To,

The Principal to Secretary,
Raj Bhavan, Patna

Sub:-**Regarding submission of proposed draft copy of course structure and uniform syllabus of Geology for 3rd to 8th Semester of 4-Year undergraduate Course under CBCS System.**

Reference:- Letter No.- BSU(UGC)- 02/2023-1457/ GS(I) dated-14.09.2023 of Raj Bhavan, Patna, Patna Univ. Letter No. Acad/416/AKS/1398, dated-16.09.2023 and BNMU-Memo no (Admin-comp-Raj Bhav.-04/22)-1017/23, dated-15.09.2023.

Sir,

In Compliance with your letter no. BSU(UGC)- 02/2023-1457/ GS(I) dated-14.09.2023 of Raj Bhavan, Patna, Patna Univ. Letter No. Acad/416/AKS/1398, dated-16.09.2023 and BNMU-Memo no (Admin-comp-Raj Bhav.-04/22)-1017/23, dated- 15.09.2023, we have prepared the Course Structure and uniform syllabus for 4 year undergraduate programme under CBCS System for **Geology** subject in Major, Minor and Multidisciplinary courses for 3rd to 8th Semester.

We are submitting the proposed course structure and syllabus of **Geology** for 3rd to 8th Semester as per UGC regulations.

Thanks & Regards,

Enclosed:-as above.

Yours faithfully

20/9/23

Dr. Atul Aditya Pandey
Subject Expert
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20/9/23

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GEOLOGY
Four Year Undergraduate Program under CBCS

SEMESTER – III

MJC3 : STRUCTURAL GEOLOGY

Course Objective

1. To educate the students about the concept of rock deformation.
2. To understand qualitative aspects of brittle and ductile deformation processes.
3. To impart knowledge about folds, faults, joints, unconformity.

MJC3 : STRUCTURAL GEOLOGY (Credit: 3)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Elementary idea of structural geology Concept of Stress and Strain, Stress and Strain ellipsoid Ductile vs. Brittle deformation Lineation, Foliation, Cleavage.	08
2	Outcrops and outcrop patterns Attitude of beds, Dip and Strike Clinometer and Brunton compass and its Uses Outliers and inliers Joint - definition and types Unconformity- definition, types and geological significance	12
3	Fold – definition, causes and mechanism of Folding Classification of Folds Recognition and significance of Fold	08
4	Fault – definition, causes and mechanism of Faulting Classification of Fault Recognition and significance of Fault	08
	TOTAL	36

MJC3 Practical: STRUCTURAL GEOLOGY (Credit: 2)
Practical 1. Study of geological maps. 2. Drawing of geological section and description of geological history of the area. 3. Plotting of Dip and Strike on stereo-net. 4. Structural problems.

Course Outcome

- Gain knowledge of factors responsible for generating structural features of rocks.
- Analyse the concept of stress and strain.
- Explain the concept and mechanism of folds, faults, joints and unconformity

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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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GEOLOGY
Four Year Undergraduate Program under CBCS

SEMESTER – III

MJC 4: GLOBAL TECTONICS AND GEODYNAMICS

Course Objective

- To train the students about the endogenic forces of the earth.
- To train the student about dynamism of the earth.

MJC4 : GLOBAL TECTONICS AND GEODYNAMICS (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Concept of Diastrophism, Orogeny and Epirogeny Isostasy: *Airy's and Pratt's Hypothesis* Mountains – *types, geological character and origin*	08
2	Continental Drift : *Wegner's Hypothesis* Evidences of Continental Drift Concept of sea floor spreading – evidences and mechanism	08
3	Brief idea of the following: *Paleomagnetism, Palaeoclimate, Mid-oceanic ridge, Polar wandering, Island arcs, Rift Valley*	10
4	Concept of Plate tectonics. Types of Plate boundary: *Convergent , Divergent and Conservative boundaries, Subduction zone, Transform fault* Structure and evolution of Himalayas.	10
5	Geodesy – Introduction, techniques of measuring active deformation. Neotectonics and geological phenomenon Neotectonic activities in Indogangetic plain and in Himalayas.	10
	TOTAL	48

Course Outcome

- Understand the basic components Geodesy.
- Explain the tectonic features of the earth.

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*

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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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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GEOLOGY
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SEMESTER – IV

MJC5 : IGNEOUS PETROLOGY

Course Objective

- To impart knowledge about the magmatic systems and igneous rocks
- To train the students to classify an igneous rock.

MJC5 : IGNEOUS PETROLOGY (Credit: 3)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to Petrology - *distinguishing features of three types of rocks.* Magma – definition, physical and chemical properties, primary magma	06
2	Forms and Structure of Igneous rock Texture of Igneous rock Generation and crystallization of Magma Plate tectonics and Magmatism	08
3	Bowen's Reaction series: *Discontinuous and Continuous series* Processes of Diversification of Igneous rocks: *Fractional crystallization, Gravitational segregation, Thermo-gravitational diffusion, Filter pressing, Liquid immiscibility, Assimilation & Magma mixing* Introduction to Phase rule; Study of the following Phase diagrams: *Binary: An-Di, Ab-An; Ternary: Ab-An-Di*	12
4	Different schemes of classification of Igneous rock. Petrographic description of the following rock types : *Granite, Rhyolite, Syenite, Nepheline-syenite, Monzonite, Diorite, Anorthosite, Gabbro, Dolerite, Basalt, Peridotite, Pyroxenite, Dunite, Trachyte and Andesite.*	10
	TOTAL	36

MJC3 Practical: IGNEOUS PETROLOGY (Credit: 2)
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.* 3. Calculation of CIPW norm.

