Postgraduate Course M.Sc Geology Syllabus

Learning Outcome Based Curriculum Framework (LOCF)

(Under CBCS)

For Affiliated Colleges
Manonmaniam Sundaranar University
Common Course Structure for M.Sc., GEOLOGY – 2023-24

Manonmaniam Sundaranar University
Tirunelveli- 627012

2023-2024

TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	**M.Sc. Geology**
Programme Code	**2511**
Duration	**PG - 2 years**
Programme Outcomes (POs)	**PO1: Problem Solving Skill**: Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context. **PO2: Decision Making Skill** Foster analytical and critical thinking abilities for data-based decision-making. **PO3: Ethical Value** Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities. **PO4: Communication Skill** Ability to develop communication, managerial and interpersonal skills. **PO5: Individual and Team Leadership Skill** Capability to lead themselves and the team to achieve organizational goals. **PO6: Employability Skill** Inculcate contemporary business practices to enhance employability skills in the competitive environment. **PO7: Entrepreneurial Skill** Equip with skills and competencies to become an entrepreneur. **PO8: Contribution to Society** Succeed in career endeavors and contribute significantly to society. **PO9: Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and a global perspective. **PO10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one's life.

Programme Specific Outcomes (PSOs)	**PSO1 – Placement** To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions. **PSO2 - Entrepreneur** To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations. **PSO3 – Research and Development** Design and implement HR systems and practices grounded in research that complies with employment laws, leading the organization towards growth and development. **PSO4 – Contribution to Business World** To produce employable, ethical and innovative professionals to sustain in the dynamic business world. **PSO5 – Contribution to the Society** To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

Course, Hours, Credits Index

Part	Semester	Title of the Course	C/E/S	Credits	Hours	Marks		
						CIA	External	Total
C	SEMESTER I	Physical Geology and Geomorphology	C	5	7	25	75	100
C		Mineralogy and Instrumentation Techniques	C	5	7	25	75	100
C		Mineralogy and Instrumentation Techniques & Paleontology Practical	C	4	6	50	50	100
E		Elective Paper- I Stratigraphy of India and its Application (Mandatory)	E	3	5	25	75	100
E		Elective Paper-II Recent Trends in Paleontology/ Urban Geology (Optional)	E	3	5	25	75	100
		Total		**20**	**30**			
C	SEMESTER II	Structural Geology and Geotectonics	C	5	6	25	75	100
C		Applied Petrology	C	5	6	25	75	100
C		Structural Geology and Geotectonics Practical & Petrology Practical	C	4	6	50	50	100
E		Elective Paper III – Applied Remote Sensing and GIS (Mandatory)	E	3	4	25	75	100
E		Elective Paper IV – Environmental Earth Science/ Isotope Geology (Optional)	E	3	4	25	75	100
SEC		Oceanography and Climatology	S	2	4	25	75	100
		Total		**22**	**30**			

C-Credit; E-Elective; S-Skill Enhancement Course; CIA-Internal

MANDATORY REQUIREMENTS FOR M.SC GEOLOGY PROGRAMME

1. **Geological Mapping** will be conducted in an area determined by the Professor-in-charge for the duration of 10 days for I M.Sc Geology students together. Each student have to submit his/her Geological Mapping report separately during II M.Sc final practical exams and there will be VIVA VOCE during Practical Exam.

2. **Short field trip**: Students have to complete at least two short field trip as determined by the Professor in- charge during First and Second year. A report on the short field trip is to be submitted by the individuals at the end of Second Year practical examinations. There will be VIVA VOCE during Practical Exam.

3. **Industries or In-plant Training** : Students have to undergo industrial training in any of the industries or implant/professional training in any of the industries, mining or institutes related to geosciences during first year summer holidays, in the form of groups/ individual. A report on the industrial training is to be submitted at the end of Second Year course during the Practical examination. There will be a viva voce on it.

4. **Geological Long Field Trip**: II M.Sc., Geology students have to undertake long field trip of duration of about three weeks to places of geological interest as determined by the Professor-in-charge. Submission of separate field report along with the specimens collected at the end of Second Year during the Practical examination is mandatory. There will be VIVA VOCE during Practical Exam.

5. **Dissertation**: Students have to carry out a research project. The problem, area and topic will be determined by the Professor-in-charge during the course of study. Each student shall submit a dissertation at the end of second year course during the practical examination. There will be a viva voce during dissertation Practical Exam.

All the above field activities carry both marks and credit.

SEMESTER – 1

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Physical Geology and Geomorphology	Core	Y	-	-	-	5	7	25	75	100

Learning Objectives	
LO1	To interpret natural processes which act on the Earth's surface and landforms
LO2	To recall the types of landforms and quaternary landscapes.
LO3	To employ geomorphological studies for structural and mineral exploration.
LO4	To understand the pedochemical process responsible for the dissolution rate.
LO5	To identify different processes involved different geological landforms.

Unit	Details	No. of Hours	Learning Objectives
I	Earth and its internal structure, composition, size and shape. An overview of plate tectonics including elementary concepts of plates, lithosphere, asthenosphere, types of plate boundaries and associated important geological features like oceanic trenches, volcanic arcs, accretionary wedges, topography of mid-ocean ridges and transform faults. Paleo-magnetism and its application for determining paleoposition of continents. Isostasy, Orogeny and Epeirogeny.	12	LO1
II	Concepts of geomorphology. Landforms in relation to climate, rock type, structure and tectonics. Earthquakes and related landscape alterations, Seismic belts of the earth. Seismicity at plate boundaries. Principles of Geodesy.	12	LO2
III	Geomorphic Processes – weathering, pedogenesis, mass movement, erosion, transportation and deposition.	12	LO3
IV	Geomorphic landforms – fluvial, glacial, Aeolian, coastal, volcanoes and karst.	12	LO4
V	Quaternary landscapes. Fluvial landscapes, Aeolian landscapes, coastal landscapes.	12	LO5
	Total	**60**	

Text Books	
1.	Holmes, D.L. (1981) Principles of Physical Geology. ELBS Edition.
2.	Pethick, J. (1984) An Introduction to Coastal Geomorphology. Arnold, London.
3	Thornbury, W.D. (1969) Principles of Geomorphology. Wiley Eastern Ltd.
4	Richar Huggett, Fundamentals of Geomorphology
5	Strahler, A.N. (1952) Physical Geology. John Wiley & Sons Inc., New York.

References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Holmes, D.L. (1981) Principles of Physical Geology.ELBS Edition.

2.	Pethick, J. (1984) An Introduction to Coastal Geomorphology. Arnold, London.
3.	Thornbury, W.D. (1969) Principles of Geomorphology.Wiley Eastern Ltd.
4.	Richar Huggett, Fundamentals of Geomorphology
5.	Strahler, A.N. (1952) Physical Geology. John Wiley & Sons Inc., New York.
Web Resources	
1.	https://journals.sagepub.com/home/jom
2.	https://www.americangeosciences.org/
3.	https://www.egu.eu/
4.	https://www.geosociety.org/

Course Learning Outcome		**Programme Outcomes**
CO1	Basic knowledge about the internal structure of earth,	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Students studied the plate tectonics theory.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Getting knowledge about the Landform: exogenic and endogenic processes.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Learning about the landform, tectonics, drainage pattern, sea level change and geomorphic cycle.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Students can introduce the basis of Quaternary landscapes.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	1	3	3	1	3	2	3	2
CO2	2	3	1	3	3	1	3	2	3	2

CO3	2	3	1	3	3	1	3	2	3	2
CO4	3	3	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	2	3	3	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	3	2	3	2	2
CO3	3	2	2	2	3
CO4	3	2	3	2	2
CO5	3	2	3	2	3
Weightage of course contributed to each PSO	15	10	14	10	13

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Mineralogy and Instrumentation Techniques	Core	Y	-	-	-	5	7	25	75	100

Learning Objectives	
LO1	To understand and explain the basic of mineral characteristics.
LO2	Will be able to employ their practical knowledge in further studies.
LO3	Can recall techniques for certain necessities.
LO4	Can evaluate the accuracy and summaries the methods adapted for certain practical activities.
LO5	Can explain and summaries problem.

