Bachelor of Science (Honours) Geology under CBCS

PATNA UNIVERSITY, PATNA

Programme Code:

Programme Outcomes

At the completion of the programme, students will attain the ability to:

PO1: Develop understanding of Earth/Geological Sciences.
PO2: Apply the knowledge of allied disciplines in understanding geological science
PO3: Develop insightful understanding of Environment with emphasis on sustainable development.

Programme Specific Outcomes

At the completion of the programme, students will attain the ability to:

PSO1: develop an understanding of dynamics of Earth and its interior, geomorphological processes that shapes earth
PSO2: impart knowledge of genesis of various rocks and earth's energy resources including metals non-metals, hydrocarbons etc
PSO3: carry out field workand work as a team, communicate andlearn project management.

Course Structure

Semester –I

Sl.No.	Name ofthe Course	Type ofCourse	L-T-P	Credit	Marks
1	FundamentalsoftheEarthSystem(Th)	CC-1(Th)	4-1-0	4	100
2	Fundamentalsof the Earth System(P)	CC-1(P)	0-0-6	2	100
3	MineralogyandCrystallography(Th)	CC-2(Th)	4-1-0	4	100
4	MineralogyandCrystallography(P)	CC-2(P)	0-0-6	2	100
5	EnglishCommunication/MIL	AECC-1	2-1-0	2	100
6	GenericElective- 1(Th)	GE-1(Th)	4-1-0	4	100
7	GenericElective-1(P)	GE-1(P)	0-0-6	2	100
					Totalcredit-20

Semester – II

Sl.No.	Name ofthe Course	Type ofCourse	L-T-P	Credit	Marks
1	Mineralogy and Optical Mineralogy(Th)	CC-3(Th)	4-1-0	4	100
2	MineralogyandOpticalMineralogy(P)	CC-3(P)	0-0-6	2	100
3	StructuralGeology(Th)	CC-4(Th)	4-1-0	4	100
4	StructuralGeology(P)	CC-4(P)	0-0-6	2	100
5	EnvironmentalScience	AECC-2	2-1-0	2	100
6	GenericElective- 2(Th)	GE-2(Th)	4-1-0	4	100
7	GenericElective-2(P)	GE-2(P)	0-0-6	2	100
					Totalcredit-20

Semester – III

Sl.No.	Name ofthe Course	Type ofCourse	L-T-P	Credit	Marks
1	Geomorphology(Th)	CC-5(Th)	4-1-0	4	100
2	Geomorphology(P)	CC-5(P)	0-0-4	2	100
3	IgneousPetrology(Th)	CC-6(Th)	4-1-0	4	100
4	Igneous Petrology(P)	CC-6(P)	0-0-4	2	100
5	MetamorphicPetrology(Th)	CC-7(Th)	4-1-0	4	100
6	MetamorphicPetrology(P)	CC-7(P)	0-0-4	2	100
7	SkillEnhancementCourse-1	SEC-1	2-1-0	2	100
8	GenericElective- 3 (Th)	GE-3(Th)	4-1-0	4	100
9	GenericElective-3(P)	GE-3(P)	0-0-4	2	100
					Totalcredit-26

Semester – IV

Sl.No.	Name ofthe Course	Type ofCourse	L-T-P	Credit	Marks
1	Sedimentology(Th)	CC-8(Th)	4-1-0	4	100
2	Sedimentology(P)	CC-8(P)	0-0-4	2	100
3	Stratigraphy(Th)	CC-9(Th)	4-1-0	4	100
4	Stratigraphy(P)	CC-9(P)	0-0-4	2	100
5	Palaeontology(Th)	CC-10(Th)	4-1-0	4	100
6	Palaeontology(P)	CC-10(P)	0-0-4	2	100
7	SkillEnhancementCourse-2	SEC-2	2-1-0	2	100
8	GenericElective- 4(Th)	GE-4(Th)	4-1-0	4	100
9	GenericElective – 4(P)	GE-4(P)	0-0-4	2	100
					Totalcredit -26

Semester – V

Sl.No.	Name ofthe Course	Type ofCourse	L-T-P	Credit	Marks
1	Hydrogeology(Th)	CC-11(Th)	4-1-0	4	100
2	Hydrogeology(P)	CC-11(P)	0-0-4	2	100
3	Economic Geology(Th)	CC-12(Th)	4-1-0	4	100
4	EconomicGeology(P)	CC-12(P)	0-0-4	2	100
5	DisciplineSpecificElective – 1(Th)	DSE-1(Th)	4-1-0	4	100
6	DisciplineSpecificElective – 1(P)	DSE-1(P)	0-0-4	2	100
7	DisciplineSpecificElective – 2(Th)	DSE-2(Th)	4-1-0	4	100
8	DisciplineSpecificElective – 2(P)	DSE-2(P)	0-0-4	2	100
					Totalcredit-24

Semester – VI

Sl.No.	Name ofthe Course	Type ofCourse	L-T-P	Credit	Marks
1	Global TectonicsandGeodynamics(Th)	CC-13(Th)	4-1-0	4	100
2	GlobalTectonicsandGeodynamics(P)	CC-13(P)	0-0-4	2	100
3	EngineeringGeologyandMineralResources(Th)	CC-14(Th)	4-1-0	4	100
4	EngineeringGeologyandMineralResources (P)	CC-14(P)	0-0-4	2	100
5	DisciplineSpecificElective-3(Th)	DSE-3(Th)	4-1-0	4	100
6	DisciplineSpecificElective-3(P)	DSE-3(P)	0-0-4	2	100
7	Discipline Specific Elective- 4 (Project/Dissertation)	DSE-4	0-0-6	6	100
					Totalcredit-24

TotalCredits–140

***L/T/P: number of classes per week**

DSE/GE may either carry 6 credit, i.e., *Theory (4 credit) + Practical (2 credit) format*

Or

Consolidated (6 credit) for Theory only

Discipline Specific Elective Course (DSE):

Course name	L-T-P
1. Remote Sensing & GIS	4-1-4
2. Earth and Climate	5-1-0
3. Urban Geology	5-1-0
4. Fuel Geology	4-1-4
5. Environmental Geology and Geogenic Disaster	5-1-0
6. Introduction to Geophysics, Mining & Exploration Geology	5-1-0
7. River Science	5-1-0
8. Oceanography	5-1-0
9. Elements of Geochemistry	5-1-0
UG courses offered by **SWAYAM/MOOC** related to Discipline Specific not studied as Core Cource (CC)/paper may be selected by the candidate with the approval of the Department.	

Generic Elective (GE):

For Geology Students		For Other Students	
Course name	L-T-P	Course name	L-T-P
1. Physics 2. Chemistry 3. Botany 4. Zoology 5. Mathematics 6. Statistics		1. Fundamentals of the Earth System 2. Geomorphology and Geotectonics 3. Mineralogy 4. Structural Geology 5. Remote Sensing & GIS 6. Environmental Geology and Geogenic Disaster 7. Petrology 8. Economic Geology & Hydrogeology 9. Stratigraphy & Palaeontology	4-1-6 5-1-0 4-1-6 4-1-6 4-1-4 5-1-0 4-1-4 4-1-4 4-1-4

Skill Enhancement courses (SEC):

UG courses offered by **SWAYAM/MOOC** related to Skill enhancement not studied as Core Cource (CC)/paper may be selected by the candidate with the approval of the Department.

SEMESTER – I

CC1 : FUNDAMENTALS OF THE EARTH SYSTEM

Course Outcomes

After the completion of the course, the students will be able to:

CO1: Gain comprehensive understanding of the Earth as a planetary body.
CO2: Explain mechanism of plate tectonics, earthquake & volcano.
CO3: Analyze the Earth's surface processes.

