ENGINEERING PHYSICS LAB DEFINITIONS & IMP THEORY

Experiment -(2)→ Photoelectric effect

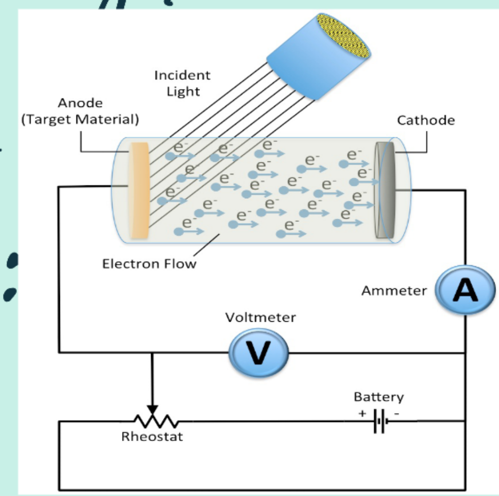
Photoelectric Effect: It is the emission of e^- when electromagnetic radiations have sufficient frequency incident on certain metal surfaces

Eqⁿ, $KE_{max} = h\nu - h\nu_0$

photocurrent: emitted electrons as photoelectrons and the current they constitute as photocurrent

Important observations which demands Quantum theory Explanation:

- It is an instantaneous phenomenon; No time Delay between incidence of light and emission of photoelectrons
- no. of photoelectrons emitted is proportional to intensity of light
- Energy of emitted photoelectrons is:
  - independent of intensity of incident light
  - directly proportional to frequency of incident light.



Work Function: Min. energy needed for electrons to escape from particular metal surface

$W = h\nu_0$

Stopping Potential : Min value of -ve potential (V) at anode which just stops the photocurrent

Threshold Frequency : min frequency of light below which photoelectric effect does not take place.

Experiment -(3) → Planck's Constant

Planck's Constant : (h) Introduced by German physicist Max Planck in 1900.

quanta → small packets of energy

It describes the behaviour of particle and waves at atomic level as well as the particle nature of light.

LED → Two terminal light source → when connected to an external voltage in forward biased direction, height of potential barrier across the p-n Junction is Reduced. At particular voltage height of potential barrier becomes very low, the LED starts to glow.

Knee Voltage / Threshold Voltage :

It is the forward voltage at which the flow of current through the p-n Junction of diode increases Rapidly.

p-n Junction Diode :

It is a two terminal (anode & cathode) which allows the electric current in only one dir^n while blocking current in opp. direction.

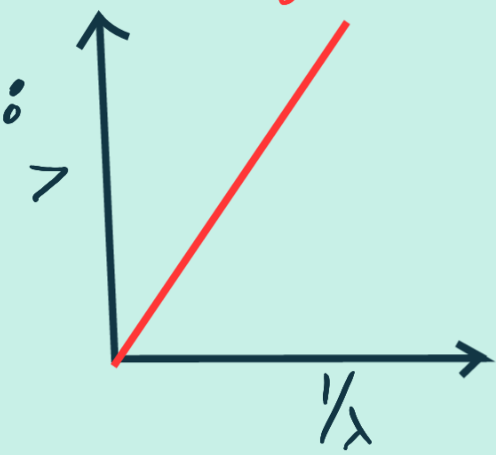
$$\boxed{E = \frac{hc}{\lambda}}$$

$$\boxed{V = \frac{hc}{e\lambda}}$$

$$\boxed{E = eV}$$

$V \rightarrow$ knee voltage

Slope of graph :



