PHY-808 Methods and Techniques in Experimental Physics

Credit Hours: 3+0

Prerequisite: None

Course Objectives: This course is designed to introduce students with experimental techniques in Physics with emphasis on data analysis. Experiments from various fields of Physics are chosen to give experimental perspective of these fields to students at graduate level.

Core Contents: Error Analysis, experiment techniques used for classical systems, statistical analysis of experimental data, techniques for elementary particle detection, gama ray spectroscopy, quantization of energy levels, applications of Maxwell's equation, electronics, Crystal structure, spectroscopy

Detailed Course Contents: The detailed contents are given in the table below along with week-wise breakdown.

Course Outcomes: On successful completion of this course, students will be able

- to understand the error in physical quantities and error propagation
- to understand the data analysis and curve fitting
- to understand the role of electronic components in measurement devices
- to understand the structure of crystals and their determination
- to understand the principle of optical component in devices
- to get hands-on experience of the measurement procedure and data analysis

Textbook: John R. Taylor, An Introduction to Error Analysis, 2nd ed. University Science Books, 1996.

Reference Books:

1. M. I. Pergament, Methods of Experimental Physics, CRC Press 2015.
2. B. D. Cullity, Elements of X-ray Diffraction, 3rd ed. Pearsons 2001.

Weekly Breakdown		
Week	***Section***	***Topics***
1.	JR Taylor	Error Analysis: Measurements and error analysis, the uncertainty of measurements, types of errors, estimating experimental uncertainty for a single measurement, estimating uncertainty in repeated measurements, standard deviation, standard deviation of the mean, anomalous data, fractional uncertainty, propagation of uncertainty, significant figures, combining and reporting uncertainties
2.	Lab + Handouts	Classical Mechanics: 1. To obtain the value of acceleration due to gravity by using simple and compound pendulum and its error analysis
3.	JR Taylor	Statistical analysis of experimental data: the mean as the best value, curve fitting, straight line fitting, Linear regression, nonlinear fitting, χ^2 as the goodness of fit, covariance and correlations, distributions, Binomial distribution, Poisson distribution, Gaussian distribution
4.	Handouts and Lab	Elementary particle detection: ionizing radiation, charged particles, photons and electrons, neutrons, radiation safety, biological effects of radiations, kinds of particle detectors, solid angle, gaseous ionization detectors, scintillation detectors, pulse processing electronics, amplifiers, discriminators and single channel analyzers, processing logic signals, e/m ratio by Millikan's oil drop method
5.	Lab	Nuclear Physics: To explore statistics of random independent events in physical measurements by varying the duration and number of trials of a radioactive decay; comparison of experimental data with theoretical statistical distributions: Gamma ray spectroscopy
6.	Handouts	Quantization of Energy levels: The nuclear atom, electron orbits, quantization of electronic orbitals, radiative transitions, interaction of atoms with a magnetic

		field
7.	Lab	Quantum Mechanics: 1. To demonstrate the concept of quantization of energy levels in atoms (Franck Hertz experiment)
8.	Lab	2. Atomic energy levels, transition between these levels, and the associated spectral lines in the presence of magnetic field (Zeeman Effect), 3. Study of electron spin resonance in DPPH sample
9.	Handouts	Basic Electronics: Basic electronics circuits, voltage, resistance, current, loop and junction rules, voltage divider, capacitor and AC circuits, DC and AC circuits, Impedance, Inductors, diodes, transistors
10.	Lab	Electronics: designing a DC power supply from an AC source
11.	Handouts and Lab	Electrodynamics: Electromotive force, Ohm's law, electromotive force, motional emf, electromagnetic induction, Maxwell equation, Experiment: Faraday's law of electromagnetic induction, lenz's law and conservation of energy
12.	Handouts and Lab	Solid State Physics: Crystal structure, fundamental types of crystals, chemical methods for the synthesis of crystals, physical methods for the synthesis of crystal, basic characterization techniques, synthesis of some metal oxide/hydroxide in lab and its structural characterization by X-ray diffraction
13.	Handouts and Lab	Motion of charge carriers in both electric and magnetic fields, principle of Hall effect, calculation of Hall voltage, Hall coefficient, charge carrier concentration, mobility, study of Hall Effect on silver and tungsten strips
14.	Lab	Special Relativity: Determining the velocity of light
15.	Handouts and Lab	Spectroscopy: Light production and detection, sources of light, thermal

	radiation, discrete line sources, lasers, measuring light intensity, Fourier Optics and Spectroscopy, photographic film, photomultiplier tubes, photodiodes