DPP – 11 (Geometrical Optics)

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COMPREHENSION (Q.1 to Q.3)

A glass prism with a refracting angle of 60^0 has a refractive index 1.52 for red and 1.6 for violet light. A parallel beam of white light is incident on one face at an angle of incidence, which gives minimum deviation for red light. Find :
[Use: sin (50º) = 0.760; sin (31.6º) = 0.520 ; sin (28.4º) = 0.475; sin (56º) = 0.832 ;π = 22/7]

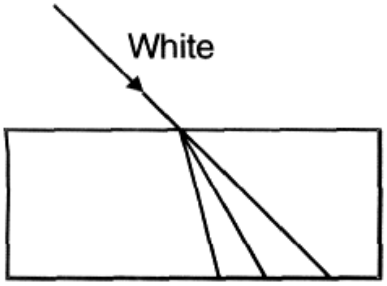
Q 1. The angle of incidence at the prism is :
(a) 30º (b) 40º (c) 50º (d) 60º

Q 2. The angular width of the spectrum is :
(a) 6º (b) 4.8º (c) 9.6º (d) 12º

Q 3. The length of the spectrum if it is focused on a screen by a lens of focal length 100 cm is :
(a) $\frac{10\pi}{3}cm$ (b) $\frac{10\pi}{3}m$ (c) $\frac{5\pi}{3}cm$ (d) $\frac{5\pi}{3}m$

Q 4. The dispersive powers of two materials are 0.30 & 0.28. They are used to construct two lenses which are kept in contact to eliminate chromatic aberration (that means the $f_v = f_r$, the focal length of combination is same for red and violet) If the focal length) (for mean color) of the lens made of the material of dispersive power 0.30 is 10 cm, then the focal length (for mean color) of the lens of other material is :
(a) 28/3 cm (b) - 0.28/3 m
(c) 0.75/7 m (d) none of these

Q 5. A white light is incident on a glass slab. Maximum lateral displacement is for



(a) Red (b)Violet (c) Green (d)Yellow

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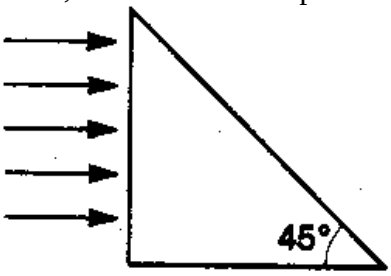
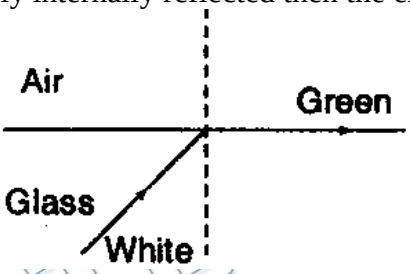
Q 6. A beam of light consisting of red, green and blue colours is incident on a right-angled prism. The refractive indices of the material of the prism for the red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. The prism will:



(a) separate the red colour from the green and blue colours
(b) separate the blue colour from the red and green colours
(c) separate all the three colours from one another
(d) not separate even partially any colour from the other two colours

Q 7. White light is incident on the interface of glass and air as shown in the figure. If green light is just totally internally reflected then the emerging ray in air contains:



(a) yellow, orange, red (b) violet, indigo, blue
(c) all colours (d) all colours except green

Q 8. A thin prism P_1 of angle 4°, and made from a glass of refractive index 1.54, is combined with another thin prism P_2 made from a glass of refractive index 1.72, to produce dispersion without deviation. The angle of P_2 is
(a) 5.33° (b) 4° (c) 3° (d) 2.6°

Q 9. When lights of different colours move through water, they must have different
(a) wavelengths (b) frequencies (c) velocities (d) amplitudes

Q 10. The dispersive powers of flint glass and crown glass are 0.053 and 0.034 respectively and their mean refractive indices are 1.68 and 1.53 for white light. Calculate the angle of the flint glass prism required to form an achromatic combination with a crown glass prism of refracting angle 4º
(a) 2º (b) 4º (c) 5º (d) 6º

Q 11.