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Course Outcome

- Understand the concept of different rock types.
- Know the factors and processes of magma generation.
- Comprehend various classifications of igneous rocks.
- Explain the factors responsible for diversity of igneous rocks.
- Understand the basics of phase-equilibria.

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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

GEOLOGY
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SEMESTER – IV

MJC6 : SEDIMENTOLOGY

Course Objective

- To impart knowledge of formation of sedimentary rocks.
- To understand the environment and facies of sedimentary terrain.

MJC6 : SEDIMENTOLOGY (Credit: 3)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Processes of formation of Sedimentary rocks. Lithification and Diagenesis. Provenance & Heavy minerals	08
2	Elementary idea of Sedimentary Environments: *Physical and Chemical parameters* Concept of Sedimentary facies Tectonics and sedimentation	08
3	Texture of Sedimentary Rocks Clastic and Non-clastic rocks Structures of Sedimentary Rocks: *Primary, Secondary, Biogenic*	10
4	Classification of sedimentary rocks Petrography of the following sedimentary rocks: *Conglomerate, Breccia, Sandstone – Arkose, Greywacke, Orthoquartzite, Limestone, Dolomite, Shale*	10
	TOTAL	36

MJC6 Practical: SEDIMENTOLOGY (Credit: 2)
Practical 1. Megascopic study of the following rocks: *Conglomerate, Breccia, Sandstones, Shale, Limestone, Dolomite* 2. Microscopic study of the following rocks: *Sandstone, Orthoquartzite, Arkose, Greywacke, Limestone* 3. Microscopic study of Heavy minerals. 4. Study of sedimentary structures in rock samples.

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Course Outcome

- Explain different processes responsible for the formation of sedimentary rocks.
- Understand the basic features and classification of sedimentary rocks.
- Understand sedimentary environments and their significance in geological studies.

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.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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GEOLOGY
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SEMESTER – IV

MJC7 : METAMORPHIC PETROLOGY

Course Objective

1. To impart knowledge about Metamorphism and metasomatism of rocks.
2. To train the students to understand the different process of formations of metamorphic rocks and their significance.

MJC7 : METAMORPHIC PETROLOGY (Credit: 3)		
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, Isograds, Index minerals	08
2	Agents of metamorphism Types of Metamorphism – Contact, Cataclastic, Regional Preliminary ideas of – Metasomatism, *Metamorphic differentiation, Prograde, Retrograde and Poly-metamorphism, Paired metamorphic belts*	08
3	Texture of metamorphic rocks Structure of metamorphic rocks Classification of metamorphic rocks	10
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.*	10
	TOTAL	36

MJC7 Practical: METAMORPHIC PETROLOGY (Credit: 2)
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.*

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Course Outcome

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

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.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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GEOLOGY
Four Year Undergraduate Program under CBCS

SEMESTER – V

MJC 8: STRATIGRAPHY

Course Objective

- To impart basic knowledge about Stratigraphy
- To understand the characteristics of different stratigraphic units in India.

MJC8 : STRATIGRAPHY (Credit: 3)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Principles of Stratigraphy. Methods of Startigraphic correlation. Brief idea about *Lithostratigraphy, Biostratigraphy, Chronostratigraphy, Magnetostratigraphy, Seismic stratigraphy* Brief study of – *cratons and mobile belts.*	08
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* *Cuddapah supergroup and Vindhyan supergroup*	10
3	Brief account of the stratigraphy of the following with special reference to classification, distribution, lithology, fossils and economic significance. *Gondwana supergroup,* *Jurassic of Kutch,* *Cretaceous of South India*	10
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.	08
	TOTAL	36

MJC8 Practical: STRATIGRAPHY (Credit: 2)
Practical 1. Exercise related to major Startigraphic units in India *Dharwar, Singhbhum, Cudappah, Vindhyan, Gondwana* 2. Study of stratigraphic rocks. 3. Exercise related to Biostratigraphy.

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Course Outcome

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

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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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GEOLOGY
Four Year Undergraduate Program under CBCS

SEMESTER – V

MJC9 : PALAEONTOLOGY

Course Objective

- To impart the basic knowledge of palaeontology
- To understand the fundamentals of organic evolution
- To train the students about Invertebrate Paleontology, fllora and importance of microfossils.

