Ch. 9

Ray Optics — Formula Sheet

1. Reflection of Light by Spherical Mirrors

(i) $\angle i = \angle r$ [Law of reflection]

(ii) $f = \frac{R}{2}$

$f \rightarrow$ focal length

$R \rightarrow$ Radius of curvature

(iii) $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ [Mirror formula] → For both type of mirrors

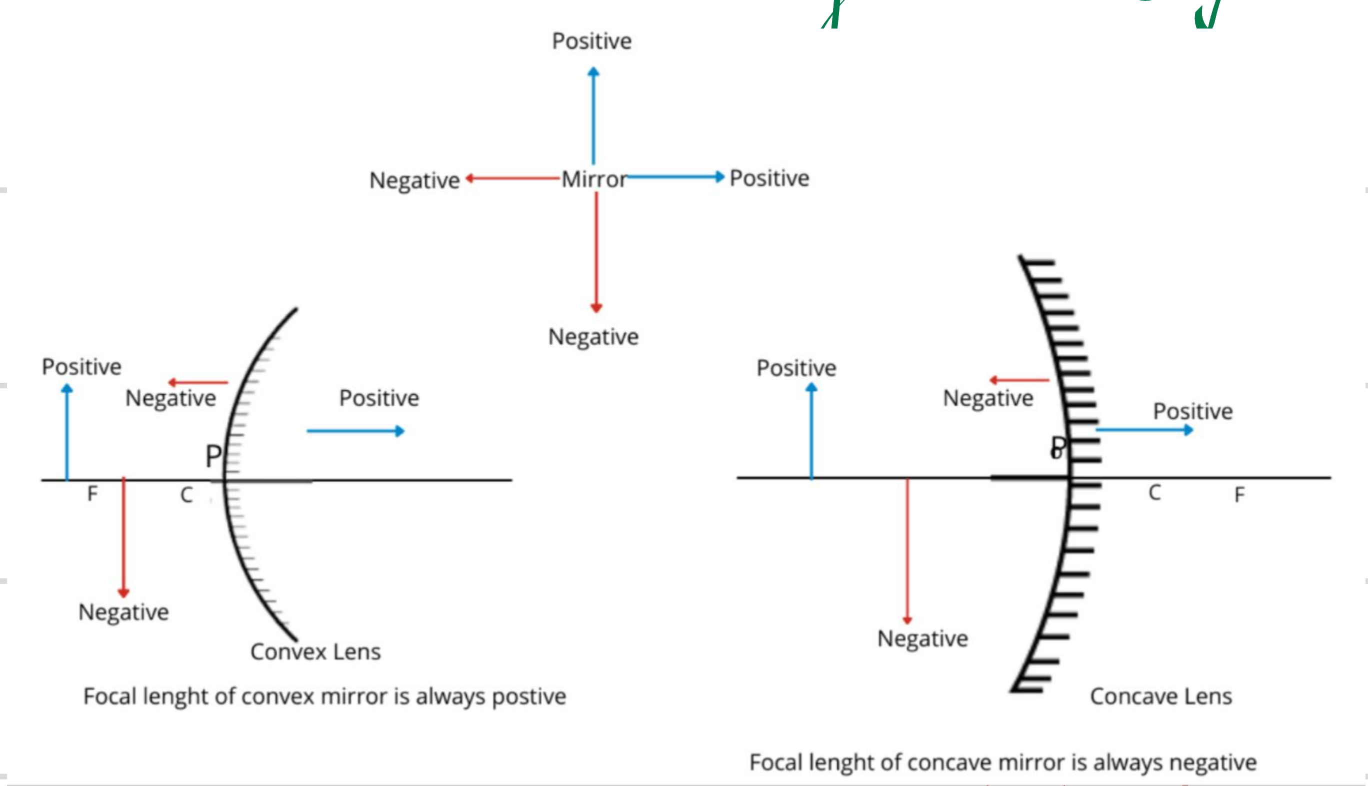
$f \rightarrow$ focal length of mirror [+ve for convex mirror, −ve for concave mirror]

$v \rightarrow$ Image distance from mirror

$u \rightarrow$ Object distance from mirror

Sign of u and v are taken according to sign convention.

