Part B

Syllabus Prescribed for Second Year 2024-25 PG Programme

Programme: M. Sc. (Geology)

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Periods
III GOG 1	DSC-I (Contemporary Applied Technological Advancements in Research relevant/supportive to Major)	60
III GOG 2	DSC-II (Hydrogeology)	60
III GOG 3	DSC-III (Ore Geology and Mining Geology)	45
III GOG 4A OR III GOG 4B	DSE-III /MOOC 1. Geochemistry and Analytical Techniques **or** 2. Indian Mineral Deposit and Mineral Economics	45
III GOG 5	LAB V (Hydrogeology and Ore Geology & Mining Geology)	8 Hrs/week
III GOG 6 (RPP-I)	**Research Project Phase-I**	6 Hrs/week

COs (III GOG 1): CONTEMPORARY APPLIED TECHNOLOGICAL ADVANCEMENTS IN RESEARCH RELEVANT/SUPPORTIVE TO MAJOR

1. Students would be able understand the Bio-mediated geotechnologies.
2. Students would be able to decribe Modern Technologies of Geomatics Applicable to Engineering Geology.
3. Students would be able to explain Global Navigation Satellite Systems.
4. Students would be able understand geological modelling and visualization.
5. Students would be familiar to use of newer technology in rediscovering solar system.
6. Students would be able to explain new technologies in surface and groundwater purification.

Unit	**Content**
Unit I	Bio-mediated geotechnologies- biomineralization, biofilm, and biogas, with a specific focus on microbially induced calcium carbonate precipitation (MICP); geocomputation and geospatial artificial intelligence (GeoAI) for mapping-comprehensive overview of geocomputation and GeoAI applications in mapping (i) buildings and infrastructure, (ii) land use analysis, (iii) natural environment and hazards, and (iv) social issues and human activities). **(10)**
Unit II	Modern Technologies of Geomatics Applicable to Engineering Geology - gathering, interpreting, processing, modelling, storing and delivering spatial information; Geomatic- tools and technologies: land surveying and positioning: topography. **(10)**
Unit III	Global Navigation Satellite Systems (GNSS), Satellite and aerial photogeology and computer programmes, Ground-based remote sensing: digital photogrammetry, LIDAR, Remotely Piloted Aircraft System (PRAS), GIS, digital mapping and geostatistics **(10)**
Unit IV	Geological modelling and visualization, three-dimensional remote sensing in geotechnical engineering, Three-Dimensional Geological Mapping, Rockfall Modelling. Use of recent technologies in economic geology for low grade minerals. **(10)**
Unit V	Use of newer technology in rediscovering solar system, long-distant planets, environment on Earth and climatic changes. New trends in plate tectonics. Watershed Management and technologies. **(10)**
Unit VI	New technologies in surface and groundwater purification, trends in water utility for irrigation and crop management, Underwater ROBOT technology for surveying and mapping to unravel ancient earth history, use of geology and archaeology. **(10)**

Course Material

Essential Reading:

NO BOOKS, ONLY INTERNET NOTES AND LINKAGES

1. Castle C.J., Crooks A.T. (2006). Principles and Concepts of Agent-based Modelling for Developing Geospatial Simulations, Centre for Advanced Spatial Analysis (UCL), London, UK.
2. Chadzynski A., Krdzavac N., Farazi F., Lim M.Q., Li S., Grisiute A., Herthogs P., von Richthofen A., Cairns S., Kraft M.
3. Semantic 3D city databaseð An enabler for a dynamic geospatial knowledge graph Energy AI, 6 (2021), Article 100106
4. Achal V, Pan X, Zhang D (2011) Remediation of copper-contaminated soil by *Kocuria flava* cr1, based on microbially induced calcite precipitation. Ecol Eng 37(10):1601ï 1605
5. Lato, M. (2018). *Leveraging three-dimensional remote sensing in geotechnical engineering (Invited lecture, 2018 Canadian Geotechnical Society Colloquium, GeoEdmonton 2018)*. Ottawa, ON: BGC Engineering. 65 pp.

6. MacCormack, K.E. (2016). *Three-Dimensional Geological Mapping: Workshop Extended Abstracts* (eds. K.E. MacCormack, L.H. Thorleifson, R.C. Berg and H.A.J. Russell), 95ï 99. Edmonton, AL: AER/AGS, Special Report 101.
7. MacCormack, K.E. (2018). Developing a 3D geological framework program at the Alberta Geological Survey; optimizing the integration of geologists, geomodellers, and geostatisticians to build multi-disciplinary, multi-scalar, geostatistical 3D geological models of Alberta. In: *Three-Dimensional Geological Mapping and Modeling: Workshop Extended Abstracts* (eds. R.C. Berg, K.E. MacCormack, H.A.J. Russell and L.H. Thorleifson), 64ï 67. Champaign, IL: Illinois State Geological Survey, Open File Series 2018-1.

Suggested Reading:

1. Pavlis, T.L. and Mason, K.A. (2017). The new world of 3D geologic mapping. *GSA Today* **27** (9): 4ï 10. https://doi.org/10.1130/GSATG313A.1.
2. Sala, Z. (2018). *Game-Engine Based Rockfall Modelling: Testing and Application of a New Rockfall Simulation Too*l. Unpublished MSc Thesis, Queen's University at Kingston. 206 pp.

