Bachelor of Science (Geology Hons)

(Undergraduate Curriculum Framework (UGCF)-2022, Based on NEP 2020)

Semester-I to Semester-VIII
Total Credits = 176

Department of Geology
University of Delhi, Delhi 110 007

Undergraduate Curriculum Framework (UGCF)-2022, Based on NEP 2020

Bachelor of (Geology)/Hons

Semester	Core (DSC)	Elective (DSE)	Generic Elective (GE)	Ability Enhancement Course	Skill Enhancement Course (SEC)	Internship/Apprentice-ship/Project/Community outreach (2)	Value addition Course (VAC)	Total Credits
I	DSC-1 (4) **Earth System Science (L3, P1)** DSC-2 (4) **Mineral Science (L3, P1)** DSC-3 (4) **Concepts of Stratigraphy (L3, P1)**		GE-1 (4) One from GE Pool **(Essentials of Geology (L3, T1)**	AEC-1 (2) One from the AEC Pool	SEC-1 (2) One from SEC Pool	-	VAC-1 One from VAC Pool	22 credits
II	DSC-4 (4) **Structural Geology (L3, P1)** DSC-5 (4) **Igneous Petrology (L3, P1)** DSC-6 (4) **Elements of Geochemistry (L3, P1)**		GE-2 (4) One from GE Pool **(Physics & Chemistry of Earth (L3, T1)**	AEC-2 (2) One from the AEC Pool	SEC-2 (2) One from SEC Pool	-	VAC-2 (2) One from VAC Pool	22 credits

	UG Certificate (Geology)					Total = 44
III	DSC-7 (4) **Palaeontology (L3, P1)** DSC-8 (4) **Sedimentary Geology (L3, P1)** DSC-9 (4) **Metamorphic Geology (L3, P1)**	DSE-1 (4) (One from DSE Pool) **Earth Surface Processes (L3, P1)** **or** **Land Survey Techniques (L3, P1)** **or** GE-3 (4) (One from GE Pool) **Fossils and Application (L3, P1)**	AEC-3 (2) One from the AEC Pool	One SEC (2) (Choose from Pool of SEC) Or Internship/Apprentice-ship/Project/Community outreach IAPC (2)	VAC-3 (2) One from VAC Pool	22 credits
IV	DSC-10 (4) **Geomorphology (L3, P1)** DSC-11 (4) **Hydrogeology (L3, P1)** DSC-12 (4) **Geology of India (L3, P1)**	DSE-2 (4) (One from DSE Pool) **Introduction to Field Geology (L2, P2)** **Or** **Paleoseismology (L3, P1)** or	AEC-4 (2) One from the AEC Pool	One SEC (2) (Choose from Pool of SEC) Or Internship/Apprenticeship/ Project/Community outreach IAPC (2)	VAC-4 (2) One from VAC Pool	22 credits

		GE-4(4) (One from GE Pool) **Natural Hazards and Mitigation (L3, T1)**					
	UG Diploma (Geology)						**Total = 88**
V	DSC-13 (4) **Economic Geology (L3, P1)** DSC-14 (4) **Engineering Geology (L3, P1)** DSC-15 (4) **Geological Mapping** (L2, P2)	DSE-3 (4) (One from DSE Pool) **River Science (L3, P1)** **or** **Introduction to geophysics (L3, T1)** **Or** **Application of thermodynamics in petrology (L3, P1)**	GE-5 (4) (one from GE Pool) **Concepts of sustainability (L3, T1)**	--	One SEC (2) (Choose from Pool of SEC) Or Internship/Apprenticeship /Project/Community outreach IAPC (2)	--	22 credits
VI	DSC-16 (4) **Remote sensing and GIS**	DSE-4 (4) (One from DSC Pool)	GE-6 (4) (one from GE Pool)	-	One SEC (2) (Choose from Pool of SEC) Or	--	22 credits

	(L3, P1) DSC-17 (4) **Fuel Geology (L3, P1)** DSC-18 (4) **Paleoceanography and Paleoclimate (L3, P1)**	**Exploration Geology (L3, P1)** **or** **Research Methods in Geoscience (L3, P1)** or **Application of Hydrogeology in Industries and Mining (L3, P1)**	**Evolution of life through time (L3, T1)**		Internship/Apprenticeship /Project/Community outreach IAPC (2)		
	Bachelor of Geology (Honours)						**Total = 132**
VII	DSC-19 (4) **Crustal Evolution through time (L4, P0)**	3 DSE (12) **i) Marine microfossils and biostratigraphy (L3, P1)** **ii) Earthquake Geology (L3, P1)** **iii) Environmental Geology (L3, P1)** Or 2 DSE (8) + 1 GE (4) Or	--	--	--	Dissertation on major (6) **Or** Dissertation on minor (6) **Or** Academic Project/Entrepreneurship (6)	22 credits

		1 DSE (4) + 2 GE (8) **(GE: Geoheritage and Geotourism (L3, T1)**					
VIII	DSC-20 (4) **Research and Analytical Methods in Geoscience (L3, P1)**	3 DSE (12) **i) Mineral Resources and Economics (L4, P0)** **ii) Applied Stratigraphy (L3, P1)** **iii) Techniques of Sample collection & processing in Geology (L3, P1)** Or 2 DSE (8) + 1 GE (4) Or 1 DSE (4) + 2 GE (8) **(GE: Groundwater management and water quality (L3, T1)**	--	--	--	Dissertation on major (6) **Or** Dissertation on minor (6) **Or**	22 credits
	Bachelor of Geology (Honours with Research/Academic Project/Entrepreneurship) or (Honours with Research in Geology (Major) with Discipline 2 (minor)						**Total = 176**

DSE (Semester III to VIII); Each course 4 credits	GE (Semester I to VIII) * Maximum 45 students can opt one GE
1. Earth Surface Processes (L3, P1)	1. Essentials of Geology (L3, T1)
2. Surveying Techniques (L3, P1)	2. Physics & Chemistry of Earth (L3, T1)
3. Introduction to Field Geology (L2, P2)	3. Fossils and Application (L3, T1)
4. Paleoseismology (L3, P1)	4. Natural Hazards and Mitigation (L3, T1)
5. River Science (L3, P1)	5. Concepts of sustainability (L3, T1)
6. Introduction to Geophysics (L3, T1)	6. Evolution of life through time (L3, T1)
7. Application of thermodynamics in petrology (L3, P1)	7. Geoheritage and Geotourism (L3, T1)
8. Exploration Geology (L3, P1)	8. Groundwater management and water quality (L3, T1)
9. Research Methods in Geoscience (L3, P1)	
10. Application of Hydrogeology in Industries and Mining (L3, P1)	
11. Marine microfossils and biostratigraphy (L3, P1)	
12. Earthquake Geology (L3, P1)	
13. Environmental Geology (L3, P1)	
14. Mineral Resources and Economics (L3, T1)	
15. Applied Stratigraphy (L3, P1)	
16. Techniques of Sample collection & processing in Geology (L3, P1)	

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER-I

GEOLOGY

COURSES OFFERED BY DEPARTMENT OF GEOLOGY

Disclaimer: The syllabi are uploaded are as approved by the Academic Council on …… and Executive Council on ….

Category I

[UG Programme for Bachelor in BSc. (Honours) degree in three years]

Eligibility criteria – Class XII pass as per UG admission bulletin 2022 of the university

Pre-requisite – None

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Structure of First Semester in Geology

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 credits	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project Community outreach 2 credits	Value addition course (VAC) 2 credits	Total Credits
I	**DSC – 1** Earth System Science (L3, P1) **DSC – 2** Mineral Science (L3, P1) **DSC – 3** Concepts of Stratigraphy (L3, P1)	NIL	**Choose one from a pool of courses GE-1** Essentials of Geology, (L3, T1)	**Choose one from a pool of AEC courses (2)**	**Choose one from a pool of SEC courses (2)**	NIL	**Choose one from a pool of VAC courses (2)**	**22 credits**

A student who pursues undergraduate programme with Geology as single core discipline is offered the following courses:

3 Discipline Specific Cores (DSCs) - 3 courses of 4 credits = 12 credits (offered by the parent Department i.e. Department of Geology)

0 Discipline Specific Electives (DSE) – No DSE courses in Semester I & II (offered by the parent Department i.e. Department of Geology as choice based electives

1 Generic Elective (GE) – 1 course of 4 credits = 4 credits (one course to be chosen from the common pool of GE courses offered by Departments other than the parent Department)

1 Ability Enhancement Course (AEC) – 1 course of 2 credits = 2 credits (one course to be chosen from either 'Environmental Science: Theory to Practice' or one of the 22 Indian Languages listed in the 8th Schedule of the Constitution in the pool of AEC courses)

1 Skill Enhancement Course (SEC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of SEC courses offered by Geology Department i.e. Fieldwork 1)
1 Value Addition Course (VAC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of VAC courses offered by any Department)

DISCIPLINE SPECIFIC CORE COURSE (DSC-1)
Earth System Science (L3, P1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-1 Earth System Science (L3, P1)	**4**	**3**	**0**	**1**	**12th Pass with science**	**-**

Learning Objectives
This course on Earth System Science is to provide students an introduction to the subject Geology and its significance in terms of Earth's evolution through time. This will provide them a holistic understanding of Earth as a planet in the Solar System and its relationships with other terrestrial planets. Understanding of the processes occurring in lithosphere, hydrosphere, biosphere, and atmosphere

Learning outcomes
After completion of this course, students will be able to understand and comprehend the connectivity and dynamics of the atmosphere, lithosphere, and hydrosphere of the Earth. They will have a thorough understanding of Geology, its various branches and the overall scope of Earth Science will be possible through this course.

SYLLABUS OF DSC-1
Credit 4
Theory 45 hours

Unit 1: **(12 hours)**

Detailed content

Holistic understanding of dynamic planet 'Earth' and its orbital parameters. Introduction to various branches of Earth Sciences. General characteristics and theories about the origin of the Universe including our Solar System and its planets. The terrestrial and Jovian planets. Interior of the Earth. Meteorites and Asteroids. Earth's origin, size, shape, mass, density, rotational and revolution parameters. Methods to determine age of the Earth. Earth's Magnetic Field and Palaeomagnetism. Applications of paleomagnetism.

Unit 2: **(9 hours)**

Detailed content

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

Unit 3: **(12 hours)**

Hydrosphere and Atmosphere: Layers of the Atmosphere. Various cells of the atmospheric circulation. World surface oceanic currents and their distribution. Earth's heat budget. Orogeny and epeirogeny. Major mountain belts of the world.

Unit 4: **(12 hours)**

Detailed content

Understanding the past from geologic records; Nature of geologic records; Standard Geological time scale and introduction to the concept of time in geological studies; Introduction to geochronological methods and their application in geological studies. History of development in concepts of uniformitarianism, catastrophism, and Neptunism, Physiographic divisions of India.

Practical

Study of major geomorphic features and their relationships with outcrops through physiographic models.

Detailed study of topographic sheets and preparation of physiographic description of an area

Study of distribution of major dams on map of India and their impact on river systems

Study of major ocean currents of the World

Study of different rock types

Study of fossils and their application

Study of physiographic map of earth during different Geological ages

Essential readings

Cesare Emiliani,1992; Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment

Arthur Holmes, 197; Holmes Principles Of Physical Geology, by John Wiley & Sons

Suggestive readings

Physical Geology, 15th Edition, Charles C. Plummer, Diane H. Carlson, Lisa Hammersley McGraw-Hill Education- 2016

Essentials of Geology, 13th Edition Frederick K. Lutgens, Edward J. Tarbuck, Dennis G. Tasa- Pearson Publications 2016

Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.

Gross, M. G. (1977). Oceanography: A view of the earth.

Duff, P. M. D. & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis.

Credit distribution, Eligibility and Prerequisites of the Course

DISCIPLINE SPECIFIC CORE COURSE (DSC-2) : Mineral Science (L3, P1)

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-2 Mineral Science (L3, P1)	4	3	0	1	12th pass with science	-

Learning Objectives

The course on mineral science is to provide students fundamental knowledge and understanding about the characteristics of major mineral groups in hand specimen and thin section, phase equilibria, formation environments and associations of rock-forming minerals, crystal symmetry, crystallography, and atomic structure.

Learning outcomes

After successful completion of this course, students will develop the key understanding and knowledge to identify common rock-forming minerals in hand specimens and in thin sections using diagnostic physical, optical, and chemical properties, infer something about the formation environment of a silicate mineral using only its formula, read a phase diagram, predict the physical properties of a substance from its symmetry content, and plot crystal faces on a stereo projection.

SYLLABUS OF DSC- 2
Credits 4
Theory 45 hours

Unit 1: **(9 hours)**

Detailed content

Chemical and Physical Fundamentals: Importance of minerals, the definition of a mineral, atoms, ions, periodic table, bonding in minerals, compositional variations in minerals. Crystallization, crystal imperfections (defects, zoning, twinning), crystal precipitation, mineral classification schemes, and physical properties of minerals (appearance, crystal shape, strength, density, magnetism, reaction with acid).

Unit 2: **(9 hours)**

Detailed Content

Optical mineralogy: Polarized light, refractive index, uniaxial and biaxial indicatrixes, interference figures.

Unit 3
Detailed content

Rock-forming minerals: Igneous minerals (silicates), phase relations. Sedimentary minerals (zeolites, clays, sulfates, halides, oxides, carbonates), weathering processes.

Unit 4: **(9 hours)**

Detailed Content

Metamorphic and Economic minerals: Metamorphic minerals, textures, reactions, phase equilibria. Economic minerals (magmatic, hydrothermal, and sedimentary ores; native metals, sulfides and sulfosalts, oxides and hydroxides, gemstones)

Unit 5: **(9 hours)**

Detailed Content

Symmetry, Crystallography, and Atomic Structure: Symmetry, stereo diagrams, forms and crystal morphology. Unit cells and lattices in two dimensions and three dimensions, Bravais lattices, unit cell symmetry and crystal symmetry, crystal structures, crystal habit and crystal faces. Ionic radii, coordination number, packing, Pauling's rules, silicate structures, substitutions, structures of non-silicates.

Practical (30 hours)

Study of physical properties of minerals in hand specimen

Silicates: Olivine, Garnet, Kyanite, Staurolite, Tourmaline, Serpentine, Talc, Muscovite, Biotite, Quartz, Orthoclase, Plagioclase, Microcline, Nepheline, Sodalite. Quartz varieties: Chert, Flint, Chalcedony, Agate, Jasper, Amethyst, Rosequartz, Smoky quartz, Rock crystal. Native Metals/non-metals, Sulfides, Oxides-Copper, Sulfur, Graphite, Pyrite, Corundum, Magnetite Hydroxides, Halides, Carbonates, Sulfates, Phosphates: Psilomelane, Fluorite, Calcite, Malachite, Gypsum, Apatite.

Study of some key silicate minerals under an optical microscope and their characteristic properties.

Mineral stochiometry related numerical.

Numericals related to parameters and indices of crystals faces.

Stereographic projection of crystal faces.

Essential readings

Cornelis Klein and Barbara Dutrow, The manual of Mineral Science, Wiley Publication 2007

Nesse W. D., Introduction to Optical mineralogy.2008, Oxford University Press.

Deer W. A., Howie.R. A. and Zussman, J., An introduction to the rock-forming minerals 1992

Suggestive readings

Cornelis Klein and Barbara Dutrow, The manual of Mineral Science, Wiley Publication 2007

Nesse W. D., Introduction to Optical mineralogy.2008, Oxford University Press.

Deer W. A., Howie.R. A. and Zussman, J., An introduction to the rock-forming minerals 1992

DISCIPLINE SPECIFIC CORE COURSE3 (DSC-3)- Concepts of Stratigraphy (L3, P1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-3 Concepts of Stratigraphy (L3, P1)	4	3	0	1	12th pass with science	

Learning Objectives

This course on concepts of stratigraphy aims to inculcate the knowledge on basic principles of stratigraphy; define the concept of rock strata and its various forms. It will try to make the students understand difference between rock-unit and time unit, Concept of Geological Time Scale, Age of rock (fossil data, geochronology). Further the objective is to generate skill amongst students to distinguish between different stratigraphic principles and their applications; Lithostratigraphy, Biostratigraphy, Magnetostratigraphy etc. The course attempts to prepare students apply the stratigraphic principles in surface and subsurface for understanding geodynamic processes in the planet Earth and to prepare students apply the acquired knowledge for exploration of natural resources.

Learning outcomes

After successful completion of this course, students will be able to comprehend i) distribution of sedimentary rocks in time and space, ii) principles of different branches of stratigraphy and their distinctiveness, correlatability. Students will be able to apply the stratigraphic principles in both Precambrian and Phanerozoic strata. Students will also be able to compare between different stratigraphic principles and identify the contrast in interpretation based on different principles. Through application of acquired knowledge in geological successions students will be able to develop/ compose template for exercise of stratigraphy in rock strata of different lithology and geological ages.

SYLLABUS OF DSC-3
Credits 4
Theory 45 hours

Unit 1: (9 hours)

Detailed content

Principles of stratigraphy, geological time scale, Stratigraphic units: lithostratigraphic, chronostratigraphic and biostratigraphic units.

Unit 2: (9 hours)

Detailed content

Stratigraphic classification and correlation. Methods of collecting stratigraphic data, identification of stratigraphic contacts and unconformities. Facies concept in stratigraphy. Applications of lithostratigraphy

Unit 3: (9 hours)

Detailed content

Fossils and stratigraphy; Evolutionary trends, Biozones and zone fossils. Biostratigraphy in relation to other stratigraphic techniques.

Unit 4: (9 hours)
Detailed Content

Radiometric dating (K-Ar, Rb-Sr, U-Pb) and correlation techniques. Basic principles of magnetostratigraphy, seismic stratigraphy and sequence stratigraphy.

Unit 5: **(9 hours)**

Detailed content

Concept of Stratotypes. Global Stratotype Section and Point (GSSP). International and Indian code for stratigraphic classification.

Practical (30 hours)

Preparation and study of stratigraphic maps: Correlation diagrams using lithologs of fossiliferous and non-fossiliferous stratigraphic units. Geophysical logs. Examination of isopach and isofacies maps. Exercises related to stratigraphic classification and correlation.

Essential readings

Blatt, H., Berry, W.B. and Brande, S., 1991. Principles of stratigraphic analysis. Blackwell scientific publications, Oxford

Nicols G., 2009 Sedimentology and Stratigraphy 2nd Edition, Wiley-Blackwell

Brookfield, M.E., 2016 Principles of stratigraphy, Wiley India

Fundamentals of Historical geology and stratigraphy of India, Ravindra Kumar

Suggestive readings

Blatt, H., Berry, W.B. and Brande, S., 1991. Principles of stratigraphic analysis. Blackwell scientific publications, Oxford Annexure-III Page 24 of 25

Nicols G., 2009 Sedimentology and Stratigraphy 2nd Edition, Wiley-Blackwell

Brookfield, M.E., 2016 Principles of stratigraphy, Wiley India

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-1): Essentials of Geology (L3, T1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
GE-1 Essentials of Geology (L3, T1)	4	3	1	0	12th Pass	Nil

Learning Objectives

This course on essentials of geology is to provide students about the Interactive and interdisciplinary nature of geology and its overall significance in the academic world. This to introduce students about the Interplanetary scope of geology and linkage and feedback amongst the atmosphere, hydrosphere, biosphere, and lithosphere.

