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1) Aim :- To determine the planck's constant using LED light

2) Apparatus :- 0-10V power supply, a one-way key, a rheostat, a digital milliammeter, a digital voltmeter, a 1K resistor and different known wavelength LED's (Light Emitting Diodes)

3) Theory :-

Planck's constant (h), a physical constant was introduced by General physicist named Max Planck in 1900. The significance of planck's constant is that "quanta" (small packets of energy) can be determined by frequency of radiation and Planck's constant. It describes the behaviour of particle and

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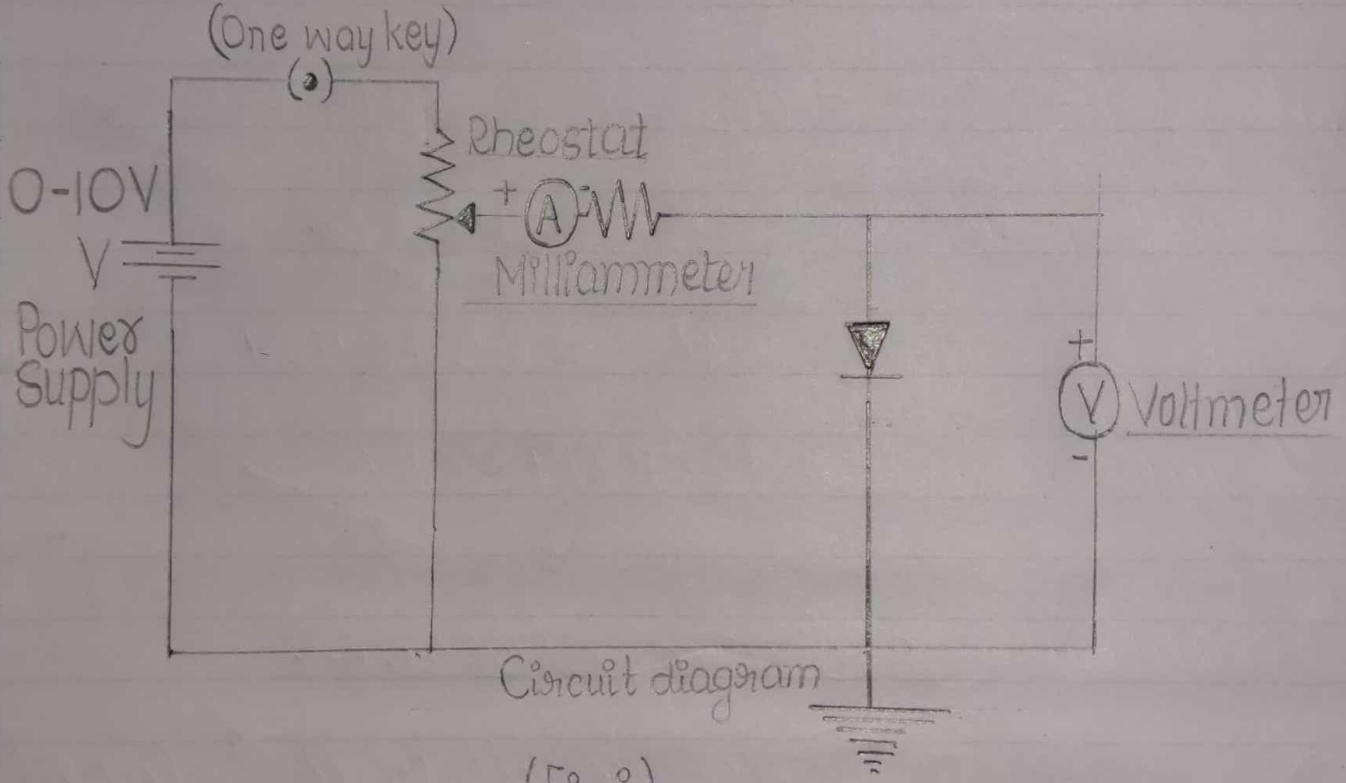

Circuit diagram

(Fig i)

pokri

waves at atomic level as well as the particle nature of light

An L.E.D is a two terminal semiconductor light source. In the unbiased condition a potential barrier is developed across the p-n junction of the L.E.D. When we connect the L&D to an external voltage in the forward biased direction, the height of potential barrier is developed across the p-n junction of the L&D. When we connect the L&D to an external voltage in the forward biased direction, the height of potential barrier across the p-n junction diode is reduced. At a particular voltage the height of potential barrier becomes very low and the L&D starts glowing, i.e.,

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In the forward biased condition electrons crossing the junction are excited, and when they return to their normal state, energy is emitted. This particular voltage is called the knee voltage or the threshold voltage. Once the knee voltage is reached, the current may increase but the voltage does not change.