CC1 : FUNDAMENTALS OF THE EARTH SYSTEM (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Aim, application and various branches of Geology Solar system; Brief idea about Meteorites Origin of the Earth Earth- important physical parameters	10
2	Age of the Earth Geological time scale Brief idea of the-*Atmosphere, Hydrosphere, Lithosphere, Biosphere*	10
3	Elementary idea about Plate tectonics. Earthquakes –types, causes and effects Internal structure of the Earth Volcanoes - types and products.	12
4	Surface processes: Weathering – *physical, chemical, biological*; Erosion Brief idea of evolution of various landforms – *Glacial, Fluvial, Karst, Eolian* Introduction to Historical Geology Concept of Stratification; Fossils and Fossilization	16
	TOTAL	48

Suggested Reading:

1. Holmes, A.: Principles of Physical Geology.
2. Longwell and Flint : Introduction to Physical Geology
3. Dutta, A.K. : An Introduction to Physical Geology
4. Singh, S. : Physical Geography
5. Singh, Praveen : Textbook of Engineering and General Geology
6. Siddarth, K. : Earth's Dynamic Surface
7. Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis
8. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment. Cambridge University Press.
9. Gross, M. G. (1977). Oceanography: A view of the earth

CC1 : FUNDAMENTALS OF THE EARTH SYSTEM (Practical) (2 credit)
Practical 1. Study of topographic maps 2. Study of contour patterns 3. Study of Seismic zones of India 4. Geological Time Scale/ Hydrogeological Cycle

CC2 : MINERALOGY AND CRYSTALLOGRAPHY

Course Outcomes

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

CO1: Gain basic knowledge of minerals and their properties

CO2: Comprehend different mineral groups.

CO3: Understand crystallographic properties.

CC2 : MINERALOGY AND CRYSTALLOGRAPHY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Mineral- *definition*; Rock forming minerals and Ore minerals. Ionic radii, Ionic substitution & Co-ordination number. Isomorphism, Polymorphism, Pseudomorphism. Physical properties of the minerals: *Form, Color, Streak, Lustre, Cleavage, Fracture, Hardness,Specific gravity, Tenacity, Magnetic properties, Electrical properties.*	14
2	Chemical classification of minerals – *native element, sulphides, oxides and hydroxides, halites, carbonate, sulphates, phosphates, silicates.*	10
3	Introduction to Crystal and their characters- *Crystal form, Face, Edge, Solid angle, Interfacial angle, Crystallographic axis and angles, Bravais lattice.* Introduction to crystal parameters and symmetry elements. Laws of Crystallography.	14
4	Fundamental idea of crystal systems. Detailed study of the following crystal systems: *Isometric, Tetragonal, Hexagonal*	10
	TOTAL	48

Suggested Reading :

1. Berry and Mason, (1961). Mineralogy. W. H. Freeman & Co.
2. Dana, E.S. and Foo, W.E., (2002). A Textbook of Mineralogy
3. Deer, W. A., Howie, R. A., &Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
4. Flint, Y., (1975). Essentials of crystallography, Mir Publishers.
5. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
6. Philips, F.C., (1963). An introduction to crystallography. Wiley, New York.
7. Perkin D. (2010) Mineralogy. Pearson
8. Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy – Concepts and Methods. Text Book Series, Geological Society of India,. Bangalore
9. Read, H. H., (1968) Rutley's Element of Mineralogy. Thomas Murby and Co.

CC2 : MINERALOGY AND CRYSTALLOGRAPHY (Practical)
(2 credits)

Practical

1. Clinographic Projection of :
   Isometric System – Cube, Octahedron, Rhombdodecahedron, and Tetrahedron (+ve and –ve)
   Tetragonal System – 1st and 2nd order Prism with Basal pinacoids,
   1st and 2nd order Pyramids, Zircon, Vesuvianite
2. Study of the following minerals:
   Calcite, Gypsum, Talc, Fluorite, Apatite, Topaz, Corundum, Baryte, Kyanite, Haematite, Galena, Bauxite, Psilomelane, Garnet, Nepheline, Beryl, Andalusite, Sillimanite, Tourmaline, Magnetite, Pyrite, Chromite, Pyrolusite.

SEMESTER- II

CC3 : MINERALOGY AND OPTICAL MINERALOGY

Course Outcomes

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

CO1: Comprehend the basics of Optics and its behavior within minerals.

CO2: Understand classification of silicate mineral groups.

CC3 : MINERALOGY AND OPTICAL MINERALOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Elementary concepts of Light, Propagation of light through minerals Polarization Double refraction	6
2	Petrological Microscope and its function Construction of Nicol prism Optical accessories and its uses	12
3	Isotropism and Anisotropism Important optical properties: *Refractive index, Pleochroism, Pleochroic haloes, Extinction and extinction angle, Birefringence, Interference colours, Optical indicatrix*	12
4	Structural classification of silicates. Detailed study of the following rock forming mineral groups with reference to their Structure, Composition, Classification, Physical and Optical properties,Paragenesis: *Olivine, Pyroxene, Amphibole,Mica, Feldspar, Silica polymorphs* Study of the following minerals in brief: *Hornblende, Tremolite, Actinolite, Hypersthene, Augite, Quartz, Orthoclase, Microcline, Muscovite, Biotite,*	18
	TOTAL	48

Suggested Reading :

1. *Berry and Mason, (1961). Mineralogy. W. H. Freeman & Co.*
2. *Dana, E.S. and Foo, W.E., (2002). A Textbook of Mineralogy*
3. *Deer, W. A., Howie, R. A., &Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.*
4. *Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.*
5. *Kerr, B. F. (1995). Optical Mineralogy. McGraw-Hill, New York.*
6. *Perkin D. (2010) Mineralogy. Pearson*
7. *Read, H. H., (1968) Rutley's Element of Mineralogy. Thomas Murby and Co.*
8. *Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.*

CC3 : MINERALOGY AND OPTICAL MINERALOGY (Practical) (Practical: 2 credits)
Practical : 1. Megascopic studies of the following minerals : *Quartz, Orthoclase, Microcline, Plagioclase, Muscovite, Biotite, Hornblende, Tremolite, Actinolite, Hypersthene, Olivine,* 2. Microscopic study of common rock forming minerals. *Quartz, Microcline, Plagioclase, Muscovite, Biotite, Hornblende, Augite, Hypersthene, Olivine*

CC4 : STRUCTURAL GEOLOGY

Course Outcomes

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

CO1: Gain knowledge of factors responsible for generating structural features of rocks.
CO2: Analyse the concept of stress and strain.
CO3: Understand the concept and mechanism of folds, faults, joints and unconformity.

CC4 : STRUCTURAL GEOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Elementary concepts of structural geology Idea of Stress and Strain Ductile vs. Brittle deformation Lineation, Foliation, Cleavage.	12
2	Attitude of beds, Dip and Strike Outliers and inliers Outcrops and outcrop patterns Clinometer and Brunton compass and its Uses Joint - definition and types	12
3	Fold – definition and its classification Causes and mechanism of Folding Recognition and significance of Fold	10
4	Fault – definition and its classification Mechanism of Faulting Recognition and significance of Fault Unconformity- definition and types Recognition and geological significance of Unconformity	14
	TOTAL	48

Suggested Reading :

1. *Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall*
2. *Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley*
3. *Hills, E.S., (1963) Elements of Structural Geology. Farrold and sons, London.*
4. *Lahee F. H. (1962) Field Geology. McGraw Hill*
5. *Park, R. G. (2004) Foundations of Structural Geology.Chapman& Hall.*
6. *Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.*
7. *Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)*
8. *Ramsay, J.G. (1967) Folding and fracturing of rocks. Mcgraw-Hill, New York*

CC4 : STRUCTURAL GEOLOGY (Practical)
(Practical: 2 credits)

Practical :

1. Study of geological maps.
2. Drawing of section and description of geological maps.
3. Plotting of Dip and Strike on stereo-net.

SEMESTER – III

CC5 : GEOMORPHOLOGY

Course Outcomes

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

CO1: Understand different landforms and their evolution.

CO2: Gain an idea of the geomorphology of Indian subcontinent.

