Curriculum Guide

Course 544: AP Physics C - Mechanics **Level:** Grades 11 & 12

1. Course Structure

This full-year course meets daily. There are no supplementary laboratory periods because investigations are incorporated into regular class periods.

2. Intended Audience

AP Physic Cs is an elective course intended for junior/senior students who have completed, or are currently enrolled in Calculus

3. Course Goals

Students in this course will develop the following: a solid understanding of many of the physical principles which govern our world, a proficiency in solving the mathematical problems which model the aforementioned physical principles, and the skills necessary to effectively collect and analyze laboratory data to form meaningful conclusions.

4. Course Objectives

Content:

I. The Tools of Physics
II. Kinematics
III. Dynamics
IV. Work and Energy
V. Momentum
VI. Circular Motion and Gravity
VII. Rotational Dyamics
VIII. Simple Harmonic Motion and Waves
IX. AP Exam Review

Skills:

- Students will demonstrate habits of mind characteristic of physicists, including the constant questioning of how and why things happen in the physical world around them.
- Students will demonstrate an ability to solve physics problems in an ordered, logical fashion using a learned problem solving strategy.
- Students will become proficient in observing, recording, analyzing, and effectively reporting data collected in the laboratory.
- Students will be able to design and conduct meaningful investigations; they will recognize inherent limitations in experimentation, and they will design

procedures that minimize sources of error.
- Students will demonstrate an ability to relate everyday experiences to the laws of physics. For example, students will be able to use Newton's three laws of motion to explain why seatbelts and airbags are necessary safety features in automobiles.

5. Essential Questions

I. The Tools of Physics
- What is the "language" through which physicists communicate?
- How are physical quantities reported and manipulated?

II. Kinematics
- What mathematical models are used to describe the motion of objects?
- How can graphical models be used to better describe motion?
- What concepts are involved in accelerated motion?

III. Dynamics
- What are the causes of motion?
- What are Newton's three laws and how do you apply them?

IV. Work and Energy
- How are work and energy related?
- What is momentum and how do you cause a change in momentum?
- What physical concepts explain collisions and explosions?

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VI. Circular Motion and Gravity
- What causes things to move along a curvilinear path?
- How does circular motion differ from linear motion?
- What is Gravity?

VII. Rotational Dynamics
- How do the rotational variables coordinate with the linear ones?
- How can you increase the rotational inertia of an object?
- What is torque?

VIII. Simple Harmonic Motion and Waves
- What objects obey Hooke's Law?
- What is the equation for the force and potential every of an ideal spring?

- How do an ideal spring and pendulum relate

IX. AP Review

6. Course Outline/ Curriculum Map

Quarter 1

I. The Tools of Physics
- Scientific Notation
- Significant Figures
- Accuracy and Precision
- Graphing

II. Kinematics

- Distance vs displacement; speed vs velocity; instantaneous vs average

- Predict and collect data on position vs time, velocity vs time; and acceleration vs time for various types of motion.

- Analyze displacement graphs to determine velocity; analyze velocity graphs to determine displacement and acceleration; analyze acceleration graphs to determine change in velocity.

- Utilize calculus to determine slopes and areas under the curve.

- Write and use the five equations of uniformly accelerated motion to solve problems in a systematic fashion.

- Given an expression x(t) for position as a function of time, use derivatives to determine velocity and acceleration as functions of time, and find when these quantities are zero or achieve their maximum and minimum values.

- Given an expression a(t) for acceleration as a function of time, plus initial conditions, use integral calculus to determine velocity and position as function of time, and find where these quantities achieve their maximum and minimum values.

- Determine the value of 'g' by using video technology to collect data and by using a computer or graphing calculator to analyze the data.

- Describe the motion of an object, in terms of displacement, velocity and acceleration, when the object is thrown straight up until it hits the ground, given that air resistance is negligible.

- Distinguish between vector and scalar quantities; Resolve any given vector into

perpendicular components.

- Calculate the sum of two or more given vectors by the method of trigonometric resolution into components.

- Solve projectile motion problems using an organized approach.

- Given functions x(t) and y(t) which describe projectile motion, determine the components, magnitude, and direction of the particle's velocity and acceleration as functions of time.

Quarter 2

III. Dynamics

- State and understand Newton's three laws of motion.

- Predict how the acceleration of a system will change as the mass of the system or the forces acting on it change.

- Qualitatively describe the effects of air resistance on falling bodies.

- Solve problems in which the application of Newton's Laws leads to two or three simultaneous linear equations involving forces or accelerations.

- Exhibit proper procedures in solving problems dealing with multiple forces.

- Draw a free-body diagram indicating the forces acting on a body when given a force problem.

- Analyze situations involving friction to determine under what circumstances a body will start to slip; calculate the magnitude of the force of static friction.

- Calculate the acceleration of a system of connected bodies and determine the tension in a cord connecting two isolated masses.

- Analyze situations in which a body accelerates on an inclined plane.

- Solve problems dealing with sliding and kinetic friction.

- Find the terminal velocity of a body moving vertically through a fluid that exerts a retarding force proportional to the velocity. Use differentials to determine the velocity at times between initial and terminal velocity.

- Describe qualitatively, with the aid of graphs, the acceleration, velocity, and displacement of a particle in a 'resistant' medium when it is released from rest or is projected vertically with specified initial velocity.

IV. Work and Energy

- Conceptually and mathematically understand the concepts of work; gravitational potential energy; kinetic energy; conservation of mechanical energy; power; conservative forces vs non-conservative forces

- Apply the work – energy theorem to determine the change in a body's kinetic energy and speed that results from the application of specified forces.

