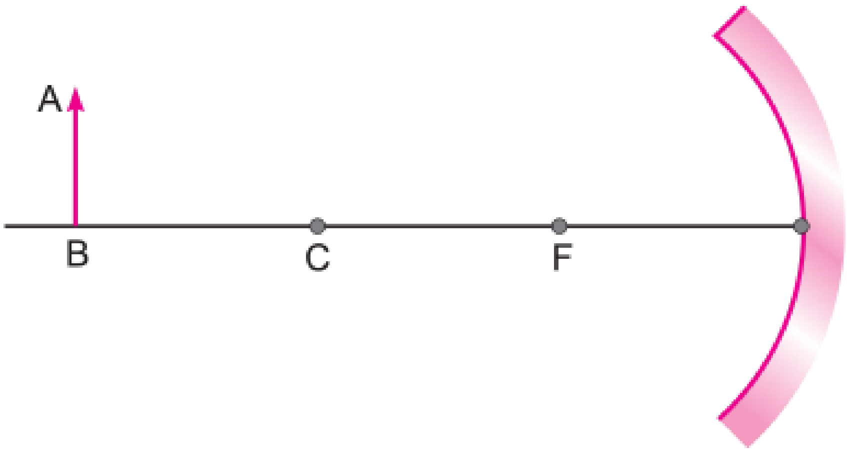
Short Answer Questions – I (PYQ)

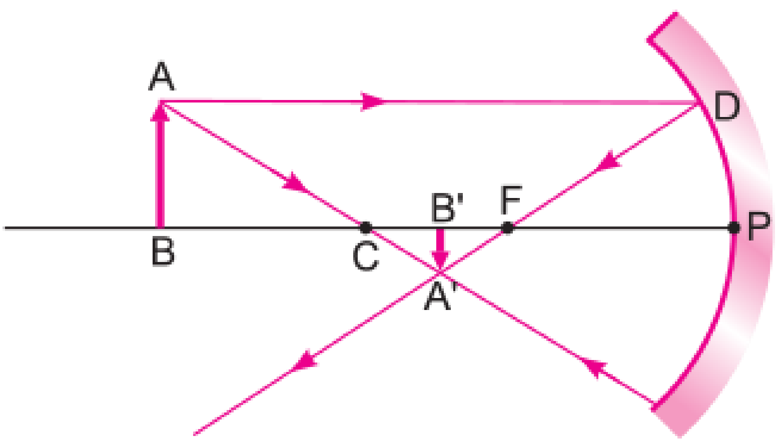
Q. 1. An object AB is kept in front of a concave mirror as shown in the figure. [CBSE (AI) 2012]



(i) Complete the ray diagram showing the image formation of the object.

(ii) How will the position and intensity of the image be affected if the lower half of the mirror's reflecting surface is painted black?

Ans. (i) Image formed will be inverted diminished between C and F.



(ii) No change in position of image and its intensity will get reduced.

Q. 2. A converging and a diverging lens of equal focal lengths are placed co-axially in contact. Find the power and the focal length of the combination. [CBSE (AI) 2010]

Ans. Let focal length of converging and diverging lenses be + f and – f respectively.

Power of converging lens $P_1 = \frac{1}{f}$ Power of diverging lens $P_2 =- \frac{1}{f}$

$\therefore$ Power of combination $P = P_1 + P_2 = \frac{1}{f} - \frac{1}{f} = 0$

$\therefore$ Focal length of combination $F = \frac{1}{P} = \frac{1}{0} = \infty$ (infinite)

Q. 3. Explain why white light is dispersed while passing through a prism.

Ans. The refractive index of prism-material depends on the wavelength λ of light. It is inversely proportional to square of wavelength i.e., n $\propto \frac{1}{\lambda^2};$ Accordingly refractive index is maximum for violet (λ=4000 Å) and minimum for red (λ=7500Å). So the deviation caused by prism f = (n –1) A is maximum for violet and minimum for red; hence on passage through the prism; the different colours are separated; thus causing dispersion of white light.

Q. 4. A convex lens is placed over a plane mirror. A pin is now positioned so that there is no parallax between the pin and its image formed by this lens-mirror combination. How will you use this observation to find focal length of the lens? Explain briefly.
[CBSE East 2016]

Ans. Focal length = distance of the pin from the mirror.

