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Fax : 0091-821-2419363/301
Phone: (0821) 2419721/730/724

UNIVERISTY OF MYSORE
DEPARTMENT OF STUDIES IN EARTH SCIENCE
CENTRE FOR ADVANCED STUDY IN PRECAMBRIAN GEOLOGY

Manasagangotri, Mysore-570006

No. MGES/
Encls.Dated.....

Dr. K.N. PRAKASH NARASIMHA
M.Sc, Ph.D., FGS, FMS
Professor & Chairman- Dept. of Earth Science
& Chairman-Board of studies
Principal Investigator UGC-MoES- MRP &
ISRO-NRSC Major Research Project
Co-Principal Investigator UGC-MHRD E-PG pathashala project

Cell: *+91-9449082138*
+91-0821-2419721 730
e-mail: *knpnsimha@gmail.com*

Date: 04.02.2023

To:
All the BOS-members
Earth Science

Sir,

Sub:- BOS meeting in Applied Geology/Geology (PG & UG) - reg.
Ref:- No.UA2/379/2013-14, Dated 24-01-2023.

=.=.=

Adverting the above, I am inviting you to participate in the BOS meeting in Geology & Applied Geology- PG & UG courses in the Dept. of Earth Science, Manasagangothri, Mysore-6 on 11th February 2023 at 11.00 AM. The members will be paid remuneration as per the university rules.

Agenda:
1. Syllabus revision and preparation of Examiners List for 2023-24 academic year.
2. Any other matter with the permission of chair.

Thanking you,
Yours sincerely,

04/2/23
Dr. K.N.PRAKASH NARASIMHA
M.Sc., Ph.D., FGS, FMS
Professor
Dept. of Studies in Earth Science
University of Mysore, Manasagangotri
MYSURU-570006

PROCEEDINGS OF THE BOS MEETING (CB) HELD ON 11-02-2023 AT 11.00 AM IN THE CHAIRMAN CHAMBER, DOS IN EARTH SCIENCE, MANASAGANGOTHRI, UNIVERSITY OF MYSORE, MYSURU.

Chairman (BOS) welcomed the members for the meeting and briefed the agenda of the current meeting and the proceedings of which are as follows :

Agenda : 1. Syllabus Revision

The members after detailed discussion, decided to make certain essential changes the existing M.Sc., Geology & Applied Geology course syllabus. The members approved the structure of the syllabus which includes, title of the paper, LTP structure, Credit value, total numbers of credits and in detail syllabus. Each semester is maintained to have minimum of 18 credits and maximum of 20 credits and the total credits are maintained to be 76.

Agenda : 2. Approval of Panel of Examiners for both PG & UG during the academic year 2023-24.

Members approved the revision of the panel of examiners for the year 2023-24 for both UG & PG courses.

Agenda : 3 Any other matter.

1. The BOS committee members brought the matter of 'Model course curriculum on Disaster of 'Model Course curriculum of Disaster Risk Reduction (DRR) and management at UG and PG' letter from UGC vide Ref: No.D.O.No.2-9/2022 (CPPII) dated 24th February 2022. And committee members after discussion, decided to adopt the same at UG level.
2. BOS members from UG have expressed their deep concern for not having involved the UG teachers while framing the syllabus under NEP. BOS members recommended to have uniform nomenclature for B.Sc., Geology courses throughout Karnataka state as Earth Science. And also members suggested to offer common OE papers throughout the state.

p.t.o

3. The committee has resolved to finalize 5th & 6th semester UG-Syllabus under NEP after finalizing the syllabus by the state syllabus framing committee in Earth Science or Geology.

The Chairman thanked all the members for their contribution and active participation.

Members Present:

1. Dr.K.N.Prakash Narasimha
   Chairman, BOS (CB)
2. Dr.Mohammed Aslam
   Member, BOS (External)
3. Dr.Budihal
   Member, BOS (External)
4. Prof.H.T.Basavarajappa
   Dean & Member, BOS
5. Prof.K.G.Ashamanjari
   Member, BOS
6. Prof.P.Madesh
   Member, BOS
7. Prof.D.Nagaraju
   Member, BOS
8. Prof.B.V.Suresh Kumar
   Member, BOS
9. Prof.S.Srikantaswamy
   Member, BOS
10. Prof.B.Chandrashekar
    Member, BOS
11. Prof.M.R.Janardhan
    Member, BOS
12. Prof.K.A.Sharvani
    Member, BOS

Members Absent :

1. Dr.H.S.Aparna

Name of the Department : **Department of Studies in Earth Science**
Program: **M.Sc., GEOLOGY**, Code: **MSGEL**

I Semester	**Code**	**Course**	**Hard Core/ Soft Core**	**LTP**	**Credit Value**	**Paper Code**	**Total Credits**
1		Crystallography & Mineralogy	Hard Core	202	4		20
2		Sedimentary Petrology & Structural Geology	Hard Core	202	4		
3		Ore Geology	Hard Core	301	4		
4		Geomorphology & Environmental Geology	Hard Core	301	4		
5		Oceanography & Climatology	Soft Core	200	2		
6		Disaster Management	Soft Core	200	2		
II Semester	**Code**	**Course**	**Hard Core/ Soft Core**	**LTP**	**Credit Value**	**Paper Code**	
7		Fuel Resources & Mineral Economics	Hard Core	400	4		20
8		Paleontology	Hard Core	301	4		
9		Igneous & Metamorphic Petrology	Hard Core	202	4		
10		Minor Project (FW & Technical Report)	Hard Core	013	4		
11		Conservation of Soil and Water Resources	Soft Core	200	2		
12		Basics of Earth Science	Open Elective	200	2		
III Semester	**Code**	**Course**	**Hard Core/ Soft Core**	**LTP**	**Credit Value**	**Paper Code**	
13		Remote Sensing & GIS Applications	Hard Core	202	4		20
14		Geochemistry & Petrogenesis	Hard Core	301	4		
15		Indian Stratigraphy & Sequence Stratigraphy	Hard Core	301	4		
16		Engineering Geology & Surveying	Hard Core	301	4		
17		Gemology	Soft Core	200	2		
18		Industrial Mineral Resources	Open Elective	200	2		
IV Semester	**Code**	**Course**	**Hard Core/ Soft Core**	**LTP**	**Credit Value**	**Paper Code**	
19		Exploration Geology & Mining Methods	Hard Core	301	4		18
20		Hydrogeology & Geophysics	Hard Core	202	4		
21		Major Project (Dissertation)	Hard Core	015	6		
22		Precambrian Crustal Evolution & Tectonics	Soft Core	400	4		
						Total Credits	**78**

M.Sc., DEGREE COURSE IN GEOLOGY
(Two year – Four Semester Scheme)

SYLLABUS
(With New Regulations - CBCCEPS)
2023-2024

SEMESTER I

HARD CORE PAPERS

HARD CORE: CRYSTALLOGRAPHY AND MINERALOGY [LTP / CREDITS = 202/4]

Unit 1: Crystallography: Form theory of Crystals, Projections, Derivation of 32 point groups. Zone and Zone Laws, Atomic and ionic radii, Bond length and measurements of Radius, Radius ratio and co-ordination polyhedra, Cordination Number, Pauling's Rules, Spheres in Closest packing, Packing Index. Voids in closest packing, Classification & Co-ordination of voids, Derivative Structures. Crystal Defects / Crystal Imperfections.

Unit 2: Mineralogy: **Olivine Group**: Chemistry and Structure of the Olivines, Diadochy between atomic pairs Mg^{+2} - Fe^{+2} and Fe^{+2} – Mn^{+2}. Forsterite – Fayalite solid solution series, MgO-SiO_2 system, optical properties of Forsterite – Fayalite system, Paragenesis of Olivine group of minerals. **Garnet group**: Pyralspite-Ugrandite series, Structure and Chemistry of Pyralspite-Ugrandite series, optical properties and paragenesis. **Al_2SiO_5 group of minerals:** Silliminite, Mullite, Andalusite and Kyanite. P-T diagram of Kyanite-Andalusite-Sillaminite, Structure and chemistry of Al_2SiO_5 group of minerals, physical and optical properties, Paragenesis. **Epidote group of minerals:** Chemistry and Structure of Epidotes, members of Epidote group, properties and paragenesis of Epidote group. **Pyroxene group of minerals**: Classification of CPx-OPx, $CaSiO_3$-$MgSiO_3$-$FeSiO_3$ diagram, Structure of Pyroxenes, $MgSiO_3$-$CaMgSi_2O_6$, $CaMgSi_2O_6$ phase diagrams, Diopside – hedenbergite phase diagram, Chemistry, optical properties and paragenesis of Pyroxenes. **Amphibole group of Minerals:** Classification of Amphiboles, Cation distribution in Mg-end members in amphiboles, Structure of Amphiboles, paragenesis and optical properties. **Mica group of minerals:** Structure and classification of Mica group of minerals, Economically important micas – Phlogopite, Muscovite and Lepidolite. Paragenesis and distribution of mica group of minerals. **Feldspar group of minerals:** Alkali feldspars, Plagioclase feldspars, An-Ab-Or system, perthites and Antiperthites, Ab-An phase diagram. **Silica group of minerals:** SiO_2 polymorphs, Structure, Symmetry and cell parameters, Chemistry and solubility of Silica minerals, Stability relations of Silica minerals, P-T diagram of SiO_2, optical and physical properties, origin, occurrence and uses of SiO_2 minerals.

Unit 3: ***Practical : Crystallography:*** Classification and quantification of crystals based on grade of symmetric elements for Isometric, tetragonal, orthorhombic, hexagonal, monoclinic and triclinic systems. Projections for each crystal. Calculation of interfacial angle and axial ratios using stereonet projections.

Unit 4: ***Practical: Mineralogy:*** Descriptive mineralogy, Mineral formula calculations based on mineral analysis for olivines, garnets, pyroxenes, amphiboles, micas and feldspars. Trilinear phase diagrams for minerals. Identification of minerals based of X-ray patterns. Determination of vibration direction and sign of elongation in minerals using optical accessories, Determination of optic sign in uniaxial and Biaxial minerals. Determination of pleochroic scheme and absorption formula of minerals. Determination of birefringence of a mineral using Berek's compensator.

Reference:

1. An Introduction to crystallography - F.C.Phillips.
2. Elementary Crystallography - Buerger

3. Solids - Azaraoff.
4. Elements of X-ray Crystallography - Azaraoff.
5. Elements of Optical Mineralogy part I and II - Winchell
6. Optical Mineralogy - P.R.J. Naidu.
7. Fundamentals of Crystal chemistry – T.R.N.Kutty and J.A.K.Tareen(Orient Longman)
8. A Basic Course in Crystallography- J.A.K.Tareen and T.R.N.Kutty
9. Introduction to Rock forming Minerals-Deer, Howie & Zussman

HARD CORE: SEDIMENTARY PETROLOGY & STRUCTURAL GEOLOGY [LTP / CREDITS = 202/4]

Unit 1:Sedimentary Petrology: Aim, Scope and importance – Historical development - Relationship with other branches of geology. **Properties of Sedimentary rocks:** Textures of sedimentary rocks, Sedimentary facies and environment. Diagenesis of sediments. **Classification and description of sedimentary rocks:** Gravels, Conglomerates, Sand and Sandstones, Argillite, Non-evaporites and Evaporites, Heavy mineral studies, Grain size parameter Modes and Mechanism controls of sedimentation, Stoke's law, Primary Sedimentary structures, Tectonics and sedimentation. **Applications of sedimentary rocks** in Petroleum Geology.

Unit 2: Structural Geology: Principles of geological mapping; kinematic and dynamic analysis of deformation; stress-strain relationships for elastic, plastic and viscous materials; measurement of strain in deformed rocks; structural analysis of fold, cleavage, boudin, lineation, joint, fault and unconformities; stereographic projection of linear and planar structures; superposed deformation; deformation at microscale-dynamic and static recrystallisation, controls of strain rate and temperature on development of microfabrics; brittle and ductile shear zones; time relationship between crystallisation and deformation, calculation of paleostress.

Unit 3: ***Practical: Mega & Microscopy of Sedimentary Rocks*****:** Identification of Sedimentary rocks in hand specimens and thin sections. Identification of Structures in Sedimentary rocks. Grain size analysis - sieving, analysis of roundness and sphericity by visual method

Unit 4: ***Practical: Structural Geology :*** Construction of geological cross-section, structural contour maps, Tracing of outcrops, Interpretation of underground structure from borehole data, solution to fault problems, use of stereographic projection in structural calculation, construction of rose diagram for structural data.

Reference:

1. Sedimentary Petrology – Pettijohn
2. Petrography – An introduction to the study of rocks in thin sections – H Kowell, Williams and Turner.
3. Manual of sedimentary petrology – Krumbein and Pettijohn.
4. Principles of sedimentation – Twenhefel.
5. Sequence in layered rocks – Shrock, R.R
6. Procedures in sedimentary petrology – R.E. Carvar
7. Origin of sedimentary rocks – Blatt, Middleton and Hurray.
8. Microscope sedimentary petrology – A.V.Carrozi.
9. Sand and Sand Stones – Pettijohn, Potter and Siever.
10. Petrology of Sedimentary rocks – R.L.Folk.
11. Hand book of subsurface geology – C.A. Moore
12. 12.Marine geology and Oceanography of the Aretic seas- Yuonne Herman.
13. Billings, M.P.(1978) Structural Geology – Prentice – Hall of India Private Ltd. New Delhi.
14. Suppe, J.(1985) – Principles of structural geology – Prentice – Hall.
15. Price, N.J. and Cosgrove, J.W. (1990) Analysis of Geologiucal Structure. Camb. Univ. Press.
16. Hobbs, B.E. Means D and Millions, P.F. (1976) an outline of structural geology. Press.

17. Ramsay, J.G. (1967) – Folding and fracturing of rocks. Mc.Graw Hills New Yark.
18. Badgley P.C. – Structural Geology for the exploration geologist.
19. Whitten, T- Structural Geology.
20. Ramsay, J.G. Structural Analysis of Metamorphic Tectonites.

HARD CORE : ORE GEOLOGY [LTP / CREDITS = 301/4]

Unit 1: Ore bearing fluids: magmatic, hydrothermal fluids, meteoric water, seawater, connate water, metamorphic fluids. Depositional textures: exsolution, replacement, colloidal – colloform and open-space filling textures. Wall rock alteration: reaction between wall rocks and fluids, alteration assemblages and types of alteration. Paragenesis and zoning in mineral deposits. Classification of ore deposits. Deposits related to ultramafic-mafic rocks (layered intrusions, anorthosites, kimberlites, carbonates, komatiites). Deposits related to intermediate to felsic rocks (Iron deposits, porphyry Mo, pegmatites, granitic Tin and U, skarn deposits with typical examples).

Unit 2: Deposits related to weathering – Nickel laterite deposits, Deposits related to clastic sedimentation: placer deposits – Witwatersrand gold and U deposits. Chemical sedimentation: phosphate deposits, evaporites, manganese nodules, Ore deposits related to subaerial (Epithermal gold – Au) and submarine volcanism (Kuroko Cu–Zn, Japan, BIFs). Ore deposits related to metamorphism, metallogenic provinces, Epochs and plate Tectonic – classification of ore deposits.

Unit 3: Metallic deposits of India: Iron, Manganese, Copper, Chromium, Gold, Lead, Zinc and Bauxite deposits, Non-metallic deposits (Industrial minerals) – Minerals used as fertilizers, refractories, abrasives, pigments, ceramic and glass-making materials.

Unit 4 : ***Practical:*** Identification of ore minerals based on megascopic (Hematite, Magnetite, Goethite Chromite, Pyrolusite, Cuprite, Chalcopyrite, Pyrite, Molybdenite, Galena, Sphalerite , Pyrrohotite, Malachite, Marcasite, Ilmenite, Laterite, Bauxite, Limonite, varieties of Coal, and Graphite) and microscopic properties: Chromite, Ilmenite, Ti-magnetite, Hematite, Pyrite, Sphalerite, Galena, Chalcopyrite, Covellite, Bornite, Pyrrhotite, Arsenopyrite, Pyrolusite. X Ray pattern study for some of the important ore minerals.

Reference:

1. The Geology of ore deposits - John M. Guilbert and charles. F.Park, Jr.W.H.Freeman and Co., New York. 1986.
2. Interpretation of ore textures - Bastin, E.S.
3. Economic Mineral deposits by Jenson and Bateman, A.M.
4. Ore microscopy -Cameraon, E.N.
5. Textures of the ore minerals - Edwards, A.B.
6. Ore deposits - Park, Jr. C.F.
7. Geology of Mineral deposiits - Smirnov, U.J.
8. The ore minerals and their intergrowths - Ramhor, Dr. Paul.
9. Ore Petrology - Stanton, R.L.
10. India's mineral resources – Sinha and Krishnaswamy, S.
11. Metallic and Industrial minerals - Lamey Carl, A.
12. Introduction to India's economic minerals - Sharma, N.L. &Ram . K.S.
13. A treatise on industrial minerals of India-Sinha, R.L.
14. Mineral deposits of India, Mukerjee 1999: Allied publications.

HARD CORE: GEOMORPHOLOGY & ENVIRONMENTAL GEOLOGY [LTP / CREDITS = 301/4]

Unit 1: Principles of Geomorphology, Relief orders of Earth. Exogenetic and endogenetic processes. Land forms formed through Fluvial , Glacial, Aeolian, Coastal and Karst geomorphic process. Principles of terrain classification –landscape and parametric divisions. Role of geomorphology in selecting Irrigation sites in arid and semi arid regions- advantages and reclamation processes, Interpretation of drainage patterns.

Unit 2: Man and environment. Earth's system, Interactions among lithosphere, hydrosphere, atmosphere and biosphere. Geological process affecting the environment. Environmental hazards created by man's **a**ctivities such as mining and industrial activities.

