EL CAMINO COLLEGE
COURSE OUTLINE OF RECORD – Approved

I. Course Information

Subject:	**PHYS**
Course Number:	**1D**
Descriptive Title:	**Optics and Modern Physics**
Division:	**Natural Sciences**
Department:	**Physics**
Course Disciplines:	**Astronomy, Physics**

Catalog Description:
This is the fourth course in four-semester calculus-based physics sequence intended for students entering majors in engineering and the physical sciences. The topics covered include geometric and physical optics, special relativity, quantum mechanics, nuclear physics, and selected topics in modern physics.

Conditions of Enrollment:
Prerequisite: Physics 1C with a minimum grade of C AND Mathematics 220 with a minimum grade of C

Course Length: Full Term

Hours Lecture (per week):	3
Hours Laboratory (per week):	3
Outside Study Hours:	6
Total Hours:	108

Course Units: 4

Grading Method:	Letter Grade only
Credit Status:	Credit, degree applicable

Transfer CSU:	Yes	Effective Date: Prior to July 1992
Transfer UC:	Yes	Effective Date:

General Education:
ECC: Area 1 - Natural Sciences
Term: **Other:**

CSU GE: Area B1 - Physical Universe and its Life Forms: Physical Science,
Area B3 - Physical Universe and its Life Forms: Laboratory Activity
Term: **Other:**

IGETC: Area 5A - Physical Science
Term: **Other:**

II. Outcomes and Objectives

A. Student Learning Outcomes (SLOs) (The course student learning outcomes are listed below.)

SLO #1 Applying Relevant Principles
Students can recognize the basic physical principles which are relevant in a given physical situation involving optics or modern physics in order to correctly answer conceptual questions.

SLO #2 Solving Physics Problems
Students can identify and apply the relevant laws of physics along with the necessary mathematics to successfully solve a problem dealing with optics or modern physics.

SLO #3 Data Collection & Analysis
Students can read and record, with appropriate units and uncertainties, measurements taken from an instrument used in an optics lab.. Students can interpret and analyze the collected data, including error analysis.

B. Course Objectives (The major learning objective for in this course are listed below)

Course Objectives:

1. Demonstrate the ability to set up and use specialized optical instruments such as spectrometers, telescopes, microscopes and systems involving lenses and mirrors, to report on the outcome of the experiment and explain the results physically.
2. Apply the ideas of geometric optics, including Snell's law and the index of refraction, to analyze the propagation of a ray of light.
3. Use the principles of geometric optics to describe image formation by a single reflecting or refracting surface, either flat or curved, and illustrate the formation of these images using ray diagrams.
4. Utilize standard theories of lenses and mirrors to relate the position and size of an object viewed through a series of optic elements to the position and size of the image produced by those optic elements. Use ray diagrams to illustrate these processes.
5. Explain the function of simple devices made of multiple optic elements, such as a telescope or microscope, and calculate the properties of these devices.
6. Describe the structure of a linearly polarized electromagnetic wave, including the spatial variation of electric and magnetic fields, and the relation between the electromagnetic fields and the propagation direction of the wave. Perform computations relating to the energy and momentum carried by such a wave.
7. Use theories of wave addition to describe the polarization state of a combination of linearly polarized electromagnetic waves as either linearly, circularly, or elliptically polarized. Compute basic properties of these waves.
8. Understand and perform calculations relating to the production of polarized electromagnetic waves using ideas and methods such as Brewster's angle, polarizing filters, and retardation plates.
9. Be able to describe, analyze, and explain interference and diffraction patterns produced by a planar electromagnetic wave passing through a single slit, or through multiple slits, possibly of finite width.
10. Explain the significance of the equivalence of inertial reference frames, and how fundamental implications of special relativity, such as length contraction and time dilation arise from this principle.
11. Explain, and perform computations using, basic ideas of special relativity including proper time, proper length, and the space-time interval.
12. Solve problems in relativistic kinematics using the Lorentz transformations, the relativistic velocity addition formulas, and related equations.
13. Apply the concepts of rest mass, and relativistic energy and momentum, to solve problems in relativistic dynamics, especially collision and particle decay problems.
14. Understand and perform computations related to basic experimental demonstrations of quantum mechanical principles, such as blackbody radiation, the photoelectric effect and the Compton effect.
15. Understand and perform calculations related to the foundational assumptions of quantum mechanics, such as the quantization of electromagnetic energy, the wave nature of particles, and the uncertainty principle.

