TECHNO INDIA UNIVERSITY
WESTBENGAL

Syllabus of Four-Year B.Sc. Course in "Applied Earth Sciences with AI," Eight Semesters (with research)

In compliance with

National **C**urriculum and **C**redit **F**ramework **(NCCF)**

Department of Earth Sciences
Techno India University, West Bengal
Kolkata- 700091
India

(2025-26)

Content

3.15 MAJOR TH10 Paleontology

3.16 MAJOR PR06 Paleontology Lab

3.17 MAJOR TH11 Tectonics and Solid Earth Geophysics

3.18 MAJOR TH12 Economic Geology

3.19 MAJOR PR07 Economic Geology Lab

3.20 MAJOR TH13 Exploration Geology

3.21 MAJOR TH14 Hydrogeology

3.22 MAJOR PR08 Hydrogeology Lab

3.23 MAJOR TH15 Engineering Geology

3.24 MAJOR TH16 Geomorphology, GIS and Remote Sensing

3.25 MAJOR PR09 Geomorphology, GIS and Remote Sensing Lab

3.26 MAJOR TH17 Coal and Petroleum Geology

3.27 MAJOR PR10 Coal and Petroleum Geology Lab

4. Detailed syllabus of Department Specific Electives (DSE) Subjects

4.1 DSE TH01A Earth's Internal Chemical Processes

4.2 DSE TH01B Sequence Stratigraphy and Basin Evolution

4.3 DSE TH02A Rheology and Mechanics of Geological Deformations

4.4 DSE TH02B Applications of Micro and Molecular Fossils

4.5 DSE TH03A Geochemical Data Analysis- Theories and Practices

4.6 DSE TH03B Earth's Evolutionary Processes and Critical Minerals Endowment

4.7 DSE TH04A Groundwater Resources and Management

4.8 DSE TH04B Unconventional Hydrocarbon and Terrestrial Water Resource

4.9 DSE TH05A Natural Hazards and its Management

4.10 DSE TH05B Drilling, Mining, Beneficiation and Mineral Economics

5. Dissertation

6. Detailed Syllabus of Skill Enhancement Course (SEC)

6.1 SEC 01 Principles and Applications of Field Instruments

6.2 SEC 02 Field Training I

1. Program Outcomes (PO) and Program Specific Outcomes (PSO)

- **PO1: Foundational Scientific Knowledge:** Apply the knowledge of mathematics and natural sciences to the solution of scientific problems.
- **PO2: Critical Thinking and Problem Analysis:** Identify the problems and formulate various methodologies for obtaining their solutions.
- **PO3: Design/Development of Solutions**: Design a system and prepare formal methodical plans, leading to solutions.
- **PO4: Conduct investigations of complex problems**: Formulate the structure and components of a complex problem and investigate it for obtaining a solution
- **PO5: Usage of Modern Methods and Tools**: Develop/ select and apply appropriate methods/tools for solving problems with an understanding of their limitations.
- **PO6: The Science and Society:** Apply scientific knowledge to assess and address critical societal issues.
- **PO7: Environment and Sustainability:** Appreciate social and environmental issues and provide scientific know-hows for the use of renewable resources.
- **PO8: Ethics**: Understand professional, ethical, legal, societal and security issues, and responsibilities.
- **PO9: Individual and team work**: Build capacity to work independently and also as a team member within an organization.
- **PO10: Communication**: Develop skills to communicate effectively with superiors, colleagues, other team members as well as the society at large.
- **PO11: Project Management and Finance:** Understand the management principles and appreciate financial implications/issues pertaining to any scientific project.
- **PO12: Life-long learning**: Identify contemporary issues due to changing technical, political and social scenarios and engage in lifelong learning to update himself/herself.
- **PSO1**: Applications of basic sciences to understand the geosphere - hydrosphere-biosphere- atmosphere of the Earth system
- **PSO2**: Adapt Self-learning and creative and critical thinking to solve Earth Science problems and communicate effectively
- **PSO3**: Analyse and interpret geological data from diverse terranes employing modern tools and techniques

2. Scheme for the 4 Year Undergraduate Course

2.1 Credit Distribution across course

Year	Semester	Credit Distribution										Total Credits
		Major	DSE	Dissertation	Minor	SEC	IDC	AEC	CVAC	Intern- ship	CAC	
1st	I	1(Th) x 4 + 1(Pr) x 2 = 6	-	-	1(Th) x 4 + 4	1(Th) x 3 = 3	1(Th) x 3 =3	1(Th) x 2 =2	1(Th) x 4 =4	-	-	22
	II	2(Th) x 4 + 1(Pr) x 2 = 10	-	-	1(Th) x 4 = 4	1(Pr) x 3 = 3		1(Th) x 2=2	1(Pr) x 4 = 4	-	-	23
2nd	III	2(Th) x 4 + 1(Pr) x 2 = 10	-	-	1(Th) x 4 =4	1(Pr) x 3 =3	1(Th) x 3 =3	1(Th) x 2 =2	-	-	-	22
	IV	3(Th) x 4 + 1(Pr) x 2 = 14	-	-	1(Th) x 4 =4	-	1(Th) x 3 =3	1(Th) x 2 =2	-	-	1(Pr) x 4 =4 *	23
3rd	V	3(Th) x 4 + 2(Pr) x 2 = 16	-	-	1(Th) x 4 = 4	-	-	-	-	1(Th) x 2 = 2	-	22
	VI	4(Th) x 4 + 2(Pr) x 2 = 20	-	-	1(Th) x 4 = 4	-	-	-	-	-	1(Pr) x 4 = 4 *	24
4th	VII	2(Th) x 4 + 2(Pr) x 2 = 12	1(Th) x 4 = 4	-	1(Th) x 4 = 4	-	-	-	-	-	-	20
	VIII	-	1(Th) x 4 = 4	1(Pr) x 12 = 12 or 3(Th) x 4 = 12	1(Th) x 4 = 4	-	-	-	-	-	3(Pr) x 4 = 12 *	20
		88	8	12	32	9	9	8	8	2		176

** Marks/grades obtained in the compulsory audit courses (CAC) will not be used in the calculation of CGPA/SGPA etc. but will be reflected separately in the Grade Card/Mark sheet*

2.2 Structure of 4 Year Under Graduate (UG) Course with Course-Credit Scheme

		Course Type	Course Code	Course Name	Credit Point	Marks
1st Year	Semester - I	Major Theory	TIU-UGL-MAJOR-T101	Earth System Science	4	50
		Major Practical	TIU-UGL-MAJOR-L101	Earth System Science Lab	2	25
		Inter Disciplinary Course	TIU-UGL-IDC-T101	Basics of AI	3	50
		Skill enhancement course	TIU-UGL-SEC-T101	Principles and applications of field instruments	3	50
	Semester - II	Major Theory	TIU-UGL-MAJOR-T100	Mineralogy	4	50
		Major Theory	TIU-UGL-MAJOR-T102	Elements of Geochemistry	4	50
		Major Practical	TIU-UGL-MAJOR-L100	Mineral Science Lab	2	25
		Skill Enhancement Course Theory	TIU-UGL-SEC-P100	Field Training- I	3	50
		Minor Theory *	TIU-UGL-MINOR-T100	Essentials of Geology	4	50
2nd Year	Semester - III	Major Theory	TIU-UGL-MAJOR-T201	Igneous Petrology	4	50
		Major Theory	TIU-UGL-MAJOR-T203	Sedimentology	4	50
		Major Practical	TIU-UGL-MAJOR-L203	Sedimentology Lab	2	25
		Inter Disciplinary Course	TIU-UGL-IDC-T201	Environmental Geology	3	50
		Skill Enhancement Course	TIU-UGL-SEC-T201	Data handling in Igneous petrology Lab	3	50
	Semester - IV	Major Theory	TIU-UGL-MAJOR-T200	Structural Geology	4	50
		Major Theory	TIU-UGL-MAJOR-T202	Geophysics	4	50
		Major Theory	TIU-UGL-MAJOR-T204	Stratigraphy	4	50
		Major Practical	TIU-UGL-MAJOR-L200	Structural Geology Lab	2	25
		Inter Disciplinary Course	TIU-UGL-IDC-T200	Geodynamics	3	50
		Compulsory Audit Course	TIU-UGL-CAC-P200	Field Training- II	4	50
		Minor Theory *	TIU-UGL-MINOR-T200	Rocks and Minerals	4	50
3rd Year	Semester - V	Major Theory	TIU-UGL-MAJOR-T301	Metamorphic Petrology	4	50
		Major Theory	TIU-UGL-MAJOR-T303	Palaeontology	4	50
		Major Theory	TIU-UGL-MAJOR-T305	Tectonics and Solid Earth Geophysics	4	50
		Major Practical	TIU-UGL-MAJOR-L301	Metamorphic Petrology Lab	2	25
		Major Practical	TIU-UGL-MAJOR-L303	Palaeontology Lab	2	25
		Summer Internship	TIU-UGL-P307	Internship	2	25
	Semester- VI	Major Theory	TIU-UGL-MAJOR-T300	Economic Geology	4	50
		Major Theory	TIU-UGL-MAJOR-T302	Exploration Geology	4	50
		Major Theory	TIU-UGL-MAJOR-T304	Hydrogeology	4	50

3rd Year	Semester -VI	Major Theory	TIU-UGL-MAJOR-T306	Engineering Geology	4	50
		Major Practical	TIU-UGL-MAJOR-L300	Economic Geology Lab	2	25
		Major Practical	TIU-UGL-MAJOR-L304	Hydrogeology Lab	2	25
		Compulsory Audit Course	TIU-UGL-CAC-P300	Field Training- III	4	50
		Minor Theory *	TIU-UGL-MINOR-T300	Elementary Geophysics	4	50
4th Year	Semester - VII	Major Theory	TIU-UGL-MAJOR-T401	Geomorphology, GIS and Remote sensing	4	50
		Major Theory	TIU-UGL-MAJOR-T403	Fuel Geology	4	50
		Major/DSE Theory	TIU-UGL-MAJOR-T405	Sequence stratigraphy and Basin Evolution		
		Major Practical	TIU-UGL-MAJOR-L401	Geomorphology, GIS and Remote sensing Lab	2	25
		Major Practical	TIU-UGL-MAJOR-L403	Fuel Geology Lab	2	25
		Major/DSE Theory	TIU-UGL- MAJOR-T400	Applications of Micro and Molecular fossils	4	50
		Dissertation	TIU-UGL- D400	Dissertation	12	150
		Major/DSE Theory**	TIU-UGL-MAJOR-T402	Geochemical Data Analysis- Theories and Practices	4	50
		Major/DSE Theory**	TIU-UGL-MAJOR-T404	Groundwater Resources and Management	4	50
		Major/DSE Theory**	TIU-UGL-MAJOR-T406	Drilling, Mining, Beneficiation and Mineral Economics	4	50
		Minor Theory *	TIU-UGL-MINOR-T400	Hydrogeology	4	50
		Compulsory Audit Course	TIU-UGL-CAC-P400	Field Training- IV	4	50
		Compulsory Audit Course	TIU-UGL-CAC-D400	Research Seminar unrelated to Dissertation	4	50
		Compulsory Audit Course	TIU-UGL-CAC-D402	Grand Viva	4	50

Note:

*1) **From a pair of two DSE courses (example, DSE-1A and DSE-1B) only one course can be selected; DSE-3, 4 and 5 are for those who will not opt for Dissertation; To run a particular DSE course, number of students must be at least 20% of the total strength of the class;*

2) The DSE courses will be dynamic in nature meaning, the offered courses may change from time to time. If any particular course is not opted by the students in consecutive two years, the coursework would be replaced by a new one, subject to approval from the competent authority;

3) Field trainings and other compulsory audit courses (CAC) are compulsory and restricted for the students with Earth Science Major. The students must acquire qualifying grade/marks in these courses for the successful completion of the courses and award of any degree with Earth Science as the major/Major subject;

4) Marks/grades obtained in the compulsory audit courses (CAC) will not be used in the calculation of CGPA/SGPA etc. but will be reflected separately in the Grade Card/Mark sheet

*5) *Minor Theory Courses will be offered by the Department of Geological Sciences for the students with major in subjects other than Earth Science.*

2.3 Choices for Discipline Specific Electives (DSE)

	Theory with Practical
DSE 01	**Sequence stratigraphy and Basin Evolution**
DSE 02	**Applications of Micro and Molecular fossils**
DSE 03	**Geochemical Data Analysis- Theories and Practices**
DSE 04	**Groundwater Resources and Management**
DSE 05	**Drilling, Mining, Beneficiation and Mineral Economics**

2.4 Skill Enhancement Courses (SEC)

	Theory	**Practical**
SEC 01	Application of AI in Earth Sciences	--
SEC 02	--	**Field Training- I (Introduction to Field Geology)**
SEC 03	--	**Igneous Petrology lab and data handling**

2.5 Compulsory Audit Courses (CAC)

	Theory	**Practical**
CAC 01	--	Field Training – II (Stratigraphy, Sedimentology and Paleontology)
CAC 02	--	Field Training – III (Metamorphic Petrology and Structural Geology)
CAC 03	--	Field Training – IV (Economic Geology, Exploration Geology, Engineering Geology)
CAC 04	--	Research Seminar unrelated to Dissertation
CAC 05	--	Grand Viva

2.6 Common Value-Added Courses (CVAC)

	Theory	Practical
CVAC 01	Introduction to Indian Constitution	--
CVAC 02	--	Physical education, Yoga and Mental health

2.7 Ability Enhancement Courses (AEC)

	Theory	Practical
AEC 01	Communicative English	--
AEC 02	Communicative English	--

2.8 Inter Disciplinary Courses (IDC) offered by the department

	Theory	Practical
IDC 01	Basics of AI	√
IDC 02	Environmental Geology	--
IDC 03	Geodynamics	--

2.9 Minor Courses offered by the department for the students with a Major subject other than Geological Sciences

	Theory	Practical
MINOR 01	Essentials of Geology	--
MINOR 02	Rocks and Minerals	--
MINOR 03	Elementary Geophysics	--
MINOR 04	Hydrogeology	--

3. Detailed Syllabus and Course Outcomes (COs) of Major Subjects

3.1 Earth System Science

Subject Code: TIU-UGL-MAJOR-T101 **4 Credits**

Unit 1: The Concept of Earth System Science

1. The scientific method
2. The system concepts
3. Dynamic interactions among Systems
4. The energy cycle
5. Branches of earth science

Unit 2: Earth as a planet in the solar system

1. Origin of the Universe and the solar system
2. Evolution of the Planets
3. The Terrestrial and Jovian Planets
4. Meteorites and Asteroids
5. Origin of atmosphere, ocean and life

Unit 3: Structure of the solid earth and related phenomenon

1. The Earth as a layered planet: mechanical layering of the Earth
2. Layers of different composition and physical state
3. Earthquake and the Earth's interior
4. Plate tectonics
5. Earth's heat source and geothermal gradient
6. Mantle melting; magmas and volcanoes

Unit 4: The Earth's evolving crust

1. Sedimentary strata
2. Sedimentary process and sedimentary Rocks
3. Metamorphism and metamorphic Rocks
4. Plate tectonics, continental crust and mountain building
5. Understanding the past from stratigraphic records
6. Geological Time Scale
7. Plate tectonics, continental crust and mountain building

Unit 5: Hydrosphere, atmosphere and biosphere

1. Water and the hydrologic cycle
2. Snow and ice
3. The oceans
4. The atmosphere
5. Winds and the global air circulation
6. The Earth's climate system and the changing climate

Unit 6: Life on earth

1. A planetary perspective on Life
2. The habitable planet
3. The biosphere
4. Biogeochemical cycles and biological evolution
5. Extinctions and the biosphere

Unit 7: Resources from the earth

1. Mineral resources
2. Coal and petroleum resources
3. Nuclear, wind and hydroelectric power energy

Reference books

- Emiliani, C. (1992) Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press. Published in USA.
- Grotzinger, J., Jordan, T.H., Press, F., Siever, R. (2007) Understanding Earth. W.H. Freeman & Co., New York, 5th Ed.
- Mathez, E.A., Webster, J.D. (2004) The Earth machine – The Science of a Dynamic Planet. Columbia University Press, New York.
- Skinner, B.J., Porter, S.C., Botkin, D.B. (1999) The Blue Planet – An Introduction to Earth System Science. John Wiley & Sons, Inc. New York.

