SOMAIYA VIDYAVIHAR

K J Somaiya College of Science & Commerce

Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

Learning Outcomes based Curriculum Framework (LOCF)

For

S.Y.B.Sc. Geology

Undergraduate Programme

from

Academic year 2022- 23

S.Y. B. Sc. (GEOLOGY)

SEMESTER III

Core Course - I

COURSE TITLE: Principles of Stratigraphy and Palaeontology

COURSE CODE: 22US3CCIPSP

[CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Explain the geologic timescale and analyse the age of strata-formation 2. Enumerate the basic principles of stratigraphy and palaeontology, the chronological arrangement of rocks and appearance and evolution of life through the geologic time 3. Acquire knowledge of the concepts of correlation and relate them to field observations, in construction of stratigraphic and sedimentological logs, outcrop description by line drawings and identification and interpretation of major sedimentary structures in outcrop 4. Understand the application of palaeontology, palaeobotany and micropalaeontology 5. Identify the various mega- and micro-fossils and gain knowledge of their geological distribution 6. Evaluate potential and limits of the fossil record for reconstructing past events and environments

Module 1	Stratigraphy	[12L]

Learning Objectives:

This module is intended to

1. Explain the Geologic Timescale and analyse the age of strata-formation

2. Study the correlation between different stratigraphic units 3. Understand unconformity		
Learning Outcomes: After the successful completion of the module, the learner will be able to 1. List major events of Geological time scale 2. Correlate lithostratigraphy, chronostratigraphy and biostratigraphy units 3. Identify the various types of unconformities		
1.1	• Geological time scale	[2L]
1.2	• Development of stratigraphic concepts: importance of stratigraphy. Stratigraphic classification and nomenclature, Fundamentals of lithostratigraphy, chronostratigraphy, and biostratigraphy, their units. Inter-relationship between lithostratigraphic, chronostratigraphic and biostratigraphic units • Brief introduction to chemostratigraphy (oxygen and carbon), magnetostratigraphy and seismic stratigraphy	[6L]
1.3	• Principles of stratigraphic analysis. Facies concept in stratigraphy, Walther's Law of Facies • Unconformity: importance of unconformities, Classification and evidence of unconformities	[4L]
References: • Weller J.M. (1960), Stratigraphic Principles and Practice, Harper • Kumar R. (1996), Fundamentals of Historical Geology and Stratigraphy of India, 4th ed., New Age International Limited		

Module 2	Palaeontology – I	[12L]

Learning Objectives:

This module is intended to

1. Explain how life evolved in the geological past, and various principles/theories of origin and evolution of life
2. Compare the evolutionary trends of Lamellibranches, Cephalopods, Trilobites and Brachiopods
3. Explain Trace fossils

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Identify various evolutionary trends
2. Differentiate between the less evolved and more evolved morphological features
3. Evaluate the importance of trace fossils
4. Identify trace fossils

2.1	Modern concept of origin and evolution of life: origin of life, principles and theories of evolution, mechanism and pattern of evolution, causes of migration, dispersal and extinction of organisms	[4L]
2.2	Invertebrate Palaeontology: Brief study of evolutionary trends of Lamellibranches, Cephalopods, Trilobites and Brachiopods	[6L]
2.3	Trace fossils: Value of trace fossils in palaeo-environmental interpretation	[2L]

References:

- Clarkson E. (1993), Invertebrate Paleontology and Evolution, Chapman and Hall

- Raup D. and Stanley S.M. (1971), Principles of Paleontology, W.H. Freeman
- Dasgupta, A.,(2005), Introduction to Palaeontology, (Ist Edition), World Press

Module 3	Palaeontology – II	[12L]

Learning Objectives:

The module is intended to

1. Identify the various mega- and micro-fossils and gain knowledge of their geological distribution
2. Discuss the application of palaeontology, palaeobotany and micropalaeontology

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Identify plant fossils from various stratigraphic horizons
2. Recognize the microfossils and their application
3. Evaluate the use of paleobotany and Micropalaentology

3.1	• Micropalaentology: Introduction, definition, different types of microfossils, their size range and composition, branches	[5L]
3.2	• Palaeobotany: Definition, conditions and different modes of preservation of plant fossils, classification and distribution of plants through geological ages • Brief study of the following genera with respect to their characteristics and distribution: Ptillophyllum, Glossopteris, Gangamopteris, Vertebraria and Nilssonia. Record of plant fossils	[5L]

	in India with reference to Gondwana and Post-Gondwana Flora	
3.3	• Application of Palaeontology, Micropaleontology, Paleobotany	[2L]

References:

- Dasgupta, A., (2005), Introduction to Palaeontology, (Ist Edition), World Press
- Saraswati, P. K., & Srinivasan, M. S. (2015), Micropaleontology: Principles and Applications. Springer