CC5 : GEOMORPHOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition, Scope and Fundamental concepts of Geomorphology Endogenic geomorphic processes; Diastrophism Exogenic geomorphic processes; Weathering, mass wasting, Erosion	12
2	Geomorphic cycle and their interpretations Brief study of the following *Causes of Rejuvenation, Peneplanation, Relief of ocean floor* Drainage patterns and their significance	12
3	Geological work of natural agencies: *Wind action and Aeolian landforms* *Underground water and Karst topography* Glacial processes and landforms Fluvial processes and landforms	12
4	Geomorphic features of India *Extra Peninsular, Peninsular, Indo-Gangetic plain* Brief study of the Physiography and geomorphology of Bihar	12
	TOTAL	48

Suggested Reading :

1. *Chorley, R. J., (1984) Geomorphology. Methuen.*
2. *M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.*
3. *Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.*
4. *Selby, M. J., (1996) Earths Changing Surface. Oxford University Press, UK*
5. *Thornbury, W. D., (1997) Principles of Geomorphology, Wiley eastern Limited, New Delhi*
6. *Verma, V. K., (1986) Geomorphology Earth Surface processes and form. Mcgraw Hill.*

CC5 : GEOMORPHOLOGY (Practical) (Practical: 2 credits)
Practical 1. Physiographic division & drainage system on outline map of India 2. Physiographic division & drainage system on outline map of Bihar. 3. Study of Drainage Pattern. 4. Basics of morphometry.

CC6 : IGNEOUS PETROLOGY

Course Outcomes

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

CO1: Understand the concept of different rock types.
CO2: Know the factors and processes of magma generation.
CO3: Comprehend various classifications of igneous rocks.
CO4: Explainthe factors responsible for diversity of igneous rocks.
CO5: Understand the basics of phase-equilibria.

CC6 : IGNEOUS PETROLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to Petrology-*distinguishing features of three types of rocks.* Magma – Definition, Composition, primary magma Bowen's Reaction series: *Discontinuous and Continuous series*	8
2	Form, Structure and Texture of Igneous rock Generation and crystallization of Magma Plate tectonics and Magmatism	10
3	Different schemes of classification of Igneous rock. Processes of Diversification of Igneous rocks: *Fractional crystallization, Gravitational segregation, Thermo-gravitational diffusion,Filter pressing, Liquid immiscibility, Assimilation & Magma mixing*	10
4	Introduction to Phase rule; Study of the following Phase diagrams: *Binary: An-Di, Ab-An; Ternary: Ab-An-Di* Petrographic description of the following rock types : *Granite, Rhyolite, Syenite, Nepheline-syenite, Monzonite, Diorite, Anorthosite, Gabbro, Dolerite, Basalt, Peridotite, Pyroxenite, Dunite, Trachyte and Andesite.*	20
	TOTAL	48

Suggested Reading :

1. *Huang : Petrology*
2. *Nockolds, Chinner and Kinox: Petrology for students*
3. *Harker : Petrology for students*
4. *Blatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)*
5. *Hall : Igneous Petrology*
6. *Hyndman, W.D. : Petrology of Igneous and Metamorphic Rocks*
7. *Turner and Verhoogen : Igneous and Metamorphic Petrology*
8. *Hatch and Wells : Petrology of the Igneous Rocks*
9. *Philpotts : Principles of Igneous and Metamorphic Petrology*
10. *Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.*

11. *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*
12. *Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.*
13. *Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.*
14. *McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),*
15. *Myron G. Best (2001). Igneous and Metamorphic Petrology,*
16. *K. G. Cox, J. D. Bell. (1979). The Interpretation of Igneous Rocks. Springer/Chapman & Hall.*
17. *Bose M.K. (1997). Igneous Petrology.*
18. *G W Tyrrell. (1926). Principles of Petrology. Springer*

CC6 : IGNEOUS PETROLOGY (Practical)
(Practical: 2 credits)

Practical :

1. Megascopic study of the following rocks:
   Granite, Syenite, Pegmatite, Diorite, Gabbro, Dolerite, Basalt, Rhyolite, Dunite, Trachyte, Obsidian, Pumice, Peridotite, Pyroxenite, Anorthosite, Norite
2. Microscopic study of the following rocks:
   Granite, Syenite, Nepheline–syenite, Granodiorite, Diorite, Gabbro, Dolerite, Basalt, Peridotite, Anorthosite.

CC7 : METAMORPHIC PETROLOGY

Course Outcomes

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

CO1: Know about various agents of metamorphism.
CO2: Understandthe basic features and classification of metamorphic rocks.
CO3: Understand the inter-relationship between plate tectonics and metamorphism

CC7 : METAMORPHIC PETROLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Aims and scope of Metamorphic Petrology Concept of Metamorphism: *Diagenesis, Anataxis, Palingenesis* Concept of Metamorphic Grade, Zones, Facies,Isograds, Index minerals	10
2	Agents of metamorphism Types of Metamorphism Preliminary ideas of - *Metamorphic differentiation, Prograde, Retrograde, and Poly-metamorphism, Paired metamorphic belts*	10
3	Texture of metamorphic rocks Structure of metamorphic rocks Classification of metamorphic rocks	12
4	Metamorphic Facies and Facies series Plate tectonics and metamorphism Petrography of the following metamorphic rocks : *Slate, Phyllite, Schist, Gneiss, Amphibolite, Marble, Quartzite, Hornfels, Charnockite, Khondalite.*	16
	TOTAL	48

Suggested Reading :

1. *Tyrell, G.W. : Principles of Petrology*
2. *Huang : Petrology*
3. *Nockolds, Chinner and Kinox: Petrology for students*
4. *Harker : Petrology for students*
5. *Blatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)*
6. *Best, M.G. : Igneous and Metamorphic Petrology*
7. *Hyndman, W.D. : Petrology of Igneous and Metamorphic Rocks*
8. *Turner and Verhoogen : Igneous and Metamorphic Petrology*
9. *Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.*
10. *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*
11. *Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.*
12. *Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.*

13. *Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series*

CC7 : METAMORPHIC PETROLOGY (Practical) **(Practical: 2 credits)**
Practical 1. Megascopic study of the following rocks: *Slate, Phyllite, Schist, Gneiss, Marble, Charnockite, Amphibolite, Khondalite.* 2. Microscopic study of the following rocks: *Schist, Gneiss, Amphibolite, Charnockite.*

SEMESTER – IV

CC8 : SEDIMENTOLOGY

Course Outcomes

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

CO1: Explain different processes responsible for the formation of sedimentary rocks.
CO2: Understandthe basic features and classification ofsedimentary rocks.
CO3: Understand sedimentary environmentsand their significance in geological studies.

CC8 : SEDIMENTOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Processes of formation of Sedimentary rocks. Lithification and Diagenesis. Provenance & Heavy minerals	11
2	Elementary idea of Sedimentary Environments: *Physical and Chemical parameters* Classification of sedimentary rocks	11
3	Texture of Sedimentary Rocks Clastic and Non-clastic rocks Elementary ideas of Grain Size, Particle Shape and Fabric.	12
4	Structures of Sedimentary Rocks: *Primary, Secondary, Biogenic* Petrography of the following sedimentary rocks: *Shale, Sandstone – Arkose, Greywacke, OrthoquartziteConglomerate, Breccia, Limestone, Dolomite,.*	14
	TOTAL	48

Suggested Reading :

1. *Allen, J.R.L., (1985). Principles of Physical Sedimentology. George Allen and Unwin, LondonBlatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)*
2. *Blatt, H., Middleton, G., and Murray, R., (1980). Origin of Sedimentary rocks. Princeton Hall.*
3. *Boggs, S.: Petrology of Sedimentary Rocks, Cambridge University Press.*
4. *Collinson, J. D. & Thompson, D. B. (1988) Sedimentary structures, Unwin- Hyman, London.*
5. *Folk, R. L., (1974). Petrology of Sedimentary Rock. Hemphill Publishing Company, Austin, Texas*
6. *Harker : Petrology for students*
7. *Huang : Petrology*
8. *Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell*
9. *Nockolds, Chinner and Kinox: Petrology for students*
10. *Pettijohn, F. J., (1984) Sedimentary rocks, Harper & Bros.*
11. *Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan.*

12. *Sengupta, S. M., (2007). Introduction to Sedimentology, CBS Publishers and Distributor, New Delhi.*
13. *Tyrell, G.W. : Principles of Petrology*
14. *Tucker, M. E. (2006) Sedimenary Petrology, Blackwell Publishing.*

CC8 : SEDIMENTOLOGY (Practical) **(Practical: 2 credits)**
Practical 1. Megascopic study of the following rocks: *Conglomerate, Breccia, Sandstones – Orthoquartzite, Arkose, Greywacke, Limestone, Dolomite, Shale.* 2. Microscopic study of the following rocks: *Sandstone, Orthoquartzite, Arkose, Greywacke.*

CC9 : STRATIGRAPHY

Course Outcomes

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

CO1: Apply principles of stratigraphy in various geological studies.
CO2: Understand geology of India.
CO3: Have a comprehensive idea of Geological evolution of Indian sub-continent.

