Course Details:PG

Course Title	Course Type	Nature of Course		Credits	Semester
		Theory (T)	Lab (L)		
Structural geology	DSC	T (03)	L (01)	4	7
Mineralogy and Geochemistry	DSC	T (03)	L (01)	4	8
Geodynamics	DSC	T (04)	L (0)	4	9
Fuel Geology	DSC	T (04)	L (0)	4	10
Igneous Petrology	GE	T (03)	L (01)	4	7
Metamorphic Petrology	GE	T (03)	L (01)	4	7
Sedimentology	GE	T (03)	L (01)	4	7
Economic Geology	GE	T (03)	L (01)	4	8
Paleontology	GE	T (03)	L (01)	4	8
Basin Analysis and Sequence Stratigraphy/ Glacial Geology	GE	T (03)	L (01)	4	8
Remote Sensing and GIS	GE	T (03)	L (01)	4	9
Hydrogeology	GE	T (03)	L (01)	4	9
Micropaleontology and Oceanography	GE	T (03)	L (01)	4	9
Tectonic Geomorphology	GE	T (03)	L (01)	4	10
Engineering Geology	GE	T (03)	L (01)	4	10
Mineral Exploration and Mineral Economics	GE	T (03)	L (01)	4	10
Igneous Petrology	DSE	T (03)	L (01)	4	7
Metamorphic Petrology	DSE	T (03)	L (01)	4	7
Sedimentology	DSE	T (03)	L (01)	4	7
Economic Geology	DSE	T (03)	L (01)	4	8
Paleontology	DSE	T (03)	L (01)	4	8
Basin Analysis and Sequence Stratigraphy/Glacial Geology	DSE	T (03)	L (01)	4	8
Remote Sensing and GIS	DSE	T (03)	L (01)	4	9
Hydrogeology	DSE	T (03)	L (01)	4	9
Micropaleontology and	DSE	T (03)	L	4	9

Oceanography			**(01)**		
Tectonic Geomorphology	**DSE**	**T (03)**	**L (01)**	**4**	**10**
Engineering Geology	**DSE**	**T (03)**	**L (01)**	**4**	**10**
Mineral Exploration and Mineral Economics	**DSE**	**T (03)**	**L (01)**	**4**	**10**
Academic Project Based on Field Training	**IAPC**	**T (0)**	**L (06)**	**6**	**7**
Dissertation	**IAPC**	**T (0)**	**L (06)**	**6**	**8**
Academic Project Based on Field Training	**IAPC**	**T (0)**	**L (06)**	**6**	**9**
Dissertation	**IAPC**	**T (0)**	**L (06)**	**6**	**10**

PROGRAMME PREREQUISITES: -

Candidates who have completed the three-year B.Sc. examination from any recognized university, including Kumaun University, or an equivalent examination from other universities, with Geology as one of their major subjects in all three years, can apply for admission to the **Four Semester M.Sc.** program in Geology.

PROGRAMME INTRODUCTION: -

Geology is an ever-evolving and most popular branch of pure and applied science amongst students having a keen interest and curiosity in understanding the origin, evolution, nature, composition, structure and processes of the Earth and its environs through time. The identification of minerals, rocks, and fossils provides insights into the age, composition, structure, and paleoenvironment of the Earth and the life that thrived on it through the geological ages. This leads to understanding the physical processes of the Earth's spatiotemporal evolution and the availability of its natural resources and reserves. A thorough knowledge of various domains of geology is, thus, beneficial in not only enriching our understanding of different physical and historical aspects of the Earth's evolution and dynamics but also in judiciously utilising its precious natural resources as well as efficiently preventing or mitigating disasters that could be caused as a result of the Earth's powerful endogenic and exogenic processes.

The programme offers fundamental and advanced knowledge and technical skills in various domains of geology. Students would study core and applied aspects of recent technological advances in the subject field. The curriculum of the programme is designed in such a stepwise manner that the student can derive benefit at any stage of the programme, even if the entire course still needs to be completed; it begins with basic essential knowledge and gradually covers advanced aspects of the subject. At the end of every academic year, the student will have a good understanding of some basic and applied aspects of the subject, which will keep growing as the student proceeds further with the subject course. At a later stage of the course, the curriculum provides the student with an opportunity to carry out field and laboratory-based project work leading to a dissertation in a specialised domain of geology, which is a training of making a professional geologist competent in generating, analysing, and synthesising the data, to resolve geoscientific problems.

The geology program opens doors to a wide range of career opportunities in fields such as geoscience, disaster management, natural resource assessment and management, civil engineering and construction projects, natural environment conservation, and other allied fields. By choosing the courses offered in geology, candidates can pave the way to a rewarding career in these sectors.

PROGRAMME OUTCOMES (POs)

The curricula of the subject of geology are designed keeping in view the following programme.outcomes:

PO1	Enabling the students to understand the age, composition, structure, processes, and evolutionary history of the Earth.
PO2	Enabling the students to identify, locate, explore, judiciously exploit, and manage various earth resources like minerals, fossil fuel and natural gas, coal, building stones, weathered crust and soils, underground and surface water, etc.
PO3	Enabling the students to understand and assess the potential of natural processes in causing hazards and disasters.
PO4	Enabling the students to understand such geological conditions that make the terrain prone to natural and anthropogenic hazards.
PO5	Enabling the students to assess the suitability of terrain for various civil engineering constructions such as dams, reservoirs, bridges, tunnels, roads, railway lines, cable-cars, and buildings etc.
PO6	Enabling the students to formulate and execute guidelines for safe developmental activities in diverse geological terrains.
PO7	Motivating the students to take up higher studies and research to bring out new knowledge. Yet to be understood the geological aspects of the Earth.

Programme specific outcomes (PSOs) for PG I Year

Programme Specific Prerequisites: To acquire *Bachelor of Science (Honours)* degree, inGeology, a student should have obtained three-year *Bachelor of Science* degree from anyrecognized university.

PSOs: Under this programme, the students will gain in-depth knowledge on successiveadvancements in the subject of geology. Focus of this programme is to inculcate in the students the spirit of researching, identifying the knowledge-gaps in the specific core branches of geology, and motivating them to take up and address such geo-scientific problems in future. The programme will enable the students to understand the intricacies of various mineral, rock, and terrain forming processes resulting from spatio-temporal variations under the prevailing physico-chemical conditions. Such a knowledge will make them able to locate, explore, and judiciously utilize the Earth's resources, solving the complex geological problems, providing the geo-engineering solutions to sundry geo-environmental problems, including the hazard vulnerability, and safety and stability of civil engineering structures, as well as fill-up the knowledge-gaps pertaining to core branches of geology.

Programme specific outcomes (PSOs): for *PG II Year/ Master of Science (Geology)*

Programme Specific Prerequisites: To acquire *Master of Science*, in Geology, a studentshould have obtained three-year *Bachelor of Science* and *one year Bachelor of Science (honours)* from any recognized university. Student should have research-oriented aptitude for gaining the advanced knowledge in the subject field so that he/she can apply the gained knowledge to resolve related research and professional issues.

PSOs: Under this programme, the students will gain in-depth, advanced knowledge on corebranches of

geology, as well as newly developed branches and techniques in the subjectfield, with particular focus on the applied aspects of it.After completing this programme, the students will have wide-spectrum, in-depth knowledge in the subject of geology, covering basic principles, gradual advancements, and classical and recent concepts. The students will be able to identify, analyse, and solve different types of geological problems, to ensure developmental activities and optimum harnessing of the earth resources without adversely affecting the geo-environment or endangering the terrain stability, and to analyse the vulnerability of any terrain to various types of geo-hazards. It will also instil in them the quest for better understanding of the subject through incessant pursuance and research.

Semester VII

Discipline Specific Core (DSC): Structural Geology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Structural Geology (DSC)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	NIL

Course Title: Structural Geology (Theory)

Course Type: DSC	Total Credit: 03	Teaching Hours: 45

Course Outcome: Deformation is continuous process occurring within the rocks in different range so this course will provide a better concept regarding such processes by providing in depth information about stress and strain. It will also give a better understanding of the mechanisms responsible for the formation of different geological structures and their associated landscapes.

Units	Course Contents	Teaching Hours
Unit-I	Concept of stress and strain. Stress-strain relationships of elastic, plastic, and viscous materials. Two-dimensional strain and stress analyses. Types of strain ellipsoids; their properties and significance. Mechanical properties of rocks and their controlling factors. Theories of rock failure	12
Unit-II	Mechanics of folding and buckling. Folds geometry and classification. Superimposed folds and their interference patterns. Causes and dynamics of faults. Normal faults and strike – slip faults, thrust faults. Thin skinned deformation and decollement. Salt domes and diapers. Concept of balanced cross-sections.	11
Unit-III	Joints, rock cleavage and foliations; their origin, domain character, relationship with major structures and geological significance. Lineation and linear structures; their origin, relationship with major structures and significance.	11
Unit-IV	Brittle and ductile shear zones; their geometry, strain pattern, kinematics, products, and significance. Rotation of structural	11

	elements. Concept of Petro-fabric analysis. Use of stereographic and equal area projections forrepresenting different types of fabric.	

Course Title: Structural Geology (Lab)		
Course Type: DSC	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Structural Geology: Study of naturally deformed rocks in hand specimens, Geometrical analysis of folds and faults. Preparation and interpretation of geological maps, Applications of stereographic and equal area projections, Strain analysis using oriented thin sections.	**30**

Suggested Reading:

- Turner, F.J. and Weiss, L.E. (2012). Structural Analysis of Metamorphic Tectonites. Literary Licensing, LLC.
- Ramsay, J.G. (1967). Folding and Fracturing of Rocks. McGraw Hill.
- Davis, G.H. (1984). Structural Geology of Rocks and Region. John Wiley.
- Ramsay, J.G. and Huber, M.I. (1983and1987). Techniques of Modern Structural Geology, Vol. I & II.Academic Press.
- Price, N.J., and Cosgrove, J.W. (1990). Analysis of Geological Structures. Cambridge Univ. Press.
- Bayle, B. (1992). Mechanics in Structural Geology. Springer Verlag
- Robert, D. Hatcher (1994). Structural Geology: Principles Concepts and Problems (2nd Edition)
- Ghosh, S.K. (1995). Structural Geology: Fundamentals of Modern Development. Pergamon.
- Pollard, D.D. and Fletcher R.C. (2005). Fundamentals of Structural Geology Cambridge University Press.
- Moores, E. and Twiss, R.J. (1995). Tectonics. Freeman.
- Twiss, R.J. and Moores, E.M. (2006). Structural Geology Second Edition, W.H. Freeman.
- Passchier, C.W. and Treuw R.A.J. (2005). Microtectonics, Springr.
- Richard H. Groshong (2008).3D Structural Geology: A Practical Guide to Quantitative Surface and Subsurface Map Interpretation. Springer
- Ragan, D.M (2009). Structural Geology: An introduction to Geometrical Techniques. Cambridge, University Press.
- Fossen, H. (2010). Structural Geology, Cambridge University Press
- Lisle, R.J. (2004). Geological Structures and Maps: A Practical Guide, Third edition. Elsevier.
- Marshak, S. and Mitra, G. (1988). Basic Methods of Structural Geology, Printice Hall.
- Hobbs, B.E., Means, W.D. and Williams, P.F. (1976). An outline of Structural Geology by John Wiley and Sons. New York.
- Lisle R.J. and Leyshon, P.R (2004). Stereographic Projection Techniques for Geologists and Civil Engineers, 2nd edition, Cambridge University Press.
- Rowland, S.M., Duebendorfer, E.M. and Schiefelbein, I.M. (2007). Structural Analysisand Synthesis: A Laboratory Course in Structural Geology 3rd edition, Wiley-Blackwell.

Suggested Online Link:

- https://www.classcentral.com/course/swayam-structural-geology-14312.

Semester VIII

Discipline Specific Core (DSC): Mineralogy and Geochemistry

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Mineralogy and Geochemistry (DSC)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II with Science.

Course Title: Mineralogy and Geochemistry (Theory)

Course Type: DSC	Total Credit: 03	Teaching Hours: 45

Course Outcome: Minerals are essential constituents of rocks and hence mineral science plays a prime and vital role in the study of geology and material science. They may be valuable if occurring in the form of precious and semi-precious minerals and gemstones and are commonly used in industries and other fields. This course will provide a better understanding on natural occurrence, identification, structure, and genesis ofSilicate and non-silicate minerals, and their applications in different fields. This course is designed to understand high-T and low-T geochemical processes that operate in the earth's deeper and near-surface environments. The major taskofgeochemistsistoknowthephysicalandchemicallawsgoverningtheabundance, distribution and migration of chemical elements from one sphere to another sphere of the Earth i.e. chemical differentiation of the Earth. Dating the geological materials are utmost important for arranging the geological events in chronological order.

