

## **M.Sc. (Tech.) Geophysics Syllabus, Semester System (2004-05)**

### **INTRODUCTION**

The M.Sc. (Tech.) course of Geophysics shall be open to the students who have passed B.Sc. examination with Physics and Mathematics securing atleast 50% aggregate marks.

There will be two fields of specialization in Geophysics course; viz.

(i) Exploration Geophysics : leading to M.Sc. (Tech.) Geophysics

(EXPLORATION GEOPHYSICS);

(ii) Meteorology : leading to M.Sc. (Tech.) Geophysics (METEOROLOGY)

The M.Sc. (Tech.) course in Geophysics shall be spread over three academic sessions (six Semesters). Candidates seeking admission in Geophysics will be required to give in writing the choice for the specialization they would like to offer at the time of admission. Out of a total of 22 seats, the allocation of seats for specialization in Exploration Geophysics and Meteorology is 15 and 7, respectively. In addition to these seats, there are two Paid seats available where the student has to pay Rs 30, 000/= each year for the three years (six Semesters) duration course. This payment is in addition to the usual fee of the University.

Candidates will be examined at the end of each Semester in the respective courses. During the First Semester, students will be required to visit different geophysical establishments and laboratories in the country to acquaint themselves with various geophysical activities.

During the Third Semester, the students will undergo field training for familiarization at specialized centres/field work for about 2-3 weeks.

During the Sixth Semester, the students must spend about 2-4 weeks for their Project work /dissertation at the laboratories of their field of specialization or with field parties depending upon the facilities. For the excursion tour, field training and seminar, the students will be required to submit separate reports, individually.

## **M.Sc. (Tech.) GEOPHYSICS COURSES**

The M.Sc. (Tech.) Geophysics course will have the following academic structure of the syllabus with regard to the paper distribution over the entire three year course (six Semesters).

### **A. M.Sc. (Tech.) Geophysics FIRST Semester Course :**

<b>Theory Papers :</b>	Course Credits
GPS-101 Elements of Geology	4
GPS-102 Geohydrology	4
GPS-103 General Meteorology	4
GPS-104 Numerical Methods and Computer Programming	4
<b>Practical Papers :</b>	
GPS-105 Geology	3
GPS-106 Geohydrology	3
GPS-107 General Meteorology	3
GPS-108 (a) Computer Programming	2
(b) Excursion and Tour Report	1
<hr/> <b>Total = 28 Credits</b> <hr/>	

### **B. M.Sc. (Tech.) Geophysics SECOND Semester Course :**

<b>Theory Papers :</b>	Course Credits
GPS-209 Solid Earth Geophysics	4
GPS-210 Geoexploration & Surveying	4
GPS-211 Digital Electronics and Microprocessors	4
GPS-212 Advanced Computer Programming	2
<b>Practical Papers :</b>	
GPS-213 Geoexploration and Surveying	3
GPS-214 Digital Electronics and Microprocessors	3
GPS-215 Advanced Computer Programming	2
<hr/> <b>Total = 22 Credits</b> <hr/>	

### **C. M.Sc.(Tech.) Geophysics THIRD Semester Course :**

<b>Common Theory Papers :</b>	Course Credits
GPS-316 Seismology	4
<b>Special Theory Papers (EXPLORATION) :</b>	
GPS-317 Gravity and Magnetic Methods	4
GPS-318 Geoelectromagnetic Method	4
<b>Special Theory Papers (METEOROLOGY) :</b>	
GPS-319 Agricultural Meteorology	4
GPS-320 Climatology	4

**Common Practical Papers :**

GPS-321 Seismology	3
GPS-322 Geophysical Field Training	3

**Special Practical Paper (EXPLORATION) :**

GPS-323 Gravity and Magnetic Methods	3
GPS-324 Geoelectromagnetic Method	3

**Special Practical Papers (METEOROLOGY) :**

GPS-325 Agricultural Meteorology	3
GPS-326 Climatology	3

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Total = 24 Credits

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**D. M.Sc.(Tech.) Geophysics FOURTH Semester Course :****Common Theory Papers :**

	Course Credits
GPS-427 Mathematical Methods in Geophysics	4
GPS-428 Instrumentation and Signal Processing	2

**Special Theory Papers (EXPLORATION) :**

GPS-429 Geoelectrical Method	4
GPS-430 Stratigraphy, Economic and Petroleum Geology	4

**Special Theory Papers (METEOROLOGY) :**

GPS-431 Dynamic Meteorology	4
GPS-432 Physical Meteorology	4

**Special Practical Papers (EXPLORATION) :**

GPS-433 Geoelectrical Method	3
GPS-434 Stratigraphy, Economic and Petroleum Geology	3

**Special Practical Papers (METEOROLOGY) :**

GPS-435 Dynamic Meteorology	3
GPS-436 Physical Meteorology	3

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Total = 20 Credits

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**E. M.Sc. (Tech.) Geophysics FIFTH Semester Course :****Common Theory Papers :**

	Course Credits
GPS-537 Communication Theory	4

**Special Theory Papers (EXPLORATION):**

GPS-538 Seismic Prospecting and Stratigraphy	4
GPS-539 Well Logging and Reservoir Geophysics	4

**Special Theory Papers (METEOROLOGY) :**

GPS-540 Synoptic and Tropical Meteorology	4
GPS-541 Advanced Dynamic Meteorology	4

**Common Practical Paper :**

GPS-542 Geophysical Data Processing	3
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**Special Practical Papers (EXPLORATION) :**

GPS-543 Seismic Prospecting and Stratigraphy	3
GPS-544 Well Logging and Reservoir Geophysics	3

**Special Practical Papers (METEOROLOGY) :**

GPS-545 Synoptic and Tropical Meteorology	3
GPS-546 Advanced Dynamic Meteorology	3

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Total = 21 Credits

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**F. M.Sc. (Tech.) Geophysics SIXTH Semester Course :**

**Common Papers :**

	Course Credits
GPS-647 Physical Oceanography and Marine Geophysics	4
*GPS-648 Elective Paper	4
GPS-649 Seminar	3
GPS-650 Group Discussion and Comprehensive viva-voce	3
GPS-651 Project work / Dissertation	6

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Total = 20 Credits

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Grand Total for all the Six Semesters = 135 Credits

**\*GPS-648 A. Elective Papers :**

- a. Advanced Hydrology
- b. Advanced Seismology
- c. Remote Sensing and GIS
- d. Environmental Geophysics
- e. Geomagnetism

**\*GPS-648 B. Elective Papers :**

- f. Non-linear Systems in Geophysics
- g. Geotomography and Computer Modelling
- h. Modern Techniques in Seismic Interpretation and Migration

**\*GPS-648 C. Elective Papers :**

- i. Advanced Physical Meteorology
- j. Applied Meteorology
- k. Advanced Climatology

\* One elective paper in the respective field of specialization must be selected from the section GPS-648 A, B or C which will be taught as per facilities available in the department.

## **FIRST SEMESTER**

### **Theory Papers:**

#### **GPS-101 : Elements of Geology**

1. Physical and Structural Geology : Introduction to geology, scope, subdisciplines and relationships with other branches of science, weathering agents , landslides and volcanic activity, Representation of altitude, dip and strike, outcrop, effect of topography on outcrops, outlier and inlier, Folds, faults, unconformities, joints and their classification, criteria of their recognition, clinometer compass and its use.
2. Mineralogy : Mineral - its definition and mode of occurrence, physical properties of minerals like form, colour, lustre, streak, cleavage, fracture, hardness and specific gravity, Physical characters and chemical composition of the following rock forming minerals : Quartz, Orthoclase, Microcline, Plagioclase, Nepheline, Muscovite, Biotite, Augite, Hornblende, Olivine, Garnet, Epidote, Calcite and Magnetite.
3. Petrology : Rock – its definition; classification and distinguishing characteristics of Igneous, Sedimentary and Metamorphic rocks; forms of Igneous rocks, elementary ideas regarding formation; Texture and structure of Igneous, Sedimentary and Metamorphic rocks; Brief petrographic description and occurrences of the following rocks : Granite, Syenite, Gabbro, Rhyolite, Dolerite, Basalt, Conglomerate, Breccia, Sandstone, Limestone , Shale, Gneiss, Schist, Quartzite and Marble; genesis of rocks with respect to plate tectonic settings.

#### **Suggested Books :**

1. Berry & Mason : Mineralogy
2. Billings : Structural Geology
3. Mukherjee : A Text Book of Geology
4. Read & Rutley's : Elements of Mineralogy
5. Singh : Structural Geology: A Practical Approach
6. Smith : Minerals and Microscope
7. Tyrrell : Principles of Petrology

#### **GPS-102 : Geohydrology**

1. Hydrological cycle, origin of groundwater, subsurface distribution of water, springs.
2. Hydrological Properties of Water Bearing Materials : Porosity, void ratio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, laboratory methods of determination of permeability.
3. Mode of occurrence of groundwater, classification of rocks with respect to their water bearing characteristics, aquifers, aquicludes, aquitards, classification of aquifers and groundwater provinces.
4. Movement of groundwater and aquifer performance tests, Darcy's law and its range of validity, theory of groundwater flow under steady and unsteady conditions, determination of permeability, transmissivity and storativity by discharging methods.

5. Precipitation, evaporation, evapotranspiration, seepage, infiltration and runoff.
6. Groundwater exploration, surface geological and geophysical methods of exploration, and subsurface geophysical methods.
7. Hydrogeochemistry : Physical and chemical characteristics of groundwater, classification of groundwater in respect to domestic, irrigation and industrial use, pollution of groundwater.
8. Ground Water Exploitation and Management: Natural and artificial recharge of groundwater, water balance, analysis of hydrograph, conjunctive and consumptive uses of groundwater.

