UNIVERSITY OF KERALA
Four Year Under Graduate Programme
(UoK FYUGP)

Syllabus
(Effective from Academic Year 2024-25)
Major Discipline : Geology

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Contents

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Preface

The Government of Kerala has initiated measures to improve higher education in the State. Kerala State Higher Education Council, an advisory body to the Government of Kerala, brings together scholars and stakeholders in State's Education to materialize its vision to revitalize Kerala Higher Education and to foster academic inquiry and research. The State Government has adopted the recommendations of Professor Syam B Menon Commission to introduce the Four-Year Undergraduate Programme (FYUGP) in the state higher education sector.

1. FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)

The UoK-FYUGP has a student centric approach in which the student can choose their own pathway for learning. On completion of 3 years (6 Semesters) the student has an option to exit the programme with 133 credits and shall be awarded with a bachelor degree. The maximum credit a student can acquire in three year period is limited to 150. On completion of 4 years of study (8 Semesters) by acquiring 177 credit the student shall be awarded with a Bachelors (Honours) Degree or Bachelors (Honours with Research) Degree. The students can aquire credits through the following categories of courses.

Details of courses under B.Sc. (Honours) Course

DSC : Discipline Specific Core :Major/Minor

DSE : Discipline Specific Elective

MDC : Multidisciplinary Course

SEC : Skill Enhancement Course

VAC : Value Added Course

AEC : Ability Enhancement Course : languages

The UoK FYUGP offers choice to the students in the first two semesters in different disciplines through Major, Minor and MDC. The student also has the choice of attending online courses in any discipline from repositories approved by the Board of Studies. At the end of second semester, the student has the choice of changing the Major and Minor disciplines, the academic pathway chosen at the time of admission.

1.1 Pathways and Credit Requirements

Sl.No	Academic Pathway	Major (4 credit)	Minor/Other Disciplines (4 credits	MDC (3 credits)	Foundation Courses : AEC-4, SEC-3, VAC-3 (3 credits)	Intership (2 credits)	Total credits
1	Single Major (A)	68	24	9	30	2	133
2	Major (A) with Multiple Disciplines (B,C)	68	12+12	9	30	2	133
3	Major (A) with Minor	68	24	9	30	2	133
4	Major (A) with vocational Minor (B)	68	24	9	30	2	133
5	Double Major (A1,A2)	A1:48 A2:44	The 24 credits in the Minor stream are distributed between the two Majors 2MDC, 2SEC, 2VAC and intership should be in Major A1. Total credits in NMajor A1 should be 48+20 = 68 (50% of 133) 1MDC, 1SEC and VAC should be in Major A2. Total credit in Major A2 should be 44+9 = 53(40% of 133)				133

2 FYUGP IN GEOLOGY : AN OVERVIEW

The goal of the FYUG Programme in Geology is to equip students with the fundamental knowledge of the diverse fields of Geology. Geology, a synonym of Earth Science, is the scientific study of the Earth. Geology includes the study of landforms, surface and subsurface processes on the earth, the minerals, rocks, groundwater resources, the interior of the earth, fossils etc. The study helps to understand the history of our planet, which help us to know and foresee how events and processes of the present day might influence the future. Geology is intertwined with our daily lives. It provides methods for predicting and mitigating the effects of geologic hazards such as earthquakes, volcanic eruptions, floods, landslides and finds its potential application in various fundamental spheres of life including exploration and management of mineral and energy resources.

Pursuing the course in Geology helps in understanding the earth more intensively and extensively. It also helps in identifying the potential applications in various fundamental areas including exploration and management of mineral and energy resources, ground water and surface water, land use and environment hazards. These diverse needs require a strong understanding of the basic concepts and principles of Earth science. It is a simple fact that as the complexity of these challenges increases, the need for well-educated geologists to provide scientific data and advice in extracting, conserving and managing earth's natural resources will assume more and more importance.

2.1 Geology Degree Programme

The Geology Four Year Degree Programme is designed to provide students with a comprehensive understanding of geological principles, theories, and methodologies. This program encompasses a wide range of topics including the basic principles of geology, mineralogy, petrology and stratigraphy. The study also includes plate tectonics, palaeontology, and geomorphology, investigating the geological processes, formation of geological structures, and the forces driving tectonic activity that have shaped the Earth over billions of years. Study helps for the understanding of natural hazards such as earthquakes, volcanoes, landslides, and their impact on society, as well as exploring environmental issues related to resource management and sustainability. The programme engage in field-based studies and research projects to apply geological principles and methodologies in real-world settings.

2.2 Program Objectives

By the completion of the Geology Degree Program, students will develop a solid foundation of geological concepts, theories, and methodologies. Acquire practical skills in field and laboratory techniques essential for geological research and exploration. Cultivate critical thinking and problem-solving abilities through the analysis of geological data and evidence. Gain an appreciation for the Earth as a dynamic system and its significance to society, the environment, and sustainable development.

2.3 Degree Requirements

The Geology FYUG Program consists of a combination of core courses, elective courses, field experiences, and project works. Students must fulfil the following requirements to earn their degree:

•Completion of required core courses covering foundational topics in geology.

•Successful completion of elective courses tailored to individual interests and career goals.

•Participation in field experiences, including field trips, field camps, and field-based research.

•Completion of a project work under the guidance of a faculty mentor.

2.4 Instructional Methods

This program employs a variety of instructional methods to enhance your learning experience, including:

Lectures: Presentation of key concepts, theories, and case studies.

Laboratory Exercises: Hands-on activities to reinforce understanding of geological processes and techniques.

Field Trips: Opportunities to observe geological features and phenomena in natural settings and apply field methods.

Research Projects: Engagement in independent or group research projects under the guidance of faculty mentors.

2.5 Geology for career

Due to its interdisciplinary character and importance in comprehending the resources and processes of the Earth, geology offers a wide range of professional benefits. A strong foundation in geology can be obtained through a variety of career paths that include managing natural resources, understanding Earth's processes, reducing risks, safeguarding the environment, and investigating the cosmos. It is an important subject of study for tackling urgent global concerns and forming a sustainable future because of its interdisciplinary nature and its applications.

Here are some key aspects that highlight the interdisciplinary nature of geology:

Physics and Chemistry: Geology relies heavily on principles from physics and chemistry to understand the physical properties of Earth materials

Biology and Palaeontology: The study of fossils and the evolution of life forms is an integral part of geology.

Mathematics and Statistics: Geology employs mathematical and statistical methods for data analysis, modelling geological processes, and interpreting spatial and temporal patterns.
Engineering and Geotechnics: Geology intersects with engineering disciplines, particularly civil engineering and geotechnical engineering, to assess geological hazards, design infrastructure, and ensure the stability of construction projects.
Environmental Science and Sustainability: Geology plays a critical role in understanding Earth's systems and their interactions with the environment.
Geography and Earth Systems Science: Geology intersects with geography and Earth systems science to study the Earth as a complex, interconnected system.
Economics and Policy: Geology informs economic decision-making and policy development related to natural resource management, energy production, and environmental regulation.

The graduates in Geology are employable as Geological Assistant/Technical Assistant in various Geological organizations like Mining & Geology and Ground Water Department. Geology Graduates with B.Ed. degree can teach courses at school level or Higher Secondary levels in Earth and Environment related subjects. Geology is an interdisciplinary science which offers employment opportunities in scientific studies, exploration of natural resources, Mining and Civil Engineering fields.

A fascinating and fulfilling journey through the dynamic field of Earth sciences is provided by the Geology Degree Program. Regardless of your preferences for environmental, petroleum, geological engineering, or planetary science geology, this program will provide you the know-how, experiences, and resources you need to pursue a successful career in the geosciences.

3 GRADUATE ATTRIBUTES

Graduate attributes bridge the gap between academia and the real world, fostering lifelong learning and meaningful contributions. They denote the skills, competencies and high-level qualities that a student should acquire during their university education. Apart from gathering content knowledge, these attributes go beyond the assimilation of information to its application in various contexts throughout a graduate's life. It aims in inculcating the art of critical thinking, problem solving, professionalism, leadership readiness, teamwork, communication skills and intellectual breadth of knowledge. The University of Kerala

envisages to pave the path in guiding the student's journey to shape these attributes uniquely, making them integral to personal growth and success in various spheres of life. The University strives to ensure that these graduate attributes are not just checkboxes, but they play a pivotal role in shaping the students into capable, compassionate and responsible individuals with a high degree of social responsibility.

3.1 Programme Outcomes (PO)

No.	Programme Outcomes (POs)
PO-1	**Critical thinking** ○ analyze information objectively and make a reasoned judgment ○ draw reasonable conclusions from a set of information, and discriminate between useful and less useful details to solve problems or make decisions ○ identify logical flaws in the arguments of others ○ evaluate data, facts, observable phenomena, and research findings to draw valid and relevant results that are domain-specific
PO-2	**Complex problem-solving** ○ solve different kinds of problems in familiar and no-familiar contexts and apply the learning to real-life situations ○ analyze a problem, generate and implement a solution and to assess the success of the plan ○ understand how the solution will affect both the people involved and the surrounding environment
PO-3	**Creativity** ○ produce or develop original work, theories and techniques. ○ think in multiple ways for making connections between seemingly unrelated concepts or phenomena ○ add a unique perspective or improve existing ideas or solutions ○ generate, develop and express original ideas that are useful or have values

PO-4	**Communication skills** ○ convey or share ideas or feelings effectively ○ use words in delivering the intended message with utmost clarity ○ engage the audience effectively ○ be a good listener who are able to understand, respond and empathize with the speaker ○ confidently share views and express himself/herself
PO-5	**Leadership qualities** ○ work effectively and lead respectfully with diverse teams ○ build a team working towards a common goal ○ motivate a group of people and make them achieve the best possible solution. ○ help and support others in their difficult times to tide over the adverse situations with courage
PO-6	**Learning 'how to learn' skills** ○ acquire new knowledge and skills, including 'learning how to learn skills, that are necessary for pursuing learning activities throughout life, through self-paced and self-directed learning ○ work independently, identify appropriate resources required for further learning ○ acquire organizational skills and time management to set self-defined goals and targets with timelines ○ inculcate a healthy attitude to be a lifelong learner
PO-7	**Digital and technological skills** ○ use ICT in a variety of learning and work situations, access, evaluate, and use a variety of relevant information sources ○ use appropriate software for analysis of data ○ understand the pitfalls in the digital world and keep safe from them

PO-8	**Value inculcation** ○ embrace and practice constitutional, humanistic, ethical, and moral values in life including universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values ○ formulate a position/argument about an ethical issue from multiple perspectives ○ identify ethical issues related to work, and follow ethical practices, including avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data, or committing plagiarism, and adhering to intellectual property rights ○ adopt an objective, unbiased, and truthful actions in all aspects of work

3.2 Programme Specific Outcomes (PSO)

No.	Upon completion of the programme the graduate will be able to
PSO-1	To Understand the origin of earth system its various components and geological processes in past and present.
PSO-2	To acquire theoretical knowledge on the formation of geological material including menerals, rocks and fissils.
PSO-3	To examine the structural disturbances and stratigraphy to evaluate the geologic environment in the past and present through geological time.
PSO-4	To apply the knowledge of the processes and materials in mineral exploration and utilization of other resources.
PSO-5	To apply the theoretical knowledge in the field for greater understanding of earth and its processes.

***Field work and Study tour**

Geology being a field-oriented science, the study cannot be restricted to a classroom. Geological formations and structures are to be studied on a vast dimension through the exposures of rocks in the field. Better understanding of the subject can be obtained by hands on training at geological investigating and research oriented institutions. Field training programs of 5 to 15days towards end of all/any Semesters increases the field interpretations of the theory. Hence study tour and field work form an inevitable part of Geology course.

3.3 Assesment and Evaluation

There shall be Continuous Comprehensive Assessment (CCA) and End Semester Examination (ESE) in the ratio 30:70. Duration of ESE shall be minimum one hour and maximum two hours. CCA can be formative and summative assessments. The practical examinations also have CCA and ESE components in the ratio 40:60 and is conducted internally

4 COURSE DISTRIBUTION IN SEMESTERS FOR B.Sc.(Honours) in Geology

Semester	DSC	DSE	MDC	SEC	VAC	AEC	Credits
Sem I	A1 B1,B2		M1			L1, L2	21
Sem II	A2 B3, B4		M2			L3,L4	21
Sem III	A3 B5,B6	E1	M3		V1		22
Sem IV	A4,A5	E2		S1	V2,V3		21
Sem V	A6,A7,A8	E3,E4		S2			23
Sem VI	A9,A10,A11	E5,E6		S3			23
Sem VII	A12,A13 B7,B8,B9	E7					20
Sem VIII	A14,A15		Mandatory research internship project				24

A :Major and E : Elective courses for Geology students,
B:Minor and M: Multi disciplinary geology courses for other discipline students,
L : Language courses for Geology students
S : Skilled and V : Value added geology courses for all disciplines

5 SEMESTER-WISE AVAILABLE COURSES IN GEOLOGY DISCIPLINE

Semester	Course type	Course Code	Course Name	Credit
Semester 1	DSC	UK1DSCGLY100	Understanding the Earth	4
		UK1DSCGLY120	Solid Earth	4
	DSC	UK1DSCGLY150	Essentials of Geology	4
		UK1DSCGLY151	Earth Processes	4
		UK1DSCGLY170	General Perspectives of Geology	4
		UK1DSCGLY171	Fundamentals of Planetary Science	4
	MDC	UK1MDCGLY100	Natural Energy Resource Management	3
		UK1MDCGLY120	Mother Earth	3

Semester	Course type	Course Code	Course Name	Credit
Semester 2	DSC	UK2DSCGLY100	Physical Geology and Geomorphology	4
		UK2DSCGLY120	Earth surface processes	4
	DSC	UK2DSCGLY150	Evolution of life on earth	4
		UK2DSCGLY151	Mineralogy	4
		UK2DSCGLY170	A brief history of Earth	4
		UK2DSCGLY171	Minerals and Rocks	4
	MDC	UK2MDCGLY100	Geoscience and Environmental Management	3
		UK2MDCGLY120	The Dynamic Earth	3
		UK2MDCGLY121	Earth Materials	3

Semester	Course type	Course Code	Course Name	Credit
Semester 3	DSC	UK3DSCGLY200	Crystals and Minerals	4
		UK3DSCGLY220	Mineral Science	4
	DSC	UK3DSCGLY250	Petrology	4
		UK3DSCGLY251	Earth Structures	4
		UK3DSCGLY270	Dynamic Earth and Earth Resources	4
		UK3DSCGLY271	Environmental Geology	4
	DSE	UK3DSEGLY200	Fundamentals of Hydrogeology	4
		UK3DSEGLY220	Hydrogeology	4
	VAC	UK3VACGLY200	Earth and its Resources	3
		UK3VACGLY220	Sustainable resource management	3

Semester	Course type	Course Code	Course Name	Credit
Semester 4	DSC	UK4DSCGLY200	Crystallography and Mineralogy	4
		UK4DSCGLY201	Stratigraphy and Palaeontology	4
		UK4DSCGLY220	Descriptive and Optical Mineralogy	4
		UK4DSCGLY221	Historical Geology and Paleontology	4
	DSE	UK4DSEGLY200	Field Geology	4
		UK4DSEGLY220	Field Techniques in Geology	4
	SEC	UK4SECGLY200	Gemology	3
		UK4SECGLY220	Coal and Petroleum Geology	3
	VAC	UK4VACGLY200	Ecosystem Services	3
		UK4VACGLY201	Disaster Management	3
		UK4VACGLY220	Natural Hazards and Disaster Management	3
		UK4VACGLY221	Earth and Environment	3
	Internship	UK2INTGLY200	*30 hours Internship*	2

Semester	Course type	Course Code	Course Name	Credit
Semester 5	DSC	UK5DSCGLY300	Igneous petrology	4
		UK5DSCGLY301	Sedimentary Petrology	4
		UK5DSCGLY302	Metamorphic Petrology	4
		UK5DSCGLY320	Magmatic process and Igneous Petrology	4
		UK5DSCGLY321	Sedimentology and Sedimentary Petrology	4
		UK5DSCGLY322	Principles of Metamorphic Petrology	4
	DSE	UK5DSEGLY300	Marine Geology	4
		UK5DSEGLY301	Advanced Palaeontology	4
		UK5DSEGLY320	Climatology and Marine Science	4
	SEC	UK5SECGLY300	Geotechnical Investigation of Soils	3
		UK5SECGLY320	Geotechnics	3

Semester	Course type	Course Code	Course Name	Credit
Semester 6	DSC	UK6DSCGLY300	Foundation of Structural Geology	4
		UK6DSCGLY301	Indian Stratigraphy	4
		UK6DSCGLY302	Economic Geology	4
		UK6DSCGLY320	Structural Geology	4
		UK6DSCGLY321	Resource Geology	4
		UK6DSCGLY322	Stratigraphy of India	4
	DSE	UK6DSEGLY300	Exploration and Mining Geology	4
		UK6DSEGLY301	Engineering Geology	4
	SEC	UK6SECGLY300	Remote Sensing & Geographic Information System	3
		UK6SECGLY320	Essentials of Geo Informatics	3

Semester	Course type	Course Code	Course Name	Credit
Semester 7	DSC	UK7DSCGLY400	Advanced Geoscience I	4
		UK7DSCGLY401	Advanced Geoscience II	4
		UK7DSCGLY420	Geochemistry and Isotope Geology	4
		UK7DSCGLY421	Applied Geophysics and Exploration Geology	4
	DSC	UK7DSCGLY450	Remote sensing and Geoinformatics	4
		UK7DSCGLY451	Crystallography	4
		UK7DSCGLY452	Paleoecology	4
		UK7DSCGLY470	Planetary Science	4
		UK7DSCGLY471	Advance Remote Sensing and GIS	4
		UK7DSCGLY472	Indian Fuel Resources and Mining Policies	4
	DSE	UK7DSEGLY400	Research Methodology in Geosciences	4
		UK7DSEGLY420	Mineral wealth of India and Mining Strategies	4

Semester	Course type	Course Code	Course Name	Credit
Semester 8	DSC	UK8DSCGLY420	Advanced Petrology	4
		UK8DSCGLY421	Advanced Mineralogy and Analytical Techniques.	4
		UK8DSCGLY422	Advanced stratigraphy and Structural Geology	4
	Project	UK8RPHGLY400	Internship Research Project (180 Hours)	12

5.1 COURSES IN GEOLOGY: Semester 1

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK1DSCGLY100**		**Understanding the Earth**		
Semester	I		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Earth System Science	**13**
Earth System Science- the concept of different geospheres- lithosphere, atmosphere, hydrosphere, biosphere and cryosphere. The interactions of different spheres of the Earth and resultant processes. Geology-Significance and important branches. Solar system, Origin of Earth, Earth parameters, rotation and revolution. Earth's gravitational and magnetic field.	
Module II- Major Theories in Earth Science and Internal Processes	**16**
Different theories of the origin of the Earth and its internal structure- crust, mantle and core. Concept of the lithosphere and asthenosphere. Theories supporting the movement of lithospheric plates- hypotheses of continental drift and seafloor spreading. Theory of plate tectonics- plate margins and associated features. Internal processes- Earthquakes and volcanoes. Earthquakes: types, causes and effects, seismic waves, focus and epicentre, seismograph and seismogram, intensity and magnitude, Seismic belts of the world, Seismic hazard zonation of India. Volcanoes: classification, distribution and products. Concept of isostasy.	
Module III- Earth Materials	**17**
Introduction to minerals, classification of minerals- based on origin, abundance in rocks and chemical classification. Importance of rock cycle. General study of different rocks-Igneous (intrusive, extrusive, plutonic, hypabyssal and volcanic rocks), Sedimentary rocks (clastic, non-clastic and organic rocks) and Metamorphic rocks (foliated and non-foliated rocks) Time Concept in Geology- Age (Relative and absolute age) determination of the Earth. Geologic time scale and units. Introduction to fossils- Types of fossils (body, chemical, trace, living, mega,micro and nanofossils)	

Module IV Practical - Toposheets and Symbols	**14**
Determination of slope of the terrain, latitude and longitude of points from toposheets, measurement of the distance between two points, determination of epicentre of earthquakes by triangulation method, preparation of profile from toposheets.	
Module V	**10**
Teacher Specific related to course Understanding the Earth	

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1. Arthur Holmes, Principles of Physical Geology (Edinburgh: Thomas Nelson and Sons, 1944 and New York: Ronald Press, 1945).
2. Strahler, Arthur Newell, The Earth Sciences, New York, Harper & Row
3. Carlson, Plummer and McGeary: Physical Geology– Earth revealed, Published by McGraw-Hill, 2006.
4. Press and Siever, Understanding Earth, W. H. Freeman; 4thedition, 2003
5. Ernst W. G., Earth Systems: Processes and Issues, Cambridge University Press, 2000.
6. Frederick K. Lutgens, Essentials of Geology (11th Edition) Pearson Prentice Hall,Pearson Education, Inc. New Jersey, 2012.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basics and significance of Earth Sciences, the origin of the Earth and its characteristics.	R,U	F,C	Assignment, Final Exam
CO2	Understand the internal processes and their related theories	R,U	F,C	Assignment, Final Exam
CO3	Understand the basic concepts of earth materials, fossils and geologic time.	R,U	F,C	Assignment, Final Exam
CO4	Analyse the applications of toposheets and maps and apply the methods for determiningthe distance and slope of a terrain. Locating the epicentre of earthquakes.	Ap, An	P	Quiz Final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					1
CO 2	3					2
CO 3		3				2
CO 4					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓	✓	✓	✓
CO 3			✓	✓
CO 4		✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**	
Course Code and Title	**UK1DSCGLY120**		**Solid Earth**	
Semester	I		Academic Level: 100 - 199	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	**Hrs.**
Module I: Earth as a planet	**12**
Introduction to various branches of Earth Science; General characteristics and origin of the Universe, Solar System, and its planets; Origin of Earth-atmosphere. Age and dimensions of earth (relative and absolute), basic concepts of atmosphere and geosphere.	
Module II: Solid Earth	**17**
Definition of endogenic and exogenic processes -agents, Seismic waves, and internal constitution of the Earth. Plate Tectonics: Concept of plate tectonics, seafloor spreading and continental drift; Plate boundaries, Earthquake; Types, causes and effects, seismic waves, focus and epicentre, seismograph and seismogram, intensity and magnitude, Seismic Belt of world. Volcanoes- types, products and their distribution.	

Module III: Earth materials and Stratigraphic records	**17**
Definition of minerals and rock - Introduction to minerals, classification of minerals -Rock forming minerals, Ore forming minerals, Metallic Non metallic Minerals. Rocks- Igneous , sedimentary and Metamorphic rocks, Rock cycle. Fundamental laws of stratigraphy: laws of superposition and faunal succession; Concepts of Neptunism, Plutonism, Uniformitarianism, and Catastrophism; Absolute and relative time in Geology. Concept of radiometric dating. Geological time scale.	
Module IV: Practical	**14**
Epicenter calculation, Problems related to half-life, plotting of volcanic sites and earth quake prone areas related to plate boundaries. Study of toposheets- latitudes, longitudes conversions and plotting.	
Module V: Teacher specific content	**10**
Teacher specific content related to Earth Processes	

Reference

1. Emiliani, C. (1992): Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press. Published in USA.
2. 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. P.552.
3. Mathez, E.A. and Webster, J.D. (2004): The Earth machine – The Science of a Dynamic Planet. Columbia University Press, New York. P.335.
4. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
5. Gross, M. G. (1977). Oceanography: A view of the earth.
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7. Press and Siever, Understanding Earth, W. H. Freeman; 4 edition, 2003
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9. Frederick K. Lutgens, Essentials of Geology (11^{th} Edition) Pearson Prentice Hall, Pearson Education, Inc. New Jersey, 20

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Identify fascinating facts about solar system	R	F	Assignment, Final Exam
CO2	Understand basic concepts about age and dimensions of earth and its dynamics.	**U**	C	Assignment, Final Exam
CO3	The students able to define various laws of stratigraphy and differentiate major events in GTS and correlation	An	P	Assignment , Final Exam
CO4	Demonstrate critical thinking and able to plot earthquake and Volcanoes on world map and location epicenter. Toposheets-latitudes longitudes conversions and plotting.	Ap	P	Quiz Final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					2
CO 2	3					2
CO 3	3					2
CO 4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2	✓		✓	✓
CO 3		✓	✓	✓
CO 4			✓	✓

Discipline and Type of Course	Geology		Discipline Specific Core - DSC		
Course Code and Title	UK1DSCGLY150		Essentials of Geology		
Semester	1		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Introduction to Earth system science	**15**
Introduction to geology, branches and significance. Solar system, Earth parameters, rotation and revolution. Age interior of Earth. Introduction to different geospheres: lithosphere, atmosphere, hydrosphere, biosphere and cryosphere.	
Module II- Endogenic processes	**15**
Brief study on Continental drift hypothesis, seafloor spreading and plate tectonics. Endogenic processes- Earthquakes and volcanoes Earthquakes: types, causes and effects, seismic waves, focus and epicentre, seismograph and seismogram, intensity and magnitude Volcanoes: classification, distribution and products	
Module III- Earth materials	**16**
Introduction to minerals, classification of minerals- based on origin, abundancy in rocks. General study of different rocks-Igneous (Intrusive, extrusive, plutonic, hypabyssal and volcanic rocks), Sedimentary rocks (Clastic, Non-clastic and organic rocks) and Metamorphic rocks (Foliated and nonfoliated rocks) rock cycle. Introduction to fossils- Body fossil, trace fossils , chemical fossil, mega and microfossils.	
Module IV – Practical	**14**
Determination of Epicentre of an Earthquake. Distinguishing igneous, sedimentary and metamorphic rocks	
Module V	**10**
Teacher Specific related to course Essentials of Geology	
Reference	
1. Carlson, Plummer and McGeary: Physical Geology– Earth revealed, Published by McGraw-Hill, 2006 2. Frederick K.Lutgens, Essentials of Geology (11 th Edition) Pearson Prentice Hall, Pearson Education, Inc. New Jersey, 2012. 3. Ernst W. G., Earth Systems: Processes and Issues, Cambridge University	

Press, 2000.
4. Tarbuck, E; Earth science Prentice hall, 2014.
5. Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the different branches of geology, geospheres, minerals, rocks and fossils; describe the characteristics of interior earth and endogenic process.	U & E	F &C	Assignment & final exam
CO2	Understand and explain the theories and hypothesis of plate tectonics associated with the geologic process as and characteristics of earthquake and volcanoes.	U & E	F &C	Quiz, Assignment& final exam
CO3	Identify the epicenter of an Earthquake and differentiate various rocks	U, E, &A	F, C &P	Assignment & final exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3	3				2
CO 2	3	2			2	2
CO 3		1			3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK1DSCGLY151**		**Earth Processes**		
Semester	1		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Exogenic processes	**12**
Exogenic processes: Weathering- agents, types and products. Soil and soil profile.	
Module II- River, Glacial and Wind	**17**
River as a geological agent. Types of streams, Drainage pattern, Drainage basin, Different stages of fluvial evolution- youth, mature and old age. Erosion, transportation and deposition. Fluvial landforms, Geological action of glaciers and associated landforms, Geological action of wind and associated landforms	
Module III- Oceans and groundwater	**17**
Oceans and seas: Coastal erosion, transportation, and deposition. Physiographic features of ocean floor. Coral reefs and its types. Geological action of groundwater and associated features	
Module IV Practical	**14**
Stream ordering, length of stream, area of drainage basin, bifurcation ratio	
Module V	**10**
Teacher Specific related to course Earth Processes	

Reference

1. Plummer, Carlson, McGeary (2003). Physical Geology. McGraw Hill.
2. Bloom, A. (2004) Geomorphology – A Systematic analysis of Late Cenozoic Landforms (Third edition) Wavel and Press Inc.
3. Vishwas S. Kale and Avjit Gupta (2000). Introduction to Geomorphology, Orient Black Swan
4. Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.
5. M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.

CO	Course Outcome	Cognitive Level*	Knowledge Category #	Evaluation Tools used
CO1	Understand the exogenic process with emphasis on weathering, various geologic agents, soil profile; describe the physiographic features of ocean floor, coral reefs and coastal erosion.	U & E	F &C	Assignment & final exam
CO2	Understand and illustrate the geological actions of the various geological agents and their associated landform features of river, glacial, wind, groundwater, oceans.	U & E	F &C	Quiz, Assignment & final exam
CO3	Determine the drainage pattern of stream in toposheets and morphometric analysis of drainage basins.	U, E, &A	F, C &P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3	3			1	2
CO 2	3	2			2	2
CO 3	1	1			3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

apping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK1DSCGLY170**		**General Perspectives of Geology**		
Semester	I		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Introduction to Earth sciences	**15**
Role of Geologist- Branches of Earth Science, Universe, Solar System, Classification of Planets, The Earth- Dimension, Rotation, Revolution, Latitude& Longitude, Seasons. Earth System- Geosphere (Earth layers), Hydrosphere, atmosphere (layers). Interior of Earth.	
Module II- Earth processes	**15**
Surface Landforms – Ocean Floor morphology, coastal morphology. Mountain – Types & examples, Plateau, valley, Plains, Endogenic& Exogenic Processes- Plate tectonics, earthquake, volcano, weathering, types, soil profile, Mass wasting- type Introduction to geological agents& their work.	
Module III- Pillers of Earth Science -	**16**
Definition of minerals –significance in mineral identification; scope and aim of mineralogy, rock forming minerals and ore forming minerals, examples. Rocks- Definition of rocks and petrology. Examples of rocks. Rock cycle. Definition of stratigraphy. Beds, strata, Definition of fossils, Significance of study of fossils. Relative and absolute age. Fundamental laws of stratigraphy. Geological timescale.	
Module IV – Practical	**14**
Understanding rock cycle, plotting of volcanoes and earthquake prone areas related to plate boundaries. Decoding the order of geological events using laws of stratigraphy from cross sections.	
Module V	**10**
Teacher Specific related to content General Perspectives of Geology	

Reference

1. Grotzinger, J., Jordan, T.H., Press, F., Siever, R. (2007): Understanding Earth. W.H. Freeman & Co., New York, 5
2. Emiliani, C. (1992): Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge UniversityPress. Published in USA.
3. 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. P.552.
4. Mathez, E.A. and Webster, J.D. (2004): The Earth machine – The Science of a Dynamic Planet. Columbia University Press, New York. P.335.
5. Duff, P. M. D., & Duff, D. (Eds.). (1993). *Holmes' principles of physical geology*. Taylor & Francis.
6. Gross, M. G. (1977). Oceanography: A view of the earth.
7. Strahler, Arthur Newell, The Earth Sciences, New York, Harper & Row
8. Carlson, Plummer and McGeary: Physical Geology– Earth revealed, Published byMcGraw-Hill, 2006
9. Carlson, Plummer and Mc Geary: Introductory Geology – Earth Revealed, Publishedby McGraw-Hill.
10. Press and Siever, Understanding Earth, W. H. Freeman; 4 edition, 2003
11. Ernst W. G., Earth Systems: Processes and Issues, Cambridge University Press,2000.
12. Frederick K. Lutgens, Essentials of Geology (11th Edition) Pearson Prentice Hall,Pearson Education, Inc. New Jersey, 2012

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand facts about Earth and Solar system, Earth Processes and Work of Geological agents	**U**	F	Assignment & final exam
CO2	Identify Minerals, Rocks, Laws of stratigraphy and basic ides of palaeontology.	**U**	C	Quiz, Assignment& final exam
CO3	Interpret Rockcycle, Earthquake and volcanic prone regions on plate Boundaries and GTS.	Ap	P	Assignment & final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					1
CO 2		3				2
CO 3					2	2
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2		✓		
CO 3	✓		✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK1DSCGLY171**		**Fundamentals of Planetary Science**		
Semester	I		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- The Universe	**13**
Universe, Big Bang theory, Milky Way, solar system, sun. Astronomical units. Dimensions and relative positions of Inner planets, Outer planets, planetoids, moons. Asteroid belts, Layers, and processes in Sun.	
Module II- Star Cycles	**15**
Abundance of elements in cosmos. Evolution and fate of stars. The characteristics of Mars and its interior; The characteristics of Moon and its interior.	
Module III- Meteorites	**15**
Meteorites: Composition and classification of meteorites. Cratering dynamics- and classification. Impact craters in India. Indian space missions	
Module IV- Practical	**14**
Calculations related to inter planetary distance and gravitational force. Identify and locate Major impact craters in India	

Module V- Teacher Specific	**10**
Teacher Specific content related to Fundamentals of Planetary Sciences	

