Physics and Astronomy

Overview

The CRC Physics department offers a full array of transferable courses that fulfill both major and general education requirements. Physics sequences include a three-semester calculus-based sequence for computer science and engineering students, a two-semester calculus-based sequence for life science and architecture students, and a two-semester trigonometry-based sequence for life science and architecture students.

Program Maps

Physics, A.S. Degree (/crc/main/doc/programs/program-maps/physics-as-degree-ho.pdf)

Physics, A.S.-T Degree (/crc/main/doc/programs/program-maps/physics-as-t-degree-ho.pdf)

Physics, A.S.-T Degree, IGETC (/crc/main/doc/programs/program-maps/physics-as-t-degree-ho-igetc.pdf)

Associate Degrees for Transfer

A.S.-T. in Physics

The Associate in Science in Physics for Transfer degree provides students with a thorough overview of the field of physics. Students will have demonstrated sufficient understanding in the fields of mechanics, electricity and magnetism, thermodynamics, mechanical and electromagnetic waves, modern physics, the scientific method and mathematics to successfully transfer to a four-year institution with a major in physics.

The Associate in Science in Physics for Transfer degree fulfills the general requirements of the California State University for transfer. Students with this degree will receive priority admission with junior status to the California State University system, although not necessarily to a particular campus or major.

Catalog Date: June 1, 2020

Degree Requirements

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<thead>
<tr>
<th>COURSE CODE</th>
<th>COURSE TITLE</th>
<th>UNITS</th>
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</thead>
<tbody>
<tr>
<td>PHYS 411</td>
<td>Mechanics of Solids and Fluids</td>
<td>4</td>
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<tr>
<td>PHYS 421</td>
<td>Electricity and Magnetism</td>
<td>4</td>
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<tr>
<td>PHYS 431</td>
<td>Heat, Waves, Light and Modern Physics</td>
<td>4</td>
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<tr>
<td>MATH 400</td>
<td>Calculus I</td>
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<tr>
<td>MATH 402</td>
<td>Calculus III</td>
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</tbody>
</table>

Total Units: 27

The Associate in Science in Physics for Transfer (A.S.-T) degree may be obtained by completion of 60 transferable, semester units with a minimum 2.0 GPA, including (a) the major or area of emphasis described in the Required Program, and (b) either the Intersegmental General Education Transfer Curriculum (IGETC) or the California State University General Education-Breadth Requirements.

Student Learning Outcomes

Upon completion of this program, the student will be able to:

- explain the scientific method and its application to the fundamental concepts of physics including mechanics, electricity and magnetism, thermodynamics, mechanical and electromagnetic waves, optics and modern physics.
- solve conceptual, numeric and symbolic problems in physics (specifically the fields of mechanics, electricity and magnetism, thermodynamics, mechanical and electromagnetic waves, optics and modern physics) using mathematics through calculus.
- demonstrate the proper use of basic laboratory devices including metersticks, balances, digital multimeters, and oscilloscopes.
- apply mathematical concepts including single and multivariable calculus, vector calculus, and basic differential equations in order to model physical systems and solve physical problems.
- create graphical representations of data and analyze those graphs to determine the results of laboratory activities.
- write a clear, coherent and thorough lab report.

Career Information
This degree is designed to facilitate successful transfer to four-year programs that prepare students for advanced study in physics and related fields including biophysics, physical chemistry, geophysics, and astrophysics. Physicists with undergraduate and graduate degrees have a wide range of employment opportunities including research, engineering, computer programming, and teaching. NOTE TO TRANSFER STUDENTS: The Associate Degree for Transfer program is designed for students who plan to transfer to a campus of the California State University (CSU). Other than the required core, the courses you choose to complete this degree will depend to some extent on the selected CSU for transfer. In addition, some CSU-GE Breadth or IGETC requirements can also be completed using courses required for this associate degree for transfer major (known as “double-counting”). Meeting with a counselor to determine the most appropriate course choices will facilitate efficient completion of your transfer requirements. For students wishing to transfer to other universities (UC System, private, or out-of-state), the Associate Degree for Transfer may not provide adequate preparation for upper-division transfer admissions, because many universities require more lower division courses than those in this degree. Even the CSU’s that accept this transfer degree may likely require more lower division courses to achieve the Bachelor degree. Specifically, courses in general chemistry, differential equations, linear algebra, and computer programming may better prepare the transfer student for certain universities. It is critical that you meet with a CRC counselor to select and plan the courses for the major, as programs vary widely in terms of the required preparation.

**Associate Degrees**

**A.S. in General Science**

Areas of Study include:

- Physical Anthropology
- Astronomy
- Biology
- Chemistry
- Engineering
- Physical Geography
- Geology
- Physics

Eighteen (18) units of transfer level course work in science is required. Two laboratory courses must be included: one in the physical sciences and one in the biological sciences. Courses may be selected from astronomy, biology, chemistry, geology, physical geography, physical anthropology, and physics. The student, in consultation with a counselor, should choose science courses to meet his or her program, transfer, or general education requirements.

Students interested in transferring to a four-year university with a science major are encouraged to complete a science AS or AS-T degree such as Anthropology, Biology, Chemistry, Engineering, Geography, Geology, or Physics. This General Science degree may not include the majors-level transfer courses needed for many science majors. Students are strongly recommended to see a counselor for guidance.

**Catalog Date:** June 1, 2020

**Degree Requirements**

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<th>COURSE CODE</th>
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<td>A. Life Science with Lab:</td>
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<tr>
<td>ANTH 300</td>
<td>Biological Anthropology (3)</td>
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<td>Bi ANTH 301</td>
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<td>BIOL 307</td>
<td>Biology of Organisms (4)</td>
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<tr>
<td>BIOL 310</td>
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<td>General Microbiology (4)</td>
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<td>B. Physical Science with Lab:</td>
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<td>ASTR 400</td>
<td>Astronomy Laboratory (1)</td>
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<td>Introduction to Astronomy (3)</td>
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<td>CHEM 300</td>
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<td>GEOG 301</td>
<td>Physical Geography Laboratory (1)</td>
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<td>and GEOG 300</td>
<td>Physical Geography: Exploring Earth's Environmental Systems (3)</td>
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<td>GEOL 301</td>
<td>Physical Geology Laboratory (1)</td>
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<td>and GEOL 305</td>
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<td>and GEOL 310</td>
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<tr>
<td>ENGR 304</td>
<td>How Things Work (3)</td>
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PHYS 360  General Physics (4)
PHYS 370  Introductory Physics - Mechanics and Thermodynamics (5)
PHYS 380  Introductory Physics - Electricity and Magnetism, Light and Modern Physics (5)
PHYS 411  Mechanics of Solids and Fluids (4)
PHYS 421  Electricity and Magnetism (4)
PHYS 431  Heat, Waves, Light and Modern Physics (4)

C. Additional Science Courses:
A minimum of 11 units from the following:

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<td>The New Plagues: New and Ancient Infectious Diseases Threatening World Health (3)</td>
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</tbody>
</table>

Total Units: 18

A total of 18 science units is required.

