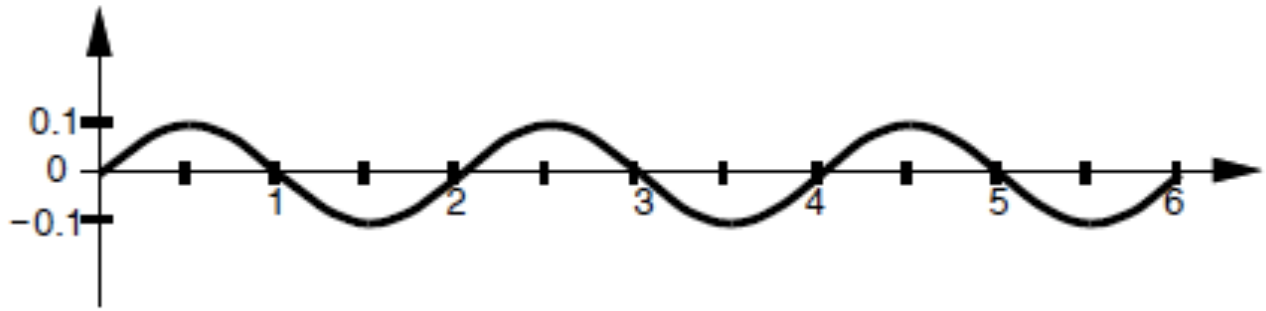
Physics 10

Lecture 19A

"Like as the waves make towards the pebbled shore,
So do our minutes hasten to their end."
--William Shakespeare

Waves

- What is a wave?
- Examples: water waves, waves on a string, sound waves, EM waves.
- A wave:



- Carries energy and momentum from one spatial location to another.
- Is created by a source.
- Can be sinusoidal or other shapes as well.

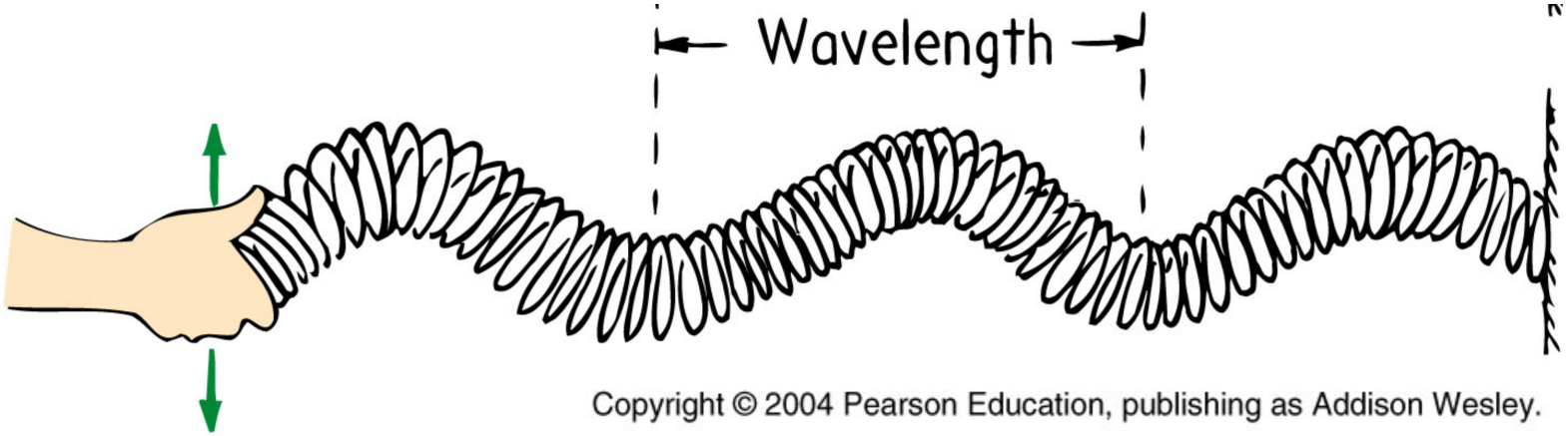
Waves

- Waves need a medium to travel through (waves are a disturbance in a medium).
- A medium can be a solid, liquid, or gas.
- For example, sound waves need air or some other medium to travel through.
- If you remove the air from the room, then sound will have no medium and you will not hear a sound.
- When creating a wave, how often a vibration occurs is known as the frequency.

