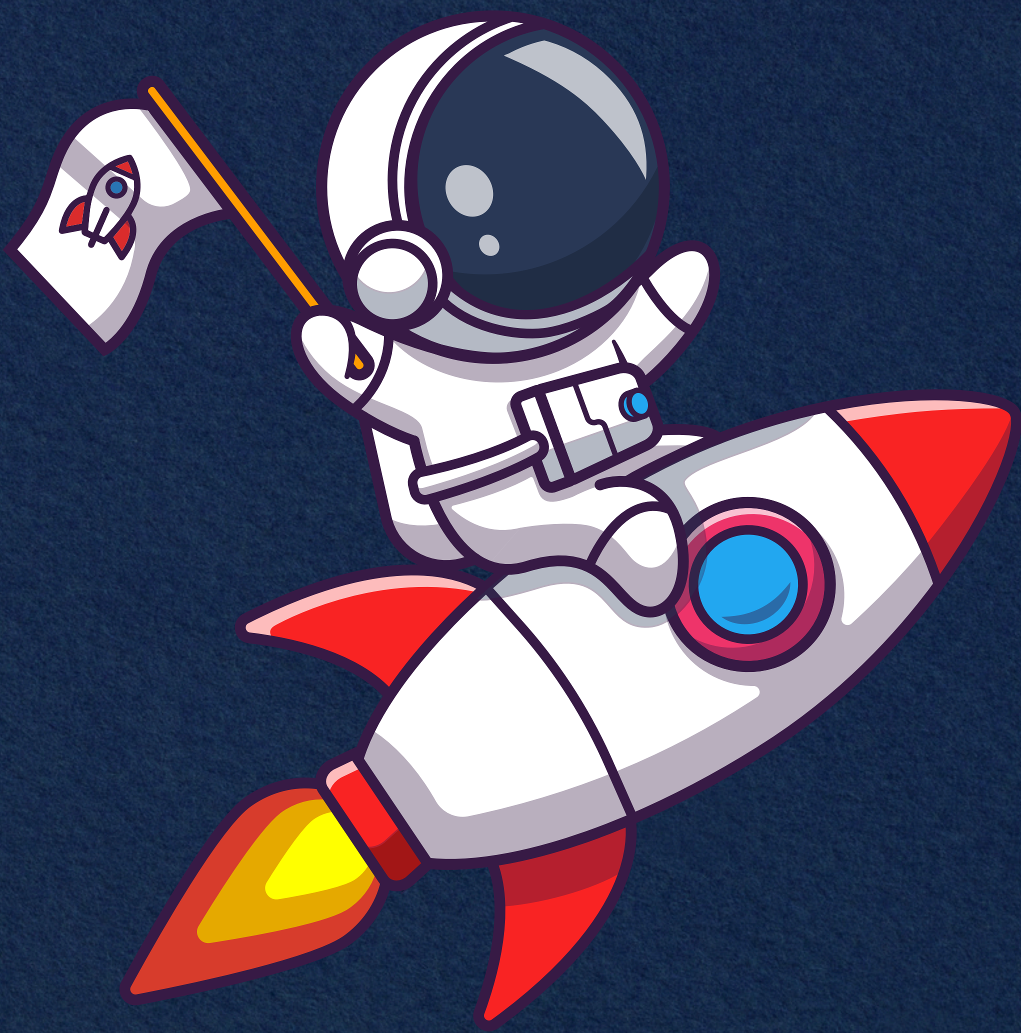
Class 12

PHYSICS

SHORT NOTES



Chapter-9

Ray Optics and Optical Instruments

☆ Reflection of light :-

When a ray of light coming from one medium return back in same medium after touching an opaque object is called reflection.

• Laws of reflection :-

① Angle of incidence = Angle of reflection

② Incident ray, reflected ray & normal lie in the same plane.

③ Velocity, wavelength, frequency not change only intensity change with nature of surface.

• Properties of Image by plane mirror :-

(i) Position :-) same distance of image and object from mirror

(ii) Nature :- Virtual.

(iii) Lateral Inversion

(iv) Shape & size similar to object.

