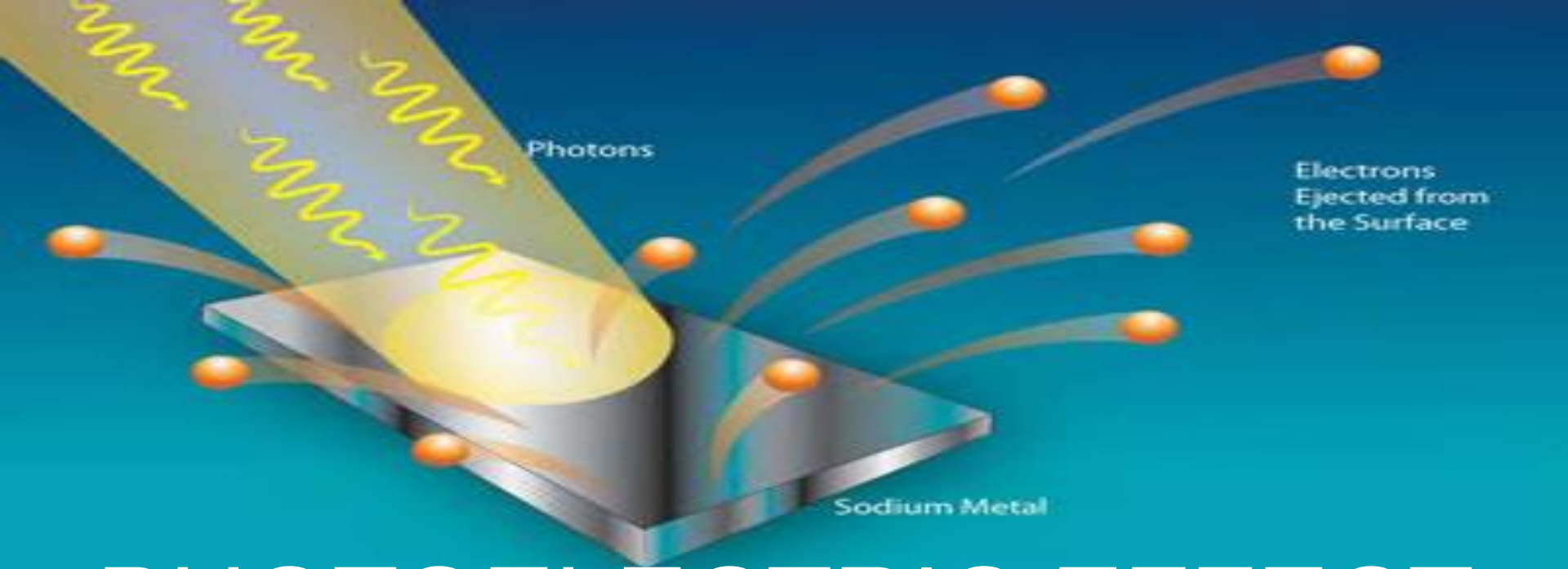

PHOTOELECTRIC EFFECT

Presented by:

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Presentation for B.Sc. (H.Sc.) IInd Year

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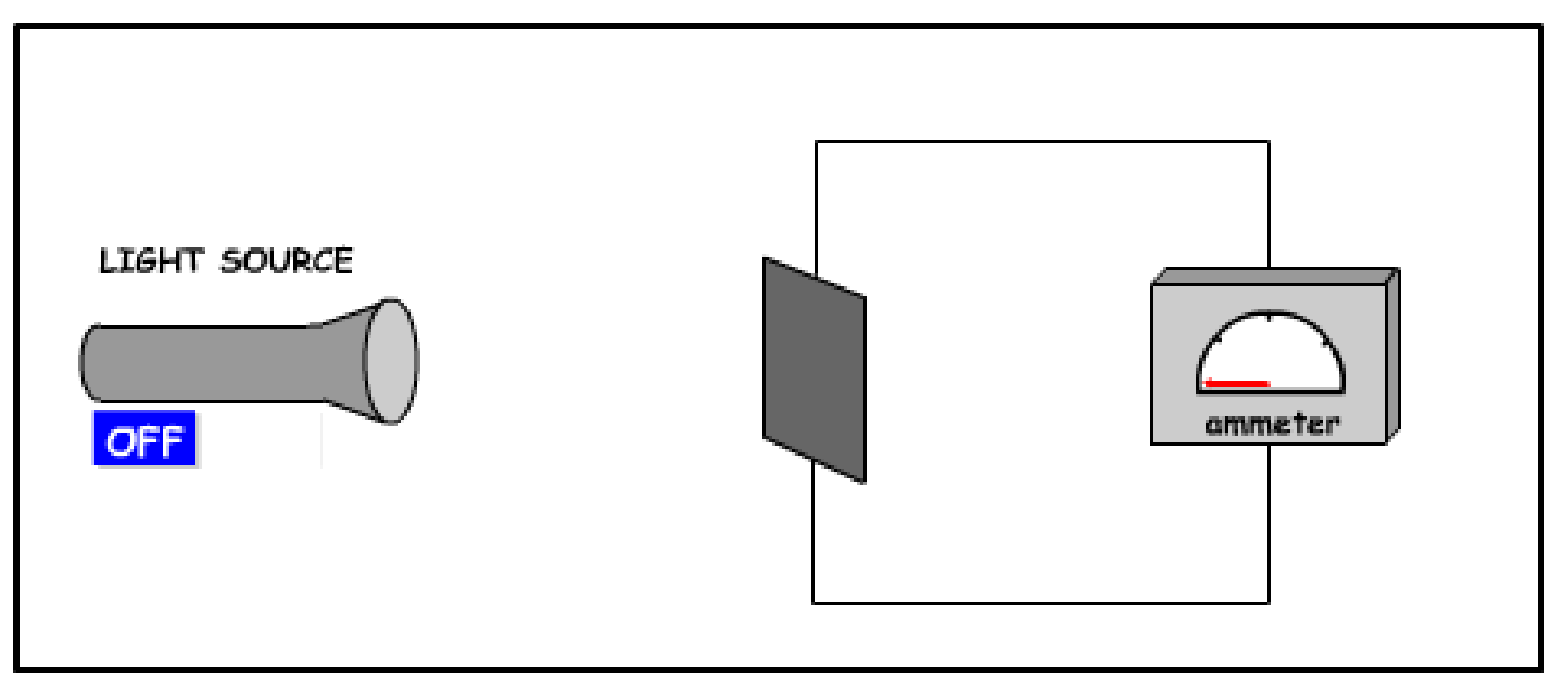
SEQUENCE OF PRESENTATION

