

Fall 2012

PHY 335 MODERN PHYSICS / 3 credits. Topics in Modern Physics including relativity, elementary particles, quantum mechanics, wave and particle theories, and spectra. Prerequisite: MTH 220, PHY 220 or PHY 250 or permission of professor.

General Education Objectives (proposed)

- 1. Students can apply critical thinking to pose and answer questions.**
- 2. Students can use the processes and methods of science and mathematics to demonstrate how reproducible results give rise to the discovery of fundamental laws and the development of theories.**
- 3. Students can articulate a basic knowledge of current scientific understanding of the universe and the scientific and mathematical laws that govern it.**
- 4. Students can summarize, interpret, analyze, and critically evaluate data and reports relating to the natural sciences and mathematics.**

The course has evolved to include approximately six short laboratory experiences during its progress. The particular experiments most recently performed are:

- (1) Charge to mass ratio of the electron
- (2) Photoelectric effect
- (3) Gas discharge spectra
- (4) Frank-Hertz experiment
- (5) Identification of radiation by stopping of radiation.
- (6) Electron diffraction.

Additionally, experiments for measurement of the speed of light and the temperature dependence of conductivity in semiconductors are also two labs in preparation for future courses although the present experiments are close to the maximum number permitted for a 3 hour lecture course. The exact number of experiments performed will thus vary from course to course.

Physics Program Objectives

There are several general goals of the Physics program that students completing the physics program should have. A non-exhaustive list of these program objectives include:

- (a) Ability to perform a mathematical formulation of a physical system
- (b) Ability to discuss (mathematically and linguistically) a physical system drawing upon a well-developed foundation built upon physical fundamentals.
- (c) Ability to formulate complex arguments based upon physical foundations and which are testable by experimentation.
- (d) Ability to produce technologically enabled students with an understanding of the basis for experimental design.

A non-exhaustive list of intended learning outcomes follows

In addition to the modern physics labs mentioned above, students completing the modern physics course should meet the following educational goals:

- (a) An ability to work with simple relativity in specific circumstances.
- (b) An ability to work with Lorentz Transformations to distinguish between time-like events and space-like events.

- (c) An understanding of relativistic energy.
- (d) An understanding of the mass spectrometer¹⁶.
- (e) The importance of the photo electric effect with regard to changing paradigms of wave-particle duality.
- (f) An understanding of the Bohr model of the atom and the importance of Rutherford scattering.
- (g) An understanding of essential characteristics of discharge spectra observed and how numerical characterization relates to the Bohr model.
- (h) An understanding of the importance of the work of Frank-Hertz with regard to direct excitation of atomic energy levels (and their observation) by means of kinetics.
- (i) Development of quantum mechanics based upon the work of De Broglie.
- (j) Development of quantum mechanics based upon the work of Schrödinger.
- (k) Separation of the time-dependent Schrödinger wave equation into stationary state solutions and time dependent solutions (based upon energy eigenvalues).
- (l) Stationary state solutions to the Schrödinger wave equation for 1-dimensional systems with infinite boundary conditions.
- (m) A detailed and highly mathematical analysis of the stationary state solutions to the Schrödinger wave equation for the 1-dimensional quantum harmonic oscillator.
- (n) Introductory application of the Schrödinger wave equation to problems involving at least one finite boundary in 1-dimension.
- (o) Application and understanding of the meaning, necessity and origin of the Heisenberg Uncertainty Principle.
- (p) A semi-rigorous solution of the Schrödinger wave equation as applied to the hydrogen atom with particular emphasis upon the results with regard to principle quantum numbers and angular momentum.
- (q) An empirical¹⁷ introduction of spin to the quantum problem of the hydrogen atom.
- (r) Introduction of the concept of selection rules based upon wave function overlap integrals as leading to the explanation for spectral intensity variations.
- (s) Symmetry requirements for multi-electron atoms. Introduction of the Slater determinate and its use to determine totally symmetric and totally anti-symmetric wave functions¹⁸.
- (t) Explanation and derivation of the origins of the exchange interaction¹⁹.
- (u) Introduction to quantum statistical mechanics, the Fermi Energy, and elementary considerations leading to the Band theory for electronic conduction.
- (v) Nuclear Radiation: modes of radiation, coupling of angular momentum, radioactive decay and applications of radioactive decay for dating.
- (w) Explorations of the stability, size and other properties of nuclei based upon quantum mechanical results. Introduction of and examination of strong and weak nuclear forces.
- (x) Extension of special relativity to general relativity²⁰.
- (y) Introduction of relativistic concerns to quantum mechanical solutions²¹.