CC9 : STRATIGRAPHY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Principles of Stratigraphy. Methods of Startigraphiccorrelation. Brief idea about *Lithostratigraphy, Biostratigraphy and Chronostratigraphy, Magnetostratigraphy.* Brief study of – *cratons and mobile belts.*	12
2	Brief account of the stratigraphy with special reference to classification, distribution, lithology, fossil content (if any) and economic significance of Archaean of *Dharwar and Singhbhum* *Cuddapahsupergroup and Vindhyansupergroup*	14
3	Brief account of the stratigraphy of the following with special reference to classification, distribution, lithology, fossils and economic significance. *Gondwanasupergroup,* *Jurassic of Kutch,* *Cretaceous of South India*	11
4	Brief account of the stratigraphy of the following with special reference to classification, distribution, lithology, fossil content and economic significance. *Tertiary of Assam* *Siwalik group* Brief idea of important stratigraphic boundaries in India.	11
	TOTAL	48

Suggested Reading :

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. *Ravindrakumar (2018). Fundamentals of Historical Geology and Stratigraphy of India, Newage Publication*
5. *Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd*
6. *Wadia, D., (1973). Geology of India. Mcgraw Hill*

CC9 : STRATIGRAPHY (Practical)
(Practical: 2 credits)

Practical :

1. Distribution of Startigraphic formations on an outline map of India.
   Archaeans of Dharwar and Singhbhum, CudappahSupergroup, VindhyanSupergroup, GondwanaSupergroup
2. Study of stratigraphic rocks:
   Khondalite, Charnockite, SinghbhumGranite, Newer Dolerites, Mica Pegmatite, Kolhan Conglomerate, BHJ, BHQ, Chotangpur Granite Gneiss, Vindhyan Sandstone, Rohtas Limestone, Porcellanite, Rajgir Quartzite, RajgirPhyllites, Talchir sandstone, Barakar sandstone, Rajmahal Traps, Talchir Shale

CC10 :PALAEONTOLOGY

Course Outcomes

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

CO1: Explain the different theories regarding evolution of life.
CO2: Identify and differentiate various types of fossils.
CO3: Understand the importance of fossils.

CC10 :PALAEONTOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition and Types of Fossils Modes of preservation of fossils Ichnofossils; Index fossil Uses of Fossils	12
2	Theories of organic evolution Life through geologic ages Mass Extinctions	12
3	Classification, Morphology and Geological history of the following: *Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, Trilobita*	14
4	Significance of Gondwana flora Extinction of Siwalik mammals Microfossils and their significance	10
	TOTAL	48

Suggested Reading :

1. *Cowen, R., (2000). History of Life. Blackwell Science.*
2. *Doyle, P.: Understanding Fossils: An Introduction to Invertebrate Palaeontology.*
3. *Raup,D.M.,Stanley,S.M.,Freeman,W.H.(1971)PrinciplesofPaleontology*
4. *Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by BlackwellPublishing.*
5. *Benton,M.(2009).Vertebratepaleontology.JohnWiley&Sons.*
6. *Shukla,A.C.,& Misra,S.P. (1975).Essentialsofpaleobotany.VikasPublisher*
7. *Armstrong,H.A.,&Brasier,M.D.(2005)Microfossils.BlackwellPublishing.*
8. *Woods, Henry : Invertebrate Palaeontology*

CC10 :PALAEONTOLOGY (Practical) (Practical: 2 credits)
Practical : 1. Identification of fossils and their geological age: *invertebrate, vertebrate, plant fossils* *Productus, Spirifer, Terebratula, Rhynchonella, Cerithium, Turritella, Conus, Physa, Murex, Voluta, Arca, Pecten, Inoceramus, Spondylus, Ostrea, Gryphaea, Exogyra, Trigonia, Cardita, Perisphinctes, Gonatite. Ceratites, Nautilus, Orthoceras, Belemnites, Calemene, Phacops, Paradoxides, Glossopteris, Gangamopteris, Vertebraria, Ptillophylum.* 2. Drawing of fossils based on morphological features.

SEMESTER – V

CC11 : HYDROGEOLOGY

Course Outcomes

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

CO1: Explain the fundmentals of hydrogeology.
CO2: Define the movement and distribution of groundwater.
CO3: Define physico-chemical nature of groundwater

CC11 : HYDROGEOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Hydrogeology: *concept, scope and its societal relevance.* Hydrologic cycle: Components *-precipitation, evapo-transpiration, infiltration, run-off and subsurface movement of water* Hydrogeological properties of water-bearing formation: *Porosity, Permeability*	10
2	Origin and types of Groundwater: *Juvenile water, Connate water, Meteoric water, Vadose water* Vertical distribution of subsurface water; *Zone of aeration and zone of saturation* Water table and Piezometric surface.	10
3	Types of Aquifer: *Unconfined, Confined and Leaky aquifers.* Springs and their Types Rain water harvesting; Artificial recharge of groundwater	14
4	Physical and chemical properties of water; Ground water quality Elementary idea of Groundwater flow; Darcy's law Groundwater resources of Bihar	14
	TOTAL	48

Suggested Reading :

1. *Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.*
2. *Hudak, P. F., (1999). Principle of Hydrogeology, Lewis Publishers*
3. *Freeze, R. A., and Cherry, J.A. (1979). Groundwater, Prentice Hall*
4. *Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.*
5. *Raghunath, H. M., (1987). Groundwater, New Age International*
6. *Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.*

CC11 : HYDROGEOLOGY (Practical) (Practical: 2 credits)
Practical : 1. Hydrogeological properties of Rocks *Granite, Rhyolite, Basalt, Gabbro* *Sandstone, Limestone, Shale* *Gneiss, Schist, Quartzite* 2. Study and drawing of hydrogeological provinces of Bihar

CC12 : ECONOMIC GEOLOGY

Course Outcomes

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

CO1: Identify various ore minerals and their deposits.

CO2: Have a comprehensive idea about genesis and distribution of major ore minerals and associated host rocks.

CO3: Describe the methods of exploration of mineral deposits.

CC12 : ECONOMIC GEOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to *Ore, Ore mineral, Deposits, Gangue, Tenor, Cut-off grade, Reserve* Forms and structure of ore deposits. Classification of Ore deposits	10
2	Processes of formation of mineral deposits with special reference to: *Magmatic Concentration, Hydrothermal processes – cavity filling and metasomatic replacement*	14
3	Processes of formation of mineral deposits with special reference to: *Supergene Sulphide enrichment Residual deposits, Placer deposits.* Metallogenic epochs and provinces	12
4	Brief idea of relationship between Plate Tectonics and Mineral deposits. Prospecting and exploration methods - *Geological, Geophysical, Geochemical*	12
	TOTAL	48

Suggested Reading :

1. *Jenson and Bateman: Economic Mineral Deposits*
2. *Prasad, U.: Economic Geology*
3. *Brown, C. and Dey, A.K.: Indian Mineral Wealth*
4. *Sinha and Sharma: Mineral Economics*
5. *Tarlings: Economic Geology and Geotectonics*
6. *Riley, Charles M.: Our Mineral Resources*
7. *Bagchi, Sengupta and Rao: Elements of Prospecting and Exploration*
8. *Kesler, Stephen E.: Mineral Resources, Economics and the Environment*
9. *Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.*
10. *Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley*
11. *Laurence Robb. (2005) Introduction to ore forming processes. Wiley.*
12. *Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.*
13. *Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.*

14. *Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications*

CC12 : ECONOMIC GEOLOGY (Practical) **(Practical: 2 credits)**
Practical : 1. Megascopic study of important ore and economic minerals. *Talc, Graphite, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Beryl, Barite, Kyanite, Sillimanite, Hematite, Magnetite, Chromite, Chalcopyrite, Malachite, Azurite, Bauxite, Galena, Pyrite, ,Garnet, Asbestos, Fire clay, and China clay.* 2. Distribution of economic minerals on the outline map of India.

