The University of Burdwan

Syllabus for B.Sc.

(Hons.) in

Geology

Under Choice Based Credit System

w.e.f. 2017-2018 onward

COURSE STRUCTURE UNDER CHOICE BASED CREDIT SYSTEM FOR B.Sc. HONOURS IN GEOLOGY

Semester-wise course structure

YEAR	SEMESTER	CORE COURSE (CC) (14)	ABILITY ENHANCEMENT COURSE (AECC) (2)	SKILL ENHANCEMENT COURSE (SEC) (2)	DISCIPLINE SPECIFIC ELECTIVE (DSE) (4)	GENERIC ELECTIVE (GE) (4)
FIRST YEAR	I	CC-1. EARTH SYSTEM SCIENCE CC-2. MINERAL SCIENCE	ENVIRONMENTAL STUDIES			GE-1 (Any discipline other than Geology)
	II	CC-3. ELEMENTS OF GEOCHEMISTRY CC-4. STRUCTURAL GEOLOGY	COMMUNICATIVE ENGLISH/MIL			GE-2 (Any discipline other than Geology)
SECOND YEAR	III	CC-5. IGNEOUS PETROLOGY CC-6. SEDIMENTOLOGY CC-7. PALEONTOLOGY		SEC-I (Field Work)		GE-3 (Any discipline other than Geology)
	IV	CC-8. METAMORPHIC PETROLOGY CC-9. PRINCIPLES OF STRATIGRAPHY AND PRECAMBRIAN STRATIGRAPHY OF INDIA CC-10. PHANEROZOIC STRATIGRAPHY OF INDIA		SEC-II (Field Work)		GE-4 (Any discipline other than Geology)
THIRD YEAR	V	CC-11. HYDROGEOLOGY CC-12. ECONOMIC GEOLOGY			DSE – 1 DSE - 2	
	VI	CC-13. GEOMORPHO-LOGY, REMOTE SENSING & GIS CC-14. ENGINEERING GEOLOGY			DSE – 3 DSE - 4	

Detail course structure

SEMESTER	COURSE OPTED	COURSE NAME	CREDIT	MARKS			No. of hours L-T-P Per Week
				IA	ESE	TOTAL	
I	Ability Enhancement: compulsory course – 1	Environmental Studies	4	--	100	100	
	Core Course – 1	Earth System Science (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Core Course – 2	Mineral Science (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Generic Elective – 1	GE – 1	6	As to be prescribed by other discipline		75	
	Total		**20**			**325**	
II	Ability Enhancement: compulsory course - 2	Communicative English/ MIL	2	--	50	50	
	Core Course - 3	Elements of Geochemistry (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Core Course - 4	Structural Geology (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Generic Elective – 2	GE - 2	6	As to be prescribed by other discipline		75	
	Total		**20**			**275**	
III	Core Course - 5	Igneous Petrology (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Core Course - 6	Sedimentology (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Core Course - 7	Paleontology (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Generic Elective - 3	GE - 3	6	As to be prescribed by other discipline		75	
	Skill Enhancement Course - 1	Field Work	2	10	40	50	0-0-4
	Total		**26**			**350**	
IV	Core Course - 8	Metamorphic Petrology (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Core Course - 9	Principles of Stratigraphy and Precambrian Stratigraphy of India (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Core Course - 10	Phanerozoic Stratigraphy of India (Th)	4	15	40	75	4-0-0
		Practical	2		20		0-0-4
	Generic Elective - 4	GE - 4	6	As to be prescribed by other discipline		75	
	Skill Enhancement Course - 2	Field Work	2	10	40	50	0-0-4
	Total		**26**			**350**	

V	Core Course - 11	Hydrogeology (Th)		4	15	40	75	4-0-0
		Practical		2		20		0-0-4
	Core Course - 12	Economic Geology (Th)		4	15	40	75	4-0-0
		Practical		2		20		0-0-4
	Discipline Specific Elective - 1	DSE - 1	Theory	4	15	40	75	4-0-0
			Practical	2		20		0-0-4
	Discipline Specific Elective - 2	DSE - 2	Theory	4	15	40	75	4-0-0
			Practical	2		20		0-0-4
	Total			**24**			**300**	
VI	Core Course - 13	Geomorphology, Remote Sensing and GIS (Th)		4	15	40	75	4-0-0
		Practical		2		20		0-0-4
	Core Course - 14	Engineering Geology (Th)		4	15	40	75	4-0-0
		Practical		2		20		0-0-4
	Discipline Specific Elective - 3	DSE - 3	Theory	4	15	40	75	4-0-0
			Practical	2		20		0-0-4
	Discipline Specific Elective - 4	DSE - 4	Theory	4	15	40	75	4-0-0
			Practical	2		20		0-0-4
	Total			**24**			**300**	
	TOTAL OF ALL SEMESTERS			**142**			**1900**	

PROGRAMME OUTCOME- PROGRAMME SPECIFIC OUTCOME- COURSE OUTCOME

1. Programme Outcome:

1. A. **Graduate Attributes**: the quality and feature or characteristics of an individual, including the knowledge, skills, attitudes, and values that are expected to be acquired by a graduate through studies at the higher education institution.

Some of the characteristic attributes that a graduate should demonstrate:

i) Disciplinary knowledge
ii) Communication Skills
iii) Critical thinking
iv) Problem solving
v) Analytical reasoning
vi) Research-related skills
vii) Cooperation/Teamwork
viii) Scientific reasoning
ix) Reflective thinking
x) Information/digital literacy
xi) Self-directed learning
xii) Multicultural competence
xiii) Moral and ethical awareness/reasoning
xiv) Leadership readiness/qualities
xv) Lifelong learning

1. B. **Qualification descriptors:** the generic outcomes and attributes expected for the award of a particular type of qualification (for e.g. a bachelor's degree or a bachelor's degree with honors).

Qualification descriptors for a bachelor's degree programme (General)

Some of the expected learning outcomes that a student should be able to demonstrate on completion of a degree-level programme may include the following:

- Demonstrate (i) a fundamental/systematic or coherent understanding of an academic field of study, its different learning areas and applications, and its linkages with related disciplinary areas/subjects; (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of study, including research and development, teaching and government and public service; (iii) skills in areas related to one's specialization and current developments in the academic field of study.
- Use knowledge, understanding and skills required for identifying problems and issues, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, and their application, analysis and evaluation using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments;
- Communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s).

- Meet one's own learning needs, drawing on a range of current research and development work and professional materials.
- Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts, rather than replicate curriculum content knowledge, to identify and analyze problems and issues and solve complex problems with well-defined solutions.
- Demonstrate subject-related and transferable skills that are relevant to some of the job trades and employment opportunities.

Qualification descriptors for a bachelor's degree with honours

- Demonstrate (i) a systematic, extensive and coherent knowledge and understanding of an academic field of study as a whole and its applications, and links to related disciplinary areas/subjects of study; including a critical understanding of the established theories, principles and concepts, and of a number of advanced and emerging issues in the field of study; (ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of study, including research and development, teaching and government and public service; (iii) skills in areas related to one's specialization and current developments in the academic field of study, including a critical understanding of the latest developments in the area of specialization, and an ability to use established techniques of analysis and enquiry within the area of specialization.
- Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to the chosen disciplinary areas (s) and field of study, and techniques and skills required for identifying problems and issues relating to the disciplinary area and field of study.
- Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources, analysis and interpretation of data using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments.
- Use knowledge, understanding and skills for critical assessment of a wide range of ideas and complex problems and issues relating to the chosen field of study.
- Communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s) of study.
- Address one's own learning needs relating to current and emerging areas of study, making use of research, development, and professional materials as appropriate, including those related to new frontiers of knowledge.
- Apply one's disciplinary knowledge and transferable skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.
- Demonstrate subject-related and transferable skills that are relevant to some of the job trades and employment opportunities.

2. Programme Specific/ Learning Outcome:

Geology Honours:

The student graduating with the Degree B. Sc. (Honours) Geology should be able to

 Acquire

a) a fundamental/systematic or coherent understanding of the academic field of Geology, its different learning areas and applications in basic Geology like Mineralogy, Petrology, Stratigraphy, Palaeontology, Economic geology, Hydrogeology, etc. and its linkages with related interdisciplinary areas/subjects like Geography, Environmental sciences, Physics, Chemistry, Mathematics, Life

sciences, Atmospheric sciences, Remote Sensing, Computer science, Information Technology;
b) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Geology, including professionals engaged in research and development, teaching and government/public service.
c) skills in areas related to one's specialization area within the disciplinary/subject area of Geology and current and emerging developments in the field of Geosciences.

 Demonstrate the ability to use skills in Geology and its related areas of technology for formulating and tackling geosciences-related problems and identifying and applying appropriate geological principles and methodologies to solve a wide range of problems associated with geosciences.

 Recognize the importance of RS&GIS, mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

 Plan and execute Geology-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories in Geology.

