PHYS 4C: GENERAL PHYSICS (CALCULUS)

Foothill College Course Outline of Record

| Heading | Value |
|-------------------------|---|
| Effective Term: | Summer 2025 |
| Units: | 6 |
| Hours: | 5 lecture, 3 laboratory per week (96 total per quarter) |
| Prerequisite: | MATH 1C and PHYS 4A. |
| 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 |
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Student Learning Outcomes

- Students should understand the following concepts about optics index of refraction and Snell's law; image formed by reflection and refraction; thin lens and lens maker equation; optical instruments; interference in Young's double slit experiment and thin film; single slit diffraction and limits of resolution.
- Students should understand the following concepts Thermal physics

 temperature, internal energy and heat transfer; specific heat and
 Calorimetry; zeroth, first, and second law of thermodynamics; thermal processes and heat engines.
- Students will articulate how thermodynamic principles affect real-world phenomena or students will be able to identify natural phenomena that are affected by heat and appraise how thermodynamic changes will affect natural systems.
- Students should understand the following concepts about waves
 - wave motion and energy transport by waves; reflection and
 transmission, interference and standing waves; intensity of sound
 and interference of sound; Doppler effect.

Description

Thermodynamics; mechanical, acoustical, and electromagnetic waves; optics.

Course Objectives

The student will be able to:

- 1. Explain the zeroth, first, and second laws of thermodynamics, and solve related problems and calculate results from statistical mechanics, such as the kinetic theory of gases.
- 2. Analyze the properties of waves and apply mathematical formulas to physical problems.
- 3. Analyze and solve problems in optics.
- 4. Assess the limitations of physical laws and make mathematical approximations in appropriate situations.
- 5. Understand how physical laws are established and the role of scientific evidence as support.
- 6. Discuss historical and current barriers to access in physics.

Course Content

- Explain the zeroth, first, and second laws of thermodynamics, and solve related problems and calculate results from statistical mechanics, such as the kinetic theory of gases
 - a. Temperature
 - i. Thermometers
 - ii. Zeroth law of thermodynamics
 - b. Thermal expansion
 - c. Heat
 - i. Definition of heat
 - ii. Calorimetry and phase changes
 - Specific heat
 - 2. Heat of vaporization
 - 3. Heat of fusion
 - d. First law of thermodynamics
 - i. Definition of work
 - ii. Relationship between work and heat
 - iii. Definition of internal energy
 - iv. Adiabats
 - v. Isotherms
 - e. Heat transfer processes
 - i. Conduction
 - ii. Convection
 - iii. Radiation
 - f. The kinetic theory of gases and the Maxwell-Boltzmann distribution functions
 - i. Molecular model of a gas
 - 1. Temperature
 - 2. Molar specific heat of an ideal gas
 - 3. Ideal gas treatment of adiabatic process
 - ii. Equipartition of energy
 - iii. Maxwell-Boltzmann distribution
 - 1. Derivation of Maxwell-Boltzmann distribution
 - 2. Velocities
 - a. Vmp
 - b. Vave
 - c. Vrms
 - g. Entropy, heat engines, and the second law of thermodynamics
 - i. Definition of a heat engine
 - 1. Work done
 - 2. Efficiency
 - 3. Kelvin-Planck formulation of the second law
 - ii. Definition of a refrigerator
 - 1. Coefficient of performance
 - 2. Clausius formulation of the second law
 - iii. Reversible and irreversible processes
 - iv. The Carnot cycle
 - 1. Efficiency
 - 2. Applications to the second law
 - v. Other engines
 - 1. Otto
 - 2. Diesel
 - vi. Entropy

- 1. Macroscopic definition
- 2. Entropy and irreversibility
- 3. Microscopic/probabilistic definition
- 2. Analyze the properties of waves and apply mathematical formulas to physical problems
 - a. The wave function and the propagation speed of a wave
 - i. Traveling waves
 - ii. Speed of a wave on a string
 - iii. Transverse vs. longitudinal waves
 - iv. Energy transfer
 - b. Reflection, transmission, and superposition of waves
 - c. Sound waves, intensity, and the Doppler effect
 - i. Sounds as a pressure wave
 - ii. Speed of sound
 - iii. Periodic sound waves
 - 1. Definition
 - 2. Intensity
 - a. Decibels
 - b. Loudness and frequency
 - iv. Doppler effect
 - 1. Source moving
 - 2. Detector moving
 - 3. Both moving
 - 4. Sonic booms
 - d. Standing waves, interference, and resonance
 - i. Superposition and interference
 - 1. Destructive interference
 - 2. Constructive interference
 - 3. Superposition of sinusoidal waves
 - ii. Standing waves
 - 1. Nodes and antinodes
 - 2. Standing waves as a function of time
 - 3. Standing waves on a string
 - 4. Standing waves in air columns
 - a. Open both ends
 - b. Closed one end
 - iii. Resonance
 - iv. Beats
- 3. Analyze and solve problems in optics
 - a. Reflection and refraction of light
 - i. Ray approximation
 - ii. Reflection
 - iii. Refraction
 - 1. Index of refraction
 - 2. Ibn-Sahl's Law (Snell's law)
 - a. Huygen's principle
 - b. Total internal reflection
 - b. Geometrical optics, mirrors, lenses, and optical instruments
 - i. Images formed by mirrors
 - 1. Image distance
 - 2. Object distance
 - 3. Magnification
 - 4. Real vs. virtual
 - 5. Upright vs. inverted

- 6. Concave vs. convex
- 7. Ray diagrams for mirrors
- ii. Images formed by lenses
 - 1. Image distance
 - 2. Object distance
 - 3. Magnification
 - 4. Real vs. virtual
 - 5. Upright vs. inverted
 - 6. Concave vs. convex
 - 7. Ray diagrams for lenses
- iii. Optical instruments
 - 1. The eye
 - 2. Microscopes
 - 3. Telescopes
- c. Optical interference, diffraction, and polarization
 - i. Young's double slit
 - 1. Constructive and destructive interference
 - 2. Intensity distribution
 - ii. Thin film interference
 - 1. Change of phase on reflection
 - 2. Coatings
 - 3. Newton's rings
 - iii. Michelson interferometer
- Assess the limitations of physical laws and make mathematical approximations in appropriate situations
 - a. Physical laws as ideal models
 - b. Methods of approximation
- 5. Discuss how physical laws are established and the role of scientific evidence as support
 - a. Historical development of a sampling of physical laws
 - b. Use of student-collected data in labs to confirm physical laws
- 6. Discuss historical and current barriers to access in physics
 - a. Discuss that historically our field has had barriers to entry and advancement due to race, gender, sexuality, class, and other factors
 - b. Discuss "hidden figures" in our field
 - c. Discuss that many of these issues persist to the current day and detail efforts to address them

Lab Content

Suggested laboratory experiments (some experiments may use computer-generated data and/or data from audio-visual media):

- 1. Absolute zero and Boyle's law
- 2. The thermal coefficient of linear expansion
- 3. The specific heat capacity of metal and latent heats of water
- 4. The ratio of the molar heat capacities of air and heat engines
- 5. Standing waves on a stretched string
- 6. The propagation speed of sound waves through air
- 7. Resonance and tubes
- 8. Light intensity and Snell's law
- 9. Focal length and law of Malus
- 10. Image formation by mirrors and lenses
- 11. Michelson's interferometer

- 12. Interference and diffraction by small apertures
- 13. The relative intensity of polarized light

Special Facilities and/or Equipment

Physics laboratory with equipment for teaching introductory thermodynamics, wave behavior, and optics.

Method(s) of Evaluation

Methods of Evaluation may include but are not limited to the following:

Weekly problem sets Periodic midterm tests Weekly quizzes Laboratory performance Project/presentation Final examination Students are evaluated using a variety of measures that can include written exams, project presentations, and discussions, in order to allow them to demonstrate their knowledge and skills by the end of the quarter

Method(s) of Instruction

Methods of Instruction may include but are not limited to the following:

Lecture (may be live/interactive or in the form of pre-recorded videos) Discussion

Cooperative learning exercises Electronic discussions/chat

Laboratory

Demonstration

Students gain an understanding of physics through connecting new terms, concepts, and procedures to what they already know through small group and large group discussions, making predictions and correcting each other's assumptions on ranking tasks, and practicing problem solving methods with the support and guidance of peers and the instructor

Representative Text(s) and Other Materials

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

OpenStax is the standard OER text for the field. Additionally, most of the content was developed prior to 1870, and has not changed substantially over the past 150 years

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

- Homework problems: Homework problems covering subject matter from text and related material ranging from 10-40 problems per week. Students will need to employ critical thinking in order to complete assignments.
- 2. 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.
- 3. Labs: Students will perform experiments and discuss their results either in 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