DEPARTMENT OF GEOLOGY

Syllabus for Five Years Integrated Master's Program in Applied Geology (FYIMPGLY)

As per NEP-2020

(session 2026 and onwards)

SCHOOL OF EARTH & ENVIRONMENTAL SCIENCE
UNIVERSITY OF KASHMIR -190006

DEPARTMENT OF GEOLOGY

VISION

To develop a world class centre of excellence in education, training & research in the field of Earth Sciences.

MISSION

Our mission is to understand Earth's natural systems, processes, and resources to foster sustainability, mitigate natural hazards, and ensure their responsible management. We are committed to developing teaching and research programs that remain socially relevant while enhancing employability. By continuously benchmarking our performance against national and international standards, we aim to address evolving societal needs and build strong global collaborations to fulfil the aspirations of our students and stakeholders.

Programme Educational Objectives (PEO): After completing **Five-Year Integrated Master's Program in Applied Geology**, the students will be able to:

- Develop a strong foundation in geosciences, gaining expertise in geological, geophysical, and geochemical methods to analyze and interpret Earth materials and processes.
- Acquire hands-on experience through local and national field training, mastering skills in geological mapping, mineral exploration, and identifying geological structures, rock types, and landforms.
- Address real-world challenges such as mineral exploration, disaster management, and environmental protection by applying field, lab, and data analysis techniques.
- Demonstrate problem-solving abilities through dissertation work, applying analytical, theoretical, or experimental approaches to geological problems and defending findings in public forums.
- Prepare for careers in academia, mineral exploration, geohazard assessment, and environmental consultancy, with the ability to publish research in reputable scientific journals.

Program Learning Outcomes (PLOs)

PLO_1	**Advanced Geological Knowledge**	Students will develop comprehensive expertise in geological principles, processes, and methods. They will be able to apply this knowledge to understand Earth's materials, structures, dynamic systems, and evolution over time.
PLO_2	**Research Aptitude**	Students will cultivate research skills by formulating geoscientific questions, designing methodologies, and analysing data to interpret geological phenomena such as stratigraphy, tectonics, paleoclimate, and mineralogy.
PLO_3	**Communication**	Students will effectively communicate geological concepts, research findings, and interpretations to scientific and public audiences through technical reports, publications, maps, and oral presentations.
PLO_4	**Problem Solving**	Students will apply geological knowledge and critical thinking to solve practical and scientific problems related to natural hazards, resource exploration, environmental challenges, and engineering geology.
PLO_5	**Individual and Team Work**	Students will demonstrate the ability to work both independently and collaboratively in multidisciplinary teams, contributing meaningfully to field studies, laboratory analysis, and geoscientific projects.
PLO_6	**Investigation and Field Skills**	Students will design and conduct geological investigations using field observations, sampling, mapping, and analytical techniques, integrating traditional and modern tools for data interpretation.
PLO_7	**Modern Tool Usage**	Students will be proficient in using modern tools and technologies such as GIS, remote sensing, geophysical instruments, analytical software, and machine learning to investigate geological questions.
PLO_8	**Science and Society**	Students will apply geological reasoning to assess and address societal and environmental issues. They will understand the relevance of geology to sustainable development, disaster mitigation, and resource stewardship.
PLO_9	**Lifelong Learning**	Students will engage in continuous learning to stay updated with advances in geosciences, embracing new techniques, tools, and interdisciplinary approaches for personal and professional growth.

a. All major courses shall be offered by the Department offering Five-Year Integrated Master's Program (FYIMP)

b. Minor (Allied Discipline Centric) Courses, to be chosen from any other allied related discipline/subject, with an intention to seek exposure beyond major subject to help in providing a wider understanding of the major discipline. However, in absence of a University department offering Minor Courses, the Department offering the Five-Year Integrated Masters Programme (FYIMP) shall make arrangements to make such courses available.

c. Multidisciplinary Courses are courses from different disciplines other than the main discipline or the related discipline (Minor) to acquire knowledge in various other fields. These courses can be chosen which a student has neither studied at the +2 level nor has taken any of these subjects as a major or minor in the programme. Ordinarily all Multi-Disciplinary Courses shall be offered by other University Departments/Institutions towards a centrally created pool of such courses.

d. Ability Enhancement Courses are designed to help students enhance their skills in communication and language. The Ability Enhancement Courses including “Communication Skills, English Language, and Modern Indian Languages (MIL)” shall be offered by relevant departments towards a centrally created pool of such courses.

e. Value-added courses including “Understanding India, Environmental Science/Education, Health & Wellness, and Digital and Technological Solutions” are courses designed to enhance the standard of the learners beyond those specified in major or related disciplines. These courses are to be offered by relevant departments towards a centrally created pool of such courses.

f. Skill Enhancement Courses are courses that provide the opportunity and knowledge to develop and strengthen the necessary skills to gain, maintain, and advance preferably in a chosen area, i.e., aligned to major or minor subjects. Skill Enhancement Courses may be offered by the Department offering Five-Year Master’s Degree Programmes and related departments. In addition, a programme may have non-UNIT Foundation Courses in first year to strengthen the fundamentals of students so as to enable them to cope with the Degree Programme in a better manner.

g. As per guidelines on Curriculum and UNIT Frame-work for Post Graduate Programmes, issued by UGC dated June 12, 2024, the curricular components of last two years of the 5- year integrated programme shall be similar to that of 2-year PG programme.

h. For the first eight (08) semesters of the integrated five-year programme, curriculum shall be based entirely on course work. However, for the 9th and 10th semester, the students be given an option to choose any combination of course work and research out of following options as reflected in the relevant regulations of the specific programme. (i) only course work in the 9th and 10th semester or (ii) course work in the 9th semester and research in the 10th semester or (iii) only research in the 9th and 10th semesters.

i. The curriculum for all types of courses shall be designed by the Boards of studies of the departments offering such courses.

PROGRAMME: Five-Year Integrated Master's Program in Applied Geology

SUBJECT: FYIMPGLY

SEME STER	COURSE CODE	TYPE OF COURSE	TITLE OF COURSE	CREDITS		
				THEORY	PRACTICAL 2 or 0	TUTORIAL 2 or 0
I	IGLYMJFG0126	Major	Fundamentals of Geology	3	1	-
		Minor	From pool of minor courses	4	-	-
	IGLYMDBR0126	MDC	Beauty of rocks	3	-	-
		AEC	From pool of Ability Enhancement Courses	3	-	-
		VAC	From pool of Value-added courses	2x2=4	-	-
	IGLYSEGT0126	SEC	Handling of Geological tools	-	2	-
II	IGLYMJIG0226	Major	Introduction to Geomorphology	3	1	-
		Minor	From pool of minor courses	4	-	-
	IGLYMDPF0226	MDC	Playing with fossils	3	-	-
		AEC	From pool of Ability Enhancement Courses	3	-	-
		VAC	From pool of Value-added courses	2x2=4	-	-
	IGLYSEGM0226	SEC	Basics of Geological Mapping	-	2	-
III	IGLYMJFS0326	Major	Fundamentals of Sedimentology	3	1	-
	IGLYMJCM0326	Major	Crystallography and Mineralogy	3	1	-
		Minor	From pool of minor courses	4	-	-
	IGLYMDNH0326	MDC	Natural Hazards	3	-	-
		AEC	From pool of Value-added courses	3	-	-
	IGLYSEFG0326	SEC	Field Geology		2	-
IV	IGLYMJIM0426	Major	Igneous and Metamorphic Petrology	3	1	-
	IGLYMJSG0426	Major	Structural Geology	3	1	-
	IGLYMJER0426	Major	Geo-energy Resources	3	0	-
	IGLYMJSG0426	Major	Stratigraphy	3	-	-
	IGLYMJFW0426	Major	Fieldwork			2
		Minor	From pool of minor courses	4	-	-
V	IGLYMJPT0526	Major	Paleontology	3	1	-
	IGLYMJEG0426	Major	Economic Geology	4	-	-
	IGLYMJGC0426	Major	Geochemistry	3	1	-
	IGLYMJGT0426	Major	Geotectonics	4	-	-
		Minor	From pool of minor courses	4	-	-
VI	IGLYMJEG0626	Major	Engineering Geology	3	1	-
	IGLYMJRG0626	Major	Remote Sensing and GIS	3	1	-
	IGLYMJFW0626	Major	Geological Fieldwork	-	0	4
	IGLYMJEM0626	Major	Exploration and Mining Geology	4	-	-

	IGLYMJHG0626	Major	Hydrogeology	**3**	**1**	**-**
		Minor	From pool of minor courses	**4**	**-**	**-**
VII	IGLYMJGP0726	Major	Geophysics	3	**1**	**-**
	IGLYMJSG0726	Major	Advanced Structural Geology	**3**	**1**	**-**
	IGLYMJEC0726	Major	Environmental Geology and Climate Change	4	**0**	**-**
	IGLYMJFT0726	Major	Field Training	**-**	**4**	**-**
	IGLYMJHG0726	Major	Himalayan Geology	**2**	**-**	**-**
	IGLYMJES0726	Major	Earth Surface Processes	**2**	**-**	**-**
	IGLYMJPC0726	Major	Petroleum and Coal Geology	**2**	**-**	**-**
VIII	IGLYMJIG0826	Major	Isotope Geology	3	**1**	**-**
	IGLYMJIP0826		Igneous Petrology	3	**1**	**-**
	IGLYMJMP0826	Major	Metamorphic Petrology	3	**1-**	**-**
	IGLYMJFT0826	Major	Field Training	**-**	**4**	**-**
	IGLYMJQG0826	Major	Quaternary Geology & Paleoclimate	2	**-**	**-**
	IGLYMJOG0826	Major	Oceanography	2	**-**	**-**
	IGLYMJGH0826	Major	Geo-Hazards	2	**-**	**-**
IX	IGLYMJRE0926	Major	Research Ethics	2		**-**
	IGLYMJRM0926	Major	Research Methodology	4		**-**
	IGLYMJGA0926	Major	Geostatistics and AI in Geosciences	3	**-**	**-**
	IGLYMJCC0926	Major	Cryosphere and Climate change	3	**-**	**-**
	IGLYMJSA0926	Major	Structural Analysis	3	**-**	**-**
	IGLYMJHG0926	Major	Hardrock Geochemistry	2	**-**	**-**
	IGLYMJIH0926	Major	Isotope Hydrology	2	**-**	**-**
	IGLYMJAS0926		Applied Sedimentology	2	**-**	**-**
	IGLYMJPR0926	Major	Paleoclimatic Reconstruction	2	**-**	**-**
	IGLYMJSMO926	Major	Seismology	2	**-**	**-**
	IGLYMJEG0926	Major	Advanced Engineering Geology	2	**-**	**-**
	IGLYMJHT0926	Major	Himalayan Tectonics	2	**-**	**-**
	IGLYMJHM0926	Major	Hydrogeophysics and Hydroclimatic Modelling	2	**-**	**-**
	IGLYMJPW0926	Major	Project work	6	**-**	**-**
X	IGLYMJDT1026		Dissertation		**-**	20

DETAILED SYLLABUS

SEMESTER-I

COURSE NAME: FUNDAMENTALS OF GEOLOGY
COURSE CODE: IGLYMJFG0126
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the scope, origin, and interdisciplinary nature of geology, including its links with physics, chemistry, and paleobiology.
CLO_2: Identify and classify major rocks and minerals and interpret Earth's structure and geological records such as fossils and structures.
CLO_3: Describe and analyse key geological processes, including weathering, erosion, tectonism, volcanism, and oceanic features.
CLO_4: Apply field skills to recognize and interpret erosional and depositional landforms shaped by various geomorphic agents.

UNIT-1 (15 HOURS)

Introduction to the science of geology: definition, branches, scope, and importance. History of Geology; Modern theories about the origin of the solar system; Origin of the Earth. Relation with other branches of sciences: The role of physics, chemistry, and paleobiology in the development of ideas about Earth. Role of physics in crystallography, gravity, geomagnetism, isostasy, earthquakes, and microscopy. Role of chemistry in chemical bonds, crystal chemistry, solution chemistry, and chemical energetics.

UNIT -2 (15 HOURS)

Introduction to rocks and minerals: Types of rocks: igneous rocks, sedimentary rocks, and metamorphic rocks. Preliminary knowledge about the most common rock-forming and economic minerals. Structure of earth: physical properties. Geology as the history of Earth: How the rocks record history—(a) Fossils (b) Mineralogy and the texture; (c) Structures; (d) Surface relief of the earth. Exogenous and endogenous processes. Various Geospheres.

UNIT -3 (15 HOURS)

Fundamental concepts: Catastrophism, uniformitarianism, cycle of erosion, and base level of erosion. Weathering: definition and types, agents of weathering. Products of weathering. Epeirogenesis and orogenesis. Mountains and types. Volcanoes: types, distribution, and eruptional features. Glaciers: Definition and types. Erosion and deposition. Aeolian processes: erosional and depositional features. Geological work of a river: erosional and depositional features. Soil formation and soil profiles. Oceans: Topography of the sea floor. Continental shelf, slope, abyssal plain, ocean ridges, submarine valleys, canyons, deep-sea trenches, and guyots.

PRACTICAL (1 CREDIT: 30 HOURS)

Field Work: Study of landforms: erosional and depositional features of rivers, glaciers, groundwater, and aeolian processes.

Suggested Readings

Berry, L. G. and Mason, B., 1988: Mineralogy. CBS Publishers.
Burbank, D. W. and Anderson, R. S., 2001: Tectonic Geomorphology. Blackwell Science.
Perkins, D., Minerals in Thin Sections.
Gribble, C. D., 1988: Rutley's Elements of Mineralogy. DBS Publications.
Holmes, A., 1996: Principles of Physical Geology. EUBS, Chapman and Hall.
Judson, S. and Kaufman, M. E., 1990: Physical Geology. Prentice Hall.
Kerr, P. F., 1984: Optical Mineralogy.
Lutgens, F. K. and Tarbuck, E. J., 1998: Essentials of Geology. Prentice Hall.
Phillips, W. R. and Griffen, D. T., 1986: Optical Mineralogy. CBS Edition.
Press, F. and Siever, R., 1989: The Earth. W. H. Freeman.
Putnis, A., 2001: Introduction to Mineral Sciences. Cambridge University Press.
Read, H. H., 1986: Rutley's Elements of Mineralogy.
Richard, V. G., 1997: Dana's New Mineralogy. John Wiley.
Ritter, D. F., 1978: Process Geomorphology. Wm. C. Brown Publishers.
Tarbuck, E. J. and Lutgens, F. K., 1997: Earth Science. Prentice Hall.
Tilley, G. W., 1958: Principles of Petrology. Methuen.
Vishwas, S. K. and Gupta, A., 2001: Introduction to Geomorphology. Orient Longman.

-X-

COURSE NAME: BEAUTY OF ROCKS

COURSE CODE: IGLYMDBR0126

COURSE TYPE: MULTIDISCIPLINARY

CREDITS: 03; Total Contact Hrs. 45

Max. Marks: 75

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain and classify major rock types, their origin, and properties and identify common rocks and minerals macroscopically.

CLO_2: Evaluate engineering properties of rocks and select suitable materials for construction based on strength, durability, and performance.

CLO_3: Assess the role of rocks in resources, environment, and landscape evolution and apply principles of sustainable utilization and geo-conservation.

UNIT -1 (15 HOURS)

Definition and types of rocks: igneous, sedimentary, and metamorphic; origin and basic formation processes; physical properties of rocks (color, texture, grain size, structure); rock cycle; introduction to common rock-forming minerals; macroscopic identification of common rocks.

UNIT -2 (15 HOURS)

Overview of the engineering properties of rocks: strength, durability, porosity, permeability; use of rocks in construction (dimension stones, aggregates, cement raw materials); weathering and deterioration of building stones; selection of suitable rocks for engineering purposes; introduction to geotechnical considerations (basic idea).

UNIT -3 (15 HOURS)

Rocks as sources of minerals and energy resources; role of rocks in soil formation and landscape evolution; environmental impacts of mining and quarrying; sustainable utilization of geological resources; concept of geodiversity and conservation of geological heritage.

Suggested Readings

Tarbuck E.J. and Lutgens F.K. – Earth: An Introduction to Physical Geology. 2008. Pearson Education.
Skinner B.J. and Porter S.C. – The Dynamic Earth. 2004. Wiley.
Blatt H., Middleton G. and Murray R. – Origin of Sedimentary Rocks. 1980. Prentice Hall.
Krynine D.P. and Judd W.R. – Principles of Engineering Geology and Geotechnics. 1957. McGraw-Hill.
Klein C. and Dutrow B. – Manual of Mineral Science. 2007. Wiley.

-X-

COURSE NAME: HANDLING OF GEOLOGICAL TOOLS
COURSE CODE: IGLYSCGT0126
COURSE TYPE: SKILL ENHANCEMENT COURSE

CREDITS: 02; Total Contact Hrs. 30

Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Demonstrate correct use, handling, maintenance, and safety practices of common geological field tools.
CLO_2: Apply basic field techniques using a compass-clinometer, GPS, measuring tape, and hand lens for accurate observations and recordings.

UNIT -1 (15 HOURS)

Introduction to commonly used geological tools: geological hammer, hand lens, compass-clinometer (Brunton), measuring tape, sample bags, and field notebook. Detailed study of parts and functions of each tool. Correct techniques of holding and using tools. Ergonomics in tool handling. Safety precautions during field use, routine care, cleaning, and maintenance of tools, and proper storage and transport of instruments.

UNIT -2 (15 HOURS)

Hands-on handling of a compass-clinometer: opening, leveling, sighting, and reading scales (bearing and inclination). Use of a measuring tape for accurate measurements. Use of a hand lens for close observation. Basic operation of a GPS device. Calibration and checking of instruments. Common handling errors and precautions. Preparation of simple tool-use records and checklists.

Suggested Readings

Compton R.R. – Geology in the Field. 1985. Wiley.
Barnes J.W. – Basic Geological Mapping. 1981. Wiley.
Maley T.S. – Field Geology Illustrated. 2005. Mineral Land Publications.
Bennison G.M. – An Introduction to Geological Structures and Maps. 2002. Hodder Education.
Lisle R.J., Brabham P. and Barnes J.W. – Basic Geological Mapping. 2011. Wiley-Blackwell.

-X-

2nd SEMESTER

COURSE NAME: INTRODUCTION TO GEOMORPHOLOGY

Course code: IGLYMJIG0226
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the scope of geomorphology and analyze the role of endogenic and exogenic processes in landform development.
CLO_2: Describe and interpret fluvial and aeolian processes and the associated erosional and depositional landforms.
CLO_3: Evaluate glacial, coastal, and groundwater processes in shaping landscapes and their role in landscape evolution.
CLO_4: Apply practical skills to interpret topographic maps and satellite data for identification of landforms and drainage patterns.

UNIT -1 (15 HOURS)

Definition, scope, and significance of geomorphology. Geomorphic processes and geomorphic agents. Endogenic and exogenic processes. Concept of denudation. Weathering (physical and chemical) and mass wasting. Factors controlling landform development (climate, lithology, structure, time); cycle of erosion and base level.

UNIT -2 (15 HOURS)

Running water as a geomorphic agent; drainage systems and patterns; erosional and depositional landforms of rivers (valleys, floodplains, terraces, deltas). Concept of rejuvenation and knickpoints. Wind as a geomorphic agent. Desert landforms (dunes, loess, pediments, inselbergs).

UNIT -3 (15 HOURS)

Glaciers, glacial processes, and landforms (erosional and depositional). Coastal processes: waves, tides, currents, and associated landforms. Groundwater action and karst topography (caves, sinkholes, stalactites, stalagmites). Role of geomorphic processes in landscape evolution.

PRACTICAL (1 CREDIT: 30 HOURS)

Interpretation of topographic maps and identification of landforms. Recognition of geomorphic features from maps and satellite images. Preparation of simple geomorphic sketches and profiles. Identification of drainage patterns. Basic field identification of landforms.

