SCHOOL OF ENVIRONMENTAL and EARTH SCIENCES

North Maharashtra University, Jalgaon

M. Sc. (Applied Geology)

Semester I

GS 101: Mineralogy and Crystallography.

GS 102: Principles of Stratigraphy and Palaeontology

GS 103: Sedimentology

GS 104: Practicals related to above courses

GS 105: Practicals related to above courses

GS 106: Tutorial 1

Semester II

GS 201: Igneous and Metamorphic Petrology

GS 202: Physics and Chemistry of the Earth.

GS 203: Geomorphology, Structural Geology and Tectonics

GS 204: Practicals related to above courses

GS 205: Practicals related to above courses

GS 206: Tutorial 2

Semester III

GS 301: Indian Stratigraphy.

GS 302: Indian mineral deposits, exploration and mining

GS 303: Remote sensing and GIS

GS 304: Practicals related to above courses.

GS 305: Practicals related to above courses.

GS 306: Seminar 1

Semester IV

GS 401: Petroleum geosciences.

GS 402: Hydrogeology

GS 403: Engineering and environmental geosciences.

GS 404: Practicals related to above courses

GS405: Dissertation

GS 406: Seminar 2

Note: Industrial training/Geological field mapping/allotted geological project work/ Dissertation is compulsory for M. Sc. (Applied Geology) students.

SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES
North Maharashtra University, Jalgaon
COURSE STRUCTURE WITH CREDIT
M.Sc. (Applied Geology)

	Course	Marks	Hrs./Week	Credit	Total
Semester I	GS-101	100	04	04	**21**
	GS-102	100	04	04	
	GS-103	100	04	04	
	GS-104	100	08	04	
	GS-105	100	08	04	
	GS-106	25	01	01	
Semester II	GS-201	100	04	04	**21**
	GS-202	100	04	04	
	GS-203	100	04	04	
	GS-204	100	08	04	
	GS-205	100	08	04	
	GS-206	25	01	01	
Semester III	GS-301	100	04	04	**21**
	GS-302	100	04	04	
	GS-303	100	04	04	
	GS-304	100	08	04	
	GS-305	100	08	04	
	GS-306	25	01	01	
Semester IV	GS-401	100	04	04	**21**
	GS-402	100	04	04	
	GS-403	100	04	04	
	GS-404	100	08	04	
	GS-405	100	08	04	
	GS-406	25	01	01	

Grand Total: 84

SEMESTER - I

GS-101: MINERALOGY AND CRSTALLOGRAPHY

Unit – I: Mineral Optics and Introduction to Instruments

1. Isotropic and anisotropic substances; 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; interference figures; Pleochroism and determination of pleochroic scheme in minerals
2. X-ray crystallography and Bragg's equation; Application of X-ray diffraction spectrometry in mineral characterization
3. Application of following techniques in mineralogy: Differential Thermal Analysis (DTA), Thermogravimetric Analysis (TGA), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) and Electron Probe Micro Analyser (EPMA)
4. Application of thermal, magnetic and radioactive properties of minerals.

Unit – II: Introduction to Mineralogy and Study of Non-Silicates

1. Principle of crystal structure; Bonding in minerals; Coordination and co-ordination numbers; Silicate structures and structural formula; Isomorphism and solid solution; Types of ionic substitution; Polymorphism and types of polymorphic transformations and Pseudomorphism Conversions of oxide and element weight percentages; Calculation of mineral formulae.
2. A detailed study of Non-silicates mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis of Non-silicates: Carbonates- Calcite Group, Aragonite Group, Dolomite Group; Phosphates- Apatite, Monazite; Sulphates- Gypsum, Anhydrite, Barite, Alunite Group; Halides- Halite, Sylvite, Fluorite; Nitrates- Trona, Soda niter; Oxides and Hydroxides- Spinel Group, Hematite Group, Rutile Group, Bauxite Group, Periclase.

Unit – III: Mineralogy of Silicates

1. A detailed study of Sillicate mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis of Silicates: Nesosilicates- Olivine Group, Garnet Group and Aluminosilicate Group; Sorosilicates- Epidote Group, Scapolite Group; Cyclosilicates- Beryl, Tourmaline; Inosilicates- Pyroxene Group,Amphibole Group; Phyllosilicate- Mica Group, Chlorite Group, Serpentine Group, Pyrophyllite, Talc; Tectosilicates- Quartz, Feldspars, Feldspathoides and zeolite Group.

Unit – IV: Crystallography

1. 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).

2. 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.