Course Outcomes

- *CO1*: Comprehend how the principal components such as geosphere, hydrosphere (including the solid cryosphere), atmosphere, biosphere of the Earth system function and control the global environment.
- *CO2*: Apply the fundamental physical and chemical laws to explain the formation of Earth as a planet.
- *CO3*: Know basic geophysical tools/methods used to explore Earth's internal constitutions.
- *CO4*: Recognize the physical and chemical characteristics of earth forming materials, such as rocks, minerals and soils, and appreciate their utilities to meet societal needs.
- *CO5*: Conceive the governing geological processes of major global cycles, such as rock cycles and Earth's dynamics, such as plate tectonics.
- *CO6*: Understand the origin of life and tracing the evolution of life from a simple to complex forms through geologic time

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2		2	2	1		1		3	3		1
CO2	3	3		2	3							3		3	2
CO3	3	3		1	2							2	1	2	
CO4	2	2			3		2	1	1			2		2	3
CO5		3	1	2		1	1						3	3	
CO6	3	3	1				2			1		1	2		

3.2 Earth System Science Lab

Subject Code: TIU-UGL-MAJOR-L101 **2 Credits**

Unit 1

1. Study of rocks and minerals in hand specimen.

Unit 2

1. Study of distribution of major lithostratigraphic units on the map of India.

Unit 3

1. Global distribution of cratons, mobile belts and major sedimentary basins.

Reference books

- Emiliani, C. (1992) Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press. Published in USA.
- Grotzinger, J., Jordan, T.H., Press, F., Siever, R. (2007) Understanding Earth. W.H. Freeman & Co., New York, 5th Ed.
- Mathez, E.A. and Webster, J.D. (2004) The Earth machine – The Science of a Dynamic Planet. Columbia University Press, New York.
- Skinner, B.J., Porter, S.C., Botkin, D.B. (1999) The Blue Planet – An Introduction to Earth System Science. John Wiley & Sons, Inc. New York.

Course Outcomes

- *CO1*: Be able to describe, identify and classify minerals and rocks using physical properties in hand specimen
- *CO2*: Learn to study topographic sheets, identify and differentiate geomorphic feature and prepare physiographic description
- *CO3*: Be able to locate major cratons, mobile belts and sedimentary basins, with special emphasis on India, using geological maps

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3				2		1			3	1
CO2	2	3	2		3	1									2
CO3		2	2		1				2						3

3.3 Minerology

Subject Code: TIU-UGL-MAJOR-T100 **4 Credits**

Unit 1: Crystallography

1. Concept of crystal and crystalline matter. Internal order in crystal.
2. Crystal structure, Elementary ideas about crystal morphology in relation to internal structures
3. Crystal parameters and indices, form and zone

Unit 2: Atomic arrangements and mineralogical structure

1. Atomic arrangements: Unit cell, CCP, FCC and HCP
2. Ionic radius and coordination, Pauling's rules. Solid Solution, Polymorphism, Pseudomorphism
3. Atomic structure of silicate minerals

Unit 3: Rock forming minerals

1. Minerals - definition and classification, physical and chemical properties
2. Chemical classification of minerals
3. Composition of common oxides, carbonated, sulphides and sulphates and phosphates
4. Composition of common rock-forming minerals

Unit 4: Crystal Optics

1. Nature of light and optical behaviour of crystals
2. Introduction to petrological microscope
3. Concept of visible electro-magnetic spectrum
4. Theory of light propagation in isotropic, uniaxial and bi-axial crystals

5. Orthoscopic and conoscopic studies of minerals under optical microscope

Reference books

- Deer, W. A., Howie, R. A., Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
- Klein, C., Dutrow, B., Dwight, J., Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Nesse, W. D. (2011) Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- Putnis, A. (1992) Introduction to Mineral Sciences. Cambridge University Press.
- Whalstrom, E.E. (1969) Optical Crystallography. John Wiley & Sons

Course Outcomes

- *CO1*: Discriminate the different groups of minerals as basic constituents of terrestrial planetary materials, such as rocks.
- ***CO2***: Learn the principles of crystallographic symmetry and apply them to study the crystal morphology of minerals.
- ***CO3***: Be able to explain the atomic structures in terms of coordination chemistry and chemical bonding.
- ***CO4***: Understand the physics of light propagation through crystals, which is required in studying minerals under optical microscopes.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				2	1	1						2	1	
CO2	3	1			1										
CO3	3	2				2	1						1	1	
CO4	3	1											1	2	

3.4 Mineralogy Lab

Subject Code: TIU-UGL-MAJOR-L100 **2 Credits**

Unit 1

Study of the symmetry of crystals. Calculation of the Face Symbol of Crystals, Stereographic projection of crystals

Unit 2

Derivation of structural formulae based on composition

Unit 3

Introduction to optical microscope in laboratory studies

Unit 4

Methods of optical properties of minerals

Unit 5

Study of optical properties of common rock-forming minerals

Reference books

- Deer, W. A., Howie, R. A., Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.

- Klein, C., Dutrow, B., Dwight, J., Klein, C. (2007). The 23rd Edition of the Manual of Mineral Science (after James D. Dana). J. Wiley & Sons.
- Nesse, W. D. (2011) Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
- Putnis, A. (1992) Introduction to Mineral Sciences. Cambridge University Press.
- Whalstrom, E.E. (1969) Optical Crystallography. John Wiley & Sons

Course Outcomes

- ***CO1***: Establish the crystallographic characteristics of minerals from their external shapes and symmetry elements.
- ***CO2:*** Learn the calculation techniques of structural formulas from mineral chemistry.
- ***CO3***: Learn the principal techniques of using polarizing optical microscope and identification of common rock forming minerals.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3				2		1			3	1
CO2	2	3	2		3	1									2
CO3		2	2		1				2						3

3.5 Elements of Geochemistry

Subject Code: TIU-UGL-MAJOR-T102 **4 Credits**

Unit 1: Basic concepts

1. Origin and cosmic abundances of elements
2. Geochemical classification of elements
3. Introduction to geochemical properties of elements
4. Chemical bonding, states of matter and atomic environment of elements

Unit 2: Composition of the earth

1. Composition of the bulk silicate Earth
2. Formation and composition of core, mantle and crust
3. Principles and applications of radiogenic and stable isotopes studies

Unit 3: Element transport

1. Advection and diffusive mass transport in geological system
2. Aqueous geochemistry- basic concepts and thermodynamic of solutions, Eh, pH relations,
3. Stability diagrams and their application (Eh/pe-pH, chemical potential diagrams), thermodynamic and kinetic control of mineral reactions.

Unit 4: Geochemistry of solid Earth

1. Geochemical variability of magma and its products. Melting processes.

Reference books

- Albarède, F. (2003) Geochemistry: an introduction. Cambridge University Press.
- McSween, H., Richardson, S., Uhle, M. (2003) Geochemistry-Pathways and processes , Columbia University Press.
- Faure, G (1998). Principles and applications of geochemistry. Prentice Hall

- Krauskopf, K.B. (1994). Introduction to Geochemistry. McGraw-Hill Book Company
- Mason, B. (1986) Principles of Geochemistry. Wiley, New York.
- Misra K.C. (2012). Introduction to Geochemistry: principles and applications. Wiley-Blackwell
- Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. Publisher Longman Scientific & Technical.
- Walther, J. V. (2009) Essentials of geochemistry. Jones & Bartlett Publishers.
- White W.M. (2013). Geochemistry. Wiley-Blackwell

Course Outcomes

- *CO1*: Understanding the principles and quantify solubility of gases and ionic/neutral species in natural fluids under variable physicochemical conditions.
- *CO2*: Quantify the mass transport, both physical and chemical, within and across the boundaries of lithosphere, hydrosphere and atmosphere in order to explain natural phenomenon namely land erosion, weathering, magmatism, concentrations and depletion of materials in specific areas of the earth, earth quake, land slides
- *CO3*: Understand the origin of elements and explain their relative concentration and distribution in the geosphere, hydrosphere and atmosphere
- *CO4*: Understand the behaviour of elements during different earth processes and their guiding principles
- *CO5*: Understand the fundamental principles of radioactive and stable isotope geochemistry and comprehend their application in geochronology and deciphering earth processes, including climate change

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	3	3	3	3	1	1	3	3	3	3
CO2	3	3	2	3	3	3	3	3	3	1	1	3	3	3	3
CO3	3	1				2							3	1	1
CO4	3	3	2	3	3	3	3	3	3	1	1	3	3	3	3
CO5	3	2	1			2	2						2	1	2

3.6 Igneous Petrology

Subject Code: TIU-UGL-MAJOR-T201 **4 Credits**

Unit 1: Introduction

1. Origin of the Earth and Earth's Interior
2. Meteorite and composition of the Earth's Interior
3. The pressure distribution inside the Earth
4. Heat sources within the Earth and the geothermal gradient
5. Magma generation inside the Earth

Unit 2: Physical properties of magma, Magma emplacement and forms of igneous rock bodies

1. Magmatic temperature, viscosity, density, and volatile content
2. Nature of magma – atomic structure of melts
3. Magma emplacement and forms of igneous rock bodies
4. Cooling of igneous bodies

Unit 3: Classification of igneous rocks

1. Crystallinity, granularity, shapes and mutual relations of grains

2. Nucleation and growth of igneous minerals
3. Composition of igneous rocks

Unit 4: Texture and microstructure of igneous rocks

1. Primary textures and secondary textures
2. Crystallinity, granularity, shapes, and mutual relations of grains
3. Nucleation and growth of igneous minerals
4. Description of the different igneous textures and microstructures with their occurrences in different rocks

Unit 5: Introduction to thermodynamics and phase equilibria

1. Introduction to thermodynamics
2. The phase rule and its application to eutectic, peritectic and solid solution system
3. Phase diagrams - binary and ternary phase diagrams in understanding crystal-melt equilibria in basaltic and granitic magmas
4. Effects of volatiles on melt equilibria
5. Phase equilibria in the binary and ternary systems, and their petrogenetic significance

Unit 6: Magma generation, magmatism and differentiation

1. Melting processes and magma generation
2. Magmatic processes - crystal settling, magma convection, crystal mush theory, igneous cumulates, liquid immiscibility, diffusion processes – Soret effect, assimilation and assimilation and fractional crystallization (AFC), mixing of magmas, trace element fractionation by magmas
3. Magmatism in the oceanic domains - magmatism in mid-ocean ridges and oceanic island; Magmatism along the subduction zones - island arcs and continental arcs;
4. Magmatism along continental rifts
5. Continental flood basalts and large igneous provinces
6. Special Precambrian associations and meteorite-impact-generated magmatic rocks

Unit 7: Petrogenesis of igneous rocks

1. Magma generation in crust and mantle
2. Emplacement and evolution of magma
3. Petrogenesis of felsic and mafic igneous rocks
4. Igneous rocks and differentiation of the Earth

Reference books

- Best, M.G. (2018) Igneous and Metamorphic Petrology. CBS Publishers.
- Cox, K.G., Bell, J.D. (1979) The Interpretation of Igneous Rocks. Springer/Chapman and Hall.
- Frost, B.R. and Frost, C.D. (2014) Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.
- Philpotts, A. R. and Ague, J. (2009) Principles of Igneous and Metamorphic Petrology. Cambridge University Press.
- Rollinson, H.R. (2014) Using geochemical data: evaluation, presentation, interpretation. Longman Geochemistry Series.
- Winter, J.D. (2014) Principles of Igneous and Metamorphic Petrology. Pearson.

Course Outcomes

- ***CO1***: Discriminate the structure, texture and mineralogy of the common igneous rocks formed under different physicochemical conditions

- ***CO2***: Read the phase diagram in one, two and three component systems and will be able to trace the crystallization path of liquids in terms of equilibrium and fractional crystallization
- ***CO3***: Interpret the formation of partial melting in terms of geological/ tectonic settings and the variation of major and trace elements in a fractionated suite of igneous rocks
- ***CO4***: Classify igneous rocks on the basis of modal mineralogy
- ***CO5***: Evaluate the controls of the different physical and chemical properties of magma and explain the mode of emplacement and differentiation of magma

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2			3		1						3	3	
CO2	3	3			2		2						3	2	
CO3	2		2		3		1						2		2
CO4	2					1	1				1		3		1
CO5		3				1	1						3		2

3.7 Sedimentology

Subject Code: TIU-UGL-MAJOR-T203 **4 Credits**

Unit 1: Introduction to sedimentology

1. Outline of sedimentation process
2. Definition of sediment; origin of sediments
3. Mechanical and chemical sediments
4. Source rock or provenance

Unit 2: Sedimentary textures

1. Grain size concept and size scale, particle size distribution, granulomeric analyses
2. Environmental connotation
3. Particle shape and fabric

Unit 3: Basic hydraulics and sedimentary structures

1. Fluid flow; Types of fluids, Laminar and turbulent flow, subcritical, critical and supercritical flows
2. Flow profile and flow separation
3. Particle entrainment, transport and deposition
4. Mass flow types, mechanisms and controlling factors, process-product relationship
5. Sedimentary structure: Primary and penecontemporaneous structures
6. Bedform stability diagram
7. Paleocurrent analysis- Data acquisition, methodology, different paleocurrent patterns

Unit 4: Types of sedimentary rocks

1. Siliciclastic rocks: Components and classification(s) of conglomerates, sandstones and mudstones
2. Tectonic control on sandstone composition
3. Carbonate rocks; controlling factors of carbonate deposition
4. Components and classifications of limestone; dolomite and dolomitization

Unit 5: Diagenesis

1. Concepts of diagenesis
2. Stages of diagenesis: diagenetic changes in sand and carbonate deposits, lithification

Unit 6: Depositional environments

1. Types, Characteristic processes and their products
2. Identification criteria in rock record.

Reference books

- Boggs, S. (1995). Principles of Sedimentology and Stratigraphy. Prentice Hall, New Jersey
- Collinson, J. D., Thompson, D. B. (1988). Sedimentary structures, Unwin- Hyman, London
- James, N.P., Jones, B. (2016). Origin of carbonate sedimentary rocks. Wiley
- Leeder, M.R. (1982). Sedimentology: Process and Product. George Alien & Unwin, London
- Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell
- Prothero, D. R., Schwab, F. (2004) Sedimentary Geology. Macmillan
- Reading, H.G. (2012). Sedimentary Environments: Processes, Facies and Stratigraphy. Wiley
- Sam Boggs, JR. (2009) Petrology of Sedimentary rocks, Cambridge University Press
- Tucker, M. E. (2006) Sedimentary Petrology, Blackwell Publishing.

Course Outcomes

*CO1***:** Identify the different types of sedimentary rocks and learn the basis of classification of the sedimentary rocks

*CO2***:** Understanding the genetic implications of their internal structures, importance of slope, particle size and flow velocity on sediment transport

*CO3***:** Discriminate the behaviour of rivers, wind, oceans and glaciers, and the boons and the banes they bring upon human society.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3			2		1					3	3	2	
CO2	3	3			2							2	2	2	
CO3	3	2	2				3					2	2		3

3.8 Sedimentology Lab

Subject Code: TIU-UGL-MAJOR-L203 **2 Credits**

Unit 1

Identification of sedimentary structures

Unit 2

Particle size distribution and statistical analysis

Unit 3

Palaeocurrent analysis

Unit 4

Methods of optical properties of minerals

Unit 5

Petrographic study of clastic and non-clastic rocks in hand specimens and thin sections

Reference books

- Folk, R.J., (1981) Petrology of Sedimentary Rocks. 2nd edition Hemphill Pub Co.
- Lindholm, R.C. (2012) A Practical Approach to Sedimentology. Springer Science & Business Media
- Pettijohn, F.J. (1975) Sedimentary Rocks. Harper and Row Publ. New Delhi
- Prothero, D.R., Schwab, F. (2004). Sedimentary geology. Macmillan
- Boggs, Jr. S. (2009) Petrology of Sedimentary rocks, Cambridge University Press Tucker, M.E., Wright, V.P. (1990) Carbonate Sedimentology. Blackwell Science

Course Outcomes

- ***CO1***: Understanding the ideas of grain-size parameters and their role in sedimentation
- ***CO2***: Study of primary sedimentary structures
- ***CO3***: Identification of arenite group of rocks under microscope
- ***CO4***: Understanding the ideas of basin evolution
- ***CO5***: Understanding the ideas of the provenance rocks
- ***CO6***: Identification of authegenic clay minerals under microscope

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3			2								3	2	1
CO2	3	2			2								3	2	1
CO3	1	2			3								2	2	2
CO4	3	2			2								3	2	2
CO5	3	2			3								2	2	3
CO6	3	3			3								3	3	3

3.9 Structural Geology

Subject Code: TIU-UGL-MAJOR-T200 **4 Credits**

Unit 1: Basic structural elements

1. Diastrophic and non- diastrophic structures
2. Application of primary sedimentary and igneous structure in structural geology.
3. Unconformity and its types; recognition of Unconformity
4. Concept of scale of observation of structures;

Unit 2: Stress and strain in rocks

1. Concept of rock deformation
2. Elementary theory of 2D Stress
3. Basic concepts of Strain- Homogeneous and inhomogeneous strain, Rotational and irrotational strain in rocks
4. Strain ellipsoids of different types and their geological significance
5. Principle of Flinn diagram

