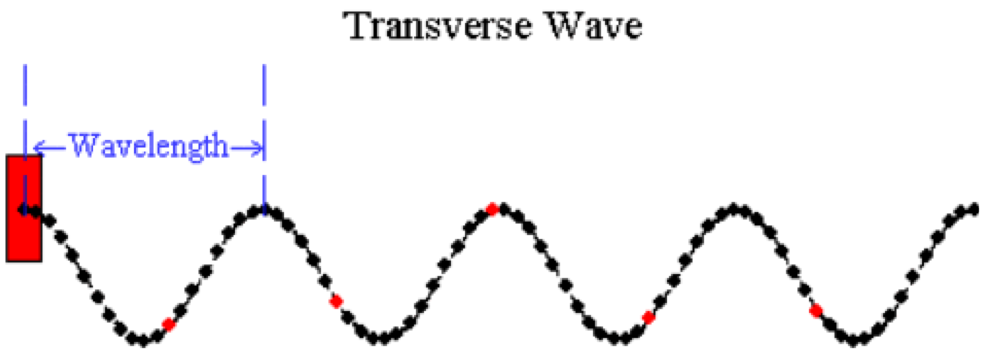
PHY131H1F - Class 32



Today:

11.1 Transverse and Longitudinal Waves

11.2 Sinusoidal Waves

11.3 Wave Speed

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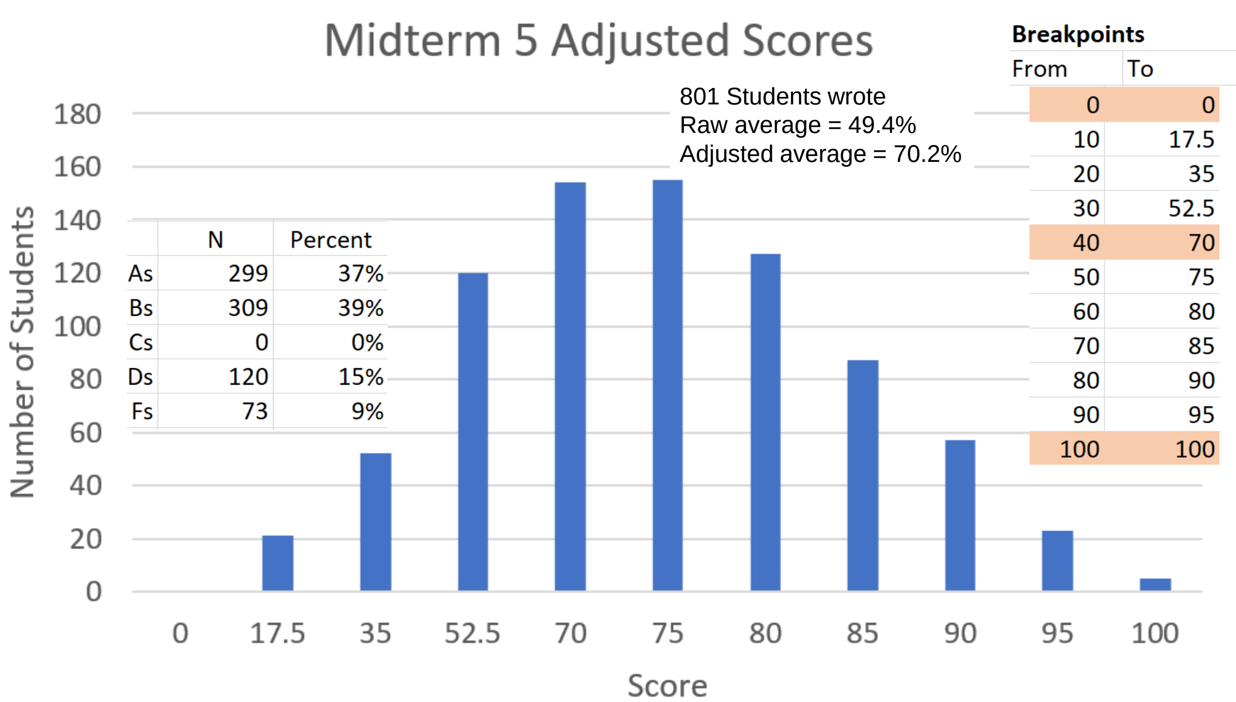


