JEE MAIN

RAY OPTICS FORMULAE

Now that's how you REVISE

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RAY OPTICS

- REFLECTION
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- REFRACTION (SNELL'S LAW)
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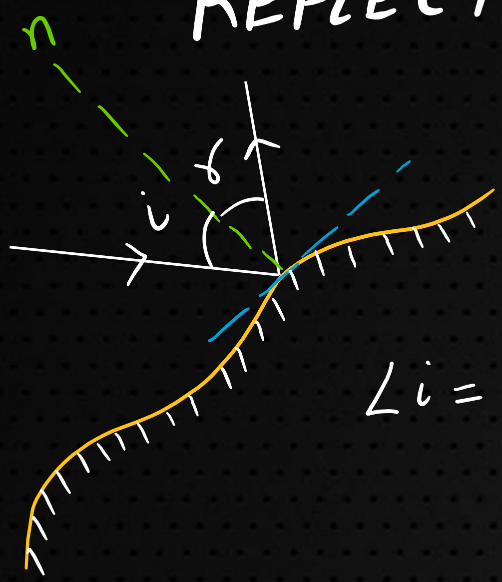
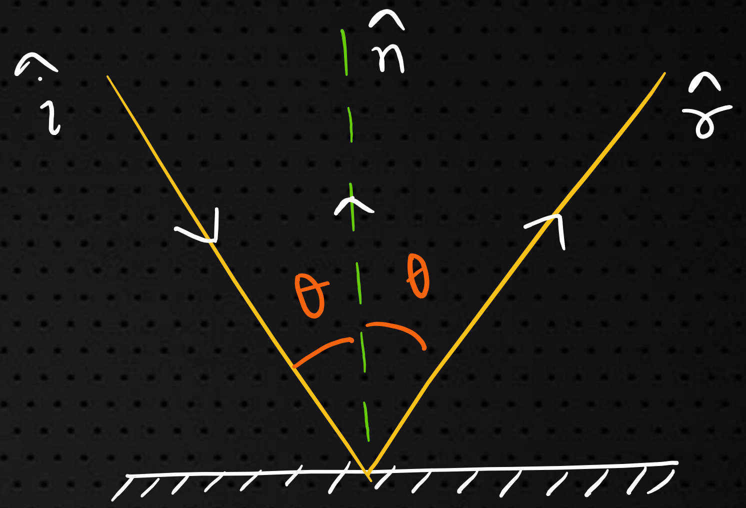
1. REFLECTION



$\angle i = \angle r$

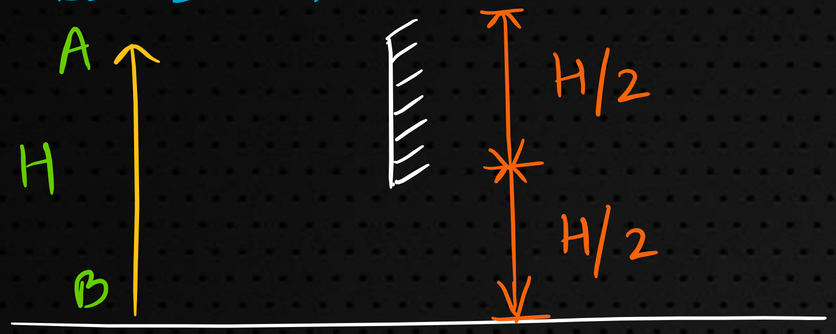
2. VECTOR FORM OF REFLECTED RAY



$$\boxed{\hat{r} = \hat{i} - 2(\hat{i}\cdot\hat{n})\cdot\hat{n}}$$

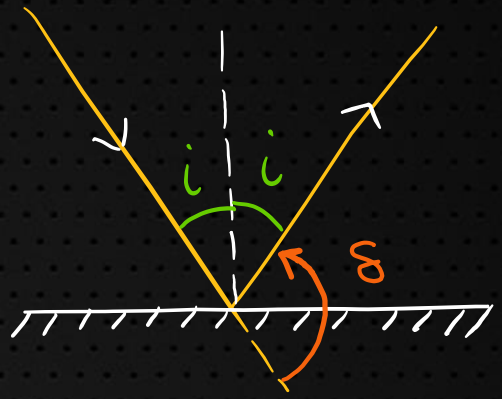
$\hat{i}$, $\hat{r}$ and $\hat{n}$ are unit vectors along incident ray, reflected ray and normal.

