PROGRAM /COURSE STRUCTURE AND SYLLABUS

as per the Choice Based Credit System (CBCS)

designed in accordance with

Learning Outcomes-Based Curriculum Framework (LOCF)

With Multiple Entries

And Exit Options under New Education Policy (NEP) – 2020

for

Bachelor of Science (Basic/Honors) Degree with Earth Science as Major/Minor having Practicals

w.e.f.

Academic Year 2021-22 and onwards

PREAMBLE

The present Curriculum Framework for B.Sc., degree in Earth Science is intended to facilitate the students to achieve the following:

- To develop an understanding and knowledge of the basic theory and principles of Geology through various branches of Geology – such as Dynamic Geology/Geomorphology, Petrology, Structural Geology, Stratigraphy, Paleontology, Environmental Geology etc.
- To develop the ability to use this knowledge and understanding to analyze, interpret and apply in the geological field.
- To acquire necessary and state-of-the-art skills to take up challenges in the field and also in various geological disciplines such as Mining, Economic Mineral Resources, Remote Sensing, Basin analysis, Watershed development etc.
- The objectives and outcomes are carefully designed to suit to the above-mentioned purpose.
- The ability to decipher the critical issues of nature and hidden natural resources treasures through acquired knowledge and experience.
- To equip with the learnt skills and hands-on training they are able to judge, imagine and interpret in a better way.
- To prepare them as a budding geoscientists.

PROGRAM OUTCOMES:

Discipline knowledge: After the completion of the BSc Course (Degree/Honors), the students will be learning the basics and important aspects of all branches of Earth Sciences mentioned in the preamble; which will enable them to apply their acquired knowledge.

1. Problem Solving: After going through 6 or 8 semesters curricula the students will be able to understand and decipher majority of the geological processes and their effects.
2. Ethics on Profession, Environment and Society: As the subject Geology is related to Earth its resources and processes the students will be taught to acquire ethics to maintain the integrity while dealing with data collection, compilation, and interpretation and finding solutions.
3. Lifelong Learning and Entrepreneurship: Geology is regarded as a technical subject one can start their own consultancy so, they will become an independent entrepreneur and hence learning will be lifelong.
4. Motivation to take up Higher Studies: Inspiration to continue towards advanced studies in Geology and Research.

PROGRAMME STRUCTURE

Earth Science as Core subject: I and II semesters

Semester	Discipline Core (DSC) (Credits) (L+T+P)	Credits	Discipline Specific Elective (DSE) / Open Elective (OE) (Credits)(L+T+P)
I	**A1 Theory (4 credits)** (4+0+0) Earth System Science - Fundamentals **P1 Practicals (2 credits)** (0+0+2) Maps, Sediment Soil, Field Visit.	**4+2**	**OE-1 (3 credits)** (3+0+0) i) Crystallography, Mineralogy, and Economic Minerals ii) Pedology iii) Basics of Earth System Science iv) Geohazards and Mitigation Strategies
II	**A2 Theory (4 credits)** (4+0+0) Basics of Crystallography, Minerology and Petrology **P2 Practicals (2 credits)** (0+0+2) Crystallography, Minerology and Petrology	**4+2**	**OE-2 (3 credits)** (3+0+0) i) Medical Geology ii) Industrial minerals iii) Paleobiology iv) Gems and Ornamental Stones
Exit option with Certificate			

Open Elective (OE) Courses: OE courses are offered to the candidates of either the same program or other undergraduate programs as decided by the competent authority of the University of Mysore and the candidate who opts for OE in Earth Science has to choose one OE from the pool in each semester. The OE courses, in addition to enhancing the knowledge on the Earth's processes and helps to acquire skills for entrepreneurship.

Concept note, abbreviation explanation, coding, eligibility for admission to the course, duration of the course, course pattern, medium of instruction, attendance, internal assessment, mode of examination, duration of examination, results of the candidates and carry over are as per the provision made in the NEP regulations of University of Mysore and Yuvaraja's College (autonomous).

COURSE-WISE SYLLABUS
I Semester Theory

Year	2021-22	**Course Code:**	**Credits**	**4**
Sem	I	**Course Title: EARTH SYSTEM SCIENCE - FUNDAMENTALS**	Hours	56
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 40		Summative Assessment Marks: 60	Duration of ESA: 2 hrs.	
Course Outcomes		At the end of the course the student should be able to: 1. Explain the origin and internal structure of the Earth. 2. Explain the conceptual and dynamic aspects of landform development. 3. Learn the relevance of applied aspects of Geomorphology in various fields. 4. Formulate conceptual and analytical descriptions of geodynamic processes such as volcanism, earthquake and formation of ocean.		
Unit No.		**Course Content**	**Suggested Pedagogy**	**Hours**
Unit I		INTRODUCTION TO EARTH SYSTEM SCIENCES Definition and scope of earth system sciences. Branches of Earth Sciences. Systems concepts for earth system science - fundamental concepts of the five spheres (lithosphere, hydrosphere, atmosphere, biosphere and cryosphere). Energy balance. Interactions between the five spheres; hydrologic cycle; Biogeochemical cycles - carbon cycle; Hydrosphere-atmosphere: Oceanic current system and effect of Coriolis force. Concepts of eustasy. Atmospheric circulation. Weather and climatic changes. Interrelationships between biological, geological, climatological, and human systems on continental and global scales. Anthropogenic influences on the Earth systems; Human- environment interactions - policy. The universe and solar system: Origin of the universe - Big bang theory. Solar system. Members of solar system – planets (Terrestrial and gaseous planets), satellite, comets, asteroids, meteorite.	Lecturing, Tutorial and Field visits	14

	Earth in the solar system. Size, shape, mass and density of the earth. Origin of the Earth – Gaseous hypothesis, Nebular hypothesis, Planetesimal hypothesis, Tidal hypothesis, Supernova hypothesis, Interstellar or dust or meteoric hypothesis. Evolution of earth. Age of the Earth: Geochronology; Absolute and relative methods; (a) Relative Methods - Sedimentation, Salinity method, varve chronology, Rate of cooling of earth. (a) Radiometric dating, atomic energy, decay scheme, half life, method - K-Ar; Rb-Sr; U-Pb, Pb-Pb. Age of the earth. Earth's internal structures and its composition. Evidence for the Earth's composition and mineralogy – 1. Seismic data, 2. Density studies, 3. Meteorites. Earth's internal layers - Crust, mantle and core. Lithosphere, asthenosphere, mesosphere and barysphere.		
Unit II	GEOMORPHOLOGY – I Introduction:- Basic concepts of Geomorphology, Definition and scope, Geomorphic agents, Geomorphic processes; endogenetic (epigene) and exogenetic (hypogene). Land forms. Weathering - physical, chemical, biological. Soil - Definition, Formation, Types of soils. Soil Profile. Rivers and fluvial landforms:- Introduction, Development of rivers - Drainage system and patterns. Stages of rivers – Davi's concept; youth, mature, old. Geologial actions: Erosion - hydraulic action, abrasion, attrition, solution. Erosional landforms – Pot holes, V shaped valleys, gorges and canyons, waterfalls and types, river meanders, ox-bow lakes, river terraces, structural benches. Transportation - suspension , solution. Deposition and depositional landforms - alluvial fans and cones, flood plains, natural levees, deltas, channel deposits Wind and Aeolian landforms: Types of wind – Breeze, Gale, Tempest, Cyclone. Geological action of wind: Wind erosion - Deflation, abrasion, attrition. Erosional features - mushroom rocks, yardangs, Hamda, ventifacts, pedestal rocks, zeugen, milletseed sands. Transportation - suspension, saltation, traction. Deposition and depositional landforms - Sand dunes and types, Loess.	Lecturing, Tutorial and Field visits	14
Unit III	GEOMORPHOLOGY - II Glaciers and glacial landforms. Growth and movement of glaciers. Types of glaciers – Mountain or valley glaciers, Piedmont glaciers, continental ice-sheets or ice caps. Glacier imprints. Geological action of glaciers; Erosional	Lecturing, Tutorial and Field visits	14

	work by glaciers – Plucking/ Excavation, Frost wedging., Abrasion. Erosional landforms - Whaleback forms. Glacial valley - U shaped valley and V- shaped valley, Crag and Tail, Hanging valley, Cirques, Fiords, Arete, Cols, Horns, Roches Moutonnes. Transportation - glacial drift. Deposition and depositional landforms - Glacial Moraines and types, Drumlins, Kames, Eskers, Outwash plains, Kettles. Groundwater:- Meaning and components of groundwater. Geological action of groundwater: Erosion and erosional landforms (lapis, solution holes and associated features, poljes, caves and caverns: valleys of karst topography, natural bridges). Transportation; solution. Depositional work; concretions, stalactites and stalagmites, Oceans and Coastal landforms:- Topography of ocean floor – continental slope, shelf, abyssal zone, mid-oceanic ridges. Geological action of oceans: Agents of coastal erosion; Waves, Tides, Currents and circulation of water. Process of marine erosion, erosional landforms (Headlands and Bays, Sea Cliffs, Wave-cut Terraces, Sea caves, stacks). Transportation. Depositional landforms (Beaches and barriers, wave built terraces, Spits and bars, Tombola). Deep sea water deposits – terrigeneous and pelagic deposits. Corals - its types and origin.		
Unit IV	GEODYNAMICS Introduction to Geodynamics. Origin of oceans, continents and mountains. Concepts and theories of isostasy. Concept of palaeomagnetism, application of palaeomagnetism. Continental drift. Sea floor spreading. Concept of plate tectonics. Nature and types of plate margins, Midoceanic ridges and trenches. Origin and distribution of Island arcs. Earthquakes:- definition, Elements of an earthquake, types of earthquake waves, intensity and magnitude, seismographs and seismometers, causes and prediction of earthquake, Effects of earthquake, Seismic zones of India. Volcanoes:- A typical volcano parts, volcanic activity, types of volcanoes, composition of lava, distribution of volcanoes. Volcanic landforms; depressed landforms: Volcanic cone (Cinder Cone), Volcanic craters, Calderas (Caldera Lake). Landforms due to the accumulation of lava: Volcanic mountains, Volcanic plateaus, Volcanic plains, Volcanic necks.	Lecturing, Tutorial and Field visits	14
Recommended Learning Resources			

Print Resources	1. Duff, P. M. D., & Duff, D. (Eds.). (1993). Holmes' principles of physical geology. Taylor & Francis. 2. Emiliani, C. (1992). Planet earth: cosmology, geology, and the evolution of life and environment.Cambridge University Press. 3. Gross, M. G. (1977). Oceanography: A view of the earth. 4. Brian, J. S., Barbara, W.M., 2010. The Blue Planet: An Introduction to Earth System Science, 3rdEdition, Wiley. 5. Ernst, W.G., 2000. Earth Systems: Processes and Issues, Cambridge University Press. 6. Sarah, E., Cornell, I., Prentice, C., Joanna, I.H., Catherine, J.D., 2012. Understanding the Earth System Global Change Science for Application, Academic Press. 7. Jacobson, M., Charlson, R., Rodhe, H., Orians, G., 2000.Earth System Science: From Biogeochemical Cycles to Global Changes, Elsevier. 8. Ehlers, E., Krafft, T., 2006. Earth System Science in the Anthropocene, Springer. 9. *Jacobson, M. C., Charlson, R. J., Rodhe, H., and Orians, G. H., 2000, Earth System Science: San Diego, CA, Academic Press, 523 p., ISBN 0-12-379370-X* 10. The Earth System, Lee R. Kump, James F. Kasting, and Robert G Crane; Prentice Hall, 2nd Ed., 2004 11. Principles of Geology – Arthur Holmes 12. Physical Geology – Longwell & Flient 13. General Geology – Radhakrishnan. Y 14. The Dynamic Earth – Wyllie. P.J 15. The way earth works - Wyllie. P.J 16. Physical Geology – Springfield 17. Geomorphology – Thornbury 18. Geomorphology – Davies 19. Physical Geography Today – Muller & Oberlander
Digital Resources	https://z-lib.org/ https://library.iitkgp.ac.in/pages/eSearch2.1/eBooks.php

I SEMESTER PRACTICAL

<table>
<tr><td>Year</td><td>2021-22</td><td>Course Code:</td><td>Credits</td><td>02</td></tr>
<tr><td>Sem</td><td>I</td><td>Course Title: Maps, Soil & Field Visit</td><td>Hours</td><td>48</td></tr>
<tr><td colspan="2">Course Pre-requisites, if any</td><td colspan="3">NA</td></tr>
<tr><td colspan="2">Formative Assessment Marks: 25</td><td colspan="2">Summative Assessment Marks: 25</td><td>Duration of ESA: 3 hrs.</td></tr>
<tr><td colspan="2">Course Outcome</td><td colspan="3">Students learn the preparation of various kinds of maps.
Students learn the skill of detecting the changes in the land use/land cover of a region and study its impacts, suggest remedial measures.
Students get acquainted with the soil properties, types, characteristics and remediation of soil.</td></tr>
<tr><td colspan="2"></td><td colspan="3">Part A:
1. Introduction to maps. Study of maps. Types of maps. Types of scale. Detailed study of topographic sheets. 2 labs.
2. Reading topographical maps of the Survey of India. 1 lab.
3. Preparation of topographical map. 1 lab.
4. Identification of drainage patterns. 1 lab.
5. Preparation of LU/LC maps. 2 lab.
6. Study of soil profile and determination of soil texture. 2 lab.
7. Study of major geomorphic features and their relationships with outcrops through physiographic models and aerial photos using pocket lens stereoscope and mirror stereoscope. 3 lab.</td></tr>
<tr><td colspan="2"></td><td colspan="3">PART B: Field visit to a place of geological/geomorphological interest.</td></tr>
</table>

I Semester, OPEN-ELECTIVE SYLLABUS (OE-1)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**I**	**Course Title: Crystallography, Mineralogy and Economic Mineral**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 3 hrs.	
Course Outcomes	Studying the basics of mineralogy and crystallography helps in understanding and building the overall knowledge in Geology. The students will be able to identify common rock-forming minerals n hand specimens as well as in thin sections. T he students get familiarized with the instruments used to analyse inorganic compounds.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Crystals, crystalline solids and their formation; Symmetry in crystals; Axial ratio, indices, order of the crystallographic axes; Crystallographic notation (Weiss and Miller indices and convention in notation); Classification of crystals, introduction to 32 classes; The crystal systems and symmetry types; Stereographic representation of crystal symmetry and their uses; Imperfection of crystals and crystal defects; Twinning-causes, effects and genetic types		Lectures, tutorials Group Discussion and IT based teaching	14
Unit II	Isotropic and anisotropic substances; Reflection, refraction and refractive index; Relief, birefringence and Becke line effect; Optically uniaxial and biaxial minerals; Determination of optic sign of uniaxial and biaxial minerals; interference figures; Pleochroism and determination of pleochroic scheme in minerals; X-ray crystallography and Bragg's equation; Application of X-ray diffraction spectrometry in mineral characterization; Application of techniques in mineralogy: Differential Thermal Analysis (DTA), Thermogravimetric Analysis (TGA), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Electron Probe Micro Analyser (EPMA); Application of thermal, magnetic and			14

	radioactive properties of minerals.		
Unit III	Definition of ore, ore mineral and gangue; Classification of ore deposits; Chemical composition, diagnostic characters, uses and distribution in India of the following minerals: Gold, Copper, Iron, Manganese, Lead, Zinc, Bauxite, Chromite, magnesite, pyrite, diamond, muscovite, beryl, fluorite, gypsum, barite, halite, phosphorite, talc, kyanite, graphite, asbestos, monazite and corundum; Origin, uses and distribution of coal and petroleum in India.		14
Recommended Learning Resources			
Print Resources	1. James D Dana. A Textbook of minerology, John Wiley and Sons 2. Verma, P K (2010), Optical mineralogy. Ane books Pvt. Ltd. 3. Buerger, Elementary crystallography 4. JAK Tareen and TRN Kutty,(1989) Elemental crystallography 5. Ram S. Sharma and Anurag Sharma (2013) Crystallography and Mineralogy - Concepts and Methods. Text Book Series, Geological Society of India, Bangalore 5. Dana, E.S. and Ford, W.E., (2002) A textbook of Mineralogy (Reprints). 6. Flint, Y., (1975) Essential of crystallography, Mir Publishers. 7. Phillips, F.C., (1963) An introduction to crystallography. Wiley, New York. 8. Berry, L.G., Mason, B. and Dietrich, R.V., (1982) Mineralogy. CBS Publ. 9. Read, H.H., (1968) Rutley's Element of Mineralogy (Rev. Ed.). Thomas Murby and Co. 10. Berry and Mason, (1961) Mineralogy. W.H. Freeman & Co. 11. Kerr, B.F., (1995) Optical Mineralogy 5th Ed. McGraw Hill, New York. 12. Deer, Howie and Zussman (1996) Introduction to Rock forming Minerals, Pearson 13. Wahlstrom E.E. (1971) Optical crystallography, John Wiley and sons. 14. R.N. Hota (2012) Practical approach to Mineralogy and Crystallography, CBS Publications & Distributions. 15. Perkin D. (2010) Mineralogy, Pearson.		

