Introduction: Simple Harmonic Motion

Unit: Simple Harmonic Motion

Topics covered in this chapter:

This chapter discusses the physics of simple harmonic (repetitive) motion.

- *Simple Harmonic Motion* (SHM) describes the concept of repetitive back-and-forth motion and situations that apply to it.

- *Springs* and *Pendulums* describe specific examples of SHM and the specific equations relating to each.

AP® This unit is part of *Unit 7: Oscillations* from the 2024 AP® Physics 1 Course and Exam Description.

Standards addressed in this chapter:

NGSS Standards/MA Curriculum Frameworks (2016):

No MA Curriculum Frameworks are addressed in this chapter.

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AP® Physics 1 Learning Objectives/Essential Knowledge (2024):

2.8.A: Describe the force exerted on an object by an ideal spring.

2.8.A.1: An ideal spring has negligible mass and exerts a force that is proportional to the change in its length as measured from its relaxed length.

2.8.A.2: The magnitude of the force exerted by an ideal spring on an object is given by Hooke's law: $\vec{F}_s = -k\Delta\vec{x}$.

2.8.A.3: The force exerted on an object by a spring is always directed toward the equilibrium position of the object–spring system.

3.3.A.4.i: The elastic potential energy of an ideal spring is given by the following equation, where x is the distance the spring has been stretched or compressed from its equilibrium length.

7.1.A: Describe simple harmonic motion.

7.1.A.1: Simple harmonic motion is a special case of periodic motion.

7.1.A.2: SHM results when the magnitude of the restoring force exerted on an object is proportional to that object's displacement from its equilibrium position.

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7.1.A.2.i: A restoring force is a force that is exerted in a direction opposite to the object's displacement from an equilibrium position.

7.1.A.2.ii: An equilibrium position is a location at which the net force exerted on an object or system is zero.

7.1.A.2.iii: The motion of a pendulum with a small angular displacement can be modeled as simple harmonic motion because the restoring torque is proportional to the angular displacement.

7.2.A: Describe the frequency and period of an object exhibiting SHM.

7.2.A.1: The period of SHM is related to the frequency *f* of the object's motion by the following equation: $T = \frac{1}{f}$.

7.2.A.1.i: The period of an object–ideal-spring oscillator is given by the equation: $T_s = 2\pi\sqrt{\frac{m}{k}}$.

7.2.A.1.ii: The period of a simple pendulum displaced by a small angle is given by the equation: $T_p = 2\pi\sqrt{\frac{\ell}{g}}$.

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

7.3.A.1: For an object exhibiting SHM, the displacement of that object measured from its equilibrium position can be represented by the equations: $x = A\cos(2\pi ft)$ or $x = A\sin(2\pi ft)$.

7.3.A.1.i: Minima, maxima, and zeros of displacement, velocity, and acceleration are features of harmonic motion.

7.3.A.1.ii: 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.

7.3.A.2: Changing the amplitude of a system exhibiting SHM will not change the period of that system.

7.3.A.3: Properties of SHM can be determined and analyzed using graphical representations.

7.4.A: Describe the mechanical energy of a system exhibiting SHM.

7.4.A.1: The total energy of a system exhibiting SHM is the sum of the system's kinetic and potential energies.

7.4.A.2: Conservation of energy indicates that the total energy of a system exhibiting SHM is constant.

7.4.A.3: The kinetic energy of a system exhibiting SHM is at a maximum when the system's potential energy is at a minimum.

7.4.A.4: The potential energy of a system exhibiting SHM is at a maximum when the system's kinetic energy is at a minimum.

7.4.A.4.i: The minimum kinetic energy of a system exhibiting SHM is zero.

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7.4.A.4.ii: 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 learned & applied in this chapter:

- Understanding and representing repetitive motion.