Government of Karnataka

Curriculum Framework for Undergraduate Programme in Colleges and Universities of Karnataka State

5th and 6th Semester Model Syllabus
for
BSc in
EARTH SCIENCES

Submitted to
Vice Chairman
Karnataka State Higher Education Council
30, Prasanna Kumar Block, Bengaluru City University Campus,
Bengaluru, Karnataka – 560009

Model Curriculum

of

BSc

in

EARTH SCIENCES

5th & 6th Semester

Karnataka State Higher Education Council

Government of Karnataka

Model Curriculum

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**Geographic Information System and GPS (Theory)**		
Course Code:	**ERS C-9- Theory**	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**Hrs**
Unit 1	Introduction to GIS, Fundamentals, Functions and Components of GIS. Data and Information. Maps and Spatial Information, Coordinate Systems of the Earth.	15hrs 1 Credit
Unit 2	Map Projection: Earth's size and shape in time and space. Properties of Map Projections, Types of basic Projections Classification - Cylindrical, Conical and Azimuthal projections Coordinate System- Geographical Coordinate System, Projected Coordinate System (UTM).	15hrs 1 Credit
Unit 3	Raster and Vector Data Models. Spatial Data Structures, Topology, Data quality and errors, Map Algebra. Buffer Analysis. Overlay Analysis. Proximity Analysis. Data Conversions. Surface Analysis.	15hrs 1 Credit
Unit 4	Introduction to GPS, History, Satellite Navigations constellations, GPS Errors. Reference Systems and Coordinate systems. Structure of GPS Signal. GPS Observables. Surveying with GPS, Data Processing, GIS and GPS data integration, Navigation with GPS, Atmospheric Effects on GPS Signal, and Applications of GPS	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Course Title	**Geographic Information System and GPS (Practical)**	Practical Credits	**02**
Course Code	**ERS C-10**	Contact Hours	**4 Hours per week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Introduction to Software and its Tools.
2. Introduction to Satellite Data Products and Maps types.
3. Georeferencing (Image Rectification).
4. Digitization of Maps, Editing the Data.
5. Displaying the data: Classification of Spatial Data.
6. Spatial data Labeling and Creating Map Layout.
7. Geo-Processing Tools: Clip, Union, Dissolve, Merge, Intersect.
8. Buffer Analysis.
9. Introduction about GPS Device.
10. GPS Data Collection and Applications.

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	Concepts and Techniques of Geographic Information Systems - C.P.Lo, Albert K.W. Yeung
2	Principles of Geoinformation sytems – Burrough and Rachel
3	Geographical information system and Science – Goodchild and Longley
4	Geographical Information Science, P.S.Roy
5	Geographic Information System – Bhatt
6	John E. Harmon & Steven J. Anderson., The design and implementation of Geographic Information Systems, John Wiley & Sons, 2003.
7	Kang Tsung Chang., Introduction to Geographic Information Systems, Tata Mc Graw Hill Publishing Company Ltd, New Delhi, 2008
8	Hofmann W.B &Lichtenegger, H. Collins., Global Positioning System – Theory and Practice, Springer-Verlag Wein, New York,2001.
9	Gunter Seeber., Satellite Geodesy Foundations-Methods and Applications,2003

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**Environmental Science and Geotectonics (Theory)**		
Course Code:	**ERS C-11**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**Hrs**
Unit 1	**Fundamentals of Environmental Science**: Introduction, structure, composition and interactions among the land, atmosphere and ocean, Earth and Sun's relationships. Principles of weather and climate systems, and their impaction by human activities. Meteorological hazards and extreme weather conditions (floods and droughts). Climate classifications and climatic zones of the earth with special reference to India. Proxies for understanding the long-term variations in the climate. **Introduction to biogeochemical cycling of elements.** Composition of air, water and sediments and its governing factors, including human activity. Principles of an ecosystem including biotic, abiotic components and foodweb. biodiversity and its conservation. Sampling equipment and analytical methods followed in the measurement of different environmental parameters.	15hrs 1 Credit
Unit 2	**Environmental pollution, mitigation and legislation:** Introduction, primary and secondary sources of pollutants in the environment. Principles of soil, air, water pollution. National and international standards for evaluating air, soil and water pollution. Solid and effluent wastes management and mitigation. Noise, thermal and marine pollution. Environmental Laws and legislation related to impact assessment conservation of water biodiversity, Forest and solid was to management.	15hrs 1 Credit
Unit 3	**Introduction to geotectonics and global tectonics**. Composition, mineralogy, and density and temperature variations in the interior layers of the earth. Continental and oceanic lithospheres, their interaction with the asthenosphere and upper mantle. Crustal heat-flow and its variations in different parts of the earth. Neotectonics and its importance in sea-level fluctuations. **Geodynamic processes**: Morphology of the continental and oceanic floors. Continental Drift, different lines of evidence to support this hypothesis. The concept of the super continents and their fragmentation and migration in the history of the Earth. Sea-floor spreading, magnetic anomalies to support this hypothesis. Plate tectonics. Convergent and divergent plate boundaries, triple junction, hotspots and mantle plumes. **Seismology:** Earthquakes, and its prediction and measurement. Seismic zones of India. Seismic Tomography. Thermal springs and geothermal energy. Concept of vertical tectonics, isostasy and its adjustment with reference to glacial isostatic adjustment. Mountains, their types and building up of the Alpine-Himalayan mountain chain. Major mountains of India and their significance.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

References	
1	Andrews, J.E., Brimblecombe, P., Jickells, T.D., Liss, P.S. and Reid, B. (2009). *An introduction to environmental chemistry*. John Wiley & Sons.
2	Beloussov, V.V. (1980) Geotectonics. Mir Publishers, Moscow, Springer-Verlag, 330 pp., 1980. ISBN: 978-3-642-67176-0
3	Bloom A.L., 2001: Geomorphology: A Systematic Analysis of Late CenozoicLandforms,Prentice-Hall of India, New Delhi
4	Condie, K.C. (2013). Plate tectonics & crustal evolution. Elsevier.
5	Keller, E.A. (2007). *Introduction to environmental geology*. Prentice-Hall, Inc..
6	Knödel, K., Lange, G. and Voigt, H.J., 2007. Environmental geology: handbook of field methods and case studies. Springer Science & Business Media.
7	Mackenzie, F.T. (2011) Our Changing Planet: An Introduction to Earth System Science and Global Environmental Change, 4th edition, Prentice Hall, New York, N.Y., 579 pp.
8	Scheidegger, A.E. (2012). *Principles of geodynamics*. Springer Science & Business Media.
9	Skinner, Brian J. and Stephen C. Porter (2000), The Dynamic Earth: An Introduction to physical Geology, 4th Edition, John Wiley and Sons
10	Turcotte, D.L. and Schubert, G. (2012) Geodynamics 2nd edition, Cambridge University Press, 2012, ISBN-13: 978-0521666244 (available in the internet).
11	Valdiya, K.S. (2004). *Geology, Environment, and Society*. Universities Press.
12	Valdiya, K.S. (2013). *Environmental Geology: Ecology, Resource and Hazard Management*. McGraw-Hill Education.
13	Valdiya, K.S., and Sanwal, J. (2017). *Neotectonism in the Indian Subcontinent: landscape evolution*. Elsevier.

