

PHYC 262 Modern Physics Laboratory

Course Description

Experimental methods and data analysis will be applied to measurements related to modern physics. Experiments, such as the measurement of radiation, the photoelectric effect, and the Millikan oil drop experiment, will be performed. Communication skills will be used to effectively report experimental results. (1 Credit Hour)

Prerequisite: PHYC 260

Course Objectives

The course goal will be to discover more about physical phenomena in the world through experimentation, specifically those topics related to modern physics. An understanding of different experimental methods and techniques used in current research will be gained through “hands-on” experience, with data taken from various instruments. An overview of experimental data and analysis, such as measurements, random and systematic uncertainties, and error propagation will be presented. Computer skills will be strengthened through calculation and analysis of experimental data, which include graphs, regression, and data manipulation in spreadsheets. Communication skills will be strengthened by presenting experimental results in written laboratory reports and through oral and poster presentations.

Course Rationale

This course is designed for physics majors and minors to be a laboratory experience that will reinforce the students’ connection between theory and experiment. The practical experience, critical thinking, and communication skills developed in this course will be helpful for success in more advanced courses and labs.

Course Content, Format, and Bibliography

Content

The course emphasizes three major components: data analysis, experiments, and communication.

Data Analysis: An introduction to data analysis is presented that includes:

Uncertainties in measurements: parent and sample distributions; mean and standard deviation of the distribution

Probability distributions: binomial, Poisson, and Gaussian distributions

Error analysis: instrumental and systematic uncertainties; propagation of errors

Estimates of means and errors: method of least squares, chi-squared test of a distribution

Least-squares fit to a straight line: method of least squares, chi-squared minimization; error estimation

Experiments: Approximately eight experiments are performed by students during the semester. A list of sample experiments is given below:

Cavendish Experiment – Measurement of the gravitational constant G , using a torsion balance

Radiation detection – Counting using a Geiger-Müller tube to find the half-life of a source; determine the effects of distance and shielding from different radiation sources

Measurement of e/m – Electron source in a vacuum tube deflected by electric and magnetic fields

Photoelectric Effect – A phototube and a reverse voltage are used to measure the work function of a material and determine Planck's constant

Franck-Hertz – Quantum absorption of energy is demonstrated in the passage of electrons through a diffuse mercury vapor.

Millikan Oil Drop – Measures the quantization of electric charge by balancing the forces of weight and electric field

Superconductivity – Uses a susceptibility probe to measure resistance as a function of temperature in a superconductor

Format

Written laboratory reports will be made based on the experiments performed. Scientific writing skills will be stressed, along with the proper presentation of data through equations, tables, and graphs. At least one of the experiments completed during the semester will be presented as a poster, in a format similar to those presented at formal physics society meetings. An oral presentation will also be made by each student on a topic related to modern physics. The presentation will be made via PowerPoint or other visual means in a 10-minute oral report.

Bibliography

Data Reduction and Error Analysis for the Physical Sciences, 3rd Ed., P.R. Bevington and D. K. Robinson, McGraw-Hill, 2003, ISBN 0-07-247227-8.

Experiments in Modern Physics, 2nd Ed., A. C. Melissinos and J. Napolitano, Academic Press, 2003, ISBN 0-12-489851-3.

Techniques in Nuclear and Particle Physics, 2nd Ed., by W. R. Leo, Springer-Verlag, 1987, ISBN 0-387-17386-2.