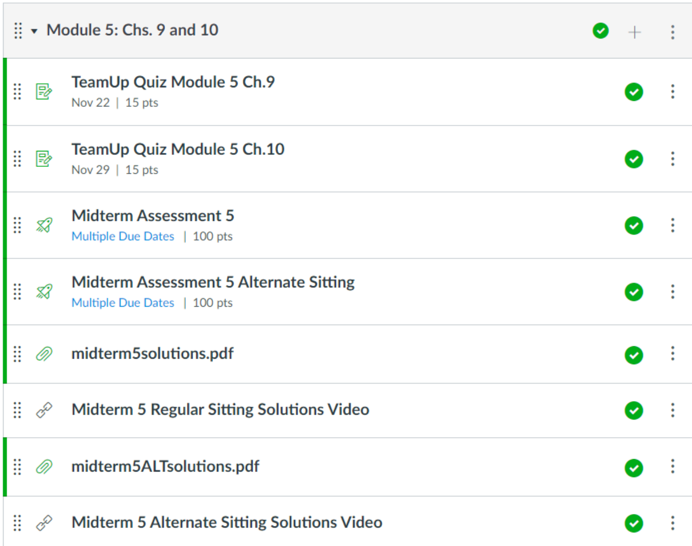
	N	Percent
As	299	37%
Bs	309	39%
Cs	0	0%
Ds	120	15%
Fs	73	9%

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.

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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.

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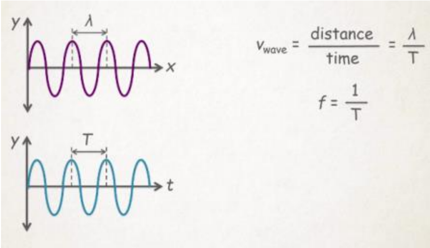
Mastering Physics

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



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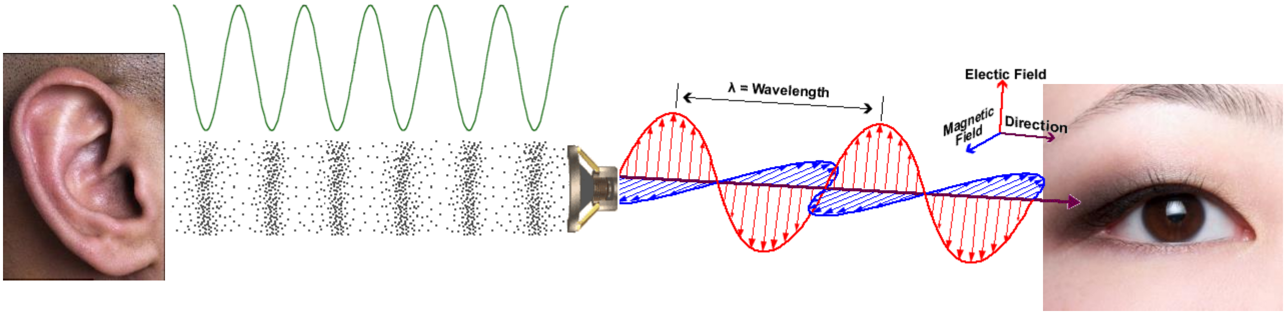
Last day I asked



- 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.

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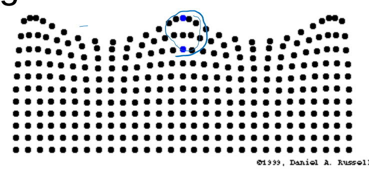
Chapter 11. Mechanical Waves

- 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]

