

COURSE DISTRIBUTION: 8-Semester Bachelor (Hons) Programme Under CBCS In Department Of Geology, Presidency University Kolkata

Semester	Paper Code	Name Of The Courses	Full Marks	Credit Point		Classes Per week	Course Type	Evaluation Method
				Theory	Prac/ Tut			
I	GEOL101C01	Earth System Science	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL102C02	Mineral Science	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL104MC01	Essentials Of Geology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL105MDC01	Geochemical thermodynamics	50	3	-	3	T	IA: 15 and End Sem:35
	103AECC01	English Communication /MIL	50	4	-	4	T	IA: 15 and End Sem:35
Total			400	25				
II	GEOL151C03	Igneous Petrology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL152C04	Structural Geology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL154MC02	Rocks And Minerals	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL191MDC02	Computational Techniques and Programming	50		3	3	S	End Sem: 50
	GEOL156MDC03	Evolutionary Palaeobiology	50	3	-	3	T	IA: 15 and End Sem:35
	153AECC02	English Communication /MIL	50	4		4	T	IA: 15 and End Sem:35
Total			450	28				
III	GEOL201C05	Sedimentology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL202C06	Palaeontology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL205MC03A/GEO L205MC03B	MARTIAN GEOLOGY/Resource Geology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL241SEC01	Field work - 1	50		4	4	S	End Sem: 50
	ENVS204VAC01	Environmental Science	50	3		3	T	IA: 15 and End Sem:35
Total			400	25				
IV	GEOL251C07	Elements of Geochemistry	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL252C08	Metamorphic Petrology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL255MC04A/GEO L255MC04B	Deep time and life/Global Tectonics and Supercontinent cycles	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL291SEC02	Field work - 2	50		5	5	S	End Sem: 50

	GEOL292VAC02	Instrumentation Techniques in Earth Sciences	50		3	3	S	End Sem: 50
	Total		400	26				
V	GEOL301C09	Precambrian Stratigraphy of India	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL302C10	Phanerozoic Stratigraphy of India	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL303C11	Economic Geology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL341SI01	Summer Internship	50		4	4	S	End Sem: 50
	Total		350	22				
VI	GEOL351C12	Hydrogeology	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL352C13	GEOPHYSICS	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL353C14	Remote Sensing & GIS	100	4	2	8	T	IA: 30 and End Sem:70
	GEOL354C15	Geodynamics	100	4	2	8	T	IA: 30 and End Sem:70
	Total		400	24				
VII	GEOL441C16	Field work-3	50		4	4	S	End Sem: 50
	GEOL402C17	Geomorphology	50	4		4	T	IA: 15 and End Sem:35
	GEOL403C18	Fuel Geology	50	4		4	T	IA: 15 and End Sem:35
	GEOL442C19	(Project/Dissertation)	50	4		4	S	End Sem: 50
	GEOL405MC05	Data analysis in earth Sciences	50		4		T	IA: 15 and End Sem:35
	Total		250	20				
VIII	GEOL451C20	Planetary Science Studies	50	4		4	T	IA: 15 and End Sem:35
	GEOL452C21	Basin Analysis	50	4		4	T	IA: 15 and End Sem:35
	GEOL453C22	Atmosphere, Ocean, and Climate Dynamics	50	4		4	T	IA: 15 and End Sem:35
	GEOL491C23	(Project/Dissertation)	100	8		8	S	End Sem: 100
	GEOL455MC06	Research and Publication ethics	50	4		4	T	IA: 15 and End Sem:35
	Total		300	24				
Total			2950	194				

1st year 1st Semester

GEOL101C01: Earth System Science

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit: 4

Contact Hours per Week: 4

Unit 1: Earth as a planet: Introduction to various branches of Earth Science; General characteristics and origin of the Universe, Solar System and its planets; Meteorites and Asteroids; Cosmic abundance of elements; Origin of Earth-atmosphere, ocean, and life.

Unit 2: Solid Earth: Seismic waves and internal constitution of the Earth; Concept of isostasy; Earth's magnetic field; Geothermal gradient and internal heat of the Earth. Introduction to structure: Structural elements: planar and linear structures, concept of strike and dip, trend and plunge, rake/pitch

Unit 3: Plate Tectonics: Concept of plate tectonics, sea-floor spreading and continental drift; Plate boundaries; Earthquake and earthquake belts; Volcanoes- types, products and their distribution.

Unit 4: Hydrosphere and Atmosphere: Atmospheric circulations; Oceanic currents, tides and waves. Climate System and the Changing Climate from rock record; Concepts of eustasy.

Unit 5: Rock types and Soils: Igneous, Sedimentary and Metamorphic rocks; Diastrophic and non-diastrophic Structures; Application of primary sedimentary and igneous structures in structural geology. Concept of scale of observation of structures.
Weathering and Erosion; Soil formation.

Unit 6: Understanding Stratigraphic records: Stratigraphy and nature of stratigraphic records; Fundamental laws of stratigraphy: laws of superposition and faunal succession; Concepts of neptunism, plutonism, uniformitarianism, and catastrophism; Absolute and relative time in Geology. Unconformity and its types, recognition of unconformity. Concept of radiometric dating. Radiometric dating of rocks and minerals: U-Pb, Rb- Sr, Sm-Nd, C-14 methods. Geological time scale; Fossil record and Mass Extinction.

Unit 7: Natural Resources: Mineral resources; hydrocarbon; Renewable energy resources.

Practical: Credit: 2

Contact Hours per Week: 4

Study of major geomorphic features and their relationships with outcrops in topographic sheets. True dip and apparent dip problems through graphical methods

Study of distribution of major stratigraphic units on the map of India.

Study of minerals in hand specimen - Silicates: olivine, garnet, andalusite, sillimanite, kyanite, staurolite, beryl, tourmaline, pyroxene, tremolite, hornblende-actinolite, serpentine, talc, muscovite, biotite, quartz, feldspar, nepheline, zeolite, asbestos, quartz

Other minerals: pyrite, chalcopyrite, galena, sphalerite, barite and gypsum, magnetite, haematite, pyrolusite, psilomelane, corundum, ilmenite, chromite, bauxite; fluorite, calcite, dolomite, apatite, graphite.

Study of common sedimentary, igneous and metamorphic rocks in hand specimens – sandstone, shale, limestone, conglomerate, chert, BIF, granite, basalt, gabbro, dolerite, pegmatite, peridotite, anorthosite, nepheline syenite, rhyolite, slate, phyllite, schist, gneiss, and granulite

Suggested Reference Books:

- Grotzinger, J., Jordan, T.H., Press, F., Siever, R. (2007): Understanding Earth. W.H. Freeman & Co., New York, 5 th Ed.
- Emiliani, C. (1992): Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press. Published in USA.
- Skinner, B.J., Porter, S.C., Botkin, D.B. (1999): The Blue Planet – An Introduction to Earth System Science. John Wiley & Sons, Inc. New York. P.552.
- Mathez, E.A. and Webster, J.D. (2004): The Earth machine – The Science of a Dynamic Planet. Columbia University Press, New York. P.335.
- Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.
- Gross, M. G. (1977). Oceanography: A view of the earth.

GEOL102C02: Mineral Science

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit: 4

Contact Hours per Week: 4

Unit 1: Crystallography: Crystal--Concept of crystalline matter; Interfacial angle and external 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 and point groups. International symbol of point groups

Unit 2: Atomic arrangements and Mineralogical structure: Atomic arrangements: Unit cell, CCP, FCC and HCP; Ionic radius and coordination, Pauling's rules. Solid Solution, Polymorphism, Pseudomorphism; Twinning.

Unit 3: Rock forming minerals: Minerals - definition and classification, physical and chemical properties; Chemical classification of minerals; Internal structure, classification and Composition of common rock-forming minerals (silicates); Derivation of structural formulae based on composition.

Unit 4: Optical Mineralogy: Nature of light- Concept of visible electro-magnetic spectrum and optical behavior of minerals-- isotropic, uniaxial and bi-axial crystals; Double refraction; polarization, Nicol Prism; indicatrix; Introduction to petrological microscope; Refractive index and birefringence, interference phenomena, extinction, Michael Levy chart of interference colours, pleochroism, extinction. Interference phenomenon in convergent light, interference figures, and use of interference figures for determination of optic sign.

