गोंय विद्यापीठ
ताळगांव पठार,
गोंय – ४०३ २०६
फोन : +९१-८६६९६०९०४८

(Accredited by NAAC)

ATMANIRBHAR BHARAT
SWAYAMPURNA GOA

Goa University
Taleigao Plateau, Goa-403 206
Tel : +91-8669609048
Email : registrar@unigoa.ac.in
Website : www.unigoa.ac.in

GU/Acad –PG/BoS -NEP/2024/354 Date: 19.07.2024

Ref: GU/Acad –PG/BoS -NEP/2024/160 dated 29.05.2024

CORRIGENDUM

In supersession to the above referred Circular, the updated Syllabus of Semester I to VIII of the **Bachelor of Science in Earth Science (Geology)** Programme with following changes is enclosed.

- Number of credits for Course GEO-211 shall be (3T+1P), the updated Course content is given in the Syllabus below.

The Dean/ Vice-Deans of the School of Earth, Ocean and Atmospheric Sciences and Principals of the Affiliated Colleges offering the **Bachelor of Science in Earth Science (Geology)** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned**.**

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2024.07.19 12:08:27 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

The Principals of Affiliated Colleges offering the Bachelor of Science in Earth Science (Geology) Programme.

Copy to:

1. The Director, Directorate of Higher Education, Govt. of Goa
2. The Dean, School of Earth, Ocean and Atmospheric Sciences, Goa University.
3. The Vice-Deans, School of Earth, Ocean and Atmospheric Sciences, Goa University.
4. The Chairperson, BOS in Earth Science.
5. The Controller of Examinations, Goa University.
6. The Assistant Registrar, UG Examinations, Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Programme Structure for Semester I to VIII Under Graduate Programme - Earth Science (Geology)										
Semester	**Major -Core**	**Minor**	**MC**	**AEC**	**SEC**	**I**	**D**	**VAC**	**Total Credits**	**Exit**
I	**GEO-100 Introduction to Mineralogy and Petrology (3T + 1P)**	**GEO-111 Introduction to Geology (4)**	**GEO-131 The Dynamic Earth (3)**		**GEO-141 Space and Drone based Remote Sensing (1T + 2P)**					
II			**GEO-132 Physical Geology (3)**		**GEO-142 Water Quality Assessment (1T + 2P)**					*
III	**GEO-200 Structural Geology and Physical Geology (3T+1P)** **GEO-201 Principles of Stratigraphy and Palaeontology (4)**	**GEO-211 The Changing Earth (4)**	**GEO-231 Natural Hazards (3)** **OR** **GEO-232 Environment of Goa – Issues and Challenges (3)**		**GEO-241 Crystals and Gems (1T + 2P)** **OR** **GEO-242 Introduction to GIS (1T + 2P)**					

IV	**GEO-202 Descriptive Mineralogy (3T+1P)** **GEO-203 Introduction to Mining Geology (3T+1P)** **GEO-204 Geotectonics and associated Rocks (3T + 1P)** **GEO-205 Geology of Goa (1T+1P)**	**GEO-221 Introduction to Engineering Geology (3T + 1P) VET** **OR** **GEO-222 Geophysical Exploration (3T + 1P) VET**								
V	**GEO-300 Ore Genesis (3T + 1P)** **GEO-301 Structural Geology (3T + 1P)**	**GEO-321 Hydrogeology (3T + 1P) VET** **OR**								

	GEO-302 Igneous Petrology - I (3T + 1P) **GEO-303 Optical Mineralogy (1T + 1P)**	**GEO-322 Gemmology (3T + 1P) VET**								
VI	**GEO-304 Sedimentary Petrology-I (3T + 1P)** **GEO-305 Metamorphic Petrology-I (3T + 1P)** **GEO-306 Indian Stratigraphy (3T + 1P)** **GEO-307 Project (4)**	**GEO-323 Introduction to Environmental Geology (2T + 2P) VET** **OR** **GEO-324 Geoheritage (2T + 2P) VET**								

VII	**GEO-400 Mineralogy and Geochemistry (3T + 1P)** **GEO-401 Advanced Structural Geology (3T + 1P)** **GEO-402 Igneous Petrology – II (3T + 1P)** **GEO-403 Field Geology (1T + 3P)**	**GEO-411 Marine Geology (3T + 1P)**								
VIII	**GEO-404 Sedimentary Petrology - II (3T + 1P)** **GEO-405**	**GEO-412 Introduction to Petroleum Geology (3T + 1P)**								

	Metamorphic Petrology-II (3T + 1P) **GEO-406 Geology of India (3T + 1P)** **GEO-407 Ore Geology (3T + 1P)**									

Note: List of Exit Course along with the syllabus shall be provided separately.

Semester I and II
Name of the Programme : B.Sc. Geology
Course Code : GEO-100
Title of the Course : Introduction to Mineralogy and Petrology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Discuss the origin, shape, and size of the Earth. CL2 2. Explain the concepts of continental drift and plate tectonics. CL2 3. Demonstrate the symmetry in crystals. CL2 4. Describe minerals and rocks using physical properties. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Geology; Applications and Career opportunities in Geosciences. Introduction to Planetary Geology, Origin of the earth: Nebular Hypothesis; Shape, Size, Structure of the earth, Introduction to Plate Tectonics. Elementary Crystallography and Mineralogy: Scope and importance, states of matter, crystalline state, atomic arrangement in crystals. External characteristics of crystals, face, form, interfacial angles, law of constancy of interfacial angles. Goniometers, crystal symmetry.	**15**
Unit 2	Classification of crystals, crystallographic axes and systems, parameters and indices, study of the normal symmetry classes. Applications of crystal properties. Physical properties of minerals, colour, streak, lustre, diaphaneity, cleavage, fracture, form, habit, hardness, specific gravity, electrical and magnetic properties. Introduction of common rock - forming minerals: quartz, feldspar, micas, pyroxenes, amphiboles and olivine. Rocks: their classification into three broad classes, igneous, sedimentary and metamorphic, Rock Cycle.	**15**
Unit 3	Igneous Rocks: plutonic hypabyssal and volcanic types. Forms, structures and textures. Bowen's Reaction series. Classification based on grain size and mineral composition. Mineralization. Sedimentary Rocks: Structures, Textures and Classification of Sedimentary Rocks. Depositional Environments. Metamorphic Rocks: agents of metamorphism, types of metamorphism, fabric and Classification of Metamorphic Rocks.	**15**
Practical:	**Crystallography, Mineralogy and Petrology** 1. Study of 15 crystal models.	**30**

	2. Identification and description of the physical properties, compositions, occurrence and uses of 20 common minerals. 3. Systematic description and Identification of 20 common rocks. 4. Field Work: All the students shall undertake geological field work to study the local geology under the guidance of a teacher. Each student shall maintain a field diary and write a geological report. The minimum time spent in the field should be 15 hours.	
Pedagogy:	• Chalk and Board • PPT and Practical • demonstration of Mineral and Rock Specimens • Class Quiz	• Videos • Group Discussion • Field Visits • Flipped Classroom • Assignments
References/ Readings:	1. Blyth, F. G. H., & de Freitas, M. H. (2018). *Geology for engineers (3rd ed.).* CRC Press. 2. Grotzinger, J. P., & Jordan, T. H. (2020). *Understanding Earth.* Macmillan Learning. 3. Holmes, A. (2013). *Principles of Physical Geology.* Routledge. 4. Klein, C., & Hurlbut, C. S. Jr. (2021). *Dana manual of mineralogy.* Wiley. 5. Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2021). *Essentials of geology(13th ed.)*. Pearson. 6. Marshak, S. (2015). *Earth science (14th ed.).* John Wiley & Sons. 7. Monroe, J. S., &Wicander, R. (2015). *The changing earth: Exploring Geology and Evolution.* Cengage Learning. 8. Mukherjee, P. K., (2013). *A Textbook of Geology.* World Press. 9. Rutley, F. (2019). *Rutley's Mineralogy.* Routledge. 10. Singh, P. (1978). *A textbook of engineering and general geology (3rd ed.).* S. Chand & Company Ltd.	
Course Outcome:	At the end of the course the student will be able to: 1. Differentiate the layers of the Earth based on their structure and composition. CL2 2. Identify minerals based on their physical properties. CL3 3. Deduce the symmetry of crystals. CL4 4. Categorize rocks based on their properties. CL4	

Name of the Programme : B.Sc. Geology
Course Code : GEO-111
Title of the Course : Introduction to Geology
Number of Credits : 4 (4 Theory)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Discuss the origin and various components of the earth system. CL2 2. Describe minerals and rocks using physical properties. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Geology;Applications and Career opportunities in Geosciences. Origin, Shape, Size and internal structure of the earth. Introduction to Plate Tectonics. The Earth System: Atmosphere: Structure and Composition, Hydrosphere: Occurrence and distribution of water, Hydrological Cycle, Biosphere: Evolution of life through geologic time, Cryosphere, Geosphere: Minerals and Rocks.	**15**
Unit 2	Introduction to Minerals and Rocks: Physical and crystallographic properties of minerals, colour, streak, lustre, diaphaneity, cleavage, fracture, form, habit, hardness, specific gravity and crystal system. Uses of Minerals. Introduction of common rock – forming minerals: quartz, feldspar, micas, pyroxenes, amphiboles and olivine.	**15**
Unit 3	Scope and importance of Petrology, Rocks: their classification into three broad classes, igneous, sedimentary and metamorphic, Rock Cycle. Igneous Rocks: Mode of occurrence, Forms, structures and textures. Bowen's Reaction series. Classification based on grain size and mineral composition.	**15**
Unit 4	Sedimentary Rocks: Structures, textures and classification. Metamorphic Rocks: Agents of metamorphism, types of metamorphism, fabric and classification.	**15**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	●Videos ●Group Discussion ●Field Visits ●Assignments
References/ Readings:	1. Blyth, F. G. H., & de Freitas, M. H. (2018). *Geology for engineers (3rd ed.).* CRC Press. 2. Grotzinger, J. P., & Jordan, T. H. (2020). *Understanding Earth.* Macmillan Learning. 3. Holmes, A. (2013). *Principles of Physical Geology.* Routledge.	

	4. Klein, C., & Hurlbut, C. S. Jr. (2021). *Dana manual of mineralogy.* Wiley. 5. Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2021). *Essentials of geology(13th ed.)*. Pearson. 6. Marshak, S. (2015). *Earth science (14th ed.).* John Wiley & Sons. 7. Monroe, J. S., & Wicander, R. (2015). *The changing earth: Exploring Geology and Evolution.* Cengage Learning. 8. Mukherjee, P. K., (2013). *A Textbook of Geology.* World Press. 9. Rutley, F. (2019). *Rutley's Mineralogy.* Routledge. 10. Singh, P. (1978). *A textbook of engineering and general geology (3rd ed.).* S. Chand & Company Ltd.
Course Outcome:	At the end of the course the student will be able to: 1. Distinguish between the layers of the earth based on the structure and composition. CL2 2. Explain the Earth System. CL2 3. Identify the minerals based on their physical properties. CL3 4. Categorize different rock types. CL4

Name of the Programme : **B.Sc. Geology**
Course Code : **GEO-131**
Title of the Course : **The Dynamic Earth**
Number of Credits : **3**
Effective from AY : **2023-24**

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Discuss the origin and various components of earth system. CL2 2. Explain geologic time. CL2 3. Describe minerals and rocks using physical properties. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Geology; Applications and Career opportunities in Geosciences. Introduction to the Dynamic Earth System. Overview of Earth's systems: Atmosphere, Biosphere, Hydrosphere, Geosphere. Cryosphere. Origin, shape, size, Internal Structure and composition of the Earth. Earth's Magnetism.	**15**
Unit 2	Plate Tectonics and Continental Drift, Evolution of Himalayas. Volcanoes and Earthquakes. Geologic Time and Evolution of Life. Relative and absolute dating.	**15**
Unit 3	Introduction to minerals and their uses. Introduction to Igneous, Sedimentary and Metamorphic Rocks and their uses. Minerals and Rocks of Goa.	**15**
Pedagogy:	● Chalk and Board ● PPT and Practical ● demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Assignments	
References/ Readings:	1. Carlson, D. H., Plummer, C. C., & McGeary, D. (2016). Earth revealed. McGraw-Hill Education. 2. Dessai, A. G. (2018). Geology and Mineral Resources of Goa. New Delhi Publishers. 3. Lutgens, F. K., Tarbuck, E. J., & Tasa, D. (2021). Essentials of geology. Pearson. 4. Marshak, S. (2015). Earth: Portrait of a planet (5th ed.). W. W. Norton & Company. 5. Marshak, S., & Rauber, R. (2017). Earth Science. W.W. Norton & Company. 6. Plummer, C. C., Carlson, D. H., & Hammersley, L. (2015). Physical geology. New York: McGraw-Hill Education.	

	7. Singh, P. (1978). A textbook of engineering and general geology (3rd ed.). S. Chand & Company Ltd. 8. Thompson, J. R., & Turk, J. (2017). Introduction to Physical Geology. Pearson.
Course Outcome:	At the end of the course the students will be able to: 1. Differentiate between the layers of the earth based on the structure and composition. CL2 2. Relate the occurrence of earthquakes and volcanoes with plate tectonics. CL3 3. Identify various minerals and rocks. CL3

Name of the Programme : B.Sc. Geology
Course Code : GEO-132
Title of the Course : Physical Geology
Number of Credits : 3
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Describe the major relief features of the Earth. CL2 2. Discuss the various geological processes that operate on and near the surface of the Earth. CL2 3. Explain the formation of different landforms. CL2	
Content:		**No. of Hours**
Unit 1	Scope and importance, Major relief features of the Earth, Characteristic features of mountain, plateaus and plains, general relief features of the ocean floor. Hypsographic curve, Isostasy. Present is key to the past – Principle of Uniformitarianism	**15**
Unit 2	Weathering and Erosion - physical, chemical and biological. Rivers: development of a typical river system, source and surface flow, erosion, transport, deposition and associated landforms. Geological work of groundwater and Karst topography	**15**
Unit 3	Glaciers: types and movements, formation and morphology, erosion, transport, deposition and resulting landforms. Wind: erosion, transport and deposition and resulting landforms, types of deserts and dunes, loess. Oceans and seas: Waves and currents, erosion, transport, deposition and resulting landforms.	**15**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration	● Class Quiz ● Videos ● Group Discussion
References/ Readings:	1. Carlson, D. H., Plummer, C. C., & Hammersley, L. (2019). Physical Geology (16th ed.). McGraw-Hill. 2. Compton, R. R. (1985). Field Geology (2nd ed.). Wiley. 3. Condie, K.C. (2015). Plate tectonics and crustal evolution. Oxford: Butterworth-Heinemann. 4. Grotzinger, J. P., & Jordan, T. H. (2014). Understanding the Earth (7th ed.). W. H. Freeman. 5. Holmes, A. (2017). Physical Geology. Wiley. 6. Livard, D. A. (2016). Satellite Geology and Geomorphology (2nd ed.). Springer. 7. Monroe, J. S., & Wicander, R. (2017). The Changing Earth: Exploring Geology and Evolution (7th ed.). Cengage Learning. 8. Plummer, C. C., & McGeary, D. (2015). Physical Geology (15th ed.). McGraw-Hill.	

