Parvatibai Chowgule College of Arts and Science
(Autonomous)

Accredited by NAAC with Grade 'A+'
Best Affiliated College-Goa University Silver Jubilee Year Award

DEPARTMENT OF GEOLOGY

SYLLABUS FOR FOUR YEAR UNDERGRADUATE DEGREE HONOURS PROGRAMME IN GEOLOGY

(Implemented from Academic Year 2023-2024 onwards)

Annexure B

COURSE STRUCTURE

SEMESTER	MAJOR (4 credits/course)	MINOR/ VOCATIONAL (4 credits/course)	MDC (3credits/course)	SEC (3 credits/course)
I	**UG-GEL-101:** Fundamentals ofGeology		**UG-GEL-MDC1:** Natural Hazard Management **UG-GEL-MDC2:** Historical Geology	**UG-GEL-SEC1:** Exploratory Drilling and Drillhole Data Management
II	**UG-GEL-102:** Earth Dynamics and Tectonism			**UG-GEL-SEC2:** Field Techniques for Geological Mapping
III	**UG-GEL-201:** Optical Mineralogy **UG-GEL-202:** Stratigraphy and Paleontology		**UG-GEL-MDC3:** Physical Geology	**UG-GEL-SEC3:** Gemmology
IV	**UG-GEL-203:** Mineralogy **UG-GEL-204:** Ore Genesis **UG-GEL-205:** Geotectonics **UG-GEL-206:** Sedimentary Petrology	**UG-GEL-VOC1:** Occupational Health and Safety		
V	**UG-GEL-301:** Magma Evolution and Igneous Rock Formation **UG-GEL-302:** Metamorphic Petrology **UG-GEL-303:** Precambrian Stratigraphy of India	**UG-GEL-VOC2:** Groundwater Exploration Techniques		
VI	**UG-GEL-304:** Phanerozoic Stratigraphy of India	**UG-GEL-VOC3:** Petroleum Exploration and Techniques		

	UG-GEL-305: Rock Mechanics and Structures **UG-GEL-306:** Surveying and Field Geology **UG-GEL-PRJ:** Minor Project			
VII	**UG-GEL-401:** Geochemistry **UG-GEL-402:** Engineering Geology and Geotechnology **UG-GEL-403:** Rock Microstructures and Deformation **UG-GEL-404:** Geophysical Exploration and Mining Methods			
VIII	**UG-GEL-405:** Remote Sensing and Digital Image Processing **UG-GEL-406:** Advanced Igneous Petrology **UG-GEL-407:** Geological Field Training **UG-GEL-408:** Ocean Sciences			

*** Implementation of fourth year (Semester VII & VIII) is subject to approval from DHE**

SEMESTER I

DISCIPLINE SPECIFIC CORE COURSE

Course Title : **FUNDAMENTALS OF GEOLOGY**
Course Code : **UG-GEL-101**
Credits : **04**
Marks : **75**
Duration : **45 hours**

Course Objectives

Mineralogy is the science of minerals whereas petrology is the science of rocks. Both basic and essential fundamentals of Geology shall be covered under this course. As minerals are building blocks of earth's material the course is designed to understand the basic concepts in mineralogy and their chemistry. Further, the students will study crystallography in understanding the morphology, symmetry, and the normal crystal classes. With respect to petrology the course will help the students to exhibit an improved understanding of fundamental petrologic processes and common rock types. In practicals, students learn to identify, describe, and classify minerals and rocks using hand specimens.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Explain what is a mineral and its formation, Link how the internal atomic structure of minerals affects the external development of a crystal in terms of crystal symmetry, crystal system and crystal forms.

CLO2 Explain the processes involved in the formation, identify the forms, textures, structures of igneous rocks.

CLO3 Explain the processes involved in the formation of sedimentary and metamorphic rocks, identify their textures, structures and classify them.

CLO4 Identify rock- forming minerals in hand specimen using their physical properties and classify minerals into crystal systems based on crystal symmetry.

CLO5 Classify andidentify the different igneous, sedimentary and metamorphic textures and structures based on hand specimens.

Module I **(15 hours)**

Elemental and Major oxide composition of the earth's crust; Ionic Radius; Radius Ratio; Co-ordination Number; Types of Co-ordinations.

Minerals: Definition; rock-forming minerals, and ore minerals.

Crystal: External Morphology, Space lattice and Unit cell.

Crystallographic Axes

Crystal Systems: Cubic; Tetragonal; Hexagonal; Orthorhombic; Monoclinic and Triclinic

Symmetry in Crystals: Axis, Plane, Centre

Common physical properties of minerals (in brief):

Colour; Streak; Diaphaneity; Cleavage and Fracture; Form; Hardness; Specific Gravity

Silicate structures:

Sorosilicate;Cyclosilicates;Nesosilicates;Inosilicate;Phyllosilicates; Tectosilicate

Introduction to rock-forming mineral groups:

Olivine; Pyroxene; Amphibole; Mica; Feldspar; Silica.

Module II **(15 hours)**

Rocks and Rock cycle

Magma and Lava: Definition;Formation;Composition.

Physical Properties:Temperature;Density; Viscosity;Pressure.

Bowen's Reaction Series

Mode of occurrences of Igneous rocks: Intrusive and Extrusive Forms

Intrusive Concordant Forms - Hypabyssal: Sills, Laccoliths, Lopoliths; Phacoliths.

Intrusive Discordant Forms – Plutonic: Batholiths (stocks, bosses); roof pendants.Hypabyssal – Dykes:Arcuate, Radiating Ring dykes,Cone sheets and Volcanic necks.

Extrusive Forms: Central and Fissure type of eruptions

Multiple and Composite intrusions.

Structures of Igneous rocks: Megastructures and Mesostructures

Textures of Igneous rocks based on Crystallinity, Granularity, and Mutual relationship.

Classification: Based on Mode of Occurrence and Colour Index

Module III **(15 hours)**

Weathering: Types – Biological, Chemical and Physical and products.

Erosion, Transportation and Deposition

Diagenesis and Lithification

Sedimentary structures: Primary

Textures: Clastic and Non clastic

Classification based on Grain size

Metamorphism and Metasomatism

Factors controlling metamorphism: Temperature, Pressure, Chemically Active Fluids,

Protolith: Types

Types of metamorphism: Local -Cataclastic and Contact and Regional - Dynamothermal

Metamorphic textures and structures: Foliated and Non-foliated.

Nomenclature of metamorphic rocks

Practical: 1 credit **(30 hours)**

Maximum Marks: 25

1. Identifying and determining the crystal symmetry, class, system in the normal class of the six systems.
2. Identification and study of minerals w.r.t their physical properties, occurrence, chemical composition.
3. Megascopic study of Igneous, Sedimentary and Metamorphic rocks.

