San Bernardino Valley College
Curriculum Approved: FA00

I. CATALOG DESCRIPTION

A. Division: Science
Department: Physics
Course ID: **PHYSIC 210**
Course Title: **Modern Physics**
Units: 4
Lecture: 3 hours per week
Laboratory: 3 hours per week

Prerequisite: PHYSIC 201 or PHYSIC 150B and MATH 251

B. Course Description:
A calculus based physics course in modern physics. Topics include relativity, quantum mechanics, atoms, molecules, condensed matter, nuclear and particle physics.

Schedule Description:
A calculus based physics course in modern physics.

II. NUMBER OF TIMES COURSE MAY BE TAKEN FOR CREDIT: One

III. EXPECTED OUTCOMES FOR STUDENTS: Upon successful completion of the course, the student should be able to:

a. Read and critically evaluate scientific literature involving basic concepts
b. Apply basic scientific principles to new situations
c. Explore the transition from classical theory to the special relativity
d. Recognize the limitations of classical physics which necessitated the intro of quantum theory
e. Understand and apply the principles of special relativity
f. Identify the fundamental experiments leading to the quantum theory
g. Understand and use photon energy equation and the matter wave equation
h. Derive the Compton scattering equation
i. Analyze atomic sprectra from your knowledge of atomic structure
j. Recognize the Schrodinger equation
k. Solve problems such as the infinite well, finite well and simple harmonic oscillator
l. Apply Schrodinger's equation to the hydrogen atom
m. Use the ideas of classical, Fermi-Dirac and Bose-Einstein statistics in the understanding of physical systems
n. Investigate applications of quantum theory to complex atoms and molecules, and solid state physics
o. Study the atomic nucleus
p. Recognize the various nuclear particles
q. Solve problems involving binding energy and nuclear cross-section
r. Understand the principles of nuclear fission and fusion
s. Develop nuclear models such as the liquid drop and shell model
t. Survey the concepts of elementary particle physics
u. Describe and apply the basic conservation laws governing elementary particles
v. Utilize calculus techniques of differentiation and integration to analyze a variety of problems such as the derivation of the Stefan-Boltzmann law from Plank's equation, the Schrodinger equation, particle in a box and Maxwell's distribution

IV. CONTENT:

A. Review of classical physics
1. mechanics
2. thermodynamics
3. electromagnetism
4. physical optics

B. Review of Special Relativity
   1. Einstein's Postulates
   2. the Lorentz transformations
   3. simultaneity
   4. time dilation and length contraction
   5. velocity addition
   6. momentum and energy
   7. spacetime, world line, and lightcone
   8. 4-vectors

C. Early quantum theory
   1. experimental evidence
   2. the photon
   3. the Rutherford atom
   4. the Bohr atom
   5. wavelike properties of particles

D. Quantum mechanics
   1. the Schrodinger equation
   2. infinite well
   3. finite well
   4. tunneling
   5. simple harmonic oscillator
   6. the Hydrogen atom
   7. quantum numbers
   8. many particles

E. Statistical Physics
   1. classical statistics
   2. Fermi-Dirac statistics
   3. Bose-Einstein statistics
   4. applications

F. Applications
   1. complex atoms and molecules
   2. lasers
   3. solid state physics

G. Nuclear physics
   1. nuclear particles and composition of the nucleus
   2. nuclear force
   3. binding energy
   4. radioactivity
   5. cross-section
   6. models
   7. fission
   8. fusion
   9. applications

H. Elementary particles
   1. particles and antiparticles
   2. fundamental interactions
   3. classification of particles
   4. conservation laws and symmetries
   5. quarks
   6. the Standard Model

I. General relativity and Astrophysics (optional)
1. equivalence principle
2. experimental tests
3. gravity waves
4. black holes
5. the Big Bang
6. the expanding universe
7. stellar evolution

J. LABORATORY
Examples of laboratory exercises are:
1. the Millikan oil-drop
2. e/m
3. atomic spectra
4. Zeeman effect
5. photoelectric effect
6. Frank-Hertz experiment
7. cloud chamber
8. Hall effect
9. radiation detectors
10. the stochastic nature of radioactivity
11. half-life
12. Simulations
    a. wave function description of quantum mechanical states
    b. Bell inequality
    c. exploration of energy eigenfunctions for bound states
    d. stationary scattering states in one dimensional potentials
    e. RelLab explorations of relativistic motion applying Lorentz transformations
    f. Spacetime
    g. Kronig-Penny approximation of atomic potentials
    h. SolidLab – build your own solid state devices
13. Internet based investigations
    Students will investigate experiments, and analyze data from a variety of on-line sources such as:
    a. the Amanda project – (muon and nutrino search)
       http://amanda.berkeley.edu/
    b. Stanford Linear Accelerator projects – on-line data analysis
       http://www.slac.stanford.edu/slac/sciinfo.shtml
       http://www.slac.stanford.edu/grp/rd/reports/00researchreport.pdf
    c. Fermilab
       http://www.fnal.gov