The General Science Associate in Science (A.S.) degree may be obtained by completion of the required program, plus general education requirements, plus sufficient electives to meet a 60-unit total. See CRC graduation requirements.

Student Learning Outcomes
Upon completion of this program, the student will be able to:

- explain the core perspectives of the scientific method and apply it to at least one scientific discipline (SLO 1).
- solve introductory problems of a conceptual and/or numerical nature at least one scientific discipline (SLO 2).
- accurately apply the basic vocabulary and concepts of at least one scientific discipline verbally and in writing (SLO 3).
- recognize the use and misuse of scientific concepts in society including politics and the media (SLO 4).

A.S. in Physics

The Associate in Science in Physics degree provides students with a thorough overview of the field of physics. Students will have demonstrated sufficient understanding in the fields of mechanics, electricity and magnetism, thermodynamics, mechanical and electromagnetic waves, modern physics, the scientific method, mathematics and chemistry to successfully transfer to a four-year institution with a major in physics.

Catalog Date: June 1, 2020

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<tbody>
<tr>
<td>CHEM 400</td>
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<td>PHYS 431</td>
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<td>4</td>
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</tbody>
</table>

Total Units: 41

The Physics Associate in Science (A.S.) degree may be obtained by completion of the required program, plus general education requirements, plus sufficient electives to meet a 60-unit total. See CRC graduation requirements.

Student Learning Outcomes

Upon completion of this program, the student will be able to:

- explain the scientific method and its application to the fundamental concepts of physics including mechanics, electricity and magnetism, thermodynamics, mechanical and electromagnetic waves, optics, modern physics and general chemistry.
- solve conceptual, numeric and symbolic problems in physics (mechanics, electricity and magnetism, thermodynamics, mechanical and electromagnetic waves, optics and modern physics) and general chemistry using mathematics through calculus.
- demonstrate the proper use of basic laboratory devices including metersticks, balances, digital multimeters, and oscilloscopes.
- apply mathematical concepts including algebra, single and multivariable calculus, vector calculus, and basic differential equations in order to model physical systems and solve physical problems.
- create graphical representations of data and analyze those graphs to determine the results of laboratory activities.
- write a clear, coherent and thorough lab report.

Career Information

This degree is designed to facilitate successful transfer to four-year programs that prepare students for advanced study in physics and related fields including biophysics, physical chemistry, geophysics, and astrophysics. Physicists with undergraduate and graduate degrees have a wide range of employment opportunities including research, engineering, computer programming, and teaching. NOTE TO TRANSFER STUDENTS: It is critical that you meet with a CRC counselor to select and plan the courses for the major, as university physics programs vary widely in terms of the required preparation. Specifically, some programs may require courses in linear algebra and computer programming as well as the courses included in this degree.

Astronomy (ASTR) Courses

ASTR 300 Introduction to Astronomy

| Units: 3 | Hours: 54 hours LEC | Prerequisite: None. | Transferable: CSU; UC | General Education: AA/AS Area IV; CSU Area B1; IGETC Area S5 | Catalog Date: June 1, 2020 |

This course is a descriptive course in general astronomy treating the nature and evolution of the solar system, stars, galaxies, cosmology and life in the universe.

Student Learning Outcomes

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

- DEVELOP AN UNDERSTANDING OF EARLY ASTRONOMY AND CELESTIAL MOTION (SLO 1, PSLO 2).
- Explain the structure of the celestial sphere.
- Differentiate between the geocentric and heliocentric models of the universe proposed by Ptolemy and Copernicus, respectively.
- State contributions made by the Greeks, Brahe, Kepler, Galileo and Newton.
- State Newton’s Law of Universal Gravitation and how it can be used to explain an orbiting body around another.
Describe the principal reasons for the daily and annual motion of the stars, Sun and Moon, and state the reason for the seasons.

Explain why planetary retrograde motion is observed.

Define the astronomical unit (AU), the light year (ly) and the parsec (pc) and express numbers in scientific notation.

Demonstrate a basic understanding of atomic structure and the origin of light and its properties.

Explain what takes place in transitions between energy levels and how this is represented in a spectrum.

State the relationship between wavelength, frequency and the speed of an electromagnetic wave.

State the regions of the electromagnetic spectrum and arrange them in order of increasing energy, wavelength, or frequency.

Explain the conditions under which the three principal spectra are produced and the effect temperature has on Blackbody radiation spectra and on color.

Explain the basics of Doppler shift.

Discuss the importance of telescopes.

Compare reflecting and refracting telescopes and any limitations they may have.

Demonstrate an understanding of nonoptical telescopes and how and where they are used.

Explain some of the techniques that are used to improve resolution.

Demonstrate knowledge of the properties of the Solar System.

List the planets in the Solar System in order and describe a possible reason for the differences between the two major groups of planets and the characteristics that distinguishes planets of each group.

State the accepted theory for the formation of the Moon and its influence on Earth.

Demonstrate knowledge of key features of smaller objects in the solar system including dwarf planets, moons, comets, asteroids, and meteoroids.

Explain how astronomers detect extra-solar planets.

Develop a basic understanding of the Milky Way galaxy and other galaxies.

Categorize galaxies according to shape and size.

Discuss how galactic motion infers the expansion of the universe.

Develop a basic understanding of Cosmology and the search for life in the universe.

Demonstrate knowledge of the Big Bang theory and of any experimental data supporting the Big Bang theory.

Describe what is meant by spacetime.

Express the current understanding of the fate of the universe.

State what methods astronomers use to search for extra-terrestrial life.

Demonstrate a basic understanding of each factor in the Drake equation.

ASTR 400 Astronomy Laboratory

Units: 1
Hours: 54 hours LAB
Prerequisite: None.
Corequisite: ASTR 300
Transferable: CSU; UC
General Education: CSU Area B3; IGETC Area 5C
Catalog Date: June 1, 2020

This course covers topics including constellations, star charts, and motions of the Earth, Moon and other astronomical bodies. Students will apply the techniques that astronomers use to study the Earth, Moon, Sun, planets and stars. The course includes observations with the naked eye, binoculars and/or telescopes.

Student Learning Outcomes

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

- Identify and classify common celestial objects. (SLO 1)
- Identify major constellations and stars.
- Classify stars according to constellation and spectrum.
- Incorporate proper astronomical observation techniques. (SLO 2)
- Operate a basic telescope and use the naked eye and binoculars to make astronomical observations.
- Assess the effects of motions of celestial objects on observations. (SLO 3)
- Explain how the Earth’s, moon’s, and Sun’s motions cause cycles in the sky.
- Predict the night sky on any given evening using star charts.
- Analyze light to determine properties of astronomical objects. (SLO 4)
- Measure relative motion of and distance to stars using Doppler shifts and relative intensities.
- Research composition of astronomical objects using spectral analysis.

