**M.Sc (Tech) Geophysics ANNEXURE 3**

I SEMESTER

**GS-101 ELEMENTS OF GEOLOGY**

**UNIT – I**

 Introduction to Geology– Branches of Geology - Scope of Geology and its relation with Geophysics. Weathering and erosion Phenomenon – Physical, chemical and Biological weathering - products of weathering. Wind erosion and its features - Sediment transport by wind - various types of Dunes. Geological work of Glaciers – Types – Movement - Erosional features. Glacial Transport – Deposition and related features.

**UNIT-II**

 Geological work of Rivers - Initial, Young and old stages of their development - Canyon, base level of erosion, meandering point bors, oxbow lakes, flood plains and natural levees. Erosion, denudation, peneplains, monad nocks, deltas and types. Volcanoes – Types, Products, Volcanic eruptions, and distribution of Volcanoes.

**UNIT-III**

 Fundamental concepts of Geomorphology. Various near shore morphological features developed due to geological work of sea. Waves and currents and transportation by sea. Features of Marine erosion and deposition and related features. Evolution of major geomorphic processes in India, Field and laboratory map scales, Topographic maps Thematic maps.

**UNIT-IV**

 Definition of Petrology –Bowen’s reaction series – Differentiation of Igneous, Sedimentary and Metamorphic rocks. Origin and forms of Igneous rocks – textures – structures and classification of Igneous rocks. Origin of sedimentary rocks, textures – structures and classification of sedimentary rocks. Types of Metamorphism - Textures and structures of Metamorphic rocks.

**UNIT-V**

 Definition of a mineral – Physical properties of minerals: Mohs scale of hardness, colour, streak, transparency, luster, tenacity, cleavage, fracture, specific gravity, - Isomorphism and Polymorphism – Structure and chemistry of Quartz, Feldspars, Mica Pyroxenes, Amphiboles, Garnet groups of minerals. Clay minerals, Elements of Crystallography.

**REFERENCE BOOKS**: 1) Physical Geology: G. Gorshkov, A. Yakushova.

 2) Physical Geology: A.K. Datta

 3) A text book of Geology: P.K. Mukherjee.

 4) The Principle of petrology: G.W. Tprell.

 5) Rutleys mineralogy: H. M. Read.

 6) Physical Geology: Arthur Holmes.

 7) Principle of Engineering Geology: K. M. Bangar.

 8) A text book of Geology: G.B. Mahapatra.

 9) A text book of Physical Geology: G. B. Mahapatra.

 10) Engineering and general Geology: Parbin singh.

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I SEMESTER

**GS 102: Numerical Analysis & Computer programming**

**Unit I**: Numerical Analysis; finding the roots by numerical methods- bisection method, False position method, Newton-Raphson method. Interpolation: finite difference, symbolic relations. Interpolation by Newton’s formula. Gauss's Central difference formula, Bessel’s formula, Lagrangian formula and Richardson's extrapolation. Numerical differentiation and Integration: Maximum and minimum of a tabulated function. Numerical Integration-Trapezoidal rule, Simpson' s rule, Romberg integration, Weddle's formula.

**Unit II:** Numerical solution of differential equations- Introduction, Solution by Taylor series, Picard's method of successive approximation, Euler’s method, Runga-Kutta method. Finite element methods: Basic concept of the finite element method. Boundary and Initial value problems, Classical Optimization Techniques-The Ritz method, I-D and 2-D problems. Linear and Non-linear Programming, One dimensional minimization, Fibonacci method, Unconstrained optimization, Steepest descent method, gradient techniques and Marquardt's method.

**Unit III:** Introduction: General architecture of a computer. Types of computers, Structure of a computer, programming languages Low level and High Level, object program, compilers and assemblers. Algorithm, Flowchart, Different types of operating systems, MSDOS; Multi-tasking operating system- MS WINDOWS, Multi-user and multi-tasking operating systems- UNIX, File system in UNIX, File management, UNIX commands and Shell programming.

**Unit IV:**  Structure of FORTRAN-77, programming preliminaries, Constant and Variables, expressions- Statements Library functions, Control statements - GOTO, Logical expressions, DO statement & Nesting, STOP, END and PAUSE statements; subscripted variables. Arrays and DIMENSION statement; Special statements - COMMON, DATA statements. Input and Output statements; Subprograms –SAVE & EQUIVALANCE, Function and Subroutines Double Precision. Programming Examples in Fortran to handle Geophysical Problems.

