COURSE CURRICULUM FOR M.SC. IN GEOLOGY

Syllabus for

2 year Master of Science

Under CBCS

DEPARTMENT OF GEOLOGY

Jagannath Barooah University

(Formerly Jagannath Barooah College)

(Approved by Board of Studies on 21 June 2025)

1. Objectives of the Course:

The Department of Geology at Jagannath Barooah College offers an M.Sc. in Geology program that is intended to provide a strong foundation and a more profound comprehension of the fundamental topics of geology. The course's main goal is to produce postgraduate students with expanded understanding of the foundational concepts of all geological fields as well as higher level critical, analytical, and problem-solving competencies. Additionally, by using and developing their capacity to think critically and independently on a specific earth science subject with current academic and/or industry significance, the applicants will be prepared to do both basic and/or applied research. Additionally, this program aims to develop effective personnel who can teach at both the undergraduate and post graduate levels.

2. Course pattern

The Course in M.Sc. Geology is based on Choice Based Credit System (CBCS)and consists of two major types of courses as mentioned below.

1. **Credit Course:** These are Core or Elective Courses that are registered by a student during a semester to be taken into account for the credits earned by him/ her. There are five components of this type of course.
    a. **Core Course:** Core courses shall consist of those courses which a candidate must complete as compulsory requirement for the M.Sc. in Geology programme. Core courses will consist of components like Theory, Practical and Projects.
    b. **Elective Course:** The course is also offered by the parent department. It provides choice and flexibility within the department to choose a particular area of Geology. The student can choose his/her elective paper subject to certain criteria. The department will offer various elective papers subject to the availability of sufficient infrastructure.
        i. Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
        ii. Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement/support study to a project work, and a candidate studies such a course on his own with advisory support by a teacher/faculty member is called dissertation/project.
        iii. Open / General Elective (OE/ GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called an Open Elective. A core course offered in a discipline/subject in the same stream may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as General Elective.
    c. **Ability Enhancement Courses (AEC):** The Ability Enhancement (AE) Courses are credit courses. This course is based upon the content that leads to knowledge enhancement.
2. **Audit Course:** A student may take some courses which he/she does not want to include in the list of courses that are to be considered for the credits earned by him/ her. Such courses are registered as Audit (non- credit) courses. The grades earned in the audit courses do not affect the performance score of the student.

STRUCTURES OF M.Sc. GEOLOGY PROGRAM, J.B. COLLEGE

Program offered by the Department: M. Sc. Geology.

Types of Course offered by the Department

1. Core Course
2. Electives Course
   a. Discipline Specific Elective (DSE)
   b. Generic Elective (GE)
   c. Dissertation
3. Ability Enhancement Course (AEC)
4. Audit (Optional)

Credit Distribution of different courses

Semester	Core	DSE/ Dissertation	GE	AEC	Total Credit per semester
1	4+4+4+4*+2**	4	4	-	26
2	4+4+4+4*	4	4	-	24
3	4+4+4+4*+4**	4	-	2	26
4	4+4+4*	4+ 4***	-	2	22
Total	**66**	**20**	**08**	**04**	**98**

Total Paper (Geology):
Theory (C) = 11
Theory (DSE) = 04
*Laboratory (C-PR) = 04
** Field School (Core) = 02
*** Dissertation = 01
Total Paper (GE): 02
Total Paper (AEC): 02

* Geology Laboratory-I, II, III & IV semester (One Lab paper per semester)
** Geological Field work- I & III semester
*** Dissertation – IV semester

SEMESTER WISE GEOLOGY COURSE STRUCTURE
Major/Open Elective/Audit Course

Papers						
Semester	**Electives**		**Generic Elective (3credits each)**	**Ability Enhancement Course (2creditseach)**	**Audit Course (2 credit optional)**	**Total Credit**
	CORE (4 credits each)	**Core/Discipline Specific Elective**				
I	Mineralogy and Geochemistry		GE-I		Soft Skills	26
	Igneous Petrology					
	Metamorphic Petrology					
	Structural Geology & Tectonics	DSE-I				
	Geology Laboratory-I					
	Field School-I					
II	Sedimentology & Principles of Stratigraphy		GE-II			24
	Advanced Paleontology					
	Indian Stratigraphy					
	Economic Geology	DSE-II				
	Geology Laboratory-II					
III	Hydrogeology					
	Climatology and Oceanography			AEC I (AECC): (Computer Programming in C++, Python or Fortran or Geostatistics) SWAYAM		26
	Geomorphology & Geoinformatics					
	Environmental Geology and Natural Hazard	DSE-III				
	Geology Laboratory-III					
	Field School-II (Industrial)					
IV	Engineering Geology					
	Mineral Exploration			AEC II (SEC): (Scientific and Technical Communication)		22
	Petroleum & Coal Geology	DSE-IV				
	Geology Laboratory-IV					
	Dissertation	DSE-V				
Total Credit	66	20	08	04		**98**

SEMESTER WISE GEOLOGY COURSE STRUCTURE- II
Major/Open Elective/Audit Course

Semester	Course	Course Code	Credit	Course Title	Course Type and Credit (Theory 3 + Practical 1)	Marks Distribution			
						TH	PR	IA	Total
1st	**Core & DSE Course**	GEOMC-101	4	Mineralogy and Geochemistry	Theory	60	-	40	100
		GEOMC-102	4	Igneous Petrology	Theory	60	-	40	100
		GEOMC-103	4	Metamorphic Petrology	Theory	60	-	40	100
		GEOMD-101	4	Structural Geology & Tectonics	Theory	60	-	40	100
		GEOML-101	4	Laboratory-I (101, 102, 103, 104)	Practical		60	40	100
		GEOMP-101	2	Field School-I	Practical	-	30	20	50
	Open Elective	GEOGE-101	4	GE-I Fundamentals of Earth System Science	Theory	60	-	40	100
	Audit Course	GEOMA-101	2	Soft Skills		30	-	20	50
		Total Credit	**26**						
2nd	**Core & DSE Course**	GEOMC-201	4	Sedimentology & Principles of Stratigraphy	Theory	60	-	40	100
		GEOMC-202	4	Advanced Paleontology	Theory	60	-	40	100
		GEOMC-203	4	Indian Stratigraphy	Theory	60	-	40	100
		GEOMD-201	4	Economic Geology	Theory	60	-	40	100
		GEOML-201	4	Laboratory-II (201, 202, 203, 204)	Practical		60	40	100
	Open Elective	GEOGE-201	4	GE-II Earth Resources	Theory	60	-	40	100
		Total Credit	**24**						
3rd	**Core & DSE Course**	GEOMC-301	4	Hydrogeology	Theory	60	-	40	100
		GEOMC-302	4	Climatology and Oceanography	Theory	60	-	40	100
		GEOMC-303	4	Geomorphology & Geoinformatics	Theory	60	-	40	100
		GEOMD-301	4	Environmental Geology	Theory	60	-	40	100

				and Natural Hazard					
		GEOML-301	4	Laboratory-III (301, 302, 303, 304)	Practical		60	40	100
		GEOMP-301	4	Field School-II (Industrial Field)	Practical	-	60	40	100
	AEC-I	GEOMS-301	2	Computer Programming in C++, Python or Fortran or Geostatistics (SWAYAM)	Practical	-	40	10	50
		Total Credit	**26**						
4th	**Core & DSE Course**	GEOMC-401	4	Engineering Geology	Theory	60	-	40	100
		GEOMC-402	4	Mineral Exploration	Theory	60	-	40	100
		GEOMD-401	4	Petroleum & Coal Geology	Theory	60	-	40	100
		GEOML-401	4	Laboratory-III (401, 402, 403, 404)	Practical	-	60	40	100
		GEOMP-401	4	Dissertation	Practical	-	60	40	100
	AEC-II	GEOMS-401	2	Scientific and Technical Communication	Theory	30	-	20	50
		Total Credit	**22**						