Learning outcomes

After successful completion of this course, students will develop basic but critical skills to understand the Earth, its origin and concept of geological time, formation of planets and solar system, composition of inner as well as surficial components of planet earth, major geomorphic features, and compositions of various parts of earth and major earth processes, and the Earth Resources.

SYLLABUS OF GE-1
Credits 4
Theory 45 hours

Unit 1: **(9 hours)**

Detailed content

Introduction to geology, scope, sub-disciplines and relationship with other branches of sciences Solar system and its origin: Terrestrial and Jovian planets; Nebular hypothesis.

Unit 2: **(9 hours)**

Detailed content

Earth's size, shape, mass, density, rotational and evolutional parameters Earth in comparison to other bodies in the solar system.

Unit 3: **(9 hours)**

Detailed content

Internal constitution of the earth - core, mantle and crust (Chemical and mechanical differentiation) Convections in the earth's core and production of magnetic field; Concept of Plate Tectonics as a unifying theory.

Unit 4: **(9 hours)**

Detailed content

Origin and composition of hydrosphere and atmosphere; Origin of biosphere; Origin of oceans, continents and mountains.

Unit 5: **(9 hours)**

Detailed Content

Geological Time Scale Radioactivity dating and its application in determining the age of the rocks. Earth Resources and their sustainable use.

Tutorials (30 hours)

Student in small batches or groups will be given assignments based on basic geological concepts in terms of interdisciplinary nature of geoscience, interplanetary aspects of Earth, origin and evolution of Earth and resolve the key issues under guidance.

Essential readings

Holmes, A. (1992). Principles of Physical Geology, 1992, Chapman and Hall.
Emiliani, C. (1992). Planet Earth, Cosmology, Geology and the Evolution of Life and Environment, Cambridge University Press.

Suggestive readings

Holmes, A. (1992). Principles of Physical Geology, 1992, Chapman and Hall.
Emiliani, C. (1992). Planet Earth, Cosmology, Geology and the Evolution of Life and Annexure-IV Page 25 of 25 Environment, Cambridge University Press.
Gross, M.G. (1977). Oceanography: A view of the Earth, Prentice Hall.
Grotzinger, J.P. & Jordan, T.H. (2020) Understanding Earth. 8th Edition, W.H. Freeman and Company

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -II

Disclaimer: The syllabi are uploaded are as approved by the Academic Council on …… and Executive Council on ….

Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline

(B.Sc. Honours in Geology in three years)

Structure of Second Semester in Geology

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 credits	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project Community outreach 2 credits	Value addition course (VAC) 2 credits	Total Credits
II	**DSC - 4** Structural Geology (L3, P1) **DSC – 5** Igneous Petrology (L3, P1) **DSC – 6** Elements of Geochemistry (L3, P1)	NIL	**Choose one from a pool of courses GE-2 (4)** Physics & Chemistry of Earth, (L3, T1)	**Choose one from a pool of AEC courses (2)**	**Choose one from a pool of SEC courses (2)**	NIL	**Choose one from a pool of VAC courses (2)**	**22 credits**

A student who pursues undergraduate programme with Geology as single core discipline is offered the following courses:

3 Discipline Specific Cores (DSCs) - 3 courses of 4 credits = 12 credits (offered by the parent Department i.e. Department of Geology)

0 Discipline Specific Electives (DSE) – No DSE courses in Semester I & II (offered by the parent Department i.e. Department of Geology as choice based electives

1 Generic Elective (GE) – 1 course of 4 credits = 4 credits (one course to be chosen from the common pool of GE courses offered by Departments other than the parent Department)

1 Ability Enhancement Course (AEC) – 1 course of 2 credits = 2 credits (one course to be chosen from either 'Environmental Science: Theory to Practice' or one of the 22 Indian Languages listed in the 8th Schedule of the Constitution in the pool of AEC courses)

1 Skill Enhancement Course (SEC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of SEC courses offered by Geology Department i.e. Fieldwork 1)

1 Value Addition Course (VAC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of VAC courses offered by any Department)

DISCIPLINE SPECIFIC CORE COURSE (DSC-4) – Structural Geology (L3, P1)

Credit distribution, eligibility and pre-requisites of the course:

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
(DSC-4) Structural Geology (L3, P1)	4	3	0	1	12th pass with science	Studied Earth System Science, Mineral science, stratigraphy and Equivalent

Learning Objectives

The main objective of this course is to teach the basic principles and concepts of structural geology that helps in understanding rock deformation. The course aims to provide a preliminary introduction to the concepts of stress, strain and rock behaviour. This course also aims to develop fundamental skills in geological mapping, structural data plotting and their interpretation.

Learning outcomes

By the end of this course, students will learn the principles, theories, mechanisms and concepts involved in the deformation of rocks. Students will be able to visualise and interpret three-dimensional geological structures from geological mapping and stereographic projections. They will be able to identify different geological structures, such as folds, faults, and fractures. Students will be able to identify and explain the geometry, dynamics and kinematics involved during the deformation of rocks.

SYLLABUS OF DSC-4

Theory (45 Hours)

UNIT – I (9 hours)

Detailed contents

Introduction to Structure and Topography: Understanding a topographic map; Effects of topography on structural features: Rule of V; Planar and linear structures; Concept of dip and strike, trend and plunge.

UNIT – II (9 hours)

Detailed contents

Stress and strain in rocks: Concept of rock deformation: Definition of Stress and Strain, Strain ellipses of different types and their geological significance. Mohr circle for stress and its application.

UNIT – III (9 hours)

Detailed contents

Folds: Fold morphology; Geometric and genetic classification of folds; Introduction to the mechanics of folding: Buckling, Bending, Flexural slip and flow folding.

UNIT – IV (9 hours)

Detailed contents

Foliation and lineation: Description and origin of foliations: axial plane cleavage and its tectonic significance; different types of foliations: crenulation cleavage, disjunctive cleavage, salty cleavage, schistosity, gneissosity etc. Description and origin of lineation and relationship with major structures; stretching lineation and its relationship with strain.

UNIT – V (9 hours)

Detailed contents

Fractures and faults: Geometric and genetic classification of fractures and faults; Effects of faulting on the outcrops; Geologic/geomorphic criteria for recognition of faults and Mechanism of faulting: Anderson theory of faulting. Joints – different types of joints and their geological significance – columnar joint, pinnate joint, plumose structure. Shear Zones: Introduction, Geometry, strain profile, shear zones rocks and shear sense indicators.

Practical component (30 hours)

Basic idea of topographic contours, Topographic sheets of various scales.
Structural contouring and 3-point problems of dip and strike
Introduction to Geological maps: Drawing profile sections and interpretation of geological maps of different complexities.
Exercises of stereographic projections

Essential/recommended readings

Fossen, H. (2010) Structural Geology. Cambridge University Press
Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.

Suggestive readings

Fossen, H. (2010) Structural Geology. Cambridge University Press.
Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
Billings, M. P. (1987). Structural Geology, 4th edition, Prentice-Hall.
Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

DISCIPLINE SPECIFIC CORE COURSE (DSC-5): Igneous Petrology (L3, P1)

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
(DSC-5) Igneous Petrology (L3, P1)	4	3	0	1	12th pass with science	Studied Earth System Science, Mineral science, Stratigraphy and Equivalent

Learning Objectives

This course on Igneous Petrology is intended to provide students an understanding of the types of magma as well as types of igneous rocks. They will be taught about magma generation in relation to different geodynamic settings and its relation with the petrological and geochemical features of the igneous rocks.

Learning outcomes

On completion of the course, the students will be able to identify the igneous rocks in hand-specimen and in microscopic scale. They will be able to identify different textures and structures developed in the igneous rock. They will learn to use different petrographical, mineralogical and geochemical indices to characterise the rock. They will develop an understanding of the petrogenesis of different types of igneous rocks particularly in relation to different geodynamic settings.

SYLLABUS OF DSC- 5
Credits-4
Theory (45 hours)

UNIT – I (9 hours)
Detailed contents
Introduction to Igneous Petrology: Scope of Igneous petrology, classification of Igneous rocks, igneous textures, igneous structures.

UNIT – II (9 hours)
Detailed contents
Silicate melts and magmas: Physical properties of magma, the ascent of magmas, magmatic differentiation.

UNIT – III (9 hours)
Detailed contents
Igneous Phase diagrams: The phase rule, the lever rule, Two Component systems involving melt: Binary system with a Eutectic, Binary system with a peritectic, Binary system thermal barrier, Binary system with solid solution.

UNIT – IV (9 hours)
Detailed contents
The chemistry of igneous rocks: Modal mineralogy, normative mineralogy, variation diagrams based on major elements, trace elements and their significance, application of radioactive isotopes in igneous petrology.

UNIT – V (9 hours)
Detailed contents
Introduction to igneous environments: Basalts and mantle structure, Magma generation and igneous rocks associated with various plate tectonic settings.

Practical component (30 hours)
Study of important igneous rocks in hand specimens and thin sections- granite, granodiorite, diorite, gabbro, anorthosites, ultramafic rocks, basalts, andesites, trachyte, rhyolite.
Classification of Igneous Rocks.
Plotting and interpretation of variation diagrams.
Igneous rock occurrences in Indian context.

Essential/recommended readings
Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
Wilson, M. (1989) Igneous Petrogenesis, Springer-Verlag Berlin Heidelberg.
Frost, B. R. and Frost, C. D., (2013) Essentials of Igneous and Metamorphic Petrology Cambridge University Press.

Suggestive readings (if any)
Frost, B. R. and Frost, C. D., (2013) Essentials of Igneous and Metamorphic Petrology Cambridge University Press.
Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
Sen, G. (2014) Petrology Principles and Practice, Springer-Verlag Berlin Heidelberg
Bose M.K. (1997). Igneous Petrology.
Wilson, M. (1989) Igneous Petrogenesis, Springer-Verlag Berlin Heidelberg.

DISCIPLINE SPECIFIC CORE COURSE (DSC-6): Elements of Geochemistry (L3, P1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-6 **Elements of Geochemistry (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science, Mineral science, Stratigraphy and Equivalent**

Learning Objectives

This course on element of geochemistry is intended to provide students with basic scientific knowledge and understanding about the geochemical nature of the earth and other planetary material in relation to relate mineralogy, geochemistry, and bulk chemistry and their evolution.

Learning outcomes

After completing the course, the students will acquire knowledge on the formation and abundance of elements in the solar system, in the earth and within different reservoirs of the earth. The students will learn about the chemical characters of different elements present in the periodic table and how they behave in different geological systems. The students will learn the basic concept of stable and radiogenic isotopes. After the end of the course they will develop an understanding on how these isotopes can be used to understand different geological processes. They will be able to plot, analyse and interpret geochemical (oxide, elemental and isotopic) data from different geological materials.

SYLLABUS OF DSC-6
Credits 4
Theory (45 hours)

UNIT – I (9 hours)
Detailed contents
Introduction to geochemistry: The abundance of elements in the cosmos, solar system and earth. Meteorites, distribution of elements in core, mantle, crust.

UNIT – II (12 hours)
Detailed contents
Introduction to properties of elements: periodic table, chemical bonding, states of matter and atomic environment of elements, geochemical classification of elements, the concept of elemental fractionation.

UNIT – III (12 hours)
Detailed contents
Geochemistry of igneous rocks: geochemical variability of magma and its products. Near-surface geochemical environment: Chemical weathering of minerals and rocks.

UNIT – IV (12 hours)
Detailed contents
Isotope geochemistry: Application of stable and radiogenic isotopes in earth science.

Practical component: (30 hours)

Geochemical analysis of geological materials (analytical methods, concept of normalization)
Geochemical variation diagrams, common geochemical plots, and their interpretations.
Basic idea about handling and interpretation of isotope data.

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Essential/recommended readings

Mason, B (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
Faure, G., 1986. Principle of Isotope Geology, J. Wiley & Sons.

Suggestive readings

Mason, B (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
Rollinson H. (2007). Using geochemical data evaluation. Presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
Walther John, V., 2009 Essentials of geochemistry, student edition. Jones and Bartlett Publishers
Albarede, F, 2003. An introduction to geochemistry. Cambridge University Press.
Faure, G., 1986. Principle of Isotope Geology, J. Wiley & Sons.
Geochemistry by William M White, Wiley-Blackwell (2013).

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

GENERIC ELECTIVES (GE-2): Physics & Chemistry of Earth

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
GE-2 **Physics & Chemistry of Earth (L3, T1)**	**4**	**3**	**1**	**0**	**12th pass**	**-**

Learning Objectives

This course on physic and chemistry of earth is intended to provide students with basic knowledge and understanding of the surface and internal structure of the Earth and its mineralogy and chemistry. This will equip the students about the present and past processes operative in shaping the physical and chemical make-up of the planet Earth

Learning outcomes

After completion of this course students will acquire knowledge about the major surface features and the subsurface processes of the earth. Students will learn about the physical, mineralogical and chemical structure of the earth. They will be able to correlate how different geological processes produce different rocktypes and different landforms. Students will learn about the concepts of geological time and they will learn to calculate the age of the different rocks. They will develop understanding of the Earth's magnetic field and its variation through time. After completing the course the course, students will be able to analyse different types of geophysical data and how they can be applied to unravel the different subsurface geological structures.

SYLLABUS OF GE-2
Credits 4
Theory (45 hours)

UNIT – I (9 hours)

Detailed contents

Earth: surface features: Continents, continental margins, oceans

Earth's materials: Rocks and Minerals

UNIT – II (9 hours)

Detailed contents

Earth's interior - variation of physical parameters and seismic wave velocity inside the earth, major sub divisions and discontinuities. Depth-wise mineralogical variation in the Earth. Concepts of Isostasy; Airy and Pratt Model. Core and Mantle: Seismological and other geophysical constraints. The geodynamo - Convection in the mantle. Plate Tectonics. Types of plate margins and their Dynamics.

UNIT – III (9 hours)

Detailed contents

Elements of Earth's magnetism: Secular variation and westward drift. Solar activity and magnetic disturbance. Paleomagnetism

UNIT – IV (9 hours)

Detailed contents

Elements: Origin of elements/nucleosynthesis. Abundance of the elements in the solar system/planet Earth. Geochemical classification of elements. Earth accretion and early differentiation. Isotopes and their applications in understanding Earth processes.

UNIT – V (9 hours)

Detailed contents

Isotopes: Radiogenic and Stable. Radiogenic isotopes and their applications
Stable isotope fractionation. Oxygen isotopes. Sublithospheric Mantle (Mineralogy/phase transitions) Concept of mantle heterogeneity. Low-temperature geochemistry; surface and near-surface processes

Tutorial (30 hours)

Students in small batches or groups will be given assignments about the critical aspects related to physics and chemistry of Earth and understand how resolve important issues.

Essential/recommended readings

Holmes, A. (1992). Principles of Physical Geology, 1992, Chapman and Hall.
Anderson, G. M. (1996). Thermodynamics of natural systems. John Wiley & Sons Inc.
Condie, K.C. (2016) Earth as an evolving planetary system (3rd Edn.) Elsevier

Suggestive readings

Krauskopf, K. B., & Dennis, K. Bird, 1995, Introduction to Geochemistry. McGraw-Hill
Faure, G. Principles and Applications of Geochemistry, 2/e (1998), Prentice Hall, 600 pp.
Anderson, G. M. (1996). Thermodynamics of natural systems. John Wiley & Sons Inc.
Steiner, E. (2008). The chemistry maths book. Oxford University Press.
Yates, P. (2007) Chemical calculations. 2nd Ed. CRC Press.

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -III

Disclaimer: The syllabi are uploaded are as approved by the Academic Council on …… and Executive Council on ….

Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline

(B.Sc. Honours in Geology in three years)

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits Or One GE (4 credits)	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project/ Community outreach 2 credits	Value addition course (VAC) 2 credits	Total Credits
III	DSC – 7 Palaeontology (L3, P1) DSC – 8 Sedimentary Geology (L3, P1) DSC – 9 Metamorphic Geology (L3, P1)	DSE-1 (Choose one from DSE Pool) Earth Surface Processes (L3, P1) or Land Survey Techniques (L3, P1) or One from GE pool Fossils and Applications (L3, P1)	Choose one from a pool of AEC courses (2)	Choose one from a pool of SEC courses (SEC-2) or Internship/ Apprentice-ship/Project /Community outreach IAPC (2)	-	Choose one from a pool of VAC courses (2)	22 credits

Structure of Third Semester in Geology

A student who pursues undergraduate programme with Geology as single core discipline is offered the following courses:

3 Discipline Specific Cores (DSCs) - 3 courses of 4 credits = 12 credits (offered by the parent Department i.e. Department of Geology)

1 Discipline Specific Electives (DSE) – One DSE courses in Semester III (offered by the parent Department i.e. Department of Geology as choice based electives

1 Generic Elective (GE) – 1 course of 4 credits = 4 credits (one course to be chosen from the common pool of GE courses offered by Departments other than the parent Department)

1 Ability Enhancement Course (AEC) – 1 course of 2 credits = 2 credits (one course to be chosen from either 'Environmental Science: Theory to Practice' or one of the 22 Indian Languages listed in the 8th Schedule of the Constitution in the pool of AEC courses)

1 Skill Enhancement Course (SEC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of SEC courses.

1 Value Addition Course (VAC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of VAC courses offered by any Department)

DISCIPLINE SPECIFIC CORE COURSE -7 (DSC-7) – : Palaeontology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
(DSC-7) Palaeontology (L3, P1)	4	3	0	1	12th Pass with science	Studied Stratigraphy, Sedimentology, and Earth System Science and Equivalent

Learning Objectives

The principal objective of the course is to impart knowledge on the life forms of the geological past, their diversity dynamics and evolution. It is also aimed at acquainting the student with evolutionary transitions and functional adaptations in different groups of animals and plants, and relevance of fossils in dating of rocks and reconstructing past ecosystems.

Learning outcomes

On successful completion of the course, the student will be able to appreciate how fossils get preserved in rocks, the nature of fossil record and how fossils are named in a taxonomic framework. The student will gain knowledge on different invertebrate, vertebrate, and plant fossil groups, their palaeobiology, and the methodology used in relative dating of rocks and reconstruction of past climates, environments, and geography.

SYLLABUS OF DSC-7

Credit-4
Theory (45 hours),
Practical (30 hours)

UNIT – I (9 hours)

Detailed content

Introduction of palaeontology:

Fossils - Taphonomic processes and modes of preservation; nature and importance of fossil record.

Taxonomic hierarchy; Speciation, species concept in palaeontology; Evolution and the fossil record; Modes of Evolution.

