Marshak, S. and Mitra, G. (1988). Basic Methods in Structural Geology. Prentice Hall.
- Phillips, F. C. (1973). The use of stereographic projection in structural geology. Hodder.
- Ragan, D. M. (2009). Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
- Twiss, R. J. and Moores, E. M. (2007) Structural Geology. Second Edition. W. H. Freeman and Company.

Paper – GELA-DSC-610-Th

Remote sensing and GIS

(Full Marks – 50)

Unit 1: Basic Concepts of Remote Sensing

Definition and development of Remote Sensing; its advantages and limitations; Properties of electromagnetic waves; electromagnetic spectrum, atmospheric window, interaction of EM wave with target, specular and Lambertian reflector, Types of scattering – Mie scattering, Rayleigh scattering etc. Spectral Signature curve of different objects, passive and active RS systems, types of RS; thermal remote sensing & microwave remote sensing.

Unit 2: Photogeology

Types and acquisition of aerial photographs; scale and resolution; principles of stereoscopy, relief displacement, vertical exaggeration, and distortion. Elements of air photo interpretation.

Unit 3: Optical Remote Sensing

Satellite Remote Sensing – orbits, platform, scanners (along-track and across-track), optical mechanical scanners, CCD linear arrays, CMOS, sensor characteristics – resolution (spatial, spectral, radiometric, temporal), types of satellite data (panchromatic, multi-spectral and hyperspectral data), DEM analysis. Indian space program from IRS-1A (1962) till date.

Unit 4. Digital Image Processing:

Digital image rectification and restoration techniques; radiometric and geometric correction; Image enhancement techniques- image histogram, contrast manipulation, edge enhancement. Multispectral image analysis;-Band ratio, classification method- supervised & un-supervised

Unit 5: GPS & GIS:

Datum, concepts of GPS, components of GPS, factors affecting GPS accuracy, DGPS, Indian Regional Navigation Satellite System (IRNSS), Integrating GPS data with GIS, Projection and Co-ordinate systems. Definition & Elements of GIS, types of GIS data (Raster & Vector), attribute data, geodatabase, Application of GIS in Earth Science

Paper – GELA-DSC-610-P

Remote Sensing and GIS (Practical)

(Full Marks – 50)

Unit 1: Aerial photo interpretation

Study of aerial photographs with common rock types – granites, mafic rocks, sandstones, claystones/shales.

Study of large-scale structures (dykes, faults, folds) from aerial photographs.

Various aeolian, glacial, fluvial and marine landforms in aerial photographs.

Unit 2: Image interpretation.

Interpretation of single band/PAN satellite images including border/annotation lines information (metadata). Interpretation of MSS and FCC images; visual and digital interpretation of digital images.

Unit 3: GIS Application.

Georeferencing of toposheet/satellite imagery; creation of vector data (point, line and polygon), adding an attribute, spatial analysis, Map generation using open source GIS software, Analysis and interpretation of satellite data in different band combination.

Unit 4: DEM analysis.

Generating slope map, aspect map and drainage network map and its applications (?)

Reference Books

- Bhatta, B., 2008. Remote Sensing and GIS. Oxford, New Delhi.
- Demers M., Fundamentals of GIS
- Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.
- Gupta, R.P., 1990. Remote Sensing Geology. Springer Verlag.
- Hoffmann, W.B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory & Practice, Springer Wien New York.
- Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer-Verlag.
- Joseph, George 2018, Fundamentals of Remote Sensing, The Orient Blackswan.
- Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.
- Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag.
- Millor, V.C., 1961 Photogeology. Mc Graw Hill
- Moffitt, F.H. and Mikhail, E.M., 1980 Photogrammetry-Harper and Row
- Pandey, S.N., 1987. Principles and Application of Photogeology. Wiley Eastern, New Delhi.
- Rampal K.K. 1999. Hand book of aerial photography and interpretation. Concept publication.
- Sabbins, F.F., 1985. Remote Sensing – Principles and Applications. Freeman.
- Siegal, B.S. and Gillespie, A.R., 1980. Remote Sensing in Geology. John Wiley.
- www.isro.org, www.nrsc.gov.in

Engineering Geology

(Full Marks – 50)

Unit 1: Introduction: Role of engineering geologists in planning, design and construction of major man-made structural features.

Site investigation and characterization.

Unit 2: Slope stability and mass wasting; Types of block failure, factor of safety, landslide classification.

Unit 3: Foundation: Types of foundations. Foundation treatment: Grouting, Rock Bolting and other support mechanisms.

Unit 4: Mechanical properties of rocks – Strength (Compressive, Tensile, Shear), Various moduli and Stress-Strain responses of rocks.

Stress Strain Models: Constitutive relationships – Elastic, Elasto-plastic, Visco-elastic, Visco-plastic and Elasto-viscoplastic.