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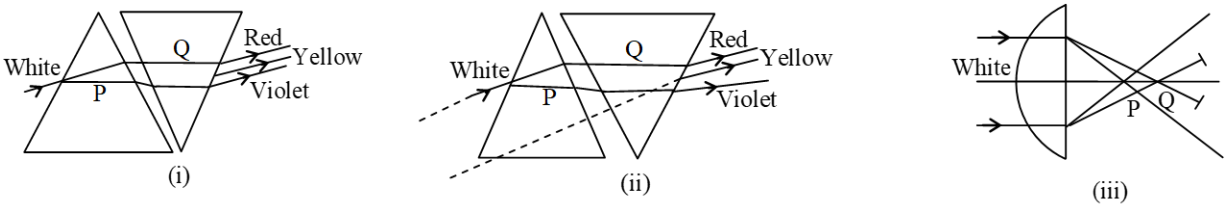
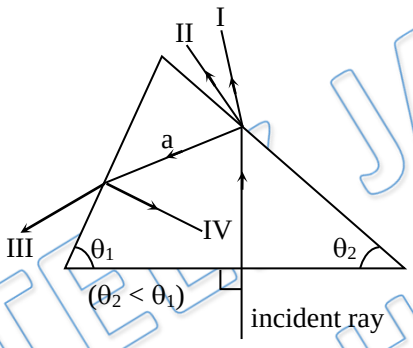


(a) Figure (i) shows deviation without dispersion
(b) Figure (ii) is for showing dispersion without deviation
(c) In figure (i) prism P is of flint glass and Q of crown glass (if these two are the only options and $m_{flint} > m_{crown}$)
(d) In figure (iii) a transverse screen at P would show violet at centre, red outside

Q 12. A white light ray is incident on a glass prism, and it create four refracted rays I, II, III and IV. Match (one to one) the refracted rays with the colours given (a & IV are rays due to total internal reflection)



Column - I (Ray)		Column-II (Colour)	
(A)	I	(P)	Red
(B)	II	(Q)	Green
(C)	III	(R)	Yellow
(D)	IV	(S)	Blue

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Answer Key

Q.1 c	**Q.2 a**	**Q.3 a**	**Q.4 b**	**Q.5 b**
Q.6 a	**Q.7 a**	**Q.8 c**	**Q.9 a, b, c**	**Q.10 a**
Q.11 a, b, d	**Q.12 (A) P; (B) R; (C) Q; (D) S**			