Unit	Details	No. of Hours	Learning Objectives
I	Introduction to crystallography – Crystal systems – Symmetry elements – Isometric, Tetragonal, Orthorhombic, Hexagonal, Monoclinic and Triclinic systems – Normal classes.	12	LO1
II	Stereographic projections – Axial ratio – Zones and zonal symbols – Tautozonal faces – Equation of the normal – Napier's Theorem – Tangent relations – Sine ratio – Cosine ratio.	12	LO2
III	Description and composition of the following mineral groups: Quartz, Feldspars, Feldspathoids, Micas, Garnets, Olivine, Pyroxenes, Amphiboles, Zeolites and Carbonate minerals.	12	LO3
IV	Introduction to Optical Mineralogy Electrical, magnetic and optical properties of minerals – Properties of light – Transmissivity and Reflectivity – Polarization – Extinction – Dichroism – Pleochroism – Interference colors – Refringence and Birefringence – Order of interference – Conoscopy – Interference figures - Concepts of crystal field theory and mineralogical spectroscopy.	12	LO4
V	Spot tests – Paper chromatography – Nephelometry – Turbidimetry – Spectroscopy – Flame photometry – X-ray spectroscopy – UV spectroscopy – Mass spectroscopy – Accelerated mass spectroscopy.	12	LO5
	Total	**60**	

Text Books	
1.	Donald Bloss F. (1971) Crystallography and Crystal Chemistry – An Introduction published by Holt, Rinehart and Winston, Inc., New York.
2.	William M. Blackburn and William H. Dennen (1988) Principles of Mineralogy (Second Edition) published by WCB Publishers England.
3.	Kerr P.F, Optical Mineralogy, 4th ed McGraw Hill New York (1977)

4.	Gribble C.D. &A.J. Hall, A. Practical Introduction to Optical Mineralogy,Springer.London(1985)
5.	Tisljar, S.K. Haldar, Josip (2013). Introduction to mineralogy and petrology. Burlington: Elsevier Science. ISBN 9780124167100.
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Cornelis Klein and Cornelius S. Hurlbut, Jr. (1993) Manual of Mineralogy published by John Wiley & Sons, Inc. Singapore.
2.	Paul F. Kerr (1967) Optical Mineralogy, John Wiley & Sons, New York.
3.	Wenk, Hans-Rudolf; Bulakh, Andrey (2016). Minerals: Their Constitution and Origin. Cambridge University Press. ISBN 9781316425282.
4.	Whewell, William (2010). "Book XV. History of Mineralogy". History of the Inductive Sciences: From the Earliest to the Present Times. Cambridge University Press. pp. 187–252. ISBN 9781108019262.
5.	Laudan, Rachel (1993). From mineralogy to geology: the foundations of a science, 1650-1830 (Pbk. ed.). Chicago: University of Chicago Press. ISBN 9780226469478.
Web Resources	
1.	https://mineralogy-ima.org/
2.	https://www.socminpet.it/dwl.php?file=SIMP/GNM/SIMP_ELEM.pdf
3.	https://www.mineralogicalassociation.ca/
4.	https://www.cambridge.org/core/societies/mineralogical-society-of-great-britain-and-ireland
5.	http://www.minsocam.org/

Course outcome

Course Learning Outcome		**Programme Outcomes**
CO1	Basic knowledge on crystal structures and bonding and laws	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Student can learn about the Silicate structures and their physical and chemical properties	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Students get knowledge about the description and composition the minerals	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Student gain knowledge on Optical mineralogical studies	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Student applies the instrumentation techniques in mineralogical studies.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**2**	**3**	**3**	**2**
CO2	**3**	**2**	**3**	**2**	**2**
CO3	**3**	**2**	**2**	**3**	**2**
CO4	**3**	**2**	**3**	**2**	**2**
CO5	**3**	**2**	**3**	**3**	**2**
Weightage of course contributed to each PSO	**15**	**10**	**14**	**13**	**10**

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Mineralogy and Instrumentation Techniques & Paleontology Practical	Core	Y	-	-	-	5	7	50	50	100

Learning Objectives	
LO1	Identification of crystal models from different system.
LO2	Stereographic projection of minerals.
LO3	Megascopic and microscopic identification of minerals from different group.
LO4	Study and identification of megascopic fossils from different Phylum.
LO5	Study and identification of micro fossils.

Unit	Details	No. of Hours	Learning Objectives
I	Identification of crystal models of the following systems Normal class: Isometric, Tetragonal, Orthorhombic, Hexagonal, Monoclinic and Triclinic systems.	12	LO1
II	Stereographic projections – Axial ratio – Zones and zonal symbols – Tautozonal faces – Equation of the normal – Napier's Theorem – Tangent relations – Sine ratio – Cosine ratio.	12	LO2
III	Megascopic and Microscopic identification of the following group of minerals: Quartz, Feldspars, Feldspathoids, Micas, Garnets, Olivine, Pyroxenes, Amphiboles, Zeolites and Carbonate minerals.	12	LO3
IV	Study of the morphological characters and distribution of Porifera, Bryozoa, Mollusca, Brachiopoda, Trilobita, Echinoides, Coelenterata , Graptoloidea, corals and plant fossils.	12	LO4
V	Study and identifying the morphological features of micro-fossils : Foraminifera (Benthic and planktonic) Ostracoda and pteropods.	12	LO5
	Total	**60**	

Text Books	
1.	Donald Bloss F. (1971) Crystallography and Crystal Chemistry – An Introduction published by Holt, Rinehart and Winston, Inc., New York.
2.	William M. Blackburn and William H. Dennen (1988) Principles of Mineralogy (Second Edition) published by WCB Publishers England.
3.	Kerr P.F, Optical Mineralogy, 4th ed McGraw Hill New York (1977)
4.	Palaeontology Evolution and animal distribution. C. Jain and M.S. Anantharaman, (1996), Vishal Publications, Jalandhar.
5.	Invertebrate Palaeontology - H.Woods, (1985), CBS Publishers and Distributors, New Delhi.

References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Cornelis Klein and Cornelius S. Hurlbut, Jr. (1993) Manual of Mineralogy published by John Wiley & Sons, Inc. Singapore.
2.	WILLIAM D. NESSE (2017) Introduction to Mineralogy, Third edition, Oxford University Press, New York.
3.	Wenk, Hans-Rudolf; Bulakh, Andrey (2016). Minerals: Their Constitution and Origin. Cambridge University Press.
4.	Whewell, William (2010). "Book XV. History of Mineralogy". History of the Inductive Sciences: From the Earliest to the Present Times. Cambridge University Press. pp. 187–252.
5.	Amal Dasgupta (2012) An Introduction to Palaeontology. The World Press Pvt.Ltd, Kolkata.
Web Resources	
1.	https://mineralogy-ima.org/
2.	https://www.socminpet.it/dwl.php?file=SIMP/GNM/SIMP_ELEM.pdf
3.	https://www.mineralogicalassociation.ca/
4.	https://www.cambridge.org/core/societies/mineralogical-society-of-great-britain-and-ireland
5.	https://naturalhistory.si.edu/education/teaching-resources/paleontology

Course Outcome

Course Learning Outcome		**Programme Outcomes**
CO1	Identification of crystal models from different system.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Stereographic projection of minerals.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Megascopic and microscopic identification of minerals from different group.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Study and identification of megascopic fossils from different Phylum.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Study and identification of micro fossils.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.
The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2
CO2	3	2	2	3	2
CO3	3	2	3	2	2
CO4	3	2	2	3	2
CO5	3	2	3	3	2
Weightage of course contributed to each PSO	15	10	13	14	10

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Stratigraphy of India and its Applications (Elective-Mandatory)	Elective	Y	-	-	-	3	5	25	75	100

Learning Objectives	
LO1	Can recall the Stratigraphy of India.
LO2	Can differentiate different deposits of geological time.
LO3	To understand and compare different applications related to Stratigraphy.
LO4	Can interpret the sequence of stratigraphic column.
LO5	Can identify different processes involved during different geological time.

