Kurukshetra University, Kurukshetra

(Established by the State Legislature Act XII of 1956)

('A+' Grade, NAAC Accredited)

Scheme of Examinations and Syllabus
of
M.Sc. Applied Geology

Under

Choice Based Credit System (CBCS)
Learning Outcome Based Curriculum (LOCF)
Ist to IVth Semester w.e.f. Session 2020-21
in phased manner

DEPARTMENT OF GEOLOGY
KURUKSHETRA UNIVERSITY KURUKSHETRA

M.Sc. APPLIED GEOLOGY

OUTCOME BASED SYLLABUS

M.Sc. APPLIED GEOLOGY COURSE
DURATION OF COURSE - 2 YEARS

VISION

To be globally acknowledged as a distinguished center of academic excellence.

MISSION

To prepare a class of proficient scholars and professionals with ingrained human values and commitment to expand the frontiers of knowledge for the advancement of society.

DEPARTMENT VISION AND MISSION

VISION

- To be acknowledged as a distinguished center for Geoscience education.

MISSION

M1: To provide quality education to aspiring young minds for improving their skills, inculcating values, creating leadership qualities and enhancing research with innovative methods.

M2: To produce young geoscientists capable of being utilized in the areas of new technological design, environment, ethics and sustainable technologies.

M3: To develop teaching-learning methods which can produce socially committed professional human beings who can contribute effectively in nation building and represent the country internationally.

Mapping of University vision and mission to Department vision and mission

University vision and mission	Department vision and mission
To be globally acknowledged as a distinguished center of academic excellence.	Yes
To prepare a class of proficient scholars and professionals with ingrained human values and commitment to expand the frontiers of knowledge for the advancement of society.	Yes

Programme Outcomes (PO) with Post Graduate Attributes

Programme outcomes are attributes of the post graduates from the Programme that are indicative of the post graduate's ability and competence to work after being a qualified Geologist upon completion of post-graduation. Programme outcomes are statements that describe what students are expected to know or do by the time of post-graduation, they must relate to knowledge and skills that the students acquire from the Programme. The achievement of all outcomes indicates that the student is well prepared to achieve the Programme educational objectives down the road. The department of geology has the following eleven PO's. The course syllabi and the overall curriculum have been designed to achieve these outcomes:

PROGRAMME OUTCOMES (POs):

Programme Outcomes (POs) for Post Graduate Programmes (CBCS) in the Faculty of Sciences, Kurukshetra University, Kurukshetra

PO1	Knowledge	Capable of demonstrating comprehensive disciplinary knowledge gained during course of study
PO2	Research Aptitude	Capability to ask relevant/appropriate questions for identifying, formulating and analyzing the research problems and to draw conclusion from the analysis
PO3	Communication	Ability to communicate effectively on general and scientific topics with the scientific community and with society at large
PO4	Problem Solving	Capability of applying knowledge to solve scientific and other problems
PO5	Individual and Team Work	Capable to learn and work effectively as an individual, and as a member Or leader in diverse teams, in multidisciplinary settings.
PO6	Investigation of Problems	Ability of critical thinking, analytical reasoning and research based knowledge including design of experiments, analysis and interpretation of data to provide conclusions
PO7	Modern Tool usage	Ability to use and learn techniques, skills and modern tools for scientific practices
PO8	Science and Society	Ability to apply reasoning to assess the different issues related to Society and the consequent responsibilities relevant to the professional scientific

		practices
PO9	Life-Long Learning	Aptitude to apply knowledge and skills that are necessary for participating in learning activities throughout life
PO10	Ethics	Capability to identity and apply ethical issues related to one's work, avoid unethical behavior such as fabrication of data, committing plagiarism and unbiased truthful actions in all aspects of work
PO11	Project Management	Ability to demonstrate knowledge and understanding of the scientific principles and apply these to manage projects

Programme Specific Outcomes (PSO's):

PSO1: Basic understanding of fundamental concepts of Geology and applying it on the various natural processes occurring on and inside the Earth as a complete system.

PSO2: Clearly formulate and solve real life challenges with respect to human environment interactions.

PSO3: Applications of fundamental principles of Geology in finding out various minerals and other natural resources for the betterment of the human society.

PSO4: Acquisition of skills to effectively communicate the knowledge of Geology to the society for safeguarding the physical environment.

Kurukshetra University Kurukshetra
Scheme of Examination and Syllabus for M. Sc. Applied Geology
under Choice Based Credit System (CBCS) Ist to IVth Semester w.e.f. 2020-21 in phased manner

Course Code and Type	Nomenclature of the Paper	Credits	Hours/ Week	External Assessment Marks	Internal Assessment Marks	Total Marks	Duration of Exam.
Semester-I							
G-101	Geology I	4	4	75	25	100	3 Hours
G-102	Geology II	4	4	75	25	100	3 Hours
G-103	Physics and Chemistry of the Earth	4	4	75	25	100	3 Hours
G-104	Geo-exploration	4	4	75	25	100	3 Hours
G-105	Practical G-105 based on G-101	6	12	75	25	100	3 Hours
G-106	Practical G-106 based on G-101, 102 and 103	6	12	75	25	100	3 Hours
G-107	Geological Field Training	4	4	75	25	100	3 Hours
Semester-II							
G-201	Mineralogy, instrumentation and analytical techniques	4	4	75	25	100	3 Hours
G-202	Structural Geology and Tectonics	4	4	75	25	100	3 Hours
G-203	Computing techniques in Geosciences	4	4	75	25	100	3 Hours
G-204	Palaeo-biology and Micro-palaeontology	4	4	75	25	100	3 Hours
G-205	Mining Geology	4	4	75	25	100	3 Hours
G-206	Practical G-206 based on G-201,G-203 and G-205	6	12	75	25	100	3 Hours
G-207	Practical G-207 based on G-202 and G-204	6	12	75	25	100	3 Hours
OE-205	Geoscience and Society	2	2	35	15	50	3 Hours
Semester III							
G-301	Geohydrology	4	4	75	25	100	3 Hours
G-302	Stratigraphy, Palaeo-geography and Palaeo-ecology	4	4	75	25	100	3 Hours
G-303	Igneous and Metamorphic Petrology	4	4	75	25	100	3 Hours
G-304	Sedimentology and Geomorphology	4	4	75	25	100	3 Hours
G-305	Engineering Geology	4	4	75	25	100	3 Hours
G-306	Practical G-306 based on G-302, G-303 and G-304	6	12	75	25	100	3 Hours
G-307	Practical G-307 based on G-301 and G-305	6	12	75	25	100	3 Hours
OE-305	Natural Disasters	2	2	35	15	50	3 Hours
G-308	Geological Field Training	4	4	75	25	100	3 Hours
Semester IV							
G-401	Geochemistry	4	4	75	25	100	3 Hours
G-402	Remote Sensing and GIS	4	4	75	25	100	3 Hours
G-403	Fuel Geology	4	4	75	25	100	3 Hours
G-404	Environmental Geology (Elective)	4	4	75	25	100	3 Hours
G-405	Ore Geology and Mineral Economics (Elective)	4	4	75	25	100	3 Hours
G-406	Oceanography and Marine Geology (Elective)	4	4	75	25	100	3 Hours
G-407	Practical G-407 based on G-401, G-402 and G-403	6	12	75	25	100	3 Hours
G-408	Practical G-408 based on G-404, G-405 and G-406	6	12	75	25	100	3 Hours

M.Sc. APPLIED GEOLOGY (I SEMESTER)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-101**
COURSE TITLE: **GEOLOGY – I**
COURSE OBJECTIVE: To provide a basic understanding of various aspects of Geology.

Course Contents:

Unit No.	Contents
UNIT-I INTRODUCTION	Earth science: its subdivisions and relation to other sciences. Historical development of geological thoughts. Geo-morphological processes: exogenic processes, weathering, erosion, transportation and deposition by wind; river; glacier; waves and tides.
UNIT-II MINERALOGY AND PETROLOGY	Chemical nature of minerals, isomorphism, solid solution and polymorphism. Physical properties of minerals, classification of minerals, common rock forming and ore minerals and rock cycle. Texture, structure, mineralogy and classification of igneous rocks. Sedimentary rocks and their texture, mineralogy and classification. Metamorphic facies, texture, structures, mineralogy and classification of metamorphic rocks.
UNIT-III STRUCTURAL GEOLOGY AND ENGINEERING GEOLOGY	Primary and secondary structures in rocks, stress and strain, behaviour of rocks under stress, folds, faults, joints and unconformities- their definition, classification and criteria for recognition in the field and on maps. Shear zones, transform faults and lineaments. Elementary idea about Engineering Geology, geological materials used in construction.
UNIT-IV SURVEYING	Principles of surveying and leveling, methods of surveying by chain, plane table, compass, dumpy level, theodolite and total station, Use of field instruments such as pocket compass, prismatic compass, clinometer compass, brunton compass, abney level, pedometer and altimeter. Indexing and reading of toposheet.

COURSE OUTCOMES (COs): - After successful completion of the course, the students will:

1. Get to know about the basics of geology, its related disciplines and its relation with mankind.
2. Gain knowledge about the basics of mineralogy and petrology.
3. Identify and classify rocks and minerals based on various physical properties and know the basics of structural Geology.
4. Gain knowledge regarding the basics of surveying instruments and the techniques applicable in the field.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO1
101.1	3.0	3.0	2.0	1.0	3.0	1.0	3.0	3.0	3.0	2.0	2.0
101.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	1.0	2.0
101.3	3.0	3.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	1.0	3.0
101.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
101.5	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	3.0	2.4	1.8	3.0	2.0	2.6	3.0	2.8	1.6	2.6

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
101.1	3.0	3.0	2.0	3.0
101.2	3.0	3.0	2.0	2.0
101.3	3.0	3.0	3.0	2.0
101.4	3.0	3.0	3.0	3.0
101.5	3.0	3.0	2.0	3.0
Average	3.0	3.0	2.4	2.6

BOOKS RECOMMENDED:

1	*Understanding the Earth*, Press, F. and Siever, R., W.H. Freeman & Co.
2	*Physical Geology*, Moore, J.S. and Wicander, R., Brooks-Cole.
3	*An Outline of Structural Geology*, Hobbs, M B.E., Means, W.D. and Williams, P.F., John Wiley & Sons
4	*Structural Geology: An Introduction to Geometrical Techniques*, Ragan, D.M., John Wiley & son.
5	*Fundamentals of Structural Geology*, Pollard, D.D. and Fletcher, R.C., Cambridge University Press.
6	*Structural Geology*, Billings, M.P., Prentice Hall India.
7	*Danas Manual of Mineralogy*, Klein, C., Cornelius, S.H., and Dana, J.D., John Wiley & Sons.
8	*An Introduction to the Rock-Forming Minerals*, Deer, W.A., Howie, R.A. and Zussman, J., ELBS.
9	*Rutley's Elements of Mineralogy*, Read, H.H., Springer.
10	*Introduction to Mineral Sciences*, Putnis, A., Cambridge University press.
11	*Igneous and Metamorphic Petrology*, Best, M.G., Blackwell.
12	*Igneous and metamorphic petrology*, Turner, F.J. and Verhoogen, J., CBS Publishers.
13	*Igneous petrology*, Best, M.G., CBS Publishers.
14	*Igneous petrogenesis*, Wilson, M., Springer.
15	*Igneous petrology*, Bose, M.K., World Press.
16	*An introduction to metamorphic petrology*, Yardley, B.W.D., Longman series, Prentice Hall.
17	*Surveying Volume I*, Punmia, B.C. and Jain, A., Laxmi publications (P) Ltd.

