LAB-11 PLANCK'S CONSTANT

12.1 Introduction

Planck's constant (h), a physical constant was introduced by German 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 behavior of particle and waves at atomic level as well as the particle nature of light, and is of fundamental importance in quantum Mechanics. Due to mass-energy equivalence, the Planck constant also relates mass to frequency.

12.2 Objective

12.2.1 Educational:

Planck's Constant relates the energy of light photons to their frequency. It also shows up in de Broglie's relation for the wavelength of matter waves and Schrödinger's Equation. Thus, the number is of fundamental importance in 20th Century physics. A common device, the light emitting diode or LED, could be designed only because some engineers understood quantum science. Thus, knowledge of the value of Planck's constant is "hidden" in the making of many electronic devices like LED.

12.2.2 Experimental:

Determination of Planck's constant.

12.3 Prelab Preparation:

12.3.1 Reading:

Black Body Radiation, Planck's Hypothesis, Einstein's Theory, De Broglie concept of matter waves.

12.3.2 Written:

Keep the worksheet ready with required write up, Formulae, Tabular columns and theoretical values.

12.4 Equipment needed

1. Variable voltage source
2. Current meter
3. Temperature controlled oven

4. different known wavelength LED's (Light-Emitting Diodes).

12.5 Background

Planck's constant (h), a physical constant was introduced by German 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 behavior of particle and waves at atomic level as well as the particle nature of light. An LED is a two terminal semiconductor light source. In the unbiased condition a potential barrier is developed across the p-n junction of the LED. When we connect the LED to an external voltage in the forward biased direction, the height of potential barrier across the p-n junction is reduced. At a particular voltage the height of potential barrier becomes very low and the LED starts glowing, i.e., 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.

12.6 Formula

$$\mathbf{V_o} = \mathbf{V} - \left(\frac{\triangle \mathbf{lnI}}{\triangle \mathbf{T}} * \frac{\mathbf{k}}{\mathbf{e}} * \eta\right)$$

where

V= Voltage across LED

K= Boltzman constant

e = charge of electron

η is the material constant

Therefore

The Plank Constant $\mathbf{h} = \frac{\mathbf{e} * \mathbf{V_0}}{\mathbf{c}} * \lambda$

12.7 Procedure

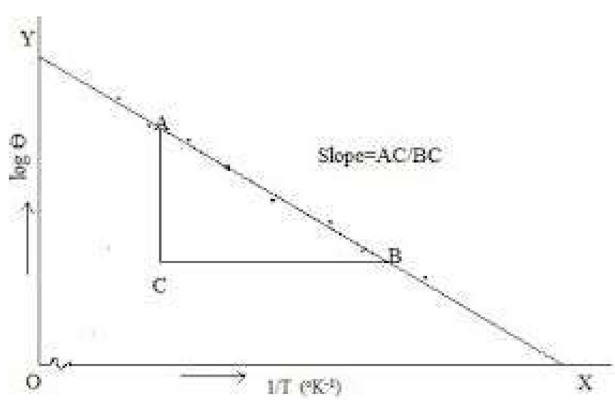
1. To draw the T-I characteristics at constant applied voltage.
2. Set the switch to m.A position.
3. Adjust the voltage across LED slightly below the band gap of
4. Corresponding voltage across the LED is measured using a voltmeter, which is the knee voltage.
5. Repeat, by changing the LED and note down the corresponding knee voltage.
6. Calculate 'h' using equation
7. The wave length of infrared LED is calculated by using equation.

12.8 Diagram

12.9 Observation Table

S No	Temperature $t^O C$	Temperature T(K)	$\frac{1}{T} * 10^3$	Current I in m.A	$\log_{10} I$
1					
2					
3					
4					
5					

12.10 Graph



12.11 Results

Plank constant h = ...

12.12 Viva Voce

1. What is LED.
2. What are direct bandgap semiconductors.
3. What is the value of h?
4. Explain forward biasing.
5. What are the units of Planck's constant?

12.13 Further Probing Experiments

Q_1: Determine the stopping potentials for different colors of LED's and calculate the value of h.
Q_2: Determine the effect of temperature on luminous efficiency of different LED's.