Reference

1. Cook, AH, 1973, Physics of Earth and planets. London: MacMillian
2. Kaula, WM, 1996, Theory of Satellite Geodesy. Blaisedell
3. Beatty, J., Petersen C. and Chaikin, A., 1999, The New Solar System, Cambridge University Press, Cambridge, England.
4. Lodders K. and Fegley, B., 1998, The Planetary Scientist's Companion, Oxford UniversityPress, New York, 1998
5. Morrison, D.,1993, Exploring Planetary Worlds,Scientific American Library, New York.
6. Ahrens, T. (ed.), 1995, Global Earth Physics - A Handbook of Physical Constants, American Geophysical Union, Washington, D.C.
7. Pamela Clark, 2007, Dynamic Planet: Mercury in the Context of its Environment, Springer,New York.
8. Cattermole, P., 1994, Venus, The Geological Story, Johns Hopkins University Press, Baltimore.
9. Wilhelms, D., 1993, To a Rocky Moon - A Geologist's History of Lunar Exploration,University of Arizona Press, Tucson.
10. Cattermole, P., 1993, Mars - The Story of the Red Planet, Chapman and Hall, London.
11. Mutch, T., Arvidson, R., Head, J., Jones, K., and Saunders, R., 1976, The Geology ofMars, Princeton University Press, Princeton.
12. Rogers, J., 1995, The Giant Planet Jupiter, Cambridge University Press, Cambridge,England.
13. Hunt G., and Moore, P., 1982, Saturn, Rand McNally, New York.
14. Miner, E., 1998, Uranus - The Planet, Rings, and Satellites, Wiley, New York.
15. Miner, E. and Wessen, R., 2002, Neptune - The Planet, Rings, and Satellites, Praxis,Chichester, England.
16. White, A., 1980, The Planet Pluto, Pergamon, New York.
17. Davies, J., 2001, Beyond Pluto - Exploring the Outer Limits of the Solar System, Cambridge University Press, Cambridge, England.
18. Planetary Geomorphology by Ronald Greely
19. Planetary Surface Processess by J. H. Melosh
20. Planetary tectonics by T. R. Watters and R. A. Schultz
21. Asteroids by T. H. Burbine
22. Introduction to Planetary Science by G. Faure and T.M. Mensing

CO	Course Outcome	Cognitive Level*	Knowledge Category #	Evaluation Tools used
CO1	Understand Fascinating facts solar system and star cycle.	U	F	Assignment & final exam
CO2	Recognize geology of Mars, Moon, and meteorites.	**U**	C	Quiz, Assignment& final exam
CO3	Analyse the dynamics of impact cratering.	Ap	P	Assignment & final exam

* - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create

\# - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					2
CO 2	3					2
CO 3					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2	✓	✓		
CO 3			✓	✓

Discipline and Type of Course	**Geology**		**Multi-Disciplinary Course - MDC**		
Course Code and Title	**UK1MDCGLY100**		**Natural energy resource and management**		
Semester	1		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Introduction to geosphere energy resources	**10**
Introduction to Geosphere Energy Source-Brief description and their economic uses of Atomic minerals,precious minerals, Petroleum, Coal,Natural gas, atomic minerals, Gas hydrates, Geothermal energy	
Module II- Geosphere energy resources	**13**
Nation development and geosphere energy resources. Economic importance and distribution of geosphere energy sources in India, Petroleum (Assam shelf, Bombay offshore, Cambay basin, Cauvery basin, Krishna-Godavari basin, Andaman-Nicobar and Lakshwadeep basins), Coal (Coal deposits of Raniganj and Jharia.Lignite deposits of Neyveli and Palana. Tertiary oil fields of Assam). Atomic minerals (Beach deposit of Kerala). Exosphere mineral resources.	
Module III- Sustainable geosphere energy sources	**13**

Sustainable usage, development and management of geosphere energy source. National Mineral policy. Natural resources management and associated problems. Current and future scenario of geosphere energy source and their influence on national economy.	
Module IV	**6**
Teacher Specific related to course Geosphere energy resource and management	

Reference

1. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
2. Deb, S. (1980) Industrial minerals and rocks of India. Allied Publishers.
3. Sarkar, S.C. and Gupta, A. (2014) Crustal Evolution and Metallogeny in India. Cambridge Publications.
4. Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.
5. Bateman, A.M. and Jensen, M.L. (1990) Economic Mineral Deposits. John Wiley.
6. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the various geosphere energy sources and their economic uses.	U & E	F &C	Assignment & final exam
CO2	Understand the economic importance and distribution of geosphere energy sources in India	U & E	F &C	Quiz, Assignment & final exam
CO3	Understand the sustainable usage, development and management of geosphere energy sources	U & E,	F &C	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3		3	3		2
CO 2	1		2	3		2
CO 3				3		2
Level		1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	Geology		Multi-Disciplinary Course - MDC		
Course Code and Title	UK1MDCGLY120		Mother Earth		
Semester	1		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module I: Introduction to Earth Science	**9**
Introduction- Various branches of Earth Science; General characteristics and origin of the Universe, Solar System and its planets; Origin of Earth-atmosphere. Age and dimensions of earth.	
Module II: Dynamic Earth	**9**
Definition of endogenic and exogenic processes -agents, Seismic waves, and internal constitution of the Earth. Plate Tectonics: Concept of plate tectonics, seafloor spreading and Continental drift; Plate boundaries, Earthquake and earthquake belts; Volcanoes- types, products, and their distribution	
Module III: Gravity and magnetism of Earth	**9**
Basic concepts of Gravity and variation of gravity with latitudes, Basic concepts of Earth's magnetism. Origin of earth's magnetism, Palaeo poles and magnetic time scale. Isostacy.	
Module IV: Fundamentals of Stratigraphy	**9**
Laws of Superposition and Faunal succession; Concepts of Neptunism, Plutonism, Uniformitarianism, and Catastrophism; Absolute and relative time in Geology. Concept of radiometric dating. Geological time scale.	
Module V- Teacher Specific content	**6**
Teacher Specific content related to Mother Earth	

Reference

1. Frederick K. Lutgens, Essentials of Geology (11thEdition) Pearson Prentice Hall, Pearson Education,Inc.NewJersey,2012
2. Grotzinger,J.,Jordan,T.H.,Press,F.,Siever,R.(2007):Understanding Earth. W.H.Freeman & Co.,NewYork,5
3. Emiliani, C.(1992):Planet Earth: Cosmology, Geology, and the Evolution of Life and Environment. Cambridge University Press. Published in USA.
4. 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. P.552.
5. Mathez, E.A. and Webster, J.D. (2004): The Earth machine – The Science of a

Dynamic Planet. Columbia University Press, New York. P.335.
6. Duff,P.M.D.,&Duff,D.(Eds.).(1993).Holmes' principles of physical geology. Taylor & Francis.
7. Gross,M.G.(1977).Oceanography: A view of the earth.
8. Ernst W .G. ,Earth Systems : Processes and Issues, Cambridge University Press,2000

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the various branches of Earth Science and understanding of the dynamic processes shaping the Earth's surface and interior of the earth to analyze the processes driving Earth's geological evolution.	U, An	C, F	Assignment, Final Exam
CO2	Understanding the origin of the Universe providing foundational understanding of planetary formation and evolution. Analyze the age and dimensions of Earth and timeline of geological processes.	An	C	Assignment, Final Exam
CO3	Understand the fundamental laws of stratigraphy age calculations to interpret the age and history of Earth's formations and events.	U, E	F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					3
CO 2	3					3
CO 3			3			3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO 3		✓	✓	✓

5.2 COURSES IN GEOLOGY: Semester 2

Discipline and Type of Course	**Geology**		**Discipline Specic Core - DSC**		
Course Code and Title	**UK2DSCGLY100**		**Physical Geology and Geomorphology**		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- External Processes	**15**
Weathering- agents, types, and products. Regolith and Soil. Soil profile and factors affecting soil formation. Process of downslope movements- Types of mass wasting: Landslides- causes, types and mitigation, Landslides prone areas in India- Foothills of Himalayas, Western Ghats and Kerala. Problems associated with land subsidence.	
Module II- Agents of Landform Development	**15**
River as a geological agent. Types of streams, Drainage pattern, Drainage basin, Drainage order, Stream profile, Different stages of fluvial evolution- youth, mature and old age. Geological action of Streams (erosion, transportation and deposition) and associated fluvial landforms Geological action of glaciers and associated landforms. Groundwater as a geological agent and its erosional and depositional features. Karst topography. Lakes: Origin, classification and geological significance. Kayals of Kerala.	
Module III- Interactions of different Geospheres	**16**
Oceans and Seas- waves, currents and tides. Coastal erosion, transportation and deposition. Classification of coasts and coastal morphology. Estuaries and lagoons. Physiographic features of the ocean floor. Coral reefs and their types. Geological action of wind and associated landforms.	
Module IV – Practical	**14**
Determination of stream order, length of the stream, area of the drainage basin, and bifurcation ratio from a given drainage basin map	
Module V	**10**

Teacher Specific related to course Physical Geology and Geomorphology	

Reference

1. Ahamed, E. (1972) Coastal Geomorphology of India. Orient Longman, New Delhi.
2. Thornbury, W. D. (1968). Principles of Geomorphology, Wiley.
3. Plummer, Carlson, McGeary (2003). Physical Geology. McGraw Hill.
4. Weisberg, J, and Parish, H. (1974). Introductory Oceanography. McGraw Hill.
5. Arthur Holmes (1977) Principles of Physical Geology (Edinburgh: Thomas Nelson and Sons, 1944 and New York: Ronald Press, 1945.
6. Bloom, A. (2004) Geomorphology – A Systematic analysis of Late CenozoicLandforms (Third edition) Wavel and Press Inc.
7. Vishwas S. Kale and Avjit Gupta (2000). Introduction to Geomorphology, OrientBlack Swan.
8. Frederick K. Lutgens, Essentials of Geology (11th Edition) Pearson Prentice Hall,Pearson Education, Inc. New Jersey, 2012.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the external processes, weathering, soils and mass wasting	R,U	F	Assignment ESE
CO2	Understand and analyze the different geological agents, their geological actionand associated landforms	U, An	F	Assignment ESE
CO3	Analyse the interactions of different geospheres and associated landforms	An	F	Quiz ESE
CO4	Apply and analyze the method of determining the length of streams, order of streams, drainage basin and its pattern and bifurcation ratio in map and field.	Ap.An	P	Quiz ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					2
CO 2	2					2
CO 3	3					3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO 3		✓	✓	✓
CO 4		✓	✓	✓

Discipline and Type of Course	**Geology**			**Discipline Specific Core - DSC**	
Course Code and Title	**UK2DSCGLY120**			**Earth Surface Processes**	
Semester	2			Academic Level: 100 - 199	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	**Hrs.**
Module I: Exogenic Processes	**12**
Weathering –Basic concepts, Factors, types and products of weathering, cycle of erosion. Physical and chemical processes. Soil, factors affecting soil formation and soil profile, important soil types in India. Slope stability and Mass wasting - types, causes and control	
Module II: Fluvial processes	**18**
Drainage basin and drainage pattern, geological work of Stream- evolution of land forms. Groundwater as a geological agent - erosional and depositional features. Karst topography. Eustatic sea level changes. Ocean floor morphology: continental shelf, continental slope, continental rise, submarine canyons, abyssal plains, MORs, deep sea trenches, guyots, seamounts. Basic concepts of coastal morphology.	

Module III: Glacier and wind	**16**
Glaciers – Formation, movement, and morphology. Types of glaciers. Erosion, transportation, and deposition by glaciers. Glacial landforms. Global warming and its effects on glaciers. Wind – Geological action of winds. Landforms of Aeolian origin. Desertification process. Lakes – Origin, Classification, geologic significance	
Module IV: Practical	**14**
Basic concepts of slope analysis, Basic morphometric analysis of drainage basin	
Module V: Teacher specific content	**10**
Teacher specific content related to Earth Processes	

Reference

1. Misra, H.C. (1995) A Handbook on GIS. GIS India, Hyderabad.
2. Ian Haywood, Sarah Cornelius and Steve Carver (2000) An introduction to Geographical Information Systems. Addison Wesley Longman Ltd., New York.
3. Smith, T.R. and Piquet (1985) GIS. London Press, London.
4. Heywood, D. I., Cornelius, S., and Carver, S. (1998). An introduction to Geographical Information Systems. Longman, New Delhi.
5. Lo C.P. and Young, A.K.W. (2003) Concepts and Techniques of Geographical Information System. Prentice Hall of India, New Delhi.
6. Pandey S. N. (1987) Principles and Applications of Photogeology, Wiley Eastern.
7. Ahamed, E. (1972) Coastal Geomorphology of India. Orient Longman, New Delhi.
8. Thornbury, W. D. (1968). Principles of Geomorphology, Wiley.
9. Plummer, Carlson, McGeary (2003). Physical Geology. McGraw Hill.
10. Weisberg, J, and Parish, H. (1974). Introductory Oceanography. McGraw Hill.
11. Arthur Holmes (1977) Principles of Physical Geology (Edinburgh: Thomas Nelson and Sons, 1944 and New York: Ronald Press, 1945.
12. Bloom, A. (2004) Geomorphology – A Systematic analysis of Late Cenozoic Landforms (Third edition) Wavel and Press Inc.
13. Vishwas S. Kale and Avjit Gupta (2000). Introduction to Geomorphology, Orient Black Swan.
14. Sparks B. W. (1969). Geomorphology, Longman.
15. Holmes' Principles of Physical Geology. (1992). Chapman and Hall.
16. Emiliani, C, (1992). Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge UniversityPress.
17. Gross,M.G. (1977). Oceanography: A view of the Earth. Prentice Hall.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain various Exogenic Processes	R	F	Assignment, Final Exam
CO2	Identify gradational landforms created by various geological agents.	**U**	C	Assignment, Final Exam
CO3	Interpret drainage basin using morphometric analysis	AP	P	Assignment, Final Exam
CO4	Explain various Exogenic Processes	R	F	Quiz Final exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					2
CO 2	2					3
CO 3					3	3
CO4					3	2
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO 3			✓	✓
CO 4	✓		✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK2DSCGLY150**		**Evolution of life on earth**		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Introduction to Historical Geology	**12**
Historical geology and its branches, Stratigraphic principles and and classification. Standard stratigraphic Column, Guiding principles in Stratigraphy. Geologic time scale. Stratigraphy of Kerala.	
Module II- Fossils and fossilization	**17**
Conditions and methods of fossilisation. Uses of fossils. Branches of palaeontology. Major event of earth history. Evolution of life though time.	
Module III- Invertebrate fossils	**16**
Morphology of important invertebrate fossils (Brachiopods, Mollusca, Pelecypods, Gastropods, Trilobita). Brief study of plant fossils of India.	
Module IV – Practical	**14**
Identification and morphological features of important brachiopods, pelecypods, gastropods and trilobites	
Module V	**10**
Teacher Specific related to course Evolution of life on Earth	

Reference

1. Anis Kumar Ray, (2008) Fossils in Earth Sciences, Prentice-Hall of India Pvt. Ltd, New Delhi.
2. Woods, H. (1961) Invertebrate Palaeontolgy. Cambridge University Press.
3. Moore, R.C., Lalicker, C.G. and Fishcher, A.G. (1952) Invertebrate Fossils, Mc-Graw Hill.
4. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell Publishing.
5. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the principles of stratigraphy, geologic time scale, evolution of life through time, branches of palaeontology and major event of earth history.	U & E	F &C	Quiz& final exam&
CO2	Understand and describe the stratigraphy of Kerala, characteristics of fossils, plant fossils of India and morphology of important invertebrate fossils	U & E	F &C	Assignment & final exam
CO3	Identify and illustrate the morphologic features of various invertebrate fossils and plant fossils.	U, E, &An	F, C &P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3	3		2	2
CO 2		3	3		3	2
CO 3		2	1		3	3
Level		1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK2DSCGLY151**		**Mineralogy**		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture Per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	**Hrs.**
Module-1- Minerals	**15**
Mineral - definition of Mineral and Mineraloid, scope and aim of Mineralogy. Physical mineralogy: physical properties of minerals - form, habit, cleavage, fracture, color, diaphaneity, luminescence, fluorescence, phosphorescence, play of colours,luster, streak, hardness, specific gravity. Electrical, magnetic and radioactive properties of minerals.	
Module II- Chemical mineralogy	**15**
Chemical Mineralogy: Types of Bonds, ionic radii, ionic ratios, Polymorphism, isomorphism, pseudomorphism, solid solution and exsolution in minerals. Silicate structure	
Module III- Physical properties	**16**
Physical and chemical properties of the following: olivines, garnets, pyroxenes amphiboles, micas, feldspars, feldspathoids, quartz.	
Module IV Practical	**14**
Megascopic study of minerals like Quartz, orthoclase, microcline, plagioclase, hypersthene, diopside, augite, wollastonite, anthophyllite, tremolite, actinolite, hornblende, olivine, serpentine, muscovite, biotite, phlogopite, chlorite, epidote, garnet, natrolite, stilbite, apophyllite, talc, gypsum, apatite, andalusite, kyanite, sillimanite, staurolite, cordierite, apatite, beryl, topaz, calcite, dolomite, tourmaline, zircon, fluorite, magnetite, hematite, chromite, sphalerite, psilomelane, pyrolusite, graphite, corundum.	
Module V	**10**
Teacher Specific related to course Mineralogy	

Reference

1. Read, H. H. (1984) Rutley's elements of Mineralogy. CBS Publishers, Delhi
2. Berry, L.G., Mason, B. and Dietrich, R.V. (2004) Mineralogy. CBS Publishers and & Distributors, New Delhi, India.
3. William D. Nesse (2008) Introduction to Mineralogy. Oxford University Press
4. Perkins Dexter (2006) Mineralogy. Pearson Education; Prentice Hall
5. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand basic ideas of Mineralogy regarding its scope and aim; and describe silicate structures, physical, electrical, magnetic and radioactive properties	U & E	F &C	Assignment & final exam
CO2	Understand chemical Mineralogy and explain bonds in minerals, morphological characters of minerals, solid solution and exsolution in minerals.	U & E	F &C	Quiz, Assignment & final exam
CO3	Determine and describe the physical properties of minerals and identify different minerals.	U, E, &A	F, C &P	Assignment final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3		3	1	2
CO 2		3		2	2	2
CO 3		2		2	3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK2DSCGLY171**		**Minerals and Rocks**		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Mineralogy	**15**
Minerals – definition, classification of physical properties of minerals -form, habit, cleavage, fracture, colour, diaphaneity, luminescence, fluorescence, phosphorescence, play of colours, luster, streak, hardness, specific gravity. Electrical, Magnetic, and radioactive properties of minerals. Brief description of major rock forming minerals like Quartz, Feldspar, Pyroxene, Mica, Olivine, Amphiboles, Garnet etc	
Module II- Igneous petrology	**15**
Magma: Types & properties, Igneous rock: texture: crystallinity ,shape of grains , Porphyritic, Poikilitic, Perthite, Forms: Lacolith, Lopolith, Phacolith ,Dyke ,Sill, Batholith, Stock, Boss : major igneous rock Granite, Rhyolite , Syenite , Dolerite, Gabbro , Pegmatite .	
Module III- Sedimentary petrology and Metamorphic petrology	**16**
Sediments - Process of formation, Texture-grain size, morphology, sorting, packing , Fabric- textural maturity: Structures: Physical- bedding, graded bedding ,ripple marking-cross bedding, mud cracks , Major rocks: Sandstone, limestone , conglomerate, breccia, shale. Metamorphic petrology: Definition, factors, types, limits: textures, major rocks: Slate schist, Phyllite , Gneiss , Khodalite ,Marble , Charnokite.	
Module IV- Practical	**14**
Megascopic properties of important igneous rocks, Sedimentary rocks and Metamorphic rocks.	

Module V- Teacher specific	**10**
Teacher specific Content related to Minerals and Rocks	

Reference

1. Dana, E. S. (1955) A Textbook of Mineralogy. Asia Publishing House, Wiley.
2. Phillips, F.C. (1956) An Introduction to Crystallography. Longmans Green.
3. Read, H.H. (1984) Rutley's Elements of Mineralogy. C.B.S. Publishers.
4. Mason, B. and L.G. Berry (1968) Elements of Mineralogy. W. H. Freeman & Co.
5. Klein, C. and C.S. Hurlbut (1993) Manual of Mineralogy. John Wiley, New York.
6. Deer, W.A., Howie, R.A. and J. Zussman (1983) An introduction to the Rock forming minerals. Longman.
7. Kerr, P.F. (1977) Optical Mineralogy. McGraw Hill Book Company, New York.
8. Perkins Dexter (2015) Mineralogy. Pearson Education.
9. Tyrrell, G.W. (1978) Principles of Petrology. Chapman and Hall Ltd., London.
10. Pettijohn, F.J. (1983) Sedimentary Rocks. Harper & Bros.
11. Harker, A. (1964) Petrology for Students. Cambridge.
12. Folk, R.L. (1981) Petrology of Sedimentary Rocks. Hemphils Pub. Co.
13. Greensmith, J. (1989) Petrology of the Sedimentary Rocks. 7th Edn., CBS Publishers, Delhi.
14. Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology. Prentice Hall, New Jersey.
15. Winkler, H.G.F. (1974) Petrogenesis of Metamorphic Rocks, 5th, 6th and 7th eds. Springer Verlag.
16. Yardley, B.W.D. (1989) Textbook of Metamorphic Petrology. Longman.
17. Turner, F.J. and Verhoogen, J. (1960) Igneous and Metamorphic Petrology. McGraw Hill.
18. Williams, H., Turner, F.J. and Gilbert, C.M. (1982) – Petrography. W. H. Freeman and Company, San Francisco, CA.
19. Bowen, N.L.M. (1956) The Evolution of the Igneous Rocks. Dover Publication, Inc, New York.
20. Barth, T.W. (1962) Theoretical Petrology. Wiley.
21. Walstrom, E.E. (1961) Theoretical Igneous Petrology, Wiley.
22. Turner, F.J. and Verhoogen, J. (1960) Igneous and Metamorphic Petrology. McGraw Hill.
23. Hatch, F.H. and A.K. Wells (1949) Petrology of Igneous Rocks. Thomas Murby &Wells, M.K.(Publ.)
24. Johannesen, A (1962) Descriptive Petrography of Igneous Rocks. Vols. I to IV, Allied Pacific. Allied Pacific.
25. Mackenzie, W.S., Donaldson, C.H. and C. Guilford (1988) Atlas of Igneous rocks and their textures. ELBS Longman.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Discuss mineral and its physical Properties.	U	F	Assignment & final exam
CO2	Identify Igneous, Sedimentary and Metamorphic rocks with Texture and Structure.	**U**	F	Quiz, Assignment& final exam
CO3	Interpret the association of various rock forming Minerals and major Igneous Sedimentary and Metamorphic rocks .	Ap	F, P	Assignment & final exam
* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create** # - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**				

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			3
CO 2			3			3
CO 3			3			3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO 3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK2DSCGLY170**		**A brief history of Earth**		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Nothing to the Present	**15**
Origin of Universe and evolution of Solar system. Internal structure of earth; crust, mantle, core; density and chemical composition; major seismic discontinuities. Earth systems: Subsystems-Hydrosphere, Biosphere, lithosphere: Cryosphere, and atmosphere. Evolution of Earth through time: Age of Earth: Relative and absolute age concepts. Introduction to geological time scale.	
Module II- The Dynamic Earth	**15**
Endogenic and Exogenic activities. Basic ideas of weathering, erosion, transportation, and deposition. Examples of geological agents. Plate tectonics and isostasy. Distribution of earthquake and volcanos.	
Module III- Evolution of life through time	**16**
Fossils and methods of fossilization. Precambrian life, The Cambrian Explosion. Biomineralization and skeletonization. Origin of vertebrates and early land plants, Mesozoic Life in the Jurassic, origin of mammals, Rise and fall of dinosaurs, Origin of birds; and spread of flowering plants. significance of trilobites and ammonoids, The age of humans. Mass extinctions.	
Module IV- Practical	**14**
Epicentre calculation, plotting of volcanoes and earthquake prone areas related to plate boundaries.	
Module V	**10**
Teacher Specific content related to a brief history of Earth	

Reference

1. Stanley, S.M., 2008 Earth System History
2. Jonathan I. Lumine W.H. Freeman Earth-Evolution of a Habitable World, Cambridge University Press.
3. Canfield, D.E. & Kon Hauser, K.O., 2012 Fundamentals of Geobiology Blackwell
4. Cowen, R., 2000 History of Life, Blackwell
5. Strahler, Arthur Newell, The Earth Sciences, New York, Harper & Row
6. Carlson, Plummer and McGeary: Physical Geology– Earth revealed, Published by McGraw-Hill, 2006
7. Carlson, Plummer, and Mc Geary: Introductory Geology – Earth Revealed, Published by McGraw-Hill.
8. Press and Siever, Understanding Earth, W. H. Freeman; 4 edition, 2003
9. Ernst W. G., Earth Systems: Processes and Issues, Cambridge University Press,2000.
10. Frederick K. Lutgens, Essentials of Geology (11th Edition) Pearson Prentice Hall, Pearson Education, Inc. New Jersey, 2012

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Introduction to Earth, Age of Earth, Interior of earth and Earths Dynamics.	U	F	Assignment & final exam
CO2	Understand Basic concepts of Stratigraphy, GTS, and methods of fossilization.	**U**	C	Quiz, Assignment& final exam
CO3	Analyze various events in GTS	An	P	Assignment & final exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					
CO 2			2			
CO 3					2	

Level		1	2	3
Correlation	Nil	Slightly/Low	Moderate / Medium	Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	
CO 2		✓		✓
CO 3			✓	

Discipline and Type of Course	**Geology**		**Multi-Disciplinary Course - MDC**		
Course Code and Title	**UK2MDCGLY100**		**Geoscience and Environmental management**		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial Per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Earth and water	**12**
Introduction and branches of Geology. Earth-Size, shape, and interior structure. Hydrologic cycle. Hydrologic cycle, groundwater - Infiltration, zones of groundwater, ground and perched water tables, open wells and bore wells	
Module II- Surfaces process	**12**
Surface process: Weathering – agents, types, and products of weathering. Mass wasting-Types. Landslide. Subsurface process-Earthquakes (Epicenter and focus, intensity and magnitude scales, Seismographs, and seismogram). Volcanoes - types and distribution of major volcanoes. Tsunami. Brief idea of roles played by streams, oceans, wind, and glaciers on modifying the earth's surface.	
Module III- Climate change influence on Geosphere	**12**
Climate change: Greenhouse effect and global warming. Anthropogenic influence on Geosphere and their impact on climate change. Geosphere exploitation and Environmental pollution. Natural Hazards and vulnerability scenario in India.	
Module IV	**10**
Teacher Specific related to course Geosphere and Environment management	
Reference	
1. Valdiya, K.S. (1987) Environmental Geology: Indian Context, Tata Mc-Graw Hills. 2. Strahler, A.N. and Strahler, A.H. (1973) Environmental Geosciences: Interaction between natural systems and man. John Wiley & Sons Inc. 3. Donald R Caotes (1981) Environmental Geology. John Wiley and Sons. 4. Keller, E.A. (1978) Environmental Geology. Bell and Howell, Prentice Hall, USA. 5. Bryant, E. (1985) Natural Hazards. Cambridge University Press	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and explain the subject meaning of Geology and its branches; describe the characters of earth; explain hydrologic cycle and role of groundwater.	U & E	F &C	Assignment & final exam
CO2	Understand and describe the various exogenic and endogenic processes that form a part of earth system, including earthquakes and volcanoes.	U & E	F &C	Quiz, Assignment & final exam
CO3	Understand and describe Global climate change, causes and effects; explain the significance of pollution. and waste disposal	U & E	F &C	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3	3			3	2
CO 2	2	2			2	3
CO 3	2	2			3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	Geology		Multi-Disciplinary Course - MDC		
Course Code and Title	UK2MDCGLY120		The Dynamic Earth		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3

Detailed Syllabus:

Content	Hrs.
Module I: Introduction to Geomorphology	**9**
The concept of Geomorphic Cycle and geological agents. Geological work of Streams, types of streams, drainage basin, patterns. Stream erosion- Concept of base level, degradational landforms transportation, types of loads, deposition. Long profile of stream - graded stream. Fluvial aggradation.	
Module II: Groundwater and its sources	**9**
Sources of Groundwater. Hydrologic cycle. Hydrological characteristics of earth materials -porosity & permeability - Aquifer, aquiclude, aquitard, aquifuge – Subsurface occurrence of groundwater, types of aquifers - confined and unconfined and artesian aquifers - springs, Recharge, and discharge of groundwater - different types of wells. Geological work of groundwater.	
Module III: Earth's thermal environment and Climates.	**9**
Glaciers and wind as Geological agent.: Glaciers – types, distribution, geological work- glacial landforms and moraines. Geological action of wind and aeolian landforms.	
Module IV: Introduction to Structural Geology	**9**
Concept of primary and secondary structures. Brief idea of deformation structures - fold fault, joint, foliation, lineation. Mass Movements with special emphasis on landslide and causes of hill slope instability; stability of slopes.	
Module V- Teacher Specific content	**6**
Teacher Specific content related to The Dynamic Earth	

Reference

1. Misra, H.C. (1995) A Handbook on GIS. GIS India, Hyderabad.
2. Ian Haywood, Sarah Cornelius, and Steve Carver (2000) An introduction to Geographical Information Systems. Addison Wesley Longman Ltd. New York.
3. Smith, T.R. and Piquet(1985)GIS. London Press, London.
4. Heywood, D.I., Cornelius,S.,and Carver,S. (1998). An introduction to Geographical Information Systems. Longman, New Delhi.
5. LoC.P.and Young, A.K.W. (2003) Concepts and Techniques of Geographical

Information System. Prentice Hall of India, New Delhi.
6 Pandey S. N.(1987) Principles and Applications of Photogeology, Wiley Eastern.
7 Ahamed,E.(1972)Coastal Geomorphology of India. Orient Longman, New Delhi.
8 Thornbury,W.D.(1968).Principles of Geomorphology, Wiley.
9 Plummer,Carlson, McGeary (2003).Physical Geology. McGraw Hill.
10 Weisberg,J ,and Parish,H.(1974). Introductory Oceanography. McGraw Hill.
11 Arthur Holmes (1977) Principles of Physical Geology (Edinburgh: Thomas Nelson and Sons,1944 and New York: Ronald Press,1945.
12 Bloom,A.(2004) Geomorphology – A Systematic analysis of Late Cenozoic Landforms (Third edition) Waveland Press Inc.
13 Vishwas S. Kaleand Avjit Gupta (2000). Introduction to Geomorphology, Orient Black Swan.
14 SparksB.W.(1969).Geomorphology, Longman.

Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
Understand the concept of Geomorphic cycle, geological action of Ground water, glacier and wind and its role in shaping landscapes.	U, An	C, F	Assignment, Final Exam
Evaluate Groundwater Systems and analyze Mass Movements and Slope Stability to identify different types of mass movements, with a focus on landslides.	Ap, An, E	C	Assignment, Final Exam
Introduce Structural Geology to understand the significance of deformation structures in interpreting the Earth's history and tectonic processes.	U, E	F, P	Assignment Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					
CO 2	3					
CO 3			3			

Level		1	2	3
Correlation	Nil	Slightly/Low	Moderate / Medium	Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO 3		✓	✓	✓

Discipline and Type of Course	**Geology**		**Multi-Disciplinary Course - MDC**		
Course Code and Title	**UK2MDCGLY121**		**Earth Materials**		
Semester	2		Academic Level: 100 - 199		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3

Detailed Syllabus:

Content	Hrs.
Module I: The Minerals	**9**
Definition and physical properties of minerals -form, habit, cleavage, fracture, colour, diaphaneity, luminescence, fluorescence, phosphorescence, play of colours, luster, streak, hardness, specific gravity. Electrical, magnetic and radioactive properties of minerals. Brief description of major rock forming minerals like quartz, feldspar, pyroxene, mica, olivine, amphiboles, garnet etc.	
Module II: Igneous Rocks	**9**
Magma: Types & properties. Igneous rock: texture, crystallinity, shape of grains, Porphyritic, poikilitic, Perthite. Forms: Lacolith, Lopolith, Phacolith, dyke, sill, batholith, stock .Major igneous rocks: - Granite, Rhyolite, Syenite, Dolerite, Gabbro and Pegmatite.	
Module III: Sedimentary Rocks:	**9**
Sediments -process of formation. Texture: -grain size, morphology, sorting, packing, Fabric and textural maturity. Structures: bedding, graded bedding, ripple marking, cross bedding and mud cracks. Major rocks: Sandstone, Limestone, Conglomerate, Breccia and shale.	