I Semester, OPEN-ELECTIVE SYLLABUS (OE-2)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**I**	**Course Title: Pedology**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	The students will be able to learn the processes of formation of soil, its classification, texture and structure, soil characteristics of each textural and structural class.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Soil pedological and edaphological concepts. Composition of earth crust and its relationship with soils; Rocks, minerals and other soil forming materials; Weathering of rocks and minerals; Factors of soil formation soil profile, horizons and their nomenclature. Soil texture, textural classes, mechanical analysis, specific surface. Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage-basic concepts. Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability, soil conditioners. Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential. soil classification, soil mineralogy and soil maps – usefulness		Lectures, tutorials Group Discussion and IT based teaching	14
Unit II	Soil Erosion And Conservation: History, distribution, identification and description of soil erosion problems in India. Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; Soil survey and its types; soil survey techniques - conventional and modern; soil survey interpretations; soil mapping, thematic soil maps Soil conservation planning; soil conservation in special problem areas such as hilly, arid and semi-arid regions,			14

	waterlogged, wet lands and methods (agromormic, physical and biological methods)		
Unit III	Soil Management: Area and distribution of problem soils - acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible. Morphological features of saline, sodic and saline-sodic soils; characterization of salt- affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties. Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils. Acid soils - nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management. Reclamation of salt-affected soils; mine land reclamation, afforestation, organic products. Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and participatory approach for reversing land degradation; global issues for twenty first century.		14
Recommended Learning Resources			
Print Resources	1. Brady NC & Weil RR. 2002. The Nature and Properties of Soils. 13th Ed. Pears on Edu. 2. Biswas TD & Narayanasamy G. (Eds.) 1996. Soil Management in Relationto Land Degradation and Environment. Bull. Indian Society of Soil Science No. 17. 3. Boul SW, Hole ED, MacCraken RJ & Southard RJ. 1997. Soil Genesis andthe Classification. 4 Ed. Panima Publ. 4. Brewer R. 1976. Fabric and Mineral Analysis of Soils. John Wiley & Sons. 5. EW, Hole ED, MacCracken RJ & Southard RJ. 1997. Soil Genesisand Cl assification. 4th Ed. Panima Publ. 6. Dixon JB & Weed SB. 1989. Minerals in Soil Environments. 2nd Ed. SoilScienc e Society of America, Madison. 7. Doran JW & Jones AJ. 1996. Methods of Assessing Soil Quality. Soil Science Society of America, Spl Publ. No. 49, Madison, USA. 8. Grim RE. 1968. Clay Mineralogy. McGraw Hill. 9. Greenland DJ & Szabolcs I. 1994. Soil Resilience and Sustainable Land Use. CABI. 10. Gurmal Singh, Venkataramanan C, Sastry G & Joshi BP. 1990.		

Manual of Soil and Water Conservation Practices. Oxford & IBH.
11. Hudson N. 1995. Soil Conservation. Iowa State Univ. Press. Indian Society of Soil Science 2002. Fundamentals of Soil Science. ISSS,New Delhi.
12. JurinakJJ. 1978. Salt-affected Soils. Department of Soil Science &Biometeorology. Utah State Univ
13. Lal R, Kimble J, Levine E & Stewart BA. 1995. Soil Management and Greenhouse Effect. CRC Press.
14. Lal R, Blum WEH, Vailentine C & Stewart BA. 1997. Methods forAssessment of Soil Degradation. CRC Press.
15. Middlebrooks EJ. 1979. Industrial Pollution Control. Vol. I. AgroIndustries. John Wiley Interscience.
16. Oswal MC. 1994. Soil Physics. Oxford & IBH.
17. Ross SM. Toxic Metals in Soil Plant Systems. John Wiley & Sons.
18. Sehgal J. 2002. Introductory Pedology: Concepts and Applications. NewDelhi
19. Sehgal J. 2002. Pedology - Concepts and Applications. Kalyani.
20. Sehgal J & Abrol IP. 1994. Soil Degradation in India - Status and Impact. Oxford & IBH.
21. USDA. 1999. Soil Taxonomy. Hand Book No. 436. 2nd Ed. USDA NRCS,Washi ngton.
22. Vesilund PA & Pierce 1983. Environmental Pollution and Control. Ann Arbor Science Publ.
23. Wade FA & Mattox RB. 1960. Elements of Crystallography andMineralogy. Oxfo rd & IBH.
24. Wilding LP & Smeck NE. 1983. Pedogenesis and Soil Taxonomy: II. TheSoil Orders. Elsevier.
25. Wilding NE & Holl GF. (Eds.). 1983. Pedogenesis and Soil Taxonomy. I. Conc ept and Interaction. Elsevier.

I Semester, OPEN-ELECTIVE SYLLABUS (OE-3)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**I**	**Course Title: Basics of Earth System Science**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	At the end of the course the student should be able to: 1. Explain the origin and internal structure of the Earth. 2. Explain the conceptual and dynamic aspects of landform development. 3. Learn the relevance of applied aspects of Geomorphology in various fields			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Introduction to Earth Sciences with a special focus to Geology, scope, sub-disciplines and relationship with other branches of sciences		Lectures, tutorials Group Discussion and IT based teaching	14
Unit II	Earth in the solar system, origin Earth's size, shape, mass, density, rotational and evolutional parameters Solar System- Introduction to Various planets - Terrestrial Planets Solar System- Introduction to Various planets - Jovian Planets Internal constitution of the earth - core, mantle and crust			14
Unit III	Convections in the earth's core and production of magnetic field Composition of earth in comparison to other bodies in the solar system. Origin and composition of hydrosphere and atmosphere Origin of biosphere Origin of oceans, continents and mountains Age of the earth; Radioactivity and its application in determining the age of the Earth, rocks, minerals and fossils			14
Recommended Learning Resources				
Print Resources	1. Arthur Holmes, Principles of Physical Geology. 1992. Chapman & Hall. 2. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press. 3. Gross,M.G., 1977. *Oceanography: A view of the Earth*, Prentice Hall. 4. The Dynamic Earth – Wyllie. P.J 5. The way earth works - Wyllie. P.J 6. D.R. Johnson, M. Ruzek, M. Kalb, What is Earth System Science? Proceedings of the 1997 International Geoscience and Remote Sensing Symposium Singapore, August 4 - 8, 1997, pp 688 - 691			

Digital Resources	https://z-lib.org/ https://library.iitkgp.ac.in/pages/eSearch2.1/eBooks.php

I Semester, OPEN-ELECTIVE SYLLABUS (OE-4)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**I**	**Course Title: Geohazards and Mitigation Strategies**	**Hours**	**48**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	After completing the course, student 1. Can understand the geology behind natural disasters. 2. Will understand the origin and occurrence of geohazards and evaluate the prediction and mitigations. 3. can understand the causes, threats, impact, magnitude and intensity of the natural hazards 4. Will be able to qualitatively estimate risk, and envisage risk-appropriate mitigation strategies.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Geohazards: assessment and planning- Introduction, types of hazards; characteristic features, occurrence and impact of different types, Causes and Strategies for Mitigation of Geological Hazards; Risk assessment, Hazard maps, Land-use planning and hazards		Lectures, tutorials Group Discussion	14
Unit II	**Earthquakes, Mitigation Approaches:** – Earthquake, its Causes, Specific threats, Community impacts, and Mitigation strategies. Characteristic features; Earthquake Risk Mitigation Magnitude and Intensity of earthquake; Major earthquakes; Seismic zoning; Earthquake vulnerability of India; Earthquake risk mitigation – Seismic performance examination of RCC Buildings, retrofitting of vulnerable buildings, Construction of			14

	earthquake resistant buildings following proper BIS codes, Earthquake preparedness; Case study – 'Bhuj Earthquake'. **Volcanic hazard**: Introduction, Types of volcanoes, Volcanic form and structure, Types of central eruption, Causes of volcanic eruptions, Volcanic products: volatiles, Volcanic products: pyroclasts, Volcanic products: lava flows, Specific threats, Community impacts, Volcanic hazard and prediction Mitigation strategies		
Unit III	**Tsunami Events, Mitigation Approaches:** An introduction to Tsunami; Magnitude & Intensity of a Tsunami; Types of Tsunami; Features of **Flood and Mitigation Approaches:** Types of floods**,** Causes of floods**,** Specific threats**,** Community impacts**.** Mitigation strategies**:** Floodplain Management**,** Flood Insurance**,** Flood Mitigation Programs**,** Property Acquisitions**,** Retrofitting Flood Prone Residential Structures **Mass movements:** Soil creep and valley bulging, Causes of landslides, Classification of landslides, Landslides in soils Landslides in rock masses, A brief note on slope stability analysis. Monitoring slopes, Landslide hazard, investigation and mapping, Methods of slope control and stabilization Landslide Specific threats, Community impacts, Mitigation strategies.		14
Recommended Learning Resources			
Print Resources	1. Alexander, D. (1993) Natural Disasters. University College London Press, London. 2. Alden, W. C., 1928. Landslide and Flood at Gros Ventre, Wyoming, Focus on Environmental Geology, Tank R., Ed., Oxford University Press, New York (1973), 1928, pp. 146–153. 3. Baker, P.E. (1979) Geological aspects of volcano prediction. Journal Geological Society, 136, 341-346. 4. Bell, F.G., (1999). Geological hazards: their assessment, avoidance, and mitigation. (an imprint of Routledge). E&FN Spon, London, UK, Hardbound, ISBN 0-419-16970-9;631 Pages. 5. Bell, F.G. (1994) Floods and landslides in Natal and notably the greater Durban region, September 1987: a retrospective view. Bulletin Association Engineering Geologists, 31, 59-74. 6. Broms, B. B., Landslid es , Foundation Engineering Handbook , Winterkorn, H. F. and Fang, H.-Y., eds., Van		

	Nostrand Reinhold Co., 7. Bernard, E.N. (Ed.), Developing Tsunami-Resilient Communities: The National Tsunami Hazard Mitigation Program, Reprinted from Natural Hazards, 35:1 (2005) 2005, VI, 186 p., ISBN: 978-1-4020-3353-7. 8. Bollinger, G. A., 1976. The seismic regime in a minor earthquake zone, Proc. ASCE Numer. Methods Geomech., 2, 917–937. 9. Bullard, R.M. (1976) Volcanoes of the Earth. University of Texas Press, Austin. 10. Bolt, B.A. (1978) Earthquakes: A Primer, W.H.Freeman, San Francisco. 11.Bolt, B.A. (1993) Earthquakes. W. H. Freeman, New York. 11. Forgione, G., Luongo, G. and Romano, R. (1989) Mt Etna (Sicily): Volcanic hazard assessment. In Volcanic Hazards: Assessment and Monitoring, Latter, J.H. (ed.), Springer-Verlag, Berlin, 137-150. 12. Hamilton, R. M., 1978. Earthquake Hazards Reduction Program-Fiscal Year 1978 Studies Supported by the U.S. Geological Survey, Geological Survey Circular 780, U.S. Dept of the Interior. 13. Leeds, D. J., 1973. The Design Earthquake, in Geology, Seismicity and Environmental Impact, Special Publication Association of Engineering Geology, Los Angeles, CA. 14. Ramesh P. Singh & Darius Bartlett, 2018. Natural Hazards: Earthquakes, Volcanoes, and Landslides.527 Pages. 15. Sassa, K., Fukuoka, H., Yang, Q.J., and Wang, F.W., 1997. Landslide Hazard Assessment in Cultural Heritage, Lishan, Xian, Proceedings International Symposium on Landslide Hazard Assessment, 1–24, Xian, China. 16. Seed, H. B., 1966. A method for earthquake resistant design of earth dams, Proc. ASCE J. Soil Mech. Found. Engrg. Div., 92, 13–41. 17. Thenhaus, P. C. and Campbell, K. W.,2003. Seismic hazard analysis, in Earthquake Engineering Handbook, Chen, W. and Scawthorn, C., Eds., CRC Press, Boca Raton, FL,
Digital Resources	www.google.com

II SEMESTER

Year	**2021-22**	**Course Code:**	**Credits**	**4**
Sem.	**II**	**Course Title: Basics of Crystallography, Mineralogy and Petrology**	**Hours**	**56**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	At the end of the course the student should be able to: 1. To understand the states of matter, atomic arrangement in crystals, and classification of crystals based on crystal symmetry To understand the characteristics of common rock-forming minerals 2. To acquire knowledge on different types of rocks, their distinction from each other and the rock cycle. 3. To understand the occurrence and distribution of rocks in India.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Crystal morphology and internal structures. Crystal parameters and indices. Crystal symmetry and classification of crystals into six systems and 32-point groups. Stereographic projections of symmetry elements and forms. Introduction to analytical techniques like XRD (X-ray diffraction), SEM (secondary electron microscopy).		Lectures, tutorials Group Discussion and IT based teaching	14
Unit II	Elements of crystal chemistry and aspects of crystal structures. Minerals: definition and classification, physical and chemical composition of common rock-forming minerals. Nature of light and principles of optical mineralogy. Introduction to the petrological microscope and identification of common rock forming minerals			14
Unit III	Rock associations in time and space. Physical aspects of magma generation in crust and mantle. Physical properties of magmas; igneous cumulates, liquid immiscibility, pneumatolitic action, magmatic assimilation and mixing of magmas. Textures of igneous rocks. Classification of igneous rocks. Igneous rock associations.			14
Unit IV	Origin, classification and occurrence of sedimentary rocks. Siliciclastic Sedimentary Rocks: Sedimentary		Lecture, Tutorials and	14

	textures, Sedimentary structures. Sandstones, Conglomerates, Mudstones and shales. Diagenesis of sandstones and shales, Limestones, Dolomites. Metamorphic rocks- Metamorphism, types of metamorphism, classification of metamorphic rocks, common textures and Structures.	Group discussion	
Recommended Learning Resources			
Print Resources	1. James D Dana. A Textbook of minerology, John Wiley and Sons 2. Verma, P K (2010), Optical mineralogy. Ane books Pvt. Ltd. 3. Philips, RC, An Introduction to crystallography, 4. Buerger, Elementary crystallography 5. JAK Tareen and TRN Kutty,(1989) Elemental crystallography 6. Tyrrel, T.W Principles of Petrology, Chapman and Hall, UK 7. Turner and Verhoogen (1962),Igneous and metamorphic petrology, Allied publisher, Bombay 8. Prasad C (1980), A Textbook of sedimentology		
Digital Resources	https://z-lib.org/ https://library.iitkgp.ac.in/pages/eSearch2.1/eBooks.php		