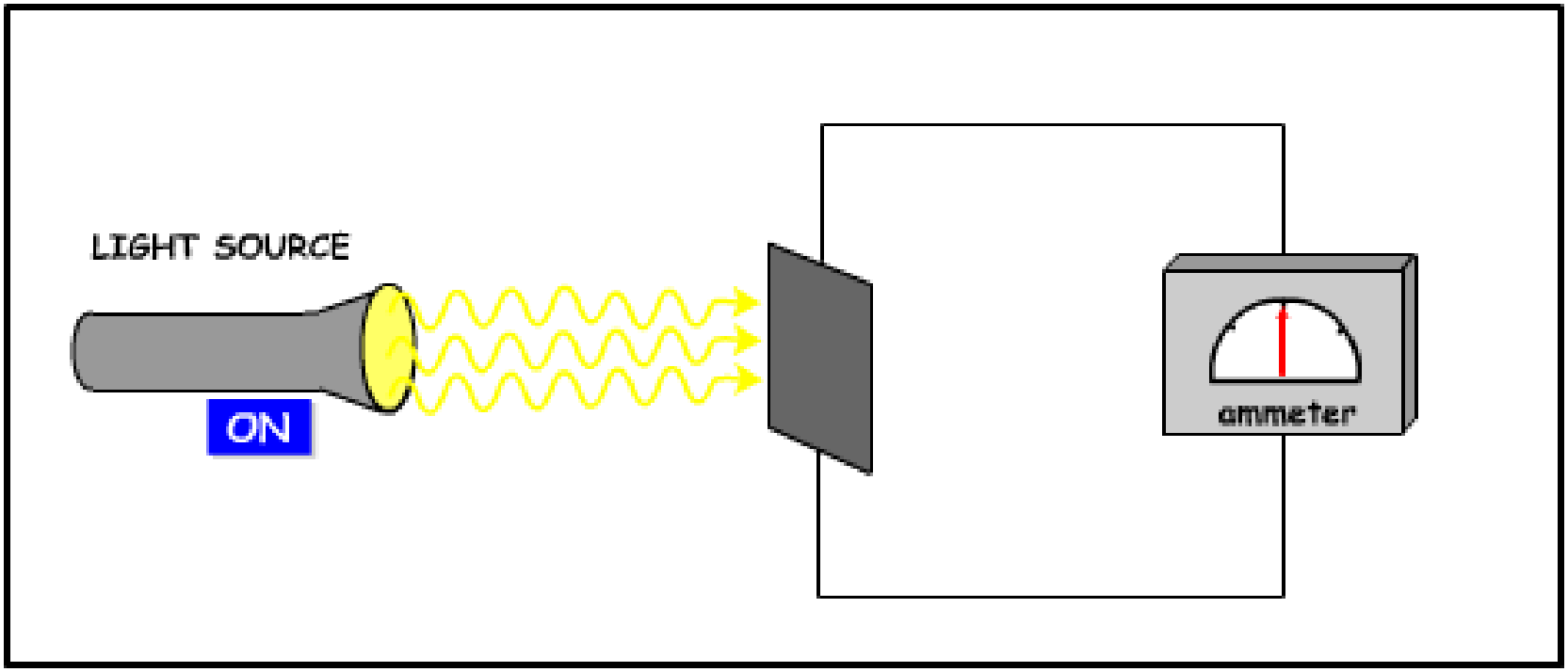
- What is Photoelectric Effect ?
- Experimental study of Photoelectric Emission.
- Basic Variables/ Parameters in Photoelectric Experiment.
  - Intensity of Incident Radiation.
  - Potential.
  - Frequency of Incident Radiation.
- Laws of Photoelectric Emission.
- Photoelectric Cell.
- Applications of Photoelectric Cell.

WHAT IS PHOTOELECTRIC EFFECT ?

Photo → Light ;