18	*Surveying and leveling, Volume 1*, Kanetkar, T.P. and Kulkarni, S.V., Pune Vidyarthi Griha Prakashan.
19	*Surveying Volume 2*, Punmia, B.C., Laxmi Publications (P) Ltd.
20	*Surveying and leveling, Volume 2*, Kanetkar, T.P. and Kulkarni, S.V., Pune Vidyarthi Griha Prakashan.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-102**
COURSE TITLE: **GEOLOGY II**
COURSE OBJECTIVE: To provide knowledge of various disciplines of Geology.

Course Contents:

Unit No.	Contents
UNIT-I PALAEONTOLOGY	Fossils, fossilization processes (taphonomy) and modes of preservation; geological time scale and a brief history of life on Earth, major mass extinctions in the geological past, significance of fossils.
UNIT-II STRATIGRAPHY	Broad outline of physiographic and tectonic framework of India, introduction to lithostratigraphy, biostratigraphy, chronostratigraphy, magnetostratigraphy and stratigraphic principles.
UNIT-III ECONOMIC GEOLOGY AND ORE PROCESSES	Classification of ore deposits, igneous, metamorphic and sedimentary processes of formation of ore deposits, hydrothermal process, supergene enrichment, evaporites and anoxic deposits, stratified and strata-bound deposits etc. Concept of ore, gangue, tenor, grade and specifications. Distribution and geological set up of important metallic and non-metallic mineral deposits of India including coal, petroleum and atomic minerals.
UNIT-IV ENVIRONMENTAL GEOSCIENCE	Basic principles of environment and ecosystem in relation to Geology. Man's activities and their impact on the environment. Depleting natural resources and sustainable development, conservation of mineral resources, mitigation of pollution and environmental hazards and geogenic contamination of groundwater.

COURSE OUTCOMES (COs): - After successful completion of the course, the students will:

1. Understand different types of fossils and their various uses to mankind.
2. Get to know about the geological time scale and stratigraphic division of India.
3. Provide knowledge regarding various types of deposits of ores, petroleum and coal, their distribution and usefulness to mankind.
4. Understand the basics and importance of sustainable development and environmental geology to society.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO	PO	PO	PO	PO	PO	PO	PO10	PO11
102.1	3.0	3.0	2.0	1.0	3.0	1.0	3.0	3.0	3.0	2.0	2.0
102.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	1.0	2.0
102.3	3.0	3.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	2.0	3.0
102.4	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
102.5	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	3.0	2.6	2.0	3.0	2.0	2.6	3.0	2.8	2.0	2.6

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
102.1	3.0	3.0	2.0	3.0
102.2	3.0	3.0	2.0	2.0
102.3	3.0	3.0	3.0	2.0
102.4	3.0	3.0	3.0	3.0
102.5	3.0	3.0	3.0	3.0
Average	3.0	3.0	2.6	2.6

BOOKS RECOMMENDED

1. *A Manual of Geology of India and Burma*, Vol. I-IV, Krishnan, M. S. Gov. of India Press.
2. *Palaeontology*, Jain, P.C. and Anantharaman, M.S., Vishal Publishing Co.
3. *Economic mineral deposits*, Bateman, A.M., Jensen, M.L., John Wiley and Sons.
4. *Ore Deposits of India*, Gokhale and Rao, Thomson Press, Delhi.
5. *India's mineral resources*, Krishnaswami S., New Delhi, Oxford and IBH Pub. Co. (1972).
6. *A Handbook of minerals, Crystals, Rocks and Ores*, Parmod, A.O., New India Publishing Agency – 2009.
7. *Economic Geology – Economic Mineral Deposits of India* , Prasad, U., CBS Publishers Ltd.
8. *Natural Disasters*, Alexander, D. UCL Press Ltd, Univ College London.
9. *Mitigation of Natural hazards and disasters: international perspectives*, Haque, C. Emdad., Dordrecht, Springer.
10. *Environmental Geosciences*, Keller, E.A., Prentice Hall, New Jersey.
11. *Fundamental of Historical Geology and Stratigraphy*, Kumar Ravinder., New Age International Publishers.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-103**
COURSE TITLE: **PHYSICS AND CHEMISTRY OF THE EARTH**
COURSE OBJECTIVE: To provide information regarding physics and chemistry of the Earth and the geodynamic evolution of the Himalayas.

Course Contents:

Unit No.	Contents
UNIT-I	Theories of origin of Earth and a brief review of knowledge about the solar system. The Earth in relation to other planets and major surface features of the Earth. The Earth-Moon system.
UNIT-II	The Earth's interior: the nature of the crust-mantle boundary, low velocity zone in the upper mantle, the chemical composition and mineralogy of the Earth's crust, mantle and core, evidence from experimental petrology & study of meteorites, geochemical evolution of the Earth, thermal evolution and state of Earth, continental and oceanic heat flow and convection in mantle.
UNIT-III	Earthquakes, global seismicity, Earth's internal structure derived from seismology, continental drift, Earth's magnetic field, origin of geomagnetic fields, palae-omagnetism, polar wandering, sea-floor spreading, plate tectonics, triple junctions, hot spots & plumes.
UNIT-IV	Major features of the Earth's gravitational field and their relationship with tectonic processes in crust and upper mantle, geochronology: radiometric dating and its significance, mountain belts and new global tectonics, tectonic evolution of the Himalaya and the Indian shield.

COURSE OUTCOMES (COs): The paper will provide:

1. Knowledge about the Earth and its relation to other planets. Importance of Earth science to mankind.
2. Knowledge regarding earth's interior and the dynamic processes of Earth.
3. Detailed knowledge regarding tectonic evolution of the Himalayas and the Indian shield.
4. Significance of geochronology, dating techniques and tectonics.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
103.1	3.0	2.0	2.0	1.0	3.0	1.0	3.0	3.0	3.0	2.0	2.0
103.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	1.0	2.0
103.3	3.0	3.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	2.0	3.0
103.4	3.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Average	3.0	2.5	2.3	2.0	3.0	2.0	2.6	3.0	2.8	2.0	2.6

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
103.1	3.0	3.0	2.0	3.0
103.2	3.0	3.0	2.0	2.0
103.3	3.0	3.0	3.0	2.0
103.4	3.0	2.0	3.0	3.0
Average	3.0	2.8	2.6	2.6

BOOKS RECOMMENDED:

1.	*The Solid Earth*, Fowler, C.M.R., Cambridge University Press, New York,
2.	*Understanding Earth*, Gauss, I.G., Smith, P.S. and Wilson, R.G.L., MIT Press (1973).
3.	*The Dynamic earth - A textbook in Geosciences*, Wyllie, P.J., Wiley.
4.	*Physics and Geology*, Jacobs, J.J., Russel, R.D. and Wilson, J.T., McGraw Hill.
5.	*Fundamental of Geodynamics*, Schiedegger, A.E., Springer.
6.	*Aspects of tectonics: focus on south-central Asia*, Valdiya, K.S., Tata Mc Graw Hill Pub. Co.
7.	*The Inaccessible Earth*, Brown, G.C. and Mussett, A.E., Chapman and Hall.
8.	*Understanding the Earth*, Brown, J., Hawkesworth, C.,and Wilson, C., Paperback, Book Depository, U.S.A.
9.	*Earth*, Siever, R., Frank Press.
10.	*Plate Tectonics & Crustal Evolution*, Condie, K.C., Butterworth-Heinemann Ltd; 4th revised edition (1997).

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-104**
COURSE TITLE: **GEOEXPLORATION**
COURSE OBJECTIVE: To introduce basic concepts of prospecting and exploration methods.

Course Contents:

Unit No.	Contents
UNIT-I	Prospecting and exploration, history of geophysical methods, planning a prospecting PROGRAMME, various types of geo-exploration methods, electrical properties of rocks and minerals, a brief outline of various types of electrical methods, quantities measured in electrical methods, wenner and schlumberger methods of resistivity profiling and sounding.
UNIT-II	Magnetic properties of rocks and minerals, determination of rock densities, introduction to gravity and magnetic methods, gravity anomalies, quantities measured in gravity and magnetic prospecting.
UNIT-III	Seismic prospecting and seismology, elementary principles of reflection and refraction methods, quantities measured in seismic methods, two layered reflection and refraction problems, principles of radioactive methods, examples/case histories of application of various geophysical methods for minerals, coal, and oil, groundwater and geotechnical investigations.
UNIT-IV	Geological prospecting criteria and guides to ore search, principles of geochemical and geo-botanical prospecting. Geological, geochemical and geo-botanical exploration for important metallic and non-metallic deposits with Indian examples. Elementary ideas about methods of drilling, core-logging and ore reserve estimation. Examples/case histories of application of geological methods of exploration.

COURSE OUTCOMES (COs): After completion of the course, the students will be able to:

1. Gain information regarding geo- exploration methods and its usefulness in exploration programmes and to society.
2. Information regarding magnetic methods of geo-exploration.
3. Know application of various geophysical methods for minerals, coal, oil, groundwater and geotechnical investigations
4. Know their applications in solving geological problems on the field.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
104.1	3.0	2.0	2.0	1.0	3.0	1.0	3.0	3.0	3.0	3.0	3.0
104.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0
104.3	3.0	3.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	3.0	3.0
104.4	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Average	3.0	2.8	2.3	2.0	3.0	2.0	2.6	3.0	2.8	3.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
104.1	3.0	3.0	3.0	3.0
104.2	3.0	3.0	2.0	3.0
104.3	3.0	3.0	3.0	3.0
104.4	3.0	2.0	3.0	3.0
Average	3.0	2.8	2.8	3.0

BOOKS RECOMMENDED:

1	*Applied Geophysics*, Telford, W.M., Geldart, L.P. and Sheriff, R.E., Cambridge University Press.
2	*An Introduction to Geophysical Exploration*, Kearey, P. Brooks, M. and Hill, I., Blackwell.
3	*Principles of Applied Geophysics*, Parasnis, D.S., Chapman and Hall.
4	*Introduction to Geophysical Prospecting*, Dobrin, M.B. and Savit, C.H., McGraw-Hill.

G- 105 PRACTICAL

BASED ON G- 101 (MINERALOGY, PETROLOGY AND STRUCTURAL GEOLOGY)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Course contents:

Megascopic study of important earth materials, including loose soils, sediments, minerals, ore minerals and rocks in hand specimens.

Microscopic study of important minerals and rocks in thin sections and polished sections.

Elementary exercises relevant to recognition of folds, faults and unconformities on maps and in models. Preparation of geological cross sections of horizontal, dipping, folded and faulted structures.

Note: -
5 marks (20%) in each Unit are reserved for practical records / regularity / assiduity and the same are to be given by the teachers teaching the course.

COURSE OUTCOME (CO): After successful completion of the course the students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

G- 106 PRACTICAL

BASED ON G-102 (PALAEONTOLOGY AND STRATIGRAPHY),

G-101 (SURVEY) AND G-103 (PHYSICS AND CHEMISTRY OF THE EARTH)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Course contents:

Megascopic and microscopic study of important fossils. Study of important stratigraphic rocks in relation to Geological time and mineral deposits.

Preparation of site plans with the help of chain, tape and plane table. Profiling using dumpy level and determination of height using theodolite. Use of field instruments viz., clinometer, brunton, prismatic compass, abney level, altimeter and pedometer. Toposheet reading, total station.

Note: -
As regarding Surveying practical, end semester examination / test shall be internally conducted by the teacher teaching the course in consultation with the Chairman and marks out of 20 (15+5) shall be communicated by him to the Chairman before the practical examination.

COURSE OUTCOME (CO): After successful completion of the course the students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

G – 107
GEOLOGICAL FIELD TRAINING

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

COURSE OBJECTIVE: To impart understanding of mapping methods, sampling in the field and using different tools and instruments in the field.

