PHYS 201: PHYSICS A: MECHANICS

Citrus College Course Outline of Record

Heading	Value
Effective Term:	Fall 2024
Credits:	5
Total Contact Hours:	126
Lecture Hours :	72
Lab Hours:	54
Hours Arranged:	0
Outside of Class Hours:	144
Total Student Learning Hours:	270
Prerequisite:	MATH 190.
District General Education:	B2. Natural Sciences - Physical Sciences, B3. Natural Sciences - Laboratory
Transferable to CSU:	Yes
Transferable to UC:	Yes - Approved
Grading Method:	Standard Letter

Catalog Course Description

Fundamental principles of mechanics, vectors, motion, work, energy, momentum, and rotational motion. Required for all majors in engineering, physics, chemistry, computer science and some geology and mathematics majors. 72 lecture hours, 54 lab hours.

Course Objectives

- KINEMATICS
- Apply kinematics concepts to two dimensions: distinguish between radial and tangential accelerations and how these quantities are related to other kinematic quantities such as speed or angular acceleration.
- Apply kinematics concepts to two dimensions: understand angular acceleration and the kinematics of non-uniform circular motion.
- Understanding relative motion.
- VECTORS
- Understand vectors as mathematical quantities with magnitude and direction.
- Determine the components of a vector along two specified, mutually perpendicular axes use the basic unit vectors and reassembling vector components into a magnitude and a direction.
- Add and subtract vectors both graphically and using components.
- Calculate vector dot products and cross products and know how to use the right-hand rule for cross products.
- NEWTON'S LAWS OF MOTION
- Recognize what does and does not constitute a force and identify the specific forces acting on an object.
- Differentiate between the concepts of position, velocity, and acceleration and recognize the relationship between velocity and acceleration when an object is speeding up, slowing down, curving, or at a turning point.
- Draw an accurate free-body diagram of an object.
- Calculate the net force.
- Understand the relationship between the forces that act on an object and the resulting acceleration for both linear and circular motion as formulated in Newton's first and second laws of motion.
- Understand how Newton's third law of motion describes a force as an interaction between two objects
- Identify action/reaction pairs of forces in interacting objects and understand their role in propulsion and tension forces.
- Apply Newton's Laws of Motion to solve quantitative static, dynamic equilibrium, and dynamics problems for linear and circular motion and interpret the results.
- Apply the basic ideas of calculus (differentiation and integration) to Newton's Second law of Motion.
- Learn and use simple model of friction including: distinguishing between static, kinetic and rolling friction; and understanding the relationship between the normal and frictional forces from a surface and the significance of the coefficient of friction.
- Learn and use simple model of drag, including: determining the terminal velocity of an object moving vertically under the influence of a drag force dependent on velocity and deriving an expression for the acceleration as a function of time for an object falling under the influence of drag forces.
- WORK, ENERGY AND POWER
- Translate kinematic information between verbal (word problem), pictorial (picture or motion graph), graphical, and algebraic representations.
- Distinguish between the various forms of energy including kinetic energy, potential energy and thermal energy.
- Recognize transformations between kinetic, potential, and thermal energy.
- Distinguish between the concepts of work, energy and power.
- Calculate the work done by a force graphically using the area under a graph of force as a function of position.
- Calculate the work done by a force by using integration to calculate the work done by a force on an object that undergoes a specified displacement.
- Calculate the work done by a force by calculating the dot product of force and displacement.
- Understand the relationship between work and kinetic energy as formulated in the work-kinetic energy theorem.
- Distinguish between conservative and non-conservative forces and understand the relationship between a force and potential energy for conservative forces.
- Calculate a potential energy function associated with a specified force; calculate the magnitude and direction of a force when given the potential energy function for the force.
- Interpret and/or draw energy diagrams.
- Apply the basic ideas of calculus (differentiation and integration) both symbolically and graphically to kinematics, including: Determining the functions of time for two of the kinematic quantities (position, velocity, or acceleration) when given any one of them as a function of time. Determining the maxima or minima for the functions of time of kinematic quantities and the time when these functions are zero.
- Understand the basic energy model to identify and analyze situations in which total energy is or is not conserved.
- Apply the basic energy model to solve quantitative problems and interpret their results.