Module IV: Metamorphic Rocks	**9**
Definition of metamorphism and metamorphic rock. Factors affecting metamorphism, types and limits of metamorphism. Major textures and structures of metamorphic rocks. Major rocks: Slate, Schist, Phyllite, Gneiss, Khondalite, Marble and Charnockite.	
Module V- Teacher Specific content	**6**
Teacher Specific content related to Earth Materials	

Reference

1. Dana, E.S.(1955) A Textbook of Mineralogy .Asia Publishing House Wiley.
2. Read, H.H.(1984)Rutley's Elements of Mineralogy. C.B.S. Publishers.
3. Mason, B. and L.G. Berry(1968) Elements of Mineralogy. W. H. Freeman & Co.
4. Klein, C. and C.S. Hurlbut (1993) Manual of Mineralogy. John Wiley, New York.
5. Deer, W.A., Howie, R. A. and J.Zussman (1983) An introduction to the Rock forming minerals. Longman.
6. Perkins Dexter (2015) Mineralogy. Pearson Education.
7. Tyrrell,G.W. (1978) Principles of Petrology. Chapman and Hall Ltd. London.
8. Pettijohn,F.J. (1983) Sedimentary Rocks .Harper & Bros.
9. Folk,R.L.(1981) Petrology of Sedimentary Rocks .Hemphils Pub. Co.
10. Greensmith,J. (1989) Petrology of the Sedimentary Rocks. 7thEdn., CBS Publishers, Delhi.
11. Winter,J.D. (2001) An introduction to Igneous and Metamorphic Petrology. Prentice Hall, New Jersey.
12. Winkler, H.G.F.(1974) Petrogenesis of Metamorphic Rocks, 5th, 6thand7theds.SpringerVerlag.
13. Turner,F.J. and Verhoogen,J. (1960) Igneous and Metamorphic Petrology. McGraw Hill.
14. Turner, F.J. and Verhoogen,J .(1960) Igneous and Metamorphic Petrology. McGraw Hill.
15. Hatch,F.H.andA.K.Wells(1949) Petrology of Igneous Rocks. Thomas Murby & Wells, M.K. (Publ.)
16. Mackenzie, W.S., Donaldson, C. H .and C. Guilford (1988) Atlas of Igneous rocks and their textures. ELBS Longman.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the Properties and Classification of Minerals and rocks.	U	C, F	Assignment, Final Exam
CO2	Identify Minerals and rocks including their structures, compositions, and occurrence.	Ap	C	Assignment, Final Exam
CO3	Analyze Igneous, Sedimentary and Metamorphic rocks include their texture, classification and formation.	An	F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				3
CO 2		3				3
CO 3		2			1	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2	✓		✓	✓
CO 3	✓	✓	✓	✓

5.3 COURSES IN GEOLOGY: Semester 3

Discipline and Type of Course	Geology		Discipline Specific Core - DSC		
Course Code and Title	UK3DSCGLY200		Crystals and Minerals		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture Per week	Tutorial Per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- The Study of Crystals	**15**
Crystallography-Crystalline state and crystals, Elements of crystals (face, edge and vertex). Angles in crystals (plane, interfacial and solid angles) and their determination using Goniometer (contact and reflection). Concept of symmetry in crystals and operations- Axis, plane, centre and roto-inversion. General Mathematical relations in Crystals-Crystallographic axes, Axial ratio and axial plane. Nomenclature of crystal faces-Unit face, Intercepts of crystals-Parameters (Weiss notation) and Indices (Miller Index and Miller-Bravais index). Zones and Zone symbols. Overview of crystal systems and classes. Brief study of holohedral, hemihedral, hemimorphic and enantiomorphic classes. Important laws in Crystallography- Law of constancy of interfacial angle, law of rational indices and law of constancy of symmetry.	
Module II- Introduction to Minerals	**15**
Originof Minerals. Chemical bonding in minerals, Classification of minerals. Silicate structures and types, Isomorphism, Polymorphism, Pseudomorphism, exsolution and solid solution. Physical properties of minerals- Properties depending on external appearance (form and habit), on light (colour, streak, lustre, diaphaneity and luminescence), on mechanical cohesion (hardness, tenacity, cleavage, fracture and parting) on mass (density and specific gravity) and action of senses (odour, taste, feel and reaction with acids). Properties depending on electricity, magnetism and radioactivity.	

Module III- Optical mineralogy	**16**
Ordinary and polarized light, polarization of light, refractive index, critical angle and total internal reflection. Polarization by reflection, absorption, and refraction. Isotropic and anisotropic substances. Uniaxial and biaxial minerals. Double refraction, construction of Nicol prism. Petrological microscope - parts and functions. Optical accessories - mica plate, gypsum plate and quartz wedge. Optical properties- Colour, relief, pleochroism, interference colour and its order, extinction and its types, birefringence and optic sign, Basic description of optical indicatrix.	
Module IV – Practical	**14**
Systematic study and physical identification of important non-silicate minerals- Calcite, dolomite, aragonite, magnesite, diamond, graphite, sulphur, molybdenite, sphalerite, galena, chalcopyrite, pyrite, magnetite, hematite, marcasite, barite, gypsum, halite, fluorite, corundum, cuprite, chromite, rutile, ilmenite, monazite, psilomelane, pyrolusite, limonite, bauxite, malachite, azurite, realgar and orpiment.	
Module V	**10**
Teacher Specific related to course Crystals and Minerals	

Reference

1. Dana, E. S. (1955) A Textbook of Mineralogy. Asia Publishing House, Wiley.
2. Phillips, F.C. (1956) An Introduction to Crystallography. Longmans Green.
3. Read, H.H. (1984) Rutley's Elements of Mineralogy. C.B.S. Publishers.
4. Mason, B. and L.G. Berry (1968) Elements of Mineralogy. W. H. Freeman & Co.
5. Klein, C. and C.S. Hurlbut (1993) Manual of Mineralogy. John Wiley, New York.
6. Deer, W.A., Howie, R.A. and J. Zussman (1983) An introduction to the Rock forming minerals. Longman.
7. Kerr, P.F. (1977) Optical Mineralogy. McGraw Hill Book Company, New York.
8. Perkins Dexter (2015) Mineralogy. Pearson Education.
9. Perkins D. and Henke K. R. Minerals in thin section. Pearson Education Inc., 2004.
10. Nesse W. D. Introduction to Optical Mineralogy. Oxford University Press, 2004.
11. Nesse W. D. Introduction to Mineralogy. Oxford University Press, 2008.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic elements of crystallography and measurement of interfacial angles	U,R	F	Quiz, ESE
CO2	Understand and analyze the structure, physical, and chemical. properties of minerals	U,An	F,P	Assignment ESE
CO3	Understand and analyse the principles, parts of Petrological microscopes and the elements of optical Mineralogy.	U,An	F,P	ESE
CO4	Physical identification of important non-silicate minerals	Ap, An	P	Quiz ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				2
CO 2		3				3
CO 3		3				2
CO4					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO 3			✓	✓
CO 4		✓	✓	✓

Discipline and Type of Course	Geology			Discipline Specific Core - DSC	
Course Code and Title	UK3DSCGLY220			Mineral Science	
Semester	3			Academic Level: 200 - 299	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I: Crystallography	**16**
Crystallography: Crystal-Concept of crystalline matter; Interfacial angle and external morphology in relation to internal structures; Repetition Theory and laws of crystallography. Translation periodicity of crystals. Space lattices. Weiss parameters and Miller indices; form and zone. Crystal symmetry- elements and operations. Classification of crystals into systems and point groups. Hermann Mauguin notation	
Module II: Crystallography and Projection	**12**
Detailed study of Symmetry elements, forms, type minerals, holohedral, hemihedral, hemimorphic and enantiomorphic forms HM symbols of normal classes of six crystal systems, Twinning, Twin Laws, twin plane, twin axes and mineral examples. Morphological imperfections in crystals. Basic concepts of spherical and stereographic projections in crystallography, Wulff net.	
Module III: Physical and chemical mineralogy	**18**
Physical and chemical mineralogy: Minerals – definition, classification. Physical properties of minerals -form, habit, cleavage, fracture, colour, diaphaneity, luminescence, fluorescence, phosphorescence, play of colours, luster, streak, hardness, specific gravity. Electrical, magnetic and radioactive properties of minerals. Atomic arrangements: Chemical bonding- Types, Close packing in crystals- CCP, FCC and HCP; Ionic radius, ratio and coordination; Pauling's rules. Solid Solution, Polymorphism, Pseudo morphism.	
Module IV: Practical	**14**
Calculation of crystal parameters, indices and zone symbols, Identification of crystal forms in normal classes, Stereographic projections of normal classes of isometric and tetragonal systems, Identification of physical properties of minerals.	

Module V: Teacher specific content	**10**
Teacher specific content related to Mineral Science	

Reference

1. 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.
2. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman.
3. Nesse, W. D. (2011). Introduction to Optical Mineralogy (Fourth Edition). Oxford University Press.
4. Putnis, A. (1992): Introduction to Mineral Sciences. Cambridge University Press.
5. Whalstrom, E.E. (1969): Optical Crystallography. John Wiley & Sons
6. Verma, P. K. (2010). Optical Mineralogy (Four Colour). Ane Books Pvt Ltd.
7. Nesse, W.D., 2000, Introduction to Mineralogy, Oxford University Press, New York, 442 p.
8. Phillips, F.C. (1956) An Introduction to Crystallography. Longmans Green.
9. Read, H.H. (1984) Rutley's Elements of Mineralogy. C.B.S. Publishers.
10. Mason, B. and L.G. Berry (1968) Elements of Mineralogy. W. H. Freeman & Co.
11. Kerr, P.F. (1977) Optical Mineralogy. McGraw Hill Book Company, New York.
12. Perkins Dexter (2015) Mineralogy. Pearson Education.

CO	**Course Outcome**	**Cognitive Level***	**Knowledge Category#**	**Evaluation Tools used**
CO1	Understand crystal structures and symmetry	R	F	Assignment, Final Exam
CO2	Identify crystal forms through crystallographic orientation and derive indices and parameters	**U**	C	Assignment, Final Exam
CO3	Interpret various minerals through physical properties.	AP	P	Assignment, Final Exam
CO4	Understand crystal structures and symmetry	R	F	Quiz Final exam

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\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				2
CO 2		3				2
CO 3					3	3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO 3			✓	✓
CO 4			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK3DSCGLY250**		**Petrology**		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Rocks	**15**
Rock - definition, types, rock cycle, plutonic, hypabyssal and volcanic igneous rocks. Forms of Intrusive igneous rocks: Concordant and Discordant forms. Forms of extrusive igneous rocks: lava flows, pyroclastic deposits - agglomerate, lapilli, volcanic ash and pumice. Classification of igneous rocks based on texture and mineralogy (felsic and mafic minerals and colour index). Chemical classification – Based on silica saturation and based on alkali & silica.	
Module II- Sediments	**15**
Origin of sediments. Diagenesis - Compaction, cementation, authigenesis, recrystallization and replacement. Classification of sedimentary rocks – Clastic and non-clastic rocks. Clastic texture - concept of size, Udden-Wentworth and Phi scale scheme. Grain shape, morphology and fabric. Non- clastic texture – different	

types of crystalline texture. Brief study of the following: Primary, secondary and organic structures. Categorization of mechanical rocks: Argillaceous, arenaceous and rudaceous rocks. Introduction to the following: sandstone, shale, conglomerate and breccias.	
Module III- Metamorphism	**16**
Definition of metamorphism. Factors of metamorphism - pressure, temperature, chemically active fluids, time and parent rock chemistry, Limits of metamorphism. Types of metamorphism –Contact metamorphism, Regional metamorphism – orogenic and ocean floor, Burial metamorphism, Cataclastic metamorphism, hydrothermal metamorphism Impact/shock metamorphism and plutonic metamorphism. Metamorphic textures – Crystalloblastic and Relict textures. Metamorphic structures – foliations, lineations, cataclastic and miscellaneous. Brief study of the following metamorphic rocks: Slate, Phyllite, Quartzite, Marble, Schists, Amphibolite, Gneisses, Eclogite, Blueschist.	
Module IV Practical	**14**
Megascopic study of important igneous, sedimentary and metamorphic rocks	
Module V	**10**
Teacher Specific related to course Petrology	

Reference

1. Tyrrell, G.W. (1978) Principles of Petrology. Chapman and Hall Ltd., London
2. Turner, F.J. and Verhoogen, J. (1960) Igneous and Metamorphic Petrology. McGraw Hill.
3. John D. Winter (2012) An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.
4. Ehlers, G.E. and Blatt, H. (1999) Petrology – Igneous, Sedimentary and Metamorphic. CBS Publishers and Distributors, New Delhi
5. Pettijohn, F.J. (1983) Sedimentary Rocks. Harper & Bros.
6. Folk, R.L. (1981) Petrology of Sedimentary Rocks. Hemphils Pub. Co.
7. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
8. Myron G. Best (2001). Igneous and Metamorphic Petrology
9. Nichols, G. (2009) Sedimentology and Stratigraphy Second Edition. Wiley Blackwell

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the igneous rocks, metamorphic rocks, sedimentary rocks, rock cycle and origin of sediments.	U & E	F &C	Assignment & final exam
CO2	Understand and explain the origin, factors, types, forms, texture, classification of igneous, metamorphic and sedimentary rocks.	U & E	F &C	Quiz, Assignment & final exam
CO3	Identify and describe the megascopic and microscopic properties of important igneous, sedimentary and metamorphic rocks.	U, E, &A	F, C &P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3		2	1	3
CO 2		3		3	3	3
CO 3		1		3	3	3

Level		1	2	3
Correlation	Nil	Slightly/Low	Moderate / Medium	Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Core - DSC		
Course Code and Title	UK3DSCGLY251		Earth Structures		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Introduction to Structures	**14**
Introduction to Structures- Geologic significance of structures in rocks. - Primary and Secondary structures: Igneous structures (extrusive and intrusive) - Sedimentary structures (Primary and secondary), Metamorphic structures (Foliation, lineation, schistose, gneissose, slaty cleavage, cataclastic structure)	
Module II- Fold and faults	**16**
Attitude of planar and linear features on earth- Strike, dip, pitch and plunge. Brief idea of measurements of structural features using Brunton compass. Folds –Parts of fold, Types (antiform, synform, anticline, syncline and recumbent fold) , - Fault- Fault terminology and types (normal, reverse, strike-slip, dip-slip, horst and graben)	
Module III- Structural landforms	**16**
Major Structural landforms of Earth- Mountains (folded, faulted, relict and volcanic), Mid Oceanic Ridges, Continental shelf, slope, Abyssal plains, Subduction zones, Island arc and volcanic arcs, Seamounts and guyots	
Module IV Practical	**14**
Geological maps and structural problems involving true dip and apparent dip.	
Module V	**10**
Teacher Specific related to course Earth Structures	
Reference	
1. Billings (1974) Structural Geology. 11th edition, Prentice Hall. 2. Ken McClay (1991) The mapping of Geological Structures. Geological Society of London. Wiley, New edition. 3. R. J. Twiss and E M Moore (2007) Structural Geology 2nd edition. Freeman & Company	

4. Park R. G. (1997) Foundations of Structural Geology 3rd, Chapman & Hall.
5. Park, R. G. (2004) Foundations of Structural Geology.Chapman& Hall.
6. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
7. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the geologic significance of structures in rocks, and structural landforms of earth emphasis on mountains and features of ocean floor.	U & E	F &C	Assignment & final exam
CO2	Understand and describe the attitude of planar and linear features on earth, folds and faults with reference to their origin, terminologies, classification and their significance.	U & E	F &C	Quiz, Assignment & final exam
CO3	Illustrate and analysis of geologic maps with different structural features. .	U, E, &A	F, C &P	Assignment & final exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3	3			2	3
CO 2	3	3			3	3
CO 3	1	2			3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO 3	✓	✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK3DSCGLY270**		**Dynamic Earth and Earth Resources**		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Geomorphology	**16**
Streams: types of streams, drainage basin, patterns. Geological work of streams – erosion- Concept of base level, degradational landforms transportation, types of loads, deposition - -long profile of stream - graded stream. - fluvial aggradation. Glaciers – types, distribution, geological work- glacial landforms, moraines. Groundwater and its sources. Sources of groundwater. Hydrologic cycle. Hydrological characteristics of earth materials -porosity & permeability - Aquifer, aquiclude, aquitard, aquifuge – Subsurface occurrence of groundwater types of aquifers - confined and unconfined and artesian aquifers - springs, Recharge and discharge of groundwater - different types of wells. Geological work of groundwater	
Module II- Structural geology	**15**
Concept of primary and secondary structures, Attitude of planar and linear structures. Parts and Geometrical classification of deformation structures - fold fault, joint, foliation, lineation. Engineering application of deformation structures in construction of dams and reservoirs, tunnels, roads, railways, bridges and buildings. Mass Movements with special emphasis on landslide and causes of hill slope instability.	
Module III- Economic Geology	**15**
Basic Concepts and significance of Economic Geology, Ore, gangue, industrial minerals, tenor ,grade. Assay value . Brief study of important process of ore mineral formation: Magmatism, hydrothermal processes, contact metasomatism, metamorphism, evaporates, residual and mechanical concentration, supergene and sulphide enrichment. Occurrence of Iron Kudremukh , Coal – Bokaro, Jharkhand, Petroleum–Naharkotiya, Assam & Bombay. Mica deposits-Nellore, Andrapradesh	

Module IV- Practical

Megascopic identification of ore minerals of Iron , Lead and Zinc , Manganese Copper and Aluminium. Basics of topographic maps and contours. Structural map reading and creation of cross sections.

Module V - Teacher Specific content

Teacher Specific content related to Dynamic Earth and Earth Resources

Reference

1. Thornbury, W. D. (1968). Principles of Geomorphology, Wiley.
2. Plummer, Carlson, McGeary (2003). Physical Geology. McGraw Hill.
3. Weisberg, J, and Parish, H. (1974). Introductory Oceanography. McGraw Hil
4. Arthur Holmes (1977) Principles of Physical Geology (Edinburgh: Thomas Nelson and Sons, 1944 and New York: Ronald Press, 1945.
5. Bloom, A. (2004) Geomorphology – A Systematic analysis of Late Cenoz Landforms (Third edition) Wavel and Press Inc.
6. Vishwas S. Kale and Avjit Gupta (2000). Introduction to Geomorphology, Orient Black Swan.
7. Sparks B. W. (1969). Geomorphology, Longman
8. Strahler, Arthur Newell, The Earth Sciences, New York, Harper & Row
9. Press and Siever, Understanding Earth, W. H. Freeman; 4 edition, 2003
10. Ernst W. G., Earth Systems: Processes and Issues, Cambridge University Press,2000.
11. Frederick K. Lutgens, Essentials of Geology (11th Edition) Pearson Prentic Hall, Pearson Education, Inc. New Jersey, 2012.
12. Anthony M. Evans (1980). An introduction to Ore Geology, second edition, ELBS.
13. Umeshwer Prasad (1996). Economic Mineral Deposits, CBS Publishers.
14. Mead L. Jensen and Alan M. Bateman (1981). Economic Mineral Deposits, John Wiley& Sons Third edition, revised printing Billings (1974) Structural Geology. edition, Prentice Hall.
15. Park R. G. (1997) Foundations of Structural Geology 3rd, Chapman & Hall.
16. Hills, E. S. (1961) Elements of Structural Geology, Asia Publishing House.
17. Hobbs, Means and Williams (1976). An Outline of Structural Geology. John Wiley.
18. John Robberts (1982) Introduction to Geological Maps and Structures, Pergar Press.
19. Ken McClay (1991) The mapping of Geological Structures. Geological Soci of London. Wiley, New edition.
20. R. J. Twiss and E M Moore (2007) Structural Geology 2 edition. Freeman & Company

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Students able to Classify various Geological agents and their Work.	U	C	Assignment & final exam
CO2	Discuss economic importance of Minerals, various processes of ore formation and Engineering application of various deformation structures.	**U**	C, F	Quiz, Assignment& final exam
CO3	Use knowledge to locate various Ore deposits in India.	Ap	F, P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					2
CO 2		3				2
CO 3				3		3
Level		1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓		✓
CO 2	✓		✓	✓
CO 3			✓	

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK3DSCGLY271**		**Environmental Geology**		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Fundamentals of Environmental Geology	**16**
Introduction to the concept and dimensions of environmental geology; Relationships between geological processes and environmental/ecological changes; Role of an environmental geologist in social and economic development. Introduction to environmental hazards. Types and classifications of disasters. Comprehensive disaster management plan. The Disaster Management Cycle: Mitigation, preparedness, Response and Recovery phases. Relevance of disaster management plan in Kerala. Land use planning.	
Module II- Environmental Geology and Natural Resources	**15**
Definition and characteristics of natural resources; economic importance of different types of natural resources (mineral and fuel resources, construction resources, water resources, biological resources, aesthetic, and scientific geological resources); Geological dimension of conservation and sustainable development of natural resources	
Module III- Geology of Urban Environments	**15**
Introduction to urban environments and issues associated with them (waste generation and urban pollution in open dumps, landfills and drains); Role of geologists in urban planning and management issues (effluent treatment and waste disposal). Environmental Impact Assessment, Concept of environmental impact assessment (EIA).	
Module IV- Practical	**14**
Case studies based on EIA regarding land use planning and disaster management	
Module V- Teacher Specific content	**10**
Teacher Specific content related to Environmental Geology	

Reference

1. Coates D. R. (Ed). Environmental Geomorphology and Environmental Geoscience. Wiley, 1973.Strahler A. N. Strahler A. H. Environmental Science. 1973.
2. Simmons I. G. The Ecology of Natural Resources. Edward Arnold Ltd., 1981.
3. Barlin L. G. Earthquakes and Urban Environment. Vol.2 and 3. CRC Press Inc., 1980. Lillesand T. M and Kiefer R. W. Remote Sensing and Image interpretation. John Wiley, 1979.Estors J. E. and Senger L. W. Remote Sensing. Hamilton Publishing Company, 1974.
4. Seigal B. S. and Gillespie A. R. Remote Sensing in Geology. John Wiley & sons, 1980.
5. Kerr J. M. and others. Natural Resource Economics. Oxford and IBH Publ. Co. Pvt. Ltd, 1997.Hanley N. and others. Environmental Economics. Mac Millan Ind. Ltd., 1997.
6. Frampton S. and others. Natural Hazards. Holder and Stoughton, 1996.
7. Skinner C. H. & Berger R. A. Geology and Health. Oxford University Press, 2000.Selnius (Ed). Essentials of Medical Geology. Elsevier, 2005.
8. 8.Flawan P. T. Environmental Geology John Wiley & Sons, 1970.Coates D. R. Environmental Geology. John Wiley & Sons, 1981.
9. 9.Valdiya, K. S. Environmental geology, Indian context. Tata McGraw-Hill Pub. Co., 1987.
10. Bennett, Matthew R., and Peter Doyle. Environmental geology: geology and the human environmental. John Wiley, 1997.
11. Botkin, Daniel B., and Edward A. Keller. Environmental science: earth as a living planet. No. Ed. 2. John Wiley &Sons Ltd, 1998.
12. Mareddy, Anji Reddy, Shah, A. and Davergave, N. Environmental impact assessment: theory and practice. Butterworth-Heinemann, 2017.
13. Reichard, J. Environmental Geology 3rd Edition. McGraw Hill, 2017

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Explain concepts of environmental geology and relation to geologic processes and Detailed study of earth resources.	U	C, F	Assignment & final exam
CO2	Understand Urban environmental issues, EIA, Hazards and their mitigation.	**U**	F	Quiz, Assignment& final exam
CO3	Organize various disasters faced in India.	An	F, P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			3
CO 2			3			3
CO 3			3			3
Level		1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓		
CO 3			✓	✓

Discipline and Type of Course	**Geology**	**Discipline Specific Elective - DSE**			
Course Code and Title	UK3DSEGLY200	**Fundamentals of Hydrogeology**			
Semester	3	Academic Level: 200 - 299			
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4

Detailed Syllabus:

Content	Hrs.
Module-1- Hydrologic Cycle Occurrence of Groundwater	**15**
Concept of Hydrosphere and distribution of water on earth, Hydrologic cycle, Importance and origin of Ground water, Vertical distribution of ground water, Water table, Storage and Ground water bearing formations- aquifer, aquiclude, aquitard, aquifuge. Aquifer properties-- Porosity, permeability, transmissivity, storativity, specific yield and specific retention. Types of aquifer- Confined, unconfined, perched, leaky and idealized aquifer.	
Module II- Groundwater movement and wells	**15**
Movement of Ground water- Types of Fluid flow, Darcy's law, hydrologic conductivity of geologic materials, Types of wells- dug well, bore well, artesian well. Springs and its Types.	

Module III- Groundwater quality	**16**
Quality of Ground water- Physical, chemical and biological measures, Groundwater pollution, Brief idea on Groundwater provinces of India and Groundwater status in Kerala	
Module IV Groundwater recharge methods and saltwater intrusion	**14**
Concept of Ground water recharge and discharge, Groundwater management. Artificial recharge techniques, Saltwater intrusion: causes, effects and prevention	
Module V	**10**
Teacher Specific related to course Hydrogeology	

Reference

1. Todd, D.K. (1980). Groundwater Hydrology. John Wiley & Sons.
2. Todd, D.K. and L.W. Mays (2004). Groundwater Hydrology. 3rd Edn. John Wiley & Sons.
3. Davis, S.N. & Deweist, R.J.M. (1966). Hydrogeology, John Wiley & Sons, New York.
4. Ragunath, H.M (2007). Groundwater, New Age International Publishers, Delhi
5. Karanath, K.R. (1987). Groundwater Assessment, Development & Management, TataMc-Graw Hill.
6. Ramakrishnan, S. (1998). Groundwater. K.G. Graph Arts, Chennai.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concept of hydrologic cycle and movement and occurrence of groundwater.	R,U	F,C	Assignment, Final Exam
CO2	Understand the movement of groundwater, types of wells and springs	R,U	F,C	Assignment, Final Exam
CO3	Understand the groundwater quality and pollution with respect to Indian and Kerala Scenario.	R,U	F,C	Assignment, Final Exam
CO4	Understand the concept of groundwater recharge methods and saltwater intrusion.	R, Ap,	C	Quiz Final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	1					2
CO 2	2					2
CO 3	2					3
CO4		2			3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Elective - DSE**		
Course Code and Title	**UK3DSEGLY220**		**Hydrogeology**		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4

Detailed Syllabus:

Content	Hrs.
Module I- Ground water a Resource	**12**
Ground water as a Resource- Chemistry and properties of water, Global distribution of fresh water, Resource of groundwater, Hydrological cycle: Hydrological measurements - evapo- transpiration, Latent heat, Humidity-Clouds, Precipitation-types, Soil moisture: gravitational water, field capacity, soil infiltration & Percolation, Run off, Through flow, Base flow, Interflow and river flow. Water budgeting, water balance studies. Impact of hydrological cycle (hydrometeorology)	

Module II- Hydrological Characteristics of Earth materials	**12**
Properties- Porosity, permeability, specific Yield, Specific retention, aquifer, aquiclude, aquifuge Distribution of ground water: Confined & Unconfined aquifer, Zones of aeration and saturation, Capillary fringe water table and potentiometric surfaces, Artesian aquifers; Perched aquifers, Leaky or Semi-confined aquifers; Darcy's law & application, hydraulic conductivity, hydraulic gradient, transmittivity, Springs: Definition, origin, types of springs. Causes for water table fluctuations.	
Module III- Water Quality	**12**
Physical and chemical characters, Major, Secondary, minor and trace constituents, Criteria for different uses, Graphical representations of chemical data, Determination of agricultural suitability, Role of rocks and minerals in water quality. Groundwater investigation techniques - geophysical exploration methods with special emphasis on electrical resistivity method, well logging, tracer techniques. water conservation methods – check dams, ponds, sub surface dykes, concept of artificial recharging of groundwater. Hydrogeological provinces of India. Groundwater status in India. Major aquifers and groundwater exploitation in Kerala. Saline intrusion, Land subsidence, Contamination.	
Module1V- Teacher Specific	**6**
Teacher Specific related to Hydrogeology	

Reference

1. Bouwer,H.GroundwaterHydrology,1978.
2. Davis,S.N.andDewiest,R.J.N.Hydrogeology,JohnWileyandSonsInc.NewYork,1966.
3. HiscockK(2005)Hydrogeology,Principle&Practice,Blackwellpublishing.
4. Krisch R(2006)Groundwater geophysics, Springer -Verlag
5. Linsley,R.K.,Kohler,M.A.andTaulhus,J.L.H.AppliedHydrology,TataMcGrawHill, 1975.
6. Todd,D.K. Groundwater Hydrology, John Wileyand Sons, 1980.
7. Walton, W.C. Groundwater Resource Evaluation, McGraw HillInc.,1970.
8. Reghunath, H.M.Groundwater.2nd Edn.WileyEasternLimited.1992.
9. Sharma H.S.Well Hydraulics and Tube Wells.
10. KaranthK.R.,1987,Groundwater:Assessment,Developmentandmanagement,TataMc Graw- Hill Pub. Co. Ltd.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand Groundwater as a Resource,	An	C, F	Assignment, Final Exam
CO2	Differentiate rock properties affecting Ground water flow and Flow parameters	**An**	C	Assignment, Final Exam
CO3	Critically Evaluate Physical and chemical properties of water and water quality. And Groundwater investigation techniques	E	F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				3		2
CO 2				3		3
CO 3					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	Geology		Value added Course - VAC		
Course Code and Title	UK3VACGLY200		Earth and its Resources		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Earth as a System	**12**
Components of Earth system- Geosphere, Hydrosphere, Atmosphere and Biosphere. Processes of origin of Resources- A brief study of magmatic, sedimentary, metamorphic, hydrothermal and metasomatic processes. Earth Materials- A brief study of the significance, uses and management of minerals, rocks, fossils, soil, water and fuels.	
Module II- Resources of Lithosphere	**12**
Minerals- Origin, Classification and distribution in the earth's crust. Uses of major minerals- Quartz, feldspar, clay, iron oxides, bauxite, gemstones. Rocks- Types, classification and economic and industrial applications. Rocks as construction materials- Granite, gabbro, sandstone, limestone, gneiss and marble. Earth's Fuels- Origin, occurrence and distribution of coal, petroleum and natural gas in the Indian subcontinent.	
Module III- Issues of Resource Management -	**12**
Problems associated with Resource-mining, utilization and waste disposal. Types of mining- Open cast and underground and their environmental issues (pollution of land, water and air). Utilization- Generous use (Reduce, reuse and recycling) and protection of resources. Waste disposal- Methods of disposal of waste- landfills, sanitary landfills, safe disposal.	
Module IV	**6**
Teacher Specific related to course Earth and its Resources	

Reference

1. Frederick K. Lutgens and Edward J. Tarbuck(2018), Essentials of Geology, 13th Edition. Pearson Education, Inc. New York. P. 607.
2. Carla W Montgomery (2006), Environmental Geology
3. Edward A. Keller (1992) Introduction to Environmental Geology, 6th Edition, Maxwell Macmillan International, New York, P. 520.
4. W. Murch, B. J. Skinner and S. C. Porter (1996), Environmental geology John Wiley & Sons, Chichester, P.533.
5. Merritts, D., De Wet, A., & Menking, K. (1998). Environmental geology: an earth system science approach. Macmillan.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the different components of the Earth's system and processes	U, An	F, C	ESE Quiz
CO2	Understand more about the resources of the lithosphere and their wise use	An, Ap	F, C, P	Assignment ESE
CO3	Understand the major issues of resource management and its solutions .	U, An	F, C, P	Assignment ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				2
CO 2		3				3
CO 3			3			3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	✓

Discipline and Type of Course	**Geology**		**Value Added Course - VAC**		
Course Code and Title	**UK3VACGLY220**		**Sustainable resource management**		
Semester	3		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module I: Earth Resources:	**9**
Introduction to Natural Resources and Mineral Resources. Fuel minerals. Strategic and critical minerals of India. Basic concepts of conventional and non-conventional energy. Origin of coal and petroleum.	
Module II: Sustainability.	**9**
Sustainability concept, evolution of the concept; Social, Environmental and Economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM).	
Module III: Environmental Pollution.	**9**
Air pollution and its effects, Water pollution and its sources, zero waste concept and 3 R concepts in solid waste management. Greenhouse effect, Global warming and Climate change. Ozone layer depletion, Carbon credits, carbon trading and carbon footprint, legal provisions for environmental protection.	
Module IV: Resources and its utilization.	**9**
General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, Bio-fuels, Energy derived from oceans and Geothermal energy.	
Module V- Teacher Specific content	**6**
Teacher Specific content related to Sustainable resource management	
Reference	
1. Arthur N. Strahler and Alan H Strahler, Environmental Science, Wiley, 1973. 2. Bent Sorensen, (2007) Renewable Energy Conversion, Transmission and Storage., Springer 3. Fowler, J.M (1984) Energy and the Environment. McGraw-Hill	

4. Hermann-Josef Wagner and Jyotirmay Mathur. (2009) Introduction to Wind Energy Systems:, Springer
5. Keller, E.A. (1978) Environmental Geology. Bell and Howell, Prentice Hall, USA.
6. Krishnaswamy, S. (1988) Indian Mineral Resources. South Asia Books.
7. Nebojsa Nakicenovic. (1998) Global Energy Perspectives, Cambridge University Press.
8. Simmons, I. G., The Ecology of Natural Resources, Edward Arnold Ltd. 1981.
9. Tushar K. Ghosh and M. A. Prelas. (2009) Energy Resources and Systems: Fundamentals and Non-Renewable Resources. Springer.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand natural resources and discuss on important mineral, fuel and energy resources.	U	C, F	Assignment, Final Exam
CO2	Identify environmental pollutions and its effects and analyze the impacts of pollution on environment	**Ap/ An**	C	Assignment, Final Exam
CO3	Examine the concept of sustainable development in energy resources and illustrate sustainable development goals.	U/ An	F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			3
CO 2			3			3
CO 3			3			3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓

5.4 COURSES IN GEOLOGY: Semester 4

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK4DSCGLY200**		**Crystallography and Mineralogy**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Systematic crystallography	**15**
The concept of symmetry in Crystallography and its application in the identification of different crystal systems. Study of symmetry elements, simple forms and combinations of the following crystal systems: Isometric system- Normal, tetrahedral, pyritohedral and plagiohedral classes. Tetragonal system- Normal, tripyramidal and sphenoidal classes.	
Module II- Crystal systems	**16**
Hexagonal system- Hexagonal Division: Normal, tripyramidal, trapezohedral classes. Rhombohedral Division: Rhombohedral, trirhombohedral and trapezohedral classes. Orthorhombic system- Normal, hemimorphic and sphenoidal classes. Monoclinic system- Normal class. Triclinic system- Normal class. Twinning in crystals- Twin laws, elements of twinning, twin axis, twin plane, composition plane and important examples of twinning. Brief study of morphological imperfections in crystals. Basic concepts of spherical and stereographic projections in crystallography, Wulff net, projection of symmetry elements of Isometric system Normal Class.	
Module III- Descriptive Mineralogy	**15**
Detailed study of the structure, and properties (physical, chemical and optical), origin and occurrence of common rock-forming mineral groups-Olivine, pyroxene, amphibole, mica, quartz, feldspar, feldspathoids, zeolites, clay minerals, garnet, aluminosilicates, Epidotes, beryl, tourmaline and cordierite.	
Module IV - Practical	**14**

Identification of crystal models of normal classes of all crystal systems. Megascopic and microscopic identification of minerals. Stereographic projections of normal classes of Isometric and tetragonal systems.	
Module V	**10**
Teacher Specific related to course Crystallography and Mineralogy	

Reference

1. Dana, E. S. (1955) A Textbook of Mineralogy. Asia Publishing House, Wiley.
2. Phillips, F.C. (1956) An Introduction to Crystallography. Longmans Green.
3. Read, H.H. (1984) Rutley's Elements of Mineralogy. C.B.S. Publishers.
4. Mason, B. and L.G. Berry (1968) Elements of Mineralogy. W. H. Freeman & Co.
5. Klein, C. and C.S. Hurlbut (1993) Manual of Mineralogy. John Wiley, New York.
6. Deer, W.A., Howie, R.A. and J. Zussman (1983) An introduction to the Rock forming minerals. Longman.
7. Kerr, P.F. (1977) Optical Mineralogy. McGraw Hill Book Company, New York.
8. Perkins Dexter (2015) Mineralogy. Pearson Education.
9. Perkins D. and Henke K. R. Minerals in thin section. Pearson Education Inc., 2004.
10. Nesse W. D. Introduction to Optical Mineralogy. Oxford University Press, 2004.
11. Nesse W. D. Introduction to Mineralogy. Oxford University Press, 2008.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and analyse the symmetry and forms of different classes of all crystal systems, the concept of twinning, twin laws, imperfections in crystals and Stereographic projection of Isometric normal class	U, An	F, C	ESE Quiz
CO2	Understand and analyze the structure and properties of important rock-forming mineral groups	U, An	F, C	Assignment ESE
CO3	Identify crystal models and plotting of stereographic projections of Isometric and Tetragonal system normal class	Ap, An	F, C, P	Quiz ESE
CO4	Identify minerals based on their properties	Ap	F ,P	ESE Quiz

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				3
CO 2		3				3
CO 3		2				3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK4DSCGLY201**		**Stratigraphy and Paleontology**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	**Hrs.**
Module-1- Introduction to Historical Geology	**13**
Significance of Historical Geology and its branches. Brief idea on Concept of Plutonism, Neptunism, Catastrophism and Uniformitarianism. Stratigraphic principles. Elements of lithostratigraphic, chronostratigraphic and biostratigraphic classification. Type area, type section. Stratigraphic correlation-criteria and methods. Breaks in stratigraphic succession-hiatus, diastem, non-sequences and their significance. Offlap and overlap.	

