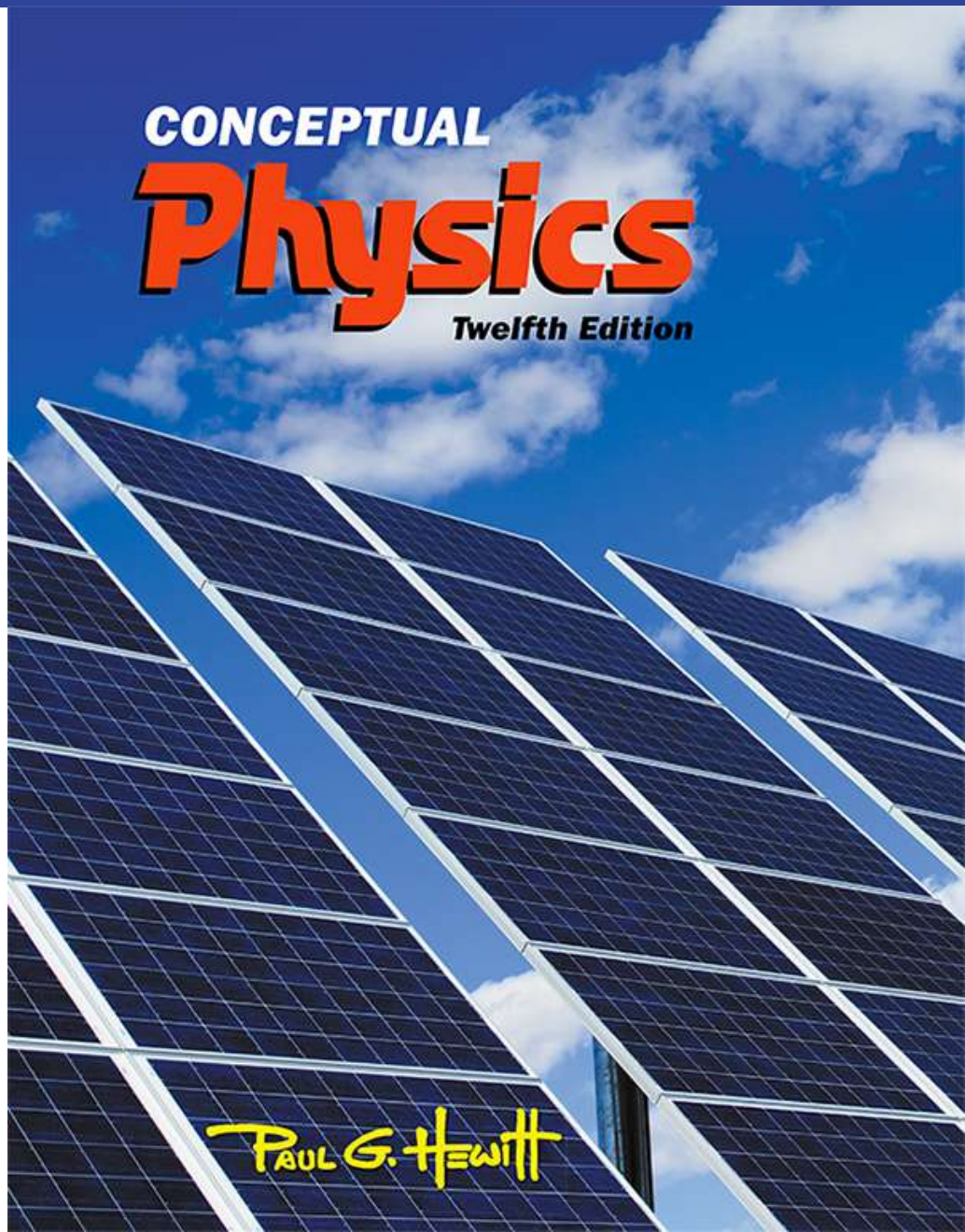
Lecture Outline



Chapter 19: Vibrations And Waves

Part 2

Review

1. An electric toothbrush completes 90 cycles every second. What are (a) its frequency and (b) its period?

2. Gusts of wind make the Willis Tower in Chicago sway back and forth, completing a cycle in 10 s. What are (a) its frequency and (b) its period?