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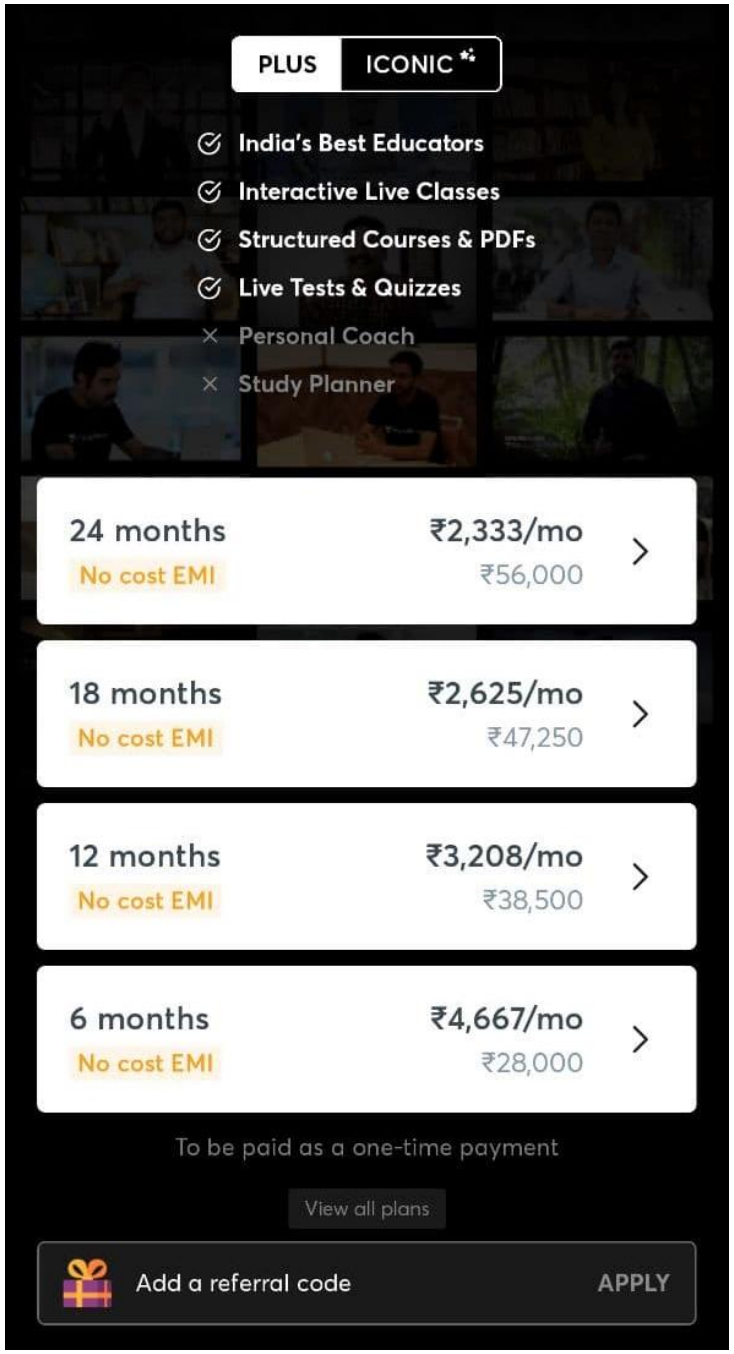

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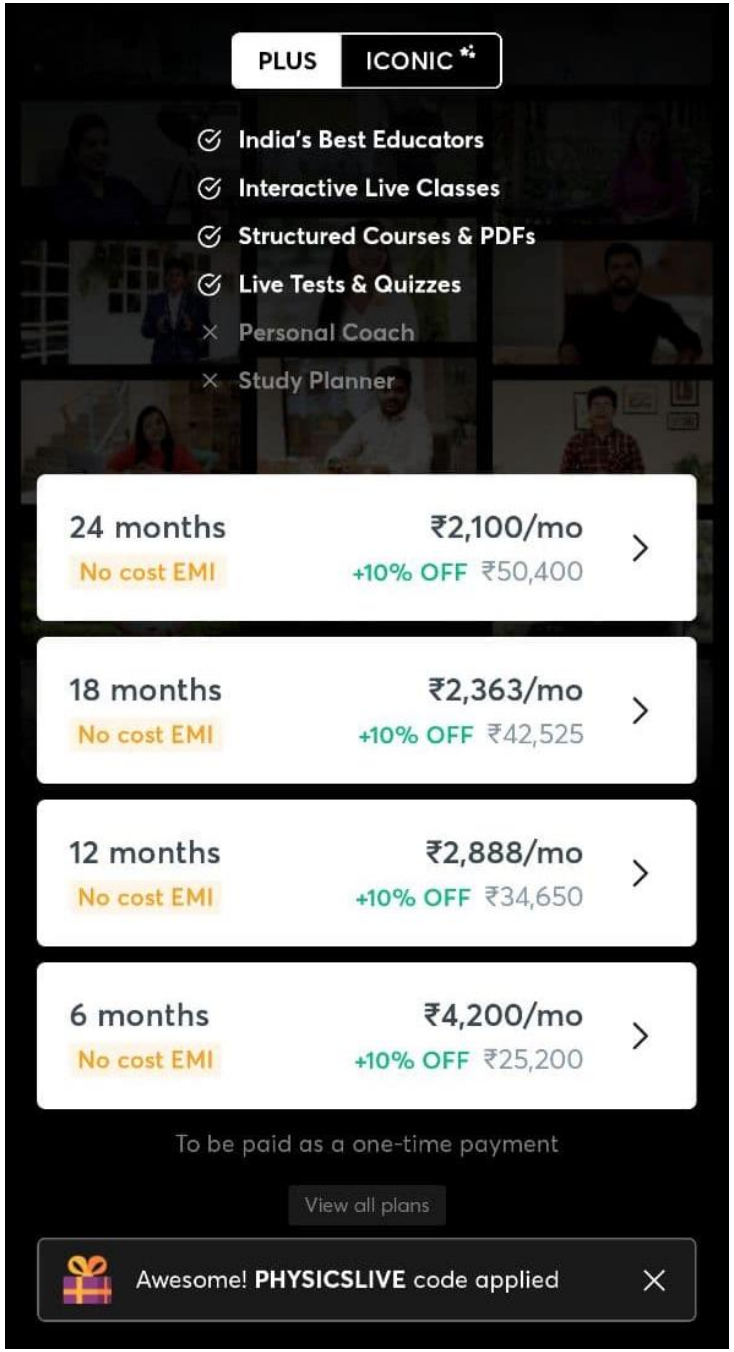