- Understand what is meant by an isolated system.
- Understand and apply the concept of power to calculate the power supplied to or dissipated by a system.
- IMPULSE AND LINEAR MOMENTUM
- Understand the experimental technique for finding center of mass; calculate the center of mass.
- Understand the relationship between mass, velocity and momentum and be able to calculate the total momentum of a system.
- Understand the relationship between force, time and impulse and be able to calculate the impulse graphically and using integration.
- Understand and apply the Impulse-Momentum Theorem and identify situations in which linear momentum or a component of linear momentum is conserved.
- Understand how linear momentum conservation follows as a consequence of Newton's Third Law for an isolated system.
- Draw and interpret kinematic graphs for linear motion, projectile motion and circular motion.
- Apply linear momentum conservation to elastic and inelastic collisions, explosions and recoil.
- ROTATIONAL DYNAMICS, ENERGY, AND MOMENTUM
- Understand the relationship between mass, size, symmetry and rotational inertia
- Compute rotational inertia of a collection of point masses lying in a plane about an axis perpendicular to the plane and simple symmetric objects.
- Understand the analogy between translational and rotational kinematics and dynamics.
- Understand the relationship between torque, force and the force's distance from the pivot/axis of rotation.
- Calculate the magnitude and direction of the torque associated with a given force.
- Understand and apply the conditions for translational and rotational equilibrium of a rigid object.
- Understand and use the relationship between angular acceleration, torque and rotational inertia for a rigid body rotating about a fixed axis when subjected to a specified external torque or force.
- Apply the equations of translational and rotational motion simultaneously in analyzing rolling without slipping.
- Solve quantitative kinematics problems for linear motion, projectile motion and circular motion and interpret the results.
- Calculate the total kinetic energy of an object that is undergoing both translational and rotational motion, and apply energy conservation in analyzing such motion.
- Understand angular momentum conservation and recognize the conditions under which the law of conservation is applicable and relate this law to one and two-particle systems such as satellite orbits.
- Understand the relationship between net external torque and angular momentum, and identify situations in which angular momentum is conserved.
- OSCILLATIONS
- Recognize that a system with motion described by a specific differential equation will execute simple harmonic motion.
- Understand and apply the mathematical representations of oscillatory motion.
- Understand the relationship between acceleration, velocity, and displacement for simple harmonic oscillators and identify points in the motion where these quantities are zero or achieve their greatest positive and negative values.
- Draw and interpret motion graphs and energy diagrams of oscillatory motion.
- Understand and apply the concepts of phase and phase constant when describing simple harmonic oscillators.
- Understand and use energy conservation in oscillatory systems and the relationship between total energy and the amplitude of the motion.
- Apply kinematics concepts to two dimensions: compute two-dimensional trajectories for projectiles.
- Understand the basic ideas of damping and resonance.
- GRAVITATION
- Apply Newton's law of universal gravitation to determine the force that one spherically symmetrical mass exerts on another and to solve orbital motion problems.
- Determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass.
- Distinguish between the concepts of mass, gravitational force and weight.
- Understand the three components of Newton's theory of gravity.
- Understand Kepler's laws of planetary orbits and their relationship to law of universal gravitation and conservation of angular momentum.
- LABORATORY
- Design and implement laboratory investigations to analyze phenomena appropriate to the course.
- Develop expertise in clear, cogent reporting of experimental design, observations, analysis, and conclusions in a variety of formats ranging from informal discussion and oral presentations to formal laboratory papers.
- Apply kinematics concepts to two dimensions: write expressions for the horizontal and vertical components of velocity and position as functions of time.
- Apply kinematics concepts to two dimensions: understand the kinematics of uniform circular motion