$$\text{frequency} = \frac{\text{completed cycles}}{\text{second}}$$

Types of Waves

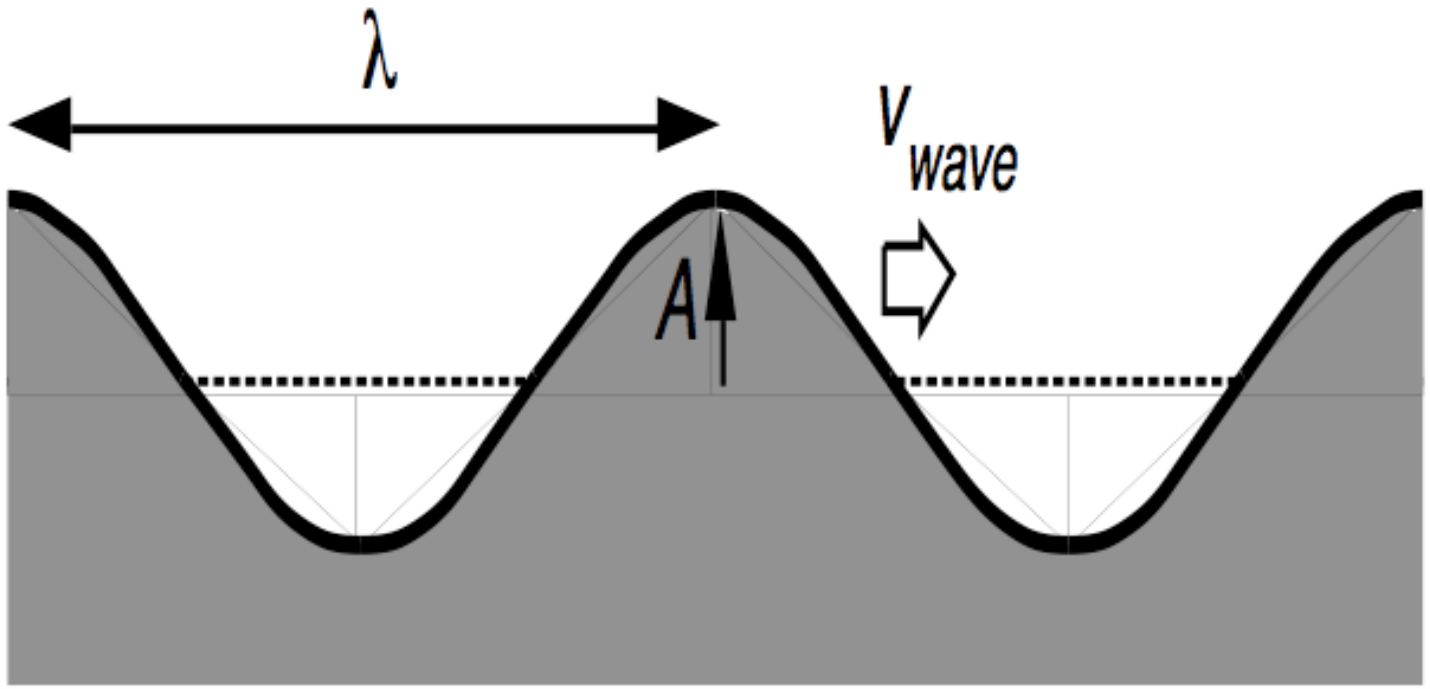
- Transverse:
- Displacement is perpendicular to the direction of wave travel.