Module II- The Process of Fossilization and Phyla	**16**
Conditions and methods of fossilisation, Classification and nomenclature of fossils. Type specimens and kinds-holotype, genotype and paratype. Uses of fossils. Phylum Protozoa-morphology,classification, geologic history and stratigraphic importance.Phylum Coelenterata-Class Anthozoa. Phylum Brachiopoda	
Module III- Fossils at a glance	**17**
Phylum Mollusca- Class Pelecypoda, Gastropoda, Cephalopoda (Order Nautiloidea and Ammonoidea). Phylum Arthropoda- Class Trilobita, Phylum Echinodermata- Class Echinoidea. Phylum Hemichordata-Class Graptolithina Morphology and stratigraphic significance of the important plant fossils- Glossopteris, Gangamopteris, Ptilophyllum, Calamites, Lepidodendron, Sigillaria.	
Module IV Practical	**14**
Identification of fossils based on their morphologic features and a brief idea of geologic significance.	
Module V	**10**
Teacher Specific related to course Stratigraphy and Palaeontology	

Reference

1. Woods, H. (1961) Invertebrate Palaeontolgy. Cambridge University Press.
2. Haq, B.U. and Boersma, A. (1978) Introduction to marine Micropalaeontology. Elsevier,Netherlands.
3. Raup, D.M. and Stanely, M.S. (1978) Principles of Palaeontology. CBS Publishers.
4. Moore, R.C., Lalicker, C.G. and Fishcher, A.G. (1952) Invertebrate Fossils, Mc-GrawHill.
5. Shrock, R.R. and Twenhofel, W.H. (1953) Principles of Invertebrate Palaeontology. 2ndEdn.Mc-Graw Hill.
6. Brasier, M.D. (1980) Microfossils. George Allen & Unwin.
7. Bignot, G. (1985) Elements of Micropaleontology. IHRDC-Boston.
8. Nield, E.W.; Tucker, V.C.T. (1985) Palaeontology – An Introduction. Pergamon Press, Oxford, England.
9. Anis Kumar Ray, (2008) Fossils in Earth Sciences, Prentice-Hall of India Pvt. Ltd, NewDelhi.
10. Sreepat Jain (2019) Fundamentals of invertebrate paleontology (microfossils) Springer Geology
11. Ravindra Kumar (2020) Fundamentals of Historical Geology and Stratigraphy of India.2nd edition, New Age International Private Limited.

12. Brookfield M. E. Principles of Stratigraphy. Blackwell Publishing, 2004.
13. Dunbar C. O. & Rogers J. Principles of Stratigraphy. Wiley, 1960
14. Eicher L. D. Geologic Time. Prentice Hall, 1968.
15. Kay & Golbert. Stratigraphy & Life history. Wiley, 1965.
16. Weller J. M. Stratigraphic principles & Practice. Harper & Row, 1959.
17. Krumbein N. C. & Sloss L. D. Stratigraphy and sedimentation. Freeman, 1963.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the concept, principles, stratigraphic classification, correlation and breaks in record	U	C,F	ESE
CO2	Understand and analyse the fossils, types, significance, conditions and methods of fossilisation.	U, An	F	Assignment ESE
CO3	Understand and analyse the important invertebrate fossils and their geologic significance.	U,An	F	Quiz ESE
CO4	Identify the invertebrate fossils based on morphology and analyse their geologic history.	Ap,An	F,P	ESE

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					2
CO 2	2	3				3
CO 3		3				3
CO4					3	3

Level		1	2	3
Correlation	Nil	Slightly/Low	Moderate / Medium	Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓
CO4			✓	✓

Discipline and Type of Course	**Geology**			**Discipline Specific Core - DSC**	
Course Code and Title	**UK4DSCGLY220**			**Descriptive and Optical Mineralogy**	
Semester	4			Academic Level: 200 - 299	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I: Optical Mineralogy	**14**
Significance of Optical mineralogy in Mineral Identification, light- Ordinary and polarized light, polarization of light, refractive index, critical angle and total internal reflection. Polarization by reflection, absorption, refraction. Double refraction, construction of Nicol prism. Isotropic and anisotropic substances. Petrological microscope - parts and functions. Optical accessories - mica plate, gypsum plate and quartz wedge. Birefringence, uniaxial and biaxial minerals, optic sign, relief, pleochroism, interference colour and its order, extinction. Basic description of indicatrix, interference, interference figures, Michel Levy interference chart.	
Module II: Descriptive mineralogy	**20**
Classification of minerals. Rock forming and ore forming minerals. Silicates - Structure and classification of silicate minerals. Physical, chemical, optical properties and structure of the following: Olivine, Garnets, Alumino silicates, Epidote, Pyroxenes, Pyroxenoid, Amphiboles, Micas, Chlorite, Clay, Feldspars, Feldspathoids, Quartz, Zeolite. Systematic study of Beryl, Cordierite and Tourmaline	
Module III: Non Silicates	**12**
Classification of non-silicates with examples. Systematic study of the important non-silicate minerals - calcite, dolomite. diamond, graphite, sulphur, gold, silver, copper, realgar, orpiment, stibnite, molybdenite, cinnabar, sphalerite, galena, chalcopyrite, pyrite, magnetite, hematite, marcasite, barite, gypsum, halite, fluorite, corundum, cuprite, chromite, rutile, cassiterite, ilmenite, monazite, psilomelane, pyrolusite, goethite, limonite, bauxite, aragonite, magnesite, malachite and azurite.	

Module IV: Practical	**14**
Familiarization of optical microscope. Microscopic study of following minerals: Olivines, Garnets, Alumino silicates, Pyroxenes, Amphiboles, Micas, Feldspars, Feldspathoids, Quartz, Cordierite, Tourmaline, Calcite, Apatite and Zircon. Megascopic study and identification of following minerals: Olivines, Garnets, Alumino Silicates, Pyroxenes, Amphiboles, Micas, Feldspars, Feldspathoids, Quartz, Chlorite, Epidote, Talc, Cordierite, Tourmaline, Calcite, Apatite, Zircon, Beryl, Topaz, Dolomite, Gypsum and Fluorite.	
Module V: Teacher specific content	**10**
Teacher specific content related to Descriptive an optical mineralogy	

Reference

1. Dana, E. S. (1955) A Textbook of Mineralogy. Asia Publishing House, Wiley.
2. Read, H. H. (1984) Rutley's elements of Mineralogy. CBS Publishers, Delhi.
3. Mason, B. and L.G. Berry (1968) Elements of Mineralogy. W. H. Freeman & Co.
4. Deer, W.A., Howie, R.A. and J. Zussman - An introduction to rock forming minerals. Longman.
5. Berry, L.G., Mason, B. and Dietrich, R.V. (2004) Mineralogy. CBS Publishers and &Distributors, New Delhi, India.
6. Cornelius Klein and Cornelius S. Hurlbut (1985) Manual of Mineralogy. John Wiley& Sons.
7. Winchel, N.H and A.H. Winchel (1929) Elements of Optical Mineralogy.
8. William D. Nesse (2008) Introduction to Mineralogy. Oxford University Press.
9. Kerr, P.F. (1977) Optical Mineralogy. McGraw Hill Book Company, New York.
10. Perkins Dexter (2006) Mineralogy. Pearson Education; Prentice Hall.
11. Perkins Dexter and Henke Kevin, R. (2007) Minerals in Thin Section. Pearson Education.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basics of optical mineralogy	R	F	Assignment, Final Exam
CO2	Systematic study of major silicate and non silicate minerals	**E**	P	Assignment, Final Exam
CO3	Identification of minerals in hand specimen and thin section using megascopic and optical properties	AP	P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1						2
CO 2		3			3	2
CO 3					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**	
Course Code and Title	**UK4DSCGLY221**		**Historical Geology and Palaeontology**	
Semester	4		Academic Level: 200 - 299	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	**Hrs.**
Module I: Stratigraphy	**14**
Stratigraphy: Types- Chrono, Geochronostratigraphy, Lithostratigraphy, Biostratigraphy, Magneto-stratigraphy, Sequence stratigraphy, Cyclo stratigraphy. Unconformities and types of unconformities. Significance of unconformity in stratigraphic studies. Introduction to fossilization and fossil record, Nature and importance of fossil record; Fossilization processes and modes of preservation, Taxonomy and Species concept- with special reference to palaeontology, Taxonomic hierarchy, Conditions and methods of fossilization, body fossils, trace fossils and micro fossils, Classification and nomenclature of fossils. Binomial nomenclature, type specimens and kinds - holotype, genotype, paratype: Uses of fossils.	

Module II: Fossils:	**20**
Fossils: Morphology, Classification, geological history and stratigraphic importance of Phylum Protozoa, Phylum Coelenterata - Class Anthozoa, Phylum Brachiopoda, Phylum Mollusca - Class Pelecypoda, Class Gastropoda, Class Cephalopoda, Phylum Arthropoda, Class – Trilobita. Phylum Echinodermata, Phylum Hemichordata – Class Graptolithina,	
Module III: Microfossils and plant fossils	**12**
. Microfossils and plant fossils: Introduction , general classification, uses and distribution of Microfossils. Significance of microfossils in petroleum exploration. Brief introduction to Palynology. Brief account of the following plant fossils - Glossopteris, Gangamopteris, Ptilophyllum, Calamites, Lepidodendron and Sigillaria. Indian distribution of major plant fossils. Evolution of human.	
Module IV: Practical	**14**
Megascopic: Identification and morphological description of fossils representing major phylum.	
Module V: Teacher specific content	**10**
Teacher specific content related to Stratigraphy and Plaeontology	

Reference

1. Foote, M. and Miller, I.A. (2007) Principles of Paleontology. 3rd Edition by W. H. Freeman and company
2. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution. 4th Edition by Blackwell Publishing.
3. Moore, R.C., Lalicker, C.G. and Fishcher, A.G. (1952) Invertebrate Fossils, Mc-Graw Hill.
4. Shrock, R.R. and Twenhofel, W.H. (1953) Principles of Invertebrate Palaeontology. 2ndEdn. Mc-Graw Hill.
5. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons. 4th Edition.
6. Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
7. Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.
8. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
9. Woods, H. (1961) Invertebrate Palaeontolgy. Cambridge University Press.
10. Romer, A.S. (1966) Vertebrate Palaeontology. 3rd Edn., Chicago Univ. Press.
11. Arnold C,A. (1947) An Introduction to Palaeobotany. McGraw Hill.
12. Haq, B.U. and Boersma, A. (1978) Introduction to marine Micro palaeontology. Elsevier,Netherlands.
13. Brasier, M.D. (1980) Microfossils. George Allen & Unwin.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding types of stratigraphy and fossilization	R	F	Assignment, Final Exam
CO2	Systematic study of fossils	An	P	Assignment, Final Exam
CO3	Examine fossils and analyze its applications in stratigraphy	AP	P	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				2
CO 2		3				2
CO 3				2	3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Elective - DSE**		
Course Code and Title	**UK4DSEGLY200**		**Field Geology**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Significance of Geology as a Field Science	**15**
Topographical expressions and relief features-Identification of landforms and their geologic importance- Fluvial, Aeolian, Coastal, groundwater. Comparison of geomorphic features in the topographic maps and in the field. Field Equipment- Brunton compass and clinometers compass, Geological hammer, pocket and hand lens, magnet, haversack, GPS	
Module II- Topographical maps	**15**
interpretation of contour lines, map scale and symbols, grid systems. Measurement of the attitude of geological surfaces- bearing and reading direction techniques. Attitude of planar and linear features- strike, dip, plunge and pitch. Location and positioning techniques- Concept of pacing, traversing methods, landmarks, determination of gradient	
Module III- Identification of minerals and rocks in the field.	**16**
Sample collection methods. Concept of the base map, Preparation of Geological maps- Techniques in preparation of maps, Digital mapping tools, georeferencing, Incorporating the concept of lithology and structures in the maps. selection of symbols and legends. Field documentation- notebooks, observation recording techniques, field sketches and their significance, field photographs and digital documentation equipment.	
Module IV Field Visit	**14**
Problems related to fore bearing and back bearing, plotting of location in toposheet In Field.	
Module V	**10**
Teacher Specific related to course Field geology	
Reference	
1. Rex a Crouch, 2008. Basics of Field Geology. 2. Lahee FH, Field Geology. McGraw-Hill Book Co., New York, 1961. 3. Gokhale, NW. A guide to Field Geology, 2023, CBS Publishers & Distributors Pvt.Ltd 4. Mathur SM, Guide to Field Geology, Phi Learning Pvt.Ltd. 5. Compton R. R. Manual of Field Geology. Wiley. 6. Angela L.Coe, Geological Field Techniques, 2011.Wiley.	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand geological fieldwork, field equipments and familiarising maps and identifying landforms.	U,An	F,P	Assignment , ESE
CO2	Analyse topographic maps, measuring attitude and understand sampling methods	An,Ap,U	F,P	Assignment, ESE
CO3	Understand the basic concepts of. geologic mapping, identification of structures, rocks and minerals in the field documentation of field data and modern mapping tools	U,Ap	F,C,P	Quiz ESE
CO4	Apply the theoretical knowledge in field	Ap	P	Quiz ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					3	2
CO 2		2			3	2
CO 3			3		3	2
CO4	3	3	3	1	3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Elective - DSE**		
Course Code and Title	**UK4DSEGLY220**		**Field Techniques in Geology**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Introduction to Field Geology	**11**
Overview of field geology and its significance in geological studies: Introduction to field equipment and safety protocols: Basic techniques in geological mapping and measurements.	
Module II- Geological Mapping and Observation	**12**
Principles of geological mapping: Topographic map - interpretation and navigation: Orientation of Topographic sheet in field, marking location in toposheet, Bearing (Front and back), morphometric elements and parameters. Concepts of map reading, Distance, height, and pace approximation	
Module III- Field Identification	**12**
Geomorphological features mountains & residual hills, streams: -valley, waterfall, meandering, braided, estuaries, flood plains, Lakes: backwaters, Coastal geomorphological features: -Cliff, Dunes, islands, Springs: reservoirs and dams Groundwater: springs, Cave. Different Sample collection conventions and methods	
Module IV- Practical	**12**
Problems related to fore bearing and back bearing, plotting of location in toposheet In Field.	
Module V	**9**
Teacher Specific related to Field Techniques in Geology	
Reference	
1. Rex a Crouch, 2008. Basics of Field Geology. 2. Lahee FH, Field Geology. McGraw-Hill Book Co., New York, 1961. 3. Gokhale, NW. A guide to Field Geology, 2023, CBS Publishers & Distributors Pvt.Ltd 4. Mathur SM, Guide to Field Geology, Phi Learning Pvt.Ltd. 5. Compton R. R. Manual of Field Geology. Wiley. 6. Angela L.Coe, Geological Field Techniques, 2011.Wiley.	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand geological fieldwork and basic equipment needed	U	F	Assignment, Final Exam
CO2	Analyse various geomorphic features on field and in toposheets and reading contours and topography	**F**	P	Assignment, Final Exam
CO3	Demonstrate the orientation of toposheet in field and marking location using forebearing and back bearing, Map reading	Ap	C,F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			2
CO 2			3			3
CO 3			3			3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Skill Enhancement Course - SEC**		
Course Code and Title	**UK4SECGLY200**		**Gemology**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture Per week	Tutorial Per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Introduction to Gemstones	**10**
Crystalline and amorphous solids- minerals, mineraloids and metamict minerals. Significance of Gemology, Origin, nature and quality of gem materials- beauty, rarity and durability. Classification and uses of gemstones. Navaratnas and other semi-precious gemstones.	
Module II- Properties of Gemstones	**13**
Physical properties of gemstones and their importance in lapidary work - Form, hardness, toughness, cleavage, fracture, parting, specific gravity and its determination (hydrostatic weighing, pycnometer, heavy liquids and floatation) and common inclusions in gemstones. Optical properties of gemstones- Reflection, colour, lustre, diaphaneity, sheen, luminescence (tribo-, thermo- and photoluminescence (fluorescence and phosphorescence), colour from mechanical causes (chatoyancy, asterism and play of colours).	
Module III- Industrial Applications and Identification	**13**
Gem enhancement and treatment-Dyeing, bleaching, surface coating, waxing, oiling and fracture, filling. Gem treatment- heat treatment, High Pressure, High Temperature (HPHT) treatment, impregnation, irradiation, laser drilling and lattice diffusion. Identification of common gemstones – Diamond, Ruby, Sapphire, Emerald, Pearl, Corundum, Quartz, Garnet and Tourmaline. Industrial application, Occurrence, mining methods and distribution of gemstones in India.	
Module IV	**6**
Teacher Specific related to course Gemology	

Reference

1. Shipley, R. M. (2011). Dictionary of Gems and Gemology. Read Books Ltd.
2. Altman, J. (2012). Gem and stone: Jewels of earth, sea, and sky. Chronicle Books.
3. Anderson, B. (2011). Gem testing. Read Books Ltd.
4. Karanth R. V. (2000) Gem and gem industry in India, Memoir. 45, Geological Society of India, Bangalore.

Babu T M., (1998). Diamonds in India. Economic Geology Series 1, Geological Society of India, Bangalore.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand more about gemstones-their significance, origin, classification and uses	U, An	F,C	ESE Quiz
CO2	Understand the characteristic physical and optical properties of different Gemstones	U, Ap	F,C, P	Assignment ESE
CO3	Understand and evaluate the importance of different enhancements and treatment techniques for gemstones	An, E	F,C, P	Assignment ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				2
CO 2		3				2
CO 3			3			3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓	✓	✓	
CO3	✓	✓	✓	✓

Discipline and Type of Course	**Geology**		**Skill Enhancement Course - SEC**		
Course Code and Title	**UK4SECGLY220**		**Coal and Petroleum Geology**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module I- Coal Geology	**9**
Origin of Coal, Coalification process, Insitu and transported theory of coal formation. Microscopic and Megascopic constituents of Coal. Macerals and its types. Micro lithotype and Lithotype. Impurities in Coal.	
Module II- Different varieties of Coal	**9**
Humic and sapropelic coal. Concept of coal maturity and ranks of coal. Thermal maturity indicator – Vitrinite reflectance. Classification of coal - Peat, lignite, bituminous and anthracite coal. Analysis for the assessment of coal quality - Proximate and ultimate analysis. Spatial and temporal distribution of coal in India – Gondwana and Tertiary coal.	
Module III- Petroleum geology	**9**
Introduction – Chemical and physical properties of petroleum. Origin of petroleum- Organic and Inorganic concepts. Kerogen and its types. Migration, accumulation, and entrapment of petroleum	
Module IV- Source and Reservoir rocks	**9**
Characteristics of reservoirs. Types of reservoir traps – Classification of traps- Structural, Diapiric, Stratigraphic, Hydromorphic traps and Combination traps. Geological age of reservoir rocks. Reservoir mechanics – Methods of petroleum exploration – surface, sub surface and geophysical methods. Petroliferous basins with special reference to India.	
Module V- Teacher Specific content	**6**
Teacher Specific content related to Coal and Petroleum Geology	

Reference

1. John M Hunt Petroleum Geochemistry and Geology, W H Freeman and Company, 1996.
2. Leverson,A.I,GeologyofPetroleum,2ndEdn,CBSPublishersanddistributor s, New Delhi.
3. North, F.K .,Petroleum geology,UnwinHymanInc,USA,1990.
4. ChapmanR.E, Petroleum Geology ,Elseiver Science Publishing company Inc. Newyork,1983
5. Jon Gluyas& Richard Swarbrick, Petroleum Geoscience, Blackwell Science publishing LtdUK2004.
6. Knut Bjorlykke, Petroleum Geoscience- From Sedimentary to Rock Physics, Springer Heidelberg Dordrecht, London, New York 2010.
7. Stach,E.,(eds.),1975, Stach's Textbook of Coal Petrology, Gebruder Borntraeger, Berlin
8. Thomas, L.,2012, Coal Geology, Wiley India Pvt Ltd, Delhi.
9. ShellyR. C.(2014).Elements of Petroleum geology :Third Edition, Academic Press
10. Bjorlykke,K.(1989).Sedimentologyandpetroleumgeology.Springer-Verlag.
11. Bastia,R.,and Radhakrishna,M.(2012).Basin evolution and petroleum prospectively of the continental margins of India(Vol. 59). Newness.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the Origin and Formation of Coal and petroleum. Identify Source and Reservoir Rocks and analyze reservoir mechanics and methods of petroleum exploration.	U, Ap	C, F	Assignment, Final Exam
CO2	Analyze Different Varieties and Ranks of Coal and properties of petroleum.	**An**	C	Assignment, Final Exam
CO3	Analyze Spatial and Temporal Distribution of Coal and Petroleum in India.	An	F, P	Assignment Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				3		2
CO 2				3		3
CO 3				2		3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	
CO3			✓	✓

Discipline and Type of Course	**Geology**	**Value added Course - VAC**			
Course Code and Title	UK4VACGLY200	**Ecosystem Services**			
Semester	4	Academic Level: 200 - 299			
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Ecosystem	**12**
Ecosystem as an interface of different spheres of the earth, its Importance, resources, management and conservation. Major ecosystems of the earth- ocean, river, lake and forests.	
Module II- Surface Water System Services	**12**
Ocean environment and its resources. Role of the ocean in the regulation of global climate. Major oceanic exploration programmes Riverine system services- Role of the river as an ecosystem, major resources and its conservation. Deltaic environments. Importance of wetlands and forests- Significance, resource and conservation. Ramsar sites and major Ramsar sites of Kerala Western Ghats as a fragile ecosystem	

Module III- Management of the Ecosystem	**12**
Problems associated with Resource-mining, utilization and waste disposal. Types of mining- Open cast and underground and their environmental issues (pollution of land, water and air). Utilization- Generous use (Reduce, reuse and recycling) and protection of resources. Waste disposal- Methods of disposal of waste- landfills, sanitary landfills, safe disposal.	
Module IV	**6**
Teacher Specific related to course Ecosystem Services	

Reference

1. Begon, M., & Townsend, C. R. (2021). Ecology: From individuals to ecosystems. John Wiley & Sons.
2. Hudson, T. (2016). Living with Earth: An introduction to environmental geology. Routledge.
3. Zektser, I. S., Marker, B., Ridgway, J., Rogachevskaya, L., & Vartanyan, G. (Eds.). (2007). Geology and ecosystems. Springer Science & Business Media.
4. Knödel, K., Lange, G., & Voigt, H. J. (2007). Environmental geology: handbook of field methods and case studies. Springer Science & Business Media.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the significance of the ecosystem and its components	U, An	F, C	ESE Quiz
CO2	Understand and identify the surface water systems of the globe and their importance	An, Ap	F, C, P	Assignment ESE
CO3	Understand the major issues of ecosystem services and methods of conservation.	U, An	F, C, P	Assignment ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO

	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				
CO 2		3				
CO 3			3			

Level		1	2	3
Correlation	Nil	Slightly/Low	Moderate / Medium	Substantial/ High

Mapping of COs to Assessment Rubrics

	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	
CO3	✓		✓	✓

Discipline and Type of Course	**Geology**		**Value added Course - VAC**		
Course Code and Title	UK4VACGLY201		**Disaster Management**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Fundamentals of Disaster Management	**12**
Elements of Disaster Management- Prevention, mitigation, preparedness, response and recovery with major case studies. Legislations of the central and state governments in disaster management practices.	
Module II- Geological Disasters	**12**
Disasters- Classification, effects and management practices. Geological Disasters- The basic idea of causes and effects of Earthquakes, Volcanism, and Mass movements with special reference to landslides and avalanches. Seismic belt of the word, Seismic hazard zones of India. Coastal hazards- Tsunamis- Prediction and monitoring.	
Module III- Other natural and anthropogenic disasters	**12**
Hydrometeorological Disasters- Causes, effects and types of Floods, drought, cyclones and storms. Biological Disasters- Major Pathogenic micro-organisms, toxins and bioactive substances. Pandemic, epidemic, stampede and insect infestation. Anthropogenic Disasters- technological, chemical and biological	
Module IV	**6**
Teacher Specific related to course Disaster Management	

Reference

1. Pandey, R. K. (2023). Disaster Management in India: Policies, Institutions, Practices. Taylor & Francis.
2. Subramanian, R. (2018). Disaster Management. Vikas Publishing House.
3. López-Carresi, A., Fordham, M., Wisner, B., Kelman, I., & Gaillard, J. C. (2014). Disaster management. International Lessons in Risk Reduction, Response and Recovery. London: Earthscan.
4. Murthy, D. B. N. (2007). Disaster Management: Text and case studies. Deep and Deep Publications.
5. Goel, S. L. (2007). Disaster Administration and Management: Text and case studies. Deep and Deep Publications.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the major elements of disaster management practices and legislation in India	U, An	F, C	ESE Quiz
CO2	Understand the significance of geological disasters and their mitigation procedures	U, An	F, C, P	Assignment ESE
CO3	Understand the major issues of other natural and anthropogenic disasters and their management	U, An	F, C, P	Assignment ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		2				2
CO 2		3				2
CO 3			3			2
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	
CO3	✓		✓	✓

Discipline and Type of Course	Geology		Value Added Course - VAC		
Course Code and Title	UK4VACGLY220		Natural Hazards and Disaster Management		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3

Detailed Syllabus:

Content	Hrs.
Module I: Hazard and Disaster	**9**
Definition and Terminologies. Concept of Disaster management. Disaster management – zoning and risk assessment. Hazard zonation maps. Climate change: Global warming, Sea level rise, Ozone depletion, Carbon sink and sources.	
Module II: Natural Disasters.	**9**
Earthquake, Landslide, Avalanches, Volcanic eruptions. Heat and Cold Waves. Coastal disasters, Cyclone, Flood, Drought and Tsunami. Environmental Disasters - Dam collapse and Mitigation measures. Nuclear disasters, Chemical Disasters, Biological Disasters, Forest fire and Oil fire. Coastal Regulation Zone.	
Module III: Disaster Risk Management.	**9**
Institutional arrangement: - Prevention, Preparedness, and Mitigation; Disaster Preparedness Plan. Application of GIS in Disaster Preparedness and Management. Hazards and Vulnerability scenario in India.	
Module IV: Kerala and disasters.	**9**
Kerala: - Flood, Drought, Coastal erosion, Landslides, Pesticide contaminations and Accident-related disasters, Prevention and Mitigation. Emergency procedures and warning.	
Module V	**6**
Teacher Specific content related to Disaster Management	
Reference	
1. Abbott P L., 2009. Natural Disasters 8thEdn McGraw-Hill New York. 2. Bell, F.G., 1999. Geological Hazards, Routledge, London.	

3. Bryant, E., 1985. Natural Hazards, Cambridge University Press. 4. Donald Hyndman, David Hyndman, 2011. Natural Hazards and Disasters 3rdEdn Brooks Cole. 5. Smith, K., 1992. Environmental Hazards. Routledge, London. 6. Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International 7. www.sdma.ker.in	8.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Gain a comprehensive understanding of the concepts of hazard and disaster and familiarize with environmental disasters and understand the causes and effects of climate change.	U	C, F	Assignment, Final Exam
CO2	Understanding of disaster management principles, and the institutional arrangements for disaster risk management.	**U**	C	Assignment, Final Exam
CO3	Examine the application of information technology in disaster preparedness and analyze the hazards and vulnerability scenarios specific to India.	Ap, An	F, P	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			3
CO 2			3			3
CO 3			3			3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓

Discipline and Type of Course	**Geology**		**Value Added Course - VAC**		
Course Code and Title	**UK4VACGLY221**		**Earth and Environment**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3

Detailed Syllabus:

Content	Hrs.
Module I: Fundamentals of Environmental Geology	**9**
Introduction to the concept and dimensions of environmental geology; Relationships between Geological processes and Environmental/Ecological changes; Role of an Environmental Geologist in social and economic development.	
Module II: Natural Resources:	**9**
Definition and characteristics of natural resources; Economic importance and types of natural resources (Mineral and Fuel Resources, Construction Resources, Water Resources, Biological Resources, aesthetic, and scientific Geological Resources); Geological dimension of conservation and sustainable development of Natural Resources.	

