Punyashlok Ahilyadevi Holkar Solapur University, Solapur

NAAC Accredited-2022
'B^{++}' Grade (CGPA 2.96)

Name of the Faculty: Science & Technology

New Education Policy 2020

Syllabus: Applied Geology

Name of the Course: M. Sc. I (Sem.– I & II)

(Syllabus to be implemented from June 2023)

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

M.Sc Applied Geology

PREAMBLE:
Department of Applied Geology of Punyashlok Ahilydevi Holkar Solapur University is one of the oldest Departments in the Solapur district. The Department of Applied Geology at Punyashlok Ahilydevi Holkar Solapur University offers the Master of Geology (M.Sc.) program. This program is designed to provide deep knowledge and develop necessary skills to acquire good jobs in various Industries such as Petroleum, Geotechnical, NRSA, Groundwater consultancy, Gemology, Exploration, Mining and in Government sector. Over the past 40 years, the faculty members of department have been committed to improving curriculum, increasing experiential learning, and identifying best practices in teaching through rigorous assessment and review of our programs.

PROGRAM OBJECTIVES:
The program objectives for student's post graduating with a degree from Applied Geology are;
1. Effective use of literature for evaluation of data, hypothesis and conclusions.
2. To communicate scientific ideas and interpretations of data in writing.
3. An interdisciplinary approach for solving the geologic problems associated with earth's geological material.
4. Conducting advanced study in many areas of geology and also eliminate deficiencies in their geological education.
5. Prepare for jobs in the Geology or student may be enrolled in doctoral program.

PROGRAMME SPECIFIC OUTCOMES:
1. Students can understand effective use of scientific methods in the geological sciences. They should have thorough knowledge about the;
   a) Earth's interior, plate movement and the development of new features on the surface of the earth.
   b) Formation process and classification of rocks and mineral.
   c) Work of geological agents with the solid earth and the formation of new landforms.
   d) Sequential arrangement of the strata and establishing history of deposition.
2. Apply knowledge and techniques from allied fields, including chemistry, physics, biology, mathematics, and computing, to solve geological problems.
3. Acquiring basic skills of geological science including use of modern technology in presenting public data, hypothesis and conclusion.
4. Applying existing field and laboratory procedures to acquire original data, and using appropriate means to analyze research data.
5. Students participate in workshops/seminar/conferences on current geological issues.
6. Contributing in public issues related with geological sciences and be ready for resolution.
7. Develop and present scientific proposal, conduct original research for Master's thesis.

PAHSUS Proposed structure for Two Year PG Program (M. Sc. Applied Geology)

<table>
<tr><td rowspan="2">Level / Difficulty</td><td rowspan="2">SEM</td><td colspan="5">Major</td><td rowspan="2">Field Project/ RP/CC/Internship/ Apprenticeship/ Community Engagement & Services</td><td rowspan="2">Credits</td><td rowspan="2">Cumulative Credits</td></tr>
<tr><td>Mandatory</td><td>Practical</td><td>Elective</td><td>Practical Elective</td><td>Minor</td></tr>
<tr><td rowspan="2">4.5
100-200</td><td rowspan="2">I</td><td>DSC1-1
Mineralogy
(4 credits)</td><td>Practical DSC1-1
Mineralogy
(2 credits)</td><td rowspan="2">DSE 1-1 (4 credits)
1) Geochemistry
2) Sedimentology and Palaeontology
3) Geotechnical Engineering & Rock Mechanics</td><td rowspan="2">Practical based on DSE 1-1
(2credits)</td><td rowspan="2">Research Methodology (4 credits)</td><td></td><td>22</td><td rowspan="2">44
PG diploma in Discipline (44</td></tr>
<tr><td>DSC1-2
Igneous and Metamorphic petrology
(4 credits)</td><td>Practical DSC1-2
Igneous and Metamorphic petrology
(2 credits)</td><td>OJT/In-house Project/ Internship/ Apprenticeship (4)</td><td>22</td></tr>
<tr><td colspan="10">Exit option: Award of PG Diploma in Discipline with 44 credits OR Continue with Discipline</td></tr>
<tr><td rowspan="2">5.0/200</td><td rowspan="2">II</td><td>DSC1-3
Indian Stratigraphy
(4 credits)</td><td>Practical DSC1-3
Indian Stratigraphy
(2 credits)</td><td rowspan="2">DSE 1-2 (4credits)
1) Fundamental of Remote Sensing and GIS
2) Geomorphology
3) Watershed Management</td><td rowspan="2">Practical based on DSE 1-2
(2credits)</td><td rowspan="2"></td><td>RP (04)</td><td>22</td><td rowspan="2">88
PG degree in discipline</td></tr>
<tr><td>DSC1-4
Structural Geology and Geotectonics
(4 credits)</td><td>Practical DSC1-4
Structural Geology and Geotectonics
(2 credits)</td><td>RP (06)</td><td>22</td></tr>
</table>

Abbreviations:

OJT: On Job Training: Internship/ Apprenticeship , **FP:** Field projects, **RM**: Research Methodology , **RP**: Research Project

Paper No: DSC 1: MINERALOGY

Load/week:04 **Credits:04**

Marks: 80 **Internal:20**

Unit 1	Isotropic and anisotropic substances; Concepts of light under microscope, Reflection, refraction and refractive index; Relief, birefringence and Becke line effect; Optically uniaxial and biaxial minerals; Determination of optic sign of uniaxial and biaxial minerals, Determination of optic axial angle(2V); Interference figures; Pleochroism and determination of pleochroic scheme in minerals; X-ray crystallography and Bragg's equation; Application of X-ray diffraction spectrometry in mineral characterization;	
Unit2	Principle of crystal structure; Bonding in minerals; Silicate structures and structural formula; Isomorphism and solid solution; Types of ionic substitution; Polymorphism and types of polymorphic transformations; Pseudomorphism. A detailed study with reference to their atomic structure, chemistry, optical and physical properties and Paragenesis of the following Non silicates groups of mineral: Carbonates- Calcite Group, Phosphates- Apatite, Sulphates- Barite, Halides- Halite, Fluorite; Oxides and Hydroxides- Spinel Group, Hematite Group, Rutile Group.	
Unit3	A detailed study with reference to their atomic structure, chemistry, optical and physical properties and Paragenesis of the following Silicates groups of mineral: Nesosilicates- Olivine Group, Garnet Group and Aluminosilicate Group; Sorosilicates: Epidote Group, Cyclosilicates- Beryl, Inosilicates- Pyroxene Group, Amphibole Group; Phyllosilicate- Mica Group, Chlorite Group, Pyrophyllite: Talc; Tectosilicates- Quartz, Feldspars, Feldspathoides and Zeolite Group.	
Unit4	Crystals, crystalline solids and their formation; Ordered patterns, nets and lattices; Symmetry in crystals; Axial ratio, indices, lettering and order of the crystallographic axes; Crystallographic notation (Weiss and Miller indices and convention in notation); Classification of crystals, Introduction to 32 classes of symmetry; The crystal systems and symmetry types; Stereographic representation of crystal symmetry and their uses; Imperfection of crystals and crystal defects; Twinning- causes, effects and genetic types.	

REFERENCEBOOKS:

- Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans.
- Berry, L.G. and Mason, B. and Dietrich, R.V. (1983) Mineralogy, 2nd Edn, Freeman.
- Bunn, C.W. (1961) Chemical Crystallography, Clarendon.
- Deer, W.A., Howie, R.A. and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman. Donald Bloss (1971) Crystallography and Crystal chemistry, Holt, Rinehart and Winston.
- Hota, R.N. (2011) Practical Approach to Crystallography and Mineralogy, CBS Publisher and Distributors Pvt Ltd., New Delhi.
- Hutchinson, C.S. (1974) Laboratory Handbook of Petrographic Techniques, John Wiley.
- Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill
- Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.

- Phillips, Wm, R. and Griffen, D.T. (1986) Optical Mineralogy, CBS Edition.
- Putnis, Andrew (1992) Introduction to Mineral Sciences, Cambridge University Press.
- Santosh, M. (1988) Fluid Inclusions, Geological Society of India, Banglore.
- Slemmons, D.B. (1962)Determination of Volcanic and Plutonic Plagioclases using a three- or FourAxis Universal Stage, Geological Society of America.
- Spear, F.S. (1993) Mineralogical Phase Equilibria and Pressure -Temperature-Time Paths, Mineralogical Society of America Publication.
- Szymanski, A. (1988). Technical Mineralogy and Petrography, Elsevier.
- Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.

INTERNAL EVALUATION (20 Marks)

(Seminar + Term paper + Test)

PRACTICAL OF MINERALOGY

1. Physical properties of common rock forming minerals in hand specimen.
2. Optical properties of common rock forming minerals in thin sections.
3. Study of Interference figures of uniaxial and biaxial minerals and determination of optic sign.
4. Conversions of oxide and element weight percentages.
5. Calculation of mineral formulae.
6. Study of Crystallographic systems.

Paper No: DSC 2 : IGNEOUS AND METAMORPHIC PETROLOGY

Load/week:04 **Credits:04**

Marks: External : 80 **Internal:20**

Unit 1	Magma–physical and chemical properties and cooling behavior, magmatic crystallisation ,differentiation and assimilation Phase equilibria studies of binary and ternary silicate systems 1. Silica –Lucite, 2.Forsterite- Silica, 3.Orthoclase – Albite, 4.Diopside–Anorthites–Albite with petrogenetic significance, IUGS classification of igneous rocks, Magmatism related to plate tectonics- tholeiitic basalts, calc–alkaline magmatism.	
Unit 2	Petrogenetic, Chemical, Mineralogical and field aspects of important rocks of India–Deccan flood basalts ,Layered intrusions, Carbonatites, Granitoids and formation of perthites, Kimberlites, Lamprophyres.	
Unit 3	Metamorphism and metamorphic processes, characteristics of metamorphic reactions solid- solid, dehydration, decarbonation, Oxidation and their significance, Diagrammatic representation of mineral paragenesis– ACF,AKF,AFM ,Isograde and borrowian metamorphic zones, metamorphic facies differentiation, Retrograde metamorphism, metamorphism related to plate tectonics and paired metamorphic belts	
Unit 4	Eskolas regional metamorphic facies Zeolite Greenschist , Glaucophane schist, Amphibolite schist, Granulite, Eclogite, products of pelite, basic, ultrabasic and impure calcareous rocks. Thermal metamorphic facies sanidinite), Hornfels	