Unit 3: Water land and soil pollution causes and effects of urban and industrialization. Land use planning and terrain evaluation for environmental management. Solid Wastes and their methods of Management. Sewage sources and their treatment methods. **Marine pollution:** Causative factors – land based sources – marine based sources – types of pollution – oil spill and its effects on marine and continental environment. Global warming causes and its effects.

Unit 4: ***Practicals****:* Tracing and identification of drainage patterns and interpretation of the bed rock morphology- terrain, slope and structure. Drainage basin morphology- Linear aspect; Stream order, stream number, bifurcation ratio, stream length ratio. Drainage basin morphology-Aerial aspect- Stream frequency, drainage density, drainage texture. Drainage basin morphology- Relief aspect- Basin relief, relief ratio, ruggedness number. Fluvial geomorphology and landforms.

References:

1. Geomorphology by William D. Thornbury.
2. Modern Physical Geography by Arthur N. Strahler& Alan H. Strahler.
3. Applied Geomorphology by Hails.
4. Environmental Geology – Peter TP Flawn
5. Environmental geosciences – Arthur H Strahler& Alan Strauler
6. Geology in Environmental planning- A.D. Howard &I.Ramson
7. Focus on Environmental Geology –R Turk
8. Environmental Science –S C Santra
9. Environmental geology by Waldia K.S

SOFT CORE: OCEANOGRAPHY & CLIMATOLOGY[LTP / CREDITS = 200/2]

Unit 1: Physical Oceanography: Characteristics of important water masses. Wind generated waves in the oceans and their characteristics. Shallow and deep water waves. Propagation, refraction, and reflection of waves. Tide-producing forces and their magnitudes; Tsunami; interaction of waves and structure. The global wind system; action of wind on ocean surface; Ekman‟s theory; Sverdrup, Stommel and Munk‟s theories; upwelling and sinking with special reference to the Indian ocean. Barotropic and baroclinic conditions; oceanic eddies, Wind driven coastal currents; typical scales of motion in the ocean. El Nino; monsoonal winds and currents over the North Indian Ocean. **Chemical Oceanography:** Composition of seawater – Classification of elements based on their distribution; major and minor elements, their behavior and chemical exchanges across interfaces and residence times in seawater. **Geological Oceanography:** Oceanography: Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. hydrothermal vents. Ocean margins and their significance. Ocean Circulation, Coriolis effect and Ekman spiral, convergence, divergence and upwelling. Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, diagenetic changes in oxic and anoxic environments. Tectonic evolution of the ocean basins. Mineral resources.

Unit 2: Climatology: Fundamental principles of climatology. Earth‟s radiation balance; latitudinal

and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Air masses, monsoon, Jet streams, tropical cyclones, and ENSO. Classification of climates – Koppen‟s and Thornthwaite‟s scheme of classification. **Climate change-** Natural factors- Geological and secular changes, periodic variations and Role of Anthropogenic activities in climatic change with case studies. Climate Observations, stations and networks. Climate data management. Instruments and climatic measurements. Thermometer, barometer, hygrometer, rain and snow gauges, Sunshine recorders. Weather maps and charts. Extreme climatic events- Cyclones, Jet Streams, Western Disturbances, Ozone Depletion, Storms, Hurricanes and Tornadoes. Droughts. Elements of Weather forecast and methods. Global Climate Models. General Weather Systems of India. Monsoon systems. Green house effect.

References:

1. Climatology: An Atmospheric Science, 2/e, Pearson Education India, 1993 - 423 p.
2. Encyclopedia of World Climatology,John E. Oliver, Springer Science & Business Media, 2008, 854 p.
3. Climatology, Majid Husain, Anmol Publications, 1994 - 376 p.
4. Advances in Meteorology, Climatology and Atmospheric Physics, Costas Helmis, Panagiotis T. Nastos, Springer Science & Business Media, 2012 , 1278 p.
5. Remote Sensing Applications in Meteorology and Climatology, Robin A. Vaughan, Springer Science & Business Media, 2012, 480 p.
6. Applied Climatology: An Introduction, John F. Griffiths, Oxford University Press, Incorporated, 1976, 136 p.
7. Principles of climatology: a manual in earth science, Hans Hermann Neuberger, John Cahir, Holt, Rinehart and Winston, 1969, 178 p.
8. Climatology, an introduction, John E. Oliver, John J. Hidore, Merrill, 1984 , 381 p.
9. Global Physical Climatology, Dennis L. Hartmann, Academic Press, 1994, 411 p.
10. Weather, radar and Flood forecasting, Collings. V. K (1987) John Wiley and sons.
11. General Climatology, Crithfield. H. J, (1996) Prentice Hall, New Jersey.
12. Climatology by Miller, Austin A Publication: London Methuen and company 1961 .xii, 320p.
13. General climatology by Flohn, H [ed.] Publication: Amsterdam Elsevier Publishing
14. company 1969 . xi, 266p.
15. Climatology by Miller, A. Austin Publication: London Methuen And Co 1938 . x, 304pp
16. Climatology by Haurwitz, Bernhard Publication: New York McGraw-Hill 1944 . xi, 409p.
17. Methods in climatology by Conrad, Victor Publication: Cambridge Harvard University
18. Press 1946 .xx, 228p.
19. Climatology by Kendrew, W G Publication: Oxford The Clarendon Press 1957 .xv, 400p.
20. Climatology by Blair, Thomas A Publication: New York Prentice-Hall 1942 .xvi, 484p.
21. Essentials of oceanography, 5th Edition,-Tom Garrison-Brooks/Cole-2009
22. Essentials of oceanography,10th Edition, Trugillo and Thurman-Prentice Hall 2011

SOFT CORE: DISASTER MANAGEMENT [200/2]

Unit 1: Geological Disasters (earthquakes, landslides, tsunami, and mining); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, and forest fire); Technological Disasters (chemical, industrial, radiological, and nuclear) and Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters. Man-made Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemicals and biological disasters). Gas and radiation leak, toxic waste disposal, oil spills, forest fires. seismic zones of India, major fault systems of Indian plate, social economics and environmental impact of disasters. Case studies.

Unit 2: Mitigation and Management techniques of Disaster. Basic principles of disaster management, Disaster Management cycle, Disaster management policy, National and State Bodies for Disaster Management, Early Warming Systems, building design and construction in highly seismic zones,

retrofitting of buildings. Training, awareness program. Usages of GIS and Remote sensing techniques in disaster management, Disaster risk assessment and Hazard mitigation with reference to India.

References:

1. Disaster Management Guidelines, GOI-UND Disaster Risk Program (2009-2012)
2. Damon, P. Copola, (2006) Introduction to International Disaster Management, Butterworth Heineman.
3. Gupta A.K., Niar S.S and Chatterjee S. (2013) Disaster management and Risk Reduction, Role of Environmental Knowledge, Narosa Publishing House, Delhi.
4. Murthy D.B.N. (2012) Disaster Management, Deep and Deep Publication Pvt. Ltd. New Delhi.
5. Modh S. (2010) Managing Natural Disasters, Mac Millan publishers India Ltd.
6. A Manual on Disaster Management. Parag Diwan (2010), Pentagon Earth.
7. Bryant Edwards., Natural Hazards, Cambridge University Press, U.K, 2005.
8. Handbook of Disaster Risk Reduction & Management. Christian N Madu and Chu-Hua Kuei (2017). World Scientific.
9. Handbook of Hazards and Disaster Risk Reduction. Ben Wisner, J.C. Gaillard, Ilan Kelman (2012) Routledge.
10. H.K. Gupta., Disaster Management, 2003.

II SEMESTER

HARD CORE PAPERS

HARD CORE : FUEL RESOURCES & MINERAL ECONOMICS [LTP/CREDITS= 400/4]

Unit 1: Definition and origin of coal. Stratigraphy of coal measures. Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Microscopic constituents of coal. Indian coal deposits. Origin, migration and entrapment of hydrocarbons. Characters of source and reservoir rocks. Structural, stratigraphic and mixed traps. Geographical and geological distributions of onshore and offshore petroliferous basins of India.

Unit 2: Mineralogy and geochemistry of radioactive minerals. Instrumental techniques of detection and measurement of radioactivity. Radioactive methods of prospecting and assaying of mineral deposits. Distribution of radioactive minerals in India. Nuclear waste disposal and its geological constraints.

Unit 3: Introduction and concepts of mineral economics. Peculiarities in mineral deposits. Concepts in mineral exploration and mineral resource estimation. Classification of Indian mineral resources. Role of mineral industry in national economy. Strategic, critical and essential minerals. India's status in mineral production. Changing patterns of mineral consumption.

Unit 4: National Mineral Policy. Mineral Concession Rules. Mineral legislation in India. Mineral production, processing, co-products and by products. Mineral inventory. Consumption and substitution of minerals. Demand Analysis and market survey. Mineral conservation and environment. Mineral information system. Marine mineral resources and Law of Sea.

Reference Books:

1. Nuclear geology and Atomic mineral Resources – S.N. Virnave. Published by BharatiBhawan 1995.
2. Mineral Resources of India – D.K. Banerjee. Published by the world press.
3. Radioactive minerals – R. Dhanaraju –2005 published by Geological Society of India.
4. Economic Mineral deposits – A.M. Bateman

5. Geology of Mineral deposits – Smirnov U.G.
6. Indian Mineral Resources – Krishna Swamy.S.
7. Introduction to India Economic Mineral deposits – Sharma, N.L. & Ram, K.S.
8. Basic Petroleum Geology – P.K.Link
9. Petroleum Stratigraphy – R.L.Breuner
10. World Oil Energy Economics – H.A.Kerklelin
11. Jaharia Coal Field – D.Chandra
12. Petroleum Formation and Occurrence – B.P. Tissot
13. Petroleum Geology – Levorsen
14. Mineral Economics by Truscot, John Wiley and Sons, Inc, 1987.
15. An introduction to mineral Economics – K.K.Chatterjee. publisher : - Wiley Eastern. 1993.
16. Mineral Economics : - R.K. Ssinha and N.L.Sharma. Oxford and IBH publicatio

HARD CORE : PALEONTOLOGY [LTP / CREDITS = 301/4]

Unit: 1 Micro-Paleontology: Origin and Evolution of Life: Introduction of Microfossils; Classification of Microfossils; Separation of various Microfossils: Morphology, stratigraphic significance and applications of – Foramanifera, Ostracoda, Palynofossils, Acritarchs, Bryozoa, Chitinozoa, conodonts, Scoleconodonts. Diatoms, Radiolarians, Dinoflagellates and Nanoplanktons. Application of microfossils in fossil fuel exploration, paeoclimatic interpretation and maturation of sediments, Oxygen and Carbon Isotope studies on Fossils.

Unit: 2 Invertebrates: Morphology, classification, paleo-ecology and evolutionary trends of porifera. Mollusca: Pelecypoda, Classification on the basis of dentition and dental formula, dental system with example. Class Cephalopoda suture pattern. Arthropoda: Class Trilobita, Echinodermata, Trace fossils – marine & terrestrial, Hemicardata: Class Graptozoa

Unit: 3 Vertibrates & Paleobotany: Vertibrate**s:** Evolution, classification and geological signigicance of – Fishes; Amphibian, Reptiles, Mammals: Elephant, Horse and Man. Paleobotony: Techniques of spores and pollens analysis, Morphology, General classification of algae and stromatolies and their stratigraphic importance. Paleozoic, Mesozoic and Cenozoic plants – Bryophytes, pterdophytes, Gymnosperms and Angiosperms their stratigraphic significance.

Unit 4: ***Practicals:*** Identification, Diagnosis and Geological distribution of the following Groups: Invertebrate – Brachipods – 5 genera, Cephalopoda: 5 genera, Pelecypoda: 5 Genera, Trilobita: 5 genera, Graptozoa: 2 Genera, Plant Fossils: 6 genera, Microfossils – Foraminifera: 8 genera, Ostracoda: 3 genera, Palynofossils: 6 genera. Problems on biostratigraphy &Palaeo-ecology.

References:

1. Clarkson, E.N.K., 1998, *Invertebrate Paleontology and Evolution*, IV edition, publ., Blackwell
2. Stearn, C.W. & Carroll R. L. 1989, *Paleontology-the record of Life*, Publ. John Wiley.
3. Smith, A.B, 1994, *Systematics and the Fossils Record-Documenting Evolutionary Patterns.*, publ., Blackwell
4. Prothero. D.R., 1998, *Bringing Fossils to Life- An Introduction to Palaeontology.*, publ., McGraw Hill
5. D. J. Jones, 1956. *Microfossils*
6. F.T.Banner and A.R,Lord., *Aspects of Micropaleontology*
7. M.P.Glaessner, *Principles of Micropaleontology*
8. M.D,Brasier, 1955, *Microfossils*, publ.Georgeallan and Wiley & Sons
9. Romer.A, *Vertebrate Paleontology*
10. Colbert, *Introduction to Vertebrate Paleontology*
11. Sukla., A.C &Misra S.P, 1975, *Studyof Paleobotany*Vikar Publ. House
12. Sripad.N.Agashe, *Palaeobotany*

13. Maohotra, A K, Ocean Science and Technology
14. Tchernia,P, Descriptive regional oceanography
15. K.Siddhartha, Oceanography- A brief introduction
16. William A Anikouchine and Richard W Stenbegr; the world Ocean- An Introduction to oceanography
17. Cuchlaine A M King, oceanography for Geographers
18. H.V. Thurman, Introduction to Oceanography

HARD CORE : IGNEOUS AND METAMORPHIC PETROLOGY [LTP / CREDITS = 202/4]

Unit 1: Igneous Petrology: IUGS and Chemical classification of Igneous rocks, Classification, texture and its petrogenetic significance, origin of Granite, Syenite, gabbro, and Layered Igneous complex , Kimberlite, Anorthosite, Carbonatite and Peridotite. Mineralogy, classification, textural peculiarities and origin of Pegmatite, Dolerite, Lamprophyre, Basalt, Rhyolite, Trachyte and Andesite. Add a note on their economic importance and Indian occurrence.

Unit2:Metamorphic Petrology: Introduction, Definition, Limits and agents of Metamorphism.Structures and Textures of Metamorphic rocks- Types of metamorphism based on principal process (Orogenic, Hydrothermal, Burial, Regional, fault zone, Ocean floor metamorphism Prograde- Retrograde, progressive retrograde metaorphism. Regional and Contact Metamorphism of Peiltic and impure Calcareous rocks. Major metamorphic rocks. Protoliths and types- Zones of Metamorphism. Metamorphic reactions- Kinetics of metamorphism- Mineral assemblages equilibrium/Reaction. Characteristics of different grades and facies of metamorphism, Metasomatism and Granitization, Migmatites. Plate tectonics and Metamorphic Zones. Paired metamorphic belts. Metamorphism of mafic rocks and meta peilites, meta carbonate rocks. Material transport through metamorphism, metamorphism and dynamic process through P-T-t path. Metamorphic field gradient and tectonic cycle.

Unit 3: ***Practicals: Igneous petrology :*** Megascopic and Microscopic identification of different types of Igneous rocks. Significance of micro-textures in understanding magmatic and tectonic process.

Unit4: ***Practicals: Meatamorphic Petrology:*** Megascopic and Microscopic identification of different types of metamorphic rocks (1.Gnessic group, 2.Amphoblite group, 3. Mafic group, 4. Granulite group, 5. Schistose group, 6.Meta sedimentary group). Significance of structure and micro textures in understanding metamorphic and tectonic process.

References:

1. Petrology of Igneous and Metamorphic rocks by **Hyndman**
2. Principles of of Igneous and Metamorphic rocks by **Anthony R. Philpotts.**
3. Igneous petrology by **Anthony Hall**
4. Petrology of Igneous and Metamorphic rocks by **Best.**
5. Sedimentary Petrology – Pettijohn
6. Petrography – An introduction to the study of rocks in thin sections – H Kowell, Williams and Turner.
7. Hand book of subsurface geology – C.A. Moore
8. Petrography – An introduction to the study of rocks in thin sections – H Kowell,,Williams and Turner.
9. Migmatites - Ashworth.
10. Metamorphism - A. Methuen & Co.
11. Migmatites and the origin of granitic rocks - Mehnert K.R. Elsevier & Co.
12. Metamorphism and Metamorphic rocks - Miyashro, A. George, Allen and Unwin.
13. Petrogenesis of metamorphic rocks- Winkler, H.G.F. Springer, verly.

HARD CORE: MINOR PROJECT -FIELD WORK AND TECHNICAL REPORT [LTP / CREDITS = 013/4]

SOFT CORE

SOFT CORE: CONSERVATION OF SOIL AND WATER RESOURCES [LTP / CREDITS = 200/2]

Unit 1: Definition of Soil. Soil genesis and morphology. Factors of Soil Formation. Processes of Soil Formation. The Soil profile. Concept of Pedon and Landforms. Components and Composition of Soils. Physical Properties of Soils. Soil Structure. Chemical Properties of Soils. Soil pH, Soil Mineralogy. Ion-exchange Capacity of Soils. Soil Salinity, Acidic Soils, Alkaline soils. Engineering properties of soils. Soil Moisture. Role of Nutrients in Soils. Soil Microbiology & Organic Matter. Soil testing and surveys. Soil Classification systems & Soil Taxonomy. Soil related problems. Soil pollution. Soil erosion- causes and effects. Soil loss measurements. Universal Soil Loss Equation and its application. Soil surface management and soil stabilization practices. Sediment traps. Soil conservation practices-Tillage methods. Biological soil conservation. Mechanical conservation works including terracing methods. Irrigation and Engineering Practices.

