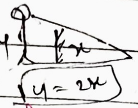
1

Optics

① deviation of two successive refl^n $\boxed{\delta_N = 2\pi - 2\theta}$

② minimum size of mirror required,

③ field of view. → use Δ similarity



④ effect of rotation of incident ray & mirror on Reflected ray

i) incidented ray : with same speed rotates reflected ray

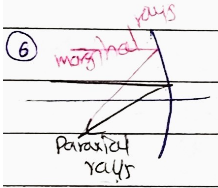
ii) mirror : doubles the incidented ray θ.

⑤ Relative motion in plane mirror

a) $\vec{v}_{O/m} = (v_0)_\perp \hat{i} + (v_0)_{\parallel} \hat{j}$
$\vec{v}_I = (v_0)_\perp (-\hat{i}) + (v_0)_{\parallel} \hat{j}$. } when mirror at rest.

b) $\vec{v}_{O/M} \longrightarrow \vec{v}_{I/M} \longrightarrow \vec{v}_I \longrightarrow \vec{v}_{I/O}$
(Rel) (SRT) (Rel) (SRT)

⑥

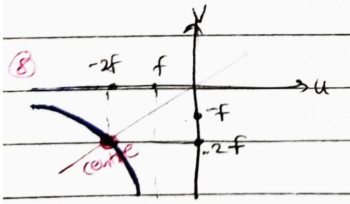


⑦ dependence of focal length on angle of incidence

marginal rays → $\boxed{f = R - \frac{R}{2\cos i}}$ i = large

paraxial rays → $\boxed{f = \frac{R}{2}}$ i = small.

⑧



⑨ mirror formula ⇒ $\boxed{1/f = 1/v + 1/u}$

⑩ Transverse magnification

$\boxed{M_T = \frac{I}{O} = \frac{-v}{u} \Rightarrow \boxed{\frac{f}{(f-u)}}}$

+ve for lens $\boxed{v = \frac{uf}{u-f}}$

$\boxed{R\mu_0 \Rightarrow \frac{\mu_D}{\mu_R}}$

$\boxed{(M_T)_{\text{for lens}} \Rightarrow \left[\frac{f}{f+u}\right]}$

⑪ $\boxed{v = \frac{uf}{(u-f)}}$

⑫ Axial magnification

$\boxed{M_{ax} = |M_{TA} \times M_{TB}|}$ →

$\boxed{M_{ax} = |M_T|^2}$ → short linear object

⑬ Relative motion in spherical mirror

$\boxed{V_{O/M} = (V_{I/M}) = V_I = V_{I/O}}$ $\boxed{m_T = f/(f-u)}$

$\Rightarrow \boxed{V_{I/M} = -(M_T)^2 \times V_{O/M}}$ → car problem

⑭ snell's law

$\boxed{\mu \sin\theta = \text{const}}$ or $\boxed{\sin\theta = 1/\mu}$

a) multiple medium

$\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2 = \mu_3 \sin\theta_3 = \mu_n \sin\theta_n \ldots$

$\mu_w = 4/3 \Rightarrow 1.33$
$\mu_g = 3/2 \Rightarrow 1.5$
$\mu_{air} = 1$

b) vector form of light. $\boxed{\hat{i} \times \hat{n} = \mu(\hat{r} \times \hat{n})}$

c) $\boxed{\lambda_{med} = \frac{\lambda_{vaccum}}{\mu_{med}}}$ $\boxed{V_{med} = \frac{\lambda_{vaccum}}{\mu_{med}}}$

⑮ Real & Apparent depth

a) when object is in denser med. & observer in rarer medium

$\boxed{\text{Apparent depth} = \frac{\text{Real depth}}{\mu}}$

$\boxed{\text{shifting} = h(1 - 1/\mu)}$

b) object is in rarer medium and observer is in denser medium,

~~App. depth = μ × Real depth~~

$\boxed{\text{App. ht} = \mu \times \text{Real ht}}$

⑯ Thickness of glass slab

$$\boxed{t = \mu (v_1 + v_2)}$$

v_1 = image dist.
v_2 = image dist.

⑮ Real & App. depth when Multiple med.

$$\boxed{X_{obj/observer} = \mu_{observer}\left[\frac{x_1}{\mu_1} + \frac{x_2}{\mu_2} + \dots + \frac{x_n}{\mu_n}\right]}$$

a) bird fish problem.

$$X_{fish/Bird} = \mu_B\left[\frac{y}{\mu_B} + \frac{x}{\mu_F}\right]$$

$$X_{Bird/fish} = \mu_F\left[\frac{y}{\mu_B} + \frac{x}{\mu_F}\right]$$

Relative motion

$$V_{fish/Bird} = \mu_B\left[\frac{V_B}{\mu_B} + \frac{V_F}{\mu_F}\right]$$

surface से away = (+ve)
towards surface = (−ve)

like flux incoming = (−ve)
outgoing = (+ve)

⑯ shifting by glass slab of image when kept b/w mirror & image

$$\boxed{s = t\left[1 - \frac{1}{\mu}\right]}$$

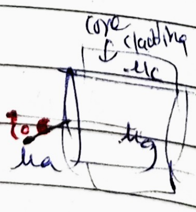
* Total Internal Reflection *

① $\boxed{\sin i_c = \frac{\mu_r}{\mu_D} \Rightarrow D\mu_r}$

glass-air (i_c) ⇒ 42°
water-air (i_c) ⇒ 48.5° ≈ 49°
Glass-water (i_c) ⇒ 63°

② optical fiber

$$\boxed{\sin i_0 = \frac{\sqrt{\mu_g^2 - \mu_c^2}}{\mu_a}}$$



③ Area of visible region

$$\boxed{r_{visible} = \frac{h}{\sqrt{\mu_D^2 - 1}}}$$

Area = πr^2

$$\frac{\pi h^2}{\mu_D^2 - 1}$$

Prism

① snell's law

$\mu_1 \sin i = \mu_2 \sin r_1$

$\mu_2 \sin r_1 = \mu_3 \sin e$

↓ spherical deviation

② deviation

$$\boxed{\delta = 2(i - r)}$$

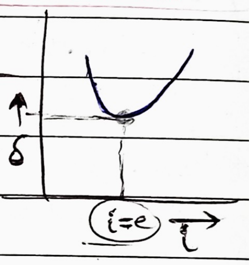
$$\boxed{\delta_{nett} = i + e - A} \qquad \boxed{r_1 + r_2 = A}$$

$$\boxed{\delta_{min} = 2i - A}$$ → minimum devn

$i = e$

$r_1 = r_2 = \frac{A}{2}$

$$\mu = \frac{\sin\frac{A+\delta_m}{2}}{\sin A/2}$$



$\sin i = \mu \sin r_1$

$$\boxed{\sin i = \mu \sin A/2}$$ → minimum deviation

→ under minimum deviation refracted ray is ||el to base of prism → isosceles triangle
→ equivalent triangle

③ condn for TIR in prism

$$\boxed{i_c < i_{prism}}$$

$$\boxed{\mu_c > \mu_{prism}}$$

④ cauchy's theorem

$$\boxed{\mu = A + \frac{B}{\lambda^2}}$$

V I B G Y O R

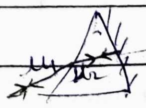
$\lambda_V <$ ______ $< \lambda_R$

$\mu_V >$ ______ $> \mu_R$

$(i_c)_V <$ ______ $< (i_c)_R$

⑤ silvering of prism.

$$\boxed{\mu_1 \sin i = \mu_2 \sin A}$$



⑥ Thin prism (θ = very small)

$\boxed{\delta = A(\mu-1)}$ $\boxed{\sin\theta \simeq \theta}$

⇒ ~~Dispersion~~ Mean Ray

$\boxed{\mu_y = \frac{\mu_v+\mu_R}{2}}$ $\boxed{\delta_y = A(\mu_y-1)}$

⇒ Angular dispersion (θ)

$\boxed{\theta = A(\mu_v-\mu_R)}$

→ Dispersive power (ω)

$\boxed{\omega = \frac{\theta}{\delta_y}} \Rightarrow \frac{\text{Angular dispersion}}{\text{dev}^n\text{ of mean ray}}$

$\boxed{\omega = \frac{(\mu_v-\mu_R)}{(\mu_y-1)}}$ ***

⑦ combination of prism of opposite action

① $\theta_{Nett} = \theta_1 - \theta_2$

$\Rightarrow A_1(\mu_{v_1}-\mu_{R_1}) - A_2(\mu_{v_2}-\mu_{R_2})$

② δ_{Nett}

$\Rightarrow \delta_{y_1} - \delta_{y_2}$

$\Rightarrow \boxed{A_1(\mu_{y_1}-1) - A_2(\mu_{y_2}-1)}$

a) Dispersion without devⁿ

i) No devⁿ: $\delta_y = \delta_{y_1} - \delta_{y_2} = 0$

$\boxed{\delta_{y_1} = \delta_{y_2}}$

$\boxed{A_1(\mu_y-1) = A_2(\mu_y-1)}$

ii) Nett dispersion $\theta_{Nett} = \theta_1 - \theta_2$

$\Rightarrow \boxed{A_1(\mu_{v_1}-\mu_{R_1}) - A_2(\mu_{v_2}-\mu_{R_2})}$

b) deviation without dispersion

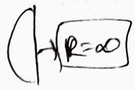
i) No dispersion: $\theta_N = \theta_1 - \theta_2 \Rightarrow 0$

$\boxed{A_1(\mu_{v_1}-\mu_{R_1}) = A_2(\mu_{v_2}-\mu_{R_2})}$

ii) Net devⁿ:

$\delta_{Nett} = \delta_{y_1} - \delta_{y_2}$

$\boxed{A_1(\mu_y-1) - A_2(\mu_{y_2}-1)}$



Biconvex ⇒

⑧ I − O = S technique besides the len's formula.

