Physics 233 **Lab 5**
October 2011 **Photoelectric Effect**

Goals

- To become familiar with the apparatus used to study the photoelectric effect.
- To observe the particle nature of light and to experimentally determine Planck's constant and the work function of a photocathode.
- To learn to use linear regression.
- To practice writing the analysis section of a lab report.

Lab equipment:

- The Daedalon EP-05 Photoelectric Effect Apparatus (shown to the right) is similar to the idealized apparatus shown in figure Q3.1. The specific characteristics of the photocathode are a trade secret of the manufacturer, but the RCA 1P39 Phototube in the apparatus is believed to have a photocathode made of the semiconductor Cs_3Sb. This Photoelectric Effect Apparatus has a dial to control the potential difference between the plates, which is read with an external voltmeter, and a built-in meter to record the resulting current.

- The Pasco AP-9368 Photoelectric Effect Apparatus (shown to the right) does not allow the user to vary the potential difference, but can more accurately measure the stopping potential, which is read with an external voltmeter. Since it can only measure stopping voltage, there is no meter to record the current.

- Light for the experiments will be provided by mercury vapor lamps that produce the spectral lines listed in the table below. A monochrometer will be used to select the wavelength entering the Daedaulus photoelectric effect apparatus. A grating (and sometimes a filter) will be used to select the wavelength entering the Pasco photoelectric effect apparatus

Color	Wavelength (nm)
Yellow	578
Green	546
Blue/violet	436
Violet	405
UV	365

Reading:

- Chapter 8 (Linear Regression) and section 3.5 (The Analysis Section) of the lab reference manual
- Review chapter Q3

Pre-Lab Problems:

1. Exercises 8.1 and 8.2 (Note that the *y* intercept is $b = +2.83$, not -2.83) in WebAssign.

The other two Pre-Lab questions go in your notebook. You may want to use the applet at http://phet.colorado.edu/en/simulation/photoelectric to explore the scenarios discussed in questions 2 and 3.

2. In the first part of the lab, the wavelength will remain fixed.

a. You will alter the potential difference and measure the resulting current. Based on the photon model, what do you expect to see?
b. Next, you will decrease the intensity of the incoming light and measure the current as a function of the potential difference. Based on the photon model, what do you expect to see?

3. In the second part of the lab, you will measure the *stopping voltage* for different frequencies of incident light. How can you determine Planck's constant and the work function from a plot of the stopping voltage vs. the frequency of the light?

Lab Procedure:

1. Use the Daedalus photoelectric apparatus to measure current as a function of applied potential for two different intensities for light with a fixed wavelength.

   (a) Set the monochrometer to 436 nm and be sure the correct color is exiting the monochrometer and falling on the photoelectric effect apparatus with as little stray light entering as possible.
   (b) Make sure the voltmeter is connected properly to the apparatus and that both pieces of equipment are on.
   (c) Zero the apparatus by turning the "VOLTAGE" knob to its full clockwise position. Adjust the "ZERO" knob so that the current meter reads zero.
   (d) Turn the "VOLTAGE" knob to its full counterclockwise position so that the *voltmeter* reads very close to zero.
   (e) Be very careful not to move anything. Take readings of the current as a function of the applied voltage, be sure to get readings with a zero current. In your notebook, plot the measured current as a function of applied potential.
   (f) Put a filter in front of the aperture on the Daedalus to decrease the intensity of the light. Repeat steps (c) – (e). On the same graph as above plot the measured current as a function of applied potential. Compare the two graphs. Do they match your predictions? Explain the differences and similarities between the two graphs.

2. Use the Pasco photoelectric apparatus to measure the stopping voltage for each wavelength produced by the mercury vapor lamp.

   (a) Align the apparatus so that the only one color of light that falls on the photodiode. You will be able to see the UV lines because of the fluorescent material on the apparatus. For the green and yellow lines, attach the same color filter to the apparatus to make sure no stray visible light enters.
   (b) Press the button marked "Push to Zero" and wait for the voltage to stabilize before taking a reading.

Post-Lab Assignment:

1. Plot the stopping voltage as a function of frequency. Find the slope and intercept of the best-fit line using linear regression.
2. Using your graph, calculate Planck's constant and the work function for the photocathode. You should also find an uncertainty for each value. Compare your result for Planck's constant to the accepted value.
3. Write the analysis section of a lab report for the experiment in the second part of the procedure. This should be typed.