Physical properties of rocks: Porosity, Density, Moisture content, Degree of saturation, Coefficient of permeability.

Unit 5: Engineering Classification of Rocks: Classification of intact rocks, Rock mass classifications – Rock Quality Designation (RQD), Rock Structure Rating (RSR), Rock Mass Rating (RMR), Norwegian Geotechnical Classification (Q-system).

Unit 6: Engineering structures: Dams, Tunnels, Bridges: their classification based on geometry and uses.

Geological, Geotechnical and Environmental considerations for dams and reservoirs.

Tunnels and Tunnelling methods: geological considerations for tunnel alignment; soft ground tunnelling and hard rock tunnelling methods.

Paper – GELA-DSC-620-P

Engineering Geology

(Full Marks – 50)

Computation of reservoir area, catchment area, reservoir capacity and reservoir life.

Computation of RQD by direct and indirect methods; RSR.

Analysis of discontinuities in rocks for estimating stability of surface – Stereonet analysis for slope stability; identifying modes of failure by stereonet analysis (Markland Test).

Stability of mass: Mohr diagram construction for rock failure and potential slip planes.

Reference Books

- Bell, F.G. (2007). Engineering Geology. Butterworth-Heineman.
- Bell, F.G. (2006). Basic Environmental and Engineering Geology. Whittles Publishing.
- Blyth, F.G.H. and M. H. de Freitas (1984) Geology for Engineers, Butterworth- Heinemann
Title
- Gokhale, K.V.G. (2006) Principles of engineering geology, BS publications.
- Goodman, R.E. (1993). Engineering Geology: Rock in Engineering constructions. John Wiley and Sons, New York.
- Johnson, R.B. and De Graf, J.V. (1988). Principles of Engineering Geology, John Wiley.
- Keshvally, Chenna (2018) Text book of Engineering Geology, Laxmi Publications.
- Krynin, D.P. and Judd W.R. (1957). Principles of Engineering Geology and Geotechnique. McGraw Hill (CBS Publ).
- Pradhan S.P., Vishal V., Singh T.N. (2019) Landslides: Theory, Practice and Modelling, Springer.
- Ries, H. and T. L. Watson, (1949) Elements of Engineering Geology, New York, John Wiley & Sons, Inc.
- Schroeder, W.L., Dickenson, S.E., Warrington, D.C. (1984)-Soils in construction-John Wiley and Sons.
- Singh, B and Goel, R.K. (2011)-Engineering Rock Mass Classification: Tunneling, Foundations, and Landslides-Elsevier.
- Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.). Taylor and Francis.
- Wyllie, D.C., & Mah, C. (2004). Rock Slope Engineering: Fourth Edition (4th ed.). CRC Press.
- Wyllie, Duncan C. (2018)-Rock Slope Engineering: Civil Applications-CRC Press, Taylor and Francis Group.

Paper – GELA-SI-600

Summer Internship

(Full Marks – 100)

Compulsory training to each student for at least one week duration in a reputed industry/ corporate house/laboratory and report preparation.

Paper – GELA-DSC-700-Th

Exploration Geology

(Full Marks – 50)

Unit 1: Mineral Resources

Resource reserve definitions, Mineral resources in industries – historical perspective and present,

A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Unit 2: Prospecting and Exploration

Principles of mineral exploration,

Prospecting and exploration- conceptualization, methodology and stages,

Sampling, subsurface sampling including pitting, trenching and drilling. Geochemical exploration.

Geophysical methods of exploration: Resistivity, gravity, seismic and magnetic methods.

Unit 3: Evaluation of data

Evaluation of sampling data

Mean, mode, median, standard deviation and variance

Unit 4: Drilling and Logging

Core and non-core drilling

Planning of bore holes and location of boreholes; on ground Core-logging

Introduction to drilling technology: percussion, diamond, reverse circulation, air core, wireline, BH deviation survey

Unit 5: Reserve estimations and Errors

Principles of reserve estimation, density and bulk density

Factors affecting reliability of reserve estimation

Reserve estimation based on geometrical models of uneven ore bodies. Regular and irregular grid patterns, statistics and error estimation.

Reserve estimation: cutoff, ROM, cross section, lo core, bulk/muck/grab/car/stack ng section, level plan and inverse distance; classification of reserves/resources (conventional, USGS, UNFC, and JORC)

Paper – GELA-DSC-700-P

Exploration Geology

(Full Marks – 50)

Identification of anomaly.

Concept of weighted average in anomaly detection Geological cross-section.

Models of reserve estimation.

Problems on ore reserve estimation from surface and sub-surface bodies, Fe ores surface sampling data.

Reference Books

- Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons. Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
- Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.

