University of California, Berkeley
Physics 7C Spring 2002

Problem Set 9
due April 18, 2003

Reading assignment: Giancoli, chapter 39, 40
Typos corrected in problem 1, and problem 2 add hint, problem 3 clarified.

1. A particle is in a sum of two states in the infinite square well:

$$\Psi(x,t) = \frac{1}{\sqrt{2}}\psi_1(x)e^{-iE_1 t/\hbar} + \frac{1}{\sqrt{2}}\psi_2(x)e^{-i4E_1 t/\hbar} \tag{1}$$

where $\psi_1 = \sqrt{\frac{2}{L}}\sin(\frac{\pi x}{L})$, $0 \le x \le L$, and $\psi_2 = \sqrt{\frac{2}{L}}\sin(\frac{2\pi x}{L})$, $0 \le x \le L$. (**typo corrected!**)

- Show that the total probability of finding this particle anywhere is one.
- Sketch the wavefunction at $t = 0$.
- What is the probability of finding this particle at position x as a function of time? You can assume $0 \le x \le L$.
- What is the average value of x measured in this state as a function of time? Note that you can integrate something like $(\sin x)^n \cos x\ x$ by parts,
$$\int u dv = uv - \int v du \tag{2}$$
by taking $u = x$. Note that the average value of x is the average of all the values I could find if I took several copies of the same system and measured x in each of them. If I averaged all those values, I would find the average calculated here.
- The average *energy* in this state is $(E_1 + E_2)/2$. What values are possible for me to measure for energy in any one given measurement?

2. Giancoli 39-31. Hint: approximate the ground state energy by that of the infinite square well. As the ground state energy is a lot less than U_0 this is a good approximation.

3. You are putting electrical wiring in your place, and considering using Aluminum–it's cheap and a good conductor. However, Aluminum forms an oxide layer (Al_2O_3), which can be several nm thick. This can be a problem in making electrical contact with outlets, since it presents a barrier of roughly 10 eV to the flow of electrons in and out of the Aluminum.

   The transmission coefficient must be **greater** than 10^{-10}, i.e. $T > 10^{-10}$ or else the resistance will be too high for the currents you are using and present a fire risk. What is the transmission coefficient in this case (and so do you use Aluminum)? Assume that the energy of the electrons is much less than 10 eV.

4. Giancoli 39-33

5. Giancoli 40-8

6. Giancoli 40-13

7. Giancoli 40-19 *This problem turns out to require a numerical solution. Try out* $1.2r_0, 1.34r_0, 2.2r_0, 2.7r_0, 3.9r_0, 4.2r_0$.

8. Giancoli 40-43

9. Giancoli 40-65