Units	Course Contents	Teaching Hours
Unit-I	Study of following group of minerals with reference to chemical and structuralformula,classification,atomicstructure, chemistry, physical and optical properties, occurrences: Olivine, Garnet, Pyroxene, Amphibole, Feldspars, Feldspathoids, Mica, Silica and Al silicates.	12
Unit-II	Formation of Uni-axial and Bi-axial interference figures, Interference colors, Pleochroism and determination of pleochroic scheme, Interference figures and determination of optic sign; Extinction; Uniaxial and Biaxial indicatrix and dispersion in minerals. Applicationofspectroscopictechniquesin	11

	mineralogy-Raman and Mossbauer spectroscopy, An Overview of environmental and radiation mineralogy.	
Unit-III	Chemical composition of Earth and its constituents (Crust, mantle, and core); Ionic and co-ordination number; Rules of ionic substitution, coupled substitution; Distribution coefficient: Capture admission and camouflage, Geochemical classification of elements; Behaviour of major, trace and rare earth elements during magmatic crystallization. Near-Earth surface geochemical environment: Eh-pH diagram; Principle of chemical mass balance and rock- cycle; Chemical weathering of minerals and rocks.	**11**
Unit-IV	Radiogenic isotopesingeochronologyand Petrogenesis. Stable isotopesgeochemistry. Basic concepts of common radiometric dating techniques. Rb-Sr, Sm-Nd, U-Pb isotopic system., Fission Track (FT), TL andOSL, C^{14} dating techniques.	**11**

Course Title: Mineralogy and Geochemistry (Lab)

Course Type: DSC	Total Credit: 01	Teaching Hours: 30
Sections	**Course Contents**	**Teaching Hours**
Section-A	Mineralogy and Geochemistry: Study of physical and optical properties of important rock forming minerals; Determination of An content of plagioclase feldspars; Determination of elongation and optic sign of minerals; Determination of Pleochroism and absorption schemes. Construction of geochemical variation diagrams (Spiderdiagrams; Harker's variation diagrams; addition-substraction diagrams); Calculation of stoichriometric formula from chemical analysis of minerals.	**30**

Suggested Reading:

- Battey, M.H. (1981). Mineralogy for students. Longman, London, NewYork.
- Berry, L.G.andMason, B (1959).Mineralogy:concepts,descriptions, determinations, London Publication.
- Dana, E.S. and Ford, W.E. (2002). A textbook of Mineralogy (Reprint)
- Deer, W.A., Howie, R.A., and Zussman, J. (1992). An Introduction to the rock forming minerals, Harlow, Essex, England: New York, NY: Longman Scientific & Technical
- Sharma, R.S. and Sharma, A. (2014). Crystallography and mineralogy. Graduate Textbook Series, Geological Society of India, Bangalore.
- Gribble, C.D. (2005). Rutley's elements of Mineralogy, Springer.
- Klein, C. and Hurlbut, Jr., C.S. (1993). Manual of Mineralogy, John Wiley.
- Kerr, P.F. (1977). Optical Mineralogy,4thEditionMcGraw-Hill
- Putnis, Andrew (1992). Introduction to Mineral Sciences, Cambridge University Press.
- Winchell, A.N. (1962). Elements of Optical Mineralogy, John Wiley.
- Nesse, W.D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- Allegre, C.J. and Michard, G. (1974). Introduction to Geochemistry, Reidel, Holland.
- Evans, R.C. (1964). Introduction to Crystal Chemistry, Cambridge Univ. Press.
- Faure, G. (1998). Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersy, 593p.
- Faure, G. (1986). Principles of Isotope Geology,2nd Edn., John Wiley.

- Albarde Francis (2003). Geochemistry- Introduction. Cambridge University Press.
- Misra, K.C. (2012). Introduction to Geochemistry: Principles and Applications, Wiley- Blackwell.
- Alan P. Dickins (2005). Radiogenic Isotope Geology. Cambridge University Press
- Hoefs, J. (1980). Stable Isotope Geochemistry, Springer and Verlag.
- Gunter Faure (1977). Principles of Isotope Geology by John Wiley & Sons Ltd.
- Krauskopf, K.B. (1967). Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991). Introduction to Geochemistry, Wiley Eastern.
- Rollinson, H.R. (1993). Usinggeochemicaldata: Evaluation,Presentation, Interpretation, Longman, U.K.
- Gill, R. (2015) Chemical Fundamental of Geology, Wiley Blackwell

Suggested Online Link:

- https://www.classcentral.com/course/swayam-geology-geochemistry-14083.
- https://www.classcentral.com/course/swayam-subject-geology-papercrystallography-mineralogy-17820.

Semester IX

Discipline specific Core (DSC): Geodynamics

No. of Teaching Hours (Theory): 60 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Geodynamics (DSC)	04	04	0	0	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	NIL

Course Title: Geodynamics (Theory)

Course Type: DSC	Total Credit: 04	Teaching Hours: 60

Course Outcome: This subject covers the dynamic processes of the solid earth which is responsible for large-scale tectonics and evolution of the earth through deep time. The course introduces advanced topics in Plate Tectonics that have shaped the earth, its deep interior and processes such as earthquakes, volcanoes, lithosphere and asthenosphere interaction vis-á-vis mantle dynamics; Evolution of continental-oceanic crust and orogenic belts and their relationship to continental amalgamation and fragmentation.

Units	Course Contents	Teaching Hours
Unit-I	Planetary evolution of the earth and its internal structure. Heterogeneity of the earth crust. Major tectonic features of theOceanicandContinentalcrust.Isostacyandepeirogeny.	15
Unit-II	Gravity and magnetic anomalies and heat flow patterns at Mid- Ocean ridges, deep sea trenches, continental shield areas and mountain chains. Continental drift-geological and geophysical evidence, mechanics, objections, presentstatus. Nature of plate margins.	15
Unit-III	Paleomagnetism,magnetostratigraphy,seafloor spreading, mechanics of plate motion and Plate Tectonics. Island arcs, oceanic islands, hotspots and plume tectonics. Seismic belts of the earth vis-á-vis plate movements. Concept of seismic tomography.	15
Unit-IV	Orogeny, geodynamic evolution of Indian cratons and mobile	11

	belts. Structure and origin of the Himalaya. Metallogeny in relation to plate tectonics. Neo-tectonicMovements concepts and evidence.	

Suggested Reading:

- Valdiya, K.S. (1984). Aspects of tectonics, Tata McGraw-Hill Pub. Co., NewDelhi.
- Kearey P., Klepeis, K.A. and Vine, F.J. (2009). Global Tectonics, John Wiley &Sons, Ltd., Publication. E-book available
- Valdiya, K.S. (2010). Making of India. Macmillam Publishers, India.
- Windley, B.F. (1984). Evolving Continents (2nd edition), Wiley–Blackwell publisher.
- Condie, K.C. (1976). Plate Tectonics,1st edition, Elsevier Science. E-book available.
- Condie, K. (1989) Plate Tectonics and Crustal Evolution. Pergamon Press, Oxford, 476 p.
- Cox, A. and Hart, R.B. (1986). Plate Tectonics, Blackwell Publishing.
- Moores, E. and Twiss, R.J. (1995). Tectonics, Waveland Press Freeman.
- Keary, P. and Vine, F.J. (1990). Global Tectonics- Balckwell Publishing.
- Storetvedt, K.N. (1997). Our Evolving Planet: Earth's History in New Perspective-Bergen (Norway), Alma Mater Fortag
- Valdiya, K.S. (1998). Dynamic Himalaya- Universal Press, Hyderabad 12.
- Summerfield, M.A., 2000: Geomorphology and Global Tectonics-SpringerVerlag
- Turcotte, D. Land Schubert, G. (2002). Geodyanamics, second edition., Cambridge University Press.

Suggested Online Link:

- https://www.mooc-list.com/course/planet-earth-and-you-coursera
- https://www.mooc-list.com/course/dynamic-earth-course-educators-coursera

Semester X

Discipline specific Core (DSC): Fuel Geology

No. of Teaching Hours (Theory): 60 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Fuel Geology (DSC)	04	04	0	0	Bachelor (Honours) of Science in Geology or M.Sc. Ist Year in Geology	NIL

Course Title: Fuel Geology (Theory)

Course Type: DSC	Total Credit: 04	Teaching Hours: 45

Course Outcome: This course will enable students to explore various fossil fuels including coal, petroleum and gas regarding their formation and mode of occurrence. The prospecting and exploration techniques of radioactive minerals will also help students to enhance their knowledge about nuclear energy. All these sources form base for a country's development so it will be beneficial for the students as they can contribute for its development by choosing a carrier related to fuel energy.

Units	Course Contents	Teaching Hours
Unit-I	Introduction: Sources of energy, Coal Geology: Introduction, origin and distribution of coal, Bio-chemical and dynamo-chemical changes in coal formation. Grade and Rank of coal Macroscopic and Microscopic constituents, Macerals and micro-lithotypes, Physical and chemical properties. Indian classification.	15
Unit-II	Petroleum Geology: Composition and physical properties of petroleum, Origin of Petroleum; Kerogen and their types. Migration of natural hydrocarbon. Petroleum Reservoir: source rock, reservoir rock, caprocks. Traps:Structural, stratigraphic and combination traps.	15
Unit-III	Distribution of Oil and Natural gas, and Coal in India.Coal fields and Petroliferous basins of India.	15
Unit-IV	Nuclear Fuel: Minerology, Geochemistry, mode of occurrence;	15

	Distribution of radioactive minerals in India; Radiogenic waste disposal - geological constrains. Gas-hydrates and Coal Bed Methane.	

Suggested Reading:

- Barker, C. (1996): Thermal Modeling of Petroleum Generation, Elsevier Science.
- Jahn, F., Cook, M. andGraham, M. (1998):HydrocarbonExplorationand Production, Elsevier Science.
- Makhous, M. (2000): The Formation of Hydrocarbon Deposits in North African Basins, Geological and Geochemical Conditions, Springer-Verlag.
- North, F.K. (1985): Petroleum Geology, Allen Unwin. Selley, R.C. (1998): Elements of petroleum geology, Academic Press.
- Tissot, B.P. and Welte, D.H. (1984): Petroleum formation and occurrence, Springer– Verlag.
- Chandra, D., Singh, R.M. and Singh M.P., (2000): Textbook of coal (Indian context), Tara Book Agency, Varanasi.
- Scott, A.C., (1987): Coal and coal bearing strata: Recent Advances, Blackwell Scientifics Publications.
- Isabel Suárez Ruiz John Crelling. (2008). Applied Coal Petrology: The Role of Petrology in Coal Utilization, Academic Press.
- Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert P., (1998). Organic Petrology, GebruderBorntraeger, Stuttgart.
- Singh, M.P. (1998). Coal and organic Petrology. Hindustan Publishing Corporation, NewDelhi.
- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmulle, R. (1982). Stach Textbook of Coal petrology. GebruderBorntraeger, Stuttgart.
- Holson, G.D. and Tiratso, E.N. (1985). Introduction to Petroleum Geology. Gulf Publishing, Houston, Texas.
- Tissot, B.P. and Welte, D.H. (1984). Petroleum Formation and Occurrence, Springer–Verlalg.
- North, F.K. (1985). Petroleum Geology. Allen Unwin.
- Selley, R.C. (1998). Elements of Petroleum Geology. Academic press.
- Durrance, E.M. (1986). Radioactivity in Geology-principles and application. Ellis Hoorwool.
- Dahlkamp, F.J. (1993). Uranium Ore Deposits. Springer Verlag.
- Boyle, R.W. (1982). Geochemical prospecting for Thorium and Uranium deposits, Elsevier.

Suggested Online Link:

- https://www.my-mooc.com/en/mooc/geoscience-earth-its-resources-delftx-geo101x/.
- https://www.mooc-list.com/course/oil-gas-industry-operations-and-markets-coursera
- https://www.classcentral.com/course/swayam-petrology-14084
- E-pathshala.https://epgp.inflibnet.ac.in/

Semester VII

Generic Elective (GE): Igneous Petrology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Igneous Petrology (GE)	04	03	0	01	Bachelor of Science with Geology as a Core subject	X+II with Science.

Course Title: Igneous Petrology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will provide in-depth knowledge about the origin and evolution of igneous rocks in diverse tectonic environments through a number of major and subsidiary magmatic processes. The petrogenesis of igneous rocks can be very well demonstrated in the light of modern phase equilibria experimental works. Igneous rocks, also called primary rocks, are most abundant and were formed throughout the Earth's evolutionary history that essentially make up the continents as a stable platform to live on it. Students will come to know about the igneous processes and world class examples of igneous provinces, complexes, and suites of India.

Units	Course Contents	Teaching Hours
Unit-I	Magma generation in the mantle, their nature and evolution; Magmatic processes: Partial melting, fractional crystallization, magma mixing, assimilation, liquidimmiscibility, and other subsidiary processes.	12
Unit-II	Petrography and genetic interpretation of igneous textures in terms of rate of nucleation and crystal growth; IUGS classification schemes and nomenclature of igneous rocks: Ultramafic, mafic and felsic igneous rocks; total-alkali-Silica (TAS) classification of volcanic igneous rocks.	11
Unit-III	Study of phase equilibria in binary (Diopside-Anorthite, Forsterite-Silica, Nepheline-Silica, Forsterite-Fayalite; Albite-Anorthite; Orthoclase-Albite) and ternary (Diopside- Nepheline-Silica, Diopside-Albite-Anorthite, Anorthite- Forsterite-Silica; Fayalite-Leucite-Silica, Orthoclase-Albite- Silica) silicate systems in the light of modern experimental works.	11

Unit-IV	Petrogenesis and tectonic setting of major igneous rock types and suites: Ultramafic rocks, komatiite, lamprophyres, kimberlite, ophiolite, flood basalt, anorthosite, Tonalite-Trondhjemite-Granodiorite (TTG), granitoids, alkaline rocks and carbonatites with special reference to Indianexamples.	**11**

Course Title: Igneous Petrology (Lab)

Course Type: GE	Total Credit: 01	Teaching Hours: 30
Sections	**Course Contents**	**Teaching Hours**
Section-A	Igneous Petrology: Megascopic and microscopic studies of major igneous rock types. CIPW normative mineral calculation. Introduction to software: Sinclass, GCDkit, MELT, R-Crust.	**30**

Suggested Reading:

- Phillpotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
- Best, M.G. (2003). Igneous and Metamorphic Petrology,2nd Edition, Blackwell.
- Bose, M.K. (1997). Igneous Petrology, World Press, Kolkata.
- Cox, K.G., Bell, J.D. and Pankhurst, R.J. (1979). Interpretation of Igneous Rocks, Unwin Hyman, London
- Frost, B.R. and Frost, C.D. (2014). Essentials of Igneous and Metamorphic Petrology, Cambridge University Press
- McBirney, A.R. (1993). Igneous petrology. Jones & Bartlet Publication.
- LeMaitre, R.W. (2002). Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
- Wilson, M. (1993). Igneous Petrogenesis, Chapman and Hall, London.
- Kumar, S, and Singh, R.N. (2014). Modelling of Magmatic and Allied Processes. Springer, Switzerland.
- Powell, R. (1978). Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.
- Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
- Wood, B.J. and Fraser, D.G. (1976). Elementary Thermodynamics for Geologists, Oxford University Press, London.
- Gill, R. (2015). Chemical Fundamental of Geology, Wiley Blackwell
- Hibbard, M.J. (1995). Petrography to petrogenesis. MacMillan USA

Suggested Online Link:

- https://www.classcentral.com/course/swayam-petrology-14084.
- E-pathshala.https://epgp.inflibnet.ac.in/

Generic Elective (GE):
Metamorphic Petrology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Metamorphic Petrology (GE)	04	03	0	01	Bachelor of Science with Geology as a Core subject	X+II With Science.

