**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF THE DEPARTMENT: **Department of Earth Sciences**

1. Subject Code: **ESN-510** Course: **Numerical Techniques and Computer Programming**
2. Contact Hours: **L: 3 T: 0 P: 2**
3. Examination Duration (Hrs): **Theory 0 3 Practical 0 0**

4. Relative Weight **CWS 1 5 PRS 2 5 MTE 2 0 ETE 4 0 PRE 0 0**

5. Credits : **0 4** 6. Semester: **Autumn** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To provide basic concepts of probability and statistics

10. Details of Course:

| S. No | Contents | Contact Hours |
|---|---|---|
| **1** | Role of mathematical and numerical techniques in geological sciences. Measurement systems. Computers and numerical computation. | **4** |
| **2** | Measures of central tendency and dispersion. Concept of probability. Binomial, Poisson and normal distributions. Covariance and correlation, examples from earth sciences | **7** |
| **3** | Matrices and elementary matrix operations. Matrix multiplication. Matrix inversion and solution of simultaneous equations. Eigen values and eigenvectors. | **7** |
| **4** | Numerical Integration and Differentiation**,** Quadrature formulae: Trapezoidal and Simpson's rules. Forward, backward and central difference formulae. | **6** |
| **5** | Linear regression. Correlation and correlation coefficient. multiple regression, Kriging method of interpolation | **6** |
| **6** | Fundamental of programming, various examples of numerical operations, Operating Systems and system software concept | **6** |
| **7** | Spreadsheet and database concepts, graphics and CAD and elements of networking | **6** |
| | **Total** | **42** |

**List of Practical:**

1. Various exercises based on computer programming and numerical techniques

11. **Suggested Books:**

| S. No | Name of Books/ Authors | Year of Publication |
|---|---|---|
| 1 | Jensen, J.R., Lake, L.W., Corbett, P.W.M. and Goggin, D.J., "Statistics for Petroleum and Geoscientists", Prentice-Hall | 1997 |
| 2 | Lipschutz, S. and Lipson, M., "Theory and Problems of Probability", McGraw-Hill | 2000 |
| 3 | Davis, J.C., "Statistics and Data Analysis in Geology", John Wiley & Sons | 2002 |
| 4 | Lafore, R., Object oriented Programming in C++, 4th edition Pearson Education | 2002 |
| 5 | Borradaile, G.J., "Statistics of Earth Science Data", Springer | 2003 |
| 6 | Schabenberger, O. and Gotway, C.A., "Statistical Methods for Spatial Data Analysis", Chapman & Hall | 2004 |
| 7 | Step by Step 2007 Microsoft Office System (W/CD) by Curtis Frye, M. Dow Lambert, Joan Preppernau, Steve Lambert, John Pierce, 2007 Microsoft Office System step by step, second edition Microsoft Press | 2007 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-511** Course Title: **Crystallography and Mineralogy**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To provide advanced concepts in crystallography, crystal chemistry and stability of major rock forming mineral groups

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction: definition of minerals and basics of crystallography | **2** |
| **2.** | Crystal systems, external symmetry, symmetry with respect to planes/axes/center, combination of symmetry elements, point groups | **2** |
| **3.** | Lattice, line/plane/space lattices, 14 space lattices, simple space group | **3** |
| **4.** | combination of point groups and space lattices, 73 simple space groups | **2** |
| **5.** | Internal symmetry, rotational-translational symmetry, glide planes, 230 space groups, unit cell | **3** |
| **6.** | Crystal chemistry, ionization potential, electronegativity, chemical bonds, types of closest packing, Pauling's rules, co-ordination number/polyhedra, Classification silicate structures | **6** |
| **7.** | X-ray crystallography: nature of x-ray diffraction, powder method, single crystal method, identification of minerals from XRD | **3** |
| **8.** | Crystal chemistry and stability of olivines, pyroxenes, amphiboles, micas, feldspars, SiO2 polymorphs, sulfide and oxide mineral groups | **20** |
| | **Total** | **42** |

**11. Suggested Books:**

| S. No. | Name of Authors / Books / Publishers | Year of Publication |
|---|---|---|
| 1. | R. S. Sharma and A. Sharma: Crystallography and Mineralogy, Geological Society of India Text Book Series | 2013 |
| 2 | W. A. Deer, R. A. Howie and J. Zussman, An introduction to rock forming minerals, Longman ELBS edition | 1992 |
| 3. | J. J Papike, Crystal chemistry of silicate minerals of geophysical interests, Reviews in geophysics and Space Physics, American Geophysical Union | 1976 |
| 4. | F. D. Bloss, Crystallography and Crystal Chemistry, Holt, Rinehart and Winston, Inc. | 1971 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-512** Course Title: **Geochemistry**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Chemistry as a subject in +2 or +3**

9. Objective: To introduce geochemistry as a tool in understanding the Earth

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction:** Origin of Earth, Differentiation and formation of core, mantle, crust, hydrosphere, atmosphere, Earth composition | **4** |
| **2.** | **Reaction Kinetics:** Chemical thermodynamics, chemical equilibrium, free-energy, oxidation-reduction, ion-exchange, reaction rates and mass transfer, geochemical classification of elements, phase equilibria | **8** |
| **3.** | **Crystal Chemistry:**, Various bonds in minerals, silicate structure, isomorphism, polymorphism, substitution, problem exercises | **4** |
| **4.** | **Rock and Fluid Geochemistry:** Basics of magma and different rock genesis, hydrothermal ore solutions | **4** |
| **5.** | **Isotope Geochemistry:** Radiogenic isotopes, age dating, petrogenesis, stable isotopes in environment, problem exercises | **6** |
| **6.** | **Organic Geochemistry:** Organic matter characterization, hydrocarbons and fossil fuels, biogeochemical cycles of carbon, phosphorus, nitrogen, silicon, and sulfur | **6** |
| **7** | **Analytical Geochemistry:** Methodologies for sampling and analysis of geological samples, introduction of basic instrumentation | **10** |
| | **Total** | **42** |

**List of Practical:**

1. Flow Chart of geologic samples preparation for various analysis
2. Single and multiple standards preparation
3. Determining strengths of acids
4. Analytical methodologies for rock, sediment and water samples
5. Spectroscopy and chromatography analysis
6. Data analysis and interpretations

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Krauskopf, K., and Bird, D.K.,"Introduction to Geochemistry", McGraw-Hill Publ. | **2005** |
| **2.** | Holland, H.H. (Ed.), "A Treatise on Geochemistry" Prentice-Hall Publ. | **2004** |
| **3.** | McSween, H., Richardson, S.M., and Uhle, M.E., "Geochemistry: Pathways and Processes" Overseas Press | **2006** |
| **4.** | Schlesinger, W.H. and Bernhardt, E.S. "Biogeochemistry: An Analysis of Global Change", Associated Press, 3rd Ed. | **2013** |
| **5.** | Walther, J.V., "Essentials of Geochemistry", Jones and Bartlette Publ. | **2008** |
| **6.** | Killops, S.D. and Killops, V.J., "Introduction to Organic Geochemistry", Wiley Publ. | **2010** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-513** Course Title: **Igneous Petrology**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide in-depth knowledge of igneous rocks including their geochemical characteristics and petrogenesis.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | Introduction to Igneous Petrology, Classifications of igneous rocks | 4 |
| 2 | Igneous Textures and Structures | 4 |
| 3 | Phase diagrams | 4 |
| 4 | Processes involving modification of primary magma | 4 |
| 5 | Fractional crystallization and crustal contamination | 4 |
| 6 | Plate Tectonics and Igneous Petrogenesis | 2 |
| 7 | Magmatism at constructive plate margin, mid-oceanic ridges, | 4 |
| 8 | Magmatism at destructive plate margin, subduction zone magmatism, island arc systems, continental arc magmatism | 4 |
| 9 | Intraplate magmatism, mantle plume, oceanic island | 4 |
| 10 | Alkaline Rocks, Carbonatites | 4 |
| 11 | Ultramafic rocks, Kimberlite | 4 |
| | **Total** | 42 |

**List of Practicals:**

1. Microscopic studies of acidic, basic and ultramafic igneous rocks and their petrogenesis
2. Geochemical variation diagram studies
3. CIPW normative calculations based on geochemical data

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Philpotts, A.R. and Ague, J.J., "Principles of Igneous and Metamorphic Petrology" Cambridge University Press | **2010** |
| **2.** | Winter, J., "An Introduction to Igneous and Metamorphic Petrology", Prentice-Hall | **2001** |
| **3.** | Hall, A., "Igneous Petrology", John Wiley & Sons | **1995** |
| **4.** | Rollinson, H., "Using geochemical data: evolution, presentation, interpretation" Pearson Education Limited | **1993** |
| **5.** | Willson, M., "Igneous Petrogenesis: A Global Tectonic Approach", Unwin-Hyman | **1989** |
| **6.** | Cox, K.G., Bell., J.D. and Pankhurst, R.J., "The Interpretation of Igneous Rocks" George Allen and Unwin Publishers Ltd. | **1979** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Earth Sciences**

