NYU General Physics 1—Problem set 10

Problem 1: *(a)* For an ideal gas, find out what the "intensive" properties are. What combinations of them have units of speed? Can you find more than one? Find the true speed of sound on the internet and check your dimensional answer(s) for standard temperature and pressure. How far off are you and are you upset by that?

(b) An organ pipe of length L (filled with air at STP) supports a standing wave (like the standing wave on the string done in lecture) but with L being one-quarter wavelength. What length L do you need to make a pipe that plays the note middle C? Use the Wikipedia-reported value for the speed of sound in air at STP.

Problem 2: Consider a string stretched in the x direction, waving transversely (look it up), with the y displacement being a function of position x and time t according to

$$y = A\,\cos(\frac{2\pi\,x}{\lambda} - \frac{2\pi\,t}{T})$$

where A is an amplitude, λ is the wavelength, and T is the period. For definiteness, set $A = 1\,\mathrm{cm}$, $\lambda = 0.75\,\mathrm{m}$, and $T = 0.25\,\mathrm{s}$.

(a) Draw a picture of $y(t)$ over the time period $0 < t < 1\,\mathrm{s}$ for the position $x = 0.0\,\mathrm{m}$

(b) Draw a picture of $y(x)$ over the spatial interval $0 < x < 3\,\mathrm{m}$ for the time $t = 0.00\,\mathrm{s}$

(c) Draw a picture of $y(x)$ over the spatial interval $0 < x < 3\,\mathrm{m}$ for the time $t = 0.05\,\mathrm{s}$.

(c) Draw a picture of $y(x)$ over the spatial interval $0 < x < 3\,\mathrm{m}$ for the time $t = 0.10\,\mathrm{s}$.

(d) Which way is the wave moving, and how fast?

Problem 3: You hit a bell with a hammer and it rings middle C. It starts out loud (because you just hit it) and then slowly it rings down; that is, it gets less loud with time.

(a) Why do you think the bell stops ringing? Where does that elastic energy go?

(b) Look up the definition of Q or *quality factor* for an oscillator. If the bell rings for about three seconds before it has significantly faded away, what

(very roughly) is the Q of the oscillator? *Hint: Ignore stuff on the web about "bandwidth" and look for stuff about "energy dissipated"; these concepts are related, but the latter is more comprehensible.*

(c) If you are a geek, look up the highest-Q oscillators known. What are the Q factors for these oscillators?