List of books recommended for reference

Mandatory Reading

- Perkins, D., (2015), Mineralogy, Pearson Education Limited.

- Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2014). Essentials of Geology. Pearson Higher Ed.
- Marshak, S., (2013) Essentials of Geology. New York: W.W. Norton.
- Dana, J.D & Ford, W. E., (2010). Dana's Manual of Mineralogy. J. Wiley & Sons.
- Deer, W.A., Howie, R.A. and Zussman, J. (1992) An Introduction to the Rock-Forming Minerals. 2nd Edition, Prentice Hall, Harlow
- Klein, C. and Dutrow, B., (2007). The Manual of Mineral Science, John Wiley & Sons, Inc.
- Winter, J D., (2014). Principles of Igneous and Metamorphic Petrology, Pearson Education Limited.
- Boggs S., (2009) Petrology of Sedimentary rocks (2nd edition), Cambridge University Press.
- Prothero, D. R., and Schwab, F.; (2004) Sedimentary Geology. Macmillan.
- Best, M., (2003). Igneous and Metamorphic Petrology, Blackwell Publishing.
- Tucker E.M. (2001) Sedimentary Petrology (3rd Edition), Blackwell Science Ltd.
- Pettijohn F.J., (1984) Sedimentary Rocks (3rd Edition), CBS Publishers, New Delhi.

Supplementary Reading

- Lutgens, F. K., Tarbuck, E. J., & Tasa, D. G. (2014). Essentials of Geology. Pearson Higher Ed.
- Johnson, O. (2004). Minerals of the World: Ole Johnson. Princeton University Press.
- Read, H. H., (1988). Rutley'sElements of Mineralogy, CBS Publications.
- Battey, M H. (1971), Mineralogy for students, Oliver & Boyd

MULTI DISCIPLINARY COURSES (MDC)

Course Title : **NATURAL HAZARDS AND MANAGEMENT**
Course Code : **UG-GEL-MDC1**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives

The course is designed with an aim to give the student an understanding about: various natural hazards; stages in management aimed at avoiding and /or reducing loss to life and property

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Understand the causes, effects, and mitigation measures for natural hazards such as droughts, floods, cyclones, tsunami, landslides & subsidence, Earthquake, salinity hazards, coastal erosion.

CLO2 Understand the framework and roles of various bodies under the National disaster management plan of India.

CLO3 Prepare a simple disaster management plan for a building/unit.

Module I **(15 hours)**

- Classification of hazards: Natural and Man-made disasters
- Floods: causes and effects, prediction, Cloud burst/Flash floods, remedial measures
- Cyclones: Structures, origin, effects, prediction, path tracking and early warning systems.
- Earthquakes: Causes, Magnitude and intensity, Recording, effects andpreparedness, Earthquake Zonation Map; Prediction.
- Tsunamis: relation of Tsunamis to tectonics; Damage due to tsunamis, Co-ordinated approach to early warning of tsunamis.

Module II **(15 hours)**

- Landslides and Avalanches: Classification of mass wasting, mechanics, causes of landslides and stabilizing methods of slopes; civil engineering measures.
- Subsidence: Causes, slow and brisk types
- Salinity hazards: Inland and Coastal
- Coastal erosion and mitigatory measures
- Droughts: Types, causes, mitigation
- Forest Fires: Causes and Management
- Disaster Management Cycle
- National Disaster Management

Practical : **1 credit**
Marks : **25** **(30 hours)**

- Earthquake Zonation Map and Locating Epicenter
- Visit to local beach and documenting features of coastal erosion.
- Analysis of satellite imagery to document areas prone to erosion.

- Prepare a model disaster management plan for Parvatibai Chowgule College of Arts and Science Autonomous Margao based of NDMA guidelines for school disaster management plan.

List of books recommended for reference

- Hess, D., (2012) Mc Knight's Physical Geography, PHI learning, Pvt Ltd, New Delhi.
- Paul, K, B., (2011) Environmental Hazards and Disasters: Context, Perspectives and Management, Wiley-Blackwell, West Sussex.
- Keller, E. A., 2011) Environmental Geology, Santa Barbara Prentice Hall.
- Sethi, V. K., (2009) Disaster Management, Essential Books PW, New Delhi.
- Joshi M.V., (2004) Environmental Disaster, Causes, Impacts and Remedies, Adhyayan Publishers.
- Krynine, D. and Judd W., (1998) Principles of Engineering Geology and Geotectonics, McGraw Hill.
- Holmes, A., edited by Duff P.M.D., (1993) 4th edition, Physical Geology, E.L.B.S Publications.
- Valdiya K.S., (1987) Environmental Geology: Indian Context, Tata-McGraw Hill

Online resources

https://ndma.gov.in/Governance/Guidelines

Course Title : **HISTORICAL GEOLOGY**
Course Code : **UG-GEL-MDC2**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives

The Objective of this course is to provide the students with a glimpse the Earth's past. The course includes introduction to techniques of radiometric dating and fossils correlation, that help us to understand the geological history of an area. Further through this course the students will be aware of Geoheritage sites and will be able to explain its significance.

Course Learning Outcomes

Upon completion of the course, the student will be able to :
CLO1 Explain the geological time scale and how fossils help us infer the geological past.
CLO2 Explain significance of Geoheritage sites and the need for its conservation.
CLO3 Identify fossil casts, moulds, and impressions.

Module I **(15 hours)**

Scope andSignificance of Historical Geology
Origin of the Earth
Age of the Earth: Absolute and Relative age.
Radiometric Dating
Geological Time scale
Life through the geological time scale
Mass Extinctions.
Fossils: Mega- Micro-Ichnofossils
Conditions for fossilization; Favourable environments for fossilization.
Modes of fossilization: Petrification, Carbonization, Natural moulds, and casts

Module III **(15 hours)**

Earth Heritage Conservation
Need for Conservation of sites
Conservation & community participation
Case studies: Geoheritage sites (any four)

- Cretaceous Formations of Trichinopoly District, Tamil Nadu
- Pillow lavas near Mardihalli, Chitradurga District, Karnataka
- Peninsular Gneiss, Lalbagh Botanical Garden, Bengaluru, Karnataka
- Columnar Basalt, Coconut Island (St. Mary's Island), Udupi District, Karnataka
- Lonar Lake, Buldhana District, Maharashtra
- Stromatolite Park, Jhamarkotra, Udaipur District, Rajasthan
- National Fossil Wood Park, SathanurPerambalur District, Tamil Nadu

Practical: 1 credit **(30 hours)**

Maximum Marks: 25

- Plot Geoheritage sites/ fossil locations on outline maps of India.
- Study of fossils/casts/shells w.r.t their morphology and geological age.
  Phylum: Mollusca , Brachiopoda, Arthropoda (Trilobites) and Plant fossils

List of books recommended for reference

Mandatory Reading

- Indian National Trust for Art and Cultural Heritage. (2016). A Monograph on National Geoheritage Monuments of India.
- Wicander, R., & Monroe, J. S. (2010). Historical Geology- Evolution of Earth and Life Through Time. Belmont: Brooks/Cole, Cengage Learning.
- Doyle, P. (1996). Understanding Fossils: An Introduction to Invertebrate Palaeontology. England: John Wiley & Sons Ltd.
- Black. R M., (1989). The Elements of Palaeontology, Cambridge University Press.
- Koregave, M A., Fundamentals of Invertebrate Palaeontology, Book World Enterprises.
- Spencer, E, (1962) W, Basic concepts of Historical Geology, Oxford & IBH Publishing Co.

