SOMAIYA VIDYAVIHAR
K J Somaiya College of Science And Commerce

Somaiya TRUST

K.J. SOMAIYA COLLEGE OF SCIENCE AND COMMERCE

AUTONOMOUS – Affiliated to University of Mumbai

Re-accredited "A' Grade by NAAC

Vidyanagar, Vidyavihar, Mumbai 400077

Syllabus for T.Y.B.Sc.

Program: B.Sc.

Course: Geology

Learning Outcomes based

Curriculum Framework (LOCF)

From the academic year 2023–2024

Structure of Syllabus - Semester V

Course Number	Course Title	Course Code	Credits	Hours	Periods (50 mins)	Unit / Module	Lectures (50 mins)
CC-1	Geology of India: Precambrian Stratigrapgy	23US5GECC1PCS	2	30	36	3	12
CC-2	Igneous Petrology - Evolution of Igneous Rock	23US5GECC2IGP	2	30	36	3	12
CC-3	Structural Geology	23US5GECC3STG	2	30	36	3	12
CC-4	Sedimentary Geology	23US5GECC4SDG	2	30	36	3	12
DSE-1	Element of Geochemistry	23US5GEDS1EOG	2	30	36	3	12
DSE-2	RS-GIS	23US5GEDS2RSG	2	30	36	3	12
DSE-3	Exploration Geology	23US5GEDS3EXG	2	30	36	3	12
SEC-1	Field Geology-1	23US5GESE1FGO1	2	30	36	3	12
SEC-2	Statistics in Geology	23US5GESE2SIG	2	30	36	3	12
GE	Oceanography	23US5GEGEOEC	2	30	36	3	12

Structure of Syllabus - Semester VI

Course Number	Course Title	Course Code	Credits	Hours	Periods (50 mins)	Unit / Module	Lectures (50 mins)
CC-1	Geology of India: Phanerozoic	23US6GECC1PHS	2	30	36	3	12
CC-2	Igneous Textures and Structures	23US6GECC2ITS	2	30	36	3	12
CC-3	Metamorphic Petrology	23US6GECC3MTP	2	30	36	3	12
CC-4	Engineering Geology	23US6GECC4ENG	2	30	36	3	12
DSE-1	Earth and Climate	23US6GEDS1EAC	2	30	36	3	12
DSE-2	Environmental Geology	23US6GEDS2EVG	2	30	36	3	12
DSE-3	Evolution of Life Through Time	23US6GEDS3ELT	2	30	36	3	12
SEC-1	Field Geology-II	23US6GESE1FGO2	2	30	36	3	12
SEC-2	Mathematics in Earth Sciences	23US6GESE2MES	2	30	36	3	12
GE	Geophysical Exploration	23US5GEGEGPE	2	30	36	3	12

Semester V - Theory

Course Number	Course Code	Course Name	Number of Lectures
CC-1	23US5GECC1PCS	Geology of India: Precambrian Stratigraphy	12 L / module

Course Learning Outcome:

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

1. Define the tectonic elements of continent and ocean
2. Understand the history and evolution of Earth and Indian subcontinent since its formation during Archean and Proterozoic Era
3. Describe the tectonic divisions of Precambrian India and their geology
4. Explain the depositional environment of different Precambrian formations of India and its mineralization
5. Discuss the evolution of different life forms during Proterozoic Era

Module 1 - Tectonic Elements of Continents, Oceans and Tectonic division of India	
Learning Objective	To define tectonic elements of continent and ocean. Describe tectonic division of India.
Learning Outcome	1. Understand crustal structure and tectonics 2. Understand Precambrian basement of Indian Peninsula
1.1	Earth's crustal structure, tectonic divisions of continents, tectonic in the ocean
1.2	Tectonic divisions in India and Precambrian basement of Indian Peninsula.

Module 2 - Cratons of India	
Learning Objective	To define cratons of Indian subcontinent
Learning Outcome	1. Understand craton, folded mountain belt. 2. Describe geology of different cratons of India.
2.1	Precambrian: Dharwar Province, Central Indian Province
2.2	Precambrian: Singhbhum Orissa Province, Aravalli Bundelkhand Province.

Module 3 - Proterozoic Basins of India	
Learning Objective	Comprehensive knowledge on Precambrian sedimentary basin.
Learning Outcome	1. Describe about Proterozoic sedimentary basins of India and its mineralization. 2. Explain sedimentary environment of different formation.
3.1	Spatio-temporal distribution of proterozoic basins in India.
3.2	*Krol-Tal formation and Pc-C Boundary*

Recommended books for References

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
3. Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd
5. Sharma, R. S., Sharma, R. (2009). Cratons and Fold Belts of India. Germany: Springer.

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T.Y. B. Sc. (Geology) SEMESTER V

Core Course- I

COURSE TITLE: Geology of India: Precambrian Stratigraphy

COURSE CODE: 23US5GECC1PCS [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

Course Number	Course Code	Course Name	Number of Lectures
CC-2	23US5GECC2IGP	Igneous Petrology - Evolution of Igneous Rocks	12 L / module

Course Learning Outcome:

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

1. Explain the interior structure of Earth and role of magma in formation of different types of igneous rocks
2. Describe the variation of seismic waves within the Earth and its significance
3. Discuss the evolution of magma and several mechanisms of magma differentiation
4. Understand the role of plate tectonics, temperature, pressure and fluids in generation of magma
5. Discuss the importance of Phase Equilibrium and Phase Rule
6. Describe the crystallization and melting relationships in multi component systems

Module 1 - Earth's Interior and Evolution of Magmas	
Learning Objective	1. Discuss the formation and composition of Earth and seismic variation within the Earth. 2. Describe several mechanisms of evolution and differentiation of magma.
Learning Outcome	1. Acquainted with different divisions of Earth present and its significance. 2. Assess the role of plate tectonics, temperature, pressure and fluids in generation of magma.
1.1	The Interior of the Earth: Evidence of the Earth's Composition and Mineralogy: Seismic data, Meteorites, Xenoliths. Mantle Petrology; Low Velocity Zone, Pressure and Temperature variations with Depth. Magma generation and plate tectonics.
1.2	The Evolution of Magmas: Differentiation: Fractional Crystallization and Other Differentiation Mechanisms. Magmatic Mixing and Assimilation. Melting of the mantle, generation of Basaltic magma from a Chemically Uniform Mantle.

Module 2 - One component and Binary Systems	
Learning Objective	1. Demonstrate the importance of Phase Equilibrium and Phase Rule. 2. Compare one component and two component systems and its petrogenetic significance.
Learning Outcome	1. Define the basic principle governing systems in thermodynamic equilibrium. 2. Discuss the role of temperature and pressure on crystallization of magma.
2.1	The Phase Rule and System with One and two Component Systems: Melting Behavior of Natural Magmas, Phase Equilibrium and The Phase Rule, One Component Systems, Two Component (Binary Systems) and Its Petrogenetic Significance.
2.2	Binary Systems with Complete Solid Solution, Binary Eutectic Systems, Binary Peritectic Systems, the Alkali Feldspar System.

Module 3 - Ternary systems	
Learning Objective	1. Illustrate the crystallization and melting relationships in multi component systems. 2. The effects of pressure variation and different fluids on the melting and crystallization of magma.
Learning Outcome	1. Comment on the petrogenetic significance and igneous textures associated with multi component systems.
3.1	System with More Than Two Components. Ternary Systems:- Ternary Eutectic Systems, Ternary Systems with Solid Solution Reaction Series, The effect of fluids on Melting Behaviour. The effects of Pressure on the Melting and Crystallization of Magma

Recommended books for References

1. Cox, K. G., Bell, J. D. (1979). The Interpretation of Igneous Rocks. Netherlands: Springer Netherlands.
2. Best M.G. Igneous and Metamorphic Petrology, Blackwell Publications
3. Bose M.K. (1997), Igneous Petrology. The World Press Pvt. Ltd. 568 p.
4. Blatt H., Tracy R.J. and Owens B.E. (2006), Petrology Igneous, sedimentary and Metamorphic rocks (3rd Edition), W.H. Freeman and Company, New York.
5. Bowen N.L. (1928), The evolution of Igneous Rocks. Princeton Univ. Press. N.J. 332 p
6. Hatch F.H., Wells A.K and Wells M.K. (1984), Petrology of the igneous rocks. CBS Publishers, 551 p.
7. Turner F.J and Verhoogen J. (1960), Igneous and Metamorphic Petrology, McGrawHill
8. Winter J. D. (2001), an Introduction to Igneous and Metamorphic Petrology, Prentice Hall, 697p
9. Ehlers, E.G. a nd H. Blatt (1982), Petrology, Igneous, Sedimentary and Metamorphic, W.H Freeman, San Francisco.
10. Philpotts, A., Ague, J. J., Ague, J. (2009). Principles of Igneous and Metamorphic Petrology. Spain: Cambridge University Press.
11. Hall, A. (1987). Igneous Petrology. United Kingdom: Longman Scientific & Technical.
12. McBirney, A. R. (2007). Igneous Petrology. United Kingdom: Jones and Bartlett Publishers.
13. Gill, R. (2011). Igneous Rocks and Processes: A Practical Guide. Germany: Wiley.

