Waves and Sound

- 11 Harmonic Motion
- 12 Properties of Waves
- 13 Sound
- 14 Light

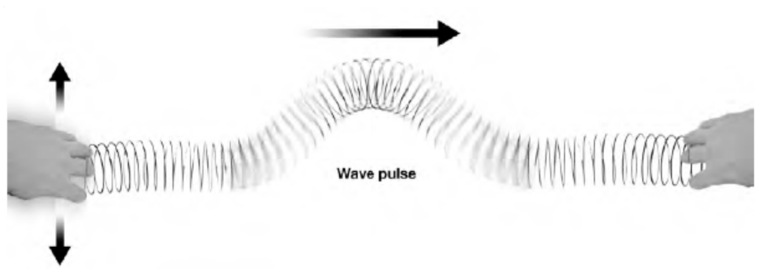
Chapter 12 Learning Goals

- Describe the properties and behavior of waves.
- Calculate the speed of waves.
- Demonstrate an understanding of wave interactions.

Investigation 12

Waves in Motion

- **Key Question:**
  How do waves move?

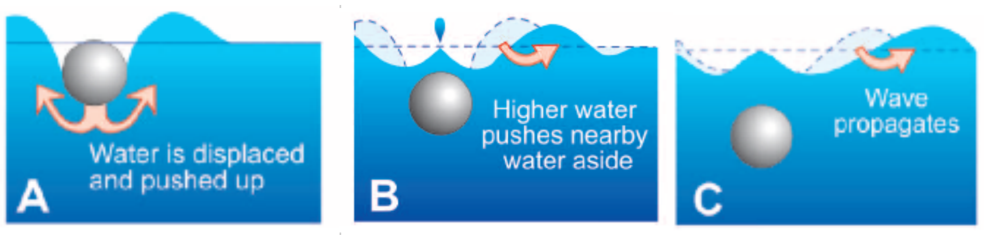


What is a wave?

- A wave is an oscillation that travels from one place to another.
- If you poke a floating ball, it oscillates up and down.
- The oscillation spreads outward from where it started.

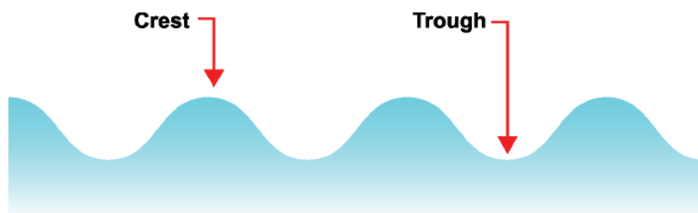
Waves

- When you drop a ball into water, some of the water is pushed aside and raised by the ball.



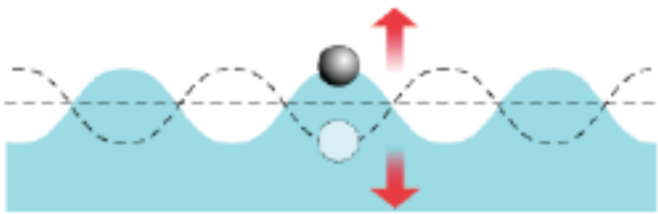
Parts of a wave

- You can think of a wave as a moving series of high points and low points.
- A crest is the high point of the wave.
- A trough is the low point.



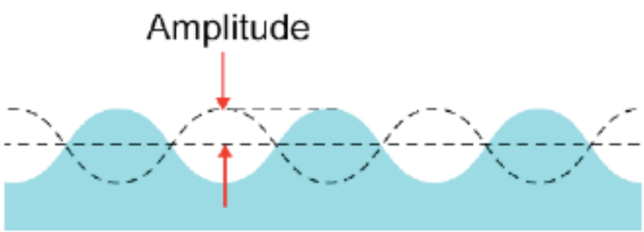
Parts of a wave

- The frequency of a wave is the rate at which every point on the wave moves up and down.
- Frequency means “how often”.



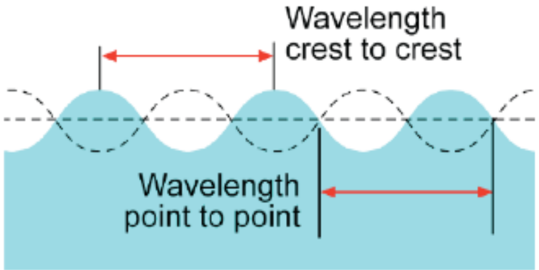
Parts of a wave

- The amplitude of a water wave is the maximum height the wave rises above the level surface.

