

B.Sc. Blended Programme in Earth Science: -

Outcome based learning is the principal end of pedagogical transactions in higher education in today's world in the light of exponential changes brought about in science and technology, and the prevalent utilitarian world view of the society. Geology as a discipline falls within the special category of science with a multidisciplinary approach.

Academic model of Indian higher education has remained more or less the same for the past century and more. The entire higher education spectrum was divided into streams like Arts, Commerce, Science, Engineering, Medicine, Law, Agriculture etc. Each stream will select the student after the secondary education and provide three or four to five years of education so as to award a degree. The silos created are so strong that now we have even institutes of "this and that" based on the stream. In fact, the comprehensive university concept was thrown out in the window. Now, we are seeing the drawbacks of such unitary higher education process.

The academic world is increasingly a global village now. Academic institutions from Singapore, Japan, Korea and China are marching ahead very fast in the international scenario. The Americans and Europeans are reforming many aspects of the academic world. India will have to look at reforms of the academic world as well. In fact, Indian graduates will have to seek placements not at the national level but at the international level in future. The number of graduates will be far more than the number of jobs. However, the Indian graduates will be able to grab the international placements only when their academic background and skills will be suitable at the international level.

Many surveys and reviews have indicated that a large number of Indian graduates are not employable since they do not possess the skills that are needed in today's world. Neither the knowledge nor the skills are adequately provided through the current academic model of higher education.

In the Solar System amongst the terrestrial planet the Earth is the only living planet which has Lithosphere, oxygenated Atmosphere, Hydrosphere and the Biosphere. There is seamless interaction among these spheres. The Earth has hot interior and this very heat acts as the fuel to run the Earth engine. To understand how our planet works, at depth and at the surface, the ideas and principles of Biology, Chemistry, Physics, Mathematics and Geography are

integrated in the exciting and stimulating studies which make up Earth Sciences. It is a fast-moving, diversifying, multidisciplinary field that ranges from understanding the Earth's origin in the solar system, the evolution of hydrosphere and atmosphere as well as the earth's materials at the atomic level, through the geological processes that drive volcanoes and earthquakes, surface processes that shape landscapes and create the geological record, biological processes that build diversity and bring extinction, up to planetary-scale systems, such as plate tectonics, climate and the origins of life and ecosystems. The Earth Science takes you very close to the nature as this is basically a field Science. The geology program integrates field trips with classroom learning to give you the hands-on experience you need to succeed. These opportunities develop your technical skills using measuring instruments and laboratory equipment.

**Proposed Curriculum Structure for the B. Sc. (Blended) Earth Science Course
(Semesters V – VI)**

Nomenclature: GEO – Earth Science

1 Credit = 1 Contact hour per week both for theory and lab courses

Semester V

Semester V		
Subject Code	Title of the Subject	Credits
GEO 501	Structure, Tectonics and Geodynamics of the lithosphere	3
GEO 502	Hydrogeology	3
GEO 503	Engineering Geology	3
GEO 504	Economic Geology and Mineral Exploration	3
GEO 505	Elective 1	2
GEO 506	Elective 2	2
GEO 507	Hydrogeology Lab	2
GEO 508	Economic Geology Lab	2
GEO 509	Project/Dissertation	2
Total Credits		22

Elective Courses Semester V		
Subject Code	Title of the Subject	Credits
GEO 505	Elective 1 - Introduction to Marine Geology	2
GEO 506	Elective 2 - Introduction to Analytical chemistry	2

Semester VI

Semester VI		
Subject Code	Title of the Subject	Credits
GEO 601	Indian Stratigraphy	3
GEO 602	Stratigraphic Principles and Sedimentation	3
GEO 603	Remote Sensing, GIS and Applications	3
GEO 604	Geophysical Exploration	3
GEO 605	Elective 3	2
GEO 606	Elective 4	2
GEO 607	Geological Field Methods and Mapping Lab	2

GEO 608	Geophysical Exploration Lab	2
GEO 609	Project/Dissertation	2
Total Credits		24

Elective Courses Semester VI		
Subject Code	Title of the Subject	Credits
GEO 605	Elective 3 - Environmental Geoscience and Disaster Management	2
GEO 606	Elective 4 - Paleontology and Paleobotany	2