Practical: Credit: 2

Contact Hours per Week: 4

Study of the symmetry of crystals. Stereographic projection of crystals. Introduction to optical microscope in laboratory studies.

Study of optical properties of common rock-forming minerals: quartz, orthoclase, microcline, plagioclase, perthite, nepheline, olivine, orthopyroxene, clinopyroxene, hornblende, staurolite, garnet, muscovite, biotite, calcite, tourmaline, sillimanite, kyanite, andalusite

Suggested Reference Books:

- Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
- Nesse, W. D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- Putnis, A. (1992): Introduction to Mineral Sciences. Cambridge University Press.
- Whalstrom, E.E. (1969): Optical Crystallography. John Wiley & Sons
- Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
- Nesse, W.D., 2000, Introduction to Mineralogy, Oxford University Press, New York, 442 p.

1st year 2nd Semester

GEOL151C03: Igneous Petrology

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit: 4

Contact Hours per Week: 4

Unit 1: Introduction to Igneous Petrology: 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, plutonic.

Unit 2: Forms, Texture and Microstructure of Igneous rocks of Igneous rock bodies: Mode of occurrence of igneous rocks. Forms of igneous rocks. Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of minerals in magma; 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, perthitic, myrmekitic, variolitic, speherulitic and spinifex.

Unit 3: Classification and Petrographical analysis of Igneous Rocks: Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical and associational. Norm and mode. Standard classification schemes – Niggli, Hatch and Wells and IUGS. TAS diagram for volcanic rocks;

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

Unit 4: Phase Diagrams: Phase rule and its application to eutectic, peritectic and solid solution system. Phase equilibria in the following binary and ternary systems under high dry and wet pressure with respect to their nature under low pressure (1 atmosphere), and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite, albite – orthoclase, diopside – albite – anorthite, forsterite – diopside – silica and nepheline - kalsilite – silica.

Unit 5: Diversification of igneous rock and Mantle Petrology: Bowen's reaction Series and its application, Magmatic differentiation- fractional crystallization, partial melting, assimilation and their role in magmatic differentiation. Bi-variate and tri-variate chemical variation diagram, idea about Mg.no., Fe-no., D.I. alkali-lime index, Petrgraphic Province. Mineralogy of upper mantle, phase transition in upper mantle, broad geochemical composition of upper mantle, variation in composition (mineralogical and geochemical) of upper mantle through space and time- mantle heterogeneity and its causes. Fluid phases in upper mantle.

Unit 6: Petrogenesis of Igneous Rocks: Petrogenesis felsic and mafic igneous rocks: granitoids (I-, S-, M-, and A-type), basalt, gabbros, anorthosite, alkaline rocks, kimberlites.

Unit 7: Magmatism in the following plate tectonic settings-

- i) Mid Oceanic Ridge setting
- ii) Subduction Zone setting
- iii) Continental and oceanic rift zone

Types of magmatic rocks/series/suite in all these tectonic setting, petrography-mineralogy of magmatic rocks, major and trace element geochemistry, Sr-Nd-Pb isotopic abundances to characterize petrogenetic processes (nature of source rock, processes of magma generation, role of volatiles in magmatic system), magma emplacement in relation to tectonic activity. Trace element abundance of magmatic rocks (especially basalt and granite) from different tectonic setting, trace element discrimination diagrams and identification of tectonic setting.

Practical: Credit: 2

Contact Hours per Week: 4

Study of important igneous rocks in thin sections: granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosite, ultramafic rock, basalt, andesite, dolerite, rhyolite, dacite, Lamprophyre and lamproite, pyroclastic rock and ignimbrite and alkaline rocks.

Norm calculation for silica undersaturated and silica oversaturated rocks

Plotting of modal data in IUGS classification diagram for plutonic rocks (Streckeisen diagram).

Numerical problems related to petrogenetic processes like fractional crystallization, partial melting, assimilation, magma mixing

Numerical/graphical problems on solid-liquid equilibrium system, magma viscosity, magma ascent rate

Suggested Reference Books:

- Philpotts, A. and Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
- Myron G. Best (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.
- Frost B. R. and Frost C. D (2014). Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.
- Pitcher, W.S. 1997. The Nature and Origin of Granitic Rock. Springer.
- Wilson, M., 1989. Igneous Petrogenesis: a global tectonic approach, Cambridge University Press

GEOL152C04: Structural Geology

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit: 4

Contact Hours per Week: 4

Unit 1: Stress and Strain in Rocks

Concept of Stress: normal stress, shear stress, stress ellipse concept, principal axes of stress, planes of maximum shear stress, Mohr circle of stress.

Concept of strain: Longitudinal and shear strain, principal axes of strain, strain ellipse concept, Mohr circle for strain

Homogenous and inhomogeneous strain, Rotational and irrotational strain in rocks. Strain ellipsoids of different types and their geological significance. Flinn and Ramsay's diagram.

Basic methods of strain analysis

Rheological properties of rocks, Concept of rock deformation- brittle and ductile deformation, Factors controlling deformation behaviour of rocks.

Unit 2: Folds

Fold morphology and structural elements; Morphological classification of folds

Outcrop patterns of folds, Geometric classification of folds

Mechanics of folding- buckling, bending. Kinematics of folding- flexural folding, flexural slip and flow folding, shear folding and passive folding

Superposed folding, morphological types, classification and basic geometric analysis in polydeformed terranes

Unit 3: Foliation and Lineation

Morphological features of foliations and lineations.

Tectonic significance of foliation and lineation, Relation of foliation and lineation with folds.

Brief idea of origin of foliation, Deformation mechanism, microstructure and fabric development

Unit 4: Faults, joints and shear zones

Classification of fractures- Faults and Joints

Joint- common terminology, characteristics and classification.

Relation of Joints to Folds, exhumation and igneous bodies

Fault zone terminology, Geometric classification of faults.

Effects of faulting on the outcrops, Criteria for recognition of faults, Fault zone rocks.

Anderson dynamic analysis of faulting, Characteristics of Normal, Thrust and Strike slip fault systems

Mechanics of fracturing and faulting, Fault plane solutions

Types of Shear zones and their kinematics, Shear zone rocks and shear sense indicators.

Practical: Credit: 2

Contact Hours per Week: 4

Topographic maps. Outcrop patterns of different structures.

Stereographic projections of planes and lines

3-point problems, fold-fault problems and their solutions through graphical methods and stereographic projection methods.

Interpretation of geological maps with unconformity, fault, fold and igneous bodies.

Construction of structural cross section.

Application of Borehole and Rotational Problems in Structural analyses

Suggested Reference Books

- Davis, H.G, Reynolds, S.J, Kluth, C. F. (2011), Structural Geology of Rocks and Region, John Wiley
- 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.
- Fossen, H (2010), Structural Geology, Cambridge University Press.
- Marshak, S and Mitra G. (1988) Basic Methods in Structural Geology, Prentice Hall.
- Ben A. van der Pluijm and Stephen Marshak (2004) Earth Structure: An Introduction to Structural Geology and Tectonics (Second Edition) 2nd Edition

- Ghosh, S.K., 1993. Structural Geology: Fundamentals, and modern developments, Pergamon Press.
- Passhier, C. and Trouw, RAJ, 2005. Microtectonics. Springer, Berlin.
- Pollard, D.D. and Fletcher, R.C., 2005. Fundamentals of structural geology, Cambridge University Press.
- Ramsay, J.G and Huber, M.I., 1983. Techniques of Modern Structural Geology: Vol.I & 11. Academic Press
- Ramsay, J. G, 1967. Folding and Fracturing of Rocks, McGraw-Hill Book Company, New York.
- Rowland, S.M., Duebendorfer, E. and Schiefelbein, I.M., 2007. Structural analysis and synthesis: a laboratory course in structural geology, Blackwell Pub.

2nd year 1st Semester

GEOL201C05: Sedimentology

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit : 4

Contact Hours per Week : 4

Unit 1: Origin of sediments and Sediment granulometry: Physical and chemical weathering, soils and paleosols; Grain-size scale, particle size analysis and connotations; particle shape and fabric.

