INDEX
DEPARTMENT OF GEOLOGY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VII

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

UNIT – II (10 hours)
Detailed contents
Origin of Tonalite-trondhjemite-granite (TTG) suite of rocks and granites. Greenstone belts and related tectonics

UNIT – III (10 hours)
Detailed contents
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 (10 hours)
Detailed contents
'Supercontinent' cycles, crustal evolution and proxies.Drawing link between evolution of lithosphere, atmosphere, hydrosphere and biosphere.

UNIT – V (5 hours)
Detailed contents
Crustal evolution of the Indian craton, The Himalayas: evidence of dynamic crustal evolution

Tutorial (30 Hours)

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), (iv) Glacial Geology

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 (9 Hours)
Detailed Content

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

UNIT –II (9 Hours)

Detailed Content

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 (9 Hours)

Detailed Content

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

UNIT –IV (9 Hours)

Detailed Content

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

UNIT –V (9 Hours)

Detailed Content

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.

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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 **Environmental Geology (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and 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)
Detailed content
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)
Detailed content
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)
Detailed content
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)
Detailed content
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.

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-8 Glacial Geology (L3, P1)	4	3	0	1	12th pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

DSE-85: Glacial Geology (L3, P1)
Theory (45 hours)
Practical (30 hours)

Learning Objectives
Main aim of this course is to introduce students about the critical aspects of glaciers in the three cryosphere's of the Earth and their significance in geological processes, biotic life, and natural hazards.

Learning outcomes
After completing this course, students will gain knowledge and understanding about the important process of ice sheets and valley glaciers that are influencing landscape evolution, climate changes, natural hazards and life on Earth.

SYLLABUS OF DSE-8 (Glacial Geology L3, P1))
Theory (45 Hours)

Unit 1 (9 hrs)

Introduction to Glacial Geology: Cryosphere: Ice sheets, valley glaciers, formation of glaciers; Characteristics of glacial ice; climate and glaciers; Implication of Glacial geology; Techniques in Glacial geology.

Unit 2 (9 hrs)

Glacial Morphology and Processes: Glacial landforms: erosional process and landforms, depositional landforms, Ice flow mechanism, sediment entrainment and transportation, Glacial mass balance and Equilibrium Line Altitude (ELA). Glacial lakes and outburst floods.

Unit (9 hrs)

Periglacial Environment and Processes: Periglacial concept: climate, soils, vegetation cover; Periglacial processes: weathering, ground freezing and thawing; Permafrost: characteristics, distribution and type; slope movement, movement and hillslope evolution.

Unit 4 (9 hrs)

Glacial Sediments: Clast characteristics: shape-form, roundness and texture, size, macro fabrics; sediment sampling and analysis; glacial fluvial, glacio-lacustrine and glacio-marine sediments.

Unit 5 (9 hrs)

Past Glaciations: Climate change and glaciations; Glaciation during the earth's history, Quaternary Glaciations: Last Glacial Maximum, Little Ice Age.

Practicals (30 hrs):

I. Identification of glacial and periglacial landforms in satellite image
II. Glacial mass balance exercise
III. Identification and reconstruction of Equilibrium Line Altitude
IV. Glacial sediments: Glacial sediment shape, form and texture

Essential readings

Glacial Geology: Ice sheets and landforms. 2009. By Matthew R. Bennett and Neil F.
Periglacial Geomorphology. 2018. By Colin K. Ballantyne, Wiley Blackwell, second edition, A John Wiley & Sons Ltd. Publication, Oxford, U.K.

Recommended Readings:

Glasser. Wiley Blackwell, second edition, A John Wiley & Sons Ltd. Publication, U.K.
Global geomorphology. 2014. By Summerfield, Michael A. Routledge.
A practical guide to the study of glacial sediments. Routledge, 2014. By Evans, David JA, and Douglas I. Benn, eds.

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

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

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)
Detailed contents
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 (9 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.

UNIT – IV (9 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

UNIT – V (9 Hours)
Detailed contents
Basic concepts of geology in relation to Geoheritage: 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

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VIII

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 (9 hours)
Detailed content
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 (9 hours)

Detailed contents
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 (9 hours)
Detailed contents
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 (9 hours)
Detailed contents
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.