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

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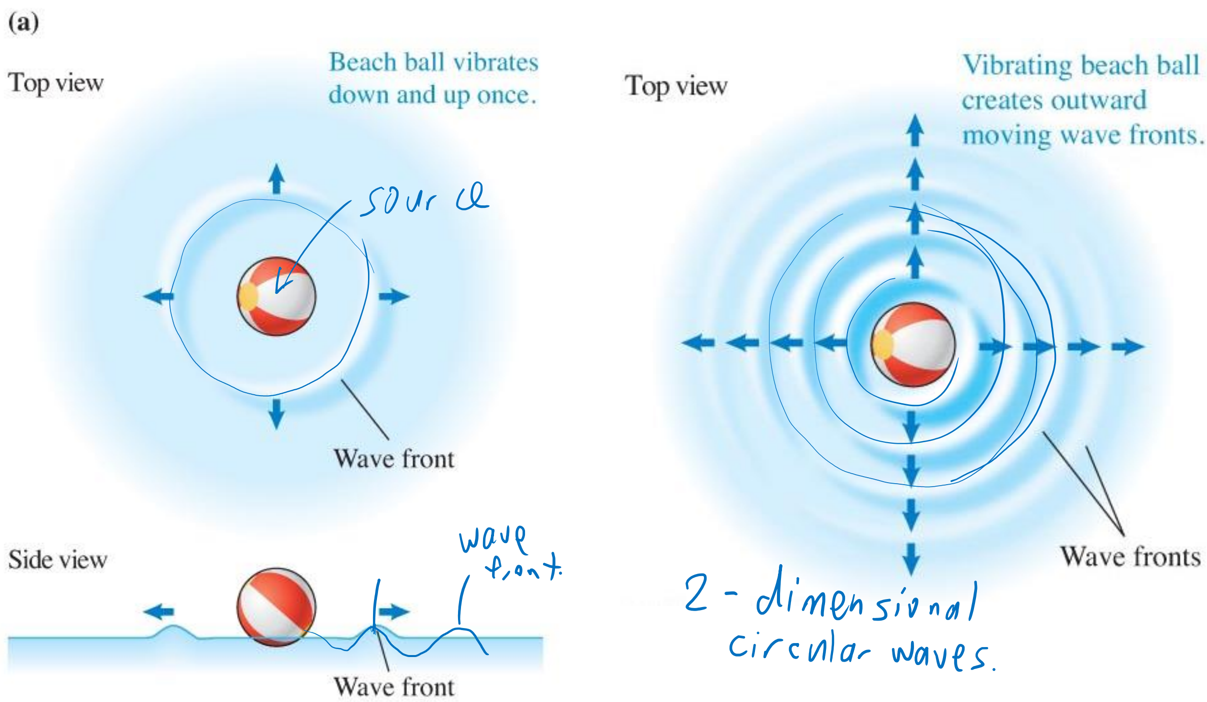

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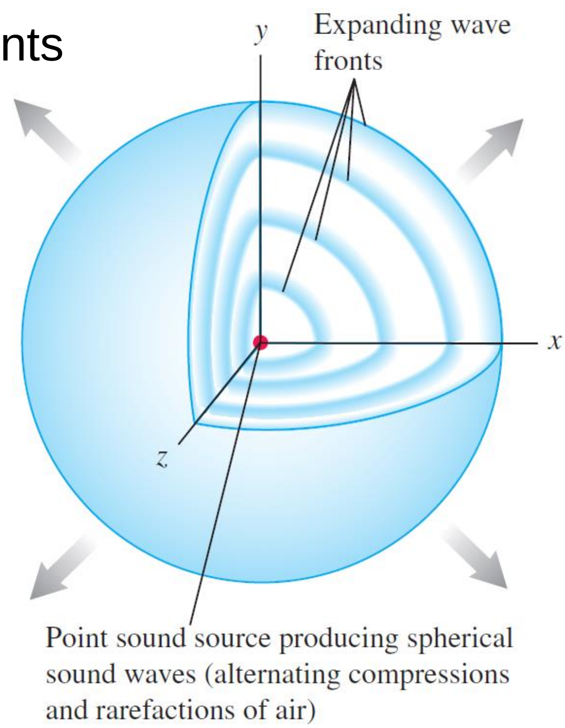
Waves and Wave Fronts

- 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.