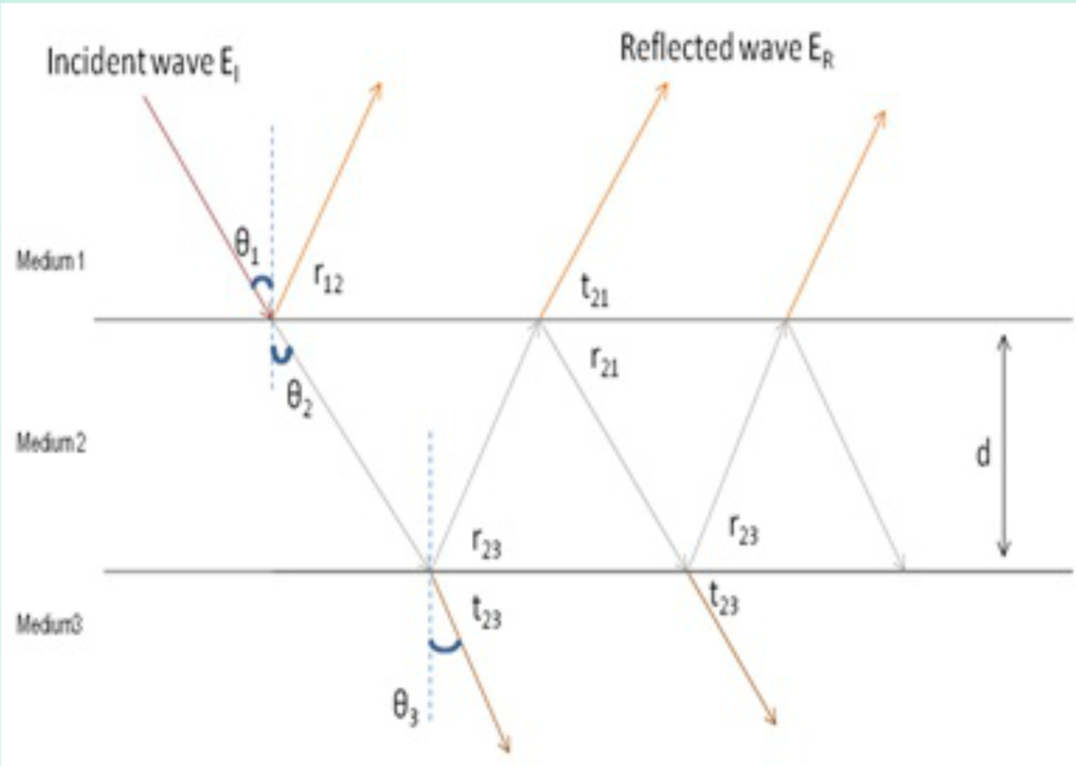
$$\frac{e}{c} = 5.33 \times 10^{-28} \frac{CS}{m}$$

Experiment-(4)

Newton's Rings — wavelength of Light

Thin Film Interference:

Phenomenon of modification in intensity of light due to intermixing or superimposing of two or more light waves.



$2\mu_2 d \cos r_{12} = (2m+1)\lambda/2 \longrightarrow$ constructive Interference

$$2\mu_2 d\cos r_{12} = m\lambda \longrightarrow \text{destructive Interference.}$$

$m \rightarrow$ order of Interference

Thin Film Interference with Films of varying Thickness:

Newton's Rings: These are circular fringes discovered by Newton. The Rings are fringes of equal thickness. They are observed when light is reflected from plano-convex lens of a long focal length placed in contact with a plane glass plate.

If the lens plate system is illuminated with monochromatic light falling on it normally, concentric bright and dark interference rings are observed in reflected light.

$$2t = (2m+1)\lambda/2 \longrightarrow \text{constructive Interference}$$

$$2t = m\lambda \longrightarrow \text{destructive Interference}$$

- . **Central dark spot:** At the point of contact of the lens with the glass plate the thickness of the air film is very small compared to the wavelength of light therefore the path difference introduced between the interfering waves is zero. Consequently, the interfering waves at the centre are opposite in phase and interfere destructively. Thus a dark spot is produced.

- **Circular fringes with equal thickness:** Each maximum or minimum is a locus of constant film thickness. Since the locus of points having the same thickness fall on a circle having its centre at the point of contact, the fringes are circular.

- **Fringes are localized:** Though the system is illuminated with a parallel beam of light, the reflected rays are not parallel. They interfere nearer to the top surface of the air film and appear to diverge from there when viewed from the top. The fringes are seen near the upper surface of the film and hence are said to be localized in the film.

- **Radii of the mth dark rings:**

.

$$r_m = \sqrt{m\lambda R}$$

- **Radii of the mth bright ring:**

.

$$r_m = \sqrt{(2m+1)R\frac{\lambda}{2}}$$

- The radius of a dark ring is proportional to the radius of curvature of the lens by the relation,

.

$$r_m \; \alpha \sqrt{R}$$

- Rings get closer as the order increases (m increases) since the diameter does not increase in the same proportion.

- In transmitted light the ring system is exactly complementary to the reflected ring system so that the centre spot is bright.

- Under white light we get coloured fringes.

$$\lambda = \frac{D_{m+p}^2 - D_m^2}{4\,p\,R}$$

- The wavelength of monochromatic light can be determined as,

.

Where, Dm+p is the diameter of the (m+p)th dark ring and

Dm is the diameter of the mth dark ring.

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Experiment -(5) — Hall Effect

Hall effect Phenomenon:

If a current carrying conductor is a perpendicular magnetic Field, a potential diff. is generated in the conductor which is perpendicular to both magnetic field and current.