MJC9 : PALAEONTOLOGY (Credit: 3)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition, Branches and Scope of Palaeontoology Fossils – definition and types Modes of preservation of fossils Ichnofossils; Index fossil Uses of Fossils	08
2	Theories of organic evolution Life through geologic ages Mass Extinctions	08
3	Classification, Morphology and Geological history of the following: *Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, Trilobita*	10
4	Palaeobotany and its application Significance of Gondwana flora Extinction of Siwalik mammals Microfossils and their significance	10
	TOTAL	36

MJC9 Practical: PALAEONTOLOGY (Credit: 2)
Practical 1. Identification of fossils and their geological age: ***Gastropods***- *Cerithium, Turritella, Conus, Physa, Murex, Voluta* ***Bivalvia/Lamellibranchia/Pelycepods***- *Arca, Pecten, Inoceramus, Spondylus, Ostrea, Gryphaea, Exogyra, Trigonia and Cardita* ***Cephalopods***- *Perisphinctes, Goniatite, Ceratite, Nautilus, Orthoceras, Belemnites* ***Brachiopods***- *Productus, Spirifer, Terebratulla, Rhynconella* ***Trilobites***- *Calymene, Phacops, Paradoxides, Agnostus* ***Plant fossils***- *Gangamopteris, Glossopteris, Vertebraria, Ptillophylum* ***Microfossils***- *Foraminifera, Ostracods, Diatoms and Radiolaria* 2. Drawing of fossils morphological features.

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Course Outcome

- Explain the different theories regarding evolution of life.
- Identify and differentiate various types of fossils.
- Understand the importance of fossils.

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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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GEOLOGY
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SEMESTER – VI

MJC 10: ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER

Course Objective

- To train students about the basic fundamental aspects of environment.
- To impart knowledge about the impact of the natural/anthropogenic hazards on environment.

MJC10 : ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to Environmental geology; Environmental Pollution Interaction between Human activities and the natural environment Geological factors of environmental health Biogeochemical cycle	10
2	Water Quality Parameters and BIS standards Heavy Metal Pollution Remedial measures of pollution Impact of Urban waste disposal	08
3	Floods: *Interaction between rivers and its flood plain* Flood plain mapping and zoning Landslides – *Causes, Types and Mitigation*	10
4	Earthquakes: *Causes, Effects and Mitigation* Volcanoes and Volcanic hazards	10
5	Climate change Cyclones - *Monitoring and early warning.* Droughts – *Meteorological, Agriculture and Hydrological types* Environmental legislations in India	10
	TOTAL	48

Course Outcome

- Understand the structure and functions of ecosystem.
- Comprehend natural and anthropogenic factors affecting Environment.
- Explain natural disasters and its mitigation

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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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks
10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks
04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks
03 x 10 = 30 marks

GEOLOGY
Four Year Undergraduate Program under CBCS

SEMESTER – VI

MJC11 : ECONOMIC GEOLOGY

Course Objective

1. To impart knowledge about mineral deposits and processes of formation of deposits.
2. To know genesis and distribution of major ore minerals in India.
3. To understand the techniques of exploration.

MJC11 : ECONOMIC GEOLOGY (Credit: 3)		
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 Metallogenic epochs and provinces.	08
2	Processes of formation of mineral deposits with special reference to: *Magmatic Concentration, Hydrothermal processes, Supergene Sulphide enrichment, Residual deposits, Placer deposits*	08
3	Detailed study of the following economic mineral deposits of India: *Iron, Manganese, Bauxite, Base-metals, Coal, Petroleum, Atomic minerals* Mineral resources of Bihar	10
4	Brief idea of relationship between Plate Tectonics and Mineral deposits. Prospecting and exploration methods - *Geological, Geophysical, Geochemical*	10
	TOTAL	36

MJC11 Practical: ECONOMIC GEOLOGY (Credit: 2)
Practical 1. Study of the Physical properties, chemical composition and distribution of important economic minerals: *Talc, Graphite, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Beryl, Barite, Kyanite, Sillimanite, Hematite, Magnetite, Chromite, Chalcopyrite, Malachite, Azurite, Pyrolusite, Psilomelane, Magnesite, Bauxite, Galena, Pyrite, ,Garnet, Asbestos, Fire clay, and China clay, Coal.* 2. Distribution of economic minerals on the map of Bihar. 3. Distribution of economic minerals on the map of India.

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Course Outcome

- Identify various ore minerals and their deposits.
- Have a comprehensive idea about genesis and distribution of major ore minerals and associated host rocks.
- Describe the methods of exploration of mineral deposits.

Suggested Reading:

1. *Bagchi, Sengupta and Rao: Elements of Prospecting and Exploration*
2. *Brown, C. and Dey, A.K.: Indian Mineral Wealth*
3. *Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.*
4. *Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley*
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. *Guilbert, J.M. and Park Jr., C.F. (1986) The Geology of Ore deposits. Freeman & Co.*
7. *Kesler, Stephen E. : Mineral Resources, Economics and the Environment*
8. *Jenson and Bateman: Economic Mineral Deposits*
9. *Laurence Robb. (2005) Introduction to ore forming processes. Wiley.*
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. *Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications*
14. *Sinha and Sharma: Mineral Economics*
15. *Tarlings: Economic Geology and Geotectonics*
16. *Wadia : Minerals of India*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – VI

MJC12 : ENGINEERING GEOLOGY AND HYDROGEOLOGY

Course Objective

1. To understand the fundamentals of engineering geology.
2. To impart knowledge of basic hydrogeology including groundwater origin, occurrence and distribution.
3. To train students on basics of groundwater, water budget and management.