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T.Y. B. Sc. (Geology) SEMESTER V

Core Course- II

COURSE TITLE: Igneous Petrology - Evolution of Igneous Rocks

COURSE CODE: 23US5GECC2IGP [CREDITS - 02]

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

Course Number	Course Code	Course Name	Number of Lectures
CC-3	23US5GECC3STG	Structural Geology	12 L / module

Course Learning Outcome:

1. Understand, comprehend, assess, analyse different structures and develop core competencies to apply this knowledge in field and practical problems in structural geology
2. Describe the concept of strike, dip, apparent dip and its significance
3. Utilise the understandings of contours, strike, rule of Vs and right hand thumb rule to analyse and interpret maps
4. Describe the concept of stress and strain and its significance and application.
5. Classify and understand joints/fractures
6. Classify and understand faulting
7. Classify and understand folding

Module 1 - Fundamental Concepts	
Learning Objective	To get a thorough understanding and definitions of the fundamental concepts of structural geology.
Learning Outcome	1. Define structural geology and understand its significance 2. Analyze the topographic, structural features and understand structural maps .

1.1	Structure and Topography: Effects of topography on structural features, Topographic and structural maps; Importance representative factors of the map, Concept of dip and strike; Outcrop patterns of different structures
1.2	Concept of deformation/Rock Rheology: Elastic (Hookean) Behavior, Permanent Deformation – Ductility Controlling Factors
1.3	Stress: Definition, Stress on a Plane, Stress at a Point, Mohr's Construction, Stress Ellipsoid
1.4	Strain: Definitions, Strain Ellipsoid, Simple and Pure Shear, Measurement of Strain in Rocks, Strain Markers, Flinn Diagram

Module 2 - Joints and Faults	
Learning Objective	To get comprehensive understanding of brittle deformations.
Learning Outcome	1. Understand and illustrate the mechanism for the formation of Joints and Faults 2. Classify the type of fault based on geometry and genetics 3. Understand, analyse and illustrate the effect of faulting on the outcrops
2.1	S-L Tectonites (lineations, foliations)
2.2	Study of Structures – (Joints): Joints, fractures and Shear Fractures, Formation of a Fracture Griffith Theory, Joints and Fracture Mechanics, Joints in Plutons
2.3	Study of Structures – (Faults): Geometric and genetic classification and terminology, Criteria for Faulting; Brittle versus Ductile Faults, Introduction to Shear Zones, Types of shear-zones, Shear – Sense Indicators
2.4	Effects of faulting on the outcrops : Outcrop patterns, Geologic/geomorphic criteria for recognition of faults and fault plane solutions

Module 3 - Folds	
Learning Objective	To get comprehensive understanding of ductile deformations
Learning Outcome	1. Classify the type of folds 2. Understand, analyse and illustrate the complex folding patterns 3. Understand and illustrate the mechanism for the formation of folds

3.1	Study of Structures – (Folds): Fold Geometry and Classifications, Ramsay standard classification
3.2	Mechanism of folding.
3.3	Elementary idea of fold interference pattern,

Recommended books for References

1. Fossen, H. (2016). Structural geology. Cambridge University Press.
2. Davis, G. H., Reynolds, S. J., & Kluth, C. F. (2011). Structural geology of rocks and regions. John Wiley & Sons.
3. Mitra, G., Marshak, S. (2018). Basic Methods of Structural Geology. India: Pearson India.
4. Ghosh, S. (2013). Structural Geology: Fundamentals and Modern Developments. United Kingdom: Elsevier Science.
5. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
6. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
7. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press
8. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.

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Core Course- III

COURSE TITLE: Structural Geology

COURSE CODE: 23US5GECC3STG [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

Course Number	Course Code	Course Name	Number of Lectures
CC-4	23US5GECC4SDG	Sedimentary Geology	12 L / module

Course Learning Outcome:
After successful completion of the Course, the learner will be able to:

1. Identify different sedimentary rocks and the process of their formation
2. Describe different types sedimentary structures associated with the sedimentary rock and the energy conditions during which they were formed
3. Explain the significance of sedimentary texture in understanding the provenance
4. Discuss origin and classification of clastic sedimentary rocks
5. Discuss origin and classification of non-clastic sedimentary rocks

Module 1 - Classification and Structures	
Learning Objective	Understanding the process of formation of various sedimentary rocks and structures.
Learning Outcome	1. Classify different sedimentary rocks. 2. Be acquainted with the different types of primary and deformational structures found in a sedimentary rock 3. Identify the energy conditions during which a sedimentary structure was formed in any sedimentary rock.
1.1	Classification of sedimentary rocks,Origin and Transport of sedimentary materials: Origin, Transportation, and deposition of sediments. Classification of sedimentary rocks, Sedimentary textures: Laboratory Techniques, Grain Size, Udden-Wentworth Size Scale, Phi Scale, Grain Size Measurement, Roundness and Shape, Grain to Grain relationship, permeability and porosity.
1.2	Sedimentary structures: Stratification and bedforms: Laminated bedding, Graded bedding, Ripples, Dunes, Antidunes, cross-stratification. Convolute bedding and Lamination, Flame structure, Dish and Pillar structures, Scour and fill Structures. BeddingPlane Marking: Groove Cast, Striation, bounce, brush, prod, and roll marks Flute Cast, Load Cast, Tracks, Trails, Burrows and Mudcracks.

Module 2 - Clastic Sedimentary Rocks	
Learning Objective	Discuss origin of the clastic sedimentary rocks
Learning Outcome	1. Students will be able to identify and classify the clastic sedimentary rocks. 2. Be acquainted with the significance of grain size and mineralogy in understanding the provenance
2.1	Clastic sedimentary rocks: Classification of sedimentary rocks, Sandstone: Framework minerals, Cement, Matrix, Classification of Sandstone, Sandstone Maturity. Conglomerate: Particle Composition, Classification, Origin and occurrence of Conglomerates. SHALES: Composition, Classification, Origin and Occurrence of Shales. Diagenesis and Provenance of Siliciclastic rocks.

Module 3 - Non-clastic Sedimentary Rocks	
Learning Objective	Discuss origin of the non-clastic sedimentary rocks
Learning Outcome	1. Students will be able to identify and classify the non-clastic sedimentary rocks. 2. Attain knowledge of the genesis of various types of non-clastic rocks
3.1	Non-clastic Sedimentary Rocks: Limestones and Dolomites: chemistry and Mineralogy, Limestone texture, Dolomite texture, classification of carbonate rocks, Other Types of Sedimentary Rocks: Evaporites, Kinds of Evaporites and Origin of Evaporite deposits. Cherts: Phanerozoic Marine Cherts; Phanerozoic Nonmarine Cherts; Precambrian Cherts.

Recommended books for References

1. Pettijohn F.J. (1984), Sedimentary Rocks (3 rd Delhi Edition), CBS Publishers and Distributors, New
2. Sengupta S.M. (2007), Introduction to Sedimentology (2 nd Edition), CBS Publishers and Distributors, New Delhi.
3. Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin Hyman, London
4. Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell
5. Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.
6. Boggs Jr, S. (2014). Principles of sedimentology and stratigraphy. Pearson Education.

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Core Course- IV

COURSE TITLE: Sedimentary Geology

COURSE CODE: 23US5GECC4SDG [CREDITS - 02]

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

Course Number	Course Code	Course Name	Number of Lectures
DSE-1	23US5GEDS1EOG	Element of Geochemistry	12 L / module

Course Learning Outcome:
After successful completion of the Course, the learner will be able to:

1. Describe the geochemical properties of elements and solar system
2. Discuss the basics of periodic table and chemical bonding
3. Explain the composition of different Earth reservoirs
4. Understand the importance of radioactivity and radiogenic isotopes in geochronology
5. Describe the formation of solar system and the composition of Earth using meteorites
6. Analyse the geochemical variation of important silicate elements in solid Earth

Module 1 - Concepts of Geochemistry	
Learning Objective	Get introduced to geochemical properties of elements
Learning Outcome	Learn the basics of periodic table and bonding states of elements
1.1	Introduction to properties of elements: The periodic table, Chemical bonding, states of matter and atomic environment of elements, Geochemical classification of elements

Module 2 - Layered Structure of Earth and Geochemistry	
Learning Objective	Discuss the composition of layered Earth and isotopic and elemental abundance
Learning Outcome	Study of nuclides and radioactivity in different reservoirs of Earth

2.1	Composition of different Earth reservoirs and the nuclides and radioactivity, Conservation of mass, isotopic and elemental fractionation, Concept of radiogenic isotopes in geochronology and isotopic tracers

Module 3 - Geochemistry of Solid Earth	
Learning Objective	Analyse the geochemical variation in solid Earth and behaviour of important silicate elements
Learning Outcome	1. Describe the process of formation of solar system 2. Study the composition of Earth using meteorites
3.1	The solid Earth – geochemical variability of magma and its products.
3.2	The Earth in the solar system, the formation of solar system, Composition of the bulk silicate Earth, Meteorites, Geochemical behaviour of selected elements like Si, Al, K, Na etc.