- Wave motion
  - Waves transport energy and not matter.

Examples:

- Drop a stone in a quiet pond and the resulting ripples carry no water across the pond.
- Waves travel across grass on a windy day. The grass does not travel across the field.
- Molecules in air propagate a disturbance (a sound) through the air.

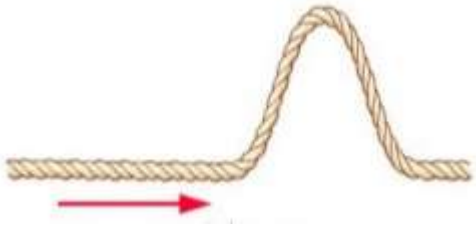
Classwork: Start a new sheet of paper.

9. In one word, what is it that moves from source to receiver in wave motion?

10. Does the medium in which a wave travels move with the wave?

A pulse vs a wave

A pulse = a single disturbance of the medium that propagates (moves) through a medium



A wave = a series of periodic pulses

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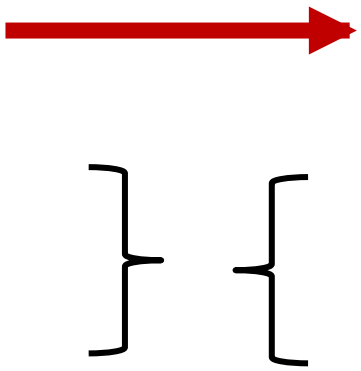