Unit 2: Definition of water conservation. Water Conservation Practices. Water Resources in Watersheds and River Basins. Water Use and Consumption. Water management. Improving Drainage and reclaiming salt-affected soils. Technological options for drainage study. Design principles. The effect of scale. Methods of Irrigation -modern techniques. In-situ conservation of soil and water. Runoff management- Decreasing runoff amount (contour farming, strip cropping, contour barriers, vegetative hedges). Water Erosion Control practices. Reducing runoff velocity (slope management, waterways, diversion channels, engineering structures, etc). Flood control- Inundation methods and Flood diversion. Water storage- Small earthen dams, Weirs, Sand dams. Losses of stored water- seepage/ evapotranspiration and its controlling methods.

References:

1. Principles of Soil Conservation and Management- Humberto Blanco-Canqui, Rattan Lal, Springer, 16-Sep-2008 - 617 pages
2. Soil and Water Conservation Policies and Programs: Successes and Failures, Ted L. Napier, Silvana M. Napier, Jiri Tvrdon, CRC Press, 24-Nov-1999 - Technology & Engineering - 656 pages
3. Advances in Soil and Water Conservation, Francis J. Pierce,CRC Press, 01-Feb-1998 - Technology & Engineering - 300 pages
4. Soil and water conservation engineering, Richard K. Frevert, Glenn Orville Schwab, Wiley, 1966 - Nature - 683 pages
5. Soil And Water Conservation Handbook: Policies, Practices, Conditions, and Terms, Paul W. Unger,Haworth Food & Agricultural Products Press, 23-Oct-2006 - Political Science - 248 pages
6. Soil Erosion and Conservation,R. P. C. Morgan,John Wiley & Sons, 05-Feb-2009 - Science - 320 pages
7. Soil Erosion: Processes, Prediction, Measurement, and Control,Terrence J. Toy, George R. Foster, Kenneth G. Renard, John Wiley & Sons, 27-May-2002 - Science - 338 pages
8. Soil Erosion by Water: Some Measures for Its Control on Cultivated Lands, **Food and Agriculture Organization of the United Nations**,Food& Agriculture Org., 01-Jan-1965 - **Nature** - 284 pages
9. Water Conservation, Management and Analysis,**Madireddi V. SubbaRao**,Readworthy, 2011 - **Water** - 144 pages

10. Soil and Water Conservation Policies and Programs: Successes and Failures, Ted L. Napier, Silvana M. Napier, Jiri Tvrdon, CRC Press, 24-Nov-1999 - Technology & Engineering - 656 pages
11. A Practical Approach to Water Conservation for Commercial and Industrial Facilities, Mohan Seneviratne, Elsevier, 11-Jul-2007 - Technology & Engineering - 400 pages
12. Soil and Water Conservation in Semi-arid Areas, Issue 57, Norman Hudson, Food & Agriculture Org., 01-Jan-1987 - Arid regions - 172 pages

OPEN ELECTIVE

OE- BASICS OF EARTH SCIENCE [LTP / CREDITS = 200/2]

Unit 1: **Physical Geology & Structural Geology** -Introduction to geology. Origin of the Earth. Age of the earth. Interior of the Earth. Geomorphic processes and cycles - Geological action of Wind, Water, Glaciers, Volcanoes and Earthquakes. Morphology of Oceans, Principles of Isostasy and uniformitarinism. - Rock deformation. Earth forces. Folds and Foldings, Fault and Faulting, Joints, Cleavage, Unconformities, Concept of plate tectonics, sea floor spreading and geosyncline.

Unit 2: Stratigraphy & Paleontology - Introduction, Definition of Stratigraphy, Branches of Stratigraphy and its relation with other branches of Geology, Principles of Stratigraphy- Law of Uniformatianism, Law of order of superposition, Law of Faunal succession. Geological Record and its nature- Eon, Era, Period. Geological Time Scale. Classification of Standard Stratigraphic scale. Nomenclature and Litho, Bio and Chrono stratigraphic units, Correlation- Lithostratigraphy and Biostratigraphy.

Introduction & Definition of Paleontology, Classification of Plants, Invertebrate and Vertebrate fossils. Fossils-Taphonomy (Burial Law), types of Fossilization, mode of preservation- Mummification, Carbonization, Silification, Casts, Moulds, Tracks and Trails. Applications of Fossils. General morphological characters and Geological age of the following Invertebrate and Plant Fossils: Brachiopoda, Cephalopoda, Pelecypoda and Trilobita. Plant fossils: Glossopteris, Gangamopteris, Ptillophylum, Calamites and Lepidodendron.

References:

1. Physical Geology by Arthur Holmes
2. Structural Geology by Billings
3. General Geology By P.K. Mukerjee
4. Physical Geology By Strahler
5. Stratigraphic Principles and Practice-Weller
6. Stratigraphy-Kumberlein and Sloss
7. Paleontology of the Invertebrates-TaschPubl.Jhon Wiley and Sons
8. Paleontology- Henry Wood
9. Fossils Plants- Arnold
10. The Elements of PaleontologyBlack,R.M Pub. Cambridge university press

SEMESTER III

HARD CORE PAPERS

HARD CORE: REMOTE SENSING AND GIS APPLICATIONS [LTP / CREDITS = 202/4]

Unit 1: Remote Sensing: Basic Principles and elements of Remote Sensing. Energy Interactions with the Atmosphere. Radiation and Black Body Radiation. Types of Remote Sensing, Sensors. Scanners and their capabilities. Platforms - Types of Platforms, capabilities of Indian Satellite Remote

Sensing. Satellite Data Products with the scale and their characteristics. Resolution and types of Resolution. Digital Image Processing. Remote Sensing in Visible, Infrared, Microwave and Thermal regions. Application of RS in geomorphology, lithological mapping, structural mapping, mapping of ground water potential zones and mineralized zones. Remote Sensing for Disaster Management. Global Satellite Data Sources. Hyperspectral studies, application on environmental aspects, climate change and global warming

Unit 2: GIS: Definition of Geographic Information System, elements of GIS. The nature of geospatial information and data representation. Cartography - Maps and map projections. Cartographic symbology. Components of GIS. Database used in GIS. Data Structures: Relational, hierarchical and network. RDBMS. Data models used in GIS. Spatial data models. Vector data Model. Raster data Model. DEM. TIN. Vector and Raster -advantages and disadvantages. Attribute data models. Topological relationships of spatial data. Data Sources, components of GPS and DGPS. Data input techniques. Digitization of maps and imageries; Coordinate transformation; Attribute data generation. Spatial data layers. Data retrieval and querying. Spatial analysis - Spatial overlay operations, buffering, trend surface mapping. Network analysis and proximity analysis; 3D models. GIS Modeling for decision support. Applications of GIS in earth's resources evaluation and management.

Unit 3: ***Practicals: Remote Sensing:*** Visual and Digital interpretation of Topomaps and Satellite Imageries. Interpretation and Demarcation of lithological Units. Interpretation of Drainage patterns and water bodies. Interpretation and Measurement of Lineaments. Interpretation of Geological Structures, Interpretation of land use/land cover. Interpretation of vegetation. Interpretation of Mining and Mineralized zones. ERDAS imagine Functionalities (Geo referencing of Toposheet and satellite image, image subsetting, resolution merge, stitching of images, Layer stacking).

Unit 4: ***Practicals : GIS:*** Methods of digitizing geospatial data(toposheet/ satellite image). Preparing contour maps. Georeferencing co-ordinates in scanned toposheets or maps and computing the geometrical properties of digitized zones. Methods of using DEM files, analysing hydrological components, basins, slopes, aspects and other features. Carrying out different kinds of spatial analysis including buffering, Proximity, split, clip and neighbourhood analysis. Application of GIS model for various spatial analysis using Arc GIS.

Reference:

1. Text book of Remote sensing and geographical Information system, 1st& 2nd Ed. By M. Anjireddy, BS Publications, Hyderabad
2. Remote sensing principles and Interpertations, 3rd edition, Floyd. F. Sabins
3. Applications of Remote sensing and GIS by H T Basavarajappa, Et. Al
4. Cartography: Visualization of Geospatial data – Menno-Jan Kraak and FerjanOrmeling
5. Principles and application of Photogeology – Shiv N Pandey
6. Aerial photographic interpretation, Principles and applications - D.R.Leuder.
7. Photogeology - Miller, J.C.
8. Mannual of colour aerial photography -Ed. Smith, J.T.Jr.
9. Manual of photogrammetry - Ed: MorrieM.Thompson.
10. Manual of Remote sensing - Ed: Robert G Reeves.
11. Theory of pattern recognition and modern forecasting - V.Karpin and Wright Pattern.
12. Remote sensing in Geology - Parry S. Siegal& Alan. R.Gillespie
13. Manual of photographic interpretation - Ed: Colwell, R.N.
14. Principles of Remote Sensing – Patel Singh; SP publication
15. Digital Remote Sensing – Pritivish Nag M Kudrat ; Concept publication
16. Principles of GIS for land and resources assessment, Burrough, P.A., 1986, Oxford.
17. Introductory cartography, Campbell, 1984, Prentice Hall
18. Map data processing, Freeman and Pieroni, 1980, Academic Press.
19. An introduction to Geographical information systems: Ian Heywood et. al.

20. Geographical information systems and digital image processing – Muralikrishna 1999. Allied Publication
21. Fundamentals of remote sensing and Geoinformatics , by Anjireddy, Hyderabad ed. 1and 2.
22. Geographic Information Systems: An Introduction, 3rd Ed, Bernhardsen,John Wiley & Sons, 01-Jan-2007 - 444 pages
23. Geographic information systems and science, Paul Longley,Wiley, 13-Jul-2001 - Education - 454 pages
24. Geographic Information Systems for Geoscientists: Modelling with GIS, Graeme F. Bonham-Carter,Elsevier, 18-May-2014 - Science - 416 pages
25. Geographic Information Systems and Science, Paul Longley, John Wiley & Sons, 22-Mar-2005 - Science - 517 pages
26. Handbook on Geographic Information Systems and Digital Mapping,United Nations. Statistical Division, United Nations Publications, 2000 - Census - 197 pages
27. Introductory Readings In Geographic Information Systems,D J Peuquet, D F Marble,CRC Press, 16-Dec-2003 - Technology & Engineering - 371 pages
28. Geographic Information Systems (GIS) and Mapping: Practices and Standards, Issue 1126, Arnold Ivan Johnson, C. BerntPettersson, ASTM International, 01-Jan-1992 - Travel - 346 pages
29. Introduction to Geographic Information Systems,Kang-tsungChang,McGraw-Hill Education, 16-Jan-2015 - Science - 448 pages
30. Fundamentals of Geographical Information Systems,Michael N. DeMers,Wiley, 2009 - Science - 443 pages
31. Textbook of Remote Sensing and Geographical Information Systems,KaliCharanSahu,Atlantic Publishers & Dist, 01-Dec-2007 - 512 pages
32. Geographic Information System,B. Gurugnanam,New India Publishing, 09-Jun-2009 - Geographic information systems - 206 pages
33. Fundamentals of Geographical Information Systems,Michael N. DeMers,Wiley, 2009 - Science - 443 pages

HARD CORE: GEOCHEMISTRY AND PETROGENESIS [LTP / CREDITS = 301/4]

Unit 1: Geochemistry: Basic concepts and scope of geochemistry, age, origin and composition of the universe with special reference to solar system, Geochemical classification of elements, primary differentiation of the earth, Meteorites- classification, composition and origin. Geochemical cycle, geochemical fractionation of trace and REE elements in magmatic process and its importance.

Unit 2: Geochronology: Radioactive decay schemes, Radioactive dating, Radiogenic isotope systematics: U-Pb, Rb- Sr, K- Ar systematics. Stable isotopes: Carbon, Oxygen, Sulphur and Hydrogen.

Unit 3: Petrogenesis: Genesis- properties- emplacement- crystallization and differentiation of magmas. Bowens reaction series. Mechanism of magma diversification (differentiation)- partial melting, crystal fractionation, Thermogravitational diffusion, liquid immiscibility, vapour transport, vapour phase alterations, magma mixing, exsolution phenomena, assimilation. Phase equilibria studies- Basic concepts -phase and component, phase rule, unary system with examples of P-T diagrams of water and Al_2SiO_5/ Silica, ternary system and binary system -Diop-An and Fo-Fa.

Unit 4: ***Practicals:*** P-T calculations and construction of P-T diagrams. Petrochemical calculations- Niggli verte and Niggli base, CIPW norm calculation, Trilinear plots , construction of Variation/ Discriminant diagrams using major, trace and REE geochemistry data and interpretation. Isotopic age determination of rocks/minerals.

References:

1. Geochemistry- William.M.White-Wiley black well publications

2. Introduction to carbon capture and sequestration- BerendSmit, Jeffrey.A. Reimer, CurtisM. Oldenburg and Ian.C.Bourg.
3. Rare earth element Geochemistry by Henderson
4. Geochemistry by Rankama and sahama
5. Petrologic Phase equilibria – W.G.Ernst
6. The Interpretation of Geological Phase diagrams - Ernest G Ehlers
7. Petrogenesis – Wilson
8. Solutions, Minerals and Equilibria – Garrels and Christ, 1966
9. Simulating the Earth- J.R. Holloway and B.J. Wood,1988
10. Basic analytical Petrography – Ragland, 1989
11. Principles of Igneous and Metamorphic Petrology by Antony R Philpotts, 1979.**1.**
12. Geohemical Thermodynamics by Darrell Kirk Nordstrom and James L. Munoz
13. Chemical Thermodynamics for earth scientists by Philip Fletcher, 1993
14. Chemical Fundamentals of Geology by Robin Gill.
15. Elementary Thermodynamics by B.J. Wood and D.G. Fraser, 1976
16. Equilibrium Thermodynamics by Roger Powell
17. Prinicples of Geochemistry – Brain Mason
18. Geochemistry by Anderson
19. Chemical Thermodynamics by Bruce H Mahan

HARD CORE: INDIAN STRATIGRAPHY & SEQUENCE STRATIGRAPHY [LTP / CREDITS = 301/4]

Unit1: Paleozoic Era: Introduction, Tethyan basin, Paleozoic life, Trace fossils and Stromatolites. Precambrian/Cambrian boundary, PC/C boundary in Himalayan basins. *Cambrian* – Jammu and Kashmir, Himachal Pradesh, Tal Basins and Uttaranchal. *Ordovician and Silurian* - Jammu and Kashmir, Himachal Pradesh and Uttaranchal, *Devonian* - Jammu and Kashmir, Himachal Pradesh and Uttaranchal. *Carboniferous* - Jammu and Kashmir, Eastern Karakoram, Himachal Pradesh and Uttaranchal. *Permian* - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Arunachal Pradesh of India and Bhutan. Peninsular India-Cauvery Basin. *Gondwana Supergroup* – Introduction, Characteristics, Stratigraphy and Structure, Classification and age, life in Gondwana, Coastal Gondwana basins, Gondwana in Extra-Peninsular India, Environment of deposition and economic significance.

Unit 2: Mesozoic Era: Introduction, life of Mesozoic Era, *Triassic* - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Rajasthan and Kutch. Permo-Triassic Boundary. *Jurassic* – Kutch, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Jharkhand of India and Bhutan. *Cretaceous* – Gujarat, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, East Coast, Tiruchirappalli, Narmada Basin, Lameta Formation, Jharkhand, Assam/Meghalaya, Andaman and Nicobar Islands. Cretaceous/Tertiary Boundary. *Deccan Volcanic Province* – Introduction, Regional Stratigraphy, Subprovinces, Volcano-Plutonic Complexes, Petrology and Petrogenesis, Inter-Trappean beds, Distribution and its age. ***Cenozoic Era –*** Introduction, Distribution, Climate, Correlation, Fauna and Flora, Classification and Stratigraphy. *Paleogene* – Introduction, Fauna and Flora, Stratigraphy and Distribution. *Neogene*– Introduction, Fauna and Flora, Stratigraphy and Distribution. *Quaternary* – Introduction, Distribution, Quaternay climatic changes, Quaternary Sea level changes. Siwalik – Stratigraphy and Sedimentation. Distribution of Fauna in Siwalik. Geology of Offshore Basins its Morphology and Evaluation.

Unit 3: Sequence Stratigraphy: Introduction to Stratigraphy, branches of Stratigraphy. Terms and concepts of Sequence Stratigraphy and its relationship with other branches of Stratigraphy. Sedimentary basin analysis through sequence Stratigraphy. Out crop and subsurface procedures. Global sea level changes/ eustatic sea level. Applications of sequence stratigraphy in petroleum exploration with case studies.

Unit 4: ***Practicals:*** **1.**Mark the sequence surfaces ; LST, TST, HST, MFS, down lap, Onlap, erosion surface etc on the seismic section **2.** Identification of the lithology in the given well log. **3.**Draw the

cratons of India and locate the metalliferous deposits **4.** Mark the Gondwana basins on an map of India and the describe the coal deposits & **5.**Describe the litho section profile to its order of super position and stratigraphy.