Each student in the course is required to undergo few days' field training in an academic session.

COURSE OUTCOME: Students will get knowledge about methods of geological mapping, sampling and learn use of tools and instruments in the field and also learn about preparing field training reports.

M.Sc. APPLIED GEOLOGY (II SEMESTER)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-201**
COURSE TITLE: **MINERALOGY, INSTRUMENTATION AND ANALYTICAL TECHNIQUES**
COURSE OBJECTIVE: To provide basic information regarding structure and optical properties of minerals.

Course Contents:

Unit No.	Contents
UNIT-I	Crystals: definition, elements of symmetry, notations-Weiss and miller, space lattice. Morphological classification of crystals into systems and symmetry classes (Holohedral classes). Twinning in crystals. Projections in crystals - spherical, stereoscopic and gnomonic.
UNIT-II	Pleochroic scheme of minerals. Extinction phenomenon: Extinction angle and its determinations. Interference phenomenon, order of interference colors and figures. Uniaxial and biaxial minerals: optical indicatrix. Optic sign.
UNIT-III	Structure of silicate minerals: neso-, soro-, cyclo-, iono-, phyllo- and tecto-silicates and their bearing on properties of minerals. Study of the following mineral groups/minerals with reference to structure, PT - stability, physical, chemical and optical properties, and their mode of occurrence: quartz, feldspar, feldspathoid, pyroxene, amphibole, olivine, mica, clay minerals, garnet, alumino-silicates, staurolite, epidote, zircon, sphene, zeolite, carbonate, and phosphates.
UNIT-IV	Sampling and sample preparation; thin section and polished section making. Sample etching, staining and modal count techniques. Technique in photomicrography. Brief introduction to: principles and geological application of thermo-luminescence; atomic absorption spectrophotometry; ICP-MS; mass spectrometry; x-ray diffractometry; electron microscopy and electron-probe microanalysis.

COURSE OUTCOMES (COs):

1. Understanding of crystal systems.
2. Optical properties of various mineral groups and its application in various geological techniques.
3. Understanding mineral optics and structure.
4. Knowledge regarding applications of various instruments in data acquisition.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
201.1	3.0	2.0	2.0	1.0	3.0	1.0	3.0	3.0	3.0	3.0	3.0
201.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	3.0	3.0
201.3	3.0	3.0	2.0	1.5	2.0	1.0	2.0	3.0	2.0	2.0	2.0
201.4	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Average	3.0	2.8	2.3	1.9	2.8	2.0	2.6	3.0	2.8	2.8	2.8

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
201.1	3.0	3.0	3.0	3.0
201.2	3.0	2.0	2.0	3.0
201.3	2.0	3.0	3.0	3.0
201.4	3.0	2.0	2.0	3.0
Average	2.8	2.5	2.5	3.0

BOOKS RECOMMENDED:

1.	*An Introduction to the rock forming minerals*, Deer, W.A., Howie, R.A. and Zussman, J. Longman., Prentice Hall.
2.	*Manual of Mineralogy*, Klein, C. and Hurlbut, Jr.C.S, John Wiley.
3.	*Introduction to Mineral Sciences*, Putnis, A., Cambridge University press.
4.	*Mineralogical phase equilibria and Pressure-Temperature-Time paths*, Spear,F.S. Mineralogical Society of America Publ., 1993.
5.	*Optical Mineralogy*, Phillips, W.R. and Griffen, D.T., CBS publishers.
6.	*Laboratory handbook of petrographic techniques*, Hutchinson, C.S., John Wiley.
7.	*Dana's textbook of Mineralogy*, Ford, W.E., Wiley Eastern.
8.	*Rutley's Elements of Mineralogy*, Read, H.H., CBS publishers.
9.	*Mineralogy*, Berry, Mason and Dictrich, CBS publishers.
10.	*Optical Mineralogy*, Kerr, P.F., McGraw Hill.
11.	*Elements of Optical Mineralogy I & II*, Winchell, A.N.
12.	*Practical Manual of crystal optics*, Babu, S.K. and Sinha, D.K., CBS Publishers.
13.	*Mineral optics*, Phillips, R.W., Freeman & Company, USA.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-202**
COURSE TITLE: **STRUCTURAL GEOLOGY AND TECTONICS**
COURSE OBJECTIVE: To provide the conceptual knowledge of structural Geology.

Course Contents:

Unit No.	Contents
UNIT-I	Mechanical principles and properties of rocks and their controlling factors. Theory of rock failure. Concept of stress and strain and their relationships of elastic, plastic and viscous materials. Strain markers in naturally deformed rocks. Behavior of minerals and rocks under deformation conditions.
UNIT-II	Fold: mechanics of folding and buckling. Fractures and joints: their nomenclature, age relationship, origin and significance. Causes and dynamics of faulting, strike-slip faults, normal faults, over thrust and nappe. Planar and linear fabrics in deformed rocks, their origin and significance. Structural behavior of diapirs and salt domes.
UNIT-III	Concept of petro-fabrics and symmetry: objective, field and laboratory techniques and types of fabrics. Time relationship between crystallization and deformation.
UNIT-IV	Major tectonic division of Himalaya, collision of India with Asia, evolution of volcanic island arc, Indus- suture zone, emergence and evolution of Himalaya, orogeny, fore arc basin and back arc basin. Study of stereographic projection.

COURSE OUTCOMES (COs):

1. Concept and tectonics of deformation structures.
2. Kinematic study of deformation structures, their origin and significance.
3. Concept of petrofabric analysis and relationship between crystallization and deformation.
4. Detailed Himalayan Orogeny, various Map projections and its applicability in field and society.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
202.1	3.0	3.0	2.0	1.5	3.0	1.0	3.0	3.0	3.0	3.0	3.0
202.2	3.0	3.0	3.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0
202.3	3.0	3.0	2.5	1.5	2.0	1.0	2.0	3.0	2.0	2.0	3.0
202.4	3.0	3.0	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Average	3.0	3.0	2.5	2.0	2.5	2.0	2.6	3.0	2.8	2.8	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
202.1	3.0	3.0	3.0	3.0
202.2	3.0	2.0	2.0	3.0
202.3	2.0	3.0	2.0	2.0
202.4	3.0	2.0	3.0	3.0
Average	2.8	2.5	2.5	2.8

BOOKS RECOMMENDED:

1.	*Folding and fracturing of rocks*, 1967, Ramsay, J.G., McGraw Hill.
2.	*An outline of Structural Geology*, Hobbs, B.E., Means, W.D. and Williams, P.F., John Wiley.
3.	*Structural Geology of rocks and region*, Davis, G.R., 1984. John Wiley.
4.	*Modern Structural Geology, Volume I & II*, 1987, Ramsay, J.G. and Hubber, M.I., Academic Press.
5.	*Analysis of geological structures*, Price, N.J. and Cosgrove, J.W., 1990, Cambridge Univ. Press.
6.	*Structural Geology fundamentals of modern developments*, Ghosh, S.K., 1995, Pregamon Press.
7.	*Geological structures and Moving plates*, Park, R.G., Springer science + Business Media
	Dordrecht 1988.
8.	*Global tectonics*, 1990 Keary, P. and Vine, F.J., Blackwell.
9.	*Dynamic Himalaya*, 1998. Valdiya, K.S., Universities press, Hyderabad.
10.	*Geomorphology and Global tectonics*, 2000, Summerfield, M.A., Springer Verlag.
11.	*Mechanics in structural geology*, Bayly, B. 1992, Springer Verlag.
12.	*Micro-tectonics*, Passchier, C.W. and Trouw, R.A.J. 1998, Springer.
13.	*Aspects of tectonics: focus on south-central Asia*, Valdiya, K.S., Tata Mc Graw Hill Pub. Co., 1984.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-203**
COURSE TITLE: **COMPUTING TECHNIQUES IN GEOSCIENCES**
COURSE OBJECTIVE: To provide basic information regarding basics of computer and statistical methods in relation to Geology.

Course Contents:

Unit No.	Contents
UNIT-I	Computer system, hardware components: CPU, memory, input/ output devices and information storage media. Software, computer PROGRAMMEs, operating system concepts, DOS and its use.
UNIT-II	Problem solving and computer programming languages useful for scientific computing, various data types, expression and statements, iterative statements, input/output statements, subroutines and functions, data sharing among sub programmes/programmes. Programming examples to handle problems of numerical and statistical type.
UNIT-III	Computer applications in Geology: preparation of charts, frequency diagrams, geological maps, thematic maps, cross sections and litho logs.
UNIT-IV	Statistical parameters: mean median, mode, skewness, and kurtosis. Statistical techniques: probability, correlation and regression. Frequency curve, cumulative curve and histogram.

COURSE OUTCOMES (COs):

1. Students will gain knowledge regarding the basics of computers and its use to society.
2. Knowledge regarding computer languages useful to handle problems of numerical and statistical type in Geology.
3. Various applications of computers in Geology.
4. Knowledge regarding statistical methods and their significance to Geology and society.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
203.1	3.0	3.0	2.0	2.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0
203.2	3.0	3.0	3.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0
203.3	3.0	3.0	2.5	2.0	2.0	2.0	2.0	3.0	2.0	3.0	3.0
203.4	3.0	3.0	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Average	3.0	3.0	2.5	2.3	2.5	2.3	2.6	3.0	2.8	3.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
203.1	3.0	3.0	3.0	3.0
203.2	3.0	2.0	2.0	3.0
203.3	3.0	3.0	3.0	3.0
203.4	3.0	2.0	3.0	3.0
Average	3.0	2.5	2.8	3.0

BOOKS RECOMMENDED:

1.	*Fundamentals of Computer*, Rajaraman, V., Prentice Hall India.
2.	*Computer applications in Earth Sciences*, Merriam, D. F., Springer.
3.	*Computer Oriented Numerical Methods*, Rajaraman,V., Prentice Hall India, 1984.
4.	*Computer programming for science & Engineering*, Bhirud, L.L., Oxford and IBH Publishing Co Pvt. Ltd., (1991).
5.	*Computer methods in Geology*, Loudon, T.V., Academic Press, 1979.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-204**
COURSE TITLE: **PALAEOBIOLOGY AND MICROPALAEONTOLOGY**
COURSE OBJECTIVE: To impart basic understanding and significance of different aspects of Micropalaeontology and Palaeobiology.

Course Contents:

Unit No.	Contents
UNIT-I	Concepts of organic evolution: evolution of horse, elephant and man. An overview of palaeobotany and Gondwana flora.
UNIT-II	Functional morphology, evolutionary trends. Geological history of Brachiopods, Trilobites, Mollusca, Echinoderms and Graptolites.
UNIT-III	Sampling techniques in micro-palaeontology, processing of samples for preparation of microfossils, morphology and geological distribution of Foraminifera, Ostracoda, Conodonts, Radiolarians, Silicoflagellates, and Chitinozoans. Palaeo-environmental interpretations based on microfossils.
UNIT-IV	Morphology, ecology and geological history of Charophytes, Dinoflagellates and Acritarchs. Morphology of fossil spores and pollen grains. Applications of microfossils in fossil fuel exploration.