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Course Title	**Structural Geology and Field Visit (Practical)**	Practical Credits	**02**
Course Code	**ERS C-12**	Contact Hours	**4 Hours per week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Thickness calculation problems.
2. Dip and strike Problems.
3. Interpretation of underground structure from borehole data.
4. Construction of geological cross-section.
5. Structural contour maps: Tracing of Outcrops.

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References:

Billings, M.P. (1978) Structural Geology – Prentice – Hall of India Private Ltd. New Delhi.

Manual of geological maps N W GOKHALE

Suppe, J.(1985) – Principles of structural geology – Prentice – Hall

Badgley P.C. – Structural Geology for the exploration geologist.

Whitten, T- Structural Geology.

Field Visits:

Visit to important field areas showing good geological settings. Some selected areas like: Karighatta, Doddakanya mines, Pegmatite dykes in and around KRS Dam, Holenarasipura, Bageshapura, Chamundi Hills, Hutti Gold Mines, Arasikere areas, Byrapur, Ingaldhal, famous Igneous, Sedimentary and Metamorphic terrains of Karnataka.

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**Geochemistry and Mining Geology (Theory)**		
Course Code:	**ERS C-13**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Geochemistry	
Unit 1	Geochemistry: Basic concepts and Scope of Geochemistry. Geochemical classification of elements, Age, origin and composition of the universe with special reference to solar system. Biochemical classification of element and geochemical cycles. Geochemistry- Elements, Atoms, and Chemical Bonds, Principles of Geothermobarometry. Energy, Entropy and Fundamental Thermodynamic Concepts, Laws of Thermodynamics, Enthalpy, Entropy, Heat capacity and free energy, concept of equilibrium and equilibrium constant. Gibbs phase rule, application to mineralogical system - Forsterite-Fayalite; Albite-Anorthite; Albite-Orthoclase. Forsterite-Quartz and Diopside-Anorthite. Basics of Radiogenic Isotope Geochemistry, Decay Systems and Their Applications- Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, U-Th-Pb, C. Stable Isotope Geochemistry- C, S, and O isotope geochemistry.	15hrs 1 Credit
	Mining Geology	
Unit 2	Introduction, mining terminologies, Classification of mining methods – Alluvial mining methods, open-cast mining methods, Quarrying, Underground mining methods – Open stopes, stoping with supports. Geological parameters for mine planning and designing. Drilling: methods and types of drilling methods and their uses. Mine safety, mine ventilation, Mining hazards, advantages and disadvantages of surface and subsurface mining. Impact of mining and mineral processing on environment and human health.	15hrs 1 Credit
	Mineral Economics	
Unit 3	Concept of economics and its importance in national development and economy. Resource scenario of India. Production, demand, supply and substitution of natural resources in global contest. Structure and organisation of mineral industry, valuation of mineral property. Mineral deposits – meaning, specialities. Mineral legislation in India, Concept of mineral resources and its estimation, classification of mineral resources – Indian and International. Mineral legislation, national mineral policy, Mineral Conservation: Introduction, Growth and awareness. Methods of conservation. Limitations in the scope of conservation.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Course Title	**Ore Geology (Practical)**	Practical Credits	**02**
Course Code	**ERS C-14**	Contact Hours	**4 Hours per week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

Identification (with the help of physical properties), chemical composition, origin and Indian occurrences of the following Ore minerals and Industrial minerals

Barite	Bauxite	Biotite	Calcite	Chalcopyrite	Chromite
Cuprite	Dolomite	Fluorite	Galena	Garnet	Graphite
Gypsum	Hematite	Ilmenite	Kyanite	Limonite	Magnesite
Magnetite	Malachite	Muscovite	Psilomelane	Pyrite	Pyrolusite
Serpentine	Sphalerite	Stibnite	Talc	Tourmaline	

Distribution of mineral deposits

Formation, association and Indian distribution of following ore minerals: Mica, Copper, Manganese, Lead and Zinc, Bauxite, Chromite and Gold

Numerical on Ore reserve estimation

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References	
1	William M. White, Geochemistry, 2013, Wiley-Blackwell
2	Krauskopf, K. B. and D. K. Bird. 1995.Introduction to Geochemistry. New York:McGraw-hill.
3	Principles of Geochemistry – Brain Mason
4	Geochemistry by Rankama and sahama
5	Rare earth element Geochemistry by Henderson
6	Elements of Mining Geology - Young
7	Elements of Mining - Lewis
8	Mining of mineral deposits - Shevyekov
9	Introduction of mining - stoces
10	Principles of Mining Geology, Arogyaswamy
11	An Introduction to Mineral Economics by K K Chatterjee
12	Mineral Economics by Sinha R.K & Sharma N L, Oxford &IBH

Discipline Specific Electives(Any one to be Chosen)

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**A. Earth and Health (Theory)**		
Course Code:	**ERS E-1**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Introduction	
Unit 1	History of mineral medicine. Advantages and disadvantages of minerals in medicine. Formation of minerals and rocks. Properties of minerals- Physical properties, Chemical properties, Magnetic properties. Study of selected minerals with reference to the Physical, chemical properties, Types, occurrence and medicinal properties of following minerals: Sulphur, Iron oxide, Iron hydroxide, Ferrous sulphate, Copper sulphate, Calcium carbonate, Magnesium silicate, Cinnabar, Orpiment, Realgar, Potash alum, Ammonium chloride, Borax, Talc, Asbestos.	15 hrs 1 Credit
Earth Minerals in Health		
Unit 2	Study of selected minerals with reference to the Physical, chemical properties, Types, occurrence and medicinal properties of following minerals and metals. Gold, Silver, Copper, Iron, Lead, Tin, Zinc. Knowledge of animal products with mineral contents. Cowry shells, Egg shells, Antlers (Horns), Pearl oyster, and related.	15 hrs 1 Credit
Mineral Processing for Pharmaceutical Products		
Unit 3	Pharmaceutical processing techniques for minerals. Formulating Simple minerals like : Formulating Sulphur, Formulating Zinc ointment, Formulating Iron oxide, Formulating Copper sulphate, Formulating Ferrous sulphate, Formulating Orpiment, Formulating Realgar, Formulating Ammonium chloride, Formulating Borax, Formulating Alum, Formulating Cinnabar	15 hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10

Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

1. Laura Koniver, The Earth Prescription: Discover the Healing Power of Nature with Grounding Practices for Every Season. (2021), Tantor Media Inc., USA.
2. Gary S. Moore, Living with the Earth: Concepts in Environmental Health Science (2007), CRC Press, USA.
3. Bernard J. Turnock , Public Health, Jones and Bartlett Learning, USA (2015).
4. O. Selinus (Editor), Essentials of Medical Geology. Springer Science Business Media Dordrecht. (2013)
5. C.B. Dissanayake and R. Chandrajith, (2009), Introduction to Medical Geology. Springer.
6. M. Ibaraki and H. Mori, Progress in Medical Geology. Cambridge Scholars Publishing. (2017).
7. Miomir M. Komatina, Effects of Geological Environments On Human Health, Burgess Publishers (2004).
8. Centeno, J.S; Finkelman, R.B; and Selinus, O. *Medical Geology: Impacts of the Natural Environment on Public Health*. (2016).
9. Rolf O. Hallberg, Medical Geology, Environmental Geology–Burgess Publishers, (2007).