SEMESTER – VI

CC13 : GLOBAL TECTONICS AND GEODYNAMICS

Course Outcomes

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

CO1: Understand the basic components of geo-tectonics.

CO2: Explain the tectonic features of the earth.

CC13 : GLOBAL TECTONICS AND GEODYNAMICS (Th) (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Concept of Diastrophism, Orogeny and Epirogeny Isostasy: *Airy's and Pratt's Hypothesis*	10
2	Continental Drift : *Wegner's Hypothesis* Evidences of Continental Drift Concept of sea floor spreading	12
3	Brief idea of the following: *Paleomagnetism, Palaeoclimate, Polar wandering, Island arcs, Rift Valley* Mountains – *types, character and origin*	14
4	Concept of Plate tectonics. Types of Plate boundary: *Convergent , Divergent and Conservative boundaries* Structure and evolution of Himalayas. Indo-gangetic plain.	12
	TOTAL	48

Suggested Reading :

1. *Badgley, P. C., (1965). Structural and Tectonic Principles, Harper & Row.*
2. *Beloussov, V.V., (1980). Geotectonics, Springer-Verlag Berlin Heinemann*
3. *Condie. Kent. C., Plate Tectonics and Crustal Evolution, Pergamon Press*
4. *Gass I.G., Understanding the Earth. Artemis Press (Pvt.) Ltd. U.K.*
5. *Moores, E. M. and Twiss, R. J., (1995). Tectonics, W. H. Freeman*
6. *Singh, S. : Physical Geography*
7. *Steers, J.A. : The Unstable Earth*
8. *Valdiya, K.S., (1984). Aspects of Tectonics, Tata McGrath Hills.*
9. *Wiley : Dynamic Earth*

CC13 : GLOBAL TECTONICS AND GEODYNAMICS (Practical) (Practical: 2 credits)
Practical 1. Study of Tectonic maps of India 2. Study of different plate boundaries on world map 3. Study of Paleogeographic maps

CC14 : ENGINEERING GEOLOGY AND MINERAL RESOURCES

Course Outcomes

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

CO1: Carry out the field sampling.
CO2: Define physio-mechanical properties of rocks.
CO3: Define the role of geology in planning and construction of civil structures..
CO4: Understand and describe the genesis and distribution of major ore minerals and associated host rocks.

CC14 : ENGINEERING GEOLOGY AND MINERAL RESOURCES (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Sampling: Principle, Methods, Size and Quantity Pits, Trenches, Bore-holes and Logging Geology and mineral resources of Bihar	10
2	Engineering properties of Rocks. Role of Geology in planning and Construction of Engineering Projects: *Dam site selection, Tunnels,Bridge and Road alignment*	14
3	Detailed study of the following economic mineral deposits of India: *Iron, Manganese, Bauxite, Base-metals, Coal, Petroleum, Atomic minerals*	10
4	A brief study of the physical properties, chemical composition, mode of occurrence, uses and distribution of following economic minerals in India: *Galena, Chromite, Ilmenite, Rutile, Monazite, Barite, Garnet, Beryl, Graphite, Talc, Gypsum, Calcite, Fluorite, Apatite, Feldspar, Quartz, Topaz, Corundum, Diamond, Kyanite, Sillimanite, Asbestos, Fire clay, and China clay.*	14
	TOTAL	48

Suggested Reading :

1. *Bell, F.G., (2006). Basic Environmental and Engineering Geology Whittles Publishing.*
2. *Bell, F.G, (2007). Engineering Geology, Butterworth-Heineman*
3. *Brown, C. and Dey, A.K. : Indian Mineral Wealth*
4. *Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.*
5. *Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.*
6. *Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.*
7. *Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.*
8. *Kesler, Stephen E. : Mineral Resources, Economics and the Environment*
9. *Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).*
10. *Prasad, U. : Economic Geology*

11. *Ramakrishnan, M. &Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.*
12. *Riley, Charles M. : Our Mineral Resources*
13. *Sinha and Sharma : Mineral Economics*
14. *Wadia : Minerals of India*
15. *Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.*

CC14 : ENGINEERING GEOLOGY AND MINERAL RESOURCES (Practical)
(Practical: 2 credits)

Practical

1. Structural problems relating to dip and strike, thickness of beds, three-point problems.
2. Megascopic study of important ore and economic minerals:
   Talc, Graphite, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Beryl, Barite, Kyanite, Sillimanite, Hematite, Magnetite, Chromite, Chalcopyrite, Malachite, Azurite, Bauxite, Galena, Pyrite, ,Garnet, Asbestos, Fire clay, and China clay.
3. Distribution of economic minerals on the map of India.

Discipline Specific Elective (DSE)

DSE1 :REMOTE SENSING & GIS

Course Outcomes

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

CO1: Understand the basics of aerial photography.

CO2: Explain the principles, applications of Remote Sensing and Geographic Information System.

DSE1 :REMOTE SENSING & GIS (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to aerial photographs. Types of aerial photographs and classification Scale of aerial photographs Principles of stereoscopic viewing	12
2	Basic concepts in remote sensing, electromagnetic spectrum EMR interaction with atmosphere and earth surface Atmospheric windows, atmospheric effects on remotely sensed data	10
3	Types of satellites. Sensors and their characteristics, Sensor platforms. Spatial, Spectral and Temporal resolution Introduction to Digital Image Processing Indian Remote Sensing satellites	14
4	Introduction to GIS, Components of GIS, Applications of GIS Data input, Data output and visualization, Raster and vector data Geo-referencing, Map projections GPS and its applications	12
	TOTAL	48

Suggested Reading :

1. *Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.*
2. *Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory & Practice, Springer Wien New York.*
3. *Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer- Verlag.*
4. *Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.*
5. *Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag*

DSE1 :REMOTE SENSING & GIS (Practical)
(2 credits)

Practical :

1. Study of Toposheets, Contours, spot heights
2. Scale conversion: *RF, linear, Verbal*
3. Stereoscopic study of Aerial photographs

DSE2 : ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER

Course Outcomes

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

CO1: Understand the structure and functions of ecosystem.
CO2: Comprehend natural and anthropogenic factors affecting Environment.
CO3: Explain natural disasters and its mitigation

DSE2 : ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER (Credit: 6)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to Environmental geology Interaction between Human activities and the natural environment Pollution: *Point, line and area source of Pollution* Water Quality Parameters and BIS standards	12
2	Organic & Inorganic Pollutants Heavy Metal Pollution Remedial measures of pollution	10
3	Earthquakes: *Causes, Effects and Mitigation* Magnitude and Intensity of Earthquakes Seismic Hazard Zoning Map Volcanoes and Volcanic hazards	12
4	Floods: *Interaction between rivers and its flood plain* Flood plain mapping and zoning Landslides –*Causes, Types and Mitigation*	14
5	Cyclones- *Monitoring* Droughts – *Meteorological, Agriculture and Hydrological types* Climate change	12
	TOTAL	60

Suggested Reading :

1. *Bell,F.G.,1999.GeologicalHazards,Routledge,London.*
2. *Bryant,E.,1985.NaturalHazards,CambridgeUniversityPress.*
3. *Keller, E. A., (1987). Environmental Geology, Shales E. Merril Publishing Co., Columbus, Ohio.*
4. *Liu, B. C., (1981). Earthquake Risk and Damage, Westview.*
5. *Montgomery, C., (1984). Environmental Geology, John Wiley and Sons, London.*
6. *Sharma, J. P., Environmental Studies, Laxmi Publications (P) Ltd., New Delhi.*
7. *Smith,K.,1992.EnvironmentalHazards.Routledge,London.*
8. *Subramaniam,V.,2001.TextbookinEnvironmentalScience,NarosaInternational*
9. *Valdiya, K. S., (1987). Environmental Geology- Indian context. Tata Mcgraw Hill, New Delhi*

DSE3 : FUEL GEOLOGY

Course Outcomes

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

CO1: Understand the basics of coal geology
CO2: Get acquainted to coal deposits and its geographical distribution in India.
CO3: Understand the basics of petroleum geology
CO4: Get acquainted to petroleum deposits and its geographical distribution in India.

