Photo Electric Effect

Planck's Constant

AP2342-001 Dual LCD Meters, 5 LEDs, Experiments 1 & 2

Description:

IEC's modern version of the "Photo-Electric Effect" for teaching this very important phenomenon. For the determination of "Planck's Constant" to a reasonable accuracy. A choice of 5 different LEDs of known wavelength provide photons to a cell that generates electrons to create a very small current. A 'backing voltage' is applied to the cell to stop the current flow and this becomes the measurement of the energy level of the photon. These energy levels are plotted against the frequencies of the LEDs. Improvements to this model include: The backing voltage and the photo-cell current in mA or nA can be viewed together without switching from one to the other. LEDs are used as the specific wavelength light sources instead of an incandescent lamp and colour filters.

Details:

- Photo-Electric Effect instrument requires 12V AC or DC from either a mains PlugPak or from a classroom power supply. Provides 2x digital meters to read Backing Volts and Cell Current at the same time. Controls are for the selection of LED colour, adjustment of brightness or intensity, option of Backing Volts coarse and fine adjustment and selection of Expt.1 in mA or nA and Expt.2. Very quick to use.
- Includes set of 5x LEDs of specific wavelength mounted on a small panel with cable & plug. Mounts on the rear of the instrument. The LED wavelengths are indicated on a label on the rear face of the instrument.
- Includes experiment sheets for using the instrument.

Length: 272mm	Width: 160mm	Height: 110mm	Weight: 1.2kg

The 'IEC' Photo-Electric Unit: Description

A bench mounting instrument with 2 digital meters to simultaneously indicate both the current through the internal photo-cell and the backing voltage applied to the cell.

This model requires 12V. AC or DC and the set of 5 LEDs is mounted on a small panel that slides into location in the rear of the unit to place the LEDs directly in front of the cell. A small cable connects the LEDs to the instrument for selection and brightness control.

The image above shows the LED panel positioned correctly and plugged into the unit. The 12V.AC or DC PlugPak socket and the 4mm banana sockets are on the right side.
An instruction label provides basic assistance to the user in the operation of the instrument to avoid unnecessary reference to the full set of instruction sheets.

This image shows the 5 LEDs grouped tightly to provide good cathode illumination in the photo-cell.

A switch selects each LED colour and the brightness or intensity of any colour can be adjusted by the 'intensity' control on the front panel.

The photo-cell itself can be seen through the orifice in the rear of the instrument however it is always best to keep the orifice covered by the LED panel so the photo-cell is always in total darkness.

The previous model was illuminated by a 12V light source and the colours were created by using filters. Altering brightness was achieved by selecting different orifices in front of the filter. This new model CAN BE USED in exactly this same way if desired by purchasing a "Lamp and Filter Kit" which provides the lamp, 5x filters and 5x orifices. PA2342-150

Principle of Operation:

Experiments can be performed in the following areas:

a) Photo Electric Effect … that light can create an electric current.
b) Illumination / Current relationship ... that current changes with luminous intensity.
c) Energy of a Photon … that a photon can drive an electron from a surface.
d) Planck's Constant … the amazing relationship between energy and wavelength.
e) Energy Distribution … where the energy is expended

The experiment sheets form a separate document, so in this small document we mention only the "Planck's Constant" experiment. Explanation is below:

When light falls on the cathode of the photo-cell, providing the energy level of the photon is high enough, the photon drives an electron from the metallic surface of the cathode (coated with caesium and antimony on silver oxide). This electron has the energy imparted to it from the photon, therefore the higher energy of the photon, the higher energy of the electrons driven from the surface.

These electrons pass across the vacuum space in the cell to the Anode pin inside the cell. When a voltage is applied to the Anode in a direction to repel the electrons from the anode, the current flow completely stops as the last electrons of the highest energy levels cannot quite reach the anode. This voltage applied to the cell to stop the electron flow through the cell is called the "backing voltage". Therefore, the backing voltage that JUST causes this current to become zero is a measurement of the energy level of the MOST energised electrons caused by the wavelength of the light applied to the cell.