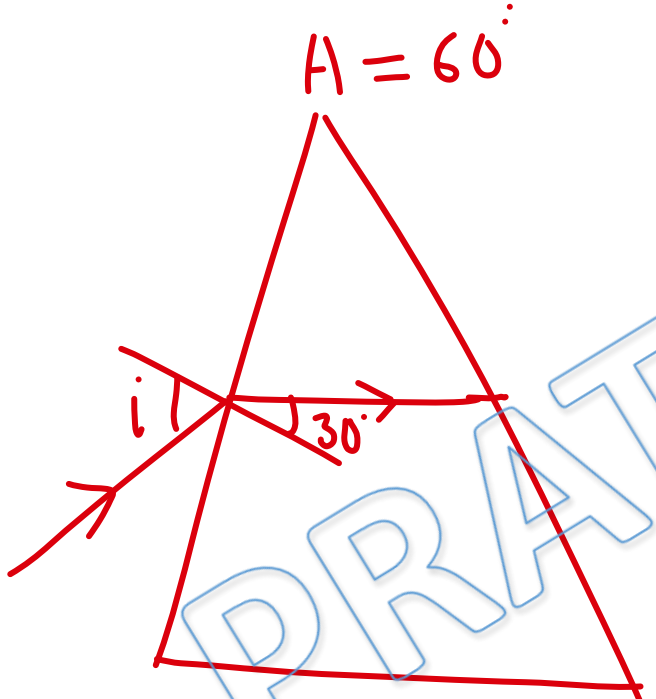
Written Solution

DPP – 11 : Geometrical Optics - Dispersion

By Physicsaholics Team

Solution: 1

For minimum deviation $r_1 = r_2 = A/2 = 30^\circ$



for red light

$1 \times \sin i = \mu_r \sin 30^\circ$

$\sin i = 1.52 \times \frac{1}{2}$

$i = \sin^{-1}(.76)$

Since $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right) < \sin^{-1}(.76) < \sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$

$\Rightarrow i = 50^\circ$

Ans(C)

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Solution: 2

for red

$$i = \frac{60^\circ + \delta_{min}}{2} = 50^\circ \Rightarrow \delta_{min} = 40^\circ$$

for violet

$$\mu = 1.60 = \frac{\sin 50^\circ}{\sin r_1} \Rightarrow \sin r_1 = \frac{.76}{1.6} = .475$$

$$\Rightarrow r_1 = 28.4^\circ \Rightarrow r_2 = 60^\circ - 28.4^\circ = 31.6^\circ$$

$$1.6 \sin r_2 = 1 \times \sin e \Rightarrow \sin e = 1.6 \times .52 = .832$$

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$\Rightarrow \quad e = 56^\circ$

$$i + e = A + \delta_v$$

$$\Rightarrow \quad \delta_v = 50^\circ + 56^\circ - 60^\circ = 46^\circ$$

$$\theta = \delta_v - \delta_R = 46^\circ - 40^\circ = 6^\circ$$

Ans(a)

