Unit 18 · Dispersion

HARDER PRACTICE QUESTIONS

Full marks 28

Write your answers on separate paper. Show your working. Treat every prism as small-angled ($\delta = (\mu - 1)$A) and every lens as thin.

1 Spot the error [3]

Find the mistake in the working and correct it.

Sushant was asked for the dispersive power of a glass with $\mu_v = 1.530$, $\mu_r = 1.514$ and mean $\mu = 1.517$. He wrote:
"$\omega = (\mu_v - \mu_r) \div \mu = 0.016 \div 1.517 = \mathbf{0.0105}$."

2 Design it [4]

Sanskriti wants a direct-vision prism, which spreads white light into colors without turning yellow light. She has a crown prism of angle 10° ($\mu = 1.52$, $\mu_v - \mu_r = 0.016$) and flint glass ($\mu = 1.62$, $\mu_v - \mu_r = 0.040$).

i. What angle must the flint prism have, placed the other way up against the crown prism?
ii. Find the net angular dispersion of the pair.
iii. Which prism's spread wins, and why?

3 Which glass is it? [3]

Rahul measured the focal length of a convex lens using a red filter and then a violet filter: 30.5 cm and 29.6 cm. A data sheet gives the dispersive power between violet and red as about 0.031 for crown glass and 0.083 for dense flint. Which glass is his lens made of? Show how you decide.

4 Predict, then explain [3]

Write your prediction first, then explain it.

On a showery afternoon the Sun is 30° above the horizon behind Dolma. Predict how high above the horizon the top of the red band of the rainbow will be, and whether red or violet is on top. Then predict what happens to the bow as the Sun sinks to the horizon.

5 Estimate it [2]

Using $I \propto 1/\lambda^4$, estimate how many times more strongly air scatters violet light (400 nm) than red light (700 nm), and blue (450 nm) than red.

6 Show that [3]

Using the condition $\omega/f + \omega'/f' = 0$, show that an achromatic doublet can't be made from two lenses of the same glass, and that the stronger lens of a converging doublet must have the smaller dispersive power.

7 What if? [3]

A lens of crown glass and focal length 40 cm has a chromatic aberration of 1.24 cm. Say what happens to the chromatic aberration, and why, if

i. the same glass is ground into a lens of focal length 20 cm;
ii. the lens is made of flint glass of dispersive power about 2.7 times as large, with the same focal length;
iii. a concave mirror of focal length 40 cm is used instead.

8 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Sapana wrote: “The sky is blue because of dispersion. In a raindrop, the light is totally internally reflected at the back of the drop. The angular dispersion of a prism, like its dispersive power, does not depend on the prism's angle.”

9 Think [2]

Diamond's dispersive power (about 0.018) is close to that of crown glass, yet diamond shows much brighter flashes of color, its “fire”. How can that be?

10 Make your own [2]

Choose a pair of thin prisms, with angles, refractive indices and values of $\mu_v - \mu_r$ of your own, that turn white light without splitting it into colors. Show that your pair works and find its deviation.