COURSE OF STUDIES

[GEOLOGY]

Programme Level	Master of Science (MSc)
Subject / Discipline	Geology
Faculty	Faculty of Science
University	Universities of Bihar Established under the BSU AC 1976/PU Act 1976.
Duration	Two Years / Four Semesters
NHEQF Level	Level 6.5
Effective from	2026-27 onwards

A PART A — PROGRAMME OVERVIEW & OBJECTIVES

A.1 Graduate Attributes (GAs)

The programme nurtures the following Graduate Attributes in alignment with the National Higher Education Qualifications Framework (NHEQF) Level 6.5:

- The students demonstrate a comprehensive, systematic understanding of core and specialized geological sub-disciplines. They can critically evaluate existing geological paradigms and demonstrate active awareness of current research boundaries or unsolved problems in Earth Science.
- The students can extrapolate realistically from fragmented field data, to construct scientific models. They can test geological hypotheses.
- The students can independently identify rocks and minerals in the field and execute geological investigations. This includes megascopic and microscopic study of samples and structural mapping using GIS mapping software, stereographic structural programs, and geochemical analysis.
- The students are capable of conceiving, designing, and carrying out an independent geological research project. They can analyze and evaluate quantitative datasets in the field of geological science.
- The students apply geological principles directly to social issues. They can conduct professional environmental impact assessments and design sustainable resource extraction strategies.
- The students can synthesize scientific literature and prepare technical reports or research papers from raw scientific findings. They are capable of working independently, leading field teams safely under challenging wilderness conditions, and engaging in continuous professional development.

A.2 Programme Outcomes (POs)

The Programme Educational Objectives describe the career and professional accomplishments that graduates are expected to attain within three to five years of graduation.

1. PO 1 — To generate trained personnel who are equipped and ready to serve in academia, teaching, and advanced research within the realms of Earth Science.

24/07/26
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2. PO 2 — To produce a contingent of Earth scientists who are adequately competent in both the theoretical principles and practical field/laboratory aspects of geology.
3. PO 3 — To equip students with modern technological tools, software, and analytical skills, enabling them to competently analyse, complex geological data and information for optimal utilization in Earth Science studies.
4. PO 4 — To develop versatile geologists who deeply understand the significance of sustainable utilization, conservation, and development of Earth's natural resources.

A.3 Programme Specific Outcomes (PSOs)

Upon successful completion of this programme, a student shall demonstrate the following learning outcomes:

5. PSO 1 — Identify and classify minerals and rocks in both hand specimens and thin sections using polarizing microscopes, and interpret geochemical data to model igneous, metamorphic, and sedimentary processes.
6. PSO 2 — Independently conduct geological field mapping, use structural tools to decipher spatial and temporal rock relationships.
7. PSO 3 — The program shall equip students with the technological tools and skills competent enough to analyze geological data and information for the best utilization in Earth Science studies.
8. PSO 4 — Analyze the genetic models of ore deposits and utilize exploration data to evaluate economic viability and sustainable resource extraction.
9. PSO 5 — A significant outcome of the program shall be the production of versatile geologists who understand the significance of sustainable utilization & development of Earth resources.

B PART B — COURSE STRUCTURE (CBCS/NHEQF FRAMEWORK)

B.1 Semester-wise Course Structure

The following table presents the full four-semester course structure. Column headings: L = **Lectures per week**; T = Tutorials per week; P = Practicals per week; CC = Core Course; DSE = Discipline Specific Elective; GE/OE = Generic/Open Elective; SEC = Skill Enhancement Course; PROJ = Project/Dissertation.

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
SEMESTER I								
1	MSCGEOL-CC101	Core Course I: [General Geology, Geomorphology, Remote Sensing & GIS]	3	1	0	4	100	CC
2	MSCGEOL-CC102	Core Course II: [Structural Geology & Geotectonics]	3	1	0	4	100	CC
3	MSCGEOL-CC103	Core Course III: [Mineral Science]	3	1	0	4	100	CC
4	MSCGEOL-PR104	Core Course IV: [Practical]	0	0	4	4	100	CC
5	MSCGEOL-GE105/GE106	Generic Elective I: (One course to be chosen from the	3	1	0	4	100	GE

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04/07/25

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
		basket I)						
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester I	14	4	4	**22**	**600**	
SEMESTER II								
1	MSCGEOL-CC201	Core Course I: [Igneous & Metamorphic Petrology]	3	1	0	4	100	CC
2	MSCGEOL-CC202	Core Course II: [Sedimentology & Geostatistics]	3	1	0	4	100	CC
3	MSCGEOL-CC203	Core Course III: [Economic Geology]	3	1	0	4	100	CC
4	MSCGEOL-PR204	Core Course IV: [Practical]	0	0	4	4	100	CC
5	MSCGEOL-GE205/GE206	Generic Elective I: (One course to be chosen from the basket I)	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester II	14	4	4	**22**	**600**	

Particulars	Semester	Course Code	Course Title
Basket I	I	MSCGEOL-GE105	River Science
		MSCGEOL-GE106	Geoarchaeology
Basket II	II	MSCGEOL-GE205	Environmental Geology
		MSCGEOL-GE206	Geoheritage & Geotourism

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-CC101
Title of the Paper	Core Course I: [GENERAL GEOLOGY, GEOMORPHOLOGY, REMOTE SENSING & GIS]
Programme / Subject	MSc — [Geology]
Semester	Semester I

24/07/26

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Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide students with a fundamental understanding of the origin and evolution of the Solar System and the Earth, including meteorites, Earth's formation, age, and internal structure.
COB 2	To provide students with a fundamental understanding of the Earth's physical properties and dynamic processes, including geodesy, isostasy, geomagnetism, continental drift, and plate tectonics.
COB 3	To provide students with a basic understanding of geomorphic processes, landform evolution, tectonic controls, and their practical applications.
COB 4	To provide students with a basic understanding of aerial photography, remote sensing, and digital image processing, and their geological applications.
COB 5	To provide students with a basic understanding of GIS, GPS, spatial analysis, and geohazard applications.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Students will be able to explain the origin and evolution of the Solar System and the Earth using meteorites, seismology, and isotope geochronology.
CLO 2	Students will be able to interpret the Earth's physical properties and geodynamic processes using the principles of geodesy and plate tectonics.
CLO 3	Students will be able to interpret landforms and apply geomorphological concepts to tectonic, engineering, resource, and environmental studies.
CLO 4	Students will be able to interpret aerial photographs and satellite data and apply remote sensing and digital image processing techniques in geological investigations.
CLO 5	Students will be able to apply GIS, GPS, and remote sensing techniques for spatial

24/07/26

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	data analysis and geohazard mapping and management.

C.5 Syllabus — Unit-wise Breakdown

Course Name: GENERAL GEOLOGY, GEOMORPHOLOGY, REMOTE SENSING & GIS (MSCGEOL-CC101)		
Unit	**Content**	**Suggested Lectures hours**
I	▪ Solar system, Meteorites, Modern concepts of origin of the Earth ▪ Seismology and internal Structure of the Earth ▪ Radioactive Isotopes and age of the Earth	06
II	▪ Geodesy, Isostasy, gravitational field of the Earth ▪ Geomagnetism and Palaeomagnetism; Continental drift ▪ Plate tectonics- relationship with earthquakes, volcanism and mountain buildings	10
III	▪ Basic concepts of Geomorphology, Geomorphic cycles and their interpretation; development and evolution of landforms in continental and oceanic settings ▪ Tectonic geomorphology; Neotectonics: Geomorphological indicators, active faults, drainage changes ▪ Application of geomorphology in mineral prospecting, Civil engineering; Hydrology, Land use planning and environmental studies; Geomorphology of the Indian subcontinent	08
IV	▪ Aerial photographs- Types, Scale, Parallax, Relief, Displacements; elements of image interpretation, Photogrammetry, mirror Stereoscopes ▪ Principles of remote sensing, polar-orbiting & Geostationary satellites. Electromagnetic spectrum, electromagnetic bands in remote sensing, Spectral reflectance of land covers, Optical, Thermal, near-infrared and microwave remote sensing ▪ Digital Image processing- spectral, spatial, and radiometric enhancement techniques, Georeferencing, FCCs, principal component analysis, IHS and DVI images, supervised and unsupervised classification and its utility in land-cover mapping.	15

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	▪ Indian remote sensing satellites, satellite data products, IRS, LANDSAT, SPOT, Characteristics and uses, Applications of remote sensing in geology	
V	▪ Introduction to GIS and its components. Raster and Vector data. Functions of GIS. Data integration and overlay analysis in GIS. Digital Elevation Model ▪ Principles and application of GIS and RS in geohazards monitoring (landslides, floods, droughts, cyclones, earthquakes). ▪ Global Positioning System.	06
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

- Strahler, A. N., & Strahler, A. H. (2005). Physical Geography: Science and Systems of the Human Environment (3rd ed.). John Wiley & Sons.
- Bloom, A. L. (1998). Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. Prentice Hall.
- Summerfield, M. A. (1991). Global Geomorphology. Longman Scientific & Technical.
- Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). *Remote Sensing and Image Interpretation* (7th ed.). John Wiley & Sons.
- Jensen, J. R. (2015). *Introductory Digital Image Processing: A Remote Sensing Perspective*. Pearson.
- Chang, K. T. (2019). *Introduction to Geographic Information Systems* (9th ed.). McGraw-Hill Education.