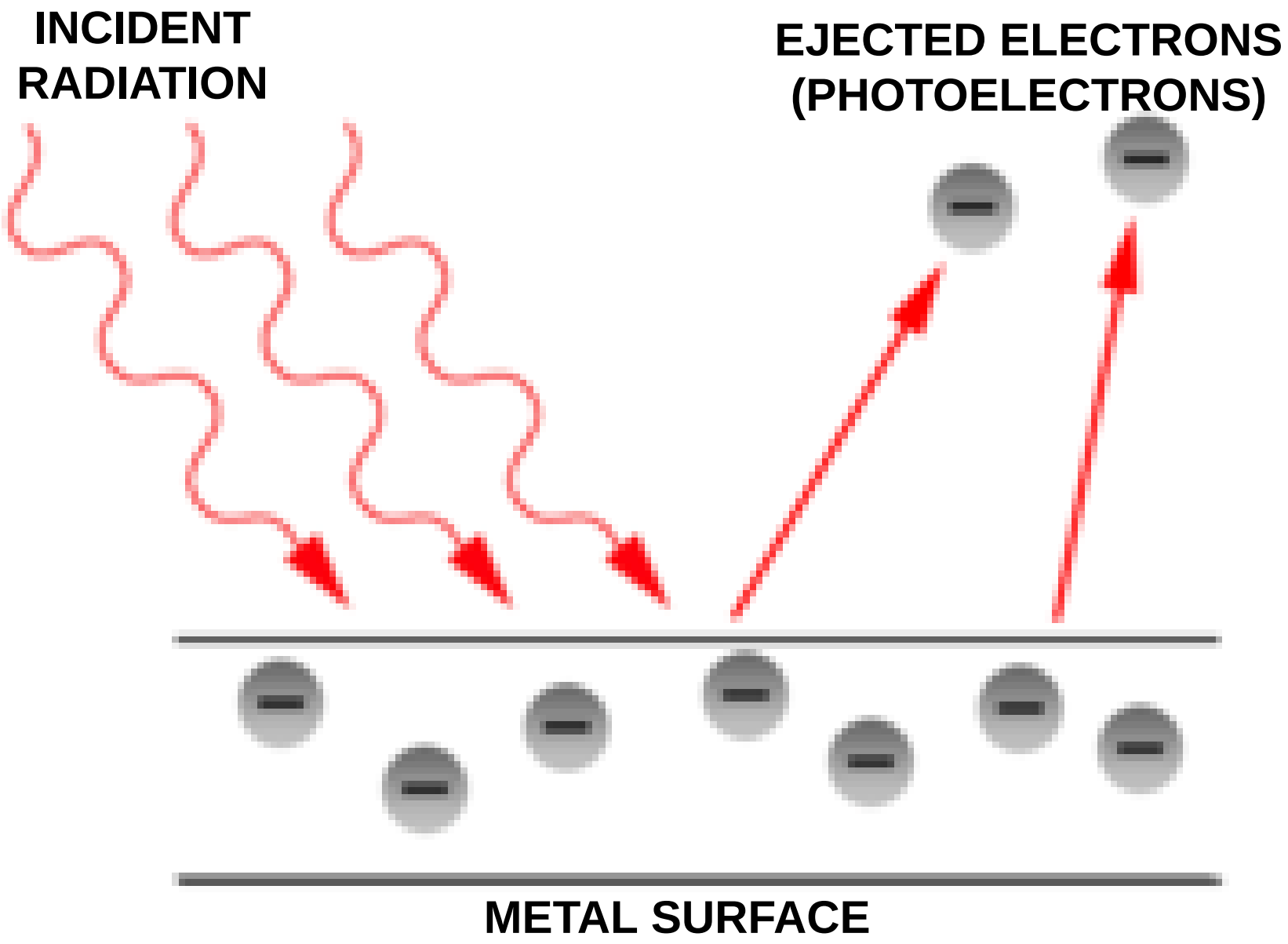
Electric → Electrons/ Electric Current





What happens when the Light is turned on ?

Thus Photoelectric Effect is a phenomenon in which electrons are emitted from matter (metals & non-metallic solids, liquids or gases), whenever light of suitable wavelength / frequency (i.e. beam of photons) falls on the surface.


INCIDENT RADIATION
EJECTED ELECTRONS (PHOTOELECTRONS)
METAL SURFACE

Matter	Light
Alkali Metals (e.g. Sodium, Potassium, Lithium, Cesium etc.)	Visible Light
Other Metals (e.g. Cadmium, Zinc, Magnesium etc.)	Near Ultra Violet
Non Metals (e.g. Carbon, Phosphorus etc)	Extreme Ultra Violet

EXPERIMENTAL STUDY OF PHOTOELECTRIC EMISSION

APPARATUS

1. Evacuated quartz tube.
2. Photosensitive emitter metal plate -- Cathode.
3. Collector metal plate -- Anode.
4. Voltmeter-V.
5. Ammeter-A.
6. Variable Resistance.
7. Battery.

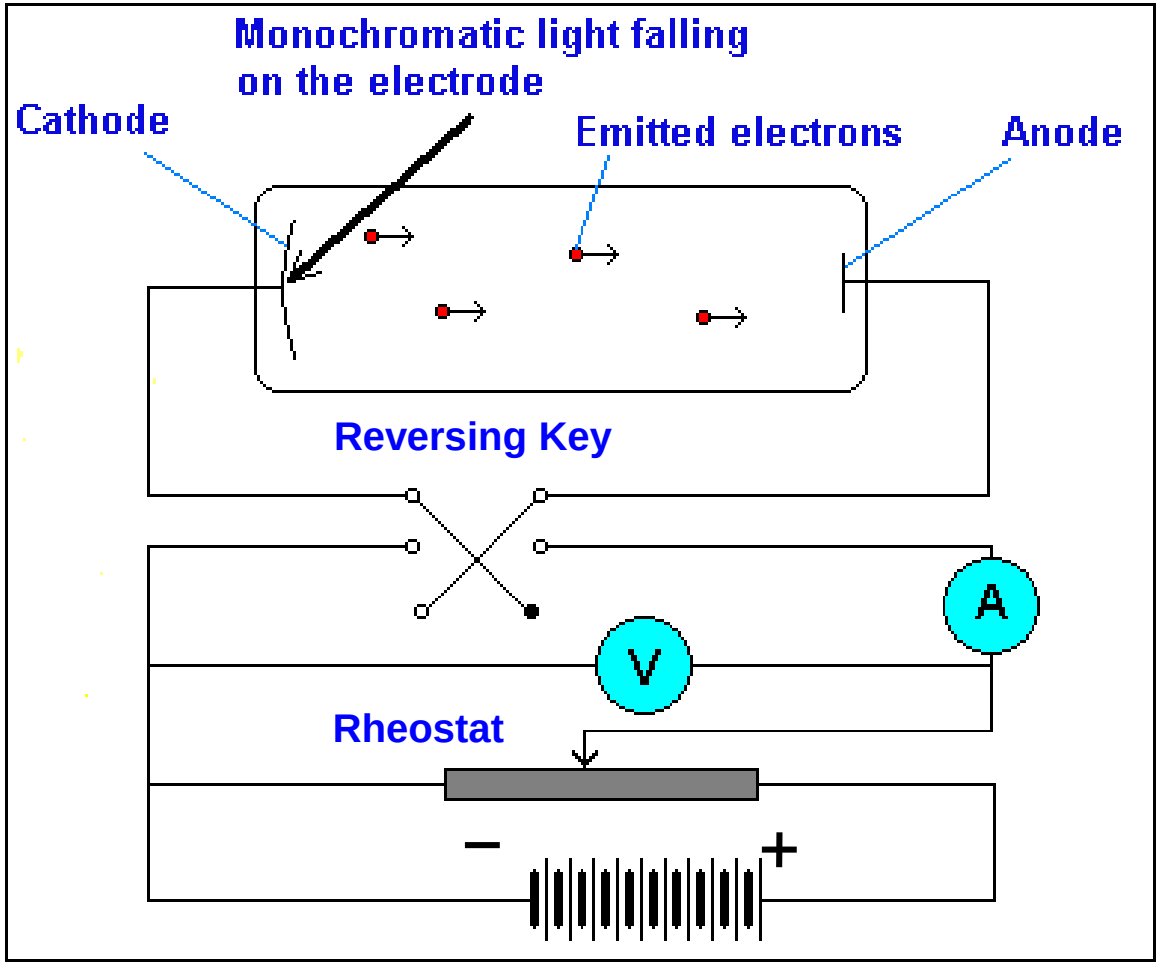


Diagram of the experimental system for studying photoelectric effect.

