Assignment VII, PHYS 230 (Introduction to Modern Physics)
Spring 2017
Due Wednesday, 3/15/17 at start of class

1. Star 1 is a perfectly spherical blackbody emitter, with temperature T, radius R, and has a spherical planet of radius r a distance D away from the star. Star 2 is a different perfectly spherical blackbody emitter (in a completely different part of the sky) with temperature $3T$, radius $4R$, and has a spherical planet of radius $\frac{r}{2}$ a distance $\frac{D}{3}$ away from the star.

   a) What is the ratio $\frac{\text{Total power emitted by star 1}}{\text{Total power emitted by star 2}}$?

   b) What is the ratio $\frac{\text{Power per unit area received by planet 1}}{\text{Power per unit area received by planet 2}}$?

2. A photoelectric experiment is carried out and, for a particular value of λ, the stopping potential is $V_\circ$.

   a) Show that the maximum velocity that an electron could take if the battery were set to $-V_\circ$ would be:

   $$v = \left(\frac{4e|V_\circ|}{m_e}\right)^{1/2}$$

   (ignoring relativistic effects), where m_e is the mass of the electron and e is the magnitude of the charge of an electron.

   b) What would the maximum velocity of the photoelectrons be (again ignoring relativity) if the battery was set to $-V_\circ$ and a wavelength of of $\frac{2\lambda}{3}$ was used?

3. Light of wavelength 500 nm is incident on sodium, with work function 2.28 electron volts. What is the maximum kinetic energy of the ejected photoelectrons (in Joules)?

4. If a high energy photon (e.g. $E \gg m_e c^2$) is incident on an electron, show that the photon that is scattered through an angle of approximately 180° has an energy of about 0.25 MeV, independent of how large E intially was (so long as it was much larger than $m_e c^2$).

5. Compute the Compton wavelength (aka the wavelength shift when $\theta = \pi/2$) when light scatters off of:

   a) A proton

   b) A muon

   c) An electron

6. Compute the energy (in eV) of a photon whose wavelength is equal to the Compton wavelength of:

   a) A proton

   b) A muon

   c) An electron

7. What would the maximum wavelength of a photon have to be if it contained enough energy to pair-produce a muon/anti-muon pair?

8. A beam of electrons is accelerated through a potential difference of 40 kV in an x-ray tube. What is the shortest wavelength in the x-ray spectrum emitted by the target at the end of the tube?

9. An x-ray undergoes Bragg diffraction in a crystal that has planes of spacing d. At what angle(s) would you need to put a detector/detectors if you wanted to see the Bragg scattering if the wavelength of the x-ray was $5d/7$?

10. Mathematica Question: Someone takes the following data for the photoelectric effect:

Incident λ (nm)	Stopping Voltage (V)
252.0	2.61
312.3	1.69
368.5	1.06
405.1	0.72
436.2	0.51

    a) Graph the data and use a linear fit in Mathematica to determine the work function for Lithium.

    b) Find the experimental value of Planck's constant from the slope of the fit.

    (Save a notebook that does this under the name `Yourlastname_Phys230_hw7.nb` and email it to me at `LarsenML@cofc.edu`.)