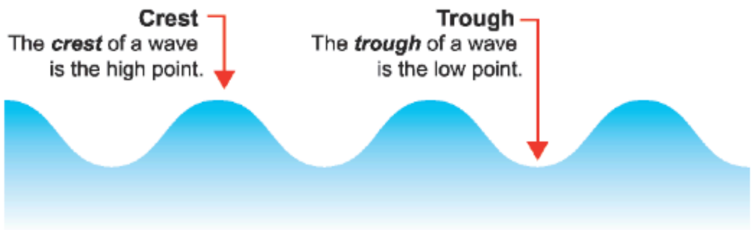


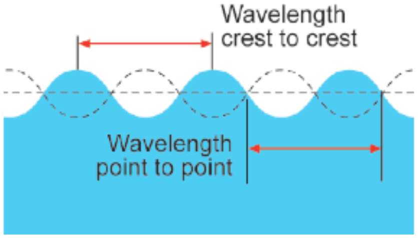
Parts of a wave

- Wavelength is the distance from any point on a wave to the same point on the next cycle of the wave.
- The distance between one crest and the next crest is a wavelength.



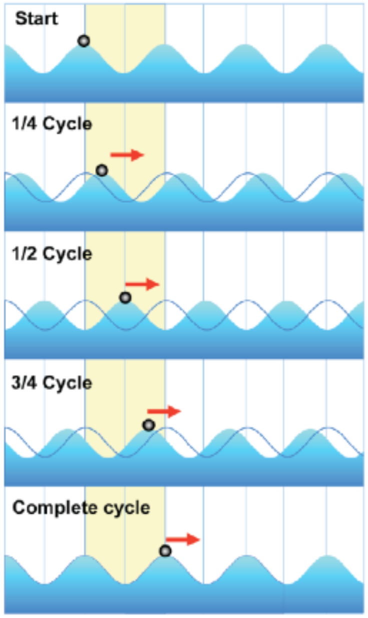
Frequency, Amplitude and Wavelength





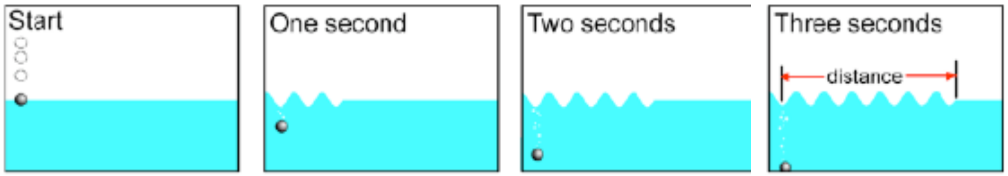
The speed of waves

- A wave moves one wavelength in each cycle.
- Since a cycle takes one period, the speed of the wave is the wavelength divided by the period.



The speed of waves

- The speed of a water wave is how fast the wave spreads, NOT how fast the water surface moves up and down or how fast the dropped ball moves in the water.



How do we measure the wave speed?

The speed of waves

- The speed is the distance traveled (one wavelength) divided by the time it takes (one period).
- We usually calculate the speed of a wave by multiplying wavelength by frequency.

$$Speed = \frac{\text{Distance traveled}}{\text{Time taken}} = \frac{\text{Wavelength}}{\text{Period}} = \left(\frac{1}{\text{Period}}\right) \times \text{Wavelength}$$

$$Speed = Frequency \times Wavelength$$

cpo science
making it real.

Solving Problems: Wave Speed

WAVE SPEED

Frequency (hertz or $\frac{1}{T}$)

Period (s)

Speed (m/s) $v = f\lambda$

Wavelength (m)

Solving Problems

The wavelength of a wave on a string is 1 meter and its speed is 5 m/s.

Calculate the frequency and the period of the wave.