Unit	Details	No. of Hours	Learning Objectives
I	Stratigraphy of India –Dharwar Supergroup – Mineral riches of Archaean. Cuddapah system and its mineral riches. Vidhyan system and its mineral riches. Cambrian System – Salt Range and Age of Saline Series. Ordovician and Silurian systems.	12	LO1
II	Stratigraphy of India (Contd.) - Devonian system. Carboniferous system. The Gondwana Group – Structure of the Gondwana Basin – Climate and Sedimentation – Economic minerals in the Gondwanas. Upper Carboniferous and Permian systems – Triassic system – Lilang system - Jurassic system – Jurassic of Kutch - Cretaceous system – Cretaceous of Trichinopoly.	12	LO2
III	Stratigraphy of India (Contd.) - Deccan traps – Lameta beds – Infra-trappean and Inter-trappean beds – Age of Deccan traps – Economic riches of Deccan traps. Tertiary group – Rise of the Himalayas – Eocene system and its Economic minerals – Oligocene and Lower Miocene systems and Petroleum – Middle Miocene and Lower Pleistocene – Siwalik system – Pleistocene and Recent – Culture, Climate and deposits in India – Human evolution and Culture – Glaciation and Human Culture – Chronology of Glaciation – Karewa formation – Potwar silts and Loess – Indo-Gangetic alluvium – Coastal deposits – Aeolian and other deposits – Recent deposits – Useful Mineral deposits of Pleistocene and Recent – Soils – Recent changes of level along the coast – Changes in the courses of rivers.	12	LO3
IV	Applications of Stratigraphy – Geological time - Geologic time Units – Geochronology. Chronostratigraphy - Golden spikes – Global Standard Section and Point (GSSP) – Stratigraphic Units.	12	LO4

	Lithostratigraphy - Stratigraphic relationships - Lithostratigraphic Units – Lithodemic units – Application of Lithostratigraphy – Gaps in the record. Biostratigraphy – Fossils and Stratigraphy – Classification of organisms – Evolutionary trends – Biozones and Zone fossils – Taxa used in Biostratigraphy – Biostratigraphic correlation – Biostratigraphy in relation to other stratigraphic techniques.		
V	Applications of Stratigraphy (Contd.) Dating and correlation techniques – Radiometricdating – Application of radiometric dating – Other isotopic and chemical techniques – Chemostratigraphy – Magnetostratigraphy – Dating in the quaternary. Sequence stratigrphy - Sea-level changes – Sea level changes and sedimentation – Depositional sequences and systems tracts – Parasequences and its components of system tracts – Carbonate sequence stratigraphy – Sequence stratigraphy in non-marine basins – Alternative schemes in sequence stratigraphy – Applications of sequence stratigraphy – Causes of sea level fluctuations.	12	LO5
	Total	**60**	
	Text Books		
1.	Geology of India and BurmaM.S. Krishnan, (2010), 6th Edi., C.B.S publishers and Distributors, Delhi		
2.	Geology of India, D.N. Wadia, (1966), McMillan company, London		
3.	Vaidyanadhan.R&M.Ramakrishnan, Geology of India. Geological Society of India. Bangalore(2008)		
4.	MehdirattaR.C,Geology of India, Pakisthan, Bangladesh and Burma. Atma Ram &Sons.Delhi(1974)		
5.	Geology& Mineral Resources of the States of India. Misc Pub.No.30.Geological Survey of India. Kolkota. (Several individual volumes available online at GSI portal) GSI(2005).		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Fundamentals of Historical Geology and Stratigraphy of India, Ravindrakumar (1985), Wiley Eastern ltd, New Delhi.		
2.	Principle of Stratigraphy, Dunbar and Roggers, (1964), John Wiley and co, New York		
3.	An Introduction in Stratigraphy, Stamp L.D, (1964), Thomas Murby, Museum St, WCI, London.		
4.	Stratigraphic Principles and Practices, Weller, J.M, (1962), Harper & Bros, New York		
5.	Kumar R,Fundamentals of Historical Geology and Stratigraphy of India,WiIey.New Delhi (1988).		
Web Resources			
1.	https://stratigraphy.org/		
2.	https://www.sepm.org/		
3.	https://www.geosocindia.org/		
4.	https://www.moes.gov.in/		

5.	https://isegindia.org/

Course Outcomes:

Course Learning Outcome		**Programme Outcomes**
CO1	Students studied and gain knowledge on Dharwar Supergroup – Mineral riches of Archaean.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Students able to understand about the Gondwana Group and its stratigraphy	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Students get knowledge on Deccan traps	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Students understand the Stratigraphy of India	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Students used to study the Applications of Stratigraphy	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	3	1	3	3	1	3	2	3	2
CO2	2	3	1	3	3	1	3	2	3	2
CO3	2	3	1	3	3	1	3	2	3	2
CO4	3	3	3	3	3	3	2	3	3	3
CO5	3	3	3	3	3	3	2	3	3	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	3	2	2	2	3
CO3	3	2	3	2	2
CO4	3	2	2	2	3
CO5	3	2	3	2	3
Weightage of course contributed to each PSO	15	10	13	10	14

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Recent Trends in Paleontology (Elective-II Optional)	Elective	Y	-	-	-	3	5	25	75	100

Learning Objectives	
LO1	Learn about the origin and evolution of life, understanding species concept and study of the major events in the history of Precambrian and Phanerozoic life. Detailed study about vertebrate paleontology.
LO2	Learn about the morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms.
LO3	To explain about geological history, geographical distribution and description of more important genera
LO4	Demonstrating the sampling methods and sample processing techniques of micropaleontology.
LO5	To know about the application of micropaleontology in hydrocarbon exploration.

Unit	Details	No. of Hours	Learning Objectives
I	Fossil record and geological time-scale. Evolutionary changes in mollusca and mammals in geological time. Principles of evolution. Use of species and genera of foraminifera and Echinodermata in biostratigraphic correlation. Different microfossil groups and their distribution in India. Functional morphology, evolution and significance of Plant Fossils, Fishes, Horse, Elephant and Man. Dinosaurs and their extinction. Taphonomy and environmental factors, Oxygen and Carbon isotope studies of fossils and paleoclimates – Palaeobiogeographic Provinces.	12	LO1
II	Theories on origin and evolution of life – Phylogenetic and Ontogenic Analysis – Species Concept – Types of Fossils and Types of Species – Palingensis – Coenogensis – Proterogenesis - Thanatocoenosis – Biocoenosis – Sidocoenosis- Biomineralisation and Trace Fossils – Fossils and their uses – Biometrics – Major events in the history of Precambrian and Phanerozoic life.	12	LO2
III	Vertebrate paleontology: Succession of vertebrate life through geologic time. Broad classification and study of some characteristic Indian vertebrate genera. Indian pre-Tertiary vertebrate - their distribution and paleogeographic implication; extinction of dinosaurs. Indian Tertiary vertebrate - Siwalik mammals; phylogeny - Equidae and Proboscidae. Indian fossil Hominoides and	12	LO3

	modern theories regarding human evolution.		
IV	Invertebrate paleontology: an overview. Morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms - Porifera, Bryozoa, Mollusca, Brachiopoda. Geological history, geographical distribution and description of more important genera of Trilobita, Echinoides, Coelenterata and Graptoloidea.	12	LO4
V	Micropaleontology: Sampling methods and sample processing techniques. Types of microfossils. Calcareous Microfossils - Foraminifera - major morphologic groups; Benthic Foraminifera; depth biotopes, value in paleobathymetric determination. Larger foraminifera – their utility in Indian stratigraphy. Planktonic foraminifera and calcareous nannofossils. Ostracoda - outline morphology, paleoecology & geological history. Brief knowledge about pteropods, calpionellids and calcareous algae. Application of micropaleontology in hydrocarbon exploration.	12	LO5
	Total	**60**	
	Text Books		
1.	Palaeontology Evolution and animal distribution. C. Jain and M.S. Anantharaman, (1996), Vishal Publications, Jalandhar.		
2.	Invertebrate Palaeontology - H.Woods, (1985), CBS Publishers and Distributors, New Delhi.		
3.	Agashe, S.N, Paleo botany, Oxford & IBH. Delhi(1995)		
4.	Stewart W.N. & G.W. Rothwell, Palaeobotany, Cambridge University Press. D 2005)		
5.	Moore R.C. et al., Invertebrate Fossils. CBS. Delhi (1952).		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Principles of Invertebrate Palaeontology, Shrock R.R and Twenohofel W.H, (2005), CBS Publishers and Distributors, New Delhi.		
2.	Invertebrate Fossils. Moore R.C, Lalicker C.G and Fisher A.G (1952) McGraw Hill.		
3.	The Vertebrate Story, Romer A.S, (1959) University of Chicago Press, 4thEdt. Chicago.		
4.	Palaeontology An Introduction, E.W.Nield and V.C.T.Tucker (1985) Pergamon Press, Oxford.		
5.	Colbert E.H. et al.,Evolution of the Vertebrates, Wiley. New Delhi 2002)		
Web Resources			
1.	https://en.wikipedia.org/wiki/Age_of_Earth		
2.	https://www.lyellcollection.org/doi/10.1144/GSL.SP.2001.190.01.14.		
3.	https://digitalatlas.cose.isu.edu/geo/basics/fossil.htm		
4.	https://www.sciencedirect.com/topics/immunology-and-microbiology/hemichordata		
5.	https://www.qm.qld.gov.au/Explore/Research/Biodiversity		