References:

1. Geology of India Vol.1 & 2. M.Ramakrishnan and R Vaidyanatahan
2. Geology of India – Wadia, D.N., McMillan and Co.
3. Geology of India and Burma – Krishnan M.S. Higginbotham, Madras.
4. A hand book of the Geology of the Mysore State – B. Rama Rao, Bangalore press.
5. Precambrian Stratigraphy and Geochronology of the Peninsular India – Sarkar, S.N. Dhanbad Publishers.
6. Review papers on the Stratigraphy of India –Rec.Geol.Surv.India Vol.101, Part 2.1972Cretaceous Tertiary formations –Geol.Soc. India, seminar Vol. 1958.
7. Paleozoic of Himalayas. HPC publn.
8. ReconnaaissanceRb-Sr dating of the Precambrian of Southern Peninsular India-Crawford, A.R., J.G.S.I 1972. 117-126.
9. Sequence stratigraphy- BHP petroleum (America) Inc – Michael Yeaman, Lavy Holcomb, Gill Tailor 1990
10. Sequence stratigraphy – BP Exporation. Stockley Park UK Bridge London, Publn. Blackwell science
11. Sea Level Changes- An Integrated Approach Spl. Pbln.42, Barbara H.Lidz, Edtor of Spl. Publn. Oklahoma USA 1998
12. Sequence in Layered Rocks- Blatt Middleton &Humay
13. Sedimentary Petrology- Pettijhon

HARD CORE: ENGINEERING GEOLOGY & SURVEYING [LTP / CREDITS = 301/4]

Unit 1: Engineering properties of rocks. Rocks as construction material, Site investigation, characterization and problems related to civil engineering projects: geological and geotechnical investigations for dams, reservoirs and spillways, tunnels, underground caverns, bridges, highways, shorelines. Reservoir sedimentation: Causes – effects- basin, channel and geological factors, climatic influence, monitoring- desilting methods.

Unit 2: Geological studies and evaluation in planning, design and construction of major civil structures. Elementary concepts of rock mechanics and soil mechanics. Problems of groundwater in engineering projects. Coastal geotechniques. Environmental considerations related to civil engineering projects. Resource evaluation of construction materials.

Unit 3: Geological hazards: Mass movements (landslides and subsidence) and earthquakes, their significance, causes, preparedness and mitigation. Recent trends in geotechnical engineering. Geotechnical case studies of major projects in India. Coastal Erosion: Near shore dynamics, erosion mechanisms- long shore drift, Effects of coastal erosion – Controlling methods – barriers, groins, sea walls, Jetties and stone revetments. Geology of soils and elements of soil and soil mechanics.

Unit 4: ***Practical: Surveying*** **:** Chain survey, Compass survey, Plane table survey, Dumpy level survey, GPS survey and Total Station Survey. ***Engineering Geology*****:** Particle Size Distribution calculations, USDA Soil texture classification, Problems on Engineering properties of soils & rocks.

References:

1. Soil mechanics- B.C Punmia
2. Manual of Field geology – Compton.
3. Soil their Orgin, constitution and classification – Robinson G.W

4. Soils – Tambane and others
5. Nature and Properties of Soil- Harry O BuckmenNylc C. Brady
6. Fundamentals of Soil Science – Miling, Truck and Forth. H.D(1984) John
7. willey
8. Engineering Geology by S.K Garg
9. Climatology – Stringer (1982) Surjeet Publication Soil Atlas of Karnataka, NBSSLUP Publication.
10. Engineering Geology by F.G Bell
11. Textbook of Surveying (2nd Edn) by Venkataramaiah C. Orient Blackswan Private Limited - New Delh.
12. Surveying Fundamentals and Practices (What's New in Trades & Technology) 7th Edition by Jerry Nathanson, Michael Lanzafama, Philip Kissam. Pearson publication.
13. Engineering Surveying by W Schofield and Mark Breach. Published by CRC Press, February 14, 2007. ISBN 9781138046535, pp 1-638
14. Fundamentals of Surveying By S.K.Roy. Prentice Hall India Learning Private Limited; 2nd edition (1 January 2010).

SOFT CORE

SOFT CORE : GEMOLOGY [LTP / CREDITS = 200/2]

Unit 1:Gemology: Introduction to Gemology, classification of gemstones, detailed study of different physical and optical properties of minerals with special reference to gem minerals. Physical- optical effects in gemstones. Colour and Cause of colour in gems, Colour enhancement in gems. Cutting and polishing of gemstones. A detailed study of important precious and semi-precious gem minerals, their characters and occurrences, World occurrences in general and Indian occurrences in particular (i)Precious varieties 1. Diamond 2.Gem corundum 3.Topaz 4. Emerald (ii) Semi-precious varieties Garnets, Quartz, Lapis lazuli, Turquoise and Organic gems.

Unit 2: Crystal Growth: Introduction to crystal growth and growth phenomena. Crystal Growth methods- Melt (Bridgeman, Crystal pulling, Czochralski technique, zone melting), Verneuil process from solution, flux growth. CVT/CVD technique, Sol gel technique, Hydrothermal growth (low temperature, low pressure, High temperature, high pressure). Sintering technique.

References:

1. Gems and Gem industry in India-GSI Memoir 45- R.V Karanth.
2. Gem and Gem Minerals – EH Kvans and CB Slawsan
3. Encyclopedia of Minerals and Gem stones - Edited by Michael O' Don Oghal.
4. Precious stones - by Max-Bauer Vol. I and II. Publisher Dover publications Ink. New york.
5. Gems and precious stones- Simon and Schusters, Publ.Fire side book publishers.
6. Gems and precious stones- Cally Hall, the apple press publishers
7. Gemmological instruments-Peter.G.read, Butterworth publ.
8. Gem stone enhancement-Kurt Nassau, Butterworth publ.
9. Rutley's Elements of Mineralogy- by H.H. Read, CBS publication
10. Dana's Manual of Mineralogy
11. GEMS by R.Webster - Batter work and co. ltd., London
12. Gemstones - Herbert Smith - Published by Methuen co. Ltd., London
13. Introduction to Rock forming minerals-Deer, Howie and Zussman.
14. Physical Geology-P.K.Mukherjee
15. Geology of India-R.Vaidyanathan and M.Ramakrishnan
16. Geology of Karantaka-B.P.Radhakrishna
17. Mineral Resources of Karnataka-B.P Radhakrishna
18. Encyclopedia of crystal , gem and metal magic by Scot Cunningham-Llewellyn world wide, 2011.
19. Crystals and crystal growing by Holden A.

20. Themodynamic basis of Crystal growth-: P-T-X phase equilibrium and non-stoichiometry-Jacob Greenburg
21. Modern Theory of crystal growth (crystals) A.A Chernov & Hener Muller- Krumbhaar
22. Crystal growth-: Theory & techniques, Vol.1 by Chlgoodman
23. Advances crystal growth research-: 11th International summer school on crystal growth - Furokouka & K. Nakajima.

OPEN ELECTIVE

OE- INDUSTRIAL MINERAL RESOURCES [LTP / CREDITS = 200/2]

Unit 1: Definition of a Mineral. Classification of Minerals – Rock forming minerals & Ore forming Minerals, Silicate and Non-Silicate minerals. Physical, Chemical and optical properties of Minerals. Description of Industrial Minerals: Gold, Silver, Coal, Copper, Diamond, Asbestos, Barite, Calcite, Diatomite, Feldspar, Gypsum, Kaolin, Mica, Silica, Talc, and Zeolite.

Unit 2: Minerals Used in Paint, Fertilizers, Pesticides, Abrasives, Refractories, Ceramics, Glass, Pharmaceuticals, Petrochemical and Nuclear Energy**.** Gem Minerals: (i) Precious varieties 1. Diamond 2.Gem corundum 3.Topaz 4. Emerald (ii) Semi-precious varieties Garnets, Quartz, Lapis lazuli, Turquoise and Organic gems. Minerals Used in Civil work: Sandstones, Marbles, Granites, Sand and Gravel.

References:

1. Industrial Minerals and Thier Uses: a hand book and formulary. Ed. By Peter A Ciullo, Noyes Publications, 1996,
2. India's Mineral Resources by S. Krishnaswamy, Revised by R.K.Sinha, Oxford & IBH Publishing Co.PVT. LTD.

IV SEMESTER

HARD CORE PAPERS

HARD CORE : EXPLORATION GEOLOGY & MINING METHODS [LTP/CREDITS = 301/4]

Unit 1: Geological Exploration: Mode of occurrence of commercial grade deposits of Fe, Mn, Au-Ag-(W), Cu,Pb-Zn,Ti,Ni,Mo,Sn,Al,Pt - group. U-Th. Geological criteria for mineral prospecting. Indications of ore. Geological prospecting methods. Small and large scale geological mapping. Methods of geological exploration - exploratory grids, location and documentation of exploratory workings (pits, trenches underground workings), drilling, core logging. Sampling techniques and evaluation of grade.

Unit 2: Mining Methods : Mining terminology, methods of open cast, underground and alluvial mining. Definition and scope of mineral processing, communition, crushers and classifiers. Froth flotation techniques of separation.

Unit 3: Geochemical Exploration: Geochemical cycle, mobility of elements and geochemical anomaly. Mode of occurrence of trace elements. Primary dispersion patterns of deep seated origin, syngenetic and epigenetic. Geochemical rock surveys. Weathering and its products. Mobility of elements in the surficial environment and surficial dispersion patterns and forms. Anomalies in residual and transported over burden. Anomalies in waters and drainage sediments. Uptake of mineral matter by plants. Biogeochemical anomalies and survey techniques. Vapour geochemistry

.

Unit 4: ***Practical: Geological Exploration:*** Delineation of ore deposit based on exploration data. Classification of ore reserves. Economic evaluation of ore deposit. Preparation of technical report.
Gechemical Exploration: Geochemical methods in mineral exploration and choice of materials and methods. Interpretation of Geochemical maps for locating ore mineralization. Preparation of geochemical anomaly maps.

References:

1. Geochemistry in mineral exploration Rose, A.W Hawkes. H.E & Webb J.S. 1979. Academic press.
2. Principles of geochemical prospecting. Ginzburg. I.I. Petgamon Press, N.Y. London.
3. Biochemical methods of Prospecting - Malyuga, D.P.
4. Principles of Mining Geology, Arokiaswamy.
5. Geological prospecting and exploration – Kreiter,V.M.
6. Rock geochemistry in Mineral Exploration. G.J.S.Govett. Elsevier Publication. 1983.

HARD CORE: HYDROGEOLOGY & GEOPHYSICS [LTP/CREDITS = 202/4]

Unit 1: HYDROGEOLOGY : Occurrence and distribution of groundwater, Origin of water, global water cycle and budget; residence time concept, geologic formations as aquifers; confined and unconfined aquifers; groundwater table mapping and piezometric nests; porosity, void ratio, effective porosity and representative porosity range; primary and secondary porosities; groundwater zonation; specific retention, specific yield; groundwater basins; springs. Subsurface profile of groundwater including detailed study of zones of aeration and saturation. Groundwater movement and well hydraulics, Groundwater flow concepts; Darcy's Law in isotropic and anisotropic media and validity; water flow rates, direction and water volume in aquifers; permeability and hydraulic conductivity and ranges in representative rocks; Bernoulli equation; determination of hydraulic conductivity in field and laboratory; concept of groundwater flow through dispersion and diffusion; transmissivity and aquifer thickness. Introduction: Definition, concepts of watershed, major objectives of watershed management, effects of watershed on community, ecosystem, Monitoring and evaluation of watershed. Principles of watershed management: Delineating the watershed. Natural processes at work in watershed, common elements of watershed management, multidisciplinary approach in watershed management, participatory resources mapping and appraisal, benefits of watershed approach. Water wells and groundwater levels, Unidirectional and radial flow to a well (steady and unsteady), well flow near aquifer boundaries; methods for constructing shallow wells, drilling wells, well completion; testing wells, pumping test, slug tests for confined and unconfined aquifers; fluctuations in groundwater levels; stream flow and groundwater flows; groundwater level fluctuations; Groundwater exploration, Surface investigation of groundwater- geologic, remote sensing, rock-water interaction, Physical, chemical and biological properties of water, Graphic representation of chemical data; groundwater hardness, microorganisms in groundwater; water quality standards; sea-water intrusion, waste disposal Application of isotopes (H, C, O) in groundwater; concepts of artificial recharge methods; managing groundwater resources; groundwater basin.

Unit 2: Geophysics: **Gravity method:** Nature of gravity and its variation. Accuracy and precision of measurements. Gravimeters. Field procedures. Corrections. Free-air & Bouger anomalies. Interpretation of anomalies. Explorations for minerals. **Magnetic method:** Geomagnetic field and its variations. Magnetometers. Field procedures for land and airborne surveys. Exploration for minerals and oil and engineering sites. **Seismic method:** Seismic waves and their speeds in rocks. Snell"s law. Critical refraction. Instruments and field procedures for seismic refraction method. Corrections, Interpretation of data. Seismic reflection methods for oil exploration. Equipment for seismic reflection. Time and depth sections. **Electrical methods**: Introduction to S.P method and its use. Resistivity, true and apparent D.C. resistivity, true and apparent D.C. resistivity equipment, electrode arrangement, field procedure, and use for mineral exploration and at engineering sites. **well logging methods**. **Radioactivity methods:** of rocks and minerals, instruments (GM counter, scintillation counter and gamma ray spectrometer) and measurements of radiation.

Unit 3: ***Practical 1:*** Rainfall patterns of distribution, methods of preparing, Arithmetic, thiessen polygon maps, isohyetal map and analysis water level fluctuation data, Interpretation of water quality data using numerical and graphical approaches - Preparation of water level fluctuation data - Preparation of water table contour maps and interpretation. Analysing pumping test data using Jacob's straight line method. Graphical representation of hydrochemical data:- Piper Trilinear diagram. Vector diagram. Circular diagrams, Stiff's polygon. Determination of pH and TDS of ground water samples.

Unit 4: ***Practical 2:*** Curve matching techniques-s-line method, Second and third layers techniques, Preparation of-iso-resistivity maps and delineating groundwater potential zones.

Reference:

1. Groundwater-C.F.Tolman
2. Groundwater Hydrology-D.K.Todd
3. Hydrology-S.N.Davis and R.J.M Dewiest
4. Groundwater studies-R.H.Brown and others
5. Groundwater Hydrology-Herman Bouver
6. Hydrology-C.W.Fetter
7. Hand book of Applied hydrology-Van te Chew
8. Groundwater and wells-Hohnson Publications
9. Applied Hydrology-Chow M.Mays.Mac.Graw Hill Publication
10. Hydrology and wetland conservation-Gulam
11. Groundwater survey and inverstigation-Guatham Mahajan
12. Hydrology-Raghunath
13. Hydrogeology-Karanth
14. Worcester: A Text Book of Geomorphology
15. Todd: Groundwater Hydrology Ward: Principles of Hydrology
16. Chow: Handbook of Applied Hydrology
17. Health & Trainer: Introduction to Groundwater Hydrology
18. Singh: Elements of Hydrology
19. Raghunath: Introduction to Hydrology
20. Tolman: Hydrology
21. Karanth: Development, Assessment and Management of Water Resources.
22. Hydrogeology, S.N.Davis and RJ.M.Dewiest.
23. Applied Geophysics, W.M.Telford et. al
24. Outlines of geophysical prospecting, M.B.Ramachandra Rao
25. Applications of Surface Geophysics to Groundwater investigations, A.A.R.Zohdy et al.
26. Introduction to Geophysical Prospecting , M.B.Dobrin and Savit.
27. Direct current Geoelectric sounding principle and interpretation, P.K.Bhattacharya and H.P.Patra.

HARD CORE: DISSERTATION [LTP / CREDITS = 015/6]

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. The Dissertation entails fieldwork, lab investigations, preparation of report, its presentation and viva voce. Out of six credits one credit is for tutorials of the dissertation work.

Following are the components of the dissertation work:

a) Literature review and origin of the research problem
b) Objective/s and Methodology
c) Observations and the data **recorded by the candidate**.
d) Details of laboratory investigations,

e) Synthesis of results and interpretation
f) Concluding remarks and future direction.

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, a teacher from the parent department would be the supervisor/ internal guide and an expert from the industry/ research organization the co-supervisor/ external guide. Every student has to do the dissertation work independently. The project title, content and layout should be unique. The project reports of students should not be identical in content.

SOFT CORE

SOFT CORE :PRECAMBRIAN CRUSTAL EVOLUTION & TECTONICS [LTP / CREDITS = 400/4]

Unit 1: Geological time span. Early earth features. Mountain Building activity. Era- Breaking up of Pangea- the Precambrian- Hadean, Archean, Proterozoic, Structure of the Earth. A magma of Ocean-Composition of early Crust- Solidifying Basalt. The earth hotspot and fluid basalts. Lithosphere and Mantle reactions. Origin of the crust. Lower crust-first continents , early continental crust. Growth of crust- Mechanism of continental growth and its growth rate.

Unit 2: Growth of Continents. Primary Atmosphere. Secondary Atmosphere .Oxygen in atmosphere-geologic indicators of atmosphere-BIFs of Precambrian. Red beds, sulfates and Detrital uraninite and Pyrites, Decreasing Heat in Precambrian Time. paleosols –Biological indicators. Ocean prevailing theory, outgassing. Life in Archean Proterozoic orogeny. Earth- Moon system.

Unit 3: Precambrian mineral Deposits. Proterozoic life oldest rocks. Continental foundation. Distribution of Precambrian rocks. Proterozoic tectonics. Proterozoic assembly of laurestia-Proterozoic oxygen rocks. atmosphere- Precambrian assembly of Rodinia- grenville orogeny – Proterozoic rifting. Mid-continent rift- snowball earth. Crustal provinces- Precambrian provinces of North America. Cratons of America- hadean Crust. Archean and Proterozoic: Shield areas- Canadian Shield. Archean rocks. Green stone belt of South Africa. Cratons - Origin of Cratons, Rift Valleys, Mobile belts, Archean mineral resources and Proterozoic sedimentary basin in India.

Unit: 4: Tectonic features of extensional-, compressional-, and strike-slip-terrains and relevance to plate boundaries. mantle plumes. Himalayan Orogeny, Plate tectonics in the Precambrian.

