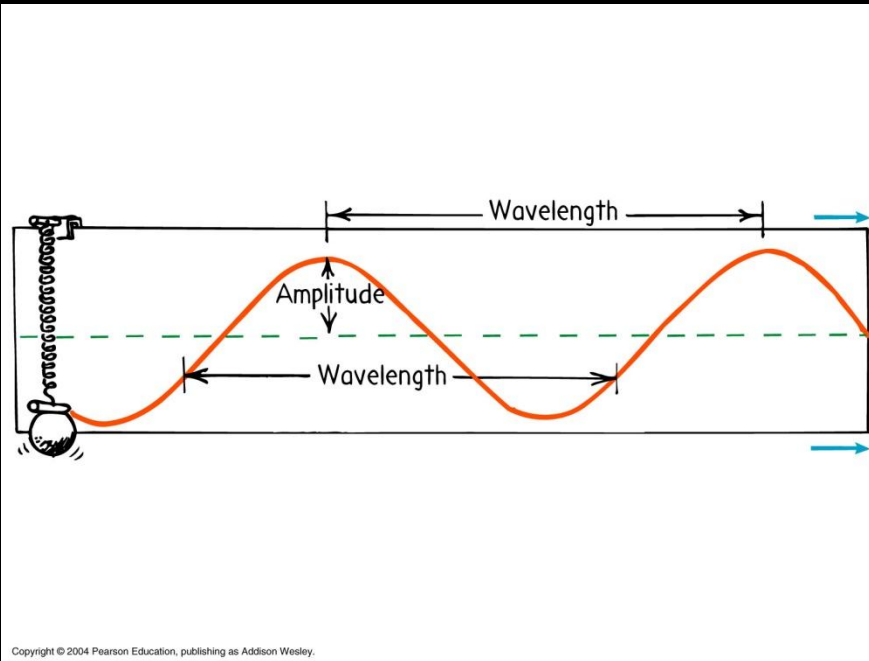


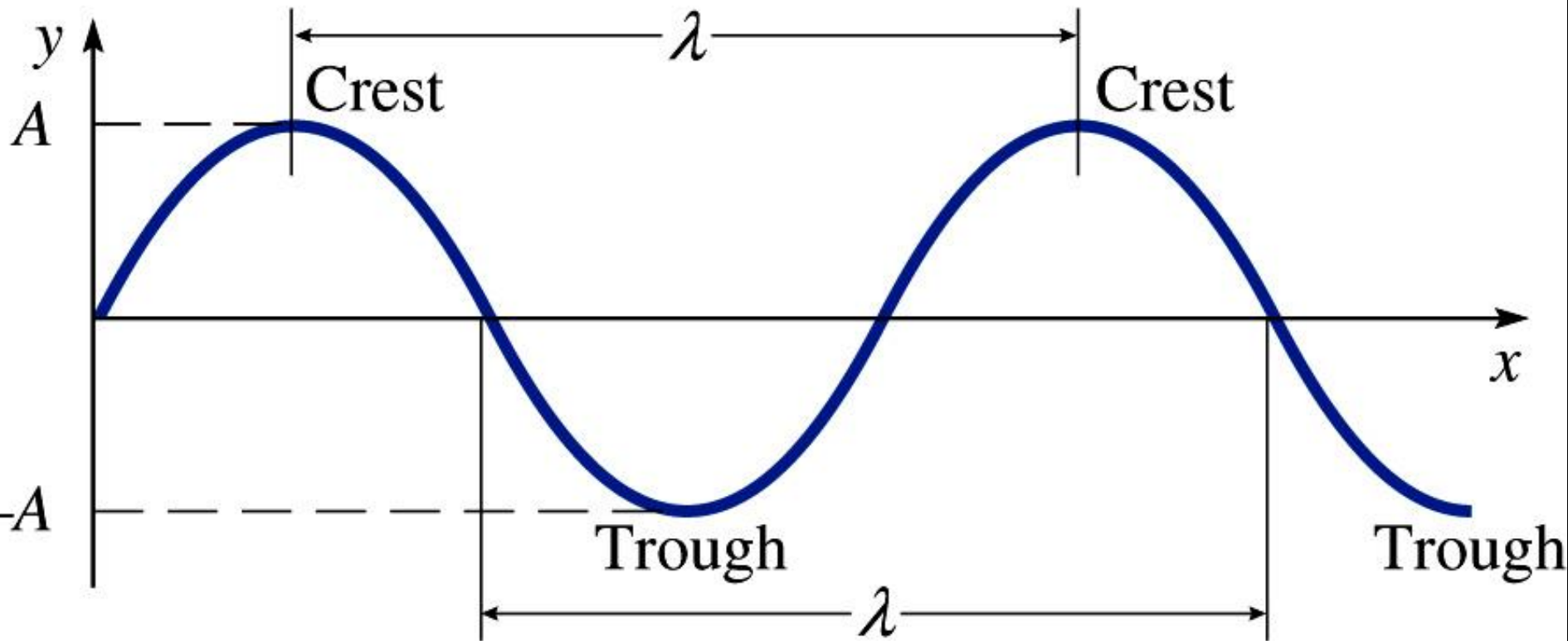
# Waves



A wiggle in time  
is a vibration.

A wiggle in time  
and space is a  
wave.

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The human ear relates  
**amplitude to**  
**loudness**  
**and**  
**frequency to**  
**pitch.**



# Definition: Wave

- A wave can be described as a disturbance that travels through a medium from one location to another location.

# Frequency & Period

$$\textit{frequency} = \frac{1}{\textit{period}}$$

$$\textit{period} = \frac{1}{\textit{frequency}}$$

# Frequency & Period

- If the frequency goes up what happens to the period?

The period goes down