Recommended books for References

1. White, W. M. (2013). Geochemistry. Germany: Wiley.
2. Misra, K. C. (2012). Introduction to Geochemistry: Principles and Applications. Germany: Wiley.
3. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
4. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
5. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
6. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
7. Faure, Gunter and Teresa M. Mensing (2004). Isotopes: Principles and Applications, Wiley India Pvt. Ltd
8. Wilson, B. (2007). Igneous Petrogenesis A Global Tectonic Approach. Germany: Springer.

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T.Y. B. Sc. (Geology) SEMESTER V

Discipline Specific Elective- I

COURSE TITLE: Element of Geochemistry

COURSE CODE: 23US5GEDS1EOG [CREDITS - 02]

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

Course Number	Course Code	Course Name	Number of Lectures
DSE-2	23US5GEDS2RSG	Remote Sensing and GIS	12 L / module

Course Learning Outcome:
After successful completion of the Course, the learner will be able to:

1. Recognize and explain the fundamental principles of remote sensing, including the electromagnetic spectrum; the emission, scattering, reflection, and absorption of electromagnetic (EM) radiation
2. Analyse the principles and components of photogrammetry and remote sensing and describe the process of data acquisition
3. Assess the requirement of satellite images for the required task and determine the datasets required based on sensor characteristics
4. Explain the basic principles of image processing and satellite image interpretation
5. Enumerate the importance and use of GIS technique in daily life

Module 1 - Electromagnetic Radiation Principles and Energy Matter Interactions

Learning Objective	To understand the basic principles of electromagnetic radiation and study the basic principles used in remote sensing techniques
Learning Outcome	1. Understand the energy interactions in the atmosphere and with the different earth surface features 2. Analyse the spectral responses from different earth surface features
1.1	Concept of remote sensing. Active and Passive Remote Sensing. Electromagnetic radiation models: Wavel model, Particle model. Energy Interaction in Atmosphere: Refraction, Scattering, Absorption, Reflectance. Energy Interactions in Earths surface: Reflection, Absorption, Transmittance.
1.2	Spectral Response pattern of Vegetation, Soil, Water and common surface matterials, Atmospheric and geometric Influences on Spectral Response Patterns.

Module 2 - Satellite sensors and their operating principles	
Learning Objective	To learn the different characteristics of a scanning system and get introduced to various scanning systems in use
Learning Outcome	1. Learn about the types of data characteristics that are used in remote sensing, their characteristics and interaction with one another 2. Analyse the different digital formats used to save datasets
2.1	Scanners, Along and Across-track scanning. Data aquisition and Digital Image, Resolution: Spatial, spectral. radiometric, temporal
2.2	Satellite Sensor and Scanner Systems: Multispectral and Hyper spectral Sensing. Thermal imaging. Thermal Radiation principles.

Module 3 - Photogrammetry and GIS	
Learning Objective	To understand the basic principles of landform identification and factors controlling a geographical information system
Learning Outcome	1. Become conversant with the use of aerial photography for measurements using photogrammetry methods 2. Learn the use of aerial photos and satellite imageries in landform evaluation 3. Understand the basics of a GIS system and its governing data models
3.1	Elements of Visual image interpretation, Principles of Landform identification and evaluation

3.2	Type of aerial photos, Geometric Characteristics of aerial photographs Photographic scales, ground coverage of aerial photographs, relief displacement, making stereo images, Image parallax, flight planning
3.3	Basic Mapping Concepts, Components of GIS system, hardware and software requirements of a GIS system, Datums and coordinate systems, Map Projections
3.4	Raster and Vector GIS modelling and analysis

Recommended books for References

1. Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.
2. Jensen, J. R. (2009). Remote Sensing of the Environment: An Earth Resource Perspective 2/e. India: Pearson Education.
3. Jensen, J. R. (2016). Introductory Digital Image Processing: A Remote Sensing Perspective. United Kingdom: Pearson Education, Incorporated.
4. Bhatta, B. (2011). Remote Sensing and GIS. India: OUP India.
5. Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & Inc.
6. Hoffmannsons. Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory & Practice, Springer Wien New York
7. Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer Verlag.
8. Wise, S. (2018). GIS Fundamentals. United Kingdom: CRC Press.
9. Hwang, S., McHaffie, P., Follett, C. (2018). GIS: An Introduction to Mapping Technologies. United Kingdom: CRC Press.

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T.Y. B. Sc. (Geology) SEMESTER V

Discipline Specific Elective- II

COURSE TITLE: Remote Sensing and GIS

COURSE CODE: 23US5GEDS2RSG [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

Course Number	Course Code	Course Name	Number of Lectures
DSE-3	23US5GEDS3EXG	Exploration Geology	12 L / module

Course Learning Outcome:
After successful completion of the Course, the learner will be able to:

1. Understand different types of mineral deposits with respect to processes of formation in relation to exploration strategies
2. Evaluate the sampling data using different statistical parameters
3. Describe the drilling and logging techniques, planning and location of boreholes on ground
4. Analyse the mineral reserves, their estimation and errors associated with them

Module 1 - Mineral Resources	
Learning Objective	To understand the basic principles of economic Geology and identification of mineral reserves
Learning Outcome	1. Understand the various processes that form the mineral reserves 2. Classify the various types of mineral deposits
1.1	Resource reserve definitions, Mineral resources in industries – historical perspective and present, A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Module 2 - Prospecting and Exploration	
Learning Objective	To learn the different Principles of mineral exploration and mineral Prospecting
Learning Outcome	1. Understand the various principles of mineral exploration 2. Get acquainted with various processes of mineral exploration

2.1	Principles of mineral exploration, Prospecting and exploration-conceptualization, methodology and stages, Sampling, subsurface sampling including pitting, trenching and drilling, Geochemical exploration.

Module 3 - Drilling and Logging	
Learning Objective	To understand the core and non-core drilling methods
Learning Outcome	Understand the various Core and non-core drilling methods
3.1	Core and non-core drilling
3.2	Planning of bore holes and location of boreholes on ground
3.3	Core-logging

Recommended books for References

1. Haldar, S. K. K. (2018). Mineral Exploration: Principles and Applications. Netherlands: Elsevier Science.
2. Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.
3. Gandhi, S. M., Sarkar, B. C. (2016). Essentials of Mineral Exploration and Evaluation. Netherlands: Elsevier Science.
4. Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
5. Reedman, J. H. (1979). Techniques in mineral exploration. London: Springer Netherlands.
6. Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH

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T.Y. B. Sc. (Geology) SEMESTER V

Discipline Specific Elective- III

COURSE TITLE: Exploration Geology

COURSE CODE: 23US5GEDS3EXG [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

Course Number	Course Code	Course Name	Number of Lectures
SEC-1	23US5GESE1FGO1	Field Geology - I (Economic Geology and Mining Methods	12 L / module

Course Learning Outcome:

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

1. Analyse the mode of origin and occurrence of ore
2. Understand the ore-host rock interrelation and different ore formation process
3. Discuss the basic techniques of surveying and outcrop mapping
4. Enumerate several types of mines and analyse the mining methods used in those mines

Module 1 - Ore mineral Formation	
Learning Objective	To learn ore minerals and their interrelations with host rocks
Learning Outcome	1. Understand ore mineralization 2. Understand outcrop mapping on field
1.1	Visit to any mineral deposit
1.2	Mode of occurrence of ore, Ore mineralogy
1.3	Ore-Host rock interrelation
1.4	Ore formation process
1.5	Basic techniques of surveying, concept of outcrop mapping

Module 2 - Mine Visit	
Learning Objective	To visit an operating mine and learn the various mining and mapping techniques
Learning Outcome	1. Understand the functioning of an open cast or underground mine 2. Understand underground mapping / bench mapping
2.1	Visit to underground or open cast mine
2.2	Practical experience of mining methods
2.3	Underground mapping/ Bench mapping
2.4	Isopach and Isochore maps.

Course Number	Course Code	Course Name	Number of Lectures
SEC-2	23US5GESE2SIG	Statistics in Geology	12 L / module

Course Learning Outcome:

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

1. Understand primary idea about various laws of statistical distribution
2. Primary attributes (indices) to characterize a geological data
3. Identify appropriate analyses for a given question or hypothesis, with a particular dataset.
4. Apply familiar statistical tests to new datasets.

