

SOLUTIONS TO CONCEPTS CHAPTER – 20

1. Given that,

Refractive index of flint glass = $\mu_f = 1.620$

Refractive index of crown glass = $\mu_c = 1.518$

Refracting angle of flint prism = $A_f = 6.0^\circ$

For zero net deviation of mean ray

$$(\mu_f - 1)A_f = (\mu_c - 1)A_c$$

$$\Rightarrow A_c = \frac{\mu_f - 1}{\mu_c - 1} A_f = \frac{1.620 - 1}{1.518 - 1} (6.0)^\circ = 7.2^\circ$$

2. Given that

$\mu_r = 1.56$, $\mu_y = 1.60$, and $\mu_v = 1.68$

$$(a) \text{ Dispersive power } = \omega = \frac{\mu_v - \mu_r}{\mu_y - 1} = \frac{1.68 - 1.56}{1.60 - 1} = 0.2$$

$$(b) \text{ Angular dispersion } = (\mu_v - \mu_r)A = 0.12 \times 6^\circ = 7.2^\circ$$

3. The focal length of a lens is given by

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

$$\Rightarrow (\mu - 1) = \frac{1}{f} \times \frac{1}{\left(\frac{1}{R_1} - \frac{1}{R_2} \right)} = \frac{K}{f} \quad \dots(1)$$

$$\text{So, } \mu_r - 1 = \frac{K}{100} \quad \dots(2)$$

$$\mu_y - 1 = \frac{K}{98} \quad \dots(3)$$

$$\text{And } \mu_v - 1 = \frac{K}{96} \quad (4)$$

$$\text{So, Dispersive power } = \omega = \frac{\mu_v - \mu_r}{\mu_y - 1} = \frac{(\mu_v - 1) - (\mu_r - 1)}{(\mu_y - 1)} = \frac{\frac{K}{96} - \frac{K}{100}}{\frac{K}{98}} = \frac{98 \times 4}{9600} = 0.0408$$

4. Given that, $\mu_v - \mu_r = 0.014$

$$\text{Again, } \mu_y = \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{2.00}{1.30} = 1.515$$

$$\text{So, dispersive power } = \frac{\mu_v - \mu_r}{\mu_y - 1} = \frac{0.014}{1.515 - 1} = 0.027$$

5. Given that, $\mu_r = 1.61$, $\mu_v = 1.65$, $\omega = 0.07$ and $\delta_y = 4^\circ$

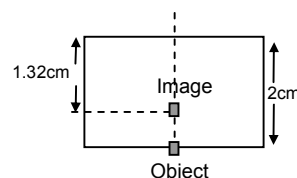
$$\text{Now, } \omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$$

$$\Rightarrow 0.07 = \frac{1.65 - 1.61}{\mu_y - 1}$$

$$\Rightarrow \mu_y - 1 = \frac{0.04}{0.07} = \frac{4}{7}$$

$$\text{Again, } \delta = (\mu - 1) A$$

$$\Rightarrow A = \frac{\delta_y}{\mu_y - 1} = \frac{4}{(4/7)} = 7^\circ$$



6. Given that, $\delta_r = 38.4^\circ$, $\delta_y = 38.7^\circ$ and $\delta_v = 39.2^\circ$

$$\text{Dispersive power} = \frac{\mu_v - \mu_r}{\mu_y - 1} = \frac{(\mu_v - 1) - (\mu_r - 1)}{(\mu_y - 1)} = \frac{\left(\frac{\delta_v}{A}\right) - \left(\frac{\delta_r}{A}\right)}{\left(\frac{\delta_y}{A}\right)} \quad [\because \delta = (\mu - 1) A]$$

$$= \frac{\delta_v - \delta_r}{\delta_y} = \frac{39.2 - 38.4}{38.7} = 0.0204$$

7. Two prisms of identical geometrical shape are combined.

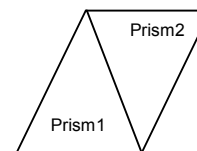
Let A = Angle of the prisms

$$\mu'_v = 1.52 \text{ and } \mu_v = 1.62, \delta_v = 1^\circ$$

$$\delta_v = (\mu_v - 1)A - (\mu'_v - 1)A \quad [\text{since } A = A']$$

$$\Rightarrow \delta_v = (\mu_v - \mu'_v)A$$

$$\Rightarrow A = \frac{\delta_v}{\mu_v - \mu'_v} = \frac{1}{1.62 - 1.52} = 10^\circ$$



8. Total deviation for yellow ray produced by the prism combination is

$$\delta_y = \delta_{cy} - \delta_{fy} + \delta_{cy} = 2\delta_{cy} - \delta_{fy} = 2(\mu_{cy} - 1)A - (\mu_{fy} - 1)A'$$