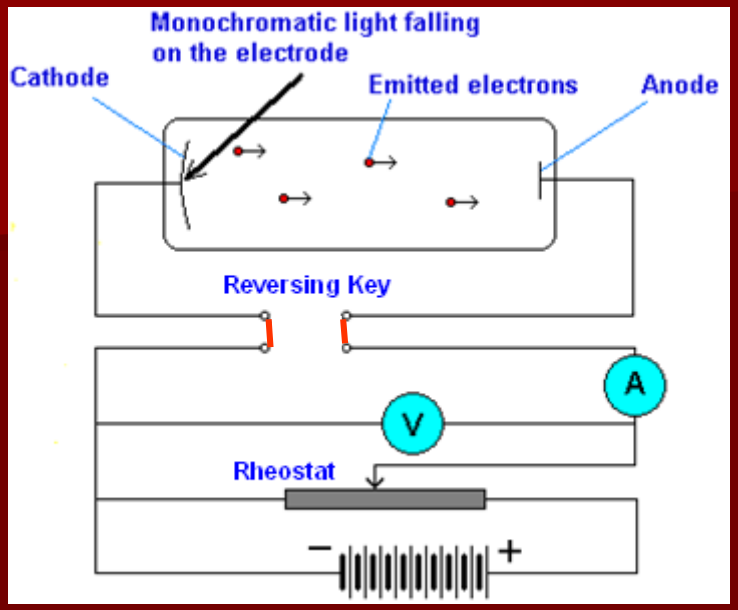
HOW DOES IT WORK ?

1. Monochromatic radiations of suitable frequency fall on the Cathode.
2. Photoelectrons are emitted which get accelerated towards the Anode (kept at positive potential).
3. These electrons flow in the outer circuit resulting in the Photoelectric Current.
4. Ammeter shows a deflection measuring Photoelectric Current.

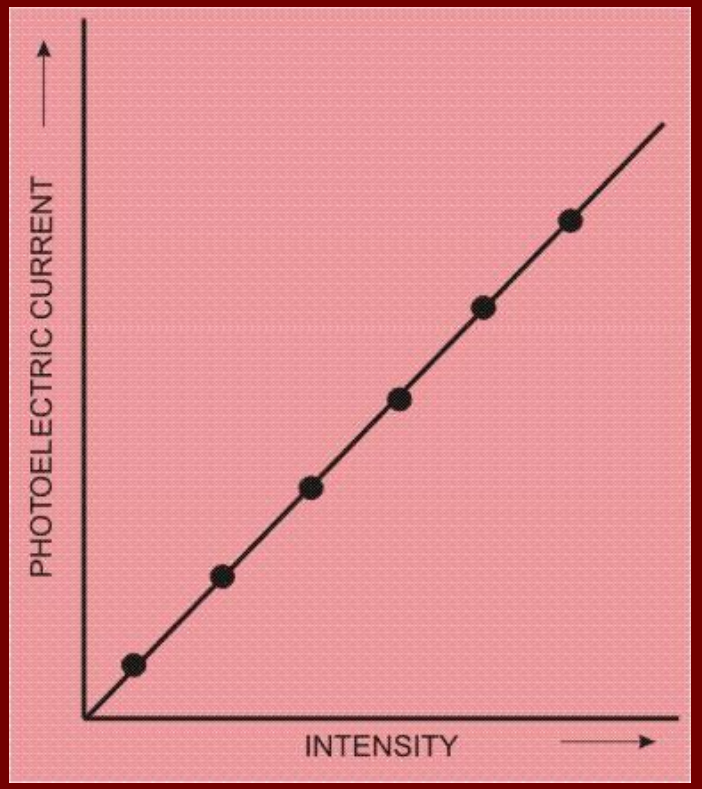
BASIC VARIABLES/ PARAMETERS IN PHOTOELECTRIC EXPERIMENT

a. Intensity of incident light (I)
b. Applied potential (V)
c. Frequency of incident light (ν)

(a) Effect of Intensity of incident radiation (I)



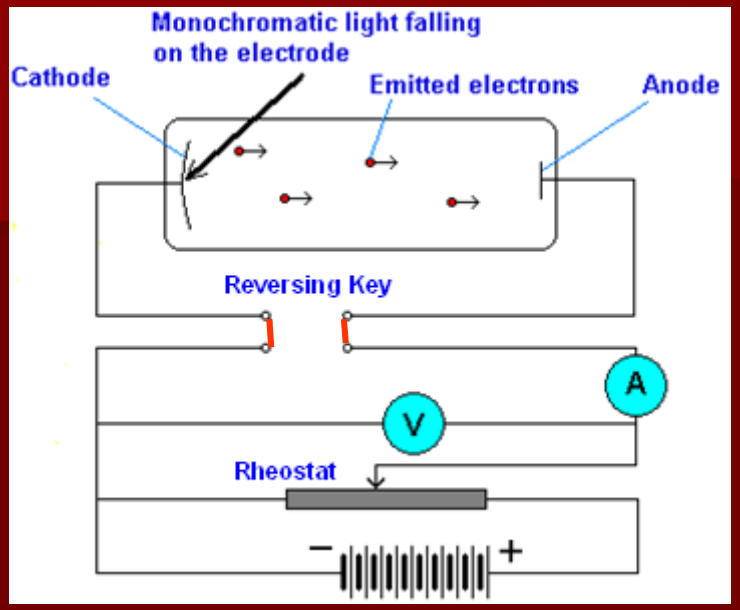
- Anode maintained at definite positive potential w.r.t. Cathode.
- Incident Radiations of a fixed frequency are used.

