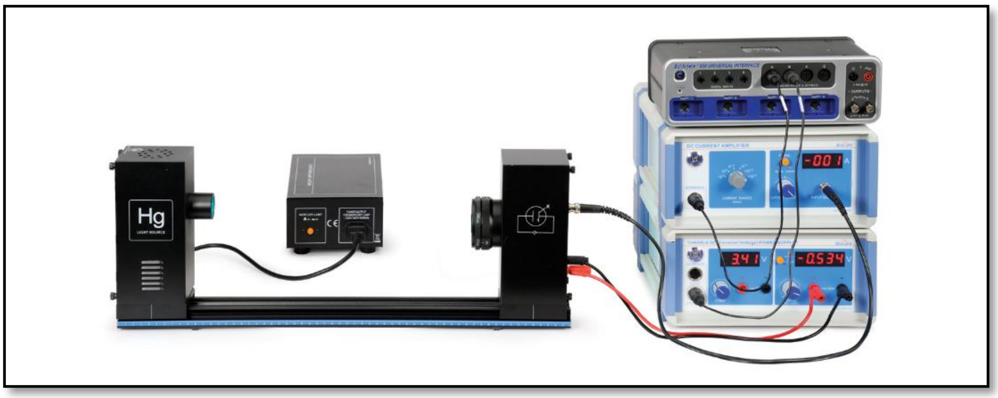
Lab Experiment: Photoelectric Effect

Name 1: ___________________________ **Student Number:** _________________________

Name 2: ___________________________ **Student Number:** _________________________

Name 3: ___________________________ **Student Number:** _________________________

Name 4: ___________________________ **Student Number:** _________________________



Lab Purpose: In this lab, you will study the effect of varying the light intensity, wavelength and frequency have on the energy of the emitted electrons and the magnitude of the photo-current. You will also determine Planck's constant. The complete setup of the experiment is shown in Figure 1.

Equipment

1. Mercury Lamp and Power Supply
2. Photodiode
3. Track
4. DC Current Amplifier (Figure 2).
5. DC Power Supply (Figure 3).
6. 850 Universal Interface

Preparation before measurement

1. Mount the mercury lamp and the photodiode case on the track as shown in Figure 1.

2. Turn on the Mercury Lamp and let it warm up for at least 10 minutes. Leave the cover on the lamp to avoid looking directly into the lamp.

3. Do not connect any cords to the photodiode yet.

4. On the DC Current Amplifier, turn the CURRENT RANGES switch to 10^{-13}A. Press the Calibration button to set the meter to zero. Turn the knob until the meter reads 000 A (see Figure 2).

5. Press the Calibration button to put it in the OUT position for measuring.

NOTE: For the rest of the experiment, do not change the knobs on the DC Current Amplifier.

6. On the DC Power Supply, make sure the button is out to select the -4.5 V to 0 V range (see Figure 3).

7. Connect the cables to the photodiode:
   a. Connect the special BNC-plug-to-BNC-plug cable between the port marked “K” on the Photodiode enclosure and the BNC jack on the DC Current Amplifier.
   b. Connect the red banana-plug patch cord between the port marked “A” on the Photodiode enclosure and the red banana jack on the right side of the DC Power Supply.
   c. Connect the black banana-plug patch cord between the black banana jack on the Photodiode enclosure and the black banana jack on the right side of the DC Power Supply.

