CENTRAL UNIVERSITY OF SOUTH BIHAR

Doctor of Philosophy (Ph.D.) Physics Programme

Syllabus

(Effective from Academic Session 2020-2021)

The broad areas of research in the department of Physics are hard/soft condensed matter physics, spectroscopy, nanoscience and nanotechnology, materials science, and Nuclear and Astroparticle Physics. In due course we will also open research areas related to computational physics, theoretical biophysics, and space physics. All the students will be required to successfully complete a course work before beginning the research towards their Ph.D. thesis. The tentative course work structure, subjected to the approval from the Board of Studies, is as follows:

Course Code	Course Title	Credits
Core	Research Methodology	4
Core	Theoretical and Experimental Techniques of Physics Research	4
Core	Review, Report and Seminar	2
Core	Research and Publication Ethics (RPE)	2

Course Title: Research Methodology			
Course Code	PHDPHY1001C04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L)

Unit :1

Research objectives: Types of research, Development of a research question; Science, pseudoscience and rationalism; Physical science and metaphysics; Literature survey, Identification of knowledge gaps and a research problem; Concept of novelty, Formulation and implementation of a research plan; Serendipity, creativity, discovery and innovation.
Research process and tools: Design of experiments, testing and characterization; Measurement - Standardization, calibration and sampling; Primary and secondary data; Computer programming, theory, modelling and simulation; Data acquisition, processing, observation, critical analysis and interpretation; Presentation of data; Reliability and reproducibility.

(15 Lectures)

Unit:2
Computer applications and tools: Software for documentation, graphs, graphics, drawing and presentation.
Search engines and databases: Web literature search; International standards, reference data and constants.
Library system: Physical cataloguing of books and journals; Online catalogue search; Subscribed books and journals.
Good laboratory practices: Organization and cleanliness; Maintenance of laboratory records; Biological, chemical, electrical and fire safety; Safe disposal of hazardous materials; Upholding environmental and human concerns in planning and conducting experiments; Government regulations.

(15 Lectures)

Unit :3
Communicating research results: Journal paper – types of available publishing services; Research proposal, Report, Thesis; Presentation in Seminar and conference; Journal abbreviations, Bibliography standards; Indices of quality assessment of publications.
Statistical techniques: Mathematical tools for analysis, Statistical data treatment and evaluation; Probability and probability distributions; Sampling and sampling designs, Data analysis, Testing of hypothesis, statistical tests and analysis, Data interpretation, multivariate analysis, Model building.

(15Lectures)

Unit:4
Analytical and numerical techniques: Mean deviation, Root mean square deviation, Histogram, Skewness, Kurtosis, Moments, Variance, Chi-square, Correlation, Factor analysis, Mean square weighted deviation, Regression, Time series analysis
Statistical and graphical packages: MS Excel, MATLAB, Microcal Origin / Sigma plot, gnu plot, xmgr – Key Features; Developing algorithms and applications, Tex.

(15 Lectures)

Text Books:

1. Research Methodology: The Aims, Practices and Ethics of Science, P. Pruzan, Springer, 2016
2. Research Methods for Science, M. P. Marder, Cambridge University, 2011
3. Fundamentals of Research Methodology and Statistics, Y.K. Singh, New Age, 2006

Reference Books:

1. Research Methodology: An Introduction for Science and Engineering Students; Melville
2. and Goddard, Juta, 1996
3. Research Methods in Science and Engineering, Scott A. Gold, CRC Press, 2016

Course Title: Theoretical and Experimental Techniques of Physics Research			
Course Code	PHDPHY1002C04	**Credits**	4
L + T + P	4 + 0 + 0	**Contact Hours**	60 (L)

Unit: 1

Quantum Mechanics: Schrödinger Picture, **Time independent perturbation theory**: Theory and an example; S**cattering theory**: Quantum theory, Partial wave analysis (one example), Born Approximation and its validity (One example); P**ath integral formulation**: propagator, Schrödinger wave equation from path integral, eg: free particles; Introduction to second quantization; Q**uantum field theory**: quantization of scalar field and Dirac field.