6. Characteristics of brittle and ductile deformations.

Unit 3: Folds, foliation and lineation

1. Definition and principal geometrical elements of Folds
2. Geometric and genetic classifications of folds
3. Analysis of fold outcrop patterns
4. Introduction to folding mechanisms- Buckling, Bending, Shear, Flexural slip and flow folding
5. Classifications of foliations
6. Description and origin of foliations: axial plane cleavage and its tectonic significance
7. Description and origin of lineations and their geometrical relationship with the major structures

Unit 4: Fractures, faults and shear zones

1. Geometric and genetic classification of fractures and faults
2. Geologic/geomorphic criteria for recognition of faults and fault plane solutions
3. Ductile shear zones and their characteristics structural descriptions
4. Boudinage structures- Types of boudins, use of boudinage structures as kinematic indicator

Reference books

- Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall.
- Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
- Ghosh, S.K. (1993) Fundamentals and Modern Developments of Structural Geology. Pergamon Press
- Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
- Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
- Ramsay, J. G. (1967) Folding and Fracturing of Rocks. Mc-Graw Hill, New York
- Twiss, J.R. and Moores, M.E. (2006). Structural Geology. W.H. Freeman and Company, New York

Course Outcomes

- *CO1*: Learn the basic theories of stress and strain, and their relations in rock deformations under geological conditions.
- *CO2*: Learn quantitative geometrical techniques for identifying tectonic structures, such as fractures, faults and folds in geological terrains, and apply them for practical works, e.g., geological survey and exploration.
- *CO3*: Interpret the deformation kinematics from structural features in tectonic belts.
- *CO4*: Explain the underlying mechanics of observed dynamic geological phenomena, such as mountain building, earthquake generation and landslides

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**		**2**								**3**	**2**		**2**
CO2	**3**	**3**		**2**		**1**						**3**		**3**	**3**
CO3	**3**	**2**		**2**		**1**						**2**		**3**	**3**
CO4	**3**	**2**			**2**	**1**							**3**		**2**

3.10 Structural Geology Lab

Subject Code: TIU-UGL-MAJOR-L200 **2 Credits**

Unit 1

Basic elements of topographic maps, Topographic sheets of various scales

Unit 2

Interpretation of topographic maps; construction of topographic profile

Unit 3

Interpretation of Geological maps with unconformity, fault, fold and igneous bodies Construction of structural cross section

Unit 4

Stereographic projections of planes and lines: theory and practice

Unit 5

True dip and apparent dip problems, 3-point problems, fold problems, fault problems and their solutions through stereographic projection method

Reference books

- Lahee F. H. (1962) Field Geology. McGraw Hill
- Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed.). Cambridge University Press

Course Outcomes

- ***CO1***: Apply graphical and projection methods to determine the attitudes of rock structures from field data, as practiced for various geological work, like mapping, mineral exploration and mining.
- ***CO2***: Learn geometrical techniques for preparing geological maps, which is a basic requirement for any geological investigation of natural resources.
- ***CO3***: Interpret 3D topology of geological structures from 2D geological maps and prepare structural cross-sections for geological interpretations and exploration for economic deposits.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2				1		1						3
CO2	2	2	2				1		1						2
CO3	2	3	3				1		1						3

3.11 Geophysics

Subject Code: TIU-UGL-MAJOR-T202 **4 Credits**

Unit 1: Geology and Geophysics

1. What is geophysics?
2. Interrelationship between geology and geophysics.
3. History of Geophysics

Unit 2: Basics and applied geophysics

1. Different types of geophysical methods - gravity, magnetic, electrical and seismic
2. Principles of different methods. Applications of different methods.
3. Elements of well logging
4. Corrections in geophysical data

Unit 3: Geophysical field operations

1. Data acquisition and Processing. Data reduction. Signal and noise
2. Different types of surveys, grid and route surveys, profiling and sounding techniques
3. Scales of survey
4. Presentation of geophysical data

Unit 4: Application of geophysical methods

1. Regional geophysics, oil and gas geophysics, ore geophysics,
2. Mining geophysics, groundwater geophysics,
3. Engineering geophysics: Environmental geophysics,
4. Geological interpretation of geophysical data

Unit 5: Application of geophysical methods

1. Correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies,
2. Factors controlling anomaly; Depth of exploration

Unit 6: Application of geophysical methods

1. Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

Reference books

- Bhimasarikaram V.L.S. (1990) Exploration Geophysics - An Outline. Association of Exploration Geophysicists, Osmania University, Hyderabad, 1990.
- Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
- Lowrie, W. (2007) Fundamentals of geophysics. Cambridge University Press.
- Mussett, A. E., Khan, M. A. (2000) Looking into the Earth. Cambridge University Press.
- Ramachandra Rao, M.B., Prasaranga, (1975) Outlines of Geophysical Prospecting - A manual for geologists. University of Mysore, Mysore.
- Telford, W. M., Geldart, L. P., Sheriff, R. E. (1990) Applied geophysics (Vol. 1). Cambridge university press.

Course Outcomes

- *CO1*: Interpret fundamental physical properties (magnetic, electrical, thermal etc.) of rocks and other geological materials using basic laws of physics.
- ***CO2***: Understand the underlying physical principles of important geophysical methods (seismic, gravity etc.).

- ***CO3***: Know the basics of instruments and their application for geophysical surveys.
- ***CO4***: Apply various geophysical methods in exploration of natural economic resources, like petroleum and metal ore deposits.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**3**	**3**			**3**							**2**		**3**	**3**
CO2	**3**	**2**	**3**		**3**								**1**	**2**	**3**
CO3	**3**	**2**	**2**		**3**							**3**		**2**	**1**
CO4	**2**	**2**	**3**	**3**	**3**				**2**		**2**	**2**		**2**	**2**

3.12 Stratigraphy

Subject Code: TIU-UGL-MAJOR-T204 **4 Credits**

Unit 1: Principles of stratigraphy

1. Fundamentals of lithostratigraphy, biostratigraphy and chronostratigraphy
2. Introduction to concepts of dynamic stratigraphy (chemostratigraphy, seismic stratigraphy, sequence stratigraphy, magnetostratigraphy and their subdivisions with Indian examples)
3. Relevance of Type section; Principles of stratigraphic correlation.
4. Code of stratigraphic nomenclature: International Stratigraphic Code – development of a standardized stratigraphic nomenclature; Concepts of Stratotypes; Global Stratotype Section and Point (GSSP).

Unit 2: Principles of stratigraphic analysis facies concept in stratigraphy

1. Walther's Law of Facies; Concept of paleogeographic reconstruction.
2. Stratigraphic boundaries in India- Archaean-Proterozoic boundary
3. Precambrian-Cambrian boundary
4. Permian-Triassic boundary
5. Cretaceous-Tertiary boundary and their status from a global perspective.

Unit 3: Physiographic and tectonic subdivisions of India

1. Brief introduction to the physiographic and tectonic subdivisions of India
2. Introduction to Indian Shield, Craton; Introduction to Indian Precambrian belts
3. Introduction to Proterozoic basins of India.

Unit 4: Geologic evolution important Precambrian terrains

1. Geologic evolution with emphasis on sedimentation, lithology, magmatism, structure, metamorphism and geochronology of Dharwar, Singhbhum, Aravalli, Bastar, Rajasthan, Central India and Eastern Ghats; Vindhyan and Cudappah basins of India.

Unit 5: Phanerozoic stratigraphy of India

1. Important Stratigraphic boundaries during Phanerozoic time in India
   Important Palaeozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and palaeoenvironment (Palaeozoic Succession of Kashmir and its correlatives from Spiti and Zanskar Stratigraphy
2. Stratigraphy Structure of Gondwana basins
3. Mesozoic stratigraphy of India- Triassic successions of Spiti, Jurassic of Kutch, Triassic and Jurassic non-marine successions of peninsular India (Upper Gondwana formations, relevant Formations of Rajasthan basin).
4. Cretaceous, successions of Cauvery basins, Lameta and Jabalpur Formations
5. Cenozoic stratigraphy of India -Kutch basin, Siwalik successions, Assam, Andaman and Arakan basins
6. Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration
7. Stratigraphy of the inter-trappeans- Deccan, Rajmahal, Sylhet Trap
8. Quaternary Geology- Definition, Principles of subdivision of Quaternary succession in India

Reference books

- Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi
- Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley
- Ramakrishnan, M. & Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
- Valdiya, K. S. (2010). The making of India, Macmillan India Pvt. Ltd.
- The Evolving Continents by B.F. Windley (1984); 2nd Edition; John Wiley and Sons

Course Outcomes

- ***CO1****:* Learn the fundamental laws of stratigraphy
- ***CO2***: Learn to consider temporal and spatial variation in stratigraphic sequence development
- ***CO3***: Study of different stratigraphic units and paleo-geographic reconstruction
- ***CO4***: Understanding the characteristics and evolution of the Indian Shield, cratons, Proterozoic mobile belts and Proterozoic basins in India
- *CO5*: Familiarity with important stratigraphic successions of India throughout Phanerozoic Eon; and understanding with the Physiographic configuration and tectonic subdivisions of India and also acquainted with their succession, lithology, flora and fauna, their paleo-environment of deposition
- ***CO6***: Analyze and interpret stratigraphic boundaries in India
- ***CO7***: Analyze the geologic evolution of significant Precambrian terrains in India

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2											3		2
CO2	3	3	2		2						1				3
CO3		2			3			1	2						3
CO4	3	3		3		1	2								2
CO5		2		2		1	1								3
CO6	2	3		3									2		3
CO7	2	3		3									2		3

3.13 Metamorphic Petrology

Subject Code: TIU-UGL-MAJOR-T301 **4 Credits**

Unit 1: Metamorphism: controls and types

1. Definition of metamorphism. Factors controlling metamorphism
2. Types of metamorphism – contact, regional, fault zone metamorphism, impact metamorphism
3. Causes of metamorphism and concept of metamorphic P-T-t paths

Unit 2: Metamorphic facies and grades

1. Metamorphic Structures and Textures; Index minerals, metamorphic zones and isograds. Structure and textures of metamorphic rocks
2. Concept of metamorphic facies and grade
3. Mineralogical phase rule of closed and open system
4. Composition-paragenesis diagrams. ACF, AKF and AFM diagrams
5. Metamorphic products of pelitic, carbonate and mafic igneous rocks

Unit 3: Metamorphic reactions

1. Metamorphism and deformation
2. Progressive and retrogressive metamorphism of politic, mafic and calcareous rocks
3. Prograde and retrograde metamorphic minerals reactions: the application of AFM- ACF-AKF diagrams
4. Relationship between metamorphism and deformation, nucleation and growth of minerals under metamorphic/metasomatic conditions

Unit 4: Fluid-rock interaction and crustal anatexis

1. Metasomatism and the role of fluids in metamorphism
2. Brief idea of crustal anatexis; Migmatites and its origin.

Unit 5: Metamorphic rock associations and plate tectonic settings

1. Regional occurrence and tectonic significance of metamorphic rocks
2. Metamorphism along convergent plate margins, in continent-continent collisions, in rifting terrains and sea floor metamorphism.

Unit 6: Quantification of the physical conditions of metamorphism: the geothermobarometry

1. Principle, pitfalls and application of common mineralogical and stable isotope geothermobarometers in metamorphic rocks

Reference books

- Philpotts, A., & Ague, J. (2009) Principles of igneous and metamorphic petrology. Cambridge University Press.
- Raymond, L. A. (2002) Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
- Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
- Spear F. S. (1993) Metamorphic phase equilibria and Pressure-Temperature-Time paths. Mineralogical Society of America. Monograph 799
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.

Course Outcomes

- *CO1*: Identify and distinguish the natural rocks and minerals (including materials of economic importance) that are formed at different depths of the earth
- ***CO2***: Apply the principles of the laws of conservation of mass and energy and their application in quantification of the different intensive and extensive variables at the time of formation and subsequent evolution of rocks

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	3	3	3	3	1	1	3	3	3	3
CO2	3	3	2	3	3	3	3	3	3	1	1	3	3	3	3

3.14 Metamorphic Petrology Lab

Subject Code: TIU-UGL-MAJOR-L301 **2 Credits**

Unit 1

Hand specimen study of metamorphic rocks

Unit 2

Textural and mineralogical study of metamorphic rocks in thin sections

Unit 3

Graphical plots of metamorphic mineral assemblages using chemographic diagrams

Reference books

- Philpotts, A., Ague, J. (2009) Principles of igneous and metamorphic petrology. Cambridge University Press.
- Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
- Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.

Course Outcomes

- *CO1*: Identify the sequence of mineral growth and quantify the changing physical conditions of metamorphism,
- ***CO2***: Estimate the composition of metamorphic fluids, fluid/rock ratios and fluid flux

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	3	3	3	3	1	1	3	3	3	3
CO2	3	3	2	3	3	3	3	3	3	1	1	3	3	3	3

3.15 Palaeontology

Subject Code: TIU-UGL-MAJOR-T303 **4 Credits**

Unit 1: Introduction to Palaeontology

1. Fossils - Taphonomic processes and modes of preservation
2. Nature and importance of fossil record
3. Taxonomic hierarchy
4. Speciation, species concept in palaeontology
5. Evolution and the fossil record
6. Modes of Evolution

Unit 2: Invertebrate Palaeontology

1. Brief introduction to important invertebrate groups (Bivalvia, Gastropoda, Brachiopoda, Trilobites, Corals and Echinoderms) and their biostratigraphic significance
2. Significance of ammonites in Mesozoic biostratigraphy and their palaeobiogeographic implications
3. Functional adaptation in trilobites and ammonoids
4. Introduction to ichnofossils

Unit 3: Vertebrate Palaeontology

1. Origin of vertebrates and major steps in vertebrate evolution
2. Mesozoic reptiles with special reference to origin, diversity and extinction of dinosaurs
3. Evolution of horse and intercontinental migrations
4. Human evolution

Unit 4: Palaeobotany

1. Introduction to Palaeobotany
2. Study of Gondwana Flora
3. Plants as indicator of past climate

Unit 5: Application of fossils

1. Application of fossils in Stratigraphy
2. Fossils and paleobiogeography
3. Fossils as a window to the evolution of ecosystems.

Reference books

- Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
- Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing, 24.
- Foote, M. & Miller, A. I. (2006). Principles of Paleontology (3rd Ed.)
- Colbert, E.H. (1990). Morales, M., Evolution of the Vertebrates. Wiley & Sons.
- Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
- Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher.

Course Outcomes

- ***CO1:*** Identification modes of preservation of fossil organisms and concepts of species
- ***CO2:*** Identify the characteristic features of invertebrates and vertebrates
- ***CO3:*** Understanding of morphological features of extinct plants
- ***CO4:*** Understanding of vertebrate evolution through time
- ***CO5:*** Methodology used in relative dating of rocks and reconstruction of past climates environments, and geography

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2			2						3		2
CO2	3	2		2				1					2		
CO3	3	2		1	3							3		2	
CO4	3	2			3								3		
CO5		2	3						3			2	2		1

3.16 Palaeontology Lab

Subject Code: TIU-UGL-MAJOR-L303 **2 Credits**

Unit 1

Study of fossils showing various modes of preservation

Unit 2

Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate fossils

Unit 3

Study of morphological features of the vertebrate skulls and dentition

Unit 4

Identification of Gondwana flora

Unit 5

Biostratigraphy

Reference books

- Benton, M. J., Harper, D. A. T. (2010). Introduction to Paleobiology and the Fossil Record, Wiley Blackwell.