SKILL ENHANCEMENT COURSE (SEC)

Course Title : **EXPLORATORYDRILLING AND DRILLHOLE DATA MANAGEMENT**
Course Code : **UG-GEL-SEC1**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives

Drilling is the ultimate test to all geological interpretations made during the prospecting phase. Invariably, it is an essential task that needs to be taken up to complete any exploration project related to ground water, oil & gas or mineral prospecting. The objective of this course is to provide the students an understanding of the various processes involved in a drilling project and the role of a geologist in it. The course focuses on developing skills pertaining to drillhole data management using Ms Excel.

Course Learning Outcomes

Upon completion of the course, the student will be able to:
CLO1 Explain the stages of an exploratory drilling program.
CLO2 Explain the processes involved in collection of drillhole data.
CLO3 Create Excel tables for managing drilling data and construct a dummy drillhole database in MS Excel

Module I **(15 hours)**

Introduction to Drilling: Purpose and Types of drilling
Planning a drilling Programme
Outline of a drilling contract
Defining job responsibility: Driller and the geologist
Drill site hazards: Environment and Safety
Site preparation
Measures needed to abandon drilling site

Module II **(15 hours)**

Drill hole data Management
Daily drilling report
Survey data- drill hole location and drillhole deviation
Geological data- Geological map, Borehole logging, sampling data
Quality Assurance and Quality Control (QAQC)
Management of drill hole data in excel: Types of files (mandatory and optional files)

Practical : 1 credit **(30 hours)**
Marks : 25

- Excel Tables for managing and reporting of drilling data
- Creating digital borehole logs
- Constructing and analysis of QAQC data: scatter plots and control charts
- Creating a drillhole plan and cross sections manually
- Create a drillhole database in MS Excel
- Importing the database into QGIS and viewing the drillholes in 3-D. (demonstration)

List of books recommended for reference

- Abzalov, M. (2016). Applied Mining Geology. Switzerland: Springer International Publishing.
- Marjoribanks, R. (2010). Geological Methods in Mineral Exploration and mining (Second Edition ed.). New York: Springer Heidelberg Dordrecht London.
- Charles J. Moon, M. K. (2005). Introduction to Mineral Exploration. Oxford, UK: Blackwell Publishing.

SEMESTER II

DISCIPLINE SPECIFIC CORE

Course Title : **EARTH'S DYNAMICS AND TECTONICS**
Course Code : **UG-GEL-102**
Credits : **03**
Marks : **75**
Duration : **45 hours**

Course Objectives

This is a core branch of earth science which deals with basic concepts of natural internal forces shaping the earth. Earth's Dynamics and Tectonics aims at acquainting the student with these forces as well as the geological structures resulting from the action of these forces on rocks. The course also aims at providing an understanding of the processes in action on the earth's surface and their impact on man and his institutions.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Explain the origin and nature of the earth, the internal layering, the earth's Gravity and magnetic field.
CLO2 Differentiate between the different types of forces operating in the lithosphere, responses to these forces and relate them to geological hazards.
CLO3 Explain the formation of structural features likes fold, faults, joints and unconformities.
CLO4 Read and interpret geological maps and draw geological cross – sections.
CLO5 Derive graphical solution to structural problems

Module I **(15 hours)**

Origin of the universe (Big Bang Theory); Origin of Solar System (Nebular Concept);Formation of a layered Earth.
Size and shape of the Earth.
Internal structure of the Earth: Geosphere;Asthenosphere; Lithosphere;Hydrosphere;Biosphere, Atmosphere (anoxic to oxic conditions) wrt to earth dynamics.
Earth's Gravity: Acceleration due to gravity; Change with latitude and altitude.
Earth's Magnetism: Earth as a magnet; Lines of force, Source of Earth's Magnetic field, Declination
and Inclination, Geomagnetic axis, and Geographic axis.

Module II **(15 hours)**

Introduction to Plate Tectonics:Continental Drift Theory; Sea Floor Spreading; Types of Plates.
Concept of Isostacy
Lithostatic or Confining Pressure, Differential forces: tension; compression; couple.
Concept of Stress and Strain: Stages of Deformation: Elastic, Plastic and Rupture.
Brittle and Ductile substances.
Introduction to geological hazards: exogenous (floods, drought and cyclones) and endogenous (volcanic hazards, earthquakes and tsunamis, mass wasting)

Module III **(15 hours)**

Map and Scales

Stratification, Strike and Dip (True and Apparent dip); Strike and dip symbols.

Outcrop patterns of Horizontal, Inclined,and vertical strata on various types of grounds (horizontal ground, valley, and spur).

Folds: Terminology; Causes.

Types of Folds:Symmetrical; Asymmetrical;Overturned;Recumbent; Isoclinal;Fan;Chevron; Monocline;Structural terrace;Plunging and Non-plunging.

Outcrop pattern of folds on horizontal ground, valley, and spur. Significance

Faults: Definition and terminology;Geometric classification;Significance; Horst and Graben; Criteria for identification in field.

Joints: Geometric classification;Map symbols; Columnar joints and sheet structure;Significance.

Unconformities: Stages of development;Types, Significance; Outliers and Inliers; Overlap and Offlap; Criteria for identification in field.

Practical: 1 credit **(30 hours)**

Maximum Marks: 25

1. Drawing cross-section and description of structural maps involving single series (Horizontal and Inclined).
2. Graphical solution to structural problems based on Strike and Dip.

List of books recommended for reference

Mandatory reading

- Travis, H., (2012) Living with Earth, Phi Learning Pvt. Ltd., New Delhi.
- Press, Siever, Grotzinger and Jordan., (2003) Understanding the Earth (4th edition).
- Charles C. Plummer and David McGeary., (2001) Physical Geology, (4th edition), Wm C. Brown Publishers.
- Monroe and Wicander., (2001) The Changing Earth: Exploring Geology and Evolution (3rd edition).
- Jain, A K ., (2014) An Introduction to Structural Geology, Geological Society of India.
- Holmes, (1978) Principles of Physical Geology edited by P.McL.D.Duff (ELBS).
- Hills, E. S.,(1972) Elements of Structural Geology, Methuen.