Unit 2: Sedimentary textures, structures and paleocurrent: Sediment transport mechanism-types of flow (Newtonian and Non-Newtonian), laminar and turbulent flow, subcritical, critical and supercritical flows; concept of mean flow velocity, unit discharge and bed shear stress; flow profile and flow separation; particle entrainment, transport and deposition, bedform stability diagram. Sediment-gravity flow—types and deposits; Sedimentary structure- Primary, penecontemporaneous deformation and biogenic structures

Paleocurrent analysis: data acquisition, methodology, different palaeocurrent patterns

Unit 3: Sedimentary rocks: Components and classification(s) of conglomerates, sandstones, carbonate rocks and iron formations. General outline of controls on deposition of sandstones and carbonate rocks.

Unit 4: Diagenesis: Concepts of diagenesis, processes and stages of diagenesis, dolomites and dolomitisation

Unit 5: Depositional environment: Facies models for fluvial, deltaic, siliciclastic shelf, carbonate platforms and deep-sea fan.

Unit 6: Tectonism and Sedimentation: Tectonic classification of sedimentary basins.

Unit 7: Stratigraphy: Principles of Litho-stratigraphy and Sequence Stratigraphy.

Practical: Credit: 2

Contact Hours per Week: 4

Exercises on sedimentary structures in hand specimens; Particle size distribution & statistical treatment,

Palaeocurrent analysis, Petrography of clastic and non-clastic rocks through thin sections and their environmental inference.

Suggested Readings:

- Allen, P.A., 1997. Earth Surface Processes, Blackwell publishing.
- Catuneanu, O., 2006. Principles of Sequence Stratigraphy. Elsevier, Amsterdam, 375 pp.
- Collinson, J.D. and Thompson, D.B., 1988. Sedimentary Structures, Unwin- Hyman, London.
- Folk, R.L. (1980) Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, 184 p
- Leeder, M.R., 1982. Sedimentology: Process and Product. George Alien &Unwin, London, 344p.
- Lindholm, R.C., 1987. A Practical Approach to Sedimentology, Allcn and Unwin, London.
- Pettijohn, F.J., 1975. Sedimentary Rocks, Harper and Row Publ. New Delhi.

- Miall, A.D., 1999. Principles of Sedimentary Basin Analysis 3rd Ed Springer Verlag, New York.
- Nichols, G., 1999. Sedimentology and Stratigraphy, Blackwell publishing.
- Reading, H. G., 1996. Sedimentary Environments: Processes, Facies and Stratigraphy, Blackwell Publishers
- Boggs, S., 1995. Principles of Sedimentology and Stratigraphy, Prentice Hall, New Jersey.
- Tucker, M.E., 2006. Sedimentary Petrology. Blackwell Publishing.
- Tucker, M.E. and Wright, V.P., 1990. Carbonate Sedimentology, Blackwell.
- Walker, R.G., Facies model 1976. Geoscience Canada.
- Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.
- Posamentier, H.W., and Walker, R.G., 2006. Facies Models revisited, SEPM.

GEOL202C06: Palaeontology

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit: 4

Contact Hours per Week: 4

Unit 1: Taxonomy and Species concept: Species concept with special reference to palaeontology; Taxonomic hierarchy; Binomial nomenclature

Unit 2: Invertebrate Palaeontology: Brief introduction to important invertebrate groups (e.g., Trilobita, Mollusca); their biostratigraphic and evolutionary significance

Unit 3: Micropalaeontology: Brief introduction to important microfossil groups (e.g., Foraminiferida); their biostratigraphic and evolutionary significance; introduction to palynology

Unit 4: Introduction to Vertebrate Palaeontology: Origin and divisions of vertebrates; Major turning points in vertebrate evolution – evolution of jaw, terrestrialization, amniote evolution, evolution of flight, evolution of mammals.

Unit 5: Introduction to Palaeobotany: Origin and divisions of plants; Major steps in plant evolution.

Unit 6: Organic skeleton as a machine – An introduction to the relation between morphology and life habit; mechanical properties of benthic, oceanic (planktonic, nektonic) and terrestrial (flying, land-dwelling) organisms; concept of allometry in ontogeny.

Practical: Credit: 2

Contact Hours per Week: 4

Unit 1 - Study of fossils showing various modes of preservation

Unit 2 - Functional morphology of invertebrates (including microfossils)

Unit 3 - Plant morphology and climate

Unit 4 - Vertebrate teeth and feeding habit

Suggested Reference Books:

Foote, M. and Miller, I.A. (2007) Principles of Paleontology. 3 rd Edition by W. H. Freeman and company

Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution. 4th Edition by Blackwell Publishing.

Benton, M. (2009). Vertebrate paleontology. 4th Edition by John Wiley & Sons.

Arnold, C.A. (2018) An Introduction to Paleobotany. Surjeet Publications

Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher

Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

2nd year 2nd Semester

GEOL251C07: Elements of Geochemistry

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit:4

Contact Hours per Week:4

Unit 1: Basic Concepts: Introduction to properties of elements: Meteorite-classification and significance; Chemical bonding; Cosmic abundance of elements; Geochemical classification of elements.

Unit 2: Layered Structure of Earth and Geochemistry: Composition of the bulk silicate Earth; Composition of core; Composition of mantle: depleted mantle and enriched mantle; Composition of crust: Continental and Oceanic.

Unit 3: Element transport: Advection and diffusion; Aqueous geochemistry- basic concepts and application in geological processes like Weathering, diagenesis & hydrothermal system; Eh, pH relation; Elements of marine chemistry; Geochemical behavior of elements.

Unit 4: Geochemistry of solid Earth: Geochemical behavior of elements during magmatic crystallization, partial melting; Concept of partition coefficient (K_d), compatible and incompatible elements; REE-essential characters, behavior and importance;

Unit 5: Isotope geology: Introduction to isotope geochemistry; Stable isotope geochemistry (C, O, S) and its application in geology; basic principles of Radioactive dating Methods: Rb-Sr, Sm-Nd, and C-14.

Unit 6: Tools of organic biogeochemistry: Sample collection, handling, storage, and analyses; Analytical techniques; Application of stable isotopes of organic carbon and nitrogen in organic matter source identification; Concept of lipid biomarkers and biomarker application in paleoclimate and palaeoecological reconstructions.

Practical Credit:2

Contact Hours per Week: 4

Instrumental data calibration, Distribution coefficient and associated problems, Simple batch melting and Rayleigh fractionation models, CIA calculation and A-CN-K diagram, Residence time calculations, Normalization of REEs and trace elements, Ionic charge and ionic size relationships.

Suggested Reference Books:

- Mason, B. (1986). Principles of Geochemistry. 3rd Edition, Wiley, New York.
- Rollinson, H. (2007). Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific and Technical.
- Walther, J. V. (2009). Essentials of geochemistry. Jones and Bartlett Publishers.
- Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
- Faure, Gunter and Teresa M. Mensing (2004). Isotopes Principles and Applications. Wiley India Pvt. Ltd
- Killops S.D., Killops V.J. 2005. An introduction to organic geochemistry. 2nd ed. Blackwell Publishing, Malaysia.

GEOL252C08: Metamorphic Petrology

Credits - 6: (Theory- 04, Practical- 02)

Theory Credit : 4

Contact Hours per Week : 4

Unit 1: Metamorphism: controls and types

- Definition of metamorphism
- Factors controlling metamorphism
- Types of metamorphism: contact, regional, fault zone metamorphism, impact metamorphism

Unit 2: Metamorphic Facies and Grades

- Index minerals, metamorphic zones and isograds.
- Concept of metamorphic facies and grade
- Composition-paragenesis diagrams. ACF, AKF and AFM diagrams
- Schreinemakers' analyses, petrogenetic grid and phase equilibria modelling
- Concept of metamorphic P-T-t path

Unit 3: Metamorphism and deformation

- Structure and textures of metamorphic rocks
- Relationship between metamorphism and deformation.

Unit 4: Metamorphic reactions

- Types of metamorphic reactions
- Kinetics of metamorphic reactions
- Progressive metamorphism of pelitic, basic and carbonate rocks

Unit 5: Quantification of metamorphic processes

- Geothermobarometry
- Ultrahigh temperature (UHT) and ultrahigh pressure (UHP) metamorphism
- Metamorphic fluid and metasomatism
- Geochronology of metamorphic rocks

Unit 6: Metamorphism and crustal evolution

- Anatexis and migmatites
- Partial melting of crustal rocks

Unit 7: Tectonics and metamorphism

- Heat flow and thermal models of orogenic belts
- Metamorphism along convergent and divergent plate margin
- Metamorphic styles through ages

Practical Credit : 2

Contact Hours per Week : 4

- Textural and mineralogical study of metamorphic rocks in thin sections: varieties of schists, amphibolite, charnockite, khondalite, mafic granulite.
- Graphical plots of metamorphic mineral assemblages using chemographic diagrams
- Calculation of P and T using geothermobarometry
- Construction P-T grid using Schreinemakers' rules

Suggested Reference Books :

- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
- Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.
- Spear F. S. 1993. Metamorphic phase equilibria and Pressure-Temperature-Time paths. Mineralogical Society of America Monograph 799.