1. Subject Code: **ESN-514** Course Title: **Structural Geology**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To study the principles and techniques of development and analysis of structures in rocks.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction and significance of continuum mechanics in structural geology | **4** |
| **2.** | Concepts and representation and analysis of homogeneous stress states | **6** |
| **3.** | Concept and techniques of strain estimation in rocks | **6** |
| **4.** | Ductile shear zones and fault rocks | **4** |
| **5** | Geometry and mechanism of development of folds and interference structures | **6** |
| **6.** | Origin of foliation and lineation in rocks and their relationship with strain ellipsoid | **4** |
| **7.** | Analysis of superposed folding: principles, techniques and case studies | **6** |
| **8.** | Geometry and mechanism of development of fault-related folds | **6** |
| | **Total** | **42** |

11. Suggested Books:

| Sl. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1** | Davis, G.H. and Reynolds, S. J. Structural geology of rocks and regions. | 2011 |
| **2** | Fossen, H. Structural Geology. Cambridge University Press. London. | 2010 |
| **3.** | Ragan, D. M. Structural Geology. Cambridge University Press. London. | 2009 |
| **4.** | Ramsay, J.G. and Lisle, R. The Techniques of Modern Structural Geology, Vol. 3.Application of Continuum Mechanics in Structural Geology, Academic Press, London. | 2000 |
| **5.** | Marshak S. and Mitra S. Basic methods in structural geology. | 1988 |
| **6.** | Ramsay, J. G. and Huber, M. I. The Techniques of Modern Structural Geology, Vol. 1. Strain Analysis, Academic Press, London. | 1983 |
| **7.** | Jaeger, J. C. and Cook, N. G .W. Fundamentals of rock mechanics. Methuen, London, 593p | 1979 |
| **8.** | Ramsay, J. G. Folds and fractures. Mc-Graw Hills, NY | 1967 |

**List of Practical:**

Exercises on the following topics:

1. Stress analysis in rocks. Representation of homogeneous stress states and stress analysis.
2. Rf/phi method, Fry method and Wellman method for strain estimation
3. Estimation of flattening in folds
4. Superposed folding

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department Earth Sciences**

1. Subject Code: **ESN-521** Course Title: **Paleontology**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To give an in depth knowledge of Paleontology and governing principles.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Paleontology and its Application in solving Geological Problem:** Definition and scope of the Subject. Principles of Paleontology. Surface and Subsurface sampling. Indian contributions towards paleontological study. Sample processing techniques. Equipments for paleontological studies. | **12** |
| **2.** | **Microfossils:** Foraminifera, Nannofossils, Osctracoda, Pteropoda, Calpionellids, Calcareous Algae, Radiolaria, Diatoms, Dinoflagelates, Silicoflagellates and Conodonts. Their modern biogeography, outline of morphology, surface ultrastructure. Significance in Phanerozoic Oceanic biostratigraphy and application in paleoceanography, correlation, paleoecological interpretations with case histories, microfossils as a tool in petroleum exploration | **16** |
| **3.** | **Paleobotany:** Introduction to Gondwana flora and their applications. Role of C3 and C4 plants in paleoclimatic study. Introduction to palynology and its applications. Indian examples and their geological significance | **8** |
| **4.** | **Vertebrate Paleontology:** Introduction to Vertebrate Paleontology, broad classification, outline of morphology and its applications. Micro-vertebrate and their application. Major steps in vertebrate evolution. Typical Indian examples of Vertebrate fossils and their geological significance. . □ | **8** |
| | **Total** | **42** |

**List of Practicals:**

1. Megascopic study of important vertebrate and plant fossils
2. Microscopic study of important microfossils group and microvertebrate fossils.
3. Approaches to Biostratigraphic classification and correlation.

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1** | Walton, J., "An Introduction to the Study of Fossil Plants", Adam & Charles Black | **1953** |
| **2** | Woods, H., "Paleontology Invertebrate", CBS Publications | **1963** |
| **3** | Haq B. U. and Boersma, A., "Introduction to Marine Micropaleontology", Elsevier. | **1978** |
| **4** | Braiser, M.D., Microfossils, Geogrge Alien and Unwin Publisher. | **1980** |
| **5** | Benton, M.J., "Vertebrate Paleontology", Chapman & Hall | **1997** |
| **6** | Jones, R. W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford. | **1998** |
| **7** | Colbert, R.L., "Paleontology", John Willey & Sons | **1987** |
| **8** | Milsom, C., and Rigby, S., "Fossils at a Glance", Blackwell | **2004** |
| **9** | McGowran, B., "Biostratigraphy: Microfossils & Geological Time", Cambridge University Press | **2005** |
| **10** | Michel F. and Arnold I. Miller, David M. Raup, Steven M. Stanley "Principales of Paleontology", W. H. Freeman, 2007 | **2007** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-522** Course Title: **Metamorphic Petrology**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 00**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide in-depth knowledge of phase rule, classification of metamorphic rocks and metamorphic assemblages

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | Various types of metamorphism, metamorphic rocks and facies | 4 |
| 2 | Texture, structure and classification of metamorphic rocks | 3 |
| 3 | Phase rule, metamorphic reactions and phase equilibria in metamorphic rocks | 4 |
| 4 | Graphical representation of various mineral assemblages in different P-T conditions | 4 |
| 5 | Phase diagrams and petrogenetic grid for metamorphic assemblages in various grades of metamorphism | 4 |
| 6 | Thermodynamics of metamorphic reactions and mineral assemblages in different metamorphic isograds | 6 |
| 7 | Different types of metamorphic facies and their tectonic settings | 3 |
| 8 | Mineral assemblages for different rock types in zeolite, prehnite, pumpellyite, greenschist, amphibolite, granulite, eclogite, and blueschist facies | 7 |
| 9 | Mineral paragenesis and chemographic relations in metamorphism of calcareous, mafic and ultramafic rocks | 7 |
| | **Total** | 42 |

**List of Practical:**

1. Textural studies of different types of metamorphic rocks under microscope
2. Construction of phase diagrams

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Spear, F.S., "Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths", Mineralogical Society of America Monograph | **1993** |
| **2.** | Kornprobst, J., "Metamorphic Rocks and their Geodynamic Significance: A Petrological Handbook", Springer | **2002** |
| **3.** | Vernon, R.H and Clarke, G., "Principles of Metamorphic Petrology", Cambridge University Press | **2008** |
| **4.** | Winter, J.D., "Principles of Igneous and Metamorphic Petrology", Prentice Hall | **2009** |
| **5.** | Bucher, K. and Grapes, R., "Petrogenesis of Metamorphic Rocks", Springer | **2011** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-523 Course Title: **Geohydrology**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce fundamental characteristics and distribution of groundwater resources.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction:** Hydrologic cycle, importance of ground water as a resource, residence time, reservoirs, water-balance equation | **4** |
| **2.** | **Principles of groundwater Flow:** Basic principles of ground water flow, types of porosities, Darcy's law and its limitations, permeability and hydraulic conductivity, field and laboratory measurements of flow characteristics, problem exercises | **5** |
| **3.** | **Occurrence and distribution of groundwater:** Aquifers, confined and unconfined beds, measurement of ground water content, specific yield and retention, geologic formations as aquifers, problem exercises | **5** |
| **4.** | **Hydrogeochemical reactions and groundwater compositions:** Equilibrium kinetics, key reactions of ground water chemistry, oxidation-reduction reactions, ion exchange processes, micro-organisms in groundwater, global and Indian water standards | **7** |
| **5.** | **Groundwater sampling and analysis:** Groundwater sampling and analysis, data plotting and interpretations, groundwater pollution, environmental isotopes in hydrogeology, salt water intrusion, problem exercises | **4** |
| **6.** | **Groundwater exploration:** Geological and geophysical exploration methods, ground water level fluctuations and implications, | **4** |
| **7.** | **Groundwater management:** Natural and artificial recharge concepts, site selections for recharge, concepts of groundwater basin management, safe and conjunctive use, groundwater economics | **3** |

| | | |
|---|---|---|
| **8** | Estimation of Groundwater flow velocity and hydraulic conductivity, flow directions, pump testing, groundwater sampling and analysis | **10** |
| | **Total** | **42** |

**List of Practical:**

1. Preparation of ground water flow directions
2. Determination of porosity, permeability and hydraulic conductivity
3. Groundwater sampling and analysis
4. Water composition diagrams
5. Groundwater exploration methodologies