Reference Book:

1) Metamorphism and metamorphic belts Miyashiro A.
2) Metamorphic petrology Turner F.J.
3) Metamorphic petrology Turner and Verhoogen.
4) Igneous and metamorphic petrology by Turner and Verhoogen.
5) Metamorphic Petrology by Winkler.
6) The Dynamic Earth System, A.M. Patwardhan, PHI Publication
7) Deccan Volcanism, K.V. Subbarao and R.N. Sukheswala, Geological Society of India, Memoir.No:3
8) Principles of Igneous and Metamorphic Petrology, John D Winter, PHI Publication 9) Petrology: Igneous and metamorphic best.
10) Metamorphic petrology, Harker.
11) Petrology: Igneous, metamorphic, sedimentary, Elher/ Blatt.
12) Evolution of Igneous rocks, Bowen N.L.

INTERNAL EVALUATION **(30 Marks)**

(Seminar + Term paper + Test)

Practical Igneous and Metamorphic Petrology

IGNEOUS PETROLOGY:-

1. Study of the mineralogy and textures of igneous rocks in thin sections.

2. Calculation of CIPW norms and Niggli calculations for all types of saturated and unsaturated rocks. Megascopic and microscopic study of representative rocks.
3. Quantitative mineralogical studies on thin section and rock classification. Classification of igneous rocks under IUGS scheme
4. Classification of volcanic rocks under TAS scheme.

METAMORPHIC PETROLOGY:-

1. Study of representative metamorphic rocks megascopically and microscopically.
2. Study of mineralogy and structures of metamorphic rocks in thin sections, paragenetic (Chronological) interpretations.
3. Model analysis and calculations of ACF, AFM, AKF diagrams. Geothemobarometric calculations.

Paper No: DSE 1-1 : GEOCHEMISTRY

Load/week:04 **Credits:04**

Marks: External :80 **Internal:20**

Unit 1	Introduction to the principles of geochemistry. Formation of universe, Origin and cosmic abundance of elements, Geochemical composition of the Solar System, the Sun, Planets, Moon, Comets, Asteroids and meteorites; Geochemical composition of the earth and its constituent parts such as crust, mantle, core. Chemical Bonding: Ionic bonding, Ionic substitution in crystals, Crystal-field theory, Covalent bonding, Metallic bonds, Van der Waals bonds, Hydrogen bond; Goldschmidt's geochemical classification of elements	
Unit 2	Basic Thermodynamic Concepts: Aspects of equilibrium thermodynamics- enthalpy and entropy, free energies, chemical potentials, fugacity and activity. Few problems related to thermodynamics. Major, minor and trace elements and their representation on variation diagrams for presentation of geochemical data (bivariate, multivariate, element ratio variation, enrichment-depletion and vector diagrams); Primary differentiation of earth, Use of major elements for classification and characterization of igneous, metamorphic and sedimentary rocks.	
Unit 3	The composition of atmosphere, biosphere and hydrosphere, Global biogeochemical cycles (Carbon, Oxygen, Nitrogen and Sulphur cycles), Primary and secondary dispersion of elements and their use in geochemical exploration for mineral deposits; Anomalies and various methods of geochemical surveys; Eh-pH diagrams Mineral stability– Pauling rules, speciation of elements during magmatic crystallization. laws of Goldschmidt, Ahren rules and Ringwood rules, Secondary environmental geochemistry	
Unit 4	Discovery of radioactivity, radioactive decay and growth, Radioactive & stable Isotope, Dating techniques using Rb-SR, K-Ar, U-Th-Pb, C-14, Applications of above methods for determining ages of igneous, metamorphic and sedimentary rocks, Stable isotopes and their applications Oxygen and hydrogen in hydrosphere and atmosphere, in ore deposit, in igneous, sedimentary rocks. Quality controls of data generation, Wet and Dry chemical analysis, Partial and total analysis	

Reference Books:

- Geochemistry pathways and processes 2nd edition, Harryy.mc sween Jr, Steven M. Richards on and Maria E Uhle. Overseas Press
- Radioactive minerals, Dhanaraju, geological society of India, Banglore.
- Principles of Geochemistry, Mason and Moore; John Wiley & Sons
- Introduction to geochemisty .K.B. Krauskopf; Mcgraw- Hill Publication
- Geochemistry in Mineral Exploration. A.W. Rose, H.E. Hawkes &J.S. Webb; Applied Publication
- Handbook of Geochemistry Wadephol.
- Statistical Methods in Exploration Geochemistry. Govett. J. G.S. Elsevier Publication
- Stable Isotope Geochemistry, J.Hoefs, Springer- Verlag

PRACTICAL GEOCHEMISTRY

1. Demonstration of sampling methods for geochemical analysis.
2. Preparation of anomaly maps using chemical data.
3. Calculation of important indices related to petrogenesis and weathering.
4. Discriminant diagrams and interpretation of geochemical data.
5. REE and trace elements plotting and interpretation.

