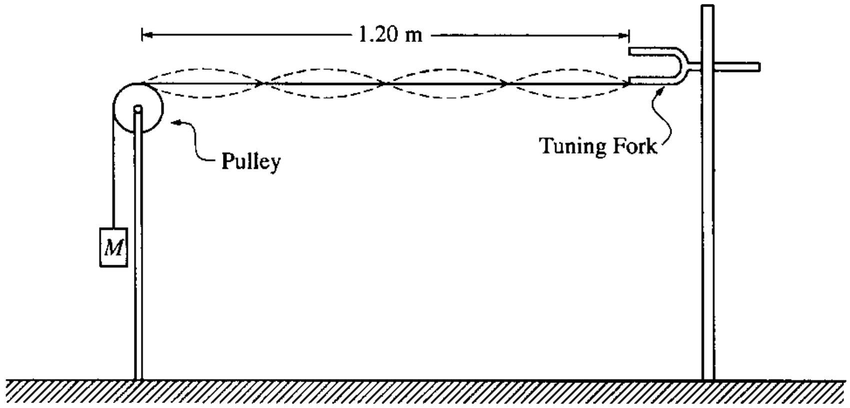
1. A rope is stretched between two vertical supports. The points where it's attached (P and Q) are fixed. The linear density of the rope, μ, is 0.4kg/m, and the speed of a transverse wave on the rope is 12m/s.

(a) What is the tension in the rope?
(b) With what frequency must the rope vibrate to create a traveling wave with a wavelength of 2m?

The rope can support standing waves of lengths 4m and 3.2m, whose harmonic numbers are consecutive integers.

(c) Find:
  (i) the length of the rope
  (ii) the mass of the rope

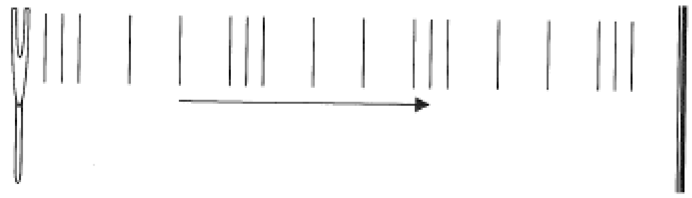
(d) What is the harmonic number of the 4m standing wave?
(e) On the diagram above, draw a sketch of the 4m standing wave, labeling the nodes and antinodes.



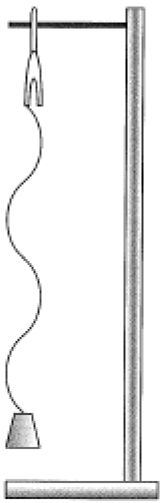
2. To demonstrate standing waves, one end of a string is attached to a tuning fork with frequency 120 Hz. The other end of the string passes over a pulley and is connected to a suspended mass M as shown in the figure above.

The value of M is such that the standing wave pattern has four "loops." The length of the string from the tuning fork to the point where the string touches the top of the pulley is 1.20 m. The linear density of the string is 1.0×10^{-4} kg/m, and remains constant throughout the experiment.

a. Determine the wavelength of the standing wave.
b. Determine the speed of transverse waves along the string.
c. The speed of waves along the string increases with increasing tension in the string. Indicate whether the value of M should be increased or decreased in order to double the number of loops in the standing wave pattern. Justify your answer.
d. If a point on the string at an antipode moves a total vertical distance of 4 cm during one complete cycle, what is the amplitude of the standing wave?

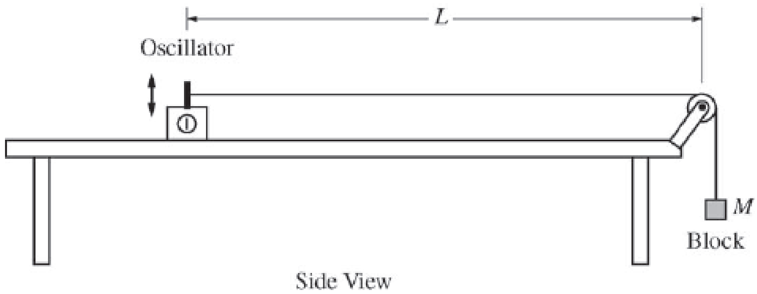


3. A tuning fork of frequency 300Hz is activated and sends a sound wave toward a classroom wall, and the echo is detected at the location of the tuning force 0.06s later.
(a) Determine the wavelength of the sound wave.
(b) Determine the distance from the tuning fork to the wall.

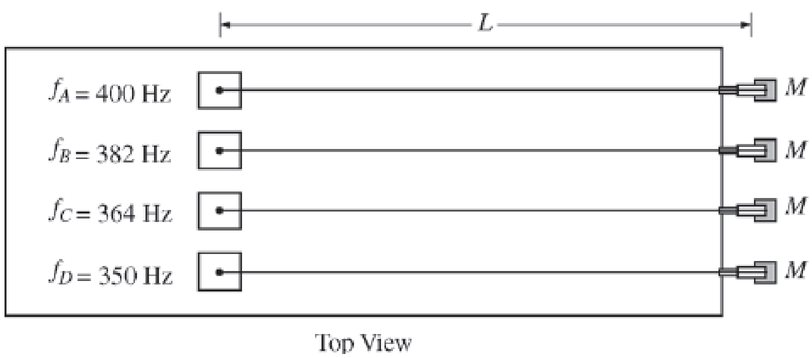


The same tuning fork is mounted vertically on a ring stand. A string of length 2m is attached to the tuning force and a mass *m* is hung on the end of the string. The tuning fork is activated, and a wave passes through the string (the size of the amplitude of the wave is exaggerated for clarity). Assume that the tension in the string does not affect the frequency of vibration of the tuning fork.

