SYLLABI AND SCHEME OF EXAMINATIONS FOR MINOR COURSES FOR UNDER GRADUATE PROGRAMS (SINGLE MAJOR/PHYSICAL SCIENCES PROGRAMS) in GEOLOGY

(Based on Curriculum and Credit Framework for UG Programs under NEP 2020)

WITH EFFECT FROM THE SESSION 2024-25

MAHARSHI DAYANAND UNIVERSITY ROHTAK (HARYANA)

SYLLABI AND SCHEME OF EXAMINATIONS FOR MINOR COURSES FOR UNDER GRADUATE SINGLE MAJOR/MULTIDISCIPLINARY PROGRAMS/ SINGLE MAJOR PROGRAM AFTER 2nd SEMESTER OF MULTIDISCIPLINARY PROGRAM

Minor Courses (MIC)/ Minor (Vocational) Course MIC(VOC)	TYPE OF PROGRAM				Credits Distribution			Total Credits	Workload			Total Workload	Marks			
	SINGLE MAJOR PROGRAM	MULTIDISCIPLINARY PROGRAM / SINGLE MAJOR PROGRAM AFTER 2nd SEMESTER OF MULTIDISCIPLINARY PROGRAM	Nomenclature of Course	Course Code	L	T	P		L	T	P		Theory		Practical	Total Marks
	SEMESTER	SEMESTER											Internal	External	Only Internal	
MIC 1 @ 4 credits	1	1	Introduction to Earth Sciences	24GOL401MI01	4	0	0	4	4	0	0	4	30	70	-	100
MIC 2 @ 4 credits (Only for Single Major Program)	2	-	The World of Minerals and Rocks	24GOL402MI01	3	0	1	4	3	0	2	5	25	50	25	100
MIC 3 @ 4 credits	3	3	Stratigraphy and Earth's History	25GOL403MI01	3	0	1	4	3	0	2	5	25	50	25	100
MIC 4 (VOC) @ 4 credits	4	4	Hydrology and Water Management System	25GOL404MV01	3	0	1	4	3	0	2	5	25	50	25	100
MIC 5 (VOC) @ 4 credits	5	5	Indian Economic Minerals	26GOL405MV01	3	0	1	4	3	0	2	5	25	50	25	100

MIC 5 @ 4 credits (Only for Multidisciplinary Program)	-	6	Remote Sensing and Photogrammetry	26GOL406MI01	3	0	1	4	3	0	2	5	25	50	25	100
MIC 6 (VOC) @ 4 credits	6	6	GIS and Applications	26GOL406MV01	3	0	1	4	3	0	2	5	25	50	25	100
MIC 7 (VOC) @ 4 credits (if offered as an option)	7	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MIC 8 (VOC) @ 4 credits (if offered as an option)	8	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-

L: Lecture; T: Tutorial; P: Practical

Note:

1. The Syllabi and Scheme of Examinations (SOE) for Minor (Vocational) Courses for UG Semester 7 and Semester 8 will be same as applicable for Vocational Course in Post Graduate semester 1 and semester 2 respectively.
2. Course coding of Minor courses for Single Major Programs will be applicable for Multidisciplinary Programs/ Multidisciplinary Programs after 2nd semester irrespective of their offering in any semester.
3. The student who selects any Minor Course (MIC) of any discipline in first semester should study the Minor courses (MIC) in the same discipline in the subsequent semesters. However, while exercising the option for choosing Minor Vocational Course MIC (VOC), the student may opt the discipline either related to the discipline of Minor Course or the discipline of Major Course or any other discipline as per his/her choice.

Name of Program		**Program Code**	
Name of the Course	Introduction to Earth Sciences	**Course Code**	24GOL401MI01
Hours per Week	04 Hours	**Credits**	04 (L:4 , P:0)
Maximum Marks	100{External (term-end exam) – 70} (Internal – 30)	**Time of Examinations**	03 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Describe the structure and composition of the Earth.
CLO 2: Explain geological processes such as plate tectonics, earthquakes, and volcanism.
CLO 3: Discuss the origin and evolution of Earth's atmosphere and oceans.
CLO 4: Analyze weather patterns, climate change, and their impacts on the environment.

Unit 1 Earth as a planet Holistic understanding of dynamic planet 'Earth' through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences. General characteristics and origin of the Universe, Solar System and its planets. Meteorites and Asteroids, Earth in the solar system - origin, size, shape, mass, density, rotational and revolution parameters and its age

Unit 2: Earth's magnetic field Earth's magnetic field Formation of core, mantle, crust, hydrosphere, atmosphere and biosphere Convection in Earth's core and production of its magnetic field Mechanical layering of the Earth.