Q. 5. Light from a point source in air falls on a convex spherical glass surface of refractive index 1.5 and radius of curvature 20 cm. The distance of light source from the glass surface is 100 cm. At what position is the image formed?
[CBSE Central 2016]

Ans. R = 20 cm, n_2 = 1.5, n_1 = 1 and u = –100 cm

$$\text{Using } \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

$$\frac{1.5}{v} - \frac{1}{-100} = \frac{1.5 - 1}{20}$$

$$\Rightarrow \frac{1.5}{v} = \frac{0.5}{20} - \frac{1}{100} \quad \Rightarrow \quad \frac{1.5}{v} = \frac{2.5 - 1}{100}$$

$$\Rightarrow \quad \frac{1.5}{v} = \frac{1.5}{100}$$

$$\therefore \quad v = 100 \text{ cm}$$

A real image is formed on the other side at 100 cm away from the surface.

Q. 6. The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. If the focal length of the lens is 12 cm, find the refractive index of the material of the lens. [CBSE Delhi 2010]

Ans. Given R_1 = 10 cm, R_2 = –15 cm, f = 12 cm

Lens Maker's formula is

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

$$\Rightarrow \frac{1}{12} = (n-1)\left(\frac{1}{10} + \frac{1}{15}\right) \quad \Rightarrow \quad \frac{1}{12} = (n-1) \times \frac{5}{30}$$

$$n - 1 = \frac{30}{5} \times \frac{1}{12} = 0.5$$

$$\therefore \quad \text{Refractive index, } n = 1 + 0.5 = 1.5$$

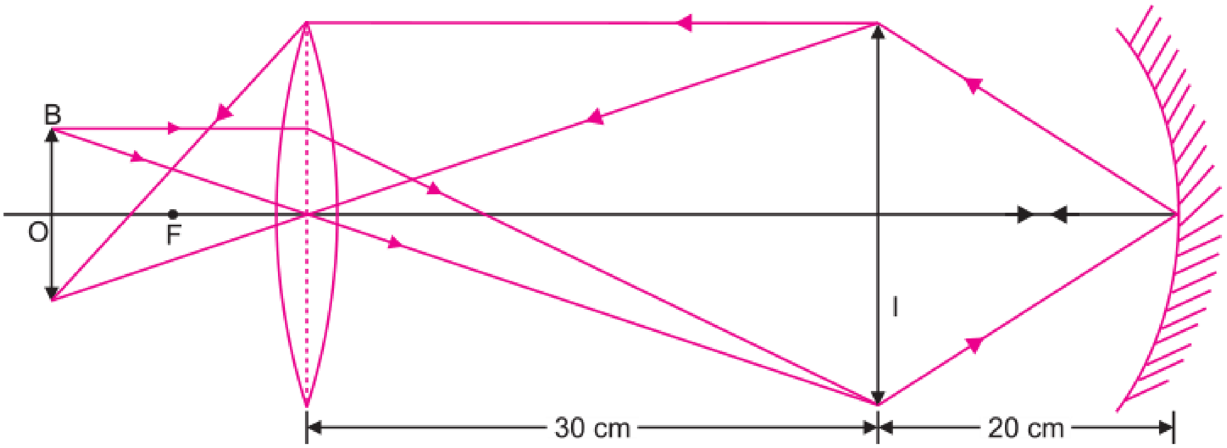
Q. 7. Calculate the distance d, so that a real image of an object at O, 15 cm in front of a convex lens of focal length 10 cm be formed at the same point O. The radius of curvature of the mirror is 20 cm. Will the image be inverted or erect?

OR

An object is placed 15 cm in front of a convex lens of focal length 10 cm. Find the nature and position of the image formed. Where should a concave mirror of

radius of curvature 20 cm be placed so that the final image is formed at the position of the object itself? [CBSE Panchkula 2015]

Ans. For lens, u = – 15 cm, f = + 10 cm



$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u} \quad \Rightarrow \quad \frac{1}{v}=\frac{1}{f}+\frac{1}{u}=\frac{1}{10}-\frac{1}{15} \quad \Rightarrow \quad v=30cm$$

For image to be formed at O, the rays incident on mirror should form the image at centre of curvature. It will be so if the image I formed by the lens lies at the centre of curvature of the mirror, then the final image of mirror will be at centre of curvature and inverted, this image will be object for the lens.

$$\therefore d=|v|+|R|=30+20=\mathbf{50\ cm}$$

The image is inverted.