C.7 Reference Books & Readings

- Tarolli, P. (2014). High-resolution topography for understanding Earth surface processes: Opportunities and challenges. *Geomorphology*, 216, pp. 295–312.
- Weng, Q. (2012). Remote sensing of impervious surfaces in the urban areas: Requirements, methods, and trends. *Remote Sensing of Environment*, 117, pp. 34–49.
- Chang, K. T. (2019). *Introduction to Geographic Information Systems*. McGraw-Hill Education.
- Burrough, P. A., & McDonnell, R. A. (1998). *Principles of Geographical Information Systems*. Oxford University Press.
- Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. *GeoJournal*, 69(4), pp. 211–221.
- Knighton, D. (1998). *Fluvial Forms and Processes: A New Perspective*. Arnold.
- Schowengerdt, R. A. (2007). *Remote Sensing: Models and Methods for Image Processing*. Academic Press

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Remote sensing and GIS, https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ce108], {Geomorphology, https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_ce29}
- e-PG Pathshala: [Geology, https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=8zYwEsyFCoiPyJlPmzHDxg==]
- SHODHGANGA / Shodhgangotri — for research thesis reference: https://shodhganga.inflibnet.ac.in/
- NDL India (National Digital Library): ndl.gov.in

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-CC102
Title of the Paper	Core Course II: [STRUCTURAL GEOLOGY AND GEOTECTONICS]
Programme / Subject	[MSc] — [Geology]
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70

24/07/26

(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To introduce the fundamental principles of structural geology and develop the foundational skills required to prepare geological section.
COB 2	To impart a comprehensive understanding of the concepts of stress and strain.
COB 3	To elucidate the genetic mechanisms, kinematics, and geometric classifications of folds and faults, enabling students to interpret the dynamic forces responsible for brittle and ductile crustal deformation.
COB 4	To develop proficiency in identifying and interpreting structural fabrics and microstructures.
COB 5	To explore the large-scale framework of Geotectonics, providing a global perspective on planetary dynamics, plate boundary interactions, mountain building processes, and the structural evolution of the Earth's lithosphere.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Upon completion, students will be able to Analyse deformation mechanics
CLO 2	Students will be able to Evaluate structural features and reconstruct the kinematic and dynamic mechanisms behind the formation of folds, faults, and joints.
CLO 3	Students will be able to Identify and analyse structural fabrics to deduce the deformation history and identify localized shear zones or weak zones.
CLO 4	Students will be able to Evaluate large-scale geodynamics, such as plate boundary interactions, orogeny and the structural evolution of major tectonic features.
CLO 5	Students will be able to Collect, plot, and interpret structural data to solve engineering problems and assess slope/rock stability.

C.5 Syllabus — Unit-wise Breakdown

Course Name: STRUCTURAL GEOLOGY AND GEOTECTONICS (MSCGEOL-CC102)		
Unit	**Content**	**Suggested Lectures hours**
I	▪ Introduction to structural geology, Classification of geologic structures; primary structures; microstructures, Principles of geological mapping.	08

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	▪ Mechanical properties of rocks and their controlling factors. (Confining pressure, temperature, time, pore fluid pressure, etc.) ▪ Concept of stress and strain. Behaviour of rocks under stress: elastic, plastic, viscous and visco-elastic responses and their geological significance.	
II	▪ Strain Analysis: Methods of strain measurements in naturally deformed rocks. Introduction to fracture mechanics. ▪ Graphical representations of strain, Types of strain ellipses & ellipsoids - their properties and geological significance. (Flinn, Ramsay and Nadai-Hossack plots). ▪ Mohr diagrams and their use; Coulomb's criterion and Griffith's theory.	09
III	▪ Planar and Linear fabrics in deformed rocks, their origin and significance. Basic idea about petro-fabrics. ▪ Stereographic projection of linear and planar structures ▪ Shear zones: geometry, kinematics and their significance.	08
IV	▪ Description of Joints and their geological significance. ▪ Description of Folds. Mechanics of folding and buckling, Flexure folds; flexure flow folds. Concept of superposed deformation. ▪ Description of Faults. Mechanics of faulting: Anderson's theory and its limitations, Effects of faulting on the outcrops & folded strata.	12
V	▪ Tectonic features of extensional-, compressional- and strike-slip-terrains and relevance to plate boundaries. Mantle plumes. ▪ The Himalayan Orogeny	08

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	▪ Concept of supercontinent, their assembly and breakup.	
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

- Fossen, H. (2016). Structural Geology (2nd ed.). Cambridge University Press.
- Twiss, R. J., & Moores, E. M. (2007). Structural Geology (2nd ed.). W. H. Freeman and Company.
- Kearey, P., Klepeis, K. A., & Vine, F. J. (2009). Global Tectonics (3rd ed.). Wiley-Blackwell.
- Billings, M. P. (1972). Structural Geology (3rd ed.). Prentice-Hall.
- Davis, G. H., Reynolds, S. J., & Kluth, C. F. (2011). Structural Geology of Rocks and Regions (3rd ed.). John Wiley & Sons.

C.7 Reference Books & Readings

- Davis, G. H., Reynolds, S. J., & Kluth, C. F. (2011). Structural Geology of Rocks and Regions. John Wiley & Sons.
- Kearey, P., Klepeis, K. A., & Vine, F. J. (2009). Global Tectonics. Wiley-Blackwell.
- Condie, K. C. (2016). Earth as an Evolving Planetary System (3rd ed.). Academic Press.
- Dewey, J. F., & Bird, J. M. (1970). Mountain belts and the new global tectonics. Journal of Geophysical Research, 75(14), pp. 2625–2647.
- Wilson, J. T. (1965). A new class of faults and their bearing on continental drift. Nature, 207(4995), pp. 343–347.
- Billings, M. P. (1972). Structural Geology. Prentice-Hall.
- Ramsay, J. G., & Huber, M. I. (1987). The Techniques of Modern Structural Geology, Volume 2: Folds and Fractures. Academic Press.
- Moores, E. M., & Twiss, R. J. (1995). Tectonics. W. H. Freeman and Company.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Structural Geology https://onlinecourses.nptel.ac.in/e-learning/preview/noc19_ce47]
- e-PG Pathshala: [chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000017GE/P001786/M025383/ET/1512629568Revised_Module_10_Plate_tectonics(2.pdf]
- SHODHGANGA / Shodhgangotri — for research thesis reference
- NDL India (National Digital Library): ndl.gov.in

24/07/26
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C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)

- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-CC103
Title of the Paper	Core Course III: [MINERAL SCIENCE]
Programme / Subject	[MSc] — [Geology]
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Introduce the fundamental principles of mineralogy, including chemical compositions, physical properties, and the underlying mechanisms of mineral formation.
COB 2	Explain the mathematical and spatial concepts of the Crystal Systems to define the crystal symmetry.

KP 24/07/26

COB 3	To understand distribution and applications of various groups of elements in Geology
COB 4	Provide a comprehensive structural and chemical analysis of major mineral groups.
COB 5	Instruct students on the behavior of light passing through crystalline matter and the use of the petrological microscope to identify optical properties.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the diagnostic physical, chemical and optical properties of minerals and utilize standard testing methods to identify minerals..
CLO 2	Analyze how atomic radii, coordination numbers, and chemical bonding dictate the internal arrangement and stability of crystal lattices.
CLO 3	Analyze minerals as a tool to understand Earth processes and Earth history
CLO 4	Utilize a petrological microscope to observe, measure, and interpret diagnostic optical properties to identify minerals in thin sections

C.5 Syllabus — Unit-wise Breakdown

Course Name: MINERAL SCIENCE (MSCGEOL-CC103)		
Unit	**Content**	**Suggested Lectures hours**
I	▪ Introduction to mineralogy: Chemical classification of minerals. ▪ Structural and chemical principles of minerals, ionic radii, coordination number, Isomorphism, Polymorphism, Pseudomorphism, Solid solution, Exsolution, Zoning, Polytypism, Polysomatism ▪ P-T stability- Phase diagram.	08
II	▪ Structural classification of Silicates. ▪ Detailed study of mineral groups including structure, classification, physical & optical properties, paragenesis of *Olivine, Pyroxene, Amphibole, Mica, Feldspar, Silica* groups. ▪ SEM, TEM and EPMA and their geological application; Mineral formula calculation.	15
III	▪ Crystal structure, diagnostic properties, paragenesis, and alteration - Kyanite, Sillimanite, Andalusite, Felspathoids, Epidote, Garnet ▪ Study of the following minerals- - Talc, Gypsum, Calcite, Fluorite, Apatite, Topaz, Corundum, Magnetite, Pyrite, Spinel, Galena, Tourmaline, Beryl, Barite, Chlorite, Sphene, Vesuvianite.	05
IV	▪ Formation and growth of crystals; Space lattices and space groups; Symmetry elements, Derivation of 32 classes of symmetry.	08

