Lab Activity: Measuring Planck's Constant
(adapted from The Perimeter Institute of Theoretical Physics)

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.

\[ e \Delta V = hf \]

- \( e = \) elementary charge = \( 1.6 \times 10^{-19} \) C
- \( \Delta V = \) potential difference across LED
- \( f = \) frequency of a photon emitted by LED

Materials
- Set of 5 LEDs
- 6 V battery
- 1 kΩ potentiometer
- 330 Ω resistor
- voltmeter
- 5 connecting leads

CAUTION
Do not stare directly at a brightly lit LED.

Procedure

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:

<table>
<thead>
<tr>
<th>Color of LED</th>
<th>Red</th>
<th>Amber</th>
<th>Yellow</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency ( x 10^{14} Hz )</td>
<td>4.54</td>
<td>5.00</td>
<td>5.08</td>
<td>5.31</td>
<td>6.38</td>
</tr>
<tr>
<td>Potential Difference (V)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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?