Lb Manual

B.Sc. Sem III & IV

Expt I

Aim: Verification of Laws of Photoelectric Effect

Apparatus: Photocell, Ammeter, Voltmeter, Source of light, Connecting wires, filters.

Theory:

Laws of Photoelectric Effect

Ist law: For a given metal and freq. of incident radiation the no. of photoelectrons ejected per sec. is directly proportional to intensity of incident light.

2nd law: For a given metal there exists a certain minimum freq. of incident radiation below which no emission of photoelectrons takes place. This frequency is called threshold frequency.

3rd law: Above the threshold the maximum kinetic energy of the emitted photoelectron is independent of the intensity of the incident light but depends only upon the frequency of incident light.

4rd law: The photoelectric emission is an instantaneous.

Explanation of laws:

Einstein Photoelectric equation

$$h\upsilon = h\upsilon_0 + \frac{1}{2}mv^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Ist law: Since one incident photon ejects one photoelectron from a metal surface, therefore, number of photoelectrons emitted per second depends upon the number of photons falling on the metal surface per second which in turn depends on the intensity of incident light. If the intensity of light is increased, the number of incident photons increases, which results in an increase in the number of photoelectrons ejected. This is first law of photoelectric emission.

2nd law: Einstein Photoelectric equation

$$h\upsilon = h\upsilon_0 + \frac{1}{2}mv^2$$

$$\frac{1}{2}mv^{2=} h\upsilon - h\upsilon_0$$

$$K_{max} = h(\upsilon - \upsilon_0)$$

We see that if $\upsilon < \upsilon_0$ maximum kinetic energy is negative , which is impossible hence photoelectric emission does not take place for the incident radiation below threshold frequency. This is second law of photoelectric equation.

3rd law: We see that if $\upsilon > \upsilon_0$ maximum kinetic energy is directly proportional on incident frequency of incident light. If the intensity of incident light radiation is increased , the no. of incident photons falling per second on the metal surface increases but energy of each photon remains the same. This is the third law of photoelectric emission.

4th law: Phenomenon is instantaneous.

Experimental Verification:

1) One photon emit one electron. This can be verified

   a) by showing dependence of photoelectric current on the intensity of light , more photons are generated hence more will be the current, which shows more emission of electrons.

   b) by showing independence of photoelectric current of the frequency of light. When we change the frequency of the given light source we are increasing the energy of photons , but there is no change in the photocurrent, Which shows that increasing energy does not increase the no. of electrons. Hence photocurrent does not depend on frequency.

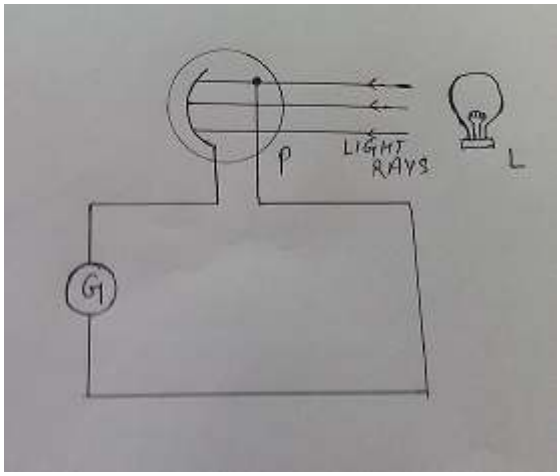
2) Kinetic energy of photoelectron is given by

   $K_{max}=h(\upsilon - \upsilon_0)$ This can be verified

   a) by showing dependence of stopping potential on the frequency of light. With increasing the energy of the given source, value of stopping potential also increases.

   b) by showing independence of stopping potential with intensity of light. But when we change the no. of photons , i.e. changing the intensity , there is no change in the stopping potential. It shows it does not depend on intensity of light source.

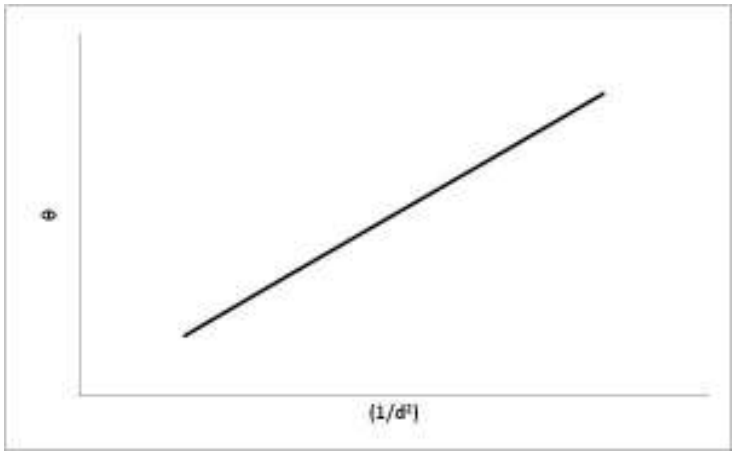
Procedure: Photoelectric current is dependent on intensity.