Reference:

1. Archaean Geology- C.S. Pichamuthu
2. Early Precambrian supracrustal of southern Karantaka-Memoir 112. Geol.Surv. Ind
3. Geology of Karantaka- B.P Radhakrishna
4. Geology of India (Volume 1 and 2)- R.Vaidyanathan and M. Ramakrishnan
5. Geology of India and Burma- M.S Krishnan
6. Geology of India- M. Wadia
7. Crustal Evolution and Metalogeny in India- Sanib Chandra Sarkar and Anupendu Gupta

Name of the Department : **Department of Studies in Earth Science**
Program: **M.Sc., APPLIED GEOLOGY**, Code: **MSAPG**

I Semester	Course	Hard Core/ Soft Core	LTP	Credit Value	Paper Code	Total credits
1	Advanced Paleontology	Hard Core	301	4		20
2	Applied Hydrogeology & Geophysics	Hard Core	202	4		
3	Engineering Geology and Surveying	Hard Core	301	4		
4	Geology of India and Sequence stratigraphy	Hard Core	301	4		
5	Oceanography and Climatology	Soft Core	200	2		
6	Disaster Management	Soft Core	200	2		
	Foundation Course in Geology **(compulsory for Non-Geology Students)**	Soft Core	400	4		
II Semester	**Course**	**Hard Core/ Soft Core**	**LTP**	**Credit Value**	**Paper Code**	**Total credits**
7	Advanced Mineralogy	Hard Core	202	4		20
8	Economic Geology	Hard Core	301	4		
9	Geomorphology and Environmental Geology	Hard Core	301	4		
10	Minor Project (FW & Technical Report)	Hard Core	013	4		
11	Conservation of Soil and Water Resources	Soft Core	200	2		
12	Basics of Earth Science	OPEN ELECTIVE	200	2		

III Semester	Course	Hard Core/ Soft Core	LTP	Credit Value	Paper Code	Total credits
13	Geo-exploration and Mining Methods	Hard Core	301	4		20
14	Advanced Igneous and Metamorphic Petrology	Hard Core	202	4		
115	Sedimentary Petrology and Geotectonics	Hard Core	202	4		
16	Fuel Geology and Mineral Economics	Hard Core	400	4		
17	Gemology	Soft Core	200	2		
18	Industrial Mineral Resources	OPEN ELECTIVE	200	2		
IV Semester	**Course**	**Hard Core/ Soft Core**	**LTP**	**Credit Value**	**Paper Code**	**Total credits**
19	Geochemistry and Geochronology	Hard Core	301	4		18
20	Remote Sensing and Geospatial technology	Hard Core	202	4		
21	Major Project (Dissertation)	Hard Core	015	6		
22	Precambrian Crustal Evolution & Tectonics	Soft Core	400	4		
					Total Credits	**78**

M.Sc., DEGREE COURSE IN APPLIED GEOLOGY
(Two year – Four Semester Scheme)

SYLLABUS
(With New Regulations - CBCCEPS)
2023-2024

SEMESTER I

HARD CORE PAPERS

HARD CORE : ADVANCED PALEONTOLOGY [LTP / CREDITS = 301/4]

Unit: 1 Micro-Paleontology: Origin and Evolution of Life: Introduction of Microfossils; Classification of Microfossils; Separation of various Microfossils: Morphology, stratigraphic significance and applications of – Foramanifera, Ostracoda, Palynofossils, Acritarchs, Bryozoa, Chitinozoa, conodonts, Scoleconodonts. Diatoms, Radiolarians, Dinoflagellates and Nanoplanktons. Application of microfossils in fossil fuel exploration, paeoclimatic interpretation and maturation of sediments, Oxygen and Carbon Isotope studies on Fossils.

Unit: 2 Invertebrates: Morphology, classification, paleo-ecology and evolutionary trends of porifera. Mollusca: Pelecypoda, Classification on the basis of dentition and dental formula, dental system with example. Class Cephalopoda suture pattern. Arthropoda: Class Trilobita, Echinodermata, Trace fossils – marine & terrestrial, Hemicardata: Class Graptozoa

Unit: 3 Vertibrates & Paleobotany: Vertibrate**s:** Evolution, classification and geological signigicance of – Fishes; Amphibian, Reptiles, Mammals: Elephant, Horse and Man. Paleobotony: Techniques of spores and pollens analysis, Morphology, General classification of algae and stromatolies and their stratigraphic importance. Paleozoic, Mesozoic and Cenozoic plants – Bryophytes, pterdophytes, Gymnosperms and Angiosperms their stratigraphic significance.

Unit 4: ***Practicals:*** Identification, Diagnosis and Geological distribution of the following Groups: Invertebrate – Brachipods – 5 genera, Cephalopoda: 5 genera, Pelecypoda: 5 Genera, Trilobita: 5 genera, Graptozoa: 2 Genera, Plant Fossils: 6 genera, Microfossils – Foraminifera: 8 genera, Ostracoda: 3 genera, Palynofossils: 6 genera. Problems on biostratigraphy &Palaeo-ecology.

References:

1. Clarkson, E.N.K., 1998, *Invertebrate Paleontology and Evolution*, IV edition, publ., Blackwell
2. Stearn, C.W. & Carroll R. L. 1989, *Paleontology-the record of Life*, Publ. John Wiley.
3. Smith, A.B, 1994, *Systematics and the Fossils Record-Documenting Evolutionary Patterns.*, publ., Blackwell
4. Prothero. D.R., 1998, *Bringing Fossils to Life- An Introduction to Palaeontology*., publ., McGraw Hill
5. D. J. Jones, 1956. *Microfossils*
6. F.T.Banner and A.R,Lord., *Aspects of Micropaleontology*
7. M.P.Glaessner, *Principles of Micropaleontology*
8. M.D,Brasier, 1955, *Microfossils*, publ.Georgeallan and Wiley & Sons
9. Romer.A, *Vertebrate Paleontology*
10. Colbert, *Introduction to Vertebrate Paleontology*
11. Sukla., A.C &Misra S.P, 1975, *Studyof Paleobotany*Vikar Publ. House
12. Sripad.N.Agashe, *Palaeobotany*
13. Maohotra, A K, Ocean Science and Technology
14. Tchernia,P, Descriptive regional oceanography
15. K.Siddhartha, Oceanography- A brief introduction

16. William A Anikouchine and Richard W Stenbegr; the world Ocean- An Introduction to oceanography
17. Cuchlaine A M King, oceanography for Geographers
18. H.V. Thurman, Introduction to Oceanography

HARD CORE: APPLIED HYDROGEOLOGY & GEOPHYSICS [LTP/CREDITS = 202/4]

Unit-1: HYDROGEOLOGY : Occurrence and distribution of groundwater, Origin of water, global water cycle and budget; residence time concept, geologic formations as aquifers; confined and unconfined aquifers; groundwater table mapping and piezometric nests; porosity, void ratio, effective porosity and representative porosity range; primary and secondary porosities; groundwater zonation; specific retention, specific yield; groundwater basins; springs. Subsurface profile of groundwater including detailed study of zones of aeration and saturation. Groundwater movement and well hydraulics, Groundwater flow concepts; Darcy's Law in isotropic and anisotropic media and validity; water flow rates, direction and water volume in aquifers; permeability and hydraulic conductivity and ranges in representative rocks; Bernoulli equation; determination of hydraulic conductivity in field and laboratory; concept of groundwater flow through dispersion and diffusion; transmissivity and aquifer thickness. Introduction: Definition, concepts of watershed, major objectives of watershed management, effects of watershed on community, ecosystem, Monitoring and evaluation of watershed. Principles of watershed management: Delineating the watershed. Natural processes at work in watershed, common elements of watershed management, multidisciplinary approach in watershed management, participatory resources mapping and appraisal, benefits of watershed approach. Water wells and groundwater levels, Unidirectional and radial flow to a well (steady and unsteady), well flow near aquifer boundaries; methods for constructing shallow wells, drilling wells, well completion; testing wells, pumping test, slug tests for confined and unconfined aquifers; fluctuations in groundwater levels; stream flow and groundwater flows; groundwater level fluctuations; Groundwater exploration, Surface investigation of groundwater- geologic, remote sensing, rock-water interaction, Physical, chemical and biological properties of water, Graphic representation of chemical data; groundwater hardness, microorganisms in groundwater; water quality standards; sea-water intrusion, waste disposal Application of isotopes (H, C, O) in groundwater; concepts of artificial recharge methods; managing groundwater resources; groundwater basin.

Unit-2: Geophysics: **Gravity method:** Nature of gravity and its variation. Accuracy and precision of measurements. Gravimeters. Field procedures. Corrections. Free-air & Bouger anomalies. Interpretation of anomalies. Explorations for minerals. **Magnetic method:** Geomagnetic field and its variations. Magnetometers. Field procedures for land and airborne surveys. Exploration for minerals and oil and engineering sites. **Seismic method:** Seismic waves and their speeds in rocks. Snell"s law. Critical refraction. Instruments and field procedures for seismic refraction method. Corrections, Interpretation of data. Seismic reflection methods for oil exploration. Equipment for seismic reflection. Time and depth sections. **Electrical methods**: Introduction to S.P method and its use. Resistivity, true and apparent D.C. resistivity, true and apparent D.C. resistivity equipment, electrode arrangement, field procedure, and use for mineral exploration and at engineering sites. **well logging methods**. **Radioactivity methods:** of rocks and minerals, instruments (GM counter, scintillation counter and gamma ray spectrometer) and measurements of radiation.

Unit 3: Practical: 1 Rainfall patterns of distribution, methods of preparing, Arithmetic, thiessen polygon maps, isohyetal map and analysis water level fluctuation data, Interpretation of water quality data using numerical and graphical approaches - Preparation of water level fluctuation data- Preparationof water table contour maps and interpretation. Analysing pumping test data using Jacob's straight line method. Graphical representation of hydrochemical data:- Piper Trilinear diagram. Vector diagram. Circular diagrams, Stiff's polygon. Determination of pH and TDS of ground water samples.

Unit 4: Practical 2: Curve matching techniques-s-line method, Second and third layers techniques, Preparation of-iso-resistivity maps and delineating groundwater potential zones.

References:

1. Groundwater-C.F.Tolman

2. Groundwater Hydrology-D.K.Todd
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4. Groundwater studies-R.H.Brown and others
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7. Hand book of Applied hydrology-Van te Chew
8. Groundwater and wells-Hohnson Publications
9. Applied Hydrology-Chow M.Mays.Mac.Graw Hill Publication
10. Hydrology and wetland conservation-Gulam
11. Groundwater survey and inverstigation-Guatham Mahajan
12. Hydrology-Raghunath
13. Hydrogeology-Karanth
14. Worcester: A Text Book of Geomorphology
15. Todd: Groundwater Hydrology Ward: Principles of Hydrology
16. Chow: Handbook of Applied Hydrology
17. Health & Trainer: Introduction to Groundwater Hydrology
18. Singh: Elements of Hydrology
19. Raghunath: Introduction to Hydrology
20. Tolman: Hydrology
21. Karanth: Development, Assessment and Management of Water Resources.
22. Hydrogeology, S.N.Davis and RJ.M.Dewiest.
23. Applied Geophysics, W.M.Telford et. al
24. 0utlines of geophysical prospecting, M.B.Ramachandra Rao
25. Applications of Surface Geophysics to Groundwater investigations, A.A.R.Zohdy et al.
26. Introduction to Geophysical Prospecting , M.B.Dobrin and Savit.
27. Direct current Geoelectric sounding principle and interpretation, P.K.Bhattacharya and H.P.Patra.

HARD CORE: ENGINEERING GEOLOGY & SURVEYING [LTP / CREDITS = 301/4]

Unit 1: Engineering properties of rocks. Rocks as construction material, Site investigation, characterization and problems related to civil engineering projects: geological and geotechnical investigations for dams, reservoirs and spillways, tunnels, underground caverns, bridges, highways, shorelines. Reservoir sedimentation: Causes – effects- basin, channel and geological factors, climatic influence, monitoring- desilting methods.

Unit 2: Geological studies and evaluation in planning, design and construction of major civil structures. Elementary concepts of rock mechanics and soil mechanics. Problems of groundwater in engineering projects. Coastal geotechniques. Environmental considerations related to civil engineering projects. Resource evaluation of construction materials.

Unit 3: Geological hazards: Mass movements (landslides and subsidence) and earthquakes, their significance, causes, preparedness and mitigation. Recent trends in geotechnical engineering. Geotechnical case studies of major projects in India. Coastal Erosion: Near shore dynamics, erosion mechanisms- long shore drift, Effects of coastal erosion – Controlling methods – barriers, groins, sea walls, Jetties and stone revetments. Geology of soils and elements of soil and soil mechanics.

Unit 4: ***Practical: Surveying*** **:** Chain survey, Compass survey, Plane table survey, Dumpy level survey, GPS survey and Total Station Survey. ***Engineering Geology*****:** Particle Size Distribution calculations, USDA Soil texture classification, Problems on Engineering properties of soils & rocks.

References:

1. Soil mechanics- B.C Punmia
2. Manual of Field geology – Compton.
3. Soil their Orgin, constitution and classification – Robinson G.W
4. Soils – Tambane and others
5. Nature and Properties of Soil- Harry O BuckmenNylc C. Brady

6. Fundamentals of Soil Science – Miling, Truck and Forth. H.D(1984) John
7. willey
8. Engineering Geology by S.K Garg
9. Climatology – Stringer (1982) Surjeet Publication Soil Atlas of Karnataka, NBSSLUP Publication.
10. Engineering Geology by F.G Bell
11. Textbook of Surveying (2nd Edn) by Venkataramaiah C. Orient Blackswan Private Limited - New Delh.
11. Surveying Fundamentals and Practices (What's New in Trades & Technology) 7th Edition by Jerry Nathanson, Michael Lanzafama, Philip Kissam. Pearson publication.
12. Engineering Surveying by W Schofield and Mark Breach. Published by CRC Press, February 14, 2007. ISBN 9781138046535, pp 1-638
13. Fundamentals of Surveying By S.K.Roy. Prentice Hall India Learning Private Limited; 2nd edition (1 January 2010).

HARD CORE: GEOLOGY OF INDIA & SEQUENCE STRATIGRAPHY [LTP / CREDITS = 301/4]

Unit1: Paleozoic Era: Introduction, Tethyan basin, Paleozoic life, Trace fossils and Stromatolites. Precambrian/Cambrian boundary, PC/C boundary in Himalayan basins. *Cambrian* – Jammu and Kashmir, Himachal Pradesh, Tal Basins and Uttaranchal. *Ordovician and Silurian* - Jammu and Kashmir, Himachal Pradesh and Uttaranchal, *Devonian* - Jammu and Kashmir, Himachal Pradesh and Uttaranchal. *Carboniferous* - Jammu and Kashmir, Eastern Karakoram, Himachal Pradesh and Uttaranchal. *Permian* - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Arunachal Pradesh of India and Bhutan. Peninsular India-Cauvery Basin. *Gondwana Supergroup* – Introduction, Characteristics, Stratigraphy and Structure, Classification and age, life in Gondwana, Coastal Gondwana basins, Gondwana in Extra-Peninsular India, Environment of deposition and economic significance.

Unit 2: Mesozoic Era: Introduction, life of Mesozoic Era, *Triassic* - Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Sikkim, Rajasthan and Kutch. Permo-Triassic Boundary. *Jurassic* – Kutch, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Jharkhand of India and Bhutan. *Cretaceous* – Gujarat, Rajasthan, Jammu and Kashmir, Himachal Pradesh, Uttaranchal, East Coast, Tiruchirappalli, Narmada Basin, Lameta Formation, Jharkhand, Assam/Meghalaya, Andaman and Nicobar Islands. Cretaceous/Tertiary Boundary. *Deccan Volcanic Province* – Introduction, Regional Stratigraphy, Subprovinces, Volcano-Plutonic Complexes, Petrology and Petrogenesis, Inter-Trappean beds, Distribution and its age. ***Cenozoic Era –*** Introduction, Distribution, Climate, Correlation, Fauna and Flora, Classification and Stratigraphy. *Paleogene* – Introduction, Fauna and Flora, Stratigraphy and Distribution. *Neogene*– Introduction, Fauna and Flora, Stratigraphy and Distribution. *Quaternary* – Introduction, Distribution, Quaternay climatic changes, Quaternary Sea level changes. Siwalik – Stratigraphy and Sedimentation. Distribution of Fauna in Siwalik. Geology of Offshore Basins its Morphology and Evaluation.

Unit 3: Sequence Stratigraphy: Introduction to Stratigraphy, branches of Stratigraphy. Terms and concepts of Sequence Stratigraphy and its relationship with other branches of Stratigraphy. Sedimentary basin analysis through sequence Stratigraphy. Out crop and subsurface procedures. Global sea level changes/ eustatic sea level. Applications of sequence stratigraphy in petroleum exploration with case studies.

Unit 4: ***Practicals:*** **1.**Mark the sequence surfaces ; LST, TST, HST, MFS, down lap, Onlap, erosion surface etc on the seismic section **2.** Identification of the lithology in the given well log. **3.**Draw the cratons of India and locate the metalliferous deposits **4.** Mark the Gondwana basins on an map of India and the describe the coal deposits & **5.**Describe the litho section profile to its order of super position and stratigraphy.

