Syllabus for Course Work
(As prerequisite for Ph.D. registration)

PHYSICS

Sl. No.	Paper	Subjects	Marks
1	I	Research Methodology	100
2	II	Advance topics in Physics	100
3	III	Software and its application in Physics	100
4	IV	Elective paper	100

Total Marks: 400

Paper-I: Research Methodology

Research methods, problem selection, literature survey, Familiarity with ideas and concept of investigation, acquiring technical skills, drawing inference from data, qualitative and quantitative analysis, assessing the problem, results and conclusions, presenting a scientific seminar, publication of research paper, synopsis: concepts, scope and components, art of writing a thesis.

Paper-II: Advance topics in Physics

a) Nanotechnology:

Introduction, History of Nanotechnology, Emergence of nanotechnology, Importance, Applications in different field, Special materials for nanotechnology- their fabrication and properties, tools to measure nanostructures, Impact of nanotechnology on environment, society and industry, Challenges in Nanotechnology, toxic affect and Future scenario.

b) Space environment and its effects on biosphere:

Introduction to space environment, solar activity and its influence on Earth's atmosphere, different solar and geophysical indices, effects of solar events on troposphere: cloud formation and its activity, possible relation to thunderstorm activity, long term climate change and global warming.

c) Sensors:

Introduction, Use of Sensors. Different types of sensors, Sensors made up of organic and polymeric materials. Their applications as gas sensors, Blood sugar sensors, alcohol sensors, alcohol sensors, fish freshness sensors etc. Bio – Sensors and their applications.

d) Solar Features:

Structure and composition, solar rotation, the quiet Sun, sunspots, radiation characteristics, 11 year periodicity, solar flares, coronal mass ejection, prominences, calcium plages, monitoring the sun with radio emission and X-rays, solar wind, solar proton event, solar magnetic field and its variation and solar noise storms.

e) Relativistic Effects in Molecules:

Introduction, Brief review of relativistic quantum mechanics, applications to diatomic molecules

f) Thin Film Technology:

Introduction, Importance of thin films, different thin film preparation techniques characterizations and applications of thin films.

Paper-III : Software and its application in Physics

Introduction
Software packages:

(i) Origin
(ii) Webpage development using M.S. FrontPage.
(iii) M.S. Office: Power Point presentation, M.S. Word.
(iv) Mathematica
(v) Gaussian 03
(vi) Matlab
(vii) Linux

Paper-IV (Elective paper)

1. Condensed Matter Physics, Material Science and Spectroscopy
Or
2. Atmospheric Science
Or
3. Atomic-Molecular physics and Density Functional Theory
Or
4. Solar Radio Physics
Or
5. Nanomaterials and Nanoscience

1. Condensed Matter Physics, Material Science and Spectroscopy

A review of Material Science: Introduction, structure, defects in solids, bands and bonds in materials, thermodynamics of materials kinetics, an introduction to mechanical behaviour of materials.

Thin Films: Introduction, Langmuir-Blodgett films, Layer-by-Layer self assembled films, spin coated films, sputtering, vacuum deposition, Sol-Gel method etc.

Characterizations of thin films and surfaces: Film thickness, structural characterizations of films and surfaces, chemical characterizations of surfaces and films, Spectroscopic characterizations of thin films and surfaces.

Characterizations techniques: Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Fluorescence Imaging Microscopy (FIM), UV-Vis absorption Spectroscopy, Fluorescence Spectroscopy, Infrared Reflection Absorption Spectroscopy (IRRAS), Fourier Transform Infrared Spectroscopy (FTIR) etc.

Applications of thin films.

2. Atmospheric Science

Influence of solar environment and space weather on earth's atmosphere, ionosphere, magneto ionic theory, mode theory of electromagnetic waves, DC and AC global electric circuit: worldwide thunderstorm activity, lightning activity and its characteristics, Schumann resonance, natural VLF phenomena: sferics, sprite, blue jets, whistlers, tweaks and its interaction with ionosphere, relevance of global electric circuit parameters with global warming and long term climate change, characterization of lower ionospheric parameters from VLF and LF manmade transmitted signal, interaction of solar wind and particles with ionosphere: solar flare, SID, SPA, CME, geomagnetic storm etc., characterization of different properties of cloud with the help of atmospheric electricity and VLF measurements, coupling among different layers of atmosphere, perturbation at the ionosphere due to earthquake, importance of study in connection to advancement in space physics, electrical environment at other planets in solar system.