MJC12 : ENGINEERING GEOLOGY AND HYDROGEOLOGY (Credit: 3)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Engineering properties of Rocks. Surface and sub-surface soil investigation for geo-engineering purposes Role of Geology in planning and Construction of Engineering Projects: *Dam site selection, Tunnels, Bridge and Road alignment*	08
2	Hydrogeology: *concept, scope and its societal relevance.* Hydrologic cycle; Origin and types of water: *Juvenile water, Connate water, Meteoric water, Vadose water* Hydrogeological properties of water-bearing formation: *Porosity, Permeability, Specific yield, Transmissivity, Storage coefficient* Darcy's law	08
3	Vertical distribution of subsurface water; *Zone of aeration and zone of saturation* Water table and Piezometric surface. Types of Aquifer: *Unconfined, Confined and Leaky aquifers.* Springs and their Types	10
4	Physical and chemical properties of water; Ground water quality Groundwater resources of Bihar Rain water harvesting; Artificial recharge of groundwater	10
	TOTAL	36

MJC12 Practical: ENGINEERING GEOLOGY AND HYDROGEOLOGY (Credit: 2)
Practical 1. Numerical problem on engineering geology 2. Solving problems using stereonet. 3. Hydrogeological properties of Rocks *Granite, Rhyolite, Basalt, Gabbro*

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Sandstone, Limestone, Shale
Gneiss, Schist, Quartzite

4. Study of hydrogeological provinces of Bihar.
5. Physical and chemical characteristics of water.

Course Outcome

- Explain the fundamentals of hydrogeology.
- Define the movement and distribution of groundwater.
- Define physico-chemical nature of groundwater.
- Define physico-mechanical properties of rocks.
- Define the role of geology in planning and construction of civil structures.

Suggested Reading:

1. *Bell, F.G., (2006). Basic Environmental and Engineering Geology Whittles Publishing.*
2. *Bell, F.G, (2007). Engineering Geology, Butterworth-Heineman*
3. *Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.*
4. *Freeze, R. A., and Cherry, J.A. (1979). Groundwater, Prentice Hall*
5. *Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y.*
6. *Hudak, P. F., (1999). Principle of Hydrogeology, Lewis Publishers*
7. *Johnson, R.B. and De Graf, J.V. 1988. Principles of Engineering Geology, John Wiley.*
8. *Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.*
9. *Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).*
10. *Raghunath, H. M., (1987). Groundwater, New Age International*
11. *Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.*
12. *Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – VII

MJC13 : OCEANOGRAPHY

Course Objective

1. To impart the basic concept of Oceanography.
2. To understand the link between ocean and atmosphere.
3. To develop a comprehensive idea about marine life and environment.

MJC13 : OCEANOGRAPHY (Credit: 3)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definitions and Scope of Oceanography Origin of Ocean; Relief of the Ocean floor; Hypsographic curve - *continental shelf, slope, rise and abyssal plains, submarine canyons* Introduction to Ocean Stratification/Layers	08
2	Atmosphere-Ocean interaction; Concept of Coriolis Effect Ocean current system; warm and cold current and their distribution Indian Monsoon System	08
3	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	10
4	Primary productivity in the Oceans Environmental Factors for Marine Life – *Physical and Biological factors* Communities of Oceans – *Pelagic and Benthic Communities* Nature of Marine deposits Classification of Marine Sediments	10
	TOTAL	36

MJC13 Practical: OCEANOGRAPHY (Credit: 2)
Practical 1. Study of major Ocean currents of the world 2. Preparation of Palaeo-oceanographic maps (distribution of land and sea) of India during specific geologic time intervals. 3. Study of microfossils

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Course Outcome

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

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.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – VII

MJC15 : FUNDAMENTALS OF GEOCHEMISTRY AND GEOPHYSICS

Course Objective

1. To impart basis knowledge of elemental and isotopic concentrations, classification and behaviour of elements in the earth.
2. To impart knowledge of Geophysics and applications of physics in geology.

MJC15 : FUNDAMENTALS OF GEOCHEMISTRY AND GEOPHYSICS (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	The Periodic Table Cosmic abundance of element; Oddo-Harkin's Principle. Geochemical classification of elements; Partition Coefficient: *Compatible and Incompatible Elements*	08
2	Meteorites & its Composition. Composition of the Earth's Crust, Mantle and Core. Basics of Isotope Geology: Radiogenic and Stable isotopes.	10
3	Inter-relationship between geology and geophysics Preliminary ideas of geophysical anomalies Different types of survey: Scales of survey; Profiling and Sounding techniques	10
4	Concept of gravity and gravitational field; variations of gravity over the Earth's surface Geomagnetic field and its variations; concept of magnetic declination and magnetic inclination. Basic principles of resistivity Fundamental principles of seismic wave propagation	12
5	Brief idea of the principles and applications of different types of geophysical methods: *gravity, magnetic, electrical, seismic* Brief outline of various well-logging techniques.	08
	TOTAL	48

MJC15 Practical: FUNDAMENTALS OF GEOCHEMISTRY AND GEOPHYSICS (Credit: 2)
Practical 1. Study of physical and chemical characteristics- Colour, Turbidity, TSS, TDS, pH, Alkalinity. 2. Interpretation of geochemical data. 3. Study and interpretation of geophysical data: resistivity, gravity, magnetic, seismic

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4. Study of well-logging data.