Unit 3: Concept of plate tectonics, sea-floor spreading and continental drift Geodynamic elements of Earth-Mid Oceanic Ridges, trenches, transform faults and island arcs Origin of oceans, continents, mountains and rift valleys Earthquake and earthquake belts Volcanoes- types, products and their distribution

Unit 4: Cosmic abundance of elements, Distribution of elements in solar system and in Earth Chemical differentiation and composition of the Earth, Geochemical behavior of major elements Mass conservation of elements and isotopic fractionation.

References:

1. Tarbuck, E. J., Lutgens, F. K., & Tasa, D. (2019). *Earth Science* (15th ed.). Pearson.
2. Skinner, B. J., Porter, S. C., & Park, J. (2015). *Dynamic Earth: An Introduction to Physical Geology* (6th ed.). Wiley.
3. Plummer, C. C., Carlson, D. H., & McGeary, D. (2017). *Physical Geology* (16th ed.). McGraw-Hill Education.
4. Marshak, S. (2015). *Earth: Portrait of a Planet* (5th ed.). W. W. Norton & Company.
5. Grotzinger, J., Jordan, T. H., Press, F., & Siever, R. (2007). *Understanding Earth* (5th ed.). W. H. Freeman.

Name of Program		**Program Code**	
Name of the Course	The World of Minerals and Rocks	**Course Code**	24GOL402MI01
Hours per Week	03 Hours	**Credits**	03 (L:3, P:0)
Maximum Marks	75{External (term-end exam) – 50} (Internal – 25)	**Time of Examinations**	03 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLO):

CLO 1: Students will classify minerals into major mineral groups (silicates, carbonates, oxides, sulfides, etc.) based on their chemical composition, crystal structure, and physical properties.

CLO 2: Students will apply mineralogical knowledge to interpret geological processes, environments of mineral formation, and the significance of minerals in geological studies.

CLO 3: Students will effectively communicate mineralogical concepts, observations, and interpretations through written reports, oral presentations, and scientific discussions.

Unit 1: Definition and classification of minerals; Silicate structure and classification of silicates. Elementary ideas about atomic minerals. Polymorphism, Isomorphism and Pseudo-morphism. Physical properties of minerals.

Unit 2: Rocks and rock cycle, Magma: Definition, composition, origin and process of crystallization. Crystallization of uni-component magma, Bowen reaction series. Igneous Petrology: Formation of Igneous rocks and their types. Forms of Igneous rocks: Intrusive (Concordant and discordant) and extrusive

Unit 3: Sedimentary Rocks: Formation, composition, texture and structures of sedimentary rocks. Classification of Sedimentary rocks.

Unit 4: Metamorphic Rocks: Metamorphism, definition, factors affecting metamorphism. Types of metamorphism. Textures, structures and classification of metamorphic rocks.

References:

1. Klein, C., & Dutrow, B. (2017). *Manual of Mineral Science* (23rd ed.). John Wiley & Sons.
2. Deer, W. A., Howie, R. A., & Zussman, J. (2013). *An Introduction to the Rock-Forming Minerals* (3rd ed.). Mineralogical Society of Great Britain and Ireland.
3. Nesse, W. D. (2021). *Introduction to Mineralogy* (3rd ed.). Oxford University Press.
4. Pellant, C. (2002). *Rocks and Minerals* (Smithsonian Handbooks). DK Publishing.
5. Boggs Jr., S. (2006). *Principles of Sedimentology and Stratigraphy* (4th ed.). Pearson Prentice Hall.
6. Best, M. G., & Christiansen, E. H. (2001). *Igneous Petrology* (2nd ed.). Wiley-Blackwell.
7. Winter, J. D. (2001). *An Introduction to Igneous and Metamorphic Petrology*. Prentice Hall.
8. Philpotts, A. R., & Ague, J. J. (2009). *Principles of Igneous and Metamorphic Petrology* (2nd ed.). Cambridge University Press.

Name of Program		**Program Code**	
Name of the Course	Practical (The World of Minerals and Rocks)	**Course Code**	24GOL402MI01
Hours per Week	02 Hours	**Credits**	01 (L:0 , P:1)
Maximum Marks	25	**Time of Examinations**	1.5 Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set by the internal examiner. The distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Attendance :	05
Total:	25

Course Learning Outcomes (CLO):

CLO 1: Students will be able to identify minerals based on their physical properties such as crystal form, color, streak, hardness, cleavage etc.

CLO 2: Students will demonstrate proficiency in classifying igneous rocks according to established classification schemes (e.g., Bowen's reaction series, modal mineralogy, texture).