3rd year 1st Semester

GEOL301C09: Precambrian Stratigraphy of India

Credits - 6: (Theory- 04, Practical- 02)

Theory Credit : 4

Contact Hours per Week : 4

Unit 1: Introduction to Precambrian Stratigraphy

Divisions of Precambrian time scale, Characteristics and status of Archaean and Proterozoic Eons in global perspective, Archaean-Proterozoic boundary.

Models of Precambrian tectonics and crustal development

Unit 2: Physiographic and Tectonic subdivisions of India

Brief Introduction to the physiographic and tectonic subdivisions of India.

Study of geological map of India and identification of major Precambrian stratigraphic units.

Introduction to Indian cratons, mobile belts and Proterozoic sedimentary basins

Unit 3: Geologic evolution of important Precambrian terrains in India

Geologic evolution with emphasis on sedimentation, lithology, magmatism, structure, metamorphism and geochronology of: Singhbhum Craton, Dharwar Craton, Bastar Craton, Aravalli-Bundelkhan Craton; Central Indian Tectonic Zone, Chhotanagpur Granite Gneiss Belt, Eastern Ghats Belt, Southern Granulite Terrane; Vindhyan and Cudappah basins

Practical Credit : 2

Contact Hours per Week : 4

Structural analyses of polydeformed terrains: map and data analyses

Interpretation of geochronological dataset

Suggested Reference Books:

- Krishnan, M.S., 2006, Geology of India and Burma, 6th Edn., CBS, 536 p. [Earlier editions also useful]
- Ramakrishnan, M. and Vaidyanathan, R., 2008, Geology of India, Vol. 1, Geological Society of India, Bangalore.
- Pascoe, E.H., 1950, A manual of the geology of India and Burma (3 volumes), 3rd Edn., Geological Survey of India.
- Valdiya K.S. (2010). The making of India, Macmillan India Pvt. Ltd.

GEOL302C10: Phanerozoic Stratigraphy of India

Credits - 6: (Theory- 04, Practical- 02)

Theory Credits: 4

Contact Hours per Week: 4

Unit 1: Introduction- Definition; Distribution of major Phanerozoic basins in India; Important stratigraphic boundaries during Phanerozoic time in India - a. Precambrian-Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.

Unit 2: Important Indian successions- Detailed study of important Phanerozoic successions in India with emphasis on lithology, structural and tectonic set up as well as paleo-environment of the following:

- Gondwana succession of Peninsular India;
- Successions of extra-peninsular India, with special reference to Kashmir and Spiti valley;
- Mesozoic successions in peninsular India with special reference to Kutch and Cauvery basins;
- Cenozoic successions: Siwalik succession, Assam and Bengal basins.

Unit 3: Stratigraphy of the Deccan Traps and Intertrappean beds.

Unit 4: Quaternary Geology- Definition; Principles of subdivisions; Major paleoclimatic and paleo-geographic events in Quaternary period with special emphasis on the Indian Subcontinent; Quaternary successions in India.

Unit 5: Evolution of life: Indian context- Indian fauna and flora in the light of evolution as well as global and regional geological phenomena: Gondwana flora and vertebrates; Major invertebrate groups from Kashmir, Spiti, Kutch and Cauvery; Siwalik vertebrates; Human evolution in Indian context.

Practical Credit: 2

Contact Hours per Week: 4

Unit 1: Mapping of major stratigraphic units from India.

Unit 2: Studying major features of paleogeographic maps from Phanerozoic.

Unit 3: Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate (including microfossils), vertebrate and plant fossils from India.

Unit 4: Exercises on lithostratigraphic, biostratigraphic and chronostratigraphic correlation.

Suggested Reference Books:

- Krishnan, M. S. (1982). Geology of India and Burma, CBS Publishers, Delhi.
- Doyle, P. and Bennett, M. R. (1996). Unlocking the Stratigraphic Record. John Wiley.
- Ramakrishnan, M. and Vaidyanadhan, R. (2008). Geology of India Volumes 1 and 2. Geological society of India, Bangalore.
- Valdiya, K. S. (2010). The making of India. Macmillan India Pvt. Ltd.

GEOL303C11:Economic Geology

Credits - 6: (Theory- 04, Practical- 02)

Theory Credit : 4

Contact Hours per Week : 4

Unit 1: Introduction to ore geology:

Basic concepts of Ores, gangue minerals, tenor, grade, resources and reserves.

Morphology of ore bodies

Review of concepts of ore genesis process

Unit 2: Ore-forming processes

Orthomagmatic processes

Sedimentary processes

Hydrothermal

Supergene and Residual enrichment processes

Metamorphic processes

Unit 3: Plate Tectonics and ore deposits

Role of plate tectonics in ore mineralization.

Metallogeny through ages

Unit 4: Nuclear Fuel

Important minerals.

Types of U and Th deposits.

U and Th deposits in India

Unit 5: Metallic and Non-metallic ores of India

Metallic ores

Non-metallic and industrial rocks and minerals

Atomic minerals

Gem & Gemstones

.

Practical Credit : 2

Contact Hours per Week : 4

Hand specimen study of important ores
Study of microscopic properties of ore minerals.

Suggested Reference Books:

1. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
2. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
3. Ridley, J. (2013): Ore Deposit Geology. Cambridge University Press, UK. P398.
4. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
5. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
6. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
7. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
8. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.
9. Mukherjee, A. (1999): Ore Genesis – A Holistic Approach. Allied Publishers Ltd., New Delhi, India. P657.

3rd year 2nd Semester

GEOL351C12: Hydrogeology

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit:4

Contact Hours per Week: 4

Unit 1: Introduction and basic concepts

Scope of hydrogeology; Groundwater quality and its societal relevance.

Hydrologic cycle; Origin of groundwater, vertical distribution of subsurface water. Genetic classification of groundwater.

Unit 2: Groundwater flow and well hydraulics

Types of aquifer– unconfined, confined and semi-confined. Water table and piezometric surface. Darcy's law; Groundwater velocity.

Intrinsic permeability and hydraulic conductivity, Transmissivity.

Theory of groundwater flow, Introduction to Well Hydraulics.

Concepts of diffusivity, drawdown, specific capacity, etc.

Unit 3: Groundwater chemistry

Physical, chemical and bacteriological properties of water and water quality. Introduction to methods of interpreting groundwater quality data using standard graphical plots.

Unit 4: Water Quality Issues

Elementary concept on groundwater pollution: arsenic, fluoride and nitrate, sea water intrusion in coastal aquifers and their remedial measures.

Unit 5: Groundwater development and management

Surface and subsurface water interaction. Groundwater level fluctuations. Basic concepts of water balance studies, Issues related to groundwater resources development and management. Rainwater harvesting and Artificial Recharge of groundwater, Watershed and Springshed Management, Groundwater Legislation in India.

Unit 6: Groundwater provinces and aquifer systems

Groundwater provinces in India and West Bengal, Aquifer systems around the world.

Practical: Credit:2

Contact Hours per Week : 4

- Preparation and interpretation of water level contour maps and depth to water level maps.
- Preparation and analysis of hydrographs for different groundwater conditions.
- Water potential zones of India and Major aquifer systems in World (map-based study).
- Graphical representation of chemical quality data and analysis.
- Simple numerical problems related to aquifer properties.

Suggested Reference Books:

- Todd, D. K. and Larry, W.M. (2005). Groundwater Hydrology, 3rd Ed. John Wiley and Sons, N.Y.
- Davis, S. N. and De Weist, R. J. M. (1966). Hydrogeology. John Wiley and Sons Inc., New York.
- Karanth K.R. (1987). Groundwater: Assessment, Development and management. Tata McGraw- Hill Pub. Co. Ltd.
- Raghunath H, M. (2007). Groundwater. 3rd Ed. New Age International Publishers, New

GEOL352C13: GEOPHYSICS

Credits - 6: (Theory- 04, Practical- 02)

Theory: Credit:4

Contact Hours per Week: 4

Unit 1. Introduction to Geophysics. Different branches of Geophysics. Relationship between Geology and Geophysics.