Module III: Earth's thermal environment and Climates.	**9**
Global warming and Climate change, Greenhouse effect, Ozone depletion, sea levels fluctuation, Milankovitch cycles.	
Module IV: Environmental Geology and Disasters	**9**
Introduction to the concepts of hazards and disasters; Their types and associated environmental issues; Role of Geologists in hazard mitigation and disaster management. Environmental Impact Assessment (EIA).	
Module V	**6**
Teacher Specific content related to Earth & Environment	

Reference

1. Abbott P L Natural Disasters 8thEdn McGraw-Hill New York 2009
2. Arthur N. Strahler and Alan H Strahler Environmental Science, Wiley, 1973.
3. Donald Hyndman, David Hyndman Natural Hazards and Disasters 3rdEdn Brooks Cole 2011
4. Donald R Caotes (1981) Environmental Geology. John Wiley and Sons.
5. Keller, E.A. (1978) Environmental Geology. Bell and Howell, Prentice Hall, USA.
6. Krishnaswamy, S. (1988) Indian Mineral Resources. South Asia Books.
7. Mead L. Jensen and Alan M. Bateman (1981). Economic Mineral Deposits, John Wiley & Sons Third edition, revised printing.
8. Peter, T. Flawn. Environmental Geology, John Wiley and Sons, 1970.
9. Simmons, I. G., The Ecology of Natural Resources, Edward Arnold Ltd. 1981.
10. Strahler, A.N. and Strahler, A.H. (1973) Environmental Geosciences: Interaction between natural systems and man. John Wiley & Sons Inc.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamentals of environmental geology and correlate the interplay between geological processes and environment	U, An	C, F	Assignment, Final Exam
CO2	Define natural resources and conservation and sustainable development of natural resources. Analyze Earth's thermal environment and climates.	**Ap, An**	C	Assignment, Final Exam
CO3	Understand the concepts of hazards and disasters, role of geologists in hazard mitigation and disaster management and apply theoretical knowledge to practical scenarios in addressing environmental challenges and promoting sustainable practices.	U, Ap	F, P	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				3		3
CO 2				3		3
CO 3					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓

Discipline and Type of Course	**Geology**		**Internship - INT**		
Course Code and Title	**UK4INTGLY200**		**Internship in Geology**		
Semester	4		Academic Level: 200 - 299		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	2		-		30

5.5 COURSES IN GEOLOGY: Semester 5

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK5DSCGLY300**		**Igneous Petrology**		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module-1- Magmas and Magmatic Processes	**11**
Types and physical properties of Magma. Nucleation and growth of crystals. Bowen's reaction series. Phase rule, Study of following binary systems: Diopside-Anorthite (Eutectic), Albite-anorthite (solid solution), Forsterite silica (Incongruent). Diversity of igneous rocks - magmatic differentiation process, fractional crystallization, liquid immiscibility and assimilation/contamination.	
Module II- Deciphering Igneous Perentage	**12**
Forms, texture and structures. Classification: texture, mineralogy and chemistry. Classification based on mineralogy – felsic and mafic minerals, mode, colour index and IUGS classification - QAP classification of plutonic and volcanic rocks and ultramafic rock classification. Chemical classification – Based on silica saturation and based on alkali & silica (brief introduction of alkalic, subalkalic, calc-alkali and tholeiitic groups only) – Total alkali vs silica classification for volcanic rocks. A short account of CIPW norm and normative minerals.	
Module III- Igneous Rocks of the Crust	**11**
Tectonic association of igneous bodies. Large layered igneous complexes, continental alkaline rocks, ultra-alkaline and silica-poor alkaline rocks. Texture, mineralogy, classification, occurrence and origin of granites and basalts. Brief study of Kimberlites, Komatiite, Peridotite, Lamprophyres, carbonatites.	
Module IV Practical	**12**
A brief study of the petrography of common igneous rocks –granite, syenite, diorite, gabbro, dolerite, basalt, andesite, rhyolite, pegmatites, dunite, peridotite, granodiorite	

Module V	**10**
Teacher Specific related to course Igneous Petrology	
Reference	

1. John D. Winter (2012) An Introduction to Igneous and Metamorphic Petrology.Prentice Hall. New Jersey.
2. Tyrrell, G.W. (1978) Principles of Petrology. Chapman and Hall Ltd., London.
3. Bowen, N.L.M. (1956) The Evolution of the Igneous Rocks. Dover publication, Inc, New York.
4. Barth, T.W. (1962) Theoretical Petrology. Wiley.
5. Walstrom, E.E. (1961) Theoretical Igneous Petrology, Wiley.
6. Turner, F.J. and Verhoogen, J. (1960) Igneous and Metamorphic Petrology. McGraw Hill.
7. Hatch, F.H. and A.K. Wells (1949) Petrology of Igneous Rocks. Thomas Murby&Wells, M.K.(Publ.)
8. Johannesen, A (1962) Descriptive Petrography of Igneous Rocks. Vols. I to IV, Allied Pacific. Allied Pacific.
9. Mackenzie, W.S., Donaldson, C.H. and C. Guilford (1988) Atlas of Igneous rocks and their textures. ELBS Longman.
10. Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology. Prentice Hall, New Jersey.
11. Ehlers, G.E. and Blatt, H. (1999) Petrology – Igneous, Sedimentary and Metamorphic. CBS Publishers and Distributors, New Delhi.
12. Hyndman, D.W. (1972) Petrology of Igneous and Metamorphic Rocks. MC-Graw Hill.
13. Wilson, M. (1989) Igneous Petrogenesis: A Global Tectonic Approach. Unwin Hyman, London Inc., USA.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and analyse the processes of origin and diversity of igneous rocks and the concept of binary systems	**U, An**	F,C,M	ESE Quiz
CO2	Understand and analyse the forms, structures and textures of igneous rocks	**U, An**	F,M	Assignment ESE
CO3	Understand and analyse the different modes of classification and the tectonic associations of different igneous rocks.	**U, An**	F,C	Quiz ESE
CO4	Identify the igneous rocks in lab and field	Ap,An	P	ESE

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	1	3				3
CO 2		3				2
CO 3		3				3
CO4					3	2
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓
CO4			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK5DSCGLY301**		**Sedimentary Petrology**		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module-1- Sediments and Sedimentary Rocks	**11**
Sediment – Provenance, Lithification and Diagenesis. Texture - Clastic texture - concept of grain size (Udden-Wentworth and Phi scale of size determination), grain shape, fabric and packing. Non-clastic texture – different types of crystalline texture. A brief study of the following: Primary, secondary and organic structures.	
Module II- Classification of Sedimentary Rocks	**11**
Formation, Characteristics, and Classification of sedimentary rocks. General study of Shale, Dolomite and evaporates Conglomerate and Breccia. Classification of Sandstone and Limestone (Folk & Dunham).	

Module III- Concept of Sedimentary Facies	**12**
Brief study of depositional environments of sedimentary rocks and facies associations. An introduction to Sedimentary Basins and their formation. A brief study of sedimentary basins in India. Platetectonics and sedimentation.	
Module IV Practical	**12**
Megascopic and microscopic identification of major sedimentary rocks: Sandstone, limestone (oolitic, fossiliferous), shale, conglomerate, breccia, arkose, greywacke, grit.	
Module V	**10**
Teacher Specific related to course Sedimentary Petrology	

Reference

1. Tucker, M.E, Jones SJ(2023) Sedimentary Petrology, Wiley
2. Tyrrell, G.W. (1978) Principles of Petrology. Chapman and Hall Ltd., London.
3. Pettijohn, F.J. (1983) Sedimentary Rocks. Harper & Bros.
4. Harker, A. (1964) Petrology for Students. Cambridge.
5. Folk, R.L. (1981) Petrology of Sedimentary Rocks. Hemphils Pub. Co.
6. Greensmith, J. (1989) Petrology of the Sedimentary Rocks. 7th Edn., CBS Publishers,Delhi.
7. Williams, H., Turner, F.J. and Gilbert, C.M. (1982) – Petrography. W. H. Freeman andCompany, San Francisco, CA.
8. Blatt H., Middleton G. and Murray R. Origin of Sedimentary rocks. Prentice Hall, 1972.
9. Carver R. E. (Ed). Procedures in Sedimentary Petrology, Interscience, 1971.
10. Krumbein W. C. and Pettijohn E. J. Manual of Sedimentary Petrology. Appleton, 1938
11. 10.Stelley R. C. Ancient Sedimentary Environments, Cornell University Press, 1972.
12. Pettijohn F. J, Potter P. E., Siever R. Sand and Sandstone. Springer-Verlag, 1972.

Nichols G. Sedimentology and Stratigraphy. Wiley-Blackwell, 2009.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and analyse the origin, texture and structure of sedimentary rocks and its applications.	**U, An**	F,C	ESE Quiz
CO2	Understand and analyse the classification of sedimentary rocks and a brief study of important sedimentaryrocks.	**U, An**	F,M	Assignment ESE
CO3	Understand the depositional environments, facies and sedimentary basins and analyse the relationship between plate tectonics and sedimentation.	**U, An**	F,C,P	ESE
CO4	Identify the sedimentary rocks both in the field and lab based on their megascopic and microscopic characters.	Ap, An	P	ESE Quiz

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	1	3				2
CO 2		3				2
CO 3			3			3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3			✓	✓
CO4		✓	✓	

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	UK5DSCGLY302		**Metamorphic Petrology**		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	**Hrs.**
Module-1- The Concept of Metamorphism	**15**
Definition of metamorphism. Factors and limits of metamorphism. Anatexis, palingenesis and migmatites. Types of metamorphism – Contact metamorphism, regional metamorphism – orogenic, ocean floor and burial metamorphism, Cataclastic metamorphism, hydrothermal metamorphism and metasomatism, Impact/shock metamorphism. Prograde and retrograde metamorphism	
Module II- Metamorphic textures	**16**
Crystalloblastic and relict textures and their types. Different metamorphic Structures and their types. Concept of metamorphic grade and zone, Index minerals and Isograd, Metamorphic facies and Facies Series.	
Module III- Protolith and Metamorphism	**15**
Metamorphic mineral paragenesis. Metamorphic rocks and tectonic association. Regional metamorphism of carbonate, pelitic and mafic rocks. Thermal metamorphism of carbonate rocks. Metamorphic rocks of Kerala.	
Module IV - Practical	**14**
Brief study and Petrography of the following metamorphic rocks: Slate, Phyllite, Quartzite, Marble, Schists, Amphibolite, Gneiss, Eclogite, Mylonite, Hornfels and Granulites – Charnockite, Khondalite and Leptynite.	
Module V	**10**
Teacher Specific related to course Metamorphic Petrology	
Reference	
1.Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology. PrenticeHall, New Jersey. 2. Winkler, H.G.F. (1974) Petrogenesis of Metamorphic Rocks, 5th, 6th and 7th eds.Springer Verlag. 3. Yardley, B.W.D. (1989) Textbook of Metamorphic Petrology. Longman.	

4. Turner, F.J. and Verhoogen, J. (1960) Igneous and Metamorphic Petrology. McGrawHill.
5. Williams, H., Turner, F.J. and Gilbert, C.M. (1982) – Petrography. W. H. Freeman andCompany, San Francisco, CA.
6. Tyrrell, G.W. (1978) Principles of Petrology. Chapman and Hall Ltd., London.
7. Harker, A. (1964) Petrology for Students. Cambridge.
8. Blatt, J., Tracy J. R. and Owens B.E. 2006 Petrology: Igneous, Sedimentary, and metamorphic.W. H. Freeman.
9. Shelley D. Igneous and metamorphic rocks under the microscope: classification, textures,microstructures, and mineral preferred - orientations Springer, 1993.
10. Fry N. The field description of metamorphic rocks. Geological Society of London handbook series. Open University Press, 1984
11. Vernon R. H. and Clarke G. L. 2008 Principles of metamorphic petrology Cambridge University Press.
12. Winter J. Principles of Igneous and Metamorphic Petrology 2nd Edition 2009
13. Vernon R. H. A practical guide to rock microstructure Cambridge University Press, 2004
14. Bucher K and Frey M. 1994 Petrogenesis of metamorphic rocks Edition6 Springer-Verlag.
15. Barker A. J. 1998 Introduction to metamorphic textures and microstructures Edition 2, Routledge.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the process of metamorphism, factors, limits and types of metamorphism.	U,R	F,C	ESE Assignment
CO2	Understand and analyze metamorphic textures and structures, metamorphic facies, zone, and grade concepts.	**U,An**	F,C	ESE
CO3	Understand mineral paragenesis, tectonic association and analyse the effects of metamorphism in different rocks	U,An	F,C	ESE Quiz
CO4	Identification of metamorphic rocks in lab and field based on megascopic and microscopic study.	Ap	P	ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	2					2
CO 2		3				3
CO 3	1	3				3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2			✓	✓
CO3		✓	✓	✓
CO4			✓	

Discipline and Type of Course	**Geology**			**Discipline Specific Core - DSC**	
Course Code and Title	**UK5DSCGLY320**			**Magmatic Processes and Igneous Petrology**	
Semester	5			Academic Level: 300 - 399	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module I: Magma to Rocks:	**14**
Magma generation in the crust and upper mantle. Primary and parental magmas. Definition of felsic, mafic and alkaline magma. Physical properties of magma - temperature, viscosity, density and volatile content.; Diversity of igneous rocks - magmatic differentiation process, fractional crystallization, liquid immiscibility and assimilation/ contamination. Igneous rocks- plutonic, hypabyssal and volcanic igneous rocks. Cooling history of igneous rocks. Bowen's reaction series. Brief idea of major, minor and trace element trends in magmatic evolution. Harker diagram. Phase rule and Lever rule and its application to eutectic, peritectic and solid solution system. Phase equilibria in the following binary systems, and their petrogenetic significance: diopside – anorthite, forsterite – silica, albite – anorthite systems. Distribution of igneous rocks along different tectonic settings.	

Module II: Igneous forms, Structures, and Textures	**14**
Intrusive igneous forms- Concordant forms - sill, laccolith, lopolith and phaccolith. Discordant forms - dykes, cone sheets, volcanic neck, ring dyke, batholiths, stocks, bosses and bysmaliths. Igneous structures: Vesicular and amygdaloidal structures, flow structure, sheet joints, mural jointing, and columnar jointing. Textures: definition and description -Types with examples; Crystallinity – crystallites, microlites, devitrification; Granularity- absolute and relative grain size; Shapes of crystals; Mutual relations – Equigranular textures: allotriomorphic, hypidiomorphic, Panidiomorphic, Inequigranular textures: porphyritic and poikilitic textures, Intergrowth texture – perthite, antiperthite, graphic, vermicular textures, Overgrowth textures - orbicular structure, Reaction textures – coronas, Directive textures – trachytic texture, spherulitic structure and perlitic fracture.	
Module III: Classification of Igneous rocks	**14**
Classification based on texture, mineralogy and chemistry. Classification based on mineralogy – felsic and mafic minerals, mode, colour index and IUGS classification - QAP classification of plutonic and volcanic rocks and ultramafic rock classification. Chemical classification – Based on silica saturation and based on alkali & silica (brief introduction of alkalic, subalkalic, calc-alkalic and tholeiitic groups only) – Total alkali vs silica classification for volcanic rocks. A short account of CIPW norm and normative minerals. Tabular classification. Texture, mineralogy, classification, occurrence and origin of granites, basalts and ultramafics. Intrusive rocks of Kerala.	
Module IV: Practical	**8**
Problems related to Phase rule and lever rule, Classification of rock according to QAPF: Brief petrographic character of common igneous rocks – granodiorite, syenite, diorite, gabbro, dolerite, andesite, rhyolite, pegmatites, lamprophyres, komatiite carbonatite, dunite, peridotite, anorthosite and kimberlite. Megascopic and Microscopic identification of major igneous rocks.	
Module V: Teacher specific content	**6**
Teacher specific content related to Magmatic processes and igneous rocks	

Reference

1. Philpotts, A. and Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
4. Myron G. Best (2001). Igneous and Metamorphic Petrology.
5. Cox, K. G. and Bell. J. D. (1979). The Interpretation of Igneous Rocks. Springer/Chapman and Hall.
6. Bose M. K. (1997). Igneous Petrology.
7. Winter, J.D. (2001) An introduction to Igneous and Metamorphic Petrology. Prentice Hall, New Jersey.
8. Ehlers, G.E. and Blatt, H. (1999) Petrology – Igneous, Sedimentary and Metamorphic. CBS Publishers and Distributors, New Delhi.
9. Hyndman, D.W. (1972) Petrology of Igneous and Metamorphic Rocks. MC-Graw Hill.
10. Frost B. R. and Frost C. D (2014). Essentials of Igneous and Metamorphic Petrology. Cambridge University Press.
11. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
12. Raymond, L. A. (2002). Petrology: the study of igneous, sedimentary, and metamorphic rocks. McGraw-Hill Science Engineering.
13. McBirney, A. R. (1984). Igneous Petrology. San Francisco (Freeman, Cooper & Company) and Oxford (Oxford Univ. Press),
14. G W Tyrrell. (1926). Principles of Petrology. Springer
15. Bowen, N.L.M. (1956) The Evolution of the Igneous Rocks. Dover publication, Inc, New York.
16. Barth, T.W. (1962) Theoretical Petrology. Wiley.
17. Walstrom, E.E. (1961) Theoretical Igneous Petrology, Wiley.
18. Turner, F.J. and Verhoogen, J. (1960) Igneous and Metamorphic Petrology. McGraw Hill.
19. Hatch, F.H. and A.K. Wells (1949) Petrology of Igneous Rocks. Thomas Murby & Wells, M.K.(Publ.)
20. Johannesen, A (1962) Descriptive Petrography of Igneous Rocks. Vols. I to IV, Allied Pacific. Allied Pacific.
21. Mackenzie, W.S., Donaldson, C.H. and C. Guilford (1988) Atlas of Igneous rocks and their textures. ELBS Longman.
22. Wilson, M. (1989) Igneous Petrogenesis: A Global Tectonic Approach. Unwin Hyman, London Inc., USA.
23. John D. Winter (2012) An Introduction to Igneous and Metamorphic Petrology. Prentice Hall.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understanding properties magma and formation of various igneous rocks from magma	U	C	Assignment, Final Exam
CO2	Scientific study of Igneous Rocks.	**An**	P	Assignment, Final Exam
CO3	Identification of igneous rocks in hand specimen and	AP	P	Assignment Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				2
CO 2		3				3
CO 3					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK5DSCGLY321**		**Sedimentology and Sedimentary Petrology**		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module I: Sedimentology	**12**
Origin of sediments. Diagenesis - Compaction, cementation, authigenesis, recrystallization and replacement. Sediment transport mechanism- types of flow (Newtonian and Non-Newtonian), laminar and turbulent flow, subcritical, critical and supercritical flows; concept of mean flow velocity; particle entrainment, transport and deposition. Depositional environments, facies concept and sedimentary provinces.	
Module II: Sedimentary structures and textures	**17**
Sedimentary structure, Primary, penecontemporaneous deformation and biogenic structures. Paleocurrent analysis using sedimentary structures. Clastic texture - concept of size, Udden-Wentworth and Phi scale. Grain shape, morphology and fabric. Non- clastic texture – crystalline texture. Plate Tectonics and major types of sedimentary basin. Quaternary sediments.	
Module III: Classification and Descriptions of sedimentary rocks.	**17**
Classification of sedimentary rocks – Clastic and non-clastic rocks. Argillaceous, arenaceous and rudaceous rocks. Classification of Sedimentary rocks: Conglomerates, sandstones, Claystone, Shale. Non clastic rocks. Allogenic and authigenic matter. Classification of limestone – Folk and Dunham scheme. dolomites and dolomitization. General outline of controls on deposition of sandstones and carbonate rocks. Evaporates. Diagenesis: Concepts of diagenesis, processes and stages of diagenesis. Sedimentary rocks of Kerala	
Module IV: Practical	**14**
Megascopic and microscopic study (textural and mineralogical) of major sedimentary rocks. Study of sandstone, shale, conglomerate, breccias, limestone, dolomite	

Module V: Teacher specific content	**10**
Teacher specific content related to sedimentology and sedimentary petrology	

Reference

1. Prothero, D. R., & Schwab, F. (2004). Sedimentary geology. Macmillan
2. Tucker, M. E. (2006). Sedimentary Petrology, Blackwell Publishing
3. Collinson, J. D. & Thompson, D. B. (1988). Sedimentary structures, Unwin-Hyman, London
4. Nichols, G. (2009). Sedimentology and Stratigraphy Second Edition. Wiley Blackwell
5. Folk, R.L. (1980) Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, 184 p
6. Pettijohn FJ, 1970, Sedimentary rocks, New York: Harper & Row, 628p.
7. Blatt H., Middleton G. and Murray R. Origin of Sedimentary rocks. Prentice Hall, 1972.Carver R. E. (Ed). Procedures in Sedimentary Petrology, Inter science, 1971.
8. Krumbein W. C. and Pettijohn E. J. Manual of Sedimentary Petrology. Appleton, 1938Stelley R. C. Ancient Sedimentary Environments, Cornell University Press, 1972.
9. Pettijohn F. J, Potter P. E., Siever R. Sand and Sandstone. Springer-Verlag, 1972.
10. Nichols G. Sedimentology and Stratigraphy. Wiley-Blackwell, 2009.
11. Harker, A. (1964) Petrology for Students. Cambridge.
12. Greensmith, J. (1989) Petrology of the Sedimentary Rocks. 7th Edn., CBS Publishers, Delhi.
13. Carver R. E. (Ed). Procedures in Sedimentary Petrology, Inter science, 1971.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basic sedimentological process.	U	F	Assignment, Final Exam
CO2	Systematic study of sedimentary rocks.	**An**	P	Assignment, Final Exam
CO3	Examine sedimentary rocks	AP	P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			2
CO 2		3				2
CO 3					3	2
Level		1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓			✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**	
Course Code and Title	**UK5DSCGLY322**		**Principles of Metamorphic Petrology**	
Semester	5		Academic Level: 300 - 399	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I: Definition of metamorphism	**12**
Metamorphism- Factors of metamorphism - pressure, temperature, chemically active fluids, time and parent rock chemistry, limits of metamorphism. anatexis, palingenesis and migmatites. Depth zone concepts. Types of metamorphism – Contact metamorphism, regional metamorphism – orogenic and ocean floor, burial metamorphism, cataclastic metamorphism, hydrothermal metamorphism Impact/shock metamorphism and plutonic metamorphism.	
Module II: Metamorphic Facies, Grades, Zones, Isograds and Index minerals	**16**
Concept of metamorphic facies, Mineralogical phase rule of closed and open system. Composition-paragenesis diagrams. Basic concept of ACF, AKF and AFM diagrams. Winkler's grade concept. Progressive and retrogressive metamorphism. Stability of alumina silicate minerals in P-T field. Metamorphic mineral zone concept - index minerals and isograd, Metamorphic facies series.	

Module III: Metamorphic textures and structures	**18**
Crystalloblastic and Relict textures. Metamorphic structures – foliations, lineations, cataclastic and miscellaneous. Metamorphism of pelitic, carbonate and mafic rocks. Regional occurrence and tectonic significance of metamorphic rocks: Metamorphism along convergent plate margins, in continent-continent collisions, in rifting terrains and sea floor metamorphism. Metamorphic rocks of Kerala.	
Module IV: Practical	**14**
Megascopic and microscopic study (textural and mineralogical) of the following metamorphic rocks: Slate, Phyllite, Quartzite, Marble, Schists, Amphibolite, Gneisses, Eclogite, Blueschist, mylonite, Hornfels and Granulites – Charnockite (massive, incipient), Khondalite and Leptynite.	
Module V:Teacher specific content	**10**
Teacher specific content related to Metamorphic petrology	

Reference

1. Philpotts, A., & Ague, J. (2009). Principles of igneous and metamorphic petrology. Cambridge University Press.
2. Winter, J. D. (2014). Principles of igneous and metamorphic petrology. Pearson.
3. Rollinson, H. R. (2014). Using geochemical data: evaluation, presentation, interpretation. Routledge.
4. Yardley, B. W. D. (1989). An introduction to metamorphic petrology. Longman Scientific and Technical, London.
5. Spear F. S. 1993. Metamorphic phase equilibria and Pressure-Temperature-Time paths. Mineralogical Society of America. Monograph 799
6. Raymond, L. A. (2002). *Petrology: the study of igneous, sedimentary, and metamorphic rocks*. McGraw-Hill Science Engineering.
7. Blatt, J., Tracy J. R. and Owens B.E. 2006 Petrology: Igneous, Sedimentary, and Metamorphic.
   Edition3, W. H. Freeman.
8. Shelley D. Igneous and metamorphic rocks under the microscope: classification, textures, micro structures, and mineral preferred - orientations Springer, 1993.
9. Fry N. The field description of metamorphic rocks. Geological Society of London hand book series. Open University Press, 1984
10. Vernon R. H. and Clarke G. L. 2008 Principles of metamorphic petrology Cambridge University Press.
11. Vernon R. H. A practical guide to rock microstructure Cambridge University Press, 2004 Books
12. Bucher K and Frey M. 1994 Petrogenesis of metamorphic rocks Edition6, Illustrated Publisher Springer-Verlag.
13. Barker A. J. 1998 Introduction to metamorphic textures and microstructures Edition 2, Routledge

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Discuss types and process and environment of metamorphism	U	F	Assignment, Final Exam
CO2	Analyze texture, structure and classification of metamorphic rocks.	An	P	Assignment, Final Exam
CO3	Identification of metamorphic rocks and interpretation of their textures and structures.	AP	P	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				2
CO 2		3				3
CO 3					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2			✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Elective - DSE**		
Course Code and Title	**UK5DSEGLY300**		**Marine Geology**		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture Per week	Tutorial Per week	Practical per week	Total Hours/Week
	4	2 hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module-1-	**15**
Oceanographic expedition, Ocean floor drilling programmes - ODP, DSDP and JOIDES. Morphology of ocean floor, Mid-oceanic ridge system, Subduction zones, island arcs, trenches, conjugate oceanic basins, seamounts. Guyots and ridges. Ocean floor mapping - Echo sounding - multi beam survey and ROVs.	
Module II	**15**
Turbidity currents and turbidites, Mud banks. Marine pollution - Oil spill, algal blooms, industrial effluents. Tar balls. Upwelling and Oxygen minimum zone. EEZ and CRZ. Law of sea.	
Module III	**16**
Marine Sediments - Classification and distribution. Factors controlling the deposition and distribution of oceanic/marine sediments - Biogenous, Cosmogenous, Hydrogenous, Terrigenous and Authigenic.	
Module IV	**14**
Mineral resources of the oceans – Distribution and classification of minerals of economic importance in different oceanographic settings: Seawater as a source of elements/minerals. Placer and heavy mineral deposits, petroleum, phosphorites, phosphatic deposits, gas hydrates, poly-metallic nodules, metals enriched crusts, hydrothermal and metalliferous sediments	
Module V	**10**
Teacher Specific related to course Marine geology	

Reference

1.Pinet Paul, R. (1992). Oceanography – An Introduction to the Planet Oceanus, West Publishing Co.

2.Pond, S. and Pickard, G. L. (1983). Introductory Dynamical Oceanography, 2nd Ed.,Pergamon Press.

3.King, C. A. M. (1972). Beaches and Coasts, Arnold, London.

4.Trask P. D. (1939). Recent Marine Sediments, Denver Publications.

5.Krumbein, W. C. and Pettijohn, F. J. (1938). Manual of Sedimentary Petrology, Appleton Century Co.

6.Pickering, K. T. Hiscott, R. N. and F. J. Hedn (1989). Deep Marine Environments – clastic sedimentation and Tectonics, Unwin and Hyman.

7.Roy Chester (1990). Marine Geochemistry, Unwin Hyman.

. 8.Shepard F. P. (1963) Submarine Geology, Harper & Row, New York.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the morphological features of ocean floor , Oceanographic expeditions and ocean drilling programs and ocean floor mapping, marine pollution and law of the sea.	R,U	F,C	Assignment, Final Exam
CO2	Understand the various physical and chemical parameters of ocean water .	R,U	F,C	Assignment, Final Exam
CO3	Understand the various aspects of marine sediments	R,U	F,C	Assignment, Final Exam
CO4	Understand the different mineral resources of the ocean floor.	R,U	F,C	Quiz Final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	1					2
CO 2	2					2
CO 3		2				2
CO4				2		2
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Elective - DSE		
Course Code and Title	UK5DSEGLY301		Advanced Paleontology		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1-	**15**
Vertebrate Palaeontology – Introduction, Brief study of vertebrate life through ages. Origin and early evolution of life Patterns of evolution-Trends in the evolution of invertebrates-Ammonoidea-Trilobita- Graptozoa.	
Module II	**15**
Basic morphologic characters and evolution ofPisces, Horse and Man. Principal groups of vertebrates in Gondwana and Siwalik formations. Siwalik mammals; Gondwana flora and fauna.	
Module III	**16**
Micropalaeontology: scope and subdivisions. Sampling methods and sample processing techniques. Types of microfossils. Foraminifera: their palaeoecology and applications in petroleum exploration. Radiolarians, Diatoms, Ostracoda, Pteropods and Conodonts—morphology and classification. The role of microfossils in the study of Paleoclimatology and Paleoceanography. Palynology--General morphology of spores and pollens and their classification and significance.	
Module IV	**14**
Collection, Separation and identification of microfossils	
Module V	**10**
Teacher Specific related to course Advanced Paleontology	
Reference	
1. Ager D. V. Principles of palaeoecology, Mc Graw Hill, 1963. 2. Krishnan M.S. Geology of India and Burma. Higginbothams, 1968. 3. Easton W. H. Invertebrate Palaeontology. Harper and Brother, 1960. 4. Cushman A. J. Foraminifera. Harvard University Press, 1959. 5. Colebert H. E. Evolution of the Vertebrates. John Wiley & Sons, 1961. 6. Moore R.C., Lalicker C.G., Fisher A.G. Invertebrate fossils. Mc Graw Hill, 1952. 7. Glaessnar M. F. Principles of Micro Palaeontology. Mc Graw Hill, 1953. 8. Woods H. Invertebrate Palaeontology. Cambridge University Press, 1961. 9. Benton,M. J. Vertebrate Palaeontology, 2nd edition, Blackwell Science, 2000.	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand and remember the vertebrate life through various ages. Evaluate the trends in evolution of important invertebrates.	R,U	F,C	Assignment, Final Exam
CO2	Analyze the morphologic characters and evolution of Pisces, horses and man. Understand the principal groups of vertebrates in Gondwana and Siwalik formations and Gondwana flora and fauna.	An,U	F,C	Assignment, Final Exam
CO3	Understand about various types of microfossils and analyze the role of microfossils in palaeoclimatology and paleoceanography.	R,U	F,C	Assignment, Final Exam
CO4	Identification of microfossils	Ap	F,C	Quiz, Final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		2				2
CO 2		2				3
CO 3		2				3
CO4		2				3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Elective - DSE		
Course Code and Title	UK5DSEGLY320		Climatology & Marine Science		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2hours	-	2hours	4

Detailed Syllabus:

Content	Hrs.
Module I- Atmosphere and atmospheric processes	**12**
Atmosphere- Structure and composition, role of ozone, water vapor and carbon dioxide. Heat budget and radiation balance, factors affecting solar radiation. Milankovitch Cycle. Temperature Distribution on Earth: Heat transfer ways: Radiation, Conduction, convection: Factors - Transparency of atmosphere: Scattering, Absorption, Reflection, Albedo, Atmospheric window, Pressure systems & Wind system: Atmospheric pressure, Isobars: Cyclones and anti-cyclones, Factors affecting wind: Pressure Gradient force, Buoyant force, Frictional force, Coriolis force, Fundamentals of Monsoon systems in India, Koppen system of climate classification	
Module II-	**12**
Ocean floor morphology, tectonic origin of ocean basins, Paleo oceanographic expeditions & development of Marine Geology. Ocean floor drilling programmes – DSDP, ODP & JOIDES. General distribution of temperature, salinity and density in sea water, TS diagrams, deep ocean circulation and conveyor belt. Surface currents - origin, distribution, influencing factors, Coriolis Effect, Warm & Cold currents, and Ekman Transport. Concepts of coastal and deep-water upwelling and downwelling. Greenhouse effect and global warming, basics of El Niño and La Nina. Tides	
Module III- Marine sedimentation & distribution	**12**
Marine sediments- Terrigenous, biogenous and homogenous sediments with particular reference to oozes. Turbidity currents and turbidites. classification of marine environments, Redox environments and diagenesis in marine sediments. Mineral resources of oceans and factors controlling their distribution– polymetallic nodules, phosphatic and Hydrothermal sulphide deposits, beach placers.	
Module IV- Teacher Specific	**6**

Teacher Specific related to Climatology& Marine Science	

Reference	
1. Pinet Paul,R .Oceanography– An Introduction to the Planet Oceanu s,West PublishingCo, 1992. 2. King,C.A.M. Beachesand Coasts, Arnold, London,1972. 3. Krumbein,W.C.andPettijohn,F.J.ManualofSedimentaryPetrology,AppletonCenturyCo., 1938. 4. Pettijohn,F.J Sedimentary Rocks, Harper and Row,1957 5. Pettijohn,F.J, ,Potter, P.E and Siever, R Sand and sandstone,SpringerVerlag,1972. 6. Pickering, K.T. Hiscott, R.N. and F.J. Hedn. Deep Marine Environments– clastic sedimentation and Tectonics, Unwin and Hyman,1989. 7. Pond,S.andPickard,G.L.IntroductoryDynamicalOceanography,2nd Ed.,Pergamo nPress,1983. 8. Roy Chester. Marine Geochemistry, Unwin Hyman, 1990. 9. Selley ,R.C Ancient SedimentaryEnvironments,CorwellUniversityPress,1972. 10. Trask P.D Recent Marine Sediments, Dever Publications .1939. 11. William L. Donn– Meteorology, McGraw –Hill Books Co., NewYork,1975 12. Narora B ,Atmosphere, Weather and Climate: An introduction to Meteorology, Saunders Co., Philadelphia. 13. M. Grant Gross, Principles of Oceanography. 14. Emerson, Eand Hedges, J–Chemical Oceanography and the Marine Carbon Cycle. Cambridge University Press, 2008	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand various Atmospheric Processes	U	C, F	Assignment, Final Exam
CO2	Analyze Ocean Floor Drilling programs and General distribution of temperature, salinity and density of sea water.	**An**	C	Assignment, Final Exam
CO3	Classify various Marine Sediments, marine environments and marine resources	U	F, C	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				3		2
CO 2				3		3
CO 3				3		3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Skill Enhancement Course - SEC**		
Course Code and Title	**UK5SECGLY300**		**Geotechnical Investigation of Soils**		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Fundamentals of Soils	**12**
Geological processes responsible for soil formation- weathering, erosion, transportation and deposition. Soil profile. Classification of soils- Origin (Residual and transported soils),depositional regimes (alluvial, colluvial, aeolian, glacial, organic and volcanic soils), textural (coarse-grained, fine-grained, and organic soils). Soil types of India, characteristics and occurrence (alluvial soil, black soil, lateritic soil, red soiland other soil types).	
Module II- Soil Mechanics	**12**
Physical properties of soils (colour, texture, structure, porosity, density, void ratio, consistency, aggregate stability, and temperature). Soil sampling methods- Boring, Auguring and Drilling. Field testing of soils-Insitu soil density and compactiontests, Rollers, Pressure meters, Piezometer, Pressure cells, Sensors, Inclinometers, and Strain gauge. Laboratory testing of soils-Grain size analysis (sieve analysis, hydrometer analysis), Atterberg limits tests (liquid limit, plastic limit), Compaction tests	

(Standard Proctor, Modified Proctor) and Consolidation and permeability tests	
Module III- Factors Influencing Strength of Soil	**12**
Soil Strength and Shear Strength Testing- Unconfined compression test, Triaxial compression test and Direct shear test. Interpretation of Soil Investigation data- Analysis of field and laboratory data, Soil profile interpretation, Bearing capacity analysis and Slope stability analysis.	
Module IV Practical	**12**
Soil testing experiments- Preparation of a laboratory procedure or field investigation report of soil testing methods adopted for a major engineering project (either in India or in the world).	
Module V	**10**
Teacher Specific related to course Geotechnical Investigation of Soils	

Reference

1. Das, B. M. (Ed.). (2011). Geotechnical engineering handbook. J. Ross publishing.
2. Simons, N., Menzies, B., & Matthews, M. (2002). A short course in geotechnical site investigation (Vol. 5). Thomas Telford.
3. Budhu, M. (2010). Soil mechanics and foundations. John Wiley and Sons.
4. Venkatramaiah, C. (1995). Geotechnical engineering. New Age International.
5. Kesavalu N. C. (1993) A Textbook of Engineering Geology, Macmillan India Ltd. New Delhi
6. Krynine, D P. Judd W. F. (1957) Principle of Engineering Geology and Geotectonics. Mc Graw Hill, New York.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand more about soil and its types- origin, types and classification	U, An	F,C	ESE Quiz
CO2	Understand the physical properties of soil and major soil tests adopted for geotechnical investigation	U, Ap	F,C, P	Assignment ESE
CO3	Understand the major factors and tests for the determination of soil strength	Ap, An	F,C, P	Assignment ESE
CO4	Preparation of a laboratory procedure or field investigation report of soil testing methods adopted for a major engineering project	E	F, C, P	Assignment (Field Report)

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				3
CO 2		3				3
CO 3		3				3
CO4					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2	✓	✓	✓	✓
CO3	✓		✓	✓
CO4			✓	✓

Discipline and Type of Course	**Geology**		**Skill Enhancement Course - SEC**		
Course Code and Title	**UK5SECGLY320**		**Geotechnics**		
Semester	5		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3

Detailed Syllabus:

Content	**Hrs.**
Module I- Introduction to Engineering Geology	**11**
Role of Geology in Civil engineering. Role of Engineering geologists in planning, design and construction of major man-made structural features. Site investigation and characterization, Engineering properties of rocks. Rock as construction and foundation material, road aggregate. Rock mass classification – general ideas of RMR, RQD and SMR. Soils – Geological and Engineering classification.	
Module II- Geology & Construction	**12**
Significance of Geology in the construction of dams and reservoirs, tunnels, roads, railways, bridges, buildings, and shorelines. Foundation treatment; Grouting, Rock Bolting and other support mechanisms.	

