THE PHOTOELECTRIC EFFECT

In photoelectric emission, light strikes a material causing electrons to be emitted. The classical wave model of light predicts that as the intensity of light increases, the amplitude and thus the energy of the wave would increase. This would then cause more energetic photoelectrons to be emitted. In this model the energy of electrons should not depend on the frequency of the light, and all frequencies of light should cause photoelectrons to be emitted by the material. You will test this model by measuring photoelectron energy as a function of intensity of incident light and frequency of incident light.

BEFORE LAB:

Do the appropriate library research, and write up your Introduction.

THE EXPERIMENT:

You will measure the kinetic energy of the photoelectrons by measuring the stopping potential V_s = KE/e, where KE is the kinetic energy and e is the charge of a single electron. The photodiode tube has a small capacitance which becomes charged by the photoelectric current. When the potential on this capacitance reaches the stopping potential of the photoelectrons, the current decreases to zero and the anode-to-cathode voltage stabilizes. This final voltage between the anode and cathode is therefore the stopping potential of the photoelectrons.

Your light source is mercury, which has 5 spectral lines. At the bottom of this page are the wavelengths for several lines in the mercury spectrum: you should determine which ones are relevant to this experiment.

ENERGY DEPENDENCE ON INTENSITY

1. Rotatate the apparatus to view the various sets of spectra produced by the light source and diffraction grating. Choose the brightest spectrum for the following. Adjust the apparatus so that only the brightest of the spectral colors falls on the opening of the mask of the photodiode. If you select the green or yellow line, place the corresponding colored filter over the white reflective mask.
2. Place the variable transmission filter in front of the white reflective mask so that the light passes through the section marked 100% and reaches the photodiode. Record the voltage from the digital voltmeter. Press the instrument discharge button, release it, and observe approximately how much time is required to recharge the instrument to maximum voltage. Record this value.

3. Repeat for all sections of the filter (T=100%, T=80%, etc.).
4. Repeat all steps for a second color.
5. Use Kaleidagraph to plot V_s vs the transmission, T. (Use a graph which includes V_s = 0 on the y-axis.)

ENERGY DEPENDENCE ON FREQUENCY

1. You can see five colors in three orders of the mercury light spectrum. Adjust the apparatus carefully so that only one color from the first order (the brightest color) falls on the opening of the mask of the photodiode.
2. For each color in the first order, measure the stopping potential with a voltmeter. (You may have to be patient for this value to stabilize.) Use the yellow and green colored filters on the reflective mask of the apparatus when you measure the yellow and green spectral lines.
3. Move to the second order and repeat the process.

ANALYSIS:

Using whatever techniques you think are appropriate, determine to what extent the maximum kinetic energy of the photoelectrons depends upon intensity of incident light. Discuss how well your results agree with the classical theory of light.

Determine the frequency of each spectral line. Use Kaleidagraph to make a graph of stopping potential, V_s, vs. frequency, f. Discuss this graph in terms of a quantum model of light. Determine a value for Planck's constant, h, and the work function of the phototube, Φ. Compare your h (and its uncertainty!) to the accepted value. You can compare your Φ to your neighbors, who supposedly have identical equipment.

Color	**Wavelength (nm)**
yellow	579
yellow	577
green	546
blue-green	496
blue-green	492
blue	436
violet	405
violet	365

Table 1 shows some of the visible wavelengths in the mercury spectrum Note that not all of the wavelengths listed above are clearly visible in your spectrum, and that some of them may appear blurred together into a single line. Part of your task is to figure out which wavelengths are relevant.