Syllabus for
M.Sc. in Geology
1st semester

COURSE TITLE: MINERALOGY AND GEOCHEMISTRY

Course Code: GEOMC-101

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	**Crystal structure of minerals** Concept of space lattice; Introduction to crystal chemistry; Bonding in Crystal structures, Close-packed structures-Hexagonalclose-packing, cubic close-packing and body centred structure with minerals examples; structures built from polyhedral; Transformation of minerals (polymorphism, polytypism, polysomatism). Solid solution and exsolution.	07	8
Unit 2	**Crystals structure of silicate minerals:** Silicates with isolated tetrahedra, Single chain silicates, Double chain silicates, the layer silicates, Bioppyriboles, the framework silicates.	10	10
Unit 3	**Mineral Physics & Optical Properties:** Electrical, magnetic, and advanced optical properties of minerals. Mineralogical spectroscopy (Optical classification of minerals, Isotropic materials, Anisotropic materials; Interference phenomena; Concept of Optical indicatrix). Determinative mineralogy of common rock-forming minerals: Mineral colour and pleochroism, Extinction angle and sign of elongation, Interference figures. Basics of diffraction and imaging: X-ray diffraction, Reciprocal lattice, Ewald's Sphere, Crystal field theory. Application of SEM, TEM and EPMA in mineral characterisation.	12	12
Unit 4	**Basics of Geochemistry:** Atomic structure and properties of elements, the Periodic Table. Cosmic abundance of elements; meteorites. Geochemical evolution of the Earth (crust and mantle differentiation). Geochemical cycles. Distribution of major, minor, and trace elements in crust and mantle. Equilibrium and distribution coefficients.	10	9
Unit 5	**Redox, Diffusion & Sensors:** Redox reactions and Eh-pH diagrams and their applications. Nucleation and diffusion processes in igneous, metamorphic and sedimentary environments. Mineral/mineral assemblages as "sensors" of ambient environments.	10	11
Unit 6	**Isotope Geochemistry:** Radioactive decay schemes and their application to geochronology and petrogenesis. Stable isotopes (Oxygen and Carbon) and their application to Earth system processes (e.g., paleoceanography/ paleoclimatology). Geochemistry of aerosols, surface, marine, and ground waters.	11	10

Reference Books:

1. Putnis A. Introduction to mineral Sciences, Cambridge publication,1992
2. Cornelis Klein and Barbara Dutrow, The manual of Mineral Science, Wiley Publication2007
3. Kerr P.F. Optical Mineralogy, 1959.McGraw-Hill.
4. VermaP.K., Opticalmineralogy, CRCpress2009
5. Nesse W.D., Introduction toOpticalmineralogy.2008, Oxford University Press.
6. Deer W. A., Howie.R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication I962-1963
7. Mishra, K. C. Introduction of Geochemistry: Principles and Applications. Blackwell Publications. 2012.
8. Walther, J. V. Elements of Geochemistry. J. B. Publishers, Inc. 2005.

COURSE TITLE: IGNEOUS PETROLOGY
Course Code: GEOMC-102
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Fundamentals of Thermodynamics:** First, second, and third laws of thermodynamics. Enthalpy, entropy, Gibbs Free Energy function, and their variation with temperature and pressure. Clausius-Clapeyron equation. Chemical potentials, fugacity, activity, and equilibrium constant. Silica activity, buffers, saturation; alumina saturation; Fe-Ti oxide buffers.	09	12
Unit 2	**Properties & classification of Magma** Nucleation, crystal growth, vesiculation, fragmentation of magma. Igneous rock series. Genesis of magmas (partial melting of mantle and crust). Physical properties of magma: Steady-state geotherms. Magma ascent and emplacement mechanisms. Chemical and mineralogical properties; Textures and structures of Igneous rocks. Classification of igneous rocks: CIPW, QAPF, IUGS classification, Suit Classification of igneous rocks	10	08
Unit 3	**Magmatic processes** Magma-mixing, mingling, and immiscibility. - Magmatic differentiation: fractional crystallization, assimilation. Phase equilibrium studies of simple binary and ternary systems (e.g., Di-An, Fo-SiO2, Ab-An-Or). Effect of volatiles on melt equilibria. Geobarometers and geothermometers.	08	08

Unit 4	**Mantle Dynamics** Analytical principles (XRF, ICP-MS, EPMA, SEM-EDS). Major and trace elements as monitors of partial melting and magma evolutionary processes. Stable and radiogenic isotope systems (K-Ar, Rb-Sr, U-Pb, Sm-Nd). Isochron techniques, model ages, and reservoir identification. Mantle Plumes, Hotspots & Large Igneous Provinces (LIPs): Their relation to global tectonics.	12	12
Unit 5	**Petrotectonic Associations** Igneous Petrology in Different Plate Tectonic Settings: -Mid-ocean ridges, subduction zones, continental rifts. Igneous Rocks of Oceanic Regions: - Oceanic spreading ridges and related basaltic rocks. - Mantle plumes and oceanic island volcanic rocks. - Plume heads and flood basalt plateau lavas. - Arc magmatism, oceanic island arcs. Other Associations: - Igneous rocks associated with convergent plate boundaries. - Continental flood basalt and large igneous provinces. - Large layered igneous complexes.	11	10
Unit 6	**Petrogenesis of Important Rock Suites** Petrogenetic aspects of important rock suites of India, such as the Deccan Traps, Abor volcanics, Sylhet Trap etc. Layered intrusive complexes (e.g., Stillwater, Bushveld). Petrogenetic aspects of felsic, intermediate, mafic, ultramafic rocks. - Alkaline rocks, Kimberlites, Charnokites, carbonatites and ophiolites.	10	10

Reference Books:

1. Shrivastava, J. P. 2009 Igneous Rocks National Science Digital Library, CSIR, New Delhi http://hdl.handle.net/123456789/1034
2. Cox, K. G., Bell, J. D. and Pankhurst, R. J. 1979 Interpretations of igneous rocks. George Allen and Unwin, London.
3. Wilson,M.1989 Igneous Petrogenesis. London Unwin Hyman.
4. Blatt,H.Tracy,R.J.andOwens,B.E.2006Petrology. W.H.FreemanandCompany.
5. Ragland,P.C.1989Basicanalytical Petrology.OxfordUniversityPress.
6. AnthonyR.PhilpottsandAgue,J.J.2009PrinciplesofIgneousandMetamorphicPet rology. Cambridge
7. Winter,J.D.2001Igneous andMetamorphicPetrology.PrenticeHall
8. Best,M.G.2013Igneous andMetamorphicPetrology. Wiley Blackwell
9. White,W.M.Isotope Geochemistry.WileyBlackwell
10. Faure,G.andMensing,T.M.2009Isotopeprinciples andApplications.
11. Rollinson, H. R. 1993 Using Geochemical Data: Evaluation, Presentation, Interpretation

COURSE TITLE: METAMORPHIC PETROLOGY

Course Code: GEOMC-103

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction to Metamorphism:** Definition and limits of metamorphism, Overview of different types of metamorphism (contact, regional, dynamic, burial, shock, hydrothermal); Factors controlling metamorphism, Heat flow, Minerals as pure and impure phases, Textures & Structures of metamorphic rocks (Foliation, lineation, schistosity, gneissosity. Granoblastic, poikiloblastic, porphyroblastic textures. Relict textures), Tectonic context of metamorphic transformations	10	08
Unit 2	**Rocks as chemical system**: intensive and extensive variables, closed and open systems, Gibbs phase rule and Goldschimdt's mineralogical phase rule, composition-space, Cartesian and Barycentric projections, Phase diagrams including pseudocomponent diagrams (ACF, AFM etc.), Tie-line flip and rotations, continuous and discontinuous reactions, exchange vectors, Clausius-Clayperon equation	9	08
Unit 3	**Zones and isograds:** Progressive metamorphism of atleast any two types of bulk compositions (from pelites, quartzfeldspathic rocks, mafic rocks, ultramafics or calcareous rocks) illustrating localized variation of bulk composition as well as that of the metamorphic path in evolution of mineral assemblages.	8	10
Unit 4	**Metamorphic facies:** Concept of metamorphic facies;combinatorial formula and Schreinemakers rules, Mineral formula calculation, Petrogenetic grid and pseudosections, Time scales of metamorphism, metasomatism, migmatites, Metamorphic field gradient and P-T-t paths.	10	11

Unit 5	**Mineral Reactions and Thermobarometry:** Mineral reactions with condensed phases, solid solutions, mixed volatile equilibria. Introduction to chemographic projections. Metamorphic differentiation. Principles of thermobarometry. Material transport during metamorphism. Role of bulk composition including fluids in metamorphism.	11	10
Unit 6	**Metamorphism and Plate Tectonics:** Relationships between plate tectonics and metamorphism, Prograde and retrograde metamorphism in plate boundaries, formation of different rock types and associated minerals: zeolite, greenstone, greenschist, hydrated minerals, glaucophane, blueschist and eclogite	12	13

Reference Books:

1. Bucher, K. and Grapes, R., 2010. Petrogenesis of Metamorphic Rocks, Springer.
2. Fry, N., 1985. Field Description of Metamorphic Rocks, New York, Geological Society of London Handbook Series.
3. Best, M.G., 2003. Igneous and Metamorphic Petrology, Blackwell Science.
4. Vernon, R. H., and Clarke G.L. 2008. Principles of Metamorphic Petrology, Cambridge University Press.
5. Winter, 1.D., 2001. An Introduction to Igneous and MetamorphicPetrology, Prentice Hall.
6. Yardley, B.W.D., 1997. An Introduction to Metamorphic Petrology, Longman Earth Science Series.
7. Spear, F.S., 1995, Metamorphic Phase Equilibria and Pressure-Temperature-Time paths, Mineralogical Society of America Monograph

COURSE TITLE: STRUCTURAL GEOLOGY AND TECTONICS

Course Code: GEOMD-101

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction to rock mechanics and rheology**: Concept of Stress and Strain, 2-D/3-D stress and strain analysis; Types of Strain ellipses and ellipsoid and their geological significance: L-, L-S-, and S-tectonic fabrics; Techniques of strain analysis (quantitative methods). Mohr diagrams and their use; Rheological behaviour of rocks under stress: elastic, plastic, viscous and visco- elastic responses and their geological significance. Mechanics of rock fracturing: fracture initiation and propagation; Coulomb's criterion and Griffith's theory.	10	12
Unit 2	**Analysis of geological structures–I: Ductile regime** *Fold:* Morphological classification of folds. Mechanical aspects of folding: buckling, bending, flexural slip and flow folding. Mechanics of single layer and multilayer buckling: Ptygmatic fold, cuspate-lobate fold, disharmonic and polyharmonic folds, kink fold. Fold interference and superposed folds. Strain distribution on folded layer and its significance. *Foliation and Lineation*: Different types of planar and linear structures in deformed rocks; Mechanism of cleavage formation; Axial plane cleavage and Transected cleavage. Kinematic significance of foliation and lineation. Importance of cleavage bedding intersection in a folded terrain. Use of stereographic projection for plotting linear and planar structures and their geologic applications.	10	12

Unit 3	**Analysis of geological structures–II: Brittle and brittle-ductile regime** *Fault:* Mechanics of faulting: Anderson's theory and its limitations. Complex geometry of normal, strike-slip and thrust faults with natural examples. Concept of fault zone weakening; fault reactivation and its significance. *Joints:* Geometric analyses of joints – Importance of Tectonic, Columnar and Release joints. Mechanical aspect of fracturing and joint formation. Joints with relation to folds and faults.	11	12
Unit 4	**Shear Zone** Shear zones-geometry and kinematics: Analysis of strain in shear zones; Kinematic significance of different shear zone structures; Shear sense indicators; Flow behaviour of sheared rocks – ductile and brittle-ductile shear zones. Large scale shear zones and their importance in continental crustal evolution. Fault/shear zone rocks: Cataclasite/Gouge/ Breccia, Mylonite, Pseudotachylyte.	9	12
Unit 5	**Large-scale deformation of the lithosphere** Driving mechanisms of plate motion, Mantle plumes; Brittle-plastic transition and seismic behavior of the continental and oceanic lithosphere. Plate convergence and continental deformation: transpressional and transtensional tectonics; Concept of subduction and orogeny - Indian and overseas examples.	10	10
Unit 6	**Orogenesis & Regional Tectonics** Relationship of plate tectonics with earthquakes, volcanism, and mountain building (e.g., Himalayan Orogeny). Concept of supercontinent cycles (assembly and breakup). Tectonic features of extensional, compressional, and strike-slip terrains.	10	8

References Book:

1. Bayly, B.,1992.Mechanics inStructural Geology,Springer.
2. Davis,GH.andReynolds,S.J.,1996.StructuralGeologyofrocksandregions,JohnWiley. and Sons. . .
3. Ghosh,S.K.,1993.StructuralGeology:Fundamentals,andmodern developments, Pergamon Press.
4. Leyson,P:R.andLisle,R.J.,1996.Stereographicprojectiontechniquesinstructural geology, Cambridge University Press.
5. Passhier,C.andTrouw,RAJ,2005.Microtectonics. Springer,Berlin.
6. Pollard, D.D. and Fletcher, R.C., 2005. Fundamentals of structural geology, CambridgeUniversity Press.
7. Ramsay,J.GandHuber,M.I.,1983.TechniquesofModernStructural Geology: Vol.I & 11. Academic Press
8. Ramsay,J.G,1967.Folding andFracturingofRocks, McGraw-Hill Book Company,New York .
9. Rowland,S.M.,Duebendorier,E.andSchiefelbein,I.M.,2007.Structuralanalysisand synthesis: a laboratory course in structural geology, Balckwell Pub.
10. Suppe, J.,ThePrinciplesofStructuralGeology,Prentice-Hall, Inc.,NewJersey, 1985.
11. Twiss,R.J.andMoores,E.M.,2007.Structural Geology. Freeman.
12. VanderPluijm,B.A.andMarshak,S.,2004.Earthstructure:anintroductiontostructural geology and tectonics, W.W.Norton&CompanyLtd.
13. Takawale,R.G.,andPuranik,P.S.,*IntroductiontoClassicalMechanics*, (Tata McGraw Hill)

COURSE TITLE: GEOLOGY LABORATORY – I
Course Code: GEOML-101
Credits: 4 (0 -Theory, 4 - Practical) **No. of Class hours: 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Unit	Topics	Teaching Hours	Allotted Marks
I	**Mineralogy and Geochemistry Lab:** Geochemical contour pattern and analysis; Physical properties identification of common minerals. Megascopic identification of important rock-forming minerals. Crystallography exercises (symmetry elements, forms). Introduction to polarizing microscope and basic optical properties. Study of XRD, XRF data; Study of SEM, TEM and EPMA images	30	20
II	**Igneous Petrology Lab:** Megascopic and microscopic identification of common igneous rocks. Classification based on texture and mineralogy. Interpreting cooling histories from textures. Plotting representative diagrams: Whole rock analysis of igneous rocks using XRF Norm calculations and application of GEOSOFTWARE. Mineral formulae calculations MELT programme Ar40-Ar39 age calculations using the ArArCALC software. Model age calculations	30	20
III	**Metamorphic Petrology Lab:** Megascopic and microscopic identification of common metamorphic rocks. Classification based on texture and mineralogy. Interpreting metamorphic histories from textures. Plotting representative diagrams; Study of Metamorphic grades and facies; Mapping of possible metamorphism in different tectonic domains.	30	20
IV	**Structural Geology Lab:** Interpretation of geological maps (cross-sections, identifying structures). Stereographic projections (plotting planar and linear features, analyzing fold axes and fault planes) and training to use specialized software. Analysis of stress and strain using models. Hand sample identification of various primary and secondary structures. Structural problems related to borehole data. Cross-section balancing.	30	20
Total		**120**	**80**

COURSE TITLE: FUNDAMENTALS OF EARTH SYSTEM SCIENCE

Course Code: GEOGE-101

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Holistic understanding of the planet Earth** Introduction to various branches of Earth Sciences and its relation to other branches of science. Origin of the Universe, Solar System and its planets. The terrestrial and jovian planets. Meteorites and Asteroids	10	08
Unit 2	**Earth and its Spheres** Earth in the solar system - size, shape, mass, density, rotational and revolution parameters, and its age. Geosphere (Atmosphere, Hydrosphere, Cryosphere, Lithosphere): Origin and composition, Biosphere: Components Pedosphere: Soil and soil profile	12	10
Unit 3	**Interior of the earth** Understanding the mechanical layering of the Earth through seismic waves. Formation and elemental composition of crust, mantle, and core Geomagnetism: Causes of Earth's magnetism, Earth's magnetic field- changes and effects	9	10
Unit 4	**Geodynamics** Heat-flow pattern in the Earth Concept of plate tectonics, sea-floor spreading, continental drift and isostasy. Geodynamic elements of Earth- mid oceanic ridges, trenches, transform faults and island arcs Origin of ocean basins, continents, mountains, and rift valleys Earthquake and earthquake belts Volcanoes- types, products, and their distribution. Introduction to Neotectonics and Landforms	9	12

Unit 5	**Understanding the past from stratigraphic records** Nature of stratigraphic records The concept of time in geological studies. Geologic Time and Standard Geological time scale. Uniformitarianism, catastrophism and neptunism.	10	10
Unit 6	**Geohazards** Dynamic Earth Process- Plate Tectonics Hazards, Risks & Disasters. Geo Hazards: Causes, effect and mitigation of earthquake, landslide, flood and bank erosion, Urban Floods Disaster Management.	10	10

Reference Books:

1. Klein, C., Dutrow, B., Dwight, J., & Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
2. Kerr, P. F. (1959). Optical Mineralogy. McGraw-Hill.
3. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
5. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
6. Rollinson, H. (2007) Using geochemical data – evaluation, presentation, and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
7. Walther, J. V. (2009). Essentials of geochemistry. Jones& Bartlett Publishers.
8. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
9. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
10. Shukla, A. C., &Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
11. Neser, Laura (2023): Introduction to Earth Science, Virginia Tech University

Syllabus for
M.Sc. in Geology
2nd semester

COURSE TITLE: SEDIMENTOLOGY & PRINCIPLES OF STRATIGRAPHY

Course Code: GEOMC-201

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Sedimentary Processes and Products:** Weathering and sedimentary flux, soils and paleosols Fluid flow and sediment transport. Types of fluids; Laminar vs. turbulent flow. Reynolds number, Froude Number, Boundary layer effect, Particle entrainment, transport and deposition, sediment gravity flows, Concept of flow regimes and bedforms.	08	08
Unit 2	**Sediment texture, Sedimentary structure and Paleocurrent:** Sedimentary texture: Grain size scale, particle size distribution, statistical treatment of particle size data, particle shape and fabric Sedimentary structures: Primary (Depositional, Erosional, Penecontemporaneous deformational) and secondary Paleocurrent analysis (Scalar and Vector attributes)	10	10
Unit 3	**Siliciclastic & Non-siliciclastic rocks:** Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification and origin and occurrence) Carbonate rocks: controls on carbonate deposition, Carbonate Mineralogy, Allochemical and Orthochemical components. Classification of limestone, Diagenesis of carbonate: Meteoric (Vadose, Phreatic) and Deep burial; Lithification Carbonate sedimentary environments: Chert and siliceous sediments; Phosphorites, Evaporites, Dolomite and dolomitisatiion.	12	12
Unit 4	**Sedimentary environment and basin analysis:** Concept of facies and facies association. Sedimentary Environment: Continental (Glacial, Fluvial, Eolian, Lacustrine), marginal marine (Delta, Estuary, tidal, Chenier) and marine (shelf, slope, deep marine); Lithification and diagenesis of siliciclastic rocks Sedimentary basins and their classification, Sedimentation in Intra- and Inter-plate basins. Basins in Orogenic belts. Plate tectonics and sedimentation.	10	10

Unit 5	**Stratigraphic Principles & Classification:** Basic principles of stratigraphy (superposition, original horizontality, lateral continuity, faunal succession, cross-cutting relationships). Recent developments in stratigraphic classification. Code of stratigraphic nomenclature (Stratotypes, GSSP). Lithostratigraphic, chronostratigraphic, biostratigraphic subdivisions.	10	10
Unit 6	**Stratigraphic Correlation & Sequence Stratigraphy:** Methods of stratigraphic correlation including Shaw's Graphic correlation. Concept of sequence stratigraphy: depositional sequences, systems tracts, applications. Rates of sediment accumulation, unconformities. Facies concept in Stratigraphy: Walther's law.	10	10

Reference Books:

1. Allen, P.A., 1997. Earth Surface Processes, Blackwell publishing.
2. Collinson, J.D. and Thompson, D.B., 1988. Sedimentary Structures, Unwin- Hyman, London.
3. Hsu, K.J., 2004. Physics of Sedimentology, Springer Verlag, Berlin.
4. Leeder, M.R., 1982. Sedimentology: Process and Product. George Alien&Unwin, London, 344p.
5. Lindholm, R.C., 1987. A Practical Approach to Sedimentologv, AllcnaneUnwin, London.
6. Pettijohn, F.J., 1975. Sedimentary Rocks, Harper and Row Publ. New Delhi.
7. Prothoreo and Schwab, 2004. Sedimentary Geology, Freernam and <. I)New York, 557p
8. Miall, A.D., 1999. Principles of Sedimentary Basin Analysis 3rdFdSpringer Verlag, New York.
9. Nichols, G., 1999. Sedimentology and Stratigraphy, Blackwell publishing.
10. Sam Boggs, 1995. Principles ofSedimentology and Stratigraphy, Print iceHall, New Jersey.
11. Tucker, M.E., 2006. Sedimentary Petrology. Blackwell Publishing.
12. James, N.P and Jones, B., 2016 Origin of carbonate sedimentary rocks. Wiley

COURSE TITLE: ADVANCED PALEONTOLOGY

Course Code: GEOMC-202

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction & Evolutionary Concepts:** Theories on origin of life. Organic evolution (Punctuated Equilibrium and Phyletic Gradualism models). Mass extinctions and their causes. Taphonomy: processes of fossilization, modes of preservation.	10	10
Unit 2	**Systematics & Invertebrate Fossils:** Taxonomy. Diversity of life through time. Morphology and functional morphology of important invertebrate fossils (e.g., Bivalves, Brachiopods, Gastropods, Echinoids, Ammonoids).	10	12
Unit 3	**Microfossils, Vertebrates & Paleobotany:** Types of microfossils (e.g., Foraminifera, Ostracoda, Conodonts, Bryozoa). Vertebrate paleontology (e.g., Equus, Proboscidea, Human evolution - brief). Paleobotany (plant fossils, spores, pollens).	12	12
Unit 4	**Isotope Paleontology in Indian Context:** Oxygen and Carbon isotope studies of microfossils and their use in paleoceanographic and paleoclimatic interpretation. Important invertebrate, vertebrate, plant fossils and microfossils in Indian stratigraphy.	11	10
Unit 5	**Applications of Paleontology:** Application of fossils in age determination and correlation. Use of microfossils in interpretation of sea-floor tectonism. Application of micropaleontology in hydrocarbon exploration.	8	08
Unit 6	**Paleoecology & Paleobiogeography:** Basic concepts of ecology/paleoecology; Life habitats and various ecosystems. Paleobiogeography. Environmental significance of fossils and trace fossils. Ordovician-Devonian, Permian-Jurassic, Triassic-Jurassic and cretaceous-Paleogene extinction events.	09	08

Reference Books:

1. Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell. Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London. Dobzhansky, Ayala, Stebbins and Valentine (1977): Evolution, Freeman.

2. Horowitz, A.S. and Potter, E.D. (1971): Introductory Petrography of Fossils, Springer Verlag. Mayr, E. (1971): Population, Species and Evolution, Harvard.

Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill. Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology CBS Publ.

3. Smith, A.B. (1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell. Strean, C.W. and Carroll, R.L. (1989): Paleontology – the record of life, John Wiley.

COURSE TITLE: INDIAN STRATIGRAPHY

Course Code: GEOMC-203

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Precambrian stratigraphy and its subdivisions.** Plate tectonics during the Precambrian. Tectonostratigraphic framework of Dharwar craton, an overview of Bastar, Singhbhum, Bundelkhand and Aravalli cratons, Eastern Ghat mobile belt, Central Indian Tectonic Zone; Proterozoic sedimentary basins of India; Precambrian biota and its stratigraphic significance.	12	08
Unit 2	**Phanerozoic stratigraphy:** Major plate movements during Phanerozoic. Subdivisions of Phanerozoic up to Stage level. Stratigraphic framework of Marine Palaeozoic rocks of Himalaya with special reference to Kashmir, Spiti, Kumaon and their correlatives in Salt Range and peninsular India. Criteria for recognising major stratigraphic boundaries of Phanerozoic and their GSSPs. Permianl-Triassic boundary sections of India	10	10
Unit 3	**Mesozoic stratigraphy:** Marine Mesozoic Rocks of the Himalaya; Gondwana Supergroup of rocks, its fauna and flora, depositional history, economic importance and climate; Jurassic sedimentary basins of Kachchh and Jaisalmer; Cretaceous stratigraphy of the Cauvery Basin and Narmada Valley; Deccan Volcanic Province; Cretaceous-Palaeogene boundary sections of India.	8	12
Unit 4	**Tertiary Stratigraphy:** Palaeogene stratigraphy of Kachchh. Stratigraphy of the Himalayan foreland basin (Subathu, Murree/Dagshai-Kasauli , Siwalik) and recent advances. Indus Basin sediments of the Indus Tsangpo Suture Zone. Quaternary deposits of Andaman Islands, continental Quaternary deposits and their significance. Tertiary of Assam-arakan basin.	12	12

Unit 5	**Quaternary Geology of India:** Definition of Quaternary. Quaternary Stratigraphy (Oxygen Isotope stratigraphy, biostratigraphy, magnetostratigraphy). Quaternary climates (glacial-interglacial cycles, eustatic changes, proxy indicators). Quaternary dating methods.	08	10
Unit 6	**Quaternary stratigraphy of India**: continental & marine records; continental-marine correlation. Evolution of man, Stone Age cultures, plant and animal life in relation to glacial and interglacial cycles during Quaternary in India.	10	08

Reference Books:

1. Doyle, P. and Bennett, M.R., 1996. Unlocking the Stratigraphic Record, John Willey.
2. Dunbar, C.O. and Rodgers, J., 1957. Principles of Stratigraphy. John Wiley & Sons.
3. Krishnan, M.S., 1982. Geology of India and Burma, C.B.S. Publishers, Delhi
4. Naqvi, S.M. 2005. Geology and Evolution of the Indian Plate: From Hadean to Holocene- 4 Ga to 4 Ka.
5. Capital Pub., New Delhi.
6. Pascoe, E.H., 1968. A Manual of the Geology of India & Burma (Vols.IN), Govt. of India Press, Delhi.
7. Pomerol, C., 1982. The Cenozoic Era - Tertiary and Quaternary. Ellis Harwood Ltd., Halsted Press.
8. Schoch, R.M., 1989. Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
9. R. Vaidyanathan & M. Ramakrishnan, 2008. Geology of India, Geological Society of India.