Course Outcomes

- ***CO1*:** Understanding various modes of preservation of fossils
- ***CO2*:** Identification of invertebrate fossils and how they are named in the taxonomic framework.
- ***CO3***: Study of morphological characters of Gondwana plant fossils and different vertebrates
- ***CO4***: Understanding of the food habit of vertebrates from the dentition pattern

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3			2								3		2
CO2	2	3			2								3		2
CO3	2		2		2									2	
CO4	3	3												3	

3.17 Tectonics and Solid Earth Geophysics

Subject Code: TIU-UGL-MAJOR-T305 **4 Credits**

Unit 1: Earth's plate structures

1. Plates and Plate boundaries
2. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs

Unit 2: Basic theory of plate tectonics

1. Historical development of the concept of continental drift and plate tectonics
2. Paleomagnetism and Apparent Polar Wandering (APW) Path
3. Sea -floor spreading and Theory of continental drift
4. Euler's theory of plate motion
5. Stability of triple junctions of plate boundaries

Unit 3: Earthquake seismology

1. Basic theory of elastic waves and seismic signal analysis
2. Seismological structure of the upper and lower crust

Unit 4: Gravity- the figure of the Earth

2. Concept of gravitational potential, geoid and gravity anomalies

Unit 5: Geo-electricity

1. Electrical properties of geological materials
2. Origin of telluric current

Unit 6: Geomagnetism

1. Magnetic properties of geo-materials
2. Geomagnetic field of the Earth
3. Basic theory of magnetic survey

Reference books

- Condie, K.C. (2003) Plate Tectonics and Crustal Evolution. Butterworth-Heinemann. P. 282
- Cox, A. (1986) Plate Tectonics: How It Works. Blackwell Scientific Publication. P. 392.
- Eldridge, M. Moores, E.M., Twiss, R.J. (1995): Tectonics. Waveland Press. P. 415.
- Fowler, C.M.R. (2005) The Solid Earth_ An Introduction to Global Geophysics. Cambridge University Press. P. 685.
- Kearey, P., Klepeis, K.A., Vine, F.J. (2009) Global tectonics. Wiley-Blackwell. P. 482.
- Lowrie, W. (2007). Fundamentals of Geophysics. Cambridge University Press.
- Windley BF (1984): The Evolving Continents, 2nd Edition; John Wiley and Sons

Course Outcomes

- ***CO1***: Learn the processes of the collision of India and Eurasian Plates and its impact on Tertiary Geology of Himalayan Mountain Belts, Foreland basins of Himalaya and their evolution
- ***CO2:*** Understanding of Plate, Plate boundaries and Geodynamic elements of Earth
- ***CO3:*** Understand the basics of Paleo-magnetism and Polar wandering curve
- ***CO4***: Learning the Euler's theory of plate motion
- ***CO5***: Learning the various physical laws, e.g. gravity and thermodynamics are used to handle important physical phenomena of the solid earth, such as geoid construction and earthquake wave propagation.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3			2	1	3		1			2	2		3
CO2	3	3			2	1	2					3	3		1
CO3	3	2			3								3		1
CO4	3	3			3	1							3	2	1
CO5	3	2			2									2	1

3.18 Economic Geology

Subject Code: TIU-UGL-MAJOR-T300 **4 Credits**

Unit 1: Introduction

1. Economic geology and related science
2. Earth's differentiation and mineral deposits

3. Ore, ore mineral, ore deposit, gangue, tenor, grade, lodes, resources and reserves
4. Introduction to critical metals
5. Metallogenic provinces and epochs
6. Syngenetic and epigenetic ores
7. Morphology of orebodies

Unit 2: Earth's geochemical differentiation and Ore Deposits

1. Hotspots and mantle plumes and their relation to ore-forming processes
2. Magmatic ore-forming processes and affiliated ores

Unit 3: Hydrothermal deposits

1. Hydrothermal ore forming processes and related deposits
2. Sources of ore fluids and metals, mechanism of metal transport and deposition

Unit 4: Geochemical differentiation and ore Deposits

1. Hydrothermal ore forming processes and related deposits
2. Sources of ore fluids and metals, mechanism of metal transport and deposition
3. Large Igneous Provinces (LIP) and mineral deposits

Unit 5: Sedimentary ore-forming processes and related deposits

1. Ore deposits affiliated to weathering and weathered profiles
2. Ores of metamorphic affiliation

Unit 6: Understanding mineral deposit sciences

1. Geological setting, mineral assemblages and textures
2. Primary and secondary stability relations of mineral assemblages in ores
3. Geochemistry of ore minerals and ore deposits
4. Application of fluid inclusions in ore deposits
5. Geothermometry and geobarometry

Unit 7: Spatial and temporal distribution of ore deposits

1. Study of important metallic and non-metallic deposits in India
2. Mineral deposits on the Moon, Mars, asteroids, and exoplanets

Reference books

- Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
- Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers
- Evans, A.M. (1993): Ore Geology and Industrial Minerals – An Introduction. Blackwell Publishing, USA. P389
- Laurence Robb. (2005) Introduction to ore forming processes. Wiley.
- Mishra, K.C. (2000): Understanding Mineral Deposits. Kluwer Academic Publishers, The Netherland. P845
- Mukherjee, A. (1999): Ore Genesis – A Holistic Approach. Allied Publishers Ltd., New Delhi, India. P657
- Ridley, J. (2013): Ore Deposit Geology. Cambridge University Press, UK. P398.
- Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge University Publications.

Course Outcomes

- ***CO1****:* Be acquainted with the concepts and definition of common terminologies used in Ore geology
- ***CO2***: Understand the fundamental processes of ore-deposit formation and their classifications
- *CO3*: Understand the fundamental characteristics of important Indian ore deposits and their spatiotemporal distribution in the context of global tectonics and metallogeny
- ***CO4***: Comprehend the methods of physical and geochemical characterization of ore minerals and ores

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		2		3		2	2				3		2	3
CO2	3	2	1		2		3					2		3	2
CO3		3	2	2			3		1		2				3
CO4	3		2	1	2		2		1		2			2	
CO5	3	3		2		1	2		1						2
CO6		2	3		2		3		2		2			2	3

3.19 Economic Geology Lab

Subject Code: TIU-UGL-MAJOR-L300 **2 Credits**

Unit 1

Study of ore minerals in hand specimens
Study of ore-bearing assemblages in hand specimens

Unit 2

Study of ore minerals (oxides and sulphides) and ore-bearing assemblages in microscopes

Unit 3:

Identification and interpretation of ore textures

Reference books

- Craig, J.R., Vaughan, D.J. (1981) Ore microscopy and Ore Petrography. John Wiley and Sons Inc. New York.
- Mishra, K.C. (2000) Understanding Mineral Deposits. Kluwer Academic Publishers, The Netherland. P845
- Mukherjee, A. (1999) Ore Genesis – A Holistic Approach. Allied Publishers Ltd., New Delhi, India. P657
- Ramdohr, P. (1969) The ore minerals and their intergrowths. Pergamon Press. New York. P1142.

Course Outcomes

- ***CO1:*** Learn to examine, identify, distinguish and describe different ore minerals and ores in hand specimen
- ***CO2***: Learn to identify and describe ore minerals using optical microscope
- ***CO3***: Learn to interpret morphology and micro-textures of ores and ore minerals

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2		2	3							2	1	3	2
CO2	2	3			3							2	2	2	2
CO3	3	3	3	2		1	3				1	1	3	3	3

3.20 Exploration Geology

Subject Code: TIU-UGL-MAJOR-T302 **4 Credits**

Unit 1: Mineral deposits, resources and reserves

1. Classification of Mineral Resources concerning processes of formation
2. Concepts of resources and reserves; Geological distribution of Mineral Resources

Unit 2: Prospecting and exploration

1. Principles of mineral prospecting and exploration
2. Outline of Exploration Techniques - Conceptualisation, Methodology and Stages, Sampling including pitting and trenching, subsurface sampling by drilling
3. Greenfield and Brownfield Exploration

Unit 3: Geochemical exploration

1. Geochemistry in Mineral Exploration - Basic Principles
2. Geochemical environment,
3. Geochemical dispersion – Primary and Secondary Dispersion,
4. Dispersion Halo, Geochemical Mobility,
5. Geochemical Reactions,
6. Association of Elements - Pathfinder Element,
7. Patterns of Geochemical Distribution – Background, Threshold and Anomaly

Unit 4: Types of geochemical exploration, sampling methods and sample treatments

1. Lithogeochemical Exploration
2. Pedogeochemical Exploration
3. Hydrogeochemical Exploration
4. Biogeochemical and Geobotanical Exploration
5. Atmogeochemical Exploration
6. Radiometric exploration

Unit 5: Geophysical exploration

1. Application scopes of geophysical methods in earth sciences
2. Practical field techniques and equipment used in seismic survey
3. Gravity survey; Resistivity field survey

Unit 6: Geological criteria studies for economic exploration

1. Stratigraphic analysis of a geological terrain
2. Structural and lithological mapping on varied scales of economical mineral deposits and their interpretations
3. Application of remote sensing in exploration of surface and near-surface economic deposits.

Reference books

- Arogyaswami, R.P.N. (1996) Courses in mining geology. 4th Ed. Oxford-IBH
- Haldar, S.K. (2013) Mineral Exploration: principles and applications. Elsevier Marjoribanks, R. (2012) Geological Methods in Mineral Exploration. Springer, P. 238
- Moon, C.J., Whateley, M.K.G., Evans, A.M. (2009) Introduction to Mineral Exploration. Wiley.
- Rose, A.W., Hawkes, H.E., Webb, J.S. (1979) Geochemistry in Mineral Exploration. Academic Press.

Course Outcomes

- *CO1*: Understand the fundamental concepts of resource, reserve, prospecting and exploration
- *CO2*: Learn the governing principles of geochemical exploration, and different surface and sub-surface sampling techniques
- ***CO3***: Learn the techniques of different geochemical exploration methods and related sampling and sample treatments
- ***CO4***: Learn the techniques of sub-surface mapping of economic deposits by employing suitable geophysical methods, e.g., gravity, seismic, and electrical methods.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2			3	3	2	3	2		2	2		1	
CO2	3	3	3	3	2		1						2	2	2
CO3	3	3	3	2	3		2	2	2		2	2	3	2	2
CO4	3	3	3	3	3		2	2	2		2	2	3	2	2

3.21 Hydrogeology

Subject Code: TIU-UGL-MAJOR-T304 **4 Credits**

Unit 1: Introduction and basic concepts

1. Scope of hydrogeology and its societal relevance.
2. Relation of hydrogeology to other disciplines,
3. Global and Indian distribution of water resource
4. Hydrologic cycle: precipitation, evapotranspiration, run-off, infiltration and groundwater flow, water balance equation
5. Basic concept of hydrographs Origin of groundwater, Vertical distribution of subsurface water, Genetic classification of groundwater
6. Classification of rocks based on water bearing characteristics, geomorphic and geologic controls of groundwater and types of aquifers– unconfined, confined and

semi-confined. Water table and piezometric surface. Groundwater provinces in India and West Bengal

Unit 2: Rock properties affecting groundwater

1. Porosity, void ratio, specific retention and Storage coefficient - specific yield, specific storage and storativity,
2. Anisotropy and heterogeneity of aquifers

Unit 3: Groundwater flow

1. Darcy's law and its validity
2. Reynold's Number. Groundwater velocity
3. Intrinsic permeability and hydraulic conductivity, Hydraulic conductivilty of heterogenous media, Transmissivity,
4. Measurement of hydraulic conductivity in the laboratory – Constant Head Permeameter and Falling (Variable) Head Permeameter;
5. In-situ field estimation of permeability for unconfined and confined aquifer
6. Water Table and Piezometric surface contour maps and Groundwater flow direction,
7. Laminar and turbulent groundwater flow, groundwater flow equations, groundwater flow in fractures, example of flow systems.

Unit 4: Well hydraulics and groundwater exploration

1. Basic Concepts (drawdown, specific capacity etc.)
2. Elementary concepts related to equilibrium and non-equilibrium (Steady and unsteady) conditions for groundwater flow to a well
3. Surface and sub-surface exploration techniques of groundwater
4. Potentiometric Maps and flow Nets

Unit 5: Groundwater chemistry

1. Physical, chemical and bacteriological properties of water and water quality
2. Reactions of groundwater with aquifer material, Introduction to methods of interpreting groundwater quality data using standard graphical plots
3. Elementary concept and remedial processes of Groundwater pollution- Arsenic, Fluoride and Nitrate, Sea water intrusion in coastal aquifers - Ghyben-Herzberg Relation

Unit 6: Groundwater management

1. Surface and subsurface water interaction. Sustainable groundwater use and recharge techniques, Recharge and discharge areas. Groundwater level fluctuations.
2. Effects of Climate Change on Groundwater
3. Basic concepts of water balance studies, issues related to groundwater resources development and management
4. Rainwater harvesting and artificial recharge of groundwater

Reference books

- Fetter, C.W., Applied Hydrogeology (4th edition) Prentice Hall, Inc.
- Todd, D. K. (2006) Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
- Davis, S. N. and De Weist, R.J.M. (1966) Hydrogeology, John Wiley & Sons Inc., N.Y. 34
- Domenico, P. A., Schwartz, F. W. Physical and Chemical Hydrogeology (2nd Edition) by John Wiley & Sons Inc.

- Karanth K.R., (1987) Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.
- Raghunath H, M. (2007) Groundwater. New Age International Publishers, New Delhi

Course Outcomes

- *CO1*: Understanding the Hydrologic cycle and contribution towards ground water reserve.
- ***CO2***: Learn the Global water budget – the importance of proper water management and its use (with the status of Indian and global context). Understanding the importance of rain water harvesting and other conservation methods in water scarcity areas.
- ***CO3***: Offers a thorough understanding of basic measures of mechanical characteristics of freshwater reservoirs to be explored economically.
- ***CO4***: Understanding the concept of aquifer mapping and an idea on groundwater zones and subsurface porous media
- ***CO5***: Understanding the implications of Darcy's law including its basic considerations
- ***CO6***: Identify physicochemical appraisal of groundwater and understand the salinity Arsenic, Fluoride and Nitrate contamination
- ***CO7***: Understanding the effect of saltwater intrusion in coastal aquifers and the impact of climate change on groundwater resource calculation

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3		1	2	2	1			2	3	3		2
CO2	3	2	2	2	2	1	3	2	1	1	2	3		3	2
CO3	2	3		1	1				1					2	1
CO4	3	2		2	1				1					2	3
CO5	3	3			1									3	
CO6	3				2	3	3			2				2	3
CO7	3	3			3	3				2				3	3

3.22 Hydrogeology Lab

Subject Code: TIU-UGL-MAJOR-L304 **2 Credits**

Unit 1

Preparation and interpretation of depth to water level and contour maps. Groundwater recharge and storage estimation.
Applications of water balance equations. Study, preparation and analysis of hydrographs for differing groundwater conditions

Unit 2

Water potential zones of India (map study)

Unit 3

Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams)
Simple numerical problems related to the determination of permeability in field and laboratory and Groundwater flow

Unit 4

Study of Hydrogeochemical facies from field data

Reference books

- Davis, S. N. and De Weist, R.J.M. (1966) Hydrogeology, John Wiley & Sons Inc., N.Y. 34
- Fetter, C. W. Applied Hydrogeology (4th edition) Prentice Hall, Inc.
- Karanth K.R., (1987) Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.
- Domenico, P. A., Schwartz, F. W. Physical and Chemical Hydrogeology (2nd Edition) John Wiley & Sons Inc.
- Todd, D. K. (2006) Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
- Raghunath H, M. (2007) Groundwater, 3rd Ed. New Age International Publishers, New Delhi

Course Outcomes

- *CO1*: Understand the processes of estimating of coefficient of permeability for non-cohesive and cohesive aquifer materials in the laboratory. Estimating hydraulic conductivity for confined and unconfined aquifer from real-time field data.
- ***CO2***: Understanding the relationship between groundwater and other water cycle components with real-world data
- ***CO3***: Learn the technique of measuring water table depth, detecting groundwater flow pattern and their spatio-temporal fluctuation
- *CO4*: Calculate recharge and discharge rates and delineate these zones from real-time field data for sustainable availability of better-quality water
- ***CO5:*** Hydrogeochemical facies for water quality analysis

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3			2	3		1		1					3	
CO2	3			3	2		2		1					2	
CO3	2			2	3		3		2					2	
CO4	1		2	2	2	1	3		2					2	3
CO5	3		2	3	3									2	3

3.23 Engineering Geology

Subject Code: TIU-UGL-MAJOR-T306 **4 Credits**

Unit 1: Role of engineering geologists

1. Role in planning, design and construction of major man-made structural features
2. Site investigation and characterization

Unit 2: Rockmass classification

1. Rock Quality Designation (RQD)
2. Rock Structure Rating (RSR)
3. Rock Mass Rating (RMR)
4. Tunnelling Quality Index (Q)

Unit 3: Earthquakes

1. Causes, Factors and corrective/Preventive measures

Unit 4: Landslides

1. Causes, Factors and corrective/Preventive measures
2. Landslide hazards Zonation (LHZ) mapping techniques
3. BIS standards

Unit 5: Basics of soil mechanics

1. Index properties of soil & relations in between.
2. Indian Standard Soil Classification System (ISSCS) & its importance in engineering practices.

Unit 6: Geological, geotechnical and environmental considerations

1. Dams and Reservoirs
2. Tunnels and Tunnelling
3. Methods
4. Highways

Reference books

- Bell, F.G. (2006). Basic Environmental and Engineering Geology Whittles Publishing.
- Bell, F.G. (2007). Engineering Geology, Butterworth-Heineman
- Goodman, R.E. (1993). Engineering Geology: Rock in engineering constructions. John Wiley & Sons, N.Y.
- Krynin, D.P. and Judd W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
- Johnson, R.B. and De Graf, J.V. (1988). Principles of Engineering Geology, John Wiley.
- Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.