**Suggested Books :**

1. Worcester : A Text Book of Geomorphology
2. Todd : Groundwater Hydrology
3. Ward : Principles of Hydrology
4. Chow : Handbook of Applied Hydrology
5. Heath & Trainer : Introduction to Groundwater Hydrology
6. Singh : Elements of Hydrology
7. Raghunath : Introduction to Hydrology
8. Tolman : Hydrology
9. Karanth : Development, Assessment and Management of Water Resources

**GPS-103 : General Meteorology**

1. Instrumentation : Surface, self recording and upper air meteorological instruments (mercury and aneroid barometer, barograph, air thermometers, bimetallic thermograph, psychrometer, hair hygograph, cup anemometer, Dines pressure tube anemograph, ordinary and recording raingauges, nephoscope, sunshine recorder, pilot balloon, theodolite, radio sonde, rawin and radar).
2. Composition and structure of the atmosphere.
3. Evaporation, condensation, fog, cloud and precipitation, thunderstorm, supercell and multicell structures.
4. Thermodynamics : Thermodynamic principles, properties of dry and moist air, adiabatic processes, hydrostatic stability and instability, parcel method, tephigram.
5. Radiation : Solar and terrestrial radiation, definitions, laws of radiation, albedo, green house effect, Simpson's method of computing long wave radiation flux, heat balance of the earth and its atmosphere.
6. Wind System : Geostrophic wind, gradient wind, thermal wind, cyclostrophic wind and inertial wind, land and sea breezes, mountain and valley winds.
7. Condensation, precipitation, air masses, front, jet stream, extratropical and tropical cyclones, western disturbances, anticyclone, tornado.
8. General Circulation of the Atmosphere : N.E. and S.W. monsoon, seasons, climate and weather.
9. Principles of weather forecasting.

**Suggested Books :**

1. Byers : General Meteorology IV edition
2. Cole : Introduction to Meteorology
3. Pettersen : Introduction to Meteorology
4. Banerjee & Upadhyay : Mausam Vigyan
5. Lutgens & Tarbuck : The Atmosphere : An Introduction to Meteorology
6. Rama Sastry : Weather and Weather Forecasting
7. Das : The Monsoons
8. Wallace and Hobbs : Meteorology and Introductory Survey

**GPS-104 : Numerical Methods and Computer Programming**

1. Solution of algebraic and transcendental equations, bisection and Newton-Raphson methods, solution of simultaneous linear equations, matrix inversion method, interpolation, Newton and Lagrange formulae, numerical differentiation, numerical integration, Simpson, trapezoidal and Gaussian quadrature methods, least square curve fitting, straight line and polynomial fits, numerical solution of ordinary differential equations, Euler and Runge-Kutta methods, finite element and finite difference methods.
2. Digital computer: Architecture and working, low level and high level languages, overview of compilers, interpreters and operating systems, problem solving on a computer, algorithms and flow charts, integer and floating point arithmetic, Fortran preliminaries: constants, variables, data types and expressions, built in functions, executable and nonexecutable statements, assignment, control and input /output statements, subroutines and functions, operations with files.

**Suggested Books :**

1. Sastry : Introductory Methods of Numerical Analysis
2. Jain, Iyengar & Jain : Numerical Methods for Scientific and Engineering Computation
3. Raja Raman : Numerical Analysis
4. Raja Raman : Fundamentals of Computers
5. Raja Raman : Fortran Programming
6. Ram Kumar : Programming with Fortran77

**Practical Papers:****GPS-105 : Geology**

1. Clinometer compass and its use for determination of dip and strike of different beds.
2. Geological problems on slope, dip and thickness of the beds.
3. Drawing of geological sections of the given maps.
4. Study of the physical properties of rock forming minerals (given in theory syllabus).
5. Megascopic study of rocks given in theory syllabus.

### **GP-106 : Geohydrology**

1. Determination of average rainfall.
2. Determination of evaporation and evapotranspiration.
3. Determination of storativity and transmissivity.
4. Determination of porosity and permeability.

### **GPS-107 : General Meteorology**

1. Familiarisation with meteorological instruments and record surface meteorological observations.
2. Study of surface weather and upper air codes.
3. Exercises in coding and decoding.
4. Exercises in plotting station models.

### **GPS-108 (a) : Computer Programming**

To write and execute computer programs in Fortran language for the following problems:

1. Solution of transcendental or polynomial equation by Newton Raphson methods.
2. Numerical integration using Simpson / Gaussian quadrature method.
3. Solution of first order differential equation using Runge-Kutta method.
4. Linear curve fitting and calculation of linear correlation coefficients.
5. Matrix inversion and solution of simultaneous equations.
6. Numerical first order differentiation of a given function.

### **GPS-108 (b) : Excursion and Tour Report**

**During the first Semester, the students will be required to visit some geophysical establishments and laboratories in the country to acquaint themselves with various geophysical activities and submit the tour report to the Head of the Department. The visit may be arranged during the intra/inter Semester break.**

## **SECOND SEMESTER**

### **Theory Papers:**

#### **GPS-209 : Solid Earth Geophysics**

1. History of development and scope of geophysics, monistic and dualistic hypotheses for the origin of solar system, Kepler's law of planetary motion, planet and satellites of the system and their characteristics, shape and size of the earth, international gravity formula and rotation of the earth.
2. Importance of heat flow, thermal history of the earth, sources of heat generation and temperature distribution inside the earth, Jacob's hypothesis for liquid nature of the outer core.
3. Internal constitution of the earth, characteristics of lithosphere and asthenosphere, causes of geodynamical process, geodynamic models, continental drift, ocean floor spreading, plate tectonics and its geological implications, new global tectonics and plate margin process, geomagnetic time scale, Benioff zones, oceanic ridges, evolution of the triple junction, trenches and island arcs, hot



spots, geodynamics of Indian subcontinents and formation of Himalayas, 90° E ridge, concept of isostasy, Airy, Heiskanen and Pratt-Hayford hypotheses.

4. Origin of geomagnetic field, polar wandering, secular variations and westward drift, reversals of geomagnetic field, geomagnetic storms, earth's current, sun spot, solar flares, lunar and solar variations, palaeomagnetic studies of rock samples and their applications in geophysics, radiometric dating principles and ages of rocks and the earth.

#### **Suggested Books :**

1. Howell : Introduction to Geophysics
2. Stacey : Physics of the Earth
3. Gubbins: Seismology and Plate Tectonics
4. Condie: Plate Tectonics and Crustal Evolution
5. Lowrie : Fundamentals of Geophysics
6. Bird & Lacks : Plate Tectonics
7. Chapman : Earth's Magnetism
8. **Jacobs : Earth's Core and Geomagnetism**

#### **GPS-210 : Geoexploration and Surveying**

1. Basic principles of geophysical exploration.
2. Physical properties of minerals and rocks.
3. Gravity Method : Stable and unstable gravimeters, Mottsmith, Worden, Lacoste & Romberg, Hartley, Askania and Gulf gravimeters, field procedure and reduction of gravity data.
4. Magnetic Method : Schmidt type magnetometers, field due to point pole and dipole, field practices and corrections.
5. Electrical Method : Elements of SP, IP and resistivity methods, Wenner and Schlumberger configurations, methods of resistivity profiling and sounding, theory of images, Tagg's method of interpretation.
6. Seismic Method : Elementary principle of reflection and refraction methods, two layer reflection and refraction problems including inclined layer, fundamentals of conventional seismic instruments, fan shooting, profile shooting, continuous profiling and correlation methods of surveying.
7. Radiometric Method : Physical and geological principles of radiometric method, successive disintegrations and equilibrium conditions, GM counter, scintillation counter and gamma ray spectrometer.

#### **Suggested Books :**

1. Dobrin & Savit : Introduction to Geophysical Prospecting
2. Parasnis : Principle of Applied Geophysics
3. Telford et al : Applied Geophysics
4. Sharma : Geophysical Prospecting for Geologists and Engineers
5. Israel & Krebs : Nuclear Radiation in Geophysics

## **GPS-211 : Digital Electronics and Microprocessors**

1. Number Systems: Decimal, binary, octal and hexadecimal number systems, Interconversion of decimal, binary and hexadecimal numbers, BCD numbers, BCD addition and subtraction.
2. Logic Gates : AND, OR, NOT, NAND, NOR, and exclusive OR gates, NAND and NOR gates as universal gates.
3. Logic Families : TTL logic circuits (NAND and NOR gates only), comparison of TTL, ECL and CMOS.
4. Boolean Algebra : De Morgan's theorems, standard POS and SOP forms, min-term and max-term representation of Boolean functions, simplification of Boolean functions using K-maps (upto 4 variables).
5. Combinational Circuits : Half and full adders, half and full subtractors, multiplexer, demultiplexer, encoder, decoder, BCD-to-seven segment decoder.
6. Flip-flops : R-S, J-K, master-slave and edge triggered J-K, T and D Flip-flops.
7. Sequential Circuits : Shift registers, ring counters, ripple and synchronous counter, modulo- N counter, decade counter, digital-to-analog converter (binary weighted register and ladder types), analog -to- digital converter (using D/A converter and comparator).
8. Digital Wave form Generator : Concept of timer IC 555 and its use for waveform generation (astable and monostable only).
9. OP-AMP : Concept and Characteristics of OP-AMP and its use as : Adder, subtractor, differentiator, integrator, logarithmic and exponential operators, inverting and non-inverting amplifiers, differential amplifier, CMRR, analog computer (for 2<sup>nd</sup> order differential equations).
10. Memories : Concept of Random Access Memory (RAM), static and dynamic RAM, Read Only Memory (ROM), PROM and EPROM.
11. Introduction to Microprocessors : Evolution of microprocessors, organisation, architecture and pin description of 8085 microprocessor, addressing modes and instruction set, input / output interfacing devices (8255, 8251), simple programs for addition / subtraction, developmental trends in microprocessor technology (8086, 80186, 80286, 80386, 80486 and Pentium).
12. Application of Microprocessors : Application of Microprocessors in Geophysical Instrumentation : Microprocessor based data acquisition, frequency, temperature and voltage measurements using microprocessors.