Suggested Readings

Thornbury W.D. – Principles of Geomorphology. 1984. Wiley Eastern.
Pitty A.F. – Introduction to Geomorphology. 1971. Methuen, London.
Bloom A.L. – Geomorphology: A Systematic Analysis of Late Cenozoic Landforms. 1998. Prentice Hall.
Tarbuck E.J. and Lutgens F.K. – Earth: An Introduction to Physical Geology. 2008. Pearson.
Summerfield M.A. – Global Geomorphology. 1991. Longman.

COURSE NAME: PLAYING WITH FOSSILS
COURSE CODE: IGLYMDPF0226
COURSE TYPE: MULTIDISCIPLINARY

CREDITS: 03; Total Contact Hrs. 45
Max. Marks: 75

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the nature, types, and preservation of fossils, and outline their distribution within the geological time scale.
CLO_2: Identify and describe major fossil groups and interpret their ecological and environmental significance, including the use of index fossils.
CLO_3: Apply fossils in relative dating, correlation, and paleoenvironmental reconstruction, and recognize their importance in resource exploration and conservation.

UNIT -1 (15 HOURS)

Definition and nature of fossils. Types of fossils: body fossils, trace fossils, and microfossils. Processes of fossilization (permineralization, recrystallization, molds and casts, carbonization, and impressions). Conditions favoring preservation: role of sedimentation and burial. Introduction to the geological time scale and major fossil-bearing eras.

UNIT -2 (15 HOURS)

Overview of major fossil groups: plant fossils, invertebrates (corals, brachiopods, and molluscs), and vertebrates. Basic morphology of shells and skeletal structures; simple criteria for fossil identification. Ecological significance of fossils (marine vs. terrestrial environments). Fossils as indicators of climate and depositional environments. Introduction to index fossils.

UNIT -3 (15 HOURS)

Overview of the use of fossils in relative dating and correlation of rock layers (biostratigraphy). Fossils and evolution; reconstruction of paleoenvironments and paleoclimate. Introduction to the importance of fossils in oil, coal, and mineral exploration. Fossil conservation, museum collections, and ethical aspects of fossil collection.

Suggested Readings

Prothero D.R. – Bringing Fossils to Life. 2013. Columbia University Press.
Benton M.J. and Harper D.A.T. – Introduction to Paleobiology and the Fossil Record. 2009. Wiley-Blackwell.
Briggs D.E.G. and Crowther P.R. – Palaeobiology II. 2001. Blackwell Publishing.
Clarkson E.N.K. – Invertebrate Palaeontology and Evolution. 1998. Wiley-Blackwell.
Taylor P.D. – Fossils: A Very Short Introduction. 2015. Oxford University Press.

-X-

COURSE NAME: BASICS OF GEOLOGICAL MAPPING

COURSE CODE: IGLYSEGM0226

COURSE TYPE: SKILL ENHANCEMENT

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course Learning Outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain and interpret basic concepts of geological mapping, including map types, scales, contours, and structural elements like strike and dip.

CLO_2: Apply fundamental field mapping techniques to prepare simple geological maps, sketches, and basic interpretations using field data.

UNIT-1 (15 HOURS)

Definition and importance of geological mapping. Types of maps: topographic and geological. Map components (scale, direction, symbols, legend). Types of scales (RF, statement, graphical). Introduction to contours: concept, characteristics, and representation of relief. Reading of simple topographic maps and topographic profiles. Geological maps and geological cross-sections. Reading, understanding, and making simple geological maps and sections. Basic idea of strike and dip. Pre-mapping preparations: Planning, tools & instruments. Base map.

UNIT-2 (15 HOURS)

Introduction to field mapping procedures (basic steps). Basic mapping symbols. Plotting of location and simple geological data (rock types & structural data) on maps. Identification and marking of rock boundaries (basic concept). Preparation of simple geological maps. Introduction to cross-sections. Use of a Brunton compass for basic measurements. Preparation of field sketches and simple interpretation of mapped features. Geological mapping of horizontal and dipping stratigraphical successions. Recording and plotting of planar and linear structural data.

Suggested Readings

Barnes J.W. – Basic Geological Mapping. 1981. Wiley.

Lisle R.J., Brabham P. and Barnes J.W. – Basic Geological Mapping. 2011. Wiley-Blackwell.

Compton R.R. – Geology in the Field. 1985. Wiley.

Bennison G.M. – An Introduction to Geological Structures and Maps. 2002. Hodder Education.

-X-

3rd SEMESTER

COURSE NAME: FUNDAMENTALS OF SEDIMENTOLOGY

COURSE CODE: IGLYMJFS0326

COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course Learning Outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain sedimentary processes, transport mechanisms, and depositional environments involved in the formation of sedimentary rocks.

CLO_2: Analyze sediment texture and grain size characteristics to interpret depositional conditions and environments.

CLO_3: Identify and classify sedimentary structures and rock types and evaluate their significance in paleoenvironmental reconstruction.

CLO_4: Apply practical skills in grain size analysis and basic interpretation of sedimentological data through laboratory and field observations.

UNIT -1 (15 HOURS)

Definition and scope of sedimentology. Origin of sediments. Processes involved in the formation of sedimentary rocks, including erosion, transportation, deposition, diagenesis, and lithification. Agents of sediment transport (water, wind, ice). Modes of transportation (traction, saltation, suspension, solution). Depositional environments (fluvial, aeolian, glacial, marine).

UNIT -2 (15 HOURS)

Texture of sedimentary rocks, including grain size, roundness, sphericity, surface texture, fabric, porosity, and permeability. Significance of texture in interpreting depositional environment. Grain size classification and grade scale. Methods of grain size analysis. Sieving method: types, procedures, and applications. Introduction to statistical representation of sediment data.

UNIT -3 (15 HOURS)

Sedimentary structures: primary, secondary, and biogenic. Major primary sedimentary structures, including cross-bedding, cross lamination, horizontal bedding, graded bedding, ripple marks, dunes, sole marks, and rain prints. Significance of sedimentary structures in interpreting paleoenvironments. Classification of sedimentary rocks into clastic and non-clastic types. Clastic rocks: rudaceous, arenaceous, and argillaceous. Non-clastic rocks: calcareous and other chemical/biogenic deposits.

PRACTICAL (1 CREDIT: 30 HOURS)

Grain size analysis using the sieving method; basic interpretation of grain size data, porosity, and permeability; and field observation with sketches.

Suggested Readings

Tucker M.E. – Sedimentary Rocks in the Field. 2011. Sedimentary Rocks in the Field (4th Edition). Wiley-Blackwell.

Boggs S. – Principles of Sedimentology and Stratigraphy. 2012. Principles of Sedimentology and Stratigraphy (5th Edition). Pearson Education.

Nichols G. – Sedimentology and Stratigraphy. 2009. Sedimentology and Stratigraphy (2nd Edition). Wiley-Blackwell.
Reading H.G. – Sedimentary Environments: Processes, Facies, and Stratigraphy. 1996. Sedimentary Environments: Processes, Facies, and Stratigraphy (3rd Edition). Blackwell Science.
Friedman, G. M. and Sander, J. E., 1978: Principles of Sedimentology. John Wiley.
Krishanan, M. S., 1968: Geology of India and Burma. HigginbothamsPvt. Ltd., Madras.
Kumar, R, 1998: Fundamentals of Historical Geology and Stratigraphy. Wiley Eastern Limited.
Miall, A. D., 1999: Principles of Sedimentary Basin Analysis. Springer-Verlag.
Pettijohn, F. J., Potter, P.E. and Siever, R, 1990: Sand and Sandstone. Springer Verlag.
Reading, J. G. 1996: Sedimentary Environment and Facies. Blackwell.
Selley, R. C., 1976: Introduction of Sedimentology. Academic Press, London.
Sengupta, S., 1997: Introduction to Sedimentology. Oxford-IBH.

-X-

COURSE NAME: CRYSTALLOGRAPHY AND MINERALOGY

COURSE CODE: IGLYMJCM0326
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75

Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain fundamental concepts of crystallography, including crystal structure, symmetry elements, and crystallographic laws.

CLO_2: Classify and recognize crystal systems, forms, and symmetry using crystallographic principles and models.

CLO_3: Identify and describe minerals based on physical and basic optical properties, and **classify** them accordingly.

CLO_4: Apply practical skills in crystal measurement and mineral identification using hand specimens and standard tests.

UNIT -1 (15 HOURS)

Definition of crystal and crystallography. Distinction between crystalline and amorphous substances. Concept of lattice, space lattice, and unit cell (Bravais lattices, symmetry operations). Crystal faces, edges, and solid angle**.** Laws of crystallography: law of constancy of interfacial angles. Introduction to symmetry elements: plane, axis, and center of symmetry—basic crystallographic notation.
Axial system and axial ratios. Parameter system of Weiss, Miller indices. Law of rationality of indices.

UNIT -2 (15 HOURS)

Classification of crystals into seven crystal systems: cubic, tetragonal, orthorhombic, hexagonal, trigonal, monoclinic, and triclinic. Crystallographic axes and axial relationships. Forms and combinations. Concept of crystal classes (brief introduction). Symmetry elements in different crystal systems.

UNIT -3 (15 HOURS)

Definition of minerals. Physical properties of minerals: color, streak, luster, hardness, cleavage, fracture, and specific gravity. Chemical composition and chemical classification of minerals.

Introduction to common rock-forming mineral groups: quartz, feldspar, mica, amphibole, pyroxene, and calcite. Basics of optical properties of minerals. Isotropic and anisotropic minerals.

PRACTICAL (1 CREDIT: 30 HOURS)

Demonstration of unit cell and space lattice models, Identification of crystal systems using models; study of symmetry elements with crystal models. Measurement of interfacial angles. Identification of common minerals in hand specimens based on physical properties. Use of the hardness scale (Mohs scale). Recognition of cleavage and fracture. Simple crystal drawings and recognition of crystal forms.

Suggested Readings

Dana J.D. – Manual of Mineralogy. 1993. Manual of Mineralogy (21st Edition). John Wiley & Sons.

Klein C. and Dutrow B. – Manual of Mineral Science. 2007. Manual of Mineral Science (23rd Edition). John Wiley & Sons.

Phillips F.C. – An Introduction to Crystallography. 1971. An Introduction to Crystallography. Longman Group Ltd.

Nesse W.D. – Introduction to Mineralogy. 2012. Introduction to Mineralogy (2nd Edition). Oxford University Press.

-X-

COURSE NAME: NATURAL HAZARDS
COURSE CODE: IGLYMDNH0326
COURSE TYPE: MULTIDISCIPLINARY

CREDITS: 03; Total Contact Hrs. 45
Max. Marks: 75

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain the types and mechanisms of natural hazards, including earthquakes, landslides, floods, and cyclones, with regional examples.

CLO_2: Analyze causes, impacts, and spatial distribution of hazards, particularly in Kashmir and along Indian coasts.

CLO_3: Evaluate and apply mitigation, preparedness, and disaster management strategies for reducing hazard risks.

UNIT-1 (15 HOURS)

Natural Hazards: Definition and Types. Earthquakes: magnitude and intensity, seismic waves (P, S, and surface waves), seismographs, and seismograms. Elastic rebound theory. Earthquake location (focus, epicenter, hypocenter). Earthquake belts and focal depth. Earthquake prediction and precautionary measures. History of earthquakes in Kashmir.

UNIT-2 (15 HOURS)

Landslides: definition, classification, causes, and preventive measures. Landslide-prone areas along the Srinagar–Jammu National Highway. Floods: definition, types, causes, and mitigation. History of floods in Kashmir. Cloudbursts: definition, causes, impacts, and precautionary measures.

UNIT-3 (15 HOURS)

Coastal hazards and hazards along the Indian coasts. Cyclones and mitigation methods. Sea-level rise: causes, impacts, and risks. Introduction to disaster management and mitigation strategies. Role of awareness and preparedness in reducing disaster risk.

Suggested Readings

Bell F.G. – Geological Hazards. 1999. Routledge, London.
Hyndman D. and Hyndman D. – Natural Hazards and Disasters. 2013. Brooks/Cole.
Keller E.A. and DeVecchio D.E. – Natural Hazards. 2011. Pearson.
Bryant E. – Natural Hazards. 1985. Cambridge University Press.
Sheridan S. – The Disaster Diaries. 2013. Penguin Books.
Patwardhan A.M. – The Dynamic Earth System. 1999. Prentice Hall.

-X-

COURSE NAME: FIELD GEOLOGY
COURSE CODE: IGLYSEFG0326
COURSE TYPE: SKILL ENHANCEMENT

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain and demonstrate fundamental field geology practices, including observation, identification of structures, and systematic field recording with attention to safety and ethics.
CLO_2: Apply basic field techniques for data collection, mapping, sample handling, and preparation of field notes, sketches, and simple geological reports.

UNIT-1 (15 HOURS)

Definition and scope of field geology. Importance of fieldwork in geosciences. planning of field visits and organization of field equipment. observation and description of rocks (color, texture, grain size, structure). identification of basic geological features (bedding, joints, folds, faults). recognition of weathering features. Use of a field notebook for systematic recording. basics of field safety, discipline, and ethics; environmental sensitivity during fieldwork.

UNIT-2 (15 HOURS)

Methods of recording geological data. Preparation of field notes, logs, and annotated sketches. Basic handling of a Brunton compass. Locating positions using maps and GPS. Methods of sample collection, labeling, and preservation. Preparation of simple geological field reports. Photographic documentation of field features and common errors in field recording and their correction.

Suggested Readings

Compton R.R. – Geology in the Field. 1985. Wiley.
Maley T.S. – Field Geology Illustrated. 2005. Mineral Land Publications.
Bennison G.M. – An Introduction to Geological Structures and Maps. 2002. Hodder Education.
Barnes J.W. – Basic Geological Mapping. 1981. Wiley.
Lisle R.J., Brabham P. and Barnes J.W. – Basic Geological Mapping. 2011. Wiley-Blackwell.
Tucker M.E. – Techniques in Sedimentology. 2011. Wiley-Blackwell.

-X-

4th SEMESTER

COURSE NAME: IGNEOUS AND METAMORPHIC PETROLOGY

COURSE CODE: IGLYMJIM0426
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain classification, composition, and evolution of magma, and interpret processes responsible for diversity in igneous rocks.
CLO_2: Describe and identify structures and textures of igneous rocks and distinguish between petrography and petrogenesis.
CLO_3: Explain and evaluate processes, types, and controlling factors of metamorphism, including textures and fabrics of metamorphic rocks.
CLO_4: Apply practical skills to identify mineral composition, textures, and structures of igneous and metamorphic rocks in hand specimens and thin sections.

UNIT -1 (15 HOURS)
Igneous petrology and its scope. Primary Magma. Magma generation, composition, and types. Physical properties of magma. Differentiation of magma. Principles of classification of igneous rocks, IUGS modal and chemical classifications of igneous rocks. Discordant and concordant igneous bodies. Igneous enclaves: origin, types, and petrogenetic significance. Concept of alkaline and subalkaline series of rocks.

UNIT -2 (15 HOURS)
Primary volcanic and lava flow structures. Fundamentals of magmatic crystallization. Bowen's reaction Series and its significance in understanding magmatic differentiation. Unicomponent and bicomponent systems. Crystal growth. Igneous textures—crystallinity, granularity (phaneric and aphanitic), shapes of crystals, mutual relations of crystals, equigranular and unequigranular textures, porphyritic, poikilitic, ophitic, intersertal and intergranular textures, directive textures, intergrowth textures. Reaction textures. Reaction structures—corona and calyphitic borders.
Factors controlling ascent of magmas. Volcanoes: types and products. Solubility of CO_2 and H_2O in silicate melts. Mantle Plumes: morphology, origin, and evolution.

UNIT -3 (15 HOURS)
Introduction to metamorphism: Concepts, agents, and types of metamorphism. Classification based on the principal agents (thermal, dynamic, dynamo-thermal, and hydrothermal); based on geological setting—contact, shock, high-strain, and regional (burial, ocean-ridge, orogenic); based on plate tectonic setting—metamorphism at convergent, divergent, and transform plate margins. Metamorphic facies. Metamorphic textures: augen, cataclastic, corona, decussate, epitaxial, flaser, granoblastic. lepidoblastic, megacrystic, nematoblastic, poikiloblastic, porphyroblastic, and relict textures.

PRACTICAL (1 CREDIT: 30 HOURS)
Study the hand specimen and, under the microscope, the mineral composition and textures (granularity, crystallinity, shapes of crystals/structures of important igneous and metamorphic rocks). CIPW Norm calculation.

Suggested Readings
Berry & Mason, 1988: Mineralogy. CBS Pub.

Best, M. G., 1986: Igneous Petrology, CBS Pub.
Blatt H.& Tracy R.J. 1995. Petrology: Igneous, Sedimentary & Metamorphic.
Barker, A.J., 1990. Introduction to Metamorphic Textures and Microstructures. Blackie, 162p.
Bucher, K. and Grapes, R., 2011. Petrogenesis of Metamorphic Rocks. Springer
Frost, C.D., Frost, B.R, 2013. Essentials of Igneous and Metamorphic Petrology
Kretz, R., 1994. Metamorphic Crystallization. John Wiley & Sons, 507p.
Miyashiro, A., 1978. Metamorphism and Metamorphic Belts. 3rd Edition.
Vernon, R.H. and Clarke, G.L., 2008. Principles of Metamorphic Petrology.
Winter, J.D., 2011. Principles of Igneous and Metamorphic Petrology, Prentice-Hall, 728p.

-X-

COURSE NAME: STRUCTURAL GEOLOGY
COURSE CODE: IGLYMJSG0426
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain fundamental concepts of structural geology, including stress, strain, deformation mechanisms, and rheological behavior of rocks.

CLO_2: Identify and classify folds, faults, joints, and unconformities, and interpret their geometry in field and map views.

CLO_3: Apply principles of structural analysis to measure and represent geological structures using strike, dip, and basic projections.

CLO_4: Develop practical skills in geological map interpretation, cross-section construction, and solving simple structural problems.

UNIT-1 (15 HOURS)

Definition and scope of structural geology. Primary and secondary structures. Concept of stress and strain. Types of stress (compressional, tensional, shear). Types of strain: elastic, plastic, and brittle deformation. Factors controlling deformation (temperature, pressure, time). Behavior of rocks under stress. Concept of rheology. Strain ellipsoid. Deformation mechanisms: fracturing, flow, and creep.

UNIT-2 (15 HOURS)

Classification and geometry of folds: anticline, syncline, symmetrical, asymmetrical, overturned, recumbent. Elements of folds. Recognition of folds in the field and maps. Faults: types, normal, reverse, thrust, strike-slip. Fault terminology. Recognition of faults: fault planes, slickensides, and fault breccia in the field. Joints and fractures. Unconformities: definition and types. Drag folds and minor structures.

UNIT-3 (15 HOURS)

Measurement of structural elements: strike and dip. Representation of structures on maps. Outcrop patterns. Construction and interpretation of geological maps and cross-sections. Introduction to stereographic projection and interpretation of simple structural problems. Apparent dip and true dip. Block diagrams and their interpretation.

PRACTICAL (1 CREDIT: 30 HOURS)

Measurement of strike and dip using a Brunton compass. Identification of folds, faults, and joints from hand specimens, models, and maps. Interpretation and completion of geological maps. Drawing of cross-sections. Plotting of structural data (strike/dip) on maps. Solution of simple structural problems.

Suggested Readings

Billings M.P. – Structural Geology. 1972. Prentice Hall.
Park R.G. – Foundations of Structural Geology. 1997. Springer.
Davis G.H., et al. –Structural Geology of Rocks and Regions. 2011. Wiley.
Hobbs B.E., Means W.D. and Williams P.F. – An Outline of Structural Geology. 1976. Wiley.
Twiss R.J. and Moores E.M. – Structural Geology. 2007. Freeman.
Ramsay J.G. – Folding and Fracturing of Rocks. 1967. McGraw-Hill.
Ghosh S.K.–Structural Geology: Fundamentals and Modern Developments. 1993.
Fossen H. – Structural Geology. 2010. Cambridge University Press.
Price N.J. and Cosgrove J.W. – Analysis of Geological Structures. 1990. Cambridge Uni. Press.