 Demonstrate relevant generic skills and global competencies such as
a) problem-solving skills that are required to solve different types of geoscience-related problems with well-defined solutions and tackle open-ended problems that belong to the disciplinary area boundaries;
b) investigative skills, including skills of independent investigation of geoscience-related issues and problems.
c) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature; d) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Geology and ability to translate them with popular language when needed; e) ICT skills; f) personal skills such as the ability to work both independently and in Teams

 Demonstrate professional behavior such as
a) being objective, unbiased, and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism; b) the ability to identify the potential ethical issues in work-related situations; c) appreciation of intellectual property, environmental and sustainability issues; and d) promoting safe learning and working environment.

Core Course B.Sc. (Hons.) Geology

Sr No	Learning Outcomes	CC-I	CC-II	CC-III	CC-IV	CC-V	CC-VI	CC-VII	CC-VIII	CC-IX	CC-X	CC-XI	CC-XII	CC-XIII	CC-XIV
1	Fundamental understanding of the field	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Application of basic Geology Concepts	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Linkages with related disciplines	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	Skills in related fields of specialization	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Ability to use in Geological Problems	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	Skills in Mathematical modeling			X	X							X			X
8	Skills in performing analysis and interpretation of data		X	X	X		X	X	X			X	X	X	X
9	Develop investigative Skills	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10	Skills in problem solving in geology and related discipline	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	Develop Technical Communication skills		X	X	X							X	X		X
12	Developing analytical skills and popular communication	X	X	X	X	X	X	X	X			X	X	X	X
13	Developing ICT skills	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, selfreading etc.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Discipline Specific Course B.Sc. (Hons.) Geology

Sr No	Learning Outcomes	DSE-I	DSE-II	DSE-III	DSE-IV
1	Fundamental understanding of the field	X	X	X	X
2	Application of basic Geology Concepts	X	X	X	X
3	Linkages with related disciplines	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X
5	Skills in related fields of specialization	X	X	X	X
6	Ability to use in Geological Problems	X	X	X	X
7	Skills in Mathematical modeling	X	X	X	X
8	Skills in performing analysis and interpretation of data	X	X	X	X
9	Develop investigative Skills	X	X	X	X
10	Skills in problem solving in geology and related discipline	X	X	X	X
11	Develop Technical Communication skills		X	X	X
12	Developing analytical skills and popular communication	X	X	X	X
13	Developing ICT skills	X	X	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, selfreading etc.	X	X	X	X

Skill Enhancement Course (SEC) for B.Sc. (Hons) Geology

Sr No	Learning Outcomes	SEC-I	SEC-II
1	Fundamental understanding of the field	X	X
2	Application of basic Geology Concepts	X	X
3	Linkages with related disciplines	X	X
4	Procedural knowledge for professional subjects	X	X
5	Skills in related fields of specialization	X	X
6	Ability to use in Geological Problems	X	X
7	Skills in Mathematical modeling		
8	Skills in performing analysis and interpretation of data		
9	Develop investigative Skills	X	X
10	Skills in problem solving in geology and related discipline	X	X
11	Develop Technical Communication skills	X	X
12	Developing analytical skills and popular communication	X	X
13	Developing ICT skills	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, selfreading etc.	X	X

Core Course and Generic Elective (GE) for B.Sc. (Hons.) Geology

Sr No	Learning Outcomes	CC-I/GEC-I	CC-II/GEC-II	CC-III/GEC-III	CC-IV/GEC-IV
1	Fundamental understanding of the field	X	X	X	X
2	Application of basic Geology Concepts	X	X	X	X
3	Linkages with related disciplines	X	X	X	X
4	Procedural knowledge for professional subjects	X	X	X	X
5	Skills in related fields of specialization	X	X	X	X
6	Ability to use in Geological Problems	X	X	X	X
7	Skills in Mathematical modeling		X	X	X
8	Skills in performing analysis and interpretation of data		X		X
9	Develop investigative Skills	X	X	X	X
10	Skills in problem solving in geology and related discipline	X	X	X	X
11	Develop Technical Communication skills	X	X	X	X
12	Developing analytical skills and popular communication	X	X	X	X
13	Developing ICT skills	X	X	X	X
14	Demonstrate Professional behaviour with respect to attribute like objectivity, ethical values, selfreading etc.	X	X	X	X

DETAILED SYLLABUS OF GEOLOGY HONOURS

CC-1

EARTH SYSTEM SCIENCE

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

Earth System science course aims to explore, understand, communicate, and teach the Earth as a planet, its complex processes, past and future evolution and interactions with society. The main objective is to study the atmosphere, hydrosphere, and lithosphere, including their interaction and interrelationships with the biosphere.

Course Learning Outcomes:

On completion of this course the students

i) Analyze the interactions between biological, chemical and physical processes that shape and define the earth system
ii) Correlate between the past Earth evolution and its current changes.
iii) Develop effective communication skills to help diffusing major current environmental problems.

THEORY

Unit 1: Earth System Science **(9 Lectures)**

Definition and scope; General characteristics and origin of the Universe, Solar System, and its planets; the Terrestrial and Jovian planets.
Meteorites and Asteroids
Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters, and its age.

Unit 2: Solid Earth and its fluid cover **(8 Lectures)**

Internal constitution - its recognition vis-à-vis solid earth geophysics: crust, mantle, core, evidence from seismic waves and rocks
Hydrosphere, atmosphere, and biosphere: Elementary
idea Nature of Earth's magnetic field

Unit 3: Plate Tectonics **(9 Lectures)**

Concept of continental drift vis-a-vis plate tectonics, seafloor spreading
Plate boundaries: Mid Oceanic Ridges, trenches, transform faults and island arcs
Concept of isostasy, isostatic condition of India

Internal process and its superficial manifestation – volcanoes and volcanism, distribution of volcanoes causes of earthquakes and their effects, intensity and magnitude, earthquake belts, seismic zones of India.

Unit 4: Hydrosphere and Atmosphere **(8 Lectures)**

Oceanic current system and effect of Coriolis force
Concepts of eustasy
Land-sea interaction along coast
Weather and climatic changes

Unit 5: Earth surface processes **(8 Lectures)**

Weathering; erosion; mass wasting; Geological work of wind, river and glacier
Formation of soil, soil profile and soil types

Unit 6: Introduction to the concept of time in geological studies **(9 Lectures)**

Stratigraphy: definition and scope
Brief history of development of stratigraphic principles; concepts of Neptunism, Plutonism and Uniformitarianism
Geological Timetable, introduction to geochronological methods and their application in geological studies
Fundamental laws of stratigraphy: Superposition, Faunal succession, and correlation

Unit 7: Cosmic abundance of elements **(9 Lectures)**

Distribution of elements in solar system and in Earth
Introduction to chemical differentiation and composition of the Earth
General concepts about geochemical cycles

PRACTICAL

Study of major geomorphic features and their relationships with outcrops through physiographic models and maps
Detailed study of topographic sheets and preparation of physiographic description of an area
Study of distribution of cratons, mobile belts, and major sedimentary basins on the map of India.

SUGGESTED READINGS:

1. Duff, P. M. D., & Duff, D (Eds.) (1993) *Holmes' principles of physical geology*. Taylor & Francis.
2. Emiliani, C. (1992) *Planet earth: cosmology, geology, and the evolution of life and environment*. Cambridge University Press.
3. Gross, M. G. (1977) *Oceanography: A view of the earth*.

CC - 2

MINERAL SCIENCE

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

This course helps to understand the fundamentals of crystallography and structural chemistry of minerals along with descriptive mineralogy. The students will be able to learn the optical and crystallographic properties of the minerals and their occurrences. The course provides better understanding of crystallography, mineralogy and optical mineralogy and their application involved during the origin and evolution of the rocks.

Course Learning Outcomes:

After studying the course, the students can

i) Describe and recognize various physical properties of minerals, including lustre, cleavage, hardness, density etc. as well as optical properties

ii) Explain different symmetry elements of the crystals and how these relate to crystal systems.

THEORY

Unit 1: Crystallography **(12 Lectures)**

Elementary ideas about crystal morphology in relation to internal structures

Crystal parameters and Miller indices

Crystal symmetry and classification of crystals into point groups, space groups and crystal systems

Unit 2: Crystal projection **(12 Lectures)**

Stereographic projections of symmetry elements and forms, Herman Mauguin notation

Unit 3: Rock forming minerals **(18 Lectures)**

Minerals - definition and classification, physical and chemical properties

Substitution principles – Goldschmidt's rule of substitution of elements; partitioning of elements between coexisting phases; Brief idea about Isomorphism, Solid solution, Pseudo morphism and Polymorphism: elementary concept on principle types – common polymorphic forms of C, SiO_2 and Al_2SiO_5

Crystal structure and its controls: bonding and coordination principles.

Classification of silicate groups based on structure and derivation of structural formulae based on composition

Non-silicate structures; CCP and HCP structures

Unit 4: Optical mineralogy **(18 Lectures)**

Optical behaviour of crystals – Isotropic and anisotropic minerals; Nicol prism and its principle of construction; Polaroid; Refractive index of minerals; Uniaxial & Biaxial minerals; Optical indicatrix of uniaxial and biaxial minerals; Birefringence, Interference colour and use of interference colour chart; Relation between crystallographic and optical axes of crystals

Pleochroism and pleochroic scheme; Extinction; Study of interference figures; Optic sign of uniaxial and biaxial minerals

PRACTICAL

Study of the symmetry of crystals

Study of physical properties of minerals in hand specimen: Olivine, Garnet, Sillimanite, Kyanite, Staurolite, Beryl, Tourmaline, Pyroxene, Actinolite, Tremolite, Hornblende, Serpentine, Talc, Muscovite, Biotite, Quartz, Alkali feldspar, Plagioclase, Nepheline, Sodalite, Zeolite, Pyrite, Chalcopyrite, Galena, Sphalerite, Graphite, Magnetite, Haematite, Fluorite, Calcite, Dolomite, Gypsum, Asbestos, Ilmenite, Chromite, Pyrolusite, Psilomelane, Bauxite

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

SUGGESTED READINGS:

1. 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.
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.