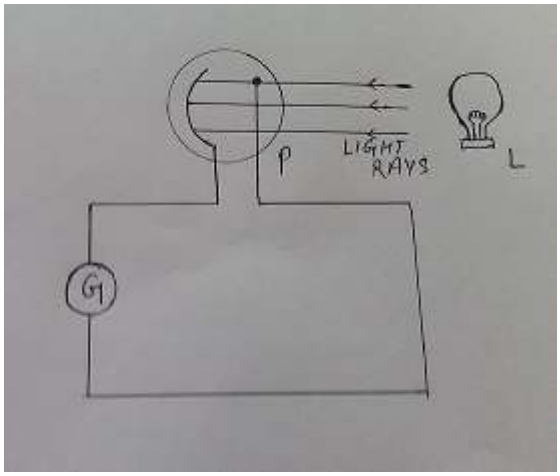
1. Make connection of photocell as shown in figure 1.
2. Switch on the lamp and bring it near photocell in very small steps and note down the position of lamp and corresponding deflections in micro ammeter.
3. Now increase the distance between photocell and lamp in very small steps and go on noting the corresponding deflections.
4. Tabulate the various readings and plot the curve between $\frac{1}{d^2}$ and deflection θ.
5. As intensity of light varies inversely proportional to d^2. Graph of ammeter deflection vs $1/d^2$ shown below gives variation of photoelectric current with intensity.

Observations:

S. No	Distance PL=d	Deflection θ	$\frac{1}{d^2}$



Procedure : Photocurrent is independent of frequency.

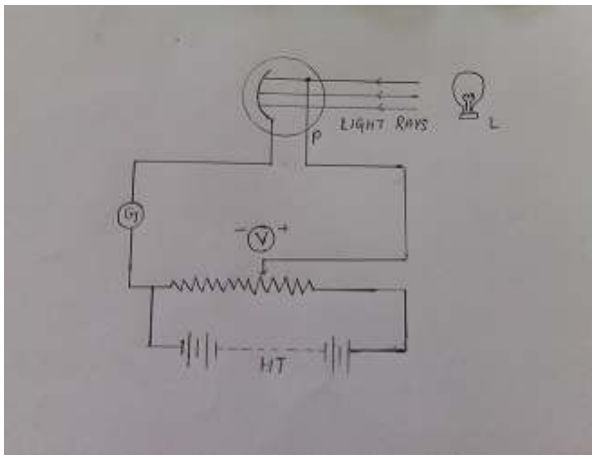


1) Make the connection as shown in the figure.
2) Keeping the distance fixed, we need to change the frequency of source of light by changing the filters of source.
3) Note the reading of photocurrent in micro ammeter corresponding to each filter.

Observation:

S .no.	filters	Ammeter reading
1	Red	
2	Green	
3	Yellow	
4	blue	

Procedure : Stopping potential is dependent on frequency of light.

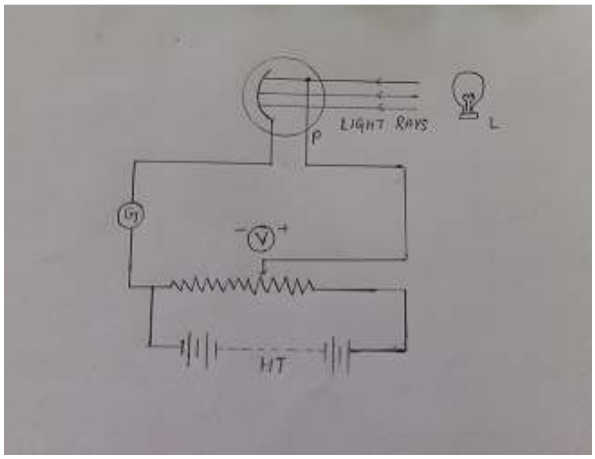


1. Make the connection as shown in the figure.
2. Keep distance between source of light and photocell fixed.
3. By changing the filter, note the reading of stopping potential where current becomes zero.
4. Repeat the process for different filters.

Observation:

S.No.	Filters	Voltmeter reading

Procedure: Stopping potential is independent of intensity of light.



1) Make the connection as shown in the figure.
2) Now place the photocell and source of light at some distance keeping the frequency of light source constant.
3) Note the reading of voltmeter.
4) Now repeat the steps varying the distance between light source and photocell. Say 10, 20, 30, 40cm and note the corresponding reading of voltmeter.

Observation:

S .no	Distance d cm	Voltmeter reading

Precautions:

1. The source should be very intense.
2. Experiment should be performed in a dark room.
3. The distance between source and cell should be constant for one set of reading.
4. The whole surface of the cathode should be exposed to the incident light.
5. The initial distance should be adjusted so as to get good deflection on the scale.