☆ Angle of deviation in Reflection :-

Angle between actual path and reflected ray.

$$\boxed{\delta = 180 - (i + r)}$$

✩. Spherical Mirror :-

1. Concave mirror (reflecting surface curved outward)
2. Convex mirror (Reflecting surface curved inward)

✩. Relation between focal length & radius of curvature of Mirrors :-

$$f = \frac{R}{2}$$

✩. Note :-

1. focal length :-
   a) Concave mirror = $-ve$
   Convex mirror = $+ve$
2. The distance measured in direction of incident ray is $+ve$ and in opposite direction is taken $(-ve)$.
3. Distance above principle axis is $+ve$ and below axis is $-ve$.

✩. Mirror formula or Mirror Equation / Relation between V, u & f :-

$$\frac{1}{f} = \frac{1}{V} + \frac{1}{u}$$

✩. Magnification :-

$$M = \frac{\text{height of Image}}{\text{height of object}}$$

$$M = \frac{h'}{h} = -\frac{V}{u}$$

If M → +ve, then virtual & erect image
M → -ve, Real & Inverted

→ for two mirrors :-

$$M = M_1 \times M_2$$

☆. Power of Mirror :- capability to converge or diverge

$$P = -\frac{1}{f}$$

→ Unit → Dioptre (D)
→ f always in meter

P → +ve (Concave Mirror)
P → -ve (Convex Mirror)

☆. Note :-
→ To solve numericals, image of 1st mirror will act as object for 2nd mirror.

☆. Types of Medium :-
① Rarer Medium (Speed ↑)
② Denser Medium (Speed ↓)

• Exception :-

Water	Turpentine Oil
ρ ↑	ρ ↓
But Denser ✗	Rarer ✗
Rarer (V ↑)	Denser (V ↓)

☆. Refraction :-
The bending of light when light transmit from one medium to another medium is called Refraction of light.

• Reason of Refraction :- Change in speed of light whet it travel from one medium to another medium

Rarer to Denser → Speed decrease
Denser to Rarer → Speed increase

• Laws :-

① Incident ray, refracted ray & normal lie on same plane.

② Snell's Law :-

$$\frac{\sin i}{\sin r} = \text{constant} = \mu_{21}$$

③ Speed, wavelength, intensity of incident ray and refracted ray are different. Only frequency same.

★. Refractive Index (μ or n) :-
Ratio of speed of light in two different medium.
→ Unitless.

① Absolute Refractive Index :-
Ratio of speed of light in vaccum to the speed of light in any medium.

$$\mu = \frac{c}{v}$$ where $c = 3 \times 10^8$ m/s.

$$\mu = \frac{\mu_m}{\mu_{vaccum}}$$

→ $\mu_{water} = 1.33$ or $4/3$
→ $\mu_{air} = 1$
→ $\mu_{glass} = 3/2$ or 1.5

★ Note :-

→ Absolute refractive index is always greater than 1.

→ Refractive Index ↑, Medium will become more denser.

② Relative Refractive Index :-

Ratio of refractive index in two different medium.

$$\mu_{21} = \frac{\mu_2}{\mu_1} = \frac{V_1}{V_2} = \frac{\sin i}{\sin r} = \frac{\lambda_1}{\lambda_2}$$

• factor on which it depend :-

① Nature of medium

② Colour of light or wavelength

③ Temperature ($T\uparrow, \mu\downarrow$)

★ Note :-

$$\mu_1 \sin i = \mu_2 \sin r$$

→ If light incident at 90° at the surface then light travel without any deviation.

★ Real & Apparant Depth :-

Apparent Depth :-

$$h' = \frac{\text{(Real) Actual Depth}}{\text{Refractive index of medium}} = \frac{h}{\mu_{21}}$$

★ Total Internal Reflection :-

When light travels from denser to rarer medium then, when angle of incidence exceeds critical angle then light again reflected back in denser medium.

- Conditions:-

① Light must travel from denser to rarer medium.

② Angle of incidence must be greater than critical angle.

- Critical angle:-

Angle of incidence at which the angle of refraction becomes 90°.

