M.Sc. HYDROLOGY:

Semester – I			Semester - II		
Theory			**Theory**		
Code	Subject	Marks	Code	Subject	Marks
HS 101	Geology – I	85+15*	HS 201	Geology – II	85+15*
HS 102	Hydrometeorology and Water Balance	85+15*	HS 202	Mathematics	85+15*
HS 103	Geohydrology	85+15*	HS 203	Computer Programming	85+15*
HS 104	Surface Water Hydrology-I	85+15*	HS 204	Surface Water Hydrology-II	85+15*
Practicals**			**Practicals**		
HS 105	Geology – I	50	HS 205	Geology – II	50
HS 106	Hydrometeorology and Water Balance	50	HS 206	Computer Programming	50
HS 107	Geohydrology	50	HS 207	Surface Water Hydrology	50
HS 108	Viva-Voce	50	HS 208	Viva-Voce	50
Total		600	Total		600

Semester – III			Semester - IV		
Theory			**Theory**		
Code	Subject	Marks	Code	Subject	Marks
HS 301	Optical Remote Sensing	85+15*	HS 401	Advances in Remote Sensing & GIS	85+15*
HS 302	Hydrochemistry	85+15*	HS 402	Environmental Hydrology	85+15*
HS 303	Hydrologic Modelling	85+15*	HS 403	Watershed Management	85+15*
HS 304	Groundwater Geophysics	85+15*	HS 404	Well Hydraulics and Water Wells	85+15*
Practicals**			**Practicals**		
HS 305	Optical Remote Sensing	50	HS 405	Advances in Remote Sensing & GIS	50
HS 306	Hydrochemistry	50	HS 406	Environmental Hydrology	50
HS 307	Groundwater Geophysics	50	HS 407	Project Work	100
HS 308	Viva-Voce	50	HS 408	Viva-Voce	100
Total		600	Total		700
Grand Total					2500

Semester End Examination Marks: 85

* Mid Semester Examination Marks: 15

Theory and Practice Individual Paper Minimum Pass: 40%

Viva-Voce Pass : 50%

Theory, Practical and Viva-Voce Total Aggregate Pass : 50%

** I, & III Semester Practical Examinations will be conducted along with II & IV semester end practical examinations respectively.

HS-101 GEOLOGY I

UNIT I: Basic assumptions in Geology, relation of geology with sciences-branches of geology-figure and dimensions of earth, structure, composition and origin of earth-Envelops of the earth-crust, mantle, core, External dynamic process- weathering, geological work of wind-weathering, erosion and denudation, cycle of erosion, transportation and deposition agents-loess, relief. Desert types.

UNIT II: Geological work of surface flowing water-streams, rivers, their development. River systems-meandering, oxbow lakes, flood plains, peneplains and deltas. Geological work of underground water-permeability of rocks, types of water in rocks-classification of underground water-springs. Minerals waters-carbonate, sulphide and radioactive waters. Karst-forms, landslides, lakes and swamps, estuaries. Internal dynamic process-tectonic dislocations, neotectonics, earthquakes. Magmatism-volcanoes. Geological work of the sea-marine basins-relief features of the world, ocean floor. Temperature, salinity of seawater. Destructive work of sea-near shore accumulation forms-sedimentation in various zones of sea. Distribution of marine sediments.

UNIT III: Fundamental concepts in geomorphology-geomorphic processes-distribution of landforms-drainage patterns -development. Morphometric analysis of drainage basins, water sheds. Elements of hill slopes-pediment, bazadas. Landforms in relation to rock types, paleochannels, buried channels. Soils types and their classification. Evolution of major geomorphic process in India. Marine geomorphic processes, coastal morphological processes. Field and laboratory map scales, topographic maps, thematic maps, topographic and geomorphic profiles.

UNIT IV: Structural, textural, and chemical classification and origin of igneous, metamorphic and sedimentary rocks- Petrogenisis, granitisation. Petrographic characters of pegmatites, kimberlites and gondites- Sedimentary structures- petrographic characters of conglomerate, sandstone, shale, limestones. Process of dolamitisation. Metamorphism-structural classification of shale, phyllite, schist, gneiss, marble quartzite and granulites.

UNIT V: Science of minerals, physical and optical properties of minerals. Classification, structure and chemistry of Feldspar, Mica, Pyroxenes, Amphiboles, Olivine, Quartz and Garnet groups. Clay minerals, genesis and chemistry of native elements. Elements of crystallography, crystallographic axes, symmetry form of crystals and classification of crystals.

Books:

l. Physical Geology, G.Gorshkov, A.Yakushova
2. Physical geology, A.K.Datta
3. A textbook of Geology, P. K Mukherjee.
4. The principles of petrology, G.W.Tyrell.
5. Rutleys mineralogy, H.M.Read
6. Physical Geology, Arthur Holmes

HS 102 HYDROMETEOROLOGY AND WATER BALANCE

UNIT-1: Elements of Meteorology:

Hydrologic Cycle, Water Vapour, Atmospheric Humidity, Measurement of Humidity, Atmospheric Thermodynamics, Formation of clouds. Types of clouds, Air masses, Cyclones, Anti cyclones, Hurricanes, Tornado, convection, Extra tropical cyclones, Convective weather, Tropical disturbances and storms, Weather systems and regimes, Monsoons (12 Hours)

UNIT-II: Precipitation;