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://youtu.be/wcPal-25er0
https://www.youtube.com/watch?v=6AWVTi9-SYo
https://www.youtube.com/watch?v=Fmw-bm25p1g
https://www.youtube.com/watch?v=kHOsM9dGTEA
https://www.youtube.com/watch?v=JlNaXFpT7BQ
https://www.youtube.com/watch?v=dbQTlQ9udi4

COs (III GOG 2): HYDROGEOLOGY

1. Students would be able to explain the hydrologic cycle processes and budget.
2. Students would be able to explain the groundwater flow.
3. Students would be able to describe the quality of ground water
4. Students would be able to describe the groundwater exploration.
5. Students would be able to explain the groundwater development and management
6. Students would be able to describe the artificial recharge.

Unit	Content
Unit I	Hydrologic cycle processes and budget: Groundwater origin, types, importance. Residence time concept; Water bearing properties of rocks - Porosity, Permeability, Specific yield, Specific retention, Hydraulic conductivity ,Transmissivity and Storage coefficient. Water table contour maps and their interpretation, Fluctuation of water table **(10)**
Unit II	Groundwater flow - Darcy's Law in isotropic and anisotropic media and its applications, formation constant, flow through aquifers, storage equation, differential equation governing groundwater flow; Bernoulli equation. Evaluation of aquifer properties-aquifer test, confined, semi confined and unconfined aquifers, bounded and leaky aquifers, partially penetrated aquifers. **(10)**
Unit III	Quality of ground water - physical and chemical qualities. Presentation of the results of chemical analysis. Diagrammatic representation of geochemical data. Quality standard of ground water in domestic, agriculture& industries. Sodium adsorption ratio, Permeability index, CPHEEO, BIS standards for drinking water. Sea-water intrusion. **(10)**
Unit IV	Groundwater exploration - geomorphic and geologic control on groundwater. Groundwater provenances of India. Geologic and hydrologic methods, Surface geophysical methods, Geophysical well logging. Water well technology: well types, drilling methods, construction, design and development of wells. **(10)**
Unit V	Groundwater development and management, groundwater recharge discharge and balance. Estimation of recharge components. Estimation of groundwater discharge. Groundwater resource evaluation. **(10)**
Unit VI	Artificial recharge - spreading methods, induced recharge, recharge well method, sub-surface, dams etc. Conjunctive and consumptive use, water logging problems, Rainwater harvesting, Watershed management. **(10)**

Course Material/Learning Resources
Essential Reading:

1. Tolman, C. F. (1937): Groundwater, Mcgraw Hills Book co Inc. New York and London.
2. Todd, D. K. (1980): Groundwater hydrology, Toppan Co. ltd., Tokiyo, Japan
3. Ramakrishnan, S. (1998): Groundwater.
4. Freeze, R. A. and Cherry, J. A. (1979): Groundwater. Prentice Hall.
5. Karanth, K.R. 1987: Groundwater Assessment - Development and Management. Tata Mc-Graw Hill.
6. Raghunath N.M. 1982: Ground Water, Wiley Eastern.

Suggested Reading:

1. Patrick, A. (1972): Concepts and models in groundwater hydrology. McGraw Hills
2. Sharma, R. K. (1979): A text book of hydrology & water resources, Dhanpatrai & Sons.
3. Walton, W. C. (1970): Ground water resource evaluation McGraw Hills Book C.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc23_ge13/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://youtu.be/KjaL1WMnNzQ
https://youtu.be/G7CnE5NBxZs
https://youtu.be/DvAdCsk0NeM

COs (III GOG 3): ORE GEOLOGY AND MINING GEOLOGY

1. Students would be able to explain basic concept of ore geology.
2. Students would be able to describe texture paragenesis and origin of ore geology.
3. Students would be able to describe trace elements, REE and different isotopes.
4. Students would be able to describe different petrological association of ore.
5. Students would be able to understand concept Mining Geology.
6. Students would be able to understand different mining method selection.

Unit	Content
Unit I	Introduction to Ore Geology- Modern concepts of ore genesis; Mode of occurrence of ore bodies. Morphology and relationship of host rock, Wall-rock alteration. Classification of ore deposits. Ore deposits and plate tectonics. **(7)**
Unit II	Texture, paragenesis; Paragenitic sequence and zoning of ores. Ore bearing fluids, movement. Origin and migration. Structural, physiochemical and stratigraphic control of ore localization. Fluid inclusion in ores - principles, assumption, limitation and application. **(8)**
Unit III	Trace elements. Rare earth elements. Radio isotopes; Carbon isotopes, Study of rubidium - strontium, uranium-thorium - lead isotopes. Stable isotope (S, C, O, H) in ore genesis-geothermometry, source of ore constituents; global tectonics and mineralisation. **(7)**
Unit IV	Petrological ore association: Orthomagmatic ores of mafic, felsic association - diamonds in Kimberlites; chromite; Cyprus type Cu-Zn; Kiruna type Fe-P; Pegmatites, Skarns. Porphyry association. Ores of sedimentary affiliation. Ores of metamorphic affiliation. **(8)**
Unit V	Basic concepts and broad classification of mining methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods. **(8)**
Unit VI	Mining of surface and underground mineral deposits Geological factors considered for the selection of mining method; Advantages and disadvantages of underground mining. **(7)**