UNIT – II (9 hours)

Detailed contents

Invertebrate Palaeontology: Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda, Graptolites, Trilobites) and their biostratigraphic significance. Significance of ammonites in Mesozoic biostratigraphy and their palaeobiogeographic implications. Functional adaptation in trilobites and ammonoids.

UNIT – III (9 hours)

Detailed contents

Vertebrate Palaeontology: Origin of vertebrates and major steps in vertebrate evolution; Vertebrate evolution in the Palaeozoic Era; Mesozoic reptiles with special reference to origin diversity and extinction of dinosaurs

UNIT – IV (9 hours))

Detailed contents

Palaeobotany: Introduction to Palaeobotany; fossil record of plants through time; Gondwana Flora.

UNIT – V (9 hours)

Detailed contents

Ichnology: Introduction to Ichnology; Application of fossils in Stratigraphy, Fossils and paleobiogeography; Fossils as a window to the evolution of ecosystems.

Practical Component- (30 Hours)

Study of fossils showing various modes of preservation. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils.

Essential/recommended readings

Raup, D. M. & Stanley, S.M. (1985). Principles of Paleontology, W.H.Freeman & Company
Clarkson, E. N.K. (2012) Invertebrate Paleontology and evolution 4th Edition by Blackwell

Suggestive readings

Raup, D. M. & Stanley, S.M. (1985). Principles of Paleontology, W.H.Freeman & Company
Clarkson, E. N.K. (2012) Invertebrate Paleontology and evolution 4th Edition by Blackwell.
Foote, M. & Miller, A. I. (2006). Principles of Paleontology, third edition.
Benton, M. (2014). Vertebrate Palaeontology, fourth edition.
Jones, R.W. (2011). Applications of Palaeontology - Techniques and Case Studies
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Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE (DSC-8): Sedimentary Geology (L3, P1)

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
(DSC-8) Sedimentary Geology	4	3	0	1	12th pass with science	Studied Stratigraphy, Earth System

(L3, P1)						**Science or Equivalent**

Learning Objectives

Objective of this course is to provide basic knowledge to students about sediment origin, sediment transport, and deposition al history. Attempt will be made to make students understand the processes that transform sediments in to sedimentary rocks. Distribution of sedimentary rocks (siliciclastic and carbonate) in space and time will be discussed

Learning outcomes

After going through this course, students will learn and develop skills to appreciate the concepts of weathering and sedimentary flux, basic concepts of sediment transport and formation of sedimentary structures, grain size scales and analysis. Students will be able to understand about sedimentary facies, classification of sedimentary rocks, sedimentary environments and provenance. Students will alost be able to appreciate how sedimentary rocks are formed from sediments.

SYLLABUS OF DSC- 8
Credit-4
Theory (45 hours),
Practical (30 hours)

UNIT – I (9 hours)

Detailed contents

Introduction to Sedimentary Geology: Geology and Chemistry of weathering processes. Sediments: origin, transportation, deposition, consolidation and diagenesis

.

UNIT – II (9 hours)

Detailed contents

Sediment granulometry: Grain size scales Udden-Wentworth and Krumbein (phi) scale, particle size distribution; mean, median, mode, standard deviation, skewness. Environmental connotation.
Classification of sedimentary rocks

UNIT – III (9 hours)

Detailed contents

Sedimentary texture and structure: Sedimentary fabric, textures, Porosity and permeability. Sedimentary structures: Syn-sedimentary, Penecontemporaneous

UNIT – IV (9 hours)

Detailed contents

Ichnofossils: Sediment-organism interaction, Environmental interpretation with help of ichnofossils
Depositional controls and Diagenesis: . Tectonics and Climate Diagenesis of terrigenous and chemical sediments

UNIT – V (9 hours)

Detailed contents

Sedimentary facies and environment: Concept of sedimentary facies, facies association, paleoenvironment and paleocurrent analyses. Introduction to sedimentary environment: aeolian, glacial, fluvial, near-shore and deep-marine environments. Introduction to carbonate rocks: classification

Practical Component- (30 Hours)

Study of megascopic characters of major sedimentary rocks:
Sketching of primary sedimentary structures in laboratory and museum specimen: ripple marks, cross beddings, sole marks, biogenic structures.
Microscopic study of textures and diagenetic features in sedimentary rocks:

Essential/recommended readings

Prothero, D.R., and Schwab, F. 2003. Sedimentary Geology. Freeman & Co.
Boggs Sam Jr. 1995. Principles of Sedimentology and Stratigraphy, Prentice Hall

Suggestive readings (if any)

Prothero, D.R., and Schwab, F. 2003. Sedimentary Geology. Freeman &Co.
Boggs Sam Jr. 1995. Principles of Sedimentology and Stratigraphy, Prentice Hall.
Stanley, S. M. 1985. Earth and Life through time. Freeman & Co.
Tucker, M., 1988 Techniques in sedimentology Blackwell scientific publications
Nicols, G., 2009 Sedimentology and Stratigraphy Wiley-Blackwell

DISCIPLINE SPECIFIC CORE COURSE– (DSC-9): Metamorphic Geology (L3, P1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutoria	Practical/ Practice		
(DSC-9) Metamorphic Geology (L3, P1)	4	3	0	1	12th pass with science	Studied Earth System Science, Structural Geology, and Mineralogy or Equivalent

Learning Objectives

Focuses of the course on metamorphic geology is to provide students scientific knowledge and understanding about mineralogical and textural transformations in solid state. The main aim is course is to motivate them to appreciate and learn about the natural state variables at the time of transformation as well as inferring the geodynamic settings of such changes.

Learning outcomes

After completing the course students will acquire knowledge about changes that occur within the minerals and in the rocks in response to changing physical and chemical conditions in the Earth. Using hand-specimen and microscopic studies, they will be able to identify different structures and textures that develop in the rock due to changing geological processes. Students will learn about the basic concepts of phase equilibrium and how they can be correlated with the fundamental concepts of thermodynamics. Students will be apply the concepts of the chemical equilibrium to retrieve the physical conditions of the formation of the rocks. After completing the course students will be able to correlate the textural and phase equilibrium concepts to comprehend the different mountain-building processes that shaped the Earth.

SYLLABUS OF DSC-9
Credit-4
Theory (45 hours),

UNIT – I (9 hours)
Detailed contents
Metamorphism: Definition of metamorphism. Factors controlling metamorphism, Types of metamorphism. Structure and textures of metamorphic rocks, Relationship between metamorphism and deformation

UNIT – II (12 hours)
Detailed contents
Phase rule: Phase rule and Goldschmidt mineralogical phase rule. Chemographic projections, concept of compatible and incompatible assemblages, bulk composition influence on metamorphic assemblages.

UNIT – III (12 hours)
Detailed contents

Metamorphic reaction and minerals: Metamorphic zones, index minerals and isograds. Continuous and discontinuous reactions, basics of geothermobarometry.

UNIT – IV (12 hours)
Detailed contents
Metamorphism and tectonic settings: Metamorphism of various protoliths, metamorphic rock associations-schists, gneisses, charnockites and eclogites. Melting and migmatites. Tectonic setting of metamorphic rocks, paired metamorphic belts, concept of P-T-t path.

Practical Component- (30 Hours)
Hand specimen study of metamorphic rocks.
Textural and mineralogical study of metamorphic rocks in thin sections.
Inferring mineral growth versus deformation in metamorphic rocks
Graphical plots of metamorphic mineral assemblages using chemographic projections.
Application of mineral formula calculations in metamorphic rocks
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Essential/recommended readings
Winter, J. D. (2014).Principles of igneous and metamorphic petrology, Pearson.
Yardley, Bruce, and Clare Warren. (2021). An introduction to metamorphic petrology. Cambridge University Press.

Suggestive readings
Winter, J. D. (2014).Principles of igneous and metamorphic petrology, Pearson.
Yardley, Bruce, and Clare Warren. (2021). An introduction to metamorphic petrology. Cambridge University Press.
Philpotts, A. R., and Ague, J. J. (2022). Principles of igneous and metamorphic petrology. Cambridge University Press.
Metamorphic Phase Equilibria And Presure-Temperature-Time-Paths
Frank S. Spear (reprinted 1995)

Discipline Specific Elective (DSE-1):
Earth Surface Processes (L3, P1) or Surveying Techniques (L3, P1)

Or

One GE from GE pool (GE-3): Fossils and Applications (L3, P1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-1 **Earth Surface Processes (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

Learning Objectives

The course on Earth Surface Processes is intended to provide students a holistic approach to study the surficial features and the processes of the Earth with emphasis on links and feedbacks between its components. They will be motivated to appreciate the dynamic and physical account of the processes at the surface with an integrated approach involving the principles of geomorphology and sedimentology.

Learning outcomes

After going through this course students will have sound idea about the Earth's Energy Balance, Hydrological cycle, Topography and bathymetry. This will enable them to have basic skills and understanding about the sedimentary flux: origin, transport and deposition and the geomorphic and sedimentological processes related to fluvial, coastal, aeolian, and glacial regimes.

SYLLABUS OF DSE-1

Credit-4
Theory (45 hours),

UNIT – I (9 Hours)
Detailed contents
Introduction to Earth Surface System: Earth's energy balance, hydrological cycle, carbon cycles, heat transfer, topography and bathymetry.

UNIT – II (9 Hours)
Detailed contents
Earth's critical zone: weathering and formation of soils, sediment routing systems, sediment and solute in drainage basins, importance and impact of climate change and tectonics on sediment yield and transport.

UNIT – III (9 Hours)
Detailed contents
Fluid and sediment dynamics and transport: Natural substances, settling of grains, types of flows and boundary separation layers, sediment continuity, modes of sediment transport, bedforms and stratification.

UNIT – IV (9 Hours)
Detailed contents
Sediment transport and deposition: Sediment transport and deposition associated with fluvial, aeolian, glacial, coastal and marine regimes.

UNIT – V (9Hours)
Detailed contents
Earth surface processes through time: Impact of environmental changes on Earth Surface processes.

Practical Component- (30 Hours)
Exercises on flexural isostasy.
Exercises related to settling of sediments.
Sediment flux exercises.
Preparation of river profiles (Hack Profile, calculation of SL index, Ksn).
Exercises related to fluvial geomorphology.
Exercises on rate of uplift and incision.

Essential/recommended readings
P. A. Allen, 2009, Earth Surface Processes. Wiley
John Bridge and Robert Demicco: Earth Surface Processes and Landforms and Sediment Deposits

Suggestive readings
P. A. Allen, 2009, Earth Surface Processes. Wiley
John Bridge and Robert Demicco: Earth Surface Processes and Landforms and Sediment Deposits
Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education
Summerfield, M.A., 1991. Global Geomorphology, Prentice Hall.
Jon D.Pelletier.2008. Quantitative Modelling of Earth Surface Processes. Cambridge University Press

Or

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-II **Land Survey Techniques (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

Learning Objectives

This course on surveying techniques is intended to provide students with basic knowledge and techniques to operate modern surveying instruments. Also, develop skills to carry out topographic mapping and prepare maps.

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Learning outcomes

After going through this course, students will have the necessary knowledge about the survey method and various types of mapping skills. They will have a clear understanding of the principles of surveying techniques, how to operate modern surveying instruments, and how to prepare maps.

SYLLABUS OF DSE-11

Theory (45 hours)

UNIT – I (9 Hours)
Detailed Content
Basics of Surveying: Fundamental concepts and principles; Types of surveys; Classes of surveys; Surveying Instrumentation; Units of measurement; Locating position; Errors.in surveying.

UNIT – II (12 Hours)
Detailed Content
Levelling: Theory and Methods: Coordinate system; Geoid; Datum; Curvature and refraction; Categories of levels; Traversing; Differential levelling; sources of error in levelling; Distance measurement; Angles, azimuth and bearings.

UNIT – III (12 Hours)
Detailed Content
Surveying Techniques: Principles and use of – Plane Table survey, Compass survey, Theodolite survey, Total Station survey, Global Positioning System (GPS) survey, UAV survey

UNIT – IV (12 Hours)
Detailed Content
Map Preparation: Introduction to QGIS; Map design; Map layout; Basic map plotting procedures; Plotting contours; Lettering; Cartographic map elements; Sources of error in mapping.

Practical Component- (30 Hours)

1. Plane Table survey
2. Total Station survey
3. Survey using GPS
4. Survey using Drone (if drone is available)
5. Map making

Essential/recommended readings

Surveying – Vol – I – By S.K.Duggal, Tata McGraw Hill Book Co.
Surveying – Vol – II – By S.K. Duggal, Tata McGraw Hill Book Co

Suggestive readings

Surveying – Vol – I – By S.K.Duggal, Tata McGraw Hill Book Co.
Surveying – Vol – II – By S.K. Duggal, Tata McGraw Hill Book Co
Engineering survey by Schofield W, Elsevier India, 2013

Or

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-3 **Fossils and Applications (L3, P1)**	**4**	**3**	**0**	**1**	**12th Pass**	**Nil**

Learning Objectives

This course on fossils and applications is to provide students basic but important knowledge abouth fossils, their preservation in rocks and different groups of invertebrate, vertebrate and plant fossils. This will impart knowledge and make them aware abouth utility of the fossils in relative dating of sedimentary rocks and their importance for palaeoecological, palaeoenvironmental, palaeobiogeographical reconstruction.

Learning outcomes

After sucessful completion of this course, students will be able to understand about different types of life forms that existed in the geological past. Students will be able to appreciate the evolutionary trends of the important fossil groups and their role to understad the Earth's history. The will learn usage of fossils to reconstruct paleoenvironments, ecosystems, past-climate and paleogeographic setting. The students will learn the sampling and proceessing techniques of various fossils groups and their applications in hydrocarbon exploration and correlation of coal seams.

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SYLLABUS OF GE-3
Theory (45 hours)

UNIT – I 9 hours)
Detailed contents
Introduction to fossils: Definition of fossil, fossilization processes (taphonomy), taphonomic attributes and their implications, modes of fossil preservation, role of fossils in development of geological time scale and fossil sampling techniques.

UNIT – II (9 Hours)
Detailed contents
Species concept: Definition of species, species problem in palaeontology, speciation, methods of description and naming of fossils, code of nomenclature.

UNIT – III (9 hours)
Detailed contents
Introduction to various fossils groups: Brief introduction of important fossils groups: invertebrate, vertebrate, microfossils, spore, pollens and plant remains. Important fossiliferous horizons of India

UNIT – IV (9 Hours)
Detailed contents
Application of fossils: Principles and methods of paleoecology, application of fossils in the study of paleoecology, paleobiogeography and paleoclimate; Role of fossils in palaeoenvironmental reconstructions.

UNIT – V (9 Hours)
Detailed contents
Societal importance of fossils: Implication of larger benthic and microfossil in hydrocarbon exploration: identification of reservoirs and their correlation. Application of spore and pollens in correlation of coal seams, spore and pollens as indicator of thermal maturity of hydrocarbons reservoirs, fossils associated with coal deposits, fossils as indicators of pollution.

Practical Component- (30 Hours)
Lab exercises based on different fossil assemblages in geological records and their utility, identification of different fossils, time record, morphology, evolution, and response to changes in climate and paleogeography

Essential/recommended readings

Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution, George Allen &Unwin

Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.

Suggestive readings

Clarkson, E.N.K.1998. Invertebrate Paleontology and Evolution, George Allen &Unwin

Prothero, D.R. 1998. Bringing fossils to life - An introduction to Paleobiology, McGraw Hill.

Benton, M.J. 2005. Vertebrate Palaeontology (3rd edition), Blackwell Scientific, Oxford.

Colbert's Evolution of the Vertebrates: A History of the Backboned Animals Through Time, Edwin H. Colbert, Michael Morales, Eli C. Minkoff, John Wiley & Sons, 1991.

Benton, M.J. & Harper, D.A.T. (2016). Introduction to Palaeobiology and the fossil record. Wiley.

Jones, R.W. (2011). Applications of Palaeontology - Techniques and Case Studies

Raup, D.M. & Stanley, S.M. (1985), Principles of Paleontology, W.H. Freeman and Company

Shukla, A. C. & Mishra, S.P. (1982). Essentials of Palaeobotany

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -IV

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Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for the UG Programme of study with Geology as single core discipline

(B.Sc. Honours in Geology in three years)

Semester	Core (DSC) 4 credits	Elective DSE-4 (4 credits) Or GE (4 credits)	Ability Enhancement Course (AEC) – 2 credits	Skill Enhancement Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project/ Community outreach 2 credits	Value addition course (VAC) 2 credits	Total Credits
IV	**DSC – 10:** Geomorphology (L3, P1) **DSC – 11:** Hydrogeology (L3, P1) **DSC – 12:** Geology of India (L3, P1)	**DSE-2** (Choose one from DSE Pool) **Introduction to Field Geology (L2, P2)** **or** **Paleoseismology (L3, P1)** **or** **one from GE pool (GE-4)** Natural Hazards and Mitigation (L3, T1)	**Choose one from a pool of AEC courses (2)**	**Choose one from a pool of SEC courses (SEC-2)** **or** Internship /Apprentice-ship/Project/Community outreach IAPC (2)	-	**Choose one from a pool of VAC courses (2)**	**22 credits**

Structure of Fourth Semester in Geology

A student who pursues an undergraduate programme with Geology as single core discipline is offered the following courses:

3 Discipline Specific Cores (DSCs) - 3 courses of 4 credits = 12 credits (offered by the parent Department i.e. Department of Geology)
1 Discipline Specific Electives (DSE) – One DSE courses in Semester III (offered by the parent Department i.e. Department of Geology as choice based electives
1 Generic Elective (GE) – 1 course of 4 credits = 4 credits (one course to be chosen from the common pool of GE courses offered by Departments other than the parent Department)
1 Ability Enhancement Course (AEC) – 1 course of 2 credits = 2 credits (one course to be chosen from either 'Environmental Science: Theory to Practice' or one of the 22 Indian Languages listed in the 8th Schedule of the Constitution in the pool of AEC courses)
1 Skill Enhancement Course (SEC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of SEC courses.
1 Value Addition Course (VAC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of VAC courses offered by any Department)

DISCIPLINE SPECIFIC CORE COURSE -10 (DSC-10) – : Geomorphology (L3, P1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
(DSC-10) **Geomorphology (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Equivalent**

Learning Objectives

The course on geomorphology is intended to provide students basic scientific knowledge Earth surface process and evolution of the landforms. Students will be aught about the basic and fundamentals of geomorphology to comprehend the process and evolution of landscapes through time.

Learning outcomes

After going through this course, students will develop basic skills and understanding about the key concepts of geomorphology, i.e., systems (morphological, cascading, process-response), threshold, magnitude and frequency, unifying concepts such as conservation of mass and energy in geomorphic systems, sediment routing, equilibrium and steady state. They will be able to use the knowledge to identify various landforms and processes in different environments i.e., glacial, fluvial, aeolian, coastal regions. They will also be able to examine the landforms at primary scale. They will be able to analyse the morphometric parameters of a basin. They will develop skills to prepare a geomorphic map using topographic sheets and Google Earth images.