Condensation and precipitation, Precipitation processes, Forms of Precipitation, Measurement of rainfall, Types of gauges, Non recording and self-recording gauges, Storage gauges, Radar measurement of rainfall, intensity of rainfall, Rain gauge network. Distribution and measurement of snow, Standard and recording snow gauge, Seasonal storage, snow surveying, Radio isotope snow gauge, Intensity saturation frequency analysis, Spatial and temporal variations, Interpretation of precipitation data.
(12 Hours)

UNIT-III: Soil Moisture:

Formation and mechanical composition of soils, Soil classification, Soil-Water, Water retention in soil, Water movement in saturated & unsaturated soils and ice lenses, Soil, Air, Soil temperature and soil structure, Field capacity, Measurement Techniques, Water Movement
(12 Hours)

UNIT-IV: Infiltration:

Concept of Infiltration, Factors affecting Infiltration, Measurement of infiltration, Single ring and Double ring infiltrometers, Flood type infiltrometers, Rainfall Simulators, Hydrograph analyses to estimate infiltration, Relation of infiltration to run-off. (12 Hours)

UNIT-V: Evaporation & Evapotranspiration:

Definitions, Evaporation from free water surfaces, Factors effecting Evaporation, Measurement of evaporation. Estimation of evaporation, Evaporation reduction, Evaporation from soil surfaces, Transpiration Determination of transpiration, Evapotranspiration Methods of estimation. Soil moisture; sampling, Lysimeter measurements, Inflow outflow measurements, Integration method, Energy balance, Vapour transfer and Groundwater fluctuations, EvapoTranspiration equations, Pan evaporometer, Lysimeter, Thornthwaite approach, Potential and actual evapotranspiration, Energy budget and Penmann approach, Water Balance Studies, Forecast of climatic Parameters and World Water Balance.
(12 Hours)

Books:

1. Hand book of Applied Hydrology,Ven Te Chow
2. Applied Hydrology , R.K.Linsley, M.A.Kohler & Paulhus
3. Engineering Hydrology , R.S.Varshney
4. Hydrology and Water Resources Engineering , R.L.Sharma & T.K.Sharma
5. A textbook of Geology,P.K.Mukherjee
6. Handbook on Principles of Hydrology , Donald. M. Grey
7. Groundwater , H.M.Raghunath
8 Facets of Hydrology , John C Rodda
9. A textbook of Hydrology , Dr. PJayaramiReddy
10. Hydrometeorology and Water Balance , Prof. V.P.Subrahmanyam

HS 103 GEOHYDROLOGY

Unit-1

Geohydrology, Hydrogeology and Groundwater Hydrology, Groundwater in Hydrologic cycle, Occurrence of Groundwater: Aquifer, Aquiclude, Aquifuge and Aquitard, Porosity, Effective porosity, Vertical distribution of Groundwater; Zone of aeration, zone of saturation, Division of subsurface water.
(12 Hours)

Unit-11

Specific retention, specific yield, Geologic formations as aquifers, Types of aquifers, Storage coefficient, Groundwater Basins and springs. Water movement in saturated soils, Darcy's law. Permeability, Intrinsic permeability. Hydraulic conductivity, Transmissivity, Determination of Hydraulic conductivity, Anisotropic aquifers, Groundwater flow directions, dispersion.
(12 Hours)

Unit-III

Groundwater fluctuations: Secular, Seasonal and Short-term fluctuations due to stream flow, Evapotranspiration, Meteorological phenomena, tides, Urbanization, Earthquakes and External load, Land subsidence. (12 Hours)

Unit-IV

Artificial Recharge of Groundwater: Concept, Recharge methods, Basin method, Stream channel method, Ditch and Furrow method, Flooding method, Irrigation method, Pit method and Recharge well method, Incidental recharge, Water spreading, Waste water recharge, Recharge mounds and Induced recharge.
(12 Hours)

Unit-V

Salt water intrusion of coastal aquifers: Occurrence of salt water intrusion, the Ghyben - Herzberg concept, the dynamic concept, Shape and Structure of the interface, Upconing of saline water, Fresh-Salt water relations in Oceanic Islands, Control of intrusion, Development of Groundwater in intrusion areas.
(12 Hours)

Books:

1. Hand book of Applied Hydrology,Ven Te Chow
2. Groundwater Hydrology , D.K.Todd
3. Facets of Hydrology , John C Rodda
4. Groundwater ,H.M.Raghunath
5 Groundwater Mannual , U.S.Department of the Interior
6 Hydrogeology , Davis & De weist
7. Geohydrology , De weist
8. Applied Hydrology, K.N.Mutreja
9. A textbook of Hydrology, prof. PJayaramireddy
10. Applied Hydrology , R.K.Linsley, M.A.KohIer & Paulhus

HS 104 SURFACE WATER HYDROLOGY-I

UNIT-1

'The main content of hydrology, Hydrology as a science, the relation of Hydrology to other sciences, Historical development of Hydrology. (4 Hours)
The significance of water in different fields of anthropogenic human activities and its role in the development of civilization. Water resources of the earth. Global water budget. (4 Hours)
Interrelation between hydrological processes and atmosphere, hydrosphere and lithosphere, Hydrologic cycle. (4 Hours)