Q. 8. A compound microscope has an objective of focal length 1.25 cm and eyepiece of focal length 5 cm. A small object is kept at 2.5 cm from the objective. If the final image formed is at infinity, find the distance between the objective and the eyepiece.
[CBSE (F) 2014]

Ans.

Using $\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_o}$

$$\frac{1}{v_o} - \frac{1}{-2.5} = \frac{1}{1.25} \quad \Rightarrow \quad \frac{1}{v_o} = \frac{1}{1.25} - \frac{1}{2.5}$$

$$\frac{1}{v_o} = \frac{4}{5} - \frac{2}{5} \quad \Rightarrow \quad v_o = 2.5 \text{ cm}$$

$$\therefore \quad f_o = 2.5 \text{ cm}$$

Distance between objective and eyepiece

$$L = |f_o| + |f_e| = 2.5 + 5.0 = 7.5 \text{ cm.}$$

Q. 9. Two convex lenses of same focal length but of aperture A1 and A2 (A2 < A1), are used as the objective lenses in two astronomical telescopes having identical eyepieces. What is the ratio of their resolving power? Which telescope will you prefer and why? Give reason. [CBSE Delhi 2011]

Ans.

Resolving power $R = \frac{A}{1.22\lambda}$, where A is aperture

$$\therefore \quad \frac{R_1}{R_2} = \frac{A_1}{A_2}$$

Magnification of telescope, m = $\frac{f_o}{fe}$ same for both. We prefer telescope of higher resolving power to view the fine details of the object i.e., telescope having convex lens of aperture A_1.

Q. 10. The radii of curvature of both the surfaces of a lens are equal. If one of the surfaces is made plane by grinding, then will the focal length of lens change? Will the power change? [CBSE Guwahati 2015]

Ans.

Focal length of lens $\frac{1}{f} = (n-1)\left(\frac{1}{R} + \frac{1}{R}\right) \Rightarrow f = \frac{R}{2(n-1)}$

When one surface is made plane, $\frac{1}{f} = (n-1)\left(\frac{1}{R} + \frac{1}{\infty}\right)$

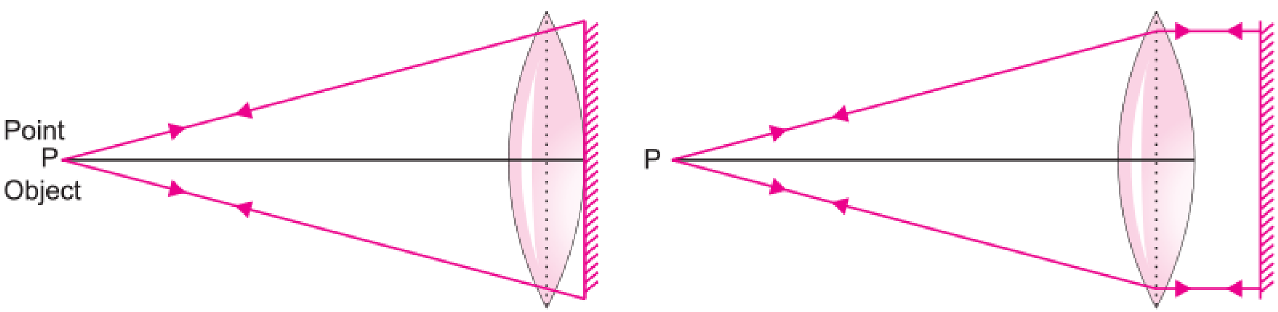
$\therefore\ f' = \frac{R}{(n-1)} = 2f$. That is, the focal length will be doubled.

As $P = \frac{1}{f}$, so power will be halved.

Q. 11. A convex lens is placed in contact with a plane mirror. A point object at a distance of 20 cm on the axis of this combination has its image coinciding with itself. What is the focal length of the lens? [CBSE (Delhi) 2014]

Ans. The focal length of the lens = 20 cm

Explanation:



As the image of this combination coincides with the object itself, the rays from the object, after refraction from the lens should fall normally on the plane mirror, so that they retrace their path. So the rays from the point object after refraction from the lens must form parallel beam. Hence the rays must be originating from the focus.