SYLLABUS OF DSC-10 (Credits: 4)
Theory: 45 hours, Practical: 30 hours

UNIT – I (9 hours)

Detailed content

Introduction to Geomorphology: Concepts in geomorphology, Geosphere-Hydrosphere-Biosphere; Unifying concepts

UNIT – II (9 hours)

Detailed contents

Morphological features of Earth: Geoid, Topography, Hypsometry, Global Hypsometry, Major Morphological features. Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya)

UNIT – III (9 hours)

Detailed contents

Earth Surface Processes: Surficial processes and geomorphology; 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 – IV (9 hours))

Detailed contents

Methods and techniques: Dating Methods, measuring rates; Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development.

UNIT – V (9 hours)

Detailed contents

Overview of Indian Geomorphology. Introduction to Extra-terrestrial landforms

Practical Component- (30 Hours)

Reading topographic maps, Concept of scale, Preparation of a topographic profile, Preparation of longitudinal profile of a river, Preparing Hack Profile and Calculating Stream length gradient index, Morphometry of a drainage basin - Calculating different morphometric parameters, Preparation of geomorphic maps.

Essential/recommended readings

M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.

Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.

Suggestive readings

Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.

Paul R. Bierman and D.R. Montgomery (2014): Key Concepts in Geomorphology. W.H. Freeman and Company Publishers.

M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE : DSC-11- Hydrogeology (L3, P1)

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
(DSC-11) Hydrogeology (L3, P1)	**4**	**3**	**0**	**1**	**12th Pass with Science**	**Studied Stratigraphy, Earth System Science or Equivalent**

Learning Objectives
Main objective of the course is to make students comprehend about the nature, occurrence and movement of groundwater in geological context. To develop basic understanding about ground water exploration and management.

Learning Outcomes:
After completing the course, the students will get a basic understanding of aquifers and groundwater systems. The students will be able to comprehend the groundwater flow dynamics and well hydraulics, enhancing their numerical skills for development of groundwater resources. Learners will gain expertise in fundamentals of groundwater exploration helping them to identify groundwater sources in field. The students will be able to analyse and compare the groundwater quality. This would help them to categorise the use of groundwater for various purposes. Learners will be skilled with fundamentals of water balance, groundwater resource estimation and groundwater resource management practices.

SYLLABUS OF DSC- 11
Theory (45 Hours)

UNIT – I (9 hours)
Detailed contents
Introduction and basic concepts: Scope of hydrogeology and its societal relevance. Hydrologic cycle: precipitation, run-off, infiltration and subsurface movement of water. Hydrogeological formations: Aquifer; Aquitard; Aquiclude; Aquifuge. Vertical distribution of subsurface water. Types of aquifers, aquifer properties, anisotropy and heterogeneity of aquifers. Introduction to geologic formation as aquifers.

UNIT – II (9 hours)
Detailed contents
Groundwater flow: Darcy's law and its validity (discussions on laminar and turbulent groundwater flow), intrinsic permeability and hydraulic conductivity, Groundwater flow rates and flow direction.

UNIT – III (9 hours)
Detailed contents
Well hydraulics and Groundwater exploration: Basic Concepts of well hydraulics (drawdown; specific capacity etc). Elementary concepts related to: equilibrium conditions for water flow to a well in confined and unconfined aquifers, estimation of permeability in field and laboratory. Introduction to non-equilibrium groundwater flow condition. Surface-based groundwater exploration methods.

UNIT – IV (9 hours)
Detailed contents
Groundwater chemistry: 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 – V (9 hours)

Detailed contents

Groundwater management: Basic concepts of water balance studies, issues related to groundwater resources development and management. Groundwater level fluctuations. Rainwater harvesting and artificial recharge to groundwater.

Practical Component- (30 Hours)

Preparation and interpretation of water level contour maps and depth to water level maps. Preparation and analysis of hydrographs for differing groundwater conditions. Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams). Simple numerical problems related to: estimation of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.

Essential/recommended readings

Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.

Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw- Hill Pub. Co. Ltd.

Suggested readings

Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.

Raghunath, H.M. 2007. Groundwater, Third Edition, New Age International Publishers.

Shekhar Shashank . 2017a. Aquifer Properties. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448

Shekhar Shashank. 2017b. Darcy's law. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448

Shekhar Shashank. 2017c. Assessment of groundwater quality. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448

Syed Tajdarul Hassan. 2017a. Introduction to Hydrology. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448

Syed Tajdarul Hassan. 2017b. Hydraulic Head, Fluid Potential, Reynolds number and Pumping Tests-I. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448

Syed Tajdarul Hassan. 2017c. Hydraulic Head, Fluid Potential, Reynolds number and Pumping Tests-II. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448

DISCIPLINE SPECIFIC CORE COURSE– 12 (DSC-12): Geology of India (L3, P1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-12 Geology of India (L3, P1)	4	3	0	1	12th Pass with Science	Studied Earth System Science, Concepts of Stratigraphy, Structural Geology, and Mineralogy or Equivalent

Learning Objectives

The course on Geology of India is to provide students a comprehensive understanding about the overall geology of the Indian subcontinent through stratigraphic approach. Students will be taught about the geological history of the Indian subcontinent spanning from Archean to Quaternary times. They will be motivated to learn the role of tectonics, climate and sea level in framing the geological history of India through time.

Learning Outcomes:

After completion of the course, students will have understanding of stratigraphic sub-divisions of India from Archaean to Cenozoic times. They will acquaint with depositional environments, paleogeographic setting and tectonic evolution of various Indian sedimentary basins and their fossils and mineral assets. They will understand the major mass extinction events, its effect on various faunas and their recovery after mass extinction.

SYLLABUS OF DSC-12

Theory (45 Hours)

UNIT – I (9 hours)

Detailed contents

Introduction to geology of India: Physical and tectonic subdivisions of Indian subcontinent

UNIT – II (9 hours)

Detailed contents

Major sub-divisions Indian Geology: Distribution of stratigraphic units in the Peninsula and in the Himalayas. Stratigraphy, geographic distribution, lithological characteristics, fossil contents and economic importance.

UNIT – III (9 hours)

Detailed contents

Precambrian and Phanerozoic successions of India: Precambrian basement rocks of Dharwar, Aravalli-Bundelkhand, Bastar, Singhbhum, central provinces of northeastern India; Proterozoic mobile belts in northwestern, central, eastern and southern Indian peninsular regions and in the extra-peninsula; Proterozoic basins including: Vindhyan, Cuddapah, Kurnool, Bhima, and Kaladgi. Marine Paleozoic formations of India: Tethyan regions, Lesser Himalayan region. Marine Mesozoic formations of India: Himalayan and Peninsular region.

Gondwana sequences of India. Cenozoic formations in western, eastern, southern and Himalayan regions. Deccan Traps, Rajmahal Traps.

.

UNIT – IV (9 hours)

Detailed contents

Stratigraphic boundary problems: Precambrian-Cambrian boundary; Permian-Triassic boundary; Cretaceous-Tertiary boundary

UNIT – V (9 hours)

Glacial Events: Major glacial events in the Earth's history, stratigraphic implication of the sea-level changes in the Quaternary period and their significance in Indian subcontinent.

Practical Component- (30 Hours)

Study of rocks in hand specimens from the known stratigraphic horizons, Drawing various paleogeographic maps and tectonic maps of sedimentary basins. Study of different Proterozoic supercontinent reconstructions, Interpretation of various stratigraphic logs and their correlation.

Essential/recommended readings

Wadia,D.N. 1957. Geology of India, 3rd Ed., McMillan, London.
Ravindra Kumar, 1985. Fundamentals of historical geology and stratigraphy of India. Wiley Eastern Ltd., Delhi.
Ramakrishnan, M. & Vaidyanathan, R. (2008) Geology of India. Volume 1 & 2, Geological Society of India, Bangalore.

Suggestive readings

Wadia,D.N. 1957. Geology of India, 3rd Ed., McMillan, London.
Naqvi, S.M. and Rogers, J.J. 1986. Precambrian Geology of India. Clarendon Press.
Ravindra Kumar, 1985. Fundamentals of historical geology and stratigraphy of India. Wiley Eastern Ltd., Delhi.

Discipline Specific Elective (DSE-2):

Introduction to Field Geology (L2, P2) or Paleoseismology (L3, P1)

or

One GE from GE pool (GE-4): Natural Hazards and Mitigation (L3, T1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-2 Introduction to Field Geology (L2, P2)	4	2	0	2	12th pass with science	Studied Earth System Science and Structural Geology or Equivalent

Learning Objectives

This course on Introduction to Field Geology is intended to provide students of geology about the basic techniques of observation and description of various primary and secondary rock structures and landforms during geological fieldwork. They will learn and develop skills to extract information about an area through the investigation of topographic maps and techniques of field geology.

Learning outcomes

After completion of this course, students will develop the technique of carrying out the field work in different geological terrains. Specifically, they will be able to locate themselves in field Identify sedimentary structures in field, measure grain size in the field, prepare lithologs, identify structures in the field, and prepare and interpret profiles from the topographic maps and how to prepare a field report.

SYLLABUS OF DSE-2

Theory (30 hours)

UNIT – I (6 Hours)

Detailed Content

Rock Particles and Fragments: characters of larger rock fragments, pebbles etc.; Shape and surface markings; Dimensions of Particles and fragments; composition; shape; angular particles; subangular particles; rounded particles;

UNIT – II (6 Hours)

Detailed Content

Sedimentary Structures: process of formation and their interpretation; laminae, bed, ripple marks, wave marks, rill marks, mud cracks, slump marks, cross-stratifications etc. Importance of litholog (theory)

UNIT – III (6 Hours)
Detailed Content
Deformed rocks: Tilted and folded strata; Principal kinds of folds or flexures; Types of folds; Strike, dip, plunge and pitch; Classification of faults; kinds of displacement; principal evidences of faulting; relation of folds and faults; Topographic expression of folds and faults.

UNIT – IV (6 Hours)
Detailed Content
Landforms in various environment: Fluvial landforms, coastal landforms, aeolian landforms, and glacial landforms.

UNIT – V (6 Hours)
Detailed Content
Topographic maps and profile sections: Contours; spacing of contours; scale; direction; requisite data on a completed contour map. Techniques used in examination of outcrops.

Practical Component- (60 Hours)
In the practical class, all components of the field geology and measurement techniques will be demonstrated and practised in the field. The practical classes of this course will be conducted at a go through field visit (10 days) in a suitable geological terrain in India. This will cover- Measuring large grain sizes in the field (Grid method), Identification of sedimentary structures, Preparation of litholog, Identification of landforms (glacial/fluvial/coastal/aeolian), Identification of folds and faults; evidences of faulting, Construction of a profile section; Enlargement of profile section, Measurement of slope from the topographic map, Location in the toposheet thorough GPS/bearing, Measurement of dip, strike, trend, plunge, pitch, Identification of bedding, flow banding, metamorphic foliation.

Essential
Field Geology by F.H. Lahee, CBS Publishers
Basic geological mapping, R. Lisle, Wiley-Blackwell, 2014

Recommended readings
Sedimentary Rocks in the field, M. Tucker, Wiley-Blackwell, 2011

Or

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-3 **Paleoseismology** (L3, P1)	**4**	**3**		**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

DSE-3:
Paleoseismology (L3, P1)
Credit: 4
Theory (45 hours), Practical (30 hours)

Learning Objectives

The goal of this course is to provide students an understanding about: Geological techniques to study the pre-instrumental earthquakes and its application to Seismic Hazard Assessment. What do past earthquakes look like in the geologic record in different environments? To estimate the magnitude of past and future earthquakes using trench logs and geochronology as a case study from different seismically active regions of the world, e.g., Himalaya, Japan, New Zealand, etc. Learn the deformation on short- and long-term time scales.

Learning outcomes

After going through this course, students will understand how the Earth deforms from individual earthquakes to systems of faults to the construction of mountain ranges. They can able to map the active faults and their recurrence time of earthquake and seismic hazard in a seismically active area.

SYLLABUS OF DSE-3
Theory (45 hours)

Unit-1 (9 hours)
Detailed Content

Landscape Response to Tectonics: Introduction to Seismicity, its causes and nucleation, Introduction to geodesy and short-term deformation. Earthquakes in the Indian Subcontinent. Tectonic landforms. Climate-Tectonic interaction in landscape evolution. Erosion and uplift in orogenic settings. Active tectonics and rivers.

Unit-2 (9 hours)
Detailed Content

Introduction to Paleoseismology: The Scope of Paleoseismology, Evidences to identify past earthquakes- Primary and Secondary evidences, On-fault and Off-fault structures, Recurrence time of earthquake, Slip-rate Determination and Magnitude Estimation, Development of Paleoseismology. Distinguishing Paleoseismic Features from Non-Seismic or Non-Tectonic Features.

Unit-3 (9 hours)
Detailed Content

Paleoseismic Investigation Techniques: Geomorphic expressions of fault, Surveying and Mapping Paleoseismic Landforms. Trenching, logging and sampling the fault scarps. Stratigraphic and Structural evidences of Paleoearthquakes. Quaternary Dating techniques- ^{14}C, OSL, surface exposures dating.

Unit-4 (9 hours)
Detailed Content
Paleoseismology of different Tectonic Environments: Introduction to paleoseismic investigations in Contractional, Extensional, and Strike-Slip Tectonic Settings. Surface Rupture studies in Himalaya. Interpreting the Paleoseismic History by Retro-deformation. Introduction to Long term deformation study, Quaternary and Neogene Geomorphic Responses to Tectonics- the Himalayan case.

Unit-5 (9 hours)
Detailed Content
Applications on different time scale: Seismic Hazard Assessment, Estimating Paleo-earthquake Magnitude and Recurrence Cycle, Fault Segmentation.

Practical Component- (30 Hours)
Exercises covering various practical based problems on paleoseismology and tectonic events, past earthquakes, and to assess magnitude and recurrence of the seismic events and futures perspectives.

Essential/Recommended readings
James P. McCalpin (editor), 2009, Paleoseismology (2nd edition), Elsevier/Academic Press: Burlington, MA, 629 pp.
Robert S. Yeats, Kerry E. Sieh, and Clarence R. Allen, 1997, Geology of Earthquakes, Seismological Research Letters 68(5).

Recommended readings
Jayangondaperumal, R., Thakur, V. C., Joevivek, V., Rao, P. S., & Gupta, A. K. (2018), Active Tectonics of Kumaun and Garhwal Himalaya. Singapore: Springer.
Douglas W. Burbank and Robert S. Anderson, 2012, Tectonic Geomorphology (2nd edition), Wiley-Blackwell: UK, 454 pp.
William B. Bull, 2008, Tectonic Geomorphology of Mountains: A New Approach to Paleoseismology, Wiley-Blackwell: Malden, MA, 328 pp.
William B. Bull, 2009, Tectonically Active Landscapes, Wiley-Blackwell: Malden, MA, 320 pp.
Edward A. Keller and Nicholas Pinter, 2002, Active Tectonics: Earthquakes, Uplift, and Landscape (2nd edition), Prentice Hall: Upper Saddle River, NJ, 362 pp.

or

Credit distribution, Eligibility and Pre-requisites of the Course GE-4

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-4 Natural Hazards and Mitigation (L3, T1)	**4**	**3**	**1**	**0**	**12th Pass**	**Nil**

Learning Objectives

The main objective of this course is to teach students how to evaluate risks and implement mitigation strategies. This course introduces students to the concept of disaster risk reduction and gives a foundational understanding of natural hazards around the world with a focus on India. This course also lays the foundation for advanced study in climate change impacts, environment science, sustainability, and disaster management.

Learning outcomes

After going through this course, student will know the genesis of major natural hazards of the world, the impact of climate change and understand the disaster management system of India. The students will be able to assess the risk of natural hazards to a specific place and suggest the basic disaster risk reduction measures and emergency plan.

SYLLABUS OF GE-4
Theory (45 hours)

UNIT – I (9 Hours)
Detailed contents
Introduction to natural hazards: Concept of hazards, vulnerability, exposure, risk and disaster. Major natural and manmade hazards and their impact.

UNIT – II (9 hours)
Detailed contents
Hydrometeorological hazards: Floods, storms/cyclone, cloudburst, heat and cold waves, genesis of hydrometeorological hazards, extreme events.

UNIT – III (9 Hours)
Detailed contents
Geological hazards: Geological processes and hazards. Different forms of mass movement: landslide, subsidence, debris flow; Volcanic hazards: major volcanic eruption; Earthquake and secondary hazard: Tsunami, snow avalanche.

UNIT – IV (9 Hours)
Detailed contents
Climate change and pandemic: Climate change, global warming, sea-level rise, impact of climate change on natural resources; Global climate agreements. Pandemics; other natural hazards.

UNIT – V (9 Hours)
Detailed contents
Hazard mitigation: Hazard zonation; Early warning system; Engineering measures. Hazard/disaster profile of India. Disaster management cycle; Different stakeholder in disaster management; Disaster mitigation structure in India; Emergency plan.

Tutorial (30 hours)
Students in small batches or groups will be assigned different exercises about the natural hazards and resolve the key issues to handle and mitigate.

Essential/recommended readings
Edward Bryant (2005). Natural Hazards. Cambridge University Press
Smith, Keith, (2013). Environmental hazards: assessing risk and reducing disaster: Routledge Taylor & Francis Group. London.

Suggestive readings
Edward Bryant (2005). Natural Hazards. Cambridge University Press
Smith, Keith, (2013). Environmental hazards: assessing risk and reducing disaster: Routledge Taylor & Francis Group. London.
Stephen Marshak, (2013). Essential of Geology, W W Norton & Co Inc, New York
Edward A. Keller; Duane E. DeVecchio (2014). Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes. Routledge.
Bell, F.G., 1999. Geological Hazards, Routledge, London.
David C. Alexander (1993). Natural Disasters. CRC Press

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -V

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Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline

(B.Sc. Honours in Geology in three years)

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE-5) 4 credits	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project/ Community outreach 2 credits	Value addition course (VAC) 2 credits	Total Credits
V	**DSC – 13:** Economic Geology (L3, P1) **DSC – 14:** Engineering Geology (L3, P1) **DSC – 15:** Geological Mapping (L2, P2)	**DSE-3** (Choose one from DSE Pool) **River Science (L3, P1)** **or** **Introduction to geophysics (L3, T1)** **or** **Application of thermodynamics in petrology (L3, P1)**	**GE-5** Choose one from a pool of courses **Concepts of Sustainability (L3, T1)**	**Nil**	**Choose one from a pool of SEC courses (SEC-2)** **or** Internship/ Apprentice-ship/Project/Community outreach IAPC (2)	-	**Nil**	**22 credits**

Structure of Fifth Semester in Geology

A student who pursues undergraduate programme with Geology as single core discipline is offered the following courses:

3 Discipline Specific Cores (DSCs) - 3 courses of 4 credits = 12 credits (offered by the parent Department i.e. Department of Geology)

1 Discipline Specific Electives (DSE) – One DSE courses in Semester III (offered by the parent Department i.e. Department of Geology as choice based electives

1 Generic Elective (GE) – 1 course of 4 credits = 4 credits (one course to be chosen from the common pool of GE courses offered by Departments other than the parent Department)

1 Skill Enhancement Course (SEC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of SEC courses.

DISCIPLINE SPECIFIC CORE COURSE - DSC – 13: Economic Geology (L3, P1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 13: Economic Geology (L3, P1)	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Equivalent**

Learning Objectives

This course on economic geology is provide basic knowledge and leaning to students to about morphology, structure, mineralogy, petrology and geochemistry of various ore deposits, and to help them to develop a basic idea and comprehension of different ore forming processes.