**Unit V:** C programming language: Basic concepts of C; Symbolic and arithmetic constants and variables; Data types in C Decision control. Loop control and Case control structures in C; Functions; Pointers and Arrays; Input and Output; Iteration with Hardware through C and Operations on Bits; Some selected Geophysical problems and their C programs.

**Books:**

1. Generalized inverse of matrices and its application, C.K.Rao & S.R.Mitra
2. An Introduction to Finite Element Method, J.N.Reddy
3. Introduction to Numerical analysis, S.S.Sastry
4. Introduction to Numerical analysis, F.B.Hiderbrand
5. Optimisation theory and application, S.S.Rao
6. Fortran programming. A.K. Jain & M.N.Kesava Rao
7. Fortran 77 programming, V.Rajararnan ,
8. Let us C, Yashavant Kanetkar
9. UNIX shell programming , Yashavant Kanetkar

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 **M.Sc (Tech) Geophysics**

I SEMESTER **GS 103 - EARTH SYSTEM SCIENCE**

**Unit I**:             Origin of the earth- the Universe and our galaxy, chemical evolution of galaxy formation of the earth and planets, primary differentiation of the earth. Composition of the various zones, abundance of elements in the earth, the rotation of the earth, the moon, salient concepts of plate tectonics.  The earth's gravity field, the force of gravity on the surface of the earth, the figure of the earth, Clairaut's theorem, the geometric and gravitational flattening, International gravity formula, geoid and spheroid, the gravity potential

**Unit II**:            Geochronology, Radioactive decay. Dating of rocks - potassium-argon – rubidium strontium-uranium-lead-carbon 14 methods, age of the earth. The earth's thermal properties, the basic thermal data, the measurement of terrestrial flow, calculation and analysis of heat flow rate, heat flow over the ocean floor, flow over continents, sources of heat in the earth, temperature distribution in earth. The equality of continental and oceanic heat flows, regions of anomalous flow, hot spots, relationship of heat flow to the radioactivity of the earth.

**Unit III:**          Geohydrology:  Hydrological cycle, origin of ground water, subsurface distribution of water, springs.  Hydrological properties of water bearing materials: porosity, void ratio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, laboratory methods of determination of perrmeability. Mode of occurrence of Groundwater: Classification of  rocks with respect to their water bearing characteristics aquifers, aquicludes, aquitards, classification of aquifers and ground water province.  Evaporation, evapotranspiration, seepage, infiltration and run off.  Hydrogeochemistry : Physical and chemical characteristics of ground water, classification of ground water with respect to domestic irrigation and industrial use, pollution of ground water.

**Unit IV:**          General Meteorology: surface, self recording and upper an meteorological instruments, aneroid barometer, barograph, air thermometers, psychromoter, hair hydrograph, cup anemamoter, ordinary and recording rainguages, sunshine recorder, pilot ballon, theodolit, radiosonde, Rawin and Radar.  The Atmosphere; composition and structure; Air pressure & winds; general circulation of the atmosphere; monsoons, local winds, Humidity, Fog & Clouds, precipitation, Air masses, fronts, atmospheric disturbances of climate, cyclones, anticyclones and tornadoes, hurricanes, air masses and fronts, jet streams, Koppers classification, Thornawite, classifications, Trewertha’s classification, Climatic types and their distribution climatic changes, applied climatology, Air pollution, Global warming, Green house effect.

  **Unit V**:           Physical oceanography: Physical properties of sea water temperature of the oceans, water masses, bottom relief of the oceans, the morphology of the ocean bottom. Chlorinity, salinity, thermal properties, density, optical properties, water masses, T-S diagram, heat budget of the ocean, Bowen reaction.  Salinity Density measurement, Nansen bottle, light in sea, reversing thermometers, battery thermograph, current meters, ocean currents of the world, Eli-nano, upwelling & sinking waves, breakers, surf, internal waves, storm surges, Tsunami tides, tide generating force, types of tides, prediction of tides, tide gauge, Air sea interaction.