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**B. Geology for Society (Theory)**		
Course Code:	**ERS E-1**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
Unit 1	**Introduction Geology and its importance for society**: For industry including energy, minerals, water and food industries and for sustainable living on planet earth. Climate change and its impacts, managing carbon emissions, Natural and anthropogenic hazards, and how to build resilience. **Geology and economy of a country**: Mineral and energy resources, soil resources and their types and importance for agriculture, surface and groundwater resources, Industrial, agricultural and water security. **Mineral Resources**: Major metallic mineral resources- iron, manganese, chromium, nickel, aluminium; Energy minerals- fossil fuels, radioactive minerals; Industrial minerals- construction materials; ceramic, refractory and abrasive minerals; zeolites; Critical/strategic minerals- rare earth element minerals; minerals for agriculture- fertilizer minerals; precious metallic and non-metallic minerals; Natural and synthetic minerals.	15 hrs 1 Credit

Unit 2	**Water**: Climate change and water security, recession of glaciers and impact on future water resources especially in the Indo-Gangetic and Brahmaputra valleys; rising sea level, sea water invasion and water security in coastal areas, groundwater resources, water cycle and water budget, sustainability of groundwater resources; quality of surface and groundwater, geogenic and anthropogenic contaminants; impact on human and animal health. **Air quality**: Climate change and its relation carbon emissions, arresting carbon emissions and global warming, carbon sequestration.	15 hrs 1 Credit
Unit 3	**Natural hazards**: Earthquakes, tsunamis, volcanoes, landslides, cyclones, heat and cold waves, floods and droughts, land degradation and desertification. **Engineering and protecting ourselves**: River linking, interstate and international sharing of water resources, water treaties, infrastructure development-roads, bridges, tunnels, railways, airports, geological repositories for waste management etc., earthquake resistant structures, slope stabilization, regulating and protection of environment - air, water and soil, desert greening.	15 hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

1. Geology and Society, by Donald R. Coates, Springer, N.Y. USA (1985).
2. Humans as Geologic Agents, by J.Ehlern, W.C. Haneberg and R.A. Larson, Publisher The Geological Society of America, USA, Vol.16 (2005).
3. Geology of Mankind, by Paul J.Crutzen, Nature 415, 23(2002).
4. Modern Geology, by N.A. Yasamanou Science for Everyone series, Publishers MIR Books, Moscow (2020).

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**C. Critical Minerals of Karnataka (Theory)**		
Course Code:	**ERS E-1**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Introduction	
Unit 1	Critical Minerals – Definition, Distribution, Geological significance, Economic and National importance. Role of critical minerals in National Policies, International Policies, contribution to advanced technology. National Security. Indirect measure of the quantum use of a mineral in industrial development.	15 hrs 1 Credit
	Critical Minerals Evaluation	
Unit 2	Evaluation of criticality of minerals, economic importance, strategic and supply risks. Some important critical minerals of India with examples Mic minerals, Gold, Tungsten, Rare Earths Platinum, Lithium. Their economic values reserves and distribution. Supply chain studies involved in their exploration and beneficiation	15 hrs 1 Credit
	Critical Minerals of Karnataka	
Unit 3	Critical minerals of Karnataka: Gold, Platinum, Lithium, Tungsten, Atomic minerals, Rare Earths, Trace Elements, Their reserves, distribution, occurrence and origin. Laboratory and Field studies involved. Various directorates like Atomic Minerals Division, Rare Earths India Ltd., Mines and Geology Department, GIS, etc.	15 hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10

Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

1. Minerals, Critical Minerals and the US Economy, National Academies Press, Washington DC., USA (2008)
2. Critical Metals Handbook (Wiley Online Book), Editor: Gus Gunn, Publishers: 2014 John Wiley & Sons, Ltd.
3. Critical Minerals for India Assessing their Criticality and Projecting their Needs for Green Technologies, By Rajesh Chadha and Ganesh Sivamani. CSEP Working Paper-19 (2021).

Vocational Papers (Any one paper to be chosen)

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**A. Remote Sensing and GIS (Theory)**		
Course Code:	**Vocational V-1**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Remote Sensing	
Unit 1	Concepts of Remote Sensing, electromagnetic spectrum, energy interactions with earth surface features & atmosphere, atmospheric effects, satellite orbits, Sensor Resolution, types of sensors. Remote Sensing Platforms and Sensors, IRS and other satellites. Visual interpretation techniques, spectral properties of soil, water and vegetation. Concepts of Thermal and Hyperspectral remote sensing	15hrs 1 Credit
	GIS	
Unit 2	Introduction to GIS: Introduction, History of GIS, GIS Components, Maps, Types of maps, Map scale, Types of scale, Co- ordinate systems, Map projections, Map transformation, Geo-referencing, GIS Applications in Real life. Data storage, Database structure models, database management system, GIS Data model, vector data, raster data, attribute data, geo-database and metadata.	15hrs 1 Credit
	Introduction to GPS	
Unit 3	Overview of GPS, GPS segments, GPS satellite generations, current GPS satellite constellation, control sites. Photo geology: Types & geometry of aerial photographs; factors affecting aerial photography; types of camera, film and filters; factors affecting scale; Concepts of Digital image processing, image enhancements, qualitative & quantitative analysis and pattern recognition, classification techniques and accuracy estimation.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10

Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Books

1. Remote Sensing and Image Interpretation by Thomas M. Lillesand and Ralph W. Kiefer, Wiley Publishers, 7th Edition,
2. Geographic Information systems – An Introduction by Tor Bernhardsen, Wiley India Publication,
3. Concepts and Techniques of Geographic Information Systems (2016) By Lo and Yeung

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**B. Geo-Statistics and Computer Applications in Earth Science (Theory)**		
Course Code:	**Vocational V-1**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
Unit 1	Introduction to statistics**,** sampling, data collection, random variables, probability frequency function & frequency distribution. Measures of central tendency – Averages; Measures of dispersion; and skewness and kurtosis of the given geological parameters. Correlation and regression analysis, Testing of Hypothesis – t-test, F – test, and Chi square test.	15hrs 1 Credit
Unit 2	Introduction to computers, Organization of a computer, concepts of Information Technology, benefits and limitations of IT. Implementation of IT in the field of Geology stake holders and interfaces-Challenges in the geology field induced by I.T. Applications of I.T related to Geophysics, Geochemistry, Remote Sensing, Hydrogeology, Environmental Geology, Mining Geology & Applications to modeling in Geology.	15hrs 1 Credit
Unit 3	Computer applications for calculation of mineral formula using Microsoft excel program, Generation of graphs – line graph Histogram, Pie graph, and Trilinear plots, Petrochemical calculations using IGPET / GDP-Pet software programs. Application of MS Office for geological report generation. Pressure-Temperature calculations using relevant computer programs. Testing of hypothesis with examples from geological populations and discussing their significance. Solving problems using Geological data on measures of central tendency, Frequency distribution, Correlation and Regression and Testing of Hypothesis with the help of open source statistical programs.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