V. METHODS OF INSTRUCTION:

Instructors will include some or all of the following instructional components:

A. Classroom lecture. May be accompanied by activities such as demonstrations, video, film, and computer simulations.
   1. Specific reading assignments to reinforce and extend classroom presentations.
   2. Demonstration experiments evoking discussion and problem solving.
   3. Computer aided instruction.
   4. Written assignments involving the solution of problems illustrative of various physical situations requiring critical thinking skills.

B. Laboratory experimentation. Students work toward specific goals of observation and analysis.
   1. Students write and summarize their laboratory observations.
   2. Writing includes background, data analysis, and documentation of principles and apparatus.

C. On-line search of various topics in modern physics culminating in discussion, analysis, and report writing.
D. Other written assignments such as library research including analysis of current popular scientific literature.

VI. TYPICAL ASSIGNMENTS:

A. LECTURE ASSIGNMENT:

Lorentz transformations and Time Dilation: Read pp. 50-58

End of Chap. Exercises: (Examples of 10 – 15 assigned exercises)

1. Start with the expression $x'^2 + y'^2 + z'^2 - c^2t'^2$ and show, with the aid of the Lorentz transformations, that this quantitiy is equal to $x^2 + y^2 + z^2 - c^2t^2$.
2. Astronomers discover a planet orbiting around a star similar to our sun that is 20 light-years away. How fast must a rocket go if the round trip is to take no longer than 40 years in time for the astronauts aboard? How much time will have elapsed on earth?

B. LAB ASSIGNMENT

AMANDA is a detector being constructed at the South Pole, whose purpose is to observe high-energy (~ 1 TeV or 10^12 electron volt) neutrinos from astrophysical point sources. Use the AMANDA web site http://amanda.berkeley.edu/ as your resource for the following.

1. *Describe the Experiment*: What does the experiment look like? What is it trying to detect? How does it detect particles? What is unique/novel about this experiment that gives it the potential for observing or measuring something new?

2. *Data Analysis:* How does your experiment analyze its data to determine results? Include and explain important plots or figures

3. *Results:* Do you buy this experiment's results? Do you think what was learned (or what will be learned) justifies the cost and effort? Is more work suggested by the outcome of this experiment?

VII. EVALUATION:

A. Methods of Evaluation:

Grading may be comparative (scaling, curve) or based on an absolute standard. Questions are designed to evaluate student comprehension of the learning goals enumerated in item IV above. Students will be asked to identify basic principles, recognize and apply common terminology, and apply fundamental knowledge to real world situations.

Methods of evaluation will vary with the instructor, and may include some or all of the following components.

1. Objective tests which may include true-false, multiple choice, and matching items.
2. Subjective tests which may include completion items and essay questions.
3. Laboratory performance
4. Problem solutions
5. Projects
6. Written assignments as described in V above.

B. Frequency of evaluation:

1. There are typically three to five exams during the semester.
2. Other, more frequent evaluation techniques, such as quizzes, may be utilized.

C. Typical exam questions:

1. Show that Planck's radiation law avoids the ultraviolet catastrophe.
2. What is the series limit for the Lyman series? For the Balmer series?
3. Show that the wave function $\Psi_n(x,t)$ for a particle in an infinite square well corresponds to a standing wave in a box.
4. In a particular semiconductor device, electrons accelerated through a potential of 5 V attempt to tunnel through a barrier of width 0.8 nm and height 10 V. What fraction of the electrons are able to tunnel through the barrier if the potential is zero outside the barrier?

5. Neutrons are used to study structures of solids and their properties. What energy and temperature neutrons are needed if the atomic structures are of the size of 0.06 nm?

VIII. TYPICAL TEXT(S):

6. Bernstein, et.al., Modern Physics, 2000, Prentice-Hall
7. Thornton, Rex, Modern Physics, 2nd ed., 2000, Harcourt
8. Tipler, Llewellyn, Modern Physics, 3rd ed., 1999, Freeman

IX. OTHER SUPPLIES REQUIRED OF STUDENTS:

Graphing Calculator
Blank quadrille notebook