

HC VERMA Solutions for Class 11 Physics Chapter 20 Dispersion and Spectra

Question 1

A flint glass prism and a crown glass prism are to be combined in such a way that the deviation of the mean ray is zero. The refractive index of flint and crown glasses for the mean ray are 1.620 and 1.518 respectively. If the refracting angle of the flint prism is 6.0° , what would be the refracting angle of the crown?

Solution 1

For deviation to be zero, flint and crown glass prism are kept inverted to each other.

Deviation of flint prism = Deviation of by crown prism

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

$$(1.62 - 1)6 = (1.518 - 1)A_c$$

$$A_c = 7.2^\circ$$

Question 2

A certain material has refractive indices 1.56, 1.60 and 1.68 for red, yellow and violet light respectively.

(a) Calculate the dispersive power. (b) Find the angular dispersion produced by a thin prism of angle 6° made of this material.

Solution 2

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

$$(a) \quad = \frac{1.68 - 1.56}{1.6 - 1}$$

$$\omega = 0.2$$

$$(b) \quad \theta = (\mu_v - \mu_r)A$$

$$= (1.68 - 1.56)6$$

$$\theta = 0.72^\circ$$

Question 3

The focal lengths of a convex lens for red, yellow and violet rays are 100 cm, 98 cm and 96 cm respectively. Find the dispersive power of the material of the lens.

Solution 3

focal length of convex lens

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

$$(\mu - 1) = \frac{1}{f} \times \frac{1}{\left(\frac{1}{R_1} - \frac{1}{R_2}\right)} = \frac{k}{f} \quad \left[k = \frac{1}{\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}\right]$$

$$\text{So, } \mu_R - 1 = \frac{k}{100}$$

$$\mu_y - 1 = \frac{k}{98}$$

$$\mu_v - 1 = \frac{k}{96}$$

Dispersive power,

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

$$\omega = \frac{\frac{k}{96} - \frac{k}{100}}{\frac{k}{98}}$$

$$\omega = 0.041$$

Question 4

The refractive index of a material changes by 0.014 as the colour of the light changes from red to violet. A rectangular slab of height 2.00 cm made of this material is placed on a newspaper. When viewed normally in yellow light, the letters appear 1.32 cm below the top surface of the slab. Calculate the dispersive power of the material.

Solution 4

Here, $\mu_r - \mu_v = 0.014$

$$\mu_r = \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{2}{1.32} = 1.515$$

And,

Now, dispersive power,

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

$$= \frac{0.014}{(1.515 - 1)}$$

$$= \frac{0.014}{0.515}$$

$$\omega = 0.026$$

Question 5

A thin prism is made of a material having refractive indices 1.61 and 1.65 for red and violet light. The dispersive power of the material is 0.07. It is found that a beam of yellow light passing through the prism suffers a minimum deviation of 4.0° in favourable conditions. Calculate the angle of the prism.

Solution 5

Dispersive power

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

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

$$\mu_y = \frac{11}{7}$$

Now, deviation $\delta = (\mu_y - 1)A$

$$4 = \left(\frac{11}{7} - 1\right)A$$

$$A = 7^\circ$$

Question 6

The minimum deviations suffered by red, yellow and violet beams passing through an equilateral transparent prism are 38.4° , 38.7° and 39.2° respectively. Calculate the dispersion power of the medium.

Solution 6

Given that, $\delta_R = 38.4^\circ$; $\delta_y = 38.7^\circ$ & $\delta_v = 39.2^\circ$

$$\text{Dispersive power} = \frac{\mu_v - \mu_R}{\mu_y - 1}$$

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

$$= \frac{\frac{\delta_v}{A} - \frac{\delta_R}{A}}{\frac{\delta_y}{A}} \quad [\because \delta = (\mu - 1)A]$$

$$= \frac{\delta_v - \delta_R}{\delta_y}$$

$$= \frac{39.2 - 38.4}{38.7}$$

$$= 0.0206$$

Question 7

Two prisms of identical geometrical shape are combined with their refracting angles oppositely directed. The materials of the prisms have refractive indices 1.52 and 1.62 for violet light. A violet ray is deviated by 1.0° when passes symmetrically through this combination. What is the angle of the prisms?

Solution 7

Since both prism are geometrically identical so their prism angle is same.

Let prism angle be A.

Deviation by both prism will be in both opposite direction.

$$\delta_{Net} = \delta_v - \delta'_v$$

$$\delta_{Net} = (\mu_v - 1)A - (\mu'_v - 1)A$$

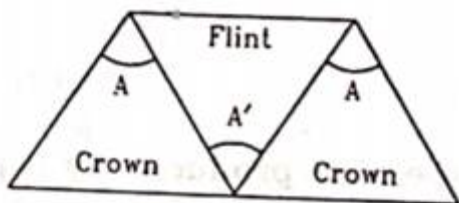
$$\delta_{Net} = (\mu_v - \mu'_v)A$$

$$1^\circ = (1.62 - 1.52)A$$

$$A = 10^\circ$$

Question 8

Three thin prisms are combined as shown in figure. The refractive indices of the crown glass for red, yellow and violet rays are μ_r , μ_y and μ_v respectively and those for the flint glass are μ'_r , μ'_y and μ'_v respectively. Find the ratio A'/A for which (a) there is no net angular dispersion and, (b) there is no net deviation in the yellow ray.