	9. Singh, P. (2010). Engineering and general geology. S. K. Kataria & Sons. 10. Tarbuck, E. J., & Lutgens, F. K. (2017). The Earth: An Introduction to Physical Geology (12th ed.). Pearson. 11. Thompson, G. W., & Turk, J. T. (2017). Introduction to Physical Geology (2nd ed.). Pearson. 12. Tucker, M. E. (2016). Field Geology (6th ed.). Wiley-Blackwell.
Course Outcome:	At the end of the course the student will be able to: 1. Recognize the major relief features of the earth based on their characteristics. CL2 2. Identify the landforms. CL3

Name of the Programme : B.Sc. Geology
Course Code : GEO-141
Title of the Course : Space and Drone based Remote Sensing
Number of Credits : 3 (1 Theory + 2 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Describe the remote sensing process. CL2 2. Explain the applications of remote sensing in various fields. CL2	
Content:		**No. of Hours**
Unit 1	Remote Sensing: Definition, scope and limitations. Elements of Remote Sensing, active and passive sensing. Electromagnetic radiation (EMR), Interaction of EMR with atmosphere and earth surface. Remote Sensing Platforms, Satellites: geostationary, geosynchronous and sun-synchronous satellites, types of sensors. Resolutions: spatial, spectral, radiometric, temporal resolutions. Introduction to drone photography: History of drone photography, Applications of drone photography: Environmental monitoring, Geological studies, Agriculture; Types of drones and their features.	**15**
Practical:	1. Image interpretation exercises: Using satellite or aerial images identify land cover types, features, and other relevant information based on interpretation of the image. 2. Time-series analysis: Using time-series of satellite images analyze and interpret changes in land cover, vegetation and other relevant parameters over time. 3. Remote sensing applications: Research and present on real-world applications of remote sensing technology, such as landslide monitoring or natural disaster response. 4. Drone technology and equipment: Drone components and operation, Camera and gimbal systems, Remote control and mobile app. 5. Hands-on training on Drone Photography 6. Legal and ethical considerations: Research and present on the legal and ethical considerations of drone photography, such as privacy, safety, and airspace regulations. 7. Create a short film or photo essay using drone footage.	**60**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration	●Class Quiz ●Videos ●Group Discussion

References/ Readings:	1. Carroll, M. (2019). *Drone photography basics: Your guide to the sky.* Skyhorse Publishing. 2. Gupta, R. P. (2013). *Remote sensing geology*. Springer. 3. Hall, C. (2018). *The drone photography handbook: Capture stunning aerial photos and videos with your drone.* Ilex Press. 4. Hall, M. (2018). *Aerial photography and videography using drones.* CRC Press. 5. LaRue, M. A. (2018). *Introduction to drone photography: Learn how to take stunning aerial photos and videos.* Skyhorse Publishing. 6. Lillesand, T. M., & Kiefer, R. W. (2018). R*emote sensing and image interpretation.* John Wiley & Sons. 7. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2020). *Remote sensing and image interpretation.* John Wiley & Sons. 8. Miller, M. M., & Miller, J. D. (2014). *Photogeology.* Springer Science & Business Media. 9. Moffitt, F. H., & Mikhail, E. M. (2010). *Photogrammetry.* Wiley. 10. Pande, P. C. (1987). *Principles and applications of photogeology*. IBH. 11. Reed, B. (2019). *Physical principles of remote sensing.* Cambridge University Press.
Course Outcome:	At the end of the course the student will be able to: 1. Demonstrate EMR interactions. CL2 2. Analyze the applications of satellites and sensors. CL4 3. Identify ground features using aerial photos and satellite images. CL3 4. Operate a drone according to proper procedures and safety measures. CL3

Name of the Programme : B.Sc. Geology
Course Code : GEO-142
Title of the Course : Water Quality Assessment
Number of Credits : 3 (1 Theory + 2 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Explain the occurrence and distribution of water on Earth. CL2 2. Discuss the water quality parameters and standards. CL2 3. Recognize the sources of water pollution, types of pollutants and their effects on human health and ecosystems.CL2	
Content:		**No. of Hours**
Unit 1	Introduction, hydrologic cycle Precipitation, runoff, evapotranspiration, infiltration, groundwater recharge: measuring instruments and methods Occurrence of water: surface and groundwater. Water quality parameters and WHO and BIS standards. Water pollution: Point and non-point source, major water pollutants and toxic pollutants, their properties, Arsenic and Fluoride pollution in India, microbiological pollution.	**15**
Practical:	1. Water sampling and sampling techniques. Creation of geotagged inventory of available surface water bodies around the institution. 2. Estimation of Water Quality Parameters: pH, Temperature, Electrical Conductivity, Ca Hardness, Mg Hardness, Biological Oxygen Demand (BOD), Turbidity. Rapid Test for E. coli 3. Graphical Representation of water quality parameters: Collin's Bar Graph, Stiff's Polygon, Piper's Trilinear Diagram, Schoeller's Diagram. 4. Calculation of Water quality parameters: Total Hardness, Total Dissolved Solids (TDS), Sodium Absorption Ratio, % Na, Residual Carbonate. 5. Flow Net Analysis. 6. Visit to a water purification plant or laboratory facility where water is tested.	**60**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration	● Class Quiz ● Videos ● Group Discussion
References/ Readings:	1. BIS (2001). *Bureau of Indian Standards Catalogue*, 2001. 2. David, T. (2008). *Fundamentals of Hydrology.* In Routledge eBooks. Informa. https://doi.org/10.4324/9780203933664	

	3. Dessai, A. G. (2023). *Environment, Resources and Sustainable Tourism: Goa as a Case Study (Advances in Geographical and Environmental Sciences).* Springer Verlag. 4. Fetter, CW., Bowing, T & Kreamer, D (2018): *Contaminant Hydrogeology,* Waveland. 5. Hiscock, K. M., & Bense, V. F. (2014). *Hydrogeology: Principles and Practice.* John Wiley & Sons. 6. Raghunath, H. M. (2007). *Ground Water*. New Age International. 7. WHO (1993b). *Guidelines for Drinking-water Quality.* World Health Organization.
Course Outcome:	At the end of the course the student will be able to: 1. Describe the hydrologic cycle and its components. CL2 2. Identify point and non-point sources of pollution. CL3 3. Test important water quality parameters in the field and in the laboratory. CL4 4. Illustrate water quality data graphically. CL3

Semester III
Name of the Programme : B.Sc. Geology
Course Code : GEO-200
Title of the Course : Structural Geology and Physical Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Explain the structural characters in rocks. CL2 2. Describe relief features of the Earth. CL2 3. Classify landforms formed due to action of the rivers, wind, glaciers and oceans and seas. CL3	
Content:		**No. of Hours**
Unit 1	Contours, contour reading and contour patterns; Scale and compass bearing, Stratification, Strike, Dip (true and apparent dip), Strike and Dip symbols. Folds: Causes and geometric classification of folds; importance of folds Joints: Geometric classification, importance; Faults: general characteristics, geometric classification and importance, Horst, Graben and Thrust faults;	**15**
Unit 2	Unconformities: Stages of development, types and importance of unconformities; Outliers, Inliers. Scope and importance, Major relief features of the Earth, Characteristic features of mountain, plateaus and plains, general relief features of the ocean floor. Hypsographic curve. Principle of Uniformitarianism Weathering and Erosion - physical, chemical and biological. Rivers: development of a typical river system, source and surface flow, erosion, transport, deposition and associated landforms.	**15**
Unit 3	Geological work of groundwater and Karst topography Glaciers: types and movements, formation and morphology, erosion, transport, deposition and resulting landforms. Wind: erosion, transport and deposition and resulting landforms, types of deserts and dunes, loess. Oceans and seas: Waves and currents, erosion, transport, deposition and resulting landforms.	**15**

Practical:	**PRACTICAL** 1. Clinometer compass: construction, working and uses; Fore and back bearings 2. Description and Drawing of Vertical sections of minimum 6 geological maps involving a Single Series of Horizontal, Dipping strata with vertical intrusive. 3. Structural problems involving a) Strike, True and Apparent Dips, b) Thickness and width of outcrop. 4. Representing joint sets using Rose Diagram. 5. Study of Drainage Patterns.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Duff, P. M. D. (1993). *Holmes' Principles of Physical Geology.* Springer. 2. Jain, S. (2014). *Fundamentals of Physical Geology*. Springer Geology 3. Skinner, B. J., Porter, S. C., Park, J. J., & Park, J. (2004). *The Dynamic Earth: An Introduction to Physical Geology.* John Wiley & Sons. 4. Tarbuck, E. J., & Lutgens, F. K. (2002). *Earth: An Introduction to Physical Geology.* 7th ed. Upper Saddle River, N.J., Prentice Hall. 5. Twidale, C.R. (1975). *Analysis of landforms.*	
Course Outcome:	At the end of the course the student will be able to: 1. Identify rock structures in the field. CL3 2. Identify the landforms in the field. CL3 3. Collect structural data of the rocks. CL4 4. Relate the structural features of the rocks with the landforms. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-201
Title of the Course : Principles of Stratigraphy and Palaeontology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Describe the principles of stratigraphy. CL2 2. Illustrate the modes of preservation of fossils. CL2 3. Classify the fossils. CL2	
Content:		**No. of Hours**
Unit 1	Stratigraphy: scope and importance; Principles of Stratigraphy: Laws of uniformitarianism, original horizontality, order of superposition, faunal succession, cross-cutting relationship, inclusions; Correlation and methods of correlation: Structural relations (tectonic criteria), Lithological similarity (Marker horizon or key bed), Paleontological criteria (Index fossils), Standard Stratigraphic timescale; Indian stratigraphic timescale; Geological Time Units: - Eon, Era, Period, Epoch, Age, Phase. Chronostratigraphic Units: - Erathem, System, Series, Stage and Zone. Lithostratigraphic Units: - Group, Formation, Member, Bed and laminae. Relative and Absolute Age. Radiometric Dating.	**15**
Unit 2	Fossils: Definition and types: Mega fossils (dinosaurs), Microfossils, Ichnofossils; Conditions for fossilization; Modes of preservation of organic remains: Biologic, mechanical and chemical destruction; Factors limiting distribution of organisms: sunlight, depth of water, oxygen, seawater temperature, salinity, substratum & food. Modes of fossilization; Derived fossils; transported fossils; Index fossils and Endemic fossils; Uses of fossils; Introduction to taxonomy and species concept.	**15**
Unit 3	Study of general characteristics, morphology, habitats and geological history of the following Phylla with their biostratigraphic significance: Phylum Mollusca: Pelecypoda, Gastropoda, Cephalopoda (Classes Nautiloidea, Ammonoidea, Belemnoidea) with Indian examples, if any; Significance of ammonites. Phylum Brachiopoda: Articulata, Inarticulata; Phylum Echinodermata: Echinoidea, Crinoidea; Phylum Arthropoda: Trilobita; Phylum Protozoa: Foraminifera with examples. Origin of Vertebrates and major steps in vertebrate evolution, Mesozoic reptiles with special reference to diversity	**15**

	and extinction of Dinosaurs with Indian examples. Human evolution. Gondwana flora.	
Practical:	1. Problems on correlation. 2. Study of fossils showing various modes of preservation. 3. Description, Classification and Identification, Habitat, and Geological Time Range of minimum 25 Fossils	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ●Videos ●Group Discussion ●Field Visits ●Flipped Classroom ●Assignments	
References/ Readings:	1. Black, R. M. (1988). *The elements of Palaeontology*. Cambridge University Press. 2. Brookfield, M. E. (2008). *Principles of Stratigraphy.* John Wiley & Sons. 3. Clarkson, E. N. K. (2013). *Invertebrate Palaeontology and Evolution.* John Wiley & Sons. 4. Doyle, P. (2014). *Understanding fossils: An Introduction to Invertebrate Palaeontology*. John Wiley & Sons. 5. Kumar, R. (1985). *Fundamentals of Historical Geology and Stratigraphy of India.* 6. Press, F., & Siever, R. (2001). *Understanding Earth*. 7. Shah, SK. (2013) *Elements of Palaeontology (1st ed.).* The Geological Society of India. 8. Spencer, E. W. (1962). *Basic concepts of Historical Geology*.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain the principles of stratigraphy. CL2 2. Explain modes of preservation of fossils. CL2 3. Classify various types of fossils. CL3 4. Correlate the stratigraphic sections. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO 211
Title of the Course : The Changing Earth
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Discuss the processes involved in shaping the Earth's surface by natural agencies. CL2 2. Describe various erosional and depositional landforms. CL2	
Content:		**No. of Hours**
Unit 1	Weathering and Erosion: Mechanical Weathering – Pressure Release, Frost Action, Thermal Expansion and Contraction, Salt Growth. Chemical Weathering – Organisms Role, Oxidation, Acid Action, Dissolution/Leaching, Hydrolysis, Spheroidal Weathering, Biological Weathering Agents of Transportation – Wind, Water, Glaciers, Gravity, Modes of transportation – Bed Load (sliding, rolling, saltation), Suspension, dissolved load, Factors Affecting Deposition.	**15**
Unit 2	Geological work of Wind: Generation of Winds, types and Characteristics of Deserts. Sediment Transport. Desert Landforms: Depositional; sand dunes, Sand Seas/Ergs, Playa, sabkha, loess, Erosional; Grooves, Ventifacts & Yardangs, mushroom rock, Inselbergs, Mesas and Buttes. Deflation Basin, Desert Pavement and Lag Gravel. Geological work of groundwater: Erosion: Karst Topography – Caves, Sinkholes, Solution Valleys, Disappearing Streams, Tower Karst. Deposition: Speleothems – Stalactites, Stalagmites.	**15**
Unit 3	Geological work of River: Drainage Basin and River System: Drainage Patterns. Erosion by River: Erosional Features - Steep Valleys, Gorges, Potholes, Waterfall, Meander, Ox Bow Lake, Hogbacks, Cuestas. Depositional Landforms by River; Floodplains, Deltas, Alluvial Fans. Geological work of Oceans and Seas: Waves and Currents, Erosional Features - Sea-cliffs, wave-cut platform, sea-arches, sea-caves, sea-stacks. Geological work of Glaciers: Erosional Features of Glaciers: Valley glacier - U-shaped Valleys, Cirques, Fjords. Erosional Striations, Drumlins, Erratics. Depositional Features of Glaciers - Glacial Drift; Till and Stratified Drift, Moraines.	**15**
Practical:	**PRACTICAL** 1. Study of Drainage Patterns.	**30**

