

Planck's Constant Experiment

Guided Project Instructions

nPoints
BY NTS PRESS

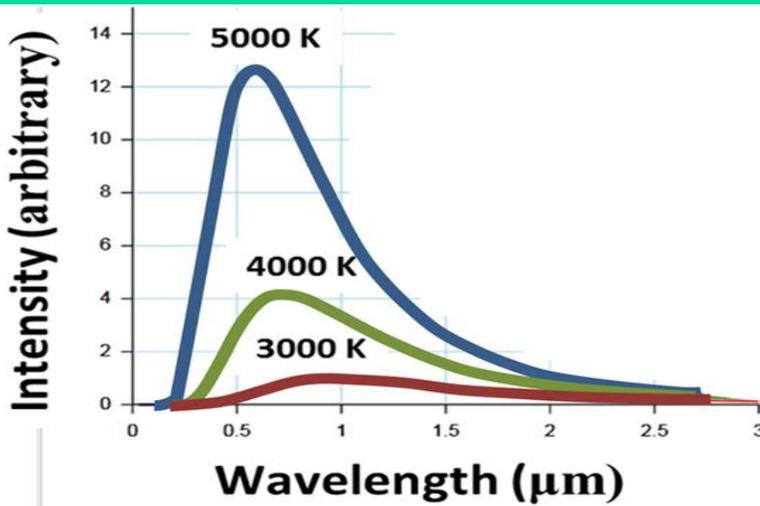


Figure 1 Black Body radiation vs Wavelength

Learn It!

One of the coolest aspects of science is the fact that laws and equations are made based off of experiments that can be reproduced. Major advancements in human history are built off of things like the speed of light Boltzman's constant and Avagadro's number. These values can be proven by setting up the same experiments that were used to define them in the first place. Planck's constant is a revolutionary number that ushered in a new era of science called Quantum Physics. Now the number itself is not the full basis of quantum physics but rather

the idea behind it. The idea that energy is not continuous but discrete packets proportional to the wavelength of the energy multiplied by some constant (Planck's constant) is ground breaking. In this module you will create an experiment that proves this very theory. Using a series of LEDs you will be able to show that as the frequency of the light (the color) changes so does the voltage required to turn the LED on. When this relationship is plotted the trend is a straight line whose slope can be used to calculate Planck's Constant.

Build It!

To calculate the constant we will need both the wavelength of the LED we are testing as well as the voltage where the LED turns on. If you just purchased the LED it should come with the wavelength listed, otherwise you can use a spectrometer to test the LEDs wavelength.

Task 1: Construct a test circuit that will properly supply the LED under test with a voltage that will increase from 0-5V. Create code that will run through this voltage stepping process. Use two analog input channels to acquire the voltage across the LED as well as the current in the circuit.

Task 2: Create LabVIEW code that acquires data from both MSP analog input channels. Using this data find the intersection point of the two graphs which will give us the threshold voltage of each LED.

Task 3: Create LabVIEW code that acquires data from both MSP analog input channels. Using this data find the intersection point of the two graphs which will give us the startup voltage of each LED. Write your code to successfully gather and store the wavelength of the LED being tested (make sure the wavelength information must be input before running the test, throw a warning message if necessary).

Related Core Concepts:

IV Analysis

Waveform Generation

"The idea that energy is not continuous but discrete packets proportional to the wavelength of the energy multiplied by a constant is ground breaking"

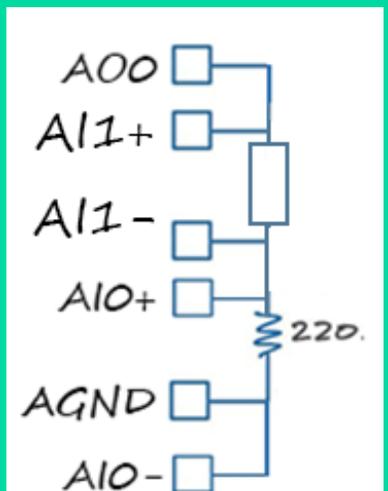


Figure 2 Transistor driven LED circuit

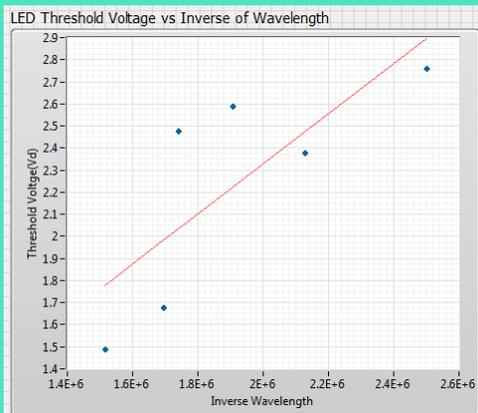


Figure 3 LED Threshold Voltage vs Inverse Wavelength

Task 3: Using the entered wavelength data and the array of LED threshold voltages, reference the following equation to calculate Planck's constant:

$$h = \frac{eV_{threshold}\lambda}{c}$$

This equation says that the ratio of the threshold voltage and 1/wavelength multiplied by a constant (derived from the the charge an electron and the speed of light yields Planck's constant which means it can be derived from graphing the acquired data from the LEDs, creating a best fit line from the data and finding the slope of that line.

Guiding Questions:

- Since you have accumulated a measure of the current in the test series circuit, what is another way to find the turn on voltage of the test LED?
- How can a series of test voltages be applied to the test circuit and current be measured and stored for later use with no manual interference?
- What limitations are apparent in using a DAQ device to apply voltage and current to the test circuit?

Expand it!

- Make the test fully automated by allowing for multiple LEDs to be wired into some form of test setup. Create code and design hardware that can test a single LED to gather current measurements then switch to the next LED under test. This fully automated experiment should only require the user input the frequencies of the LEDs under test.

Research It!

Determination of Planck's constant using LEDs

<http://www.physics.fsu.edu/courses/Summer13/YSP/experiments/LEDPlanckExpt.pdf>

Light Emitting Diodes

http://www.electronics-tutorials.ws/diode/diode_8.html

Planck's Constant Experiment

<https://www.youtube.com/watch?v=eO6JaaBhn-M>