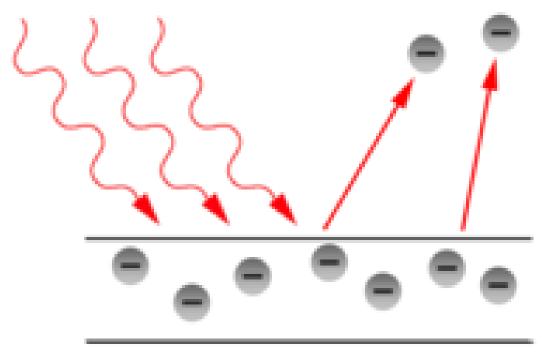
# EXPERIMENT-3

**Aim of the Experiment:** Determination of Planck's constant using vacuum type photo-cell.

**Apparatus:** Trainer board of the experiment, photo-cell, incandescent lamp, colour filters (blue, green and red), circuit setup and connecting wire.

**Theory:**

The phenomenon of emission of electrons from the metal surface when light of suitable frequency is incident on it is called the photoelectric effect. The emitted electrons are called photoelectrons. A systematic study of the photoelectric phenomenon revealed the following:



1. For any given metal there is a minimum frequency (maximum wavelength) called as threshold frequency $\nu_o$ below which electrons are not emitted. Each metal has its own characteristic $\nu_o$. The alkali metals have the lowest threshold frequencies, lying in visible region. For other metals, such as those used in the early experiments (copper, nickel, zinc) the threshold frequencies are in the ultraviolet.

2. For a given surface, the number of photoelectrons emitted per unit time (i.e., the photoelectric current) is directly proportional to the intensity of the light and is independent of frequency.
3. For a given metal surface, the kinetic energy of the emitted electrons depends only on the frequency of the light, and is independent of the intensity of the light.

4. In 1905 an explanation of the photoelectric effect was proposed by Einstein. He made use of Planck's postulates that a light wave has a huge number of discrete wave packets, called quanta each having energy hν.

5. According to Einstein's theory, a light wave may transfer energy to an electron only in units of these quanta. If w is the work function of metal the kinetic energy of photo electrons must be $KE = h\nu - w$.

In this experiment, we measure the electron energy by operating the photocell in reverse. The photocathode is connected to the positive terminal of a power supply and the anode to the negative. The photoelectrons are ejected from the cathode with energy according to Einstein's equation, and then slowed down by the ***retarding potential***. When the retarding potential times the electron charge is just equal to the maximum *KE* of the photoelectrons, the current ceases. This potential is called the ***stopping potential*** ($V_S$) and measures the maximum photoelectron energy as $KE_{max} = eV_S$ , when $I=0$. To measure Planck's constant we plot stopping voltage versus frequency ν graph; the slope of which gives the quantity *h/e*.

**Procedure:**

1. Set up the apparatus on a table so that the aperture in front of the photocell faces the light source and can be slid against it. Use a block of wood or a box to bring the photocell to the same level as the light source.

2. Connect all the devices with patch cords as mentioned on the trainer board.

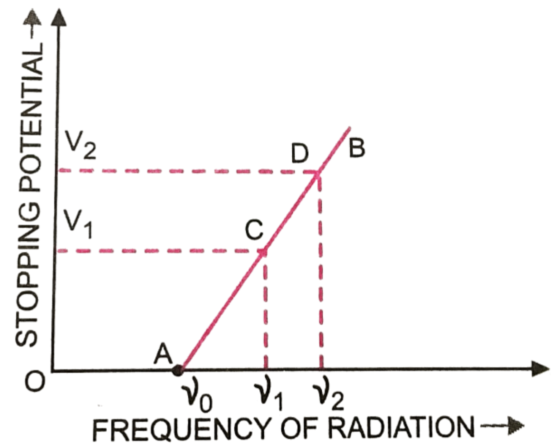
3. Switch on the equipment. With the retarding voltage set to zero and no light on the photocathode set the "Zero Adjustment" knob so that the photocurrent is nearly zero.

4. Switch on the light source such that photoelectric current appears. Now, using three filters (blue, red and green) one by one and note down the stopping potentials for each case, by increasing the retarding potential up to the point when photoelectric current becomes zero each time.

**5.** Plot the graph of $V_s$ versus $v$ and measure the slope of the graph.

## Observations:

| Filter colour | Frequency ($v$) | Stopping Potential ($V_s$) |
|---|---|---|
| Red | | |
| Green | | |
| Blue | | |




**Result:**

Slope of $V_s - v$ graph = $slope = \frac{V_2 - V_1}{v_2 - v_1}$

**The value of Planck's constant $h = slope \times e$ = ____________ Js**