II SEMESTER PRACTICALS

Year	**2021-22**	**Course Code:**	**Credits**	**02**
Sem	**II**	**Course Title: Crystallography, Mineralogy and Petrology**	**Hours**	**48**
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration of ESA: 3 hrs.	
Course Outcomes		At the end of the course the student should be able to: 1. To understand the states of matter, atomic arrangement in crystals, and classification of crystals based on crystal symmetry 2. To understand the characteristics of common rock-forming minerals 3. To acquire knowledge on different types of rocks, their distinction from each other and the rock cycle. 4. To understand the occurrence and distribution of rocks in India.		
		A. Practical Lab 1. Study of crystals based of geometrical constants. - 1 Practical 2. Measurement of interfacial angle using contact goniometer and Verification of Euler's theorem 1 Practical 3. Study of holohedral forms of six crystal system. 3 Practicals 4. Study of Physical properties of rock forming minerals (list-given below) - 3 Practicals 5. Study of the optical properties of important rock forming minerals using polarizing microscope: Quartz, Plagioclase, Orthoclase, Microcline, Biotite, Hornblende, Augite, Hypersthene, Olivine, Garnet, Calcite. 1 Practical 6. Megascopic studies of common igneous, sedimentary and metamorphic rocks 3 practical		
		PART B: Field visit to a place of geological/geomorphological interest.		

Silicates	Non-silicates				Native elements
	Non-Metallic minerals		Metallic minerals		
These minerals are important rock forming minerals and all are silica bearing minerals	Hydroxides	-	Hydroxides	Bauxite, Psilomelane	Sulphur, Graphite
	Sulphates	Barite, Gypsum	Sulphides	Chalcopyrite, Galena Realgar, Orpiment, Spalerite (& dodecahedral), Cinnabar, Pyrite, Stibnite	
	Oxides	Corundum	Oxides	Haematite (& botryoidal, micaceous), Magnetite, Pyrolusite, Chromite	
	Carbonates	Dolomite, Calcite, Magnesite	Carbonates	Malachite, Azurite	
	Phosphates	Monazite			
	Halides	Rock salt (Halite), Fluorite			

*Silicates		**Group**	**Mineral Name**
Nesosilicates		Olivine Group	Olivine
		Garnet Group	Garnet
		Al_2SiO_5 Group	Andalusite, Sillimanite, Kyanite, Staurolite
		Zircon Group	Zircon
Sorosilicates		Epidote Group	-
Cyclosilicates		Beryl Group	Beryl
		Tourmaline	Tourmaline
Inosilicates	Single Chain Silicates	Pyroxene Group	Augite, Hypersthene
	Double Chain Silicates	Amphibole Group	Actinolite, Hornblende
Phyllosilicates		Serpentine Group	Serpentine, Asbestos
		Clay Minerals Group	Talc, Kaolin
		Mica Group	Muscovite, Biotite, Phlogopite, Vemiculite
Tectosilicates		Quartz Group	Quartz
		Feldspar Group	Orthoclase, Plagioclase, Microcline
		Feldspathoid Group	Nepheline, Sodalite
		Zeolite Group	Zeolite

II Semester

OPEN-ELECTIVE SYLLABUS (OE-1)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**II**	**Course Title: Medical Geology**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	The course provides a basic understanding of geogenic and anthropogenic distribution of trace elements, its cyclic movement through the abiotic-biotic environment and their toxic effects on human health and that of flora and fauna.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	**Foundations of medical geology:** Ancient findings, More recent findings, Environmental classification of elements in relation to public health ; inorganic poisons affecting public health in addition to pathogens with some examples from India ; developments in medical geology **Environmental biology** Distribution of elements in Nature - A chemically variable earth; Mineral chemistry, diversity in the composition of rocks, biogeochemical cycle, establishing geochemical baselines, geochemical baseline map of India, Total composition and bioavailability, integrating epidemiological research with high quality geochemical composition of drinking water and food, agriculture and forest management.		Lectures, tutorials Group Discussion	14
Unit II	**Anthropogenic sources of contaminating elements**: Mining, Mineral processing and metal refining; power generation, other industrial activities, waste disposal, agricultural practices, contamination from transport industry, atmospheric deposition of contaminants, contamination in urban environment, treatment and transport of drinking water. **Uptake of elements from chemical biological points of view, bioavailability of elements in soil** Gain knowledge about the medicinal value of various			14

	minerals by understanding the physical and chemical properties. Study the minerals that have health benefits or cause harm **Geological impacts on nutrition** Geological sources of nutrient elements, quantitative estimates of mineral needs, clinical assessment of mineral status, ecological aspects of mineral nutrients		
Unit III	**Pathways of exposure** Volcanic emissions and health, radon and U in water, Arsenic in water and environment, fluoride in drinking and irrigation water, health effects of hardness of water, selenium and iodine deficiency, selenium toxicity **Geophagy ; Soil borne pathogens** **Natural aerosolic mineral dusts and human health** – dust storms, pnemoconioses, lung diseases, silicosis, asbestosis . tuberculosis **Quality of groundwater** **Thresholds for metal and non-metal ions from health point of view: as prescribed by :** WHO, Bureau of Indian Standards, other international standards, AERB India, Methods of analysis of risk factors		14
Recommended Leaning Resources			
Print Resources	1. Selinus, Olle (Ed.), 2013, Essential of Medical Geology, Revised Edition. Springer. 2. Syed E. Hasan, 2020, Medical Geology, PMCID publications. 3. Carlos-Alberto Ríos-Reyes, María-Paula Ríos-Gutiérrez and Santiago Joya-Neira, Archivos de Medicina Volumen, 2021, The importance of minerals in medical geology: impacts of the environment on health. Enero-Junio de.		
Digital Resources	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7241403/ https://en.wikipedia.org/wiki/Medical_geology		

II Semester

OPEN-ELECTIVE SYLLABUS (OE-2)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**II**	**Course Title: Industrial Minerals**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	This course is a good opportunity for most of science and social science students not only to know about the mineral resources of India starting the principles of rock formation including minerals genesis during the rock formation and after their formation. Students exit with a certificate course will have skills to work in quarrying, mining, rock polishing, cement, silica/glass, sand mining, brick, ceramic, pottery and refractory industries. They will be exposed to start their own entrepreneurship. Similarly, students exit with a diploma, to Honors degree will be benefited work/carryout research in the interdisciplinary science to get original ideas and look for new reserves.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Introduction to minerals and rocks Introduction to rock forming and economically important minerals. Principles of rock cycle, origin and classification of economically important mineral deposits.		Lectures, tutorials Group Discussion	14
Unit II	Properties of minerals and rocks, and their occurrences: Physical properties, chemical composition, and diagnostic criteria for the identification of minerals. Ore minerals and gangue minerals, tenor and grade of the ore for industrial processing of minerals. Selection criteria followed for quarrying of decorative and dimensional rock blocks/slabs. National mineral policy.			14
Unit III	Properties, occurrences and distribution of the following minerals/rocks in India, with special reference to Karnataka:			14

Industry	Minerals
Jewelry	Gold, diamonds, precious minerals, corals, pearl and opals, sapphires, rubies, and emeralds.
Metallic Bauxite,.	Chromite, ilmenite, magnetite, hematite, sphalerite, galena, chalcopyrite, pyrolusite
Cement and Refractory minerals	Calcite, lime stone, gypsum, clay minerals, magnesite, graphite, chalk, marble, dolomite, zircon, kaolin, magnesia and alumina minerals,
Ceramics and glass	Clay minerals, kaolinite, silica sand and bauxite, limestone and feldspar
Abrasives, and rock and mineral polishing	Industrial diamond, corundum, garnet and quartz magnesite, pumice, and diatomaceous earth
Strategic/defense	Rare earth elements, Ilmenite, monazite, mica, vanadium from magnetite, poly metallic nodules and rock encrustation in the ocean to extract cobalt and nickel.
Chemicals and fertilizers	Barite, calcite, magnesite, asbestos, diatomite, feldspar, gypsum, kaolinite, phosphorite, mica, talc, zeolite, bauxite, chromite, ilmenite, magnetite, hematite, sphalerite, galena, clay minerals chalcopyrite, pyrolusite, pyrite and monazite.
Dimensional and decorative rocks & dimensional stones	Marble, granites, gneiss, dolerite, phylllite, slate, sand stones, sand, gravel, pebble and boulders.
Nanotechnology:	Clay minerals, ilmenite, polymorphs of carbon, titanium and anhydrous iron oxide minerals and mineral composite for rare mineral

		substitutes		
Recommended Leaning Resources				
Print Resources	1. Klein, C and Philpotts (2016) Earth Materials Introduction to Mineralogy and Petrology Cambridge University Press. 2. Jensen M.L. and Bateman, A. (2013) Economic Mineral Deposits, John Wiley & Sons; Revised Edition. 3. National Mineral Policy, 2019 approved by Cabinet of the Government of India			
Digital Resources	https://pib.gov.in/Pressreleaseshare.aspx?PRID=1566733 Mineral Distribution in India http://ismenvis.nic.in/KidsCentre/Mineral_Distribution_in_India_13948.aspx Jetli, K.N. and Narindar, K.J. (2011) Mineral Resources and Policy in India. Mineral scenarios of India https://ibm.gov.in/writereaddata/files/09182018162439Mineral%20Scenario%20pdf.pdf UNLOCKING INDIA'S MINERAL WEALTH https://mines.gov.in/writereaddata/UploadFile/GSI_PDAC_2013.pd			

II Semester

OPEN-ELECTIVE SYLLABUS (OE-3)

Year	**2021-22**	**Course Code:**	**Credits**	3
Sem.	II	**Course Title: Paleobiology**	**Hours**	42
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 30	Summative Assessment Marks: 70		Duration of ESA: 3 hrs.	
Course Outcomes	At the end of the course, students understand the types of invertebrate fossils, their mode of preservation, examination of the fossils, methodologies for the reconstruction of the past through evolutionary studies.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Modes of preservation of fossils- Cast, moulds, petrification, coalification, Tracks and Trails, Foot prints, Burrowing and Boring. Types of fossils – Index fossil, Synthetic fossil, Persistent fossils.		Lectures, tutorials Group Discussion	14
Unit II	Invertebrate and Vertebrate fossils Definition, Classification, and stratigraphic significance of phylum: Mollusca (Pelecypoda, Cephalopoda, Gastropoda) Phylum: Arthropoda, Class: Trilobita			14
Unit III	Paleobotany and Microfossils classification of plants, plants through geological ages, Gondwana plants, Microfossils- Classification of microfossils. Foraminifera, Ostracoda.			14
Recommended Leaning Resources				
Print Resources	1. Clarkson, E.N.K., 1998, Invertebrate Paleontology and Evolution, IV edition, Publ., Blackwell. 2. Smith, A.B., 1994, Systematics and the Fossils Record- Documenting Evolutionary Patterns, Publ., Balckwell 3. Colbert, Introduction to Vertebrate Paleontology. 4. D.J.Jones, 1956. Microfossils.			
Digital Resources	https://en.wikipedia.org/wiki/Paleobiology https://www.nhbs.com/applications-of-palaeontology-book			

II Semester

OPEN-ELECTIVE SYLLABUS (OE-4)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**II**	**Course Title: Gems and Ornamental Stones**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 30	Summative Assessment Marks: 70		Duration of ESA: 2 hrs.	
Course Outcomes	At the end of the course the student should be able to: 1. To understand mineralogy and genesis of gemstones. 2. To identify main physical and optical techniques used in the gems characterisation.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Introduction to Gemology, classification of gemstones, detailed study of different physical characters and Optical properties of minerals with special reference of to gem minerals. Physico-optical effects in gem stones. Colour and cause of color in gems.		Lectures, tutorials Group Discussion	14
Unit II	Cutting and polishing of gemstones. A detailed study of important precious and semi-precious gem minerals- their characters and occurrences- world occurrences in general and Indian occurrences in particular. Precious Varieties:1. Diamond, 2. Ruby, 3. Sapphire, 4. Topaz, 5. Emerald ii) Semi-Precious varieties: Garnets, Quartz, Lapislazuli, Turquoise and Organic gems.			14
Unit III	Ornamental stones: Introduction to petrology, Classification of rocks, Properties of Igneous, Sedimentary and Metamorphic rocks. Suitability of rocks for ornamental purposes. Occurrence and distribution rocks in Indian sub-continent with particular reference to Karnataka. Evaluation, Quarrying , cutting and polishing of rocks.			14
Recommended Leaning Resources				
Print	1. Gems and Gem industry in India-GSI Memoir 45- R.V Karanth.			

Resources	2. Gem and Gem Minerals – EH Kvans and CB Slawsan 3. Encyclopedia of Minerals and Gem stones - Edited by Michael O' Don Oghal. 4. Precious stones - by Max-Bauer Vol. I and II. Publisher Dover publicationsInk. New york. 5. Rutley's Elements of Mineralogy- by H.H. Read, CBS publication 6. Dana's Manual of Mineralogy 7. GEMS by R.Webster - Batter work and co. ltd., London 8. Gemstones - Herbert Smith - Published by Methuen co. Ltd., London 9. Introduction to Rock forming minerals-Deer, Howie and Zussman. 10. Physical Geology-P.K.Mukherjee 11. Geology of India-R.Vaidyanathan and M.Ramakrishnan 12. Geology of Karantaka-B.P.Radhakrishna 13. Mineral Resources of Karnataka-B.P Radhakrishna
Digital Resources	https://z-lib.org/ https://library.iitkgp.ac.in/pages/eSearch2.1/eBooks.php

ASSESSMENT METHODS

EVALUATION SCHEME FOR THEORY AND PRACTICAL PAPERS

Discipline Core theory paper carries 100 marks and Discipline Core practical paper carries 50 marks.

Distribution of marks for Discipline Core theory and Discipline Elective/Open Elective papers among C1:C2:C3 is 20:20:60. C1 and C2 are internal assessments and C3 is the main examination.

Distribution of marks for Discipline Core practical paper among C1:C2:C3 is 10:10:25. In addition, 5 marks are kept for practical record.