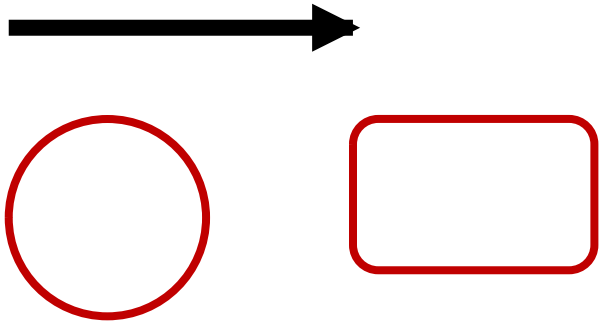

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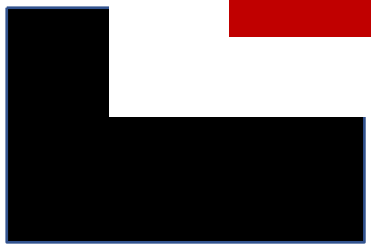
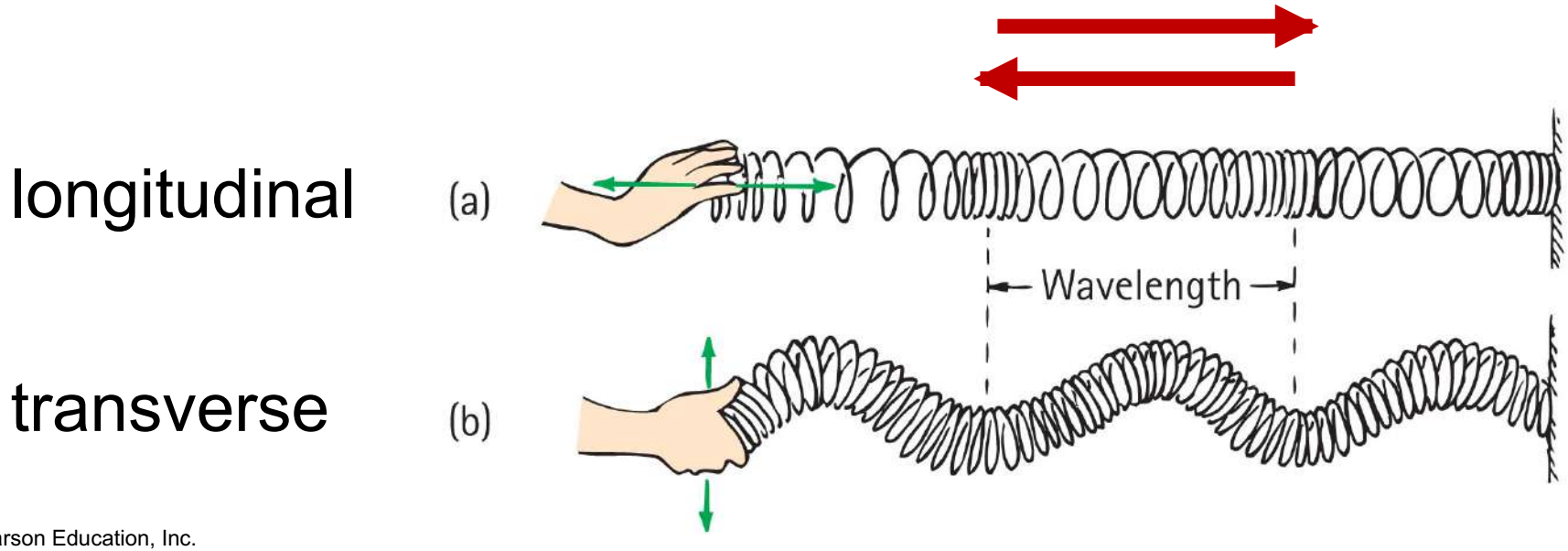
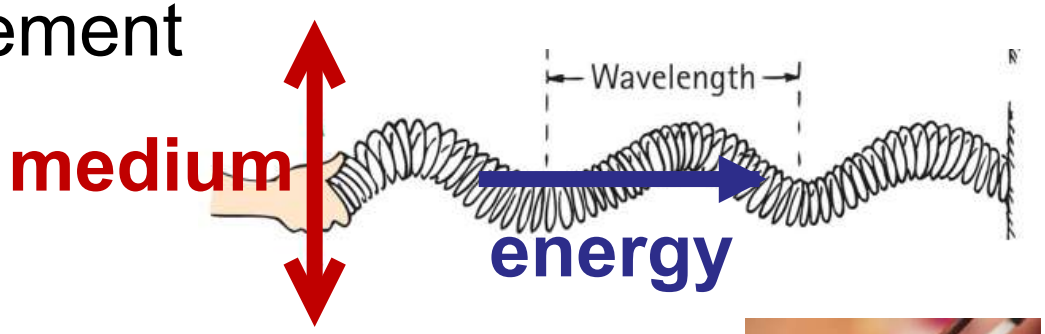


Transverse and Longitudinal Waves

- Two common types of waves that differ because of the direction in which the medium vibrates compared with the direction of travel:
  - longitudinal wave
  - transverse wave



- Transverse wave
  - Medium vibrates perpendicularly to direction of energy transfer (wave velocity)
  - Side-to-side movement



Examples:

