Physics 202H - Introductory Quantum Physics I **Homework #08**

Fall 2004 Due 5:01 PM, Monday 2004/11/15

[55 points total]

"Journal" questions. Briefly share your thoughts on the following questions:
– Of the material that has been covered in the course up to the mid term test, what has been the most difficult for you to understand? What material has been the most interesting? What material has been the most surprising? Is there any material that you thought you understood before this course that you now have a drastically different understanding of? What was is and what has changed?
– Any comments about this week's activities? Course content? Assignment? Lab?

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1. Please complete the anonymous mid-course survey online on WebCT. Early feedback will hopefully allow us to have the best possible course this semester rather than just having next year's students benefit. In addition to the bonus assignment marks, survey participation may count towards overall class participation scores. [5.01-bonus]

2. (From Eisberg & Resnick, Q 5-15, pg 168) What is the basic connection between the properties of a wave function and the behaviour of the associated particle? Limit your discussion to about 50 words or so. [10]

3. (From Eisberg & Resnick, P 5-9, 5-10, 5-11, 5-12, pg 168)

   (a) Following the procedure of Example 5-9, verify that the wave function

   $$\Psi_2(x,t) = \begin{cases} 0, & x < -a/2, \\ A\sin\left(\dfrac{2\pi x}{a}\right)\mathrm{e}^{-\mathrm{i}E_2 t/\hbar}, & -a/2 < x < +a/2, \\ 0, & +a/2 < x. \end{cases}$$

   is a solution to the Schroedinger equation in the region $-a/2 < x < +a/2$ for a particle which moves freely through the region but which is strictly confined to it and determine the value of the total energy E_2 of the particle in this excited state of the system, and compare with the total energy of the ground state E_1 found in Example 5-9. [10]

   (b) Plot the space dependence of this wave function $\Psi_2(x,t)$. Compare with the ground state wave function $\Psi_1(x,t)$ of Figure 5-7, and give a qualitative argument relating the difference in the two wave functions to the difference in the total energies of the two states. [5]

   (c) Normalize the wave function $\Psi_2(x,t)$ above by adjusting the value of the multiplicative constant A so that the total probability of finding the associated particle somewhere in the region of length a equals one. Compare with the value of A obtained in Example 5-10 by normalizing the ground state wave function $\Psi_1(x,t)$. Discuss the comparison. [10]

   (d) Calculate the expectation value of x, the expectation value of x^2, the expectation value of p, and the expectation value of p^2 for the particle associated with the wave function $\Psi_2(x,t)$ above. [10]

4. (From Eisberg & Resnick, P 5-16, pg 169) Show by direct substitution into the Schroedinger equation that the wave function $\Psi(x,t) = \psi(x)\mathrm{e}^{-\mathrm{i}Et/\hbar}$ satisfies that equation if the eigenfunction $\psi(x)$ satisfies the time-independent Schroedinger equation for a potential $V(x)$. [10]

Headstart for next week, Week 09, starting Monday 2004/11/15:
– Read Chapter 5 “Schroedinger’s Theory of Quantum Mechanics” in Eisberg & Resnick
– – Section 5.6 “Required properties of Eigenfunctions”
– – Section 5.7 “Energy Quantization in the Schroedinger Theory”
– – Section 5.8 “Summary”