Module III- Significance of Structures	**12**
Earthquake resistant structures, Groundwater problems related manmade structures, Landslides; Causes, Factors and corrective/Preventive measures	
Module IV - Practical	**14**
Simple calculations related to engineering properties of rocks and soil (Porosity, permeability calculation)	
Module V- Teacher Specific content	**7**
Teacher Specific content related to Geotechnics	

Reference

1. Krynin, D.P.andJuddW.R.1957.PrinciplesofEngineeringGeologyandGeotechnique, McGraw Hill (CBS Publ).
2. Johnson,R.B.andDeGraf,J.V.1988.PrinciplesofEngineeringGeology,JohnWiley.
3. Goodman,R.E.,1993.EngineeringGeology:RockinEngineeringconstructions.JohnWile y& Sons, N.Y.
4. Waltham,T.,2009.FoundationsofEngineeringGeology(3rdEdn.)Taylor&Francis.
5. Bell:F.G-,2006.BasicEnvironmentalandEngineeringGeologyWhittlesPublishing.
6. Bell,.F.G,2007.EngineeringGeology,Butterworth-Heineman
7. Crozier.M.J.(1989)Landslides:causes,consequencesandenvironment.AcademicPress.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the role of Geology in Civil Engineering and analyze Geology's Influence in the construction of various infrastructure projects	U, Ap	C, F	Assignment, Final Exam
CO2	Understand the geological factors causing earthquake, identify and evaluate issues related to Groundwater and Landslide. .	**U, Ap, E**	C	Assignment, Final Exam
CO3	Recommend earthquake resistant Structures and preventive measures to mitigate hazards. Apply Engineering Calculations to analyses engineering properties of rocks and soils.	Ap. An	F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					3	3
CO 2					3	3
CO 3					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3			✓	✓

5.5 COURSES IN GEOLOGY: Semester 6

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK6DSCGLY300**		**Foundation of Structural Geology**		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Attitude of Structural Planes	**11**
Attitude of planar and linear structures. Strike, dip, plunge and pitch. Width of outcrops, outlier and inlier, Rule of Vs. Primary and secondary structures. Use of primary structures in determining the top and bottom of beds.	
Module II- Rock Deformation	**11**
Concept of Stress and strain, Stress and strain ellipsoids. Stages of rock deformation, Basic concepts of stereographic projections. Tectonites and its classification.	
Module III- Major Rock Structures	**12**
Folds: Terminology, Classification-genetic and geometric. Recognition of folds in the field and map. Unconformity-types and their recognition in the field. Fault terminology and classification. Fault mechanics. Recognition of faults in the field and map. Foliation– Tectonites, Compositional, Disjunctive, Continuous, Slaty cleavage, Schistosity, Flow cleavage, Fracture cleavage, Shear cleavage. Relationship of foliation with fold and shear zones. Lineation - Discrete, constructional and mineral lineation. Joints – Nature, origin, classification and geologic significance. Fractures and its types.	
Module IV Practical	**12**
Rose diagram, Structural problems involving true dip, apparent dip, true thickness and width of outcrop. Geological Maps.	
Module V	**10**
Teacher Specific related to course Structural Geology	

Reference

1. Billings (1974) Structural Geology. 11th edition, Prentice Hall.
2. Park R. G. (1997) Foundations of Structural Geology 3rd, Chapman & Hall.
3. Hills, E. S. (1961) Elements of Structural Geology, Asia Publishing House.
4. Hobbs, Means and Williams (1976). An Outline of Structural Geology. John Wiley.
5. John Robberts (1982) Introduction to Geological Maps and Structures, Pergamon Press.
6. Ken McClay (1991) The mapping of Geological Structures. Geological Society of London. Wiley, New edition.
7. R. J. Twiss and E M Moore (2007) Structural Geology 2nd edition. Freeman & Company
8. Ghosh SK (2013) Structural Geology Fundamentals and Modern developments, Elsevier Science.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand basic concepts in structural geology, primary and secondary structures and their significance.	U,Ap	F,C	ESE
CO2	Understandand analyse rock deformation and its stages, stereographic projections, tectonites and their classification.	U,An	F,C	ESE Quiz
CO3	Understand and analyse the folds, faults, foliations, lineation, unconformities, joints, fractures-classification, identification, mechanism and geological significance.	U,An	F, M	ESE Assignment
CO4	Apply the concepts of structural geology in determining the attitude of beds and for solving problems using stereographic projections and analyse geological maps	Ap,An	P	ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			2			2
CO 2			2			2
CO 3			3			3
CO4					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2		✓	✓	✓
CO3	✓		✓	✓
CO4			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK6DSCGLY301**		**Indian stratigraphy**		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4hours	-	-	4

Detailed Syllabus:

Content	Hrs.
Module-1- Precambrian Stratigraphy	**11**
Physiographic divisions of India. Major cratons and fold belts of the Indian shield. Detailed study of the lithology, classification, age, structure, syn- and post-tectonic intrusives, organic remains, radiometric age and economic resources of Dharwar Craton- Sargur Schist Complex, Peninsular Gneiss. Charnockite–Khondalite bearing High-Grade terrains of Peninsular India. Eastern Ghat belts and Southern Granulite terrain.	
Module II- Proterozoic Succession in India	**12**
Detailed study of the lithology, classification, age, structure, syn- and post-tectonic intrusives, organic remains, radiometric age and economic resources of Cudappah Supergroup, Aravalli Supergroup, Delhi Supergroup, and Vindhyan Supergroup.	

Module III- Phanerozoic formations of India	**12**
A brief study of the distribution of marine Palaeozoic and Mesozoic successions of India and detailed study of the following – Palaeozoic, Mesozoic and Triassic successions of Spiti, Jurassic of Spiti and Kutch. Cretaceous of Trichinopoly and Narmada valley, Distribution, lithology, classification, age, structural features, fossils and coal resources of Gondwana Supergroup. Deccan Traps and associated sedimentaries, their distribution, lithology, classification, fossils and age.	
Module IV Cenozoic Deposits	**11**
Detailed study of following Cenozoic succession of India. Tertiaries of Tamilnadu. Siwalik Supergroup. Karewa Formation. Indo – Gangetic alluvium. Stratigraphy of Kerala- Precambrian rocks, Intrusive rocks of Kerala, Tertiaries of Kerala, Quaternary sediments.	
Module V	**10**
Teacher Specific related to course Indian Stratigraphy	

Reference

1. Krishnan, M.S. (1982) Geology of India and Burma, 6th Edition, CBS.
2. Wadia, D.N. (1944) Geology of India, Tata McGraw–Hill.
3. Ravindra Kumar (2020) Fundamentals of Historical Geology and Stratigraphy of India. 2nd edition, New Age International Private Limited.
4. Pascoe, E.H. (1954) A Manual of the Geology India and Burma, Govt. of India Publications.
5. Vaidyanathan and Ramakrishnan (2008). Geology of India (Vol. I & II). Geological Society of India, Bangalore.
6. Soman, K. (2013) Geology of Kerala, Geological Society of India, Bangalore.
7. Radhakrishna, B.P and R. Vaidyanathan (1997) Geology of Karnataka, Geological Society of India, Bangalore.
8. Sanjib Chandra, Sarkar, Anupendra Gupta (2012). Crustal evolution and Metallogeny in India. Cambridge University Press, Delhi, India.
9. Amal Das Gupta (2006). An introduction to Earth Science, World Press Private Limited, Kolkata.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the physiographic, geologic divisions, and the Precambrian formations of India	U, R	F	ESE Quiz
CO2	Understand the Proterozoic, Paleozoic, Mesozoic and Cenozoic formations in India.	U	F	ESE Assignment
CO3	Understand the geologic formations in Kerala and its stratigraphic significance	U	F	ESE Quiz

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			2		2	2
CO 2			3		2	2
CO 3			3		2	2
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3		✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Core - DSC		
Course Code and Title	UK6DSCGLY302		Economic Geology		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module-1- Classification of Mineral Deposits	**12**
Ore and gangue minerals, Tenor and grade of ore, Bateman's classification of mineral deposits. A brief introduction to UNFC classification of mineral deposits. Strategic and critical minerals, National mineral policy of India, EEZ, SEZ	
Module II- Processes of Formation	**17**
Processes of formation of mineral deposits: Origin due to internal processes- Magmatic, Hydrothermal, contact metasomatic and metamorphic processes. Skarn and Greisen deposits. Origin due to external or surface processes- Evaporite deposits, sedimentary deposits: mechanical and residual concentration, Oxidation and supergene enrichment, Volcanic exhalative deposits.	
Module III- Metallogeny in India	**17**
Metallogenic epochs and provinces in India. Atomic minerals (U, Th) occurrence and distribution. Coal- theories of origin, Distribution of Coal resources in India. Petroleum- Origin, Source rock, cap rock and traps. Brief study on the petroliferous basins of India. Mineral deposits of Kerala.	
Module IV Practical	**14**
A brief study on physical properties, economic uses, mode of occurrence and Indian distribution of the following ore and industrial minerals: Bauxite, chromite, gold, magnetite, haematite, chalcopyrite, pyrite, galena, pyrolusite, psilomelane, ilmenite, monazite, sphalerite, realgar, orpiment, asbestos, uranium minerals, abrasives, refractories and clay minerals.	
Module V	**10**
Teacher Specific related to course Economic Geology	

Reference

1. Anthony M. Evans (1980). An introduction to Ore Geology, Second edition, ELBS.
2. Gokhale, K. V. G. K. and Rao, T.C. (1978) Ore Deposits of India. Thomson Press (India).
3. Krishnaswamy, S. (1988) Indian Mineral Resources. South Asia Books.
4. Mead L. Jensen and Alan M. Bateman (1981). Economic Mineral Deposits, John Wiley& Sons Third edition.
5. Park and Macdiarmid (1964). Ore Deposits, Freeman.
6. Roy Chacko (ed.) (2005) Mineral Resources of Kerala. Dept of Mining and Geology.
7. Soman, K. (2002) Geology of Kerala, Geological Society of India, Second revised edition.
8. Umeshwar Prasad (1996). Economic Mineral Deposits, CBS Publishers.
9. Wadia, D.N. (1994) Minerals of India, National Book Trust, India, 5th Edition.
10. Leverson (1967). Geology of Petroleum, McGraw Hill

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the terminologies, classification of economic mineral deposits, national mineral policy, EEZ and SEZ	U	F	ESE Quiz
CO2	Understand and analyse the processes of formation of mineral deposits.	U,An	F	Assignment ESE
CO3	Understand the metallogenic epochs and provinces, distribution and occurrence of natural energy resources in India and analyse the mineral deposits of Kerala.	U,An	F,C	Assignment ESE
CO4	Identify the economic minerals based on their physical properties and understand its uses, occurrence and distribution.	Ap,U	P	ESE Quiz

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		2		3		2
CO 2	1	2	2	3		3
CO 3		3		3		3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	
CO4		✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK6DSCGLY320**		**Structural Geology**		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I: Introduction to structural Geology:	**12**
Introduction and basic concepts in Structural Geology, Primary and secondary structures, planar and linear structures, Structural elements, concept of strike and dip, trend and plunge, rake/pitch, contour, Rule of V's. Geological Mapping - Procedures and equipment in mapping. Concept of rock deformation, Stress and Strain in Rocks. Stages of deformation.	
Module II: Stress & Strain:	**17**
Concept of Stress: normal stress, shear stress, stress ellipse concept, principal axes of stress, Brief idea of Mohr's circle of stress. Concept of strain: Longitudinal and shear strain, principal axes of strain, strain ellipsoid concept. Strain ellipsoids- different types and their geological significance. Concept of brittle and ductile deformation, Factors controlling deformation behaviour of rocks.	

Module III: Secondary structures	**17**
Fold morphology; Geometric classification of folds- Ramsay's classification, Fleuty diagram; elementary idea on mechanism of folding-buckling, bending, flexural slip and flow folding, Foliation and Lineation. Tectonic significance of foliation and lineation. Classification of fractures, Faults and Joints, fault zone terminology, geometric classification of faults. Anderson dynamic analysis of faulting. Effects of faulting on the outcrops. Criteria for recognition of faults and fold on field and map. Basic idea of shear zone and shear sense indicators.	
Module IV: Practical	**14**
Interpretation of geological maps with unconformity, fault, fold and igneous bodies. Construction of structural cross section. Stereographic projections of planes and lines. Outcrop thickness, True dip and apparent dip problems, 3-point problems.	
Module V: Teacher specific content	**10**
Teacher specific content related to Structures and deformations	

Reference

1. Davis, H.G, Reynolds, S.J, Kluth, C. F. (2011), Structural Geology of Rocks and Region, John Wiley
2. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th. Ed.) Cambridge University Press(For Practical)
3. Twiss, R. J. and Moores, E. M (2007) Structural Geology, Second Edition. W. H. Freeman and Company.
4. Fossen, H (2010), Structural Geology, Cambridge University Press.
5. Marshak, S and Mitra G. (1988) Basic Methods in Structural Geology, Prentice Hall.
6. Ben A. van der Pluijm and Stephen Marshak (2004) Earth Structure: An Introduction to Structural Geology and Tectonics(Second Edition) 2nd Edition
7. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
8. Park, R. G. (2004) Foundations of Structural Geology.Chapman & Hall.
9. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press.
10. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical)
11. Lahee F. H. (1962) Field Geology. McGraw Hill
12. Hills, E. S. (1961) Elements of Structural Geology, Asia Publishing House.
13. Hobbs, Means and Williams (1976). An Outline of Structural Geology. John Wiley.
14. John Robberts (1982) Introduction to Geological Maps and Structures, Pergamon Press.
15. Ken McClay (1991) The mapping of Geological Structures. Geological Society of London. Wiley, New edition

CO	Course Outcome	Cognitive Level*	Knowledge Category #	Evaluation Tools used
CO1	Understand the basics of structural deformation	U	F	Assignment, Final Exam
CO2	Examine different geological structures based on geometry and genesis.	**An**	P	Assignment, Final Exam
CO3	Evaluate structural features and its attitude using construction and calculation methods.	AP	P	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			2
CO 2			3			3
CO 3					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK6DSCGLY321**		**Resource Geology**		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module I: Introduction to Earth's Resources	**14**
Types of Resources: Ore deposits & Fossil Fuel. Ore geology definitions: Assay value and Clark value. Basic concepts of ores, gangue minerals, tenor, grade, resources, reserves. Syngenetic and epigenetic deposits, stratiform and strata bound deposits. Morphology of ore bodies. Characters of ore deposits: Rock-Mineral association and association among ore minerals. Classification of ore deposits on the basis of formation- Bateman's classification.	
Module II: Processes of formation of mineral deposits	**15**
Ore forming fluids. Origin due to internal processes - Magmatic deposits, Contact metasomatic deposits- (Skarn and Greisen), Metamorphic deposits. Origin due to Hydrothermal activities- Replacement and filling – VMS and SEDEX, Origin due to External / Surface processes - Evaporite deposits, Sedimentary deposits - mechanical concentration, residual concentration, Oxidation and Supergene enrichment. Polymetallic nodules.	
Module III: Fuel Geology: Fossil Fuels, Coal	**15**
Physical Properties, types and grade of coal, Macroscopic and microscopic constituents. origin, theories of origin; coal resources in India – classification and distribution. Petroleum – origin and migration of petroleum, Source and reservoir rock characters. theories of origin – Source rocks – Cap rocks – Traps – Structural – Stratigraphic - Distribution. brief study on the petroliferous basins of India; Non-conventional Petroleum resources – Introduction to Coal Bed Methane (CBM), Shale gas, Gas hydrates, Tar sands, Oil shales. Mineral Policy of India. Mineral resources of Kerala. Critical and Strategic Minerals. Materials for Abrasives, Refractories, Ceramics and Cement. Gemstones. Strategic and Critical minerals.	

Module IV: Practical	**12**
Study of important economic minerals and coal samples in hand specimen - Physical properties, economic uses, mode of occurrence and Indian distribution of the following ore and industrial minerals: Bauxite, chromite, gold, magnetite, haematite, chalcopyrite, pyrite, galena, pyrolusite, psilomelane, ilmenite, monazite, sphalerite, realgar, orpiment, asbestos, uranium minerals, abrasives, refractories and clay minerals	
Module V: Teacher specific content	**10**
Teacher specific content related to Economic Minerals and Ore forming processes	

Reference

1. Evans, A.M. (1993) Ore Geology and Industrial minerals. Wiley
2. Thomas L. (2013) Coal Geology: Second Edition, John Wiley & Sons, Ltd.
3. Anthony M. Evans (1980). An introduction to Ore Geology, second edition, ELBS.
4. Park and MacDiarmid (1964). Ore Deposits, Freeman.
5. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
6. Wadia, D.N. (1994) Minerals of India, National Book Trust, India, 5th edition
7. Gokhale, K. V. G. K. and Rao, T.C. (1978) Ore Deposits of India. Thomson Press(India).
8. Krishnaswamy, S. (1988) Indian Mineral Resources. South Asia Books.
9. Anthony M. Evans (1980). An introduction to Ore Geology, second edition, ELBS.
10. Mead L. Jensen and Alan M. Bateman (1981). Economic Mineral Deposits, John Wiley& Sons Third edition, revised printing.
11. Park and Macdiarmid (1964). Ore Deposits, Freeman.
12. Roy Chacko (ed.) (2005) Mineral Resources of Kerala. Dept of Mining and Geology.
13. Soman, K. (2002) Geology of Kerala, Geological Society of India, Second revised edition.
14. Umeshwer Prasad (1996). Economic Mineral Deposits, CBS Publishers.
15. Leverson (1967). Geology of Petroleum, McGraw Hill.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Realize the basic concepts of ore geology and ore formation process	U	F	Assignment, Final Exam
CO2	Perceive the basic concepts and occurrence of fossil fuels in India	**U**	C	Assignment, Final Exam
CO3	Identification of economic minerals and analyzing their uses.	AP	P	Assignment FinalExam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				3		2
CO 2				3		2
CO 3					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK6DSCGLY322**		**Stratigraphy of India**		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4

Detailed Syllabus:

Content	Hrs.
Module I: Introduction to Precambrian Stratigraphy-	**18**
Introduction to lithostratigraphy; Divisions of Precambrian time scale, Characteristics and status of Archaean and Proterozoic Eras in global perspective. Physiographic and Tectonic subdivisions of India, Introduction to Indian shield, cratons and mobile belts, Detailed study of the stratigraphy, lithology, classification, age, structure and economic resources of Dharwar supergroup, Aravalli, Delhi Supergroup, Cuddapah Supergroup, Vindhyan Supergroup and Kurnool Group.	
Module II: Important Phanerozoic successions in India:	**18**
Important Palaeozoic and Mesozoic successions in India with emphasis on succession, lithology, flora and fauna, correlation and paleoenvironment of the following: palaeozoic and Mesozoic of spiti, Gondwana succession of Peninsular and extra-peninsular India, Jurassic of Kutch, Cretaceous of Trichinapoly, Cretaceous of Narmada valley, Deccan Traps.	
Module III: Cenozoic successions of India	**10**
Cenozoic successions of Siwalik, Assam and Cuddalore. Karewa and Indo Gangetic Alluvium. Pre Cambrian, Tertiaries and Quaternary Geology of Kerala.	
Module IV: Stratigraphic boundaries	**6**
Introduction of important stratigraphic boundaries and their significance: a) Cambrian boundary, b. Permian-Triassic boundary, and c. Cretaceous-Tertiary boundary.	
Module V: Teacher specific content	**4**
Teacher specific content related to Geology of India	

Reference

1. Doyle P. and Bennett, M.R. (1996), Unlocking the Stratigraphic Record. John Wiley
2. Ramakrishnan, M. and Vaidyanadhan, R. (2008), Geology of India Volumes 1 and 2,
3. Geological Society of India, Bangalore,
4. Valdiya K.S. (2010). The making of India, Macmillan India Pvt. Ltd.
5. Nichols, G. (2009). Sedimentology and Stratigraphy Second Edition. Wiley Blackwell
6. Wadia, D.N. (1944) Geology of India, Tata McGraw–Hill.
7. Pascoe, E.H. (1954) A Manual of the Geology India and Burma, Govt. of India Publications.
8. Soman, K. (2013) Geology of Kerala, Geological Society of India, Bangalore.
9. Radhakrishna, B.P and R. Vaidyanadhan (1997) Geology of Karnataka, Geological Society of India, Bangalore.
10. Sanjib Chandra, Sarkar, Anupendra Gupta (2012). Crustal evolution and Metallogeny inIndia. Cambridge University Press, Delhi, India.
11. Amal Das Gupta (2006). An introduction to Earth Science, World Press Private Limited, Kolkata.
12. Code of International Stratigraphy Commission

CO	Course Outcome	Cognitive Level*	Knowledge Category #	Evaluation Tools used
CO1	Understand the basic physiographic and tectonic units of India	U	F	Assignment, Final Exam
CO2	Analyze various stratigraphic units in Indian Shield.	**An**	F	Assignment, Final Exam
CO3	Examine the major events marking lithostratigraphic boundaries in India	An	F	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			2
CO 2			3			3
CO 3					2	3
Level		1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓			
CO 2		✓		
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Elective - DSE**		
Course Code and Title	**UK6DSEGLY300**		**Exploration and Mining Geology**		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 -hours	-		4

Detailed Syllabus:

Content	Hrs.
Module-1-	**15**
Introduction to Exploration and prospecting-Geologic exploration-Exploratory grids, Location and Documentation. Significance of exploration in Resource identification. Reconnaissance survey, Exploratory methods-Trenching and pitting. Drilling- methods and types. Geophysical prospecting- Gravity, Magnetic, Electrical and Seismic methods. Logging methods.	
Module II	**15**
Geochemical exploration- Mobility of geochemical elements, factors controlling mobility of elements. Sampling techniques, Types of sampling techniques- Rock soil, stream sediment, water, vegetation and vapour sampling. Gossan-Threshold values and Geochemical anomalies. Biogeochemical exploration- Accumulation of mineral elements by plants, relation of biogeochemical anomalies with ore deposits. Biogeochemical surveys and techniques. Indicator plants.	

Module III	**16**
Mining methods- Different methods of opencast mining and underground mining. Mine design, metallurgical design and planning. Environmental baseline data needed for mine planning, its acquisition and documentation during different stages of mineral exploration. Nature and extent of environmental problems due to surface and underground mining. Mine waste management.Role of the geologist at operative mines. Grade control in open-pit and underground operations. Blending and stock-piling of ores.Mining legislation in India, Mining plan and mine closure plan. Beach placer mining in Kerala.	
Module IV -	**14**
Selection of suitable sampling method. Recognition of anomalies. Preparation of level plans and sections. Averaging assays.	
Module V	**10**
Teacher Specific related to course Exploration and Mining Geology	
Reference	
1. Peters W. C. Exploration and mining geology. Wiley. 2. Rose A. W. Hawkes H. E. and Webb J. S. Geochemistry in mineral exploration Academic Press. 3. Arogyaswamy R. N. P. Courses in Mining Geology. Oxford and IBH, New Delhi. Low J. W. Geological field methods. Mc Graw Hill. 4. Lahee F. H. Field Geology. Mc Graw Hill. Compton R. R. Manual of Field Geology. Wiley. 5. Malyuga D. P. Biochemical methods of prospecting. Consultants Bureau N York. Dobrin M. B. 6. Introduction to geophysical prospecting. Pergamon Press. 7. Ginzburg D. H. Principles of geochemical prospecting. Pergamon 8. Ginzburg D. H. and Kind R. F. Applied geophysics for geologists and engineers. Pergamon. 9. Bagchi T. C. Elements of prospecting and exploration. Kalyan Publishers. Sinha R. K. and Sharma N. L. Mineral economics. Oxford and IBH. Reedman J. H. Techniques in Mineral exploration. Allied Scientific. 10. Umathy R. M. Textbook of Mining Geology. 11. Chandra D., Singh R. M. and Singh M. P. Textbook of coal (Indian context) Tara Book Agency,Varanasi, 2000. 12. Banerjee P. K. and Ghosh S. Elements of prospecting for non – fuel mineral deposits 1997. 13. Moon, Charles J., Whatley, Michael, K. G. and Evans, Anthony M., (ed.). Introduction to Mineral Exploration. 2 Edn. Blackwell, 2012. 14. Roger W. Marjoribanks. Geological Methods in Mineral Exploration and Mining.Chapman &Hall, 1997.	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamentals of geological and geophysical explorations.	R,U	F,C	Assignment, Final Exam
CO2	Understand the concepts of geochemical exploration, mobility of geochemical elements, sampling techniques and biogeochemical exploration	R,U	F,C	Assignment, Final Exam
CO3	Understand the basics of mining, its type, legislature and beach placer mining. Analyse the effects of mining and apply the geological knowledge in mine design, plan and operations.	R,U	F,C	Assignment, Final Exam
CO4	Apply the knowledge in selection of suitable mining methods, recognition of anomalies, preparation of level plans and sections and averaging assays.	Ap	C	Quiz, Final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				2		2
CO 2				2		2
CO 3				2		3
CO4				2		3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Elective - DSE		
Course Code and Title	UK6DSEGLY301		Engineering Geology		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1-	**15**
Introduction to Engineering Geology. Role of Engineering geologists in planning, design and construction of major man-made structural features. Mechanical properties of rocks, Stresses in rocks, modulus of elasticity, deformation. Poisson's ratio, and their measurement.	
Module II	**15**
Soil mechanics; Origin of soil and soil profile. Physical and engineering properties of soil - unit weight, specific gravity, bulk density, porosity, void ratio, water content, degree of saturation; shear strength of soil; concept of Atterberg limit and soils, Engineering classification of soils. Determination of water content in soils, specific gravity of soils, void ratio, porosity	
Module III	**16**
Geological considerations involved in the construction of dams and reservoirs, tunnels, roads, railways, bridges, buildings and shoreline structures, their design and Indian case histories. Engineering problems related to planning of precautionary measures and mitigations of geological hazards such as Earthquakes, Landslides and coastal erosion.	
Module IV- Practical	**14**
Laboratory study of engineering properties of rocks and soil.	
Module V	**10**
Teacher Specific related to course Engineering Geology	
Reference	
1. Krynine D.P. and Judd W.R. (1957) Principles of Engineering Geology & Geotechnics. McGraw-Hill Book. 2. Kesavulu, N.C. (2009) A Text book of Engineering Geology. Macmillan Publishing IndiaLtd. 3. Crozier. M.J. (1989) Landslides: causes, consequences and environment. AcademicPress. 4. Bell, F.G. (1983) Fundamentals of Engineering Geology. Butterworth and Co. 5. Parbin Singh (2013) Engineering & General Geology. S.K. Kataria & Sons. 6. Waltham T. Foundations of Engineering Geology. Spon Press. 1994.	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the significance of engineering geoogy and various mechanical properties of rocks.	R,U	F,C	Assignment, Final Exam
CO2	Understand the fundamentals of soil mechanics	R,U	F,C	Assignment, Final Exam
CO3	Apply the geological knowledge in major civil engineering constructions and analyse the engineering problems related to various hazards	Ap,An	C,P	Assignment, Final Exam
CO4	Apply the knowledge to calculate the engineering properties of rock and soil samples	Ap	P	Quiz, Final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		2				2
CO 2		2				2
CO 3		2				3
CO4		2				3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	Geology		Skill Enhancement Course - SEC		
Course Code and Title	UK6SECGLY300		Remote Sensing & Geographic Information System		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-	-	3

Detailed Syllabus:

Content	Hrs.
Module-1- Principles and Materials for Remote Sensing	**12**
Basic principles of remote sensing. Electromagnetic spectrum and interaction with Earth's surface. Types of remote sensing platforms (satellites, aerial platforms, UAVs), Characteristics of remote sensing sensors (optical, thermal, radar). Aerial photography–types of aerial photographs, their geometry and characters. Geostationary and sun-synchronous satellites. Global Positioning System.	
Module II- Introduction to Geographical Information System	**12**
Geographical Information System – Introduction, definition, components of GIS – GIS software – Raster and Vector data – Spatial data – Introduction – Maps and GIS – thematic characters of spatial data – Different sources of spatial data. Spatial data modelling – Entity – definition – spatial data models – spatial data structures.	
Module III- Applications of Remote Sensing	**12**
Remote sensing applications in geological studies and natural hazards. Brief idea on Thermal IR remote sensing, Microwave sensing and SLAR system. Applications of GIS in urban planning, geology and agriculture. Status of remote sensing studies in India-Bhaskara and IRS systems.	
Module IV Remote Sensing Practical	
Interpretation of aerial photographs and satellite imageries for the identification of major landforms, structures and lithology on earth's surface.	
Module V	**6**
Teacher Specific related to course Remote Sensing & Geographic Information System	

Reference

1. Shekhawat, N. (2021). Geographic information systems and remote sensing.
2. Sahu, K. C. (2007). Textbook of remote sensing and geographical information systems. Atlantic Publishers & Dist.
3. Favorskaya, M. N., & Jain, L. C. (2017). Handbook on advances in remote

sensing and geographic information systems. New York: Springer.