CLO 3: Students will apply their knowledge in field settings to identify all three types of rock outcrops, interpret field relationships, and make observations that contribute to their understanding of petrology.

List of Practicals:

1. Identification of important rock forming and ore forming minerals in hand specimen (e.g. Talc, Gypsum, Calcite, Apatite, Orthoclase, Quartz, Muscovite, Garnet etc).
2. Identification and listing properties of important Igneous, sedimentary and metamorphic rocks in hand specimen in Lab and Field (e.g. Granite, Basalt, Gabbro, Shale, Sandstone, Limestone, Slate, Schist, Quartzite and Marble etc.)

References:

1. Compton, R. R. (1985). *Manual of Field Geology*. John Wiley & Sons.
2. Rutherford, M. J. (2001). *Introducing Geology: A Guide to the World of Rocks*. Dunedin Academic Press.
3. Marshak, S. (2019). *Laboratory Manual for Introductory Geology*. W.W. Norton & Company

Name of Program		**Program Code**	
Name of the Course	Stratigraphy and Earth's History	**Course Code**	25GOL403MI01
Hours per Week	03 Hours	**Credits**	03 (L:3, P:0)
Maximum Marks	75{External(term-end exam) – 50} (Internal– 25)	**Time of Examinations**	03 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes(CLO):

CLO1: Understand and apply the basic principles of stratigraphy to interpret the order and relative age of rock layers.

CLO2: Identify different types of sedimentary basins and depositional environments using stratigraphic records.

CLO3: Explain the geological time scale, major events in Earth's history, and the methods used to date rocks.

CLO4: Describe the major stratigraphic divisions of India and interpret fossil records to reconstruct past environments.

CLO5: Students will be able to correlate stratigraphic sequences across different regions and use these correlations to interpret regional geological history.

Unit 1: Basics of Stratigraphy

Fundamental principles of stratigraphy, laws of superposition, original horizontality, and cross-cutting relationships, types of stratigraphic units, and basics of correlation methods.

Unit 2:Sedimentary Basins and Stratigraphic Records

Types of sedimentary basins, depositional environments, sedimentary facies, unconformities, and introduction to sequence stratigraphy.

Unit 3:Geological Time and Earth's Evolution

Geological time scale, radiometric dating, major events in Earth's history, origin of life, plate tectonics, and mass extinctions.

Unit 4:Indian Stratigraphy and Fossils

Overview of Indian stratigraphic divisions, key formations and fossil records, and their importance in understanding Earth's history in the Indian context.

References:

1. Doyle, P. & Bennett, M. R. (1996). *Unlocking the Stratigraphical Record*. John Wiley & Sons.
2. Prothero, D. R. & Schwab, F. (2013). *Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy*. W.H. Freeman.
3. Krishnan, M. S. (2006). *Geology of India and Burma*. CBS Publishers & Distributors.
4. Ramakrishnan, M. & Vaidyanadhan, R. (2008). *Geology of India*, Volumes 1 & 2. Geological Society of India.
5. Gradstein, F. M., Ogg, J. G., Schmitz, M. D., & Ogg, G. M. (2012). *The Geologic Time Scale 2012*. Elsevier.
6. Tucker, M. E. (2001). *Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks*. Blackwell Science

Name of Program		Program Code	
Name of the Course	Practical (Stratigraphy and Earth's History)	Course Code	25GOL403MI01
Hours per Week	02 Hours	Credits	01 (L:0 , P:1)
Maximum Marks	25	Time of Examinations	1.5 Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paperwill set by the internal examiner. The distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Attendance :	05
Total:	25

Course Learning Outcomes(CLO):

CLO1: Describe fundamental principles of stratigraphy and applications in the geologic history of Earth.

CLO2: Analyse stratigraphic records and fossil assemblages to reconstruct past environments, paleogeography, and major events in Earth's history.

CLO3: Evaluate the chronological framework of Earth's history using radiometric dating, biostratigraphy, and correlation techniques across different geological timescales.

CLO4: Students will be able to identify and interpret key stratigraphic markers, such as unconformities, fossil zones, and lithological changes, to correlate stratigraphic sequences across different regions.

CLO5: Students will be able to apply sequence stratigraphy and basin analysis techniques to interpret depositional environments and regional tectonic history.

List of Practicals:

1. Identify and classify common sedimentary rocks using hand specimens, focusing on texture, composition, and fossil content.
2. Study and describe primary sedimentary structures such as bedding, ripple marks, and cross-bedding.
3. Prepare simple stratigraphic columns from given lithological data, depicting the vertical sequence of rock layers.
4. Analyze and interpret geological photographs or block diagrams, identifying key features like faults, sills, and sedimentary layers.
5. Apply stratigraphic principles to determine the sequence of geological events based on geological photographs or block diagrams.
6. Integrate field observations and laboratory analysis to reconstruct the geological history of an area using sedimentary rock sequences and structures.