Left of mirror −ve
Right of mirror +ve



(iv) Magnification

$$m = \frac{I}{O} = \frac{-v}{u} = \frac{f-v}{f} = \frac{f}{f-u}$$

$I \rightarrow$ height of image, $O \rightarrow$ height of object

m is +ve for virtual and erect image

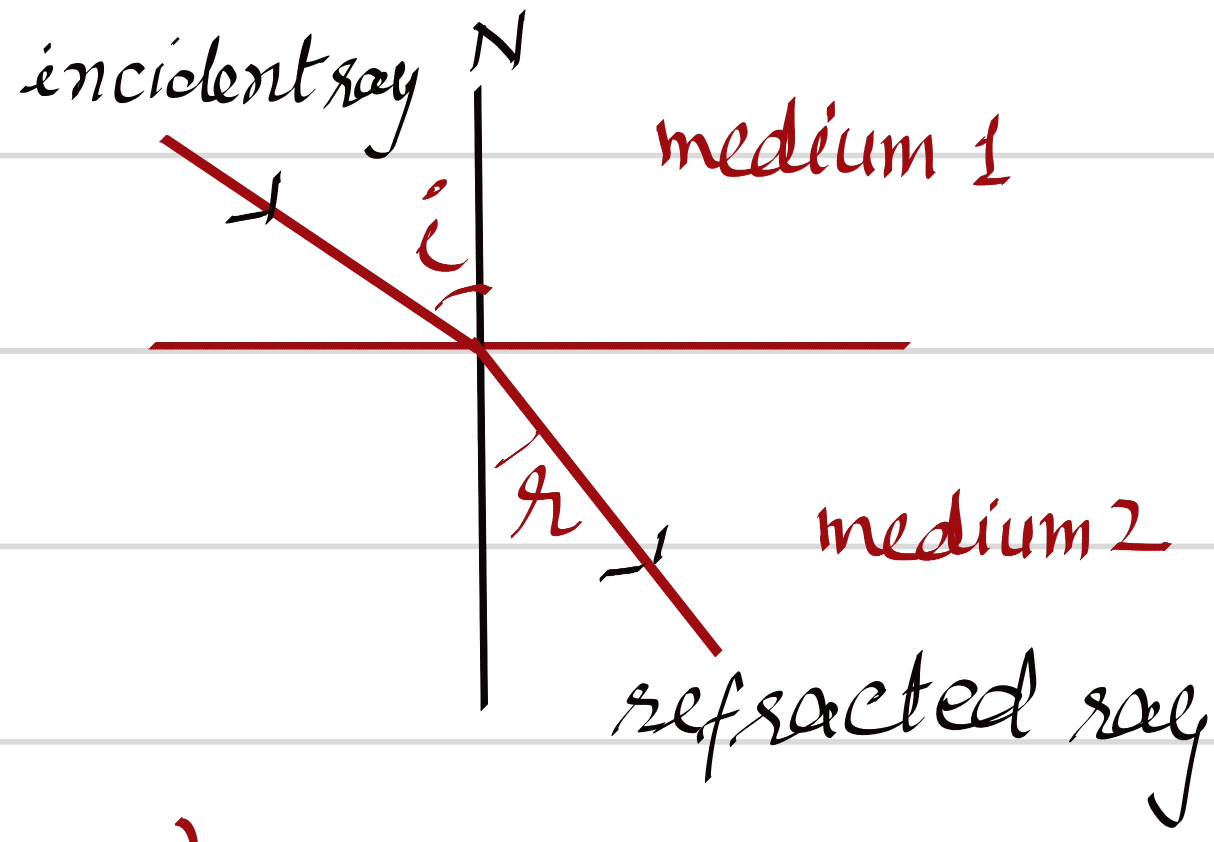
m is −ve for real and inverted image

2. Refraction of light (Light goes one medium to another medium)

(i) Snell's law $n_{21} = \frac{\sin i}{\sin r} = \frac{n_2}{n_1}$

$n_{21} = \frac{n_2}{n_1}$

$n_{21} \rightarrow$ Refractive index of medium 2 with respect to medium 1.



(ii) If light travels from vacuum / air to any other medium then

Refractive index (n or μ)

