College of San Mateo
Official Course Outline

1. **COURSE ID:** PHYS 270 **TITLE:** Physics with Calculus III **C-ID:** PHYS 215, PHYS 200S (PHYS 250 & 260 & 270)
   Units: 4.0 units **Hours/Semester:** 48.0-54.0 Lecture hours; 48.0-54.0 Lab hours; and 96.0-108.0 Homework hours
   Method of Grading: Letter Grade Only
   Prerequisite: PHYS 250, and completion of or concurrent enrollment in MATH 253.

2. **COURSE DESIGNATION:**
   Degree Credit
   Transfer credit: CSU; UC
   AA/AS Degree Requirements:
   CSM - GENERAL EDUCATION REQUIREMENTS: E5a. Natural Science
   CSU GE:
   CSU GE Area B: SCIENTIFIC INQUIRY AND QUANTITATIVE REASONING: B1 - Physical Science
   CSU GE Area B: SCIENTIFIC INQUIRY AND QUANTITATIVE REASONING: B3 - Laboratory Activity
   IGETC:
   IGETC Area 5: PHYSICAL AND BIOLOGICAL SCIENCES: A: Physical Science
   IGETC Area 5: PHYSICAL AND BIOLOGICAL SCIENCES: C: Science Laboratory

3. **COURSE DESCRIPTIONS:**
   Catalog Description:
   Third semester in a three-semester sequence for students majoring in the Physical Sciences and Engineering. Topics covered are thermodynamics, geometric and physical optics, and modern physics.

4. **STUDENT LEARNING OUTCOME(S) (SLO'S):**
   Upon successful completion of this course, a student will meet the following outcomes:
   1. Identify problems that should be solved using concepts of geometric optics and correctly solve them. This includes but is not limited to solving image formation problems.
   2. Identify problems that should be solved using physical optics and correctly solve them. This includes but is not limited to solving single and double slit and thin film interference problems.
   3. Identify and correctly solve problems involving heat and temperature. This may include calorimetry, heat transfer, and thermal expansion.
   4. Identify and correctly solve problems involving ideal gases. This may include defining an ideal gas, using the ideal gas law (equation of state), problems involving work and energy, distribution of speeds, definition of temperature, explanation of Cv for a diatomic gas, and identifying whether a cycle is a heat engine or not and computing its efficiency.
   5. Identify problems that should be solved using the First and/or Second Law of Thermodynamics and correctly solve them.
   6. Identify problems involving quantization of energy and correctly solve them. This includes but is not limited to the photoelectric effect and energy levels in atoms.
   7. Identify problems that should be solved using wave functions and correctly solve them. These may involve using Schrodinger's Equation to verify that a wave function is a solution and to find energy levels. These may also include problems involving probability.
   8. Collect and analyze data to verify physics principles.

5. **SPECIFIC INSTRUCTIONAL OBJECTIVES:**
   Upon successful completion of this course, a student will be able to:
   Content-specific objectives: Upon completion of this course, students will have a working knowledge of the skills and concepts listed in the course outline. For example, they will be able to:
   1. Identify problems that should be solved using concepts of geometric optics and correctly solve them. This includes but is not limited to solving image formation problems.
   2. Identify problems that should be solved using physical optics and correctly solve them. This includes but is not limited to solving single slit and double slit and thin film problems.
   3. Identify and correctly solve problems involving heat and temperature. This may include calorimetry, heat transfer, and thermal expansion.

4. Identify and correctly solve problems involving ideal gases. This may include defining an ideal gas, using the ideal gas law (equation of state), problems involving work and energy, distribution of speeds, definition of temperature, explanation of Cv for a diatomic gas, and identifying whether a cycle is a heat engine or not and computing its efficiency.
5. Identify problems that should be solved using the First and/or Second Law of Thermodynamics and correctly solve them.
6. Identify problems involving quantization of energy and correctly solve them. This includes but is not limited to the photoelectric effect and energy levels in atoms and diatomic molecules.
7. Identify problems that should be solved using wave functions and correctly solve them. These may involve using Schrodinger's Equation to verify that a wave function is a solution and to find energy levels. These may also include problems involving probability.
8. Collect and analyze data to verify physics principles.