Paper – GELA-DSC-710-Th

Geophysics

(Full Marks – 50)

Unit 1: Geology and Geophysics

Interrelationship between geology and geophysics, Role of geological and geophysical data in explaining geodynamical features of the earth.

Unit 2: General and Exploration geophysics

Basic principles of Geophysics. Different types of geophysical methods – gravity, magnetic, electrical and seismic; their principles and applications.

Unit 3: Methodologies

Gravity methods: introduction, Gravity potential and field due to different simple bodies and structures. Field procedure. Bouguer gravity anomalies, interpretations & field-cases.

Magnetic methods: introduction, magnetic properties of rocks, geomagnetic field, field procedure, measurement of magnetic anomalies, interpretation.

Electrical method: Introduction, self-potential, earth resistivity, different arrays, profiling & sounding techniques, interpretation & field cases. Induced polarization. Telluric & electromagnetic methods.

Seismic method: introduction, refraction methods, layered earth refraction studies, hidden layer problem, correction, instruments, field procedures, interpretation.

Concepts and Usage of corrections in geophysical data (seismic and gravity data).

Unit 4: Geophysical field operations

Different types of surveys, grid and route surveys, profiling and sounding techniques.

Scales of survey, Presentation of geophysical data.

Unit 5: Application of Geophysical methods

Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics

Unit 6: Geophysical anomalies

Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors

controlling anomaly, and depth of exploration

Reference Books

- Bhimasarikaram V.L.S., 1990, Exploration Geophysics – An Outline by Association of Exploration Geophysicists, Osmania University, Hyderabad.
- Dentith M. and Mudge S. (2014) Geophysics for the Mineral Exploration Geoscientist. Cambridge University Press, New York. 438p
- Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
- Keary P, Brooks M and Hill I (2002) An introduction to Geophysical Exploration (3rd ed.) Balckwell Science, Oxford. 262p.
- Lowe C., Thomas M.D., Morris W.A. (1999) Geophysics in Mineral Exploration: Fundamentals and Case Histories. Geological Association of Canada, Ontario. 175p.
- Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
- Rao R., Prasaraanga M.B., 1975, Outlines of Geophysical Prospecting – A manual for geologists by University of Mysore, Mysore.
- Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied geophysics* (Vol. 1). Cambridge university press.

Paper – GELA-DSC-710-P

Geophysics and Application of Statistics in Geology

(Full Marks – 50)

Geophysics

(Full Marks- 15)

1. Determination of time of Earthquake from P and S wave data.

Application of Statistics in Geology

(Full Marks-35)

1. Some basic concept of statistics:
2. Sample- Universe: Measurement- scale & error; Models; Measurement of variability; Probability
3. Population distribution- binomial, normal, Poisson.
4. Statistical inferences- errors in judgment
5. Confidence Intervals.

6. Small sampling theory- Chi-square, Student's t, F tests
7. Non –parametric tests- Kolmogorov-Smirnov.
8. ANOVA-correlation & linear regression
9. Time Series, autocorrelation, cross correlation
10. Kriging
11. The semi-variogram

Reference Books

- John C Davis -Statistics and Data analysis in Geology

Paper – GELA-DSC-720-Th
Environmental Geology and Marine Geology
(Full Marks – 75)

Part – A: Environmental Geology
(Full Marks – 40)

Unit 1: Definition, Concept, Scope and Importance of Environment Geology;

Unit 2: Global Environmental concerns; Environmental Treaties and Accords; Concepts of Sustainability

Unit 3: Concept of risk, hazards, disaster and catastrophe.

Unit 4: Basics of Environmental Geomorphology: Geomorphic Mapping and Environmental Project Planning. Geological factors for selection of waste (Solid, Liquid and Nuclear) disposal sites.

Unit 5: Environmental impacts of Natural and Man-made hazards and their mitigation – Earthquake, volcanism, landslides, floods, droughts.

Unit 6: Preliminary Concepts of Pollution. Climate change and global warming; sea level rise.

Unit 7: Energy Crisis and Transition: Conventional, Non-Conventional and Alternative Energy Resources. Potential alternative (renewable) energy sources such as geothermal, solar, wind, wave, tidal, OTEC, biofuel, etc.

Unit 8: Renewable and Non-Renewable Resources: Eco-friendly utilization, conservation and management. The 3Rs Rule.

Unit 9: Environmental Impacts of Mining; Mineral Concession and development rules.

Unit 10: Environmental Impacts of River Valley projects (dams, reservoirs) and other infrastructure development projects. Micro irrigation projects.

Unit 11: Principles and Methods of Environmental Impact Statement (EIS), Environmental Impact Assessment (EIA), Environmental Management Plan (EMP) including Disaster Management Plan (DMP), Corporate Environmental Management; Environmental Audit.