Unit 2. Gravity Method: Gravity and its variation over the surface of the Earth. Principle of Gravimeters; Gravity field surveys. Interpretation of gravity anomaly curve in groundwater prospecting and mineral exploration, Gravity maps and their interpretation.

Unit 3. Magnetic Method: - Geomagnetic field, Principle of Magnetometers. Magnetic field survey, preparation of magnetic anomaly maps and their interpretation. Aeromagnetic survey. Earth's Magnetic Field: Internal and external fields, Measurements of horizontal, vertical, declination, inclination and total field, A brief introduction of the various theories of the main field and its secular variation, Rock magnetism and palaeomagnetism, Palaeopole determination. palaeomagnetism in plate tectonics.

Unit 4. Electrical and Electromagnetic Methods: - Electrical properties of rocks. Resistivity method, Induced Polarisation Method and Self potential method. Field procedure, interpretation of electrical profile and sounding curves. typical sounding curves, pseudosections; Electromagnetic field techniques, methods and interpretation. Principles and practices of Ground Penetrating Radar (GPR).

Unit 5. Seismic Method- Refraction and Reflection seismic surveys. Concept of seismic channel and multi-channel recording of seismic data. Seismic data acquisition and interpretation,

Unit 6. Petrophysics and well logging: - Principle of electrical logging and its application in petroleum, groundwater and mineral exploration. Open hole, cased hole and production logging; Electrical logs - lateral, latero, induction, temperature, S.P; porosity logs; sonic, density, neutron; natural gamma; Determination of formation factor, porosity, permeability, density, water saturation, lithology; Logging while drilling.

Unit 7. Seismology Elastic theory: Elements of earthquake seismology; seismic sources: faulting source, Focal mechanism and fault plane solutions; seismic gaps; seismotectonic and structure of the earth; Himalayan and stable continental region earthquakes, reservoir induced

seismicity; seismic hazards; earthquake prediction, travel time residuals, velocity anomalies, seismic tomography.

Unit 8. Application of Geophysics in geological studies: groundwater prospecting, mineral exploration, engineering geology, petroleum exploration, archeological studies, environmental studies.

Practical:

1. Interpretation of gravity anomaly curve in terms of depth and shape of the object.
2. Determination of palaeopoles using palaeomagnetic data.
3. Interpretation of magnetic anomaly data.
4. Experiments with resistivity meter.
5. Plotting of VES curve & ERT data and its interpretation.
6. Interpretation of S.P. anomalies & I.P. data.
7. Interpretation of seismic velocity of the layer and depth of the body using seismic refraction data and Interpretation of seismic profile data.
8. Well log interpretation and correlation
9. Handling of different Geophysical tools and software's
10. Determination of the epicentral distance of an earthquake and interpretation of Travel - Time curves.

Suggested Readings:

1. Lowrie, W. (2007) Fundamental of geophysics (second edition). Cambridge University Press.
2. Robinson, E.S. and Coruh, C. (1988) Basic Exploration Geophysics. Wiley.
3. Telford, W.M., Geldart, L.P., Sheriff, R.E. (1990) Applied Geophysics. Cambridge University Press.
4. Musset, A.E. and Khan, M.A. (2000) Looking into the Earth, Cambridge University Press.
5. Dobrin, M.B. and Saviet, C.H. (1988) Introduction to Geophysical Prospecting. McGraw-Hill Education.
6. Keary, P., Brooks, M. and Hill, I. (2002) Introduction to Geophysical Exploration. Wiley-Blackwell.
7. Rider, M. and Kennedy, M. (2011) The geological Interpretation of Well Logs. Rider-French Consulting Limited.

GEOL353C14: Remote Sensing & GIS

Credits - 6: (Theory- 04, Practical- 02)

Theory Credit : 4

Contact Hours per Week : 4

Unit 1: Fundamentals of remote sensing, Electromagnetic Radiation (EMR), Satellite, sensors and scanners, data formats; Remote sensing techniques: Optical, thermal and hyperspectral remote sensing.

Unit 2: Digital Image Processing, Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment. GIS integration and Case studies-Indian Examples

Unit 3: Hyperspectral remote sensing - Basic concept, spectroscopy, use of spectroradiometer, spectral signature library, hyperspectral sensors and imagery. Application of hyperspectral remote sensing in geological studies.

Unit 4: Active remote sensing: Synthetic Aperture Radar (SAR) and Side Looking Airborne Radar (SLAR) – principle and applications in geological studies.

Unit: 5: Remote sensing application in lithological mapping, structural mapping, mineral exploration, groundwater exploration. Introduction to DEM analysis.

Unit-6: GIS: Spatial and non-spatial data analysis; applications in prospecting natural resources, risk assessment of natural hazards. GNSS and GPS: Recent development; Applications in earth system sciences.

Practical: Credit : 2

Contact Hours per Week : 4

Introduction to DIP and GIS softwares. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures. Creating a FCC from raw data, Visual Image Classification, Registration of satellite data with a toposheet of the area, Enhancing the satellite images; Generating NDVI images and other image ratio and its interpretation. Exercises on hyperspectral images and their interpretation

Classification of images, DEM analysis: generating slope map, aspect map and drainage network map and its applications

Suggested Reference Books:

- Demers, M.N. (1997). Fundamentals of Geographic Information System, John Wiley and sons. Inc.
- Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J. (2001). GPS: Theory and Practice, Springer Wien, New York.
- Jensen, J.R. (1996). Introductory Digital Image Processing: A Remote Sensing Perspective. Springer- Verlag.
- Lillesand, T. M. and Kiefer, R.W. (2007). Remote Sensing and Image Interpretation. Wiley.
- Richards, J.A. and Jia, X. (1999). Remote Sensing Digital Image Analysis. Springer-Verlag.

GEOL354C15: Geodynamics

Credits - 6: (Theory- 04, Practical- 02)

**Theory Credit : 4
: 4**

Contact Hours per Week

Unit 1: Earthquakes, Seismic waves and internal constitution of the Earth; Lithosphere: continental and oceanic lithosphere, Rheology of the lithosphere: Elastic deformation, bending and buckling of lithospheric plates, Lithosphere as a thermal boundary layer.

Unit 2: Constitution of the core and mantle, heat flow and convection patterns; Gravity anomalies and the Concept of isostasy; Earth's magnetic field; Geothermal gradient and internal heat flow of the Earth. Concept of Hot spot and plumes.

Unit 3: Historical Perspective: Continental Drift and Sea Floor spreading, Wegener's continental drift hypothesis and its evidences. Continental position in the past. Sea-Floor spreading theory and its evidences. Magnetic time scale. Palaeomagnetism and motion of plates. Evolution of modern plate tectonics.

Unit 4: Plate and Plate boundaries: Distribution of plates in the Earth, physical character of plates. Macro and micro plates. Plate boundaries: types, character, identification of boundaries, Motion along plate boundaries. Triple junction, Kinematics of plate motion, Rate of plate motion. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults, Magmatism and earthquake in oceanic ridges and in subduction zones.

Unit 5: Plate Tectonics- Past and Present: Plate tectonics model and its evidences. Reconstruction of plates. Supercontinent, their break up and assembly. Assembly and break up of Pangaea. Wilson cycle. Driving Mechanisms of plates, Plate tectonics and mantle convection.

Practical: Credit : 2

Contact Hours per Week : 4

Problems on Stress and Strain analyses

Study of Tectonic maps of India

Stability analysis of plate boundaries

Fault slip analysis

Earthquake focal mechanism solutions

Balanced Cross-section Construction

Suggested Reference Books :

Turcotte, D. L. and Schubert, G., 2002. Geodynamics. Cambridge university press.

Schubert, G., Turcotte, D. L., and Olson, P., 2001. Mantle convection in the Earth and planets. Cambridge University Press.

Stuwe, K., 2007. Geodynamics of the Lithosphere. Springer

Cox and Hart, 1986. *Plate tectonics: How it works* by, Blackwell.

Kearey, P., Klepeis, K.A. and Vine, F.J. (2009) Global Tectonics. Third edition. Wiley-Blackwell, Oxford.