- Vibrations in stretched strings of musical instruments

- Radio waves and light waves

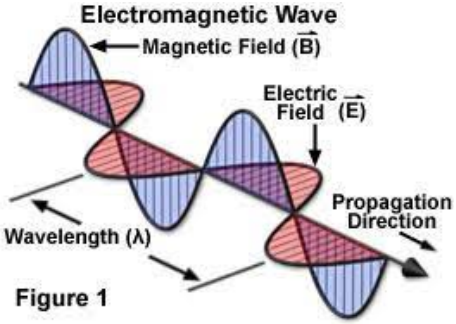


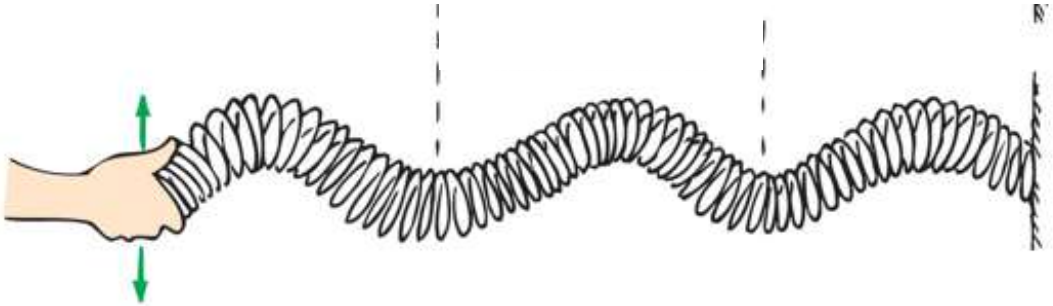
Figure 1

11. In what direction are the vibrations relative to the direction of wave travel in a transverse wave?

Transverse Waves
CHECK YOUR NEIGHBOR

The distance between adjacent peaks in the direction of travel for a transverse wave is its

A. frequency.
B. period.
C. wavelength.
D. amplitude.



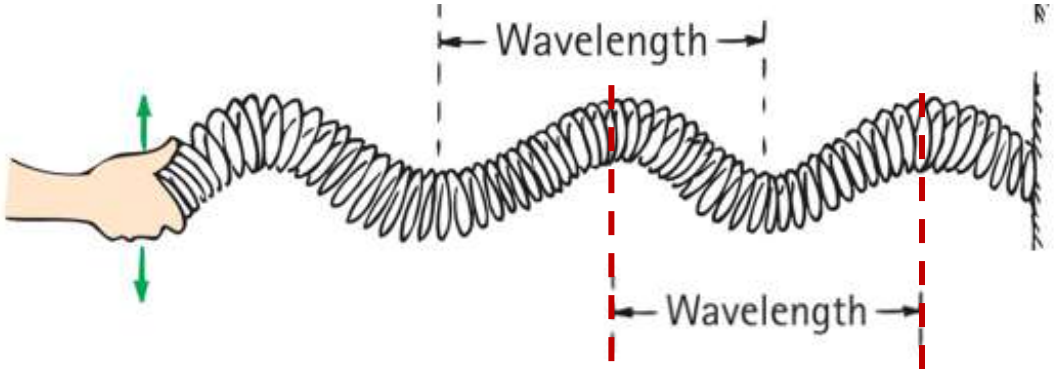
Transverse Waves
CHECK YOUR ANSWER

The distance between adjacent peaks in the direction of travel for a transverse wave is its

C. wavelength.

Explanation:

The wavelength of a transverse wave is also the distance between adjacent troughs, or between any adjacent identical parts of the waveform.

