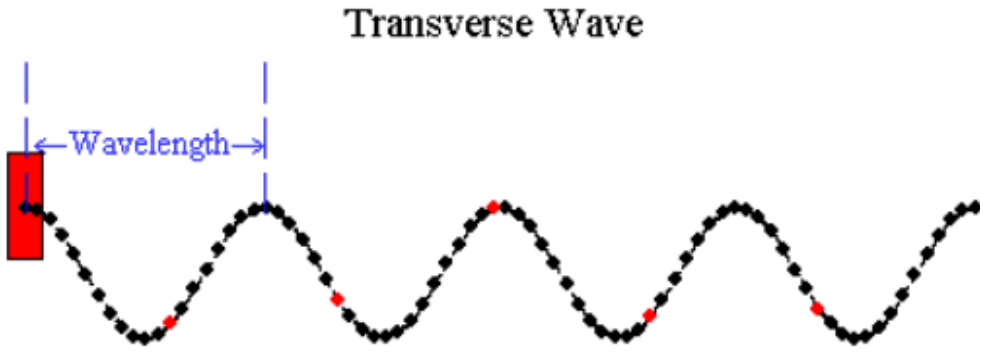
PHY131H1F - Class 32



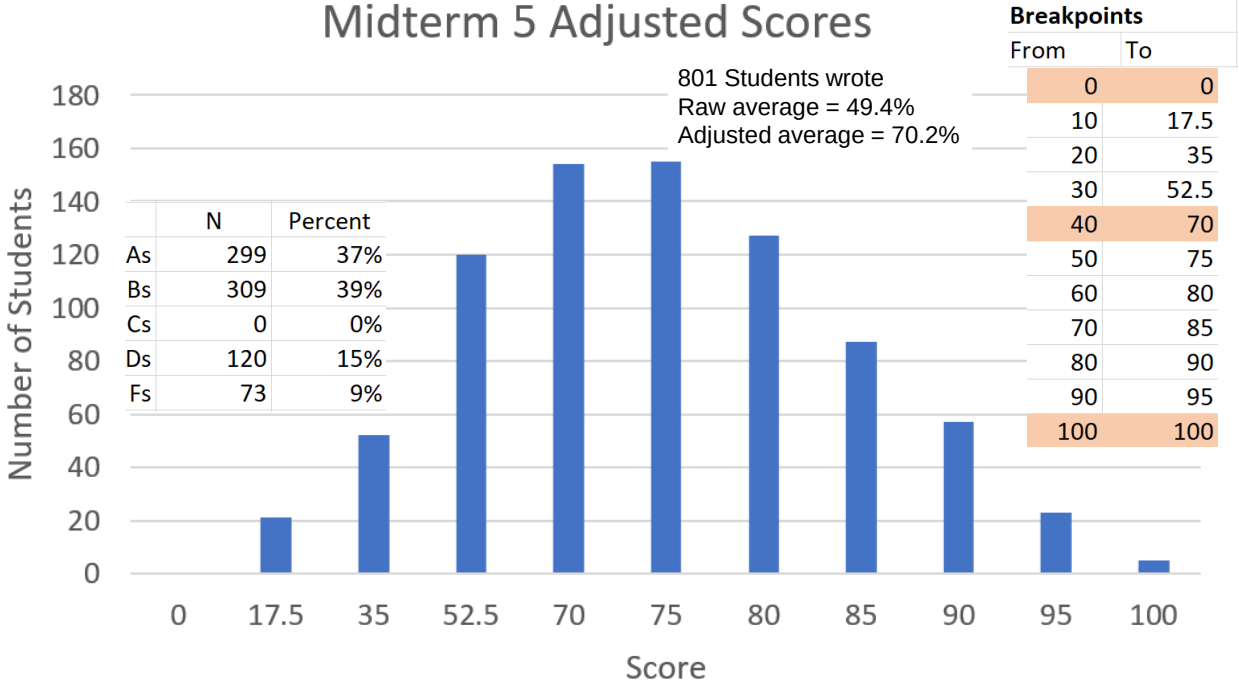
Today:

11.1 Transverse and Longitudinal Waves

11.2 Sinusoidal Waves

11.3 Wave Speed

1



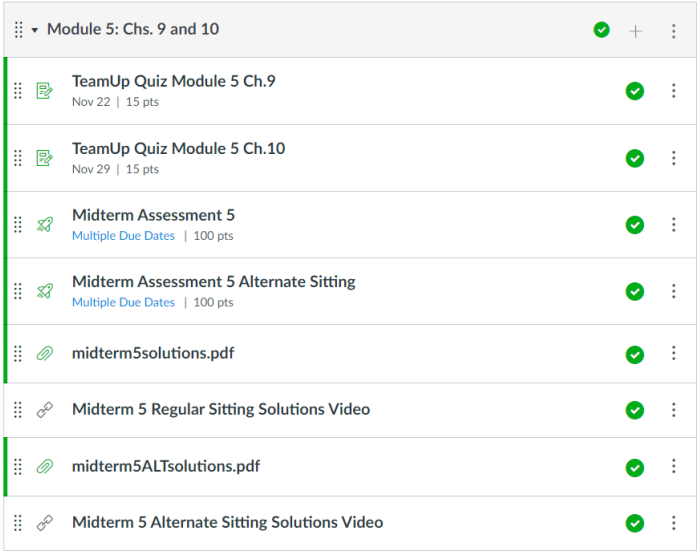
	N	Percent
As	299	37%
Bs	309	39%
Cs	0	0%
Ds	120	15%
Fs	73	9%

Breakpoints

From	To
0	0
10	17.5
20	35
30	52.5
40	70
50	75
60	80
70	85
80	90
90	95
100	100

2

Solutions Video Is Posted



- 21 minute Youtube video with carefully drawn out solutions is posted on Quercus.
- Written solutions with reasoning also posted.
- Video and Written solutions are also posted for the alternate sitting.
- Today, let's continue with Chapter 11. I'm happy to discuss the test after class today or during office hours, or by email.

3

Mastering Physics

LAST Homeworks have been posted now!

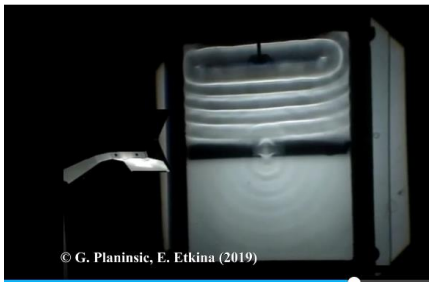
- Notice that Homework 11 – the final homework assignment - has been posted on MasteringPhysics.
- It is due *Wednesday* Dec. 9 at 8:00am (not Monday!)
- Also, I have posted a not-for-homework-credit item called "Videos and Practice for Chapter 11" which I recommend you check out.

4

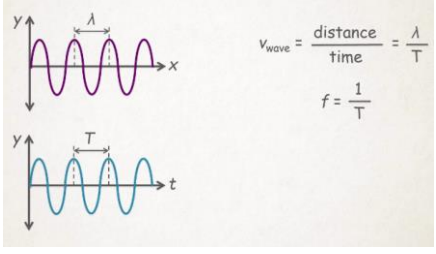
Mastering Physics

Videos and Practice for Chapter 11

- Cool waves on an overhead projector video by the author of the book!