CC - 3

ELEMENTS OF GEOCHEMISTRY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

Geochemistry aims to give an introduction in how chemical principles are used to explain the formation of the elements and solar system, the Earth's geochemical composition and differentiation into different reservoirs, the age of rocks, the surface environment and the chemical traces of early life.

Course Learning Outcomes:

The students can

i) Demonstrate the behavior of elements in geochemical context and relate this to hoe elements redistribute within the earth.

ii) Establish the Earth's chemistry in terms of interactions between reservoirs.
iii) Analyze the major processes operating in the Earth's crust and mantle.
iv) Use isotopes to trace geological processes and age date specific events.

THEORY

Unit 1: Concepts of geochemistry **(10 Lectures)**
Introduction to properties of elements: The periodic table
Chemical bonding, states of matter and atomic environment of elements
Geochemical classification of elements

Unit 2: Layered structure of Earth and geochemistry **(10 Lectures)**
Composition of different Earth reservoirs and the nuclides and radioactivity
Concept of radiogenic isotopes in geochronology and isotopic tracers

Unit 3: Element transport **(10 Lectures)**
Advection and diffusion
Aqueous geochemistry- basic concepts and speciation in solutions, Eh, pH relations

Unit 4: Geochemistry of solid Earth **(10 Lectures)**
The solid Earth – geochemical variability of magma and its products
Composition of the bulk silicate Earth
Meteorites

Unit 5: Geochemical behavior of selected elements **(10 Lectures)**
Si, Al, K, Na, Ca, Fe, Mg, Ti.

Unit 6: Brief introduction to analytical instruments and geochemical data **(10 Lectures)**
EPMA, XRF, ICPMS

PRACTICAL

Interpretation of geochemical data: Bivariate and trivariate plots to delineate the control of different compositional variables: Harker variation diagram, AFM diagram, MgO diagram, compatible and incompatible element variation.

SUGGESTED READINGS:

1. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
2. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.

3. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
4. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
5. Faure, Gunter, and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd.

CC - 4

STRUCTURAL GEOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives

The objectives of this course are to make students able to understand the

- Concepts of stress, strain, and deformation.
- Significance of brittle, plastic and ductile deformation and their products.
- Origin and mechanisms of faults, fractures, and folds.
- Processes and fabrics that occur in shear zones and their kinematic significance.
- Deriving tectonic histories from analysis of geological maps.

Course Learning Outcomes:

This course enables the students to

i) Understand the structure of the rocks in the earth's crust and mantle.
ii) Determine the deformational history based on fabrics and geometric relationships.
iii) Quantitatively describe stress and strain transformation.

THEORY

Unit 1: Basic structural elements (12 Lectures)

Introduction to structural geology; Diastrophic and non- diastrophic structures; Components of structural elements: planar and linear features, concept of dip and strike, trend and plunge, rake/pitch; Application of primary sedimentary and igneous structure in structural geology for determining younging direction; Unconformity and its types.

Unit 2: Rock deformation (12 Lectures)

Concept of rock deformation: Stress and Strain in rocks, Strain ellipse and ellipsoids of different types and their geological significance.

Unit 3: Folds (12 Lectures)

Fold morphology; Geometric classification, mechanics of folding: Buckling, Bending, Flexural slip and flow

folding; genetic classification of folds

Unit 4: Foliation and lineation **(12 Lectures)**

Types of foliations and lineations, their tectonic significance and relationship with other structures

Unit 5: Fractures, joints, and faults **(12 Lectures)**

Classification of fractures, joints and faults and their relationship with strain

Effects of faulting on the outcrops

Geologic/geomorphic criteria for recognition of faults and determination of net slip

PRACTICAL

Basic idea of topographic contours, Topographic sheets of various scales.

Solution of true dip and apparent dip problems, Three-point problem, Fold problems, Fault problems by graphical method

Introduction to Geological maps: Lithological and Structural maps

Structural contouring and 3-point problems of dip and strike

Drawing profile sections and interpretation of geological maps of different complexities; Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.)

SUGGESTED READINGS:

1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
6. Ghosh, S. K. (2013) Structural Geology Fundamentals and Modern Developments Pergamon Press
7. Twiss, R. J. and Moores, E. M. (2007) Structural Geology (2nd Ed.), W. H. Freeman and Co.
8. Lahee F. H. (1962) Field Geology. McGraw Hill.

CC - 5

IGNEOUS PETROLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

Igneous petrology in the field of geology, the objective of the study to gain an appreciation for how the final appearance of characteristics of igneous rocks is controlled by chemical and physical properties of magmas

and their surroundings.

Course Learning Outcomes:

Study of igneous rocks is a key component of geology curriculum (because these rocks not only abundant throughout the crust of the Earth, but, dominate some crustal and upper mantle environments). Students apply the knowledges of melt generation and crystallization mechanisms, diverse rock types and their link to tectonic settings in different earth processes.

THEORY

Unit 1: Introduction to Igneous petrology (8 Lectures)

Principal modes of magma formation in the crust and upper mantle; physical properties of magma - temperature, viscosity, density, and volatile content; formation and types of igneous rocks: volcanic, hypabyssal, plutonic.

Unit 2: Form and structure (8 Lectures)

Description of different forms and structures of igneous bodies with emphasis on their mode of emplacement - sill, dyke, ring dyke, cone sheet, laccolith, lopolith, phaccolith, batholith, pillow structure, ropy and aa lava structure, columnar joints etc.

Unit 3: Textures and microstructures (10 Lectures)

Crystallinity, granularity, shapes and mutual relations of grains; nucleation and growth of igneous minerals Description of the following textures and microstructures with their occurrence in different rocks - panidiomorphic, hypidiomorphic, allotriomorphic, porphyritic, vitrophyric, poikilitic, ophitic, sub-ophitic, intergranular, intersertal, pilotaxitic, trachytic, graphic, granophyric, rapakivi, orbicular, corona, perthitic, myrmekitic, variolitic, speherulitic & spinifex.

Unit 4: Classification of igneous rocks (8 Lectures)

Bases of classification of igneous rocks: mineralogical, textural, chemical, chemico-mineralogical, and associational; Norm and mode; Standard classification schemes –Niggli, Hatch, Wells & Wells and IUGS

Unit 5: Phase diagrams (10 Lectures)

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

Unit 6: Petrography of the common igneous rock types (8 Lectures)

Granitoids, Pegmatite, Syenite, Monzonite, Diorite, Norite, Gabbro, Anthrothosite, Dolerite, Pyroxenites, Peridotite, Lamprophyres, Carbonatite, Rhyolite, Andesite, Dacite, Basalt, Komatiite.

Unit 7: Petrogenesis of igneous rocks (8 Lectures)

Crystallization – Differentiation of a magma, brief idea on several mechanisms of magmatic differentiation,

Bowen's reaction series and its implications; Elementary knowledge of petrogenesis of the following rocks: granite, basalt, and ultramafic rocks.

PRACTICAL

Study of important igneous rocks in hand specimens and thin sections- granite, granodiorite, diorite, syenite, nepheline syenite, gabbro, anorthosites, ultramafic rocks, basalts, andesites.
Norm Calculation, Visual estimation of Modes from thin sections. Plotting of modes in IUGS classification of Plutonic rocks (Streckeisen diagram)

SUGGESTED READINGS:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
6. Myron G. Best (2001). Igneous and Metamorphic Petrology,
7. K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.
8. Bose M.K. (1997). Igneous Petrology.
9. G W Tyrrell. (1926). Principles of Petrology. Springer

CC - 6

SEDIMENTOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

Sedimentary rocks are storehouse of many necessities of modern civilization viz. water, hydrocarbon etc. Major objective of the course is to make students understand fundamentals of sedimentary processes and their products, formation, and filling history of sedimentary basins in different tectonic backdrop. Nuances of both clastic and chemical sedimentation processes will be covered.

Course Learning Outcomes:

1. To describe scales of sedimentary grain size measurement and statistical analysis of data to interpret

provenance, transportation history or depositional environment.
2. To determine the texture and structure of clastic sedimentary rocks; procedure and importance of paleocurrent analysis.
3. To recognize how sediments become sedimentary rocks, how porosity forms and evolves and how they can interpret the diagenetic evolution of ancient sedimentary rocks.
4. To comprehend concept of sedimentary environment and description of processes and products of different sedimentary environments viz. continental, marginal marine and marine.

THEORY

Unit 1: Introduction to Sedimentology (12 Lectures)

Outline of sedimentation process: Definition of sediment; origin of sediments: mechanical and chemical sediments; source rock or provenance.