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Fitts, C.R., "Groundwater Science", Academic Press | **2012** |
| **2.** | Schwartz, F.W. and Zhang, H., "Fundamentals of Groundwater", Wiley Publ. | **2008** |
| **3.** | Todd, D.K., "Groundwater Hydrology", 3rd Edition, Willey Publ. | **2005** |
| **4.** | Ward, A.D. and Trimble, S.W., "Environmental Hydrology". Lewis Publ. | **2004** |
| **5.** | Domencio, P.A. and Schwartz, F.W., "Physical and Chemical Hydrogeology", Wiley Publ. | **2002** |
| **6.** | Clark, I. and Fritz, P., "Environmental Isotopes in Hydrogeology" , Lewis Publ. | **1998** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-524 Course Title: **Advanced Geomorphology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To understand the geomorphic processes of landform formation and evolution with time and space.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction to Geomorphology, timescale and processes of landform development, role of structure, time and processes, palimpsest nature of present major landforms, equilibrium and evolution, energy flow in geomorphic systems, role of uniformitarianism vs catastrophism in landscape development | 4 |
| **2.** | Weathering- mechanical, chemical and biological weathering, weathering of silicate minerals; soils- horizonation, factors affecting pedogenesis, use of paloesols in climatic interpretation and dating of geomorphic surfaces and events | 4 |
| **3.** | Mass wasting processes – classification and hillslope evolution | 3 |
| **4.** | **Fluvial Geomorphology:** Stream and river processes, processes of transport, channel geometry, concept of grade; depositional features- floodplain, fans, deltas, drainage patterns; morphometric analysis of drainage basins | 4 |
| **5.** | **Desert Geomorphology**- Deserts and global wind patterns, environments of wind action, erosion, transportation and depositional processes of wind. Use of desert geomorphology to study paleoclimate and paleogeography | 3 |
| **6.** | **Glacial Geomorphology-** Formation glacier ice from snow, morphological and thermal classification of glaciers, glacial landforms. Glaciation and isostasy. Quaternary glaciations and their significance | 3 |
| **7.** | **Coastal geomorphology** - Ocean waves, currents and tides, wave reflection and refraction, longshore and rip currents, littoral drift, typical landscapes, effects of base level changes on coastal and fluvial geomorphology: | 4 |

| | | |
|---|---|---|
| | emergence, submergence progradation and erosion level | |
| **8.** | **Tectonic Geomorphology** - Geomorphic indicators of tectonic activity and paleoseismicity- geomorphic indices, process -response models, use of geomorphic elements such as drainage patterns, terminal fans, fluvial and marine terraces, paleosols and alluvial fans in neotectonic interpretation. Geomorphic processes effect on Isostatic adjustment. Mountain front and foreland geomorphology | 6 |
| **9.** | **Seismic Geomorphology:** Seismic Geomorphology an over view, Seismic geomorphology in fluvial environment, in paleogeographic reconstruction, seismic geomorphology on sea bed. | 3 |
| **10.** | **Exploration geomorphology:** Geomorphology in mineral exploration, in ground water exploration, in hydrocarbon exploration | 2 |
| **11.** | **Engineering geomorphology:** Geomorphology in constructing engineering structures such as dam, tunnel, flood control structures and urban planning such as waste disposal sites, water storage sites | 2 |
| **12.** | **Geomorphological mapping:** Methods of preparation of geomorphological map, map elements in different environments. preparation of geomorphological map from satellite images. Study of geomorphic features from toposheets. Use of geomorphological map in developmental projects | 4 |
| | **Total** | **42** |

## 11. Suggested Books:

| S. No. | Name of Authors / Books / Publishers | Year of Publication / Reprint |
|---|---|---|
| 1. | Martian Geomorphology. Balme, M. R., Bargery, A. S; Gallagher, C. J. and Gupta, S.,. The Geological Society, London | 2011 |
| 2. | Geoinformatics in Applied Geomorphology. Anbazhagan, S.; Subramanian, S. K. and Yang X., CRC Press,Taylor & Francis Group, London and New York | 2011 |
| 3. | Geomorphology and Global Environmental Change. Slaymaker, O.; Spencer, T. and Hamann, C.E., Cambridge University Press, New York | 2009 |
| 4. | Fundamentals of geomorphology. Huggett, R. J.,. Routledge, Taylor & Francis Group, New York | 2007 |
| 5. | Seismic Geomorphology: Application to hydrocarbon exploration and production. Davies, R.J.; Posamentier, H.W.; Wood, L. J. and Cartwright J.A,. The Geological Society of London. | 2007 |
| 6. | Applied Geomorphology. Allision, R.J, John Wiley and Sons Ltd. England | 2002 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-525 Course Title: **Economic and Ore Geology**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide concepts on ore formation processes and genetic interpretation for evaluation of economic mineral resources.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction to mineral deposit and ore body, styles of mineralization and global distribution of minerals in time and space. | **4** |
| **2.** | Major theories of ore genesis – Origin due to internal and surface processes. | **4** |
| **3.** | Principles of ore microscopy, identification of ore minerals based on optical and physical properties, textures in ore minerals and application of ore microscopy. | **6** |
| **4.** | Chemical analysis of ores and interpretation of major, trace and REE elements for genetic interpretation. | **4** |
| **5.** | Principles of fluid inclusions, data collection and applications to infer the nature-evolution of ore/mineral forming fluids in different geological setting. | **5** |
| **6.** | Stable isotope studies (oxygen, hydrogen, carbon and sulfur) of economic mineral deposits and their application. | **5** |
| **7.** | Types, characteristic features, mineralogy, host rocks and environment of formation of select mineral deposits(Chromite, Nickel, Platinum, Diamond, copper, gold, lead, zinc, iron, manganese, uranium, tungsten and industrial minerals). | **14** |
| | **Total** | **42** |

## 11. Suggested Books:

| S. No. | Name of Authors / Books / Publishers | Year of Publication / Reprint |
|---|---|---|
| 1. | Evans, A.M., "Ore Geology and Industrial Minerals: An Introduction", Blackwell Science, 3rd Ed. | **1993** |
| 2. | Guilbert, J.M. and Charles F. P. Jr., "The Geology of Ore Deposits", Waveland | 1986 |
| 3. | Mookherjee, A., "Ore Genesis: A Holistic Approach", Allied Publishers | 1999 |
| 4. | Mishra, K.C., "*Understanding Mineral Deposits*", Kluwer Academic publishers | 2000 |
| 5. | Pohl, W.L., "*Economic Geology*", Wiley Blackwell | 2011 |

## List of Practical:

1. Identification of ore minerals under reflected-light microscope
2. Study of ore minerals textures under reflected-light microscope
3. Determination of paragensis under reflected-light microscope

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-531 Course Title: **Sedimentology and stratigraphy**

2. Contact Hours: **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge of depositional environments and reconstructing characteristic 3-D facies models with the help of advanced stratigraphic methods.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction: brief idea on fundamentals of sedimentology | 2 |
| **2.** | Concept of Facies, facies association, facies modelling | 4 |
| **3.** | Classification and characteristics of common marine and non-marine sedimentary environments | 7 |
| **4.** | 2-D and 3-D facies modelling of common depositional environments | 5 |
| **5.** | Eustasy and sea level changes – concept and controls | 2 |
| **6.** | Concept of cyclicity in sedimentary successions | 2 |
| **7.** | Fundamental concepts of stratigraphic principles and correlation | 2 |
| **8.** | Advanced stratigraphic concepts and their applications: Magnetostratigraphy, Seismic stratigraphy, Isotope stratigraphy, Cyclostratigraphy | 8 |
| **9.** | Sequence stratigraphy – basic concepts and principles | 4 |
| **10.** | Sequence stratigraphy of common sedimentary environments | 6 |
| | **Total** | **42** |

**11. Suggested Books:**

| S. No. | Name of Authors / Books / Publishers | Year of Publication / Reprint |
|---|---|---|
| 1. | Nichols, G.: *Sedimentology and stratigraphy*, 2nd Ed. Wiley-Blacwell | 2009 |
| 2. | Boggs, Sam (Jr.): Principles of *Sedimentology and Stratigraphy, 4th Ed*. Pearson/Prentice Hall. | 2006 |
| 3. | Catuneanu, O.: *Principles of Sequence Stratigraphy*. Elsevier. | 2006 |
| 4. | Allen, P.A. and Allen, J.R.: *Basin Analysis: Principles and applications*. Blackwell publishing | 2005 |
| 5. | Van Loon A.J.: *Cyclic development of sedimentary basins*. Elsevier. | 2005 |
| 6. | Brookefield, M.E.: *Principles of Stratigraphy*. Blackwell Publishing. | 2004 |
| 7. | Reading, H.G.: *Sedimentary Environments and Facies*. 6th Ed., Blackwell Scientific Publ., Oxford. | 1996 |