### **Suggested Books :**

1. Jain : Modern Digital Electronics
2. Malvino : Digital Computer Electronics
3. Puri : Digital Electronics
4. Mathur : Introduction to Microprocessors
5. Sheth & Hebber : Microprocessors
6. Gaonkar : Microprocessors Architecture, Programming and Application
7. Ram : Microprocessors and Microcomputers
8. Gaikwad : Operational Amplifier

### **GPS-212 : Advanced Computer Programming**

1. Programming Language C: Constants, variables, data types, expressions operators, conditional statements, iterative statements, array, function, storage, class, pointers, structure, union and file handling.
2. Object Oriented Programming: Procedural approach VI, object approach, object oriented methodology, concept of object and class, reusability, encapsulation and polymorphism.
3. C<sup>++</sup> An Object Oriented Language: Class, object, constructor, destructor, operator, overloading, function overloading, inheritance, virtual function, multiple inheritance, generic classes.
4. Software: Application software, system software, support software and firmware.
5. Introduction to UNIX operating system.
6. Introduction to JAVA, Visual BASIC and data base management system.
7. Internet, intranet, multimedia and LAN.

#### **Suggested Books :**

1. Balagoswami : Programming in C
2. Gotfried : Programming in C
3. Yashwant Kanetkar : C Programming
4. Yashwant Kanetkar : C<sup>++</sup> Programming
5. Robert Lafore : Object Oriented Programming C<sup>++</sup>
6. Hasbest Scheilds : Object Oriented Programming
7. Stephen Prata : Advanced Unix-A Programmers Guide

#### **Practical Papers:**

### **GPS-213 : Geoexploration And Surveying**

#### **Geoexploration**

1. Handling of gravimeter and magnetometer.
2. Interpretation of resistivity sounding data by Tagg's method.
3. Determination of velocities and depth of the interface by refraction method.

#### **Surveying**

1. Handling of surveying instruments- theodolite, dumpy level, microptic alidade, electronic distance measuring devices, GPS.
2. Preparation of site map with the help of plane table.
3. Determination of height using theodolite.

### **GPS-214 : Digital Electronics and Microprocessors**

1. Experiment with logic gates.
2. Experiment with Flip-flops.
3. Experiment with digital ICs.
4. Experiment with 555 timer.
5. Experiment with microprocessors.

### **GPS-215 : Advanced Computer Programming**

1. Numerical solution of non-linear equations using available softwares.
2. Solution of differential equations using available softwares.
3. Interpretation of data by finite difference method.
4. Development of programme and solution of some problems by finite element method.

## **THIRD SEMESTER**

### **Common Theory Paper:**

#### **GPS-316 : Seismology**

1. Introduction to earthquake phenomena, concept of focus, focal depth, epicentre, great Indian earthquakes, intensity and magnitude scales and energy of earthquakes, foreshocks and aftershocks, elastic rebound theory, seismicity of India, Himalayas and global seismicity, seismic microzonation, seismic zoning of India, induced seismicity, concept of inhomogeneity and anisotropy, types and causes of earthquakes.
2. Seismic ray theory for spherically stratified earth and velocity structure from travel time data, propagation and characteristics of body waves, surface waves, group and phase velocities, different phases of body waves and their applications, preparation of preliminary reports on seismograms determination of epicentre, focal depth and magnitudes, theory of elasticity, reflection of body waves, focal mechanism solutions and tectonic implications, earthquake generation models, hazard analysis, reflection of seismic waves from the free surface.
3. Principle of electromagnetic seismograph, displacement meters, velocity meter, accelerometer and strain meter seismographs, WWSSN stations, seismic arrays for detection of nuclear explosions, wide band seismometry, strong motion seismograph.

#### **Suggested Books :**

1. Richter : Elementary Seismology
2. Bullen & Bolt : An Introduction to the Theory of Seismology
3. Agrawal : Engineering Seismology
4. Gutenberg : Internal Constitution of the Earth
5. Rikitake : Earthquake Prediction
6. Bath : Introduction to Seismology
7. Slawomir & Andrezej : An introduction to Mining Seismology
8. Stein & Wysession : An Introduction to Seismology, Earthquakes and Earth structure

## **Special Theory Papers (Exploration):**

### **GPS-317 : Gravity And Magnetic Methods**

1. Basic Theory : Magnetic elements, I.G.R.F., Inverse square law, concept of potential, Poisson's and Laplace's equations, magnetism on atomic scale, Dia- para- ferro magnetic materials. Susceptibilities and densities of various rocks and minerals, factors affecting density and susceptibilities, density and susceptibility determination.
2. Instrumentation : Gravity prospecting instruments : Stable and unstable gravimeters, borehole and airborne gravimeters. Magnetic prospecting instruments: flux gate, proton precession and Rubidium vapour magnetometers.
3. Data Acquisition and Correction : Aeromagnetic surveys, plan of the field surveys, station spacing, corrections for gravity and magnetic data. Calculation of derivatives, continuation methods, polynomial fitting for regional-residual separation of gravity and magnetic anomalies. Filter theory and filtering of potential field data, Gravity anomalies over spheres, cylinders, dykes, faults and sheets. Magnetic anomalies over single pole, dipole, line pole, spheres, cylinders, faults and dykes, graticules and anomalies of irregular bodies. Relation between gravity and magnetic potentials, depth estimation, curve matching techniques. Transformation of gravity and magnetic anomalies in frequency domain, spectral representation of field data and interpretation of gravity and magnetic profiles.
4. Processing and interpretation.
5. Gravity and magnetics for the exploration of the minerals, oil /gas and groundwater.

### **Suggested Books :**

1. Grant & West : Interpretation Theory in Applied Geophysics
2. Nettleton : Gravity and Magnetics in Oil Prospecting
3. Rao & Murthy : Gravity and Magnetics
4. Dobrin & Savit : Introduction to Geophysical Prospecting
5. Telford et. al : Applied Geophysics
6. Murthy & Mishra : Interpretation of Gravity and Magnetic Anomalies in Space and Frequency Domain

### **GPS-318 : Geoelectromagnetic Methods**

1. Basic Principles and Theory : Maxwell's equations, electromagnetic potential and wave equations, boundary conditions, long wavelength approximation, depth of penetration, electromagnetic field due to straight wire, rectangular and circular loops, elliptical polarisation, amplitude and phase relations, real (in phase) and imaginary (quadrature) components.
2. Methods of Prospecting : Bieler Watson method, Dip angle methods- fixed vertical loop transmitter, broadside and shoot back methods, two frame method, compensator method, Turam method, Moving source- receiver methods- horizontal loop (Slingram) method, AFMAG and VLF methods, airborne EM systems- rotary field method, INPUT method, EM profiling and sounding.

3. Interpretation : Principles of EM similitude and modelling, response of conducting sphere to uniform alternating magnetic field and infinitely long horizontal cylinder to line source, response of sheet conductors to dip angle, Turam and horizontal loop EM systems, dip angle characteristic curves and phasor diagrams for horizontal loop EM system for sheets, effect of overburden on EM anomalies, principles and practices of Ground Penetrating Radar (GPR).
4. Magnetotelluric (MT) method : Origin and characteristic of MT fields, MT instrumentation, field practices, MT effect over a conducting half space and two layer model.

**Suggested Books :**

1. Parasnis : Mining Geophysics
2. Grant & West : Interpretation Theory in Applied Geophysics
3. Telford et. al : Applied Geophysics
4. Patra & Mallick : Geosounding Principles Vol. II
5. SEG Publication : Mining Geophysics Vol. II

**Special Theory Papers (Meteorology)**

**GPS-319 : Agricultural Meteorology**

1. Meaning and scope of agricultural meteorology.
2. Intent and extent of agricultural meteorology, plant physiology and animal physiology, long term and short term modifications of growth process, avoidable and unavoidable dangers.
3. Agrometeorological Observations : Air, surface and soil temperature, air and soil humidity, wind, precipitation and sunshine.
4. Solar Radiation and Plants : Reflection, transmission and absorption, incoming, outgoing and net radiation, Spectral distribution of solar radiation and physiological response to plants, Light distribution in canopy, Phototropism and Photoperiodism : Meteorological factors in photosynthesis.
5. Environmental Temperature and Plants : Soil temperature and factors affecting them, thermal properties of soil, Cardinal temperatures, Soil moisture and its measurement, estimation and water balance, water use and plant growth, evaporation and evapotranspiration, wind effect on evapotranspiration, wind damage to plants, transportation of pollen disease and insects by winds, wind profile near ground.
6. Climatic Requirements of Important Crops : Rice, wheat, cotton, soyabean and sugarcane.
7. Plant and Crop Diseases : The effect of weather on pathogenic agents- Insects, Fungi, Bacteria, Bacilli and Virus, combating plant diseases, natural and artificial methods, the integrated campaign, insect against insects, Bacteria and Bacilli against insect, Virus against Insects, effect of weather on the host.
8. Meteorological Hazards and Agriculture : Frost and frostfighting methods, hail damage and hail modification method, wind damage and wind breakers, Agricultural drought and drought fighting devices, flood, flood damage and flood fighting.
9. Soils: Composition, structure and physical properties of soils, simple classification of soils, soil air, soil erosion, soil improvement devices and drainage.
10. Agrometeorological forecasts systems, short, medium and long range forecasts, yield forecasts model.
11. A brief outline of remote sensing in agriculture.

**Suggested Books :**

1. Smith : Methods in Agricultural Meteorology
2. Seemann et. al. : Agrometeorology
3. Vitchewich : Agrometeorology
4. WMO Compendium of lecture notes

**GPS-320 : Climatology**

1. Introduction : Concept of weather and climate, climatic elements, climatic factors, earth-sun relationship, ecliptic and equatorial plane, rotation and revolution of the earth, equinox, solstice, perihelion, cause of seasons, radiation balance.
2. World distribution of insolation and air temperature and effects of land, sea and ocean current on it, diurnal and annual variation of surface air temperature at different latitudes, continentality, world distribution of sea level pressure and wind, effect of land and sea on wind, upper air circulation over the whole world.
3. World distribution of precipitation, effects of continents, oceans and topography on rainfall, diurnal and annual variation of precipitation, world distribution of atmospheric perils.
4. Climatology of air masses, fronts, extratropical cyclones and tropical cyclones.
5. Climatic Classification : Koppen and Thornthwait, schemes applicable to India.
6. Climatic changes and cycles, elements of microclimatology, palaeoclimatology.
7. Indian Climatology : Principal seasons of India, winter season; western disturbances, anticyclones and associated weather, fog, hail, thunderstorms, cold waves, subtropical westerly jet stream, premonsoon season; cyclonic storms, dust storm, norwesters, premonsoon thunderstorm activity, heat waves, southwest monsoon season; onset and advance of monsoon; semi permanent components of monsoon, active and break cycle, monsoon depressions, rainfall and its variability, drought, aridity, Postmonsoon season ; north-east monsoon, cyclonic storms in Indian seas.