Module 1	
Learning Objective	Learning the fundamental concepts of statistics
Learning Outcome	Understand the fundamentals and statistical tests
1.1	Introduction to Binomial, Poisson, normal gamma, Chi-square, t and f distribution.

Module 2	
Learning Objective	Learn various data analysis methods using statistics
Learning Outcome	Understand Statistical analysis and application of statistics in sedimentological studies

2.1	Statistics and Data Analysis: Frequency distribution, Histograms, Probability, Correlation coefficient, Regression, Least squares method, Curve fitting, Error estimation; Principal Component Analysis, Analysis of Uni-variate and Multi-variate data
2.2	Case studies, application in sedimentological studies and Petroleum sector.

Recommended books for References

1. Davis, J. C. (2002). Statistics and data analysis in geology. United Kingdom: Wiley.
2. Borradaile, G. J. (2010). Statistics of earth science data: Their distribution in time, space, and orientation. Springer.
3. Ross, S. M. (2020). Introduction to Probability and Statistics for Engineers and Scientists. Netherlands: Elsevier Science.
4. Merriam, D. F., Marsal, D. (2014). Statistics for Geoscientists. United Kingdom: Elsevier Science.
5. Link, R. F., Koch, G. S. (2002). Statistical Analysis of Geological Data. United States: Dover Publications.
6. Stephens, L. J. (2018). Schaum's Outline of Statistics. McGraw-Hill Education.

Course Number	Course Code	Course Name	Number of Lectures
GE	23US5GEGEOEC	Oceanography	12 L / module

Course Learning Outcome:
After successful completion of the Course, the learner will be able to:

1. Describe Earth's hydrologic and atmospheric system and explain how they interact
2. Explain the theory of plate tectonics and how it explains the origin, distribution, and geological and physical features of the ocean basins
3. Demonstrate knowledge of the properties of seawater and apply methods for studying it
4. Explain the causes, locations, and behaviors of ocean waves, currents, and tides and their influence on coastal zones
5. Demonstrate knowledge of common marine organisms, their habitat, interaction and factors influencing productivity
6. Understand Ocean mineral deposits

Module 1 - Physical Oceanography	
Learning Objective	To learn the physical constraints of ocean and ocean water properties
Learning Outcome	Understand the Ocean basins, Formation and properties of ocean water
1.1	The Physiography of the ocean floor. The Origin of Ocean Basins: Continental drift, Global Plate tectonics. Properties of Sea Water, Characteristics of tides.

Module 2 - The atmosphere and Ocean Dynamics and Biological Oceanography	
Learning Objective	Understand the ocean atmosphere interaction and its effect on ocean waves and tides
Learning Outcome	1. Understand the atmosphere and ocean dynamics. 2. Understand various types of waves and currents in ocean

2.1	Wind and Ocean Circulation: Atmospheric Processes, Surface ocean currents, Deep ocean circulation. Waves: Ocean wave properties, Wave motion, standing waves, types of waves. Tides: Tidal characteristics, Origin of tides,Tidal currents.

Module 3 - Ocean Mineral Deposits	
Learning Objective	To understand the laws of ocean associated with mineral deposits
Learning Outcome	Understand the laws of the sea and sea bed mining
3.1	Law of the Sea. (Marine Mineral Resources: Oil and Natural Gas, Gas Hydrates, Sand and Gravel, Manganese, Phosphate.), Sea bed mining.

Recommended books for References

1. Pinet, P. R. (2003). Invitation to oceanography. Boston: Jones and Bartlett Publishers..
2. Trujillo, A. P., Thurman, H. V. (2010). Essentials of Oceanography. United Kingdom: Pearson Prentice Hall.
3. Stewart, R. H. (2009). Introduction to Physical Oceanography. United States: University Press of Florida.
4. Handbook of Marine Mineral Deposits. (2017). United States: CRC Press.
5. Roonwal, G. S. (2012). The Indian Ocean: Exploitable Mineral and Petroleum Resources.: Springer
6. Earney, F. C. F. (2012). Marine Mineral Resources. United Kingdom: Taylor & Francis.
7. Garrison, T. (2009). Essentials of Oceanography. United States: Brooks/Cole, Cengage Learning.
8. Gross, M. G., Gross, E. R., Gross, E., Gross, M. G. (1996). Oceanography, a view of earth. United Kingdom: Prentice Hall.

Question Paper Template

T.Y. B. Sc. (Geology) SEMESTER V

General Elective

COURSE TITLE: Oceanography

COURSE CODE: 23US5GEGEEOC [CREDITS - 02]

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

Semester V - Practical

Course Number	Course Code	Course Name
CP-1	23US5GECC1P	Geology of India: Precambrian Stratigraphy

Learning Objective	The practical is intended to • Understand the Stratigraphic time scale • Understand Lithostratigraphic Boundaries • Understand complex geological maps and its chronological order • Correlate different stratigraphic units
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Classify different lithostratigraphic boundaries • Decipher complex geological history and chronological order with the help of geological maps • Correlate different stratigraphic units

1	Standard Geological Time Scale
2	Diagrammatic examples of Lithostratigraphic boundaries and classification
3	Study of fold and fault characteristics from Geological maps with geological history of the area in chronological order
4	Exercise on correlation between different stratigraphic units

Course Number	Course Code	Course Name
CP-2	23US5GECC2P	Igneous Petrology

Learning Objective	The practical is intended to • Observe and learn megascopic textures and structures in rocks • Study texture, mineral composition and association
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Identify various Megascopic structures and textures of igneous rocks • Identify the mineral composition, mode of occurrence and association of igneous rocks.
Megascopic Structures and Textures Identification of Igneous Rocks	Equigranular: Hypidiomorphic, Panidomorphic. (Orthophyric), Allotriomorphic (Aplitic), Aphanitic Inequigranular: Porphyritic, Glomeroporphyritic, Ophitic/ Subophitic, Poikilitic, Intergranular, Intersertal Directive: Banded (Fluidal), Trachytic Intergrowth: Graphic/Micrographic, Perthitic, Granophyric
Igneous Mega-Structures	Vesicular/ Amygdaloidal Lava, Blockery/ Clinkery Lava, Ropy Lava Surface, Columnar Joint Block, Flow Banding, Intrusive Contacts and Xenoliths
Study of the Texture, Mineral composition, Mode of occurrence, and Association of the following Rock Types	Granite, Rhyolite, Pegmatite, Aplite, Quartz porphyry Pitchstone, Obsidian Syenite (Hornblende / Biotite), Trachyte, Feldspar porphyry Nepheline Syenite

Course Number	Course Code	Course Name
CP-3	23US5GECC3P	Structural Geology

Learning Objective	The practical is intended to • Understand how to solve structural maps • Understand three point problems • Understand Stereographic Projection
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Make Structural profiles and cross sections • interpolate structural information using three point data • Use stereographic projections to analyze structural data
Profiles and cross sections	• Geological maps showing various structural features: Sills, Dykes, two series of dipping beds. (4 maps) • Patterns of dipping strata (folds/faults/unconformity) (3 maps)
Structural Problems	• Three-Point problems. • Thickness and depth of strata
Stereographic Projection	• Plotting a line that lies in a plane, poles to plane • Determining the angle between two lines • Strike and Dip from apparent dips • Attitude of intersection of two planes • π and ß diagrams

Course Number	Course Code	Course Name
CP-4	23US5GECC4P	Sedimentary Petrology

Learning Objective	The practical is intended to • Identify Clastic and non clastic sedimentary rocks • Understand Sedimentary structures and textures
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Identify Sedimentary rocks in hand specimen • Identify the various sedimentary textures of clastic and non clastic sedimentary rocks • Identify the various sedimentary structures
Sedimentary Textures	(Clastic) Rudaceous, (Conglomeratic/ Brecciatic), Arenaceous (Gritty/Sandy), Argillaceous
Sedimentary Structures	Stratification, Current Bedding, Graded Bedding, Ripple Marks, Rain Imprints, Concretions/Secretions
Identification of Sedimentary Rocks	Conglomerate, Breccia, Grit , Sandstone, Shale, Limestone, Fossiliferous Limestone , Oolitic Limestone, Laterite

Course Number	Course Code	Course Name
DSE - 1 PR	23US5GEDS1P	Element of Geochemistry

Learning Objective	The practical is intended to • Understand Geochemical data analysis • Understand Variation diagrams
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Use different types of geochemical data analysis • Plot and interpret variation diagrams
1	Types of geochemical data analysis and interpretation; of common geochemical plots
2	Geochemical analysis of geological materials.
3	Geochemical variation diagrams and its interpretations.

