Standing Waves on a String

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PHYS-111 2pm Lab

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$$\lambda = \frac{v}{f} \tag{1}$$
$$v = \sqrt{\frac{T}{\mu}} = 2f_0L$$
$$f_0 = fundamental\ frequency$$
$$n = harmonic$$
$$2L = wavelength\ of\ fundamental\ wave$$

Frequency determination for Two modes

Set linear mass density to $\mu \approx 2.00 \times 10^{-3} kg/m$ and tension to $T = 55.00N$, according to instructions.

(All numbers in this portion of the lab are found using the μ of $2.00 \times 10^{-3} kg/m$)

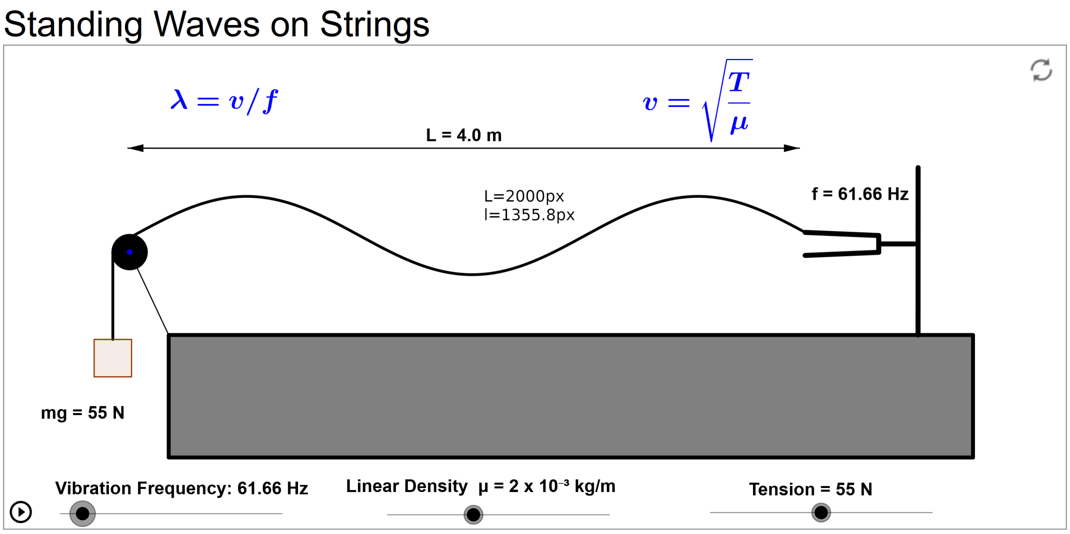
1. Calculate the speed v of any wave in this string at this tension, and show the calculation.

$$v = \sqrt{\frac{T}{\mu}} \tag{2}$$
$$v = \sqrt{\frac{55.00N}{2.00 \times 10^{-3} kg/m}}$$
$$v = 165.8312395m/s$$
$$\boxed{v = 166.m/s}$$

2. What is the purpose of the mass hanging on the end of the string?
   To provide tension in the string so that a wave can be simulated. Waves on strings cannot exist without tension.
   1. Calculate the magnitude of the hanging mass:

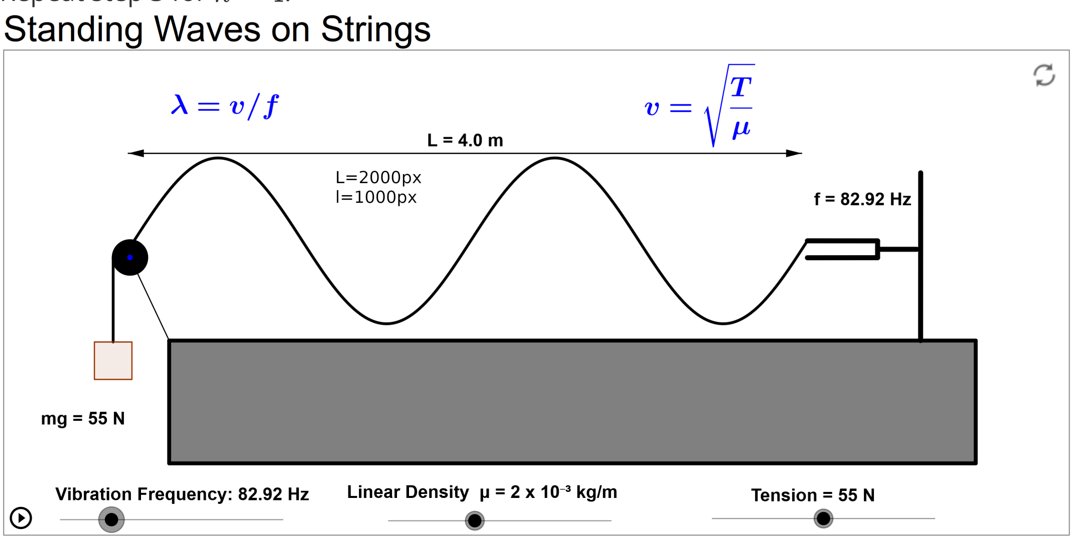
$$F = ma;\ a = g \tag{3}$$
$$m = \frac{F}{g}$$
$$m = \frac{55.00N}{9.81m/s^2}$$
$$m = 5.606523955kg$$
$$\boxed{m = 5.61kg}$$

3. Use the slider under the frequency values to adjust the frequency such that you see the third mode for a standing wave in this string. ($n = 3$) Record the frequency. Record the wavelength as well.



$$f_{n=3} = 61.66Hz \tag{4}$$
$$\lambda_{n=3} = \frac{L_m}{L_{px}} \times \lambda_{px}$$
$$\lambda_{n=3} = (\frac{4.0m}{2000px} \times 1355.8px)$$
$$\lambda_{n=3} = 2.7116m = 2.7m$$

4. Repeat step 3 for $n = 4$.



$$f_{n=4} = 82.92Hz \tag{5}$$
$$\lambda = (\frac{4.0m}{2000px} \times 1000px) = 2.0m$$

5. Calculate the speed of the wave for both $n = 3, 4$. How do they compare?

$$v = f\lambda \tag{6}$$
$$v_3 = 61.66Hz * 2.7m | v_4 = 82.92Hz * 2.0m$$
$$v_3 = 166.482m/s | v_4 = 165.84m/s$$
$$\boxed{|v_3 = 166m/s | v_4 = 166m/s|}$$

These values are functionally equivalent, when taken to the correct significant figures. This makes sense.

Examine the Effect of Increasing and Decreasing Linear Mass Density and Tension

Do not modify the frequency from $n = 4$.

1. Keeping frequency and tension constant, increase the linear mass density μ by moving the slider slowly to the right until you find another standing wave. What is the harmonic?
   $n = 5$
2. Decrease the linear mass density μ by moving the slider slowly to the left until you find another standing wave. What is the harmonic mode number of this new wave?
   $n = 3$
3. Given 1 and 2, describe how μ changes speed of the standing wave and wavelength, given a fixed frequency.
   Increasing the linear mass density will decrease the speed of the standing wave $v = \sqrt{\frac{T}{\mu}};\ v \propto \frac{1}{\mu}$. Because speed and wavelength inversely proportional when frequency is constant ($f = \frac{v}{\lambda}$) , this means that as the speed decreases, the wavelength will increase.
4. Keeping the frequency and linear mass density constant ($\mu = 2.01 \times 10^{-3} kg/m$), increase the tension by moving the slider slowly to the right until you find another standing wave. What is the harmonic of the new wave?
   $n = 3$
5. Decrease the tension by moving the slider slowly to the left until you find another standing wave. What is the harmonic of the new wave?
   $n = 5$
6. Given 4 and 5, explain how tension affects speed and wavelength for a fixed frequency.
   Increasing the tension will increase the speed of the wave $v = \sqrt{\frac{T}{\mu}};\ v \propto T$. Because the speed and wavelength are inversely proportional when frequency is constant ($f = \frac{v}{\lambda}$), this means that as speed increases, the wavelength will decrease.