3. Atomic-Molecular physics and Density Functional Theory

Electron spin and Pauli Exclusion principle, Slater determinants. Many-electron atoms: Hartree-Fock self consistent method, Orbitals and the periodic table, electron correlation and correlation energy, addition of angular momentum and angular momentum in many electron atoms, atomic terms and their derivation, the atomic Hamiltonian and atomic wave functions, tables of atomic energy levels, Spin-orbit interaction, the Condon-Slater rule.

Elements of crystallography

Density functional theory : Introduction to density functional theory, early density functional theories, the H-K theorems, the Kohn-Sham approach, K-S equation and their solution, exchange-correlation functional, Local density Approximation (LDA), Local Spin Density Approximation (LSDA), concept of LCAO and basis set, applications of DFT.

4. Solar Radio Physics

Radio emission from the sun, characteristic features of radio emission from quiet the quiet Sun, relation between radio emission and X-ray emission, variation of radio emission with sunspot numbers, Solar radio bursts: Type I, II, III, IV and V, Relationship among different types of solar radio bursts, Physical mechanism of solar radio emission, The theory of solar flares and noise storms.

5. **Nanomaterials and Nanoscience**

Introduction:-

Nanomaterials and their speciality. Different types of nanomaterials- Inorganic Quantum well, Quantum wires and Quantum dots, Metal cluster, Metal oxide nanocrystals, Semiconductor nanocrystals, Assemblies of Nanocrystals, Carbon based nanomaterials, Carbon nanotubes (SWCNT and MWCNT), and Graphene, Core shell structure of different materials, different Nanocomposites.

Quantum size effect, Surface energy. Different properties of nanoparticles, Surface Plasmon Resonance (SPR), Band structure of solids-Drude-Lorentz-Sommerfield model, Mie Theory, Maxwell-Garnett theory. Shape and size related Emission and absorption mechanisms of different nanoparticles, red shift and blue shift. Toxic effect of nanomaterials-Cytotoxicity and Genotoxicity of nanomaterials.

Stability of nanoparticles- ligands, polymer, capping materials, matrices. Theory of Nucleation, Growth mechanisms of nanoparticles, different stabilization processes, Phase transition, Self assembly and Functionalization.

Synthesis and Fabrication- Nanomaterial and their fabrication, Top down and Bottom up approaches. Physical and Chemical methods of nanomaterial fabrication. Nanolithographic technique, Molecular Beam Epitaxy (MBE), Sputtering, Ball Milling, Chemical Vapour Deposition (CVD), Wet chemical method- Reaction kinetics, Vacuum Deposition Technique, Laser ablation method. Sol-Gel method, Micelle and Reverse Micelle. Template based synthesis.

Characterization:

Structural Characterization by X-ray diffraction study (XRD), Scanning Slectron microscopy (SEM), High Resolution Transmission electron microscopy (HRTEM), Atomic force Microscopy (AFM). Spectroscopic characterization by UV/Vis, Photoluminescence study (PL), Fourier transformed infrared spectroscopy (FTIR), Pump probe spectroscopy, Raman spectroscopy, Magnetic characterization by Vibrating sample magnetometer (VSM), and Superconducting and Quantum interference Device (SQUID), and LCR meter, Electrical Characterization by Impedance spectroscopy and LCR meter. Thermal stability studies by Thermo gravimetric analysis (TGA)

Application:

Different applications of nanomaterials- Solar cell, Sensors, Spintronics, Plasmonic devices, Photovoltaic devices, Energy storing devices, Drug delivery, Cancer cell detection by SERS and therapy, Antibacteial activity of different nanomaterials- shape and size related. Catalytic effect of nanoparticles, Nanomedicines.