Hall Voltage (V_H):

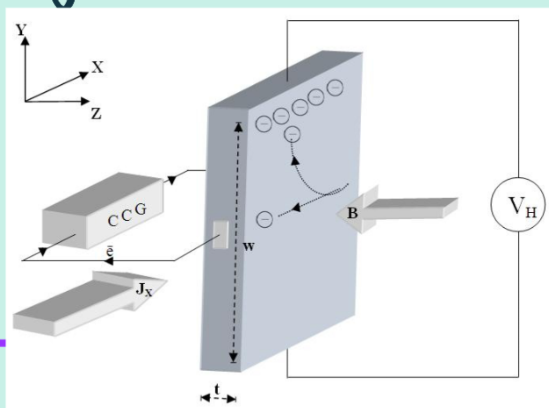
If the magnetic field is applied along -ve z-axis, the Lorentz force moves the charge carriers (e^-) towards the y- dir^n.

This Results in accumulation of charge carriers at the top edge of the sample. This sets up electric Field E_y in the sample. This develops a potential difference along y-axis Known as Hall Voltage (V_H)

Drift Velocity: $I_d = neAv$

In steady state condition, the magnetic Force is balanced by the electric force.

$$eE = evB$$



Hall coefficient: $R_H = 1/ne$

Experiment -(6)

Resistivity by Four Probe Method

Resistivity: At constant temperature, the Resistance R of a conductor is proportional to its length L and inversely proportional to Area of section A

$$R = \rho \frac{L}{A}$$

(It is uniform across material)

where,

ρ = Resistivity of conductor

units = ohm·meter

According to Band Theory, semiconductors can be grouped into two Bands, Valence band and conduction band.

In presence of an external field → e^- in valence band move freely

Responsible for electrical conductivity in Semiconductors ←

Fermi levels in Intrinsic semiconductor lies in betn conduction band minimum & Valence band maximum.

Why conduction is possible at 0 Kelvin?

Since, conduction band lies above the Fermi at 0K

↓

No thermal excitations are available

↓

the conduction band is not occupied and Resistance is Infinite

As temp. ↑, occupany of conduction goes up, thereby Resulting in Decrease of electrical Resistivity created by Resulting in Decrease of Electrical Resistivity

$$\rho = \frac{\rho_0}{f(W/S)}$$

$$\rho_0 = \frac{V}{I} \times 2\pi S$$

where,

W = thickness of slice

S = Spacing between probes in metres

I = current through outer pair of probes in ampere

V = p.d in inner probes in volts.

Temperature Dependence of Resistivity in semicon.

$$\rho = A \exp \frac{E_g}{2kT}$$

where,

E_g = band gap of semiconductor

T = Temp in Kelvin

K = Boltzmann Const = 8.6×10^{-5} eV/K

NOTE: Resistivity of semiconductor increases exponentially on decreasing the temp.

Applications:

(i) Remote Sensing areas

(ii) Resistance thermometer

(iii) Induction Hardening process

(iv) Accurate geometry factor estimation

(v) characterization of fuel cells bipolar plates

Experiment -(7)

Energy Band-Gap of Semiconductor

In case of insulators, the region between highest level of completely filled valence band and lowest level of conduction band is very wide. This is energy gap (Eg)

For insulators, Eg = 3 ev to 7ev

For semicoductors, Eg is quite small

For germanium, Eg = 0.7 ev

For silicon, Eg = 1.1 ev

In semiconductors, At low temps

↓

few carrier charges to move

↓

Low conductivity

In semiconductors, At high temps

↓

Donor or acceptor levels come into action and provide charge carriers

↓

Conductivity increases

mobility of charge carriers decreases with increasing temperature, but on an average the conductivity ↑ when temperature ↑

In Reverse Bias, the saturated value of reverse current for a PN Junction diode is :

$$I_s = A \cdot T^{3/2} e^{-E_g/KT}$$

where, $A \rightarrow$ const

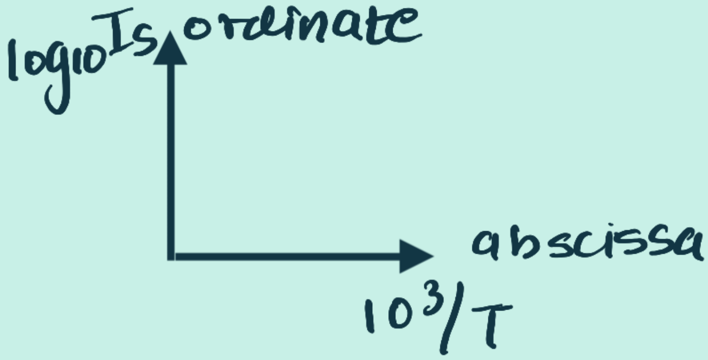
$I_s \rightarrow$ saturation current in micro ampere

