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

1. A number of different phenomena that we have been talking about in class recently (brehmstrahlung most notable among them) relies on the fact that accelerated charges emit energy in the form of electromagnetic radiation. Although I showed you an in-class applet demonstrating this in a cartoon-y way, you have enough skills to play with these ideas a little bit more quantitatively. This will still be a very "approximate" treatment of the pheneomena; if you want a more complete understanding of this – make sure to take E&M 2 (PHYS 410) someday.

   a) What are the units for power emitted (in terms of kg, m, and s)?

   b) The power emitted due to an accelerating charge depends on 3 possible quantities. These are the speed of light (c), the acceleration of the charge (a) and a quantity related to the force between two charged objects. (The Coulomb force between equally charged objects is $\frac{q^2}{4\pi\epsilon_\circ r^2}$. Empirical observations suggest that the radius doesn't really come into this, so the third quantity we will concern ourselves with is $\frac{q^2}{4\pi\epsilon_\circ}$. What are the units of (i) c, (ii) a, and (iii) $\frac{q^2}{4\pi\epsilon_\circ}$?

   c) We will use dimensional analysis to "build" a relationship governing the power emitted by a decelerating charge. We will assume the relationship takes the basic form $P \propto a^\alpha c^\beta \left[\frac{q^2}{4\pi\epsilon_\circ}\right]^\gamma$ with α, β, and γ unknowns and the proportionality factor a (dimensionless) constant. By looking at units only, determine α,β, and γ. (There is only one valid answer here).

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

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

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

   c) If both planets are also blackbodies, what is the ratio $\frac{\text{Equilibrium temperature of planet 1}}{\text{Equilibrium temperature of planet 2}}$?

   d) If both planets are blackbodies, what is the ratio of $\frac{\text{peak thermal emission wavelength of planet 1}}{\text{peak thermal emission wavelength of planet 2}}$?

3. This question has to do with the Compton effect.

   a) Compute the Compton wavelength of an electron, a muon, and a proton.

   b) What is the energy of a photon whose wavelength is equal to the Compton wavelength of (i) an electron, (ii) a muon, and (iii) a proton?.

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 initially was (so long as it was much larger than $m_e c^2$).

5. True story. I once met someone at a conference that was interested in examining Compton scattering of infrared radiation in the atmosphere. After talking with the guy for about 10 seconds, I realize that he was kind of nuts. Explain why this guy was a loony. (Hint – calculate $(\lambda_2 - \lambda_1)/\lambda_1$ for radiation in the IR area of the spectrum).

Mathematica-Based Portion of the Assignment

6. 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_part1.nb` and email it to me at `LarsenML@cofc.edu`.)