COURSE TITLE: ECONOMIC GEOLOGY

Course Code: GEOMD-201

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction to Ore Geology:** History and scope of ore geology; distribution, morphology and disposition of ore bodies; classification of ore minerals and industrial ores; physical and optical properties of ore minerals.	06	08
Unit 2	**Magmatic Ore Deposits:** Petrological and geochemical background to ore formation; role of element partitioning in magmatic systems; ore formation in relation to partial melting, differentiation, melt immiscibility, extreme melt fractionation and melt assimilation; general characteristics and genesis of magmatic ore deposits - LREE ores in carbonatites, chromite deposits, base-metal Ni-Cu sulfide deposits, PGE sulfide deposits, rare-metal pegmatites and diamond deposits associated with kimberlites and lamproites	10	10
Unit 3	**Hydrothermal Ore Deposits:** Basic concepts related to hydrothermal ore formation - Role of physical and chemical environment on metal complexing, transport and deposition; General characteristics and genesis of hydrothermal ore deposits - Porphyry deposits; greisens and related ore deposits; skarn and carbonate- replacement deposits; epithermal deposits; volcanic- hosted massive sulfide deposits; orogenic gold deposits; carlin-type deposits; iron oxide-copper-gold (IOCG) deposits; Mississippi Valley-type (MVT) Pb- Zn deposits; SEDEX Pb-Zn-Ag deposits; Kuperschiefer or red-bed copper deposits and various type of uranium deposits (unconformity- related, tabular-shaped, roll-front type and shear zone-hosted).	14	12

Unit 4	**Ore deposits Formed by Chemical and Clastic Sedimentary Processes:** Ore deposits formed by chemical precipitation from surface waters (hydrogene deposits) and clastic sedimentation - Iron ores in ironstones; sedimentary-rock-hosted Mn and P deposits; coastal heavy mineral sand deposits; and fluvial placer (and paleoplacer) deposits. Ore deposits formed by supergene processes - In-situ supergene; ores and formation of lateritic bauxite and Ni-Co deposits; overprinting of hypogene ores and formation of supergene gold (in lateritic weathering) and copper (in arid and semi-arid climates) ores.	12	12
Unit 5	**Mineral Economics:** Importance of minerals in national economy; concepts of strategic minerals and their supplies in time of peace and war material in various important industries; problem relating to their marketing; developing substitute to cover internal shortage, production cost & its relation to mineral in short supply; internal controls (monopolies and cartel), trade restriction and production incentives; concession rules, world resources and production of important minerals; classification schemes of mineral deposits: UNFC, JORC; MMDR, NMET, DMF	10	10
Unit 6	**Nuclear, Non-conventional & Marine Resources:** Nuclear energy resources (Uranium, Thorium deposits). Non-conventional energy resources. Marine mineral resources (e.g., Manganese nodules, phosphorites). Impact of atomic energy over conventional fuels; conservation of non renewable & associated renewable resources.	08	08

Reference Books:

1. Ridley, John. (2013). Ore deposit geology. Cambridge University Press.
2. Barnes, H.L., 1979. Geochemistry of Hydrothermal Ore Deposits, John Wiley.
3. Mookherjee, A, 2000. Ore Genesis - A Holistic Approach. Allied Publisher.
4. Craig, J. R., and D. J. Vaughn. "Ore microscopy and ore mineralogy." (1994).
5. Pracejus, Bernhard. The ore minerals under the microscope: an optical guide. Vol. 3. Elsevier, 2015.
6. Bateman, Alan Mara, and Mead L. Jensen. Economic mineral deposits. Vol. 259. New York: Wiley, 1950.

GEOLOGY LABORATORY- II
Course: GEOML-201
Credits: 4 (0 -Theory, 4 - Practical) **No. of Class hours: 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Unit	Topics	Teaching Hours	Allotted Marks
I	**Sedimentology Lab:** Identification of sedimentary textures and structures in hand samples/cores. Grain size analysis. Description and interpretation of sedimentary facies. Microscopic study of sedimentary rock thin sections. Study of sedimentary structures and features and their use in basin analysis. Sedimentary analysis in tectonic domains	30	20
II	**Paleontology Lab:** Megascopic identification and description of major invertebrate fossil groups. Introduction to microfossil slides. Study of an assorted group of trace fossils; Study of ammonoid suture pattern, coiling, whorl section and ontogenic variation; Measurements of dimensional parameters and preparation of elementary bivariate growth curves and scatter plots. Interpreting paleoenvironments from fossil assemblages.	30	20
III	**Stratigraphy Lab:** Interpretation of stratigraphic columns and correlation**.** Study of stratigraphic columns from key Indian basins. Identification of key index fossils and use of them in Stratigraphic correlation in India.	30	20
IV	**Economic Geology Lab:** Megascopic identification of Ores; Study of microscopic properties of ore forming minerals (Oxides and sulphides); Preparation of maps: Distribution of important ores and other economic minerals in India.	30	20
Total		**120**	**80**

COURSE TITLE: EARTH RESOURCES

Course Code: GEOGE-201

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction:** Earth Resources, Resource reserve definitions; mineral, energy and water resources in industries. Historical perspective and present. A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies	08	08
Unit 2	**Ore processes:** Ore and gangue minerals; Grade and tenor of ore Ore forming processes: Endogenous processes- Magmatic concentration, skarns, and hydrothermal deposits; Exogenous processes- weathering products and residual deposits, oxidation and supergene enrichment, placer deposits.	10	12
Unit 3	**Energy and Environment:** Definition of Energy: Primary and Secondary Energy Difference between Energy, Power and Electricity Renewable and Non-Renewable Sources of Energy. The concept and significance of Renewability: Social, Economic, Political and Environmental Dimension of Energy.	10	10
Unit 4	**Energy Resources:** Major Types and Sources of Energy, Resources of Natural Oil and Gas. Coal and Nuclear Minerals. Potential of Hydroelectric Power, Solar Energy, Wind, Wave and Biomass Based power and Energy	12	12
Unit 5	**Energy Sources and Power Generation:** Nuclear, Hydroelectric, Solar, Wind and Wave- General Principles. Ground water resources and its role in economic development of a country Current Scenario and Future Prospects of Solar Power, Hydrogen Power and Fuel Cells.	10	10
Unit 6	**Sustainable Resource Management & Environmental Governance:** Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA): Process, methodologies, and challenges; Role of critical minerals in energy transition technologies. Policies promoting low-carbon resource pathways.	08	08