Supplementary Reading

- Zumberge J.H. & Nelson C.A., (1963) Elements of Geology (3rd edition), John Wiley & Sons, New York.

SKILL ENHANCEMENT COURSE (SEC)

Course Title : **FIELD TECHNIQUES FOR GEOLOGICAL MAPPING**
Course Code : **UG-GEL-SEC2**
Credits : **03**
Marks : **50**
Duration : **30 hours**

Course Objectives:
Earth materials and structures can be studied better when seen with related features, this is where field study becomes an important part of learning geology. The objective of this course is to offer the students a basic knowledge of performing a field study. This includes understanding map basics, getting acquainted with the geological equipment, making field observations, and recording it in a systematic manner.

Course Learning Outcomes
Upon completion of the course, the student will be able to:
CLO1 Read a geological map and toposheet
CLO2 Use a clinometer compass
CLO3 Make field observations and record them systematically

Module I **(15 hours)**
Field Geology in General: Aims and Objectives
Outcrop and exposure
Topography and features
Toposheets: Toposheet Indexing and Scale
Reading a Geological Map and Scale
Maintaining a Field diary
Reconnaissance studies: field equipment and their utility in the field
Compass: Clinometer working and use

Module II **(15 hours)**
Bearings: Whole Circle Bearings (WCB), Quadrantal Bearings (QB).
Measuring distances
Map Symbols- Attitude of the bed, Structural features.
Observations done in field.
Collecting Rock samples in field.
Surveying
PreparingGeological Field Report.

Practical : **1 credit** **(30 hours)**
Marks : **25**
Plane Table Survey
Geological Field Work and Report Writing

List of books recommended for reference:

- Lisle R., Brabham P and Barnes J., (2011) Basic Geological Mapping (Geological Field Guide), Wiley Blackwell.
- Gokhale, N W., (2001) A Guide to Field Geology, CBS Publishers & Distributors.

- Lambert, D A., (1998) Field Guide to Geology, Facts on File Inc.
- Compton, R R., (1985) Geology in the Field, John Wiley & Sons, Inc.
- Compton, R R., (1962) Manual of Field Geology, John Wiley & Sons, Inc.

SEMESTER III

DISCIPLINE SPECIFIC CORES

Course Title : OPTICAL MINERALOGY
Course Code : UG-GEL-201
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

The objective of the course is to provide the basics of geoscientific studies in Optical Mineralogy involving optical properties of minerals in plane polarized light, in between crossed polars and convergent light. Further, it will strengthen their knowledge in understanding of optical indicatrices and determination of optic sign of minerals.

Course Learning Outcomes

Upon completion of the course, the student will be able to :

CLO1 Explain basic concepts in optical mineralogy and relate them to study of minerals in Plane Polarised Light (PPL)

CLO2 Explain basic concepts in optical mineralogy and relate them to study of minerals Between Crossed Polars (BXP).

CLO3 Distinguish Uniaxial and Biaxial Indicatrix and study behavior of minerals under convergent light.

CLO4 Identify major rock-forming minerals in microsections and detecting optic sign for Uniaxial and Biaxial Minerals using Interference Figures, Determine Anorthite content of Plagioclase and calculate Optic Axial Angle.

Module I **(15 hours)**

Introduction: Nature of light, Polarized light, Refractive Index, Critical angle and Total Internal reflection, Wave Surface, Double Refraction.

Parts and working of a Polarizing / Petrological microscope

Properties of minerals in Plane Polarised Light (PPL): Colour, Form, Cleavage/Cracks; Relief, Twinkling; Pleochroism, Pleochroic halos.

Alteration, Inclusions.

Module II **(15 hours)**

Optical characters of minerals: Isotropism and Anisotropism

Properties of minerals Between Crossed Polars (BXP): Interference colours: Formation, Newton's Scale, Anomalous interference colours;

Extinction and Extinction types.

Twinning and Zoning

Module III **(15 hours)**

Optical accessories: Quartz Wedge, Gypsum plate, Mica plate
Uniaxial indicatrix
Biaxial indicatrix
Convergent Light: Principle
Uniaxial Interference Figure
Biaxial Interference Figure
Optic Sign of Uniaxial and Biaxial Minerals
2V and 2E (Measurement of True and Apparent Optic Axial Angle)

Practical: 1 credit **(30 hours)**

Maximum Marks: 25

1. Identification of common rock forming minerals based on optical properties
2. Determination of Optic sign for Uniaxial and Biaxial Minerals
3. Determination of An-content using extinction angles
4. Determining 2V using Mallards Method.

List of books recommended for reference

Mandatory Reading

- Perkins, D., (2015). Mineralogy. Pearson New International Edition
- Nesse, D. W., (2012), Introduction to Optical Mineralogy, Oxford University Press.
- Kerr, P., (1977), Optical Mineralogy, McGraw Hill Publishers.
- MacKenzie, W. S and Guilford, C., Atlas of Rock forming minerals in thin section_

Supplementary reading

- Cornelis, K and Cornelis, H. (1993). Manual of Mineralogy, John Wiley and Sons Ltd.

Course Title : STRATIGRAPHY AND PALEONTOLOGY
Course Code : UG-GEL-201
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

Stratigraphy and Paleontology, the two branches of Geology work together to unearth the secrets of age from rocks of the earth's crust. Stratigraphers study the composition and arrangement of layered or stratified rocks. Paleontologists study the remains of plants and animals which have been preserved in the earth's crust by natural processes. With these objectives in mind, it becomes pertinent to understand the basic concepts of Stratigraphy and Paleontology.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Explain principles of Stratigraphy, concept of Facies, correlation, and measurements of geologic time.

CLO2 Describe types of fossils, conditions, and modes for fossilization, how fossils can be used to locate economic deposits

CLO3 Describe and explain morphology of the hard parts of body fossils belonging to the different phyla and their geological time

CLO4 Read maps, solve problems on bearings and handle clinometer compass.

CLO5 Describe and identify fossils/casts/shells w.r.t their morphology and geological age.

Module I **(15 hours)**

Principles of stratigraphy: Uniformitarianism, Original horizontality, Order of superposition, Faunal succession, Cross-cutting relationship, Inclusions.

Principles of stratigraphic analysis, Facies concept in stratigraphy

Walther's Law of Facies.

Age of the earth: radiometric dating; Principles.

Measurement of geologic time:

Time Units: Eon-Era-Period-Epoch-Age

Lithostratigraphic/ Rock Units: Group-Formation-Member-Bed

Chrono-/ Time stratigraphic units: Erathem-System-Series-Stage

Biostratigraphy and Biozones

Standard Stratigraphic Scale.

Correlation and methods of Correlation:

Paleontological Criteria: Index/ Zone fossils

Lithological Similarity: Marker/ Key bed

Structural relations: Tectonic criteria

Brief account of the Geological Formations of Goa.