Unit 2: Granulometry (12 Lectures)

Grain size: concept and size scale, particle size distribution, environmental connotation; particle shape and fabric; Sedimentary textures

Unit 3: Basic hydraulics and Sedimentary structures (12 Lectures)

Fluid flow: Types of fluids, 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

Mass flow: types, mechanisms and controlling factors, process-product relationship Penecontemporaneous deformation: mechanisms and controlling factors Sedimentary structure: Primary and penecontemporaneous deformation structures Bedform stability diagram

Paleocurrent analysis: Data acquisition, methodology, different paleocurrent patterns.

Unit 4: Sedimentary rocks (12 Lectures)

Siliciclastic rocks: Components and classification(s) of conglomerates and sandstones Tectonic control on sandstone composition. General introduction to mud rocks Carbonate rocks, controlling factors of carbonate deposition, components, and classifications of limestone; dolomite and dolomitization

Unit 5: Diagenesis (12 Lectures)

Concepts of diagenesis

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

PRACTICAL

Exercises on sedimentary structures

Particle size distribution and statistical analysis

Paleocurrent analysis

Petrographic study of clastic and non-clastic rocks in hand specimens and thin sections

SUGGESTED READINGS:

1. Allen, J.R.L., 1985. *Principles of Physical Sedimentology*. George Allen and Unwin, London
2. Prothero, D. R., & Schwab, F. (2004). *Sedimentary geology*. Macmillan.
3. Tucker, M. E. (2006) *Sedimentary Petrology*, Blackwell Publishing.
4. Collinson, J. D. & Thompson, D. B. (1988) *Sedimentary structures*, Unwin- Hyman, London.
5. Nichols, G. (2009) *Sedimentology and Stratigraphy*, Second Edition. Wiley Blackwell

CC - 7
PALEONTOLOGY
(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

To understand the Invertebrate, Vertebrate and Micropaleontology in the light of their morphology, adaptation, ecology, and Evolution. The present course will also teach on the evidences and records of the earliest life on the earth.

Course Learning Outcomes:

1. Identification of older life forms with their external and internal features.
2. Application of morphological modifications to deduce the ecology.
3. Application of principles of speciation and evolution.

THEORY

Unit 1: Fossilization and fossil records (8 Lectures)

Processes relating to fossilization of invertebrates, vertebrates, plants, and trace fossils; taphonomy, modes of preservation; Importance of fossil records – fossil lagerstätten.

Unit 2: Taxonomy and species concept (8 Lectures)

Species concept with special reference to Palaeontology, Taxonomic hierarchy, Procedures for formal description and nomenclature of species. Theory of organic evolution: speciation, microevolution, macroevolution, examples from fossil records.

Unit 3: Invertebrates (10 Lectures)

Study of morphological features as preserved in fossils of important invertebrate groups: Bivalvia, Gastropoda, Cephalopoda, Brachiopoda, Echinodermata and their functional aspects.

Unit 4: Vertebrates **(10 Lectures)**

Origin of vertebrates and major steps in vertebrate evolution: origin of jaws, amniotic eggs, diversification of terrestrial habitat, Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs; Major traits in horse evolution and intercontinental migrations; major traits in hominid evolution and records of hominid fossils in Indian subcontinent.

Unit 5: Palaeobotany **(8 Lectures)**

Study of plant morphology found to be preserved as fossils, Gondwana flora.

Unit 6: Microfossils **(8 Lectures)**

General overview of microfossils; Study of foraminifera: morphology of living and fossil forms; dimorphic and trimorphic variations; wall structure and composition of foraminiferal tests.

Unit 7: Application of Palaeontology **(8 Lectures)**

Biostratigraphy: biozone, index fossil, correlation. Significance of ammonite in Mesozoic Biostratigraphy
Palaeobiogeography: biogeographic provinces, dispersal, and barriers
Palaeoecology: Interpretation of palaeoechological aspects from fossil record

PRACTICAL

Study of fossils showing various modes of preservation
Study of diagnostic morphological characters up to family level of Bivalvia, Gastropoda, Cephalopoda, Brachiopoda and Echinodermata
Study of the functional aspects of morphological features of Bivalvia
Study of morphological features of Gondwana flora.

SUGGESTED READINGS

1. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
2. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
3. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
4. Shukla, A. C., & Mishra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
5. Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.

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METAMORPHIC PETROLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

Dynamic nature of lithosphere leads to solid state transformations of rocks which hold clue to the past

processes which are not possible to reconstruct by other means. This course aims to enable students to identify critical data as well as provide theoretical basis for interpreting this data for past geodynamic processes, especially the orogenic events.

Course Learning Outcomes:

1. Identifying equilibrium mineral assemblages through textural and mineralogical observations
2. Plotting the quantitative as well as qualitative mineral and mineral assemblage data to interpret the discontinuous reactions and to infer the nature of continuous reactions
3. Apply the basics of Schreinemakers geometric plots for a set of reactions

THEORY

Unit 1: Metamorphism - controls and types (10 Lectures)

Definition of metamorphism; factors controlling metamorphism; types of metamorphism - contact, regional, fault zone metamorphism, impact metamorphism.

Unit 2: Quantification of equilibrium in metamorphism (10 Lectures)

Metamorphic rocks as geochemical systems; Application of chemical thermodynamics in homogeneous phase equilibria; Geothermobarometry

Unit 3: Metamorphic facies and grades (10 Lectures)

Concept of equilibrium; Index minerals; composition paragenesis diagram (ACF, AKF, AFM projection); metamorphic zones and isograde.
Concept of metamorphic facies and grade; mineralogical phase rule of closed and open system

Unit 4: Metamorphism and Tectonism (10 Lectures)

Relationship between metamorphism and deformation; structure and textures of metamorphic rocks metamorphic mineral reactions (prograde and retrograde); Metamorphic Facies Series; Paired Metamorphic Belt.

Unit 5: Types of metamorphism (10 Lectures)

Progressive metamorphism of pelitic and basic rocks; Contact metamorphism of impure limestone; Crustal anatexis, Partial melting in metamorhic rocks; Migmatites and their origin; Metasomatism and role of fluids in metamorphism.

Unit 6: Metamorphic rock associations (10 Lectures)

Schists, gneisses, khondalites, charnockites, blue schists and eclogites.

PRACTICAL

Hand specimen study of following metamorphic rocks: Slate, Phyllite, Schist, Gneiss, Amphibolite, Charnockite, Khondalite, Mafic granulite, Marble
Textural and mineralogical study of following metamorphic rocks in thin sections: schists, gneisses, amphibolite, charnockite, khondalite, mafic granulite, eclogite, marble,
Graphical plots of metamorphic mineral assemblages using chemographic diagrams

SUGGESTED READINGS:

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
5. Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.

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PRINCIPLES OF STRATIGRAPHY AND PRECAMBRIAN STRATIGRAPHY OF INDIA
(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

Objective of this course is to perform lithostratigraphic correlation, construct rank charts for lithostratigraphy, biostratigraphy and chronostratigraphy and to have an idea about different Precambrianstratigraphic successions of India.

Course Learning Outcomes:

On successful completion of the course, the student will be able to:

1. Analyze basic principles of stratigraphy, different types of stratigraphic units and how they are named.
2. Use the fossil record in establishing age of the rock unit and correlation with other area.
3. Give an account of criteria of stratigraphic correlation.
4. Appreciate how plate tectonic movements separated India from contiguous landmasses and shaped the depositional basins of the Indian Phanerozoic, and what were their effects on climate and life.

THEORY

Unit 1: Principles of stratigraphy (10 Lectures)

Concepts of neptunism, plutonism, and catastrophism; Fundamentals of lithostratigraphy, biostratigraphy and chronostratigraphy. Introduction to concepts of dynamic stratigraphy (chemo-stratigraphy, seismic stratigraphy, sequence stratigraphy). Relevance of Type section. Principles of stratigraphic correlation.

Unit 2: Code of stratigraphic nomenclature (10 Lectures)

International Stratigraphic Code – development of a standardized stratigraphic nomenclature. Concepts of Stratotypes. Brief introduction to the concepts of lithostratigraphy, biostratigraphy, chronostratigraphy, seismic stratigraphy, chemo stratigraphy, magnetostratigraphy, sequence stratigraphy and their subdivisions with Indian examples.

Unit 3: Principles of stratigraphic analysis & Facies concept in stratigraphy (10 Lectures)

Principles of stratigraphic correlation

Facies concept in stratigraphy; Walther's Law of Facies.

Basic concept of paleogeographic reconstruction

Unit 4: Stratigraphic boundaries in India (10 Lectures)

Archaean-Proterozoic boundaries. Precambrian-Cambrian boundary and their status in global perspective.

Unit 5: Physiographic and tectonic subdivisions of India (10 Lectures)

Brief introduction to the physiographic and tectonic subdivisions of India. Introduction to Indian Shield, Craton. Introduction to Indian Precambrian belts.

Unit6: Geologic evolution Important Precambrian terrains (10 Lectures)

Geologic evolution with emphasis on sedimentation, lithology, magmatism, structure, metamorphism, and geochronology of: Singhbhum, Dharwar, Rajasthan, Central India and Eastern Ghats. Vindhyan and Cudappah basins of India.

