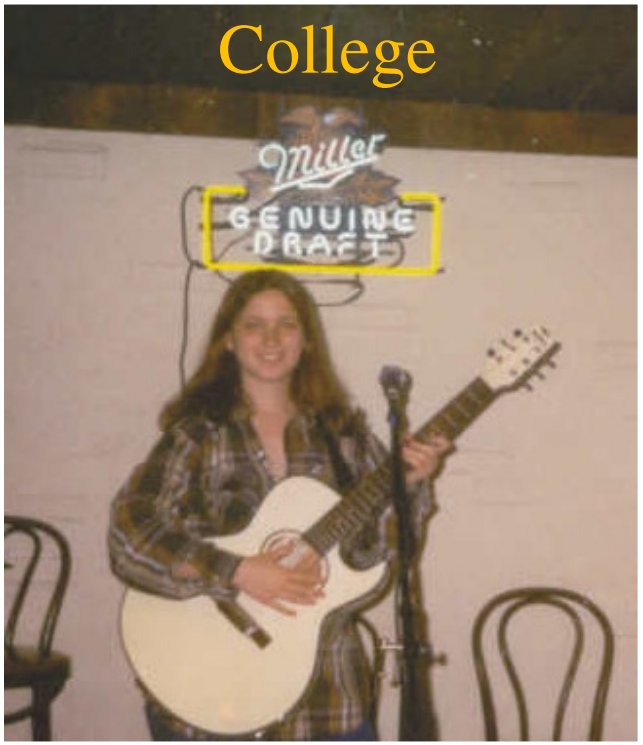
Main Idea Today: Waves

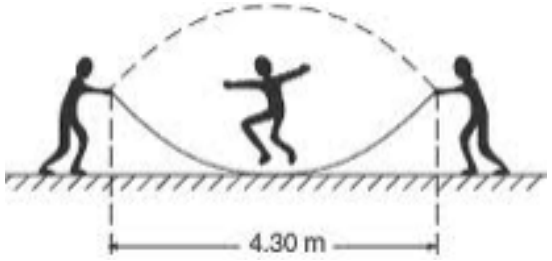
What kinds of waves do we experience while I play guitar?

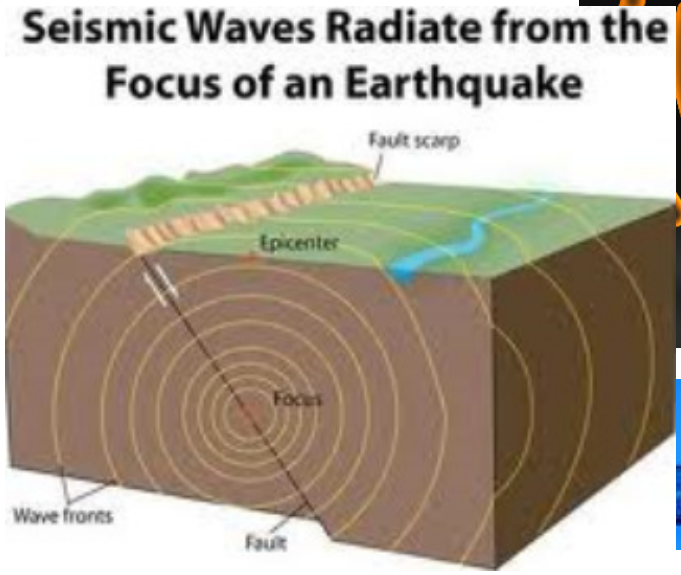
(and other kinds of waves)

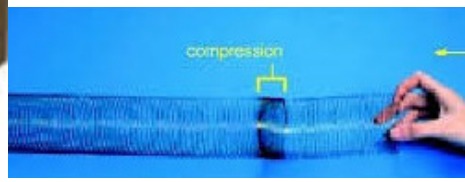


When I was your age…

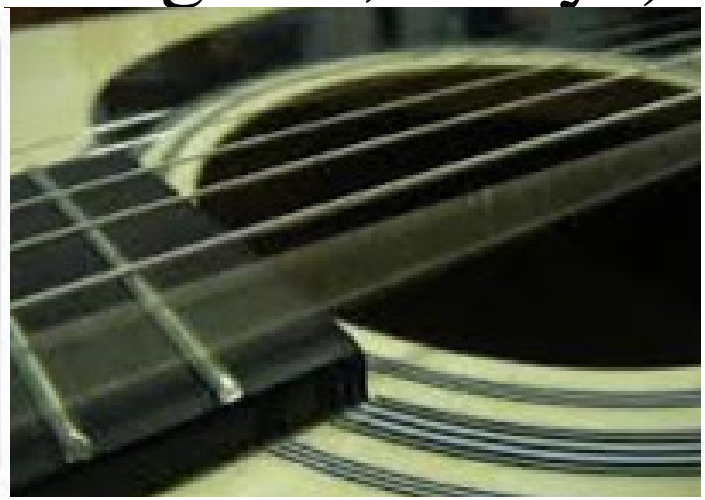
The World is Full of Waves



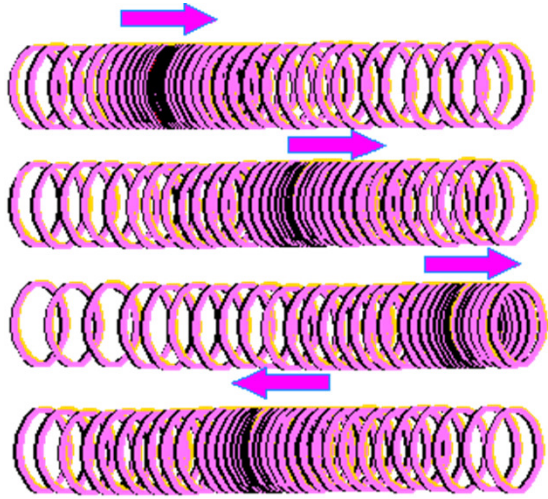




- Sound waves
- Waves on strings
- Seismic waves
- Electromagnetic waves (visible light, radio waves, television signals, x-rays)



The source of waves



- Waves are caused by some **vibration** or disturbance (a plucked string or vibration of electrons in an antenna)
- So we describe waves by simple harmonic motion
- **Mechanical waves** require
  - A medium that can be disturbed (water, air, string)
- **Light waves** (like sunlight) do not require a medium (can travel through space; starlight)

Main Ideas in Class Today

After today's class, you should be able to:

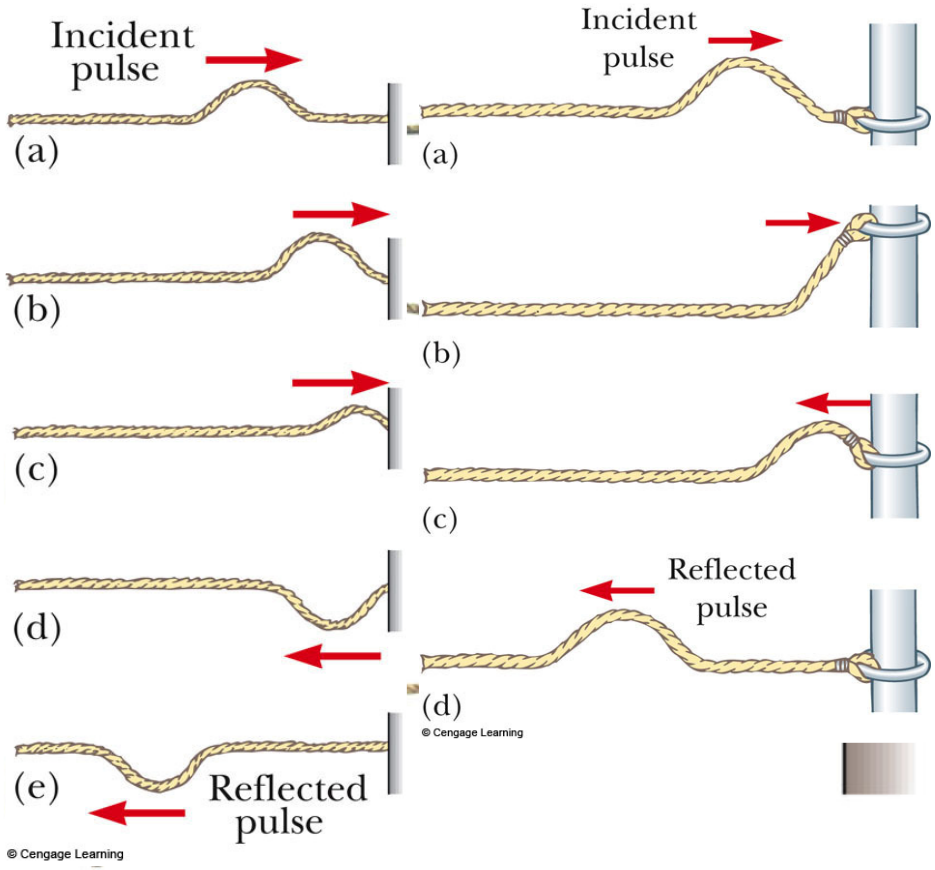
- Identify different types of waves
- Calculate wave velocity, period and frequency.
- Calculate tension or velocity for a wave on a string.
- (If time) Understand wave interference and some applications of it (otherwise quickly next time)

Suggested Practice: 13.41, 13.49, 13.51, 13.53, 13.57

What does it look like this disturbance is doing?