Q. 12. Define the magnifying power of a compound microscope when the final image is formed at infinity. Why must both the objective and the eyepiece of a compound microscope have short focal lengths? Explain. [CBSE Delhi 2017]

Ans. Magnifying power of a compound microscope is defined as the ratio of angle subtended by the final image at the eye to the angle subtended by the object at the unaided eye (seen directly).

$$m = m_o \times m_e = \frac{L}{f_o} \times \frac{D}{f_e}$$

Where D = least distance of distinct vision

L = tube length of the microscope

Clearly, to achieve a large magnifying power, the objective and eyepiece should have small focal lengths.

Q. 13. Why should the objective of a telescope have large focal length and large aperture? Justify your answer. [CBSE Delhi 2017]

Ans. (i) Magnifying power = $-\frac{f_o}{f_e}$

Where f_o is the focal length of objective lens and f_e is the focal length of eyepiece. Clearly, for large magnifying power, f_o should be large.

(ii) Resolving power = $\frac{d}{1.22\lambda}$

Where d is the diameter (aperture) of the objective and is the wavelength of light used. Therefore, to increase the resolving power of telescope, large aperture of the objective lens is required.

Q. 14. Answer the following questions.

(i) State the condition under which a large magnification can be achieved in an astronomical telescope.

(ii) Give two reasons to explain why a reflecting telescope is preferred over a refracting telescope. [CBSE (F) 2017]

Ans. (a) When final image is formed at least distance of distinct vision, magnification

$$m = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

(b) Magnification in normal adjustment,

$$m = \frac{f_o}{f_e}$$

Clearly, for large magnification

$F_o >> f_e$

(ii) Reflecting telescope is preferred over refracting telescope because

(a) No chromatic aberration, because mirror is used.

(b) Spherical aberration can be removed by using a parabolic mirror.

(c) Image is bright because no loss of energy due to reflection.

(d) Large mirror can provide easier mechanical support.

Q. 15. Calculate the speed of light in a medium whose critical angle is 45°. [CBSE Patna 2015]

Ans.

Critical angle in the medium, $i_C = 45^\circ$

So, refractive index, $\mu = \frac{1}{\sin i_C} = \frac{1}{\sin \ 45^\circ}$

$\Rightarrow \qquad \mu = \sqrt{2}$

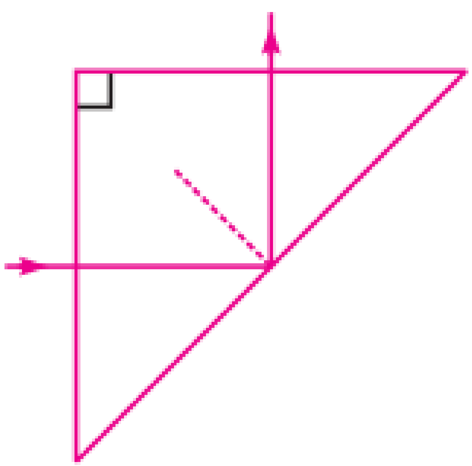
Refractive index, $\mu = \frac{c_0}{c_m}$ =

$\sqrt{2} = \frac{3\times10^8}{c_m}$

$c_m = \frac{3\times10^8}{\sqrt{2}} = 2.1 \times 10^8 \ m/s$

Yes, critical angle for a pair of media depends on wavelength, because $\mu = a + \frac{b}{\lambda^2}$, where a and b are constants of the media.

Q. 16. A ray of light incident normally on one face of a right isosceles prism is totally reflected as shown in figure. What must be minimum value of refractive index glass? Give relevant calculations. [CBSE Delhi 2016]