Condie K.C. (1997), Plate Tectonics and Crustal Evolution. Fourth Edition, Butterworth Heinemann.

Moores E.M. and Twiss, R.. J. (1995) Tectonics . W.H. Freeman, New York.

Van Kranendonk, Martin J., Vickie Bennett, and Elis Hoffmann, 2018. eds. Earth's oldest rocks.

4th year 1st Semester

GEOL441C16: Field work-3

Credits – 4

Module-A: Ancient and modern depositional environments: Sediments and Biota

1. Interpretation of sedimentary structures, Facies analysis, Factors controlling the nature and distribution of facies.
2. Identification of depositional environments, Evolution over time from sediment to sedimentary rock.
3. Stratigraphy and stratigraphical principles, Stratigraphic architecture - a hierarchical study of bounding surfaces.
4. Study of Palaeontological features in field and their interpretations.
5. Taphonomic analysis – live-dead (bioerosion, encrustation etc.) and live-live interaction (predation etc.).
6. Biozonation and correlation.
7. Ichnology and its relation with depositional environment.
8. Sample collection and preparation methods.
9. Analysis of samples and data collected in field.
10. Preparation of a comprehensive field report.

Module-B: Economic deposit survey

1. Study of regional Geology of the target area.
2. Study of lithological association.
3. Identification of ore and host rock units.
4. Study of mode of occurrences and structures of the ore and host rock units.
5. Understanding of mining systematics by opencast and/or underground mine visit.
6. Preparation of a comprehensive field report.

GEOL402C17: Geomorphology

Credits - 4:

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: Major morphological features of the earth surface; Large scale topography - plate tectonics overview, large scale mountain ranges (with emphasis on Himalayas), Geomorphic expressions of active structure.

Unit 3: Surficial processes and geomorphology; weathering and associated landforms; soil formation, slope processes, drainage basin morphometry, Landforms associated with glacial, periglacial processes, fluvial processes, aeolian processes, coastal processes, karst; Landforms associated with igneous activities.

Unit 4: Anthropogenic Geomorphology; nature and direction of changes made in the landscape due to human intervention, their long-term implications for the human society and environment and feedback to the earth's environment.

Practical: Reading topographic maps, Preparation of a topographic profile.

Suggested Reference Books:

- Robert S. Anderson and Suzanne P. Anderson (2010). Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
- M.A. Summerfield (1991). Global Geomorphology. Wiley and Sons.
- R G Huggett. Fundamentals of Geomorphology (3rd ed). Routledge
- Allison, R. Applied Geomorphology: Theory and Practices, Wiley Europe, 2002
- Small, R.J. The Study of Landforms – A Textbook of Geomorphology, Cambridge University Press, 1970
- Hails, J.R. Applied Geomorphology, Elsevier, Amsterdam, 1977
- Szabó, J., Dávid, L., & Lóczy, D. (Eds.). (2010). Anthropogenic geomorphology: a guide to man-made landforms. Springer Science & Business Media.

GEOL403C18: Fuel Geology

Credits - 4:

Theory

Unit 1: Energy resources

Different sources of energy: Global and Indian scenario.

Unit 2: Coal

Definition and origin of Coal. Basic classification of coal.

Fundamentals of coal petrology - introduction to lithotypes, microlithotypes and macerals in coal. Proximate and ultimate analysis of coal.

Unit 3: Coal as a fuel

Concept of clean coal technology Coal Bed Methane (CBM) Underground coal gasification Liquefaction of coal

Unit 4: Petroleum

Chemical composition and physical properties of crudes oil Origin of and migration of petroleum

Kerogen: maturation of kerogen; biogenic and thermal effect

Unconventional hydrocarbon resources

Unit 5: Petroleum Reservoirs and Traps

Reservoir rocks: general attributes and petrophysical properties Cap rocks: definition, general properties

Hydrocarbon traps: definition, classification of hydrocarbon traps - structural, stratigraphic and combination trap.

Plate tectonics and global distribution of hydrocarbon reserves

Unit 6: Sequence stratigraphy and geographic distribution

Sequence stratigraphy and its implications in petroleum exploration.

Detailed study of major coal depositions and petroliferous basins in India.

Suggested Reference Books:

- Thomas L. (2013) Coal Geology: Second Edition, John Wiley & Sons, Ltd.
- Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
- Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
- Bastia, R., and Radhakrishna, M. (2012). Basin evolution and petroleum prospectively of the continental margins of India (Vol. 59). Newness.

GEOL442C19: Project/ Dissertation

Credits - 4

4th year 2nd Semester

GEOL451C20: Planetary Science Studies

Credits - 4

Theory

Unit 1: Solar system materials, Milky way; Structure of solar system; Orbits and celestial coordinates; Kepler's law of planetary motions. Concepts of planetary evolutions.

Unit 2: Space probe: types of space missions; Space infrastructure.

Unit 3: Space exploration of Celestial bodies

Unit 4: Exoplanets

Tutorial:

Planetary surface mapping using remote sensing

Suggested Reference Books:

- Planetary Geomorphology by Ronald Greeley
- Planetary Surface Processes by J. H. Melosh
- Planetary tectonics by T. R. Watters and R. A. Schultz
- Asteroids by T. H. Burbine
- Introduction to Planetary Science by G. Faure and T.M. Mensing

GEOL452C21: Basin Analysis

Credits - 4

Theory

1. Purpose and scope of basin analysis. Basin mapping methods: structure and isopach contouring, lithofacies maps, paleocurrent analysis, stratigraphic architecture analysis, paleohydrology.
2. Tectonics and sedimentation: Sedimentary basins in different tectonic settings. Examples from India (Epeiric platforms, rift valleys, passive margins, foreland basins, active margins).
3. Principles and Methods of provenance analysis.
4. Application of well log analysis in sequence stratigraphy, sequence stratigraphy of carbonate platforms, fluvial sequence stratigraphy. Sedimentary ore deposits and hydrocarbon resources in relation to sequence stratigraphy
5. Subsidence and thermal history of sedimentary basins.

Practical

1. Exercises related to determination of source area and tectonics from composition of sandstones.
2. Exercises related to environmental reconstruction and sequence stratigraphy of siliciclastic and carbonate successions.

Suggested Readings:

1. Catuneanu, O., 2006. Principles of Sequence Stratigraphy. Elsevier, Amsterdam, 375 pp.
2. Leeder, M.R., 1982. Sedimentology: Process and Product. George Allen & Unwin, London, 344p.
3. Einsele, G., 2000. Sedimentary Basins, Springer.
4. Miall, A.D., 1999. Principles of Sedimentary Basin Analysis 3rd ed Springer Verlag, New York.
5. Nichols, G., 1999. Sedimentology and Stratigraphy, Blackwell publishing.
6. Reading, H. G., 1996. Sedimentary Environments: Processes, Facies and Stratigraphy, Blackwell Publishers
7. Sam Boggs, 1995. Principles of Sedimentology and Stratigraphy, Prentice Hall, New Jersey.
8. Tucker, M.E., 2006. Sedimentary Petrology. Blackwell Publishing.
9. Tucker, M.E. and Wright, V.P., 1990. Carbonate Sedimentology, Blackwell.
10. Walker, R.G., Facies model 1976. Geoscience Canada.
11. Posamentier, H.W., and Walker, R.G., 2006. Facies Models revisited, SEPM

GEOL453C22: Atmosphere, Ocean, and Climate Dynamics

Credits - 4

Theory

Unit 1: Climate system: Forcing and Responses Components of the climate system. Climate forcing, Climate controlling factors, Responses and Feedbacks. Insolation and Earth's heat budget

Unit 2: Ocean-Atmosphere Interaction: Thermal stratification and chemical composition of atmosphere. Atmospheric circulations. Atmosphere and ocean interaction and its effect on climate, ENSO, IOD, cyclones, and anti-cyclones. ENSO and the Indian Monsoon

Global oceanic conveyor belt and its control on earth's climate.

Unit 3: Chemistry of Seawater: Physical properties of water. Composition of seawater. Variation in concentration of solutes in the oceans: conservative vs non-conservative; Residence time. Carbon dioxide-carbonate system; alkalinity and control of pH; biological pump

Unit 4: Climatic cyclicity and major climatic events: Milankovitch cycles and variability in the climate. Interplay of tectonic-weathering and climate in geological time. Important climatic events.