It can be proven that the AMOUNT of light does not alter the energy level of the electrons, but, amazingly, the various wavelengths of the light alter the energy levels of the electrons. The graphing of the backing voltage against the frequency of the light for each of the 5 LED wavelengths creates a straight line proving a linear relationship between frequency of the radiation and the energy of its photons. The slope of this straight line multiplied by 'e' (charge on an electron) is the value of "Planck's Constant" ('h').

The Experiment:

- Slide the LED housing containing 5x LEDs into the slot provided and plug the LED cable into multi-pin socket on the rear panel.
- Connect 12V. AC or DC and note that the 2 meters show readings. Select maximum light intensity and the Blue colour light source.
- Set the FINE control to about 'half' position. Using the COARSE control, adjust the BACKING VOLTS until the NANOAMPS reading is very close to zero. Then use the FINE control to achieve exactly zero nanoamps. Wait several seconds to be sure it is exactly zero. Take note of the BACKING VOLTS reading for the LED colour being used as the light source. Repeat the measurement to get an average.
- Repeat the above for each colour LED in turn and note the backing volts in each case. Each time, repeat the measurement once or twice to obtain average volts.
- Graph the results with the 'X' axis scaled as frequency of the colour in Hz $x10^{14}$ and the "Y" axis as backing volts in volts, then plot each relationship. Draw a straight line graph of best fit through the 5 points.
- Planck's Constant ('h') is the SLOPE of this line (dV/df) x the charge on an electron ($1.6x10^{-19}$ coulombs). Theoretically, this value of 'h' = $6.626x10^{-34}$

Front Panel Controls:

When 12V. AC or DC is applied to the instrument it is automatically ON, there is no On/Off switch. When on, the digital displays will show digits.

'Wavelength' Rotary Switch:

Selects the desired LED to illuminate the photo-cell.

The unit for wavelength is 'nanometres' = Metres $x10^{-9}$. Abbreviation: 'nm'.

Frequency is: (3,000 / nm) $x10^{14}$ Unit: Hertz (Hz)

- Blue: 480 nm wavelength (or 6.250 $x10^{14}$ Hz frequency)
- Green: 522 nm wavelength (or 5.747 $x10^{14}$ Hz frequency)
- Yellow: 583 nm wavelength (or 5.146 $x10^{14}$ Hz frequency)
- Orange: 613 nm wavelength (or 4.894 $x10^{14}$ Hz frequency)
- Red: 660 nm wavelength (or 4.545 $x10^{14}$ Hz frequency)

Intensity Rotary Control:

Adjusts the brightness or intensity of the light coming from the selected LED. The change of light intensity is to prove the proposal that it is not the amount of light that governs the energy levels of the electrons driven from the cathode of the photo-cell by the photons, but it is the wavelength of the light. The energy level will be found to be close to the same at both high and low light intensity levels down to 30%.

'Backing Volts"– Coarse / Fine Rotary Controls:

Adjusts the DC volts applied to the anode and cathode of the photo cell attempting to completely top the flow of electrons from the cathode to the anode.

The value of this voltage is a measurement of the energy level of the electrons that relate to the selected wavelength of the light. The "coarse" control adjusts the voltage rapidly.

The "fine" control adjusts the voltage more slowly to determine exactly zero current flow (zero electrons reaching the anode).

'Volts" and "Nanoamps" Meters:

The VOLT meter displays the value of the backing voltage required to bring the photo-cell current to exactly zero. This voltage value is graphed against the frequency of the light to determine Planck's Constant.

The NANOAMPS meter displays the small current passing through the photo-cell down to 0.1 nanoamps (amps $x10^{-10}$). 1 nanoamp = $1/1000^{th}$ of 1 microamp.

Experiment Selection 1 or 2:

Exp.1 permits 1a, 1b, 1c, 1d and 1e. Some require nA and others require uA measurements and this can be selected. EXPT.1) experiments relate to Photo Electric and Planck's Constant. EXPT.2) is for Characteristic curve of Photo Tube.

Note:

IEC produces an "Experiment Sheet" outlining the use of the equipment and the experiments to be performed.

Developed, Designed and Manufactured in Australia