# Photoelectric Effect

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The photoelectric effect is the emission of electrons when light shines on a material. These emitted electrons can be referred to as photo electrons. To simulate the photoelectric effect, 10 various LED's with differing wavelengths were put into a circuit with a teensy arduino and values for the current and the voltage were obtained. These values were then plotted in order to obtain a slope of Planck's constant.

## I. INTRODUCTION

In 1905 Albert Einstein released his revolutionary paper on the photoelectric effect, which stated that when light shines on a material, electrons are emitted. This electron emission is due to electrons being dislodged by the impingement of photons reaching a certain threshold frequency.

The photoelectric effect can be tested by using a teensy arduino, 10 LED's of varying wavelengths, and a 10 kilo-ohm resistor. By wiring these components together and using an arduino program, one can observe that an LED with a certain wavelength reaches a threshold frequency in which photons are created. Through motion, electrons are able to create current which can activate an LED with a threshold current. Once the threshold current has been reached, the LED then begins emitting light. These threshold currents can be measured using a teensy to take data as electrons are being emitted.

## II. PROBLEM AND RELEVANT THEORY

The main problem of this lab was to find graphically, the value of Planck'S constant. This was done throughout the relevant theories and formula relation wavelength, energy and frequency. This relation between energies and frequency is known as Planck's Relation as shown in Equation 1, where $E$, $h$, and $f$, are energy, Planck's Constant and frequency respectively.

$$E = hf \tag{1}$$

With this applied to the basics of wavelength as shown in Equation 2 where $c$ is the speed of light, it is easy to relate how wavelength can effect frequency and in turn effect energy.

$$f = \frac{c}{\lambda} \tag{2}$$

This final relation can be represented by Equation 3.

$$E = h\frac{c}{\lambda} \tag{3}$$

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Thus we have the direct relationship through the use of the Planck Relation. This relationship between frequency and wavelength to energy allows us to take a look at multiple LED's (Light Emitting Diode) and see how the voltage and current relates to specified wavelengths. This is done through the use of Arduino components and python programming. These graphical representations of multiple wavelength LED's allows the final plot between voltage and frequency to be made. The relation between the turn on voltage and the frequency allows a ling of best fit to be produced graphically and the slope defined. From the Planck Relation this slope should be equivalent to Planck's Constant.

## III. EXPERIMENTAL SKETCH AND SALIENT DETAILS

The experimental apparatus used consists of a teensy arduino circuit, allowing a computer program to easily record, measure, and plot the data of 10 LEDs of differing wavelengths as shown in Fig. 2. While the hardware played an important role in being able to obtain values for calculating Plancks constant, both the Arduino and Python programs were essential in being able to measure and graph the values received from the hardware. In order to obtain values and plot them on Python, both Arduino and Python had to be connected by a common serial port which would allow values from the Adruino program to be transferred into a .csv file on Python, which then can be used to create graphs.

## IV. DATA PRESENTATION AND ERROR ANALYSIS

When the data points for the 850 nm LED are plotted, the graph is that of an exponential growth curve (Fig. 2) which represents the current increasing with certain voltages. Using this information, Equation 3 can be used to find frequency and can then be plotted on a graph with respect to voltage (Fig. 3). When these points are plotted, the slope can then be measured using python. Our measured slope was $4.82 \times 10^- 15 eV$, which is close to the received value of Plancks constant of $4.3 \times 10^- 15 eV$. This small discrepancy in values can mainly be attributed to human error, especially during
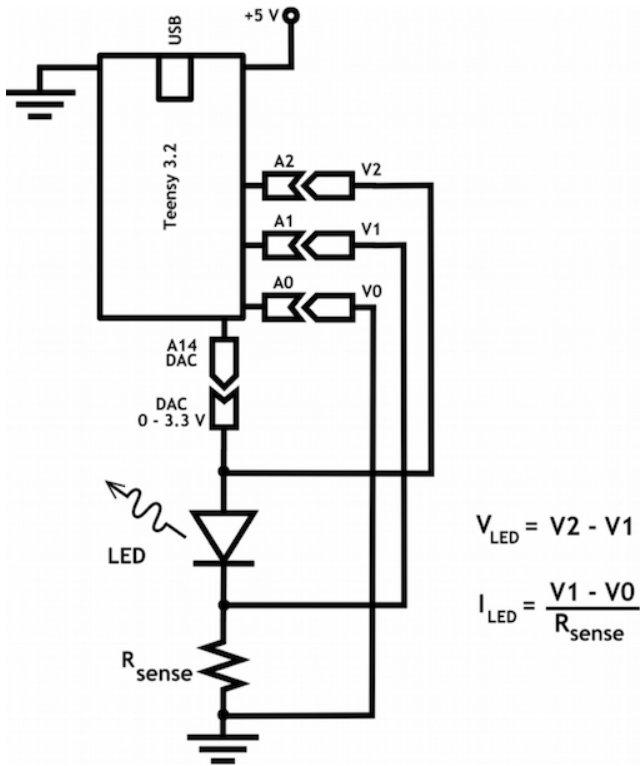
FIG. 1. This is a schematic of the main apparatus. Here the LED position was changed out for multiple LED's to be tested. The teensy arduino program could then record the measurements to be represented graphically in a python program as shown in FIG. 2. [? ].