References:

1. Boggs, S. (2012). *Principles of Sedimentology and Stratigraphy* (5th ed.). Pearson Education. – A foundational text covering sedimentary processes and stratigraphic principles.
2. Prothero, D. R., & Dott, R. H. (2010). *Evolution of the Earth* (8th ed.). McGraw-Hill. – Comprehensive overview of Earth's geologic history with stratigraphic context.
3. Gradstein, F. M., Ogg, J. G., Schmitz, M., & Ogg, G. (2020). *Geologic Time Scale 2020*. Elsevier. – The most current and authoritative global chronostratigraphic framework.
4. Stanley, S. M., & Luczaj, J. A. (2014). *Earth System History* (4th ed.). W.H. Freeman. – Focuses on Earth's dynamic systems through geologic time, emphasizing stratigraphic evidence.
5. Catuneanu, O. (2006). *Principles of Sequence Stratigraphy*. Elsevier. – Key reference for advanced stratigraphic interpretation, especially in sedimentary basin analysis.
6. Tucker, M. E. (2009). Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks (3rd ed.). Wiley-Blackwell. – Offers an in-depth look at sedimentary rock origins, classifications, and depositional environments.
7. Nichols, G. (2009). Sedimentology and Stratigraphy (2nd ed.). Wiley-Blackwell. – A comprehensive guide to sedimentary processes, environments, and the application of stratigraphic principles.
8. Reading, H. G. (2013). Sedimentary Environments: Processes, Facies, and Stratigraphy (4th ed.). Wiley-Blackwell.
9. Explores the relationship between sedimentary environments, sedimentary structures, and their stratigraphic significance. Harris, R. A., & McDonald, D. A. (2009). Fundamentals of Basin Analysis: Principles and Applications in Petroleum Geology. Cambridge University Press. – Focuses on the analysis of sedimentary basins and the methods used for their exploration, including stratigraphic methods.
10. Miall, A. D. (2013). The Geology of Fluvial Deposits: Sedimentary Facies, Basin Analysis, and Petroleum Geology. Springer.

Name of Program		**Program Code**	
Name of the Course	Hydrology and Water Management System	**Course Code**	25GOL404MV01
Hours per Week	03 Hours	**Credits**	03 (L:3, P:0)
Maximum Marks	75{External(term-end exam) – 50} (Internal– 25)	**Time of Examinations**	03 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes(CLO):

CLO1: Understand the fundamental components of the hydrologic cycle and their significance in water resource systems.

CLO2: Analyse surface and groundwater flow processes using hydrologic data and measurement techniques.

CLO3: Apply principles of water resources planning and management for efficient irrigation and sustainable use.

CLO4: Evaluate strategies for flood control, drought mitigation, and integrated water resource governance.

CLO5: Students will be able to assess the impact of land use changes and climate variability on the hydrological cycle and water resource availability.

Unit 1: Introduction to hydrology, hydrologic cycle, precipitation, evaporation, infiltration, and runoff processes, basic concepts of watershed characterization and management, catchment hydrology.

Unit 2: Streamflow measurement, hydrograph analysis, flow duration and mass curves, groundwater hydrology, aquifers, well hydraulics, and groundwater-surface water interaction.

Unit 3: Water resources planning and management, irrigation methods and efficiency, demand and supply analysis, water budgeting, and integrated water resource management (IWRM).

Unit 4: Flood and drought management, urban hydrology, water quality assessment, pollution control strategies, legal and institutional frameworks for water governance.

References:

1. Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). *Applied Hydrology*. McGraw-Hill. – A comprehensive text on hydrologic processes and applications.
2. Subramanya, K. (2013). *Engineering Hydrology* (4th ed.). McGraw-Hill Education. – Widely used in Indian and international universities for core hydrology concepts.
3. Todd, D. K., & Mays, L. W. (2005). *Groundwater Hydrology* (3rd ed.). Wiley. – Authoritative book on groundwater theory and well hydraulics.
4. Garg, S. K. (2017). *Irrigation Engineering and Hydraulic Structures*. Khanna Publishers. – Covers irrigation methods, water management, and structures.
5. UNESCO (2009). *Integrated Water Resources Management in Action*. United Nations Educational, Scientific and Cultural Organization. – Global perspective on sustainable water resource management.