Curriculum for B.Sc. (Blended) Earth Science Course (Semesters V – VI)

Nomenclature: GEO – Earth Science

Semester V

GEO 501 - Structure, Tectonics and Geodynamics of the lithosphere	
Topic Details	Lectures
Concept of isostasy, ocean floor spreading, continental drift, plate tectonics. Definition of plate, platform and shield. Different tectonic settings on Earth (MOR, Rift valleys, Island arcs).	36
Concept of strike and dip, Dipping strata, unconformities, Brunton compass, Understanding stress and strain, ductile vs. brittle deformation, the effects of temperature, time, pressure, pore fluids and strain rate on rock strength, and the mechanisms of rock deformation.	
Definition, elements, types and nature of joints, fractures, shear zones, faults, and folds.	
<u>Recommended Books/references:</u> <ul style="list-style-type: none"> • <i>Patwardhan, A.M. (2012) The dynamic Earth System, PHI Learning Pvt. Ltd.,</i> • <i>Moore E.M. and Twiss R.J. (1995) Tectonics, W. H. Freeman</i> • <i>Valdiya, K.S.,(1984) Aspects of Tectonics: Focus on Southcentral Asia, Tata-McGraw Hill, New Delhi,</i> • <i>Belousov, V.V. (1980) Geotectonics, Springer-Verlag Berlin Heidelberg</i> • <i>Condie, K.C.(1989) Plate Tectonics &Crustal Evolution, Butterworth-Heinemann</i> 	

- *Billings, M.P. (1942) Structural Geology, Prentice Hall,*
- *Badgley, P. C. (1965) Structural & Tectonic Principles, Harper & Row*
- *Valdiya K.S. (2014) Making of India, Springer.*
- *Valdiya K.S. (1984) Aspects of tectonics, Tata Mcgrath Hill.*

GEO 502 - Hydrogeology	
Topic Details	Lectures
Qualitatively and quantitatively investigations of the fundamental physical and chemical processes governing groundwater flow and composition.	36
Aquifer properties: porosity, permeability, regional geology and hydrology.	
Hydrogeology of crystalline rocks, water-rock interactions, and subsurface microbial activity.	
Well inventory, Field and laboratory methods used to characterize aquifer properties and including well pumping tests.	
Groundwater chemistry: major ion and isotope analyses and chemical tracers.	
Groundwater Resources of India with special reference to each state.	
Groundwater quality hotspots in India: TDS, F, Ar, U, Fe, etc.	
<u>Recommended Books/references:</u>	
<ul style="list-style-type: none"> • <i>Todd, D.K. and Mays, L.W. (2004) Groundwater Hydrology, John Wiley & Sons.</i> • <i>2. Karanth, K.R. (1987) Groundwater Assessment Development and Management, Tata McGraw-Hill Education.</i> • <i>Raghunath, H.M. (1987) Groundwater, New Age International</i> • <i>Davis, S.N. and Dewiest R.J.M. (1966) Hydrogeology, John Wiley & Sons.</i> • <i>Freeze, R. A. and Cherry, J. A. (1979) Groundwater, Prentice Hall</i> • <i>Hiscock, K. M. (2005) Hydrogeology: Principles and Practice, Blackwell Publishing</i> • <i>Kresic, N. (1997) Hydrogeology and Groundwater Modeling, Lewis Publishers</i> • <i>Brassington, R. (2017) Field Hydrogeology, Wiley Blackwell</i> • <i>Hudak, P. F. (1999) Principles of Hydrogeology, Lewis Publishers</i> • <i>Pawar, N.J, Das, S. And Duraiswami R.A (2012) Hydrogeology of Deccan Traps and associated Formations in Peninsular India, Geol. Soc. India, Bangalore.</i> • <i>Das Subhajyoti (2011) Groundwater Resources of India. National Book Trust. 1st Edition, 248 p.</i> 	