24/07/26

Kalpana Srivastava
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	▪ Detailed study of the six crystal systems- Isometric, Tetragonal, Hexagonal, Orthorhombic, Monoclinic, Triclinic; ▪ Twinning and laws of twinning, ▪ X-ray studies of crystals.	
V	▪ Isotropic and Anisotropic minerals, Optical properties of minerals: Refractive index and its determination, Scheme of Pleochroism, Extinction angle, Order of Interference colour, Birefringence, Optic axis angle, Dispersion ▪ Concept of Optical indicatrix: Uniaxial and Biaxial minerals, Behavior of convergent polarized light in uniaxial and biaxial minerals. Determination of Optic sign. ▪ Construction and uses of accessory plates: Quartz wedge, Mica Plate and Gypsum plate.	09
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. William Nesse, Introduction to Mineralogy, Oxford University Press.
2. Dexter Perkins, Mineralogy, Prentice Hall.
3. Cornelis Klein & Barbara Dutrow, Manual of Mineral Science, Wiley.
4. Dana, E.S. and Ford, W.E., 2002. A text book of Mineralogy (Reprint)
5. Berry, L.G., Mason, B. and Dietrich, R.V., 1985. Mineralogy: Concepts, Descriptions and determinations. CBS Publishers.
6. Kerr, P.F., 1977. Optical Mineralogy McGrew Hill.
7. Deer, W.A., Howie, R.A. & Zussman, J., 2013.An Introduction to the rock forming minerals, ELBS and Longman.
8. Gribble, C.D., 2005.Rutley's elements of Mineralogy, Springer.
9. Winchell, E.N., 1951.Elements of Optical Mineralogy, Wiley Eastern.

C.7 Reference Books & Readings

1. Rollinson, H., 2007. Using geochemical data-evaluation. Presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
2. Nesse, D.W., 1986. Optical Mineralogy, McGraw Hill

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Relevant Course Name and Link]
- e-PG Pathshala: [Subject Portal Link]
- SHODHGANGA / Shodhgangotri — for research thesis reference
- NDL India (National Digital Library): ndl.gov.in
- Geological Survey of India. gsi.gov.in

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C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL- PR104
Title of the Paper	Core Course IV: [PRACTICAL]
Programme / Subject	[MSc] — [Geology]
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	0 – 0 – 4
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	—	70	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	—	**70**	**30**	**100**
Passing Marks	—	**32**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide students with practical skills in aerial photograph interpretation, stereoscopic analysis, and the use of satellite data, DIP, and GIS techniques for geospatial investigations

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

COB 2	To develop practical skills in geological map interpretation, structural analysis, stress–strain evaluation, and stereographic projection techniques for solving geological problems
COB 3	To provide students with practical skills in the identification and optical characterization of rock-forming minerals and in mineral formula determination.
COB 4	To develop practical skills in crystallographic projection methods and the determination of crystal symmetry and axial ratios using clinographic and stereographic techniques

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Upon completion, students will be able to apply stereoscopic, remote sensing, DIP, and GIS techniques to interpret aerial photographs and satellite imagery for geospatial and geological analysis.
CLO 2	The students will be able to apply geological mapping, stress–strain analysis, stereographic projection, and dip-related calculations to interpret and solve structural geological problems.
CLO 3	The students will be able to identify and characterize rock-forming minerals using megascopic and microscopic properties, optical techniques, and mineral formula calculations.
CLO 4	The students will be capable of constructing and interpreting crystallographic projections and determining crystal symmetry and axial ratios using clinographic and stereographic methods.

C.5 Syllabus — Unit-wise Breakdown

Course Name: PRACTICAL (MSCGEOL-CC104)		
Unit	**Content**	**Suggested Lectures hours**
I	**GENERAL GEOLOGY, GEOMORPHOLOGY, REMOTE SENSING & GIS** ▪ Study of aerial photographs and uses of stereoscope. ▪ Study and interpretation of satellite data on the basis of their spectral signatures ▪ Exercise on DIP and GIS software.	15
II	**STRUCTURAL GEOLOGY AND GEOTECTONICS** ▪ Preparation and interpretation of geological maps and sections. ▪ Exercises on stress and strain analysis. ▪ Structural problems related to true and apparent dips, thickness of beds and three point problem. ▪ Stereographic projection and their use in structural analysis.	15
III	**MINERALOGY AND OPTICAL MINERALOGY:** ▪ Megascopic and microscopic study of important rock-forming minerals. ▪ Determination of scheme of Pleochroism, Determination of	15

24/02/26

Kalpana Srivastava
Officer on special duty (Judicial)

	An-content of Plagioclase Feldspar, Optic sign determination. ▪ Mineral formula calculations.	
IV	**CRYSTALLOGRAPHY** ▪ Clinographic projections of Trapezohedron, Pyritohedron, Zircon, Vesuvianite, Cassiterite ▪ Stereographic projection and determination of axial ratio of Zircon, Vesuvianite, Cassiterite, Barite	15
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

- Rowland, S. M., Duebendorfer, E. M., & Schiefelbein, I. M. (2012). Structural Analysis and Synthesis: A Laboratory Course in Structural Geology (3rd ed.). Wiley-Blackwell.
- Compton, R. R. (1985). Geology in the Field. John Wiley & Sons.
- Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote Sensing and Image Interpretation (7th ed.). John Wiley & Sons.
- Jensen, J. R. (2015). Introductory Digital Image Processing: A Remote Sensing Perspective. Pearson.
- Nesse, W. D. (2013). Introduction to Optical Mineralogy (4th ed.). Oxford University Press.
- Perkins, D. (2011). Mineralogy (3rd ed.). Pearson.
- Klein, C., & Dutrow, B. (2007). Manual of Mineral Science (23rd ed.). John Wiley & Sons.
- Phillips, F. C. (1971). An Introduction to Crystallography (4th ed.). Longman.
- Tarolli, P. (2014). High-resolution topography for understanding Earth surface processes: Opportunities and challenges. Geomorphology, 216, pp. 295–312.
- Fossen, H. (2010). Structural analysis and interpretation using stereographic projection techniques. Journal of Structural Geology, 32(10), pp. 1419–1430.
- Weng, Q. (2012). Remote sensing of impervious surfaces in urban areas: Requirements, methods, and trends. Remote Sensing of Environment, 117, pp. 34–49.
- 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.

C.7 Reference Books & Readings

- Passchier, C. W., & Trouw, R. A. J. (2005). Microtectonics and deformation mechanisms in rocks.
- Bhattacharyya, A. (2011). Petrography and mineral chemistry of the Chotanagpur Granite Gneiss Complex, eastern India.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

- Chatterjee, N., & Ghose, N. C. (2011). Structural evolution and tectonic framework of the Chotanagpur Gneissic Complex, eastern India.
- Mohan, M. R., & Singh, S. P. (2013). Optical mineralogy and petrographic characterization of metamorphic rocks from the Eastern Ghats Belt, India.
- Sarkar, A., & Gupta, S. (2014). Crystallographic and mineral chemical studies of feldspars from granitoids of eastern India.
- Sengupta, P. (2018). Mineralogical and textural evolution of high-grade metamorphic rocks: Insights from the Eastern Indian Shield.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Relevant Course Name and Link]
- e-PG Pathshala: [Subject Portal Link]
- SHODHGANGA / Shodhgangotri — for research thesis reference
- NDL India (National Digital Library): ndl.gov.in
- [Any other relevant Open Educational Resource]

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-GE105
Title of the Paper	Generic Elective: [RIVER SCIENCE]
Programme / Subject	[MSc] — [Geology]
Semester	Semester I
Nature of Course	Generic elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide students with a fundamental understanding of river systems, fluvial processes, sediment dynamics, and surface–groundwater interactions.
COB 2	To provide students with a basic understanding of river diversity, fluvial processes, drainage evolution, and the applications of fluvial geomorphology.
COB 3	To provide students with a basic understanding of river discharge, flood hydrology, sediment transport, and channel erosion–deposition processes.
COB 4	To provide students with a basic understanding of river chemistry, ecosystems, water quality, river health, and environmental assessment.
COB 5	To provide students with a basic understanding of river dynamics, watershed management, and the applications of remote sensing and GIS in river studies.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Upon completion, students will be able to interpret river processes, channel dynamics, sediment transport, and surface–groundwater interactions in fluvial systems
CLO 2	Students will be able to interpret river patterns, drainage evolution, and fluvial processes for geomorphological analysis and practical applications.
CLO 3	Students will be able to analyze river discharge, flood characteristics, and sediment transport processes in fluvial systems.
CLO 4	Students will be able to interpret geochemical data of the fluvial system.
CLO 5	Students will be able to assess river dynamics and apply watershed management, remote sensing, and GIS techniques in river studies.