ASTR 495 Independent Studies in Astronomy
An independent studies project involves an individual student or small group of students in study, research, or activities beyond the scope of regularly offered courses. See the current catalog section of "Special Studies" for full details of Independent Studies.

Student Learning Outcomes

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

- SLO #1: Actively engage in intellectual inquiry beyond that required in order to pass a course of study (College Wide Learning Outcome – Area 4).
- Discuss and outline a proposal of study (that can be accomplished within one semester term) with a supervising instructor qualified within the discipline.
- Design an independent study (to be completed individually or by collaboration of a small group) to foster special knowledge, skills, and experience that are not available in any one regularly scheduled course.
- Use information resources to gather discipline-specific information.
- SLO #2: Utilize modes of analysis and critical thinking to apply theoretical perspectives and/or concepts in the major discipline of study to significant problems and/or educational activities (College Wide Learning Outcome – Area 3).
- Analyze and apply the knowledge, skills and experience that are involved in the independent study to theoretical perspectives and/or concepts in the major discipline of study.
- Explain the importance of the major discipline of study in the broader picture of society.
- SLO #3: Communicate a complex understanding of content matter of the major discipline of study (College Wide Outcome – Area 3).
- Demonstrate competence in the skills essential to mastery of the major discipline of study that are necessary to accomplish the independent study.
- SLO #4: Identify personal goals and pursue these goals effectively (College Wide Outcome – Area 4).
- Utilize skills from the “academic tool kit” including time management, study skills, etc., to accomplish the independent study within one semester term.

ASTR 498 Work Experience in Astronomy

Units: 1 - 4
Hours: 60 - 300 hours LAB
Prerequisite: None.
Enrollment Limitation: Students must be in a paid or unpaid internship, volunteer position or job related to career goals in Astronomy.
Transferable: CSU
General Education: AA/AS Area III(b)
Catalog Date: June 1, 2020

This course provides students with opportunities to develop marketable skills in preparation for employment in their major field of study or advancement within their career. It is designed for students interested in work experience and/or internships in transfer level degree occupational programs. Course content includes understanding the application of education to the workplace; completion of required forms which document the student's progress and hours spent at the work site; and developing workplace skills and competencies. Appropriate level learning objectives are established by the student and the employer. During the semester, the student is required to participate in a weekly orientation and 75 hours of related paid work experience, or 60 hours of unpaid work experience for one unit. An additional 75 or 60 hours of related work experience is required for each additional unit. Work Experience may be taken for a total of 16 units when there are new or expanded learning objectives. Only one Work Experience course may be taken per semester.

Student Learning Outcomes

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

- DEMONSTRATE AN UNDERSTANDING AND APPLICATION OF PROFESSIONAL WORKPLACE BEHAVIOR IN A FIELD OF STUDY RELATED ONE'S CAREER.(SLO 1)
- Understand the effects time, stress, and organizational management have on performance.
- Demonstrate an understanding of consistently practicing ethics and confidentiality in a workplace.
- Examine the career/life planning process and relate its relevancy to the student.
- Demonstrate an understanding of basic communication tools and their appropriate use.
- Demonstrate an understanding of workplace etiquette.
- DESCRIBE THE CAREER/LIFE PLANNING PROCESS AND RELATE ITS RELEVANCY TO ONE’S CAREER.(SLO 2)
- Link personal goals to long term achievement.
- Display an understanding of creating a professional first impression.
- Understand how networking is a powerful job search tool.
- Understand necessary elements of a résumé.
- Understand the importance of interview preparation.
- Identify how continual learning increases career success.
- DEMONSTRATE APPLICATION OF INDUSTRY KNOWLEDGE AND THEORETICAL CONCEPTS AS WRITTEN IN LEARNING OBJECTIVES IN PARTNERSHIP WITH THE EMPLOYER WORK SITE SUPERVISOR. (SLO 3)

ASTR 499 Experimental Offering in Astronomy

Units: 0.5 - 4
Prerequisite: None.
Transferable: CSU; UC (Credit for variable topics courses is given only after a review of the scope and content of the course by the enrolling UC campus.)
Catalog Date: June 1, 2020

Physics (PHYS) Courses
PHYS 310 Conceptual Physics

Units: 3
Hours: 54 hours LEC
Prerequisite: None.
Advisory: MATH 100 or 102, or placement through the assessment process.
Transferable: CSU; UC (No credit for PHYS 310 if taken after PHYS 350, PHYS 360, PHYS 370, PHYS 380, PHYS 411, PHYS 411 or PHYS 431)
General Education: AA/AS Area IV; CSU Area B1; IGETC Area 5A
Catalog Date: June 1, 2020

This course provides a conceptual overview of Newtonian and modern physics for non-science and science students alike. The conceptual approach to physics is tied to the student's personal experience in the everyday world, so that the student learns to see physics not as just a classroom or laboratory activity, but as a part of his or her surroundings. The class is open to students with no previous physics background.

Student Learning Outcomes

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

- SLO #1: EXPLAIN THE SCIENTIFIC METHOD AND HOW SCIENTISTS APPLY IT TO UNDERSTANDING NATURE.
- SLO #2: EVALUATE SIMPLE AND COMMON MECHANICAL SYSTEMS USING CLASSICAL MECHANICS INCLUDING ONE- AND/or TWO-DIMENSIONAL KINEMATICS, NEWTON'S LAWS OF MOTION, GRAVITATION, MOMENTUM, WORK AND ENERGY.
- determine the forces acting on a familiar system and draw the appropriate free body diagram.
- solve conceptual problems of a mechanical nature using kinematics, the laws of motion, momentum, gravitation, work and energy.
- solve simple numerical problems using kinematics and the laws of motion.
- SLO #3: EXPLAIN BASIC ATOMIC STRUCTURE AND DIFFERENT STATES OF MATTER.
- describe basic atomic theory.
- compare and contrast solids, liquids and gases.
- solve conceptual problems applying the atomic theory of matter and the definitions of solid, liquid, gas and concepts such as density and fluid mechanics.
- SLO #4: EXPLAIN AND DEFINE HEAT, HEAT TRANSFER AND ITS RESULTS.
- compare and contrast heat and temperature.
- recognize the different ways in which heat can be transferred.
- discuss some effects of heat transfer such as temperature or phase change and thermal expansion.
- SLO #5: EXPLAIN THE SOURCES AND BEHAVIORS OF WAVES.
- recognize the different types of waves and discuss the quantities used to describe waves.
- discuss the wave nature of phenomena such as light and sound.
- SLO #6: EXPLAIN THE FUNDAMENTAL CONCEPTS AND DEFINITIONS RELATED TO CHARGE AND CHARGE INTERACTIONS INCLUDING BASIC ELECTRICAL CIRCUITS.
- compare and contrast electrostatic and magnetic forces and the dependence of each on charge, distance, motion, etc.
- explain the terms potential difference and current, their relation to each other and application to basic DC circuits.
- solve conceptual problems applying the basic theories of electricity and magnetism and DC circuit analysis.
- solve simple numerical problems using the basic theories of DC circuit analysis.

