COURSE-STRUCTURE
10-Semester BSc-MSc Degree
BSc Geology (Honours)
1000 marks-(96-credit Major) (1 to 6 Semester)
B. Sc. First Semester

Year 1, Semester 1 (100 Marks = Th 50 + Pr 50)
Theory (50) Major - 1

Paper	Group	Name & Description	Marks (Internal Assessment*)	Credit Point
Major –Theory 1 (GEOL 0101)	A	Introduction to Earth Systems Science	30 (20+10*)	2
	B	Crystallography and Crystal chemistry	20 (15+5*)	2
		TOTAL	**50**	**4**

Practical (50) Major – P1

Paper	Group	Name & Description	Marks	Credit Point
Major – Pract. 1 (GEOL 0191)		Introduction to minerals, rocks, toposheets and attitudes of strata (Toposheet study Hand specimen study of Rocks and Minerals Crystallography Elementary problems of structural geology)	50	
		TOTAL	**50**	**6**

Field Work-1 (for about two weeks duration compulsory) (introduction to rock types and elements of geological mapping)

B. Sc. Second Semester

Year 1, Semester 2 (100 Marks = Th 50 + Pr 50)

Theory (50) Major – 2

Paper	Group	Name & Description	Marks (Internal Assessment*)	Credit Point
Major –Theory 2 (GEOL 0201)		Mineralogy	50 (35+15*)	
		TOTAL	**50**	**4**

Practical (50) Major – P2

Paper	Group	Name & Description	Marks	Credit Point
Major – Pract. 2 (GEOL 0291)	A	Optical Mineralogy	35	
	B	Field Report	15	
		TOTAL	**50**	**6**

B. Sc. Third Semester

Year 2, Semester 3 (150 Marks = Th 100 + Pr 50)
Theory (100) Major – 3 & 4

Paper	Group	Name & Description	Marks (Internal Assessment*)	Credit Points
Major –Theory 3 (GEOL 0301)		Sedimentology	50 (35+15*)	4
Major –Theory 4 (GEOL 0302)		Structural Geology	50 (35+15*)	4
		TOTAL	**100**	**8**

Practical (50) Major – P3

Paper	Group	Name & Description	Marks	Credit Points
Major –Pract.3 (GEOL 0391)	A	Sedimentology	35	
	B	Structural Geology 1 (Graphical & Stereographic Problems)	15	
		TOTAL	**50**	**6**

Field Work 2 (of about three weeks duration compulsory) (geological mapping)

B. Sc. Fourth Semester

Year 2, Semester 4 (150 Marks = Th 100 + Pr 50)
Theory (100) Major – 5 & 6

Paper	Group	Name & Description	Marks (Internal Assessment*)	Credit Points
Major –Theory 5 (GEOL 0401)		Igneous Petrology	50 (35+15*)	4
Major –Theory 6 (GEOL 0402)		Metamorphic Petrology	50 (35+15*)	4
		TOTAL	**100**	**8**

Practical (50) Major – P4

Paper	Group	Name & Description	Marks	Credit Points
Major –Pract. 4 (GEOL 0491)	A	Metamorphic petrology	35	
	B	Field Report	15	
		TOTAL	**50**	**6**

B. Sc. Fifth Semester

Year 3, Semester 5 (250 Marks = Th 150 + Pr 100)

Theory (150) Major – 7, 8 & 9

Paper	Group	Name & Description	Marks (Internal Assessment*)	Credit Points
Major –Theory 7 (GEOL 0501)		Palaeontology I	50 (35+15*)	4
Major –Theory 8 (GEOL 0502)		Geodynamics	50 (35+15*)	4
Major –Theory 9 (GEOL 0503)		Economic Geology	50 (35+15*)	4
		TOTAL	**150**	**12**

Practical (100) Major – P5 & P6

Paper	Group	Name & Description	Marks	Credit Points
Major –Pract. 5 (GEOL 0591)		Igneous petrology	50	6
Major –Pract. 6 (GEOL 0592)		Interpretation of Geological Maps	50	6
		TOTAL	**100**	**12**

Field Work 3: (for about two weeks compulsory) (mines visit and stratigraphic studies)

B. Sc. Sixth Semester

Year 3, Semester 6 (250Marks = Th 150 + Pr 100)

Theory (150) Major – 10, 11 & 12

Paper	Group	Name & Description	Marks (Internal Assessment*)	Credit Points
Major –Theory 10 (GEOL 0601)		Precambrian stratigraphy of India	50 (35+15*)	4
Major –Theory 11 (GEOL 0602)		Phanerozoic stratigraphy of India	50 (35+15*)	4
Major –Theory 12 (GEOL 0603)	A	Paleontology II	30 (25+10*)	4
	B	Geohydrology-Engineering Geology-Geohazards	20 (15+5*)	
		TOTAL	**150**	**12**

Practical (100) Major – P7 & P8

Paper	Group	Name & Description	Marks	Credit Points
Major –Pract. 7 (GEOL 0691)	A	Palaeontology	50	6
Major –Pract. 8 (GEOL 0692)	A	Ore Geology	35	6
	B	Field report	15	
		TOTAL	**100**	**12**

GenEDs : (50 marks/4-credit each)

Department may offer interdisciplinary GenEDs for students of all disciplines: some examples:

1. **Earth, Atmosphere and Life: Early Days**
2. **Earth: The Living Planet**
3. **Mass extinction/Apocalypse in Earth's history**
4. **Man and Environment**

- *The evaluation for any practical paper in Major and GenED may be based on continuous assessment method.*

COURSE-STRUCTURE
Applied Geology
M. Sc.
80 Credit course (20-credit /semester) (1 to 4 Semester)

PG Semester I (Theory 150 + Practical 100 = 250)

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL0701: I		Geochemistry	50 (35+15*)	**4**
GEOL0702: II	A	Coal and **Nuclear fuels**	20 (15+5*)	2
	B	Engineering Geology	30 (25+10*)	2
GEOL0703: III		Petroleum Geology	50 (35+15*)	**4**

Practical

Paper	Group	Subject	Marks	Credit
GEOL0791: PR I		Hydrogeology I	50	**4**
GEOL0792: PR II		Hydrogeology II	50	**4**

Field Work of two (02) weeks duration (Compulsory)

PG Semester II (Theory 150 + Practical 100 = 250)

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL0801: V		Geophysics	50 (35+15*)	4
GEOL0802: VI		Remote sensing and GIS	50 (35+15*)	4
GEOL0803: VII		Mineral Exploration, Mining and orebody modeling	50 (35+15*)	4

Practical

Paper	Group	Subject	Marks	Credit
GEOL0891: PR II		Remote sensing and GIS	50	**4**
GEOL0892: PRIII		Ore Reserve Estimation and Modelling	50	**4**

Industrial Training/Summer Project of two/three (02/03) weeks duration

PG Semester III (Theory150 + Practical 100 = 250)

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL0901: VIII		Compulsory Module I & II	50 (35+15*)	**4**
GEOL0902: IX		Elective Module I & II	50 (35+15*)	4
GEOL0903: X		Assignments related to Dissertation	50 (35+15*)	**4**

Practical

Paper	Group	Subject	Marks	Credit
GEOL0991: PR-IV		Field work and Viva Voce	50	**4**
GEOL0992: PR-V	A	Open Seminar	25	2
	B	Industrial training/Summer Project	25	2

***PG Semester X (Theory 150 + Practical 100= 250)**

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL1001: XI		Research methodologies - Analytical Techniques, 'Scientific writing' skill	50 (35+15*)	4
GEOL1002: XII		Research methodologies - Geomathematics and computational methods I	50 (35+15*)	4
GEOL1003: XIII		Geomathematics and computational methods II	50 (35+15*)	4

Practical

Paper	Group	Subject	Marks	Credit
GEOL1091: PR-VI		Evaluation of Dissertation	50	4
GEOL1092: PR-VII		Seminar-Viva-voce on Dissertation	50	4

- *The evaluation for any practical paper may be based on continuous assessment method.*
- *The assessment for any theory or practical paper of last two Semesters may be based on either end-semester examination or sessional assessment or term paper based assessment or seminar based assessment or continuous evaluation or any combination thereof.*
- ****The x- semester course may fulfill the 20-credit mandatory course requirement for PhD degree subject to the approval of the University. This will facilitate our master's students to minimize time taken for PhD and for those of our Master's degree holders in employment who would like to pursue PhD degree and otherwise will not be able to manage continuous leave for 6 months to undertake the mandatory course.***

Syllabus for
Undergraduate GenEd Course
in Geology

Department of Geology,
Presidency University, Kolkata

To be introduced from 2013-14 academic session

Syllabus for Undergraduate GenEd Course in Geology

Paper Code: ***GenEd-GEOL-01***

The Earth, Atmosphere and Life: Early Days

Full Marks 50: 4 Credit

Marks: 35

1. Elementary information on the Universe and the Solar System, members of the Solar System. Origin of the Solar System, Nebular Hypothesis, formation of planets. Origin of the Moon. Major types of Meteorites.
2. Differentiation of Earth's core, mantle and crust.
3. Earth's materials, minerals and rocks. Broad groups of minerals and rocks.
4. Earth's oldest rocks. Nature of early crust.
5. Early atmosphere and Rise of atmospheric oxygen.
6. Origin of life: Brief idea on the origin of life. Biomarkers, Early life: fossil record of early protoctists, evolution of metazoans, Ediacaran fauna; Cambrian explosion.