	2. Basin morphometry - Perimeter Calculation, Area Calculation, Stream Ordering, Bifurcation and Length ratio, Basin Circularity, Drainage Density, Stream Frequency 3. Drawing long and cross profile of rivers. 4. Identify and interpret the formation of landforms using images.	
Pedagogy:	• Chalk and Board • PPT and Practical demonstration of Mineral and Rock Specimens	• Videos • Field Visits • Assignments • Class Quiz
References/ Readings:	1. Monroe, S. J and Wicander R. (2014). *The Changing Earth: Exploring Geology and Evolution*. Brooks Cole Publishers. 2. Carlson, D.H., Plummer, C.C., McGeary, D. (2008). *Physical Geology: Earth revealed.* Higher Education. 3. McConnell, D., Steer, D., Knight, C., Owens, K., Park, L. (2008). *The Good Earth – Introduction to Earth Science.* Higher Education. 4. Monroe, J.S., Wicander, R., Hazlett, R. (2007). *Physical geology – Exploring the Earth (6th Ed.)* Thomson Brooks/Cole.	
Course Outcome:	At the end of the course, the student will be able to: 1. Explain the processes of weathering, erosion, transportation and deposition by various agents. CL3 2. Interpret various landforms associated with work of wind and groundwater. CL3 3. Identify various landforms formed by action of rivers, glaciers and oceans and seas. CL3 4. Solve problems related to fluvial geomorphology. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-231
Title of the Course : Natural Hazards
Number of Credits : 3 (3 Theory)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Discuss the causal factors for natural hazards. CL2 2. Discuss past disasters. CL2 3. Describe methods of mitigation. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Natural Hazards: Definition, distinction between natural and anthropogenic hazards, global distribution and frequency of hazards. Earthquakes: Definition, Magnitude and Intensity, Causes, Seismic waves, earthquake-prone zones, earthquake prediction; Impacts: primary and secondary effects and mitigation. Case study. Tsunamis: mode of origin, hazard mitigation; Case studies.	**15**
Unit 2	Coastal hazards and mitigation: cyclones, coastal flooding, coastal erosion. Hurricanes, Typhoons, and Cyclones: Formation, tracking, and impacts. Floods and their management: Types of floods, factors governing flood severity, development in floodplains, flood mitigation. Droughts: Causes, impacts on ecosystems and societies, and mitigation. Tornadoes: Formation, characteristics, and safety measures.	**15**
Unit 3	Slope stability and mass movements: Forces acting on slopes and factors affecting them, Factor of safety; Types of mass movements: Creep, rockfalls, landslides and slumps, mudflows and debris flows, snow avalanches, sinkholes and land subsidence; Impact, preventive measures and monitoring of mass movements: Loss of life and property, landslide hazard zones of India, preventive measures, monitoring and recognition of impending movements; Case study. Volcanic Eruptions: Types of volcanoes, volcanic hazards and mitigation.	**15**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration	● Class Quiz ● Videos ● Group Discussion
References/ Readings:	1. Alexander, D.C. (1993). Natural Disasters (1st ed.). Routledge. https://doi.org/10.1201/9780203746080 2. Edward Keller (2012) Introduction to Environmental Geology. Pearson Prentice Hall. 5th Edition.	

	3. Hyndman, D.W., & Hyndman, D.W. (2005). Natural hazards and disasters. 4. Keller, E.A., & DeVecchio, D.E. (2019). Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes (5th ed.). Routledge. 5. Montgomery, C. W. (2020). Environmental geology. New York, NY McGraw-Hill Education 6. Singh, R., & Bartlett, D. (Eds.). (2018). Natural Hazards: Earthquakes, Volcanoes, and Landslides (1st ed.). CRC Press. https://doi.org/10.1201/9781315166841 7. Valdiya, K. S., 2010. The Making of India: Geodynamic Evolution, Macmillan, Noida. 8. Valdiya. (2013). Environmental geology. McGraw Hill Education (India) Private Limited.
Course Outcome:	At the end of the course the student will be able to: 1. Explain the causes behind the natural hazards. CL2 2. Identify and predict the impact of natural hazards. CL3 3. Suggest measures to mitigate the impact of natural hazards. CL3

Name of the Programme : **B.Sc. Geology**
Course Code : **GEO 232**
Title of the Course : **Environment of Goa – Issues and Challenges**
Number of Credits : **3 (3 Theory)**
Effective from AY : **2023-24**

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Describe the environmental components of Goa. CL2 2. Discuss the sources of contamination and degradation of natural environment in Goa. CL2 3. Deliberate on the various solutions for different environmental concerns in Goa. CL2	
Content:		**No. of Hours**
Unit 1	Physiographic divisions of Goa, climate, demography, major industries: tourism, mining and pharmaceutical. Land and water resources of Goa. Ecologically sensitive areas of Goa: wetlands, khazan lands, Western Ghats. Solid Waste: Generation and its disposal with least impediment to Environment. Types of waste: municipal waste, bio-medical waste, electronic waste, construction and demolition waste, plastic waste, microplastics, glass waste, mining waste and rubber waste. Disposal of waste, recycling of waste, reuse of waste.	**15**
Unit 2	Impact of waste on land, soil and water resources both - surface and groundwater, quality control, impact on aquifers, remedial measures. Leachates and their impact. Biodegradable waste as major concern of the State. Contamination of water resources both - surface and groundwater. Quality of water: physical, chemical and biological pollutants. Sewage treatment and disposal. Ballast waters.	**15**
Unit 3	Overexploitation of groundwater in coastal areas, salt water intrusion. Stress on limited resources due to urbanization. Threat to forest cover, landscape adjustment / modification, effect of roads and railways. Mass tourism- State population vs floating population, impact on environment.	**15**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration	● Class Quiz ● Videos ● Group Discussion
References/ Readings:	1. Alvares Claude (1999*) Fish, Curry and Rice*, Goa Foundation. 2. Alvares Claude and Reboni Saha (2008) *Goa: Sweet Land of Mine*, Goa Foundation. *3.* Dessai A. G. (2021) *Geology and Mineral Resources of Goa, Om publications.*	

	4. Dessai A. G. (2023) *Environment Resources and Sustainable tourism, Goa as case study*, Springer Nature.
Course Outcome:	At the end of the course the student will be able to: 1. Identify physiographic features and the natural resources of Goa. CL3 2. Explain the effect of anthropogenic activities on the natural resources of Goa. CL3 3. Categorize different kinds of contaminants that are degrading Goa's natural resources. CL3 4. Deduce solutions to minimize the degradation of Goa's natural resources. CL3

Name of the Programme : B.Sc. Geology
Course Code : GEO-241
Title of the Course : Crystals and Gemstones
Number of Credits : 3 (1 Theory + 2 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Discuss the occurrence of minerals in rocks and the processes involved in their formation. CL2 2. Describe the natural, synthetic, and organic gemstones. CL2 3. Describe the physical and optical properties of crystals and gemstones. CL1	
Content:		**No. of Hours**
Unit 1	Minerals and Mineraloids. Occurrence of Minerals in rocks. Crystals and their characteristics - Faces, Systems, Symmetry, Forms. Gemstones - natural, synthetic gemstones and organic products. Physical and optical properties of crystals/gemstones Colour, Pleochroism, Lustre, Play of colours (Iridescence, Labradorescence, Adularescence, Aventurescence, Opalescence), Luminescence (Fluorescence,Phosphorescence, Thermoluminescence, Triboluminescence), Crystal habit, Cleavage, Parting, Fracture. Imperfections in Crystals.Internal (point defects, Inclusions), Chatoyancy, Asterism.Factors deciding the cost of a gemstone.Enhancement and Treatments of gemstones.Synthesis of gemstones. Need for Faceting. Styles of cut.	**15**
Practical:	1. Study of crystal models/ crystals. 2. Identification and description of minerals. 3. Description & Identification of cuts in gemstones. 4. Identification of gemstones using Dichroscope, Polariscope, Spectroscope, Refractometer, Ultra Violet lamp, Gemological Microscope.	**60**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration ● Class Quiz ● Videos ● Group Discussion	
References/ Readings:	1. Fernandes S. and Choudhary G., (2010). *Understanding Rough Gemstones*, Indian Institute of Jewellery. 2. Karanth, R V; (2000). *Gem and Gem deposits of India*, Geological Society of India. 3. Read, P. G., (1991). *Gemmology*, Butterworth-Heinemann Ltd.	

	4. Sinkankas, J., (1969) *Mineralogy: A First Course*, Van Nostrand Reinhold Company. 5. Webster, R., edited by Anderson, B, W., (1983) *Gems: Their Sources, Descriptions and Identification,* Butterworth-Heinemann Ltd.
Course Outcome:	At the end of the course the student will be able to: 1. Explain the Physical and optical properties of crystals/gemstones. CL2 2. Examine imperfections in crystals and gemstones. CL3 3. Identify crystals and gemstones.CL3

Name of the Programme : B.Sc. Geology
Course Code : GEO-242
Title of the Course : Introduction to GIS
Number of Credits : 3 (1 Theory + 2 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to:: 1. Describe the components of GIS. CL2 2. Explain the working of GIS and GPS. CL2	
Content:		**No. of Hours**
Unit 1	Definition, Components of GIS; hardware, software, data, skill, layout and Objectives of GIS. Geographic Phenomena, Geographic Objects, Scale and Resolution, Coordinate Systems, Geo-referencing. Geographic Data: Data Sources, Data types: Spatial and Non-Spatial; Spatial Data Types: Vector (point, line, polygon) and Raster (pixels); non-spatial: information about features (roads, schools, census data); Database Management System: Definition, difference between Standard and Spatial Database. Spatial Analysis: Vector based and Raster based Operations for Spatial analysis: Attribute Query and Spatial Query, Digital Elevation Model. Geographical Positional System (GPS); types and applications.	**15**
Practical:	1. Use GIS software (such as ArcGIS, QGIS, or others) to create a simple map. 2. Importing raster and vector images. 3. Georeferencing raster and vector data by adding or editing geographic coordinates. 4. Creating new vector layers (point, line or polygon). 5. Customize the map's appearance by changing colours, symbols, and labels. 6. Digitizing geographic features on a map and adding attribute data. 7. Use attribute queries to filter and select specific data based on certain criteria. 8. Using mobile GIS applications to collect data in the field. 9. Design a map layout by adding and arranging map elements like legend, scale bar and north arrow.	**60**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration	● Class Quiz ● Videos ● Group Discussion
References/ Readings:	1. Fotheringham, S., & Rogerson, P. (2013). *Spatial analysis and GIS*. CRC Press.	

	2. Kang-tsung C (2007). *Introduction to Geographic Information Systems.* Tata MCGraw Hill, New Delhi. 3. Maguire, D. J., Goodchild, M. F., & Rhind, D. (1991). *Geographical Information Systems: applications*. 4. Yeung (2006). *Concepts and Techniques of Geographic information Systems*. Prentice Hall of India, New Delhi.
Course Outcome:	At the end of the course the student will be able to: 1. Use GIS software. CL3 2. Operate GPS. CL3 3. Generate maps using GIS software. CL6

Semester IV
Name of the Programme : B.Sc. Geology
Course Code : GEO-202
Title of the Course : Descriptive Mineralogy
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals, their properties and chemical composition.	
Course Objectives:	The objectives of this course are to: 1. Explain the binary systems and their applications to magmatic textures and processes CL2 2. Discuss different mineral groups. CL2 3. Identify minerals megascopically. CL2 4. Demonstrate mineral chemical calculations. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to mineralogy: definition of a mineral, Phase rule, system, Phase components, degrees of variance, Mineralogical Phase rule. Binary system-with eutectic (Di-An) and with solid solution (Ab-An).	**15**
Unit 2	Classification of Minerals: Silicates and Non-silicates. Opaque and transparent minerals. Structure of silicate minerals - Nesosilicates, sorosilicates, inosilicates, cyclosilicates, phyllosilicates and tectosilicates. Description of following silicate mineral groups with respect to chemical composition, structure, physical properties and paragenesis: olivine, pyroxene, amphibole and mica.	**15**
Unit 3	Description of following silicate mineral groups with respect to chemical composition, structure, physical properties and paragenesis: feldspar, feldspathoids and silica. Non-Silicate minerals: Sulphides (Cu, Pb, Zn), oxides, hydroxides (Fe, Mn, Cr, Ti), hydroxides of aluminum (Bauxite). Metamorphic minerals: garnet, staurolite, chlorite, andalusite - kyanite - sillimanite. Uses of X-rays in crystallography and mineralogy.	**15**
Practical:	1. Identification and description of the physical properties, compositions, occurrence and uses of 30 common minerals. 2. Calculation of weight percent of elements and oxides. 3. Calculation of mineral formula. 4. Calculation of end-members for olivine, pyroxene and feldspar group of minerals. 5. Calculation of Structural Formula for the common silicate group of minerals.	**30**
Pedagogy:	● Chalk and Board	● Videos

	● PPT and Practical ● demonstration of Mineral and Rock Specimens ● Class Quiz	● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Berry and Mason: *Mineralogy*. CBS Publ. and Distr. 2. Deer, W. A., Howie, R. A., & Zussman, J. (1978). *Rock-forming minerals: Feldspars, Volume 4A.* Geological Society of London. 3. Klein, C., & Hurlbut, C. S. Jr. (2021). *Dana manual of mineralogy.* Wiley. 4. Perkins, D. (2013). *Mineralogy*: Pearson Higher Ed. 5. Rutley, F. (2012). *Rutley's Elements of Mineralogy.* Springer Science & Business Media.	
Course Outcome:	At the end of the course the student will be able to: 1. Compare the working of various binary systems and their applications to magmatic textures and processes. CL2 2. Distinguish between different minerals/mineral groups. CL2 3. Identify minerals based on their physical properties. CL3 4. Calculate mineral formula. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-203
Title of the Course : Introduction to Mining Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Explain the types and processes involved in the mining industry. CL2 2. Discuss laws governing the mining industry. CL2 3. Describe environmental concerns related to mining. CL2 4. Demonstrate preparation of mine development plan, Environmental Management Plan and Key Plan. CL2	
Content:		**No. of Hours**
Unit 1	Mining: Introduction to Mining, Mining methods (Surface, Underground); Overview of the Mining Industry (Exploration stage, Planning stage, Mining stage, Ore processing, Exports, Environmental management). Role of a geologist in the mining industry, Case study: Mining Scenario in Goa. Mineral exploration (G4, G3, G2 and G1), Geological mapping, Types of drilling, drilling equipment and accessories. Sampling techniques, borehole logging, core, sludge.	**15**
Unit 2	Mineral resources and reserves, Types of mineral resources, Categorization of reserves based on UNFC, Estimation of ore reserves. Grades of Ore: mine cut-off, mill cut-off, breakeven grades. Rules and regulations: MM(DR) Act 1957, Offshore Areas Minerals Concession Rules 2006, Mineral Auction Rules 2015, MCDR 2017, MCR 2016, Mineral (Evidence of Mineral Content) Rules 2015, Manual for preparation of Mining plan, NMET Rules. Regulatory Bodies and their role- National Mineral Exploration Trust (NMET), Ministry of Earth Sciences (MOES), Ministry of Environment & Forest (MoEF), District Mineral Foundation (DMFs), Indian Bureau of Mines (IBM), Central Pollution Control Board (CPCB), Directorate of Mine (DMG - Goa).	**15**
Unit 3	Mine Planning, Mining machinery, Mining below water table and mine drainage, quality control. Mineral beneficiation (dry, wet). Environmental impact due to mining. Environmental Impact Assessment (EIA), Environmental Management Plan (EMP). Utilization and conservation of mineral resources. Case studies.	**15**
Practical:	1. Preparation of lithologs from core data. 2. Drawing of cross-section and longitudinal sections based on borehole data.	**30**