UNIT-II

Formation of surface water resources; streams, rivers, lakes, swamps, caves, seas and oceans. Definition of river, river basin and water divide, formation of river valleys, flood plains, fluvial deposits, alluvial fans, meandering of rivers, formation of ox-bow or horse shoe lakes, deltas, solution valleys and karst topography (8 Hours)
Sediment discharge, sediment transportation, sediment yield of watersheds, suspended load and bed load measurements. (4 Hours)

UNIT-III

Runoff, virgin flow, surface runoff, overland flow, sub surface runoff, groundwater runoff, direct runoff, base flow and total runoff. Precipitation excess, effective precipitation, disposition of total precipitation to total runoff, runoff phenomena, factors affecting runoff, disposition of storm rainfall and estimation of runoff, ϕ-index, W-index and W-minimum index.
(12 Hours)

UNIT-IV

Definition of discharge, units of discharge measurement, objects of discharge measurement. Determination of stage, stage indicators, gauge site, essential requirements of gauge sites, types of gauges, selection of discharge sites, segmentation and depth measurements Stage discharge relationship and extension of rating curves (4 Hours)

UNIT-V

Current meter: Gurely current meter, Rotating cup current meter, Pigmi current meter and Optical current meter. Velocity measurements: Velocity distribution method, one point, two point, three point, six point, integration and surface velocity methods, velocity measurement by floats and velocity rod. Methods of discharge estimation: Colour velocity method, Salt velocity method, Hydraulic model method, Radio tracer method, Electronic method, Ultra sonic river gauge and Hydraulic structures. (12 Hours)

Books:

1. Hand Book of Applied Hydrology , Ven Te Chow (ed.)
2. Applied Hydrology , R.K.Linsley, M. A. Kohler & Paulhus
3. Engineering Hydrology ,R.S.Varshney
4. Engineering Hydrology , E.M.Wilson
5. Hydrology and Water Resources Engineering , R.K.Sharma & T.K.Sharma
6. A Textbook of Geology , P.K.Mukherjee
7. Applied Hydrology, K.N. Muthreja
8. Handbook on the Principles of Hydrology , Donald M Grey
9. Facets of Hydrology , John C Rodda
10. A textbook of Hydrology , Dr. P. Jayaramireddy

HS-201 GEOLOGY II

UNIT I: Objectives of structural geology-composition and resolution of forces-stress, strain. Description of folds. Classification, mechanics and causes of folding. Foliation and lineation. Classification of faults, brittle and ductile structures, shearing and shear zones. Classification of unconformities. Map patterns and their uses in determination of large scale structures. Tectonic evolution of Dharwars, Eastern Ghats, Aravalis, Singhbhum and Cuddapahs. Evolution of Himalayas and tectonics. Outlines of geological mapping.

UNIT II: Earth and stratified rocks-importance of stratigraphy-geological cycle and time scale. Stratigraphic nomenclature and classification. Sargur, Dharwar, Singhbhum super groups, Aravalis and Eastern Ghat Mobile Belts, Cuddapahs, Vindyan and Kurnool systems, Deccan basalts, Cretaceous formations, and quaternary formations- boundary problems in stratigraphy.

UNIT III: Geochemical cycle, geochemical exploration methods, classification of elements. Analytical techniques for geochemical analysis. Outlines of standards preparation. Instruments and their exposure. Elements of ore petrology, characteristic features and genesis of ferrous and non-ferrous ore deposits of India. Mettalogeny, origin, migration and entrapment of petroleum deposits. Properties of source and reservoir rocks. Petroliferous basins of India- an outline. Classification of coal, ranking, and grading of coal deposits of India.

UNIT IV: Physiography and divisions of seas and world oceans. Properties of sea water-salinity, temperature, density. Littoral and sublittoral zones. Continental shelves, slopes, deep sea, aprons, seamounts and guyots, abyssal plains- Mid ocean ridge system, aseismic ridges. Coral reefs and their formation. Tectonic domains of oceans, island arcs, trenches, hotspot mechanism. Turbidity currents and deep sea sediments, placers on the beach and shelfs, conditions for formation of polymettalic nodules. Law of the seas.

UNIT V: Orogency-continental drift hypothesis-breakup of continents-plate tectonics-convergent and divergent margins, eustatic changes of sea level, lithosphere. subduction, obduction and benioff zones, plate margins, mineralisation near plate margin, major and minor plates. Transform and transcurent faults, driving mechanism of the plates, convection currents, triple junction, movement of Indian subcontinent. Origin and evolution of life, fossils and their uses. Biomineralisation studies on fossils, pale ecology, oxygen and carbon isotopic studies on fossils, and analysis of paleontoiogical record for tracing plate tectonic process.

Books :

1. Sub marine geology, P.H.Kunen
2. Submarine geology, F.P.Sheppard.
3. Stratigraphy of India, M.S.Krishnan
4. Structural Geology, M.P.Billings
5. Geochemistry, Rankama and Sahama
6. Economic mineral deposits, A-M.Bateman and M.N.Jenson
7. Aspects of Tectonics, focus on south central India, K.S.Valdiya

HS-202 MATHEMATICS

Unit I: Line Integrals, Green's theorem in two-dimensions. Complex Integration, Cauchy' s Integral theorem, Cauchys Integral formula, Types of Residues, Cauchy's Residue Theorem, Evaluation of certain improper integrals involving trigonometric functions.

Unit II: Matrices: Principles and definitions, Single value decomposition method. Introduction to various generalized inversion techniques and their properties. Least square polynomial approximation: the principle of least squares, least square approximation over discrete sets of points, Chebysev Polynomial.