Course Outcomes

- *CO1*: Assess geological factors and their control in triggering natural hazards, such as landslides and earthquake-driven damages.
- ***CO2***: Gain a basic knowledge of different mitigation techniques employed in engineering geological work.
- ***CO3***: Suggest viable sites for engineering constructions, e.g., tunnel from geological perspective.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	2	2	2			1					3
CO2	2	3	3	3					1			2			2
CO3		3	3	3	2	1	3			1				3	1

3.24 Geomorphology, GIS and Remote Sensing

Subject Code: TIU-UGL-MAJOR-T401 **4 Credits**

Unit 1: Introduction to Geomorphology

1. Definition of Geomorphology; Concepts in Geomorphology
2. Relationship between the landforms and the properties of earth material and different kind of geomorphological processes

3. Endogenic and Exogenic processes

Unit 2: Geoid, topography, hypsometric study and its quantitative assessment

1. Major Morphological features of the earth surface
2. Large Scale Topography -Plate tectonics overview
3. Large-scale mountain ranges (with emphasis on Himalaya)

Unit 3: Exogenic processes and geomorphology

1. Weathering and associated landforms
2. Hill slopes Glacial, Periglacial processes and landforms
3. Fluvial processes and landforms
4. Aeolian Processes and landforms
5. Groundwater processes and landforms
6. Coastal Processes and landforms
7. Landforms associated with igneous activities

Unit 4: Endogenic-exogenic interactions

1. Rates of uplift and denudation
2. Tectonics and drainage development
3. Sea-level change
4. Long-term landscape development; Landform dating techniques.

Unit 5: Photogeology

1. Types and acquisition of aerial photographs
2. Scale and resolution
3. Principles of stereoscopy, relief displacement, vertical exaggeration and distortion determination
4. Elements of air photo interpretation by using stereoscope
5. Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms.

Unit 6: Remote sensing

1. Concepts in Remote Sensing
2. Idea about electromagnetic radiation and its role in remote sensing techniques
3. Understanding the interaction between electromagnetic radiation with different target objects on the surface of the earth and its reflectance pattern
4. Sensors and scanners
5. Platform and Resolutions & their types (spectral, radiometric, temporal etc.)
6. Satellites and their characteristics
7. Data formats - Raster and Vector
8. Applications- Agriculture (Crop Type Mapping, Crop Monitoring), Forestry, Geology (e.g., Structural Mapping), Hydrology, Land Cover, Oceans & Coastal

Unit 7: Image analysis

1. Digital Image Pre-processing, Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing
2. Image classification and accuracy assessment; GIS integration and Case studies-Indian examples.

Unit 8: GIS and GPS

1. Datum, Coordinate systems and Projection systems
2. Spatial data models and data editing
3. Introduction to DEM analysis
4. Concepts of GPS
5. Integrating GPS data with GIS
6. Applications in earth system sciences

Reference books

- Demers, M.N., (1997). Fundamentals of Geographic Information System, John Wiley & sons. Inc.
- Hoffmann -Wellenhof, B., Lichtenegger, H. and Collins, J. (2001). GPS: Theory & Practice, Springer Wien New York.
- Huggett, R. J. (2011) Fundamentals of Geomorphology, 3rd Ed., Routledge, Taylor & Francis Group.
- Jensen, J.R. (1996). Introductory Digital Image Processing: A Remote Sensing Perspective, Springer Verlag.
- Kale, V.S. & Gupta, A. (2018) Introduction to Geomorphology. University Press
- Lillesand, T. M., Kiefer, R.W. (2007). Remote Sensing and Image Interpretation, Wiley.
- Thornbury, W. D. (2018) Principle of Geomorphology. New Age International Pub.
- Richards, J.A. , Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag.
- Anderson, R.S., Anderson, S.P. (2010) Geomorphology -The Mechanics and Chemistry of Landscapes. Cambridge University Press.
- Summerfield, M.A. (1991). Global Geomorphology. Wiley & Sons.

Course Outcomes

- ***CO1:*** Learn dynamic equilibrium concept, regional and global patterns of denudation, weathering and associated landforms. Learn mass movement, fluid movement and universal soil loss equation
- ***CO2:*** Learn negative and positive concept under plate tectonic and associated landforms. Learn about Fluvial, Aeolian, Glacial and coastal landscape, processes and form
- ***CO3:*** Understand bifurcation theory and landscape evolution for long-term geomorphology and dating technique
- ***CO4:*** Learn relict landforms and climatic implication, rock and relief under differential erosion condition and the global tectonic system under world climate system
- *CO5*: Understand Remote Sensing techniques, their applications, sensors, and platforms.
- ***CO6***: Learn about Electromagnetic radiation in Remote sensing
- ***CO7***: Learn the basic concept, elements, types of GIS data and examples of GIS applications.
- ***CO8***: Learn the principles of digital image processing and analysis.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		2			2								2	
CO2	2				2	3								3	3
CO3	3	2	3	3	3	3	2		1					2	3
CO4	3	2	3	2	2	3									2
CO5	3		3		3	2	1		1					2	1
CO6	3	2		2	3										1
CO7	3		3		3		1								1
CO8	3	2	2	1	3							1		1	3

3.25 Geomorphology, GIS and Remote Sensing Lab

Subject Code: TIU-UGL-MAJOR-L401 **2 Credits**

Unit 1: Geomorphology

1. Interpretation of topographic maps. Toposheet interpretation and Preparation of a topographic profile
2. Preparation of longitudinal profile of a river
3. Calculating Geomorphic indices and Stream length gradient index
4. Morphometry of a drainage basin.
5. Interpretation of geomorphic processes from the geomorphology of the area

Unit 2: Remote sensing and GIS

1. Aerial Photo interpretation: Identification of sedimentary, igneous and metamorphic rocks and various aeolian, glacial, fluvial and marine landforms
2. Quantification of scale and resolution, vertical exaggeration, relief displacement from aerial photo
3. Introduction to DIP and GIS software.
4. Digital Image Processing exercises including analysis of satellite data in different bands and interpretation of various objects on the basis of their spectral signatures. Registration of satellite data with a toposheet of the area.
5. DEM analysis: generating slope map, aspect map and drainage network map and its application
6. Image classification (e.g. Land-use classification and change detection)

Reference books

- Demers, M.N., (1997) Fundamentals of Geographic Information System, John Wiley & sons. Inc.
- Hoffmann -Wellenhof, B., Lichtenegger, H. and Collins, J. (2001) GPS: Theory & Practice, Springer Wien New York.
- Huggett, R. J. (2011) Fundamentals of Geomorphology, 3rd Ed., Routledge, Taylor & Francis Group.
- Jensen, J.R. (1996). Introductory Digital Image Processing: A Remote Sensing Perspective, SpringerVerlag.
- Kale, V.S. & Gupta, A. (2018) Introduction to Geomorphology. University Press
- Lillesand, T. M. & Kiefer, R.W. (2007) Remote Sensing and Image Interpretation, Wiley.
- Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag
- Robert S. Anderson and Suzzane P. Anderson (2010) Geomorphology -The Mechanics and Chemistry of Landscapes. Cambridge University Press.
- Summerfield, M.A. (1991) Global Geomorphology. Wiley & Sons.
- Thornbury, W. D. (2018) Principle of Geomorphology. New Age International Pub.

Course Outcomes

- *CO1*: Interpret the topographic maps and prepare a topographic profile
- *CO2*: Construct the longitudinal profile of a river in different geological set-up
- *CO3:* Understanding of morphometry of a drainage basin.

- *CO4:* Interpretation of landscape feature by geomorphic processes
- *CO5* Learn handling Image processing softwares and GIS software such as TNT mips
- *CO6*: Learn aerial photo and digital image interpretation, and identification of sedimentary, igneous and metamorphic rocks and various landforms.
- *CO7*: Analyse satellite data in different bands and their interpretation based on their spectral signatures and analyse DEM
- *CO8*: Learn how satellite imagery can be used for classification and change detection

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		2	2	3		1							3	
CO2	3		2	3	2		2		1					2	2
CO3	2	2	2		2		2		1					3	
CO4	3	3												3	3
CO5	3			3	2		2		1					2	
CO6	2			2	3		3		2					2	
CO7	1		2	2	2	1	3		2					2	3
CO8	1		2	2	3	1	3		2					2	3

3.26 Fuel Geology

Subject Code: TIU-UGL-MAJOR-T403 **4 Credits**

Unit 1: Different sources of energy

1. Global and Indian scenario

Unit 2: Coal

1. Definition and origin of Coal
2. Basic classification of coal
3. Fundamentals of Coal Petrology
4. Introduction to lithotypes, microlithotypes and macerals in coal
5. Coal quality and analytical procedures
6. Major coal basins of India

Unit 3: Coal utilization

1. Concept of clean coal technology
2. Coal carbonization
3. Coal gasification
4. Liquefaction of coal
5. Coal Bed Methane (CBM): global and Indian scenario

Unit 4: Petroleum source and reservoir

1. Chemical composition and physical properties of crude oil
2. Origin and migration of petroleum
3. Kerogen: Maturation of kerogen
4. Biogenic and thermal effect
5. Reservoir rocks and petrophysical properties

Unit 5: Petroleum trap and well logging

1. Cap Rocks- definition and general properties
2. Hydrocarbon traps- definition
3. Classification of hydrocarbon traps - structural, stratigraphic and combination
4. Time of trap formation and time of hydrocarbon accumulation.
5. Plate tectonics and global distribution of hydrocarbon reserves
6. Petroliferous basins of India
7. Well logs for open hole and closed holes, drilling fluids, casing and cementation

Reference books

- Bastia, R., Radhakrishna, M. (2012) Basin evolution and petroleum prospectively of the continental margins of India (Vol. 59).
- Bjorlykke, K. (1989) Sedimentology and petroleum geology. Springer-Verlag.
- Chandra D. (2007) Chandra's Textbook on applied coal petrology. Jijnasa Publishing House.
- Colin R. Ward (1984) Coal geology and coal technology. Blackwell Science Inc
- Larry Thomas (2020) Coal geology. 3rd Edition, Wiley
- Scott, A.C. (1987) Coal and Coal bearing strata (Recent Advances). Blackwell Scientific Publications
- Shelly R. C. (2014) Elements of Petroleum geology: Third Edition, Academic Press
- Thomas, L. (2020) Coal geology. 3rd Edition. Wiley.
- Ward, C. R. (1984) Coal geology and coal technology. Blackwell Science Inc.

Course Outcomes

- *CO1*: Understand the origin of coal and their varieties
- ***CO2***: Learn coalification and coal bed methane
- ***CO3***: Offers a clear knowledge about origin of petroleum
- ***CO4***: Understanding of petroleum reservoirs and their distribution

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2					2					3			2
CO2	2	3					3					1			3
CO3	3	2		2	3		3								3
CO4		3	3	2	3	2			1			3		3	2

3.27 Fuel Lab

Subject Code: TIU-UGL-MAJOR-L403 **2 Credits**

Unit 1

Macroscopic as well as microscopic study of coal samples

Unit 2

Reserve estimation of coal

Unit 3

Section correlation and identification of hydrocarbon prospect

Unit 4

Well log exercise and seismic interpretation

Reference books

- Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
- Chandra, D., Singh, R.M., Singh, M.P. (2000). Textbook of Coal (Indian context). Tara Book Agency
- Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
- Singh, M.P. (1998). Coal and organic petrology. Hindustan Publishing Corporation.
- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D. , Teichumullelr, M., Teichumullelr, R. (1982) Textbook of Coal Petrology 3rd Edition; Schweizerbart Science Publications

Course Outcomes

- *CO1*: Learn to examine, identify, and distinguish different types of coals
- *CO2*: Learn to estimate the reserve of coal
- *CO3*: Understand section correlation and hydrocarbon prospecting

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3		2	2									3	1
CO2	2	3	2		3		2				3			2	3
CO3		2	3	3											2

4. Detailed syllabus and Course Outcomes (COs) of Discipline Specific Elective (DSE) Subjects

4.1 Sequence stratigraphy and Basin Evolution

Subject Code: TIU-UGL-MAJOR-T405 **4 Credits**

Unit 1: Sequence stratigraphy

1. An integrated methodology to understand the predictability in the course of development of sedimentary successions,
2. Historical developments, Definitions and key concepts.
3. Base level (stratigraphic and geomorphic) changes, Eustatic and Relative Sea level, Transgressive-Regressive sequences, Hierarchy of sequences and bounding surfaces, T-R cycles
4. Regional and global controls; Stratigraphic surfaces, Systems Tracts, Predictable differences between their products and Sequence Models;
5. Sequences in carbonate systems
6. Genetic stratigraphic sequences
7. Event stratigraphy
8. Sequence stratigraphic approach in hydrocarbon exploration, coal and mineral resources.

Unit 2: Basin evolution

1. Formation of sedimentary basins in different tectonic environments
2. Mechanisms for basin formation and parameters that control subsidence, sedimentary architecture and thermal history, Burial history reconstruction and Geohistory analysis
3. Fundamentals and key concepts of basin mapping methods: structure and isopach contouring, lithofacies maps
4. Palaeocurrent analysis
5. Provenance analysis;
6. Tectonic classification of sedimentary basins
7. Sedimentary basins of India.

Reference books

- Allen P.A., Allen,J.R. (1990) Basin Analysis: Principles and Applications. Blackwell Publishing
- Buby, C., Azor, A. (2012) Tectonics of Sedimentary basins. Wiley Blackwell
- Catuneanu, O. (2006) Principles of Sequence Stratigraphy. Elsevier
- Emery, D., Mayers, K. (1996) Sequence Stratigraphy. Blackwell Publishers
- Miall, A.D. (1997) The geology of stratigraphic sequences. Springer
- Miall, A.D. (2000) Principles of Sedimentary Basin Analysis. Springer Verlag, New York.

Course Outcomes

- ***CO1***: Develop ideas about the reconstruction of a sedimentary sequence considering different sequence stratigraphic surfaces
- ***CO2:*** Understanding the basin evolution processes in relation to tectonism

- ***CO3:*** Learn techniques of burial and geo-historical analysis of a basin
- ***CO4***: Understanding the relationship between fundamental processes and tectonically induced sedimentation in different depositional basins

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	2	1		1		2	1		3	3	1	
CO2	3	3	2	3	1	2	2		1	2	2	1	2	2	
CO3	3	2	3	3	3		1		2	1		3	3	3	2
CO4	2	3	3	3	1	2	3		1	1		1	3	2	

4.2 Applications of Micro and Molecular fossils

Subject Code: TIU-UGL-MAJOR-T400 **4 Credits**

Unit 1: Sample collection and processing

1. Surface and sub-surface sampling methods, sample processing techniques
2. Morphology, classification, and evolution of foraminifera.
3. Study of selected benthic and planktonic foraminifera.
4. Morphology and geological distribution of ostracoda, calcareous nannofossils, radiolaria, conodonts and diatoms.

Unit 3: Applications of microfossils

1. Application in biostratigraphy, palaeoenvironmental interpretation and sequence stratigraphy
2. Deep sea record and stable isotopes studies of calcareous microfossils
3. Role of micropalaeontology in hydrocarbon exploration.

Unit 3: Palynology

1. Overview, spore and pollen morphology, sporoderm stratifications
2. Geological distribution
3. Application in paleobotany, paleoclimatic study, biostratigraphy and geochronology

Unit 4: Molecular fossils

1. Description and types
2. Sampling, extraction and analytical procedure
3. Laboratory visit for understanding of sample preparation methods
4. Application in paleochemotaxonomy and petroleum source rock characterization.

Reference books

- Haynes, J.R. (1981) Foraminifera. John Wiley and Sons.

- Armstrong, H.A. and Brasier, M.D. (2005) Microfossils, II Edition, Blackwell Publishing,
- Haq, B.U. and Boersma, A. (1978) Introduction to Marine Micropaleontology. Elsevier,
- Murray, J.W. (1991) Ecology and Palaeoecology of Benthic Foraminifera. Longman,
- Jain, S. (2020) Fundamentals of Invertebrate Palaeontology. Springer,
- Tissot, B.P., Welte, D.H., (1984) Petroleum Formation and Occurrence. Springer.

Course Outcomes

- ***CO1*:** Knowledge of different groups of microfossils and their morphology
- ***CO2*:** Practical experience of microfossils identification, study of evolution, its applications and their response towards climate change
- ***CO3*:** Ideas of spore and pollen and their geological distribution
- ***CO4*:** Study of molecular fossils, their application, and understanding the analytical methods of molecular fossils in the laboratory

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		1		2	2	2						3	2	1
CO2		3	3	3	3				3				3	2	2
CO3	3	3	1	3	3								1	3	3
CO4	3	2	2	1	1	1							3	2	2

4.3 Geochemical Data Analysis- Theories and Practices

Subject Code: TIU-UGL-MAJOR-T402 **4 Credits**

Unit 1: Mineral chemistry and Phase equilibria

1. Methods for determining the mineral composition and estimation of structural formulae with Fe^{2+} / Fe^{3+} correction.
2. Derivation and application of Classeus-Clapeyron equations.
3. Gibbs phase rule and mineralogical phase rule.
4. Construction of compatibility diagrams, construction and analysis of phase equilibria
5. Concept of isochemical phase diagrams and its use in petrogenesis.