EVALUATION SCHEME FOR INTERNAL ASSESSMENT:

1. **Theory (for DSC and OE Papers):**

Assessment Criteria	
C1 and C2 will be for 20 marks each. Assessment under C1 and C2 is as detailed below	
1st Internal Assessment Test (C1) of 1 hr duration for 10 marks after 8 weeks and 2nd Internal Assessment Test (C2) of 1 hr duration for 10 marks 1 hr after 15 weeks.	20
Assignment/Field report for 10 marks in both C1 and C2 components	20
Total	**40 marks**

2. **Practical (for DSC paper):**

Assessment Criteria	
C1 and C2 will be for 10 marks each. Assessment under C1 and C2 is as detailed below	
C1 - Internal Assessment Test of 2 hr duration for 10 marks may be conducted after 12 weeks and	10
C2 – Evaluation of Assignment/field report for 10 marks at the end of the semester	10
Practical Record	05
Total	**25 marks**

Geological Field Report: As the geological features, structures, rock and mineral occurrence are better understood in the field, there will be a Geological Study Tour to the places of geological interest for a day in the first and second semesters mainly to study the landforms and field occurrence of rocks and minerals which carries weightage during semester end exam. Each student shall submit a study tour report along with the practical record at the end of the semester.

However, for those students, who are unable to undertake field study, assignment on a topic of geological interest may be given and evaluated based on the report.

QUESTION PAPER PATTERN for I and II SEMESTERS

(DSC-1 and DSC-2 Papers / Open Electives)

EARTH SCIENCE

Time: 2 hrs Max. Marks: 60

Draw neat-labeled diagrams and give examples wherever necessary

SECTION A

Answer any FIVE questions of the following **5 X 2 = 10 marks**

Q1. Write a short notes on

a)
b)
c)
d)
e)
f)

SECTION B

Answer any FOUR of the following: **4 X 5 = 20 Marks**

Q2.
Q3.
Q4.
Q5.
Q6.
Q7.

SECTION C

Answer any THREE of the following: **3 x 10 = 30 Marks**

Q8.
Q9.
Q10.
Q11.

MODEL QUESTION PAPER
I and II SEM: SCHEME OF VALUATION (PRACTICALS)

IN EARTH SCIENCE

Internal Assessment Max (25 Marks)				**Final Examination (25 Marks)**	**Total**
C1 (Test) Marks	**C2 (Assignment/Field report) Marks**	**Record**	**Total Marks**	**C3 Exam**	**Cumulative of C1, C2 and C3**
10	**10**	**05**	**25**	**25**	**50**

Assessment Criteria for I semester		**Marks**
C3	Interpretation of Topo/drainage map	**05**
	Preparation of LU/LC maps using Topomaps	**10**
	Identification and description of Geomorphic features through models/stereoscopes	**05**
	Identification of soil texture and brief report on its characteristics	**05**
Total		**25**

Assessment Criteria for II semester		**Marks**
C3	Holohedral forms of crystals – 1 No.	**03**
	Handspecimen identification of minerals – 5 No.	**10**
	Optical identification of minerals – 1 No.	**03**
	Handspecimen identification of rocks – 3 Nos.	**09**
Total		**25**

PROGRAM /COURSE STRUCTURE AND SYLLABUS

as per the Choice Based Credit System (CBCS)

designed in accordance with

Learning Outcomes-Based Curriculum Framework (LOCF)

With Multiple Entries

And Exit Options under New Education Policy (NEP) – 2020

For

III and IV semesters

Bachelor of Science (Basic/Honors) Degree with Earth Science as Major/Minor having Practicals

w.e.f.

Academic Year 2021-22 and onwards

PROGRAMME STRUCTURE

Earth Science as Core subject: III and IV semesters

Semester	Discipline Core (DSC) (Credits) (L+T+P)	Credits	Discipline Specific Elective (DSE) / Open Elective (OE) (Credits)(L+T+P)
III	**A3 Theory (4 credits)** (4+0+0) Principles of Stratigraphy & Palaeontology **P3 Practicals (2 credits)** (0+0+2) Stratigraphy & Palaeontology	**4+2**	**OE-3 (3 credits)** (3+0+0) i) Dimensional Stone Technology ii) Marine Geology iii) Climatology iv) Watershed Management
IV	**A4 Theory (4 credits)** (4+0+0) Structural Geology and Hydrogeology **P4 Practicals (2 credits)** (0+0+2) Hydrogeology and Structural Geology	**4+2**	**OE-4 (3 credits)** (3+0+0) i) Geology and Society ii) Geophysical Exploration iii) Geostatistics iv) Geotourism
Exit option with Certificate			

Concept note, abbreviation explanation, coding, eligibility for admission to the course, duration of the course, course pattern, medium of instruction, attendance, internal assessment, mode of examination, duration of examination, results of the candidates and carry over are as per the provision made in the NEP regulations of University of Mysore and Yuvaraja's College (autonomous).

COURSE-WISE SYLLABUS
III Semester Theory

Year	2021-22	**Course Code: ES301**	**Credits**	**4**
Sem	III	**Course Title: PRINCIPLES OF STRATIGRAPHY AND PALAEONTOLOGY**	Hours	56
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 40		Summative Assessment Marks: 60	Duration of ESA: 2 hrs.	
Course Outcomes		At the end of the course the student should be able to: • Understand fossils, types, fossilization process and modes of preservation, economically important fossils, geotourism related fossils. • Understanding the origin and evolution of life on the Earth. • Learn rich mineral deposits like petroleum, coal, and other minerals associated with fossils. Understanding the paleoclimate and Paleoenvironment		
Unit No.		**Course Content**	**Suggested Pedagogy**	**Hours**
Unit I		**Principles of Stratigraphy**: Concepts in stratigraphy: Basic principles and definitions, Concept of facies, Walther's Law of facies succession. Stratigraphic classification and code of Stratigraphic nomenclature, Stratigraphic correlation. Brief description of principal stratigraphic units: Lithostratigraphy, Biostratigraphy, Chronostratigraphy. Standard Geological time scale.	Lecturing, Tutorial and Field visits	14
Unit II		**Palaeontology**: Introduction to palaeontology. Definition and classification of fossils. Types of fossils and fossilization – Modes of Preservation- Fossils of soft parts, fossils of hard parts (unaltered hard parts, altered hard parts (Molds & Casts, Petrifaction: Permineralization & Replacement, and Carbonization) and indirect fossils (Imprints, Traces of Biological Activity: Tracks, Trails and Burrows – Ichnofossils). Significance of fossils. General classification, morphological characters,	Lecturing, Tutorial and Field visits	14

	distribution and geological History of Following Invertebrate Fossils: Coelenterata, Graptolites, Brachiopods, Lamellibranchia, Cephalopods, Echinodermata, Arthropoda. Classification of Microfossils, Morphology,classification and evolution of foraminifera. A brief study of vertebrate life through ages. Plant fossils through ages. Gondwana flora and their significance.		
Unit III	**Geology of India** **Physiographic divisions of India**: Brief Introduction to the physiographic and tectonic subdivisions of India **Archaean and Proterozoic** Formations of Peninsular India – distribution and classification concerning Karnataka. Sargur Group, Dharwar Super Group, Peninsular Gneiss. **Proterozoic**: distribution, classification and economic importance of Cuddapah and Kaladgi, Vindhyan, Bhima and Kurnool Groups. **Paleozoic Group**: Paleozoic rocks of the Spiti.	Lecturing, Tutorial and Field visits	14
Unit IV	**Mesozoic:** (i) Triassic successions of Spiti, (ii) Jurassic of Kutch, (iii) Cretaceous successions of Cauvery basins **Cenozoic stratigraphy of India**: (i) Kutch basin, (ii) Siwalik successions,(iii) Assam, Andaman and Arakan basins. **Volcanic provinces of India:** Deccantraps: Distribution, lithology and biostratigraphy, classification, intertrappeans, intratrappeans, infratrappeans, Bhag beds and lameta beds, age of Deccan traps, economic importance of Deccan traps. Rajmahal, Sylhet Trap Siwaliks– lithology, distributions, classification, life and age. **Stratigraphic boundaries:** Important Stratigraphic boundaries in India- a.Precambrian-Cambrian boundary,b.Permian-Triassic boundary, and c.Cretaceous-Tertiaryboundary.	Lecturing, Tutorial and Field visits	14
Recommended Learning Resources			
Print Resources	1. Krishnan, M. S. (1982) Geology of India and Burma, CBS Publishers, Delhi 2. Doyle, P. & Bennett, M. R. (1996) Unlocking the Stratigraphic Record. John Wiley 3. Ramakrishnan, M. &Vaidyanadhan, R. (2008) Geology of India Volumes 1 & 2, Geological society of India, Bangalore. 4. Valdiya, K. S. (2010) The making of India, Macmillan India Pvt. Ltd.		

5. Raup, D. M., Stanley, S. M., Freeman, W. H. (1971) Principles of Paleontology
6. Clarkson, E. N. K. (2012) Invertebrate paleontology and evolution 4th Edition by Blackwell
7. Publishing.
8. Benton, M. (2009). Vertebrate paleontology. John Wiley & Sons.
9. Shukla, A. C., & Misra, S. P. (1975). Essentials of paleobotany. Vikas Publisher
10. Armstrong, H. A., & Brasier, M.D. (2005) Microfossils. Blackwell Publishing.
11. Wadia, D., 1973. Geology of India. Mc Graw Hill Book co.
12. Ravindra Kumar, 1985. Fundamentals of Historical Geology & Stratigraphy of India. Wiley Eastern.
13. Shrock, R.R. & Twenhoffel, W.H., 1952. Principles of Invertebrate Paleontology. CBS Publ.
14. Swinerton, HH., 1961. Outlines of Paleontology. Edward Arnold Publishers
15. Jain, P.C. & Anantharaman, M.S., 1983. Paleontology: Evolution & Animal Distribution. Vishal Publ.
16. Lehmann, U., and Hillmer 1983. Fossil Invertebrate. Cambridge Univ. Press.
17. Rastogi, 1988. Organic evolution. Kedrnath and Ramnath Publ.
18. Moore, Lalicker and Higher: - Invertebreate Palaeontology
19. Remer : - Invertebrate Palaeontology
20. Arnold: - Introduction to Palaeontology
21. Glaessner: - Principles of Micropalaeontology
22. Mem.GeoI.Soc.India Geology of Karnataka
23. GSI Publication Geology of Karnataka.
24. Mem. Geol. Soc of India Deccan Basalts
25. Henry Woods - Invertebrate paleontology - Cambridge press
26. Romer. A.S - Vertebrate paleontology, Chicago press.
27. Arnold. C.A - An introduction to paleobotany, MC-Graw-Hill
28. B.U.Hag and A. Boersma (1978) Introduction to Marine Micropaleontology, Elsevier, Netherlands
29. Ramp. D.M. and Stanely.M.S - Principles of Paleontology
30. Moore.R.C. Laliker C.G & Fishcher.A.G – CBS Publishers InvertebrateFossils, Horper brothers
31. The Elements of Palaeontology Rhona M.Black Cambridge University press.

III SEMESTER PRACTICAL

Year	2021-22	Course Code: ES302	Credits	02
Sem	III	Course Title: Stratigraphy&Palaeontology	Hours	48
Course Pre-requisites, if any		**NA**		
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration of ESA: 3 hrs.	
Course Outcome		Students learn the preparation of various kinds of stratigraphic maps. Students learn the skill of identifying various fossils, deduce Palaeoenvironmental condition		
		Part A: 1. Preparation and study of stratigraphc maps. 1 lab. 2. Study of fossils showing various modes of preservation– Molds &Casts, Petrifaction, Permineralization & Replacement and Carbonization, Imprints.1 lab. 3. Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate and plant fossils: Graptolites-Monograptus, Diplograptus Brachiopoda - Terebratulata, Productus, Lingula, Orthis, Atria, Spirifer. Lamellibranchia - Lima, Trigonia, Pectin, Gryphaea, Trigonia, Alectryonia. Cephalopods-Ammonite, Orthoceras, Nautilus, Ceratite, Goniatite, Accanthoceras, Belemnites. Suture lines in Ammonites. Echinodermata- Clypeaster, Clypeolampus, Breynia Cidaris, Micrastar, Hemiaster, Holaster, Stigmatopygus, Schizaster. Trilobites-Calamine, Dalmanite, Paradoxide, Phacops. 9 labs 4. Plant fossils - Lepidodendron, Calamites, Sigillaria, Glossopteris, Gangamopteris, Ptilophyllum, 1 lab.		

III Semester, OPEN-ELECTIVE SYLLABUS (OE-9)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**III**	**Course Title: Dimention Stone Technology**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 3 hrs.	
Course Outcomes	**Course out comes:** After completing the course, the student will be able to understand the importance of Ornamental rocks and their reserves. Basics of Quarrying techniques, commercial values, cutting and polishing, and marketing of the ornamental stones. Also some knowledge on the environmental impacts of stone industry.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	**Introduction:** General, legal and Leasing Policy, Exploration of Resources, Estimation of Reserves, Classification of dimensional stone based on Grade, hardness and quality factors, Quarrying Techniques, Processing Units, commercial values, Marketing, etc. **Geology and Exploration**: General, Dimensional Stone Reserves in India, Geology and Geographical distribution of Marble, Granite, Sandstone, Limestone, Slate Deposits, soap stone, dolerite, basalt, Laterite with special reference to Karnataka. Prospecting and exploration of dimensional Stone deposits, Reserve Estimation, Evaluation parameters. **Characterization of Dimensional Stone**: Introduction, Petrography Examination, chemical and mineralogical composition, Physico-mechanical Properties,		Lectures, tutorials Group Discussion and IT based teaching	14
Unit II	**Mining of Dimensional Stone:** General, Stages – Over burden removal, primary cutting, manual operation, Semi - mechanized operation - line drilling machines. Mechanized operations- Plane cutting,			14

	water jet cutting, splitting method, Hydraulic splitting, Conventional Mining of Limestone (Kotah stone), Sandstone, Granite and Marble. **Specification and tests** – Indian standard BIS and International Market ASTM .		
Unit III	**Processing:** General, Flow chart of Processing; Dressing, Cutting/Sawing, Surface Grindingand Polishing/Flaming, Edging/Trimming/Grooving, Gang Saw, Circular Saw, Various types of Polishing Machines. **Abrasives:** Types, Use and Selection,Shaping. **Dimensional Stones**: Uses, Marketing and Environmental impacts of Stone Industry.		14
Recommended Learning Resources			
Print Resources	1. Dimensional stone technology by S.S Rathore , Bharadwaj G.S, Jain.S. C himanshu publ. New Delhi 2. Recent development in machinery and equipment for dimensional stone mining- S.S Rathore,Gupta.Y.C , Fermor R.L 3. Text book of Geology-P.K.Mukherjee 4. Indian Mineral Resources- Krishnaswamy 5. Geology of India- R.Vaidyanathan&M.Ramakrishnan		

III Semester, OPEN-ELECTIVE SYLLABUS (OE-10)

