केरळकेंद्रीयविश्वविद्यालय

Central University of Kerala

M.Sc. Geology

SCHEME AND SYLLABUS

2021

TITLE OF THE PG PROGRAMME : M.Sc. Geology

PROGRAMME STRUCTURE

This PG programme is offered in four semesters and includes theory and practical classes, field training and a dissertation.

Duration of the Programme	**:**	4 semesters
Number of seats	**:**	38+2 (Supernumerary)
Type of the programme	**:**	Regular
Eligibility for admission	**:**	B.Sc. Geology / B.Sc.Geology and Water Management/B.Sc. (Hons.) Geology with minimum 55% marks or equivalent grade in aggregate and in the concerned subject separately, from a recognized University (studied in 10+2+3 system). B.Sc. triple main programme with Geology as one of the main/major/core subject is also eligible. However, Geology should have equal or more weightage with respect to the other two main subjects. The student must have studied Geology in all the three years of B.Sc. Programme. The B.Sc. triple main programme with Geology as a subsidiary/ minor subject or having less weightage compared to other two main subjects is not eligible.
Admission	**:**	Through CUCET

PROGRAMME STRUCTURE

I SEMESTER		Credits	Lecture hrs./Week	Lab hrs./Week	Field hrs./Week
EGE 5101	Geomorphology	3	3		
EGE 5102	Structural Geology	3	3		
EGE 5103	Stratigraphy	3	3		
EGE 5104	Mineralogy	3	3		
EGE 5191	Lab 1: Structural Geology and Geological Field Mapping	3		4	2
EGE 5192	Lab 2: Mineralogy	3		4	2
	Elective	3	3		
Total		**21**	**15**	**8**	**4**
II SEMESTER					
EGE 5201	Igneous Petrology	3	3		
EGE 5202	Metamorphic Petrology	3	3		
EGE 5203	Sedimentology	3	3		
EGE 5204	Palaeontology	3	3		
EGE 5291	Lab 3: Igneous and Metamorphic Petrology	3		4	2
EGE 5292	Lab 4: Sedimentology and Palaeontology	3		4	2
	Elective	3	3		
Total		**21**	**15**	**8**	**4**
III SEMESTER					
EGE 5301	Economic Geology	3	3		
EGE 5302	Hydrogeology	3	3		
EGE 5303	Geospatial Technology and Engineering Geology	3	3		
EGE 5391	Lab 5: Ore Geology	3	3	4	2
EGE 5392	Lab 6: Hydrogeology and Geospatial Technology	3		4	2
	Elective	3	3		
Total		**18**	**15**	**8**	**4**
IV SEMESTER					
EGE 5491	Dissertation	9		6	12
	Elective	3	3		
Total		**12**	**3**	**6**	**12**
Core Course		**60**			
Elective		**12**			
Total		**72**			

ELECTIVE PROGRAMME

Sl. No	**ELECTIVECOURSES**	Credits	Elective Type
1	Industrial Minerals and Gemstones	3	Internal
2	Geospatial Technology	3	External
3	Coal and Petroleum Geology	3	Internal
4	Environmental Geology and Natural Hazards	3	Open
5	Water Resource Management	3	Open
6	Isotope Geology	3	Internal
7	Quaternary Geology	3	Internal
8	Structural Analysis	3	Internal
9	Planetary Science	3	Open
10	Oceanography and Marine Geology	3	Open
11	Climatology	3	Open
12	Mineral Wealth of India	3	Internal
13	Geostatistics	3	Internal
14	Physical Geology	3	Open
15	Geochemistry	3	Internal
16	**Any PG MOOCs from SWAYAM/NPTEL**	**1-4**	

PROGRAMME OVERVIEW

Geology is the study of our planet Earth. In this programme we mainly address the fundamental questions about the origin, development, and future of the Earth. This course will train the students to acquire the skills in the field of interpretations of geological landforms and structures, distribution and chemistry of earth materials, origin and classifications of rocks, Identification of fossils and palaeo-life, investigations of natural resources and groundwater. It will enable the students to apply the theory and techniques, which they acquire during the programme, to develop a sustainable Earth and environment management. It will also provide an opportunity to learn about how our planet works, and address some of the major issues of our times: from the origin of the solar system, the Earth and life, to the climate system, natural hazards and groundwater investigations. The diverse range of courses cover processes from the Earth's interior, as mapped by seismic waves, to the evolution of the Earth's crust documented in the rocks at its surface. The department has a pretty decent state-of-the-art laboratories and field geological facilities. The course is also having a major field componet. This will enable the students to have real life experience in geological investigations and field work.

PROGRAMME OUTCOMES

The students after completing the Post-graduation shall be able to:

1. Develop thinking skills in spatial and temporal perspectives.
2. Develop thinking skills in geological systems.
3. Undertake field mapping in any part of India with respect to lithology, structure and stratigraphy and produce geological map.
4. Conduct lithological, structural, hydrogeological and geophysical field surveys and prepare geological reports.
5. Carry out petrographical, sedimentological, geochemical, paleontological laboratory analysis and prepare reports.
6. Undertake jobs related to Geology and offer consultancy services to different academic institutes and industry.
7. Apply the geological concepts in theoretical and practical situations, solve geological problems and offer extension services to the society.
8. Carry out independent research work in various branches of Geology.

PROGRAMME SPECIFIC OUTCOMES

At the end of programme, students will be able to:

1. Understand the basic geomorphic principles and evolution of various landforms developed under various structures, lithology and climate.
2. Identify the geological structures and can interpret their spatial and temporal relations.
3. Understand sedimentological principles, carry out sedimentological analysis, data analysis and decipher depositional environment and provenance.
4. Gain knowledge on hydrogeological environment, distribution of ground water, ground water flow direction and carry out electrical resistivity survey and remote sensing techniques for ground water exploration.
5. Undertand the diversified igneous processes which modified the eath surfaces.
6. Understand the various lithological units, stratigraphic succession and general distribution of rocks in India.
7. Gain knowledge on stratigraphic principles and their applications in the field of earth science.
8. To identify fossils and use them to understand the evolution of life, biostratigraphy and past climate, geography and ocean conditions.
9. Demonstrate confidence and accuracy in identifying important ore minerals in hand specimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
10. Use geospatial technology for a sustainable earth sand environmental management.
11. Synthesis observations, evidence and theory to recognise and explain similarities and differences between different ore mineral groups.
12. Discuss with confidence the theories, principles and outstanding controversies related to commercial mineral deposits.
13. Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to economic geology.

Course Code	EGE 5101	Semester	I
Course Title	Geomorphology		
Credits	3	Type	Core

Course Description

The course focuses on the origin, evolution of landforms, and the physical processes responsible for their creation and modification. This course will examine how surface processes interact to create landscapes and how climate, rock type, structure, and tectonics influence the formation of different landforms. The course also includes quantitative evaluation of landforms by morphometric analysis and identification of landforms from topographic maps and satellite images.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the key characteristics of fluvial, coastal and tectonic geomorphology.
- Specify the linkages between geomorphic forms and processes.
- Appreciate the importance of tectonics in landform development.
- Ability to classify and describe landforms in a variety of environmental and climatic settings.
- Quantitatively use and evaluate geomorphological data with numerical and statistical methods.
- Identify, interpret and critically evaluate landforms and geomorphic processes from topographic maps, satellite images, and aerial photographs.

Course Structure

Module - 1

Fundamental concepts in geomorphology. Different models for the Evolution of landscape: Davis, Penck, King, Hack.Hill slopes: slope elements, classification, models of slope evolution, slope movement and stability factors. Influence oflithology and structure on geomorphic processes and landforms.Climatic geomorphology: Development of landforms under different climatic conditions.

Module – 2

Fluvial Geomorphology: Erosional and depositional landforms of rivers. Drainage systems and patterns. Stream ordering. Hypsometry. Morphometric elements and parameters - morphometric analysis of drainage basins. Laws of drainage composition,drainage density, stream frequency. Coastal geomorphology: Coastal processes, Coastal erosional and depositional landforms.Effect of sea-level changes. Tectonic geomorphology: Landforms in relation to tectonics. Geomorphic indicators of neotectonic activity.

Module – 3

Geomorphological mapping: Study of geomorphic features from topographic maps, aerial photographs and satellite images. Methods of preparation of the geomorphological map.Application of geomorphology in various fields of earth sciences, viz. Mineral exploration, Hydrogeology, Civil Engineering and Disaster Management. Geomorphology of India.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Agrawal, L.C. (2008). Introduction to Geomorphology. Pointer Publishers, 128p.
- Arthur L. Bloom (1978). Geomorphology (A Systematic Analysis of Late Cenozoic Landforms). Prentice-Hall, 510 p.
- Chorley, R.J., Schumm, S.A. and Sugden, D.E. (1984). Geomorphology, Methuen & Co., 605p.
- Holmes, A. (1993). Holmes Principles of Physical Geology, Edited by P. McL. D. Duff. Chapman and Hall, London; New York, 791p.
- Kale, V.S. and Gupta, A (2012). Introduction to Geomorphology. Anmol Publications, India.
- Ritter, D.F., Kochel, R.C., Miller, J.R. (2006). Process Geomorphology, Waveland Pr Inc., 652p.Huggett, R. (2016): Fundamentals of Geomorphology, Taylor&Francis, 578p.
- Savindra Singh (2018). Geomorphology, Pravalika Publications, Allahabad. 652p.
- Savindra Singh (2017). Physical Geography, Pravalika Publications, Allahabad.
- Sen, P.K. and Prasad, N. (2002).An Introduction to the Geomorphology of India. Allied Publishers Pvt. Ltd, 396p.
- Sharma, H.S. (1991). Indian Geomorphology, Concept Publishing Co., New Delhi, 358p.
- Sparks, B.W. (1979). Geomorphology, John Wiley & Sons Inc., 561p.
- Strahler A. N. and Strahler, A. H. (2008). Modern Physical Geography, John Wiley & Sons, New York, 652p.
- Thornbury, W.D. (1984). Principles of Geomorphology, John Wiley & Sons, 594p.

Course Code	EGE 5102	Semester	I
Course Title	Structural Geology		
Credits	3	Type	Core

Course Description

Structural geology is the study of deformation and deformed structures on earth surface. It will explain the complex deformational history of earth structures in terms of various spatial and chronological units at different scale. Understanding on present day geological structure will provide a clue towards the past geological event, which modified our earth in geological time.

Course Outcome

By the end of the course, students are expected to be able to:

- identify the geological structures in both macroscopic and microscopic scale.
- describe the deformational structures of an area from the geologic maps and outcrop patterns.
- elucidate the deformation history of an area using rock fabrics and geometric relationships
- get a proper enlightenment towards the geological literature

Course Structure

Module - 1

Deformation-concept, component and type. Continuum mechanics and rheology. Elastic, plastic and brittle deformation. Concept of stress. Concept of strain. Stress and strain ellipsoids. Mohr circles. Rock failure. Mohr-Coulomb failure criteria. Faults, Joints and Fractures.

Module - 2

Mechanics of folding and Buckling. Biot-Ramberg theory of buckling. Folds - Geometry of cylindrical, non-cylindrical and conical folds. Fold classifications -Donath and Parker and Ramsay. Fold interference and Superposed folding.

Module - 3

Fabric- Planar and linear fabrics. Tectonites- classification. Foliation -types, classification and origin. Lineation - types, classification and origin. Stereographic projections in structural geology. $\boldsymbol{\pi}$ and $\boldsymbol{\beta}$ diagrams. Geometric analysis of geological structures on macroscopic scale. Petrofabrics.

Evaluation &Grading

Lab Assessment – 10%
Field Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 10%

End Semester Assessment – 60%

References

1. Billings, M. P. (2016) Structural Geology. Pearson Education; Third edition, 624p.
2. Park, R.G. (1989), Foundation of Structural Geology, Blackie, 148p.
3. Ragan, D.M. (1969), Structural Geology, Wiley, 2nd edition, 602p.
4. Turner, E.J. and Weiss, L.E. (1963), Structural Analysis of Metamorphic Tectonites, Mc. Graw Hill, 545p.
5. Hobbs, B.E., Means, W.D. and William, P.F. (1976), An outline of Structural Geology, John Wiley and Sons, 571p.
6. Robert. J.Twiss and Eldridge.M.Moores (2007). Structural Geology, W.H.Freeman and Company, 695p.
7. Ramsay, J.G. (1967) Folding and Fracturing of Rocks. Mc Graw Hill, 586p.
8. Ramsay, J.G. and Huber M.I. (1987) The Techniques of Modern Structural Geology: Folds and Fractures, Academic Press, 391p.

Course Code	EGE 5103	Semester	I
Course Title	Stratigraphy		
Credits	3	Type	Core

Course Description

Stratigraphy is the science of understanding the variations in the successively layered character of rocks and their composition. These rocks may be sedimentary, volcanic, metamorphic or igneous This program aims to teach systematic stratigraphy with special reference to Indian geology with special case studies of world stratigraphy. The students are equipped with different correlation methods and stratigraphic nomenclature.

Course Outcome

By the end of the course, students are expected to be able to:

- Define and apply the principles of stratigraphy in Geological problems, describe the evolution of Precambrian and Proterozoic stratigraphic units of India.
- Summarise the main environmental conditions that occurred in each geological period, illustrate the paleogeography, tectonic history of the Earth during the Precambrian and the Phanerozoic time, apply stratigraphic methods to analyse the evolution of past environments.
- To better understand the newer fields of stratigraphy, include Sequence stratigraphy, seismic stratigraphy, cyclostratigraphy, magnetostratigraphy and chemostratigraphy.
- Intellectual and practical skills in order to apply stratigraphic principles in order to understand the stratigraphy of an area. Compare between different methods of stratigraphic correlation and apply the suitable one in an area.

Course Structure

Module - 1

Development of Stratigraphy: Contributions of the pioneers of Stratigraphy, Code of stratigraphic nomenclature. Major incidents in the Earth's History. The concept of the Precambrian. Distinguishing features and classification of the Precambrian. Precambrian stromatolites, their status as time markers and classification of the Late Proterozoic.

Module - 2

Fundamental and newer classification of stratigraphy, Lithostratigraphy: Procedures for establishing, extending and naming of Lithostratigraphic units. Biostratigraphy: Nature of biostratigraphic units – Life communities and Death assemblages. Procedures for establishing and extending biostratigraphic units. Chronostratigraphy: Formal and Informal chronostratigraphic units, Procedures for establishing and naming of chronostratigraphic units. Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy and Sequence stratigraphy.