Course Title: Metamorphic Petrology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will allow students to gain in- depth knowledge about the origin of metamorphic rocks from different protoliths. The identification of structures, textures and mineral assemblages provide information on involved reactions under different pressures and temperature regimes, and its implication on understanding the metamorphic evolutionary history and geodynamics of mobile belts thorough time. Some noted Indianexamples will be demonstrated.

Units	Course Contents	Teaching Hours
Unit-I	Mineralogical Phase rule of open and closed systems; Types of metamorphism; Textures of regional and contact metamorphic rocks; Deformation and metamorphism; Nature and types of metamorphic reactions; Concept and classification of metamorphic facies; Facies series; Graphical representation of minerals in ACF, AKF, AFM and A'F'M' diagrams; Time relation between phases of Deformation and metamorphic crystallization.	12
Unit-II	Description of each facies of low pressure, medium to high pressure and very high pressure with special reference to characteristics minerals, subdivisions into zones / sub- facies, mineral assemblages, metamorphic reactions and pressure temperature conditions of metamorphism. Introduction to Ultra-high temperature and Ultra-high-pressure metamorphism. Metamorphism of shale, mafic and calcareous rocks.	11
Unit-III	Isograds and Reaction Isograds; Schreinmakers rule and	11

	construction of Petrogenetic grids; Metamorphic differentiation; Anatexis and origin of migmatites; Paired metamorphic belts	
Unit-IV	Gibb's free energy; Entropy; Enthalpy; Clausius- Clapeyron equation;Geothermobarometry; Pressure-Temperature-Time (P-T-t) paths.	**11**

Course Title: Metamorphic Petrology (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Metamorphic Petrology: Study of metamorphic rocks of different metamorphic facies in hand specimens. Calculation of ACF, AKF, AFM and A'F'M values from the given chemical data / structural formula of minerals and their graphical representation. Study of metamorphic rocks in thin sections with reference to texture/structure, time relation between phases of deformation and metamorphic crystallization, mineral association, parent rock, metamorphic facies/subfacies/ zones to which rock can be assigned and representation of assemblage in ACF, AKF, AFM and A'F'M' diagrams. Estimation of pressure and temperature from important models of Geothermobarometry.	**30**

Suggested Reading:

- Turner, F.J. (1980). Metamorphic Petrology, McGraw Hill, NewYork.
- Yardlley, B.W.D. (1989). An introduction to Metamorphic Petrology, Longman Scientificand Technical, New York.
- Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995). Atlas of Metamorphic Rocks and their textures, Longman Scientific & Technical, England.
- Philopotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Kretz, R. (1994). Metamorphic Crystallization, John Wiley.
- Bucher, K. and Frey, M. (2002). Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag.
- Powell, R. (1978). Equilibrium thermodynamics in Petrology: An Introduction,Harper and Row Publ., London.
- Wood, B.J. and Fraser, D.G. (1976). Elementary Thermodynamics for Geologists, OxfordUniversity Press.
- Rastogy, R.P. and Mishra, R.R.1993: An Introduction to Chemical Thermodynamics, Vikash Publishing House.
- Spry, A. (1976). Metamorphic Textures, Pergamon Press.
- Sharma, R.S. (2016). Metamorphic Petrology: Concepts and Methods, Geological Society of India
- Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
- Winkler, H.G.F. (2013). Petrogenesis of Metamorphic rocks, Springer New York, eBook.
- Barker, A.J. (1998). Introduction to Metamorphic textures and Micro-textures,
- Miyashiro, A. (1994). Metamorphic Petrology, Taylor &Francis.

Suggested Online Link:

- https://www.classcentral.com/course/swayam-petrology-14084
- https://www.classcentral.com/course/swayam-geology-metamorphic-petrology-thermodynamics-22994

Generic Elective (GE):
Sedimentology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Sedimentology (GE)	04	03	0	01	Bachelor of Science with Geology as a Core subject	X+II with Science.

Course Title: Sedimentology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: The course in-depth knowledge about the types and origin of sedimentary rocks, and source-to-sink sedimentary processes. It emphasizes upon the modern concepts of paleoenvironmental analysis, as well as provenance determination of sedimentary rocks. The course content deals with all the essential aspects required in exploring oil and natural gas, underground water, mechanically concentrated mineral deposits (placerdeposits), and building stones.

Units	Course Contents	Teaching Hours
Unit-I	Sedimentary texture, textural parameters and their significance. Textural and compositional maturity. Fluid flow concepts, sediment transport, bedforms and sedimentary structures. Allogenic and autogenic controls on sedimentation.	12
Unit-II	Types and petrogenesis of conglomerates, sandstones, and argillites. Problem of greywacke. Plate tectonics and sandstone composition.	11
Unit-III	Classification and genesis of limestones and dolomites. Evaporites: Gypsum andanhydrite.	11
Unit-IV	Digenesis–Physical and chemical processes. Diagenetic stages and regimes Evidence of diagenesis in sandstones, mudrocks and carbonate rocks. Provenance of sedimentary rocks. Provenance reconstruction of sandstones through petrographic, petrofacies, and heavy mineral analyses.	11

Course Title: Sedimentology (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Sedimentology: Detailed study of clastic and non-clastic rocks in hand specimen. Study of sedimentary structures hand specimen inform-process context. Petrography of important rock types with emphasis on depositional setting, provenance and diagenesis.	**30**

Suggested Reading:

- Blatt, H., Middleton, G.V. and Murray, R.C. (1980). Origin of sedimentary rocks. Prentice Hall Inc.
- Collins, J.D. and Thompson, D.B. (1982). Sedimentary structures. George Allen and Unwin, London.
- Lindholm, R.C. (1987). A practical approach to sedimentology. Allen and Unwin, London.
- Miall, A.D. (2000). Principles of basin analysis, Springer-Verlag.
- Pettijohn, F.J. (1975). Sedimentary rocks (3rd Ed), Harper and Row Publ., NewDelhi.
- Reading, H.G. (1997). Sedimentary environments and facies, Blackwell Scientific Publication.
- Reineck, H.E. and Singh, I.B. (1973). Depositional sedimentary Environments, Springer-Verlag.
- Selley, R.C. (2000). Applied Sedimentology, Academic Press.
- Tucker, M.E. (1981). Sedimentary Petrology: An introduction. Wiley and sons, New York.
- Tucker, M.E. (1990). Carbonate Sedimentology, Blackwell Scientific Publication.

Suggested Online Link:

- https://www.classcentral.com/course/youtube-earth-120-sedimentology-stratigraphy-90982
- https://ocw.mit.edu/courses/12-110-sedimentary-geology-fall-2004/
- https://www.classcentral.com/course/youtube-the-weird-and-wonderful-world-of-sedimentology-137502

Semester VIII

Generic Elective (GE):
Economic Geology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Economic Geology (GE)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II with Science.

Course Title: Economic Geology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: The course is intended to impart basic knowledge about the occurrence and distribution of metallic and non-metallic ores and energy resources in India, and to understand ore-forming processes.

Units	Course Contents	Teaching Hours
Unit-I	Geological setting, characteristics, and genesis of ferrous, base and noble metals. Geological controls and localization of ore deposits, metallogenic provinces, and metallogenic epochs.	**12**
Unit-II	Geochemical behaviour of elements in ore geological systems. Laboratory analysis of common metallic minerals including ore microscopy, fluid inclusions and isotopic systematics.	**11**
Unit-III	Origin, migration, and entrapment of petroleum. Properties of source and reservoir rocks. Structural, stratigraphic and combination traps. Petroliferous basins of India.	**11**
Unit-IV	Origin of coal deposits. Classification, rank and grading of coal. Coal resources of India. Gas hydrates, coal bed methane and nuclear resources. Mineral resources in the Himalaya.	**11**

Course Title: Economic Geology (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Economic Geology:Study of ores in hand specimen. Geographical distribution of classic ore deposits of India and world. Study of metallic minerals under the reflecting microscope.	**30**

Suggested Reading:

- Craig, J.M. & Vaughan, D.J., 1981: Ore Petrography and Mineralogy-John willey
- Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
- Sawkins, F.J., 1984: Metal deposits in relation to plate tectonics-Springer Verlag
- Stanton, R.L., 1972: Ore Petrography-McGraw Hill
- Torling, D.H., 1981: Economic Geology and Geotectonics-blackwell Sci publ.
- Barnes, H.L., 1979: Geochemistry of Hydrothermal Ore Deposits-John Wiley
- Klemm, D.D. and Schneider, H.J., 1977: Time and Strata Bound Ore Deposits-Springer Verilog
- Guibert, J.M. and Park, Jr. C.F., 1986: The Geology of Ore Deposits-FreemanMookherjee, A., 2000: Ore genesis-a Holistic Approach-Allied Publisher

Suggested Online Link:

- https://www.mooc-list.com/course/minerals-and-mining-business-edx
- https://www.classcentral.com/course/swayam-drilling-and-blasting-technology-58442
- https://www.classcentral.com/course/swayam-underground-mining-ofmetalliferous-deposits-43673

Generic Elective (GE): Paleontology

No. of Teaching Hours (Theory): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Paleontology (GE)	04	03	0	01	Bachelor of Science with Geology as a Core subject	X+II with Science.

Course Title: Paleontology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course intends to acquaint the students with the origin and evolution of life through geological time and the major evolutionary breakthroughs, and to correlate evolutionary history with other synchronous geological events. It would add to their knowledge regarding the basic concept of paleontology using mode and methods of fossil preservation and species identification, thereafter, suggesting the organic evolutionary path and paleo-environment. Also, they will know the causes of major events of mass extinctions in geological past including the glaciations periods.

Units	Course Contents	Teaching Hours
Unit-I	Theories of the origin of life. Organic evolution: Micro- and macro-evolution, types of heterochrony in evolutionary lineages, application to biochronology with Indian examples. Punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Ichnology, classification, and use.	12
Unit-II	Palaeobiology (palaeoecology, communities, modern environments, functional morphology and taphonomy). Distribution, migration, and dispersal of organisms applied to palaeobiogeography and plate-tectonics with Indian examples.	11
Unit-III	Brief morphology, evolution, and classification of Cnidarians, Brachiopoda, Mollusca (Cephalopoda, Gastropoda, Bivalvia), Trilobita.	11
Unit-IV	Introduction to palaeobotany. Important lower and upper Gondwana plant fossils. Evolution of vertebrates: elephant, horse, man, and dinosaurs. A brief idea of Siwalik vertebrate fauna.	11

Course Title: Paleontology (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Palaeontology:Systematic description of Brachiopoda, Bivalvia, Cephalopoda and Gastropoda; vertebrates and Plant Fossils.	**30**

Suggested Reading:

- Raup and Stanley, Principles of Palaeontology,
- Bilal U. Haq and A. Boersome , Introduction to Marine Micropalaeontology,
- G. Bignot , Elements of Micropalaeontology,
- Clarkson, E.N.K. (1986). Invertebrate Palaeontology and Evolution. ELBS, London.
- Cushman, J.A. (1940). The Formanifera, their classification and use. Harvard Univ. Press.
- Moore, R.C. Lalliker, C.G. and Fischer, A.G. (1952). Textbook of Invertebrate Palaeontology.
- David Raup and Stanley (1985). Principles of Palaeontology., CBS Pub., Delhi
- Glaessner, M.F. (1945). Principles of Micropaleontology. Melbourne Univ. Press.
- Schrock, Twenhofel and Williams (1953). Principles of Invertebrate Palaeontology. CBS, Delhi

Suggested Online Link:

- https://www.futurelearn.com/courses/extinctions-past-present/19/steps/1312906.

Generic Elective (GE):
Basin Analysis and SequenceStratigraphy/Glacial Geology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Basin Analysis and Sequence Stratigraphy (GE)/ Glacial Geology (GE)	04	03	0	01	Bachelor of Science with Geology as a Core subject	X+II with Science.

Course Title: Basin Analysis and Sequence Stratigraphy (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will provide in-depth knowledge about the basin development including the involved source to sink processes, rock exhumation, erosion and sediment transport to the sedimentary basins. Students will also understand about the effects of controls of lithology, tectonics and climate, as well as base level change on the basin's depositional environments. They will also gain thorough knowledge of sequence stratigraphic analysis and its role in the reconstruction and correlation of environments via lateral as well as vertical facies change patterns. It also emphasizes upon the modern concepts of paleoenvironmental analysis, as well as provenance determination of sedimentary rocks.