Unit – V: Gemology

1. Physical properties, Optical properties and Chemical properties of inorganic gems like Diamond, corundum, beryl, chrysoberyl, garnet, spinel, topaz, tourmaline, ziroon, peridot, jadeite, nephrite, opal, quartz, chalcedony, orthoclase, moonstone, labradorite, lapis lazuli, apatite, cordierite, zoisite, malachite, bowenite, denburite, diopside, enstatite, serpentine, steatite, natural glasses (obsidian and moldavite).
2. Study of Organic gems like Pearl, corals etc., their formation, structure and identification.
3. Introduction to instruments used in the study of gems.

Books Recommended

- 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.
- Donald Bloss (1971) Crystallography and Crystal chemistry, Holt, Rinehart and Winston.
- Deer, W.A., Howie, R.A., and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.
- Hutchinson, C.S. (1974) Laboratory Handbook of Petrographic Techniques, John Wiley.
- Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.
- Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill.
- 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.
- Spear, F.S. (1993) Mineralogical Phase Equilibria and Pressure - Temperature-Time Paths, Mineralogical Society of America Publication.
- Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.
- Slemmons, D.B. (1962).Determination of Volcanic and Plutonic Plagioclases using a three- or Four- Axis Universal Stage, Geological Society of America.
- Szymanski, A. (1988). Technical Mineralogy and Petrography, Elsevier.
- Hota, R.N. (2011) Practical Approach to Crystallography and Mineralogy, CBS Publisher and Distributors Pvt Ltd., New Delhi.

GS-102: PRINCIPLES OF STRATIGRAPHY AND PALAEONTOLOGY

Unit – I: History and development

1. History and development of Stratigraphy
2. Stratigraphic procedures (Surface and Subsurface)
3. Concept of Litho-facies and Bio-facies

Unit – II: Stratigraphic Correlation

1. Stratigraphic Correlation (Litho-, Bio- and Chrono-stratigraphic Correlation
2. Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic)
3. Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy
4. Techniques in Palaeontology - megafossils - microfossils - nannofossils - ichnofossils - collection, reformation and illustration - binomial nomenclature

Unit – III: Invertebrate Paleontology

1. Invertebrate Paleontology - A brief study of morphology, classification, evolutionary trends and distribution of Molluscs i.e. Bivalves, Gastropods and Cephalopods.
2. study of morphology, classification, evolutionary trends and distribution of Trilobites, Graptolites, Echinoids, Corals and Brachiopods.

Unit – IV: Vertebrate Paleontology

1. Vertebrate Paleontology - Study of vertebrate life through Geologic time scale.
2. Study of reptiles, birds, fishes and mammals.

Unit – V: Paleontological perspective

1. Introduction to Micropaleontology, Types of Microfossils, Paleo-palynology
2. Foraminifera and Ostracods
3. Plants of Gondwana Period.
4. Paleontological perspective : Use of paleontological data in
   a) Stratigraphy b) Paleo-ecology c) Paleogeography

Books Recommended

- Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988) Fossil Invertebrates, Blackwell.
- Clarksons, E.N.K. (1998) Invertebrate Paleontology and Evolution, Allen and Unwin, London.
- Dobzhansky, Ayala, Stebbins and Valentine (1977) Evolution, Freeman.

- Horowitz, A.S. and Potter, E.D. (1971) Introductory Petrography of Fossils, Springer Verlag.
- Mayr, E. (1971) Population, Species and Evolution, Harvard.
- Prothero, D.R. (2004) Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
- Raup, D.M. and Stanley, S.M. (1985) Principles of Paleontology , CBS Publishers, New Delhi.
- Smith, A.B. (1994) Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
- Strean, C.W. and Carroll, R.L. (1989) Paleontology – the record of life, John Wiley.

GS-103: SEDIMENTOLOGY

Unit – I: Field procedures

1 Field procedures in Sedimentary Petrology
2 Geologic cycle
3 Sedimentary textures (Granulometric analysis, shape and roundness studies, surface textures)
4 Heavy mineral and Insoluble residue analysis

Unit – II: Petrography

1 Petrography of rocks of clastic, chemical and biochemical origin (Conglomerates, Sandstone, Mudstone, Limestone and Dolomite)
2 Evaporite, Phosphorite, Chert, Iron and Manganese rich sediments
3 Volcanogenic sedimentary rocks

Unit – III: Clastic transport and fluid flow

1. Clastic transport and fluid flow (fluid flow in theory and in nature, Reynold's Numbers, Froude Number, Sediment lift, transport, deposition, sedimentary gravity flow)

Unit – IV: Sedimentary structures

1. Sedimentary structures (Physical structures, Biogenic sedimentary structures, Diagenetic structures).
2. Sedimentary Textures.