	3. Estimation of reserves. 4. Preparation of mine development plan. 5. Preparation of Environmental Management Plan and Key Plan.	
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Arogyaswamy, R. N. P. (1973). *Courses in Mining Geology*. III Edition, Oxford and IBH publication Co. 2. Babu S.K. and Sinha D. K. *Practical Manual of Exploration and Prospecting*, CBS Publishers and Engineers. 3. McKinstry, H. E. (1948). *Mining Geology*, Prentice Hill Inc.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain the different processes related to the mining industry. CL3 2. Evaluate mineral resources. CL3 3. Practice sustainable mining methods. CL3 4. Interpret lithologs and cross-sections based on borehole data. CL4	

Name of the Programme : B.Sc. Geology
Course Code : GEO-204
Title of the Course : Geotectonics and Associated Rocks
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of structural geology and plate tectonics.	
Course Objectives:	The objectives of this course are to: 1. Describe the earth's internal processes in regards to magnetism, gravity and high-pressure transformations. CL2 2. Explain the process of plate tectonics and plate interactions. CL2 3. Illustrate the causes of earthquakes and volcanoes. CL2 4. Identify various rock types associated with plate boundaries. CL2	
Content:		**No. of Hours**
Unit 1	Seismic exploration of the Earth's interior, high pressure transformations. Earth's Gravity: acceleration due to gravity, change with latitude and altitude, mass and density; Isostasy. Earth's Magnetism: Earth as a magnet, Origin of magnetic field, lines of force, inclination and declination, geomagnetic axis and geographic axis.	**15**
Unit 2	Continental drift: Geographic, geological, paleontological, paleoclimatic and paleomagnetic evidence. Sea Floor spreading and Vine & Matthews hypothesis. Introduction to Plate tectonics, Lithospheric plates, Plate boundaries (Subduction zones, mid-ocean ridges, and transform faults) and plate interactions, plate motions. Mantle convection and its role in plate tectonics. Growth and assembly of continents, Supercontinent cycles. Rise of Himalayas.	**15**
Unit 3	Earthquakes: Seismic waves, Magnitude (Richter Scale), Intensity (Mercalli Scale), Types of Earthquakes (shallow, intermediate, deep); Tsunamis: mode of origin; Volcanoes: Types and distribution, Ring of fire. Petrotectonic assemblages: Ophiolites, Basalt (MORB, OIB, Tholeiitic), Granite (S-I-A-M types), Eclogite, Blueshists, Greenschists, Granulites, Marble, Slate, Gneiss, Sandstone, Limestone, flysch and molasse.	**15**
Practical:	1. Plotting the epicenter of an earthquake. 2. Problems based on the magnitude of an earthquake. 3. Assigning Mercalli values to hypothetical descriptions. 4. Hand specimen descriptions of 10 rock types.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom

		• Assignments
References/ Readings:	1. Billings, M. P. (1954). *Structural Geology*. 2. Duff, P. M. D. (1993). *Holmes' Principles of Physical Geology*. Springer. 3. Ghosh, S. (2013). *Structural Geology: fundamentals and modern developments.* Elsevier. 4. Gokhale, N. (2006). *Manual of Problems Structural Geology.* 5. Monroe, J. S., &Wicander, R. (2001). *The changing Earth: Exploring Geology and Evolution*. Brooks Cole. 6. Plummer, C. C., Carlson, D. H., & McGeary, D. (2007). *Physical Geology*. 7. Press, F., & Siever, R. (2001). *Understanding Earth*. 8. Valdiya, K. (2015). *The Making of India: Geodynamic Evolution.* Springer.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain the variation of magnetism and gravity on the surface of the Earth. CL2 2. Identify plate boundaries. CL2 3. Calculate the Richter magnitude and Mercalli intensity values of an earthquake. CL3 4. Classify various rock types. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-205
Title of the Course : Geology of Goa
Number of Credits : 2 (1 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of different rock types.	
Course Objectives:	The objectives of this course are to: 1. Discuss the physiography and drainage of Goa. CL2 2. Explain the stratigraphy and structure of the rocks in Goa. CL2 3. Describe the ore deposits of Goa. CL2	
Content:		**No. of Hours**
Unit 1	Physiography and Drainage of Goa. Supracrustals of Goa, Shimoga-Goa Schist Belt, lithostratigraphic Classification of supracrustal rocks of Goa: Barcem Group and Ponda Group. Correlation of Goa Group to Dharwar Supergroup. Goa Group: environments of deposition, Komatiitic ultramafics, Granitic Gneisses, Late Intrusive granites, mafic intrusive rocks, laterites and recent sands. Bondla mafic-ultramafic complex: petrography. Structure of Goa Group of rocks. Economic deposits of Goa: age, regional structure, ore types, mineralogy, grade of ore.	**15**
Practical:	**Field work:** All the students shall undertake geological field work under the guidance of a teacher. Each student shall maintain a field diary and write a geological report.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments	
References/ Readings:	1. Dessai, AG. (2018). *Geology and mineral resource of Goa*. New Delhi Publishers. 2. Gokul, A. R. (1985) *Structure and tectonics of Goa.* In: Proceedings of the Seminar on Earth's resources for Goa's development, Geological Survey of India, 14–21. 3. Gokul, A. R., Srinivasan, M. D., Gopalkrishnan, K. and Vishwanathan, L. S. (1985) *Stratigraphy and structure of Goa.* In: Proceedings of the Seminar on Earth's resources for Goa's development, Geological Survey of India, 1-13. 4. Natural Resources of Goa – A Geological Perspective, Geological Society of Goa (2009).	
Course Outcome:	At the end of the course the student will be able to: 1. Describe Geology and Physiography of Goa. CL2	

	2. Classify the rocks of Goa with respect to the stratigraphy and age. CL3

Name of the Programme : B.Sc. Geology
Course Code : GEO-221 (VET)
Title of the Course : Introduction to Engineering Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of structural geology	
Course Objectives:	The objectives of this course are to: 1. Explain the engineering properties of rocks. CL2 2. Discuss methods of geological investigations for selection of sites for engineering projects. CL2 3. Describe various techniques for the improvement of sites. CL3	
Content:		**No. of Hours**
Unit 1	Role of geologists in engineering projects. Engineering properties of rocks. Rock as material for construction, rock as site for construction. Geotechnical Projects: Geological Investigations and methods of investigation (geophysical).	**15**
Unit 2	Dams and reservoirs: types of dams, site selection and influence of geological conditions stability and failure of dams. Induced seismicity related to dams and environmental impact. Tunnels: types of tunnels (based on shape and utility), stress conditions in tunnels, site selection and influence of geological conditions on stability, effect of water table in tunnelling project.	**15**
Unit 3	Buildings (types of foundations and geological considerations), Bridges (types and geological considerations), Roads (construction in different geological terrains). Canals: stability and problems. Improvement in sites: Grouting, backfilling, soil stabilization. Rock Quality Designation (RQD), Rock Mass Rating (RMR) and slope stability study.	**15**
Practical:	1. Exercises in engineering geology with respect to tunnel alignment. 2. Exercises in engineering geology with respect to dam locations. 3. Calculation of RQD on the basis of core log. 4. Calculation of RMR based on Bieniawski, 1989 table.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Assignments
References/ Readings:	1. Bell F. G. (2007).*Engineering Geology*, Second Edition, Butterworth-Heinemann. 2. Blyth, F. G. H., & De Freitas, M. H. (1967). *Geology for engineers*. http://ci.nii.ac.jp/ncid/BA07203247	

	3. Kesavulu C. (2009).*A textbook of Engineering Geology*, Macmillan publishers. 4. Singh P. (2013).*Engineering and General Geology*. Katson books. 5. Valdiya, K. S. (1985).*Environmental Geology Indian Context,* TMH.
Course Outcome:	At the end of the course the student will be able to: 1. Compare engineering properties of rocks and determine its suitability for various engineering projects. CL4 2. Select the appropriate sites for engineering projects.CL5 3. Suggest remedial measures for the improvement of sites.CL4 4. Calculate of RQD and RMR. CL3

Name of the Programme : B.Sc. Geology
Course Code : GEO-222 (VET)
Title of the Course : Geophysical Exploration
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Explain the role of geophysics in exploration of earth's natural resources. CL2 2. Describevarious geophysical techniques employed in exploration. CL2 3. Select the suitable geophysical technique-based nature of the resource. CL2 4. Interpret the retrieved geophysical data. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Geophysics, applications of geophysics in various fields of earth science. Seismic method of geophysical exploration: Introduction, principles of seismic reflection and seismic refraction surveying, applications.	**15**
Unit 2	Gravity method of geophysical exploration: Introduction, corrections to gravity data, Interpretation and applications. Magnetic method of geophysical exploration: Introduction, Types of magnetic surveying instruments, Corrections, Interpretation of magnetic anomalies, Applications of magnetic surveying.	**15**
Unit 3	Electrical method of geophysical exploration: Introduction, resistivity method, Applications of resistivity methods. Induced Polarization (IP) method: Introduction, interpretation and applications. Self-Potential (SP) method: Introduction, interpretation of SP anomalies, applications. Radioactive methods: Introduction and instruments.	**15**
Practical:	1. Working of geophysical tools: Gravimeter, Magnetometer, Resistivity meter. 2. Plotting of Geophysical data. 3. Interpretation of Geophysical data.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Assignments	
References/ Readings:	1. Keary P, Brooks M, Hill I. (2002) *An Introduction to Geophysical Exploration*. Blackwell Publishers. 2. Lowrie, W. (2007). *Fundamentals of geophysics*. Cambridge University Press.	

	3. Rao, R, Prasaranga, M. B. (1975). *Outlines of Geophysical Prospecting: A manual for geologists.* University of Mysore, Mysore 4. Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). *Applied Geophysics*. Cambridge university press.
Course Outcome:	At the end of the course the student will be able to: 1. Relate the role of geophysics in exploration of natural resources. CL3 2. Choose a suitable exploration method depending on the nature and type of the resource under investigation. CL3

Semester V
Name of the Programme : B.Sc. Geology
Course Code : GEO-300
Title of the Course : Ore Genesis
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of economic minerals.	
Course Objectives:	The objectives of this course are to: 1. Distinguish the ores based on their physical properties and plate tectonic environments. CL2 2. Describe the ore forming process. CL2 3. Discuss the distribution of ore minerals and deposits found in India. CL2	
Content:		**No. of Hours**
Unit 1	Definition of ore, gangue, grade of ore/ tenor, assaying, beneficiation, Prospects, Resource & Reserves. Classification of Ore Deposits: Modified Lindgren's Scheme; Bateman Scheme. Processes of ore formation and ore genesis. Hypogene, Supergene, Epigenetic and Syngenetic mineral deposits. Ore Deposits in Space and time - Metallogenic Epochs. Formation of ore deposits in relation to plate tectonics.	**15**
Unit 2	Ore Processes: Magmatic, sublimation, contact metasomatic (skarn), hydrothermal, Volcanic exhalative, Sedimentary, Residual Concentration, Mechanical concentration (Placer deposits). Oxidation and supergene enrichment.	**15**
Unit 3	Geology, of occurrence, distribution and origin of the following ore/mineral deposits in India: Metallic: Iron, Manganese, Aluminum, Chromium, Copper-Lead-Zinc, Gold. Non-metallic Deposits: Coal and petroleum, Diamond, Baryte, Bauxite. Radioactive Minerals. Industrial Minerals: Refractory, Abrasives, Cement, Fertilizer, Electrical and Electronics.	**15**
Practical:	1. Identification and Description of the Physical Properties, Composition, Occurrences and Uses of minimum 20 economic minerals. 2. Identification and Description of 5 ore minerals under reflected light. 3. Plotting the occurrence of economic mineral deposits on an outline map of India.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments

References/ Readings:	1. Bateman, A. M. (1950). *Economic mineral deposits*. 2. Condie, K. C. (2015). *Plate Tectonics & Crustal Evolution*. Elsevier. 3. Craig, J. R., & Vaughan, D. J. (1994). *ORE microscopy and Ore petrography*. Wiley-Interscience. 4. Evans, A. M. (2011). *ORe Geology and Industrial Minerals: An Introduction*. http://ci.nii.ac.jp/ncid/BA19370745 5. Sawkins, F. J. (2013). *Metal deposits in relation to plate tectonics*. Springer Science & Business Media. 6. Tarling, D. H. (1981). *Economic Geology and Geotectonics*. Wiley-Blackwell.
Course Outcome:	At the end of the course the student will be able to: 1. Identify the ore minerals in hand specimens and under the microscope. CL3 2. Explain the ore forming process. CL2 3. Plot the ore deposits on the outline map of India. CL2 4. Describe various ore minerals and deposits found in India. CL2