Unit 5: Basics of palaeoclimatology: Archives of climate change and paleoclimate. Interpretation of proxy records for paleoclimate, Applications of elemental and isotope geochemistry in palaeoclimatology

Unit 6: Ocean in a Changing World: The Keeling curve; Drivers and mechanisms of ocean deoxygenation, Ocean acidification; Ocean circulation in a warming climate

Tutorial

Suggested Reference Books:

Millero, F. J. (2005). Chemical oceanography (Vol. 30). CRC press.

Lamb, H. H. (2013). Climate: present, past and future (Routledge revivals): volume 2: climatic history and the future. Routledge.

Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlett

Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher

Aguado, E., and Burt, J., 2009. Understanding weather and Climate. 5th Edition, Pearson Publisher

Dorothy Merritts, Kirsten Menking and Andrew deWet, 2014. Environmental Geology: An Earth Systems Science Approach. Edition 2, W.H.Freeman and Co Ltd

GEOL491C23: Project/ Dissertation

Credits – 8

Suggested Readings:

- Valdiya, K. S. Environmental geology, Indian context. Tata McGraw-Hill Pub. Co., 1987.
- Bennett, Matthew R., and Peter Doyle. *Environmental geology: geology and the human environmental*. John Wiley, 1997.
- Botkin, Daniel B., and Edward A. Keller. *Environmental science: earth as a living planet*. No. Ed. 2. John Wiley & Sons Ltd, 1998.
- Mareddy, Anji Reddy, Shah, A. and Davergave, N. *Environmental impact assessment: theory and practice*. Butterworth-Heinemann, 2017.
- Reichard, J. *Environmental Geology 3rd Edition*. McGraw Hill, 2017.

GEOL104MC01: Essentials of Geology

Credits - 6: (Theory- 04, Practical- 02)

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1

Introduction to geology: scope, sub-disciplines and relationship with other branches of sciences.

Unit 2

Earth in the solar system, origin.

Earth's size, shape, mass, density, rotational and evolutionary parameters.

Solar System- Introduction to various planets - Terrestrial Planets, Jovian Planets.

Unit 3: Solid Earth, Hydrosphere, Atmosphere and Biosphere

Mechanical layering of the Earth: lithosphere, asthenosphere, mantle and core.

Earthquake and earthquake belts: seismic waves and internal constitution of the Earth.

Volcanoes and volcanism, distribution of volcanoes.

Concept of isostasy.

Formation of core, mantle, crust, atmosphere, hydrosphere and biosphere.

Convection in Earth's core and production of its magnetic field.

Geothermal gradient and internal heat of the Earth.

Unit: 4. Rocks, Mineral and fossils

Definition. General character. Usefulness.

Unit 5: Plate Tectonics

Fundamental Earth process: plate tectonics.

Plates and plate boundaries.

Origin of oceans, continents, mountains and rift valleys.

Unit 6: Earth's Surface Processes

Weathering and Erosion.

Landforms in deserts, glaciated region and river valleys.

Unit 7:

Age of the earth; radioactivity and its application in determining the age of the Earth.

Practical

Credit : 2

Contact Hours per Week : 4

Study of topographic sheets and description of physiographic features of an area.

Study of geological maps with simple outcrop patterns.

Study of distribution of major lithostratigraphic units on the map of India.

Suggested Reference Books:

Holmes' Principles of Physical Geology. (1992). Chapman and Hall.

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. Prentice Hall.

GEOL154MC02: Rocks and Minerals

Credits - 6: (Theory- 04, Practical- 02)

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1

Minerals: definitions. Physical properties of minerals. Chemical classification of minerals.

Internal structure of minerals.

Atomic structure of silicate minerals.

Unit 2

Mineralogical composition of common crustal rocks. Mineralogical Composition of mantle.

Unit 3

Rocks: Definitions and types, processes of formation of Igneous rocks, sedimentary rocks and metamorphic

rocks.

Classification of Igneous rocks (Hatch and Wells and IUGS), sedimentary rocks (Folk) and metamorphic rocks.

Concept of grade in metamorphic rocks.

Brief idea about the plate tectonic settings of the common rock types.

Practical

Credit : 2

Contact Hours per Week : 4

Study of physical properties of common rock forming minerals – quartz, feldspar, mica, calcite.

Study of common sedimentary, igneous and metamorphic rocks in hand samples – granite, basalt, dolerite,

sandstone, limestone, schist, gneiss

Suggested Reference Books:

□ Cornelis Klein and Anthony Philpotts (2013), Earth Materials- Introduction to Mineralogy and Petrology, Cambridge

University Press.

□ John Grotzinger and Thomas H. Jordan, (2010), Understanding Earth. 6th Edition, W.H. Freeman and company, New York.

GEOL205MC03A: MARTIAN GEOLOGY

Credits - 6: (Theory- 05, Tutorial- 01)

Contact Hours per Week : 7

Assessment type: End Sem Examination of Theoretical type (80 marks). Tutorial will be continuously assessed / assignment based (20 marks)

Unit 1: History of the exploration of Mars; The Journey of Mangalyaan, Evolution of Mars

Unit 2: The characteristics of Mars and its interior; The Martian atmosphere and hydrosphere.

Unit 3: Surface provinces of Mars, Surface processes on Mars and its evidences from Earth-based analogs – Impact structures, Volcanic, features on Mars, Layered deposits, Eolian dunes, Debris flow, Martian outflow channels, Glacial Origin of Fretted Terrains on Mars, Mountain building

Unit 4: Geochemical analogs and Martian meteorites, Martian time scale.

Unit 5: Life in Mars, Is there evidence for life on Mars? Physical and chemical conditions supportive of permanent Mars occupation; Terraforming of Mars and its challenges, Mars –our potential home? New Trends for Human Missions to Mars and Human colonization of Mars

Tutorial courses

Related to theory.

SUGGESTED READINGS:

- Sagan, C. (1973). Planetary Engineering on Mars, *Icarus*, 20, 513.
- Chapman, M. (Ed.). (2007). *The geology of Mars: evidence from earth-based analogs (Vol. 5)*. Cambridge University Press.
- Beech, M. (2009). The Terraforming of Mars. *Terraforming*, 125-173.

* The course can be opted after successful Completion of MC1

GEOL205MC03B: Resource Geology

Credits - 6: (Theory- 04, Practical- 02)

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1: Introduction to Earth's Resources

Types of Resources: Ore Deposits, Fossil Fuel, Groundwater

Unit 2: Ore Geology

Definitions: Basic concepts of Ores, gangue minerals, tenor, grade, resources and reserves.

Types of Ore Deposits: Brief outline of magmatic, hydrothermal, sedimentary ore forming processes

Major Metallic (Iron, Chromite, Gold, Copper, Lead-zinc) and Non-metallic ores with an overview of Indian distribution

Unit: 3: Fossil Fuels

Brief outline of Coal and Petroleum deposits with reference to nature, origin and Indian distribution

Unit 4: Ground Water

Hydrologic cycle; Origin of groundwater, vertical distribution of subsurface water. Genetic classification of groundwater.

Types of aquifer– unconfined, confined and semi-confined. Water table and piezometric surface

Groundwater quality and its societal relevance with reference to India.

Practical

Credits: 2

Contact Hours per Week : 4

Study of important ore minerals and coal samples in hand specimen.

Elementary idea of preparation and interpretation of water level contour maps.

Suggested books

- Todd, D. K. and Larry, W.M. (2005). Groundwater Hydrology, 3rd Ed. John Wiley and Sons, N.Y
- Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley

Thomas L. (2013) Coal Geology: Second Edition, John Wiley & Sons, Ltd.

GEOL255MC04A: Deep time and life

Credits - 6: (Theory- 04, Practical- 02)

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1 – Fossil and fossilization (Taphonomy)

Unit 2 – Concept of Geological time – role of fossils in establishment of geological time scale; evolutionary faunas; mass-extinctions.

Unit 3 – Taxonomy and systematics: concept and significance.

Unit 4 – Major invertebrate animals belonging to the Cambrian, Paleozoic and Modern evolutionary faunas.

Unit 5 – Vertebrates and plants through geological time: classification and major groups.

Unit 6 – Microfossils through geological time: major groups.

Unit 7 – Co-evolution of plants and animals in geological past: (1) Terrestrialization: Plants, invertebrates and vertebrates, (2) Angiosperms and insects, (3) Grasslands and grazers.