KS 24/07/26

Kalpana Srivastava I
Officer on special duty (Judicial)

C.5 Syllabus — Unit-wise Breakdown

Course Name: RIVER SCIENCE (MSCGEOL-GE105)		
Unit	**Content**	**Suggested Lectures hours**

I	▪ Introduction to river science, River diversity: Channel pattern, Channel geometry, Channel morphology, instream features. Flood Plains ▪ Surface and groundwater hydrology; Groundwater-river interaction ▪ River morphology- spatial and temporal scale	05
II	▪ River diversity ▪ Patterns of alluvial rivers - braided, meandering and anabranching channels, anastomosing ▪ Evolution of drainage network in geological time scale ▪ Bedrock channel processes and evolution of fluvial landscapes ▪ Fluvial geomorphology and its applications	05
III	▪ River Flow, discharge and discharge measurements, River hydrographs and their application in hydrological analysis. ▪ Flood hydrology, Flood frequency analysis. ▪ Sediment transport processes in rivers. ▪ Sediment load and sediment yield	10
IV	▪ Environmental chemistry of river systems ▪ Water quality assessment and monitoring ▪ River ecosystem Processes ▪ E-flow, River health, Environmental impact assessment	10
V	▪ Climate change and its impacts on river systems ▪ River response to tectonics and human disturbance ▪ River Styles Framework in integrated approach to river management ▪ Watershed management ▪ Remote Sensing and GIS applications in river studies	15
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

24/07/26

Kalpana Srivastava I
Officer on special duty (Judicial)

C.6 Prescribed Textbooks

- Knighton, D. (1998). Fluvial Forms and Processes: A New Perspective. Arnold.
- Charlton, R. (2008). Fundamentals of Fluvial Geomorphology. Routledge.

- Bridge, J. S. (2003). Rivers and Floodplains: Forms, Processes, and Sedimentary Record. Blackwell Publishing.
- Leopold, L. B., Wolman, M. G., & Miller, J. P. (1964). Fluvial Processes in Geomorphology. W. H. Freeman and Company.
- Brierley, G., & Fryirs, K. (2013). Geomorphology and River Management: Applications of the River Styles Framework. Wiley-Blackwell.
- Kale, V. S. (2014). Landscapes and Landforms of India. Springer.
- Valdiya, K. S. (2016). The Making of India: Geodynamic Evolution (2nd ed.). Springer.
- Sinha, R. (Ed.). (2022). Indian Rivers: Scientific and Socio-economic Aspects. Springer.

C.7 Reference Books & Readings

- Sinha, R., Jain, V., Prasad, M., & Ghosh, S. (2005). Geomorphic characterization and diversity of the fluvial systems of the Gangetic plains. Geomorphology, 70(3–4), pp. 207–225.
- Jain, V., Sinha, R., & Tandon, S. K. (2004). Holocene dynamics of the Himalayan foreland rivers and development of the Gangetic plains. Current Science, 86(7), pp. 1026–1034.
- Sinha, R., Friend, P. F., Switsur, V. R., & Tandon, S. K. (1996). Palaeochannels and their significance in the fluvial evolution of the Ganga plains, India. Sedimentary Geology, 103(1–2), pp. 1–15.
- Jain, V., & Sinha, R. (2003). Hyperavulsive reorganization of the Kosi megafan and its implication for river management. Zeitschrift für Geomorphologie, 47(4), pp. 469–491.

- Bridge, J. S. (2003). Rivers and Floodplains: Forms, Processes, and Sedimentary Record. Blackwell Publishing.
- Sinha, R., Friend, P. F., Switsur, V. R., & Tandon, S. K. (1996). Palaeochannels and their significance in the fluvial evolution of the Ganga plains, India. Sedimentary Geology, 103(1–2), pp. 1–15.
- Jain, V., & Sinha, R. (2003). Hyperavulsive reorganization of the Kosi megafan and its implication for river management. Zeitschrift für Geomorphologie, 47(4), pp. 469–491.
- Sinha, R., Jain, V., Prasad, M., & Ghosh, S. (2005). Geomorphic characterization and diversity of the fluvial systems of the Gangetic plains. Geomorphology, 70(3–4), pp. 207–225.
- Jain, V., Sinha, R., & Tandon, S. K. (2004). Holocene dynamics of the Himalayan foreland rivers and development of the Gangetic plains. Current Science, 86(7), pp. 1026–1034.

- Sinha, R., Tandon, S. K., Gibling, M. R., Bhattacharjee, P. S., & Dasgupta, A. S. (2007). Avulsion threshold and planform dynamics of the Kosi River in north Bihar, India. Geomorphology, 82(1–2), pp. 4–19.
- Wells, N. A., & Dorr, J. A. (1987). Shifting of the Kosi River, northern India. Geology, 15(3), pp. 204–207.
- Sinha, R. (2009). The Great avulsion of Kosi on 18 August 2008. Current Science, 97(3), pp. 429–433.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

▪ Ghosh, S., Sinha, R., & Fulong, C. (2015). Understanding dynamics of large rivers in the Gangetic basin using remote sensing and GIS. Geocarto International, 30(5), pp. 523–542.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Sustainable river basin management, https://nptel.ac.in/courses/105106145] [River Engineering, https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_ce79],] [Water resources and watershed management https://onlinecourses.swayam2.ac.in/e-learning/preview/cec21_ge14]
- e-PG Pathshala: [Basin Hydrology, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000017GE/P001785/M028340/ET/1521538373basinhydrologyfinal.pdf]
- SHODHGANGA / Shodhgangotri — for research thesis reference https://shodhgangotri.inflibnet.ac.in/
- NDL India (National Digital Library): ndl.gov.in

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

24/07/26

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL – GE106
Title of the Paper	Generic Elective: [GEOARCHAEOLOGY]
Programme / Subject	[MSc] — [Geology]
Semester	Semester I
Nature of Course	Generic Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide students with a basic understanding of the relationship of geoarchaeology with Geology. History of Geoarchaeology.
COB 2	To impart knowledge on landforms evolution and techniques applicable for its evaluation.
COB 3	To provide students with knowledge of field, laboratory, geophysical, GIS, and dating techniques used in geoarchaeological investigations.
COB 4	To provide students with an understanding of past environmental changes and their influence on human cultures, landscapes, and ecological adaptations.
COB 5	To develop an understanding of geoarchaeological sites in Bihar and to acquaint about ancient monument preservation act.

24/07/26

C.4 Course Outcomes (COs)

Kalpana Srivastava
Officer on special duty (Judicial)

CLO No.	Course Learning Outcome
CLO 1	Upon completion, students will be able analyse geoarchaeological processes, soil and sediment formation, and the evolution of fluvial, glacial, aeolian, and lacustrine landforms
CLO 2	Students will be able to apply advanced field, laboratory, geophysical, GIS, and dating

	techniques to analyse and interpret geoarchaeological records.
CLO 3	Students will be able to analyse the interactions between environmental change, landscape evolution, cultural development, and human adaptation through time..
CLO 4	Students will be able to evaluate and compare geoarchaeological studies and approaches in India and internationally.
CLO 5	Students will understand the geoarchaeological significance of prehistoric sites in Bihar and the legal framework for the conservation and protection of archaeological heritage.

C.5 Syllabus — Unit-wise Breakdown

Course Name: GEOARCHAEOLOGY **(MSCGEOL-GE106)**		
Unit	**Content**	**Suggested Lectures hours**
I	▪ Concepts of Earth Science in Archaeology ▪ History and development of geoarchaeology ▪ Geological Time Scale and cultural Time Scale ▪ Origin, growth and decay of cultures, Human impact on landscape ▪ Human responses to changing environment; Palaeo-landscape ▪ Cultural Ecology	05
II	▪ Landform Evolution; Fluvial (with reference to Gangetic basin), Glacial, Aeolian, lacustrine ▪ Soil horizon, texture and structure ▪ Soil horizon in alluvial plain ▪ Laws of superposition and cross-cutting relationship ▪ Harris matrix and archaeological stratigraphy, Alluvial stratigraphy ▪ Palaeo-climate and Sea level changes	10
III	▪ Methods and Field techniques (Physical, Chemical, Geological) in Geoarchaeology ▪ Coring, test pitting, bulk sampling techniques ▪ Radiocarbon and Luminescence dating ▪ Satellite imagery interpretation of palaeochannels of Ganga, Kosi, Son, Gandak ▪ Resistivity, Magnetometry ▪ Ground Penetrating Radar (GPR) applications	15
IV	▪ Pleistocene and Holocene- Climate shifts in India ▪ Urban geoarchaeology	07

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	▪ Geoarchaeological studies in India ▪ International studies in Geoarchaeology	
V	▪ Geoarchaeological settings of Palaeolithic sites in Bihar ▪ Neolithic and Chalcolithic sites at Chirand (Saran) and Taradih (Gaya), Panr (Samastipur), Senuwar (Rohtas) ▪ Ancient Monuments Preservation Act ▪ Indian Antiquarian Laws.	08
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

- Rapp, G., Jr., & Hill, C. L. (2006). Geoarchaeology: The Earth-Science Approach to Archaeological Interpretation (2nd ed.). Yale University Press.
- Goldberg, P., & Macphail, R. I. (2006). Practical and Theoretical Geoarchaeology. Blackwell Publishing.
- Waters, M. R. (1992). Principles of Geoarchaeology: A North American Perspective. The University of Arizona Press.
- Pollard, A. M. (Ed.). (1999). Geoarchaeology: Exploration, Environments, Resources. Geological Society, London, Special Publications.
- Renfrew, C., & Bahn, P. (2020). Archaeology: Theories, Methods and Practice (8th ed.). Thames & Hudson.
- Pappu, S. (2001). Geoarchaeology of the Pleistocene Sites of North Tamil Nadu, South India. Geological Society of India.
- Misra, V. N. (2001). Prehistory and Protohistory of India: An Appraisal. Aryan Books International.
- Allchin, B., & Allchin, R. (1997). The Rise of Civilization in India and Pakistan (2nd ed.). Cambridge University Press.
- Korisettar, R., Venkatasubbaiah, P. C., & Fuller, D. Q. (Eds.). (2021). Indian Archaeology in Retrospect, Vol. I: Prehistory. Manohar Publishers & Distributors.
- Valdiya, K. S. (2016). The Making of India: Geodynamic Evolution (2nd ed.). Springer. (Useful for understanding the geological framework underlying archaeological landscapes in India.)