3. MINIMUM MIRROR LENGTH TO SEE ONES IMAGE



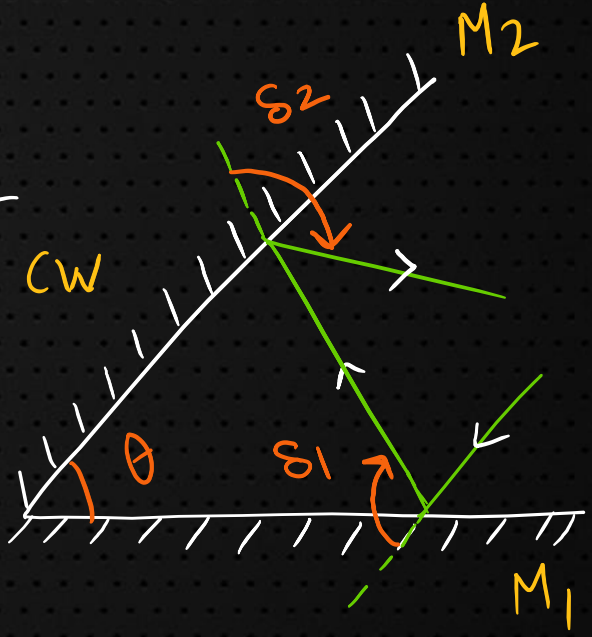
* Assuming eye level at A

4. ANGLE OF DEVIATION (δ)



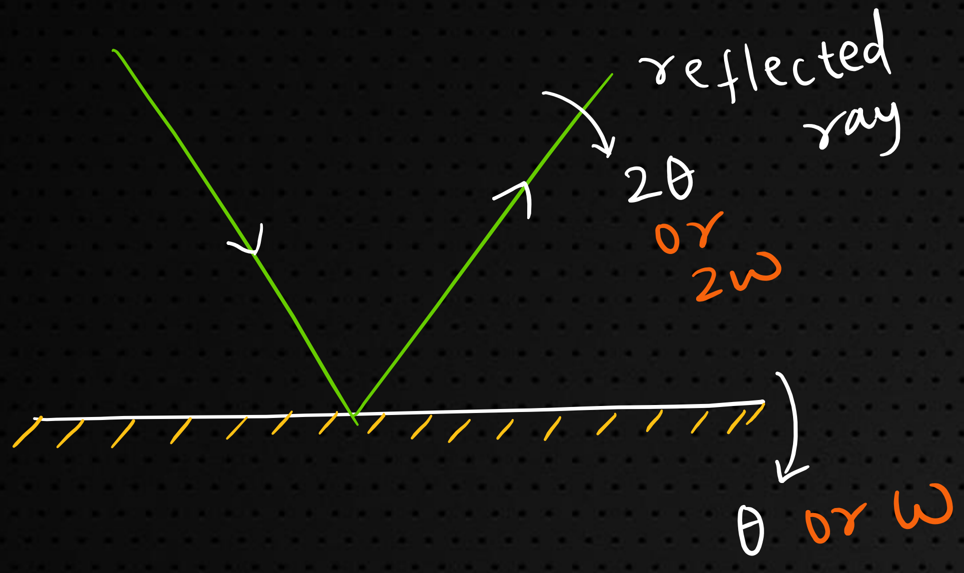
$$\delta = \pi - 2i$$

Here it is ACW rotation

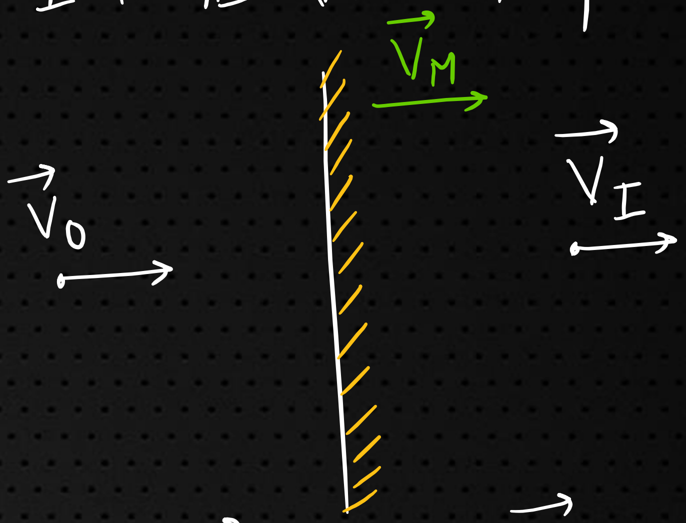


$$\delta_{NET} = \delta_1 + \delta_2$$
$$= 2\pi - 2\theta \quad \text{CW}$$

5. MIRROR ROTATION



6. IMAGE VELOCITY



$$\vec{V}_{O/M} = -\vec{V}_{I/M}$$

$$\Rightarrow \vec{V}_O - \vec{V}_M = -(\vec{V}_I - \vec{V}_M)$$

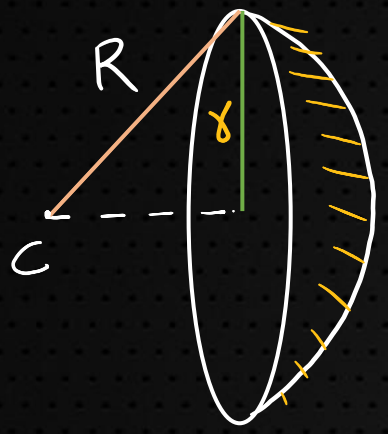
$$\Rightarrow \boxed{\vec{V}_I = 2\vec{V}_M - \vec{V}_O}$$

* these are all velocities Normal to mirror surface.

SPHERICAL MIRROR

7. MIRROR IMPORTANT TERMS

(a)



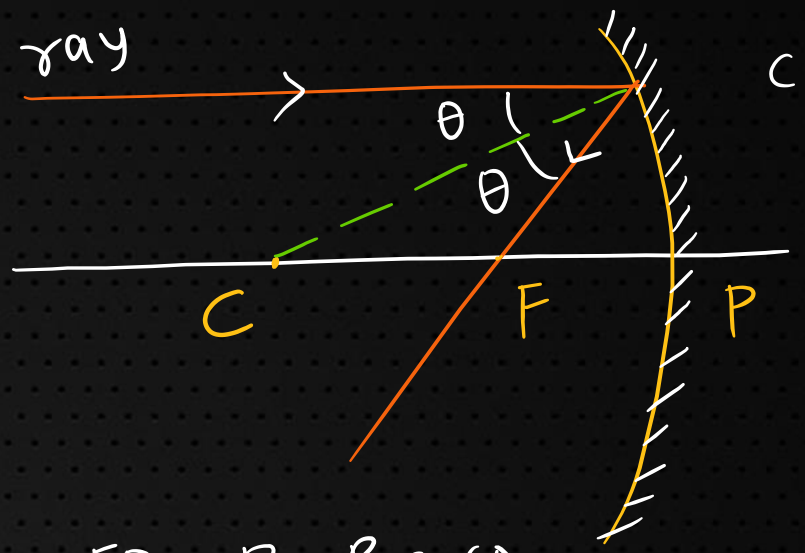
r : radius of aperture

$2r$: Aperture size

C : center of Curvature

R : Radius of Curvature

(b)



$CP = R$

$$FP = R - \frac{R}{2}\sec\theta$$

NOTE:

If rays were PARAXIAL (close to axis)

then θ is very small.

$\Rightarrow$ F is FOCUS

and $\boxed{FP = \frac{R}{2}}$

8. MIRROR FORMULAE

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ or $\boxed{v = \frac{uf}{u-f}}$

- Put u, f with sign
- f is -VE for concave and +VE for convex Mirror

9. MAGNIFICATION

→ Transverse, $m = \frac{h_i}{h_o} = \frac{-v}{u} = -\frac{f}{u-f}$

* Put terms with sign
* Errect image ⇒ m is +VE
* INVERTED ⇒ m is -VE

→ LONGITUDNAL

$m = \frac{\text{Image Length along P.A.}}{\text{Object Length along PA}}$

EX:

$m = \frac{A'B'}{AB}$

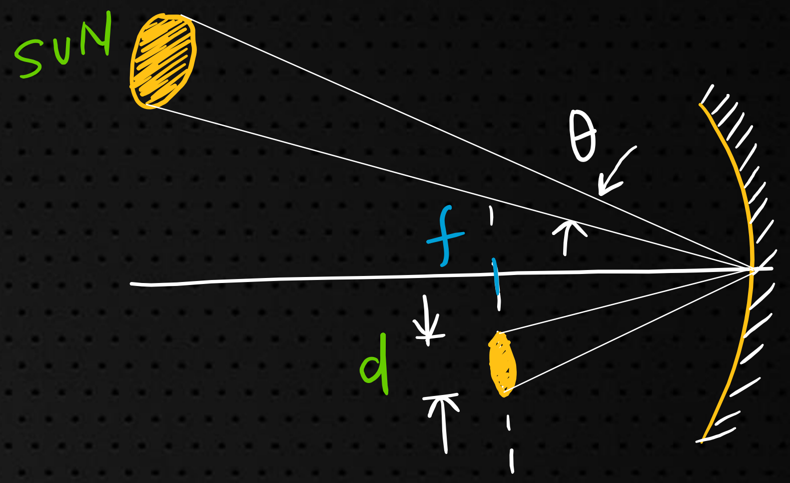
10. Six standard cases of image formation in CONCAVE MIRROR.

→ Must remember them all

→ Magnified image

- Object between f and C (Real image) m is -VE
- Object between Pole and focus (Virtual image) m is +VE.

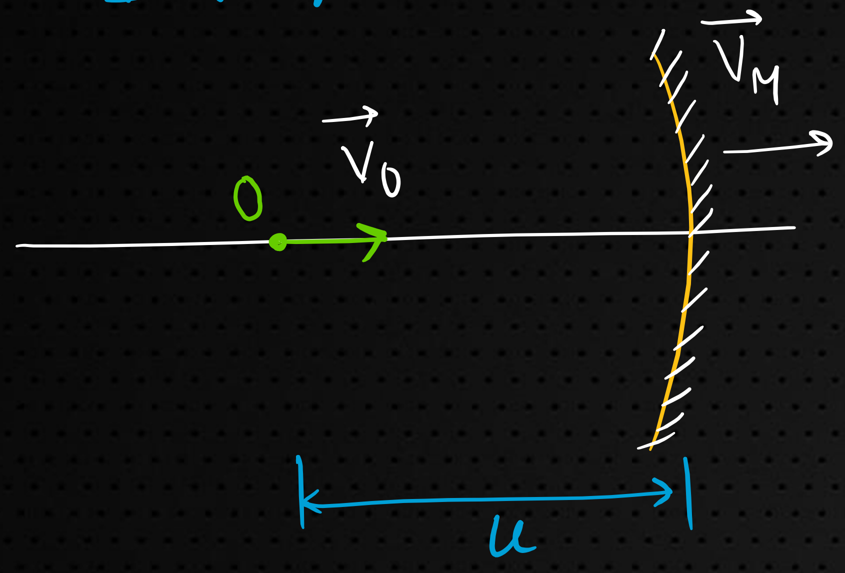
11. Diameter of image of SUN (Distant object)



$d = \theta f$

→ θ in radians

12. IMAGE VELOCITY



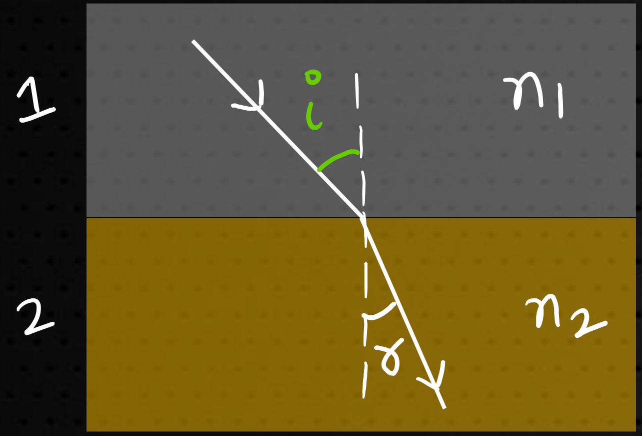
$$V_{I/M} = -\left(\frac{v}{u}\right)^2 V_{O/M}$$

If $V_M = 0$ then, $V_I = -\left(\frac{f}{u-f}\right)^2 V_O$

↳ put u, f, V_O with sign

REFRACTION

13. SNELL'S LAW



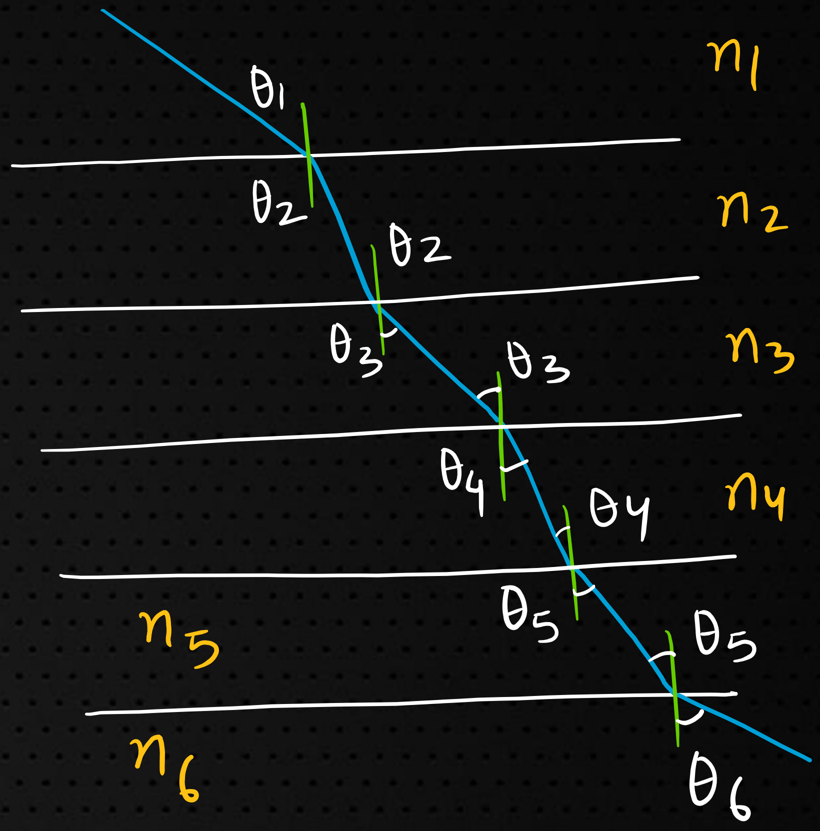
(a.) $n_1 \sin i = n_2 \sin r$

(b) As per this fig.
$n_2 > n_1$

(c) $\dfrac{n_2}{n_1} = \dfrac{V_1}{V_2} = \dfrac{\lambda_1}{\lambda_2}$

V_1 and V_2 are speed of light in medium 1 and 2.

#

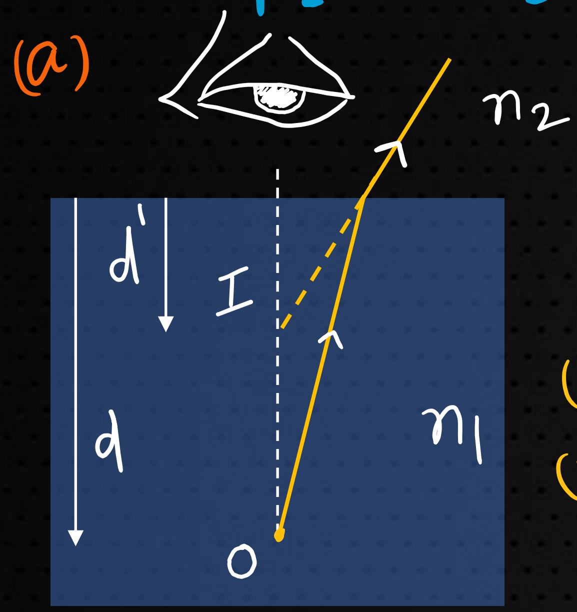


$n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3$
$= \dots\dots = n_6 \sin\theta_6$

$\therefore \boxed{n \sin\theta = \text{constant}}$

14. IMAGE FORMATION DUE TO PLANE SURFACE

(a)



$$\boxed{d' = d\,\frac{n_2}{n_1}}$$

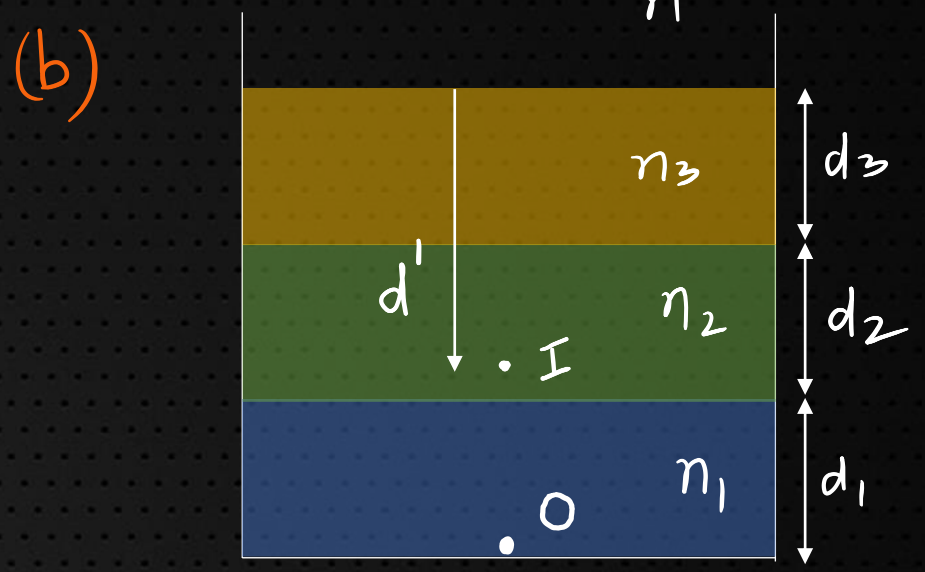
(1.) d' is Apparent depth

(2.) $d' < d$ If $n_1 > n_2$

$d' > d$ If $n_1 < n_2$

(3.) Paraxial rays or observer is looking from above.

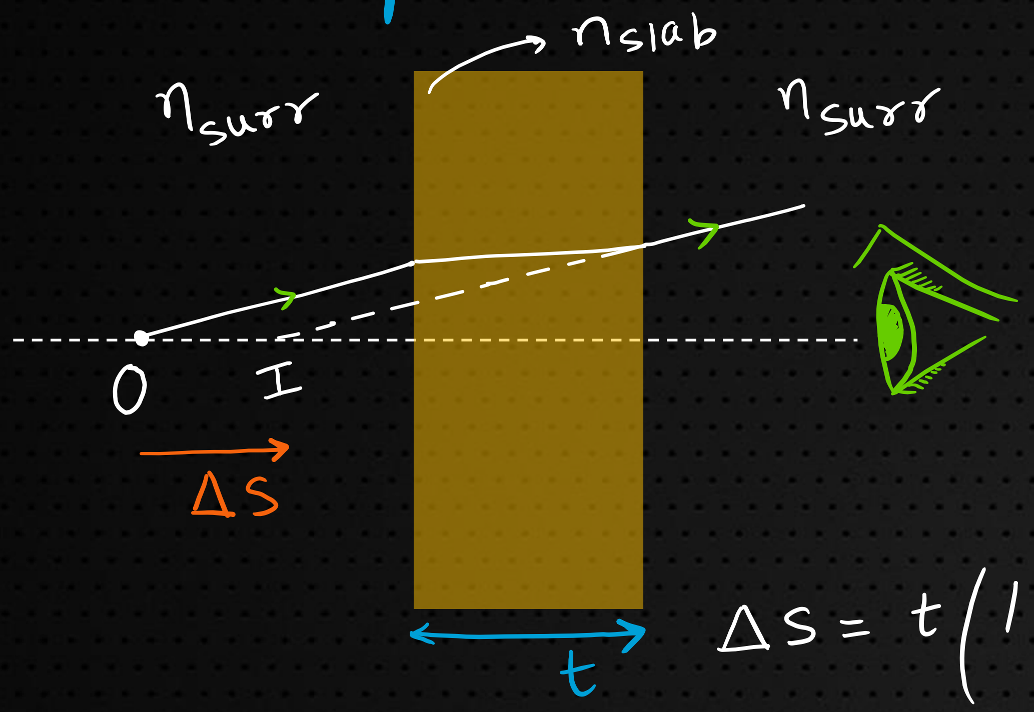
(b)



$$d' = n\left(\frac{d_1}{n_1} + \frac{d_2}{n_2} + \frac{d_3}{n_3}\right)$$

15. SHIFTING DUE TO SLAB

(a)

