Physics 225

Homework Assignment 6

Due 11 March

1 End corrections

Check the calculations we did in class, computing the lowest resonance frequency for various tubes including end corrections. Show your work. Use $c_\mathrm{s} = 344$ m/s.

Big tube: the large tube has length $l = 0.708$ m and radius $a = 0.031$ m. Find its lowest resonant frequency when open-open, and its lowest resonant frequency when open-closed.

Narrow tube: same as big tube but with $l = 0.250$ m and radius $a = 0.0085$ m.

Wine bottle: the bottle volume is $V = 0.000750$ m^3 (3/4 litre). The neck has radius $a = 0.009$ m (and cross-section area $A = \pi a^2$) and length $d = 0.080$ m. One end of the neck is "open" and the other end is "flanged". Find the lowest resonant frequency.

2 Sound radiation from a flute

A flute is a tube approximately 0.7 meters long and 1.9 cm in diameter, hence 0.0095 meters in radius. It is open on both ends.[1]

When the flute is being played, an intense sound wave is bouncing back and forth along the tube. Think of this sound wave as bouncing back and forth between the ends of the flute. How many times per second does the sound wave bounce off of one of the open ends of the flute?

Find the frequency and wavelength of the lowest two resonances. Use the formula found in class to compute the fraction of the sound energy which is "transmitted" [radiated] when the sound bounces from one of the open ends, at each of these resonant frequencies.

During loud playing at the higher frequency you found, the flute can emit [radiate] about 10^{-3} Watts of sound power. What does the sound power and sound intensity INSIDE the flute need to be, to produce this intensity outside?

[1] Actually, the flute is closed on one end but has a hole in the side, just before the closed end, which is the same size as the end. This functions the same as an open end for the purpose of this problem.

The radiation of sound energy (found above) means that, with each "bounce," there is less sound energy left inside the tube. Therefore the sound energy inside the tube will decrease with time. Explain why the decrease is *exponential*.

Compute the decay constant τ for the sound energy inside the tube,

$$\frac{\Delta E}{\Delta t} = -\frac{E}{\tau}$$

for each of the two lowest resonant frequencies. Hint: choose Δt to be the time that it takes for the sound to reflect one time from an open end. Find an expression for the amount of energy lost, ΔE, in this amount of time. Then just plug these values for ΔE and Δt into the equation above, and solve for what τ has to be.

There was a hidden assumption in the above calculation: we assumed that the *only* way that the sound wave inside the flute loses energy is through radiation of sound from the ends. Think about how fast the sound of a flute or other wind instrument really does die down when someone stops blowing on it. Estimate how fast the sound really does die down (based on your EXPERIENCE as a listener), and use your answer to guess whether our hidden assumption was good or lousy.