16. Apply the one-dimensional Schrodinger equation to standard problems such as the infinite and finite wells, the quantum harmonic oscillator potential, and tunneling.
17. Apply separation of variables to solve Schrodinger's equation in simple multi-dimensional geometries, such as the three-dimensional box with infinite walls.
18. Use the Bohr model of the atom to compute basic properties of electron orbitals in one-electron atoms. Also, use the Bohr model to predict the emission and absorption spectra of one-electron atoms.
19. Explain in outline the separation-of-variables procedure used to solve for the allowed orbitals in a single-electron atom. Although a full treatment of this problem is beyond the scope of Physics 1D, students will be able to perform calculations to verify relatively simple tabulated orbitals.
20. Compute the energy associated with the interaction between an electron's spin and an external magnetic field.
21. Explain the significance of the fundamental quantum numbers of a one-electron atom. Use these fundamental quantum numbers to explain the basic structure of the periodic table of the elements.
22. Describe the basic mechanisms of nuclear fission and fusion. Compute the binding energy of a nucleus and the energy liberated or absorbed by a nuclear reaction.

III. Outline of Subject Matter

(Topics should be detailed enough to enable an instructor to determine the major areas that should be covered to ensure consistency from instructor to instructor and semester to semester.)

Major Topics

I. GEOMETRIC OPTICS (10 hours, lecture)

A. The index of refraction and Snell's law. Reflection and refraction at planar surfaces.
B. Dispersion.
C. Formation of images by reflection and refraction at curved and planar surfaces. Use of ray diagrams to illustrate these processes.
D. Optical instruments (magnifier, telescopes, microscopes, the eye, etc.)

II. PHYSICAL OPTICS (12 hours, lecture)

A. Electric and magnetic field components of an electromagnetic wave.
B. Energy and momentum carried by an electromagnetic wave. Relation between electric and magnetic fields and energy propagation.
C. Methods by which polarized electromagnetic waves are produced. Use of polarizers.
D. Linear, Circular, and Elliptical polarization of electromagnetic waves. Use of retardation plates to change the polarization of an electromagnetic wave.
E. Interference patterns by planar electromagnetic waves passing through multiple slits.
F. Interference due to reflection from and transmission through thin films.
G. Diffraction patterns produced by electromagnetic waves passing through slits of finite width.

III. SPECIAL RELATIVITY (8 hours, lecture)

A. Equivalence of inertial reference frames and implications thereof.
B. Time dilation and length contraction.
C. Lorentz transformations and relativistic velocity addition.
D. Rest energy, relativistic momentum and energy.
E. Relativistic collisions and particle decays.

IV. QUANTUM MECHANICS-FOUNDATIONS (6 hours, lecture)

A. Empirical motivation of quantum mechanics. Selected from photoelectric effect, Compton effect, blackbody radiation, single-electron and single-photon diffraction, etc.
B. Quantization of electromagnetic energy, i.e. "photons."
C. Wave properties of particles and de Broglie wavelength.
D. Fourier series and uncertainty principle.
E. Wavefunctions and interpretation thereof.

V. SCHRODINGER'S EQUATION (6 hours, lecture)

A. Motivation for Schrodinger's Equation

B. Solutions of one-dimensional Schrodinger's equation for standard geometries such as infinite well, finite well, and harmonic oscillator potential.

C. Tunneling.

D. Separation of variables for mutli-dimensional Schrodinger's equation.

VI. ONE-ELECTRON ATOMS (6 hours, lecture)

A. Bohr model of the atom. Properties of orbitals computed from the Bohr model, including energy, radius, etc.

B. Schrodinger's equation in spherical coordinates. Separation of variables in spherical coordinates.

C. Schrodinger's equation in spherical coordinates for one-electron atoms, and solutions thereof.

D. Electron spin.

E. Quantum numbers of the one-electron atom. Relation between quantum numbers of the one-electron atom and periodic table of the elements.

VII. NUCLEAR PHYSICS (2 hours, lecture)

A. Nuclear structure and binding energy

B. Nuclear reactions, including fission and fusion.

VIII. ADDITIONAL TOPICS (4 hours, lecture)

Topics will be selected from:

A. Quantum statistical mechanics

B. Molecular Physics

C. Solid State Physics

D. Superconductivity

E. Particle Physics

F. Cosmology

IX. LABORATORY EXERCISES (54 hours, lab)

A. Refraction at a Plane Surface

B. Spherical Lenses and Mirrors

C. Simple Telescope

D. Spectrometer with a Prism

E. Polarization

F. Interference and Diffraction

G. Measurement of Planck's Constant

H. Spectroscopy of Hydrogen

Total Lecture Hours:	54
Total Laboratory Hours:	54
Total Hours:	108

IV. Primary Method of Evaluation and Sample Assignments

A. Primary Method of Evaluation (choose one):

2) Problem solving demonstrations (computational or non-computational)

B. Typical Assignment Using Primary Method of Evaluation

A stack of n ideal polarizers is arranged so that the transmission axes of the first and last polarizers are perpendicular to each other. The remaining polarizers are oriented so that there are equal angles between any two successive polarizers (giving a net rotation of 90° for light passing all the way through the stack).