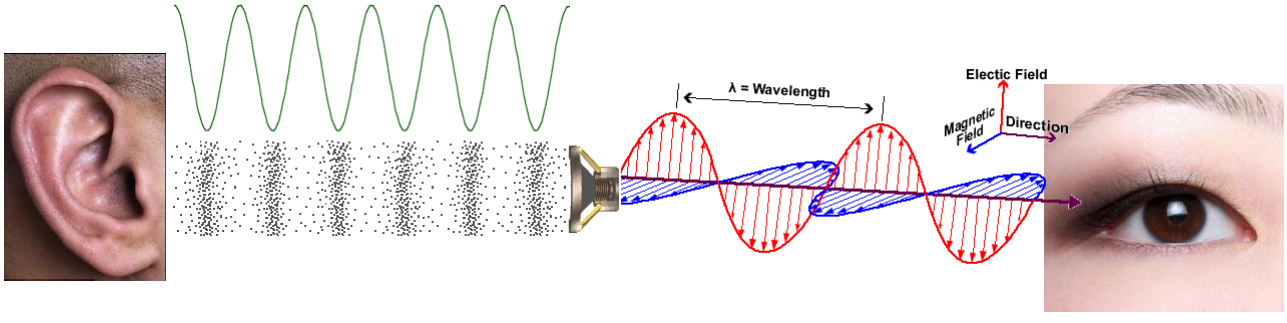


- And one last Khan-Academy-style video, all about Mechanical Waves



5

Last day I asked

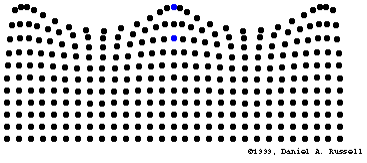


- Two of the five senses depend on **waves** in order to work: which two?
- Answer: Sight and Sound!
- Sound is a pressure wave which travels through the air.
- Light is a wave in the electric and magnetic fields.

6

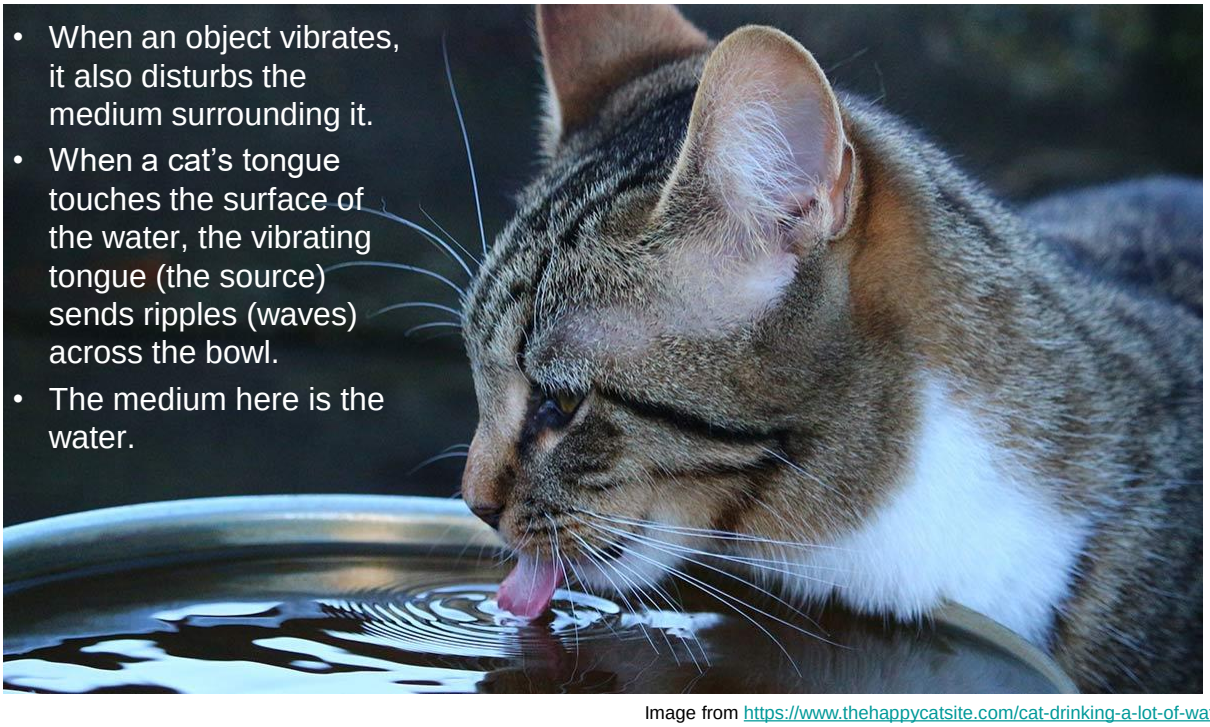
Chapter 11. Mechanical Waves

- A *vibration* is a periodic linear motion of a particle about an equilibrium position.
- When many particles vibrate and carry energy through space, this is a *wave.* A wave extends from one place to another.
- Examples are:
  - water waves
  - light, which is an electromagnetic wave
  - sound



[image from https://webspace.utexas.edu/cokerwr/www/index.html/waves.html ©1999 by Daniel A. Russell]

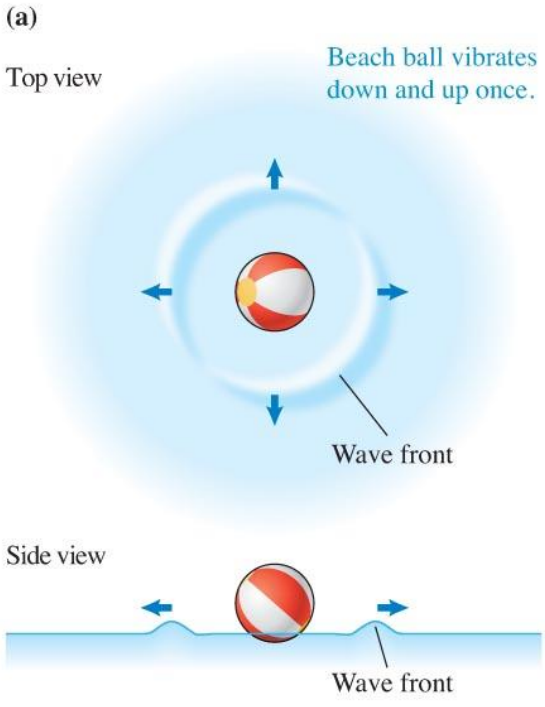
7

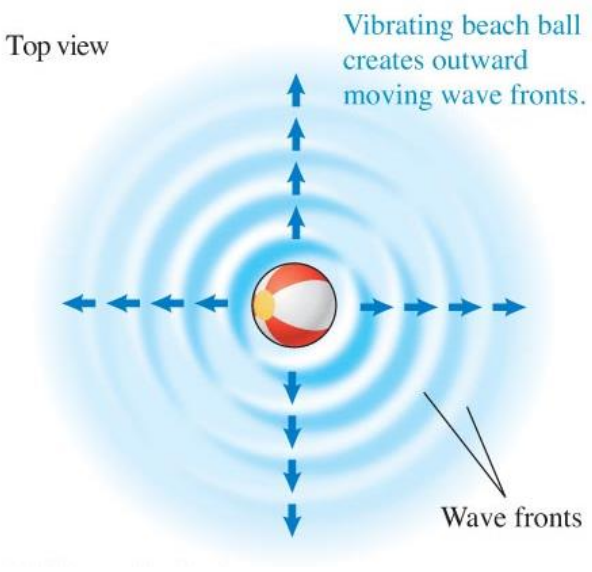


- When an object vibrates, it also disturbs the medium surrounding it.
- When a cat's tongue touches the surface of the water, the vibrating tongue (the source) sends ripples (waves) across the bowl.
- The medium here is the water.

Image from https://www.thehappycatsite.com/cat-drinking-a-lot-of-water/

8

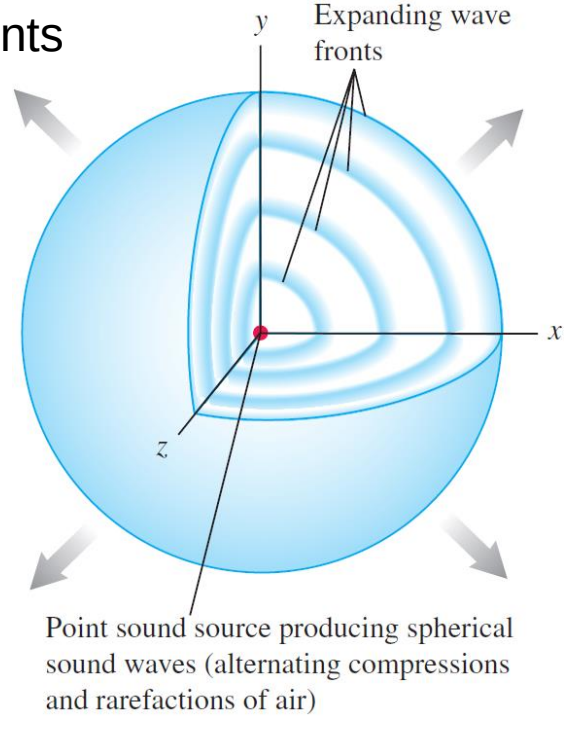




9

Waves and Wave Fronts

- A **wave front** is the locus of all crest points at which the *disturbance* of a wave is at a maximum.
- Spherical wave fronts of sound spread out uniformly in all directions from a point source.
- Electromagnetic waves in vacuum also spread out as shown here.