Unit 12: Risk Analyses; ISO 14000; Life Cycle Analysis (LCA);

Unit 13: Corporate Social Responsibility; Environmental Ethics, Case Studies of EIA/EMP.

Part – B: Marine Geology

(Full Marks – 35)

Unit 1: Broad Physical, Chemical, and Geological Processes of the Ocean and their environmental impacts

Unit 2: Physiography of the Ocean Bed; Ocean Sediments

Unit 3: Arctic Ocean and climate; Southern Ocean and climate
Classification of the Sea Coast; Natural Disaster and Its Influence on Coastal Environment;

Unit 4: Mineral and Energy Resources of the Ocean: Poly-metallic Deposits, Gas Hydrates; Conflicts in Oceanic Resource Use

Unit 5: Air-Sea-Land Interaction; Waves and Currents

Unit 6: Practices in Oceanic Pollution Management – Anthropogenic Impacts and Causes of ocean degradation

Unit 7: Brief Overview on Marine ecosystem – Its Preservation;

Unit 8: Introduction to Palaeo-oceanography

Unit 9: International Ocean Policies; Laws of the Sea, Coastal Regulation Zone and Management. United Nations Sustainable Development Goals with special emphasis on SDG-14.

Paper – GELA-DSC-720-Tutorial

(Full Marks – 25)

Reference Books

Group – A

- Bell, F.G., 1999: Geological Hazards-Routledge, London
- Bender, M. (2013) Paleoclimate, Princeton Premiers in Climate
- Bradley R. S., (1999), Paleoclimatology: Reconstructing climates of the quaternary. Academic Press v. 64 of International Geophysical series.
- Bryant, E., 1985: Natural Hazards-Cambridge University Press
- Keller, E.A., 1978: Environmental Geology-Bell and Howell, USA
- Patwardhan, A.M., 1999: The Dynamic Earth System-Prentice Hall
- Ruddiman, W.F. (2008) Earth's Climate, Past and Future, WH Freeman & Co. Shepherd, Submarine Geology.
- Smith, K., 1992: Environmental Hazards-Routledge, London
- Subramaniam, V., 2001: Textbook in Environmental Science-Narosa International
- Valdiya, K.S., 1987: Environmental Geology-Indian Context-Tata McGraw Hill

Group – B

- Ahmed, E. (1972). Coastal Geomorphology of India. Orient Longman. New Delhi, 222.
- Brian, J. S., Barbara, W.M., 2010. The Blue Planet: An Introduction to Earth System Science, 3rd Edition, Wiley.
- Carlson D., Plummer C.C., McGearry D. 2006. Physical Geology Earth Revealed (Sixth Edition). 2006. McGraw-Hill
- Dronkers J. (2005) Dynamics of coastal systems, World Scientific
- Einsele, G. (1982) Sedimentary basins-evolution, facies and sediment budget. Springer-Verlag.
- Fowler, C.M.R. (1993) The Solid Earth, Cambridge Press University.
- Gross, M. G. (1977). Oceanography: A view of the earth.
- Kenneth, J. (1982) Marine Geology and Geophysics.
- Mukherjee S., Ghosh K.K., Chanda A. 2023, Environmental Oceanography and Coastal Dynamics: Current Scenario and Future Trends. Springer, 440p.
- Nittrouer, C.A., Austin, J. A., Field M.E., Kravitz J. H., Syvitski J.P.M., Wiberg P.L. (2007) Continental margin, sedimentation from sediment transport to sequence stratigraphy, Wiley Blackwell.
- Seibold E., Berger W.H. 1996. The Sea Floor: An Introduction to Marine Geology, Springer.
- The Open University (1989) Ocean chemistry and deep sea sediments.
- Tuscot, D.L. and Schubert, G (1992) Geodynamics, Wiley and Sons.
- Weisberg J., and Parish, H., Introductory Oceanography. McGraw Hill, 1974.
- Woodroffe, C.D. (2013) Coast: Form, process and evolution, Cambridge University Press.
- Wright J. and Colling A. (1995) Seawater: its Composition, Properties and Behaviour, The Open University

Paper – GELA-DSC-730-Th

Palaeontology– 2

(Full Marks – 50)

Unit 1. Study of major micro-invertebrate groups

Study of biostratigraphic significance, adaptation and major steps in evolution of Foraminifera. Introduction to Ostracoda, Pteropoda, Calcareous algae, Radiolaria, Conodont, Bryozoa and Cocolithophores.

Unit 2: Study of vertebrates

Origin of vertebrates and major steps in vertebrate evolution

Brief accounts of Gondwana vertebrates of India with special reference to the dinosaurs.

Evolution of horse and elephant and their intercontinental migrations.

Human evolution.

Unit 3: Ichnology

Introduction Ichnology.