Units	Course Contents	Teaching Hours
Unit-I	Tectonic classification of sedimentary basins. Sedimentation pattern and depositional environments of selected undeformed sedimentary basins of India: Vindhyan, Lesser Himalayan sedimentary basins, Gondwana, Siwalik Foreland basin.	12
Unit-II	Walthers law and sedimentary environments. Concept of sedimentary facies, facies associations, and facies model and basin analysis. Characteristics, processes, and facies of modern and ancient continental clastic depositional sedimentary environments: alluvial, fluvial, lacustrine, aeolian and glacial deposits, and transitional and marine sedimentary facies models: deltaic, estuarine, tidal flat, lagoonal, barrier beach islands, terrigenous shelves, shallow seas and deep-sea sedimentary environments.	11
Unit-III	Sedimentary cycles, rhythmites and cyclothems. Concept of sequence Stratigraphy. Evolution, order and duration of sequences. Applications and significance of sequence Stratigraphy.	11

Unit-IV	Palaeocurrent analysis and its significance. Types of palaeocurrent indicators. Sediment dispersal pattern. Controls on provenance and techniques for provenance determination: petrography, heavy mineral analysis and geochemistry.	**11**

Course Title: Basin Analysis and Sequence Stratigraphy (Lab)

Course Type: GE	Total Credit: 01	Teaching Hours: 30
Sections	**Course Contents**	**Teaching Hours**
Section-A	Basin analysis and Sequence Stratigraphy: Prepration of lithologs, Interpretation and reading depositional environments from the given idealized lithologs and data. Heavy mineral identification and provenance interpretation. Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks. Study of important facies models.	**30**

Suggested Reading:

- Reading H. G. 1996: Sedimentary Environments and Facies, Balckwell
- Reading H.E. and Singh, I.B. 1980: Depositional Sedimentary Environments, Springers Verlag
- Boggs Sam Jr, 1995. Principles of Sedimentary and Stratigraphy, Prentice Hall
- Selley R.C.,1998. Applied Sedimentology, Academic Press
- Miall, A.D. 2000: Principles of Sedimentary Basin Analysis, Springer Verlag
- Eirsele, G. 1992: Sedimentary Basins, Springers Verlag.
- Bhattacharya A and Chakraborti, C .2000. Analysis of Sedimentary Successions, Oxford and IBH

Suggested Online Link:

- https://www.classcentral.com/course/youtube-earth-120-sedimentology-stratigraphy-90982
- https://ocw.mit.edu/courses/12-110-sedimentary-geology-fall-2004/
- https://www.classcentral.com/course/youtube-the-weird-and-wonderful-world-of-sedimentology-137502
- http://www.sepmstrata.org/Page.aspx?pageid=1

Course Title: Glacial Geology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45
Course Outcome: This course will provide in-depth knowledge about glaciers, their fundamental types, characteristics and in-depth information about climatic change. After completing this course, students will understand past and present-day climate changes as glaciers are the major focus of climate change study. Their behavior and geomorphology will provide detailed information to predict future changes. Glaciology or glacial geology also enables students to opt for the regime of polar research as these are the key areas of polar research.		
Units	**Course Contents**	**Teaching Hours**
Unit-I	Cryosphere: Ice sheets, valley glaciers, formation of glaciers; Characteristics of glacial ice; climate and glaciers; Implication of Glacial geology; Techniques in Glacial geology.	**10**

Unit-II	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.	**11**
Unit-III	Periglacial concept: climate, soils, vegetation cover; Periglacial processes: weathering, ground freezing and thawing; Permafrost: characteristics, distribution and type; slope movement, movement and hillslope evolution.	**11**
Unit-IV	Clast characteristics: shape-form, roundness and texture, size, macro fabrics; sediment sampling and analysis; glacial fluvial, glacio-lacustrine and glacio-marine sediments. Climate change and glaciations; Glaciation during the earth's history, Quaternary Glaciations: Last Glacial Maximum, Little Ice Age.	**13**

Course Title: Glacial Geology (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	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	**30**

Suggested Reading:

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

Suggested Online Link:

- https://www.antarcticglaciers.org/glacial-geology

Semester IX

Generic Elective (GE):
Remote Sensing and GIS

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Remote Sensing and GIS (GE)	04	03	0	01	Bachelor (Honours) of Science in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Remote Sensing and GIS (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course pertains to recent technologies of Remote Sensing and Geographical Information System (GIS). The course introduces various types of remote sensing data in different ranges of the electromagnetic spectrum, and the basic concepts and potential of GIS in geological investigations. It develops skills in students for interpreting visual and digital remote sensing image from different spectral bands and use them to understand the various physical processes operating on earth's surface through integration of other sources' data in a GIS.

Units	Course Contents	Teaching Hours
Unit-I	Atmospheric scattering and absorption; Concepts of Optical, NIR, SWIR, TIR and RADAR remote sensing; Satellite and Aerial remote sensing platforms; SpectralReflectance curves of soil, water and vegetation.	12
Unit-II	Types and characteristics of sensors. Concepts of mono- band, multispectral and hyperspectral remote sensing. Basics of optical, thermal and microwave remote sensing.Basic concept of LiDAR. Characteristics of IRS sensors.	11
Unit-III	The structure of Digital Image. Conceptual aspects ofDigital Image Processing. Basic processes of imagerectification, enhancement, and classification. Definition andcomponents of Geographic Information System (GIS). Raster and vector data	11

	formats. Basic knowledge about dataacquisition, manipulation, analyses, and representation in GIS.	
Unit-IV	Application of remote sensing and GIS in geomorphological investigations, tectonic investigations, lithological mapping, groundwater exploration, mineral exploration, Oil & Gas exploration and geohazardmanagement.	**11**

Course Title: Remote Sensing and GIS (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Remote Sensing & GIS: Determination of the scale of aerial photographs and imageries. Visual interpretation of aerial photographs and imageries for geomorphological, lithological, tectonic and geological mapping.	**30**

Suggested Reading:

- Lillesand, T.M., Kiefer, R.W. and Chapman, J. (2015): Remote Sensing and Image Interpretation, 7th Edition. Wiley
- Gupta, R.P. (2003). Remote Sensing Geology. 2nd Edition. Springer
- Drury, S.A. (1993). Image Interpretation in Geology. 2nd Edition. Chapman &Hall
- Jensen, J.R. (2000). Remote Sensing of the Environment, An earth Resource Perspective. Pearson Education.
- DeMers M.N. (2008). Fundamentals of geographic Information System. 4th Edition. Wiley
- Richards, J.A. and Jia, X. (2006). Remote Sensing Digital Image Analysis: An Introduction. 4th Edition, Springer
- George Joseph (2005). Fundamentals of Remote Sensing 2nd edition: Universities Press
- Gopi, S, Sathikumar, R and Madhu, N (2006). Advanced Surveying total station GIS and Remote Sensing, Pearson Education
- Sabins, F.F. (2007). Remote Sensing Principles and Interpretations 3rd Edition, Waveland Pr Inc.
- Lilles T.M., Kiefer, R.W. and Chipman, J. (2008). Remote Sensing and Image Interpretation. 6th Edition, John Willey, and Sons.
- Bhatia, S.C. (2008). Fundamentals of Remote Sensing Atlantic Publications.
- Bhatta, B. (2011). Remote Sensing and GIS2nd Edition, Oxford University Press
- Sabins, F.F. (2012). Remote Sensing Principles and Practice 3rd Edition, Levant Books
- Jensen, JR. (2013). Remote Sensing of the Environment: An Earth Resource Perspective 2nd Edition, Pearson India.

Suggested Online Link:

- https://www.classcentral.com/course/swayam-photogeology-remote-sensing-45165.

Generic Elective (GE): Hydrogeology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Hydrogeology (GE)	04	03	0	01	Bachelor (Honours) of Science in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Hydrogeology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course has a direct relationship to society as it provides a deep information regarding the most important factor required for a life to sustain i.e water. Groundwater is the purest form of water that can be yielded from rocks. It provides a better knowledge about its origin, prospecting, and extraction. It explains the lawsGoverning groundwater flow and various methods of groundwater exploration.

Units	Course Contents	Teaching Hours
Unit-I	Groundwater origin, type and occurrences, Renewable and Non-renewable groundwater resources. Hydrological Cycle. Sub Surface movement and Concept of depth to water level and waterTable contour map. Water table and piezometric surface. Aquifers and their type. Water bearing properties of rocks and aquifer parameters: porosity, permeability, specific yield, specific retention, Hydraulic conductivity, transmissivity, intrinsic permeability, Storage coefficient, storativity, specific storage. Darcy Law, range, and its validation.Introduction to hydrogeology of India, and the groundwater provinces of India.	12
Unit-II	Theory of groundwater flow, numerical solutions for steady state linear groundwater flow in confined and unconfined aquifers and Dupuit's assumption for unconfined flow. Numerical solutions for steady state radial flow to a well in confined (Thiem's equation) and unconfined aquifers (Dupuit's equation). Numerical solutions for unsteady state groundwater flow condition. Evaluation of aquifer parameters of confined Aquifer using Theis and Jacob methods.	11

Unit-III	Quality of Groundwater: Chemical characteristics of groundwater in relation to various uses- domestic, irrigation and industrial purposes. Groundwater contamination and pollution from natural (geogenic) and anthropogenic sources. Graphical presentation of water quality data. Saline water intrusion in aquifer sand its prevention. Groundwater quality in different provinces of India.	**11**
Unit-IV	Brief idea about geological and geophysical methods of groundwaterexploration. Seismic and Resistivity Method. Concept of geophysical Logging and Electric Logging method. Geologicandgeomorphiccontrolson groundwater.	**11**

Course Title: Hydrogeology (Lab)

Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Preparation of ground water flow directions, Estimation of aquifer parameters using different mathematical equations, plotting groundwater quality properties (Hill & piper diagram, Durov plot and SAR plotting), Plot hydrological provinces in India.	**30**

Suggested Reading:

- Todd, D.K. (1980). Groundwater Hydrology- JohnWiley.
- Davis, S.N. and DeWiest, R.J.M. (1966). Hydrogeology-John Wiley.
- Freeze, R.A. and Cherry, J.A. (1979). GroundWater- Prentice Hall.
- Fetter, C.W. (1990). Applied Hydrogeology- MerillPublishing.

Suggested Online Link:

- https://www.classcentral.com/subject/hydrology
- https://www.classcentral.com/course/swayam-engineering-hydrology-58453

Generic Elective (GE): Micropaleontology and Oceanography

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Micropaleontology and Oceanography (GE)	04	03	0	01	Bachelor (Honours) of Science in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Micropaleontology and Oceanography (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will enable students to develop skills regarding modern techniques and methods employed in micropalaeontology and marine life. It will provide idea about the different Ocean Drilling Programs. The students will gain an advanced knowledge on applications of microfossils and will be able to interpret atmospheric and oceanic circulation systems so as to analyze their driving forces. This all will also help them to evaluate a relationship between ocean chemistry and climate change.

Units	Course Contents	Teaching Hours
Unit-I	Definition and scope of the subject; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry); Concepts of micro paleontological indicators useful in understanding geological evolution, environmental changes and biostratigraphic correlation.	12
Unit-II	Morphology, geological distribution, evolution, significance and applications of organic-walled microfossils (acritarchs, dinoflagellates, spores and pollens) and inorganic walled microfossils (Foraminifers, Ostracoda, Calcareous Nannofossils, Radiolaria, Diatoms, silicoflagellates and Conodonts). Application of Micropaleontology in hydrocarbon exploration, paleoceanography, paleoclimatologyand tracing history of marine pollution. Interpretation of seafloor	11

	tectonism from micro-paleontological evidence.	
Unit-III	History and development of Oceanography. Methods of measuring properties of seawater (horizontal and vertical distribution of temperature, salinity, dissolved gases in sea water; density stratification in oceans). Depositional processes and distribution of Calcareous oozes, silicious oozes, and pelagic sediments in oceans. Ocean drilling Programmes (DSDP, ODP, IODP) and its major accomplishments.	**11**
Unit-IV	Ocean circulation, surface circulation and concept of mixed layers. Coriolis force and Ekman spiral Thermocline and Pycnocline, concept of upwelling and downwelling of ocean water. El Nino, La Nina. Deep Ocean circulation. Formation of bottom water, water masses of the world ocean and sea sediments.	**11**

Course Title: Micropaleontology and Oceanography (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30 Hours**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Micropaleontology and Oceanography: Surface and Deep Ocean circulation, Upwelling, Indian Monsoon circulation. Techniques of separation of microfossil from the matrix. Study of representative genera of microfossils, Preparation of bio-zonation charts.	**30**

Suggested Reading:

- Garrisson T and Ellis, R. (2016). Oceaanography: An invitation to marine Science. National Geographic Learning.
- Trujillo, A.P and Thurman, H.V. (2011). Essentials of Oceanography. Prentice Hall (10^{th} edition)
- Armstrong, and Brasier, M. (2005). Microfossils. Blackwell Publishing (2^{nd}edition)
- Saraswati, P.K. and Srinivasan, M.S. (2016). Micropaleontology: Principles and Applications, Springer.
- Arnold (2002). Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford
- Haq B.U. and Boersma, A. (1998). Introduction to Marine Micropaleontology, Elsvier.
- Pinet, P.R. (1992): Oceanography: An introduction to the Planet Oceanus, West Pub, Co
- Bignot, G., GrahmandTrottman (1985). Elements of Micropaleontoogy, London.
- David Tolmazin (1985). Elements of Dyanamic Oceanography, Allen and Unwin
- Grant Gross, M. (1977). Oceanography; A view of the Earth, Prentice Hall.
- John Houghton (1997). Global Warming, Cambridge Univ. Press.
- Jones, T.P. and Rowe, T.P. (1999). Fossil plants and spores, Modern Techniques, Geological Soc. Of London.