-X-

COURSE NAME: GEO-ENERGY RESOURCES
COURSE CODE: IGLYMJER0426
COURSE TYPE: MAJOR

CREDITS: 03; Total Contact Hrs. 45
Max. Marks: 75

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the classification, formation, and geological controls of conventional energy resources such as coal, petroleum, and natural gas.
CLO_2: Describe and evaluate unconventional energy resources and critical minerals, including their occurrence and environmental implications.
CLO_3: Analyze geothermal systems, energy storage, and carbon sequestration processes and assess sustainable management of geo-energy resources.

UNIT-1 (15 HOURS)

Definition and classification of energy resources: renewable and non-renewable. Global energy demand and supply. Geological controls on energy resources. Processes of formation, accumulation, and preservation of fossil fuels: coal, petroleum, and natural gas. Basic concepts of exploration methods.

UNIT-2 (15 HOURS)

Unconventional hydrocarbons: shale gas, coal bed methane (CBM), tight gas, gas hydrates, oil shale, and tar sands: geological controls and occurrence. Nuclear (radioactive) energy: uranium and thorium occurrence, modes of formation, and basic principles of nuclear energy generation. Environmental concerns of nuclear energy. Critical minerals for energy transition: lithium, cobalt, nickel, rare earth elements, and their geological occurrence.

UNIT-3 (15 HOURS)

Geothermal energy: origin of Earth's heat, geothermal gradient, heat flow. Hydrothermal systems: formation, circulation of fluids, types (hot springs, geysers, fumaroles). Geothermal reservoirs and classification: methods of utilization (electricity generation and direct heating). Enhanced geothermal systems (EGS). Carbon capture, utilization, and storage (CCUS): geological sequestration in saline aquifers and depleted reservoirs. Energy storage in geological media. Environmental impacts and sustainable management of geo-energy resources.

Suggested Readings

Gluyas J. and Swarbrick R. – Petroleum Geoscience. 2004. Blackwell Publishing.
Selley R.C. – Elements of Petroleum Geology. 1998. Academic Press.
Bjorlykke K.–Petroleum Geoscience: From Sedimentary Environments to Rock Physics. 2010.
Boyle G. – Renewable Energy: Power for a Sustainable Future. 2012. Oxford University Press.
Durrance E.M. – Radioactivity in Geology: Principles and Applications. 1986. Ellis Horwood.
Dickson M.H. and Fanelli M. – Geothermal Energy: Utilization and Technology. 2004. UNESCO.
IPCC – Carbon Capture and Storage Special Report. 2005. Cambridge University Press.
Edwards R. – Energy Resources. 2002. Routledge.

-X-

COURSE CODE: STRATIGRAPHY
COURSE CODE: IGLYMJSG0426
COURSE TYPE: MAJOR

CREDITS: 03; Total Contact Hrs. 45
Max. Marks: 75

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain and apply fundamental principles of stratigraphy, including facies laws, stratigraphic units, correlations, and unconformities.
CLO_2: Describe and interpret the stratigraphic framework of the Indian subcontinent, including Precambrian shields, basins, and major geological provinces.
CLO_3: Analyze type sections and major stratigraphic boundaries of India to understand geological time correlations and boundary problems.

UNIT-1 (15 HOURS)

Introduction to Stratigraphy and its branches. Principles of Stratigraphy. Walther's Law of Facies and Laws of Stratigraphy. Principle of Uniformitarianism vs. Catastrophism. Unconformities: angular, disconformity, nonconformity, and paraconformity. Lithostratigraphic Units: Hierarchy and Boundaries. Shaw's graphic correlation. Biostratigraphic units. Chronostratigraphy: Rock vs. Time Units. GSSPs (Global Boundary Stratotype Section and Point) and FAD (First Appearance Datum). Type sections and type localities: their importance in establishing formal nomenclature. Stratigraphic codes and nomenclature. Magnetostratigraphy.

UNIT-2 (15 HOURS)

The Indian Precambrian shield: Archaean cratonic nuclei of Peninsular India (Dharwar, Singhbhum, Bastar, Bundelkhand, and Aravalli cratons); Proterozoic mobile belts (Central Indian Tectonic Zone, Aravalli-Delhi and Eastern Ghats, and Southern Granulite Terrain); Purana sedimentary basins (Cuddapah, Vindhyan, and Chattisgarh basins); supracrustal belts (Mahakoshal, Betul, and Chitradurga); Gondwana rift basin; Ediacaran biota and earliest life in Indian Precambrian sequences. Eparchean unconformity: Its significance as a global event

UNIT-3 (15 HOURS)

Stratigraphy of Type sections of India: Cambrian of Salt Range, Paleozoic of Kashmir, Spiti, Kumaon and Gondwana. Mesozoic: Jurassic of Kutch and Narmada, Triassic of Spiti and Kashmir. Cretaceous of Trichinopoly and Deccan Traps. Cenozoic of Assam and Siwalik. Quaternary of Kashmir. Boundary problems in stratigraphy and fixing of boundaries from Indian stratigraphy: Precambrian-Cambrian (PC) Boundary: Permian-Triassic (PT) Boundary; Cretaceous-Tertiary (KT) Boundary and Neogene-Quaternary.

Suggested Readings

Bignot G., 1985, Elements of Micropalaeontology, Graham Trotman,
Clarkson, E.N.K., 1998: Invertebrate Palaeontology and Evolution. IV Ed.-Blackwell.
Colbert E.M., 1960, Evolution of the vertebrates, Wiley Eastern.
Danbar, C.O. and Rodgers, J., 1957: Principles of Stratigraphy, John Viley and Sons.
Doyle, Peter, 1996, Understanding fossils: an introduction to invertebrate palaeontology
GSI 1990 Stratigraphic Boundary Problems in India, Memoir 16, ISSN No: 0016-7622, Geological Society of India, Bangalore, 116p.
Krishnan, M. S. 1982. Geology of India and Burma. C.B.S. Publ. and Distributors, Delhi.
Krumbein and Sloss 1956 Stratigraphy and Sedimentation, McGraw Hill.
Naqvi, S.M. and Rogers, J.J.W., 1987: Precambrian Geology of India, Oxford University Press.
Pascoe, E.H., 1968: A Manual of the Geology of India and Burma (Vols. I-IV).
Ramkrishnan, M. and Vaidhyanadhan, R. 2008. Geology of India, Volume I and II, Geological Society of India, Bangalore.

-X-

COURSE CODE: FIELDWORK
COURSE CODE: IGLYMJFW0426
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs.: 90
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion of this course, the students will be able to:
CLO_1: This course will impart the field knowledge of identifying various geological structures, rock types, mineral deposits, mapping skills, etc., necessary for mineral exploration, disaster management, environmental protection, etc.
CLO_2: During this course, students will be exposed to various geological sites across Kashmir Valley, so that they get a deep knowledge of the Geology and geomorphology of the valley, prepare a brief field report and communicate findings through oral presentations.

Contents: Subject-based geological field training shall be conducted on every alternate week in the Kashmir Valley or whatever may be decided by the DC for a total duration of 7 days or as may be decided by the DC to give the students basic field geological knowledge.

5th SEMESTER

COURSE NAME: PALEONTOLOGY
COURSE CODE: IGLYMJPT0526
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: This course will enable the students to understand the processes and patterns of fossilization and applications of fossils.
CLO_2: Detailed morphology, classification, and geological distribution of fossils would help the students in understanding the evolution of life.
CLO_3: Describe and interpret the concepts of biostratigraphy, paleobiogeography, and paleoecological significance of various groups of fossils.
CLO_4: Apply practical skills to interpret and understand the fossilization environment of the given fossils.

UNIT-1 (15 HOURS)
Overview of paleontology: Introduction & scope of paleontology. Fossils & Fossilization: Definition and processes of fossilization. Types of fossils and applications of fossils. Origin of life. Precambrian fossil record. Origin of Metazoa; Taphonomy parameters in taphonomic studies; Fossil assemblages and communities and their applications; Concept of paleoecology and paleobiogeography; Mass extinctions and their causes.

UNIT-2 (15 HOURS)
Invertebrate Paleontology: Overview of invertebrate paleontology and its application. Functional morphology, classification, evolutionary trends and geological history of Brachiopoda, Lamellibranchia, Gastropoda, Cephalopoda, Trilobites.

Vertebrate Paleontology: Vertebrate life through ages and landmarks in the evolution of vertebrate life. Evolution of horses and humans. Siwalik mammals and possible causes of their extinction.

UNIT-3 (15 HOURS)
Micropaleontology: Morphology classification and application of Foraminifera, Conodonts, and Ostracoda. Oxygen and carbon isotope studies of microfossils and their use in paleo-oceanographic and paleoclimatic interpretation and hydrocarbon exploration.

Paleobotany: Introduction to paleobotany and an overview of plant life through geological time. Morphology of Gondwana flora and their paleoclimatic significance. Palynology: Introduction to Pollen and Spores and their applications.

PRACTICAL (1 CREDIT: 30 HOURS)
Identification, classification, and morphological study of selected invertebrate fossils microfossils and taxonomic study of selected Gondwana plant fossils with labelled diagrams.

Suggested Readings
Armstrong, H.A. and Brasier, M.D. (2005). Microfossils. Blackwell Publishing.
2. Benton, M. (2009). Vertebrate Paleontology. John Wiley.
3. Clarkson, E.N.K. (2012). Invertebrate Paleontology and Evolution, 4th Edn.
4. Raup, D.M., Stanley, S.M. and Freeman, W.H. (1971). Principles of Paleontology.
5. Shukla, A.C. and Misra, S.P. (1975). Essentials of Paleobotany. Vikas Publisher, New

-X-

COURSE NAME: ECONOMIC GEOLOGY
COURSE CODE: IGLYMJEG0526
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 60
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the genesis, classification, and geological settings of mineral deposits, including magmatic and hydrothermal systems.
CLO_2: Identify and interpret ore minerals, textures, structures, and paragenetic sequences using basic ore microscopy concepts.
CLO_3: Analyze the relationship between plate tectonics, crustal evolution, and global metallogenic patterns.
CLO_4: Evaluate important mineral deposits of India and assess their economic significance, resource potential, and policy framework.

UNIT-1 (15 HOURS)

Mineral deposits: types, morphology, and forms of ore bodies. Source of ore-forming materials. Physico-chemical environment of ore formation. Genetic classification of mineral deposits. magmatic ore deposits (chromite, magnetite, PGE—Bushveld Complex). Hydrothermal deposits (VMS, porphyry, SEDEX, MVT, IOCG). Basic concepts of ore genesis and migration of ore-forming solutions.

UNIT-2 (15 HOURS)

Ore microscopy, polishing, and mounting techniques. Physical and optical properties of important ore minerals. Textures and structures of ore and gangue minerals. Paragenesis and zoning. Metallogenic epochs and provinces. Introduction to geothermometers (trace elements, isotopes) and fluid inclusions.

UNIT-3 (15 HOURS)

Global tectonics and metallogeny. Patterns in distribution of mineral deposits. Crustal evolution and metallogenesis. Plate tectonics and ore deposits. Metallogeny through geological time. Stratiform and stratabound deposits: distribution, setting, and origin.

UNIT-4 (15 HOURS)

Mineral deposits associated with ultramafic, mafic, and felsic rocks. Anorthosite-associated Fe-Ti deposits. Post-magmatic, sedimentary, and supergene deposits (placer deposits, residual concentration, enrichment). Important Indian deposits: U (Jaduguda), Pb-Zn (Rajasthan), Cu (Singhbhum and Malanjkhand), bauxite (east coast), and iron ores (Bailadila and Kudremukh). Strategic and critical minerals. National mineral policy.

Suggested Readings

Barnes H.L. – Geochemistry of Hydrothermal Ore Deposits. 1997. John Wiley & Sons.
Craig J.R. and Vaughan D.J. – Ore Microscopy and Ore Petrography. 1994. J. Wiley & Sons.
Evans A.M. – Ore Geology and Industrial Minerals. 1992. Blackwell Science.
Jensen M.L. and Bateman A.M. – Economic Mineral Deposits. 1981. John Wiley & Sons.
Misra K.C. – Understanding Mineral Deposits. 1999. Kluwer Academic Publishers.
Mookherjee A. – Ore Genesis: A Holistic Approach. 1998. Allied Publishers.
Stanton R.L. – Ore Petrology. 1981. McGraw Hill.

Arndt N. and Ganino C. – Metals and Society. 2012. Springer.
Robb L. – Introduction to Ore-Forming Processes. 2004. Blackwell Science.
Deb M. and Sarkar S.C. – Minerals and Allied Natural Resources and Their Sustainable Development. 2017. Springer.

-X-

COURSE NAME: GEOCHEMISTRY
COURSE CODE: IGLYMJGC0526
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO-1: To explain the origin of earth, origin of elements and classification and substitution of minor ions in place of major ions in rock forming minerals.

CLO-2: To understand the partition coefficient or distribution of trace elements in mineral and melt phases.

CLO-3: To apply geochemical data in petrogenesis of igneous, metamorphic rocks and to understand the paleoredox, paleoweathering and provenance characteristics of sedimentary rocks.

UNIT-1 (15 HOURS)

Introduction and scope of geochemistry. Modern theories of origin of Earth, Differentiation and formation of core, mantle, crust, hydrosphere, atmosphere. Origin and abundance of elements in the solar system and in the Earth. Meteorites: Classification, mineralogy and chemical composition. Goldschmidt's classification of elements. Goldschmidt's rules for ionic substitution. Geochemical classification of elements. Significance of PGE and REEs.

UNIT-2 (15 HOURS)

Chemical kinetics in geoscience and its applications. thermodynamics of reactions involving pure phases, ideal and non-ideal solutions, and fluids; equilibrium and distribution coefficients. Concept of partition and distribution coefficient of trace elements. Physical control of the values of partition coefficients in mineral/melt systems. Geological controls on the distribution of trace elements.

UNIT-3 (15 HOURS)

Application of trace elements in the petrogenesis of igneous rocks. Application of immobile trace elements in understanding protoliths of metamorphic rocks. Application of trace elements in sedimentary environments and provenance studies. Paleoweathering and redox indicators. Stability diagrams and their applications (Eh/pH). Stable isotopes (H, B, C, O, S): abundance, distribution, and fractionation in natural systems.

PRACTICAL (1 CREDIT: 30 HOURS)

- Mineral formula recalculation (on Excel worksheets) of olivine, pyroxene, amphibole, mica, and feldspars.
- Calculation of weathering indices in soil and sedimentary rocks and sediments.
- Preparation of classificatory and variation diagrams of some important igneous, metamorphic, and sedimentary rocks and their interpretation.
- Plotting of REE data and their interpretation.
- Software & worksheets for geochemical data analysis (GCD kit, Norm4, etc.).

Suggested Readings

Faure, G., 1986: Principles of Isotope Geology-John Wiley.
Henderson, P., 1987: Inorganic Geochemistry-Pergamon Pres.
Hoefs, J., 1980: Stable isotope Geochemistry –Springer Verlag.
Hugh, R. Rollinson. 1993: Using Geochemical Data: Evaluation, Presentation and Interpretation, Pearson Prentice Hall.
Krauskopf, K. B., 1967: Introduction to Geochemistry-McGraw Hill.
Kula, C. Misra., 2012: Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.
Lentz D.R., 2003, Geochemistry of Sediments and Sedimentary Rocks. Publisher: Geological Assn of Canada
Marshal, C. P. and Fairbridge, R.W., 1999: Encyclopaedia of Geochemistry-Kluwer Academic.
Mason, B. and Moore, C. B., 1991: Introduction to Geochemistry-Wiley Eastern.
Nordstrom, D. K. and Munoz, J. L., 1986: Geochemical Thermodynamics-Blackwell.
Paul Alexandre, 2022: Practical Geochemistry. Springer Nature Switzerland AG.
White, W. M., 2018: Encyclopaedia of Geochemistry. Springer.
White, W. M., 2023: Isotope Geochemistry, Wiley.

-X-

COURSE NAME: GEOTECTONICS
COURSE CODE: IGLYMJGT0526
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 60
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain Earth’s internal structure, heat flow, isostasy, and the evolution of tectonic theories, including plate tectonics and paleomagnetism.

CLO_2: Analyze plate boundary processes, subduction dynamics, mantle plumes, and supercontinent cycles in global tectonic frameworks.

CLO_3: Evaluate lithospheric deformation, basin formation, and the linkage between tectonics and sedimentation.

CLO_4: Assess tectonic evolution through geological time and its controls on resources and geohazards using modern investigative tools.

UNIT-1 (15 HOURS)

Introduction to Dynamic Earth and Geotectonics. Internal Structure & Composition. Origin and age of the Earth. Earth's interior. Composition of the earth. Earth’s geological process. Earth Movements: Exogenous Processes and Endogenous Processes. Earth’s layers (crust, mantle, core) based on seismic evidence and physical properties. Endogenetic forces, including folding, faulting, and their topographic expressions.

UNIT-2 (15 HOURS)

Mountain Building: Theories including Geosynclinal theory (Kober), thermal contraction (Jeffreys), and convection current (Holmes). Continental Drift Theory: Evidence for

Continental Drift; Seafloor Spreading: Evidence for Seafloor Spreading Theory, Paleomagnetism, Concept of Isostasy, and Theories: Theories of Airy and Pratt regarding the equilibrium of the Earth's crust.

UNIT-3 (15 HOURS)

Concept of Plate Tectonics: The Three Types of Plate Boundaries and Plate Margins; Wilson Cycle; Hot Spots: An Intraplate Feature; Plate Movement and Motion; Driving Mechanism of Plate Tectonics; Plate Tectonics and Distribution of Earthquakes and Volcanoes.

UNIT-4 (15 HOURS)

Plate Tectonics and Igneous Activity. Plate Tectonics and Metamorphism. Plate Tectonics and the Distribution of Natural Resources. Plate Tectonics and Mountain Building. Features Found in the Deep-Ocean Basins: Crustal growth and continental evolution.

Suggested Readings

Kearey P., Klepeis K.A. and Vine F.J. – Global Tectonics. 2009. Wiley-Blackwell.
Turcotte D.L. and Schubert G. – Geodynamics. 2014. Cambridge University Press.
Condie K.C. – Plate Tectonics and Crustal Evolution. 2011. Butterworth-Heinemann.
Windley B.F. – The Evolving Continents. 1995. Wiley.
Fowler C.M.R. – The Solid Earth: An Introduction to Global Geophysics. 2005. Cambridge University Press.
Frisch W., Meschede M. and Blakey R. – Plate Tectonics: Continental Drift and Mountain Building. 2011. Springer.

-X-

6^{th} SEMESTER

COURSE CODE: ENGINEERING GEOLOGY
COURSE NAME: IGLYMJEG0626
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain the principles of engineering geology and evaluate the role of geological investigations in site selection and failure analysis of engineering structures.

CLO_2: Analyze engineering properties of rocks and soils and classify them using standard geotechnical systems for construction suitability.

CLO_3: Assess geological factors in the design and stability of engineering structures such as dams, tunnels, slopes, and seismic-resistant infrastructure.

CLO_4: Apply practical skills to determine engineering properties of rocks, perform classifications, and evaluate slope stability through field and laboratory studies.

UNIT-1 (15 HOURS)

Principles of Engineering Geology: Role of engineering geology in civil construction and mining. Stages of geological site investigations for the selection of a site for engineering structures. Important geo-engineering failures: Geological causes for mishaps and failures of engineering structures (e.g., Joshimath land subsidence). Surface and subsurface investigations for site selection

UNIT-2 (15 HOURS)

Engineering properties and classification of rocks. Physical characteristics of building stones, concrete, and other aggregates. Alkali-aggregate reactions and artificial aggregate. Engineering properties of soil, Atterberg limits, and cohesive and non-cohesive soils. Quick clay, quicksand, thixotropy, soil liquefaction, and creep Rock mass classification: Terzaghi's rock mass classification, Coates geomechanical classification (C-factor), Q-system, and geochemical classification.

UNIT-3 (15 HOURS)

Geological investigations for the construction of buildings, dams, reservoirs, bridges, highways, tunnels, and coastal protection structures. Dams: Types, foundation problems in dam construction. Seismic design of buildings and infrastructure. Seismic zones of India. Rock stability tests. Structural and nonstructural slope stability measures.