Unit 2: Major and trace element geochemistry

1. Principles and applications of major element and trace element geochemistry in silicate systems
2. Handling major and trace element data of rocks and their use in petrogenesis.

Unit 3: Radioactive and radiogenic isotope geochemistry

1. Evolution and characterization of Earth's Isotopic Reservoir
2. Geochemistry of crust and mantle reservoirs and application to petrogenesis
3. Geochronology: Concepts and calculations of Isochron age, Model age, Chemical age
4. Concepts, construction and implications of Concordia and Discordia diagram
5. Methods, limitations and advantages of Rb-Sr, K-Ar, Sm-Nd, U-Th-Pb, Pb-Pb, Re-Os dating of minerals and rocks.

Unit 4: Stable isotopes geochemistry

1. Abundance, distribution and fractionation of H, B, C, O, S isotopes in nature
2. Concepts of Mass independent fractionation and their implications
3. Stable isotope thermometers: principles and applications

4. Applications of traditional and non-traditional stable isotope geochemistry in ore genesis and petrogenesis

Reference books

- Rollinson. H.R. Using Geochemical Data: Evaluation, Presentation, Interpretation. Prentice Hall
- Dyar, M.D., Gunter, M.E., Tasa D. *Mineralogy and Optical Mineralogy*.: Mineralogical Society of America, Chantilly, Virginia, USA
- Philpotts, A.R. (2022) Ague Principles of Igneous and Metamorphic Petrology. Cambridge University Press
- Faure, G. (1986) Principles of Isotope Geology. John Wiley and Sons
- White, W.M. (2020) Geochemistry. Wiley-Blackwell
- Hoefs, J. (2015) Stable Isotope Geochemistry. Springer
- Dickin, A.P. (2018) Radiogenic Isotope Geology. Cambridge University Press

Course Outcomes

- ***CO1***: Be able to use mineral chemical data from Electron Probe Micro Analyzer (EPMA) in various diagrams and to understand the formation and evolution of rocks.
- ***CO2***: Be able to use major element, trace element and radiogenic isotope data for understanding rock petrogenesis.
- ***CO3***: Be able to calculate ages of rocks and minerals using different methods and isotope systematics
- ***CO4***: Learn the principles and applications of stable isotopes in understanding earth processes

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	3			1	1	1	2		2	2	1
CO2	3	3	2	3	3			1	1	1	2	1	3	3	2
CO3	3	3	2	3	3			1	1	1	2	2	3	3	3
CO4	3	3	2	3	3			1	1	1	2	2	3	3	2

4.4 Groundwater Resources and Management

Subject Code: TIU-UGL-MAJOR-T404 **4 Credits**

Unit 1: Groundwater resources

1. Concept of Natural resources of water in surface and sub-surface area. Capacity building of groundwater recharge through Hydrological Cycle. Identification of groundwater resources through aquifer mapping of Groundwater Basin Investigation in unconsolidated alluvium and hard rock aquifers.
2. Methodology of construction of well and Geophysical technics of Groundwater Exploration in unconsolidated alluvium and hard rock aquifers.
3. Artificial recharge and rain water harvesting for improving groundwater quality and quantity in water scarcity area. Impact of Climate on Groundwater resources.
4. Impact of saltwater intrusion in coastal aquifers.

5. Wastewater recharge for reuse through Recharge Well by Irrigational method, Spreading method, Overland flow method to improve groundwater water balance and quality.
6. Evaluation of hydro-geochemical parameters to asses groundwater quality for drinking and irrigational purposes.
7. Identifying toxic elements (Arsenic, Fluoride, and Nitrate) in multilayer aquifers for safe drinking water option.

Unit 2: Concepts of basin and groundwater management

1. Concept of rejuvenation of major rivers –Indian perspective.
2. Integrating remote sensing data on land use pattern for configuration of water shade bodies on groundwater recharge processes. Equation of hydrological equilibrium for Basin investigation and application of Isotope study for groundwater movement. Depletion of groundwater due to overdraft and its effect on aquifers.
3. Groundwater management in Indian scenario - safe, critical, semi-critical, and over-exploited zone influenced by geogenic and human induced processes.
4. Hyetograph and Hydrograph – relation in-between.
5. Investigating precipitation infiltration and groundwater recharge in confined and unconfined aquifers. Evaluation of perennial yield and salt balance
6. Data collection through field survey of geologic (aquifer depth, aquifer properties etc.) and hydrologic units
7. Methodology of groundwater resources Estimation and Assessment and Categories of assessment.

Reference books

- Todd, D.K. (2006). Groundwater hydrology, 2nd Edition, John Wiley & Sons, N.Y.
- Davis, S.N., De Weist, R.J.M. (1966). Hydrogeology, John Wiley & Sons Inc., N.Y.
- Herman, B. (2008) Groundwater Hydrology, McGrawHill Education, CBS Pub
- Karanth K.R., (1987). Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.
- Raghunath H,M. (2007) Groundwater, 3rd Ed. New Age International Publishers, New Delhi.
- Sen, S. (2014) Practical and Applied Hydrogeology, Elsevier Science.
- .

Course Outcomes

- ***CO1***: Learn the need of harnessing water – societal relevance – water stress index.
- ***CO2***: Understanding national water scenario and management policies & mitigations
- ***CO3***: Identify the processes related to real-time hydro-geological field data acquisition and its analysis and aquifer mapping techniques
- ***CO4***: Understanding the basics of well hydraulics and related unidirectional and radial flow, confined and unconfined aquifer
- ***CO5***: Deciphering the effects of overexploitation – degradation of water quality and related health hazards
- ***CO6***: Understanding the groundwater resource under the impact of climate change
- ***CO7***: Groundwater resource management for future development of well.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		3		3	3	3	2	2	1	2	2	3	2	1
CO2	3		3	2	1	3	3	2	2	1	2	2		3	
CO3	3	3	3	1	2		3	1	1	1			3	2	2
CO4	3	3	2	2	3		1		2			1		3	2

CO5	**3**	**2**	**2**	**2**	**1**		**1**		**2**			**2**	**3**	**2**	
CO6	**2**	**2**	**1**	**2**	**2**	**1**	**1**	**2**	**1**	**1**	**1**			**3**	**2**
CO7	**2**	**2**	**3**	**2**		**2**	**3**		**2**			**2**	**3**	**2**	**2**

4.5 Drilling, Mining, Beneficiation and Mineral Economics

Subject Code: TIU-UGL-MAJOR-T406 **4 Credits**

Unit 1: Drilling and logging

1. Purpose of drilling; Types, methods and application of drilling
2. Core and non-core drilling; Types of drill bits
3. SPC and use of mud filtrate;
4. Planning of bore holes and location of boreholes on ground
5. Core and non-core sampling and litho-logging
6. Bore hole deviation, reasons and measurements.

Unit 2: Mining

1. Mining terminologies
2. Common methods of mining
3. Mine entry and development
4. Development drilling
5. Mine sampling; Estimation of mining operational cost
6. Environmental impact of mining and mitigation

Unit 3: Ore reserve estimations

1. Calculations of over burden, stripping ratio, average grade, cut-off grade and tonnage
2. Principles of reserve estimation
3. Reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks)
4. Regular and irregular grid patterns; Statistics and error estimation.

Unit 4: Mineral beneficiation

1. Definition and scope of mineral beneficiation
2. Concepts and methods of comminution, separation and de-watering
3. Methods of ore beneficiation and recent advances in extractive technology
4. Beneficiation of coal and selected metallic ores

Unit 5: Mineral economics

1. Concepts
2. Mineral Law and land access
3. National Mineral policy

Reference books

- Thomas, L.J. An introduction to mining Hicks Smith & Sons
- Arogyaswamy, R.N.P. Courses in Mining Geology' by, Oxford & IBH publishing Co.
- Majoribanks, R. Geological Methods in Mineral Exploration. Springer
- S.K. Halder, S.K. Mineral Exploration: Principles and Applications. Elsevier
- Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.

Course Outcomes

- ***CO1***: Learn the techniques of subsurface sampling by different drilling methods and their application
- ***CO2***: Learn the mining methods, role of a geologist in mining and environmental impact of mining
- ***CO3****:* Learn the different techniques of ore reserve estimation, their advantages and disadvantages
- ***CO4****:* Learn the principles and application of beneficiation techniques used in coal and major metal industries
- ***CO5:*** Acquiring knowledge of mineral economics and government policy

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	3	2	1	1		2	3	3	2	3			2	2
CO2	1	1	1				2	3	3	2	2	2		1	
CO3	3	3	2	2	3					3	1		2	3	1
CO4	1	2			2	1			1	1				1	
CO5	2	3				2			2	1					

5. Detailed Syllabus and Course Outcomes (COs) of Dissertation

5.1 Dissertation

Subject Code: TIU-UGL- D402 **12 Credits**

Unit 1

Each student has to independently work on a contemporary research problem under the supervision of a teacher, submit a comprehensive dissertation thesis and appear for a viva- voce examination

Course Outcomes

- ***CO1***: Identify and develop a contemporary research problem of interest in consultation with the supervisor
- ***CO2***: Learn methodologies to address and execute a research problem
- ***CO3***: Learn to generate, organize, assemble and analyse data
- ***CO4***: Synthesize the data generated to develop new concepts and ideas and generate new knowledge
- ***CO5***: Learn to document the results of research in the form of a thesis

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	3	3					2		3	3	3	
CO2	3	3	1	3	3					2		3		3	2
CO3	3	3	1	3	3					2		3		3	2
CO4	3	3	1	3	3					2		2		3	
CO5	3	3	1	1	2			3		3	1	3		3	3

6. Detailed Syllabus and Course Outcomes (COs) of Skill Enhancement Courses (SEC)

6.1 Application of AI in Earth Sciences	
Subject Code: TIU-UGL-SEC-T101	**4 Credits**

Unit 1: Introduction to AI and Earth Sciences

Overview of Artificial Intelligence, Machine Learning, Deep Learning
Introduction to key branches of Earth Sciences
Role and need of AI in analyzing complex Earth systems
Tools & platforms (Python, TensorFlow, Scikit-learn, QGIS, Google Earth Engine)

Unit 2: Data Sources and Preprocessing in Earth Sciences

Earth Observation data (satellite, sensor networks)
GIS and Remote Sensing datasets
Data cleaning, normalization, transformation
Handling spatio-temporal data

Unit 3: Machine Learning Basics for Earth Science

Supervised vs. Unsupervised learning
Regression, classification, clustering
Model evaluation metrics (RMSE, MAE, accuracy, F1-score)

Unit 4: Remote Sensing and Image Classification

AI for satellite image classification
Land use/land cover mapping using CNNs
Case study: Sentinel/Landsat data

Unit 5: AI in Meteorology and Climate Science

Weather prediction models
AI in climate pattern analysis and forecasting (e.g., El Niño, cyclones)
Time-series modeling (RNNs, LSTMs)

Unit 6: AI in Hydrology and Water Resources

Streamflow and flood prediction
Groundwater mapping
Water quality monitoring using sensor data

Unit 7: Mid-Term Project Proposal

Submission and review of project ideas
Dataset selection and model design plans

Unit 8: AI in Seismology and Geohazards

Earthquake prediction and risk assessment
Landslide susceptibility mapping
Real-time hazard detection using AI

Unit 9: Geological Mapping and Mineral Exploration

AI in geospatial data interpretation
Predictive mapping of mineral deposits
Case study: Mining exploration with ML

Unit 10: AI in Oceanography and Marine Science

Ocean current and sea surface temperature predictions
Monitoring marine ecosystems using satellite data
Marine pollution detection using AI

Unit 11: Ethical Considerations & Limitations

Data privacy, model biases, and ethical implications
Interpretable AI and explainability in Earth sciences
Limitations of AI models in scientific research

Unit 12: Final Project Presentation and Evaluation

Project submission
In-class presentations and peer review
Instructor feedback

Course Outcomes

- CO1: Understand the fundamentals of AI, machine learning (ML), and deep learning (DL)
- CO2: Explore how AI is applied in various branches of Earth sciences (geology, meteorology, hydrology, remote sensing, etc.)
- CO3: Work on datasets from Earth science domains and apply ML/DL models
- CO4: Evaluate AI models and interpret their relevance in real-world Earth system problems

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2				2				3					2	
CO2	2				2			1	3				2	2	
CO3	2	3	3	3	2				2		1	3	3		3
CO4	2	2						3	3	3		2		2	

6.2 Field Training- I (Introduction to Field Geology)

Subject Code: TIU-UGL-SEC-P100 **4 Credits**

Unit 1: Handling field instruments

1. Use of topographic sheets in the field. Identifying location on the topographic sheet using physical features and bearing.
2. Use of field equipment: Clinometer, Brunton compass and GPS.
3. Distance, height and space approximation in field.
4. Techniques of geological data collection
5. Techniques of sample collection

Unit 2: Observation and identification of field features

1. Identification of different types of rocks and minerals in the field
2. Identification of primary and deformational structures in the field
3. Litholog preparation
4. Correlation of different Litho units

Unit 3: Observation of geomorphological features

1. Study of Geomorphological process
2. Types of landscape features (mountain, valley, plateau, river terrace, alluvium fan etc.) and their interpretations

Unit 4: Archiving field data

1. Recording field data in maps and notebooks.
2. Procedures of Report writing.

Reference books

- Bates, D. E. B., Kirkaldy, J.F. (1977) Field Geology. New York: Arco.
- Berkman, D. A., Ryall, W.R. (1976) Field Geologist's Manual. Parkville,
- Campbell, C. V., (1967) Lamina, lamina set, bed, and bed set, Sedimentology 8, 7–26.
- Compton, R. R., (1962) Manual of Field Geology. New York: Wiley.
- Day, M. J., Goudie, A.S. (1977) Field assessment of rock hardness using the Schmidt test hammer, in Shorter Technical Methods (II), BGRG Tech. Bull. No. 18. Norwich, England: Geo Abstracts.
- Deere, D. U., Miller, R. P. (1966) Engineering classification and index properties for intact rock, U.S. Air Force Weapons Lab. Tech. Rept. AFWL-TR-65-116.
- Dietrich, R. V., J. T. Dutro, Jr., R. M. Foose, (1982) AGI Data Sheets for Geology in the Field, Laboratory, and Office. Falls Church, Va.: American Geological Institute.
- Freeman, T., (1971) Field Guide to Layered Rocks. Earth Science Curriculum Project Pamphlet Series. Boston: Houghton Mifflin.

- Fry, N., (1984) The Field Description of Metamorphic Rocks. Milton Keynes, England: Open University Press.
- Gardiner, V., Dackombe, R. (1983) Geomorphological Field Manual. London: Allen and Unwin.
- King, C. A. M., (1966) Techniques in Geomorphology. New York: St. Martin's.
- Langstaff, C. S., Morrill, D. (1981) Geological Cross Sections. Boston: International Human Resources Development Corporation.
- Moseley, F., (1981) Methods in Field Geology. San Francisco: W. H. Freeman.
- Platt, J. I., Challinor, J. (1980) Simple Geological Structures. London: Pergamon Press.
- Roberts, J. L., (1982) Introduction to Geological Maps and Structures. Oxford: Pergamon Press.
- Selby, M. J., (1980) A rock mass strength classification for geomorphic purposes: With tests from Antarctica and New Zealand, Zeitschr. Geomorphologie 24, 31–51.
- Shelton, J., (1966) Geology Illustrated. San Francisco: W. H. Freeman.
- Thomas, J. A. G., (1979) An Introduction to Geological Maps. London: Allen and Unwin.
- Tucker, M. E., (1982) The Field Description of Sedimentary Rocks. Milton Keynes, England: Open University Press.

Course Outcomes

- *CO1*: Learn the use of clinometer and locate oneself in the field
- *CO2*: Identify minerals and rocks and describe and interpret textures right on the field
- ***CO3***: Interpretation of geomorphic processes from the geomorphology of an area.
- ***CO4***: Learn to present the observational data in the form of a project report

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2				2				3					2	
CO2	2				2			1	3				2	2	
CO3	2	3	3	3	2				2		1	3	3		3
CO4	2	2						3	3	3		2		2	

6.3 Igneous Petrology Lab and Data Handling

Subject Code: TIU-UGL-SEC-L201 **4 Credits**

Unit 1:

Study of important igneous rocks in hand specimens and thin sections

Unit 2:

Norm calculation. Visual estimation of modes from thin sections

Unit 3:

Plotting of mode in IUGS classification of plutonic rock

Unit 4:

Geochemical and isotopic data plots of igneous rocks and minerals and interpretation

Reference books

- Philpotts, A.R., Ague, J. (2009) Principles of Igneous and Metamorphic Petrology. Cambridge University Press.

