extension

Integrating Earth Science

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Keyword HF6VIBX

Waves transfer energy

When a pebble is dropped into a pond, the water wave that is produced carries a certain amount of energy. As the wave spreads to other parts of the pond, the energy likewise moves across the pond. Thus, the wave transfers energy from one place in the pond to another while the water remains in essentially the same place. In other words, waves transfer energy by the vibration of matter rather than by the transfer of matter itself. For this reason, waves are often able to transport energy efficiently.

The rate at which a wave transfers energy depends on the amplitude at which the particles of the medium are vibrating. The greater the amplitude, the more energy a wave carries in a given time interval. For a mechanical wave, the energy transferred is proportional to the square of the wave's amplitude. When the amplitude of a mechanical wave is doubled, the energy it carries in a given time interval increases by a factor of four. Conversely, when the amplitude is halved, the energy decreases by a factor of four.

As with a mass-spring system or a simple pendulum, the amplitude of a wave gradually diminishes over time as its energy is dissipated. This effect, called *damping*, is usually minimal over relatively short distances. For simplicity, we have disregarded damping in our analysis of wave motions.

SECTION REVIEW

1. As waves pass by a duck floating on a lake, the duck bobs up and down but remains in essentially one place. Explain why the duck is not carried along by the wave motion.

2. Sketch each of the following waves that are on a spring that is attached to a wall at one end:
   - **a.** a pulse wave that is longitudinal
   - **b.** a periodic wave that is longitudinal
   - **c.** a pulse wave that is transverse
   - **d.** a periodic wave that is transverse

3. Draw a graph for each of the waves described in items **(b)** and **(d)** above, and label the *y*-axis of each graph with the appropriate variable. Label the following on each graph: crest, trough, wavelength, and amplitude.

4. If the amplitude of a sound wave is increased by a factor of four, how does the energy carried by the sound wave in a given time interval change?

5. The smallest insects that a bat can detect are approximately the size of one wavelength of the sound the bat makes. What is the minimum frequency of sound waves required for the bat to detect an insect that is 0.57 cm long? (Assume the speed of sound is 340 m/s.)