GEO 503 – Engineering Geology	
Topic Details	Lectures
<p>Topics include: engineering properties of soil and rock geological site investigations of slopes, foundations tunnels, dams, mines, roads, and other developments.</p> <p>Building stones and aggregates.</p> <p>Geophysical survey methods used in Engineering Geology (e.g. Electrical Resistivity).</p>	36
<p><u>Recommended Books/references:</u></p> <ul style="list-style-type: none"> • <i>Blyth, F.G.H. and M. H. de Freitas (1984) Geology for Engineers, ButterworthHeinemann</i> • <i>Krynine, D.P and Judd, W.R (2005) Principles of Engineering Geology and Geotechniques, CBS Publishers & Distributors</i> • <i>Ries, H. and T. L. Watson, (1949) Elements of Engineering Geology, New York, John Wiley & Sons, Inc.</i> • <i>Tony Waltham (2009) Foundations of Engineering Geology, Taylor and Francis.</i> • <i>Chenna Keshvalli (2018) Text book of Engineering Geology, Laxmi Publications.</i> • <i>Gokhale, K.V.G. (2006) Principles of engineering geology, BS publications.</i> 	

GEO 504 - Economic Geology and Mineral Exploration	
Topic Details	Lectures
<p>Indian occurrences of metallic (iron, manganese, chromite, copper, lead zinc, gold, etc.) and non-metallic (barite, fire clay, gypsum, bauxite, etc.) deposits.</p>	36
<p>Type of mineral deposit, ore forming processes, mineral exploration techniques.</p>	
<p>Coal and petroleum geology.</p> <p>Construction and building material, dimension stones.</p> <p>Uranium-Thorium and REE minerals</p>	
<p>Environmental and social issues that relate to mineral resource extraction will also be discussed.</p>	

Recommended Books/references:

- *Tiwari S.K. (2010) Ore Geology, Economic Minerals and Mineral Economics, Atlantic Publishers & Distributors (P) Limited*
- *Aswathanarayana, U.(2005) Mineral Resources Management and the Environment, Nalkema Publishers*
- *Guilbert, John M. and Charles Frederick Park(2007) The Geology of Ore Deposits, Waveland Press*
- *Arogyaswamy R.N.P. (2017) Courses in mining geology, Oxford and IBH publishers*

GEO 505 - Introduction to Marine Geology	
Topic Details	Lectures
Physical oceanography, ocean salinity and ocean currents. El-Nino-La Nino effect relation between climate and ocean in the Indian context.	24
Exclusive economic zones and their economic potential. Principles behind echo sounder and side scan sonar systems and seismic methods.	
Physiographic divisions of oceans, Origin, stricter and evolution of Indian Ocean shelf and margins (estuaries, deltas, tidal flats).	
Approach to be interdisciplinary requiring integration of biological, chemical, physical and geological processes. Past historical impact of sea level changes, coastal erosion and conservation methods, Coastal Regulatory Zones.	

Recommended Books/references:

- *Kenneth, J. (1982) Marine Geology and Geophysics.*
- *Wright J. and Colling A. (1995) Seawater: its Composition, Properties and Behaviour, The Open University*
- *The Open University (1989) Ocean chemistry and deep sea sediments.*
- *Dronkers J. (2005) Dynamics of coastal systems, World Scientific*
- *Woodroffe, C.D. (2013) Coast: Form, process and evolution, Cambridge University Press.*
- *Nittrouer, C.A., Austin, J. A., Field M. E., Kravitz J. H., Syvitski J. P. M., Wiberg P.L.(2007) Continental margin, sedimentation from sediment transport to sequence stratigraphy, Wiley Blackwell.*
- *Bender, M. (2013) Paleoclimate, Princeton Premiers in Climate*
- *Bradley R. S., (1999), Paleoclimatology: Reconstructing climates of the quaternary. Academic Press v. 64 of International Geophysical series.*
- *Einsele, G. (1982) Sedimentary basins-evolution, facies and sediment budget. Springer-Verlag.*
- *Ruddiman, W.F. (2008) Earth's Climate, Past and Future, WH Freeman & Co.*

GEO 506 - Introduction to Analytical Geochemistry	
Topic Details	Lectures
Introduction to Geochemistry – Chemical Classification of igneous and metamorphic rocks, Hydrothermal processes, Geothermometry, Chemical solubility products, Organic geochemistry.	24
Qualitative Chemical Analysis – Preparation of solutions, Analysis of Carbonate Rocks.	
Chemical Analysis of Minor Elements, Cerium and Rare earth elements, Rb-Sr, U, Zr-Hf etc.	
Emission Spectrography – Qualitative and semi-quantitative analysis. Quantitative analysis, Analysis of geochemical samples, Flame Photometry, X-Ray Spectrography, XRD etc.	
Recommended Books/references:	
<ul style="list-style-type: none"> • <i>Brealey, A (1971), Analytical Geochemistry, Volume 5 1st Edition, Elsevier</i> 	