- Rollinson, H.R. (2014) Using geochemical data: evaluation, presentation, interpretation. Longman Geochemistry Series.
- Winter, J.D. (2014) Principles of Igneous and Metamorphic Petrology. Pearson.

Course Outcomes

- *CO1*: Identify the primary and secondary minerals in different igneous rocks
- *CO2*: Interpret the textures of igneous rocks in terms of the cooling rate and composition of the parent magma

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**2**			**3**	**3**									**3**	**1**
CO2	**2**	**3**			**2**							**3**			

7. Detailed Syllabus and Course Outcomes (COs) of Compulsory Audit Course (CAC)

7.1 Field Training- II (Stratigraphy, Sedimentology and Palaeontology)

Subject Code: TIU-UGL-CAC-P202 **4 Credits**

Unit 1

Study of sedimentological features in the field to reconstruct stratigraphic sequence.

Unit 2

Study of Palaeontological features in the field and their interpretations.

Unit 3

Preparation of a geological map of the area and report writing.

Course Outcomes

- ***CO1*: Understanding the sedimentological process and product relationship**
- ***CO2***: Learn the interaction between sedimentation and biotic influence
- ***CO3***: Learn sedimentological and biological data collection from modern environment and their interpretation
- ***CO4***: Comprehend the ancient environment from the knowledge acquired from modern environment

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2	2		1		2	1		3	3	2	
CO2	2	3		2	1		1					2	2	3	
CO3	2	1	3	3	1				2		1	3	3		2
CO4	2	1	3	3	1				2		1	3	3		3

7.2 Field Training- III (Metamorphic Petrology and Structural Geology)

Subject Code: TIU-UGL-CAC-P300 **4 Credits**

Unit 1: Metamorphic geology

1. Preparation of a geological map of a small area with deformation and metamorphic features.
2. Identification of protolith composition of the deformed and metamorphosed rocks and reconstruction of geological evolution of the area in the form of a report.

Unit 2: Structural geology

1. Collection of structural data in the field, identification and uses of primary structures in structural analysis
2. Direct and indirect measurement of attitude in the field
3. Identification of mechanism of folding from typical structural features and superimposition of deformation from deformed rock in the field
4. Types of interference patterns of folding and the conditions of their formation
5. Brittle fractures and determination of stress axes and the sense of rotation

6. Ductile shear zone and its associated structures, Common shear sense indicator; Preparation of Geological Mapping

Course Outcomes

- *CO1*: Learn the techniques (including contour analyses, application of GPS and DEM) of preparation of geological maps, including mapping of metamorphic isograds
- ***CO2***: Apply the acquired knowledge to reconstruct stratigraphy (both litho- and event stratigraphy) in tectonically active terrains.
- ***CO3***: Learn to present the observational data in the form of project report
- ***CO4***: Use geological criteria to delineate lithological boundaries in multiply deformed, complex terrains and prepare high-resolution geological maps on local as well as regional scales.
- ***CO5:*** Apply advanced structural methods to recognize the tectonic events in a terrain**.**
- ***CO6***: Learn geological and structural data processing techniques, which are required in practical work, such as drilling and mining etc.
- ***CO7:*** Learn to interpret observational data and present them in the form of a project report

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	3	3	3	1	1	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	1	1	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	1	1	3	3	3	3
CO4	3	3	3	3	3	2	1	3	3	3	1	3	1	3	3
CO5	3	3	3	2	2	1		1		3		3	1	3	3
CO6	3	3	3	2	2	2			2	1		3	1	3	2
CO7	3	3	3					3	2	3	1	1		2	2

7.3 Field Training- IV (Economic Geology, Exploration Geology, Engineering Geology)

Subject Code: TIU-UGL-CAC-P400 **4 Credits**

Unit 1

Geological traverses in economically important Indian Archaean and Proterozoic belts in the context of mineralization

Unit 2

Surface and sub-surface exploration methodologies of Cr, Ti, Fe-Mn, U-Cu, coal, petroleum

Unit 3

Principles of litho-logging; laboratory techniques related to exploration and quality management

Unit 4

Methods of open cast and underground mining

Unit 5

Fundamental principles of mineral beneficiation

Unit 6

Measurement of RQD, RMR, RSR etc., Slope Stability analysis, Factor of Safety (FoS)

Unit 7

Groundwater Exploration in multi- layer aquifers system Resistivity

survey, Borehole logging, Pump test, Groundwater flow net, quality and quantity estimation

Course Outcomes

- ***CO1***: Examine the regional and local geology related to ore deposits of Cr, PGE, U, Cu, Fe-Mn and coal
- ***CO2***: Hand on experience on surface and sub-surface exploration techniques and laboratory techniques applied for mineral exploration
- ***CO3***: Be familiar with mining of metal methods and mineral beneficiation
- ***CO4:*** Learn to interpret observational data and present them in the form of a project report
- ***CO5:*** Determining the rockmass classification in the field**,** Factor of Safety of slope
- ***C06***: Assessment and management of groundwater resources through field

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3		2	1		1		3	1		2	3	3	3
CO2	3	3	3	2	3		1	1	2		1	2	3	3	3
CO3	2	2	1	1	1	2	3	2	2	1	1	1		1	
CO4	3	3	3					3	2	3	1	1		2	2
CO5	3	3	3	2	2							1	3	2	3
CO6	3	3	3	2	2			3	2	3	2	2		2	2

7.4 Research Seminar unrelated to Dissertation

Subject Code: TIU-UGL-CAC-D400 **4 Credits**

Unit 1

Each student has to present a science seminar on contemporary research using audio-visual techniques

Course Outcomes

- ***CO1:*** Identify and comprehend contemporary research problems through literature survey
- ***CO2:*** Assemble and synthesize data and information from published articles on relevant topics
- ***CO3***: Organize and present scientific talks using the modern audio –visual technology

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3				1		2		3	1	2	
CO2	3	2		3				1		2		3	1	2	
CO3	3	1	3		2			3	2	3	1	3	1	2	3

7.5 Grand Viva

Subject Code: TIU-UGL-CAC-D402 **4 Credits**

Unit 1

Viva- voce on all topics covered under eight semester course curricula

Course Outcomes

- ***CO1***: Be equipped with an overall and in-depth understanding of all the courses taught to be able to face any interview
- ***CO2***: Enhance communication skills and inculcate positive gesture while addressing questions posed before her/him in professional interview/interaction

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	3	3	3	3	3	1	3	3	3	3
CO2	3	3	2	3	3	3	3	3	3	3	1	3	3	3	3

8. Detailed Syllabus and Course Outcomes (COs) of Common Value Added Course (CVAC)

8.1 Introduction to the Indian Constitution

Subject Code: TIU-UGL-CVAC-101 **Credit -4**

Course Objectives:

- To introduce students to the fundamental principles, philosophy, and framework of the Indian Constitution.
- To understand the evolution, structure, and working of the Indian political system.
- To analyze the rights and duties of Indian citizens and the functioning of democratic institutions.
- To explore the role of the judiciary and the constitutional remedies available to citizens.

Course Structure:

Unit 1: Introduction to the Constitution (Weeks 1–2)

- Meaning and Importance of Constitution
- Historical Background: British colonial rule, freedom movement
- Constituent Assembly: Composition, debates, and drafting
- Preamble: Meaning, key terms (Sovereign, Socialist, Secular, Democratic, Republic), objectives

Unit 2: Fundamental Rights and Duties

- Fundamental Rights: Articles 12–35
- Right to Equality, Freedom, Protection from Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies
- Reasonable Restrictions and Landmark Judgments
- Fundamental Duties: Article 51A – Significance and Challenges

Unit 3: Directive Principles of State Policy

- Classification: Socialist, Gandhian, Liberal
- Relationship between Fundamental Rights and Directive Principles
- Implementation and Judicial Interpretation

Unit 4: Union and State Government

- Structure of Parliament and State Legislatures
- Executive: President, Prime Minister, Governor, Chief Minister
- Legislative Process: Passing of Bills, Budget, and Committees
- Centre-State Relations: Legislative, Administrative, and Financial

Unit 5: Judiciary and Constitutional Remedies (Weeks 10–11)

- Structure and Independence of Judiciary

- Jurisdiction of Supreme Court and High Courts
- Public Interest Litigation (PIL) and Judicial Activism
- Writs under Article 32 and 226

Unit 6: Federalism and Local Self-Government (Weeks 12–13)

- Nature of Indian Federalism
- Emergency Provisions and Their Impact on Federal Structure
- 73rd and 74th Constitutional Amendments
- Role of Panchayati Raj and Urban Local Bodies

Unit 7: Constitutional Amendments and Current Developments (Weeks 14–15)

- Procedure for Amendment (Article 368)
- Important Amendments (42nd, 44th, 52nd, 73rd, 74th, 86th, 101st, 103rd, 104th, etc.)
- Recent developments and contemporary issues in constitutional law

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Course Outcome

CO1: *Explain* the origin, evolution, and philosophical foundations of the Indian Constitution, including the role of the Constituent Assembly and the significance of the Preamble.

CO2: *Interpret and analyze* the Fundamental Rights and Duties enshrined in the Constitution, and evaluate their application through landmark judicial decisions.

CO3: *Differentiate* between Fundamental Rights and Directive Principles of State Policy and *assess* their significance in ensuring social and economic justice.

CO4: *Describe* the structure, powers, and functions of the Union and State governments, and *examine* the distribution of powers under Indian federalism, including Centre-State relations.

CO5: *Critically evaluate* the working of the judiciary, constitutional remedies, and recent constitutional amendments, with reference to contemporary legal and political developments.

COs)	PO1	PO2	PO3	PO4	PO5	PSO1
CO1	3	2	2	–	–	3
CO2:.	3	2	2	1	–	3
CO3:.	3	3	3	2	–	3
CO4:	2	3	2	–	2	2
CO5:.	3	3	3	2	3	3

8.2 Physical education, Yoga and Mental health

Subject Code: TIU-UGL-CVAC-201 **Credit 4**

	Theory Topics	Practical/Activity
1	Introduction to Physical Education and Health	Fitness screening & BMI calculation
2	Components of Physical Fitness	Warm-up routines, aerobic activities
3	Principles of Training and Exercise Prescription	Creating simple workout plans
4	History and Philosophy of Yoga	Introduction to basic yogic postures
5	Yogic Practices: Asanas (Standing, Sitting)	Asana performance & alignment
6	Pranayama: Breathing Techniques	Daily practice + breath awareness
7	Meditation Techniques and Benefits	Guided mindfulness meditation
8	Mental Health: Definitions and Disorders	Mental health case study discussion
9	Role of Exercise and Yoga in Stress Reduction	Journaling and reflection on stress
10	Sports Psychology and Emotional Regulation	Group activity: Emotional IQ games
11	Time Management and Academic Performance	Weekly planner design
12	Nutrition and Lifestyle for Mental Wellness	Nutritional analysis workshop
13	Fitness Technology and Apps	App demo: fitness trackers, yoga tools
14	Personal Routine Design Project	Peer evaluation and feedback
15	Revision & Final Practical + Theory Exams	Viva + demonstration

Course Outcomes

- **CO1**: Understand the fundamentals and importance of physical education and mental well-being.
- **CO2**: Gain proficiency in yoga practices, breathing techniques, and meditation.
- **CO3**: Evaluate the impact of physical activity and yoga on mental health.
- **CO4**: Develop effective stress and time management techniques.
- **CO5**: Design a personal routine integrating fitness, yoga, and mental health strategies.
- **CO6**: Apply knowledge to promote mental wellness and fitness in academic and personal life.

CO-PO-PSO mapping

COs /	PO1	PO2	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1:	3	2	0	0	2	1	3	0	0
CO2:	3	2	2	0	3	2	3	3	0
CO3:	3	0	3	0	3	1	0	3	3
CO4:	2	3	3	2	3	2	0	3	3
CO5:	3	3	3	3	3	3	3	3	3
CO6:	3	3	3	3	3	3	3	3	3

9. Detailed Syllabus and Course Outcomes (COs) of Ability Enhancement Course (AEC)

9.1 Communicative English I

Subject Code: TIU-UGL-AEC-101 **CREDIT-4**

Unit 1: Literature

1. "Sonnets" by William Shakespeare
2. "The Wild Swans at Coole" by William Butler Yeats
3. "Riders to the Sea" by John Millington Synge
4. "The Fly" by Katherine Mansfield
5. "Of Studies" & "Of Travel" By Francis Bacon

Course Outcomes

CO1	Analyze the thematic and stylistic elements of Shakespeare's *Sonnets*, focusing on form, language, and emotional depth.
CO2	Interpret the symbolism and Romantic imagery in W.B. Yeats's *The Wild Swans at Coole*, with attention to personal and political undertones.
CO3	Examine Irish culture, fatalism, and dramatic techniques in Synge's *Riders to the Sea*.
CO4	Evaluate modernist elements and psychological depth in Katherine Mansfield's *The Fly*.
CO5	Discuss Francis Bacon's use of aphoristic style and critical thinking in his essays *Of Studies* and *Of Travel*.
CO6	Develop comparative insights between different literary periods (Renaissance, Modernism, Irish Literary Revival) and genres (poetry, drama, essay, short story).

CO-PO-PSO Mapping

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO1**	**PSO2**	**PSO3**
CO1:	3	2	1	2	0	1	1	3	2	0
CO2: I	3	2	1	2	1	1	2	3	2	1
CO3:	3	3	2	2	0	2	2	3	2	2
CO4:	3	3	2	2	1	2	2	3	3	2

CO5:	3	3	3	3	2	3	3	3	3	2
CO6:	3	3	2	3	1	2	3	3	3	2

9.2 Communicative English II

Subject Code: TIU-UGL-AEC-200 CREDIT-4

Unit 1

1. Job application letter and CV/Resume
2. Paragraph writing
3. Precis writing
4. Comprehension

Unit 2

1. Viva part
2. Group presentation
3. Individual presentation

Course Outcomes

1. **Develop professional written communication skills** by crafting effective job application letters and resumes tailored to specific roles.
2. **Write well-structured paragraphs** that clearly express ideas using proper grammar, coherence, and unity.
3. **Summarize lengthy texts concisely** and accurately through precis writing, demonstrating comprehension and clarity.
4. **Interpret and analyze written passages** to answer comprehension questions with accuracy and critical thinking.
5. **Communicate ideas effectively in oral formats** through structured individual and group presentations.
6. **Demonstrate confidence and fluency in verbal communication** during viva voce sessions and professional interactions.
7. **Collaborate efficiently in team settings**, contributing meaningfully to group discussions and presentations.

CO-PO-PSO Mapping

COs	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	2	-	1	2	3	3
CO2	3	-	-	2	2	3	2
CO3	3	-	-	2	-	2	2
CO4	3	-	-	3	-	2	2

CO5	3	2	3	1	2	3	3
CO6	3	2	2	2	-	3	3
CO7	3	2	3	1	-	3	3

10. Detailed Syllabus and Course Outcomes (COs) of Interdisciplinary Course

10.1 : Basics of AI

Subject Code: TIU-UGL-IDC-T101 **3 Credits**

Unit:1-Introduction to AI

Topics Covered: What is AI? History and evolution; Branches of AI: Machine Learning, Computer Vision, NLP, Robotics;Applications of AI in daily life (chatbots, recommendation systems, etc.);AI vs Machine Learning vs Deep Learning

Practical Component: Setting up Python environment (Anaconda, Jupyter Notebooks, Google Colab);Writing your first AI program: Simple decision-making using conditionals.

Unit:2-Problem Solving and Search Techniques

Topics Covered: Search problems in AI; Uninformed search algorithms: Breadth-First Search (BFS), Depth-First Search (DFS);Informed search algorithms: A*, Greedy Best-First Search

Practical Component: Implementing BFS and DFS in Python;Solving simple search problems like a maze.

Unit:3-Basics of Machine Learning

Topics Covered: Introduction to Machine Learning (ML): Types of ML (Supervised, Unsupervised, Reinforcement Learning);Common ML Algorithms: Linear Regression, Decision Trees;Understanding datasets: Features, Labels, and Splitting (Train/Test).

Practical Component: Training a simple Linear Regression model using Scikit-learn; Visualizing data and model predictions.

Unit:4 -Data Handling and Preprocessing

Topics Covered: Data collection and cleaning (handling missing values, outliers); Normalization and scaling techniques;Introduction to Pandas and NumPy for data manipulation.

Practical Component: Loading and exploring datasets (e.g., Titanic dataset); Writing Python code to clean and preprocess real-world datasets.

Unit:5-Introduction to Neural Networks

Topics Covered: What are Neural Networks? Understanding perceptrons and activation functions (ReLU, Sigmoid); Introduction to Feedforward Neural Networks.