Learning outcomes

After going through this course students will develop basic understanding and skill about the characteristics and distribution of mineral resources and the knowledge on different ore-bearing geological systems. They will learn about the different processes that are responsible for producing different types of ores corresponding to different tectonic settings. They will learn about the different major ore bodies that have been identified in different parts of the India.

SYLLABUS OF DSC-7

Theory (45 hours)

UNIT – I (9 hours)

Detailed content

Introduction to ore geology: Economic and academic definitions/terminologies of ore geological components. Ore minerals and their uses. Morphology and style of ore mineralization. General textures and structures

UNIT – II (9 hours)

Detailed contents

Basic principles of an ore deposit formation: Geochemical behaviour of elements in ore geological systems. Concept of source-transporting agent-driving mechanism-trap

UNIT – III (9 hours)

Detailed contents

Ore forming processes: Magmatic ore forming processes. Hydrothermal ore forming processes. Sedimentary ore forming processes. Surficial and supergene ore forming processes

UNIT – IV (9 hours))

Detailed contents

Basic mineral economics and policies: Introduction to mineral economics related to metal an non-metallic commodities. Application of mineral economics to understand mineral commodity markets. An assessment of the mineral economics for the public and corporate policies.

UNIT – V (9 hours)
Detailed contents
Distribution of major metallic and non-metallic ore deposits in India

Practical Component- (30 Hours)
Identification of common ore minerals by physical and optical properties

Essential/recommended readings
Robb, L., 2020. Introduction to ore-forming processes. John Wiley & Sons.
Evans, A.M., 2009. Ore geology and industrial minerals: an introduction. John Wiley & Sons

Suggestive readings
Robb, L., 2020. Introduction to ore-forming processes. John Wiley & Sons.
Evans, A.M., 2009. Ore geology and industrial minerals: an introduction. John Wiley & Sons.
Bateman, A.M. and Jensen, M.L. 1990. Economic Mineral Deposits. John Wiley & Sons.
Misra, K., 2012. Understanding mineral deposits. Springer Science & Business Media.
Ramdohr, P., 2013. The ore minerals and their intergrowths. Elsevier.
Sarkar, S.C. and Gupta, A., 2012. Crustal evolution and metallogeny in India. Cambridge University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC – 14: Engineering Geology ((L3, P1)

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 14: Engineering Geology (L3, P1)	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Stratigraphy, Earth System Science or Equivalent**

Learning Objectives

The main objective of this course is to provide a basic introduction on the role of geology in slope stability and civil engineering projects. It is aimed to provide various insights of topography, lithology and geological structures to ensure the stability and economy of engineering projects.

Learning outcomes

After going through this course, students will know the basic geological and geotechnical requirements for the site selection of engineering projects. They will be able to characterize the rock-mass strength of the site for various engineering projects and suggest the necessary support system. They will be able to identify the primary causative factors of the slope failure and suggest the preliminary mitigation measures. They will be able to investigate the various geological factors to assess environmental impacts of any engineering project.

SYLLABUS OF DSC- 14

Theory (45 Hours)

UNIT – I (9 hours)

Detailed contents

Introduction to engineering geology: Principles and scope of engineering geology: material, material fabrics and environmental factors. Geological and geotechnical investigations.

UNIT – II (9 hours)

Detailed contents

Engineering properties of geological material: Rock strength; Rock aggregates; Significance of rock as construction material; Rock mass: discontinuities, Rock mass classification; Soil: strength, standard penetration test and engineering bedrock.

UNIT – III (9 hours)

Detailed contents

Engineering structures: dams, tunnels and roads: Engineering structures: Dams, tunnels, road, their types, acting forces, ground conditions; tunnelling methods; geological considerations for site selection.

UNIT – IV (9 hours)

Detailed contents

Slope failure and mitigation measures: Concept of slope failure mechanism; Landslide types and causes, landslide mapping; Engineering treatment of slope and foundations: grouting, retaining walls, rock bolting and other support mechanisms.

UNIT – V (9 hours)
Detailed contents
Site investigation and assessment for engineering structures: Site investigation and characterization; Reconnaissance survey; Environment impact assessment (EIA); Detailed project report (DPR)

Practical Component- (30 Hours)
Merits, demerits & remedial measures based upon geological cross sections of project sites. Computation of Index properties of rocks and soil. Concept, significance and computation of Rock Mass Classification schemes like Rock Structure Rating (RSR), Rock Mass Rating (RMR)/ Tunnelling Quality Index (Q)/Rock Quality Designation (RQD).

Essential/recommended readings
Krynin, D.P. and Judd, W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
Gangopadhyay, S. (2013). Engineering geology. Oxford University Press.

Suggestive readings (if any)
Krynin, D.P. and Judd, W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
Gangopadhyay, S. (2013). Engineering geology. Oxford University Press.
Goodman, R.E. (1993). Engineering Geology: Rock in engineering constructions. Wiley& Sons, N.Y.
Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
Bell, F.G. (2007). Engineering Geology, Butterworth-Heinema.
Anbalagan, R. Singh, B, Chakraborthy, D. and Kohli, A. (2007) "A filed Manual for Landslide investigations". DST, Government of India, New Delhi.
Duncan C. Wyllie and Christopher W. Mah. (2004). Rock Slope Engineering. CRC Press. London.
David George Price (2009). Engineering Geology: Principles and Practice. Springer-Verlag Berlin Heidelberg

DISCIPLINE SPECIFIC CORE COURSE– DSC – 15: Geological Mapping (L2, P2)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 15: Geological Mapping (L2, P2)	**4**	**2**	**0**	**2**	**12th Pass with science**	**Studied Earth System Science, Structural Geology, and Mineralogy or Equivalent**

Learning Objectives

This course on geological mapping to provide basic skills to carry out geological fieldwork in different terrains and prepare a geological map with all aspects related to lithology, structures, deformation patterns. Which is essential for basic understanding of geoscience and any detailed exploration activity.

Learning Outcomes

After going through this course, students will develop the following skills and knowledge about: How to identify a rock and broadly define its composition? How to identify and measure lithological and/or structural details of rocks at the outcrop/hand-specimen scale? How to plot the data on a base map/toposheet to create a lithological and/or structural map of the terrain? How to appreciate the possible origin of the rock and their genetic process. How to reconstruct the geological history of the terrain?

SYLLABUS OF DSC-15

Theory (30 hours)

UNIT – I (6 hours)

Introduction to toposheets and maps: Concepts of scale, contour density, numbering system. Global Positioning Systems, their types and uses. Choosing a suitable geological traverse.

UNIT – II (6 hours)

Outcrop geology: Pattern of beds in a undulating topography – rule of V. Identification of rock types, and their classification based on field criteria. Textural features of different rocks through field study and microscopy. Preparation of litholgs.

UNIT – III (6 hours)

Basic concept of structural measurements: Measurement of Strike, dip, trend, plunge, pitch etc. at the outcrop in the field. Distinguishing characters of planar and linear structures in the outcrop scale. Overprinting nature of folds/ metamorphic foliations etc.

UNIT – IV (6 hours)

Folds: Identification and structural measurement of a fold in the field. Geometric classification of a fold based on field data. Understanding the outcrop pattern of a fold in non-ideal sections

UNIT – V (6 Hours)

Faults: Distinguishing criteria of a fault in the field. Understanding the slip pattern of faults in an outcrop. Measuring the orientation of different planar and linear structures associated with a fault.

Practical Component- (60 Hours)

In the practical class, all the aforesaid techniques of measurement and identification will be demonstrated and practised in the field. The practical classes of this course will be conducted at a go through field visit (10 days) in a suitable geological terrain

Essential/recommended readings

Lahee F. H. (1962): Field Geology. McGraw Hill
Billings, M. P. (1987). Structural Geology, 4th edition, Prentice-Hall.
Lisle, R.J., Brabham, P., Branes, J. 2011. Basic Geological mapping, Wiley

Suggestive readings

Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.

Discipline Specific Elective (DSE-3):

River Science (L3, P1) or Introduction to geophysics (L3, T1) or Application of thermodynamics in petrology (L3, P1)

or

One GE from GE pool (GE-4): Concepts of Sustainability (L3, T1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-3 **River Science (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

Learning Objectives

This course on river science is intended to provide student with basic science and understanding of the life cycle of a river especially in relation to societal development. It is to provide them knowledge and comprehension about the processes of erosion and transportation of sediments and its connection with the landforms.

Learning outcomes

After going through this course, students will be able to gain a thorough understanding of the evolution of a river. They will develop an understanding of stream hydrology concepts such as river hydrographs, river discharge, and flood frequency. Students will be able to comprehend the movement of sediments from source to sink. Students will develop the basic skills to identify different types of drainage networks and the impact of catchment morphometry and shape on the hydrological parameters of the river. Students will be able to analyze river profiles and explain their anomalies. They will be able to calculate the stream power and perform flood frequency analysis.

SYLLABUS OF DSE-3

Theory (45 hours)

UNIT – I (9 Hours)

Detailed Content

Stream hydrology: 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 – II (9 Hours)

Detailed Content

River basin: Sediment source and catchment erosion processes; Sediment load and sediment Yield; Sediment transport processes in rivers; Erosion and sedimentation processes in channel.

UNIT – III (9 Hours)

Detailed Content

Drainage: Drainage network; Quantitative analysis of network organization – morphometry Role of drainage network in flux transfer. Evolution of drainage network in geological time scale.

UNIT – IV (9 Hours)

Detailed Content

Rivers in time and space: 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 – V (9 Hours)

Detailed Content

Channels and Landscapes: Bedrock channels, Bedrock incision process; River response to climate, tectonics and human disturbance; Bedrock channel processes and evolution of fluvial landscapes. Fluvial hazards: Integrated approach to stream management. Introduction to river ecology.

Practical Component- (30 Hours)

Exercises based on River visit during weekend, Stream power calculation, Longitudinal profile analysis, Hydrograph analysis, and Flood Analysis

Essential/Recmmended readings

Fryirs and Brierly (2013) Geomorphology and river management. Wiley-Blackwell Pub.
Julien, P.Y. (2002) River Mechanics. Cambridge University Press.

Recommended readings

Bridge, J.S., (2003) Rivers and Floodplain: Forms, Processes and Sedimentary Record. Blackwell Science.
Gibling, M.R., (2021) River Planet. Dunedin Press.
Wohl, E., (2010) Mountain Rivers Revisited. American Geophysical Union.

Or

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-3 **Introduction to Geophysics** (L3, T1)	**4**	**3**	**1**	**0**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

DSE-3:
Introduction to Geophysics (L3, T1)
Credit: 4
Theory (45 hours), Tutorial (30 hours)

Learning Objectives

This course on introduction to geophysics is intended to provide basic scientific knowledge to students to understand the interrelationship of geology and geophysics, which is essential to know the geodynamic behavior of the Earth and its interior. Students will be taught about the basic concepts in geophysics, different types of geophysical exploration methods, and geophysical anomalies to appreciate the geodynamics of the Earth and its resources.

Learning outcomes

After going through this course, students will be able to have an elementary knowledge and comprehension about the geophysical methods and their application to understand and explore Earth

and its interior. They will also develop basic skills about the geophysical anomalies and their relation to geological process that are essential for any detailed exploration activity.

Theory (45 hours),

UNIT – I (9 Hours)
Detailed content
Basic concepts of geophysics: Interrelationship between geology and geophysics, Role of geology and geophysics in explaining geodynamical features of the earth.

UNIT – II (9 Hours)
Detailed content
Exploration geophysics: General and Exploration geophysics: Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications; Concepts and Usage of corrections in geophysical data

UNIT – III (9 Hours)
Detailed content
Geophysical surveys: Geophysical field operations: Different types of surveys, grid and route surveys, profiling and sounding techniques; Scales of survey,

UNIT – IV (9 Hours)
Detailed content
Geophysical Methods: Application of Geophysical methods. Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics, internal structure of the Earth based on major discontinuities in seismic velocities.

UNIT – V (9 Hours)
Detailed content
Geophysical anomalies: Correction to measured quantities, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration. Integrated geophysical methods: Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

Tutorials (30 Hours)
Students in small batches or groups will be assigned to resolve different types geophysical problems concerning calculating the free air and Bouguer anomalies, determining the gravity anomaly arising due to density contrast in the subsurface, calculating paleolatitude and paleopole, numerical problems on resistivity survey, Problems on seismic survey.

Essential/Recommended readings
Kearey, P., Brooks, M. and Hill, I., 2002. *An Introduction to Geophysical Exploration* . Third Edition. Blackwell Publishing.
Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
Mussett, A.E. and Khan, M.A., 2000. *Looking into the Earth: An Introduction to Geological Geophysics*. Cambridge University Press.
Bhimasankaram, V.L.S. (1990). Exploration Geophysics - An Outline by, Association of Exploration Geophysicists, Osmania University, Hyderabad.
Dobrin, M.B. (1984) An introduction to Geophysical Prospecting, McGraw-Hill, New Delhi.

Recommended readings
Bhimasankaram, V.L.S. (1990). Exploration Geophysics - An Outline by, Association of Exploration Geophysicists, Osmania University, Hyderabad.
Dobrin, M.B. (1984) An introduction to Geophysical Prospecting, McGraw-Hill, New Delhi.
Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). Applied geophysics (Vol. 1), Cambridge University press.

Or

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-2 **Application of thermodynamics in petrology (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

Learning Objectives

The course intends to provide the concept of various thermodynamic parameters and application of the laws thermodynamics in different petrological systems. It attempts to demonstrate the effect of pressure temperature and chemical compositions in controlling stability of different mineral associations in open and closed systems. The course intends to demonstrate the application of thermobarometers in natural systems.

Learning Outcome

After completing the course, students will learn to calculate the free energy of the system. Students will learn to construct the stability fields of different mineral associations through Gibb's free energy minimization. Student will be able to apply the thermobarometers and will be able to calculate the pressure temperature conditions of stability of different magmatic, metamorphic and economically valuable mineral associations.

Theory (45 hours)

UNIT 1 (9 hours)

Introduction to thermodynamics, Irreversible and Reversible Processes, Thermodynamic Systems and variables, Energy in the form of heat and work, First law of thermodynamics, enthalpy, entropy, second and third law of thermodynamics, concept of free energy, Gibbs equation: thermodynamic potentials, free energy of formation at any temperature and pressure, equilibrium condition in closed system.

UNIT 2 (9 hours)

Free energy surface in G–T–P space, Clausius–Clapeyron equation, Schreinemakers rules, petrogenetic grid, Concept of stability (phase) diagrams, Phase rule, Free energy of solutions, ideal and non-ideal solutions, fugacity and activity, equilibrium constant,

UNIT3 (9 hours)

Temperature and pressure dependence of equilibrium constant, Geothermometry, geobarometry, mineral reactions among solid solutions, computer-generated phase relations, Introduction to pseudosections.

UNIT 4 (9 hours)

Partial melting and fractional crystallisation in magmatic systems along different geothermal gradients, modelling the role of magmatic processes in controlling the major, trace and REE budget in the crust, modelling the effect of composition on phase stability.

UNIT 5 (9 hours)
Thermodynamics of open system, Mass and heat transfer, effect of fluid ingress and composition of fluid in controlling the stability of different phases.

Practical (30 hours)
Calculation of free energy of formation at any temperature and pressure, Plotting univariant lines in P–T diagrams, Geothermo-barometric calculation, construction of pseudosections, use of mass balancing techniques on natural rocks

Essential/Recommended readings

Philpotts, A.R. and Ague, J.J., 2022. *Principles of igneous and metamorphic petrology*. Cambridge University Press.

Spear, F.S., 1993. Metamorphic phase equilibria and pressure-temperature-time paths. *Mineralogical Society of America Monograph*, *799*.

Ganguly, J., 2008. *Thermodynamics in earth and planetary sciences* (p. 501). Berlin: Springer.

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-5 Concepts of Sustainability (L3, T1)	**4**	**3**	**1**	**0**	**12th Pass**	**Nil**

Learning Objectives

The course on concepts of sustainability is aimed at providing students with knowledge-based concepts to understand the challenges of global sustainability and motivate them to think about solutions to these challenges. This course is also intended to encourage students to discuss and propagate issues of sustainability with others and create awareness.

Learning outcomes

After completing this course, students should be able to understand the major challenges and opportunities in the area of global sustainability. Develop an understanding of the system concept and the interconnectivity of humans and nature. They will be able to communicate issues related to sustainability. Critically analyze problems and solutions related to global sustainability.

SYLLABUS OF GE-5

Credits 4
Theory (45 hours)

UNIT – I (12 Hours)
Detailed contents
Basic concept of sustainability: Introduction to Sustainability; basic concepts Human Population – Past and Future trends

UNIT – II (12 hours)
Detailed contents
Ecosystems: Extinctions and Tragedy of Commons; Climate and Energy; Water Resources and Agriculture

UNIT – III (9 Hours)

Detailed contents
National and international issues about sustainability: National Resources Accounting, Environmental Economics and Policy, Measuring Sustainability

UNIT – IV (12 Hours)
Detailed contents
Major challenges about sustainability: Systems interconnectivity among Primary Sustainability challenges Sustainability Solutions: Some examples

Tutorials (30 Hours)
Students leaning the concepts of sustainability will be divided in small batches or groups and assigned critical exercises and problems to resolve major issues of sustainability of national and international importance.

Essential/recommended readings
Rogers, P.P., K. F. Jalal, and J.A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan Publishers, 416 pp.

Suggestive readings
Rogers, P.P., K. F. Jalal, and J.A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan Publishers, 416 pp.
Brown, L. 2009. Plan B 4.0. Norton Publishers, New York. (The entire book is available in pdf format: http://www.earthpolicy.org/images/uploads/book_files/pb4book.pdf)

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VI

Disclaimer: The syllabi are uploaded are as approved by the Academic Council on …… and Executive Council on ….

Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline

(B.Sc. Honours in Geology in three years)

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 6 credits	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project/ Community outreach 2 credits	Value addition course (VAC) 2 credits	Total Credits
VI	**DSC – 16:** Remote Sensing and GIS (L3, P1) **DSC – 17:** Fuel Geology (L3, P1) **DSC –18:** Paleooceanography and Paleoclimate (L3, P1)	**DSE-4** (Choose one from DSE Pool) **Exploration Geology (L3, P1)** or **Research Methods in Geoscience (L3, P1)** or **Application of Hydrogeology in Industries and Mining (L3, P1)**	**GE-6** (Choose one from a pool of courses) **Evolution of life through Time (L3, T1)**	**Nil**	**Choose one from a pool of SEC courses (SEC-2)** **or** Internship /Apprentice-ship/Project/Community outreach IAPC (2)	-	**Nil**	**22 credits**
	Bachelor of Geology (Honours)							**Total = 132**

Structure of Sixth Semester in Geology

A student who pursues an undergraduate programme with Geology as a single core discipline is offered the following courses:

3 Discipline Specific Cores (DSCs) - 3 courses of 4 credits = 12 credits (offered by the parent Department i.e., Department of Geology)

1 Discipline Specific Electives (DSE) – One DSE course in Semester III (offered by the parent Department i.e., Department of Geology as choice-based electives

1 Generic Elective (GE) – 1 course of 4 credits = 4 credits (one course to be chosen from the common pool of GE courses offered by Departments other than the parent Department)

1 Skill Enhancement Course (SEC) - 1 course of 2 credits = 2 credits (one course to be chosen from the common pool of SEC courses.

DISCIPLINE SPECIFIC CORE COURSE - DSC – 16: Remote Sensing and GIS (L3, P1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 16: Remote Sensing and GIS (L3, P1)	4	3	0	1	12th pass with science	Studied Earth System Science and Equivalent

Learning Objectives

This course is intended to provide basic understanding of remote sensing, geographic information system and photogrammetry. The course also aims to familiarize the students with utilization of geo-processing tools in the field of geosciences.

Learning outcomes

After completing this course, the students will understand the basics of remote sensing and GIS techniques and their applications in various fields of the Earth Sciences. They will be able to utilize open source image processing and GIS software to make basic image correction and thematic maps. They will be able to integrate the GNSS and field-based data with the GIS to create maps for further analysis.

SYLLABUS OF DSC-16

Theory (45 hours)

UNIT – I (12 hours)

Detailed content

Fundamentals of remote sensing: Concept of remote sensing, electromagnetic spectrum, atmospheric windows, remote sensing system, sensors and scanners, remote sensing platforms, image resolution, data procurement, data formats- raster and vector, digital image processing.

UNIT – II (12 hours)

Detailed contents

Photogeology: Types and acquisition of aerial photographs, concept of scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion. Elements of air photo interpretation, identification of the primary and secondary structures of rocks, lithology, landforms and surface processes.

UNIT – III (11 hours)

Detailed contents

Geographic Information System (GIS): Introduction to GIS, datum, coordinate systems and projection systems, spatial data models and data editing. Introduction to digital elevation model (DEM) analysis. Spatial and Temporal interpolation of datasets.

UNIT – IV (10 hours))

Detailed contents

Global navigation satellite systems (GNSS): Introduction to GNSS, GPS, GPS signals. Integrating GNSS data with GIS; GNSS applications in earth system sciences and disaster studies.

Practical Component- (30 Hours)

Introduction to QGIS software, plugins in QGIS, data procurement, creating FCC from raw data, Registration of satellite images, Image enhancement, Classification of images (Visual interpretation), Classification of images (Supervised and Unsupervised), Identification of geological structures, landforms and surface processes. Stereo viewing of images. Vector data editing, Generating slope map, aspect map and drainage network map, Spatial interpolation of datasets, Introduction to GPS.

Essential/recommended readings

Gupta, R.P. Remote Sensing Geology, Springer
Bhatta, B., Remote Sensing and GIS, 2nd Edition, Oxford.
Joseph, G., and Jeganathan, C., Fundamental of Remote Sensing, University Press, Hyderabad.

Suggestive readings

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

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – DSC – 17: Fuel Geology ((L3, P1)

Credit distribution, Eligibility and Prerequisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 17: Fuel Geology (L3, P1)	4	3	0	1	12th pass with science	Studied Stratigraphy, Earth System Science, Structural Geology or Equivalent

Learning Objectives

The course on fuel geology is intended to provide basic scientific knowledge and understanding about the natural fossil fuels i.e., petroleum and coal to students of geology. Because use of petroleum resources and its exploration is the most powerful driving forces shaping our modern world.

Learning outcomes

After completion of this course students will be able to understand and comprehend the processes involved in generation of hydrocarbons and the formation of coal and the exploration methods. Students will also have a comprehension about the conventional and non-conventional fuels and their demand through time.

SYLLABUS OF DSC- 17

Theory (45 hours)

UNIT – I (9 hours)

Detailed contents

Coal: Definition and origin of Coal; Classification of coal; Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal, Proximate and Ultimate analysis.

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UNIT – II (9 hours)

Detailed contents

Coal as a fuel: Coal Bed Methane (CBM): global and Indian scenario**;** Underground coal Gasification**;** Coal liquefaction

UNIT – III (9 hours)

Detailed contents

Petroleum: Chemical composition and physical properties of crudes in nature; Origin of petroleum; Maturation of kerogen; Biogenic and Thermal effect. Van Krevelen diagram

UNIT – IV (9 hours)

Detailed contents

Oil migration: Primary and secondary. Role of capillary pressure and Buoyancy. Petroleum Reservoirs and Traps: Reservoir rocks: general attributes and petrophysical properties.

UNIT – V (9 hours)

Detailed contents

Classification of reservoir rocks - clastic and chemical. Hydrocarbon traps: definition, Structural, Stratigraphic and Mixed. Time of trap formation and time of Hydrocarbon accumulation. Cap rocks - definition and general properties. Plate tectonics and global distribution of hydrocarbon reservoir.

Practical Component- (30 Hours)

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

Essential/recommended readings

Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press.
Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.

Suggestive readings (if any)

Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press.
Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jinasa Publishing House
North, F.K., 1985 Petroleum Geology
Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

DISCIPLINE SPECIFIC CORE COURSE– DSC – 18: Paleoceanography and Paleoclimate (L3, P1)

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 18: Paleoceanography and Paleoclimate (L3, P1)	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science, Structural Geology, and Mineralogy or Equivalent**

Learning Objectives

The course is intended to make students aware about the climate changes through geological time periods, the chaotic nature of the Climate System, its behaviour at various time scales, and its influence on biotic system. Students will also be introduced to futuristic approaches and projections of the Inter-Governmental Panel of Climate Change, and scientific issues related to climate change. As the Oceans cover 70 percent of the Earth's surface understanding the evolution of oceans through time is essential to understand their role in controlling the earth's climate at various time scales.

Learning Outcomes:

After completing the course, the student will be able to comprehend the role of Oceans in controlling the Earth's climate at various time scales. The students will be able to independently interpret the proxy record generated from various paleoclimate archives. Archives. The student will develop an overall understanding of the Ocean-Climate linkages, Tectonics -climate linkages and modern climate change.

SYLLABUS OF DSC-18

Theory (45 hours)

UNIT – I (9 hours)

Detailed contents

Weather, Climate, Components of climate, Climate classification. Insolation, short and long-term changes in Insolation.

UNIT – II (9 hours)

Detailed contents

Aerosols: Definition, origin, role in climate change. Greenhouse gases: Introduction, causes of changing concentration, role in climate change.

UNIT – III (9 hours)

Detailed contents

Origin and evolution of Oceans. Closing and opening of Ocean Gateways and the resultant effect on climate. Climate of the Arctic and Antarctica through the ages. Bipolar See Saw, Polar Amplifications. Ice core studies and climate change. Oceanic sediments, Terrigenous, biogenic sediments, and their distribution.

UNIT – IV (9 hours)

Detailed contents

Sea-level: factors affecting sea-level changes, Short and long-term sea-level variability, evidence of sea-level change from marine sediments. Ocean-climate linkage. Effect of topography/tectonics on climate. Natural variability in climate. Human influence on climate change.

UNIT – V (9 hours)

Detailed contents

Historical evidence of climate change. Effects of climate change on mankind. Sampling methods for retrieving archives of climate/oceanographic change. Various dating methods of the marine cores., merits and demerits of various dating methods Paleoclimatic/paleoceanographic reconstruction from archives. Elemental and isotopic analysis for paleoclimatic/paleoceanographic reconstruction, Instruments used for paleoclimatic/paleoceanographic studies. Modeling climate change, IPCC climate change projections.

Practical Component- (30 Hours)

Processing of marine core samples for paleoclimatic/ paleoceanographic studies. Exercises in oceanography. Interpretation of various types of paleoceanographic and paleoclimatic data.

Essential/recommended readings

Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press.
Brasier, M.D. 1980 Microfossils, George Allen and Unwin.

Suggestive readings

Frank J Millero, Chemical Oceanography, CRC Press, Taylor and Francis Group, 2013
Alan Trujillo (Author), Harold Thurman (Author), Essentials of Oceanography 13th Edition, 2023, Pearson Education.
Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press.
Brasier, M.D. 1980 Microfossils, George Allen and Unwin.
Cronin, T.M., 1999. Principles of Paleoclimatology, Columbia University Press.
Fischer, G. and Wefer, G 1999 Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer.
Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.
Kennett, J.P.1982 Marine Geology, Prentice-Hall Inc.
North, G.R. and Crowley, T.J., 1995. Palaeoclimatology, Oxford University Press
Schopf, TJ.M., 1980. Paleoceanography, Harvard University Press.
Tolmazin, D., 1985. Elements of Dynamic Oceanography, Allen and Unwin.

Discipline Specific Elective (DSE-4): Exploration Geology or Geophysics or Application of Hydrogeology in Industries and Mining
(L3, P1)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-4 **Exploration Geology (L3, P1)** or **Research Methods in Geoscience (L3, P1)** or **Application of Hydrogeology in Industries and Mining (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent**

DSE-4: Exploration Geology (4 credits)
Theory (45 hours)
Practical (30 hours)

Learning Objectives

The course on exploration geology is intended to provide introductory knowledge of mineral exploration at different stages though geological, geochemical, geophysical, and remote sensing methods. Students will also be provided basic understanding about the estimation of reserves.

Learning outcomes

After going through this course, students will have a clear idea and knowledge about the exploration methods and tools, and their application in mineral resource exploration and exploitation.

SYLLABUS OF DSE-4 (Exploration Geology)

Theory (45 Hours)

UNIT – I (9 Hours)
Detailed content
Introduction to exploration geology: Definitions and different terminologies of exploration components. Basic exploration and exploitation steps or stages. Classification of mineral deposits with respect to exploration strategies. Mineral resources and their uses

UNIT – II (9Hours)
Principles of mineral exploration: Importance of mineralogy, grain size-shape and texture in exploration. Mineral identification and analytical techniques. Sampling techniques, drilling and logging. Estimation of grade in samples.

UNIT – III (9 Hours)
Detailed content
Prospecting and exploration: Surficial survey methods and applications. Geochemical survey methods and applications. Geophysical survey methods and applications. Remote sensing methods and applications

Unit – IV (9 Hours)
Detailed content
Importance of drilling and logging in exploration: Core and non-core drilling. Basic parts of drilling machine. Types of drilling techniques. Planning and location of bore holes on ground.

Unit – V (9 Hours)
Detailed content
Principles of reserve estimation: Reserves estimation methods and models. Critical geological data to be considered. Factors affecting reliability of reserve estimation and types of errors. Evaluation of sampling data: mean, median, mode, standard deviation and variance.

Practical Component- (30 Hours)
Exercises based on Evaluation of data Average grade and reserve estimation techniques. Geological cross-section and borehole problems.

Essential/Recmmended readings
Moon, C.J., Whateley, M.K.G. & Evans, A.M. 2006. Introduction to Mineral Exploration, Blackwell Publishing.
Haldar, S.K., 2013. Mineral Exploration – Principles and Applications. Elsevier Publication.

Recommended readings
Moon, C.J., Whateley, M.K.G. & Evans, A.M. 2006. Introduction to Mineral Exploration, Blackwell Publishing.
Haldar, S.K., 2013. Mineral Exploration – Principles and Applications. Elsevier Publication.
Arogyaswami, R.P.N.(1996. Courses in Mining Geology. 4th Ed. Oxford-IBH.
Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.

or

DSE-4: Research Methods in Geoscience (L3, P1)
Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives
Main objective of this course to provide an introduction to research methods relevant to geoscience through lectures and practical training about literature review, proper referencing and citation, professional ethics, geoscience hypotheses, analytical techniques, data analysis, preparation of scientific reports and proposals.

Learning outcomes
After successful completion of this course, students will have a basic understanding and skill to develop a research plan related to critical issues in geoscience. The students will also be able to develop skills to synthesise scientific ideas and appreciate the scope of research work in geoscience.

SYLLABUS OF DSE-4

Research Methods in Geoscience (4 credits)

Theory (45 hours)

UNIT – I (9 Hours)

Detailed Content

Fundamentals of research in geoscience: Concept and definitions of research issues in geoscience, types of research in geosciences, testing of hypothesis in geosciences, literature survey of scientific articles relevant to geoscience, critical gaps and key questions to resolve through scientific research in geoscience.

UNIT –II (9 Hours)

Detailed Content

Planning and development of research work: Defining major objective and sub-objectives of geological research in a particular field. Assessment of required methodologies and experimental setups. Types of field and laboratory data, time period and key millstones of the progress, synthesis of acquired data and writing of thesis.

UNIT –III (9 Hours)

Detailed Content

Analytical techniques: Geological fieldwork and collections of representative samples, sample preparation, petrographic techniques, mineralogical and geochemical analytical techniques.

UNIT –IV (9 Hours)

Detailed Content

Data handling and statistical treatments: Basic statistical methods, correlation and regression, principal component analysis, factor analysis, cluster analysis, making of different geological maps and figures using software's.

UNIT –V (9 Hours)

Detailed Content

Writing of thesis and scientific reports: Review of concerned geoscience research articles. Introduction, significance and utility of the concerned geoscience research. Easy to follow stepwise chapters on different aspects of the research work. Synthesis and interpretations, conclusions, referencing, bibliographies, ethics and plagiarism.

Practical: 30 hours

Students will be exposed to basic instrumentation facilities and their working, such as thin section preparation, petrographic analysis, mineralogical and geochemical analytical techniques and writing of project reports.

Essential readings

Lisle, R.J., Brabham, P., Branes, J. 2011. Basic Geological mapping, Wiley

Wilson M. J. 1987. A handbook of determinative methods in clay mineralogy. Blackie

Recommended readings

Lindholm, R.C. 1963. A practical approach to Sedimentology, Allen & Unwin
Faure, G. and Mensing, T.M.2009. Isotopes principles and Applications. Willey.

Jackson M. (1975) Soil Chemical Analysis–Advanced Course: 10th printing, published by author, Dept. Soil Science, University of Wisconsin, Madison, Wisconsin.

Or

Application of Hydrogeology in Industries and Mining (L3, P1)
Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives
The course introduces the students to the legal and constitutional framework of ground water governance in India. It aims to provide knowledge about the scientific processes and protocols involved in impact assessment and comprehensive hydrogeological studies for developmental projects involving groundwater extraction.

Learning outcomes
After completing the course, students will become familiar with the salient aspects of India's ground water governance framework. They will develop an understanding of the groundwater resources estimation methods, and acquire basic skill to undertake impact assessment, comprehensive hydrogeological and water audit studies for developmental projects involving groundwater extraction. Learners will be trained to write professional grade Impact Assessment Report, Comprehensive Hydrogeological Report and Water Audit Report. They will be skilled with capability of formulating and processing No Objection Certificate (NOC) application for ground water extraction.

SYLLABUS OF DSE-4
Application of Hydrogeology in Industries and Mining (4 credits)

Theory (45 hours)

Unit 1: (9 hours)
Detailed content
Ground water governance: Ground water ownership: The Indian Easement Act 1882. Constitutional provisions regarding ground water. National Water Policy. Environment Protection Act 1986 – Central Ground Water Authority (CGWA) and State Ground Water Regulatory Bodies. National Green Tribunal.

Unit 2: (9 hours)
Detailed content
Guidelines to regulate and control ground water extraction in India: Preamble and background: exemptions from seeking No Objection Certificate, Drinking & Domestic use for Residential apartments/ Group Housing Societies/ Government water supply agencies in urban areas, Agriculture Sector, Commercial Use, Industrial Use, Mining Projects, Infrastructure projects, Ground water abstraction/ restoration charges, Bulk Water Supply, Abstraction of Saline ground water, Protection of Wetland Areas, General compliance conditions in No Objection Certificate, Monitoring of compliance of No Objection Certificate Conditions, Renewal and extension of No Objection Certificate, Delegation of powers against illegal ground water withdrawal, Ground Water Level Monitoring, Environmental Compensation, Provision of penalty and other important conditions. No Objection Certificate Application Portal (NOCAP). Water Audit Report. Accreditation of Ground Water Professional.

Unit 3: (9 hours)
Detailed content
Ground Water Resources Estimation: Dynamic ground water resources of unconfined aquifers for command and non-command areas: assessment unit, estimation of monsoon and non-monsoon recharge from all sources and provision for natural discharges, estimation of monsoon and non-monsoon extraction by different sectors, categorization of assessment blocks and validation. Poor ground water quality area. Waterlogged and shallow water table areas. In-storage ground water resources of unconfined aquifer. INGRES portal.

Unit 4: (9 hours)
Detailed content
Impact Assessment Report (IAR): Buffer zone demarcation, Land Use Land Classification (LULC), Digital Elevation Model (DEM), geomorphology, details of water bodies, geological set up. Hydrogeological set up: aquifer characteristics, depth to water level, water table contours and ground water flow, surface ground water interaction, hydrogeological map, seasonal and long-term water level fluctuation, ground water quality, water quality of nearby water bodies. Assessment of impact of proposed ground water extraction using analytical modelling/numerical solutions, etc. Socio-economic analysis and mitigation measures. Case studies.

Unit 5:
Detailed content
Comprehensive Hydrogeological Report (CHR): Buffer zone demarcation, Land Use Land Classification (LULC), Digital Elevation Model (DEM), geomorphology, details of water bodies, geological set up. Hydrogeological set up: geophysical studies and aquifer characteristics, depth to water level, water table contours and ground water flow, surface - ground water interaction, hydrogeological map, seasonal and long-term water level fluctuation, ground water quality, water quality of nearby water bodies. Mine plan and seepage estimation. Assessment of impact of proposed ground water extraction using analytical modelling/numerical solutions, etc. Socio-economic analysis and mitigation measures. Case studies.

Practicals (30 hours)

Students will be trained to carry out Ground Water Resource estimation, hands on exercises on IAR and CHR, hands on exercises on Water Audit, and exercises based on analytical modelling/numerical solutions for impact assessment, mine seepage estimation analysis.