PHYS 350 General Physics

Units: 4
Hours: 54 hours LEC; 54 hours LAB
Prerequisite: MATH 335 with a grade of "C" or better, or placement through the assessment process.
Transferable: CSU; UC (PHYS 350, 360, 370, 380, 411, 421, 431 combined: maximum transfer credit of one series*; deduct credit for duplication of topics)
General Education: AA/AS Area IV; CSU Area B1; CSU Area B3; IGETC Area 5A; IGETC Area 5C
C-ID: C-ID PHYS 105; Part of C-ID PHYS 100S
Catalog Date: June 1, 2020

This course, the first semester of General Physics, is a transferable course required for many life science and other majors and may also be taken for general education credit. Materials covered will include classical mechanics (including kinematics, statics, dynamics, Newton's Laws, energy and momentum conservation, rigid body motion and oscillatory motion), fluid mechanics, mechanical waves (including sound), and thermodynamics.

Student Learning Outcomes

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

- APPLY APPROPRIATELY NEWTON'S LAWS OF MOTION TO MECHANICAL SYSTEMS, DEVELOP AND ARTICULATE A NEWTONIAN WORLDVIEW (SLO 1; PSLO 2, 4)
- differentiate between terms that describe motion such as displacement, velocity and acceleration.
- compare and contrast vector and scalar quantities.
- analyze a mechanical system to identify all external forces acting on it, and using Newton's Laws of Motion, predict the resulting motions of the system.
- evaluate mechanical systems for conserved quantities such as momentum or mechanical energy, and use these conserved quantities to predict the motion.
- recognize the forces resulting in oscillations and mechanical waves and correctly apply definitions and mechanical concepts to these systems to make predictions.
- DEVELOP CONNECTIONS BETWEEN THE BEHAVIOR OF ATOMS AND MOLECULES AND THE MACROSCOPIC QUANTITIES PHYSICISTS USE TO DESCRIBE SYSTEMS THROUGH THE APPLICATION OF THERMODYNAMIC PRINCIPLES (SLO 2; PSLO 2, 4)
- distinguish between pressure, temperature, heat, internal energy and their relation to the molecules of a system.
- evaluate thermodynamic systems using the Laws of Thermodynamics.
- SOLVE CONCEPTUAL, SYMBOLIC AND NUMERIC PHYSICAL PROBLEMS AT AN APPROPRIATE LEVEL USING MATH THROUGH COLLEGE ALGEBRA AND TRIGONOMETRY. MORE SPECIFICALLY, STUDENTS WILL BE ABLE TO DIFFERENTIATE BETWEEN DIFFERENT TYPES OF PROBLEMS, EVALUATE THE GIVEN DATA FOR ITS SIGNIFICANCE, FORMULATE A SOLUTION STRATEGY, AND EVALUATE THE RESULTS. (SLO 3; PSLO 3)
- identify and analyze conceptual, symbolic and numeric problems in one- and two-dimensional motion, formulate solution strategies and evaluate results.
- analyze conceptual, symbolic and numeric dynamics, statics, circular motion and gravitation problems using Newton's Laws, formulate solution strategies and evaluate results.
- graphically and mathematically add and subtract vectors.
identify mechanical systems appropriate to the application of the work-energy theorem, apply this theorem to conceptual, symbolic and quantitative problems and evaluate results.

identify and analyze conceptual, symbolic, and quantitative problems applying the conservation of mechanical energy and/or linear momentum, formulate solution strategies and evaluate results.

identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles or rotational motion, including rotational kinematics, torque, rotational inertia, mechanical energy, and angular momentum, formulate solution strategies and evaluate results.

identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles or simple harmonic motion and mechanical waves, including pendulums and spring oscillators, waves on a string and sound, and wave interference, formulate solution strategies and evaluate results.

identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles of thermodynamics, including temperature, thermal expansion, heat transfer and calorimetry, formulate solution strategies and evaluate results.

MODEL BASIC LAB SKILLS AND APPLY AND EVALUATE METHODS FOR DISPLAYING AND INTERPRETING EXPERIMENTAL DATA. (SLO 4, PSLO 5, 6)

design, conduct, analyze and interpret scientific experiments in the fields of mechanics and thermodynamics.

demonstrate skilled laboratory techniques, including use of metersticks, timing devices, thermometers, computer-aided data acquisition devices, etc.

create graphical representations of experimental data to clearly demonstrate trends, and use those representations to formulate conclusions relevant to mechanical and thermodynamic systems.

### PHYS 360 General Physics

**Units:** 4  
**Hours:** 54 hours LEC; 54 hours LAB  
**Prerequisite:** PHYS 350 with a grade of "C" or better  
**Transferable:** CSU; UC (PHYS 350, 360, 370, 380, 411, 421, 431 combined: maximum transfer credit of one series*; deduct credit for duplication of topics)  
**Catalog Date:** June 1, 2020

This course, the second semester of General Physics, is a transferable course required for many life science and other students. Material covered will include classical electricity and magnetism (electrostatics, electric fields and potentials, magnetic fields, electromagnetic induction and electromagnetic radiation), DC and AC circuits, light, geometric and wave optics, special relativity, atomic structure, quantum physics and nuclear physics.

**Student Learning Outcomes**

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

- SLO #1 – EVALUATE A PHYSICAL SYSTEM FOR ELECTROMAGNETIC INTERACTIONS; PROPERLY APPLY THE LAWS OF ELECTRICITY AND MAGNETISM TO PHYSICAL SYSTEMS, AND INTEGRATE THIS INTO A NEWTONIAN VISION OF THE UNIVERSE.

- Evaluate motions of charges in electric and magnetic systems using Newtonian mechanics including forces, work and energy.

- Generate appropriate shapes and relative magnitudes of electric and magnetic fields based on different charge and/or current distributions.

- Predict the behavior of simple DC electrical circuits using power sources, resistors and capacitors.

- Compare and contrast the different regions of the electromagnetic spectrum based on frequency and/or wavelength.

- SLO #2 – DEVELOP AND ARTICULATE A BASIC UNDERSTANDING OF THE BRANCHES OF MODERN PHYSICS INCLUDING SPECIAL RELATIVITY AND QUANTUM PHYSICS.

- Critique classical physics and assess its limitations. More specifically, the student will evaluate physical phenomena that classical physics does not adequately explain.

- Discuss the quantum mechanical model of the atom.

- SLO #3 – SOLVE CONCEPTUAL, SYMBOLIC AND NUMERIC PHYSICAL PROBLEMS AT AN APPROPRIATE LEVEL USING MATH THROUGH TRIGONOMETRY AND COLLEGE ALGEBRA BY RECOGNIZING DIFFERENT TYPES OF PROBLEMS, EVALUATING THE GIVEN INFORMATION FOR ITS SIGNIFICANCE, FORMULATING A SOLUTION STRATEGY, AND EVALUATING THE RESULTS.