- Sarma D.D. Geostatistics with applications in Earth Sciences, Springer Publ., pp.205.
- J.-P. Chiles and P. Delfiner, Geostatistics; Modeling spatial uncertainty, Wiley Publ., pp.731.
- H. Wackernagel, Multivariate Geo-statistics, Springer Publ., pp.257.
- Kitanidis, P.K., Introduction to Geo-statistics, Cambridge University Press., pp.271.
- C. Lantuejoul, Geo-statistical Simulation, Springer Publ., pp.262.
- J. Awange, B. Palancz, R.H. Lewis, L. Volgyesi, Mathematical Geosciences, Springer Publ., pp.615.
- Olea, R.A., Geo-statistics for Engineers and Earth Scientists, Springer Publ., pp.309.
- RobsonWendy, Strategic management and information systems-Pitman Publishers.
- S.K Banasandra, Computers Today.
- Richard Fox-Information Technology-An introduction for today's digital world Elmansic / Navathe-Fundamentals of database system

Program Name	**BSc in EARTH SCIENCES**	Semester	**V**
Course Title	**A. Water Quality and Management (Theory)**		
Course Code:	**Vocational V-1**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Introduction	
Unit 1	Physical, chemical and Biological properties of water, Water quality and health linkage; impurities (pollutants and contaminants) in water, their significance and estimation techniques, water borne diseases, standards of potable water. Impact of water pollutants on environment; self-purification of waste in streams; zones of purification, eutrophication; disposal standards**.** Lakes systems: thermal stratification, dissolved oxygen.	15hrs 1 Credit

Water treatment		
Unit 2	Aeration and types of aerators; purpose and mechanism of flocculation; coagulants used in water treatment, factors influencing coagulation, estimation of coagulant dose, types of flash mixers and flocculators, sedimentation, analysis of discrete and flocculent settling, sedimentation tanks, Filtration: types and design of filters, factors effecting efficiency of filtration, operational issues in filtration, Disinfection: chemical and non-chemical methods, chick's law, Tertiary treatment methods for removal of color, salinity, hardness, fluorides, Arsenic, iron and manganese, Treatment process including Adsorption, Reverse Osmosis, Electro-dialysis, Ion-exchange, Chemical and Distillation techniques. **Physical treatment** methods-screen chamber; grit separators; primary and secondary settling tanks. **Biological treatment**: Biology of sewage treatment; BOD growth curve and analysis; estimation of BOD rate constant; types of biological treatment processes; process description and design principals; removal of nitrogen and phosphorus. Sludge stabilization and dewatering systems; Low cost sewage treatment technologies-septic tanks; reed bed; oxidation ponds and lagoons.	15hrs 1 Credit
Water resources and quality management in India		
Unit 3	Water availability; water stress index; status and trend of surface and groundwater; issues and policy interventions; pollution of rivers, lakes and ground water, GAP and National River Action Programme; role of national and international agencies in water health and sanitation.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

1. Gilbert M. Masters and Wendell P. Ela (2017) Introduction to Environment Engineering and Science. 3rd ed. Pearson,
2. Garg S.K. (2007) *Sewage Disposal and Air Pollution Engineering,* 20th ed, Vol. II, New Delhi, Khanna Publisher.
3. Garg S.K. (2007) *Water Supply Engineering,* 18th ed, Vol.I, New Delhi, Khanna Publisher.
4. Birde G.S. and Birde J.S. (2004) *Water Supply and Sanitary Engineering*, 7th ed., New

Delhi,Dhanpat Rai Publishing.
5. Chatterjee A.K. (2010) *Water Supply, Waste Disposal and Environmental Engineering*, 8th ed., NewDelhi, Khanna Publisher.
6. Eckenfelder W.Jr. (1999) *Industrial Water Pollution Control*, 3rd ed., New York, McGraw-Hill.
7. Metcalf and Eddy (2003) *Wastewater Engineering: Treatment and Reuse*, 4th ed., New Delhi, TataMcGraw-Hill.
8. Nathanson J.A. (2009) *Basic Environmental Technology: Water Supply, Waste Management andPollution Control,* 4th ed., New Delhi, PHI Learning.

Advanced Reading Material (Must Read/Watch)

1. Joan Rose: Water is Life but Water Quality is Helath http://www.iwa-network.org/news/water-is-life-but-water-quality-is-health/
2. Video Presentation: Sedlak David, Healthy Tasty or Toxic: A Chemists view of Drinking Water
3. Animation Movie: Rango 2011
4. Documentary: Parched NAT GEO
5. Iran Water Crisis: https://www.aljazeera.com/programmes/peopleandpower/2016/11/iran-water-crisis-161109114752047.html
6. Victor Mallet (2018) River of Life and River of Death

Journals

1. American Society of Civil Engineering, Environmental Engineering.
2. Indian Water Works Association
3. Water Research
4. Water Science and Technology
5. Environment Pollution

Model curriculum for VI semester

Government of Karnataka

Model Curriculum

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**Basic Computer Programming with C and Python (Theory)**		
Course Code:	**ERS C-15- Theory**	No. of Credits	**04**
Contact hours	**60 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**Hrs**
Unit 1	Introduction to C language: Introduction to computing, Constants, variables, Data types, operators and expressions, Input and output operations. Textbook 1: Chapter 1, 3, 4, 5 Decision making & Branching: Introduction, Decision making with if statement, simple if statement, the if-else statement, nesting of if-else statement, the else-if ladder, the switch statement, ternary operator? Goto statement, Programming examples and exercises. Textbook 1: Chapter 6	15hrs 1 Credit
Unit 2	Looping: Introduction, the while statement, the do statement, the for statement, break and continue, Programming examples and Exercises. Textbook 1: Chapter 7 Arrays: Introduction, One-dimensional array, Declaration of One-Dimensional arrays, Initialization of one- dimensional arrays programming examples (Linear search, binary search, bubble sort), Two-dimensional arrays, Initialization of two-dimensional arrays, programming examples (Addition of two matrices, multiplication of two matrix) Textbook 1: Chapter 8	15hrs 1 Credit

Unit 3	Strings: Introduction, Declaring and Initializing string variables, Reading and writing strings, String handling functions, String input and output functions, Array of strings. Textbook 1: Chapter 9 Functions: Introduction, need for user-defined functions, elements of user defined function, Definition of functions, parameter passing mechanisms: Call by value and call by reference. Textbook 1: Chapter 10 Textbook 2: Chapter 14.3	15hrs 1 Credit
Unit 4	Why should you learn to write programs, Variables, expressions and statements, Conditional execution, Functions, Iteration, Strings? Textbook 3: Chapters 1 – 6	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Recommended Books:

Text Books:

1. E. Balagurusamy, "Programming in ANSI C", Eighth Edition McGraw-Hill
2. Vikas Gupta: Computer Concepts and C Programming, Dreamtech Press 2013.
3. Charles R. Severance, "Python for Everybody: Exploring Data Using Python 3", 1st Edition, CreateSpace Independent Publishing Platform, 2016. (http://do1.drchuck.com/pythonlearn/EN_us/pythonlearn.pdf

Reference Books:

1. Brian W. Kernighan and Dennis M. Ritchie: The C Programming Language, 2nd Edition, PHI, 2012.

2. Charles Dierbach, "Introduction to Computer Science Using Python", 1st Edition, Wiley India Pvt Ltd, 2015. ISBN-13: 978-8126556014

3. Gowrishankar S, Veena A, “Introduction to Python Programming”, 1st Edition, CRC Press/Taylor & Francis, 2018. ISBN-13: 978-0815394372

Course Title	**Basic Computer Programming with Languages (Practical)**	Practical Credits	**02**
Course Code	**ERS C-16**	Contact Hours	**4 Hours per week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Develop an algorithm and implement simple C program to solve simple computational problems using arithmetic expressions, demonstrate familiarization with programming environment, concept of naming the program files, storing, compilation and debugging, using different data types.
2. Draw the flowchart and implement a simple C program to solve problems involving if-then-else structures to find the largest of given three positive integers.
3. Write a menu driven C program using switch-case to find: (a) Sum of the digits of number (b) Factorial of N.
4. Design and develop a flowchart or an algorithm that takes three coefficients (a, b, and c) of a Quadratic equation ($ax^2+bx+c=0$) as input and compute all possible roots. Implement a C program for the developed flowchart/algorithm and execute the same to output the possible roots for a given set of coefficients with appropriate messages. (Using switch statement).
5. Design and develop an algorithm to find the reverse of an integer number NUM and check whether it is PALINDROME or NOT. Implement a C program for the developed algorithm that takes an integer number as input and output the reverse of the same with suitable messages. Ex: Num: 2014, Reverse: 4102, Not a Palindrome.
6. Write a Python program to find sum and average of two numbers?
7. Write a Python program to convert temperature in Celsius to Fahrenheit.
8. Write a Python program to check whether a given number is prime or not.
9. Write a Python program to find length of string and to convert upper to lower case of a string.
10. Write a program to count a number of vowels in a string.

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**Applied Geophysics (Theory)**		
Course Code:	**ERS C-17**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**Hrs**
Unit 1	Solid Earth Geophysics: Introduction to Geophysics and its branches. Solar system: origin, characteristics of planets, Earth: rotation and figure, Geoid, Spheroid and topography. Plate tectonics and Geodynamic processes, Thermal history and heat flow, Temperature variation in the earth, convection currents. Normal gravity field; Clairaut"s theorem; Shape of the earth; deflection of the vertical, geoid, free-air, Bouguer and isostatic anomalies.Gravity field of earth and Isostasy. Geomagnetism, elements of earth's magnetism: Internal and External fields and their causes, Paleomagnetism, Polar wandering paths, Continental drift, Seafloor spreading and its geophysical evidences. Electromagnetic radiation and propagation of Waves: EM Radiation	15hrs 1 Credit
Unit 2	Elements of earthquake seismology;focal depth, epicenter, great Indian earthquakes, Intensity and Magnitude scales. Energy of earthquakes. Seismic waves: types and their propagation characteristics, absorption, attenuation and dispersion. Principles of Seismic prospecting, Elastic properties of rocks and minerals,various seismic methods.Principle of electromagnetic seismograph, displacement meters, velocity meters, accelerometers, Broadband Seismometer. Principles of Gravity method, geophysical anomalies, regionaland local gravity anomalies, instruments, interpretation of gravity anomalies. Principles of Magnetic method, magnetic properties of rocks and minerals, various instruments used in magnetic prospecting, and interpretation of magnetic anomalies.Interpretation of anomalies of simple geometric bodies using gravity and magnetic methods. Electrical properties of rocks and minerals, concepts and assumptions of horizontally stratified earth, anisotropy and its effects on electrical fields, geoelectric and geological sections, D.C Resistivity method. Concept of natural electric field, various electrode configurations, Profiling and Sounding (VES). Types of Sounding curves, Concept of Electrical Resistivity Tomography (ERT).	15hrs 1 Credit

Unit 3	SP Method: Origin of SP, application of SP surveys. Induced Polarization (IP) Method: Origin of IP, Membrane and Electrode polarization, time and frequency domains of measurement, chargeability, percent frequency effect and metal factor. Principles of Electromagnetic prospecting, various EM methods: VLF (very low frequency); AFMAG (Audio frequency magnetic) methods; and central frequency sounding; transient electromagnetic methods; magneto-telluric method; geomagnetic depth sounding. (Only working principles, limitation and its application in geology, No derivations and problems) Principles of Well logging method, instrumentations, operational procedures and interpretations of various geophysical logs: SP, resistivity and micro resistivity, gamma ray, neutron, sonic, temperature, calliper and directional logs. Radiometric and Airborne Geophysics: Principles of radioactivity, radioactivity decay processes, units, radioactivity of rocks and minerals, Instruments, Ionization chamber, G-M counter, Scintillation counter, Gamma ray spectrometer	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

References	
1	Introduction to geophysical prospecting - Milton BDobrin
2	Exploration geophysics – Jakaosku JJ
3	Outlinesofgeophysicalprospecting-Amanualforgeologists–MBRamachandraRao
4	Geophysical Methods in Geology – P V Sharama
5	Exploration Geophysics for geologist and Engineers – Bhimasanakaran andGaur
6	Principles of Applied Geophysics – D SParansis
7	Introduction to Geophysics – C H Howel
8	Fundamentals of Geophysics - William Lowrie
9	Applied Geophysics – W. M. Telford

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Course Title	**Applied Geophysics (Practical)**	Practical Credits	**02**
Course Code	**ERS C-18**	Contact Hours	**4 Hours per week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Geophysical Surveys and their Applications (Magnetic, Gravity, Seismic and Electrical methods)
2. Study and interpretation of Electrical Resistivity Data, methods of resistivity profiling and sounding. Vertical Electrical Sounding and Interpretation of Resistivity Curves. Calculation of apparent resistivity; Curve matching techniques.
3. Interpretation of Magnetic, Gravity and Seismic Data.

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**
Formative Assessment as per guidelines are compulsory	

References

1. Interpretation of Resistivity Data, US geological survey professional paper 499
2. Geophysics for Mineral Exploration: A Manual for Prospectors

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**Mineral Processing including Marine Mineral Resources (Theory)**		
Course Code:	**ERS C-19**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Mineral Processing	
Unit 1	**Mineral Processing:** Definition, scope and necessity of Mineral Processing. Physical properties of Ores and their importance in Mineral Processing. Sampling: Definition, purpose, types of sampling and measurements of accuracy of sampling. Simple problems on estimation of recovery and concentration ratio. **Laboratory Analyses:** Definition and measurement of particle size, screening and sub-sieve sizing. Wet and dry sieving. Graphical representation of size analysis data and their applications. Industrial screens and their efficiency. Liberation: Definition, importance and application of ore microscopy in liberation studies and its analysis. Methods of liberation and behavior of locked particles.	15hrs 1 Credit
Unit 2	**Methods of Separation:** Gravity separation, Magnetic separation and Electrical separation. **Flotation**: Introduction, classification of flotation machines and machine features. Physical aspects of flotation. Electrokinetic phenemenon, Electrical Double Layer at the Solid-Liquid interface. Adsorption and its characteristics, pH, Solid/Liquid ratio. Micro flotation tests, Laboratory flotation tests, Flotation Kinetics and Factors affecting flotation. **Dewatering and Drying**. Flocculation and dispersion, principles of flocculation and dispersion phenomena. Different types of flocculants used in dewatering techniques, selective flocculation and their applications. Dewatering by gravity sedimentation and by using screens. Applications of dewatering processes in mineral industries. **Filtration**: Principles and factors affecting the filtration, different types industrial filters, cake filtration. Centrifuging and drying: Different types of thermal dryers and their application, centrifugal sedimentation. **Tailing Disposal:** Tailing ponds and Design & construction, Types, Industrial applications and water reclamation.	15hrs 1 Credit
	Marine Resources	

