phys 225 homework due Nov 27

6.30

a.) pattern repeats every 5 ms = period

$$\text{so } f_0 = \frac{1}{5\times10^{-3}} = 0.2\ kHz$$

b.) the wiggles appear 4 per 5 ms - so this is $4 \times f_0 = 0.8\ kHz$

6.31 a.) $\Delta' k \Delta x \approx 1/2$ but $\Delta' k$ is $\frac{1}{2}$ the "range of wave numbers"

so $\Delta k \Delta x \approx 1.0$ for this definition

thus $\Delta k = 1/\Delta x = 1/30 = 0.03\ cm^{-1} = 3.0\ m$.

note that the answer in the back of the book is for $\Delta k'$, which is the usual thing, but not the whole range of wave numbers.

b.) pulse goes half way past in $\Delta t = \Delta x / v$ - so without knowing $F(t)$ in detail we know Δt.

Since $\Delta t \Delta \omega \approx 1/2$

$$\Delta\omega = \frac{1}{2\Delta t} = \frac{v}{2\Delta x} = \frac{6}{(2)(0.3)} = 10\ s^{-1}$$

6.39

$$\Delta p = \hbar / 2\Delta x$$

$$K = \frac{\Delta p^2}{2m} = \frac{\hbar^2}{8\Delta x^2 m} = \frac{(1.0\times10^{-34})^2}{(8)(10^{-6})^2(60\times10^{-3})}$$

$$= 2\times10^{-56}\ J$$

$$K = mv^2/2 \rightarrow v = \sqrt{2K/m} = \sqrt{\frac{4\times10^{-56}}{60\times10^{-3}}} = 8\times10^{-28}\ m/s$$

in a year it would go 2.5×10^{-20} m

6.39 – Continued.

Note the thermal energy, kT at room temp (300K) is

$(1.4\times10^{-23})(300) = 4\times10^{-21}$ J – much bigger than the minimum uncertainty principle energy. Even at $T = 10^{-6}$ K (K for kelvin) this is true.

6.42 as in 6.39, $K = \frac{\hbar^2}{8\Delta x^2 m}\cdot\frac{c^2}{c^2}$

a)

$$= \frac{197^2}{(8)(5)^2(1000)} = 0.2 \text{ MeV}$$

b) in 3-dimensions $\Delta p^2 = \Delta p_x^2 + \Delta p_y^2 + \Delta p_z^2$

and each Δp_i^2 is what we got in a)

So $K = 0.6$ MeV

6.46 $\Delta E\,\Delta t \geq \hbar/2$

$$\Delta E \approx \frac{\hbar}{2\Delta t} = \frac{\hbar c}{2\Delta t c} = \frac{197 \text{ eV-nm} \times 10^{-9} \text{ m/nm}}{(2)(10^{-23}\text{ s})(3\times10^{8}\text{ m/s})}$$

$$= \frac{197}{6}\times10^{6} \text{ eV} = 32.8 \text{ MeV}.$$

6.48 again $\Delta E = \frac{\hbar c}{2\Delta t c}$ but $\Delta t = 10^{-3}$ not 10^{-23} s

a) so $\Delta E = 10^{-20} \times 33$ MeV $= 3.3\times10^{-13}$ eV

from 6.46

b) $\lambda = hc/E$ (for photons)

so $d\lambda = \frac{hc}{E^2}dE = \frac{\lambda^2}{hc}dE = \frac{550^2}{1240}(3.3\times10^{-13})$ nm

$\Delta\lambda = 8.1\times10^{-11}$ nm

$\Delta\lambda/\lambda = \frac{8.1}{550}\times10^{-11} = 1.5\times10^{-13}$

6.50

$v_w = \sqrt{g/k} \qquad = \omega/k$

a.) wave packet

$$v_p = d\omega/dk = \frac{d}{dk} v_w k = \frac{d}{dk}\sqrt{gk}$$

$$= \frac{1}{2}\frac{g}{\sqrt{gk}} = \frac{1}{2}\sqrt{g/k} = \frac{1}{2} v_w$$

b.) if $v_w = \sqrt{gh}$ $\quad v_p = \frac{d}{dk} k\sqrt{gh} = \sqrt{gh} = v_w$

h is the depth, so ~~as~~ waves come to the ~~shore~~, the back, in deep water, catches up to the front, making the waves break.