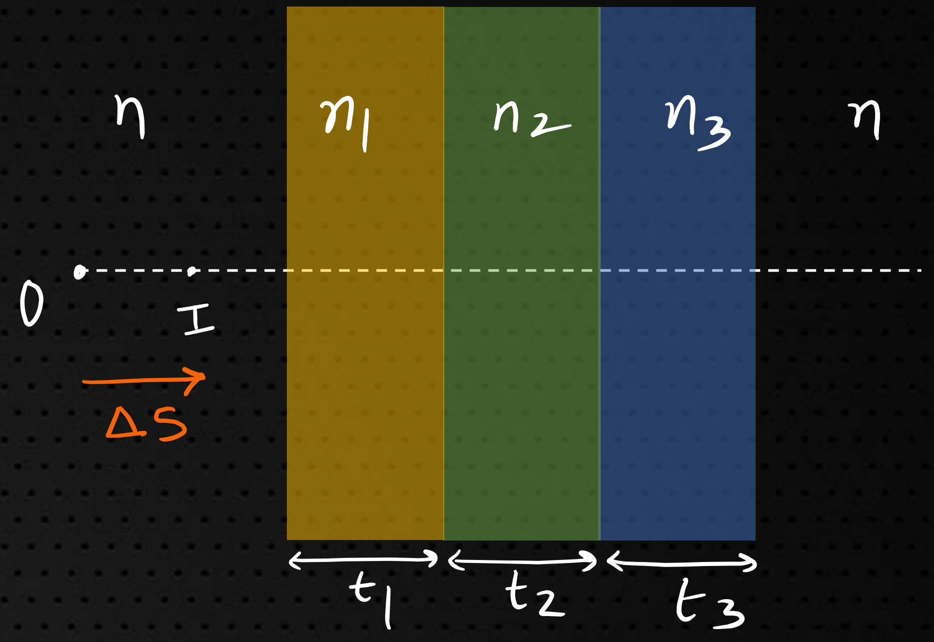


$$\Delta S = t\left(1 - \frac{n_{surr}}{n_{slab}}\right)$$

(1.) valid for paraxial

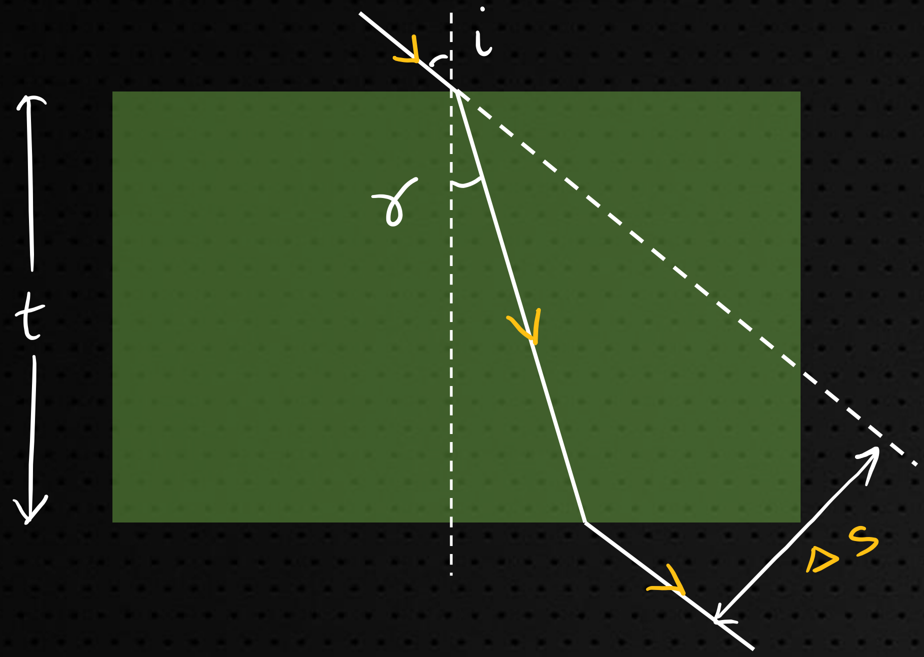
(2.) valid only if medium around slab is same

(b)



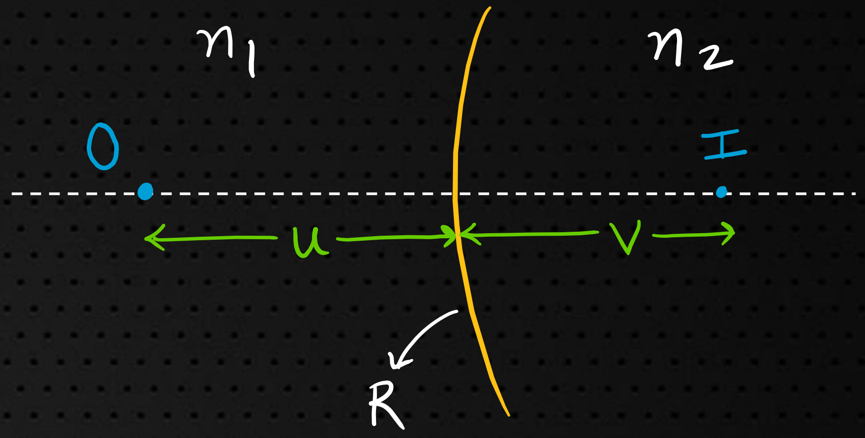
$$\Delta S = t_1\left(1 - \frac{n}{n_1}\right) + t_2\left(1 - \frac{n}{n_2}\right) + t_3\left(1 - \frac{n}{n_3}\right)$$