Course Outcome

- Explain the key concepts of geochemistry.
- Understand the interrelation between different spheres of geochemistry.
- Explain various applications of geochemistry.
- Understand different components of geophysics and its applications.
- Explain different methods of geophysical exploration.

Suggested Reading:

1. *Albarede, F. (2003). Geochemistry: an introduction. Cambridge University Press.*
2. *Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.*
3. *Exploration Geophysics- An Outline by Bhimasarikaram V.L.S., Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.*
4. *Faure, Gunter and Teresa M. Mensing (2004). Isotopes Principles and Applications. Wiley India Pvt. Ltd*
5. *Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.*
6. *Mason, B. (1986). Principles of Geochemistry.3rd Edition, Wiley, New York.*
7. *Moon, C.J., Whateley, M.K.G., Evans, A.M., 2006, Introduction to Mineral Exploration, Blackwell Publishing.*
8. *Outlines of Geophysical Prospecting- A manual for geologists by Ramachandra Rao, M. B., Prasaranga, University of Mysore, Mysore, 1975.*
9. *Rollinson, H. (2007). Using geochemical data - evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific and Technical.*
10. *Telford, W.M., Geldart, L.P., & Sheriff, R.E. (1990). Applied geophysics (Vol.1). Cambridge university press.*
11. *Walther, J. V. (2009). Essentials of geochemistry. Jones and Bartlett Publishers.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

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SEMESTER – VIII

MJC16 : REMOTE SENSING AND GIS

Course Objective

1. To impart the knowledge of basic tools of aerial photography
2. To study the techniques of image interpretation
3. To understand the concepts of GIS, DIP, etc.

MJC16 : REMOTE SENSING AND GIS (Credit: 3)		
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	06
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	10
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	10
	TOTAL	36

MJC16 Practical: REMOTE SENSING AND GIS (Credit: 1)
Practical 1. Study of Toposheets, Contours, spot heights. 2. Scale conversion: *RF, linear, Verbal.* 3. Stereoscopic study of Aerial photographs. 4. Study of Satellite imageries. 5. Introduction to DIP and GIS software

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Course Outcome

- Understand the basics of aerial photography.
- Explain the principles, applications of Remote Sensing and Geographic Information System.

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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

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SEMESTER – III

MIC3 : STRUCTURAL GEOLOGY AND GEOMORPHOLOGY

Course Objective

1. To educate the students about the concept of rock deformation.
2. To understand qualitative aspects of brittle and ductile deformation processes, and descriptive analysis.
3. To impart knowledge about folds, faults, joints, unconformity.
4. Understand different landforms and their evolution.
5. Gain an idea of the geomorphology of Indian subcontinent.

MIC3 : STRUCTURAL GEOLOGY AND GEOMORPHOLOGY (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Elementary idea of structural geology Concept of Stress and Strain, Stress and Strain ellipsoid Attitude of beds, Dip and Strike Clinometer and Brunton compass and its Uses Outliers and inliers	05
2	Joint - definition and types Unconformity – definition and types Fold – definition, classification and its recognition in field Fault – definition, classification and its recognition in field	07
3	Definition, Scope and Fundamental concepts of Geomorphology Exogenic and Endogenic geomorphic processes; Diastrophism Geomorphic cycle Geomorphic features of India	05
4	Geological work of natural agencies: *Wind action and Aeolian landforms* *Underground water and Karst topography* Glacial processes and landforms Fluvial processes and landforms	07
	TOTAL	24

MIC3 Practical: STRUCTURAL GEOLOGY AND GEOMORPHOLOGY (Credit: 1)
Practical 1. Study of geological maps. 2. Drawing of geological section and description of geological history of the area. 3. Physiographic division of India. 4. Exercise on drainage pattern.

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Course Outcome

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

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

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – IV

MIC4 : IGNEOUS PETROLOGY

Course Objective

- To impart knowledge about the magmatic systems and igneous rocks
- To train the students to classify an igneous rock.

MIC4 : IGNEOUS PETROLOGY (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to Petrology - *distinguishing features of three types of rocks.* Magma – definition, physical and chemical properties	04
2	Forms and Structure of Igneous rock Texture of Igneous rock Plate tectonics and Magmatism	04
3	Bowen's Reaction series: *Discontinuous and Continuous series* Different schemes of classification of Igneous rock. Diversity of Igneous rocks.	08
4	Petrographic description of the following rock types : *Granite, Rhyolite, Syenite, Nepheline-syenite, Monzonite, Diorite, Anorthosite, Gabbro, Dolerite, Basalt, Peridotite, Pyroxenite, Dunite, Trachyte and Andesite.*	08
	TOTAL	24

MIC4 Practical: IGNEOUS PETROLOGY (Credit: 1)
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.*

Course Outcome

- Understand the concept of different rock types.
- Comprehend various classifications of igneous rocks.
- Explain the factors responsible for diversity of igneous rocks.