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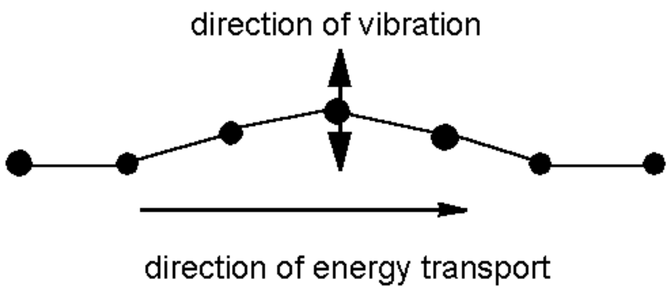
Transverse waves

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

  Example:
  - Vibrations in stretched strings of musical instruments

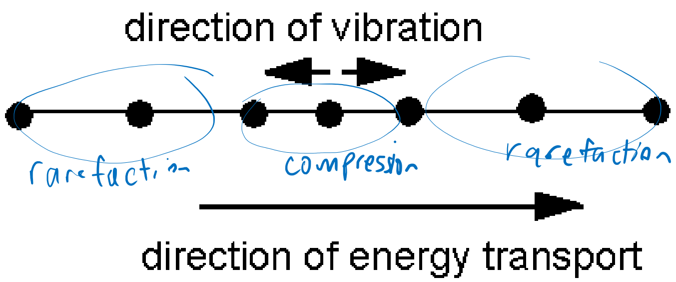


[image from http://www.maths.gla.ac.uk/~fhg/waves/waves1.html]

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

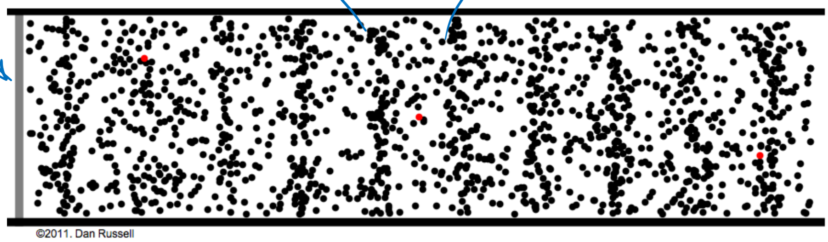


[image from http://www.maths.gla.ac.uk/~fhg/waves/waves1.html]

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.

speaker — air particles in a tube of air



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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. Longitudinal

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

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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]

Reflection from a Heavier end

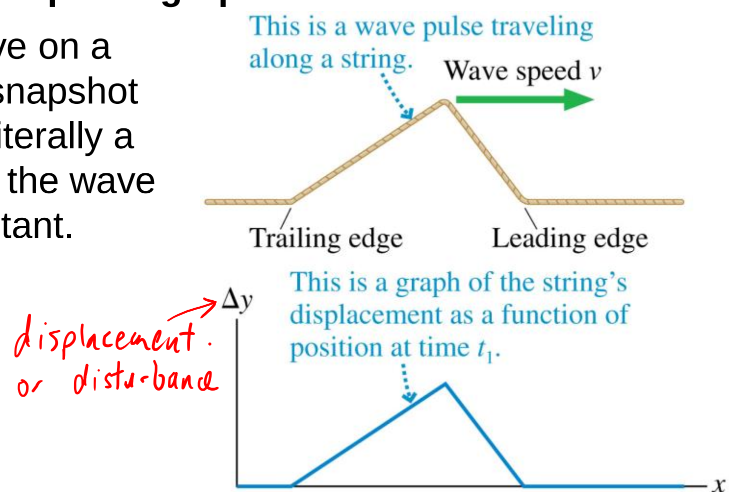
- A pulse traveling to the right on a light string attached to a heavier string
- The reflected pulse is "inverted".
- Also a small pulse is transmitted into the second medium.

[Animation courtesy of Dan Russell, Penn State]

[PhET Demonstration]

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.



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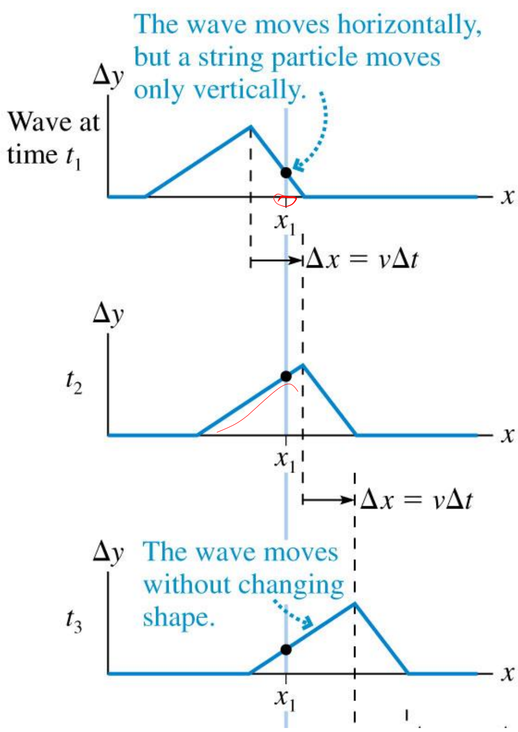
One-Dimensional Waves

