Virtual Lab

SAP ID : 60004200132

Name: Ayush Jain

Experiment 3

Aim:

Determination of Planck's constant.

Apparatus:

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

Theory:

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.

The light energy emitted during forward biasing is given as ,

$$E = \frac{hc}{\lambda} \tag{1}$$

Where
c -velocity of light.
h -Planck's constant.
λ -wavelength of light.

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,

$$E = eV \tag{2}$$

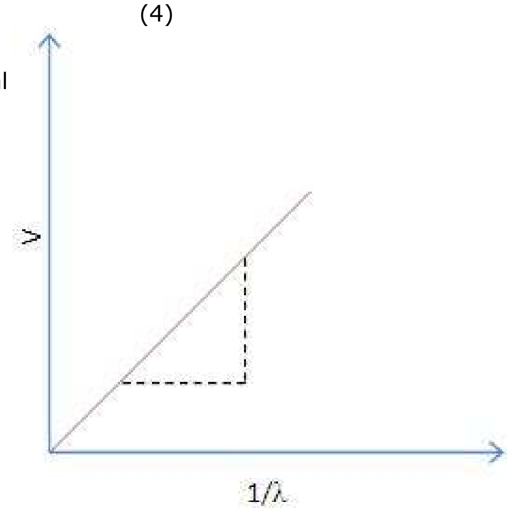
Equating (1) and (2), we get

$$eV = \frac{hc}{\lambda} \tag{3}$$

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

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

Now from equation (4), we see that the slope s of a graph of V on the vertical axis vs. 1/λ on the horizontal axis is



$$s = \frac{hc}{e} \tag{5}$$

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

$$h = \frac{e}{c}s$$

using the known value

$$\frac{e}{c} = 5.33 \ x \ 10^{-28} \frac{Cs}{m}$$

Alternatively, we can write equation (3) as

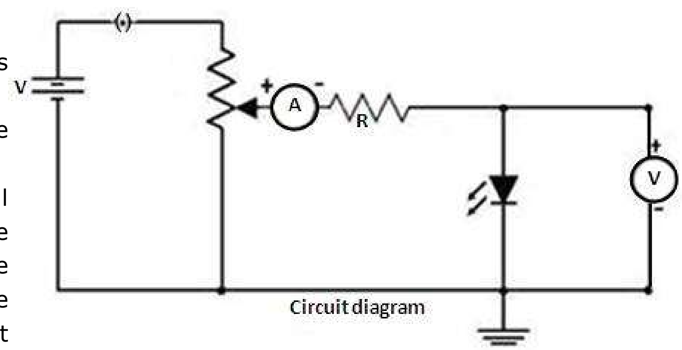
$$h = \frac{e}{c}\lambda V$$

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

Procedure for Simulation:

1. After the connections are completed, click on 'Insert Key' button.
2. Click on the combo box under 'Select LED' button.
3. Click on the 'Rheostat Value' to adjust the value of rheostat.
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 $$h = \frac{e\lambda V}{c}$$
7. The wave length of infrared LED is calculated by using equation, $$\lambda = \frac{hc}{eV}$$

Procedure for Real lab:



1. Connections are made as shown in circuit diagram.
2. Insert key to start the experiment.
3. Adjust the rheostat value till the LED starts glowing, or in the case of the IR diode, whose light is not visible, until the ammeter indicates that current has begun to increase.
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. Using the formula given,find the value of the Planck's constant.

Observations Table:

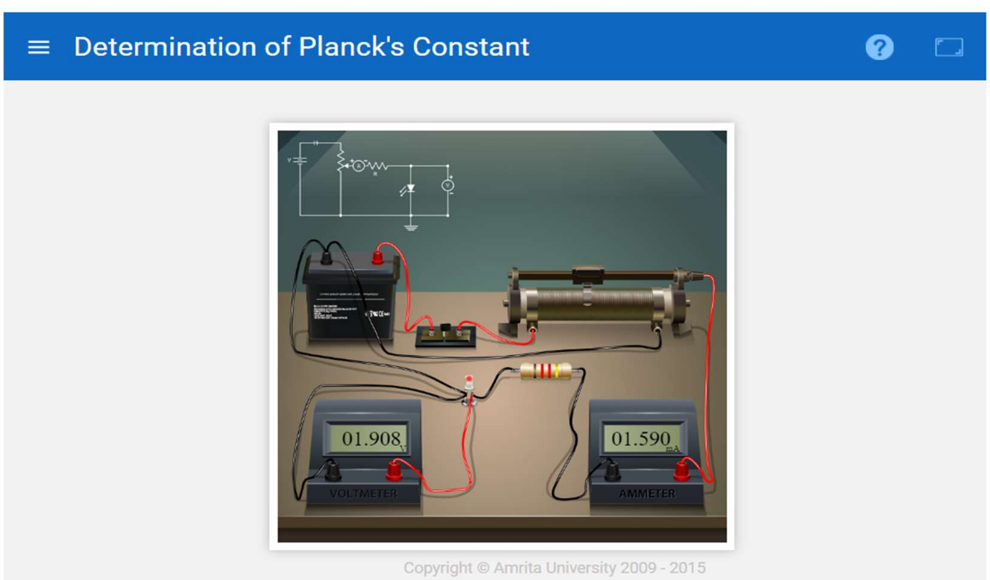
Colour of LED	Wavelength (λ) (nm)	Knee Voltage (v)	λ x V (nm)	$h = \frac{e\lambda V}{c}$
RED	650	1.908	1240.2	6.614 x 10^{-34}
GREEN	510	2.434	1241.34	6.620 x 10^{-34}
YELLOW	570	2.178	1241.46	6.621 x 10^{-34}
BLUE	475	2.615	1242.125	6.625 x 10^{-34}
INFRARED	1110	1.125	1248.75	6.660 x 10^{-34}

