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# A Physics Tutorial
# Waves 2.0

**Question 1**

For this question, you will be using the "wave on a string" PHET. Start by choosing the "no end" option and set the dampening to zero.

a) Wiggle the wrench quickly up and back down to make a single pulse. What happens to the shape of the pulse as it moves? You can use pause to stop the pulse.

*(note: this behaviour doesn't always hold for real waves)*

b) Describe the motion of the beads on the string as the pulse moves.

c) If you decrease the tension in the rope, how does that affect things?

d) Now try choosing "fixed end". What happens to the pulse when it reaches the end? Explain why you see what you see.

e) What about "loose end"? What happens to the pulse when it reaches the end? Explain why you see what you see.

f) With the tension set to the middle, and with the "loose end" setting, try setting up two pulses at separate times and watch what happens when they collide.

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g) How do you make a pulse shaped like this: 

## **Question 2**

Choose “no end”, damping =0, tension = “high” and “oscillate”. Start with amplitude = 50 and frequency = 50.

a) How long does it take for a wave crest to go from the left to the right? (use the timer). What is the velocity (use the ruler also)?

b) What is the wavelength? (use the ruler)

c) Now switch to frequency = 25. What is the new wavelength compared to the old one?

d) What is the new velocity?

e) Now double the amplitude to 100. What is the new wavelength and velocity?

f) Finally, go back to the amplitude = 50 and frequency = 50. Now, decrease the tension (and thus the velocity). What happens to the wavelength?

g) Are the results consistent with $v = \lambda f$?

h) It turns out that the speed of the wave only depends on the string tension and the linear mass density of the wave. Use dimensional analysis to determine and equation for the velocity of the wave.

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## Question 3

Now choose: fixed end, tension = high, damping = 2, amplitude = 50,
frequency = 36.

Click the restart button and wait for a while for the glitches in the string to settle down.

a) Draw the shape of your string (press pause to see it).

b) Look at the individual beads on the string. Are some beads moving more than others? Are the peaks in the waves traveling?

This wave is a STANDING WAVE, a superposition of a wave moving to the left and a wave moving to the right. On a string of fixed length with one end fixed and one end free to move, standing waves can only exist with certain specific frequencies.

c) How does the length of the string compare with the standing wave of your string? (e.g. 2λ, 3/2 λ, etc…)

d) Draw some other possible shapes for standing waves. For each one write, write down how the length L is related to the wavelength. For example, the simplest one is drawn on the left. (*Try Amplitude 50, frequency =10, dampening = 2, tension = high to find a possible one)*

$L = \frac{1}{4}\lambda$

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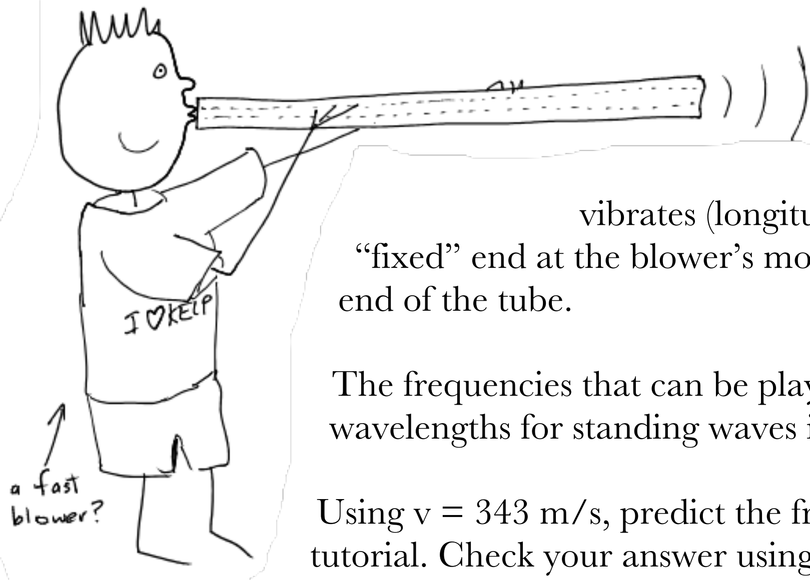
**Question 4 – Music!**




When A piece of kelp (or other tube) is used as a musical instrument, the air in the tube vibrates (longitudinally) as a standing wave, with the "fixed" end at the blower's mouth and the "free" end at the open end of the tube.