Similarly the angular dispersion produced by the combination is

$$\delta_v - \delta_r = [(\mu_{vc} - 1)A - (\mu_{vf} - 1)A'] + (\mu_{vc} - 1)A - [(\mu_{rc} - 1)A - (\mu_{rf} - 1)A' + (\mu_r - 1)A]$$

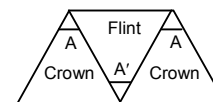
$$= 2(\mu_{vc} - 1)A - (\mu_{vf} - 1)A'$$

(a) For net angular dispersion to be zero,

$$\delta_v - \delta_r = 0$$

$$\Rightarrow 2(\mu_{vc} - 1)A = (\mu_{vf} - 1)A'$$

$$\Rightarrow \frac{A'}{A} = \frac{2(\mu_{cv} - \mu_{rc})}{(\mu_{vf} - \mu_{rf})} = \frac{2(\mu_v - \mu_r)}{(\mu'_v - \mu'_r)}$$



(b) For net deviation in the yellow ray to be zero,

$$\delta_y = 0$$

$$\Rightarrow 2(\mu_{cy} - 1)A = (\mu_{fy} - 1)A'$$

$$\Rightarrow \frac{A'}{A} = \frac{2(\mu_{cy} - 1)}{(\mu_{fy} - 1)} = \frac{2(\mu_y - 1)}{(\mu'_y - 1)}$$

9. Given that, $\mu_{cr} = 1.515$, $\mu_{cv} = 1.525$ and $\mu_{fr} = 1.612$, $\mu_{fv} = 1.632$ and $A = 5^\circ$

Since, they are similarly directed, the total deviation produced is given by,

$$\delta = \delta_c + \delta_r = (\mu_c - 1)A + (\mu_r - 1)A = (\mu_c + \mu_r - 2)A$$

So, angular dispersion of the combination is given by,

$$\delta_v - \delta_y = (\mu_{cv} + \mu_{fv} - 2)A - (\mu_{cr} + \mu_{fr} - 2)A$$

$$= (\mu_{cv} + \mu_{fv} - \mu_{cr} - \mu_{fr})A = (1.525 + 1.632 - 1.515 - 1.612) 5 = 0.15^\circ$$



10. Given that, $A' = 6^\circ$, $\omega' = 0.07$, $\mu'_y = 1.50$

$$A = ? \quad \omega = 0.08, \quad \mu_y = 1.60$$

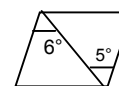
The combination produces no deviation in the mean ray.

$$(a) \delta_y = (\mu_y - 1)A - (\mu'_y - 1)A' = 0$$

[Prism must be oppositely directed]

$$\Rightarrow (1.60 - 1)A = ((1.50 - 1)A')$$

$$\Rightarrow A = \frac{0.50 \times 6^\circ}{0.60} = 5^\circ$$



(b) When a beam of white light passes through it,

$$\text{Net angular dispersion} = (\mu_y - 1)\omega A - (\mu'_y - 1)\omega' A'$$

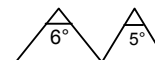
$$\Rightarrow (1.60 - 1)(0.08)(5^\circ) - (1.50 - 1)(0.07)(6^\circ)$$

$$\Rightarrow 0.24^\circ - 0.21^\circ = 0.03^\circ$$

(c) If the prisms are similarly directed,

$$\delta_y = (\mu_y - 1)A + (\mu'_y - 1)A'$$

$$= (1.60 - 1)5^\circ + (1.50 - 1)6^\circ = 3^\circ + 3^\circ = 6^\circ$$



(d) Similarly, if the prisms are similarly directed, the net angular dispersion is given by,

$$\delta_v - \delta_r = (\mu_y - 1)\omega A - (\mu'_y - 1)\omega' A' = 0.24^\circ + 0.21^\circ = 0.45^\circ$$

11. Given that, $\mu'_v - \mu'_r = 0.014$ and $\mu_v - \mu_r = 0.024$
 $A' = 5.3^\circ$ and $A = 3.7^\circ$

(a) When the prisms are oppositely directed,
 angular dispersion $= (\mu_v - \mu_r)A - (\mu'_v - \mu'_r)A'$
 $= 0.024 \times 3.7^\circ - 0.014 \times 5.3^\circ = 0.0146^\circ$

(b) When they are similarly directed,
 angular dispersion $= (\mu_v - \mu_r)A + (\mu'_v - \mu'_r)A'$
 $= 0.024 \times 3.7^\circ + 0.014 \times 5.3^\circ = 0.163^\circ$

