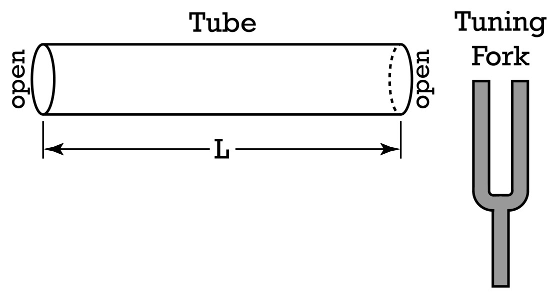
Flipping Physics Lecture Notes:

2019 #5 Free Response Question - AP Physics 1 - Exam Solution
http://www.flippingphysics.com/ap1-2019-frq5.html

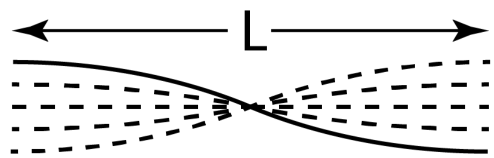
This is a Short Answer question.



A tuning fork vibrating at 512 Hz is held near one end of a tube of length L that is open at both ends, as shown. The column of air in the tube resonates at its fundamental frequency. The speed of sound in air is 340 m/s.

(a) Calculate the length L of the tube.

Because the tube is open at both ends, each end will have a displacement antinode. When resonating at its fundamental frequency, the standing wave created will have the longest possible wavelength to create a standing wave pattern in this tube, therefore, there will be no other displacement antinodes in the tube, and the standing wave pattern will have a displacement antinode on each end and a displacement node in the middle.



Half a wavelength will then equal the length of the tube. We also know, for a wave, that speed equals frequency times wavelength. Therefore, we can determine the length of the tube.

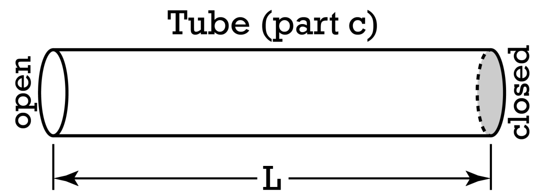
$$L=\frac{1}{2}\lambda \;\&\; v=f\lambda \Rightarrow \lambda=\frac{v}{f} \Rightarrow L=\frac{v}{2f}=\frac{340}{(2)(512)}=0.332031\approx 0.33\text{m}$$

(b) The column of air in the tube is still resonating at its fundamental frequency. On the axes below, sketch a graph of the maximum speed of air molecules as they oscillate in the tube, as a function of position x, from x = 0 (left end of tube) to x = L (right end of tube). (Ignore random thermal motion of the air molecules.)

From the Scoring Guidelines: This graph is worth 3 out of 7 points for this problem. 1 point each for:

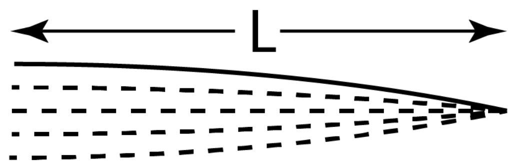
- A curve with a node (zero) at L/2.
- A curve with maxima at 0, L, and no other points.
- A nonhorizontal curve that is symmetric around L/2 and nonnegative everywhere.

To clarify this, as long as your curve is 0 at L/2, shows a maximum value at 0 and L, is never negative, is not horizontal, and is symmetric around L/2, you get full points. In other words, the exact shape of your drawn curve is not graded and they do not expect you to know exactly what the shape of the curve should be. So, do not freak out if you do not fully understand how to draw a graph. Sometimes, you will only know specific locations and have to interpolate from there.



(c) The right end of the tube is now capped shut, and the tube is placed in a chamber that is filled with another gas in which the speed of sound is 1005 m/s. Calculate the new fundamental frequency of the tube.

(d)



Now that the tube is closed on one end, the closed end is a displacement node, and the open end is still a displacement antinode. Again, when resonating at its fundamental frequency, the standing wave created will have the longest possible wavelength to create a standing wave pattern in this tube, therefore, there will be no other displacement nodes or antinodes in the tube and the standing wave pattern will look like this:

Here only one quarter of a wavelength fits in the length of the tube. And we can calculate the new fundamental frequency of the tube using the new speed of sound:

$$L = \frac{1}{4}\lambda \Rightarrow \lambda = 4L \ \& \ v = f\lambda \Rightarrow f = \frac{v}{\lambda} = \frac{v}{4L} = \frac{1005}{(4)(0.332031)} = 756.706 \approx 760\text{Hz}$$