Using Sound

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CHAPTER 1 Using Sound

Standard:

MS-PS4-2 Develop and use a model to describe how waves are reflected, absorbed, or transmitted through various materials. (SEP: 2; DCI: PS4.A, PS4.B; CCC: Structure)

Lesson Objectives

- Explain how musical instruments produce sound.
- Identify uses of ultrasound.

Lesson Vocabulary

- resonance
- sonar

Introduction

If you have normal hearing, it's hard to imagine life without sound. A silent world would seem like an eerie place. Sound is an important part of how we sense the world around us. Whether it's the chirping of a bird, the sigh of a friend, or the whistle of a train, sound gives us important clues about our environment. We also depend on sound to communicate and for many other purposes. One very pleasant way we use sound is to make music.

Making Music

People have been using sound to make music for thousands of years. They have invented many different kinds of musical instruments for this purpose. Despite their diversity, however, musical instruments share certain similarities.

- All musical instruments create sound by causing matter to vibrate. The vibrations start sound waves moving through the air.
- Most musical instruments use resonance to amplify the sound waves and make the sounds louder. **Resonance** occurs when an object vibrates in response to sound waves of a certain frequency. In a musical instrument such as a guitar, the whole instrument and the air inside it may vibrate when a single string is plucked. This causes constructive interference with the sound waves, which increases their amplitude.
- Most musical instruments have a way of changing the frequency of the sound waves they produce. This changes the pitch of the sounds.

There are three basic categories of musical instruments: percussion, wind, and stringed instruments. In **Figure** 1.1, you can see how instruments in each category make sound and how the pitch of the sound can be changed.

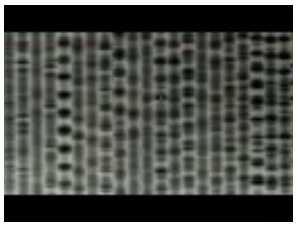
KQED: How Edison Got His Groove Back

Researchers at Lawrence Berkeley National Laboratory are pioneering a new way to recover 100-year-old recordings. Found on fragile wax cylinders and early lacquer records, the sounds reveal a rich acoustic heritage, including

FIGURE 1.1

A drum, saxophone, and violin represent the three basic categories of musical instruments. Can you name other instruments in each category?

languages long lost. For more information on how to recover recordings, see http://science.kqed.org/quest/video/how-edison-got-his-groove-back/ .



MEDIA

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Using Ultrasound

Ultrasound has frequencies higher than the human ear can detect (higher than 20,000 hertz). Although we can't hear ultrasound, it is very useful. Uses include echolocation, sonar, and ultrasonography.

Echolocation

Animals such as bats, whales, and dolphins send out ultrasound waves and use their echoes, or reflected waves, to identify the locations of objects they cannot see. This is called echolocation. Animals use echolocation to find prey and avoid running into objects in the dark. **Figure** 1.2 and the animation at the URL below show how a bat uses echolocation to locate insect prey.

http://www.bsos.umd.edu/psyc/batlab/headaimmovies/nsf_challenge/nsf4.wmv

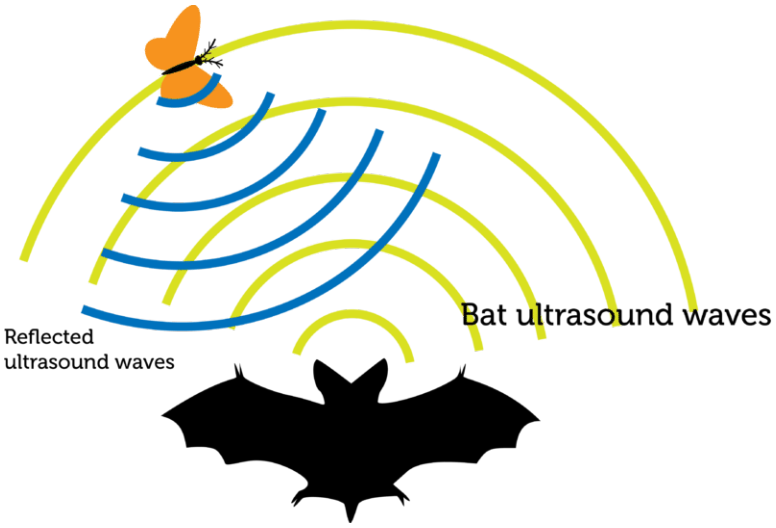


FIGURE 1.2
Bats use ultrasound to find prey.