$$n_{21} = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{c}{v}$$

$c = 3\times10^8$ m/s

$c \rightarrow$ speed of light in space/vacuum/air

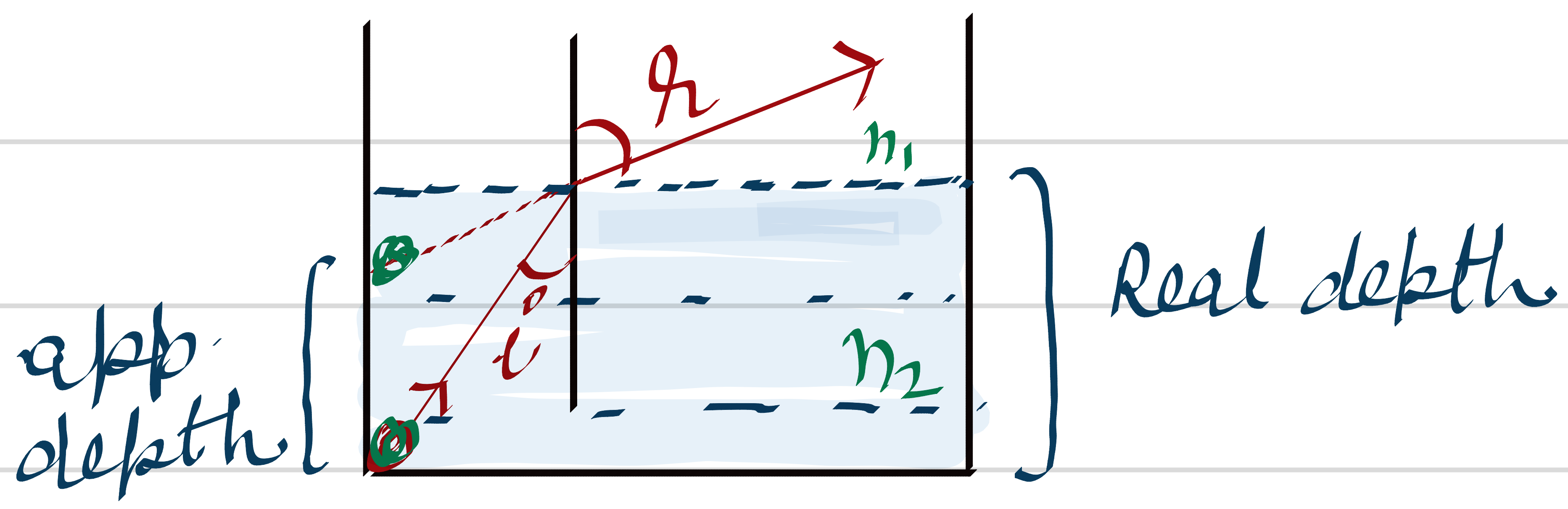
$v \rightarrow$ speed of light in any medium

also,
$$n_{12} = \frac{n_1}{n_2} = \frac{v_2}{v_1}$$

$n_{12} \rightarrow$ Refractive index of medium 1 w.r. to medium 2.

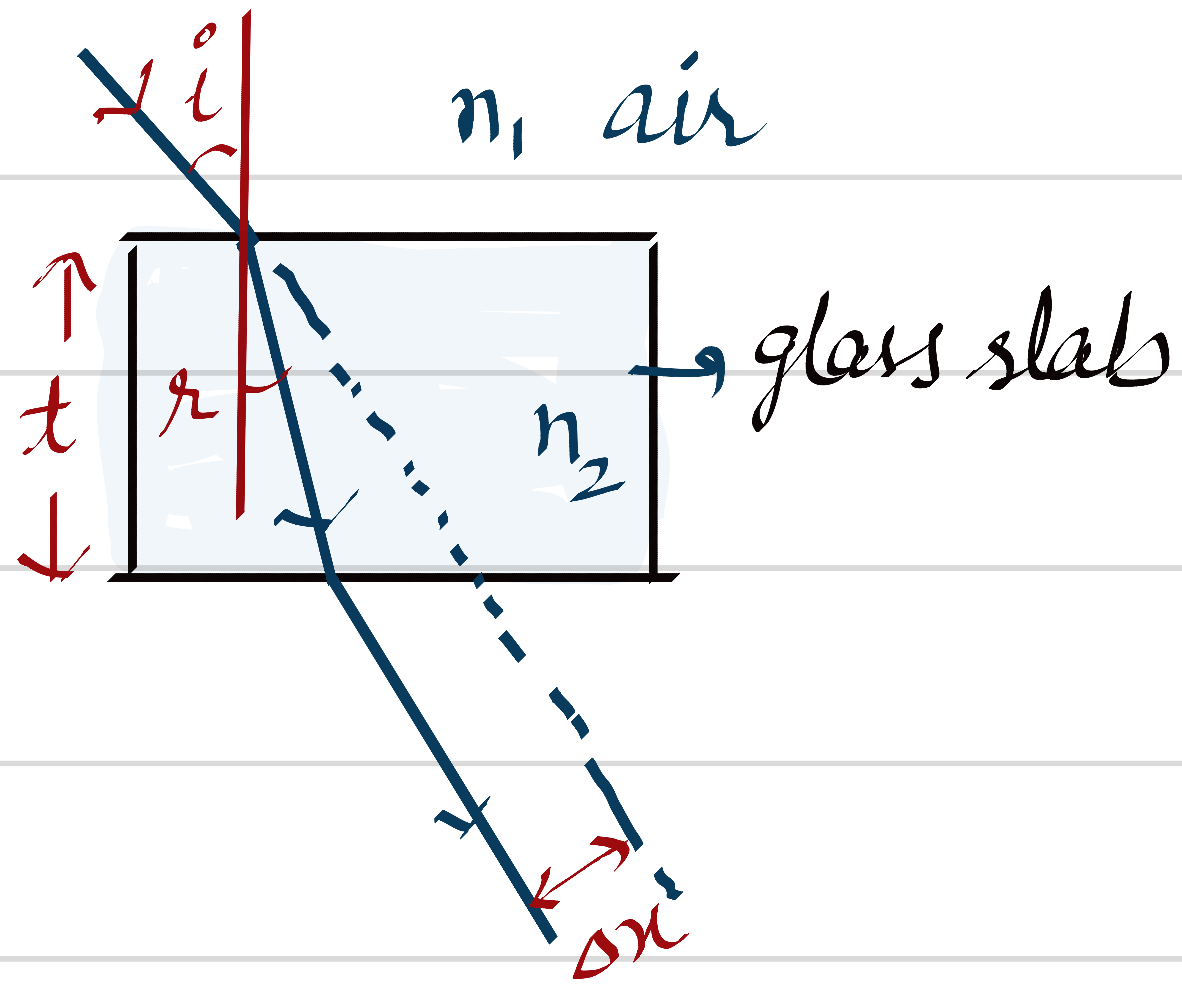
3. Relation b/w Real depth and Apparent depth