Course Number	Course Code	Course Name
DSE - 2 PR	23US5GEDS2P	Remote Sensing and GIS

Learning Objective	The practical is intended to • Understand aerial photographs and landform identification • Learn to use open source RS-GIS software • Create composite images from raw dataset
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Interpret aerial photographs and interpret the various landforms • Use QGIS to process Remote sensing datasets • Create composite images and extract the spectral signatures to interpret various objects

1	Aerial Photo interpretation, identification of sedimentary, igneous and metamorphic rocks
2	Landform Identification and Evaluation from imageries and various aeolian, glacial, fluvial and marine landforms
3	Introduction to different remote sensing software
4	Creating a FCC from raw data analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures.

Course Number	Course Code	Course Name
DSE - 3 PR	23US5GEDS3P	Exploration Geology

Learning Objective	The practical is intended to • Learn anomalies used in mineral exploration • Make geological cross sections • Evaluate the sample data of ore bodies
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Identify anomalies in various geophysical methods • Draw geological cross section to delineate mineralized zones • Evaluate sample data to estimate reserve and grade of ore

1	Identification of anomaly
2	Concept of weighted average in anomaly detection
3	Geological cross-section
4	Evaluation of sampling data

Semester VI - Theory

Course Number	Course Code	Course Name	Number of Lectures
CC-1	23US6GECC1PHS	Geology of India: Phanerozoic	12 L / module

Course Learning Outcome:

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

1. Understand the origin and tectonic history of different Phanerozoic stratigraphic formations of India and problems associated with stratigraphic boundaries
2. Discuss the evolution of different life forms during Phanerozoic Era
3. List the age, lithology, fossil content and economic minerals present in different Phanerozoic successions of India
4. Comment on their stratigraphic significance and its correlation with different formations present all over India

Module I: Paleozoic and Gondwana succession in India	
Learning Objective	1. Discuss the tectonic history of Palaeozoic period and evolution of different life forms during the same. 2. Categorise different Palaeozoic formations of India with respect to their age, lithology, fossil content and important economic minerals.
Learning Outcome	1. Identify different Palaeozoic succession of India. 2. Comment on their stratigraphic significance and its correlation with different formations present all over India.
1.1	Palaeozoic History: Tectonic History, Palaeozoic Life, Precambrian Cambrian Boundary, Marine Palaeozoic Formations of India, Tethyan Regions.
1.2	Gondwana Sequence of India: Sedimentation and Palaeoclimates, Lower Gondwana Sequence, Talchir Formations, Damuda Group, Upper Gondwana Sequences of Damodar Valley Basin, Satpura Basin, Rajmahal Hills, Mahanadi-Son Valley Basin, Pranhita-Godavari Basin

Module 2: Mesozoic succession in India	
Learning Objective	1. Discuss the tectonic history of Mesozoic period and evolution of different life forms during the same. 2. Categorise different Mesozoic formations of India with respect to their age, lithology, fossil content and important economic minerals.
Learning Outcome	1. Identify different Mesozoic succession of India. 2. Comment on their stratigraphic significance and its correlation with different formations present all over India.
2.1	Mesozoic History: Tectonic History, History of Mesozoic Life, Marine Forms, Permian-Triassic Boundary, Marine Mesozoic Formations of India, Tethyan Himalaya, Lesser Himalaya (Krol Belt), Indian Peninsula, Indus belt, Deccan Volcanics

Module 3 - Cenozoic succession of India & Geology of Maharashtra	
Learning Objective	1. Discuss the tectonic history of Cenozoic period and evolution of different life forms during the same. 2. Categorise different Cenozoic formations of India with respect to their age, lithology, fossil content and important economic minerals.
Learning Outcome	1. Identify different Cenozoic succession of India. 2. Comment on their stratigraphic significance and its correlation with different formations present all over India.
3.1	Cenozoic History: Tectonic History, History of Cenozoic Life, Boundary Problems, Indian Cenozoic Formations, Himalayan Neogene Succession, Indus Belt, Assam–Arakan Region.

3.2	Geology of Maharashtra: Geology of the State, Geological and Geographical distributions of minerals

Recommended books for References

1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
3. Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd
5. Sharma, R. S., Sharma, R. (2009). Cratons and Fold Belts of India. Germany: Springer.

Question Paper Template

T.Y. B. Sc. (Geology) SEMESTER VI

Core Course- I

COURSE TITLE: Geology of India: Phanerozoic

COURSE CODE: 23US6GECC1PHS [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

Course Number	Course Code	Course Name	Number of Lectures
CC-2	23US6GECC2ITS	Igneous Textures and Structures	12 L / module

Course Outcome:

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

1. Understand the petrogenesis of different igneous rocks
2. Describe different igneous textures and its importance in magma behaviour
3. Discuss the igneous structures and field relationships of extrusive and intrusive rocks
4. Enumerate the classification and nomenclature of igneous rock

Module 1 - Igneous Textures	
Learning Objective	Understand the primary igneous textures.
Learning Outcome	1. Differentiate between extrusive and intrusive rock 2. Define different volcanic landforms. 3. Discuss contact relationships of plutons and time of intrusion.
1.1	Define textures of volcanic and pyroclastic rocks. Textures of Igneous rocks: Primary Textures (Crystal/Melt Interactions), Rates of Nucleation, Growth and Diffusion Nucleation at preferred sites, Compositional Zoning Crystallization sequence Magmatic Reaction and Resorption, Cumulate Textures, Volcanic textures and Pyroclastic textures.

Module 2 - Igneous Structures	
Learning Objective	Discuss field relationships of extrusive and intrusive igneous rocks.
Learning Outcome	1. Differentiate between extrusive and intrusive rocks. 2. Define different volcanic land forms. 3. Discuss contact relationships of plutons and time of intrusion.

2.1	Igneous structures and Field Relationship Extrusive or volcanic, Processes, Products and Landforms: Properties of Magma and Eruptive Style, Central vent Landforms, Fissure Eruptions, lava flow features, pyroclastic deposits, Intrusive, or Plutonic, Processes and Bodies: Tabular Intrusive Bodies, Non-Tabular Intrusive Bodies, Contact Relationships of Plutons, time of intrusions.

Module 3 - Igneous Rock Classification	
Learning Objective	Discuss the nomenclature of magmatic and volcanic rocks
Learning Outcome	Name the different igneous rocks and understand their petrogenesis process
3.1	Classification and Nomenclature of Magmatic Rocks Introduction, Compostional terms, IUGS classification, Phaneritic Rocks, felsic, mafic and Ultra-mafics, Aphanitic rocks, Pyroclastic rocks.
3.2	Subduction –Related Activity: Island Arc Volcanic Rocks and Magma Series, The Ophiolite Suite; Calcalkaline and Tholeiite Groups; Petrogenesis of Island Arc Magmas, Plutonic Rocks – Batholiths related to subduction zones. Petrogenesis of Mid-Oceanic Volcanism, Gabbroic Layered Intrusions; Anorthosites; Nephelinites; Carbonatites, Kimberlites and related Rocks.

Recommended books for References

1. Cox, K. G., Bell, J. D. (1979). The Interpretation of Igneous Rocks. Netherlands: Springer Netherlands.
2. Best M.G. Igneous and Metamorphic Petrology, Blackwell Publications
3. Bose M.K. (1997), Igneous P etrology. The World Press Pvt. Ltd. 568 p.
4. Blatt H., Tracy R.J. and Owens B.E. (2006), Petrology Igneous, sedimentary and Metamorphic rocks (3 rd Edition), W.H. Freeman and Company, New York.
5. Bowen N.L. (1928), The evolution of Igneous Rocks. Princeton Univ. Press. N.J. 332 p
6. Hatch F.H., Wells A.K and Wells M.K. (1984), Petrology of the igneous rocks. CBS Publishers, 551 p.
7. Turner F.J and Verhoogen J. (1960), Igneous and Metamorphic Petrology, Mc GrawHill
8. Winter J. D. (2001), an Introduction to Igneous and Metamorphic Petrology, Prentice Hall, 697p
9. Ehlers, E.G. a nd H. Blatt (1982), Petrology, Igneous, Sedimentary and Metamorphic, W.H Freeman, San Francisco.
10. Philpotts, A., Ague, J. J., Ague, J. (2009). Principles of Igneous and Metamorphic Petrology. Spain: Cambridge University Press.
11. Hall, A. (1987). Igneous Petrology. United Kingdom: Longman Scientific & Technical.
12. McBirney, A. R. (2007). Igneous Petrology. United Kingdom: Jones and Bartlett Publishers.
13. Gill, R. (2011). Igneous Rocks and Processes: A Practical Guide. Germany: Wiley.

