Introduction: Mechanical Waves

Unit: Mechanical Waves

Topics covered in this chapter:

This chapter discusses properties of waves that travel through a medium (mechanical waves).

- *Waves* gives general information about waves, including vocabulary and equations. *Wave Interactions* describes what happens when two waves share space within a medium.
- *Sound & Music* describes the properties and equations of waves that relate to music and musical instruments.
- *Sound Level* describes the decibel scale and how loudness is measured.
- *The Doppler Effect* describes the change in pitch due to motion of the source or receiver (listener).
- *Exceeding the Speed of Sound* describes the Mach scale and sonic booms.

Standards addressed in this chapter:

NGSS Standards/MA Curriculum Frameworks (2016):

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling within various media. Recognize that electromagnetic waves can travel through empty space (without a medium) as compared to mechanical waves that require a medium.

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AP® Physics 2 Learning Objectives/Essential Knowledge (2024):

14.1.A: Describe the physical properties of waves and wave pulses.

14.1.A.1: Waves transfer energy between two locations without transferring matter between those locations.

14.1.A.1.i: A wave pulse is a single disturbance that transfers energy without transferring matter between two locations.

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14.1.A.1.ii: A wave is modeled as a continuous, periodic disturbance with well-defined wavelength and frequency.

14.1.A.2: Mechanical waves or wave pulses require a medium in which to propagate. Electromagnetic waves or wave pulses do not require a medium in which to propagate.

14.1.A.3: The speed at which a wave or wave pulse propagates through a medium depends on the type of wave and the properties of the medium.

14.1.A.3.i: The speed of all electromagnetic waves in a vacuum is a universal physical constant, $c = 3\times10^{8}\,\frac{\text{m}}{\text{s}}$.

14.1.A.3.ii: The speed at which a wave pulse or wave propagates along a string is dependent upon the tension in the string, F_T, and the mass per length of the string.

14.1.A.3.iii: In a given medium, the speed of sound waves increases with the temperature of the medium.

14.1.A.4: In a transverse wave, the direction of the disturbance is perpendicular to the direction of propagation of the wave.

14.1.A.5: In a longitudinal wave, the direction of the disturbance is parallel to the direction of propagation of the wave.

14.1.A.5.i: Sound waves are modeled as mechanical longitudinal waves.

14.1.A.5.ii: The regions of high and low pressure in a sound wave are called compressions and rarefactions, respectively.

14.1.A.6: Amplitude is the maximum displacement of a wave from its equilibrium position.

14.1.A.6.i: The amplitude of a longitudinal pressure wave may be determined by the maximum increase or decrease in pressure from equilibrium pressure.

14.1.A.6.ii: The loudness of a sound increases with increasing amplitude.

14.1.A.6.iii: The energy carried by a wave increases with increasing amplitude.

14.2.A: Describe the physical properties of a periodic wave.

14.2.A.1: Periodic waves have regular repetitions that can be described using period and frequency.

14.2.A.1.i: The period is the time for one complete oscillation of the wave.

14.2.A.1.ii: The frequency is the rate at which the wave repeats.

14.2.A.1.iii: The amplitude of a wave is independent of the period and the frequency of that wave.

14.2.A.1.iv: The energy of a wave increases with increasing frequency.

14.2.A.1.v: The frequency of a sound wave is related to its pitch.

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14.2.A.1.vi: Wavelength is the distance between successive corresponding positions (such as peaks or troughs) on a wave.

14.2.A.2: A sinusoidal wave can be described by equations for the displacement from equilibrium at a specific location as a function of time. A wave can also be described by an equation for the displacement from equilibrium at a specific time as a function of position.

14.2.A.3: For a periodic wave, the wavelength is proportional to the wave's speed and inversely proportional to the wave's frequency.

14.3.A: Describe the interaction between a wave and a boundary.

14.3.A.1: A wave that travels from one medium to another can be transmitted or reflected, depending on the properties of the boundary separating the two media.

14.3.A.1.i: A wave traveling from one medium to another (for example, a wave traveling between low-mass and high-mass strings) will result in reflected and transmitted waves.

14.3.A.1.ii: A reflected wave is inverted if the transmitted wave travels into a medium in which the speed of the wave decreases.

14.3.A.1.iii: A reflected wave is not inverted if the transmitted wave travels into a medium in which the speed of the wave increases.

14.3.A.1.iv: The frequency of a wave does not change when it travels from one medium to another.

Skills learned & applied in this chapter:

- Visualizing wave motion.