Paper : DSE 1-1 SEDIMENTOLOGY AND PALAEONTOLOGY

Load/week:04 **Credits:04**

Marks External :70 **Internal:30**

Unit 1	Introduction and principles of sedimentology, Sedimentary cycle and diastrophic cycle, Sedimentary processes : Weathering–Mechanical ,Chemical and Biological , Transport mechanism saltation, traction and suspension, Deposition by fluids, Reynold number and Froude number, their application. Sedimentary textures of clastic and nonclastic rocks,concept of size and shape, Shape aspects–sphericity and roundness, surface textures fractals, Fabric measurements.	**14**
Unit 2	Classification of sedimentary environments: continental, marine and transition. Structures in alluvial, fluvial, deltaic, lacustrine, coastal, marine, glacial and Aeolian conditions, classification of clastic and non clastic rocks, classification of sandstone, classification of sedimentary basin and their tectonic setting, products of various basins, heavy minerals and their significance in province studies . Dolomitisation and dedolomitisation, Lithification and types of diagenesis.	**14**
Unit 3	Concepts of fossil records its significance in mineral exploration stratigraphy and paleo□environmental studies, Morphology and classification of forminifera and their applications, morphology and classification of trilobites and their significance.	**14**
Unit 4	Evolution of 1.Devonian fishes, 2. Mesozoic reptiles, Siwalik mammals and their paleogeology, Gondwana flora, evolution of man.	**14**

REFERENCE BOOKS:

1. An introduction to sedimentology, Selley R.C.,Academic press.
2. Sedimentary rocks 3rd edition, Pettijohn F.J., CBS Publication Stratigraphy and sedimentation 2nd edition, W.H. Freeman and Co.
3. Principles of sedimentology, Friedman and Sanders J.m., John Wiley.
4. Origin of sedimentary rocks., Blatt H., Middleton Gand Murry R, Pentile Hall.
5. Petrology of sedimentary rocks., Folk R. L., Hemphill publication Co.
6. Sedimentary petrology: An introduction., Tucker M.E., ELBS., Blackwell Scientific Publication.
7. Applied sedimentology – Sukhtankar R.K . CBS Publishers.
8. Invertebrate palaeontology and evolution(2nd ed.) By Clarkson E.N.K.
9. Elements of Palaeontology Babin C.
10. Principles of Invertebrate Paleontology Shock & Twenhofel.
11. Paleontology of Vertebrates Jean Chaline.
12. Macropaleontology Bignot.
13. Paleontology Invertebrate Wood. Henry.

INTERNAL EVALUATION **(30 Marks)**

(Seminar + Term paper + Test)

PRACTICAL SEDIMENTOLOGY & PALAEOTOLOGY

1. Megascopic and Microscopic characters of Clastic rocks, Limestone and heavy minerals.

2. Study of Sedimentary structures and their attributes, study of sedimentary textures -size analysis by sieving and other techniques.

3. Determination of sphericity and roundness of grains, graphical presentation of data and determination of statistical parameters; insoluble residue analysis and preparation of acetate peels of limestone.

4. Identification and study of Invertebrate fossils, illustration functional morphology and classification. Identification of Micro-fossils-foraminifera and ostracoda.

5. Identification of plant fossils- Gondwana and intertrappean. Sample preparation in micropalaeontological studies

Paper No: DSE 1-1 Geotechnical Engineering & Rock Mechanics

Load/week:04 **Credits:04**

Marks: External :80 **Internal:20**

Unit 1	Scope of geology in civil engineering and mining industry; Various stages of engineering geological investigations for civil engineering projects; Engineering properties of rocks and soils: soil classification, rock discontinuities; Physical characters of building stones, metal and concrete aggregates; Use of remote sensing in engineering geology.	
Unit 2	Preliminary geological investigations for the various engineering projects: dams, reservoirs, tunnels, highways, bridges, hydroelectric power projects, shoreline and airfield engineering; Case history of engineering projects and geological causes for mishaps and failure of engineering structures.	
Unit 3	Mass movements with special emphasis on landslides and cause of hill slope instability; Earthquake and seismicity, seismic zones of India, aseismic design of building; Influence of geological conditions on foundation and design of buildings.	
Unit 4	Geophysical methods for the selection of engineering sites; exploratory drilling, study and construction of subsurface sections based upon drilling data; Core logging: core recovery, preservation of cores, R.Q.D. analyses; Preparation and presentation of geotechnical reports.	

