April 3, 2017 Physics 132 Prof. E. F. Redish

- **Theme Music: Gregory Paul Aubuchon**

  Pulse

- **Cartoon: Pat Brady**

  Rose is Rose

4/3/17 Physics 132 **1**

Outline

- Quiz 8
- Introduction to waves:
  - Pulses on a beaded string
- Interpreting the motion
- Examples

4/3/17 Physics 132 **2**

The Equation of the Day

Moving a pulse

$$y(x,t) = f(x - v_0 t)$$

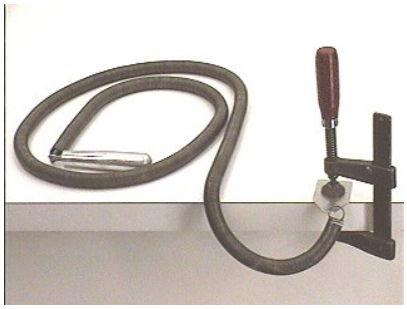
Physics 132

What's a "wave"?

- In common speech, a "wave" can be a traveling pattern of any kind that doesn't (usually) involve the transport of matter.
  - Think of "the wave" in a stadium or a tidal wave. (No, the water in a tidal wave doesn't cross the ocean.)
- In science classes, a "wave" is often an endlessly repeating wiggle.
  - Such as "a sine wave".
- In this class, "wave" will include both of these.

Demonstration: Waves on a long spring

- Pulses
  - Transverse
  - Longitudinal

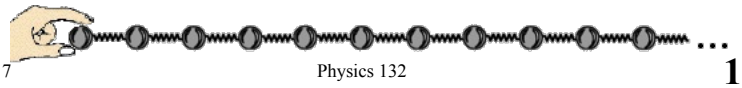


What happens when the demonstrator shakes the end of a taut spring?

- A pulse forms and moves down the spring.
- Does it change its shape? *(much)*
  A. Yes
  B. No
- Does it get bigger or smaller? *(significantly)*
  A. Bigger
  B. Smaller
  C. Stays the same

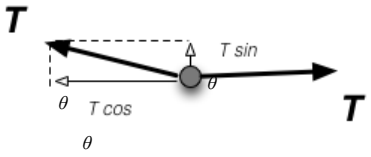
A Model of an elastic string / spring

- The critical characteristics for what happens on the spring are:
  - The bits of the spring are elastic, so they pull displaced bits back towards equilibrium.
  - The bits of the spring have mass (inertia) so they overshoot.
- We will create a model that separates these characteristics so we can talk about them more easily:
  - massive beads
  - massless springs (under tension)



Forces on the beads

- Small amplitudes ➔ Small angles



Small angles $\rightarrow$

$\sin\theta \approx \theta$

$\cos\theta \approx 1 - \frac{1}{2}\theta^2$

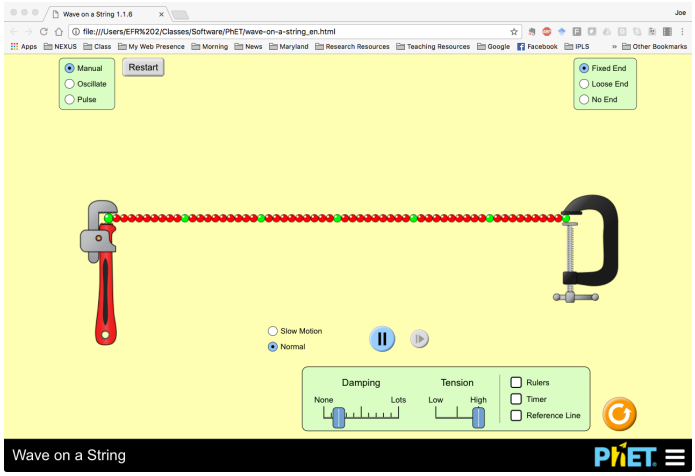
- Ignoring θ^2 ➔ horizontal forces cancel. Motion of the beads is vertical (*transverse*)

Displacements on an elastic string / spring

- Each bit of the string can move up or down (perpendicular to its length).
- To describe the motion of the string we need to describe the motion of each bit of the string at every instant of time.
- We therefore need to tell both which bit and when in order to specify a displacement.

$$y_i = f_i(t) \qquad y = f(x,t)$$

Play with the sim



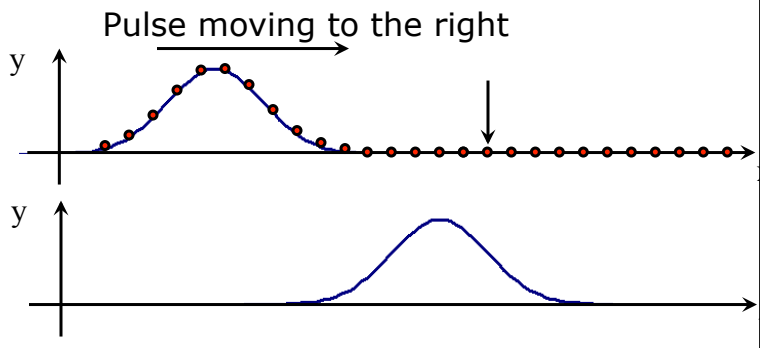
https://phet.colorado.edu/en/simulation/wave-on-a-string

Foothold principles: Mechanical waves

- *Key concept*: We have to distinguish the motion of the bits of matter and the motion of the pattern.
- *Pattern speed*: a disturbance moves into a medium with a speed that depends on the properties of the medium (but not on the shape of the disturbance)
- *Matter speed*: the speed of the bits of matter depend on both the size and shape of the pulse and on the pattern speed.
- *Mechanism*: the pulse propagates by each bit of string pulling on the next.

How do the beads move?

What is the velocity of each bead in the top figure at the time shown?
How does the bead indicated by the arrow move as a function of time?



Why do I draw beads on the x-graph but not on the t?
Are the widths of the x- and t-graphs the same?