Remember these relationships...

period = T

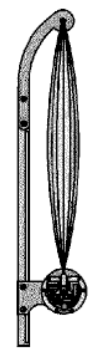
frequency = $^1/_T$

Speed = wavelength ÷ period

Speed = frequency × wavelength

Solving Problems

1. **Looking for:**
   - ...frequency in hertz
   - ...period in seconds
2. **Given**
   - ...λ = 1 m; s = 5 m/s
3. **Relationships:**
   - s = f x λ or f = s ÷ λ
   - f = 1/T or T = 1/f
4. **Solution**
   - f = 5 m/s ÷1 m = 5 cycles/ s



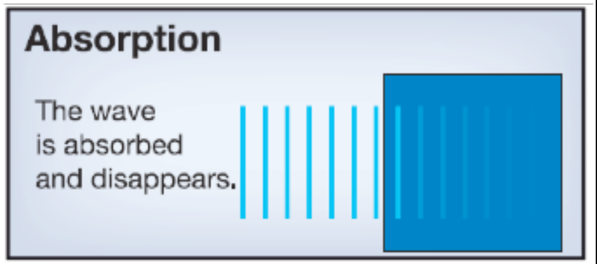
***f* = 5 Hz**

T = .2 s

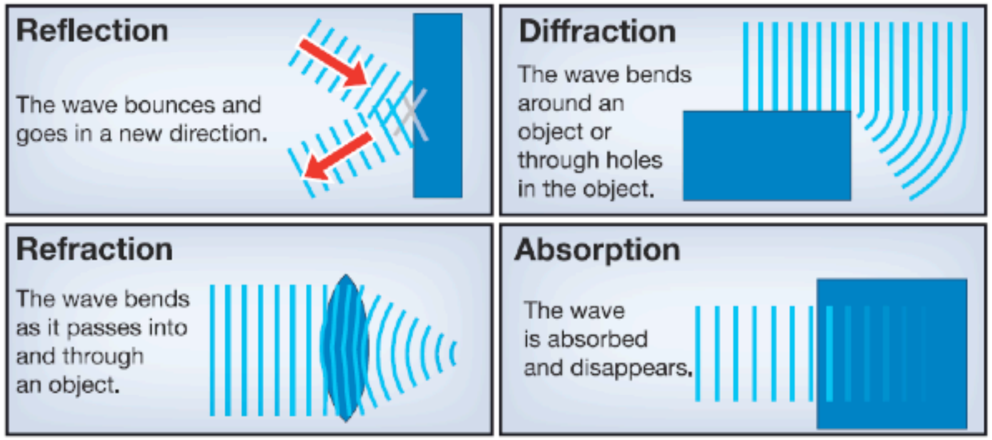
Four wave interactions

- When a wave encounters a surface, four interactions can occur:

1. reflection,
2. refraction,
3. diffraction, or
4. absorption.



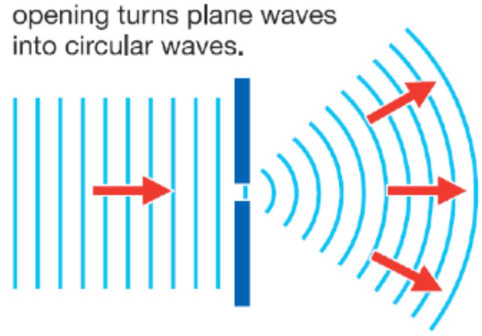
Wave Interactions



Wave interactions

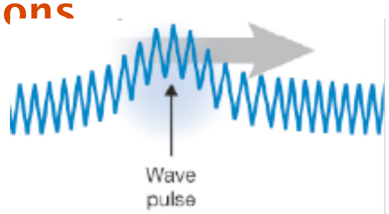
- Diffraction usually changes the direction and shape of the wave.
- When a plane wave passes through a small hole diffraction turns it into a circular wave.

Diffraction through a small opening turns plane waves into circular waves.