The frequencies that can be played are determined by the allowed wavelengths for standing waves in the tube, and the relation $f = v/\lambda$.

Using $v = 343$ m/s, predict the frequencies for one of the tubes at the tutorial. Check your answer using a tuner app!

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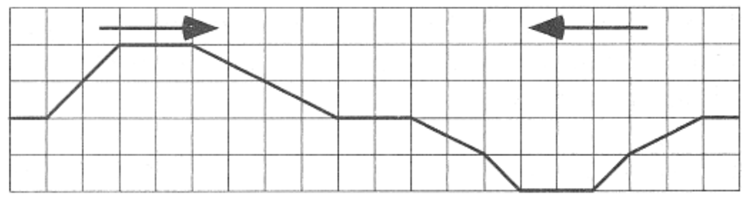
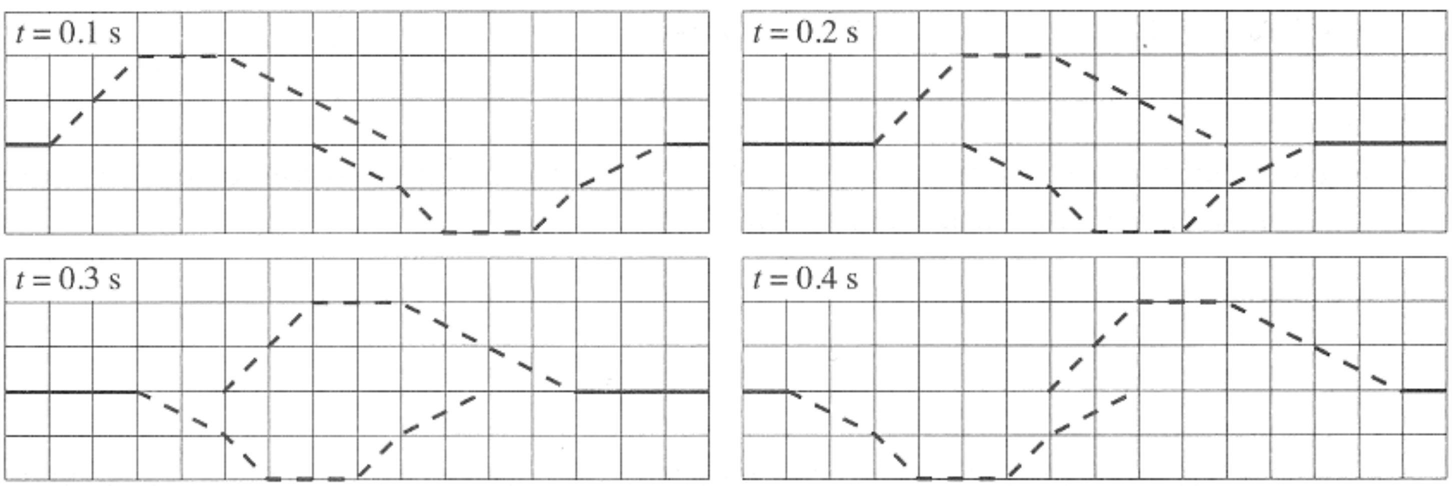
## Question 5 – Drawing Superposition

Two pulses on opposite sides of a spring are moving toward each other. The diagrams below show the pulse locations at four successive instants. One each diagram, sketch the shape of the spring for the instant shown






## Question 6 – Visualizing Reflection

a) A pulse on a spring with speed 1.0 m/s is incident on a fixed end. Determine the shape of the spring at t = 0.2 s, 0.4 s and 0.6 s. Remember that the end of the spring must remain fixed. A model for hard reflections is that the spring extends past the fixed end and we send a pulse along the imaginary portion (the grey area beyond the fixed end) toward the fixed end. We choose the shape, orientation and location of the imagined pulse so that as it passes the incident pulse, the end of the spring *remains fixed*.