$$n_{21} = \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{h_{Real}}{h_{apparent}}$$



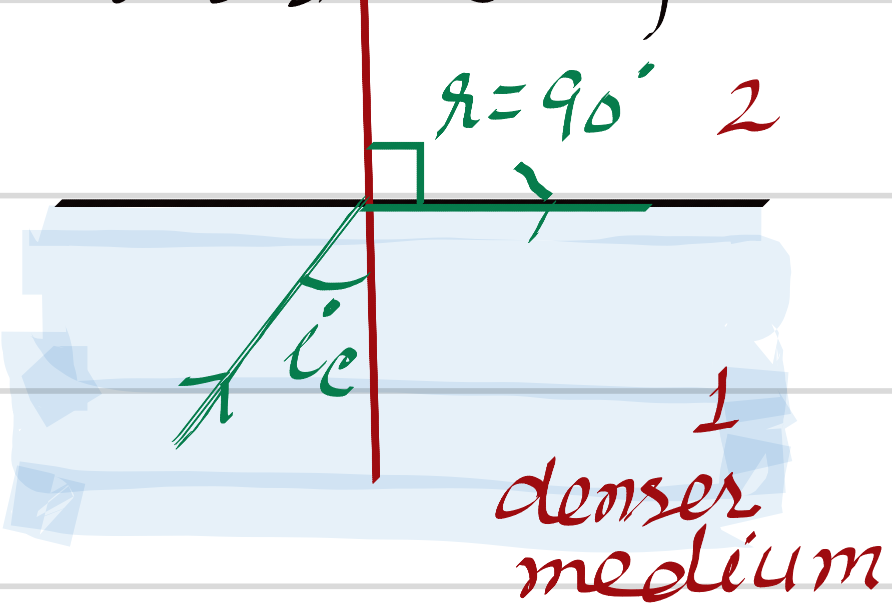
4. Lateral Shift

$$\Delta x = \frac{t \sin(i-r)}{\cos r}$$



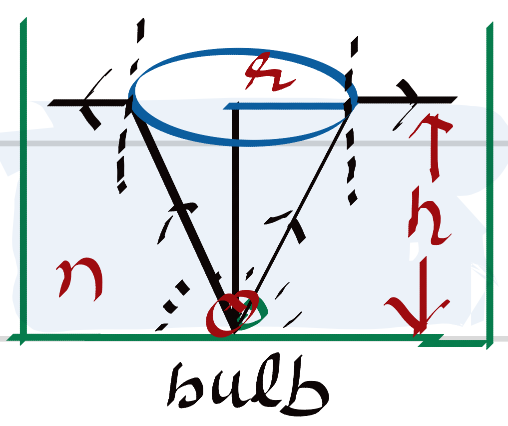
5. Relation between critical angle (i_c) refractive index (n) [Total internal Reflection]

$$n_{denser} = n_{12} = \frac{1}{\sin i_c}$$



radius of circular area of light

$$r = \frac{h}{\sqrt{n^2-1}}$$ (h = height)