Unit 3	**Polymetallic nodule deposits:** Introduction – First discovery of nodules from different environments. Distribution; morphology; internal structure; mineralogy; geochemistry; accretion rate and genesis. **Hydrothermal sulfides:** Introduction; geological setting, genesis – hydrothermal activities, direct / indirect evidences, hydrothermal circulation, black and white smokers, mineralogy; geochemistry; ancient analogues; exploration methods. **Metalliferous sediments:** Introduction, definition, characteristics, geological setting genesis; occurrences; ancient analogues; Red Sea deposits-geology history of exploration / discovery details of deposits. **Phosphorites:** Introduction, geological setting and occurrences; associations; form; mineralogy; geochemistry; environments of modern phosphorite deposition; controls on phosphorite formation; genesis - inorganic precipitation and replacement theories, long-term conversion of disseminated deposits. **Placers:** Introduction - Characteristics, placer minerals, classification, environments of placer mineral deposition - rivers, beaches and offshore areas; sand as a resource. **Ocean-energy resources:** Introduction - importance, general characteristics; tidal energy-potential, harnessing, special features of tidal power plants in operation / under active consideration; the Indian scenario.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

List of Reference Books:

1. Indian Mineral Resources – Kirshnaswamy.
2. Industrial Minerals & Rocks of India - Allied Publishers - Deb, S. (1987)
3. Mineral Economics - Call.No.553 - Sinha & Sharma
4. Ore Deposits - W.H. Freeman - Park C.F. (1975).
5. Principles of Mineral Dressing: A.M. Gaudin
6. Ore Processing: S.K. Jain
7. Mineral Processing Technology: B.A. Wills
8. Text Book of Ore Dressing: A.F. Taggart
9. Hand Book of Mineral Dressing: A.F. Taggart

10. Mineral Processing – Recent advances and future trends: S.P. Mehrotra & P. Sarkar
11. Laboratory Experiments in Mineral Processing: S. Venkatachalam & Degaleeson
12. Practicle Size Measurement: T. Allen
13. Mineral Deposits of the Deep Ocean Floor – by Emery, K.O. and Skinner, Brian J (1977)
14. The Indian Ocean: Exploitable Mineral and Petroleum Resources: by G. S. Roonwal Springer Berlin Heidelberg (1986) 198 pages.
15. Sedimentology and Petoleum Geology: Bjorlykke K. (1989).
16. Production of Oil and Gas: by F. Abdulin (1985).
17. Drilling Oil and Gas Wells by Sidorov, N. A., MIR Publishers (1985) (p. 35).
18. Petroliferous basins of India: Bhandari et al. (Ed.).

Course Title	**Economic Geology (Practical)**	Practical Credits	**02**
Course Code	**ERS C-20**	Contact Hours	**4 Hours per week**
Formative Assessment	**25 Marks**	Summative Assessment	**25 Marks**

Practical Content

1. Megascopic study of important economic minerals.
2. Megascopic study of industrial minerals – Abrasives, Refractory, Ceramic, Fertilizer, Chemical minerals, Mineral pigments.
3. Microscopic study of important economic minerals.
4. Mineral sampling and statistical calculations.
5. Calculation of mineral and ore reserves – average thickness of bed, assay value, assay width, specific gravity, tonnage, grade, volume and life of a mine.

Pedagogy: Experiential learning, Problem solving, Project

Formative Assessment for Practical	
Assessment Occasion/ type	**Marks**
Class Records	05
Test	10
Attendance	05
Performance	05
Total	**25 Marks**

Formative Assessment as per guidelines are compulsory

Discipline Specific Electives (Any one paper to be Chosen)

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**A. Nanogeoscience (Theory)**		
Course Code:	**ERS E-2**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
Unit 1	**Introduction:** Nanotechnology – Brief Introduction, Richard Feynman's concept, History, Geological background. Natural nano minerals, Nanoparticles, and their properties. Evolutionary aspects of Nanoparticles. Geological Significance of Natural Nano minerals. Technological significance of Natural Nanoparticles. Anthropogenic nanomaterials and emerging threats to the environment. Classification of nanomaterials based on the structure and morphology.	15 hrs 1 Credit
Unit 2	**Nano minerals:** Occurrence and Origin of Nano minerals. Naturally occurring nanoparticles and their sizes. Natural, incidental, and engineered nanomaterials and their impacts on the Earth system. Examples of Natural Nanominerals – Clay, Carbon Nanotubes, Fullerenes, Magnetite, Perovskite, Garnets, Microplastics, etc. Brief study of Laboratory Synthesis Methods for Nanominerals. Nanofossils, Nanostructures, Nanogeochemistry, Nanogeoscience in Paleoeconology studies. Biomimetic processes of Nanaomaterials formation.	15 hrs 1 Credit
Unit 3	Characterization of Natural Nanomaterials: Analytical Techniques used in understanding of Nanominerals, Nanostructures, and Nanofossils. Powder X-ray Diffraction Technique, Electronic Microscopy, Size estimation using Light Scattering Techniques, Spectroscopic Tools – UV-Visible, Raman, FTIR, Surface Area Measurements, Biological assays to estimate the toxicity of the natural nanomaterials.	15 hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10

Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

1. M. Hochella et al., Science 363, eaau8299 (2019) DOI: 10.1126/science.aau8299
2. M. F. Hochella Jr. et al., Nanominerals, mineral nanoparticles, and Earth systems. Science 319, 1631–1635 (2008). doi: 10.1126/science.1141134; pmid: 18356515.
3. K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, Ed.2, Eslevier Science Publications, UK (2013).
4. K. Namratha, et al., Hydrothermal from – Geology to Nanotechnology and Nanogeoscience (Part - II), J. Geol. Soc. India, (2022) 98:1708-1720 https://doi.org/10.1007/s12594-022-2241-5
5. G.A. Waychunas, and H. Zhang (2008). "Structure, Chemistry, and Properties of Mineral Nanoparticles". *Elements*. **4** (6): pp. 381-387, doi:10.2113/gselements.4.6.381. S2CID 93011769.