Essential readings
Todd, D.K., 2004. Ground Water Hydrology, John Wiley & Sons, New York.
Fetter, C.W., 1984. Applied Hydrogeology, McGraw-Hill Book Co., New York
Ministry of Jal Shakti (Department of Water Resources, River Development and Ganga Rejuvenation) (Central Ground Water Authority). Guidelines to regulate and control ground water extraction in India. Notification No. 2941. The Gazette of India: Extraordinary [Part II—Sec. 3(ii)]. 24th September, 2020. Weblink: https://cgwb.gov.in/CGWA/CGWA%20New%20Guidelines%202020.pdf

Recommended Readings
Raghunath, H.M., 1987. Ground Water, Wiley Eastern Ltd., Calcutta.
Ministry of Water Resources, River Development & Ganga Rejuvenation Government of India. 2017. Report of The Ground Water Resource Estimation Committee (GEC-2015) Methodology. Weblink: http://cgwb.gov.in/Documents/GEC2015_Report_Final%2030.10.2017.pdf
Central Ground Water Authority, Ministry of Jal Shakti. 2022. Standard Operating Procedures: Impact Assessment Report and Comprehensive Hydrogeological Report. Weblink: https://cgwa-noc.gov.in/landingpage/UserAssistance/ImpactAssessmentRepMin3.pdf
Central Ground Water Authority, Ministry of Jal Shakti. 2023. Notification of Guidelines dated 24th September 2020 & Amendments dated 29th March 2023: Standard Operating Procedure for Implementation of Guidelines. Weblink: https://cgwa-noc.gov.in/LandingPage/UserAssistance/STANDARDOPERATINGPROCEDUREV-9.1.pdf (SOPs are updated at regular intervals and the updated SOP from CGWA site will be additional reference material)

One GE from GE pool (GE-6): Evolution of life trough time (L3, T1)

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-6 Evolution of life through time (L3, T1)	**4**	**3**	**1**	**0**	**12th Pass**	**Nil**

Learning Objectives

The main objective of the course is to make the student aware about the evolution of life through geological time from simple prokaryotic to complex multicellular life forms, and the role of geological processes and climatic events in shaping the evolution of life on the Earth.

Learning outcomes

On completion of the course, the student will be able to learn how fossilization processes operate in nature and what early planetary conditions led to the origin and evolution of early life. The student will also be able to understand mass extinction events in the Phanerozoic Era and their causes, and how various geological and climatic events influenced the evolution of life and how life itself has influenced the geological processes.

SYLLABUS OF GE-6

Theory (45 hours)

UNIT – I (9 Hours)

Detailed contents

Life through ages: Fossilization processes and modes of fossil preservation, exceptional preservation; Geological Time Scale with emphasis on major bio-events.

UNIT – II (9 hours)

Detailed contents

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

Origin of life; possible life sustaining sites in the solar system.

UNIT – III (9 Hours)

Detailed contents

Archean life: Earth's oldest life, the oxygen revolution and radiation of life.

Proterozoic life: The Garden of Ediacara and the evolution of metazoan life.

UNIT – IV (9 Hours)

Detailed contents

Palaeozoic Life: The Cambrian Explosion of Life; Biomineralisation and the fossil record. Palaeozoic Marine Life; Origin and progression of vertebrates; Early adaptations of plants to terrestrial life.

Mesozoic Life: 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 – V (9 Hours)

Detailed contents
Cenozoic Life: Radiation of placental mammals following K/Pg mass extinction; Evolution of modern grasslands and co-evolution of hoofed grazers; Palaeocene-Eocene Thermal Maximum (PETM) deep time analogue for modern greenhouse state; Back to water – Evolution of Whales; The age of humans; Hominid dispersals and climate setting

Tutorial (30 hours)
Students in different batches or groups will be given exercises to prepare shorts reports about the life evolution and extinction through different geological times on Earth.

Essential/recommended readings

Stanley, S.M. & Luczaj, J.A. (2014). Earth System History (4th Edition), W.H.Freeman (Macmillan)
Cowen, R. (2000). History of Life. Wiley-Blackwell.
Benton, M.J. & Harper, D.A.T. (2016). Introduction to Paleobiology and the fossil record. Wiley

Suggestive readings

Stanley, S.M. & Luczaj, J.A. (2014). Earth System History (4th Edition), W.H.Freeman (Macmillan)
Cowen, R. (2000). History of Life. Wiley-Blackwell.
Benton, M.J. & Harper, D.A.T. (2016). Introduction to Paleobiology and the fossil record. Wiley
Canfield, D.E. & Konhauser, K.O. (2012). Fundamentals of Geobiology, Blackwell.
Suggested Reading:
Cowen, R. (2000). History of Life. Wiley-Blackwell.
Lumine, J.I. (1999). Earth-Evolution of a Habitable World, Cambridge University Press.
Lieberman, B.S. & Kaesler, R. (2010). Prehitoric Life-Evolution and the Fossil Record, Wiley-Blackwell.
Lieberman, B.S. & Kaesler, R. (2010). Prehitoric Life-Evolution and the Fossil Record. Wiley-Blackwell.
Cockell, C., Corfield, R., Edwards, N. & Harris, N. (2007). An Introduction to the Earth-Life System Cambridge University Press.

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VII

Disclaimer: The syllabi are uploaded are as approved by the Academic Council on …… and Executive Council on ….

Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline Bachelor of Geology (Honours with Research/Academic Project/Entrepreneurship) or (Honours with Research in Geology (Major) with Discipline 2 (minor)

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 credits	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Value addition course (VAC) 2 credits		Total Credits
VII	DSC-19 (4) **Crustal Evolution through time (L3, T1))**	3 DSE (12) **i) Marine microfossils and biostratigraphy (L3, P1)** **ii) Earthquake Geology (L3, P1)** **iii) Environmental Geology (L3, P1)** Or 2 DSE (8) + 1 GE (4) Or 1 DSE (4) + 2 GE (8)	**(GE: Geoheritage and Geotourism (L3, T1)**				Dissertation on major (6) **Or** Dissertation on minor (6) **Or** Academic Project /Entrepreneurship (6)	**22 credits**

Structure of VIIth Semester in Geology

A student who pursues an undergraduate programme with Geology as a single core discipline is offered the following courses:

1 Discipline Specific Cores (DSCs) - 4 credits (offered by the parent Department i.e., Department of Geology)

3 Discipline Specific Electives (DSE) – DSE course in Semester VII (offered by the parent Department i.e., Department of Geology as choice-based electives- 12 Credits

2 Generic Elective (GE) – 4 credits each (To be chosen from the common pool of GE courses offered by Departments other than the parent Department)

Dissertation on major (6) **Or** Dissertation on minor (6) **Or** Academic Project/ Entrepreneurship -6 credits

DISCIPLINE SPECIFIC CORE COURSE - DSC-19 (4)
Crustal Evolution through time (L3, T1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-19 (4) **Crustal Evolution through time (L3, T1)**	**4**	**3**	**1**	**0**	**12th pass with science**	**Studied Earth System Science and Equivalent**

Learning Objectives

To expose students to the evolution of lithosphere, hydrosphere, atmosphere and biosphere from the early earth to the present form with particular emphasis on lithosphere.

Learning outcomes

After this course students will be able to decipher the early earth processes that was responsible for transforming the early molten Earth into a stratified Earth structure. Evolution of early Continent and amalgamation/fragmentation of continental fragments through the geological history

SYLLABUS OF DSC-19

Theory (45 hours)

UNIT – I (10 hours)

Origin of the Earth and initial Earth: common perceptions. Evolution of minerals and early differentiation. Geochemical and geochronological proxies

UNIT – II (10 hours)

Origin of Tonalite-trondhjemite-granite (TTG) suite of rocks and granites. Greenstone belts and related tectonics

UNIT – III (12 hours)
Geological time scale and Archean-Proterozoic boundary; Evolution of early atmosphere and hydrosphere; Great Oxidation Event (GOE), Early geodynamics of the Earth; initiation of plate tectonics and related debates

UNIT – IV (13 hours)
'Supercontinent' cycles, crustal evolution and proxies. Drawing link between evolution of lithosphere, atmosphere, hydrosphere and biosphere.
Crustal evolution of the Indian craton, The Himalayas: evidence of dynamic crustal evolution

Tutorial (30 Hours)

Exercises related to theory. Petrogenetic plots, Tectonic discrimination diagrams

Essential/recommended readings
Plate Tectonics and Crustal Evolution by Kent C. Condie 4th Edition Oxford: Butterworth/Heinemann

Suggestive readings
Plate Tectonics and Crustal Evolution by Kent C. Condie 4th Edition Oxford: Butterworth/Heinemann

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 3 DSE (12): **(i) Marine microfossils and biostratigraphy (L3, P1), (ii) Earthquake Geology (L3, P1), (iii) Environmental Geology (L3, P1)**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-5 **Marine microfossils and biostratigraphy (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent**

DSE-5: Marine microfossils and biostratigraphy (L3, P1)
Theory (45 hours)
Practical (30 hours)

Learning Objectives

Microfossil evolution has provided a rich archive for establishing relative time in marine sedimentary sequences This course basically aims to make the student learn about marine microfossil distributions in oceanic sediments. Students will be trained in applying biostratigraphic zonation, quantitative stratigraphic correlation, and magnetic stratigraphy and interpret relative age. The students will be taught the various methods of integrated stratigraphic correlation at regional and global scales. The integrated stratigraphy will include biostratigraphy integrated with magneto, chemo, event stratigraphy and tuning of biostratigraphy with astronomical time scale.

Learning outcomes

After completing the course, students gain experience using microfossil distributions in deep-sea cores to apply a biostratigraphic zonation and interpret relative age, correlate from one region of the world ocean to another, and calculate rates of sediment accumulation. In addition, the student will be able to independently take out biostratigraphic studies of the marine sections, evolve integrated stratigraphy and perform stratigraphic correlation of the marine sections at the regional and global scale to understand the cause-and-effect relationship in the ocean- climate system and teleconnections.

SYLLABUS OF DSE-5 (Marine microfossils and biostratigraphy)
Theory (45 Hours)

UNIT – I (12 Hours)
Detailed content

Definition and scope of Micropaleontology. Relationship of Micropaleontology with Ocean Science. Deep Sea Drilling Project (DSDP); Ocean Drilling Program (ODP) and Joint Global Ocean Flux Studies (JGOFS) and their major accomplishments. Integrated Ocean Drilling Program (IODP) and its aims and objectives; Sampling Modern Ocean Biogenic Flux including Joint Global Ocean Flux Studies (JGOFS). Introduction to important Deep Sea Drilling Vessels like Sagar Kanya, GLOMAR Challenger, JOIDES Resolution and Chikyu.

UNIT – II (12Hours)

Sample processing techniques and brief idea about Equipment like mass spectrometer, scanning electron microscope and stereo zoom binocular microscope which are used for micropaleontological studies.

UNIT – III (11 Hours)

Detailed content

A brief study of various types of microfossils including calcareous (Foraminifera, Calcareous nannofossils, Ostracoda, Pteropods, Calpionellids and Calcareous algae), Siliceous microfossils (Diatoms, Radiolaria and Silicoflagellates), Phosphatic microfossils (Conodonts) and Organic walled microfossils (Acritarchs and Dinoflagellates, Pollens and spores) and their application in biostratigraphy.

Unit – IV (10 Hours)

Detailed content

Application of microfossil biostratigraphy in hydrocarbon exploration. Basic concepts of Biostratigraphy, Chemostratigraphy, magnetostratigraphy, and astronomical tuning. Regional and global stratigraphic correlation. Diachronism and methods to identify the extent of diachronism. Diachronism and paleoceanographic interpretation.

Practical Component- (30 Hours)

Techniques of separation of microfossils from the matrix

Microscopic identification of (a) Types of microfossils: Calcareous, Siliceous, Phosphatic and organic-walled microfossils

Microscopic study of important planktic foraminifera useful in surface water paleoceanography and biostratigraphy

Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India

Study of modern surface water mass assemblages of planktic foraminifera from Indian, Atlantic and the Pacific Ocean

Exercises on Integrated Oceanic Biostratigraphy for regional and global correlation.

Essential/Recmmended readings

Bignot, G, 1985. Elements of micropalaeontology; Microfossils, their geological and palaeobiological applications, Graham & Trotman, London, United Kingdom.

Braiser, M.D., 1980. Microfossils, George Alien and Unwin Publisher.

Fischer, G and Wefer, G, 1999. Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer,

Recommended readings

Gross, M.G, 1977. Oceanography: A view of the Earth, Prentice Hall.

Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.

Hasllett, S.K., 2002. Quaternary Environmental Micropalaeontology, Oxford University Press, New York.

Jones, R.W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford.

Kennett and Srinivasan, 1983. Neogene Planktonic Foraminifera: A phylogenetic Atlas, Hutchinson Ross, USA. 9.

Sinha, D.K., 2007. Micropaleontology: Application in Stratigraphy and Paleoceanography, Alpha Science International, Oxford & Narosa Publishing House Pvt. Ltd. Delhi.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-6 **Earthquake Geology (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent**

DSE-6: Earthquake Geology (L3, P1)
Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives

Earthquakes are one of the most unpredictable natural catastrophes, wreaking havoc on human lives and property. A substantial portion of the population of India and the world is living at risk of earthquakes. The susceptibility of this population can be significantly lowered by mitigation measures such as earthquake microzonation, earthquake resistant design, raising awareness and preparing for earthquake safety. This course covers the principles of earthquake science for students interested in earth sciences, disaster management, seismology, earthquakes and geotechnical engineering, among other fields.

Learning outcomes

Introduction to the basics of the earthquake sources, size and their determination. Understating the nature of different type of earthquake waves in terms of their property and hazard potential. Understanding the role of geological structures and processes in earthquake hazards. Introduction to the advance techniques of crustal deformation measurement for earthquake analysis. Understanding the basic disaster terminology their significance. Secondary hazards associated with the earthquake. Concept of earthquake safety for people and structure.

SYLLABUS OF DSE-6

Earthquake Geology (L3, P1) (4 credits)

Theory (45 hours)

UNIT – I (10 Hours)

Earthquake definition and parameters: Earthquake definition and sources. Earthquake parameters- epicenter, focus, magnitude and intensity.

UNIT –II (10 Hours)

Seismic waves and instrumentation: Types of seismic waves- body waves and surface waves; Seismograph and seismogram; Determining the epicenter and magnitude. Ground motion parameters: peak ground acceleration (PGA).

UNIT –III (12 Hours)

Seismotectonics: Plate-boundaries and earthquakes, Style of faulting, active faults, Earthquake source zone in Indian subcontinents. Historical large earthquake of India.

UNIT –IV (13 Hours)

Geodetic measurement of crustal deformation: Geodetic data/measurement of interseismic deformation, trilateration, SAR interferometry of earthquake.

Earthquake hazard and mitigation measures: Concepts of earthquake Hazard and Risk and disaster, Secondary hazards of earthquake: liquefaction, landslides, Avalanches, Tsunami; seismic hazard zonation, basics of earthquake safety: safely of structure; awareness.

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Practical: 30 hours

Earthquake size determination and calculation: Calculation of earthquake magnitude and intensity. Identification of different phases of earthquake wave in seismogram. Calculation of epicenter location using triangulation method. Earthquakes and plate boundaries: Plotting of important earthquake epicenters on the tectonic map. Plotting of seismic source zones and important historical earthquakes of India. Plotting fault plane solutions.

Essential readings

Lowrie, W., (1997). Fundamental of Geophysics. Cambridge University Press. The Edinburgh Building, Cambridge CB2 8RU, UK

Kayal, J.R., (2008). Microearthquake Seismology and seismotectonics of south Asia. Springer. Capital Publishing Company, New Delhi

Recommended readings

S. Stein and M. Wysessions. (2003). An Introduction to Seismology, Earthquakes, and Earth Structure. Blackwell Publishing, Boston; ISBN 0-865-42078-5.

Yeats, R.S., Sieh, K. and Allen, C.R., (1997). The Geology of Earthquakes. Oxford University Press

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-7	4	3	0	1	12th pass with science	Studied Earth System Science and

Environmental Geology (L3, P1)						**Structural Geology, Hydrogeology or Equivalent**

Environmental Geology (L3, P1)
Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives
The main objective is to help equip students with an understanding of the interactions between geologic processes, ecological processes, and society. Future standard of life and living quality will be governed by the use of earth's resources. Environmental geology is the application of geologic information to the entire spectrum of interactions between people and the physical environment.

Learning outcomes
Introduce to the basic concepts and principles of physical and environmental geology, focusing on Earth materials and processes. Provide with sufficient information concerning natural hazards and the geologic environment. Develop an understanding of relationships between natural resources and pollution. Systematic understanding of the basic concepts of environmental management as they relate to the geologic environment in areas such as waste management, environmental health, global change, and environmental assessment

SYLLABUS OF DSE-7
Environmental Geology (4 credits)

Theory (45 hours)

Unit 1: (12 hours)
Concept and definition of Environmental Geology. Components of Earth System and their mutual inter-relations and interactions (atmosphere, hydrosphere, lithosphere and biosphere). Concept of biodiversity

Unit 2: (13 hours)
Earth Processes and Natural Hazards: Distribution, magnitude and intensity of earthquakes. Neotectonics and seismic hazard assessment. Seismic hazard maps. Impact of seismic hazards on long and short term environmental conditions. Mechanism of landslides, causes of major floods, Coastal hazards, cyclones and storms

Unit 3: (10 hours)
Resources and Pollution: Soil degradation and changing land use pattern. Soil contamination due to urbanization, industrialization and mining. Water pollution: Impact assessment of water availability, quality and contamination of surface water and groundwater. Major Water Pollutants, Surface-Water Pollution and Treatment, Groundwater Pollution and Treatment , Water-Quality Standards, Wastewater Treatment, Air pollution: Introduction to Air Pollution, Pollution of the Atmosphere, Sources of Air Pollution, Air Pollutants, Urban Air Pollution, Indoor Air Pollution, Control of Air Pollution, Air Quality Standards, Deforestation
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Unit 4: (10 hours)

Environmental management: Global Climatic Change, Anthropogenic influence on environment, Basic tenets of environmental laws. Environmental Protocols. Environmental Planning: Site Selection Environmental Impact Analysis and Use and Planning

Practicals (30 hours)

Study of maps of seismic zones, earthquake-prone, landslide-prone and flood-prone areas in India. Methods of water analyses for physical, chemical and biological parameters. Classification of groundwater for use in drinking and industrial purposes. Evaluation of environmental impact of air pollution, groundwater pollution, landslides, deforestation.

Essential readings

Valdiya, K.S., 2013. Environmental Geology – Ecology, Resource and Hazard Management, 2nd Edition, McGraw Hill (Education) Pvt. Ltd. India.

Richards J.S., 2013. Environmental Geology. 2nd Edition, McGraw-Hill Science Engineering

Smith, K., 2013. Environmental Hazards. Assessing Risk ang Reducing Disaster, 6th Edition, Routledge, London.

Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International

Kellar, E. A. 2017. Introduction to Environmental Geology. 5th Edition, Pearson

Recommended Readings

Botkin, D,B. and Keller, E. A. Environmental Science: Earth as a Living Planet, 9th Edition, Wiley.

Merritts, D., de Wet, A. and Menking, K. 1998. Environmental Geology: an earth system science approach. W.H. Freeman & Co., N. Y.

