Phys 2053: Homework II

due January 29, 2016

The Photoelectric Effect – PhET Simulation Project

https://phet.colorado.edu/en/simulation/legacy/photoelectric

Meet in Clippinger 035

You may use either the setup in the Clippinger undergraduate laboratory (Rm045b), or the Java installation in the Clippinger Computer Lab (Rm 257) in the directory JavaS. To access it, log into one of the Linux computers and open an xterm window. Type "*cd*" to go to the main directory, and then "*cd JavaS*" to enter the directory with the Java simulations.

To run the simulation, type
java -jar bound-states_en.jar
and a window with the simulation will pop up.

Worksheet

1.1 Familiarize yourself with the controls.
Non-obvious controls:

- Options Menu:
  - **Show photons** shows the light beam as composed of individual photons.
  - **Control photon number instead of intensity** changes the **Intensity** slider to a **Number of Photons** slider.
- Use the camera icon to take snapshots of the graphs so that you an compare graphs for different settings.
- You can **Pause** the simulation and then use **Step** to incrementally analyze.

1.2 List all variables you can control in the simulation.

1.3 From your knowledge of light, energy, electrons, wavelength, and frequency, sketch your prediction for a graph of electron energy as function of frequency.

Metal	Wavelength [nm]	Frequency [Hz]	Energy [J]	Energy [eV]
Sodium				
Zinc				
Copper				
Platinum				
Calcium				

Table 1: First determination of the threshold frequencies

1.4 What determines if electrons are ejected from the metal surface? Explain and write down the equations you should use.

1.5 Make the following adjustments to the simulation: Set the intensity to 50%, and check the box "electron energy vs light frequency". Once these adjustments have been made, you should notice the ejection of electrons from the surface.

1.6 Decrease the frequency of the light until electrons are no longer ejected. Record the wave length in Table 1, and complete the calculations. Reminder: 1 eV = $1.6 \cdot 10^{19}$J
Repeat the above step for each of the metals under the pull down menu.

1.7 The minimum amount of energy required for an electron to escape from a metal is called the work function W, and given by $W = hf_c$. Calculate the work function for each of the metals in [J] and [eV] using the previously determined threshold frequencies. Create a table similar to Table 1 for the work functions.

Reminder: $h = 6.63 \cdot 10^{-34}$ Js or $h = 4.14 \cdot 10^{-15}$ eV

1.8 You can determine a work-function also from choosing a fixed light frequency and adjusting the battery voltage until no electrons reach the surface anymore. This is along the lines of the original experiments carried out by Lennard. Choose light of 300 nm and determine the voltage you need so that no electron reaches the surface of the other plate. List the battery voltage you need for each of the elements in the list. For this part, stepping through the motions may be useful. Create a table similar to Table 1 for the work functions you find, and compare to the calculated values from **1.7**. After you found the battery voltages for all the given elements, find the one for the "mystery" element. Guess, what this element could be. You may ask the "Google tutor" for help.

1.9 What effects the number of electrons ejected? Make the following adjustments to your simulation: Check the box "current vs light intensity", and select the metal platinum.
Adjust the frequency of the incident light slightly above the threshold frequency.
Vary the intensity of the light and observe any changes in the number of ejected electrons.
Increase the frequency of the incident light until it is well above the threshold frequency.

Vary the intensity of the light and observe any changes in the number of ejected electrons. Record all you observations and interpret what you see according what you learned about the photoelectric effect.

1.10 Robert Millikan determined the value of Planck's constant h through a careful study of the photoelectric effect. Design your own experimental setup so that you can repeat his experiment within the simulation. Describe your reasoning for the setup, carry out the experiment and determine your own value of Planck's constant.

The entire project is worth 14 pts.
For next week (on the deadline), you should turn in the project as group work electronically as pdf file. please export your word file into the pdf format. Clearly indicate your group as authors. Everybody in the group will receive the same amount of points, so it is in your own interest to contribute to the work and make sure it is perfect.

Make sure you addressed all points of the worksheet and add explanations of figures and calculations.