The light energy emitted during forward biasing is given as,

$E = \frac{hc}{\lambda}$ where, → (1)

c - velocity of light

h - Planck's constant

λ - Wavelength of light

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If 'V' is the forward voltage applied across the LED when it begins to emit light (the knee voltage), the energy given to electrons crossing the junction is,

$$E = eV \longrightarrow (2)$$

Equating (1) and (2), we get

$$eV = \frac{hc}{\lambda} \longrightarrow (3)$$

The knee voltage 'V' can be measured for LED's with different values of λ (wavelength of light)

$$V = \frac{hc}{e}\left(\frac{1}{\lambda}\right) \longrightarrow (4)$$

Now from equation (4), we see that the slope of a graph of 'V' on the vertical axes vs $(1/\lambda)$

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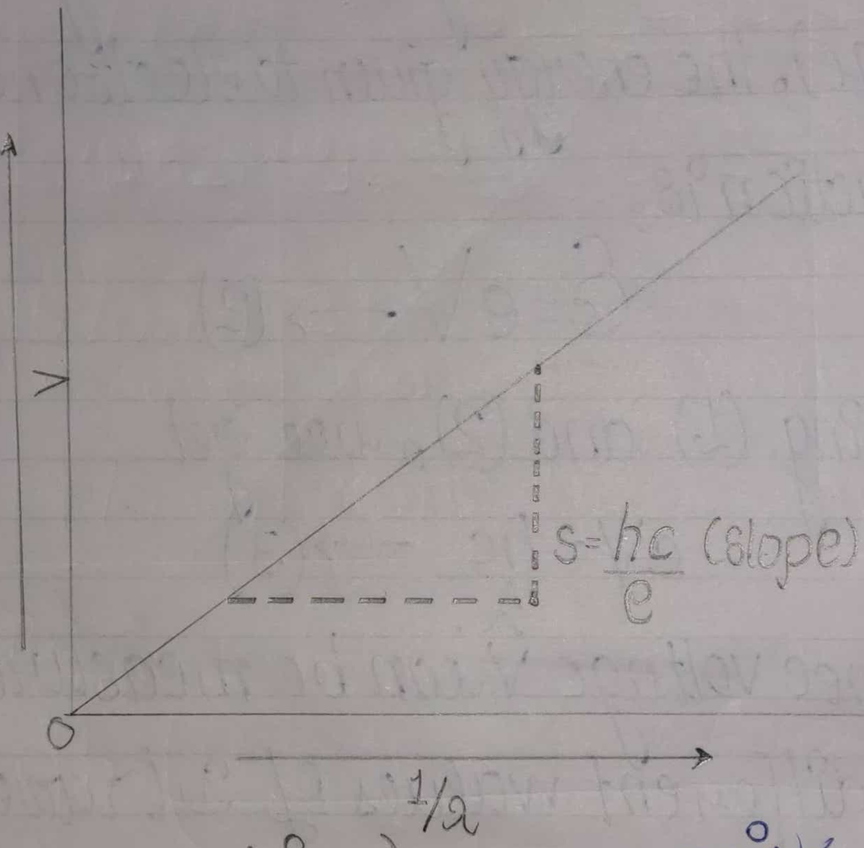

(fig ii)

on the horizontal axis is

$$S = \left(\frac{hc}{e}\right) \longrightarrow (5)$$

To determine Planck's constant 'h', we take the slope 'S' from our graph and calculate

$$h = \left(\frac{e}{c}\right) S$$

using the known value

$$\frac{e}{c} = 5.33 \times 10^{-28} \left(\frac{Cs}{m}\right)$$

Alternatively, we can write equation (3) as

$$h = \left(\frac{e}{c}\right) \lambda V.$$

calculate 'h' for each LED, and take the average of our results.

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OBSERVATION TABLE

Sr No	Colour of LED	Wavelength λ (nm)	Knee voltage (V) volt	λV (10^{-6})	$h = \left(\frac{e \lambda V}{c}\right)_{10^{-34}}$ Js
1	Red	650nm	1.908 V	1.2402	6.6144
2	Green	510nm	2.434V	1.24134	6.62048
3	Yellow	570nm	2.178V	1.24146	6.62112
4	Blue	475nm	2.615V	1.242125	6.62466

Calculations :->

Mean value of $h = \left(\frac{6.6144 + 6.62048 + 6.62112 + 6.62466}{4}\right) \times 10^{-34}$

$h_{mean} = 6.620165 \times 10^{-34}$ Js

Slope $= \frac{2.615 - 1.908}{2.105 - 1.5384} = 1.247793858 \times 10^{-6}$ m

Planck's constant $= \left(\frac{e}{c}\right)(s) = 6.654900577 \times 10^{-34}$ Js

$\left(\frac{1.6 \times 10^{-19}}{3 \times 10^{8}}\right)\left(1.247793858 \times 10^{-6}\right) = 6.654900577 \times 10^{-34}$ Js