Unit III: Numerical Analysis; finding the roots by numerical methods- bisection method, False position method, Newton-Raphson method. Interpolation: finite difference, symbolic relations. Interpolation by Newtons 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 IV: Numerical solution of differential equations- Introduction, Solution by Taylor series, Picard's method of successive approximation, Eulers method, Runga-Kutta method. Finite element methods: Basic concept of the finite element method. Boundary and Initial value problem, Variational formulation of boundary value problem, Variational methods of approximation- The Ritz method. Introduction to finite element analysis of I-D and 2-D problems.

Unit V: Introduction to Classical Optimisation Techniques, Introduction to Linear Programming and Non-linear Programming, One dimensional minimization methods- Introduction, Fibonacci method. Introduction to unconstrained optimisation techniques. Introduction of Steepest descent method, gradient techniques and Marquardt's method.

Books :

1. Higher mathematics for Engineering and Science, M.K.Venkata Raman
2. Engineering mathematics, M.K.Venkata Raman
3. Complex Variables, R-C.Churchill
4. Matrix theory for scientific and engineers, Jennings
5. Generalized inverse of matrices and its application, C.K.Rao & S.R.Mitra
6. An Introduction to Finite Element Method, J.N.Reddy
7. Introduction to Numerical analysis, S.S.Sastry
8. Introduction to Numerical analysis, F.B.Hiderbrand
9. Optimisation theory and application, S.S.Rao

HS 203: Computer programming

Unit I: Introduction: General architecture of a computer. Types of computers. Advantage of digital computers, structure of a computer, programming languages, object program, compilers and assemblers.

Unit II : Computer Operating systems: Different types of operating systems: Single user operating system- MSDOS; Basic structure of DOS, DOS commands, Control-Function keys. DOS editing keys. Formatting etc.; Multi-tasking operating system-MS WINDOWS, Basic concepts of windows. Advantages of WINDOWS over MSDOS; Multi-user and multi-tasking operating systems- UNIX, File system in UNIX, File mangement, UNIX commands and Shell programming.

Unit III: Programming Languages: Structure of FORTRAN-77, programming 'preliminaries, compilation and execution; FORTRAN expressions-Arithmetic expressions, order of computation, use of parenthesis, value and mode of expression. Library functions-Flow Charts; Control statements - GOTO, Computed GOTO and Assigned GOTO statements; Logical expressions, different types of IF statements. DO statement. Nesting of Control statements, STOP, END and PAUSE statements; subscripted variables. Arrays and DIMENSION statement; Special statements - COMMON, DATA statements. Input and Output statements; Subprograms - Arithmetic statement functions. Function and Subroutine subprograms, Compilation and debugging.

Unit IV : BASIC programming language: Introduction, Constants, variables and expressions in BASIC; Input of data. Conditional and loop structure, control statements, GO SUB functions

UnitV: 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; Interation with Hardware through C and Operations on Bits; Some selected Geophysical problems and their C programs.

Books:

1. Fortran programming. A.K. Jain & M.N.Kesava Rao

2. Fortran 77 programming, V.Rajararnan ,

3. Let us C, Yashavant Kanetkar

4. UNIX shell programming , Yashavant Kanetkar

HS 204 SURFACE WATER HYDROLOGY - II

Unit-I: Hydrographs: Discharge hydrograph, features of a hydrograph, factor affecting shape of hydrograph, components of hydrograph, base flow separation methods.
(6 Hours)

Unit II: Unit-hydrograph: Principle of unit hydrograph, application of unit hydrograph and its limitations and derivation of unit hydrograph from simple hydrograph and complex hydrograph. (6 Hours)

S-hydrograph: Principle, derivation of unit hydrographs from S-hydrograph, synthetic unit hydrograph, construction of synthetic unit hydrograph for ungauged areas, synthetic unit hydrograph parameters for Indian catchments.
(6 Hours)

Dimensionless unit hydrograph, its computations, unit hydrograph for design flood computation, unit hydrograph for computations of inflow to major rivers, computation of design flood hydrograph instantaneous unit hydrograph.
(6 Hours)

Unit-III: Floods: flood elevation, Flood discharge, flood volume and duration of floods, Flood estimation, causes of flood, factors affecting flood flow, flood flow determination.
(6 Hours)

Peak discharge: flood formulae, floods of selected frequency, flood records, maximum probable flood, flood volume, floods from small basins.
Flood frequency: methods of determining flood frequency. (6 Hours)

Unit-IV: Design flood, standard project flood (SPF), standard project storm (SPS), SPS for small drainage basins, SPF estimates for small and large drainage basins.
(6 Hours)

Maximum probable flood, probable maximum storm, flood control, flood control works, flood control methods, limitations of flood control measures
(6 Hours)

Unit-V: Flood routing: Definition and scope, mathematics of flood routing, routing methods. Flood forecasting, functions of flood forecasting and flood warning, flood forecasting system, flood control methods, flood forecasting in India and other countries.
(12 Hours)

Books:

1. Hand Book of Applied Hydrology , Ven Te Chow (ed.)
2. Applied Hydrology ,R.K.Linsley, M.A.Koh1er & Paulhus
3. Engineering Hydrology , R.S.Varshney
4. Engineering Hydrology , E.M.Wilson
5. Hydrology and Water Resources Engineering , R.K.Sharma & T.K.Sharma
6. Applied Hydrology , K.N.Muthreja
7. Hand book on the Principles of Hydrology , Donald M Grey
8. Facets of Hydrology , John C Rodda
9. A textbook of Hydrology, Dr. PJayaramireddy
10. Hydrological Forecasting , Andersen, M.D, and T.P, Burt
11. Applied Surface Hydrology , 0. Starosolszky
12. Floods and drainage , R.C. Penning-Rowsell

HS 301 OPTICAL REMOTE SENSING

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

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

HS-302 HYDROCHEMISTRY

UNIT I: The water molecule, isotopic composition of waters-physical properties of water-latent heat, density, compressibility, coefficient of cubic expansion, viscosity, surface tension. Chemical properties-electrolytic dissociation, solubility product, hydrogen ion concentration, specific electrical conductance, water and electrolytes, organic constituents, dissolved gases. Law of mass action, chemical equilibrium-activity coefficient, ionic strength, Debye-Huckel principle, reporting equilibrium status of water and related norms, calacite, dolomite, fluorite equilibrium-dissolution of solid and liquids, factors causing solubility changes, solubility in aqueous solution, saturation index, pH and solubility, redox potential, stability diagrams, specific conductance of aqueous solutions.

UNIT II: Geochemical processes-dissolution of salts, rock water interaction, role of contact-surface, residence time. Adsorption and ion exchange, ion selectivity, adsorption process in unsaturated and saturated zone, base exchange index, sorption and filter effect, biological processes, organism in ground water, sulphate reduction, influence of higher plants on chemistry of waters, mobility salts, mobility of ions.

UNIT III: Geochemical classification of waters-magmatic, meteoritic, juvenile waters, oil field brines, thermal waters- their nature and chemistry. Subterranean waters in oil fields-case histories. Water associated with natural brines, saltdomes, geysers, and mud volcanoes, metaliferrous deposits. Groundwater in igneous, metamorphic, and sedimentary rocks. Unconsolidated aquifer material-clay, marl, silty rocks, gypsum, anhydrates, salt bearing rocks and limestone deposits. Hydrodynamic zones and geochemistry of water, metamorphism of waters, chemical relationship of major groups. Coefficient of Variation, coefficient of metamorphism, ionic ratios-role in interpreting hydrological problems. Mechanisms controlling the groundwater chemistry.

UNIT IV: Chemical dissolved constituents-major, minor and traces in ground water-source mechanism. Insoluble constituents, organic substances, suspended matter, dissolved gases. Sampling of water-rivers, lakes, ponds, open wells, bore wells. Objective of sampling, plan, extent, frequency of sampling, precautions. Standard laboratory techniques-titrimetric, colorometric, and spectrophotometry. Instruments-visible and UV spectrophotometers, ion Selective electrodes, DO meters, pH and conductivity meters, flame photometers and atomic absorption Spectrophotometer, Inductively Coupled Plasma (ICP). Preparation of the standards-estimation and Reporting units. In-situ measurements-pH, conductivity, salinity and dissolved oxygen, chemical demand, biological demand. Bacteriological studies.

UNIT V: Interpretation of physical and chemical data of water, methods of illustration-pictorial, bar, circular radial, multivariate schoeller diagrams, four coordinate diagram, stiffs diagram, horizontal and vertical scale diagram. Plotting on maps-Piper, Wilcox, SAR, and Gibbs representation, Durov plots. Statistical techniques in presenting hydrochemical data-correlation, discriminant analysis, factor analysis, principle component analysis, Exposure to Statistica Soft-ware. Outlines of global hydrochemical soft-ware-Wateq, Phreeq, Aquachem, MINTEQA2 and UNESCO hydrochemical soft water.

BOOKS:

1. Study and interpretation of the chemical characteristics of Natural wate, USGS Edition , J.D.Hem
2. The properties of groundwater, George Mathess
3. Facet of Hydrology, J.C.Rodda.
4. Advances in Hydrosciences Vol.2 , Ven te Chow.
5. Physical and Chemical hydrology, Patrick A.Domenico and Franklin W.Schwartz.
6. Standard methods for the examination of water and waste water, American Public Health Association, Ed. 1980.
7. Hand Book of applied Hydrology, Ven te Chow.
8. Applied Hydrogeology, C.W-Fetter.
9. Groundwater Hydrology, D.K.Todd.

HS 303 HYDROLOGIC MODELLING

Unit I: Introduction, Hydrological Prototype system, Conceptual and system representation of hydrological cycle and water Balance Parameters. Process of model development-Identification of objectives, system identification, Evaluation and analysis of available data, Stream flow synthesis; Methods of extending hydrological time series: MASS curve analysis, Random generation method, MARKOV generation Techniques. Model formulation-Verification-calibration.Different Types of Hydrological models: Physical models, Mathematical models. Introduction to Continuous and Discrete models, Dynamic and Static, Lumped parameter and Distributed parameter models, Block-Box model, Conceptual model, Stochastic and Deterministic models. Physical models: Sand models, Tank model to simulate network of reservoirs; Laboratory tank models used in Electrical resistivity modelling Horizontal and Vertical HELESHAW (Viscous fluid) model, Electrical analog models, continuous systems: Conductive liquid and solid analogue models, Discrete systems: Resistance-Capacitance Networks, Resistance Networks. Application of analog models. Comparison of Analogue and application of Digital Models.