Unit – V: Sedimentation and Tectonics

1. Concept of Sedimentary facies association models (Marine, Nonmarine, and Mixed Depositional Environment)
2. Sedimentation and Tectonics
3. Paleocurrents and Basin Analysis.

Books Recommended

- Blatt, H., Middleton, G.V. and Murray, R.C. (1980) Origin of Sedimentary Rocks, Prentice-Hall Inc.
- Collins, J.D. and Thompson, D.B. (1982) Sedimentary Structures, George Allen and Unwin, London.
- Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
- Miall, A.D. (2000) Principles of Basin Analysis, Springer-Verlag.

- Pettijohn, F.J. (1975) Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.
- Reading, H.G. (1997) Sedimentary Environments and facies, Blackwell Scientific Publication.
- Reineck, H.E. and Singh, I.B. (1973) Depositional Sedimentary Environments, Springer-Verlag.
- Selley, R.C. (2000) Applied Sedimentology, Academic Press.
- Tucker, M.E. (1981) Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
- Tucker, M.E. (1990) Carbonate Sedimentolgy, Blackwell Scientific Publication.
- Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi

GS-104: PRACTICALS ON MINERALOGY, CRYSTALLOGRAPHY AND PALEONTOLOGY

1. Study of interference figures - determination of optical sign of minerals, determination of 2V and 2E, determination of composition of plagioclase feldspars - determination of birefriengence of minerals - Scheme of pleochroism
2. Construction of Stereograms and Gnomonograms - measurement of interfacial angle with contact goniometer - study of X-ray diffractograms
3. Study of rock forming minerals in thin sections
4. Study of rock forming minerals in hand specimens
5. Construction of rank charts for lithostratigraphy, biostratigraphy andchronostratigraphy
6. Construction of graphical logs from text descriptions
7. Exercises in correlation from given data or logs
8. Study of palaeontological technique related to megafossils.
9. Study of morphology of Bivalves, Gastropods Echinoids, Brachiopods
10. Separation, Processing, wet sieve analysis, preparation of slides of microfossils.
11. Morphology and morphological descriptions of planktonic and benthonic foraminifera, ostracodes.

GS-105: PRACTICALS ON SEDIMENTOLOGY

1. Size Analysis (Procedures, Cumulative curve, Histogram, Visher's curve and Statistical calculation)
2. Shape analysis (Calculation and Classification)
3. Heavy mineral analysis (Procedure and identification)
4. Insoluble residue analysis (Procedure and identification)
5. Megascopic and studies of conglomerate and breccia
6. Megascopic and microscopic study of sandstone
7. Megascopic and microscopic study of limestone
8. Sedimentary structure (identification and classification)
9. Paleocurrent and basin analysis calculation

SEMESTER – II

GS-201: IGNEOUS PETROLOGY AND METAMORPHIC PETROLOGY

Unit – I: Igneous Petrology

1. Magma- its nature and composition. Factors controlling evolution of magma
2. Classification of Igneous rocks - historic perspective and the IUGS systematic
3. Introduction to mantle petrology mantle metasomatism and mantle heterogeneities;
4. Magmatism in relation to plate tectonics
5. Chemical characteristics of igneous rocks in the following tectonic setting: Mid Oceanic Ridge, Island Arcs, Oceanic plateaus, Continental Margins, Continental Rifts and Continental intraplates; Plume magmatism and hot spots; Large igneous provinces, mafic dyke swarms and layered complexes.
6. Equipments used in petrological study: Scanning electron microscope (SEM), electron Probe Microanalysis (EPMA), Atomic Absorption Spectrophotometry, Inductively Coupled Plasma Mass Spectrometry (ICPMS) and infrared spectrometers.

Unit – II: Igneous Petrology

1. Mantle melting: Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting.
2. Crystallisation of magma, fractional crystallization and differentiation, liquid immiscibility and assimilation. Influence of volatiles and role of oxygen fugacity in magmatic crystallizations.
3. Phase equilibrium studies - binary systems, ternary systems and their relations to magma genesis and crystallization in the light of modern experimental works.