Traveling Waves

When you flip one end of a long rope that is under tension and fixed at one end, the pulse travels at a fixed speed



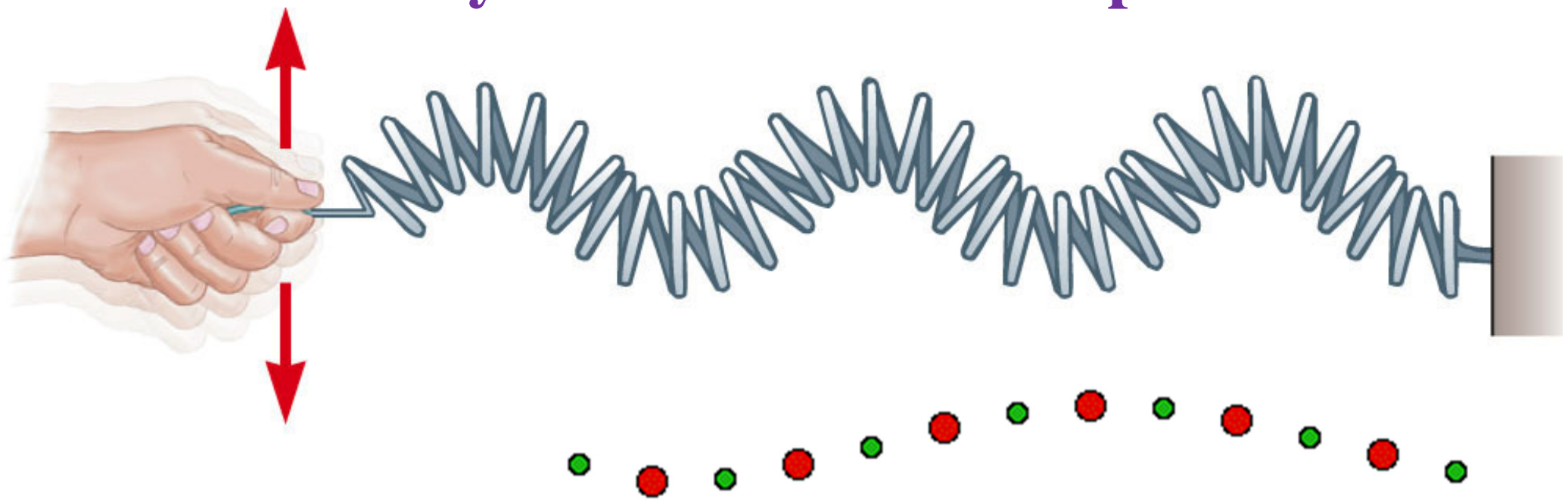
What does the wave do after it hits the wall (section 13.11)?

http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html

Types of Waves – Transverse

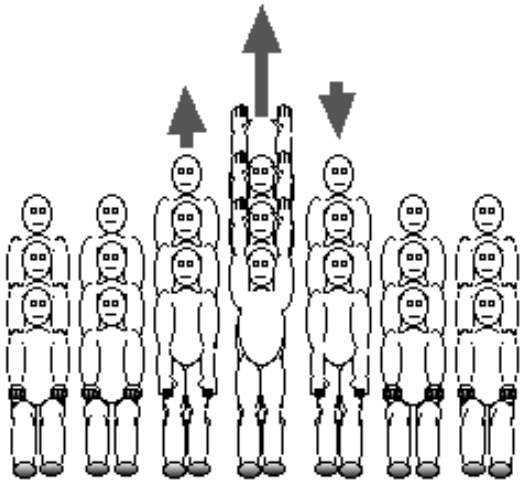
In a transverse wave, each element that is disturbed moves in a direction perpendicular to the wave motion

Can you think of an example?



Transverse: Doing "The Wave"

Synchronized standing and sitting is an example of a **transverse** wave.

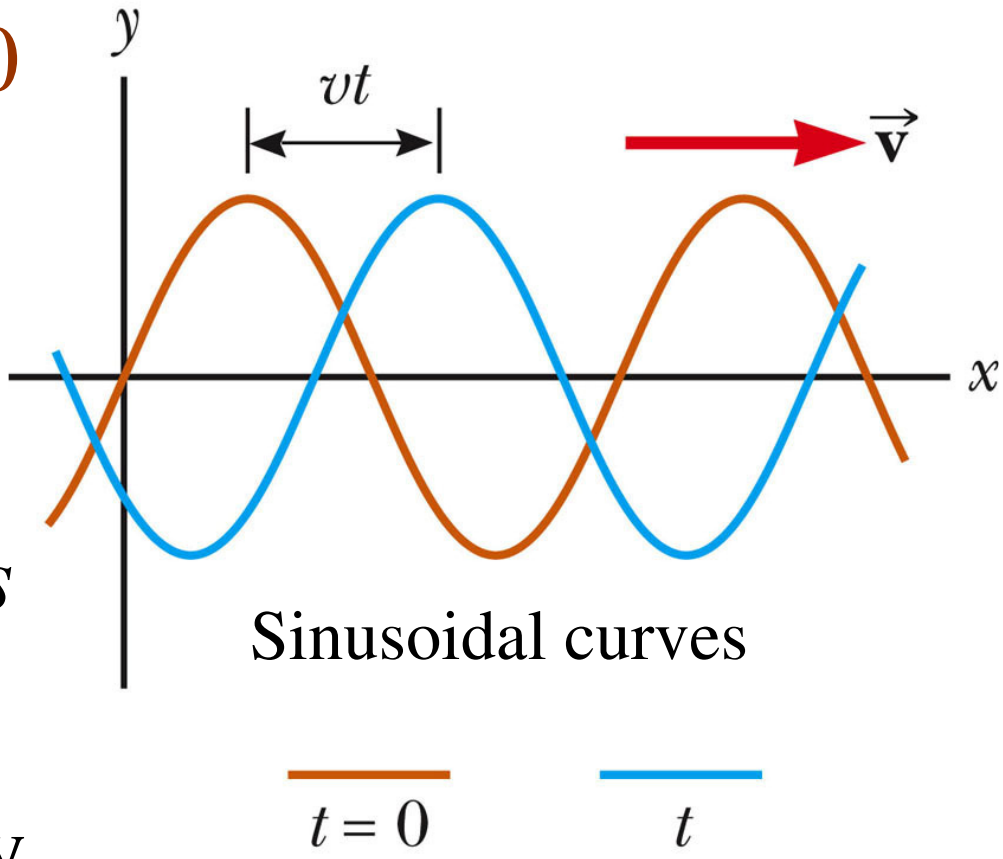


People move up and down but wave moves horizontally.

Fun facts: It typically takes only a few dozen fans leaping to their feet with their arms up to trigger a wave. This wave typically travels at 20 seats/second (~27 mph).