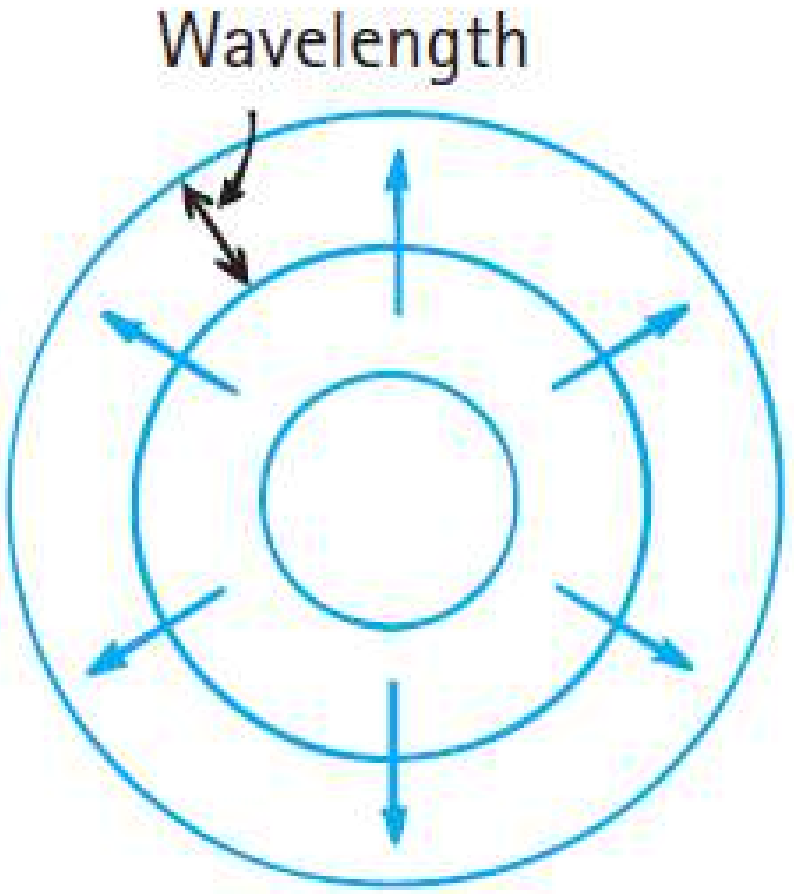


Wavefronts

Drop rock in pond.
Waves move in circles

Distance from peak to peak is wavelength.

These circles are called *wavefronts*.



Transverse Waves
CHECK YOUR NEIGHBOR, Continued

The vibrations along a transverse wave move in a direction

A. along the wave.
B. perpendicular to the wave.
C. Both A and B.
D. Neither A nor B.

Transverse Waves
CHECK YOUR ANSWER, Continued

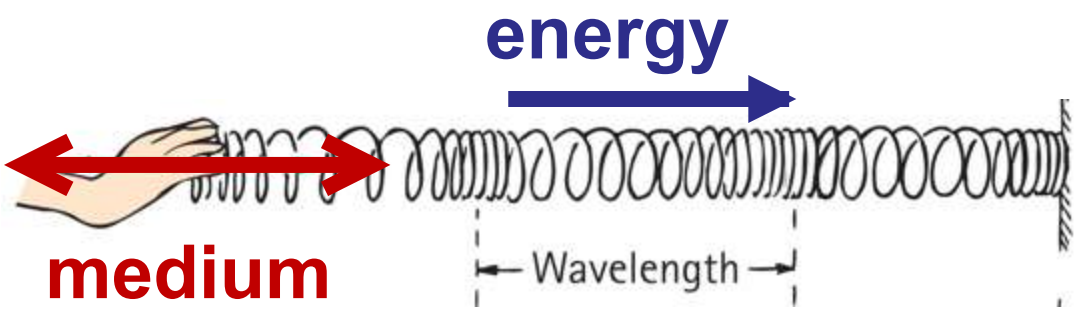
The vibrations along a transverse wave move in a direction

B. perpendicular to the wave.

Comment:

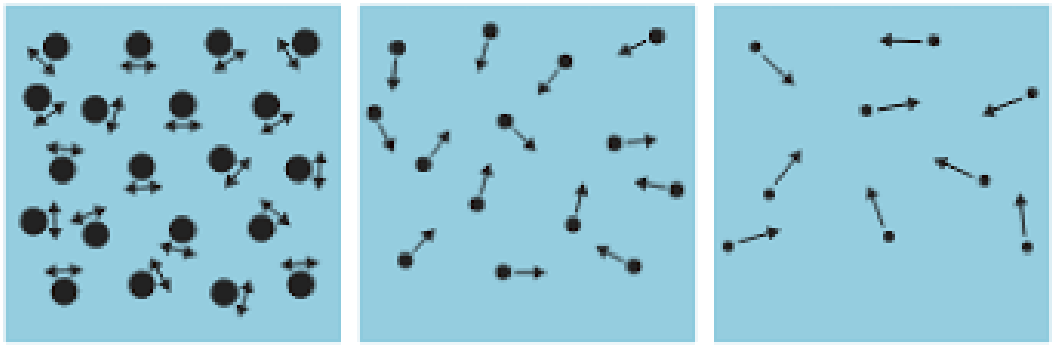
The vibrations in a longitudinal wave, in contrast, are along (or parallel to) the direction of wave travel.