Practical

Credits: 2

Contact Hours per Week : 4

Unit 1 – Features and functional interpretation of fossil invertebrates from India

Unit 2 – Features and climatic interpretation of fossil plants from India

Unit 3 – Features and feeding habit of vertebrate teeth

Suggested Reference Books:

Benton, M.J. and Harper, D.A.T. (2009) Introduction to Paleobiology and the Fossil Record.

1 st Edition by Wiley-Blackwell

Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution. 4th Edition by Blackwell Publishing.

Benton, M. (2009). Vertebrate paleontology. 4th Edition by John Wiley & Sons.

Arnold, C.A. (2018) An Introduction to Paleobotany. Surjeet Publications

Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

GEOL255MC04B: Global Tectonics and Supercontinent cycles

Credits - 6: (Theory- 04, Practical- 02)

Theory

Credit : 4

Contact Hours per Week : 4

Unit 1

Tectonics – definitions and scope; Crustal types and their properties; active and passive continental margins.

Unit 2

Constitution of the Earth: Evidences from Seismic studies.

Earthquakes, intensity and magnitude, elastic rebound theory, focus and epicenter, seismograms. Global earthquake belts. Seismic zones of India.

Unit 3

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

Unit 4

Volcanoes and volcanism, eruptive styles.

Unit 5

Rock deformation and deformation structures.

Unit 6

Continental drift hypothesis; Seafloor spreading hypothesis; Palaeomagnetism and polarity reversals. Plate tectonics: Definition of plates; Plate motion – absolute and relative; driving forces and **evidences. Plate boundaries and orogeny.**

Practical

Credit : 2

Contact Hours per Week : 4

Drawing of block diagrams depicting tectonic features.

Interpretation of maps showing tectonic elements on planar and uneven topography.

Construction of structural cross sections.

Fault plane solutions.

Suggested Reference Books:

- Kearey, P., Klepeis, K.A., and Vine, F.J., 2009, Global Tectonics, 3rd Edn., Wiley-Blackwell, Oxford, 482 p. [Earlier edition

- of this book with Keary and Vine as authors is also useful]
- Condie, K.C., 1997, Plate tectonics and crustal evolution, 4th Edn., Butterworth-Heinemann, Oxford, 294 p.
- Press, F., Siever, R., Grotzinger, J. and Jordan, T.H., 2004, Understanding Earth, 4th Edn., W.H. Freeman, 567 p.
- Skinner, B.J., Porter, S.C. and Park, J., 2003, The Dynamic Earth: An Introduction to Physical Geology [With CDROM], John Wiley & Sons, 631 p.
- Tarbuck, E.J. and Lutgens, F.K., 2006, Earth Science, 11th Edn., Pearson Prentice Hall, New Jersey, 726 p.

GEOL405MC05: Research Methodology: Data analysis in Earth Sciences
Credit - 4

1. Basic Statistics – Classification and presentation of statistical data, measures of central tendency and dispersion, correlation and regression, probability and probability distributions, concept of population and sample, Sampling and sample distributions.
2. Concept and methodology of Hypotheses Testing and its application in geology - student's t test, F test, χ^2 test, Kolmogorov and Smirnov test.
3. Elementary matrix operations. Concept and determination of eigenvalues and eigenvectors using matrix algebra.
4. Analysis of sequences of data: Markov chains, Least square method and regression analysis, auto correlation and cross correlation.
5. Analysis of multivariate data.
6. Spatial analysis: spherical distribution, Variogram, kriging, ANOVA, fractals in geology.

GEOL455MC06: Research and Publication Ethics

Credit-4

- PHILOSOPHY AND ETHICS
 1. Introduction to philosophy: definition, nature and scope, concept, branches
 2. Ethics: definition, moral philosophy, nature of moral judgments and reactions
- SCIENTIFIC CONDUCT
 1. Ethics with respect to science and research
 2. Intellectual honesty and research integrity
 3. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)
 4. Redundant publications, duplicate and overlapping publications, salami slicing
 5. Selective reporting and misrepresentation of data
- PUBLICATION ETHICS
 1. Definition, introduction and importance
 2. Best practices/ standards setting initiative and guidelines, COPE, WAME etc.
 3. Conflicts of interest
 4. Publication misconduct, definition, concept, problems that lead to unethical behaviour and vice versa, types
 5. Violation of publication ethics, authorship and contributorship
 6. Identification of publication misconduct, complaints and appeals
 7. Predatory publishers and journals
- OPEN ACCESS PUBLISHING
 1. Open access publications and initiatives
 2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
 3. Software tool to identify predatory publications developed by SPPU
 4. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester etc.
- PUBLICATION MISCONDUCT
 - A. Group Discussion (2 hrs.)
 1. Subject specific ethical issues. FFP, authorship
 2. Conflicts of interest
 3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs.)

Use of plagiarism detecting software like Turnitin, Urkund and other open source software tools

- DATABASES AND RESEARCH METRICS

A. Databases (4 hrs.)

1. Indexing databases
2. Citation databases: Web of Science, Scopus etc.

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

GEOL105MDC01: Geochemical thermodynamics

Credits - 3: (Theory)

Contact Hours per week: 3

Unit 1: Concept of geochemical thermodynamics

- Geochemical systems: Isolated, close and open systems
- Reversible and irreversible processes
- Thermodynamic variables: Intrinsic and extrinsic
- Equilibrium, disequilibrium and steady states
- Gibb's Phase Rule

Unit 2: Laws of thermodynamics

- First Law of thermodynamics; concept of Enthalpy, Internal Energy
- Second Law of thermodynamics and concept and Entropy
- Third Law of thermodynamics and measurement of Entropy
- Gibbs' Equation and thermodynamic potentials

Unit 3: Thermodynamics of solution

- Raolt's Law and Henry's Law
- Gibbs-Duhem equation
- Activity, Fugacity and Standard State

Unit 4: Application in Geosciences

- Mineral sciences
- Petrological processes

Suggested Reference Books :

- Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
- Nordstrom, D.K. & Munoz, J.L. (1985) Geochemical thermodynamics. The Benjamin/Cummings Publishing Co.
- Ganguly, J. (2008) Thermodynamics in Earth and Planetary Sciences. Springer

GEOL191MDC02: Computational Techniques and Programming

Credits - 3: (Theory)

Contact Hours per week: 3

Unit 1: Elements of Computer Architecture

- a. Basic Computer organization and design, Digital logic circuits
- b. Computer arithmetic
- c. Memory system

Unit 2: Data Structures and Programming algorithm

- a. Introduction to data structures: algorithm and flowchart, array, types of data structures, Static and dynamic Memory allocation, Function and recursion
- b. Linked lists and tree structure
- c. Searching and sorting algorithms

Unit 3: C-Programming

- a. Elements of C Language
- b. Concept of user defined data types
- c. Functions and pointers
- d. File handling in C

Unit 4: Commonly used Softwares in Earth Science studies

Suggested Readings:

E. Horowitz and Sahni, S., 1982, Fundamentals of Data Structures , Computer Science Press, Maryland, USA.

Kanetkar, Yashavant P., 2004, Let us C. BPB publications, India.

Mano, M. Morris., 2003, Computer system architecture. 3rd Edition, Prentice-Hall of India.

GEOL156MDC03:Evolutionary Palaeobiology

Credits - 3: (Theory)

Unit 1: Fossil and Fossilization: Chemical composition of skeletal and soft body parts, and their preservability. Relative abundance of skeletal types with respect to composition. Fossilization – conditions, processes (Taphonomy) and modes; Fossil lagerstätten, soft part preservation.

Unit 2: Organisms through the dimension of time – Geological time scale and evolutionary faunas. An introduction to the concept of biostratigraphy.

Unit 3: An introduction to the principles of organic evolution – speciation, micro- and macroevolution, theories of evolution.

Unit 4 – Fossils and Geography – disjunct distribution; dispersal mechanisms of different types of organisms; controls on dispersal.

Suggested Reference Books:

Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution. 4th Edition by Blackwell Publishing.

Foote, M. and Miller, I.A. (2007) Principles of Paleontology. 3 rd Edition by W. H. Freeman and company

Benton, M.J. and Harper, D.A.T. (2009) Introduction to Paleobiology and the Fossil Record. 1st Edition by Wiley-Blackwell