PRACTICAL

Study of geological map of India and identification of major Stratigraphic units. Major features of paleogeographic maps –Precambrian

SUGGESTED READINGS:

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

CC - 10

PHANEROZOIC STRATIGRAPHY OF INDIA

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

The main objective is to enable the students to gather knowledge about different Phanerozoic stratigraphy of India and to know Precambrian-Cambrian boundary, Permian-Triassic boundary, and Cretaceous-Tertiary boundary in India.

Course Learning Outcomes:

On successful completion of the course the students can identify different Phanerozoic stratigraphic units and can correlate with the respective fossil assemblages.

THEORY

Unit 1: Introduction (15 Lectures)

Definition. Important Stratigraphic boundaries during Phanerozoic time in India -a. Precambrian- Cambrian boundary, Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.

Unit 2: Important Palaeozoic successions in India (25 Lectures)

Important Palaeozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and palaeoenvironment of the following: Paleozoic Succession of Kashmir, Stratigraphy & Structure of Gondwana basins. Mesozoic stratigraphy of India: Triassic successions of Spiti; Jurassic of Kutch; Triassic and Jurassic non marine successions of peninsular India (Upper Gondwana formations ,relevant Formations of Rajasthan basin); Cretaceous, successions of Cauvery basins, Lameta and Jabalpur Formations, Cenozoic stratigraphy of India: Kutch basin, Siwalik successions, Assam, Andaman and Arakan basins. Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration.

Unit 3: Stratigraphy of the intertrappeans (10 Lectures)

Deccan, Rajmahal, Sylhet Trap.

Unit 4: Quaternary Geology **(10 Lectures)**

Definition. Principles of subdivision of Quaternary succession in India.

PRACTICAL

Study of geological map of India and identification of major Phanerozoic stratigraphic units. Stratigraphic correlation of Phanerozoic stratigraphic units in geological map of India, Pangaea reconstructions.

SUGGESTED READINGS:

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

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HYDROGEOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

Water is a basic life supporting system. The rise in global population and the quest for better living standard has greatly stressed the water resources. The course content primarily focuses on groundwater, which being easily available is amenable to greater exploitation. Thus, this course aims to enable students to acquire knowledge about the physical and chemical attributes, occurrence, movement, and exploration of the groundwater resources.

Course Learning Outcomes:

1. The students can access the occurrence of groundwater, water bearing properties of formations, aquifer types and aquifer parameters.
2. They can develop an idea about construction, design and development of water wells, aquifer parameter estimation and the science of groundwater flow under different conditions.
3. The students will use the concepts of groundwater exploration.

THEORY

Unit 1: Introduction and basic concepts (12 Lectures)

Scope of hydrogeology and its societal relevance

Hydrologic cycle: precipitation, evapo-transpiration, run-off, infiltration, and subsurface movement of water. Rock properties affecting groundwater, Vertical distribution of subsurface water

Types of aquifer, aquifer parameters, anisotropy, and heterogeneity of aquifers

Unit 2: Groundwater flow (12 Lectures)

Darcy's law and its validity

Intrinsic permeability and hydraulic conductivity

Groundwater flow rates and flow direction

Laminar and turbulent groundwater flow

Unit 3: Well hydraulics and Groundwater exploration (12 Lectures)

Basic Concepts (drawdown; specific capacity etc.)

Elementary concepts related to equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers.

Surface-based groundwater exploration methods

Introduction to subsurface borehole logging methods

Unit 4: Groundwater chemistry (12 Lectures)

Physical and chemical properties of water and water quality

Introduction to methods of interpreting groundwater quality data using standard graphical plots

Sea water intrusion in coastal aquifers.

Unit 5: Groundwater management (12 Lectures)

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

Brief idea about groundwater pollution and its mitigation

PRACTICAL

Preparation and interpretation of water level contour maps and depth to water level maps

Study, preparation and analysis of hydrographs for differing groundwater conditions

Water potential zones of India (map study)

Determination of hydraulic gradient/slope from water table depth data.

Simple numerical problems related to determination of permeability in field and laboratory

SUGGESTED READINGS:

1. Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
2. Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
3. Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.

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ECONOMIC GEOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

The objectives of this course are to: (a) familiarize with common ore minerals and their identifying criteria at various scales of study; (b) demonstrate knowledge of the variety of ore-forming processes; (c) understand the genetic controls exerted by physical and chemical processes on ore formation in various geologic settings; (d) differentiate between resources and reserves and how to estimate them.

Course Learning Outcomes:

On completion of this course, students should have developed skills in the following areas:

1. Recognize common ore minerals in hand samples and under microscope.
2. Knowledge about a wide range of ore deposits, the geometry of ore bodies, alteration patterns and assemblage of ore and gangue minerals.
3. Awareness about distribution of mineral deposits in India.

THEORY

Unit 1: Ores and gangues **(10 Lectures)**

Ores, gangue minerals, tenor, grade and lodes

Resources and reserves- Economic and Academic definitions

Unit 2: Mineral deposits and classical concepts of Ore formation **(10 Lectures)**

Mineral occurrence, Mineral deposit and Ore deposit

Historical concepts of ore genesis: Man's earliest vocation- Mining

Plutonist and Neptunist concepts of ore genesis

Unit 3: Structure and texture of ore deposits **(20 Lectures)**

Concordant and discordant ore bodies

Endogenous processes: Magmatic concentration, skarns, greisens, and hydrothermal deposits Exogenous processes: weathering products and residual deposits, oxidation and supergene enrichment, placer deposits,

Unit 4: Metallic and Nonmetallic ores **(20 Lectures)**

Metallogenic provinces and epochs
Important deposits of India including atomic minerals
Non-metallic and industrial rocks and minerals in India
Introduction to gemstones.

PRACTICAL

Hand specimen identification of important ores and non-metallic minerals Study of microscopic properties of ore forming minerals (Oxides and sulphides)
Preparation of maps: Distribution of important ores and other economic minerals in Indi

SUGGESTED READINGS:

1. Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.
2. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
3. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
4. Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
5. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
6. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
7. Sarkar, S.C. and Gupta, A. (2012) Crustal Evolution and Metallogeny in India. Cambridge Publications.

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GEOMORPHOLOGY, REMOTE SENSING AND GIS
(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

The course provides an overview of landforms, land forming processes, and landscape evolution. In particular, it aims to shed light on various land forming processes and how these depend on climate and tectonic regimes, and time.

Remote Sensing provide exposure to students in gaining knowledge on concepts and applications leading to modeling of earth resources management, to acquire skills in storing, managing digital data for planning and development, to acquire skills in advance techniques such as hyper spectral, thermal and LiDAR scanning for mapping, modeling and monitoring.

Course Learning Outcomes:

Students analyze how variations in climate, tectonics and environment affect the development of **landforms**, assess how different scales of time and space affect **geomorphological** processes and explain and

apply **geomorphological** methods used in research today.

Students recognize and explain at a basic level fundamental physical principles of remote sensing, including the electromagnetic spectrum; the emission, scattering, reflection, and absorption of electromagnetic (EM) radiation; how EM radiation interactions vary across a limited number of substances, geometries, and temperatures; and geometric properties of photographs and imagery.

THEORY

Unit 1: Introduction to Geomorphology **(7 Lectures)**
Endogenic and Exogenic processes

Unit 2: Major Morphological features **(7 Lectures)**
Geoid, Topography, Hypsometry, Global Hypsometry, Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya).

Unit 3: Surficial Processes and geomorphology **(9 Lectures)**
Weathering and associated landforms, Hill slopes
Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities

Unit 4: Endogenic- Exogenic interactions **(7 Lectures)**
Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development.

Unit 5: Photogeology **(9 Lectures)**
Types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration, and distortion; Elements of air photo interpretation; Identification of sedimentary, igneous, and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms

Unit 6: Remote Sensing, Concepts in Remote Sensing **(7 Lectures)**
Concepts in Remote Sensing; Sensors and scanners; Satellites and their characteristics; Data formats- Raster and Vector.

Unit 7: Digital Image Processing **(7 Lectures)**
Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing. Image classification and accuracy assessment. GIS integration and Case studies- Indian Examples.

Unit 8: GIS and GPS **(7 Lectures)**
Datum, Coordinate systems and Projection systems. Spatial data models and data editing. Introduction to DEM analysis. Concepts of GPS. Integrating GPS data with GIS. Applications in earth system

sciences.

PRACTICAL

Reading topographic maps. Preparation of a topographic profile. Preparation of longitudinal profile of a river. Calculating Stream length gradient index; Morphometry of a drainage basin. Interpretation of geomorphic processes from the geomorphology of the area. Aerial Photo interpretation: Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms. Introduction to DIP and GIS software. Digital Image Processing exercises including analyses of satellite data in different bands and interpretation of various objects based on their spectral signatures. Registration of satellite data with a toposheet of the area. DEM analysis: generating slope map, aspect map and drainage network map and its applications.

SUGGESTED READINGS:

1. Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology-The Mechanics and Chemistry of Landscapes. Cambridge University Press.
2. M.A. Summerfield (1991) Global Geomorphology. Wiley&Sons.
3. Demers, M.N., 1997. Fundamentals of Geographic Information System, JohnWiley&Sons.Inc.
4. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001.GPS: Theory&Practice, Springer Wien New York.
5. Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer-Verlag.
6. Lillesand. T. M. & Kiefer, R.W., 2007.Remote Sensing and Image Interpretation, Wiley.
7. Richards,J.A.and Jia ,X., 1999. Remote Sensing Digital Image Analysis, Springer- Verlag.