Module - 3

Distribution of Precambrian rocks in India. Indian Standard stratigraphic column, hiatuses and breaks. Models for the evolution of Precambrian crust. Shields - cratons and mobile belts. Low-grade and high-grade terrains. Precambrian shield areas. Precambrian's of southern India. Palaeozoic stratigraphy: Palaeozoic formations of

India with special reference to type localities, history of sedimentation and fossil content. Mesozoic stratigraphy: Mesozoic formations of India with special reference to type localities, history of sedimentation and fossil content. Gondwana Supergroup and Gondwanaland. Deccan Volcanics. Cenozoic stratigraphy: Cenozoic formations of India. Rise of the Himalayas and the evolution of Siwalik basin. Kerala and Cambay basins. Quaternary Stratigraphy – glacial and interglacial cycles. Paleogeography and major events during different periods. Age problems in stratigraphy.

Evaluation &Grading

Lab Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Balasubrahmanyan, M. N. (2006), Geology and Tectonics of India: An Overview, IAGR Memoir No.9, 204p.
- Brookfield, E B. (2004), Principles of Stratigraphy, Blackwell Publishing Ltd, 340p.
- Claude, C. and Albritton J. (1995), Catastrophic Episodes in Earth History, Chapman & Hall, 221p.
- Donovan, S K (Ed.), (1989). Mass Extinctions – Processes and Evidence, Belhaven Press, 266p.
- Gradstein, F M, Ogg, J G, Schmitz, M D and Ogg, G M. The Geological Time Scale 2012. Vol I and Vol II, Elsevier, Amsterdam.
- Hedberg, H.D. (Ed.), International Stratigraphic Guide - International Subcommission on Stratigraphic Classification of IUGS Commission on Stratigraphy.
- Kumar, R, (1985), Fundamentals of Historical Geology and stratigraphy of India, Wiley Eastern Ltd., New Delhi, 254p.
- Lemon, R.R. (1990), Principles of Stratigraphy, Merrill Publishing Company, 559p.
- Miall, A D (2000). Principles of Sedimentary Basin Analysis, Springer Verlag.
- Naganna, C. (Ed.), (1975), Studies in Precambrians, Bangalore University, 291p.
- Naqvi, S. M., Mahmood, S. and Rogers,J.W. (1983), Precambrian Geology of India., Oxford University Press, 240p.
- Naqvi, S.M. and Rogers, J.W. (Eds.) (1987), Precambrian of South India, Geological Society of India, 575p.
- Pichamuthu, C.S. (1985), Archaean Geology, Indian Soc. of Earth Scientists, Oxford and IBH Publishing Co., New Delhi, vol.14, 221p
- Ramakrishnan, M. and Vaidyanathan, R. (2008), Geology of India. Geological Society of India, Bangalore, Vol. 1 & 2.
- Schoch, R.M. and Reinhold, V.N. (1969), Stratigraphy -Principles and Methods, New York, 375p.
- Spencer, E W (1962) Basic concepts of Historical geology, Oxford IBH, New Delhi
- Stanley S M (2005) Earth system history, II Edn., W H freeman & Co., New York
- Weller, Marvin, J. (1960), Stratigraphic principles and practice, Harper and Brothers, New York, 725 p.

Course Code	EGE 5104	Semester	1
Course Title	Mineralogy		
Credits	3	Type	Core

Course Description

Mineralogy is the branch of geology that deals with the fundamental building blocks of all rocks, i.e., minerals. It involves the systematic study that deals with the characteristics of the individual and group of minerals.The course deals with the analytical, macroscopic and microscopic investigations of minerals to understand their crystal chemistry, crystal structure, physical properties, optical properties and genesis.The course aims to give an overall understanding of how the textures of the minerals control the chemical budget, and in turn aids the chemical evolution of the solid Earth.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of mineralogy
- Demonstrate confidence and accuracy in identifying important minerals in handspecimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
- Synthesis observations,evidence and theory to recognise and explain similarities and differences between different mineral groups.
- Discuss with confidence the theories, principles and outstanding controversies related to mineralogy.
- Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to mineralogical investigations.

Course Structure

Module - 1

Crystallography – symmetry and its types, crystal faces, crystal forms and crystal habit. Crystal chemistry and structure – fundamentals of crystal chemistry, chemical controls on crystal structure, isostructural minerals, polymorphism, compositional variations, graphical representations. Introduction to X-ray crystallography, chemical analysis of minerals using EPMA, SEM, XRF and Mass spectrometry

Module - 2

Mineral growth and thermodynamics –mineral stability, phase diagrams, mineral nucleation, crystal growth, structural defects, twinning, post-crystallization processes, mineral evolution. Description of common rock forming minerals

Module - 3

Optical mineralogy - Optical properties of minerals: some physical background, refractive index and petrographic microscope, isotropic and anisotropic minerals, polarization and birefringence, optical indicatrix, dispersion, pleochroism. Identification of minerals using a petrographic microscope.

Evaluation &Grading

Lab Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Perkins, D., 2014, Mineralogy, Pearson
- Okrusch, M. and Frimmel, H.E., 2020, Mineralogy – an introduction to minerals, rocks and mineral deposits, Springer Publications
- Kerr, P. F., 1959, Optical Mineralogy, McGraw Hill.
- Naidu, P.R.J., 1967, Johnannsen's Optical Mineralogy. Allied publishers.
- Naidu, P.R.J., 1958, Four Axis Universal Stage, Commercial Printing and Publishing House.
- Philips, F.C., 1963, Introduction to Crystallography, Thomas Nelson.
- Philips, W.R., 1971, Mineral Optics – Principles and Techniques, Freeman.
- Read, H.H., 1974, Rutley's Elements of Mineralogy, Thomas Murby & Co.
- Sinkankas, J., 1969, Mineralogy, East West Edition.
- Tutton, A. E.H., 1965, Crystallography and Practical Crystal Measurements. Vol. I. Today and tomorrow.
- Wahlstrom, E.C., 1962, Optical Crystallography. Wiley.
- Winchell, A.N., 1951, Elements of optical Mineralogy Part I Principles and Methods, 5th edn., Wiley.
- Krauskopf, K. B. (1967), Introduction to Geochemistry, McGraw-Hill Book Co., New York, 721 p.
- Mason, Brian, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley&Sons, New York, 344 p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Holt, K.H.W. (1971), Geochemistry, Rinehart and Winston Inc, USA.
- Rankama, K. and Sahama, T.H.G. (1950), Geochemistry, Univ. Chicago press, 911p.
- Walther. J.V.(2010) Essentials of Geochemistry, Jones and Barlett Publishers, New Delhi. 797p.

Course Code	EGE 5191	Semester	I
Course Title	Structural Geology and Geological Field Mapping		
Credits	3	Type	Core

Course Description

This course deals with various structural analysis and geological field studies. It will offer the preparation and interpretation of geological maps and sections for the understanding of complex geological history in an area. Stereographic projection or stereonets will enable the students to interpret the deformational events. Geological field work will provide a real life experiences towards the proper understandings of various geological phenomenon.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the interpretation of geological maps and sections.
- Solve various stereonet based problems .
- Interpretation of geological history and deformational events.
- Perform field identification of geological structures.
- Interpretation and classification of geological terrain based on field work.

Course Structure

Module - 1

Preparation and interpretation of geological maps and sections. Structural problems. Recording and plotting of field data. Study of deformation structures in hand specimen. Study of dip isogons from fold profiles.

Module – 2

Stereographic projection in structural analysis. Application of stereographic projection in solving structural problems. Beta diagram and Pi diagram. Solving problems relating to faults and shear zones.

Module – 3

Topo sheets: Map scales, features in toposheet, finding the coordinates of points. Surveying - Chain Survey- Plane Table Survey – Leveling- Dumpy Level surveying, Total Station and GPS surveys. Geological field visit and mapping of litho-units in igneous, metamorphic and sedimentary terrains. Identification and Mapping of Faults, folds, foliations, cleavages, lineations, joints and shear zones

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Field work – 20%
End Semester Assessment – 60%

References

- Punmia.B.C., Ashok K Jain and Arun K Jain (2010). Surveying Vol I and II. Laxmi Publications pvt. Ltd, New Delhi.
- Basak.N.N. (2012). Surveying and Levelling, Mc-Graw Hill Publishing Company, New Delhi, 570p.
- Lahee, F.H. (2002). Field Geology. 6th Edition, CBS Publishers.
- Gokhale, N.W. (2009). A Guide to Field Geology. 1st Edition, CBS Publishers, 96p.
- Mathur, S.M. (2001). Guide to Field Geology (Revised Edition), 1st Edition. Phi Learning, 220p.
- Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.
- DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.
- Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.
- Konecny, G. (2003), Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor& Francis, London, 266p.
- Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.
- Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p.
- Curran, P. (1985) Principles of Remote Sensing, Longman, London, 260p.
- Shiv N. Pandey (1987) Principles and applications of Photogeology, Wiley Eastern Limited, 366p.
- Drury S.A, (1990) A Guide to Remote Sensing - Interpreting Images Of Earth, Oxford Science Publications, Oxford.
- Park, R.G., (1989), Foundation of structural Geology. Blackie, 148p.
- Ragan, D.M. (1969), Structural Geology, Wiley, 2nd edition, 602p.
- Turner, E.J. and Weiss, L.E. (1963), Structural Analysis of Metamorphic Tectonites, Mc. Graw Hill, 545p.
- Ramsay, J.G. (1967) Folding and fracturing of rocks. Mc Graw Hill, 586p.

Course Code	EGE 5192	Semester	1
Course Title	Mineralogy		
Credits	3	Type	Core

Course Description

The course deals with various analytical techniques to investigate the optical properties of minerals, reading mineral chemical and bulk-rock petrochemical data. This course gives a hands on experience to the students on how to use the optical properties and petrochemical data of minerals/rocks to perform rock classification, and investigate the pressure and temperature conditions of formation of a given rock/mineral.

Course Outcome

By the end of the course, students are expected to be able to:

- perform quantitative and qualitative microscopic investigations of minerals.
- develop the ability to read and interpret the mineral chemical and bulk-rock petrochemical datasets.
- perform calculations using geothermeters and geobarometers.

Course Structure

Module - 1

Determination of extinction angle, pleochroism; Determination of birefringence – using Michel Levy's chart and Berek's compensator; Determination of interference figure; Determination of optic sign.

Module – 2

Study of optical characters of the following minerals/mineral groups: olivine, epidote, almandine, pyroxene, amphibole, mica, feldspar and feldspathoid.

Module – 3

Discriptive mineralogy of comon rock forming minerals. Mineral chemical recalculation, Structural Formulas, Crystal Size Distribution

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Practical Test – 20%

End Semester Assessment – 60%

References

- Burger, M.J. (1962). Elements of Crystallography, Wiley.
- Dana,E.S (1962). Text book of Mineralogy Revised by Ford,W.E.,Wiley..
- Deer, Howie, R.A.andZussman, J. (1964). Rock forming minerals, Vol.1,2,3,4 and 5, Longman.
- Hans- Rudolf Wenk and Andrei Bulakh. (2004). Minerals – Their constitution and Origin, Cambridge University Press.
- Smith. J.V. (1982). Geometrical and structural Crystallography. John Wiley & Sons.
- Burger. M.J. (1970). Contemporary Crystallography. Mc Graw – Hill book company.
- Naidu, P.R.J. (1958). Four axes Universal Stage, Commercial Printing and Publishing house.
- Philips,F.C. (1963). Introduction to Crystallography, Thomas Nelson.
- Phillips W.J (1980). An introduction to Mineralogy for Geologists. John Wiley & Sons.
- Phillips, R.W (1971). Mineral Optics; Principles and Techniques, W.H.Freeman and Co, San Francisco.
- Kerr, P.F. (1959) Optical Mineralogy, Mc Graw Hill, New York.
- Winchell, A.N (1949). Elements of Optical Mineralogy, Part –I Principles and Methods, Wiley, New York.

Course Code	EGE 5201	Semester	II
Course Title	Igneous Petrology		
Credits	3	Type	Core

Course Description

The study of igneous petrology is basic necessity to know the geological sciences. Igneous rocks are the first to form on Earth's crust by cooling, crystallization, and solidification of plutonic magma or volcanogenic lava. This course will discuss the origin, evolution and classification of igneous rocks on earth surface. It will also discuss the origin and evolution of magma and associated processes.

Course Outcome

By the end of the course, students are expected to be able to:

- understand the origin of magama.
- understand the origin of diversified igneous rocks.
- understand various igneous processes which modified thee earth surfaces.
- classify the igneous rocks.

Course Structure

Module - 1

Igneous processes–Nature and evolution of magma – Generation of magma – Silicate systems - Phase rule and its application in the study of silicate systems - phase diagrams, primary phase diagrams and liquidus projections.

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Module – 2

Equilibria involving two solids + liquid.Eutecticcrystallization – Solid solution series – Incongruent melting. Course of crystallization in typical binary systems. Equilibrium crystallization and melting paths in ternary and quaternary systems. Diopside - Anorthite– Silica; Diopside - Anorthite–Albite; Quartz-Albite-Orthoclase; Reaction principle and reaction series.

Module – 3

Plume magmatism and hot spots- Large Igneous Provinces and dyke swarms. Classification of igneous rocks. Modal composition and Normative mineral composition. Niggli calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index(MI). CIPW Norm. Granites and granitic rocks. Ultramafic rocks. Alkaline rocks. Kimberlites and ultrapotassic rocks. Anorthosite and carbonatite. Classification of basalts.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Bose, M. K. (1997), Igneous Petrology, The World Press Private Limited, Calcutta, 568 p.
- Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974), Igneous Petrology, McGraw Hill Book Company, 739 p.
- Ehlers, E. G. and Blatt, H. (1981), Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
- Faure, G. (2001), Origin of Igneous Rocks: The Isotopic Evidence, Springer-Verlag, New York, 496 p.
- Gupta, A. K. (1998), Igneous Rocks, Allied Publishers Limited, 690 p.
- Hall, A. (1988), Igneous Petrology, English Language Book Society/Longman, 573 p.
- Hughes, C. J. (1982), Igneous Petrology, Elsevier, 551 p.
- Le Maitre, R. W. (2002), Igneous Rocks: A classification and Glossary of Terms. Second Edition, Cambridge University Press, 236 p.
- Mueller, R.F. and Saxena, S. K. (1977), Chemical Petrology, Springer Verlag, 394 p.
- Ragland, P. C. (1989), Basic Analytical Petrology, Oxford Unversity Press, 369 p.
- Raymond, L. A. (1995), Petrology, Wm. C. Brown Publishers, 742 p.
- Sood, M. K. (1981), Modern Igneous Petrology, A Wiley-Interscience, 244 p.
- Wilson, M. (1989), Igneous Petrogenesis, Chapman and Hall, 466 p.