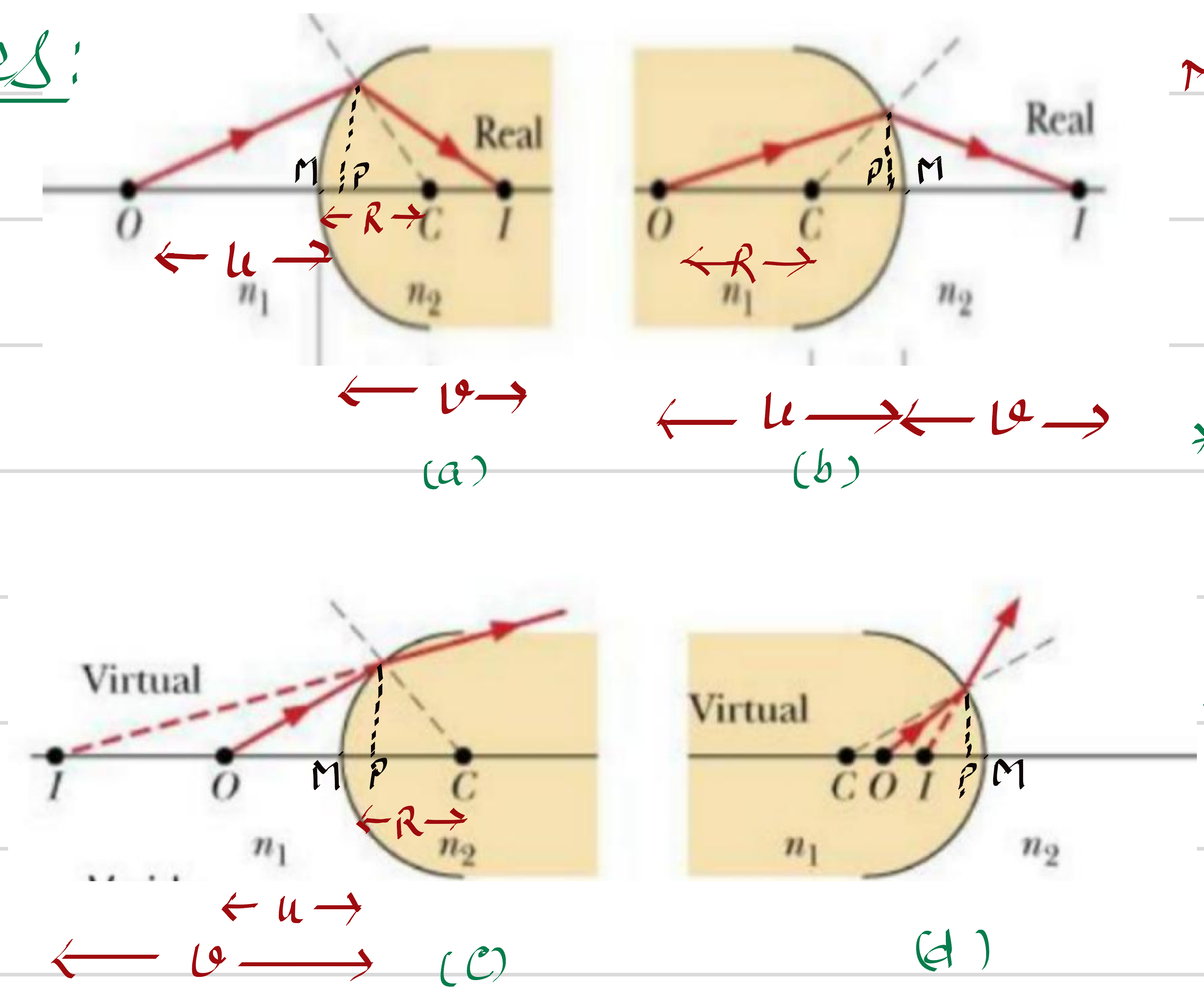


* higher the R.I of denser medium, smaller the critical angle.