Ans. The critical angle depends on refractive index μ as

$\sin i_c = \frac{1}{\mu}$

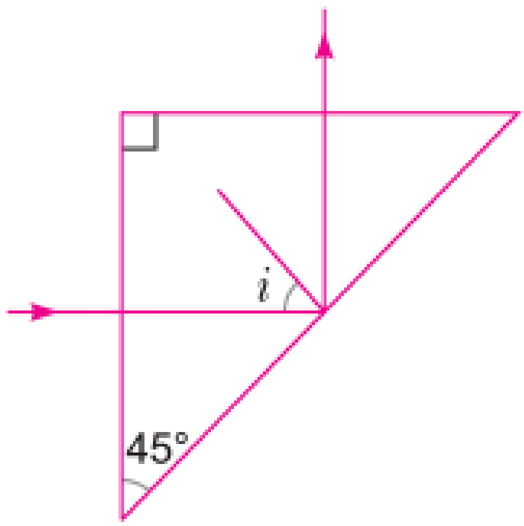
For total internal reflection,

$\angle i > \angle i_c$ (critical angle)

$\Rightarrow \quad 45^\circ > \angle i_c \quad \Rightarrow \quad \angle i_c < 45^\circ$

$\Rightarrow \quad \sin i_c \leq \sin 45^\circ \quad \Rightarrow \quad \sin i_c \leq \frac{1}{\sqrt{2}}$

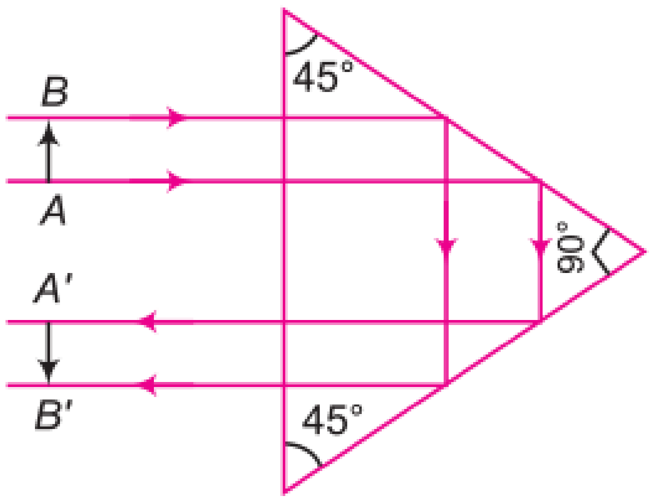
$\Rightarrow \quad \frac{1}{\sin i_c} \geq \sqrt{2} \quad \Rightarrow \quad \mu \geq \sqrt{2}$



Hence, the minimum value of refractive index must be $\sqrt{2}$.

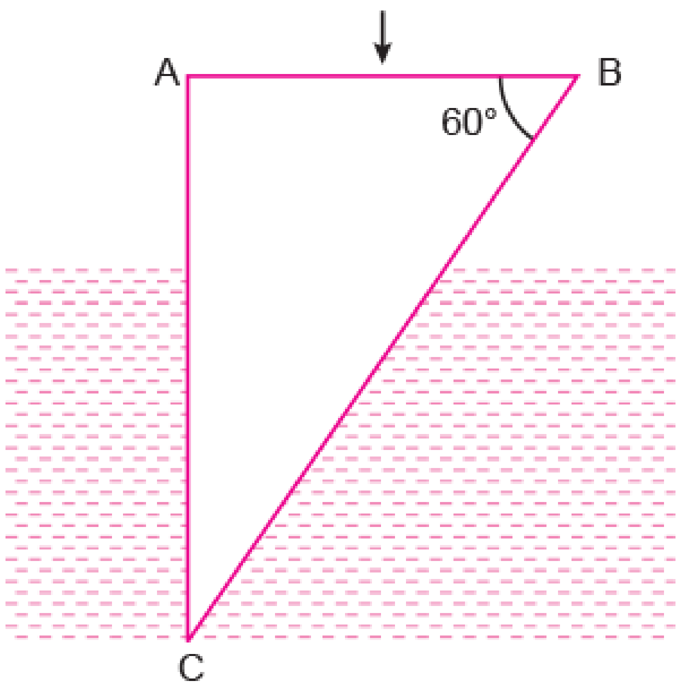
Q. 17. Draw a ray diagram to show how a right isosceles prism made of crown glass can be used to obtain the inverted image. [CBSE Guwahati 2015]

Ans.



Q. 18. Answer the following questions.

(i) A ray of light is incident normally on the face AB of a right-angled glass prism of refractive index $_a\mu_g$ = 1.5. The prism is partly immersed in a liquid of unknown refractive index. Find the value of refractive index of the liquid so that the ray grazes along the face BC after refraction through the prism.