 **Books:**

1. Introduction of Geophysics, Howell

2. Physics and Geology, Jacobs and Russel

3. Physics of the earth, Stacy

4. The interior of the earth, M.H.P. Bott

6. Fundamentals of Geophysics, William Lowrie

7. Groundwater Hydrology, D.K. Todd

8. General Climatology, HJ. Critchfield

9. Earth, Press & Siever

10. Climatology & Oceanography, D.S. Lal Contd...

11. The Ocean their physics, chemistry and General Biology

 12.H.U. Sverdrup, Matrin W. Johnson, Richard H. Fleming

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I SEMESTER

**GS-104 SEISMOLOGY**

**Unit I:** Introduction to seismology. Elastic waves- Elastic, Anelastic and Plastic behavior of materials. Stress, Strain, elastic constants. Seismic waves- Introduction, Body waves. Surface Waves, Types and Phases of waves. Free oscillations of the Earth, the internal Structure of the Earth- Refraction and Reflection in the earth's interior. Types of Earthquakes.

**Unit II:** Seismometry: Introduction, Principle of Seismometer, Vertical motion seismometer, and Horizontal motion seismometer. Broad Band seismometer, Analog recorders. Digital recorders, Seismogram- Identification of Phases on a seismogram. Selection of seismograph stations. Global seismic network

**Unit III:** Travel-Time curves, Seismogram Interpretation, locating earthquakes. Earthquake intensity Magnitude, Frequency, Energy released in an earthquake. Epicenter determination Seismic Sources - Faults, Introduction of earthquake focal mechanism, Single- Couple and Double couple radiation patterns.

**Unit IV:** Analysis of earthquake focal Mechanism, Mechanics of faulting, Fault-plane solutions. Micro earthquakes- Analysis and interpretation of seismograms, Reservoir induced earthquakes. Prediction of location of the earthquake. Earthquake control. Monitoring of Nuclear explosions. Hydro seismicity, rain induced seismicity.

**Unit V:** Earthquakes and Plate Tectonics: Intra plate seismicity, earthquakes in oceans, tsunami, inter plate seismicity, Continental earthquakes and tectonics. Faulting and Fracture, Secondary effects of earthquakes: landslides, fires and fatalities, Seismicity of India and Globe, Seismic zoning. Earthquake effects and hazards.

**Books:**

1. Fundamentals of Geophysics, William Lowrie

2. Modem Global Seismology, Thorne Lay

3. Earthquakes, Bolt, B.A.,

4. Introduction to Seismology, Perry Byrle

5. The Earth, Jeffreys.S.H.

6. Elementary Seismology, Charles.F. Richter

7. Earthquake Mechanics, Kasahara. K.

8. The Mechanics of Earthquakes-faulting, Scholtz.C.H.

9. An introduction to the theory of seismology, Bullen. K.E.

10. Quantitative seismology: theory & methods, Aki. K. and Richrds. P.G

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II SEMESTER

**GS-201 ECONOMIC AND PETROLEUM GEOLOGY & STRATIGRAPHY**

**UNIT-I**

 Stratigraphy: Introduction - principles of Correlation. Fossils - uses of fossils - their importance in statigraphy Physiographic divisions of India - Peninsular India, Indogangitic plain and Extra peninsular India. Geological time scale and Stratigraphic units of India.

**UNIT-II**

 Important Indian groups and systems: Archean and Dharwar System – Introduction, distribution, classification and economic importance. Study of Cuddapah – Vindhyan – Gondwana group – Deccan traps – Siwaliks and Quaternary formations.

**UNIT-III**

 Structural features of rocks. Stress and strain. Primary and secondary structures – dip and strike. Folds: Introduction – classification and origin. Faults: Introduction – classification and recognition and causes of faulting. Joints: Introduction – classification and origin. Unconformities: Definition – Origin and types.

**UNIT-IV**

 Economic mineral deposits: Origin of ore deposits – Igneous, sedimentary and metamorphic. – Metallic and Non metallic types - Placer minerals. Classification of coals - Origin, migration and entrapment of petroleum deposits with special reference to KG basin.

**UNIT-V**

 Physiographic divisions of seas and world oceans, Seamounts and guyots – Properties of sea water: Temperature, salinity and density –– Hotspot mechanism – turbidity currents – Mid oceanic ridge system – Coral reefs and their formation – Island arcs – trenches – Deep sea sediments: placers on the beach and shelves - Conditions for formation of polymettallic nodules.

**REFERENCE BOOKS:** 1) Physical and engineering geology: S.K. Garg

2) A text book of geology: G.B. Mahapatra.

3) Principles of engineering geology: K.M. Bangar.

4) Submarine geology: P.H. Kunen.

5) Submarine geology: F.P. Sheppard.

6) Stratigraphy of India: M.S. Krishnan.