- Examples of transverse waves are:
- water waves, EM waves, waves on a string…

Pictorial Description

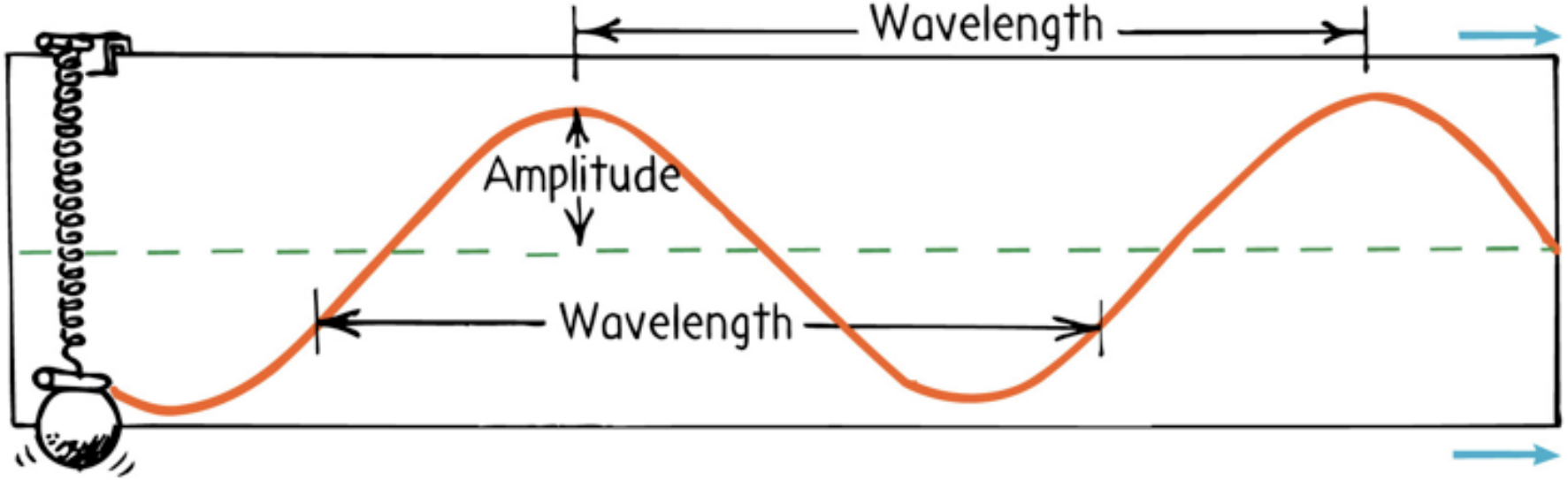
- We like to represent a traveling wave pictorially with a moving sine wave.



- Here the traveling wave is moving to the right at a certain velocity, v_{wave}.

Pictorial Description

- The highest points of the wave are known as crests. The lowest points of the wave are known are as troughs.