Course Code	EGE 5202	Semester	II
Course Title	Metamorphic Petrology		
Credits	3	Type	Core

Course Description

Metamorphic petrology covers the chemical and physical work done in natural systems in response to changing physical conditions. Petrogenetic processes such as recrystallization, continuous and discontinuous reactions, mixed volatile reactions and deformation are addressed. The principles of metamorphic petrology are then applied to a number of orogenic events through geologic time, and modern advances in research in metamorphic petrology are explored

Course Outcome

By the end of the course, students are expected to be able to:

- understand the concept of metamorphism.
- understand the origin of diversified metamorphic rocks.
- understand various metamorphic processes.
- describe metamorphic rocks, their mineral assemblages and textures.

Course Structure

Module - 1

Concepts of metamorphism: Limits of metamorphism, Types of metamorphism, Factors of metamorphism, Role of fluids. Metamorphic structures and textures. Nature of metamorphic reactions. Concept and classification of metamorphic facies and facies series, P-T-t paths

Module – 2

Graphical representation of metamorphic mineral assemblages, composition paragenesis diagrams. Principal Types of Phase Diagrams, ACF, A'KF, AFM Diagrams. ACF and AKF diagrams and representation of metamorphic assemblages.

Module – 3

Metamorphic differentiation; Metamorphism and plate tectonics; Ultra High Temperature (UHT) and Ultra High Pressure (UHP) metamorphism.General characteristics of metamorphic domains – contact metamorphism, Regional metamorphism,Pairedmetamorphic belts, Orogeny and Metamorphism, Prograde and retrograde metamorphism.Metamorphism of carbonate rocks, pelites, mafic and ultramafic rocks.Granulitic rocks of Southern India, Migmatites.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Blatt, H. and Tracy, R.J. (1996), Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co. New York.
- Bucher, K. and Martin, F. (2002), Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag, 341p.
- Kerr, P.F. (1959), Optical Mineralogy, McGraw Hill Book Company Inc., New York,
- Philpots A.R. and Ague, J.J. (2009), Principles of Igneous and Metamorphic petrology, second edition, Cambridge University press, New York, 667p.
- Powell, R. (1978), Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London, 284 p.
- Rastogy, R.P. and Mishra, R.R. (1993), An Introduction to Chemical Thermodynamics, VikashPublishing house.
- Spear, F. S. (1993), Mineralogical Phase Equilibria and Pressure – Temperature – Time Paths, Mineralogical Society of America, 799p.
- Spry, A. (1976), Metamorphic Textures, Pergamon Press, 350p.
- Winter, J.D. (2001), An introduction to Igneous and Metamorphic Petrology, Prentice Hall 697p.
- Wood, B.J. and Fraser, D.G. (1976), Elementary Thermodynamics for Geologists, Oxford University Press, London, 303p.
- Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995), Atlas of Metamorphic Rocks and their Textures, Longman Scientific and Technical, England, 120p.
- Yardley, B.W. (1989), Introduction to Metamorphic Petrology, Longman, New York, 248p.
- Vernon, R.H. and Clarke, G.L. (2008), Principles of Metamorphic Petrology, Cambridge, 446p.
- Winkler, H.G.F. (1976), Petrogenesis of Metamorphic rocks, 4th edition, Springer- Verlag, New York, 347p.
- Miyashiro, A. (1994), Metamorphic Petrology, Akiho, Research Press, New Delhi,416p.
- Pitchamuthu. C.S. (1984), Granulites of South India,Geological Society of India.

Course Code	EGE 5203	Semester	II
Course Title	Sedimentology		
Credits	3	Type	Core

Course Description

Sedimentologyis the study of sediments and sedimentary rocks and the processes by which they are formed. The course will provide an understanding of sedimentary processes, collection and analysis of sedimentary data. Italso develops an understanding of the processes involved in the formation and diagenesis of sedimentary rocks. The course deals with the analysis of deposits from a variety of continental, marginal marine and marine sedimentary environments using various sedimentary techniques.This course develops the skills needed to make interpretations of sedimentary successions, decipher sedimentary processes, past environmental conditions and provenance of sediments.

Course Outcome

By the end of the course, students are expected to be able to:

- Describe and interpret sedimentary rocks and their depositional environment.
- Describe and illustrate the various types of sedimentary structures and relate these to the processes which are responsible for these structures.
- Summarise the composition and properties of sedimentary rocks and justify the classification schemes used for these sediments.
- Evaluate the physical, chemical and biological processes that lead to sedimentary rock formation under different environmental conditions.
- Be conversant with the principal environments in which sediments are deposited and be able to identify these in the geological record on the basis of their distinguishing features.
- Interpret sedimentary processes based on the composition of the rock and sedimentary structures.
- Identify the depositional environment of sediments (i.e. continental; shallow and deep marine)
- Identify sedimentary deposits that are characteristic of various types of sedimentary basins

Course Structure

Module - 1

Fluid flow and sediment transport- Reynolds number, Froude Number, Hjulstrom's diagram. Sedimentary Textures:Concept of grain size and classification. Grain size estimation: direct measurement, sieving and settling methods. Modern methods- Laser diffraction analysis. Frequency distribution and grain size (statistical) parameters. Grain shape and fabric.Sedimentary structures: Classification and origin- depositional structures, deformational structures, erosional structures and

biogenic structures.Applications of sedimentary structures in paleo-environmental and paleocurrent studies.

Module – 2

Sedimentary Petrology: Mineralogy, classification and depositional environments of conglomerate, sandstone, limestone and mud rock. Diagenesis of clastic and non-clastic rocks- diagenetic processes and diagenetic environments. Provenance studies: mineral stability, mineralogical maturity and mobility. Use of heavy minerals in provenance studies.

Module – 3

Depositional environments - marine, non-marine, and mixed depositional environments. The association of primary sedimentary structures and textural characteristics with depositional environments and settings. Concept of sedimentary facies, association models. Walther's Law of correlation of sedimentary facies. Typesand classification of sedimentary basins.Basin analysis. Sedimentary basins of India.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Blatt, H., Middleton, G.V. and Murray, R.C. (1980). Origin of Sedimentary Rocks, Prentice-Hall Inc., 768p.
- Collins, J.D. and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London, 194p.
- Gary Nichols (2016) Sedimentology and Stratigraphy. Wiley India, 336p.
- Lindholm, R.C. (1987). A Practical Approach to Sedimentology, Allen and Unwin, London, 160p.
- Miall, A.D. (2000). Principles of Basin Analysis, Springer-Verlag, 616p.
- Pettijohn, F.J. (1975). Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi, 718p.
- Prothero, D.R. and Schwab, F., (2003) Sedimentary Geology. W. H. Freeman; 2nd edition, 593p.
- Reading, H.G. (1997). Sedimentary Environments and facies, Blackwell Scientific Publication, 615p.
- Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag, 439p.
- Sam Boggs Jr (2016). Principles of Sedimentology & Stratigraphy. Pearson Education India, 568p.

- Selley, R. C. (2000). Applied Sedimentology, Academic Press, 523p.
- Sengupta, S.M. (2015). Introduction to Sedimentology. CBS Publications, 339p.
- Tucker, M.E. (1981). Sedimentary Petrology: An Introduction, Wiley and Sons, New York, 272p.
- Tucker, M.E. (1990). Carbonate Sedimentology, Blackwell Scientific Publication, 482p.

Course Code	EGE 5204	Semester	II
Course Title	Paleontology		
Credits	3	Type	Core

Course Description

Paleontology is the scientific study of life that existed in the geological past. It includes the study of fossils to classify organisms and study their interactions with each other and their environment. The course aim to observe and examine the anatomy, morphology, and evolutionary history of vertebrate and invertebrate organisms and plants, understand the major lineages of organismal life through study of their anatomy and diversity, describe the major events (extinctions, diversifications, and environmental transitions) in the history of life and relate these events to possible causes.

Course Outcome

By the end of the course, students are expected to be able to:

- To understand palaeontological principles, terms, definitions and classifications, the applications of fossils in understanding Earth history.
- Recognize and identify invertebrate fossils, label key anatomical features and explain their function, recognize and classify fossil plants and animal traces, understand general characteristics and evolution of vertebrates.
- Application of fossils to constrain the age of the enclosing rock, identify and describe the principal microfossil groups, describe the methods of sample collection and laboratory preparation of microfossils.
- Summarise the value of microfossils in paleoenvironmental reconstruction, assess the importance of microfossils in hydrocarbon sub-surface exploration.
- Students will master complex and specialized knowledge, concepts and ideas in palaeontology which includes identification and description of vertebrate, invertebrate, plant and micro fossils. To develop research capability and practical competency in the field of palaeontology.

Course Structure

Module - 1

Life during the Precambrian, Diversification of life. Evolution of life during the Palaeozoic, Mesozoic and Cenozoic eras. Cambrian explosion. Fossil record and modes of evolution: Microevolution, Macroevolution and Tree of life. Theory of organic evolution and the factors in the Darwinian theory. Theory of Punctuated Equilibria. Origin of life: extra-terrestrial and terrestrial. Miller's experiment. Mass extinction and its causes.

Module - 2

General characteristics, geologic history, classification and evolution of Pisces, Amphibians, Reptiles, Birds and Mammals (Elephant, Horse and Human being). Human fossils from different parts of the world. Use of fossils in palaeoclimatic, paleoecological and palaeogeographic studies. Major fossil discoveries from India

Module - 3

Micropalaeontology: scope and subdivisions - types, extraction of microfossils from sediments and sedimentary rocks. Foraminifera: their palaeoecology and application in paleoclimate, paleoceanography and biostratigraphy. Radiolaria, Diatoms, Ostracoda, Pteropods, Cocolithophores, Stromatolites and Conodonts – morphology, classification and importance. Palynology: General morphology of spores and pollen and their applications. Palaeobotany: Plant life through geological ages. Gondwana plant fossils. Application of microfossils in petroleum exploration.

Evaluation &Grading

Lab Assessment – 10%
Skill development (Analytical, Writing and Presentation) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Benton, J.M. and Harper (2009) Introduction to palaeobiology and the fossil record, Wiley-Blackwell, 608p.
- Benton, M.J (2000). Vertebrate Palaeontology, Blackwell Science, 269p.
- Black, R.M (1989) The elements of palaeontology, Cambridge University Press, 420p
- Brasier. M.D (1980) Microfossils, George Allen and Unwin Ltd, 193p.
- Clarkson, E.N.K (1998). Invertebrate Palaeontology and Evolution, ELBS Publishers. 468p.
- Glaessner,M.F. Principles of Micropalaeontolgy, Hafner Publishing Company, 296p.
- Lehmann.U and Hilimer, G (1983) Fossil Invertebrates, Cambridge University, 350p
- Porthero, D.R. (2004) Bringing fossil to life- An Introduction to Paleontology Mc Graw Hill, 512p.
- Pough.H. F, Heiser, J.B. and McFarland, W.N. (1996). Vertebrate Life, Prentice hall, 720p.
- Raup D.M. and Stanley .S (1985) Principles of Palaeontology, 481p.
- Ray, A.K (2008). Fossils in earth Sciences, Prentice Hall of India Private Limited, 444p.
- Shrock, R.R., Twenhofel, W.H (1953). Principles of Invertebrate Palaeontology, Mc Graw Hill, 816p.

Course Code	EGE 5291	Semester	II
Course Title	Igneous and Metamorphic Petrology		
Credits	3	Type	Core

Course Description

The objective of this course will be to instruct the student in the processes that control the genesis of igneous and metamorphic rocks, with emphasis on its diversification. The laboratory portion of the course will be devoted to applying various classification systems to laboratory specimens. This course will focus on various megascopic, microscopic and analytical studies in the classification of igneous and metamorphic rocks.

Course Outcome

By the end of the course, students are expected to be able to:

- apply fundamental principles of petrology
- describe igneous and metamorphic rocks, their mineral assemblages and textures,
- interpret igneous and metamorphic processes from evidence obtained in hand sample, thin section, and analytical data (mineral composition),
- interpret tectonic setting

Course Structure

Module - 1

Preparation of binary phase diagrams. Megascopic and microscopic identification of igneous rocks. Normative mineralogical calculations of acid, intermediate, basic and ultrabasic rocks (3 each).

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Module – 2

Preparation of variation diagrams: Harkar, Larsen, Nockold and Allen, Niggli calculation of Fractionation Indices: Larsen Index, Nockolds Index, Mafic Index(MI), Mg-Number, Solidification Index, Felsic Index, Differentiation Index. Spider Diagram.

Module – 3

Study of metamorphic rocks in hand specimen. Preparation of metamorphic rock thin sections. Study of metamorphic rocks in thin sections: metamorphic mineral assemblages, structures and textures, grain boundary relations, strain effects. Plotting and interpretation of chemical data on ACF, AKF diagrams, Schreinmaker's rule and construction of petrogenetic grids, geothermometers and geobarometers.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Ragland.P.C (1989). Basic Analytical Petrology, Oxford University Press, 369p.
- Carmichael, I. S. E., Turner, F. J. and Verhoogen, J. (1974), Igneous Petrology, McGraw Hill Book Company, 739 p.
- Ehlers, E. G. and Blatt, H. (1981). Petrology, CBS Publishers and Distributors, New Delhi, 732 p.
- Faure, G. (2001), Origin of Igneous Rocks: The Isotopic Evidence, Springer-Verlag, New York, 496 p.
- Gupta, A. K. (1998), Igneous Rocks, Allied Publishers Limited, 690 p.
- Hall, A. (1988), Igneous Petrology, ELBS, Longman, 573 p.
- Bucher, K. and Martin, F. (2002), Petrogenesis of Metamorphic Rocks (7th Rev. Ed.),
- Kerr, P.F. (1959), Optical Mineralogy, McGraw Hill Book Company Inc., New York, 442p.
- Philpotts, A.R. (1994), Principles of Igneous and Metamorphic Petrology, Prentice Hall, 684p.
- Philpots A.R. and Ague, J.J. (2009), Principles of igneous and metamorphic petrology, second edition, Cambridge University Press, New York, 667p.