**List of Practical:**

1. Study of sedimentary rocks under microscope
2. Study of texture and structures of sedimentary rocks
3. Palaeocurrent analysis
4. Grain size analysis
5. XRD analysis of clay minerals
6. Preparation and correlation of sedimentary logs

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code**: ESN-532** Course Title**: Geophysical Prospecting**

2. Contact Hours : **L: 3** **T: 0** **P: 2**

3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**

4. Relative Weight **: CWS 15 PRS 25 MTE 20 ETE 40 PRE 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area**: DCC**

8. Pre requisite: **Nil**

9. Objective: To introduce basic concepts of geophysical methods and their applications in solving geological problems

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | **Introduction:** Overview and importance of various geophysical methods in geological studies | 2 |
| 2 | **Gravity Method:** Basic principles, gravity anomalies, gravimeters, data acquisition procedures, data reduction and processing, interpretation of Bouguer anomalies for basic geometrical shapes, depth rules; Applications | 8 |
| 3 | **Magnetic Method:** Basic principles, magnetic anomalies, magnetometers, data acquisition procedures, data reduction and processing, interpretation of magnetic anomalies for basic geometrical shapes, depth rules; Applications | 8 |
| 4 | **Seismic Methods:** Refraction, reflection and attenuation of seismic waves, geophones and hydrophones, recording instruments, seismic refraction method, travel time curves for flat and dipping interfaces, interpretation of refraction profiles, seismic reflection method, CDP shooting, geophone grouping, elementary ideas about processing and interpretation of seismic reflection data; Applications | 10 |
| 5 | **Electrical Method:** Apparent resistivity, sounding and profiling, different electrode configurations, field procedures, resistivity meters, data interpretation using curve matching method, electrical section; Applications | 7 |
| 6 | **Electromagnetic Methods:** Basic concepts, dip angle techniques, measurement of amplitude and phase, various transmitter and receiver loop configurations, response curves, airborne electromagnetic method; Applications | 7 |
| | **Total** | 42 |

**List of Practicals**

1. Determination of velocity and thickness of bed from seismic refraction and reflection survey
2. Determination of dip of bed from seismic refraction survey
3. Preparation of regional and local gravity anomaly map
4. Calculation of depth and extent of simple structure from gravity survey
5. Collection, processing and interpretation of magnetic data
6. Collection, processing and interpretation of resistivity data for Schlumberger and Wenner configurations

**11. Suggested Books:**

| S. No. | Name of Books/ Authors/Publishers | Year of Publication/ reprints |
|---|---|---|
| 1. | Lowrie, W., "*Fundamentals of Geophysics*", Cambridge University Press. | 2007 |
| 2. | Kearey, P., Brooks, M. and Hill, I., "*An Introduction to Geophysical Exploration*", Blackwell. | 2002 |
| 3. | Telford, W.M., Geldart, L.P. and Sheriff, R.E., "*Applied Geophysics*", Cambridge University Press. | 1999 |
| 4. | Parasnis, D.S., "*Principles of Applied Geophysics*", Chapman and Hall. | 1997 |
| 5. | Dobrin, M.B. and Savit, C.H., "*Introduction to Geophysical Prospecting*", McGraw-Hill. | 1988 |
| 6. | Robinson, E.S., Coruh, C., "*Basic Exploration Geophysics*", John Wiley & Sons. | 1988 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-601** Course Title: **Himalayan Geology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide basic knowledge of geology, structure and tectonics of Himalaya.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction, importance and significance of Himalaya, their morphology, classification of Himalaya - regional, physical and geological. | **4** |
| **2** | Formation of Himalaya, Indian plate margin, plate movement and rise of Himalaya, Himalayan foredeep, Indo Gangetic plain and its relation with peninsular India. | **8** |
| **3** | Major litho-tectonic boundaries. | **4** |
| **4** | Geology of lesser Himalaya, geological history and structures, sedimentary basins and igneous and metamorphic belts. | **4** |
| **5** | Geology of higher Himalaya, structural framework, inverted metamorphism, Magmatism and its geological history. | **6** |
| **6** | Tethys Himalaya, its geology and structure, and relationship with higher Himalaya and trans-Himalayan geology | **4** |
| **7** | Concept of exhumation in the Himalaya | **4** |
| **8** | Himalayan seismicity, its characteristics, major earthquakes, gravity and magnetotelluric characteristics and structure of Himalaya | **4** |
| **9** | Mineral deposits and metallogeny of Himalaya | **4** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Srikantia S.B. and Bhargava, O.N. , "Geology of Himachal Pradesh", Geological Society of India | **2005** |
| **2.** | K. S. Valdiya, "Geology of Kumaon Himalaya", Wadia Institute of Himalayan Geology, Dehradun | **2004** |
| **3.** | G. Kumar, "Geology of Uttar Pradesh and Uttaranchal", Geological Society of India, Bangalore | **2005** |
| **4.** | Brown G.G., Hawkesworth C.J. and Wilson, R.C.L., "Understanding the Earth- A New Synthesis", Cambridge Univ. Press | **1992** |
| **5.** | Gansser A., "Geology of Himalayas", Wiley and Sons | **1964** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-602** Course Title: **Computational Thermodynamic Modeling**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE** 25 **ETE 50 PRE 00**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide in-depth knowledge of thermodynamic modelling technique.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction to thermodynamics | **8** |
| **2** | Heat sources in planetary bodies | **3** |
| **3** | Thermodynamics and phase equilibria | **4** |
| **4** | Thermodynamics of natural magmatic and metamorphic processes | **6** |
| **5** | Computational thermodynamic modelling from metamorphic using THERMOCALC, PERPLE_X, THERIAK- DOMINO | **12** |
| **6** | Computational thermodynamic modelling of igneous systems using MELTS algorithm | **6** |
| **7** | Tectonic interpretations of phase diagrams constructed by different computational modelling techniques | **3** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Vernon, R.H and Clarke, G., "Principles of Metamorphic Petrology", Cambridge University Press | **2008** |
| **2.** | Winter, J.D., "Principles of Igneous and Metamorphic Petrology", Prentice Hall | **2009** |
| **3.** | Philpotts, A.R. and Ague, J.J., " Principles of Igneous and Metamorphic Petrology", Cambridge University Press | **2009** |
| **4.** | Pattino Douce, A., " Thermodynamics of the Earth and Planets", Cambridge University Press | **2011** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-603** Course Title: **Isotope Geology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart various aspects of Isotope Geology and geochronology and their application in the study of evolution of earth and terrestrial planets.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Basics of geochronology/isotope geology | **4** |
| **2** | Sample preparation and ion chromatography, Isotopic dilution mass spectrometry | **8** |
| **3** | Principles of mass-spectrometry, types of mass-spectrometer for geochronology/ isotope geology and their uses, | **6** |
| **4** | Rb-Sr Systematics for geochronology and its importance in igneous petrogenesis, dating of fabric, water system, paleontology | **4** |
| **5** | Sm-Nd system, isochron dating, modal ages, εNd and their uses in crustal processes | **4** |
| **6** | U-Th-Pb dating technique | **4** |
| **7** | Concept of closure temperature and Exhumation of terrains | **2** |
| **8** | Cosmogenic nuclides, new frontiers in isotope geology | **4** |
| **9** | Lu-Hf and other lithophile isotope system | **2** |
| **10** | Geochemistry of radiogenic isotopes for evolution of earth | **4** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Claude, A. C.,and Allegre, C. Sutcliffe "Isotope Geology", Cambridge University Press, | **2009** |
| **2.** | Dickin, A.P. "Radiogenic Isotope Geology**"** Cambridge University Press, | **2005** |
| **3.** | Faure, G. and Mensing, T. M., "Isotopes: Principles and Applications**"** John Wiley, New York | **2004** |
| **4.** | Rollinson, H., "Using geochemical data: evolution, presentation, interpretation" Pearson Education Limited | **1993** |
| **5.** | Faure, G., "Principles of Isotope Geology", John Wiley | **1986** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF THE DEPARTMENT**:** **Department of Earth Sciences**