Question Paper Template

S.Y. B. Sc. (GEOLOGY) SEMESTER III

Core Course - I

COURSE TITLE: Principles of Stratigraphy and Palaeontology

COURSE CODE: 22US3CCIPSP [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	11	08	05	03	03		30
II	13	09	03	03	02		30
III	10	09	06	03	02		30
Total marks per objective	34	26	14	09	07		90
% Weightage	38	29	16	10	07		100

S.Y. B. Sc. (GEOLOGY)

SEMESTER III

Core Course - II

COURSE TITLE: Crystallography

COURSE CODE: 22US3GECC2CTG [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. State concepts such as lattice, point and space groups 2. Understand the basic principles of structure of materials, crystallography and crystal defects 3. Explain Bragg's Law and explain its the relation to crystal structure 4. Identify and describe different diffraction methods 5. Interpret and assign X-ray and electron diffraction patterns 6. Determine Miller indices of a plane in a crystal 7. Discuss and identify the 32 point group and its symmetry elements 8. Identify and draw the different crystal forms 9. Formulate the Hermann-Mauguin symbols of Cubic, Tetragonal and Hexagonal systems 10. Explain and discuss twinning in crystals 11. Describe and illustrate the symmetry elements, operations of Orthorhombic, Monoclinic and Triclinic systems

Module 1	XRD and Characteristics of crystals	[12L]
Learning Objectives:		

This module is intended to

1. Make the learner understand Bravais lattice and atomic arrangement in crystal
2. Teach the characteristic symmetry of point groups
3. Formulate the relationship between crystal axes and symmetry notation of crystal systems

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Explain Baravis lattices and atomic arrangement in crystals
2. Articulate the elements of symmetry
3. Classify the crystals

1.1	• Atomic arrangement in crystals: Bravais Lattices, Crystal symmetry	[4L]
1.2	• Elements of symmetry: Planes, Axes and Centre, Axis of inversion symmetry, Crystallographic axes, Miller Indices, Axial ratios	[4L]
1.3	• Classification of crystals, Stereographic projections of symmetry	[4L]

References:

- Hurlbut, C. S., & Klein, C. (1993), Manual of mineralogy (after James D. Dana). Wiley
- Read H.H. (Rev. ed. C.D. Gribble) (1988), Rutley's Elements of Mineralogy (27TH Edition), CBS Publications
- Perkins Dexter (2011), Mineralogy (International Edition), Pearson Education
- Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy - Concepts and Methods. Text Book Series, Geological Society of India, Bangalore

Module 2	Crystal Systems - I	[12L]

Learning Objectives:

This module is intended to

1. Explain the forms and crystal morphology
2. Teach characteristic symmetry and operations in Cubic, Tetragonal and Hexagonal system

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Identify, classify and distinguish between different forms of crystals
2. Describe and illustrate the symmetry elements, operations of Cubic, Tetragonal and Hexagonal systems
3. Formulate the Hermann-Mauguin symbols of cubic, tetragonal and hexagonal systems

2.1	• Forms and crystal morphology: Name of forms, Illustration and description of forms, open forms and closed forms, point groups and crystal systems	[4L]
2.2	• Cubic, Tetragonal And Hexagonal: Characteristic symmetry, relationships between crystal axes and symmetry notation of crystal systems	[4L]
2.3	• Hermann-Mauguin symbols of Cubic, Tetragonal And Hexagonal	[4L]

References:

- Hurlbut, C. S., and Klein, C. (1993), Manual of mineralogy (after James D. Dana). Wiley
- Berry L.G., Mason B.H. and Dietrich R.V. (1983), Mineralogy, concepts, descriptions, determinations, W.F. Freeman and Co.
- Flint, Y., (1975) Essential of crystallography, Mir Publishers

- Dana, E.S. and Ford, W.E., (2002) A textbook of Mineralogy (Reprints)
- R.N. Hota (2012) Practical approach to Mineralogy and Crystallography, CBS Publications & Distributions

Module 3	Crystal Systems - II	[12L]

Learning Objectives:

The module is intended to

1. Explain the forms and crystal morphology and characteristic symmetry and operations in Orthorhombic, monoclinic and triclinic systems
2. Demonstrate the twinning of crystals and discuss the types of twinning
3. Teach the principles of XRD and its application in understanding the atomic arrangement and symmetry elements in crystals

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Identify, classify and distinguish between different forms of crystals
2. Describe and illustrate the symmetry elements, operations of Orthorhombic, monoclinic and triclinic systems
3. Formulate the Hermann-Mauguin symbols of Orthorhombic, monoclinic and triclinic
4. Explain the origin of twinning
5. Identify, classify and distinguish the different types of twinning and twin laws
6. Describe the principles of XRD
7. Describe Bragg's Law