Practical/Tutorial/Mini Project (1 Credit: 30 HOURS)

- Study of properties of common rocks with reference to their utility in engineering projects.
- Determination of engineering properties of rocks.
- Exercises on various rock classifications.
- Fieldwork for assessing different types of slope instability in J&K (e.g., Mughal Road-Hirpora to Pir Ki Gali).

Suggested Readings

Arms, K., 1990: Environmental Science. Saunders College Pub.

Bell, F. G., 1999: Geological Hazards: Their Assessment, Avoidance & Mitigation. E&FN S. London.

Bell, F. G., 1999: Geological Hazards. Routledge, London.
Bell, F. G., Engineering Properties of Soils and Rocks.
Bieniawski, Z.T. 1989: Engineering rock mass classifications. New York Wiley.
Bryant, E., 1985: Natural Hazards. Cambridge University Press.
Goodman, R. E., Engineering Geology.
Keller, E. A., 1978: Environmental Geology. Bell and Howell, USA.
Krynine, D. H. and Judd, W.R., 1998: Principles of Engineering Geology. CBS Pub.
Masroor, A. M., 2012: Fundamentals of Engineering Geology and Geoengineering. Agrawal Publications.
Singh, B and Goel, R. K., 2011: Engineering Rock Mass Classification: Tunnelling, Foundations, and Landslides-Elsevier.

-X-

COURSE NAME: REMOTE SENSING AND GIS
COURSE CODE: IGLYMJRG0626
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the fundamentals of remote sensing, including electromagnetic radiation, image acquisition, and principles of visual image interpretation.
CLO_2: Analyze and process remote sensing data using digital image processing techniques, including enhancement, classification, and accuracy assessment.
CLO_3: Apply GIS and GNSS concepts to interpret spatial data for geological, environmental, and hydrological applications.
CLO_4: Develop practical skills in handling remote sensing and GIS software to generate thematic maps and perform spatial analysis.

UNIT-1 (15 HOURS)
Remote Sensing: Basic concepts, fundamentals, data sources. Types of scanners and image acquisition. History and scope of remote sensing, concepts of remote sensing, electromagnetic radiation, and matter interactions with the atmosphere and terrain. Atmospheric windows. Spectral reflectance of vegetation, soils, minerals, and rocks. Elements of visual image interpretation. Factors governing image interpretation, verification, and validation of RS data (ground truthing).

UNIT-2 (15 HOURS)
Digital analysis of remote sensing data: Picture element and image statistics. Geometric and radiometric distortions. Pre-processing of satellite data (radiometric and geometrical corrections). Image enhancement techniques. Image filtering techniques. Spectral ratios and indices. Digital image classification: Supervised and unsupervised classification. Accuracy assessment: sources of errors and measurement of map accuracy, and Kappa coefficient.

UNIT-3 (15 HOURS)
Geographic Information System (GIS), GIS software, and applications. Introduction to GNSS and GPS, Applications of Remote Sensing and GIS to Geosciences: Lithology and Structure (Faults, Folds). Environmental: Land Use and Land Cover (LULC) changes, monitoring erosion, urbanization, and deforestation. Survey: Cadastral mapping, digital terrain models. Hydrology: Hydrological modeling and groundwater prospecting.

Practical/Tutorial/Mini Project (1 Credit: 30 HOURS)
Working with remote sensing and GIS software systems Erdas and ArcGIS.

- Import and export of satellite data
- Different image and remote sensing data formats.
- Earth surface features on the images.
- Generation of shapefiles and image clips; preparation of lithological, drainage, LULC, slope, and aspect maps.
- Grass GIS for Geomorphon: hands-on practices on open-source GIS software like QGIS.

Suggested Readings
Lillesand, T. M., Kiefer, R. W., and Chipman, J. W., 2015: *Remote Sensing and Image Interpretation*.
Joseph, G. and Jeganathan, C., 2018: *Fundamentals of Remote Sensing*.
Bhatta, B., 2011: *Remote Sensing and GIS*.
Gonzalez, R. C. and Woods, R. E., 2018: *Digital Image Processing*.
Jensen, J. R., 2015: *Introductory Digital Image Processing*.
Longley, P. A., et al., 2015: *Geographic Information Systems and Science*.
Burrough, P. A., et al., 2015: *Principles of Geographic Information Systems*.
Leick, A., Rapoport, L., and Tatarnikov, D., 2015: *GPS Satellite Surveying*. Wiley.
ArcGIS — Developed by Esri. Widely used GIS platform for spatial analysis and mapping.
QGIS — Developed by the QGIS Development Team.

-X-

COURSE NAME: GEOLOGICAL FIELDWORK
COURSE CODE: IGLYMJFW0626
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 120
Max. Marks: 100

CLO_1 This course will impart the field knowledge of identifying various geological structures, rock types, mineral deposits, mapping skills, etc., necessary for mineral exploration, disaster management, environmental protection, etc.

CLO_2 During this course, the students will be taken to various geological field sites selected across different states/UTs of India so that they get a deep knowledge of the geology of the country.

Content: Geological field training of one, two, or three weeks or whatever is decided by the DC shall be conducted in different parts of the country. Students are required to prepare a detailed field report after the field trip, which will contain data collected by them in the field, along with analysis and interpretation of the data as well as other supplemental information from the course material. The students are expected to include primary research data in support of their interpretation in addition to the basic report requirements, followed by a field report presentation and viva voce.

-X-

COURSE NAME: EXPLORATION AND MINING GEOLOGY
COURSE CODE: IGLYMJEM0626
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain principles of mineral exploration, including geochemical and geophysical prospecting methods and their applications.

CLO_2: Describe drilling techniques, sampling methods, and core logging procedures, and evaluate common drilling problems and their mitigation.

CLO_3: Analyze mining methods and apply concepts of rock mechanics, ventilation, and safety in surface and underground mining operations.

CLO_4: Apply integrated exploration and mining concepts through practical exercises or mini-projects for real-world problem-solving.

UNIT-1 (15 HOURS)

Exploration Geology: Introduction to Mineral Resources, Classification of mineral deposits based on genesis and morphology. Concepts of geochemical prospecting: dispersion, pathfinder elements, geochemical sampling, and geochemical field techniques. Geophysical methods: gravity, magnetic, electrical, radioactive, seismic, and electromagnetic methods—their principles and applications in mineral exploration.

UNIT-2 (15 HOURS)

Drilling Techniques: Percussion drilling, rotary drilling, diamond core drilling, reverse circulation (RC) drilling, blast hole drilling, and auger drilling. Geophysical logging (SP, resistivity, gamma). RQD and types of core barrels (single/double/triple tube), core orientation, handling, and preservation. Methods of sampling: channel, bulk, grab, chip, car, core, and sludge. Trenching and pitting method. Drilling Problems: Loss of core, stuck pipe, deviation, water ingress, borehole collapse, and mitigation measures.

UNIT-3 (15 HOURS)

Application of rock mechanics in mining. Planning, exploration, and exploratory mining of surface and underground mineral deposits. Classification of mining methods. Mining Methods: Placer mining methods, open pit methods, underground mining methods, and ocean bottom mining. Ventilation in underground mining: Purpose, types, and arrangements of ventilation in underground mining. Mining hazards and safety measures. Mine inundation, fire, and rock burst.

Mini Project/Tutorial (1 Credit: 30 HOURS)

Students will choose a topic/problem from the course and prepare a mini-project under the supervision of the concerned faculty member or do an internship with any institute that works on mining.

Suggested Readings

Barnes, H. L., 1979: Geochemistry of Hydrothermal Ore Deposits. John Wiley and Sons, 798pp.

Craig, J. R., and Vauhan, d. J., 1994: Ore Microscopy and Ore Petrography.

Evans, A. M., 2013: Ore Geology and Industrial Minerals. John Wiley and Sons, 400pp.

Klemmand, D. D. and Schneider, H. J., 2012: Time and Strata Bound Ore Deposits. Springer Science & Business Media, 446pp.

Oobrin, M. B. and Savit, C. H., 1988: An introduction to Geophysical Prospecting by McGraw Hill, New Delhi.

Stanton, R. L., 1972: Ore Petrology. McGraw-Hill, 713 pp.

Telford W. M. Geldart L. P., Sheriff, R. E. and Keys D. A., 1976: Applied Geophysics. Oxford and IBH Publishing Co. Pvt., Ltd. New Delhi. Rao, R., Prasaranga, M. B., 1975: Outlines of Geophysical Prospecting - A manual for geologists. University of Mysore, Mysore.

COURSE NAME: HYDROGEOLOGY
COURSE CODE: IGLYMJHG0626
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the occurrence, distribution, and properties of groundwater, including aquifer types and subsurface water zones.
CLO_2: Apply principles of groundwater flow, including Darcy's law, to analyze aquifer behavior and well hydraulics.
CLO_3: Evaluate methods of groundwater exploration, quality assessment, and issues of contamination and recharge.
CLO_4: Apply practical techniques for groundwater analysis, including map interpretation, basic calculations, and data representation.

UNIT -1 (15 HOURS)
Scope and importance of hydrogeology; hydrological cycle; origin and occurrence of groundwater; zones of subsurface water (zone of aeration and zone of saturation); water table and piezometric surface; types of aquifers (unconfined, confined, semi-confined, perched); porosity and permeability; specific yield and specific retention; factors controlling groundwater occurrence; types of geological formations as aquifers.

UNIT -2 (15 HOURS)
Principles of groundwater flow; Darcy's law and its applications; hydraulic conductivity and transmissivity; groundwater flow in porous media; concept of recharge and discharge; cone of depression; steady and unsteady flow (introductory); types of wells (dug wells, tube wells, artesian wells); well interference and well efficiency.

UNIT -3 (15 HOURS)
Methods of groundwater exploration (geological, geophysical – basic idea); groundwater quality and contamination; water quality parameters (pH, hardness, salinity); sources of groundwater pollution; artificial recharge of groundwater; groundwater management and conservation; role of hydrogeology in water resource planning and environmental protection.

PRACTICAL (1 CREDIT: 30 HOURS)
Study of hydrological maps and water table maps; identification of aquifer types from geological sections; measurement of water levels (demonstration/field); calculation of porosity and permeability (simple methods); application of Darcy's law (numerical problems); interpretation of pumping test data (basic level); preparation of groundwater level contour maps and simple hydrographs.

Suggested Readings
Todd D.K. and Mays L.W. – Groundwater Hydrology. 2005.
Fetter C.W. – Applied Hydrogeology. 2001. Applied Hydrogeology (4th Edition). Prentice Hall.
Karanth K.R. – Groundwater Assessment, Development and Management. 1987.
Freeze R.A. and Cherry J.A. – Groundwater. 1979. Prentice Hall.
Domenico P.A. and Schwartz F.W. Physical and Chemical Hydrogeology. 1998. J. Wiley & Sons.
Raghunath H.M. – Groundwater. 2006. New Age International.
Subramanya K. – Engineering Hydrology. 2013. McGraw-Hill Education.
Singhal B.B.S. and Gupta R.P. – Applied Hydrogeology of Fractured Rocks. 2010. Springer.
Central Ground Water Board Reports and Publications.

7^{th} SEMESTER

COURSE CODE: GEOPHYSICS
COURSE NAME: IGLYMJGP0726
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain fundamental principles of geophysics, Earth structure, and physical properties governing geophysical methods.

CLO_2: Analyze geophysical data acquisition, processing, and interpretation, including sources of errors and uncertainties.

CLO_3: Apply gravity, magnetic, electrical, seismic, and radiometric methods for geological, environmental, and resource investigations.

CLO_4: Evaluate the use of GPS/GNSS and integrated geophysical techniques in tectonics, hazard assessment, and modern geoscientific studies.

UNIT-1 (15 HOURS)

Introduction to geophysics and its scope; concept of geoid and Earth's shape; internal structure of the Earth; physical properties of Earth materials—density, porosity, permeability, electrical resistivity, magnetic susceptibility, and seismic velocity; elastic properties—Young's modulus, shear modulus, bulk modulus, and Poisson's ratio; heat flow and geothermal gradient (introductory); principles and classification of geophysical methods—gravity, magnetic, electrical, seismic, radiometric, and electromagnetic; and basics of satellite geodesy.

UNIT-2 (15 HOURS)

Fundamentals of wave propagation, electrical conduction, magnetic response, and radioactive decay; geophysical field measurements and instrumentation; data acquisition techniques, noise, and error sources; basic data processing and interpretation; types of geophysical anomalies (local, regional) and corrections (drift, terrain, diurnal); forward and inverse problems (conceptual); uncertainty and limitations in geophysical interpretation.

UNIT-3 (15 HOURS)

Applications of geophysics in geology. Gravity and magnetic methods for structural mapping, basin analysis, and mineral exploration. Electrical and electromagnetic methods in groundwater studies, environmental investigations, and mineral prospecting. Seismic methods for subsurface imaging, tectonic studies, and hydrocarbon exploration. Radiometric methods for lithological mapping and alteration detection. Integrated geophysical interpretation using multi-method datasets.

UNIT-4 (15 HOURS)

Principles of GPS and GNSS systems; satellite-based positioning and accuracy; applications of GPS in geology—tectonic deformation, crustal movement, landslide monitoring, and hazard assessment; introduction to remote sensing and GIS in geophysics; geophysical applications in engineering geology, environmental monitoring, and natural hazard studies; emerging trends—geophysical modeling, real-time monitoring, and interdisciplinary approaches.

Suggested Readings

Active Tectonics. Studies in Geophysics. Nat. Acad. Press, Washington, DC, p136-147.

Keller E., 1986. Investigation of active tectonics: use of surficial earth processes. In: Wallace, R. E. (Ed.).
Lowrie, W., 2007. Fundamentals of Geophysics (Second Ed.). Cambridge University Press, 381p.
Parasnis, D. S., 1975: Principles of Applied Geophysics. Chapman and Hall.
Stanislave, M., 1984: Introduction to Applied Geophysics. Reidel Publ.
Telford W.M., Geldart L.P. and Sheriff R.E. – Applied Geophysics. 1990. Cambridge Uni. Press.
Dobrin M.B. and Savit C.H. – Introduction to Geophysical Prospecting. McGraw Hill.
Kearey P., Brooks M. and Hill I. –An Introduction to Geophysical Exploration. Blackwell Science.
Reynolds J.M. – An Introduction to Applied and Environmental Geophysics. Wiley-Blackwell.

-X-

COURSE CODE: ADVANCED STRUCTURAL GEOLOGY
COURSE NAME: IGLYMJSG0726
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion the students will be able to:

CLO_1: Explain stress-strain concepts, failure criteria, and methods of strain analysis in naturally deformed rocks.

CLO_2: Analyse brittle deformation features including faults, fractures, joints, and shear zones, and their tectonic significance.

CLO_3: Interpret ductile deformation structures such as folds, boudinage, and superposed folding patterns using geometric and kinematic principles.

CLO_4: Apply practical skills in geological map preparation, stereographic projection, and interpretation of structural data from field and laboratory studies.

UNIT -1 (15 HOURS)

Rock Mechanics: Concept of stress. Stress ellipses and ellipsoids and their applications. Calculation of stress acting on a plane. Construction of Mohr circle. Mohr stress envelope. Rock failure criteria: Coulomb's criterion and Griffith's theory. Geometry and mechanics of fracturing. Concept of strain. Calculating the variations in strain. Strain ellipsoid and its application. Strain marker in naturally deformed rocks. Methods of strain measurement in deformed rocks. Finite and infinitesimal strain. Flinn diagram: constriction, plain strain and flattening, strain ellipse, and its calculation. Particle paths and flow patterns. Simple shear, pure shear, sub-simple shear, and super shear deformation and their respective particle paths. Progressive strain history.

UNIT -2 (15 HOURS)

Brittle Deformation: Fractures—Nature and their nomenclature, age relationship, origin, and significance. Failure and fracture criteria. Fracture termination and interaction. Concept of faults. Mechanics of faulting: Anderson's theory and its limitations. Normal fault, strike-slip, and thrust faults. Thrust systems: thin-skinned and thick-skinned deformation and decollement. Geometric and structural analyses of joints, meso-fracture analyses, and fractography.
Shear zones: Geometry and kinematics, their significance in continental crustal evolution, mylonites, cataclasites, and pseudotachylytes. Transpression and transtension.

UNIT -3 (15 HOURS)

Ductile Deformation: Concept of folds. Ramsay's classification of folds, a variation of the thickness of the folded layer. Biot's law of buckling. Geometry and mechanics of the development of folds. Mechanism of single-layer and multilayer folds and associated structures. Flexural slip, flexural shear folding. Basic concepts of superimposed folding, interference patterns. Fault-related folding. Principles and methods of structural analysis in areas of superposed folding. Sheath folds. Folds in shear zones. Folding at shallow crustal depths. Linear and planar structures: classification and origin. Boudinage and pinch-and-swell structures.

PRACTICAL (1 CREDIT: 30 HOURS)

- Preparation and interpretation of geological maps and cross-sections.
- Stereographic projections and structural analysis
- Acquiring geological and structural data from the field and interpreting it in the lab.

Suggested Readings

Bayly, B., 1992. Mechanics in Structural Geology, Springer.
Davis, G. H., Reynolds, S. J. and Kluth, C. F., 2011: Structural Geology of Rocks and Regions.
Davis, G. R., 1984: Structural Geology of Rocks and Region. John Wiley.
Fossen, H, 2010: Structural Geology (2nd Ed), Cambridge University Press.
Ghosh. S. K., 1995: Structural Geology Fundamentals of modem Developments. P. Press.
Hobbs, B. E., Means, W. D. & Williams, P. F., 1976: An Outline of Structural Geology. JW.
Lisle, R. J. and Leyshon, P. R., 2004: Stereographic projection techniques for geologists and civil engineers. Cambridge University Press.
Pollard, D.D. and Fletcher, R.C., 2005. Fundamentals of structural geology.
Price, N. J. and Cosgrove, J., 1990: Analysis of geological structures. Cambridge University Press.
Raga, D. M., 2009: Structural Geology (4th Ed). Cambridge University Press.
Ramsay, J. G, 1967: Folding and Fracturing of Rocks. McGraw7 Hill.
Ramsay, J. G. and Huber, M. I., 2010: Modem Structural Geology.
Ramsay, J. G. and Lisle, R. J., 2010: The techniques of modern structural geology.
Twiss, R. J, and Moors, E. M., 1992. Structural Geology.

-X-

COURSE CODE: ENVIRONMENTAL GEOLOGY AND CLIMATE CHANGE
COURSE NAME: IGLYMJEC0726
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Learning outcomes (CLOs): Upon completion, students will be able to.

CLO_1: Explain fundamental concepts of environmental geology, including contaminant behavior, pollution sources, and rock–water interactions.

CLO_2: Evaluate geological and hydrogeological criteria for waste disposal, contaminant migration, and remediation strategies.

CLO_3: Analyze atmospheric processes, climate systems, and their influence on weathering, sedimentation, and geomorphic dynamics.

CLO_4: Assess impacts of climate change and anthropogenic activities on geological environments and propose sustainable mitigation approaches.

UNIT -1 (15 HOURS)

Environmental Geology: Introduction to environmental geology and fundamental concepts of environmental geosciences. The Earth system and its components. Geochemical speciation and mobility of contaminants. Soil pollution: sources and major contaminants. Water pollution and major geogenic contaminants in surface and groundwater. Rock-water–contaminant interaction:

Natural Attenuation: geochemical and biological mechanisms. Introduction to Waste Types: Municipal, Industrial, Radioactive, Mining, and Agricultural

UNIT -2 (15 HOURS)

Geological Criteria for Landfill and Repository Site Selection. Hydrogeological assessment for leachate and contaminant migration control. Geotechnical evaluation for waste dumping and storage sites. Subsurface migration pathways and natural geologic barriers. Geochemical controls on acid mine drainage (AMD) and leachate generation. Geological Controls on Remediation Technology Feasibility. In-Situ Remediation Methods: Permeable Reactive Barriers, Bioremediation, Chemical Oxidation

UNIT -3 (15 HOURS)

Structure of the Atmosphere and Earth's Radiation Balance. Latitudinal and Seasonal Variation of Insolation. Temperature, Pressure, and General Circulation of the Atmosphere. Humidity, Cloud Formation, and Precipitation Mechanisms. Air Masses, Fronts, and Mid-Latitude Cyclones. Monsoon Systems: Onset, Active-Break Cycles, and Intraseasonal Variability. Jet Streams and Western Disturbances. Tropical Cyclones and ENSO Teleconnections. Atmospheric Boundary Layer: Structure, Diurnal Cycle, and Orographic Effects. Orographic Precipitation and Rain Shadow Effects. Climate Controls on Chemical and Mechanical Weathering Rates. Sediment Production and the Precipitation-Sediment Yield Relationship. ENSO Teleconnections and Sediment Flux Dynamics.