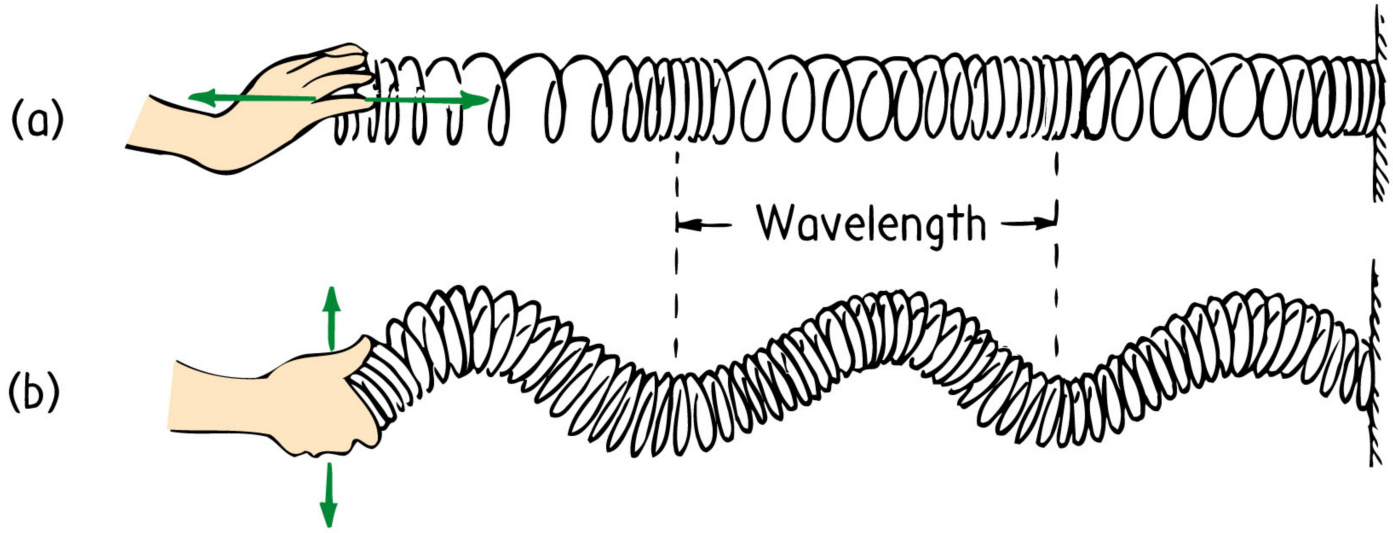


- The distance from equilibrium to crest (or trough) is called the amplitude, A.

- Distance from one crest to another (or trough to trough) is called the wavelength, λ.

Types of Waves

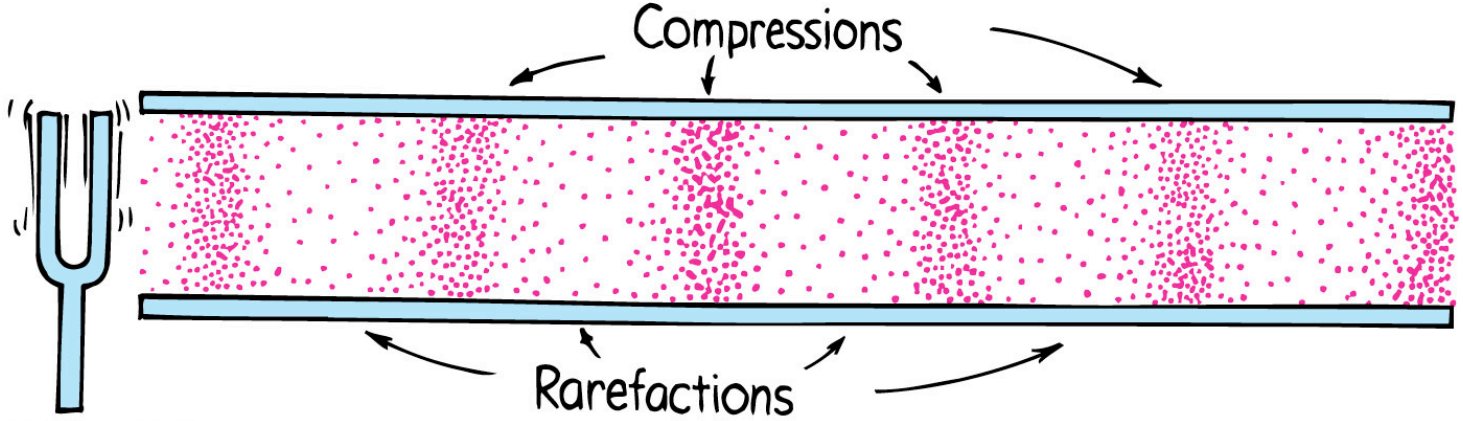
- Longitudinal:
- Displacement is in the direction of wave travel.



- Examples of longitudinal waves are:
- sound waves, compression waves on a slinky…