Module II **(15 hours)**

Fossils: Mega- Micro-Ichnofossils

Conditions for fossilization; Favorable environments for fossilization.
Modes of fossilization: Petrification, Carbonization, Natural moulds and casts
Frozen and mummified fossils.
Uses of fossils in locating coal and petroleum deposits.

Module III **(15 hours)**

Binomial Nomenclature of Organisms and Taxonomy
Morphology of the hard parts and geological time range of the following:
Phyllum: Arthropoda- Class: Trilobita
Phylum: Mollusca- Class: Pelecypoda; Gastropoda and Cephalopoda- Nautiloidea; Ammonoidea; Belemnoidea
Phyllum: Brachiopoda
Phyllum: Echinodermata- Class: Echinoidea

Practical: 1 credit
Maximum Marks: 25

- Drawing cross-section and description of structural maps involving two series (Horizontal and Inclined)
- Study of fossils/casts/shells w.r.t their morphology and geological age.
- Preparation of lithologs from field data

List of books recommended for reference

- Dana, J.D., (2010), Manual of Geology, Anmol Publications.
- Monroe, J and Wicander, R., (1994). The Changing Earth: Exploring Geology and Evolution, Brooks/Cole
- Black. R M., (1989). The Elements of Palaeontology, Cambridge University Press.
- Doyle, P. (1996). Understanding Fossils: An Introduction to Invertebrate Palaeontology. England: John Wiley & Sons Ltd.
- Spencer, E, W, Basic concepts of Historical Geology, Oxford & IBH Publishing Co.
- Koregave, M A., Fundamentals of Invertebrate Palaeontology, Book World Enterprises.

MULTIDISCIPLINARY COURSE

Course Title : PHYSICAL GEOLOGY
Course Code : UG-GEL-MDC3
Credits : 3 (30 contact hours theory + 30 hours practical)
Marks : 75

Course Objectives

The natural agencies like wind, rivers, glaciers have been moulding and remoulding the surface of the earth over millions of years. This course aims at the understanding of the processes and the physical forces responsible in developing the surficial features and highlighting the role of these natural agencies in grading and degrading the land surface.

Course Learning Outcomes

Upon completion of the course, the student will be able to :

CLO1 Explain the processes of weathering, erosion, transportation, deposition, and how these geological processes create desert landforms.

CLO2 Identify and explain formation of various landforms created by geological action of streams, underground water, glaciers and the sea.

CLO3 Assign stream order as per Strahler's Method, hypsometric curve and preparation of long and cross sections of river profiles from SOI Toposheet.

Module I **(15 Hours)**

Weathering and erosion

Earth Systems Affecting Weathering

Types of weathering: Mechanical, Chemical and Biological

Factors Affecting rate of Weathering.

Weathering versus Erosion

Transportation and deposition

Laminar and Turbulent Flow

Agents of Transportation – Wind, Water, Glaciers, Gravity

Modes of transportation – Bed Load (sliding, rolling, saltation), Suspension, dissolved load

Factors Affecting Depositions

Action of Wind

Generation of Winds,

Characteristics of Desert.

Problems Associated with Desertification.

Desert Landforms:

Depositional: sand dunes, Sand Seas/Ergs, Playa, sabkha

Erosional: Grooves, Ventifacts & Yardangs mushroom rock, Inselbergs, Mesas, and Buttes,

Desert Pavement

Module II **(15 Hours)**

Drainage Basin and River System – Drainage Patterns

Geological Action of Rivers

Erosion by River

Process of Stream Erosion – Removal of Regolith, Downcutting, Headward Erosion.

Erosional Feature in Upper Course - Steep Valleys, Gorges, Interlocking Spurs, Potholes, Waterfall and Rapid

Erosional Features in Middle and Lower Course – Meander, Ox Bow Lake, Hogbacks, Cuestas

Depositional Landforms by River

Floodplains – Meanders, Point Bars, Natural Levees, Backswamps, Braided Stream, Deltas

Alluvial Valleys – Step Terraces

Alluvial Fans

Deposition by Groundwater

Speleothems – Stalactites, Stalagmites

Types of glaciers and Glacial Budget

Ablation – Melting, Evaporation, Calving

Action of Sea Waves

Erosional and depositional features of the coast.

Practical: 1 Credit

1. Basin Morphometry Perimeter Calculation using rotameter
2. Area Calculation – Square Grid/Planimeter/Area using triangles
3. Stream Ordering (Strahler's Method)
4. Hypsometric Curve
5. Long Profile and Cross Profile of River – Upper Course, Middle Course, Lower Course of river from SOI Toposheet.
6. Field visit to nearby area to understand and describe the various physical geology features.

List of books recommended for reference

- Monroe, S. J and R. Wicander., 2014. The Changing Earth: Exploring Geology and Evolution. Brooks Cole Publishers.
- Mathur, S. M., 2012. Physical Geology of India. National Book Trust
- Carlson, D.H., Plummer, C.C., McGeary, D., 2008. Physical Geology: Earth revealed. Higher Education.
- McConnell, D., Steer, D., Knight, C., Owens, K., Park, L., 2008. The Good Earth – Introduction to Earth Science. Higher Education.
- Monroe, J.S., Wicander, R., Hazlett, R., 2007. Physical geology – Exploring the Earth (6^{th} Ed.) Thomson Brooks/Cole.
- King, C.A.M., 2006: Techniques in Geomorphology, Edward Arnold, London

SKILL ENHANCEMENT COURSE

Course Title : GEMMOLOGY
Course Code : UG-GEL-SEC3
Credits : 3 (30 contact hours theory + 30 hours practical)
Marks : 75

Course Objectives
To introduce students to the scientific identification of gemstones.

Course Learning Outcomes
Upon completion of the course, the student will be able to:

CLO1 Decide on the factors deciding cost of a gemstone, explain the causes of colours in gemstones.

CLO2 Explain how gemstones are synthesized, explain how gemstones are enhanced from low-grade to saleable quality, and explain the styles of cuts preferred for different gemstones.

CLO3 Identify gemstones based on visual observations, by using a dichroscope, polariscope, refractometer, spectroscope, ultraviolet lamp, gemmological microscope and determining Specific Gravity by hydrostatic method.