Course Outcome:

Course Learning Outcome		Programme Outcomes
CO1	Student can understand about the fossil record and geological time-scale	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	To get knowledge about the theory and Origin of life	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Students get more knowledge about vertebrate paleontology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Students get more knowledge about Invertebrate paleontology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Student gain knowledge on micropaleontology: Sampling methods and sample processing techniques	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2
CO2	3	2	2	3	2
CO3	3	2	3	2	2
CO4	3	2	2	3	2
CO5	3	2	3	3	2
Weightage of course contributed to each PSO	15	10	13	14	10

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Urban Geology (Elective-II Optional))	Elective	Y	-	-	-	3	5	25	75	100

Learning Objectives	
LO1	The objectives this course is to enhance the knowledge to protect the environment
LO2	To improve public health and safety,
LO3	To increase the wealth of choices.
LO4	To Analyze responsive technology for long-term changes in urban coastal and river
LO5	To understand the concepts of GIS in Urban Geology

Unit	Details	No. of Hours	Learning Objectives
I	Geology and Society, Necessity of Geology in Urban life. Geology in Urban Constructions, Geotechnical feature and mapping for subsurface in Metropolitan areas, Building materials, Excavation and cutting in urban areas.	12	LO1
II	Geology and Urban Agriculture, Soil studies, Chemistry and geochemistry of soil in relation to groundwater and fertilizer Effect of pollutants on agricultural land.	12	LO2
III	Geotechnical site characterization, Geotechnical and land use mapping, Decision making in urban landuse, Geological problems in construction of underground structures in urban areas. Urban Tunnelling: Tunnelling for road and rail in urban areas, Method, Equipments, Important Geological parameters.	12	LO3
IV	Urban water: Water lagging in built-up areas, Source of water, Standards for various uses of water. Sources of contamination, Ground water surveys and resource development. Urban wastes and Treatment, Geotechnical characterization for waste sites, Domestic waste, Industrial waste, Minedrainage, Power production waste, Radio active waste, mapping for selection of waste disposal site	12	LO4
V	GIS in Urban Geology: GIS-An introduction, Application in Urban development, Application in landuse, Application in groundwater. Precaution from	12	LO5

	seismic hazard in Urban planning Micro-zonation mapping for hazard.		
	Total	**60**	
	Text Books		
1.	P. Willems, J. Olsson, K. Arnbjerg-Nielsen, S. Beecham, A. Pathirana, I. B. Gregersen, H. Madsen, V.-T.-V. Nguyen (2012) Impacts of Climate Change on Rainfall Extremes and Urban Drainage Systems.IWA Publishing, UK.		
2.	M.G.Mansell (2003) Rural and urban hydrology, ICE Publishing.		
3.	Martin van Maarseveen, Javier Martinez and Johannes Flacke (2019) GIS in Sustainable Urban Planning and Management : A Global Perspective. CRC Press.		
4.	John Randolp (2003) Environmental Land Use Planning and Management.,Island Press.		
5.	Timothy L. Nyerges, PiotrJankowski, StanGeertman, Helen Couclelis and Jacek Malczewski (2010) Regional and Urban GIS: A Decision Support Approach. CRCPress		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Daniel T. Rogers, (2020) Urban Watersheds Geology Contamination Environmental Regulations And Sustainability. Taylor and Francis.		
2.	Mary J. Thornbush and Casey D. Allen (2018) Urban Geomorphology: Landforms and Processes in Cities. Elsevier Science.		
3.	Lollino,G. et al.(2015), Engineering Geology for Society and Territory. Springer.		
Web Resources			
1.	https://en.wikipedia.org/wiki/urban geology		
2.	https://www.lyellcollection.org/doi/10.1144/GSL.SP.2001.190.01.14.		
3.	https://digitalatlas.cose.isu.edu/geo/basics/hazards.htm		
4.	https://www.sciencedirect.com/topics/landuse and landcover		
5.	https://www.qm.qld.gov.au/Explore/Research/watershed		

Course Outcome:

Course Learning Outcome		**Programme Outcomes**
CO1	Remember the basic fundamentals of geomorphology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Understand the geohazards or disaster for the establishment of the intelligent monitoring and predictive evaluation techniques;	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Apply the concepts complex geological disaster vulnerability;	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Analyze responsive technology for long-term changes in urban coastal and river	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Evaluate the land use techniques for various geological aspects and civil projects	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	2	3	1	3	3	1	3	2	3	2
CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2
CO2	3	2	2	3	2
CO3	3	2	3	2	2
CO4	3	2	2	3	2
CO5	3	2	3	3	2
Weightage of course contributed to each PSO	15	10	13	14	10

Semester- II

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Structural Geology and Geotectonics	Core	Y	-	-	-	5	6	25	75	100

Learning Objectives	
LO1	The student can interpret and evaluate different structures that exist in the earth.
LO2	Can critically assess and review the energy needed to cause different structures.
LO3	Can describe and explain major and minor structures.
LO4	Can understand to compare and contrast structures related to each other.
LO5	Can evaluate and explain the causes of different structures.

Unit	Details	No. of Hours	Learning Objectives
I	Theory of stress and strain – Behavior of rocks under stress – Mohr's circle – Various states of stress and their representation by Mohr's circles – Different types of failure and sliding criteria – Geometry and mechanics of fracturing and conditions for re-activation of pre-existing discontinuities – Paleostress analysis – Common types of finite strain – Ellipsoids – L, L-S-, and S-tectonic fabrics.	12	LO1
II	Techniques of strain analysis – Particle paths and flow patterns – Progressive strain history and methods for its determination.Deformation mechanisms – Role of fluids in deformation processes – Geometry and analysis of brittle-ductile and ductile shear zones – Petro-fabric analysis – Field and laboratory techniques – Point and percentage diagrams – Preparation of petro-fabric diagrams of quartz, biotite and calcite – Symmetry of fabric – Symmetry of movement.	12	LO2
III	Rotated minerals – Syn-, pre- and post-kinematic – Differential movement in rocks using rotated minerals – Oscillatory movements – Characteristics – Neotectonics – Indian and global evidences – Methods of study of neotectonics. Sheath folds – Geometry and mechanics of development of folds – Boudins – Foliation and lineation – Interference patterns and structural analysis in areas of superposed folding – Fault-related folding – Geometry and mechanics of faults – Gravity-induced structures.	12	LO3
IV	Major tectonic features and associated structures in extensional-, compressional-, and strike-slip terrains – Joints and unconformities – Penecontemporaneous deformational structures of sedimentary rocks. Plate tectonics – Concept and principles – Continental drift – Geological and geophysical evidences – Mechanics, objections and present status of plate tectonics.	12	LO4