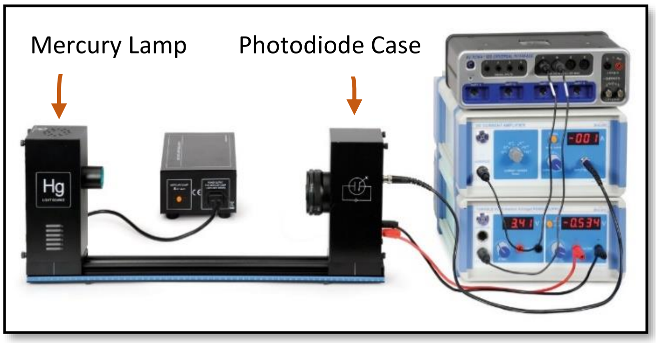


Figure 1: Complete Setup

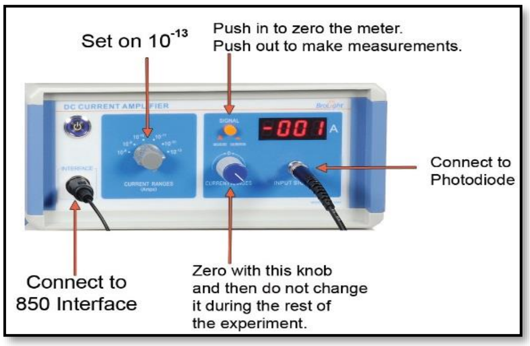


Figure 2: Current Amplifier Settings

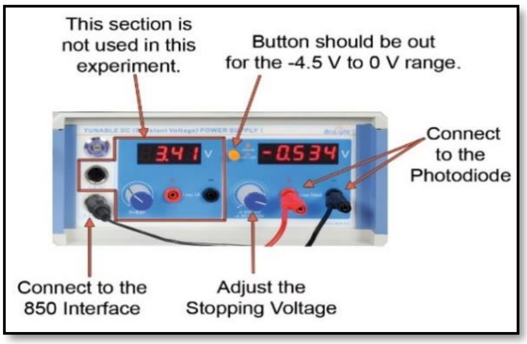


Figure 3: DC Power Supply Settings

Measurement

1. Uncover the window of the photodiode enclosure. Place the 4mm diameter aperture and the 365nm filter onto the window of the enclosure
2. Uncover the window of the Mercury Light Source. Spectral lines of 365nm wavelength will shine on the cathode in the phototube.
3. Adjust the VOLTAGE ADJUST knob on the DC power supply till the current on the DC current amplifier is zero.
4. Record the magnitude of the stopping potential for the 365nm wavelength in Table 1.
5. Cover the window of the Mercury Light Source with the mercury lamp cap from the optical filters box.
6. Replace the 365nm filter with the 405nm filter.
7. Uncover the window of the Mercury Light Source. Spectral lines of 405nm wavelength will shine on the cathode in the phototube.
8. Adjust the VOLTAGE ADJUST knob on the DC power supply till the current on the DC current amplifier is zero.
9. Record the magnitude of the stopping potential for the 405nm wavelength in Table 1.
10. Cover the window of the Mercury Light Source.
11. Repeat the measurement procedure for the other filters. Record the magnitude of the stopping potential for each wavelength in Table 1.

Table 1: Stopping Potential of Spectral Lines, 4 mm diameter Aperture

Item	1	2	3	4	5
Wavelength, λ (nm)	365.0	404.7	435.8	546.1	577.0
Frequency, $\nu = c/\lambda$, (x 10^{14} Hz)	8.214	7.408	6.879	5.490	5.196
Stopping Potential, V (V)					

Calculating

1. Plot a graph of Stopping Potential (V) versus Frequency (x 10^{14} Hz).
2. Find the slope of the best-fit line through the data points on the Stopping Potential (V) versus Frequency (x 10^{14} Hz) graph.

Note: The slope is the ratio of *h/e*, so Planck's constant, *h,* is the product of the charge of the electron (e = 1.602 x 10^{-19} C) and the slope of the best-fit line.

According to the theory of linear regression, the slope of the Stopping Potential versus Frequency graph can be calculated using the following equation:

$$\text{slope} = \frac{\bar{\nu} \cdot \bar{V} - \overline{(\nu \cdot V)}}{\bar{\nu}^2 - \overline{\nu^2}}$$

where $\bar{\nu} = \frac{1}{n}\sum_{i=1}^{n} \nu_i$, $\overline{\nu^2} = \frac{1}{n}\sum_{i=1}^{n} \nu_i^2$, $\bar{V} = \frac{1}{n}\sum_{i=1}^{n} V_i$, and $\overline{\nu \cdot V} = \frac{1}{n}\sum_{i=1}^{n} \nu_i \cdot V_i$.

3. Record the calculated slope and use it to calculate the value of Planck's constant, *h*.

Slope = ___________________

h = e x slope = ________________________

4. Estimate the error in the slope and round your result to the appropriate value. Compare your calculated value of *h* to the accepted value, h_0, 6.626 x 10^{-34} J s.

$$\text{percent difference} = \left|\frac{h - h_0}{h_0}\right| \text{x} 100$$

5. Record your percent difference _______________________

Questions

1. How does your calculated value of *h* compare to the accepted value?
2. What do you think may account for the difference – if any – between your calculated value of *h* and the accepted value?
3. How can you find the value of the Work Function from the graph of Stopping Potential versus Frequency?

3. How can you find the value of the Work Function from the graph of Stopping Potential versus Frequency?

Extension

Repeat the data measurement and analysis procedure for the other two apertures in the OPTICAL FILTERS box

Table 2: .Stopping Potential of Spectral Lines, 2 mm diameter Aperture

Item	1	2	3	4	5
Wavelength, λ (nm)	365.0	404.7	435.8	546.1	577.0
Frequency, ν, (x 10^{14} Hz)	8.214	7.408	6.879	5.490	5.196
Stopping Potential, V (V)					

Table 3: .Stopping Potential of Spectral Lines, 8 mm diameter Aperture

Item	1	2	3	4	5
Wavelength, λ (nm)	365.0	404.7	435.8	546.1	577.0
Frequency, ν, (x 10^{14} Hz)	8.214	7.408	6.879	5.490	5.196
Stopping Potential, V (V)					

Questions

1. How does your calculated value of h for each different aperture compare to the accepted value, h_0, 6.626 x 10^{-34} J s?
2. How does light intensity affect the Stopping Potential?