DSE3 : FUEL GEOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition and Origin of coal Classification of coal Fundamentals of Coal Petrology: *lithotypes, microlithotypes and macerals in coal* Proximate and Ultimate analysis	14
2	Coal carbonization Coal Bed Methane (CBM) Distribution of Gondwana and Tertiary coal	10
3	Chemical composition and physical properties of hydrocarbons. Origin of petroleum. Migration & Accumulation of Petroleum	12
4	Basic ideas of Reservoir rocks Reservoir traps. Petroliferous basins of India.	12
	TOTAL	48

Suggested Reading :

1. *Bastia,R.,& Radhakrishna,M.(2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol.59). Newnes*
2. *Bjorlykke, K.., (1989). Sedimentology and petroleum geology. Springer-Verlag.*
3. *Chandra D. (2007). Chandra's Text book on applied coal petrology. Jijnasa Publishing House.*
4. *Colin R. Ward (Edited), Coal Geology and Technology.*
5. *F.K. North, Petroleum Geology, (Publishers- Allen and Unwiry.)*
6. *North, F.K., 1985, Petroleum Geology, Allen and Unain.*
7. *Shelly R.C. (2014).Elements of Petroleum geology: Third Edition, Academic Press*
8. *Singh, M.P. (Ed.) 1998 - Coal and Organic Petrology. Publ. Corp. New Delhi.*
9. *Tissot B.P. and Welge, D.ll., 1986, Petroleum Formation Occurrence Springer Verla*
10. *Wilcon and Wells , Coal, Coke and Coal chemical*

DSE3 : FUEL GEOLOGY (Practical) (Practical: 2 credits)
Practical : 1. Identification of coal samples. 2. Distribution of coalfieldson outline map of India. 3. Distribution of petroliferous basins onoutline map of India.

DSE4 :EARTH AND CLIMATE

Course Outcomes

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

CO1: Explain global climate system.
CO2: Understand atmospheric circulation and mechanism of Indian monsoon.
CO3: Develop an integrated perspective on climate change.

DSE4 : EARTH AND CLIMATE (Credit: 6)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Componentsof the climate system. Climate controlling factors Heat budget of the Earth. Atmosphere – *physical and chemical aspects.*	10
2	Layering of atmosphere and atmospheric circulation Atmosphere and Ocean interaction and its effect on climate Global oceanic conveyor belt and its control on earth's climate	14
3	Mechanism of monsoon Factors associated with monsoonal intensity Effects of monsoon	10
4	Response of biosphere to Earth's climate Climate Change: *natural and anthropogenic factors* Brief introduction to archives of climate change	14
5	Milankovitch cycles and variability in the climate Pleistocene Glacial-Interglacial cycles Marine isotope stages	12
	TOTAL	60

Suggested Reading :

1. *Rudiman, W.F., (2001). Earth's climate: past and future. Edition2, 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*

DSE5 :OCEANOGRAPHY

Course Outcomes

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

CO1: Understand the ocean topography and global ocean circulation.
CO2: Explain atmosphere-ocean interaction and Indian monsoon system.
CO3: Understand marine resources and factors affecting marine life.

DSE5 : OCEANOGRAPHY (Credit: 6)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definitions and Scope of Oceanography Relief of the Ocean floor; Hypsographic curve - *continental shelf, slope, rise and abyssal plains, submarine canyons* Introduction to Ocean Stratification/Layers	12
2	Nature of Marine deposits Classification of Marine Sediments Methods to study Marine Sediments Laws of the Sea	12
3	Structure and chemical composition of the Atmosphere Atmosphere - Ocean Interaction Concept of Coriolis Effect Indian Monsoon System	12
4	Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Concept of Thermohaline circulation and Oceanic Conveyor Belt El Nino and La Nina	12
5	Primary productivity in the Oceans Environmental Factors for Marine Life – *Physical and Biological factors* Communities of Oceans – *Pelagic and Benthic Communities*	12
	TOTAL	60

Suggested Reading :

1. *Garrison, Tom, 2011. Essentials of Oceanography, Brooks/Cole; International edition.*
2. *Thomas D. & Bowers D., 2012. Introducing Oceanography (Introducing Earth and Environmental Sciences); Dunedin Academic Press.*
3. *Ruddiman, W.F., 2008, Earth's Climate Past and Future, WH Freeman & Co.*
4. *Bender, M., 2013, Paleoclimate, Princeton Premiers in Climate.*
5. *Kenneth, J., 1982, Marine Geology and Geophysics.*
6. *Wright J. and Colling A., 1995, Seawater: its composition, properties and behaviors, The Open University.*

DSE6 :RIVER SCIENCE

Course Outcomes

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

CO1: Understand the dynamic characters of a river system.
CO2: Explain the evolution fluvial morphology
CO3: Understand the basis of stream management.

DSE6 : RIVER SCIENCE (Credit: 6)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Sediment and channel flow River discharge, River hydrographs *(UH, IUH, SUH, GIUH)* and its application in hydrological analysis. Flood frequency analysis	12
2	Sediment load and sediment yield Sediment transport processes in rivers Erosion and sedimentation processes in channel.	12
3	Quantitative analysis of network organization- *morphometry* Role of drainage network in flux transfer Evolution of drainage network in geological time scale.	12
4	Patterns of alluvial rivers - *braided, meandering and anabranching channels, anastomosing* Dynamics of alluvial rivers. Different classification approaches in fluvial geomorphology and its applications.	12
5	River response to climate, tectonics and human disturbance Bedrock channel processes and evolution of fluvial landscapes. Integrated approach to stream management.	12
	TOTAL	60

Suggested Reading :

1. *Bryirely and Fryirs (2005) Geomorphology and river management. Blackwell Pub.*
2. *Davies, T. (2008) Fundamentals of hydrology. Routledge Publications.*
3. *Julien, P. Y. (2002) River Mechanics. Cambridge University Press Knighton, D. (1998) Fluvial forms and processes: A new perspective. Arnold Pubs.*
4. *Richards. K. (2004) Rivers: Forms and processes in alluvial channels. Balckburn Press.*
5. *Robert, A. (2003) River Processes: An introduction to fluvial dynamics. Arnold Publications.*
6. *Tinkler, K. J., Wohl, E. E. (eds.) 1998. Rivers over rock. American Geophyscial Union Monogrpah, Washington, DC.*

7. *Vanoni, V. A. (2006) Sedimentation Engineering. ASCE Manual, Published by American Society of Civil Engineering*

DSE7 : INTRODUCTION TO GEOPHYSICS, MINING & EXPLORATION GEOLOGY

Course Outcomes

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

CO1: Understand different components of geophysics and its applications.
CO2: Explain different methods of geophysical exploration.
CO3: Understand estimation of natural reserve and resources

DSE7 : INTRODUCTION TO GEOPHYSICS, MINING & EXPLORATION GEOLOGY (Th) (Credit: 6)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Inter-relationship between geology and geophysics Preliminary ideas of the geophysical anomalies Different types of survey: Scales of survey; Profiling and Sounding techniques	10
2	Brief idea of the principles and applications of different types of geophysical methods: *gravity, magnetic, electrical, seismic*	14
3	Resource & reserve Mineral resources in industries A brief overview of classification of mineral deposits	10
4	Principles ofProspecting and exploration. Sampling, subsurface sampling including pitting, trenching and drilling. Geochemical exploration.	12
5	Principles of reserve estimation, density and bulk density. Factors affecting reliability of reserve estimation. Reserve estimation based on geometrical models *(square, rectangular, triangular and polygon blocks)*. Regularand irregular grid patterns, statistics and error estimation.	14
	TOTAL	60

Suggested Reading :

1. *Outlines of Geophysical Prospecting- A manual for geologists by Ramachandra Rao, M. B., Prasaranga, University of Mysore, Mysore, 1975.*
2. *Exploration Geophysics- An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.*
3. *Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.*
4. *Telford, W.M., Geldart, L.P., & Sheriff, R.E. (1990). Applied geophysics*

(Vol.1). Cambridge university press.