3.1	• Orthorhombic, monoclinic and triclinic: Characteristic symmetry and relationships between crystal axes and symmetry notation of crystal systems • Hermann-Mauguin symbols of Orthorhombic, Monoclinic and Triclinic	[4L]

3.2	• Twin crystals: Twin axis, Twin plane, Composition plane • Types of Twinning: Simple and Multiple contact twins, Simple and Multiple penetration twins, Cyclic twins • Twinning in Feldspars: Carlsbad, Manebech, Baveno, Albite, Albite-Carlsbad	[4L]
3.3	• X-ray Diffraction: Brief introduction of X-rays, Diffraction effects and Bragg equation, Application of X-rays in crystallography and mineralogy	[4L]

References:

- Hurlbut, C. S., and Klein, C. (1993), Manual of mineralogy (after James D. Dana). Wiley
- Dana J.D. and Ford W.E. (rev. ed.) (2010), Dana's Manual of Mineralogy, J. Wiley & Sons
- Perkins Dexter (2011), Mineralogy (International Edition), Pearson Education
- Flint, Y., (1975) Essential of crystallography, Mir Publishers
- Dana, E.S. and Ford, W.E., (2002) A textbook of Mineralogy (Reprints)
- R.N. Hota (2012) Practical approach to Mineralogy and Crystallography, CBS Publications & Distributions

Question Paper Template

S.Y. B. Sc. (GEOLOGY) SEMESTER III

Core Course - II

COURSE TITLE: Crystallography

COURSE CODE: 22US3GECC2CTG [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	11	08	05	03	03		30
II	13	09	03	03	02		30
III	10	09	06	03	02		30
Total marks per objective	34	26	14	09	07		90
% Weightage	38	29	16	10	07		100

S.Y. B. Sc. (GEOLOGY)

SEMESTER III

Core Course - III

COURSE TITLE: Geomorphology

COURSE CODE: 22US3GECC3GMP [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Analyze geomorphological systems in terms of resisting and driving forces 2. Evaluate the creation of landforms by different surface processes 3. Describe the exogenous and endogenous processes in the landscape, their importance in landform development, and distinguish the mechanisms that control these processes 4. Analyse how variations in climate, tectonics and environment affect the development of landforms 5. Assess how different scales of time and space affect geomorphological processes

Module 1	Introduction to Geomorphology	[12L]

Learning Objectives:

This module is intended to

1. Distinguish between the endogenic and exogenic sources of energy
2. Evaluate the evolution of the geomorphic theory over time
3. Identify landforms created by various weathering processes
4. Identify the geomorphic landforms created by aeolian processes and evaluate the role of various aeolian parameters in their formation
5. Assess the role of anthropogenic activities on a landscape

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Identify the interactions that result in formation of different landscapes and predict the outcome given a set of geomorphic conditions
2. Judge the applicability of an isotopic dating method in a given situation to solve a geomorphic problem
3. Distinguish between the different types of deserts based on their causative mechanisms and generate a list of common factors that lead to formation of deserts

1.1	Basic concepts of Geomorphology: Energy for landform change, landform evolution models, mountains and relief, rock uplift, denudation, exhumation, endogenic and exogenic processes, isotopic dating and its application to geomorphic problems. Geomorphic Systems: People as Geomorphic Agents, People as creators	[4L]
1.2	Drainage patterns and concept of watershed: Antecedent, Consequent, Superimposed, Captured drainage, headward erosion Weathering and Landforms: Weathering processes: Physical, Chemical, Biological, Corestones, Tors, Pits, Pans, Caverns, Rills, Duricrust	[4L]
1.3	Aeolian Processes and Landforms: Aeolian erosion, transport and deposition	[4L]

References:

- Selby M.J. (1985), Earth's Changing Surface - An Introduction to Geomorphology, Oxford University Press

- Huggett, R. J. (2016), Fundamentals of geomorphology. Routledge
- Vaidyanadhan, K. (2001), Introduction to Geomorphology. Journal of Geological Society of India (Online archive from Vol 1 to Vol 78), 58(1), 92-92

Module 2	Geomorphological Processes - I	[12L]

Learning Objectives:

This module is intended to

1. Identify the geomorphic landforms created by fluvial processes
2. Estimate the scale of a flood and determine its severity based on a time-dependent change in the hydrographs
3. Differentiate between consequent and transverse drainage patterns
4. Identify geomorphic landforms created by glacial processes and evaluate the role of various glacial parameters in their formation

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Evaluate the role of various fluvial parameters in their formation
2. Evaluate the tectonic changes in the landscape
3. Classify and distinguish between the different types of glaciers, their formation and the mechanisms of their movement
4. Evaluate the effect of epeirogeny in a region and determine its effect on isostatic rebalance of the tectonic plate

