# Photoelectric Effect

## Equipment

Daedalon photoelectric effect device
Green laser pointer ($532nm$)
Red laser pointer ($654nm$)
Yellow laser pointer ($592nm$)
Purple laser pointer ($401nm$)
He-Ne Laser ($633nm$)
filters, including polarizing filters
supports for light sources
multimeter, with connecting wires (patch cords)
**Warning:** Do not point the lasers at the eyes.

## Purpose

We will study the photoelectric effects using red and green lasers and use the results to measure the value of the Planck's constant.

## Equation

The basic equation of the photoelectric effect is the following:

$$KE = hf - \phi.$$

$KE$ is the maximum kinetic energy of the electrons, $f$ is the frequency of the light causing the photoelectric effect (recall that $f = c/\lambda$), and $\phi$ is the work function of the metal. The kinetic energy is experimentally determined using:

$$KE = eV_s$$

where $V_s$ is the stopping potential. Note that if we write $KE$ in the unit of electron volts ($eV$), a stopping potential of $V_s = 0.52V$ simply gives $KE = 0.52eV$.

# Procedure

1. Connect and turn on the photoelectric effect detector, and connect a multimeter to the detector to measure voltage. Wait five minutes for the detector to warm up. (Connect the red terminal of the photoelectric device to the $V$ terminal or voltage terminal of the multimeter, and connect the black terminal of the photoelectric device to the $COM$ terminal or ground terminal of the multimeter. Use patch cords.)

2. Notice, with the multimeter turned on to register voltage, that the current reading on the scale of the photoelectric detector may not read zero. Turn the voltage dial in a counterclockwise direction, to its full extent so the voltmeter gives exactly $0V$. Without lasers entering the device, use the Zero dial to set the photoelectric current to zero. The procedure is call "zeroing" the device. This is to eliminate the current due to the photoelectrons produced by the ambient light.

3. Prepare a stand for the laser pointer. Place a utility clamp on the stand. Place the green laser in the metal cradle, and clamp the cradle in place so that the laser is horizontal. Move the laser close to the aperture of the photoelectric detector and adjust the height of the laser so that its beam, if on, would be directed into the aperture.

4. Check again to make sure both the voltmeter and the ammeter are giving zero reading, then you can turn on the laser. When you do, you will most likely find the ammeter reading goes beyond the maximum scale, but it will not be a problem as we will turn on the stopping potential next to stop the current. If the reading seems small, your laser is probably not pointing directly at the metal inside the device. In this case you should move the laser around until you get the maximum signal.

5. Adjust the potential knob until you get a zero reading on the ammeter. The potential that stops the current is called the stopping potential, $V_s$. Record the value of $V_s$ in Table 1 below.

6. Turn off the green laser, and set the voltage back to zero. Zero the ammeter again using the zero dial, and repeat the above steps with all other available lasers.

# Data

Table 1: Stopping potential for different wavelengths

| Laser | Wavelength<br>$\lambda$ $(nm)$ | Frequency<br>$f$ $(10^{14}Hz)$ | Stopping Potential<br>$V_s(V)$ |
|---|---|---|---|
| Green LED | 532 | | |
| Red LED | 654 | | |
| Yellow LED | 592 | | |
| Purple LED | 401 | | |
| He-Ne | 633 | | |

# Analysis

Plot the data points on a $KE$ versus $f$ graph. The $y$-axis should have the unit of $eV$ (electron volts), and the $x$-axis should have the unit $10^{14}Hz$. (For example, $f = 2.3 \times 10^{14}Hz$ and $KE = 0.52eV$ should be plotted as the point $(2.3, 0.52)$.) Find the slope of the line. Note that the unit of the slope plotted using the units specified here would be $\frac{eV}{10^{14}Hz} = 1.6 \times 10^{-33} Js$, from this find the value of the Planck's constant in SI unit. Also find the work function of the metal inside the device.

Slope = ________________________ $\frac{eV}{10^{14}Hz}$

Planck's constant $h$ = ________________________ $Js$

Work function $\phi$ = ________________________ $eV$ = ________________________ $J$