COURSE OUTCOMES (COs):

1. Knowledge of micro-palaeontology and palaeo-biology
2. Applications of micro-palaeontology and palaeo-biology in biostratigraphy, bio-chronology and palaeo-environmental interpretations.
3. Understanding evolutionary trends and geological history of invertebrates.
4. Applications of microfossils and palyno-fossils in coal and petroleum exploration.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
204.1	3.0	1.0	2.0	3.0	3.0	1.0	3.0	3.0	3.0	2.0	2.0
204.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
204.3	3.0	2.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	2.0	2.0
204.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Average	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.3	2.5

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
204.1	3.0	3.0	2.0	3.0
204.2	3.0	2.0	3.0	3.0
204.3	3.0	3.0	3.0	3.0
204.4	3.0	2.0	3.0	3.0
Average	3.0	2.5	2.8	3.0

BOOKS RECOMMENDED:

1. *Invertebrate Palaeontology and Evolution*, Clarkson, E.N.K., 1998, IV Ed., Blackwell.
2. *Palaeontology- The record of life*, Stearn, C.W. & Carroll, R.L., 1989, John Wiley.
3. *Systematics and the Fossils Record- Documenting Evolutionary Patterns*, Smith, A.B., 1994, Blackwell.
4. *Bringing Fossils to Life- An introduction to Palaeobiology*, Prothero, D.R., 1998, McGraw Hill.
5. *Introduction to Marine Micropalaeontology*, Haq, B.V. and Boersma, A., 1998, Elsevier.
6. *Foraminifera*, Haynes, J.R., 1981, John Wiley.
7. *Elements of Micropalaeontology*, Bignot, G., Graham and Trotman, 1985, Springer.
8. *Principles of Micropalaeontology*, Glassner, M.E., Hafner Publ.
9. *Principles of Zoological Micropalaeontology*, Pokherny V., Pargamon Publ.
10. *Introduction to Microfossils*, Jones, D.J., Hafner Publishing Co Ltd., 1969.
11. *Foraminifera: Their classification and economic use*, Cushman, J.A., Andesite Press, 2015.
12. *Microfossils*, Brasier, M. and Armstrong, H., Wiley Blackwell, 2013.
13. *Invertebrate Fossils*, Moore, Lalicker and Fischer, McGraw Hill.
14. *Principles of Invertebrate Palaeontology*, Shrock and Twenoffel, CBS.
15. *Essentials of Palynology*, Nair, P.K.K., Asia Pub. House.
16. *Treatise on Invertebrate Palaeontology*, Moore, R.O., (Editor), New York: Geological Society of America; Lawrence Kansas: University of Kansas Paleontological Institute, 1953-1981.
17. *The Micropalaeontology of Oceans*, Funnel, D.M. and Riede, W.R., Cambridge Univ. Press.
18. *Palaeontology Invertebrate*, Woods, H., CBS.
19. *Vertebrate Palaeontology*, Ramer, A.S., Univ. of Chicago Press.
20. *Organic Evolution*, Lull, R.S., Nabu Press.
21. *Micropaleontology*, Kathal, K., CBS publication.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-205**
COURSE TITLE: **MINING GEOLOGY**
COURSE OBJECTIVE: This course is designed to give an idea about the various types of geological field operations, which are carried out in opencast/underground mines.

Course Contents:

Unit No.	Contents
UNIT-I	Elements of mining, its methods (alluvial mining, opencast mining and underground mining) for metallic and nonmetallic ores. Coal mining and Ocean bottom mining.
UNIT-II	Preparation of mine plans. Role of geologists in mine operation. Drilling methods and core logging. Sampling and its methods. Mineral processing techniques. Methods of ore reserve estimation.
UNIT-III	Types of explosives, equipment and material required for blasting, method of charging explodes.
UNIT-IV	Shafting, ventilations, drainage and pumping. Mine support and mechanization. Mine safety measures and mine legislation.

COURSE OUTCOMES (COs):

1. Basic knowledge regarding mining and different types of mining methods.
2. Role of geologist in mine working operations.
3. Methods of blasting and explosion.
4. Knowledge on various mine safety measures and legislation.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
205.1	3.0	1.0	2.0	3.0	3.0	1.0	3.0	3.0	3.0	2.0	3.0
205.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
205.3	3.0	2.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	2.0	3.0
205.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
205.1	3.0	3.0	2.0	3.0
205.2	3.0	2.0	3.0	3.0
205.3	2.0	2.0	3.0	3.0
205.4	3.0	2.0	3.0	3.0
Average	2.8	2.3	2.8	3.0

BOOKS RECOMMENDED:

1.	*Mining Engineer's hand books*, Roberts, P., John Wiley and Sons.
2.	*Mining Geology*, Mckinstry, H.E., Asia publishing house.
3.	*Courses in mining Geology*, Arogyaswami, R.P.N., Oxford IBH.
4.	*Elements of mining*, Clark, G.B., John Wiley.

G-206 PRACTICAL

BASED ON G-201 (MINERALOGY, INSTRUMENTATION AND ANALYTICAL TECHNIQUES), 203 (COMPUTING TECHNIQUES IN GEOSCIENCES) AND G-205 (MINING GEOLOGY)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Mineralogy
Determination of the following crystallographic parameters:
(a) Zone symbols between faces (b) Angle between faces in different crystal systems (c) Axial ratio with the help of stereogram of different crystal systems.

Study of detailed physical and optical properties of various minerals. Interpretation of X-ray diffractograms.

Exercises on Instrumentation and analytical techniques: sample preparation, thin section making, etching, staining, and spectrometers.

Diagrammatic representation of open cast and underground mining. Methods of mining survey. Exercise on mine sampling and determination of tenor, cut-off grades, and ore reserves.

Computer Lab.

COURSE OUTCOME (CO): Students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

G-207 PRACTICAL

BASED ON G-202 (STRUCTURAL GEOLOGY AND TECTONICS) AND G-204 (PALAEONTOLOGY AND MICROPALAEONTOLOGY)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Preparation and interpretation of geological map and section.
Structural problems concerning economic mineral deposits.
Recording and plotting of field data.
Plotting and interpretation of petro-fabric data and resultant diagrams.
Study of large-scale tectonic features of the earth.

Processing of samples, picking and mounting of fauna. Preparation of oriented sections. Study of invertebrate and vertebrate fossils of important groups. Microscopic study of foraminifera, ostracoda, fossil spores, pollen grains and phytoplanktons of different periods. Delineation of environmental conditions on the basis of fossil assemblages

COURSE OUTCOME: Students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

M.Sc. APPLIED GEOLOGY (III SEMESTER)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G- 301**
COURSE TITLE: **GEOHYDROLOGY**
COURSE OBJECTIVE: To provide understanding regarding the hydro-geological properties of water bearing formations and chemical parameters of water.

Course Contents:

Unit No.	Contents
UNIT-I	Introduction to hydrogeology, hydrologic cycle, water budget on earth, water balance studies, origin of groundwater, springs, their classification and characteristics, quality of groundwater, drinking water criteria, standards of industrial and agricultural use of water.
UNIT-II	Hydrological properties of water bearing materials, porosity, void ratio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, and field and laboratory methods of determination of permeability. Movement of groundwater and aquifer performance tests. Darcy law and its range of validity. Theory of groundwater flow under steady and unsteady conditions, determination of permeability, transmissivity and storativity by discharging well methods.
UNIT-III	Mode of occurrence of ground water, classification of rocks with respect to their water bearing characteristics, aquifers, aquicludes, aquitards, aquifuse, classification of aquifers, photo-geological and remote sensing studies for water resources evaluation, groundwater exploration, water well drilling, development of wells, groundwater management, hydrograph analysis, conjunctive and consumptive use of groundwater and hydrograph analysis.
UNIT-IV	Physical properties used for groundwater exploration, groundwater exploration methods, resistivity method, concept of apparent and true resistivity, profiling and sounding, range of resistivity values for various rocks and minerals and application of seismic refraction method for groundwater problems.

COURSE OUTCOMES (COs):

1. Basic knowledge of geohydrology and groundwater prospecting techniques.
2. knowledge regarding groundwater flow under steady and unsteady conditions
3. Knowledge regarding groundwater exploration and management.
4. Application of seismic refraction methods in groundwater problems.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
301.1	3.0	1.0	2.0	3.0	3.0	1.0	3.0	3.0	3.0	2.0	3.0
301.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
301.3	3.0	2.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	2.0	3.0
301.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
301.1	3.0	3.0	2.0	3.0
301.2	3.0	2.0	3.0	3.0
301.3	2.0	2.0	3.0	3.0
301.4	3.0	2.0	3.0	3.0
Average	2.8	2.3	2.8	3.0

BOOKS RECOMMENDED:

1.	*A text book of Geomorphology*, Worcester, P.G., East West Press.
2.	*Ground water Hydrology*, David K. Todd., John Wiley and Sons.
3.	*Principle of Hydrology*, Ward, R.C. and Robinson, M., Tata McGraw Hill.
4.	*HandBook of applied Hydrology*, Chow, V.T., McGraw Hill.
5.	*Introduction to groundwater hydrology*, Heath, R.C. and Trainer, F.W., John Wiley and Sons.
6.	*Hydrology*, Meinzer, O.E., Dover.
7.	*Hydrogeology*, Davis, S.N., and Dewiest. R.J.M., John Wiley and Sons.
8.	*Ground water*, Toman, C.F., McGraw Hill.
9.	*Hydrology*, Wister, C.P. & Brater, E.F., Yoppen Co. Ltd, Tokyo.
10.	*Geohydrology*, Dewiest, R.J.M., John Wiley and Sons.
11.	*Ground water*, Walton, W.C., McGraw Hill.
12	*Ground water*, Raghunath, H.M., Wiley Eastern Ltd.
13	*Hydrology*, Joya, P. and Reddy Remi, Laxmi Publications, Delhi.
14	*Basic Exploration Geophysics*, Robinson, E.S., Wiley.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-302**
COURSE TITLE: **STRATIGRAPHY, PALAEO-GEOGRAPHY AND PALAEO-ECOLOGY**
COURSE OBJECTIVE: To impart basic understanding regarding significance of different aspects of stratigraphy, palaeo-geography and palaeo-ecology.

Course Contents:

Unit No.	Contents
UNIT-I	Code of stratigraphic nomenclature, principles of stratigraphic correlation, cyclo-stratigraphy, pedo-stratigraphy, event stratigraphy, sequence stratigraphy.
UNIT-II	Precambrian stratigraphy of India, Paleozoic stratigraphy (Spiti, Kashmir and Kumaon), Mesozoic stratigraphy (Spiti, Kutch, Narmada Valley and Trichinopoly).
UNIT-III	Gondwana Supergroup, Cenozoic stratigraphy (Assam, Bengal basins and Garhwal-Shimla Himalayas), Siwaliks and Indo Gangetic alluvial plains.
UNIT-IV	Palaeo-geographic reconstruction of India during Gondwana time, Palaeogene and Neogene periods. Palaeoecological analysis of foraminifera and ostracods.