Unit – III: Igneous Petrology

1. Textures and structures of igneous rocks; Petrography and Interpretation of igneous textures in terms of rate of nucleation and crystal growth.
2. Major, Trace and Rare Earth Element systematics in igneous rocks
3. Silica/alumina saturation, variation diagrams (Harker, AFM and TAS diagrams) their applications and limitations; Mg Number, Alteration Index, Saturation Index and other geochemical parameters.
4. Fractional crystallization, liquid lines of descent and lever rule.
5. Indian Igneous Rocks and their genesis

Unit – IV: Metamorphic Petrology

1. Types of metamorphism and their controlling factors
2. Grades of Metamorphism
3. Common minerals of metamorphic rocks
4. Metamorphic Texture and Structures
5. Prograde and retrograde metamorphism, Metasomatism
6. Metamorphic facies

Unit – V: Metamorphic Petrology

1. Phase diagrams and graphic representation of mineral assemblages
2. Metamorphic reactions, elemental exchange and P-T conditions of isograds.
3. Plate tectonics and metamorphic processes.
4. Paired metamorphic belts, Archaean and Proterozoic terrains.
5. Pressure-temperature time paths in regional metamorphic rocks, Polymetamorphism

Books Recommended

- Best, M. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
- Bose, M.K. (1997) Igneous Petrology, World Press, Kolkata.
- Cox, K. G., Bell, J. D. and Pankhurst, R. J. (1979) The Interpretation of Igneous Rocks, Unwin Hyman.
- Faure, G. (2001) Origin of Igneous Rocks, Springer.
- Hall, A. (1996) Igneous Petrology, 2nd Edn., Longman.
- LeMaitre R.W. (2002) Igneous Rocks: A Classification and Glossary of Terms, Cambridge Uni. Press.
- McBirney, A.R. (2006) Igneous Petrology, 3rd Edn., Jones and Bartlett.
- Middlemost, E.A.K. (1985) Magmas and Magmatic Rocks, Longman.
- Parfitt, E. and Wilson, L. (2008) Fundamentals of Physical Volcanology, Wiley-Blackwell.
- Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
- Sood, M.K. (1982) Modern Igneous Petrology, Wiley-Interscience Publ., New York.
- Srivastava, R.K. and Chandra, R. (1995) Magmatism in Relation to Diverse Tectonic Settings, A.A. Balkema, Rotterdam.
- Wilson, M. (1993) Igneous Petrogenesis, Chapman and Hall, London.
- Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
- Bell, Keith (Ed.) (1989) Carbonatites: Genesis and Evolution, Unwin Hyman, London.
- Bell, K., Kjarsgaard, B.A. and Simonetti, A. (1998) Carbonatites – Into the twenty-first Century, Journal of Petrology, Spl. Vol.39 (11 and 12).
- Carmichael, J., Turner and Verhoogen (1974) Igneous Petrology, McGraw Hill.

- Fitton, J.G. Upton, B.J.G. (Eds) (1987) Alkaline Igneous Rocks, Geological Society, London.
- LeBas, M.J. (1977) Carbonatite-nephelinite Volcanis, Wiley.
- Rock, N.M.S., (1991) Lamprophyres, Blackie, Glasgow.
- Perchuk, L.L. and Kushiro, I. (Eds.) (1991) Physical Chemistry of Magmas, Springer Verlag.
- Gupta, Alok (1998) Igneous Rocks, Allied Publishers Limited.
- Allegre, C.J. and Hart, S.R. (1979) Trace elements in Igneous Petrology, Elsevier.
- Hughes, C.J. (1982) Igneous Petrology, Elsevier.
- Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi.
- Harker, Alfred (1964) Metamorphism, Methuen, London.
- Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
- Yardlley, B.W.D. (1989) An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.
- Philopotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Bhaskar Rao, B. (1986) Metamorphic Petrology, IBH and Oxford.

GS-202: PHYSICS AND CHEMISTRY OF THE EARTH

Unit – I: Universe and Planetary System

1. Origin and components of solar system
2. Meteorites and their classification
3. Earth in relation to the solar system and universe
4. Cosmic Abundances of elements
5. Composition of the planets and meteorites

Unit – II: Physics of the Earth

1. Seismic waves and their velocities
2. Internal structure of the earth,
3. Density distribution, shape and mass of the earth. density Vs depth profile.
4. Gravity and gravitational mechanics, gravity anomalies and their interpretation
5. The earth as Magnet, Earth's magnetic field, changes in magnetic field, origin of geomagnetic field, palaeomagnetism.

Unit – III: Introduction to Geochemistry

1. Introduction to Geochemistry – its scope, Geochemical Classification of the elements
2. Geochemical Cycle, path finder Elements, threshold values and Mode of Occurrence.
3. Geochemical classification and distribution of elements in the earth
4. Structure and atomic properties of elements
5. The Periodic table
6. Laws of Thermodynamics and phase diagrams
7. Geochemistry of hydrosphere, biosphere and atmosphere
8. Elementary crystal chemistry and thermodynamics
9. Structure Composition and evolution of the earth and distribution of elements.