Reference Books :

1. Jaeger – Rock Mechanics in Engineering, Cambridge Univ Press London, 1990.
2. Megaw T. M.& Tunnels: Planning, Design, Construction
3. Goodmann – Engg. Geology.
4. J. V. Bartlett - Int. ED, Ellis Horwood ltd. John Willey & Sons
5. Bieniawski Z. T. - Engineering Classification of jointed Rock Masses.
6. Introduction to Rock Mechanics by B. P. Verma-Khanna Pub New Delhi

INTERNAL EVALUATION **(20 Marks)**

(Seminar + Term paper + Test)

PRACTICAL GEOTECHNICAL ENGINEERING & ROCK MECHANICS

1. Study of Engineering Geological map
2. Study and Interpretation of seismic zonation map of India
3. Preparing geological cross sections from drill hole data & using them for designing of civil engineering structures in folded & faulted region, spillways on igneous rocks etc.
4. Study of soil profile of different terrains of India
5. Study of Morphometric parameters of terrain
6. Computation of RQD & Joint Frequency Index

Paper No: Research Methodology

Load/week:04 **Credits:04**

Marks: External :80 **Internal:20**

Unit 1:	Formulation of Research Problem: Criteria of quality research, types of research, significance, literature review, purpose, process of literature review, analysis of an article, search engine, formulation of research problems. Research ethics and plagiarism	**14**
Unit 2:	Definition of problem, objectives of research, planning of experiments, data collection and record keeping, results and discussions, presentation of research outcome as a research paper or filing patent	**14**
Unit 3:	Indices, publications, types, Impact factor, calculation of Impact Factor, uses, Calculation of immediacy Index, SCOPUS index, h – index, advantages, criticism ISSN, ISBN numbers.	**14**
Unit 4:	Various search engines available on internet, normal vs advanced search, key –words, formulation of search statement, Listing various journals in relevant topic, Science abstracts, e – database. Application of Computers in research, internet browsing, tool bar options, provisions of MS – word, MS – Excel, MS – PowerPoint, Coral draw, SPSS	**14**

Reference Books:

1. Research Methods - Ram Ahuja, Rawat Publications
2. Philosophy of Science – Mario Bunge, Transaction Publishers
3. Research Methodology - Methods and Techniques, C. R. Kothari New Age
4. Fundamentals of Statistics - Goon, Gupta and Das Gupta (Vol. I & Vol. II)

INTERNAL EVALUATION **(20 Marks)**

(Seminar + Term paper + Test)

SEMESTER II

Paper No. DSC 1-3 : INDIAN STRATIGRAPHY

Load/week:04 **Credits:04**

Marks: External :80 **Internal:20**

Unit 1	Approaches to measurement of geological time; Surface and subsurface stratigraphic procedures, Stratigraphic Principles and concept of Litho, Bio and Chrono Stratigraphy, brief idea about sequence, magneto- seismic-chemo- and event stratigraphy; Stratigraphic correlations (Litho-, Bio- and Chronostratigraphic Correlation)	**14**
Unit 2	Precambrian Stratigraphy of Peninsular India. Classification, Structure and Tectonics of Archaean Provinces of Peninsular India. Archaeans of the Extra- Peninsular region. Archaean- Proterozoic boundary problem Stratigraphy, classification and evolution of the following proterozoic basins of Peninsular India. Cuddapah Basin, Vindhyan Basin, Delhi-Arvalli Supergroup, Pranhita- Godavari Basin, Indravati Basin, Bhima-Kaladgi Basin, Chhattisgarh basin	**14**
Unit 3	Stratigraphy, tectonic and classification of Gondwana formations of India. Palaeozoic stratigraphy of Himalayan sequences from Kashmir, Spiti, Kumaon region, Cambrian of Spiti, Triassic of Spiti, Triassic of Pin valley. Indus Ophiolite belts, Trans-Himalayan and Karakoram granite batholiths. Stratigraphy, classification and evolution of the Siwalik group. Stratigraphy, tectonic and classification of Deccan volcanic, Stratigraphy and classification of marine transgression in South India, Stratigraphy and classification of Jurassic formation in Kutch,	**14**
Unit 4	K.T. boundary problem, Quaternaries of Peninsular India, Rise of Himalaya, Glacial periods in Indian stratigraphic, Neogene-Quaternary boundary	**14**

Reference Books :

1. Historical Geology and Stratigraphy of India Ravindra kumar
2. Geology of India & Burma D.N.Wadia
3. A Manual of Geology of India and Burma Pascoe volume1,2,3,4
4. Geology of Maharashtra, G, G, Deshpande, Geological Society of India, Banglore.
5. Geology of India Vol.1.and Vol2. Ramakrishnanand Vidynathan,
6. Geological Society of India, Bangalore.