Using a Sine Curve to Describe a Wave

- The brown curve is a "snapshot" of a wave at t=0
- The blue curve is later in time
- The high points are *crests*
- The low points are *troughs*

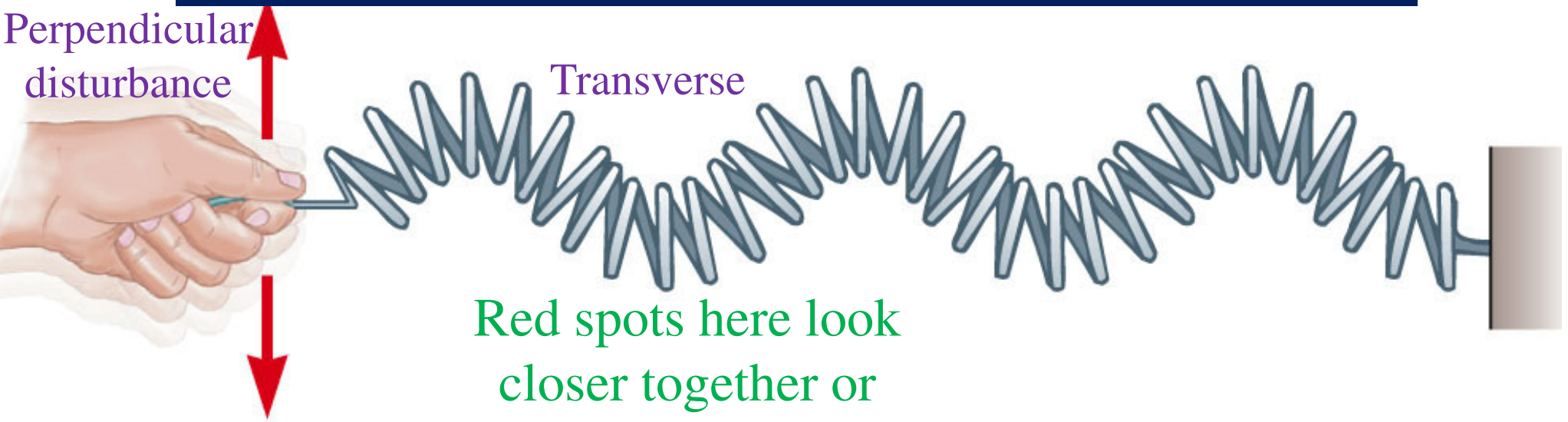


Sinusoidal curves

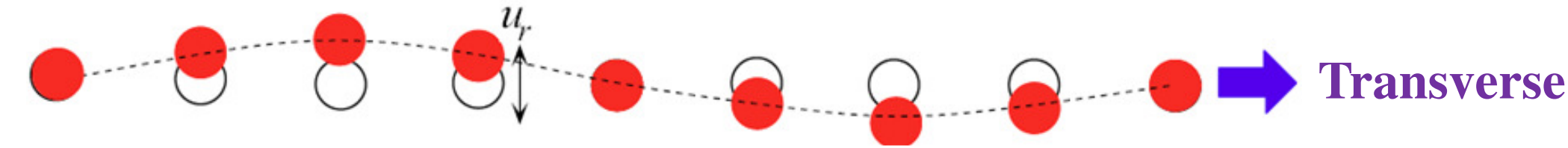
- The distance Δx traveled by the wave is = v t (Ch. 2)

If you move your hand up and down to create a transverse wave, what would you do to create a longitudinal wave?

https://www.youtube.com/watch?v=aguCWnbRETU

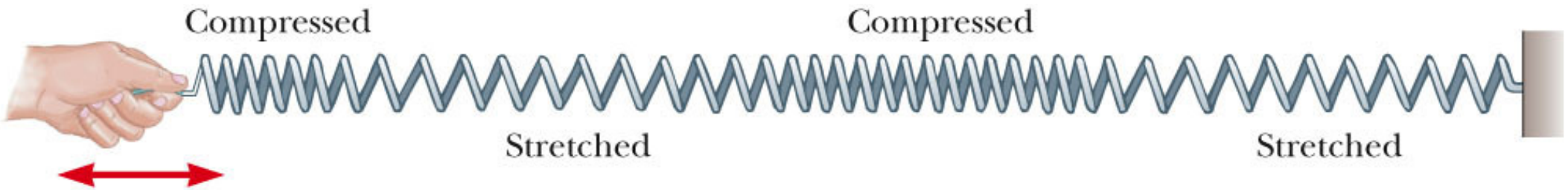


Red spots here look closer together or more dense

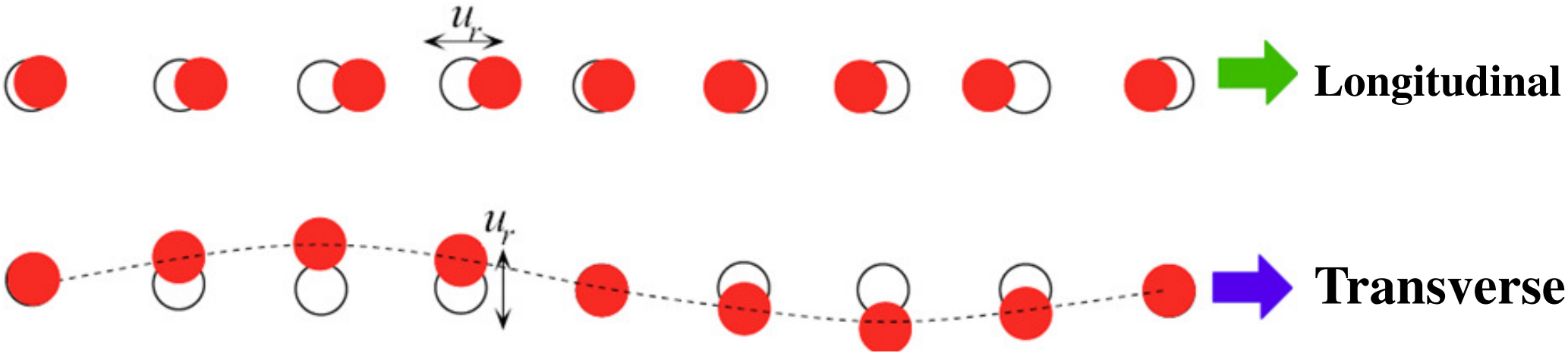


In a longitudinal wave, the elements of the medium undergo displacements parallel to the motion of the wave (e.g. sound waves)