UNIT – V (9 hours)
Detailed contents
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
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.
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), (iv) Urban Geology

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-9 **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-10 Applied Stratigraphy (L3, P1)	4	3	0	1	12^{th} pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

DSE-10: Applied Stratigraphy (L3, P1)
Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives

To prepare students ready for hydrocarbon industry and research

Learning outcomes

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

SYLLABUS OF DSE-10

Applied Stratigraphy (L3, P1) (4 credits)

Theory (45 hours)

UNIT – I (15 Hours)

Detailed Content

Sequence Stratigraphy: Historical developments. Definitions and key concepts. Base level changes, Transgressions and regressions, T-R cycles. Stratigraphic surfaces: Stratal terminations, sequence stratigraphic surfaces. Unconformity and correlative conformity, Ravinement surface, Initial and maximum flooding surface. Systems Tracts: Lowstand, Transgressive, Highstand, Falling stage. Sequence Models: Depositional sequence (Type I, 11, Ill), Genetic stratigraphic sequence, Transgressive-Regressive sequence. Hierarchy of sequences and bounding surfaces. Application of sequence stratigraphy in hydrocarbon exploration; stratigraphic trap delineation. Concepts of event stratigraphy

UNIT –II (15 Hours)

Detailed Content

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 –III (15 Hours)

Detailed Content

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 Precambnan age, and marine and nonmarine sediments.

Practical: 30 hours

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

Essential readings

Sequence Stratigraphy: D. Emery, and K. Mayers (1996) Blackwell Publishers
Principles of Sequence Stratigraphy Octavian Cateneanu (2006) Elsevier

Recommended readings

Basin Analysis: Principles and Applications: P. A. Allen and J.R. Allen (1990) Blackwell Publishing
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-11 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-11
Techniques of Sample collection & processing in Geology (L3, P1) (4 credits)

Theory (45 hours)

Unit 1: (9 hours)
Detailed content
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: (9 hours)
Detailed content
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: (9 hours)
Detailed content
Sampling in mineral exploration or mineral deposits: Placer deposit; stratiform or strata-bound ore bodies

Unit 4: (9 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

Unit 5: (9 hours)
Detailed content
Sample processing for different scientific and industrial purposes; Clean processing laboratory. Heavy mineral separation. Safety protocols and ethics

Tutorials (30 hours)

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

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

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

Learning Objectives
It is an emerging discipline in an increasingly urbanized world, particularly fast developing nation like India. Main aim of this course to introduce students about the application of the earth sciences to the problems arising at the interface of geosphere, hydrosphere, and biosphere within urban and urbanizing areas for planning purposes.

Learning outcomes
After this course students will be able to learn and apply the knowledge of geology for sustainable infrastructure developments and urban planning. This will also help them develop guidelines for implementation, upkeep, and optimization of natural resources like water and soil.

SYLLABUS OF DSE-12

Unit 1(9 hrs)
Geology and Society: Necessity of Geology in Urban life. Geology in Urban Constructions Geotechnical feature and mapping for subsurface in Metropolitan areas. Building materials, Excavation and cutting in urban areas.

Unit 2 (9 hrs)
Geology and Urban Agriculture:
Soil studies, Chemistry and geochemistry of soil in relation to ground water and fertilizer Effect of pollutants on vegetable contamination

Unit 3(9 hrs)
Urban land use: Geotechnical site characterization, Geotechnical and land use mapping, Decision making in urban land use, Geological problems in construction of underground structures in urban areas. Urban Tunnelling: Tunnelling for road and rail in urban areas; Methods, Equipments, Importance of Geology

Unit 4 (9 hrs)
Urban water: Water lagging in built-up areas, Source of water, Standards for various uses of Water; Sources of contamination; Waste waters: Sources and its disinfection and treatment, Ground water surveys and resource development.

Unit 5 (9 hrs)
Urban wastes and Treatment, Geotechnical characterization for waste sites, Domestic waste, Industrial waste, Mine drainage, Power production waste, radioactive waste, Need for special purpose mapping for selection of waste disposal sites. Urban planning in relation to possible natural hazards.

Suggested Readings:
Huggenberger, P. & Eptin, J. (2011). Urban Geology: Process-Oriented Concepts for Adaptive and Integrated Resource Management, Springer.
Lollino, G. et al. (Ed.), Engineering Geology for Society and Territory. Springer
Practicals

Recommended Readings:
Rodrigo Sal Gado (2022). The engineering of foundations, slopes and retaining structures CRC publication.
C. Venkatramiah (2018). Geotechnical Engineering. New Age International Publisher Ltd. New Delhi

Practicals (30 hrs)
1. Mapping of critical geological features in the urban areas
2. Mapping of land use and landcover in the urban areas
3. Ground water flow direction estimation in the urban areas
4. Case studies of Urban flood; Flood hydrographs
5. Case studies of urban planning

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

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

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 (9 Hours)

Detailed contents

Water science and its societal relevance, Hydrologic cycle and interaction of the surface and subsurface water, Vertical distribution of subsurface water.

UNIT – II (9 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.

UNIT – III (9 Hours)

Detailed contents

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 – IV (9 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 – V (9 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 and Mays (2011). *Groundwater hydrology, 3ed*. Wiley India Edition.

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.