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ENGINEERING GEOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

The objectives of the course are to study and identify different types natural materials like rocks & minerals and soil, to understand the various natural dynamic processes their influence on the surfacial features, natural material and their consequences and to know the physical properties of rocks & minerals.

Course Learning Outcomes:

1. Ability to categorize rocks and minerals by their origin and engineering properties.
2. Ability to apply geological principles to rock masses and discontinuities for use in engineering design e.g. rock slopes, foundation.

THEORY

Unit 1: Introduction **(8 Lectures)**

Role of Engineering geologists in planning, design, and construction of major man-made structural features.

Unit 2: Site investigation and characterization. **(8 Lectures)**

Unit 3: Foundation treatment **(6 Lectures)**

Grouting, Rock Bolting and other support mechanisms.

Unit 4: Intact Rock and Rock Mass properties **(6 Lectures)**

Rock aggregates; Significance as Construction Material.

Unit 5: Rock Quality Designation (RQD) **(8 Lectures)**

Concept, Mechanism and Significance of

a. Rock Structure Rating (RSR)
b. Rock Mass Rating (RMR)
c. Tunneling Quality Index (Q)

Geological, Geotechnical and Environmental considerations for Dams and Reservoirs.

Unit 6: Tunnel **(6 Lectures)**

Tunneling Methods.

Unit 7: Landslides **(6 Lectures)**

Causes, Factors and corrective/preventive measures.

Unit 8: Earthquakes **(6 Lectures)**

Causes, Factors and corrective/preventive measures.

Unit 9: Case histories related to Indian Civil Engineering Projects **(6 Lectures)**

PRACTICAL

Computation of reservoir area, catchment area, reservoir capacity and reservoir life
Merits, demerits & remedial measures based upon geological cross sections of project sites
Computation of Index properties of rocks
Computation of RQD, RSR, RMR and ‘Q’

SUGGESTED READINGS:

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
6. Bell, F.G, 2007. *Engineering Geology*, Butterworth-Heineman.

DISCIPLINE SPECIFIC ELECTIVE (ANY FOUR)

DSE - 1

EARTH AND CLIMATE

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

These courses provide students with a global view of their discipline of study and may be taken either as required courses or as electives.

Course Learning Outcomes:

Students can enhance their knowledge through Discipline Specific Elective subjects.

THEORY

Unit 1: Climate system **(10 Lectures)**

Forcing and Responses
Components of the climate system
Climate forcing, Climate controlling factors
Climate system response, response rates and interactions within the climate system
Feedbacks in climate system.

Unit 2: Heat budget of Earth **(10 Lectures)**

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

Unit 3: Atmosphere – Hydrosphere **(10 Lectures)**

Layering of atmosphere and atmospheric Circulation

Atmosphere and ocean interaction and its effect on climate
Heat transfer in ocean
Global oceanic conveyor belt and its control on earth's climate
Surface and deep circulation
Sea ice and glacial ice

Unit 4: Response of biosphere to Earth's climate **(10 Lectures)**

Climate Change: natural vs. anthropogenic effects
Humans and climate change
Future perspectives
Brief introduction to archives of climate change
Archive based climate change data from the Indian continent.

Unit 5: Orbital cyclicity and climate **(10 Lectures)**

Milankovitch cycles and variability in the climate
Glacial-interglacial stages
The Last Glacial maximum (LGM)
Pleistocene Glacial-Interglacial cycles
Younger Dryas
Marine isotope stages.

Unit 6: Monsoon **(10 Lectures)**

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

PRACTICAL

Study of distribution of major climatic regimes of India on map
Distribution of major wind patterns on World map
Preparation of paleogeographic maps (distribution of land and sea) of India during specific geological time intervals
Numerical exercises on interpretation of proxy records for paleoclimate

SUGGESTED READINGS:

1. Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt
3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher
4. Aguado, E., and Burt, J., 2009. Understanding weather

Or

GEODYNAMICS
(CREDITS: THEORY-4, PRACTICAL-1)

THEORY

Unit1: Introduction (15 Lectures)

Definition. Continents and oceans. Continental and oceanic crust. Internal processes of earth; Concept of lithosphere and asthenosphere. Physical character of lithosphere and asthenosphere. Concept of plate. Concept of hotspot and mantle plume. Ophiolites. Palaeomagnetism.

Unit2: Plate and Plate boundaries (15 Lectures)

Plates: Physical character of plates. Macro and microplates. Plate boundaries: types, character, Identification of boundaries. Movement of plates along boundaries. Plate velocities. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults. Magmatism in oceanic ridges and in subduction zones.

Unit 3: Continental Drift, Seafloor spreading and Plate tectonics (15 Lectures)

Wegner Continental drifts hypothesis and its evidences. Continental position in the past; Seafloor spreading process and its evidences; Platetectonics model and its evidences. Distribution of plates in the Earth.

Unit 4: (15 Lectures)

Palaeomagnetism and motion of plates; Driving mechanisms of plates. Plate tectonics and mantle convection; Supercontinents and their breakup and assembly. Wilson cycle.

PRACTICAL

Position of Indian sub-continent during different geological times between break-up of Gondwanaland and formation of the Himalayas.
Different stages of Red sea formation with respect to continental rift system.
Different satges of Atlantic Ocean formation with respect to continental rift system.
Distribution of volcanoes along Ring of Fire in Pacific Ocean.
Schematic drawings of different stages of ocean-continent collision and continent-continent collision.

SUGGESTED READINGS:

1. Turcotte, D.L.andSchubert,G.Geodynamics.SecondEdition. Cambridge
2. Kearey,p., Klepeis, K.A.,and Vine,F.J.(2009). Global Tectonics. Third edition.Wiley- Blackwell, Oxford.

DSE - 2

INTRODUCTION TO GEOPHYSICS

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Unit 1: Geology and Geophysics (10 Lectures)

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

Unit 2: General and Exploration geophysics (10 Lectures)

Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications

Concepts and Usage of corrections in geophysical data.

Unit 3: Geophysical field operations (10 Lectures)

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

Scales of survey, Presentation of geophysical data.

Unit 4: Application of Geophysical methods (10 Lectures)

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

Unit 5: Geophysical anomalies (10 Lectures)

Correction to measured quantities, geophysical anomaly, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration.

Unit 6: Integrated geophysical methods (10 Lectures)

Ambiguities in geophysical interpretation, planning and execution of geophysical surveys.

PRACTICAL

Anomaly and background- Graphical method

Study and interpretation of seismic reflector geometry

Problems on gravity anomaly

SUGGESTED READINGS:

1. Outlines of Geophysical Prospecting - A manual for geologists by Ramachandra Rao, M.B., Prasaranga, University of Mysore, Mysore, 1975.

2. Exploration Geophysics - An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.

3. Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
4. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied geophysics* (Vol. 1). Cambridge university press.
5. Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.

Or

OCEANOGRAPHYAND MARINE SCIENCE
(CREDITS: THEORY-4, PRACTICAL-2)

Unit 1: Fundamentals of Ocean (15 Lectures)

Concept of land and Ocean. Land-Ocean distribution; Marine Provinces; Plate Tectonics and Sea Floor spreading.

Unit 2: Chemical and Physical aspects of Ocean (15 Lectures)

Ocean dynamics; Ocean Chemistry; Marine Sediments; Sea Water: Composition, Controls on sea water composition; Sea-Air Interaction.

Unit 3: Waves, Tides and Coasts (15 Lectures)

Ocean Circulation; Waves and Water Dynamics; Ocean Energy; The Coast: Beaches and Shoreline; The Coastal Ocean -Migration for Coastal Erosion.

Unit 4: Life in the Ocean (15 Lectures)

Marine Life and the Environment; Biologic Productivity and in Ocean; Animals of the Pelagic Environment and Life; Animals of the Benthic environment and Life.

PRACTICAL

Study of land-ocean distribution, sea floor features, plate boundaries, sea floor spreading, distribution of marine sediments and distribution of marine life
Preparation and study of T-S diagrams, Oxygen & carbon dioxide in sea water
Study of global winds and ocean currents, divergence, and convergence zones in the oceans

SUGGESTED READINGS:

1. Introductory Oceanography by Harold V.Thurman, Mt. San Antonio College, Charles E. Merrill Publishing Company.

2. Oceanography for Beginners, by Pronab K. Banerjee, Allied Publishers Pvt Limited
3. Coastal Hydraulics, by A.M. Muirand C.A. Fleming 198 1, The MacMillan Press Ltd, London.
4. Pinet, P.R., (2006): Invitation to oceanography, Jones & Berlett Pub.