2.1	• Fluvial Processes and Landforms: W.M. Davis Cycle of erosion, Fluvial Transport and Deposition: Alluvial Fans, Floodplains and Terraces, Alluvial Bars, Braided Channels, Straight and Meandering Channels	[4L]
2.2	• Discharge of Water: Hydrograph Shapes, Flood Frequency, Patterns of Discharge	[4L]

2.3	• Glaciers and Glaciated landforms: Ice movement, flow patterns, forms of glacier surfaces, Glaciated erosional landforms and glaciated depositional landforms	[4L]

References:

- Huggett, R. J. (2016), Fundamentals of geomorphology. Routledge
- Vaidyanadhan, K. (2001), Introduction to Geomorphology. Journal of Geological Society of India (Online archive from Vol 1 to Vol 78), 58(1), 92-92

Module 3	Geomorphological Processes - II	[12L]

Learning Objectives:

The module is intended to

1. Identify the geomorphic landforms created by coastal processes
2. Assemble a list of factors that affect the formation of karst landforms
3. Identify the surface and sub-surface geomorphic landforms created by karst processes in tropical and temperate climates

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Analyze the formation of waves and determine the areas of high-energy and low-energy wave action that may lead to coastal erosion or coastal deposition respectively
2. Evaluate the role of relative tectonic uplift or subsidence in generating coastal landforms

3.1	Coastal Processes and Landforms: Morphology of a wave, Dominant influences on Coastal landforms, Sea level changes. Erosional landforms of the coast: wave-cut platforms, cliffs, marine terraces.	[6L]

	Depositional landforms of the coast: beaches berm, longshore drift	
3.2	Karst Processes and Landforms: Limestone Solution and erosion rates Surface landforms: Minor solution sculpture, Enclosed depressions. Caves and springs Landforms controlled by Faults and Folds	[6L]

References:

- Huggett, R. J. (2016), Fundamentals of geomorphology. Routledge
- Vaidyanadhan, K. (2001), Introduction to Geomorphology. Journal of Geological Society of India (Online archive from Vol 1 to Vol 78), 58(1), 92-92
- Bloom, A. L. (1998), Geomorphology: a systematic analysis of late Cenozoic landforms (No. 551.79 BLO)
- King C.A.M., (1967), Techniques in Geomorphology., Edward Arnold, London

Question Paper Template

S.Y. B. Sc. (GEOLOGY) SEMESTER III

Core Course - III

COURSE TITLE: Geomorphology

COURSE CODE: 22US3GECC3GMP [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	11	08	05	03	03		30
II	13	09	03	03	02		30
III	10	09	06	03	02		30
Total marks per objective	34	26	14	09	07		90
% Weightage	38	29	16	10	07		100

SEMESTER IV

Core Course - I

COURSE TITLE: Economic Geology

COURSE CODE: 22US4GECCIEGE [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Discuss the basic terminology used in economic geology 2. Explain the various endogenous processes of formation of ore minerals 3. Describe the exogenous processes of formation of ore minerals 4. Understand the origin and formation of coal and hydrocarbon 5. Enumerate the different geographical and geological distribution of various economic minerals in India and the important metallogenic epochs

Module 1	Introduction and Endogenous processes of formation of ore Minerals	[12L]

Learning Objectives:

This module is intended to

1. Become acquainted with the basic terminology used in economic geology
2. Explain the various endogenous processes of formation of ore minerals
3. Understand metallogenic epochs and provinces

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Evaluate the various factors that control ore formation
2. Identify the processes of ore mineral formation by Magmatic concentration, Hydrothermal processes, sublimation and Contact Metasomatic processes
3. Differentiate between various endogenous processes

4. Enumerate the different geographical and geological distribution of various economic minerals in India and the important metallogenic epochs		
1.1	Introduction: Definition of metalliferous and non metalliferous resources, ore mineral, gangue, tenor of ore, industrial minerals, overburden and country rock Classification of economically important metalliferous and non-metalliferous mineral resources. Stratabound and Stratiform ore deposits. Structural and stratigraphic controls on mineralization, metallogenic epochs and provinces	[4L]
1.2	Processes of formation of mineral resources Magmatic concentration (early and late magmatic mineral process) Sublimation and pegmatitic process. Hydrothermal processes – Cavity filling mineral formation and Metasomatism	[4L]
1.3	Principle, character of solution, types of openings in rocks, factors affecting deposition from hydrothermal solutions, wall rock alterations Contact Metasomatic processes: definition, criteria of replacement	[4L]

References:

- Jensen M.R. and Bateman A.M. (1981), Economic mineral deposits, John Wiley & Sons
- Evans A.M. (1993), Ore geology and Industrial minerals, Blackwell Science