Course Code	EGE 5292	Semester	II
Course Title	Sedimentology and Palaeontology		
Credits	3	Type	Core

Course Description

The course deals with various sedimentological and paleontological techniques like sieve, pipette analysis for grain size determination and microfossils studies. It will provide an understanding of plotting, analysis and interpretation of sedimentary data to infer depositional environment. The course also includes megascopic and microscopic identification of sedimentary rocks.In Paleontology, students will be trained in sample processing for microfossil studies and identification of various microfossil groups.

Course Outcome

By the end of the course, students are expected to be able to:

- Perform grain size analysis of sediment samples using sieving and pipetting techniques.
- Calculation of various grain size statistical parameters, plotting the data and interpretation of depositional environment of sediments.
- Identify and classify the sedimentary rocks based on hand specimen and microscopic examination of thin sections.
- Perform sampling, processing and extraction of micro fossils from sediments.
- Identification of various microfossil groups and its application in geological studies.

Course Structure

Module - 1

Sieve analysis, plotting and interpretation of data (Trask method & Folk and Ward method). Estimation of statistical parameters - mean, skewness, kurtosis and standard deviation (sorting). Pipette analysis and estimation of silt and clay content. Plotting of gravel-sand-mud and sand-silt-clay data in triangular coordinate sheets. Interpretation of depositional environment.

Module – 2

Study and description of hand specimens and thin sections of conglomerate, breccia, sandstone, limestone, silt stone and shale.Sample processing techniques and separation of microfossils from matrix and marine sediments.

Module – 3

Identification of the following types of microfossils (calcareous and siliceous):Planktonic foraminifera, Benthic foraminifera, Ostracods, Pteropods and Radiolaria.Identification and separation of important species of planktonic foraminifera.

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag, 616p.
- Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi, 718p.
- Prothero, D.R., Schwab, F., (2003) Sedimentary Geology. W. H. Freeman; 2nd edition, 593p.
- Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag, 439p.
- Tucker, M. E (2011). Sedimentary rocks in the Field. A Practical Guide. 4th Edition. Wiley, 288p.
- Selley, R. C. (2000) Applied Sedimentology, Academic Press, 523p.
- Tucker, M.E. (1988). Techniques in Sedimentology. Wiley–Blackwell, 408p.
- Barghoorn, E.S. (1971) The Oldest Fossils, Scientific American, V. 224, No.5, 30-42.
- Brouver, A. (1967) General Palaeontology, Oliver & Boyd, 216p.
- Cushman, A. J. (1959) Foraminifera, Harward University Press, 605p.
- Glaessner, M.F. (1953) Principles of Micro Palaeontology, McGraw Hill.
- Jain, P.C. and Anantharaman, M.S. (1980) Palaeontology, Evolution and Animal Distribution, Vishal Pub., N.D, 320p.
- Jones, D.J. (1956) Introduction to Microfossils, Harper & Bros. Pub.
- Moore, R.C., Lalicker, C.G. and Fischer, A.G. (1952) Invertebrate Fossils, McGraw Hill.
- Neverson, E. (1962) Stratigraphic Palaeontology, Oxford University Press.
- Swinnerton, H.H. (1961) Outlines of Palaeontology, 3rdedn., Edward Arnold Ltd.
- Tiwari, S.K. (2004) A Text Book of Stratigraphy, Micropalaeontology and Palaeobotany, Kalyani Pub., N.D.

Course Code	EGE 5301	Semester	III
Course Title	Economic Geology		
Credits	3	Type	Core

Course Description

Economic geology is a professional skill development course that deals with the discovery of economic mineral deposits. The economic mineral deposits are the backbone of any nation's economy. A country with significant economic mineral deposits can be a wealthy nation if it has proper technology, manpower and application strategies. The course in economic geology aims to train the students in the professional and academic skills of an economic geologist.This course deals with the economic mineral genesis, global mineral laws and the mineral laws of India, mineral economics and mineral resource exploration techniques.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of economic geology
- Demonstrate confidence and accuracy in identifying important ore minerals in hand specimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
- Synthesis observations, evidence and theory to recognise and explain similarities and differences between different ore mineral groups.
- Discuss with confidence the theories, principles and outstanding controversies related to commercial mineral deposits.
- Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to economic geology

Course Structure

Module - 1

Mineral resource crisis, factors controlling mineral availability, minerals and global economic patterns, future of ore deposit geology; Geology of ore deposits – classification and deposit models. Textures of ore and gangue minerals; Paragenesis, zoning; Magmatic ore deposits; Hydrothermal ore deposits – magmatic and orogenic environments, sedimentary environments; Ore deposits formed in sedimentary environments; Supergene ores and supergene overprinting of ores.

Module - 2

Mineral law and land access: National Mineral Policy – MM (R & D) Act, 1957 – procedures for grant of mineral concessions in India; Types of land and mineral ownership in different countries; Exploration versus exploitation concessions. Mineral Economics: History and structure of the mineral industry; Profits in the mineral industry; Mineral taxation and mineral profits; Mineral commodity prices; Distribution of profits. Law of the Sea Treaty – marine mineral resources.

Module - 3

Mineral resources and exploration; search for ore deposits and chances of success – geological, geochemical, geophysical, drilling, sampling and other field techniques; Remote sensing applications in mineral exploration; Surveying and exploration; statistical treatment of exploration data and computer applications.

Evaluation &Grading

- Lab Assessment – 10%
- Skill development (Analytical, Writing and Presentation) – 10%
- Class Test – 20%
- End Semester Assessment – 60%

References

- Banerjee (2001), Mineral Resources of India.
- Evans, A.M., (1980) An introduction to Ore geology, Blackwell Scientific Publications, 231p.
- Evans, A. M. (1993), Ore Geology and Industrial Minerals: An Introduction, Blackwell, 403p
- Geological Survey of India (2009), Miscellaneous publication no. 30, part-xxii: Geology and mineral resources of India,152p
- Geological Survey of India, Detailed information dossier (DID) of ores in India, (Available at GSI portal: www.portal.gsi.gov.in).
- Indian Bureau of Mines Bulletins of Mineral Information (availabile at IBM website) Ministry of Mines Annual Report 2011-12, 248p.
- Mookherjee, A., (1999), Ore Genesis- A Holistic Approach, Allied Publishers, 657p.
- Ministry of Mines (2011), Report of the working group on mineral exploration & development (other than coal & lignite) for the 12th five-year plan subgroup – on survey and mineral exploration, 310p.
- Nuclear Power in India Indian Nuclear Energy, http://www.world-nuclear.org/info/inf53.html
- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Soman, K. (2001), Geology of Kerala, GeolSoc of India, Bangalore, 335p
- Stanton, R.L., (1972), Ore Petrology, McGraw Hill Inc, 213p
- Uranium 2009: Resources, Production and Demand, (The Red Book) Nuclear Energy Agency, OECD, 452p.
- Wellmer, F.W., Dalheimer, M. and Wagner, M. (2008), Economic Evaluation in Exploration, Springer-Verlag, Berlin.
- Zoellner, T. (2009) Uranium: war, energy, and the rock that shaped the world, Viking, London, 353p.
- Arogyaswamy, R.N.P. (1980), Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
- Arthur, W., Hawkes, H.E. and Webb, J.S. (1979), Geochemistry in Mineral Exploration, Academic Press, USA, 657p.
- Banerjee, P.K and Ghosh, S. (1997), Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991), An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Krisch, R (2006). Groundwater Geophysics, A tool for hydrogeology, Springer – Verlag Berlin Hiedelberg.,Berlin 548 pp
- Lowrie, W (2007). Fundamentals of Geophysics, Cambridge University press, New York, 381pp.
- Mckinstry, H.E. (1947), Mining Geology, 1st Indian Ed., Asia Publishing House, New Delh

- Milsom,J (1989). Field Geophysics,A Geological Society of London Handbook, John Wiley&sons, New York.182 pp.
- Mishra D,C. (2011). Gravity and Magnetic Methods for Geological Studies,BS publications Pvt.Ltd Hyderabad 938pp.

Course Code	EGE 5302	Semester	III
Course Title	Hydrogeology		
Credits	3	Type	Core

Course Description

Hydrogeology is the study ofthe occurrence, distribution, and movement of groundwater below the Earth's surface. The course deals withvarious hydrogeologic processes, hydrological properties of rocks and principles of groundwater flow. It gives an overview of different groundwater exploration methods and water quality standards. The basic skills to apply pumping-test data to determine aquifer properties and an understanding of the chemical constituents in groundwater and surface waters is also provided by the course. The course will provide the theoretical knowledge required for the role of a professional hydrogeologist.

Course Outcome

By the end of the course, students are expected to be able to:

- Define hydrogeological terms, properties, methods of measurement and examine the significance of hydrogeological results.
- Explain the principles of groundwater flow and groundwater chemistry.
- Appraise the different types of aquifers, their composition, flow patterns, chemistry and vulnerability to pollution.
- Demonstrate an understanding of the laws governing groundwater flow in porous media.
- Apply basic quantitative analysis techniques to solve practical hydrogeology problems.
- Analyse of pumping test data to understand aquifer properties

Course Structure

Module - 1

Hydrological cycle and origin of ground water. Classification of rocks with respect to their water bearing properties- aquifers, aquicludes, aquitards, aquifuges. Types of aquifers. Hydrological properties of rocks: Porosity, permeability, void ratio, specific yield and specific retention, hydraulic conductivity, storativity, transmissivity.Barometric efficiency and tidal efficiency.

Module – 2

Groundwater flow: Darcy’s law and its experimental verification, flow nets, fluid potentials.Well hydraulics: Pumping tests and data analysis. Steady radial flow to a well in confined and unconfined aquifers-Theim’s equation, Dupuit-Forhemeir equation. Unsteady radial flow to a well in confined and unconfined aquifers- Theis,

Chow's and Jacob's methods.Application of isotope studies and tracer techniques in ground water flow.

Module – 3

Ground water exploration: Geological methods- lithological and structural mapping. Geophysical methods- Electrical Resistivity methods, Wenner and Schlumberger arrays, Profiling and VES methods. Seismic Refraction methods. Well logging: Spontaneous Potential Logging, Radiation logging, Gamma-gamma ray logging. Use of Aerial photos and satellite imageries in ground water prospecting. Well design criteria: Types, construction, maintenance and development of wells. Physical, chemical and bacterial measures of water quality. Water quality standard for different purposes – Drinking, Domestic, Irrigation and Industrial. Saline water intrusion in coastal aquifers and its prevention – Ghyben-Herzberg relationship. Artificial recharge and rain water harvesting methods.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Bouwer,H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis,S.N. and Dewiest, R.J.N. (1966). Hydrogeology, John Wiley and Sons Inc. New York, 463p.
- Karanth, K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Linsley, R.K, Kohler, M.A. and Taulhus, J.L.H. (1975) Applied Hydrology, Tata McGraw Hill, 689p.
- Todd, D.K. (1980) Groundwater Hydrology, John Wiley and Sons, 552p.
- Walton,W.C. (1970) Groundwater Resource Evaluation, McGraw Hill Inc, 664p.
- Reghunath, H.M. (1992) Groundwater. 2nd Edn.Wiley Eastern Limited, 456p.
- Fetter, C.W. (2007) Applied Hydrogeology.Pearson, 624p.

Course Code	EGE 5303	Semester	III
Course Title	Geospatial Technology and Engineering Geology		
Credits	3	Type	Core

Course Description

This course will discuss the fundamentals of geospatial technology and engineering geology. Geospatial technology is an applied branch of earth science which deals with the modern tools contributing to the geographic mapping and analysis of the Earth and human societies. Engineering Geology is the branch of geology which describes the application of geology in engineering studies.

Course Outcome

By the end of the course, students are expected to be able to:

- understand the basics of geospatial technology and engineering geology.
- have an introduction towards remote sensing and GIS .
- have an idea about the applications of remote sensing and GIS.
- understand various geotechnical investigations and interpretations.

Course Structure

Module - 1

Geospatial Technology-Concept, Software and Hardware, Data. Map-Map projections-Map Scale, Datum. Space mission and satellites. Global Positioning System: Basic features, NAVSTAR GPS, GLONASS, IRNASS. Remote sensing- Basic concept, Electromagnetic Energy. Energy sources and radiation principles. Energy interactions in the atmosphere, energy interaction with earth surface features, Spectral Reflectance. Remote Sensing Platforms. Photogrammetry: basic principles – geometric characteristics of aerial photographs. Aerial photo interpretation. Thermal Remote Sensing and Microwave Remote Sensing. Digital image processing. Geographic Information System-Fundamentals of GIS and Components of GIS. Data and database management system

.

Module – 2

Applications of remote sensing in Geology, land use-land cover mapping-NDVI,Natural resource management, Water resources management; Disaster management and Environmental management. Applications of GIS in Geology, Water Resource Management,Environmental Impact Analysis, Urban planning, Disaster Management and Mitigation, Natural Resources Management.

Module – 3

Physical and engineering properties of rocks. Rock deformation and mechanical properties. Principal geological factors affecting engineering projects – Earth movements, stability of slopes and cuttings, groundwater, volcanoes, earthquakes; Geological materials used in construction. Geological considerations in engineering projects and site selection such as dams, reservoirs bridges, highways and tunnels. Geological investigation of engineering projects. Landslide hazard zonation mapping. Aseismic design of buildings and earthquake-resistant structures. Influence of geological conditions on foundation and design of buildings. Seismic zonation.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Campbell, J. B.and Wynne, R. H. (2008), Introduction to Remote Sensing, Fifth Edition, The Guilford Press, New York, 718p.
- Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.
- Lillesand, T.M., Kiefer,R.W. and Chipman, J.W. (2004), Remote sensing and image interpretation, Fifth Edition, Wiley, NJ, 812p.
- Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.
- McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.
- DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.
- Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.
- Konecny, G. (2003), Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor& Francis, London, 266p.
- Shekar, S., Xiong, H. eds. (2008), Encyclopaedia of GIS, Springer-Verlag, New York, 1392p.
- Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.
- Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p.
- Jensen, J.R., (2000). Remote Sensing of the Environment an Earth Resource Perspective. New Jersey: Prentice Hall, Inc, 608p.
- Jensen, J.R., (2005). Introductory Digital Image Processing: A Remote Sensing Perspective. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 544p.
- G.L. Prost (2002). Remote sensing for Geologists: A guide to image interpretations. CRC Press, 326p.
- Floyd F. Sabins (1997) Remote Sensing: Principles and interpretations.WH Freeman & Company, 494p.
- P. A. Burrough, Mcdonnell R A (1998). Principles of geographical information systems. Oxford university press, 332p.