Also called a compression wave



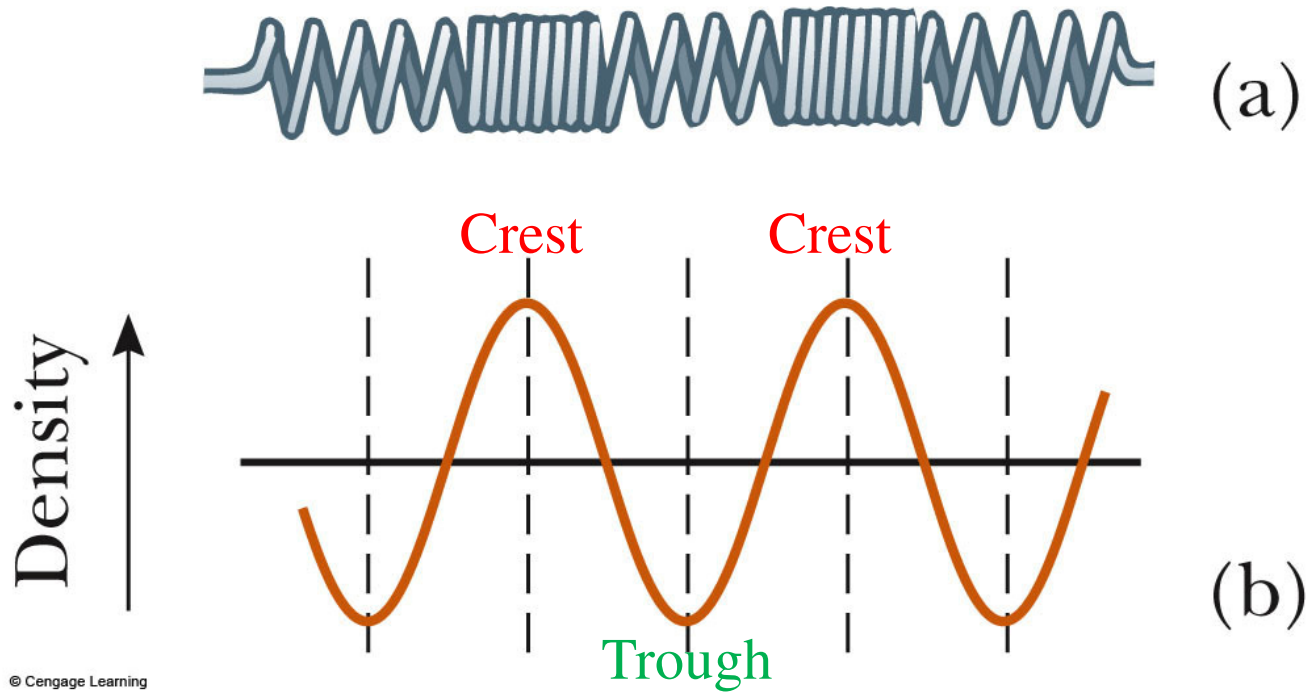
(b) Longitudinal wave



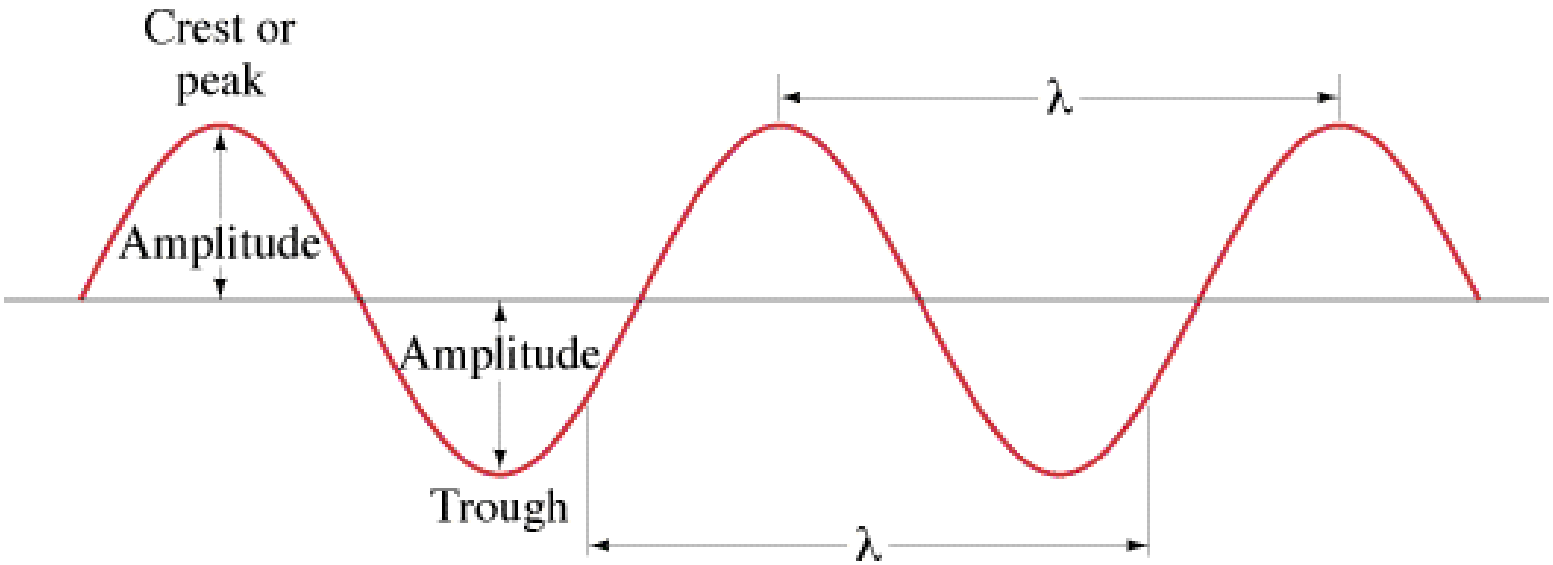
Longitudinal waves can also be represented as a sine curve

Crests = Compressions, Troughs = stretches

Also called density waves



Mechanical Wave Definitions



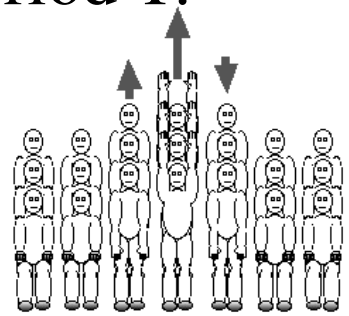
Amplitude: maximum height of crest or depth of trough (not both!)

Wavelength (λ): distance over which wave repeats itself

Frequency (f): Number of crests that pass a given point per unit time

Wave velocity: a crest travels one wavelength in one period T:

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

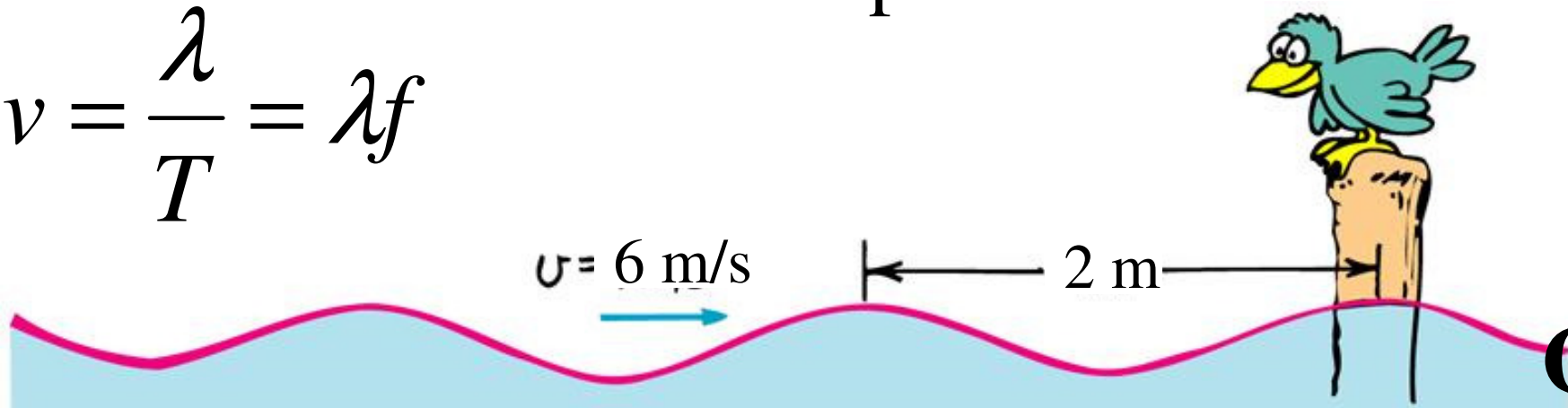


Note: this is the velocity of the wave, not of the particles in the medium

If the water wave below has a velocity of 6 m/s, how many times per second does a crest pass by the sitting bird?

A. 0.33 times per second
B. 0.5 times per second
C. 2 times per second
D. 3 times per second
E. 12 times per second

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



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Waves on Strings

If I wanted to change the sound of my guitar string, what variable would I be changing?

How could I change *f* ?