UNIT -4 (15 HOURS)

Overview of Global Climate Change: Causes and Indicators: Greenhouse Gases: Sources and Radiative Forcing. Positive and Negative Feedback Mechanisms in the Climate System. Sea Level Rise. Cryosphere Changes: Glacier Retreat, Snow Cover Decline, and Arctic Sea Ice Loss. Permafrost Thaw: Thermokarst, Ground Ice Degradation, and Slope Instability. Ocean Acidification: Carbonate System Chemistry and Geological Implications. Ozone Depletion and Acid Deposition. Slope Instability under Changing Hydroclimatic Regimes. Anthropogenic Modification of Precipitation and Water Balance. Climate Change Impacts on Coastal Geological Environments: Saltwater Intrusion, Coastal Erosion, Delta Subsidence

Suggested Readings

Bell, F. G., 1999: Geological Hazards-Routledge, London.
Bryant, E., 1985: Natural Hazards-Cambridge University Press.
Keller, E. A., 1978: Environmental Geology–Belland Howell, USA.
Patwardhan, A. M., 1999: The Dynamic Earth System-Prentice Hall.
Smith, K., 1992: Environmental Hazards-Routledge, London.
Subramanian, V., 2001: Textbook in Environmental Science-Narosa International.
Valdiya, K. S.,1987: Environmental Geology-Indian Context-Tata McGraw Hill.

-X-

COURSE CODE: FIELD TRAINING
COURSE NAME: IGLYMJFT0726
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 120
Max. Marks: 100

- **CLO_1** This course will impart the field knowledge of identifying various geological structures, rock types, mineral deposits, mapping skills, etc., necessary for mineral exploration, disaster management, environmental protection, etc.
- **CLO_2** During this course, the students will be taken to various geological field sites selected across different states/UTs of India so that they get a deep knowledge of the geology of the country.

Content: Geological field training of 2-3 weeks shall be conducted within or outside the J&K state or as decided by DC in consent with the field tour in-charge. The students are responsible for a field report after the field trip, which will contain data collected by them in the field, analysis of the data, interpretation, and other supplemental information from the course material. The students expected to include primary research data in support of their interpretation in the basic report requirements. It will be followed by field report evaluation by an external examiner, presentation, and viva voce.

-X-

COURSE CODE: HIMALAYAN GEOLOGY
COURSE NAME: IGLYMJHG0726
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion of this course, the students will be able to:
CLO_1 Understand the origin, evolution, and geotectonic subdivision of the Himalaya with emphasis on its major physiographic and structural divisions.
CLO_2 Explain the geology and regional framework of key tectonic units in the NW Himalaya, including their lithologies and economic mineral resources.

UNIT -1 (15 HOURS)

Origin and evolution of the Himalaya. Phases of upheaval in the Himalayas. Physiographic and geotectonic subdivisions of the Himalaya. A brief introduction to the geology and regional framework of different geotectonic divisions of the Himalaya: Outer Himalaya, Lesser Himalaya, Tethys Himalaya, Higher Himalayan Crystalline, and Trans-Himalaya.

UNIT -2 (15 HOURS)

Brief introduction about the geology and regional framework of different tectonic units: Dras Volcanics, Indus Ophiolites and Ophiolitic Melange, and Indus Flysch & Molasse sediments of the Indus Suture Zone (ISZ) and Ladakh Batholith in the NW Ladakh Himalaya. Mineral resources of the Himalaya. Brief idea about the Shyok Suture Zone (SSZ) and the accreted Eastern Karakoram Orogen.

Suggested Readings

Biyani, A. K., 2006: Dimensions of Himalayan Geology. Satish Serial Publishing House.
Condie, K. C., 1982: Plate Tectonics and Crustal Evolution Pergamon Press.
Sharma, K. K., 1991: Geology and Geodynamic evolution of the Himalayan Collision Zone.
Sinha, A. K., 1989: Geology of Higher Central Himalaya, John Wiley & Sons, New York.
Tethys, Sinha, A. K., 1992: Himalayan Orogen and Global Tectonics.
Thakur, V. C., 1992: Geology of Western Himalaya. John Wiley & Sons, New York.
Windley B. 1973: The Evolving continents. John Wiley & Sons, New York.

-X-

COURSE CODE: EARTH SURFACE PROCESSES
COURSE NAME: IGLYMJES0726
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30

Max. Marks: 50

Course learning outcomes (CLOs): Upon completion the students will be able to:

CLO_1 Explain key geomorphic processes and landforms across different environments, and analyse tectonic influences on landscape evolution.

CLO_2 Interpret geomorphic markers and apply dating techniques to understand landform development, with emphasis on applications in land use, urbanization, and hazard assessment.

UNIT -1 (15 HOURS)

Geomorphic processes and resulting landforms in glacial, periglacial, fluvial, eolian, karst, and coastal environments. Pedogenesis. Geomorphological cycle. Drainage patterns. Morphometric and morphotectonic analysis of basins. Introduction to tectonic geomorphology: Energetics, active tectonics, and the models of landscape development and modern controversies in tectonic geomorphology. Alluvial river response to active tectonics.

UNIT -2 (15 HOURS)

Geomorphic expressions of dynamic earth processes. Geomorphic markers: Linear and planar geomorphic markers. Landform dating techniques: Relative and absolute dating techniques—clast seismic velocity method, weathering rinds, obsidian hydration rinds, soil development and the carbonate coating method, lichenometry, tree rings, luminescence dating, and carbon-14 dating. Geomorphology in relation to land use, urbanization, and natural hazards.

Suggested Readings

Bloom, A. L. 2011: Geomorphology: A systematic analysis of Late Cenozoic Landforms 3rd Edition. Rawat Publications.
Burbank, D. W. and Anderson, R.S., 2001: Tectonic Geomorphology Blackwell Sciences.
Easterbrook, Easterbrook, 1994: Surface Processes and Land Forms.
Gautam, A., 2015: Geomorphology 5th Edition. Sharda Pustak Bhavan Allahabad.
Halis, J. R. 1983: Applied Geomorphology.
Holmes, A. 1992: Principles of Physical Geology, London.
Kale, V. S. and Gupta, A., 2010: Introduction to geomorphology. University Press.
Sharma, H. S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.
Siddhardha, K. 2016: The Earth's Dynamic Surface- A book of Geomorphology, Kitab Mahal.
Singh, S., 2016: Geomorphology. Pravalika Publication Allahabad.
Summerfield M. A., 2011: Geomorphology and Global Tectonics, Wiley India Pvt Ltd.
Thornbury, W. D., 2004: Principles of Geomorphology. 2nd edition CBS Publication.

-X-

COURSE CODE: PETROLEUM AND COAL GEOLOGY
COURSE NAME: IGLYMJPC0726
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30

Max. Marks: 50

Course learning outcomes (CLOs): Upon completion the students will be able to:

- **CLO_1:** Explain the origin, maturation, and migration of petroleum, and assess source rocks, reservoir characteristics, and exploration methods, including sequence stratigraphy.
- **CLO_2:** Describe coal formation, classification, petrography, and resource distribution, and evaluate unconventional resources and sustainable energy considerations.

UNIT -1 (15 HOURS)

Origin of petroleum: Biogenic and abiogenic theories on the origin of petroleum. Formation of kerogens: diagenesis, catagenesis, and metagenesis. Maturation of kerogen. Migration of Petroleum. Types and characteristics of source and reservoir rocks. Traps: types. Cap rocks and their properties. Petroliferous basins of India and their classification.

UNIT -2 (15 HOURS)

Coal: Origin, rank, types and grade. Physical and chemical properties of coal. Structure and petrography of coal. Maturation of coal. Biochemical coalification. Concepts of lithotype, maceral and micro-lithotype. Petrological methods: Vitrinite reflectance, Geological and geographical distribution of coal deposits in India. Coal bed methane, shale gas. Pros and cons of coal exploration vis-à-vis energy, environment, and policy for sustainable development.

Suggested Readings

Apello, C. A. J. and Postma, D. Geochemistry, Groundwater & Pollution. Balkema, 2005
Chandra, D., Singh, R.M. and Singh, M.P., 2000: Textbook of Coal (Indian Context) Tara Book Agency, Varanasi.
Glennie, K. W., 1998: Petroleum Geology of the North Sea. Blackwell Science.
Guillemot, J., 1986: Oil and Gas Exploration Techniques. Additions Technip.
Holson, G. D. and Tiratsoo, E.N., 1985: Introduction Petroleum Geology. Gulf Pub.
Houston, Keller, S. E., 1994: Mineral Resources, Economic and the Environment. McMillan College Pub.
Landon, R. C., 1996: Principles of Petroleum Development Geology. Printice Hall.
Levarson, 1985: Geology of Petroleum. CBS Pub.
North, F. K., 1985: Petroleum Geology. Allen &Unwin.
Salley, R. C., 1988. Elements of Petroleum Geology. Academic Press.
Singh, M. P., (Ed.), 1998: Coal and Organic Petrology-Hindustan Publ. Corp., New Delhi.
Stach, E., Mackowsky, M. T. H., et al., 1982:7. Stach's Text Book of Coal Petrology- Gebruder Borntraeger, Stuttgart.
Taylor, G. H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert, P., 1998: Organic Petrology-GebruderBorntraeger, Stuttgart.
Tedesco, S. A., 1995: Surface Geochemistry in Petroleum Exploration. Chapman Hall. 15. Tissot, B. P. &Welte, D. H., 1984: Petroleum Formation and Occurrence, Springer Verlag.

-X-

8th SEMESTER

COURSE CODE: ISOTOPE GEOLOGY
COURSE NAME: IGLYMJIG0826
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain fundamental principles of isotope geology, including radioactive decay, nuclear stability, and parent–daughter relationships.
CLO_2: Describe radiogenic isotope systems and evaluate their applications in geochronology and Earth evolution studies.
CLO_3: Analyze stable and cosmogenic isotope data for applications in paleoclimate reconstruction and environmental investigations.
CLO_4: Apply practical skills in interpretation of isochron plots, Concordia–Discordia diagrams, and stable isotope datasets.

UNIT -1 (15 HOURS)

Scope and significance of isotope geology. Historical development: discovery of radioactivity and evolution of isotope studies. Atomic structure, nuclear structure, atomic weights, nuclides, isotopes, and nuclear stability. Radioactive decay: Law of radioactivity, decay constant, half-life, parent–daughter relationships, growth and retention of daughter isotopes in Earth systems.

UNIT -2 (15 HOURS)

Mass spectrometer: Instrumentation, chemical separation, isotope dilution, and ratio analysis. Model Ages: T-CHUR model ages, T-Depleted Mante (DM) model ages. Major radiogenic isotope systems and their geological applications: K–Ar, Rb–Sr, Sm–Nd and U–Th–Pb & Pb-Pb methods.

UNIT -3 (15 HOURS)

Stable isotopes of oxygen and hydrogen, carbon, nitrogen, and sulfur. O and C isotope studies. Cosmogenic isotopes: ^{14}C, Ar-Ar, and beryllium 10. Applications of isotopes in paleoclimate reconstruction and environmental studies.

PRACTICAL (1 CREDIT: 30 HOURS)

Preparation and interpretation of isochron plots (Rb–Sr concept).
Study and interpretation of Concordia–Discordia diagrams.
Use of stable isotope data in paleoclimate interpretation.

Suggested Readings

Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.
Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag, 188p.

-X-

COURSE CODE: IGNEOUS PETROLOGY
COURSE NAME: IGLYMJIP0826
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 60
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain magma generation, evolution, and processes such as crystallization, differentiation, and partial melting in various tectonic settings.
CLO_2: Classify igneous rocks and evaluate their petrogenesis using phase equilibria and global examples like large igneous provinces.
CLO_3: Analyze geochemical data, including major, trace, and isotopic signatures, to interpret magma evolution and metallogenic processes.
CLO_4: Apply practical skills in petrography, CIPW calculations, and geochemical diagram interpretation for igneous rock analysis.

UNIT -1 (15 HOURS)

Concept of primary, parental and evolved magma. Petrology of mantle. Advective heat transfer in the Earth. Mechanisms for partial melting of the mantle and accumulation of melts. Composition of the source of magmas. Role of volatiles (H_2O, CO_2) in modifying magma composition and crystallization paths. Mantle heterogeneities. Kinetic paths and fabric of magmatic rocks.

UNIT -2 (15 HOURS)

Phase Rule and Lever Rule. Phase equilibrium of binary (Ab-An, Di-An, Fo-Si) and ternary (Di-Ab-An, Di-Fo-Si, Fo-An-Si) systems. Petrology of Granites (Caledonian, Cordilleran, Collission granites) and Adakites. Petrology of Kimberlites, Carbonatites, Lamprophyres, Lamproits, Nephline syenite, Alkali basalt, Basanite, High Mg- rocks (Komatiites, Boninites, Picrites and Sanukitoids). Petrology of MORBs, OIBs, BABB, and CFBs with special refernce to Panjal and Deccan Traps.

UNIT-3 (15 Hours)

Geochemical characteristics of primary magma. Chemical fractionation, partition coefficient, and trace element compatibility. Magma evolution models (batch melting, incremental batch melting, dynamic melting, fractional crystallization, Rayleigh fractionation). Isotopes as petrogenetic indicators. Application of geochemistry (major, trace and REE's) in igneous petrology. Metallogeny and plate tectonics: ore formation vis-a-vis igneous processes.

Practical /Tutorial (1 Credit: 30 hours)

- Megascopic and microscopic examination of acidic, basic and ultramafic igneous rocks.
- CIPW normative calculations based on geochemical data of a few ultramafic, mafic and felsic rocks (Manual and computer programming).
- Preparation and interpretation of a few geochemical diagrams (Harker variation diagrams, AFM, Rb-Hf-Ta, Rb-Yb+Nb, and Nb-Th diagrams).
- Normalization and interpretation of rare earth element data some ultramafic, mafic and felsic rocks.
- Identification and sample collection of some common igneous rocks in field in Kashmir valley.

Suggested Readings

Albert, J., 1967: Descriptive petrology of the Igneous Rocks. Mc-Graw Hill, New York.
Alexander, Mc. B., 1987: Igneous Petrology. Prentice Hall.
B. Ronald Frost and Carol D. Frost (2014) Essentials of Igneous and Metamorphic Petrology.
Best, M. G., 1986: Igneous Petrology, CBS Pub.
Blatt H. & Tracy R.J. 1995. Petrology: Igneous, Sedimentary & Metamorphic.
Bose, M. K., 1997: Igneous Petrology. World Press.
Hall, A., 1988: Igneous petrology. ELBSI Longman.
Kearey, P., Klepeis, K.A. and Vine, F. J., 2013. Global Tectonics. John Wiley & Sons Ltd. UK.
McBirney, A. R., 1993: Igneous Petrology. John Wiley.
Moores, E. M. and Twiss, R. J., 2006. Tectonics, W.H. Freeman & Company,
Philpotts, A., & Ague, J. 2009: Principles of Igneous and Metamorphic Petrology.
Piper, J.D.A. 1987: Paleomagnetism and the continental Crust. New York, J. Wiley, 434 pp.
Shelley, D., 1995: Descriptive Petrology of the Igneous Rocks. Chapman & Hall.
Turner &Verhoogen, 1999: Igneous and Metamorphic Petrology. CBS Pub.
Valdiya, K.S., 2009: Aspects of Tectonics: Focus on South-Central Asia. Tata McGraw-Hill.
Winter, J.D. 2010: Principles of Igneous and Metamorphic Petrology: Pearson New

-X-

COURSE CODE: METAMORPHIC PETROLOGY
COURSE NAME: IGLYMJMP0826
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 75
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion of this course the students will be able to:

CLO_1 Explain metamorphic processes, types, and controlling factors, and analyse metamorphic textures and structures.

CLO_2 Classify metamorphic facies and reactions, and apply geothermobarometry to interpret metamorphic conditions.

CLO_3 Interpret P-T-t paths, petrogenetic grids, and the tectonic context of regional and extreme metamorphism.

CLO_4 Describe key gemmological properties and evaluate the quality, origin, and characteristics of major gemstones.

UNIT -1 (15 HOURS)

Metamorphism and metamorphic processes; factors controlling metamorphism; temperature, pressure, role of fluids and bulk mineralogy in metamorphism. Concept of metamorphic grade, index minerals, metamorphic zones and facies and Barrowian Zones. Concept of Mineral assemblages. Metamorphic differentiation. Metamorphic structures –, foliation, schistosity, cleavage, gneissosity, lineations.

UNIT -2 (15 HOURS)

Metamorphic facies: Pressure, temperature and mineral assemblages of albite-epidote hornfels; hornblende-hornfels; pyroxene hornfels; greenschist; amphibolite; granulite; prehenite – pumpellite; glaucophane-lawsonite (blueschist); eclogite. Metamorphic reactions and diagrams. Metamorphic facies series. Anatexis and origin of migmatites. Geothermo-barometry.

UNIT -3 (15 HOURS)

Concepts and laws of thermodynamics in metamorphic petrology. Metamorphic Application of thermodynamics in metamorphic rock formation: Enthalpy, Entropy, Intensive and Extensive variables, Gibbs Free Energy & Phase rule and its derivation for a component system. Claussius-Clapeyron equation. Schrienemaker's rule, petrogenetic grids. P-T-t path. Progressive metamorphism of pelitic and mafic rocks.

Practical/Tutorial (1 Credit: 30 Hours)

- A detailed study of rock textures in hand specimens and thin sections with reference to the timing relationships between deformation phases and the recrystallization of minerals.
- Calculation of ACF, AKF and AFM values from the chemical and structural formulas of Rock & minerals and their graphical representation.
- Examination of metamorphic rocks in both hand specimens and thin sections representing different metamorphic facies, with emphasis on texture, structure, mineral composition, parent rock and metamorphic facies classification.

Suggested Readings

Best, M.G., 1986: Igneous Petrology-CBS Publ.
Bose, M.K., 1997: Igneous Petrology-World Press.
Bucher, K. and Frey, M.1994: Petrogenesis of Metamorphic Rocks-Springer Verlag.
Kretz, R., 1994: Metamorphic Crystallization-John Wiley.
Perchuk, L.L. and Kushiro, I.1991: Physical Chemistry of Magmas-Springer Verlag.
Philpotts, A., & Ague, J. 2009: Principles of Igneous and Metamorphic Petrology.
Cambridge: Cambridge University Press.
Turner, F.J., 1990: Metamorphic Petrology, McGraw Hill, New York.
Webster, R. and edited by Anderson, B.W. (1983) Gems: Their Sources, Descriptions and Identification, Butterworth-Heinemann Ltd.
Yardley, B.W. 1989: An Introduction to Metamorphic Petrology-Longman.

-X-

COURSE CODE: FIELD TRAINING
COURSE NAME: IGLYMJFT0826
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 120
Max. Marks: 100

CLO_1 This course will impart the field knowledge of identifying various geological structures, rock types, mineral deposits, mapping skills, etc., necessary for mineral exploration, disaster management, environmental protection, etc.
CLO_2 During this course, the students will be taken to various geological field sites selected across different states/UTs of India so that they get a deep knowledge of the geology of the country.
Content: Geological field training of 2-3 weeks, or whatever is decided by the DC, shall be conducted in different parts of the country/UT.

-X-

COURSE CODE: QUATERNARY GEOLOGY & PALEOCLIMATE
COURSE NAME: IGLYMJQG0826
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1 Analyze past climate variations using proxy indicators and understand tectonic, glacial, and geomorphic responses during the Quaternary.
CLO_2 Apply Quaternary stratigraphic tools and dating methods to interpret depositional records, with focus on Kashmir's Quaternary deposits.