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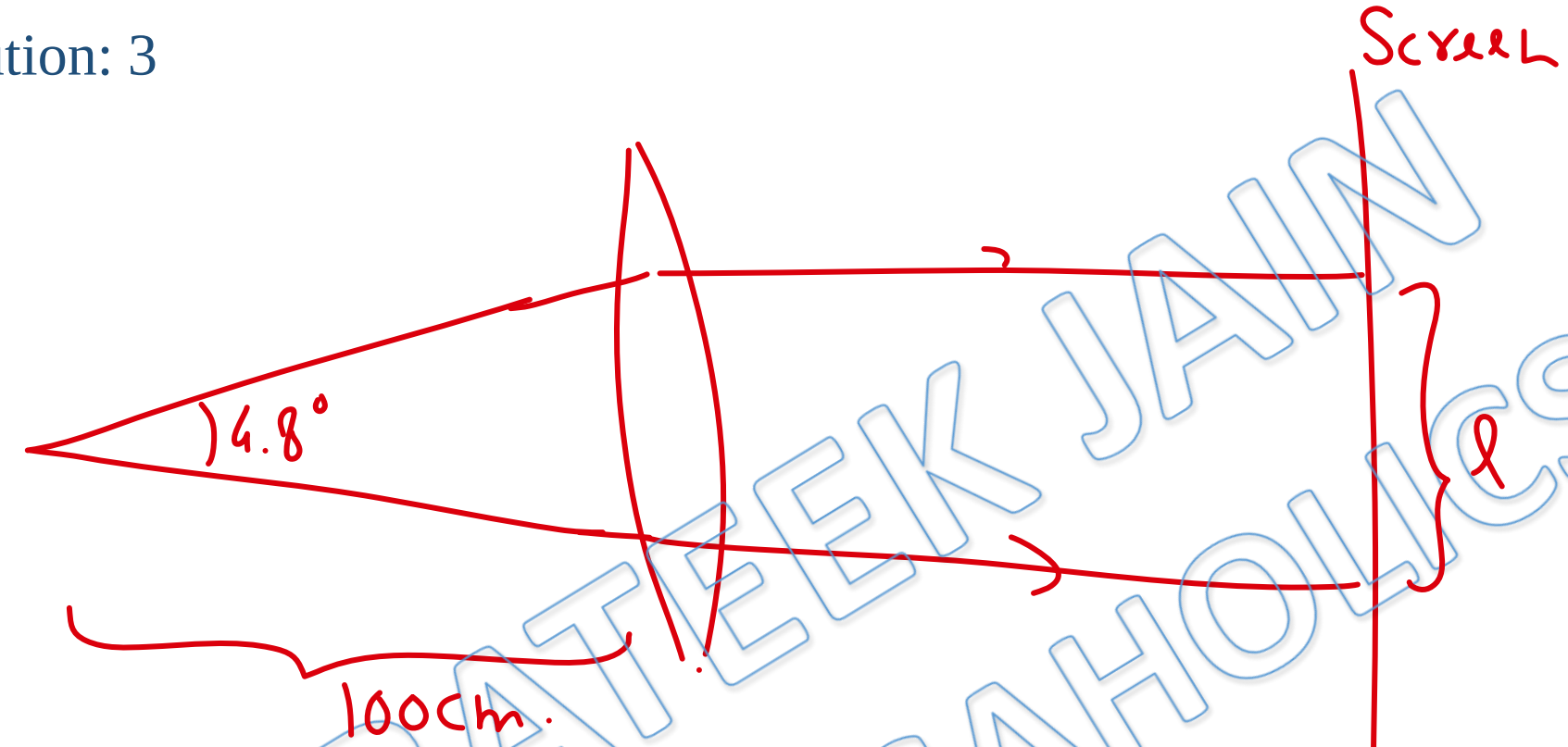
Solution: 3



$$\ell = 100 \times \frac{6^\circ}{180}\pi$$

$$= \frac{60}{18}\pi = \frac{10\pi}{3}\ \text{cm}$$

Ans(a)