- Longitudinal wave
  - Medium vibrates parallel to direction of energy transfer



Example: sound waves in solid, liquid, gas

The molecules transfer the energy by to and fro collisions

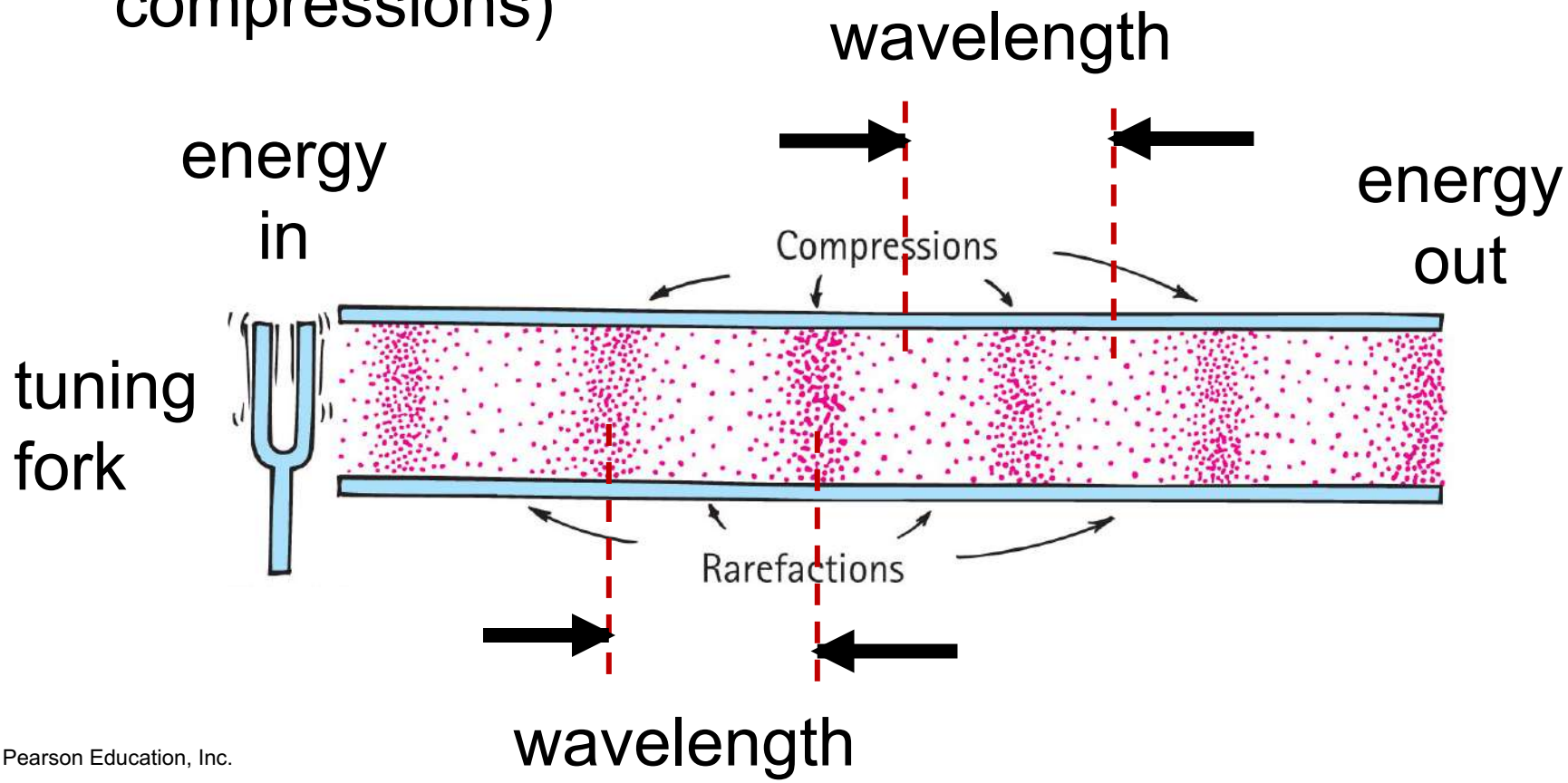


12. In what direction are the vibrations relative to the direction of wave travel in a longitudinal wave?

Sound is a longitudinal wave

Backward and forward movement consists of:

1) compressions (wave compressed)
2) rarefactions (stretched region between compressions)



Longitudinal Waves
CHECK YOUR NEIGHBOR

The wavelength of a longitudinal wave is the distance between

A. successive compressions.
B. successive rarefactions.
C. Both A and B.
D. None of the above.

Longitudinal Waves
CHECK YOUR ANSWER

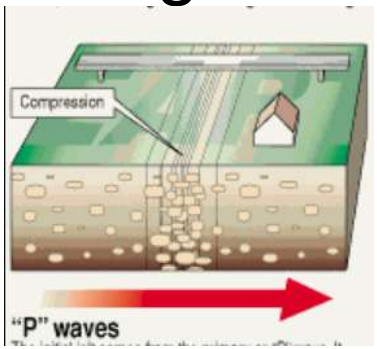
The wavelength of a longitudinal wave is the distance between

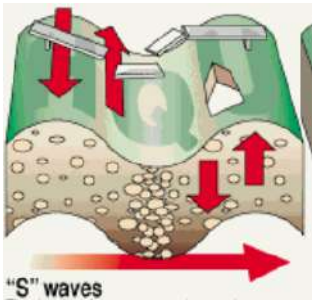
C. Both A and B.

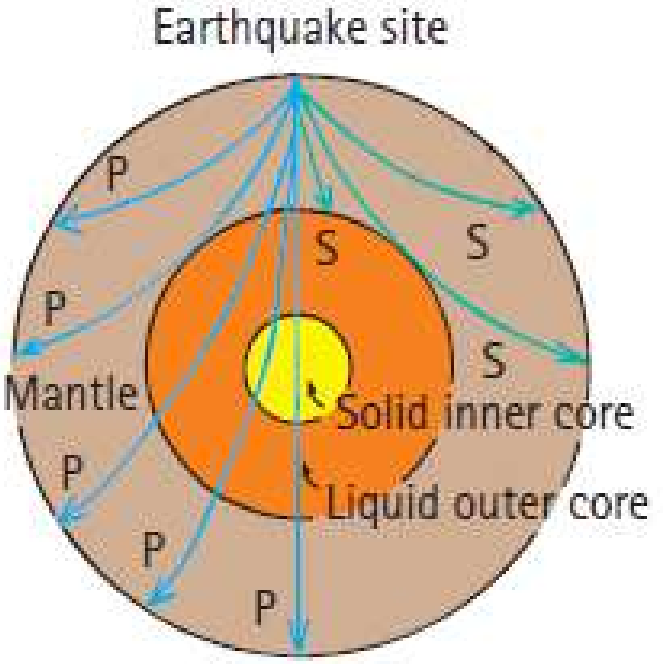
13. The wavelength of a transverse wave is the distance between successive crests (or troughs). What is the wavelength of a longitudinal wave?

Earthquake waves

Can be longitudinal or transverse:







Transverse waves (S waves):