Condensed Matter Physics: **Electronic Structure Calculation:** Hartree-Fock Theory, Introduction to Density Functional Theory; **Correlated Electron States:** Mott Transition, Hubbard Model, Magnetic impurities and Kondo Model; **Quantum Hall effect:** Integer and fractional Hall Effect, Laughlin wave function; **Magnetism:** Mean field approximation for Heisenberg Hamiltonian model for Ferromagnetism.

(15 Lectures)

Unit: II

High Energy Physics: Introduction to relativistic kinematics, Review of Experimental methods: fixed target and collider experiments, Introduction of four forces and interactions, Feynman diagrams Basics of quantum electrodynamics: Glashow-Salam-Weinberg model,
Standard Model Physics.

Nonlinear Optics: Nonlinear wave propagation in Anisotropic media; Second Harmonic Generation (SHG); Phase Matching Techniques; Three-Wave Interactions; Third Harmonic Generation (THG); Density Matrix and Perturbation approach to Nonlinear susceptibility.

(15 Lectures)

Unit: III

Vacuum Generation and Measurement Techniques: Introduction to vacuum, gas law; Rotary vane pump, Turbomolecular pump, Cryo pump; Pirani gauge, Penning gauge.

Fundamentals of Synthesis and Fabrication of Materials: Classification of powders; Synthesis of powders: Sol-gel, Hydrothermal, Combustion techniques; Synthesis of thin films: Spincoating, Dip coating, Thermal and electron beam evaporation, Pulsed laser deposition; General concept of lithography, Photolithography, Electron beam lithography; Clean room. **Introduction to Basic Measurements and Characterization Techniques:** ***Study of Crystal Structure:*** X-ray diffraction (XRD), Transmission Electron diffraction (TED), ***Microscopic Techniques:*** Optical Microscopes (Bright field, Confocal, Super-resolution), Scanning Electron Microscope, Transmission Electron Microscope, Scanning Probe Microscopes.

(15 Lectures)

Unit: IV

Spectroscopic Techniques: UV-Vis, Fluorescence, IR and FTIR, Photo-Acoustic, Laser Induced Breakdown, Raman, Twyman-Green interferometer as a special case of Michelson Interferometer for testing of optical components, Lateral shearing interferometers and its applications such as testing. Collimation of a lens, laser speckle techniques and its applications. **Surface and Compositional Analysis Methods**: EDAX, XPS. **Dielectric Characterization**: Complex impedance spectroscopy, Analysis of Nyquist plot, Various RC network schemes, Analysis of CV curves, ac conductivity, Charging-discharging cycle of capacitors. **Electrochemical Measurements**: Different potentiometric /galvanometric techniques.
Methods for studying electrical, magnetic, thermal properties. **Accelerator and Fusion Techniques:** Pelletron, Linear accelerator, Cyclotron, Synchrotron, Tokamac; Applications in High energy physics, Materials science and Particle therapy. **Low Temperature Methods :** Temperature measurement and control; Cryostats and cooling methods.

(15 Lectures)

Text Books:

1. Handbook of Vacuum Science and Technology; Hoffman, Singh and Thomas; Academic Press, 1998.
2. Nanostructures and Nanomaterials - Synthesis, Properties and Applications; Guozhong Cao, World Scientific, 2004
3. Thin Film Phenomena; Chopra; McGraw-Hill; 1969
4. ASM Handbook: Volume 10: Materials Characterization; Crankovic; ASM International;1986
5. Surface Characterization Methods: Principles, Techniques and Applications; Milling; CRC Press; 1999

Course Title: Review, Report and Seminar			
Course Code	PHDPHY1003C02	**Credits**	2
L + T + P	2 + 0 + 0	**Contact Hours**	30 (L)

Course Title: Research and Publication Ethics (RPE)			
Course Code	PHDPHY1003C02	**Credits**	2
L + T + P	2 + 0 + 0	**Contact Hours**	30 (L)

Research ethics: Ethics code of American Psychological Association; Collaboration, cooperation and teamwork; Research outcome; Intellectual property right, Copy-right, patent**,**
fundamentals of patent filing; Usage of pirated version of literatures and software; Plagiarism – Case Studies, Web based verification.

References:

1. Research Methods for Science, M. P. Marder, Cambridge University, 2011
2. Fundamentals of Research Methodology and Statistics, Y.K. Singh, New Age, 2006