Chem 442: Homework for lecture L5

(due first lecture next week; turn in the one marked in bold)

1. Turn in: A flute tone is played for a duration of 2 seconds at a frequency of ν=440 Hz (middle A on the keyboard). Note that $\omega=2\pi\nu$.

a. As a percentage of the frequency ν, what is the uncertainty $\Delta\nu$ in the pitch being played?

Now someone hits a drum for 1 millisecond, making a sound centered at ν=440 Hz (a 'tuned drum like they use in orchestras).

b. As a percentage of the frequency ν, now what is the uncertainty $\Delta\nu$ in the pitch being played?

c. Based on your finding above, which of these two instruments would be more useful for playing a melody?

d. If you sped up your playing and you could play a note on the flute every 1 millisecond, is it still possible in principle to tell the difference between an A and A# (440 Hz and 466.1 Hz)? Can one play melody on a flute that fast as a matter of basic principle, no matter how nimble?

2. The inverse Fourier transform is given by $\Psi(t) = (1/2\pi) \int d\omega\, \Psi(\omega) \exp[-i\omega t]$. It's just like the Fourier transform, with a minus sign in front of the "i". The Fourier transform gets you from $\Psi(t)$ to $\Psi(\omega)$, and the inverse transform gets you from $\Psi(\omega)$ back to $\Psi(t)$. Comparing the two,

$$\Psi(\omega) = \quad 1 \cdot \int dt\, \Psi(t) \exp[+i\omega t]$$

and

$\Psi(t) = (1/2\pi) \int d\omega\, \Psi(\omega) \exp[-i\omega t]$. It's shown in the "T1 Reading" handout on the course schedule.

Use this knowledge to prove, using integration by parts of the inverse Fourier transform like we did in lecture with the Fourier transform, that $\partial/\partial\omega \rightarrow +it$. Fourier transforms turn multiplication into differentiation and vice-versa!