24/07/26

(Kalpana Srivastava)
Officer-On-Special Duty (Acad.)

Rajaguru, S. N., Kale, V. S., & Badam, G. L. (Eds.). (1993). Quaternary Environments and Geoarchaeology of India. Deccan College Post-Graduate and Research Institute.

C.7 Reference Books & Readings

- Sinha, A. K., & Narain, A. (1970). Palaeolithic industries of the Belan and Son valleys and their geological context. Man and Environment, 4(1), pp. 23–36.
- Ghosh, A. (Ed.). (1989). An Encyclopaedia of Indian Archaeology. Munshiram Manoharlal Publishers.
- Chakrabarti, D. K. (2001). Archaeological geography of the Ganga Plain: The lower and the middle Ganga. Pragdhara, 11, pp. 1–26.
- Rajaguru, S. N., Kale, V. S., & Badam, G. L. (1995). Geoarchaeological studies in the Middle Ganga Plain: Implications for landscape evolution and human settlement. Man and Environment, 20(1), pp. 15–28.
- Sinha, R., Tandon, S. K., & Gibling, M. R. (2007). The Ganga plains and their geomorphic evolution: Implications for archaeology and Quaternary studies. Quaternary International, 159(1), pp. 3–18.
- Coningham, R., Young, R., & Acharya, K. (2015). The archaeology of early historic South Asia and the geoarchaeological context of the Middle Ganga Plain. Journal of Field Archaeology, 40(5), pp. 517–533.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [An Introduction to Field Archaeology: Method & Practices, https://onlinecourses.swayam2.ac.in/e-learning/preview/ini26_hs16],
- e-PG Pathshala:
- SHODHGANGA / Shodhgangotri — for research thesis reference, [https://shodhganga.inflibnet.ac.in/]
- NDL India (National Digital Library): ndl.gov.in

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the*

National Education Policy (NEP), 2020.
For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-CC201
Title of the Paper	Core Course I: [IGNEOUS & METAMORPHIC PETROLOGY]
Programme / Subject	[MSc] — [Geology]
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Detail the origin, generation, and differentiation mechanisms of magma as it ascends through the crust and mantle.
COB 2	Introduce the thermodynamic principles governing unary, binary, and ternary silicate phase diagrams to understand mineral crystallization pathways.
COB 3	Review the significant igneous provinces of India, connecting their volcanic/plutonic activities

24/07/26

	to regional tectonic evolution.
COB 4	Formulate the concept of metamorphic facies and mineral assemblages as indicators of specific depth-temperature regimes in the Earth's crust.
COB 5	Train students in utilizing chemographic projections and interpreting metamorphic reactions to track mineralogical changes.
COB 6	Evaluate how different initial rock types (pelitic, mafic, carbonate, and quartzo-feldspathic) mineralogically evolve under varying metamorphic grades.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Utilize textural, mineralogical, and whole-rock chemical data to accurately classify and name igneous rocks according to IUGS and chemical classification schemes.
CLO 2	Analyze silicate phase systems to track and predict the exact crystallization or melting paths of magmatic melts under varying temperatures and pressures.
CLO 3	Correlate major Indian igneous suites with their specific geodynamic settings and tectonic history.
CLO 4	Explain the thermodynamic, structural, and fluid-driven mechanisms that govern the transformation of protoliths into metamorphic rocks
CLO 5	Construct and interpret chemographic projections (such as AFM, ACF, and AKF diagrams) to model metamorphic reaction pathways and determine mineral stability fields.
CLO 6	Synthesize field, textural, and P-T data from regional metamorphic terrains to reconstruct historical tectonic settings and crustal evolution.

C.5 Syllabus — Unit-wise Breakdown

Course Name: IGNEOUS & METAMORPHIC PETROLOGY (MSCGEOL-CC201)		
Unit	**Content**	**Suggested Lectures hours**
I	• Magma: types, composition, properties and generation. • Processes involved in Evolution of primary magma: *Fractional crystallization, Gravitational differentiation, Assimilation and crustal contamination, Magma mixing and mingling, Gas streaming, Liquid immiscibility*. • Magmatism in relation to plate tectonics: Mantle plumes and associated magmatism. • Genesis and petrogenetic significance of igneous textures and structure: Nucleation and growth of minerals in magmatic rocks.	10
II	• Different schemes of Classification of igneous rocks;	10

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	Chemical classification of igneous rocks; IUGS classification of plutonic and volcanic rocks. • Tectonic setting and Petrogenesis of – Granites, Basalts, Ophiolite suites, Komatiites, Syenites, Boninites, Anorthosites, Alkaline rocks (Carbonatite, Kimberlite, Lamprophyre) • Major Igneous activities in India.	
III	• Concept of system, component and phase. Unicomponent and multicomponent system. • Binary system with complete solid solution and liquid immiscibility • Ternary system with solid solution, congruently melting binary phase, incongruently melting binary phase and with liquid immiscibility • Trace elements and REE in igneous systems • Concept of thermobarometry.	08
IV	• Concept of Metamorphism and metamorphic processes: factors controlling metamorphism; role of fluids in metamorphism; types of metamorphism; Index minerals; Mineral assemblages; metamorphic differentiation. • Metamorphic structures and textures. • Plate tectonics and metamorphism; Paired metamorphic belts • Metamorphic facies – Concept and classification; Facies series. • Schrienemakers rule and construction of petrogenetic grids; P-T-t path and tectonic setting.	08
V	• Isograds and Nature of metamorphic reactions, solid-solid reactions, dehydration reactions, decarbonization and oxidation-reduction reactions. • Representation of metamorphic assemblages – ACF, AKF and AFM diagrams • Progressive and retrogressive metamorphism of pelitic, calcareous and basic rocks. • Petrogenesis of Charnockites, Migmatites and Granulites.	09

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	Total Suggested Lectures	45 (For 4 Credit Course)
	Tutorial	15
	Total Suggested Contact Hours For Practical/Field Work Courses	120 Hours/Semester

C.6 Prescribed Textbooks

1. Best, M. G., 1986.Igneous and Metamorphic Petrology, CBS Pub.
2. Blatt, H. and Tracy, R.J. 1996 Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman & Co.
3. Bose, M. K., 1997.Igneous Petrology. World Press.
4. Bucher. K. and Martin, F. 2002 Petrogenesis of Metamorphic Rocks, Springer - Verlag, 7th Edition.
5. Hall, A., 1988.Igneous petrology. ELBSI Longman.
6. Winter, J.D., 2010. Igneous and Metamorphic Petrology.
7. McBirney, A. R., 1993.Igneous Petrology. John Wiley.
8. Philpotts, A.R. and Ague, J.J., 2022. Principles of igneous and metamorphic petrology. Cambridge University Press.
9. Rastogy, R.P. and Mishra, R.R. 1993: An Introduction to Chemical Thermodynamics, Vikash Publishing House.
10. Turner & Verhoogen, 1999.Igneous and Metamorphic Petrology. CBS Pub.

C.7 Reference Books & Readings

1. Spry. A. 1976 Metamorphic Textures, Pergamon Press
2. Wilson, M., 1989. Igneous Petrogenesis: A Global Tectonic Approach. Chapman and Hall publishing.
3. Yardley, B.W.D., 1997. An Introduction to Metamorphic Petrology, Longman Earth Science Series.
4. Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. 1995 Atlas of Metamorphic Rocks and their textures, Longman Scientific & Technical, England.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Relevant Course Name and Link]
- e-PG Pathshala: [Subject Portal Link]
- SHODHGANGA / Shodhgangotri — for research thesis reference
- NDL India (National Digital Library): ndl.gov.in

KS 24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-CC202
Title of the Paper	Core Course II: [SEDIMENTOLOGY & GEOSTATISTICS]
Programme / Subject	[MSc] — [Geology]
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To impart a deep understanding of sedimentary processes and facies analysis.
COB 2	To enable students to decode stratigraphic sequences and reconstruct continental, transitional, and marine depositional systems.
COB 3	To develop advanced skills in the petrographic characterization and nomenclature of

(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	sedimentary rocks.
COB 4	To evaluate the structural and tectonic controls on basin formation.
COB 5	To apply statistical tools in sedimentology.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Upon completion, students will be Analyse and quantitatively evaluate fluid flow mechanics, sediment transport processes and depositional structures.
CLO 2	Students will be able to Reconstruct past environmental conditions by synthesizing lithofacies models.
CLO 3	Students will be able to Systematically classify and name sedimentary rocks; interpret provenance, diagenetic history.
CLO 4	Students will be able to Evaluate the genetic relationship between tectonic settings and their sedimentary fills, utilizing various scientific modelling.
CLO 5	Students will be able to apply statistical methods in understanding sedimentary characters.

C.5 Syllabus — Unit-wise Breakdown

Course Name: SEDIMENTOLOGY & GEOSTATISTICS (MSCGEOL-CC202)		
Unit	**Content**	**Suggested Lectures hours**
I	▪ Sedimentary Processes- weathering, sediment transport and deposition, lithification and diagenesis. ▪ Concept of flow regimes and bedforms. Types of fluids, Laminar vs. Turbulent flow, Reynolds number, Froude Number, Particle entrainment, Sediment gravity flows, Hjulstrom diagram ▪ Sedimentary textures- grade scales, grain size, graphical representation and statistical analysis, sphericity, roundness, Porosity & Permeability.	10
II	▪ Classification of sedimentary rocks ▪ Clastic Sedimentary Rocks - origin and classification ▪ Non-clastic Sedimentary Rocks - origin and classification ▪ Sedimentary structures - Origin, types and geological significance. ▪ Paleocurrent analysis	12
III	▪ Environment of sedimentation: Parameters, Classification,	08

24/07/26

(Kalpana Srivastava)
Officer On Special Duty (Univ.)

	and Characteristics ▪ Sedimentary environments: terrestrial, coastal and marine ▪ Sedimentary facies: Orthoquartzite, Carbonate, Red Beds, Euxenic, Molasse, Flysch, and Sabkha facies.	
IV	▪ Heavy minerals- heavy minerals as indicators of provenance ▪ Tectonics and Sedimentation. ▪ Sedimentary basins and their classification ▪ Sedimentary basins of India	10
V	▪ Definition and scope of Statistics, Collection and classification of data, Frequency tables, Diagrammatic and Graphical representation of data. ▪ Measures of central tendency- mean, median, Mode, ▪ Measures of Coefficient of variation, Skewness. Kurtosis.	05
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

1. Blatt, H., Middleton, G., & Murray, R. (1980). Origin of Sedimentary Rocks (2nd ed.). Prentice-Hall.
2. Boggs, S. (2012). Principles of Sedimentology and Stratigraphy (5th ed.). Pearson.
3. Davis, J. C. (2002). Statistics and Data Analysis in Geology (3rd ed.). John Wiley & Sons.
4. Deutsch, C. V. (2002). Geostatistical Reservoir Modeling. Oxford University Press.
5. Journel, A. G., & Huijbregts, C. J. (1978). Mining Geostatistics. Academic Press

C.7 Reference Books & Readings

1. Krishnan, M. S. (1982). Geology of India and Burma.
2. Rao, D. P. (2015). Sedimentology: Concepts and Applications.
3. Rao, M. S. (2001). Geostatistics and Mineral Resource Evaluation.
4. Sahay, B. N. (2010). Statistics in Geology
5. Sengupta, S. M. (1997). Sedimentary Structures and Facies Analysis.
6. Tucker, M. E. (2001). Sedimentary Petrology: An Introduction to the Origin of Sedimentary Rocks.

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: Petrology, https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ce09]
- e-PG Pathshala: [Sedimentology and Stratigraphy, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000010ES/P001694/M020128/ET/1494494853021.N003.ES07-241Sedimentologyanoutline.pdf]
- SHODHGANGA / Shodhgangotri — for research thesis reference
- NDL India (National Digital Library): ndl.gov.in

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.3 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-CC203
Title of the Paper	Core Course III: [ECONOMIC GEOLOGY]
Programme / Subject	MSc — GEOLOGY
Semester	Semester II
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

KB 24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	—	**30**	**100**
Passing Marks	**32**	—	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	Provide a foundational understanding of the concepts, origins, and geological environments of mineral deposits.
COB 2	Detail the genetic origins, spatial distribution, and tectonic settings of major global and regional ore minerals.
COB 3	Demystify the principles of mineral economics, market dynamics, and national/international mining legislations.
COB 4	Train students to systematically differentiate and classify the nature, morphology, and characteristics of diverse mineral deposits.
COB 5	Enable students to critique and model the complex physical and chemical processes responsible for mineral deposit formation.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Identify, describe, and compare the geological environments, source rocks of essential deposits.
CLO 2	Analyze mining project feasibility using mineral economic indicators and evaluate operations for compliance with relevant environmental and mining legislations.
CLO 3	Synthesize geological, geochemical, and tectonic data to reconstruct the physical and chemical processes that formed a given mineral deposit.
CLO 4	Map the global distribution of major ore minerals and correlate their genetic origins with specific historical geologic periods

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

C.5 Syllabus — Unit-wise Breakdown

Course Name: ECONOMIC GEOLOGY (MSCGEOL-CC203)		
Unit	**Content**	**Suggested Lectures hours**
I	• Classification of mineral deposits • Processes of formation of mineral deposits – - Magmatic ore deposits - chromite deposits, Ni-Cu	10

	sulphide deposits, PGE sulphide deposits, rare-metal pegmatites and diamond deposits associated with kimberlites and lamproites. - Oxidation & Supergene enrichment deposits, Residual and Placer deposits. - Hydrothermal deposits	
II	• Controls of Ore Localisation • Formation, association and distribution of Essential, Critical and Strategic minerals. • Fluid inclusion and its application in Ore geology. • Metallogenic epochs & provinces with special reference to India.	07
III	• Plate tectonics and Metallogeny • Host rock lithology, mineralogy, tectonic setting and distribution of – Porphyry copper deposits, Volcanogenic Massive sulphide (VMS) deposits, BIF's, Skarn deposits • Occurrence, genesis, distribution in India and uses of – Iron, Copper, Lead-Zinc, Manganese, Chromite, Bauxite, Mica, Gold, Atomic minerals, Abrasive & Refractory minerals.	10
IV	• Coal: Origin, Classification and composition of coal; lithotype and micro-lithotype. • Maceral: physical chemical and optical properties; Coal Bed Methane (CBM) • Proximate and Ultimate analysis of Coal • Geological and geographical distribution of coal and lignite in India. • Petroleum: Origin, Migration and Accumulation • Hydrocarbon traps; structural, stratigraphic and combination. • Petroliferous basins of India	10
V	• Mineral economics: Concept and significance. • Mineral beneficiation & Ore-dressing; paragenesis & zoning • Environmental impacts of mineral resource exploitation. • National Mineral Policy: Conservation of minerals, export and imports, taxation and subsidies, pricing policy; UNFC classification.	8
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

24/07/26

(Kalpana Srivastava)
Officer on Special Duty (Edn.)

C.6 Prescribed Textbooks

1. Barnes, H.L., Geochemistry of Hydrothermal Ore Deposits, Pubs: John Wiley.
2. Chandra, D., Singh, R.M., Singh M.P., Text book of coal (Indian context), Pubs: Tara Book Agency, Varanasi.
3. Craig, J. R., and Vaughn, D.J., Ore microscopy and ore mineralogy.
4. Evans, A. M., Ore Geology and Industrial Minerals, Pubs: Blackwell.
5. Kula Misra, Understanding Mineral Deposits: Springer
6. Mukherjee, A., Ore Genesis - A Holistic Approach, Pubs: Allied Publisher.
7. Richard, H. Sillitoe (2024). Metallogeny and Mineral Exploration – Some Personal Reminiscences. Geochemical Perspectives
8. Ridley, J., Ore deposit geology, Pubs: Cambridge University Press.
9. Robb, L.J., Introduction to ore-forming processes, Blackwell Science Ltd.
10. Sawkins, F. J., Metal deposits in relation to plate tectonics, Pubs: Springer Science & Business Media.
11. Selley, R.C., Elements of petroleum geology, Pubs: Academic Press.

C.7 Reference Books & Readings

1. Bateman, Alan Mara, and Mead L. Jensen. Economic mineral deposits. Vol. 259, Pubs: Wiley.
2. McDonald, I., Boyce, A. J., Butler, I.B., Herrington, R. J. and Polys, D. A. (Eds), Mineral Deposits and Earth Evolution, Pubs: The Geological Society of London

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Relevant Course Name and Link]
- e-PG Pathshala: [Subject Portal Link]
- SHODHGANGA / Shodhgangotri — for research thesis reference
- NDL India (National Digital Library): ndl.gov.in
- Indian Bureau of Mines. ibm.gov.in

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-PC204
Title of the Paper	Practical Course: [PRACTICAL]
Programme / Subject	[MSc] — [Geology]
Semester	Semester II
Nature of Course	Practical Course (PC)
L – T – P	0 – 0 – 4
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	—	70	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	—	70	**30**	**100**
Passing Marks	—	**32**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To develop practical skills in the identification and petrographic analysis of igneous rocks, CIPW norm calculation, and REE data interpretation.
COB 2	Aims to develop practical skills in the identification and petrographic analysis of metamorphic rocks and the construction and interpretation of chemographic diagrams.
COB 3	To develop practical skills in the identification and petrographic analysis of sedimentary rocks, interpretation of sedimentary structures, and statistical analysis of grain-size data.
COB 4	Develop practical skills in the identification and optical characterization of ore minerals and in mapping the distribution of metallic and industrial mineral resources in India.