Practical/Projects/Internal Assignment:

Marks: 15

Earth's materials: study of minerals and rocks in Laboratory or in field, or Projects related to Earth's materials

Suggested books on Introduction to Earth Systems Science

Text

1. Press, F., Siever, R., Grotzinger, J. and Jordan, T.H., 2004, Understanding Earth, 4th Edn., W.H. Freeman, 567 p.
2. Tarbuck, E.J. and Lutgens, F.K., 2006, Earth Science, 11th Edn., Pearson Prentice Hall, New Jersey, 726 p.
3. Roy, A. B., 2010, Fundamentals of Geology, Narosa Publishing House, p. 316.
4. Bose, M.K., 1997, Igneous Petrology, World Press, Kolkata, 568 p.
5. Park, R. J., 2004, Foundations of Structural Geology, Routledge, 3rd Edition, p. 202.
6. 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.
7. Mukherjee, P. K., Text book of Geology, The world press Pvt. Limited.

Paper Code:

Earth: The Living Planet: *GenEd-GEOL-02*

Full Marks 50

Marks: 35

1. Internal Constitution of the Earth: Evidences from Seismic studies
2. Earthquakes, intensity and magnitude, elastic rebound theory, focus and epicenter, seismograms. Global earthquake belts. Seismic zones of India.
3. Gravity and gravity anomaly on Earth, Bouguer and free-air anomaly. Concept of isostasy and compensation, hypotheses of Airy, and Pratt.
4. Volcanoes and volcanism, eruptive styles.

5. Earth's surface processes. Weathering, erosion, mass wasting and sedimentation; bed rock, regolith, soil, soil profile. Erosion, transportation and deposition.
6. Rock deformation and deformation structures
7. Plate tectonics: Definition of plates; Plate motion – absolute and relative; driving forces and evidences. Plate boundaries and orogeny.

Practical/Projects/Internal Assignment:

Marks: 15

Study of rock deformations in laboratory/in field, or Projects related to rock deformation

Suggested books :

1. Press, F., Siever, R., Grotzinger, J. and Jordan, T.H., 2004, Understanding Earth, 4th Edn., W.H. Freeman, 567 p.
2. Tarbuck, E.J. and Lutgens, F.K., 2006, Earth Science, 11th Edn., Pearson Prentice Hall, New Jersey, 726 p.

Paper Code: *GenEd-GEOL-03*
Mass extinction/Apocalypse in Earth's history
Full marks: 50: 4 Credit

Marks 35

1. Life in the Precambrian – prokaryotes, eukaryotes, metazoans;
2. Cambrian explosion, the evolutionary Big Bang.
3. Mass-extinction – definition, history of study; big extinction events – end-Ordovician, Late Devonian, end-Permian, end-Triassic, end-Cretaceous; evidences and causes;
4. Tempo of evolution – mass-extinction and adaptive radiation as sources of change;
5. Sixth big mass-extinction of the Recent – man vs. nature.

Practical/Projects/Internal Assignment:

Marks: 15

Study of fossils in laboratory/in field, or Projects related to life in rock record

Suggested books :

1. Ray, A.K.: Fossils in Earth Sciences.
2. Clarkson, E.N.K.: Invertebrate Palaeontology and Evolution
3. Doyle, P.: Understanding Fossils.
4. Foote, M. and Miller, A.I.: Principles of Paleontology
5. Lieberman, B.S. and Kaesler, R.: Prehistoric Life.

Paper Code: *GenEd-GEOL-03*
Man and Environment
Full marks: 50: 4 Credit

Marks 35

1. Concept of risk, hazards, disaster and catastrophe.
2. Natural hazards and Environmental impacts: earthquake, volcanism, landslides, floods, Erosions, droughts, dams and reservoirs.

3. Preliminary concepts of pollution: air, water, soil and noise pollution, Biochemical Cycle, eutrophication, greenhouse effect and climate change, acid rain, pesticide contamination; the chemical parameters affecting water, air, soil, sediment qualities
4. Climate change and global warming; sea level rise.
5. Ore deposits, Mining and environment; concepts of sustainability.
6. Solid and nuclear waste disposal.
7. Carbon cycle and carbon sequestration
8. The effect of anthropogenic activities on the environment.
9. Global Environmental concerns; Environmental Treaties and Accords.

Practical/Projects/Internal Assignment:

Marks: 15

Projects on Application of GIS in environmental monitoring/EIA/Natural Hazard Management/Environmental Policies/Climate Change/any related issues.

Suggested books:

1.Edward Kellar, Environmental Geology, 9th Edition
2.D Foley, G McKenzie, R Utgard, Investigations in Environmental Geology, 3rd Edition
3.T Hudson, Living with Earth: An introduction to Environmental Geology
4.Singh, Parbin, Engineering and General Geology, S. K. Kataria and Sons, Delhi - 110 006
5.Waltham, T, Foundations of Engineering Geology, 3rd Edition
6.Alverson K.D., Bradley R.S., Pedersen T.F. [Eds.] 2003. Paleoclimate, global change and the future. Springer, Berlin.
7.Selinus O. 2005. Essentials of medical geology: Impacts of the natural environment on public health. Academic Press.
8.Manahan S. E. 2009. Environmental Chemistry, 9th ed. CRC Press

Syllabus for
Undergraduate Course
in Geology

COURSE-STRUCTURE
Geology (Honours)
B. Sc. First Semester

Year 1, Semester 1 (100 Marks = Th 50 + Pr 50)

Theory (50) Major - 1

Paper	Group	Name & Description	Marks	Credit Point
Major - 1	A	Introduction to Earth Systems Science	30	2
	B	Crystallography and Crystal chemistry	20	2
		TOTAL	**50**	**4**

Practical (50) Major – P1

Paper	Group	Name & Description	Marks	Credit Point
Major – P1	A	Introduction to minerals, rocks, toposheets and attitudes of strata (Toposheet study Hand specimen study of Rocks and Minerals Crystallography Elementary problems of structural geology)	35	
	B	Internal Assignment	15	
		TOTAL	**50**	**4**

Field Work-1 (for about two weeks duration compulsory) (introduction to rock types and elements of geological mapping)

B. Sc. Second Semester

Year 1, Semester 2 (100 Marks = Th 50 + Pr 50)

Theory (50) Major – 2

Paper	Group	Name & Description	Marks	Credit Point
Major – 2		Mineralogy	50	
		TOTAL	**50**	**4**

Practical (50) Major – P2

Paper	Group	Name & Description	Marks	Credit Point
Major – P2	A	Optical Mineralogy	25	
	B	Field Report	10	
	C	Internal Assignment	15	
		TOTAL	**50**	**4**

B. Sc. Third Semester

Year 2, Semester 3 (150 Marks = Th 100 + Pr 50)

Theory (100) Major – 3 & 4

Paper	Group	Name & Description	Marks	Credit Points
Major – 3		Sedimentology	50	4
Major – 4		Structural Geology	50	4
		TOTAL	**100**	**8**

Practical (50) Major – P3

Paper	Group	Name & Description	Marks	Credit Points
Major – P3	A	Sedimentology	20	
	B	Structural Geology 1 (Graphical & Stereographic Problems)	15	
	C	Internal Assignment	15	
		TOTAL	**50**	**4**

Field Work 2 (of about three weeks duration compulsory) (geological mapping)

B. Sc. Fourth Semester

Year 2, Semester 4 (150 Marks = Th 100 + Pr 50)

Theory (100) Major – 5 & 6

Paper	Group	Name & Description	Marks	Credit Points
Major - 5		Igneous Petrology	50	4
Major - 6		Metamorphic Petrology	50	4
		TOTAL	**100**	**8**

Practical (50) Major – P4

Paper	Group	Name & Description	Marks	Credit Points
Major – P4	A	Metamorphic petrology	25	
	B	Field Report	10	
	C	Internal Assignment	15	
		TOTAL	**50**	**4**

B. Sc. Fifth Semester

Year 3, Semester 5 (250 Marks = Th 150 + Pr 100)

Theory (150) Major – 7, 8 & 9

Paper	Group	Name & Description	Marks	Credit Points
Major – 7		Palaeontology I	50	4
Major – 8		Geodynamics	50	4
Major – 9		Economic Geology	50	4
		TOTAL	**150**	**12**

Practical (100) Major – P5 & P6

Paper	Group	Name & Description	Marks	Credit Points
Major – P5	A	Igneous petrology	35	4
	B	Internal Assignment	15	
Major – P6	A	Interpretation of Geological Maps	35	4
	B	Internal Assignment	15	
		TOTAL	**100**	**8**

Field Work 3: (for about two weeks compulsory) (mines visit and stratigraphic studies)

B. Sc. Sixth Semester

Year 3, Semester 6 (250Marks = Th 150 + Pr 100)

Theory (150) Major – 10, 11 & 12

Paper	Group	Name & Description	Marks	Credit Points
Major - 10		Precambrian stratigraphy of India	50	4
Major - 11		Phanerozoic stratigraphy of India	50	4
Major - 12	A	Paleontology II	25	4
	B	Geohydrology-Engineering Geology-Geohazards	25	
		TOTAL	**150**	**12**

Practical (100) Major – P7 & P8

Paper	Group	Name & Description	Marks	Credit Points
Major – P7	A	Palaeontology	35	4
	B	Internal Assignment	15	
Major – P8	A	Ore Geology	25	4
	B	Field report	10	
	C	Internal Assignment	15	
		TOTAL	**100**	**8**

DETAILED SYLLABUS

B. Sc. First Semester

Theory

Major – 1 Full marks 50

Group A: Introduction to Earth Systems Science; Marks – 30; Lectures – 36

1. Elementary information on the Universe and the Solar System, members of the Solar System. Origin of the Solar System, Nebular Hypothesis, formation of planets. Origin of the Moon. Major types of Meteorites. Differentiation of Earth's core, mantle and crust, formation of Earth's oceans and atmosphere. Earth's oldest rocks. Nature of early crust, early atmosphere and Rise of atmospheric oxygen. Origin of life; History of development of geological thoughts, Neptunism, Plutonism, Uniformitarianism, Law of Superposition, Law of Faunal succession. Contribution of Werner, Hutton, Smith and Lyell.
2. Earth's materials: minerals and rocks. Broad groups of minerals. Rocks as mineral assemblages, fabric, texture. *Igneous rocks* - general classification, texture, common rock types. *Sedimentary rocks* – general classification, texture, common rock types, and primary sedimentary structures. *Metamorphic rocks*: general classification, texture, common rock types.
3. Internal Constitution of the Earth, Crustal movements and deformation structures
4. Concept of Stratigraphy. Principles of determination of relative and absolute ages of rock bodies and geologic events. Concept of unconformity. Geologic Time Table up to the level of Era and Period.
5. Earth's surface processes. Weathering, erosion, mass wasting and sedimentation; 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; drainage pattern. Ice ages, evidence and causes. Oceanic and atmospheric circulation patterns.
6. Earth Systems Science: Definitions and Scope. Branches of Geology. Role of geologists in sustainable development.