7) Structural geology: M.P. Billings.

8) Economic mineral deposits: A. M. Bateman.

 9) Text book of Physical geology: G.B. Mahapatra.

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II SEMESTER

#### GS 202: Solid Earth Geophysics

#### Unit I Internal constitution of the earth, characteristics of lithosphere and asthenosphere, causes of geodynamical process, continental drift, ocean floor spreading, plate tectonics and its geological implications, neo tectonics, plate margins, their processes, geomagnetic time scale, Benioff zones, Subduction and obduction, ocean ridges, triple junction of world oceans, their evolution, trenches and island arcs, hot spots, thermal hot plumes

#### Unit II Earths magnetic field, internal and external fields, main fields, and variational field, components of the main, magnetic and geomagnetic coordinates, measurement and recording of main field, measurement of horizontal, vertical, declination, inclination and total field. Magnetometers and variographs. Theories of the earths main magnetic field, a brief introduction of the various theories of the main field and its secular variation, dynamo theory of the main field, geomagnetic indices, Ci, CR, Ks, Kp indices, concepts of quite and disturbed days, geomagnetic observatories in India, functions, IGRF concept, its role in magnetic method

**Unit III** Solar quiet day variation (Sq), disturbance daily variation (SD), storm time variation DST and lunar variation L, morphology of the equatorial electrojet, geomagnetic storms, morphological features of geomagnetic storms, gradual and sudden commencement of storm, DS and DST field, ring current, Van Allen belts theory of the geomagnetic storms, the sun spots and solar flares, classification, causes of auroras

 **Unit IV:** The main magnetic field, magnetic observatories, Instruments - proton precision magneto meter, magnetic elements, magnetic charts, the magnetic dipole, the magnetic field of an electric current, separation of magnetic fields of external and internal origin, the magnetic field of the external origin, ionosphere, magnetosphere, diurnal variations of magnetic field, Sq and L variations, magnetic storms and Aurora.

**Unit V:** Reversals of the magnetic field, polarity of the geomagnetic field, geomagnetic scale, projective method of presenting palaeomagnetic data, magnetic latitude and co - latitude, calculation of mean direction of virtual geomagnetic poles, palaeomagnetic poles, reconstruction of palaeomagnetic poles, continental drift, northward drift of India, results from different continents.

**Books**

1. Debate about the Earth, H. takenchi, S. Uyeda and H. Kanamori

2. Fundamentals of Geophysics, William Lowrie

3. Geomagnetism, Sydney Chapman

4. Application of Palaeomagnetism, E. Erwing

5. Palaeomagnetism and Continents, J D A Piper

6. Palaomagnetism and Plate tectonics, M W McElhimy

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II SEMESTER

#### GS 203: Remote sensing & GIS

UNIT-1 Fundamentals of Remote Sensing: Introduction: basic principles of remote sensing; electromagnetic spectrum; Planck’s law and wien's displacement law; concept of incoming short wave and outgoing long wave radiation: passive and active remote sensing, interaction of electromagnetic radiation with matter; interaction of electromagnetic radiation with atmosphere; selective and non-selective scattering; impact of scattering on remotely sensed data; atmospheric windows and absorption bands

UNIT-2 Spectral reflectance properties and Sensors: interaction of electromagnetic radiation with solids and liquids of the earth's surface; spectral reflectance curves of water, snow, clouds, and vegetation. Soils/rocks/minerals. Sensors: imaging and non-imaging sensors: radiometers, spectrometers. Spectroradiometers; Scanner dependent systems: line scan systems, array scanning systems, multispectral scanner systems: whiskbroom and pushbroom imaging systems; circular/conical/side scanning systems: sensor characteristics - spatial resolution, spectral resolution, radiometric resolution and temporal resolution.

UNIT -3 Aerial photography: various types of aerial cameras and black and white films; scale, brightness, contrast of photograph; resolution of photograph - resolving power of film and camera lens; vertical and oblique aerial photographs; methods of aerial photographic surveys; parallax/relief displacement, stereophotography, mirror arid pocket stereoscopes, Photomosaic, low and high sun elevation angle photography. Color theory - primary and secondary colors; additive and subtractive color mixtures to generate colors, color code, working principle of normal and infrared color films and photographs; color composites - true, standard false color and false color composites; application of normal and infra red photographs.