Suggested Online Link:

- https://www.classcentral.com/tag/palaeontology
- https://www.coursera.org/courses?query=paleontology
- https://www.classcentral.com/subject/oceanography
- https://www.coursera.org/learn/oceanography

Semester X

Generic Elective (GE):
Tectonic Geomorphology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Tectonic Geomorphology (GE)	04	03	0	01	Bachelor (Honours) of Science in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Tectonic Geomorphology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course pertains to studying the active terrain deformation in response to activities on structural discontinuities of the earth, and/or climatic fluctuations, and/or isostatic adjustments of the earth. The course will enable the students to identify active tectonic structures of an area and measure the extent of activities of them based on their geomorphic signature. Knowledge on such aspects of an area is quite useful in analyzing the hazard proneness and vulnerability of any area, as well as assessing the safety of any geo-Engineering project therein.

Units	Course Contents	Teaching Hours
Unit-I	Definition and scope of tectonic geomorphology. Landscape evolution. Davis', Penck's, and Hack's models of landscape evolution. Modern concepts of landscape evolution. Concept of Form-Process relationship inLandscape evolution.	12
Unit-II	Geomorphic Markers of active tectonics: Planar and Linear. Landforms of active strike-slip faults, normal faults, reverse faults, and folds. River response to active tectonics. Sudden (coseismic) versus gradual modifications in river systems. Tectonic modifications of alluvial and bedrock-channel e drivers: longitudinal profiles, river pattern, sinuosity, drainage patterns and drainage anomalies.Effects of base level.	11
Unit-III	Geomorphic Indices of active tectonics – Morphometric analysis: mountain-front sinuosity, hypsometric curve and hypsometric integral, stream- length gradient index, and valley-	11

	floor width to valley height ratio, basin elongationratio, basin shape, relief ratio, drainage basin asymmetry factor, transverse topography symmetry factor.	
Unit-IV	Introduction to geodesy. Fundamentals of ground- based and space geodetic techniques of measuring active tectonic deformations: Alignment arrays, Trilateration nets, Dry-tilt nets, electronic distance measurement (EDM) systems, very long beam interferometry (VLBI), Radar Interferometry, and Global PositioningSystem (GPS).	**11**

Course Title: Tectonic Geomorphology (Lab)

Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Tectonic Geomorphology: Exercises on mapping ofTectonic geomorphological features and computation ofgeomorphic indices, using map and remote sensing data.	**30**

Suggested Reading:

- Burbank, D.W. and Anderson, R.S. (2011). Tectonic Geomorphology 2nd Edition. Blackwell Science.
- Burbank, D.W. and Anderson, R.S. (2001). Tectonic Geomorphology 1st Edition. Blackwell Science.
- Keller, E.A. and Pinter, N. (1996). Active tectonics: Earthquakes, Uplift, and Landscape. Prentice Hall
- Bull, William. (2009). Tectonically active landscapes. Wiley-Blackwell
- Schumm, S.A, Dumont, J.F. and Holbrook, J.M. (2000). Active tectonics and alluvial rivers. Cambridge University Press.
- Bull, W. (2007). Tectonic Geomorphology of Mountains: A new approach to palaeo-seismology. Blackwell Publishing.
- Small, R.J. (1978). Study of Landforms: A Textbook of geomorphology (2ndEdition), Cambridge University Press.
- Halis, J.R. (1983). Applied Geomorphology.
- Sharma, H.S. (1990). Indian Geomorphology. Concept Publishing Co. NewDelhi.
- Thornbury, W.D. (2004). Principles of Geomorphology. 2nd edition CBS Publication.
- Kale, V.S. and Avijit Gupta (2010). Introduction to geomorphology. University Press
- Bloom, A.L. (2011). Geomorphology: A systematic analysis of Late Cenozoic Landforms 3rd Edition. Rawat Publications.
- Condie, Kent. C. (1989). Plate Tectonics and Crustal Evolution.3rd Edition. Butterworth-Heinemann Ltd.
- Windlley, B. (1995). The Evolving Continents. 3rd Edition Wiley-Blackwell.
- Davies, G.F. (1999). Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
- Keller, E.A and Pinter, N (2001). Active Tectonics. 2nd Edition. Pearson Publications.
- Kearey, P., Klepeis, KA and Vine, F. J (2009). Global Tectonics3rd Edition. Wiley- Blackwell.
- Burbank, D.W. and Anderson, R.S. (2016). Tectonic Geomorphology. Wiley India.

Suggested Online Link:

- https://www.classcentral.com/course/swayam-geomorphology-17628
- https://alison.com/course/advanced-diploma-in-geomorphology#google_vignette
- https://onlinecourses.nptel.ac.in/noc20_ce28/preview

Generic Elective (GE):
Engineering Geology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Lab		
Engineering Geology (GE)	04	03	0	01	Bachelor (Honours) of Science in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Engineering Geology (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

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

Units	Course Contents	Teaching Hours
Unit-I	Introduction to Engineering geology, geo-technical engineering, and geo-technics. Role of geology in major engineering projects. Concept of Detailed Project Report (DPR) and Environmental Impact Analysis (EIA). Engineering properties of rocks and soils, field, and laboratory techniques for their determination.	12
Unit-II	Geological consideration for evaluation of Dams and reservoir sites. Reservoir induced seismicity. Dam foundation rock problems. Grouting and Rock bolting. Problem of piping in reservoir areas.	11
Unit-III	Geological evaluation of tunnel alignment. Bridges, their types and causes of their failure. Building, their types and influence of geological conditions on foundation. Concept, mechanism, and significance of Rock Mass Rating (RMR), Rock Quality Designation (RQD), Geological Strength Index (GSI), and Tunnelling Quality	11

	index (Q) and its application on tunnel design.	
Unit-IV	Mass movement with emphasis on landslides. Causes of hill slope instability and preventive measure. Rock Mass Classification system for assessing the stability condition of slopes. Indian case studies related to major civil engineering projects.	**11**

Course Title: Engineering Geology (Lab)

Course Type: GE	Total Credit: 01	Teaching Hours: 30
Sections	**Course Contents**	**Teaching Hours**
Section-A	Engineering Geology:Study of engineering geological maps, preparation of cross sections and description of the terrain. Stress distribution in rocks and soils. Shear strength, angle of repose and utility of Mohr's circle, Problems related to hill slope instability and interpretation of geological maps for landslide problems	**30**

Suggested Reading:

- Sharma P.V., Environmental and Engineering Geophysics
- Krynine D.P. and Judd W.R., Principles of Engineering Geology and Geotechniques
- Bell F.G., Fundamental of Engineering Geology
- Jeger C., Rock Mechanics and Engineering
- Valdiya K.S., Environmental Geology
- C.C. Mathewson, Engineering Geology
- A.C. Mc Lean and Gribble C.D., Geology for Civil Engineers
- D.P. Coduto, Geotechnical Engineering
- Dunn I.S., Anderson L.R. and Kiefer F.W., Fundamentals of Geotechnical Analysis

Suggested Online Link:

- https://www.classcentral.com/course/youtube-civil-engineering-geology-47669
- https://onlinecourses.nptel.ac.in/noc23_ce107/preview

Generic Elective (GE):
Mineral Exploration and Mineral Economics

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Mineral Exploration and Mineral Economics (GE)	04	03	0	01	Bachelor (Honours) of Science in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Mineral Exploration and Mineral Economics (Theory)

Course Type: GE	Total Credit: 03	Teaching Hours: 45

Course Outcome: The main objective of this course is to provide basic knowledge of mineral exploration at different stages, and the estimation of ore reserves. It is aimed to provide a clear idea and knowledge about the method and tools used in mineral exploration from survey to mineral extraction.

Units	Course Contents	Teaching Hours
Unit-I	Concept of exploration. Geological, geophysical, geochemical and geobotanical criteria and methods of surface and sub-surface exploration.	12
Unit-II	Pitting, trenching, drilling, and sampling methods. Methods of petroleum exploration. Estimation of grade and reserve of ores.	11
Unit-III	Principles of mineral beneficiation. Communition classification, liberation, concentration, floatation methods, jigging, electromagnetic and magnetic separation, amalgamation, syndication.	11
Unit-IV	Strategic, critical, and essential minerals. India's status in mineral production. National Mineral Policy. Substitution and conservation. Mineral concession rules. Marine mineral resources and Law of Sea.	11

Course Title: Mineral Exploration and Mineral Economics (Lab)		
Course Type: GE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Mineral Exploration and Mineral Economics:Ore reserve estimation and vetting of easy values. Interpretation of bore hole logs. Interpretation of seismic and resistivity data. Study of gravity data maps and their interpretation.	**30**

Suggested Reading:

- Mckinstry, H.E., 1962: Mining Geology. II Ed.-Asia Publishing House
- Clark, G.B., 1967: Elements of Mining.III Ed.-John Wiley
- Arogyaswami, R.P.N., 1996: Courses in Mining Geology. IV Ed.-Oxford IBH
- Mason, B.C. (1982). Principles of Geochemistry, John Wilay& Sons.
- Jeffery, G.H, Basett, J., Mendhan, J. and Denney, R.C. (1989). Vogel's text book ofquantitative Chemical analysis. 5th ed. ELBS.
- Gill, R. (Editor), (1977). Modern analytical geochemistry. Longman , Singapore.
- Jeffery, P.G. and Hutchison, D., (1983). Chemical methods of rock analysis.
- Pergamon press, Oxford, N.Y.
- Rose, A.W., Hawkes, H.E. and Webb, J. A., (1979). Geochmeistry in MineralExploration. Academic Press.
- Skoorg, D.A. et al. (2004). Fundamental of analytical chemistry. 8th ed. Thomson Books.

Suggested Online Link:

- https://www.mooc-list.com/course/minerals-and-mining-business-edx
- https://www.classcentral.com/course/swayam-drilling-and-blasting-technology-58442
- https://www.classcentral.com/course/swayam-underground-mining-of-metalliferous-deposits-43673

Semester VII

Discipline Specific Elective (DSE): Igneous Petrology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Igneous Petrology (DSE)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II with Science.

Course Title: Igneous Petrology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will provide in-depth knowledge about the origin and evolution of igneous rocks in diverse tectonic environments through a number of major and subsidiary magmatic processes. The petrogenesis of igneous rocks can be very well demonstrated in the light of modern phase equilibria experimental works. Igneous rocks, also called primary rocks, are most abundant and were formed throughout the Earth's evolutionary history that essentially make up the continents as a stable platform to live on it. Students will come to know about the igneous processes and world class examples of igneous provinces, complexes, and suites of India.

Units	Course Contents	Teaching Hours
Unit-I	Magma generation in the mantle, their nature and evolution; Magmatic processes: Partial melting, fractional crystallization, magma mixing, assimilation, liquidimmiscibility, and other subsidiary processes.	12
Unit-II	Petrography and genetic interpretation of igneous textures in terms of rate of nucleation and crystal growth; IUGS classification schemes and nomenclature of igneous rocks: Ultramafic, mafic and felsic igneous rocks; total-alkali-Silica (TAS) classification of volcanic igneous rocks.	11
Unit-III	Study of phase equilibria in binary (Diopside-Anorthite, Forsterite-Silica, Nepheline-Silica, Forsterite-Fayalite; Albite-Anorthite; Orthoclase-Albite) and ternary (Diopside- Nepheline-Silica, Diopside-Albite-Anorthite, Anorthite- Forsterite-Silica; Fayalite-Leucite-Silica, Orthoclase-Albite- Silica) silicate systems in the light of modern experimental works.	11
Unit-IV	Petrogenesis and tectonic setting of major igneous rock types	11

	and suites: Ultramafic rocks, komatiite, lamprophyres, kimberlite, ophiolite, flood basalt, anorthosite, Tonalite-Trondhjemite-Granodiorite (TTG), granitoids, alkaline rocks and carbonatites with special reference to Indianexamples.	

Course Title: Igneous Petrology (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Igneous Petrology: Megascopic and microscopic studies of major igneous rock types. CIPW normative mineral calculation. Introduction to software: Sinclass, GCDkit, MELT, R-Crust.	**30**

Suggested Reading:

- Phillpotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
- Best, M.G. (2003). Igneous and Metamorphic Petrology,2nd Edition, Blackwell.
- Bose, M.K. (1997). Igneous Petrology, World Press, Kolkata.
- Cox, K.G., Bell, J.D. and Pankhurst, R.J. (1979). Interpretation of Igneous Rocks, Unwin Hyman, London
- Frost, B.R. and Frost, C.D. (2014). Essentials of Igneous and Metamorphic Petrology, Cambridge University Press
- McBirney, A.R. (1993). Igneous petrology. Jones & Bartlet Publication.
- LeMaitre, R.W. (2002). Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press.
- Wilson, M. (1993). Igneous Petrogenesis, Chapman and Hall, London.
- Kumar, S, and Singh, R.N. (2014). Modelling of Magmatic and Allied Processes. Springer, Switzerland.
- Powell, R. (1978). Equilibrium thermodynamics in Petrology: An Introduction, Harper & Row Publishers, London.
- Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
- Wood, B.J. and Fraser, D.G. (1976). Elementary Thermodynamics for Geologists, Oxford University Press, London.
- Gill, R. (2015). Chemical Fundamental of Geology, Wiley Blackwell
- Hibbard, M.J. (1995). Petrography to petrogenesis. MacMillan USA

Suggested Online Link:

- https://www.classcentral.com/course/swayam-petrology-14084.
- E-pathshala.https://epgp.inflibnet.ac.in/

Discipline Specific Elective (DSE):
Metamorphic Petrology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Metamorphic Petrology (DSE)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II With Science.