Course Material/Learning Resources

Essential Reading

1. Evans, A. M. (1992): Ore geology and industrial minerals, Blackwell Science.
2. Umeshwer Prasad (2019): Economic geology, CBS; 2nd edition.
3. Tiwari, S. K. (2018) Ore Geology, Economic Minerals and Mineral Economics, Atlantic Publishers and Distributors Pvt Ltd; 1st edition
4. Umathay R. M. (2006) Mineral Deposits of India, Dattsons Publishers; First Edition
5. Arogyaswamy, R. N. P. (2017) Courses in mining geology, CBS publishers and distributors pvt ltd; fourth edition.

Suggested Reading:

1. Jensen, M. L. & Bateman, A. M. (1981): Economic mineral deposits, John Wiley & Sons.
2. Misra, K. C. (1999): Understanding Mineral Deposits, Kluwer Academic Publishers
3.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc23_ce39/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://youtu.be/lhx1nvZFPS4

https://youtu.be/Z6Y4WpsZ288

https://youtu.be/iM5J7u5--5U

COs (III GOG 4A): GEOCHEMISTRY AND ANALYTICAL TECHNIQUES

1. Students would be familiar with the main aspects of the Geochemistry.
2. Students would be able to understand the Cosmochemistry
3. Students would be able to describe the different types of Isotopes and radiometric dating methods
4. Students would be able to illustrate the Thermodynamics and crystal chemistry
5. Students would be familiar with the analytical instruments and its techniques used in geosciences.
6. Students would be familiar with the analytical instruments used in geosciences.

Unit	Content
Unit I	Geochemistry: Introduction, history, scope and present status. Atomic structure and properties of elements in the periodic table. Special properties of transition and rare earth elements. Origin and abundance of elements in the Earth and its constituents. Distribution coefficients. **(8)**
Unit II	Cosmochemistry: Principles of distribution of elements in the cosmos, composition of planets; classification, mineralogy, origin and significance of Meteorites. Geochemical composition of the Earth. Geochemical classification of elements. Weathering indices. **(8)**
Unit III	Isotopes: Stable isotopes, its nature and abundance. Radiogenic isotopes, Growth of daughter isotopes, U-Pb, Sm-Nd, Rb-Sr, K-Ar methods of radiometric dating of rocks. Geochemical cycle and concepts of Geochemical prospecting & exploration; Geochemical association and pathfinder elements. **(8)**
Unit IV	Thermodynamics and crystal chemistry: Principles of ionic substitution in minerals, elements partitioning in mineral and rock formation. Nucleation & diffusion processes in Igneous, Sedimentary and Metamorphic environments, Redox reactions and Eh-pH diagram & their applications. **(7)**
Unit V	Dissolution procedure in Geological and environmental samples; Instrumentation Technique used in geosciences, Principles and geological applications of UV-VIS Spectrophotometry, Atomic absorption spectrometry (AAS). **(7)**
Unit VI	Inductively coupled plasma mass spectrophotometry (ICP-MS), X-Ray diffraction (XRD), Scanning Electron Microscopy (SEM), Electron Microprobe analysis. **(7)**

Course Material/Learning Resources
Essential Reading:

1. Albarede, F. (2009):**Geochemistry an Introduction,** Cambridge Univ. press, (II Ed) 330p
2. Beus, A. A. and Grigorian, S. V. (1977): **Geochemical Exploration Methods for Mineral Deposits**, Applied Publication, University of California, 287p.
3. Brownlow, A. H. (1979): **Geochemistry,** Englewood Cliffs and London Prentice Hall, 498p.
4. Deckin, A. P.(2005): **Radiogenic Isotope Geology,** Cambridge University press, 492p (II Ed)
5. Hawkes, H. E. & Webb, J. S. (1962): **Geochemistry in Mineral Exploration,** Harper & Row.
6. Krauskopf, K. B. and Bird, D. K.(1995): **Geochemistry,** McGraw Hill, New York,640p
7. Nordstorm, D.K. and Munoz, J.L. (1986): **Geochemical Thermodynamics**, Blackwell.
8. Robin Gill, (1997): **Modern Analytical Geochemistry,** Addison Wesley Longman.
9. Hota, R. N. (2011): **Geochemical Analysis**, CBS Publication, Delhi.
10. M. W. Rowe and M. Hyman, (1993): **Advances in Analytical Geochemistry**, Volume 1, JAI Press Inc., Greenwich, Connecticut, U.S.A.