Name of the Programme : B.Sc. Geology
Course Code : GEO-301
Title of the Course : Structural Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of structural geology.	
Course Objectives:	The objectives of this course are to: 1. Illustrate the concept of stress, strain and rock deformation.CL2 2. Classify folds, faults, lineations, joints and unconformities. CL2 3. Infer structures from geological data. CL2	
Content:		**No. of Hours**
Unit 1	Introduction, Non- Tectonic and Tectonic structures. Force: Definition, Units, Balanced vs unbalanced Force, Composition and Resolution of forces. Stress: Definition, Stress on a plane (2D), stress at a point (3D), Stress Ellipsoid. Concept of rock deformation and Strain (Translation, Rotation, strain and volume change). Strain Ellipsoid. Mechanical behavior of rocks and the factors that control mechanical behavior in rocks.	**15**
Unit 2	Folds: Nomenclature and geometry of simple folds. Genetic classification of folds: Fold mechanics: Active vs passive), types of folding: Bending, buckling, flexure slip folding, neutral surface folding, shear folding, flow folding). Kinds of folds: Antiform, synform, isoclinal, recumbent, chevron, box, kink, open, close, similar, parallel and homocline. Anticline and Syncline. Determination of top of the beds. Drag folds Foliation: Tectonites, Types Secondary Foliations Rock cleavage, fracture cleavage, shear cleavage, slip cleavage. Mechanism of development of foliation in rocks. Relationship of cleavage and schistosity with major structure.	**15**
Unit 3	Lineations: Types of Secondary Lineation: Mineral lineation, Intersection lineation, surface lineation, slickensides, boudins, mullions, rods. Origin of Lineation. Joints: Terminology of joints: Systematic, Nonsystematic joints, Joint set, system, tensional and shear fractures. Development of Tensional and Shear fractures under different stress conditions. Genetic classification of joints. Faults: Terminology and anatomy of Faults, Recognition of Faults, Brittle and Ductile faults. Shear sense indicators. Genetic classification of faults: Anderson's classification of faults. Unconformities: Recognition of unconformities and distinction of faults from Unconformities in the field.	**15**

Practical:	1. Drawing of sections of minimum three geological maps involving two series with vertical and inclined intrusions, vertical and inclined faults and folds. 2. Completion of minimum three outcrops including one three-point problem and one fault. 3. Three-point problems using borehole data 4. Interpretation of Shear sense indicators in rocks. 5. Minimum four structural problems using Stereographic Projection.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments	
References/ Readings:	1. Billings, M. P. (1974). Structural Geology, 3rd Ed. Pearson 2. Davis, G. H., Reynolds, S. J., & Kluth, C. F. (2011). *Structural geology of rocks and regions*. John Wiley & Sons. 3. Fossen, H. (2016). *Structural Geology*, Cambridge University Press. 4. Ragan, D. M. (2009). *Structural Geology: An Introduction to Geometrical Techniques*. Cambridge University Press. 5. Van Der Pluijm, B. A., & Marshak, S. (2004). *Earth structure: An Introduction to Structural Geology and Tectonics.* W. W. Norton.	
Course Outcome:	At the end of the course the student will be able to: 1. Identify the kinds of folds, faults, lineations, foliations, joints and unconformities. CL3 2. Interpret the geological history based on shear sense indicators. CL3 3. Draw and describe geological maps. CL2 4. Compare and Contrast between Ductile and Brittle deformation. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-302
Title of the Course : Igneous Petrology-I
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of rock cycle and various rock types	
Course Objectives:	The objectives of this course are to: 1. Describe the processes involved in the formation of igneous rocks and their diversity. CL2 2. Classify igneous rocks. CL2 3. Discuss the crystallization of melts by studying textures and structure of igneous rocks. CL2	
Content:		**No. of Hours**
Unit 1	Distribution of igneous activity in relation to plate margins and plate interiors. Factors responsible for generation and ascent of magma. Magmas: characteristics with respect to temperature, density, viscosity, chemical composition and role of volatiles. Magmatic evolution (differentiation: liquid immiscibility, liquid fractionation and movement of volatiles; fractional crystallization: gravity settling, filter pressing and flow differentiation; magma mixing and assimilation). Classification based on mineral composition: Hatch, Wells & Wells and IUGS classification.	**15**
Unit 2	Mode of occurrence: Intrusive (Plutonic, hypabyssal) and Extrusive (volcanic); Forms: Concordant and discordant; Batholiths, stocks, bosses, lopoliths, laccoliths, phacoliths, dykes and sills, volcanic neck; central and fissure type eruptions. Structures: Ropy lava, blocky lava, pillow lava, vesicular, amygdaloidal, columnar, exfoliation joints, lava tubes. Textures of igneous rocks: Crystallinity, granularity, shape of the grains, mutual relationship of grains: equigranular and inequigranular (Porphyritic: glomeroporphyritic, orthophyric, poikilitic, ophitic, sub-ophitic, intergranular, intersertal, hyalo-ophitic, hyalopilitic, intergrowth: graphic, granophyric, perthitic, anti-perthitic, myrmekitic; cumulate; reaction textures: corona; directive: trachytic, pilotaxitic). Crystallization trend of Di-Ab-An system and Ne-Ka-Si system.	**15**
Unit 3	Study of following group of rocks with respect to its mineralogy, textures, structures and origin: granites (I-type, S-type,) rhyolites and pegmatites; syenites and trachytes (oversaturated, saturated, undersaturated), gabbroic (gabbros, norites, dolerites and basalts) and ultramafic (dunites,	**15**

	pyroxenites, peridotites, lamprophyres, anorthosites, carbonatites, kimberlites). Characteristics of layered igneous intrusions (types of layering: modal, phase, rhythmic and cryptic).	
Practical:	1. Megascopic identification of 20 igneous rocks. 2. Normative analysis of minimum 6 igneous rocks. 3. Microscopic identification of 15 igneous rock thin-sections.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments	
References/ Readings:	1. Barker, D. S. (1983). *Igneous Rocks*. Prentice Hall. 2. Best, M. G. (2013). *Igneous and metamorphic petrology*. John Wiley & Sons. 3. Bose Mihir: *Igneous Petrology*, World Press, 1997. 4. Hall, A. (1987). *Igneous Petrology*. Longman Scientific and Technical. 5. Hatch, F. H., & Wells, A. K. (1926). *The Petrology of the Igneous Rocks*. 6. Middlemost, E. a. K. (1985). *Magmas and magmatic rocks: An Introduction to Igneous Petrology*. Longman Scientific and Technical. 7. Raymond, L. A. (2002). *Petrology: The Study of Igneous, Sedimentary, and Metamorphic Rocks*. McGraw-Hill Science, Engineering & Mathematics. 8. Winter, J. D. (2013). *Principles of igneous and metamorphic petrology: Pearson New International Edition*. Pearson Higher Ed.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain formation and diversity of igneous rocks. CL2 2. Interpret the cooling history of igneous rocks using textures and structures. CL3 3. Illustrate crystallization trends in magmatic systems. CL3 4. Identify common igneous rocks both in hand specimen and thin section. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-303
Title of the Course : Optical Mineralogy
Number of Credits : 2 (1 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals, their properties and chemical composition.	
Course Objectives:	The objectives of this course are to: 1. Demonstrate the characteristics of light and its interaction with minerals. 2. Discuss the optical methods.	
Content:		**No. of Hours**
Unit 1	Optical Mineralogy: nature of light, polarized light, polarizing microscope. Properties in plane polarized light and between cross polars: colour, pleochroism, relief, twinkling, birefringence, interference colors, twinning, zoning, extinction, inclusions. Properties under conoscopic light and its applications in the study of uniaxial and biaxial minerals. Uniaxial and Biaxial indicatrix. Accessory plates: Mica, Quartz, Gypsum, 2v, 2e.	**15**
Practical:	1. Microscopic identification of minimum 15 mineral thin-sections in orthoscopic illumination. 2. Optical methods: (Determination of order of interference colours, birefringence, sign of elongation, An- content). 3. Determination of optic sign.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Berry, L. G., Mason, B. H., & Dietrich, R. V. (1983). *Mineralogy: Concepts, Descriptions, Determinations*. 2. Deer, W. A., Howie, R. A., & Zussman, J. (1978). *Rock-forming minerals: Feldspars, Volume 4A*. Geological Society of London. 3. Gribble, C. D., & Hall, A. J. (1992). *Optical Mineralogy: Principles and Practice*. Routledge. 4. Kerr, P. F. (1959). *Optical Mineralogy*. New York ; Toronto : McGraw-Hill. 5. Mackenzie, W., & Guilford, C. (2014). *Atlas of the Rock-Forming minerals in thin section*. Routledge.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain the optical properties of minerals. CL2 2. Identify minerals based on their optical properties and interference figure. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-304
Title of the Course : Sedimentary Petrology - I
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of rock cycle and various rock types	
Course Objectives:	The objectives of this course are to: 1. Explain the sedimentary processes and diagenesis.CL2 2. Describe the textures and structures of sedimentary rocks.CL2 3. Discussthe sedimentary depositional environments. CL2	
Content:		**No. of Hours**
Unit 1	Sedimentary processes: weathering (types and products), erosion, transportation and deposition with the help of Hjulstrom Diagram, diagenesis: Compaction, cementation, lithification, recrystallization, authigenesis, pressure solution. Classification of sedimentary rocks: Clastic and Non-Clastic. Textures in Clastic Sedimentary rocks: grain size (Udden-Wentworth scale), size frequency distribution, grain size and depositional processes, shape of grains: sphericity and roundness, fabric and framework geometry, porosity and permeability. Textures in Non-clastic sedimentary rocks	**15**
Unit 2	Primary sedimentary structures: depositional, erosional, and post depositional. Secondary structures: chemical, biogenic. Heavy minerals, authigenic, allogenic minerals and provenance. Depositional environments: physical, chemical, organic factors.	**15**
Unit 3	Descriptive study of sedimentary rocks with respect to textures, composition, and classification of following groups of sedimentary rocks: Clastic (Conglomerate, Breccia, Sandstone, Shale). Non-clastic: chemical (limestones, dolomites, ferruginous, silicious and phosphatic sediments and evaporites). Organic (coral limestones, siliceous and calcareous oozes, phosphatic rocks, bog ores and coal). Bioclastic: fossiliferous limestone. Residual: laterite and bauxite	**15**
Practical:	1. Megascopic identification of minimum 15 sedimentary rocks. 2. Exercises on sorting, sphericity & roundness 3. Microscopic identification of 10 sedimentary rocks in thin-sections.	**30**
Pedagogy:	● Chalk and Board	●Videos ●Group Discussion

	● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	●Field Visits ●Flipped Classroom ●Assignments
References/ Readings:	1. Tucker, M. E. (2013). *Sedimentary petrology: An Introduction to the Origin of Sedimentary Rocks*. John Wiley & Sons. 2. Pettijohn, F. J. (1969). *Sedimentary rocks*. CBS Publication and distribution. 3. Boggs, S., Jr, & Boggs, S. (2009). *Petrology of sedimentary rocks*. Cambridge University Press. 4. Greensmith, J. (2012). *Petrology of the sedimentary rocks*. Springer Science & Business Media. 5. Folk, R. L. (1980). *Petrology of sedimentary rocks*. Hemphill Publishing Company 6. Nichols, G. (1999). *Sedimentology and Stratigraphy*. John Wiley & Sons.	
Course Outcome:	At the end of the course the student will be able to: 1. Interpret the depositional environments based on types of sedimentary rocks. CL3 2. Identify sedimentary rocks based on textures and structures. CL3 3. Deduce the provenance of sediment based on grain size and grain size parameters. CL4 4. Explain the economic importance of sedimentary rocks. CL2	

Name of the Programme : B.Sc. Geology
Course Code : GEO-321 (VET)
Title of the Course : Hydrogeology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Describe the occurrence and movement of freshwater on Earth.CL2 2. Illustrate the occurrence of groundwater and its flow. CL2 3. Discuss water quality parameters and standards. CL2	
Content:		**No. of Hours**
Unit 1	Introduction. Scope of hydrogeology and its societal relevance, Hydrological cycle and its components: precipitation, evaporation, transpiration, evapotranspiration, surface storage, overland flow, infiltration, soil moisture, interflow, percolation, groundwater recharge and storage, baseflow and surface runoff, Instruments for measurement of precipitation, evapotranspiration, infiltration and streamflow. Concepts of watershed, drainage network, and their relation to surface runoff and infiltration.	**15**
Unit 2	Subsurface water and groundwater, Rock properties affecting groundwater: porosity, permeability and hydraulic conductivity; vertical distribution of groundwater, saturated and unsaturated zones. Types of geologic formations: Aquifer, aquitard, aquiclude, aquifuge, types of aquifers: unconfined, confined, perched, confining layers, water table, piezometric head, anisotropy and heterogeneity of aquifers. Groundwater flow and Darcy's law, Aquifer parameters: specific retention, specific yield, transmissivity, storativity. Groundwater recharge estimation using GEC, 1997 methodology, Groundwater distribution in India.	**15**
Unit 3	Groundwater chemistry: Physical and chemical properties of groundwater, parameters of water quality; physical, chemical and biological, major, minor, and trace constituents, ISI standards for drinking water. Irrigation water quality, Sea water intrusion in coastal aquifers. Groundwater pollution. Artificial groundwater recharge.	**15**
Practical:	1. Groundwater level measurement; Preparation and analysis of hydrographs. 2. Preparation and interpretation of water level contour maps (flow-nets). 3. Graphical representation of chemical quality data and water classification.	**30**

Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Assignments
References/ Readings:	1. Davis, S.N. and De Weist, R.J.M. (1966). *Hydrogeology,* John Wiley & Sons Inc., N.Y. 2. Fetter, C.W. (2001). *Applied Hydrogeology,* Prentice Hall Inc., N.J., U.S.A. 3. Hiscock, K. M. (2005). *Hydrogeology: Principles and practice*. Blackwell Publishing. 4. Karanth K.R., (1987). *Groundwater: Assessment, Development and Management,* Tata McGraw-Hill Pub. Co. Ltd 5. Raghunath, H. M. (2007). *Ground water*. New Age International. 6. Todd, D.K. (2006). *Groundwater Hydrology, 2nd Ed.,* John Wiley & Sons, N.Y.	
Course Outcome:	At the end of the course the student will be able to: 1. Measure the various components of the hydrological cycle. CL3 2. Recognize types of aquifers and infer groundwater flow direction. CL3 3. Prepare and interpret stream hydrographs. CL5 4. Assess groundwater quality. CL5	