**Suggested Books :**

1. Sellers : Physical Climatology
2. Trewartha : Introduction to Climates
3. Haurwitz & Austin : Climatology
4. I.M.D. Forecasting Manuals
5. Lockwood : World Climatology

**COMMON PRACTICAL PAPERS****GPS-321 : Seismology**

1. Identification of different phases on a seismogram and to determine the epicentral distance of an earthquake.
2. Determination of group velocity from a record and draw the group velocity dispersion curve.
3. Use of stereographic projection map for locating the epicentre of an earthquake.
4. To prepare the intensity map and find out the epicentre and focal depth for an earthquake.

5. Determination of magnitude from a given seismic records.
6. To draw travel time curve for body waves and find out the velocities of the upper mantle.

### **GPS-322 : GEOPHYSICAL FIELD TRAINING**

During the third Semester, the students will undergo field training for familiarization of the equipment and techniques at specialized centres/field work for about a fortnight and submit the report to the Head of the Department. The field training may also be conducted during the Semester break.

### **SPECIAL PRACTICAL PAPER (EXPLORATION):**

#### **GPS-323 : Gravity and Magnetic Methods**

1. Determination of density by Nettleton method.
2. Handling of gravimeter, Magnetometers and calibration.
3. Structure contouring from subsurface informations.
4. Preparation of a residual map by (a) Graphical method and (b) Grid method.
5. Upward and downward continuation of gravity and magnetic fields.
6. Computation of gravity effect of a sphere horizontal cylinder and fault.
7. Computation of effect of a magnetic dipole of finite length, sphere and horizontal cylinder.

#### **GPS-324 : Geoelectromagnetic Methods**

1. Computation of dip angle response over sheet type bodies.
2. Analysis of dip angle data and its interpretation.
3. Computation of Turam profiles over sheet type bodies.
4. Reduction of Turam data and its interpretation.
5. Interpretation of Slingram profiles over sheet conductors using phasor diagrams.

### **SPECIAL PRACTICAL PAPER (METEOROLOGY):**

#### **GPS-325: Agricultural Meteorology**

1. To compute the soil moisture index by Mavi and Mahi's method.
2. Estimation of components of hydrological cycle  
(a) Precipitation      (b) Surface run off      (c) Deep drainage      (d) Change in water storage
3. Computation of evaporation and evapotranspiration by water balance equation.
4. Forecasting of crop yield on the basis of weather parameters.
5. Weather forecast for agriculture, study of farmer's weather bulletin and agromet advisory bulletin.

#### **GPS-326: Climatology**

1. Basic analysis of global distribution of mean climatic parameters.
2. Computation of weighted and running means of a time series.
3. Computation of rainfall variabilities and coefficient of variation.
4. Computation of mean wind, resultant wind, prevailing wind and persistence.



5. Computation of zonal index.
6. Computation of climatic types according to Koeppen and Thornthwaite.
7. Exercise in curve fitting, least square, correlation and regression.

## **FOURTH SEMESTER COURSE**

### **Common Theory Papers:**

#### **GPS-427 : Mathematical Methods in Geophysics**

1. Complex variables and various integral transforms, Fourier transform, Laplace transform and Hankel transform.
2. Introduction to various element shapes, discretization of a structure, element stresses and strains, boundary conditions, truncation error, stability and convergence relationship, application of finite element and finite difference methods in solving geophysical problems.
3. Solutions of Partial Differential Equations : Euler's method, Taylor series method, Runge-Kutta method, classification of linear partial differential equation, wave and diffusion equations.
4. Introduction and applications of orthogonal systems and Green's function to geophysical problems, Bessel's function, Hermite, Laguerre and Legendre polynomials and their applications.
5. Non-linear Systems : Non-linear equations and their application in geophysics.
6. Various kinds of matrices and their applications in geophysics.
7. Analysis of statistical data and variance analysis in geophysics.

#### **Suggested Books :**

1. Sastry : Introduction Methods of Numerical analysis
2. Gerald : Applied Numerical Analysis
3. Gerald et.al. : Finite Element Simulation in Surface and Subsurface Hydrology
4. Bath : Mathematical Aspects of Seismology
5. Jain, Iyengar & Jain : Numerical Methods for Scientific and Engineering Computation
6. Jain : Numerical Solution of Differential equations
7. Mitchell : Computational Methods in Partial Differential Equations

#### **GPS-428 : Instrumentation and Signal Processing**

1. Amplitude and frequency response characteristics of geophones, critical and optimum damping, seismic amplifier and its frequency response, principles of magnetic tape recording, digital multiplexed recording and shot moments, principles of binary gain ranging amplifier and floating point, dynamic range, Automatic Gain Control (AGC) circuit, Programmable Gain Control (PGC), timing system and recording formats (SEG A, SEG B and SEG C).
2. Elements of wave shaping by R-C network (for sine wave, step function and square wave inputs), clipping and clamping circuits.

3. Analog and digital filters, low and high pass filters and their alpha / beta diagrams, characteristic impedance of symmetrical T and pie networks, band pass filter and comb filters, active filters.
4. Elements of signal processing, analog and digital signals, digitization, sampling theorem, aliasing, random signals, convolution and correlation techniques.

**Suggested Books :**

1. Kennedy & Davis : Electronic Communication Systems
2. Anstey : Seismic Prospecting Instruments Vol. 2
3. Ryder : Network, Lines and Fields
4. Rabiner & Gold : Theory and application of Digital Signal Processing
5. Kanasevich : Time Sequence Analysis

**SPECIAL THEORY PAPERS (EXPLORATION)**

**GPS-429 : Geoelectrical Methods**

1. General : Electrical properties of rocks and minerals and their determinations, fundamentals of direct current flow, relationship between point and line pole potential distribution.
2. Measuring System : Quantities measured in various electrical methods and description of the instruments used, discussion of various configurations used in electrical method and field procedure adopted.
3. D.C. Resistivity Methods : Potential distribution at the surface of a horizontally stratified earth, Kernel function and its relation to the subsurface parameters, apparent resistivity function, computation of apparent resistivity model curves, principle of digital linear filtering.
4. Vertical Electrical Sounding : Interpretation of resistivity VES data, empirical methods for interpretation of resistivity sounding data, indirect interpretation techniques, auxiliary point method, partial curve matching, complete curve matching, direct interpretation techniques, automatic direct interpretation method, Dar Zarrouk parameters, inversion techniques in resistivity method of interpretation, computer-aided resistivity data interpretation (softwares), principles of equivalence, suppression and detectibility problems, effects of deviations from the fundamental assumptions.
5. Electrical Profiling : Profiling near a vertical contact and thin vertical dykes and discussion of the expected apparent resistivity curves.
6. Self Potential Method : Mechanism of SP, field techniques, field due to vertically polarized sphere and interpretation.
7. Induced Polarisation Method : Mechanism of IP instruments and principles of measurements both in time and frequency domain and its interpretation.
8. Other methods : Principles, application and interpretation of potential drop ratio method, equipotential lines method and telluric current methods.

**Suggested Books :**

1. Bhattacharya & Patra : D.C. Geoelectric Sounding : Principles and Interpretation

2. Kunetz : Principles of Direct Current Resistivity Prospecting
3. Keller & Frischknecht : Electrical Methods in Geophysical Prospecting
4. Nostrand & Cook : Interpretation of Resistivity Data
5. Wait : Overvoltage Research and Geophysical Application
6. Koefoed : Geosounding Principle-I : Resistivity Sounding Measurements
7. Patra & Nath : Schlumberger Geoelectric Sounding in Ground Water
8. Ghosh : The Application of Linear Filter Theory to the Direct Interpretation of Geoelectrical Resistivity Measurements

### **GPS-430 : Stratigraphy, Economic and Petroleum Geology**

1. Stratigraphy : Principles of stratigraphy, geological time scale, elements of stratigraphic classification, physical and structural subdisciplines of Indian subcontinent and their characteristics, An outline of the geology of India with respect to the distribution, classification, lithology and economic importance of the following : Dharwar, Cuddapah, Vindhyan, Gondwana, Tertiary of Assam Himalaya including Siwaliks.
2. Economic Geology : Definition of ore, ore mineral and gangue, classification of ore deposits, Elementary ideas of the following processes of formation of ore deposits: Magmatic concentration, Pegmatitic, Sedimentation, Evaporation, Residual concentration, Mechanical concentration and Metamorphism, Chemical composition, diagnostic characters, occurrences, uses and distribution in India of important metallic and non-metallic mineral deposits.
3. Petroleum Geology : Origin of petroleum, source rocks, migration and accumulation of oil and gas, reservoir rocks, reservoir pore spaces, reservoir traps and petroleum exploration (geological modelling), surface occurrences of oil and gas, brief geological account of important petroleum occurrences in India, case histories, introductory knowledge about environmental effects of petroleum industry.

### **Suggested Books :**

1. Bateman : Economic Geology
2. Krishna Swami : India's Mineral Resources
3. Sharma & Ram : Introduction to India's Economic Minerals
4. Levorsen : Geology of Petroleum
5. Evans & Mathur : Oil in India
6. Krishnan : Geology of India and Burma
7. Wadia : Geology of India

### **SPECIAL THEORY PAPERS (METEOROLOGY)**

#### **GPS-431: Dynamic Meteorology**

1. Principles of Thermodynamics : First law of thermodynamics, internal energy, specific heat capacity and enthalpy, adiabatic process, entropy and the second law of thermodynamics.
2. Thermodynamics of Water Vapour and Moist Air : Isotherms on an  $\alpha, e$  diagram, equation of state of moist air, Clausius Clapeyron equation, adiabatic processes of saturated air and moisture variables.