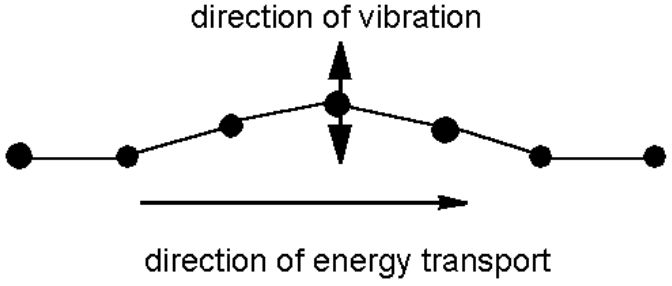


10

Transverse waves

- Medium vibrates perpendicularly to direction of energy transfer
- Side-to-side movement

  Example:
  - Vibrations in stretched strings of musical instruments



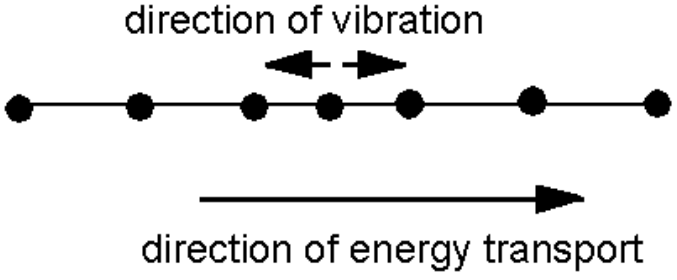
[image from http://www.maths.gla.ac.uk/~fhg/waves/waves1.html]

11

Longitudinal waves

- Medium vibrates parallel to direction of energy transfer
- Backward and forward movement consists of
  - compressions (wave compressed)
  - rarefactions (stretched region between compressions)

  Example: sound waves in solid, liquid, gas

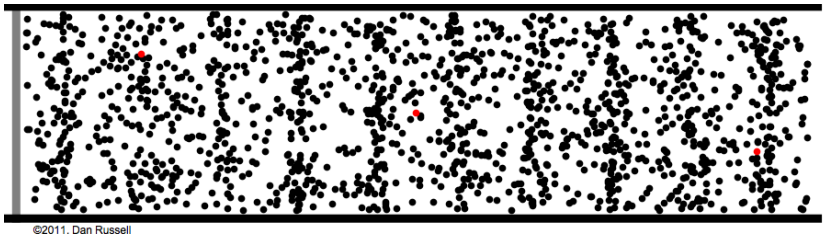


[image from http://www.maths.gla.ac.uk/~fhg/waves/waves1.html]

12

Longitudinal Waves

- Sound is a longitudinal wave.
- Compression regions travel at the speed of sound.
- In a compression region, the density and pressure of the air is higher than the average density and pressure.



13

Quick Poll Question

What is a “Transverse Wave”?

A. A wave in which the energy is transmitted in the opposite direction to the wave motion.

B. A wave in which the energy is transmitted in the same direction as the wave motion.

C. A wave in which the medium oscillates in a direction that is parallel to the direction the wave energy travels.

D. A wave in which the medium oscillates in a direction that is perpendicular to the direction the wave energy travels.

14

Reflection from a Lighter end

- A pulse traveling to the right on a heavy string attached to a lighter string
- The reflected pulse is “upright”.
- Also a larger pulse is transmitted into the second medium.

[Animation courtesy of Dan Russell, Penn State]

15

Reflection from a Heavier end

- A pulse traveling to the right on a light string attached to a heavier string
- The reflected pulse is “inverted”.
- Also a small pulse is transmitted into the second medium.