Ichnotaxonomy and classification.

Palaeoecology and trace fossils.

Paper – GELA-DSC-730-P

Palaeontology– 2

(Full Marks – 50)

Applied Micropaleontology: Morphology of major groups of micro-invertebrates under microscope; Determination of relative age and depth of deposition from larger and smaller foraminiferal fossil assemblages respectively; Elementary problems on biostratigraphy using foraminifera.

Study of morphological characteristic of vertebrate teeth: *Stegodon*, *Rhinoceros*, *Hipparion* and *Equus*.

Identification of ichnofossils in hand specimen: *Domichnia*, *Pascichnia*, *Repichnia*, *Fodinichnia*, *Cubichnia* and Trackways.

Reference Books

- Armstrong, H. A., & 23.Brasier, M.D. (2005) Microfossils. Blackwell Publishing
- Atlas of Benthic Foraminifera by Ann Holbourn, Andrew S. Henderson, Norman MacLeod
- Atlas of Benthic Shelf Foraminifera of the Southwest Atlantic by Esteban Boltovskoy, Graciela Giussani, Silvia Watanabe, Ramil Wright
- Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.

- Bignot, G., 1985: Elements of Micropalaeontology-Graham and Trotman
- Bromley, R.G. (1996) Trace Fossils, Chapman & Hall.
- Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
- Colbert, E.H. and Minkoff, Eli C. (2001) Evolution of vertebrates, Wiley Liss
- Cowen, R. (2000) History of Life, Blackwell Science.
- Frey, R.B. (1975) The Study of Trace Fossils, Springer-Verlag.
- Haq, B.V. and Boersma, A., 1998: Introduction to Marine Micropalaeontology-Elsevier
- Haynes, J.R., 1981: Foraminifera-John Wiley
- Johansson, C. Z., Underwood, M. Richter, (2019) Evolution and development of Fishes, Cambridge University Press.
- Mángano, M.G and Buatois, L.A. (2016) The Trace-Fossil Record of Major Evolutionary Events, Volume-I & II, Springer.
- McIlroy, D. (2004) The Application of Ichnology to Palaeoenvironmental and Stratigraphic Analysis, Geological Society, London, Special Publication 228.
- Milsom C. and Rigby S. (2010). Fossils at a Glance. Wiley-Blackwell. (Second Edition).
- Romer, A.S. 2004. Vertebrate Palaeontology, (3rd edition). Chicago University Press.
- Saraswati P.K., Srinivasan M.S., (2016) Micropaleontology: Principles and Applications, Springer International Publishing Switzerland.
- Seilacher, A. (2007) Trace Fossil Analysis, Springer Berlin Heidelberg New York
- Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

Paper – GELA-DSC-740

Earth Science Colloquium / Dissertation / Thesis

(Full Marks – 100)

Compulsory seminar presentation by students on geologically important themes based on published papers.

The presentation is related to dissertation thesis for Hons with research students.

Paper – GELA-DSC-800-Th

Climatology and Planetary Geology

(Full Marks – 75)

Part – A: Earth and Climate

(Full Marks – 40)

Unit 1: Climate system: Forcing and Responses

Components of the climate system.

Climate forcing, Climate controlling factors. Feedback in climate system (positive and negative).

Unit 2: Heat budget of Earth

Incoming solar radiation, receipt and storage of heat transformation. Earth's heat budget. Interactions among various sources of earth's heat.

Unit 3: Atmosphere – Hydrosphere

Layering of atmosphere and atmospheric Circulation. Atmosphere and ocean interaction and its effect on climate. Surface and deep circulation. Sea ice and glacial ice.

Unit 4: Response of biosphere to Earth's climate

Climate change: natural vs. anthropogenic effects. Future perspectives. Brief introduction to archives of climate change. Brief introduction to palaeoclimate. Palaeoclimate data from India.

Unit 5: Orbital cyclicity and climate

Milankovitch cycles and variability in the climate. Glacial-interglacial stages The last glacial maximum (LGM) Pleistocene Glacial-Interglacial cycles.

Unit 6: Monsoon

Mechanism of monsoon. Monsoonal variation through time. Factors associated with monsoonal intensity. Effects of monsoon.

Part – B: Planetary Geology

(Full Marks – 35)

Unit 1: Solar System concepts; Earth's orbit, Kepler's laws of planetary motion.

Unit 2: Important space odysseys; Indian space mission.

Unit 3: Planetary landscape (with special reference to Mars Moon and Venus) and responsible endogenic and exogenic causes.

Unit 4: Major cosmic events: From the Big Bang to the Dark Era

Unit 5: Internal thermal and rheological constitution of different planets.

Unit 6: Planetary volcanism and impact cratering.