General objectives: Upon completion of this course, the student will be better able to:

1. Follow scientific arguments, including derivations of formulas, presented either orally or in writing.
2. Determine whether a physical law or principle applies in a given situation and use it appropriately if it applies.
3. Use the language and notation of differential calculus and other mathematics correctly in the solution of physics problems, and use appropriate style and format in written work.
4. Demonstrate good problem-solving habits, including: 1) estimating solutions and recognizing unreasonable results. 2) considering a variety of approaches to a given problem, and selecting one that is appropriate. 3) rejecting the temptation to rely on mechanical techniques (either pencil¬and-paper or electronic) that they do not understand. 4) interpreting results of problems and experiments correctly, and answering the questions that were actually asked.
5. Read and follow laboratory procedures. Use a variety of instruments to take physical measurements and record them with correct precision and units.

6. **COURSE CONTENT:**

Lecture Content:

Typical hours listed for topics below

The Nature and Propagation of Light 3 to 4 lecture hours
The nature of light; reflection and refraction; total internal reflection; dispersion; polarization; scattering of light; Huygens's Principle

Geometric Optics and Optical Instruments 3 to 5 lecture hours
Reflection and refraction at a plane surface; reflection and refraction at a spherical surface; thin lenses; cameras; the eye; the magnifier; microscopes and telescopes

Interference 3 to 4 lecture hours
Interference and coherent sources; two-source interference of light; intensity in interference patterns; interference in thin films; the Michelson interferometer

Diffraction 3 to 5 lecture hours
Fresnel and Fraunhofer diffraction; diffraction from a single slit; intensity in the single slit pattern; multiple slits; the diffraction grating; x-ray diffraction; circular apertures and resolving power

Temperature and Heat 3 to 5 lecture hours
Temperature and thermal equilibrium; thermometers and temperature scales; gas thermometers and the Kelvin scale; thermal expansion; quantity of heat; calorimetry and phase changes; mechanisms of heat transfer

Thermal Properties of Matter 3 to 4 lecture hours
Equations of state; molecular properties of matter; kinetic-molecular model of an ideal gas; heat capacities; molecular speeds; phases of matter

The First Law of Thermodynamics 3 to 5 lecture hours
Thermodynamic systems; work done during volume changes; paths between thermodynamic states; internal energy and the first law of thermodynamics; kinds of thermodynamic processes; internal energy of an ideal gas; heat capacities of an ideal gas; adiabatic processes for an ideal gas

The Second Law of Thermodynamics 3 to 5 lecture hours
Directions of thermodynamic processes; heat engines; internal-combustion engines; refrigerators; the second law of thermodynamics; the Carnot cycle; entropy; microscopic interpretation of entropy

Photons, Electrons, and Atoms 3 to 5 lecture hours
Emission and absorption of light; the photoelectric effect; atomic line spectra and energy levels; the nuclear atom; the Bohr model; the laser; x-ray production and scattering; continuous spectra; wave-particle duality

The Wave Nature of Particles 3 to 5 lecture hours
De Broglie waves; electron diffraction; probability and uncertainty; the electron microscope; wave functions and the Schrodinger equation

Quantum Mechanics 3 to 4 lecture hours
Particle in a box; potential wells; potential barriers and tunneling; the harmonic oscillator; three-dimensional problems

Atomic Structure, Molecules and Condensed Matter 2 to 4 lecture hours
The hydrogen atom; the Zeeman effect; electron spin; many-electron atoms and the exclusion principle; x-ray spectra; Types of molecular bonds; molecular spectra; structures of solids; energy bands; free-electron model of metals; semiconductors; semiconductor devices; superconductivity

Nuclear Physics 2 to 4 lecture hours
Properties of nuclei; nuclear binding and nuclear structure; nuclear stability and radioactivity; activities and half-lives; biological effects of radiation; nuclear reactions; nuclear fission and fusion

Lab Content:

The following is a list of the experiments in the current Physics 270 Laboratory Manual, College of San Mateo Physics Department. Students typically complete between 10 and 13 experiments per semester. Specifics of Experiments will vary if labs are taught online using lab kits.