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Solution: 4

for achromatic Combination

$$\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0 \Rightarrow \frac{.30}{10} + \frac{.28}{f_2} = 0$$

$$\Rightarrow f_2 = \frac{-2.8}{3} = -\frac{28}{3}\ m$$

Ans(b)

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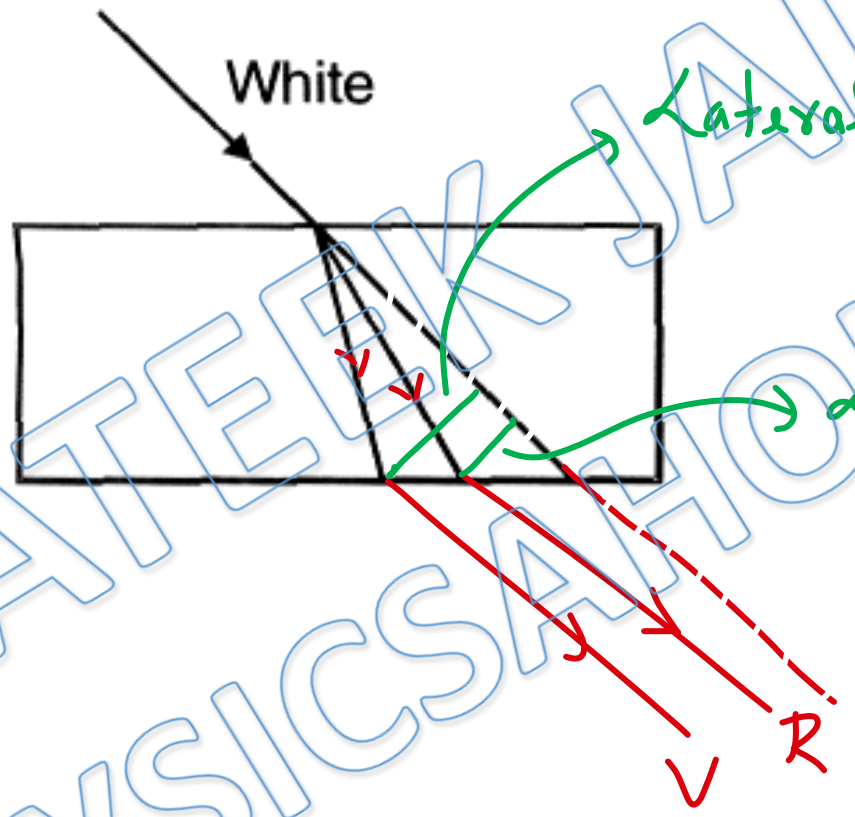
Solution: 5



Lateral displacement for violet

Lateral displacement for red.

Lateral displacement is maximumm for violet.

ANS(b)

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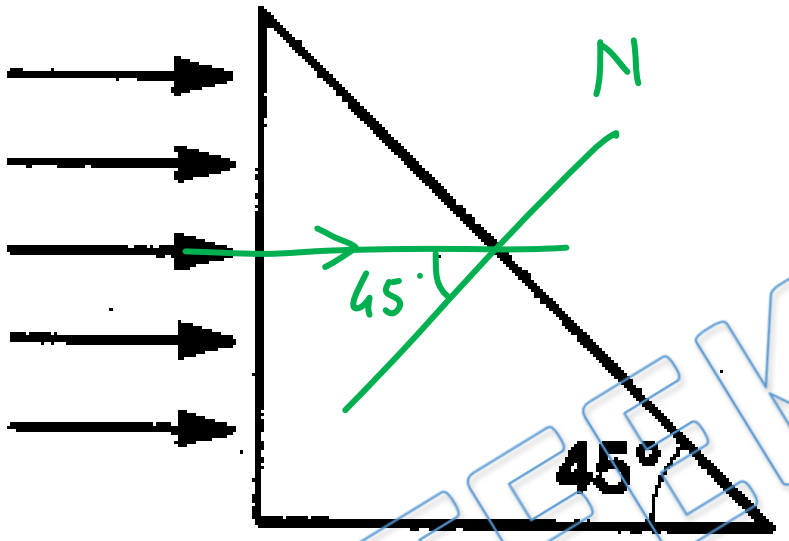
Solution: 6