1. Subject Code : **ESN-604** Course Title**: Coal Geology**
2. Contact Hours : **L : 3 T : 1 P : 0**
3. Examination Duration (Hrs) : **Theory: 3 Practical: 0**
4. Relative weight : **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits : **4** 6. Semester: **Autumn** 7. Subject Area: **DEC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on various aspects of the formation, occurrence and distribution of coal, and basic and advanced analysis of coal.
10. Details of course:

| S. No | Contents | Contact Hours |
|---|---|---|
| **1** | Types of coal, physical properties of coal, rank and grade, classification of coal, constituents of coal | 5 |
| **2** | Coal petrography including microscopic study of coal, macerals and microlithotypes | 5 |
| **3** | Chemical characterization: proximate and ultimate analysis; Trace elements in coal | 3 |
| **4** | Origin of coal, allochthonous and autochthonous theories | 3 |
| **5** | Origin of peat swamps, climatic, palegeographic and tectonic requirements; Depositional models of coal bearing sequences | 4 |
| **6** | Diagenesis of peat and coalification process – causes, role of time, temperature; Physical changes associated with increased coal rank | 4 |
| **7** | Combustion, Gasification, Carbonisation and coke, Hydrogenation; Coal and Environment | 3 |
| **8** | Gondwana and Tertiary coal deposits in India; Geology of important coalfields of India | 6 |
| **9** | Distribution of coal in space and time in the world | 3 |
| **10** | Coal mining and industrial use of coal | 3 |
| **11** | Coal as a source rock for hydrocarbons | 3 |
| | **Total** | **42** |

11. **Suggested Books:**

| S. No | Name of Books/ Authors | Year of Publication |
|---|---|---|
| **1** | Suarez-Ruiz et al.: "*Applied coal petrology"*. Elsevier | 2008 |
| **2** | Thomas L.: "*Coal Geology*", John Wiley and Sons Inc | 2002 |
| **`3** | Harder, V. M., R. P., Alexander, C. H., James, C. P., Douglas: "*Atlas of Coal Geology: Coal Geology and Coal Petrology*", American Association of Petroleum Geologists (AAPG) | 1998 |
| **4** | Douglas, C. P.: "*Geology in Coal Resource Utilization*", American Association of Petroleum Geologists | 1991 |
| **5** | Ward, C. R.: "*Coal Geology and Coal Technology*", Blackwell Scientific Publications | 1985 |
| **6** | Ross, C. A. and Ross, June R. P.: "*Geology of Coal*", Hutchinson Ross Pub. Co. | 1984 |
| **7** | Tatsch, J.H.: "*Coal Deposits* ", Tatsch Associates | 1980 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department Earth Sciences**

1. Subject Code: ESN-605 Course Title: **Paleoecology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS** 0 **MTE 25 ETE 50 PRE** 0

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart basic concepts of paleoecology

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Nature and classification of environments:** Non marine environment (Continental), Transitional environment, Marine environment (Plankton, Nekton, Pelagic, Benthos), Ecologic factors in marine environment | **10** |
| **2.** | **Physical and Chemical Parameters:** Temperature and morphological variations in flora fauna, Oxygen isotopes: the thermometer of the Earth, The oxygen isotopic composition of sea water, Cenozoic climates, Currents and Tides, Salinity and morphological variation, Calcium Carbonate Equilibria, Solubility of Calcium Carbonates, Oxygen in marine environments, Oxygen requirements of foraminifera, Nutrition, Trophic resources and faunal assemblages | **8** |
| **3.** | **Biological Parameters:** Dispersal and migration, Habitat, microhabitat, Competition to exploit energy, Distribution of food resource in time and space. | **6** |
| **4.** | **Biologic aspects in palaeoecology**: Land plants, Planktonic plants, Foraminifera, Sponges Corals, Graptolites, Brachiopods, Pelecypods, Gastropoda, Cephalopods, Trilobites and Major Vertebrates. | **8** |
| **5** | **Fossil preservation involving both biotic and geological processes:** Nature of bias within the fossil record, exceptional fossil assemblages and their significance, relationships between fossil assemblages and their depositional and preservational palaeoenvironments; biotic and abiotic limitations on the spatial and temporal distribution of organisms; The nature of major extinction events and their causes. | **10** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1** | Allmon W. and Bottjer D. J. (Editors), "Evolutionary Paleoecology", Columbia University Press | 2000 |
| **2** | Schopf, T.J.M. "Models in Paleobiology", Freeman Cooper & Co. | 1972 |
| **3** | Ziegler, "Introduction to paleobiology", Ellis Horwood Ltd | 1983 |
| **4** | Paleobiology: A Synthesis_ Eds. D.E.G. Brigs & Peter Crowther, 1990, Blackwell Scientific Publ. | |
| **5** | Dodd, J. R. and Stanton, R.J. "Palaeoecology: Concepts and Applications", John Wiley & Sons. | 1981 |
| **6** | Phleger, F. B. "Ecology and Distribution of Recent Foraminifera", The John Hopkins. | 1960 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-606 Course Title: **Indian Mineral Deposits**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide concepts on occurrence, geology, geochemistry and genesis of important economic mineral deposits of India.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1. | Introduction and distribution of various mineral deposits in India with special reference to crustal evolution and metallogeny | 5 |
| 2. | Mineralogy, classification, mode of occurrence, geochemistry and genesis of bauxite, iron and manganese deposits | 8 |
| 3. | Types, characteristics and geological setting of copper, lead-zinc, chromite, tin and tungsten deposits. | 10 |
| 4. | Geology, pattern of mineralization, genetic models of gold, silver and platinum deposits, current exploration scenario in India | 7 |
| 5. | Nature and distribution of mica, magnesite, bentonite, baryte limestone and phosphate deposits of India | 5 |
| 6. | Geological controls, occurrence and reserves of coal and petroleum in India | 5 |
| 7. | Importance of mineral deposits in national economy | 2 |
| | **Total** | 42 |

**11. Suggested Books:**

| S. No. | Name of Authors / Books / Publishers | Year of Publication / Reprint |
|---|---|---|
| 1. | Sarkar, S. and Gupta, A. "*Crustal evolution and Metallogeny in India*", Cambridge University Press | 2011 |
| 2. | *Indian Minerals Yearbook*, Part I and II, IBM Publications | 2007 |
| 3. | Talapatra, M., "*Modeling and Exploration of Mineral Deposits*", Capital Publishing | 2006 |
| 4. | Prasad, U. "*Economic Geology*", CBS publishers | 1996 |
| 5. | Banerjee, D.K. "*Mineral Resources of India*", The World Press | 1992 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT/CENTRE: **DEPARMENT OF EARTH SCIENCES**

1. Subject Code: ESN-607 Course Title: **Engineering Geology**

2. Contact Hours **: L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory** **3** Practical **0**

4. Relative Weight : **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5.Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **DEC**

7. Pre-requisite: **Nil**

9. Objective: To impart knowledge of fundamental concepts of Engineering Geology

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction to Engineering Geology, Master Plan for river valley projects | **4** |
| **2** | Dams – parts, types, criteria for site selection, forces acting on dams | **6** |
| **3** | Environmental Impacts of Dams & Reservoirs | **4** |
| **4** | Tunnels – parts, classification, ground conditions, geological considerations | **6** |
| **5** | Engineering Geological mapping for major civil projects | **2** |
| **6** | Engineering properties of rocks – laboratory and field tests | **2** |
| **7** | Concepts of rock mass classification – utilities – RMR and Q systems | **5** |
| **8** | Landslides – concepts, classification, mapping techniques and analysis | **4** |
| **9** | Rock as construction materials and aggregate properties | **3** |
| **10** | Engineering Geological investigations related to highways, buildings, bridges and other structures | **6** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Anbalagan,R. Singh,B, Chakraborthy,D. and Kohli,A. "A filed Manual for Landslide investigations". DST, Government of India, New Delhi | **2007** |
| **2.** | Krynine, D.P.Judd,W.R. "Principles of Engineering Geology and Geotectonics" CBS Publications & Distributors | **2001** |
| **3.** | Bell, F.G. "Fundamentals of Engineering Geology" Elsevier | **2007** |
| **4** | Singh, B.& Goel, R.K ., `Rock mass classification: A practical approach in civil Engineering', Elsevier | **1999** |
| **5.** | Gokhale, K.V.G.K. "Principles of Engineering Geology" B.S.Publications | **2006** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-608 Course Title: **Mineral Exploration and Mining Geology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**: Nil**