<table>
<tr><td>Year</td><td>2021-22</td><td colspan="2">Course Code:</td><td>Credits</td><td>3</td></tr>
<tr><td>Sem.</td><td>III</td><td colspan="2">Course Title: Marine Geology</td><td>Hours</td><td>42</td></tr>
<tr><td>Course Pre-requisites, if any</td><td colspan="5">NA</td></tr>
<tr><td>Formative Assessment Marks: 40</td><td colspan="3">Summative Assessment Marks: 60</td><td colspan="2">Duration of ESA: 2 hrs.</td></tr>
<tr><td>Course Outcomes</td><td colspan="5">Marine resources – Oceans and Seas. Mineral deposits in the deep sea like metals, petroleum, coal, phosphorites, metallic nodules.
Marine life and their economic importance.</td></tr>
<tr><td>Unit No.</td><td colspan="2">Course Content</td><td>Suggested Pedagogy</td><td>Hours</td></tr>
<tr><td>Unit I</td><td colspan="2">Oceanography - Physical properties of sea water, waves, tides and currents, Composition of sea water and processes controlling it. Food-web, primary, secondary and tertiary production. Classification of marine life, planktonic and benthic life in the ocean.</td><td rowspan="3">Lectures, tutorials Group Discussion and IT based teaching</td><td>14</td></tr>
<tr><td>Unit II</td><td colspan="2">Geological oceanography: Morphology of Ocean floor, Origin and evolution of the ocean basins. Continental drift, Sea-floor spreading and plate tectonics.</td><td>14</td></tr>
<tr><td>Unit III</td><td colspan="2">Marine mineral resources: Distribution and classification of minerals of economic importance in different oceanographic settings: Sea water as sources of elements/minerals. Placer and heavy mineral deposits, petroleum and coal, phosphorites, gashydrates, poly-metallicnodules, hydrothermal and metalliferous sediments.</td><td>14</td></tr>
<tr><td colspan="6">Recommended Learning Resources</td></tr>
<tr><td>Print Resources</td><td colspan="5">1. Alan Strahler (2016) Introducing Physical Geography, 6th Edition, Wiley.
2. Miller, C.B. (2004) Biological Oceanography. Blackwell Publishers. 416p.
3. Paul R. Pinet (1992) Oceanography: An introduction to the Planet Oceanus, West Publ., Co.571p.
4. Thruman, H. V. (1994) Introductory Oceanography. 7th Ed. McMillan Pub., Co.
5. George Karleskint, Richard Turner, James Small, (2012) Introduction to Marine Biology Publisher: Brooks Cole, 512p.
6. Fasham, Michael J.R. (2003) Ocean Biogeochemistry. The Role of the Ocean Carbon Cycle in Global Change Series.
7. Komar, P. D., (1976) Beach Processes and Sedimentation, Prentice-Hall. 429p.
8. Reddy M.P.M. (2001) Descriptive Physical Oceanography, AA Balkema Press. 440p.</td></tr>
</table>

III Semester, OPEN-ELECTIVE SYLLABUS (OE-11)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**III**	**Course Title: Climatology**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	**Skills, employability and entrepreneurship:** The above subject is very relevant to the current processes operating on the Earth System that has implications on the society. In India, this subject is quite rarely studied at graduate level, quite often included in M.Sc./P.G. courses such as Meteorology, Agriculture, Geography, Oceanography, and at M.Tech. Courses in Climatology/Meteorology and Atmospheric Science. Since weather is highly dynamic, it requires skill's to understand to a maximum extent from the multidisciplinary perspectives. The main purpose of this course is to create interest among young and talented students from multidiscipline. This study is also useful for predicting the extreme variability of weather including what has happened in the History of the Earth. Students pass out from this subject have opportunities for employment and also study advance courses offered in different CSIR, DST, R and D labs., and private organizations.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Meteorology Elements of meteorology and their significance. Temperature, atmospheric pressure and air masses, wind, humidity, clouds precipitation (rainfall).Earth's radiation balance and human interference: Meteorological hazards: floods, drought, famine, cyclones, cloud burst, thunder storms, dust storms and hailstones. General weather system of India. Monsoons, their seasonality, onset and withdrawal, causative factors and trends. A brief introduction to Satellite Meteorology and its applications.		Lectures, tutorials Group Discussion and IT based teaching	14
Unit II	**Climatology** Principles of climatology and differences between meteorology and climatology. Climate of the globe and its classification. Climate Change: short-term and long-term climate cycles. Classification of continental and oceanic climates: Greeks, Koppen's and Thornthwaite's schemes of classification.			14
Unit III	Paleoclimatology: Tracers or proxies for understanding the long-term paleoclimate. Archives of paleoclimate: ice cores, tree			14

	rings, lake and marine sediments, speleothem/cave deposits. Principles of General Circulation and Climate Modelling.		
Recommended Learning Resources			
Print Resources	Ahrens, C.D. and Henson, R. (2017) Meteorology today: an introduction to weather, climate, and the environment. 12th Ed. www.cengage.com/highered, www.cengagebrain.com. Bryant, E. (1997) Climate Processes and Change Cambridge Univ. Press. Cambridge. Donn, W.L. (1975) Meteorology - - McGraw-Hill Book Co., New York. Holton, J. R. (1992) An introduction to Dynamic Meteorology, III Ed, Academic Press, London. Kelkar, R. R. (2017) Satellite Meteorology, Second Edition, CRC Press, Florida. Lutgens, F., Tarbuck, E. and Herman, R. (2018) Atmosphere: An Introduction to Meteorology 14th Ed., Pearson 0135213134 / 9780135213131 Pearson. Pick W.P. (2017) A Short Course in Elementary Meteorology. Andesite Press (22 August 2017). Raymond S.B. Reconstructing Climates of the Quaternary. 3rd Edn, Academic Press, New York.		

III Semester, OPEN-ELECTIVE SYLLABUS (OE-12)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**III**	**Course Title: Watershed Management**	**Hours**	**48**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	After completing the course, the student will be able to understand the importance of water resources both – Surface and subsurface water, water harvesting, water conservation, watershed planning and management. It also helps to understand the role of remote sensing, water law and NGOs.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Introduction, Watershed–definition, concept, objectives, Land capability classification, priority watersheds, land resource regions in India. Watershed Planning – Principles, collection of data, present land use, Preparation of watershed development plan, Estimation of costs and benefits, Financial plan, selection of implementation agency, Monitoring and evaluation system.		Lectures, tutorials Group Discussion	14
Unit II	Watershed management: Participatory watershed Management, run off management, factors affecting run off, Temporary & Permanent gully control measures, Water conservation practices in irrigated lands, Soil and moisture conservation practices in dry lands. Water conservation practices: *In-situ & Ex-situ* moisture conservation principle and practices, Afforestation principle, Microcatchment water harvesting, Groundwater recharge, percolation ponds,Water harvesting, Farmpond, Supplemental irrigation, Evaporation suppression,Seepage reduction.			14
Unit III	Watershed Development Programme: River Valley Project (RVP), Hill Area Development Programme (HADP).National Watershed Development Programme for Rain fed Agriculture (NWDPRA), Other similar projects operated in India. Govt. of India guidelines on watershed development programme, Watershed based rural development, Infrastructure			14

	development, Use of Aerial photography and Remote sensing in watershed management. Role of NGOs in watershed development.		
Recommended Learning Resources			
Print Resources	1. Suresh, R. 2005. Soil and Water Conservation Engineering, Standard Publishers & Distributors, New Delhi. 2. Ghanashyam Das, "Hydrology and Soil Conservation Engineering", Prentice Hall of India Private Limited, New Delhi, 2000. 3. Gurmel Singh et al. 2004. Manual of soil and water conservation practices. Oxford & IBH publishing Co. New Delhi. 4. Suresh, R. 2008. Land and water management principles, Standard Publishers & Distributors, New Delhi. 5. Tripathi R.P. and H.P.Singh 2002, Soil erosion and conservation, Willey Eastern Ltd., New Delhi 6. Murthy, V.V.N. 2005, Land and water management, Kalyani publishing, New Delhi. 7. Tideman, E.M., "Watershed Management", Omega Scientific Publishers, New Delhi, 1996		

IV SEMESTER

Year	**2021-22**	**Course Code:**	**Credits**	**4**
Sem.	**IV**	**Course Title: Structural Geology and Hydrogeology**	**Hours**	**56**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	At the end of the course the student should be able to: • Students will understand the natural structures and rock mechanics. • It helps to understand various primary and secondary structures occurring in rocks. Students will know about the water cycle, ground water related issues, water conservation, estimation of ground water and also quality.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Structural Geology: Introduction. Structural Forms of Rocks: Primary Structural Forms & Secondary Structural Forms. Concept of brittle and ductile deformation. Forces – compression, tension, torsion and shear. Primary structural forms–Sedimentary and Igneous Rocks. Lineation, Foliation and Unconformity. Description and origin of foliations: axial plane cleavage and its tectonic significance. Description and origin of lineation and relationship with the major structures. Unconformity types – para, dis, non, angular and regional unconformities. Secondary structural forms: *Cohesive Dislocations* –Distortion, bending and Folds. Folds: Definitions - parts of folds, axis, axial planes, limb, plunge. Crest and troughs. Mechanics of folding: Buckling, Bending, Flexural slip and flow folding. Types of folds – symmetrical and asymmetrical – anticline, syncline, anticlinorium, synclinorium, overturned fold, recumbent fold. isoclinal, chevron, fan folds, monocline and drag folds. Denudational structures – Outlier and inlier.		Lectures, tutorials Group Discussion and IT based teaching	14

Unit II	Disruptive Dislocations – Joints and Faults. Joints: Definition, Dip, Strike. Joint plane, block Joint, Joint set, Joint system. Classification – I. Geometrical: Dip, Strike, Oblique and bedding joints. II. Genetic – columnar, mural sheet joints, Master joints. Importance of joints. Fractures and Faults: Definition-Elements of fault, Fault planes, Dip, Strike, Hade, Heave and Throw. Hanging and footwalls. Classification – I. Geometrical: a) Based on attitude of faults as compared to the adjacent beds. Dip, Strike, Diagonal and Bedding faults. b) Based on Apparent movement, normal and reverse faults. II. Genetic: Thrust faults, over thrust, and under thrust. Gravity faults - Step fault, Ridge fault. Trough faults. Criteria for recognition of faults in the field.		14
Unit III	Hydrogeology: Introduction and basic concepts. Scope of hydrogeology and its societal relevance Hydrologiccycle. Precipitation, evapotranspiration, runoff, infiltration and subsurface movement of water. Rock properties were affecting groundwater, Vertical distribution of subsurface, types of the aquifer, aquifer parameters, anisotropy and heterogeneity of aquifers. Groundwater flowsunder Darcy's law and its validity, intrinsic permeability and hydraulic conductivity, Groundwater flow rates and flow direction, and Laminar and turbulent groundwater flow. Well, hydraulics and Groundwater exploration, Basic Concepts (Drawdown, specific capacity),and Elementary concepts related to equilibrium and Non-equilibrium conditions for water flow to a well in confined and unconfined aquifers. Surface-based groundwater exploration methods,Introductionto subsurfaceborehole logging methods.		14
Unit IV	Groundwater chemistry: Physical and chemical properties of water and water quality, Introduction to methods of interpreting groundwater quality data using standard graphical plots, Seawater intrusion in coastal aquifers. Groundwater management, Surface and subsurface water interaction, Groundwater levelfluctuations, and Basic concepts of water balance studies. Rainwater harvesting and artificial recharge of groundwater.	Lecture, Tutorials and Group discussion	14

Recommended Learning Resources	
Print Resources	1. Basic Methods of Structural Geology (Pearson Paper Back Edition) By Marshak Stephen and Mitra Gautum. (2017). 2. Structural Geology, By Haakon Fassen, (2016). 3. Structural Geology – Mechanics of Deforming Metamorphic Rocks, By Hobbs. (2015). 4. Structural Geology of Rocks and Regions, By George H. Davis, Stephen J. Ronalds, Charles F. Kluth. (2022) 5. Todd, D. K. 2006. Groundwater Hydrology, 2nd Ed., John Wiley & Sons, N.Y. 6. Davis, S.N., and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y. 7. Karanth K.R., 1987, Groundwater: Assessment, Development and Management, Tata McGraw Hill Pub. Co. Ltd.

IV SEMESTER PRACTICALS

Year	**2021-22**	**Course Code:**	**Credits**	**02**
Sem	**IV**	**Course Title: Hydrogeology and Structural Geology**	**Hours**	**48**
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration of ESA: 3 hrs.	
Course Outcomes		At the end of the course the student should be able to: 1. To prepare rainfall maps 2. To calculate the water quality parameters and its spatial maps 3. To surveying. 4. To understand the measurement of determination of attitude of the beds.		
		1) Rainfall determination isohyetal and polygon methods quality – 1 Practical 2) Computation of water parameters – 2 Practicals 3) Methods of surveying (Chain, Dumpy, Table, Compass Surveys) – 3 Practicals 4) Structural Geology problems and maps – 5 Practicals 5) Field visit to study the structures - 1Practical		

IV Semester

OPEN-ELECTIVE SYLLABUS (OE-13)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**IV**	**Course Title: Geology and Society**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	Course outcomes: The challenges and opportunities posed by the climate change, resource demands and conflicts, and natural disasters (due to man-made structures as well as natural climate change) point to the importance of studying transdisciplinary nature of the earth processes and their implications to our society. This interdisciplinary nature of Earth Science draws a special attention from the students with other branches of science. From this interdisciplinary optional course on Earth and Social Science, students gain an understanding of natural processes and the impact the distribution and use of natural resources such as water, fossil fuels, and critical minerals for economic growth. It also facilitates the understanding natural hazards such as climate change, landslides, tsunami induced coastal erosions, thermal Disturbances in sea water & sea food, and earthquakes.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Geological History of mineral evolution; Critical minerals for economic growth; rare earth elements and their uses in modern technology for low carbon economic growth. Water-Future: ground water exploration and exploitation, recycling water and pollution monitoring and water management. Desalination of coastal region water to improve the water quality. Understandingofhydrogeologyandenvironmentalconditionsforwatermanagement.		Lectures, tutorials Group Discussion	14

Unit II	Engineering geology for construction of earthquake resilience infrastructure for public; micro-zonation studies of seismic hazards analyses of smart cities, dams and nuclear power stations.		14
Unit III	Understanding the basics of past climate change through field work near ancient stalagmites bearing caves to provide basic parameters for future Earth. Thermodynamic modelling of carbon capture and sequestration using naturally occurring minerals. Modelling of probable risks of natural hazard and climate change with precise uncertainties.		14