Course Title: Metamorphic Petrology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will allow students to gain in- depth knowledge about the origin of metamorphic rocks from different protoliths. The identification of structures, textures and mineral assemblages provide information on involved reactions under different pressures and temperature regimes, and its implication on understanding the metamorphic evolutionary history and geodynamics of mobile belts thorough time. Some noted Indianexamples will be demonstrated.

Units	Course Contents	Teaching Hours
Unit-I	Mineralogical Phase rule of open and closed systems; Types of metamorphism; Textures of regional and contact metamorphic rocks; Deformation and metamorphism; Nature and types of metamorphic reactions; Concept and classification of metamorphic facies; Facies series; Graphical representation of minerals in ACF, AKF, AFM and A'F'M' diagrams; Time relation between phases of Deformation and metamorphic crystallization.	12
Unit-II	Description of each facies of low pressure, medium to high pressure and very high pressure with special reference to characteristics minerals, subdivisions into zones / sub- facies, mineral assemblages, metamorphic reactions and pressure temperature conditions of metamorphism. Introduction to Ultra-high temperature and Ultra-high-pressure metamorphism. Metamorphism of shale, mafic and calcareous rocks.	11
Unit-III	Isograds and Reaction Isograds; Schreinmakers rule and construction of Petrogenetic grids; Metamorphic	11

	differentiation; Anatexis and origin of migmatites; Paired metamorphic belts	
Unit-IV	Gibb's free energy; Entropy; Enthalpy; Clausius- Clapeyron equation;Geothermobarometry; Pressure-Temperature-Time (P-T-t) paths.	**11**

Course Title: Metamorphic Petrology (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Metamorphic Petrology: Study of metamorphic rocks of different metamorphic facies in hand specimens. Calculation of ACF, AKF, AFM and A'F'M values from the given chemical data / structural formula of minerals and their graphical representation. Study of metamorphic rocks in thin sections with reference to texture/structure, time relation between phases of deformation and metamorphic crystallization, mineral association, parent rock, metamorphic facies/subfacies/ zones to which rock can be assigned and representation of assemblage in ACF, AKF, AFM and A'F'M' diagrams. Estimation of pressure and temperature from important models of Geothermobarometry.	**30**

Suggested Reading:

- Turner, F.J. (1980). Metamorphic Petrology, McGraw Hill, NewYork.
- Yardlley, B.W.D. (1989). An introduction to Metamorphic Petrology, Longman Scientificand Technical, New York.
- Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995). Atlas of Metamorphic Rocks and their textures, Longman Scientific & Technical, England.
- Philopotts, A.R. (1994). Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Kretz, R. (1994). Metamorphic Crystallization, John Wiley.
- Bucher, K. and Frey, M. (2002). Petrogenesis of Metamorphic Rocks (7^{th} Rev. Ed.), Springer–Verlag.
- Powell, R. (1978). Equilibrium thermodynamics in Petrology: An Introduction,Harper and Row Publ., London.
- Wood, B.J. and Fraser, D.G. (1976). Elementary Thermodynamics for Geologists, OxfordUniversity Press.
- Rastogy, R.P. and Mishra, R.R.1993: An Introduction to Chemical Thermodynamics, Vikash Publishing House.
- Spry, A. (1976). Metamorphic Textures, Pergamon Press.
- Sharma, R.S. (2016). Metamorphic Petrology: Concepts and Methods, Geological Society of India
- Winter, J.D. (2001). An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
- Winkler, H.G.F. (2013). Petrogenesis of Metamorphic rocks, Springer New York, eBook.
- Barker, A.J. (1998). Introduction to Metamorphic textures and Micro-textures,
- Miyashiro, A. (1994). Metamorphic Petrology, Taylor &Francis.

Suggested Online Link:

- https://www.classcentral.com/course/swayam-petrology-14084
- https://www.classcentral.com/course/swayam-geology-metamorphic-petrology-thermodynamics-22994

Discipline Specific Elective (DSE):
Sedimentology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title & Code	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Sedimentology (DSE)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II with Science.

Course Title: Sedimentology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45
Course Outcome: The course in-depth knowledge about the types and origin of sedimentary rocks, and source-to-sink sedimentary processes. It emphasizes upon the modern concepts of paleoenvironmental analysis, as well as provenance determination of sedimentary rocks. The course content deals with all the essential aspects required in exploring oil and natural gas, underground water, mechanically concentrated mineral deposits (placerdeposits), and building stones.		
Units	**Course Contents**	**Teaching Hours**
Unit-I	Sedimentary texture, textural parameters and their significance. Textural and compositional maturity. Fluid flow concepts, sediment transport, bedforms and sedimentary structures. Allogenic and autogenic controls on sedimentation.	**12**
Unit-II	Types and petrogenesis of conglomerates, sandstones, and argillites. Problem of greywacke. Plate tectonics and sandstone composition.	**11**
Unit-III	Classification and genesis of limestones and dolomites. Evaporites: Gypsum andanhydrite.	**11**
Unit-IV	Digenesis–Physical and chemical processes. Diagenetic stages and regimes Evidence of diagenesis in sandstones, mudrocks and carbonate rocks. Provenance of sedimentary rocks. Provenance reconstruction of sandstones through petrographic, petrofacies, and heavy mineral analyses.	**11**

Course Title: Sedimentology (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Sedimentology: Detailed study of clastic and non-clastic rocks in hand specimen. Study of sedimentary structures hand specimen inform-process context. Petrography of important rock types with emphasis on depositional setting, provenance and diagenesis.	**30**

Suggested Reading:

- Blatt, H., Middleton, G.V. and Murray, R.C. (1980). Origin of sedimentary rocks. Prentice Hall Inc.
- Collins, J.D. and Thompson, D.B. (1982). Sedimentary structures. George Allen and Unwin, London.
- Lindholm, R.C. (1987). A practical approach to sedimentology. Allen and Unwin, London.
- Miall, A.D. (2000). Principles of basin analysis, Springer-Verlag.
- Pettijohn, F.J. (1975). Sedimentary rocks (3rd Ed), Harper and Row Publ., NewDelhi.
- Reading, H.G. (1997). Sedimentary environments and facies, Blackwell Scientific Publication.
- Reineck, H.E. and Singh, I.B. (1973). Depositional sedimentary Environments, Springer-Verlag.
- Selley, R.C. (2000). Applied Sedimentology, Academic Press.
- Tucker, M.E. (1981). Sedimentary Petrology: An introduction. Wiley and sons, New York.
- Tucker, M.E. (1990). Carbonate Sedimentology, Blackwell Scientific Publication.

Suggested Online Link:

- https://www.classcentral.com/course/youtube-earth-120-sedimentology-stratigraphy-90982
- https://ocw.mit.edu/courses/12-110-sedimentary-geology-fall-2004/
- https://www.classcentral.com/course/youtube-the-weird-and-wonderful-world-of-sedimentology-137502

Semester VIII

Discipline Specific Elective (DSE):
Economic Geology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Economic Geology(DSE)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II with Science.

Course Title: Economic Geology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: The course is intended to impart basic knowledge about the occurrence and distribution of metallic and non-metallic ores and energy resources in India, and to understand ore-forming processes.

Units	Course Contents	Teaching Hours
Unit-I	Geological setting, characteristics, and genesis of ferrous, base and noble metals. Geological controls and localization of ore deposits, metallogenic provinces, and metallogenic epochs.	12
Unit-II	Geochemical behaviour of elements in ore geological systems. Laboratory analysis of common metallic minerals including ore microscopy, fluid inclusions and isotopic systematics.	11
Unit-III	Origin, migration, and entrapment of petroleum. Properties of source and reservoir rocks. Structural, stratigraphic and combination traps. Petroliferous basins of India.	11
Unit-IV	Origin of coal deposits. Classification, rank and grading of coal. Coal resources of India. Gas hydrates, coal bed methane and nuclear resources. Mineral resources in the Himalaya.	11

Course Title: Economic Geology (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Economic Geology:Study of ores in hand specimen. Geographical distribution of classic ore deposits of India and world. Study of metallic minerals under the reflecting microscope.	**30**

Suggested Reading:

- Craig, J.M. & Vaughan, D.J., 1981: Ore Petrography and Mineralogy-John willey
- Evans, A.M., 1993: Ore Geology and Industrial Minerals-Blackwell
- Sawkins, F.J., 1984: Metal deposits in relation to plate tectonics-Springer Verlag
- Stanton, R.L., 1972: Ore Petrography-McGraw Hill
- Torling, D.H., 1981: Economic Geology and Geotectonics-blackwell Sci publ.
- Barnes, H.L., 1979: Geochemistry of Hydrothermal Ore Deposits-John Wiley
- Klemm, D.D. and Schneider, H.J., 1977: Time and Strata Bound Ore Deposits-Springer Verilog
- Guibert, J.M. and Park, Jr. C.F., 1986: The Geology of Ore Deposits-FreemanMookherjee, A., 2000: Ore genesis-a Holistic Approach-Allied Publisher

Suggested Online Link:

- https://www.mooc-list.com/course/minerals-and-mining-business-edx
- https://www.classcentral.com/course/swayam-drilling-and-blasting-technology-58442
- https://www.classcentral.com/course/swayam-underground-mining-ofmetalliferous-deposits-43673

Discipline Specific Elective (DSE): Paleontology

No. of Teaching Hours (Theory): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Paleontology (DSE)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II with Science.

Course Title: Paleontology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course intends to acquaint the students with the origin and evolution of life through geological time and the major evolutionary breakthroughs, and to correlate evolutionary history with other synchronous geological events. It would add to their knowledge regarding the basic concept of paleontology using mode and methods of fossil preservation and species identification, thereafter, suggesting the organic evolutionary path and paleo-environment. Also, they will know the causes of major events of mass extinctions in geological past including the glaciations periods.

Units	Course Contents	Teaching Hours
Unit-I	Theories of the origin of life. Organic evolution: Micro- and macro-evolution, types of heterochrony in evolutionary lineages, application to biochronology with Indian examples. Punctuated equilibrium and phyletic gradualism models. Mass extinctions and their causes. Ichnology, classification, and use.	12
Unit-II	Palaeobiology (palaeoecology, communities, modern environments, functional morphology and taphonomy). Distribution, migration, and dispersal of organisms applied to palaeobiogeography and plate-tectonics with Indian examples.	11
Unit-III	Brief morphology, evolution, and classification of Cnidarians, Brachiopoda, Mollusca (Cephalopoda, Gastropoda, Bivalvia), Trilobita.	11
Unit-IV	Introduction to palaeobotany. Important lower and upper Gondwana plant fossils. Evolution of vertebrates: elephant, horse, man, and dinosaurs. A brief idea of Siwalik vertebrate fauna.	11

Course Title: Paleontology (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Palaeontology:Systematic description of Brachiopoda, Bivalvia, Cephalopoda and Gastropoda; vertebrates and Plant Fossils.	**30**

Suggested Reading:

- Raup and Stanley, Principles of Palaeontology,
- Bilal U. Haq and A. Boersome , Introduction to Marine Micropalaeontology,
- G. Bignot , Elements of Micropalaeontology,
- Clarkson, E.N.K. (1986). Invertebrate Palaeontology and Evolution. ELBS, London.
- Cushman, J.A. (1940). The Formanifera, their classification and use. Harvard Univ. Press.
- Moore, R.C. Lalliker, C.G. and Fischer, A.G. (1952). Textbook of Invertebrate Palaeontology.
- David Raup and Stanley (1985). Principles of Palaeontology., CBS Pub., Delhi
- Glaessner, M.F. (1945). Principles of Micropaleontology. Melbourne Univ. Press.
- Schrock, Twenhofel and Williams (1953). Principles of Invertebrate Palaeontology. CBS, Delhi

Suggested Online Link:

- https://www.futurelearn.com/courses/extinctions-past-present/19/steps/1312906.

Discipline Specific Elective (DSE):
Basin Analysis and SequenceStratigraphy/Glacial Geology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Basin Analysis and Sequence Stratigraphy(DSE)/ Glacial Geology (DSE)	04	03	0	01	Bachelor ofScience with Geology as a Core subject	X+II with Science.

Course Title: Basin Analysis and Sequence Stratigraphy (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will provide in-depth knowledge about the basin development including the involved source to sink processes, rock exhumation, erosion and sediment transport to the sedimentary basins. Students will also understand about the effects of controls of lithology, tectonics and climate, as well as base level change on the basin's depositional environments. They will also gain thorough knowledge of sequence stratigraphic analysis and its role in the reconstruction and correlation of environments via lateral as well as vertical facies change patterns. It also emphasizes upon the modern concepts of paleoenvironmental analysis, as well as provenance determination of sedimentary rocks.