6. Refraction at spherical surface

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

Six Cases:



M and P are very close

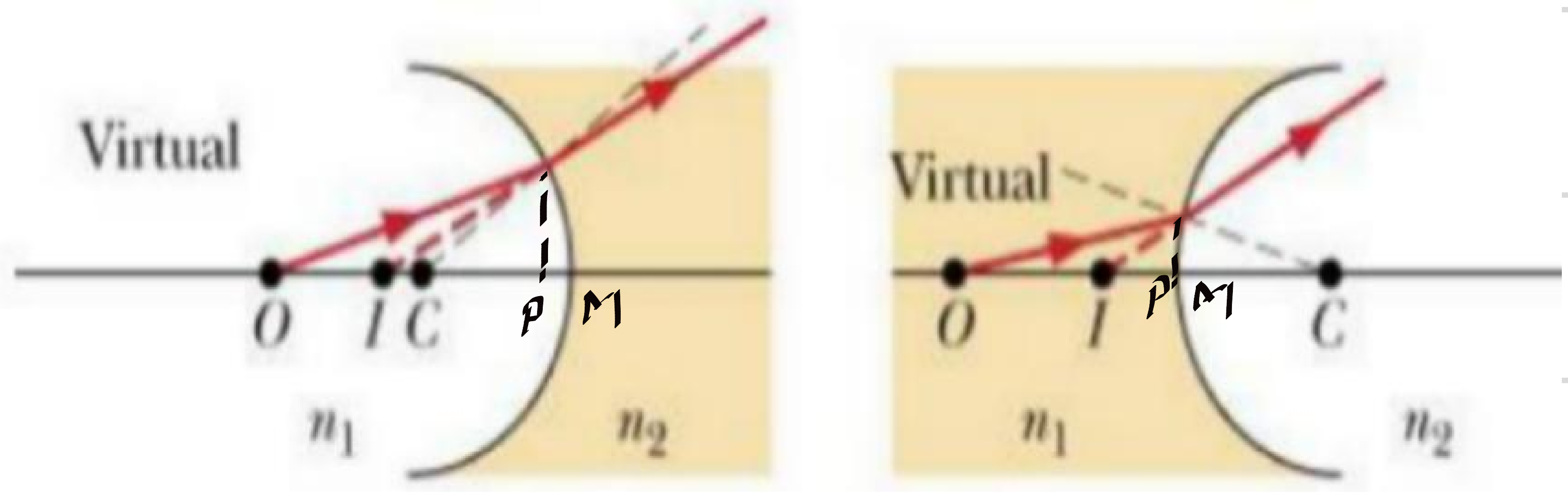
MO ≈ PO = u

MC ≈ PC = R

MI ≈ PI = v

*(Sign of u, v and R are taken by sign convention)

*[−ve for left of M
+ve for right of M]



(e) (f)

7. Lens formula (For both lenses - Concave & convex)

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$f \rightarrow$ focal length

$v \rightarrow$ image distance

$u \rightarrow$ object distance

(Sign of u and v are taken according to sign convention. Focal length f → +ve for convex, → -ve for concave)

8. Lens maker's formula

$$\frac{1}{f} = (n_{21}-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$n_1 \rightarrow$ R.I of medium

$n_2 \rightarrow$ R.I of lens

(Sign of R_1 and R_2 are taken according to sign convention)

* If $n_1 > n_2$, behaviour of lens changes.

i.e concave lens behaves as convex and vice-versa.