- Arogyaswamy, R.N.P (2017). Courses in Mining Geology. Oxford and IBH Publishers, 735p.
- Hartman H. L. and Mutmansky, J.M. (2002). Introductory mining Engineering, John Wiley and Sons Inc.
- Gaudin, A .M. (1938) Principles of Mineral Dressing, McGraw Hill, 554p.
- Petters, W.C. (1987) Exploration and Mining Geology. John Wiley, 706p.
- Reedman, J.H. (1979) Techniques in mineral exploration, Allied Scientific Publishers, 534p.
- Bell, F.G. (1983) Fundamentals of Engineering Geology. Butterworth-Heinemann, 656p.
- Coduto, D.P. (2001) Geotechnical Engineering –Principles and Practices. Prentice Hall of India, Pvt Ltd, New Delhi.
- Duggal, S.K. Pandey, H.K. and Rawal, N. (2014) Engineering Geology, McGraw Hill Education (India) Pvt. Ltd.
- Lee. F. and Griffiths (2007). Engineering Geomorphology, Whittles publishing, 288p.
- Krynine, D.P. and Judd, W.R. (2001) Principles of engineering geology and Geotectonics, CBS Publishers and Distributers, New Delhi.

Course Code	EGE 5391	Semester	III
Course Title	Lab: Ore Geology		
Credits	3	Type	Core

Course Description

The Ore Geology lab is a professional skill development coursethat deals withvarious analytical techniques to investigate the physical and optical properties of ore minerals, ore dressing techniques andpreparation of polished sections. The course also deals with the numerical problems related to exploration geology.

Course Outcome

By the end of the course, students are expected to be able to:

- Perform quantitative and qualitative hand-specimen and microscopic investigations of ore minerals.
- Develop a skill towards solving mineral exploration problems.
- Perform logging of geophysical and geological datasets.
- Design on their own the ore dressing sequences in order to extract ore minerals from the run-of-mines (RoMs).

Course Structure

Module - 1

Megascopic and microscopic study and identification of ore minerals. Preparation and study of orepolished sections.
Gravity, magnetic, seismic and electrical resistivity exploration problems.

Module – 2

Preparation of litho logs using exploration data. Calculation of grade, tonnage and cut-off grade. Ore reserve estimation.

Module – 3

Fundamentals of ore dressing: Crushing, grinding, sizing, concentration by washing, scrubbing, jigging, tabling, floatation. Magnetic and Electrostatic separation. Flow-charts of mineral separation.

Evaluation &Grading

Lab assessment – 10 %
Skill development (Analytical and lab skills) – 10%
Practical Test – 20%

End Semester Assessment – 60%

References

- Arogyaswamy, R.N.P. (1980) Courses in Mining Geology, 2nd Ed., Oxford & IBH Pub. Co., New Delhi
- Banerjee (2001) Mineral Resources of India.
- Banerjee, P.K and Ghosh, S. (1997) Elements of Prospecting for Non-fuel Mineral Deposits, Allied Publishers Pvt Ltd, 320p.
- Kearey, P. and Brooks,M. (1991) An Introduction to geophysical Exploration, Blackwell scientific Publications, Musset, 272p.
- Mckinstry, H.E. (1947) Mining Geology, 1st Indian Ed., Asia Publishing House, New Delhi.
- Prasad, U (2002) Economic Mineral Deposits, CBS Publishers, New Delhi.
- Sinha, R.K and Sharma, N.L. (1970), Mineral Economics, New Delhi Oxford and IBH Pub.co., 317p.

Course Code	EGE 5392	Semester	III
Course Title	Lab 6: Hydrogeology and Geospatial Technology		
Credits	3	Type	Core

Course Description

The course will provide practical skills necessary for solving various hydrogeologic problems and software training in geospatial technoloy. It deals with interpretation of aquifer properties based on hydrogeological data, electrical resistivity survey techniques, preparation of ground water contour and flow direction maps and analysis of water quality data. The students will develop skills in hydrogeologic data collection and interpretation, assessing hydrologic properties of aquifers, identification of ground water potential zones and determine depthof ground water occurrence. In geospatial technology students will be trained to perform various GIS and remote sensing based analysis in Arc GIS, Envi and Q GIS.

Course Outcome

By the end of the course, students are expected to be able to:

- Apply basic quantitative analysis techniques to solve practical hydrogeological problems.
- Acquire practical skills to apply hydrogeological principles and methodologies for groundwater exploration.
- Carry out electrical resistivity survey and interpret the data for determining the depth of groundwater occurrence.
- Prepare groundwater contour maps and flow direction maps.
- Assess groundwater potential zones using remote sensing techniques.
- Prepare water quality diagrams and interpret the quality of water.
- Professionally report findings and recommendations from a groundwater study in written and oral formats.
- Become proficient in GIS and Remotesensing softwares.
- Perfom various GIS and remote sensing analysis

Course Structure

Module - 1

Identification and demarcation of watershed boundaries. Collection and interpretation of well inventory data. Determination of groundwater flow direction. Preparation and interpretation of water table contour map. Pumping test –Evaluation of aquifer parameters from pumping test data. Calculation and evaluation of hydrogeological parameters: porosity, permeability, hydraulic conductivity, transmissivity, specific yield, specific retention, storativity. Problems based on Darcy’s law.

Module – 2

Electrical resistivity survey and interpretation of data. Study of Electric resistivity sounding data for delineation of depth of ground water occurrence. Exercises on groundwater exploration using remote sensing techniques. Preparation of ground water potential maps. Analysis of water quality parameters. Graphical representation of water quality data(Bar diagrams, Piper Trilinear diagram, Vector diagram, Circular diagrams, Stiff's polygon). Interpretation of hydrochemical data.

Module – 3

Geospatial Technology- Introduction to software and hardware. Introduction to Remote sensing analysis. Introduction to GPS. Aerial photo interpretation. Geographic Information System- software and applications.

Evaluation &Grading

Lab/field assessment – 10 %
Skill development (Analytical, writing and lab skills) – 10%
Class Test – 20%
End Semester Assessment – 60%

References

- Bouwer,H. (1978) Groundwater Hydrology. McGraw Hill Education, 480p.
- Davis,S.N. and Dewiest, R.J.N. (1966). Hydrogeology, John Wiley and Sons Inc. New York, 463p.
- Karanth, K.R.(1987). Groundwater Assessment Development and Management, Tata McGraw Hill, 720p.
- Linsley, R.K, Kohler, M.A. and Taulhus, J.L.H. (1975) Applied Hydrology, Tata McGraw Hill, 689p.
- Todd, D.K. (1980) Groundwater Hydrology, John Wiley and Sons, 552p.
- Walton,W.C. (1970) Groundwater Resource Evaluation, McGraw Hill Inc, 664p.
- Reghunath, H.M. (1992) Groundwater. 2nd Edn.Wiley Eastern Limited, 456p.
- Fetter, C.W. (2007) Applied Hydrogeology.Pearson, 624p.
- Jensen, J.R., (2005). Introductory Digital Image Processing: A Remote Sensing Perspective. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 544p.
- Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p
- Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.
- McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.
- G.L. Prost (2002). Remote sensing for Geologists: A guide to image interpretations. CRC Press, 326p.

Course Code	EGE 5491	Semester	IV
Course Title	Dissertation		
Credits	9	Type	Core

Course Description

This course will have an independent project work including field and laboratory investigations of geological significance. Preparation and presentation of Dissertation will be in the fourth semester although the work related to the dissertation can be initiated in the third semester itself.

Course Outcome

By the end of the course, students are expected to be able to:

- have a basic understanding an independent geological fieldwork.
- have a basic understanding on lab investigations.
- have a basic understanding on preparation of research report.
- have a basic understanding on an oral presentation of independent research work.

Course Structure

Project work shall be carried out under the supervision of a teacher in the parent department. The candidate may be permitted to work on the project in an industrial / research organization on the recommendation of the supervising teacher and the Head of the Department. In such cases also, a teacher from the parent department would be the sole supervisor no co-supervisor/ external guide will be permitted. Every student has to do the dissertation work independently. The project title, content and layout should be in university standard format. The project reports of students should not be identical in content.

Evaluation &Grading

Skill development (Lab work and Research report) – 20%
Field work – 20%
Assessment of Dissertation Report – 40%
Presentation and viva voce-20%

Course Code	EGE 5001	Semester	Any
Course Title	Industrial Minerals and Gemstones		
Credits	3	Type	Elective

Course Description

Industrial minerals and gemstones is a professional development course that deals with the occurrences and distribution of industrial minerals, characteristics and economic importance of gemstones, special properties of gemstones and gem testing techniques. The course aims to introduce the skills of gem testing using advanced techniques to the students and enable them to identify and discuss the economic importance of industrial minerals and gemstones.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of industrial minerals and gemmology
- Demonstrate confidence and accuracy in identifying important industrial minerals and gemstones in hand specimens, in outcrop, and under the microscope, and apply the theories to the solution of problems in the field.
- Synthesis observations, evidence and theory to recognise and explain similarities and differences between various industrial minerals and gemstones.
- Discuss with confidence the theories, principles and outstanding controversies related to the origin of industrial minerals and gemstones.

Course Structure

Module - 1

Industrial Minerals - Mode of occurrence - Uses and distribution in India - Ceramic minerals, Granite and Building stones, Cement - Raw materials - Mineral pigments - Refractory and abrasive minerals - Fertilizer minerals- Diamond - Gemstones, Asbestos, Mica, Vermiculite, Barite, Talc, Glass, Sand and Fullers earth.

Module - 2

Introduction to Gems – Precious and Semiprecious stones and their economic importance. Classification of gem stones materials.General characteristics and chemical composition of gemstones. Physical characteristics: Form, cleavage, fracture, hardness and specific gravity; Optical characteristics: colour, lustre, refractive index, reflectivity, pleochroism, and dispersion. Introduction to special optical properties of gemstones: Chatoyancy, Asterism, Luminescence, Play of colours, Labradorescence, Inclusions. Formation of gemstones.

Module - 3

Gem Testing- Refractometers, Polariscope, Dichroscope, Ultra-violet lamps. Principles and Uses. Application of ultra-violet rays, X-rays and Infra-red rays in gem identification. Electrical, thermal and magnetic characters of gemstones. Methods of determination of specific gravity. Distinction between synthetic and natural gemstones. Gem enhancement methods: Polishing, Carving and engraving, colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment etc. Utility of gemstones: (1) Technical applications and (2) Use as jewels. Occurrence of gems in India. Gem Industry in India.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Anderson B.(2014).Gem Testing, Sutton Press.
- Babu T. M. (1998). Diamonds in India, Geological Society of India, Bangalore.
- Bates, (1969). Geology of Industrial Rocks and Minerals, Dover book earthsciences.
- Baumgart,W., Dunham A.C., and Amstutz, G.C.(1985).Process Mineralogy of CeramicMaterials. Elsevier Science Ltd.
- Cally Hall (1994). Gemstones, Dorling Kindersley.
- Deb,S. (1980). Industrial Minerals and Rocks of India, Allied Publishers (P) Ltd.
- Karanth, R.V. (2000). Gems and Gem Industry in India, Geological Society of India.
- Krishnasamy, S. (1972). India's Mineral Resources, Oxford and IBH Publishers.
- Taggart, A.P. Hand book of Mineral dressing, John Wiley & Sons Inc., 1905p.

Course Code	EGE 5002	Semester	III
Course Title	Geospatial Technology		
Credits	3	Type	Elective

Course Description

This course will discuss the fundamentals of geospatial technology. Geospatial technology is an applied branch of earth science which deals with the modern tools contributing to the geographic mapping and analysis of the Earth and human societies. This course will be offered as an external elective for other branch students. This present course curriculum offers an opportunity for the other branch students to understand the basics of geospatial technology for developing an interest in the principles, practical uses, and resources related to geospatial technologies.

Course Outcome

By the end of the course, students are expected to be able to:

- understand the basics of geospatial technology.
- have an introduction towards remote sensing and GIS .
- have an idea about the applications of remote sensing and GIS.

Course Structure

Module - 1

Concepts and foundation of remote sensing: energy sources and radiation principles, energy interactions in the atmosphere, energy interaction with earth surface features – Spectral Reflectance - Introduction to aerial photographs and aerial photo interpretation. geometric characteristics of aerial photographs. Binocular-Mirror-pocket Stereoscopes. Photogrammetric problems.

Module – 2

Introduction to remote sensing- land use-land cover mapping-NDVI. Applications of remote sensing in Water resources management; Disaster management, Public Health, Urban Planning and Environmental management. Geographic coordinates. Map projections. Global Positioning System: Basic features, NAVSTAR GPS, GLONASS, IRNASS.

Module – 3

Fundamentals of Geographic Information System – data input, data management, data manipulation, data output. Data Input and Editing: Coordinate Conversion. Digitizing, data encoding, re-projection and transformation. Vector and Raster data analysis.Applications of GIS inmapping, Urban planning, Water resources management; Disaster management; Environmental management and public health.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Campbell, J. B.and Wynne, R. H. (2008), Introduction to Remote Sensing, Fifth Edition, The Guilford Press, New York, 718p.
- Falkner, E. and Morgan D. (2002), Aerial Mapping: Methods and Applications, Lewis Publishers, Boca Raton, 192p.
- Lillesand, T.M., Kiefer,R.W. and Chipman, J.W. (2004), Remote sensing and image interpretation, Fifth Edition, Wiley, NJ, 812p.
- Mather, P.M. and Koch, M. (2011),Computer Processing of Remotely-Sensed Images – An Introduction, Fourth Edition, John Wiley, New York, 462p.
- McCoy, R. M. (2005), Field methods in remote sensing, Guilford Press, New York, 177p.
- DeMers, M. N. (2009), GIS for dummies, Wiley, NJ, 388p.
- Iliffe, J. (2000), Datums and Map Projections for remote sensing, GIS, and surveying, Whittles Publishing, Scotland, 159p.
- Konecny, G. (2003), Geoinformation: Remote sensing, photogrammetry and geographic information systems, Taylor& Francis, London, 266p.
- Shekar, S., Xiong, H. eds. (2008), Encyclopaedia of GIS, Springer-Verlag, New York, 1392p.
- Sickle, J. V. (2010), Basic GIS Coordinates, CRC Press, FL, 190p.
- Verbyla, D. L. (2003), Practical GIS analysis, Taylor & Francis, London, 305p.
- Jensen, J.R., (2000). Remote Sensing of the Environment an Earth Resource Perspective. New Jersey: Prentice Hall, Inc, 608p.
- Jensen, J.R., (2005). Introductory Digital Image Processing: A Remote Sensing Perspective. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall, 544p.
- G.L. Prost (2002). Remote sensing for Geologists: A guide to image interpretations. CRC Press, 326p.
- Floyd F. Sabins (1997) Remote Sensing: Principles and interpretations.WH Freeman & Company, 494p.
- P. A. Burrough, Mcdonnell R A (1998). Principles of geographical information systems. Oxford university press, 332p.