- Prasad U. (2000), Economic Geology - Economic Mineral Deposits, 2nd ed., CBS, India

Module 2	Exogenous processes of Formation of Ore Minerals	[12L]

Learning Objectives:

This module is intended to

1. Explain the various exogenous processes of formation of ore minerals
2. Learn the factors that affect the formation of ore minerals by exogenous processes

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Identify the processes of ore mineral formation by sedimentation, metamorphism, Evaporation processes, Residual mineral formation Mechanical concentration, Oxidation and Solution and Supergene sulphide enrichment
2. Differentiate between the various exogenous processes
3. Evaluate the various factors that affect the ore formation by exogenous processes

2.1	Mineral resources from sedimentation and metamorphism Evaporation processes: brief account of non-metallic mineral resources of ocean water, lake water, ground water and hot springs	[4L]
2.2	Residual mineral formation: conditions favouring formation of residual resources	[4L]

	Mechanical concentration: principles and processes of formation of placers (eluvial, alluvial, beach and eolian)	
2.3	Oxidation and Solution: in the zone of oxidation, ore formations in the zone of oxidation Supergene sulphide enrichment: requirements for supergenesulphide deposition, recognition of sulphide enrichment Gossans and cappings: role of iron gossans, limonite and false gossans	[4L]

References:

- Jensen M.R. and Bateman A.M. (1981), Economic mineral deposits, John Wiley and Sons
- Evans A.M. (1993), Ore geology and Industrial minerals, Blackwell Science.
- Prasad U. (2000), Economic Geology - Economic Mineral Deposits, 2nd ed., CBS, India

Module 3	Introduction and distribution of Economic minerals in India	[12L]

Learning Objectives:

The module is intended to

1. Understand the origin and formation of coal
2. Learn the formation, association and Indian distribution of major metallic ore minerals
3. Learn the formation, association and Indian distribution of major non-metallic ore minerals

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Evaluate coal formation and its various varieties 2. Label coaliferous and petroliferous basins of India 3. Enumerate the different geographical and geological distribution of major metallic ore minerals in India 4. Enumerate the different geographical and geological distribution of major non-metallic ore minerals in India		
3.1	Introduction to coal and its origin. Introduction to hydrocarbon: its origin and migration. Coaliferous and Petroliferous basins of India	[4L]
3.2	Formation, association and Indian distribution of major metallic ore minerals	[4L]
3.3	Formation, association and Indian distribution of major non-metallic ore minerals	[4L]

References:

- Prasad U. (2000), Economic Geology - Economic Mineral Deposits, 2nd ed., CBS, India

Question Paper Template

S.Y. B. Sc. (GEOLOGY) SEMESTER IV

Core Course - I

COURSE TITLE: Economic Geology

COURSE CODE: 22US4GECCIEGE [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	11	08	05	03	03		30
II	13	09	03	03	02		30
III	10	09	06	03	02		30
Total marks per objective	34	26	14	09	07		90
% Weightage	38	29	16	10	07		100

S.Y. B. Sc. (GEOLOGY)

SEMESTER IV

Core Course - II

COURSE TITLE: Optical Mineralogy and Systematic Mineralogy

COURSE CODE: 22US4GECC2OPM [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Describe the different parts of a petrological microscope and its use in mineral identification 2. Explain the optical and physical properties of minerals in hand specimen 3. Identify the minerals in thin sections based on their different optical properties 4. Enumerate the physical and optical properties of Silica, feldspar, feldspathoid and mica mineral groups 5. Know the conditions of formation, origin and occurrence for Silica, feldspar, feldspathoid and mica mineral groups 6. Enumerate the physical and optical properties of Olivine, Pyroxene, Amphibole. and Garnet mineral groups 7. Know the conditions of formation, origin and occurrence for Olivine, Pyroxene, Amphibole and Garnet mineral groups

Module 1	Optical properties of minerals	[12L]

Learning Objectives:

This module is intended to

1. Learn the different parts of a petrological microscope and its use in mineral identification
2. Study the optical properties of minerals

3. Identify the minerals in thin-sections based on their different optical properties		
Learning Outcomes: After the successful completion of the module, the learner will be able to 1. Understand and explain the different optical properties 2. Explain the working of Polarizing microscope 3. To utilize and apply these principles and concepts to identify and distinguish minerals		
1.1	Nature and behavior of light: Non-polarised and Polarised light, Refraction and Refractive index, Double refraction, Nicol prism and Filter polaroid, Isotropic and Anisotropic substances Polarizing Microscope: Its Construction and Working	[6L]
1.2	Optical characteristics: Relief, Becke's test, Twinkling, Pleochroism, Birefringence, Polarization colours, Newton's scale, Extinction and Extinction angle, Anomalous polarization colours, Uniaxial and Biaxial minerals, Optical indicatrix, Interference figures, Optic sign, Sign of elongation, Use of Quartz wedge, Mica plate and Gypsum plate	[6L]

