El Camino College

COURSE OUTLINE OF RECORD - Official

I. GENERAL COURSE INFORMATION

Subject and Number: Physics 1D
Descriptive Title: Optics and Modern Physics

Course Disciplines: Physics/Astronomy

Division: Natural Sciences

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 1A
AND

Mathematics 191
with a minimum grade of C

Course Length: [X] Full Term [ ] Other (Specify number of weeks):
Hours Lecture: 4.00 hours per week [ ] TBA
Hours Laboratory: 2.00 hours per week [ ] TBA
Course Units: 4.00

Grading Method: Letter
Credit Status Associate Degree Credit

Transfer CSU: [X] Effective Date: Prior to July 1992
Transfer UC: [X] Effective Date: Prior to July 1992

General Education:

El Camino College: **1 – Natural Sciences**
Term: Other: Approved

CSU GE: **B1 - Physical Science**
Term: Fall 1991 Other:
B3 - Laboratory Sciences
Term: Fall 1991 Other:

IGETC:

II. OUTCOMES AND OBJECTIVES

A. COURSE STUDENT LEARNING OUTCOMES (The course student learning outcomes are listed below, along with a representative assessment method for each. Student learning outcomes are not subject to review, revision or approval by the College Curriculum Committee)

1. 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.
2. 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.
3. 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.

The above SLOs were the most recent available SLOs at the time of course review. For the most current SLO statements, visit the El Camino College SLO webpage at http://www.elcamino.edu/academics/slo/.

B. Course Student Learning Objectives (The major learning objective for students enrolled in this course are listed below, along with a representative assessment method for each)

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.

   Laboratory reports

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.

   Other exams

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.

   Other exams

4. Utilise 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.

   Objective Exams

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.

   Other exams

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.

   Other exams

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.

Other exams

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.

   Quizzes

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.

   Other exams

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.

    Other exams

11. Explain, and perform computations using, basic ideas of special relativity including proper time, proper length, and the spacetime interval.

    Objective Exams

12. Solve problems in relativistic kinematics using the Lorentz transformations, the relativistic velocity addition formulas, and related equations.

    Other exams

13. Apply the concepts of rest mass, and relativistic energy and momentum, to solve problems in relativistic dynamics, especially collision and particle decay problems.

    Other exams

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.

    Objective Exams

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.

    Other exams

16. Apply the one-dimensional Schrodinger equation to standard problems such as the infinite and finite wells, the quantum harmonic oscillator potential, and tunneling.

    Other exams

17. Apply separation of variables to solve Schrodinger's equation in simple multi-dimensional geometries, such as the three-dimensional box with infinite walls.

    Other exams

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.

    Other exams

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.

    Other exams

20. Compute the energy associated with the interaction between an electron's spin and an external magnetic field.

Other exams

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.

    Other exams

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.

    Other exams

III. OUTLINE OF SUBJECT MATTER (Topics are detailed enough to enable a qualified instructor to determine the major areas that should be covered as well as ensure consistency from instructor to instructor and semester to semester.)

Lecture or Lab	Approximate Hours	Topic Number	Major Topic
Lecture	12	I	I. GEOMETRIC OPTICS A. The index of refraction and Snell's law. 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.)
Lecture	15	II	II. PHYSICAL OPTICS 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. Interfernce 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.
Lecture	9	III	III. SPECIAL RELATIVITY 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.
Lecture	8	IV	IV. QUANTUM MECHANICS-FOUNDATIONS 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.
Lecture	8	V	V. SCHRODINGER'S EQUATION 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.
Lecture	8	VI	VI. ONE-ELECTRON ATOMS 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.
Lecture	3	VII	VII. NUCLEAR PHYSICS A. Nuclear structure and binding energy B. Nuclear reactions, including fission and fusion.
Lecture	9	VIII	VIII. ADDITIONAL TOPICS Topics will be selected from: A. Quantum statistical mechanics B. Molecular Physics C. Solid State Physics D. Superconductivity E. Particle Physics F. Cosmology
Lab	36	IX	IX. LABORATORY EXERCISES 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	72		
Total Laboratory Hours	36		
Total Hours	108		

IV. PRIMARY METHOD OF EVALUATION AND SAMPLE ASSIGNMENTS

A. PRIMARY METHOD OF EVALUATION:

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 I_0 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 I_0.

C. **COLLEGE-LEVEL CRITICAL THINKING ASSIGNMENTS:**

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.

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:**

Performance exams

Objective Exams

Other exams

Quizzes

Written homework

Laboratory reports

Homework Problems

Multiple Choice

V. INSTRUCTIONAL METHODS

Demonstration
Discussion
Laboratory
Lecture

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

Study
Answer questions
Required reading
Problem solving activities

Estimated Independent Study Hours per Week: 6

VII. TEXTS AND MATERIALS

A. **UP-TO-DATE REPRESENTATIVE TEXTBOOKS**

Wilson. Physics 1D. El Camino College Bookstore, 2013.
Young, Freedman, and Ford. University Physics with Modern Physics. 13th ed. Addison-Wesley, 2011.

B. **ALTERNATIVE TEXTBOOKS**

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 and Non-Course Prerequisites and Corequisites)

Requisites	Category and Justification
Course Prerequisite Physics-1A AND	Sequential
Course Prerequisite Mathematics-191	Computational/Communication Skills

B. Requisite Skills

Requisite Skills
Ability to identify and analyze the forces acting on an object, and predict the motion of the object resulting from those forces. PHYS 1A - Draw a free-body diagram which depicts forces acting on a rigid object, and use this diagram to quantitatively analyze these forces. PHYS 1A - Analyze the motion of a rigid object using a free-body diagram analysis together with Newton's laws of motion.
Ability to analyze problems involving motion in one or two dimensions, and in particular, problems in which the relative motion of two moving objects must be determined. PHYS 1A - Analyze the motion of objects moving in one- or two-dimensions with constant or variable acceleration, including free-falling objects.
Ability to apply the concepts of energy and momentum conservation to analyze the motion of objects and the interactions of multiple objects. PHYS 1A - Use the concepts of work, energy, impulse and momentum to analyze the motion of rigid objects.
Ability to determine errors introduced with any measurement, and their effect on the results. PHYS 1A - Use different measuring devices, such as the micrometer or vernier caliper and determine the errors that are introduced with each measurement.
Ability to use graphical techniques to analyze data - experimental and theoretical. PHYS 1A - Analyze data graphically using linear, semi-log, and log-log scales.
Ability to set up and evaluate integrals using a variety of methods, including integration by parts and trigonometric substitution. MATH 191 - Evaluate integrals using integration techniques including: integration by parts; trigonometric substitutions; partial fraction decomposition and tables of integrals.
Ability to use numerical approximation methods. MATH 191 - Use numerical techniques (both with and without technology) to approximate the values of integrals.
Ability to solve problems involving finite and infinite series. MATH 191 - Determine the convergence or divergence of sequences, series and power series.MATH 191 - Solve problems using Taylor series, including differentiation and integration of power series.

C. Recommended Preparations (Course and Non-Course)

Recommended Preparation	Category and Justification

D. Recommended Skills

Recommended Skills

E. Enrollment Limitations

Enrollment Limitations and Category	Enrollment Limitations Impact

Course created by Physics Sub-Committee on 02/01/1965.

BOARD APPROVAL DATE:

LAST BOARD APPROVAL DATE:

Last Reviewed and/or Revised by Eyal Goldmann on 02/19/2014

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