16. LATERAL DISPLACEMENT



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

17. SPHERICAL REFRACTION IMAGE FORMULAE



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

(1.) Put u, v, R with sign

(2.) n_2 is medium where rays are going

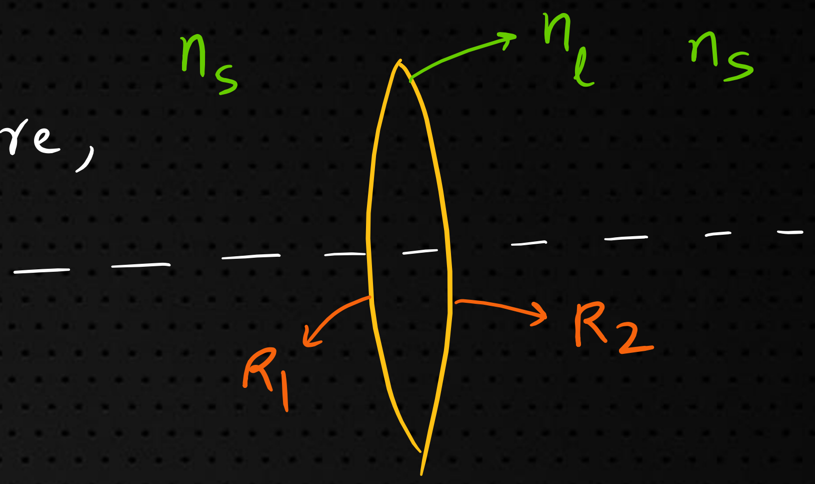
18. THIN LENSES: LENS FORMULAE

$$\frac{1}{V} - \frac{1}{u} = \frac{1}{f} \quad \text{or} \quad V = \frac{uf}{u+f}$$

(1.) f is +VE for converging lens and -VE for diverging lens

(2.) Valid for paraxial rays

Here,



$$\frac{1}{f} = \left(\frac{n_l}{n_s} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

(1.) Valid only if lens is surrounded by only one medium.

(2.) Put R_1, R_2 with sign

LENS MAKER'S FORMULAE

19. MAGNIFICATION

$$\boxed{m = \frac{h_i}{h_o} = \frac{V}{u} = \frac{f}{u+f}}$$

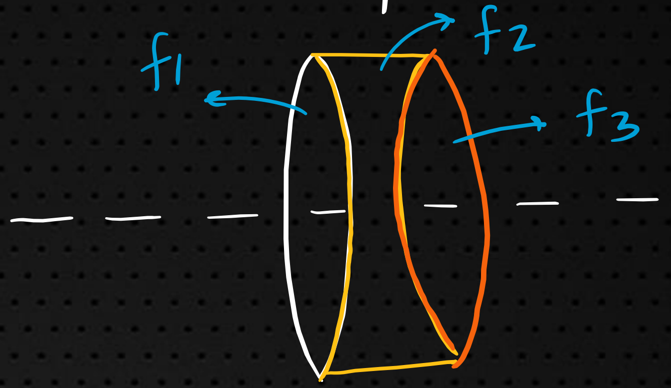
↳ Transverse mag.

20. OPTICAL POWER

$$P = \frac{1}{f_\ell}$$

- UNIT: DIOPTER
- put f_ℓ with sign
- put f_ℓ in meters

21. Combination of thin lenses, f_{eq}



$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

(1.) put f_1, f_2, f_3 with sign

(2.) Lenses must be in contact

(3.) f_1, f_2, f_3 are individual focal lengths w.r.t surrounding medium.

22. COMBINATION OF LENS and MIRRORS (f_{eq})

$$\frac{1}{f_{eq}} = \frac{1}{f_m} - \frac{2}{f_l}$$

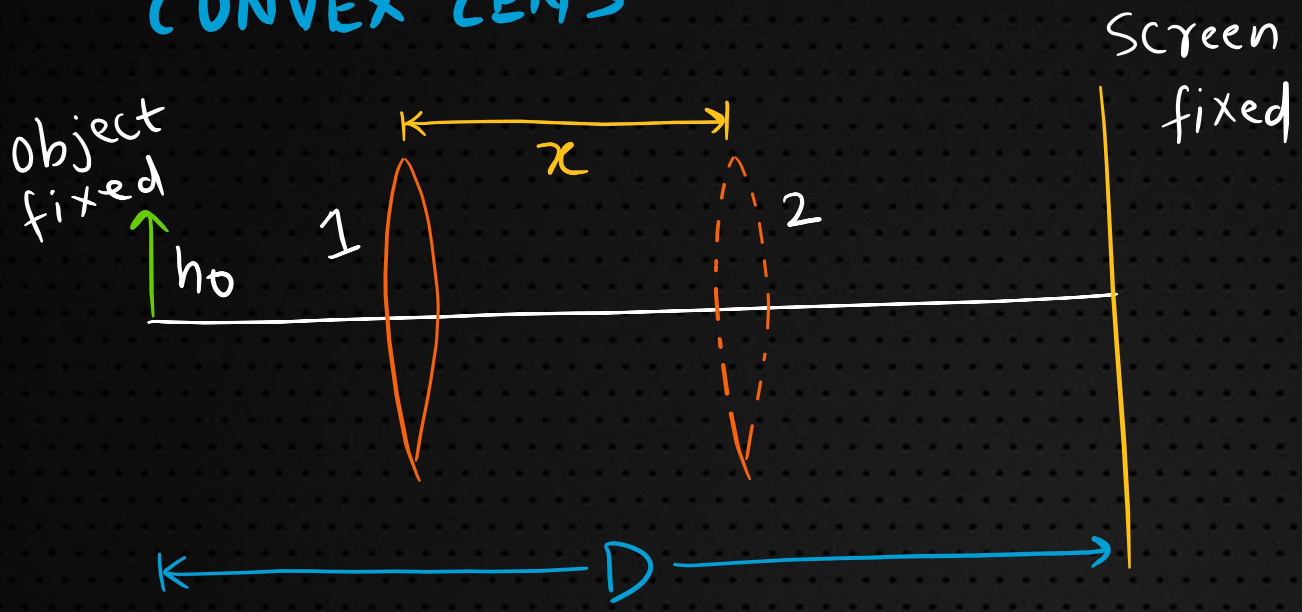
(1.) Put f_m, f_l with sign.