V	Gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains – Geological and geophysical characteristics of plate boundaries – Geodynamic evolution of the Himalayas – Paleomagnetism – Sea floor spreading and plate tectonics – Island arcs, oceanic islands and volcanic arcs – Isostasy, orogeny and epeirogeny – Geodynamic of the Indian Plate.	12	LO5
	Total	**60**	
	Text Books (Latest Editions)		
1.	Billings, M.P. (2014) Structural Geology. Prentice-Hall, Inc., Learning Pvt. Ltd., Delhi. 3rd Edition. ISBN: 978-81-203-0059-03.		
2.	Beloussov, V.V. (1962).Basic Problems in Geotectonics. McGraw-Hill Book Co., New York.		
3	Badgeley, P.C. (1965) Structural and Tectonic Principles. Harper & Row Publishers, New York. ASIN: BOOBXTMTK6.		
4	Twiss, R.J. and Moores, E.M. (2007).Structural Geology. W.H.Freeman and Company, New York. 2nd Edition. ISBN: 10: 0-7167-4951-		
5	B.A. van derPluijm and S. Marshak (2004). Earth Structure - An Introduction to Structural Geology and Tectonics (2nd ed.). New York: W. W. Norton. p. 656. ISBN 0-393-92467-X.		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Suppe, J. (1985) Principles of Structural Geology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. ISBN: ISBN 0137105002.		
2.	Marshak, S. and Mitra, G. (1988) Basic Methods of Structural Geology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. ISBN: 0130651788.		
3.	M. King Hubbert (1972). Structural Geology. Hafner Publishing Company.		
4.	G.H. Davis and S.J. Reynolds (1996). The structural geology of rocks and regions (2nd ed.). Wiley. ISBN 0-471-52621-5.		
5.	C.W. Passchier and R.A.J. Trouw (1998). Microtectonics. Berlin: Springer. ISBN 3-540-58713-6.		
Web Resources			
1.	http://www.labotka.net		
2.	http://www.patnasciencecollege.org		
3.	https://geomorphology.org.uk		
4.	https://gradeup.co		
5.	https://www.nps.gov>subjects>gla		

Course Outcome:

Course Learning Outcome		Programme Outcomes
CO1	To gain knowledge about the geological structures like fold, fault, unconformity, foliation and lineation and its causes and mechanisms	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	To gain knowledge on strain analysis techniques	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	To learn about the neotectonics and resultants geomorphology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Student to understand on major tectonic features and associated structures in extensional, compressional, and strike-slip terrains – Joints and unconformities	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Student to gain knowledge on gravity and magnetic anomalies at mid-oceanic ridges, deep sea trenches, continental shield areas and mountain chains.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	3	3	2	3	3	2
CO2	3	3	3	2	3	3	2	3	3	2
CO3	3	3	3	2	3	3	2	3	3	2
CO4	3	3	3	2	3	3	3	3	3	2
CO5	3	3	3	2	3	3	3	3	3	2

S-Strong (3)M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2
CO2	3	2	2	3	2
CO3	3	2	3	2	2
CO4	3	2	2	3	2
CO5	3	2	3	3	2
Weightage of course contributed to each PSO	15	10	13	14	10

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Applied Petrology	Core	Y	-	-	-	5	6	25	75	100

Learning Objectives	
LO1	Understanding the basics of the Earth as a System.
LO2	To analyze various magmatic compositions to understand the formation of various igneous rocks.
LO3	To comprehend the genesis of metamorphic rocks.
LO4	To understand the formation of sedimentary rocks, their depositional environments and provenance.
LO5	Understanding the complete system of the Earth.

Unit	Details	No. of Hours	Learning Objectives
I	Forms, textures and structures of igneous rocks. Petrology and geotectonic evolution of granites, basalts, andesites and alkaline rocks. Petrology of gabbros, kimberlites, anorthosites and carbonatites.Origin of primary basic magmas. Classification of igneous rocks. Steady-state geotherms. Genesis, properties, emplacement and crystallization of magmas. Phase equilibrium studies of simple systems, effect of volatiles on melt equilibria. Magma -mixing, - mingling and - immiscibility. Generation of magmas. Factors affecting their evolution and their relation to plate tectonics– Magmatic differentiation and Assimilation. Variation diagrams.	12	LO1
II	Silicate melts equilibria, binary and ternary phase diagrams. Experimental Petrology - Phase equilibrium of binary and ternary silicate systems and its petrological implications – Effect of Pressure on silicate systems – Trace elements in magmatic crystallization – Trace element modelling. Petrogenetic aspects of important rock suites of India, such as the Deccan Traps, layered intrusive complexes, anorthosites, carbonatites, charnockites, alkaline rocks, Kimberlites, ophiolites and granitoids.	12	LO2
III	Basic Concepts of Metamorphic Petrology – Types of metamorphism – agents of metamorphism – Zones and grades. Facies concept of metamorphism. Graphical Representation of metamorphic paragenesis. Petrogenesis of important metamorphic rocks – charnockite – eclogite – amphibolite – migmatites – Khondalites – metamorphic belts Textures and structures of metamorphic rocks. Regional and contact metamorphism of pelitic and	12	LO3

	impure calcareous rocks. Mineral assemblages and P/T conditions. Experimental and thermodynamic appraisal of metamorphic reactions. Characteristics of different grades and facies of metamorphism. Metasomatism and granitization, migmatites. Plate tectonics and metamorphic zones. Paired metamorphic belts. Mineral reactions with condensed phases, solid solutions, mixed volatile equilibria and thermobarometry.		
IV	Earth Surface System: Liberation and flux of sediments, Processes of transport and generation of sedimentary structures, Control on the sedimentary record, Cyclic Sediments, – Classification of sedimentary rocks – Definition, measurements and interpretation of grain size. Evolution of Sedimentary Basins: Classification and definition of Sedimentary basins, Tectonics and Sedimentation – Plate tectonic concepts – Sedimentary basins of India – Paleocurrent and Basin analysis – Provenance and Diagenesis of sediments.	12	LO4
V	Sedimentary environments and facies, Continental alluvial – fluvial, lacustrine, desert – Eolian and Glacial sedimentary systems; Shallow Coastal Facies, Marine and Continental Evaporates; Shallow water Carbonates; Deep sea basins; Volcanoclasts Petrography of rocks of Clastic, Chemical and Biochemical origin, Clastic Petrofacies, Paleoclimate and Paleoenvironment analyses; Application of trace elements, Rare-earth elements and Stable isotope geochemistry to sedimentological problems. Depositional environments and systems. Paleocurrent analysis.	12	LO5
	Total	**60**	
	Text Books		
1.	Philpotts, A., 1992, Igneous and Metamorphic Petrology, Prentice Hall.		
2.	Turner,F. J., 1980, Metamorphic Petrology, McGraw Hill., New York.		
3.	Best M.G,IgneousPetrology.Wiley.NewDelhi(2005)		
4.	Hatch,F.H. et al,Petrology of the Igneous Rooks, CBSDelhi.		
5.	Hyndman D.W, Petrology of the Igneous and Metamorphic Rocks McGrawHill.New York(1985)		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Bose, M.K., 1997, Igneous Petrology., World Press.		
2.	Bucher, K and Frey, M., 1994, Petrogenesis of Metamorphic Rocks, Springer – Verlag.		
3.	Winter,J.D,Principles of Igneous and Metamorphic Petrology, PHI.New		
4.	Middlemost E.A.K,Magmas and Magmatic Rocks.Longman UK(1985)		
5.	Winkler,H.G.F, Petrology of the Metamorphic Rocks. Springer,New Delhi(1970)		
Web Resources			
1.	https://minerva.union.edu/hollochk/c-petrology/resources.html		
2.	https://topex.ucsd.edu/es10/lecture/lecture10/lecture10.html		
3.	https://geology.com/rocks/igneous-rocks.shtml		
4.	https://course.lumenlearning.com/wmopen-geology/chapter/outcome-		

	metamorphic-rocks/
5.	https://serc.carleton.edu/NAGTWorkshops/coursedesign/goalsdb/10875.html

Course Outcome:

Course Learning Outcome		**Programme Outcomes**
CO1	To gain knowledge about the study of rocks - igneous, metamorphic, and sedimentary – and the processes that form and transform them.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Students gain on Silicate melt equilibrium, binary and ternary phase diagrams.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	students learn about the Basic Concepts of Metamorphic Petrology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Students learn Definition, measurements and interpretation of grain size	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Students get knowledge on Sedimentary environments and facies	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level

Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	3	3	3	3	3	3	3
CO2	3	2	3	3	3	3	2	3	1	3
CO3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	2	3	3	3	3
CO5	1	1	2	3	3	3	2	1	2	2

S-Strong (3) M-Medium (2)L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2
CO2	3	2	3	2	2
CO3	3	2	2	3	2
CO4	3	2	3	2	2
CO5	3	2	3	3	2
Weightage of course contributed to each PSO	15	10	14	13	10

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Structural Geology, Geotectonics, and Petrology Practical	Core	Y	-	-	-	4	6	50	50	100

Learning Objectives	
LO1	To estimates the structural data in the field
LO2	To draw a map of fold and fault data.
LO3	Interpretation of geological maps using different structural characteristics.
LO4	To identify different rock types by megascopic and microscopic characters.
LO5	To enhance the knowledge about minerals in rocks using petrographic techniques.

