Subject: Atmospheric & Space Sciences

Ph.D. Course Work

Paper- I: Research Methodology (5 credits)

Numerical methods (1 credit)

Finite Difference methods, Finite difference of first and second order differential equation, Interpolation and extrapolation techniques, Numerical Integration schemes, Numerical solution of Partial Differential Equations.

Statistical methods (1 credit)

Central tendency, dispersion, correlation, linear regression, partial correlation, multiple regression, Harmonic analysis**,** Auto-correlation theory, standard statistical distributions (Normal, binomial, gamma, student's t-test). Sampling and test of Hypothesis.

Computer programming: FORTRAN / C (1 credit)

Data collection methods and quality check: Surface, Upper air and Satellite observations of Meteorological parameters/ Ocean Parameters. **(2 Credits)**

(Option for Space Science) Telescopes: Radio and Optical. Methods of data collections: Ground based and Satellite platform. Detectors. Photometery and Spectrometery procedures. Radio astronomy signal processing, detection and data collection'. **(2credits)**

Paper-II: Subject Paper

Option-A Atmospheric Science (10 credits)

Structure of the Atmosphere and its constituents, Diurnal variation of temperature, pressure, relative humidity, clouds etc. Easterly Waves, ITCZ, Synoptic systems in different seasons- Western disturbance, Rossby Waves, Westerly Jet Stream, Cold Wave, Thunderstorms, Dust storms, Heat wave, Cyclonic disturbances. Monsoon - Onset, Activity, Withdrawal, Breaks, Depressions, Easterly Jet Stream. Post Monsoon - Cyclones in the Indian Seas, N.E. Monsoon.

General circulation of atmosphere, major categories of world climates.

Equation of state for dry and moist air, Adiabatic and Isothermal Processes, Humidity Parameters, Virtual Temperature, Standard Atmosphere, Laws of thermodynamics, Entropy, Potential Temperature, Pseudo- adiabatic Process, Equivalent Temperature, Equivalent, Potential Temperature, Claussius – Clapeyron Equation, Stability and Instability, Thermodynamic Diagram: T - ϕ gram, Precipitable Water Vapor, Role of Convective Available Potential Energy (CAPE) and Convective Inhibition Energy (CINE) in thunderstorm development.

Radiative Transfer in the Atmosphere- solar radiation, long wave radiation, black body radiation, laws of radiation, Absorption spectra of atmospheric gases.

Equations of motion in Cartesian coordinate, natural coordinate and spherical coordinate. Scale Analysis, Rossby number, Trajectory and Stream lines, balanced flow- Geostrophic Flow, Inertial Flow, Cyclostrophic Flow and Gradient Flow. Continuity equation. Thermodynamic energy equation, Barotropic and baroclinic fluids. Thermal Wind, veering and backing, Kinematics of Pressure Fields.

Stream function and velocity potential, Circulation, vorticity, divergence, Stokes Theorem, Divergence Theorem , Circulation theorems – Kelvin's Theorem and Bjerknes Theorem, applications of Circulation theorems – Sea Breeze and Land Breeze; Vorticity and divergence equations,

Option-B Space Sciences (10 credits)

Definitions of local time, UT, ST etc. co-ordinate system, celestial sphere, accuracies.

Absorption, scintillation, atmospheric extinction, scattering, turbulence, 'seeing effect', air-mass and extinction coefficient, 'seeing noise', 'seeing disk', scale length of Fried's parameter. Active and adaptive optics. Night sky brightness and night sky pollution.

Stellar spectrum formation, Kirchoff's laws of radiation, Absorption and emission spectrum with both exhibiting line and band type spectra, Black body radiation laws and related special cases. Stellar spectral sequence and effective temperature. Stellar spectral

classification and relation to HR diagram. Spectral line from a star and concepts of equivalent width, various types of line broadening effects.

Classification of plasma (mathematical): metal gas discharges, classification according to temperature, density, composition, magnetic field, plasma's state in laboratory and space, configurations for plasma's containment, stellar, galactic and cosmic plasmas.
The ionospheric layers D,E,F, and their formation, effect of radiation on earth's atmosphere, Geomagnetic and magnetic coordinates, poles, measurement of geomagnetic field components, micro-pulsation indices, variations of geomagnetic field, quiet and disturbed variations, geomagnetic storms, equatorial and auroral phenomena.
Cosmic rays: solar and galactic cosmic rays, phenomenology and interpretation.
Sun: physical dimensions, sun as typical star in a galaxy, solar constant. Source of solar energy, thermonuclear reaction and building up of higher elements, solar composition, photosphere, structure and astrophysics of outer layers of sun,

Paper-III: Guide's Course (5 credits)

Literature review and seminar presentation of your Ph.D. problem. **(1 credit)**

Presentations in symposium or conferences **(1 credit)**

Workshops and training of at least one week duration **(1 credit)**

Research Proposal writing (giving Definition of the problem, Objectives, Technical Details, National and International Status, Work plan, Organization of work elements, Time schedule and budget). To be evaluated by two referees for 1 credit and defense of the proposal for 1 credit. **(2 credits).** The topic of proposal should be different from your Ph.D. proposal.