Unit 6 Simple Harmonic Motion

Content Area: **Science**
Course(s): **AP Physics 1**
Time Period: **February**
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Enduring Understandings

- 3.B: Classically, the acceleration of an object interacting with other objects can be predicted by using **a** = **ΣF**/m.
- 5.B: The energy of a system is conserved.

- A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy.

Essential Questions

- How does a restoring force differ from a "regular" force?
- How does the presence of restoring forces predict and lead to harmonic motion?
- How does a spring cause an object to oscillate?
- How can oscillations be used to make our lives easier?
- How does the law of conservation of energy govern the interactions between objects and systems?
- How can energy stored in a spring be used to create motion?
- How is simple harmonic motion connected to uniform circular motion?
- What properties determine the motion of an object in simple harmonic motion?
- What are the relationships between velocity, wavelength, and frequency of an object in SHM?
- How can oscillatory motion be represented graphically and mathematically?
- How is conservation of energy applied in simple harmonic oscillators?

Vocabulary

- Linear restoring forces
- Simple harmonic motion
- Simple harmonic motion graphs
- Simple pendulum
- Mass-spring oscillators
- oscillation
- period
- displacement
- work
- amplitude

- cycle
- driving
- restoring force
- phase
- equilibrium position
- frequency
- damping

Skills

Enduring Understanding	Topic	
3.B	6.1 Period of Simple Harmonic Oscillators	• 2.2 The student can apply mathematical r • 4.2 The student can design a plan for coll • 5.1 The student can analyze data to identi • 6.2 The student can construct explanation • 6.4 The student can make claims and pred • 7.2 The student can connect concepts in a
5.B	6.2 Energy of a Simple Harmonic Oscillator	• 1.4 The student can use representations ar • 2.1 The student can justify the selection o • 2.2 The student can apply mathematical r • 6.4 The student can make claims and pred • 7.2 The student can connect concepts in a

- Learning Objective (2.B.1.1): The student is able to apply **F** =m**g** to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems.
- Learning Objective (3.A.2.1): The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation.
- Learning Objective (3.B.3.1): The student is able to predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties.
- Learning Objective (3.B.3.2): The student is able to design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force.
- Learning Objective (3.B.3.3): The student can analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown.
- Learning Objective (3.B.3.4): The student is able to construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force.
- Learning Objective (3.C.4.1): The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces.

- Learning Objective (3.C.4.2): The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions.
- Learning Objective (5.B.2.1): The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system.

Standards

AP: Physics 1 (2021 - 2022)

Big Idea 3: The interactions of an object with other objects can be described by forces.

- Enduring Understanding 3.B: Classically, the acceleration of an object interacting with other objects can be predicted by using $\mathbf{a} = \Sigma\mathbf{F}/m$.
    - Learning Objective (3.B.3.1): The student is able to predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. [See Science Practices 6.4 and 7.2]

      Learning Objective (3.B.3.2): The student is able to design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force. [See Science Practice 4.2]

      Learning Objective (3.B.3.3): The student can analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion and use those data to determine the value of an unknown. [See Science Practices 2.2 and 5.1]

      Learning Objective (3.B.3.4): The student is able to construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force. [See Science Practices 2.2 and 6.2]

Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws.

- Enduring Understanding 5.B: The energy of a system is conserved.
    - Learning Objective (5.B.2.1): The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system. [See Science Practices 1.4 and 2.1]
    - Learning Objective (5.B.3.1): Describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. [See Science Practices 2.2, 6.4, and 7.2]
    - Learning Objective (5.B.3.2): Make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. [See Science Practices 1.4 and 2.2]
    - Learning Objective (5.B.3.3): Apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system. [See Science Practices 1.4 and2.2]
    - Learning Objective (5.B.4.1): Describe and make predictions about the internal energy of systems. [See Science Practices 6.4 and 7.2]
    - Learning Objective (5.B.4.2): Calculate changes in kinetic energy and potential energy of a system using information from representations of that system. [See Science Practices 1.4, 2.1, and 2.2]

The Standards above were taken from the 2014-2015 curriculum. The left over ones are not in the College Board for Unit 6.

AP: Physics 1 (2014 -15)
AP: AP
Enduring Understanding 3.A: All forces share certain common characteristics when considered by observers in inertial reference frames.
Learning Objective (3.A.2.1): The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [See Science Practice 1.1]

Enduring Understanding 3.C: At the macroscopic level, forces can be categorized as either long-range (action-at-a-distance) forces or contact forces.
Learning Objective (3.C.4.1): The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces . [See Science Practice 6.1]

Learning Objective (3.C.4.2): The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. [See Science Practice 6.2]

Resources