1. Specific Heat Capacity
2. Heats of Fusion and Vaporization
3. Thermal Conductivity
4. Gas Laws — A Qualitative Study
5. Clement and Desormes' Experiment
6. Heat Engines
7. Reflection and Refraction
8. Dispersion of a Glass Prism
9. Ray Tracing
10. Thin Lenses and Telescopes
11. Newton's Rings
12. Diffraction and Interference Using Microwaves
13. The Photoelectric Effect
14. The Balmer Series of Hydrogen
15. Electron Diffraction

7. **REPRESENTATIVE METHODS OF INSTRUCTION:**

Typical methods of instruction may include:

A. Lecture
B. Lab
C. Discussion
D. Experiments
E. Other (Specify): 1. Lecture: Introduce and explain the concepts, define the appropriate terms, provide examples and solve problems to illustrate the application of the concepts. 2. Demonstrations: Use physical demonstrations to reinforce the understanding of the physical concepts 3. Collaborative learning: Guided discussions and in class exercises, which lead to clarification of the concepts and sharpen the problem solving skills. 4. Homework assignments: Outside of classroom problem solving which helps further students understanding of concepts, including the range of validity, and develops their ability to apply the concepts. Part of instruction is feedback students receive on assignments. 5. Laboratory work: Group and individual work to investigate physical principles; observe, record, and analyze the results of experiments, which deepens the understanding of concepts introduced during in lecture. Feedback on laboratory

assignments is part of instruction.

8. **REPRESENTATIVE ASSIGNMENTS**
Representative assignments in this course may include, but are not limited to the following:
Writing Assignments:
Students complete written laboratory reports in which they analyze the results of experiments performed in the lab. This analysis requires critical thinking and requires students to connect lecture topics to the experiments performed. These assignments also require students to effectively communicate their ideas in writing.
Reading Assignments:
Reading the textbook prior to lectures to become familiar with the topics to be presented. Reading the textbook after lectures to review the key points and concepts.
Other Outside Assignments:
Solving textbook (or similar) problems after each lecture. Problems are of varying difficulty and are completed by students to help further their understanding of the concepts and to learn how physics formulas and mathematics are used to apply the concepts to specific situations.

The problems require critical thinking to determine what principles apply to the problem and may require mathematical techniques ranging from algebra to multivariable calculus.

9. **REPRESENTATIVE METHODS OF EVALUATION**
Representative methods of evaluation may include:
   A. Class Participation
   B. Exams/Tests
   C. Homework
   D. Lab Activities
   E. Quizzes
   F. Written examination
   G. 1. Lab activities require students to participate in performing measurements and observations during the lab period. 2. Lab reports assess students' careful recording of observations and measurements, correctness of calculations, and critical thinking ability. Furthermore, these reports evaluate students' ability to communicate their results in clear writing. Department policy is that students must pass the lab portion of the course to receive a grade of "C" higher. 3. Homework assignments allow students to receive feedback from instructors on their understanding of the material before they are required to demonstrate their understanding on the exams. Homework problems require and develop critical thinking and other problem solving skills. 4. Exams are designed to assess both students' conceptual understanding of the material and their problem solving skills, logical reasoning, and analytic thinking. Department policy is for a comprehensive final exam to be required which accounts for at least 20% of a student's grade.

10. **REPRESENTATIVE TEXT(S):**
Possible textbooks include:
   A. Hugh D. Young and Roger A. Freedman. *University Physics with Modern Physics*, 15th ed. Pearson, 2020
Other:
   A. CSM Physics Department, Physics 270 Lab Manual, CSM

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Course Originator: David Locke