$T \rightarrow$ temperature of Junction Diode in K

$K \rightarrow$ Boltzmann const. in eV/K

$$\log_{10} I_s = \text{constant} - 5.04\, E_g\, 10^3/T$$

$$E_g = \frac{\text{slope of Line}}{0.54}$$



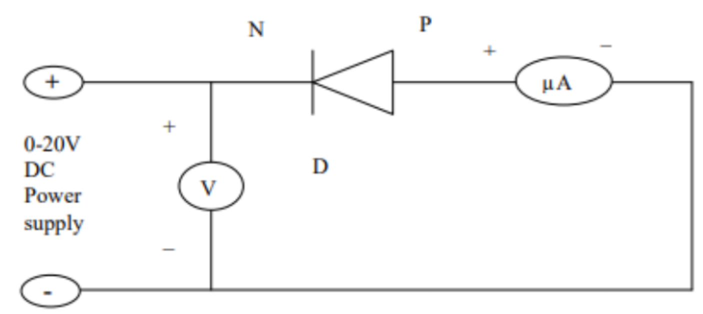


Figure 1

Experiment -(8)

Numerical Aperture of Optical Fibre

Optical Fibre : They are Fine transparent glass or plastic fibres which can propogate light. They work under principle of TIR from diametrically opp. sides

This enough flexibility to cores. This property makes them suitable for data communication, design of Fine Endoscopes, micro sized microscope, etc

An optical Fibre consists of a core that is surrounded by a cladding which are Normally made of silica glass or Plastic. The core transmits an optical signal while the cladding guides light within the core. Since, light is guided through the fiber it is sometimes called an Optical wave guide.

Acceptor Angle : It is maximum angle with the axis at the optical fibre at which light can enter

$$\sin\theta = \frac{r}{\sqrt{r^2+d^2}} \qquad \theta = \sin^{-1}\left(\frac{r}{\sqrt{r^2+d^2}}\right)$$

Refractive Index : $\dfrac{\text{Speed of Light in vaccum}}{\text{Speed of Light in medium.}}$

Snell's Law : $\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2$

Total Internal Reflection :

phenomenon in which waves arriving at the Interface from medium to another medium are not Refracted but are Reflected into 1^{st} medium.

Critical Angle :

It is defined as angle of incidence of a light Ray in the denser medium which is such that angle of Refraction is 90°

$$\sin\theta_c = \frac{\mu_2}{\mu_1}$$

Numerical Aperture : Light gathering capacity of a optical Fibre

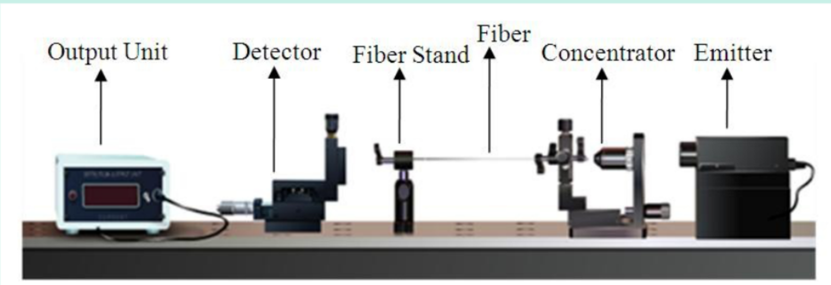
$$\sin\theta = \frac{r^2}{\sqrt{r^2+d^2}}$$

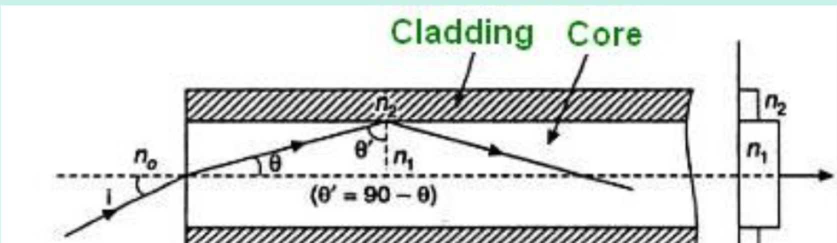
$$N.A. = \mu_0 \sin I_{max}$$

Distance between Fibre and Detector,

$$2\gamma = \frac{I_{max}}{2.71}$$

Higher value of Imax ⟶ N.A is more (more light is collected for propogation in Fibre)





