107 Answer Key HW #10- Chapter 14 assignment

Conceptual: 8, 20, 24, 16
Problems: 4

November 16, 2005

1 Conceptual Exercises

8.) "Assuming the the string's length in Figure 14.5 is 2 m, could the string vibrate in a standing wave whose wavelength is 2.1 m? 1.9 m? 0.5 m? Explain."

The standing wave on the string must be able to to be "tacked down" at the two ends. If we try and make a vibrating string with wavelengths $\boxed{\text{2.1 m or 1.9 m, then it doesn't work}}$ - the string doesn't connect at each endpoint, since the nodes are not at the endpoints. In general, one needs a whole number of half-wavelengths to fit into the space exactly for this to work. However, $\boxed{\text{we can make a standing wave out of 0.5 m}}$, because this wave will connect both the endpoints (four whole wavelengths fit exactly).

20.) "If Planck's constant were smaller than it is, how would the indeterminacy principle be affected? What if Planck's constant were zero?"

The indeterminacy principle is $\Delta x * \Delta s = \frac{h}{mass}$; if we made $h = 6.6 * 10^{-34} J * s$ smaller, than the $\boxed{\text{indeterminacy principle would get smaller,}}$ i.e. the number of possibilities would decrease. This means quantum mechanics becomes less important! If h were zero, there would $\boxed{\text{not be an indeterminacy principle,}}$ since we could have Δx and Δs both equal to zero, and we could know both the position and the speed simultaneously! Quantum mechanics would cease to be if Planck's constant were zero!

24.) "One everyday example in which a measurement disturbs the measured object is the measurement of the temperature of a pan of water using a thermometer. How does this disturb the temperature? Is this a quantum effect?"

The thermometer will, in general, be a different temperature than the water - when you place it in the water to make a measurement, the $\boxed{\text{water and the thermometer will interact:}}$ one getting warmer, the other getting cooler, both coming to the same temperature eventually. This is not necessarily a quantum effect, since it would happen whether quantum mechanics existed or not. A quantum effect would be if the simple act of knowing what the temperature was somehow changed the state, and it wasn't that, it was a physical property of the thermometer that changed the state.

26.) "Your friend flips a coin but covers it up so that neither of you can tell whether it is heads or tails. What odds (probability) would be fair to put on heads? Suppose he uncovers it and you see that it is tails. What odds should you now assign to heads? Does this sudden shift in the probabilities have anything to do with quantum theory?"

Before seeing the coin, one should assign a $\boxed{\text{50\% chance}}$ of the coin being heads, and a 50% chance of it being tails. After it is uncovered to be tails, then there is a $\boxed{\text{0\% chance}}$ of the coin being heads and a $\boxed{\text{100\% chance}}$ of it being tails (because we know it is tails!).

This sudden shift in probabilities is similar to, but not because of, quantum theory. In quantum theory, before one makes a measurement of where a particle is it has a probability of being in many places - it's wavefunction (which tells us about probabilities) is spread out. But once one makes a measurement of where it is, then the particle <u>should</u> be there - the wavefunction collapses to a point, saying that the particle is actually somewhere in particular.

2 Problems

4.) "According to Section 14.2, quantum states of the hydrogen atom occupy larger volumes as the quantum number N gets larger. Quantitatively, the electron's psi-field occupies a more-or-less spherical region, centered on the nucleus, whose radius is proportional to N^2. For a ground-state (N=1) hydrogen atom, the diameter of this psi-field is about 10^{-10} m. Find the diameter of a hydrogen atom in the state $N = 3$."

We are told in that the diameter of a ground state hydrogen atom is $10^{-10}m = 10^{-7}mm$, expressing the answer in millimeters. We are also told that the radius is proportional to N^2. This is all we need if we attack the problem using proportionalities. Since the radius is proportional to N^2, so is the diameter, since the diameter is just twice the radius. So: $Diameter \sim N^2$. If we increase N from 1 to 3, then the diameter must increase by:

$(3N)^2 = 3^2N^2 \sim 3^2(Diameter)$. Notice that the diameter increases by a factor of $3^2 = 9$! Since we started with a diameter of $10^{-7}mm$, for $N = 3$ we have $Diameter = \boxed{9 * 10^{-7}mm}$!