References:

1. Geology of India Vol.1 & 2. M.Ramakrishnan and R Vaidyanatahan
2. Geology of India – Wadia, D.N., McMillan and Co.
3. Geology of India and Burma – Krishnan M.S. Higginbotham, Madras.
4. A hand book of the Geology of the Mysore State – B. Rama Rao, Bangalore press.
5. Precambrian Stratigraphy and Geochronology of the Peninsular India – Sarkar, S.N. Dhanbad Publishers.
6. Review papers on the Stratigraphy of India –Rec.Geol.Surv.India Vol.101, Part 2.1972Cretaceous Tertiary formations –Geol.Soc. India, seminar Vol. 1958.
7. Paleozoic of Himalayas. HPC publn.
8. ReconnaaissanceRb-Sr dating of the Precambrian of Southern Peninsular India-Crawford, A.R., J.G.S.I 1972. 117-126.
9. Sequence stratigraphy- BHP petroleum (America) Inc – Michael Yeaman, Lavy Holcomb, Gill Tailor 1990
10. Sequence stratigraphy – BP Exporation. Stockley Park UK Bridge London, Publn. Blackwell science
11. Sea Level Changes- An Integrated Approach Spl. Pbln.42, Barbara H.Lidz, Edtor of Spl. Publn. Oklahoma USA 1998
12. Sequence in Layered Rocks- Blatt Middleton &Humay
13. Sedimentary Petrology- Pettijhon

SOFT CORE: OCEANOGRAPHY AND CLIMATOLOGY[LTP / CREDITS = 200/2]

Unit 1: Physical Oceanography: Characteristics of important water masses. Wind generated waves in the oceans and their characteristics. Shallow and deep water waves. Propagation, refraction, and reflection of waves. Tide-producing forces and their magnitudes; Tsunami; interaction of waves and structure. The global wind system; action of wind on ocean surface; Ekman‟s theory; Sverdrup, Stommel and Munk‟s theories; upwelling and sinking with special reference to the Indian ocean. Barotropic and baroclinic conditions; oceanic eddies, Wind driven coastal currents; typical scales of motion in the ocean. El Nino; monsoonal winds and currents over the North Indian Ocean. **Chemical Oceanography:** Composition of seawater – Classification of elements based on their distribution; major and minor elements, their behavior and chemical exchanges across interfaces and residence times in seawater. **Geological Oceanography:** Oceanography: Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. hydrothermal vents. Ocean margins and their significance. Ocean Circulation, Coriolis effect and Ekman spiral, convergence, divergence and upwelling. Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, diagenetic changes in oxic and anoxic environments. Tectonic evolution of the ocean basins. Mineral resources.

Unit 2: Climatology: Fundamental principles of climatology. Earth‟s radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Air masses, monsoon, Jet streams, tropical cyclones, and ENSO. Classification of climates – Koppen‟s and Thornthwaite‟s scheme of classification. **Climate change-** Natural factors- Geological and secular changes, periodic variations and Role of Anthropogenic activities in climatic change with case studies. Climate Observations, stations and networks. Climate data management. Instruments and climatic measurements. Thermometer, barometer, hygrometer, rain and snow gauges, Sunshine recorders. Weather maps and charts. Extreme climatic events- Cyclones, Jet Streams, Western Disturbances, Ozone Depletion, Storms, Hurricanes and Tornadoes. Droughts. Elements of Weather forecast and methods. Global Climate Models. General Weather Systems of India. Monsoon systems. Green house effect.

References:

1. Climatology: An Atmospheric Science, 2/e, Pearson Education India, 1993 - 423 p.
2. Encyclopedia of World Climatology,John E. Oliver, Springer Science & Business Media, 2008, 854 p.
3. Climatology, Majid Husain, Anmol Publications, 1994 - 376 p.

4. Advances in Meteorology, Climatology and Atmospheric Physics, Costas Helmis, Panagiotis T. Nastos, Springer Science & Business Media, 2012 , 1278 p.
5. Remote Sensing Applications in Meteorology and Climatology, Robin A. Vaughan, Springer Science & Business Media, 2012, 480 p.
6. Applied Climatology: An Introduction, John F. Griffiths, Oxford University Press, Incorporated, 1976, 136 p.
7. Principles of climatology: a manual in earth science, Hans Hermann Neuberger, John Cahir, Holt, Rinehart and Winston, 1969, 178 p.
8. Climatology, an introduction, John E. Oliver, John J. Hidore, Merrill, 1984 , 381 p.
9. Global Physical Climatology, Dennis L. Hartmann, Academic Press, 1994, 411 p.
10. Weather, radar and Flood forecasting, Collings. V. K (1987) John Wiley and sons.
11. General Climatology, Crithfield. H. J, (1996) Prentice Hall, New Jersey.
12. Climatology by Miller, Austin A Publication: London Methuen and company 1961 .xii, 320p.
13. General climatology by Flohn, H [ed.] Publication: Amsterdam Elsevier Publishing
14. company 1969 . xi, 266p.
15. Climatology by Miller, A. Austin Publication: London Methuen And Co 1938 . x, 304pp
16. Climatology by Haurwitz, Bernhard Publication: New York McGraw-Hill 1944 . xi, 409p.
17. Methods in climatology by Conrad, Victor Publication: Cambridge Harvard University
18. Press 1946 .xx, 228p.
19. Climatology by Kendrew, W G Publication: Oxford The Clarendon Press 1957 .xv, 400p.
20. Climatology by Blair, Thomas A Publication: New York Prentice-Hall 1942 .xvi, 484p.
21. Essentials of oceanography, 5th Edition,-Tom Garrison-Brooks/Cole-2009
22. Essentials of oceanography,10th Edition, Trugillo and Thurman-Prentice Hall 2011

SOFT CORE: DISASTER MANAGEMENT [200/2]

Unit 1: Geological Disasters (earthquakes, landslides, tsunami, and mining); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves) Biological Disasters (epidemics, pest attacks, and forest fire); Technological Disasters (chemical, industrial, radiological, and nuclear) and Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters. Man-made Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemicals and biological disasters). Gas and radiation leak, toxic waste disposal, oil spills, forest fires. seismic zones of India, major fault systems of Indian plate, social economics and environmental impact of disasters. Case studies.

Unit 2: Mitigation and Management techniques of Disaster. Basic principles of disaster management, Disaster Management cycle, Disaster management policy, National and State Bodies for Disaster Management, Early Warming Systems, building design and construction in highly seismic zones, retrofitting of buildings. Training, awareness program. Usages of GIS and Remote sensing techniques in disaster management, Disaster risk assessment and Hazard mitigation with reference to India.

References:

1. Disaster Management Guidelines, GOI-UND Disaster Risk Program (2009-2012)
2. Damon, P. Copola, (2006) Introduction to International Disaster Management, Butterworth Heineman.
3. Gupta A.K., Niar S.S and Chatterjee S. (2013) Disaster management and Risk Reduction, Role of Environmental Knowledge, Narosa Publishing House, Delhi.
4. Murthy D.B.N. (2012) Disaster Management, Deep and Deep Publication Pvt. Ltd. New Delhi.
5. Modh S. (2010) Managing Natural Disasters, Mac Millan publishers India Ltd.
6. A Manual on Disaster Management. Parag Diwan (2010), Pentagon Earth.
7. Bryant Edwards., Natural Hazards, Cambridge University Press, U.K, 2005.
8. Handbook of Disaster Risk Reduction & Management. Christian N Madu and Chu-Hua Kuei (2017). World Scientific.
9. Handbook of Hazards and Disaster Risk Reduction. Ben Wisner, J.C. Gaillard, Ilan Kelman (2012) Routledge.
10. H.K. Gupta., Disaster Management, 2003.

FOUNDATION COURSE IN GEOLOGY (FOR NON-GEOLOGY STUDENTS) [LTP / CREDITS = 400/4]

Unit 1: Mineralogy and Petrology: Basics of mineralogy. Physical properties of minerals. Classification of minerals based on chemical composition and structure. Rock forming minerals. Ore minerals. Oxides, carbonates, phosphates, sulphates, sulphides, and hydrocarbon. Silicates- quartz, feldspar, olivine, garnet, pyroxene, amphibole. Definition and basics of Petrology. Classification of Rocks. Igneous, sedimentary and metamorphic rocks. Forms, Structures and textures of Igneous Rocks. Lithification and diagenesis. Structures of sedimentary rocks. Classification of sedimentary rocks based on grain size, and mode of formation. Agents and structures of metamorphic rocks. Grades and facies of metamorphism. Petrographic properties of all three kinds of rocks.

Unit 2: Structural Geology and Geodynamics: Mechanical characters of the rock. Rock deformation. Kinds of rock deformation. Relationship between stress and strain in rocks compressive strength, tensile strength, residual stresses in rock. Mechanics of plastic deformation, stress and strain ellipsoids. Folds - Origin, characteristics, geometrical classification. Faults- Description and classification of all types of Faults. Unconformities: Definition and different types of unconformities. Salt domes and Plutons. Joints-characteristic features & classification of joints. Geodynamics. Earths interior-Characteristic features of the crust, mantle and core. Continents and ocean basins. Plate Tectonics: Concept and its development, parts of a plate, spreading centres, mid-oceanic ridges, consuming margins, subduction zones, island arc volcanism at spreading centres: accretion, Mantle convection. Sea floor spreading and its impact.

Unit 3: Stratigraphy and Palaeontology: Stratigraphc principles. Nature of Geological Record. Branches of Stratigraphy, Correlation – Physical and Biological Criteria. Standard Stratigaphic scale. Introduction to Palaeontology - Classification of life. Fossils: Definition, fossilization, types of fossils, Casts and Moulds. Tracks and Trails. Uses of fossils. Morphology and Geologcial distribution of - Foraminifera, Brachiopods, Mollusca-Lamellibranchs, Gastropods, Cephalopods, Echinoids & Trilobites. Plant fossils - Morphology and distribution of Lepidodendron, Siggillaria, Calamites, Glossopteris, Ptillophyllum.

Unit 4: Economic Geology: Introduction - Definition and importance of Economic Geology. Ore minerals, Gangue minerals, Tenor and Grade of Ore. Ore Genesis - Principles and Ore formation Processes: Magmatic concentration, contact metasomatism, hydrothermal processes: cavity filling and replacement, weathering: Residual and Mechanic concentrations, sedimentation: Oxidation and supergene enrichment and metamorphism. Occurrence and distribution of following mineral deposits. of India a) Metallic Deposits: Gold, Copper, Iron, Manganese and Aluminium. b) Non-metallic Deposits: Mica, Abrasives, Refractories and Cermaics, Fossils Fuels - Coal and Petroleum.

Reference:

1. Physical Geology by Arthur Holmes
2. Structural Geology by Billings
3. General Geology By P.K. Mukerjee
4. Physical Geology By Strahler
5. Stratigraphic Principles and Practice-Weller
6. Stratigraphy-Kumberlein and Sloss
7. Paleontology of the Invertebrates-TaschPubl.Jhon Wiley and Sons
8. Paleontology- Henry Wood
9. Fossils Plants- Arnold
10. The Elements of Paleontology Black,R.M Pub. Cambridge university press

II SEMESTER

HARD CORE PAPERS

HARD CORE: ADVANCED MINERALOGY [LTP / CREDITS = 202/4]

Unit 1: Crystallography: Form theory of Crystals, Projections, Derivation of 32 point groups. Zone and Zone Laws, Atomic and ionic radii, Bond length and measurements of Radius, Radius ratio and co-ordination polyhedra, Cordination Number, Pauling's Rules, Spheres in Closest packing, Packing Index. Voids in closest packing, Classification & Co-ordination of voids, Derivative Structures. Crystal Defects / Crystal Imperfections.

Unit 2: Mineralogy: **Olivine Group**: Chemistry and Structure of the Olivines, Diadochy between atomic pairs Mg^{+2} - Fe^{+2} and Fe^{+2} – Mn^{+2}. Forsterite – Fayalite solid solution series, MgO-SiO_2 system, optical properties of Forsterite – Fayalite system, Paragenesis of Olivine group of minerals. **Garnet group**: Pyralspite-Ugrandite series, Structure and Chemistry of Pyralspite-Ugrandite series, optical properties and paragenesis. **Al_2SiO_5 group of minerals:** Silliminite, Mullite, Andalusite and Kyanite. P-T diagram of Kyanite-Andalusite-Sillaminite, Structure and chemistry of Al_2SiO_5 group of minerals, physical and optical properties, Paragenesis. **Epidote group of minerals:** Chemistry and Structure of Epidotes, members of Epidote group, properties and paragenesis of Epidote group. **Pyroxene group of minerals**: Classification of CPx-OPx, $CaSiO_3$-$MgSiO_3$-$FeSiO_3$ diagram, Structure of Pyroxenes, $MgSiO_3$-$CaMgSi_2O_6$, $CaMgSi_2O_6$ phase diagrams, Diopside – hedenbergite phase diagram, Chemistry, optical properties and paragenesis of Pyroxenes. **Amphibole group of Minerals:** Classification of Amphiboles, Cation distribution in Mg-end members in amphiboles, Structure of Amphiboles, paragenesis and optical properties. **Mica group of minerals:** Structure and classification of Mica group of minerals, Economically important micas – Phlogopite, Muscovite and Lepidolite. Paragenesis and distribution of mica group of minerals. **Feldspar group of minerals:** Alkali feldspars, Plagioclase feldspars, An-Ab-Or system, perthites and Antiperthites, Ab-An phase diagram. **Silica group of minerals:** SiO_2 polymorphs, Structure, Symmetry and cell parameters, Chemistry and solubility of Silica minerals, Stability relations of Silica minerals, P-T diagram of SiO_2, optical and physical properties, origin, occurrence and uses of SiO_2 minerals.

Unit 3: ***Practical : Crystallography:*** Classification and quantification of crystals based on grade of symmetric elements for Isometric, tetragonal, orthorhombic, hexagonal, monoclinic and triclinic systems. Projections for each crystal. Calculation of interfacial angle and axial ratios using stereonet projections.

Unit 4: ***Practical: Mineralogy:*** Descriptive mineralogy, Mineral formula calculations based on mineral analysis for olivines, garnets, pyroxenes, amphiboles, micas and feldspars. Trilinear phase diagrams for minerals. Identification of minerals based of X-ray patterns. Determination of vibration direction and sign of elongation in minerals using optical accessories, Determination of optic sign in uniaxial and Biaxial minerals. Determination of pleochroic scheme and absorption formula of minerals. Determination of birefringence of a mineral using Berek's compensator.

Reference:

1. An Introduction to crystallography - F.C.Phillips.
2. Elementary Crystallography - Buerger
3. Solids - Azaraoff.
4. Elements of X-ray Crystallography - Azaraoff.
5. Elements of Optical Mineralogy part I and II - Winchell
6. Optical Mineralogy - P.R.J. Naidu.
7. Fundamentals of Crystal chemistry – T.R.N.Kutty and J.A.K.Tareen(Orient Longman)
8. A Basic Course in Crystallography- J.A.K.Tareen and T.R.N.Kutty
9. Introduction to Rock forming Minerals-Deer, Howie & Zussman

HARD CORE : ECONOMIC GEOLOGY [LTP / CREDITS = 301/4]

Unit 1: Ore bearing fluids: magmatic, hydrothermal fluids, meteoric water, seawater, connate water, metamorphic fluids. Depositional textures: exsolution, replacement, colloidal – colloform and open-space filling textures. Wall rock alteration: reaction between wall rocks and fluids, alteration assemblages and types of alteration. Paragenesis and zoning in mineral deposits. Classification of ore deposits. Deposits related to ultramafic-mafic rocks (layered intrusions, anorthosites, kimberlites, carbonates, komatiites). Deposits related to intermediate to felsic rocks (Iron deposits, porphyry Mo, pegmatites, granitic Tin and U, skarn deposits with typical examples).

Unit 2: Deposits related to weathering – Nickel laterite deposits, Deposits related to clastic sedimentation: placer deposits – Witwatersrand gold and U deposits. Chemical sedimentation: phosphate deposits, evaporites, manganese nodules, Ore deposits related to subaerial (Epithermal gold – Au) and submarine volcanism (Kuroko Cu–Zn, Japan, BIFs). Ore deposits related to metamorphism, metallogenic provinces, Epochs and plate Tectonic – classification of ore deposits.

Unit 3: Metallic deposits of India: Iron, Manganese, Copper, Chromium, Gold, Lead, Zinc and Bauxite deposits, Non-metallic deposits (Industrial minerals) – Minerals used as fertilizers, refractories, abrasives, pigments, ceramic and glass-making materials.

Unit 4 : Practical: Identification of ore minerals based on megascopic (Hematite, Magnetite, Goethite Chromite, Pyrolusite, Cuprite, Chalcopyrite, Pyrite, Molybdenite, Galena, Sphalerite , Pyrrohotite, Malachite, Marcasite, Ilmenite, Laterite, Bauxite, Limonite, varieties of Coal, and Graphite) and microscopic properties: Chromite, Ilmenite, Ti-magnetite, Hematite, Pyrite, Sphalerite, Galena, Chalcopyrite, Covellite, Bornite, Pyrrhotite, Arsenopyrite, Pyrolusite. X Ray pattern study for some of the important ore minerals.

Reference:

1. The Geology of ore deposits - John M. Guilbert and charles. F.Park, Jr.W.H.Freeman and Co., New York. 1986.
2. Interpretation of ore textures - Bastin, E.S.
3. Economic Mineral deposits by Jenson and Bateman, A.M.
4. Ore microscopy -Cameraon, E.N.
5. Textures of the ore minerals - Edwards, A.B.
6. Ore deposits - Park, Jr. C.F.
7. Geology of Mineral deposiits - Smirnov, U.J.
8. The ore minerals and their intergrowths - Ramhor, Dr. Paul.
9. Ore Petrology - Stanton, R.L.
10. India's mineral resources – Sinha and Krishnaswamy, S.
11. Metallic and Industrial minerals - Lamey Carl, A.
12. Introduction to India's economic minerals - Sharma, N.L. &Ram . K.S.
13. A treatise on industrial minerals of India-Sinha, R.L.
14. Mineral deposits of India, Mukerjee 1999: Allied publications.