24/07/26

(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome

CLO 1	Upon completion, students will be able to identify and classify igneous rocks and apply CIPW norm and REE data analysis to interpret their petrogenesis and geochemical evolution.
CLO 2	Students will be able to apply identify and classify metamorphic rocks and apply ACF, AKF, and AFM chemographic diagrams to interpret metamorphic mineral assemblages and processes.
CLO 3	The students will be able to identify and classify sedimentary rocks, interpret sedimentary structures, and analyze grain-size data to infer depositional environments and sedimentary processes.
CLO 4	The students will be able to identify and characterize important ore minerals using hand specimens and ore microscopy, and prepare distribution maps of metallic and industrial minerals in India.

C.5 Syllabus — Unit-wise Breakdown

Course Name: PRACTICAL (MSCGEOL-PR204)		
Unit	**Content**	**Suggested Lectures hours**
I	**Igneous Petrology** ▪ Megascopic and microscopic study of igneous rocks. ▪ CIPW norm ▪ Plotting of REE data and their interpretation	15
II	**METAMORPHIC PETROLOGY** ▪ Megascopic and microscopic study of metamorphic rocks. ▪ Chemographic diagrams; Calculation of ACF, AKF and AFM values and their graphical representation.	15
III	**SEDIMENTOLOGVY & GEOSTATISTICS** ▪ Megascopic and microscopic study of sedimentary rocks. ▪ Study of sedimentary structures and their sedimentological significance. ▪ Graphical representation of size analysis and determination of statistical parameters	15
IV	**ECONOMIC GEOLOGY** ▪ Study of Ore minerals in hand specimen. ▪ Study of optical properties and identification of important ore minerals under ore-microscope ▪ Preparation of maps showing distribution of metallic and industrial minerals in India.	15
	Total Suggested Lectures	**60 (For 4 Credit Course)**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

24/07/26

(Kalpana Srivastava)

Officer-On-Special Duty (Judl.)

C.6 Prescribed Textbooks

1. Bose, M. K. (2001). Ore mineralization and metallogeny of the Indian Precambrian shield.
2. Folk, R. L., & Ward, W. C. (1957). Brazos River bar: A study in the significance of grain size parameters.
3. Fossen, H. (2010). Structural analysis and interpretation using stereographic projection techniques.
4. Miyashiro, A. (1974). Volcanic rock series in island arcs and active continental margins.
5. Passchier, C. W., & Trouw, R. A. J. (2005). Microtectonics and deformation mechanisms in rocks.
6. Sarkar, S. C., & Gupta, A. (2010). Crustal evolution and metallogeny in India.
7. Taylor, S. R., & McLennan, S. M. (1985). The continental crust: Its composition and evolution.
8. Yardley, B. W. D. (1977). An introduction to metamorphic facies and metamorphic processes.

C.7 Reference Books & Readings

1. Boggs, S. (2012). Principles of Sedimentology and Stratigraphy.
2. Compton, R. R. (1985). Geology in the Field.
3. Evans, A. M. (2013). Ore Geology and Industrial Minerals: An Introduction
4. Jensen, J. R. (2015). Introductory Digital Image Processing: A Remote Sensing Perspective.
5. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote Sensing and Image Interpretation.
6. Nesse, W. D. (2013). Introduction to Optical Mineralogy.
7. Perkins, D. (2011). Mineralogy.
8. Phillips, F. C. (1971). An Introduction to Crystallography.
9. Rowland, S. M., Duebendorfer, E. M., & Schiefelbein, I. M. (2012). Structural Analysis and Synthesis: A Laboratory Course in Structural Geology.
10. Shelley, D. (1993). Optical Mineralogy.
11. Winter, J. D. (2010). Principles of Igneous and Metamorphic Petrology.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL:
- e-PG Pathshala:
- SHODHGANGA / Shodhgangotri — for research thesis reference, https://shodhganga.inflibnet.ac.in/
- NDL India (National Digital Library): ndl.gov.in

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks

- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-GE205
Title of the Paper	Generic Elective: [ENVIRONMENTAL GEOLOGY]
Programme / Subject	[MSc] — [Geology]
Semester	Semester II
Nature of Course	Generic Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To provide students with a basic understanding of environmental geology, Earth system interactions, and biodiversity.
COB 2	To provide students with a basic understanding of Earth processes, natural hazards, and their environmental impacts.
COB 3	To provide students with a basic understanding of resource degradation, soil and water

24/07/26
(Kalpana S...)
Officer-On-Special Duty (Judl.)

	pollution, and environmental monitoring and treatment methods.
COB 4	To provide students with a basic understanding of air pollution, its sources, impacts, control measures, air quality standards, and the role of deforestation
COB 5	To provide students with a basic understanding of environmental management, climate change, environmental laws, and sustainable planning practices.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Upon completion, students will be able to explain Earth system interactions and the role of biodiversity in environmental sustainability.
CLO 2	Students will be able to assess natural hazards and evaluate their impacts on the environment and society.
CLO 3	Students will be able to assess soil and water pollution and apply environmental monitoring and management techniques for sustainable resource use.
CLO 4	Students will be able to assess air pollution sources and impacts and apply measures for air quality management and environmental conservation.
CLO 5	Students will be able to evaluate environmental issues and apply principles of environmental planning, impact assessment, and sustainable management.

C.5 Syllabus — Unit-wise Breakdown

Course Name: ENVIRONMENTAL GEOLOGY (MSCGEOL-GE205)		
Unit	**Content**	**Suggested Lectures hours**
I	▪ Concept and definition of Environmental Geology. ▪ Components of the Earth System and their mutual interrelations and interactions- Atmosphere, Hydrosphere, Lithosphere and Biosphere. ▪ Concept of biodiversity.	08
II	▪ Earth Processes, Natural Hazards and their mitigation ▪ Neotectonics and seismic hazard assessment ▪ Impact of seismic hazards on long and short-term environmental conditions. ▪ Environmental consequences of Landslides, Floods, Coastal hazards, Cyclones and Storms	08
III	▪ Changing land use pattern, Soil degradation ▪ Soil contamination due to Irrigation, Urbanization, Industrialization and Mining. Degradation of soil due to use of	09

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	fertilisers and pesticides. ▪ Water pollution: Geogenic contamination, contamination of surface water and groundwater due to Urbanization, Industrialization and Mining activities ▪ Major Water Pollutants, Environmental impact of radioactive waste disposal	
IV	▪ Air pollution: Introduction to Air Pollution, Natural and anthropogenic sources of air pollution, Air Pollutants, Urban Air Pollution, Air Quality Standards, Air pollution due to Mining activity	08
V	▪ Environmental management: Global Climatic Change, Anthropogenic influence on environment, Elements of environmental impact assessment ▪ Environmental Laws and legislations in India ▪ Environmental Protocols	12
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

- Keller, E. A. (2019). Introduction to Environmental Geology (6th ed.). Pearson.
- Montgomery, C. W. (2017). Environmental Geology (10th ed.). McGraw-Hill Education.
- Keller, E. A. (2012). Environmental Geology (9th ed.). Pearson.
- Skinner, B. J., Porter, S. C., & Botkin, D. B. (2001). The Blue Planet: An Introduction to Earth System Science (2nd ed.). John Wiley & Sons.
- Kump, L. R., Kasting, J. F., & Crane, R. G. (2010). The Earth System (3rd ed.). Pearson.
- Valdiya, K. S. (1987). Environmental Geology: Indian Context. Tata McGraw-Hill Publishing Company.
- Kumaraswamy, K., Kannan, K., & Thangarajan, M. (2018). Environmental Studies (2nd ed.). Bharathidasan University Publications.
- Singh, S. (2020). Environmental Geography (3rd ed.). Prayag Pustak Bhawan.
- Rana, S. V. S. (2008). Essentials of Ecology and Environmental Science (4th ed.). Prentice-Hall of India.
- Singh, V. P., & Singh, P. (Eds.). (2013). Environmental Geosciences. Springer India.

C.7 Reference Books & Readings

24/07/26

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Officer-On-Special Duty (Judl.)

- Maheshwari, B. L., Singh, V. P., & Thoradeniya, B. (Eds.). (2020). Balanced Urban Development: Options and Strategies for Liveable Cities. Springer.
- Singh, C. K., Shashtri, S., Mukherjee, S., Kumari, R., Avatar, R., & Singh, A. (2017). Application of groundwater quality indices and GIS for assessment of groundwater quality in the Indo-Gangetic alluvial plains, India. Environmental Monitoring and Assessment, 189(6), pp. 300–316.
- Mukherjee, A., Fryar, A. E., & Thomas, W. A. (2007). Major ion chemistry of the arsenic-affected groundwater of the western Bengal Basin, India. Applied Geochemistry, 22(4), pp. 863–894.
- Saha, D., & Ray, R. K. (2019). Groundwater arsenic contamination in the Middle Ganga Plain, India: Evolution and management. Current Science, 117(8), pp. 1271–1280.
- Raju, N. J. (2012). Hydrogeochemical processes and environmental implications of groundwater quality in India: An overview. Environmental Earth Sciences, 67(7), pp. 1917–1931.
- Tiwari, A. K., & Singh, A. K. (2014). Hydrogeochemical investigation and groundwater quality assessment for drinking purposes in a part of the Ganga alluvial plain, northern India. Journal of Earth System Science, 123(3), pp. 539–556.
- Ramakrishnan, P. S. (2001). Ecology and Sustainable Development. National Book Trust, India