5. *Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.*
6. *Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.*
7. *Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford- IBH.*
8. *Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.*

DSE8 : ELEMENTS OF GEOCHEMISTRY

Course Outcomes

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

CO1: Explain the key concepts of geochemistry.
CO2: Understand the interrelation between different spheres of geochemistry.
CO3: Explain various applications of geochemistry.

DSE8 : ELEMENTS OF GEOCHEMISTRY (Credit: 6)		
Unit	**Topics to be covered**	**No. of Lectures**
1	The Periodic Table: Introduction to properties of elements. Nucleosynthesis: *Cosmic, Stellar, Explosive* Cosmic abundance of element; Oddo-Harkin's Principle.	10
2	Geochemical classification of elements: *Atmophile, Lithophile, Chalcophile, Siderophile.* Partition Coefficient: *Compatible & Incompatible Elements.* Geochemical Cycle.	14
3	Meteorites & its Composition. Composition of the Earth's Crust: *Continental & Oceanic.* Composition of the Earth's Mantle & Core.	10
4	Aqueous Geochemistry: *Basic concepts, Ionic & Redox potential, pH.* Basics of Isotope Geology. Radiogenic & Stable isotopes.	12
5	Fundamentals of Environmental Geochemistry. Composition of the Atmosphere. Composition of the Biosphere.	14
	TOTAL	60

Suggested Reading :

1. *Mason, B. (1986). Principles of Geochemistry.3rd Edition, Wiley, New York.*
2. *Rollinson, H. (2007). Using geochemical data - evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific and Technical.*
3. *Walther, J. V. (2009). Essentials of geochemistry. Jones and Bartlett Publishers.*
4. *Albarede, F. (2003). Geochemistry: an introduction. Cambridge University Press.*
5. *Faure, Gunter and Teresa M. Mensing (2004). Isotopes Principles and Applications. Wiley India Pvt. Ltd*

DSE9 : URBAN GEOLOGY

Course Outcomes

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

CO1: Explain the role of geological phenomenon in urban life.

CO2: Correlate water and soil contamination due to urbanization and natural hazards control in urban center.

DSE9 : URBAN GEOLOGY (Credit: 6)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Role of Geology in Urban life. Geologicalfeatureandmappingforsubsurfaceinmetropolitanareas. Geotechnical site characterization.	12
2	Soil: d*efinition, types* ; Soil Horizon. Chemistry of Soil. Effectofpollutantson Agriculture.	10
3	Geologicalproblemsinconstructionofundergroundstructuresinurbanareas. Underground Constructions in Urban areas : *Rail and Road*	12
4	Sourcesof contamination of water in Urban Areas Standards of water: *drinking and irrigation purpose* Wastewater treatment.	12
5	GIS – *Introduction and applicationinUrbandevelopment* Seismic Hazards: *Micro-zonation of hazard based on engineering, geological features* Precaution from Seismic Hazard in Urban Planning.	14
	TOTAL	60

Suggested Reading :

1. *Huggenberger, P. and Eptin, J. 2011. Urban Geology: Process-Oriented Concepts for Adaptive andIntegratedResourceManagement.Springer*
2. *Lollino,G.etal.(Ed.),EngineeringGeologyforSocietyandTerritory.Springer*

DSE10 :FIELD WORK / TRAINING / DISSERTATION / PROJECT / INTERNSHIP
(Credit: 6)

GE1 :FUNDAMENTALS OF THE EARTH SYSTEM

Credit: Theory (4) Practical (2)
Same as CC – 1

GE2: GEOMORPHOLOGY AND GEOTECTONICS

Course Outcomes

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

CO1: Explain and classify different landforms.
CO2: Understand the evolution of the continents and Ocean basins
CO3: Explain tectonic evolution with geologic time.

GE2: GEOMORPHOLOGY AND GEOTECTONICS (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Basic principles of Geomorphology. Endogenic geomorphic processes; Diastrophism. Exogenic geomorphic processes; weathering, mass wasting, erosion.	12
2	Geomorphic cycles. Brief study of the following: *causes of Rejuvenation, Peneplanation, Relief of ocean floor*	12
3	Geological work of: *river, wind, glacier.* Drainage patterns and their significance.	12
4	Elementary idea of continental drift, sea floor spreading Basic concepts of Plate tectonics; Plate margins Mountains – *Types, character and origin*	12
	TOTAL	48

Suggested Reading :

1. *Beloussov, V.V., (1980). Geotectonics, Springer-Verlag Berlin Heinemann*
2. *Chorley, R. J., (1984) Geomorphology. Methuen.*
3. *Gass I.G., Understanding the Earth. Artemis Press (Pvt.) Ltd. U.K.*
4. *M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.*
5. *Moores, E. M. and Twiss, R. J., (1995). Tectonics, W. H. Freeman*
6. *Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.*
7. *Singh, S. : Physical Geography*
8. *Selby, M. J., (1996) Earths Changing Surface. Oxford University Press, UK*
9. *Thornbury, W. D., (1997) Principles of Geomorphology, Wiley eastern Limited, New Delhi*
10. *Valdiya, K.S., (1984). Aspects of Tectonics, Tata McGrath Hills*
11. *Verma, V. K., (1986) Geomorphology Earth Surface processes and form. McGraw Hill.*
12. *Wiley : Dynamic Earth*

GE2 : GEOMORPHOLOGY AND GEOTECTONICS (Practical)
(Practical: 2 credits)

Practical :

1. Physiographic division & drainage system on outline map of Bihar.
2. Study of different plate boundaries on world map.

GE3 : MINERALOGY

Course Outcomes

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

CO1: Gain comprehensive ideas about silicates and their classification
CO2: Explain different properties of minerals
CO3: Understand various crystals structure & crystal system

GE3 : MINERALOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Minerals – definition and physical properties –*forms, colour, streak, luster, cleavage, fracture, hardness, specific gravity.* Moh's scale of hardness. Isomorphism and Polymorphism.	10
2	Crystal – *definition, faces, edges & solid angles, crystallographic axis, crystallographic planes, crystal notations.* Symmetry elements: *axis-, plane- and center of symmetry.* Laws of crystallography. Contact goniometer and its use. Introduction to the crystal system; Study of the normal class of the following crystal systems: *Isometric system, Tetragonal system, Orthorhombic system.*	14
3	Propagation of light through minerals; Nicol prism Petrological Microscope and its function. Study of important optical properties – *Relief, Pleochroism, Interference colour, Double refraction and Extinction.*	12
4	Structural Classification of silicates. Mineralogy of important group of rock forming minerals with reference to composition, structure, physical and optical properties *Pyroxene, Amphibole, Feldspar, Silica polymorph.*	12
	TOTAL	48

Suggested Reading :

1. *Berry and Mason, (1961). Mineralogy. W. H. Freeman & Co.*
2. *Dana, E.S. and Foo, W.E., (2002). A Textbook of Mineralogy*
3. *Deer, W. A., Howie, R. A., &Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.*
4. *Flint, Y., (1975). Essentials of crystallography, Mir Publishers.*
5. *Kerr, B. F. (1995). Optical Mineralogy. McGraw-Hill, New York*
6. *Philips, F.C., (1963). An introduction to crystallography. Wiley, New York.*
7. *Perkin D. (2010) Mineralogy. Pearson*
8. *Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy – Concepts and Methods. Text Book Series, Geological Society of India, Bangalore*
9. *Read, H. H., (1968) Rutley's Element of Mineralogy. Thomas Murby and Co.*

10. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.