- Relate the work done by a force to the area under a graph of force as a function of position; use integration to calculate the work performed by force F(x) on a body that undergoes a specified displacement in one dimension.

- Use Integration to calculate a potential energy function associated with a force F(x); use differentiation to calculate the magnitude and direction of a force if given a potential energy function U(x).

- Analyze a graph of potential energy as a function of distance to determine the turning points and to understand the significance of those turning points.

- Recognize and solve problems that call for application both of conservation of energy and Newton's Laws.

V. Momentum

- Define and calculate the linear momentum for a moving body, and calculate the total linear momentum of a system of bodies; relate impulse to the change in linear momentum and the average force acting on a body.

- Analyze collisions of particles in one or two dimensions to determine unknown masses or velocities, and calculate how much kinetic energy is lost in such a situation.

- Distinguish between an elastic collision and an inelastic collision.

- Mathematically determine the center of mass of a system consisting of two or more regularly shaped bodies; state and apply the relation between center-of-mass velocity and linear momentum, and between center of mass acceleration and net external force for a system of particles.

- Use the rocket equations to calculate changes in velocity of a rocket as fuel is burned.

Quarter 3

VI. Circular Motion

- Perform an experiment in which you use graphical analysis to study the relationship between centripetal force, velocity, and radius for an object moving in a circular path.

- Use
- mathematics to solve centripetal force and acceleration problems.

- Write a qualitative and quantitative statement of Newton's law of universal gravitation; determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass.

- Use Integration to determine (and use) the formula for gravitational potential energy from the Gravitational Force formula.

- Solve problems that relate the orbital velocity and period of a satellite to its distance from the earth.

- Apply energy conservation in analyzing the 'escape velocity' types of problems.

VII. Rotational Dynamics

- Name and write the correct symbol for the angular quantity that corresponds to each of the following: linear displacement, linear velocity, and linear acceleration; convert an angle in degrees, radians, or revolutions into each of the other units.

- Write the equations relating the quantities 's', 'v', and 'a' to 'ø', 'ω', and 'α'; use the rotational form of the five linear kinematics equations to solve problems in rotational kinematics.

- Calculate the moment of inertia of point masses about a given axis of rotation; solve problems applying to moment of inertia of point objects, cylinders, and spheres, and rods.

- State and apply the parallel-axis theorem.

- Calculate the torque on an object about a given axis, given the magnitude, direction, and point of application of the acting force; derive, write, and use the rotational form of Newton's second law of motion.

- Analyze problems involving strings and massive pulleys.

- Apply conservation of energy principles to problems of fixed-axis rotation.

- Determine the work done on an object by integrating a torque – angular

displacement equation; or by analyzing a torque – angular displacement graph.

- Draw a free-body diagram of an object and apply the two conditions of equilibrium to calculate unknown forces acting on an object, given adequate information about known forces and distances.

- Determine the angular acceleration with which a rigid body is accelerated about a fixed axis when subjected to a specified external torque or force.

- Apply conservation of energy to problems of fixed-axis rotation.

- Write down, justify, and apply the relation between linear and angular velocity, or between linear and angular acceleration, for a body of circular cross-section that rolls without slipping along a fixed plane, and determine the velocity and acceleration of an arbitrary point on such a body.

- Calculate angular momentum for a rotating object with a known moment of inertia .

- State the relation between net external torque and angular momentum.

- Analyze a collision between a moving particle and a rigid body that can rotate about a fixed axis or about its center of mass.

VIII. Simple Harmonic Motion and Waves

- Define simple harmonic motion in terms of restoring force (or acceleration) and displacement; determine the spring constant for a spring and verify Hooke's Law; explain how motion in a reference circle and sinusoidal motion are related to simple harmonic motion.

- Sketch or identify a graph of displacement as a function of time, and determine from such a graph the amplitude, period, and frequency of the motion.

- Given a sinusoidal curve, be able to write an equation for the displacement along the x-axis; use this equation to determine the velocity and acceleration by finding the first derivative and the second derivative.

- Derive a formula for acceleration (in simple harmonic motion) from Newton's second law and Hooke's law.

- Derive and apply the expression for the period of oscillation of a mass on a spring; draw a force diagram for the simple pendulum and derive the expression for the period of a simple pendulum.

- Explain how the kinetic, potential, and total energies are related as a system

vibrates. Solve problems involving the interchange of energy in an oscillating system.

- Analyze the motion of a physical pendulum in order to determine the period of small oscillations.

Quarter 4

IX. AP Review

- Review of all material for the AP exam. Old AP exam questions – both multiple choice and free response will be utilized.

7. Course Text and Other Materials

The text for this course is:
Holliday, David, Robert Resnick, and Jearl Walker. *Fundamentals of Physics* 8th ed, Vol. 1. New York: John Wiley & Sons.

Support materials include:
- Past AP Physics C Exams

8. Instructional Methods and Course Activities

Content will be conveyed through:
- Class dialogue and discussion
- Interactive lecture demonstrations
- Instructor-designed laboratory investigations
- Student-designed laboratory investigations

9. Learning Strategies

- Class discussion and problem-solving, accompanied by laboratory experiences, are designed to illustrate and reinforce physical principles learned in class.
- Computer-assisted instruction (interactive lecture demonstrations, microcomputer based laboratories) will be used to increase learning and to support a variety of learning styles.
- The development and effective use of a problem solving strategy will also be used.

10. Assessment

The assessment of students will occur through:
- Evaluation of class preparation and participation

- Laboratory performance including observations, analysis, and reporting of data
- Formal testing and quizzing

11. Course Evaluation

The assessment of this course will occur through:

- Feedback from current students and graduates
- A formal student questionnaire