- Identify and analyze conceptual, symbolic and numeric problems of the electric and magnetic fields and forces, formulate solution strategies and evaluate results.

- Identify and analyze conceptual, symbolic and numeric electrostatic energy problems including electric potential, formulate solution strategies and evaluate results.

- Identify and analyze conceptual, symbolic, and numeric problems of DC circuits, formulate solution strategies and evaluate results.

- Identify and analyze conceptual, symbolic, and quantitative problems of electromagnetic induction, formulate solution strategies and evaluate results.

- Identify and analyze conceptual, symbolic, and quantitative problems of the ray and wave natures of light including reflection, refraction, mirrors and thin lenses, interference and polarization, formulate solution strategies and evaluate results.

- Identify and analyze conceptual, symbolic, and quantitative problems of the modern physics including special relativity and introductory quantum physics. Formulate solution strategies and evaluate results.

- SLO #4 – DEVELOP BASIC LAB SKILLS AND APPLY AND EVALUATE METHODS FOR DISPLAYING AND INTERPRETING EXPERIMENTAL DATA.

- Design, conduct, analyze and interpret scientific experiments in the fields of electricity and magnetism, light and modern physics.

- Design and build simple DC circuits using basic circuit elements such as power sources, resistors and capacitors.

- Demonstrate skilled laboratory techniques, including use of multimeters.

- Create graphical representations of experimental data to clearly demonstrate trends, and use those representations to formulate conclusions relevant to electromagnetic systems, light and modern physics.

### PHYS 370 Introductory Physics - Mechanics and Thermodynamics

**Units:** 5  
**Hours:** 72 hours LEC; 54 hours LAB  
**Prerequisite:** MATH 350 with a grade of "C" or better  
**Transferable:** CSU; UC (PHYS 350, 360, 370, 380, 411, 421, 431 combined: maximum transfer credit of one series*; deduct credit for duplication of topics)  
**Catalog Date:** June 1, 2020

This course, the first semester of the Introductory Physics sequence, is designed for students transferring to programs which require two semesters of calculus-based physics such as some life science and architecture programs. Material covered will include classical mechanics (kinematics, statics, dynamics, Newton's Laws, work, conservation of mechanical energy and momentum, rotations and oscillations), fluid mechanics, mechanical waves including sound, and thermodynamics. Basic calculus skills will be assumed in the derivation and application of physical principles.

**Student Learning Outcomes**

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

- identify mechanical systems appropriate to the application of the work-energy theorem, apply this theorem to conceptual, symbolic and quantitative problems and evaluate results.

- identify and analyze conceptual, symbolic, and quantitative problems applying the conservation of mechanical energy and/or linear momentum, formulate solution strategies and evaluate results.

- identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles or simple harmonic motion and mechanical waves, including pendulums and spring oscillators, waves on a string and sound, and wave interference, formulate solution strategies and evaluate results.

- identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles of thermodynamics, including temperature, thermal expansion, heat transfer and calorimetry, formulate solution strategies and evaluate results.
SLO #1 – develop and articulate a Newtonian worldview. The student will appropriately apply Newton’s Laws of motion to mechanical systems, will recognize prior misconceptions about the mechanical universe and replace them with correct concepts.  

- differentiate between terms that describe motion such as displacement, velocity and acceleration.  
- compare and contrast vector and scalar quantities.  
- analyze a system to identify all external forces acting on it.  
- evaluate a mechanical system using Newton’s Laws of Motion, apply these laws to the system, predict the resulting motions.  
- evaluate mechanical systems for conserved quantities, determine the quantities that are conserved, and defend these conclusions.

SLO #2 – develop connections between the behavior of atoms and molecules and the macroscopic quantities physicists use to describe systems through the application of thermodynamic principles  

- distinguish between pressure, temperature, heat, internal energy and their relation to the molecules of a system.  
- evaluate thermodynamic systems using the Laws of Thermodynamics.  
- SLO #3 – solve conceptual, symbolic and numeric physical problems at an appropriate level using math through trigonometry and basic calculus. More specifically, students will be able to differentiate between different types of problems, evaluate the given data for its significance, formulate a solution strategy, and evaluate the results.  
- identify and analyze conceptual, symbolic and numeric problems in one- and two-dimensional motion, formulate solution strategies and evaluate results.  
- analyze conceptual, symbolic and numeric dynamics, statics, circular motion and gravitation problems using Newton’s Laws, formulate solution strategies and evaluate results.  
- graphically and mathematically add and subtract vectors.  
- identify mechanical systems appropriate to the application of the work-energy theorem, apply this theorem to conceptual, symbolic and quantitative problems and evaluate results.  
- identify and analyze conceptual, symbolic, and quantitative problems applying the conservation of mechanical energy and/or linear momentum, formulate solution strategies and evaluate results.

SLO #4 – develop basic lab skills and apply and evaluate methods for displaying and interpreting experimental data.  

- design, conduct, analyze and interpret scientific experiments in the fields of electricity and magnetism.  
- identify and analyze conceptual, symbolic, and numeric problems applying the concepts, definitions and principles or the modern physics including special relativity and introductory quantum physics.  
- identify and analyze conceptual, symbolic, and numeric problems of the wave nature of light including interference and polarization.  
- design, conduct, analyze and interpret scientific experiments in the fields of mechanics and thermodynamics.  
- demonstrate skilled laboratory techniques, including use of metersticks, timing devices, thermometers, etc.  
- create graphical representations of experimental data to clearly demonstrate trends, and use those representations to formulate conclusions relevant to mechanical and thermodynamic systems.

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**PHYS 380 Introductory Physics - Electricity and Magnetism, Light and Modern Physics**

**Units:** 5  
**Hours:** 72 hours LEC; 54 hours LAB  
**Prerequisite:** PHYS 370 with a grade of “C” or better  
**Transferable:** CSU UC (PHYS 350, 360, 370, 380, 411, 421, 431 combined: maximum transfer credit of one series*; deduct credit for duplication of topics)  
**General Education:** CSU Area B1; CSU Area B3; IGETC Area 5A; IGETC Area 5C  
**C-ID:** C-ID PHYS 110; Part of C-ID PHYS 100S  
**Catalog Date:** June 1, 2020  

This course, the second semester of the Introductory Physics sequence, is designed for students transferring to programs which require two semesters of calculus-based physics such as some life science and architecture programs. Material covered will include electrostatics, electrical circuits and devices, magnetism, light, and modern physics (including special relativity, quantum, atomic and nuclear physics). Basic calculus skills will be assumed in the derivation and application of physical principles.