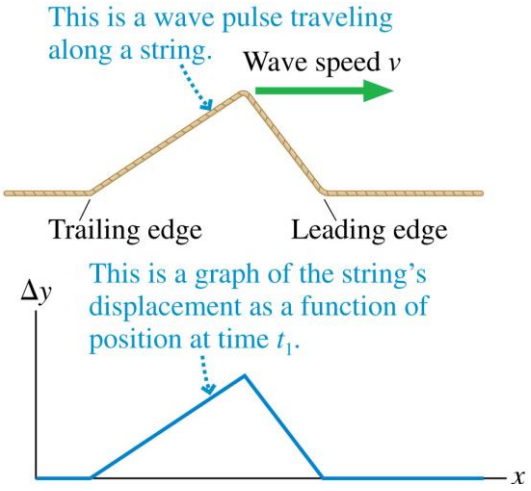
[Animation courtesy of Dan Russell, Penn State]

[PhET Demonstration]

16

Snapshot Graph

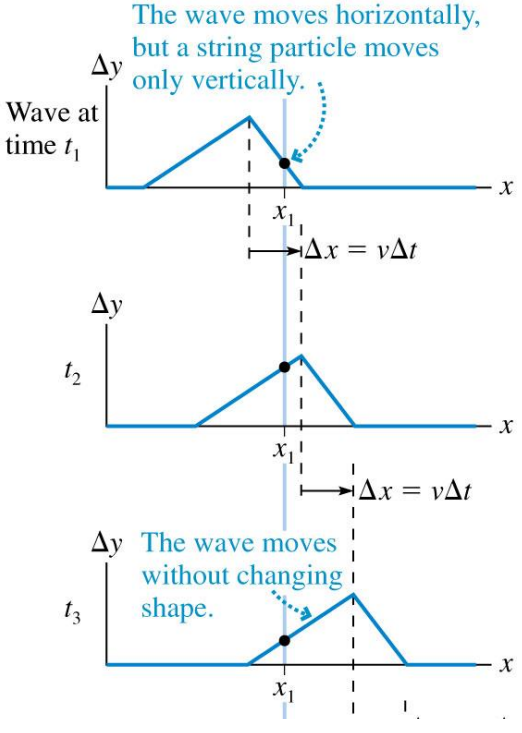
- A graph that shows the wave's displacement as a function of position at a single instant of time is called a **snapshot graph**.
- For a wave on a string, a snapshot graph is literally a picture of the wave at this instant.



17

One-Dimensional Waves

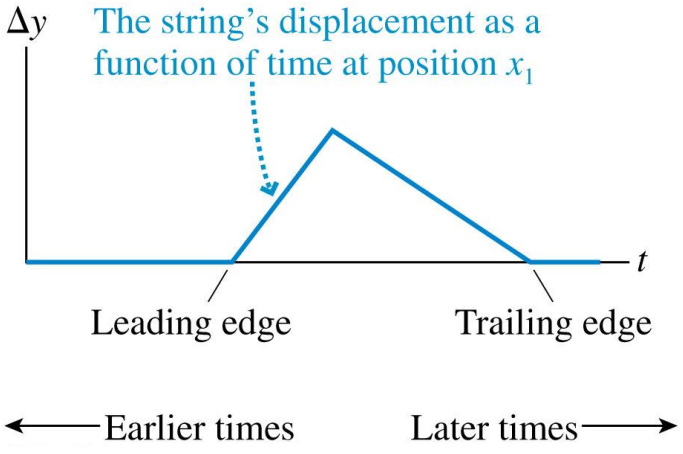
- The figure shows a sequence of snapshot graphs as a wave pulse moves.
- These are like successive frames from a movie.
- Notice that the wave pulse moves forward distance $\Delta x = v\Delta t$ during the time interval Δt.
- That is, the wave moves with *constant speed.*



18

History Graph

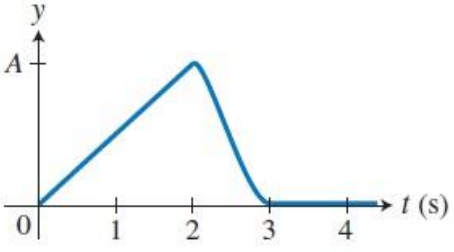
- A graph that shows the wave's displacement as a function of time at a single **position** in space is called a **history graph.**
- This graph tells the history of that particular point in the medium.
- Note that for a wave moving from left to right, the shape of the history graph is *reversed* compared to the snapshot graph.