Unit – IV: Geochronology and age of the Earth

1. Law of Radioactivity,
2. Principles of isotopic dating, Decay schemes and Derivation of equation of age.
3. Introduction to isotope geochemistry
4. Rb/Sr, U-Th-Pb methods of dating the rocks.
5. Age of the Earth.
6. Trace elements

Unit – V: Geochemical Methods

1. Geochemical methods – Geochemical Anomalies – Dispersion patterns – Geobotonical indicators of minerals – surface and subsurface methods of sampling.
2. Geological Principles of ore search – Introduction to Assaying and valuation of mineral deposits

Books Recommended

- Telford, W.M., Geldart, L.P., Sherrif, R.E. and Keys, D.A. (1976) Applied Geophysics, Cambridge Univ. Press.
- Howel, B.F. (1959) Introduction to Geophysical Prospecting, McGraw Hill.
- Lowrie, W. (1997) Fundamentals of Geophysics, Cambridge University Press.
- Mussett, A.E. and Khan, M.A. (2000) Looking into the Earth: An Introduction to Geological Geophysics, Cambridge University Press.
- Sharma, P.V. (1986) Geophysical Methods in Geology, Elsevier.
- Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
- Anderson, G.M. (2005) Thermodynamics of Natural Systems, Cambridge University Press.
- Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology. Prentice-Hall.
- Bloss, F.D. (1971) Crystallography and Crystal Chemistry, Holt, Rinehart, and Winston, New York.
- Drever, J.I. (1997) The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall.
- Evans, R.C. (1964) Introduction to Crystal Chemistry, Cambridge Univ. Press.
- Faure, G. (1998) Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersy, 593p.
- Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
- Hoefs, J. (1980) Stable Isotope Geochemistry, Springer-Verlag.
- Klein, C. and Hurlbut, C.S. (1993) Manual of Mineralogy, John Wiley and Sons, New York.
- Krauskopf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
- Rollinson, H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman U.K.
- Wood, B.J. and Fraser, D.G. (1977) Elementary Thermodynamics for Geologists, Oxford University Press, London.
- Rastogy, R.P. and Mishra, R.R. (1993) An Introduction to Chemical Thermodynamics, Vikash Pub. House.
- Anderson, G.M. and Crerar, D.A. (1993) Thermodynamics in Geochemistry-the equilibrium model, Oxford University Press, New York.
- Fletcher, P. (1993) Chemical thermodynamics for earth sciences. Longman Scientific and Technical, London.
- Glasstone, S. (1947) Thermodynamics for Chemists, East and West Pub.

GS-203: GEOMORPHOLOGY, STRUCTURAL GEOLOGY AND TECTONICS

Unit – I: Introduction to Geomorphology

1. Introduction to Geomorphology : History, basic concepts type and tools
2. Landforms : Role of lithology, climate and tectonics
3. Denudational processes - weathering, erosion, transportation, weathering products and soils - profiles, types, duricrusts
4. Hillslopes : Their characteristics and development, fluvial processes on hill slopes
5. River and Drainage basin : Drainage patterns, network characteristics, Valleys and their development. Process of river erosion, transportation and deposition

Unit – II: Geomorphic Landforms and Applied Geomorphology

1. Landforms produced by geomorphic agents
   a) Fluvial b) Coastal c) Aeolian, d) Glacial, e) Karst, and Desert landforms
2. Applied Geomorphology : Application of geomorphology in geohydrology, mineral prospecting, engineering geology, watershed management, urban planning and environmental studies
3. Geomorphology of India : Geomorphological features and zones
4. Geomorphic mapping
5. Slope analysis and drainage basin analysis
6. Physiographic zones of Maharashtra
7. Topographical maps

Unit – III: Introduction to Structural Geology

1. Principles of geological mapping and map reading
2. projection diagrams
3. Mechanical principles of rock deformation,
4. Behaviour of rock material under stress, strain analysis
5. Classification and genesis of folds, faults, lineations, foliations, joints and fractures

Unit – IV: Structural Analysis

1. Scope of structural analysis , concept of Tectonite fabric and Tectonite Symmetry
2. Structural analysis on microscopic, mesoscopic and macrosopic scales
3. Introduction to petrofabrics
4. Structural behavior of igneous rocks, diapers and salt domes diapers and salt domes