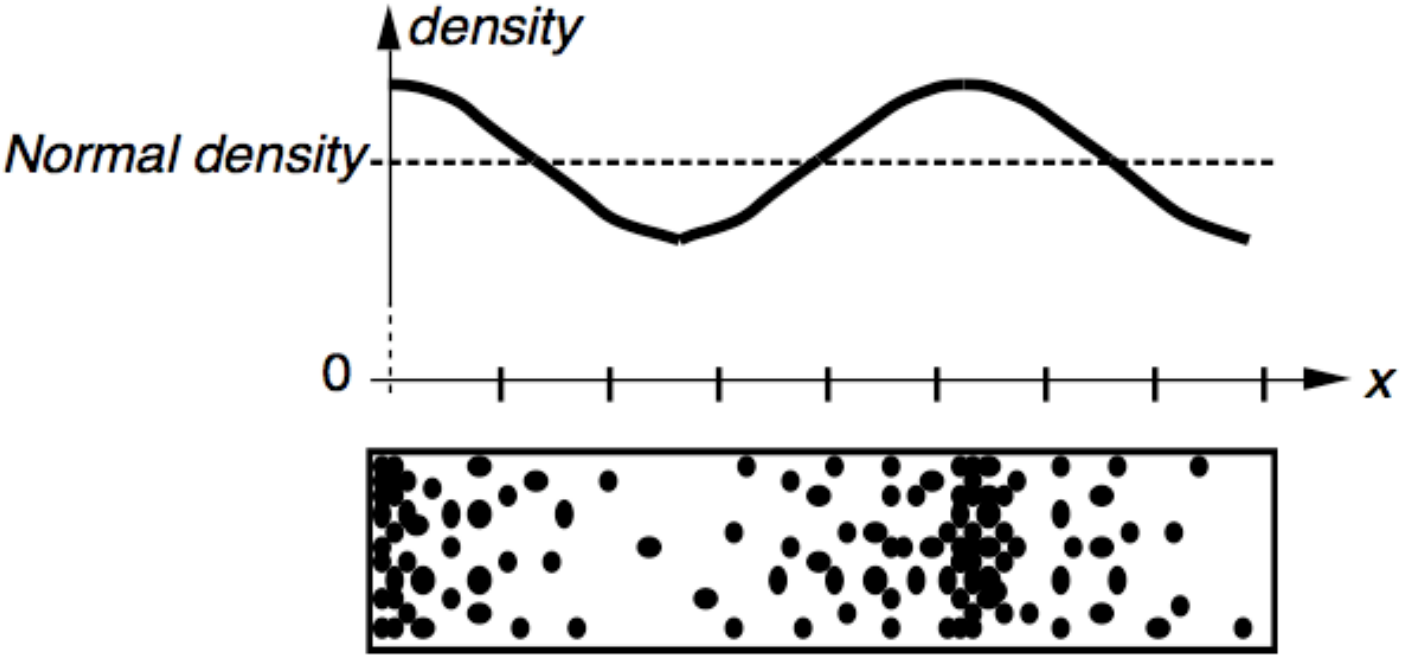
Types of Waves

- Longitudinal waves have compressions (like crests) and rarefactions (like troughs).
- Compressions are points with high particle concentration and rarefactions are points with low particle concentration.
- The wavelength of a longitudinal wave is given by its distance between adjacent compressions or adjacent rarefactions.



Types of Waves

- Longitudinal waves are similar in nature to transverse waves.