What happens when I tune the guitar?

$$v = \lambda f = \sqrt{\frac{F}{\mu}}$$

F = tension in the string

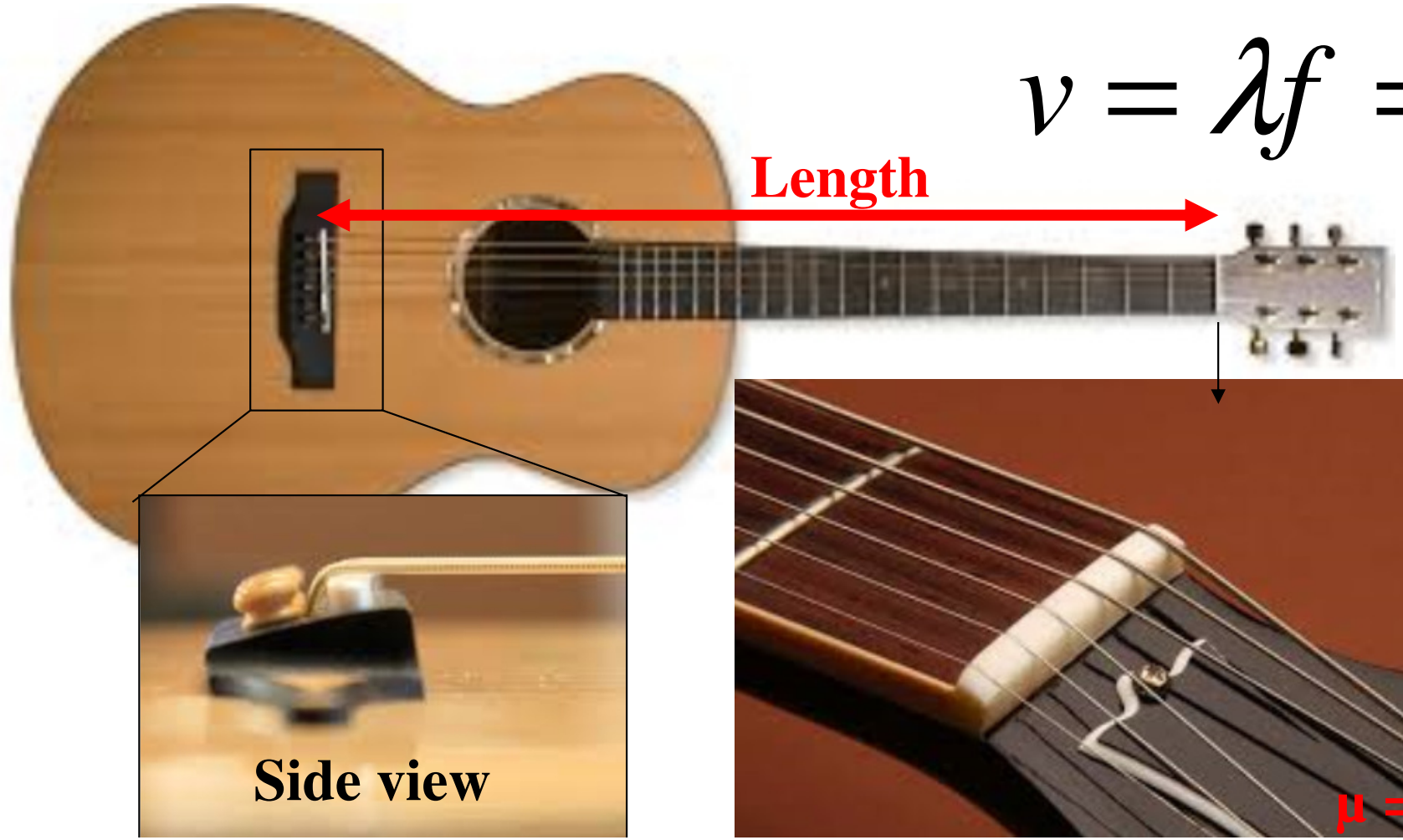
μ = linear density = mass/Length

The 6 strings on a guitar have frequencies of 82 Hz, 110 Hz, 147 Hz, 196 Hz, 247 Hz, 330 Hz.

String Wave Example

How could we find the tension in one of my guitar strings?

$$v = \lambda f = \sqrt{\frac{F}{\mu}}$$



If we had the guitar string, how could we figure this out?

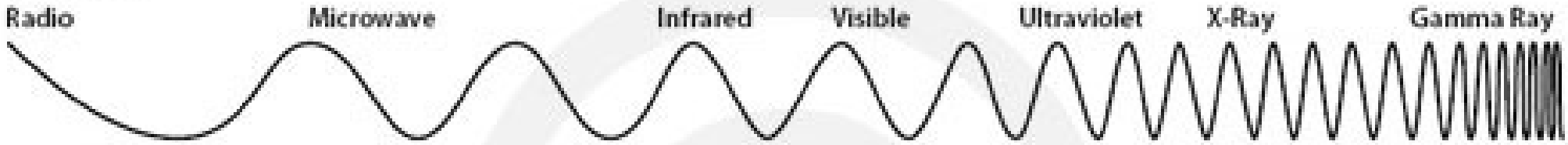
μ = mass/Length

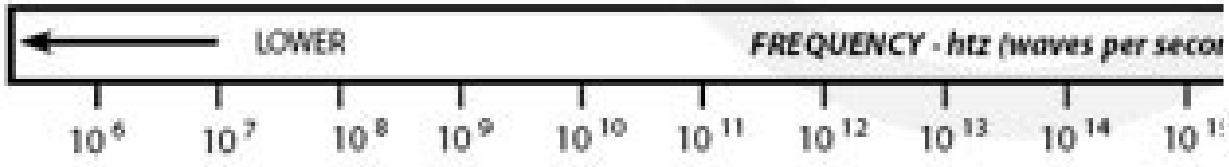
THE ELECTRO MAGNETIC SPECTRUM

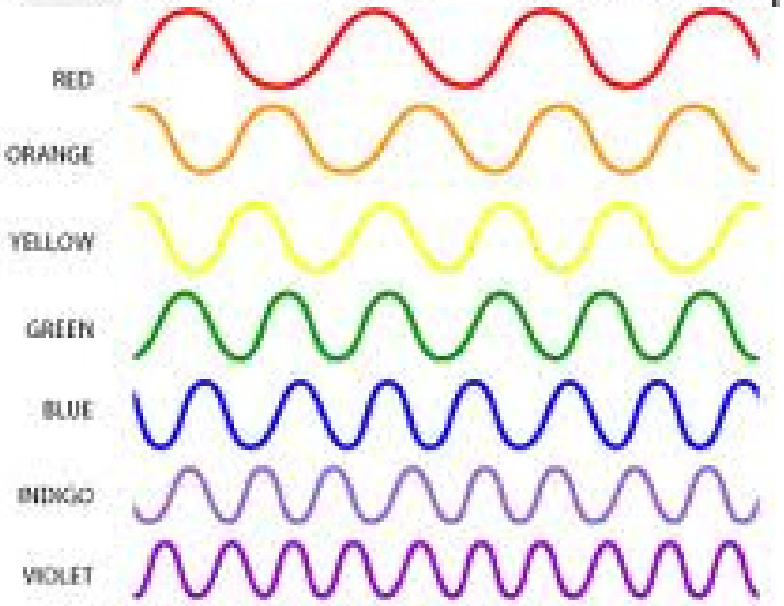
1 metre = 100cm 1 cm = 10mm 1 millimetre = 1000 microns 1 micron = 1000 nanometres (nm) - one nanometer is one billionth of a metre

$10^{-5} = 0.00001$ $10^{5} = 100{,}000$

What do you think are the most dangerous kinds of waves?



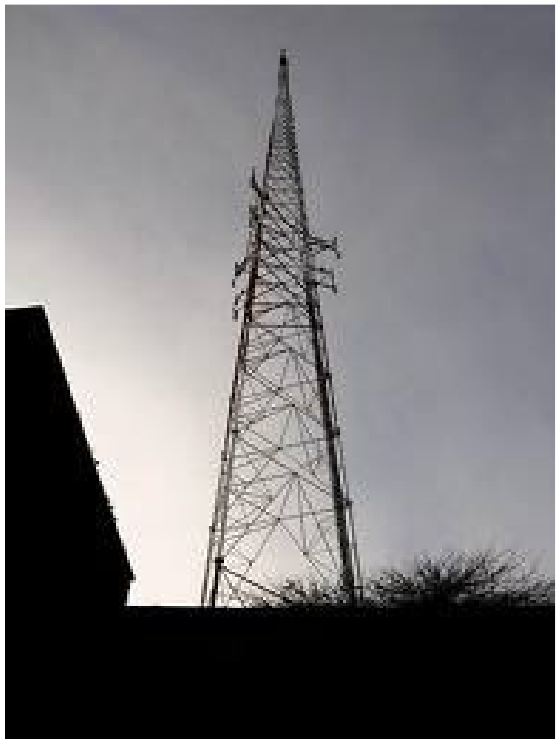




A certain FM radio station broadcasts music at a frequency of 101.9 MHz.