Sonar

Sonar uses ultrasound in a way that is similar to echolocation. **Sonar** stands for sound navigation and ranging. It is used to locate underwater objects such as sunken ships or to determine how deep the water is. A sonar device is usually located on a boat at the surface of the water. The device is both a sender and a receiver (see **Figure** 1.3). It sends out ultrasound waves and detects reflected waves that bounce off underwater objects or the bottom of the water. If you watch the video at the URL below, you can see how sonar is used on a submarine.

http://dsc.discovery.com/videos/ultimate-guide-to-submarines-sonar.html

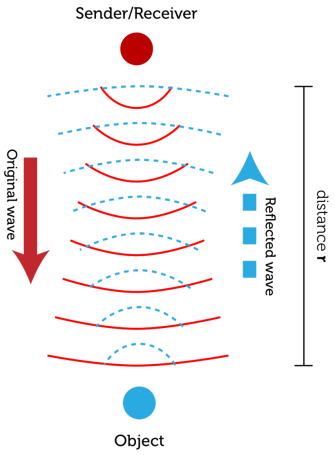


FIGURE 1.3
Sonar works on the same principle as echolocation.

The distance to underwater objects or the bottom of the water can be calculated from the known speed of sound in water and the time it takes for the waves to travel to the object. The equation for the calculation is:

$$\text{Distance} = \text{Speed} \times \text{Time}$$

Assume, for example, that a sonar device on a ship sends an ultrasound wave to the bottom of the ocean. The speed of the sound through ocean water is 1437 m/s, and the wave travels to the bottom and back in 2 seconds. What is the

distance from the surface to the bottom of the water? The sound wave travels to the bottom and back in 2 seconds, so it travels from the surface to the bottom in 1 second. Therefore, the distance from the surface to the bottom is:

$$\text{Distance} = 1437 \text{ m/s} \times 1 \text{ s} = 1437 \text{ m}$$

You Try It!

Problem: The sonar device on a ship sends an ultrasound wave to the bottom of the water at speed of 1437 m/s. The wave is reflected back to the device in 4 seconds. How deep is the water?

Ultrasonography

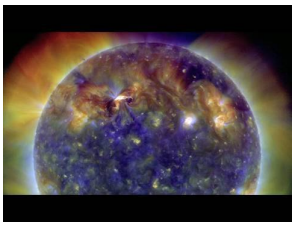
Ultrasound can be used to "see" inside the human body. This use of ultrasound is called ultrasonography. Harmless ultrasound waves are sent inside the body, and the reflected waves are used to create an image on a screen. This technology is used to examine internal organs and unborn babies without risk to the patient. You can see an ultrasound image in **Figure** 1.4. You can see an animation showing how ultrasonography works at this URL: http://health.howstuffworks.com/pregnancy-and-parenting/pregnancy/fetal-development/adam-200128.htm .

FIGURE 1.4

This ultrasound image shows an unborn baby inside its mother's body. Do you see the baby's face?

KQED: Music of the Sun

In this QUEST web extra, Stanford University astrophysicist Todd Hoeksema explains how solar sound waves are a vital ingredient to the science of helioseismology, in which the interior properties of the sun are probed by analyzing and tracking the surface sound waves that bounce into and out of the Sun. For more information on solar sound waves, see http://science.kqed.org/quest/video/web-extra-music-of-the-sun/ .



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Lesson Summary

- All musical instruments make sound by causing something to vibrate and starting sound waves moving through the air. Most instruments use resonance to amplify the sound waves. Most also have a way to change pitch of the sounds. There are three categories of musical instruments: percussion, wind, and stringed instruments.
- Ultrasound has frequencies higher than the human ear can hear. Uses of ultrasound include echolocation, sonar, and ultrasonography.

Lesson Review Questions

Recall

1. Describe ultrasound.
2. How does resonance occur? Give an example.
3. What does sonar stand for?
4. List two uses of sonar.
5. What is ultrasonography?

Apply Concepts

6. Create a sketch to show how a whale might use echolocation to locate a school of fish.

Think Critically

7. Compare and contrast echolocation, sonar, and ultrasonography.

Points to Consider

In this chapter, you read about sound waves, which start with a disturbance of matter and travel through matter as longitudinal waves. In the chapter "Electromagnetic Radiation," you'll read about electromagnetic waves, such as light and X rays, which can travel through empty space.

- How do you think electromagnetic waves might be different from waves that travel through matter?
- How do you think electromagnetic waves get started?

References

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