IV Semester

OPEN-ELECTIVE SYLLABUS (OE-14)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**IV**	**Course Title: Geophysical Exploration**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration of ESA: 2 hrs.	
Course Outcomes	To study the physical properties of the Earth and application of physics in Geoscience. To understand subsurface features and structures for better understanding of subsurface of the Earth. To understand the various geophysical techniques and their field setup. To understand the geophysical data processing and interpretation			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Introduction: Physical properties of the Earth, Scope of exploration geophysics, Geophysical survey methods, Uses of geophysical Surveys, Geophysical surveying applications		Lectures, tutorials Group Discussion	14
Unit II	Electrical and ElectromagneticMethods *Electrical methods:* Introduction, Electrical methods – Self-Potential, Induced Polarization, Electromagnetic and Resistivity methods, Methods of electrode arrangement, Field methods, Data Interpretation and Application, *Electromagnetic methods:* Principle, Field procedure, Magnetometers, Interpretation of magnetic data, Size and shape of bodies, Correction of magnetic data, Applications.			14
Unit III	Gravity and Seismic Methods *Gravity Methods:* Principle, Units of gravity, Measurement of gravity, Gravity anomalies, Field methods, Gravimeters, Corrections, Interpretation of gravity data, Determination of shape and depth of ore bodies, Corrections and			14

	applications. *SeismicMethods*: Seismic waves, Travel velocity in various geological formations, Principles offshore and onshore field operation, refraction and reflection survey, Correction of seismic data, Methods of interpretation, Types of seismic shooting and Application Airborne and Subsurface Geophysical methods *Airborne Geophysical methods:* Scope of Airborne Investigations, Airborne Geophysical Measures. *Subsurface Geophysical methods:* Introduction to drilling and logging, Principles of well logging, Formation evaluation, Resistivity logging, Self-potential logging, Sonic logging and Application.		
Recommended Leaning Resources			
Print Resources	1. Dobrin, M.B. and C.H. Savit, Introduction to Geophysical Prospecting, 4th Edition, McGraw-Hill, 1988 2. Fowler, C.M.R., The Solid Earth, Cambridge University Press, 1990 3. G. R. Foulger and C. Peirce - Geophysical Methods in Geology 4. Keary, P., M. Brooks and I. Hill, An Introduction to Geophysical Exploration, 3rd edition Blackwell Science, 2002, ISBN0632049294 5. Martin Landrø and Lasse Amundsen - Introduction to Exploration Geophysics with Recent Advances Bivrost 2018. ISBN: 978-82-303-3763-9 6. P. Kearey, M. Brooks and I. An Introduction to Geophysical Exploration, Hill, 3rd edition Blackwell Science, 2002, ISBN0632049294, 7. Parasnis, D.S., Principles of applied geophysics, Chapman & Hall, 1996 8. Reynolds, J.M., An introduction to applied and environmental geophysics, Wiley & Sons Ltd., 1997. 9. Robert H. Griffin - Geophysical exploration for engineering and environmental investigations, Department of the ARMY U.S. Army Corps of Engineers Washington, DC 20314-1000. 10. Telford, W.M., L.P. Geldart, R.E. Sheriff and D.A. Keys, Applied Geophysics, 2nd Edition, Cambridge University Press, 1990		

IV Semester

OPEN-ELECTIVE SYLLABUS (OE-15)

Year	**2021-22**	**Course Code:**	**Credits**	3
Sem.	IV	**Course Title: Geostatistics**	**Hours**	42
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 30	Summative Assessment Marks: 70		Duration of ESA: 3 hrs.	
Course Outcomes	Candidate will be exposed to the basics of geostatistics, which helps in the analysis of survey data, reserves data, and cluster analysis including factor analysis and contouring. Such statistical analysis can be used in mining industries and hydrogeology.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	Mean, median and mode. Quartiles, deciles and percentages. Correlation co-efficient, regression analysis and skewness.		Lectures, tutorials Group Discussion	14
Unit II	Measures of dispersion-Absolute Measures of Dispersion and Relative Measures of Dispersion Range method------R=H-L(H =highest value, L=lowestvalue) Quartile method Qd=Q_3-Q_1 SemiInter Quartile----SIQ =$\underline{Q_3}$-$\underline{Q_1}$ Mean deviation or Average deviation Standard deviationor Root mean deviation and Charlier's check Cluster analysis, factor analysis and contouring.			14
Unit III	Karl Pearson's co-efficient of skewness and kurtosis, Students' T Test. Discriminate and Cluster Analyses – Hierarchical cluster analysis (HCA). Multivariate analysis - Multiple Linear Regression (MLR). Dendrogram.			14

Recommended Leaning Resources	
Print Resources	1. An Introduction to Applied GeostatisticsBy : Edward H. Isaaks& R. Mohan Srivastava, Publishers: OUP, USA. 2. Geostatistics with Applications in Earth Science By D.D. Sarma, Springer Publications 2009. 3. Spatial Statistics and GeostatisticsBy Y. Chen & D.A. Griffith 4. Geostatistics for Beginners By Anil Kumar Mehrotra, Publishers: Zorba Books, 2020. 5. Introduction to Geostatistics : Applications in Hydrogeology By P.K. Kitanidis, Publishers: Cambridge University Press, UK. 6. Introduction to GeostasticsBy A. Bardossy

IV Semester

OPEN-ELECTIVE SYLLABUS (OE-16)

Year	**2021-22**	**Course Code:**	**Credits**	**3**
Sem.	**IV**	**Course Title: Geotourism**	**Hours**	**42**
Course Pre-requisites, if any	NA			
Formative Assessment Marks: 30	Summative Assessment Marks: 70		Duration of ESA: 2 hrs.	
Course Outcomes	To understand the beauty and rarity of the geological features, landscapes, mountains, geysers, rock monuments, national parks, Fossils parks, etc. To understand the preservation of the geological features and monuments. Propagating the importance of these geological features to the common man.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	**Introduction -** Geodiversity and rarity of geological features, Geo-conservation, Geo-site, Geo-heritage and Geo-park and their role in geo-tourism development. Concept of National Parks of geological origin. Natural and cultural landscapes**,** A geo-conservation plan for geosites and the development of UNESCO's Global Geopark.Geotourism - impacts and other types of tourism.		Lectures, tutorials Group Discussion	14
Unit II	Geodiversity values and threats**,** Geo-tour guides and basic knowledge of geodiversity. Important Geosites of India and			14

	in particular Karnataka, Geotourism Development & Sustainable Management, Education on Geosites preservation.		
Unit III	Locations of important fossil parks in India - Marine Gondwana Fossil Park, Fossil Wood Parks, Siwalik Fossil Park, Stromatolite Parks, etc. Rock monuments of India – Peninsular Gneiss, Columnar Basalt, Pillow Lava, Pyroclastic Rocks, Nepheline Syenite, Barr Conglomerate, Welded Tuff, Charnockite. Geological Marvels - Lonar Lake, Eddy Current Markings, Natural Arch, Wind erosion structures, Sendra Granite, etc. Other monuments – stratigraphic and economic important locations/ mines. Natural caves and tunnels, Stalactites and Stalagmites.		14
Recommended Leaning Resources			
Print Resources	1. Gray, M., 2004. Geodiversity: Valuing and conserving abiotic nature. John Wiley & Sons Ltd. 434 p. (or later edition). 2. Dowling, R.K., and Newsome, D., 2006. Geotourism. Elsevier, 260p. 3. Gray, M. (2004) Geodiversity: valuing and conserving abiotic nature; John Wiley & Sons. 4. Henriques, M.H.; dos Reis, R.P.; Brilha, J.; Mota, T. Geo-conservation as an Emerging Geo-science. Geo-heritage 2011, 3, 117–128. 5. IUCN Geo-diversity, World Heritage and IUCN Available online: https://www.iucn.org/theme/world-heritage/our-work/global-world-heritageprojects/geodiversity-world-heritage-and-iucn. 6. National Geological Monument, from Geological Survey of India website. (www.gsi.gov.in). 7. "Geo-Heritage Sites". pib.nic.in. Press Information Bureau. 2016-03-09.		

ASSESSMENT METHODS

EVALUATION SCHEME FOR THEORY AND PRACTICAL PAPERS

Discipline Core theory paper carries 100 marks and Discipline Core practical paper carries 50 marks.

Distribution of marks for Discipline Core theory and Discipline Elective/Open Elective papers among C1:C2:C3 is 20:20:60. C1 and C2 are internal assessments and C3 is the main examination.

Distribution of marks for Discipline Core practical paper among C1:C2:C3 is 10:10:25. In addition, 5 marks are kept for practical record.

EVALUATION SCHEME FOR INTERNAL ASSESSMENT:

1. **Theory (for DSC and OE Papers):**

Assessment Criteria	
C1 and C2 will be for 20 marks each. Assessment under C1 and C2 is as detailed below	
1st Internal Assessment Test (C1) of 1 hr duration for 10 marks after 8 weeks and 2nd Internal Assessment Test (C2) of 1 hr duration for 10 marks 1 hr after 15 weeks.	20
Assignment/Field report for 10 marks in both C1 and C2 components	20
Total	**40 marks**

2. **Practical (for DSC paper):**

Assessment Criteria	
C1 and C2 will be for 10 marks each. Assessment under C1 and C2 is as detailed below	
C1 - Internal Assessment Test of 2hr duration for 10 marks may be conducted after 12 weeks and	10
C2 – Evaluation of Assignment/field report for 10 marks at the end of the semester	10
Practical Record	05
Total	**25 marks**

Geological Field Report: As the geological features, structures, fossils are better understood in the field, there will be a Geological Study Tour to the places of geological interest for three days either in the third or fourth semesters mainly to study the structural features and fossiliferous beds. Each student may submit a study tour report in lieu of assignment along with the practical record at the end of the semester. However, for those students, who are unable to undertake field

study, assignment on a topic of geological interest may be given and evaluated based on the report.

QUESTION PAPER PATTERN for III and IV SEMESTERS

(DSC-3 and DSC-4 Papers / Open Electives)

EARTH SCIENCE

Time: 2hrs Max. Marks: 60

Draw neat-labeled diagrams and give examples wherever necessary

SECTION A

Answer any FIVE questions of the following 5 X 2 = 10 marks

Q1. Write a short notes on

a)
b)
c)
d)
e)
f)

SECTION B

Answer any FOUR of the following: 4 X 5 = 20 Marks

Q2.
Q3.
Q4.
Q5.
Q6.
Q7.

SECTION C

Answer any THREE of the following: 3 x 10 = 30 Marks

Q8.
Q9.
Q10.
Q11.

MODEL QUESTION PAPER
III and IV SEM: SCHEME OF VALUATION (PRACTICALS)

IN EARTH SCIENCE

Internal Assessment Max (25 Marks)				**Final Examination (25 Marks)**	**Total**
C1 (Test) Marks	**C2 (Assignment/Field report) Marks**	**Record**	**Total Marks**	**C3 Exam**	**Cumulative of C1, C2 and C3**
10	**10**	**05**	**25**	**25**	**50**

Assessment Criteria for III semester		**Marks**
C3	preparation of lithostratigraphy chart from the given geological map	**04**
	Identification and description of given invertebrate fossil 6 x 3	**18**
	Identification and description of a plant fossil	**03**
Total		**25**

Assessment Criteria for IV semester		**Marks**
C3	Preparation of isohyetal/polygons map	**05**
	Calculation of water quality parameters and its plotting.	**05**
	Table/compass survey	**05**
	Structural geology maps 2 x 5	**10**
Total		**25**

PROGRAMME STRUCTURE

Earth Science as Core subject: V and VI semesters

Semester	Discipline Core (DSC) (Credits) (L+T+P)	Credits	Employability Skill Paper (Credits)(L+T+P)
V	**A5 Theory (4 credits)** (4+0+0) Ore Geology and Indian Mineral Deposits **P5 Practicals (2 credits)** (0+0+2) Ore Genesis and IMD **A6 Theory (4 credits)** (4+0+0) Remote Sensing, GIS & GPS and Marine Geology **P6 Practicals (2 credits)** (0+0+2) RS and GIS, GPS	**4+2+4+2**	**Employability Skill Paper (3 credits)** (2+0+1) Groundwater Exploration
VI	**A7 Theory (4 credits)** (4+0+0) Exploration Geology and Mining Geology **P7 Practicals (2 credits)** (0+0+2) Exploration Geology **A8 Theory (4 credits)** (4+0+0) Engineering Geology, Geochemistry, Disaster and Natural Hazards Management **P8 Practicals (2 credits)** (0+0+2) Engineering geology and Geochemistry	**4+2+4+2**	**Employability Skill Paper (3 credits)** (2+0+1) Groundwater Exploration
Exit option with Degree Certificate			

NEP Vth and VIth Sem Syllabus

V SEMESTER Paper - 1

Year	**2023-24**	**Course Code: ESDSC 501** **Course Title: Ore Geology and Indian Mineral Deposits**	**Credits**	**4**
Sem.	**V**		**Hours**	**60**
Course Pre-requisites, if any				
Formative Assessment Marks: 40	Summative Assessment Marks: 60			Duration of ESA: 2 ½ hrs.
Course Outcomes	This course provides a better understanding of the ore forming process and also it gives an insight on the types of ore deposits present in the country. A student will understand and learn about the basic concepts of Petrology Geology withrespect to geology as to enable them to work as a Petroleum Geologist.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	**ORE GEOLOGY** Introduction to ore geology in relation of industry, commerce and national economy. Ore minerals. Gangue minerals, Tenor of ore. Economic Minerals – Strategic, Critical and Essential minerals Principles and Processes of Ore formation: Magmatic processes: Early magmatic deposits: Dissemination, Segregation and Injection deposits. Late magmatic deposits: Residual Liquid Segregation, Residual Liquid Injection, Immiscible Liquid Segregation, Immiscible Liquid Injection. Contact metasomatism: Skarn deposits. Hydrothermal processes: Hydrothermal fluids and their migration and deposition. Cavity filling and Replacement deposits. Sources of solutions and their contents, Means of transport. Weathering processes: Residual, mechanical concentrations (placers) - Eluvial,Stream and Marine Deposits. Sedimentation: Fe and Mn cycles. Oxidation and supergene enrichment: Gossans. Metamorphism: Metamorphic deposits – Asbestos, Garnet, Al-Si minerals like kyanite, sillimanite and staurolite Classification of ore deposits - Jenson and Bateman. Metallogenic Epochs and Provinces. Metallogeny in relation to plate tectonics.		Lectures, tutorials Group Discussion and IT based teaching	15
Unit II	**INDIAN MINERAL DEPOSITS** **Metallic Mineral Resources:** Introduction, Study of the following deposits of India with special reference to Karnataka with regards to their mineralogy, origin, occurrence and distribution: Gold (Kolar, Gadag, Hutti), Copper (Ingaldhal, Kalyadi, Thintini), Iron (Chikamagalur, Bellary, North			15

	Kanara), Manganese (Shivamogga, North Kanara, Sandur, Tumkur), Aluminium (Boknur-Navge, Paduvare, Bababudan). National Mineral Policy: Major and minor minerals		
Unit III	**Non-metallic Mineral Resources:** Introduction, Study of the following deposits of India with special reference to Karnataka with regards to their mineralogy, origin. occurrence and distribution: Mica - Bihar mica belt, Nellore mica belt, Andrapradesh. Mica deposits of Rajasthan. Abrasives - Natural abrasives - *High grade natural abrasive*- Diamond, Corundum, Garnet Siliceous abrasives: Grindstones and millstone, Flint, Sandstone, Quartzite, Miscellaneous abrasives: Calcite, Feldspars, Fuller's earth, Magnesia, Soapstone, and talc. Refractories - Principal varieties of refractories, Classification of refractories. Fire clays refractories, Silica refractories, High alumina refractories, Magnesia refractories, Chromite refractories, Zirconia refractories. Building and Ornamental stone:Granites, Dolerite, Sandstone, Basalt, Limestone, Marbles, Laterite, Slate, Soapstone. Glass and ceramics:Quartz, Clay, Feldspar, calcite Fertilizer minerals: Gypsum, Phosphate (apatite), Rock Phosphate (Phosphorite), Potash, Pyrite and sulphur. Definitions of the term's ore grade and Reserve. Assessment of grade. Reserve estimation		15
Unit IV	**FUEL GEOLOGY** A brief introduction on coal, petroleum, gas hydrates and nuclear fuel. **Coal** – Definition of coal, types, stages and periods of coal formation (Gondwana, Tertiary and Cretaceous coals), Chemical composition, Properties of coal, Seyler's classification of coal, Origin, Accumulation and distribution of Coal deposits of India including Peat and lignite deposits. Methods of mining coal. Coal as a fuel: Coal Bed Methane (CBM): global and Indian scenario, Underground coal gasification, Coal liquefaction. Briefly discuss the coal deposits of India with reference to geology, origin and distribution of Singrauli Coalfield, Jaharia Coalfield and Godavari valley coalfield. **Petroleum** – Introduction, elemental analysis of crude oil, chemical composition and physical properties of crudes in nature. Occurrence, accumulation and origin. Formation of Source Rocks. Maturation of kerogen: Biogenic and Thermal effect. Migration. Petroleum Reservoirs and Traps: Reservoir rocks: general attributes and petrophysical properties. Classification of reservoir rocks - clastic and chemical. Hydrocarbon traps: definition, anticlinal theory and trap		15

	theory. Classification of hydrocarbon traps – structural (Anticline, Fault traps & Salt Domes), stratigraphic and combination. Cap rocks - definition and general properties. Distribution of On-shore and Off-shore oil fields of India. Briefly discuss the oil deposits of India with reference to Geology, origin. Occurrence and distribution of Digboi oil field, Mumbai High and Ankleshwar oil field.		
Recommended Learning Resources			
Print Resources	• Economic Mineral Deposits - Jenson and Bateman, A.M • Mineral Deposits by Lindgren • Ore Deposits by Park and Mc Diarmid • Ore-deposits of India - Gokhale and Rao • Indian Mineral Resources - Krishnaswamy, S and Sinha.. • Metallic and Industrial minerals - Lamey, G.A. • Introduction to India's economic minerals - Sharma, N.L. and Ram. K.S. • A treatise on Industrial Minerals of India - Sinha. R.L. • Coal in India - H. S. Pareek • Coal Petrology - H. S. Pareek • Ore Deposits by Park and Mc Diarmid • Ore-deposits of India - Gokhale and Rao • Indian Mineral Resources - Krishnaswamy, S and Sinha.. • Introduction to India's economic minerals - Sharma, N.L. and Ram. K.S. • A treatise on Industrial Minerals of India - Sinha. R.L. • Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jijnasa Publishing House. • Shelly R. C. (2015). Elements of Petroleum geology: Third Edition, Academic Press • Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag. • Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes		

V SEMESTER PRACTICALS
Paper – 1

Year	**2021-22**	**Course Code: ESDSC 502**	**Credits**	**02**
Sem	**V**	**Course Title: Ore Genesis and IMD**	**Hours**	**60**
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration: 4 hrs.	
		Completion of outcrops- 5 maps.2 practical Calculation of the thickness of the strata: Geometric & mathematical 3 types- 4 problems each.3 practical Dip and Strike Problems. Geometric and trigonometric – 4 types – 4 problems each. 4 practical Generation of Maps: Geochemical prospecting maps 2 practical Problems on Ore Reserve Estimation: Included and Extended area Methods. 2 practical Preparation of maps showing distribution of important metallic, non-metallic deposits and important coal and oil fields of India. 2 practicals		
		PART B: Field tour of a minimum of three days to an active mining area and also to a mineral processing unit.		

MODEL QUESTION PAPER
V SEM: SCHEME OF VALUATION (PRACTICALS)

IN EARTH SCIENCE

Internal Assessment Max (25 Marks)				**Final Examination (25 Marks)**	**Total**
C1 (Test) Marks	**C2 (Assignment/Field report) Marks**	**Record**	**Total Marks**	**C3 Exam**	**Cumulative of C1, C2 and C3**
10	**10**	**05**	**25**	**25**	**50**

Assessment Criteria for V semester Paper ESDSC 502		**Marks**
C3	Completion of outcrop - 1 map	**03**
	Calculation of the thickness of the strata: Geometric & mathematical 3 types- 1 problem	**03**
	Dip and Strike Problems. Geometric and trigonometric – 3 types – 1 problem	**04**
	Generation of Maps: Geochemical prospecting maps 1 map	**03**
	Problems on Ore Reserve Estimation: Included and Extended area Methods. **1** problem	**03**
	Preparation of maps showing distribution of important metallic, non-metallic deposits and important coal and oil fields of India. 1 map	**04**
	Viva-voce on field work	**05**
Total		**25**

V SEMESTER

Paper - 2

Year	2023-24	Course Code: ESDSC 503	Credits	4
Sem.	V	Course Title: **Remote Sensing, GIS & GPS and Marine Geology**	Hours	60
Course Pre-requisites, if any				
Formative Assessment Marks: 40	Summative Assessment Marks: 60		Duration: 2 ½ hrs.	
Course Outcomes	• The course is meant to address the fundamental techniques used for remote sensing. At the end of this course, the student will be appraised with all the theoretical knowledge,information and skills to use Remotely Sensed data for geological applications. • This course provides a theoretical and practical, hands-on approach to spatial database design and spatial data analysis with Geographical Information Systems as applied to the various fields of geosciences			

Unit No.	Course Content	Suggested Pedagogy	Hours
Unit I	**Remote Sensing** **Aerial Remote Sensing**: Definition and scope of remote sensing in natural resources survey. Aerial Photography: Scale, sidelap overlap, drift and crab.Photographic flight mission;purpose, area, scale, aerial cameras and lens, flight direction, Time of photography, season ofphotography,overlaps.Typesofaerialphotography:Classification-vertical,lowoblique,highobliquestereoscopy:Abriefintroductionofviewing,measuringandplottinginstruments.Viewing instruments-lensandmirrorstereoscopes.PreparationofPhoto-Geological map- Mosaics and its types, photo interpretation and annotation, preparation offinalphoto-geologicalmap.Elementsofaerialphotointerpretation:photographictone,texture,shapeof objects,sizeof objects, patterns,scale. **SatelliteRemoteSensing:**PrinciplesofRemotesensing,stagesinremotesensing.Electromagnetic radiation - characteristics of electromagnetic spectrum; interaction of EMRwith the earth's surface (reflection, surface		15

	roughness, transmission, spectral signature) andwith the atmosphere (scattering, absorption, atmospheric windows, refraction, atmospherichaze). Platform, sensors, resolution, multispectral scanners- across- track and along-trackmultispectral Scanning, data reception and product generation.Microwave remote sensing:SLAR&SAR. Applicationofremotesensing ingeoscienceandgeomorphologicalstudies.		
Unit II	**Geographical Information System and Its Application:** Introduction to GIS. Map projection and its types - Cylindrical, UTM, Conical and Azimuthal, selecting suitable mapprojection. Representation of earth features in GIS: point, line, polygon. spatial data andattributes. Components of GIS: GIS infrastructure input and output devices. GIS software's -Computer fundamentals of GIS. Data for GIS: layers in GIS. GIS techniques and nature of Data:spatial and aspatial data, temporal data. Data structures - Raster and vector data structures.Advantages and disadvantages of raster and vector data models. Raster data input and Vectordata input, applications of GIS		15
Unit III	Fundamentals of Global positioning System Introduction of Global Positioning System,Satellite constellation, GPS signals and data,Geo-Positioning-Basic Concepts. Discussion onNAVSTAR, GLONASS,GALLILEO,COMPASS Basic geodesy, Coordinate Systems, SpecialReferencing system, Map Scale, Scale factors,Indian geodetic System Segments of GPS: Control Segment, SpaceSegments, User Segment -operations of GPS,accuracy, error sources and analysis, methodologyfor collection of data, adjustment computations andanalysis. Selection of datum, units and scale; GPSmeasurement. GPS Positioning Types- Absolute Positioning,Differential positioning Methods Application of GPS in Surveying and Mapping,Navigation, Military, Location Based Services, Vehicletracking, etc. Limitation of GPS & DGPS		15
Unit IV	**MARINE GEOLOGY** Introduction. Morphology and physiographic features of the ocean floor. Classification of sub marine topography. Physico-chemical characteristic of sea water - distribution of temperature,salinity and density of sea water. Waves, Tides, Currents- its types, distribution and their significance. Ocean deposits- source, nature and distribution of marine sediments. Marine resources- type of marine resources and their distribution and utilization, marine mineral resources, marine energy resources and manganese nodules, methods of		15

	itsexploitation. Sea level changes and impacts.		

Recommended Learning Resources	
Print Resources	• Aerial photographic interpretation. Principles and applications – D.R.Leuder. • Photogeology – Miller.J.C • Manual of colour aerial photography – Ed. Smith, J.T.Jr. • Manual of Remote sensing – Ed Robert G Reeves. • Remote sensing in Geology – Parry S.Siegal& Alan. R.Gillespie. • Principles of Remote sensing – Patel singh; SP Publication. • Digital Remote Sensing – Pritivish Nag M Kudrat; concept publication. • Remote sensing and its applications – LRA Narayan • Principles and application of Photogeology by Shiv N Pandey • Remote sensing of environment by Joseph Lintz, jr. David S. Simonett. • Text book of GIS fundamentals, applications and implementations by Dr. K. Elangovan. • New Indian publishing agency, New Delhi. • Text book of An Introduction to Geographic Information Technology by Sujith choudhury, • deepankarchakrabarti and suchandrachoudhury. I.K. International publishing house Pvt.Ltd • New Delhi and Bangaluru. • 3.Text book of Remote sensing and geographical Information system, 1st & 2nd Ed. By M. • Anjireddy, BS Publications, Hyderabad. • Handbook on Geographic Information Systems and Digital Mapping,United Nations. • Statistical Division, United Nations Publications. • Fundamentals of Geographical Information Systems,Michael N. DeMers,Wiley, 2009 - • Science. • Textbook of Remote Sensing and Geographical Information Systems,Kali Charan • Sahu,Atlantic Publishers &Dist, 01-Dec-2007 - 512 pages

V SEMESTER PRACTICALS

Paper - 2

Year	**2021-22**	**Course Code: ESDSC 504**	**Credits**	**02**
Sem	**V**	**Course Title: RS and GIS, GPS**	**Hours**	**60**
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration: 4 hrs.	
		Interpretation of aerial photographs using Pocket and Mirror stereoscope (landform, drainage, patterns and settlement) ….2 Prac.		

	Interpretation and study of satellite images ….1 Prac. Digital mapping applications: Basic Introduction and application of digital mapping software's of Map Maker & Surfer. MAPMAKER- Introduction and Basic information of map features like – Point, line and polygons and digitations of toposheet: landform, drainage pattern, and settlement. ….3 Prac. SURFER – Introduction and Generation of contour and 3D elevation maps of spatial data. 3 Prac.
	PART B: Field visit to a place of geological interest.

Assessment Criteria for V semester Paper ESDSC 504		**Marks**
C3	Interpretation of aerial photographs using Pocket and Mirror stereoscope (landform, drainage, patterns and settlement) 1	**05**
	Interpretation of a satellite imagery 1	**05**
	Generation of digital map (drainage, contour, LU/LC) using MAPMAKER 1	**05**
	Generation of digital map using Surfer software 1	**05**
	Viva-voce on field work	**05**
Total		**25**

VI SEMESTER

Paper - 1

Year	**2023-24**	**Course Code: ESDSC 601** **Course Title: Exploration Geology and Mining Geology**	**Credits**	**4**
Sem.	**VI**		**Hours**	**60**
Course Pre-requisites, if any				
Formative Assessment Marks: 40	Summative Assessment Marks: 60			Duration: 2 hrs.
Course Outcomes	The course provides the student essential and basic concepts of mineral expiration techniquesand the art and science of mining mineral resources.In Exploration Geology the student will gain first-hand knowledge dealing with the principles and their significance in exploring the deposits.			
Unit No.	**Course Content**		**Suggested Pedagogy**	**Hours**
Unit I	**EXPLORATION GEOLOGY** Introduction to Prospecting and Exploration. Classification of Prospecting methodsPrinciples of Exploration: Geological, Geophysical and Geochemical Methods. Geological Exploration: Geological methods: River float tracing and panning.Guides and criteria for locating ore deposits. Guides: Geological and Non-geological guides.Primary and Secondary dispersion haloes, Gossans, Old workings. Criteria: Stratigraphic,lithological, structural, geomorphological, paleogeographic and paleoclimatic Criteria.Preliminary and detailed exploration, exploratory works – drilling and core logging. Exploratory grids. Sampling methods. Economic evaluation of mineral deposits based onUNFC classification. Geochemical Exploration and Bio-Geochemical Exploration: Introduction,Geochemical Cycle – Deep seated & surficial, geochemical mobility ofelements. Pathfinder elements. Threshold values and geochemical anomaly.Dispersion – Primary & secondary. Lithogeochemistry, soil metallometry, streamsediments, Hydrochemical, Atmochemical and Biogeochemical methods, Geobotany.		Lectures, tutorials Group Discussion and IT based teaching	15
Unit II	**GEOPHYSICAL EXPLORATION** Introduction. Methods of Geophysical exploration.Gravity Method: Introduction, basic principle, gravity of the earth, gravity reductions,densities of rocks and minerals, density estimates from field results, Gravimeters-Stable type,field			15

	operations, results and interpretation. Numerical problems on vertical component,gravity gradient and gravity curvature. Magnetic Method: Introduction, Basic principle, Magnetism of the Earth, Magnetism andmagnetic susceptibilities of rocks and minerals, Field instruments, field operations.Results and interpretation. Numerical problems on vertical and horizontal components. Seismic Methods: Introduction, principles of reflection and refraction methods, fieldequipment's – Geophones, results and interpretation. Numerical problems on reflection andrefraction methods. Electrical Methods: Introduction, electrical properties of rocks and minerals. Resistivitymethod: Elemental theory, resistivity meters, electrode layouts – Wenner andSchlumberger spreads, Field procedure, Application of resistivity method in ground watersearch.		
Unit III	**MINING GEOLOGY** Introduction. Mining methods – surface, underground and Oceanic Mining terminologies: Shaft, adits, rise, winze, tunnel, cross-cut, veins, hanging and foot walls. Surface mining methods including strip mining, open pit mining, hydraulic mining and dredging. Mineplanning. Design criteria for surface mines including scheduling, material removal andcapacity-rated equipment- sizing, availability and utilization calculations, slope design,stripping ratio, pit ramp and waste dump design, pit dewatering andland reclamation. Capital and operating cost estimation. Underground Mining Methods and Design: Description and usage of the following underground mining methods: room and pillar, long-hole, longwall, open stoping, shrinkage, cut and fill sub-level stoping, timbered stoping, topslicing, underhand and overhand stoping, block caving, sublevel caving, and vertical craterretreat. Requirements for development and services including shafts, hoists, ramp and multi-level access design. Design of pumping, ventilation, compressed air and power facilities. Underground design including stope development, haulage systems, backfill, equipmentselection, and scheduling of development and operations. Capital and operating costestimation associated with underground mining activities. **Mining and Environment** Environmental practices in mining including waste rock and tailings disposal systems; prediction/prevention/treatment/control of acid rock drainage;control of dust/noise/gaseous emissions; environmental effects monitoring (surface water		15

	andgroundwater); reclamation and decommissioning; government regulations relating toenvironmental protection in design/operation/closure of mines; sustainable developmentprinciples and application to mining; risk assessment and management principles with respectto the environment.		
Unit IV	MINERAL DRESSING: Definition and Scope of Mineral dressing, Physical and Chemical Properties of minerals made use of in Mineral dressing. Communition: Principles, theories of Communition, ore grindability. Crushers: Primary and Secondary Crushers. Grinding Mills (Tumbling Mills):- types of Mills : Rod, Ball and Autogenous mills. Industrial Screening: Screens and their types. Classification: Types of classifiers. Gravity concentration: principles. Types of Gravity separators; Heavy Medium Separation - Separating Vessels. Magnetic Separation: Types of Magnetic Separators. Froth Flotation technique of Separation of Complex Sulfideover:Reagents : Collectors, Frothers and Regulators - Activators & Depressants..		15
Recommended Learning Resources			
Print Resources	1. Lahee F. H. (1962) Field Geology. McGraw Hill 2. Geochemistry in mineral exploration Hawkes. H & Wobb J.S. Harper & Row New York. 3. Principles of Geochemical prospecting. Ginzburg. I.I. Petgaon Press, N.Y. London. 4. Biochemical methods of Prospecting - Malyuga, D.P. 5. Principles of Mining Geology, Arogya Swamy. 6. Introduction to geophysical prospecting - Milton B, Dobrin Mc Graw Hill Book 7. Outlines of geophysical prospecting - A manual for Geologists. M.B.R. Rao. Prasaranga, Mysore University. 8. Geophsical Methods in Geology - P.V. Sharma. 9. Geophysical Exploration - Heilava. C.H. 10. Exploration Geophysics for Geologists and Engineers - Edited by Bhimasanakaran, V.L.S. Gour. V.K. - The Association of Exploration Geophysists - Hyderabad 11. Applied Geophysics – W.M.Telford,L.P.Geldart,R.E.Sheriff,D.A.Keys. Cambridge univ., Press,1976, pp 860		