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Environmental Geosciences, https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ce18],
  [Environmental Geology, https://onlinecourses.swayam2.ac.in/e-learning/preview/cec25_ce04]
- e-PG Pathshala: [Environmental Science, https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=0Xvq9yUM2ILDrJ07FvlArQ==]
- SHODHGANGA / Shodhgangotri — for research thesis reference, https://shodhganga.inflibnet.ac.in/
- NDL India (National Digital Library): ndl.gov.in

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSCGEOL-GE206
Title of the Paper	Generic Elective: [GEOHERITAGE & GEOTOURISM]
Programme / Subject	[MSc] — [Geology]
Semester	Semester II
Nature of Course	Generic Elective (GE)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRAC)
End Semester Examination	70	—	—	70
Practical / Lab Work	—	—	—	—
Internal Assessment	—	—	30	30
Maximum Marks	**70**	**—**	**30**	**100**
Passing Marks	**32**	**—**	**13**	**45 (45%)**

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

C.3 Course Objectives (COBs)

24/09/26

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COB No.	Course Objectives
COB 1	To provide students with a basic understanding of geodiversity, geoheritage, geoconservation, and the principles and significance of geotourism.
COB 2	To provide students with a basic understanding of geoheritage conservation, geoparks, legal frameworks, and their role in sustainable development.
COB 3	To provide students with a basic understanding of geoscience education, geotourism, and the role of Earth science museums in promoting geoheritage.
COB 4	To provide students with a basic understanding of sustainable geotourism, its socio-economic significance, and entrepreneurship opportunities in the tourism sector.
COB 5	To provide students with a basic understanding of geotourism, geoparks, and Indian geoheritage sites, and the use of GIS for assessing their socio-economic significance, with special reference to Bihar.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Upon completion, students will be able to explain the significance of geodiversity, geoheritage, and geoconservation and evaluate their role in sustainable geotourism.
CLO 2	Students will be able to identify and evaluate geoheritage sites and apply geo-conservation principles for sustainable development.
CLO 3	Students will be able to explain the role of geoscience education and Earth science museums in promoting geoheritage and sustainable geotourism.
CLO 4	Students will be able to evaluate the role of geotourism in sustainable development, cultural heritage conservation, and regional economic growth.
CLO 5	Students will be able to assess the geotourism potential and socio-economic significance of Indian geoheritage sites using GIS, with emphasis on GSI-developed geosites in Bihar.

C.5 Syllabus — Unit-wise Breakdown

Course Name: GEOHERITAGE & GEOTOURISM (MSCGEOL-GE206)		
Unit	**Content**	**Suggested Lectures hours**
I	▪ Introduction to Geology of India, Importance of geodiversity, geoheritage and geoconservation, Concept of geoheritage in relation to other historical heritages ▪ Geotourism: definition, characteristics and international/national perspectives, Eco-tourism and Geo-tourism ▪ Geodiversity, Geoheritage, Geoconservation and their relationship to geotourism.	08

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

	▪ Defining the geoheritage sites and the concept of Geoheritage parks (UNESCO guidelines). Geoheritage inventory of India and its curation context ▪ Legal framework of geoheritage, Role of locals, States and National Government, Threats to geodiversity and geological sites, Relevance of geoheritage to Sustainable Development Goals (SDG).	10
III	▪ Earth Science Education- Geoheritage and Geotourism, Opportunities for effective geoscience education in geotourism; ▪ Earth Science Museums and their role in promotion of Geotourism.	08
IV	▪ Geotourism, Society and Sustainability: Public–private partnership framework for sustainable geopark development. ▪ Geotourism—a focus on the urban environment including historical Geotourism, Geotourism and cultural heritage. ▪ Potential of Geotourism for economic development. Role of the geotourism sector in the Indian economy ▪ Role of Geotourism in the tourism industry with special reference to Bihar; Entrepreneurship and start-up in Geotourism	10
V	▪ Geotourism and geoparks: Geo sites developed by Geological Survey of India with special reference to Bihar ▪ The application of geographical information systems in geotourism ▪ Geotourism potential of the Indian geoheritage sites; societal and economic context	09
	Total Suggested Lectures	**45 (For 4 Credit Course)**
	Tutorial	**15**
	Total Suggested Contact Hours For Practical/Field Work Courses	**120 Hours/Semester**

C.6 Prescribed Textbooks

- Singh, V. P. (Ed.). (2021). Geoheritage and Geoparks in India. Springer Nature Singapore.
- Wadhawan, S. K. (Ed.). (2022). Geoheritage Sites of India. Geological Survey of India.
- Dowling, R., & Newsome, D. (2018). Handbook of Geotourism (2nd ed.). Edward Elgar Publishing.

24/07/26

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Dowling, R. K., & Newsome, D. (Eds.). (2006). Geotourism. Elsevier Butterworth-Heinemann.

- Newsome, D., & Dowling, R. (2010). Geotourism: The Tourism of Geology and Landscape. Goodfellow Publishers.
- Bhosekar, V. (2014). Geology of Maharashtra: Geological Landmarks and Heritage Sites. Geological Society of India.
- Wadhawan, S. K. (2021). Geoheritage and Potential Geotourism in Geoparks—Indian Perspective. In Global Geographical Heritage, Geoparks and Geotourism. Springer Nature.

C.7 Reference Books & Readings

- Tripathi, S. C., Pant, N. C., & Rajora, S. (Eds.). (2025). *Geoconservation and Geotourism Potential of India*. Springer.
- Brilha, J. (2016). Inventory and quantitative assessment of geosites and geodiversity sites: A review. Geoheritage, 8(2), pp. 119–134.
- Dowling, R. (2011). Geotourism's global growth. Geoheritage, 3(1), pp. 1–13.
- Newsome, D., & Dowling, R. (2018). Geoheritage and geotourism. Geoheritage, 10(3), pp. 305–306.
- Gordon, J. E. (2018). Geoheritage, geotourism and the cultural landscape: Enhancing the visitor experience and promoting geoconservation. Geoheritage, 10(2), pp. 191–203.
- Joyce, E. B. (2006). Geomorphological sites and the new geotourism in Australia. Geological Society of Australia Special Publication, 25, pp. 1–17.
- Prosser, C. D., Díaz-Martínez, E., & Larwood, J. G. (2011). The conservation of geosites: Principles and practice. Proceedings of the Geologists' Association, 122(3), pp. 337–342.

C.7 Suggested E-Resources / Digital Repositories

- SWAYAM / NPTEL: [Heritage Tourism, https://onlinecourses.swayam2.ac.in/e-learning/preview/nou26_ge54]
- e-PG Pathshala:
- SHODHGANGA / Shodhgangotri — for research thesis reference
- NDL India (National Digital Library): ndl.gov.in

C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

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Internal Assessment (20 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

24/07/26

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Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and*

Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

D PART D — GENERAL REGULATIONS & PROVISIONS

D.1 Attendance & Eligibility

- A student must have a minimum of 75% attendance in each paper to be eligible to appear in the Semester / Annual Examination.
- Condonation of attendance deficiency shall be governed by the Regulation..
- A student detained due to shortage of attendance may appear to the examinations of same semester in the next academic session subject to payment of prescribed fees.

D.2 Examination & Promotion Rules

- A student is required to clear **at least** 60% (4 out of 6) papers of a particular Semester before being promoted to the succeeding Semester.
- Back / Ex-Student candidates shall be governed by the rules in force at the time of their original admission unless otherwise specifically notified.
- A candidate who fails in one or more papers shall be required to appear only in the failed paper(s) (Carry Forward System) in subsequent examinations of the same Semester.
- A candidate is required to clear all his papers within a maximum of **Five Years of duration** to qualify for the degree.

D.3 Grading System (CBCS)

Letter Grade	% Range	Grade Point	Performance Description	Remarks
O	≥90-100	10	Outstanding	Pass
A+	≥80<90	9	Excellent	Pass
A	≥70<80	8	Very Good	Pass
B+	≥60<70	7	Good	Pass
B	≥55<60	6	Above Average	Pass
C	≥50<55	5	Average	Pass
P	≥45<50	4	Pass	Pass
F	<45	0	Fail	Fail
Ab/M	0	0	Absent/Malpractice	Fail / Reappear

24/07/26

(Kalpana Srivastava)

Officiating Registrar

E PART E — ABBREVIATIONS & AUTHENTICATION

E.1 List of Abbreviations

Abbr.	Expansion	Abbr.	Expansion
CC	Core Course	DSE	Discipline Specific Elective
GE	Generic Elective	OE	Open Elective
AEC	Ability Enhancement Course	VAC	Value Added Course
SEC	Skill Enhancement Course	IKS	Indian Knowledge System
L	Lecture (hours per week)	T	Tutorial (hours per week)
P	Practical (hours per week)	IA	Internal Assessment
CCA	Continuous & Comprehensive Assess.	CLO	Course Learning Outcome
PLO	Programme Learning Outcome	GA	Graduate Attribute
NHEQF	National HE Qualifications Framework	PROJ	Project / Dissertation

E.2 Authentication

16.6.26

Prof. Atul Aditya Pandey
Professor
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[Patna University, Patna]
Date: 16.6.26

16/6/26

Dr. Prahlad Kumar Arya
Assistant Professor
[Department of Geology]
Patna Science College, Patna
Date: 16/06/2026

Shekhar
Assistant Professor
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