9. Magnification of lenses

$$m = \frac{I}{O} = \frac{v}{u}$$

$I \rightarrow$ height of image

$O \rightarrow$ height of object

m is +ve for virtual and erect image

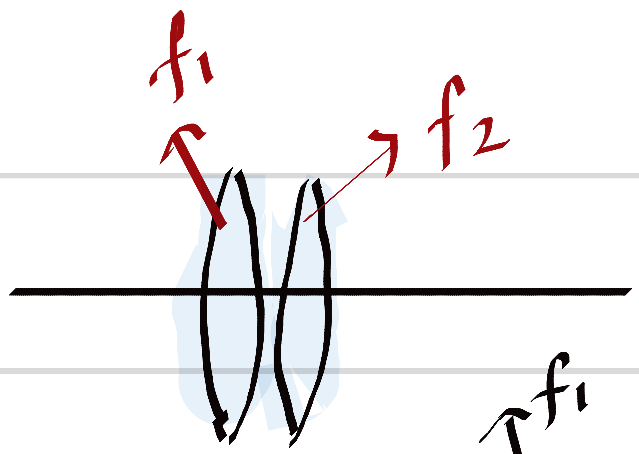
m is -ve for real and inverted image

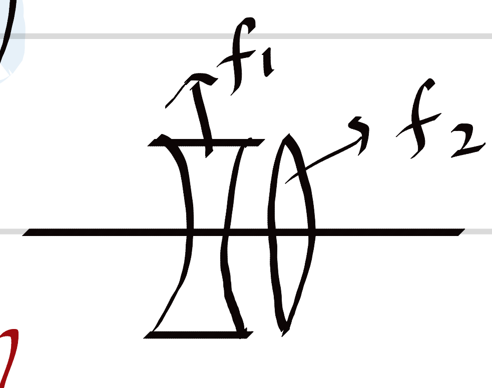
10. Power of lens

$$P = \frac{1}{f(m)} = \frac{100}{f(cm)}$$

SI unit of P is Dioptre (D)

11. Combination of lenses





(i) For focal length of combination

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$ [for two lenses]

[* Focal lengths are taken with sign]

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \cdots \frac{1}{f_n}$$ [for n lenses]

(ii) For power of combination

$$P = P_1 + P_2$$ [For two lenses]

$$P = P_1 + P_2 + \cdots P_n$$ [For n lenses]

(iii) For magnification

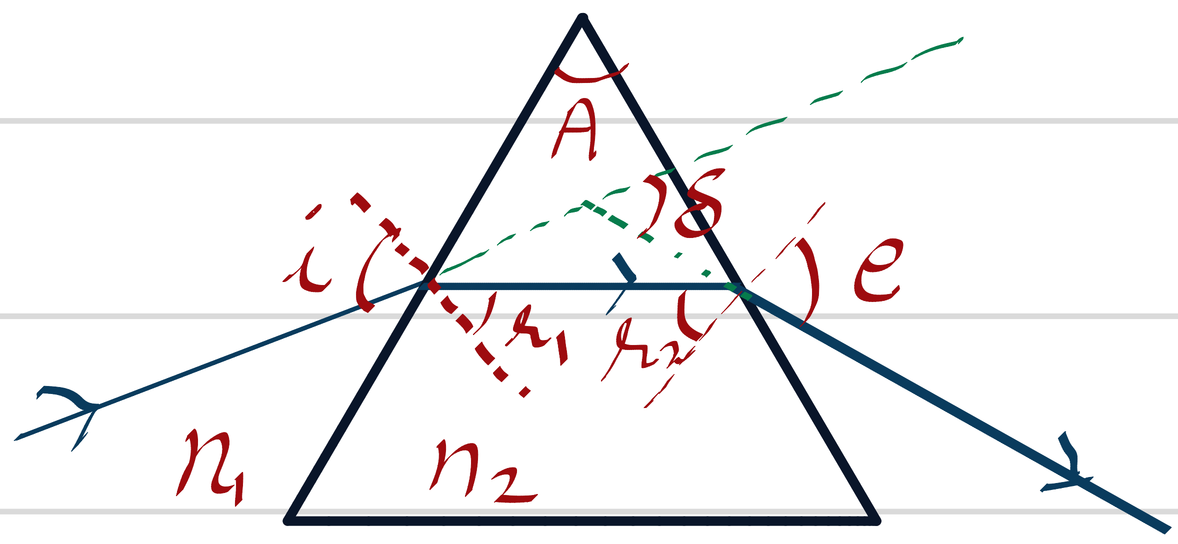
$$m = m_1 m_2 \cdots$$

* Magnifications are multiplied

12. Dispersion of light by Prism

(1) Angle of deviation δ

$$\delta = i + e - A$$



For minimum angle of deviation

$$\delta_m = 2i - A \quad [\because i = e]$$

Refractive index of prism

$$n_{21} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

$A \rightarrow$ Prism angle
$i \rightarrow$ incident angle
$e \rightarrow$ emergent angle
$\delta \rightarrow$ angle of deviation
[$n_{21} \rightarrow$ R.I of prism meterial]