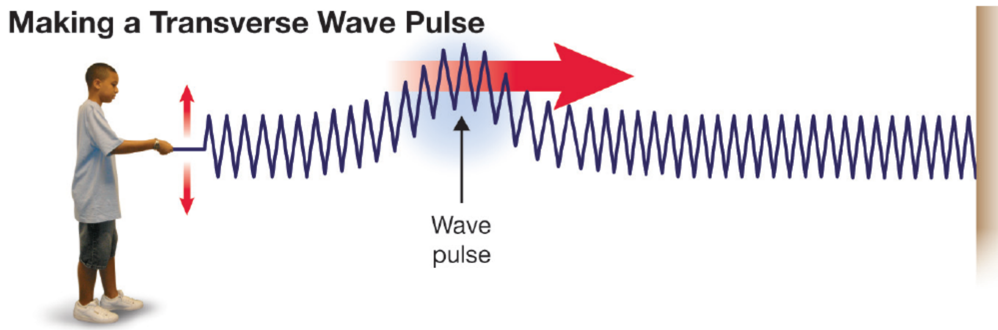
Transverse and longitudinal waves

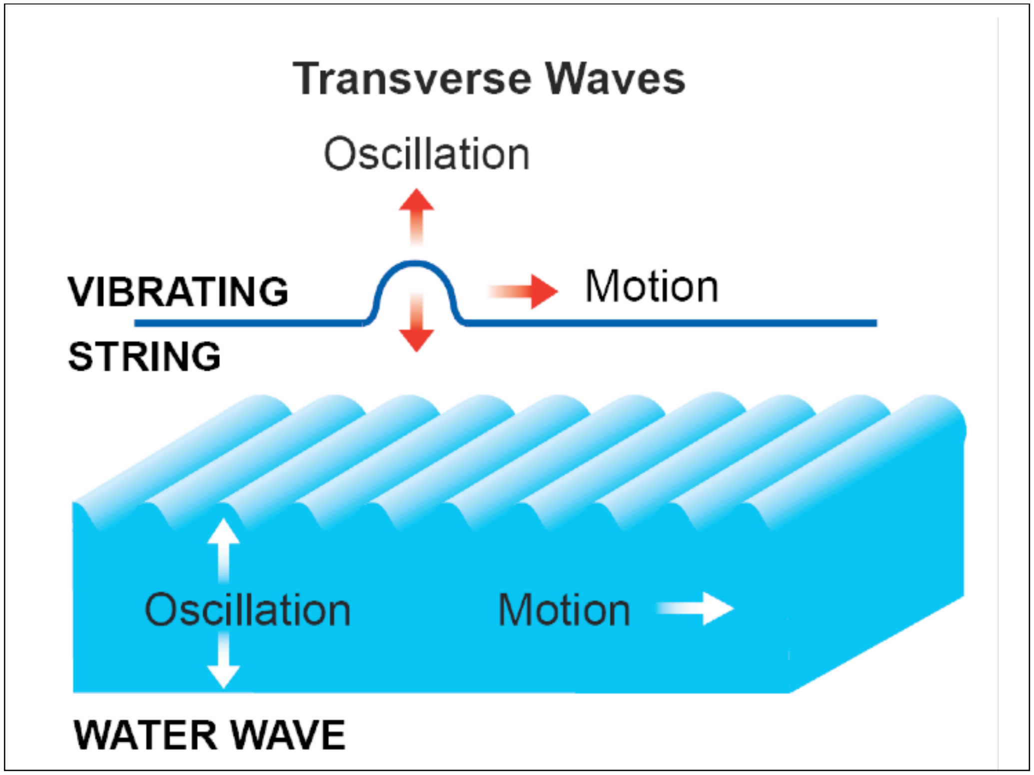
- A wave pulse is a short ‘burst’ of a traveling wave.
- It is sometimes easier to see the motion of wave pulses than it is to see long waves with many oscillations.



Transverse waves

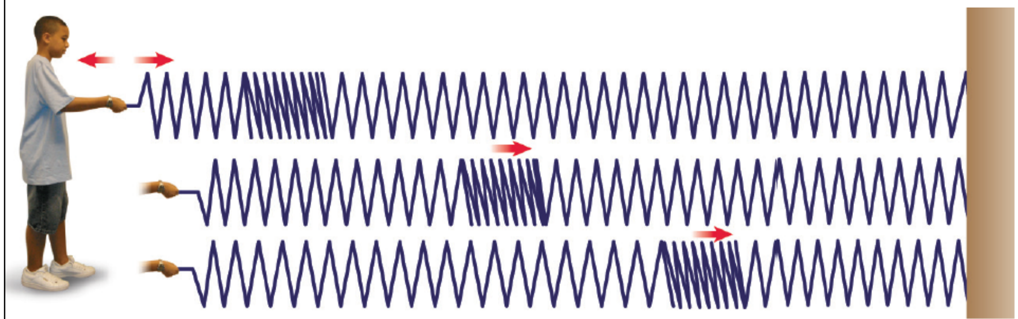
- The oscillations of a transverse wave are not in the direction the wave moves.