Course Code	EGE 5003	Semester	Any
Course Title	Coal and Petroleum Geology		
Credits	3	Type	Elective

Course Description

This course will discuss the Fundamentals of coal and petroleum geology. It provide proper enlightenment towards the Origin of coal, Petrography of coal, petroleum source rock, reservoir, and trap studies etc.

Course Outcome

By the end of the course, students are expected to be able to:

- have a basic understanding of the petroleum system and petroleum as a resource.
- have an idea about the origin of coal and petroleum.
- have an understanding on the global distribution of coal, oil and gas through geologic ages.

Course Structure

Module – 1

Origin of coal: accumulation of vegetative matter - *in situ* and drift theories; stages of formation of coal.. Classification, Ranks and Grading of coal. Petrography of coal: lithotypes, macerals and microlithotypes. Coal-bed Methane as an energy resource. Physical and chemical characteristics of coal. Geological and geographical distribution of coal deposits in India.

Module – 2

Origin of petroleum- organic and inorganic theories. Transformation of organic matter into petroleum; Kerogen, transformation and maturation of kerogen. Primary and secondary migration of oil and gas. Reservoir rocks: classification and characteristics; Structural traps, stratigraphic traps and combination traps for oil and gas accumulation.

Module – 3

Global distribution of oil and gas through geologic ages. Petroliferous basins of India. Geological setting of major oil and natural gas fields of India. The surface indications and direct detection of hydrocarbons. Introduction to the oil belts of the world. An outline of well-site geological techniques and exploration techniques. Introduction to basin analysis. Gas hydrate and shale gas – origin and extraction.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%

Class Test – 20%
End Semester Assessment – 60%

References

- Deshpande B. G. (1992) The world of petroleum. New Age International, 260p.
- Levorson A. I. (2004) Geology of Petroleum. CBS Publishers and Distributors Pvt Ltd, 260p.
- North F. K. (1985) Petroleum Geology. Alllen&Unwin, Boston, 607p.
- Chandra, D., Singh, R.M. Singh, M.P. (2000): Textbook of Coal (Indian context), Tara Book Agency, Varanasi, 402p.
- Scott, A.C. (1987) Coal and coal-bearing strata: Recent Advances and future prospects, Geological Society, London, Special Publications, 32p.
- Singh, M.P. (1998) Coal and Organic Petrology, Hindustan Publishing Corporation, New Delhi, 128p.
- Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller R. (1982): Stach's Texbook of Coal petrology, GebruderBorntraeger, Stuttgart, 535p.
- Thomas L. (2002) Coal Geology, John Wiley and Sons Ltd., England, 384p.
- Sharma, N.L. and Ram K.S.V. (1966) Introduction to the Geology of Coal and Indian Coalfields. Dhanbad Publications, Dhanbad, 183p.
- Acharyya S.K. (2000) Coal and Lignite Resources of India-An Overview. Geol. Soc. of India, 50p.
- Tissot, B.P and Welte, D.H (2003). Petroleum formation and Occurrence. Springer-Verlag, 699p.
- Selley, R.C (1999) Elements of Petroleum Geology. Academic press, 470p.
- Milton B. Dobrin & Carl H. Savit (1988). Introduction to Geophysical prospecting, McGraw-Hill, 867p.
- Gupta, P. K. and Nandi, P. K. (1995). Wellsite Geological Techniques and Formation Evaluation: A user's manual, Vol. Oil and Natural Gas Corporation, Dehradun.
- Ransom, R.C. (1995) Practical Formation Evaluation, John Wiley and Sons, 490p.
- Rider, M.H. (1985) The Geological Interpretation of Well Logs, Blackie, London, 280p.

Course Code	EGE 5004	Semester	Any
Course Title	Environmental Geology and Disaster Management		
Credits	3	Type	Elective

Course Description

Environmental geology and Disaster Management programme deals with a multidisciplinary approach that covers a broad range of topics, ranging from the concepts of environment to Disasters Management, including natural hazards and their impact on human lives. It will address the interactions between humans and the physical environment. Also discuss sustainable approaches in Environmental management, Land-use management, Disaster risk reduction, Risk management, integrated disaster risk management and post-disaster response

Course Outcome

By the end of the course, students are expected to be able to:

- get a proper enlightenment towards environment management.
- understand the fundamental concepts of natural hazards
- elucidate the sustainable approaches in Disaster Management
- understand the Risk management
- have a preparedness in post-disaster response

Course Structure

Module - 1

Our environment - an introduction. Fundamental concepts of environmental geology. Land-use and its Management –Land use pattern in India. Soil conservation- Strategy, Practices in hilly areas, Controlling gully erosion in ravine lands, Shelter belts in deserts. Energy and environment- Environmental impacts of quarrying and mining, Waste management. Environmental pollution- land, air and water.

Module – 2

Hazards- Introduction to key concepts, terminology. Natural hazards – Geologic and atmospheric. Earthquake, Landslide, Tsunami, Flood, Drought, Cyclone, Volcanic eruption, and Avalanche. Hazard- vulnerability, Exposure, Risk, Crisis, Disasters, Significant aspects of disasters

Module – 3

Disaster risk reduction, Risk management framework, Integrated Disaster risk management and post-disaster response. Natural disasters and their management- Problems, prospects and case studies. Climate change and its impact on coastal environment. Coastal management planning. Disaster management process- Prevention, preparedness, Mitigation, Application of Information technology in Disaster Preparedness, Application of geospatial technology in disaster management,

Trauma and Stress management, First Aid and Emergency procedures, Early Warning systems.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Pritchard, C.L. (2005), Risk Management, ESI International, Virginia, 474p.
- Coates, D.R. (1981) Environmental Geology, John Wiley and sons, 701p.
- Lee, F and Griffiths (2007) Engineering Geomorphology, Whittles publishing, 288p.
- Gupta, H.K. (2003) Disaster Management, University Press, 188p.
- Keller, E.A (2010). Environmental Geology. Pearson, 624p.
- Bennett M.R and Doyle, P. (1997) Environmental Geology, Wiley, 512p.
- Elawan, P.T. (1970) Environmental Geology, Harper and & Raw.
- Rajib Shaw and R.R. Krishnamurthy (2010) "Disaster Management: Global Challenges and Local Solutions", Disaster Prevention and Management, v. 19, No. 4, pp. 518-518.
- Radhakrishna B.P and Ramachandran K.K. (1986). India's Environment, GSI, Bangalore
- Valdiya K.S. (2004) Geology, Environment Society, Orient Blackswan Private Limited, New Delhi, 240p.
- Valdiya K.S. (2013) Environmental Geology, McGraw Hill, New Delhi.
- www.ndma.gov.in
- www.sdma.ker.in

Course Code	EGE 5005	Semester	Any
Course Title	Water Resource Management		
Credits	3	Type	Elective

Course Description

Water resource management is planning, developing, distributing and managing the optimum use of water resources. It deals with the development and utilization of water resources to meet increasing socioeconomic water demand. The course aims to develop the professional skills required for a career in the management of water resources. The course deals with assessing surface and groundwater resources, water resources planning, integrated water resources management, watershed conservation practices, and water quality evaluation.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand basic principles of water resources management, including surface and groundwater hydrology and water quality.
- Discuss issues regarding water use, management, anddevelopment.
- Assess surface and groundwater resources of a region.
- Develop suitable plans for water resource development and management.
- Estimate sustainable yield of water resources and determine the required storage of water resources.

Course Structure

Module - 1

Introduction to water resources - Ground water, Surface water, Glaciers and Rainwater. History of water resource development, Global water resources, Water cycle, Relation between water resources and environment. Concept of Integrated Water Resource Management (IWRM). Need for Water Resource Management, available water resources, Water scarcity- Lowering of Ground water level, vanishing of fresh water ponds, lakes and wet-lands.

Module – 2

Water supply Planning and Management-Domestic, agricultural and industrial. Cost-benefit analysis in water resource planning, Planning of watershed conservation practices, artificial recharging, contour bunding, sub-surface dams, geo-textile, rainwater harvesting. Estimation of available water resources. Water budgeting. Artificial reservoirs, construction of dams, Design and Planning of Distribution system- Drinking water, Irrigation water, Canal design, principles of irrigation, evapo-transpiration.

Module – 3

Water quality- pollution, Chemical and biological. Different Water quality standards. Water analysis techniques – Rainfall data, Acidic and alkali rain, Soil moisture analysis, evaporation, transpiration, Flood frequency analysis, rainfall - runoff analysis, reservoir function study, Generation of hydro-electric power. Treatment of waste water. Desalination methods.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Cech Thomas V. (2003). Principles of water resources: History, development, management and policy. John Wiley& Sons.
- Todd, D.K. (2004) Ground Water Hydrology, John Wiley & Sons, 636p.
- Karanth, K.R. (1987) Groundwater Assessment, Development and Management. Tata McGraw Hill, New Delhi, 720p.
- Mays, L.W. Water resource engineering, John Wiley& Sons
- Linsley R.K and Franzini J.B (1979) Water resource engineering, McGraw-Hill
- Mays L.W. (1996) Water resources hand book, McGraw-Hill.
- Jain S.K. and SnghV.P.,Water resources system planning and Management Elsevier
- Walton, W.C. Ground Water Resources evaluation, McGraw-Hill.

Course Code	EGE 5006	Semester	Any
Course Title	**Isotope Geology**		
Credits	3	Type	Elective

Course Description

Isotope Geology is an aspect of geology based upon the study of natural variations in the relative abundances of isotopes of various elements. This program introduces the student to theoretical and practical aspects of radiometric geochronology and stable isotope geology. The isotopic geochemistry has a great importance in geology is radiometric age dating.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate advanced knowledge of the geochemistry of rocks. Recognize the importance of isotope investigation of waters and of the atmosphere. Understand appropriate sample preparation procedures for analytical isotope geochemistry
- Demonstrate a basic understanding of the analytical methods used to measure element concentration in geochemistry. Understand precision and accuracy of geochemical measurements.
- Describe geochemical data in the context of environmental processes and application of stable and unstable isotopes in earth system science.

Course Structure

Module - 1

Isotope geochemistry: Physical and chemical properties of isotopes; stable and unstable isotopes. Unstable or radio-isotopes**:** radiometric dating methods, Principles of isotope dating. U –Th - Pb methods, principles, merits and demerits. K-Ar method. Ar gain, Ar loss and their effects. Ar^{40} - Ar^{30} method. Rb–Sr method. Whole- rock and isochron methods. Sr loss. Sm -Nd method. Rb - Sr and Sm - Nd ratios and their significance. Fission track dating. ^{14}C dating. Suitability of samples or materials for dating. Preparation of samples for dating. Interpretation of isotope dates. Limitations of isotope dating. Distribution of dates in space and time.

Module – 2

Stable Isotopes**:** Geochemistry, Notation. Theoretical Considerations. The Mass Spectrometer- principles, components and sensitivity. Thermal-ionization mass spectrometry (TIMS), ICP-MS, LA-MS, Secondary-Ion Mass Spectrometry (SIMS). Measurement of stable isotopes using isotope ratio Mass Spectrometer (IRMS). Isotope Fractionation in Hydrologic and Biological Systems.

Carbon Isotope Fractionation during Photosynthesis. Nitrogen Isotope Fractionation during biological processes. Oxygen and Hydrogen Isotope Fractionation during

precipitation, evaporation and absorption by Plants. Paleoclimatology. The Marine Quaternary $\delta^{18}O$ Record and Milankovitch Cycles.

Module – 3

Sulfur Isotopes and Ore Deposits. Stable Isotopes in the mantle and magmatic system. Stable Isotopic Composition of the Mantle. Boron isotopes. Stable Isotopes in Crystallizing Magmas. Combined Fractional Crystallization and Assimilation. Isotope Geothermometry. Paleothermometer, carbonate thermometer, $^{18}O/^{16}O$ isotope composition of silicates and high-temperature thermometry, isotopic cycle of water, Paleothermometry and the water cycle: paleoclimatology, paleoclimatic records: sediment and ice. Carbonate paleoclimatology.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Allegre, C. (2008), Isotope Geology, Cambridge University Press, New York, 534p.
- Baskaran, M. (ed) (2011), Handbook of Environmental Isotope Geochemistry, Springer-Verlag, Berlin, 943p.
- Claude Hillaire–Marcel and Anne De Vernal (2007) Proxies in Late Cenozoic Paleoceanography (2007), Elsevier, Amsterdam, Tokyo, 843p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Hoefs, J. (2009), Stable Isotope Geochemistry, 6th Edition, Springer-Verlag, Berlin, 293p.
- Krauskopf, K. B. (1967), Introduction to geochemistry, McGraw-Hill Book Co., New York, 721 p.
- Mason, B, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley & Sons, New York, 344 p.
- Mook, W. G. (2000), Environmental Isotopes in the Hydrological Cycle: Principles and Applications, Vol 1, UNESCO/IAEA, Paris, 297p.
- Valley, J. and Cole, D. (2001), Stable Isotope Geochemistry, Reviews in Mineralogy 43, Mineralogical Society of America, Washington DC, 660p.
- White, W. M., Geochemistry, 695p (Unpublished book, available online)
- Wolfsberg, M., Hook, V.W.A., Paneth, P. and Rebelo, L.P.N. (2010), Isotope Effects in the Chemical, Geological, and Bio Sciences, Springer-Verlag, Berlin, 477p.

Course Code	EGE 5007	Semester	Any
Course Title	**Quaternary Geology**		
Credits	3	Type	Elective

Course Description

Quaternary Geology programme provides a comprehensive examination of the climate and geological events during the Quaternary period (last 2.6 million years). The Quaternary period comprises the Pleistocene and the Holocene and is the youngest of the geological periods. To provide an advanced understanding of the causes and consequences of climatic changes on long and short timescales with specific reference to glaciated terrains during the Quaternary Period. The students are exposed to different methods, proxies and archives for reconstructing Quaternary climate change.