References:

- Read H.H. (Rev. ed. C.D. Gribble) (1988), Rutley's Elements of Mineralogy (27TH Edition), CBS Publications
- Perkins Dexter (2011), Mineralogy (International Edition), Pearson Education
- Kerr, B.F., (1995) Optical Mineralogy 5th Ed. McGraw Hill, New York
- Deer, Howie and Zussman (1996) Introduction to Rock forming Minerals, Pearson

Module 2	Systematic Mineralogy - I	[12L]

Learning Objectives:

This module is intended to

1. Understand the properties of different mineral groups and enumerate the different minerals belonging to each group
2. Know the conditions of formation for different mineral groups

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Explain the basic mineralogy of Silica, Feldspar, Feldspathaoid and Mica group
2. Explain the condition of formation, stability relationships, occurrences and uses of the mineral groups

2.1	Stability Relationships: Condition of formation, Crystallography, Physical and optical properties, Composition and structure, Diagnostic Features, Occurrence and Uses	
	a) Silica Group	[4L]
	b) Feldspar Group	[4L]
	c) Feldspathoid Group and Mica Group	[4L]

References:

- Rogers A.F. and Kerr P.F. (1942), Optical Mineralogy (2nd Edition), McGraw-Hill Co. Inc., New York
- Shelly David (1985), Optical Mineralogy (2nd Edition), Elsevier
- Deer W.A., Howie A.H. and Zussman J. (1992), An introduction to rock forming minerals, Longman Scientific and Technical

Module 3	Systematic Mineralogy - II	[12L]

Learning Objectives:

The module is intended to

1. Understand the properties of different mineral groups and enumerate the different minerals belonging to each group
2. Know the conditions of formation for different mineral groups

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Explain the basic mineralogy of Amphibole Group, Pyroxene Group, Olivine Group, Garnet Group and Zeolite Group
2. Understand and explain the condition of formation, stability relationships, occurrences and uses of the mineral groups

3.1	Stability Relationships: Condition of formation, Crystallography, Physical and optical properties, Composition and structure, Diagnostic Features, Occurrence and Uses	
	a) Amphibole Group	[4L]
	b) Pyroxene Group	[4L]
	c) Olivine Group, Garnet Group and Zeolite Group	[4L]

References:

- Rogers A.F. and Kerr P.F. (1942), Optical Mineralogy (2nd Edition), McGraw-Hill Co. Inc., New York
- Shelly David (1985), Optical Mineralogy (2nd Edition), Elsevier
- Kerr, B.F., (1995) Optical Mineralogy 5th Ed. McGraw Hill, New York

- Deer, Howie and Zussman (1996) Introduction to Rock forming Minerals, Pearson

Question Paper Template

S.Y. B. Sc. (GEOLOGY) SEMESTER IV

Core Course - II

COURSE TITLE: Optical Mineralogy and Systematic Mineralogy

COURSE CODE: 22US4GECC2OPM [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	11	08	05	03	03		30
II	13	09	03	03	02		30
III	10	09	06	03	02		30
Total marks per objective	34	26	14	09	07		90
% Weightage	38	29	16	10	07		100

S.Y. B. Sc. (GEOLOGY) SEMESTER IV

Core Course - III

COURSE TITLE: Geohydrology

COURSE CODE: 22US4GECC3GHY [CREDITS - 02]

Course Learning Outcomes
After the successful completion of the Course, the learner will be able to: 1. Describe the basics of hydrogeologic cycle and groundwater 2. Discuss the groundwater occurrences in different rock types and identify the groundwater provinces in India 3. List the principles of groundwater movement and describe the different methods of groundwater investigation 4. Evaluate the different sources of contamination and assess the BIS standards of drinking water 5. Demonstrate the methods of artificial recharge and analyse the technique of rainwater harvesting

Module 1	Introduction to Hydrometerology	[12L]

Learning Objectives:

This module is intended to

1. Learn the basics of hydrogeologic cycle and groundwater sources
2. List the properties of rocks that affect its water holding capacity
3. Learn the concept of potentiometric surface and the zones of groundwater

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Describe the different types of aquifers based on the properties of rocks
2. Analyse the relationship between infiltration, run-off and groundwater recharge

3. Evaluate hydrographs of run-off and infiltration to determine the recharge potential		
1.1	Ground Water: Definition, Hydrogeologic cycle and groundwater sources: Precipitation, Evapo-transportation and Phreatophytes. Runoff and Hydrograph Components. Measuring run-off and evapo-transpiration, Infiltration	[4L]
1.2	Subsurface movement of water. Zones of groundwater. Concept of water table and potentiometric surface. Discharge of groundwater	[4L]
1.3	Occurrence of groundwater. Rock properties affecting groundwater. Types of aquifers. Geological formations as aquifers	[4L]

