Physics 214b-2008 Walter F. Smith Assignment 5

Due: 4 pm Wednesday 2-27-08

Reading: Ch. 3

Exercises

All problems are group problems, unless otherwise marked; you are encouraged to work in small groups on these.. For the individual problems, you are not allowed to consult any other students, but you may ask me for help.

Part one: Problems relating to the exam material. There will be no rewrite for these problems.
A.14 (p. 481, individual problem)
A.16 (p. 481, individual problem) G = "Giga" = 10^9, T = "Tera" = 10^{12}
A.236 (p. 482)
1.26
1.46
2.21 (individual problem, you may not use Mathematica)
2.29 (individual problem)

Part two: Problems unrelated to the exam. The usual rewrite policy will apply to these problems.
5A. Ehrenfest's theorem (improved version of Townsend problem 2.31). In this problem, you will prove <u>one of the most important results of the semester</u>: that classical physics can be derived from the Schrödinger equation.

a. Make sure you fully understand everything on p. 97 through the top part of p. 98. In particular, be sure you understand the footnote on p. 97, and the argument for why Newton's second law can be expressed as $-\frac{\partial V}{\partial x} = \frac{dp}{dt}$.

b. Starting from equation 2.62 and the Schrödinger equation, show that

$$\frac{d}{dt}\langle p_x\rangle = \int_{-\infty}^{\infty}\left[\frac{-1}{i\hbar}\left(-\frac{\hbar^2}{2m}\frac{\partial^2\Psi^*}{\partial x^2} + V(x)\Psi^*\right)\right]\frac{\hbar}{i}\frac{\partial\Psi}{\partial x}\,dx + \int_{-\infty}^{\infty}\Psi^*\frac{\hbar}{i}\frac{\partial}{\partial x}\left[\frac{1}{i\hbar}\left(-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + V(x)\Psi\right)\right]dx$$

c. The second integral above can be broken into two parts, one of which is $\frac{\hbar^2}{2m}\int_{-\infty}^{\infty}\Psi^*\frac{\partial^3\Psi}{\partial x^3}dx$. Integrate this by parts twice, and show that what is left cancels with the similar term in the first integral from part b.

d. Use what's left to show that $\frac{d}{dt}\langle p_x\rangle = \left\langle -\frac{\partial V}{\partial x}\right\rangle$, which you should recognize as Newton's second law.