Course Outcome

By the end of the course, students are expected to be able to:

- Provide a comprehensive examination of Quaternary glacial and interglacial environments drawing on a range of case studies from both modern and ancient glaciated regions
- Advanced understanding of the causes and consequences of climatic changes on long and short timescales with specific reference to glaciated terrains during the Quaternary Period (last 2.6 million years)
- Describe the variety of proxy records that are available for reconstructing Quaternary climate change.
- Understand the processes involved in producing different proxy records and be aware of the complexities involved in interpreting those records.
- Synthesize the findings from different proxy records to form a coherent picture of Quaternary climate change.
- Critically evaluate the advantages and disadvantages of different techniques and their usefulness in reconstructing Quaternary environments.
- Show analytical skills in the written, summative assignment, and Critical engagement with research papers related to Quaternary research, Present scientific information and debates in an oral presentation.

Course Structure

Module - 1

Definition of Quaternary; concept and importance of Quaternary, Quaternary chronostratigraphic unit, standard sub-divisions of the Quaternary Period and their climatic significance, standard global stratotype sections, Plio-Pleistocene boundary. Quaternary Glaciations – causes, the pattern of glacial-interglacial cycles and associated eustatic changes. Milankovitch orbital cycles. Lines of evidence for Recent and historical sea-level fluctuations; Ice core records of glaciations during the Pleistocene and Holocene; Pleistocene faunal extinctions.

Module – 2

Tools for Quaternary studies- application of stable isotopes of oxygen and carbon. Marine isotope stages in the Quaternary, biostratigraphy and magneto-stratigraphy. Paleoclimatic archives and Proxies for paleoenvironmental/ paleoclimatic changes. Various Archives of Quaternary history: tree rings (dendrochronology), corals, speleothems (cave deposits), peat deposits, ice cores, lake sediments, marine sediments, glaciers, fluvial deposits. The 'proxy indicators' for the reconstruction of Quaternary environments--geological, geochemical (major and trace elements), biological (microfossils, pollen), sedimentological, isotopic (oxygen, carbon and nitrogen isotopes) and magnetic proxies.

Module – 3

Quaternary dating methods – Radiocarbon chronology - other radiogenic clocks. Fission track and thermoluminescence dating methods. Planetary clocks. Quaternary Stratigraphy of India– continental records (fluvial, glacial, aeolian, palaeosols and duricrust); marine records.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Sirocko, F., Claussen, M., Goni, M.F.S. and Litt, T. (Eds., (2008): The Climate of Past Interglacials, Elsevier, 638p.
- Burrough, W.J.S. (2005): Climate Change in Prehistory, Cambridge University Press, 368p.
- Rapp, D. (2009): Ice Ages and Interglacial – Measurements, Interpretation and Models, Springer, 243p.
- Saltzman, B. (2002): Dynamical Paleoclimatolgy – Generalised Theory of Global Climate Change, Academic Press, 354p.
- Birks, H. J. B. and Birks, H. H. (1980): Quaternary Paleoecology, Edward Arnold, 369p.
- Battarbee, R.W. and Binney, H.A. edt. (2008), Natural Climate Variability and Global Warming – A Holocene Perspective, Wiley Blackwell, 354p.
- Bloom, A.J. (2010): Global Climate Change – Convergence of Disciplines, Sinauer Associates, 269p
- Bradley, R. S. (1999): Paleoclimatology – Reconstructing Climates of the Quaternary, Elsevier, 613p.
- Dawson A.G., (1992): Ice Age Earth: Late Quaternary Geology and Climate (Physical Environment), Routledge, 293p.
- Lowe, J.J. and Walker, M.J.C., (1997): Reconstructing Quaternary Environments Longman, 446p.
- Mathur, U.B., (2006): Quaternary Geology, Indian Perspective, Geological Society of India, Bangalore, Vol: 67, 344p.

Course Code	EGE 5008	Semester	Any
Course Title	Structural analyses		
Credits	3	Type	Elective

Course Description

Structural analyses designate investigations of geometric features in the rocks to elucidate large-scale structures and tell their history. The objective of this course is to introduce the fundamentals of structural analysis including kinematic and dynamic analytical techniques. Plate tectonics and its relationships with structural analysis will also be covered throughout. The important relationship of geologic time with deformational structures is covered within the context of various macroscopic and microscopic stuctures.

Course Outcome

By the end of the course, students are expected to be able to:

- learn to recognize and classify geologic structures associated with folding and fracturing of the lithosphere.
- understand the Fault movement analysis
- elucidate the meso- and micro-fabric elements associated with igneous and metamorphic processes
- introduced to structural analysis with computer software

Course Structure

Module - 1

Deformation: Translation – Rotation – Dilation – Distortion. Deformation and changes in length and angle. Rheology. Geological significance of displacements. Deformation mechanisms and processes: Cataclastic flow – pressure solution – intracrystalline deformation – recrystallisation – diffusion – grain boundary sliding.

.

Module – 2

Principles of displacement and strain. Homogeneous and heterogeneous strain. Finite strain theory. Stress-Strain diagrams. Factors affecting stress-strain relations. Concept of strain ellipse. Rapid methods of strain determination. Strain analysis- analysis of strain in linear, initially circular/spherical objects. Various methods of strain analysis. Strain partitioning. Strain in three dimensions. Simple and pure shear. Shear zones - geometry and classification. Shear indicators. Shear zone rocks - Mylonites and fragmental rocks produced by shearing. Shear sense indicators, Stress-strain relationships in different types of shear zones. Deep crustal fluids and shear zones. Shear zones of Southern India

Module – 3

Fabric development: Progressive deformation. Rotation, pressure solution, recrystallisation and plastic deformation of grains. Tectonites – S and L tectonites.Microfabric analysis – sampling techniques. Modern techniques in microstructural analysis – 4-axes Universal stage – X-ray texture goniometry – Transmission Electron Microscopy – SEM-EBSD. Fabric symmetry – Crystallographic Preferred Orientation – Lattice Preferred Orientation. Kinematic analysis.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Dennis, J.G. (1987), Structural Geology: an introduction, Wm.C.Brown Publishers, Dubuque, 437 p.
- Ramsay, J.G. (1967), Folding and fracturing of rocks, Mc. Graw Hill, New York, 563 p.
- Ramsay, J.G. and Huber, M. (1983), The techniques of modern structural geology, Academic Press, London, V.1, 305 p.
- Davis, G. H. (1984), Structural Geology of rocks and regions, John Wiley&Sons, New York, 492 p.
- Passchier, C.W. and Trouw, R. A. J. (1996), Microtectonics, Springer, Berlin, 289 p.
- Hancock, P. L. (1994), Continental Deformation, Pergamon Press, New York, 421 p.
- Marshak, S. and Mitra, G. (1988), Basic Methods of Structural Geology, Prentice Hall, New Jersey, 446 p.
- Ramsay, J. G. (1980), Shear Zone Geometry: a review, Jour. Struct. Geol., V.2, N.1/2, pp 83-99.
- Sibson, R. H. (1977), Fault Rocks and Fault Mechanisms, Jour. Geol. Soc., London, V.133, pp191-213 .

Course Code	EGE 5009	Semester	Any
Course Title	Planetary Science		
Credits	3	Type	Elective

Course Description

Planetary Geoscience, is a planetary science discipline concerned with the geology of the celestial bodies such as the planets and their moons, asteroids, comets, and meteorites. It studies objects ranging in size from micrometeoroids to gas giants, aiming to determine their composition, dynamics, formation, interrelations and history. This programme also includes such topics as determining the internal structure of the terrestrial planets, and also looks at planetary volcanism and surface processes such as impact craters, fluvial and aeolian processes

Course Outcome

By the end of the course, students are expected to be able to:

- To understand the geology of the celestial bodies such as the planets and their moons, asteroids, comets, and meteorites.
- To have a better knowledge including their composition, dynamics, formation, interrelations and history of a celestial objects ranging in size from micrometeoroids to gas giants
- Interpret the data concerning the internal structure of the terrestrial planets, and also looks at planetary volcanism and surface processes such as impact craters, fluvial and aeolian processes.

Course Structure

Module - 1

Milky Way and the solar system. Modern theories on the origin of solar system: condensation and accretion of planets and other planetary bodies. Members of the solar system. The Sun-Planetary and Orbital characteristics. General characteristics of the terrestrial planets- crust, surface features, thermal history, volcanism.

Module – 2

Moon: The Earth-Moon System, General Physiography, Atmosphere, Tectonic features, Craters, Degradational features, History of the Moon and time scale, Lunar volcanism, Lunar rocks, soil and internal structure, Lunar phases and cycles, Lunar influence on Earth. Mars: Phobos and Dimos, Physiography, Atmosphere, Craters, Volcanism, Tectonism, Hydrology, Martian rocks and soils.

Module – 3

Meteorites: Chondrites, SNC meteorites, Refractory inclusions, Iron meteorites and Parent body cooling rates, meteorite chronology. Asteroids: Classification and composition, Surface features, Asteroid sources, Past asteroid impacts on the Earth. KT events – iridium anomaly, Comets and other Icy bodies. Planetary images, Digital and Analog studies of Martian, Lunar samples with those of Earth samples. Planetary missions. Lunar and Mars Missions. Chandrayan and Mangalyan. Exploring the planets and asteroids for minerals.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Condie, K.C. (2011): Earth as an evolving Planetary system, II edn. Elsevier, Amsterdam, 574p.
- Dalrymple, G.B. (1991): The Age of the Earth, Stanford University Press, California, 474p
- de Pater, I and Lissauer, J.J. (2010): Planetary Sciences, Cambridge University Press, 2nd Edition. 326p
- McBride, N and Gilmour, I (Eds) (2004): An introduction to the solar system, Cambridge University Press, 269p
- Seeds, M and Backman, D. (2010): The Solar System, Brooks/Cole, 7th Edition, 326p.

Course Code	EGE 5010	Semester	Any
Course Title	Oceanography and Marine Geology		
Credits	3	Type	Elective

Course Description

Oceanography is the study of all aspects of the ocean and covers a wide range of topics, from marine life and ecosystems to currents and waves, the movement of sediments, and seafloor geology. The program aims to give a broad outline of the geological evolution of the ocean basins, the methods employed to investigate the superficial and deep structural features of the sea bed and techniques used in the investigation of the marine geological environment. It also covers oceanographic expeditions, marine mineral resources and paleoceanographic reconstructions.

Course Outcome

By the end of the course, students are expected to be able to:

- Have a solid grounding in marine geology and understand the framework provided by plate Tectonics.
- Describe sediments found in different water depths and settings, and understand the sedimentary processes leading to their deposition. Describe the main geological and geophysical techniques for observing the seabed and sub-seabed.
- Understand the driving forces behind, consequences, and importance of sea-level changes in the geological record.
- Handling of marine and oceanographic instruments, Interpretation of oceanographic data like seismic data and SONAR data.
- Interpret the paleoceanography from marine sediments, importance of scientific expeditions and marine mineral resources and their potential importance.

Course Structure

Module - 1

Ocean floor: Morphologic and tectonic domains. Bathymetric features- Submarine Canyons, Mid-Ocean ridges and Trenches. Morphologic and tectonic domains of the Indian Ocean. Origin of ocean basins. Physico-chemical characteristics and chemistry of seawater: temperature, salinity, density, light transmission, sound transmission in seawater. Gases in seawater. Carbon dioxide and pH of seawater- ocean acidification. Instruments used in the study of seawater.

Module – 2

Offshore exploration techniques: Instruments and Measurements-Position fixing systems-GPS. Sampling devices - Grabs, Dredgers, Corers, Water Samplers. Various platforms for ocean studies. Tools for studying the ocean floor: Echo-sounding

methods, Side scan Sonar, Current meters, SCUBA diving-submersibles. Ocean floor drilling - JOIDES, DSDP, ODP, IODP.

Module – 3

Marine sediments: Distribution and geochronology of marine sediments. Eustatic changes of sea level and its effects. Calcite Compensation Depth (CCD). Turbidity currents and turbidites. World ocean circulation patterns— ocean water masses; role of ocean in deciding global climate. Paleoceanography, Paleoceanographic reconstructions based of microfossils. UN Convention on the Law of the Sea (UNCLOS)- EEZ-coastal zone environment and its protection - CRZ Act. Mineral resources of the ocean basins, factors controlling their distribution. Origin and distribution of polymetallic nodules.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Balkema, A.A. (2001): Descriptive Physical Oceanography, Balkema Publishers, Tokyo, 420p
- Beer, T (1997): Environmental Oceanography, CRC Press, New York, 402p
- Emery, K.O. and Skinner, B.J. (1977): Mineral Deposits of the Deep Ocean Floor. Marine Minerals (United States).22p
- Ghosh, A.K. and Mukhopadhyay, R. (1999): Mineral Wealth of the Ocean, Oxford & IBH Pub. Co., New Delhi, 260p
- Gross, G.M. (1967): Oceanography, Merril Physical Science Series. 150p
- Gross, G.M. (1995): Principles of Oceanography, VII edn., Prentice Hall, 240p.
- King, C.A.M. (1979): Introduction to Physical and Biological Oceanography, Edward Arnold, 373p.
- Lal, D.S. (2018): Climatology and Oceanography, Sharada Pustak Bhawan, Allahabad, 502p
- Pinet, P.R. (2000): Invitation to Oceanography, II edn., Jones & Bartlett.
- Qasim, S.Z. (1998): Glimpses of Indian Ocean, University Press.
- Qasim, S.Z. (1999): The Indian Ocean, Oxford & IBH Pub. Co., New Delhi.
- Shepard, F.P, (1963): Submarine Geology, II edn., Harper & Row.
- Siddhartha, K. (2013): Oceanography A Brief Introduction, Kitab Mahal, Allahabad.
- Sverdrup, H.V. et al. (1961): The Oceans, Asia Publishing House.
- Trujillo, A.P and Thurman, H.V. (2013): Essentials of Oceanography, Pearson, Boulevard.

Course Code	EGE 5011	Semester	Any
Course Title	Climatology		
Credits	3	Type	Elective

Course Description

Climatology is the study of the nature of the climate, the causes, and interpretations of its spatial variation and its association with biosphere.The course provides an overview of the physical processes responsible for determining global and regional climate, including radiative energy transfer, the atmospheric and surface energy balances, and the general atmospheric circulation. The course also deals with the components of the climatic system, precipitation and condensation mechanisms, climate change and its causes, and climate classification. Special emphasis will be given to high frequency internal climatic variability such as ENSO, IOD etc. etc. Some basic elements of meteorology is also covered in the course.