(a) Suppose that light polarized parallel to the transmission axis of the first polarizer with intensity I0 is incident on the stack. What is the intensity of the outgoing light? (Find a general formula in terms of n.)

(b) Show that in the limit where n goes to infinity your answer from (a) becomes I0.

C. College-level Critical Thinking Assignments

Critical Thinking Assignment 1:

According to observers in an inertial system S in which the earth is at rest, a galaxy has been moving away from the earth at constant speed of 0.60c. When the galaxy was 4.00 x 10^9 light-years from the earth, a star was born in this galaxy. An observer riding with the galaxy finds that this star's lifetime in his system(S') is 1.0 x 10^10 years.

a) What is the lifetime of the star as measured by S?

b) According to S, how far does the galaxy travel during the lifetime of this star, and what is the distance to the galaxy at the time of the star's death?

c) Over what period of time would a long-lived observer on earth see light from this star?

Show all calculations.

Critical Thinking Assignment 2:

Triplets A, B, and C are born simultaneously on the earth. A stays at home, and B travels immediately after birth to a nearby star 25 light-years away at a speed of 0.80c. C travels to another star 25 light-years away at a speed of 0.60c. B and C both reverse and return to earth with their same respective speeds immediately after reaching their destination.

a) What is A's age when B returns?

b) What is B's age when she meets A?

c) What is A's age when C returns?

d) What is C's age when he meets A?

(Note: All space and time measurements were measured in A's frame of reference.)

Show all calculations

D. Other Typical Assessment and Evaluation Methods

Homework Problems, Laboratory Reports, Multiple Choice, Objective Exam, Other Exams, Performance Exams, Quizzes, Written Homework

V. Instructional Methods

Demonstration, Discussion, Lab, Lecture

If other:

Note: In compliance with Board Policies 1600 and 3410, Title 5 California Code of Regulations, the Rehabilitation Act of 1973, and Sections 504 and 508 of the Americans with Disabilities Act, instruction delivery shall provide access, full inclusion, and effective communication for students with disabilities.

VI. Work Outside of Class

Answer questions, Problem solving activity, Required reading, Study

If Other:

VII. Texts and Materials

A. Up-to-date Representative Textbooks: (Please use the following format: Author, Title, Edition, Publisher, Year. If you wish to list a text that is more than 5 years old, please annotate it as a "discipline standard".)
Wilson. Physics 1D. El Camino College Bookstore, 2013.

Young, Freedman, and Ford. University Physics with Modern Physics. 15th ed. Addison-Wesley, 2020.

B. Alternative Textbooks: (Please use the following format: Author, Title, Edition, Publisher, Year. If you wish to list a text that is more than 5 years old, please annotate it as a "discipline standard".)

C. Required Supplementary Readings

D. Other Required Materials
Ruler, protractor, and compass
Scientific calculator
Graph paper (linear, log-log)

VIII. Conditions of Enrollment

A. Requisites (Course Prerequisites and Corequisites) Skills needed without which a student would be highly unlikely to succeed.

Requisite: Prerequisite
Category: Sequential

Requisite course(s): List both prerequisites and corequisites in this box.
Physics-1C AND Mathematics-220

Requisite and Matching skill(s):Bold the requisite skill. List the corresponding course objective under each skill(s).
Understanding of electric and magnetic phenomena

PHYS 1C - Electric and magnetic fields, dielectric constants, electric potential energy, phasors, Maxwell's equations in free space and materials, and energy and momentum carried by electromagnetic waves.

MATH 220 - Understanding of Vector algebra, vector fields, vectors tangent and normal to a surface, partial derivatives, divergence, gradient and curl.

B. Requisite Skills: (Non-Course Prerequisite and Corequisites) Skills needed without which a student would be highly unlikely to succeed.
Requisite:
Requisite and Matching Skill(s): Bold the requisite skill(s). If applicable

C. Recommended Preparations (Course) (Skills with which a student's ability to succeed will be strongly enhanced.)
Requisite course:
Requisite and Matching skill(s):Bold the requisite skill. List the corresponding course objective under each skill(s).

D. Recommended Preparation (Non-Course) (Skills with which a student's ability to succeed will be strongly enhanced.)

Requisite:

Requisite and Matching skill(s): Bold the requisite skill. List the corresponding course objective under each skill(s). If applicable

E. Enrollment Limitations

Enrollment Limitations and Category:

Enrollment Limitations Impact:

Course Created by: Physics Sub-Committee on Date: 02/01/1965

Original Board Approval Date:

Last Reviewed and/or Revised by: Susan Stolovy Date: 05/13/2021

Last Board Approval Date: 06/21/2021