PHYS 4D: GENERAL PHYSICS (CALCULUS)

Foothill College Course Outline of Record

Heading	Value
Units:	6
Hours:	5 lecture, 3 laboratory per week (96 total per quarter)
Prerequisite:	PHYS 4C.
Corequisite:	Completion of or concurrent enrollment in MATH 2A.
Degree & Credit Status:	Degree-Applicable Credit Course
Foothill GE:	Non-GE
Transferable:	CSU/UC
Grade Type:	Letter Grade (Request for Pass/No Pass)
Repeatability:	Not Repeatable

Student Learning Outcomes

- Students should have both a conceptual and computational understanding of Einstein's theory of special relativity.
- The lab experiments should give students deeper understanding into the historical experiments that form the basis of modern physics and the science involved.
- Students should have an understanding of the Schrodinger Equation and be able to solve problems with introductory-level potentials.

Description

Special relativity, statistical mechanics, quantum mechanics, atomic physics, nuclear physics, particle physics.

Course Objectives

The student will be able to:
A. Compute special relativity problems and interpret related paradoxes and special cases.
B. Explain wave-particle duality and its implications through both historical and thought experiments.
C. Discuss the concepts of quantum mechanics and solve simple problems.
D. Discuss models and solve problems pertaining to the hydrogen atom, the periodic table and condensed matter physics.
E. Explain models of nuclear physics, how they relate to observed results, and solve problems concerning radioactive decay.
F. Explain current theories in particle physics.

Course Content

A. Compute special relativity problems and interpret related paradoxes and special cases.
1. Frames of reference
a. Inertial vs. noninertial frames
b. Galilean tranforms
2. The speed of light
a. Maxwell's equations
b. Ether
c. Michelson-Morley results
3. Einstein's postulates
a. Laws of physics same in inertial frames
b. Speed of light constant in inertial frames
4. Lorentz transformations
a. Length contraction
b. Time dilation
c. Simultaneity
d. Experimental evidence
1) Muon decay
2) Airborne atomic clocks
5. Paradoxes
a. Twin paradox
b. Ladder in barn paradox
6. Addition of velocities
7. Momentum
a. Momentum is conserved
b. Discussion of "relativistic mass"
8. Energy
a. Derivation of e=mc^2
b. Conservation of energy
c. Relativistic collisions
9. General relativity
B. Explain wave-particle duality and its implications through both historical and thought experiments.
1. Light acting like a particle
a. Blackbody radiation
1) Definition of a black body
2) Wien's law
3) T^4 law
4) Classical attempts at solution
5) Planck's solution
b. The photoelectric effect
1) Experimental evidence
2) Einstein's solution
c. The Compton effect
2. Wave properties of particles
a. The de Broglie hypothesis
b. Electron diffraction
3. Wave-particle duality
a. Two slit experiments
1) Predictions for waves
2) Predictions for particles
3) Experimental results
b. The concept of probabilistic results
C. Discuss the concepts of quantum mechanics and solve simple problems.
1. The Stern-Gerlach experiment
a. The concept of spin
b. Experimental results
1) Alignment and anti-alignment
2) Results of consecutive measurements
c. Mathematical representation
1) State vectors
2) Eigenvectors
3) The collapse of the state vector
4) Assignment of probability based upon amplitude
5) Normalization of recombined waves
6) Time evolution
2. Wave functions and the Schrodinger equation
a. Justification of the Schrodinger equation
1) Probability results
2) Energy eigenfunctions

b. Heisenberg uncertainty principle
c. Particle in a box
1) Infinite walls
a) Solutions
b) Quantized energy levels
2) Finite box
3) Two-dimensional box
d. Scattering and tunneling
e. Quantum harmonic oscillator
f. Correspondence principle
D. Discuss models and solve problems pertaining to the hydrogen atom, the periodic table and condensed matter physics.
1. Bohr's model of the hydrogen atom and the hydrogen spectrum
a. Restriction of angular momentum to integer multiples of Planck's constant
b. Bohr radius
c. Energy levels and the hydrogen spectrum
d. Shortcomings of the Bohr model
2. Quantum mechanical approach
a. Schrodinger's equation
1) Three dimensions
2) Electrostatic potential
3) Spherical coordinates
4) Separation of variables
b. The need for four quantum numbers
c. Wave functions for the hydrogen atom
1) Shapes
2) Probabilities
d. Pauli exclusion principle
e. The periodic table
f. Wave functions in solid state
1) Energy bands
2) Statistical distribution functions
E. Explain models of nuclear physics, how they relate to observed results, and solve problems concerning radioactive decay.
1. Models of the nucleus
a. Stability
b. Ratio of protons to neutrons
2. Radioactivity
a. Decay and half-lives
b. Biological effects of radiation
3. Fission
4. Fusion
F. Explain current theories in particle physics.
1. Inventory of particles
a. Leptons
b. Hadrons
1) Baryons
2) Mesons
2. Conservation laws
3. Quarks
a. Eightfold way
b. Color
4. Particles as force mediators
a. Virtual particles
b. Different views of the strong force

Lab Content

A. Suggested laboratory experiments (some experiments may use computer-generated data and/or data from audio-visual media):
1. Exponential decay
2. Time dilation
3. The photoelectric effect
4. Black body radiation
5. Atomic spectra
6. Particle scattering (mechanical simulation)
7. The Franck-Hertz experiment
8. Radioactive decay
9. Electron diffraction
10. Charge-to-mass of the electron

Special Facilities and/or Equipment

A. Physics laboratory with equipment for teaching introductory relativity and modern physics.

Method(s) of Evaluation

A. Weekly problem sets
B. Periodic midterm tests
C. Laboratory performance
D. Final examination

Method(s) of Instruction

A. Lecture
B. Discussion
C. Cooperative learning exercises
D. Laboratory
E. Demonstration

Representative Text(s) and Other Materials

Moebs, Ling, and Sanny. University Physics. OpenStax, 2017.

Types and/or Examples of Required Reading, Writing, and Outside of Class Assignments

A. Homework problems: Homework problems covering subject matter from text and related material ranging from 10-20 problems per week. Students will need to employ critical thinking in order to complete assignments.

B. Lecture: Five hours per week of lecture covering subject matter from text and related material. Reading and study of the textbook, related materials and notes.

C. Labs: Students will perform experiments and discuss their results in either the form of a written lab report or via oral examination. Reading and understanding the lab manual prior to class is essential to success.

Discipline(s)

Physics/Astronomy