Unit	Details	No. of Hours	Learning Objectives
I	Determination of attitude of beds – Geometrical, graphical and trigonometric projections – Tabular and nomograph methods.	12	LO1
II	Reconstruction of parallel fold and fault – Preparation and analysis of structure contour map – Isopachs. Construction of perpendicular and vertical sections of plunging fold. Geochronology – Pi and beta diagrams – Structural complex	12	LO2
III	Depth to strata – True thickness of beds - Interpretation of geological maps involving normally dipping beds, bore well data. Interpretation of geological maps involving symmetrical and asymmetrical fold, isoclinal fold, recumbent fold, plunging fold, strike fault and step fault.	12	LO3
IV	Megascopic and microscopic studies of important Igneous, Metamorphic and Sedimentary rocks	12	LO4
V	Harker's, Larsen's variation diagrams – Peacock's Alkali-Lime Index – Niggli's variation diagram – Grain size analysis – Statistical parameters in Sedimentology – Frequency and cumulative frequency distribution curves – Moment and graphic measures – Gravel analysis	12	LO5
	Total	**60**	

	Text books
1.	Brian Simpson. (1968).Geological Maps. Pergamon Press Limited, Oxford.
2.	Lisle, R.J. (1988).Geological Structures and Maps. Pergamon Press, Oxford.
3	Gass, J.G., Butcher, N.E., Clark, P., Francis, P.W., Jackson, D.E., McCurry, P., Skipsey, E., Smith, P.J., Stevenson, J., Thorpe, R.S., Turner, C., Wilson, R.C.L., Wright, J.B. (1972). Field Relations – A Second Level Course in Science. The Open University Press, London.
4.	Structural geology, Billing. M.P. (1974), Prentice Hall, New Delhi

5.	An outline of Structural Geology, Hobbs, B.E., Means, W.D. and Williams, P.F. (1976), John Wiley, New York.
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Bhattacharya, D.S. and Bagchi, T.C. (1973).Elements of Geological Map Reading and Interpretation with Exercises. Orient Longman Limited, Calcutta.
2.	Gokhale, N.W. (2006).A Manual of Problems in Structural Geology. CBS Publishers and Distributors, New Delhi.
3.	Basic Problems of GeotectonicsBelousov.V.V. (1962): McGraw Hill, New York
4.	Structural GeologyDe Sitter. L.U. (1956): McGraw Hill, New York
5.	Elements of Structural GeologyHill. E.S. (1972): John Wiley, New York
Web Resources	
1.	https://stratigraphy.org/
2.	https://www.sepm.org/
3.	https://www.geosocindia.org/
4.	https://www.moes.gov.in/
5.	https://isegindia.org/

Course Outcome:

Course Learning Outcome		**Programme Outcomes**
CO1	To describe and explain the solution to follow.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	To select a particular solution for some specific problems. To interpret and calculate through different procedures to find out solution.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Interpretation of geological maps using different structural characteristics.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	To compare and contrast different rock types by means of megascopic and microscopic studies.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	To enhance the knowledge about minerals in rocks using petrographic techniques.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	2	3	1	3	2	3	1	1
CO2	3	3	2	3	1	3	2	3	1	1
CO3	3	3	2	3	1	3	2	3	1	1
CO4	3	3	2	3	1	3	2	3	1	1
CO5	3	3	2	3	1	3	2	3	1	1

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	3	2	3
CO2	3	2	3	2	2
CO3	3	2	2	2	3
CO4	3	2	3	2	2
CO5	3	2	3	2	3
Weightage of course contributed to each PSO	15	10	14	10	13

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Applied Remote Sensing and GIS (Elective III Mandatory)	Elective	Y	-	-	-	3	4	25	75	100

Learning Objectives	
LO1	Understand the basics of remote sensing, electromagnetic radiation (EMR) and its properties, aerial photography and to list the important merits of these technology tools.
LO2	Students will comprehend the core part of remote sensing i.e. spectral properties of earth objects, interaction of EMR with the atmosphere and the acquisition of data by different satellite sensors including the generate of False Color Composite (FCC) imagery.
LO3	Based on the understanding of the basics, the students are expected to do thorough interpretation of aerial photographs and FCC imagery for the preparation of various thematic maps.
LO4	Acquiring advanced skills on the aspects of digital image processing and the Spatial Information Technology tools, the students are expected to do quantitative analysis on change detection, monitoring of resources etc.
LO5	Evaluate the importance of these technology tools over conventional techniques and its way forward.

Unit	Details	No. of Hours	Learning Objectives
I	Fundamentals of remote sensing: History of remote sensing technology – Remote sensing system – Electromagnetic radiation – Spectral properties of terrestrial objects – Analysis of spectral reflectance curves – Types of satellites – Image acquisition – Multi-spectral scanners – Remote sensing resolution – Introduction to thermal remote sensing – Introduction to microwave remote sensing and new satellite sensors – Remote sensing in landform and land use mapping, structural mapping, coastal and ocean studies – Global and Indian space missions.	12	LO1
II	Aerial photography: Introduction – Vertical and oblique photographs – Photoscale – Image displacement due to relief – Parallax in aerial photographs – Aerial photographic procedures – Camera and flight requirement – Flight planning – Filters – Compensation – Stereoscopy – Photomosaics. Photographical studies – Photo recognition elements and keys – Interpretation of lithology, structures and landforms from aerial photographs.	12	LO2
III	Image processing in remote sensing: Digital data recording – Digital data format. Introduction to digital	12	LO3

	image processing – Pre-processing techniques – Image classification methods – Image enhancement techniques.		
IV	Applications of remote sensing: Visual interpretation – Different sensors – Data and image interpretation key elements. Exercises on mapping of geology – Land use/land cover and geomorphology based on visual method – Preparation of base maps and transformation of thematic maps. Validation of remote sensing analysis output by ground truth – Accuracy, estimation and introduction to GPS technology.	12	LO4
V	Fundamentals and application of GIS: Concept of GIS – GIS types – Data storage – Retrieval and analysis. GIS database organization and development – Combined use of remote sensing and GIS. Preparation of spatial decision support system (SDSS).Highlights on different applications using GIS tool with particular reference to Applied Geosciences and Ocean Science.	12	LO5
	Text Books		
1.	Asrar, G. (1989) Theory and Applications of Optical Remote Sensing. John Wiley & Sons, New York.		
2.	Curran, P.J. (1984) Principles of Remote Sensing. Longman Group Ltd.		
3	Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2007) Remote Sensing and Image Interpretation. Wiley India, 763.		
4	Paul R. Wolf. (1986) Elements of Photogrammetry, McGraw-Hill Book company. 628.		
5.	Lasaponara, R. and Masini N. 2012: Satellite Remote Sensing - A new tool for Archaeology. Remote Sensing and Digital Image Processing Series, Volume 16, 364 pp., ISBN 978-90-481-8801-7.		