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

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – V

MIC5 : SEDIMENTOLOGY AND METAMORPHIC PETROLOGY

Course Objective

- To impart knowledge of formation of sedimentary rocks.
- To understand the environment of sedimentary terrain.
- To impart knowledge about Metamorphism and metasomatism of rocks.

MIC5 : SEDIMENTOLOGY AND METAMORPHIC PETROLOGY (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Processes of formation of Sedimentary rocks. Elementary idea of Sedimentary Environments: *Physical and Chemical parameters* Classification of sedimentary rocks	06
2	Texture of Sedimentary Rocks Structures of Sedimentary Rocks: *Primary, Secondary, Biogenic*	06
3	Aims and scope of Metamorphic Petrology Agents of metamorphism Types of Metamorphism – Contact, Cataclastic, Regional	08
4	Texture and structure of metamorphic rocks Concept of Metamorphic Grade, Zones and Facies,	04
	TOTAL	24

MIC5 Practical: SEDIMENTOLOGY AND METAMORPHIC PETROLOGY (Credit: 1)
Practical 1. Megascopic study of the following rocks: *Conglomerate, Breccia, Sandstones, Shale, Limestone, Dolomite* 2. Microscopic study of the following rocks: *Sandstone, Limestone* 3. Megascopic study of the following rocks: *Slate, Phyllite, Schist, Gneiss, Marble, Charnockite, Amphibolite, Khondalite.* 4. Microscopic study of the following rocks: *Schist, Gneiss, Amphibolite, Charnockite.*

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Course Outcome

- Explain different processes responsible for the formation of sedimentary rocks.
- Understand the basic features and classification of sedimentary rocks.
- Know about various agents of metamorphism and basic features of metamorphic rocks.

Suggested Reading:

1. *Allen, J.R.L., (1985). Principles of Physical Sedimentology. George Allen and Unwin, LondonBlatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)*
2. *Best, M.G. : Igneous and Metamorphic Petrology*
3. *Blatt, H., Middleton, G., and Murray, R., (1980). Origin of Sedimentary rocks. Princeton Hall.*
4. *Boggs, S.: Petrology of Sedimentary Rocks, Cambridge University Press.*
5. *Folk, R. L., (1974). Petrology of Sedimentary Rock. Hemphill Publishing Company, Austin, Texas*
6. *Harker : Petrology for students*
7. *Huang : Petrology*
8. *Nockolds, Chinner and Kinox: Petrology for students*
9. *Pettijohn, F. J., (1984) Sedimentary rocks, Harper & Bros.*
10. *Sengupta, S. M., (2007). Introduction to Sedimentology, CBS Publishers and Distributor, New Delhi.*
11. *Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.*
12. *Tyrell, G.W. : Principles of Petrology*
13. *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*
14. *Yardley, B. W., & Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Earth Science Series.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – V

MIC 6: STRATIGRAPHY

Course Objective

- To impart basic knowledge about Stratigraphy
- To understand the characteristics of different stratigraphic units in India.

MIC6 : STRATIGRAPHY (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Principles of Stratigraphy. Methods of Startigraphic correlation. Brief idea about *Lithostratigraphy, Biostratigraphy and Chronostratigraphy*	05
2	Stratigraphy of India – an overview Brief account of the Precambrian stratigraphy of *India*	05
3	Brief account of the stratigraphy of the following with special reference to classification, distribution, lithology, fossils and economic significance. *Gondwana supergroup, Jurassic of Kutch, Cretaceous of South India*	08
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*	06
	TOTAL	24

MIC6 Practical: STRATIGRAPHY (Credit: 1)
Practical 1. Exercise related to major Startigraphic units in India *Dharwar, Singhbhum, Cudappah, Vindhyan, Gondwana* 2. Study of stratigraphic rocks.

Course Outcome

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

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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. *Naqvi, S.M. and Rogers, J.J.W. (1987) Precambrian Geology of India. Oxford University Press*
5. *Ravindrakumar (2018). Fundamentals of Historical Geology and Stratigraphy of India, Newage Publication*
6. *Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd*
7. *Wadia, D. N., (1973). Geology of India. Mcgraw Hill*
8. *Weller. J. Marvin (1960) Stratigraphic Principles & Practice, Harper & Row Publishers New York & London*

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Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – VI

MIC7 : PALAEONTOLOGY

Course Objective

- To impart the basic knowledge of palaeontology
- To understand the fundamentals of organic evolution
- To train the students about Invertebrate Paleontology, fllora and importance of microfossils.