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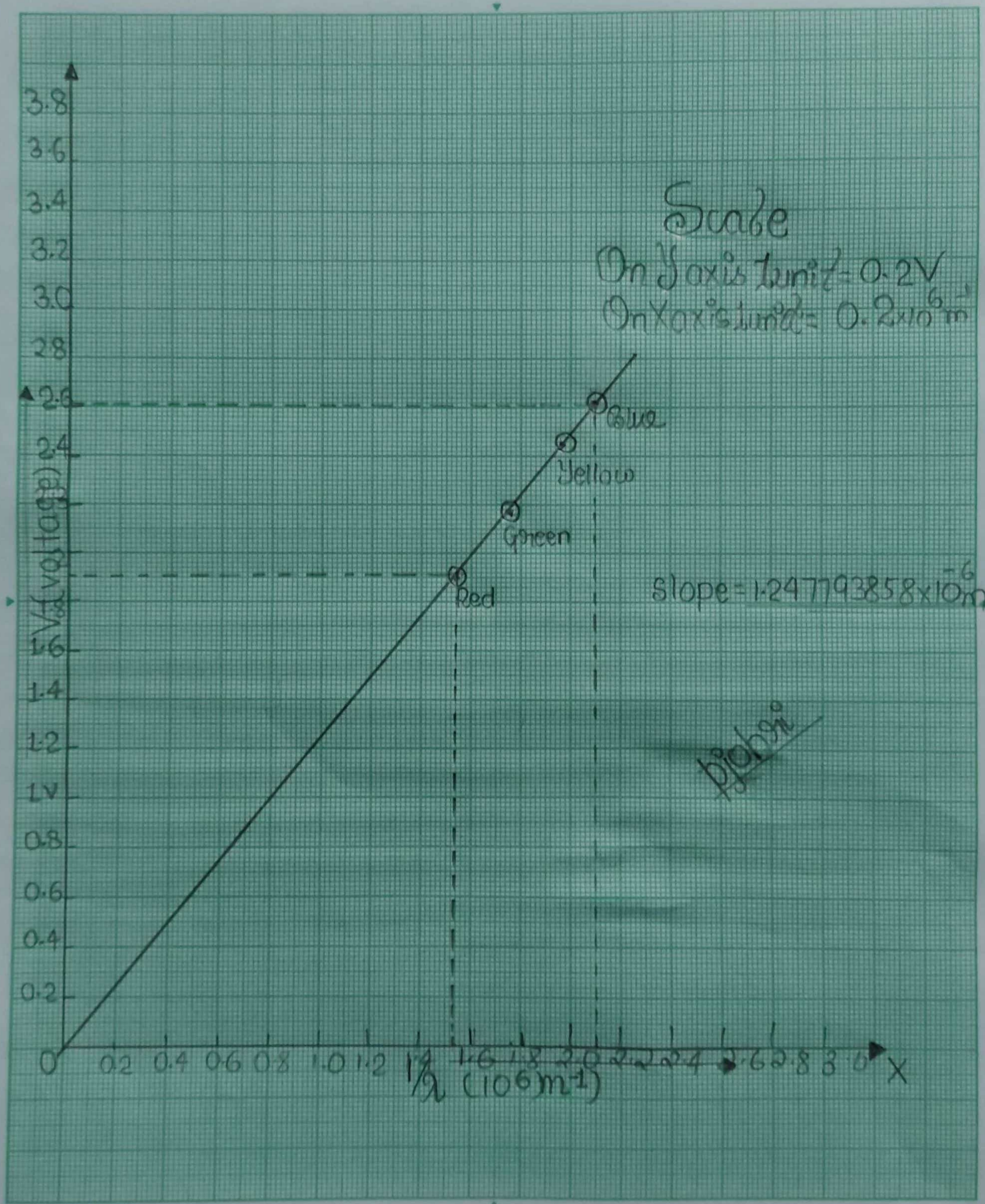
Scale
On Y axis 1unit = 0.2V
On X axis 1unit = 0.2×10^6 m^-1
Blue
Yellow
Green
Red
Slope = 1.247793858×10^-6
Biplosi
V (voltage)
1/λ (10^6 m^-1)
X
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8

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4) Formula Used :->

$E = \frac{hc}{\lambda} \rightarrow (1)$

$E = eV \rightarrow (2)$

$eV = \frac{hc}{\lambda}$ Equating (1) & (2)

Where,
c = velocity of light
h = planck's constant
λ = wavelength of light

$h = \left(\frac{e}{c}\right)(\lambda V)$

$\therefore \frac{e}{c} = 5.33 \times 10^{-28} \left(\frac{Cs}{m}\right)$

$\therefore h = \left(\frac{e}{c}\right) s$ (Planck's constant)

5) % Percentage Error :->

$\%\,error = \frac{|Observed\ value - Experimental\ value|}{|Observed\ value|} \times 100\%$

$\%\,error = \left(\frac{6.654900577 - 6.620165}{6.620165}\right) \times 100\%$

$\%\,error = 0.524693516\%$

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Result:-> The value of the planck's constant using 'L.E.D' from the slope comes out to be $6.654900577 \times 10^{-34}$ Js Ans

% error = 0.524693516%.

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6) Result :- The value of the planck's constant using LED from the slope comes out to be $6.6549005771 \times 10^{-34}$ Js and % error ~~0.05~~ 0.5246931516% Ans.

7) Precautions and Sources of error

1) To insert eye, we have to drag all wires properly

2) To measure exact knee voltage, increase rheosted value slowly

3) Graph between ΔV & $1/\lambda$ should be a straight line

X ——— X

END

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