(ii) Trace the path of the rays if it were incident normally on the face AC.
[HOTS] [CBSE Ajmer 2015]

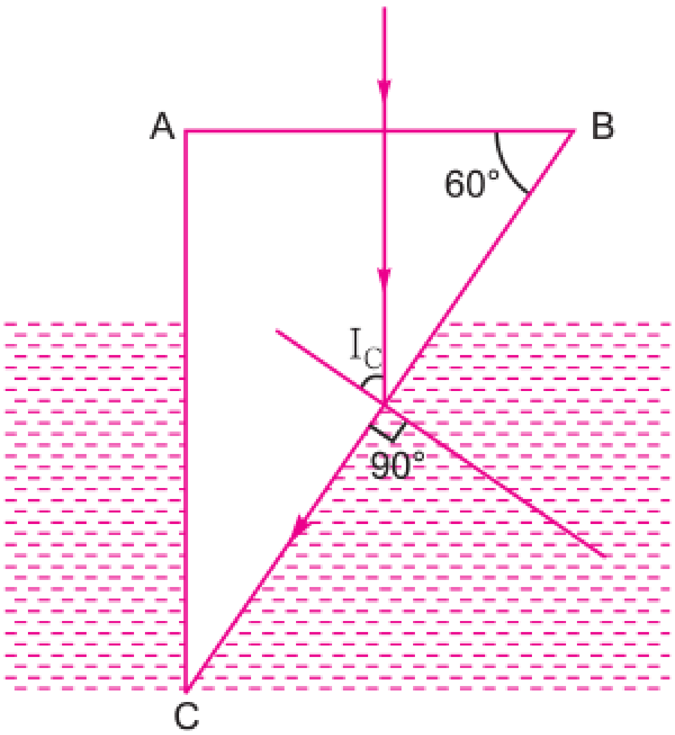
Ans. (i)

From Snell's law

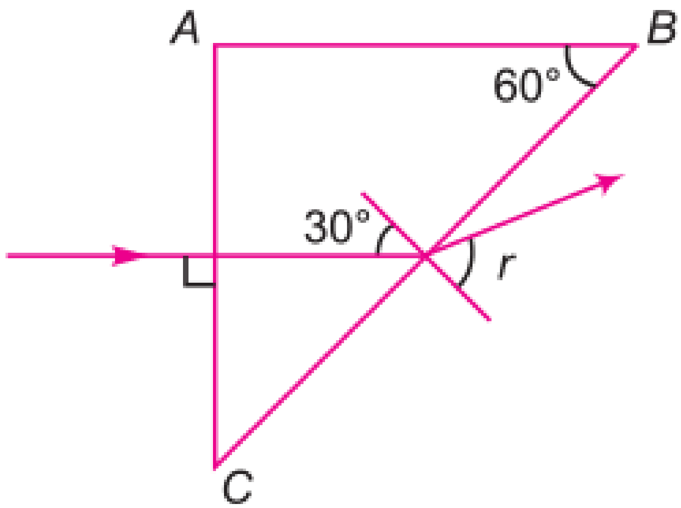
$_a\mu_g \sin i_c = {}_a\mu_l \sin 90°$

$1.5 \times \sin 60° = {}_a\mu_l$

$\therefore \quad {}_a\mu_l = 1.5 \times \frac{\sqrt{3}}{2} = 1.3$

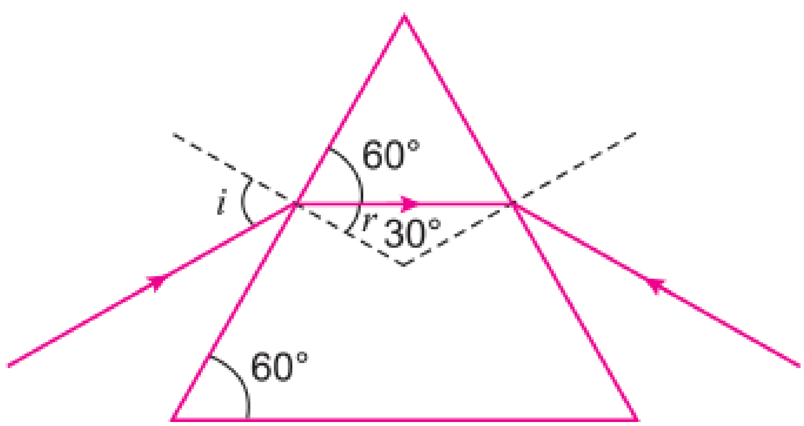


(ii) The ray strikes at an angle of 30° <i_c. So, the ray of light deviates apart from the normal, as it moves from denser to rarer medium