**Student Learning Outcomes**

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

- SLO #1 – evaluate a physical system for electromagnetic interactions, properly apply the laws of electricity and magnetism to physical systems, and integrate this into a Newtonian vision of the universe.  
- evaluate motions of charges in electric and magnetic systems using Newtonian mechanics including forces, work and energy.  
- generate appropriate shapes and relative magnitudes of electric fields based on different charge and/or current distributions.  
- predict the behavior of simple DC electrical circuits using power sources, resistors and capacitors.  
- compare and contrast the different regions of the electromagnetic spectrum based on frequency and/or wavelength.  
- SLO #2 – develop a basic understanding of the branches of modern physics including Special Relativity and Quantum Physics.  
- critique classical physics and assess its limitations. More specifically, the student will evaluate physical phenomena that classical physics can not adequately explain.  
- design a working quantum mechanical model of the atom.  
- SLO #3 – solve conceptual, symbolic and numeric physical problems at an appropriate level using math through trigonometry and basic calculus. More specifically, students will be able to differentiate between different types of problems, evaluate the given data for its significance, formulate a solution strategy, and evaluate the results.  
- identify and analyze conceptual, symbolic and numeric problems of the electric field and force, formulate solution strategies and evaluate results.  
- identify and analyze conceptual, symbolic and numeric electrostatic energy problems including electric potential, formulate solution strategies and evaluate results.  
- identify and analyze conceptual, symbolic, and numeric problems of DC circuits, formulate solution strategies and evaluate results.  
- identify and analyze conceptual, symbolic, and numeric problems of magnetic fields and forces, formulate solution strategies and evaluate results.  
- identify and analyze conceptual, symbolic, and quantitative problems of electromagnetic induction.  
- identify and analyze conceptual, symbolic, and quantitative problems of the ray nature of light including reflection, refraction, mirrors and thin lenses. Formulate solution strategies and evaluate results.  
- identify and analyze conceptual, symbolic, and quantitative problems of the wave nature of light including interference and polarization. Formulate solution strategies and evaluate results.  
- identify and analyze conceptual, symbolic, and quantitative problems of the modern physics including special relativity and introductory quantum physics. Formulate solution strategies and evaluate results.

- SLO #4 – develop basic lab skills and apply and evaluate methods for displaying and interpreting experimental data.  
- design, conduct, analyze and interpret scientific experiments in the fields of electricity and magnetism, light and modern physics.
design and build simple DC circuits using power sources, resistors and capacitors.

demonstrate skilled laboratory techniques, including use of multimeters.

create graphical representations of experimental data to clearly demonstrate trends, and use those representations to formulate conclusions relevant to electromagnetic systems and light.

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**PHYS 411 Mechanics of Solids and Fluids**

**Units:** 4  
**Hours:** 54 hours LEC; 54 hours LAB  
**Prerequisite:** MATH 401 and PHYS 411 with grades of "C" or better  
**Transferable:** CSU; UC (PHYS 350, 360, 370, 380, 411, 421, 431 combined: maximum transfer credit of one series*; deduct credit for duplication of topics)  
**General Education:** CSU Area B1; CSU Area B3; IGETC Area 5A; IGETC Area 5C  
**C-ID:** C-ID PHYS 205; Part of C-ID PHYS 200S  
**Catalog Date:** June 1, 2020

The course examines the fundamentals of mechanics: vectors, kinematics, Newton's laws of motion, work, energy, momentum, conservation principles, oscillations, fluids, and gravitation. This course is recommended for students studying the Physical Sciences, Engineering, and Computer Information Science, as well as some students studying Architecture or Mathematics.

**Student Learning Outcomes**

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

- **DEVELOP AND ARTICULATE A NEWTONIAN WORLDVIEW AND APPROPRIATELY APPLY NEWTON'S LAWS OF MOTION TO MECHANICAL SYSTEMS. (SLO 1, PSLO 2)**
- **differentiate between terms that describe motion such as displacement, velocity and acceleration.**
- **compare and contrast vector and scalar quantities.**
- **analyze a mechanical system to identify all external forces acting on it, and using Newton's Laws of Motion, predict the resulting motions of the system.**
- **evaluate mechanical systems for conserved quantities such as momentum or mechanical energy, and use these conserved quantities to predict the motion.**
- **recognize the forces that produce oscillatory motion and correctly apply definitions and mechanical concepts to these systems to predict the motion.**
- **SOLVE CONCEPTUAL, SYMBOLIC AND NUMERIC PHYSICAL PROBLEMS AT AN APPROPRIATE LEVEL USING MATH THROUGH CALCULUS. MORE SPECIFICALLY, STUDENTS WILL BE ABLE TO DIFFERENTIATE BETWEEN DIFFERENT TYPES OF PROBLEMS, EVALUATE THE GIVEN DATA FOR ITS SIGNIFICANCE, FORMULATE A SOLUTION STRATEGY, AND EVALUATE THE RESULTS. (SLO 2, PSLO 3)**
- **identify and analyze conceptual, symbolic and numeric problems in one- and two-dimensional motion, formulate solution strategies and evaluate results.**
- **analyze conceptual, symbolic and numeric dynamics, statics, circular motion and gravitation problems using Newton's Laws, formulate solution strategies and evaluate results.**
- **graphically and mathematically add and subtract vectors, and calculate the vector and scalar products.**
- **identify mechanical systems appropriate to the application of the work-energy theorem, apply this theorem to conceptual, symbolic and quantitative problems and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the conservation of mechanical energy and/or linear momentum, formulate solution strategies and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles or rotational motion, including rotational kinematics, torque, rotational inertia, mechanical energy, and angular momentum, formulate solution strategies and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles of simple harmonic motion, formulate solution strategies and evaluate results.**
- **develop and articulate a newtonian worldview and appropriately apply newton's laws of motion to mechanical systems. (slo 1, pslo 2)**
- **develop and articulate a newtonian worldview and appropriately apply newton's laws of motion to mechanical systems.**
- **analyze a mechanical system to identify all external forces acting on it, and using newton's laws of motion, predict the resulting motions of the system.**
- **evaluate mechanical systems for conserved quantities such as momentum or mechanical energy, and use these conserved quantities to predict the motion.**
- **recognize the forces that produce oscillatory motion and correctly apply definitions and mechanical concepts to these systems to predict the motion.**
- **solve conceptual, symbolic and numeric physical problems at an appropriate level using math through calculus. more specifically, students will be able to differentiate between different types of problems, evaluate the given data for its significance, formulate a solution strategy, and evaluate the results. (slo 2, pslo 3)**
- **identify and analyze conceptual, symbolic and numeric problems in one- and two-dimensional motion, formulate solution strategies and evaluate results.**
- **analyze conceptual, symbolic and numeric dynamics, statics, circular motion and gravitation problems using newton's laws, formulate solution strategies and evaluate results.**
- **graphically and mathematically add and subtract vectors, and calculate the vector and scalar products.**
- **identify mechanical systems appropriate to the application of the work-energy theorem, apply this theorem to conceptual, symbolic and quantitative problems and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the conservation of mechanical energy and/or linear momentum, formulate solution strategies and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles or rotational motion, including rotational kinematics, torque, rotational inertia, mechanical energy, and angular momentum, formulate solution strategies and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles of simple harmonic motion, formulate solution strategies and evaluate results.**
- **develop and articulate a newtonian worldview and appropriately apply newton's laws of motion to mechanical systems. (slo 1, pslo 2)**
- **develop and articulate a newtonian worldview and appropriately apply newton's laws of motion to mechanical systems.**
- **analyze a mechanical system to identify all external forces acting on it, and using newton's laws of motion, predict the resulting motions of the system.**
- **evaluate mechanical systems for conserved quantities such as momentum or mechanical energy, and use these conserved quantities to predict the motion.**
- **recognize the forces that produce oscillatory motion and correctly apply definitions and mechanical concepts to these systems to predict the motion.**
- **solve conceptual, symbolic and numeric physical problems at an appropriate level using math through calculus. more specifically, students will be able to differentiate between different types of problems, evaluate the given data for its significance, formulate a solution strategy, and evaluate the results. (slo 2, pslo 3)**
- **identify and analyze conceptual, symbolic and numeric problems in one- and two-dimensional motion, formulate solution strategies and evaluate results.**
- **analyze conceptual, symbolic and numeric dynamics, statics, circular motion and gravitation problems using newton's laws, formulate solution strategies and evaluate results.**
- **graphically and mathematically add and subtract vectors, and calculate the vector and scalar products.**
- **identify mechanical systems appropriate to the application of the work-energy theorem, apply this theorem to conceptual, symbolic and quantitative problems and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the conservation of mechanical energy and/or linear momentum, formulate solution strategies and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles or rotational motion, including rotational kinematics, torque, rotational inertia, mechanical energy, and angular momentum, formulate solution strategies and evaluate results.**
- **identify and analyze conceptual, symbolic, and quantitative problems applying the concepts, definitions and principles of simple harmonic motion, formulate solution strategies and evaluate results.**
- **develop and articulate a newtonian worldview and appropriately apply newton's laws of motion to mechanical systems. (slo 1, pslo 2)**
- **develop and articulate a newtonian worldview and appropriately apply newton's laws of motion to mechanical systems.**
- **analyze a mechanical system to identify all external forces acting on it, and using newton's laws of motion, predict the resulting motions of the system.**
- **evaluate mechanical systems for conserved quantities such as momentum or mechanical energy, and use these conserved quantities to predict the motion.**
- **recognize the forces that produce oscillatory motion and correctly apply definitions and mechanical concepts to these systems to predict the motion.**