Suggested books

Text

8. Press, F., Siever, R., Grotzinger, J. and Jordan, T.H., 2004, Understanding Earth, 4th Edn., W.H. Freeman, 567 p. [A later 5th Edn., will also be useful]
9. Tarbuck, E.J. and Lutgens, F.K., 2006, Earth Science, 11th Edn., Pearson Prentice Hall, New Jersey, 726 p. [Earlier editions e.g. 10th or 9th, or even earlier, will also be useful].

Reference

10. 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. [Earlier editions will also be helpful]
11. Skinner, B.J., 2010, The Blue Planet: An Introduction to Earth System Science, John Wiley & Sons, 592 p.

Group B: Crystallography and Crystal Chemistry ; Marks – 20; Lectures – 28

1. Essential characteristics of crystalline and non-crystalline states of matter. Definition of crystal. Morphological elements of a crystal.
2. Interfacial angle, law of constancy of interfacial angles, crystallographic axes, notation of crystal faces, edges and corners, Miller indices, law of rational indices, zone, concept of tautozonality.
3. Principles of stereographic projection.
4. Crystal symmetry: Definition, elements of symmetry, Hermann-Mauguin notation, crystal forms – classification and nomenclature.
5. Classification of crystal into 7 systems and 32 classes; their Hermann-Mauguin notation and representation of symmetry elements; symmetry, forms and representative minerals of seven normal classes.
6. Crystal habit, types of crystal aggregates, twinning in crystals.
7. Space lattice, unit cell, lattice symmetry.
8. Diffraction of X-ray by crystal lattice, Bragg's law.
9. Crystal chemistry: chemical bonds of different types, crystal types, Coordination Principles, Pauling's Rules, Polymorphism types and examples, solid solution and exsolution.

Suggested books

Text

1. Klein, C., 2002, The Manual of Mineral Science, 22nd Edn., John Wile & Sons, 641 p. [Earlier editions of this book with Hurlbut and Klein as authors will be also useful]

Reference

2. Nesse, W.D., 2000, Introduction to Mineralogy, Oxford University Press, Oxford, 442 p.
3. Atkins, P.W. 1983, Physical Chemistry, Second ELBS Edition, Oxford University Press, Oxford, 1095 p.

Practical Paper

Major – P1 Full Marks: 50

Group A: Introduction to minerals, rocks, toposheets and attitudes of strata

(Toposheet study Hand specimen study of Rocks and Minerals, Crystallography, Elementary problems of structural geology)

Marks 35

1. Study of different contour patterns; Reading and interpretation of topographic maps and preparation of topographic cross sections.
2. Graphical solution of true dip – apparent dip problems, three-point problems.
3. Systematic study of the minerals in hand specimens listed below on the following points: Form and structure, colour, transparency, lustre, streak, cleavage, parting, fractures, hardness, specific gravity, magnetism, and treatment with dilute HCl. Haematite, magnetite, goethite, ilmenite, chromite, pyrolusite, psilomelane, bauxite, pyrite, chalcopyrite, stibnite, sphalerite,

galena, calcite, aragonite, dolomite, magnesite, siderite, malachite, fluorite, gypsum, barite, wolframite, apatite, graphite, quartz, feldspar, muscovite, biotite, pyroxene, amphibole, beryl, tourmaline, garnet, serpentine (including asbestos variety), talc, chlorite, kyanite, sillimanite, staurolite, zeolite, asbestos.

4. Identification of the following rock types in hand specimen by studying mineralogical composition and texture: Granite, granodiorite, syenite, nepheline syenite, aplite, granophyre, diorite, gabbro, anorthosite, pyroxenite, peridotite, mica-lamprophyre, dolerite, basalt, andesite, and rhyolite.

5. Description and identification of the following rocks in hand specimens : quartzite, marble, schists (including biotite-, muscovite-, chlorite-, garnet-, staurolite-, hornblende- kyanite-, schists), amphibolite, charnockite/enderbite, khondalite, calc-silicate rock, mafic granulite.

6. Description and identification of different clastic and non-clastic rocks.

7. Study of crystal models: symmetry elements and forms.

8. Orthographic projection of isometric, tetragonal and orthorhombic crystal models.

9. Clinographic projection of cube, octahedron and dodecahedron.

10. Stereographic projection (with and without the stereonet) of given crystallographic data; determination of axial ratio, interfacial angles and system of crystal from stereographic projection.

Group B ***Internal Assignment*** ***Marks 15***

B. Sc. Second Semester

Theory

Major – 2 Full Marks – 50

Mineralogy ; Marks – 50; Lectures - 64

1. Scope and definitions; Physical properties of minerals, classification of minerals
2. Crystal structure of silicates; Effect of changing pressure, temperature and composition in silicate structures; Composition and generalized formula of different mineral groups and calculation of their structural formulae, optical properties of major rock forming minerals.
3. Defects in crystal structure – Point, Line and Planar defects; Role and nature of defects in mineral behaviour.
4. Energetics and mineral stability –Solid solutions, exsolution and ordering, transformation processes in minerals, polymorphic transition
5. Optical behaviour of crystals: polarization, refractive index and indicatrix, interference phenomena, birefringence, extinction, Michael Levy chart of interference colours, pleochroism, extinction.
6. Interference phenomenon in convergent light, interference figures, and use of interference figures for determination of optic sign.

Suggested books

Text

1. Putnis, A. 1992, An Introduction to Mineral Sciences, Cambridge University Press.
2. Nesse, W.D., 2003, Introduction to Optical Mineralogy, 3rd Edn., Oxford University Press.[Older edition of this book will also be useful].
3. Klein, C., 2002, The Manual of Mineral Science, 22nd Edn., John Wile & Sons, 641 p. [Earlier editions of this book with Hurlbut and Klein as authors will be also useful]

Reference

4. Deer, W.A., Howie, R. Zussman, J., 1992, An Introduction to Rock Forming Minerals, 2nd Revised Edn, Pearson Education Limited, 712 p. [Any edition of this book will be equally useful].
5. Nesse, W.D., 2000, Introduction to Mineralogy, Oxford University Press, New York, 442 p.

Practical Paper

Major – P2 Full Marks: 50

Group A; Optical Mineralogy; Marks - 25

1. Study of some major and minor minerals in transmitted and polarized light.

2. Becke test, determination of order of interference colour, use of 1 lambda, and ¼ lambda accessory plate; sign of elongation, extinction angle, scheme of pleochroism of minerals.
3. Determination of optic sign of uniaxial minerals from interference figure

Group B; Field Report; Marks - 10

Group C; Internal Assignment; Marks - 15

B. Sc. Third Semester

Theory

Major –3 Full Marks: 50

Sedimentology ; Full Marks – 50; Lectures - 64

1. Introduction: Scope and purpose, classification of sedimentary rocks
2. Texture of sedimentary rocks
3. Outline of principles of sediment transport and deposition, primary sedimentary structures, paleocurrent analysis.
4. Petrology of sedimentary rocks: Definition, composition, classification, diagenesis and broad implications: Siliciclastic rocks, Carbonate rocks, Siliceous sedimentary rocks (chert and banded iron formation) and Volcaniclastic rocks.
5. Facies Analysis: Facies Models for major depositional systems of siliciclastics and carbonate sediments.
6. Basin tectonics
7. Sequence Stratigraphy
8. Principles of stratigraphy: stratigraphic units and stratigraphic correlation. Geochronology: principles of Rb-Sr, Sm-Nd, and U-Pb dating and their applicability

Suggested books

Text

1. Pettijohn, F.J., 1975, Sedimentary Rocks, 3rd Edn., Harper and Row, New York, 628 p.
2. Tucker, M.E., 2001, Sedimentary Petrology – an introduction to the origin of sedimentary rocks, Blackwell, Oxford, 262 p.
3. Folk, R.L., 1974, Petrology of Sedimentary Rocks, Hemphill Publishing Company, Austin, 159 p.
4. Collison, J.D. and Thompson, D.B., 1989, Sedimentary Structures, Allen and Unwin, London, 194 p.
5. Allen, J.R.L., 1985, Principles of Physical Sedimentology, Allen and Unwin, London, 272 p.

Reference

6. Boggs, S.Jr., 2006, Principles of Sedimentology an d Stratigraphy, 4th Edn., Prentice Hall, New Jersey.
7. Reineck, H.E. and Singh, I.B., 1980, Depositional Sedimentary Environments, 2nd Edn., Springer-Verlag, Berlin, 551 p.
8. Blatt, H., Middleton, G., and Murray, R., 1972, Origin of Sedimentary Rocks, 2nd Edn., Prentice-Hall, New Jersey, 782 p.
9. Leeder, M.R., 1999, Sedimentology and Sedimentary Basins: from turbulence to tectonics, Blackwell, Oxford, 592 p.
10. Tucker, M.E. and Wright, V.P., 1990, Carbonate Sedimentology, Blackwell, Oxford, 482 p.