COURSE OUTCOMES (COs): The students will acquire basic knowledge on:

1. GTS, stratigraphy and applications in Geology and society.
2. Stratigraphic procedures of correlation and their applications.
3. Stratigraphic sequences with reference to India.
4. Palaeo-geographic reconstruction of India.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
302.1	3.0	1.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0
302.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
302.3	3.0	2.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	3.0	3.0
302.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Average	3.0	2.25	2.5	2.8	3.0	2.3	2.5	3.0	2.5	2.8	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
302.1	3.0	3.0	3.0	3.0
302.2	3.0	2.0	3.0	3.0
302.3	3.0	3.0	3.0	3.0
302.4	3.0	2.0	3.0	3.0
Average	3.0	2.5	3.0	3.0

BOOKS RECOMMENDED:

1.	*The Cenozoic Era: Tertiary and Quaternary*, Pomerol, C., 1982, Ellis Horwood Ltd.
2.	*Precambrian Geology: The Dynamic Evolution of Continental Crust*, Goodwin, A.M., (1991), Academic Press.
3.	*Principles of Sedimentology and Stratigraphy*, Boggs, Sam Jr. 1995, Prentice Hall.
4.	*Integrative Stratigraphy: Concepts and Applications*, Brenner, R.L. and Mcttargue, T.R., 1988, Prentice Hall.
5.	*Sedimentary and Evolutionary Cycles*, Bayer, U. and Seilacher, A., 1985, Springer-Verlag.
6.	*Palaeozoic; Vol.1; Mesozoic, Vol. II; Cenozoic Vol. III*, Moullade, M. and Nairn, A.E.M., 1983, Elsevier.
7.	*Seismic Stratigraphy-Applications to Hydrocarbon Exploration*, Payton, C.E., Amer. Assoc. Petrol. Geol. Publ., 1977.
8.	*Unlocking the Stratigraphic Record*, Doyle, P and Benett, M.R., 1996, John Wiley.
9.	*Precambrian Geology of India*, Naqvi, S.M. and Rogers, J.J.W., 1987, Oxford Univ. Press.
10.	*A Manual of Geology of India and Burma*, Krishnan, M.S., Vol. I-IV, Govt. of India Press.
11.	*Palaeomagnetism-Principles and Applications in Geology, Geophysics and Archaeology*, Tarling, D.H., 1983, Chapman and Hall.
12.	*Seismic Stratigraphy*, Sheriff, R.E., 1980, International Human Resource Development Corp. Boston.
13.	*Introduction to Palaeoecology*, Ager,D.V. 1980, McGraw Hill.
14.	*Principles of Palaeoecology*, Ager, D.V., 1963, McGraw Hill.
15.	*The Ecology of Fossils*, Mckerrow, W.S., 1982, MIT Press.
16.	*Palaeoecology: Concepts and Application*, Dodd, J.R. and Stanton, R.J., John Wiley.
17.	*Treatise on Marine Ecology & Palaeoecology, Vol. 2*, Ladd, H.S., 1957, (Palaeoecology) Mem. Soc. America.
18.	*Geology of India*, Wadia, D.N., Alpha Edition.
19.	*Manual of Geology of India, Vol. I, II and III*, Pascoe, Geological Survey of India.
20.	*Fundamental of Historical Geology and Stratigraphy*, Kumar, R., New Age (publisher).
21.	*Stratigraphic Geology*, Gignoux, M., W.H. Freeman and Company.
22.	*Historical Geology*, Dunbar, C.O. & Waage, K.M., John Wiley.
23.	*Principles of Precambrian Geology*, Goodwin, A., Academic Press.
24.	*Vertebrate Paleontology*, Ramer, A.S., Univ. of Chicago Press.
25.	*Colbert's Evolution of the Vertebrates*, Colbert, E.H., Wiley-liss.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-303**
COURSE TITLE: **IGNEOUS AND METAMORPHIC PETROLOGY**
COURSE OBJECTIVE: To provide in depth knowledge regarding genesis and association of igneous and metamorphic rocks.

Course Contents:

Unit No.	Contents
UNIT-I	Magma generation and emplacement in the crust, mantle and their relation to plate tectonics. Factors affecting magma and evolution of magma (differentiation, assimilation, mixing and mingling). Phase equilibrium of ternary system: (a) Ab-An-Di system, (b) Fo-An-SiO_2 system (c) Fo-Di-SiO_2 and their relation to magma genesis and crystallisation in the light of modern experimental work.
UNIT-II	Criteria for classification of the igneous rocks - IUGS classification of plutonic and volcanic rocks. Variation diagrams. CIPW Norms. Texture, chemical composition, distribution and petrogenesis of major igneous rock types such as granite, pegmatite, granodiorite, rhyolite, syenite, diorite, trachyte, andesite, gabbro, basalt, komatiite, alkaline and mono-mineralic rocks.
UNIT-III	ACF, AKF, AFM diagrams. A detailed description of each facies of low-pressures, medium- to high- pressures, very high pressure with special reference to characteristic metamorphic zones and sub-facies. Nature of metamorphic reactions and pressure-temperature conditions of metamorphism. Mineral assemblages and application of mineralogical phase rule to metamorphic rocks. Iso-reactiongrad, schreinemakers rule and construction of petrogenetic grids.
UNIT-IV	Metasomatism, metamorphic differentiation. Anatexis and origin of migmatites, granitisation in the light of experimental studies. Regional metamorphism and paired metamorphic belts in reference to plate tectonics. Ultra-high temperature, ultra-high pressure and ocean floor metamorphism. Study of charnockite, khondalites and gondites. Regional and contact metamorphism of pelitic and impure calcareous rocks.

COURSE OUTCOMES (COs):

1. Knowledge on magma generation and relation to plate tectonics. The students will understand the process and kinematics involved in the genesis of igneous and metamorphic rocks.
2. Classification of the igneous rocks, variation diagrams, CIPW Norms and their applicability.
3. Detailed description of facies and assemblages and applications to metamorphic rocks.
4. Detailed study on metamorphism and relation to plate tectonics.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
303.1	2.0	2.0	2.0	1.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0
303.2	3.0	2.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	1.0	2.0
303.3	2.0	3.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	1.0	3.0
303.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	2.5	2.5	2.5	1.8	3.0	2.0	2.5	3.0	2.8	1.5	2.8

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
303.1	3.0	2.0	2.0	3.0
303.2	2.0	3.0	3.0	3.0
303.3	3.0	3.0	3.0	3.0
303.4	3.0	2.0	3.0	3.0
Average	2.8	2.5	2.8	3.0

BOOKS RECOMMENDED:

1.	*Igneous and metamorphic petrology*, Turner, F.J. and Verhoogen, J., CBS Publishers.
2.	*Igneous petrology*, Best, M.G., CBS Publishers.
3.	*Igneous and metamorphic petrology*, Philipotts,A., Prentice Hall.
4.	*Igneous petrology*, Bose, M.K., World press.
5.	*Igneous petrogenesis*, Wilson, M., Unwin Hyman Ltd, London.
6.	*Metamorphic petrology*, Turner, F.J., McGraw Hill, NY.
7.	*An introduction to metamorphic petrology*, Yardley, B.W., Longman, NY.
8.	*Petrogenesis of metamorphic rocks*, Bucher, K. and Frey, M., Springer - Verlag.
9.	*Petrogenesis of metamorphic rocks*, Winkler, H.G.F., Narosa publishers, New Delhi.
10.	*Petrography*, Williams, H., Turner, F.J. and Gilbert, C.M., CBS Publishers, New Delhi.
11.	*Metamorphic crystallisation*, Kretz, R., John Wiley.
12.	*Physical chemistry of magmas*, Perchuk, L.L. and Kushiro, I. (eds), Springer Verlag.
13.	*Igneous petrology*, Mc Birney, A.R., Jones & Bartlet, Publ.
14.	*A descriptive petrography of igneous rocks*, Johansen, A., Allied Pacific Pvt. Ltd, Bombay.
15.	*Petrology of metamorphic rocks*, Mason, R., CBS publishers.
16.	*The study of rocks in thin sections*, Moorhouse, W.W., CBS publishers.
17.	*Atlas of igneous rocks and their textures*, Mackenzie, W.S., Donaldson, C.H. and Guilford, C., ELBS/Longman.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-304**
COURSE TITLE: **SEDIMENTOLOGY AND GEOMORPHOLOGY**
COURSE OBJECTIVE: To provide in-depth knowledge of sedimentological and geomorphic processes.

Course Contents:

Unit No.	Contents
UNIT-I	Concept of size, size classification of sedimentary aggregates, causal factors of grain size distribution- provenance, transportation and depositional processes, shape, roundness, porosity and permeability. Sedimentary structures. Maturity of sediments: lithification and diagenesis. Facies.
UNIT-II	Conglomerate types -ortho, para, intraformational. Sandstone types - feldspathic and arkose, lithic, wackes and quartz arenites. Shales and clays. Classification of sandstones. Sedimentological characteristics of fluvial, glacial and aeolian environments. Provenance of sediments, paleocurrent analysis.
UNIT-III	Size analysis of sediments by sieving method, staining technique, X-ray and DTA analysis of clays, heavy mineral analysis and its significance. Application of sedimentary petrology to science, industry and technology. Active tectonic studies of sedimentary basins. Paleochannels of the ancient Saraswati and Drishadvati river systems and their geological significance.
UNIT-IV	Fundamental concepts of geomorphology, base level erosion and peneplanation, cycle concept, rejuvenation and interruption of geomorphic cycle. Climate and geomorphic processes. Factors governing evolution of landforms. Influence of structure and lithology on drainage. Application of geomorphology in civil engineering and strategic terrain evaluation.

COURSE OUTCOMES (COs):

1. Detailed knowledge of sedimentary rocks, structures, environments of sedimentation and sedimentary facies in nature.
2. Characteristics of various sedimentary environments and palaeo-current analysis.
3. Field and laboratory methods to study and analyze sedimentary rocks.
4. Fundamental concepts of geomorphology and their application in society.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
304.1	3.0	2.0	2.0	2.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0
304.2	3.0	2.0	3.0	2.0	3.0	2.0	2.0	3.0	3.0	2.0	3.0
304.3	3.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
304.4	3.0	3.0	3.0	2.5	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2.5	2.5	2.2	3.0	2.3	2.5	3.0	2.8	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
304.1	3.0	2.5	2.0	3.0
304.2	3.0	3.0	3.0	3.0
304.3	3.0	3.0	3.0	3.0
304.4	3.0	2.5	2.0	3.0
Average	3.0	2.8	2.5	3.0

BOOKS RECOMMENDED:

1.	*Sedimentary Rocks*, Pettijohn, F.J., CBS.
2.	*Depositional Sedimentary Environments*, Reineck and Singh, Springer.
3.	*Manual of Sedimentary petrography*, Krumbein and Pettijohn.
4.	*Principles of Sedimentary deposits: Stratigraphy and Sedimentology*, Friedman, Gerald and Sanders, Macmillan USA.
5.	*Introduction of Sedimentology*, Shelly, R.C., Academic Press.
6.	*Petrography of Sedimentary rocks*, Folk, R.L., Hemphill Pub. Co.
7.	*Procedures in Sedimentary environments*, Carver, R.F., New York, Wiley Interscience, 1971.
8.	*Palaeocurrent and Basin analysis*, Pettijohn and Potter, Springer.
9.	*Sedimentology*, Mclane, M., OUP USA.
10.	*Petrology of the Sedimentary rocks*, Greensmith, J.T., Springer.
11.	*Applications of Sedimentology*, Trask, scholarly article.
12.	*Sequence in Layered rocks*, Shrock and Robert, R., McGraw Hill.
13.	*Introduction to Sediment analysis*, Rouse, F., Arizona State Univ.
14.	*Principles of Geomorphology*, Thornbury, W.D., CBS.
15.	*Introduction to Sedimentology*, Sengupta, S., 1997 Oxford and IBH.
16.	*Sand and Sandstone*, Pettijohn, F.J., Potter, P.E. and Siever, R., 1990, Springer Verlag.
17.	*Introduction to Physical Geology*, Dutta, A.K., Kalyani Publishers.
18.	*Geomorphology*, Sharma, V.K., 1986, Tata McGraw Hill.