Module I **(15 hours)**

Introduction to Gemmology
Association of Gemstones with rocks
Factors deciding the cost of a gemstone
Causes of colour in gemstones
International grading of diamonds
Composites

Module II **(15 hours)**

Enhancement of gemstones
Treatments of gemstones
Synthesis of gemstones
Need for Faceting
Styles of cut
Diamond Cutting

Practical: 1 credit **(30 hours)**

Visual observation of gemstones: Colour changing Sapphire, Colour changing Alexandrite, Opal, Sunstone, Star Garnet, Star Ruby, Diamond, Spectrolite, Lapis Lazuli, Chrysoberyl cats' eye, Tigers eyes, Aquamarine Cats eye, sillimanite Cats eye, Labradorite, Moss Agate, Amber,

Study of Natural crystals: Garnet, Emerald, Spinel, Tourmaline, Gypsum, Magnetite, Aquamarine, Ruby

Dichroscope for identifying gemstones: Andalusite, Tsavorite Garnet, Chrome Tourmaline, Green Tourmaline, Pink Tourmaline, Alexandrite, Sapphire, Natural Ruby, Synthetic Ruby, Tanzanite, Kyanite, Iolite.

Polariscope for identifying gemstones: Rose Quartz, Lemon Quartz, Rock crystal, Aquamarine, Iolite, Alexandrite, Scapolite.

Determination of Specific Gravity by Hydrostatic Method

Spectroscope in gemstone identification: Cubic Zirconia (American Diamond), Zircon, Diamond, Synthetic Ruby, Natural Ruby, Synthetic Sapphire, Natural Sapphire.

Refractometer in gemstone identification: Aquamarine, Tourmaline, Quartz (Uniaxial), Iolite, Kyanite (Biaxial)

Ultra Violet lamp in gemstone identification: Synthetic and Natural Ruby, Synthetic and Natural Sapphire, Zircon, Cubic Zirconia, Colour Changing Sapphire.

Gemmological Microscope in gemstone identification: Tourmaline, Sillimanite, Emerald, Kyanite, Spectrolite

List of books recommended for reference:

- Fernandes S. and Choudhary G., (2010) Understanding Rough Gemstones, Indian Institute of Jewellery.
- Karanth, R V; (2000) Gem and Gem deposits of India, Geological Society of India.
- Read, P. G., (1991). Gemmology, Butterworth-Heinemann Ltd.
- Webster, R., edited by Anderson, B, W., (1983) Gems: Their Sources, Descriptions and Identification, Butterworth-Heinemann Ltd.
- Sinkankas, J., (1969) Mineralogy: A First Course, Van Nostrand Reinhold Company.

SEMESTER IV

DISCIPLINE SPECIFIC CORE

Course Title : MINERALOGY
Course Code : UG-GEL-203
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

The course provides geoscientific study of mineralogy in understanding the structure, chemistry, optical and physical properties, stability relations and genesis of minerals.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Explain the concept of Gibbs Phase Rule, geochemistry and collate structure, chemical composition with physical and optical properties of minerals of major silicate group of minerals, interpret stability relations of minerals using Phase diagrams of Olivine and Pyroxene group of minerals. Explain how minerals originate and associate with each other in a rock

CLO2 Collate structure, chemical composition with physical and optical properties of minerals of major silicate group of minerals and interpret stability relations of minerals of Amphibole, Micas, and Feldspar Group of minerals. Explain how minerals originate and associate with each other in a rock

CLO3 Collate structure, chemical composition with physical and optical properties of minerals of major silicate group of minerals and interpret stability relations of minerals of Feldspathoid and Silica group of minerals. Explain how minerals originate and associate with each other in a rock

CLO4 Calculate end-members for olivine, pyroxene and feldspar group of minerals and determine the structural formula for the various silicate group of minerals.

Module I **(15 hours)**

Introduction to mineral chemistry
Gibbs Phase Rule
Phase diagrams.
Whole rock chemistry (Major, Minor and Trace elements)
Concept of compatible and incompatible elements

Structure, mineral chemistry, paragenesis, and Phase diagrams of the following silicate group of minerals: Olivine group (Forsterite-Fayalite System); Pyroxene group (Diopside-Anorthite System);

Module II **(15 Hours)**

Structure, mineral chemistry, paragenesis, and stability relations of the following silicate group of minerals: Amphibole Group; Mica Group; Feldspar group (Albite-Anorthite System; Orthoclase-Albite System);

Module III **(15 Hours)**

Structure, mineral chemistry, paragenesis, and stability relations of the following silicate group of minerals: Feldspathoid group (Leucite-Silica System, Nepheline-Silica System; Silica Group.

Practical: 1 credit **(30 hours)**

1. Calculation of end-members for olivine, pyroxene and feldspar group of minerals.
2. Calculation of Structural Formula for the common silicate group of minerals

List of books recommended for reference

- Deer, W. A, Howie, R. A and Zussman. J., (2013). An Introduction to Rock-Forming Minerals, Mineralogical Society.
- Ford, W. E., (2006). Dana's Textbook of Mineralogy (with extended treatise Crystallography and Physical Mineralogy). CBS Publishers, New Delhi.
- Griffen, D. T, Phillips, W. R and William, R. Phillips., (2004). Optical Mineralogy: The Nonopaque Minerals. CBS Publishers, New Delhi.
- Mason and Berry, (2004). Mineralogy, CBS Publishers, New Delhi.
- Faure, G (1998) Principles and Applications of Geochemistry. Prentice Hall
- White, W M (1997) Geochemistry, Wiley-Blackwell
- Krauskopf, K B and Bird, D K (1995) Introduction to Geochemistry. McGraw-Hill
- Mason, B and Moore, C., (1982). Principles of Geochemistry, John Wiley & Sons.

Course Title : ORE GENESIS
Course Code : UG-GEL-204
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

The course aims at understanding the various types of mineral deposits, classification, their mode of occurrence, geologic and geographical distribution and genesis. It primarily focuses on the processes of formation of ore deposits. Furthermore, it also aims at identification of economic minerals in hand specimens.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Classify and differentiate the stages of ore-formation and ores, explain the igneous origin of ore minerals.

CLO2 Explain the role of hydrothermal solutions and submarine volcanism forming ore-deposits. Also, describe sedimentation process in creating ore deposits.

CLO3. Describe various ore minerals and deposits found in India.

CLO4 Identify various industrial and ore minerals with the help of their physical properties.

