Section 10.7: Nature and Sound Waves

Research This: Dolphin Echolocation and Detecting Underwater Mines, page 473

A.–C. Answers may vary. Students should form opinions based on their research and present their reasoning using what they have learned. Some possible arguments for the use of dolphins are human lives can be saved, dolphins in research facilities are humanely cared for, dolphins could be bred for future work, and dolphins' echolocation abilities are superior to any device developed so far by humans. Some possible arguments against the use of dolphins is that they are living, breathing creatures whose lives are just as valuable as humans, and with advances in technology, scientists should be able to develop detection devices that are just as effective as dolphins.

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1. Sonar is a technique that measures distances based on the echoes propagated through water. Echolocation is called biosonar since it is a form of sonar used naturally by animals.

2. The times for the echoes to return will be the speed of sound divided by twice the distance (since the sound waves must travel there and back).

For the farthest object (200 m):

$$\Delta t = \frac{2\Delta d}{v}$$
$$= \frac{2(200\ \cancel{\text{m}})}{1470\ \frac{\cancel{\text{m}}}{\text{s}}}$$
$$\Delta t = 0.3\ \text{s}$$

For the nearest object (5 m):

$$\Delta t = \frac{2\Delta d}{v}$$
$$= \frac{2(5\ \cancel{\text{m}})}{1470\ \frac{\cancel{\text{m}}}{\text{s}}}$$
$$\Delta t = 0.007\ \text{s}$$

So, the maximum and minimum times for the echoes to return are 0.3 s and 0.007 s or 7 ms.

3. (a) Bats hunt small insects and echolocation requires objects to be longer than a wavelength, so bats must use very high frequencies because they have very short wavelengths.

(b) Given: T = 22 °C; f = 110 kHz = 110 000 Hz

Required: λ

Analysis: $v = f\lambda$

$$\lambda = \frac{v}{f}$$

Solution: Determine the speed of sound at 22 °C:

$$v_{\text{sound}} = 331.4\ \text{m/s} + (0.606\ \text{m/s/°C})T$$
$$= 331.4\ \text{m/s} + \left(0.606\ \frac{\text{m/s}}{\cancel{°\text{C}}}\right)(22\ \cancel{°\text{C}})$$
$$v_{\text{sound}} = 344.7\ \text{m/s}$$

Determine the wavelength:

$$\lambda = \frac{v}{f}$$
$$= \frac{344.7\ \text{m/s}}{110\ 000\ \text{Hz}}$$
$$= 0.003134\ \text{m}$$
$$\lambda = 3.1\ \text{mm}$$

Statement: The smallest object a bat can detect when the air temperature is 22 °C is 31 mm long.

(c) Dolphins use high frequencies because the speed of sound is much faster in water than in air.

4. Answers may vary. Students should research another species of animal that uses echolocation, such as a shrew, an orca, or a flying squirrel. Comparisons include the methods of producing and receiving sound, the frequencies used, and the information gained through echolocation.

5. Answers may vary. Diagrams should resemble Figure 5 on page 473 of the student book. The diagram should include the following labels: Large pinnae help to detect sounds over large distances. The trunk contains hearing receptors to detect low frequency sound vibrations in the ground. The feet contain hearing receptors to detect low frequency sound vibrations in the ground.

6. Answers may vary. Sample answer:

The Elephant Listening Project is dedicated to studying the ways elephants communicate through seismic waves. Elephant hearing is much more sensitive than ours and they can also sense sounds through their feet and trunks. In addition to communicating with sound, vision and smell, elephants use infrasound, frequencies below the limit of human hearing (20 Hz). Their language is complex and humans are only beginning to understand it.

7. Answers may vary. Sample answer: Elephants' large pinnae may help amplify the sound and sense the direction from which the sound is coming, like a cat's movable pinnae.
8. (a) Elephants can detect sounds through their trunks and feet.
(b) House cats can detect higher frequencies than humans. They have large movable pinnae, which help amplify the sound and sense the direction from which the sound is coming.