Suggested Reading:

1. Levinson, A.A. (1980): **Introduction to Exploration Geochemistry**, (2nd Ed) App. Pub., 924p.
2. Mason, B. and Moore, C. B. (1982): **Principles of Geochemistry,** Wiley Eastern Ltd., 344p.
3. Fairbridge, R. W. (1972): **Encyclopedia of Geochemistry and Environmental Sciences,** Von Nostrond Reinhold Co, 1321p.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.swayam2.ac.in/cec19_mm01/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://www.youtube.com/watch?v=pHj7ytPirEI
https://www.youtube.com/watch?v=93O0PXba0hI&list=PLdZcCa6mtW23cvplUz2IoqBDvI24pK82b
https://www.youtube.com/watch?v=pHj7ytPirEI
https://www.youtube.com/watch?v=bl_pzBdvbns
https://www.youtube.com/watch?v=Lng0hVDvsu0&list=PLOzRYVm0a65dtbpo_DP7acjsLYdmWT99r

COs (III GOG 4B): Indian Mineral Deposit and Mineral Economics

1. Students would be able to explain the basics concept of classification of mineral deposit.
2. Students would be able to describe mineralogy, mode of occurrence of metals.
3. Students would be able to describe mineralogy, mode of occurrence of non- metals.
4. Students would be able to describe mineralogy, mode of occurrence of atomic minerals, ceramic materials, metallurgical materials
5. Students would be able to explain mineral legislation in India.
6. Students would be able to compare strategic, critical and essential minerals of India.

Unit	**Content**
Unit I	Classification of mineral deposit, Basic Process of formation of mineral deposits. Metallurgical epoch and provinces. Mineralogy, mode of occurrence, origin, geological association, geographical distribution and use of gold, copper, lead, zinc and silver. **(08)**
Unit II	Mineralogy, mode of occurrence, origin, geological association, geographical distribution and use of metals aluminium, magnesium, iron, manganese, Chromium, nickel. **(08)**
Unit III	Mineralogy, mode of occurrence, origin, geological association, geographical distribution and use of atomic minerals, ceramic materials, metallurgical materials. **(07)**
Unit IV	Mineralogy, mode of occurrence, origin, geological association, geographical distribution and use of refractory materials; Industrial and manufacturing materials; Abrasive and abrasion minerals. **(07)**

Unit V	Mineral economics and its concept, Mineral Legislation in India, Economic consideration in mineral exploration, National mineral policy, Mineral processing, Economics of mineral production, Co-products-by products of mining and Mineral processing, Mineral dressing. **(08)**
Unit VI	International scenario of mineral wealth; Strategic, critical and essential minerals of India, War minerals, Internal and External mineral trade, consumption and substitution of minerals, economical mineral conservation. **(07)**

Course Material/Learning Resources
Essential Reading:

1. Evans, A. M. (1992): Ore geology and industrial minerals, Blackwell Science.
2. Jensen, M. L. & Bateman, A. M. (1981): Economic mineral deposits, John Wiley & Sons.
3. Misra, K. C. (1999): Understanding Mineral Deposits, Kluwer Academic Publishers.
4. Umeshwer Prasad (2019): Economic geology, CBS; 2nd edition.
5. Tiwari, S. K. (2018) Ore Geology, Economic Minerals and Mineral Economics, Atlantic Publishers and Distributors Pvt Ltd; 1st edition.
6. Umathay R. M. (2006) Mineral Deposits of India, Dattsons Publishers; First Edition

Suggested Reading:

1. Mookherjee, A. (1998): Ore genesis - a holistic approach. Allied Publishers.
2. Stanton, R. L. (1981): Ore Petrology, McGraw Hill.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc23_ce39/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://youtube.com/playlist?list=PLrb2lGnLJld_E7C0wVAqU4JGabm2IiT38

PRACTICLES

Programme: M. Sc. (Geology)
Semester III

Code of the Course/Subject	Title of the Course/Subject (Laboratory/Practical/practicum/hands-on/Activity)	No. of Periods/Week
III GOG 6	LAB-V (Hydrogeology and Ore Geology & Mining)	08
III GOG 6 (RPP-I)	Research Project Phase-I	06

COs (III GOG 6): Hydrogeology and Ore Geology & Mining Geology

Students would be able to

1. Calculate different hydrogeological data by doing hydrogeological calculations.
2. Perform physio-chemical analysis of water.
3. Identify the megascopic properties of various Ore Minerals.
4. Identify the microscopic properties of various Ore Minerals.
5. Perform exercise on mine sampling and determination of tenor, cutoff grades and ore reserves.

*** List of Practical/Laboratory Experiments/Activities etc.**

1. Hydrogeology Well Inventory Data Collection.
2. Preparation and interpretation of water table counter maps, Fence diagrams, groundwater budgeting.
3. Estimation of Porosity and Permeability.
4. Physio-chemical analysis of water. Pumping test, groundwater provinces of India.
5. Identify the megascopic properties of various Ore Minerals.
6. Identify the microscopic properties of various Ore Minerals.
7. Perform exercise on mine sampling and determination of tenor, cutoff grades and ore reserves.

Reference Books:

1. Karanth, K.R. 1987: Groundwater Assessment - Development and Management. Tata Mc-Graw Hill.
2. Raghunath N.M. 1982: Ground Water, Wiley Eastern.
3. Umeshwer Prasad (2019): Economic geology, CBS; 2nd edition.
4. Tiwari, S. K. (2018) Ore Geology, Economic Minerals and Mineral Economics, Atlantic Publishers and Distributors Pvt Ltd; 1st edition
5. Arogyaswamy, R. N. P. (2017) Courses in mining geology, CBS publishers and distributors pvt ltd; fourth edition.

COs (III GOG 6): Research Project Phase-I

Students would be able to

1. Carry out geological field work.
2. Write the project report.

*** List of Practical/Laboratory Experiments/Activities etc.**

1. Project work, submission of report, presentation and viva

Part B

Syllabus Prescribed for Second Year 2024-25 PG Programme

Programme: M. Sc. (Geology)

Semester IV

Code of the Course/Subject	Title of the Course/Subject	Total Number of Periods
IV GOG 1	DSC-I (Remote Sensing and GIS)	60
IV GOG 2	DSC-II (Geomorphology and Field Geology)	60
IV GOG 3	DSC-III (Paleobiology)	45
IV GOG 4A OR IV GOG 4B	DSE-III /MOOC 1. Environmental and Engineering Geology **OR** 2. Basic Oceanography and Climatology	45
IV GOG 5	LAB V (Remote Sensing and Geomorphology & Field Geology)	6 Hrs/week
IV GOG 6	LAB IV (Paleobiology)	2 Hrs/week
IV GOG 7 (RPP-II)	**Research Project Phase-II and Field tour report**	10 Hrs/week

COs (IV GOG 1): REMOTE SENSING AND GIS

1. Students would be able to understand basics of remote sensing.
2. Students would be able to explain the basics of Photogrammetry.
3. Students would be able to describe Digital image processing..
4. Students would be able to explain Geological applications of remote sensing imaginaries.
5. Students would be able to describe Image elements.
6. Students would be able to understand Geographical information system

Unit	Content
Unit I	Remote Sensing- principles, electromagnetic spectrum and atmospheric windows. Platforms and sensors- multispectral scanners (MSS) & scanning modes. Types of remote sensing- thermal & microwave remote sensing, scale & resolutions, interpretation of panchromatic, black & white, false colour composites (FCC), colored infrared, thermal infrared, radar, MSS and hyper spectral imageries, spectral signature. Indian space missions and Satellite. **(10)**
Unit II	Photogrammetry- geometric characteristics scale, factors affecting scale & aerial

	photography, mosaics, film and filter combination, aerial cameras, stereoscopic parallax, relief displacement. **(10)**
Unit III	Digital image processing: Introduction, characteristics of digital images, pixel parameters. Image processing techniques applied to satellite imagery - image reduction, image magnification, image enhancement, contrast enhancement, ratioing, and principal component analysis. **(10)**
Unit IV	Filtering techniques - discrete linear operations, spatial smoothing operators, spatial sharpening operators, edge detection. Classification pattern recognition. Configuration of digital analysis system. **(10)**
Unit V	Geological applications: Image elements - tone, colour, texture, pattern, shape, size, shadows, sites, associations. Terrain elements ï drainage patterns, landforms, erosion. Remote sensing for lithological discrimination and geological mapping. **(10)**
Unit VI	Geographical information system: Definition and importance of GIS; Data input and output; GIS data - Types, representation and sources, Georeferncing, GIS data base and data base, management system; Imageries and IRS products; Application of remote sensing in groundwater exploration, petroleum exploration, engineering geology. **(10)**

Course Material/Learning Resources

Essential Reading:

1. Avery, T. U. and Berlin, G. L. (1992): Fundamentals of Remote Sensing and Air Photo Interpretation, McMillion Publishing Co., New York.
2. Burrough, P. A. (1986): Principles of Geographic Information Systems for Land Resources Assessment.
3. Campbell, J. B. (1996): Introduction to Remote Sensing, 622pp.
4. Drury, S. A. (1987): Image Interpretation in Geology, Chapman and Hall.
5. Gupta, R. P. (2003): Remote Sensing Geology. 2nd Ed., Springer-Verlag, Heidelberg.
6. Jensen, J. R. (1986): Introductory Digital Image Processing-A Remote Sensing Perspective, Prentice Hall, New Jersey.
7. Lillesand, T. M. and Kiefer, R. (1987): Remote sensing and image interpretation, John Wiley.
8. Miller, V. C. (1961): Photogeology, McGraw Hill Book Co., New York.

Suggested Reading:

1. Pandey, S. N. (1987): Principles and Applications of Photogeology. Wiley Eastern Ltd., Delhi.
2. Ray, R. G. (1969): Aerial photographs in Geologic Interpretation. USGS Professional Paper 373.
3. Siegal, B. S. and Gillespie, A. R. (1980): Remote Sensing in Geology. John Wiley & Sons.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc23_ce64/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://youtu.be/4Rn0M39HOPU
https://youtu.be/qGBA_RVM-t0
https://youtu.be/4VKvZMPccjE

COs (IV GOG 2): GEOMORPHOLOGY AND FIELD GEOLOGY

1. Students would be able to explain the basics concept and process of Geomorphology.
2. Students would be able to explain the Morphometric Analysis and Fluvial Landforms.
3. Students would be able to describe the Eolian, Glacier and other types of landform.
4. Students would be able to understand the **I**mportance and application of geomorphology
5. Students would be able to understand the **I**mportance and scope of field geology.
6. Students would be able to familiar with Geological surveying instruments.