(2.) If f_{eq} is +VE $\Rightarrow$ Equivalent Convex mirror

If f_{eq} is −VE $\Rightarrow$ Concave mirror

If f_{eq} is ∞ $\Rightarrow$ Plane Mirror

23. DISPLACEMENT METHOD TO MEASURE FOCAL LENGTH OF CONVEX LENS



$$\boxed{f = \frac{D^2 - x^2}{4D}}$$

D : Distance between screen and object

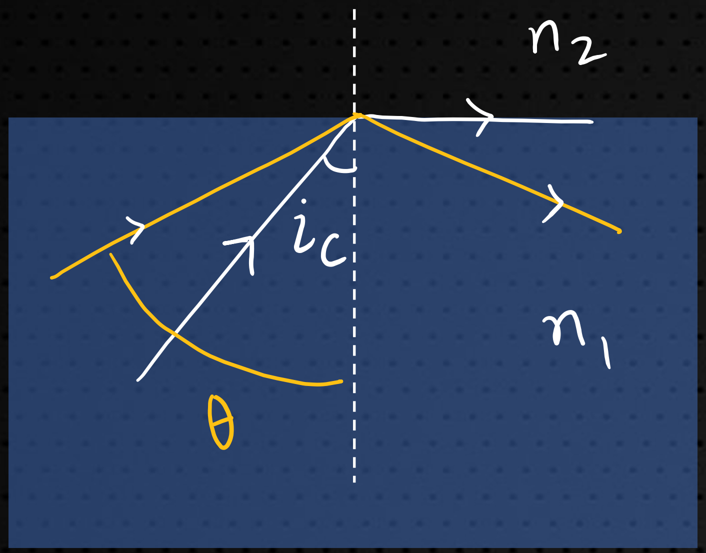
x : Distance between two positions of lens.

$$\boxed{h_o = \sqrt{h_1 h_2}}$$

↳ h_1 : image height when LENS is at pos^n 1

↳ h_2 : when at pos^n 2

24. CRITICAL ANGLE AND TIR



(1.) Here $n_1 > n_2$

(2.) i_c : critical angle for which $r = 90^\circ$

(3.) If $\theta > i_c \Rightarrow$ TIR

$$\sin i_c = \frac{n_2}{n_1} \quad \text{or} \quad \boxed{i_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)}$$

NOTE: Question type

(1.) OPTICAL FIBRE

(2.) slab or prism

(3.) Light source in liquid, find area of patch at top surface.

25. PRISM

(1.) A: ANGLE of PRISM, $A = r_1 + r_2$

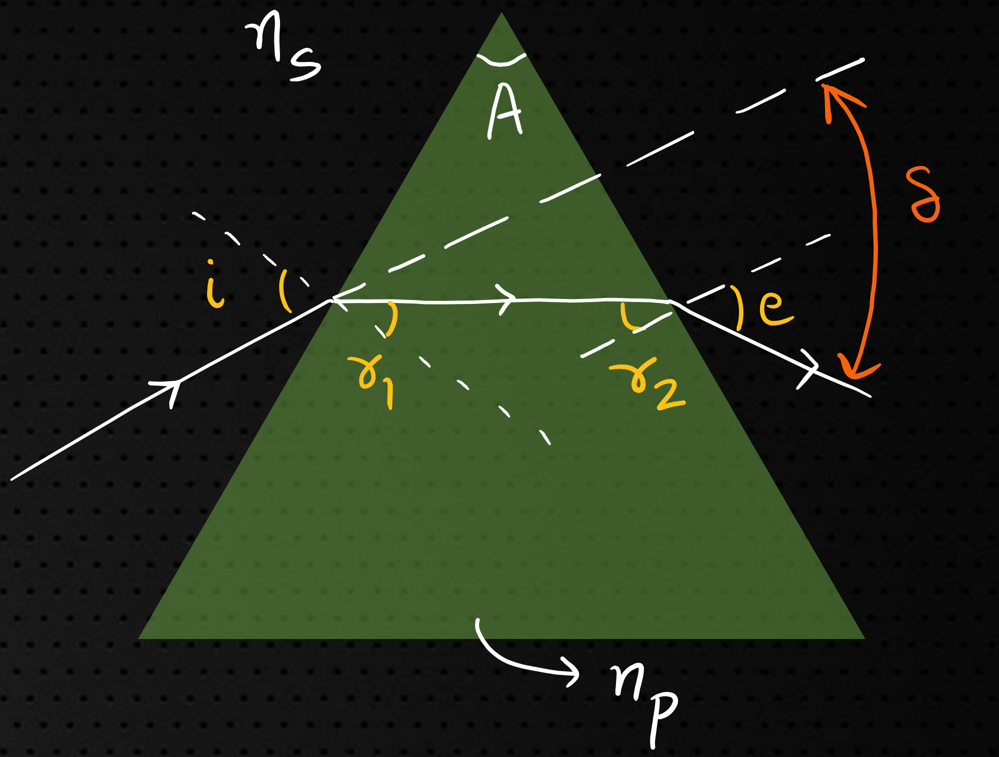
(2.) δ : ANGLE of Deviation

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

(3.) For δ to be minimum, δ_{min}

$i = e \Rightarrow r_1 = r_2 = r$

$$\therefore \frac{n_p}{n_s} = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$