Syllabus for
M.Sc. in Geology
3rd semester

COURSE TITLE: HYDROGEOLOGY

Course Code: GEOMC-301

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction to Hydrogeology:** Water on earth. Types of water: meteoric, juvenile, magmatic and sea waters. Hydrologic cycle. Concept of hydrograph. Vertical distribution of water: zone of aeration and zone of saturation. Concept of depth to water level and water table contour maps. Concepts of drainage basin and groundwater basin. Rock properties affecting groundwater.	12	08
Unit 2	**Aquifers & Hydraulic Properties:** Aquifers and their types (unconfined, confined, leaky, perched), Water table and piezometric surface. Water bearing properties of rocks and aquifer parameters: porosity, permeability, specific yield, specific retention, hydraulic conductivity, transmissivity, intrinsic permeability, storage coefficient, storativity, specific storage. Anisotropy and heterogeneity of aquifers. Fluctuations of water table and piezometric surface; Barometric and tidal efficiencies. Geologic and geomorphic controls on groundwater. Hydrostratigraphic units. Springs. Introduction to hydrogeology of India and the groundwater provinces of India.	12	12
Unit 3	**Groundwater Flow Dynamics and well hydraulics:** Basic Principles of Groundwater Flow: Darcy's Law and its applications, validity, limitations. Laminar and turbulent groundwater flow. Groundwater flow rates and flow direction. Types of wells, drilling methods, construction, design, development, maintenance and revitalization of wells. Specific capacity and its determination. Basic concepts of well hydraulics: drawdown; specific capacity etc. Equilibrium and non-equilibrium conditions for water flow to a well in confined and unconfined aquifers. Theory of Groundwater Flow & Numerical Solutions (Steady State): Numerical solutions for steady state linear groundwater flow in confined and unconfined aquifers. Dupuit's assumption for unconfined flow. Numerical solutions for steady state radial flow to a well in confined (Thiem's equation) and unconfined aquifers (Dupuit's equation). Unsteady State Flow & Permeability Estimation: Numerical solutions for unsteady state groundwater flow condition. Methods of permeability estimation in laboratory and field. Evaluation of aquifer parameters of confined aquifer using Theis and Jacob methods.	12	12

Unit 4	**Groundwater Exploration** Groundwater Exploration Methods: Geological, lithological, structural, and hydrogeomorphic mapping. Fracture trace analysis, lineament mapping, Remote sensing as a tool in groundwater exploration. Geophysical Methods: Surface-based geophysical methods (seismic, gravity, electrical resistivity, and magnetic). Subsurface geophysical methods (borehole logging methods).	07	10
Unit 5	**Groundwater Development & Management** Concept of groundwater resource development & management. Surface and subsurface water interaction. Groundwater level fluctuations. Basic concepts of water balance studies, issues related to groundwater resources development and management (Principles of sustainable groundwater development and management). Rainwater harvesting and artificial recharge of groundwater.	07	10
Unit 6	**Groundwater Pollution & Contamination** Groundwater Quality and Standards, Concept of Groundwater Pollution and Contamination. Source and types of contamination (industrial, agricultural, domestic). Contaminant transport in groundwater. Remediation techniques. Groundwater pollution: arsenic, fluoride, and nitrate. Sea water intrusion in coastal aquifers and their remedial measures. Case Studies: Case studies on arsenic pollution of Gangetic-Brahmaputra plains. Global Groundwater Systems: Groundwater provinces in India, Aquifer systems around the world.	10	08

Reference Books:

1. Davies, S.N. and De-West, R.J.N., 1966. Hydrogeology, John Wiley & Sons, New York.
2. Driscoll, F.G., 1988. Ground Water and Wells, UOP, Johnson, Div. St. Paul. Min. USA.
3. Fetter, C.W., 1984. Applied Hydrogeology, McGraw-Hill Book Co., New York.
4. Fitts, C.R., 2006. Groundwater Science, Academic Press.
5. Freeze, R.A. and Cherry, J.A., 1979. Groundwater, Englewood Cliffs, New Jersey: Prentice-Hall.
6. Karanth K.R., 1987. Groundwater: Assessment, Development and Management, Tata McGraw-Hill Pub. Co. Ltd.
7. Raghunath, H.M., 1987. Ground Water, Wiley Eastern Ltd., Calcutta.
8. Schward and Zhang, 2003. Fundamentals of Groundwater, John Willey and Sons.
9. Todd, D.K., 2004. Ground Water Hydrology, John Wiley & Sons, New York.

COURSE TITLE: CLIMATOLOGY AND OCEANOGRAPHY

Course Code: GEOMC-302

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Fundamentals of Oceans and Atmosphere** Hypsography: Continental shelf, slope, rise, and abyssal plains. Seawater Properties: Physical and chemical characteristics, spatial variations, and residence times of elements. Ocean Dynamics: Ocean currents, waves, and tides; important current systems, thermohaline circulation, and the oceanic conveyor belt. Water Masses: Major water masses of the world's oceans. Fluid Motion: Waves in atmospheric and oceanic systems. Atmospheric Structure: Structure and chemical composition of the atmosphere, lapse rate, stability, and scale height. Greenhouse Effect: Greenhouse gases and global warming. Cloud Formation: Cloud formation and precipitation processes.	12	10
Unit 2	**Ocean-Atmosphere Interactions and Global Circulation:** Scales of Interaction: Air-sea interactions on different space and time scales. Energy Balance: Insolation, heat budget, and radiation balance. General Circulation: General circulation of the atmosphere and ocean. Climatic and Sea Level Changes: Changes on different time scales. Coupled Ocean-Atmosphere System: El Nino Southern Oscillation (ENSO). Indian Weather Systems: General weather systems of India, Monsoon system, cyclone and jet stream, Western disturbances, and severe local convective systems, distribution of precipitation over India.	12	12
Unit 3	**Physical Oceanography: Dynamics and Processes** Ocean Water Characteristics and Mixing; T-S Diagrams: Understanding temperature-salinity relationships. Mixing Processes: Processes in the oceans and characteristics of important water masses. Waves and Tides: Wind-Generated Waves: shallow and deep water waves. Wave Propagation, refraction, reflection, wave spectrum, and principles of wave forecasting. Tides: Tide-producing forces, magnitudes, prediction by harmonic method, and tides/tidal currents in various water bodies.	14	12

Unit 4	**Ocean Cycles:** Global Conveyor Belt: Characteristics and causes of the global conveyor belt circulation. Major Current Systems: Subtropical gyres, western boundary currents, equatorial current systems, monsoonal winds and currents over the North Indian Ocean, Somali current, and Southern Ocean. Arabian Sea Upwelling: Upwelling process in the Arabian Sea.	08	10
Unit 5	**Marine Ecosystems:** Marine Productivity and Food Webs; Production: Primary and secondary production. Plankton Dynamics: Factors controlling phytoplankton and zooplankton abundance and diversity. Nekton and Benthos: Nekton and fisheries oceanography, benthic organisms; Energy Flow: Energy flow and mineral cycling, energy transfer and transfer efficiencies through different trophic levels, food webs including the microbial loop.	07	08
Unit 6	**Climate Change and Paleoceanographic Reconstruction:** Global Warming: Revisit greenhouse gases and global warming; Human Impacts: Impacts of climate change on marine biodiversity. Various proxy indicators for paleoceanographic interpretation. Reconstruction of monsoon variability using marine proxy records. Sea level processes and sea level changes; Methods of paleo Sea Surface Temperature quantifications.	07	08

Reference books:

1. Climate Change 2021 – The Physical Science Basis: by the Intergovernmental Panel on Climate Change (IPCC): This is a key report summarizing the physical science of climate change.
2. Climatology: by Savindra Singh: A comprehensive textbook on the subject.
3. General Climatology: by D.S. Lal: Another well-regarded textbook.
4. Climatology by Dr D S Lal: A popular book for understanding climate.
5. Climatology & Oceanography: by D.S. Lal,.
6. Elements of Climatology and Oceanography: by Dr. BR Ambedkar Open University.
7. International Journal of Climatology A journal publishing research in the field.
8. On Fire: The (Burning) Case for a Green New Deal: by Naomi Klein: Explores the urgency of climate action.
9. Interacting Climates of Ocean Basins: by Carlos R. Mechoso.

COURSE TITLE: GEOMORPHOLOGY & GEOINFORMATICS

Course Code: GEOMC-303

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Geomorphology Concepts & Processes:** Concepts in geomorphology (historical, process). Landforms in relation to climate, rock type, structure, and tectonics. Geomorphic processes: weathering (physical, chemical, biological), pedogenesis (soil formation), mass movement (landslides, creeps, flows), erosion, transportation, and deposition.	10	06
Unit 2	**Fluvial & Aeolian Geomorphology:** River forms and processes (stream flow, hydrographs, flood frequency analysis). Fluvial landforms. Eolian processes and landforms (dunes, loess). Submarine relief.	10	14
Unit 3	**Glacial, Coastal & Karst Geomorphology:** Glacial geomorphic processes and landforms (moraines, cirques, valleys). Coastal geomorphic processes and landforms (beaches, deltas, cliffs). Karst geomorphic processes and landforms (caves, sinkholes).	10	12
Unit 4	**Remote Sensing Principles:** Elements of photogrammetry, elements of photo-interpretation. Electromagnetic spectrum: emission range, interaction of energy with Earth's surface (spectral signatures). Sensors and platforms. Multispectral remote sensing in visible, infrared, thermal IR, and microwave regions. Digital processing of satellite images (image enhancement, classification, rectification).	10	13
Unit 5	**GIS & GPS Principles:** Basic concepts of GIS. Data structures: raster and vector data models. Attribute data. Thematic layers and overlay analysis. Query analysis. Global Positioning Systems (GPS): principles and applications.	10	07
Unit 6	**Geoinformatics Applications:** Geomorphic analysis and topographic analysis including DEM (Digital Elevation Models). Tectonic geomorphology, neotectonics, active tectonics, and their applications to natural hazard assessment. Environmental change: causes, effects on processes and landforms.	10	08