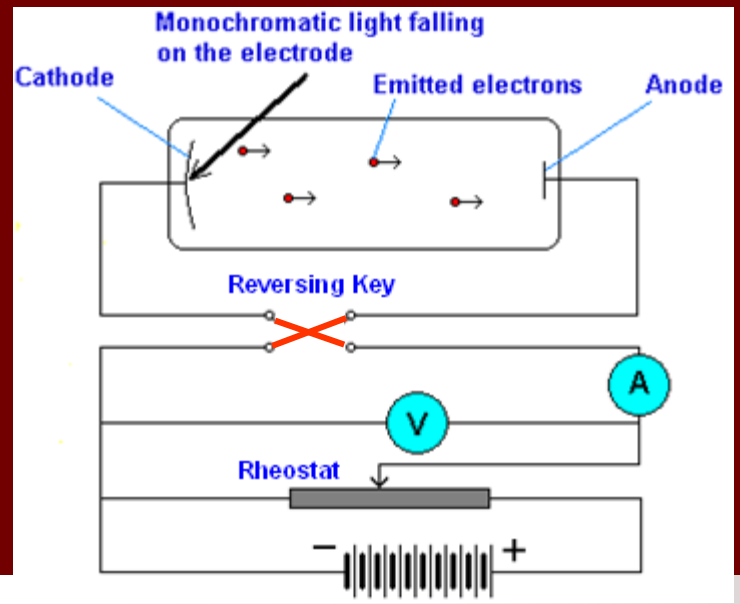


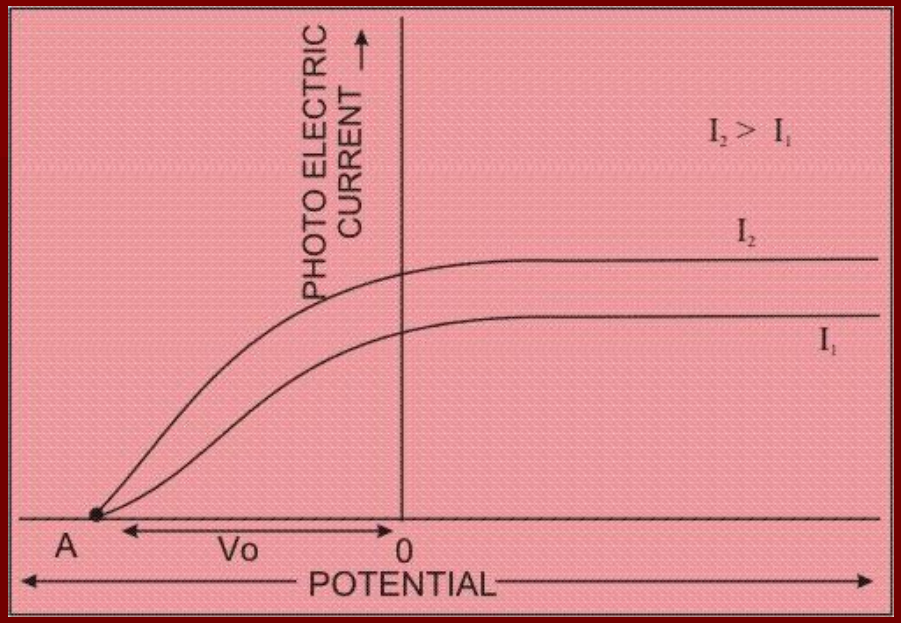
- Photoelectric current increases linearly with the intensity of incident light.
- Photoelectrons emitted from sensitive Cathode α Intensity of incident radiation.

(b) Effect of Potential (V)

- Frequency and Intensity of incident radiation are kept fixed.