19.	*A Text Book of Geomorphology*, Worcester, P.G., D. Van Nostrand Co.
20.	*Fundamentals of Geomorphology*, Rice, R.J., Longman.
21.	*An Introduction to Physical Geology*, Miller, W.J., 1949, D. Van Nostrand Co.
22.	*An outline of Geomorphology: the physical basis of geography*, Morgan, R.S. and Wooldridge, S.W., 1959, Orient Longman Limited.
23.	*Introduction to Marine Geology and Geomorphology*, King, A.M.C., 1975, Hodder and Stoughton Educational.
24.	*Principles of Physical sedimentation*, Allen, J.R.L., 1985, The Blackburn Press and Springer.
25.	*Earth Surface Processes*, Allen, P., 1997, Wiley-Blackwell.
26.	*Sedimentology and Stratigraphy*, Nichols, G., 1999, Wiley India Pvt. Ltd.
27.	*Sedimentary Environments*, Readings, H.G., 1996, Wiley-Blackwell.
28.	*Depositional Systems*, Davis, R.A., 1992, Pearson College Div.
29.	*Sedimentary Basins: evolution, facies and sediment budget*, Einsele, G., 1992, Springer- Verlag.
30.	*Sedimentary Geology*, Prothero, D.R. and Schwab, F., 1996, W.H. Freeman.
31.	*Principles of Sedimentary Basin Analysis*, Miall, A.D., 2000, Springer.
32.	*Origin of Sedimentary rocks*, Blatt, Middleton and Murray, 1980, Prentice Hall.
33.	*Analyses of sedimentary Successions*, Bhattacharya, A. and Chakraborti, C., 2000, CRC Press.
34.	*Principles of Sedimentology and Stratigraphy*, Boggs, Sam. Jr., 1995, Pearson.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-305**
COURSE TITLE: **ENGINEERING GEOLOGY**
COURSE OBJECTIVE: To provide knowledge regarding basic concepts of engineering Geology and its applications in engineering projects.

Course Contents:

Unit No.	Contents
UNIT-I	Mechanics of rocks- compressive and shear strength, modulus of elasticity, Poisson's ratio, residual stresses, engineering properties of rocks, bearing strength of foundations, strength of discontinuities. Rock mass classification: rock quality design index, rock structure rating, rock mass ratings, rock tunnel quality index, rock mass index and geological strength index. Slope mass ratings.
UNIT-II	Mechanics of soils- soil profile, soil description and classifications, Atterberg's limits, porosity, permeability and weathering, swelling and pore pressure of soils, cohesion and friction of soil, shear strength of soils, Mohr's envelope, engineering geological characteristics of sediments and problematic soils.
UNIT-III	Construction materials in practice. Dam: types and their foundations, case histories. Tunnel: classification, method of tunneling and case histories. Application of geological and geophysical methods in civil engineering projects. Role of engineering Geology in planning, designing and constructions of civil engineering projects: dam, tunnel, rail, road and highways, bridges and building.
UNIT-IV	Landslides, types of rock slope failures, slope stability assessment, causes and consequences of earthquakes and landslides on engineering structures and preventive/mitigation measures. Watershed management, river improvement and flood control. Engineering geological maps.

COURSE OUTCOMES (COs):

1. Knowledge of Soil and rock mechanics.
2. Identification and classification of soil properties and soil types.
3. Investigation and analyses of construction materials, slopes, landslides and foundations.
4. Application of Geology in civil engineering, watershed management and other applications in society.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
305.1	3.0	2.5	2.0	2.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0
305.2	3.0	2.5	3.0	3.0	3.0	2.0	2.0	3.0	3.0	2.0	3.0
305.3	3.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
305.4	3.0	3.0	3.0	30	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2.8	2.5	2.5	3.0	2.3	2.5	3.0	2.8	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
305.1	3.0	2.0	2.0	3.0
305.2	3.0	3.0	3.0	3.0
305.3	3.0	3.0	3.0	3.0
305.4	3.0	20	3.0	3.0
Average	3.0	2.5	2.8	3.0

BOOKS RECOMMENDED:

1.	*Engineering Geology*, Krynine and Judd, CBS publishers.
2.	*Soil mechanics*, Lambe, T.W. and Whitman, R., Wiley India Pvt Ltd.
3.	*Soil mechanics and foundation engineering*, Bharath Singh and Shamser Prakash, Nem Chand and Bros.
4.	*Soil mechanics*, Tsytovich, N.A.,Central Books Ltd.
5.	*Design of small dams*, Udall, S.L. and Dominy, F.E., United States Govt. Printing Office.
6.	*Manual of Engineering Geology*, Blyth, F.G.H. and Freitas, M., CRC Press.
7.	*Geological Engineering*, Luis González de Vallejo and Ferrer, M., CRC Press.

G-306 PRACTICAL

BASED ON G-302 (STRATIGRAPHY, PALAEO-GEOGRAPHY AND PALAEO-ECOLOGY), G-303 (IGNEOUS AND METAMORPHIC PETROLOGY) AND G-304 (SEDIMENTOLOGY AND GEOMORPHOLOGY)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Study of rocks from different stratigraphic horizons. Exercises on stratigraphic classification and correlation. Exercises on interpretation of seismic records. Study of paleogeographic maps of different geological periods.

Megascopic and microscopic study of the following rocks types: -
Igneous rocks: acidic, intermediate, basic, ultrabasic and alkaline rocks.

Metamorphic rocks: slate, phyllite, quartzite, marble, schist, gneiss, amphibolite, eclogite, migmatite, granulite and charnockite.
Graphic construction and interpretation of variation diagrams.

Study of primary, secondary and biogenic sedimentary structures in hand specimens, in photographic atlases, field photographs and wherever possible on the outcrops. Analysis and interpretation of depositional sedimentary environments using actual case histories from the Indian stratigraphic records. Megascopic and microscopic study of clastic and chemical sedimentary rock. Detailed study of diagenetic features in thin sections. Microscopic study of heavy minerals. Exercises on mineralogical and geochemical data plots for environmental interpretations. Interpretation of different sedimentological characteristics from size data. Roundness and sphericity analysis. Paleo-current data interpretation.
Geomorphological analysis from maps and toposheets evaluation.

COURSE OUTCOME (CO): Students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

G-307 PRACTICAL

BASED ON G-301 (GEOHYDROLOGY) AND G-305 (ENGINEERING GEOLOGY)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Preparation and interpretation of water table contour map and depth of water table maps. Chemical quality maps, hydrographic maps, analytical instruments and their uses, interpretation of hydro-geochemical data, evaluation of hydrological parameters of aquifers, processing and interpretation of pumping test data. Numerical and graphical exercises.

Analysis of stress-strain diagrams of different rock types and soil. Engineering index properties and diagrams. Problems related to foundations and soil properties: Atterberg's Limits. Weathering coefficient of rocks and soils. Identification of building materials/stones for various constructions. Study of maps and models of important engineering structures/dam sites and tunnels, engineering geological maps. Soil/rock slope stability analysis. Assessment of mode of failure of rock slopes.

COURSE OUTCOME (CO): Students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

G – 308
GEOLOGICAL FIELD TRAINING

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

COURSE OBJECTIVE: To impart understanding of mapping methods, sampling in the field and using different tools and instruments in the field.

Each student in the course is required to undergo few days' field training in an academic session.

COURSE OUTCOME: Students will get knowledge about methods of geological mapping, sampling and learn use of tools and instruments in the field and also learn about preparing field training reports.

M.Sc. APPLIED GEOLOGY (IV SEMESTER)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-401**
COURSE TITLE: **GEOCHEMISTRY**
COURSE OBJECTIVE: To provide knowledge regarding basics and significance of geochemistry in Geosciences.

Course Contents:

Unit No.	Contents
UNIT-I	Objective and history of geochemistry, chemical composition and characteristics of atmosphere, lithosphere and hydrosphere, geochemical cycles, meteorites - types and composition, Goldschmidt's classification of elements, application of thermodynamics in Geology.
UNIT-II	Principles of ionic substitution in minerals, concept of distribution coefficient and its uses in geochemical modeling, Nernst's partition coefficient (compatible and incompatible elements), physico-chemical factors in sedimentation. Applications of trace elements in Geology and REE patterns.
UNIT-III	Geochemistry of uranium, thorium, rubidium and strontium. Principles and application of Rb-Sr, K-Ar, U-Pb and Sm-Nd methods of dating. Principle methodology and application of fission track dating method. Cosmo-genic radionuclides, production of ^{10}Be and ^{26}Al in the atmosphere, and their application in dating sediments.
UNIT-IV	Significance of stable isotope geochemistry in Geology, isotope fractionation in nature. Stable isotopes of oxygen, carbon and hydrogen and their determination. Delta $^{18}O/^{16}O$ in marine planktonic foraminifera as paleo-temperature indicator, other factors governing its variations. Pleistocene glacial and de-glacial cycles and delta ^{18}O event stratigraphy. $^{13}C/^{12}C$ ratios in marine planktons and organic matter. Delta ^{13}C characterization of ocean-water masses, factors affecting variations of carbon isotope ratios. Significance of delta D and delta ^{18}O in hydrological studies - relative age determination of groundwater reservoirs, effect of mixing and evaporation.

COURSE OUTCOMES (COs):

1. Applications of geochemistry in Geology and nature.
2. Knowledge regarding geochemical cycle and modeling.
3. Methods of dating and their applications.
4. Emphasis on Significance of stable isotope geochemistry in Geology.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
401.1	3.0	1.0	2.0	3.0	3.0	1.0	3.0	3.0	3.0	2.0	3.0
401.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
401.3	3.0	2.0	2.0	2.0	3.0	1.0	2.0	3.0	2.0	2.0	3.0
401.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
401.1	3.0	3.0	2.0	3.0
401.2	3.0	2.0	3.0	3.0
401.3	2.0	2.0	3.0	3.0
401.4	3.0	2.0	3.0	3.0
Average	2.8	2.3	2.8	3.0

BOOKS RECOMMENDED:

1.	*Introduction to Geochemistry*, Mason, B. and Moore, C.B., 1991, Wiley Eastern.
2.	*Introduction to Geochemistry*, Krauskopf, K.B., 1967, McGraw Hill.
3.	*Principles of Isotope Geology*, Faure, G., 1986, John Wiley.
4.	*Stable Isotope Geochemistry*, Hoefs, J., 1980, Springer-Verlag.
5.	*Geochemistry*, Wedepohl, K.H. Holt, Rinehart and Winston Inc. USA.
6.	*Geochemistry*, Brownlow, A.H., Prentice-Hall.
7.	*Inorganic Geochemistry*, Henderson, P., Pergamon Press.
8.	*Geochemical Thermodynamic*, Nordstrom, D.K. and Munoz, J.L., Blackwell.
9.	*Hand book of Exploration Geochemistry*, Govett, G.J.S.,Elsevier.
10.	*Encyclopedia of Geochemistry*, Marshal, C.P. and Fairbridge, R.W. Kluwer Academic.
11.	*Using geochemical data*, Rollinson, H. Longman Scientific & Technical NY.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-402**
COURSE TITLE: **REMOTE SENSING & GIS**
COURSE OBJECTIVE: To introduce the principles of satellite based remote sensing, GIS and its application in the field of Geoscience.

Course Contents:

Unit No.	Contents
UNIT-I	Electromagnetic spectrum, interaction of electromagnetic waves with earth's surface and atmosphere, image characteristics - scale, brightness and tone, contrast ratio, detectability, recognizability, signature, texture, interpretation key, spatial resolution and resolving power, remote sensing platforms. Remote sensing systems - framing systems, scanning systems and multispectral systems. Aerial photographs: types of aerial photographs, photographic scale, relief displacement, stereoscopic vision, vertical exaggeration, geotechnical elements, photo-mosaics.
UNIT-II	Active and passive sensors; MSS, LISS, CCD, infra-red and thermal scanners. Low earth orbit and geostationary orbit, Indian remote sensing series, different satellite PROGRAMMEs, microwave sensors, fundamentals of image interpretation and analysis and false color composite.
UNIT-III	Interpretation and analysis of aerial photographs and images for identification of different rock types, structures, lineaments, recognition of landforms, drainage patterns. Application in engineering projects, (dam, reservoir, tunnel alignment, route location etc.), groundwater prospecting, geothermal studies, geo-environmental studies (soil conservation, land degradation etc.) and disaster management (flood, landslides etc.). Role in resource management.
UNIT-IV	Components of GIS: hardware and software. GIS data types, raster and vector data models. Concept of thematic layers and topology. Triangulated irregular networks (TIN), digital elevation model, digital terrain model and their applications. Global positioning system and its application in Geology.