References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Sabins, F.F. (1998) Remote Sensing Principles and Interpretation. W.H.Freeman& Co
2.	Agarwal, C.S. and P.K. Garg (2000) Textbook on Remote Sensing In natural resources monitoring and management, Wheeler Publishing, 196.
3.	Campbell, J. B. (2002). Introduction to remote sensing (3rd ed.). The Guilford Press. ISBN 978-1-57230-640-0.
4.	Jensen, J. R. (2007). Remote sensing of the environment: an Earth resource perspective (2nd ed.). Prentice Hall. ISBN 978-0-13-188950-7.
5.	Richards, J. A.; X. Jia (2006). Remote sensing digital image analysis: an introduction (4th ed.). Springer. ISBN 978-3-540-25128-6.
Web Resources	
1.	https://stratigraphy.org/
2.	https://www.sepm.org/
3.	https://www.geosocindia.org/
4.	https://www.moes.gov.in/
5.	https://isegindia.org/

Course Outcome:

Course Learning Outcome		Programme Outcomes
CO1	To gain the basic concept of remote sensing	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Students study the Photogeology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Student get knowledge on Image processing in remote sensing	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Students learn about the applications of remote sensing	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Students gain knowledge on fundamentals and application of GIS	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	3	3	2	3	3	3	2	3	3
CO2	S	3	3	3	3	3	3	3	3	3
CO3	S	3	3	3	3	3	2	2	3	2
CO4	S	3	3	3	2	3	3	3	3	3
CO5	S	3	2	3	3	2	3	3	2	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	3	2	2	2	3
CO3	3	2	3	2	2
CO4	3	2	2	2	3
CO5	3	2	3	2	3
Weightage of course contributed to each PSO	15	10	13	10	14

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Environmental Earth Science (Elective IV Optional)	Elective	Y	-	-	-	3	4	25	75	100

Learning Objectives	
LO1	To identify knowledge on various types of environmental issues in relation to the Earth as a System.
LO2	To explain the various causes of pollution.
LO3	To explain the various types of pollution.
LO4	To select the remedial measures to be taken as an individual and a group.
LO5	Understanding the dynamics of the Earth.

Unit	Details	No. of Hours	Learning Objectives
I	Concept of environment – Environmental monitoring – Water as a resource, Water pollution – Point and non-point pollution sources – Ground water pollution.	12	LO1
II	Air pollution – Natural and anthropogenic sources of air pollution – Primary and secondary air pollutants – Anthropogenic activities and air pollution – Indoor air quality – Biological sources of indoor pollution – Health effects – Air quality standards – Case histories – Air quality monitoring – Acid rain – Adverse effects of acid rain – Health effects – Mitigation measures – Roles and responsibilities.	12	LO2
III	Smog – Mechanism of smog formation – Health disorders – Photochemical smog – Ozone and PAN formation – Health effects – Catalytic converters – Greenhouse gases and effect – Processes of removal of greenhouse gases.	12	LO3
IV	Methods of waste disposal – Landfills – Trash compactors – Incineration – Recycling – Biological processing – Mulch and compost – Energy production – Waste reduction – Waste handling and transport – Waste management – Concept of waste hierarchy – Education and awareness.	12	LO4
V	Medical geology – Problems associated with fluoride, arsenic, asbestos, mercury, chromium, cadmium, zinc, copper and lead contamination – Alternate energy resources – Climate change.	12	LO5
	Total	**60**	

	Text Books
1.	Fairbridge, R.W. (1972) Encyclopedia of Geochemistry and Environmental Science. John Wiley.
2.	Keller, Edward A. (1996) Environmental Geology. New Jersey: Prentice-Hall.

3.	Coppola D.P, Introduction to International Disaster Management, Butterworth Heinemann (2007).
4.	Pine,J.C, Natural Hazards Analysis: Reducing the Impact of Disasters, CRC Press, Taylor and Francis Group(2009).
5.	Smith K, Environmental Hazards: Assessing Risk and Reducing Disaster Rout ledge Press (2001).
References Books (Latest editions, and the style as given below must be strictly adhered to)	
1.	Strahler, A.N. and Strahler, A.H. (1973) Environmental Geoscience – Interaction between Natural Systems and Man. Hamilton Publishing Co., Santa Barbara, California.
2.	Kudesia, V.P. (1980) Water Pollution. Pragathi Prakasam, Meerut.
3.	Groundwater Assessment Development and Management, Karanth.K.R. (1987) Tata McGraw Hill Publishing Company, Ltd.
4.	Miller T.G. Environmental Science. Wadsworth Publishing.US(2004).
5.	Coates, D.R. Environmental Geology. McGraw Hill. NewYork(1984)
Web Resources	
1.	https://www.britannica.com/science/geology/sedimentary-petrology
2.	https://limk.springer.com/chapter/10
3.	https://www.geo.mtu.edu/UPSeis/hazards.html
4.	https://www.omafra.gov.on.ca/english/engineer/facts/
5.	https://geology.com/rocks/rock-salt.shtml

Course Outcome:

Course Learning Outcome		**Programme Outcomes**
CO1	To know the basic knowledge about the Climate-Classification, Global warming and climate change.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Student gets knowledge on Pollution Monitoring studies.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Student knows about the Environmental Health hazard.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Students learn the Waste management studies.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Students get involved in Medical geology applications.	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level

- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	1	2	3	3	1	2	2	3
CO2	3	2	1	2	3	3	1	2	2	3
CO3	3	2	1	2	3	3	1	2	2	3
CO4	3	2	1	2	3	3	1	2	2	3
CO5	3	2	1	2	3	3	1	2	2	3

S-Strong (3) M-Medium (2)L-Low (1)

Program Specific Outcomes

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	3	2	3
CO2	3	2	3	2	2
CO3	3	2	2	2	3
CO4	3	2	3	2	2
CO5	3	2	3	2	3
Weightage of course contributed to each PSO	15	10	14	10	13

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Isotope Geology (Elective IV Optional)	Elective	Y	-	-	-	3	5	25	75	100

Learning Objectives	
LO1	To understand the mechanisms of distribution (stable isotopes)
LO2	To understand the evolution (radiogenic isotopes) of isotope composition in natural materials.
LO3	To study instrument application in isotopic study
LO4	To gain knowledge about stable isotopes and its nature
LO5	Students to learn tracer techniques in hydrogeology field

Unit	Details	No. of Hours	Learning Objectives
I	Introduction to Isotope Geology: Introduction Basic principles of Isotope Geology–Chemical properties of Isotopes, Thermo dynamic properties of Isotopic compounds Equilibrium constants, separation of isotopes-Physical and chemical methods-Classification of Isotopes-Relationship between radio nuclides and its decay products, Units of radio activity measurement.	12	LO1
II	Distribution and properties of Isotopes: Distribution of Radioactive elements in Igneous, Sedimentary and Metamorphic rocks and waters-Study of important unstable isotopes. Distribution of Radioactive mineral deposits in India - Geochemical behaviour of Uranium and Thorium – Natural production-Anthropogenic releases of radio nuclides.	12	LO2
III	Instrumentation and methods of application of radioactive isotopes: Measurement of radioactivity-Scintillation counters, Mass spectrometer. Isotopic dilution techniques. Geochronometry, Age of the earth, Age of the element, rate and age of deposition, radioactivity and genesis of petroleum. Use of radioactivity in Well logging. Application of environmental isotopes. Fractionation of stable isotopes in lithosphere, Hydrosphere and Atmosphere. Stable isotopes and their uses.	12	LO3
IV	Stable isotopes and its nature: Stable isotopes in water	12	LO4

	cycle - Relation between $^{18}O/^{16}O$ and $^{2}H/^{1}H$ Hinnatural waters–Evaporation, Clouds and Precipitation-marine and continental atmosphere. Isotope effects in precipitation - The latitude / annual temperature effect - Seasonal effect – Oceanic and continental precipitation - Altitude effect – Amount effect – Inter annual variations - Small-scale variations - Palaeoclimate reconstruction. Tritiumin the atmosphere - Characteristics of tritium - Geophysical aspects - Hydrological aspects. Atmospheric CO_2 -Atmospheric CO_2 concentrations – Stable carbon isotopes in atmospheric CO_2-Stable oxygen isotopes in atmospheric CO_2-Radiocarbon in atmospheric CO_2. Water Sampling and Treatment - Water sampling and storage -Laboratory treatment of water samples - $^{18}O/^{16}O$ analysis - $^{2}H/^{1}H$ analysis - ^{3}H analysis of water -^{14}C analysis of dissolved inorganic carbon -$^{13}C/^{12}C$ analysis of dissolved inorganic carbon.		
V	Micropaleontology: Sampling methods and sample Tracer techniques in hydrogeology: Tracers and transports- Types of tracers-Types of tracer experiments – Isotopic tracers. Water Rock Interaction - physical absorption -Chemical absorption -Exchange of ions - Chemical interaction between solutes. Low Temperature System - Unsaturatedzone-Geohydraulicaspects-Solutetransport–Applications-Saturatedzone-Origin of groundwater- Groundwater dating -The radiocarbon dating - ^{14}C standard - natural ^{14}C variations - ^{14}C age determination - Dating groundwater with DIC and DOC - Relation between ^{13}C and ^{14}C variations –Comparison of ^{3}H and ^{14}C variations. High Temperature Systems-Natural processes-Anthropogenic processes	12	LO5
	Total	**60**	
	Text Books		
1.	Henry Faul,(1954). NuclearGeology, JohnWiley & Sons, NewYork,		
2.	Kalvero Rankama, (1954). Progress in Isotope Geology, Pergamon press, London.		
3.	Gaunter Faure,(1986). Principles of Isotope Geology, JohnWiley & Sons, NewYork, 2nded.		
4.	Aswathnarayana, U.(1985). Principles of Nuclear Geology, Oxonian Press(P) Ltd., NewDelhi.		
5.	Rankama and Sahama,(1950).Geochemistry, University of Chicago Press,.		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Albarede F.(2003) Geochemistry-An introduction, Cambridge University press		