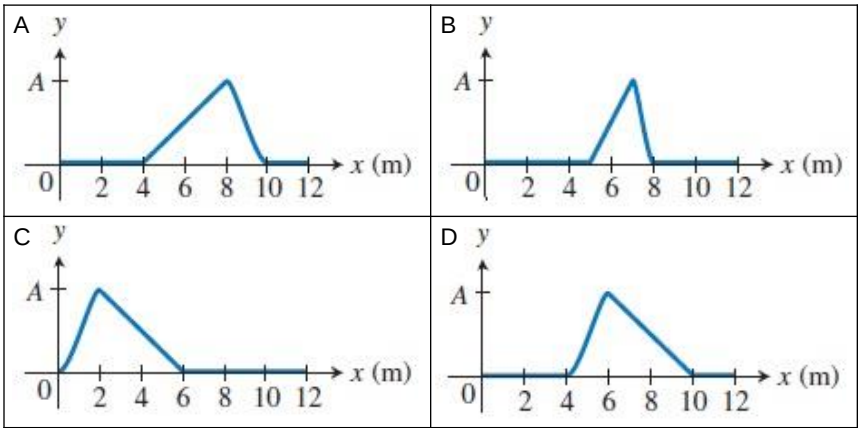


19

Poll Question (straight outta Homework 11!)

The figure shows the displacement-versus-time graph of the left end of a 12-m-long rope. The wave velocity on the rope is +2 m/s. Which graph below correctly shows a snapshot of the rope at a clock reading of $t = 5$ s?





20

"Cosine" is one shape a wave can have!

$y = A\cos\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)\right]$ is a "sinusoidal" wave traveling in the $+x$ direction.

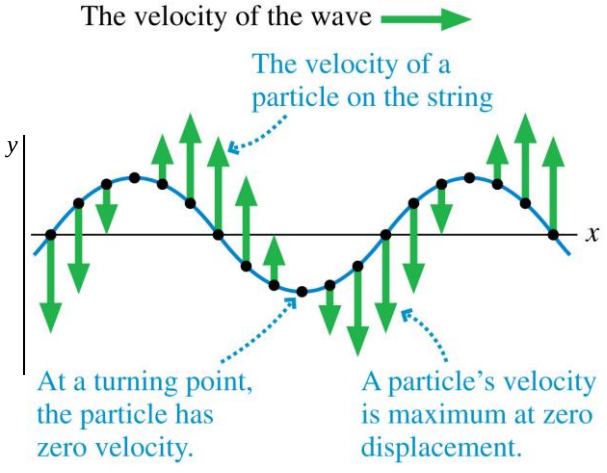
$y = A\cos\left[2\pi\left(\frac{t}{T} + \frac{x}{\lambda}\right)\right]$ is a "sinusoidal" wave traveling in the $-x$ direction.

- The **Period** T in seconds is the time for one complete vibration of a point in the medium anywhere along the wave's path.
- The **Frequency** f in Hz (s^{-1}) $f = 1/T$, is the number of vibrations per second of a point in the medium as the wave passes.
- The **Amplitude** A is the maximum distance of a point of the medium from its equilibrium position as the wave passes.
- The **Wave Speed** v in m/s is the distance a disturbance travels in a time interval divided by that time interval.

21

Sinusoidal Wave on a String

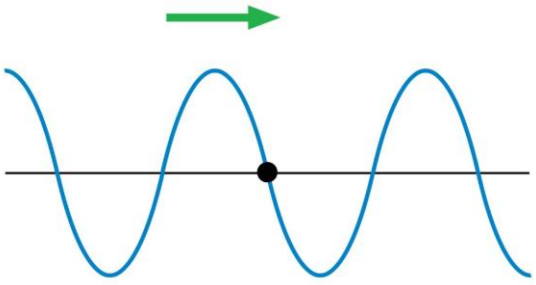
- Shown is a snapshot graph of a wave on a string with vectors showing the velocity of the string at various points.
- As the wave moves along x, the velocity of a particle on the string is in the y-direction.