Units	Course Contents	Teaching Hours
Unit-I	Tectonic classification of sedimentary basins. Sedimentation pattern and depositional environments of selected undeformed sedimentary basins of India: Vindhyan, Lesser Himalayan sedimentary basins, Gondwana, Siwalik Foreland basin.	12
Unit-II	Walthers law and sedimentary environments. Concept of sedimentary facies, facies associations, and facies model and basin analysis. Characteristics, processes, and facies of modern and ancient continental clastic depositional sedimentary environments: alluvial, fluvial, lacustrine, aeolian and glacial deposits, and transitional and marine sedimentary facies models: deltaic, estuarine, tidal flat, lagoonal, barrier beach islands, terrigenous shelves, shallow seas and deep-sea sedimentary environments.	11
Unit-III	Sedimentary cycles, rhythmites and cyclothems. Concept of sequence Stratigraphy. Evolution, order and duration of sequences. Applications and significance of sequence Stratigraphy.	11

Unit-IV	Palaeocurrent analysis and its significance. Types of palaeocurrent indicators. Sediment dispersal pattern. Controls on provenance and techniques for provenance determination: petrography, heavy mineral analysis and geochemistry.	**11**

Course Title: Basin Analysis and Sequence Stratigraphy (Lab)

Course Type: DSE	Total Credit: 01	Teaching Hours: 30
Sections	**Course Contents**	**Teaching Hours**
Section-A	Basin analysis and Sequence Stratigraphy: Prepration of lithologs, Interpretation and reading depositional environments from the given idealized lithologs and data. Heavy mineral identification and provenance interpretation. Petrography of selected sedimentary rock types. Staining and Mineral identification in Carbonate rocks. Study of important facies models.	**30**

Suggested Reading:

- Reading H. G. 1996: Sedimentary Environments and Facies, Balckwell
- Reading H.E. and Singh, I.B. 1980: Depositional Sedimentary Environments, Springers Verlag
- Boggs Sam Jr, 1995. Principles of Sedimentary and Stratigraphy, Prentice Hall
- Selley R.C.,1998. Applied Sedimentology, Academic Press
- Miall, A.D. 2000: Principles of Sedimentary Basin Analysis, Springer Verlag
- Eirsele, G. 1992: Sedimentary Basins, Springers Verlag.
- Bhattacharya A and Chakraborti, C .2000. Analysis of Sedimentary Successions, Oxford and IBH

Suggested Online Link:

- https://www.classcentral.com/course/youtube-earth-120-sedimentology-stratigraphy-90982
- https://ocw.mit.edu/courses/12-110-sedimentary-geology-fall-2004/
- https://www.classcentral.com/course/youtube-the-weird-and-wonderful-world-of-sedimentology-137502
- http://www.sepmstrata.org/Page.aspx?pageid=1

Course Title: Glacial Geology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45
Course Outcome: This course will provide in-depth knowledge about glaciers, their fundamental types, characteristics and in-depth information about climatic change. After completing this course, students will understand past and present-day climate changes as glaciers are the major focus of climate change study. Their behavior and geomorphology will provide detailed information to predict future changes. Glaciology or glacial geology also enables students to opt for the regime of polar research as these are the key areas of polar research.		
Units	**Course Contents**	**Teaching Hours**
Unit-I	Cryosphere: Ice sheets, valley glaciers, formation of glaciers; Characteristics of glacial ice; climate and glaciers; Implication of Glacial geology; Techniques in Glacial geology.	**10**

Unit-II	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.	**11**
Unit-III	Periglacial concept: climate, soils, vegetation cover; Periglacial processes: weathering, ground freezing and thawing; Permafrost: characteristics, distribution and type; slope movement, movement and hillslope evolution.	**11**
Unit-IV	Clast characteristics: shape-form, roundness and texture, size, macro fabrics; sediment sampling and analysis; glacial fluvial, glacio-lacustrine and glacio-marine sediments. Climate change and glaciations; Glaciation during the earth's history, Quaternary Glaciations: Last Glacial Maximum, Little Ice Age.	**13**

Course Title: Glacial Geology (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	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	**30**

Suggested Reading:

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

Suggested Online Link:

- https://www.antarcticglaciers.org/glacial-geology

Semester IX

Discipline Specific Elective (DSE):
Remote Sensing and GIS

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Remote Sensing and GIS (DSE)	04	03	0	01	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Remote Sensing and GIS (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course pertains to recent technologies of Remote Sensing and Geographical Information System (GIS). The course introduces various types of remote sensing data in different ranges of the electromagnetic spectrum, and the basic concepts and potential of GIS in geological investigations. It develops skills in students for interpreting visual and digital remote sensing image from different spectral bands and use them to understand the various physical processes operating on earth's surface through integration of other sources' data in a GIS.

Units	Course Contents	Teaching Hours
Unit-I	Atmospheric scattering and absorption; Concepts of Optical, NIR, SWIR, TIR and RADAR remote sensing; Satellite and Aerial remote sensing platforms; SpectralReflectance curves of soil, water and vegetation.	12
Unit-II	Types and characteristics of sensors. Concepts of mono- band, multispectral and hyperspectral remote sensing. Basics of optical, thermal and microwave remote sensing.Basic concept of LiDAR. Characteristics of IRS sensors.	11
Unit-III	The structure of Digital Image. Conceptual aspects ofDigital Image Processing. Basic processes of imagerectification, enhancement, and classification. Definition andcomponents of Geographic Information System (GIS). Raster and vector data	11

	formats. Basic knowledge about dataacquisition, manipulation, analyses, and representation in GIS.	
Unit-IV	Application of remote sensing and GIS in geomorphological investigations, tectonic investigations, lithological mapping, groundwater exploration, mineral exploration, Oil & Gas exploration and geohazardmanagement.	**11**

Course Title: Remote Sensing and GIS (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Remote Sensing & GIS: Determination of the scale of aerial photographs and imageries. Visual interpretation of aerial photographs and imageries for geomorphological, lithological, tectonic and geological mapping.	**30**

Suggested Reading:

- Lillesand, T.M., Kiefer, R.W. and Chapman, J. (2015): Remote Sensing and Image Interpretation, 7th Edition. Wiley
- Gupta, R.P. (2003). Remote Sensing Geology. 2nd Edition. Springer
- Drury, S.A. (1993). Image Interpretation in Geology. 2nd Edition. Chapman &Hall
- Jensen, J.R. (2000). Remote Sensing of the Environment, An earth Resource Perspective. Pearson Education.
- DeMers M.N. (2008). Fundamentals of geographic Information System. 4th Edition. Wiley
- Richards, J.A. and Jia, X. (2006). Remote Sensing Digital Image Analysis: An Introduction. 4th Edition, Springer
- George Joseph (2005). Fundamentals of Remote Sensing 2nd edition: Universities Press
- Gopi, S, Sathikumar, R and Madhu, N (2006). Advanced Surveying total station GIS and Remote Sensing, Pearson Education
- Sabins, F.F. (2007). Remote Sensing Principles and Interpretations 3rd Edition, Waveland Pr Inc.
- Lilles T.M., Kiefer, R.W. and Chipman, J. (2008). Remote Sensing and Image Interpretation. 6th Edition, John Willey, and Sons.
- Bhatia, S.C. (2008). Fundamentals of Remote Sensing Atlantic Publications.
- Bhatta, B. (2011). Remote Sensing and GIS2nd Edition, Oxford University Press
- Sabins, F.F. (2012). Remote Sensing Principles and Practice 3rd Edition, Levant Books
- Jensen, JR. (2013). Remote Sensing of the Environment: An Earth Resource Perspective 2nd Edition, Pearson India.

Suggested Online Link:

- https://www.classcentral.com/course/swayam-photogeology-remote-sensing-45165.

Discipline Specific Elective (DSE): Hydrogeology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Hydrogeology (DSE)	04	03	0	01	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Hydrogeology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course has a direct relationship to society as it provides a deep information regarding the most important factor required for a life to sustain i.e water. Groundwater is the purest form of water that can be yielded from rocks. It provides a better knowledge about its origin, prospecting, and extraction. It explains the lawsGoverning groundwater flow and various methods of groundwater exploration.

Units	Course Contents	Teaching Hours
Unit-I	Groundwater origin, type and occurrences, Renewable and Non-renewable groundwater resources. Hydrological Cycle. Sub Surface movement and Concept of depth to water level and waterTable contour map. Water table and piezometric surface. Aquifers and their type. Water bearing properties of rocks and aquifer parameters:porosity, permeability, specific yield, specific retention,Hydraulic conductivity, transmissivity, intrinsic permeability,Storage coefficient, storativity, specific storage. Darcy Law, range, and its validation.Introduction to hydrogeology of India, and the groundwater provinces of India.	12
Unit-II	Theory of groundwater flow, numerical solutions for steady state linear groundwater flow in confined and unconfined aquifers and Dupuit's assumption for unconfined flow. Numerical solutions for steady state radial flow to a well in confined (Thiem's equation) and unconfined aquifers (Dupuit's equation). Numerical solutions for unsteady state groundwater flow condition. Evaluation of aquifer parameters of confined Aquifer using Theis and Jacob methods.	11

Unit-III	Quality of Groundwater: Chemical characteristics of groundwater in relation to various uses- domestic, irrigation and industrial purposes. Groundwater contamination and pollution from natural (geogenic) and anthropogenic sources. Graphical presentation of water quality data. Saline water intrusion in aquifer sand its prevention. Groundwater quality in different provinces of India.	**11**
Unit-IV	Brief idea about geological and geophysical methods of groundwaterexploration. Seismic and Resistivity Method. Concept of geophysical Logging and Electric Logging method. Geologicandgeomorphiccontrolson groundwater.	**11**

Course Title: Hydrogeology (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Preparation of ground water flow directions, Estimation of aquifer parameters using different mathematical equations, plotting groundwater quality properties (Hill & piper diagram, Durov plot and SAR plotting), Plot hydrological provinces in India.	**30**

Suggested Reading:

- Todd, D.K. (1980). Groundwater Hydrology- JohnWiley.
- Davis, S.N. and DeWiest, R.J.M. (1966). Hydrogeology-John Wiley.
- Freeze, R.A. and Cherry, J.A. (1979). GroundWater- Prentice Hall.
- Fetter, C.W. (1990). Applied Hydrogeology- MerillPublishing.

Suggested Online Link:

- https://www.classcentral.com/subject/hydrology
- https://www.classcentral.com/course/swayam-engineering-hydrology-58453

Discipline Specific Elective (DSE): Micropaleontology and Oceanography

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Micropaleontology and Oceanography (DSE)	04	03	0	01	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Micropaleontology and Oceanography (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course will enable students to develop skills regarding modern techniques and methods employed in micropalaeontology and marine life. It will provide idea about the different Ocean Drilling Programs. The students will gain an advanced knowledge on applications of microfossils and will be able to interpret atmospheric and oceanic circulation systems so as to analyze their driving forces. This all will also help them to evaluate a relationship between ocean chemistry and climate change.

Units	Course Contents	Teaching Hours
Unit-I	Definition and scope of the subject; Relationship of micropaleontology with ocean sciences; Modern field and laboratory techniques in the study of microfossils (collection, sampling and processing techniques, scanning electron microscopy and mass spectrometry); Concepts of micro paleontological indicators useful in understanding geological evolution, environmental changes and biostratigraphiccorrelation.	12
Unit-II	Morphology, geological distribution, evolution, significance and applications of organic-walled microfossils (acritarchs, dinoflagellates, spores and pollens) and inorganic walled microfossils (Foraminifers, Ostracoda, Calcareous Nannofossils, Radiolaria, Diatoms, silicoflagellates and Conodonts). Application of Micropaleontology in hydrocarbon exploration, paleoceanography, paleoclimatologyand tracing history of marine pollution. Interpretation of seafloor	11

	tectonism from micro-paleontological evidence.	
Unit-III	History and development of Oceanography. Methods of measuring properties of seawater (horizontal and vertical distribution of temperature, salinity, dissolved gases in sea water; density stratification in oceans). Depositional processes and distribution of Calcareous oozes, silicious oozes, and pelagic sediments in oceans. Ocean drilling Programmes (DSDP, ODP, IODP) and its major accomplishments.	**11**
Unit-IV	Ocean circulation, surface circulation and concept of mixed layers. Coriolis force and Ekman spiral Thermocline and Pycnocline, concept of upwelling and downwelling of ocean water. El Nino, La Nina. Deep Ocean circulation. Formation of bottom water, water masses of the world ocean and sea sediments.	**11**

Course Title: Micropaleontology and Oceanography (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30 Hours**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Micropaleontology and Oceanography: Surface and Deep Ocean circulation, Upwelling, Indian Monsoon circulation. Techniques of separation of microfossil from the matrix. Study of representative genera of microfossils, Preparation of bio-zonation charts.	**30**

Suggested Reading:

- Garrisson T and Ellis, R. (2016). Oceaanography: An invitation to marine Science. National Geographic Learning.
- Trujillo, A.P and Thurman, H.V. (2011). Essentials of Oceanography. Prentice Hall (10^{th} edition)
- Armstrong, and Brasier, M. (2005). Microfossils. Blackwell Publishing (2^{nd}edition)
- Saraswati, P.K. and Srinivasan, M.S. (2016). Micropaleontology: Principles and Applications, Springer.
- Arnold (2002). Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford
- Haq B.U. and Boersma, A. (1998). Introduction to Marine Micropaleontology, Elsvier.
- Pinet, P.R. (1992): Oceanography: An introduction to the Planet Oceanus, West Pub, Co
- Bignot, G., GrahmandTrottman (1985). Elements of Micropaleontoogy, London.
- David Tolmazin (1985). Elements of Dyanamic Oceanography, Allen and Unwin
- Grant Gross, M. (1977). Oceanography; A view of the Earth, Prentice Hall.
- John Houghton (1997). Global Warming, Cambridge Univ. Press.
- Jones, T.P. and Rowe, T.P. (1999). Fossil plants and spores, Modern Techniques, Geological Soc. Of London.

Suggested Online Link:

- https://www.classcentral.com/tag/palaeontology
- https://www.coursera.org/courses?query=paleontology
- https://www.classcentral.com/subject/oceanography
- https://www.coursera.org/learn/oceanography

Semester X

Discipline Specific Elective (DSE):
Tectonic Geomorphology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Tectonic Geomorphology(DSE)	04	03	0	01	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Tectonic Geomorphology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: This course pertains to studying the active terrain deformation in response to activities on structural discontinuities of the earth, and/or climatic fluctuations, and/or isostatic adjustments of the earth. The course will enable the students to identify active tectonic structures of an area and measure the extent of activities of them based on their geomorphic signature. Knowledge on such aspects of an area is quite useful in analyzing the hazard proneness and vulnerability of any area, as well as assessing the safety of any geo-Engineering project therein.