★. Relation b/w critical angle and refractive Index:-

$$\theta_c = \sin^{-1}\left(\frac{1}{\mu_{DR}}\right)$$

★. Principle focus:-

Point on principle axis where all the light rays meet or appear to meet after refraction.

★. Refraction through Curved Surface:-

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

2012, 2017

★. Refraction by thin lens (Lens Makers formula)

Lens formula:- $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

Lens makers formula:- $\frac{1}{f} = (\mu_{Lm} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

where $\mu_{Lm} = \frac{\mu_L}{\mu_m}$

★. Note:-

For convex lens, $R_1 \rightarrow +ve$, $R_2 = -ve$

For concave lens, $R_1 \rightarrow -ve$, $R_2 = +ve$.

★ Linear Magnification for Lens :-

$$M = \frac{h'}{h} = \frac{v}{u}$$

If $M \rightarrow +ve$ (Virtual & Erect)

$M \rightarrow -ve$ (Real & Inverted)

★ Note :-

① for Biconvex lens :- $R_1 = +R$, $R_2 = -R$

$$f = \frac{R}{2(\mu_{Lm} - 1)}$$

② for Plano Convex Lens :- $R_1 = \infty$, $R_2 = R$.

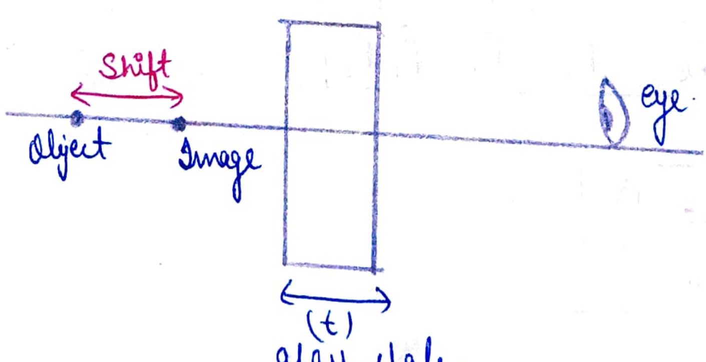
$$f = \frac{R}{\mu_{Lm} - 1}$$

$$f_{Biconvex} = \frac{1}{2} f_{Plano\ convex}$$

③ f for convex lens $= +ve$

f for Concave lens $= -ve$.

④



$$Shift = t\left(1 - \frac{1}{\mu}\right)$$

Shift will be always in direction of incident Ray.

Power of lens :-

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The tangent of the angle by which it converges or diverges a beam of light at unit distance from optical centre is called Power.

$$\delta = P = \frac{1}{f}$$

Here f is in meter

→ Unit → Dioptre ($1D = 1m^{-1}$)

→ Power for Convex = +ve
Concave = −ve

2015

Combination of thin lenses :-

$$\frac{1}{f_e} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + \text{------} + \frac{1}{f_n}$$

Power:- $P = P_1 + P_2 + P_3 + \text{-----} + P_n$

Magnification :- $M = M_1 \times M_2 \times M_3 \times \text{-----} \times M_n$

Note :-

① If 'd' distance betn both lens.

$$\frac{1}{f_e} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

②

$$\frac{f_w}{f_a} = \frac{(\mu_{La} - 1)}{(\mu_{Lw} - 1)}$$

✲ Refraction Through Prism:-

- **Prism:-** It is an arrangement in which incident and refracting surfaces are not parallel to each other.

- **Angle of Prism:-** The angle b/w incident & refracting face is called angle of prism (A).

✲ Refraction through prism (Relation b/w angle of deviation, prism angle, angle of minimum deviation).

Prism Angle :- $A = r_1 + r_2$

Angle of deviation :- $\delta = i + e - A$

- Angle of deviation depends on :-

1. Angle of incidence (i)
2. Angle of prism ($A\uparrow, \delta\uparrow$)
3. Refractive index of prism ($\mu\uparrow, \delta\uparrow$)
4. Wavelength of light ($\lambda\uparrow, \delta\downarrow$)

- Conditions for Minimum deviation:-

1. $i = e$
2. $r_1 = r_2$
3. At δ_m, intermediate ray becomes parallel to base of prism.

$$\delta_{min} = 2i - A$$

Refractive Index of prism :-

$$\mu_p = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Case:- If prism is thin ($A \le 10^\circ$), then, minimum deviation

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$$\delta_{min} = (\mu_p - 1)A$$

★. Optical Instruments :-

① Microscope ② Telescope

① **Far Point of Eye :-**
Maximum distance upto which eye can see object in relaxed state is called far point.