Unit – V: Tectonics

1. Structure and physical characters of continental and oceanic crust
2. seismic belts of the earth
3. Continental drift – geological and geophysical evidence, mechanics, objections, present status
4. Sea - floor spreading and Plate Tectonics, Structure and Tectonics of divergent margins, transform faults, convergent margins
5. Geodynamics of the Indian Plate and Tectonic framework of India
6. Heterogeneity of the earth's crust
7. seismicity and Plate movements
8. Neotectonics - Features and evidences-characterastic landforms, Methods of analysis
9. Orogeny and epeirogency
10. Isostasy
11. Gravity and magnetic anomalies at Mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains, , Island arcs, Oceanic islands and volcanic arcs,

Books Recommended

- 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.
- 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.
- Marshak, S. and Mitra, G. (1988) Basic methods of Structural Geology, Prentice-Hall, New Jersey.
- Condie, K.C. (1989) Plate Tectonics and Crustal Evolution, 3rd Ed., Pergamon, Oxford Press.
- Kearey Phillips and Vine, F.J. (1996) Global Tectonics, Blackwell Science, Oxford.
- Windley, B.F. (1977) The Evolving Continents, John Wiley and Sons, New York.
- Moores, E and Twiss, R.J. (1995) Tectonics. Freeman.
- Keary, P., Klepeis, K.A. and Vine, F.J. (2012) Global Tectonics. Third Edition (Reprint), Wiley-Blackwell, Wiley India Pvt. Ltd.
- Storetvedt, K.N. (1997) Our Evolving Planet: Earths History in New Perspective. Bergen (Norway), Alma Mater Fortag.
- Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice-Hall, New Delhi
- Gass, I.G. (1982) Understanding the Earth, Artemis Press (Pvt) Ltd. U.K.

- Moores, Eldridge M. and Twiss, Robert J. (1995) Tectonics, Freeman and Company.
- Valdiya, K.S. (1984) Aspects of Tectonics -Focus on south central Asia, Tata McGraw- Hill.
- Sharma, H.S. (1990) Indian Geomorphology, Concept Publishing Company, New Delhi
- Thornbury, W.D. (1980) Principles of Geomorphology, Wiley Easton Ltd., New York
- Kale and Gupta, Introduction to Geomorphology.
- Rice, Fundamentals of Geomorphology.

GS-204: PRACTICALS RELATED TO IGNEOUS AND METAMORPHIC PETROLOGY

1. Characterisation of Igneous rocks, textures and structures.
2. Characterisation of differentg rock types under microscope.
3. Igneous rocks and Metamorphic rocks
4. CIPW normative calcaluation for igneous rocks.
5. Variation diagrams (Binary and Ternary)

GS-205: PRACTICALS RELATED TO GEOMORPHOLOGY, STRUCTURAL AND TECTONICS

1. Structural problems by orthographic and stereographic methods.
2. Construction of structural sections and interpretation of geological maps.
3. Plotting and interpretation of mesoscopic structural data
4. Drainage basin and network morphometry
5. Relief and slope anlysis - Profiles and maps
6. Identification of landforms on toposheets, aerial photographs and satellite images
7. Study of representative soil profiles

SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES
North Maharashtra University, Jalgaon

Model for implementation of the

Credit-Grade based Performance and Assessment (CGPA) system

M.Sc. course

In tune with the concept and suggestions of the UGC and NAAC, technological advancement and social needs and to make the teaching effective and meaningful, School of Environmental and Earth Sciences has been permitted to adopt Credit-Grade based Performance and Assessment (CGPA) system from the academic year 2009-2010 for the course M.Sc. (Applied Geology) being run in the school. The modalities and operational details of the credit system shall be as follows.

A. Features of the CGPA System:

1. Master's degree course, M.Sc. being run in School would be of 84 credits each.
2. One credit for the theory course shall be of the one clock hour per week running for 15 weeks. Thus, each theory course of 4 h per week teaching shall be of 4 credits.
3. Four credits for each practical course shall be awarded to the 8 h of laboratory exercise per week for a semester. As per the guidelines of the work load, each batch for practical course shall consist of 10-12 students and each batch shall perform the laboratory exercise twice in a week. Thus, each practical course shall be of 8 h laboratory exercise per week with 4 credits.
4. Four credits shall be awarded to the Project course, which will commence from III Semester and the final work and report will be completed during IV Semester. The marks and the credits will be allotted in IV Semester.
5. Two credits, one each in first two semesters (i.e. for Semester I and II) have been allocated for the Tutorials/Home assignments. Besides, for every theory course one Take Home Assignments of 25 marks each shall be conducted. Average marks of all the home assignment in the given semester will be considered. No grade will be given for the tutorial. However, the completion of the credit for the tutorial shall be compulsory.
6. Two credits, one each in the III and IV semesters have been allocated for the Seminar. There shall be one seminar per student. Marks out of 25 will be allocated per semester for this as per break up given below in (g). No grade will be given for the seminar. However, the completion of the credit for the seminar shall be compulsory.
7. Every student shall complete 84 credits in a minimum of four semesters. All Semesters will have 21 credits each.
8. Academic calendar showing dates of commencement and end of teaching, internal assessment tests and term end examination shall be duly notified before commencement of each semester every year by the School.

