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Planck's Constant LED Apparatus

Part Number EPC7000

User Instructions

INTRODUCTION.

The IPC Irwin Planck's Constant LED Apparatus is a multipurpose unit allowing the user to perform a number of experiments. These include: calculating Planck's constant, measuring the wavelength of coloured light, demonstrating colour light transmission through colour filters and showing diffraction patterns for various wavelengths of coloured light. The unit contains a range of six individual LEDs, covering the visible spectrum from deep blue at 470nm to near infra-red at 940nm. Also included is a 'Meter' output for measuring the forward voltage of each LED. When monitoring this voltage, a graph of energy input as a function of light frequency emitted, can be measured with an approximate value of Plank's constant calculated. Also supplied with the product is a 500 lines/mm diffraction grating to assist with the experiments.

DESCRIPTION.

The Planck's Constant unit individually illuminates six different coloured LEDs ranging from 470nm to 940nm, the illumination level of each LED can also be adjusted from low to high. The unit provides a voltage meter connection (via Red & Black 4mm sockets located on the side of the unit) so that each LED's threshold voltage can be measured using a voltmeter, such as our 20VDC Voltmeter (IPC-1119-M). To power the unit a DC Power Supply is required, capable of suppling a voltage between 6 to 12VDC, such as our Single Regulated PSU (IPC-0201-P) and is connected via Red & Black 4mm sockets located on the side of the unit. These sockets also allow the connection of a suitable ammeter, such as our Milliammeter (IPC-1001-M).
The unit has been designed so that the LED lenses are protected from external damage and abrasion, while the unit itself is made from robust ABS plastic.

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INSTRUCTIONS & EXPERIMENTS

Connect the apparatus to a 6 to 12VDC power supply and switch on, now turn the adjustment dial up and you should see one of the LEDs illuminate. The LED that illuminates is dependent on the position of the selector switch. Next connect a multimeter set to 20VDC to the 'Meter' 4mm sockets (**note:** a wrong polarity connection with give a minus/negative reading).

First select the red (640nm) LED and, in a darkened room, turn the adjustment dial down so that the LED is at the faintest that you can see. It is worth moving your point of view slightly as the light from a LED is not uniform. **Note:** it is useful to view the led through a black sugar paper tube so that you can easily detect the lowest brightness.

Record the so called 'Threshold Voltage' (also known as the 'Striking Voltage') as well as the wavelength of the light and then select the next LED, repeat as above for the remaining five LEDs.

Now plot a graph of threshold voltage against the reciprocal of the wavelength, the photon energy (eV) is equivalent to the threshold voltage. To convert to energy in Joules, the threshold voltage should be multiplied by the electronic charge, ie. 1.6×10^{-19}.

$E = hf = hc/\lambda$; therefore $h = \frac{E \times \text{gradient}}{c}$

Using data from our experiment we got a gradient of 1.246×10^{-6}

Thus, $h = \frac{1.6 \times 10^{-19} \times 1.246 \times 10^{-6}}{3 \times 10^{8}} =$ **6.65×10^{-34} Js**

The accepted value of Planck's constant is **6.63×10^{-34} Js.**

Please note: that the slope of the line of best fit is crucial, so care should be taken in ensuring that you genuinely do have a line of best fit.

Transmission through colour filters.

Use colour filters, typically red, green, yellow, magenta, cyan and blue, view the LEDs through the filters and note which colours are reduced in intensity when viewed through the filters. You should note that, for example, the red LED, when viewed through a red filter, shines brightly, as it does when viewed through yellow and magenta filters. When viewed through other filters the red LED intensity is diminished. It should be possible to work out secondary colour mixing.

Transmission through a diffraction grating.

View the LEDs through the diffraction grating, it should be noted that first order diffraction patterns are shown. It will be noted that the first order diffraction pattern of the red LED is wider than that of the blue LED. It should also be noted that none of the LEDs gives off a pure colour (monochromatic light).

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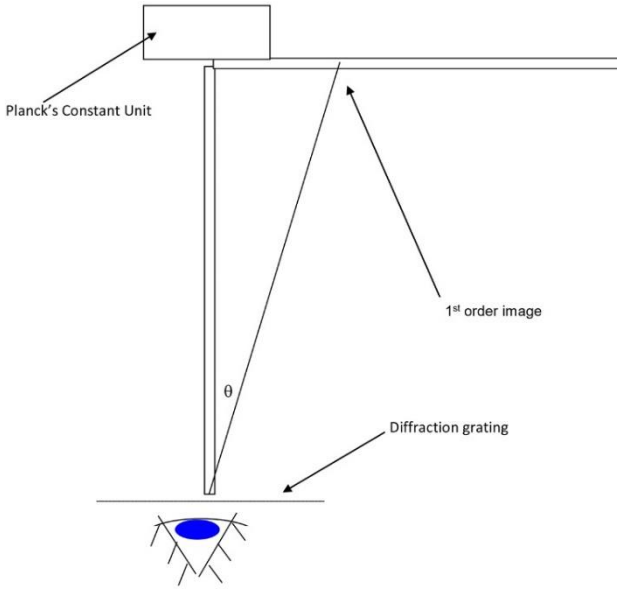
Measuring the wavelength of coloured light.

Set two metre rules at right angles and set the unit as shown below.



Using the formula **nλ = dSinθ,** the wavelength of the red light may be calculated. **d** is the diffraction grating spacing $= \frac{1}{500{,}000} = 2 \times 10^{-6}$m

(this is calculated for a 500lines/mm grating), **n** is the order of the image (in this case 1).

Using the diffraction grating, view the LEDs from the end of the metre rule as shown above. Get a partner with a retort stand to move along the perpendicular metre rule until the retort stand is in the position where, say, the red end of the partial spectrum formed by the red LED is, this point is labelled '1st order image' on the diagram. You now need to work out the angle, this may be done by using a protractor set at the end of the ruler (where your eye was) and sighting along it to the clamp stand. Alternatively, the angle may be calculated using trigonometry, it should also be possible to view the '2nd order' spectrum and apply the formula above.

The experiment may be repeated for the other five LEDs.

It is often useful to cover the wavelength markings on the unit with black tape so that it is a genuine experiment!

SPECIFICATIONS.

Supply Voltage	= 6 to 12VDC (via. red & black 4mm sockets).
Supply Current	= 50mA DC max.
LED Wavelengths	= 470nm, 525nm, 568nm, 588nm, 630nm and 640nm.
Meter Output	= 0 to 3.5VDC max. (via. red & black 4mm sockets).
Dimensions	= 150 x 100 x 55mm overall.
Mass	= 0.15kg
Diffraction Grating	= 500 lines/mm.

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Please Note: This Equipment is for Education, Training, or research Purposes Only.

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IPC Irwin also provide Portable Appliance Testers and a Calibration service, for more details please go to www.ipcirwin.com or call our sales and technical support line on 015395 58555.






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