Major –4 Full Marks: 50

Structural Geology; Full Marks – 50; Lectures - 64

1. Structural elements, their orientation and representation in projection diagrams.
2. Unconformity: types of unconformity, criteria for distinguishing unconformity from faults and intrusive contacts.
3. Folds, parts of a fold, antiform, synform, neutral fold, anticline, syncline, nomenclature of folds based on fold shape and orientation of axis and axial plane. Equal area projection diagrams of different types of folds. Ramsay's classification of folds, variation of thickness of folded layers, isogons. Outcrops of folded planes on horizontal and sloping surfaces. Relation between major folds and minor folds. Basic concepts of superposed deformation, interference patterns in superposed folding.
4. Faults: translational and rotational, slip and separation; nomenclature of faults based on geometrical relation of faults to beds, slip and separation. Effects of faults on outcrop of strata. Fault zone rocks, Criteria for recognition of faults. (8)
5. Joint sets and joint systems, relation of joints to folds. (1)
6. Foliation: morphological features of cleavage and schistosity, morphological classification of rock cleavage. Relation of cleavage and schistosity to major folds.
7. Types of lineation and their geometrical relation to folds.
8. Concept of stress, normal stress, shear stress, principal axes of stress, stress ellipse concept, planes of maximum shear stress, Mohr Circle of stress. (6)
9. 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 and their types, concept of progressive deformation. (6)
10. Factors controlling deformation behaviour of rocks – confining pressure, temperature, time, solution. Brittle and ductile deformation. Creep of rocks, elastic, viscous, and plastic behaviour. (4)
11. Fold mechanics, Concept of buckle (flexure), flexure slip, bending and slip (shear) folds, geometrical characteristics of folds formed by buckling and inhomogeneous simple shear.
12. Fracturing of rocks: tension and shear fractures; mechanics of faulting: Anderson's theory. (1)
13. Geometry of fold-thrust belt, fault related folding, autochthon, allochthon, nappe, window, klippe and duplex structure. (2)
14. Shear zone, basic concepts, shear zone rocks, common structures in shear zones. (2)

Suggested books

Text

1. Davis, G.H. and Reynolds, S.J., 1996, Structural Geology of Rocks and Regions, 2nd Edn., John Wiley & Sons, New York, 776 p.
2. Twiss, R.J. and Moores, E.M., 2007, Structural Geology, 2nd Edn., W.H. Freeman, New York , 736 p. [Earlier edition (1992) of the same book will be equally useful]
3. Fossen, H, 2010, Structural Geology, Cambridge University Press.

Reference

4. Ghosh, S.K., 1993, Structural Geology: fundamentals and modern developments, Pergamon, Oxford, 598 p.

5. Van der Pluijm B.A. and Marshak, S., 2004, Earth Structure: An Introduction to Structural Geology and Tectonics, 2nd Edn., W.W. Norton & Co., New York, 656 p.

Practical Paper

Major – P3 Full Marks: 50

Group A; Sedimentology; Marks - 20

1. Study of different types of sedimentary rocks and sedimentary structures.
2. Study of sedimentary rocks under microscope.

Group B; Structural Geology I (Graphical & Stereographic Problems) Marks-15

1. Concept of isometric blocks, Representation of planar surfaces within isometric blocks Construction of block diagrams of homoclinal beds and folded beds.
2. Stereographic projection of planes and lines: solution of true dip – apparent dip problems and fold related problems using stereographic net, problems on rotation.
3. Determination of net slip on faults using stereographic net.

Group C; Internal Assignment; Marks -15

B. Sc. Fourth Semester

Theory

Major –5 Full Marks: 50

Igneous Petrology; Full Marks – 50; Lectures - 64

1. Physical properties of magma – factors influencing physical properties of magma; ascent and emplacement of magma.
2. Forms and structures of igneous rocks: description of the major forms of extrusives and intrusives in relation to their mode of emplacement – vesicular structure, amygdaloidal structure, pillow structure , volcanic neck, sill, dyke, ring dyke, cone sheet, radial dyke, laccolith, lopolith, phacolith, stock, batholith.
3. Description and general idea of origin of different types of textures and microstructures of extrusive and intrusive igneous rocks.
4. Introduction to volcanology: Different types of volcano and their eruption style, pyroclastic deposits, and lava flow, tuff and agglomerate, ignimbrites, concept of welding of clasts and rheomorphism, flow banding, flow lines, schlieren, ropy lava, block lava, columnar joint-colonnade structure.
5. General knowledge of the basis of classification of igneous rocks – mineralogical, textural, chemical, chemico-mineralogical, and associational. Concept of CIPW norm and its

significance; Hatch and Wells classification of igneous rocks; IUGS classification of plutonic rocks and volcanic rocks.

6. Important mineralogical and textural features of common intrusive and extrusive igneous rocks with Indian examples:.
7. Concept of system, component, phase; different types of system; intensive and extensive variables; igneous rocks as system. Phase rule and its derivation; mineralogical phase rule; degrees of freedom, invariant, univariant and bivariant equilibrium condition; cryoscopic relationship; concept of the liquidus; one-, two- and three-component systems
8. Studies on crystallization of melts (at 1 atm dry pressure and high pH_2O) in the following systems with particular reference to phase rule: diopside-anorthite, forsterite-silica, albite-anorthite, albite-orthoclase, diopside-albite-anorthite; diopside-forsterite-silica, nepheline-kalsilite-silica; petrogenetic significance of these systems; Role of volatiles in magmatic crystallization; Bowen's reaction series and its use in petrogenesis.
9. Concept of petrographic province.
10. Processes of diversification of igneous rocks: differentiation, assimilation, and partial melting; Chemical variation during differentiation – silica variation diagram, Fe-Mg-(Na+K) and Ca-Na-K diagram; Commonly used parameters in differentiation: differentiation index, fractionation index, solidification index, mg-number.
11. Trends of variation in calc-alkaline and tholeiitic series in AFM diagrams.
12. Petrogenesis of the following rocks: granite, basalt, anorthosite, alkaline rocks and ultramafic rocks.

Suggested books

Text

1. Bose, M.K., 1997, Igneous Petrology, World Press, Kolkata, 568 p.
2. Winter, J.D., 2009, Principles of Igneous and Metamorphic Petrology, 2nd Edn., Prentice Hall, 702 p. [The first edition (2001) named An Introduction to Igneous and Metamophic Petrology, is also useful].
3. Hall, A. 1987, Igneous Petrology, ELBS

Reference

4. Philpotts, A.R. and Ague, J.J., 2009, Principles of Igneous and Metamrophic Petrology, Cambridge University Press, Cambridge, 667 p. [The older edition from Prentice Hall, 1990, is also useful]
5. Best, M.G., 2002, Igneous and Metamorphic Petrology, 2nd Edn., Blackwell, Oxford, 752 p.
6. Wilson, M., 1989, Igneous Petrogenesis: a global tectonic approach, Springer (2007) 466 p.
7. McBirney, A. K., 2012, Igneous Petrology

Major –6 Full Marks: 50

Metamorphic Petrology; ***Full Marks – 50;*** ***Lectures - 64***

1. Metamorphism : basic concept, agents and classification.

2. Grade, zone and concept of metamorphic facies; Metamorphic facies series; Paired metamorphic belt; Metamorphism and plate tectonics.
3. Concept of geochemical thermodynamics; chemical equilibrium and equilibrium constant; pressure-temperature dependence of Gibb's free energy; principles of geothermobarometry.
4. Metamorphic Reactions; reaction kinetics; zoning in minerals, Schreinemaker's principles and their applications; construction and application of ACF, AKF and AFM diagrams.
5. Structures and textures of metamorphic rocks; Factors controlling metamorphic fabric; reaction textures and P-T-t path.
6. Progressive metamorphism of pelitic, basic and calcareous rocks.
7. Anatexis, migmatites and crustal evolution.
8. Heat source and transfer mechanisms; Geothermal gradient.
9. Metamorphic provinces of India and their evolution with respect to orogenic cycles

Suggested books

Text

1. Winter, J.D., 2009, Principles of Igneous and Metamorphic Petrology, 2nd Edn., Prentice Hall, 702 p. [The first edition (2001) named An Introduction to Igneous and Metamophic Petrology, is also useful].
2. Philpotts, A.R. and Ague, J.J., 2009, Principles of Igneous and Metamrophic Petrology, Cambridge University Press, Cambridge, 667 p.

Reference

1. Best, M.G., 2002, Igneous and Metamorphic Petrology, 2nd Edn., Blackwell, Oxford, 752 p.
2. Yardley, B.W.D., 1989, An Introduction to Metamorphic Petrology, Longmans, 248 p.
3. Bucher, K. and Frey, M., 2002, Petrogenesis of Metamorphic Rocks, Springer, 341 p.