Solution 8

(a) Angular dispersion is given by $\theta = (\mu_v - \mu_R)A$

$$\theta_{Net} = \theta_c - \theta_f + \theta_c = 2\theta_c - \theta_f$$

$$\theta_{Net} = 2(\mu_v - \mu_R)A - (\mu'_v - \mu'_R)A'$$

$$\text{For } \theta_{Net} = 0$$

$$0 = 2(\mu_v - \mu_R)A - (\mu'_v - \mu'_R)A'$$

$$\frac{A'}{A} = \frac{2(\mu_v - \mu_R)}{\mu'_v - \mu'_R}$$

(b) deviation is given by $\delta = (\mu_r - 1)A$

$$\delta_{Net} = \delta_c - \delta_f + \delta_c$$

$$\delta_{Net} = 2\delta_c - \delta_f$$

$$\delta_{Net} = 2(\mu_y - 1)A - (\mu'_y - 1)A'$$

$$\text{For no net deviation i.e., } \delta_{Net} = 0$$

$$0 = 2(\mu_y - 1)A - (\mu'_y - 1)A'$$

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

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Question 9

A thin prism of crown glass ($\mu_r = 1.515, \mu_v = 1.525$) and a thin prism of flint glass ($\mu_r = 1.612, \mu_v = 1.632$) are placed in contact with each other. Their reflecting angles are 5.0° each and are similarly directed. Calculate the angular dispersion produced by the combination.

Solution 9

$$\theta_{Net} = \theta_c + \theta_f$$

$$\theta_{Net} = (\mu_{vC} - \mu_{rC})A_C + (\mu_{vF} - \mu_{rF})A_F$$

$$\theta_{Net} = (1.525 - 1.515)5 + (1.632 - 1.612)5$$

$$\theta_{Net} = 0.15^\circ$$

Question 10

A thin prism of angle 6.0° , $\omega = 0.07$ and $\mu_y = 1.50$ is combined with another thin prism having $\omega = 0.08$ and $\mu_y = 1.60$. The combination produces no deviation in the mean ray.

(a) Find the angle of the second prism.

(b) Find the net angular dispersion produced by the combination when a beam of white light passes through it.

(c) If the prisms are similarly directed, what will be the deviation in the mean ray?

(d) Find the angular dispersion in the situation described in (c).

Solution 10

$$A = 6^\circ; \omega = 0.07; \mu_y = 1.5$$

$$A' = ?; \omega' = 0.08; \mu'_y = 1.6$$

$$(a) \delta_{Net} = \delta - \delta' = 0$$

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

$$(1.5 - 1)6 - (1.6 - 1)A' = 0$$

$$A' = 5^\circ$$

$$(b) \theta_{Net} = \theta - \theta'$$

$$= \omega\delta - \omega'\delta'$$

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

$$= 0.07(1.5 - 1)6 - 0.08(1.6 - 1)5$$

$$= 0.03^\circ$$

(c) If prisms are similarly directed

$$\delta_{Net} = \delta + \delta'$$

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

$$= (1.5 - 1)6 + (1.6 - 1)5$$

$$\delta_{Net} = 6^\circ$$

(d) If prisms are similarly directed

$$\theta_{Net} = \theta + \theta'$$

$$= \omega\delta + \omega'\delta'$$

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

$$= 0.07(1.5 - 1)6 + 0.08(1.6 - 1)5$$

$$\theta_{Net} = 0.45^\circ$$

Question 11

The refractive index of a material M1 changes by 0.014 and that of another material M2 changes by 0.024 as the colour of the light is changed from red to violet. Two thin prisms one made of M1 ($A=5.3^\circ$) and other made of M2 ($A=3.7^\circ$) are combined with their reflecting angles oppositely directed.

(a) Find the angular dispersion produced by the combination.

(b) The prisms are now combined with their refracting angles similarly directed. Find the angular dispersion produced by the combination.

Solution 11

$$\begin{aligned}\text{(a)} \quad \theta_{Net} &= \theta - \theta' \\ &= (\mu_v - \mu_R)A - (\mu'_v - \mu'_R)A' \\ &= (0.024)(3.7) - (0.014)(5.3) \\ &= 0.0146^\circ\end{aligned}$$

$$\begin{aligned}\text{(b)} \quad \theta_{Net} &= \theta + \theta' \\ &= (\mu_v - \mu_R)A + (\mu'_v - \mu'_R)A' \\ &= (0.024)(3.7) + (0.014)(5.3) \\ &= 0.163^\circ\end{aligned}$$

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