See next page for the graph!

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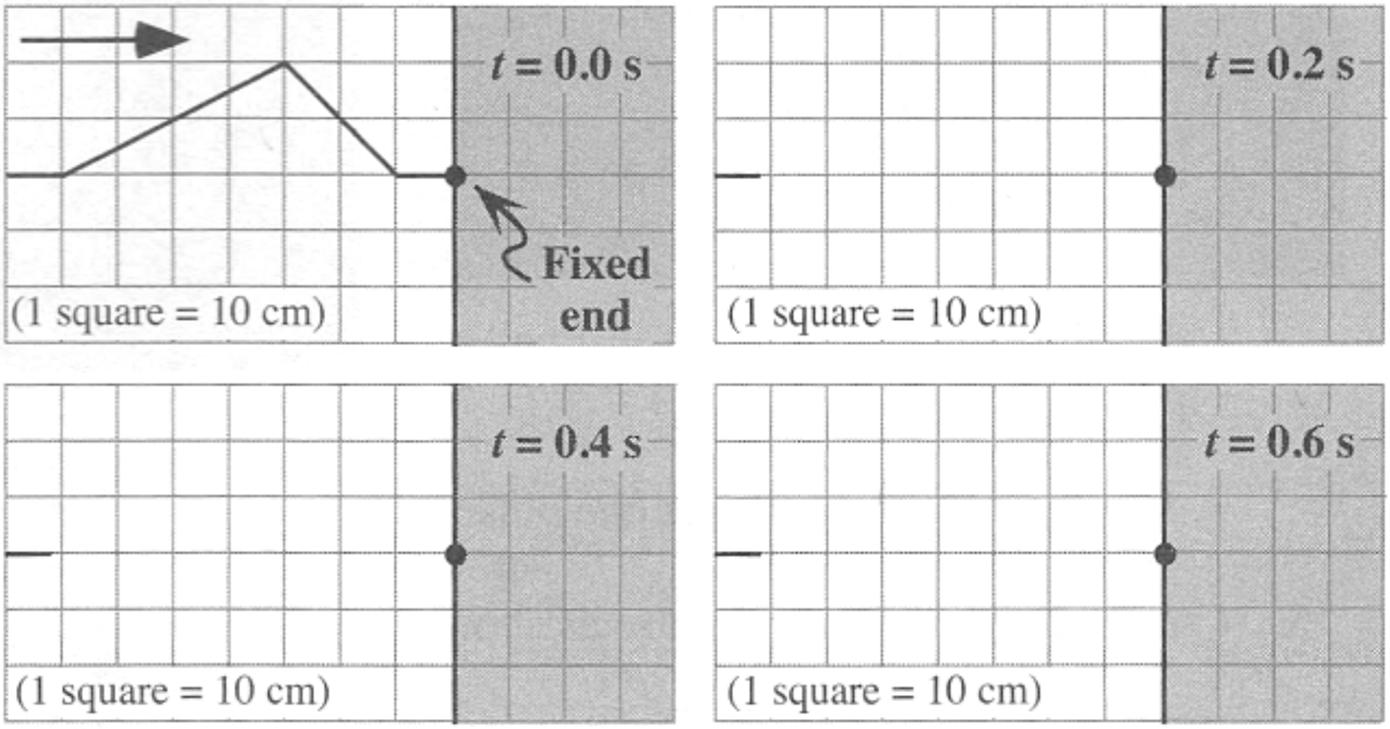


b) At $t = 0.0$ s a pulse on a spring with speed 1.0 m/s is incident on the free end of a spring as shown. Determine the shape of the spring at $t = 0.2$ s, 0.4 s and 0.6 s. Just like in the fixed end case, we imagine that the spring extends past the free end. We then imagine sending a pulse with the appropriate shape and location of the imaginary portion of the spring (beyond the free end) and have these pulses pass each other. Remember that in the case of the free end, the pulse is *not* inverted.