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**B. Geology for Society (Theory)**		
Course Code:	**ERS E-2**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Introduction	
Unit 1	Materials – Classification, Natural, and Manmade. Evolution of Materials from Historical times. Classification of Materials. Advanced Materials, Geological Materials, Earth Materials – rocks, minerals, soil, and water. Modern Materials. Materials through ages - Palaeolithic to Modern period. Natural Bulk, fine and Nanomaterials. Natural Raw Materials and Processed Materials. Crystalline, Amorphous, Glasses, Metals, Alloys, Semiconductors, Bio-materials, composites. Ornamental Stones and the Market value. Building Stones as Materials.	15 hrs 1 Credit

Materials of the Earth		
Unit 2	Earth materials as vital / basic components for life, agriculture and industry. Contribution of Crust – crustal composition, crustal evolution, and tectonics in the formation of various earth's materials. Dynamic Processes of Material Transport and Transformation in the Earth's Interior. Important Geological Processes in the genesis and evolution of various Earth's Materials. Earth's Materials and Environmental Applications. Economic Importance of Earth's Materials with Market value.	15 hrs 1 Credit
Characterization of Materials of the Earth		
Unit 3	Analytical Techniques used in the Characterization of Materials of the earth. Powder X-ray Diffraction Technique, Electronic Microscopy, Size estimation using Light Scattering Techniques, Spectroscopic Tools – UV-Visible, Raman, FTIR, Hardness, Thermal Analysis, Mechanical Properties, Luminescence Properties, etc.	15 hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

1. K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, Ed.2, Eslevier Science Publications, UK (2013).
2. Charles G. Sammis, Materials science issues in the Earth and planetary sciences, Progress in Materials Science Volume 46, Issues 3–4, 2001, Pages 231-247. https://doi.org/10.1016/S0079-6425(00)00012-8
3. Ichiro Sunagawa, Materials Science of the Earth's Interior, Springer Publishers (1984), Tokyo, Japan.
4. F. Marumo, Dynamic Processes of Material Transport and Transformation in the Earth's Interior. Springer Publishers (1985).

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**C. Experimental Petrology (Theory)**		
Course Code:	**ERS E-2**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
	Introduction	
Unit 1	Experimental Petrology – Definition, Historical Development. Significance of Experimental Petrology in Earth Science especially Igneous and Metamorphic Petrology. Nature Inspired Geological Processes – Geomimetic, Biomimetic, etc. Creating artificial magmas to measure crystallization behaviour to observing recrystallization of minerals at varying pressure/temperature conditions. Early works in Experimental Petrology in the understanding of Magmatic Crystallization and Differentiation. Synthetic Magma. Fractional Crystallization, Equilibrium Crystallization. Contribution of Experimental Petrology in the study of Rock and Mineral Chemistry.	15 hrs 1 Credit
	Experimental Petrology – as a Geological Tool	
Unit 2	Basics of Thermodynamics – phase rule and types, entropy, enthalpy, free energy, chemical potential, kinetics, etc. Understanding of different Types of Phase Diagrams - from simple unitary to Multi-component systems. Characteristic examples of phase diagrams representing various rocks and mineral systems. Understanding the origin of Basalts, Granites, Pegmatites, Ultrabasics, Gneisses and Schistose rocks from the Experimental Petrology Perspectives.	15 hrs 1 Credit
	Equipment used in Experimental Petrology	
Unit 3	Types of Commonly used equipment in Experimental Petrology. Open Systems and Closed Systems. High Pressure Systems, Low Pressure Systems. Crucibles, Materials used for crucibles making - Silica, Alumina, Noble Metal Crucibles. Basic requirements in the selection of a suitable crucible material. Reactors, Autoclaves. Hydrothermal Autoclaves. Basic designs. Pressure – Temperature range. Different metals and alloys (Stainless steel, stellite, hastealloy, etc.) used in the fabrication of autoclaves for high pressure and high temperature studies. Understanding of corrosion and sealing issues. Advanced designs of Hydrothermal Autoclaves used for High Temperature and Pressure studies. Piston Cylinder, Anvil Systems – Diamond anvil, Opposed anvil, etc. Challenges in the designing of autoclaves for special studies. Safety issues.	15 hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

1. K. Byrappa and M. Yoshimura, Handbook of Hydrothermal Technology, Ed.2, Eslevier Science Publications, UK (2013).
2. A.D. Edgar, Experimental Petrology: Basic Principles and Techniques, Clarendon Press, UK (1973).
3. W. Johannes and F. Holtz, Petrogenesis and Experimental Petrology of Granitic Rocks, Springer Publishers (1996).
4. P.J. Wyllie, Experimental Petrology of Upper Mantle Materials, Processes and Products, Journal of Geodynamics, Volume 20, Issue 4, December 1995, Pages 429-468.
5. P.J. Wyllie, Experimental Petrology: Quantitative Boundaries for Petrogenesis (Special Issue of Indian Academy of Sciences) (1990).
6. Cliff S. J. Shaw, Experimental Petrology: Methods, Examples and Applications, Geoscience Canada 45(2), DOI: 10.12789/geocanj.2018.45.134

Vocational Papers (Any one paper to be chosen)

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**A. Thin Section Making and Geological Mapping (Theory)**		
Course Code:	**Vocational V-2**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

Objectives:

- To understand the principles and techniques of thin section preparation.
- To identify and describe the major rock-forming minerals in thin sections
- To apply the principles of geological mapping in the field
- To collect and record geological data accurately and systematically to prepare geological maps and cross-sections using field data

	Contents	**45 Hrs**
Unit 1	**Introduction:** Overview of thin section making and geological mapping, Importance of thin sections and geological mapping in geological studies, Types of geological maps, Field softwares, GPS way points, Types of scales, Geological field equipments, Readings of toposheets, Line department maps, Thematic maps, Field safety and measurements, Field recordings, Field notebook and documentation	15hrs 1 Credit
Unit 2	**Thin section making and management:** *Rock sampling and preparation for thin section making:* Selection of representative rock samples, Techniques for Cutting, Grinding, and Polishing rock samples, Proper handling and storage of thin sections, Identification and naming of major rock-forming minerals in thin sections.	15hrs 1 Credit
Unit 3	**Geological mapping:** *Introduction to geological mapping:* Fieldwork safety and equipment, Understanding of the compass and clinometers. Topographic maps, field observations at different scales, Techniques for measuring and recording geological data in the field, Mapping geological formations, contacts, and boundaries, Structural analysis and measurement of geological features, Field notes, Sketches, Preparation of Layout maps, Legend, Scale, Arrow, Title, Grids and Annotations	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10

Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

Reference Books:

1. George Rapp Jr. and Christopher L. Hill - Thin-Section Petrography of Stone and Ceramic Cultural Materials
2. Lahee. Field Geology, CBS Publishers, 1987
3. SM Mathur, Guide to Field Geology, PHI Learning Pvt. Limited, New Delhi-110092, Revised Edition 2010
4. Angela. L. Coe, Geological Field Techniques, Wiley-Blackwell publishing Ltd., UK, 2010
5. Terry Maley - Field Geology Illustrated
6. Frederick L. Pough - Field Geology
7. Fakhry A. Assaad - Field Methods for Geologists and Hydrogeologists
8. Edgar W. Spencer - Geological Maps: An Introduction
9. Terry A. Slocum, Robert B. McMaster, Fritz C. Kessler, and Hugh H. Howard - Thematic Cartography and Geovisualization
10. Arthur H. Robinson, Joel L. Morrison, Phillip C. Muehrcke, A. Jon Kimerling, and Stephen C. Guptill - Elements of Cartography
11. Cynthia A. Brewer - Designing Better Maps: A Guide for GIS Users
12. John Noble Wilford - The Mapmakers: The Story of the Great Pioneers in Cartography from Antiquity to the Space Age