Reference books:

1. Principles of Geomorphology by William David Thornbury:
2. Geomorphology by Savindra Singh:.
3. Fundamentals of Geomorphology by Richard J. Huggett:
4. Geomorphology by Savindra Singh:.
5. Geomorphology: The Mechanics and Chemistry of Landscapes by Robert S. Anderson.
6. Remote Sensing in Geomorphology: by H. Th. Verstappen.
7. Remote Sensing in Geology and Geomorphology: by S.K. Singh

COURSE TITLE: ENVIRONMENTAL GEOLOGY AND NATURAL HAZARD

Course Code: GEOMD-301

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Environmental Geology Concepts:** Man-land relationship. Ecology and biodiversity. Resources: renewable and non-renewable (exploitation and conservation of mineral and other natural resources). Impact of use of energy and land on the environment.	10	08
Unit 2	**Environmental Pollution & Degradation:** Environmental pollution and deterioration (marine and atmospheric pollution, ozone depletion). Waste management (brief overview).	10	12
Unit 3	**Earthquake & Volcanic Hazards:** Natural hazards: causes, characteristics, and mitigation strategies for earthquakes (causes, measurement, seismotectonics, seismic hazards, seismic design of buildings). Volcanic eruptions.	10	12
Unit 4	**Mass Movements & Hydrological Hazards:** Landslides and mass movements: causes of hillslope instability, types of mass movements, analysis of slope stability. Floods: flood frequency analysis, flood management. Droughts. Cyclones.	10	12
Unit 5	**Tsunamis & Coastal Hazards:** Tsunamis: generation, propagation, and impact. Coastal hazards. Mitigation strategies for coastal erosion.	10	08
Unit 6	**Applied Environmental Geology:** Geological factors in the construction of engineering structures (overlap with Engineering Geology). Tectonic geomorphology, neotectonics, and active tectonics applications to natural hazard assessment. Principles of climate change.	10	08

Reference books:

1. Environmental Geology: by Edward A. Keller
2. Environmental Geology: An Earth Systems Approach: by Dorothy Merritts, Kirsten Menking, and Andrew De Wet
3. Introduction to Environmental Geology: by Edward A. Keller
4. Environmental Hazards by Keith Smith
5. The Himalaya Dilemma: Navigating Risk, Vulnerability and Resilience in Geohazard-Prone Regions edited by Sandipan Ghosh

COURSE TITLE: GEOLOGY LABORATORY III
Course Code: GEOML-301
Credits: 4 (0 -Theory, 4 - Practical) **No. of Class hours:120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Unit	Topics	Teaching Hours	Allotted Marks
I	**Hydrogeology Lab:** Hydrologic Cycle and Water Balance: Calculating water balance components for a given watershed using precipitation, evaporation, and runoff data. Interpreting hydrographs and understanding streamflow characteristics. Determining porosity and hydraulic conductivity of various geological materials (sand, gravel, clay) using laboratory methods (e.g., constant head and falling head permeameters). Investigating groundwater flow demonstrating Darcy's Law. Calculating groundwater velocity and discharge using given hydraulic gradients and hydraulic conductivity values. Analyzing pumping test data to determine aquifer transmissivity and storativity.	30	20
II	**Climatology and Oceanography Lab:** Interpreting weather maps, identifying pressure systems, fronts, and air masses. lotting and analyzing temperature, precipitation, and wind data from weather stations. Applying Köppen climate classification to different regions based on temperature and precipitation data. Demonstrating thermohaline circulation and wind-driven currents using physical models or software. Analyzing graphs and reports on observed climate change trends in oceanic systems.	30	20
III	**Geomorphology & Geoinformatics Lab:** Reading and interpreting contour lines, calculating slope, and identifying landforms on topographic maps. Delineating drainage basins and calculating stream gradients. Analyzing geomorphic landforms from satellite imagery and/or models. Basic GIS operations (data loading, display, query) using QGIS or ArcGIS; Creating a Digital Elevation Model (DEM) from contour data and generating slope and aspect maps. Performing watershed delineation, stream network extraction, and creating a geomorphic map of a given area using GIS. Analyzing landform changes over time using multi-temporal satellite imagery.	30	20
IV	**Environmental Geology Lab:** Determining soil properties; Measuring physical and chemical parameters of water samples; Assessing a development project (e.g., a mine, a dam) considering geological and environmental factors. Identifying areas prone to geological hazards (e.g., landslides, sinkholes; volcanoes) using geological maps and aerial photos. Identifying landslide-prone areas using topographic maps, geological maps, and aerial photographs (e.g., slope analysis, presence of unstable geological units). Delineating floodplains and identifying flood risk zones using GIS and hydrological data.	30	20
Total		**120**	**80**

Syllabus for
M.Sc. in Geology
4th Semester

COURSE TITLE: ENGINEERING GEOLOGY

Course Code: GEOMC-401

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction to Engineering Geology:** Role of engineering geology in civil construction and mining industry. Various stages of engineering geological investigations for civil engineering projects. Engineering properties of rocks: rock discontinuities, physical characters of building stones, concrete and other aggregates. Site Characterization; Basic concepts of Environmental Impact Assessment (EIA) for engineering projects	12	08
Unit 2	**Engineering structures I:** Dams & Tunnels Geological consideration for evaluation of dams and reservoir sites. Dam foundation, rock problems and remedial measures (grouting, rock bolting, consolidation), Geotechnical evaluations of tunnel alignments and transportation routes. Methods of tunneling; Classification of ground for tunneling purposes (e.g., RQD, RMR, Q-system); various types of support (rock bolts, shotcrete, steel ribs).	10	10
Unit 3	**Engineering structures II:** Roads, Railways & Buildings Geological considerations involved in the construction of roads, railways, bridges and buildings. Improvement techniques of sites for engineering projects (compaction, dewatering, vibro-flotation, soil stabilization). Mass Movements with special emphasis on landslide and causes of hill slope instability. Seismic designs of buildings influence of geological condition on foundation and design of buildings.	8	12
Unit 4	**Mass Movements & Earthquakes** Mass Movements: Types of mass movements (landslides, rockfalls, creeps, flows). Landslide mechanisms, causes of hill slope instability (geological factors, hydrological factors, human activities). Basic principles of slope stability analysis. Mitigation strategies for landslides (retaining walls, drainage, rock bolting, terracing). Earthquakes: Causes of earthquakes, seismic waves, earthquake intensity and magnitude. Seismic designs of buildings. Influence of geological condition on foundation and design of buildings (site amplification, liquefaction potential). Principles of natural hazard assessment related to geological phenomena.	12	12

Unit 5	**Engineering Geology Application** Importance of geological mapping in engineering projects, preparation of geological sections and reports. Detailed understanding of selected ground improvement techniques (e.g., grouting, rock bolting, soil nailing, drainage techniques). Role of Engineering Geologists: Role of engineering geologists in various phases of planning, design, and construction of civil engineering structures and infrastructure.	10	10
Unit 6	**Indian Case Histories:** Detailed discussion on selected case histories of major civil engineering projects in India (e.g., specific dam failures, tunnel construction challenges, landslide mitigation projects) highlighting the role of engineering geology.	08	08

Reference Books:

1. Krynine, D.H. & Judd, W.R. (1998) Principles of Engineering Geology, CBS Edition.
2. Schultz, J.R. & Cleaves, A.B. (1951) Geology in Engineering, John Willey & Sons, New York.
3. Ray Chowdhary, K.P. (1987): Surveying (Plane and Geodetic) Oxford & IBH Pub. Co., New Delhi
4. Shahani, P.B.(1978): Text Book of Surveying, vol.I. Oxford & IBH Pub. Co., New Delhi
5. Punmia, B.C. (2005) : Surveying. Vol. 1 Laxmi Publications (P) Limited, New Delhi
6. Venkataramaiah, C (2011): Text Book of Surveying. Orient Blackswan Private Limited - New Delhi
7. Bernhard Hofmann-Wellenhof, Herbert Lichtenegger, James Collins 2012: Global Positioning System: Theory and Practice, 4th edition, Springer Science & Business Media
8. Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. John Wiley & Sons, N.Y. 4.
9. Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.)Taylor & Francis.
10. Bell: F.G-, 2006. Basic Environmental and Engineering Geology Whittles Publishing.
11. Bell, .F.G, 2007. *Engineering Geology,* Butterworth-Heineman