9. Objective: To introduce basic concepts of mineral exploration and role of a geologist starting from prospecting to mining.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Stages of exploration, Geological indicators for mineral deposits, lithological and structural controls of mineralization | **4** |
| **2.** | **Basic concepts of geological and geochemical exploration**: orientation survey, lithogeochemical survey, weathering and soil formation, residual and transported soil and soil sampling, geochemical drainage survey, hydro-geochemical survey, biogeochemical exploration and geobotanical survey, atmo-geochemical survey | **8** |
| **3.** | **Different techniques in mineral exploration**: Drilling, sampling, bench mapping, underground mine mapping, preparation of geological plans and sections | **8** |
| **4.** | Delineation of subsurface ore bodies of different geometric shapes using various geological concepts and techniques | **4** |
| **5.** | Ore reserve estimation and grade calculation for different types of ore deposits | **4** |
| **6.** | Surface and sub-surface mining | **8** |
| **7.** | Exploration during opencast and underground mining | **4** |
| **8.** | Elements of Ore Dressing | **2** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Stevens, R., "Mineral Exploration and Mining Essentials" British Columbia Institute of Technology (BCIT) | **2011** |
| **2.** | Moon, C.J., Whateley, M.K.G. and Evans, A.M., "Introduction to Mineral Exploration", Blackwell Science, 2nd Ed. | **2006** |
| **3.** | Talapatra, A.K., "Modelling and Geochemical Exploration of Mineral Deposits", Capital Publishing | **2006** |
| **4.** | Wills, B., "Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery", Butterworth-Heinemann | **2006** |
| **5.** | Hartman, H.L. and Mutmansky, J.M. "Introductory Mining Engineering" John Wiley and Sons | **2002** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-609 Course Title: **Petroleum Geology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: DEC**

8. Pre-requisite**: Nil**

9. Objective: To introduce modes of formation, accumulation and exploration of petroleum

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Introduction: definition, petroleum in world economy, OPEC, world reserve and production, concept of peak oil, concept of total petroleum system | **2** |
| **2.** | Chemistry: composition and chemical variability of petroleum, classification, characterization | **3** |
| **3.** | Origin of petroleum:, biogenic vs. abiogenic origin, source and production of organic carbon, carbon cycle, source rock through geologic time | **5** |
| **4.** | Marine photosysthesis to petroleum formation: composition of marine biomass, kerogen, maturation, van Krevelen diagram, | **5** |
| **5.** | Subsurface environment: porosity, permeability, formation water, geothermal gradient, BHT, pressure gradient, overpressure | **6** |
| **6.** | Migration: types of migration, mechanisms of primary migration, buoyancy vs. capillary pressure, movement of oil globules through pore throats | **6** |
| **7.** | Reservoirs and seals: reservoir rocks, physical characters, estimation of physical properties in laboratory and from wireline logs | **5** |
| **8.** | Traps: structural, diapiric, stratigraphic and combination traps, mapping of traps through geological and geophysical methods | **3** |
| **9.** | Petroleum exploration, lead and prospect, reserve estimation, net/gross pay | **5** |
| **10.** | Petroleum provinces with special reference to India | **2** |
| | **Total** | **42** |

**11. Suggested Books:**

| S. No. | Name of Authors / Books / Publishers | Year of Publication/ reprint |
|---|---|---|
| 1. | K Bjorlykke (ed), Petroleum Geoscience: From Sedimentary Environments to Rock Physics, Springer-Verlag. | 2010 |
| 2. | J Gluyas and R Swarbrick, Petroleum Geoscience, Blackwell | 2004 |
| 3. | R C Selley, Elements of Petroleum Geology, Academic Press | 1998 |
| 4. | L B Magoon and W G Dow (ed), The petroleum System – From Source to trap, AAPG Memoir 60 | 1994 |
| 5. | B P Tissot and D H Welte, Petroleum Formation and Occurrence, Springer-Verlag | 1984 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF THE DEPARTMENT**:** **Department of Earth Sciences**

1. Subject Code : **ESN-610** Course Title**: Well Logging**
2. Contact Hours : **L : 3 T : 1 P : 0**
3. Examination Duration (Hrs) **Theory: 3 Practical: 0**
4. Relative weight : **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits : **4** 6. Semester: **Autumn** 7. Subject Area: **DEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce geophysical well logging techniques for interpretation of subsurface geology
10. Details of course:

| S. No | Contents | Contact Hours |
|---|---|---|
| **1** | **Introduction:** Objectives of well logging, classification of well logging methods, formation evaluation and its importance | **4** |
| **2** | **Electrical Logging:** Basic principles, normal and lateral logs, focused logs, micro-resistivity tools and their role in formation evaluation; applications; SP log measurements and interpretation | **6** |
| **3** | **Induction Logs**: Basic principles, focused induction logs, geometric factors; Applications | **6** |
| **4** | **Radiation Logs:** Basic principles of different types of radiation logs including gamma ray, gamma-gamma, neutron and chlorine logs; Porosity determination; Applications | **6** |
| **5** | **Sonic Logs:** Basic principles, sonic logging tools, porosity determination; Applications | **6** |
| **6** | **NMR Logging:** Permeability, bound and free-water estimation using NMR logging techniques; Applications | **4** |
| **7** | **Auxiliary Logging Devices:** Caliper, dipmeter, cement bond logging, casing collar locators, temperature logging; Applications | **6** |
| **8** | **Integrated analysis and interpretation of well logs:** Integrated interpretation of electrical and induction logs, resistivity-porosity, porosity-porosity crossplot methods of interpretation and field examples. | **4** |
| | **Total** | **42** |

11. **Suggested Books:**

| S. No | Name of Books/ Authors | Year of Publication |
|---|---|---|
| **1** | Serra, O., "Well Logging and Geology", TECHNIP | **2003** |
| **2** | Theys, P., "Log Data Acquisition and Quality Control", Gulf Publishing | **1999** |
| **`3** | Scott Keys W. A practical guide to Borehole Geophysics in environmental investigations, Lewis | **1995** |
| **4** | Ellis, D.V. and Singer, J.M., "Well Logging for Earth Scientists", Elsevier | **1987** |
| **5** | "Schlumberger Log Interpretation Principles/ Applications", Schlumberger Education Services | **1987** |
| **6** | Lynch, E.J., "Formation Evaluation", Harper and Row | **1962** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-611** Course Title: **Plate Tectonics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Autumn** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the concept of plate tectonics and its relevance to earth system sciences

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | Earth's interior constitution and concept of lithospheric plate. Composition, heat flow, pressure and gravity variation in earth | 4 |
| 2 | Oceanic and continental types of Earth's crust, their composition, mineralogy and major structural features | 2 |
| 3 | Plate tectonics: Historical background, Types of plates, type of plate margins, Euler's pole, sense of displacements of plates | 2 |
| 4 | Creative Plate Margin: Composition, seismic structure, magmatic activities, gravity variation, isostatic balance and evolution | 4 |
| 5 | Conservative Plate Margin: Transform and transcurrent faults and plate motions, seismicity, structure and evolution. Different structure associated with transpression and transtension environments | 3 |
| 6 | Destructive Plate Margins: Surface manifestations, geophysical and geological characteristics, sedimentological, metamorphic and magmatic characteristics, isostatic balance, gravity variation, thermal structure | 6 |
| 7 | Orogenesis: Plate tectonics and mountain building processes, orogeny and epiorogeny, Fault plane solution | 2 |
| 8 | Concept of plate tectonics in mineralization and hydrocarbon exploration: Types of plate setting and basin formation, mineralization in different plate settings | 6 |
| 9 | Plate Tectonics and magmatism: Different types of plate setting and igneous activities, Volcanoes and their products in different plate boundaries | 4 |
| 10 | Plate tectonics and Metamorphism: Different types of plate setting and metamorphic rocks | 2 |
| 11 | Indian Plate: Configuration and characters of Indian plate margins; Himalayan orogeny and tectonic models; Indian seismicity | 4 |

| | | |
|---|---|---|
| 12 | Neotectonism: Identification of paleo and neotectonic features. Surficial expression of neotectonism and its effect on geomorphology | 3 |
| | **Total** | **42** |

**11. Suggested Books:**

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| 1. | Kearey,P., Klepeis, K.A. and Vine, F. J., *Global Tectonics*. John Wiley & Sons Ltd. UK | 2013 |
| 2. | Condie, K.C., *Plate Tectonics and Crustal Evolution*, Butterworth-Heinemann | 2003 |
| 3. | Summerfield, M. A., *Geomorphology and Global Tectonics*. John Wiley & Sons Ltd. UK | 2000 |
| 4. | Davies, G.F., "*Dynamic Earth: Plates, Plumes and Mantle Convection*", Cambridge | 2000 |
| 5. | Tomecek, S.M., Plate *Tectonics*, Chelsea House, New York | 2009 |
| 6 | Frisch, W.; Meschede, M., and Blakey, R. Plate Tectonics: Continental drift and mountain building. Springer | 2011 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF THE DEPARTMENT: **Department of Earth Sciences**

