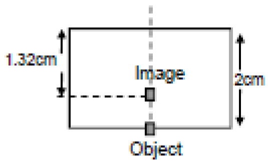
Vol 1 Chapter 20 – Dispersion and Spectra

1. Given that,
Refractive index of flint glass = μ_f = 1.620
Refractive index of crown glass = μ_c = 1.518
Refracting angle of flint prism = A_f = 6.0°
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) Dispersive power = $\omega = \frac{\mu_v - \mu_r}{\mu_y - 1} = \frac{1.68 - 1.56}{1.60 - 1} = 0.2$
(b) 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
$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
$\Rightarrow (\mu - 1) = \frac{1}{f} \times \frac{1}{\left(\frac{1}{R_1} - \frac{1}{R_2}\right)} = \frac{K}{f}$ ...(1)
So, $\mu_r - 1 = \frac{K}{100}$ ...(2)
$\mu_y - 1 = \frac{K}{98}$ ...(3)
And $\mu_v - 1 = \frac{K}{96}$ (4)
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, $\mu_v - \mu_r = 0.014$
Again, $\mu_y = \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{2.00}{1.30} = 1.515$
So, dispersive power = $\frac{\mu_v - \mu_r}{\mu_y - 1} = \frac{0.014}{1.515 - 1} = 0.027$



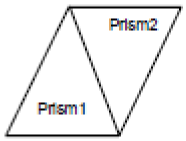
5. Given that, $\mu_r = 1.61$, $\mu_v = 1.65$, $\omega = 0.07$ and $\delta_y = 4^\circ$
Now, $\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$
$\Rightarrow 0.07 = \frac{1.65 - 1.61}{\mu_y - 1}$
$\Rightarrow \mu_y - 1 = \frac{0.04}{0.07} = \frac{4}{7}$
Again, $\delta = (\mu - 1)A$
$\Rightarrow A = \frac{\delta_y}{\mu_y - 1} = \frac{4}{(4/7)} = 7^\circ$

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

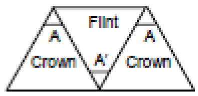
Dispersive power = $\dfrac{\mu_v - \mu_r}{\mu_y - 1} = \dfrac{(\mu_v - 1) - (\mu_r - 1)}{(\mu_y - 1)} = \dfrac{\left(\dfrac{\delta_v}{A}\right) - \left(\dfrac{\delta_r}{A}\right)}{\left(\dfrac{\delta_y}{A}\right)}$ [$\because$ $\delta = (\mu - 1)A$]

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

7. Two prisms of identical geometrical shape are combined.
Let A = Angle of the prisms
$\mu'_v = 1.52$ and $\mu_v = 1.62$, $\delta_v = 1°$
$\delta_v = (\mu_v - 1)A - (\mu'_v - 1)A$ [since A = A′]
$\Rightarrow \delta_v = (\mu_v - \mu'_v)A$
$\Rightarrow A = \dfrac{\delta_v}{\mu_v - \mu'_v} = \dfrac{1}{1.62 - 1.52} = 10°$

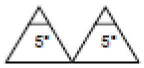


8. Total deviation for yellow ray produced by the prism combination is
$\delta_y = \delta_{cy} - \delta_{fy} + \delta_{cy} = 2\,\delta_{cy} - \delta_{fy} = 2(\mu_{cy} - 1)A - (\mu_{cy} - 1)A'$
Similarly the angular dispersion produced by the combination is
$\delta_v - \delta_r = [(\mu_{vc} - 1)A - (\mu_{vf} - 1)A' + (\mu_{vc} - 1)A] - [(\mu_{rc} - 1)A - (\mu_{rf} - 1)A' + (\mu_r - 1)A)]$
$= 2(\mu_{vc} - 1)A - (\mu_{vf} - 1)A'$
(a) For net angular dispersion to be zero,
$\delta_v - \delta_r = 0$
$\Rightarrow 2(\mu_{vc} - 1)A = (\mu_{vf} - 1)A'$
$\Rightarrow \dfrac{A'}{A} = \dfrac{2(\mu_{cv} - \mu_{rc})}{(\mu_{vf} - \mu_{rf})} = \dfrac{2(\mu_v - \mu_r)}{(\mu'_v - \mu'_r)}$

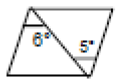


(b) For net deviation in the yellow ray to be zero,
$\delta_y = 0$
$\Rightarrow 2(\mu_{cy} - 1)A = (\mu_{fy} - 1)A'$
$\Rightarrow \dfrac{A'}{A} = \dfrac{2(\mu_{cy} - 1)}{(\mu_{fy} - 1)} = \dfrac{2(\mu_y - 1)}{(\mu'_y - 1)}$

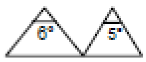
9. Given that, $\mu_{cr} = 1.515$, $\mu_{cv} = 1.525$ and $\mu_{fr} = 1.612$, $\mu_{fv} = 1.632$ and A = 5°
Since, they are similarly directed, the total deviation produced is given by,
$\delta = \delta_c + \delta_f = (\mu_c - 1)A + (\mu_f - 1)A = (\mu_c + \mu_f - 2)A$
So, angular dispersion of the combination is given by,
$\delta_v - \delta_y = (\mu_{cv} + \mu_{fv} - 2)A - (\mu_{cr} + \mu_{fr} - 2)A$
$= (\mu_{cv} + \mu_{fv} - \mu_{cr} - \mu_{fr})A = (1.525 + 1.632 - 1.515 - 1.612)\ 5 = 0.15°$



10. Given that, A′ = 6°, $\omega' = 0.07$, $\mu'_y = 1.50$
A = ? $\omega = 0.08$, $\mu_y = 1.60$
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]
$\Rightarrow (1.60 - 1)A = ((1.50 - 1)A'$
$\Rightarrow A = \dfrac{0.50 \times 6°}{0.60} = 5°$

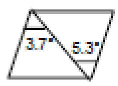


(b) When a beam of white light passes through it,
Net angular dispersion = $(\mu_y - 1)\omega A - (\mu'_y - 1)\omega' A'$
$\Rightarrow (1.60 - 1)(0.08)(5°) - (1.50 - 1)(0.07)(6°)$
$\Rightarrow 0.24° - 0.21° = 0.03°$
(c) If the prisms are similarly directed,
$\delta_y = (\mu_y - 1)A + (\mu'_y - 1)A$
$= (1.60 - 1)5° + (1.50 - 1)6° = 3° + 3° = 6°$



(d) Similarly, if the prisms are similarly directed, the net angular dispersion is given by,
$\delta_v - \delta_r = (\mu_y - 1)\omega A - (\mu'_y - 1)\omega' A' = 0.24° + 0.21° = 0.45°$

11. Given that, $\mu'_v - \mu'_r = 0.014$ and $\mu_v - \mu_r = 0.024$
A′ = 5.3° and A = 3.7°
(a) When the prisms are oppositely directed,
angular dispersion = $(\mu_v - \mu_r)A - (\mu'_v - \mu'_r)A'$
$= 0.024 \times 3.7° - 0.014 \times 5.3° = 0.0146°$



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