INTERNAL EVALUATION **(20 Marks)**

PRACTICAL INDIAN STRATIGRAPHY

1. Preparation of Indian stratigraphy column
2. Identification of Precambrian Stratigraphy of South India. Preparation of Dharwar distribution map.
3. Identification of purana basins of India.
4. Preparation of tectonic evolution map of cuddapah basin. Map showing evolution of vindhyan stratigraphy. Distribution of Aravali supergroup and Delhi group.
5. Preparation of map showing Gondwana supergroup and succession from type area. Map showing marine transgression of South India.
6. Tectonic evolution of Himalayas.

Paper No. DSC 1-4 : STRUCTURAL GEOLOGY AND GEOTECTONICS

Load/week:04 **Credits:04**

Marks: External :80 **Internal:20**

Unit 1	Introduction to structural geology: planes and line, Attitude, Bearing, Inclination, Strike, Dip, Apparent dip, Plunge, Trend and Pitch; Concept of primary and secondary structures, Types of stress and strain analysis using deformed objects homogeneous and heterogeneous deformations; Mohr circle, strain indicators, strain ellipse and reciprocal strain ellipse, behaviour of rocks with respect to stress and strain. Determination of infinite strains from originally spherical and ellipsoid ac markers.	
Unit 2	Introduction to folds: geometric classification of folds, mechanics of folding, folding in shear zones; buckling- states of strain within and outside buckled layers and field evidences of buckling; Ramsay's classification of folds. Introduction to faults: Geometric classification of faults and joints, Anderson's theory of faulting; types of shear zones(ductile and brittle), Determination of fault displacement; Recognition of faults; difference between fault and joint; Types of joints. Mylonites and cataclasites, their origin and significance; thrust (sheets, ramp anticline, thrust system, duplex brittle). Lineation and foliations morphology and classification significance of minor structures to determine major structures, Classification of unconformities and significance.	
Unit 3	Plate tectonics: Basic concepts and definition, types of plate margins & their characters and associated processes like magnetism, seismicity, volcanism mountain belts, Benioff zones. Tectonic evolution of continents, cratons and ocean basins. Tectonic framework of Indian subcontinent. Oogenesis: Precambrian and Phanerozoic orogenesis, source and nature of tectonic forces, comparisons of hypothesis of orogenesis – contraction, expansion, convection, Plume hypothesis and micro plate tectonic, sea floor spreading. Tectonic model of evolution of the Himalayas.	
Unit 4	Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. Ocean margins and their significance. Coastal geomorphology, Classification of coasts, erosional and depositional features , Lineament analysis, Neotectonic features and evidences-characteristic landforms, Methods of analysis of neotectonism, Climate and landforms.	

REFERENCEBOOKS

Structural Geology

- Ghosh, S.K. (1993) Structural Geology: Fundamental and Modern Developments. Pergamon Press.
- Hobbs, B.E., Means, W.D. and Williams, P.F. (1976) An outline of Structural Geology, John Wiley and Sons, New York.
- Marshak, S. and Mitra, G. (1988) Basic methods of Structural Geology, Prentice-Hall, New Jersey.
- Ramsay, J.G. (1967) Folding and fracturing of rocks, McGraw Hill.
- Ramsay, J.G. and Huber, M.I. (1983) Techniques of Modern Structural Geology, Vol. I, Strain Analysis, Academic Press.
- Ramsay, J.G. and Huber, M.I. (1987) Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.
- Ramsay, J.G. and Huber, M.I. (2000) Techniques of Modern Structural Geology, Vol.

III (Application of continuum mechanics), Academic Press.
- Turner, F.J. and Weiss, L.E. (1963) Structural analysis of Metamorphic Tectonites, McGraw Hill.

Geotectonics

- Condie, K.C. (1989) Plate Tectonics and Crustal Evolution, 3rd Ed., Pergamon, Oxford Press.
- Gass, I.G. (1982) Understanding the Earth, Artemis Press (Pvt) Ltd. U.K.
- Kearey Phillips and Vine, F.J. (1996) Global Tectonics, Blackwell Science, Oxford.
- Keary, P., Klepeis, K.A. and Vine, F.J. (2012) Global Tectonics, Third Edition (Reprint), Wiley-Blackwell, Wiley India Pvt. Ltd.
- Moores, E and Twiss, R.J. (1995) Tectonics, Freeman.
- Moores, Eldridge M. and Twiss, Robert J. (1995) Tectonics, Freeman and Company.
- Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice-Hall, New Delhi
- Storetvedt, K.N. (1997) Our Evolving Planet: Earths History in New Perspective, Bergen (Norway), Alma Mater Fortag.
- Summerfield, M.A. (2000) Geomorphology and Global Tectonics, Wiley.
- Valdiya, K.S. (1984) Aspects of Tectonics -Focus on south central Asia, Tata McGraw- Hill.
- Valdiya, K.S. (2010) The Making of India: Geodynamic Evolution, Macmillan Publishers India Limited.
- Windley, B.F. (1977) The Evolving Continents, John Wiley and Sons, New York.