4. Bernhardsen, T. (2002). Geographic information systems: an introduction. John Wiley & Sons.
5. Nag, P., & Sengupta, S. (2008). Introduction to geographical information systems. Concept Publishing Company.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the fundamental principles, major platforms and tools for remote sensing	U, An	F,C	ESE Quiz
CO2	Understand the components and data in Geographical Information Systems	An, Ap	F,C, P	Assignment ESE
CO3	Understand the remote sensing applications and their practices in India.	Ap, An	F,C, P	Assignment ESE
CO4	Interpretation of aerial photographs and satellite imageries for deciphering the landforms, structures and lithology	An, E	F, C, P	Assignment ESE

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		3				3
CO 2		3				3
CO 3			2			3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓	✓	✓	✓
CO3	✓	✓	✓	✓
CO4	✓		✓	✓

Discipline and Type of Course	Geology		Skill Enhancement Course - SEC		
Course Code and Title	UK6SECGLY320		Essentials of Geo Informatics		
Semester	6		Academic Level: 300 - 399		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	3	3 hours	-		3

Detailed Syllabus:

Content	Hrs.
Module I- basic concepts in Remote Sensing	**12**
Basic concepts in Remote sensing, Electromagnetic Spectrum, Energy sources, Energy interaction in the atmosphere. Atmospheric windows, atmospheric effects on remotely sensed data. Spectral signatures in Remote Sensing. Interaction with atmosphere and interaction with object. Sensors and sensor platforms. Remote Sensing, Concepts in Remote Sensing, Sensors and scanners. Satellites and data repositories in world.	
Module II- History of Aerial photographs	**12**
Photogeology -types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion elements of aerial photo interpretation, study of lithology, geological structures, and geomorphology from aerial photos	
Module III- Digital Image Processing	**12**
, Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment GIS integration and Case studies-Indian Examples. GIS, Datum, Coordinate systems and Projection systems Spatial data models and data editing Introduction to DEM analysis. GPS, Concepts of GPS Integrating GPS data with GIS Applications in earth system science.	
Module IV- Teacher Specific content	**6**
Teacher Specific content related to Remote sensing and GIS	

Reference

1. Jensen,J R, RemoteSensingof theEnvironment An Earth Resource Perspective, Pearson education,Inc2000.
2. Liiesand,ThomasM.,RalphW.Kiefer,Remote ssensing and image interpretation, ThirdEdn, John Wiley and sons, 1994.
3. Ravi P.Gupta, Remote sensing geology, Second Edn, Springer (India), PvtLtd.,2008.
4. Nayar, N.B., Encyclopedia of surveying, mapping and remote sensing, Rawat Publications, India, 1996.
5. George Joseph,2005,Fundamentals of Remotesensing, 2nd Edn, Uni. Press (India) Pvt . Ltd.

6. Demers, M.N.(1997). Fundamentals of Geographic Information System, John Wiley and sons.Inc.
7. Hoffmann-Wellenhof ,B., Lichtenegger, H.andCollins,J .(2001) .GPS: Theory and Practice, Springer Wien, NewYork.
8. Jensen,J.R.(1996).Introductory Digital Image Processing: A Remote Sensing Perspective. Springer-Verlag.
9. Lillesand,T.M.and Kiefer,R.W.(2007). Remote Sensing and Image Interpretation. Wiley.
10. Richards,J.A.and Jia,X.(1999).Remote Sensing Digital Image Analysis. Springer-Verlag.
11. Lillesand T.M. and Keifer R.W. Remote sensing and Image interpretation. John Wiley and Sons,1979.
12. Estors J. E. and Senger L. W. Remote Sensing. Hamilton Publishing Company, 1974.
13. SeigalB.S.and Gillespie A.R .Remote sensing in Geology, John Wiley &Sons, 1980.
14. GuptaR.P. RemoteSensing Geology. Springer, 2003.
15. Chandra A. MandGhosh S.K. Remote Sensing and Geographical Information Systems. Narosa Publishing House, 2007.
16. ReddyA.M. Textbook of Remote Sensing and Geographical Information Systems .BS Publications, 2006.
17. Rees W. G. Physical principles of Remote Sensing. Cambridge University Press, 2001.
18. BernhardsenT. Geographic Information Systems–introduction. Wiley India,2002.
19. LoC.P.andYeungA.K.W. Concepts and Techniques of Geographic Information Systems. PrenticeHall 2002.
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21. Bonham,G.Fand Carter. Geographic Information system for Geoscientists-Modelling with GIS, Elsevier.
22. SabbinsF.F. Remote Sensing–Principles and Applications. Freeman,1985.
23. Panda,B.C.Remote Sensing–Principles and Applications. Viva Books Private Limited, NewDelhi,2005.
24. George Joseph. Fundamentals of Remote Sensing. Universities Press, Hyderabad. 2003
25. Pandey,S.N. Principles and Applications of Photogeology. New Age International(P) Limited Publishers, NewDelhi,2001.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand Basic Concepts in Remote Sensing and analyze Sensors and Platforms in Remote Sensing.	U, An	C, F	Assignment, Final Exam
CO2	Interpret Aerial Photographs to identify geological features to apply different aspects in earth system science.	E, Ap	C	Assignment, Final Exam
CO3	Understand the integration of GIS with remote sensing and apply Remote Sensing and GIS.	U, Ap	F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					3	3
CO 2					3	3
CO 3					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

5.6 COURSES IN GEOLOGY: Semester 7

Discipline and Type of Course	Geology		Discipline Specific Core – DSC		
Course Code and Title	UK7DSCGLY400		Advanced Geosciences-1		
Semester	7		Academic Level: 400 – 499		
Course Details	Credit	Lecture per week	Tutorial Per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Advanced Geomorphology	**15**
Seismotectonics. Geodesy. Models of Landscape Evolution by Davis and Penck. Geomorphic indicators of neotectonics movements: Stream channel morphology changes, drainage modifications, fault reactivation, uplift-subsidence pattern in coastal areas.	
Module II- More about Crystals and Rocks	**16**
Repetition Theory, Translation periodicity of crystals. Basic rotational symmetries and the Possibility of simultaneous rotational symmetries indifferent directions of crystals. Space lattices. Herman-Maugin notation. Conoscopic study and interference figures. Optic orientation-optic anomalies-extinction angle-optic axial angle and optic sign. Study of important ternary and quaternary systems in Igneous petrology (Forsterite- Anorthite-Silica and Orthoclase-Anorthite-Albite.) Simple basalt systems. Trace element trends in magmatic evolution. Variation diagrams – significance and interpretation. Application of phase rule in metamorphic mineral paragenesis. Equilibrium thermodynamics in metamorphic petrology – Gibb's free energy, enthalpy, entropy, Clasius – Clapeyron equation, buffering, Schreinemaker'srule and bundle. Chemographic diagrams – principles of ACF, A'KF and Thompson's AFM diagrams. Paired metamorphic belts. P-T-t paths – isobaric cooling (IBC) and isothermal decompression (ITD) paths.	

Module III- Advanced Approach to Structures	**15**
Strain diagrams and their use in studying the stages of deformation. Mohr circle and its use in structural geology. Stress and strain ellipsoids and their application in the study of fractures. Pumpelly's rule. Fold classification of Donath, Parkar and Ramsay. Petrofabric analyses. Foliation and Lineation – Types, classification and origin. Use of axial plane foliation in the determination of major structures. Geometric analysis of folds and lineations.	
Module IV Practical	**14**
Norm analyses, Variation diagrams, ACF, AKF and AFM diagrams, Structural problems using stereographic projections, Determination of sign of elongation, extinction angle and order of interference color. Determination of optic sign and anorthite content.	
Module V	**10**
Teacher Specific related to course Advanced Geosciences	

Reference

1. Ahmad E. Coastal Geomorphology. Orient Longman, 1972.
2. Cox A. Plate Tectonics and geomagnetic reversals. Freeman, 1973.
3. Holmes A. Principles of Physical Geology. Ronald, 1965.
4. King C. A. M. Beaches and Coasts. Arnold, 1972.
5. Leopold L., Wolman C. and Miller J. P. Fluvial processes in geomorphology. Free 1963.
6. Thornbury W. D. Principles of geomorphology. Wiley, 1968.
7. Hamilton E. I. Applied Geomorphology. Academic Press, 1965.
8. Darlrymple B. G. and Lampere M. A. Potassium-Argon dating. Freeman, 1969.
9. Windley B. F. The evolving continents. John Wiley, 1977.
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11. R.D. Russell, John Arthur Jacobs, J. Tuzo Wilson. Physics and Geology. McGraw-Hill Inc., US,1974
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14. Burger M. J. Elements of Crystallography, Wiley, 1963.
15. Dana E. S. Textbook of Crystallography, Revised by Ford W E, Wiley, 1962.
16. Berry L. G. and Mason B. Mineralogy, Freeman, 1959.
17. Wahlstrom E. E. Optical Crystallography, Wiley, 1962.
18. Winchell A. N. Elements of optical mineralogy, Pt I, Wiley, 1951.
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20. Nesse W. D. Introduction to Optical Mineralogy. Oxford University Press, 2004.
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25. Wahlstrom E. Theortical Igneous Petrology. Wiley, 1961.
26. Ehlers E. G. The interpretation of Geological Phase Diagrams. Freeman, 1972.
27. Myron G. Best 2003 Igneous and metamorphic petrology Edition2, Wiley-Blackwell, 2003
28. Kornprobst J. 2002 Metamorphic rocks and their geodynamic significance: a petrological handbook, Springer.
29. Blatt, J., Tracy J. R. and Owens B.E. 2006 Petrology: Igneous, Sedimentary, and Metamorphic.Edition3, W. H. Freeman.
30. Shelley D. Igneous and metamorphic rocks under the microscope: classification, textures, microstructures, and mineral preferred - orientations Springer, 1993.
31. Fry N. The field description of metamorphic rocks. Geological Society of London handbook series. Open University Press, 1984
32. Vernon R. H. and Clarke G. L. 2008 Principles of metamorphic petrology Cambridge University Press.
33. Winter J. Principles of Igneous and Metamorphic Petrology 2nd Edition 2009
34. Bucher K and Frey M. 1994 Petrogenesis of metamorphic rocks Edition6, Illustrated Publisher Springer-Verlag.
35. Barker A. J. 1998 Introduction to metamorphic textures and microstructures Edition 2, Routledge.
36. Marshak S. and Gautam Mitra. Basic methods of Structural Geology. Prentice Hall Inc. 1988.
37. Ragan M. D. Structural Geology, Wiley 1969.
38. Philips F. C. Stereographic projection in Structural Geology. Arnold 1960.
39. Turner F.J. and Weiss L.E. Structural Analysis of Metamorphic Tectonites. Mc Graw Hill, 1963.
40. Hobbs B.E., Means W.B. and William P. F. An Outline of Structural Geology . John Wiley 1976.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse the concepts of geomorphology in land scape evolution and understand seismotectonics and geodesy.	An,U	F,C	ESE Assignment Quiz
CO2	Apply and analyse the modern concepts in the fields of crystallography, mineralogy, igneous and metamorphic petrology	Ap, An	F,C,P	ESE Assignment Quiz

CO3	Analyse the recent methods used in structural geology for studying rock deformation, petrofabric analysis, rock structures identification and problem solving.	An	C P	ESE Assignment Quiz
CO4	Identify the rocks by evaluating the chemical data, make an interpretation and analyse optical properties of minerals.	Ap An	P	ESE Assignment Quiz
* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create** # - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**				

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	1					3
CO 2		3				3
CO 3			3			3
CO4					3	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO3	✓	✓	✓	✓
CO4	✓	✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Core – DSC		
Course Code and Title	UK7DSCGLY401		Advanced Geosciences-2		
Semester	7		Academic Level: 400 – 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3hours	-	2hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- New Trends in Stratigraphy	**15**
Types of stratigraphy – Sequence stratigraphy, Magnetostratigraphy and Seismic Stratigraphy. Sedimentary Basin Analysis: Facies and interpretation of the environment. Study of GSSP and their occurrence in Tertiary and Quaternary systems. Boundary problems in Indian stratigraphy. Crustal evolution of Dharwar and Southern granulite terrains. Applications of microfossils and nano fossils in palaeoclimatology, paleoceanography petroleum exploration.	
Module II- Advanced Mineralogy	**15**
Analytical techniques and interpretation of geoscience process using instruments like XRD, ICP-MS, MS, XRF, SEM, IRMS,TEM. Isotope dating techniques of C-14, U-Pb, K-Ar, Rb-Sr and Sm-Nd and their significance in geoscience. Stable isotope application in geoscience – Carbon, Oxygen and Sulphur isotopes. Geochemical classification of elements. Geochemical cycles-Carbon, oxygen and Nitrogen. REE, Al, Fe and Mn geochemistry of Rocks, soil and sediments.	
Module III- Ore Genesis and Mineral Exploration	**16**
Principle and application of ore microscopy, Ore texture and genetic significance. Diamond in kimberlite, ores in pegmatite. Cr, Pt, Ti, Cu and Ni deposits associated with basic and ultrabasic rocks.VMS deposits, SEDEX and MVT deposits. Origin and occurrence of polymetallic nodules, coal bed methane and gas hydrates. Dating of ore deposits. Controls of ore localization. Metamorphism of ore deposits. Plate tectonic controls in mineralization. Ore mineralization through geologic time. Geophysical prospecting of mineral deposits - Magnetic, Gravity, seismic and Electric methods. Geochemical prospecting of mineral deposits – Principle, geochemical anomalies, geobotanical indicators, geochemical relief indicators and pathfinders. Surface and subsurface mining methods. Seabed mining methods. Ore dressing -Physical, Magnetic, electric and bioleaching methods	
Module IV Practical	**14**
Ore reserve estimation- grade and tonnage calculation, Interpretation of bore hole data. Geological section preparation.	

Module V	**10**
Teacher Specific related to course Advanced Geosciences	

Reference

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2. Dunbar C. O. & Rogers J. Principles of Stratigraphy. Wiley, 1960
3. Gignoux M. Stratigraphic Geology. Freeman, 1960.
4. Flint R. F. Glacial & Pleistocene Geology. Wiley, 1961.
5. Kay & Golbert. Stratigraphy & Life history. Wiley, 1965.
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8. Perkins D. Mineralogy. Pearson Education, 2002.
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17. Mukherjee A. Metamorphic and metamorphosed sulphide deposits. Econ. Geol., Vol. 65, No.70,1970.
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33. Chandra D., Singh R. M. and Singh M. P. Textbook of coal (Indian context) Tara Book Agency,
34. Varanasi, 2000.
35. Boyle R. W. Geochemical prospecting for thorium and uranium deposits. Elsevier.
36. Banerjee P. K. and Ghosh S. Elements of prospecting for non–fuel mineral deposits 1997.
37. Moon, Charles J., Whatley, Michael, K. G. and Evans, Anthony M., (ed.). Introduction to Mineral Exploration. 2nd Edn. Blackwell, 2012.
38. Ramachandra Rao, M.B. An Out line of Geophysical Prospecting-A Manual for Geologists 1975. University of Mysore.
39. William Lowrie, Fundamentals of Geophysics 1997, Cambridge.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyse the modern concepts in stratigraphy and understand the boundary problems and the models of crustal evolution with special reference to India.	An,U	F,C	ESE Assignment Quiz
CO2	Analyse the modern instruments used in various fields of geology	Ap, An	F,P	ESE Assignment Quiz
CO3	Understand the concepts of ore geology and analyse different types of ore deposits.	An	F,C	ESE Assignment Quiz
CO4	Analyse the various geophysical prospecting and mining methods.	An	F,C,P	ESE Assignment Quiz

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			3
CO 2		2				3
CO 3				3		2
CO4				3		3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO3	✓	✓	✓	✓
CO4	✓	✓	✓	✓

Discipline and Type of Course	**Geology**			**Discipline Specific Core - DSC**	
Course Code and Title	**UK7DSCGLY420**			**Geochemistry and Isotope Geology**	
Semester	7			Academic Level: 400 - 499	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I: Origin and cosmic abundance of elements	**18**
Introduction to Geochemistry- Geochemical classification of elements. Geochemical cycles. Chemical evolution of the earth. Primary geochemical differentiation. Geochemical constitution of earth's crust, mantle and core. Phase transitions in the mantle. Goldschmidt's classification of elements. Nernst's partition coefficient (compatible and incompatible elements), LILE and HFSE. Major, minor and trace elements, REEs and PGEs. Thermodynamic system, Thermodynamic potential, State function, STP and Rule of thumb and Derivation of Gibbs free energy. Oxygen Fugacity: Definitions, concepts and geology. Oxidation potential, Eh-pH diagrams, Limits of Eh-Ph in aqueous environment and their applications in sedimentation process.	

Module II: Radiogenic Isotopes	**18**
Introduction to isotope geology: Isotopes, isobars and isotones, stable and radioactive isotopes. Laws of radioactivity, half-life and basic equation for age calculation. Various decay mechanisms- alpha, beta (positron and negatron), gamma decay, electron capture and branched decay. Study of different absolute dating techniques: Rb-Sr - model age and isochron age, mineral and whole rock isochrones, their merits and demerits. Importance of Sr initial concentration in understanding the source characteristics of igneous and metamorphic rocks. Sm-Nd systematics - isochron ages, isotopic evolution of Nd, CHUR model, epsilon parameter and nature of mantle source, BABI, crustal residence of igneous and metamorphic rocks. U-Th-Pb systematics - model age, ^{207}Pb-^{206}Pb method, U-Pb Concordia-discordia method, U-Pb, Th-Pb isochron methods, Zircon dating-analysis of single zircon and SHRIMP analysis. K-Ar systematics - modal age and isochron age, the problem of Ar loss. Applications – metamorphic veil. Ar- Ar method. Fission track dating.	
Module III: Stable isotope studies	**12**
Isotope fractionation, Delta notation and its significance, significance of stable isotopes of Carbon, Oxygen and Sulphur in petrology. Isotope hydrogeology – fractionation, H-O isotopes in water vapor and hydrologic cycle, $\delta\ ^{18}O$ and $\delta^{2}H$, Global meteoric water line, altitude, continentality and latitudinal effects on rain water. Paleoclimatic records of sediments and polar ice from isotopes.	
Module IV: Practical	**12**
Sample preparation Procedures for different chemical analysis. Problems in Thermodynamics. Half-life, decay constant and age calculations using radiogenic isotopic ratios. Problems related to fractionation of stable isotope.	
Module V:Teacher specific content	**10**
Teacher specific content related to Geochemistry and Isotope Geology	

Reference

1. Mason, B. and Moore, C.B. (1985) Principles of geochemistry, Wiley Eastern Ltd,Bangalore
2. Faure G. (1986) Principles of isotope geology1, John Wiley & Sons
3. Faure, G., Mensing, T. M., Isotopes – Principles ans Applications, Wiley India Pvt. Ltd.,New Delhi
4. Krauskopf, E.B. (1979) Introduction to geochemistry, McGraw Hill Book Company,New Delhi.
5. Gill, R. (1989) Chemical fundamentals of geology, Unwin Hyman, London
6. Albarede F. (2003) Geochemistry- An introduction, Cambridge university press.

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8. Rankama K. Progress in Isotope Geology, Interscience, 1963.
9. Walther J. V. Essentials of Geochemistry. Jones and Barlett Publishers, 2005.
10. Mason, B. (1986) Principles of Geochemistry. 3rd Edition, Wiley New York.
11. Rollinson, H. (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
12. Walther, J. V. (2009). Essentials of geochemistry. Jones & Bartlett Publishers.
13. Albarède, F. (2003). Geochemistry: an introduction. Cambridge University Press.
14. Kula C. Mishra (2012). Introduction to Geochemistry Principles and Applications, Blackwell Publishing Ltd.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Evaluate thermodynamic state of natural systems using different proxies.	E	F	Assignment, Final Exam
CO2	Distinguish various radioactive decay mechanism and dating techniques.	An	C	Assignment, Final Exam
CO3	Develop an idea about radiogenic age calculation and fractionation.	C	P	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					3	2
CO 2					3	2
CO 3					2	3

Level		1	2	3
Correlation	Nil	Slightly/Low	Moderate / Medium	Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**			**Discipline Specific Core – DSC**	
Course Code and Title	**UK7DSCGLY421**			**Applied Geophysics and Exploration Geology**	
Semester	7			Academic Level: 400 – 499	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I: Planet Earth dimensions and geodesy	**18**
Earth Gravity- Gravitational Potential and acceleration. Gravity anomalies and Correction. Modern Survey methods. Isostasy- Isostatic anomalies. Significance of isostatic anomalies. Earthquake Seismology. Velocities of P& S wave, magnitude and intensity scales. Travel time curves, Phase transition inside the Earth and interior structure of Earth- PREM Model. Earth's magnetic field- properties and types, changes in magnetic field, origin of geomagnetic field, magnetic anomalies and corrections. Palaeomagnetism. Magnetic timescale Thermal conductivity of earth surface.	
Module II: Geophysical Exploration	**18**
Principles of geological prospecting and mineral exploration. Stages of exploration. Concept of geophysical exploration - Electrical prospecting, Resistivity survey, Induced Polarization and Self Potential methods. Concept of magnetic prospecting, Magnetometers, Magnetic anomalies and Magnetic time scale. Magneto telluric survey. Concept of Gravity survey, principles of gravity measurements, stable and unstable gravimeters. Gravity anomalies - regional and local, factors that affect gravity measurements, gravity corrections. Seismic survey methods- concepts of seismic refraction, reflection surveys. applications and limitations of seismic refraction and reflection survey. Instruments used in detection and measurements of nuclear minerals.	
Module III: Geochemical Exploration	**10**
Principles of Geochemical exploration, Geochemical mobility of element, factors controlling mobility of elements in the surficial and deep-seated environments, Indicators and Pathfinders, threshold values and geochemical anomalies, dispersion pattern. Geochemical survey and sampling – lithological & pedological. Atmospheric and hydrogeochemical surveys, Geobotanical survey techniques,	

Biogeochemical survey.	
Module IV: Practical	**14**
Problems related to earths gravitational field, earthquake waves, Ore reserve estimation –grade and tonnage calculation, Interpretation of borehole data. Geological section preparation.	
Module V: Teacher specific content	**10**
Teacher specific content related to Geophysical application in Exploration	

Reference

1. Bagchi, T.C. Elements of Prospecting and Exploration, Kalyan Publishers.
2. Crompton, R.R. Mannual of Field Geology, John Wiley.
3. Dobrin, M.B. Introduction to Geophysical Prospecting, Pergamon Press.
4. Davis and Dewiest. Hydrogeology, 1966.
5. Ginzburg, I.I. Principles of geochemical Prospecting, Pergamon Press.
6. Griffths, D.H. and Kind, R.F Applied Geophysics for Geologists and engineers,Pergamon Press.
7. Kearey, P Brooks (1991) An introduction to geophysical exploration, Blackwell.
8. Kovalarkim. Biochemical Hill.
9. Lahee, F.H. Field Geology, McGraw Hill.
10. Low, J.W Geologic Field Methods, Harper and Brothers.
11. Malyuga, D.P. Biochemical Methods of Prospecting, Consultants Bureau, New York.
12. Milson J (1989) Field geophysics, John Wiley & sons
13. Moon, Charles, Michel Whateley and Antony Evans (2005), Introduction to MineralExploration, Wiley – Blackwell.
14. Rose, K.W., Hawkes, H.E. and Webb, J.S., Geochemistry in Mineral Exploration,Academic Press.
15. Sinha, R.K. and Sharma, N.L. Mineral economies, Oxford and IBH Publishers.
16. Todd, D.K. Groundwater Hydrology, John Wiley and Sons, 1980.
17. William Lowrie, Fundamentals of Geophysics, Cambridge University Press, 1997.
18. Ginzburg D. H. and Kind R. F. Applied geophysics for geologists and engineers. Pergamon.
19. Chandra D., Singh R. M. and Singh M. P. Textbook of coal (Indian context) Tara Book Agency,Varanasi, 2000.
20. Boyle R. W. Geochemical prospecting for thorium and uranium deposits. Elsevier.
21. Banerjee P. K. and Ghosh S. Elements of prospecting for non – fuel mineral deposits 1997.
22. Roger W. Marjoribanks. Geological Methods in Mineral Exploration and Mining. Chapman &Hall, 1997.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Evaluate the Geophysical properties of Earth	E	F	Assignment, Final Exam
CO2	Distinguish various procedures in exploration of Economic minerals.	**An**	C	Assignment, Final Exam
CO3	Developing idea about simple geophysical calculations for exploration purpose	C	P	Assignment, Final Exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					3	3
CO 2					3	3
CO 3					2	3
Level		1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK7DSCGLY450**		**Remote sensing and Geoinformatics**		
Semester	7		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Remote sensing	**16**
Concept of Remote sensing, -Electromagnetic radiation-characteristics, energy interactions with the atmosphere, atmospheric windows. Aerial photography – types of aerial photographs, their geometry and photo characters, stereoscopy, stereoscopic parallax, relief displacement; principles of photogrammetry. Elements used for the interpretation of aerial photographs. Satellite remote sensing-Sensors and platforms. Geostationery and sunsynchronous satellites. Global Positioning System.	
Module II- Geographical information system	**16**
Geographical Information System – Introduction, definition, components of a GIS – GIS softwares – Raster and Vector data – Spatial data – Introduction – Maps and GIS – thematic characters of spatial data – Different sources of spatial data. Spatial data modeling – Entity – definition – spatial data models – spatial data structures.	
Module III- Application of remote sensing	**15**
Status of remote sensing studies in India-Bhaskara and IRS systems. Remote sensing applications in geological studies and natural hazards. Brief introduction on Thermal IR remote sensing, Microwave sensing and SLAR system. Applications of GIS in urban planning, geology and agriculture.	
Module IV Practical	**14**
Interpretation of aerial photographs	
Module V	**10**
Teacher Specific related to course Remote Sensing and Geoinformatics	

Reference

1. Ian Haywood, Sarah Cornelius and Steve Carver (2000) An introduction to Geographical Information Systems. Addison Wesley Longman Ltd., New York
2. Heywood, D. I., Cornelius, S., and Carver, S. (1998). An introduction to Geographical Information Systems. Longman, New Delhi.
3. Pandey S. N. (1987) Principles and Applications of Photogeology, Wiley Eastern.
4. LO CP and Young A.K.W.(2003) concept and technique of geographical information system. prentice hall of India, New Delhi.
5. Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.
6. Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.
7. Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the basics of remote Sensing, photogrammetry and Geographical information system and their application in geoscience.	U & E	F &C	Assignment & final exam
CO2	Understand and describe the aerial photography, satellite remote sensing, GPS, GIS software, data analysis	U & E	F &C	Quiz, Assignment & final exam
CO3	Analysis of aerial photographs.	U, E, &A	F, C &P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3			2	1	3
CO 2	3			3	3	3
CO 3	1			2	3	3

Level	-	1	2	3
Correlation	Nil	Slightly/Low	Moderate / Medium	Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO3	✓	✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Core - DSC		
Course Code and Title	UK7DSCGLY451		Crystallography		
Semester	7		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1- Crystallography	**15**
Significance of crystallography in mineralogy. Elements of crystallography: crystalline state and crystals. Morphology of crystals, faces, edges, vertex, forms and zones. Crystal angles – plane angles, interfacial angles and solid angles; Goniometer - contact and reflection, Law of Constancy of Interfacial Angles. External symmetry elements in crystals. Crystallographic axes: choice of axes, labeling and orientation.	
Module II- Classification of crystals	**15**
Classification of crystals into systems and classes. Nomenclature of crystal faces: intercepts, parameters, unit face, Weiss notation, Miller indices. Law of crystal indices, axial ratio. Brief study of holohedral, hemihedral, hemimorphic and enantiomorphic forms.	
Module III- Systematic crystallography	**16**
Systematic crystallography: The study of symmetry, simple forms and combinations of normal class of isometric, tetragonal, hexagonal, orthorhombic, monoclinic and triclinic systems.	
Module IV Practical	**14**
Forms and symmetry elements of normal class of isometric, tetragonal, hexagonal, orthorhombic, monoclinic and triclinic systems.	
Module V	**10**
Teacher Specific related to course Crystallography	
Reference	
1. Dana, E. S. (1955) A Textbook of Mineralogy. Asia Publishing House, Wile 2. Phillips, F.C. (1956) An Introduction to Crystallography. Longmans Green 3. 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. 4. Deer, W. A., Howie, R. A., & Zussman, J. (1992). An introduction to the rock-forming minerals (Vol. 696). London: Longman	

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the elements of crystallography, laws of crystallography, classification of crystals into systems and classes, crystal notations and indices and the types of crystal forms..	U & E	F &C	Assignment & final exam
CO2	Understand and explain the symmetry, simple forms and combinations of the normal crystal classes of the six crystal systems	U & E	F &C	Quiz, Assignment & final exam
CO3	Describe and illustrate the symmetry elements and identify and describe the crystal models of Normal classes of the six crystal systems.	U, E, &A	F, C &P	Assignment & final exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	2	2			1	3
CO 2	3	3			2	3
CO 3	2	2			3	3
Level	-	1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO3	✓	✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Core - DSC		
Course Code and Title	UK7DSCGLY452		Paleoecology		
Semester	7		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4

Detailed Syllabus:

Content	Hrs.
Module-1- Ecosystem science	**15**
Introduction-Basic ecosystem science concepts- Biological Interactions: Foundation Species, Ecological Engineers; Ecosystem. Geological time scale, paleobiological methods and understanding the biota of the Deep past. Plate tectonics and biotic (taxonomic and distributional) changes, late Paleozoic to early Cenozoic Eras.	
Module II- Biogeographic processes	**15**
Biogeographical Processes: Dispersal and Colonization, Major events in the earth's history. Extinction events and its causes. Evolutionary and Distributional Changes Among Land Plants; Gymnosperms and Angiosperms; Key Developments in land mammals. Expansion of Dryland and Alpine Biomes; Evolution of Grazing fauna; American Exchange of Mammals.	
Module III- Ecosystem and environments	**15**
Ecosystems and Environments: Developments Over the Cenozoic . Early to Middle-Cenozoic Environmental Changes and Development and Diversification of Terrestrial Biomes in the Eocene: Development of Cenozoic Climates and Environments; Flora and Fauna. Biogeographic Changes during Pleistocene Glacial and Inter-glacial cycles. Humans as a Force of Evolution and Extinction. Pleistocene Megafauna Extinctions: Causes and Consequences	
Module IV Anthropocene ecosystems	**15**
Anthropocene Ecosystems and Global Change Drivers. Anthropocene Policy and Management Dilemmas 1: Modern extinction; altered disturbance regimes, biogeochemical changes; Invasive species and emerging epidemics 2: Habitat Destruction, Ecosystem Fragmentation, Climate Change, Shifting Ranges.	
Module V	**10**
Teacher Specific related to course Paleoecology	

Reference

1. Carlson, D. and Plummer, C. (2010) Physical Geomorphology: Earth Revealed. 9th Edn., Mc-Graw Hill Co.
2. Keller, E.A. (1978) Environmental Geology. Bell and Howell, Prentice Hall, USA
3. Amal Das Gupta (2006). An introduction to Earth Science, World Press Private Limited, Kolkata.
4. Rudiman, W.F., 2001. Earth's climate: past and future. Edition 2, Freeman Publisher.
5. Stanley, S.M., 2008 Earth System History
6. Canfield, D.E. & Konhauser, K.O., 2012 Fundamentals of Geobiology Blackwell

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand the paleo-environmental conditions and major life events in the earth history	U & E	F &C	Assignment & final exam
CO2	Understand and explain the ecosystem and biogeographic process through geologic time with emphasis on evolution and distribution of flora and fauna	U & E	F &C	Quiz, Assignment & final exam
CO3	Describe and analysis the major causes of development and extinction of organism; explain the anthropocene Ecosystems and climate changes.	U, E, &A	F, C &P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3		2		1	2
CO 2	3		3		2	2
CO 3	1		1		3	3
Level	-	1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO3	✓	✓	✓	✓

Discipline and Type of Course	Geology		Discipline Specific Core - DSC		
Course Code and Title	UK7DSCGLY470		Planetary Science		
Semester	7		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- The expanding Universe	**15**
Universe, Big Bang theory, Milky Way, solar system, sun. Astronomical units. Dimensions and relative positions of Inner planets, Outer planets, planetoids, moons. Asteroid belts. Layers and processes in Sun.	
Module II- Into the cosmos	**15**
Origin of chemical elements- primordial and stellar nucleosynthesis, abundance of elements in cosmos. Evolution of star.	
Module III- The Mars, Moon and Meteorites	**16**
Mars and its interior; The Martian atmosphere and hydrosphere. The characteristics of Moon and its interior Composition and classification of meteorites. Cratering dynamics- and classification. Major impact craters in India.	
Module IV- Practical	**14**
Interpretation of planetary imageries and ariel photos. Calculations related to luminescence of stars and elemental origin.	
Module V- Teacher Specific content	**10**
Teacher Specific content related to Planetary Science	

Reference

1. Cook, AH, 1973, Physics of Earth and planets. London: Macmillian
2. Kaula, WM, 1996, Theory of satellite geodesy. Blaisedell
3. Beatty, J., Petersen C. and Chaikin, A., 1999, The New Solar System, CambridgeUniversity Press, Cambridge, England.
4. Lodders K. and Fegley, B., 1998, The Planetary Scientist's Companion, Oxford UniversityPress, New York, 1998
5. Morrison, D., 1993, Exploring Planetary Worlds, Scientific American Library, New York.
6. Ahrens, T. (ed.), 1995, Global Earth Physics - A Handbook of Physical Constants, American Geophysical Union, Washington, D.C.
7. Pamela Clark, 2007, Dynamic Planet: Mercury in the Context of its

Environment, Springer,New York.
8. Cattermole, P., 1994, Venus, The Geological Story, Johns Hopkins University Press,Baltimore.
9. Wilhelms, D., 1993, To a Rocky Moon - A Geologist's History of Lunar Exploration,University of Arizona Press, Tucson.
10. Cattermole, P., 1993, Mars - The Story of the Red Planet, Chapman and Hall, London.
11. Mutch, T., Arvidson, R., Head, J., Jones, K., and Saunders, R., 1976, The Geology ofMars, Princeton University Press, Princeton.
12. Rogers, J., 1995, The Giant Planet Jupiter, Cambridge University Press, Cambridge,England.
13. Hunt G., and Moore, P., 1982, Saturn, Rand McNally, New York.
14. Miner, E., 1998, Uranus - The Planet, Rings, and Satellites, Wiley, New York.
15. Miner, E. and Wessen, R., 2002, Neptune - The Planet, Rings, and Satellites, Praxis,Chichester, England.
16. White, A., 1980, The Planet Pluto, Pergamon, New York.
17. Davies, J., 2001, Beyond Pluto - Exploring the Outer Limits of the Solar System, Cambridge University Press, Cambridge, England.
18. www.pdsa.jpl.nasa.gov//planets
19. Planetary Geomorphology by Ronald Greely
20. Planetary Surface Processes by J. H. Melosh
21. Planetary tectonics by T. R. Watters and R. A. Schultz
22. Asteroids by T. H. Burbine
23. Introduction to Planetary Science by G. Faure and T.M. Mensing

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand Universe and its various components.	U	F	Assignment & final exam
CO2	Formulate an idea about Mars, Moon, meteorites and impact craters	**C**	F, C	Quiz, Assignment& final exam
CO3	Evaluate the satellite imageries and ariel photos	An	P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1	3					2
CO 2	3					3
CO 3					2	3
Level	-	1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK7DSCGLY471**		**Advanced Remote Sensing and GIS**		
Semester	7			Academic Level: 400 - 499	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Basic concepts of remote sensing	**15**
Concept of remote sensing -Types and platforms of remote sensing. Energy sources and radiation principles. Electromagnetic radiation- EMR spectrum. Energy interaction with atmosphere and earth surface. Satellite remote sensing- basic principles. LANDSAT, SPOT. Indian remote sensing satellites. Thermal, Multi-spectral and Hyper-spectral remote sensing. Microwave remote sensing- Radar, SLAR system, SRTM, LIDAR	
Module II- Aerial photography	**15**
Basic principles and geometrical characteristics of aerial photographs. Types of aerial photographs- vertical/oblique/high oblique. Aerial mosaics. Flight plan of aerial photography. Photogrammetry – analogue and digital photogrammetry. Terminologies associated with photogrammetry- Scale, Relief displacement, Vertical exaggeration and Stereoscopic Image parallax – a brief description. Stereoscopic vision – Stereoscopes – types - pocket and mirror stereoscopes. Tilt, drift and crab in aerial photographs.	