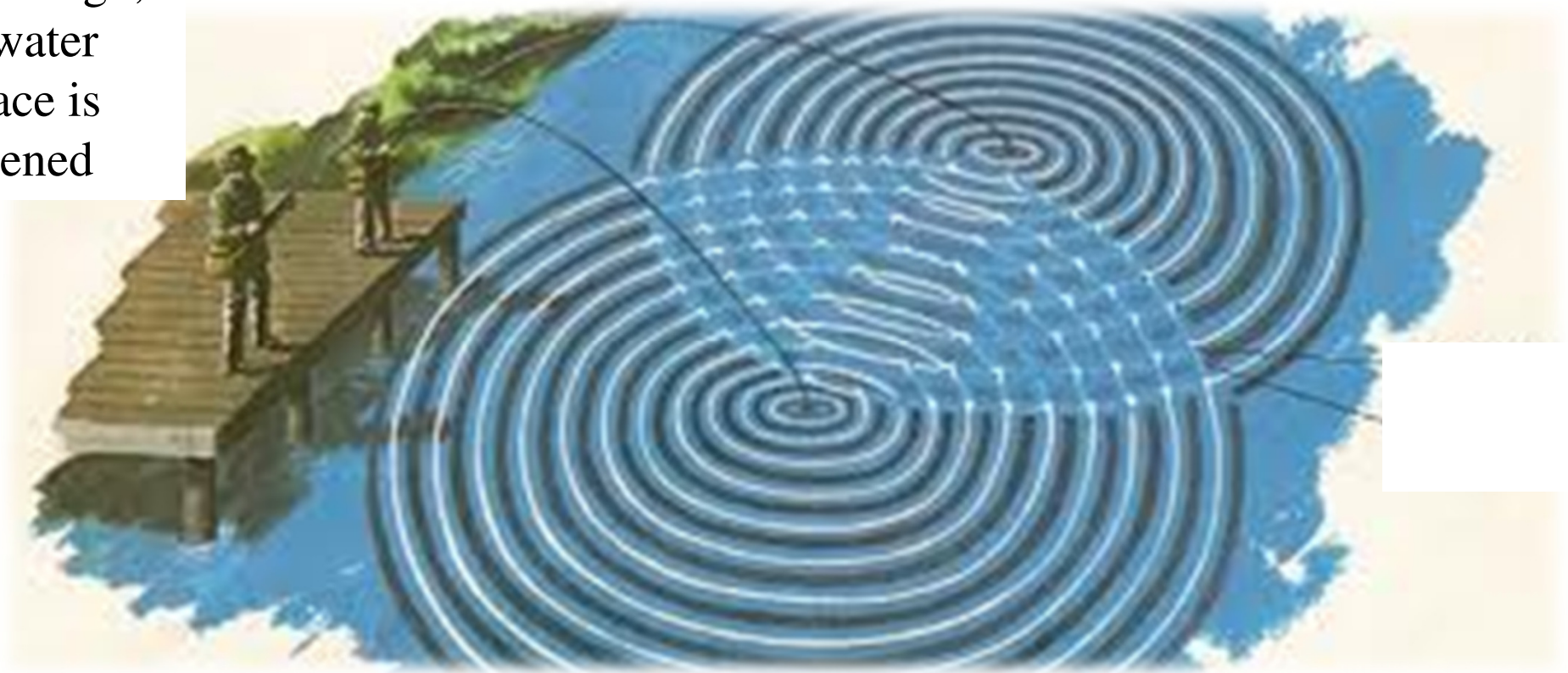
Find the wave's period and its wavelength. (Radio waves are electromagnetic waves that travel at the speed of light, 3.00×10^8 m/s.

How long would it take these waves to get to you if you were 1 mile away from the tower?



Interference of Waves

Whenever a crest coincides with a trough, the water surface is flattened

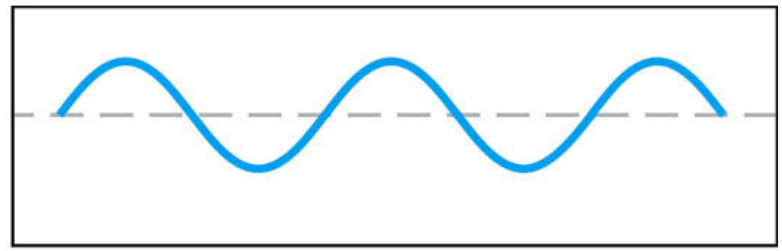


- Traveling waves can meet and pass through each other without being destroyed or even altered
- Waves obey the *Superposition Principle*
  - Meaning when 2 or more waves encounter each other, the resulting wave is found by **adding together the displacements of the individual waves**

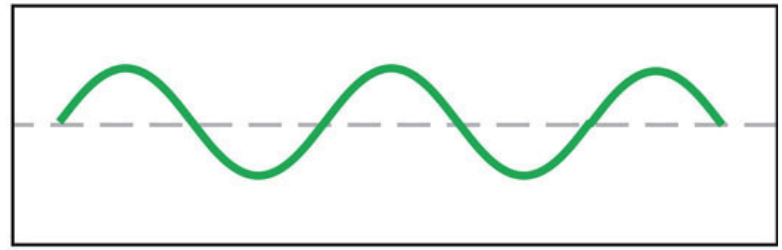
Constructive Interference

- Two waves (a and b) have the same wavelength and crests at the same times
  - Thus, they are *in phase*

  (relative amplitude is irrelevant for being in phase)



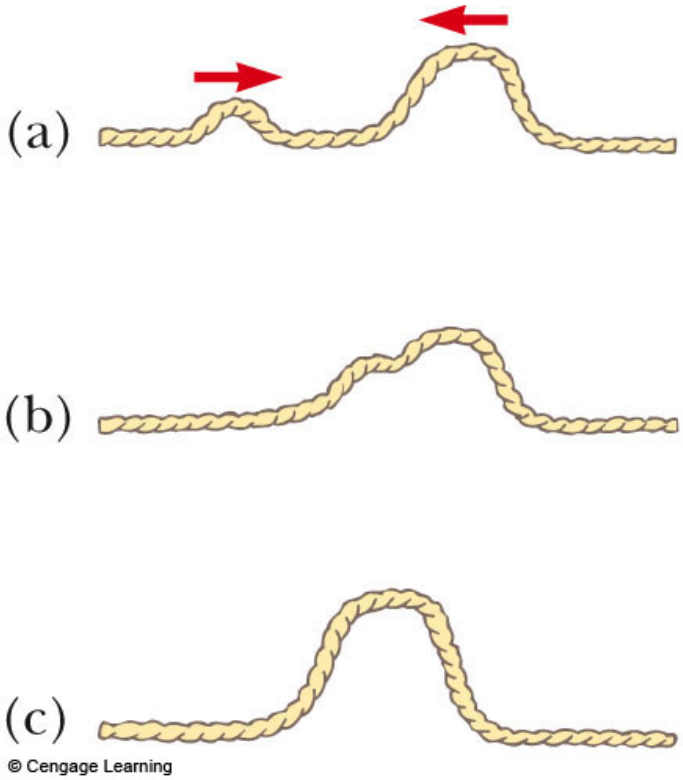
(a)

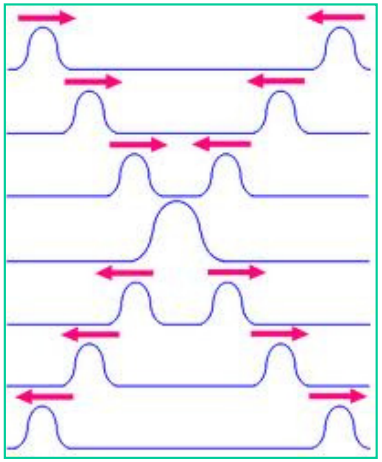


(b)

- If you add them together, the combined wave (c) has the same wavelength and a greater amplitude