Unit 7: Planetary landscape (with special reference to Mars Moon and Venus) and responsible endogenic and exogenic causes.

Unit 8: Introductory geological understanding of asteroids in the solar system

Unit 9: Tectonic regimes of different Terrestrial planets.

Unit 10: Role of remote sensing in planetary geology: Surface geomorphic features.

Paper – GELA-DSC-800-Tutorial

(Full Marks – 25)

Reference Books

- Aguado, E., and Burt, J., 2009. Understanding weather and Climate. 5th Edition, Pearson Publisher
- Bender, M. (2013) Paleoclimate, Princeton Premiers in Climate
- Bradley R. S., (1999), Paleoclimatology: Reconstructing climates of the quaternary. Academic Press v. 64 of International Geophysical series.
- Condie, K.C. 2016, Earth as an Evolving Planetary System. Elsevier, Amsterdam. ISBN: 978-0-12-803689-1
- Dorothy Merritts, Kirsten Menking and Andrew deWet, 2014. Environmental Geology: An Earth Systems Science Approach. Edition 2, W.H.Freeman and Co Ltd
- Greeley R. 2013, Planetary Geomorphology, Cambridge University Press.
- Greely, R. 1994, Planetary Landscape, Springer.
- Gunter, F. and Teresa, M. M. 2007, Introduction to planetary science: The geological perspective. Springer, the Netherlands. ISBN: 13 978-1-4020-5544-7.
- Lal, D.S. 2011 Climatology, Sharda Pustak Bhawan.
- Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
- Melosh, J.H. 2012, Planetary Surface Proceses. Cambridge University Press.
- New Views of the Solar System. Compton's by Britannica, Encyclopædia Britannica, Inc. (2013) ISBN: 978-1-62513-039-6
- Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
- Ruddiman, W.F. (2008) Earth's Climate, Past and Future, WH Freeman & Co. Shepherd, Submarine Geology.
- Singh, S. 2020, Climatology.
- Watters, T.R. and Schultz, R.A. 2009, Planetary Tectonics. Cambridge University Press.

Paper – GELA-DSC-810-Th

Analytical Techniques in EarthSciences

(Full Marks – 50)

Unit 1: Sampling and sample preparation; thin section and polished section making; sample etching; staining and modal count techniques.

Unit 2: Use of analytical spectroscopic methods, and chemical analyses

Unit 3: Basic principles of cathode luminescence; atomic absorption spectroscopy; inductively coupled plasma- atomic emission spectrometry, X-Ray fluorescent spectroscopy, and scanning electron microscopy; electron- probe microanalysis as advanced geochemical methods for generation of geochemical data.

Unit 4: Interpret results from various geological archives, such as sediments or rocks

Unit 5: Use of stable and radioactive isotopes in earth sciences to trace processes associated with for example fossils and rocks and for age estimation.

Reference Books

- Gill, R. (Ed), (1997) Modern Analytical Geochemistry Longman (Pearson Education Limited), 329 pp.
- Potts P.J. (1987) A Handbook of Silicate Rock Analysis Blackie.
- Skoog D.A., Holler F.J., and Nieman T.A., (1998) Principles of Instrumental Analysis 5th Ed., Saunders College Publishing, 832 pp.

Paper – GELA-DSC-810-P
Computer Application in Geology
(Full Marks – 50)

- Spreadsheet Application
- Basic functions and calculations
- Complex functions and their graphs
- Use of specialized software package for the management and processing of raw mineralogical and petrological data
- Use of Digital Image Processing software.
- Use of Exploration Geology / Engineering Geology Software

Paper – GELA-DSC-820
Grand viva
(Full Marks – 100)

Viva-voce on all topics covered under eight semester course curricula.

Paper – GELA-DSC-830
Dissertation / Thesis Paper
(Full Marks – 200)
(Written – 150 | Viva – 50)

Paper – GELA-DSC-840
Pedology and Natural Hazards
(Full Marks – 50)

Unit 1: Soil forming processes

Chemical weathering, major buffer maintaining ocean/atm/biosphere O₂ and CO₂, new compounds/minerals of greater volume and lower density; Oxidation; Carbonation; Hydrolysis; Hydration; Base Exchange; Chelation; Microbial weathering.

Soil forming processes: Physical weathering, loosening and particle size reduction; pressure release; thermal expansion; growth of foreign crystal.

Unit 2: General soil forming regimes

Gleization; podzolization; lessivage; ferrallitization; calcification; salinization

Unit 3: Modern soils and key pedofeatures

Horizons; roots; Fe-Mn mottles and concretions; pedogenic carbonate

Unit 4: Introduction to palaeopedology and palaeosols

Role of factors controlling paleosol formation- parent material, climate, vegetation, topography, time.

