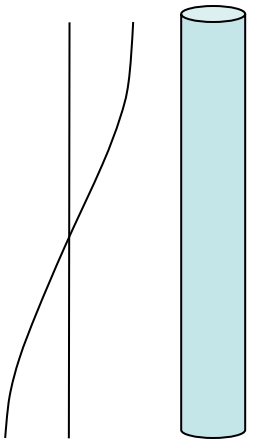
Problem 14.52

A tunnel is 20,000 meters long.

a.) At what frequency can the air in the tunnel resonate?



b.) Would it be a good idea to honk a horn in tunnel like this?

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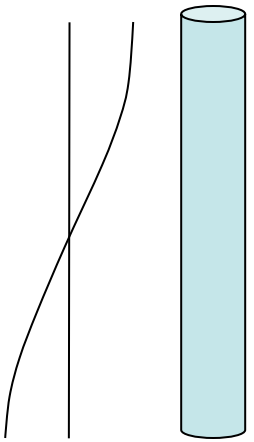

The longest wavelength that can stand (highest frequency) looks like the form shown to the right. The frequency associated with that is:

$$?\left(\lambda/4\right) = \mathrm{L}$$

$$\Rightarrow \quad 2\left(\lambda/4\right) = \mathrm{L}$$

$$\Rightarrow \quad \lambda = 2\mathrm{L} = 2\left(2\mathrm{x}10^{4}\ \mathrm{m}\right) = 4\mathrm{x}10^{4}\ \mathrm{m}$$

So:

$$\mathrm{v}_{\mathrm{lowest}} = \lambda\nu$$

$$\Rightarrow \quad \nu = \frac{\mathrm{v}}{\lambda}$$

$$\Rightarrow \quad \nu = \frac{340\ \mathrm{m/s}}{4\mathrm{x}10^{4}\ \mathrm{m}}$$

$$\Rightarrow \quad \nu = .0085\ \mathrm{cycles/sec}$$

The harmonics will be multiples of this "lowest frequency," or:

$$\nu_n = (.0085\ \text{Hz})n,$$

where "n" is any number from 1 to infinity.

b.) Would it be a good idea to honk a horn in tunnel like this?

Our ears are sensitive to frequencies between 20 Hz and 20,000 Hz (assuming we haven't messed them up by now). Trillions of trillions of multiples of .0085 happen within those bounds. In other words, just about any horn blast has the potential of resonating in a tunnel.