Name of Program		**Program Code**	
Name of the Course	Practical (Hydrology and Water Management System)	**Course Code**	25GOL404MV01
Hours per Week	02 Hours	**Credits**	01 (L:0 , P:1)
Maximum Marks	25	**Time of Examinations**	1.5 Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set by the internal examiner. The distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Attendance :	05
Total:	25

Course Learning Outcomes(CLO):

CLO 1: Demonstrate the use of standard instruments for measuring hydrologic parameters such as rainfall, infiltration, and streamflow.

CLO 2: Analyse and interpret hydrological data through the preparation of hydrographs, flow duration curves, and related computations.

CLO 3: Conduct basic field and laboratory experiments to evaluate groundwater levels, well performance, and irrigation water quality.

CLO 4: Apply Geographic Information Systems (GIS) and remote sensing techniques in hydrologic analysis and watershed management.

CLO 5: Demonstrate effective teamwork and communication in conducting hydrological investigations and presenting results.

Lists of Practicals:

1. Measure rainfall using standard rain gauges and analyze the collected rainfall data.
2. Prepare hydrographs, flow duration curves, and mass curves, and interpret the results for water flow analysis.
3. Determine the infiltration rate using a double ring infiltrometer.
4. Estimate evapotranspiration and its impact on water balance.
5. Map the groundwater table to understand aquifer conditions.
6. Conduct well yield testing to evaluate the capacity of groundwater sources.
7. Analyze the quality of irrigation water, focusing on its suitability for agricultural use.

References:

1. Viessman, W., & Lewis, G. L. (2003). *Introduction to Hydrology* (5th ed.). Pearson Education.
2. Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). *Applied Hydrology*. McGraw-Hill.
3. Hershfield, D. M. (1961). *Rainfall Frequency Atlas of the United States*. U.S. Department of Commerce, National Weather Service.
4. Singh, V. P., & Frevert, D. K. (2002). *Mathematical Models in Small Watershed Hydrology and Applications*. Water Resources Publications.
5. Garg, S. K. (2009). *Hydrology and Water Resources Engineering*. Khanna Publishers.
6. Environmental Protection Agency (EPA). (1993). *Guidelines for Water Quality Management and Control*. U.S. EPA.
7. FAO (Food and Agriculture Organization of the United Nations). (2010). *Irrigation and Drainage Paper 66: Crop Evapotranspiration – Guidelines for Computing Crop Water Requirements*. FAO.

Name of Program		**Program Code**	
Name of the Course	Indian Economic Minerals	**Course Code**	26GOL405MV01
Hours per Week	03 Hours	**Credits**	03 (L:3, P:0)
Maximum Marks	75{External(term-end exam) – 50} (Internal– 25)	**Time of Examinations**	03 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLOs)

CLO 1: Understand the classification, occurrence and economic importance of mineral resources of India.

CLO 2: Describe the geological occurrence, distribution and uses of major metallic, non-metallic and energy minerals.

CLO 3: Identify the major mineral-producing regions of India and their contribution to industrial development.

CLO 4: Explain the basic methods of mineral exploration and mining, and their role in resource development.

CLO 5: Evaluate the importance of mineral conservation and sustainable utilization of mineral resources.

Unit 1: Introduction to Economic Minerals: Definition and classification of economic minerals, ore, gangue, tenor and grade, mineral resources and mineral reserves, strategic and critical minerals, mineral exploration, mining methods, mineral conservation and sustainable utilization of mineral resources.

Unit 2: **Metallic Minerals of India**:Geological occurrence, distribution, uses and major producing states of iron ore, manganese, chromite, copper, lead-zinc, bauxite and gold.

Unit 3: Non-metallic and Industrial Minerals: Geological occurrence, distribution, uses and major producing states of limestone, dolomite, gypsum, mica, feldspar, quartz, phosphorite, clay minerals and graphite.

Unit 4: **Energy and Atomic Minerals:** Geological occurrence, distribution, uses and major producing states of coal, lignite, petroleum, natural gas, uranium, thorium and beach placer minerals, economic importance of energy and atomic minerals in India.