Unit 5: Introduction to Soil Mechanics

Basic definitions, Origin and formation of soils, Rock cycle, Weathering of rock.

Unit 6: Study of Soil

Soil particle size, Clay minerals, Soil structure, Mechanical analysis of soil, Particle size distribution, Sieve analysis & Hydrometer analysis.

Weight Volume Relationships, Components of soil and phase diagram, Definitions of void ratio, porosity, specific gravity, unit weights/density, and degree of saturation

Various unit-weight relationship, Relative density, Atterberg's limits and indices, Activity, Plasticity chart.

Stress distribution in Soils, Type of stresses in soil, Effective stress concept, Effect of water table fluctuation on effective stress, Effects of seepage and capillarity on effective stress.

Unit 7: Natural Hazards

The Lithosphere and Related Hazards Atmospheric Hazards, Hydrosphere and Related Hazards.

Unit 8: Disaster Management

Issues and concern for various causes of disasters. Disaster management, mitigation, and preparedness

Types of disaster: natural and manmade – cyclone, flood, land slide/mass movement, land subsidence, fire and earthquake, tsunami and volcanic eruption.

Unit 9: Disaster Management in India

Hazard Zonation Mapping, Remote-sensing and GIS applications in real time disaster monitoring, Prevention and rehabilitation

Reference Books

- Ashman M.R. and Puri G., 2002, Essential Soil Science, Blackwell.
- Bell, F.G. (1999) Geological Hazards, Routledge, London.
- Jothimani, S. 2022, Text book of Soil Science for Agriculture and Geology, 230p. ISBN: 978-93-93502-05-6
- Keller, Edward A. 2017, Introduction to Environmental Geology, 5th Ed., Pearson.
- Montgomery, Carla W. 2011, Environmental Geology, 9th ed., McGraw-Hill
- Palmer, Robert G. and Troeh, Frederick R. 1995, Introductory Soil Science Laboratory Manual, 3rd Ed., Oxford University Press

Paper – GELA-DSC-850-Th

Sustainable Watershed Management and Medical Geology

(Full Marks – 75)

Unit-I: Introduction

Watershed – definition, concept, objectives; watershed controls, Water demand and availability; Surface water-Groundwater interactions, Conjunctive use, Conflicts over water;

Unit-II: Hydrology and Meteorological Factors

Concepts of drainage basin, groundwater basin; water balance. Land cover and land use maps; effects of land use on hydrological components, Land capability and suitability classification; priority watersheds.

Meteorological (temperature, wind speed, sunshine hours, atmospheric pressure, relative humidity) and hydrological (suspended sediment and bed load) parameters; Crop water management.

Unit-III: Watershed Conservation Practices

Moisture and soil conservation in irrigated lands, dry lands, arid and semi-arid regions; Water management through wells, water supply, wastewater recycle and reuse, Control measures for air and soil erosion – vegetative and mechanical for agricultural and non-agricultural lands; Temporary & Permanent gully control measures; Micro-catchment water harvesting structures; Groundwater recharge – percolation ponds, water harvesting, roof catchment system, check dams, aquifer storage; Farm ponds, Supplementary irrigation, Evaporation suppression, Seepage reduction, rainwater storage and effective utilisation, Case studies.

Unit-IV: Watershed and Society

Social Aspects of Watershed Management: Community response to watershed degradation; Community participation in Watershed restoration, Private-Public participation, Water legislation, Institutional issues, Role of NGOs in watershed development, Watershed based rural and infrastructure development; Role of Decision Support System in Watershed Management; Case studies

Unit-V: Watershed Planning and Policy Issues

Planning principles; Monitoring and evaluation system; short and long term strategic planning and development. Important watersheds of India – River Valley Projects (RVP), Hill Area Development Programme (HADP), National Watershed Development Programme for Rain-fed Agriculture (NWDPA); Wetland and Ramsar Convention; National guidelines.

Unit-VI: Watershed Management and Sustainability

Watershed: From Unsustainable to Sustainable Approach; Watershed-environment relationship Integrating watershed with natural resource management, Effects of Climate Change on Watershed; Concept of bio-village and integrated farming, water budget, Inter-basin Water Transfer; application of RS-GIS and drone technology in Watershed Management,

Unit-VII: Medical Geology and Etiology of Diseases

Foundation of Medical Geology, Environmental classification of elements; Distribution and geochemical distribution of major environmental elements; Biogeochemical cycles; Bioavailability of elements and etiology of diseases.

Study of Aerosols; National and international public health standards; Geochemical baselines.

Case studies: source, pathways, sinks and public health effects of U, Th, REE, Radon, As, Fe, Se, I, NO₃.