Semester VI

GEO 601 – Indian Stratigraphy	
Topic Details	Lectures
Precambrian evolution of Peninsular India. Stratigraphy and evolution of Dharwar Craton, Aravalli craton, Singhbhum craton, etc. Central Indian Suture Zone	36
Introduction to Proterozoic basins of India Gondwana sedimentation Mesozoic basins of India Deccan Traps volcanic province	
Introduction to Himalayas: Physiographic divisions and tectono-magmatic evolution.	
<u>Recommended Books/references:</u>	
<ul style="list-style-type: none"> • <i>Wadia, D. (1973) Geology of India. McGraw Hill Book co</i> • <i>Krishnan, M.S. (1982) Geology of India and Burma, 6th Edition. CBS Publ.</i> • <i>Ramakrishnan M, and Vaidynadhan, R (1994) Geology of India, Geological Society of India Publication, Bangalore. Vol. I & II.</i> • <i>Valdiya K.S.(2010) The Making of India: Geodynamic Evolution, Springer</i> • <i>Valdiya K.S. (1984) Aspects of tectonics, Tata Mcgrath Hill.</i> • <i>Ravindrakumar (2018) Fundamentals of Historical Geology and Stratigraphy of India, Newage Publications</i> 	

GEO 602 – Stratigraphic Principles and Sedimentation	
Topic Details	Lectures
An introduction to the principles of stratigraphy	36
Nature of sediment formation, transport and deposition Concept of Sedimentary Facies	
Use of primary and secondary sedimentary structures in the interpretation and reconstruction of sedimentary facies, Paleogeography, past climates, and depositional histories.	

Recommended Books/references:

- *Friedman & Sanders, (1978) Principles of Sedimentology. John Wiley and sons.*
- *Pettijohn, F.J., (1975). Sedimentary rocks, Harper & Bros. 3rd Ed.*
- *Sengupta. S., (1997) Introduction to sedimentology. Oxford-IBH.*
- *Pettijohn F.J. (1984) Sedimentary Rocks (3rd Edition), CBS Publishers and Distributors, New Delhi.*

GEO 603 - Remote Sensing, GIS and Applications	
Topic Details	Lectures
Basic concepts in remote sensing, electro-magnetic spectrum. Energy sources, energy interaction in the atmosphere, atmospheric windows, atmospheric effects on remotely sensed data.	36
Aerial photo interpretation, photo-recognition elements, methods of photointerpretation, advantages and limitations of aerial photographs.	
Signatures in remote sensing, sensors and sensor platforms Introduction to aerial photographs, history of aerial photography, aerial camera, types of aerial photographs, classification, principles of stereoscopic viewing, conditions and cause for stereovision.	
Visual image interpretation of satellite imagery, image enhancement, digital analysis, preparation of thematic maps.	
Thermal Infrared remote sensing and microwave remote sensing for geological applications.	
Remote sensing satellites, Indian Remote Sensing Satellite programme.	

Recommended Books/references:

- *Miller Victor C. Miller Calvin F. (1961) Photogeology (International Series in the Earth Sciences. McGraw-Hill Book Company, Inc.*
- *Drury S.A, A Guide to Remote Sensing - Interpreting Images of Earth, Oxford Science Publications, Oxford. (1990)*
- *Sabins, F.F.Jr., (1978) Remote Sensing Principles and Interpretation, Freeman, Sanfrancisco.*
- *Paine, D.P (1981) Aerial photography and image interpretation for resource management, Wiley and Sons, New York. 1986.*
- *Gary L.Prost Remote Sensing for Geologists - A Guide to Image interpretation, Gordon and Breach Science Publishers, The Netherlands. 1997.*
- *Reddy A. (2012) Introduction to Remote Sensing and GIS, BS Publications.*
- *Ramasamy, SM. (1999) Trends in Geological Remote Sensing - Rawat Publishers,Jaipur Rao, D.P. Remote Sensing for Earth Resources, Second Edition, Association of Exploration Geophysicist, Hyderabad p.212, (CERS-236)*