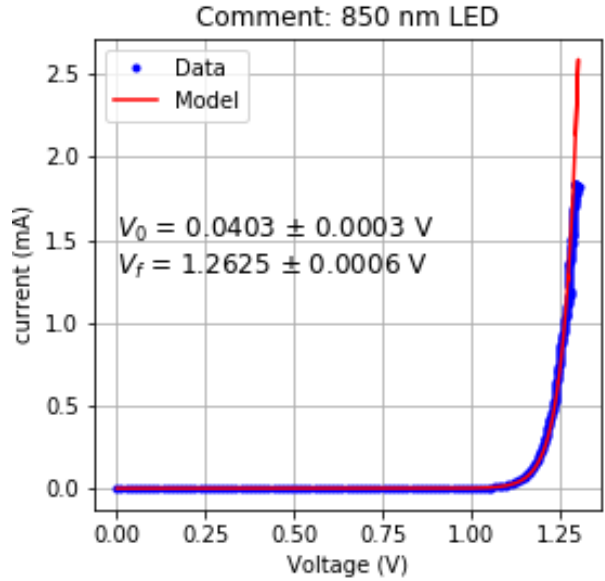values. By conducting this experiment, a deeper understanding of the photoelectric effect, Plancks constant,



FIG. 2. This is the graphical representation of the 850 nm wavelength LED data obtained from the arduino circuit.

calculations. Although the calculations were quite simple, rounding errors can easily be made because the necessary values are extremely small.

TABLE I. This table represents the frequency and voltages of the respective LED wavelengths used for plotting of FIG. 3.

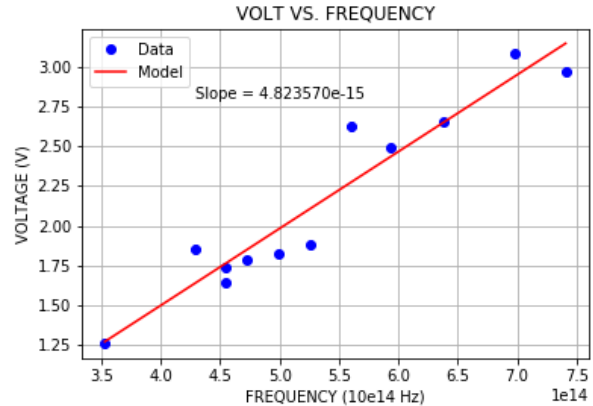| $\lambda(nm)$ | Volt (V) | f ($10^{14}$Hz) | $\lambda(nm)$ | Volt (V) | f ($10^{14}$Hz) |
|---|---|---|---|---|---|
| 405 | 2.9654 | 7.4074 | 601 | 1.8286 | 4.9917 |
| 430 | 3.0803 | 6.9767 | 635 | 1.7847 | 4.7244 |
| 470 | 2.6495 | 6.3830 | 660 | 1.7413 | 4.5454 |
| 505 | 2.4889 | 5.9406 | 660 | 1.6472 | 4.5454 |
| 535 | 2.6295 | 5.6075 | 700 | 1.8580 | 4.2857 |
| 570 | 1.8849 | 5.2632 | 850 | 1.2625 | 3.5294 |



FIG. 3. This figure represents the turn on voltages for all tested LED's versus their respective frequencies. This was done creating a program on the collaborative source CoCalc, through the use of the python programming language.

circuitry, and programming were obtained during the implementation of this experiment.

## V.  CONCLUSIONS

The obtained value of Plancks constant was $4.82356995762x10^15eV$, which was very similar to the accepted value regardless of the small variation of