COURSE OUTCOMES (COs):

1. Introduction to fundamentals of remote sensing.
2. Satellite Imagery analysis and satellite programmes till date.
3. Interpretation and analysis of aerial photographs and their various applications to mankind.
4. Introduction to fundamentals of GIS and its application in Geology.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
402.1	3.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0
402.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
402.3	3.0	2.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
402.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2. 5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
402.1	3.0	3.0	2.0	3.0
402.2	3.0	2.5	3.0	3.0
402.3	3.0	2.0	3.0	3.0
402.4	3.0	2.5	3.0	3.0
Average	3.0	2.5	2.8	3.0

BOOKS RECOMMENDED:

1.	*Remote sensing Geology*, Gupta, R.P., Springer – Verlag.
2.	*Principles and applications of photogeology*, Pandey, S.N., Tata – McGraw Hill.
3.	*Remote sensing in Geology*, Siegal, B.S. and A.R., John Wiley & sons.
4.	*Photogeology*, Miller, V.C. and Miller, C.F., McGraw Hill.
5.	*Remote sensing and image interpretation*, Lillesand, T.M., and Kieffer, R.W., John Wiley & Sons.
6.	*Remote principles and interpretations*, Sabbins, F.F., W.H. Freeman Company.
7.	*Remote sensing for earth resources*, Rao, D.P., AEG publications, Hyderabad.
8.	*Manual of remote sensing*, American Society of Photogrammetry.
9.	*Principles of Remote Sensing*, Currian, P.J., ELBS, London.
10.	*Advances in Geophysics*, Vol. 1 and 13, Landsberg, H.E., Academic Press.
11.	*Hand book/ brochures issued by Geological Survey of India* (Airborne Mineral Survey and Exploration Wing), Atomic energy commission (Atomic Minerals Division) and National Geophysical Research Institute.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-403**
COURSE TITLE: **FUEL GEOLOGY**
COURSE OBJECTIVE: To impart knowledge regarding nuclear energy, coal and petroleum deposits and their process of formation.

Course Contents:

Unit No.	Contents
UNIT-I	Introduction to coal, process of coalification. Proximate and ultimate analyses of coal; lithotypes, macerals and micro-lithotypes of coal, coal gasification and coal liquefaction.
UNIT-II	Present day peat bogs and swamps, geological and geographical distribution of coal deposits in India, origin and tectonic controls on deposition of Gondwana coals of India. Coal as a source of hydrocarbon. Coal Bed Methane (CBM), utilisation of coal and its impact on the environment.
UNIT-III	Kerogen sediment, its composition and origin, transformation of organic matter, maturation, thermal cracking, metagenesis and ketagenesis, nature of migration of oil and gas, characteristics of reservoir rocks and traps. Major oil and gas fields of India.
UNIT-IV	Radioactivity and nuclear energy; important atomic minerals – their mode of occurrence and associations. U and Th deposits of India, production, reserves and future scenario. Nuclear power production and its potential in India. Peaceful uses of nuclear energy and nuclear environmental hazards.

COURSE OUTCOMES (COs):

1. Introduction to the process of coalification and technological properties of coal.
2. Coal forming epochs in geological past and present scenario with reference to India.
3. Present and future prospects of oil and gas fields in India and World.
4. Radioactive and nuclear energy, their deposits in India and its application in Geology and to society.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
403.1	3.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0
403.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
403.3	3.0	2.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
403.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2. 5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
403.1	3.0	3.0	2.0	3.0
403.2	3.0	2.5	3.0	3.0
403.3	3.0	2.0	3.0	3.0
403.4	3.0	2.5	3.0	3.0
Average	3.0	2.5	2.8	3.0

BOOKS RECOMMENDED:

1. *Organic Petrology*, Taylor, G.H., Teichmuller, M., Davis, A., Diessel, C.F.K., Littke, R. and Robert,P. 1998, Gebruder Borntraeger, Stuttgart.
2. *Textbook of coal (Indian Context)*, Chandra, D., Singh, R.M. and Singh, M.P., Tata Book Agency, Varanasi.
3. *Coal and organic Petrology*, Singh, M.P. (Ed), Hindustan Publication Ltd, New Delhi.
4. *Text book of Coal Petrology*, Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M., and Teichmuller, R. 1982, Gebruder Borntraeger, Stuttgart.
5. *Introduction to Petroleum Geology*, Holson, G.D. and Tiratsoo, E.N. 1985, Gulf Publication Houston, Texas.
6. *Petroleum formation and occurrence*, Tissot, B.P. and Welte, D.H. 1984, Springer-Verlag.
7. *Elements of Petroleum Geology*, Selley, R.C., 1998, Academic Press.
8. *Radioactivity in Geology- Principles and Applications*, Durrance, E.M. 1986, Ellis Hoorwool.
9. *Uranium ore deposits*, Dahlkamp, F.J. 1993, Springer Verlag.
10. *Geochemical prospecting for Thorium and Uranium deposits*, Boyle, R.W. 1982, Elsvier.
11. *Coal Geology and Coal Technology*, Ward, C.R. 1984, Blackwell Scientific, Australia.
12. *Sedimentology of coal bearing sequence of North America*, Rahmani, R.A. and Flores, R.M. 1984, Blackwell Scientific, Australia.
13. *Coal Industry in India*, Kumarmangalam, S.M. 1973, Oxford and IBH.
14. *Ore deposits of India*, Gokhale and Rao, Thomson Press, Delhi.
15. *Distribution of World's Mineral Wealth*, Rajagopalswami, K. 1971, Mysore University.

16.	*India's mineral resources*, Krishnaswami S., New Delhi, Oxford and IBH Pub. Co. (1972).
17.	*Economic mineral deposits*, Bateman, A.M., Jensen, M.L., John Wiley and Sons.
18.	*Geology of Petroleum*, Leverson, A.I., CBS.
19.	*Introduction to Petroleum Geology*, Hobson, G.D., Houston, Texas, U.S.A., Gulf Pub Co.
20.	*Petroleum Geology*, Chapman, R.E., Elsevier Science Pub Co.
21.	*Basic Petroleum Geology*, Peter, K. Link, Oil and Gas Consultant Intl.
22.	*Petroleum Geology*, North, F.K., 1985, Kluwer Academic Publishers.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-404**
COURSE TITLE: **ENVIRONMENTAL GEOLOGY (Elective)**
COURSE OBJECTIVE: To provide knowledge regarding basic concepts of Environmental Geology.

Course Contents:

Unit No.	Contents
UNIT-I	Components of environment, ecology and ecosystem. Interactions between atmosphere, hydrosphere, lithosphere, biosphere and man. Principles of environmental Geology, ethics of conservation. Atmosphere and increasing trend of CO_2 and other greenhouse gases. Fossil fuel burning, ozone layer and global warming. Smog pollution and acid rains, causes and remedies. Other causes of pollution.
UNIT-II	Hydrologic cycle and Earths' water balance, pollution of surface and subsurface water. Water quality criteria for domestic and industrial use, water quality degradation due to use of fertilizers, pesticides and geogenic causes. Hydrogeologic considerations for liquid waste disposal. Hydrologic implications of solid waste disposals. Waste (solid, liquid, gases) management and control.
UNIT-III	Natural resources of lithosphere, land, soil and minerals and their depletion. Land degradation due to natural hazards. Land conservation and land use planning. Watershed management. Impact of irrigation - water logging and soil degradation. Energy minerals and their conservation, nonconventional sources of energy. Nuclear waste disposal and geological constraints.
UNIT-IV	Types of microorganisms, role of sulfur, nitrogen and iron bacteria in the environment. Biogeochemistry of iron, manganese and sulfur. Marine pollution- causes and controls. Environmental impact assessment – impact of mining on environment, environmental health and environmental law in India.

COURSE OUTCOMES (COs):

1. Introduction to ecology and their inter-relationship with mankind.
2. Water quality and waste management.
3. Natural resources and their conservation.
4. Environmental impact assessment and knowledge of environmental laws.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
404.1	3.0	3.0	2.0	3.0	3.0	2.5	3.0	3.0	3.0	2.0	3.0
404.2	3.0	2.0	3.0	2.0	3.0	2.5	2.0	3.0	2.0	2.0	3.0
404.3	3.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
404.4	3.0	2.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2.5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
404.1	3.0	3.0	2.0	3.0
404.2	3.0	2.5	3.0	3.0
404.3	3.0	2.5	3.0	3.0
404.4	3.0	3.0	3.0	3.0
Average	3.0	2.8	2.8	3.0

BOOKS RECOMMENDED:

1. *Environmental geology*, Lindgren, L., Prentice Hall.
2. *Environmental geology*, Keller, E.A., Pearson.
3. *Organic micro-pollutants in the aquatic environment*, Angeletti, G., Springer Science Business Media.
4. *Environmental Geoscience: Interaction between natural systems and man*, Strahler, A.N. and Strahler, A.H., John Wiley And Sons Inc.
5. *A text book of environmental chemistry and pollution control*, Dara, S.S. and Mishra, D.D., S. Chand and Company.
6. *Water pollution*, Tripathi, A.K. and Panday, S.N., CBS.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G-405**
COURSE TITLE: **ORE GEOLOGY AND MINERAL ECONOMICS (Elective)**
COURSE OBJECTIVE: To impart basic understanding of different types of mineral deposit and processes of their formation.

Course Contents:

Unit No.	Contents
UNIT-I	Concept of ore bearing fluids, their origin and migration. Spatial and temporal distribution of ore deposits - a global perspective. Ore deposits and plate tectonics. Paragenesis and zoning of ores and their significance. Chemical composition of ores. Fluid inclusion in ores: principles and their applications.
UNIT-II	Mineralogy, genesis, mode of occurrence, uses and Indian distribution of ore minerals related to Iron, Manganese, Copper, Lead, Zinc, Tin, Tungsten, Chromium, Nickel, Gold, Silver, Aluminum.
UNIT-III	Concept of mineral economics, importance of minerals in national economy, marketing and marketing speculation, trade and trade restriction, production and development incentives. Strategic, critical and essential minerals. National mineral policy. Foreign policy in mineral trade, Mineral concession rules in India. Mineral transport, freight, insurance and customs-INCO terms and contracts.
UNIT-IV	Changing mineral requirements. Foreign investment in the development and exploitation of mineral raw materials. Project feasibility report of minerals and ores, principles of management in mineral industries. Principles and methods of ore dressing and their economic aspects (Metallic and non-metallic). Refractory and abrasives, ceramic and glass fertilizers cements industries minerals. Precious and semi-precious stones.