Name of the Programme : B.Sc. Geology
Course Code : GEO-322 (VET)
Title of the Course : Gemmology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals and their properties.	
Course Objectives:	The objectives of this course are to: 1. Discuss about various precious stones and their properties. CL2 2. Explain various techniques to enhance the value of gems. CL2	
Content:		**No. of Hours**
Unit 1	Nature of gem material: quality necessary in gems-beauty, rarity, durability. Formation of gem materials. Distinction between crystalline, amorphous and metamict materials. Crystal form and habit. Classification of gemstones. Observations with hand lens (10x)-importance and uses. Units of measurement: metric scale, carat, pearl and grain. Physical properties: hardness its applications in gemmology and limitations. Cleavage and parting their importance in gemology and lapidary work. Specific gravity-utility and determination by hydrostatic weighing, heavy liquids, floation and pycnometer. Inclusions and other features of gemstones. Optical properties: the electromagnetic spectrum, reflection and its importance in gemology- lustre, aventurescence, sheen, chatoyancy, asterism. Refraction, refractive index, total reflection- in design of refractometer. Construction and use of refractometer.	**15**
Unit 2	Polariscope-construction and use in gemmology. Colour, causes responsible for colour in gem materials, idiochromatism, allochromatism, pseudochromatism, colour centres, charge transfer, organic material, floating electrons, dispersion, scattering, interference, diffraction. Variations in colour, pleochroism. Dichroscope: construction and use. Chelsea colour filter. Spectroscopy. Absorption spectra. Construction and use of spectroscope. Magnetic, electrical and thermal properties. Luminescence. Ultraviolet lamp its applications to gem testing.	**15**
Unit 3	Enhancement and treatments- enhancement methods - coloured and colourless impregnation, dyeing, bleaching and its identification. Methods of treatment – laser drilling, irradiation, heat treatment, surface modifications, diffusion treatment and its identification. Composites - types, classification and identification.	**15**
Practical:	1. Determination of refractive indices, optic figure, pleochroism, absorption spectrum, luminescence, SG of	**30**

	gemstones, using refractometer, polariscope, dichroscope, spectroscope, UV lamp, visual observation of gemstones. 2. Description and Identification of cuts in gemstones. 3. Identification of gemstones- natural, synthetic gemstones and organic products.	
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Assignments
References/ Readings:	1. Fernandes S. and Choudhary G., (2010) *Understanding Rough Gemstones,* Indian Institute of Jewellery. 2. Karanth, R V; (2000) *Gem and Gem deposits of India,* Geological Society of India. 3. Read, P. G., (1991). *Gemmology,* Butterworth-Heinemann Ltd. 4. Webster, R., edited by Anderson, B, W., (1983) *Gems: Their Sources, Descriptions and Identification,* Butterworth - Heinemann Ltd.	
Course Outcome:	At the end of the course the student will be able to: 1. Identify various precious stones. CL3 2. Acquire skills to evaluate the value of gems. CL4 3. Identify cuts in gemstones. CL3 4. Explain various enhancements and treatments of gemstones. CL3	

Semester VI
Name of the Programme : B.Sc. Geology
Course Code : GEO-305
Title of the Course : Metamorphic Petrology-I
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of rock cycle and various rock types	
Course Objectives:	The objectives of this course are to: 1. Describe the agents and factors of metamorphism. CL2 2. Classify metamorphic rocks using various schemes. CL2 3. Explain the mineral compatibility diagrams and their utility. CL2	
Content:		**No. of Hours**
Unit 1	Definition of metamorphism, upper and lower limits of metamorphism, Migmatites: components, classification into metatexite and ditexite, structures: dilation, stromatic, net, agmatite, Schlieren, schollen, nebulitic, raft-like, vein. Factors responsible for metamorphism: Heat (radioactive, magmatic, tectonic heat), geothermal gradient (in different crustal regions); pressure (P) (directed and load pressure); composition of the parent rock- Protolith (X); fluids (H2O and CO2) (Xf); Role of time in metamorphism.	**15**
Unit 2	Classifying the following types of metamorphism based on areal extent (local and regional): Contact metamorphism, Orogenic Metamorphism, Burial Metamorphism, Ocean Floor Metamorphism, fault zone metamorphism, Impact or shock metamorphism. Classification of metamorphic rocks: Based on fabric (Foliated and non-foliated) and based on mineralogy. Fabric: Definition, types- relict (primary features such bedding, fossil outlines, grain boundaries), Imposed: isotropic fabric (granoblastic, diablastic/decussate), anisotropic fabric (slaty cleavage, schistosity, gneissic banding, mylonitic fabric), Lineation (crenulation, mineral lineation). Porphyroblasts - definition and examples. Idioblastic series.	**15**
Unit 3	Prograde and Retrograde metamorphism, Concept of index minerals, their significance in mapping and understanding tectonic history. ACF and AFM (AKFM) diagrams their advantages and limitations. Facies concept after Goldschmidt and Eskola. Facies series [Contact Facies Series (very low-P), Buchan or Abukuma Facies Series (low-P regional), Barrovian Facies Series (medium-P regional), Sanbagawa Facies Series (high-P, moderate-T), Franciscan Facies Series (high-P, low T)].	**15**

	Metamorphism in relation to the plate tectonic environments. Paired metamorphic belts	
Practical:	1. Megascopic identification of minimum 15 metamorphic rocks. 2. Problems based on ACF & AFM diagrams. 3. Microscopic identification of minimum 10 metamorphic rocks in thin-sections.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments	
References/ Readings:	1. Turner, F.J. (1981). *Metamorphic rocks field mineralogical & tectonic aspects.* McGraw-Hill 2. Raymond, L. A. (2002). *Petrology: The Study of Igneous, Sedimentary, and Metamorphic Rocks*. McGraw-Hill Science, Engineering & Mathematics. 3. Winter, J. D. (2013). *Principles of igneous and metamorphic petrology: Pearson New International Edition*. Pearson Higher Ed. 4. Passchier, C. W., &Trouw, R. a. J. (2005). *Microtectonics*. Springer Science & Business Media. 5. Bucher, K., & Grapes, R. (2011). *Petrogenesis of metamorphic rocks*. Springer Science & Business Media. 6. Best, M. G. (2013). *Igneous and metamorphic petrology*. John Wiley & Sons. 7. Yardley, B. W. D. (1989). *An introduction to Metamorphic petrology*. Longman Scientific and Technical. 8. Philpotts, A. R., & Ague, J. J. (2009b). *Principles of igneous and metamorphic petrology*. Cambridge University Press.	
Course Outcome:	At the end of the course the student will be able to: 1. Distinguish metamorphic rocks from other types of rocks. CL2 2. Categorise and relate the metamorphic mineral assemblages according to their modes of formation. CL3 3. Interpret the deformation mechanism based on fabric. CL3 4. Identify tectonic settings based on the type of metamorphic rock. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-306
Title of the Course : Indian Stratigraphy
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of various rock types and their environment of formation.	
Course Objectives:	The objectives of this course are to: 1. Discuss the geological history of India, from the Archean era to the Quaternary period. CL2 2. Describe the different stratigraphic Groups and Formations of India. CL2 3. Associate the importance of stratigraphy in mineral and hydrocarbon exploration. CL2 4. Investigate the geology of an area. CL3	
Content:		**No. of Hours**
Unit 1	Physiographic and Tectonic divisions of India, Shield, Cratons and mobile belts of Peninsular India. Standard Stratigraphic Time Scale (as per IUGS). Archaean Formations of Peninsular India: Dharwar Supergroup and Peninsular Gneissic Complex with their distribution, lithology, stratigraphic sequence, structures and economics. Proterozoic Formations of Peninsular India: Cuddapah Supergroup: Its distribution lithology, stratigraphic sequence, structure and economics.	**15**
Unit 2	Proterozoic Formations of Peninsular India: Vindhyan Supergroup, Kaladgi Supergroup: Its distribution lithology, stratigraphic sequence, structure and economics. Paleozoic Formations of India: Marine succession of Spiti. Gondwana Supergroup. Ancient Gondwanaland, climatic changes during Gondwana. Distribution, classification, tectonic relations, origin of Gondwana rocks and their economic importance.	**15**
Unit 3	Mesozoic Formations of Peninsular India: Marine Environments, rock types and fossils. Cenozoic Era: Tertiary Formations in India. Deccan Basalt Group (Traps): distribution and age, inter-trappean and infra-trappean beds. Siwalik Group: structure, classification, lithology, climate, fossils. Pleistocene glaciation. Ice age, Pleistocene ice age in India, evidence of ice age	**15**
Practical:	**Field Work:** All the students shall undertake geological field work under the guidance of teachers to important geological sites of India. Each student shall maintain a field diary and write a geological report. The minimum time spent in the field should be 30 hours.	**30**
Pedagogy:	● Chalk and Board	● Videos

	● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Ramakrishnan, M., and Vaidyanadhan, R. (2010). *Geology of India (vol. 1)*. GSI Publications. 2. Ramakrishnan, M., and Vaidyanadhan, R. (2010). *Geology of India (vol. 2)*. GSI Publications. 3. Krishnan, M. S. (1968). *Geology of India and Burma*. CBS 4. Wadia, D. N. (1975). *Geology of India*. Oxford IBH 5. Kumar, R. (1985). *Fundamentals of Historical Geology and Stratigraphy of India*. Oxford IBH	
Course Outcome:	At the end of the course the student will be able to: 1. Infer the geological history and environment of deposition based on lithological characters. CL3 2. Classify various rock sequences in Groups and Formations. CL3 3. Correlate stratigraphy and occurrence of mineral deposits CL4 4. Prepare a geological field report of an area. CL5	

Name of the Programme : B.Sc. Geology
Course Code : GEO-307
Title of the Course : Project
Number of Credits : 4
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have knowledge of basic subjects in geology.	
Course Objectives:	The objectives of this course are to: 1. Recognize the need for research and collaborative work. CL2 2. Explain the research methodology techniques.CL2 3. Develop problem solving skills and integration of data. CL3 4. Discuss ethical standards of research. CL2	
Content:		**No. of Hours**
Unit 1	The project work by the students is to be undertaken on a topic in consultation with the mentor / guide / supervisor as assigned by the Department. Project work is based on geology related aspects of an area, involving student / students (independent / group) for mapping / study of an area / collection and analysis (Field / laboratory) of data and preparation of geological and other maps, charts and the report based on the field and laboratory analyses. Student / students have to work under supervision of a faculty. Project work can also involve any work undertaken by the student / students (individually / in groups as assigned by the department) at any national laboratory on a laboratory analytical problem related to geology of any area. The project work will be evaluated as per the evaluation procedure of the Goa University.	**120**
Pedagogy:	● Literature Review ● Fieldwork ● Sampling/collection of data	● Laboratory Analysis ● Interpretation ● Preparation of Report
References/ Readings:	1. Project Manual of Goa University 2. References relevant to the topic.	
Course outcome:	At the end of the course the student will be able to: 1. Examine an area for geological study. CL3 2. Measure and collect geological data. CL3 3. Infer the geological data. CL4 4. Prepare a scientific report. CL6	

Name of the Programme : B.Sc. Geology
Course Code : GEO-323 (VET)
Title of the Course : Introduction to Environmental Geology
Number of Credits : 4 (2 Theory + 2 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Identify the geological processes that cause natural hazards. CL2 2. Discuss the impact of natural hazards on the various components of the environment. CL2 3. Explain preventive measures and techniques for the mitigation of natural, and environmental pollution. CL2	
Content:		**No. of Hours**
Unit 1	Fundamental concepts of Environmental geology- scope, aims and objectives. Origin, Impact and mitigation measures for the following natural hazards: Volcanic and seismic hazards; Cyclones/ Hurricanes, coastal flooding, coastal erosion and Tsunamis. Pollution of water resources: Water quality parameters, major pollutants, sources, causes and effects of water pollution; remedial measures. Floods. Water Conservation.	**15**
Unit 2	Soil erosion and contamination, Slope stability and mass movements: causes, impacts, preventive measures. Energy Resources: Conventional Energy Resources and their environmental Impacts; Alternative Energy Resources: Nuclear Energy, Geothermal, Solar energy, hydro power, wind power and green hydrogen. Climate change and Global warming, depletion of ozone layer and acid rain. Sea level rise.	**15**
Practical:	1. Interpretation of Seismic maps. 2. Interpretation of natural hazards from geological maps. 3. Demarcation of geological hazards (Coastal, Earthquake and volcanic activity) on the outline map of India. 4. Plotting of stream hydrographs and flood frequency curves. 5. Field Work: Visit to sites affected by geological hazards/potential sites.	**60**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Assignments
References/ Readings:	1. Keller, E. A. (2012). *Introduction to environmental geology*. Pearson College Division.	

	2. Montgomery, C. W. (2013). *Environmental geology.* McGraw-Hill Education. 3. Botkin, D. B., & Keller, E. A. (2011). *Environmental science: Earth as a living planet.* Wiley. 4. K. S. Valdiya (1987) *Environmental Geology-Ecology, Resource and Hazard Management.* McGraw-Hill Education (India) Private Limited.
Course Outcome:	At the end of the course the student will be able to: 1. Analyze data for identification of Natural hazards and their impact on life and property. CL4 2. Recommend sustainable solutions to mitigate the impact of natural hazards. CL4 3. Demarcate geological hazards on the outline map of India.CL2 4. Prepare a geological report of a site affected by geological hazard. CL4

Name of the Programme : B.Sc. Geology
Course Code : GEO-324 (VET)
Title of the Course : Geoheritage
Number of Credits : 4 (2 Theory + 2 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Explain the importance of geoheritage. CL2 2. Describe various geoheritage sites of India. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Geoheritage, Classification of Geoheritage, Geodiversity, Geo-conservation, History of Geoheritage; conservation, protection, maintenance and threats of geodiversity. Geoparks and its models: UNESCO global geoparks (UGGp) and Global Geopark Network (GGN); Guidelines for selection of Geoheritage sites. Geotourism.	**15**
Unit 2	Geoheritage in Indian context, National geological monuments of India identified by Geological Survey of India, Geological outcrops and society, Role of local, state and national government in conservation of Geoheritage sites in India.	**15**
Practical:	1. Plotting of major Geoheritage sites on outline map of India. 2. Classification of recognised Geoheritage sites of India based on its properties. 3. Field visits to Geoheritage sites/Geoparks.	**60**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Assignments	
References/ Readings:	1. A Monograph onNational Geoheritage monuments of India, Indian National Trust for Art and Cultural Heritage, Natural Heritage Division, New Delhi India. 2. Chen, A., Lu, Y., & Ng, Y. C. Y. (2015). *The principles of Geotourism*. 3. Errami, E., Brocx, M., & Semeniuk, V. (2015). *From geoheritage to geoparks: Case Studies from Africa and Beyond*. Springer. 4. Hose A. T (2016), *Geoheritage and GeoTourism: A European Perspective*, Boydell Press. 5. Indian National Trust for Art and Cultural Heritage. (2016). A Monograph on National Geoheritage Monuments of India. 6. Publications on Geoheritage in Indian context. 7. Ranawat, P. S., George, S., (2016). *Potential Geoheritage & Geotourism Sites.* in International Journal of Scientific and Research Publications, Volume 9, Issue 6, June. 2019.	