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**PHYS 421 Electricity and Magnetism**

**Units:** 4  
**Hours:** 54 hours LEC; 54 hours LAB  
**Prerequisite:** MATH 401 and PHYS 411 with grades of "C" or better  
**Transferable:** CSU; UC (PHYS 350, 360, 370, 380, 411, 421, 431 combined: maximum transfer credit of one series*; deduct credit for duplication of topics)  
**General Education:** CSU Area B1; CSU Area B3; IGETC Area 5A; IGETC Area 5C  
**C-ID:** C-ID PHYS 210; Part of C-ID PHYS 200S  
**Catalog Date:** June 1, 2020

This course examines the fundamentals of electricity and magnetism: electric and magnetic fields and forces, electric potentials, capacitors and dielectrics, DC and AC circuits, inductance, magnetic materials, Maxwell's equations, electromagnetic waves, and the operation of general electrical circuit measuring devices including multimeters and oscilloscopes. This is the second course (although Physics 421 and 431 may be taken in either order) of the calculus-based physics sequence for physical science, engineering, computer science and other majors.

**Student Learning Outcomes**

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

- **SLO#1--DEVELOP AND ARTICULATE A NEWTONIAN WORLDVIEW AND APPROPRIATELY APPLY NEWTON'S LAWS OF MOTION TO MECHANICAL SYSTEMS. (SLO 1, PSLO 2)**
- **demonstrate a basic understanding of electric and magnetic fields and the forces associated with them.**
- **demonstrate a basic understanding of electric potential and potential energy.**
- **demonstrate a basic understanding of induction and how it relates to mechanical motion.**
- **demonstrate a basic understanding of electric current, resistance, capacitance, electromagnetic force (emf) and dielectrics.**
- **demonstrate proper usage of measuring devices such as ammeters, voltmeters, ohmmeters and oscilloscopes.**
- **SLO#2--SOLVE CONCEPTUAL, SYMBOLIC AND NUMERICAL PHYSICAL PROBLEMS INVOLVING ELECTROMAGNETIC INTERACTIONS AT AN APPROPRIATE LEVEL USING MATH UP TO AND INCLUDING CALCULUS.**
- **apply definitions and physical laws to solve conceptual and analytic problems of an electric and/or magnetic nature.**
- **identify, analyze and solve quantitative problems of an electric and/or magnetic nature requiring the application of vector components and vector sums and products.**
- **construct and evaluate integrals in problems involving Gauss' Law, electric fields and potentials of charge distributions, Ampere's Law, and the Biot-Savart Law.**
• calculate the resistance of materials given their shape and resistivity.
• solve problems that include resistors or capacitors in series or in parallel.
• discuss the theory and applications of resistors, capacitors and inductors (e.g. in RC, LC and RLC circuits).
• demonstrate a basic understanding of electric field, potential, current, magnetic field and induction.
• identify and solve problems involving electromagnetic induction by using Faraday's and Lenz's Laws.
• use Kirchhoff's Rules to solve DC and AC circuits.
• analyze and solve quantitative AC circuit problems using reactance, impedance and phasor diagrams.
• demonstrate a basic understanding of the propagation of electromagnetic radiation and Maxwell's equations.
• SLO#3--DEVELOP BASIC LAB SKILLS AND APPLY AND EVALUATE METHODS FOR DISPLAYING AND INTERPRETING EXPERIMENTAL DATA.
  • design, build, analyze and quantitatively solve basic AC and DC circuits that include electric sources, resistors, capacitors and/or inductors.
  • operate basic electric measuring devices including multimeters and oscilloscopes.
  • create and analyze graphical representations of experimental data.
  • clearly communicate experimental procedures, data and results in writing.

**PHYS 431 Heat, Waves, Light and Modern Physics**

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<th>Units:</th>
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<td>Hours:</td>
<td>54 hours LEC; 54 hours LAB</td>
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<tr>
<td>Prerequisite:</td>
<td>MATH 401 and PHYS 411 with grades of &quot;C&quot; or better</td>
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<td>General Education:</td>
<td>CSU Area B1; CSU Area B2; IGETC Area 5A; IGETC Area 5C</td>
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<tr>
<td>C-ID:</td>
<td>C-ID PHYS 215; Part of C-ID PHYS 2005</td>
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<td>Catalog Date:</td>
<td>June 1, 2020</td>
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This course examines the fundamentals of thermodynamics, waves and modern physics. Topics include temperature, heat, kinetic theory of gases, thermodynamics, mechanical waves, sound, light reflection and refraction, interference and diffraction, optics, lasers, special relativity, quantum physics, atomic physics, nuclear physics, and particle physics.