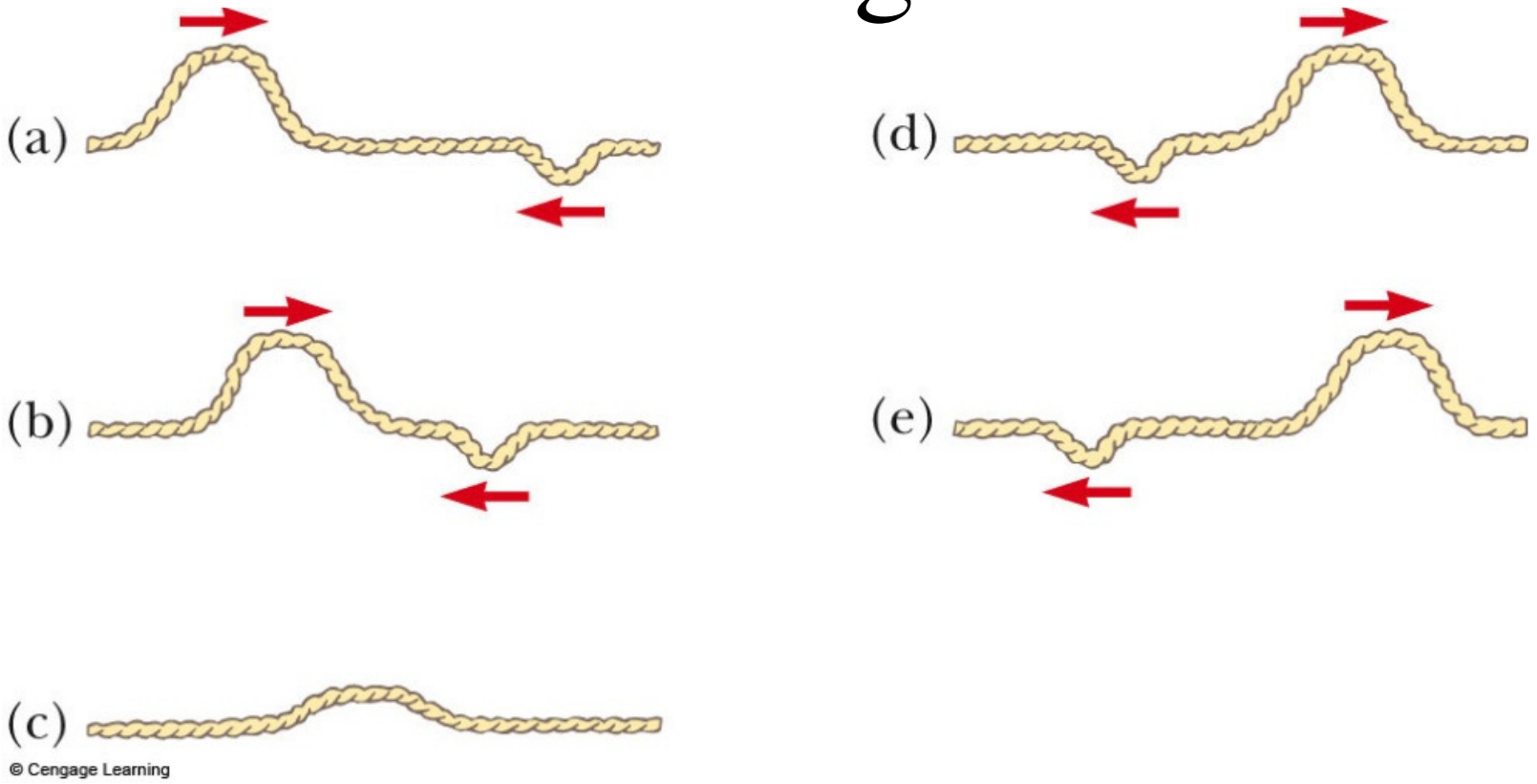
Constructive Interference in a String





- Two pulses are traveling in opposite directions
- The net displacement when they overlap is the sum of the displacements of the pulses
- Note that the pulses are unchanged after the interference

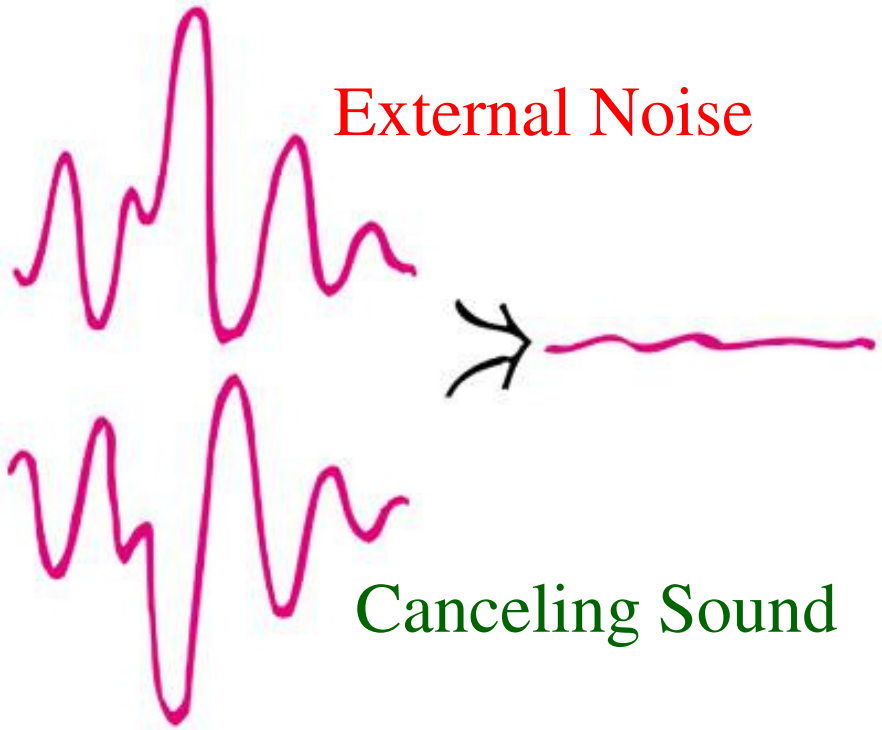
Destructive Interference in a String

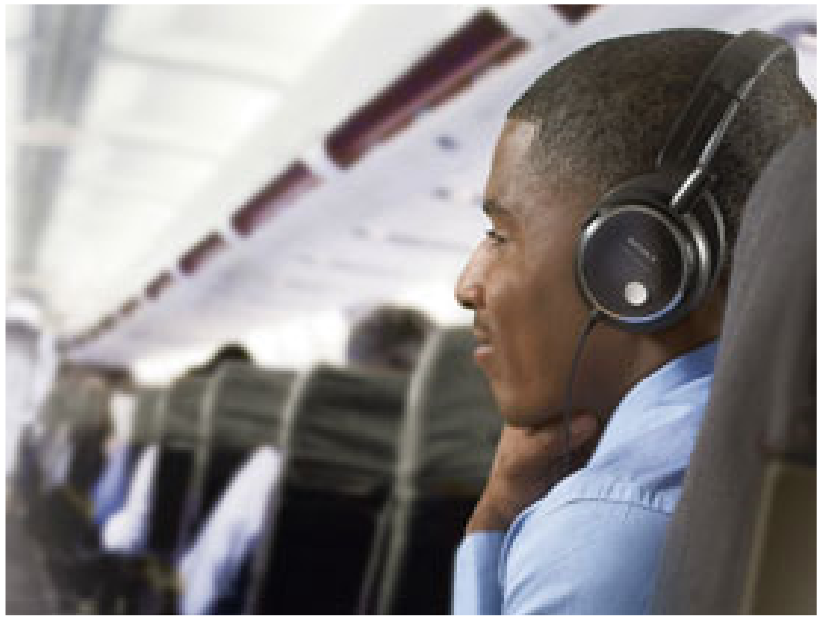


- The net displacement when they overlap is decreased since the displacements of the pulses subtract
- Note that the pulses are unchanged after the interference