HARD CORE: GEOMORPHOLOGY & ENVIRONMENTAL GEOLOGY [LTP / CREDITS = 301/4]

Unit 1: Principles of Geomorphology, Relief orders of Earth. Exogenetic and endogenetic processes. Land forms formed through Fluvial , Glacial, Aeolian, Coastal and Karst geomorphic process. Principles of terrain classification –landscape and parametric divisions. Role of geomorphology in selecting Irrigation sites in arid and semi arid regions- advantages and reclamation processes, Interpretation of drainage patterns.

Unit 2: Man and environment. Earth's system, Interactions among lithosphere, hydrosphere, atmosphere and biosphere. Geological process affecting the environment. Environmental hazards created by man's **a**ctivities such as mining and industrial activities.

Unit 3: Water land and soil pollution causes and effects of urban and industrialization. Land use planning and terrain evaluation for environmental management. Solid Wastes and their methods of Management. Sewage sources and their treatment methods. **Marine pollution:** Causative factors – land based sources – marine based sources – types of pollution – oil spill and its effects on marine and continental environment. Global warming causes and its effects.

Unit 4: ***Practicals****:* Tracing and identification of drainage patterns and interpretation of the bed rock morphology- terrain, slope and structure. Drainage basin morphology- Linear aspect; Stream order, stream number, bifurcation ratio, stream length ratio. Drainage basin morphology-Aerial aspect-Stream frequency, drainage density, drainage texture. Drainage basin morphology- Relief aspect-Basin relief, relief ratio, ruggedness number. Fluvial geomorphology and landforms.

References:

1. Geomorphology by William D. Thornbury.
2. Modern Physical Geography by Arthur N. Strahler& Alan H. Strahler.
3. Applied Geomorphology by Hails.
4. Environmental Geology – Peter TP Flawn
5. Environmental geosciences – Arthur H Strahler& Alan Strauler
6. Geology in Environmental planning- A.D. Howard &I.Ramson
7. Focus on Environmental Geology –R Turk
8. Environmental Science –S C Santra
9. Environmental geology by Waldia K.S

HARD CORE: MINOR PROJECT -FIELD WORK AND TECHNICAL REPORT [LTP / CREDITS = 013/4]

SOFT CORE

SOFT CORE: CONSERVATION OF SOIL AND WATER RESOURCES [LTP / CREDITS = 200/2]

Unit 1: Definition of Soil. Soil genesis and morphology. Factors of Soil Formation. Processes of Soil Formation. The Soil profile. Concept of Pedon and Landforms. Components and Composition of Soils. Physical Properties of Soils. Soil Structure. Chemical Properties of Soils. Soil pH, Soil Mineralogy. Ion-exchange Capacity of Soils. Soil Salinity, Acidic Soils, Alkaline soils. Engineering properties of soils. Soil Moisture. Role of Nutrients in Soils. Soil Microbiology & Organic Matter. Soil testing and surveys. Soil Classification systems & Soil Taxonomy. Soil related problems. Soil pollution. Soil erosion- causes and effects. Soil loss measurements. Universal Soil Loss Equation and its application. Soil surface management and soil stabilization practices. Sediment traps. Soil conservation practices-Tillage methods. Biological soil conservation. Mechanical conservation works including terracing methods. Irrigation and Engineering Practices.

Unit 2: Definition of water conservation. Water Conservation Practices. Water Resources in Watersheds and River Basins. Water Use and Consumption. Water management. Improving Drainage and reclaiming salt-affected soils. Technological options for drainage study. Design principles. The effect of scale. Methods of Irrigation -modern techniques. In-situ conservation of soil and water. Runoff management- Decreasing runoff amount (contour farming, strip cropping, contour barriers, vegetative hedges). Water Erosion Control practices. Reducing runoff velocity (slope management, waterways, diversion channels, engineering structures, etc). Flood control- Inundation methods and Flood diversion. Water storage- Small earthen dams, Weirs, Sand dams. Losses of stored water- seepage/ evapotranspiration and its controlling methods.

References:

1. Principles of Soil Conservation and Management- Humberto Blanco-Canqui, Rattan Lal, Springer, 16-Sep-2008 - 617 pages

2. Soil and Water Conservation Policies and Programs: Successes and Failures, Ted L. Napier, Silvana M. Napier, Jiri Tvrdon, CRC Press, 24-Nov-1999 - Technology & Engineering - 656 pages
3. Advances in Soil and Water Conservation, Francis J. Pierce,CRC Press, 01-Feb-1998 - Technology & Engineering - 300 pages
4. Soil and water conservation engineering, Richard K. Frevert, Glenn Orville Schwab, Wiley, 1966 - Nature - 683 pages
5. Soil And Water Conservation Handbook: Policies, Practices, Conditions, and Terms, Paul W. Unger,Haworth Food & Agricultural Products Press, 23-Oct-2006 - Political Science - 248 pages
6. Soil Erosion and Conservation,R. P. C. Morgan,John Wiley & Sons, 05-Feb-2009 - Science - 320 pages
7. Soil Erosion: Processes, Prediction, Measurement, and Control,Terrence J. Toy, George R. Foster, Kenneth G. Renard, John Wiley & Sons, 27-May-2002 - Science - 338 pages
8. Soil Erosion by Water: Some Measures for Its Control on Cultivated Lands, **Food and Agriculture Organization of the United Nations**,Food& Agriculture Org., 01-Jan-1965 - **Nature** - 284 pages
9. Water Conservation, Management and Analysis,**Madireddi V. SubbaRao**,Readworthy, 2011 - **Water** - 144 pages
10. Soil and Water Conservation Policies and Programs: Successes and Failures, Ted L. Napier, Silvana M. Napier, Jiri Tvrdon, CRC Press, 24-Nov-1999 - Technology & Engineering - 656 pages
11. A Practical Approach to Water Conservation for Commercial and Industrial Facilities, Mohan Seneviratne, Elsevier, 11-Jul-2007 - Technology & Engineering - 400 pages
12. Soil and Water Conservation in Semi-arid Areas, Issue 57, Norman Hudson, Food & Agriculture Org., 01-Jan-1987 - Arid regions - 172 pages

OPEN ELECTIVE

OE- BASICS OF EARTH SCIENCE [LTP / CREDITS = 200/2]

Unit 1: **Physical Geology & Structural Geology** -Introduction to geology. Origin of the Earth. Age of the earth. Interior of the Earth. Geomorphic processes and cycles - Geological action of Wind, Water, Glaciers, Volcanoes and Earthquakes. Morphology of Oceans, Principles of Isostasy and uniformitarinism. - Rock deformation. Earth forces. Folds and Foldings, Fault and Faulting, Joints, Cleavage, Unconformities, Concept of plate tectonics, sea floor spreading and geosyncline.

Unit 2: Stratigraphy & Paleontology - Introduction, Definition of Stratigraphy, Branches of Stratigraphy and its relation with other branches of Geology, Principles of Stratigraphy- Law of Uniformatianism, Law of order of superposition, Law of Faunal succession. Geological Record and its nature- Eon, Era, Period. Geological Time Scale. Classification of Standard Stratigraphic scale. Nomenclature and Litho, Bio and Chrono stratigraphic units, Correlation- Lithostratigraphy and Biostratigraphy.

Introduction & Definition of Paleontology, Classification of Plants, Invertebrate and Vertebrate fossils. Fossils-Taphonomy (Burial Law), types of Fossilization, mode of preservation- Mummification, Carbonization, Silification, Casts, Moulds, Tracks and Trails. Applications of Fossils. General morphological characters and Geological age of the following Invertebrate and Plant Fossils: Brachiopoda, Cephalopoda, Pelecypoda and Trilobita. Plant fossils: Glossopteris, Gangamopteris, Ptillophylum, Calamites and Lepidodendron.

References:

11. Physical Geology by Arthur Holmes
12. Structural Geology by Billings
13. General Geology By P.K. Mukerjee
14. Physical Geology By Strahler
15. Stratigraphic Principles and Practice-Weller

16. Stratigraphy-Kumberlein and Sloss
17. Paleontology of the Invertebrates-TaschPubl.Jhon Wiley and Sons
18. Paleontology- Henry Wood
19. Fossils Plants- Arnold
20. The Elements of PaleontologyBlack,R.M Pub. Cambridge university press

III SEMESTER

HARD CORE PAPERS

HARD CORE : GEO-EXPLORATION & MINING METHODS [LTP/CREDITS = 301/4]

Unit 1: Geological Exploration: Mode of occurrence of commercial grade deposits of Fe, Mn, Au-Ag-(W), Cu,Pb-Zn,Ti,Ni,Mo,Sn,Al,Pt - group. U-Th. Geological criteria for mineral prospecting. Indications of ore. Geological prospecting methods. Small and large scale geological mapping. Methods of geological exploration - exploratory grids, location and documentation of exploratory workings (pits, trenches underground workings), drilling, core logging. Sampling techniques and evaluation of grade.

Unit 2: Mining Methods : Mining terminology, methods of open cast, underground and alluvial mining. Definition and scope of mineral processing, communition, crushers and classifiers. Froth flotation techniques of separation.

Unit 3: Geochemical Exploration: Geochemical cycle, mobility of elements and geochemical anomaly. Mode of occurrence of trace elements. Primary dispersion patterns of deep seated origin, syngenetic and epigenetic. Geochemical rock surveys. Weathering and its products. Mobility of elements in the surficial environment and surficial dispersion patterns and forms. Anomalies in residual and transported over burden. Anomalies in waters and drainage sediments. Uptake of mineral matter by plants. Biogeochemical anomalies and survey techniques. Vapour geochemistry
.
Unit 4: ***Practical: Geological Exploration:*** Delineation of ore deposit based on exploration data. Classification of ore reserves. Economic evaluation of ore deposit. Preparation of technical report.
Gechemical Exploration: Geochemical methods in mineral exploration and choice of materials and methods. Interpretation of Geochemical maps for locating ore mineralization. Preparation of geochemical anomaly maps.

Reference:
1. Geochemistry in mineral exploration Rose, A.W Hawkes. H.E & Webb J.S. 1979. Academic press.
2. Principles of geochemical prospecting. Ginzburg. I.I. Petgamon Press, N.Y. London.
3. Biochemical methods of Prospecting - Malyuga, D.P.
4. Principles of Mining Geology, Arokiaswamy.
5. Geological prospecting and exploration – Kreiter,V.M.
6. Rock geochemistry in Mineral Exploration. G.J.S.Govett. Elsevier Publication. 1983.

HARD CORE : ADVANCED IGNEOUS AND METAMORPHIC PETROLOGY [LTP / CREDITS = 202/4]

Unit 1: Igneous Petrology: IUGS and Chemical classification of Igneous rocks, Classification, texture and its petrogenetic significance, origin of Granite, Syenite, gabbro, and Layered Igneous complex , Kimberlite, Anorthosite, Carbonatite and Peridotite. Mineralogy, classification, textural peculiarities and origin of Pegmatite, Dolerite, Lamprophyre, Basalt, Rhyolite, Trachyte and Andesite. Add a note on their economic importance and Indian occurrence.

Unit2:Metamorphic Petrology: Introduction, Definition, Limits and agents of Metamorphism.Structures and Textures of Metamorphic rocks- Types of metamorphism based on

principal process (Orogenic, Hydrothermal, Burial, Regional, fault zone, Ocean floor metamorphism Prograde- Retrograde, progressive retrograde metaorphism. Regional and Contact Metamorphism of Peiltic and impure Calcareous rocks. Major metamorphic rocks. Protoliths and types- Zones of Metamorphism. Metamorphic reactions- Kinetics of metamorphism- Mineral assemblages equilibrium/Reaction. Characteristics of different grades and facies of metamorphism, Metasomatism and Granitization, Migmatites. Plate tectonics and Metamorphic Zones. Paired metamorphic belts. Metamorphism of mafic rocks and meta peilites, meta carbonate rocks. Material transport through metamorphism, metamorphism and dynamic process through P-T-t path. Metamorphic field gradient and tectonic cycle.

Unit 3: ***Practicals: Igneous petrology :*** Megascopic and Microscopic identification of different types of Igneous rocks. Significance of micro-textures in understanding magmatic and tectonic process.

Unit4: ***Practicals: Meatamorphic Petrology:*** Megascopic and Microscopic identification of different types of metamorphic rocks (1.Gnessic group, 2.Amphoblite group, 3. Mafic group, 4. Granulite group, 5. Schistose group, 6.Meta sedimentary group). Significance of structure and micro textures in understanding metamorphic and tectonic process.

References:

1. Petrology of Igneous and Metamorphic rocks by Hyndman
2. Principles of of Igneous and Metamorphic rocks by Anthony R. Philpotts.
3. Igneous petrology by Anthony Hall
4. Petrology of Igneous and Metamorphic rocks by Best.
5. Sedimentary Petrology – Pettijohn
6. Petrography – An introduction to the study of rocks in thin sections – H Kowell, Williams and Turner.
7. Hand book of subsurface geology – C.A. Moore
8. Petrography – An introduction to the study of rocks in thin sections – H Kowell,,Williams and Turner.
9. Migmatites - Ashworth.
10. Metamorphism - A. Methuen & Co.
11. Migmatites and the origin of granitic rocks - Mehnert K.R. Elsevier & Co.
12. Metamorphism and Metamorphic rocks - Miyashro, A. George, Allen and Unwin.
13. Petrogenesis of metamorphic rocks- Winkler, H.G.F. Springer, verly.

HARD CORE: SEDIMENTARY PETROLOGY & GEOTECTONICS [LTP / CREDITS = 202/4]

Unit 1:Sedimentary Petrology: Aim, Scope and importance – Historical development - Relationship with other branches of geology. **Properties of Sedimentary rocks:** Textures of sedimentary rocks, Sedimentary facies and environment. Diagenesis of sediments. **Classification and description of sedimentary rocks:** Gravels, Conglomerates, Sand and Sandstones, Argillite, Non-evaporites and Evaporites, Heavy mineral studies, Grain size parameter Modes and Mechanism controls of sedimentation, Stoke's law, Primary Sedimentary structures, Tectonics and sedimentation. **Applications of sedimentary rocks** in Petroleum Geology.

Unit 2: Structural Geology: Principles of geological mapping; kinematic and dynamic analysis of deformation; stress-strain relationships for elastic, plastic and viscous materials; measurement of strain in deformed rocks; structural analysis of fold, cleavage, boudin, lineation, joint, fault and unconformities; stereographic projection of linear and planar structures; superposed deformation; deformation at microscale-dynamic and static recrystallisation, controls of strain rate and temperature on development of microfabrics; brittle and ductile shear zones; time relationship between crystallisation and deformation, calculation of paleostress.

Unit 3: ***Practical: Mega & Microscopy of Sedimentary Rocks*****:** Identification of Sedimentary rocks in hand specimens and thin sections. Identification of Structures in Sedimentary rocks. Grain size

analysis - sieving, analysis of roundness and sphericity by visual method

Unit 4: ***Practical: Structural Geology :*** Construction of geological cross-section, structural contour maps, Tracing of outcrops, Interpretation of underground structure from borehole data, solution to fault problems, use of stereographic projection in structural calculation, construction of rose diagram for structural data.

Reference:

1. Sedimentary Petrology – Pettijohn
2. Petrography – An introduction to the study of rocks in thin sections – H Kowell, Williams and Turner.
3. Manual of sedimenraty petrology – Krumbein and Pettijohn.
4. Principles of sedimentation – Twenhefel.
5. Sequence in layered rocks – Shrock, R.R
6. Procedures in sedimentary petrology – R.E. Carvar
7. Origin of sedimenrary rocks – Blatt, Middleton and Hurray.
8. Microscope sedimenraty petrology – A.V.Carrozi.
9. Sand and Sand Stones – Pettijohn, Potter and Siever.
10. Petrology of Sedimentary rocks – R.L.Folk.
11. Hand book of subsurface geology – C.A. Moore
12. Marine geology and Oceanography of the Aretic seas- Yuonne Herman.
13. Billings, M.P.(1978) Structural Geology – Prentice – Hall of India Private Ltd. New Delhi.
14. Suppe, J.(1985) – Principles of structural geology – Prentice – Hall.
15. Price, N.J. and Cosgrove, J.W. (1990) Analysis of Geologiucal Structure. Camb. Univ. Press.
16. Hobbs, B.E. Means D and Millions, P.F. (1976) an outline of structural geology. Press.
17. Ramsay, J.G. (1967) – Folding and fracturing of rocks. Mc.Graw Hills New Yark.
18. Badgley P.C. – Structural Geology for the exploration geologist.
19. Whitten, T- Structural Geology.
20. Ramsay, J.G. Structural Analysis of Metamorphic Tectonites.

HARD CORE : FUEL GEOLOGY & MINERAL ECONOMICS [LTP/CREDITS= 400/4]

Unit 1: Definition and origin of coal. Stratigraphy of coal measures. Fundamentals of coal petrology, peat, lignite, bituminous and anthracite coal. Microscopic constituents of coal. Indian coal deposits. Origin, migration and entrapment of hydrocarbons. Characters of source and reservoir rocks. Structural, stratigraphic and mixed traps. Geographical and geological distributions of onshore and offshore petroliferous basins of India.

Unit 2: Mineralogy and geochemistry of radioactive minerals. Instrumental techniques of detection and measurement of radioactivity. Radioactive methods of prospecting and assaying of mineral deposits. Distribution of radioactive minerals in India. Nuclear waste disposal and its geological constraints.

Unit 3: Introduction and concepts of mineral economics. Peculiarities in mineral deposits. Concepts in mineral exploration and mineral resource estimation. Classification of Indian mineral resources. Role of mineral industry in national economy. Strategic, critical and essential minerals. India's status in mineral production. Changing patterns of mineral consumption.

Unit 4: National Mineral Policy. Mineral Concession Rules. Mineral legislation in India. Mineral production, processing, co-products and by products. Mineral inventory. Consumption and substitution of minerals. Demand Analysis and market survey. Mineral conservation and environment. Mineral information system. Marine mineral resources and Law of Sea.