Paper – GELA-DSC-850-Tutorial

(Full Marks – 25)

Reference Books

- Brooks K.N., Folliott P.F. and Magner J.A., 2012, Hydrology and the Management of Watersheds, 4th Ed., John Wiley & Sons, ISBN: 978-0-470-96305-0
- Das Ghanshyam, 2008. Hydrology and Soil Conservation Engineering : Including Watershed Management. Prentice-Hall of India Learning Pvt. Ltd., New Delhi.
- Datta S.K., 1985, Soil Conservation and Land Management. International Book Distributors, Dehradun.
- Debarry P.A., 2004, Watersheds: Processes, Assessment and Management, Wiley, 720p.
- Dissanayake C. B. and Chandrajith R., 2009, Introduction to Medical Geology, Springer-Verlag
- Gonenc I.E., Vadineanu A. and Wolflin J.P., 2008, Sustainable Use and Development of Watersheds, Springer

- Heathcote I.W., 2009, Integrated Watershed Management: Principles and Practice, John Wiley & Sons Ltd., 464p. ISBN: 978-0-470-37625-6
- Katyal J.C., Singh R.P., Sharma S., Das S.K., Padmanabhan M.V. and Mishra P.K., 1995. Field Manual on Watershed Management. CRIDA, Hyderabad.
- Mahnot, S.C. 2014. Soil and Water Conservation and Watershed Management. International Books and Periodicals Supply Service. New Delhi.
- Murthy J.V.S., 2017, Watershed Management, 2nd Ed., New Age International Publisher
- Naiman, R.J. 1992, Watershed Management: Balancing Sustainability and Environmental Change, Springer, 542 pp. ISBN 0-387-97790-2
- Raghunath H. N., 2004. Hydrology. New Age International Publishers.
- Selinus, Olle (Ed.), 2013, Essential of Medical Geology: Impacts of the Natural Environment on Public Health, Revised Edition. Springer.
- Sharda, V.N., A.K. Sikka and G.P. Juyal. 2006. Participatory Integrated Watershed Management: A Field Manual. Central Soil and Water Conservation Research and Training Institute, Dehradun.
- Singh P. K., 2000. Watershed Management: Design and Practice. E-media Publications, Udaipur.
- Singh, G.D. and T.C. Poonia. 2003. Fundamentals of Watershed Management Technology. Yash Publishing House, Bikaner.
- Singh, Rajvir 2000. Watershed Planning and Management. Yash Publishing House, Bikaner.
- Suresh R., 2006. Soil and Water Conservation Engg. Standard Publishers Distributors, Delhi-6.
- Tideman, E.M., 1996, Watershed Management: Guidelines for Indian Conditions. Omega Scientific Publishers, New Delhi.

Paper –GEL-IDC-Th

Earth Systems Science

(Full Marks – 50)

Geology: Definitions and Scope.

Internal structure of the Earth; Earth's materials, minerals and rocks: Broad groups of minerals, oxides, sulphides, carbonates, sulphates and phosphates, silicates. Rocks as mineral assemblages, fabric, texture. Classification of rocks. Igneous rocks; types: acid, intermediate, mafic and ultramafic rocks. Sedimentary rocks; types: clastic and non-clastic. Metamorphic rocks; types: foliated, nonfoliated.

Structure of geologic bodies: Extrusive and intrusive igneous rock bodies, lava flows, sills, dykes, batholiths. Bed and stratum, dip and strike. Folds, antiform, synform, anticline, syncline. Fractures, joints and faults. Foliation, lineation.

The fossil record: Fossils as evidence of past life. Modes of preservation of fossils. Uses of fossils.

Gravity and gravity anomaly on Earth: Bouguer and Free-air anomaly. Concept of isostasy and compensation, hypotheses of Airy and Pratt

Elementary idea of theory of plate tectonics: Basic concepts and geological evidences of continental drift, sea-floor spreading and plate tectonics. Lithosphere, asthenosphere. Plates and plate boundaries, relative motion of plates. Present day configuration of plates. Mid-oceanic ridges, oceanic islands and trenches, hot spots and aseismic ridges. Volcanism and plate tectonics, earthquakes and plate tectonics, continental margins and their evolution. Life cycles of oceans.

Earth's internal processes: Magmatism, Volcanism types of eruption.

Earthquakes: Causes, elastic rebound theory, focus and epicentre, intensity and magnitude. Seismic waves, seismograms, travel-time curves for seismic waves, seismic discontinuities, locating epicentre, and determining magnitude. Earthquake belts. Effects of earthquakes, seismic zones of India.

Paper –GEL-IDC-Tu

Earth Systems Science

(Full Marks – 25)

Reference Books

- Mahapatra, G.B., 1994. A text book of Physical geology. CBS Publishers.
- Singh P., 2008, Engineering Geology, S.K. Kataria & Sons.
- Dasgupta, A. 2013, An introduction to Earth Science, World Press