MIC7 : PALAEONTOLOGY (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Definition, Branches and Scope of Palaeontoology Fossils – definition and types Modes of preservation of fossils Ichnofossils; Index fossil Uses of Fossils	08
2	Life through geologic ages Microfossils and their significance Mass Extinctions	04
3	Classification, Morphology and Geological history of the following: *Gastropoda,* *Bivalvia,* *Cephalopoda*	08
4	Classification, Morphology and Geological history of the following: *Brachiopoda,* *Trilobita*	04
	TOTAL	24

MIC7 Practical: PALAEONTOLOGY (Credit: 1)
Practical 1. Identification of fossils and their geological age: ***Gastropods***- *Turritella, Conus, Physa, Murex, Voluta* ***Bivalvia/Lamellibranchia/Pelycepods***- *Arca, Pecten, Spondylus, Ostrea, Gryphaea, Exogyra* ***Cephalopods***- *Perisphinctes, Goniatite, Ceratite, Nautilus, Orthoceras* ***Brachiopods***- *Productus, Spirifer, Terebratulla, Rhynconella* ***Trilobites***- *Calymene, Phacops, Paradoxides* ***Plant fossils***- *Glossopteris, Vertebraria, Ptillophylum* 2. Drawing of fossils morphological features.

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Course Outcome

- Explain the different theories regarding evolution of life.
- Identify and differentiate various types of fossils.
- Understand the importance of fossils.

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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – VI

MIC8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY

Course Objective

1. To impart knowledge about mineral deposits and processes of formation of deposits.
2. To impart knowledge of basic hydrogeology including groundwater origin, occurrence and distribution.

MIC8 : ECONOMIC GEOLOGY AND HYDROGEOLOGY (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to *Ore, Ore mineral, Deposits, Gangue, Tenor, Cut-off grade* Classification of Ore deposits Metallogenic epochs and provinces.	06
2	Brief idea of processes of formation of mineral deposits: *Magmatic Concentration, Hydrothermal processes, Supergene Sulphide enrichment, Residual deposits, Placer deposits*	06
3	*Concept and scope of hydrogeology.* Hydrologic cycle Hydrogeological properties of water-bearing formation: *Porosity, Permeability* Vertical distribution of subsurface water; *Zone of aeration and zone of saturation*	06
4	Types of Aquifer: *Unconfined, Confined and Leaky aquifers.* Springs and their Types Groundwater resources of Bihar	06
	TOTAL	24

MIC8 Practical: ECONOMIC GEOLOGY AND HYDROGEOLOGY (Credit: 1)
Practical 1. Study of the Physical properties, chemical composition and distribution of important economic minerals: *Talc, Graphite, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Beryl, Barite, Kyanite, Sillimanite, Hematite, Magnetite, Chromite, Chalcopyrite, Malachite, Azurite, Pyrolusite, Psilomelane, Magnesite, Bauxite, Galena, Pyrite, ,Garnet, Asbestos.* 2. Hydrogeological properties of Rocks *Granite, Rhyolite, Basalt, Gabbro* *Sandstone, Limestone, Shale* *Gneiss, Schist, Quartzite* 3. Study of hydrogeological provinces of Bihar.

Course Outcome

- Identify various ore minerals and their deposits.
- Explain the fundamentals of hydrogeology.
- Define the movement and distribution of groundwater.

Suggested Reading:

1. *Bagchi, Sengupta and Rao: Elements of Prospecting and Exploration*
2. *Brown, C. and Dey, A.K.: Indian Mineral Wealth*
3. *Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley*
4. *Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.*
5. *Jenson and Bateman: Economic Mineral Deposits*
6. *Laurence Robb. (2005) Introduction to ore forming processes. Wiley.*
7. *Prasad, U. : Economic Geology*
8. *Wadia : Minerals of India*
9. *Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.*
10. *Raghunath, H. M., (1987). Groundwater, New Age International*
11. *Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – VII

MIC 9: ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER

Course Objective

- To train students about the basic fundamental aspects of environment
- To impart knowledge about the impact of the natural/anthropogenic hazards on environment.

MIC9 : ENVIRONMENTAL GEOLOGY AND GEOGENIC DISASTER (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Introduction to Environmental geology; Environmental Pollution Interaction between Human activities and the natural environment Geological factors of environmental health Biogeochemical cycle	10
2	Water Quality Parameters and BIS standards Heavy Metal Pollution Remedial measures of pollution Impact of Urban waste disposal	08
3	Floods: *Interaction between rivers and its flood plain* Flood plain mapping and zoning Landslides – *Causes, Types and Mitigation*	10
4	Earthquakes: *Causes, Effects and Mitigation* Volcanoes and Volcanic hazards	10
5	Climate change Cyclones - *Monitoring and early warning* Droughts – *Meteorological, Agriculture and Hydrological types* Environmental legislations in India	10
	TOTAL	48

Course Outcome

- Understand the structure and functions of ecosystem.
- Comprehend natural and anthropogenic factors affecting Environment.
- Explain natural disasters and its mitigation

Suggested Reading:

1. *Bell,F.G.,1999.GeologicalHazards,Routledge,London.*
2. *Bryant,E.,1985.NaturalHazards,CambridgeUniversityPress.*

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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*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks
10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks
04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks
03 x 10 = 30 marks

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SEMESTER – VIII

MIC10 : EARTH AND CLIMATE

Course Objective

1. To impart knowledge about global monsoon system.
2. To understand the climate change and its effect.

MIC10 : EARTH AND CLIMATE (Credit: 4)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Components of the climate system. Climate controlling factors Heat budget of the Earth.	08
2	Layering of atmosphere and atmospheric circulation Atmosphere-Ocean interaction and its effect on climate	10
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	10
5	Milankovitch cycles and variability in the climate Pleistocene Glacial-Interglacial cycles	10
	TOTAL	48

Course Outcome

- Explain global climate system.
- Understand atmospheric circulation and mechanism of Indian monsoon.
- Develop an integrated perspective on climate change.