Course Outcome

By the end of the course, students are expected to be able to:

- Provide a reasoned account of weather and climates at different spatial scales - local, regional, and global.
- Explain the Earth's atmosphere characteristics and the role of each atmosphere layer.
- Comprehend general atmospheric circulation, the relevant theories and how the ocean and atmospheric circulation patterns redistribute heat and energy across the Earth.
- Understand the sensitivity of the Earth’s climate and its various feedback mechanisms
- Describe and explain the forms and exchanges of radiation and heat energy and discuss the laws related toEarth's radiation balance.
- Calculate adiabatic lapse rates and evaluate conditions of stability and instability in the atmosphere.
- Describe and explain natural and anthropogenic causes of climate change and the internal variability of climate.
- Understand global teleconnection indices (ENSO, NAO) and their role in weather forecasting.
- Read, evaluate, and discuss present climatic and weather phenomena taking place around the world.

Course Structure

Module - 1

Fundamental principles of climatology and meteorology. Scales and parameters of meteorology- pressure, wind, temperature, humidity, radiation. Atmosphere, its composition and structure. Radiation: Radiation laws, short wave and long wave

radiations, Albedo, Emissivity,Greenhouse effect, Radiation Budget of Earth. Latitudinal and seasonal variations of insolation, temperature, pressure.

Module – 2

Factors affecting wind motion. General circulation of the atmosphere: Hadley, Ferrel and Polar cells. Primary(tropical easterlies, westerlies, polar easterlies, jet streams), Secondary (monsoons andtropical cyclones) and Tertiary circulation system (periodic and non-periodic local winds). Coriolis Effect and geostrophic winds. Cloud classification.Process of condensation. Precipitation mechanisms: Bergeron process, coalescence process. Types of precipitation, artificial precipitation. Electric field in the atmosphere. Atmospheric equilibrium: stability and instability.

Module – 3

Climate change and variability:Causes and impacts of climate change.Forcing and feedback processes.Global warming and ozone layer depletion. High and low frequency variability:Madden–Julian oscillation (MJO), Quasi-biennial oscillation (QBO), North Atlantic oscillation (NAO), Indian Ocean Dipole (IOD), El Niño–Southern Oscillation (ENSO)Pacific decadal oscillation (PDO), Atlantic Multi-decadal oscillation (AMO). Sunspot cycles and its effect on Earth's climate. Climate types and distribution, Koppen'sclassification of climate. Basics of weather forecasting, hazardous weather elements like thunderstorms, duststorms, tornadoes.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Critchfield, H. J. (2009) General climatology, PHI Learning, New Delhi.
- Lal, D. S. (2011). Climatology, Sharda PustakBhavan.
- Lal, D. S. (2013) Climatology and Oceanography, Sharda PustakBhavan.
- Savindra Singh (2005). Climatology, PrayagPustakBhavan.
- Siddhartha, K. (2016). Climatology-Atmosphere, weather and climate. Kitab Mahal, New Delhi.
- Stringer, E. T. (1972). Foundations of Climatology, W.H.Freeman & Co Ltd.
- Burroughs, W.J. (2001) Climate change, A multidisciplinary Approach, Cambridge University Press.

Course Code	EGE 5012	Semester	Any
Course Title	Mineral Wealth of India		
Credits	3	Type	Elective

Course Description

The course Mineral Wealth of India aims to introduce the students to the various critical, strategic, and essential mineral deposits of India. It highlights the importance of the economic mineral deposits in the industrial and economic growth of the country. It also highlights the cause and importance of inequal distribution of the mineral resources in the country.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of various economic mineral resources of India
- Demonstrate confidence and accuracy in identifying the types, grades and mineralogy of the important mineral deposits of India.
- Synthesis observations, evidence and theory to recognise and explain similarities and differences between various mineral deposits.
- Discuss with confidence the theories, principles and outstanding controversies related to mineral wealth of the country.

Course Structure

Module - 1

Comparison between Global and Indian mineral resources and reserves; Strategic, critical and essential minerals of India. State-wise share of mineral production in India.

Module - 2

Mineral Deposits of India: Iron ore deposits – Mineralogy, classification, grade, origin and distribution in India, BIF – BHQ, BMQ, Iron ore deposits especially of Kerala, Bihar, Orissa and Karnataka.

Types, grades, mineralogy, uses, origin and Indian occurrences of: Manganese ore deposits (especially of Bihar, Orissa); chromium ore deposits (especially of southern India), Bauxite deposits (classification based on origin and shape); and copper ore deposits (especially of Khetri and Malanjkhand). Origin and occurrence of Lead and Zinc, Mica, Gold, PGE, Diamond, Uranium and Thorium deposits.

Module - 3

Mineral Deposits of India. Placer deposits of Kerala – General geologic and geomorphic setting, Ilmenite and rutile, monazite, Zircon, Sillimanite, Garnet, origin of Chavara Placer deposits, silica sands.

Non-metallic deposits – Refractory minerals: acid refractories – silica – Clay Deposits: Origin and Mineralogy, china clay deposits of Kerala – Kyanite – Neutral refractories: chromite – graphite – asbestos – Basic refractories – Magnesite – dolomite. Minerals used in Fertilizer industry: phosphorite, apatite. Minerals used in Cement industry: limestone – gypsum. Minerals used in Chemical industry.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

References

- Banerjee (2001), Mineral Resources of India.
- Geological Survey of India (2009), Miscellaneous publication no. 30, part-xxii: Geology and mineral resources of India,152p
- Geological Survey of India, Detailed information dossier (DID) of ores in India, (Available at GSI portal: www.portal.gsi.gov.in).
- Indian Bureau of Mines Bulletins of Mineral Information (availabile at IBM website) Ministry of Mines Annual Report 2011-12, 248p.
- Ministry of Mines (2011), Report of the working group on mineral exploration & development (other than coal & lignite) for the 12th five year plan sub group – on survey and mineral exploration, 310p.
- Nuclear Power in India Indian Nuclear Energy, http://www.world-nuclear.org/info/inf53.html
- Prasad, U (2002), Economic Mineral Deposits, CBS Publishers, New Delhi.
- Soman, K. (2001), Geology of Kerala, Geol. Soc. of India, Bangalore, 335p.

Course Code	EGE 5013	Semester	Any
Course Title	Geostatistics		
Credits	3	Type	Elective

Course Description

Geostatistics is a professional skill development course that deals with the application of the statistics knowledge to solve the geological problems. The course aims to train the students in application of statistical principles to the geological problems involving huge data sets to arrive at simple solutions. The major application of geostatistics is found in the field of mineral exploration. An appropriate background in the branch of geostatistics helps the student of geology to secure a job in private sector companies working in the field of mineral exploration.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of geostatistics
- Demonstrate confidence and accuracy in identifying applying the statistical principles to the problems related to geology.
- Discuss with confidence the theories and principles of geostatistics.
- Conceive, design, execute, critique, revise, document and present an original research project and an independent program related to the applications of geostatistics.

Course Structure

Module - 1

Introduction to statistics: sampling, data collection, random variables, probability, frequency function; Applications of statistical methods in earth sciences – quantification and prediction.

Univariate statistical methods, frequency analysis, simulation; Statistical distributions.

Module - 2

Stochastic modelling and forecasting – introduction, modelling, applications, spectral analysis; Concepts of regionalized variables and variogram modelling; Concepts of dispersion, extension and estimation variances.

Module - 3

Kriging variance and procedure, simple kriging; Introduction to advanced geostatistics; applications of computer programs for statistical calculations – open source statistical programs

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%
End Semester Assessment – 60%

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 Geostatistics, Springer Publ., pp.257.
- Kitanidis, P.K., Introduction to Geostatistics, Cambridge University Press., pp.271.
- C. Lantuejoul, Geostatistical Simulation, Springer Publ., pp.262.
- J. Awange, B. Palancz, R.H. Lewis, L. Volgyesi, Mathematical Geosciences, Springer Publ., pp.615.
- Olea, R.A., Geostatistics for Engineers and Earth Scientists, Springer Publ., pp.309.

Course Code	EGE 5014	Semester	Any
Course Title	Physical Geology		
Credits	3	Type	Elective

Course Description

Physical geology is the branch of geology that deals with the aspects related to earth's structure, composition, physical properties, constituent rocks and minerals and surficial features. It is essentially a discipline that overlaps different branches of geology such as geophysics, geochemistry, mineralogy, petrology, structural geology and geomorphology. The course aims to give a fundamental understanding of our planet earth and the processes that shape our earth.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate mastery of the terminology of physical geology
- Understand the structure of the earth and the processes that resulted the structures
- Understand various structural features of the rock units
- Discuss with confidence the internal and external geological processes and the resultant landforms
- Understand the importance of geological resources.

Course Structure

Module - 1

Introduction to Earth systems. Earth's interior and geophysical properties – internal structure, isostasy, gravity measurements, magnetic field, geothermal gradient and heat flow. Sea floor – features, seamounts, guyots and aseismic ridges, reefs; age of the sea floor. Plate tectonics – history, plates and plate motion, causes for plate motion.

Module - 2

Mountain belts and the continental crust – characteristics, thickness and density of rocks, features of active mountain ranges; evolution of mountain belts; growth of continents. Geologic structures – tectonic forces at work, structures as a record of geologic past, folds and faults. Time and Geology – key to the past, relative time, numeric age, age of the Earth.

Module - 3

Internal geological processes – igneous and metamorphic. External geological processes - weathering and soil, soil mechanics, mass wasting; Action of wind, water, glaciers; Waves, beaches and coasts. Geologic resources.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%

End Semester Assessment – 60%

References

- Kearey, P., Klepeis, K. A., & Vine, F. J. (2009). Global tectonics. John Wiley & Sons, Sussex, UK, 482p.
- Tarbuck, E. J., Lutgens, F. K., Tasa, D., &Linneman, S. (2005). Earth: an introduction to physical geology. Upper Saddle River: Pearson/Prentice Hall; 912p.
- Skinner, B. J., Porter, S. C., Park, J. J., & Levin, H. L. (2004). Dynamic Earth: An introduction to physical geology, John Wiley & Son, New York, 570p.
- Plummer, C. C., McGeary, D., & Carlson, D. H. (2005). Physical Geology: Earth Revealed. 9th ed; McGraw-Hill Education, New York; 600p.
- Jain, S. (2014). Fundamentals of physical geology., Springer; New Delhi; 488p.
- Kolay, A.K. (2010), Soil Geology. Atlantic Publications; 256p.
- Thompson and Turk (1998) Introduction to physical geology, Saunders College Publishing, Orlando; 398p.
- Monroe J.S., Wicander R, Hazlett R (2007), Physical Geology: Exploring the Earth, 6th ed, Thomson Books, Belmont, USA; 725p.
- Fletcher C. (2014), Physical Geology: Science of the Earth; 2nd ed., John Wiley and Sons, USA; 704p.
- W. Kenneth Hamblin (1991), Introduction to Physical Geology, Macmillan Publishing Company. New York; 378p.

Course Code	EGE 5015	Semester	Any
Course Title	Geochemistry		
Credits	3	Type	Elective

Course Description

The course gives an introduction to fundamental geochemical tools and directions like aqueous geochemistry, trace element geochemistry and isotope geochemistry, and how these can be used to understand the formation of the elements and the solar system, the Earth´s geochemical composition and differentiation into different reservoirs, the age of rocks, global geochemical cycles, the surface environment, and chemical traces of early life.

Course Outcome

By the end of the course, students are expected to be able to:

- describe the composition of the Earth´s main geochemical reservoirs
- explain element fractionation and how this can be used to understand endogenous and exogenous geochemical processes
- describe how radiogenic isotope signatures can be used to trace the source of minerals, rocks and fluids

Course Structure

Module - 1

Elements in the Universe – Significance of element abundance, elements and nuclides, measuring cosmic and solar system abundances, spectral analysis, the composite abundance curve, cosmic element production. Meteorites – Classification andchemical analysis of meteorites.Elements in the solar system – Cosmo chemical classification, element fractionation in the solar system, evolution of the solar system and chemical evolution of the Earth.

Module - 2

Goldschmidt's geochemical classification of elements. Geochemistry of important elements: Alkalis, alkaline earths, hydrogen, aluminium, carbon, silicon, nitrogen, oxygen and sulphur.Distribution of elements in igneous, sedimentary and metamorphic rocks.

Module - 3

Basic principles in geochemistry: Geochemical environment, surficial and deep seated environment, geochemical cycle, geochemical dispersion, - primary and secondary dispersion, dispersion halos, geochemical mobility, geochemical reactions, association of elements, indicator elemens, pathfinder elements, patterns of geochemical distribution, background value, geochemical anomaly, significant and non-significant anomaly, threshold.

Evaluation &Grading

Skill development (Analytical, Writing and Presentation) – 20%
Class Test – 20%

End Semester Assessment – 60%

References

- Krauskopf, K. B. (1967), Introduction to Geochemistry, McGraw-Hill Book Co., New York, 721 p.
- Arthur, W., Hawkes, H.E. and Webb, J.S. (1979), Geochemistry in Mineral Exploration, Academic Press, USA, 657p.
- Mason, Brian, Moore and Carleton, B. (1982), Principles of geochemistry, John Wiley&Sons, New York, 344 p.
- Gill, R. (1989), Chemical Fundamentals of Geology, HarperCollins Publishers Ltd, UK, 292p.
- Holt, K.H.W. (1971), Geochemistry, Rinehart and Winston Inc, USA.
- Rankama, K. and Sahama, T.H.G. (1950), Geochemistry, Univ. Chicago press, 911p.
- Walther. J.V.(2010) Essentials of Geochemistry, Jones and Barlett Publishers, New Delhi. 797p.

Course Code	EGE 5016	Semester	I or II
Course Title	Any PG MOOCs from SWAYAM/NPTEL		
Credits	1-4	Type	Elective

Course Description

Under this category students are free to choose any SWAYAM/NPTEL courses with a minimum of one to maximum of four credits. Students are permitted to engage the MOOC's only in first or second semester. None credit courses will not be considered in grade card. In case of any credit deficiency due to MOOC courses, students have to manage the same by themselves. University is not responsible for any MOOC examinantion delay, hence it is encouraged only in first and second semesters.