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T.Y. B. Sc. (Geology) SEMESTER VI

Core Course- II

COURSE TITLE: Igneous Textures and Structures

COURSE CODE: 23US6GECC2ITS [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

Course Number	Course Code	Course Name	Number of Lectures
CC-3	23US5GECC3MTP	Metamorphic Petrology	12 L / module

Course Learning Outcome:

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

1. Define and explain the process of metamorphism and understand the role and significance of the agents of metamorphism
2. Comprehend and illustrate the types of metamorphism and its varied effects
3. Classify the metamorphic rocks
4. Analyse and interpret the metamorphic textures
5. Analyse and interpret and give inferences based on the time deformation relationships
6. Identify the metamorphic facies and protoliths of a metamorphic rock
7. Explain and illustrate the concept of metamorphic facies on PT diagram
8. Correlate the concept of metamorphism and plate tectonics

Module 1 - Introduction to metamorphic petrology	
Learning Objective	To get comprehensive understanding of the concept of Metamorphism and its types.
Learning Outcome	1. Define and explain the process of metamorphism and understand the role and significance of the agents of metamorphism. 2. Comprehend and illustrate the types of metamorphism and its varied effects.
1.1	Introduction to metamorphism: Definition of Metamorphism, factors of Metamorphism, agents of Metamorphism: Temperature, Pressure and Fluids.
1.2	Types of Metamorphism: Contact metamorphism, Regional metamorphism, Burial metamorphism Cataclasis metamorphism, Impact or shock metamorphism, Types of protoliths

Module 2 - Metamorphic texture and structure	
Learning Objective	To get acquainted with the classification of metamorphic rocks, textures and structures.
Learning Outcome	1. Classify the metamorphic rocks 2. Analyse and Interpret the metamorphic textures 3. Analyse and interpret and give inferences based on the time deformation relationships
2.1	Foliated and Lineated Rocks, Non-Foliated and Non-Lineated rocks , High strained rocks
2.2	Texture of contact metamorphism, High-Strain metamorphic texture, Regional Metamorphic texture.
2.3	Temporal relationship between deformation and recrystallization: pre, syn, post-kinematic fabrics, patterns of deformation and flow: tectonic significance of fabric geometry.

Module 3 - Concept of facies, grades and paired metamorphic belts	
Learning Objective	To comprehensively understand the concept of metamorphic facies
Learning Outcome	1. Identify the metamorphic facies and protoliths of a metamorphic rock 2. Explain and Illustrate the concept of metamorphic facies on PT diagram 3. Correlate the concept of metamorphism and plate tectonics

3.1	Concept of metamorphic facies and grade Facies series, Index minerals, Chemographic projections, Metamorphic zones and isograde s.
3.2	Metamorphism of Mafic rocks, Pelitic Sediments, Carbonate, Ultrabasic rocks.
3.3	Paired metamorphic Belts, a brief anatomical overview of metamorphism in orogens

Recommended books for References

1. Best M.G. Igneous and Metamorphic Petrology, Blackwell Publications
2. Blatt H., Tracy R.J. and Owens B.E. (2006), Petrology Igneous, sedimentary and Metamorphic rocks (3 rd Edition), W.H. Freeman and Company, New York.
3. Turner F.J and Verhoogen J. (1960), Igneous and Metamorphic Petrology, Mc GrawHill
4. Philpotts, A., Ague, J. J., Ague, J. (2009). Principles of Igneous and Metamorphic Petrology. Spain: Cambridge University Press.
5. Winter, J. D. (2010). Principles of Igneous and Metamorphic Petrology. United Kingdom: Prentice Hall.
6. Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology, Longman Earth Science series

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T.Y. B. Sc. (Geology) SEMESTER VI

Core Course- III

COURSE TITLE: Metamorphic Geology

COURSE CODE: 23US6GECC3MTP [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

Course Number	Course Code	Course Name	Number of Lectures
CC-4	23US6GECC4ENG	Engineering Geology	12 L / module

Course Learning Outcome:

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

1. Evaluate the suitability of a geological formation for the construction of an engineering structure.
2. Students will be able to state the suitability of rocks for various engineering construction.
3. Can plan and select the rock properties needed for specific construction purposes.
4. Be able to differentiate between favourable and unfavourable geological conditions for tunnel construction.
5. Students will be able to classify the landslides.
6. Be acquainted with the various reasons for the occurrence of landslides.
7. Be able to differentiate between favourable and unfavourable geological conditions for dam and reservoir construction.
8. Be able to differentiate between favourable and unfavourable geological conditions for dam and reservoir construction

Module 1 - Engineering properties of rocks	
Learning Objective	1. Discuss physical/chemical engineering properties of rocks. 2. Explain the properties of aggregates.
Learning Outcome	1. Students will be able to state the suitability of rock for various engineering constructions. 2. Can plan and select the rock properties needed for specific construction purpose.
1.1	Specific Gravity, Porosity, Absorption, Compressive Strength, Tensile Strength, Elasticity of Rocks, Residual Stress and Shear Stress in Rocks. Rocks as Construction Materials: Types of Rocks used in construction, How are they obtained in nature, Use of Rocks as facing stone. Factors influencing Engineering usefulness of Rocks.

1.2	Use of rock as an aggregate in different types of constructions, sources of different grades of aggregates. Properties of Aggregates Shape, Size, Surface Texture, Roundness, Coating, Cement aggregate reaction, Thermal effects on aggregate. Highway aggregate, Rail – road ballast Runway aggregate

Module 2 - Tunnels and Landslides	
Learning Objective	1. Describe the geological considerations for tunnel construction 2. List the various causes of landslides and ways for its prevention.
Learning Outcome	1. Be able to differentiate between favourable and unfavourable geological conditions for tunnel construction. 2. Students will be able to classify the landslides 3. Be acquainted with the various reasons for the occurrence of landslides.
2.1	Tunnels: Terminology, Geological conditions for tunnel sites, Tunnels in folded rocks and bedded rocks. Influence of divisional planes, Effects of faults Crushed zones, Tunnels near slopes, Role of Groundwater in tunneling. Landslides: Causes and Types of Landslides Prevention of landslides, Influence of divisional planes Effects of faults, Crushed zones.

Module 3 - Dams and Reservoirs	
Learning Objective	Describe the geological considerations for dam and reservoir construction
Learning Outcome	1. Be able to differentiate between favourable and unfavourable geological conditions for dam and reservoir construction. 2. Identify the various types of dams

3.1	Types of spillways. Geological conditions for the selection of reservoir site Terminology associated with reservoir Locations of all the Hydro – electric projects in India.
3.2	Terminology associated with Dams, Geological conditions for the selection of dam site, Types of dams, Locations of all the important dams in India

Recommended books for References

1. Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
2. Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.
3. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.
4. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
5. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
6. Bell, .F.G, 2007. Engineering Geology, Butterworth-Heineman

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T.Y. B. Sc. (Geology) SEMESTER VI

Core Course- IV

COURSE TITLE: Engineering Geology

COURSE CODE: 23US6GECC4ENG [CREDITS - 02]

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

Course Number	Course Code	Course Name	Number of Lectures
DSE-1	23US6GEDS1EAC	Earth and Climate	12 L / module

Course Learning Outcome:

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

1. Assess the interaction between Earth's climate and its atmosphere, biosphere and hydrosphere
2. Recognise the interaction within the climate system
3. Understand the responses of climate because of celestial movements
4. Differentiate between the incoming and emitted sources of heat of the Earth
5. Measure the anthropogenic effects on climate
6. Illustrate the intermingling of atmospheric and oceanic currents
7. Understand the phenomenon of monsoon and the effects of its variation

Module 1 - Introduction to climate system	
Learning Objective	Get acquainted with the components of Earth's climate and its controlling factors
Learning Outcome	1. Recognize the interaction within the climatic system. 2. Understand the responses of the climate because of celestial movement.
1.1	Climate system and orbital cyclicity: Forcing and Responses. Components of the climate system. Climate forcing, Climate controlling factors. Climate system response, response rates and interactions within the climate system. Feedbacks in climate system
1.2	Milankovitch cycles and variability in the climate. Glacial-interglacial stages. The Last Glacial maximum (LGM). Pleistocene Glacial-Interglacial cycles. Younger Dryas. Marine isotope stages, changes in sea level

Module 2 - Heat Budget and Climate Change	
Learning Objective	Discuss the sources of Earth's heat and their effect on climate
Learning Outcome	1. Differentiate between the incoming and emitted sources of heat of the Earth 2. Measure the anthropogenic effects on climate
2.1	Incoming solar radiation, receipt and storage of heat, heat transformation, Earth's heat budget, Interaction amongst various sources of earth's heat
2.2	Humans and climate change, sea level fluctuation, brief introduction to archives of climate change, Importance of Indian perspective.

