PHYS 102-Concepts of Physics II-Spring 2003
Solutions to Homework #3
100 points possible

1. (30 points)

   (a) Neatly drawn diagrams.
   (b) We see 4 visible lines in the spectrum for hydrogen. According to the web site, the orange-red line is somewhere between ABOUT 6550 and 6570 x 10^{-10} meters in wavelength.
   (c) Since we are considering only the three smallest orbits, the only possible transitions during which a photon is emitted are (3 to 2), (3 to 1) and (2 to 1)
   (d) Using E =hf, and f*wavelength = c, gives the following:

   (3 to 2) gives wavelength of about 6540 x 10^{-10} meters
   (3 to 1) gives wavelength of about 1030 x 10^{-10} meters
   (2 to 1) gives wavelength of about 1220 x 10^{-10} meters

   These numbers may not be exact because of rounding off of the energy levels in hydrogen! But your numbers should be somewhere close to these.

   The (3 to 2) transition is by far the closest to the wavelength for the orange-red line, so this is the transition that causes that line.

   (e) Your eye can only see from around 4000 x 10^{-10} meters to 7000 x 10^{-10} meters (some sources state a slightly larger range), so the other two transitions are NOT visible to the human eye.

2. (25 points)

   (a) I did this twice and got 3 cm and 4 cm, which convert to 0.03 m and 0.04 m
   (b) The average is 0.035 m. Using H = 1/2 g t^2, this gives a "reaction time" of about 0.085 seconds (or 85 milliseconds).
   (c) Light travels at 3 x 10^8 m/s, so in 85 milliseconds it travels 2.55 x 10^7 meters.
   (d) There are 1609.3 meters per mile, so this translates to about 15,850 miles.
   (e) According to the "World Almanac" it is 2631 miles from Washington D.C. to Los Angeles, so that would make it about 2530 miles from Charlottesville to Los Angeles.
   (f) With the reaction time above of 85 milliseconds, the light would go FAR past Los Angeles-- 13,320 miles in fact. Light travels very fast!

3. (15 points)

   (a) There are 10^6 square millimeters in one square meter, so 1000 W/m^2 translates to 10^{-3} W/mm^2.

   (b) If the laser emits 1 W/mm^2, this is 1000 times brighter than the sun!

4. (15 points)

   If a photograph is made with an exposure of only 10 photons, the image would consist of 10 bright points, randomly located, against a dark background. You would NOT see a very dim, complete image. If you exposed it with more photons (tens of thousands, millions), then the image would be essentially complete. This is all very similar to the beginning of a rain storm: the sidewalk gets wet, spot by spot, and just from probability the whole sidewalk will eventually be hit by rain drops.

5. (15 points)

   (a) Position and Speed of an object can't be known simultaneously to arbitrary accuracy. To state it mathematically: $(\Delta x)\cdot(\Delta s)=\frac{h}{m}$, which says that uncertainty in position times uncertainty in speed equals Planck's constant divided by the mass of the object in question. For large objects, such as a baseball, the constraint is not noticeable. But for a very tiny particle such as an electron, confined to an atom for example, the constraint is very significant.

   (b) The smaller Planck's constant is, the more one is allowed to know about an object's position and speed. If Planck's constant were zero, there would be no constraints on simultaneously knowing an object's exact position and speed. In this and many other ways, Planck's constant measures the "quantumness" of our universe.