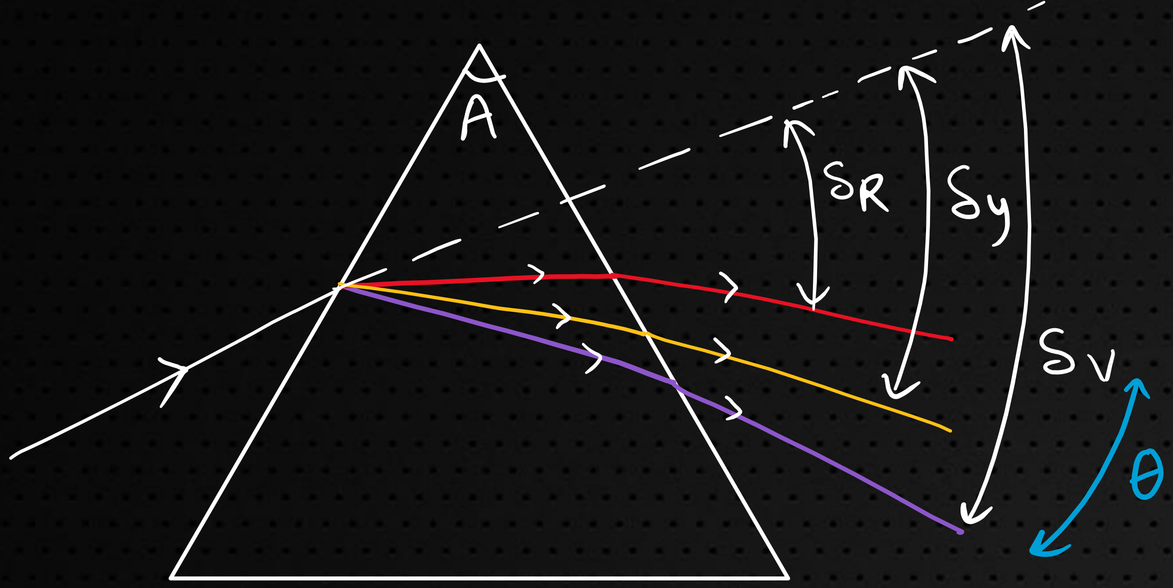
n_p : R.I of PRISM

n_s : RI of Surrounding

(4.) If A is very small (THIN PRISM), then

$$\boxed{\delta = A\left(\frac{n_p}{n_s} - 1\right)}$$

26. DISPERSIVE POWER (ω)



$\delta_R = A(n_R - 1)$, $\delta_y = A(n_y - 1)$, $\delta_V = A(n_V - 1)$

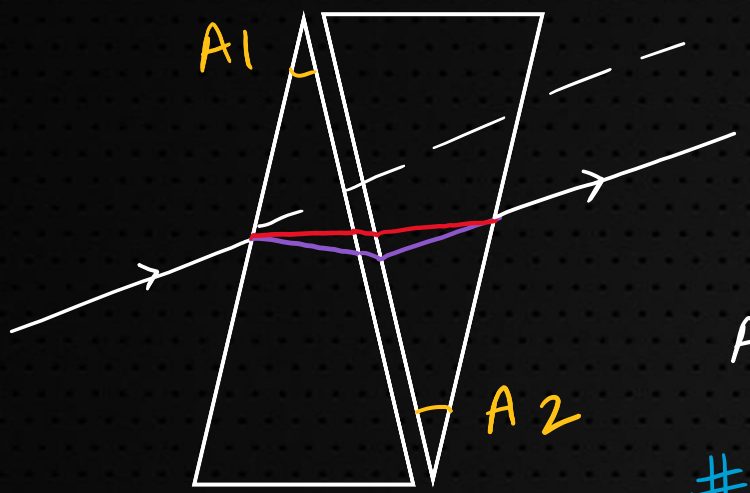
n_R, n_y, n_V are R.I. of medium for Red, yellow and violet color

(Cauchy's eq^n, $n = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \ldots$)

(a.) θ (Dispersion Angle) $= \delta_V - \delta_R = \boxed{A(n_V - n_R)}$

(b.) ω (Dispersive power) $= \frac{\delta_V - \delta_R}{\delta_y} = \boxed{\frac{n_V - n_R}{n_y - 1}}$

27. Condition for Deviation without Dispersion



$\theta_{NET} = 0$

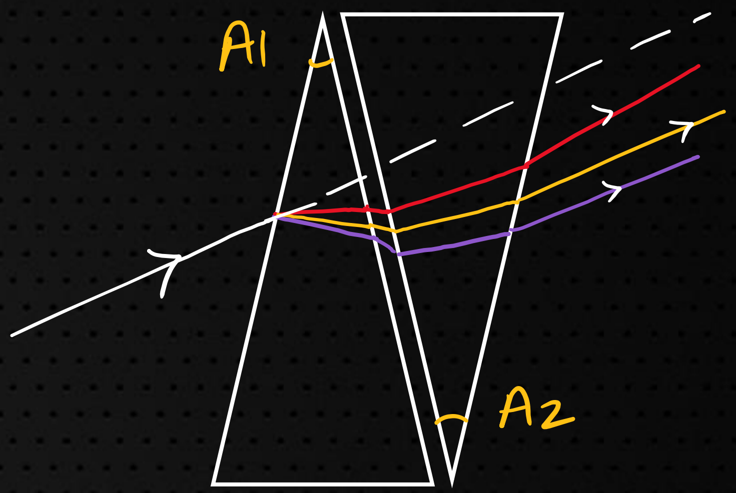
$\Rightarrow \theta_1 = \theta_2$

or

$A_1(n_{v_1} - n_{R_1}) = A_2(n_{v_2} - n_{R_2})$

Achromatic Prism Combination

28. Condition for Dispersion without Deviation



Here final emergent yellow is parallel to incident white light.

so, $\delta_{net} = 0 \Rightarrow \delta_1 = \delta_2$

$\Rightarrow A_1(n_{y_1} - 1) = A_2(n_{y_2} - 1)$

29. SIMPLE MICROSCOPE $\left(m = \theta_i / \theta_o \right)$, $\theta_o = h_o / D$

Image at D

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

Image at ∞

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

30. COMPOUND MICRSCOPE

$(f_e > f_o)$

$$m = m_o \times m_e$$

Image at D (strained cond^n)

(a.) $m = \frac{V_o}{u_o}\left(1 + \frac{D}{f_e}\right)$

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

(b) Tube Length $= V_o + u_e$

Image at ∞ (Normal adjustment)

$$m = \frac{V_o}{u_o}\frac{D}{f_e}$$

$V_o + f_e$

only magnitudes

30. TELESCOPE ($f_o > f_e$)

Image at D

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

(b.) Tube length $= f_o + u_e$

Image at ∞

$m = f_o / f_e$

Tube length $= f_o + f_e$

NOTE: put without sign.