	8. Santangelo, N., & Valente, E. (2021). *Geoheritage and Geotourism resources*. MDPI. 9. Singh, R., Wei, D., & Anand, S. (2020). *Global Geographical Heritage, Geoparks and Geotourism: Geoconservation and Development*. Springer Nature. 10. UNESCO publications on Geoheritage, Geoparks.
Course Outcome:	At the end of the course the student will be able to: 1. Explain the importance of conserving potential Geoheritage sites. CL2 2. Describe various national geological monuments of India. CL2 3. Classify Geoheritage sites of India based on their properties. CL3 4. Write a detailed field trip report of a visit to Geoheritage sites/Geoparks. CL1

Semester VII
Name of the Programme : B.Sc. Geology
Course Code : GEO-400
Title of the Course : Mineralogy and Geochemistry
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals, their properties and chemical composition.	
Course Objectives:	The objectives of this course are to: 1. Describe the crystal chemistry, mineralogy, geochemistry and isotope geology. CL2 2. Discuss the origin of the earth & the distribution of elements. CL2 3. Identify minerals based on megascopic and microscopic properties. CL2 4. Interpret partition coefficient and isotope ratios. CL3	
Content:		**No. of Hours**
Unit 1	Mineralogy: Ionic radii, co-ordination of ions, Pauling's Rule, different types of chemical bonding, crystal growth, crystal defects - external and internal, Twinning, Polymorphism and pseudomorphism. Mineral stability and phase diagram, two component eutectic/peritectic systems, incongruent melting, solid solution system, exsolution. Ternary Systems – Di-Ab-An and Ne-Kal-Si system.	**15**
Unit 2	Study of optical properties of isotropic and anisotropic minerals. Working principles of XRD, EPMA, ICPMS, Spectroscopy, SEM, X-ray tomography. Introduction to Meteorites, origin, composition, classification and mineral constituents of meteorites. Nucleosynthesis	**15**
Unit 3	Geochemistry: Introduction and scope of geochemistry, geochemical classification of elements, distribution and behavior of major, trace elements and REE in igneous, sedimentary and metamorphic processes and products. Introduction to isotope geochemistry: Elements of nuclear systematics, introduction to isotopes and their properties.	**15**
Practical:	1. Observing and recording properties of representative minerals in hand specimens. 2. Observation and recording of optical properties of rock forming minerals. 3. Numerical problems on partition coefficient and calculation of isotope ratios.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom

		• Assignments
References/ Readings:	1. Deer, W. A., Howie, R. A., and Zussman, J. (1992). *An introduction to the rock-forming minerals.* 2nd ed. Harlow, Essex, England. New York, NY. Longman Scientific and Technical. 2. Dyar, M. D., and Gunter, M. E. (2008). *Mineralogy and optical mineralogy.* Chantilly. Mineralogical Society of America. 3. Faure, G. (1986). *Principles of isotope geology.* Second edition. John Wiley and Sons Inc., New York, NY 4. Kerr, P. F. (1977). *Optical mineralogy.* New York. McGraw-Hill Book Co. 5. Klein, C., and Dutrow, B. (2007). *Manual of mineral science.* New York. John Wiley and sons ltd 6. Klein, C., Hurlbut, C. S., and Dana, J. D. (1999). *Manual of mineralogy*: (after James D. Dana). New York: J. Wiley. 7. Krauskopf, K. B., and Bird, D. K. (1995). *Introduction to geochemistry.* New York. McGraw-Hill 8. Mason B., and Moore C.B. (1982). *Principles of geochemistry.* 4th ed. Chichester John Wiley 9. Mason, B., and Moore, C. B. (1982). *Principles of geochemistry.* New York. Wiley. 10. Nesse W. (2012). *Introduction to Optical Mineralogy.* 4th ed. Oxford University Press 11. Walther, J. V. (2009). *Essentials of geochemistry.* Sudbury, Mass. Jones and Bartlett Publishers. 12. White, W. M. (2014). *Isotope Geochemistry.* Hoboken. Wiley. 13. Winchell, A. N. (1991). *Elements of optical mineralogy: An introduction to microscopic petrography.* New York. Wiley.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain the elemental distribution in the earth. CL2 2. Describe crystal chemistry. CL2 3. Identify minerals based on physical and optical properties. CL3 4. Calculate partition coefficient and isotope ratios. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-401
Title of the Course : Advanced Structural Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of structural geology and geotectonics.	
Course Objectives:	The objectives of this course are to: 1. Explain the mechanics of rock deformation. CL2 2. Relate stress to strain in rocks and quantitatively measure strain. CL2 3. Discuss brittle and ductile deformation in rocks. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Deformation and Rock Mechanics: Components of deformation, Strain in 1D, 2D and 3D, strain ellipsoid, Pure shear and simple shear, progressive deformation, strain analysis. Introduction to stress, deviatoric and mean stress, Mohr Circle diagram. Rheology: elastic, viscous and plastic deformation, rheologic stratification of the lithosphere. Deformation microstructures and mechanisms, recovery and recrystallization.	**15**
Unit 2	Fractures: brittle deformation mechanisms, failure and fracture criteria, types of fractures and joints. Faults: Characteristics of faults and fault planes, movement mechanisms, role of fluids, brittle versus ductile faults, mylonites, shear sense indicators, shear zone kinematics.	**15**
Unit 3	Folds: Mechanisms of folding, kinematic models of folding, Ramsay's classification of folds, superposed folding, occurrence and recognition. Cleavage and foliations. Linear structures and their interpretation. An overview of structures in contractional and extensional regimes with field examples.	**15**
Practical:	1. Completion of outcrops. 2. Preparation and interpretation of geological maps and sections, Structural problems concerning economic deposits. 3. Recording and plotting of the field data, stereographic projections. Petro-fabric analysis and study of deformed structures in hand specimens. 4. Strain estimation from structural data. 5. Study and interpretation of structures from aerial photographs and satellite imagery.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens	● Videos ● Group Discussion ● Field Visits

	● Class Quiz	● Flipped Classroom ● Assignments
References/ Readings:	1. Condie, K. C. (2013). *Plate tectonics and crustal evolution*. Elsevier. 2. Davis, G.H. and Reynolds, S.J. (1996). *Structural Geology of rocks and regions.* John Wiley and Sons. 3. Fossen, H. (2010). *Structural Geology,* Cambridge University Press. 4. Ghosh, S.K. (1993). *Structural Geology: Fundamentals, and modern developments*. Pergamon Press. 5. Means, W. D., and Williams, P. F. (1976). *An outline of structural geology*. John Wiley. 6. Passhier, C. and Trouw, R.A.J. (2005). *Microtectonics*. Springer, Berlin. 7. Pollard, D.D. and Fletcher, R.C. (2005). *Fundamentals of structural geology,* Cambridge University Press. 8. Ramsay, J.G and Huber, M.I. (1983). *Techniques of Modern Structural Geology: Vol. I and II,* Academic Press. 9. Ramsay, J.G. (1967). *Folding and Fracturing of Rocks,* McGraw-Hill Book Company, New York. 10. Turcotte, D.L., and Schubert, G. (2002). *Geodynamics*. Cambridge University Press. 11. Twiss, R.J. and Moores, E.M. (2007). *Structural Geology.* Freeman. 12. Van der Pluijm, B.A. and Marshak, S. (2004). *Earth structure: an introduction to structural geology and tectonics*, W.W. Norton and Company Ltd. 13. Windley, B.F. (1996). *The evolving continents.* Oceanographic Literature Review, 8(43), 785.	
Course Outcome:	At the end of the course the student will be able to: 1. Analyze rock deformation at different scales. CL4 2. Identify structural features of rocks in the field. CL3 3. Prepare Geological Maps. CL6 4. Interpret structures from aerial photographs and satellite imagery. CL3	

Name of the Programme : B.Sc. Geology
Course Code : GEO-402
Title of the Course : Igneous Petrology - II
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals and rocks.	
Course Objectives:	The objectives of this course are to: 1. Explain magmatic processes. CL2 2. Classify Igneous rocks. CL2 3. Summarize the characteristics of an igneous suite of rocks. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to Magmas and Magmatic Processes; Process of formation and description of Textures and Structures of volcanic and plutonic rocks; Classification of igneous rocks: modal, chemical, quasi-chemical-schemes: their merits and demerits. Composition of the mantle; Enriched- and Depleted-mantle and their characteristics; Magma generation: Heat source and the factors responsible to bring about melting, Fractional melting, Batch melting and Zone melting.	**15**
Unit 2	Magmatic Evolution; Magmatic differentiation: crystal fractionation, gravitational differentiation, flowage differentiation, filter pressing, liquid immiscibility; Magmatic assimilation, Magma Mixing and contamination. Magma Associations in relation to Plate Tectonics: continental flood basalts: Deccan Traps; Mid Ocean Ridge Basalts, Ocean Island basalts, Continental as well as ocean Arc magmatism;	**15**
Unit 3	Granites and Granitic rocks, I-type, S-type, A-type and M-type granites, anatexis and Granitization; Alkaline rocks - Nephelinites and Ijolites, Continental Layered Intrusions: mineralogical and petrological characteristics of Skaergaard complex. Lamprophyres and Lamproites, Carbonatites and Kimberlites; Anorthosites; Alpine type intrusions and Ophiolites.	**15**
Practical:	1. Study of the textures and structures and identification of following rocks in hand specimens and in thin sections: ultramafic rocks, mafic igneous rocks, intermediate rocks, granitic rocks and alkaline igneous rocks. 2. CIPW normative calculations of minerals based on available compositional data using excel sheet. 3. Applications of trace elements in igneous petrology, such as spider diagrams, REE distribution patterns and	**30**

	implications in deducing origin, source and evolution of magma, and tectonic diagrams-trace element ratio plots.	
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Barker, F. (Ed.). (2013). *Trondhjemites, dacites, and related rocks.* Elsevier 2. Dawson, J. B. (2012). *Kimberlites and their xenoliths (Vol. 15)*. Springer Science and Business Media. 3. Middlemost, E. a. K. (1985). *Magmas and magmatic rocks: An Introduction to Igneous Petrology*. Longman Scientific and Technical. 4. Moorhouse, W. W. (1959). *The study of rocks in thin section*. New York : Harper & Row. 5. Philpotts, A. R., and Ague, J. J. (2022). *Principles of igneous and metamorphic petrology.* Cambridge University Press. 6. Rock, N. M. (2013). *Lamprophyres*. Springer Science and Business Media. *7.* Wager, L. R., and Brown, G. M. (1967). *Layered igneous rocks. WH Freeman.* 8. Wilson, M. (Ed.). (1989). *Igneous petrogenesis.* Dordrecht: Springer Netherlands. 9. Winter, J. D. (2013). *Principles of igneous and metamorphic petrology.* Pearson education.	
Course Outcome:	At the end of the course the student will be able to: 1. Identify textures and structures of igneous rocks.CL3 2. Classify igneous rocks. CL4 3. Explain the formation of the rocks. CL3 4. Infer magma genesis based on chemical analysis. CL4	

Name of the Programme : B.Sc. Geology
Course Code : GEO-403
Title of the Course : Field Geology
Number of Credits : 4 (1 Theory + 3 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals, rocks and structural geology	
Course Objectives:	The objectives of this course are to: 1. Explain techniques of geological mapping. CL2 2. Demonstrate use of GPS, DGPS, GNSS for spatial data collection. CL2 3. Discuss the methods of writing a geological report. CL2	
Content:		**No. of Hours**
Unit 1	Theoretical knowledge and use of clinometer compass and Brunton compass. Detailed Stratigraphy and representative locations of the field study area will be discussed. The students will be taught the techniques of geological mapping, field data collection: recording the attitude of beds, foliation, lineation, joints and their analysis. Use of GPS, DGPS, GNSS for spatial data collection.	**15**
Practical:	The students will be taught 1. The techniques of geological mapping, field data collection: recording the attitude of beds, foliation, lineation, joints and their analysis. 2. Use of GPS, DGPS, GNSS for spatial data collection. Sampling of rocks, preparation of geological field report. The record of data will be maintained in a field-diary. This work will be carried out under the supervision of teachers who will accompany the students during the course of the field-traverse. There will be a viva-voce examination based on the field report.	**90**
Pedagogy:	● Chalk and Board ● PPT and Practical ● demonstration of Mineral and Rock Specimens	● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Lambert, D. (2006). *The Field Guide to Geology*. Infobase Publishing. 2. Mukherjee, S. (2021). *Structural Geology and Tectonics Field Guidebook — Volume 1*. Springer Nature. 3. Roberts, D. C. (2001). *A field guide to Geology: Eastern North America*. Houghton Mifflin Harcourt.	
Course Outcome:	At the end of the course the student will be able to: 1. Collect geological data from field observations. CL3 2. Use of GPS, DGPS, GNSS for spatial data collection. CL3 3. Prepare geological maps using field data. CL6	

	4. Prepare a geological report. CL6

Name of the Programme : B.Sc. Geology
Course Code : GEO-411
Title of the Course : Marine Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Describe the ocean floor sampling techniques. CL2 2. Discuss major oceanic expeditions. CL2 3. Illustrate the ocean floor topography. CL2 4. Discuss various deposits occurring in marine environments. CL2	
Content:		**No. of Hours**
Unit 1	History of Marine Geology, Scope and Applications of Marine Geological Investigations. Marine sediments: types and distribution. Oceanic expeditions: Challenger expedition, Deep Sea drilling Project, Ocean drilling Programme, Joint Global Flux Studies (JGOFS), Integrated Ocean Drilling Programme (IODP). Ocean Floor Sampling: Snappers or grabs, Corers: Gravity, Piston, Spade, corers. Dredges, underwater photography, and diving.	**15**
Unit 2	Ocean Floor topography-- Continental margins: continental shelf and slope, its origin, continental rise; Submarine canyon and their origin, Oceanic ridges: Ridges, fracture zones; Ocean basins: Abyssal plains, Abyssal hills, Seamounts and guyots, Marginal trenches. Submarine volcanism, Tsunamis – causes and effects. Coral reefs – their nature and theory of atoll formation. Sea level changes. Evolution of Oceans and Oceanic Circulation.	**15**
	Deposits of the continental margin: Placers- formations, mode of occurrence and distribution in India. Deposits of the continental shelf: Phosphorite, Glauconite, Barium Sulphate concretions, and petroleum deposits. Deposits of the deep seafloor: Polymetallic nodules and their formation, distribution and concentration. Hydrocarbons and Hydrothermal Sulphides beneath the sea floor.	**15**
Practical:	1. Operation of different sampling equipment for marine geological work, Preparation, and interpretation of Bathymetric charts. 2. Size analysis: Sieve techniques and pipette analysis; Graphical representation, statistical computations, and interpretation of grain size data.	**30**

	3. Visit to CSIR-NIO and NCPOR Labs	
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Assignments
References/ Readings:	1. Kennett, J. P. (1982). *Marine Geology.* Prentice Hall. 2. Emery, K., & Aubrey, D. G. (2012). *Sea levels, land levels, and tide gauges.* Springer Science & Business Media. 3. Burk, C., & Drake, C. (2013). *The geology of continental margins*. Springer. 4. Hekinian, R. (2000). *Petrology of the ocean floor.* Elsevier. 5. Condie, K. C. (2015). *Plate Tectonics & Crustal Evolution.* Elsevier.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain the different methods of sampling. CL2 2. Describe the ocean floor topographic features. CL2 3. Correlate occurrence of economic deposits with marine environment. CL4 4. Interpret grain size data. CL4	