**Student Learning Outcomes**

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

• SLO#1--DEVELOP AND ARTICULATE A BASIC UNDERSTANDING OF THERMODYNAMIC SYSTEMS, WAVE PROPERTIES, SOUND, REFLECTION AND REFRACTION OF LIGHT, GEOMETRICAL OPTICS AND MODERN PHYSICS THAT INCLUDES RELATIVITY, QUANTUM PHYSICS, AND NUCLEAR PHYSICS.
  • apply the concepts of basic thermodynamics and elementary statistical mechanics.
  • construct a conceptual understanding and intuition for the fundamental principles of mechanical waves including standing waves, normal modes and sound.
  • apply the concepts of mechanical waves and basic electromagnetic theory to describe light (electromagnetic radiation) and its properties including reflection, refraction, polarization, geometric and wave optics.
  • construct a conceptual understanding and intuition for the fundamental principles of special relativity.
  • construct a conceptual understanding and intuition for the fundamental principles of quantum, nuclear and particle physics.
• SLO#2--SOLVE CONCEPTUAL, SYMBOLIC AND NUMERIC PHYSICAL PROBLEMS AT AN APPROPRIATE LEVEL USING MATH UP TO CALCULUS.
  • identify and solve problems of thermodynamics systems that include heat capacities, heat transfer, calorimetry, heat engines, entropy and PV diagrams.
  • solve problems dealing with mechanical waves, sound, standing waves, and normal modes.
  • identify and solve problems dealing with the laws of reflection and refraction (Snell's Law) and polarization.
  • solve problems dealing with lenses and/or mirrors and create ray-tracing diagrams to identify the location of images.
  • prove the laws of reflection and refraction using Huygen's and/or Fermat's principles.
  • solve basic problems dealing with special relativity.
  • solve basic problems in the areas of elementary quantum, nuclear and particle physics.
• SLO#3--DEVELOP BASIC LAB SKILLS AND APPLY AND EVALUATE METHODS FOR DISPLAYING AND INTERPRETING EXPERIMENTAL DATA.
  • design, build, conduct and analyze experiments in the field of thermodynamics, mechanical waves, sound, geometrical optics, and modern physics.
  • create and analyze graphical representations of experimental data and compare them to theoretical predictions.
  • clearly communicate experimental procedures, data and results in writing.

**PHYS 495 Independent Studies in Physics**

<table>
<thead>
<tr>
<th>Units:</th>
<th>1 - 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours:</td>
<td>54 - 162 hours LAB</td>
</tr>
<tr>
<td>Prerequisite:</td>
<td>None.</td>
</tr>
<tr>
<td>Transferable:</td>
<td>CSU</td>
</tr>
<tr>
<td>Catalog Date:</td>
<td>June 1, 2020</td>
</tr>
</tbody>
</table>

An independent studies project involves an individual student or small group of students in study, research, or activities beyond the scope of regularly offered courses. See the current catalog section of "Special Studies" for full details of Independent Studies.

**Student Learning Outcomes**

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

• SLO #1: Actively engage in intellectual inquiry beyond that required in order to pass a course of study (College Wide Learning Outcome – Area 4).
  • Discuss and outline a proposal of study (that can be accomplished within one semester term) with a supervising instructor qualified within the discipline.
  • Design an independent study (to be completed individually or by collaboration of a small group) to foster special knowledge, skills, and experience that are not available in any one regularly scheduled course.
  • Use information resources to gather discipline-specific information.
• SLO #2: Utilize modes of analysis and critical thinking to apply theoretical perspectives and/or concepts in the major discipline of study to significant problems and/or educational activities (College Wide Learning Outcome – Area 3).
Analyze and apply the knowledge, skills and experience that are involved in the independent study to theoretical perspectives and/or concepts in the major discipline of study.

Explain the importance of the major discipline of study in the broader picture of society.

SLO #3: Communicate a complex understanding of content matter of the major discipline of study (College Wide Outcome – Area 3).

Demonstrate competence in the skills essential to mastery of the major discipline of study that are necessary to accomplish the independent study.

SLO #4: Identify personal goals and pursue these goals effectively (College Wide Outcome – Area 4).

Utilize skills from the “academic tool kit” including time management, study skills, etc., to accomplish the independent study within one semester term.

PHYS 498 Work Experience in Physics

Units: 1 - 4
Hours: 60 - 300 hours LAB
Prerequisite: None.
Enrollment Limitation: Students must be in a paid or unpaid internship, volunteer position or job related to career goals in Physics.
Transferable: CSU
General Education: AA/AS Area II(b)
Catalog Date: June 1, 2020

This course provides students with opportunities to develop marketable skills in preparation for employment in their major field of study or advancement within their career. It is designed for students interested in work experience and/or internships in transfer level degree occupational programs. Course content includes understanding the application of education to the workforce; completion of required forms which document the student's progress and hours spent at the work site; and developing workplace skills and competencies. Appropriate level learning objectives are established by the student and the employer. During the semester, the student is required to participate in a weekly orientation and 75 hours of related paid work experience, or 60 hours of unpaid work experience for one unit. An additional 75 or 60 hours of related work experience is required for each additional unit. Work Experience may be taken for a total of 16 units when there are new or expanded learning objectives. Only one Work Experience course may be taken per semester.

Student Learning Outcomes

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

- DEMONSTRATE AN UNDERSTANDING AND APPLICATION OF PROFESSIONAL WORKPLACE BEHAVIOR IN A FIELD OF STUDY RELATED ONE'S CAREER.(SLO 1)
- Understand the effects time, stress, and organizational management have on performance.
- Demonstrate an understanding of consistently practicing ethics and confidentiality in a workplace.
- Examine the career/life planning process and relate its relevancy to the student.
- Demonstrate an understanding of basic communication tools and their appropriate use.
- Demonstrate an understanding of workplace etiquette.
- DESCRIBE THE CAREER/LIFE PLANNING PROCESS AND RELATE ITS RELEVANCY TO ONE'S CAREER.(SLO 2)
- Link personal goals to long term achievement.
- Display an understanding of creating a professional first impression.
- Understand how networking is a powerful job search tool.
- Understand necessary elements of a résumé.
- Understand the importance of interview preparation.
- Identify how continual learning increases career success.
- DEMONSTRATE APPLICATION OF INDUSTRY KNOWLEDGE AND THEORETICAL CONCEPTS AS WRITTEN IN LEARNING OBJECTIVES IN PARTNERSHIP WITH THE EMPLOYER WORK SITE SUPERVISOR. (SLO 3)

PHYS 499 Experimental Offering in Physics

Units: 0.5 - 4
Prerequisite: None.
Transferable: CSU
Catalog Date: June 1, 2020

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