B. Evaluation of the student:

(a) The evaluation of the student shall be divided into two parts viz. **Internal Assessment** and **Term End Examination (semester end examination)** with a weightage in the ratio of 25:75, as approved by the committee.

(b) Standard of passing –

(i) There shall not be pass or fail for the internal assessment. However, the attendance for the internal assessment shall be compulsory.

(ii) Minimum marks for passing the Term End Examination in theory/practical/project course shall be 40%.

(iii) Minimum marks for passing the theory/practical/project course (i.e. sum of the marks obtained in internal and term end examination) shall be 40%.

(c) The distribution of marks for each theory paper of 4 credits at term (Semester) end examination and for continuous internal assessment (Minor tests), as approved by the committee shall be as follows:

Theory Examination	**Maximum marks**
Internal assessment	25
Term end examination	75
Total marks	100

(d) The distribution of marks for each laboratory course of 4 credits at term (Semester) end examination and for continuous internal assessment (Minor tests), as approved by the committee shall be as follows:

Practical Examination	**Maximum marks**
Internal assessment	25
Term end examination	75
Total marks	100

(e) The Project course will commence from III Semester and the final work and report will be completed during IV Semester. The marks and the credits will be allotted in IV Semester. The distribution of marks for Project course of 4 credits at term (Semester) end examination and for continuous internal assessment (Minor tests), as approved by the committee shall be as follows:

Practical Examination	**Maximum marks**
Internal assessment	25
Term end examination	75
Total marks	100

(f) Internal Assessment:

(i) Internal assessment for each course would be continuous and dates for each internal test/practical test will be pre-notified in the time table for teaching or placed separately as a part of time table.

(ii)

Heads	Marks	Evaluating Authority
Marks for journal	05	Concerned practical incharge
Experimental work carried by student	15	
Viva-voce	05	
Total marks	25	

Each subject teacher shall coordinate this activity and maintain the record of the internal tests conducted.

(iii) Internal assessment for each course shall be of 25 marks.

(iv) There shall not be pass or fail for the internal assessment. However, the attendance for the internal assessment shall be compulsory.

For Theory Courses:

(i) Two internal tests for each theory course comprising of 4 credits shall be conducted by the subject teacher.

(ii) Each test shall be of 25 marks.

(iii) The marks for each test shall be displayed on notice board within seven days of conducting the test.

(iv) It is mandatory to show the answer sheets of all tests to the students.

For Practical Courses:

The internal assessment for the practical courses will be based on the following 03 heads:

For Project course

(i) The Project course will commence from III Semester and the final work and report will be completed during IV Semester.

(ii) Every student has to undertake a project of interest. The project may be related to a theoretical analysis, an experimental investigation, a prototype design, a new correlation and analysis of data, fabrication and setup new equipment. Ordinarily, the Project Co-ordinator shall be chosen by the student depending on his/her subject interest. The project co-ordinator assigns the topic for the project and the work is done uniformly during both the semesters of the final year.

(iii) The marks and the credits will be allotted in IV Semester.

(iv) On the basis of marks obtained in Seminar, the marks out of 25 will be given for the Seminar.

Heads	Marks	Evaluating Authority
Performance of the student in the collection of reference material for project work and punctuality	05	Concerned Project guide
Experimental work carried out by the student	15	
Viva-voce	05	
Total marks	25	

For Tutorial:

(i) Two credits based on Tutorial component, one each in I and II semesters will constitute the compulsory part.

(ii) For every theory course one Take Home Assignments of 25 marks each shall be given.

(iii) The evaluation will be based on following two heads:

Head	**Marks**	**Evaluating Authority**
Take Home Assignment	25	Concerned subject teacher

(iv) On the basis of marks in Tutorials for theory courses, the average will be calculated and the marks out of 25 shall be awarded for the Tutorial.

For Seminar:

(i) Two credits based on Seminar component, one each in the III and IV semesters will constitute the compulsory part.

(ii) Each student shall deliver one seminar per semester and there will be a continuous evaluation of the seminar.