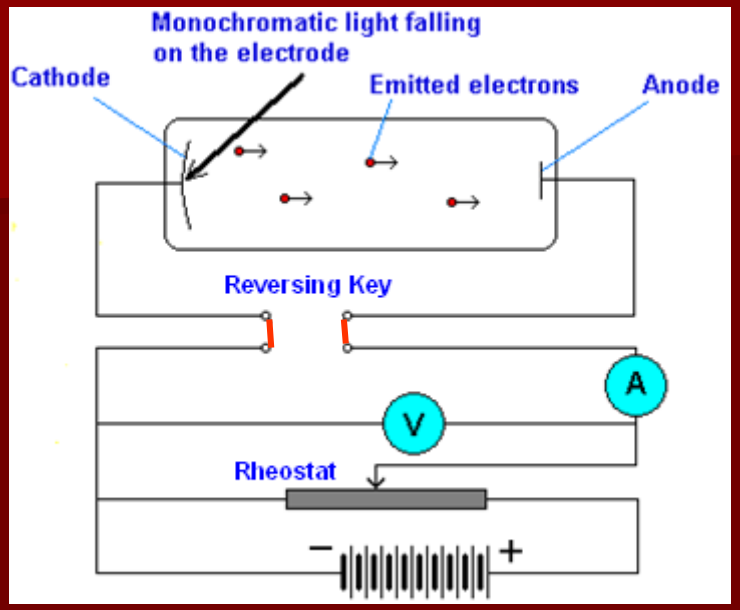


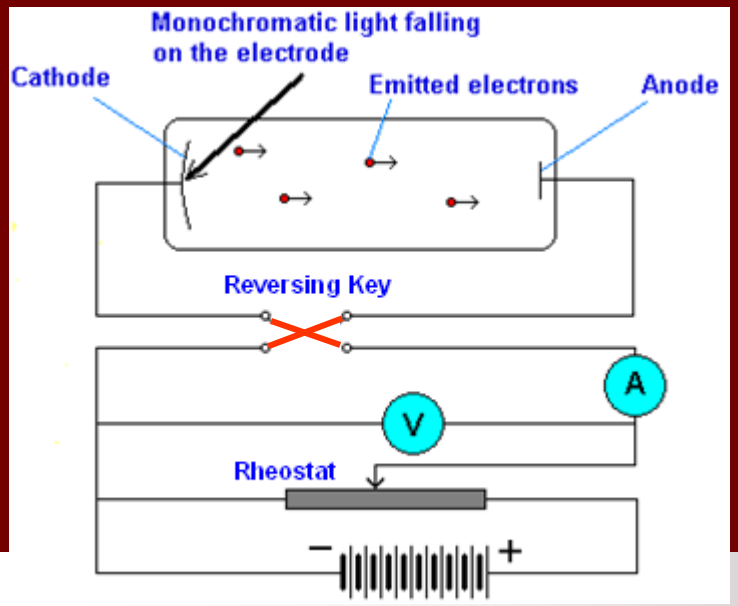


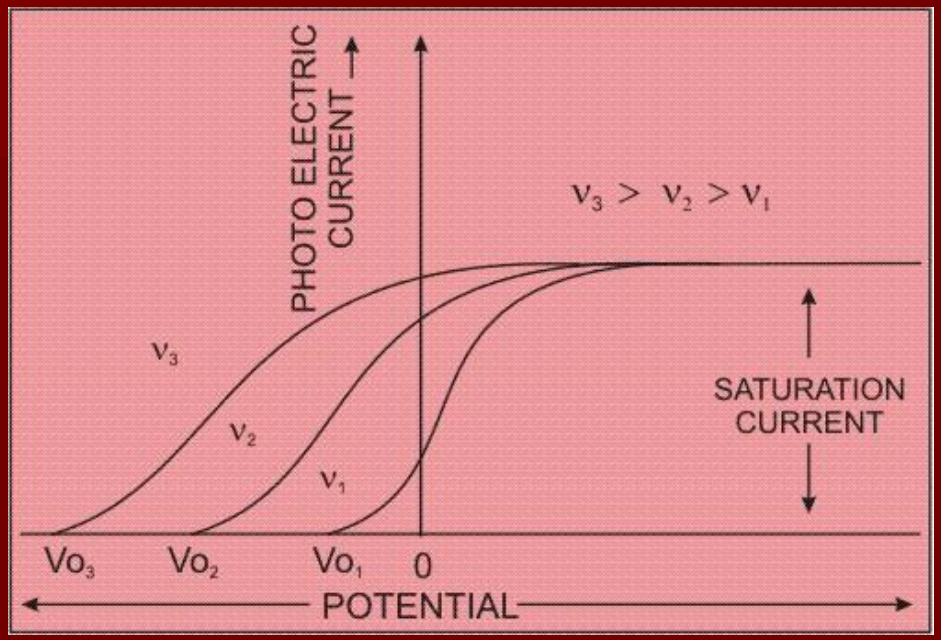
- Photoelectric current increases gradually with increase in positive potential on Anode, becomes maximum and finally attains saturation value.
- Applying gradual negative potential to Anode w.r.t. Cathode, Photoelectric current decreases rapidly and becomes zero.
- Minimum negative potential given to Anode at which Photoelectric current becomes zero is called Stopping potential or cut-off potential.

(c) Effect of frequency of incident radiation (ν)

- Radiations of different frequencies but of the same intensity are taken.

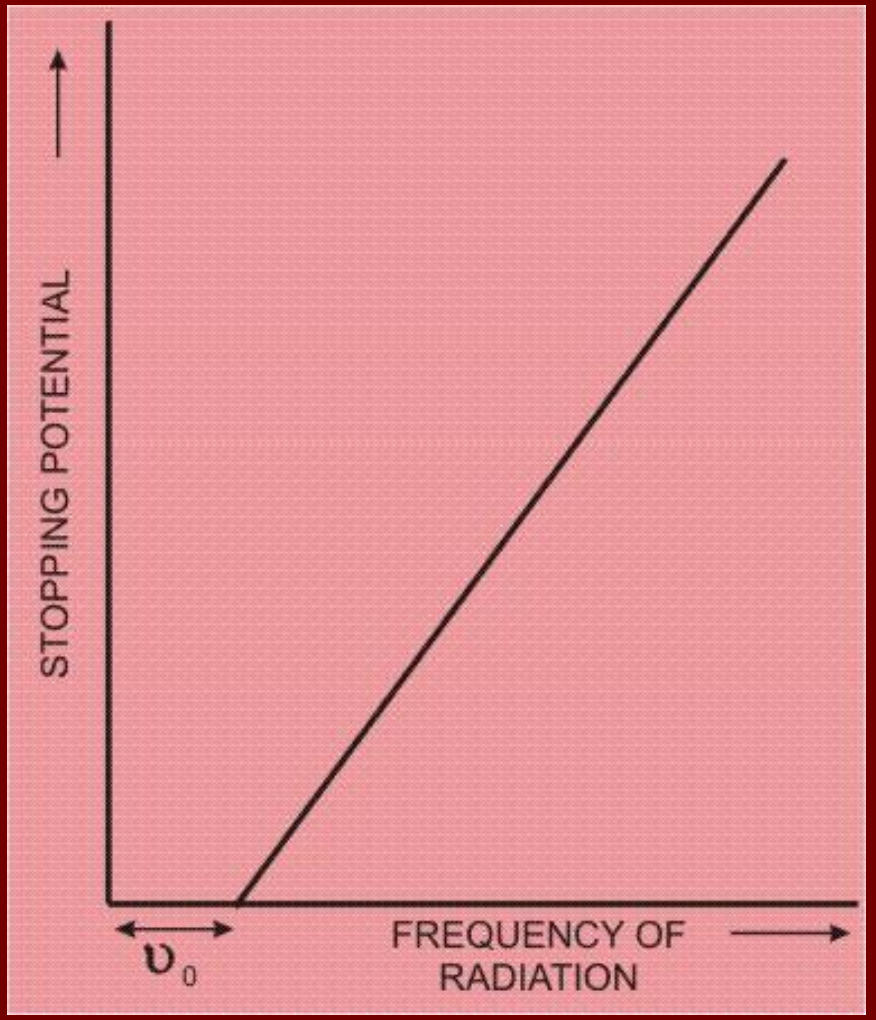






- Saturation current is the same for the radiation of different frequencies.
- Value of stopping potential is different for the incident radiation of different frequencies.
- Greater is the frequency of incident radiation, more is the value of stopping potential (i.e. higher is the energy of photoelectron emitted, as per Eintstien's relation $E = h\nu$).

- Stopping potential varies linearly with the frequency of incident radiation.
- There is a certain minimum frequency ν_0, called threshold frequency, of the incident radiation for which the stopping potential is zero.
- For incident radiation of frequency less than the threshold frequency no emission of photoelectron is possible.