3. Thermodynamics Diagrams : General considerations, emagram, tephigram, skew T/ log P diagram, Stueve diagram, choice of a diagram.
4. Hydrostatic Equilibrium : Hydrostatic equation, geopotential height computations for upper-air soundings, hydrostatics of homogeneous, isothermal, constant lapse rate and dry adiabatic atmosphere, standard atmosphere.
5. Hydrostatic Stability and Convection : General consideration, dry and moist adiabatic lapse rates, parcel method, stability and instability criterion, conditional and latent instability, convective instability, slice method, entrainment.
6. Motions of the Earth Rotation and Revolution : Mean solar time and sidereal time angular rotation centrifugal force, gravitation and gravity, geopotential.
7. Equation of motion in different coordinate systems, tangential, local, rectangular coordinates, spherical polar coordinates, natural coordinates, scale analysis of the equations of motion, approximate equations, Rossby number.
8. Continuity equation in Cartesian, isobaric and spherical coordinate.
9. Balanced Motion : Inertial wind, geostrophic wind, gradient wind, cyclostrophic wind and thermal wind.
10. Viscosity and Turbulence : Fundamental laws of viscosity, equations of mean motion in turbulent flow, mixing length theory, planetary boundary layer, power law, Ekman layer, Richardson number, Reynold's number, Froud number.
11. Circulation and Vorticity : Kelvin's circulation theorem, Bjerknes theorem, potential vorticity, vorticity equation, divergence equation, Helmholtz theorem.
12. Kinematics of gases, horizontal motion, characteristics of wind fields, construction of streamlines, isotach, trajectories, relation between stream line and trajectories, Blatons equation.
13. Kinematics of pressure fields, mechanism and influence of pressure changes, tendency equation, Bjerknes Holmboe theory, isallobaric wind.
14. Frontogenetical Functions : Frontogenesis in horizontal velocity field, frontogenetical and frontolytical sections, kinematics and dynamic boundary connections, pressure distribution over front, Morgules formula.

**Suggested Books :**

1. Hess : Introduction to Theoretical Meteorology
2. Pisharoty : Thermodynamic Diagram and Some of Their Uses (IMD Tech. Note)
3. Gordon : Introduction to Dynamic Meteorology
4. Holton : An Introduction to Dynamic Meteorology
5. Haltiner : Numerical Weather Prediction
6. Haltiner & Martin : Physical and Dynamic Meteorology
7. Haltiner & William : Numerical Weather Prediction and Dynamic Meteorology
8. Astel & Wiin-Nielsen : Compendium of Meteorology, Vol. I. Dynamic Meteorology, W.M.O. No. 364

## **GPS-432 : Physical Meteorology**

1. Radiation : Definition of terms, units, laws of black body radiation, solar radiation-nature of solar radiation, solar constant, latitudinal and seasonal variations, depletion of solar radiation in the atmosphere, absorption, scattering and reflection, albedo of the earth, direct beam insolation at the earth's surface, disposition of solar radiation under cloudless condition, disposition of solar radiation with cloudy skies, mean disposition of solar radiation, Terrestrial radiation : Characteristics, absorption in the atmosphere, green house effect, heat flux, transmission through the atmosphere, atmospheric window, Simpson's computation of terrestrial radiation transfer, Elsasser treatment, Elsasser chart; radiative heating and cooling, mean heat balance of the earth atmospheric system, poleward transport of energy, fundamental link with general circulation, radiation instruments.
2. Cloud Physics : Atmospheric aerosols and condensation nuclei, nucleation, physics of initial stages of condensation, curvature and solution effect, growth and evaporation of cloud droplets by diffusion, the physics of precipitation in warm clouds, collision-coalescence theory, collection efficiency, terminal velocity precipitation from mixed clouds, Bergeron and Findeisen's theory, artificial cloud seeding of warm and cold clouds, rain making experiments and weather modification.
3. Atmospheric Optics: Attenuation of light, refraction, scattering, turbidity, optical phenomena, rainbow, halo, corona, glory, mirage etc., atmospheric and terrestrial refraction, looming, towering, stooping, sinking.
4. Radar Meteorology : Basic radar equation, wavelengths used for detection of cloud, thunderstorm and cyclone, PPI and RHI scopes, meteorological applications of radar, radar echoes, estimation of precipitation, rain water content and upper winds using radar.
5. Atmospheric Ozone: Mechanism of formation and destruction, measurement of ozone, seasonal and latitudinal variation, Umkehr effect, vertical distribution of ozone, ozone-weather relationships, ozone hole.
6. Atmospheric Electricity : Electrical field of the earth in fair and disturbed weather, atmospheric ionisation, air-earth electric current and its maintenance, supply current, theories of charge generation and separation in thunderstorm, lightning discharges.
7. Satellite Meteorology : Kepler's Laws of planetary motion, equation of orbital motion, types of meteorological satellites, brief history of satellite meteorological programme, description of important sensors on board, visible and infra red data and their interpretation, identification of typical weather systems from cloud picture, estimation of winds, vertical temperature and humidity profile and rainfall from satellite observations, tropical cyclone grading using Dvorak's technique.

### **Suggested Books :**

1. Johnson : Physical Meteorology
2. Mason : Physics of Cloud
3. Dobson : Exploring the Atmosphere
4. Retallack : Compendium of Meteorology Vol. I, Part-III, Physical Meteorology. W.M.O. 364
5. Baton : Radar Observes the Weather

6. Kidder & Vonder Harr : Satellite Meteorology
7. Taba : Ozone Observations an Introduction and their Meteorological Applications, W.M.O. Technical Note No. 36, W.M.O. No. 108

### **SPECIAL PRACTICAL PAPERS (EXPLORATION):**

#### **GPS-433 : Geoelectrical Methods**

1. Experiments with resistivity meter.
2. Plotting of equipotential traces and current lines for a point source.
3. Interpretation of S.P. anomalies.
4. Interpretation of I.P. data.
5. Interpretation of resistivity profiling data.
6. Interpretation of field resistivity sounding curves.
7. Computer-aided interpretation of sounding curve data.

#### **GPS-434 : Stratigraphy, Economic And Petroleum Geology**

1. Study of advanced geological maps.
2. Study of common economic minerals in hand specimens.
3. Study of rocks of important stratigraphic horizons of India.
4. Study of petroleum traps and stratigraphy and structure of important petroleum fields of India.

### **SPECIAL PRACTICAL PAPERS (METEOROLOGY):**

#### **GPS-435 : Dynamic Meteorology**

1. Analysis of tephigram : (a) Computation of derived parameters, LCL,CCL and LFC, (b) Computation of precipitable water content, (c) Computation of heights of pressure surfaces by adiabatic and isothermal methods, (d) Study of stability and instability of various layers and forecasting of fog, thunderstorm, etc. (e) Determination of height of tropopause thickness of isothermal and inversion layers etc.
2. Preparation of geostrophic wind scale and computation of geostrophic wind from constant pressure charts with the help of above scale.
3. Computation of geostrophic vorticity.
4. Exercise in graphical addition and subtraction.

#### **GPS-436 : Physical Meteorology**

1. Measurement of total amount of atmospheric ozone by Dobson's ozone spectrophotometer.
2. Numerical computation in radiation, cloud physics and radar meteorology.

## **FIFTH SEMESTER COURSE**

### **Common Theory Papers:**

#### **GPS-537 : Communication Theory**

1. Introduction : Historical development of time series, classification of data, analogue and discrete signals, digitization, sampling interval and aliasing, wavelets, Z transform, linear system, Dirac

delta function and impulse response of a linear system, impulse response function, minimum delay, maximum delay and mixed delay wavelets.

2. Convolution and Correlation Techniques: Convolution, methods for convolution, properties of convolution, autocorrelation, crosscorrelation, and their applications, time domain and frequency domain concepts.
3. Fourier series and Fourier transform, Hilbert transform, Walsh transform, orthogonal function and Dirichlet conditions, complex form of Fourier Series and Fourier transform, physical significance and interpretation of Fourier transform, properties of Fourier transform, Fourier transform of a symmetrical rectangular pulse, reciprocity, Fast Fourier Transform (FFT), two dimensional Fourier transform and its applications.
4. Digital Filtering : Low, high and band pass filters, truncation of unit impulse response function, illustration of Gibb's phenomenon. Butterworth filters, Chebyshev filter, recursive filters.
5. Weighting Functions (Windows) : Hanning window, Hamming window and their comparison, triangular window, Bartlett window, Parzen window, Daniell window, practical applications of windows.
6. Techniques for Spectral Estimation : Power spectrum, method for calculation of power spectrum, three basic data models, Moving Average (MA) method, Maximum Entropy Method (MEM), Maximum Likelihood Method (MLM), Autoregressive process (AR), comparison of MA, MEM, MLM and AR techniques.
7. Deconvolution : Introduction, white spectrum, Wiener inverse filtering and its mathematical details, homomorphic applications of deconvolution filtering.
8. Applications of Time Series in Various Branches of Geophysics : Seismic method, gravity and magnetic methods, resistivity and well-logging methods, use of spectral techniques in meteorology, oceanography and groundwater hydrology.

#### **Suggested Books :**

1. Silvia & Robinson : Deconvolution of Geophysical Time Series in the Exploration for Oil and Natural Gas
2. Robinson & Trietel : Geophysical Signal Analysis
3. Kanasevich : Time Sequence Analysis in Geophysics
4. Bath : Spectral Analysis in Geophysics
5. Oppenheim & Schaffer : Digital Signal Processing
6. Papoulis: The Fourier Integral and its Applications

#### **Special Theory Papers (Exploration)**

#### **GPS-538 : Seismic Prospecting and Stratigraphy**

1. Historical Development and Background of Refraction and Reflection Methods, Difference between Refraction and Reflection Surveys, Propagation of Seismic Waves in Linear and Nonlinear medium, Waveforms and their characteristics, N Layered case, continuous increase of velocity.
2. Seismic data enhancement and Test Shooting, Explosive and Non Explosive sources of Seismic Energy for P-Wave, Seismic source energy For S-Wave, Seismic operation on Land, Common

Depth Point technique, Special weathering shot and Noise analysis, Broad Side shooting, Elevation, Weathering and Dynamic Corrections In Refraction and Reflection Data, Random and Non Random Noise, Grouping of Geophones, Data Acquisition for Vertical Seismic Profiling, Deep Seismic Sounding, Diffraction Method of Data Interpretation.