1. Subject Code: **ESN-620** Course Title: **Reservoir Geomechanics**

2. Contact Hours: **L - 3** **T - 1** **P - 0**

3. Examination Duration (Hrs): **Theory** 3 **Practical** 0

4. Relative Weight : **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** -

5. Credits: 04 6. Semester: **Autumn** 7. Subject Area: **DEC**

8. Pre-requisite: **NIL**

9. Objective: To provide fundamental and advanced knowledge on geomechanics of hydrocarbon reservoirs

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| 1 | Fundamental geology of hydrocarbon reservoirs; introduction to concept of stress in reservoirs | **4** |
| 2 | Key geomechanical attributes of reservoirs: Porosity, Permeability, Relative Permeability, Density, Strength of reservoir and cap rocks, Elasticity, Interrelation among parameters, Formation characteristics | **6** |
| 3 | Thermo-hydro-geomechanical changes during flow of fluids; Poromechanics of the reservoir; Constitutive laws; Over-pressurisation, Effective stresses | **8** |
| 4 | Rock deformation & fracturing; Failure mechanics; Estimation of insitu stresses and rock strength | **6** |
| 5 | Measuring stress magnitude in vertical, horizontal and deviated wells; Wellbore stability; Cap rock integrity, Stress configuration of depleted reservoirs, reservoir compaction, hydrofracturing | **10** |
| 6 | Geomechanics of unconventional hydrocarbon reservoirs such as coal, gas shales, tight sands; Carbon sequestration; Risks | **8** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Authors/Books/Publishers | Year of publication/ reprint |
|---|---|---|
| 1 | Zoback, M.D., Reservoir Geomechanics, Cambridge University Press | **2010** |
| 2 | Fjaer, E., Holt, R. M., Raaen A. M., Risnes, R., Horsrud, P., Petroleum Related Rock Mechanics, Elsevier Science | **2008** |
| 3 | Mavko, G., Mukerji, T., Dvorkin, J., The Rock Physics Handbook, Cambridge University Press | **2003** |
| 4 | Wang, H.F. Theory of Linear Poroelasticity with applications to Geomechanics and hydrogeology, Princeton University Press. | **2000** |
| 5 | Amadei, B. Rock Stress and its Measurement, Chapman & Hall, London | **1997** |
| 6 | Guéguen, Y., Palciauskas, V., Introduction to the Physics of Rocks, Princeton University Press | **1994** |
| 7 | Jaeger, J.C., Cook, N.G.W. Fundamentals of Rock Mechanics, 3rd edition, Chapman & Hall, London | **1979** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-621** Course Title: **Principles of Geographic Information Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory 3** **Practical 0**

4. Relative Weight : **CWS 25** **PRS 0** **MTE 25** **ETE 50** **PRE 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **Nil**

9. Objective: To provide basic understanding about GIS Technology and its application in Earth Sciences

10. Details of Course:

| S. No | Contents | Contact Hours |
|---|---|---|
| 1. | GIS definition, purpose of GIS, Differences between GIS and CAD, DBMS | 4 |
| 2. | Different Components of GIS, Hardware and software requirements of GIS | 4 |
| 3. | Concepts of thematic layers, topology, Co-ordinate systems | 4 |
| 4. | Raster and vector data models, their associated advantages and disadvantages, Raster data compression techniques, Different vector data models | 8 |
| 5. | Digital Elevation Model (DEM), Different derivatives of DEM and their applications, Triangulated Irregular Network (TIN) | 6 |
| 6. | Raster and vector integration, GIS integration with remote sensing | 4 |
| 7. | GIS analysis operations, GIS applications in Earth Sciences | 8 |
| 9. | Errors in GIS and their rectifications, Limitations of GIS | 4 |
| | **Total** | **42** |

**11. Suggested Books:**

| S. No | Name of Books/ Authors/Publishers | Year of Publication/reprint |
|---|---|---|
| 1. | *Kennedy, M.l D., " Introducing Geographic Information Systems",* John Wiley & Sons | 2013 |
| 2. | Heywood, I., Cornelius S. and Carver S., *"An Introduction to Geographical Information Systems"* (4th Edition), Pearson Prentice Hall. | 2012 |
| 3. | Chang K., *"Introduction to Geographic Information Systems", McGraw-Hill Education* | 2006 |

| | | |
|---|---|---|
| 4. | Bernhardsen, T., *"Geographic Information Systems: An Introduction"* , John Wiley & Sons | 2005 |
| 5. | Aronoff, S., *"Geographic Information Systems: A Management Perspective"* WDL Publications | 1991 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF THE DEPARTMENT**:** **Department of Earth Sciences**

1. Subject Code : **ESN-622** Course Title**: Carbonate Sedimentology**
2. Contact Hours : **L : 3 T : 1 P : 0**
3. Examination Duration (Hrs) **Theory: 3 Practical: 0**
4. Relative weight : **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area: **DEC**
8. Pre-requisite: **Nil**
9. Objective: An introduction to carbonate rocks and their depositional environments
10. Details of course:

| S. No | Contents | Contact Hours |
|---|---|---|
| **1** | Constituents of carbonate sediments | 3 |
| **2** | Carbonate mineralogy and chemistry | 4 |
| **3** | Typical sedimentary textures and structures inherent to carbonates, and their significance for interpreting environmental setting | 3 |
| **4** | Diagenesis of carbonate rocks | 4 |
| **5** | Dolomites and dolomitization models | 4 |
| **6** | Shallow marine and deep marine carbonate depositional systems | 5 |
| **7** | Lacustrine and resedimented carbonates | 4 |
| **8** | Carbonate facies through time | 4 |
| **9** | Application of sequence stratigraphy in carbonate depositional systems | 4 |
| **10** | Carbonate porosity – classification, diagenetic modifications, mode of evolution | 4 |
| **11** | Overview of carbonate reservoirs | 3 |
| | **Total** | **42** |

11. **Suggested Books:**

| S. No | Name of Books/ Authors | Year of Publication |
|---|---|---|
| **1** | Boggs, Sam (Jr.): *Petrology of sedimentary rocks, 2nd Ed*. Cambridge. | 2009 |
| **2** | Nichols, G.: *Sedimentology and stratigraphy*, 2nd Ed. Wiley-Blacwell | 2009 |
| **`3** | Tucker, M.E., Wright V.P.: *Carbonate sedimentology*. Blackwell Science | 2002 |
| **4** | Moore, C.H.: *Carbonate reservoirs*. Elsevier. | 2001 |
| **5** | Reading, H.G.: *Sedimentary Environments and Facies*. 6th Ed., Blackwell Scientific Publ., Oxford. | 1996 |
| **6** | Scholle, P.A., Bebout, D.G., and Moore, C.H.: *Carbonate Depositional Environments (4th edition)*. American Association of Petroleum Geologists | 1983 |
| **7** | Tucker, M.E.: *Sedimentary petrology- an introduction*. Blackwell Scientific Publ., Oxford | 1981 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-623** Course Title: **Marine Geology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce oceanic processes and resources

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction:** Origin of oceans, world's oceans, geographical settings | **2** |
| **2.** | **Structural and oceanographic setting:** Plate tectonics and ocean systems, ocean morphology, marine stratigraphy, ocean crust, heat distribution and age of oceanic crust, structure, petrology and sources of oceanic crust, magnetization of the oceanic crust | **8** |
| **3.** | **Ocean Circulation Patterns:** Wave dynamics, oceanic currents, surface and deep circulation, classification of marine environments, sea-level history, geologic effects of bottom currents, seismic stratigraphy, mariginal marine environments | **8** |
| **4.** | **Oceanic sediments and microfossils:** Terrigenous, biogenic and authigenic sediments, calcareous and siliceous microfossils, chemical sediments, carbonate and silicate equilibria, marine biogeochemistry | **8** |
| **5.** | **Paleoceanography:** Paleoceanographic and sediment history of the different ocean basins, paleoceanographic changes and mapping, ocean instruments, critical events in ocean history | **8** |
| **6.** | **Marine Resources, International Sea Laws, Marine Pollution:** Physical, chemical and biological marine resources, maritime economy, climate change and oceans, UN Laws of oceans, Oil and other contaminants | **8** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Stewart, R.H., Ïntroduction to Physical Oceanography", Texas A&M University Press | **2012** |
| **2.** | Berner, E.K. and Berner, R.A., "Global Environment: Water, Air and Geochemical Cycles", Prentice-Hall Publ. 2nd Ed. | **2012** |
| **3.** | Schlesinger, W.H. and Bernhardt, E.S. "Biogeochemistry: An Analysis of Global Change", Associated Press, 3rd Ed. | **2013** |
| **4.** | Shepard, R.H. "Submarine Geology", Harper & Row Publ. | **1973** |
| **5.** | Kennet, P.K. "Marine Geology", Prentice-Hall Publ. | **1996** |
| **6.** | Mellor, G.L. , "Introduction to Physical Oceanography", Springer-Verlag | **1996** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN-624** Course Title: **Mineral Economics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory 3** **Practical 0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide knowledge of mineral industry and its socio-economic role with special reference to India.