Module 3 - Atmosphere Hydrosphere and Monsoon	
Learning Objective	Comprehend the different layers of the atmosphere, circulation of ocean currents and its effect on Monsoon
Learning Outcome	1. Illustrate the intermingling of atmospheric and oceanic currents 2. Understand the phenomenon of monsoon and the effects of its variation
3.1	Layering of atmosphere and atmospheric Circulation Atmosphere and ocean interaction and its effect on climate Heat transfer in ocean Global oceanic conveyor belt and its control on earth's climate Surface and deep circulation

Recommended books for References

1. Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.

2. Rohli, R.V., and Vega, A.J., 2007. Climatology. Jones and Barlatt

3. Lutgens, F., Tarbuck, E., and Tasa, D., 2009. The Atmosphere: An Introduction to Meteorology. Pearson Publisher

4. Aguado, E., and Burt, J., 2009. Understanding weather. Pearson Prentice Hall

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T.Y. B. Sc. (Geology) SEMESTER VI

Discipline Specific Elective- I

COURSE TITLE: Earth and Climate

COURSE CODE: 23US6GEDS1EAC [CREDITS - 02]

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

Course Number	Course Code	Course Name	Number of Lectures
DSE-2	23US6GEDS2EVG	Environmental Geology	12 L / module

Course Learning Outcome:

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

1. The interaction of humans with the geological environment.
2. Familiarise students with the challenges of environmental geology in the urban environment.
3. Teach practical contributions that geologists can make in managing human interaction with the physical environment.

Module 1 - Introduction to Environmental Geology	
Learning Objective	Get familiar with the relationship between our surrounding environment and geology.
Learning Outcome	1. Concepts of environmental geology 2. Managing geological resources. 3. Appropriate use of the geological environment for waste disposal 4. recognition of natural hazards and mitigation of their human impacts.
1.1	Concept and definition of Environmental Geology. Processes of soil formation, types of soils, soil degradation and changing land use pattern. Concepts of natural ecosystems on the Earth and their mutual inter-relations and interactions (atmosphere, hydrosphere, lithosphere and biosphere). Environmental changes due to influence of human-dominated environment over nature-dominated system. Concept of biodiversity. Mobility of elements.

Module 2 - Environmental Degradation	
Learning Objective	Understanding the roots of degradation of surrounding environment and assess their remedial measures.
Learning Outcome	1. Surface geological processes cause environmental changes. 2. Sources of pollutants, i.e. geogenic and anthropogenic sources., medical geology. 3. Exploration and mining-related environmental problems.
2.1	Impact assessment of water availability, quality and contamination of surface water and groundwater. Atmosphere and air pollution. Soil contamination due to urbanization, industrialization and mining. Basic tenets of environmental laws.

Module - 3 Natural Hazards	
Learning Objective	Comprehensive knowledge on different types Natural hazards
Learning Outcome	1. Causes of Natural hazards. 2. Precautions necessary to prevent natural hazards.
3.1	Distribution, magnitude and intensity of earthquakes. Neotectonics and seismic hazard assessment. Preparation of seismic hazard maps. Impact of seismic hazards on long and short term environmental conditions. Mechanism of landslides, causes of major floods, cyclones and storms. Deforestation and land degradation

Recommended books for References

1. Valdiya, K. S. (2013). Environmental Geology: Ecology Resource and Hazard Management. India: McGraw-Hill Education LLC..
2. Strahler, A. N., & Strahler, A. H. 1973. Environmental geoscience: interaction between natural systems and man. Santa Barbara, Calif: Hamilton Pub. Co.
3. Keller, E. A. 2011. Introduction to Environmental Geology. 9th ed. Person Prentice Hall
4. Voigt, H. r., Knodel, K., Knödel, K., Lange, G. (2007). Environmental Geology: Handbook of Field Methods and Case Studies. Germany: Springer Berlin Heidelberg.
5. Montgomery, C. W. (2018). Environmental Geology. United Kingdom: McGraw-Hill Education.
6. Lundgren, L. (1999). Environmental Geology. United Kingdom: Prentice Hall.

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T.Y. B. Sc. (Geology) SEMESTER VI

Discipline Specific Elective- II

COURSE TITLE: Environmental Geology

COURSE CODE: 23US6GEDS2EVG [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

Course Number	Course Code	Course Name	Number of Lectures
DSE-3	23US5GEDS3ELT	Evolution of Life through Time	12 L / module

Course Learning Outcome:

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

1. Discuss the life on Earth through geological ages and their evolution
2. Describe the biogeochemical cycles and their role in the origin of life
3. Understand the role of plate tectonics and its effects on climate and life.

Module 1 - Life through ages	
Learning Objective	Elementary understanding of the ancient life forms, their importance and their preservation processes.
Learning Outcome	1. Different life forms. 2. Major bio-events throughout geological ages. 3. Knowledge about the fossilization process. 4. Defining early earth evolution using the evolving life-forms.
1.1	Fossils and chemical remains of ancient life. Geological Time Scale with emphasis on major bio-events. Fossilization processes and modes of fossil preservation. Exceptional preservation sites- age and fauna Origin of life Possible life sustaining sites in the solar system, life sustaining elements and isotope records Archean life: Earth's oldest life, Transition from Archean to Proterozoic, the oxygen revolution and radiation of life Precambrian macrofossils – The garden of Ediacara, The Snow Ball Earth Hypothesis.

Module 2 - Paleozoic and Mesozoic Life	
Learning Objective	Change in life-forms after major mass-extinction events in Paleozoic and Mesozoic.
Learning Outcome	1. The changes in the life forms and morphology of the animals. 2. The emergence of life out of water. 3. The arrival of lands, mammals and dinosaurs. 4. Effect of extinction in the evolution of subsequent life forms.
2.1	The Cambrian Explosion. Biomineralization and skeletalization Origin of vertebrates and radiation of fishes Origin of tetrapods - Life out of water Early land plants and impact of land vegetation
2.2	Life after the largest (P/T) mass extinction, life in the Jurassic seas Origin of mammals Rise and fall of dinosaurs Origin of birds; and spread of flowering plants

Module 3 - Cenozoic life	
Learning Objective	Significant changes in the modern life forms and their mutual interaction with climate variability.
Learning Outcome	1. Understanding the factors, responsible for major changes in the life-forms and their habitat in Cenozoic era. 2. Response of hominid species during tectonic-activity and climate change in the Cenozoic.
3.1	Aftermath of end Cretaceous mass extinction – radiation of placental mammals Evolution of modern grasslands and co-evolution of hoofed grazers Rise of modern plants and vegetation Back to water – Evolution of Whales

3.2	Hominid dispersals and climate setting Climate Change during the Phanerozoic - continental break-ups and collisions Plate tectonics and its effects on climate and life Effects of life on climate and geology.

Recommended books for References

1. Clarkson, E.N.K.1998. Invertebrate Palaeontology and Evolution, George Allen & Unwin.
2. Raup, D.M. and Stanley, S. M. 1971. Principles of Palaeontology, W.H. Freeman and Company.
3. Prothero, D.R. 1998. Bringing fossils to life – An introduction to Palaeobiology, McGraw Hill.
4. Benton, M.J. 2005. Vertebrate palaeontology (3rd edition). Blackwell Scientific, Oxford.

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T.Y. B. Sc. (Geology) SEMESTER VI

Discipline Specific Elective- III

COURSE TITLE: Evolution of Life through Time

COURSE CODE: 23US6GEDS3ELT [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

Course Number	Course Code	Course Name	Number of Lectures
SEC-1	23US6GESE1FGO2	Field Geology-II (Precambrian-Phanerozoic Geology Field)	12 L / module

Course Learning Outcome:

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

1. Understand, analyse and interpret maps
2. Identify the structures like fault, fold, and unconformity in the field
3. Use instruments like Brunton compass, clinometer, stereonets, etc.