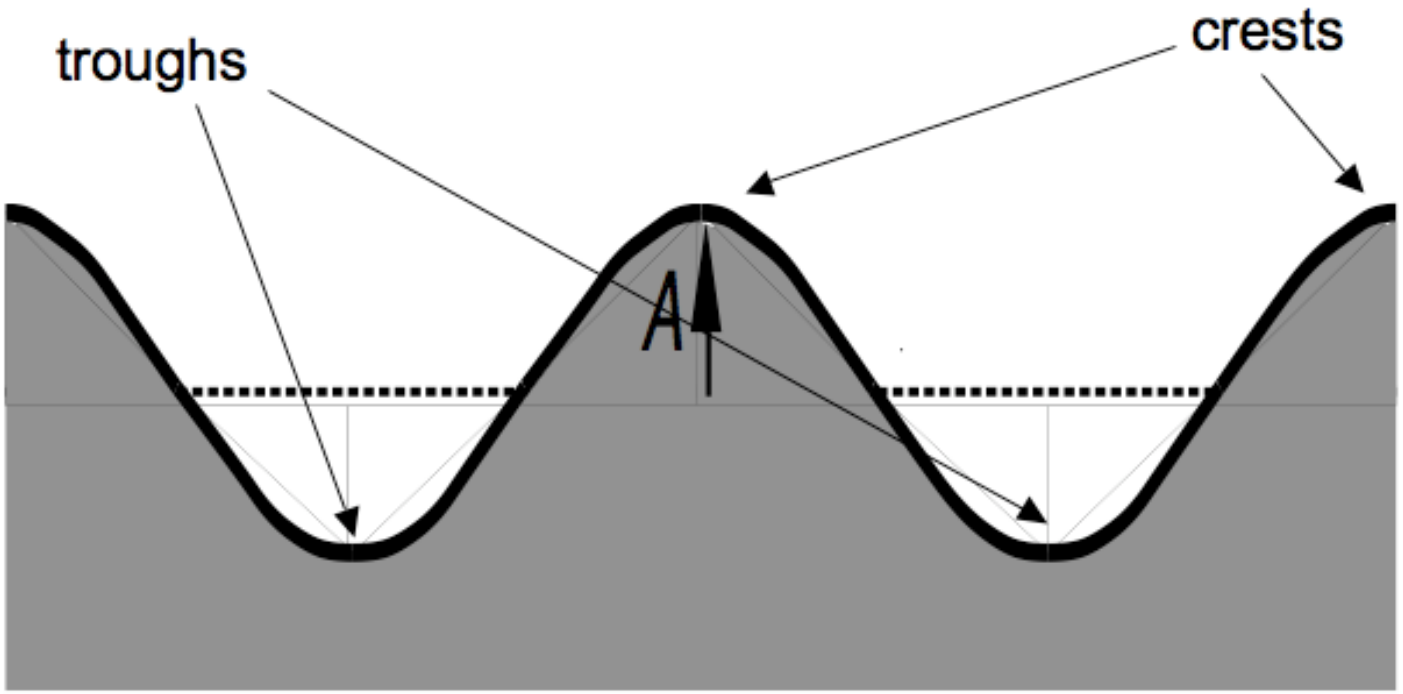


- We can use similar equations and techniques to discuss/explain both types of waves

Pictorial Description

- The time it takes between successive crests is called the period, T.
- If we were sitting on the middle crest, then the period would be how much time it took for the next crest to arrive.

If we invert period, T, then we have frequency, f.



Speed of a Wave

- Frequency is measured in units of Hertz (Hz) which is equivalent to 1/second.
- The speed of a wave is given by:

$$v_{wave} = \frac{\lambda}{T} = \lambda f$$

- The wave speed depends on the given medium.
- For example, a sound wave will have a wave speed of about 340m/s in air.
- But a sound wave will also have a wave speed of about 1,000m/s in water.

Speed of a Wave

- For example, an ocean wave is traveling in one direction has a wavelength of 1.0m and a frequency of 1.25Hz. What is the speed (in m/s) of this ocean wave?

$$v_{wave} = \lambda f = 1.25\ \mathrm{m/s}$$

- Please note that the water is not necessarily moving at this speed, but the wave is propagating at this speed.
- If a rubber duckie were sitting on the water it would mostly likely just bob up and down.

Clicker Question 19A-1

In the previous example, if the source of the wave suddenly doubled its frequency how would the previous answer change?

A) The velocity of the wave would double.

B) The velocity of the wave would half.

C) The velocity of the wave would remain the same.

D) The velocity of the wave would quadruple.

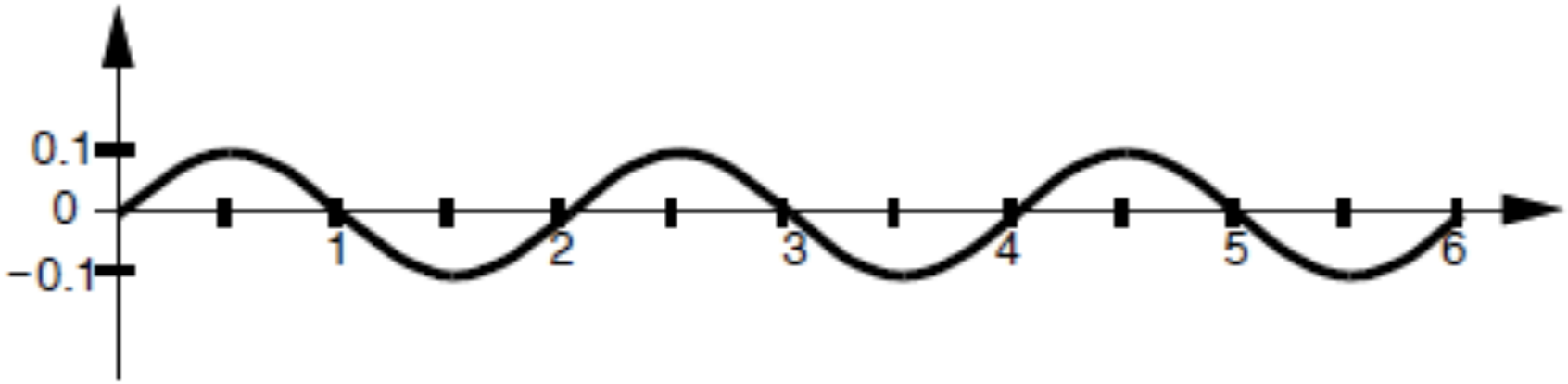
E) The velocity of the wave would decrease by a factor of four.