Semester VIII
Name of the Programme : B.Sc. Geology
Course Code : GEO-404
Title of the Course : Sedimentary Petrology-II
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals and rocks.	
Course Objectives:	The objectives of this course are to: 1. Explain the surface sedimentary processes. CL2 2. Interpret the provenance of the sedimentary rocks. CL2 3. Observe the megascopic and microscopic properties of sedimentary rocks. CL2 4. Describe the depositional environment of the sedimentary rocks. CL2	
Content:		**No. of Hours**
Unit 1	Sedimentary rocks and their distribution in time and space and their applications. Surface processes of sedimention. Fundamentals of fluid flow, particle transport by fluid and by sediment gravity flows. Textures and structures of sedimentary rocks, their origin.	**15**
Unit 2	Composition, classification, diagenesis and provenance of: Terrigenous / clastic sedimentary rocks: Conglomerates, sandstones and shales. Carbonate rocks: Limestones and dolomites. Evaporites, calcareous, silicious, phosphatic, iron and manganese-rich sedimentary rocks.	**15**
Unit 3	Introduction and classification of: Terrestrial environment: fluvial system, eolian desert system, lacustrine system and glacial system. Marine environment: Deltaic system, beach and barriers island system, estuarine system, lagoonal system, tidal flat system; shelf and deep water environment.	**15**
Practical:	**PRACTICAL** 1. Grain size analysis: Textural analyses of sediments, plotting of grain size data and statistical analyses and interpretation. 2. Palaeocurrent analysis: Exercises using sets of directional data to understand spatial variation in vectorial data. 3. Megascopic identification of sedimentary rocks, observation of texture, structure and diagenetic changes; inferences on depositional environment.	**30**

	4. Microscopic identification of sedimentary rocks, observation of texture, mineralogy and diagenetic changes.	
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments
References/ Readings:	1. Boggs Jr, S., and Boggs, S. (2009). *Petrology of Sedimentary Rocks*. Cambridge university press. 2. Boggs, S. (2006). *Principles of Sedimentology and Stratigraphy.* Pearson Prentice Hall. 3. Collinson, J. (2006). *Sedimentary structures.* Dunedin Academic Press Ltd. 4. Greensmith, J. (2012). *Petrology of the Sedimentary Rocks*. Springer Science & Business Media. 5. Nichols, G. (2009). *Sedimentology and stratigraphy.* John Wiley and Sons. 6. Pettijohn, F. J. (1969). *Sedimentary rocks*. CBS Publication and distribution. 7. Prothero, D.R. and Schwab, F. (2013). *Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy.* W.H. Freeman. 8. Selley, R. C. (2000). *Applied sedimentology*. Elsevier. 9. Tucker, M. E. (2001). *Sedimentary petrology: an introduction to the origin of sedimentary rocks.* John Wiley and Sons.	
Course Outcome:	At the end of the course the student will be able to: 1. Explain the surface sedimentary processes. CL3 2. Deduce the provenance of the sediment from the given data. CL4 3. Classify sedimentary rocks based on megascopic and microscopic properties. CL3 4. Infer the depositional environment of the sedimentary rock. CL4	

Name of the Programme : B.Sc. Geology
Course Code : GEO-405
Title of the Course : Metamorphic Petrology - II
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of minerals and rocks.	
Course Objectives:	The objectives of this course are to: 1. Explain type of metamorphism and products with tectonic settings. CL2 2. Characterize metamorphic rocks. CL2 3. Explain the principles of Thermodynamics. CL2 4. Discuss the metamorphic mineral assemblages in relation to facies. CL4	
Content:		**No. of Hours**
Unit 1	Definitions, factors and conditions of metamorphism; pressure and temperature limits of metamorphism; Types of metamorphism - orogenic metamorphism, ocean-floor metamorphism, contact metamorphism, cataclastic metamorphism, hydrothermal metamorphism, other types of small-scale metamorphism. Facies and facies series; Concept and origin of isograds; General characteristics of contact and regional metamorphic rocks; Classification and types of textures; Interpretation of porphyroblast–inclusion relations.	**15**
Unit 2	Concept of equilibrium in metamorphic systems; Gibbs phase rule and Mineralogical Phase Rule and their application in simple and complex systems. First law of thermodynamics, second law of thermodynamics- definition of entropy, third law of thermodynamics, thermodynamic equations, free energy of formation of minerals at any temperature and pressure, free energy surface in G–T–P–X space, free energy of ideal and non-ideal solutions, the regular solution model, equilibrium constant of a reaction and its relation with Gibbs free energy.	**15**
Unit 3	Different types of metamorphic reactions, reactions among solid-phase components, reactions involving volatiles as reacting species, controls of pressure, temperature and chemical compositions on the metamorphic reactions, time scale of metamorphism; ACF, AKF and AFM diagrams; Facies of contact metamorphism and Facies of regional metamorphism and their characteristics: zonation in mineralogy, Barrovian- (relatively higher P) and Buchan- (relatively lower P) series, and their significance. Products of regional metamorphism- rocks and characteristic minerals in different facies in different kinds of rocks such as shales, limestones and basalts.	**15**

	Metamorphism in the context of plate tectonics	
Practical:	1. Description, identification and classification of metamorphic rocks in hand specimen. 2. Description, identification and classification of metamorphic rocks in thin sections. 3. Problems based on ACF & AFM diagrams.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments	
References/ Readings:	1. Best, M. (2002). *Igneous and metamorphic petrology* Blackwell Science Ltd. 2. Bucher, K., and Grapes, R. (2011). *Petrogenesis of Metamorphic Rocks*, Springer. 3. Frost, R., and Frost, C., (2014). *Essentials of Igneous and Metamorphic Petrology*. Cambridge University Press, New York. 4. Philpotts, A., and Ague, J. (2009). *Principles of Igneous and Metamorphic Petrology* Cambridge University Press. doi:10.1017/CBO9780511813429. 5. Spear, F., (1993). *Metamorphic Phase Equilibria and Pressure-Temperature-Time paths*. Mineralogical Society of America, Washington, D.C. 6. Vernon, R., (2018). *A Practical guide to Rock Microstructure* Cambridge University Press, https://doi.org/10.1017/9781108654609. 7. Winkler, H.G.F., (1979). *Metamorphic petrogenesis*, Springer-Verlag, New York. 8. Winter, J. D. (2010). *An Introduction to Igneous and Metamorphic Petrology* Pearson Education, Inc.	
Course Outcome:	At the end of the course the student will be able to: 1. Relate type of metamorphism and products with tectonic settings. CL3 2. Classify metamorphic rocks. CL4 3. Explain the principles of Thermodynamics. CL3 4. Categorize the metamorphic mineral assemblages in relation to facies. CL4	

Name of the Programme : B.Sc. Geology
Course Code : GEO-406
Title of the Course : Geology of India
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of Indian Stratigraphy.	
Course Objectives:	The objectives of this course are to: 1. Explain the principles of stratigraphy. CL2 2. Describe the stratigraphic Groups and Formations of India. CL2 3. Discuss the importance of stratigraphy in mineral and hydrocarbon exploration. CL2	
Content:		**No. of Hours**
Unit 1	Stratigraphic principles and their applications. Evolution of the Stratigraphic column. Stratigraphic: Lithostratigrapic, Chronostratigraphic and Biostratigraphic; nomenclature and their inter-relationships. Palaeomagnetism and time correlation. Concepts of Magnetostratigraphy, Seismic stratigraphy, Chemostratigraphy and Event stratigraphy.	**15**
Unit 2	Cratons and mobile belts and Archaean formations, Archaean-Proterozoic boundary. Important Proterozoic basins of India. Precambrian/Cambrian boundary, Palaeozoic rocks in Himalayas. Mesozoic of Peninsular and extra peninsular India. K-T boundary. Paleocene Eocene Thermal Maxima (PETM), Cenozoic successions, Quaternary and Holocene stratigraphy.	**15**
Unit 3	Important Stratigraphic Units of India: Stratigraphy of Gondwana Supergroup with special emphasis on fossils, climate and economic important minerals. Deccan Volcanic Province, its distribution and lithological characteristics. Siwalik: Classification, significant vertebrate fauna and its basin evolution.	**15**
Practical:	1. Study of rocks and fossils from Indian stratigraphic horizons. 2. Exercises on stratigraphic classification and correlation. 3. Preparation of stratigraphic range charts.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments	
References/ Readings:	1. Boggs, S. (2006). *Principles of sedimentology and Stratigraphy*. Prentice Hall. 2. Fetter, C. W. (2018). *Applied hydrogeology*. Waveland Press. 3. Krumbein, W. C. (2013). *Stratigraphy and sedimentation*. aearpeman company.	

	4. Naqvi, S. M., and Rogers, J. J. W. (1987). *Precambrian geology of India.* Oxford University Press, USA. 5. Prothero, D. R., and Schwab, F. (2004). *Sedimentary Geology.* Macmillan. 6. Ramakrishnan, M., and Vaidyanadhan, R. (2010). *Geology of India (vol. 2)*. GSI Publications. 7. Ramakrishnan, M., and Vaidyanadhan, R. (2010). *Geology of India (vol. 1)*. GSI Publications.
Course Outcome:	At the end of the course the student will be able to: 1. Apply stratigraphic principles and techniques.CL3 2. Illustrate the tectonic framework of India. CL3 3. Explain the stratigraphic units of India. CL3 4. Prepare stratigraphic range charts. CL5

Name of the Programme : B.Sc. Geology
Course Code : GEO-407
Title of the Course : Ore Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Students should have basic knowledge of economic minerals.	
Course Objectives:	The objectives of this course are to: 1. Classify different types of ore deposits. CL3 2. Describe the processes of ore mineralization. CL2 3. Discuss methods of mineral beneficiation. CL2	
Content:		**No. of Hours**
Unit 1	Ore deposits and ore minerals; Magmatic processes of ore mineralization - Orthomagmatic, pegmatitic, pyro metasomatic and hydrothermal deposits. Wall rock alteration. Oxidation and supergene sulphide enrichment.; Plate tectonics in relation to ore genesis. Secondary processes of ore formation- placer deposits, residual deposits, deposits associated with metamorphic rocks.; Formation of coal, oil and natural gas.	**15**
Unit 2	Study of the following metallic, non-metallic and mineral fuel deposits of India with reference to their origin, mode of occurrence, distribution and uses. Metallic mineral deposits: Iron, manganese, aluminium, chromium, nickel, gold, silver, atomic minerals. Non-metallic mineral deposits: Deposits of minerals used in refractories, ceramics, glass, abrasives, fertilizers and cements; Study of micas, asbestos and barytes.	**15**
Unit 3	Principles of mineral beneficiation: Operation of jaw crusher, roll crusher, vibrating screen, ball mill and classifier. Beneficiation of ores by panning, jigging, tabling, electromagnetic method and flotation. Mineral economics: Strategic, critical and essential minerals. National Mineral Policy.	**15**
Practical:	1. Identification and Description of the Physical Properties, Composition, Occurrences and Uses of minimum 20 economic minerals and 5 polished sections under reflected light. 2. Microscopic study of ore minerals. 3. Interpretation of ore textures and their origin.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz	● Videos ● Group Discussion ● Field Visits ● Flipped Classroom ● Assignments

References/ Readings:	1. Arndt, N., Kesler, S., & Ganino, C. (2015). *Metals and society: An introduction to economic geology*. Springer. 2. Brown, J. C., & Dey, A. K. (1975). *The mineral and nuclear fuels of the Indian Subcontinent and Burma: A Guide to the Study of the Coal, Oil, Natural Gas, Uranium, and Thorium Resources of the Area*. Oxford University Press, USA. 3. Guilbert, J. M., & Park Jr, C. F. (2007). *The geology of ore deposits.* Waveland Press. 4. Jensen, M. L., & Bateman, A. M. (1991). *Economic Mineral Deposits* 3rd edition-Revised Printing. 5. Roy, B. C. (1973). *Indian Mineral Resources, Industries, and Economics*. Calcutta : Editions Indian. 6. Taylor, R. (2010). *Ore textures: recognition and interpretation.* Springer Science & Business Media.
Course Outcome:	At the end of the course the student will be able to: 1. Classify the ore deposits. CL2 2. Examine the ore minerals in hand specimens and under the microscope. CL4 3. Correlate the ore textures with their modes of origin. CL4 4. Choose an appropriate mineral beneficiation technique. CL5

Name of the Programme : B.Sc. Geology
Course Code : GEO-412
Title of the Course : Introduction to Petroleum Geology
Number of Credits : 4 (3 Theory + 1 Practical)
Effective from AY : 2023-24

Pre-requisites for the course:	Nil	
Course Objectives:	The objectives of this course are to: 1. Describe physical, optical and chemical properties of petroleum. CL2 2. Discuss the processes involved in the genesis of petroleum. CL2 3. Classify different petroliferous basins of India. CL2	
Content:		**No. of Hours**
Unit 1	Introduction to petroleum. Global petroleum scenario: production and supply. Physical properties: Colour, Odour, Density, Specific gravity, volume, boiling point. Optical properties: Fluorescence, Refractive index, Optical activity. Chemical composition of petroleum: Organic and inorganic compounds.	**15**
Unit 2	Origin of Petroleum. Kerogen. Petroleum Traps: Structural traps, Stratigraphic traps, lithologic traps and combination traps. Reservoir rocks and their properties. Igneous and Metamorphic rocks as petroleum systems. Primary and secondary migration and accumulation.	**15**
Unit 3	Petroleum exploration. Petroliferous basins of India: their categories and potential. Krishna-Godavari basin, Mumbai offshore, Cambay basin, Rajasthan and Assam- Arakan fold belt, Oil belts of the world.	**15**
Practical:	1. Determination of moisture content and the porosity of rocks. 2. Interpretative contouring method for the determination of depth of oil-bearing horizons. 3. Well-log interpretation. 4. Demarcation of petroliferous basin on outline map of India.	**30**
Pedagogy:	● Chalk and Board ● PPT and Practical demonstration of Mineral and Rock Specimens ● Class Quiz ● Videos ● Group Discussion ● Field Visits ● Assignments	
References/ Readings:	1. Selley, R. C., & Sonnenberg, S. A. (2022). *Elements of petroleum geology*. Academic Press. 2. Tissot, B., & Welte, D. (2013). *Petroleum formation and occurrence*. Springer Science & Business Media. 3. Levorsen , A.I., 1967, *Geology of Petroleum* W.H. Freeman and Company. 4. North, F.K., 1986, *Petroleum Geology*: Allen & UnWin, 607p.	

Course Outcome:	At the end of the course the student will be able to: 1. Explain physical, optical and chemical properties of Petroleum. CL3 2. Describe the process of formation of petroleum. CL2 3. Categorize different petroliferous basins of India. CL3 4. Illustrate the utility of structure and stratigraphy in Petroleum deposit. CL4