Reference Books:

1. Nuclear geology and Atomic mineral Resources – S.N. Virnave. Published by BharatiBhawan 1995.
2. Mineral Resources of India – D.K. Banerjee. Published by the world press.
3. Radioactive minerals – R. Dhanaraju –2005 published by Geological Society of India.
4. Economic Mineral deposits – A.M. Bateman
5. Geology of Mineral deposits – Smirnov U.G.
6. Indian Mineral Resources – Krishna Swamy.S.
7. Introduction to India Economic Mineral deposits – Sharma, N.L. & Ram, K.S.
8. Basic Petroleum Geology – P.K.Link
9. Petroleum Stratigraphy – R.L.Breuner
10. World Oil Energy Economics – H.A.Kerklelin
11. Jaharia Coal Field – D.Chandra
12. Petroleum Formation and Occurrence – B.P. Tissot
13. Petroleum Geology – Levorsen
14. Mineral Economics by Truscot, John Wiley and Sons, Inc, 1987.
15. An introduction to mineral Economics – K.K.Chatterjee. publisher : - Wiley Eastern. 1993.
16. Mineral Economics : - R.K. Ssinha and N.L.Sharma. Oxford and IBH publicatio

SOFT CORE

SOFT CORE : GEMOLOGY [LTP / CREDITS = 200/2]

Unit 1:Gemology: Introduction to Gemology, classification of gemstones, detailed study of different physical and optical properties of minerals with special reference to gem minerals. Physical- optical effects in gemstones. Colour and Cause of colour in gems, Colour enhancement in gems. Cutting and polishing of gemstones. A detailed study of important precious and semi-precious gem minerals, their characters and occurrences, World occurrences in general and Indian occurrences in particular (i)Precious varieties 1. Diamond 2.Gem corundum 3.Topaz 4. Emerald (ii) Semi-precious varieties Garnets, Quartz, Lapis lazuli, Turquoise and Organic gems.

Unit 2: Crystal Growth: Introduction to crystal growth and growth phenomena. Crystal Growth methods- Melt (Bridgeman, Crystal pulling, Czochralski technique, zone melting), Verneuil process from solution, flux growth. CVT/CVD technique, Sol gel technique, Hydrothermal growth (low temperature, low pressure, High temperature, high pressure). Sintering technique.

References:

1. Gems and Gem industry in India-GSI Memoir 45- R.V Karanth.
2. Gem and Gem Minerals – EH Kvans and CB Slawsan
3. Encyclopedia of Minerals and Gem stones - Edited by Michael O' Don Oghal.
4. Precious stones - by Max-Bauer Vol. I and II. Publisher Dover publications Ink. New york.
5. Gems and precious stones- Simon and Schusters, Publ.Fire side book publishers.
6. Gems and precious stones- Cally Hall, the apple press publishers
7. Gemmological instruments-Peter.G.read, Butterworth publ.
8. Gem stone enhancement-Kurt Nassau, Butterworth publ.
9. Rutley's Elements of Mineralogy- by H.H. Read, CBS publication
10. Dana's Manual of Mineralogy
11. GEMS by R.Webster - Batter work and co. ltd., London
12. Gemstones - Herbert Smith - Published by Methuen co. Ltd., London
13. Introduction to Rock forming minerals-Deer, Howie and Zussman.
14. Physical Geology-P.K.Mukherjee
15. Geology of India-R.Vaidyanathan and M.Ramakrishnan
16. Geology of Karantaka-B.P.Radhakrishna
17. Mineral Resources of Karnataka-B.P Radhakrishna
18. Encyclopedia of crystal , gem and metal magic by Scot Cunningham-Llewellyn world wide, 2011.
19. Crystals and crystal growing by Holden A.

20. Themodynamic basis of Crystal growth-: P-T-X phase equilibrium and non-stoichiometry-Jacob Greenburg
21. Modern Theory of crystal growth (crystals) A.A Chernov & Hener Muller- Krumbhaar
22. Crystal growth-: Theory & techniques, Vol.1 by Chlgoodman
23. Advances crystal growth research-: 11th International summer school on crystal growth - Furokouka & K. Nakajima.

OPEN ELECTIVE

OE- INDUSTRIAL MINERAL RESOURCES [LTP / CREDITS = 200/2]

Unit 1: Definition of a Mineral. Classification of Minerals – Rock forming minerals & Ore forming Minerals, Silicate and Non-Silicate minerals. Physical, Chemical and optical properties of Minerals. Description of Industrial Minerals: Gold, Silver, Coal, Copper, Diamond, Asbestos, Barite, Calcite, Diatomite, Feldspar, Gypsum, Kaolin, Mica, Silica, Talc, and Zeolite.

Unit 2: Minerals Used in Paint, Fertilizers, Pesticides, Abrasives, Refractories, Ceramics, Glass, Pharmaceuticals, Petrochemical and Nuclear Energy**.** Gem Minerals: (i) Precious varieties 1. Diamond 2.Gem corundum 3.Topaz 4. Emerald (ii) Semi-precious varieties Garnets, Quartz, Lapis lazuli, Turquoise and Organic gems. Minerals Used in Civil work: Sandstones, Marbles, Granites, Sand and Gravel.

References:

1. Industrial Minerals and Thier Uses: a hand book and formulary. Ed. By Peter A Ciullo, Noyes Publications, 1996,
2. India's Mineral Resources by S. Krishnaswamy, Revised by R.K.Sinha, Oxford & IBH Publishing Co.PVT. LTD.

IV SEMESTER

HARD CORE PAPERS

HARD CORE: GEOCHEMISTRY AND GEOCHRONOLOGY [LTP / CREDITS = 301/4]

Unit 1: Geochemistry: Earth in relation to solar system and universe, Cosmic abundance of elements, Geochemical classification of elements, Primary differentiation of the earth. Composition of the planets and meteorites, Structure and composition of earth and distribution of elements. Geochemistry of hydrosphere, biosphere and atmosphere. Carbon capture and sequestration studies. Role of trace and REE in magmatic processes. Geochemical principles in rock cycle (geochemical cycle).

Unit 2: Geochronology: Radioactivity and radioactive decay schemes. Radiometric dating, importance of Pb and Nd isotopes in geological processes. Radiogenic isotope systematics: U-Pb, Rb-Sr, Sm-Nd and C^{14} systematics. Stable isotopes: Carbon, Oxygen, Hydrogen and Sulphur.

Unit 3: Petrogenesis: Steady state geotherms, Phase, phase diagram, phase rule, Unary system with examples of water and Al_2SiO_5, binary (Diop- An System & Fo-Fa system) and ternary system. Properties of magma, critical point and super critical fluids, congruent and incongruent melting, eutectic crystallisation, partial melting, miscibility and immiscibility in solids and liquids, peritectic point, perthites and antiperthites. Exsolution phenomena. Nucleation and diffusion processes in igneous, metamorphic and sedimentary environments. Redox reactions and Eh-pH diagrams and their applications.

Unit 4: ***Practicals:*** P-T calculations and construction of P-T diagrams. Petrochemical calculations-Niggli verte and Niggli base, CIPW norm calculation, Trilinear plots , construction of Variation/

Discriminant diagrams using major, trace and REE geochemistry data and interpretation. Isotopic age determination of rocks/minerals.

References:

1. Geochemistry- William.M.White-Wiley black well publications
2. Introduction to carbon capture and sequestration- BerendSmit, Jeffrey.A. Reimer, CurtisM. Oldenburg and Ian.C.Bourg.
3. Rare earth element Geochemistry by Henderson
4. Geochemistry by Rankama and sahama
5. Petrologic Phase equilibria – W.G.Ernst
6. The Interpretation of Geological Phase diagrams - Ernest G Ehlers
7. Petrogenesis – Wilson
8. Solutions, Minerals and Equilibria – Garrels and Christ, 1966
9. Simulating the Earth- J.R. Holloway and B.J. Wood,1988
10. Basic analytical Petrography – Ragland, 1989
11. Principles of Igneous and Metamorphic Petrology by Antony R Philpotts, 1979.**1.**
12. Geohemical Thermodynamics by Darrell Kirk Nordstrom and James L. Munoz
13. Chemical Thermodynamics for earth scientists by Philip Fletcher, 1993
14. Chemical Fundamentals of Geology by Robin Gill.
15. Elementary Thermodynamics by B.J. Wood and D.G. Fraser, 1976
16. Equilibrium Thermodynamics by Roger Powell
17. Prinicples of Geochemistry – Brain Mason
18. Geochemistry by Anderson
19. Chemical Thermodynamics by Bruce H Mahan

HARD CORE: REMOTE SENSING AND GEO SPATIAL TECHNOLOGY [LTP / CREDITS = 202/4]

Unit 1: Remote Sensing: Basic Principles and elements of Remote Sensing. Energy Interactions with the Atmosphere. Radiation and Black Body Radiation. Types of Remote Sensing, Sensors. Scanners and their capabilities. Platforms - Types of Platforms, capabilities of Indian Satellite Remote Sensing. Satellite Data Products with the scale and their characteristics. Resolution and types of Resolution. Digital Image Processing. Remote Sensing in Visible, Infrared, Microwave and Thermal regions. Application of RS in geomorphology, lithological mapping, structural mapping, mapping of ground water potential zones and mineralized zones. Remote Sensing for Disaster Management. Global Satellite Data Sources. Hyperspectral studies, application on environmental aspects, climate change and global warming

Unit 2: GIS: Definition of Geographic Information System, elements of GIS. The nature of geospatial information and data representation. Cartography - Maps and map projections. Cartographic symbology. Components of GIS. Database used in GIS. Data Structures: Relational, hierarchical and network. RDBMS. Data models used in GIS. Spatial data models. Vector data Model. Raster data Model. DEM. TIN. Vector and Raster -advantages and disadvantages. Attribute data models. Topological relationships of spatial data. Data Sources, components of GPS and DGPS. Data input techniques. Digitization of maps and imageries; Coordinate transformation; Attribute data generation. Spatial data layers. Data retrieval and querying. Spatial analysis - Spatial overlay operations, buffering, trend surface mapping. Network analysis and proximity analysis; 3D models. GIS Modeling for decision support. Applications of GIS in earth's resources evaluation and management.

Unit 3: ***Practicals: Remote Sensing:*** Visual and Digital interpretation of Topomaps and Satellite Imageries. Interpretation and Demarcation of lithological Units. Interpretation of Drainage patterns and water bodies. Interpretation and Measurement of Lineaments. Interpretation of Geological Structures, Interpretation of land use/land cover. Interpretation of vegetation. Interpretation of Mining and Mineralized zones. ERDAS imagine Functionalities (Geo referencing of Toposheet and satellite

image, image subsetting, resolution merge, stitching of images, Layer stacking).

Unit 4: Practicals : GIS: Methods of digitizing geospatial data(toposheet/ satellite image). Preparing contour maps. Georeferencing co-ordinates in scanned toposheets or maps and computing the geometrical properties of digitized zones. Methods of using DEM files, analysing hydrological components, basins, slopes, aspects and other features. Carrying out different kinds of spatial analysis including buffering, Proximity, split, clip and neighbourhood analysis. Application of GIS model for various spatial analysis using Arc GIS.

Reference:

1. Text book of Remote sensing and geographical Information system, 1st& 2nd Ed. By M. Anjireddy, BS Publications, Hyderabad
2. Remote sensing principles and Interpertations, 3rd edition, Floyd. F. Sabins
3. Applications of Remote sensing and GIS by H T Basavarajappa, Et. Al
4. Cartography: Visualization of Geospatial data – Menno-Jan Kraak and FerjanOrmeling
5. Principles and application of Photogeology – Shiv N Pandey
6. Aerial photographic interpretation, Principles and applications - D.R.Leuder.
7. Photogeology - Miller, J.C.
8. Mannual of colour aerial photography -Ed. Smith, J.T.Jr.
9. Manual of photogrammetry - Ed: MorrieM.Thompson.
10. Manual of Remote sensing - Ed: Robert G Reeves.
11. Theory of pattern recognition and modern forecasting - V.Karpin and Wright Pattern.
12. Remote sensing in Geology - Parry S. Siegal& Alan. R.Gillespie
13. Manual of photographic interpretation - Ed: Colwell, R.N.
14. Principles of Remote Sensing – Patel Singh; SP publication
15. Digital Remote Sensing – Pritivish Nag M Kudrat ; Concept publication
16. Principles of GIS for land and resources assessment, Burrough, P.A., 1986, Oxford.
17. Introductory cartography, Campbell, 1984, Prentice Hall
18. Map data processing, Freeman and Pieroni, 1980, Academic Press.
19. An introduction to Geographical information systems: Ian Heywood et. al.
20. Geographical information systems and digital image processing – Muralikrishna 1999. Allied Publication
21. Fundamentals of remote sensing and Geoinformatics , by Anjireddy, Hyderabad ed. 1and 2.
22. Geographic Information Systems: An Introduction, 3rd Ed, Bernhardsen,John Wiley & Sons, 01-Jan-2007 - 444 pages
23. Geographic information systems and science, Paul Longley,Wiley, 13-Jul-2001 - Education - 454 pages
24. Geographic Information Systems for Geoscientists: Modelling with GIS, Graeme F. Bonham-Carter,Elsevier, 18-May-2014 - Science - 416 pages
25. Geographic Information Systems and Science, Paul Longley, John Wiley & Sons, 22-Mar-2005 - Science - 517 pages
26. Handbook on Geographic Information Systems and Digital Mapping,United Nations. Statistical Division, United Nations Publications, 2000 - Census - 197 pages
27. Introductory Readings In Geographic Information Systems,D J Peuquet, D F Marble,CRC Press, 16-Dec-2003 - Technology & Engineering - 371 pages
28. Geographic Information Systems (GIS) and Mapping: Practices and Standards, Issue 1126, Arnold Ivan Johnson, C. BerntPettersson, ASTM International, 01-Jan-1992 - Travel - 346 pages
29. Introduction to Geographic Information Systems,Kang-tsungChang,McGraw-Hill Education, 16-Jan-2015 - Science - 448 pages
30. Fundamentals of Geographical Information Systems,Michael N. DeMers,Wiley, 2009 - Science - 443 pages
31. Textbook of Remote Sensing and Geographical Information Systems,KaliCharanSahu,Atlantic Publishers & Dist, 01-Dec-2007 - 512 pages
32. Geographic Information System,B. Gurugnanam,New India Publishing, 09-Jun-2009 - Geographic information systems - 206 pages
33. Fundamentals of Geographical Information Systems,Michael N. DeMers,Wiley, 2009 - Science - 443 pages

HARD CORE: DISSERTATION [LTP / CREDITS = 015/6]

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. The Dissertation entails fieldwork, lab investigations, preparation of report, its presentation and viva voce. Out of six credits one credit is for tutorials of the dissertation work.

Following are the components of the dissertation work:
a) Literature review and origin of the research problem
b) Objective/s and Methodology
c) Observations and the data **recorded by the candidate**.
d) Details of laboratory investigations,
e) Synthesis of results and interpretation
f) Concluding remarks and future direction.

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, a teacher from the parent department would be the supervisor/ internal guide and an expert from the industry/ research organization the co-supervisor/ external guide. Every student has to do the dissertation work independently. The project title, content and layout should be unique. The project reports of students should not be identical in content.

SOFT CORE

SOFT CORE :PRECAMBRIAN CRUSTAL EVOLUTION & TECTONICS [LTP / CREDITS = 400/4]

Unit 1: Geological time span. Early earth features. Mountain Building activity. Era- Breaking up of Pangea- the Precambrian- Hadean, Archean, Proterozoic, Structure of the Earth. A magma of Ocean- Composition of early Crust- Solidifying Basalt. The earth hotspot and fluid basalts. Lithosphere and Mantle reactions. Origin of the crust. Lower crust-first continents , early continental crust. Growth of crust- Mechanism of continental growth and its growth rate.

Unit 2: Growth of Continents. Primary Atmosphere. Secondary Atmosphere .Oxygen in atmosphere- geologic indicators of atmosphere-BIFs of Precambrian. Red beds, sulfates and Detrital uraninite and Pyrites, Decreasing Heat in Precambrian Time. paleosols –Biological indicators. Ocean prevailing theory, outgassing. Life in Archean Proterozoic orogeny. Earth- Moon system.

Unit 3: Precambrian mineral Deposits. Proterozoic life oldest rocks. Continental foundation. Distribution of Precambrian rocks. Proterozoic tectonics. Proterozoic assembly of laurestia- Proterozoic oxygen rocks. atmosphere- Precambrian assembly of Rodinia- grenville orogeny – Proterozoic rifting. Mid-continent rift- snowball earth. Crustal provinces- Precambrian provinces of North America. Cratons of America- hadean Crust. Archean and Proterozoic: Shield areas- Canadian Shield. Archean rocks. Green stone belt of South Africa. Cratons - Origin of Cratons, Rift Valleys, Mobile belts, Archean mineral resources and Proterozoic sedimentary basin in India.

Unit: 4: Tectonic features of extensional-, compressional-, and strike-slip-terrains and relevance to plate boundaries. mantle plumes. Himalayan Orogeny, Plate tectonics in the Precambrian.

Reference:
1. Archaean Geology- C.S. Pichamuthu
2. Early Precambrian supracrustal of southern Karantaka-Memoir 112. Geol.Surv. Ind
3. Geology of Karantaka- B.P Radhakrishna
4. Geology of India (Volume 1 and 2)- R.Vaidyanathan and M. Ramakrishnan

5. Geology of India and Burma- M.S Krishnan
6. Geology of India- M. Wadia
7. Crustal Evolution and Metalogeny in India- Sanib Chandra Sarkar and Anupendu Gupta