INTERNAL EVALUATION (20 Marks)

(Seminar + Term paper + Test)

PRACTICAL STRUCTURAL GEOLOGY AND TECTONICS

1. Preparation and interpretation of geological maps and cross sections.
2. Structure contour maps, isopach maps and other facies maps, balanced cross-section, their importance in unraveling the geological history.
3. Structural problems concerning economic deposit based on orthographic and stereographic projections.
4. Solution to structural geology problems by orthographic and stereographic methods.
5. Completion of outcrops, construction of structural sections and interpretation of geological maps.
6. Plotting and interpretation of mesoscopic structural data.
7. Recording and plotting of the field data.

Paper No: DSE 1 - 2 : FUNDAMENTALS OF REMOTE SENSING and GIS
Load/week:04 **Credits:04**

Unit 1:	Concept of Remote Sensing : Electromagnetic energy, Interaction of EMR with atmosphere and earth material, atmospheric windows, EMR spectrum. Platforms, sensor types, MSS. Aerial Remote Sensing : Flight planning, types of aerial photographs. Photogrammetry – stereoscopic vision, scale, relief displacement, parallax, vertical exaggeration. Satellite Remote Sensing : LANDSAT & IRS characteristics, products and FCC.	
Unit 2:	Interpretation techniques, visual and digital in brief. Recognition of photo elements and terrain elements like size, shape tone, texture, pattern, shadow, sight and association. Terrain analysis: Relief, landforms, drainage pattern. Use of remote sensing in lithology, structure and geomorphology. Application of remote sensing in groundwater and mineral exploration.	
Unit 3:	Basic concept of GIS, components, history and applications. Hardware and software requirement for GIS. Map features, scale, resolution, accuracy and database extent. Map projection and parameters: Geographical co-ordinate system, types of projection and parameters, projection transformation and managing in GIS.	
Unit 4:	Geospatial data models: Spatial and non-spatial data, VECTOR AND RASTER models. GIS ANALYSIS : Digitization, editing and structuring of map data, overlay analysis. Digital elevation and terrain models (DEM/DTM),buffer analysis and query analysis. Use of GIS in lithological, structural, groundwater and mineral exploration. Introduction to Global Positioning System and its applications and limitations.	

Reference Books -

1) Principles and applications of photogeology by S.N. Pande
2) Photogeology and regional mapping by J.A.E. Allum.
3) Remote sensing and image interpretation by Lilley sand
4) Photogeology by Miller and Miller.
5) Thermal and microwave remote sensing by Sabins.
6) Photogeology by Panda
7) Textbook of Remote sensing and GIS by M. Anjireddy

PRACTICAL : Remote Sensing & GIS

1. Determination of photo scale and height determination
2. Study of different erosional, depositional landforms and tectonics landforms.
3. Interpretation of lithology and structures from aerial photographs and satellite imageries.
4. Study and analysis of lineaments and drainage from aerial photographs.
5. Nature of sources of geographical data.
6. Georeferencing and digitization
7. Preparation of DEM/DTM
8. Slope, buffer, mosaiking and overlay analysis

Paper No: DSE 1-2 Geomorphology

Load/week:04 **Credits:04**

Marks: External :80 **Internal:20**

Unit 1:	Nature of Geomorphology, Fundamental concepts in Geomorphology Major Geomorphic theories by 1) G.K. Gilbert 2) Davis 3) Penck 4) L.C. King 5)S.A. Schumm, Geomorphic theories in Indian context, Geomorphic processes and climatic control. Epeirogenic and Orogenic Earth movements , Theory of Isostasy, plate tectonics. Structural Geomorphology: Geomorphic expressions of Uniclinal structures, Fault structures & Folded structure.	**14**
Unit 2:	Concept & controlling factors of weathering, Types of weathering – Physical, Chemical & Biological, Geomorphic significance of weathering, Soils: Formation, Soil profile, Major soil groups, Paleosol; Mass wasting & Mass movement : concept, classification, factors of mass movement, Types of landslide; Hill slope; Normal cycle of erosion, Rejuvenation and associated features, Polycyclic relief. Sequent and Insequent drainage system, Types of drainage pattern, Linear and Areal aspects of the basin, Development and classification of river valleys.	**14**
Unit 3:	**Fluvial Geomorphology: T**ypes of river erosion, Depositional and erosional landforms of river. **Karst Geomorphology:** Karst topography, factors for the development Karst, Erosional landforms in Karst areas. **Coastal Geomorphology**: Agents of coastal erosion, Transportation work of sea, Erosional and depositional landforms. **Arid and semiarid Geomorphology:** Erosional and depositional landforms of wind. **Glacial Geomorphology:** Glacier types and movement, Erosional and depositional landforms of glacier.	**14**
Unit 4:	**Applied Geomorphology** : Applications of geomorphology in mineral prospecting, civil engineering, hydrology, structure, regional planning, urbanization. Lineament analysis. Neotectonism, Major geomorphic features of the Indian subcontinent, Geomorphology of Maharashtra	**14**

Reference books:

1) Geomorphology by Richard J. Chorley, Stanley A. Schumm, David E.Sugden.
2) Principles of Geomorphology Willam D. Thornbury.
3) Geomorphology Majeed Husain.
4) Geomorphology by Savindra Singh
5) Experimental fluvial Geomorphology Stanley A. Schumm, M. Paull Mosaley, W.E. Weaver.
6) Geomorphology and Remote Sensing in Environmental management S.Singh
7) Fundamentals of Geomorphology R.J. Rice
8) Geomorphology be Richard J. Chorley, Stanley A. Schumm, David E.Sugden.
9) The Evolving Continents by Windley.

