

# Lesson Plan

## Measuring Planck's Constant

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### Key Equations

$$E = hf; \quad E = eV; \quad e\Delta V = hf;$$
$$e = 1.602 \times 10^{-19} \text{ J}; \quad h = 6.636 \times 10^{-34} \text{ J}\cdot\text{s}$$

### Background

Planck's constant,  $h$ , is a universal constant that lies at the heart of quantum mechanics. It defines the scale of quantum theory just as the speed of light defines the scale of special relativity.

Using a simple circuit and LEDs, we can measure Planck's constant. The electrical energy lost by each electron ( $E = eV$ ) that crosses the LED is converted into the energy of an individual photon. This energy can be calculated using  $E = hf$ . By measuring the potential difference across a number of LEDs, students will be able to calculate the value of  $h$  to an accuracy of within 20%.

### Purpose

- To provide a hands-on approach to a fundamental aspect of quantum mechanics
- To gain a greater understanding of light quanta
- To understand the function of an LED (and semi-conductors in general)

### Materials

- Measuring Planck's Constant: Student Worksheet (voltmeter, 5 different LEDs of known frequencies, 6 V or 9 V cell, 1 k $\Omega$  potentiometer, 330  $\Omega$  resistor, voltmeter, 5 connecting wires, graph paper)
- Measuring Planck's Constant Solutions
- Measuring Planck's Constant Teacher's Notes
- Appendix A: Potentiometers, LEDs, and Viewing Tubes
- Appendix B: The Physics Behind LEDs

### Lesson (60-75 min)

1. (10 min) Introduce (or review) the wave-particle duality of light. An important vocabulary term is photon, or "particle" of light.
2. (10 min) Distribute the student worksheets. Describe what is expected and how the equipment should be set up. It is important to review proper safety practices with the students when they are using electrical circuits. Be sure to warn students about short circuits, because a short circuit will destroy the LEDs.
3. (30-45 min) Complete the lab. Students are to follow the procedure on the worksheet and provide answers to all questions and analysis.
4. (10 min) Summarize the class findings by comparing answers and calculating percentage error. Describe to the class the function of a semi-conductor and why it is significant to quantum mechanics.

## Credits

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