Practical Paper

Major – P4 Full Marks: 50

Group A; Metamorphic Petrology Full Marks-25

1. Petrographic study of important metamorphic rocks in thin sections
2. Plotting of minerals and rocks in chemographic diagrams
3. Plotting of univariant reactions using Schreinemaker's principle.
4. Construction of metamorphic phase diagrams

Group B; Field Report; Marks - 10

Group C; Internal Assignment; Marks- 15

B. Sc. Fifth Semester

Theory

Major – 7 Full Marks: 50

Palaeontology 1; *Full Marks – 50;* *Lectures - 64*

1. Introduction: Palaeontology – definition; Fossil - definition and types; major disciplines of Palaeontology; scope of plaeontological study; Fossilization – definition, conditions and modes; taphonomy; fossil lagerstätten, conditions of preservation of soft parts; imperfections of fossil record.
2. Brief idea about life through ages: fossils and geological time scale; Precambrian life, Ediacaran fauna, Cambrian Explosion, patterns of diversification and extinction in the Phanerozoic.
3. Taxonomy: hierarchical nature of classification of organisms – species to kingdom; species concepts in biology and palaeontology; binomial nomenclature.
4. Invertebrate Palaeontology: brief idea on morphology of major invertebrate fossil groups; features of distribution through time.
5. Micropalaeontology: Definition and importance of study; brief idea on morphology of major microfossil groups, major features of distribution.
6. Functional morphology: concept and examples from studied fossil groups
7. Palaeoecology: Palaeosynecology – biotic interactions; Palaeoautecology – environment-biota interactions; factors that control lateral and vertical distribution of organisms with emphasis on marine ecosystem; brief idea on palaeoecological reconstruction; coral reefs and palaeoecology.
8. Biostratigraphy: zonation and correlation, index fossil.
9. Organic evolution: definition; Darwinian concept, models of gradualism and punctuated equilibrium; micro- and macroevolution; speciation; heterochrony as an important evolutionary mechanism.

Suggested books

Text

6. Clarkson, E.N.K.: Invertebrate Palaeontology and Evolution
7. Doyle, P.: Understanding Fossils.
8. Foote, M. and Miller, A.I.: Principles of Paleontology
9. Lieberman, B.S. and Kaesler, R.: Prehistoric Life.

References

1. Nield, E.W. and Tucker, V.C.T.: Paleontology: An Introduction.
2. Black, R.M.: The Elements of Palaeontology.
3. Ray, A.K.: Fossils in Earth Sciences.

Major – 8 Full marks 50

Geodynamics; Full Marks – 50; ***Lectures - 64***

8. Tectonics – definitions and scope; Crustal types and their properties; active and passive continental margins. (3)
9. Gravitational fields of the earth, anomalies and Geoid concept.
10. Gravity and gravity anomaly on Earth, Bouguer and free-air anomaly. Concept of isostasy and compensation, hypotheses of Airy, and Pratt.
11. Volcanoes and volcanism, eruptive styles. (1)
12. Seismology and Internal structure of the earth (4)
13. Earthquakes, intensity and magnitude, elastic rebound theory, focus and epicenter, seismograms. Global earthquake belts. Earthquake prediction. Seismic zones of India. (6)
14. Continental drift hypothesis; geological, palaeoclimatological and palaeontological evidences; criticism of continental drift hypothesis. (3)
15. Palaeomagnetism and palaeopoles; Apparent polar wandering curve, and continental reconstruction; Polarity reversals, and polarity reversal scales. (2)
16. Seafloor spreading, marine magnetic anomalies and their interpretation. (1)
17. Plate tectonics: Definition of plates; plate boundaries; Plate motion – absolute and relative; driving forces, hotspots and plumes; characteristics of different plate margins on the basis of topography, structure, lithology, heat flow, gravity and mineralization.
18. Orogeny and epeirogeny, Wilson Cycle, Supercontinent and Supercontinent Cycle. (2)
19. Map projection techniques and Elementary ideas on GPS geodesy and its application in Neotectonics.

Suggested books

Text

1. 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]
2. Moores, E.M. and Twiss, R.J., 1995, Tectonics, W.H. Freeman, New York, 415 p.

Reference

3. Condie, K.C., 1997, Plate tectonics and crustal evolution, 4th Edn., Butterworth-Heinemann, Oxford, 294 p.
4. Mussett, A.E. and Khan, M.A., 2000, Looking into the Earth: an introduction to geological geophysics, Cambridge University Press, Cambridge, 470 p.

Major – 9 Full marks 50

Economic Geology; Full Marks – 50; Lectures - 64

1. Ore mineralization in relation to crustal evolution – Concept of metallogeny.
2. Definition of some important terms with examples : Ore, protore, gangue, tenor, grade, syngenetic and epigenetic ores, stratabound, stratiform and stratified mineralization, vein type mineralization.

3. Processes of formation of ore deposits.
4. Role of plate tectonics in ore mineralization.
5. Classification of ore deposits
6. ore fluids and alteration haloes
7. Indian ore deposits of iron, manganese, gold, copper, lead & zinc, aluminium, uranium and phosphate – discussion covering the following heads : Ore types, distribution, mineralogy, genesis.
8. Detail case history of iron ores of Jharkhand – Orissa; Manganese ore of central India; Gold of Hutti, Karnataka; Copper of Singhbhum Shear Zone; Lead – Zinc of Zawar, Rajasthan.
9. Industrial mineral, their specifications and occurrences.
10. Basics of coal and petroleum: brief origin and distribution

Suggested books

1. Banerjee, D.K.: Mineral resources of India.
2. Deb, S.: Industrial minerals and rocks of India.
3. Edwards, R. and Atkinson, K.: Ore deposit geology and its influence on mineral exploration.
4. Evans, M.: An introduction to ore geology.
5. Gokhale, K.V.G.K. and Rao, T.C.: Ore deposits of India.
6. Jensen, M.L. and Bateman, A.M.: Economic mineral deposits.
7. Pohl, W. Economic Geology.
8. Banerjee, D.K.: Mineral resources of India.
9. Brown, J.C. and Dey, A.K.: Coal and nuclear fuel.
10. Chandra, D.: Petroleum.

Practical Paper

Major – P5 Full Marks: 50

Group A; Igneous petrology; Marks - 35

1. Study, under microscope, of the following textures of igneous rocks: Porhpyritic, poikilitic, ophitic, intergranular, intersertal, graphic, perthitic, myrmekitic, hypidiomorphic, allotriomorphic, corona, flowage.
2. Petrographic description and identification of the following rocks under microscope: Granite, granodiorite, tonalite, syenite, nepheline syenite, aplite, granophyre, diorite, gabbro, anorthosite, pyroxenite, peridotite, mica-lamprophyre, dolerite, rhyolite, basalt, andesite.
3. Plotting of mineralogical and chemical data in triangular diagram.
4. C.I.P.W. norm calculation of granitic and basic rock (without foid).

Group B; Internal Assignment; Marks - 15

Practical Paper

Major – P6 Full Marks: 50

Group A; Interpretation of Geological Maps; Marks - 35

1. Interpretation of maps showing unconformity, intrusive bodies (4), folded (6) and faulted (8) beds on planar and uneven topography. Construction of structural cross sections.
2. Elementary maps on superposed terrains
3. Outcrop completion (6)

Group B; Internal Assignment; Marks - 15

B. Sc. Sixth Semester

Theory

Major – 10 Full marks 50

Precambrian Stratigraphy of India; ***Lectures - 64***

1. Brief idea about the Precambrian Time Scale and characteristics of the Archaean and Proterozoic Eons.
2. Subdivisions of the Indian shield in to different Precambrian terrains.
3. Geologic evolution of the following Indian Precambrian terrains in terms of sedimentation, structure, magmatism, metamorphism, and geochronology: Dharwar, Singhbhum, Rajasthan, Central India and Eastern Ghats.
4. Introduction to Proterozoic (Purana) basins of India with special reference to Cuddapah and Vindhyan basins.

Suggested books

Text

1. Krishnan, M.S., 2006, Geology of India and Burma, 6th Edn., CBS, 536 p. [Earlier editions also useful]
2. Ramakrishnan, M. and Vaidyanathan, R., 2008, Geology of India, Vol. 1, Geological Society of India, Bangalore.

Reference

3. Pascoe, E.H., 1950, A manual of the geology of India and Burma (3 volumes), 3rd Edn., Geological Survey of India.
4. Sarbadhikary, T, *Bharater shilastar o bhutatiyo itihash*, Paschim Banga Rajya Pustak Parishad, Kolkata.

Theory

Major – 11 Full marks 50

Phanerozoic Stratigraphy of India; ***Full Marks – 50;*** ***Lectures - 64***

1. Paleozoic: Distributiion of Paleozoic rocks in extrapeninsular India. Detailed stratigraphy of Kashmir basin.
2. Mesozoic: Distribution of Mesozoic rocks in India. Succession of Mesozoic rocks in Spiti, Jurassic rocks in Kutch and Cretaceous rocks in Cauvery basins.
3. Cenozoic: Stratigraphy of Cenozoic rocks of Kashmir, Assam and Bengal basins.
4. Gondwana succession of Peninsular India; a brief account of their distribution and stratigraphy.

Suggested books:

1. M S Krishnan, Geology of India and Burma, CBS Publishers
2. A Dasgupta, Phanerozoic Stratigraphy of India, World press.

Theory

Major – 12 Full marks 50

Group A; Palaeontology II; *Marks – 25;* *Lectures – 32*

1. Palaeobiogeography: Scope; Disjunct distribution – dispersal and vicariance mechanisms, evolutionary consequences of disjunction; palaeobiogeographic reconstruction of Gondwana.
2. Palaeobotany: brief idea on types of fossil plants, distribution in time and general morphology; significance in palaeoclimatic reconstruction with examples from Indian Gondwana.
3. Vertebrate Palaeontology: Scope, types of fossil vertebrates and their distribution through geological time; Gondwana and Siwalik vertebrates; brief idea on morphology.
4. Palaeoichnology: Scope, major types and importance.

Suggested books

Text

1. Foote, M. and Miller, A.I.: Principles of Paleontology.
2. Lieberman, B.S. and Kaesler, R.: Prehistoric Life.
3. Thomas, B.A. and Spicer, R.A.: The Evolution and Palaeobiology of Land Plants.
4. Stewart, W.N. and Rothwell, G.W.: Paleobotany and the Evolution of Plants.
5. Benton, M.J.: Vertebrate Palaeontoloy.
6. Colbert, E.H., Morales, M. and Minkoff, E.C.: Colbert's Evolution of the Vertebrates.