Module I **(15 hours)**

Goldsmith geochemical Classification

Tenor, Prospects, Resource and Reserves of ore minerals

Classification of Ore Deposits:

Modified Lindgren's Scheme; Bateman Scheme; Based on Tectonic Setting

Processes Forming Mineral Deposits

Requirements for ore deposit formation

Syngenetic and Epigenetic deposits

Magmatic Ore Forming Processes

Orthomagmatic ore formation (Bushveld; Sudbury)

Ore deposits at Mid-Ocean Ridges (Black and White Smokers) and in ophiolites (podiform chromites)

Ore formation related to alkaline magmatic rocks, carbonatites and kimberlites

Ore deposits in pegmatites

Module II **(15 hours)**

Magmatic-Hydrothermal Ore Forming Systems

Hydrothermal ore formation (Source of Hydrothermal Solutions; Textures and Structures; Host rock alteration)

Volcanogenic ore deposits (VMS; Terrestrial epithermal gold, silver and base metal)

Porphyry copper (Mo-Au-Sn-W) deposits

Hydrothermal-metasomatic ore deposits

Skarn, Greisen

Supergene Ore Formation Systems
- Residual (eluvial) ore deposits
- Supergene enrichment by descending (vadose) solutions

Sedimentary Ore Formation Systems
- Black shales in metallogenesis (European Copper Shale)
- Autochthonous iron and manganese Deposits
- Sediment-hosted & submarine-exhalative (sedex) base metal deposits
- Mississippi Valley type (MVT) Lead-Zinc deposits
- Placer deposits

Metamorphic Ore Forming System
- Orogenic Cu-Zn-Au deposits

Ore Deposits in Space and time
- Metallogenic Epochs
- Plate Tectonic Setting of Ore Deposits

Module III **(15 hours)**

Indian occurrences of
- Metallic Deposits:
  - Iron
  - Manganese
  - Chromium
  - Copper-Lead-Zinc
  - Gold
- Non metallic Deposits:
  - Diamond, Baryte, Bauxite,
- Nuclear Minerals
- Industrial Minerals (Refractory, Abrasives, Cement, Fertilizer, Electrical and Electronics).

Practical: 1 credit **(30 hours)**

- Descriptive evaluation of ore and industrial minerals in hand sample
- Introduction to reflected light microscopy of ore minerals (demonstration)
- Site visits to local mineralized geology

List of books recommended for reference

For Ore Forming Process: (E-books Available of All)

1. Pohl, L.W., 2011. Economic Geology – Principles and Practice. Wiley-Blackwell
2. Robb, L., 2005. Introduction to Ore-Forming Processes. Blackwell Publishing
3. Evans, A.M., 1993. Ore Geology and Industrial Minerals – An Introduction (3rd Ed.) Blackwell Publishing
4. Edwards, R. & Atkinson, K., 1986. Ore Deposit Geology and its influence on Mineral Exploration. Chapman and Hall Ltd.
5. Hutchison, C., Economic Deposits and their Tectonic Setting.

For Ore Deposits in Indian Context:

1. Prasad, U., 2014. Economic Geology: Economic Mineral Deposits (2nd Ed.), CBS Publishers, New Delhi
2. Srivastav, J.P., 2012. Introduction to Ore Microscopy. Prentice Hall India Learning Private Limited
3. Tiwari, A.K., 2010. Ore Geology, Economic Minerals and Mineral Economics. Atlantic
4. Gokhale, G.V.G.K., 1983. Ore Deposits of India. CBS Publishers, New Delhi

Mandatory Reading

Principle reference books used for course preparation will be Economic Geology by Walter Pohl and Economic Geology by Umeshwar Prasad.

Course Title : GEOTECTONICS
Course Code : UG-GEL-205
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

Ever since the creation of the earth, there have been marked changes in the distribution of land and sea. The dynamics of these changes are stupendous. The subject of Geotectonics aims at understanding the mechanism of such changes and explaining the structure of the earth and the processes responsible for the movement and redistribution of continents and seas.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Gain an insight into the earth's interior and generation of its magnetic field.
CLO2 Understand the theory of Continental Drift along with supporting evidences.
CLO3 Explain orogenesis and its relation with plate tectonics.
CLO4 Identify and plot various tectonic features on the earth's surface and apply the concept of plate tectonics to gain insight into earthquakes and hotspots.

Module I **(15 hours)**

Interior of the earth:

Clues from the study of earthquake and density;
The earth's layers; the crust-continental crust and oceanic crust;
Crust-mantle boundary
Structure of the mantle
Low Velocity Zone (LVZ)
Core-mantle boundary; P wave shadow zone,
Nature of the core; S wave shadow zone.

Earth's Magnetic field:

Origin and nature
Dynamo hypothesis and Herndon's Georeactor Theory.
Geocentric axial dipole,
Paleomagnetism,
Marine magnetic anomalies,
Magnetic reversals and magnetic stripes

Module II ***(15 hours)***

Continental drift:

Wegener's hypothesis.

- Evidences: Continental fit; similarity of rock sequences and mountain ranges; glacial evidence, fossil evidence;

Paleomagnetism and Polar wandering.

Plate tectonics:

Plate margins, plate boundaries and associated activities,
Triple junctions;
Divergent, Oceanic Ridges, Sea floor spreading, transform faults; hotspots.
Convergent: oceanic–oceanic, oceanic-continental, continental-continental; oceanic trenches, subduction zones
Transform boundaries;
Wilson Cycle (Rift valleys, the Red sea and the Gulf of Aden)

Geometrical aspects and mechanism of plate motion.

Module III ***(15 hours)***

Mountain building: Orogenesis

Plate boundaries and orogenesis: Orogenesis at oceanic-oceanic plate boundaries, oceanic-continental plate boundaries and continental-continental plate boundaries.

Case study: Tracking the rise of Himalayas.

Case study: Frequency of Earthquakes in North India and AlpineMediterranean belt

Case Study: Occurrence of Tsunami in SE Asia

Case study: Occurrence of volcanic activity along Pacific Ocean Basin

Ophiolite- Origins and Importance

Mélanges

Flysch and Molasse

Practical: 1 credit **(30 hours)**

1. Plotting of oceanic ridges, trenches, subduction zones, sea mounts, plate boundaries, plate spreading rates, old and young fold mountain.
2. Distribution of earthquakes, volcanoes, hotspots & hotspot related volcanic islands
3. Distribution of age of Atlantic Ocean floor
4. Exercises in plate tectonics and location of epicenter of earthquake

List of books recommended for reference

Mandatory reading

- Monroe, S. J and R. Wicander., 2014. The Changing Earth: Exploring Geology and Evolution, Brooks Cole Publishers.
- Marshak, S., 2011. Earth: Portrait of a Planet, W. W. Norton & Company.
- Prasad, C. V. R. K., 2005. Elementary Exercises in Geology, Universities Press.
- Skinner, J. B and S, C. Porter., 2003. The Dynamic Earth: An Introduction to Physical Geology, John Wiley and Sons.
- Condie, K. C., 1997. Plate Tectonics and Crustal Evolution, Butterworth-Heinemann.
- *Duff, D and Holmes, A., 1993, Holmes Principles of Physical Geology, Springer.*

Course Title : SEDIMENTARY PETROLOGY
Course Code : UG-GEL-206
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

To provide an understanding of the origin of sedimentary rocks, the relationship of sedimentary processes to plate tectonics, and the use of sedimentary rocks in the study of the geological past.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Explain the origin of sedimentary rocks and relate it to the associated textures and environments of deposition.

CLO2 Gain insight into the process of formation of sedimentary rocks by studying the various sedimentary structures.

CLO3 Explain the various classes of sedimentary rocks.