References:

- Todd D.K. (1980), Groundwater Hydrology, 2nd ed. John Wiley
- Fetter, C. W. (2018), Applied hydrogeology. Waveland Press

Module 2	Groundwater movement and Investigation	[12L]

Learning Objectives:

This module is intended to

1. Familiarize with the principles of groundwater movement
2. Learn Darcy's Law
3. Describe the different methods of groundwater investigation

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Explain the concept of storativity and transmissivity and use them to asses the properties of an aquifer

2. Design a flow-net based on dataset of water table levels in a region
3. List and describe the techniques involved in surface and subsurface investigation of groundwater

2.1	Ground water movement: Concept of storativity and transmissivity. Darcy's Law. Groundwater flow-lines and flow-nets	[4L]
2.2	Construction of well. Concept of drawdown and cone of depression, pumping test	[4L]
2.3	Ground water exploration techniques: Geophysical surveys and well logging	[4L]

References:

- Todd D.K. (1980), Groundwater Hydrology, 2nd ed. John Wiley
- Fetter, C. W. (2018), Applied hydrogeology. Waveland Press
- Karanth, K. R. (1987), Ground water assessment: development and management. Tata McGraw-Hill Education
- Raghunath, H. M. (1987), Groundwater Wiley Eastern Ltd. New Delhi, India

Module 3	Groundwater contamination and pollution	[12L]

Learning Objectives:

The module is intended to

1. Name and describe the physical and chemical properties of water
2. List the BIS standards of drinking water and assess the local water quality
3. Demonstrate the methods of artificial recharge

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Evaluate the severity of different sources of contamination

2. Explain and design techniques of rainwater harvesting 3. Describe the ways of wastewater reuse		
3.1	Physical and chemical properties of water, BIS standards of drinking water. Groundwater contamination	[4L]
3.2	Sea water intrusion in coastal aquifer, groundwater pollution	[4L]
3.3	Artificial recharge of ground water: Concept, methods, water spreading. Roof top rain water harvesting. Wastewater reuse. Recharge mounds. Induced Recharge	[4L]

References:

- Todd D.K. (1980), Groundwater Hydrology, 2nd ed. John Wiley
- Fetter, C. W. (2018), Applied hydrogeology. Waveland Press
- Bouwer H. (1978), Groundwater Hydrology., McGraw-Hill

Question Paper Template

S.Y. B. Sc. (GEOLOGY) SEMESTER IV

Core Course - III

COURSE TITLE: Geohydrology

COURSE CODE: 22US4GECC3GHY [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	11	08	05	03	03		30
II	13	09	03	03	02		30
III	10	09	06	03	02		30
Total marks per objective	34	26	14	09	07		90
% Weightage	38	29	16	10	07		100

S. Y. B. Sc. (Geology)

Semester III - Practical

Course I - 22US3GECC1P	Principles of Stratigraphy and Palaeontology
Learning Objectives: The practical is intended to 1. Identify morphological and evolutionary characteristics of different fossils groups and determine their geological distribution	
Learning Outcomes: After the successful completion of the practical, the learner will be able to: 1. Analyse the morphology of different fossils and classify them into respective evolutionary groups 2. List the geological distribution for species belonging to major groups	

Identification (morphology, classification, geological distribution) and study of evolutionary trends of: Lamellibranchs, Cephalopods, Trilobites and Brachiopods.
Identification of microfossils (morphology and geological distribution): Foraminifera, Ostracods and Radiolarians
Identification of plant fossils
Biozonation: Biostratigraphy, age determination and stratigraphic correlation
Paleontological problems:Trilobite moulting, Cephalopod growth curve

Course II - 22US3GECC2P	Crystallography

Learning Objectives:

The practical is intended to

1. Comprehend the characteristic symmetry of point groups and the relationship between crystal form, symmetry and symmetry notation of crystal systems

Learning Outcomes:

After the successful completion of the practical, the learner will be able to:

1. Analyse the crystal form and morphology to determine its characteristic symmetry
2. Distinguish between different forms of crystals and formulate the Hermann-Mauguin symbols of cubic, tetragonal and hexagonal systems

Study of Symmetry:
i. Symmetry elements of 32 classes of symmetry
ii. Stereographic projections of Symmetry elements of 32 classes of symmetry
Study of all possible forms of crystals belonging to 7 systems:
i. CUBIC SYSTEM
ii. TETRAGONAL SYSTEM
iii. HEXAGONAL SYSTEM
iv. TRIGONAL SYSTEM
v. ORTHORHOMBIC SYSTEM

vi. MONOCLINIC SYSTEM

vii.TRICLINIC SYSTEM

Study of Twin-axis, Twin plane and composition plane of different types of Twin crystals:

Simple contact twinning: Spinel, Rutile, Aragonite, Gypsum, Augite, Orthoclase (Baveno, Manebach, Carlsbad)

Simple penetration twinning: Staurolite, Augite, Orthoclase Carlsbad-partially penetrant.