GEO 604 – Geophysical Exploration	
Topic Details	Lectures
Principles and limitations of geophysical exploration, petrophysical properties of rocks, survey methods.	36
Introduction to gravity and magnetic surveying, processing and interpretation steps involved for gravity and magnetic methods	
Elements of seismic surveying, concept of seismic refraction and reflection, ray paths in layered media and interpretation.	
Electrical Resistivity method - Equipment, Vertical electrical sounding vs. Electrical profiling, Slumberger vs. Wenner configuration, Interpretation of resistivity data.	
Application of geophysical exploration.	

Recommended Books/references:

- *Dobrin, M B and Savit C H. (1988) Introduction to Geophysical Prospecting, McGraw Hill Inc.*
- *Ramachandra Rao and Prasaranga, M B. (1975) Outlines of Geophysical Prospecting -A Manual for Geologists by University of Mysore, Mysore.*
- *Bhimasarikaram V.L.S., (1990) Exploration Geophysics - An Outline by Association of Exploration Geophysicists, Osmania University, Hyderabad.*
- *Telford, W. M., Geldart, L. P., and Sheriff, R. E., (1990) Applied geophysics (vol. 1). Cambridge University Press.*
- *Lowrie, W., (2007) Fundamentals of Geophysics. Cambridge University Press.*
- *Parasnis D. S. (1986): Well Logging in Oil Fields, In: Principles of Applied Geophysics, Springer.*

GEO 605 – Environmental Geoscience and Disaster Management

Topic Details	Lectures
<p>Surface and subsurface water resources, hydrogeologic cycle and pollution, point, line and area sources of pollution.</p> <p>Water quality parameters, BIS standards, organic and inorganic pollutants, heavy metal pollution, remedial measures.</p>	24
<p>Earthquakes and their prediction, Richter scale, seismic hazard zoning map of India, Building codes and public education.</p> <p>Different types of volcanoes, volcanic hazards and their occurrence in the plate tectonic context.</p>	
<p>Cyclones and Floods, fundamental river processes and the interaction between a river and its floodplain.</p> <p>Examine the costs and benefits, to both humans and to ecosystems, of both technological approaches (e.g., dams and levees) and land-use planning approaches (floodplain mapping and zoning) to avoiding flood damages.</p>	
<p>Droughts, meteorological, agricultural and hydrologic types, mitigation of droughts.</p> <p>Landslides, different types and evaluation of technologies for preventing landslides.</p>	

Recommended Books/references:

- *Valdiya, K. S., (1987) Environmental Geology - Indian Context. Tata McGraw Hill New Delhi.*
- *Keller, E. A., (2000) Environmental Geology. Shales E. Merrill Publishing Co., Columbus, Ohio.*
- *Montgomery, C., (1984) Environmental Geology. John Wiley and Sons, London.*
- *Bird, Eric, (2000) Coastal Geomorphology: An Introduction. John Wiley & Sons, Ltd. Singapore.*
- *Liu, B.C., (1981) Earthquake Risk and Damage, Westview.*
- *Sharma J. P., Environmental Studies, Laxmi Publications (P) Ltd, New Delhi*

GEO 606 – Paleontology and Paleobotany	
Topic Details	Lectures
<p>Biochronology & Paleoecology</p> <p>Biochronology</p> <p>Introduction to Biostratigraphy</p> <p>Biostratigraphic Zones</p> <p>Bio-and Chronostratigraphic Units]</p> <p>Correlation of Biostratigraphic Zones</p> <p>Geochronology and Radiometric Dating Methods</p>	24
<p>Paleoecology</p> <p>Evidence of Organic Activities in Rock-layers</p> <p>Relationships among biological communities</p> <p>Comparison with modern species</p> <p>Evolution of communities through Stratigraphic Record</p>	
<p>Advanced Invertebrate Paleontology</p> <p>Application of Invertebrate Paleontology to geological problems</p> <p>Use of Paleozoic and Mesozoic Index fossil species and fossil assemblages in dating, correlation, and stratigraphical subdivision</p>	
<p>Micropaleontology</p> <p>Systematic study of Foraminifera and their biostratigraphic significance</p>	

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