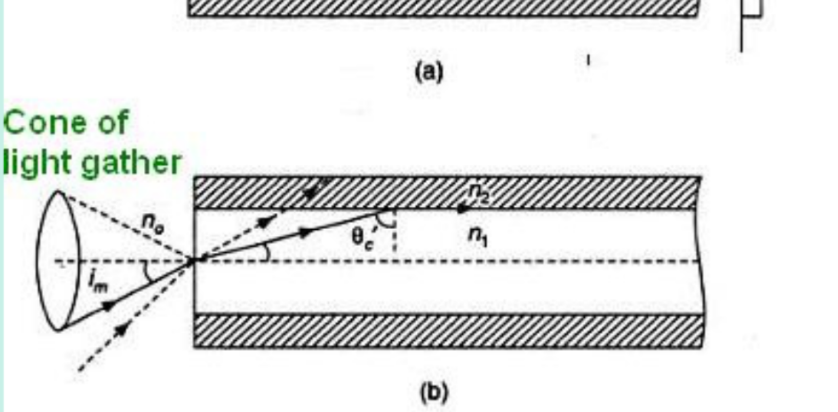
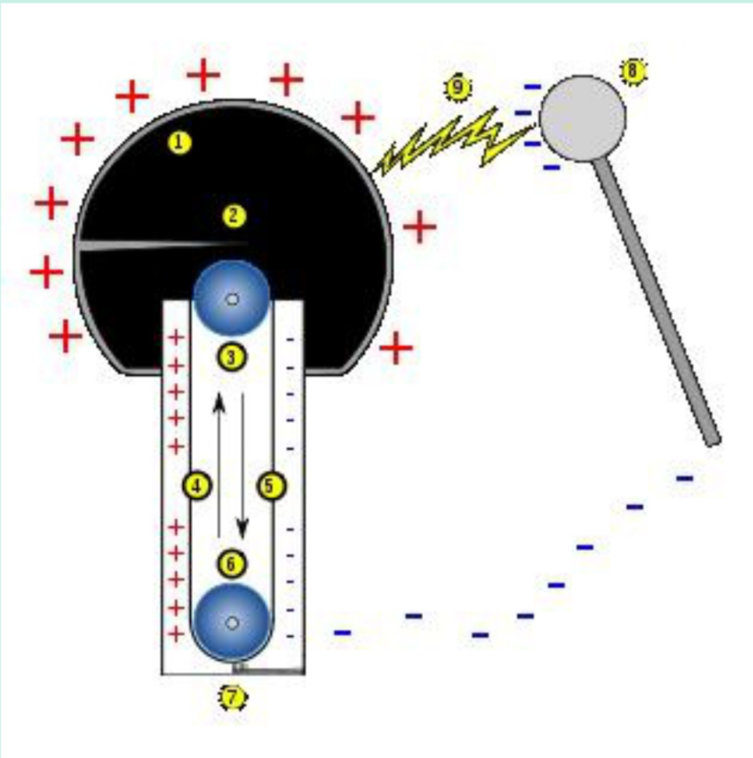


Figure 3.

Experiment -(9)
Van De Graaff Generator

Invented by Robert Jamison Van de Graaff in 1931

The device has ability to produce extremely high voltages (20 million Volts) which was used to supply high energy needed for early particle accelerator



$$V(r) - V(R) = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r} - \frac{1}{R}\right)$$

potential inside conducting sphere:

$$= \frac{1}{4\pi\varepsilon_0} \times Q/R$$

Working of the generator is based on two principles:

- Discharging action of sharp points, ie., electric discharge takes place in air or gases readily, at pointed conductors.

- If the charged conductor is brought in to internal contact with a hollow conductor, all of its charge transfers to the surface of the hollow conductor no matter how high the potential of the latter may be.

Experiment – (10)

Newton's Rings – Refractive Index of Liquid

Almost same Theory as Wave length of light

$$\text{Least count} = \frac{\text{one main scale division}}{\text{no. of divisions on vernier scale}} = \frac{0.01\,m}{} = 0.001\,cm$$

$$\mu = \frac{D^2_{m+p} - D^2_m}{D'^2_{m+p} - D'^2_m} \qquad D_n = TR(R) - TR(L)$$

TR → Total reading

$2\mu t \cos r = m\lambda$ → For dark Rings

For Normal incidence; $(\cos r = 1)$

$2\mu t = m\lambda$

$2d = m\lambda$

$$D^2_{m+p} - D^2_m = 4p\lambda R$$