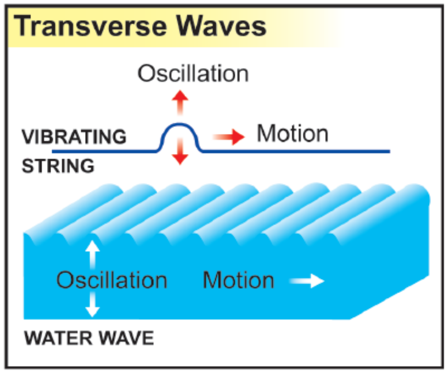

Transverse Waves
Oscillation
VIBRATING
STRING
Motion
Oscillation
Motion
WATER WAVE

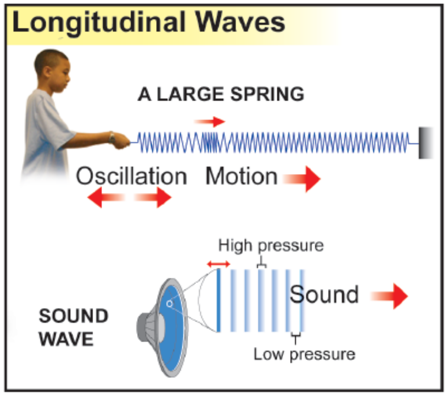
Longitudinal waves

- The oscillations of a longitudinal wave are in the same direction that the wave moves.



Transverse and Longitudinal Waves

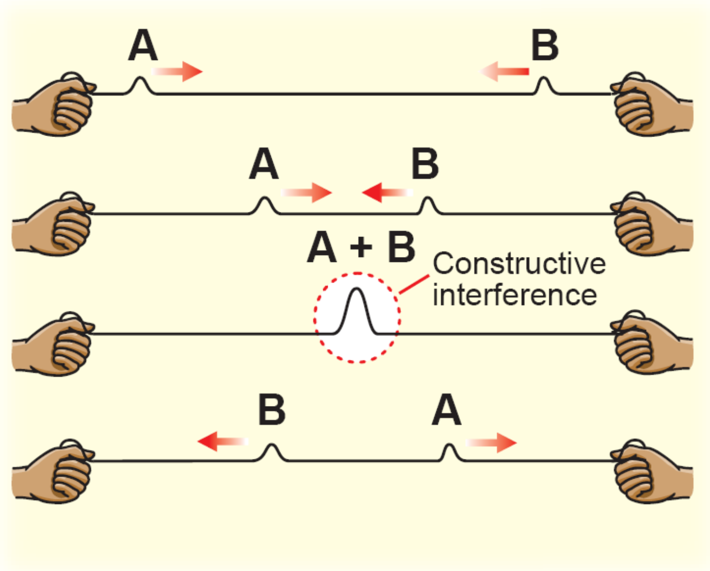




Constructive interference

- Constructive interference happens when waves add up to make a larger amplitude.
- Suppose you make two wave pulses on a stretched string.
- One comes from the left and the other comes from the right.
- When the waves meet, they combine to make a single large pulse.

Constructive Interference

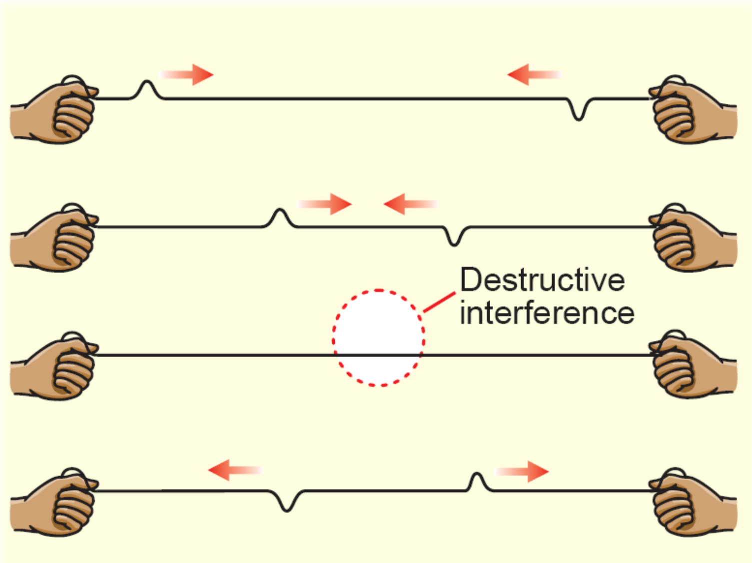


Two wave pulses that are in phase can add up to make a single, bigger pulse when they meet.

Destructive interference

- What happens when one pulse is on top of the string and the other is on the bottom?
- When the pulses meet in the middle, they cancel each other out.
- During destructive interference, waves add up to make a wave with smaller or zero amplitude.

Destructive Interference



Two equal wave pulses that are out of phase will subtract when they meet. The upward movement of one pulse can exactly cancel the downward movement of the other.