for each ray angle of incidence at second surface = 45°

45° is critical angle for $\mu = \frac{1}{\sin 45^\circ} = 1.414$

for $\mu = 1.44$ & $\mu = 1.47$, critical angle will be smaller than 45°.

$\Rightarrow$ green & Blue rays reflect but red refracts.

Ans (a)

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Solution: 7

V I B G Y O R

Rays having smaller λ & greater ν than green

$\Rightarrow$ Critical angles for V, I & B are smaller than green.

$\Rightarrow$ V, I, B reflect back.

$\Rightarrow$ Emerging rays Contain yellow, orange & red.

Ans (a)

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Solution: 8

Dispersion without deviation

$\Rightarrow \delta = 0 \quad \Rightarrow |\delta_1| = |\delta_2|$

$\Rightarrow A_1(\mu_1 - 1) = A_2(\mu_2 - 1)$

$\Rightarrow 4(1.54 - 1) = A_2(1.72 - 1)$

$\Rightarrow A_2 = \frac{4 \times .54}{.72} = 3°$

Ans(c)

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Solution: 9

In any medium except vaccum different colour rays move with different velocity, different frequency and different wavelength.

Ans(a,b,c)

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Solution: 10

for achromatic Combination

$$\theta = 0 \Rightarrow |\theta_1| = |\theta_2|$$

$$\Rightarrow \omega_1 A_1(\mu_1 - 1) = \omega_2 A_2(\mu_2 - 1)$$

$$\Rightarrow .053\, A_1(1.68 - 1) = .034 \times 4^\circ (1.53 - 1)$$

$$\Rightarrow A_1 = \frac{.034 \times 4^\circ \times .53}{.053 \times .68} = 2^\circ$$

Ans(a)

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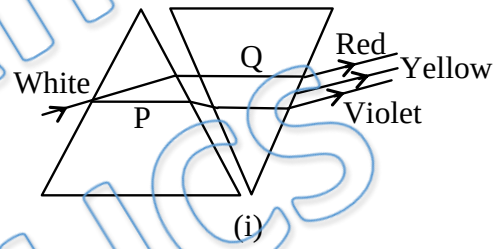
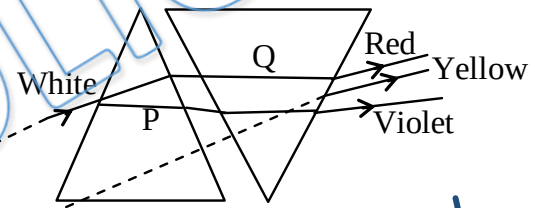
Solution: 11

In deviation without dispersion emergent rays are parallel to each other as shown in figure 1.