3. Sampling Theorem and Analysis of Seismic signals, Convolution, Correlation Techniques and Inverse Filtering of Seismic Data, Interpretation of Shear Wave Data, Hidden Layer Problem, Sequence of Seismic Processing, Seismic Inversion, Determination of Average Seismic Velocities, Tomography, Synthetic Seismograms.
4. Different Types of Display of Digital and Magnetic Recordings, Wiggle Trace, Variable Area and Variable Density Records, Analysis of Multiples and Ghost Reflections, Processing of Seismic Data, Imaging, 2D, 3D and 4D Seismics, Time and Depth Sections, Record Surface and Reflection Surface, Vertical and Horizontal Resolution.
5. Mapping of Geological Structures (Faults, Reef, Pinchouts, Anticlines), Migration Techniques (Classical and Modern), Wave Equation Migration, Time and Depth Migration, Depositional Sequence and Pit Falls of Seismic Interpretations, Seismic Stratigraphy and Sequence Analysis, Seismic Facies Analysis, Reflection Character Analysis, Bright Spots, Seismic Lithologic Modelling, Vp/Vs and Lithology, Gas Detection using AVO Analysis.

#### **Suggested Books :**

1. Clarbout : Fundamentals of Geophysical Prospecting
2. Telford et. al. : Applied Geophysics
3. Sheriff : Seismic Stratigraphy
4. Dobrin & Savit : Introduction to Geophysical Prospecting
5. Waters : Reflection Seismology
6. Sheriff & Geldart : Exploration Seismology

#### **GPS-539 : Well Logging And Reservoir Geophysics**

1. Reservoirs characteristics and objectives of well logging.  
Reservoir Rocks : Clastic and carbonate rocks.  
Reservoir Properties: Porosity, permeability, fluid saturation, need of drilling fluids and its properties, invasion process and various profiles, classification of formation evaluation methods, objective of well logging methods, logging operational field system and its procedure.
2. Electric Logging : Spontaneous Potential (SP) logging: Spontaneous potentials in boreholes and its sources, SSP and its measurements, SP curves and its interpretation, factors affecting the shape and amplitude of SP curve, Non-focussed, focussed and induction logging, principle of sonde, Interpretation of Electric Log Data : Determination of resistivity of interstitial water  $R_w$ , porosity and water saturation  $S_w$  of clean and shaly sandstones, determination of  $R_w$  of clean sandstone from SP curve, estimation of permeability.
3. Radiation Well Logging : Gamma ray logging, details of the radiation logging, density or gamma-gamma logging, principle of the neutron-gamma logging, neutron-epithermal-neutron logging,



neutron-thermal-neutron logging, interpretation and applications of radiation logging for evaluation of reservoir characteristics.

4. Other Miscellaneous Logging Techniques : Acoustic velocity (Sonic) logging, Cement Bond Log (CBL), Litho-density Tool (LDT), thermal log, calliper or section gauge log, Casing Collar Locators (CCL), dip and direction logging, gravity logging, nuclear magnetic resonance logging.
5. Advanced Logging Tools: Introduction of induced gamma-ray spectrometry, chlorine logging, introduction to natural Gamma-ray Spectrometry (NGS), Cased Hole Neutron Tool (Thermal Decay Time or TDT) measurements.
6. Cross Plots : Resistivity-porosity cross plots, Porosity Cross plots: neutron – density, sonic density and sonic neutron density cross plots.
7. Application of well logging to ground water, mineral and petroleum resources.

#### **Suggested Books :**

1. Lynch : Formation Evaluation
2. Wyllie : Fundamentals of Well Log Interpretation
3. Vaish : Geophysical Well Logging : Principles and Practices
4. Schlumberger : Schlumberger Log Interpretation Principles / Applications
5. Schlumberger : Schlumberger Log Interpretation Charts
6. Serra : Fundamentals of Well-log Interpretation
7. Pirson : Hand book of Well log Analysis for Oil and Gas formation Evaluation
8. Deveton : Log analysis of Subsurface Geology : Concepts and Computer Methods

### **SPECIAL THEORY PAPERS (METEOROLOGY)**

#### **GPS-540: Synoptic and Tropical Meteorology**

1. Meaning and scope of synoptic meteorology, Plotting of synoptic observations on different maps, analysis of surface and upper air charts, vertical time section and cross section analysis.
2. Scales of Atmospheric Weather Systems : Primary, secondary and tertiary circulations, distribution of temperature, pressure and winds fields over the globe, Streamline, Streakline and Trajectory : Relationship between streamline and trajectory, curvatures, fields of convergence, divergence and vorticity.
3. Air masses, their classification, source regions, modification and associated weather, frontogenesis and frontolysis, polar and subtropical fronts, Extratropical cyclones, their origin and associated weather, zonal index, index cycle, cutoff lows, highs, blocking.
4. Jet streams, their classification and characteristics, PFJ, STJ, TEJ, low level jet stream of Asian monsoon, structure, formation, maintenance and associated weather.
5. Principle of Weather Prediction : Short range, medium range and long range weather prediction, limits of predictability, forecast evaluation.

6. Tropical Meteorology : Mean tropical atmosphere, equatorial trough (ITCZ), basic currents, trade wind inversion, easterly waves and their dynamical aspects, formation and forecasting of easterly waves, QBO, Hadley and Walker circulation.
7. Tropical cyclones, classification of tropical disturbances, global climatology, life cycle, surface and upper air structure, thermal structure, the eye and wall cloud, rainfall, energy aspects, theories of formation, CISK, detection, movement tracks, recurvature, Fujiwara effect, forecasting, storm surges, cyclone warning.
8. Monsoons : Monsoon regions in the tropics, causes of monsoon, the Indian summer monsoons, rainfall distribution, elements of the monsoon system, monsoon disturbances, MTC, monsoon variability, onset and advancement of monsoon, withdrawal, fluctuations in monsoon activity, active, weak and break monsoon conditions, intra seasonal and interannual variability of summer monsoon, biweekly and 30-50 day oscillation, southern oscillation and El Nino, monsoon rainfall and teleconnections, long range prediction of monsoon, monsoon over China, S.E. Asia, N. Australia, east and west Africa.
9. General Circulation: Features over India during other seasons : Winter seasons, western disturbances, cold waves, fog, Pre Monsoon Seasons : different convective phenomenon, Norwesters and tropical storms, Post Monsoon Season : N.E. monsoon, tropical storms and their differences with tropical storms of pre monsoon season.

**Suggested Books :**

1. Riehl : Tropical Meteorology
2. Palmen & Newton : Atmospheric Circulation System
3. Reiter : Jet Stream Meteorology
4. Ramage : Monsoon Meteorology
5. Saucier : Principles of Meteorological Analysis
6. Wiin-Nielson : Compendium of Meteorology, Vol. I, Part 3, Synoptic Meteorology, Geneva, W.M.O. No. 364
7. Asnani : Tropical Meteorology, Vol. I and II
8. Das : Monsoons, Geneva, WMO No.613
9. Keshavamurthy & Sankar Rao : The Physics of Monsoons
10. Tarakanov : Tropical Meteorology
11. Krishnamurthi : Compendium of Meteorology, Vol. II, Tropical Meteorology, Geneva, W.M.O. 364

**GPS-541 : Advanced Dynamic Meteorology**

1. Atmospheric Waves : Perturbation theory, properties of waves, sound waves, gravity waves, vertical stability, internal gravity waves, Rossby waves, mountain waves.
2. Vertical Motion: Kinematic, adiabatic and omega equation.
3. Scale analysis of momentum, continuity, vorticity, divergence, thermodynamic and omega equation, diagnostic analysis of synoptic scale motion in middle latitude.
4. Sutcliffe's Development Theory : Thickness and vorticity advection.

5. Numerical Weather Prediction : Historical review, filtering of sound and gravity waves, filtered forecast equation, forecasting of stream function. barotropic model, equivalent barotropic model, baroclinic model-two level model, multilevel quasigeostrophic model, primitive equation models, spectral and finite element model, Sigma coordinate, hydrodynamic equations in Sigma coordinate Eta coordinate, Eta model, cumulus convection and large scale condensation, methods of cloudiness and precipitation forecasting, range of predictability.
6. Hydrodynamic Instability: Barotropic, inertial and baroclinic instability.
7. Numerical Methods: Finite difference, truncation error, linear computational instability, implicit and semi-implicit method, relaxation method.
8. General Circulation : Longitudinally averaged and varying flow, constraints on the theories of the general circulation, maintenance of mean zonal circulation (angular momentum consideration), experimental approach.
9. Energetics : Energy equation, internal and available potential energies, generation, conversion and dissipation of energies.

#### **Suggested Books :**

1. Hess : Introduction to Theoretical Meteorology
2. Holton : An Introduction to Dynamic Meteorology
3. Haltiner : Numerical Weather Prediction
4. Haltiner & Martin : Dynamic and Physical Meteorology
5. Atkinson : Dynamic Meteorology : An Introductory Selection
6. Thompson : Numerical Weather Analysis and Weather Prediction
7. Wiin-Nielsen : Compendium of Meteorology, Vol. I Geneva, W.M.O.

#### **Common Practical Paper**

##### **GPS-542 : Geophysical Data Processing**

1. To digitise analogue signal by graphical method choosing different sampling intervals, plotting the digitised record and examining the aliasing phenomenon.
2. To convolve the two signals (wavelets), plot and examine the results.
3. To compute the autocorrelation and cross-correlation functions for a given data set, plot and examine the results.
4. To perform digital filtering after designing a low, high and band pass filters and to examine the effects of truncation.
5. To apply Hanning and Hamming windows on a given set of data points.
6. To compute the amplitude, phase and power spectra of a given time series.
7. To apply Wiener inverse filtering to seismic data, comment on wavelet extraction problems.
8. To perform the spectral analysis of gravity, magnetic and meteorological data.

#### **Special Practical Papers (Exploration)**

##### **GPS-543 : Seismic Prospecting and Stratigraphy**

1. Computation of seismic records and plotting section.
2. Determination of velocity.

3. Interpretation of reflection and refraction data.
4. Plotting of seismic section.
5. Testing and handling of seismic prospecting units.
6. Automatic migration and mapping techniques.