Unit	Content
Unit I	Fundamental concepts of geomorphology; Geomorphic agents and processes: exogenetic, endogenetic and extraterrestrial; Rock weathering and mass wasting; Cycle of erosion, rejuvenation and peneplaination, **(10)**
Unit II	Fluvial Geomorphology: Drainage system and pattern; Morphometric analysis: basic principles and techniques of river basin analysis and its application; River terraces and their significance, **(10)**
Unit III	Fluvial land forms. Delta and its classification, Arid, eolian, glacial, volcanic and coastal landforms; Ocean floor topography. Karst topography. **(10)**
Unit IV	Major geomorphic features of India- coastal, peninsular and extrapeninsular. Applied Geomorphology: Meaning and Concept, Application of geomorphology in hydrogeology, engineering geology, and environmental studies. **(10)**
Unit V	**I**mportance and scope of field geology, Study of outcrops, Field observations, Topographic forms, Reconnaissance survey, Toposheets , Topographic maps, Interpretation of contour maps, Mapping and analysis of sedimentary, igneous & metamorphic terrains. **(10)**
Unit VI	Geological surveying: Plane table survey, Use of Clinometer, Brunton compass, Prismatic compass, Abney level, Dumpy level and Thedolite. Air reconnaissance. Aerial photography & elements of aerial photo interpretation, Stereoscope and stereoscopic vision.

Course Material/Learning Resources
Essential Reading:

1. Savindra Singh (2015): **Geomorphology**, Paravalika Publication
2. Jain, S. (2014): **Fundamentals of Physical Geology**, Springer
3. Summerfield, M. A. (1999): **Global geomorphology- an introduction to the study of landforms**, Longman
4. Barkbank, D. W. and Anderson, R. S, (2008): **Tectonic Geomorphology**. Blackwell Science.
5. Ford, D. and Williams, P. (2007): **Karst Hydrology and Geomorphology**. John Wiley & Sons.
6. Hugget, R. J. (2007): **Fundamentals of Geomorphology** (2nd Ed.), Routledge, London
7. Charlton, R. O. (2007): **Fundamentals of Fluvial geomorphology,** Routledge
8. Harvey, A. M., Mathar, A. E. and Stokes, M. (2005): **Alluvial fans- Geomophology, Sedimentology, Dynamics**, Geol. Soc. London, Sp Pub. 251.
9. Thornbury, W. D. (2004): **Principles of Geomorphology** ï Reprint CBS Pub., New Delhi
10. Field Geology - Lahee 1987 CBS Pub New Delhi.

Suggested Reading:

1. Allison, R. J. (2002): **Applied geomorphology,** John Wiely & Sons. Inc.
2. Turk, G. R. and Thompson, J. (1997) **Introduction to Physical Geology** (2nd Ed.), Brooks Cole.
3. Holmes, A. (1978): **Principles of Physical Geology** (3rd Ed.), Wiley,730p (3rd Ed)
4. Cotton, C. A. (1952) **Geomorphology**, John Wiley & Sons Inc.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc22_ce04/preview
https://www.classcentral.com/course/swayam-introductory-field-structural-geology-91695

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://www.youtube.com/watch?v=0QRKkiOa9Fw
https://www.youtube.com/watch?v=ZEmauGfPJOE

COs (IV GOG 3): PALAEOBIOLOGY

1. Students would be able to understand the concept of palaeobiolgy.
2. Students would be able to explain the process of fossilization and Classification of organisms.
3. Students would be able to describe the phylum- Mollusca, Brachiopoda, Echinodermata and Arthropoda.
4. Students would be able to understand the micropaleontology and its significance
5. Students would be able to describe the fossil pores and mass extinction.
6. Students would be able to explain Evolutionary histories of man, elephant and horse and also discuss geological distribution and extinction of Dinosaur.

Unit	Content
Unit I	Modern concepts of origin of life, Chemical and biological evolution, Mechanism of evolution - mutation, adaptation, isolation, variation; Species concept and speciation; Paleontological evidence of evolution. Fossil record and geological time scale. **(08)**
Unit II	Fossil: Mode of preservation, Introduction to Taphonomy, Limiting environmental factors, physico-chemical condition for Fossilization, types of fossils, significance of fossils;, Preparation and nomenclature of fossils, Classification of organisms **(07)**
Unit III	Morphology, classification, geological history and evolution of mollusca- bivalve, gastropad, cephalopod; Brachiopoda, Echinodermata. Morphology, classification, geological distribution and significance of Arthropoda **(08)**
Unit IV	Importance and scope of micropaleontology, Methods & technique of microfossil study. Foraminifers: Morphology, Classification, evolution, geological history, and palaeoecology. Ostracods: Morphology, Classification, Palaeoecology, and geological history. **(07)**
Unit V	Conodonts: Morphology, Classification, Palaeoecology, and geological history. Morphology and geological range of Radiolarians and Diatoms. Fossil spores, pollen and dinoflagellates. Applications of paleontological data in stratigraphy, paleoecology, and paleoclimatology; mass extinctions. **(07)**
Unit VI	Vertebrates of Siwalik. Evolutionary histories of man, elephant and horse. Geological distribution and extinction of Dinosaur. Gondwana Flora and its significance. **(08)**

Course Material/Learning Resources
Essential Reading:

1. Jain P. C., Anantharaman M. S. (2016) **Paelontology**
2. Dasgupta Amal: **An introduction to Palaeontology**
3. Clarkson, E.N.K., 1998 : **Invertebrate Palaeontology and Evolution**. IV Ed. Blackwell.
4. Kathal, P.K., Nigam, R. & Talib, A., (2017) **Micropaelontology, and its Applications**. Scientific publishers, New Delhi, Jodhpur 342 p.
5. Saraswati, P. K. & Srinivasan, M. S. (2016): **Micropaelontology, Principles & Applications**
6. ***Henry Woods (1958): Palaeontology*** **Invertebrate** CBS; 8th edition

Suggested Reading:

1. Prothero, D.R., 1998 : Bringing Fossils to Life- An Introduction to Palaeobiology, McGraw Hill.
2. Smith, A.B., 1994 : Systematics and the Fossils, Record-Documenting Evolutionary Patterns. Blackwell.
3. Stearn, C.W. & Carrol. R.I., 1989 Palaeontology; The Record of Life, John Wiley.

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://www.youtube.com/watch?v=ehoEid0Pneo&list=PLb1flP7NCA7KcIWABW_lu7PAVXqWIih_1
https://www.youtube.com/watch?v=ZDKtS21RruQ

COs (IV GOG 4A): ENVIRONMENTAL GEOLOGY AND ENGINEERING GEOLOGY

1. Students would be able to explain concept and principle of environmental geology.
2. Students would be able to explain problem of urbanisation and their impact on environment.
3. Students would be able to describe earthquake and seismic hazards.
4. Students would be able to describe engineering properties of rock.
5. Students would be able to explain site selection for dams and reservoirs.
6. Students would be able to explain site selection for tunnels.

Unit	Content
Unit I	Concept and principle of environmental geology. Role of physical, chemical and biological parameters influencing environment Land capability classification; Land use pattern. Assessment of impact of land use & reclamation of land. Soil: Soil as a resource-nature, profile, origin and classification. Soil conservation, soil weathering; soil degradation and remedial measures. Desertification and degradation of land, causes of desertification, measures to combat desertification. Organic and inorganic contaminations of ground water and its remedial measures. **(8)**
Unit II	Problem of urbanisation, human population and their impact on environment. Disposal of industrial & radioactive waste, Fertilizer and pesticides. Impact of mining activities on the environment. Environmental impact assessment and management of mining areas, dumping of overburdens. Global warming. Green house effect. Ozone hole depletion, ocean acidification. **(8)**
Unit III	Earthquake and seismic hazards; Origin and severity of earthquake, effects of earthquakes, seismic zones of India. Landslides: Destabilizing forces, Types, Identification of landslide zones. Controlling landslides - methods for prevention or control of landslides. Floods and Floods Management: Causes of floods ï excess flows, reduced carrying capacity of rivers, runoff verses infiltration, Management of floods - reservoirs, water spreading, groundwater recharge, stream canalization, flood embankments, hazard zoning and flood forecasting and warnings **(8)**
Unit IV	Engineering Properties of Rock: Strength characteristics - unconfined compressive strength, uniaxial tensile strength, shear strength, Deformational characters - modulus of elasticity, poisson ratio., Residual stress Engineering classification of rock masses ï Rock quality designation, rock structure rating, rock mass rating system, rock quality index system. Susceptibility or rocks towards weathering. Engineering properties of soils. Ground improvement - grouting, types, procedures, grouting applications **(7)**
Unit V	**Dams and reservoirs**: types and classification, forces acting on the dam body, reservoir induced seismicity, investigations for the construction of dams and reservoir, spillways etc., seepage problem, silting problem. **Bridges:** Types, abutment and foundation problems across river and valley crossing, geological investigations for construction of bridges. **(7)**
Unit VI	**Tunnel**s- types, problems due to underground water and fault-shear zones, tunneling in hard and soft grounds, investigations for tunnel alignment, tunnel support design, tunnel linings. Ground failure in tunnels, tunnel supports. Methods of tunnelling in hard rocks and in Soft soils **(7)**

Course Material/Learning Resources
Essential Reading

1. Valdia, K. S. (1987): Environmental Geology, Tata McGraw hills, New Delhi
2. Keller, A. E. (1978): Environmental Geology (5th Edt.) Charis and Merril Pub. Co.
3. Montgometry, C. W. (2016): Environmental Geology, Mc Graw Hall Global education Holding publishers.
4. Beavis, F. C. (1985): Engineering Geology.
5. Bell, F. G. (1999): Geological Hazards, Routledge, London.
6. Bieniawski, Z. T. (1989): Engineering Rock Mass Classification, John Wiley.

Suggested Reading:

1. Tonk, W. R. (1986): Environmental Geology, Oxford University Press, New York 1983
2. Legget, R. F. (1983): Handbook of geology in civil engineering, McGraw Hill, New York.
3. Schultz, J. R. & Cleaves, A. B. (1951): Geology in Engineering, John Willey & Sons, New York.