Unit II: Mathematical models: Hydrological simulation, Classification of simulation models. Event simulation models, Continuous stream flow simulation models, Urban runoff models Steps in digital simulation. General components of Hydrologic simulation models, Data need for Hydrologic simulation. Limitation of simulation, Advantages in simulation.

Unit III: Rainfall-Runoff event simulation models: HEC-1, TR-20, USGS, and SWMM. Continuous stream flow models: API, USPAHL, SWM-III, NWSRFS, SHE, MIKE 11, MIKE 21 models. Simulation snow Hydrology- Temperature index models, Energy budget models, Snowmelt runoff model, Model performance evaluation: NASH-SUTCLIFF coefficient, Volume deviation, Coefficient of determination.

Unit IV: Urban runoff models- Chicago Hydrograph method (CHM), Road research Laboratory method (RRL), Storage Treatment, Overflow Runoff Model (STORM), SWMM, QUAL-1, DOSAG-1, PRMS-USGS, HSPF, WATEQ, PHREEQE ect. Water quality models: Surface water quality models, Non conservation, conservative, Groundwater quantity models: Groundwater flow equations-confined, leaky confined aquifers, mass balance equation, Dupuit assumption. Groundwater flow models, Boundary conditions.

Unit V: Finite difference modeling, Iterative alternative direction implicit method. Calculation of heads with G and B arrays. Computer programme for two-dimensional steady state flow of groundwater-example. Finite element method-relative advantages and disadvantages of finite difference and finite element methods. Introduction to MODFLOW. Groundwater contamination modeling- Solute transport models, Advection models, Advection-Dispersion models, Advection-Dispersion-Chemical/Biological reaction models.

Books: Groundwater Resources Evaluation, W.C.Walton

Physical principles of water percolation and seepage, J. Bear et al

Groundwater Hydrology, D.K.Todd

Theory of Groundwater, A.Varrujt

Advances in Hydro-sciences, Ven Te Chow

Numerical methods in subsurface Hydrology, Irwin Remson et al

Computer simulation Techniques in Hydrology, George Fleming

Introduction to Hydrology, Terrence E Harbaugh

Introduction to Hydrology, W. Viessman

Environmental Hydrology, V.P.Singh

Applied Hydrogeology, E.W.Fetter

HS-304 GROUNDWATER GEOPHYSICS

UNIT I: Groundwater in Igneous, metamorphic, sedimentary rocks. Exploration Geophysics: Geological and Geochemical techniques. Importance Of geophysical techniques.

UNIT II Gravity methods: principles, instruments-survey techniques and application to Groundwater location. Effect of groundwater levels on gravity readings. Magnetic methods: principles, instruments, and survey techniques, application to groundwater exploration. Seismic method; principles, instruments, refraction survey, reflection surveys, survey techniques, depth determination to aquifer boundaries and bed rocks.

UNIT III Electrical methods: Direct current resistivity method specific resistance and apparent resistivity, Wenner, Schlumberger, Lee, Dipole-Dipole configurations. Resistivity profiling and instruments.
Resistivity sounding: procedure, principles, and elementary theory. K, H, Q and A type of curves. Hydrological significance. Interpretation techniques: Empirical and Quantitative techniques. Direct and indirect techniques. Cumulative technique, auxiliary curve interpretation, construction of master curves, and application of computer techniques in interpretation, correction of electrical data.

UNIT IV Geoelectrical parameters corresponding to hydrological zones (variation of electrical resistivity with moisture content and water quality). Application of resistivity in groundwater studies: Mapping stratigraphic units, buried stream channels, mapping fresh salt water interface, mapping clay layers, mapping water table and movement of groundwater. Electromagnetic methods: principles, instruments, survey techniques. Induced polarisation methods: principles, relationship between apparent chargeability and apparent resistivity.

UNIT V: Induced polarization groundwater-surveys, telluric and magnetotelluric principles, instrumentation and survey, EM sounding - profiling-dipole and VLF techniques. Bore hole geophysics: Well logging, techniques- Electric log, Resistivity and density log, sp log, radiation logging, sonic logging.

Books:

1. Hydrogeology, S.N.Davis and RJ.M.Dewiest.
2. Applied Geophysics, W.M.Telford et. al
3. 0utlines of geophysical prospecting, M.B.Ramachandra Rao
4. Applications of Surface Geophysics to Groundwater investigations, A.A.R.Zohdy et al.
5. Introduction to Geophysical Prospecting , M.B.Dobrin and Savit.
6. Direct current Geoelectric sounding principle and interpretation, P.K.Bhattacharya and H.P.Patra.

HS 401 ADVANCES IN REMOTE SENSING AND GIS

Unit – 1 Microwave remote sensing: Remote sensing wavelength bands under microwave region; polarization HH. HV, VH and VV types; passive microwave radiometers, satellites carried and carrying passive microwave radiometers; advantages and disadvantages of passive microwave remote sensing; Active microwave remote sensing: side looking air borne radar (SLAR), synthetic aperture radar (SAR); spatial, range and azimuth resolutions; radar return and image signatures; dielectric constant; surface roughness and its impact on return radar signals; depression angle; radar image interpretation; satellites with active microwave sensors - SEASAT, SIR- A, B, C, ERS, ENVISAT, RADARSAT, JEIRS and others; characteristics of SAR on above satellites; advantages of microwave remote sensing; SAR interferometry and differential SAR interferometry and their applications

Unit - 2 Digital image processing: image structure, conversion of photograph to digital form; image restoration, atmospheric/haze correction, geometric correction, image enhancement techniques, linear and non-linear stretch, spatial and directional filters and their applications on satellite remote sensing data; information extraction: arithmetic processing of digital data; logarithmic and exponential transforms, multi-spectral classification of digital data: unsupervised and supervised; parallelepiped, k-nearest neighbor and maximum likelihood methods.

