

Photons, work functions and matter waves

AP Physics 2 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

Can a small LED teach you about the quantum nature of light? You will find the voltage at which LEDs of different colours begin to glow and use the pattern to estimate the Planck constant.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 15

Aim

Find the Planck constant by measuring the voltage at which LEDs of different colours just begin to glow, and plotting that voltage against the reciprocal of the wavelength.

Equipment

- five LEDs: red, orange, yellow, green and blue, with known wavelengths
- variable DC supply (0–5 V) or a battery pack with a potentiometer
- protective resistor of $330\ \Omega$
- digital voltmeter and microammeter
- dark tube or card cylinder to shade each LED
- connecting leads

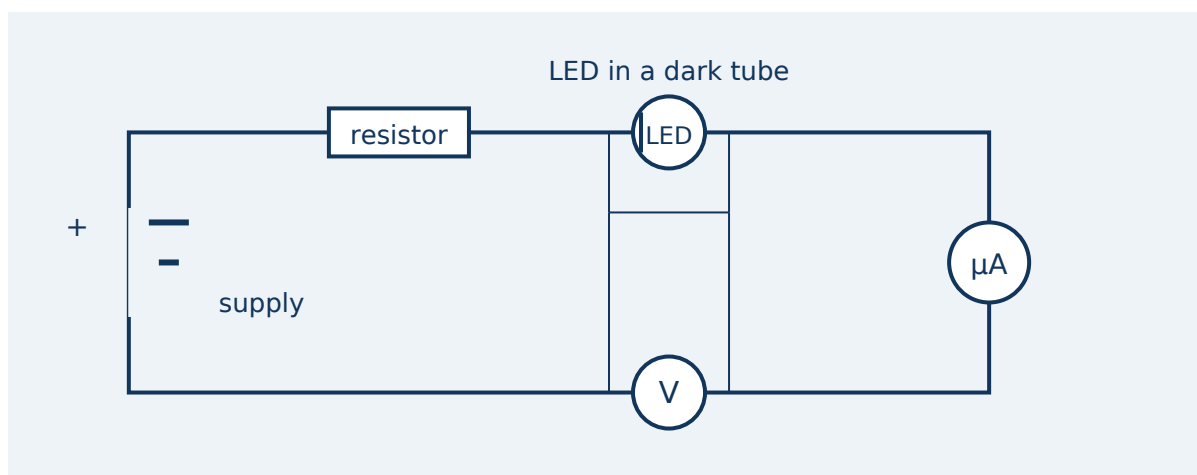
Safety

Safety

Never exceed the current rating of the LED and keep the $330\ \Omega$ resistor in the circuit. Do not look directly at bright blue LEDs from close range. Switch the supply off before changing the LED.

Method

1. Build the circuit shown, with the voltmeter across the LED and the resistor in series.
2. Place the dark tube over the first LED and start with the supply at 0 V.
3. Raise the voltage slowly until the LED first glows faintly in the tube and record the voltmeter reading.
4. Repeat three times for the same LED, then change to the next colour.



Circuit: the voltmeter is across the LED and the resistor protects it.

Results

Sample measurements by Mei in Singapore:

LED	Wavelength (nm)	Turn-on voltage (V)
red	635	1.91
orange	605	2.02
yellow	590	2.08
green	525	2.31
blue	470	2.59

Analysis questions

Question 1 Reciprocal of wavelength

Calculate $1/\lambda$ in μm^{-1} for each LED (use λ in μm).

Question 2 Plot the graph

Plot turn-on voltage V (vertical) against $1/\lambda$ (horizontal) and draw a line of best fit.

Question 3 Gradient

Calculate the gradient of the line using the red and blue LEDs. Give the unit.

Question 4 Planck constant

Use the gradient to calculate h . Use $e = 1.60 \times 10^{-19} \text{ C}$ and $c = 3.00 \times 10^8 \text{ m/s}$.

Question 5 Percentage difference

Express the gap between your result and the accepted constant, $6.63 \times 10^{-34} \text{ J}\cdot\text{s}$, as a percentage of the accepted value.

Question 6 Meaning of the intercept

State the expected intercept on the voltage axis and compare it with the line.

Question 7 Predict a violet LED

Predict the turn-on voltage of a violet LED of wavelength 405 nm, and suggest one source of uncertainty in the experiment.