Physics of Music PHY103 Worksheet #6
Set up for Flute Lab

1) The end correction

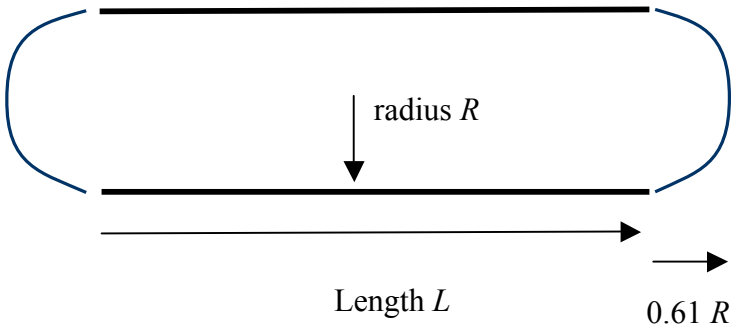
Previously we used the length of a pipe to estimate the frequency of a mode.

$$f_n = \frac{vn}{2L}$$

Here f_n is the frequency of the *n*-th overtone, L is the length of the pipe and v is the speed of sound. This formula is appropriate for a pipe with two open ends.

It turns out that the open end of a pipe behaves in such a way to mimic a slightly longer pipe. That means the above formula is not quite right, it's a little bit off and predicts overtone frequencies that are not correct. The frequency of the fundamental tone played by an open pipe is actually a bit lower than that predicted by the above formula. This effect is known as the edge effect. When the standing wave in the column of air reaches a closed end in a pipe there is a reflection. When the end is open there is also a reflection, but it doesn't occur abruptly. The moving air moves out somewhat into the open air, past the end of the pipe. The "end correction" is the extra *effective* length of the pipe. This extra length is measured to be 61% times the radius of the pipe, 0.61R, where R is the radius of the pipe. This correction is added once to an open/closed pipe and twice to an open/open pipe to estimate the effective length of a pipe. You replace L in the above equation with the new or effective length and get a more accurate prediction for the frequency of the first overtone.

End correction = 0.61 *R*



Open tube acts like a tube of length L + 0.61R+ 0.61R

You make an open flute from 2cm diameter bamboo pipe that is 45cm between the mouth hole and the end of the flute. The flute with no finger holes covered plays an E4 at 329.63Hz. You decide that you also want to make a flute in the key of F#. How long should you make the new flute?

a) Calculated without using the end correction

b) Calculated using the end correction

Note $f^{-1} \propto L + 2 \times 0.61R \sim L\left(1 + 0.61\frac{d}{L}\right)$