Unit – 3 Airborne Geophysics: Aeromagnetic methods and sensors; airborne gravity, electromagnetic and radiometric methods and their sensors; survey procedures in airborne geophysical investigations. Satellite Geophysics: Experimental satellites and sensors on-board for geophysical studies - OGO, MAGSAT, OERSTED, CHAMP, DMEIER LAGEOS-II, RADAR ALTIMETERS on GEOSAT, ERS, ENVISAT, TOPEX-POSEIDON and other future missions; Application of altimeter data to derive bouger gravity anomalies; scatterometer and its application.

Unit – 4 Remote sensing applications: Application of aerial photography, satellite optical and microwave remote sensing data for meteorological, hydrological and geological studies; monitoring and exploration of renewable and non-renewable resources like groundwater, mineral and oil; monitoring bio-resources, delineation of environmental pollution like monitoring green house gases, water pollution, oil pollution of land and water etc., natural hazard monitoring and management like earthquakes, land subsidence, land slides; planning of geophysical investigations etc.

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, JR., \V.H.. Freeman & Co.; San Francisco, 426 p
2. Introduction to the Physics and Techniques of Remote Sensing ,y Charles Elachi, Johnwiley & Sons p.413
3. Manual of Remote Sensing, Vol. I & Vol. 11, by American Society for photogrammetry and Remote Sensing
4. Information Booklets from Various Satellite Agencies
5. Remote Sensing in Sub-surface Exploration, Ed. K.R. Rao and S.K. Bhan, AEG Publication, p. 152
6. Digital Image Processing by R..C. Gonzalez and R.E. Woods , Pearson Education (Singapore) Pvt. Ltd., 716 p
7. Remote Sensing in Hydrology , E.T. Engman and R.J. Gumey, Chapman and Hall, 222 p.
8. Geographic Information Systems , P. A. Burrough, 193 p
9. Introduction to the Use of Geographic Information systems for practical Hydrology , A.M.J. Meijerink, H.A.M. de Brower, Chris Mannaerts and Carlos R. Valenzeela, ITC Publication No. 23, 243 p

HS-402 ENVIRONMENTAL HYDROLOGY

UNIT I: Man and environment-scope of environmental hydrology-relation with other sciences-Ecosystem, ecological stability, ecological imbalance and pollution. Global threat-EInino effect -Green House Effect-Ozone layer depletion and its impact on hydrological environment-Global Warming-precipitation and ecodistribution-aquatic ecosystems-anthropogenic impact on aquatic ecosystem- acid rain- its cause and impact on environment.

UNIT II: Ground water pollution- its and sources and classification- nature of contaminant-point source and non-point source-municipal dumps-hospital waste-slumps-their impact on bacteriological contamination of water. Water sanitation-Epidomology and water borne diseases, Groundwater problems that originate on the land surface-agricultural, industrial, and atmospheric origin.High way traffic borne contaminants and its impact on groundwater.Groundwater quality problems that originate above and below water table. Natural inorganic constituents and their role in usage of water- bicarbonate, carbonate, calcium, and magnesium, chloride and sodium, potassium, sulphate, fluoride and its relation with other elements, iron, manganese, arsenic. Excess pumping on coastal areas-its impact on groundwater quality-mining activity - mineral and hydrocarbons and their impact on quality of water. Aquaculture and its impact on groundwater quality.

UNIT III: Utility of water, for drinking, agriculture, industry and recreation. Standards of water-Indian, World Health Organisation, Environmental Protection Agency. Water and its suitability norms for drinking -Using Piper classification, Suitability of water agricultural classification using-Kelly's ratio. Sodium adsorption ratio, residual sodium carbonate, magnesium hazard, soluble sodium percent, Wilcox classification. Water logged areas and their impact on major ion concentration and nutrients-Bacteriological contamination, limits of MPN and E.Coli range for safe drinking, characteristics of water quality-hardness-its classification, pH, redox potential, specific electrical conductance, total dissolved solids. Norms for corrosion and scale formation characteristics, norms for identifying salt water intrusion through ionic ratios, groundwater-mixing plots. Reporting genesis of water through-Gibbs, Durov plots. Piper classification.

Unit IV: Identification of contaminant and its movement- through hydrochemical methods, role of Geophysical strategies in identification of contaminant transport and extent- Electrical resistivity methods. Self potential methods, saltwater interface demarcation in coastal aquifers and water logged areas by electromagnetic method- Radioactive methods- radio isotope equipment, selection of radio active tracers, environmental isotopes, injected tracers, application of radio isotopes in environmental problems.

Unit V: Control measures of contaminant into groundwater-prediction of migration, potential contaminants and travel times, problem of fluoride and arsenic. Defluorination-Nalgonda method, activated carbon method- Alternate source of supply-development of aquifer protection plan, emergency response plans, regulation for waste disposal-in and around human habitats. Control of Volatile Organic Substances in drinking water. Water treatment-UV method, reverse osmosis, in ground treatment, cutoff trenches, groundwater dams. Design and optimisation of groundwater monitoring networks for pollution studies-monitoring cyclic fluctuations in groundwater quality- Environmental Protection Laws.