2.	Mason, B. and Moore, C.B. (1985) Principles of geochemistry, Wiley Eastern Ltd, Bangalore
3.	Faure, G., Mensing, T. M., Tsotopes (1990) – Principles and Applications, Wiley India Pvt. Ltd.,NewDelhi
Web Resources	
1.	https://en.wikipedia.org/wiki/isotope geology
2.	https://www.lyellcollection.org/doi/10.1144/GSL.SP.2001.190.01.14.
3.	https://digitalatlas.cose.isu.edu/geo/basics/dating.htm
4.	https://www.sciencedirect.com/topics/hydrogen-and-oxygen
5.	https://www.qm.qld.gov.au/Explore/Research/isotope

Course Outcome:

Course Learning Outcome		**Programme Outcomes**
CO1	Remember the basic fundamentals of earth and it s chemical components	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Understand the radiogenic isotope geochemistry	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Apply the concepts of isotopes in geochronology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Analyze stable isotopes in geological studies	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Evaluate stable isotopes and their application for paleo climate studies	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	2	3	1	3	3	1	3	2	3	2

CO 2	2	3	1	3	3	1	3	2	3	2
CO 3	2	3	1	3	3	1	3	2	3	2
CO 4	3	3	3	3	3	3	2	3	3	3
CO 5	3	3	3	3	3	3	2	3	3	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	2
CO2	3	2	2	3	2
CO3	3	2	3	2	2
CO4	3	2	2	3	2
CO5	3	2	3	3	2
Weightage of course contributed to each PSO	15	10	13	14	10

Subject Code	Subject Name	Category	L	T	P	O	Credits	Inst. Hours	Marks		
									CIA	External	Total
	Oceanography and Climatology (Skill Enhancement Course)	SEC	Y	-	-	-	2	4	40	60	100

Learning Objectives	
LO1	To learn the physical and chemical components and phenomena related to oceanography and climatology.
LO2	To understand the morphologic and tectonic domains of the ocean floor.
LO3	Compare and Contrast cloud physics and Physical Meteorology.
LO4	Critically assess the ocean current patterns and cloud-climate classifications.
LO5	To differentiate and understand the different Oceanic Currents.

Unit	Details	No. of Hours	Learning Objectives
I	Oceans and Atmosphere Hypsography of the continents and ocean floor –continental shelf, slope, rise and abyssal plains. Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Ocean currents, waves and tides, important current systems, thermohaline circulation and the oceanic conveyor belt. Major water masses of the world's oceans. Biological productivity in the oceans.	12	LO1
II	Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, geopotential, greenhouse gases and global warming. Cloud formation and precipitation processes, heat budget, radiation balance. El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India. . Marine and atmospheric pollution, ozone depletion.	12	LO2
III	Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. Hydrothermal vents-. Ocean margins and their significance. Ocean Circulation, Coriolis Effect and Ekman spiral, convergence, divergence and upwelling, El Nino – La Nina, Indian Ocean Dipole Thermohaline circulation and oceanic conveyor belt.	12	LO3
IV	Physical Meteorology: Thermal structure of the atmosphere and its composition. Radiation: basic Laws - Rayleigh and Mie scattering, multiple scattering, radiation from the sun, solar constant, effect of clouds, surface and planetary albedo. Emission and absorption of terrestrial radiation, radiation windows, radiative transfer, Greenhouse effect, net radiation budget; Clausius – Clapeyron equation.	12	LO4

V	Cloud Physics: Cloud classification, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron, Findeisen process, coalescence process. Atmospheric turbulence: Mixing length theory, planetary boundary layer equations, surface layer, Ekman layer, eddy transport of heat. Richardson criterion.	12	LO5
	Text Books		
1.	Kennett, J.P. (1982) Marine Geology. Prentice Hall, London.		
2.	Seibold, E. and Berger, W.H. (1982) The Sea Floor. Springer Verlag, Berlin.		
3.	Sverdrup, Harald Ulrik; Johnson, Martin Wiggo*;* Fleming, Richard H. (1942).The Oceans, Their Physics, Chemistry, and General Biology. New York:Prentice-Hall.		
4.	Rice, A. L. (1999). "The Challenger Expedition". Understanding the Oceans: Marine Science in the Wake of HMS Challenger. Routledge.		
5.	Benjamin Franklin's 'Sundry Maritime Observations'. Archived from *the original* on 18 December 2005.		
References Books (Latest editions, and the style as given below must be strictly adhered to)			
1.	Strahler, A.N. and Strahler, A.H. (1987) Modern Physical Geography. 3rd Edition. John Wiley & Sons, New York.		
2.	Strahler, A.N. (1974) Physical Geography. 4thEdition.John Wiley & Sons, New York.		
3.	Boling Guo, Daiwen Huang. Infinite-Dimensional Dynamical Systems in Atmospheric and Oceanic Science, 2014, World Scientific Publishing, ISBN 978-981-4590-37-2.		
4.	Hamblin, Jacob Darwin (2005) Oceanographers and the Cold War: Disciples of Marine Science. University of Washington Press. ISBN 978-0-295-98482-7		
5.	Roorda, Eric Paul, ed. The Ocean Reader: History, Culture, Politics (Duke University Press, 2020) 523 pp.		
Web Resources			
1.	https://en.wikipedia.org/wiki/British_Oceanographic_Data_Centre		
2.	https://psl.noaa.gov/data/gridded/tables/ocean.html		
3.	http://www.vega.org.uk/video/		
4.	https://unesdoc.unesco.org/ark:/48223/pf0000030893		
5.	http://www.mcirano.ufba.br/ftp/books/baum_04.pdf		

Course Outcome:

Course Learning Outcome		Programme Outcomes
CO1	Students can introduce into the Physical and chemical properties of sea water	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO2	Students learn about the Structure and chemical composition of the atmosphere	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO3	Gain knowledge in the Morphologic and tectonic domains of the ocean floor Structure	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO4	Students can introduce into Physical Meteorology	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10
CO5	Studied and gain knowledge on Cloud Physics	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10

In order to avoid pull the score down of each PO, it is suggested that the usage L-Low (1) to the minimum.

The S, M, L is based on the course outcome. The mapping is based on the revised Bloom's Taxonomy Verbs used to describe your course outcome.

- Remember and Understanding – Lower level
- Apply and Analyze – Medium Level
- Evaluate and Create – Strong Level
-

Mapping with Programme Outcomes:

Map course outcomes for each course with programme outcomes (PO) in the 3-point scale of Strong, Medium and Low

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**
CO 1	3	3	3	2	3	3	3	2	3	3
CO 2	3	3	3	3	3	3	3	3	3	3
CO 3	3	2	3	3	3	3	3	1	3	3
CO 4	2	3	3	3	2	3	3	3	3	3
CO 5	3	3	2	3	3	3	3	3	2	3

S-Strong (3) M-Medium (2) L-Low (1)

Program Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3
CO2	3	2	3	2	2
CO3	3	2	2	2	3
CO4	3	2	3	2	2
CO5	3	2	3	2	3
Weightage of course contributed to each PSO	15	10	14	10	13