

Measuring Planck's Constant: Student Worksheet

Aim

To demonstrate the quantization of light and to measure Planck's constant (h).

Background

The energy lost by a single electron that passes through a light-emitting diode (LED) is converted into the energy of one photon.

$$e \Delta V = h f$$

e = elementary charge = 1.6×10^{-19} C

ΔV = potential difference across LED

f = frequency of a photon emitted by LED

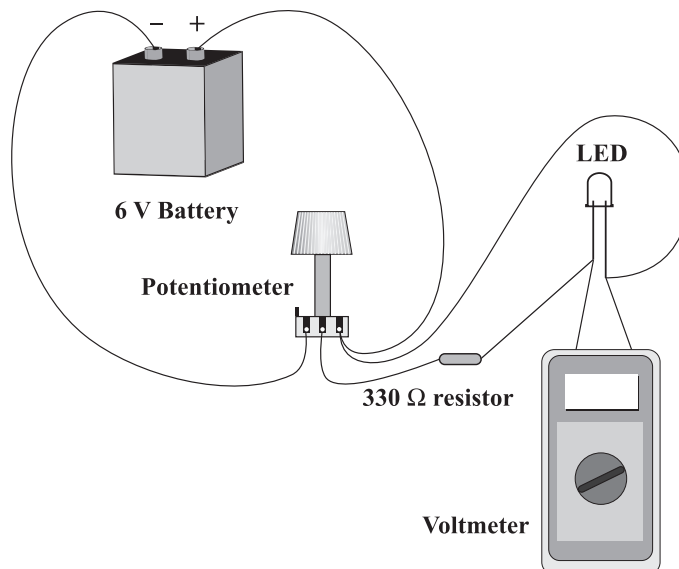
Materials

Set of 5 LEDs
6 V battery
1 k Ω potentiometer
330 Ω resistor
voltmeter
5 connecting leads

Procedure

CAUTION: Do not stare directly at a brightly lit LED.

1. Orient the potentiometer so that the terminals are pointing towards you. Turn the knob fully clockwise. Connect the negative terminal of the battery to the left-hand terminal of the potentiometer and the positive terminal of the battery to the right-hand terminal of the potentiometer, as shown in the diagram.
2. Connect any one of the LEDs to the 330 Ω resistor using a wire. Connect both of these components between the central and right-hand terminals of the potentiometer as shown in the diagram (with the *longer* wire of the LED attached to the *right-hand* terminal).
3. Connect the voltmeter across the LED.
4. Slowly increase the potential difference across the LED by turning the potentiometer knob counterclockwise until the LED **just begins** to glow. Record the potential difference at which this happens. Go backwards and forwards past the point at which the LED just begins to glow a few times to locate it as accurately as possible.
5. Repeat Step 4 for all the other LEDs. Always turn the potentiometer knob fully clockwise before changing LEDs so the initial voltage across each LED is 0 V.



6. Summarize your results in a table similar to the following:

Colour of LED	Red	Amber	Yellow	Green	Blue
Frequency ($\times 10^{14}$ Hz)	4.54	5.00	5.08	5.31	6.38
Potential Difference (V)					

Analysis

1. Plot a graph of potential difference (y-axis) versus frequency (x-axis).
2. Draw the line of best fit and measure its slope. Use this slope to calculate Planck's constant by using the equation $e\Delta V = hf$.

Questions

1. What is the percentage error in your calculated value for Planck's Constant?
2. A green laser pointer produces 530 nm light with a power rating of 1.0 mW. How many photons does the laser produce each second?
3. Weather reports monitor ultraviolet (UV) light levels. Why is UV light a concern?