(iii) The evaluation will be based on following four heads:

Heads	**Marks**	**Evaluating Authority**
collection of reference material for seminar	05	Concerned course teacher
Content of the seminar	15	
Performance in seminar/presentation	05	
Total marks	25	

iv) On the basis of marks obtained in Seminar, the marks out of 25 will be given for the Seminar.

g) Term end examination:

(i) The term end examination for 75 marks per course would be held about a week after completion of teaching for the semester.

(ii) The term end examination of maximum marks 75 and its assessment work shall be conducted by the School from the academic year 2009-10 under the academic flexibility granted to the School by the University.

For Theory Courses:

(i) The pattern of the question paper for the academic year 2009-2010 remains same as at present.

(ii) Each theory paper of 75 marks shall be of the three hours duration.

For Practical Courses:

(i) The term end practical examination shall be of 75 marks and it is of duration 06 h.

(ii) There shall be two examiners for the practical examination out of which one examiner shall be from the other University/Institute.

For Project course:

(i) The project report should be submitted by the prescribed date. Submission of the project cannot be postponed beyond the date specified in the calendar.

(ii) Students should submit 2 bound typed copies of Project Report to the department. A student who is unable to complete his/her Project may be awarded 'X' grade and he/she will be required to register for the next Semester and pay the fees under following circumstances:
Exceptional circumstances beyond students / supervisor control
Medical grounds

(iii) There shall be two examiners for the evaluation of Project, out of which one examiner shall be from the other University/Institute.

(iv) The examiners shall evaluate the report and an oral examination shall be conducted. The assessment of the project work is done on the following basis-

Heads	**Marks**	**Evaluating Authority**
Performance of the student in the presentation of the project work and report	10	Panel of examiners
Experimental work carried out by the student	50	
Viva-voce	15	
Total marks	75	

C. Grades:

(i) Marks for each course would be converted to grades as shown in Table 1.
Table 1: Conversion of marks to grades in credit system

Marks obtained	**Grade**	**Grade Points**
90-100	A+	10
80-89	A	9
70-79	B+	8
60-69	B	7
55-59	C+	6
45-54	C	5
40-44	D	4
39 and less	F	0

(ii) The grade point will be given on the total marks (sum of mark obtained in internal assessment and term end examination) obtained in the said subject.

(iii) A student who fails in a course (i.e. He scores less than 30 out of 75 marks in the Term End Examination or less than 40 out 100 marks) shall be given F grade. Student with F grade in course would be granted credit for that course but not the grade for that course and shall have to clear the concerned course within 1.5 year from appearing for first time in the concerned paper.

(v) The **total grade points earned in each course** shall be calculated as –
Grade points obtained (vide Table-1) X Credits for the course

Maximum grade points that can be earned in a semester are 200.

(vi) **Semester Grade Point Average (SGPA)** –

The performance of a student in a semester is indicated by a number called SGPA. SGPA is the weighted average of the grade points obtained in all courses registered by the student during the semester. It shall be calculated as follows-

$$SGPA = \frac{\sum_{i=1}^{n} C_i p_i}{\sum_{i=1}^{n} C_i}$$

whereCi = the number of credits earned in the i'th course of a semester for which SGPA is to be calculated **(Audit credits should not be included).**

pi = grade point earned in the i'th course

i = 1,2,3,……n represent the number of courses in which a student is registered in the concerned semester.

That is,

$$SGPA = \frac{Total\ earned\ grade\ points\ for\ the\ semester}{Total\ credits\ for\ the\ semester}$$

The SGPA is rounded upto one decimal places.

(vii) **Final result** – Up to date assessment of the overall performance of a student from the time of his/her first registration is obtained by calculating a number called Cumulative Grade Point Average (CGPA), which is weighted average of the grade points obtained in all courses registered by the student since he/she entered the School/Department.

$$CGPA = \frac{\sum_{j=1}^{m} C_j p_j}{\sum_{j=1}^{m} C_j}$$

whereCj = the number of credits earned in the jth course up to the semester for which CGPA is to be calculated

pj = grade point earned in the jth course. A letter grade lower than D (i.e. grade point < 4) in a course shall not be taken into consideration for the calculation of CGPA.

j = 1,2,3……m represent the number of courses in which a student is registered up to the semester for which the CGPA is to be calculated.

The CGPA is rounded upto one decimal places.

(viii) The final grade earned shall be as per Table 2 given below-

Table-2

CGPA	Grade
8.0-10	A+
7.0-7.9	A
6.0-6.9	B+
5.5-5.9	B
4.5-5.4	C+
4.0-4.4	C
0 -3.9	F

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