For thin prism

$$\delta_m = (n_{21} - 1) A$$

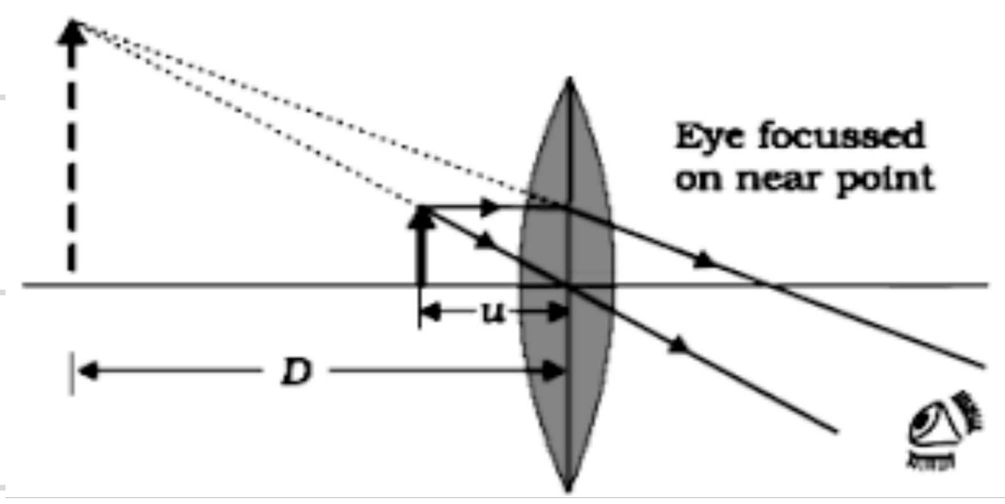
13. Magnifying Power of Microscope

(1) Simple Microscope

(i) Final image at D

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

$D \rightarrow$ Least distance of distinct vision = 25 cm (near point)



(ii) Final image at ∞

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

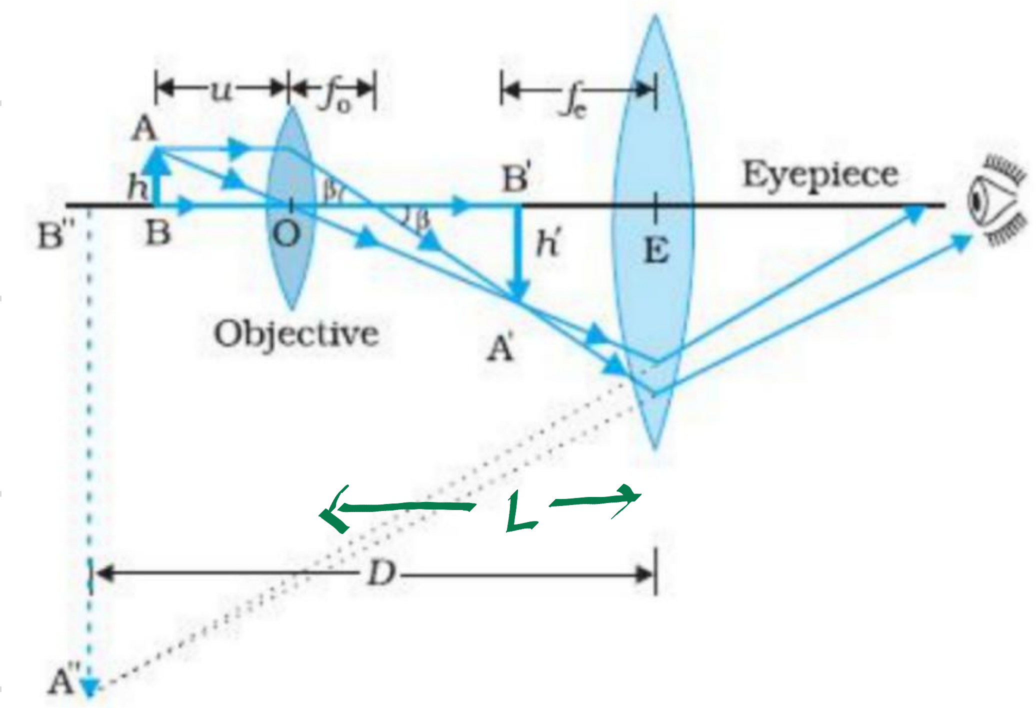
(11) Compound Microscope

(i) Final image at D

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

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

[Since image is formed very close to eyepiece $u_o \approx f_o$ and $v_o \approx L$]



(ii) Final image at ∞ [Normal adjustment]

$$m = \frac{-L}{f_o} \cdot \frac{D}{f_e}$$

14. Magnifying Power of Telescope

(i) Final image at D [near point adjustment]

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

$$\left[\because m = -\frac{f_o}{u_e},\ \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}\right]$$

(ii) Final image at ∞ [normal adjustment]

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

Tube length $L = f_o + f_e$