UNIT - 4 Satellite remote sensing: Various platforms used for remote sensing data acquisition; orbits of satellites; geo-synchronous and sun-synchronous orbits; OPTICAL REMOTE SENSING SATELLITES: environmental meteorological satellites (past and present) and their sensors - GOES, Meteosat, INSAT, GMS, NOAA etc.; earth resources observation satellites (past, present and future) and their sensors - NIMB US/coastal zone color scanner, Landsat, Spot, Mos, IRS-la, Ib, Ic, Id, p2, p3, p4, p5, p6 etc. Indian remote sensing activity; future remote sensing missions of ISRO for earth observation.

UNIT-5 Thermal infrared remote sensing: Thermal processes and properties, radiant flux, heat transfer, atmospheric transmission, thermal properties of materials, thermal infrared signatures of various rocks and minerals, influence of water and vegetation on thermal inertia; thermal infrared sensors like infrared radiometers, working principle of thermal infrared scanner; TIMS etc.; satellites and sensors acquired and acquiring data under thermal infrared region - HCMM, NOAA-AVHRR, EOS-TERRA, EOS-AQUA, Geostationery satellite sensors etc.; characteristics of thermal infrared images, relative comparison of night and daytime thermal infrared imagery; advantage of thermal infrared remote sensing

UNIT - 5 Geographical information systems (GIS): Introduction: functions of GIS, spatial data bases - position, attributes; data base structures; data base management; geographic data types - vector and raster; introduction to coordinate system and map projections; application of GIS in Hydrology and other earth sciences.

**Books :**

1. Remote Sensing: Principles and Interpretation, Floyd F. Sabins, IR.. W.H.. Freeman & Co., San Francisco, 426 p

 2. Introduction to the Physics and Techniques of Remote Sensing, Charles Elachi: Johnwiley & Sons p. 413

 3. Information Booklets form various satellite agencies

 4. Manual of Remote Sensing, Vol. I & Vol. Ed, American Society for photogrammetry and Remote Sensing

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II SEMESTER

#### GS 204: Geophysical Signal Processing and Inversion Theory

##### Unit I Introduction, Definition of signal and noise, various signal classes such as continuous, piece wise continuous, absolute integrable, singularity, unit impulse, unit step, etc. Fourier series and Fourier Transform: Time and frequency domain, relations between various operations in both the domain, Fourier Transform and its properties, FFT, Rectangular, exponential functions, singularity functions and periodic functions. Helbert transform, Walsh transformation

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**Unit II** Time-series analysis: Discrete time signals, Correlation and convolution functions, impulse response and Transfer function spectrum of observational data: Discrete Fourier Transform (DFT), Z-Transforms, Delay properties of wavelets.

**Unit III** Band limited signals: Properties, Sampling Theorem, Nyquist frequency, Aliasing, Sampling of band and time limited signals; Effect of sampling on spectrum and vice-versa; reproduction of continuous function from sampled data. Importance and effects of Windowing, Gibbs phenomenon, spectral leakage, various types of windows; hanning windows, power spectrum; Estimation of power spectrum, use of various windows in power spectrum computation, spectrum computation via Auto-correlation and Periodogram. Moving average method, maximum entropy method, maximum likelihood method, auto regression method.

**Unit IV** Digital filtering: Design of digital filters, amplitude and phase response of various filters; one-sided and two sided filters, low-pass, high pass and band-pass, optimum filters, Butter worth filter, Recursive and non-recursive filters, optimal and Weiner filters, Deconvolution and predictive deconvolution.

**Unit-V** Inversion Theory: Introduction, Fundamentals of Inversion, Linear Inversion, Non-Linear

 Inversion, Incorporating prior information, Parametric Inversion, Assessing the

 uncertainty in inverted models.

**Books:** 1. Spectral analysis in Geophysics, Markus Bath

2. Theory and application of digital signal processing, Rabiner,L.R and Gold, B.

3. Digital signal processing and time series analysis, Enders A.Robinson

4. Statistical theory of communication, Y.W.Lee

5. Analysis of Geophysical Potential Fields, P.S.Naidu & M.P.Mathew

6. Seismic Filtering, Nathan Rothenburg, SEG publication

7. Time sequence analysis in Geophysics, E.R.Kanasewich

8. Signal Analysis, B.P.Lathy

9. Inverse problem theory, Tarantola.A,1987

10.Solutions of ill-posed problems, Tikhonov.A.V, and Arsenin.V.Y, 1977

11.Computational methods for Inverse problems, Vogel.C.R, 2001