- If the frequency goes from 1 hz to 2 hz, what happens to the period?

The period goes from 1 to  $\frac{1}{2}$  second.

- If the frequency goes from 1 hz to 10 hz, what happens to the period?

The period goes from 1 second to  $\frac{1}{10}$ <sup>th</sup> second.

# Wave Speed

$$V = f\lambda$$

Wavelength (m)



Wavespeed  
(m/s)

Frequency (Hz)

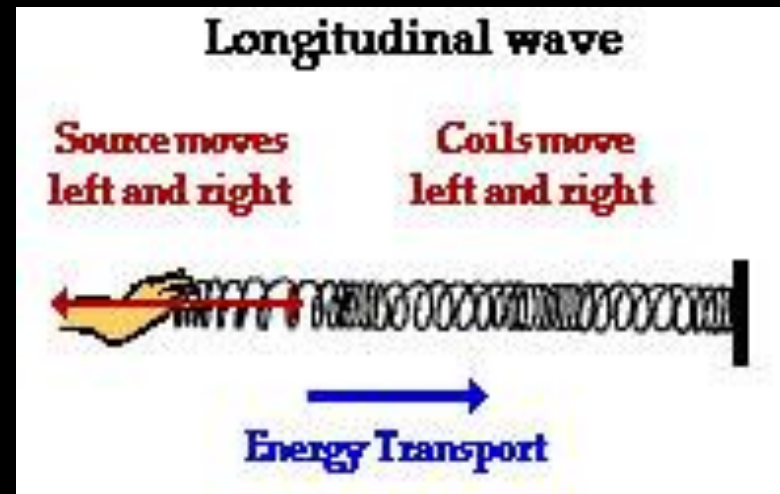
# Example

- If the frequency is 2 Hz and the wavelength is 5 meters, what is the wave speed?
- Answer: 10 m/s



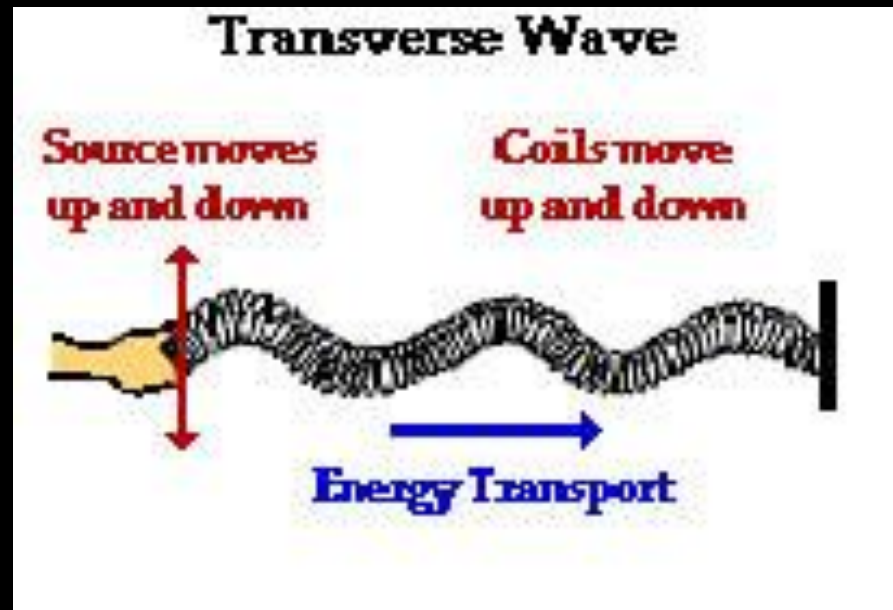
# Longitudinal Waves

- the particles of the medium move in a direction parallel to the direction of energy transport.