VI SEMESTER PRACTICALS

MODEL QUESTION PAPER
VI SEM: SCHEME OF VALUATION (PRACTICALS)

Internal Assessment Max (25 Marks)				**Final Examination (25 Marks)**	**Total**
C1 (Test) Marks	**C2 (Assignment/Field report) Marks**	**Record**	**Total Marks**	**C3 Exam**	**Cumulative of C1, C2 and C3**
10	**10**	**05**	**25**	**25**	**50**

Paper - 1

Year	**2021-22**	**Course Code: ESDSC602**	**Credits**	**02**
Sem	**V**	**Course Title: Exploration Geology**	**Hours**	**60**
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration : 4 hrs.	
		• Borehole problems 2 practicals • Problems on Geophysical Exploration: Electrical Method: Interpretation of VES data by S line method and Curve Matching Method. 3 practicals • Problems on gravity, magnetic and seismic methods 6 Practicals • Hypothetical situation in a flood and earthquake prone areas and write up of a report on disaster management 2 practicals.		
		PART B: Field visit to disaster struck area, sea erosion, tunnel, dam, landslide and to disaster management nodal centres		

Assessment Criteria for V semester Paper ESDSC 502		**Marks**
C3	Borehole problem 1	**04**
	• Problems on Geophysical Exploration: Electrical Method	**04**
	Gravity method (any one components – vertical, gradient, curvature)	**04**
	Magnetic method (any one components – vertical and horizontal)	**04**
	Seismic method	**04**
	Viva-voce on field work	**05**
Total		**25**

VI SEMESTER

Paper - 2

Year	**2023-24**	**Course Code:ESDSC603** **Course Title: Engineering Geology, Geochemistry, Disaster and Natural Hazards Management**	**Credits**	**4**
Sem.	**VI**		**Hours**	**60**
Course Pre-requisites, if any	• Upon completion of the course the student will become aware of the importance of geologicalstudies and its applicability to various engineering problems. • The course provides a forum to introduce the concept of isotopes to graduate students and theuse of radiogenic and stable isotopes in geosciences. •			
Formative Assessment Marks: 40	Summative Assessment Marks: 60			Duration: 2 ½ hrs.
Course Outcomes	At the end of the course the student should be able to:			

Unit No.	**Course Content**	**Suggested Pedagogy**	**Hours**
Unit I	**ENGINEERING GEOLOGY:** Introduction: The role of geology in civil engineering. Engineering properties of rocks –Building stones and road materials. Building stones of India- Granite, basalt, sandstone, shale, marble, charnockite,and laterite. Soil: Soil profiles. Structure and texture of soils. Physical and chemical properties of soils. Classification of soil particle size. **Gravitation sloping processes:** Classification and description of modern gravitational processes based on type of movement-Slides, falls and flows. Causes of landslides. Subsidence- Carbonate dissolution in the subsurface, subsidence caused by human activities- underground mining and withdrawal of ground water. **Stability of rock slopes and cutting in rocks**: Classification of slopes- stable and unstable slopes- Geological parameters. Measures for stabilization of slopes. Cuttings in rock slopes-cut design and geological parameters. **Building sites:** Requirements, foundation problems, ground conditions, building foundations in bedrock ground, soil, sloping ground.	Lectures, tutorials Group Discussion and IT based teaching	15
Unit II	**GEOENGINEERING STUDIES** **Bridge sites:** Bridge structure, types, bridge problems, and		15

	geological parameters. Geology of bridge sites. **Dams and reservoirs:** Types of Dams: 1. masonary or concrete dams- gravity, arch and butress.2.Earth Dams and 3.composite dams. Location of dam. Geological considerations- topography, structure and lithology. Foundation and seepage problems in dams and their treatment. Foundation treatment; Grouting, Rock Bolting and other support mechanisms. Reservoir: Reservoir problems- seepage and silting. **Tunnels:** terminology, definitions, types- hard rock and soft rock tunnels. Geological considerations- Lithology and structure. Ground failures in tunnels. Concrete aggregate sources, alkali-aggregate sources, alkali-aggregate reaction. Geological site investigations for engineering projects. Aseismic designing and earthquake resistant structures.		
Unit III	**Geochemistry** Introduction. Geochemical environment-Deep seated and Surficial, Crustal abundance of chemical elements. Soil chemistry. Phase diagrams. Geochronology - Radio activity, decay schemes, Radiometric dating. Radiogenic Isotopes: strontium isotopes and neodymium. isotopes, Application of radiogenic isotopes : K-Ar, U-Pb, Rb-Sr and Sm-Nd, Carbon isotopes.		15
Unit IV	**DISASTER AND NATURAL HAZARDS MANAGEMENT**. Disaster Management: Disaster Terminology – Disaster, Risk, Hazards and vulnerability, vulnerability types, disaster preparedness, interventions in a disaster situation – relief, rehabilitation, disaster mitigation. The disaster management cycle. Disaster Management. objectives and priorities. Efforts to mitigate disasters worldwide – International cooperation. Disaster Management System in India Disaster Management Plans at various Levels. Preparedness Types of Disasters. Nodal Ministries at Central Level Local Level Risk Management GIS & Remote Sensing for Natural Disaster Management. Hazard zonation maps. Natural Hazards Management Earthquakes – Measures for earthquake risk reduction; Pre, medium term and post disaster preventive measures, Consolidation, and reconstruction. Floods – Mitigation; structural & non-structural groups, Preparedness, Response Mechanism, Damage Assessment, Post flood Management Drought – Introduction, Types, Identification of Drought		15

	affected areas, Drought Management Landslides – Mitigatory measures, Settlement policy Avalanches – Avalanche Control Measures Coastal erosion and mitigatory measures.		

Recommended Learning Resources	
Print Resources	1. Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley 2. Billings, M. P. (1987) Structural Geology, 4th edition, Prentice-Hall. 3. Park, R. G. (2004) Foundations of Structural Geology.Chapman & Hall. 4. Pollard, D. D. (2005) Fundamental of Structural Geology. Cambridge University Press. 5. Ragan, D. M. (2009) Structural Geology: an introduction to geometrical techniques (4th Ed). Cambridge University Press (For Practical) 6. Lahee F. H. (1962) Field Geology. McGraw Hill 7. Central and State Governments published manuals on disasters and disaster management

VI SEMESTER PRACTICALS
Paper - 2

Year	**2021-22**	**Course Code: ESDSC 604** **Course Title: Engineering geology and Geochemistry**	**Credits**	**02**
Sem	**V**		**Hours**	**56**
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration of ESA: 3 hrs.	
Course Outcomes		At the end of the course the student should be able to: Create engineering geological and water quality spatial maps		
		Engineering Geology Maps Pollution Maps		
		PART B: Field visit to quarry, active mining areas, geosites. Teaching mapping technique using compass, Brunton and GPS		

Assessment Criteria for V semester Paper ESDSC 502		**Marks**
C3	Engineering Geology Maps Map on dam 1	**05**
	Map on tunnel 1	**05**
	Map on railway line 1	**05**
	Pollution zonation Map: Nitrate/WQI/Fluoride 1 map	**05**
	Viva-voce on field work	**05**
Total		**25**

V/VI SEMESTER Paper
EMPLOYIBILITY SKILL PAPER

<table>
<tr><td>Year</td><td>2023-24</td><td colspan="2" rowspan="2">Course Code: ESDSE 501/601
Course Title: Groundwater Exploration</td><td>Credits</td><td>3</td></tr>
<tr><td>Sem.</td><td>V</td><td>Hours</td><td>32</td></tr>
<tr><td>Course Pre-requisites,</td><td colspan="5"></td></tr>
<tr><td>Formative Assessment Marks: 40</td><td colspan="4">Summative Assessment Marks: 60</td><td>Duration of ESA: 2 hrs.</td></tr>
<tr><td>Course Outcomes</td><td colspan="5">Candidate after successful completion of the course will become an expert in the search groundwater potential zones and can become self-entrepreneur.</td></tr>
<tr><td>Unit No.</td><td colspan="2">Course Content</td><td>Suggested Pedagogy</td><td>Hours</td></tr>
<tr><td>Unit I</td><td colspan="2">Introduction to groundwater exploration. Aquifer and its types. Confined, Unconfined, aquitard, aquifuge, aquiclude, aquiduct. Geological features in the search of groundwater - Topography, climate and vegetation, Geology of the area. Porosity, permeability, joints and faults, folds. Proximity of any tank, reservoirs, existing wells in the vicinity.
Areas and elements favorable for groundwater recharge. Dousing Methods.</td><td rowspan="2">Lectures, tutorials Group Discussion and IT based teaching</td><td>16</td></tr>
<tr><td>Unit II</td><td colspan="2">Geophysical exploration of groundwater by resistivity method: introduction, principle, Wenner and Schlumberger method, field procedure - profiling, Depth sounding, interpretation of the data.
Well logging, hydro-fracture technique.
Profiling in the search of subsurface structures.</td><td>16</td></tr>
<tr><td colspan="5">Recommended Learning Resources</td></tr>
<tr><td>Print Resources</td><td colspan="4">• Principles of Mining Geology, Arogya Swamy.
• Introduction to geophysical prospecting - Milton B, Dobrin Mc Graw Hill Book
• Outlines of geophysical prospecting - A manual for Geologists. M.B.R. Rao. Prasaranga, Mysore University.
• Geophsical Methods in Geology - P.V. Sharma.
• Geophysical Exploration - Heilava. C.H.
• Exploration Geophysics for Geologists and Engineers - Edited by Bhimasanakaran,
V.L.S. Gour. V.K. - The Association of Exploration Geophysists - Hyderabad
• Applied Geophysics – W.M.Telford,L.P.Geldart,R.E.Sheriff,D.A.Keys. Cambridge univ., Press,1976, pp 860
•</td></tr>
</table>

V & VI SEMESTERS PRACTICAL

Year	**2021-22**	**Course Code: ESDSE 502** **Course Title: Groundwater Exploration**	**Credit**	**01**
Sem	**V**		**Hours**	**32**
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 25		Summative Assessment Marks: 25	Duration : 2 hrs.	
		1. Study of soils and rock types. 2. Profiling 3. Sounding or depth probing methods 4. Wenner and Schlumberger methods 5. Interpretation of depth sounding curves 6. Curve matching techniques		

Assessment Criteria for ESDSE 502	**Marks**
Profiling	**05**
Wenner and Schlumberger methods	**10**
Interpretation of depth sounding curves	**05**
Curve matching techniques	**05**
Total	**25**

VI SEMESTER
EMPLOYIBILITY SKILL PAPER - 2

<table>
<tr><td>Year</td><td>2023-24</td><td colspan="2">Course Code: ESDSE 601</td><td>Credits</td><td>2</td></tr>
<tr><td>Sem.</td><td>V</td><td colspan="2">Course Title: GIS</td><td>Hours</td><td>32</td></tr>
<tr><td>Course Pre-requisites, if any</td><td colspan="5"></td></tr>
<tr><td>Formative Assessment Marks: 25</td><td colspan="4">Summative Assessment Marks: 25</td><td>Duration: 2 hrs.</td></tr>
<tr><td>Course Outcomes</td><td colspan="5">.</td></tr>
<tr><td>Unit No.</td><td colspan="2">Course Content</td><td>Suggested Pedagogy</td><td colspan="2">Hours</td></tr>
<tr><td>Unit I</td><td colspan="2">Introduction, Definitions of GIS and Related Terminology, The Evolution of GIS, Components of GIS, Approaches to the Study of GIS, types of map projections and Principles of GIS. Vector data: point, Line, Area, Surface, Entity, Object, Symbol, Entity relationship model, Real world to map, representation of real world and entities on a map, Spaghetti structure and topological data structure.</td><td rowspan="2">Lectures, tutorials Group Discussion and IT based teaching</td><td colspan="2">16</td></tr>
<tr><td>Unit II</td><td colspan="2">Raster data: Raster structure, attribute classification, run-length encoding, scan order for Raster, Region quad trees and octrees, lines and points in Raster. Types of Data storage. Introduction, Overview of image processing software and GIS softwares (ERDAS, Mapinfo, ArcGIS, Arcview, Google Earth).</td><td colspan="2">16</td></tr>
<tr><td colspan="6">Recommended Learning Resources</td></tr>
<tr><td>Print Resources</td><td colspan="5">•</td></tr>
</table>

VI SEMESTER PRACTICALS

Year	2021-22	Course Code:	Credits	01
Sem	V	Course Title: **GIS**	Hours	24
Course Pre-requisites, if any		NA		
Formative Assessment Marks: 15		Summative Assessment Marks: 35	Duration of ESA: 3 hrs.	
		Working of GIS Registration. Map georeferencing, map digitization, map area calculation, Map clipping and map append. 6- practicals		

QUESTION PAPER PATTERN for V and VI SEMESTERS
(DSC-5, 6, 7 and DSC 8 Papers)
EARTH SCIENCE

Time: 2 ½ hrs Max. Marks: 60

Draw neat-labeled diagrams and give examples wherever necessary

SECTION A

Answer any FIVE questions of the following **5 X 2 = 10 marks**

Q1. Write a short notes on

a)
b)
c)
d)
e)
f)

SECTION B

Answer any FOUR of the following: **4 X 5 = 20 Marks**

Q2.
Q3.
Q4.
Q5.
Q6.
Q7.

SECTION C

Answer any THREE of the following: **3 x 10 = 30 Marks**

Q8.
Q9.
Q10.
Q11.