LAWS OF PHOTOELECTRIC EMISSION

1. For a given metal and frequency of incident radiation, the number of photoelectrons emitted per second is directly proportional to the intensity of incident light.

2. For every metal, there exists a certain minimum frequency of incident radiation, below which no emission of photoelectrons takes place, called threshold frequency.

3. Above the threshold frequency, the maximum kinetic energy of the emitted photo electron is independent of the intensity of the incident light but depends only upon the frequency (or wavelength) of the incident light.

4. Photoelectric emission is an instantaneous process. The time lag between the incidence of radiations and emission of photo electrons is very small, less than even 10^{-9} second.

PHOTOELECTRIC CELL

It is a device which converts
'Light Energy' into 'Electrical Energy'

Photoelectric cells are of 3 types:-

1) Photoemissive cell.

2) Photovoltaic cell.

3) Photoconductive cell.

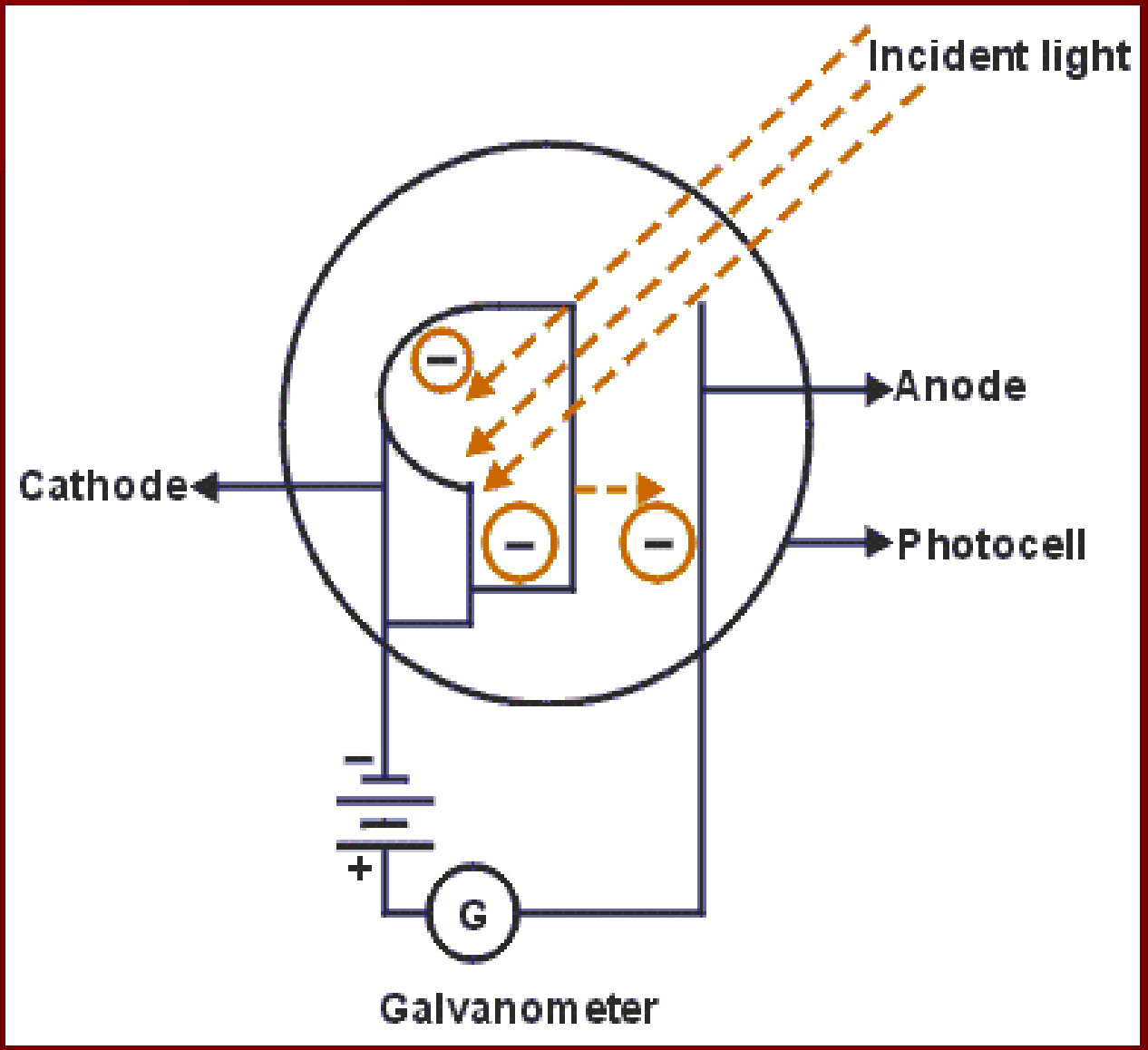
Photoemissive Cell/ Photocell

Principle :

Photoelectric effect.

Construction :

- Evacuated glass or quartz tube.
- Semi cylindrical photosensitive metal plate (Cathode).
- Wire loop (Anode).
- Insulating base with metallic pins.
- External Circuit having battery, galvanometer, resistance, etc.



How does it Work ?

- Light of suitable frequency/ wavelength is allowed to fall on the Cathode.
- Emitted Photoelectrons are attracted by Anode (kept at positive potential w.r.t. Cathode).
- Current starts flowing. Galvanometer/ Micro ammeter shows deflection.
- Photoelectric current is very small, so it is to be amplified before using for some purpose.