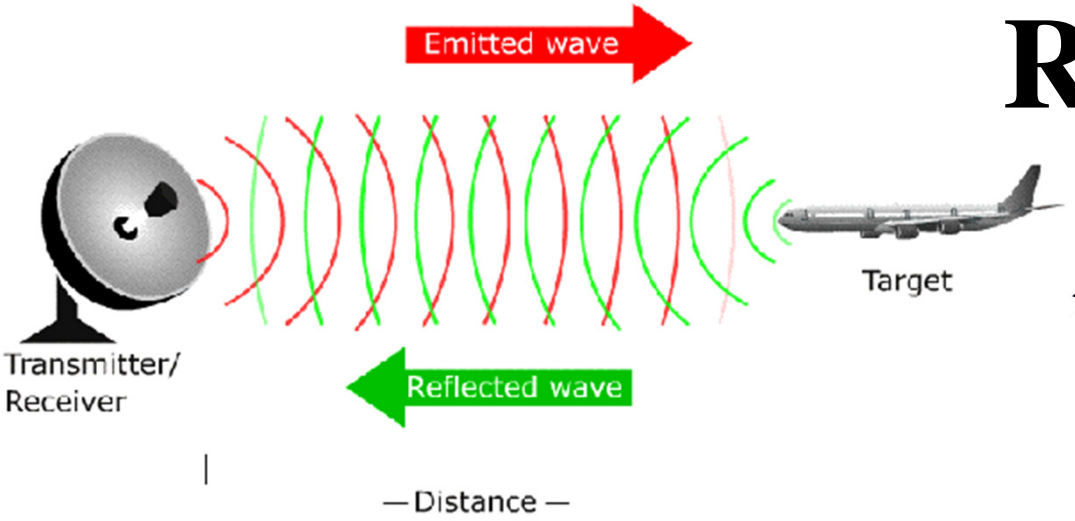
Noise-Canceling Headphones

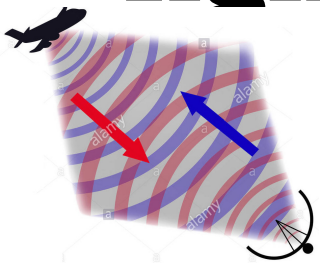
Noise-canceling headphones use a microphone that listens for noise and a speaker that produces the same noise but inverted (cancellation by destructive interference)





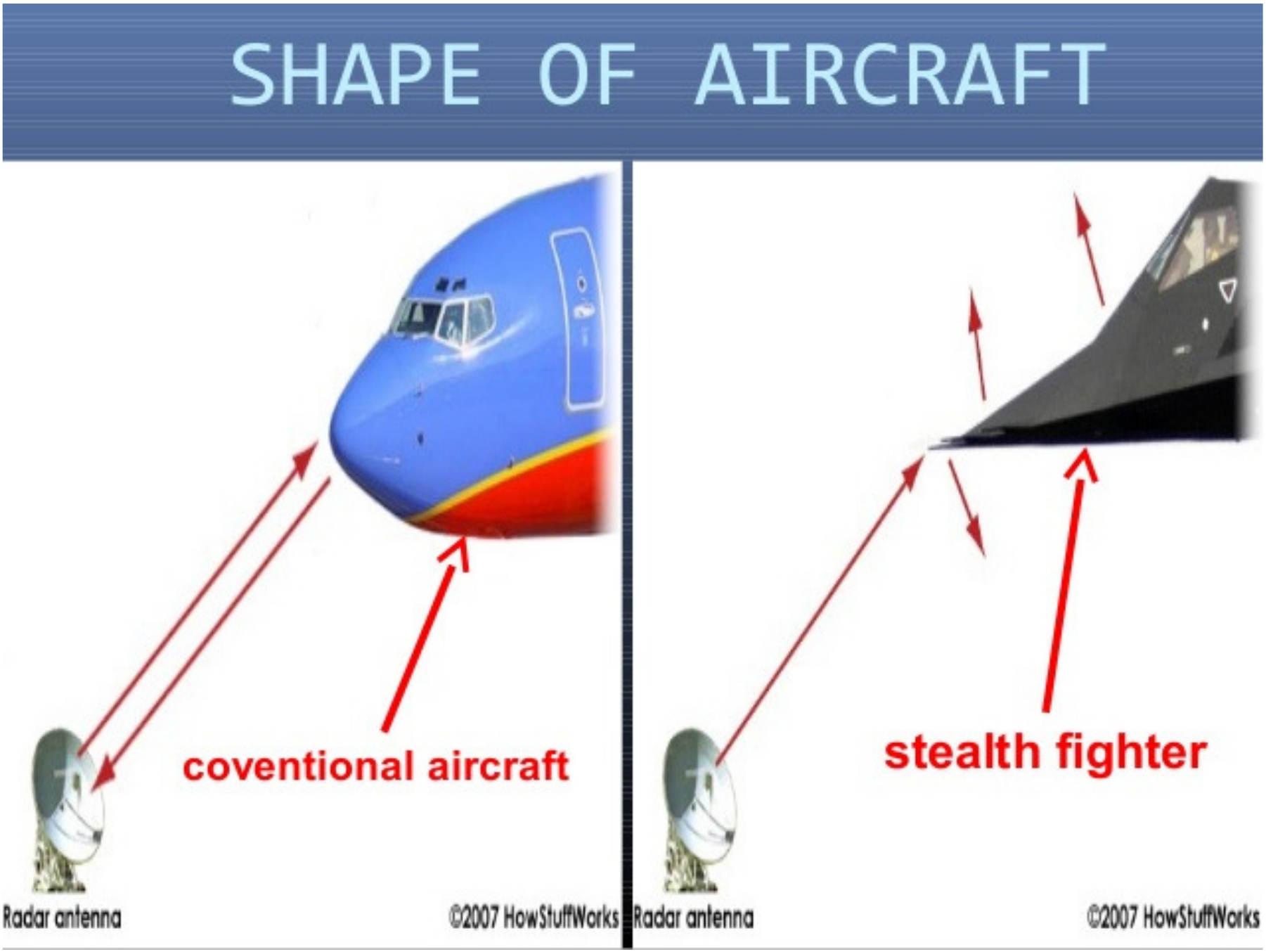
Radar misleading fighter jets





- A French fighter plane called the Rafale uses destructive interference to avoid Radar.
- Radar (**ra**dio **d**etection **a**nd **r**anging) can detect objects by sending electromagnetic waves out and measuring the time and frequency of the reflected wave (~ Xbox Kinect).
- When the jet receives an incoming wave, it sends out the direct opposite pattern of the wave.

Stealth fighter jet has weird angles so waves don't bounce back to detector



Are you on the right wavelength?

If the wave below has a velocity of 6 m/s, answer the following:

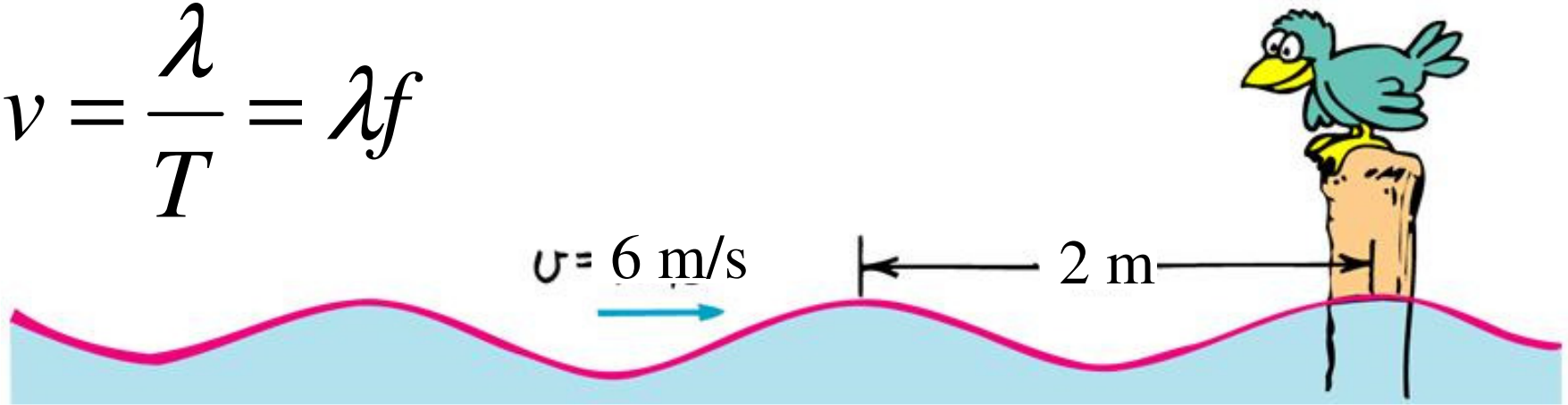
What is the wavelength? 2 m

$v = \lambda / T$

What is the wave's period? $T = \lambda / v = 2\ m / (6\ m/s) = 0.333\ s$

What is the wave's frequency? $f = 1/T = 1/0.333s = 3\ Hz$

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



Chapter/Section: Clicker #=Answer

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