Physics 202H - Introductory Quantum Physics I **Homework #09**

Fall 2004 Due 5:01 PM, Monday 2004/11/22

[50 points total]

"Journal" questions. Briefly share your thoughts on the following questions:
– Within the subject matter of this course, what do you think the best methods of evaluating student knowledge and/or skills would be? What single change to how we do evaluation in this course do you think would be best? What is the best feature of the evaluation method used in this course? Why?
– Any comments about this week's activities? Course content? Assignment? Lab?

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1. (From Eisberg & Resnick, Q 5-25, pg 168) Explain briefly the meaning of a well-behaved eigenfunction in the context of Schroedinger quantum mechanics. Why do we need the eigenfunction to be well-behaved? Limit your discussion to about 50 words or so. [10]

2. (From Eisberg & Resnick, P 5-1, pg 169) If the wave functions $\Psi_1(x,t)$, $\Psi_2(x,t)$, and $\Psi_3(x,t)$ are three solutions to the Schroedinger equation for a particular potential $V(x,t)$, show that the arbitrary linear combination $\Psi(x,t) = c_1\Psi_1(x,t) + c_2\Psi_2(x,t) + c_3\Psi_3(x,t)$ is also a solution to that equation. [10]

3. (From Eisberg & Resnick, P 5-23, pg 172) Consider a particle moving in the potential $V(x)$ plotted in Figure 5-22. For the following ranges of the total energy E, state whether there are any allowed values of E and if so, whether they are discretely separated or continuously distributed. [10]
   (a) $E < V_0$,
   (b) $V_0 < E < V_1$,
   (c) $V_1 < E < V_2$,
   (d) $V_2 < E < V_3$,
   (e) $V_3 < E$.

4. (From Eisberg & Resnick, P 5-27, 5-28, pg 173)
   (a) By substitution into the time-independent Schroedinger equation for the potential illustrated in Figure 5-23, show that in the region to the right of the binding region the eigenfunction has the mathematical form [10]

   $$\psi(x) = A\mathrm{e}^{-\frac{\sqrt{2m(V_0-E)}}{\hbar}x} \qquad x > +\frac{a}{2}$$

   (b) Using the probability density corresponding to the eigenfunction above, write an expression to estimate the distance D outside the binding region of the potential within which there would be an appreciable probability of finding the particle. [10]
   (Hint: Take D to extend to the point at which $\Psi^*\Psi$ is smaller than its value at the edge of the binding region by a factor of e^{-1}. This e^{-1} criterion is similar to one often used in the study of electrical circuits.)

Headstart for next week, Week 10, starting Monday 2004/11/22:
– Read Chapter 6 "Solutions of Time-Independent Schroedinger Equation" in Eisberg & Resnick
– – Section 6.1 "Introduction"
– – Section 6.2 "The Zero Potential"
– – Section 6.3 "The Step Potential' (Energy Less Than Step Height)'
– – Section 6.4 "The Step Potential (Energy Greater Than Step Height)"