**GPS-544 : Well Logging and Reservoir Geophysics**

1. Qualitative interpretation of well logs and their correlation.
2. Computation of porosity.
3. Computation of formation factor.
4. Computation of water saturation.
5. Computation of oil saturation.
6. Computation and estimation of producible oil per acre.
7. Applications of cross plots for estimation of various parameters.

**SPECIAL PRACTICAL PAPERS (METEOROLOGY):**

**GPS-545 : Synoptic and Tropical Meteorology**

1. Plotting and analysis of surface weather charts for different seasons and issue of inferences.
2. Plotting and analysis of constant pressure charts.
3. Plotting and analysis of vertical time section and cross section chart.
4. Streamline and isotach analysis.
5. Prognostication of synoptic systems like lows, trough etc. by kinematic methods.

**GPS-546 : Advanced Dynamic Meteorology**

1. Preparation of Bellamy grid and computation of divergence, vorticity and deformation field by Bellamy grid.
2. Preparation of curvature circle nomogram and computation of divergence and vorticity by curvature circle.
3. Computation of divergence and vorticity by finite difference method.
4. Problems in dynamic meteorology.
5. Simple exercises in numerical model.

**SIXTH SEMESTER COURSE**

**Common Papers**

**GPS-647 : Physical Oceanography and Marine Geophysics**

**(a) Physical Oceanography**

1. Physical Properties of Sea Water : Chlorinity, salinity, thermal properties, density, pressure, optical properties, transmission of sound, water masses, T-S diagram, variation of salinity, heat budget of the ocean, Bowen ratio.
2. Acquisition of Ocean Data : Salinity measurements, Nansen bottle, light in sea, measurement of SST, reversing thermometers, Bathy thermograph, current meters.

3. Ocean Currents: Hydrodynamic equations of motion, inertia currents, geostrophic currents in homogeneous and stratified ocean; relative and slope currents, thermohaline currents, drift current in homogeneous water, Ekman theory, the major surface current systems of the ocean, upwelling and sinking with special reference to Indian Ocean and their effects.
4. Waves : Wave celerity, group velocity, theory of surface gravity waves, short and long waves, generation and growth of wind waves, long waves in canals, standing waves in closed basins, seiches, swell, breakers and surf, internal waves, storm surges, tsunami.
5. Tides : Tide generating forces, principal harmonic components, theories of tides, description and types of tides, prediction of tides, tidal gauges.
6. Air Sea Interaction: Structure of the boundary layer, exchange coefficients and profiles, transfer of heat and water vapour.

**(b) Marine Geophysics**

1. Ocean and Seas : Classification, growth and decline of ocean basins, turbidity currents, submarine sedimentation and stratigraphy, physiography and divisions of the sea floor, continental shelves, slopes, aprons and abyssal planes, occurrence of mineral deposits and hydrocarbon in offshore.
2. Gravity and Magnetic Surveys: Types of magnetometers used in a survey ship, towing cable and fish, data collection, reduction and interpretation. Underwater gravity measurements, ship borne gravimeters, Graf sea gravimeter, vibrating string accelerometer, Lacoste Romberg gravimeter, problems with shipborne gravity measurements, survey procedure, data reduction and interpretation.
3. Seismic Surveys : Marine energy sources, Finger, Boomer, Sparker, explodor, airgun, vapour cook etc. hydrophones active section and streamer towing gear, shooting methods near offshore and offshore exploration techniques, recording of signals by digital system, analysis of seismic data their processing and interpretations, refraction survey with Sonobuoy's and interpretation.
4. Radio Positioning System : Short range and long range Doppler Sonar, satellite navigation, GPS and GIS.

**Suggested Books :**

1. Duxbury : The Earth and its Oceans
2. WMO No. 364 : Marine Meteorology
3. Sverdrup, Johnson & Fleming : The Oceans
4. Defant : Physical Oceanography, Vols. I and II
5. McLellen : Elements of Physical Oceanography
6. Jacob, Russel & Wilson : Physics and Geology
7. Dobrin & Savit : Introduction to Geophysical Prospecting
8. Telford et. al. : Applied Geophysics

**\*GPS-648 : Elective Paper**

**GPS-649 : Seminar**

Each student is required to prepare a seminar note (about 1500 words) in the form of a report and give oral lecture (40 minutes) on the topic assigned by the Head of the Department in consultation with the respective supervisor.

### **GPS-650 : Group Discussion and Comprehensive Viva-Voce**

Students will be assessed periodically in each Semester which will be in the form of group discussion and viva-voce in the presence of the teaching members of the department. At the end of sixth Semester, each student will be examined in this paper on the entire M.Sc.(Tech.) Geophysics course by a Board consisting of two to four internal and one external examiners in each specialisation.

### **GPS-651: Project Work/Dissertation**

Students will be required to undertake a project work/dissertation during sixth Semester. They must devote about 2-4 week's time either in the field and/or in laboratories for this purpose. The topic of their project work/dissertation will be decided towards the end of the fourth Semester by the Head of the Department in consultation with the supervisor concerned. Provision of co-supervisor(s) will also be there. The related Lab. and/or field work may also be conducted during the summer vacation/intra/inter semester break.

### **\*GPS-648 A. Elective Papers:**

#### **(a) : Advanced Hydrology**

1. Surface water: evaporation formulae and theories of surface flows, safe yield, floods, estimation of flood flow, method of unit hydrograph, synthetic hydrographs, their applications, flood routing through rivers and reservoirs, statistical methods in hydrology.
2. Water Resources : Partially saturated soils, Darcy's law in unsaturated medium, derivation of Darcy's law from Navier-stokes theorem, different forms of unsaturated flow equation, nature of the physical parameters in unsaturated flow, infiltration theories, concepts of diffusion, dispersion and redistribution in groundwater, groundwater hydrographs, application of finite difference and finite element techniques, simulation method, analog and digital modelling of aquifers, tracer techniques.
3. Water Management: Urban hydrology, practical aspects of flow of groundwaters to wells, analysis of pumping test, conservation and utilization of water and its management.

#### **Suggested Books:**

1. Ward : Principles of Hydrology
2. Todd : Groundwater Hydrology
3. Heath & Trainer : Introduction to Groundwater Hydrology
4. Guide Book on Nuclear Techniques in Hydrology
5. Dury : Face of the Earth
6. Chow : Handbook of Applied Hydrology
7. Childs : Introduction to Soil Water Physics
8. Walton : Groundwater Evaluation
9. Tolman : Groundwater

#### **(b) : Advanced Seismology**

1. Measurement and characteristics of strong ground motion, dispersion of surface waves, ray theory, travel-time curves for body waves and inversion techniques, tomography, 3-D earth structure,

attenuation, diffraction and scattering of seismic waves, fault asperities inferred from seismic waves, crust and mantle structures inferred from surface waves, broad band seismometry, recent Indian earthquakes.

2. Seismic arrays, tectonic and volcanic earthquakes and their characteristics, seismic hazard, risk analysis, seismic gaps and regions of high seismic potential, earthquake source studies, earthquake processes and source modelling, earthquake prediction problems, application of fractals and chaotic dynamics in seismology, non-linear propagation and geodynamics.

#### **Suggested Books :**

1. Kanamori & Baschi : Earthquakes: Observation, Theory and Interpretation
2. Ewing : Elastic Waves in Layered Media
3. Bath : Mathematical Aspects of Seismology
4. Bullen : Introduction to Seismology
5. Aki & Richard : Quantitative Seismology, Vol. I and II
6. Slawomir & Andrezej : An Introduction to Mining Seismology

#### **(c) : Remote Sensing and GIS**

1. Fundamentals of Remote Sensing : Energy sources, principles of solar and terrestrial radiation, laws of radiation, energy interactions, spectral patterns and signatures.
2. Characteristics of aerial photographic imagery, photogrammetry, air photo interpretation for terrain evaluation.
3. Application in geological mapping and mineral resource evaluation, concepts of GIS and applications: theory and principles, structural concepts, geological interpretation and its ambiguity, geological guides, characteristics for mineral resource.
4. Application to water resources evaluation and soil moisture determination: watershed parameters, physiographic measurements, surface water, flood plain delineation, precipitation, ice and snow monitoring, evaporation and evapotranspiration, subsurface water information system and analysis.
5. Developments of satellites and remote sensing developments in India.
6. Development in remote sensing platforms, constant level and tethered balloons, aircrafts, rockets and satellites.
7. Kepler's laws of planetary motion, circular and elliptical orbits of satellites, polar, geosynchronous and geostationary satellites.
8. Types of sensors, photographic and TV cameras, visible and infrared sensing, radiometer, side looking radar.
9. Historical development, various meteorological satellite system, INSAT system, data acquisition system, Automatic Picture Transmission (APT).
10. Remote sensing application in meteorology , visible and infrared pictures of clouds, recognition of various clouds and weather systems, estimation of surface temperature and cloud tops, vertical profiles of temperature and water vapour, wind estimation, role of weather satellites in global coverage of observation in synoptic and climatological studies.

**Suggested Books :**

1. Barret & Curtis : Introduction to Environmental Remote Sensing.
2. Lillesand & Kiefer : Remote Sensing and Image Interpretation.
3. Reeves (Ed) : Manual of Remote Sensing, Vols. I and II, American Soc. Photogrammetry.
4. Siegal & Gillespie: Remote Sensing in Geology.
5. Deekshatulu & Rajan : Remote Sensing, Indian Academy of Sciences.
6. Kidder & Vonder Haar : Satellite Meteorology : An Introduction.

**(d) : Environmental Geophysics**

1. Earth and environment, elements of environment, man and environment.
2. Atmosphere : Origin, composition and structure, the troposphere as an environmental layer, air pollution, pollutants and its impact on weather, the ozone shield, green house effects and role of trace gases, global warming, acid rains.
3. Hydrosphere : Ocean and environment, the hydrologic cycle and global water balance, surface water hydrology, water pollutants and their effects on surface and ground water, heavy metals (Hg, Cd and As) in ground water, their detection and abatements.
4. Minerals: Mineral resources and environment, impact of mining and mineral resources.
5. Energy and Environment : Coal, oil and gas, geothermal energy, nuclear energy, solar energy.
6. Role of geophysics in environmental protection.