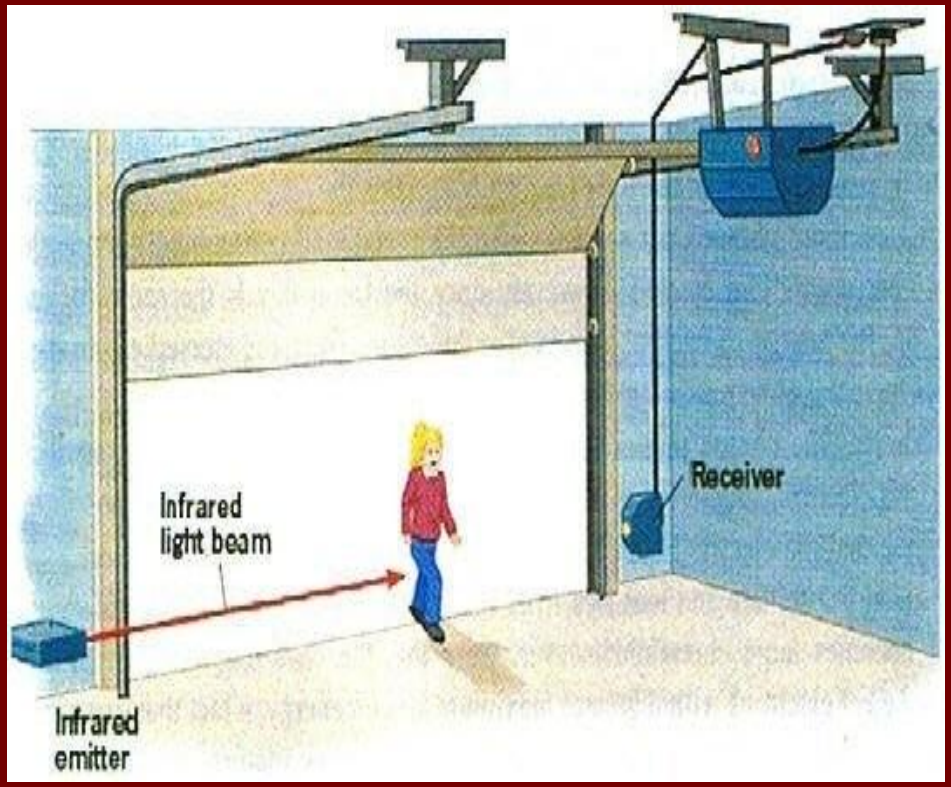
Applications of Photo Electric Cells

1. Automatic Cameras

- The camera has built-in light meter.
- Light entering into the light meter strikes the metal object; electrons are released and the current is created.
- This automatically opens and closes the lens to adjust for high and low lighting conditions.

2. Automatic Operation of Garage Door

- Source of light is fitted on one side and battery operated photocell connected to mechanical arrangement fixed on the other side of the garage door.
- The door opens or closes whenever light falling on the photocell is obstructed.

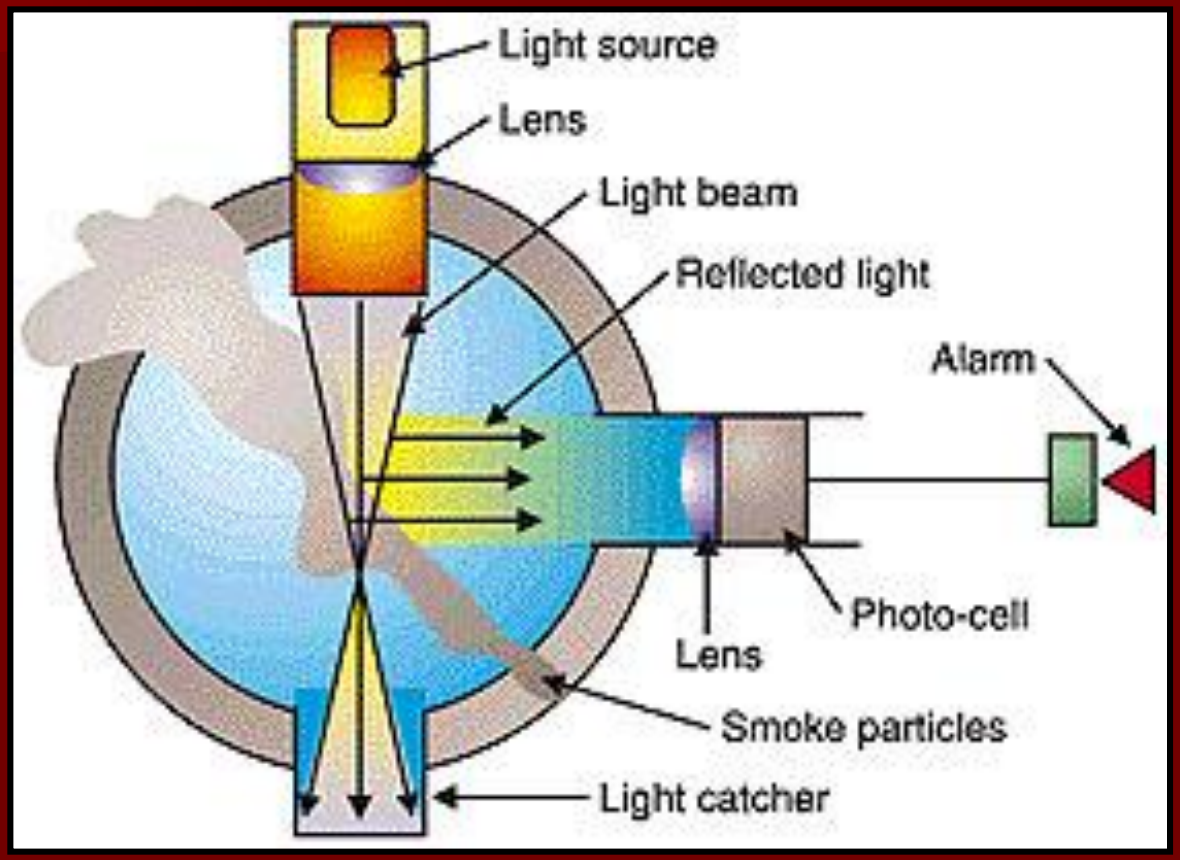


3. Burglar Alarm

- Source of light is fixed on one side of the window/ door.
- Photocell connected to a battery operated siren or buzzer is fixed on the other side.
- The buzzer goes off whenever the light falling on the photocell is broken.

4. Smoke Detector

- Battery operated detector has a constant beam of light.
- Smoke particles enter detector; scatter the light beam.
- Light detector senses scattered beam and triggers the alarm.



Based on the same principle, other applications of Photocells are:-

5. Fire Alarms
6. Counting Devices.
7. Automatic on / off of street lights.
8. Temperature of stars & spectrum of heavenly bodies
9. Photometry i.e. to compare the illuminating powers of two sources.
10. In industries for locating minor flaws or holes in metallic sheets.


Thank You!