Units	Course Contents	Teaching Hours
Unit-I	Definition and scope of tectonic geomorphology. Landscape evolution. Davis', Penck's, and Hack's models of landscape evolution. Modern concepts of landscape evolution. Concept of Form-Process relationship inLandscape evolution.	12
Unit-II	Geomorphic Markers of active tectonics: Planar and Linear. Landforms of active strike-slip faults, normal faults, reverse faults, and folds. River response to active tectonics. Sudden (coseismic) versus gradual modifications in river systems. Tectonic modifications of alluvial and bedrock-channel e drivers: longitudinal profiles, river pattern, sinuosity, drainage patterns and drainage anomalies.Effects of base level.	11
Unit-III	Geomorphic Indices of active tectonics – Morphometric analysis: mountain-front sinuosity, hypsometric curve and hypsometric integral, stream- length gradient index, and valley-	11

	floor width to valley height ratio, basin elongationratio, basin shape, relief ratio, drainage basin asymmetry factor, transverse topography symmetry factor.	
Unit-IV	Introduction to geodesy. Fundamentals of ground- based and space geodetic techniques of measuring active tectonic deformations: Alignment arrays, Trilateration nets, Dry-tilt nets, electronic distance measurement (EDM) systems, very long beam interferometry (VLBI), Radar Interferometry, and Global PositioningSystem (GPS).	**11**

Course Title: Tectonic Geomorphology (Lab)

Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Tectonic Geomorphology: Exercises on mapping ofTectonic geomorphological features and computation ofgeomorphic indices, using map and remote sensing data.	**30**

Suggested Reading:

- Burbank, D.W. and Anderson, R.S. (2011). Tectonic Geomorphology 2nd Edition. Blackwell Science.
- Burbank, D.W. and Anderson, R.S. (2001). Tectonic Geomorphology 1st Edition. Blackwell Science.
- Keller, E.A. and Pinter, N. (1996). Active tectonics: Earthquakes, Uplift, and Landscape. Prentice Hall
- Bull, William. (2009). Tectonically active landscapes. Wiley-Blackwell
- Schumm, S.A, Dumont, J.F. and Holbrook, J.M. (2000). Active tectonics and alluvial rivers. Cambridge University Press.
- Bull, W. (2007). Tectonic Geomorphology of Mountains: A new approach to palaeo-seismology. Blackwell Publishing.
- Small, R.J. (1978). Study of Landforms: A Textbook of geomorphology (2ndEdition), Cambridge University Press.
- Halis, J.R. (1983). Applied Geomorphology.
- Sharma, H.S. (1990). Indian Geomorphology. Concept Publishing Co. NewDelhi.
- Thornbury, W.D. (2004). Principles of Geomorphology. 2nd edition CBS Publication.
- Kale, V.S. and Avijit Gupta (2010). Introduction to geomorphology. University Press
- Bloom, A.L. (2011). Geomorphology: A systematic analysis of Late Cenozoic Landforms 3rd Edition. Rawat Publications.
- Condie, Kent. C. (1989). Plate Tectonics and Crustal Evolution.3rd Edition. Butterworth-Heinemann Ltd.
- Windlley, B. (1995). The Evolving Continents. 3rd Edition Wiley-Blackwell.
- Davies, G.F. (1999). Dynamic Earth: Plates, Plumes and Mantle Convection. Cambridge University Press.
- Keller, E.A and Pinter, N (2001). Active Tectonics. 2nd Edition. Pearson Publications.
- Kearey, P., Klepeis, KA and Vine, F. J (2009). Global Tectonics3rd Edition. Wiley- Blackwell.
- Burbank, D.W. and Anderson, R.S. (2016). Tectonic Geomorphology. Wiley India.

Suggested Online Link:

- https://www.classcentral.com/course/swayam-geomorphology-17628
- https://alison.com/course/advanced-diploma-in-geomorphology#google_vignette
- https://onlinecourses.nptel.ac.in/noc20_ce28/preview

Discipline Specific Elective (DSE):
Engineering Geology

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Lab		
Engineering Geology (DSE)	04	03	0	01	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Engineering Geology (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

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

Units	Course Contents	Teaching Hours
Unit-I	Introduction to Engineering geology, geo-technical engineering, and geo-technics. Role of geology in major engineering projects. Concept of Detailed Project Report (DPR) and Environmental Impact Analysis (EIA). Engineering properties of rocks and soils, field, and laboratory techniques for their determination.	12
Unit-II	Geological consideration for evaluation of Dams and reservoir sites. Reservoir induced seismicity. Dam foundation rock problems. Grouting and Rock bolting. Problem of piping in reservoir areas.	11
Unit-III	Geological evaluation of tunnel alignment. Bridges, their types and causes of their failure. Building, their types and influence of geological conditions on foundation. Concept, mechanism, and significance of Rock Mass Rating (RMR), Rock Quality Designation (RQD), Geological Strength Index (GSI), and Tunnelling Quality	11

	index (Q) and its application on tunnel design.	
Unit-IV	Mass movement with emphasis on landslides. Causes of hill slope instability and preventive measure. Rock Mass Classification system for assessing the stability condition of slopes. Indian case studies related to major civil engineering projects.	**11**

Course Title: Engineering Geology (Lab)

Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Engineering Geology:Study of engineering geological maps, preparation of cross sections and description of the terrain. Stress distribution in rocks and soils. Shear strength, angle of repose and utility of Mohr's circle, Problems related to hill slope instability and interpretation of geological maps for landslide problems	**30**

Suggested Reading:

- Sharma P.V., Environmental and Engineering Geophysics
- Krynine D.P. and Judd W.R., Principles of Engineering Geology and Geotechniques
- Bell F.G., Fundamental of Engineering Geology
- Jeger C., Rock Mechanics and Engineering
- Valdiya K.S., Environmental Geology
- C.C. Mathewson, Engineering Geology
- A.C. Mc Lean and Gribble C.D., Geology for Civil Engineers
- D.P. Coduto, Geotechnical Engineering
- Dunn I.S., Anderson L.R. and Kiefer F.W., Fundamentals of Geotechnical Analysis

Suggested Online Link:

- https://www.classcentral.com/course/youtube-civil-engineering-geology-47669
- https://onlinecourses.nptel.ac.in/noc23_ce107/preview

Discipline Specific Elective (DSE):
Mineral Exploration and Mineral Economics

No. of Teaching Hours (Theory + Lab): 75 Hours

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab		
Mineral Exploration and Mineral Economics(DSE)	04	03	0	01	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	X+II with Science

Course Title: Mineral Exploration and Mineral Economics (Theory)

Course Type: DSE	Total Credit: 03	Teaching Hours: 45

Course Outcome: The main objective of this course is to provide basic knowledge of mineral exploration at different stages, and the estimation of ore reserves. It is aimed to provide a clear idea and knowledge about the method and tools used in mineral exploration from survey to mineral extraction.

Units	Course Contents	Teaching Hours
Unit-I	Concept of exploration. Geological, geophysical, geochemical and geobotanical criteria and methods of surface and sub-surface exploration.	12
Unit-II	Pitting, trenching, drilling, and sampling methods. Methods of petroleum exploration. Estimation of grade and reserve of ores.	11
Unit-III	Principles of mineral beneficiation. Communition classification, liberation, concentration, floatation methods, jigging, electromagnetic and magnetic separation, amalgamation, syndication.	11
Unit-IV	Strategic, critical, and essential minerals. India's status in mineral production. National Mineral Policy. Substitution and conservation. Mineral concession rules. Marine mineral resources and Law of Sea.	11

Course Title: Mineral Exploration and Mineral Economics (Lab)		
Course Type: DSE	**Total Credit: 01**	**Teaching Hours: 30**
Sections	**Course Contents**	**Teaching Hours**
Section-A	Mineral Exploration and Mineral Economics:Ore reserve estimation and vetting of easy values. Interpretation of bore hole logs. Interpretation of seismic and resistivity data. Study of gravity data maps and their interpretation.	**30**

Suggested Reading:

- Mckinstry, H.E., 1962: Mining Geology. II Ed.-Asia Publishing House
- Clark, G.B., 1967: Elements of Mining.III Ed.-John Wiley
- Arogyaswami, R.P.N., 1996: Courses in Mining Geology. IV Ed.-Oxford IBH
- Mason, B.C. (1982). Principles of Geochemistry, John Wilay& Sons.
- Jeffery, G.H, Basett, J., Mendhan, J. and Denney, R.C. (1989). Vogel's text book ofquantitative Chemical analysis. 5th ed. ELBS.
- Gill, R. (Editor), (1977). Modern analytical geochemistry. Longman , Singapore.
- Jeffery, P.G. and Hutchison, D., (1983). Chemical methods of rock analysis.
- Pergamon press, Oxford, N.Y.
- Rose, A.W., Hawkes, H.E. and Webb, J. A., (1979). Geochmeistry in MineralExploration. Academic Press.
- Skoorg, D.A. et al. (2004). Fundamental of analytical chemistry. 8th ed. Thomson Books.

Suggested Online Link:

- https://www.mooc-list.com/course/minerals-and-mining-business-edx
- https://www.classcentral.com/course/swayam-drilling-and-blasting-technology-58442
- https://www.classcentral.com/course/swayam-underground-mining-of-metalliferous-deposits-43673

Semester VII

Internship/Apprenticeship/Project/Community Outreach (IAPC): Academic Project Based on Geological Field Training

No. of Teaching Hours (Practical/Lab): NA

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab (Field Training)		
Academic Project Based On Geological Field Training (IAPC)	06	0	0	06	Bachelor ofScience with Geology as a Core subject	Geology as DSC and at least one DSE in Current Semester.

Course Title: Geological Field Training

Course Type: IAPC	Total Credit: 06	Teaching Hours: NA

Course Outcome: Geology is a field and observational science. Geo-scientific hypothesis is framed in the field that can be tested through field data and laboratory investigations. This course will enable the students to explore practical aspect of geology such as preparation of geological maps, cross-section, and reconnaissance and detailed surveys for geo-resource exploration and environmental purposes etc.

Contents

The course will be based on geological field training, in which the students will be trained on the following aspects:

1. The training on geological field, laboratory techniques, and various instruments used in geological analysis. The geological field work involves exposure to various terrains of different geological characteristics, different types of mines/Mineral resources, natural resource exploration sites, various types of geohazard sites etc.
2. Geological mapping techniques, understanding the interaction between topography and geologic structures.
3. Basics of field data collection, analyses, interpretation, and geological report writing based on their training, which will be evaluated for the marking.

Semester VIII

Internship/Apprenticeship/Project/Community Outreach (IAPC): Dissertation

No. of Teaching Hours (Practical/Lab): NA

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab (Project/ Research Oriented Dissertation)		
Dissertation (IAPC)	06	0	0	06	Bachelor ofScience with Geology as a Core subject	Geology as DSC and at least one DSE in Current Semester

Course Title: Dissertation

Course Type:IAPC	Total Credit: 06	Teaching Hours: NA

Course Outcome: This course will enable students to choose any branch of geology and select a problem for research. During this course students will apply the knowledge gained so far in resolving geological problems by carrying out research work followed by a presentation of the work. It will help the student to apply all his/her skills and work practically by using different techniques including field and laboratory work.

Contents

1. The students will be assigned a minor research topic to write a dissertation, under the supervision of a guide (Faculty of the Department).
2. The dissertation will be evaluated by combined team of external examiner and internal examiner (Guide/or Research Supervisor of the specific dissertation).

Semester IX

Internship/Apprenticeship/Project/Community Outreach (IAPC): Academic Project Based on Geological Field Training

No. of Teaching Hours (Practical/Lab): NA

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab (Field Training)		
Academic Project Based On Geological Field Training (IAPC)	06	0	0	06	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	Geology as DSC and at least one DSE in Current Semester.

Course Title: Geological Field Training

Course Type: IAPC	Total Credit: 06	Teaching Hours: NA

Course Outcome: Geology is a field and observational science. Geo-scientific hypothesis is framed in the field that can be tested through field data and laboratory investigations. This course will enable the students to explore practical aspect of geology such as preparation of geological maps, cross-section, and reconnaissance and detailed surveys for geo-resource exploration and environmental purposes etc.

Contents

The course will be based on geological field training, in which the students will be trained on the following aspects:

1. The training on geological field, laboratory techniques, and various instruments used in geological analysis. The geological field work involves exposure to various terrains of different geological characteristics, different types of mines/Mineral resources, natural resource exploration sites, various types of geohazard sites etc.
2. Geological mapping techniques, understanding the interaction between topography and geologic structures.

3.	Basics of field data collection, analyses, interpretation, and geological report writing based on their training, which will be evaluated for the marking.

Semester X

Internship/Apprenticeship/Project/Community Outreach (IAPC): Dissertation

No. of Teaching Hours (Practical/Lab): NA

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITE OF THE COURSE

Course Title	Credits	Credit Distribution of the Course			Eligibility Criteria	Pre-requisite (if any)
		Lecture	Tutorial	Practical/ Lab (Project/ Research Oriented Dissertation)		
Dissertation (IAPC)	06	0	0	06	Bachelor (Honours) ofScience in Geology or M.Sc. Ist Year in Geology	Geology as DSC and at least one DSE in Current Semester

Course Title: Dissertation

Course Type:IAPC	Total Credit: 06	Teaching Hours: NA

Course Outcome: This course will enable students to choose any branch of geology and select a problem for research. During this course students will apply the knowledge gained so far in resolving geological problems by carrying out research work followed by a presentation of the work. It will help the student to apply all his/her skills and work practically by using different techniques including field and laboratory work.

Contents

1. The students will be assigned a minor research topic to write a dissertation, under the supervision of a guide (Faculty of the Department).
2. The dissertation will be evaluated by combined team of external examiner and internal examiner (Guide/or Research Supervisor of the specific dissertation).