# Transverse Waves

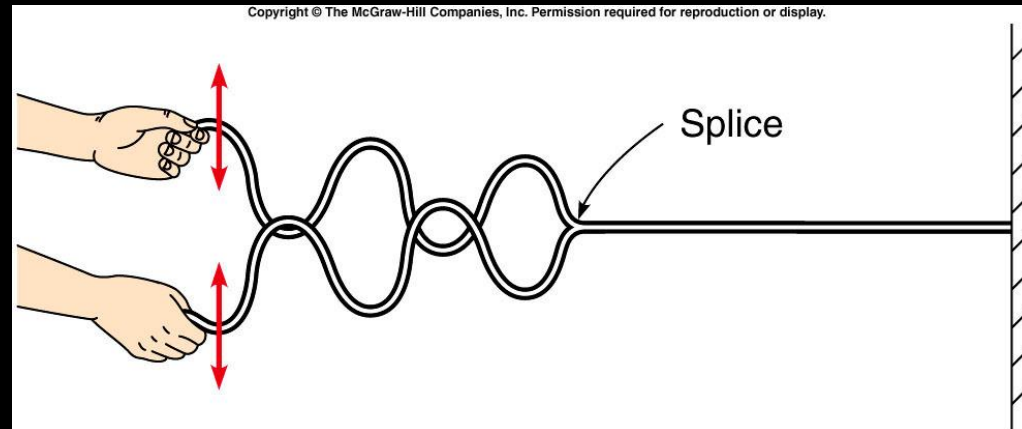
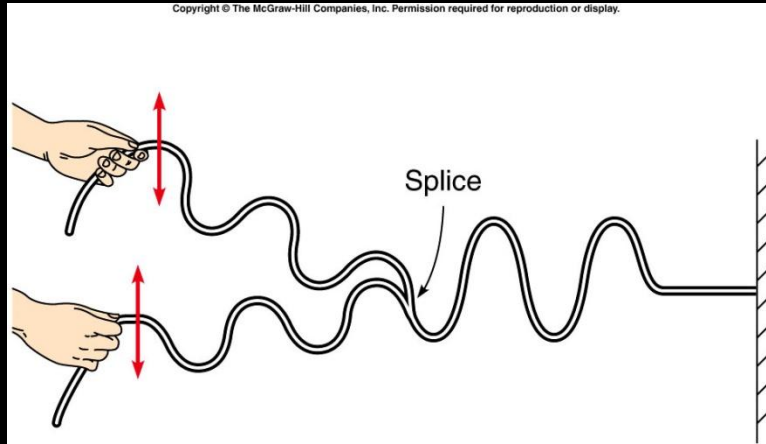
- A transverse wave is a wave in which particles of the medium move in a direction perpendicular to the direction which the wave moves.