UNIT -1 (15 HOURS)

Paleoclimatology, Paleoclimatic Reconstruction. Proxy indicators of paleoenvironmental/paleoclimatic changes. Introduction to the Quaternary Period and its characteristics. Reconstructing the climates of the Quaternary. Glaciation during times of enhanced/reduced atmospheric carbon dioxide. Glaciotectonic: Glaciotectonic structures, landforms, and processes. Plate tectonics and climate change. Responses of geomorphic systems, sea level and tectonics during the Quaternary.

UNIT -2 (15 HOURS)

Quaternary Stratigraphy-Oxygen Isotope stratigraphy, biostratigraphy and magnetostratigraphy. Application of pollens, phytoliths, magnetic susceptibility, and loess paleosols in Quaternary Stratigraphy. Quaternary deposits of Kashmir. Quaternary dating methods: Radiocarbon, cosmogenic radionuclide, and luminescence dating methods. Dating using annually banded records. Relative dating methods.

Suggested Readings

Bigg, G., 1999: Ocean and Climate. Springer- Verlag.
Bradley, F., 2000: Paleoclimatology: Reconstructing Climates of the Quaternary.
Dudeja D., 2011: Glaciostatic Pressure/Stress. In: Singh V.P., Singh P., Haritashya U.K. (eds) Encyclopedia of Snow, Ice and Glaciers. Encyclopedia of Earth Sciences Series.
Maher and Thompson, 2000: Quaternary Climates, Environments and Magnetism.
Williams, Durnkerley, Decker, Kershaw and Chhappell, 1998: Quaternary Environments.

-X-

COURSE CODE: OCEANOGRAPHY
COURSE NAME: IMGLYMJOG0826
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion of this course, the students will be able to:
CLO_1 Describe the structure and evolution of ocean basins, oceanic sediments, and marine mineral resources in the context of plate tectonics.
CLO_2 Explain ocean-atmosphere interactions and ocean circulation patterns, and apply paleoceanographic proxies for reconstructing past climate and monsoon variability.

UNIT -1 (15 HOURS)

Introduction to Ocean and Ocean Basins: Continental margins; Deep Ocean Basins. Plate tectonics and the ocean floor. Evidence Supporting Plate Tectonics: Types of features at plate boundaries. Oceanic sediments: Classification, distribution and methods of study. Marine mineral resources: Types, distribution, exploration, and utilization. Pollution and conservation of marine resources.

UNIT -2 (15 HOURS)

Air-sea interaction. Ocean circulation: thermohaline circulation and oceanic conveyor belt. Coriolis effect and Ekman spiral, convergence, divergence, and upwelling. El Nino. Indian Ocean Dipole. Paleoceanography: Methods and proxies of paleoceanographic reconstructions. Reconstruction of monsoon variability by using marine proxy records. Methods of paleo-sea surface temperature quantification. Marine stratigraphy, correlation, and chronology.

Suggested Readings

Arnold. 2002: Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford Univ. Press, New York.

Kennett, J. P., 1982: Laboratory Excercises in Oceanography Marine Geology, Prentice Hall.

Komar, P. D., 1976: Beach processes and sedimentation, Prentice Hall.

Seibold, E. and Berger, W. H., 1982: The Sea Floor, Springer-Verlag.

Shepard, F., 1963: Submarine Geology, Harper Row.

Thurman, H. V., Trujillo, A. P., Abel, D. C. and McConnell, R., 1999: Essentials of oceanography. Upper Saddle River, NJ: Prentice Hall.

-X-

COURSE CODE: GEOHAZARDS
COURSE NAME: IGLYMJGH0826
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): After completing this course, the students will be able to:

CLO_1 Identify types, causes, and mechanisms of geohazards, including seismic, landslide, flood, coastal, and volcanic hazards.

CLO_2: Analyze geohazard susceptibility, zonation, and mitigation strategies using geological knowledge and remote sensing tools.

UNIT -1 (15 HOURS)

Introduction, types and generating mechanisms of geohazards: Earthquakes, Landslides, Subsidence, Sinkholes, Avalanches, GLOF`s Floods and Droughts. Types and generating mechanisms of Coastal & Marine Hazards and Volcanic Hazards.

UNIT -2 (15 HOURS)

Geological controls on hazard susceptibility. Causes, impact and assessment of human-induced hazards (Mining-induced subsidence, reservoir-induced seismicity, and Desertification). Spatial distribution of major geohazards in India. Seismicity in India. Zonation mapping: Seismic, flood hazard and landslide hazard zonation. Preparedness, response, recovery and mitigation strategies for Earthquakes, Landslides, Avalanches, GLOF`s and Floods. Application of Remote Sensing & GIS in geohazards. Case studies of major disasters and mitigation.

Suggested Readings

Aki, K. and P. G. Richards., 2002: Quantitative Seismology, University Science Books, Sausalito.
Alcira Kreime, Margaret Arnold, Anee Carlin, 2003: Building safer cities.
Bell, F. G., 2007: Engineering Geology (2nd Edition). Elsevier.
Bolt, B. A., 1992: Inside the Earth, W.H. Freeman, San Francisco.
Denis Smith, Steve Tombs., 2000: Risk management and Society-Eve Coles.
Gupta, H. K., 2003: Disaster Management. University Press (India).
Hyndman, D. and Hyndman, D., 2016: Natural Hazards and Disasters (5th Edition). Cengage.
Iyer, H. M. and Hirahara, K.,1993: Seismic Tomography Theory and Practice.
Keller, E. A. and DeVecchio, D. E., 2016: Natural Hazards.
Landslides - Risk reduction. Kyoji Sassa, Paolo Canuti. 2008, Kluwer Academic Publishers.
Lay, T. and T. C. Wallace, 1995: Modern Global Seismology, Academic Press, San Diego.

-X-

9th SEMESTER

COURSE CODE: RESEARCH ETHICS
COURSE NAME: IGLYMJRE0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain principles of research ethics, including integrity, authorship, data management, and issues related to scientific misconduct.
CLO_2: Evaluate publication ethics, peer review processes, plagiarism issues, and research metrics in accordance with ethical guidelines and regulations.

UNIT-1 (15 HOURS)
Ethics in research: definition, importance, and scope; principles of honesty, integrity, objectivity, and accountability; scientific misconduct: fabrication, falsification, and plagiarism (FFP); questionable research practices (QRP); authorship criteria and responsibilities; conflicts of interest; data management: collection, storage, sharing, and reproducibility; ethical issues in field-based and laboratory research; guidelines for responsible conduct of research (RCR).

UNIT -2 (15 HOURS)
Publication ethics—plagiarism, duplicate publication, and salami slicing; predatory journals and conferences; peer review process—types, ethics, and responsibilities of reviewers and editors; copyright and intellectual property rights (IPR); citation practices and referencing styles; use of plagiarism detection tools (introductory); open access publishing—concepts and types; research metrics—impact factor, h-index, and citation index (basic concepts); UGC Academic Integrity and Plagiarism Regulations (2018); and ethical issues in collaborative and interdisciplinary research.

Suggested Readings
Resnik D.B. – The Ethics of Science: An Introduction. 1998. Routledge.
Macrina F.L. – Scientific Integrity: Text and Cases in Responsible Conduct of Research. 2014.
Steneck N.H. – Introduction to the Responsible Conduct of Research. 2007.
Bird A. – Philosophy of Science. 2006. Routledge.
Committee on Publication Ethics (COPE) – Guidelines and best practices.
University Grants Commission (UGC) – Academic Integrity and Plagiarism Regulations (2018).

-X-

COURSE CODE: RESEARCH METHODOLOGY
COURSE NAME: IGLYMJRM0926
COURSE TYPE: MAJOR

CREDITS: 04; Total Contact Hrs. 60
Max. Marks: 100

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the concepts, types, and design of research, and formulate research problems, hypotheses, and proposals in geosciences.

CLO_2: Conduct literature surveys, use digital resources, and apply proper referencing and academic integrity practices.
CLO_3: Develop scientific writing and presentation skills for preparing research papers, reports, and project proposals.
CLO_4: Analyze and present data using basic statistical tools and evaluate ethical and intellectual property aspects in research.

UNIT-1 (15 HOURS)
Concept and definition of research; types of research—basic, applied, theoretical, experimental; significance of research in geosciences; research hypothesis—concept and formulation; research proposal—concept and components; identifying research problems and gap areas through literature review; formulation of research objectives; research approach and design (introductory).

UNIT-2 (15 HOURS)
Literature survey and review: importance and methods; use of digital libraries and online resources; development of bibliography and referencing styles; ISSN and ISBN; impact factor, citation index, and assessment of research quality (introductory); concepts of plagiarism and academic integrity.

UNIT-3 (15 HOURS)
Structure and components of scientific reports—research papers, technical reports, thesis; layout, language, illustrations, tables, and referencing; scientific writing—abstract, results, discussion, and conclusions; preparation of manuscripts for journals; presentation of research in seminars and conferences; preparation of project proposals—title, objectives, methodology, work plan, budget and justification.

UNIT-4 (15 HOURS)
Types of data—primary and secondary data, sources and reliability; data representation and documentation tools; basic statistical and graphical presentation (introductory); integrative approach in geosciences; ethical issues in research—plagiarism, reproducibility, accountability; intellectual property rights (IPR), copyright, patents, and ethical use of published material.

Suggested Readings
Kothari C.R. – Research Methodology: Methods and Techniques. 2004. New Age International.
Kumar R. – Research Methodology: A Step-by-Step Guide for Beginners. 2011.
Creswell J.W. – Research Design: Qualitative, Quantitative and Mixed Methods Approaches. 2014. Sage Publications.
Day R.A. and Gastel B. – How to Write and Publish a Scientific Paper. 2012. Cambridge University Press.
Booth W.C. et al. – The Craft of Research. 2008. University of Chicago Press.
University Grants Commission (UGC) – Academic Integrity Guidelines (2018).

-X-

COURSE CODE: GEOSTATISTICS AND AI IN GEOSCIENCES
COURSE NAME: IGLYMJGA0926
COURSE TYPE: MAJOR

CREDITS: 03; Total Contact Hrs. 45
Max. Marks: 75

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain foundational concepts of AI, data types, statistical reasoning, and basic programming relevant to geoscientific applications.
CLO_2: Apply machine learning techniques to analyze geoscience problems such as hazards, water resources, climate systems, and resource exploration.
CLO_3: Analyze spatial data using geostatistical methods, including variograms and kriging, for modeling and prediction in Earth system studies.

UNIT-1 (15 HOURS)

Understanding human and machine intelligence; the history and philosophy behind AI. Types of data (qualitative, quantitative, categorical, continuous) and their importance in scientific investigations. Concepts of algorithms. Foundations of logical thinking: deduction, induction, and abduction. Key statistical concepts: mean, median, standard deviation, and probability distributions, emphasizing the importance of uncertainty in AI. Pattern recognition and classification in earth science data. Data visualization: techniques for visualizing data-graphs, charts, maps-and the importance of visual reasoning in geology and AI. Basics of programming, including logical instructions, flowcharts, and an introduction to Python. Introduction to digital data (numbers, images, signals). Overview of machine learning and its types (supervised vs. unsupervised learning). Concepts of overfitting, underfitting, and the importance of model validation.

UNIT-2 (15 HOURS)

Hazard and Risk Assessment: Machine learning for landslide susceptibility mapping; Deep learning for automated landslide detection using remote sensing imagery; Neural network algorithms for earthquake precursor pattern recognition; AI-enhanced seismic hazard mapping. Water Resources and Environmental Monitoring: Recurrent neural network models for groundwater level forecasting. Climate, Soil, and Environmental Systems: Machine learning-based downscaling of regional climate models; Deep learning for extreme weather event prediction; Digital soil mapping using machine learning; Deep learning for hyperspectral soil classification. Resource Exploration and Earth System Analysis: AI in petroleum and mineral prospectivity modeling; AI-based paleoclimate reconstruction from multi-proxy records; AI-enabled geological mapping and decision support systems.

UNIT-3 (15 HOURS)

Introduction to Geostatistics: Basic concepts of statistics, Fundamental Components of Geostatistics. Spatial Covariance, Correlation and Semivariance. Concept and characteristics of Variogram and Semi variogram. Semi Variogram analysis- characterization of spatial correlation. Semi Variogram Modelling. Kriging: Simple kriging and Universal kriging Ordinary kiriging and Co-Kriging. Bayesian kriging. Optimal interpolation, BLUE and Block kriging. Simulation Fundamentals and Stochastic simulation.

Suggested Readings

Russell, S. & Norvig, P. (2021). Artificial Intelligence: A Modern Approach - Pearson.
McKinney, W. (2022). O’Reilly Media. Python for Data Analysis
James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). An Introduction to Statistical Learning
Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.

Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning - MIT Press.
Webster, R. & Oliver, M. A. (2007). Statistics for Earth and Environmental Scientists —Wiley.
Isaaks, E. H. & Srivastava, R. M. (1989). Applied Geostatistics - Oxford University Press.
Chilès, J. P., & Delfiner, P. (2012). Geostatistics: Modeling Spatial Uncertainty (2nd ed.). Wiley.
Kitanidis, P. K. (1997). Introduction to geostatistics: Applications in hydrogeology.
Isaaks, E. H., & Srivastava, R. M. (1989). An Introduction to Applied Geostatistics.
Goovaerts, P. (1997). Geostatistics for Natural Resources Evaluation - Oxford University Press
Haupt, S. E., Pasini, A., & Marzban, C. (2009). Machine Learning Methods in the Environmental Sciences —Springer.

-X-

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COURSE CODE: STRUCTURAL ANALYSIS
COURSE NAME: IGLYMJSA0926
COURSE TYPE: MAJOR

CREDITS: 03; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain stress–strain relationships, deformation mechanisms, and the development of faults, folds, and shear zones in different tectonic settings.
CLO_2: Analyze rock fabrics and tectonites using geometric and stereographic methods for interpretation of deformation patterns.
CLO_3: Evaluate continuum deformation concepts, rheology, and paleostress data to interpret tectonic regimes and deformation history.

UNIT -1 (15 HOURS)

Stress and strain relationships in rocks, principles and methods of stress and strain analysis, and their application in deformed rocks. Classification and characteristic structure and textures of different types of faulted and folded rocks. Ductile shear zones: types, criteria for sense of shear, and mechanism of development. Geometry and mechanism of development of different types of fault-related folds and other structures in different tectonic regimes.

UNIT -2 (15 HOURS)

Mechanics of rock fracturing: fracture initiation and propagation. Tectonites and their significance. Descriptive and geometric analysis of Tectonites. Stereographic and equal-area projections for presenting different types of fabrics and π and β diagrams.

UNIT -3 (15 HOURS)

Continuum deformation concepts—deformation gradient and strain tensors (conceptual); coaxial vs. non-coaxial deformation and vorticity in shear zones; progressive deformation and strain path evolution; rheology of rocks—viscoelastic and viscoplastic behavior; deformation mechanisms—dislocation creep, diffusion creep, and dynamic recrystallization; paleostress analysis (fault-slip data and stress tensor concepts); integration of structural data for tectonic regime interpretation and deformation modeling.

Suggested Readings

Davis, G. R., 1984: Structural Geology of Rocks and Region. John Wiley.

Ghosh. S. K., 1995: Structural Geology Fundamentals of Modem Developments. Pergamon Press.
Hobbs, B. E., Means, W. D. and Williams, P. F., 1976: An Outline of Structural Geology. John Wiley.
Lisle, R. J., 1988: Geological Strain Analysis. Pergamon.
Price, N. J. and Cosgrove, J. W., 1990: Analysis of Geological Structure. Cambridge Univ. Press.
Ramsay, J. G. and Huber, M. I., 1987: Modem Structural Geology, Vol. 1&/1. Academic Press.
Ramsay, J. G., 1967: Folding and fracturing of Rocks. McGraw Hill.
Turner, F. J. and Weiss, L. E., 1963: Structural Analysis of Metamorphic Tectonites. McGraw Hill.

-X-

COURSE CODE: CRYOSPHERE AND CLIMATE CHANGE
COURSE NAME: IGLYMJCC0926
COURSE TYPE: MAJOR

CREDITS: 03; Total Contact Hrs. 45
Max. Marks: 75

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain cryospheric components, glacier and permafrost processes, and their interactions with climate and Earth system dynamics.
CLO_2: Analyze cryosphere–hydrology interactions and apply cryo-hydrological models to assess water resources and climate change impacts.
CLO_3: Evaluate cryosphere-related hazards, monitoring techniques, and adaptation strategies in mountain environments under changing climate conditions.

UNIT -1 (15 HOURS)
Definition and components: glaciers, snow, sea ice, permafrost, Global distribution of cryosphere Cryosphere-climate feedbacks (albedo, energy balance), Earth system interactions (atmosphere-hydrosphere-biosphere-lithosphere), Climate variability and climate change, Cryosphere as a climate indicator, Physical and thermal properties of snow and ice, Snow metamorphism and stratigraphy, Glacier formation, classification and dynamics, Glacier mass balance and equilibrium line altitude Permafrost processes: Types and distribution, Active layer dynamics, Ground ice and thermal regimes, Periglacial processes.

UNIT -2 (15 HOURS)
Role of cryosphere in hydrological cycle, Glacier melt, snowmelt, and runoff generation, Monsoon-glacier interactions in the Himalaya, Permafrost-hydrology linkages (groundwater flow, storage changes), Impacts of cryosphere change on river basins, Cryo-hydrological Modelling: Concept and need for modelling cryosphere-hydrology systems Degree-day vs energy balance approaches, Overview of major models: SPHY model, SWAT model, HBV model, VIC model, Model inputs, calibration and uncertainty, Applications in climate change impact assessment.

UNIT -3 (15 HOURS)
Cryosphere monitoring (conceptual: remote sensing, field observations), Glacier, snow, and permafrost modelling (overview), Cryosphere hazards: Glacial Lake Outburst Floods (GLOFs), Avalanches, Permafrost-related slope instability, Risk assessment and disaster management Climate adaptation strategies in mountain regions, Policy frameworks (IPCC, UNFCCC).

Suggested Readings
Barry, R. G. (2006). The cryosphere: Past, present and future. Springer.

Benn, D. I., & Evans, D. J. A. (2010). Glaciers and glaciation (2nd ed.). Hodder Education.
Cuffey, K. M., & Paterson, W. S. B. (2010). The physics of glaciers (4th ed.).
Singh, P., & Singh, V. P. (2001). Snow and glacier hydrology. Kluwer Academic Publishers.
Paterson, W. S. B. (1994). The physics of glaciers (3rd ed.). Pergamon Press.
Knight, P. G. (2010). Glaciers (2nd ed.). Oxford University Press.
Hambrey, M. J., & Alean, J. (2016). Glaciers (3rd ed.). Cambridge University Press.
IPCC. (2019). Special report on the ocean and cryosphere in a changing climate (SROCC). Intergovernmental Panel on Climate Change.
IPCC. (2021). Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report. Cambridge University Press.
ICIMOD. (2023). Water, ice, society, and ecosystems in the Hindu Kush Himalaya (HI-WISE). International Centre for Integrated Mountain Development.
Zemp, M., Huss, M., Thibert, E., Eckert, N., McNabb, R., Huber, J., Barandun, M., Machguth, H., Nussbaumer, S. U., Gärtner-Roer, I., Thomson, L., Paul, F., Maussion, F., Kutuzov, S., & Cogley, J. G. (2019). Global glacier mass changes and their contributions to sea-level rise from 1961 to 2016. Nature, 568, 382–386.
Bolch, T., Kulkarni, A., Kääb, A., Huggel, C., Paul, F., Cogley, J. G., Frey, H., Kargel, J. S., Fujita, K., Scheel, M., Bajracharya, S., & Stoffel, M. (2012). The state and fate of Himalayan glaciers. Science, 336(6079), 310–314.

-X-

COURSE CODE: HARD ROCK GEOCHEMISTRY
COURSE NAME: IGLYMJHG0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO-1: Analyze trace-element behavior and geochemical variation in igneous systems.
CLO-2: Evaluate magma genesis and tectonic setting using geochemical signatures.