References

1. Ray, A.K.: Fossils in Earth Sciences.

Group B; Geohydrology-Engineering Geology-Geohazards, Marks – 25;Lectures - 32

10. Geohydrology: Definition and scope, Concept of hydrologic cycle, surface water-groundwater interaction.
11. Genetic classification of groundwater and subsurface distribution of groundwater.
12. Classification of water bearing formations: aquifer, aquitard, aquiclude, aquifuge, classification of aquifers, water table and piezometric surface.
13. Properties of aquifer – Porosity, specific retention, hydraulic conductivity, transmissivity and storage coefficient.
14. Introduction to groundwater flow: laminar flow, turbulent flow, Darcy's Law, Reynold's Number.
15. Scope of Engineering Geology
16. Engineering properties of rocks and soils, slope stability.
17. Geological investigations for dams and reservoirs.
18. Landslides-causes and prevention.
19. Earthquake – causes, types, distribution, earthquake-resistant structures.
20. Role of Engineering Geology in watershed management: contour bund, graded bund, bench terrace, contour trench, contour stone wall, check dams, earthen gully plugs and gabions.

21. Global Environmental concerns; Environmental Treaties and Accords.
22. Biochemical Cycle.
23. Concept of risk, hazards, disaster and catastrophe.
24. Environmental impacts of earthquake, volcanism, landslides, floods, droughts, dams and reservoirs.
25. Preliminary concepts of pollution: air, water, soil and noise pollution.
26. Climate change and global warming; sea level rise.
27. Mining and environment; concepts of sustainability.
28. Solid and nuclear waste disposal.

Suggested books

Text

9. Karanth, K. R. , Groundwater Assessment, Development and Management, Tata McGraw Hill
10. Todd, D. K.,Ground Water Hydrology, John Wiley and Sons Inc. New York.
11. Edward Kellar, Environmental Geology, 9th Edition
12. D Foley, G McKenzie, R Utgard, Investigations in Environmental Geology, 3rd Edition
13. T Hudson, Living with Earth: An introduction to Environmental Geology
14. Singh, Parbin, Engineering and General Geology, S. K. Kataria and Sons, Delhi - 110 006
15. Waltham, T, Foundations of Engineering Geology, 3rd Edition
16. George, D, Engineering Geology, Principles and Practice

Reference

17. Brassington, R., Field Hydrogeology, John Wiley and Sons Inc. New York
18. Hydrology of Small Watersheds by P. V. Seethapati, D. Dutta, R. Siva Kumar (Editors), Published by NRDMS, Dept of Science and Technology, Government of India

Practical Paper

Major – P7 Full Marks: 50

Group A; Palaeontology; Marks - 35

1. Studies on modes of preservation and taphonomy.
2. Description of and functional morphologic studies on bivalves (recent and fossil)
3. Morphological studies on the following mainly from different levels of Indian stratigraphy as mentioned in parentheses: Gastropods (Cenozoic), Cephalopods – mainly ammonites (Mesozoic), Brachiopods (Paleozoic), Echinoids (Cenozoic).
4. Study of microfossils
5. Morphologic studies on plants with special reference to Indian Gondwana. Studies on features of palaeoclimatic importance.
6. Exercises on biostratigraphic zonation and correlation.
7. Exercises on palaeobiogeographic and palaeoecologic reconstructions.

Group B; Internal Assignment; Marks - 15

Major – P8 Full Marks: 50

Group A; Ore Geology; Marks -25

1. Ore structures in hand specimens.
2. Study of ore minerals under microscope; ore texture and paragenesis

Group B; Field Report; Marks -10

Group C; Internal Assignment Marks -15

COURSE-STRUCTURE

Applied Geology

M. Sc.

PG Semester I (Theory 150 + Practical 100 = 250)

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL0701: I		Geochemistry	50 (35+15*)	**4**
GEOL0702: II	A	Coal and **Nuclear fuels**	20 (15+5*)	2
	B	Engineering Geology	30 (25+10*)	2
GEOL0703: III		Petroleum Geology	50 (35+15*)	**4**

Practical

Paper	Group	Subject	Marks	Credit
GEOL0791: PR I		Hydrogeology I	50	**4**
GEOL0792: PR II		Hydrogeology II	50	**4**

Field Work of two (02) weeks duration (Compulsory)

PG Semester II (Theory 150 + Practical 100 = 250)

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL0801: V		Geophysics	50 (35+15*)	4
GEOL0802: VI		Remote sensing and GIS	50 (35+15*)	4
GEOL0803: VII		Mineral Exploration, Mining and orebody modeling	50 (35+15*)	4

Practical

Paper	Group	Subject	Marks	Credit
GEOL0891: PR II		Remote sensing and GIS	50	**4**
GEOL0892: PRIII		Ore Reserve Estimation and Modelling	50	**4**

Industrial Training/Summer Project of two/three (02/03) weeks duration

PG Semester III (Theory150 + Practical 100 = 250)

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL0901: VIII		Compulsory Module I & II	50 (35+15*)	**4**
GEOL0902: IX		Elective Module I & II	50 (35+15*)	4
GEOL0903: X		Assignments related to Dissertation	50 (35+15*)	**4**

Practical

Paper	Group	Subject	Marks	Credit
GEOL0991: PR-IV		Field work and Viva Voce	50	**4**
GEOL0992: PR-V	A	Open Seminar	25	2
	B	Industrial training/Summer Project	25	2

***PG Semester X (Theory 150 + Practical 100= 250)**

Theory

Paper	Group	Subject	Marks (Internal Assessment*)	Credit
GEOL1001: XI		Research methodologies - Analytical Techniques, 'Scientific writing' skill	50 (35+15*)	4
GEOL1002: XII		Research methodologies - Geomathematics and computational methods I	50 (35+15*)	4
GEOL1003: XIII		Geomathematics and computational methods II	50 (35+15*)	4

Practical

Paper	Group	Subject	Marks	Credit
GEOL1091: PR-VI		Evaluation of Dissertation	50	4
GEOL1092: PR-VII		Seminar-Viva-voce on Dissertation	50	4

- *The assessment for any practical paper may be based on continuous assessment method.*
- *The assessment for any theory or practical paper of last two Semesters may be based on either end-semester examination or sessional assessment or term paper based assessment or seminar based assessment or continuous evaluation or any combination thereof.*

FIRST SEMESTER

THEORY PAPERS

Paper 1(701): Geochemistry Full Marks: (35+15=50)

1. Geochemical classification of elements; element fractionation, geochemical reservoirs.
2. Concepts of Cosmochemistry; origin and abundance of elements. Brief idea about chemical abundances of elements in crust, mantle and core.
3. Meteorites and their properties and classification. Chondrites- mineralogy, age, chemistry and texture.
4. Solid Earth system; Mantle heterogeneity and phase transition. Behaviour of trace elements in magmatic crystallisation. Geochemistry as tracer to igneous petrogenesis.
5. Use of geochemical data for identification of paleotectonic settings and its limitations.
6. Thermodynamics of solutions, Free energy and phase equilibria (solid-solid, solid-melt/fluid), Phase equilibria for multicomponent systems; Free energy minimization and pseudosection analysis.
7. Chemical weathering, dissolution and redox processes; E_h-$_p$H diagrams.
8. Geochemistry of radiogenic isotopes: Examples from Rb-Sr; Sm-Nd, U-Pb, Ar-Ar systems.
9. Geochemistry of stable isotopes; Examples from C- and O- isotopes.
10. Application of geochemistry for provenance analysis.
11. Outline of Organic Geochemistry

Paper 2(702) Marks : (35+15=50)

Group A: Coal & Nuclear Fuel

1. Coal family;
2. Coal Petrography
3. Origin of Coal; Coal depositional environment
4. Coal deposits of India.
5. Nuclear fuels and their Indian occurrences.

Group B : Engineering Geology

1. Role of Engineering geology in civil construction and mining industry. Engineering properties of rocks and their measurements. Methods of soil investigation.
2. Slope stability and mass movements, classifications, detailed study of landslides, factors influencing different mass movements in nature and their remedial measures.
3. Properties of Building materials and road metals and their occurrences in India.
4. Dams and Reservoirs, different types, criteria for selecting sites for their construction, remedial measures for failure of dams and reservoirs.

5. Tunnels and Bridges, different types, stability of tunnels, criteria for selecting sites for tunnel construction, failure of tunnels and their remedial measures.
6. Role of geophysical techniques in Engineering geological investigations.

Paper 3 (703) Petroleum Geology Full Marks: (35+15=50)

1. Origin of hydrocarbon, Source rock, application of organic geochemistry in studying hydrocarbons,
2. Reservoir rock, Cap rock, Migration of petroleum, Types of Traps.
3. Petroleum exploration- Geological and Geophysical Explorations.
4. Well Drilling- Basic principles, purpose and types, Drilling mud, Well casing, Well site geological techniques.
5. Well Logging- Basic principles, types and application.
6. Principles and application of Sequence stratigraphy in petroleum exploration.
7. Reservoir Engineering.
8. Reserve estimation and Petroleum Recovery.
9. Coal Bed methane and Gas Hydrates: Origin, Mode of occurrence, Exploration and Exploitation.

