Assignment V, PHYS 230 (Introduction to Modern Physics)
Fall 2015
Due Thursday, 10/1/15 at start of class

This homework is fairly straightforward. Consider it the calm before the storm.

1. A double slit with slit separation d is placed in front of a red laser ($\lambda = 650$ nm). 4 meters away, you notice that the distance between the central maximum and the *second* minimum is 9 cm. (In other words, there's a total of two minima between the central maximum and the location of this minimum).
   a) What is the slit separation?
   b) If the screen was moved from 4 meters away to 7 meters away, how far would it be between the 6th minima to the left of the central maximum to the 3rd maximum to the right of the central maximum?
2. A diffraction grating with 2000 lines per cm is used to separate the light from a source that has wavelengths $\lambda_\circ = 493$ nm and $\lambda_1 = 524$ nm. If the light goes through the grating and is viewed on a screen 2 meters away, what physical distance would there be between the first maxima of the two constituent wavelengths?
3. X-ray tubes used by dentists often accelerate electrons with a potential difference of about 80 kV. What is the minimum wavelength of the x-rays that are produced?
4. The smallest angle of Bragg scattering in potassium chloride (KCl) is 28.4° for 0.30 nm x-rays. Find the distance between atomic planes in potassium chloride.
5. The work function of Molybdenum is 4.22 eV.
   a) What is the threshold frequency for the photoelectric effect in Molybdenum?
   b) Will yellow light of wavelength 560 nm cause ejection of photoelectrons from Molybdenum? Prove your answer.
6. A photoelectric experiment with Cesium yields stopping potentials for $\lambda = 435.8$ nm and $\lambda = 546.1$ nm to be 0.95 V and 0.38 V, respectively. Using these data only, find the threshold frequency and work function for Cesium and the value of h.

More on Back!

7. One of the funky things that didn't follow the classical expectation for the photoelectric effect is that there was no time-lag between turning on the light-source and measuring a current. In practice – if we don't know about or believe the quantum hypothesis – then we would expect there to be some finite amount of time between when you turn on the source and when a typical electron could gain enough energy from the light beam to be liberated. Let's try and ballpark this expected time-lag for a weak source.

   a) Assume a lightbulb emits total power P equally in all directions. Let us put a metal surface X meters away from this light source, and let's assume it takes energy ϕ to liberate an electron from an atom in this metal. Assuming an atom has a circular cross-section of D, how long would it take for the atom to gain energy ϕ from the source? Leave your answer in terms of P, X, ϕ, and D. (Hint: To check your answer, make sure that it makes sense. The larger P is, the less time it should take. The larger X is, the longer it should take. The higher ϕ is, the longer it should take, and the larger D is, the shorter it should take. That should tell you something about the form of the answer.)

   b) Find the actual value of the time-lag as designed in part a if P is 2 W, X is 0.1 m, ϕ is 6 eV, and D is 0.1 nm.

   c) Assuming that the photon hypothesis is correct (and that photons travel at c), how long would you expect the time-lag to be? Again, assume that $\phi = 6$ eV, that the wavelength of the light is 100 nm, and assume that the path the electron takes through the tube is a straight-line path (no acceleration once liberated). You may ignore relativistic effects for the electron.