Keller, E.A, DeVecchio, D.E and Blodgett, R.H., 2019. Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes 5th Edition, Routledge, London.

GE from GE pool (GE-7): Geoheritage and Geotourism (L3, T1)

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-7 Geoheritage and Geotourism (L3, T1)	**4**	**3**	**1**	**0**	**12th Pass**	**Nil**

Learning Objectives

This course aims to consider strategies to sample, understand, and address geoconservation and geotourism issues. It should lead to the development of the skills and knowledge to conduct and curate (geo)heritage inventories, assess prospective sites for use as geotouristic and geoeducational purposes, propose new geotouristic experiences and develop materials for geoconservation and geotourism consumers and operators. This is designed as an applied course where student learns to combine and optimize the tourism potential of spectacular geological features.

Learning outcomes

On completion of the course, the student will be able to learn, distinguish, and identify potential geological sites of tourist interest. Spectacular (e.g. geomorphic landforms, structures) as well as intrinsic sites (major time boundaries, fossil sites, LIP's, transgressions regressions etc), Economic aspects and linking geospots with other tourist destinations in a theme

SYLLABUS OF GE-7

Theory (45 hours)

UNIT – I (9 Hours)

Geodiversity, Geoheritage, Geoconservation and their relationship to geotourism. Concept of geoheritage in relation to other historical heritages, Tourism and its different forms and their interrelations, Geotourism: definition, characteristics and international/national perspectives, Eco-tourism and Geo-tourism, Defining the geoheritage sites and the concept of Geoheritage parks (UNESCO guidelines). Geographical context and contemporary geoheritage challenges, Geoheritage inventory of India and its curation context, legal framework of geoheritage, Relevance of geoheritage to Sustainable Development Goals (SDG).

UNIT – II (9 hours)

Detailed contents

Education as a key tenet of geotourism and Earth Science Education & Geotourism
Geoheritage and public geoliteracy: opportunities for effective geoscience education within geosites Earth Science Museums and their role in promotion of Geotourism
Examples of Geotourist sites from India - e.g. Glacier features, Ox-bow lakes, Deltas etc.
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UNIT – III (10 Hours)

Detailed contents

Geotourism, Society and Sustainability: Public–private partnership framework for sustainable geopark development. Geotourism—a focus on the urban environment including historical Geotourism. Geotourism and cultural heritage. Potential of Geotourism in Economic development of any region. Role of Tourism sector in terms of world economy/ Indian economy. Role of Geotourism in Tourism industry with special reference to Indian scenario Entrepreneurship and start-up.

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UNIT – IV (17 Hours)

Detailed contents

Geotourism and geoparks: UNESCO Global Geoparks and Geoconservation
Geo site developed by Geological Survey of India. The application of geographical information systems in geotourism. Geotourism potential of the Indian geoheritage sites-societal and economic context including case studies

Geoheritage in Indian Context: Study of Geological Map of India
Plotting the established geosites, geoparks and geo monuments of India on map.
Plotting geosites, geoparks and geo monuments on map of World. Detailed study of geosites of India-Locality, Approach, Geological importance and foot fall. Five Case studies from India where geosites can be developed.

Tutorial (30 hours)

Students in different batches or groups will be given exercises to prepare shorts reports about the life evolution and extinction through different geological times on Earth.

Essential/recommended readings

T.A. Hose (Ed.) (2016). Appreciating Physical Landscapes: Three Hundred Years of Geotourism, Geological Society Special Publication No. 417, London.
Thomas A. Hose (Ed.)(2016).Geoheritage and Geotourism- a European Perspective, Boydell Press Woodbridge, UK
Ross Dowling & David Newsome (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.
A monograph on National Geoheritage Monuments of India. Indian National Trust for Art and Cultural Heritage(INTACH) Natural Heritage Division, New Delhi (2016).
National Geological Monuments. Geological Survey of India, Kolkata, Special Publication No.6 1(2001)
Kale, V.S. (ed.) (2014). Landscapes and Landforms of India, Springer, Dordrecht.
C. V. Burek and C.D. Prosser (Eds.) (2008) History of Geoconservation Special Publication 300, Geological Society of London

Suggestive readings

Young C.Y. Ng. &Yunting Lu (2015). The Principles of Geotourism, Anze Chen, (Springer).
Dowling, R. & Newsome, D. (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.
National Geological Monuments. (2001) Geological Survey of India, Kolkata, Special Publication No.61
Burek, C.V. & Prosser, C.D. (Eds.) (2008). History of Geoconservation Special Publication 300, Geological Society of London.
Santangelo, N. and Valente, E. (Eds.) (2020). Geoheritage and Geotourism Resources, MdpiAG

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VIII

Disclaimer: The syllabi are uploaded are as approved by the Academic Council on …… and Executive Council on ….

Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline
Bachelor of Geology (Honours with Research/Academic Project/Entrepreneurship) or
(Honours with Research in Geology (Major) with Discipline 2 (minor)

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 credits	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Value addition course (VAC) 2 credits		Total Credits
VIII	DSC-20 (4) **Research and Analytical Methods in Geoscience (L3, P1)**	3 DSE (12) **i) Mineral Resources and Economics (L3, P1)** **ii) Applied Stratigraphy (L3, P1)** **iii) Techniques of Sample collection & processing in Geology (L3, T1)** Or 2 DSE (8) + 1 GE (4) Or 1 DSE (4) + 2 GE (8)	**(GE: Groundwater management and water quality (L3, P1)**				Dissertation on major (6) **Or** Dissertation on minor (6) **Or** Academic Project /Entrepreneurship (6)	**22 credits**

Structure of VIIIth Semester in Geology

A student who pursues an undergraduate programme with Geology as a single core discipline is offered the following courses:

1 Discipline Specific Cores (DSCs) - 4 credits (offered by the parent Department i.e., Department of Geology)

3 Discipline Specific Electives (DSE) – DSE course in Semester VII (offered by the parent Department i.e., Department of Geology as choice-based electives- 12 Credits

2 Generic Elective (GE) – 4 credits each (To be chosen from the common pool of GE courses offered by Departments other than the parent Department)

Dissertation on major (6) **Or** Dissertation on minor (6) **Or** Academic Project/ Entrepreneurship -6 credits

DISCIPLINE SPECIFIC CORE COURSE - DSC-20 (4)
Research and Analytical Methods in Geoscience (L3, P1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-20 (4) **Research and Analytical Methods in Geoscience (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Equivalent**

Learning Objectives

This course intends to familiarize students to the methods of designing and carrying out research. Also, aim is to introduce students to various laboratory and field techniques used in the field of geosciences.

Learning outcomes

After completion of this course, students will understand the significance of research philosophy. They will also learn the modern field and laboratory techniques used widely in geosciences.

SYLLABUS OF DSC-20 Research and Analytical Methods in Geoscience (L3, P1)

Theory (45 hours)

UNIT – I (10 hours)

Meaning and objective of research, significance, types of research (descriptive, analytical, qualitative, quantitative, empirical, conceptual, fundamental), hypothesis forming and testing, ethical guide for academic research.

UNIT – II (10 hours)
Field methods: Introduction to basic instruments and techniques used to collect sedimentary, structural, geomorphic and other data in field. Sample and type of samples, sampling theory.

UNIT – III (12 hours)
Laboratory techniques - X-ray diffraction, X-ray fluorescence and induced couple plasma (ICP) analysis- principles and instrumentation (TA), Reciprocal lattice, Ewald's Sphere, Crystal field theory. Raman and Mossbauer spectroscopy, Microbeam techniques- SEM, EPMA, Atomic Force Microscope, electron beam-matter interaction, secondary and back-scattered electrons, auger electrons, energy transitions and characteristic x-rays, EDS & WDS, data generation, detection limits, matrix correction and data reduction, Total organic carbon analyzer, TL/OSL dating techniques, Fluid inclusion and analog and digital modeling.

UNIT – IV (13 hours)
Quantitative methods: Basic Statistics- measures of central tendency, dispersion and asymmetry, simple and multiple correlation and regression; Plotting in Excel; Data collection and analysis; Interpolation techniques; Time series analysis; Standard error and error analyses.
Computing in Geosciences: Introduction to R, Python and Matlab. Information regarding software's used in different disciplines of geology. Testing hypothesis; Interpretation and Report writing.

Practical (30 Hours)
Computational techniques associated with different analytical techniques

Essential/recommended readings
Research Methodology: Methods and Techniques by C.R. Kothari, New Age International Publishers

Suggestive readings
1. Matlab recipes for Earth Sciences by Marin H Trauth, Springer International Publishing. Data Analysis in the Earth Sciences Using MATLAB by Gerard Middleton, This book is available for free on Mathworks website.
2. Python: Introduction to Scientific Programming with Python by Joakim Sundnes. This book is available for free from Springer

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

Discipline Specific Elective 3 DSE (12):
(i) Mineral Resources and Economics (L3, P1), (ii) Applied Stratigraphy (L3, P1), (iii) Techniques of Sample collection & processing in Geology (L3, P1)

Course title & Code	Credits	Credit distribution of the course	Eligibility criteria	

		Lecture	Tutorial	Practical/ Practice		Pre-requisite of the course (if any)
DSE-8 **Mineral Resources and Economics (L4, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent**

DSE-8: Mineral Resources and Economics (L3, P1)
Theory (45 hours)
Practical (30 hours)

Learning Objectives
To develop an understanding of Earth's mineral resources and its utilization in global economic activity.

Learning outcomes
After completing the course, students will have a basic idea of mineral resources and their distribution, exploitation and economic implications

SYLLABUS OF DSE-8 (Mineral Resources and Economics)
Theory (45 Hours)

UNIT – I (12 Hours)
Detailed content
Mineral Resources: Resource and reserve definitions; mineral resources in industries; economic considerations; historical perspective and present. A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

UNIT – II (12Hours)
Distribution of economic mineral resources: Major mineral deposits of India: reserve, grade, mineralogy and exploitation through time. Major mineral deposits of the World: reserve, grade, mineralogy and exploitation through time

UNIT – III (11 Hours)
Detailed content
Metallic, non-metallic, industrial, critical, strategic and gem minerals
Mineral beneficiation and mining

Unit – IV (10 Hours)
Detailed content
Mineral economics: Global metal markets and projections; National mineral policy; Mineral conservation. UNFC classification; Legal, social and environmental aspects affecting the mine cycles.

Practical Component- (30 Hours)
Exercises related to mineral resources of India and World. Reserve estimation
Projection on Indian mineral resource

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Essential/Recmmended readings

Evans, A.M., 2009. Ore geology and industrial minerals: an introduction. John Wiley & Sons.
Moon, C.J., Whateley, M.K.G. & Evans, A.M. 2006. Introduction to Mineral Exploration, Blackwell Publishing.
Chatterjee, K.K. (2004). An Introduction to Mineral Economics, New Age Publishers.

Recommended readings

Wills, B.A. and Finch, J.A., 2015. Wills' mineral processing technology: an introduction to the practical aspects of ore treatment and mineral recovery. Butterworth-Heinemann.
Haldar, S.K., 2013. Mineral Exploration – Principles and Applications. Elsevier Publication.
Arogyaswami, R.P.N. 1996. Courses in Mining Geology. 4th Ed. Oxford-IBH.
Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons..

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-9 **Applied Stratigraphy (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent**

DSE-9: Applied Stratigraphy

Credit 4 Theory (3) Practical (1)

Learning Objectives: To make students understand concepts of dynamic stratigraphy, how eustacy, sediment supply and tectonics control a basin filling history in space-time domain. Additionally, how magnetic signature and isotopic values help in the analysis of basin filling history.

Learning Outcome: After taking this course students will be able to cope up with the need of oil/gas industry, sustainable energy and use of isotope geochemistry. Students will be ready for cutting-edge research

Unit I: Sequence Stratigraphy

1. Historical developments. Definitions and key concepts. Base level changes, Geomorphic and Stratigraphic base level. Transgressions and regressions, T-R cycles.
2. Stratigraphic surfaces: Stratal terminations, sequence stratigraphic surfaces; surface and sub-surface signature
3. Unconformity and correlative conformity, Ravinement surface, Initial and maximum flooding surface.
4. Systems Tracts: Lowstand, Transgressive, Highstand, Falling stage.

Unit II: Sequence models and their application in hydrocarbon sector

1. Sequence Models: Depositional sequence (Type I, 11, Ill), Genetic stratigraphic sequence, Transgressive-Regressive sequence. Hierarchy of sequences and bounding surfaces.
2. Application of sequence stratigraphy in hydrocarbon exploration; stratigraphic trap delineation
3. Concepts of event stratigraphy.

Unit III: Magnetic Stratigraphy

Principles, Earth Magnetism, The magnetization process, Inclination, Declination Paleomagnetism, Magnetic epochs, magnetic properties of marine sediments.
Fundamentals of reversal magneto-stratigraphy, The Plio-Pliestocene reversal record
Magnetic stratigraphy of Cenozoics

Unit IV: Isotope stratigraphy

Geochemistry of stable isotope (C, 0, S). Application of stable isotopes: Oxygen and hydrogen in Paleothermometry, and Paleclimatology. Carbon in modem biosphere, sedimentary rocks of Precambrian age, and marine and nonmarine sediments.

Practicals:

1. Problems on paleoenvironmental interpretation
2. Problems on sequence stratigraphic surfaces (unconformity, BSRF, Correlative conformity, Transgressive surface, Maximum flooding surface)
3. Problems of stratigraphic correlation and identification of proximal-distal relationship
4. Problems involving different branches of stratigraphy

Suggested Readings:

1. Sequence Stratigraphy: D. Emery, and K. Mayers (1996) Blackwell Publishers
2. Principles of Sequence Stratigraphy Octavian Cateneanu (2006) Elsevier
3. Basin Analysis: Principles and Applications: P. A. Allen and J.R. Allen (1990) Blackwell Publishing
4. The geology of stratigraphic sequences: A.D. Miall (1997) Springer

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-10 **Techniques of Sample collection & processing in Geology (L3, T1)**	**4**	**3**	**1**	**0**	**12th pass with science**	**Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent**

Techniques of Sample collection & processing in Geology (L3, T1) Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives
To expose students to different techniques of geological sample collection from both surface (rock, soil, plant, water, sediment) and subsurface.

Learning outcomes
After the course the students will be confident in collection of samples from different environmental settings, for different objective need as well as for different state-of-the-art instrument need. They will also be able to know high-resolution sampling technique and precautions to be taken during sampling

SYLLABUS OF DSE-10
Techniques of Sample collection & processing in Geology (L3, P1) (4 credits)

Theory (45 hours)

Unit 1: (10 hours)
Sample and Specimen; philosophy of sampling as dynamic and static stochastic system with precision. Samples in different form and purpose; samples for geochemical characterization

(lithogeochemical, pedogeochemical, geobotanical, stream sediment); samples from rock and unconsolidated sediment/soil

Unit 2: (10 hours)
Sampling from surface or underground workings. Grab, Channel, Chip sampling
Trench sampling, Geochemical and environmental Sampling, Water samples, Run of mine ore feed, Crusher product sampling. Core Drilling, Reverse circulation drilling, Auger Drilling Borehole sampling, Core sampling

Unit 3: (13 hours)
Sampling in mineral exploration or mineral deposits: Placer deposit; stratiform or strata-bound ore bodies
Sample processing for different scientific and industrial purposes; Clean processing laboratory. Heavy mineral separation. Safety protocols and ethics

Unit 4: (12 hours)
Detailed content
High-resolution thematic sampling, Sampling with logging. Sampling for total metal content, Soluble metal content, Content of non-metal commodities. Sampling for heat content for coal and oil shale, ash content after combustion. Sampling for in situ density, Porosity, Permeability, Compressive strength, Compaction, Grinding index. Samples for geochronology and paleomagnetic study

Tutorials (30 hours)
Exercises related to different sampling techniques; surface, sub-surface etc.

Essential readings

Pal, S.K., 2021 Soil sampling and methods of analysis, New India publishing Agency
Watson I., Lemon R., Krupa S.L. (1988) Samples, sampling. In: General Geology. Encyclopedia of Earth Science. Springer, Boston, MA. https://doi.org/10.1007/0-387-30844-X_97

Recommended Readings

Pal, S.K., 2021 Soil sampling and methods of analysis, New India publishing Agency
Watson I., Lemon R., Krupa S.L. (1988) Samples, sampling. In: General Geology. Encyclopedia of Earth Science. Springer, Boston, MA. https://doi.org/10.1007/0-387-30844-X_97

GE from GE pool (GE-8): Groundwater management and water quality (L3, P1)

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-8 Groundwater management and water quality (L3, P1)	**4**	**3**	**0**	**1**	**12th Pass**	**Nil**

Learning Objectives

To understand about the fundamentals of: groundwater management and water quality issues.

Learning outcomes

The course will impart basic understanding about: groundwater science; aquifers; groundwater flow and groundwater management principles and practices. The concepts of water quality; water quality parameters and criteria for portable and irrigation use; contamination and pollution and graphical representation of the water quality data.

SYLLABUS OF GE-8

Theory (45 hours)

UNIT – I (10 Hours)

Geodiversity, Geoheritage, Geoconservation and their relationship to geotourism. Concept of Water science and its societal relevance, Hydrologic cycle and interaction of the surface and subsurface water, Vertical distribution of subsurface water.

UNIT – II (10 hours)

Detailed contents

Introduction to the concept of porosity and permeability, classification of rocks and sediments as aquifer, aquitard, aquiclude and aquifuge. Types of Aquifer, concept of the piezometric surface and water table and aquifer parameters.

Introduction to Darcy's law and the concept of : static water level, pumping water level, drawdown, radius of influence, cone of depression, specific capacity etc.

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UNIT – III (13 Hours)

Detailed contents

Introduction to: the basic concept of water balance and the groundwater resources estimation; principles of the groundwater management; rainwater harvesting and artificial recharge to groundwater; aspects of watershed management as an integral part of groundwater management .

UNIT – IV (12 Hours)

Detailed contents

Introduction to the concept of water quality, contamination, pollution and water quality parameters: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), organoleptic; physical; chemical; radioactive and bacteriological parameters. The criteria for portable and irrigation use and graphical representation of the water quality data.

Practical (30 hours)

Preparation and interpretation of water level contour maps and depth to water level maps. Graphical representation of chemical quality data and water classification (Trilinear diagrams). Fundamental exercise on groundwater resources estimation. Basic fundamental exercises on aspects related to designing rainwater harvesting and artificial recharge structures.

Essential/recommended readings

Todd, D. K. (1980). *Groundwater hydrology, 2ed*. John Wiley. (p. 535).

Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw- Hill Pub. Co. Ltd.

Suggestive readings

Freeze, R. A., & Cherry, J. A. (1979). Groundwater (p. 604). *New Jersey: Prentice Hall Inc Englewood cliffs*.

Syed Tajdarul Hassan. 2017. Introduction to Hydrology. E-PG Pathshala, UGC, MHRD, Govt. of India.