Module 1	
Learning Objective	Familiarity with the nature of different types of rocks in the field and their structural characters.
Learning Outcome	1. Acquaintance with rock types. 2. Identifying different structural features. 3. Lithological and structural mapping.
1.1	1. Structural mapping and contact mapping; stride mapping. 2. Use of toposheet to plan traverses and sampling location in the field. 3. Identification of fault, folds, unconformities, and joint sets. 4. Isograd mapping in metamorphic terrain and lithology preparation in sedimentary terrain

Module 2	
Learning Objective	Familiarise with mapping techniques and analysis
Learning Outcome	1. Understand mapping instruments used in field mapping 2. Understand post field analysis
2.1	1. Use of field instruments: GPS, Brunton compass, Clinometer compass 2. Post-field analysis of data: rosette diagrams, stereonets, transect mapping

Course Number	Course Code	Course Name	Number of Lectures
SEC-2	23US6GESE2MES	Mathematics in Earth Sciences	12 L / module

Course Learning Outcome:

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

1. Learn about the basic mathematical concepts and their applications to geology.
2. Learn about different statistical methods used for geological data analysis.
3. Develop fundamental mathematical skills required for geological interpretation

Module 1 - Basic Mathematical functions	
Learning Objective	Elementary level of understanding of the applications of Algebra and geometry in solving geological problems.
Learning Outcome	1. Understanding relationships between geological variables. 2. Understand mathematical equations and functions that are applicable to appreciating geological problems.
1.1	Relationships between geological variables: Straight line, Quadratic equations, Polynomial functions.
1.2	Manipulation of equations, Trigonometric functions, Cartesian coordinates, Matrices
1.3	Vectors, Triangular diagrams, Graph theory, Polar graphs, Projections

Module 2 - Applications	
Learning Objective	Solving geological problems in a precise quantitative way.
Learning Outcome	1. Understand and apply differential calculus for addressing geological problems. 2. Understand and apply integral calculus for addressing geological problems.
2.1	Applications of Differential Calculus for geological problems
2.2	Applications of Integral Calculus for geological problems

Recommended books for References

1. Waltham, D. 2013. Mathematics: a simple tool for geologists. Routledge.
2. Knoring, L. D., & Dech, V. N. 1993. Mathematics for geologists (p. 200). Rotterdam, The Netherlands: AA Balkema.
3. Davis, J. C., & Sampson, R. J. 1986. Statistics and data analysis in geology (Vol. 646). New York: Wiley.
4. Marsal, D., & Merriam, D. F. 2014. Statistics for geoscientists. First Edition, Elsevier.
5. Ferguson, J. (2013). Mathematics in Geology. Germany: Springer Netherlands.

Course Number	Course Code	Course Name	Number of Lectures
GE	23US6GEGEGPE	Geophysical Exploration	12 L / module

Course Learning Outcome:

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

1. Understand the mineral system concept and its implications for geophysical exploration, especially when exploring for blind targets.
2. Understand how the mineral exploration is initiated in different terrains

Module 1 - Gravity and Magnetic Methods	
Learning Objective	Importance of gravity and magnetic methods in exploration.
Learning Outcome	1. Fundamentals of gravity method and its application in mineral and oil exploration. 2. Fundamentals of gravity method and its application in mineral and oil exploration.
1.1	Introduction to geophysics: Geophysical methods used in mineral exploration. Gravity and Magnetic Method

Module 2 - Electrical Methods	
Learning Objective	Importance of electrical methods in exploration.
Learning Outcome	Fundamentals of electrical method and its application in mineral and oil exploration.
2.1	Different types of Electrical methods used for mineral exploration

Module 3 - Seismic Methods	
Learning Objective	Importance of seismic methods in exploration.
Learning Outcome	Fundamentals of seismic method and its application in mineral and oil exploration.
3.1	Nature and types of Seismic waves. Application of seismic method in mineral exploration

Recommended books for References

1. Dobrin, M. B., & Savit, C. H. (1960). Introduction to geophysical prospecting (Vol. 4). New York: McGraw-hill.
2. Telford, W. M., Geldart, L. P., Telford, W. M., Sheriff, R. E. (1990). Applied Geophysics. Italy: Cambridge University Press.
3. Rao, Ramachandra., & Prasaranga, M.B. (1975). Outlines of Geophysical Prospecting - A manual for geologists. University of Mysore, Mysore.
4. Hill, I., Kearey, P., Brooks, M. (2013). An Introduction to Geophysical Exploration. Germany: Wiley.
5. Lillie, R. J. (1999). Whole Earth Geophysics: An Introductory Textbook for Geologists and Geophysicists. United Kingdom: Prentice Hall.
6. Fisher, R., Fisher, R. L., Gadallah, M. R. (2008). Exploration Geophysics. Germany: Springer Berlin Heidelberg.
7. Lowrie, W. (2018). Geophysics: A Very Short Introduction. United Kingdom: Oxford University Press.

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T.Y. B. Sc. (Geology) SEMESTER VI

General Elective

COURSE TITLE: Geophysical Exploration

COURSE CODE: 23US6GEGEGPE [CREDITS - 02]

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

Semester VI - Practical

Course Number	Course Code	Course Name
CP-1	23US6GECC1P	Geology of India: Phanerozoic

Learning Objective	The practical is intended to • Understand the Stratigraphic time scale • Understand Lithostratigraphic Boundaries • Understand complex geological maps and its chronological order • Correlate different stratigraphic units
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Classify different lithostratigraphic boundaries • Decipher complex geological history and chronological order with the help of geological maps • Correlate different stratigraphic units

1	Study of common sedimentary, igneous and metamorphic rocks in Hand specimens from different stratigraphic horizons
2	Study of common fossil characteristics of a particular stratigraphic horizon.
3	Stratigraphy of a geological section-fossils & radiometric age.

Course Number	Course Code	Course Name
CP-2	23US6GECC2P	**Igneous textures and structures**

Learning Objective	The practical is intended to • Identification of different igneous rocks in hand-specimen. • Identification of mesoscopic structures and textures in igneous rocks. • Acquaintance with different microscopic textures in igneous rocks
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Identify igneous rocks in field. • Able to explain some of the mechanical properties of magma. • Can establish the sequence of crystallization of the magmatic rock.
1	Microscopic Textures, Structures, Identification of Igneous Rocks. Diorite, Diorite porphyry, Andesite, Gabbro, Norite, Dolerite, Basalt (Vesicular/ Non-vesicular/Porphyritic, Amygdaloidal) Peridotite, Dunite; Anorthosite, Carbonatite
2	Igneous Micro-Structures Reaction: (a. Corona, b. Myrmekite), Xenolithic, Spherulitic, Perthitic

Course Number	Course Code	Course Name
CP-3	23US6GECC3P	**Metamorphic textures and structures**

Learning Objective	The practical is intended to • Identification of different metamorphic rocks in hand-specimen and petrological microscope. • Identification of microscopic structures and textures in igneous rocks. • Acquaintance with different microscopic reaction-textures in metamorphic rocks.
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Identify metamorphic rocks in field and petrological microscope. • Identify different structural and textural elements in metamorphic rocks. • Can establish temporal development of new minerals and textures during progressive deformation and metamorphism.

1	Megascopic and Microscopic Structures and Textures Metamorphic Textures Idioblastic, Porphyroblastic, Granuloblastic, Xenoblastic
2	Metamorphic Structures Cataclastic, Slaty Cleavage, Maculose, Granulose, Schistose, Gneissose
3	Identification of Metamorphic Rocks Quartzite, Marble, Slate, Phyllite, Mica Schist (with Staurolite/ Garnet), Actinolite/ Chlorite Schist, Mica- Gneiss, Hornblende Gneiss, Granulite, Eclogite, Serpentinite, Khondolite, Charnockite

Course Number	Course Code	Course Name
CP-4	23US6GECC4P	Engineering Geology

Learning Objective	The practical is intended to • Provide knowledge in regard to proper geological site selection for different engineering structures.
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Evaluate the suitability of sites for different engineering structures
1	Geological maps to demarcate and evaluate the suitability of sites for engineering projects such as Tunnels, Dams and Reservoir construction.

Course Number	Course Code	Course Name
DSE-1 PR	23US6GEDS1P	Earth and Climate

Learning Objective	The practical is intended to • Providing knowledge about the climate of Indian sub-continent and major wind-patterns and ocean-currents causing global climatic variation. • Paleogeographic arrangement of Indian subcontinent.
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Apply different proxies to infer practical paleoclimatic variation exercises.

1	Study of distribution of major climatic regimes of India on map
2	Distribution of major wind patterns and oceanic currents on World map
3	Preparation of paleogeographic maps (distribution of land and sea) of India during specific geological time intervals
4	Numerical exercises on interpretation of proxy records for paleoclimate

Course Number	Course Code	Course Name
DSE-2 PR	23US6GEDS2P	Environmental Geology

Learning Objective	The practical is intended to • Introduce the basic tenants of environmental geology, sources of pollutants from natural as well as anthropogenic sources
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Understand surface geological processes causing environmental changes. • Sources of pollutants i.e. geogenic and anthropogenic sources., medical geology.

1	Study of maps of seismic zones, earthquake-prone, landslide-prone and flood-prone areas in India
2	Methods of water analyses for physical, chemical and biological parameters.
3	Classification of groundwater for use in drinking and industrial purposes.
4	Evaluation of environmental impact of air pollution, groundwater pollution, landslides, deforestation.

Course Number	Course Code	Course Name
DSE-3 PR	23US6GEDS3P	Evolution of Life Through Time

Learning Objective	The practical is intended to • Understand Fossils and their preservation • Understand evolutionary trends in important groups of animals and plant
Learning Outcome	After the successful completion of the practical, the learner will be able to: • Fossil preservation methods • Decipher evolutionary trends in important animal and plant groups
1	Study of modes of fossil preservation
2	Study of fossils from different stratigraphic levels
3	Exercises related to major evolutionary trends in important groups of animals and plants