COURSE TITLE: MINERAL EXPLORATION

Course Code: GEOMC-402

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Introduction to Mineral Exploration:** Exploration Workflow and Strategy; Stages of exploration; Reconnaissance, prospecting, detailed exploration, resource definition. Target generation and conceptual modeling. Economic considerations and risk assessment; Faults, folds, shear zones, and their relationship to fluid pathways and ore deposition. Recognition and mapping of different alteration types (e.g., potassic, phyllic, argillic, propylitic). Alteration assemblages as vectors to mineralization.	10	08
Unit 2	**Geological & geochemical methods:** Geological methods (mapping, structural analysis, remote sensing interpretation). Geochemical methods (soil, stream sediment, water, rock geochemistry; geobotanical). Sampling techniques. Assaying and evaluation of mineral deposits.	10	12
Unit 3	**Gravity & Magnetic Methods:** Principles, instruments, data acquisition, corrections (free-air, Bouguer, isostatic, IGRF, reduction to pole). Interpretation of anomalies (simple geometric bodies). Applications for mineral and oil exploration.	10	10
Unit 4	**Electrical & Electromagnetic Methods:** Conduction of electricity through rocks. DC resistivity (profiling, sounding, electrode arrangements, curves). Induced polarization (IP), Self-potential (SP). EM induction, skin depth. Ground and airborne methods. GPR. Applications.	10	10
Unit 5	**Seismic and well logging Methods:** Generalized Snell's Law, Ray theory (reflection, refraction, diffraction). Energy sources, detectors. Data acquisition, processing (CDP/CMP, velocity analysis, filtering, stacking, deconvolution, migration), and interpretation (bright/dim spots, seismic stratigraphy). Applications. Use of Radiometric methods. Well logging (principles, types of logs like SP, resistivity, gamma ray, neutron, density, sonic; determination of formation parameters). Logging while drilling.	10	12

Unit 6	**Geophysical Inversion & Specialized Logs:** Basic concepts of forward and inverse problems (ill-posedness, non-uniqueness, stability). Quantitative evaluation of formations from well logs. Advanced logs (Pulsed Neutron, Multi-Array, Triaxial Induction). Application of borehole geophysics.	10	08

Reference Books:

1. Introduction to Mineral Exploration by Charles J. Moon, Michael K. G. Whateley, and Anthony M. Evans;
2. Mineral Exploration: Principles and Concepts by S.K. Haldar
3. Dobrin, M.B and Savit, C. H., 1988. Introduction to GeophysicalProspecting, McGraw-Hill.
4. Grant, F.S. and West, G.F., 1965. Interpretation Theory in AppliedGeophysics McGraw Hill, New York.
5. Murthy, LY.R. and Mishra, D.C., 1989. Interpretation of Gravity andMagnetic Anomalies in Space and Frequency Domain, AEG publication,Hyderabad, India.
6. Nettleton, L.L., 1976. Gravity and Magnetics in Oil Prospecting, McGrawHill.
7. Parasnis, D.S., 1966. Mining Geophysics, EIsevier.
8. Patra, H.P. and Mallick, K., 1980. Geosounding Principles Vol. IITimel/aryingGeoelectric Soundings. Amsterdam: Elsevier.

COURSE TITLE: PETROLEUM AND COAL GEOLOGY

Course Code: GEOMD-401

Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours: 60**

Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	Hours	Marks
Unit 1	**Identification and characterization (Petrographic and geochemical) of petroleum source rocks.** Amount, type and maturation of organic matter. Oil and source rock correlation. Locating petroleum prospects based on principles of petroleum generation and migration (geological modeling). Quantitative evaluation of oil and gas prospects through geochemical modeling. Reconstruction of paleogeothermal gradient. Migration modeling. Inputs for the assessment of accumulation of petroleum.	10	08
Unit 2	**Geological and geophysical methods in exploration:** Preparation and significance of lithocolumns and lithologs; Magnetic, Gravity and Seismic methods. Elementary knowledge of well drilling: cable-tool drilling, rotary drilling and various types of drilling units. Borehole model, Elementary knowledge of Wireline logs: Resistivity, SP, Gamma, Density, Sonic and Neutron logs. Application of logs in petrophysical analysis and facies analysis.	10	12
Unit 3	**Definition and Origin of Coal:** Definition and origin of coal, coal forming sedimentary environments, effect of seal level change and tectonic on coal formation, distribution of coal in systems tract, process of coalification, present day peat bogs and swamps; cyclothem, cause of coal seam split, structures associated within coal seam. Classification of coal in terms of type, grade and rank. Classification of coal (cocking coal, non-coking coal, international classification).	10	10
Unit 4	**Coal Petrography:** Composition of coal, lithotype and microlithotype classification. Proximate and ultimate analysis and its implication in terms of coal classification and utilization. Application of coal petrography. Concept of maceral and its classification: their physical chemical and optical properties. Concept of carbominerates and its classification. Application of macerals in coal seam correlation, climate and paleogeography.	10	10

Unit 5	**Coals and Hydrocarbon of India:** Coal forming epochs in geological past, Concept of Gondwanaland and plate tectonics and its effect on distribution of coal on earth. Geological and geographical distribution of coal and lignite in India. Hydrocarbon occurrence in India; important petroleum basins in India	10	12
Unit 6	**Industrial application of coal and petroleum:** Concept of Coal Bed Methane (CBM) and geothermal energy as an unconventional source of energy. Concept of generation of methane in coal seam, methods of reserve estimations of CBM and its production technique, potential of CBM in India. Concept of underground coal gasification (UGC), clean coal technology-coal liquefaction, coal carbonization, coal gasification**.**	10	08

Reference Books:

1. Jahn, F., Cook, M. and Graham, M.(1998) Hydrocarbon exploration and production. Elsevier
2. Barker, C. (1996) Thermal Modeling of Petroleum Generation, Elsevier.
3. Darling, Toby (2005)Well Logging and Formation Evaluation (Gulf Drilling Guides) 2005, Second ed. edition Gulf Professional Publishing.
4. Scott, A.C., (1987): Coal and coal bearing strata: Recent Advances, Blackwell Scientifics Publications.
5. Stach, E., Mackowsky, M-Th., Tylor, G.H., Chandra, D., Teichumullelr, L . and Teichumuller, R. (1982): Text book on coal petrology, Gebruder Borntreager Stuttgart.
6. Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R and Robert, P. (1998): Organic Petrology. Gebruder Borntreager Stuttgart

COURSE TITLE: GEOLOGY LABORATORY – IV

Course : GEOML-401

Credits: 4 (0 -Theory, 4 - Practical) **No. of Class hours: 120**

Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Unit	Topics	Teaching Hours	Allotted Marks
I	**Engineering Geology Lab:** Study of properties of common rocks with reference to their utility in engineering projects. Study of maps and models of important engineering structures and dam sites and tunnels. Interpretation of geological maps for landslide problems. Analyzing factors influencing slope stability (e.g., dip of bedding, presence of water, joint sets). Interpreting borehole logs and geophysical profiles (e.g., seismic refraction, resistivity) for subsurface characterization and stabilization.	**40**	**30**
II	**Mining Geology Lab:** Basic statistical analysis of geochemical assay data (e.g., calculating mean, median, standard deviation, plotting histograms); Plotting geochemical anomalies on maps and identifying pathfinder elements; Exercises on Gravity method and correction analysis; Electrical-Magnetic method and correction analysis; Seismic method and profiling systems; Exercises on wireline logging techniques and their interpretation	**40**	**25**
III	**Hydrocarbon and Coal Lab:** Megascopic and microscopic study of cores and coal samples Preparation of geological maps and sections, and derivation of geological history in relation to petroleum and coal prospects. Calculation of oil and coal reserves. Exercise on maturation studies. Interpretation of electric and porosity logs.	**40**	**25**
Total		**120**	**80**

COURSE TITLE: DISSERTATION
Course Code: GEOMP-401

Credits: 4 (0 -Theory, 4 - Practical) **No. of Class hours: 120**

Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Preamble: This course is aimed at giving research exposure to students by giving small projects to them in physics related areas

Course outline: Each student will be given a project which they have to complete during their first semester

Modules: This course will be based on preliminary research topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the student. At the semester end, the student will submit Project Report in the form of Dissertation which will be examined by the examiners. The examination shall consist of (a) presentation and (comprehensive viva-voce).

Textbooks: As advised by the faculty member

References: As advised by the faculty member