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**B. Mineral Exploration and Mining (Theory)**		
Course Code:	**Vocational V-1**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
Unit 1	**Introduction:** *Introduction to mineral exploration*: Definition and scope of mineral exploration, Importance of mineral resources, Exploration life cycle and stages. *Geological concepts in mineral exploration:* Rock types and their significance, Plate tectonics and mineralization, Formation of mineral deposits, Ore textures and structures. **Exploration methods and techniques:** *Surface geological exploration methods:* Geological mapping and sampling, Geochemical surveys. *Geophysical methods and techniques:* Magnetic, Gravity, and Electrical surveys, Seismic methods, Electromagnetic methods, Ground-penetrating radar. *Subsurface exploration and drilling:* Diamond drilling, Reverse circulation drilling, Core logging and sampling.	15hrs 1 Credit
Unit 2	**Data analysis and evaluation:** *Data analysis and interpretation:* Statistical analysis of exploration data, Geostatistics and resource estimation. *Remote Sensing and GIS:* Satellite imagery interpretation, GIS applications in data analysis. *Mineral resource evaluation*: Classification of mineral resources, Resource estimation methods, Economic and technical considerations.	15hrs 1 Credit
Unit 3	**Social aspects and case studies:** Environmental impact assessment, Community engagement and social responsibility, Sustainable exploration practices, Analysis of real-world exploration projects, Field visits to exploration sites.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**

Formative Assessment as per guidelines are compulsory

References:

- Sarma D.D. Geostatistics with applications in Earth Sciences, Springer Publ., pp.205.
- J.-P. Chiles and P. Delfiner, Geostatistics; Modeling spatial uncertainty, Wiley Publ., pp.731.
- H. Wackernagel, Multivariate Geo-statistics, Springer Publ., pp.257.
- Kitanidis, P.K., Introduction to Geo-statistics, Cambridge University Press., pp.271.
- C. Lantuejoul, Geo-statistical Simulation, Springer Publ., pp.262.
- J. Awange, B. Palancz, R.H. Lewis, L. Volgyesi, Mathematical Geosciences, Springer Publ., pp.615.
- Olea, R.A., Geo-statistics for Engineers and Earth Scientists, Springer Publ., pp.309.
- RobsonWendy, Strategic management and information systems-Pitman Publishers.
- S.K Banasandra, Computers Today.
- Richard Fox-Information Technology-An introduction for today's digital world Elmansic / Navathe-Fundamentals of database system

Program Name	**BSc in EARTH SCIENCES**	Semester	**VI**
Course Title	**C. Medical Geology (Theory)**		
Course Code:	**Vocational V-2**	No. of Credits	**03**
Contact hours	**45 Hours**	Duration of SEA/Exam	**2 hours**
Formative Assessment Marks	**40**	Summative Assessment Marks	**60**

	Contents	**45 Hrs**
Unit 1	Introduction, Definitions and terminology of Medical Geology. Natural and Geological Environment: Atmosphere, hydrosphere, lithosphere, animal life and plant life; colour and composition of different rock types and association of elements in relation to medical geology. Elemental link between different spheres: Litho– hydro– atmo- bio - spheres and its impact on humans. Essential and Non-essential elements with reference to human health. Major, minor and trace elements of human body.Public Health and Geological Processes, Geological Impacts on Nutrition; Minerals in medical geology.	15hrs 1 Credit

Unit 2	Global Biogeochemical cycles; Element's uptake: Biological and Chemical point of View; Geochemistry and human Health Effects; Micronutrient Deficiencies in Soils, Crops and Health of Humans; Environmental Toxicology - Medical Geology relationship. Fluoride in Natural Waters; Selenium Deficiency and Toxicity; Iodine Deficiency in Soils; Arsenic in Environment: global distribution and poisoning.	15hrs 1 Credit
Unit 3	Geophagy; the Deliberate Ingestion of Soil; Medical Geology of Tropical region; Natural Aerosolic Mineral Dusts and Human Health; Geographical Information System in Human Health Studies. Health Effects, Pathways and Exposures: Air (inhalation), absorption, drinking water, food cycles. Metal induced effects: Carcinogenic, teratogenic, mutagenic. Trace element deficiency and toxicity health effects: Arsenic, Cadmium, Lead, Mercury, Radon, Fluoride and Selenium. Diseases due to deficiency and toxicity of some elements: Arsenic induced effects, cardiovascular diseases, lung diseases, liver, kidney and endemic diseases. Mapping Geological factors for human health.	15hrs 1 Credit

Pedagogy: Lectures, Seminars, Industry/Institute Visits, Debates, Quiz, Project and Assignments

Formative Assessment for Theory	
Assessment Occasion/ type	**Marks**
Attendance	10
Seminar	10
Debate/Quiz/Assignment	10
Class test	10
Total	**40 Marks**
Formative Assessment as per guidelines are compulsory	

References:

9. Gilbert M. Masters and Wendell P. Ela (2017) Introduction to Environment Engineering and Science. 3rd ed. Pearson,
10. Garg S.K. (2007) *Sewage Disposal and Air Pollution Engineering,* 20th ed, Vol. II, New Delhi, Khanna Publisher.
11. Garg S.K. (2007) *Water Supply Engineering,* 18th ed, Vol.I, New Delhi, Khanna Publisher.
12. Birde G.S. and Birde J.S. (2004) *Water Supply and Sanitary Engineering*, 7th ed., New Delhi, Dhanpat Rai Publishing.
13. Chatterjee A.K. (2010) *Water Supply, Waste Disposal and Environmental Engineering*, 8th ed., New Delhi, Khanna Publisher.
14. Eckenfelder W.Jr. (1999) *Industrial Water Pollution Control*, 3rd ed., New York, McGraw-Hill.
15. Metcalf and Eddy (2003) *Wastewater Engineering: Treatment and Reuse*, 4th ed., New Delhi, Tata McGraw-Hill.
16. Nathanson J.A. (2009) *Basic Environmental Technology: Water Supply, Waste Management and Pollution Control,* 4th ed., New Delhi, PHI Learning.

Advanced Reading Material (Must Read/Watch)

1. Joan Rose: Water is Life but Water Quality is Helath http://www.iwa-network.org/news/water-is-life-but-water-quality-is-health/
2. Video Presentation: Sedlak David, Healthy Tasty or Toxic: A Chemists view of Drinking Water
3. Animation Movie: Rango 2011
4. Documentary: Parched NAT GEO
5. Iran Water Crisis: https://www.aljazeera.com/programmes/peopleandpower/2016/11/iran-water-crisis-161109114752047.html
6. Victor Mallet (2018) River of Life and River of Death

Journals

6. American Society of Civil Engineering, Environmental Engineering.
7. Indian Water Works Association
8. Water Research
9. Water Science and Technology
10. Environment Pollution

CBCS Question Paper Pattern for UG Semester
DSC, DSEC &OEC

Paper Code:		**Paper Title:**			
Duration of Exam	**2 Hours**			Max Marks	**60**
Instruction:	**Answer all the sections**				

Section-A

……..	**Marks**

Section-B

……	**Marks**

Section-C

…….	**Marks**