**Suggested Books :**

1. Jorgensen : Principle of Environmental Sciences and Technology
2. Keller : Environmental Geology
3. Ramade & Strahler : Environmental Geoscience-Interaction Between Natural System and Man
4. Tyler & Mitter : Jr. Environmental Science
5. Sharma : Environmental Geophysics

**(e) : Geomagnetism**

1. Earth's Magnetic Field : Internal and external fields, main field and variational field, components of the main field, magnetic and geomagnetic coordinates, Measurement and recording of the main field : Measurements of horizontal, vertical, declination, inclination and total field, magnetometers and variographs, Theories of the earth's 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 quiet and disturbed days.
2. Transient Variations : Definition, computation, morphological features, current systems and causes of 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 storms, DS and Dst fields, ring current, Van Allen belts theories of the geomagnetic storms.
3. The Sun, Sunspots and Solar Flares : A brief introduction of the structure of the sun, morphological features and classification of sunspot indices, morphological features of solar flares, classification of solar flares, Morphological features, classification and causes of auroras,



Morphological features, classification, observation and causes of geomagnetic micropulsation, Morphological features, composition, structure and production of various layers of the ionosphere, sudden ionospheric disturbances, Earth currents, its measurements, morphological features and interrelation with geomagnetism.

**Suggested Books :**

1. Chapman & Bartels : Geomagnetism
2. Matsushita & Campbell : Physics of the Geomagnetic Phenomena
3. Jacob : Earth's Core and Geomagnetism
4. Mitra : Upper Atmosphere

**\*GPS-648 B. Elective Papers :**

**(f) : Non-Linear Systems in Geophysics**

1. Kinematics of deformation- the deformation gradient tensor, the strain tensor, homogeneous deformations, deformation of surface and volume elements, material and spatial coordinates, analysis of stress, Cauchy's equation of motion, balance laws, constitutive equations for elastic and thermoelasticity.
2. Introduction to constructive aspects of bifurcation and implicit function theorem, imperfect bifurcation, bifurcation and non-linear eigen value problems.
3. Non-linear stability and folding of rock strata, convection in magma chambers and mantle, core convection and dynamo theory, earthquakes and chaos.
4. Non-linear elastic waves and solutions, group velocity, dynamical treatment, fractals and multifractals measures in geophysics.

**Suggested Books :**

1. Alkin & Fex : An Introduction to the Theory of Elasticity
2. Fang : Foundation of Solid Mechanics
3. Mal & Singh : Deformation of Elastic Soils
4. Spencer : Continuum Mechanics
5. Rabinowitz : Application of Bifurcation Theory
6. Atherton : Stability of Non-Linear System
7. Bhatnagar : Non-Linear Waves in One-Dimensional Dispersive Systems

**(g) : Geotomography and Computer Modelling**

1. Concept of Tomography : Inversion, linear and non-linear inversion, inversion technique-traditional, Monte-Carlo, Backus-Gilbert, tau method, non-linear least squares, ray tomography, diffraction tomography, borehole tomography, 2D and 3D imaging, applications in various branches of geophysics.
2. Finite element and finite difference methods and their formulations, numerical modelling, super computers, Lax-Wondroff second order scheme, MacCormick fourth order scheme, stability conditions, computer simulation of P-SV, SH and acoustic cases and other geophysical problems.

**Suggested Books :**

1. Mitchell : Computational Methods in Partial Differential Equations
2. Noye : Numerical Simulation of Fluid Motion

3. Krishnamurthy & Sen : Computer Based Numerical Algorithms
4. Gold & Rader : Digital Processing of Signals
5. Boarding et. al. : Application of Seismic Travel Time Tomography
6. Dines & Lytle : Computerized Geophysical Tomography
7. Wu et. al. : Diffraction Tomography and Multisource Holography Applied to Seismic Imaging
8. Aiyer et. al. : Geotomography

**(h) : Modern Techniques in Seismic Interpretation and Migration**

1. Seismic Sources: Explosive and non-explosive sources.
2. Seismic Refraction Method : Travel time equations for simple one layer case and for variable velocity case, expressions for dipping layer and faulted bed cases, Gardner delay time method, hidden layer problems, field techniques for refraction survey, fan shooting.
3. Seismic Reflection Method : The travel time equations for horizontally layered medium, expressions for dipping interfaces, field techniques for reflection survey, split spread, end on spread, broad side configurations, 2D, 3D and 4D configurations, common depth point technique, presentation formats of seismograms, selection of field survey parameters.
4. Data processing sequence: static and dynamic correction, weathering and datum corrections, CDP stacking, migration and depth section preparation.
5. Velocity Depth Determination: Velocity-depth relation from measurements in boreholes, velocity depth relation from surface observations,  $T^2-X^2$ , T- $\Delta$ T and hyperbola methods.
6. Noise Elimination Method : The structure of noise and its classification using frequency and spatial filters (arrays), multiples identification, suppression of multiples, VSP.
7. Mapping of hydrocarbon bearing and water bearing structures, gas hydrates, pattern recognition, thin bed modelling, seismic lithologic modelling, geological interpretation, location of stratigraphic traps, direct detection of hydrocarbons, wave equation migration and its various forms, artificial intelligence, artificial neural network (ANN) and gas detection using AVO analysis.

**Suggested Books :**

1. Dobrin & Savit : Introduction to Geophysical Prospecting
2. Telford et. al. : Applied Geophysics
3. Keary & Brooks : Introduction to Geophysical Exploration
4. Waters : Reflection Seismology
5. Robinson : Basic Exploration Geophysics
6. Scheriff : Seismic Stratigraphy
7. Lavergne : Seismic Methods

**\*GPS-648 C. Elective Papers :**

**(i) : Advanced Physical Meteorology**

1. Physics of tropical monsoon clouds, precipitation mechanism from convective, stratiform and orographic clouds, artificial modification of the precipitation, artificial dissipation of fog and low cloud, atmospheric electrical and boundary layer processes.
2. Precipitation chemistry, acid rain, atmospheric aerosols and trace gases, tropospheric chemistry.
3. Atmospheric chemistry, dynamics of the middle atmosphere and troposphere-stratosphere coupling, monsoon activity, climatic change, measurement of atmospheric minor constituents and climatic effects.

4. Physics of the Upper Atmosphere: Composition and structure, energy exchanges by collisions, transport processes, mean circulation and eddy transport, the ionosphere, composition and general properties, observational methods, aurora and air glow, noctilucent clouds, nacreous clouds.
5. Atmospheric Visibility: Attenuation of light by the atmosphere, the airlight and visual range in daytime, visibility of point light sources at night, objective measurement of visual range, oblique visual range.
6. Meteorological Acoustics: Doppler effect, effect of temperature and humidity on sound velocity, sound path in a calm atmosphere, effect of wind on sound propagation, attenuation of sound, propagation of sound through stratosphere, sounds originating from meteorological elements.
7. Meteorological Physics : Coronas and related phenomenon, twilight phenomenon, colour and polarisation of sky light.

**Suggested Books :**

1. Johnson : Physical Meteorology
2. Mason : Physics of Cloud
3. Dobson : Exploring the Atmosphere
4. Retallack : Compendium of Meteorology Vol. I, Part-III, Physical Meteorology. W.M.O. 364
5. Baton : Radar Observes the Weather
6. Kidder & Vonder Harr : Satellite Meteorology
7. Mitra: The Upper Atmosphere

**(j) : Applied Meteorology**

1. Aviation Meteorology : Requirements of climatological data for sitting of runways, meteorological observations and forecasts required for aircraft operations, organization of KAO, DGCA and air traffic control, coordination between MFT and ATC, special observations for aviation, METAR, SPECT, TREND, SIGMENT, aviation forecasts and warnings, documentation and briefing for national and international flights, aviation climatology.
2. Maritime Meteorology : Voluntary observing flight routine and special observations from ship at sea weather bulletins for shipping, storm warning bulletins, storm signals at ports, weather routing of ships, climatological atlas for oceanic regions, atlas of storm tracks.
3. Biometeorology : Thermal balance between heat production and heat loss effect of climatic factors, influence of weather and diseases caused by viruses, bacteria and metabolic disorders, acclimatization, climate and insect pests, thermal comfort and comfort indices, urban and building climatology.
4. Environmental Pollution : Extent of pollution, atmospheric ventilation, meteorological factors affecting the concentration of pollutants, monitoring for prevention control of pollution, UNEP.

5. Atmospheric Transport and Diffusion : Classical diffusion theory (K-theory), similarity theory, theory of turbulence, plum rise, short term modelling and prediction technique for pollutants.
6. Effects of air pollution on climate, human health.

**Suggested Books :**

1. Stern : Air pollution
2. HMSO, London : Handbook of Aviation Meteorology
3. Munn : Biometeorology
4. WMO Note : Urban Climatology
5. WMO Technical Note : Air Pollutants, Meteorology and Plant Injury

**(k) : Advanced Climatology**

1. Climatic classification based on atmospheric circulation and geographical conditions, genetic classification, classification based on the effect originated at the surface, types of climate, various classifications of climate, Kopen, Thornthwaite, Handdel etc.
2. Function and physical description of the climates of the different continents and ocean.
3. Radiation properties of natural surfaces, radiation in crops forest canopies, cities, vertical variation and distribution of various climatic elements, heat exchange and conduction near soil surface, atmospheric pollution.
4. Elements of bioclimatology, urban building climatology, climatic change, fundamental meteorological factors affecting the climate, past climate revealed by meteorological observation, methods of palaeoclimatology, possible causes of climatic change, influence of man on climatic changes, climatological statistics.
5. Introduction to climate system, role of green house gases, global warming, climatic change and its impacts on agriculture.
6. Asian Summer Monsoon: Global teleconnections, basic concepts of climatic modelling, energy cycle, tropical ocean and their role in climate control.
7. Physical processes in general circulation.

**Suggested Books :**

1. Miller : Climatology
2. Lamb: Climate Present, Past and Future
3. Barry & Parry : Synoptic Climatology
4. Stringer : Fundamentals of Climatology
5. Winter School on Climate Change and its Impacts, IIT, Delhi

