Determining Planck's Constant Using Light Emitting Diodes (LED's)

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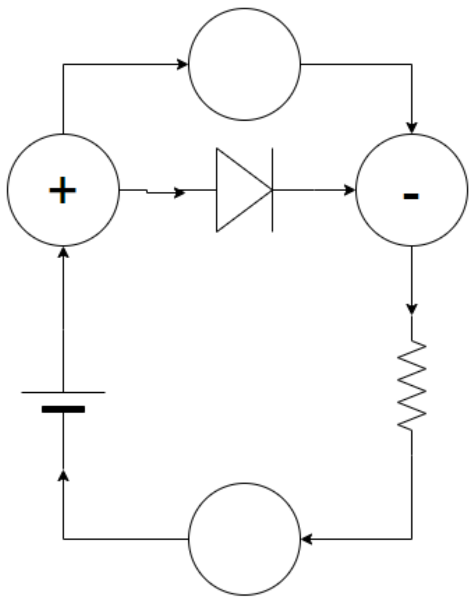
The Planck's Constant is a value that can be used to find the Energy or the frequency of a given light emission from an object that is caused by the changing of levels for an electron that causes a production of light as a result. The experiment was designed around this point, by introducing a current to various Light Emitting Diodes (LED's) and seeing the resulting color produced by the required voltage being produced from the power source. From performing the experiment it is found that the measured Planck's Constant and the expected Planck's Constant are off by 200%.

Section I: Background

Planck's method states that it can determine the type and quantity of energy emitted by all objects because of that objects temperature. The different colors observed during this experiment were a result of the electrons changing levels in the atom, which releases amounts of energy which in using Planck's Constant and the frequency of the light coming off of it can be determined. The experiment is designed around trying to measure the value of Planck's constant by using known values for wavelength, electron charge and the speed of light. The experiment consists of six LED's where the frequency is increasing going from blue, green, yellow, bright red, red and Infrared, with the following wavelengths respectively, 428 nm, 560 nm, 593 nm, 635 nm, 660nm and 940 nm.

Section II: Theory and Procedure

The process of the experiment to measure the value of Planck's constant, is to build a circuit consisting of the power source, current probe, ammeter, and led, where the current can be slowed increased and the current and voltage can be recorded and tracked on the capstone program.



Each run will consist of the circuit slowing be brought up to a maximum of 18 mA of current as to not burn out the LED's, while tracking the voltage on the capstone program, once the voltage keeps steady the recording is stopped and the current slowly turned down, as to not burn out the LED's. Once the data is collected for the 6 runs at 6 different wavelengths, the voltages are found for each of the LED's and are organized so that the mathematical portion can be done. Starting off with the finding of the energy of the LED, with the following equation.

$$E = q * V = V * 1.60217646\ x\ 10^{-19}\ C$$
(1) [1]

Once the energy found the next step is to find the frequency of the LED's which can be done with this equation.

$v = c/\lambda$ (2) [1]

Where v is the frequency, c is the speed of light and the wavelength.

Once this is found the value for the Planck's Constant can be determined.

$$E = hv$$
$$h = \frac{E}{v}$$

Once the measured value for Planck's Constant is found the percent difference is calculated.

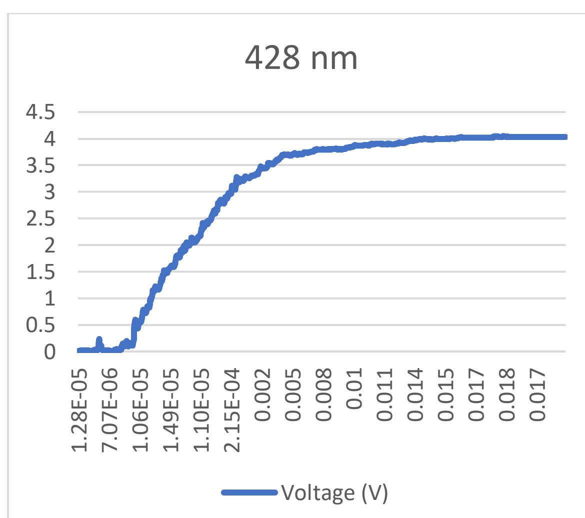
Section III: Results

The results for runs as following show a trend that as the current increases the voltage increases until the voltage for the LED is reached.

Run 1: 428 nm Blue LED

This run is concerned with the 428nm wavelength LED, which has a voltage of approximately 4.05 Volts, for the light to be produced by the component which in this case is Blue.

