Physics 200 Problem Set 7

Due at the end of class, Wed Nov 3$^{\text{rd}}$

Practice problems: do not hand in. Textbook pg 1235, problems 1, 5, 7, 11.

1. In this problem, you will use the photoelectric effect simulation again. You can find the simulation at http://phet.colorado.edu/en/simulation/photoelectric

Select the Mystery Metal (?????) as your Target. Measure and plot the stopping potential at different light frequencies. From your plot, determine:

(a) The work function of the Mystery Metal.

(b) An approximate value for Planck's constant, given that the electron change is $e = 1.6 \times 10^{-19}$C.

Make sure to label your axes, as well as explain what you did and why!

2. Batman, getting jealous of Superman's X-ray vision, decides that he wants UV vision for himself, and builds a photoelectric-effect-based gadget for measuring the wavelength UV sources. During a calibration run, he discovers that the retarding potential required to stop electrons ejected by 3.07×10^{15}Hz light is half that required to stop electrons ejected by 4.61×10^{15}Hz light.

(a) What is the work function of the metal Batman uses?

(b) You can find a list of work functions for different metals for example here:
http://hyperphysics.phy-astr.gsu.edu/hbase/tables/photoelec.html
You should be able to identify the metal Batman uses for his new gadget. Why do you think he chose that metal?

(c) Batman discovers that someone has planted a mystery UV source under his Batmobile. He points his new gadget at it and obtains a stopping voltage of 8V for the photo-emitted electrons. What is the wavelength of the mystery source?

3. The qualitative features of black body radiation are described by two laws:

- Stefan's law says that the power radiated per unit area of the body is given by

$$I = \sigma T^4$$

  where $\sigma = 5.67 \times 10^{-8}\mathrm{W/m^2K^2}$ is the Stefan-Boltzmann constant

- Wien's law gives the peak wavelength to be

$$\lambda_{\mathrm{peak}} = \frac{2.90 \times 10^6 \mathrm{nm\ K}}{T}$$

Make the approximation that most of the radiation has wavelength close to λ_{peak}. If you double the temperature, how does the number of photons radiated per second change?

4. Compton scattering.

(a) A photon with wavelength 500nm scatters off a stationary electron. If its new direction of motion is perpendicular to the original direction, by how much does the wavelength of the photon change? Based on this number, can you explain why the Compton effect is not observed with visible light?

(b) A photon with wavelength λ scatters off a free electron.
(i) In what angle of scattering is its wavelength changed the most?
(ii) What is the maximum wavelength that the photon can have if the Compton effect changes that wavelength by 1%?