BOOKS:

1. Concepts of Ecology, Edward.J.Kormondy
2. Protection of public water supplies from groundwater contamination, US Environmental Protection Agency Publication 1985
3. Study and interpretation of the chemical characteristics of Natural water- II USGS Edition by J.D. Hem
4. The properties of groundwater, George Mathess
5. Facet of Hydrology, J.C.Rodda.
6. Advances in Hydrosciences Vol.2, Ven te Chow.
7. Physical and Chemical hydrology, Patrick A.Domenico and Franklin W.Schwartz
8. Groundwater resources evaluation, W.C.Walton
9. Groundwater Hydrology, H.Bouwer
10. Hydrogeology, K.R.Karanth.

HS 403 WATERSHED MANAGEMENT

Unit-I: Watershed: Concept, Characteristics, Size, Shape, Physiography, Climate, Drainage, Land-use, Hydrological parameters. Basic data collection, Concepts of Integrated Study of Watershed Management. Conditions to develop watershed, Geological Considerations, Types of Watersheds, Integrated studies to develop watersheds. Rain water structures, design and Economic aspects. Soil and water consideration. Role of Remote sensing in establishing watersheds.

Unit-II: Contour Demarcation, Levelling and shaping, Bunding, Hedging, Terracing, Gully control, Check dams, Mini percolation tanks, Percolation Sunken gully pits, Boundary Bunds, Contour Bunds, Dug wells, Bore wells, Continuous contour Trenches, sub-surface dams, Tanks, Diversion structures, Soak pits and Trenches in Urban areas. Public soak pits. Increasing recharge in heavily silted tanks, Recharge through existing dug wells, Recharge pits, Cover crops, Trees. Watersheds and its Impact on Environment, Socioeconomic, Water quality, Remedial measures in adverse conditions-Case histories.

Unit-III: Pebble bunds, Water bunds, Water absorption Trench, Diversion drains, Vegetative Barriers, Sand bag structure, Brush wood dams, Stone check, Rock fill dam, Gabians, Sunken ponds, Farm ponds, Check walls, Check dams, pick up anicut, Nala bund.

Unit- IV: Watershed and Agricultural Practices: Crop pattern, Soil enrichment, Field moisture, Seasonal variations, Biomass management, Sprinkler Irrigation, Drip Irrigation, Pot Irrigation, Microcatchment farming, Types of farming, Cropland Percolation losses. Water-use, Afforestation, Social Forestry, Role of Women in Watersheds.

Unit-V: National projects, Appropriate Technology and action plans, Postoperative problems of watersheds, chemical weathering in watersheds, Hydrochemical response of a forested watershed to storms, hill slope contribution to storm flow, upper watershed solute sources, lower watershed solute sources. Factors affecting the response of small watersheds to precipitation in humid areas, stream flow generation in a forested watershed. Impacts and Remedial measures, Isotope studies in estimating inputs to Ecosystems, influence of surface area, surface characteristics and solution composition and weathering rates. Acidification of Aquatic ecosystems.

Books:

1. Groundwater Resources Evaluation, W.C.Walton

2. Hand book of Applied Hydrology, Ven Te Chow

3. Ground Water, H.M.Raghunath

4. Hydrogeology, Davis & De Wiest

5.Watershed Management, J.V.S.Murthy

6.Facets of Hydrology, John C Rodda

7.Watershed Development, V.V.J.Sarma, C.Subba Rao and N.V.B.S.S.Prasad

8.Watersheds Compherehensive Development, K.V.Seshagiri Rao

9.Hydrology &Watershed Management, B.Venkateswara Rao

HS 404 WELL HYDRAULICS & WATER WELLS

Unit – I : Groundwater movement; Basic flow equations. Steady flow, unsteady flow, and the analysis- Flow nets, refraction at permeable boundaries. (12 Hours)

Unit – II : Well hydraulics: Steady undirectional flow and steady radial flow for confined and unconfined aquifers,

Well in uniform flow. Unsteady radial flow for confined unconfined and leaky aquifers. (12 Hours)

Unit-III : Multiple well system, partially penetrating wells, well losses.
Well flow near aquifer boundaries: Image well theory, recharge boundary and barrier boundary and other boundaries. (12 Hours)

Unit – IV : Pumping tests: Conducting pumping tests, Theis, Jacob, Chow and Papadopulous methods of determining aquifer parameters, recovery test: Determination of transmissivity, storage coefficient, specific yield and specific capacity, recovery test.
(12 Hours)

Unit – V : Water wells: Dug wells, Bored wells, Driven wells, Jetted wells, Methods for drilling deep wells, Well design, Well completion, Well development, pumping equipment, Protection of wells, Well rehabilitation and Horizontal well.
(12 Hours)

Books:

1. Hand Book of Applied Hydrology, Ven Te Chow (ed.)
2. Groundwater, D.K.Todd
3. Analysis of pumping test data, G.P. Kruseman and N.A.De Ridder
4. Groundwater resource evaluation, W.C.Walton
5. Groundwater Manual, U.S. Department of the Interior
6. Applied Hydrology, K.N.Mutreja