Results

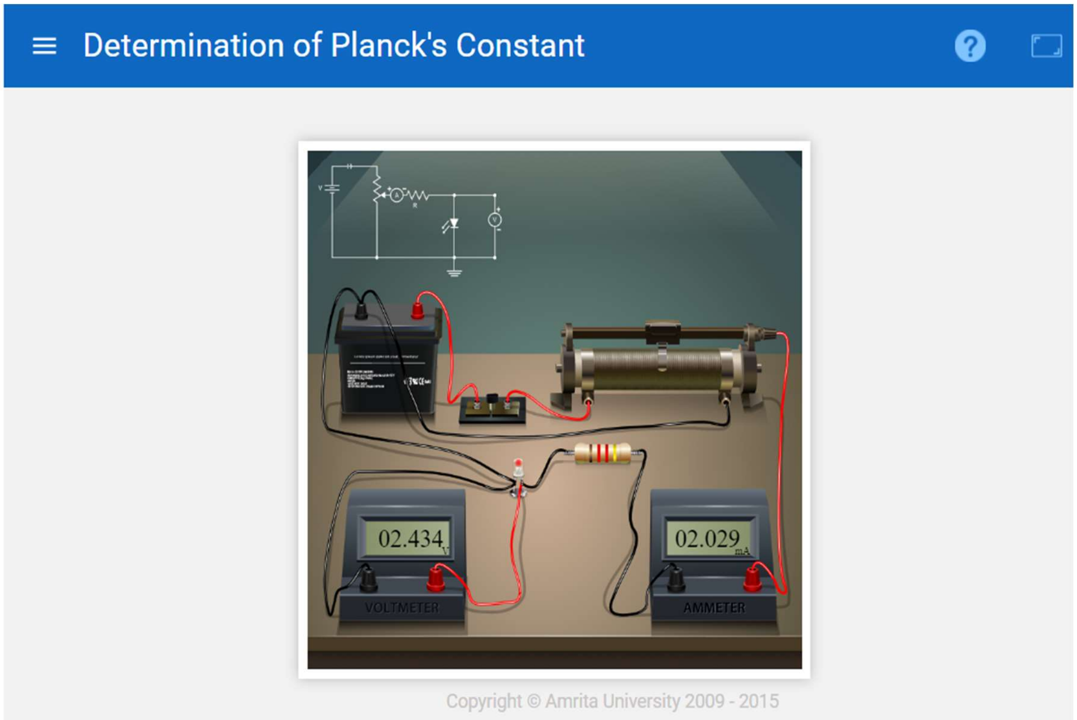
- Planck's constant = 6.628 x 10^{-34}
- Wavelength of IR LED = 1110 nm

Observations:

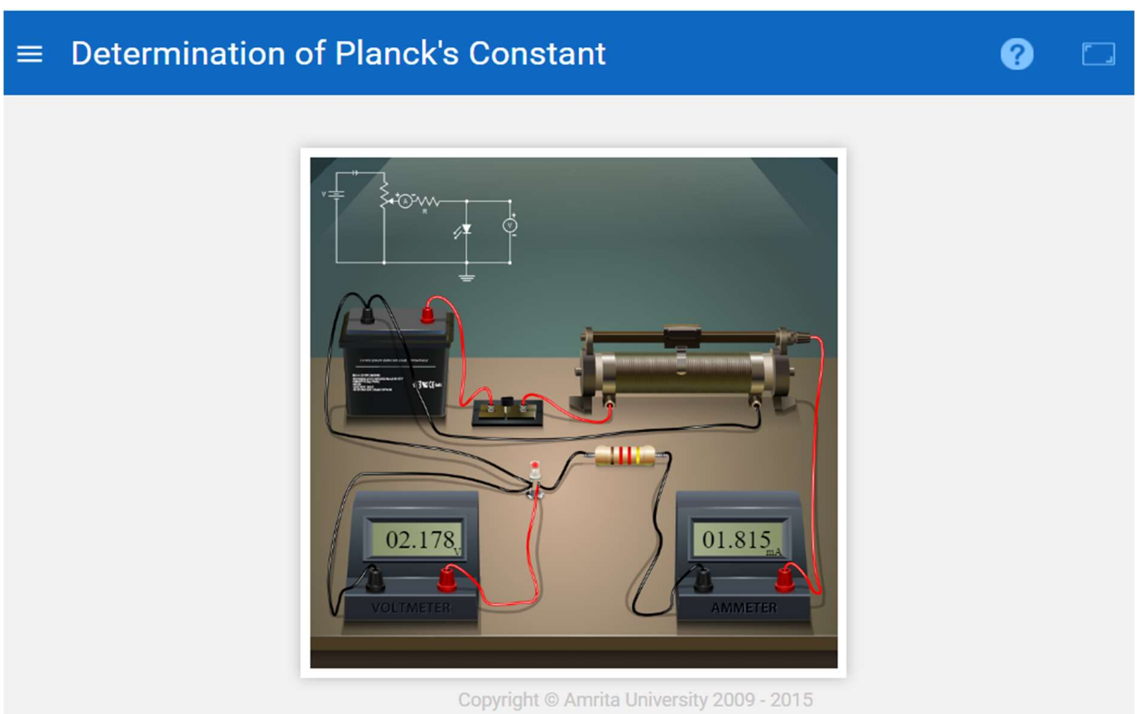
- RED



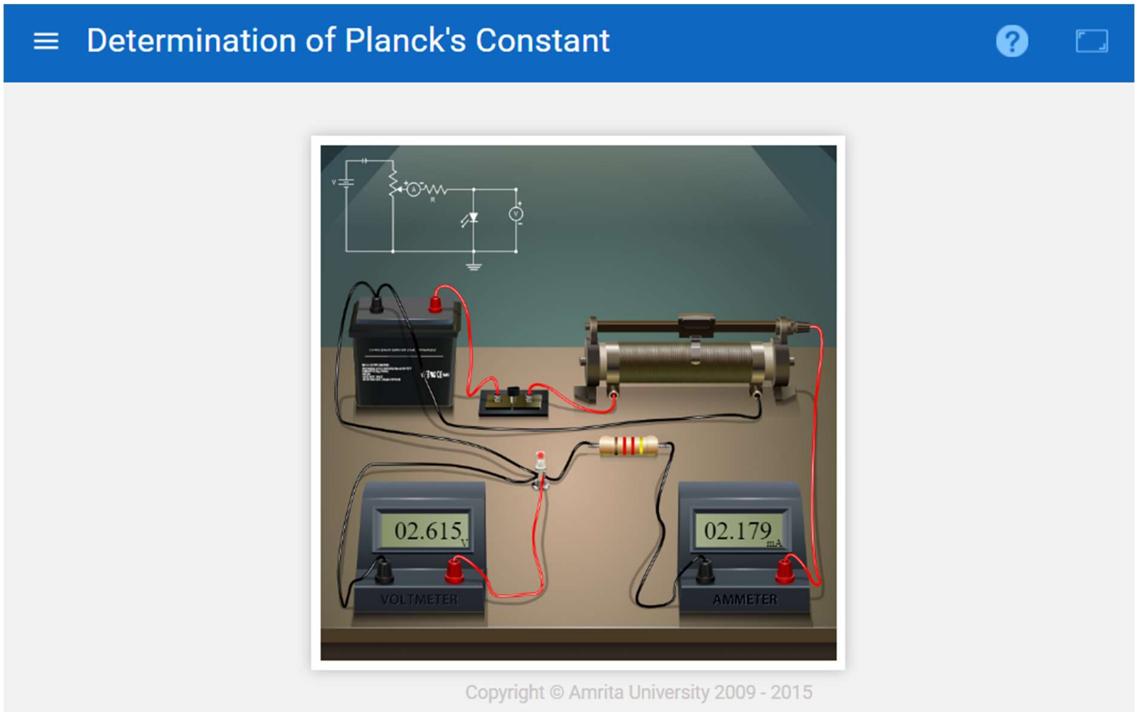
- GREEN



- YELLOW



- BLUE



- INFRARED