Speed of a Wave

- Let's say I was the source of a wave, and I wanted to increase the velocity, what can I do?
- Nothing, velocity is medium dependent.
- I would have to change the medium.
- All I can do as a source is affect the frequency, period, and amplitude of the wave.
- As I change the frequency, the wavelength will change to compensate.
- The wavelength is known as the dependent variable.

Clicker Question 19A-2

What is the wavelength of the following graph (all numbers are given in centimeters)?



A) 0.1 cm.

B) 0.2 cm.

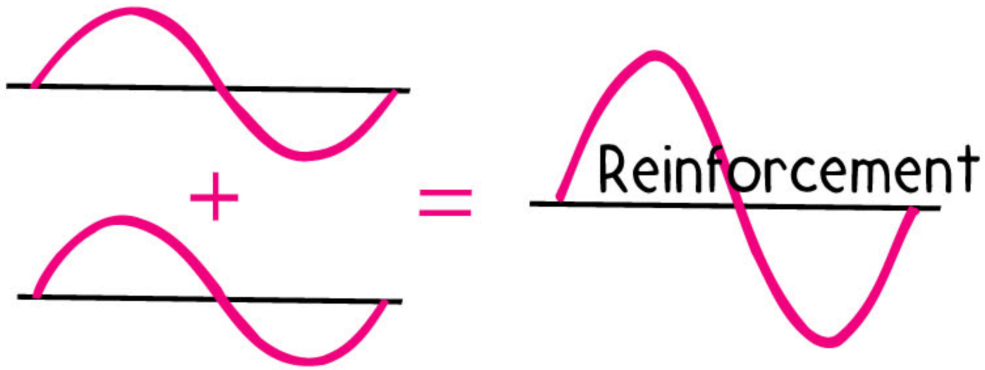
C) 1.0 cm.

D) 2.0 cm.

E) 3.0 cm.

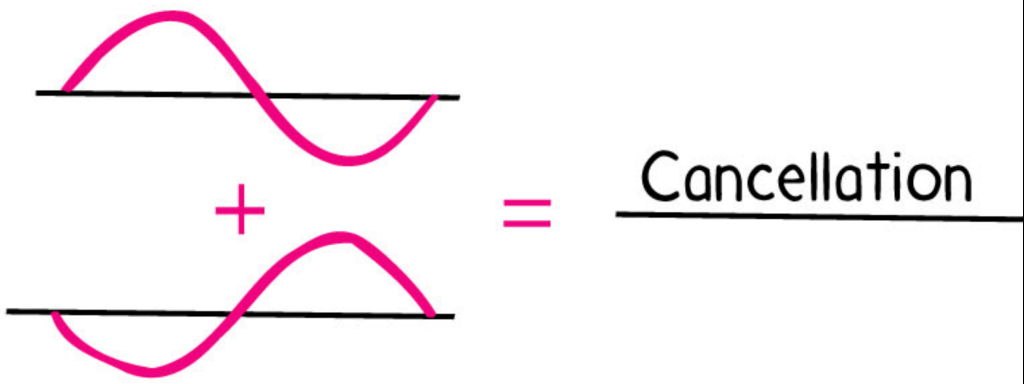
Wave Interference

- What happens if two waves on a string meet up and pass through each other?
- The obey Law of Superposition.
- This means that you add together their individual displacements.
- We can have either constructive interference:



Wave Interference

- Another way for waves to interfere is by destructive interference.
- This is when one crest of a wave overlaps with the trough of another wave which leads to a significantly decreased amplitude.
- When the waves arrive "out of step" they are said to be out of phase.



For Next Time (FNT)

- Read Chapter 20.
- Finish up the homework for Chapter 16.
- Start the homework for Chapter 19.