Multiple contact twinning: Albite

Multiple penetration twinning: Fluorite, Diamond (Star), Chrysoberyl (Wheel)

Multiple cyclic twinning: Aragonite, Chrysoberyl (Wheel)

Determination of interfacial angle using Goniometer

Course III - 22US3GECC3P	Geomorphology

Learning Objectives:

The practical is intended to

1. Familiarise with the geomorphic landforms formed by different endogenic and exogenic processes and compute the rate of processes bringing about the change

Learning Outcomes:

After the successful completion of the practical, the learner will be able to:

1. Identify the individual landforms and the overall landscape on a toposheet or map and determine their causative mechanisms and processes
2. Compute the change in exogenic processes with respect to time and their effect on the geomorphic landscape

Toposheet reading

Measurement of areas enclosed within curves

Topographic Profiles, Projected Profiles, Superimposed Profiles and Spur Profiles

Longitudinal and cross valley profiles. Drainage basin analysis – Linear aspects
Hypsometric analysis, watershed delineation
Map symbols, Color codes, Types of drainage
Problems on dynamic topography, coastal stabilization, Fluvial dynamics
Identification of geomorphic features on different types of maps and toposheets
Flood hydrographs

Semester IV - Practical

Course I - 22US4GECC1P	Economic Geology

Learning Objectives:

The practical is intended to

1. Distinguish between different metallic and non-metallic economic minerals based on their physical and optical properties and indicate their geographical distribution

Learning Outcomes:

After the successful completion of the practical, the learner will be able to:

1. Utilise the physical properties of samples to identify and distinguish between various economic minerals
2. Indicate the geographical distribution of economic minerals across the state and country and name the important mines where the mineral is obtained

Identification with the help of physical properties, chemical composition and origin

Indian occurrences and geographical distribution of the following Metallic and Non-Metallic economic minerals:

Limestone, Baryte, Bauxite, Magnesite, Mica, Coal, Biotite, Calcite, Dolomite, Fluorite, Garnet, Kyanite, Magnesite, Muscovite, Serpentine, Talc, Tourmaline.

Barytes, Bauxite, Chalcopyrite, Chromite, Cuprite, Galena, Graphite, Gypsum, Hematite, Ilmenite, Limonite, Magnetite, Malachite, Psilomelane, Pyrite, Pyrolusite, Sphalerite, Stibnite

Geographical distribution of petroliferous basins of India

Geographic distribution of important mines of India

Geographic distribution of important minerals of Maharashtra

Course II - 22US4GECC2P	Optical Mineralogy and Systematic Mineralogy

Learning Objectives:

The practical is intended to

1. Use a petrological microscope to correctly identify thin-sections of different mineral groups under polarised light and crossed nicols

Learning Outcomes:

After the successful completion of the practical, the learner will be able to:

1. Identify the parts of and correctly use a petrological microscope
2. Determine the optical properties of mineral thin-sections and use them to identify the mineral group that it belongs to and indicate its condition of formation, stability relationship and occurrence

Study of physical and optical characters, mode of formation and occurrence of Silicates and Non-Silicates minerals

Study of physical properties, mode of occurrence and conditions of origin of the following secondary minerals:

Quartz (Rock crystal), Amethyst, Calcite (Rhombohedral, Scalenohedral & Nailhead spar), Stilbite, Scolecite, Mesolite, Chabazite, Laumontite, Apophyllite, (Prismatic & Pyramidal), Gyrolite and Okenite

Identification of plagioclase composition under the microscope

Course III - 22US4GECC3P	Geohydrology

Learning Objectives:

The practical is intended to

1. Comprehend the conditions responsible for controlling the rate of flow of groundwater in different types of aquifers and interpret flow-nets to determine its flow direction and rate

Learning Outcomes:

After the successful completion of the practical, the learner will be able to:

1. Generate flow-nets and interpret them to assess the direction of groundwater flow

2. Use simple equations to calculate the quality, volume of a groundwater aquifer and determine the rate of flow of water through it
BIS standards of drinking water Water bearing properties of rocks Construction of Flow nets Delineation of watershed Measurement of runoff Streams - effluent and influent Calculation of rainwater harvesting Ground water provinces in India and Maharashtra Preparation of groundwater contour maps, perched aquifer and problems related to groundwater geology