References:

1. Bateman, A. M. (1981). Economic Mineral Deposits. John Wiley & Sons.
2. Jensen, M. L., & Bateman, A. M. (1981). Economic Mineral Deposits (3rd ed.). Wiley.
3. Evans, A. M. (2013). Ore Geology and Industrial Minerals: An Introduction. Wiley-Blackwell.
4. Robb, L. (2005). Introduction to Ore-Forming Processes. Blackwell Publishing.
5. Guilbert, J. M., & Park, C. F. (2007). The Geology of Ore Deposits. Waveland Press.
6. Edwards, R., & Atkinson, K. (1986). Ore Deposit Geology. Chapman & Hall.
7. Krishnaswamy, S. (2018). India's Mineral Resources. Oxford & IBH Publishing.
8. Deb, S. (2011). Industrial Minerals and Their Uses. Nova Science Publishers.
9. Arogyaswamy, R. N. P. (1996). Courses in Mining Geology. Oxford & IBH Publishing.
10. Singh, V. K. (2012). Economic Geology. Pragati Prakashan.
11. Krishnan, M. S. (2018). Geology of India and Burma. CBS Publishers.
12. Ramakrishnan, M., & Vaidyanadhan, R. (2010). Geology of India. Geological Society of India.
13. Geological Survey of India. Geology and Mineral Resources of India. GSI Publications.
14. Indian Bureau of Mines. Indian Minerals Yearbook (Latest Edition).
15. Ministry of Mines, Government of India. National Mineral Policy (Latest Edition).
16. Ministry of Coal, Government of India. Coal Directory of India (Latest Edition).
17. Ministry of Petroleum and Natural Gas, Government of India. Indian Petroleum and Natural Gas Statistics (Latest Edition).
18. Atomic Minerals Directorate for Exploration and Research (AMD). Publications on Atomic Minerals of India.
19. Geological Society of India. Journal of the Geological Society of India.

Name of Program		**Program Code**	
Name of the Course	Practical (Indian Economic Minerals)	**Course Code**	26GOL405MV01
Hours per Week	02 Hours	**Credits**	01 (L:0 , P:1)
Maximum Marks	25	**Time of Examinations**	1.5 Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set by the internal examiner. The distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Attendance :	05
Total:	25

Course Learning Outcomes (Practical)

CLO 1: Identify common economic minerals based on their physical properties.
CLO 2: Recognize the major metallic, non-metallic and energy minerals of India.
CLO 3: Locate important mineral-producing regions of India using outline maps.
CLO 4: Interpret the industrial uses and economic significance of mineral resources.
CLO 5: Prepare practical records based on mineral identification and map exercises.

Lists of Practicals:

1. Megascopic identification of common metallic minerals (Hematite, Magnetite, Pyrolusite, Chromite, Chalcopyrite, Galena, Sphalerite and Bauxite).
2. Megascopic identification of common non-metallic and industrial minerals (Limestone, Dolomite, Gypsum, Mica, Quartz, Feldspar, Graphite and Phosphorite).
3. Identification of common energy and atomic minerals (Coal, Lignite and Uranium-bearing minerals using photographs/hand specimens).
4. Marking of major metallic mineral-producing areas of India on an outline map.
5. Marking of major non-metallic, industrial and energy mineral-producing areas of India on an outline map.
6. Study of common mineral uses in metallurgical, chemical, cement, ceramic and energy industries.
7. Preparation of a mineral distribution map of India.

References:

1. Compton, R. R. (1985). Manual of Field Geology. John Wiley & Sons.
2. Klein, C., & Dutrow, B. (2017). Manual of Mineral Science (23rd ed.). John Wiley & Sons.
3. Deer, W. A., Howie, R. A., & Zussman, J. (2013). An Introduction to the Rock-Forming Minerals (3rd ed.). Mineralogical Society of Great Britain and Ireland.
4. Nesse, W. D. (2021). Introduction to Mineralogy (3rd ed.). Oxford University Press.
5. Pellant, C. (2002). Rocks and Minerals (Smithsonian Handbooks). DK Publishing.
6. Geological Survey of India. Geology and Mineral Resources of India. GSI Publications.
7. Indian Bureau of Mines. Indian Minerals Yearbook (Latest Edition).
8. Geological Survey of India. Mineral Atlas of India. GSI Publications.
9. Ministry of Mines, Government of India. National Mineral Inventory (Latest Edition).
10. Ramakrishnan, M., & Vaidyanadhan, R. (2010). Geology of India. Geological Society of India.

Name of Program		**Program Code**	
Name of the Course	Remote Sensing and Photogrammetry	**Course Code**	26GOL406MI01
Hours per Week	03 Hours	**Credits**	03 (L:3, P:0)
Maximum Marks	75{External(term-end exam) – 50} (Internal– 25)	**Time of Examinations**	03 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLOs)

CLO 1: Understand the principles, components and applications of remote sensing and photogrammetry.
CLO 2: Explain the characteristics of aerial photographs and satellite images for Earth observation.
CLO 3: Interpret remote sensing data for geological, environmental and natural resource investigations.
CLO 4: Apply the basic principles of image interpretation in geological mapping and resource management.
CLO 5: Recognize the applications of remote sensing and photogrammetry in sustainable development and disaster management.