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | Mineral economics and its concept and its inherent specialties, concept of Mineral resources and reserves estimation | **8** |
| **2.** | Mineral legislation | **4** |
| **3.** | Economics of Mineral Exploration and Problems related to Infrastructure, Production, Processing; Effect of co-products and byproducts | **8** |
| **4.** | Marketing and trade, Demand Analysis, Market Survey, Consumption and Substitution | **8** |
| **5.** | Mineral taxation and incentives, Pricing of minerals,Conservation and substitution; Strategic, critical and essential minerals | **8** |
| **6.** | Mineral industry and its impact on environment, National Mineral Policy | **6** |
| | **Total** | **42** |

11. Suggested Books:

| S. No. | Name of Books / Authors/ Publishers | Year of Publication/ Reprint |
|---|---|---|
| **1.** | Wellmer, F. W., Manfred, D., Markus, W., Economic Evaluations in Exploration , Springer Verlag | **2008** |
| **2.** | Chatterjee.K.K., An Introduction to Mineral Economics, New Age International | **2004** |
| **3.** | Wellmer, F. W., Statistical Evaluations in Exploration for Mineral Deposits, Springer Verlag | **1998** |
| **4.** | Sinha,R.K., and Sharma, N.L., Mineral Economics,Oxford & IBH Pub. Co | **1988** |
| **5.** | Govett, G.J.E., and Govett, M.H., World Mineral Supplies, Elsevier Scientific Pub. Co | **1976** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF THE DEPARTMENT**:** **Department of Earth Sciences**

1. Subject Code : **ESN-625** Course Title**: Basin Analysis**
2. Contact Hours : **L : 3 T : 1 P : 0**
3. Examination Duration (Hrs) **Theory: 3 Practical: 0**
4. Relative weight : **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits : **4** 6. Semester: **Spring** 7. Subject Area: **DEC**
8. Pre-requisite: **Nil**
9. Objective: To understand the basin formation process and to study the depositional sedimentary environment
10. Details of course:

| S. No | Contents | Contact Hours |
|---|---|---|
| **1** | Introduction to Sedimentary Basin | 3 |
| **2** | Basin mapping methods: Litho facies assemblage maps, Geophysical techniques, Lithofacies mapping with petrophysical logs | 6 |
| **3** | Environment and paleoslope interpretation, Paleocurrent analysis, Paleogeographic synthesis | 4 |
| **4** | Interpretation of different depositional sequences | 8 |
| **5** | Sequence in deep marine siliciclastic deposits | 3 |
| **6** | Carbonate depositional environments | 3 |
| **7** | Basin subsidence and thermal history | 3 |
| **8** | Sedimentary basin associated with plate margins | 6 |
| **9** | Sedimentary basins of India | 6 |
| | **Total** | **42** |

11. **Suggested Books:**

| S. No | Name of Books/ Authors | Year of Publication |
|---|---|---|
| **1** | Mike Leeder, Sedimentology and Sedimentary basins, from Turbulence to Tectonics, Wiley-Blackwell | **2011** |
| **2** | A. D. Miall, Principles of sedimentary Basin Analysis, Springer | **2010** |
| **`3** | Sedimentary Basins of India: Recent Developments Gondwana Geological Society | **2010** |
| **4** | Phillip A. Allen and John A. Allen, Basin Analysis Principle and Applications, Blackwell | **2005** |
| **5** | Depositional Sedimentary Environments: With Reference to Terrigenous Clastics, Springer | **1975** |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: **ESN -626** Course Title: **Principles of Remote Sensing**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory 3** **Practical 0**

4. Relative Weight : **CWS 25** **PRS 0** **MTE 25** **ETE 50** **PRE 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **DEC**

8. Pre-requisite: **Nil**

9. Objective of Course: To introduce the principles of satellite based remote sensing for studying earth resources

10. Details of Course:

| S. No | Particulars | Contact Hours |
|---|---|---|
| 1. | Introduction, development of remote sensing technology, advantages | 4 |
| 2. | Different platforms of remote sensing; EM spectrum, solar reflection and thermal emission remote sensing | 6 |
| 3. | Interaction of EM radiation with atmosphere including atmospheric scattering, absorption and emission | 4 |
| 4. | Interaction mechanisms of EM radiation with ground, spectral response curves | 4 |
| 5. | Principles of image interpretation, digital image processing | 8 |
| 6. | Multi-spectral scanners and imaging devices; Salient characteristics of LANDSAT, IRS, Cartosat, ResourceSat, SPOT, IKONOS, QuickBird, GeoEye sensors and their applications | 6 |
| 7. | Image characteristics and interpretation of different geological landforms, structures and major igneous, sedimentary and metamorphic rock types | 4 |
| 9. | Remote sensing as a fore-runner in all exploration programs, Remote Sensing integration with GIS, Limitations of Remote Sensing | 6 |
| | **Total** | **42** |

**11. Suggested Books:**

| S. No | Name of Books/ Authors/Publishers | Year of Publication/reprint |
|---|---|---|
| 1. | Campbell, J. B. and Wynne, R. H., *"Introduction to Remote Sensing"*, 5th Ed., The Guildford Press, New York | 2012 |
| 2. | Jensen, J. R., *Remote Sensing of the Environment: An Earth Resource Perspective* (*2nd Ed.*), Prentice Hall. | 2009 |
| 3. | Lillesand, T.M., Kiefer, R.W. and Chapman, J.W., "*Remote Sensing and Image Interpretation*", 5th Ed., John Wiley & Sons | 2007 |
| 4. | Gupta, R. P., "*Remote Sensing Geology*", 2nd Ed., Springer | 2003 |
| 5. | Drury, S. A., "*Image Interpretation in Geology*", 2nd Ed., Allen & Unwin | 1993 |

**INDIAN INSTITUTE OF TECHNOLOGY ROORKEE**

NAME OF DEPTT./CENTRE: **Department of Earth Sciences**

1. Subject Code: ESN-627 Course Title: **Contaminant Hydrogeology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** **0**

4. Relative Weight **: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To understand groundwater contamination

10. Details of Course:

| S. No. | Contents | Contact Hours |
|---|---|---|
| **1.** | **Introduction:** Hydrologic cycle, importance of ground water as a resource, residence time, reservoirs, water-balance equation | **2** |
| **2.** | **Principles of groundwater Flow:** Basic principles of ground water flow, Darcy's law, permeability and hydraulic conductivity, aquifers, confined and unconfined beds, measurement of ground water content, specific yield and retention, geologic formations as aquifers | **6** |
| **3.** | **Hydrogeochemical reactions and groundwater compositions:** Equilibrium kinetics, key reactions of ground water chemistry, oxidation-reduction reactions, ion exchange processes, micro-organisms in groundwater, global and Indian water standards | **6** |
| **4.** | **Groundwater quality and contaminant hydrogeology:** Common groundwater contaminants, transport of reactive and non-reactive dissolved contaminants, urban and industrial contaminants, municipal landfill, agricultural contaminants | **8** |
| **5.** | **Groundwater sampling and analysis:** Groundwater sampling and analysis, data plotting and interpretations, groundwater pollution, environmental isotopes in hydrogeology, salt water intrusion | **6** |
| **6.** | **Groundwater remediation and protection:** Groundwater pollution remediation techniques, pump-and-treat, permeable reactive barriers, monitored natural attenuation, source protection zones, risk assessment methods, spatial planning and ground water protection | **8** |
| **7.** | **Groundwater resources and management:** Natural and artificial recharge concepts, site selections for recharge, concepts of | **2** |

| | | |
|---|---|---|
| | groundwater basin management, safe and conjunctive use, groundwater economics | |
| **8** | **Groundwater contamination in India:** Case studies and projects on Arsenic, Fluoride, Chromium contaminations, human impacts on ground water | **4** |
| | **Total** | **42** |

11. Suggested Books:

| **S. No.** | **Name of Books / Authors/ Publishers** | **Year of Publication/ Reprint** |
|---|---|---|
| **1.** | Schwartz, F.W. and Zhang, H., "Fundamentals of Groundwater", Wiley Publ. | **2008** |
| **2.** | Todd, D.K., "Groundwater Hydrology", 3rd Edition, Willey Publ. | **2005** |
| **3.** | Domencio, P.A. and Schwartz, F.W., "Physical and Chemical Hydrogeology", Wiley Publ. | **2002** |
| **4.** | Hiscock, K., "Hydrogeology-Principles and Practice", Blackwell Publishers | **2005** |
| **5.** | Fitts, C.R., "Groundwater Science", Academic Press | **2012** |
| **6.** | Ward, A.D., and Trimble, S.W., "Environmental Hydrology". Lewis Publ. | **2004** |