UNIT -1 (15 HOURS)

Controls on Trace-Element Distribution: Geological controls; element mobility; effects of partial melting and fractional crystallization. Oddo-Harkins rule. Behavior of compatiable and incompatiable elements during partial melting/ fractional crystallization of magma. Normalization of geochemical data. Interpretation of REE and multi-element patterns. Significance of Eu-anomaly. Geochemical variation plots for basaltic and granitic rocks.

UNIT -2 (15 HOURS)

Magma Generation at Convergent Margins. Geochemistry of continental and Island Arc magmas. Major, trace and isotope chemistry of MORBs, OIB and CFBs. Models for the generation of Continental Flood Basalts. Classification and chemistry of granitoids. Geochemistry and isotope characteristics of Lamprophyres, Kimberlites, Carbonatites and Anorthosites.

Suggested Readings

Faure, G., 1986: Principles of Isotope Geology-John Wiley.
Henderson, P., 1987: Inorganic Geochemistry-Pergamon Pres.
Hoefs, J., 1980: Stable isotope Geochemistry –Springer Verlag.

Hugh, R. Rollinson. 1993: Using Geochemical Data: Evaluation, Presentation and Interpretation, Pearson Prentice Hall.
Krauskopf, K. B., 1967: Introduction to Geochemistry-McGraw Hill.
Kula, C. Misra., 2012: Introduction to Geochemistry: Principles and Applications, Wiley-Blackwell.
Lentz D.R., 2003, Geochemistry of Sediments and Sedimentary Rocks. Publisher: Geological Assn of Canada
Marshal, C. P. and Fairbridge, R.W., 1999: Encyclopaedia of Geochemistry-Kluwer Academic.
Mason, B. and Moore, C. B., 1991: Introduction to Geochemistry-Wiley Eastern.
Nordstrom, D. K. and Munoz, J. L., 1986: Geochemical Thermodynamics-Blackwell.
Paul Alexandre, 2022: Practical Geochemistry. Springer Nature Switzerland AG.
White, W. M., 2018: Encyclopaedia of Geochemistry. Springer.
White, W. M., 2023: Isotope Geochemistry, Wiley.
Rollinson and Pease 2021: Using Geochemical Data: To understand Geological Processes, Cambridge University Press.

-X-

COURSE CODE: ISOTOPE HYDROLOGY
COURSE NAME: IGLYMJIH0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Describe isotope systematics and fractionation mechanisms. Interpret isotope datasets ($\delta^{18}O$, δD, $\delta^{13}C$) in hydrological contexts
CLO_3: Evaluate groundwater recharge and residence time using isotopes and critically analyse isotope-based hydrological studies

UNIT -1 (15 HOURS)

Fundamentals of Isotope Geochemistry: Atomic structure, isotopes, and nuclides, stable vs. radioactive isotopes: definitions and characteristics. Isotopic abundance and measurement units, δ-notation ($\delta^{18}O$, δD, $\delta^{13}C$), and international standards (VSMOW, VPDB). Mass spectrometry basics (IRMS concept, precision and accuracy). Isotope Equilibrium fractionation: temperature dependence and phase changes. Kinetic fractionation: evaporation, diffusion processes, Rayleigh distillation, Fractionation factors and enrichment/depletion trends, Stable Isotopes in the Hydrological Cycle, Global Meteoric Water Line (GMWL) and Local Meteoric Water Line (LMWL), d-excess and its climatological significance, Altitude effect (orographic precipitation). Latitude and temperature effects, Continentality and rainout processes, Source identification of precipitation and moisture tracking, Surface water studies (river basin hydrology), Evaporation studies in lakes and reservoirs Soil water-plant water interactions

UNIT - 2 (15 HOURS)

Radioactive Isotopes in Hydrology: Radioactive decay law and half-life, Tritium (^3H) and Carbon-14 (^{14}C). Concept of groundwater age and residence time. Groundwater System Analysis. Recharge processes and flow paths. Mixing processes in aquifers. Surface Water-Groundwater Interaction. Catchment Hydrology Using Isotopes. Environmental and Pollution Applications: Multi-isotope approach ($\delta^{15}N$, $\delta^{13}C$, $\delta^{11}B$, $\delta^{34}S$). Tracing nitrate and sulfate pollution. Differentiating natural vs anthropogenic sources Applications in Urban and Agricultural

Hydrology, Mountain Hydrology, and Climate Linkages. Isotopes in glacier and snow hydrology. Isotopes as indicators of monsoon variability. Paleoclimate reconstruction using isotopes (ice cores, speleothems). Isotopic and regional hydrological modeling.

Suggested Readings

Gat, J. R. (2010). Isotope hydrology: A study of the water cycle. London: Imperial College Press.
Clark, I., & Fritz, P. (1997). Environmental isotopes in hydrogeology. Boca Raton: CRC Press.
Kendall, C., & McDonnell, J. J. (Eds.). (1998). Isotope tracers in catchment hydrology. Amsterdam: Elsevier.
Aggarwal, P. K., Gat, J. R., & Froehlich, K. F. (Eds.). (2005). Isotopes in the water cycle: Past, present and future of a developing science. Dordrecht: Springer.
Mook, W. G. (2000). Environmental isotopes in the hydrological cycle: Principles and applications. Vienna: International Atomic Energy Agency (IAEA).
Hoefs, J. (2009). Stable isotope geochemistry (6th ed.). Berlin: Springer.
Faure, G., & Mensing, T. M. (2005). Isotopes: Principles and applications (3rd ed.).
Sharp, Z. (2007). Principles of stable isotope geochemistry. Upper Saddle River:
Drever, J. I. (1997). The geochemistry of natural waters: Surface and groundwater environments.
Appelo, C. A. J., & Postma, D. (2005). Geochemistry, groundwater and pollution (2nd ed.).

-X-

COURSE CODE: APPLIED SEDIMENTOLOGY
COURSE NAME: IGLYMJAS0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Learning Outcomes: Students will be able to:

CLO_1: Interpret depositional environments from sedimentary structures and relate processes to sediment characteristics.

CLO_2: Apply sedimentological tools in basin and resource analysis. Interpret source area and tectonic setting. Understand applied significance in industry and environment.

UNIT -1 (15 HOURS)

Sediment granulometry and grain size scale. Fundamentals of sediment transport (traction, saltation, suspension). Sedimentary structures and their environmental significance. Environmental parameters and controlling factors. Classification of environments: Clastic and Non-clastic

UNIT -2 (15 HOURS)

Provenance studies: light minerals, heavy minerals, and insoluble residues
Clay minerals: classification and identification techniques (XRD).
Analytical techniques in sedimentology. Case studies (Himalayan sediments / Kashmir basin)
Geochemistry in paleoclimate and paleoenvironmental reconstruction Basics of XRF, ICP-MS, AAS. Sample preparation and limitations

Suggested Readings

F.J. Pettijohn (1975) Sedimentary rocks. Harper and Row Publ., New Delhi.
Blatt, Middleton & Murray (1980) Origin of sedimentary rocks. Printice Hall Inc.
J.D. Collins and D.B. Thompson (1982) Sedimentary Structures.

M.E. Tucker (1981) Sedimentary Petrology: an introduction. John Willey & Sons, New York.
Collinson, J., Mountney, N., Thompson, D., Sedimentary Structures, Terra Publishing.
Nicholls, G. Sedimentology and Stratigraphy. Wiley-Blackwell, 1999
Prothero. Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy.
Selley, R.C., Applied sedimentology, 2nd Edn., Academic Press, 2000
Tucker, M.E. Sedimentary Petrology, 3rd Edn., Blackwell Science, 2001

-X-

COURSE CODE: PALEOCLIMATE RECONSTRUCTION
COURSE NAME: IGLYMJPR0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain climate archives, proxies, and dating techniques used in paleoclimatic reconstruction, along with their limitations.
CLO_2: Analyze and integrate multi-proxy data to reconstruct past climate variability and interpret Quaternary paleoclimate records.

UNIT-1 (15 HOURS)
Concept and scope of paleoclimatic reconstruction; types of climate archives—marine sediments, lacustrine deposits, ice cores, speleothems, and loess–paleosol sequences; proxies used in paleoclimate studies—stable isotopes ($\delta^{18}O$, $\delta^{13}C$), trace elements, pollen, phytoliths, foraminifera, and diatoms; principles of proxy calibration and limitations; chronology and dating techniques (radiocarbon, luminescence, and cosmogenic radionuclide: case studies.

UNIT-2 (15 HOURS)
Quantitative and qualitative methods of paleoclimate reconstruction; multi-proxy approaches and data integration; reconstruction of temperature, precipitation, and monsoon variability; paleoclimate modeling; case studies from Quaternary records (glacial–interglacial cycles, monsoon evolution); uncertainties and resolution in paleoclimate data interpretation.

Suggested Readings
Bradley R.S. – Paleoclimatology: Reconstructing Climates of the Quaternary. 2015. Academic Press.
Lowe J.J. and Walker M.J.C. – Reconstructing Quaternary Environments. 2014. Routledge.
Cronin T.M. – Paleoclimates: Understanding Climate Change Past and Present. 2010. Columbia University Press.
Ruddiman, W.F. – Earth's Climate: Past and Future. 2013. W.H. Freeman.
Imbrie J. and Imbrie K.P. – Ice Ages: Solving the Mystery. 1986. Harvard University Press.

-X-

COURSE CODE: SEISMOLOGY
COURSE NAME: IGLYMJSM0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain fault mechanics, rupture dynamics, seismic waves, and focal mechanisms for interpreting stress fields and earthquake processes.

CLO_2: Analyze seismological data, earthquake location, and hazard assessment concepts to evaluate seismicity and associated risks.

UNIT-1 (15 HOURS)

Fault mechanics and rupture dynamics: stress–strain relations and elastic rebound. Seismic moment tensor and energy release. P, S, Love, and Rayleigh waves: propagation, reflection, refraction, attenuation, and anisotropy. Ray theory and wave interaction in layered Earth. Focal mechanisms and stress field interpretation.

UNIT-2 (15 HOURS)

Seismograms and signal processing (basic concepts); earthquake location and travel-time inversion. Seismic tomography and Earth structure. Global seismicity and plate tectonics. Gutenberg–Richter relation. Recurrence intervals and probabilistic seismic hazard. Earthquake prediction: concepts and limitations. Gorkha Nepal Earthquake 2015 – rupture characteristics, seismic wave analysis, aftershock distribution, and implications for Himalayan seismic hazard

Suggested Readings

Shearer P.M. – Introduction to Seismology. 2009. Cambridge University Press.
Lay T. and Wallace T.C. – Modern Global Seismology. 1995. Academic Press.
Aki K. and Richards P.G. – Quantitative Seismology. 2002. University Science Books.
Stein S. and Wysession M. – An Introduction to Seismology, Earthquakes and Earth Structure. 2003. Blackwell Publishing.
Fowler C.M.R. – The Solid Earth: An Introduction to Global Geophysics. 2005. Cambridge University Press.
Udías A. – Principles of Seismology. 1999. Cambridge University Press.
Bolt B.A. – Earthquakes. 2004. W.H. Freeman.
Kramer S.L. – Geotechnical Earthquake Engineering. 1996. Prentice Hall.

-X-

COURSE CODE: ADVANCED ENGINEERING GEOLOGY
COURSE NAME: IGLYMJEG0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:

CLO_1: Explain site investigation methods, subsurface characterization techniques, and rock mass improvement measures for engineering applications.

CLO_2: Analyze geotechnical case studies and apply modern tools and software to evaluate engineering problems and hazards.

UNIT -1 (15 HOURS)

Site investigation: Design of site investigations, selection of methods, and geology of the area. Field/Site investigations – Intrusive and non-intrusive methods Non-intrusive geophysical methods: seismic tomography, resistivity, and gravity. Subsurface site characterization: Coring, logging, and introduction to the application of geophysical methods. Improvements of properties of rock mass: grouting, guniting, rock bolting, and cable anchorage.

UNIT -2 (15 HOURS)
Recent trends in geotechnical engineering. Case histories and Indian examples
Use of softwares for solving various geotechnical problems
Case history of the following engineering projects:
(a) Sardar Sarovar hydroelectric project (b) Tehri hydroelectric project
Case studies (Himalayan terrain / Kashmir landslides)

Suggested Readings
Krynine, D.P. & Judd, W.R. 1957. Principles of engineering geology and geotechnics.
Bell, F.G. 1983. Fundamentals of engineering geology.
Beavis, F.C. 1985. Engineering geology.
Goodman, R.E. 1980. Introduction to rock mechanics.
Schuster, R.L. & Krizek, R.J. 1978. Landslide analysis and control.

-X-

COURSE CODE: HIMALAYAN TECTONICS
COURSE NAME: IGLYMJHT0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain the tectonic evolution of the Himalaya, including plate kinematics, major thrust systems, and crustal deformation processes.
CLO_2: Analyze active tectonics, seismicity, and geomorphic indicators to assess Himalayan geodynamics and associated hazards.

UNIT-1 (15 HOURS)
India–Eurasia collision and plate kinematics. Evolution of the Himalayan orogen. Major tectonic units: Sub-Himalaya, Lesser Himalaya, Greater Himalaya, and Tethyan Himalaya. Major thrust systems—MFT, MBT, MCT, and STDS and their kinematics. Crustal shortening, duplex structures, channel flow, and exhumation processes. Metamorphism and tectono-thermal evolution. Geophysical constraints on crustal structure.

UNIT-2 (15 HOURS)
Active tectonics of the Himalayas. Strain accumulation and release. Seismicity and earthquake segmentation. Geomorphic indicators of neotectonics (terraces, knickpoints, river incision). Tectonic–climate interactions and erosion–uplift feedback;
Case Studies: Kashmir Earthquake 2005: faulting, seismic hazard, and tectonic implications. Gorkha Nepal Earthquake 2015: rupture dynamics, role of Main Himalayan Thrust

Suggested Readings
Yin A. and Harrison T.M. – Geologic Evolution of the Himalayan-Tibetan Orogen. 2000. Annual Review of Earth and Planetary Sciences.
Valdiya K.S. – The Making of India: Geodynamic Evolution. 2010. Springer.
Gansser A. – Geology of the Himalayas. 1964. Wiley Interscience.

Searle M.P. – Colliding Continents: A Geological Exploration of the Himalaya, Karakoram and Tibet. 2013. Oxford University Press.
Singh S. – Tectonics of the Himalaya. 1998. Gyanodaya Prakashan.
Mukherjee S. – Structural Geology of the Himalaya. 2015. Springer.

-X-

COURSE CODE: HYDROGEOPHYSICS AND HYDROCLIMATIC MODELLING
COURSE NAME: IGLYMJHM0926
COURSE TYPE: MAJOR

CREDITS: 02; Total Contact Hrs. 30
Max. Marks: 50

Course learning outcomes (CLOs): Upon completion, the students will be able to:
CLO_1: Explain hydrogeophysical properties of geological media and apply electrical and seismic methods for subsurface and groundwater investigations.
CLO_2: Analyze recharge processes, hydrological modelling approaches, and machine learning applications in groundwater studies.

UNIT-1 (15 HOURS)

Physical properties of saturated and unsaturated geological media: resistivity, dielectric permittivity, and seismic velocity. Archie's Law: formation factor, cementation exponent, and saturation exponent. Clay correction: Waxman-Smits model and cation exchange capacity. Richard's equation. Fundamentals of Electrical Geophysical Methods: ERT electrode arrays—Wenner, Schlumberger, and dipole-dipole. ERT data acquisition, quality control, and reciprocal error assessment; ERT forward modeling and smoothness-constrained inversion (RES2DINV and ResIPy); VES sounding curve construction, equivalence, suppression, and aquifer depth estimation. Time-lapse ERT and vadose zone soil moisture monitoring. Seismic Refraction / MASW fundamentals and application—aquifer geometry, depth to bedrock, saturated zone thickness. Case studies

UNIT-2 (15 HOURS)

Atmospheric controls on recharge (A-V-A framework, recharge dynamics, and threshold behaviour). The recharge window and climate sensitivity. Recharge processes and controls. Modelling Recharge: Model types and structural assumptions, parameter, structural, and climate scenario uncertainty, Model output as a distribution. Remote sensing and global dataset acquisition: ERA5, GRACE/GRACE-FO, MODIS, ERA5, Soil Grids/ROSETTA. Download workflows, correction methods, uncertainty analysis, and quality assessment. Data Preparation and Preprocessing. Saturated and unsaturated zone modelling. Machine learning applications in hydrological modelling (random forest, feature generation, long short-term memory). Applications and Case studies

Suggested Readings

Brutsaert, W. (2005). Hydrology: An Introduction. Cambridge University Press.
Rubin, Y. & Hubbard, S. S. (2005). Applied Hydrogeophysics. Springer.
Reynolds, J. M. (2011). Near-Surface Applied Geophysics. Cambridge University Press.
Vereecken, H., Binley, A., Cassiani, G., Revil, A., & Titov, K. (2006). Hydrogeophysics.
Archie, G. E. (1942). Archie's Law.
Waxman, M. H. & Smits, L. J. M. (1968). Waxman-Smits Model.

Hillel, D. (1998). Soil Physics. Academic Press.
Freeze, R. A. & Cherry, J. A. (1979). Groundwater. Prentice Hall.
Kirsch, R. (Ed.). (2009). Groundwater Geophysics: A Tool for Hydrogeology. Springer.
Radcliffe, D. E. & Šimůnek, J. (2010). Soil Physics with HYDRUS: Modeling and Applications. CRC Press.
Bakker, M. & Post, V. (2022). Analytical Groundwater Modeling: Theory and Applications using Python. CRC Press.
Mavko, G., Mukerji, T., & Dvorkin, J. (2020). The Rock Physics Handbook.
Anderson, M. P., Woessner, W. W., & Hunt, R. J. (2015). Applied Groundwater Modeling. Academic Press.
Beven, K. (2012). Rainfall-Runoff Modelling: The Primer. Wiley-Blackwell.
Chandra, P. C. (2015). Groundwater Geophysics in Hard Rock. CRC Press / Taylor & Francis.
Fowler, C. M. R. (2005). The Solid Earth: An Introduction to Global Geophysics.

-X-

COURSE CODE: PROJECT WORK
COURSE NAME: IGLYMJPW0926
COURSE TYPE: MAJOR

CREDITS: 6; Total Contact Hrs. 180
Max. Marks: 150

Course learning outcomes (CLOs): This course introduces students to the fundamentals of research methodology.

CLO_1: Identify and formulate a relevant research problem through critical review of scientific literature.

CLO_2: Develop research objectives, hypotheses, and an appropriate methodology for geoscientific investigation.

CLO_3: Prepare and present a structured research synopsis incorporating scientific reasoning and expected outcomes.

CLO_4: Evaluate expert feedback and refine the research design for effective execution of the study.

CLO_5: Apply preliminary or pilot investigations to assess feasibility and improve research methodology.

CLO_6: Demonstrate scientific communication and presentation skills during proposal evaluation and discussion.

Contents:

- Selection of research problem in consultation with supervisor
- Identification of research gaps and critical literature review
- Formulation of research objectives and hypothesis
- Preparation of research synopsis (title, objectives, methodology, expected outcomes)
- Presentation and evaluation before expert committee
- Incorporation of feedback and refinement of research design
- Preliminary/pilot work (if required)

10^{th} SEMESTER

COURSE CODE: DISSERTATION
COURSE NAME: IGLYMJDT1026
COURSE TYPE: MAJOR

CREDITS: 20; Total Contact Hrs. 6 MONTHS
Max. Marks: 500

Course Learning Outcomes (CLOs): Upon completion of the dissertation work the student will be able to

CLO_1: Conduct detailed fieldwork, laboratory investigations, and data acquisition following the approved research methodology.
CLO_2: Apply appropriate scientific tools and techniques for systematic processing and analysis of research data.
CLO_3: Interpret and integrate research findings with existing scientific knowledge to address defined objectives and hypotheses.
CLO_4: Prepare a scientifically structured introduction and background for the dissertation.
CLO_5: Compile and synthesize relevant literature to establish the context and significance of the research problem.
CLO_6: Present materials, methods, results, and analytical interpretations in a clear and scientific manner.
CLO_7: Develop discussions, conclusions, and future research perspectives based on the obtained results.
CLO_8: Prepare high-quality maps, figures, tables, references, and graphical representations following academic standards.
CLO_9: Revise and refine the dissertation by incorporating supervisor and expert suggestions before final submission.
CLO_10: Demonstrate scientific communication and defence skills through oral presentation and viva voce examination.