PRACTICAL PAPERS

Paper 4 (791) Hydrogeology I Full Marks: 50

1. Hydrologic cycle, phases of hydrologic cycle; precipitation, evapo-transpiration, run-off, infiltration, base-flow separation. Concept of drainage basin and groundwater basin. Water resources of India and its future.
2. Geologic structures favouring groundwater occurrence; Subsurface profile of groundwater; zones of aeration and saturation;
3. Classification of groundwater; Classification of aquifer and aquifer systems; Hydrostratigraphic units.
4. Hydrological properties of aquifers: porosity, void ratio, specific retention, storage coefficient, hydraulic conductivity, transmissivity, hydraulic diffusivity, groundwater velocity.
5. Theory of groundwater flow, piezometric head of groundwater, flow of viscous fluid, Darcy's law and its application, Reynold's number, determination of permeability in laboratory.
6. Groundwater modelling – numerical and electrical models.
7. Groundwater exploration: subsurface geophysical methods- resistivity, gravity, seismic and magnetic, subsurface geophysical methods; well logging for delineation of aquifers and estimation of water quality.
8. Groundwater provinces of India.

Paper 5 (792) : HydrogeologyII Marks: 50

1. Preparation and Interpretation of hydrogeological maps, flow nets and panel diagrams, measurement of precipitation, evapo-transpiration and flow, water levels at ground and in bore holes.
2. Sampling test of quality (Physical, Chemical and Biological) of groundwater.
3. Field Test for conductivity and yield.
4. Processing of flow data, recharge estimation.
5. Water balance calculation, groundwater monitoring.

SECOND SEMESTER

THEORY PAPERS

Paper 6 (801) Geophysics **Full Marks: (35+15)**

1. Gravity method: Gravity and its variation over the surface of the Earth. Principle of Gravimeters; Gravity field surveys. Corrections to gravity data. Gravity maps and their interpretation.
2. Magnetic method- Geomagnetic field, Principle of Magnetometers. Magnetic field survey, preparation of magnetic anomaly maps and their interpretation. Aeromagnetic survey.
3. Electrical method- principles, electrical properties of rocks. Resistivity method and Self potential method. Field procedure, interpretation of electrical profile and sounding curves. Application of electrical methods in groundwater prospecting and engineering geology problems.
4. Seismic method- Refraction and Reflection seismic surveys. Concept of seismic channel and multi-channel recording of seismic data. Seismic data acquisition and interpretation. Application to petroleum and mineral exploration.
5. Well logging methods. Principle of electrical logging and its application in petroleum, groundwater and mineral exploration.

Paper 7 (802) Remote Sensing and GIS **Full Marks: (35+15=50)**

1. Principles of remote sensing. Platforms and sensors. Data acquisition, manipulation and interpretation. Elementary photogrammetry.
2. Digital image processing, Concept of resolution, spectral signature and significance, Image enhancement, Image classification,
3. Remote sensing application in natural resources.
4. GIS: Principles and applications in natural resources.
5. Concept of Geodatabase, spatial analysis, cyber-infrastructure
6. Global Positioning System: Technology and applications

Paper 8 (803): Mineral Exploration, Mining and Ore body modeling
Full Marks: (35+15=50)

1. Classification of mineral deposits for prospecting. Mineral deposits and their possible host rocks, geological prospecting, Stages of exploration: RP, LAP, Pl, ML, Diamond drilling, bore hole survey, logging.
2. Sampling : Pitting, Trenching, Channel, Chip, drill core, bulk/ Muck/ Grab/ Car /Stack sampling, sample reduction, accuracy in sampling, QC and QA analysis.
3. Geochemical Prospecting: Pedogeochemical Prospecting, Lithogeochemical Prospecting, Hydrogeochemical Prospecting, Biogeochemical Prospecting,

Geobotanical Prospecting, Atmogeochemical Prospecting.

4. Geophysical prospecting: Magnetic method, Gravimetric method, Geo-electrical method, Seismic method, Electromagnetic method, Radioactive method, Telluric and Magnetotelluric method.
5. Reserves and reserve estimation of mineral deposit – volume and tonnage, cut-off grade, ROM grade, Classification of ore reserves (Conventional, USGS, JORC and UNFC).
6. Exploration Risks: Management and Parameters for success.
7. General techniques of ore beneficiation, beneficiation of sulfide ores Pb-Zn and Cu and Iron ores.
8. Mining terminologies- shaft sinking, drifting, cross-cutting, stoping, mine subsidence, mine support, top slicing, caving, bench mapping, underground mapping, preparation of plans & sections.
9. Drilling methods- Percussion drills & Rotary drills (Jack Hammer, DTH).
10. Mining methods- Alluvial mining, Open cast & Underground mining. Shrinkage, Cut and Fill (C & F), Sublevel stoping and Vertical Retreat Mining (VRM)).
11. Mine hazards.

PRACTICAL PAPERS

Paper 9 (891) Remote Sensing and GIS, 50 Marks

1. Geoenvironmental interpretation from aerial photographs and satellite images (visual and digital).
2. Digital image processing
3. Introductory Geodatabase designing in ArcGIS

Paper 10 (892) : Orebody Modeling 50 Marks

Problems on Ore reserve estimation and orebody configuration from surface and subsurface data

THIRD SEMESTER

THEORY PAPERS

Paper 11 (901): Compulsory Module Full Marks: (35+15=50)

Group A

Economic Geology

- Ores; Nature of ore mineralization; Types of ores and their host rocks.
- Tectonics and ore mineralization.
- Crustal evolution and metallogeny.
- Indian occurrences, mode of mineralization, mineralogy and possible genesis of Fe, Mn, Cr, Pb-Zn, Cu, Mica and Bauxitic ore.
- Ores under microscope.

Group B

Palaeontology

- Vertebrate palaeontology: General body plan, classification, turning points in its evolution – appearance of jaw, terrestrialization, evolution of amniotic egg, brief idea on dinosaurs, evolution of flight, evolution of mammals; Evolution of man. Indian perspective.
- Micropalaeontology: definition, groups studied; Foraminifera – morphology, use in biostratigraphy and palaeoecology.
- Palaeobotany: Evolutionary turning points - major groups. Indian perspective.
- Key evolutionary events in the Earth's history: Precambrian, Palaeozoic, Mesozoic and Cenozoic biota – brief idea, turnover pattern through time; controls of tectonics, geography and mass-extinction.

Paper 12 (902): Elective Module Full Marks: (35+15=50)

Group A

IGNEOUS PETROLOGY:

- Petrographic mixing calculation, Extract polygon
- Study of phase diagram under high dry and wet pressure
- Elementary idea about volcanology
- Petrographic and geochemical characters of MORB, Rift and Arc basalt
- Magmatism in different tectonic setting

Group B

METAMORPHIC PETROLOGY

- Heat flow in metamorphic processes
- P-T-fluid variables: geothermobarometry and fluid inclusions
- UHT and UHP metamorphism
- Orogenesis and its driving forces
- Orogenic belts of India
- Evolution of continents

Paper 13 (903): Assignments related to Dissertation Full Marks: (35+15=50)

Group A

Structural Geology

- Lithospheric stress states and fracture development
- Progressive deformation and practical strain measurement techniques
- Deformation mechanism and petrofabric analysis
- Deformation and tectonic regimes
- Problems on deformation structures

Group B

Sedimentology

- Major depositional systems with reference to different tectonic settings;
- Basic approaches for reconstruction of tectono-sedimentary history of a basin.
- Principles and tools of Basin Analysis
- Principles of Provenance Analysis
- Sequence Stratigraphy

PRACTICAL PAPERS

Paper 14 (991) : Field work and Viva Voce 50 Marks

Geological Account of Investigation of 15 days duration preferably in a poly-deformed terrain. Evaluation will be done on the basis of field-performance, field-report and a viva-voce examination.

Paper 15 (992)

Group A : Open Seminar 25 Marks

Group B : Industrial Training/Summer Project 25 Marks

Visit to an industry of geologic interest for two/ three weeks duration or Summer Project of similar duration. Evaluation will be done upon Submission of a certificate from the concerned industry/project supervisor

FOURTH SEMESTER

THEORY PAPERS

Paper 16 (1001) : Research methodologies – Analytical techniques Full Marks: (35+15=50)

Principles and operations of Research level instruments (SEM-EBSD, XRF, EPMA, XRD etc.,)

Paper 17 (1002): Research Methodologies –Geomathematics and computational methods I Full Marks (35+15=50)

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.

Paper 18 (1003): Geomathematics and computational methods II : Full Marks (35+15=50)

1. Basics of computing, overview of system and application softwares.
2. Flowcharting, Programming algorithms, data structure (in C) and Programming in C to solve simple geological problems.
3. Application of different relevant software for solving elementary geological problems.

PRACTICAL PAPERS

Paper 19 (1091): Evaluation of Dissertation 50 Marks

Paper 20 (1092): Seminar – Viva Voce on Dissertation 50 Marks

PhD Coursework in Geology

The PhD course would consist of four papers out of which three would be compulsory and one optional (to be chosen from given as under)

Paper	Subject*	Credit
	Compulsory Course	
GEOL- PhD-01	Research methodology-1: Principles in Geomathematics and computer applications	4
GEOL: PhD-02	Research methodology-2 : Quantitative methods- Laboratory Techniques for data acquisition	4
GEOL: PhD-03	Data handling (Laboratory /field data) and problem solving	4
	Optional Courses	
GEOL: PhD-04	Review of Literature & Scientific writing skill (*any one to be chosen from folowing*) I. Structural Geology & Tectonics II. Igneous Petrology III. Metamorphic Petrology IV. Sedimentology V. Economic Geology VI. Palaeontology	4

COMPULSORY COURSES

GEOL- PhD-01:

Research Methodology 1 – Principles in Geomathematics and computer applications

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.

7. Basics of computing, overview of system and application softwares.
8. Flowcharting, Programming algorithms, data structure (in C) and Programming in C to solve simple geological problems.
9. Application of different relevant software for solving elementary geological problems.