DSE - 3

FUEL GEOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Unit 1: Coal **(12 Lectures)**

Definition and origin of Coal

Basic classification of coal on the basis of Rank

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

Proximate and Ultimate analysis, chemical properties of coal

Unit 2: Coal Bed Meathane **(12 Lectures)**

Coal Bed Methane (CBM): global and Indian scenario

Underground coal gasification

Coal liquefaction

Unit 3: Petroleum **(12 Lectures)**

Chemical composition and physical properties of crudes in nature

Origin of petroleum: favourable geological conditions, source material, maturation of organic matter - Biogenic and Thermal effect; Kerogen: types and relation to the origin of petroleum hydrocarbons

Unit 4: Petroleum system **(14 Lectures)**

Source rock, reservoirs and cap rock

Source rock: general attributes

Reservoir rocks: general attributes and petrophysical properties

Cap rocks: definition and general properties.

Migration of petroleum hydrocarbons

Hydrocarbon traps: definition, anticlinal theory and trap theory

Classification of hydrocarbon traps - structural, stratigraphic and combination

Time of trap formation and time of hydrocarbon accumulation.

Plate tectonics and global distribution of hydrocarbon reserves

Petroliferous basins of India

Unit 5: Other fuels **(10 Lectures)**

Gas Hydrate; Nuclear Fuel

PRACTICAL

1. Study of hand specimens of coal
2. Reserve estimation of coal
3. Section correlation and identification of hydrocarbon prospect
4. Panel and Fence diagrams

SUGGESTED READINGS:

1. Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
2. Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
3. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
4. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

Or

RIVER SCIENCE

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Unit 1: Stream hydrology **(10 Lectures)**

Basic stream hydrology

Physical properties of water, sediment and channel flow

River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis

Flood frequency analysis.

Unit 2: River basin **(10 Lectures)**

Sediment source and catchment erosion processes

Sediment load and sediment yield

Sediment transport processes in rivers

Erosion and sedimentation processes in channel.

Unit 3: Drainage **(10 Lectures)**

Drainage network

Quantitative analysis of network organization - morphometry

Random Topology (RT) model and fractal analysis
Role of drainage network in flux transfer
Evolution of drainage network in geological time scale.

Unit 4: Rivers in time and space **(10 Lectures)**

River diversity in space, Patterns of alluvial rivers - braided, meandering and anabranching channels
Dynamics of alluvial rivers
Channel patterns in stratigraphic sequences
Different classification approaches in fluvial geomorphology and its applications

Unit 5: Channels and Landscapes **(10 Lectures)**

Bedrock channels, Bedrock incision process
River response to climate, tectonics and human disturbance
Bedrock channel processes and evolution of fluvial landscapes.

Unit 6: Fluvial hazards **(10 Lectures)**

Integrated approach to stream management
Introduction to river ecology

PRACTICAL

Stream power calculation
Longitudinal profile analysis
Hydrograph analysis and other related problems

SUGGESTED READINGS:

1. Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.
2. Knighton, D. (1998) Fluvial forms and processes: A new perspective. Amold Pubs.
3. Richards. K. (2004) Rivers: Forms and processes in alluvial channels. Balckburn Press.
4. Bryirely and Fryirs (2005) Geomorphology and river management. Blackwell Pub.,
5. Julien, P.Y. (2002) River Mechanics. Cambridge University Press.
6. Robert, A. (2003) River Processes: An introduction to fluvial dynamics. Arnold Publications.
7. Vanoni, V.A. (2006) Sedimentation Engineering. ASCE Manual, Published y American Society of Civil Engineering,
8. Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophyscial UnionMonogrpah, Washington, DC

DSE - 4

EXPLORATION GEOLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Unit 1: Mineral Resources **(12 Lectures)**

Resource reserve definitions, Mineral resources in industries – historical perspective and present; brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies

Unit 2: Prospecting and Exploration **(12 Lectures)**

Principles of mineral exploration; Prospecting and exploration- conceptualization, methodology and stages; Sampling, subsurface sampling including pitting, trenching and drilling; Geochemical exploration.

Unit 3: Evaluation of data **(12 Lectures)**

Evaluation of sampling data

Mean, mode, median, standard deviation and variance.

Unit 4: Drilling and Logging **(12 Lectures)**

Core and non-core drilling

Planning of bore holes and location of boreholes on ground

Core-logging.

Unit 5: Reserve estimation **(12 Lectures)**

Principles of reserve estimation, density and bulk density

Factors affecting reliability of reserve estimation

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

Regular and irregular grid patterns, statistics and error estimation

PRACTICAL

Identification of anomaly

Concept of weighted average in anomaly detection

Geological cross-section

Models of reserve estimation

SUGGESTED READINGS:

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

Or

EVOLUTION OF LIFE THROUGH TIME
(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Unit 1: Life through ages **(10 Lectures)**

Fossils and chemical remain of ancient life.
Geological Time Scale with emphasis on major bio-events.
Fossilization processes and modes of fossil preservation.
Exceptional preservation sites- age and fauna.

Unit 2: Geobiology **(8 Lectures)**

Biosphere as a system, processes and products
Biogeochemical cycles
Abundance and diversity of microbes, extremophiles
Microbes-mineral interactions, microbial mats.

Unit 3: Origin of life **(8 Lectures)**

Possible life sustaining sites in the solar system, life sustaining elements and isotope records
Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life
Precambrian macrofossils – The garden of Ediacara
The Snowball Earth Hypothesis.

Unit 4: Paleozoic Life **(10 Lectures)**

The Cambrian Explosion.
Biomineralization and skeletalization
Origin of vertebrates and radiation of fishes
Origin of tetrapods - Life out of water
Early land plants and impact of land vegetation.

Unit 5: Mesozoic Life **(8 Lectures)**

Life after the largest (P/T) mass extinction, life in the Jurassic seas
Origin of mammals

Rise and fall of dinosaurs
Origin of birds; and spread of flowering plants.

Unit 6: Cenozoic Life **(8 Lectures)**

Aftermath of end Cretaceous mass extinction – radiation of placental mammals
Evolution of modern grasslands and co-evolution of hoofed grazers
Rise of modern plants and vegetation
Back to water – Evolution of Whales.

Unit 7: The age of humans **(8 Lectures)**

Hominid dispersals and climate setting
Climate Change during the Phanerozoic - continental break-ups and collisions
Plate tectonics and its effects on climate and life
Effects of life on climate and geology

PRACTICAL

1. Study of modes of fossil preservation
2. Study of fossils from different stratigraphic levels
3. Exercises related to major evolutionary trends in important groups of animals and plants

SUGGESTED READINGS:

1. Stanley, S.M., 2008 Earth System History
2. Jonathan I. Lumine W.H.Freeman Earth-Evolution of a Habitable World, Cambridge University Press.
3. Canfield, D.E. & Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell
4. Cowen, R., 2000 History of Life, Blackwell

SKILL ENHANCEMENT COURSE (SEC)

Course Objectives:

This course provides the students enhanced learning opportunities with flexibility for working students to complete the program over an extended period of time along with inter-institutional transferability. This system seems to be providing the students opportunity to choose the subjects of their interest.

Course Learning Outcomes:

- Understanding and use of soft skills to motivate team members for improved productivity.
- Understanding the link between people, processes and technology to effectively execute projects towards stakeholder satisfaction.

SEC – 1 (FIELD GEOLOGY)

Basic Field Training

(CREDITS: 2)

Unit 1: Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front andback). Concepts of map reading, Distance, height and pace approximation, Use of GPS in field
Unit 2: Identification of rock types in field; structures and texture of rocks, Use of hand lens
Unit 3: Use of Clinometer and Brunton compass in measuring geological data in field and Basic field measurement techniques: Bedding dip and strike, Litholog measurement
Unit 4: Reading contours and topography.
Unit 5: Recording field data in maps and notebooks.

Or

Stratigraphy and paleontology-related field

(CREDITS: 2)

Field training along Phanerozoic basin of India
Documentation of stratigraphic details in the field
Collection of sedimentological, stratigraphic, and paleontological details and their representation
Facies concept and its spatio-temporal relation (Walther's Law) and concept of facies distribution at basinal-scale
Fossils sampling techniques and their descriptions.

SEC – 2 (FIELD GEOLOGY)

Geological Mapping and Structural Geology Field

(CREDITS: 2)

Unit 1: Geological mapping, stratigraphic correlation
Unit 2: Primary (scalars and vectors) and secondary structures (linear and planar)
Unit 3: Trend, plunge, Rake/Pitch
Unit 4: Stereoplots of linear and planar structures, Orientation analyses.

Or

Himalayan Geology field

(CREDITS: 2)

1. Preparation of a geological transect map in the Himalayas

Or

1. Field training in a sedimentary basin. Documentation of stratigraphic details in the field.
2. Collection of sedimentological, and stratigraphic and paleontological details and their representation.

Or

1. Visit to an underground or Open cast mine
2. Underground mapping/Bench mapping Study

Or

1. Geological mapping of a project site (Dam sites, tunnel,etc).
2. Identification of environmental problems of a project site and remedial measures to be taken.

GENERIC ELECTIVE (GE)
(FOR THE STUDENTS OF DISCIPLINES OTHER THAN GEOLOGY)

GE-1

EARTH SYSTEM SCIENCE

(CREDITS: THEORY-4, PRACTICAL-2)

Course Objectives:

This course helps the students to see their strengths and affording them opportunities to be of value to their classmates.

Course Learning Outcomes:

Students can apply an interdisciplinary knowledge.