# Transverse vs. Longitudinal

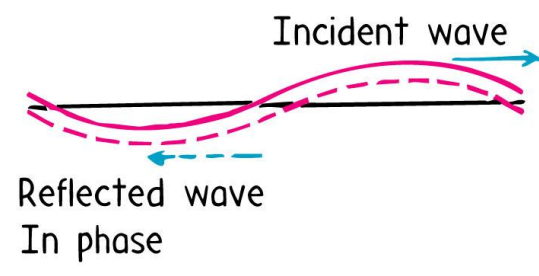
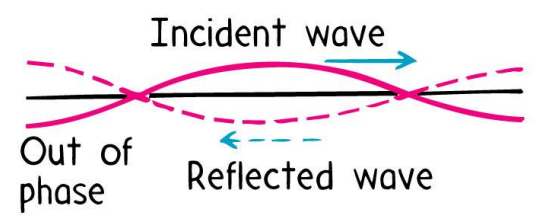
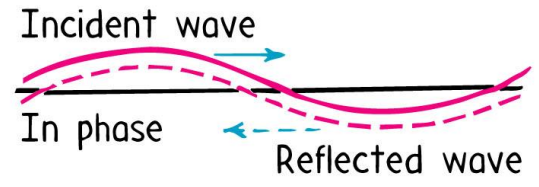
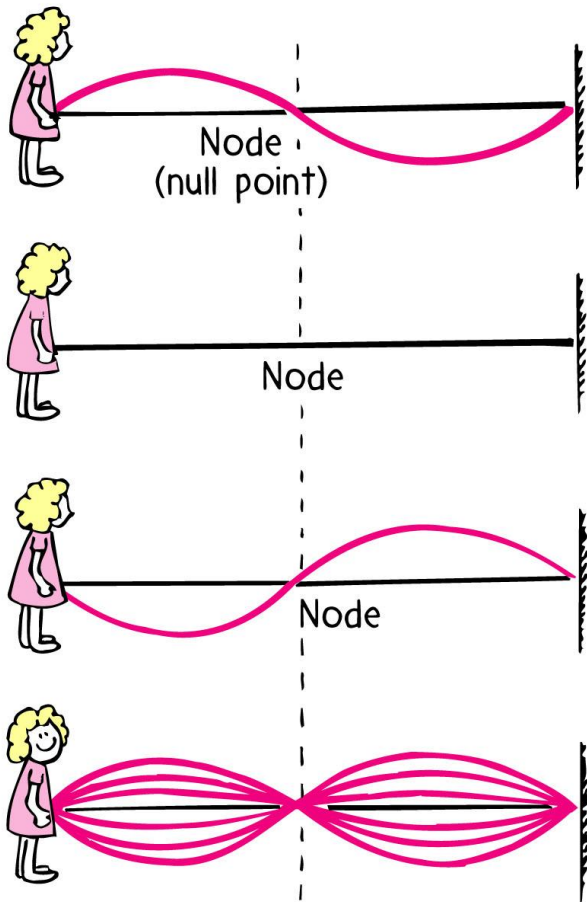
- <http://www.physics.northwestern.edu/vpl/waves/wavetypes.html>

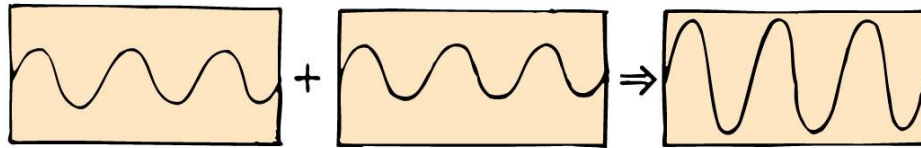
# How do two waves on a rope combine?



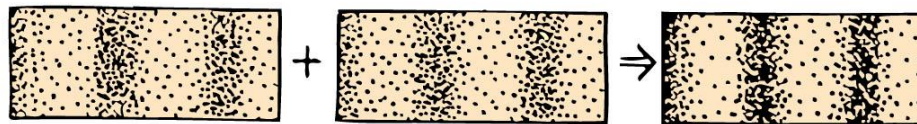
# Principles of Superposition

[http://www.kettering.edu/~drussell/  
Demos/superposition/superpositio  
n.html](http://www.kettering.edu/~drussell/Demos/superposition/superposition.html)

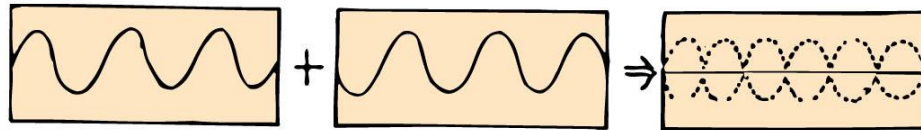




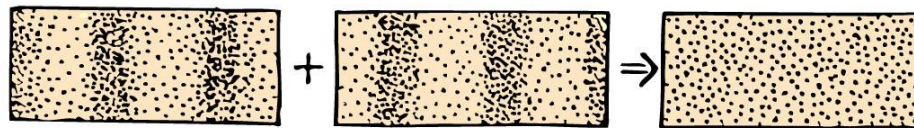
The superposition of two identical transverse waves in phase produces a wave of increased amplitude.



The superposition of two identical longitudinal waves in phase produces a wave of increased intensity.



Two identical transverse waves that are out of phase destroy each other when they are superimposed.



Two identical longitudinal waves that are out of phase destroy each other when they are superimposed.

# Speed of Sound

The speed of sound depends on the type of medium and temperature.

- 340 m/s in air.
- 1500 m/s in water
- 5100 m/s in steel.



The velocity of sound in air depends on the air temperature. The speed of sound in dry air is  $331.5 \text{ m/s}$  at  $0 \text{ }^\circ\text{C}$ .



This speed increases with temperature: about  $0.6 \text{ m/s}$  for every  $1 \text{ }^\circ\text{C}$  increase in temperature. What is speed at room temp?