GE3 : MINERALOGY (Practical)
(Practical: 2 credits)

Practical :

1. Crystal drawing of the following forms:
   Cube, Octahedron, Rhombdodecahedron, Zircon
2. Study of Physical properties of the following minerals:
   Quartz, Orthoclase, Microcline, Feldspar, Muscovite, Biotite, Hornblende, Tremolite, Actinolite, Olivine, Calcite, Gypsum, Talc, Fluorite, Apatite, Topaz, Corundum, Baryte, Kyanite, Tourmaline, Garnet, Magnetite, Hematite, Chalcopyrite, Pyrite, Bauxite, Chromite, Pyrolusite, Psilomelane.
3. Microscopic Study of the common rock forming minerals.

GE4 :STRUCTURAL GEOLOGY

Credit: Theory (4) Practical (2)

Same as CC - 4

GE5 :REMOTE SENSING & GIS

Credit: Theory (4) Practical (2)

Same as DSE - 1

GE6 :ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER

Credit: Theory (6)

Same as DSE - 5

GE7 : PETROLOGY

Course Outcomes

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

CO1: Understand the concept of rocks and their types.
CO2: Understand classification of igneous rocks.
CO3: Outline the basic features of sedimentary rocks and classify them.
CO4: Explain ideas of metamorphism and different type of metamorphic rock.

GE7 : PETROLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to Petrology- *distinguishing features of three types of rocks.* Magma – *Definition, Types and Composition* Bowen's Reaction Principle	8
2	Form and Structure of Igneous rocks Texture of Igneous rock IUGS classification of Igneous rock. Petrographic study of the following igneous rocks: *Granite, Granodiorite, Diorite,Rhyolite, Syenite, Gabbro, Dolerite, Basalt*	12
3	Modes of formation of Sedimentary Rocks Texture and structure of Sedimentary rocks Classification of Sedimentary rocks Petrographic study of the following sedimentary rocks: *Conglomerate, Sandstone, Limestone, Breccia, Shale.*	14
4	Metamorphism – *definition, agents and types* Texture and Structure of Metamorphic rocks Classification of Metamorphic rocks Petrographic study of the following metamorphic rocks : *Slate, Phyllite, Schist, Gneiss, Amphibolite, Granulite, Marble, Quartzite, Charnockite*	14
	TOTAL	48

Suggested Reading :

1. *Allen, J.R.L., (1985). Principles of Physical Sedimentology. George Allen and Unwin, London Blatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)*
2. *Blatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)*
3. *Boggs, S.: Petrology of Sedimentary Rocks, Cambridge University Press.*
4. *Bose M.K. (1997). Igneous Petrology Huang : Petrology*
5. *Harker : Petrology for students*
6. *McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),*

7. *Myron G. Best (2001). Igneous and Metamorphic Petrology,*
8. *Nockolds, Chinner and Kinox: Petrology for students*
9. *Pettijohn, F. J., (1984) Sedimentary rocks, Harper & Bros Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.*
10. *Sengupta, S. M., (2007). Introduction to Sedimentology, CBS Publishers and Distributor, New Delhi Tyrell, G.W. : Principles of Petrology*
11. *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*

GE7 : PETROLOGY (Practical)
(Practical: 2 credits)

Practical :

1. Megascopic study of the following rocks:
   Granite, Rhyolite, Diorite, Gabbro, Basalt, Granodiorite, Dolerite, Conglomerate, Breccia, Sandstones, Greywacke, Limestone, Dolomite, Shale., Slate, Phyllite, Schist, Gneiss, Marble, Charnockite, Amphibolite
2. Microscopic study of the following rocks:
   Granite, Diorite, Gabbro, Basalt, Granodiorite, Dolerite, Syenite, Sandstone, Orthoquartzite, Arkose, Greywacke, Limestone, Schists, Gneisses, Amphibolite, Charnockite

GE8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY

Course Outcomes

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

CO1: Understand classification of mineral deposits and their processes of formation.

CO2: Gain a comprehensive idea about genesis and distribution of major ore minerals and associated host rocks.

CO3: Explain basic concepts of hydrogeology.

CO4: Appreciate properties of water bearing geological formation

GE8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Concept of *Ore, Ore mineral, Gangue, Tenor of Ores.* Forms and structure of ore deposits. Classification of Ore deposits	10
2	An elementary idea of the processes of formation of mineral deposit with special reference to- *Magmatic concentrates, Supergene sulphide enrichments, Placer deposits* Study of the properties and distribution of the following economic minerals: *Talc, Gypsum, Calcite, Fluorite, Apatite, Felspar, Quartz, Topaz, Corundum, Chromite, Beryl, Barite, Kyanite, Pyrolusite, Psilomelane, Mica, Hematite, Magnetite, Chalcopyrite, Bauxite, Graphite, Galena.*	14
3	Hydrogeology: *concepts, scope and its societal relevance* Hydrologic cycle: *precipitation, evapo-transpiration, infiltration, run-off and subsurface movement of water* Physical and chemical properties of water Origin and types of Groundwater: *Juvenile water, Connate water, Meteoric water, Vadose water*	14
4	Hydrogeological properties of water-bearing formation: *Porosity, Permeability* Groundwater resources of Bihar	10
	TOTAL	48

Suggested Reading :

1. *Brown, C. and Dey, A.K.: Indian Mineral Wealth*
2. *Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.*
3. *Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley*
4. *Jenson and Bateman: Economic Mineral Deposits*
5. *Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw Hill Pub. Co. Ltd.*

6. *Prasad, U.: Economic Geology*
7. *Raghunath: Hydrology*
8. *Riley, Charles M.: Our Mineral Resources*
9. *Sinha and Sharma: Mineral Economics*
10. *Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.*

GE8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY (Practical)
(Practical: 2 credits)

Practical :

1. Observation of the following economic minerals with reference to their physical properties :

   Talc, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Beryl, Barite, Kyanite, Sillimanite, Hematite, Magnetite, Chromite, Chalcopyrite, Malachite, Azurite, Bauxite, Galena, Pyrite.

2. Groundwater provinces on an outline map of India.

GE9 : PALAEONTOLOGY AND STRATIGRAPHY

Course Outcomes

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

CO1: Unravel the geological events of the past.
CO2: Explain the order in which the rock formation formed
CO3: Understand the idea of Geological evolution of India.
CO4: Explain the evolution of life through study of fossils.

GE9 : PALAEONTOLOGY AND STRATIGRAPHY (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition and Types of Fossil Condition of Fossilization and Modes of preservation of fossils Uses of Fossils	10
2	Classification, Morphology and Geological history: *Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, Trilobita*	14
3	Definition, Principles of Stratigraphy. Methods of Stratigraphic correlation. Geological Time Scale. Brief idea about *Lithostratigraphy, Biostratigraphy and Chronostratigraphy*	12
4	An outline of Indian stratigraphy with special reference to - *Archaean of Singhbhum,Proterozoic basin of Vindhyan, GondwanaSupergroup, Siwalik Group*	12
	TOTAL	48

Suggested Reading :

1. *Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by BlackwellPublishing.*
2. *Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley*
3. *Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi*
4. *Ramakrishnan, M. &Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.*
5. *Raup,D.M.,Stanley,S.M.,Freeman,W.H.(1971)PrinciplesofPaleontology*
6. *Shukla,A.C.,& Misra,S.P. (1975).Essentialsof paleobotany.VikasPublisher*
7. *Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd*
8. *Woods, Henry : Invertebrate Palaeontology*

GE9 : PALAEONTOLOGY AND STRATIGRAPHY (Practical)
(Practical: 2 credits)

Practical :

1. Distribution of Stratigraphic formation on the outline map of India.
   Archaeans of Dharwar and Singhbhum, CudappahSupergroup, VindhyanSupergroup, GondwanaSupergroup.
2. Study of stratigraphic rocks of
   Khondalite, Singhbhum Granite, Kolhan conglomerate, BHJ, BHQ, Vindhyan Sandstone, Rohtas Limestone, Talchir sandstone, Barakar sandstone, Rajmahal Traps
3. Identification of fossils and their geological age: *invertebrate, vertebrate, plant fossils*
4. Drawing of fossils based on morphological features.