GEOL-PhD-02

Research methodology-2 : Quantitative methods- Laboratory Techniques for data acquisition

- Principles and quantitative analysis using X-ray Fluorescence (XRF) spectrometry, sample preparation and data acquisition, interpretation of data.
- Principles of Energy Dispersive Spectrometry (EDS) and Back Scatter Electron (BSE) imaging, use of Scanning Electron Microscope (SEM), acquisition of data and image analysis.

Suggested books:

(1) Electron Microprobe Analyses and Scanning Electron Microscopy in Geology. *S.J.B. Reed*, Cambridge University Press
(2) Quantitative textural measurements in igneous and metamorphic petrology. *M.D. Higgins*, Cambridge University Press
(3) X-ray Fluorescence spectrometry. *R. Jenkins*, John Wiley
(4) Using geochemical data. *H. Rollinson*, Prentice Hall

GEOL-PhD-03

Data handling (Field/Laboratory) and problem solving-

i) Statistical analysis of field and laboratory data- statistical mapping (moving average, trend surface, kriging), multivariate analysis (Principal component analysis, Factor analysis), graphical analysis (size-frequency, size-cumulative frequency, Histogram, pie diagram, rose diagram), Regression analysis, Markov chain analysis for stratigraphic sequence

ii) Analysis of geochemical data- Rock classification using major, trace and elements, Variation diagram using major, trace and REE to understand fractional crystallization, assimilation, partial melting, magma mixing, mixing lines in sedimentary rocks, mixing in metamorphic rock, identification of former weathering condition, Partition coefficient in mineral-melt, solid-solid system, Multi element diagrams for igneous rocks, sedimentary rocks, metamorphic rocks, Discrimination diagram to identify paleo-tectonic setting,

provenance of sedimentary rocks, radiogenic isotopes and non radiogenic isotopes for petrogenetic study, geochronology

Suggested books-

1. Using geochemical data: evaluation, presentation, interpretation by Hugh Rollinson

2. Geochemistry 1st Edition by William M. White

3. Isotopes: Principles and Applications, 3rd Edition by Gunter Faure, Teresa M. Mensing

4. Multivariate Geostatistics: An Introduction with Applications (3rd Edition) by Hans Wackernagel

5. An Introduction to Applied Geostatistics (1st Edition) by Edward H. Isaaks, R. Mohan Srivastava

6. A practical guide to geostatistical mapping by Tomislav Hengl

OPTIONAL COURSES

GEOL-PhD-04

Review of Literature & Scientific writing skill

Any one course from the following

I. Structural Geology and Tectonics

- Lithospheric stress states and fracture development
- Progressive deformation and practical strain measurement techniques
- Deformation mechanism and petrofabric analysis
- Deformation and tectonic regimes
- Problems on deformation structures

Suggested books

Text

6. Davis, G.H. and Reynolds, S.J., 1996, Structural Geology of Rocks and Regions, 2nd Edn., John Wiley & Sons, New York, 776 p.
7. Twiss, R.J. and Moores, E.M., 2007, Structural Geology, 2nd Edn., W.H. Freeman, New York , 736 p. [Earlier edition (1992) of the same book will be equally useful]
8. Fossen, H, 2010, Structural Geology, Cambridge University Press.

Reference

9. Ghosh, S.K., 1993, Structural Geology: fundamentals and modern developments, Pergamon, Oxford, 598 p.

10. Van der Pluijm B.A. and Marshak, S., 2004, Earth Structure: An Introduction to Structural Geology and Tectonics, 2nd Edn., W.W. Norton & Co., New York, 656 p.

II. Igneous Petrology

- Pyroclastic rocks, mode of eruption, emplacement etc
- Modeling of Petrogenetic processes- graphical and mathematical approach
- Composition of igneous rock-window to mantle composition
- Nucleation and growth of crystal in liquid medium
- Magmatism in different tectonic setting
- LIP-general character, examples, ideas on origin
- I-, S-, M-, and A-type granites

Suggested books

Text

8. Bose, M.K., 1997, Igneous Petrology, World Press, Kolkata, 568 p.
9. Winter, J.D., 2009, Principles of Igneous and Metamorphic Petrology, 2nd Edn., Prentice Hall, 702 p. [The first edition (2001) named An Introduction to Igneous and Metamophic Petrology, is also useful].
10. Hall, A. 1987, Igneous Petrology, ELBS

Reference

11. Philpotts, A.R. and Ague, J.J., 2009, Principles of Igneous and Metamrophic Petrology, Cambridge University Press, Cambridge, 667 p. [The older edition from Prentice Hall, 1990, is also useful]
12. Best, M.G., 2002, Igneous and Metamorphic Petrology, 2nd Edn., Blackwell, Oxford, 752 p.
13. Wilson, M., 1989, Igneous Petrogenesis: a global tectonic approach, Springer (2007) 466 p.
14. McBirney, A. K., 2012, Igneous Petrology

III. Metamorphic Petrology

- Material and energy transfer
- Phase equilibria modeling for common bulk composition
- Partial melting and crustal differentiation
- Metamorphism of orogenic belts
- Geochronology of metamorphic rocks
- The Supercontinent cycle and mantle-plume events

Suggested books

Text

3. Winter, J.D., 2009, Principles of Igneous and Metamorphic Petrology, 2nd Edn., Prentice Hall, 702 p. [The first edition (2001) named An Introduction to Igneous and Metamophic Petrology, is also useful].
4. Philpotts, A.R. and Ague, J.J., 2009, Principles of Igneous and Metamrophic Petrology, Cambridge University Press, Cambridge, 667 p.

Reference

4. Best, M.G., 2002, Igneous and Metamorphic Petrology, 2nd Edn., Blackwell, Oxford, 752 p.
5. Yardley, B.W.D., 1989, An Introduction to Metamorphic Petrology, Longmans, 248 p.

6. Bucher, K. and Frey, M., 2002, Petrogenesis of Metamorphic Rocks, Springer, 341 p.

IV. Sedimentology

- Major depositional systems with reference to different tectonic settings;
- Basic approaches for reconstruction of tectono-sedimentary history of a basin.
- Principles and tools of Basin Analysis
- Principles of Provenance Analysis
- Sequence Stratigraphy

Suggested books

Text

11. Pettijohn, F.J., 1975, Sedimentary Rocks, 3rd Edn., Harper and Row, New York, 628 p.
12. Tucker, M.E., 2001, Sedimentary Petrology – an introduction to the origin of sedimentary rocks, Blackwell, Oxford, 262 p.
13. Folk, R.L., 1974, Petrology of Sedimentary Rocks, Hemphill Publishing Company, Austin, 159 p.
14. Collison, J.D. and Thompson, D.B., 1989, Sedimentary Structures, Allen and Unwin, London, 194 p.
15. Allen, J.R.L., 1985, Principles of Physical Sedimentology, Allen and Unwin, London, 272 p.

Reference

16. Boggs, S.Jr., 2006, Principles of Sedimentology an d Stratigraphy, 4th Edn., Prentice Hall, New Jersey.
17. Reineck, H.E. and Singh, I.B., 1980, Depositional Sedimentary Environments, 2nd Edn., Springer-Verlag, Berlin, 551 p.
18. Blatt, H., Middleton, G., and Murray, R., 1972, Origin of Sedimentary Rocks, 2nd Edn., Prentice-Hall, New Jersey, 782 p.
19. Leeder, M.R., 1999, Sedimentology and Sedimentary Basins: from turbulence to tectonics, Blackwell, Oxford, 592 p.
20. Tucker, M.E. and Wright, V.P., 1990, Carbonate Sedimentology, Blackwell, Oxford, 482 p.

V. Economic Geology

- Ore, ore-types, ore mineralogy, ore texture and paragenesis.
- An overview on plate-tectonics and ore mineralization.
- Wall rock alterations, ore-fluids and genesis of ore-fluids.
- Crustal evolution and metallogeny of India.
- Distribution, nature of mineralization, mineralogy-texture and genesis of Fe, Cr, Mn, Cu, Pb-Zn, Au, Sn-W.
- Non-metallic ore deposits, occurrences, nature of mineralization, genesis and Utilization.
- Study of ore minerals and texture under microscope.

Suggested books

11. Banerjee, D.K.: Mineral resources of India.
12. Deb, S.: Industrial minerals and rocks of India.

13. Edwards, R. and Atkinson, K.: Ore deposit geology and its influence on mineral exploration.
14. Evans, M.: An introduction to ore geology.
15. Gokhale, K.V.G.K. and Rao, T.C.: Ore deposits of India.
16. Jensen, M.L. and Bateman, A.M.: Economic mineral deposits.
17. Pohl, W. Economic Geology.
18. Banerjee, D.K.: Mineral resources of India.
19. Brown, J.C. and Dey, A.K.: Coal and nuclear fuel.
20. Chandra, D.: Petroleum.

VI. PALAEONTOLOGY

- Growth and form - Processes of skeletal growth, allometry; evolution of form-controlling factors, Seilacher's Triangle; theoretical morphology.
- Evolutionary, numerical and phylogenetic systematics.
- Evolutionary rates and trends, Cope's Rule.
- Introduction to analytical methods in Palaeontology - biostratigraphy, palaeoecology, biogeography.
- Applied Palaeontology

Suggested books

Text

10. Clarkson, E.N.K.: Invertebrate Palaeontology and Evolution
11. Doyle, P.: Understanding Fossils.
12. Foote, M. and Miller, A.I.: Principles of Paleontology
13. Lieberman, B.S. and Kaesler, R.: Prehistoric Life.

References

4. Nield, E.W. and Tucker, V.C.T.: Paleontology: An Introduction.
5. Black, R.M.: The Elements of Palaeontology.
6. Ray, A.K.: Fossils in Earth Sciences.