- 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.*



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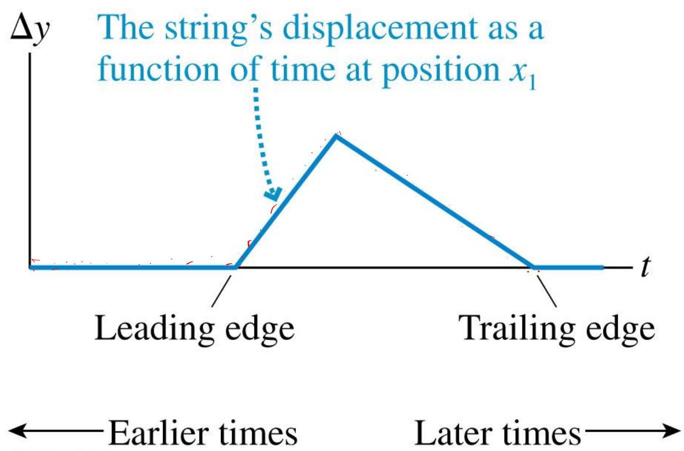
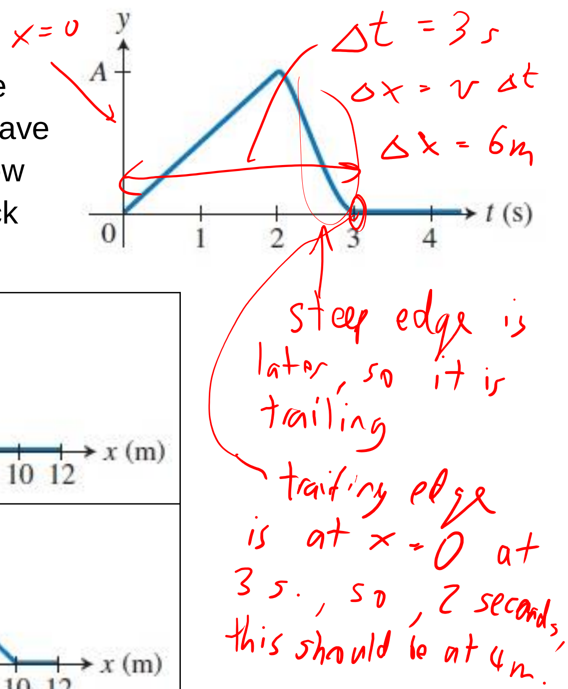
History Graph

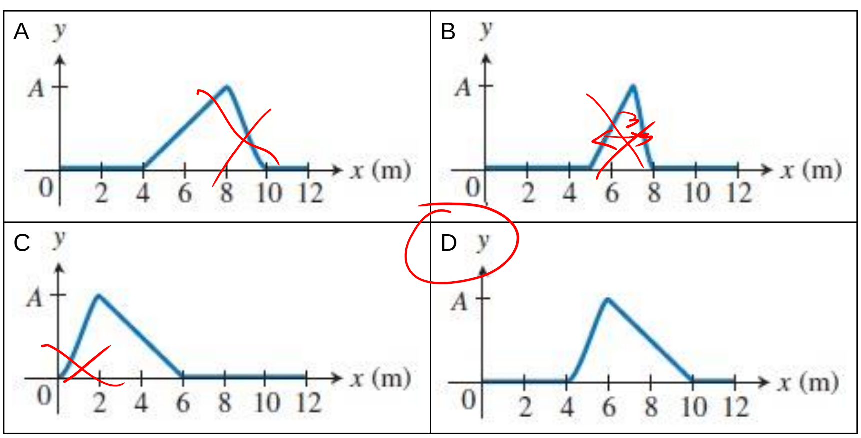
- A graph that shows the wave's displacement as a function of time at a single **position** in space is called a **history graph.**
- This graph tells the history of that particular point in the medium.
- Note that for a wave moving from left to right, the shape of the history graph is *reversed* compared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



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?





y, x, t are variable

“Cosine” is one shape a wave can have!

