Course Details: FYUP/ Honours

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
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
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
Academic Project Based on Field Training	IAPC	T (0)	L (06)	6	7
Dissertation	IAPC	T (0)	L (06)	6	8

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 **two-semester FYUP** 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 Bachelor of Science (Honours)/FYUP

Programme Specific Prerequisites: To acquire *Bachelor of Science (Honours)* degree, in Geology, a student should have obtained three-year *Bachelor of Science* degree from any recognized 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.

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 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 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 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).