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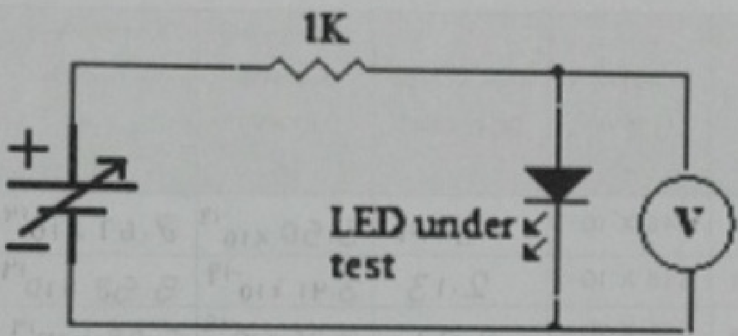
Application No: 22BTRAD018

Exp 3-Planck's Constant

Aim: To determine the Planck's constant using light emitting diodes.

Apparatus: Light Emitting Diodes of 5 different wavelengths, power supply and multimeter.

Circuit diagram



Procedure:

Circuit connections are made as shown in the circuit diagram. Power supply is switched on and using a digital peak reading voltmeter the voltage (V_k) across the LED is measured and recorded in table for given color LED light. This is repeated for the other four LEDs. Energy of the light radiation is calculated using the equation $E = e\ V_k$. Here 'e' is the charge on electron 1.6×10^{-19}C. The frequency of the light radiation is determined using $\nu = C\lambda$. Here 'C' is the velocity of light (3×10^{8} ms^{-1}) and 'λ' is the wavelength of light emitted. A plot of energy against frequency is made. According to Planck's Quantum theory the energy and frequency relationship for the radiation is given by $E=h\nu$. Here 'h' is Planck's constant. Thus, the slope of the curve gives the Planck's constant.

Note 1: Use excel or any tools for graph analysis and calculations.

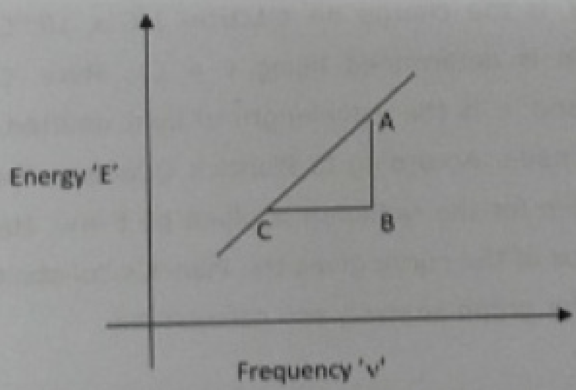
[**Note 2:** LED is P-N junction made of heavily doped transparent semiconductor. When it is forward biased, if the applied voltage is higher than the knee voltage then electrons and holes from N and P sections recombine in the depletion region resulting in the emission of photons. Thus LED glows with characteristic wavelength which depends on the composition and condition of the semiconductor material used. When the applied voltage is equal to the turn on voltage the LED just glows and the energy of the photons emitted is equal to the energy acquired by the electron from the electric field. Thus energy of the photon can be calculated from the turn on voltage knowing the wavelength of the emitted radiation a plot of energy versus frequency can be made. Thus the Planck's constant can be determined.]

Tabular Column

LED	Color	Wavelength (λ in m)	Knee Voltage (V_k in Volts)	Energy of Radiation $E = eV_k$ (J)	Frequency of the Radiation $\nu = c/\lambda$ (Hz)	$V_k \lambda$
1	Blue	346×10^{-9}	3.44	5.50×10^{-19}	8.67×10^{14}	1.19×10^{-6}
2	Green	538×10^{-9}	2.13	3.41×10^{-19}	5.58×10^{14}	1.15×10^{-6}
3	Yellow	568×10^{-9}	2.03	3.25×10^{-19}	5.28×10^{14}	1.15×10^{-6}
4	Red	630×10^{-9}	1.82	2.91×10^{-19}	4.76×10^{14}	1.15×10^{-6}
5	IR	940×10^{-9}	1.16	1.86×10^{-19}	3.19×10^{14}	1.09×10^{-6}

$(V_k \lambda)_{mean} \cdot 1.15 \times 10^{-6}$

Graph and calculations



$$h = \frac{e(V_k \lambda)_{mean}}{c}$$

$= 6.11 \times 10^{-34}$ Js

The Slope of the Curve = Planck's constant $= h = \frac{AB}{BC} = 6.65 \times 10^{-34}$

$= 6.65 \times 10^{-34}$ Js

Result:

Result: The Planck's Constant is given by
By graph, h= 6.6515×10^{-34} Js
By calculation, h= 6.11×10^{-34} Js

Note: Students are directed use excel or python tool for calculations and graph submit the filled (manually) worksheet along with excel/python file to LMS for evaluation.