Voltage	4.05
Energy	$6.49\ x\ 10^{-19}$
Frequency	$1.28\ x\ 10^{2}$
Measured Planck	$5.05\ x\ 10^{-21}$
% Difference	200%

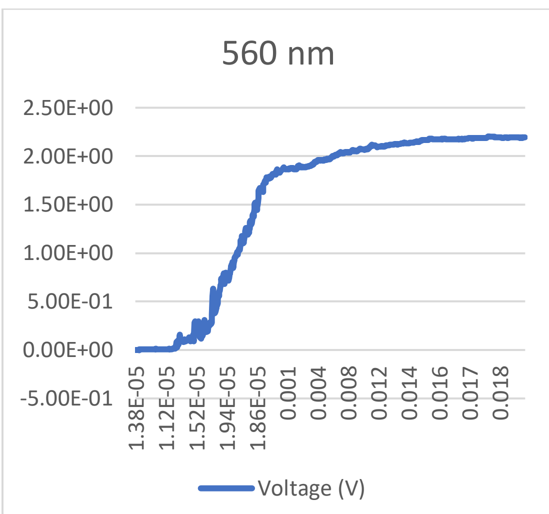


From the calculations it can be concluded that for run 1, the data was 200% off from the expected value for planck's constant.

Run 2: 560 nm Green LED

This run is concerned with the 560nm wavelength LED, which has a measure voltage of 2.2 Volts, for the light to be produced by the component which in this case is Green.

Voltage	2.20
Energy	$3.53\ x\ 10^{-19}$
Frequency	$1.68\ x\ 10^{2}$
Measured Planck	$2.1\ x\ 10^{-21}$
% Difference	200%

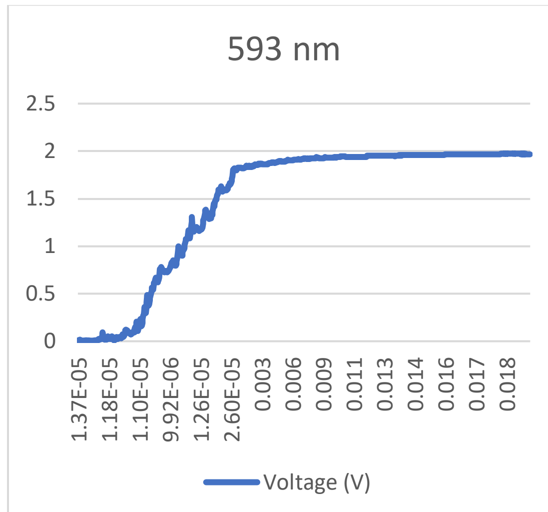


From the calculations it can be concluded that for this run aswell, the expected value and the measured value are off by 200%.

Run 3: 593 nm Yellow LED

This run is concerned with the 593nm wavelength LED, which has a voltage of 1.972, for the light to be produced by the component which in this case is yellow.

Voltage	1.972
Energy	$3.16\ x\ 10^{-19}$
Frequency	$1.72\ x\ 10^{2}$
Measured Planck	$1.78\ x\ 10^{-21}$
% Difference	200%

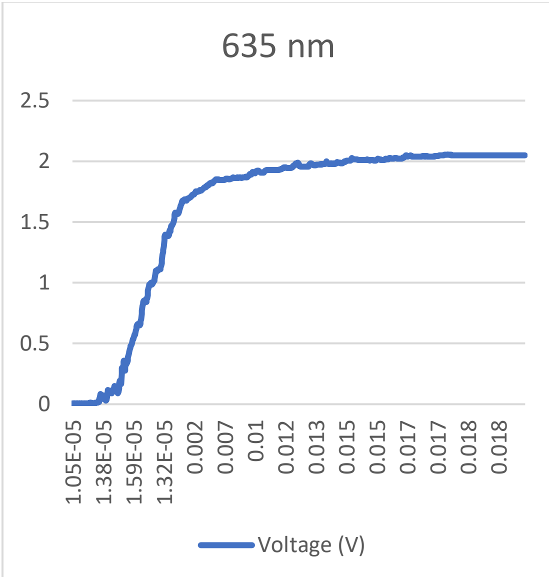


From the calculations it can be concluded that for this run, the expected value and the measured value for Planck's Constant are off by 200%.

Run 4: 635 nm Bright Red LED

This is concerned with the 635nm wavelength LED, which has a voltage of 2.054, for the light to be produced by the component which in this case is bright red.