(c) If the speed of the wave is 600m/s when the mass *m* is hung on the end of the string, how many full wavelengths will occupy the string?
(d) If the mass *m* is replaced with a mass of *4m*, how many wavelengths (or what fraction of a wavelength) will occupy the string?

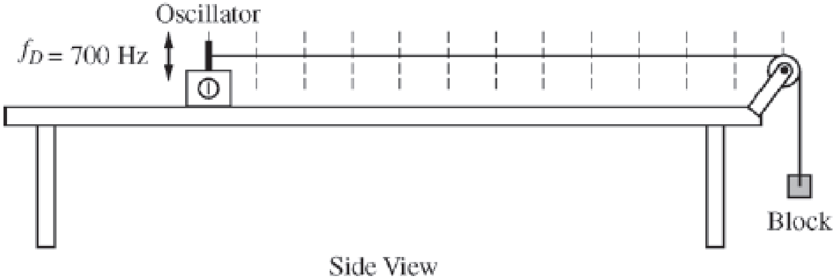


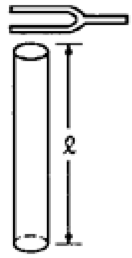
4. The figure above shows a string with one end attached to an oscillator and the other end attached to a block. The string passes over a massless pulley that turns with negligible friction. Four such strings, *A*, *B*, *C*, and *D*, are set up side by side, as shown in the diagram below. Each oscillator is adjusted to vibrate the string at its fundamental frequency *f*. The distance between each oscillator and pulley *L* is the same, and the mass *M* of each block is the same. However, the fundamental frequency of each string is different.



The equation for the velocity *v* of a wave on a string is $v = \sqrt{\frac{F_T}{\frac{m}{L}}}$ where F_T is the tension of the string and m/L is the mass per unit length (linear mass density) of the string.

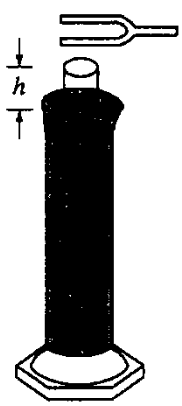
(a) What is different about the four strings shown above that would result in their having different fundamental frequencies? Explain.
(b) A student graphs frequency as a functino of the inverse of the linear mass density. Will the graph be linear? Explain.
(c) The frequency of the oscillator connected to string *D* is changed so that the string vibrates in its second harmonic. On the side view of string *D* below, mark and label the points on the string that have the greatest average vertical speed.





5. A hollow tube of length Q. open at both ends as shown above, is held in midair. A tuning fork with a frequency f_o vibrates at one end of the tube and causes the air in the tube to vibrate at its fundamental frequency. Express your answers in terms of *l* and f_o

a. Determine the wavelength of the sound.
b. Determine the speed of sound in the air inside the tube.
c. Determine the next higher frequency at which this air column would resonate.



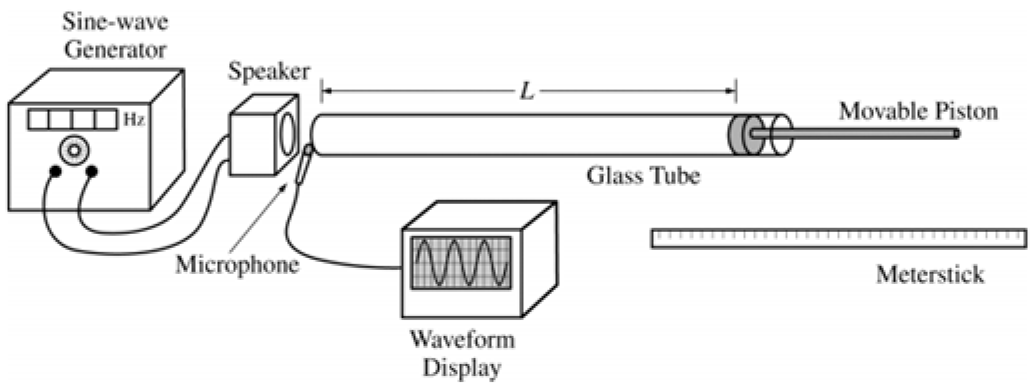
Note: **Figure not drawn to scale.**

The tube is submerged in a large, graduated cylinder filled with water. The tube is slowly raised out of the water and the same tuning fork, vibrating with frequency f_0, is held a fixed distance from the top of the tube.

d. Determine the height h of the tube above the water when the air column resonates for the first time. Express your answer in terms of *l*.

e. If a tuning fork with a higher frequency is used, what will happen to the value of *h*? Explain.

f. If the tube is raised further, at what height h will the air column resonate again? Express your answer in terms of *l*.



6. You are given the apparatus represented in the figure above. A glass tube is fitted with a movable piston that allows the indicated length L to be adjusted. A sine-wave generator with an adjustable frequency is connected to a speaker near the open end of the tube. The output of a microphone at the open end is connected to a waveform display. You are to use this apparatus to measure the speed of sound in air.

   (a) Describe a procedure using the apparatus that would allow you to determine the speed of sound in air. Clearly indicate what quantities you would measure and with what instrument each measurement would be made. Represent each measured quantity with a different symbol.
   (b) Using the symbols defined in part (a), indicate how your measurements can be used to determine an experimental value of the speed of sound.
   (c) A more accurate experimental value can be obtained by varying one of the measured quantities to obtain multiple sets of data. Indicate one quantity that can be varied, and describe how a graph of the resulting data could be used to determine the speed of sound. Clearly identify independent and dependent variables, and indicate how the slope of the graph relates to the speed of sound.