22

Poll Question

- A wave on a string is traveling to the right.
- The green arrow shows the direction of the **motion of the wave energy**.
- At this instant, the piece of string marked with a dot is moving.
- In what *direction* is the piece of string marked with a dot moving at this instant? [Choose closest]



A. 

B. 

C. 

D. 

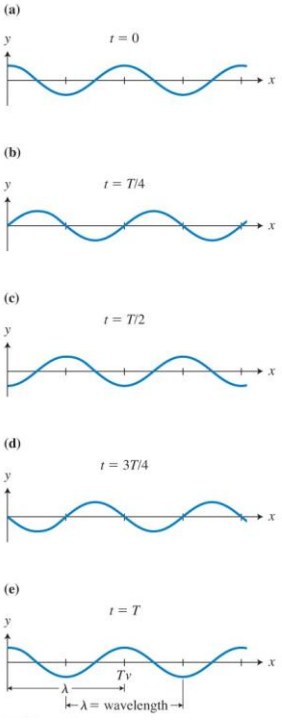
23

"Wave Speed" means speed of the **Pattern**

- Figure 11.8 on page 319 shows five "snapshots" as a wave pattern moves along the $+x$ direction.
- 11.8(e) shows that the pattern repeats at a distance Tv (period multiplied by the wave speed). This distance is called the wavelength:

$$\lambda = Tv$$

- Whenever you have two out of three of the following, you can use the equation above to solve for the third:
  1. Wave speed v
  2. Period T
  3. Wavelength λ

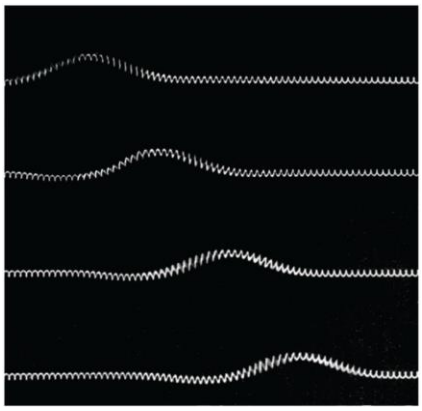


24

Transverse waves

The speed of transverse waves on a string stretched with tension F is:

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



Where μ is the string's mass-to-length ratio, also called the **linear density**:

$$\mu = \frac{m}{L}$$ Units: [kg/m]

[Doc Cam Example]

25

An 80 kg climber hangs from a rope, 20 m below a rocky overhang. The rope has a linear density of 37 g/m.

Approximately how long would it take a transverse pulse to travel the length of the rope from the climber to the overhang?

SKETCH & TRANSLATE.

SIMPLIFY & DIAGRAM

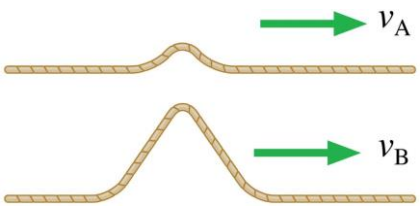
REPRESENT MATHEMATICALLY

SOLVE & EVALUATE

26

Poll Question

These two wave pulses travel along the same stretched string, one after the other. Which is true?



A. $v_A > v_B$
B. $v_B > v_A$
C. $v_A = v_B$
D. Not enough information to tell.

27

Poll Question

For a wave pulse on a string to travel twice as fast, the string tension must be

A. Increased by a factor of 4.
B. Increased by a factor of 2.
C. Decreased to one half its initial value.
D. Decreased to one fourth its initial value.
E. Not possible. The pulse speed is always the same.

28

Before Class 33 on Friday

- Please continue reading Chapter 11:
- 11.4 Wave Intensity
- 11.5 Reflection of Waves
- 11.6 The Principle of Superposition

- Plan to meet up with your Practical Pod during Friday's class – you should be able to turn on your microphone in order to participate in the TeamUp Quiz Module 6 Ch.11.
- If you cannot do the TeamUp quiz during class, it can be done either with your pod or on your own at any time over the weekend.

29