Voltage	2.054
Energy	$3.29\ x\ 10^{-19}$
Frequency	$1.91\ x\ 10^{2}$
Measured Planck	$1.73\ x\ 10^{-21}$
% Difference	200%

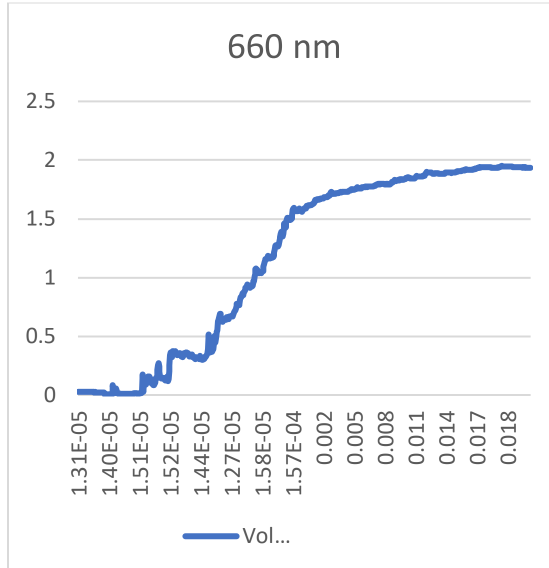


From the calculations it can be concluded that the expected and measure Planck's Constants are off by 200%

Run 5: 660 nm Red LED

This run is concerned with the 660 nm LED, which has a voltage of 1.95, which produces a red light.

Voltage	1.95
Energy	$3.12\ x\ 10^{-19}$
Frequency	$1.98\ x\ 10^{2}$
Measured Planck	$1.58\ x\ 10^{-21}$
% Difference	200%

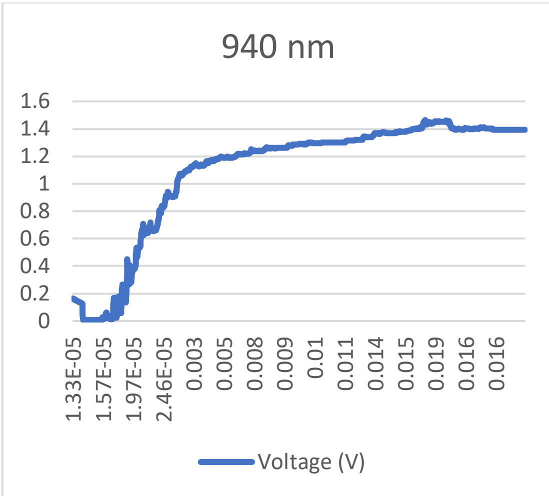


From the data collected and the calculations the expected and measured values for the Planck's Constant are off 200%.

Run 6: 940 nm IR LED

This run is concerned with the 940 nm LED, which has a voltage of 1.464 and produces Infrared Light.

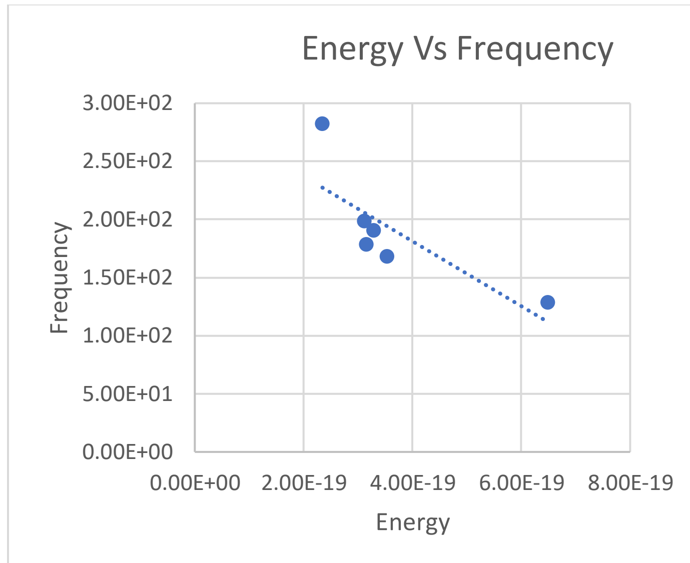
Voltage	1.464
Energy	$2.35\ x\ 10^{-19}$
Frequency	$2.82\ x\ 10^{2}$
Measured Planck	$8.32\ x\ 10^{-22}$
% Difference	200%



From the data and the calculations the expected and measured values for Planck's Constant are off by 200%.

The very large percent difference for the expected and measured values can be a result of the data be collected by the current probe and the capstone program or it could be calculation error on the side of the experimenter.

Energy	**Frequency**
$\mathbf{6.49\ x\ 10^{-19}}$	$1.28\ x\ 10^{2}$
$\mathbf{3.53\ x\ 10^{-19}}$	$1.68\ x\ 10^{2}$
$\mathbf{3.16\ x\ 10^{-19}}$	$1.78\ x\ 10^{2}$
$\mathbf{3.29\ x\ 10^{-19}}$	$1.91\ x\ 10^{2}$
$\mathbf{3.12\ x\ 10^{-19}}$	$1.98\ x\ 10^{2}$
$\mathbf{2.35\ x\ 10^{-19}}$	$2.82\ x\ 10^{2}$



Section IV: References

[1] Department of Physical Sciences. “Determining Planck’s Constant Using Light Emitting Diode (LED’s).” Daytona Beach: Embry-Riddle Aeronautical University, 2016. PDF File