λ = "lambda" = wavelength.

$y = A\cos\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)\right]$ 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. $v = \lambda/T = \lambda f$

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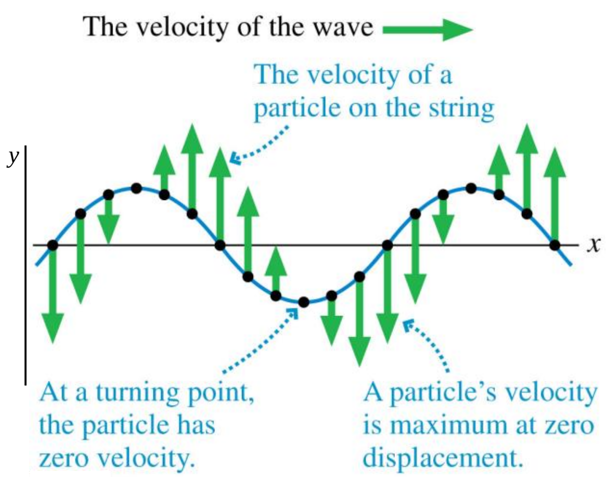
Sinusoidal Wave on a String

- 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.



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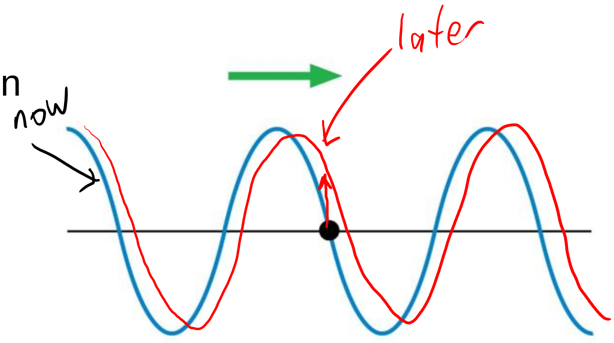
Poll Question

- 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. ←

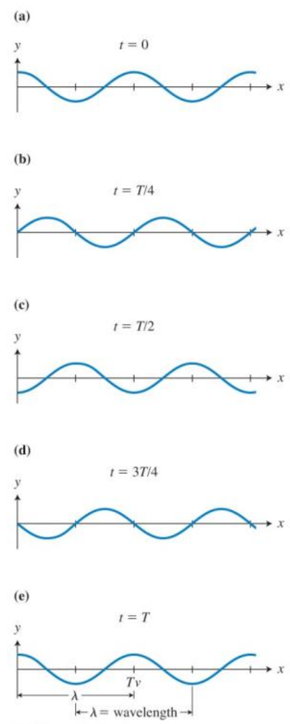
E = zero velocity

"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 $= \frac{\lambda}{T}$
  2. Period T $= \frac{\lambda}{v}$
  3. Wavelength λ $= T v$



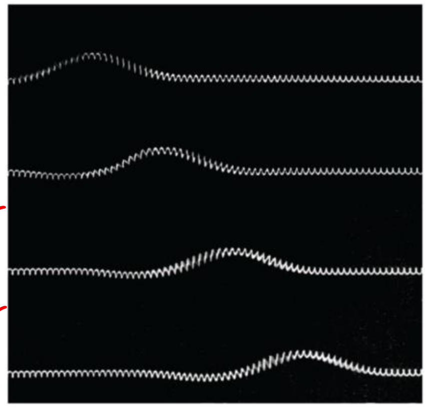
Transverse waves

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

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

"mu"

F is used for tension, since T is used for period.



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]

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.

$V = \sqrt{F/\mu}$

F = tensions.

F ↑ 4

v ↑ $\sqrt{4}$

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

Office Hour is at 1:30pm → 2:00pm today.

- 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.

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