Practical Component: Implementing a simple Neural Network using Python libraries

(TensorFlow/Keras);Solving basic classification problems (e.g., predicting digits using MNIST dataset).

Unit:6-Introduction to Natural Language Processing (NLP)

Topics Covered: Basics of text processing: Tokenization, stopwords removal; Bag of Words and TF-IDF; Applications of NLP (chatbots, sentiment analysis).

Practical Component: Writing code to preprocess text data using NLTK or SpaCy; Implementing a simple text classification model.

Unit:7-AI Ethics and Challenges

Topics Covered: Ethical concerns in AI: Bias, Privacy, and Fairness; Societal impact of AI and its limitations;Current challenges in AI development.

Practical Component: Group discussion or written assignment: Analyze a real-world AI application (e.g., facial recognition) and discuss its ethical implications.

Unit:8-Mini-Project Preparation

Description: Students will choose a simple AI problem to solve as a mini-project. Examples: Predicting house prices using regression; Building a basic sentiment analysis tool; Image classification using pre-trained models

Deliverables: Proposal submission and initial implementation.

Unit:9-Mini-Project Completion

Description: Students finalize their mini-project, integrating the techniques learned throughout the semester.

Deliverables: Final project submission (code and report).

Unit:10-Final Evaluation

Activities: Project presentations and peer feedback; Written or practical exam covering the semester's topics.

Tools and Platforms Used

- **Languages/Frameworks:** Python, Scikit-learn, TensorFlow/Keras, NLTK
- **Tools:** Jupyter Notebook, Google Colab

COURSE OUTCOME :

CO1:Students will develop a strong understanding of the fundamental principles of Artificial Intelligence, including problem-solving, knowledge representation, machine learning, and reasoning.

CO2: Graduates will be able to apply AI techniques such as supervised learning, unsupervised learning, and reinforcement learning to solve real-world problems.

CO3: Students will gain hands-on experience in implementing AI algorithms and models using programming languages such as Python and tools like TensorFlow, PyTorch, or Scikit-learn.
CO4:: Students will be able to critically analyze and evaluate the performance, limitations, and ethical implications of AI systems.
CO5:Graduates will be equipped to consider the societal and ethical challenges associated with AI deployment, including bias, fairness, transparency, and accountability.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		2	2	3	3					3	3		
CO2		2	2	2		1	1				1			2	
CO3	3	3		2								1	3		
CO4	2	2		3		2						1	2		
CO5	2					3	2	2	1			2	2	2	

10.2 Environmental G E O L O G Y

Subject Code: TIU-UGL-IDC-T201 **3 Credits**

Unit 1: Introduction and environmental issues

1. Fundamental concepts related to environmental geology
2. Introduction to environmental issues and problems including earth related processes

Unit 2: Earth's resources and natural hazards

1. Resources – its uses, exploitation and conservation
2. Concepts of hazards, disasters and their mitigation
3. Evaluating hazards, history, linkages, disaster prediction and risk assessment related to Earthquakes, Tsunami, Volcanic activity, Rivers and flooding, Landslide and Coastal processes, human induced hazards in the hilly region due to engineering constructions

Unit 3: Subsurface resources and environment

1. Interaction between surface water, groundwater and sea water – its uses, exploitation and conservation
2. Groundwater contamination and toxic wastes, disasters and its mitigation
3. Environmental issues related to exploration and mining and environmental impact on earth system and its mitigation processes.

Unit 3: Soils and environment

1. Introduction to soils, soil properties and classification, soil profile, soil pollution,
2. Engineering properties of soils, land use and environmental problems of soils.
3. Air pollution and environmental management

Unit 4: Ocean and coastal system

1. Ocean basin and coastline, hazards of the sea,
2. Coastal erosion and ocean pollution,
3. Wetlands and their role in protecting coasts

Unit 5: Environmental management and global perspective

1. The carbon cycle and greenhouse effect
2. Environmental effects of global warming
3. El Nino climatic events

Reference books

- Bell, F.G. (1998) Environmental Geology: Principles and Practice. Wiley-Blackwell
- Gredel T.E., Crutzen. P.J. (1995) Atmosphere, Climate, and Change (New York: Freeman.
- Keller, E.A. (2010) Environmental Geology (9th Edition). Pearson
- Merritts, D.J., Wet, A.D., Menking, K. (1997) Environmental Geology: An Earth System Science Approach. W.H. Freeman and Company
- Valdia, K. S. (2013) Environmental Geology: Ecology, Resource and management 2nd Edition, McGraw-Hill Education (India)

Course Outcomes

- *CO1*: Understanding the Earth's environmental 'System Approach' – its clarity on different types of systems in relation to mass & energy flow/exchange.
- ***CO2***: Study of causes and factors related to repetitive variations of earth's environmental conditions and it impact on biosphere through geologic pat.
- ***CO3***: Focus on major types of natural hazards & disasters and related inherent & external anthropological issues.
- ***CO4***: Study of hazards related to exploration and exploitation of natural resources and its environmental impact.
- ***CO5***: Understanding ocean related natural hazards and its management
- ***CO6***: Reconstruct the interrelationships between hydrosphere- biosphere-pedospehere-lithosphere.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	3		2	2	3				3	2		2
CO2	2	3		3	1							1		3	1
CO3	2	3		3	3							3	1	3	
CO4	2	3			3		2	3	2			1		2	2
CO5		3	3	2		2	3						1	3	
CO6	3	2	2	2	2	3	3					3	3	2	

10.3 Geodynamics

Subject Code: TIU-UGL-IDC-T301 **3 Credits**

Unit 1: Introduction

1. Definition. Continents and oceans. Continental and oceanic crust. Internal processes of earth
2. Concept of lithosphere and asthenosphere. Physical character of lithosphere and asthenosphere. Concept of plate
3. Concept of hot spot and mantle plume. Ophiolites.

Unit 2: Dynamics of Earth's topography

1. Theory of isostasy and its application to topography
2. Mountain building processes in collision tectonics

Unit 3: Geodynamic processes

1. Physics of mechanical and thermo-mechanical flows in Earth's interior
2. Volcanic arcs, island arcs, trenches, accretionary prisms, oceanic ridges, transform faults. Magmatism in oceanic ridges and in subduction zones
3. Basic theoretical concepts of mantle convection
4. Single and Double layered Mantle convection
5. Concept of Bending theory of elastic plate in Plate Tectonics
6. Subduction processes and associated geological phenomena

Unit 4: Geodynamic models

1. Wegner Continental drifts hypothesis and its evidences. Continental position in the past
2. Gravity induced geodynamic phenomena
3. Distribution of plates on the Earth's crust
4. Supercontinents and their breakup and assembly. Wilson cycle

Unit 5: Core dynamics

1. Physical and chemical states of core: thermal and chemical convection processes
2. Basic concepts of Self-exciting Magneto-hydrodynamic Model

Reference books

- Kearey, P., Klepeis, K. A., Vine, F. J. (2009) Global Tectonics. Third edition. Wiley-Blackwell, Oxford.
- Lowrie, W. (2007) Fundamentals of Geophysics. Cambridge University Press
- Turcotte, D.L., Schubert, G. (2002) Geodynamics. Second Edition. Cambridge

Course Outcomes

- *CO1*: Comprehend the underlying dynamics of major landforms, such as continents, mountains and rift valleys as well as catastrophic phenomena, volcanism and earthquakes.
- ***CO2***: Understand the driving mechanisms of plate motion and plate-related features, like subduction zones and mid-ocean ridges.
- ***CO3***: Explain the cause of continental drifting through geologic time.
- ***CO4***: Learn the dynamical states of Earth's core responsible for the geomagnetic field and its fluctuations with time

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		3		1				1		2	3	2	1
CO2	3	3		2		1				1		2	3	2	1
CO3	2			2	2					1		1	3	2	
CO4	3	3		3		2						3	3		
CO5	2	3		2									2		

10. Detailed Syllabus and Course Outcomes (COs) of Minor Courses

10.1 Essential of Geology

Subject Code: TIU-UGL-MINOR-T100 **4 Credits**

Unit 1: Introduction

1. Introduction to geology, scope, sub-disciplines and relationship with other branches of sciences

Unit 2: Earth as a Planet

1. Earth in the solar system, origin
2. Earth's size, shape, mass, density, rotational and evolutional parameters
3. Solar System- Introduction to various planets - Terrestrial Planets & Jovian Planets

Unit 3: Solid Earth, Hydrosphere, Atmosphere and Biosphere

1. Mechanical layering of the Earth: Lithosphere, asthenosphere, mantle and core
2. Earthquake and earthquake belts: Seismic waves and internal constitution of the Earth
3. Volcanoes and volcanism, distribution of volcanoes
4. Concept of isostasy
5. Formation of core, mantle, crust, atmosphere, Hydrosphere and Biosphere.
6. Convection in Earth's core and production of its magnetic field
7. Geothermal gradient and internal heat of the Earth

Unit 4: Plate tectonics

1. Fundamental Earth process: Plate tectonics. Plates and Plate boundaries.
2. Origin of oceans, continents, mountains and rift valleys

Unit 5: Earth's surface processes

1. Weathering and Erosion.
2. Landforms in deserts, glaciated regions and river valleys

Unit 6: Age of Earth

1. Age of the earth
2. Radioactivity and its application in determining the age of the Earth, rocks, minerals and fossils

Reference books

- Holmes, A. (1992). Principles of Physical Geology. Chapman & Hall.
- Emiliani, C. (1992). Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.
- Gross, M.G. (1977). Oceanography: A view of the Earth, Prentice Hall.

Course Outcomes

- ***CO1***: Comprehend the physical and chemical processes in the evolution of the solar system and its planets.
- ***CO2***: Explain the major atmospheric, hydrosphere and geosphere processes in the light of basic sciences.

- ***CO3***: Develop knowledge about the Earth's dynamical phenomena and their implication
- ***CO4***: Enable to interpret important earth surface processes and understand their implications including environmental impacts

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	2	3			1		3	3	2	
CO2	3	3	2	3	2		2		1			3	3	2	2
CO3	3	3		2	3	2	1					2	3	3	3
CO4	3	3		2	2	3	2	2		2		3	3	2	3

10.2 Rocks and Minerals

Subject Code: TIU-UGL-MINOR-T200 **4 Credits**

Unit 1: Minerals

1. Definition of mineral, natural and synthetic minerals, mineraloids
2. Internal structure of minerals: Bonding, Crystal structure and Crystal chemistry
3. Physical properties of minerals
4. Atomic structure of common rock forming minerals, Classification of minerals based on composition and structure
5. Structure and composition of common rock-forming minerals

Unit 2: Optical mineralogy

1. Nature of light and optical behaviour of crystals
2. Classification of minerals on the basis of optical properties

Unit 3: Classification

1. Rocks-Definitions and types, rock
2. Processes of formation of Igneous rocks, sedimentary rocks and metamorphic rocks
3. Classification of Igneous rocks (Hatch and Wells and IUGS), sedimentary rocks (Folk) and metamorphic rocks. Concept of grade in metamorphic rocks
4. Brief idea about the plate tectonic settings of the common rock types

Unit 4: Rocks in the Earth

1. Mineralogical Composition of mantle and crust

Reference books

- Klein, C., P hilpotts, A. (2013) Earth Materials - Introduction to Mineralogy and Petrology, Cambridge University Press.
- Grotzinger, J., Jordan, T. H. (2010) Understanding Earth (6th Edition), W.H. Freeman and company, New York.

Course Outcomes

- *CO1*: Understand the atomic scale characteristics of minerals and their classification
- *CO2*: Understand the physical and optical properties of minerals
- ***CO3***: Know the major rock types in terms of their constituting minerals.

- ***CO4***: Apply the knowledge of physics and chemistry to explain the formation of various rock types and their geological environments

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3		1					3	2	3	1
CO2	3	2	1	1	1							1	2	2	
CO3	2	3	3	2	3		2					2	3	3	3
CO4	3	3	3	2	3	1	2	1	1			2	3	2	2

10.3 Elementary Geophysics

Subject Code: TIU-UGL-MINOR-T300 **4 Credits**

Unit 1: Introduction

1. What is geophysics?
2. Interrelationship between geology and geophysics
3. Geophysical anomaly

Unit 2: Types of geophysical methods

1. Gravity, magnetic, electrical and seismic
2. Principles of different methods
3. Applications of different methods

Unit 3: Geophysical fieldoperations

1. Data acquisition and Processing. Data reduction. Signal and noise
2. Different types of surveys, grid and route surveys, profiling and sounding techniques
3. Presentation of geophysical data

Unit 4: Application of geophysical methods

1. Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics
2. Geophysical and geological interpretation of geophysical data

Reference books

- Dobrin, M.B. (1984) An introduction to Geophysical Prospecting. McGraw-Hill, New Delhi.
- Lowrie, W. (2007) Fundamentals of geophysics. Cambridge University Press.
- Mussett, A. E. and Khan, M. A. (2000). Looking into the Earth. Cambridge University Press.
- Rao, R., Prasaranga, M.B., (1975) Outlines of Geophysical Prospecting - A manual for geologists by University of Mysore, Mysore.
- Telford, W. M., Geldart, L. P., Sheriff, R. E. (1990) Applied geophysics (Vol. 1). Cambridge university press.

Course Outcomes

- *CO1*: Understanding fundamental physical properties (magnetic, electrical, thermal etc.) of rocks and other geological materials using basic laws of physics.
- ***CO2***: Understanding the underlying physical principles of important geophysical methods (seismic, gravity etc.).
- ***CO3***: Know the basics of instruments in applying them for geophysical surveys.
- ***CO4***: Application of various geophysical methods in exploration of natural economic resources, like petroleum and metal ore deposits

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3			3							2		3	3
CO2	3	2	3		3								1	2	3
CO3	3	2	2		3							3		2	1
CO4	2	2	3	3	3				2		2	2		2	2

10.4 Hydrogeology

Subject Code: TIU-UGL-MINOR-T400 **4 Credits**

Unit 1: Introduction to Hydrogeology

1. Scope of hydrogeology and its societal relevance
2. Global and regional distribution of water resources
3. Hydrologic cycle: precipitation, evapotranspiration, run-off, infiltration, recharge, and groundwater flow
4. Origin of groundwater and vertical distribution of subsurface water
5. Types of aquifers– unconfined, confined and semi-confined. Water table and piezometric surface

Unit 2: Groundwater flow

1. Darcy's law and its application.
2. Groundwater velocity and hydraulic conductivity.
3. Porosity, Permeability, Transmissivity and methods for measuring hydraulic conductivity
4. Examples of flow systems

Unit 3: Well hydraulics and groundwater exploration

1. Basic concepts of drawdown and specific capacity.
2. Equilibrium and non-equilibrium conditions for groundwater flow to a well.
3. Surface and subsurface exploration techniques for groundwater.
4. Potentiometric maps and flow nets

Unit 4: Groundwater chemistry

1. Physical and chemical properties of water.
2. Reactions of groundwater with aquifer material.
3. Interpretation of groundwater quality data.
4. Introduction to groundwater pollution: arsenic, fluoride, nitrate, and sea water intrusion etc.

Unit 5: Groundwater management

1. Sustainable groundwater use and recharge techniques.
2. Recharge and discharge areas.
3. Surface and subsurface water interaction
4. Effects of climate change on groundwater resources.
5. Water balance studies and issues related to groundwater management.
6. Rainwater harvesting and artificial recharge of groundwater.

Reference books

- Davis, S.N., De Weist, R.J.M. (1966). Hydrogeology, John Wiley & Sons Inc., N.Y. 34

- Domenico, P.A., Schwartz. F. W. Physical and Chemical Hydrogeology (2nd Edition) by John Wiley & Sons Inc.
- Fetter, C.W. Applied Hydrogeology (4th edition) By Prentice Hall, Inc.
- Karanth K.R., (1987). Groundwater: Assessment, Development and management, Tata McGrawHill Pub. Co. Ltd.
- Raghunath H, M. (2007). Groundwater, 3rd Ed. New Age International Publishers, New Delhi
- Todd, D. K. (2006). Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.

Course Outcomes

- ***CO1***: Understanding the hydrologic cycle, importance of groundwater on hydrologic cycle
- ***CO2***: Learn about the global water budget and the need of proper water management and use (in India and global context).
- ***CO3***: Provide an in-depth understanding of the fundamental properties of groundwater, and its subsurface characteristics.
- ***CO4***: Providing information on groundwater zones and subsurface porous medium.
- ***CO5***: Understanding and Implications of Darcy's Law, and groundwater flow, and its interactions
- ***CO6***: Identify physicochemical assessment of groundwater and learning groundwater pollution

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3		1	2	2	1			2	3	3		2
CO2	3	2	2	2	2	1	3	2	1	1	2	3		3	2
CO3	2	3		1	1				1					2	1
CO4	3	2		2	1				1					2	3
CO5	3	3			1									3	
CO6	3				2	3	3			2				2	3