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.nptel.ac.in/noc23_ce64/preview

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://youtube.com/playlist?list=PL_a1TI5CC9RH5wygqmRtq-Y7-s_0T6Z9w
https://youtube.com/playlist?list=PLDF5162B475DD915F

COs (II GOG 4B): Basics of climatology and Oceanography

1. Students would be able to explain fundamental principles of climatology.
2. Students would be able to understand, basic law and atmospheric circulation.
3. Students would be able to describe classification of climates and clouds.
4. Students would be able to explain the history of development of marine geology.
5. Students would be able to explain the oceanic circulation.
6. Students would be able to explain the sedimentation processes and different types of sediments.

Unit	**Content**
Unit I	Fundamental principles of climatology. Earthęs radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Thermal structure of the atmosphere and its composition **(8)**
Unit II	Radiation: basic Laws - Rayleigh and Mie scattering, multiple scattering, radiation from the sun, solar constant, effect of clouds, surface and planetary albedo. Atmospheric Circulation, Air masses, monsoon, Jet streams, tropical cyclones, and El Nino Southern Oscillation (ENSO). **(8)**
Unit III	Classification of climates ï Koppenęs scheme of classification. Climate change. Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron, Findeisen process, coalescence process ï Precipitation of warm and mixed clouds, artificial precipitation. **(7)**
Unit IV	History of development of marine geology; Origin of ocean basins; A brief account of tectonic history of the oceans; Oceanic crust; Deep ocean-floor topography; Morphology of ocean margins. **(8)**
Unit V	Oceanic circulation - Surface, intermediate and deep ocean circulation; Forces that produce and effect circulation patterns in world oceans; Important phenomena associated with surface circulation; Formation and movement of deep and bottom waters. Ekman spiral. **(8)**
Unit VI	Sedimentation rates; Calcite and aragonite compensation depth. Marine sediments, sources and composition, sediment types and distribution. Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, diagenetic changes in oxic and anoxic environments. **(7)**

Course Material/Learning Resources
Essential Reading

1. Lal D. S. (2011) Climatology, Sharda Pustak Bhawan.
2. Lal D. S. (2001) Climatology and Oceanography, Sharda Pustak Bhawan.
3. Kennett, J.P. (1982) Laboratory Excercises in Oceanography Marine Geology, Prentice Hall.
4. Savindra Singh (2015) Oceanography, pub. Generic
5. Siegel R, Menguc M. Pinar (2010) Thermal Radiation Heat Transfer, CRC Press 3. Lynne D.

6. TalleyL. D. (2011) : Descriptive Physical Oceanography: An Introduction, Academic Press

Suggested Reading:

1. Seibold, E. and Berger, W.H. (1982) The Sea Floor, Springer-Verlag.
2. Holton J.R.(2004), An Introduction to Dynamical Meteorology, Academic Press 2. Howell JR,

Weblink to Equivalent MOOC on SWAYAM if relevant:

https://onlinecourses.swayam2.ac.in/cec21_hs03/preview
https://nptel.ac.in/courses/119102007

Any pertinent media (recorded lectures, YouTube, etc.) if relevant:

https://youtu.be/BgNIyPnM6cE
https://youtu.be/78JPCAApA9M

PRACTICLES

Programme: M. Sc. (Geology)

Semester II

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/practicum/hands-on/Activity)	**No. of Periods/Week**
IV GOG 5	LAB-III (Remote Sensing and Geomorphology & Field Geology)	06
IV GOG 6	LAB-IV (Paleobiology)	02
IV GOG 7 (RPP-II)	Research Project Phase-II	10 Hrs/week

COs (IV GOG 5): Remote Sensing, Geomorphology & Field Geology

Students would be able to

1. Interpret the aerial photographs and satellite imageries identify the microscopic properties of various Igneous and Metamorphic Rocks.
2. Exercise morphometric analysis of river basins and its interpretation.
3. Understand Toposheet reading and handling of geological surveying equipments.

*** List of Practical/Laboratory Experiments/Activities etc.**

1. Interpretation of aerial photographs and satellite imageries ï Geological structure, lithology, landforms, minerals, soils, groundwater; Application of GIS in geological studies.
2. Exercise on morphometric analysis of river basins.
3. Toposheets reading
4. Exercise on clinometer, Brunton compass. Prismatic compass, Abney level, Dumpy level, Theodolite & Plane table.

Reference Books:

1. Gupta, R. P. (2003): Remote Sensing Geology. 2nd Ed., Springer-Verlag, Heidelberg.
2. Pandey, S. N. (1987): Principles and Applications of Photogeology. Wiley Eastern Ltd., Delhi.
3. Savindra Singh (2015): **Geomorphology**, Paravalika Publication
4. Field Geology - Lahee 1987 CBS Pub New Delhi.

COs (IV GOG 6): Paleobiology

Students would be able to

1. Identify and classify various fossils.

*** List of Practical/Laboratory Experiments/Activities etc.**

1. Identification and classification of fossils belonging to major phylums.
2. Gondwana flora fossils.

Reference Books:

1. Jain P. C., Anantharaman M. S. (2016) **Palaeontology**

COs (IV GOG 7): Research Project Phase-II

Students would be able to

3. Carry out geological field work.
4. Write the project report.

*** List of Practical/Laboratory Experiments/Activities etc.**

2. Project work, submission of report, presentation and viva