Major Course Content

1. Concepts of Motion
   a. The Particle model
   b. Position
   c. Time
   d. Velocity
   e. Linear Acceleration
   f. Motion Diagrams
   g. Units and Significant Figures
2. Vectors
   a. Properties of Vectors
   b. Coordinate Systems and Vector Components
   c. Vector Algebra
3. Kinematics in One Dimension
   a. Average velocity
   b. Instantaneous velocity
   c. Uniform Motion
   d. Motion with Constant Acceleration

        i. Free fall
        ii. Motion on an inclined plane
4. Kinematics in Two Dimensions
    a. Kinematics in Two Dimensions
    b. Projectile Motion
    c. Circular Motion
        i. Angular Position
        ii. Angular Velocity
        iii. Angular Acceleration
        iv. Relation between linear and angular kinematics
    d. Relative Motion
5. Force and Motion
    a. Identifying forces
        i. Free-Body Diagrams
    b. Inertia and Mass
    c. Newton's First Law
    d. Newton's Second Law
    e. Dynamics I: Motion along a Straight Line
        i. Gravity and Weight
        ii. Friction
        iii. Drag
        iv. Hooke's Law
    f. Dynamics II: Motion in a Plane
        i. Uniform Circular Motion
        ii. Non-uniform Circular Motion
        iii. Circular Orbits
    g. Newton's Third Law
        i. Interacting Systems
6. Conservation Laws
    a. Conservation of Momentum
        i. Momentum and Impulse
        ii. Collisions and Explosions
        iii. Reactions and decay processes
    b. Conservation of Energy
        i. Types of Energy
            1. Kinetic Energy
            2. Potential Energy
            3. Thermal Energy
        ii. Work done by a Force
            1. Conservative Forces
            2. Non-conserative Forces
        iii. Basic Energy Model
        iv. Work-Kinetic Energy Theorem
        v. Energy Diagrams/Potential Energy Curves
        vi. Power
7. Rotation of a Rigid Body
    a. Rotational Motion and Kinematics
    b. Center of mass
    c. Moment of Inertia/Rotational Inertia
    d. Torque
    e. Rotational Dynamics
    f. Rotational Energy
    g. Rolling Motion
    h. Angular Momentum of a Rigid Body
8. Oscillations
    a. Simple Harmonic Motion
    b. Simple Harmonic Motion and Circular Motion
    c. Energy and Simple Harmonic Motion
    d. Dynamics of Simple Harmonic Motion
    e. Application of Simple Harmonic Motion
    f. Damped Oscillations
    g. Driven Oscillations and Resonance
9. Newton's Theory of Gravity
    a. Newton's Law of Gravity
    b. Universal Gravitational Constant
    c. Gravitational Potential Energy
    d. Gravitational Field
    e. Satellite Orbits and Energies

Lab Content

A minimum of 10 in-person or virtual experiments focused on topics from the following list:

1. Experimental Techniques (Graphing, Uncertainty & Significant Figures)
2. 1D Motion
3. Vector Addition
4. Projectile Motion
5. Newton's Second Law
6. Applications of Newton's Laws
7. Newton's Third Law
8. Pendulum & Non-uniform Circular Motion
9. Impulse & Momentum
10. Types of Energy
11. Conservation of Energy
12. Rotational Motion
13. Oscillations
14. Project Design and Construction

Suggested Reading Other Than Required Textbook

Research articles pertinent to course topics from professional journals, such as Learning and Instruction and Journal of Mathematical Analysis and Applications.

Examples of Required Writing Assignments

Lab reports; short answer questions in homework assignments, in-class assignments, and/or exams.

Examples of Outside Assignments

You've been called to investigate a construction accident in which the cable broke while a crane was lifting a 4500kg container. The steel cable is 2.0cm in diameter and has a safety rating of 50,000N. The crane is designed not to exceed speeds of 3.0m/s or accelerations of 1.0m/s^2, and your tests find that the crane is not defective. What is your conclusion? Did the crane operator recklessly lift too heavy a load? Or was the cable defective?

Instruction Type(s)

Lab, Lecture, Online Education Lab, Online Education Lecture

IGETC Area 5: Physical and Biological Sciences

5A. Physical Science, 5C. Science Laboratory