PHYS 232
The Photoelectric Effect

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Read the paper entitled "The Photoelectric Effect Using LEDs as Light Sources" by W.P. Garver [*Phys. Teach.* **44**, 272 (2006)]. You will reproduce all of the experiments and results discussed in this reference.

Pre-lab Assignment

Question 1: The well-known photoelectric effect result is:

$$eV_\mathrm{s} = h\nu - W_0 \tag{1}$$

which gives a linear relationship between V_s and ν. What do each of the variables in Eq. (1) represent?

Question 2: In your experiment, you will measure V_s quite precisely. In contrast, the relative uncertainty in ν will be quite a bit higher. Briefly explain why, if this is case, it would be better to plot ν as a function of V_s rather than V_s as a function of ν.

Question 3: Rearrange Eq. (1) so that ν is expressed as a function of V_s. If you were to plot ν versus V_s you should obtain a straight line. What are the slope and y-intercept of that line?

Experiment

Day 1

1. Determine the frequency/wavelength of each of the LEDs that you will use as a light source. To do this, use the DC power supply and a suitable resistor to turn on the LED and the visible-light spectrometer. Configure the spectrometer to measure intensity versus wavelength. Determine the peak value and width of the intensity profile for each of the LEDs.

2. Next, measure the stopping voltage V_s required to achieve zero photocurrent for each of the LEDs. During this measurement, cover the phototube with the cardboard shield to block the unwanted light from the room. If necessary, you can also cover the entire apparatus with felt. Try this measurement using at least two different resistors in series with your LEDs (i.e. two different intensities of light).

3. Use the stopping voltage and frequency data to determine Planck's constant and the work function of the photocathode in the vacuum tube.

Day 2

1. Select an LED and measure the stopping voltage required to achieve zero photocurrent as a function of the intensity of the light emitted from the LED. To vary the LED intensity, vary the series resistance from approximately $100\,\Omega$ (high intensity) to $1000\,\Omega$ (low intensity). Do this measurement for at least two of your LEDs. Do your results support a particle or wave picture of light? Explain.

2. Finally, use a function generator in square-wave mode to repeatedly turn your LED off and on. A frequency of approximately 10 kHz will be suitable. With the stopping voltage turned to zero, observe both the function generator output and the photocurrent (as a voltage across a resistor) on an oscilloscope. What is the delay time between the LED turning on and the photocurrent reaching its equilibrium value? Does this observation support a particle or wave picture of light? Explain. Can you think of why Graver suggests adding a $10\,\mathrm{k}\Omega$ resistor in parallel with the oscilloscope input? See Fig. 5 in his paper. *Hint*: Think about the oscilloscope input impedance.