07 Oscillations

Content Area:	**Science**
Course(s):	**AP Physics C**
Time Period:	**Semester 1**
Length:	**2 weeks**
Status:	**Published**

Standards

SCI.HS-PS2-1	Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
	Analyzing and Interpreting Data
SCI.HS.PS2.A	Forces and Motion
	Cause and Effect
SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
	Using Mathematics and Computational Thinking
SCI.HS.PS3.A	Definitions of Energy
SCI.HS.PS3.B	Conservation of Energy and Energy Transfer
	Systems and System Models
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
	Developing and Using Models
SCI.HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
	Energy and Matter

AP Physics C Learning Objectives

Note: Learning Objectives are taken verbatim from the AP Physics C - Mechanics Course and Exam Description. The verb "describe" could refer to a variety of different methods of expression (e.g. words, diagrams, graphs, mathematical expressions), as appropriate.

Describe simple harmonic motion.

Describe the frequency and period of an object exhibiting SHM.

Describe the displacement, velocity, and acceleration of an object exhibiting SHM.

Describe the mechanical energy of a system exhibiting SHM.

Describe the properties of a physical pendulum.

Enduring Understandings

Interactions produce changes in motion.

Forces characterize interactions between objects or systems.

Conservation laws constrain interactions.

There are certain types of forces that cause objects to repeat their motions with a regular pattern.

Essential Questions

How can oscillations be used to make our lives easier and more comfortable?

How can an astronaut be “weighed” in space?

How could you measure the length of a long string with a stopwatch?

What do a child on a swing, a beating heart, and a metronome have in common?

Knowledge and Skills

Topic 7.1 Defining Simple Harmonic Motion (SHM)

Knowledge:

- Simple harmonic motion is a special case of periodic motion.
- SHM results when the magnitude of the restoring force exerted on an object is proportional to that object’s displacement from its equilibrium position.
- A restoring force is a force that is exerted in a direction opposite to the object’s displacement from an equilibrium position.
- An equilibrium position is a location at which the net force exerted on an object or system is zero.

Skills:

- Create diagrams, tables, charts, or schematics to represent physical situations.
- Compare physical quantities between two or more scenarios or at different times and/or locations within a single scenario.
- Apply an appropriate law, definition, theoretical relationship, or model to make a claim.
- Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

Topic 7.2 Frequency and Period of SHM

Knowledge:

- The period of SHM is related to the angular frequency of the object's motion by the following equation:
- The period of an object–ideal–spring oscillator is given by the equation:
- The period of a simple pendulum displaced by a small angle is given by the equation:

Skills:

- Create qualitative sketches of graphs that represent features of a model or the behavior of the physical system.
- A Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.
- Predict new values or factors of change of physical quantities using functional dependence between variables.
- Apply an appropriate law, definition, theoretical relationship, or model to make a claim.

Topic 7.3 Representing and Analyzing SHM

Knowledge:

- For an object exhibiting SHM, the displacement of that object measured from its equilibrium position can be represented by the equations or .
- Minima, maxima, and zeros of displacement, velocity, and acceleration are features of harmonic motion.
- Recognizing the positions or times at which the displacement, velocity, and acceleration for SHM have extrema or zeros can help in qualitatively describing the behavior of the motion.
- The position as a function of time for an object exhibiting SHM is a solution of the second order differential equation derived from the application of Newton's second law.
- Characteristics of SHM, such as velocity and acceleration, can be determined by or derived from the equation .
- The acceleration of an object exhibiting SHM is related to the object's angular frequency and position.
- It can be shown that the maximum velocity and acceleration of an object exhibiting SHM are related to the angular frequency of the object's motion.
- In the presence of a sinusoidal external force, a system may exhibit resonance.
- Resonance occurs when an external force is exerted at the natural frequency of an oscillating system.
- Resonance increases the amplitude of oscillating motion.
- The natural frequency of a system is the frequency at which the system will oscillate when it is displaced from its equilibrium position.
- Changing the amplitude of a system exhibiting SHM will not change its period.

- Properties of SHM can be determined and analyzed using graphical representations.

Skills:

- Create qualitative sketches of graphs that represent features of a model or the behavior of the physical system.
- Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.
- Compare physical quantities between two or more scenarios or at different times and/or locations within a single scenario.
- Apply an appropriate law, definition, theoretical relationship, or model to make a claim.

Topic 7.4 Energy of Simple Harmonic Motion

Knowledge:

- The total energy of a system exhibiting SHM is the sum of the system's kinetic and potential energies.
- Conservation of energy indicates that the total energy of a system exhibiting SHM is constant.
- The kinetic energy of a system exhibiting SHM is at a maximum when the system's potential energy is at a minimum.
- The potential energy of a system exhibiting SHM is at a maximum when the system's kinetic energy is at a minimum.
- The minimum kinetic energy of a system exhibiting SHM is zero.
- Changing the amplitude of a system exhibiting SHM will change the maximum potential energy of the system and, therefore, the total energy of the system.

Skills:

- Create qualitative sketches of graphs that represent features of a model or the behavior of the physical system.
- Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.
- Predict new values or factors of change of physical quantities using functional dependence between variables.
- Justify or support a claim using evidence from experimental data, physical representations, or physical principles or laws.

Topic 7.5 Simple and Physical Pendulums

Knowledge:

- A physical pendulum is a rigid body that undergoes oscillation about a fixed axis.
- For small amplitudes of motion, the period of a physical pendulum is derived from the application of Newton's second law in rotational form.
- When displaced from equilibrium, the gravitational force exerted on a physical pendulum's center of mass provides a restoring torque.

- For small amplitudes of motion, the small angle approximation can be applied to the restoring torque.
- The small-angle approximation and Newton's second law in rotational form yield a second-order differential equation that describes SHM.

Skills:

- Create quantitative graphs with appropriate scales and units, including plotting data.
- Derive a symbolic expression from known quantities by selecting and following a logical mathematical pathway.
- Calculate or estimate an unknown quantity with units from known quantities, by selecting and following a logical computational pathway.
- Create experimental procedures that are appropriate for a given scientific question.
- Apply an appropriate law, definition, theoretical relationship, or model to make a claim.

Transfer Goals

In Unit 7, students will apply previously-encountered models and methods of analysis to simple harmonic motion. They will also be reminded that, even in new situations, the fundamental laws of physics remain the same. Because this unit is the first in which students possess all the tools of force, energy, and momentum conservation—such as energy bar charts, free-body diagrams, and momentum diagrams—scaffolding lessons will enhance student understanding of fundamental physics principles and their limitation, as they relate to oscillating systems. Students will also use the skills and knowledge they have gained to make and justify claims, as well as connect new concepts with those learned in previous topics.

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing