NOVA COLLEGE-WIDE COURSE CONTENT SUMMARY
PHY 243– MODERN PHYSICS (3 CR.)

Course Description

Covers principles of modern physics including in-depth coverage of relativity, quantum physics, solid state, and nuclear physics. Lecture 3 hours. Total 3 hours per week.

General Course Purpose

PHY 243 Modern Physics is the third and last semester of calculus-based University Physics. It covers the advances made in physics during the first half of the twentieth century that led to revolutionary paradigm shifts in the understanding of nature; these advances continue to drive technologies used today.

Course Prerequisites/Corequisites

Prerequisites: PHY 242 with a grade of C or better or departmental approval.

Course Objectives

Upon completing the course, the student will be able to:

The Foundations of Modern Physics

- State phenomena that cannot be explained by classical physics, thus motivating the need for a new theory.
- Establish experimental evidence by which the existence of atoms and their properties is known.

The Special Theory of Relativity

- Explain and apply the fundamental concepts of event and reference frame.
- Explain how the principle of relativity leads to the relativity of simultaneity and length and thus to time dilation and length contraction.
- Use the Lorentz transformations of position and velocity.
- Define and calculate relativistic energy and momentum.
- Recognize the significance of Einstein's famous equation $E = mc^2$.

Photons: Light Waves Behaving as Particles

- Explain the photoelectric effect experiment and its implications.
- Explain and apply the photon model of light.

Wave Properties of Matter

- State the evidence for matter waves and the de Broglie wavelength.
- Explain why the de Broglie standing wave of a confined particle requires energy quantization.
- Explain and apply Bohr's stationary-state model of the atom.
- Use the Bohr model to explain discrete spectra and the observed differences between absorption and emission spectra.
- Apply Bohr's model of the hydrogen atom to explain its properties.

Quantum Mechanics

- Define the wave function as the descriptor of particles in quantum mechanics.
- Explain probabilistic interpretation of the wave function.
- Explain and apply the idea of normalization.
- Recognize the limitations on knowledge imposed by the Heisenberg uncertainty principle

- Define the Schrödinger equation as the "law" of quantum mechanics.
- Recognize that solutions of the Schrödinger equation give the allowed energies and wave functions for a physical situation that is modeled by the potential energy function U(x).
- Interpret wave functions and energy levels.
- Explain quantum phenomena such as bonding and tunneling.

Atomic Structure

- Interpret the quantum-mechanical solution of the hydrogen atom.
- Explain the basis for the shell model of atoms.
- Demonstrate a qualitative understanding of the energy-level structure of multielectron atoms and the periodic table of the elements.
- Explain the emission and absorption of light.
- Explain the meaning of the lifetimes of excited states and their exponential decay.
- Demonstrate qualitative understanding of lasers.

Nuclear Physics

- Explain the size and structure of the nucleus.
- Describe the properties of the strong force.
- Apply and interpret a simple shell model of the nucleus.
- Define and apply radioactive decay and half-lives.
- Interpret radiation dose and biological applications of nuclear physics.

Major Topics to be Included

- The Foundations of Modern Physics
- The Special Theory of Relativity
- Photons: Light Waves Behaving as Particles
- Wave Properties of Matter:
- Quantum Mechanics
- Atomic Structure
- Nuclear Physics