HW 8

Due November 30, 2007

Note the 2 week due date

Please answer all questions clearly and concisely. While you need not transcribe the question completely, it should be clear from your answer alone what you are talking about.

You are strongly encouraged to discuss the homework with your classmates, but you must complete the written homework by yourself, and of course, the material you submit must be your own.

Remember, show all of your work!

1. Compute the DeBroglie wavelength of the following
   (a) An electron traveling at 20m/s
   (b) A 70 kg human with a kinetic energy of 8000 J.
   (c) A proton with $\gamma = 2.5$.
2. You observe three (non-interacting) particles with:
   m_1=1 kg, m_2 =2 kg, and m_3 =3 kg, and at positions:
   $\vec{r}_1 =< 2, 1, 0 > m$, $\vec{r}_2 =< -4, 2, 0 > m$, $\vec{r}_3 =< 1, 0, 0 > m$, and with velocities:
   $\vec{v}_1 =< 3, 0, 0 > m/s$, $\vec{v}_2 =< -2, 2, 0 > m/s$, $\vec{v}_3 =< -1, 3, 0 > m/s$.
   (a) Where is the center of mass? (I'm looking for a vector.)
   (b) What is the center of mass velocity?
   (c) What is the *translational* kinetic energy?
   (d) What is the *total* energy of the system (not including mass energy)?
3. Consider a wave with a wavelength $\lambda = 500nm$, and a propagation speed $3 \times 10^8 m/s$ (you may know this as c).
   (a) What is the wavenumber of wave (k)?
   (b) What is the frequency of oscillations (ν)?
   (c) If the wave *is* a lightwave, at what energy is it?
   (d) What is the momentum of the corresponding photon?
4. A quantum mechanical particle is in the following potential:

$$U(x) = \frac{1}{2} m\omega^2 x^2$$

   (You may recognize this as a simple way of re-writing the energy of a harmonic oscillator). I assert to you that the Schroedinger Wave Equation:

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} = (E - U(x))\psi$$

   can be solved in the ground state as:

$$\psi(x) = \psi_0 \exp(-x^2/2\sigma^2)$$

(a) Using maple (if you like – in which case, please include a printout), or with pen and paper, show that my solution for the wavefunction is correct.

(b) Please plot the solution.

(c) What is the value of σ that has to be put into the solution?

(d) What is the energy of this solution?