PRACTICAL GEOMORPHOLOGY

1) Drainage basin and morphometry. Basin demarcation Ordering of streams – Strahler‟s and Horton methods
2) Soils Textural characteristics, study of representative soil profiles
3) Morphometric analysis Bifurcation ratio, Drainage density, Stream frequency, constant of channel maintenance
4) Landforms & Slope Identification of landforms on Toposheets, drainage pattern, Relief and slope analysis

Paper No: DSE 1-2 : Watershed Management

Load/week:04 **Credits:04**

Marks: External :80 **Internal:20**

Unit 1	**Watershed management –** Concept, need, principles & components of watershed management, integrated watershed management; Factors affecting watershed management; soil erosion and its types, modelling of erosion using Universal soil loss equation, socio-economic concept of watershed. Peoples participation in watershed management. **Groundwater Management:** Hydrologic cycle: precipitation, runoff, infiltration and evapotranspiration, Hydrographs. Subsurface movement and vertical distribution of groundwater, Springs, Classification of aquifers, Concepts of drainage basin and groundwater basin. hydrological properties of rocks – specific yield, specific retention, porosity, hydraulic conductivity, transmissivity, storage coefficient, Water table contour maps, Groundwater provinces of India, Hydrogeology and Zones of India. BIS and WHO parameters.	**14**
Unit 2	**Rainfall**: Formation precipitation/rainfall, rainfall pattern in India, rainfall parameters, rainfall measurement types. Estimating runoff processes, factors affecting runoff, design of peak runoff through rational and cook's method. **Rain Water Harvesting**: Introduction to rainwater harvesting; Rainwater harvesting systems; scope of Rainwater harvesting; benefits & disadvantages of rainwater harvesting system **Coastal Waters Management:** Discussion of coastal water quality issues; impacts from watershed development, and coastal management techniques.	**14**
Unit 3	**Grassland waters management -** Definition of grassland, range land and pasture land and their classification. Major grass covers of India. Management of grass land, range and pasture to improve and maintain them and watershed management, carrying capacity of grassland range and pastures. Controlled grazing, rotational and deferred grazing management of grasses and legumes for special problem sites. Drainage of pasture land. **Dryland farming practices -** Principles of conservation farming in dry and irrigated lands; dry land farming choice of crops and cropping, tillage and manuring practices, seeding, mulching for moisture conservation, moisture judging for irrigation, consumptive use of water. Water requirement of crops, water use efficiency and evapotranspiration ratios.	**14**
Unit 4	**Agronomical practices -** Role of agronomy in soil conservation. Principles of scientific land management for soils conservation viz. (i) soil and water loss (ii) soil drainage (iii) soil structure and organic matter (iv) tillage and (v) soil fertility and fertilizer programmes. conservation cropping systems, soil depleting and soil building system, basis for selecting crop rotations for different soil & climatic zones. Mixed & cover cropping. **Strip cropping -** functions and types, methods of laying out strips, selecting crops for strips and inter-culture, procedure to fix strip width and strips ratios of erosion permitting to erosion resisting crops for different soil climatic belts. **Engineering measures -** Basic engineering measures for soil and water conservation, contour cultivation, bunding, terracing, continuous contour and staggered trenches, treatment of catchments, gully plugging, check dams, small storage structures, designing of simple bund structure.	**14**

Reference Books :

1. Common guidelines for watershed development projects (2008). Government of India
2. Dhruva N.V.V., Sastry G.O., (1990): Watershed management, ICAR, New Delhi.
3. Frevert R.K., Schwab G.O., Edminster T.W., and Barnes K.K. (2009) Soil and water conservation engineering, 4th edition, John willey and sons, New York.
4. Jain S.K. and Sing V.P. (2006) Water resources system planning and management, Elsvier India, New Delhi
5. Mukherjee A. (2004) Participatory learning and action: Monitoring and evaluation and participatory monitoring and evaluation, Concept publishing company, New Delhi.
6. Rao K.V.S. (2003) Watersheds: comprehensive development, B.S. Publication.
7. Sharda V.N., Sikka A.K. and Juyal G.P. (2006) Participatory integrated watershed management: A field manual, central soil and water conservation research training institute, Dehradun.
8. Singh R.V. (2003) watershed planning and management, Yash publication, Bikaner

PRACTICAL WATERSHED MANAGEMENT

1. Toposheets reading and analysis.
2. Study of drainage pattern.
3. Determination of contour interval and profile.
4. Determination of drainage density.
5. Rainfall profiling on regional scale.
7. Estimation of peak runoff
8. Estimation soil erosion

RESEARCH PROJECT (06)