(applied for all condⁿ but it almost useful for more than two R.I having surfaces)

(i) incidented rays ⇒ (−ve)

(ii) Refracted rays ⇒ (+ve)

⑨ Len's maker's formula

$$\boxed{\frac{1}{F} = \left[\frac{\mu_2}{\mu_1}-1\right]\left[\frac{1}{R_1}-\frac{1}{R_2}\right]}$$

→ use for only Biconvex lens ($R_1 \neq R_2$)

a) equiconvex $\boxed{F = \frac{R}{2({}_a\mu_g-1)}}$ → use for equiconvex ($R_1 = R_2$)

b) equiconcave $\boxed{f_{air} = -\frac{R}{2({}_a\mu_g-1)}}$

c) plano-convex $\boxed{f_{air} = \frac{R}{({}_a\mu_g-1)}}$

$f_{planoconvex} = 2 f_{equiconvex}$.

⑩ comparison of focal length in air & liq.

$\frac{f_{air}}{f_{liq}} \Rightarrow \frac{[{}_l\mu_g-1]}{[{}_a\mu_g-1]}$ $\left[\frac{\mu_g}{\mu_l}\right]$

⑪ Two lenses sepparated by dist (d).

$\boxed{P_{eq} = P_1 + P_2 - dP_1.P_2}$

$\boxed{f_1 + f_2 = d}$

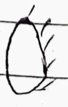
$P_{eq} = P_1 + P_2$

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

⑫ silvering of plano-convex

a) silvering of plane surface

$\boxed{f_{eq} = \frac{f_{air}}{2}} \Rightarrow \boxed{-\frac{f_{lens}}{2}}$

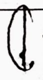


$-\frac{R}{2(2\mu_g-1)}$

$= \frac{R}{2(\mu_g-1)}$

$-\frac{R}{2(\mu_g-1)}$

$\Rightarrow -\frac{R}{2(\mu_g)}$



$= \frac{R}{(\mu_g-1)}$

$\mu \sin\theta$ = Numerical Aperture (radius of Aperture)

$2\mu \sin\theta$ = Aperture diameter

Optical Instruments

① Simple Microscope

β = angle subtended by Image

α = angle subtended by object

~~$M_{min} = \frac{D}{u_{max}}$~~

$$\boxed{M = \frac{D}{u} = \frac{\beta}{\alpha}}$$

i) Eye under relaxed state or Normal vision.

$$\boxed{M_{min} = \frac{D}{u_{max}} = \frac{D}{f_e}} \qquad * \boxed{u_{max} = f}$$

ii) Eye under strain / least distinct vision.

$$\boxed{M_{max} = 1 + \frac{D}{f_e}} \qquad * \boxed{u_{min} = \frac{Df}{D+f_e}}$$

② Compound Microscope

i) $\boxed{L = v_o + u_e}$

ii) $m = -(m_o \times m_e) \Rightarrow \ominus\left(\frac{v_o}{u_o} \times \frac{D}{u_e}\right)$

image is inverted

a) eye in Relaxed state (Normal vision)

i) $\boxed{L_{max} = v_o + f_e}$

ii) $\boxed{M_{min} = -\left[\frac{v_o}{u_o} \times \frac{D}{f_e}\right]}$

b) eye under strain / least distinct vision

$u_e = \frac{Df_e}{D+f_e}$

① $\boxed{L_{min} = v_o + \frac{Df_e}{D+f_e}}$

② $\boxed{M_{max} = -\left[\frac{v_o}{u_o} \times \left(1 + \frac{D}{f_e}\right)\right]}$

$$\boxed{\frac{M_{N.A}}{M_{strain}} \Rightarrow \left(\frac{D}{D+f_e}\right)}$$ } valid for all optical instrumen

③ Telescope (Astronomical)

$\boxed{L = f_o + u_e^*}$ $\boxed{m = \frac{-f_o}{u_e}}$ → no matters in calculation

a) Normal adjustment

$\boxed{L_{max} = f_o + f_e}$, $\boxed{M_{min} = f_o / f_e}$

b) Eye under strain

$\boxed{L_{min} = f_o + \left(\frac{Df_e}{D+f_e}\right)}$ $\boxed{M_{max} = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)}$

Resolving power

Telescope	Microscope
R. Limit $\Rightarrow \frac{1.22\lambda}{a} = \frac{1.22\lambda}{2\mu \sin\theta}$	R. Limit $\Rightarrow \frac{1.22\lambda}{2\mu \sin\theta}$
R. Power $\Rightarrow \frac{a}{1.22\lambda}$	R. Power = $\frac{2\mu \sin\theta}{1.22\lambda}$

$L = v_o + f_e$

$L - f_e$

optical density $\Rightarrow \frac{\text{speed of light in med. 1}}{\text{speed of light in med. 2.}}$

Match No. = $\frac{\text{speed of body}}{\text{speed of sound}}$

when V_o and u_o not given in question for compound microscope under normal adjustment

$\Rightarrow$

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