THEORY

Unit 1: Earth System Science **(8 Lectures)**

Definition and scope; General characteristics and origin of the Universe, Solar System, and its planets; the terrestrial and Jovian planets.

Meteorites and Asteroids

Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters, and its age.

Unit 2: Solid Earth and its fluid cover **(8 Lectures)**

Internal constitution - its recognition vis-à-vis solid earth geophysics: crust, mantle, core, evidence from seismic waves and rocks

Hydrosphere, atmosphere, and biosphere: Elementary idea

Nature of Earth's magnetic field

Unit 3: Plate Tectonics **(10 Lectures)**

Concept of continental drift vis-a-vis plate tectonics, seafloor spreading

Plate boundaries: Mid Oceanic Ridges, trenches, transform faults and island arcs

Concept of isostasy, isostatic condition of India

Internal process and its superficial manifestation – volcanoes and volcanism, distribution of volcanoes causes of earthquakes and their effects, intensity and magnitude, earthquake belts, seismic zones of India.

Unit 4: Hydrosphere and Atmosphere **(10 Lectures)**

Oceanic current system and effect of Coriolis force

Concepts of eustasy

Land-sea interaction along coast

Weather and climatic changes

Unit 5: Earth surface processes **(8 Lectures)**

Weathering; erosion; mass wasting; Geological work of wind, river and glacier

Formation of soil, soil profile and soil types

Unit 6: Introduction to the concept of time in geological studies **(8 Lectures)**

Stratigraphy: definition and scope

Brief history of development of stratigraphic principles; concepts of Neptunism, Plutonism and Uniformitarianism

Geological Timetable, introduction to geochronological methods and their application in geological studies
Fundamental laws of stratigraphy: Superposition, Faunal succession and correlation

Unit 7: Cosmic abundance of elements **(8 Lectures)**
Distribution of elements in solar system and in Earth
Introduction to chemical differentiation and composition of the Earth
General concepts about geochemical cycles

PRACTICAL

Study of major geomorphic features and their relationships with outcrops through physiographic models and maps.
Detailed study of topographic sheets and preparation of physiographic description of an area
Study of distribution of cratons, mobile belts, and major sedimentary basins on the map of India

SUGGESTED READINGS:
1. Duff, P. M. D., & Duff, D (Eds.) (1993) Holmes' principles of physical geology. Taylor & Francis.
2. Emiliani, C. (1992) Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
3. Gross, M. G. (1977) Oceanography: A view of the earth.

GE-2
STRUCTURAL GEOLOGY
(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Unit 1: Basic structural elements **(12 Lectures)**
Introduction to structural geology; Diastrophic and non- diastrophic structures; Components of structural elements: planar and linear features, concept of dip and strike, trend and plunge, rake/pitch; Application of primary sedimentary and igneous structure in structural geology for determining younging direction; Unconformity and its types.
Unit 2: Rock deformation **(12 Lectures)**

Concept of rock deformation: Stress and Strain in rocks, Strain ellipse and ellipsoids of different types and their geological significance.

Unit 3: Folds **(12 Lectures)**

Fold morphology; Geometric classification, mechanics of folding: Buckling, Bending, Flexural slip and flow folding; genetic classification of folds

Unit 4: Foliation and lineation **(12 Lectures)**

Types of foliations and lineations, their tectonic significance and relationship with other structures

Unit 5: Fractures and faults **(12 Lectures)**

Classification of fractures and faults and their relationship with strain
Effects of faulting on the outcrops
Geologic/geomorphic criteria for recognition of faults and determination of net slip

PRACTICAL

Study of clinometers/Brunton compass; Identification of different types of folds/faults from block models; Basic idea of topographic contours, Topographic sheets of various scales.
Introduction to Geological maps: Lithological and Structural maps, preparation of cross section profile from a geological map.

SUGGESTED READINGS:

1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
3. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
6. Lahee F. H. (1962) Field Geology. McGraw Hill

GE-3

CRYSTALLOGRAPHY AND MINERALOGY

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Unit-1: **(7 Lectures)**

Crystals and their characters:

Unit-2: **(7 Lectures)**

Crystal form, face, edge, solid angle; Interfacial angle and their measurements; Crystallographic axes and angles.

Unit-3: **(7 Lectures)**

Crystal parameters, Weiss, and Miller system of notations.

Unit-4: **(7 Lectures)**

Symmetry elements and description of normal class of Isometric, Tetragonal, Hexagonal, Trigonal, Orthorhombic, Monoclinic and Triclinic systems.

Unit-5: **(7 Lectures)**

Introduction to Mineralogy, Definition, and characters of mineral.

Unit-6: **(9 Lectures)**

Common physical properties of minerals; Chemical composition and diagnostic physical properties of minerals such as: Quartz, Orthoclase, Microcline, Hypersthene, Hornblende, Garnet, Muscovite, Biotite, Chlorite, Olivine, Epidote, Calcite.

Unit-7: **(9 Lectures)**

Polarizing microscope, its parts and functioning; Ordinary and polarized lights; Common optical properties observed under ordinary, polarized lights and crossed nicols.

Unit-8: **(7 Lectures)**

Optical properties of some common rock forming minerals (Quartz, Orthoclase, Microcline, Olivine, Augite, Hornblende, Muscovite, Biotite, Garnet, Calcite).

PRACTICAL

Crystallography:

Study of symmetry elements of normal class of Isometric, Tetragonal, Hexagonal, Trigonal, Orthorhombic, Monoclinic and Triclinic systems.

Mineralogy:

Study of physical properties of minerals mentioned in theory course. Use of polarizing microscope; Study of optical properties of common rock forming minerals mentioned in theory course.

SUGGESTED READINGS

1. Dana, E.S. and Ford, W.E., 2002. A textbook of Mineralogy (Reprints).
2. Flint, Y., 1975. Essential of crystallography, Mir Publishers.
3. Phillips, F.C., 1963. An introduction to crystallography. Wiley, New York.
4. Berry, L.G., Mason, B. and Dietrich, R.V., 1982. Mineralogy. CBS Publ.
5. Nesse, D.W., 1986. Optical Mineralogy. McGraw Hill.
6. Read, H.H., 1968. Rutley's Element of Mineralogy (Rev. Ed.). Thomas Murby and Co.
7. Berry and Mason, 1961. Mineralogy. W.H. Freeman & Co.
8. Kerr, B.F., 1995. Optical Mineralogy 5th Ed. Mc Graw Hill, New York.

GE-4

PETROLOGY

(CREDITS: THEORY-4, PRACTICAL-2)

THEORY

Igneous Petrology

Unit-1: **(7 Lectures)**

Magma: definition, composition, types and origin; Forms of igneous rocks; textures of igneous rocks.

Unit-2: **(7 Lectures)**

Reaction principle; Differentiation and Assimilation; Crystallization of unicomponent and bicomponent (mix-crystals); Bowen's reaction series.

Unit-3: **(7 Lectures)**

Mineralogical and chemical classification of igneous rocks.

Unit-4: **(7 Lectures)**

Detailed petrographic description of Granite, Granodiorite, Rhyolite, Syenite, Phonolite, Diorite,

Gabbro.

Sedimentary Petrology

Unit-5: **(7 Lectures)**

Processes of formation of sedimentary rocks; Classification, textures and structures of sedimentary rocks.

Unit-6: **(7 Lectures)**

Petrographic details of important siliciclastic and carbonate rocks such as - conglomerate, breccia, sandstone, greywacke, shale, limestones.

Metamorphic Petrology

Unit-7: **(9 Lectures)**

Process and products of. metamorphism; Type of metamorphism. Factors, zones and grade of metamorphism; Textures, structures and classification of metamorphic rocks.

Unit-8: **(9 Lectures)**

Petrographic details of some important metamorphic rocks such as - slate, schists, gneiss, quartzite, marble.

PRACTICAL

Igneous Petrology:

Identification of rocks: On the basis of their physical properties in hand specimen; and optical properties in thin sections.

Sedimentary and metamorphic Petrology:

Identification of sedimentary and metamorphic rocks both in hand specimen and thin sections.

SUGGESTED READINGS

1. Turner, F.J. & Verhoogen, J., 1960, Igneous & Metamorphic petrology. McGraw Hill Co.
2. Bose, M.K., 1997. Igneous petrology. World press
3. Tyrell, G. W., 1989. Principles of Petrology. Methuren and Co (Students ed.).
4. Ehlers, WG, and Blatt, H., 1987. Petrology, Igneous, Sedimentary and Metamorphic rocks, CBS Publishers.
5. Moorhouse, WW., 1969. The study of rocks in thin sections. Harper and sons.
6. Friedman & Sanders, 1978. Principles of Sedimentology. John Wiley and sons.
7. Pettijohn, F.J., 1975. Sedimentary rocks, Harper & Bros. 3rd Ed.
8. Prasad, C., 1980. A textbook of sedimentology.
9. Sengupta. S., 1997. Introduction to sedimentology. Oxford-IBH.
10. Turner, F.J., 1980. Metamorphic petrology. McGraw Hill.

11. Mason, R., 1978. Petrology of Metamorphic Rocks. CBS Publ.
12. Winkler, H.G.C., 1967. Petrogenesis of Metamorphic Rocks. Narosa Publ.

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