slower

cannot travel through liquids

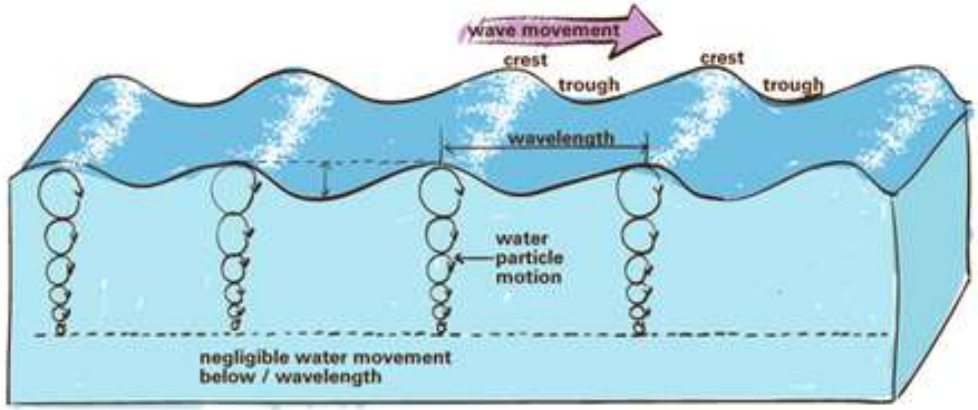
Longitudinal (P waves):

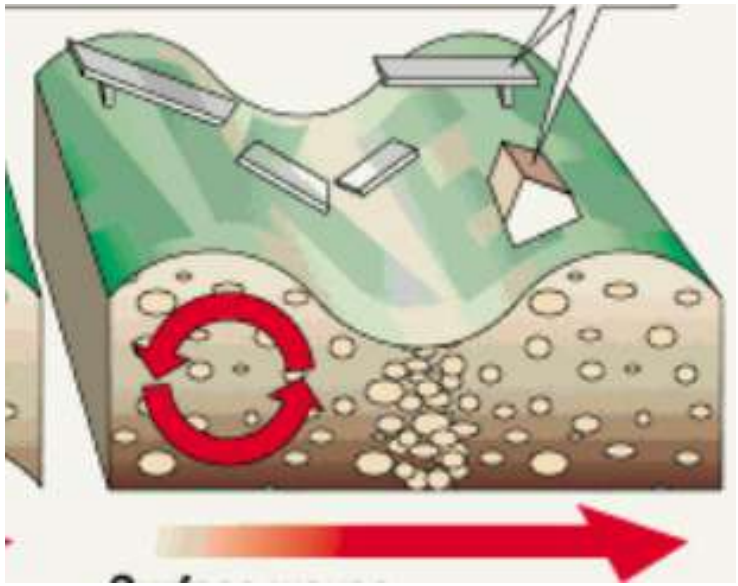
faster

can travel through solids and liquids

Water and earthquake waves:

Some earthquake waves are like water waves:





The medium moves in circles or ellipses.

Combination of transverse and longitudinal.

Wave speed

How fast a disturbance moves through a medium

$$\text{speed} = \frac{distance}{time}$$

A wave moves distance of 1 wavelength in time of 1 period.

So, $\text{wave speed} = \frac{wavelength}{period}$

Because $\frac{1}{period}$ = frequency, this can be written:

wave speed = frequency x wavelength

14. What is the relationship among frequency, wavelength, and wave speed?

Wave speed with symbols:

Wave speed = frequency x wavelength

$$v = f \times \lambda$$

v = speed

f = frequency

λ (lambda) = the wavemength

2. If a water wave oscillates up and down three times each second and the distance between wave crests is 2 m, what is its frequency? What is its wavelength? What is its wave speed?

Wave Speed
CHECK YOUR NEIGHBOR

A wave with wavelength 10 meters and time between crests of 0.5 second is traveling in water. What is the wave speed?

A. 0.1 m/s
B. 2 m/s
C. 5 m/s
D. 20 m/s

Wave Speed
CHECK YOUR ANSWER

A wave with wavelength 10 meters and time between crests of 0.5 second is traveling in water. What is the wave speed?

D. 20 m/s **Explanation:** $\text{Frequency} = \frac{1}{\text{period}}$

So: $\text{Frequency} = \frac{1}{0.5\ \text{s}} = 2\ \text{Hz}$

Also: Wave speed = frequency x wavelength

So: Wave speed = 2 Hz x 10 m = 20 m/s

34. What is the speed of a water wave of frequency 2 Hz and wavelength 1.5 m?

35. How fast does a 200-Hz sound wave with a wavelength of 1.7 m travel?