CLO4 To identify, describe and classify rocks using hand specimens and rock thin sections and to calculate various textural parameters of sedimentary rocks.

Module I **(15 hours)**

The Origin of Sedimentary Rocks:

Erosion, transportation and deposition of sediments.

Hjulstrom's diagram

Provenance

Components of clastic sediments: Heavy, Clay, Quartz, Feldspars, other minerals

Maturity: Textural, Mineralogical and Chemical Index of Alteration (CIA) and Chemical Index of Weathering (CIW) with respect to source rock.

Sedimentary Textures

Grain Size, Udden-Wentworth Size Scale modified after McPherson (1999), Phi Scale, Roundness and Sphericity.

Classification of Sedimentary rocks (Pettijohn's, Folk's and Dunham's, Embry & Klovan)

Module II **(15 hours)**

Primary sedimentary structures

Depositional, Erosional

Secondary sedimentary structures

Chemical, biogenic

Soft sediment deformations

Environment of deposition and sedimentary facies

Basins - Plate tectonics and sedimentation

Turbidites

Module III **(15 hours)**

Clastic Sedimentary Rocks

Sandstones, Breccias and Conglomerates:

Textures, Structures, Mineral composition, Textural maturity,

Mudrocks:

Structures, Colour, Mineral composition; Oil shales

Non-clastic Sedimentary Rocks

Limestones and Dolomites:

Textures; Mineralogy; Structures; Diagenesis, Reefs and Palaeoclimate; Dolomites: Dolomitization.

Residual: (Laterite and Bauxite); Origin and Climate.

Carbonaceous sediments: Nature and form of organic residues; The Coal series

Miscellaneous sedimentary rocks- Phosphate deposits and Evaporites, Siliceous rocks.

Practical: 1credit (30 hours)

1. Study and identification of sedimentary rocks w.r.t textures, structures, their classification.
2. Study of sedimentary rocks in thin sections
3. Exercises in grain size and shape analysis.

List of books recommended for reference

- Boggs S., (2009) Petrology of Sedimentary rocks (2nd edition), Cambridge University Press.
- Blatt H; Tracy R. J and Owens B. E., (2006) Petrology- Igneous Sedimentary and Metamorphic 3rd edition W H Freeman and Company New York.
- Boggs, Jr., (2005) Principles of Sedimentology and Stratigraphy (4 edition), Prentice Hall.
- Klein, C., &Philpotts, A. R. (2013). Earth materials: Introduction to mineralogy and petrology. Cambridge University Press.
- Prothero, D. R., and Schwab, F.; (2004) Sedimentary Geology. Macmillan.
- Tucker E.M. (2001) Sedimentary Petrology (3rd Edition), Blackwell Science Ltd.
- Raymond A L (1995) Petrology-The study of Igneous Sedimentary and Metamorphic rocks. Wm. C. Brown Communications, Inc.; USA.
- Greensmith, J. (1989) Petrology of the Sedimentary rocks (7th Edition), CBS Publishers, New Delhi.
- Ehlers G.E. and Blatt H., (1987) Petrology – Igneous, Sedimentary and Metamorphic, CBS Publishers, New Delhi.
- Pettijohn F.J., (1984) Sedimentary Rocks (3rd Edition), CBS Publishers, New Delhi.
- Colinson, J D & Thompson, (1982) Sedimentary Structures, Allen & Unwin.
- Miall A. D., (1984) Principles of Sedimentary Basin Analysis (3rd update and enlarged edition), Springer.
- Antonio Azor Pérez(2011) Tectonics of Sedimentary basins: Recent Advances, edited by Busby C. J. and Ingersoll R. V., Blackwell Science.

VOCATIONAL EDUCATION AND TRAINING

Course Title : OCCUPATIONAL HEALTH AND SAFETY
Course Code : UG-GEL-VOC1
Credits : 4 (45 contact hours theory + 30 hours practical)
Marks : 100

Course Objectives

Occupational Health and Safety (OHS) awareness among students is crucial as it prepares them to become responsible and safety-conscious future workers and also equips them with essential life skills. The objective of this course is not only to provide students ability to recognize workplace hazards and understand safety protocols but also create an awareness regarding right to a safe work environment. OHS education reduces the risk of workplace accidents and contributes to healthier, more productive, and socially responsible individuals.

Course Learning Outcomes

Upon completion of the course, the student will be able to:

CLO1 Identify types of hazards associated with workplace.

CLO2 Explain risks related to a workplace, risk reduction methods and significance of emergency preparedness.

CLO3 Analyze historic incidents to understand the root cause for incidents, legal implication and management measures.

CLO4 Design a Safe operating procedure, involving hazard identification, risk reduction and preventive measures.

Module I (15 hours)

Introduction to Occupational Health, Environmental and occupational illness.
Types of health hazards: Biological hazards, Chemical hazards, Physical hazards, Psychosocial Hazards.
Health and Safety Hazards Management in Oil and Gas Industry; Sea safety.
Hazards related to exposure to mineral dust and preventive measures: coal, silica and asbestos
Hazards related to exposure to chemicals and preventive measures
Ergonomic and Psychosocial Hazards
Measures for health protection of workers

Module II (15 hours)

Risk Determination: Probability and consequence
Risk Reduction: Hierarchy of Controls
Incidents reporting and investigation: Basic, Indirect and direct cause
Collection of Occupational Safety data: Key Performance Indicator (KPI)
Safety and emergency preparedness

Module III (15 hours)

Rights and duties: Workers' rights, Employers' responsibilities, Governments' duties.

Brief overview of OHSAS 18001(Occupational Health and Safety Assessment Series 18001)
Case Studies: Discussion on video documentaries on workplace incidents or situations.

Practical: 1 credit **(30 hours)**
Maximum Marks: 25

1. Hazard Identification, classification, within the campus.
2. Risk assessment using risk matrix based on likelihood (probability) and severity (consequence)
3. Creating a Safe operating procedure
4. Safety Report analysis and discussion.
5. Visit to Institute of Petroleum Safety, Health and Environment Management, Oil and Natural Gas Corporation (IPSHEM-ONGC)

List of books recommended for reference

- Alli, B. O. (2008). Fundamental Principles of Occupational Health and Safety.
- Cheremisinoff, N. P. (2001). Practical Guide To Industrial Safety. Ncw York: Marcel Dekker, INC.
- Hughes, P., & Ferrett, E. (2016). Introduction to Health and Safety at Work. New York: Routledge.
- International Standard ISO 45001. (2012). Geneva: iso.org.
- Park, K. (2015). Park′s Textbook of Preventive and Social Medicine. Jabalpur: Bhanot.
- World Health Organization. (n.d.). Retrieved from https://www.who.int/publications/i?healthtopics=de3038d6-fa15-4e55-af9a-614db8dcf184