Unit 1: Introduction to Remote Sensing: Definition, scope and principles of remote sensing, electromagnetic radiation, electromagnetic spectrum, interaction of electromagnetic radiation with atmosphere and Earth's surface, passive and active remote sensing, platforms and sensors.

Unit 2: **Aerial Photography and Photogrammetry:** Principles of aerial photography, types of aerial photographs, scale of aerial photographs, stereoscopic vision, stereoscope, fundamentals of photogrammetry, photo interpretation elements.

Unit 3: Satellite Remote Sensing: Types of satellite sensors, spatial, spectral, radiometric and temporal resolution, Indian Remote Sensing (IRS) satellites, LANDSAT, Sentinel missions, visual image interpretation techniques, digital image processing (basic concepts).

Unit 4: **Applications of Remote Sensing and Photogrammetry:** Applications in geological mapping, mineral exploration, groundwater exploration, geomorphological mapping, land use and land cover mapping, agriculture, forestry, urban planning, environmental monitoring and disaster management.

References:

1. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote Sensing and Image Interpretation (7th ed.). Wiley.
2. Jensen, J. R. (2016). Introductory Digital Image Processing (4th ed.). Pearson.
3. Campbell, J. B., & Wynne, R. H. (2011). Introduction to Remote Sensing (5th ed.). Guilford Press.
4. Sabins, F. F. (2007). Remote Sensing: Principles and Interpretation (3rd ed.). Waveland Press.
5. Drury, S. A. (2001). Image Interpretation in Geology (3rd ed.). Taylor & Francis.
6. Avery, T. E., & Berlin, G. L. (1992). Fundamentals of Remote Sensing and Air Photo Interpretation. Macmillan.
7. Curran, P. J. (1985). Principles of Remote Sensing. Longman.
8. Gupta, R. P. (2018). Remote Sensing Geology (3rd ed.). Springer.
9. NRSC, ISRO. Remote Sensing Applications.
10. ISRO. Bhuvan User Manual and Applications.
11. NPTEL. Remote Sensing and GIS Course Material.
12. Indian Space Research Organization. IRS Satellite Handbook.
13. American Society for Photogrammetry and Remote Sensing. Manual of Remote Sensing.
14. Wolf, P. R., Dewitt, B. A., & Wilkinson, B. E. (2014). Elements of Photogrammetry with Applications in GIS. McGraw-Hill.
15. Lillesand, T. M., & Kiefer, R. W. Remote Sensing for Resource Management. Wiley.

Name of Program		**Program Code**	
Name of the Course	Practical (Remote Sensing and Photogrammetry)	**Course Code**	26GOL406MI01
Hours per Week	02 Hours	**Credits**	01 (L:0 , P:1)
Maximum Marks	25	**Time of Examinations**	1.5 Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set by the internal examiner. The distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Attendance :	05
Total:	25

Course Learning Outcomes (Practical)

CLO 1: Identify different types of aerial photographs and satellite images.
CLO 2: Interpret basic geological, geomorphological and land-use features from aerial photographs and satellite imagery.
CLO 3: Apply the principles of photo interpretation for natural resource mapping.
CLO 4: Demonstrate the use of simple photogrammetric techniques for terrain interpretation.
CLO 5: Prepare basic thematic maps using remote sensing data.

Lists of Practicals:

1. List of Practicals
2. Identification of different types of aerial photographs and satellite images.
3. Determination of scale of aerial photographs.
4. Study of stereoscopes and stereoscopic vision.
5. Identification of drainage patterns, landforms and geological structures from aerial photographs.
6. Interpretation of land use/land cover features using satellite imagery.
7. Identification of geological features such as faults, folds, lineaments and lithological boundaries from satellite images.
8. Preparation of simple thematic maps from remotely sensed data.
9. Interpretation of satellite images for mineral, groundwater and environmental applications.

References:

1. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote Sensing and Image Interpretation (7th ed.). Wiley.
2. Sabins, F. F. (2007). Remote Sensing: Principles and Interpretation (3rd ed.). Waveland Press.
3. Drury, S. A. (2001). Image Interpretation in Geology (3rd ed.). Taylor & Francis.
4. Avery, T. E., & Berlin, G. L. (1992). Fundamentals of Remote Sensing and Air Photo Interpretation. Macmillan.
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8. NRSC–ISRO. Remote Sensing Applications.
9. ISRO. Bhuvan User Manual.
10. American Society for Photogrammetry and Remote Sensing. Manual of Remote Sensing.