COURSE OUTCOMES (COs):

1. Introduction to ore deposits, their distribution and relation to plate tectonics.
2. Uses and distribution of ore minerals with reference to India.
3. Mineral economics, mineral policy and concession rules in India.
4. Project feasibility reports, ore dressing techniques and uses in industry.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
405.1	3.0	3.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0
405.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
405.3	3.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
405.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0

Average	3.0	3.0	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
405.1	3.0	3.0	2.0	3.0
405.2	3.0	2.5	3.0	3.0
405.3	3.0	2.5	3.0	3.0
405.4	3.0	2.5	3.0	3.0
Average	3.0	2.7	2.8	3.0

BOOKS RECOMMENDED:

1.	*Economic mineral deposits*, Bateman, A.M., Jensen, M.L., John Wiley and Sons.
2.	*Mineral Economics: An Indian Perspective*, Randive, K., (2020), Nova Science Publishers Inc.
3.	*Ore deposits of India: their distribution and processing*, Gokhle, K.V.G.K. and Rao, T.C., Thomson Press (India).
4.	*Economic Geology*, Prasad, U., CBS.
6.	*India's mineral resources*, Krishnaswami S., New Delhi, Oxford and IBH Pub.Co.
7.	*Geology of mineral deposits*, Smirnov, V.I., Mir Publishers.
8.	*Ore Petrology*, Stanton, R.L., McGraw Hill Higher Education.
9.	*Geology of India*, Wadia, D.N., Alpha Edition
10.	*Ore Microscopy and ore petrology*, Craig, J.R. and Vaughan, D.J., Wiley Blackwell.
11.	*Principles of economic geology*, Emmons, W.H., University of California Libraries.
12.	*Mineral deposits*, Lindgren, W., McGraw Hill Book Company.
13.	*A Manual of Geology of India and Burma*, Vol. I-IV, Krishnan, M. S. Gov. of India Press.
14.	*Ore geology and industrial minerals: an introduction*, Evans, A.M., (2011), Wiley India Pvt. Ltd.

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 4

SUBJECT CODE: **G 406**
COURSE TITLE: **OCEANOGRAPHY AND MARINE GEOLOGY (Elective)**
COURSE OBJECTIVE: To impart basic understanding of oceanography and marine Geology.

Course Contents:

UNIT-I	Distribution of land, seas and oceans: structure, origin, evolution and age of ocean basins. Geomorphology of ocean floor; continental shelf, continental slope, submarine canyons, ridges, plateaus, fracture zones, sea mounts, abyssal plains, deep sea channels trenches, and coral reefs; their distribution and origin.
UNIT-II	Ocean currents and circulation pattern; turbidity and bottom currents; zones of high plankton productivity; bathymetric section, Fauna in ocean floor sediments, their distribution and climatic and palaeoclimatic significance. Eustatic changes of sea level, causes and methods of study. Temperature-salinity distribution in oceans and seas.
UNIT-III	The concept of sea floor spreading evidence of magnetic reversal for seafloor spreading, volcanism and mid oceanic ridge system Indian ocean ridge system. Marine sediments, source, transportation, deposition classification and types of sediments, CaCO3 deposition, carbonate compensation depth, pelagic and abyssal plain sediments. Biological factors in the formation of sediments. Occurrence of anoxic facies sediments in different types of marine environment. Continental margins, sedimentation on active and passive margins. Structural feature of World oceans Origin, evolution and physiography of Indian ocean.
UNIT-IV	Introduction and historical aspects of marine Geology, geological and geophysical methods for ocean floor exploration, techniques of sampling. Sample collection, underwater dragging and underwater photography. Marine mineral resources: Beach placer deposits, phosphorites, metalliferous sediments, sulphate deposits, polymetallic nodules; hydrocarbons in marine sediments. India's marine mineral resources. International sea law.

COURSE OUTCOMES (COs):

1. Knowledge regarding nature and scope of oceanography and distribution pattern of land, sea and oceans.
2. Knowledge of ocean bottom relief, waves and current in relation to origin, type, characteristics and various ocean resources and their influences upon mankind.
3. Fair knowledge about ocean sediments, different marine environments. Knowledge on structural and physiography of the world and Indian Ocean.
4. Students will acquire knowledge of economically important marine mineral resources, their exploration and International sea laws.

Mapping of Course Outcomes to Programme Outcomes

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
406.1	3.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0
406.2	3.0	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
406.3	3.0	2.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0
406.4	3.0	3.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Average	3.0	2.5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0

Mapping of Course Outcomes to Programme Specific Outcomes

COs/PSOs	PSO1	PSO2	PSO3	PSO4
406.1	3.0	3.0	2.0	3.0
406.2	3.0	2.5	3.0	3.0
406.3	3.0	2.0	3.0	3.0
406.4	3.0	2.5	3.0	3.0
Average	3.0	2.5	2.8	3.0

BOOKS RECOMMENDED:

1. *Marine geology*, Keen, M.J., Elsevier.
2. *Oceanography*, Lal, D. S., Sharada Pustak Mahal.
3. *Oceanography: A brief Introduction*, Siddhartha, K., Kisalaya Publication Pvt. Ltd.
4. *Climatology and Oceanography*, Mamoria and Sisodia, M.S., SBPD Publication.
5. *Introduction to Marine Geology and Geomorphology*, King, C., Crane Russak.

G-407 PRACTICAL

BASED ON G-401 (GEOCHEMISTRY), G- 402 (REMOTE SENSING AND GIS) AND G-403 (FUEL GEOLOGY)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Calculation of mineral formulae from the concentration of various oxides in minerals. Calculation of CIPW normative mineralogy from rock composition. Presentation and interpretation of geochemical analytical data. Study and interpretation of geochemical data. Study and interpretation of radiogenic and stable isotope data. Calculation of weathering indices in soils and sediments.

Study of aerial photographs and satellite imageries and their interpretation.

Megascopic characterization of banded coals. Proximate analysis of coal. Completion of outcrops in the given maps and calculation of coal reserves. Preparation of polished particulate mounts of coal. Megascopic examination of polished coal pellets. Megascopic and microscopic study of cores and well cuttings. Study of geological maps and sections of important oil fields of India and the world. Calculation of oil reserves. Study of geological sections of U-Th bearing rocks of the country. Megascopic study of Uranium and thorium bearing minerals and rocks.

COURSE OUTCOME (CO): Students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

G-408 PRACTICAL

BASED ON G-404 (ENVIRONMENTAL GEOLOGY), G-405 (ORE GEOLOGY AND MINERAL ECONOMICS) AND G-406 (OCEANOGRAPHY AND MARINE GEOLOGY)

Max. Marks: 75+25=100
Time: 3 Hours
Credit: 6

COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students so that they can better understand the subject and be able to apply it on the ground.

Preparation of ecological maps and their interpretation. Evaluation of water quality criteria for potable, domestic, industrial, irrigation and waste water. Evaluation of environmental impact of air pollution, groundwater pollution, soil and land degradation, landslides, deforestation, cultivation and urbanization in specified areas.

Megascopic study of ore minerals. Mineralogical and textural studies of common ore minerals under ore microscope.

Bathymetric section of an ocean. Structural features of world oceans. Study of ocean circulation pattern using ocean and land distribution map. Exercises on distribution of economic mineral deposition in the world ocean.

COURSE OUTCOME: Students will gain the practical knowledge about the subject and will be able to apply it in the field in geo-scientific projects professionally.

CHOICE BASED OPEN ELECTIVE

Max. Marks: 35+15=50
Time: 3 Hours
Credit: 2

SUBJECT CODE: **OE- 205**
COURSE TITLE: **GEOSCIENCE AND SOCIETY**
COURSE OBJECTIVE: To impart the knowledge about fundamental and applied aspects of the subject among the students.

UNIT I

Introduction to Geo-science and its various branches, Earth and its place in the solar system. Origin and structure of Earth. Geological time scale. Origin and evolution of life through Earth history. Elementary idea of rocks, their types, rock cycle, minerals and gemstones. Elementary idea of various Earth processes, continental drift and plate tectonics. Orogenic and epeirogenic movements.

UNIT II

Elementary idea of geological considerations in site evaluation of engineering, construction, mining and other geological works. Environmental changes through the Earth history. Significance of earth resources to mankind and society. Hydrological cycle and water budget of an Earth.

COURSE OUTCOME (CO): After completion of the course the students will get to know about the basics of Geology, its related disciplines and its relation with mankind.

BOOKS RECOMMENDED:

1. *Understanding the Earth*, Press, F. and Siever, R., W.H. Freeman & Co.
2. *Palaeontology*, Jain, P.C. and Anantharaman, M.S., Vishal Publishing Co.
3. *An Introduction to Physical Geology, Eleventh Edition*, Tarbuck, Lutgens and Tasa, Pearson Publication.
4. *Principles of engineering Geology and Geotechnics*, Krynine/Judd., Jain Book Agency.
5. *Ground water Hydrology*, Todd David K., PHI Learning.

CHOICE BASED OPEN ELECTIVE

Max. Marks: 35+15=50
Time: 3 Hours
Credit: 2

SUBJECT CODE: **OE- 305**
COURSE TITLE: **NATURAL DISASTERS**
COURSE OBJECTIVE: To impart the knowledge about natural and man-made disasters, their consequences and mitigation measures.

UNIT I

Introduction to hazards: Hazards' classification and distribution, Natural Hazards and their effects, hazard prediction and early warning, role of community and stakeholders. Earthquakes: classification, distribution, causes and effects. Tsunami: Types, effects, prediction and early warning systems.

UNIT II

Landslides: classification, distribution, causes, effects and prevention/mitigation of landslides. Volcanic hazards: Types, distribution, causes and effects of volcanoes and related hazards. Floods: Types and factors leading to floods, flood control/mitigation measures. Cyclones, thunderstorms and lightning, prediction and early warning, droughts and desertification.

COURSE OUTCOME (CO): After completion of the course the students will get to know about the types and causes of natural hazards and their related consequences. The course also provides understanding about various mitigation measures that can be taken during such hazard situations.

BOOKS RECOMMENDED:

1. *Natural Disasters*, Patrick Leon Abbott., McGraw-Hill Education.
2. Disasters Guidelines, NIDM.
3. Disasters Guidelines, NDMA.
4. *Citizens Guide to Disaster Management: How to Save Your Own Life & Help Others*, Satish Modh, Laxmi Publication.
5. *Disaster Management*, Mukesh Kapoor, Moti Lal Banarsi Dass Publication.
6. *Earthquake and Natural Disasters*, Manik Kar, Moti Lal Banarsi Dass Publication.

Mapping Programme Outcomes with Course Outcomes (M.Sc. Applied Geology):

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 101	3.0	3.0	2.4	1.8	3.0	2.0	2.6	3.0	2.8	1.6	2.6
CO 102	3.0	3.0	2.6	2.0	3.0	2.0	2.6	3.0	2.8	2.0	2.6
CO 103	3.0	2.5	2.3	2.0	3.0	2.0	2.6	3.0	2.8	2.0	2.6
CO 104	3.0	2.8	2.3	2.0	3.0	2.0	2.6	3.0	2.8	3.0	3.0
CO 201	3.0	2.8	2.3	1.9	2.8	2.0	2.6	3.0	2.8	2.8	2.8
CO 202	3.0	3.0	2.5	2.0	2.5	2.0	2.6	3.0	2.8	2.8	3.0
CO 203	3.0	3.0	2.5	2.3	2.5	2.3	2.6	3.0	2.8	3.0	3.0
CO 204	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.3	2.5
CO 205	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.0	3.0
CO 301	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.0	3.0
CO 302	3.0	2.25	2.5	2.8	3.0	2.3	2.5	3.0	2.5	2.8	3.0
CO 303	2.5	2.5	2.5	1.8	3.0	2.0	2.5	3.0	2.8	1.5	2.8
CO 304	3.0	2.5	2.5	2.2	3.0	2.3	2.5	3.0	2.8	2.0	3.0
CO 305	3.0	2.8	2.5	2.5	3.0	2.3	2.5	3.0	2.8	2.0	3.0
CO 401	3.0	2.25	2.5	2.8	3.0	1.8	2.5	3.0	2.5	2.0	3.0
CO 402	3.0	2. 5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0
CO 403	3.0	2. 5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0
CO 404	3.0	2.5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0
CO 405	3.0	3.0	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0
CO 406	3.0	2.5	2.5	2.8	3.0	2.5	2.5	3.0	2.5	2.0	3.0