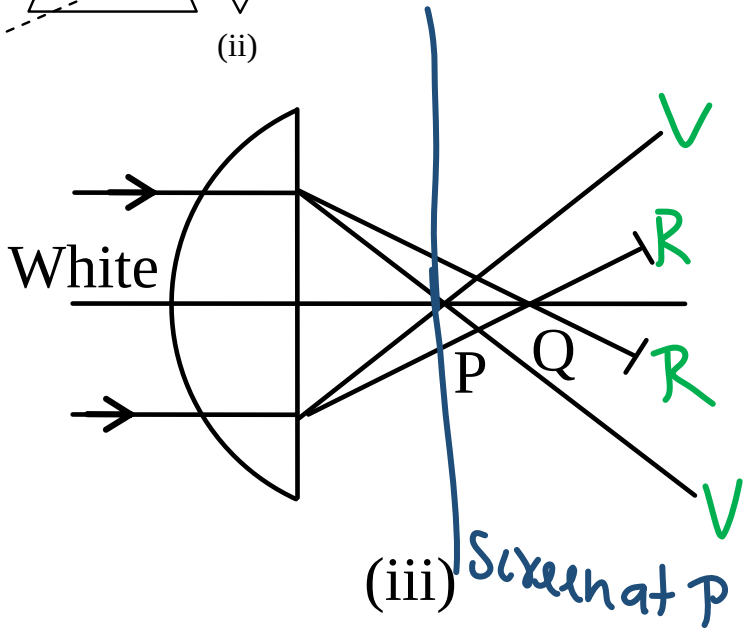
(i)

In dispersion without deviation emergent mean ray is parallel to incident white ray as shown in figure 2.



(ii)

Option D is correct according to figure (iii).



(iii)

Ans (a, b, d)

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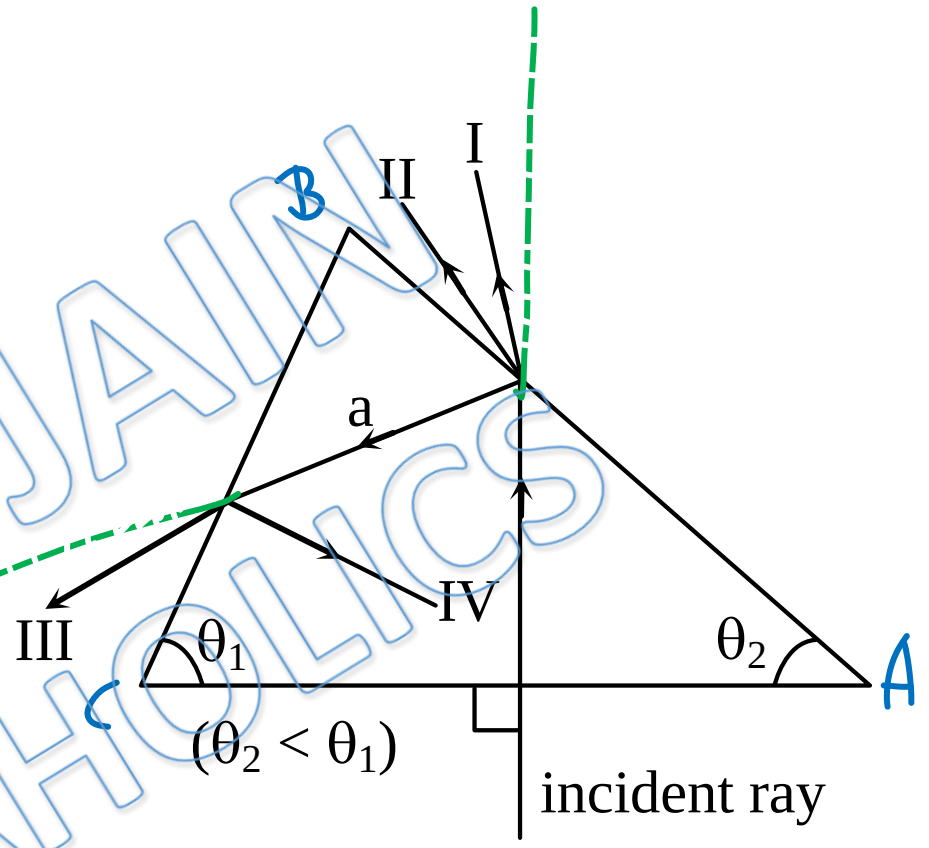
Solution: 12

Refracted Rays at Surface AB

Should have low refractive index than III & IV.



$\Rightarrow$ I & II are yellow & red.

I has less deviation than II $\Rightarrow$ I is red & II is yellow.

IV has highest refractive index as it has reflected at second surface $\Rightarrow$ IV is Blue.

$\Rightarrow$ III is green

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