Name of Program		**Program Code**	
Name of the Course	GIS and Applications	**Course Code**	26GOL406MV01
Hours per Week	03 Hours	**Credits**	03 (L:3, P:0)
Maximum Marks	75{External(term-end exam) – 50} (Internal– 25)	**Time of Examinations**	03 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 05 questions. In the remaining sections B, C, D and E there will be two questions of 10 marks each from all the four units.

Course Learning Outcomes (CLOs)

CLO 1: Understand the basic concepts, components and functions of Geographic Information Systems (GIS).
CLO 2: Explain different types of spatial and attribute data used in GIS.
CLO 3: Apply basic GIS techniques for spatial data analysis and thematic mapping.
CLO 4: Interpret GIS-based information for natural resource management and environmental planning.
CLO 5: Recognize the applications of GIS in geology, agriculture, urban planning and disaster management

Unit 1: Introduction to GIS: Definition, scope and components of GIS, history and development of GIS, spatial and attribute data, raster and vector data models, sources of spatial data, coordinate systems and map projections.

Unit 2: **Spatial Data Management:** Data input methods, database concepts, spatial database management, data editing, topology, data quality, metadata, georeferencing and digitization.

Unit 3: Spatial Analysis and Mapping: Spatial query, buffer analysis, overlay analysis, network analysis, terrain analysis, digital elevation models (DEM), thematic map preparation and map layout.

Unit 4: **Applications of GIS:** Applications of GIS in geology, mineral exploration, groundwater studies, geomorphological mapping, land-use planning, agriculture, forestry, urban planning, environmental management and disaster management.

References:

1. Burrough, P. A., & McDonnell, R. A. (1998). Principles of Geographical Information Systems. Oxford University Press.
2. Chang, K. T. (2019). Introduction to Geographic Information Systems (9th ed.). McGraw-Hill.
3. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic Information Science and Systems. Wiley.
4. DeMers, M. N. (2009). Fundamentals of Geographic Information Systems. Wiley.
5. Bolstad, P. (2016). GIS Fundamentals (5th ed.). Eider Press.
6. Lo, C. P., & Yeung, A. K. W. (2007). Concepts and Techniques of Geographic Information Systems. Pearson.
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8. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote Sensing and Image Interpretation. Wiley.
9. ESRI. Understanding GIS: An ArcGIS Project Workbook.
10. NRSC–ISRO. GIS Applications in Natural Resource Management.
11. ISRO. Bhuvan User Manual.
12. QGIS Development Team. QGIS User Guide.
13. Campbell, J. B., & Wynne, R. H. (2011). Introduction to Remote Sensing. Guilford Press.
14. Aronoff, S. (1989). Geographic Information Systems: A Management Perspective. WDL Publications.
15. Heywood, I., Cornelius, S., & Carver, S. (2011). An Introduction to Geographical Information Systems. Pearson.

Name of Program		**Program Code**	
Name of the Course	Practical (GIS and Applications)	**Course Code**	26GOL406MV01
Hours per Week	02 Hours	**Credits**	01 (L:0 , P:1)
Maximum Marks	25	**Time of Examinations**	1.5 Hours

Note: There will be five questions in all, and the students must attempt any three questions. The question paper will set by the internal examiner. The distribution of Marks will be as follows:

Marks for Question Paper:	12
Marks for Practical Record Book:	05
Marks for Viva-Voce:	03
Attendance :	05
Total:	25

Course Learning Outcomes (Practical)

CLO 1: Demonstrate the basic operation of GIS software for spatial data handling.
CLO 2: Identify and prepare different types of spatial and attribute data.
CLO 3: Create and interpret simple thematic maps using GIS.
CLO 4: Apply basic GIS tools for spatial analysis and map preparation.
CLO 5: Interpret GIS outputs for geological and environmental applications.

List of Practicals

1. Introduction to GIS software interface and basic tools.
2. Study of raster and vector data models.
3. Georeferencing of scanned maps.
4. Digitization of point, line and polygon features.
5. Preparation of attribute tables and linking spatial and attribute data.
6. Preparation of thematic maps using GIS.
7. Buffer and overlay analysis using GIS.
8. Preparation and interpretation of land use/land cover maps.
9. Preparation of drainage and contour maps using GIS.
10. Preparation of a simple geological or resource map using GIS.

References:

1. Burrough, P. A., & McDonnell, R. A. (1998). Principles of Geographical Information Systems. Oxford University Press.
2. Chang, K. T. (2019). Introduction to Geographic Information Systems (9th ed.). McGraw-Hill.
3. DeMers, M. N. (2009). Fundamentals of Geographic Information Systems. John Wiley & Sons.
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