→ for normal eye, it is "Infinity".

② **Near Point :-**
Minimum distance upto which eye can see object without stress is called near point (D).

→ It is 25 cm for normal eye.

③ **Visual Angle :-**
Angle made by object or image on our eye.

$$\alpha = \frac{h}{u}$$ where h = height of object

$$\beta = \frac{h'}{v}$$ where h' = height of image

$$\alpha_{Max} = \frac{h}{D}$$ where D = 25 cm

★. Angular Magnification / Magnifying Power :-

$$M = \frac{\beta}{\alpha} = \frac{h'/v}{h/D}$$

[ability of instrument to increase visual angle]

A. Simple Microscope :-

The device which increases the size of object using one lens.

$$M = \frac{D}{u}$$

Case - I :- Image formed at infinity

$f = u$

$$M = \frac{D}{f}$$

Minimum Magnification. Normal, Relaxed condition of eyes.

Case - II :- Image at D (25cm)

$$M = 1 + \frac{D}{f}$$

Maximum Magnification. But maximum strain in eyes. ($V_{min} \rightarrow u_{min} \rightarrow M_{max}$)

• Range of Magnification :-

$$\frac{D}{f} \leq M \leq 1 + \frac{D}{f}$$

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A. Compound Microscope :-

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It consist two convex lens and used to increase size of very small objects.

→ focal length of objective lens is always less than eyepiece lens.

$$f_o < f_e$$

$$M = -\frac{V_o}{u_o}\left(\frac{D}{u_e}\right)$$

$$M = M_o M_e$$

- Case-I :- If ($D = 25\,cm$). final image is form at D

$$M = -\frac{V_o}{u_o}\left(1 + \frac{D}{f_e}\right)$$

Maximum Magnifying Power.

Length of tube :- $V_o + u_e$

- Case-II :- Image at infinity

$$M = -\frac{V_o}{u_o}\left(\frac{D}{f_e}\right)$$

Minimum Magnification

Length of tube :- $V_o + f_e$

2012, 14.

☆ Telescope :-

It is a device used to provide angular magnification to distant objects.

① Astronomical Refracting Telescope :-

It is device used to magnify and observe distinct images of heavenly bodies like stars, planets etc.

→ $f_o > f_e$

$$M = -\frac{f_o}{u_e}$$

Case-I :- final image is at D = 25 cm

$$M = -\frac{f_o}{f_e}\left(1+\frac{f_e}{D}\right)$$

Maximum magnification

→ Length of tube :-

$$L = f_o + u_e$$

$$L = V_o + u_e.$$

Case-II :- final image is at infinity

$$M = -\frac{f_o}{f_e}$$

-ve sign shows image is inverted.

→ Length of tube :-

$$L = f_o + f_e$$

2020

② Reflecting Telescope :-

The instrument in which mirror and lens both are used to see distant objects is called telescope.

- Construction :-

① Parabolic mirror (objective mirror) (concave mirror)

② Convex mirror (secondary mirror)

$$M = \frac{f_o}{f_e}$$

Case-I :- Image at D.

$$M = \frac{f_o}{f_e}\left(1+\frac{f_e}{D}\right)$$

Case-II :- Image at ∞

$$M = \frac{f_o}{f_e}$$

☆. Advantages of Reflecting type telescope over Refracting Telescope :-

① More brighter image
② High Magnification
③ Weight & cost is less.
④ No chromatic abberation

☆. Note :-

→ Spherical abberations are obtained due to both lens & mirror. So, in reflecting telescope, a secondary convex mirror is used to remove spherical abberations.

→ Lateral Shift or Lateral Displacement :-
The sideways displacement of a light ray when it passes through a transparent slab with parallel sides like glass.