Contents: Continuation and completion of the research work approved in the 9th semester.
Detailed fieldwork/laboratory work/data acquisition as per proposed methodology.
Systematic data processing, analysis, and interpretation using appropriate scientific tools and techniques.
Integration of results with existing knowledge to address the defined research problem and objectives.
Preparation of a comprehensive dissertation including:

- Introduction and background
- Review of literature
- Materials and methods
- Results and analysis
- Discussion and synthesis
- Conclusions and future scope
- References and appendices

Preparation of high-quality maps, figures, tables, and graphical representations.
Draft submission and incorporation of supervisor's suggestions for refinement.
Final submission of the dissertation as per prescribed academic guidelines.
Oral presentation and defence (viva voce) before an expert evaluation committee.

COURSE LEARNING OUTCOMES AND **PROGRAM LEARNING OUTCOMES** OF THE FIVER YEARS INTEGRATED MASTERS PROGRAM IN **APPLIED GEOLOGY**

First Semester

CLO-PLO Matrix for the Course IGLYMJFG0126: FUNDAMENTALS OF GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	2	1	0	1	0	0	2
II	3	1	2	1	1	1	0	1	2
III	3	1	2	1	1	1	0	1	2
IV	3	2	2	2	2	2	1	1	2
Average	**3**	**1.25**	**2**	**1.25**	**1**	**1.25**	**0.25**	**0.75**	**2**

CLO-PLO Matrix for the Course IGLYMDBR0126: BEAUTY OF ROCKS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	2	1	0	0	0	1	1
II	3	2	2	1	1	1	0	1	1
III	3	1	2	2	0	1	0	1	2
Average	**3**	**1.33**	**2**	**1.33**	**0.33**	**0.66**	**0**	**1**	**1.33**

CLO-PLO Matrix for the Course IGLYSCGT0126: HANDLING OF GEOLOGICAL TOOLS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	1	2	1	2	2	1	1
II	3	3	1	2	1	2	2	1	1
Average	**3**	**3**	**1**	**2**	**1**	**2**	**2**	**1**	**1**

Second Semester

CLO-PLO Matrix for the Course IGLYMJIG0226: INTRODUCTION TO GEOMORPHOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	0	2	0	1	1	0	1	1
II	3	0	2	0	1	1	0	1	1
III	3	1	2	1	1	2	0	1	1
IV	3	2	2	2	2	2	1	1	1
Average	**3**	**0.75**	**2**	**0.75**	**1.25**	**1.5**	**0.25**	**1**	**1**

CLO-PLO Matrix for the Course IGLYMDPF0226: PLAYING WITH FOSSILS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	2	2	2	2	2	1	2	1
II	2	2	2	1	1	1	1	2	2
III	3	3	2	3	2	2	1	1	2
Average	**2.66**	**2.33**	**2**	**2**	**1.66**	**1.66**	**1**	**1.66**	**1.66**

CLO-PLO Matrix for the Course IGLYSEGM0226: BASICS OF GEOLOGICAL MAPPING

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	3	1	3	1	2	3	1	1
II	2	3	1	3	1	2	3	1	1
Average	**2**	**3**	**1**	**3**	**1**	**2**	**3**	**1**	**1**

Thirds Semester

CLO-PLO Matrix for the Course IGLYMJFS0326: FUNDAMENTALS OF SEDIMENTOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	1	1	0	1	1	0	1	0
II	2	0	1	1	1	2	0	1	1
III	2	1	1	0	1	2	0	2	1
IV	3	3	2	2	2	2	1	1	1
Average	**2.25**	**1.25**	**1.25**	**0.75**	**1.25**	**1.75**	**0.25**	**1.25**	**0.75**

CLO-PLO Matrix for the Course IGLYMJCM0326: CRYSTALLOGRAPHY AND MINERALOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	0	1	0	1	1	0	1	1
II	3	0	1	0	1	1	0	1	1
III	3	0	1	1	1	1	1	1	1
IV	3	3	2	3	2	3	2	1	1
Average	**3**	**0.75**	**1.25**	**1**	**1.25**	**1.25**	**0.75**	**1**	**1**

CLO-PLO Matrix for the Course IGLYMDNH0326: NATURAL HAZARDS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	1	1	2	2	1	2	2
II	2	2	2	2	1	2	1	2	2
III	3	3	2	3	2	3	2	2	2
Average	**2.66**	**2**	**1.66**	**2**	**1.66**	**2.33**	**1.33**	**2**	**2**

CLO-PLO Matrix for the Course IGLYSEFG0326: FIELD GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	3	1	3	1	2	3	1	1
II	2	3	1	3	1	2	3	1	1
Average	**2**	**2**	**1**	**3**	**1**	**2**	**3**	**1**	**1**

Fourth Semester

CLO-PLO Matrix for the Course IGLYMJIM0426: IGNEOUS AND METAMORPHIC PETROLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	0	1	1	0	0	1	0
II	3	1	1	1	1	1	0	1	1
III	3	1	0	1	1	0	0	1	0
IV	3	3	2	2	2	2	1	1	1
Average	**3**	**1.25**	**0.75**	**1.25**	**1.25**	**0.75**	**0.25**	**1**	**0.5**

CLO-PLO Matrix for the Course IGLYMJSG0426: STRUCTURAL GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	0	1	0	1	1	0	1	1
II	3	0	1	0	2	2	1	1	1
III	3	2	1	2	1	2	1	1	1
IV	3	3	2	3	2	3	2	2	1
Average	**3**	**1.**	**1.25**	**1.25**		**2**	**1**	**1.25**	**1**

CLO-PLO Matrix for the Course IGLYMJER0426: GEO-ENERGY RESOURCES

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	2	2	2	2	1	1	2	1

II	2	2	2	1	1	1	1	2	1
III	3	3	2	3	2	1	1	2	1
Average	**2.66**	**2.33**	**2**	**2**	**1.66**	**1**	**1**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJSG0426: STRATIGRAPHY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	0	1	0	1	1	0	1	1
II	3	0	1	0	1	1	0	1	1
III	3	2	1	2	2	2	1	2	1
Average	**3**	**0.66**	**1**	**0.66**	**1.33**	**1.33**	**0.33**	**1.33**	**1**

CLO-PLO Matrix for the Course IMGLYMJOM426: FIELDWORK

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	3	3	3	3	3	3	3
II	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Fifth Semester

CLO-PLO Matrix for the Course IGLYMJPT0526: PALEONTOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	1	1	1	0	0	1	1
II	3	1	1	1	1	0	0	1	1
III	3	2	1	1	1	1	0	1	1
IV	2	3	2	2	2	2	1	1	1
Average	**2.75**	**1.75**	**1.25**	**1.25**	**1.25**	**0.75**	**0.25**	**1**	**1**

CLO-PLO Matrix for the Course IGLYMJEG0526: ECONOMIC GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	1	1	1	1	0	2	1
II	3	2	1	2	2	1	2	2	1
III	3	1	1	1	1	1	1	1	1
IV	3	3	2	3	2	3	2	2	1
Average	**3**	**1.75**	**1.25**	**1.75**	**1.5**	**1.5**	**1.25**	**1.75**	**1**

CLO-PLO Matrix for the Course IGLYMJGC0526: GEOCHEMISTRY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	2	2	2	2	1	1	2
II	3	3	2	2	2	2	1	1	2
III	3	3	3	3	2	2	2	2	2
IV	3	3	3	3	2	2	2	2	2
Average	**3**	**3**	**2.5**	**2.5**	**2**	**2**	**1.5**	**1.5**	**2**

CLO-PLO Matrix for the Course IGLYMJGT0526: GEOTECTONICS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	0	1	0	1	1	0	1	1
II	3	1	1	1	2	1	1	1	1
III	3	1	1	1	1	1	1	1	1
IV	3	3	2	3	2	3	3	2	1
Average	**3**	**1.25**	**1.25**	**1.25**	**1.5**	**1.25**	**1.25**	**1.25**	**1**

Sixth Semester

CLO-PLO Matrix for the Course IGLYMJEG0626: ENGINEERING GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	2	1	2	2	2	1	2	1
II	3	1	1	1	1	0	0	1	1
III	3	2	1	2	2	2	1	2	1
IV	2	3	2	2	2	2	1	2	1
Average	**2.75**	**2**	**1.25**	**1.75**	**1.75**	**1.5**	**0.75**	**1.75**	**1**

CLO-PLO Matrix for the Course IGLYMJRG0626: REMOTE SENSING AND GIS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	1	1	1	1	0	1	1
II	3	1	1	1	1	1	0	1	1
III	3	2	2	2	2	1	2	2	1
IV	3	3	2	3	2	3	2	2	1
Average	**3**	**1.75**	**1.5**	**1.75**	**1.5**	**1.25**	**1**	**1.5**	**1**

CLO-PLO Matrix for the Course IGLYMJFW0626: GEOLOGICAL FIELDWORK

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9

I	3	3	3	3	3	3	3	3	3
II	3	3	3	3	3	3	3	3	3
III	3	3	3	3	3	3	3	3	3
IV	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

CLO-PLO Matrix for the Course IGLYMJEM0626: EXPLORATION AND MINING GEOLOGY

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**
I	1	2	0	1	1	2	2	1	1
II	0	3	1	2	1	2	2	2	2
III	3	1	2	2	1	3	2	2	2
IV	1	2	1	1	1	2	2	1	1
Average	**1.25**	**2**	**1**	**1 .5**	**1**	**2 .25**	**2**	**1.25**	**1.5**

CLO-PLO Matrix for the Course IGLYMJHG0626: HYDROGEOLOGY

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**
I	2	2	0	1	1	2	1	1	1
II	1	2	1	1	1	1	1	2	1
III	3	3	2	3	2	1	1	2	1
IV	2	3	2	3	2	2	2	2	1
Average	**2**	**2.5**	**1.25**	**2**	**1.5**	**1.5**	**1.25**	**1.75**	**1**

Seventh Semester

CLO-PLO Matrix for the Course IGLYMJGP0726: GEOPHYSICS

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**
I	3	2	1	2	2	2	1	2	1
II	3	2	1	3	2	2	2	2	1
III	3	2	2	2	2	2	2	2	2
IV	2	3	2	2	2	2	1	2	1
Average	**2.75**	**2.25**	**1.5**	**2.25**	**2**	**2**	**1.5**	**2**	**1.25**

CLO-PLO Matrix for the Course IGLYMJSG0726: ADVANCED STRUCTURAL GEOLOGY

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**

I	3	2	3	1	0	2	1	0	2
II	3	2	2	3	1	2	1	1	2
III	3	2	2	3	1	2	1	1	2
IV	3	3	2	3	2	3	2	2	1
Average	**3**	**2.25**	**2.25**	**2.5**	**1**	**2.25**	**1.25**	**1**	**1.75**

CLO-PLO Matrix for the Course IGLYMJEC0726: ENVIRONMENTAL GEOLOGY AND CLIMATE CHANGE

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**
I	1	0	1	3	1	1	1	2	1
II	2	2	2	3	2	2	2	2	2
III	2	2	2	3	2	2	2	2	2
IV	2	2	2	3	2	2	2	2	2
Average	**1.75**	**1.5**	**1.75**	**3**	**1.75**	**1.75**	**1.75**	**2**	**1.75**

CLO-PLO Matrix for the Course IGLYMJFT0726: FIELD TRAINING

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**
I	3	3	3	3	3	3	3	3	3
II	3	3	3	3	3	3	3	3	3
III	3	3	3	3	3	3	3	3	3
IV	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

CLO-PLO Matrix for the Course IGLYMJHG0726: HIMALAYAN GEOLOGY

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**
I	3	3	2	1	1	2	0	1	1
II	3	3	2	1	1	2	1	1	1
Average	**3**	**3**	**2**	**1**	**1**	**2**	**0.5**	**1**	**1**

CLO-PLO Matrix for the Course IGLYMJES0726: EARTH SURFACE PROCESSES

UNIT WISE CLOs	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**
I	2	2	0	0	2	0	0	0	1
II	3	2	0	3	1	3	0	3	2
Average	**2.5**	**2**	**0**	**1.5**	**1.5**	**1.5**	**0**	**1.5**	**1.5**

CLO-PLO Matrix for the Course IGLYMJPC0726: PETROLEUM AND COAL GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	1	1	3	1	1	1	2	2
II	1	1	1	2	2	0	1	1	2
Average	**2**	**1**	**1**	**2.5**	**1.5**	**0.5**	**1**	**1.5**	**2**

Eighth Semester

CLO-PLO Matrix for the Course IGLYMJIG0826: ISOTOPE GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	2	1	2	2	2	1	2	1
II	3	2	1	3	2	2	2	2	1
III	3	2	2	2	2	2	2	2	2
IV	2	3	2	2	2	2	1	2	1
Average	**2.75**	**2.25**	**1.5**	**1.75**	**2**	**2**	**1.5**	**2**	**1.25**

CLO-PLO Matrix for the Course IGLYMJIP0826: IGNEOUS PETROLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	3	2	2	2	2	1	2
II	3	3	3	2	2	2	2	1	2
III	3	3	3	3	2	3	2	2	2
IV	3	3	3	3	2	3	2	2	2
Average	**3**	**3**	**3**	**2.5**	**2**	**2.5**	**2**	**1.5**	**2**

CLO-PLO Matrix for the Course IGLYMJMP0826: METAMORPHIC PETROLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	2	3	2	3	2	2	3
II	3	3	3	3	3	2	2	2	3
III	3	2	3	2	3	2	2	2	3
IV	3	2	2	2	2	3	2	2	3
Average	**3**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2**	**2**	**3**

CLO-PLO Matrix for the Course IGLYMJFT0826: FIELD TRAINING

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	3	3	3	3	3	3	3
II	3	3	3	3	3	3	3	3	3
III	3	3	3	3	3	3	3	3	3
IV	3	3	3	3	3	3	3	3	3
Average	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

CLO-PLO Matrix for the Course IGLYMJQG0826: QUATERNARY GEOLOGY & PALEOCLIMATE

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	2	3	1	3	3	3	3
II	3	3	3	3	3	3	2	3	3
Average	**3**	**3**	**2.5**	**3**	**2**	**3**	**2.5**	**3**	**3**

CLO-PLO Matrix for the Course IMGLYMJOG0826: OCEANOGRAPHY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	1	2	1	1	1	3	3
II	2	2	2	3	1	3	1	3	3
Average	**2.5**	**2.5**		**2.5**	**1**	**2**	**2**	**3**	**3**

CLO-PLO Matrix for the Course IGLYMJGH0826: GEOHAZARDS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	2	1	1	2	0	1	1
II	3	3	2	1	1	2	1	1	1
Average	**3**	**3**	**2**	**1**	**1**	**2**	**0.5**	**1**	**1**

Nineth Semester

CLO-PLO Matrix for the Course IGLYMJRE0926: RESEARCH ETHICS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	0	3	2	0	0	0	0	2	1
II	0	3	2	0	2	2	0	2	1

Average	**0**	**3**	**2**	**0**	**1**	**1**		**2**	**1**

CLO-PLO Matrix for the Course IGLYMJRM0926: RESEARCH METHODOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	1	3	3	3	3	1	2	3	3
II	3	1	3	1	3	1	1	3	3
III	3	3	3	3	3	3	2	3	3
IV	3	2	3	3	3	2	3	3	3
Average	**2.5**	**2.25**	**3**	**2.5**	**3**	**1.75**	**2**	**3**	**3**

CLO-PLO Matrix for the Course IGLYMJGA0926: GEOSTATISTICS AND AI IN GEOSCIENCES

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	3	3	3	2	2	3	3	3
II	3	3	2	3	3	2	3	3	3
III	3	3	3	3	3	3	2	3	3
Average	**2.66**	**3**	**2.66**	**3**	**2.66**	**1.75**	**2.66**	**3**	**3**

CLO-PLO Matrix for the Course IGLYMJSA0926: STRUCTURAL ANALYSIS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	1	1	2	2	2	1	2	1
II	2	2	1	3	2	2	2	2	1
III	3	2	2	2	2	2	1	2	1
Average	**2.33**	**1.66**	**1.33**	**2.33**	**2**	**2**	**1.33**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJCC0926: CRYOSPHERE AND CLIMATE CHANGE

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	1	1	0	1	0	0	1	1
II	2	2	1	2	2	1	3	2	1
III	3	2	2	2	2	3	1	3	1
Average	**2.3**	**1.66**	**1.33**	**1.33**	**1.66**	**1.33**	**1.33**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJHG0926: HARD ROCK GEOCHEMISTRY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	2	2	2	2	2	2	2
II	3	3	3	3	3	2	2	2	3
Average	**3**	**3**	**2.5**	**2.5**	**2.5**	**2**	**2**	**2**	**2.5**

CLO-PLO Matrix for the Course IGLYMJIH0926: ISOTOPE HYDROLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	3	2	2	2	2	3	2	1
II	3	3	2	2	2	3	3	2	1
Average	**2.5**	**3**	**2**	**2**	**2**	**2.5**	**3**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJAS0926: APPLIED SEDIMENTOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	3	2	2	2	2	1	2	1
II	3	3	2	2	2	3	3	2	1
Average	**3**	**3**	**2**	**2**	**2**	**2.5**	**2**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJPR0926: PALEOCLIMATE RECONSTRUCTION

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	2	2	2	3	3	2	2	1
II	3	3	2	3	3	3	3	2	1
Average	**2.5**	**2.5**		**2.5**	**3**	**3**	**2.5**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJSM0926: SEISMOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	2	2	2	2	2	1	2	1
II	3	3	2	3	2	2	3	2	1
Average	**3**	**2.5**	**2**	**2.5**	**2**	**2**	**2**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJEG0926: ADVANCED ENGINEERING GEOLOGY

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	3	2	2	3	2	2	2	1
II	3	3	2	2	2	3	3	2	1
Average	**2.5**	**3**	**2**	**2**	**2.5**	**2.5**	**2.5**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJHT0926: HIMALAYAN TECTONICS

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	3	2	2	2	2	2	2	2	1
II	3	3	2	2	2	3	3	2	1
Average	**3**	**2.5**	**2**	**2**	**2**	**2.5**	**2.5**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJHM0926: HYDROGEOPHYSICS AND HYDROCLIMATIC MODELLING

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	3	2	2	2	2	3	2	1
II	3	3	2	2	2	3	3	2	1
Average	**2.5**	**3**	**2**	**2**	**2**	**2.5**	**3**	**2**	**1**

CLO-PLO Matrix for the Course IGLYMJPW0926: PROJECT WORK

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	1	2	2	2	2	1	1	1	1
II	2	1	2	1	2	1	1	1	2
III	2	3	3	3	3	3	2	1	1
IV	2	2	2	2	2	2	2	2	2
V	2	2	2	3	2	2	1	2	2
VI	3	3	3	3	3	3	2	2	2
Average	**2**	**2.16**	**2.33**	**2.33**	**2.33**	**2**	**1.5**	**1.5**	**1.66**

Tenth Semester

CLO-PLO Matrix for the Course IGLYMJDT1026: DISSERTATION

UNIT WISE CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
I	2	2	2	2	2	1	2	2	1
II	2	3	2	1	2	1	3	1	2
III	2	3	3	3	3	3	2	1	1

IV	2	2	2	2	2	2	2	2	2
V	2	2	2	3	2	2	1	2	2
VI	3	3	3	3	2	2	1	2	2
VII	2	2	2	2	2	2	2	2	2
VIII	2	2	2	3	2	2	1	3	2
IX	3	3	3	3	3	3	2	2	2
X	3	3	3	3	3	3	2	3	3
Average	**2.3**	**2.5**	**2.4**	**2.5**	**2.3**	**2.1**	**1.8**	**2**	**1.9**