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*

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The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – II

MDC2 : MINERAL AND HARD ROCKS

Course Objective

1. To impart fundamental knowledge of minerals and their properties.
2. To understand different rock types and their characteristic.

MDC2 : MINERAL AND HARD ROCKS (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Mineral – *definition* Physical properties of the minerals: *Form, Color, Streak, Lustre, Cleavage, Fracture, Hardness,Specific gravity, Tenacity, Magnetic properties, Electrical properties.* Rock forming minerals Introduction to crystallography	05
2	Petrological Microscope and its function Important optical properties: *Refractive index, Pleochroism, Pleochroic haloes, Extinction and extinction angle, Birefringence, Interference colours, Optical indicatrix*	07
3	Introduction to Petrology- *distinguishing features of three types of rocks.* Magma – *definition, physical and chemical properties* Form, Structure and Texture of Igneous rock.	05
4	Metamorphism – *definition, agents and types* Texture and Structure of Metamorphic rocks Classification of Metamorphic rocks	07
	TOTAL	24

MDC2 Practical: MINERAL AND HARD ROCKS (Credit: 1)
Practical 1. Megascopic and microscopic study of minerals. 2. Megascopic and microscopic study of rocks.

Course Outcome

- Gain knowledge of factors responsible for generating structural features of rocks.
- Understand the concept of rocks and their types.

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. *Kerr, B. F. (1995). Optical Mineralogy. McGraw-Hill, New York*
4. *Philips, F.C., (1963). An introduction to crystallography. Wiley, New York.*
5. *Perkin D. (2010) Mineralogy. Pearson*
6. *Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy – Concepts and Methods. Text Book Series, Geological Society of India, Bangalore*
7. *Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.*
8. *Blatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic)*
9. *Bose M.K. (1997). Igneous Petrology Huang : Petrology*
10. *Harker : Petrology for students*
11. *McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),*
12. *Myron G. Best (2001). Igneous and Metamorphic Petrology, Nockolds, Chinner and Kinox: Petrology for students*
13. *Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks

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SEMESTER – III

MDC3 : SEDIMENTOLOGY AND HISTORICAL GEOLOGY

Course Objective

1. To impart fundamental knowledge of sedimentary rocks and classify them.
2. To apprise the students about the stratigraphy.
3. To impart the basic knowledge of palaeontology.

MDC3 : SEDIMENTOLOGY AND HISTORICAL GEOLOGY (Credit: 2)		
Unit	**Topics to be covered**	**No. of Lectures**
1	Modes of formation of Sedimentary Rocks Texture and structure of Sedimentary rocks Classification of Sedimentary rocks	05
2	Definition and Types of Fossil Condition of Fossilization and Modes of preservation of fossils Uses of Fossils	04
3	Classification, Morphology and Geological history: *Gastropoda, Bivalvia, Cephalopoda, Brachiopoda, Trilobita*	10
4	Definition, Principles of Stratigraphy. Methods of Stratigraphic correlation. Geological Time Scale. Outline of Indian Stratigraphy.	05
	TOTAL	24

MDC3 Practical: SEDIMENTOLOGY AND HISTORICAL GEOLOGY (Credit: 1)
Practical 1. Megascopic and microscopic study of sedimentary rocks.. 2. Study of stratigraphic rocks. 3. Study of fossils.

Course Outcome

- Explain different processes responsible for the formation of sedimentary rocks.
- Apply principles of stratigraphy in various geological studies.
- Identify and differentiate various types of fossils

Suggested Reading:

1. *Allen, J.R.L., (1985). Principles of Physical Sedimentology. George Allen and Unwin, LondonBlatt, Ehler: Petrology (Igneous, Sedimentary and Metamorphic).*

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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. *Pettijohn, F. J., (1984) Sedimentary rocks, Harper & Bros.*
5. *Sengupta, S. M., (2007). Introduction to Sedimentology, CBS Publishers and Distributor, New Delhi.*
6. *Tyrell, G.W. : Principles of Petrology.*
7. *Doyle, P.: Understanding Fossils: An Introduction to Invertebrate Palaeontology.*
8. *Raup,D.M.,Stanley,S.M.,Freeman,W.H.(1971)PrinciplesofPaleontology*
9. *Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi*
10. *Wadia, D., (1973). Geology of India. Mcgraw Hill*

The question paper pattern shall consist of three parts –

Part A – Compulsory – consisting of Objective/ Multiple Choice type – each carrying two marks 10 x 2 = 20 marks

Part B – Short Answer Type – Four questions to be answered out of six questions – each carrying five marks 04 x 5 = 20 marks

Part C – Long Answer Type – Three questions to be answered out of five questions – each carrying ten marks 03 x 10 = 30 marks