Module III- Fundamentals of GIS	**16**
Basic concepts. Components of GIS- hardware and software. Projections, geographic and Cartesian co-ordinates; Georeferencing. Datum transformation; GIS data structures- Raster and Vector, DEM; GIS softwares- open source and commercial softwares. Data Analysis – Measurements in GIS – Queries – Reclassification – Buffering – Brief idea of Data integration, map overlay, spatial interpolation, analysis of surfaces, network analysis – Applications of GIS in geology, urban planning, hydrology, forestry and agriculture – The future of GIS – Current Issues and trends	
Module IV- Practical	**14**
Interpretation of satellite imageries. Interpretation of aerial photos with special references to topography, drainage, structure and geology. Simple calculations based on aerial photos- determination of photo scale, total number of photos required to cover a given area, height of objects and relief displacement from aerial photographs Identification and mapping of drainage patterns, lineaments, litho contacts and geological structures. Hypsometric analysis. Data inputs to GIS software. Georeferencing, digitization and digital cartography. Determination of slope and slope map preparation. Identification of lineaments and preparation of lineament maps.	
Module V- Teacher Specific content	**10**
Teacher Specific content related TO Advanced RS& GIS	

Reference

1. Jensen, J R, Remote Sensing of the Environment An Earth Resource Perspective, Pearson education, Inc 2000.
2. Liiesand, Thomas M., Ralph W. Kiefer, Remotes sensing and image interpretation, Third Edn, John Wiley and sons, 1994.
3. Ravi P. Gupta, Remote sensing geology, Second Edn, Springer (India), Pvt Ltd., 2008.
4. Nayar, N.B., Encyclopedia of surveying, mapping and remote sensing, Rawat Publications, India, 1996.
5. George Joseph, 2005, Fundamentals of Remote sensing, 2nd Edn, Uni. Press (India) Pvt. Ltd.
6. Demers, M.N. (1997). Fundamentals of Geographic Information System, John Wiley and sons. Inc.
7. Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J. (2001). GPS: Theory and Practice, Springer Wien, New York.
8. Jensen, J.R. (1996). Introductory Digital Image Processing: A Remote Sensing

Perspective. Springer- Verlag.
9. Lillesand, T. M. and Kiefer, R.W. (2007). Remote Sensing and Image Interpretation. Wiley.
10. Richards, J.A. and Jia, X. (1999). Remote Sensing Digital Image Analysis. Springer-Verlag.
11. Lillesand T. M. and Keifer R. W. Remote sensing and Image interpretation. John Wiley and Sons, 1979.
12. Estors J. E. and Senger L. W. Remote Sensing. Hamilton Publishing Company, 1974. Seigal B. S. and Gillespie A. R. Remote sensing in Geology, John Wiley & Sons, 1980. Gupta R. P. Remote Sensing Geology. Springer, 2003.
13. Chandra A. M and Ghosh S. K. Remote Sensing and Geographical Information Systems. Narosa Publishing House, 2007.
14. Reddy A. M. Text book of Remote Sensing and Geographical Information Systems. BS Publications, 2006.
15. Rees W. G. Physical principles of Remote Sensing. Cambridge University Press, 2001.
16. Bernhardsen T. Geographic Information Systems – An introduction. Wiley India, 2002.
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18. Heywood I., Cornelius. S. and Carver S. An Introduction to Geographical Information Systems, Longman Limited
19. Bonham, G. F and Carter. Geographic Information system for Geoscientists-Modelling with GIS, Elsevier.
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21. Panda, B. C. Remote Sensing – Principles and Applications. Viva Books Private Limited, New Delhi, 2005.
22. George Joseph. Fundamentals of Remote Sensing. Universities Press, Hyderabad. 2003 Pandey,
23. S. N. Principles and Applications of Photogeology. New Age International (P) Limited Publishers, New Delhi, 2001.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Recognize various concepts and components of Remote sensing, Aereal Photographs and GIS.	U	F, C, P	Assignment & final exam
CO2	Analyze data interpretation techniques in GIS.	**An**	C,P	Quiz, Assignment& final exam
CO3	create a clear-cut understanding on the various aspects and methods of Geomatics and also its applications in delineating the geomorphological characteristics.	C	P	Assignment & final exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					3	3
CO 2					3	3
CO 3					2	3
Level	-	1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK7DSCGLY472**		**Indian Fuel Resources and Mining Policies**		
Semester	7		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module I- Coal Geology	**15**
Coal- Origin of Coal, Coalification process, in situ and transported theory of coal formation. Microscopic and Megascopic constituents of Coal. Classification of coal - Peat, lignite, bituminous and anthracite coal. Spatial and temporal distribution of coal in India – Gondwana and Tertiary coal. Essential, Strategic and critical minerals in India. National Mineral Policy.	
Module II -Petroleum geology	**16**
Introduction – Chemical and physical properties of petroleum. Origin of petroleum- Organic and Inorganic concepts. Kerogen and its types. Migration, accumulation and entrapment of petroleum. Source and Reservoir rocks. Characteristics of reservoirs. Types of reservoir traps – Classification of traps- Stractural, Diapiric, Stratigraphic, Hydromorphic traps and Combination traps.	

Geological age of reservoir rocks. Reservoir mechanics – Methods of petroleum exploration – surface, sub surface and geophysical methods. Petroliferous basins with special reference to India.	
Module III - Nuclear Fuels	**15**
Atomic Minerals in India. Carbonate hosted and sandstone type uranium deposits. Major Uranium deposits in India. Beach Placers in India.	
Module IV- Practical	**14**
Simple calculation of reservoir parameters, Coal reserve estimation.	
Module V- Teacher specific content	**10**
Teacher specific content related to Indian Fuel Resources and Mining Policies	

Reference

1. John M Hunt Petroleum Geochemistry and Geology, W H Freeman and Company, 1996.
2. Leverson, A.I, Geology of Petroleum, 2nd Edn, CBS Publishers and distributors, NewDelhi.
3. North, F.K., Petroleum geology, Unwin Hyman Inc, USA, 1990.
4. Chapman R.E, Petroleum Geology, Elseiver Science Publishing company Inc. Newyork,1983
5. Jon Gluyas & Richard Swarbrick, Petroleum Geoscience, Blackwell Science publishing LtdUK 2004.
6. Knut Bjorlykke, Petroleum Geoscience- From Sedimentary to Rock Physics, Springer Heidelberg Dordrecht, London, New York 2010.
7. Stach, E., (eds.), 1975, Stach's Textbook of Coal Petrology, Gebruder Borntraeger, Berlin
8. Thomas, L., 2012, Coal Geology, Wiley India Pvt Ltd, Delhi. Thomas L. (2013) Coal Geology: Second Edition, John Wiley & Sons, Ltd.
9. Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press
10. Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
11. Bastia, R., and Radhakrishna, M. (2012). Basin evolution and petroleum prospectively of the continental margins ofIndia (Vol. 59). Newness.
12. Howard L Hartman, Jan M. Mutmansky, Introductory Mining Engineering, John Wiley andSons Inc 2002.
13. Barry A. Wills, Tim Napier-Munn. Mineral Processing Technology, An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, Elsevier Science & Technology Books
14. R.M Umathy, Text book of Mining geology, Dattsons 2002.
15. Gaudin, A.M. Principles of Mineral Dressing, McGraw Hill, 1938.
16. Taggart, A.P. Handbook of Mineral Dressing, Willey.
17. Petters, W.C. Exploration and Mining Geology. John Wiley.
18. Reedman, JH Techniques in Mineral Exploration, Allied Scientific Publishers.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Differentiate coal and petroleum based on origin, types, and properties and their distribution in India.	An	C, F	Assignment & final exam
CO2	Detailed study of Strategic, Critical , Atomic Minerals, minerals of India and National Mineral Policy.	An	C	Quiz, Assignment& final exam
CO3	Apply the knowledge of properties of coal to identify and classify various type of Coals.	Ap	F, P	Assignment & final exam

*** - R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				3		3
CO 2			3			3
CO 3					2	3
Level	-	1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of COs to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Elective - DSE**		
Course Code and Title	**UK7DSEGLY400**		**Research Methodology in Geosciences**		
Semester	7		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial Per week	Practical per week	Total Hours/Week
	4	3 hours	-	2 hours	5

Detailed Syllabus:

Content	Hrs.
Module-1-	**15**
Research Methods -An Introduction-Research Methodology -overview-Types of research in Earth Science-Literature review and its importance in problem formulation-Identification of research gaps and question formulation. Research Design and Sampling Techniques in Earth Science. Data collection-Fieldwork and laboratory techniques. Instrumentations in Earth Science research.	
Module II	**15**
Statistical Analysis for Earth Scientists - Basic statistical concepts. Concept and Application of statistical tests in Earth Science. Spatial data analysis in GIS-Data Visualization Techniques - Graphical and spatial representation of data. Qualitative data analysis, Data interpretation and drawing conclusions, Effective communication of results. Brief study about important software used in geosciences-Arc GIS, QGIS, Rocks works, GeoStudio. Emerging techniques in earth science-AI and machine learning.	
Module III	**16**
Research paper writing and presentation, Scientific design, writing and presentation of geoscience data. Understanding the peer review and publication process for successful publication. Importance of Ethics in Earth Science research.	
Module IV -Practical	**14**
Interpretation of Geoscientific data (Mineralogical, hydrological, geo-chemical and geo-physical data)	
Module V	**10**
Teacher Specific related to course Research Methodology in Geosciences	

Reference

1. Christian Tiberius, Hans van der Marel, René Reudink & Freek van Leijen (2021) Surveying and Mapping. Publisher: TU Delft OPENTU Delft Open Textbook Delft
2. University of Technology — The Netherlands. ISBN (e-book): 978-94-6366-489-9. DOI: ttps://doi.org/10.5074/T.2021.007.
3. Gautam, N.C. (2004) Development of Research tools, Shree Publishers, New Delhi
4. Gupta Santosh (2005) Research Methodology and Statistical Techniques, Deep and Deep Publications.
5. Kothari C R, Research Methodology (Methods and Techniques) New Age Publications.
6. Panneerselvam, R., Research Methodology, Prentice Hall of India, New Delhi.
7. Sharon Lohr, "Sampling: Design and Analysis" Duxbury Press
8. Williams H Roy. Earth Science New Methods and Studies (2021).

(Eds) Apple Academic Press. ISBN 9781774631874

9. Geographic Information Systems and Science, Longley, Goodchild, Rhind, Wiley & Sons
10. The Design and Analysis of Spatial Data Structures by Hanan Samet, Addison Wesley
11. Spatial Databases- A Tour by Shekhar Chawla, Upper Saddle River, NJ, USA, PrenticeHall.
12. Statistics and data analysis in geology by Davis.
13. An introduction to statistical model in geology by W.C.Krumbein and F.A. Graybill.
14. Statistical analysis in geological sciences by Miller and Khan.
15. Research Methodology – C.R.Kothari

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Understand research methodology, sampling, data collection and instrumentation.	R,U	F,C	Assignment, Final Exam
CO2	Create awareness about statistical methods, software, data analysis and interpretation in geosciences including usage of AI and machine learning.	R,U	F,C	Assignment, Final Exam
CO3	Understand research paper writing procedure, effective communication and publishing the paper in journals	Ap,An	C,P	Assignment, Final Exam
CO4	Analyse the geoscientific data	An	P	Quiz, Final exam

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\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1		2			2	2
CO 2					3	3
CO 3					3	3
CO4					3	3
Level	-	1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of Cos to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2	✓		✓	✓
CO3	✓		✓	✓
CO4		✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Elective - DSE**		
Course Code and Title	**UK7DSEGLY420**		**Mineral wealth of India and Mining Strategies**		
Semester	7		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	2	4

Detailed Syllabus:

Content	Hrs.
Module I- Mineral as a resource	**12**
Definition of minerals. Basic concepts of Ores, gangue minerals, tenor, grade, Assay value and Clark value, resources, reserves. Basic fuel minerals. Strategic and critical minerals of India	
Module II- Distribution	**12**
Mode of occurrence, geographic location in India and geology of the following mineral deposits. Iron – Kudremukh, Karnataka, Lead and Zinc – Zawar, Rajasthan, Gold – Kolar, Karnataka, Mica – Nellore, Andhra Pradesh, Manganese – Chindwara, Madhya Pradesh, Copper – Khetri, Rajasthan, Aluminium – Koraput, Orissa, Lignite – Neyveli, Tamilnadu, Coal – Bokaro, Jharkhand, Petroleum – Naharkotiya, Assam and Bombay.	

Module III - Ore Mining methods	**12**
Ore Mining and Beneficiation Surface Mining Methods – Strip mining, Open-pit mining, Auger mining, Mountaintop removal mining. Underground Mining Methods– Room-and-pillar mining, Longwall mining, Retreat mining, Blast mining and Horizon mining. Seabed mining – Marine mining equipment's and methods – General ideas.	
Module IV- Ore Mining and beneficiation	**12**
Ore Mining and Beneficiation Surface Mining Methods – Strip mining, Open-pit mining, Auger mining, Mountaintop removal mining. Underground Mining Methods– Room-and-pillar mining, Longwall mining, Retreat mining, Blast mining and Horizon mining. Seabed mining – Marine mining equipment's and methods – General ideas. Types and uses of Crushers, Grinding mills, Screens and Classifiers. Physical methods of separation by grain size, gravity, and magnetism. Chemical methods – reagents and their functions. Floatation. Flowsheets and its importance.	
Module V- Teacher Specific	6
Teacher Specific related to Mineral wealth of India and Mining Strategies	

Reference

1. Anthony M. Evans (1980). An introduction to Ore Geology, second edition, ELBS.
2. Park and MacDiarmid (1964). Ore Deposits, Freeman.
3. Gokhale, K.V.G.K. and Rao, T.C. (1978) Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
4. Wadia, D.N. (1994) Minerals of India, National Book Trust, India, 5th edition
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9. Barry A. Wills, Tim Napier-Munn. Mineral Processing Technology, An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, Elsevier Science & Technology Books
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12. Taggart, A.P. Handbook of Mineral Dressing, Willey.
13. Petters, W.C. Exploration and Mining Geology. John Wiley.
14. Reedman, JH Techniques in Mineral Exploration, Allied Scientific Publishers.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyze concepts of resource minerals.	An	C, F	Assignment, Final Exam
CO2	Understand spatial distribution and mode of occurrence of some important Ore deposits in India.	**U**	C	Assignment, Final Exam
CO3	Formulate an Idea in Ore beneficiation and mining methods in different conditions.	C	F	Assignment, Final Exam

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\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1				3		3
CO 2				3		3
CO 3				2	1	3
Level	-	1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of Cos to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1		✓	✓	✓
CO 2	✓		✓	
CO3			✓	✓

5.7 COURSES IN GEOLOGY: Semester 8

Discipline and Type of Course	Geology			Discipline Specific Core - DSC	
Course Code and Title	UK8DSCGLY420			Advance Petrology	
Semester	8			Academic Level: 400 - 499	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4

Detailed Syllabus:

Content	Hrs.
Module I: Igneous petrology	**20**
Elementary thermodynamics – Gibbs free energy, entropy, Phase rule in igneous petrology. three component systems: Ternary eutectic system- Di-An-Fo system, Ternary system with solid solution- Di-An-Ab system, Ternary peritectic system- Fo-Qtz-Di system, Ternary system with solvus- Ab-Or-Qtz system. Magma formation – Crustal and mantle melting- Fractional melting, partial melting, batch and Rayleigh melting. Magma generation in relation to tectonic setting- Mid ocean ridge volcanism, subduction related volcanism (Island arc and continental arc volcanism), Oceanic intraplate volcanism and continental flood basalts. Large Igneous Provinces and mantle plumes.	
Module II: Sedimentary Petrology	**20**
Mineral stability and mineralogical maturity of sedimentary rock. Provenance analysis using minerals and elemental ratios as proxy. Sedimentary facies and environments, Concept of Facies models. Sedimentary Basin analysis – purpose and scope. Sedimentary basins – classification and definition. Detailed study of facies Continental environment- Fluvial, alluvial fan, sabkha environment, lacustrine, Transitional environment include deltaic, estuarine, beach, barrier island and lagoonal, tidal flat environment, Marine – Deep Sea facies. Carbonate depositional environment. Bouma Sequence.	

Module III: Metamorphic Petrology	**20**
Application of phase rule in metamorphic mineral paragenesis. Equilibrium thermodynamics in metamorphic petrology, Clasius – Clapeyron equation, buffering, Schreinemaker's rule and bundle. Chemo graphic diagrams – principles of ACF, A'KF and Thompson's AFM diagrams. metamorphic zone concept – isograd and reaction isograd, metamorphic facies concept and facies series, Winkler's grade concept, Miyashiro's paired metamorphic belts and baric types metamorphism, P-T-t paths – isobaric cooling (IBC) and isothermal decompression (ITD) paths. Prograde and retrograde metamorphism, thermobarometry. Regional metamorphism of carbonate, pelitic and mafic rocks-Reactions and Paragenesis. Thermal metamorphism of carbonate rocks. Basic ideas of Geothermobarometry. Becke's Crystalloblastic series. Retrograde metamorphism. Metasomatism and metasomatic zonation, metamorphic differentiation	
Module IV:Teacher specific content	**10**
Teacher specific content related to petrology	

Reference

1. Blatt, Middleton, and Murray: Origin of Sedimentary Rocks, Prentice Hall, 1972.
2. Carver (Ed.) Procedures in Sedimentary Petrology, John Wiley, New York 1971.
3. Folk: Petrology of Sedimentary Rocks, Hempill's, Texas, 1968.
4. Krumbein and Pettijohn: Manual of Sedimentary Petrography, Appleton Century Co.,1938.
5. Pettijohn: Sedimentary Rocks, Harper and Row ,1957
6. Pettijohn, Potter and Siever: Sand and Sandstone , Springer Verlag, 1972.
7. Pickering, Hiscott and Hedn: Deep Marine Environments – Clastic Sedimentation and Tectonics, Unwin and Hyman, 1989.
8. Selley: Ancient Sedimentary Environments, Corwell University Press, 1972.
9. Gary Nichols: Sedimentology and Stratigraphy (Second Edn.) ,Wiley Blackwell, 2009
10. Prothero and Schwab: Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy, Freeman and Company, New York, 1996.
11. Boggs, S. Jr., 2010, Principles of Sedimentology and Stratigraphy, Pearson Education, Inc.
12. Winter, J.D. (2001) An introduction to igneous and metamorphic petrology, PrinticeHall, New Jersey.
13. Wilson, M. (1989) Igneous Petrogenesis. Unwin Hyman Inc., USA
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17. Gupta, A. K., (1998), Igneous rock. Allied Publishers Ltd, Chennai
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19. Mihir K. Bose (1997), Igneous petrology, The World Press Private Ltd, Calcutta.
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22. Mason, R., 1990, Petrology of the metamorphic rocks, Unwin Hyman, London.
23. Miyashiro, A., 1972, Metamorphism and Metamorphic Belts, Allen and Unwin.
24. Turner, F.J. and Verhoogen, J., 1999, Igneous and metamorphic petrology.
25. Barth, T.F.W., 1962, Theoretical Petrology, Wiley, Edition 1, Dover Publication.
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28. Ehlers E. G. The interpretation of Geological Phase Diagrams. Freeman, 1972.
29. Blatt, J., Tracy J. R. and Owens B.E. 2006 Petrology: Igneous, Sedimentary, and Metamorphic.Edition3, W. H. Freeman.
30. Shelley D. Igneous and metamorphic rocks under the microscope: classification, textures, microstructures, and mineral preferred - orientations Springer, 1993.
31. Fry N. The field description of metamorphic rocks. Geological Society of London handbook series. Open University Press, 1984
32. Vernon R. H. and Clarke G. L. 2008 Principles of metamorphic petrology Cambridge University Press.
33. Vernon R. H. A practical guide to rock microstructure Cambridge University Press, 2004
34. Bucher K and Frey M. 1994 Petrogenesis of metamorphic rocks Edition6, Illustrated Publisher Springer-Verlag.
35. Barker A. J. 1998 Introduction to metamorphic textures and microstructures Edition 2, Routledge.

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Examine magma generation process in tectonic setting and and analyze the significance of different three component systems.	An	C	Assignment, Final Exam
CO2	Evaluate various sedimentary facies and facies models.	**E**	C	Assignment, Final Exam
CO3	Analyze phase rule in metamorphic mineral paragenesis , and compare regional metamorphism of various protoliths in different conditions.	An	C	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					2	3
CO 2					3	3
CO 3					2	3
Level	-	1	2			3
Correlation	Nil	Slightly/Low	Moderate / Medium			Substantial/ High

Mapping of Cos to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓	✓	✓	✓
CO 2	✓	✓	✓	✓
CO3	✓	✓	✓	✓

Discipline and Type of Course	**Geology**		**Discipline Specific Core - DSC**		
Course Code and Title	**UK8DSCGLY421**		**Advance Mineralogy and Analytical Techniques**		
Semester	8		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	2 hours	-	2 hours	4

Detailed Syllabus:

Content	Hrs.
Module I: Principles of mineral optics	**12**
Principles of mineral optics- Birefringence , Optical accessories and their uses. Berek compensator, Bi quartz wedge and Betrand ocular. Conoscopic study and interference figures. Dispersion in minerals. Procedure for determining 2V (Mallard's method), optic orientation, extinction angle, optic axial angle, optic sign, Scheme of pleochroism and sign of elongation and Biaxial minerals.	
Module II: Paragenesis	**12**
Structure and co-ordination number of silicon tetrahedra. Structure, chemistry, paragenesis and P-T stability of the following mineral groups- Olivine, garnet, alumina-silicates, pyroxenes, amphiboles, Cordierite, Tourmaline, Beryl, clay, mica, feldspar, and quartz. Twinning in feldspars- simple and polysynthetic. Structure, chemistry and paragenesis of following non-silicates: Spinel, Perovskite, Calcite and Dolomite.	

Module III: Analytical methods on emission techniques	**12**
Principles of X- ray diffraction, Bragg's law, Basic feature of Xray diffractometer, single crystal and powder methods. Preparation of sample for XRD study and interpretation of data. Brief study of Flame Photometer, X-ray fluorescence (XRF), Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES), Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES), Instrument Neutron Activation Analysis (INAA).	
Module IV: Analytical methods on absorption techniques	**12**
Brief Atomic Absorption Spectrometer (AAS), Inductively Coupled Plasma Mass Spectrometer (ICP-MS), Laser Ablation ICP-MS, Multi-collector and Magnetic Sector ICP-MS, Thermal Ionization Mass Spectrometer (TIMS), Secondary Ion Mass Spectrometry (SIMS), Sensitive high-resolution ion microprobe (SHRIMP), Isotope Ratio Mass Spectrometer (IRMS), Electron Probe Micro Analyzer (EPMA). Analytical methods on electron microscopic techniques- Scanning Electron Microscope (SEM-EDX), Transmission Electron Microscope (TEM)-HR-TEM, Atomic Force Microscope	
Module V: Practical	**8**
Practical, Determination of the following optical characters of minerals, Relative refringence, order of interference colour, sign of elongation, birefringence, scheme of pleochroism and pleochroic formula, optic orientation, extinction angle, anorthite content. Mineral paragenesis.	

Reference

1. Ford, W. H. (1955) A textbook of Mineralogy- Asia publishing House – Wiley.
1. Phillips, (1956) An Introduction to Crystallography – Longmans Green
2. Cornelis Klein and Hurlbut (1985) Manual of Mineralogy, John Wiley
3. Deer, W. A., Howie, R.A and Zussman, J. (1992) An introduction to the rock-forming minerals, ELBS –Longman, England.
4. Hans- Rudolf Wenk & Andrei Bulakh (2004) Minerals – their constitution and origin, Cambridge University press.
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7. Philips F. C. Introduction to Crystallography. Nelson T, 1963.Burger M. J. Elements of Crystallography, Wiley, 1963.
8. Dana E. S. Textbook of Crystallography, Revised by Ford W E, Wiley, 1962. Berry L. G. and Mason B. Mineralogy, Freeman, 1959.

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10. Winchell A. N. Elements of optical mineralogy, Pt I, Wiley, 1951.Perkins D. Mineralogy. Pearson Education, 2002.
11. Wenk H. R. and Bulakh. Minerals: their constitution and origin. CUP, 2004. Perkins D. and Henke K. R. Minerals in thin section. Pearson Education Inc., 2004.Nesse W.D. Introduction to Optical Mineralogy. Oxford University Press, 2004.
12. Nesse W. D. Introduction to Mineralogy. Oxford University Press, 2008. Kerr, Paul F. Optical Mineralogy. McGraw-Hill, New York, London. 1977

CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Appraise a basic knowledge about mineral optics.	E	C, P	Assignment, Final Exam
CO2	Evaluate Structure, chemistry and paragenesis of major silicate and non silicate minerals.	**E**	C	Assignment, Final Exam
CO3	Develop an Idea about Analytical methods on emission techniques and absorption techniques for geochemical and mineralogical analysis.	C	C	Assignment, Final Exam

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 # - F-Factual, C- Conceptual, P-Procedural, M-Metacognitive

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1					3	2
CO 2					3	2
CO 3					2	3
Level	-	1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of Cos to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1			✓	✓
CO 2		✓	✓	✓
CO3	✓		✓	✓

Discipline and Type of Course	**Geology**			**Discipline Specific Core - DSC**	
Course Code and Title	**UK8DSCGLY422**			**Advance Stratigraphy and Structural Geology**	
Semester	8			Academic Level: 400 - 499	
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours/Week
	4	4 hours	-		4

Detailed Syllabus:

Content	Hrs.
Module I: Crustal evolution:	**12**
Precambrian Crust- Nature and evolution of primitive crust Models of crustal evolution Craton-mobile belt concept. Granulite and Greenstone terrains –origin, rock associations, structure, metamorphism and models of evolution. Evolution of high-grade mobile belts. Introduction to Precambrian shields of India.	
Module II: Stratigraphy of India	**12**
Detailed study of Evolution of cratons and Precambrian stratigraphy in India with special references to SGT, Dharwar, Bastar, Singhbhum, Aravalli and Bundelkhand Cratons. Mobile belts in India – Pandyan, Eastern Ghats, Satpura and Aravalli mobile belts. Evolution and stratigraphy of Proterozoic sedimentary basins of India – Cuddapah, Vindhyan, Kurnool.	
Module III: Significance of secondary structures in understanding the deformation history	**12**
Behaviour of materials under stress- material classification, Structural analysis using stress strain diagram, Graphical representation of structural data – stereographic and equal-area projections in structural geology – π and β diagrams. Folds- Minor folds and their use in determining the major fold structure. Pumpelly's rule. Superposed folding, simple fold interference patterns. Shear zone- Ductile and Brittle-Ductile shear zones. Detailed study on shear sense indicators. Petrofabric analysis – field and laboratory techniques involved in the construction of fabric diagrams and their interpretation.	
Module IV: Geodynamic settings of plate margins.	**12**
Tectonic framework of Indian plate- Evolution of Himalaya, Central Indian Tectonic Zone (CITZ). Supercontinents- Indian plate journey through Rodinia, Gondwana and Pangaea. Tectonic framework of Southern Granulite Terrain (SGT). Shear zones in SGT- Moyar, Bhavani, Attur, Palghat-Cauvery and Achenkoil.	

Module V: Teacher specific content	**8**
Teacher specific content related to structures and stratigraphy	

Reference

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CO	Course Outcome	Cognitive Level*	Knowledge Category#	Evaluation Tools used
CO1	Analyze evolution of primitive crust and models of crustal evolution and understand the tectonic framework of Indian plate.	An	C, F	Assignment, Final Exam
CO2	Compare cratons, mobile belts and Proterozoic sedimentaray basins of India .	An	C	Assignment, Final Exam
CO3	Evaluate Significance of secondary structures in understanding the deformation history	E	F, P	Assignment, Final Exam

* - **R-Remember, U-Understand, Ap-Apply, An-Analyse, E-Evaluate, C-Create**

\# - **F-Factual, C- Conceptual, P-Procedural, M-Metacognitive**

Mapping of COs with PSOs and PO						
	PSO1	PSO2	PSO3	PSO4	PSO5	PO
CO 1			3			3
CO 2			3			3
CO 3			3			3
Level	-	1		2		3
Correlation	Nil	Slightly/Low		Moderate / Medium		Substantial/ High

Mapping of Cos to Assessment Rubrics				
	Assignment	Seminar	End Semester Examinations	Internal Examinations
CO 1	✓		✓	✓
CO 2		✓	✓	✓
CO3			✓	✓

Discipline and Type of Course	**Geology**		**Research Project for Honours - RPH**		
Course Code and Title	**UK8RPHGLY400**		**Research Internship Project in Geology**		
Semester	8		Academic Level: 400 - 499		
Course Details	Credit	Lecture per week	Tutorial per week	Practical per week	Total Hours
	12		-		180