Q. 9. A ray of light incident on an equilateral glass prism propagates parallel to the base line of the prism inside it. Find the angle of incidence of this ray. Given refractive index of material of glass prism is .   [CBSE Bhubaneshwar 2015]

Ans.



From the figure, we see

$r = 30^\circ$

We know

$\Rightarrow \; n_{21} = \frac{\sin i}{\sin r}$

$\Rightarrow \; \sqrt{3} = \frac{\sin i}{\sin 30^\circ}$

$\Rightarrow \; \sin i = \sqrt{3} \sin 30^\circ = \sqrt{3} \times \frac{1}{2} = \frac{\sqrt{3}}{2}$

$\Rightarrow \; i = 60^\circ$

Q. 20. A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is $\frac{3}{4}$th of the angle of prism. Calculate the speed of light in the prism. [CBSE (AI) 2017]

Ans. Angle of prism, A = 60° (Since prism is an equilateral glass prism)

We are given that

$$i = \frac{3}{4}A = \frac{3}{4} \times 60^\circ$$

$$\therefore \quad i = 45^\circ$$

At minimum deviation,

$$r = \frac{A}{2} = 30^\circ$$

$$\therefore \quad \mu = \frac{\sin i}{\sin r} = \frac{\sin 45^\circ}{\sin 30^\circ} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}} = \frac{2}{\sqrt{2}} = \sqrt{2}$$

Speed of light in the prism is given by

$$v = \frac{c}{\mu} = \frac{3\times10^8}{\sqrt{2}} = 2.1 \times 10^8 \ m/s$$

Short Answer Questions – I (OIQ)

Q. 1. The focal length of a convex lens made of glass is 20 cm. What will be its new focal length when placed in a medium of refractive index 1.25?
[CBSE Sample Paper 2017]

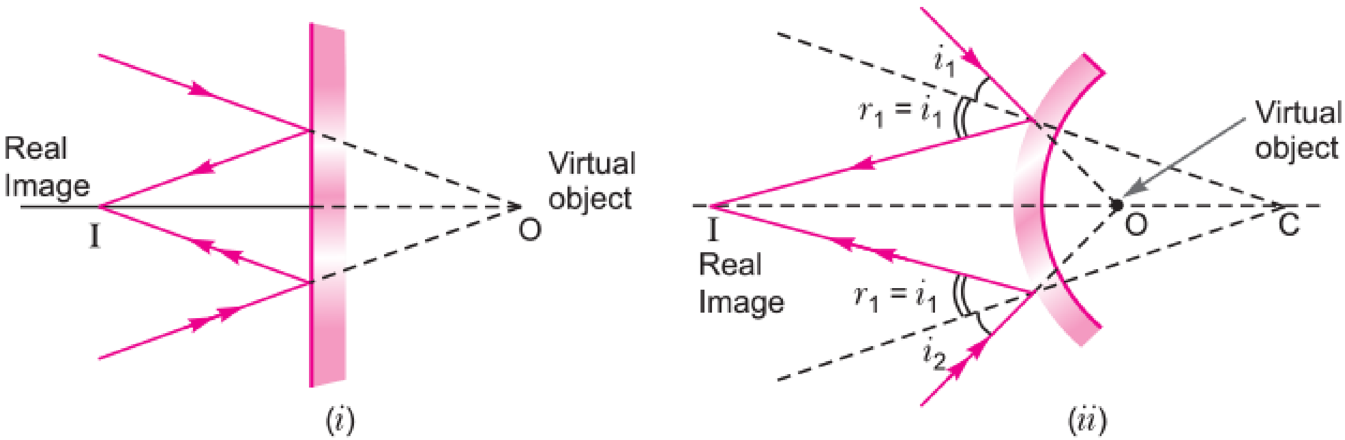
Ans.

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \Rightarrow \quad \frac{1}{20} = \frac{1}{4}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

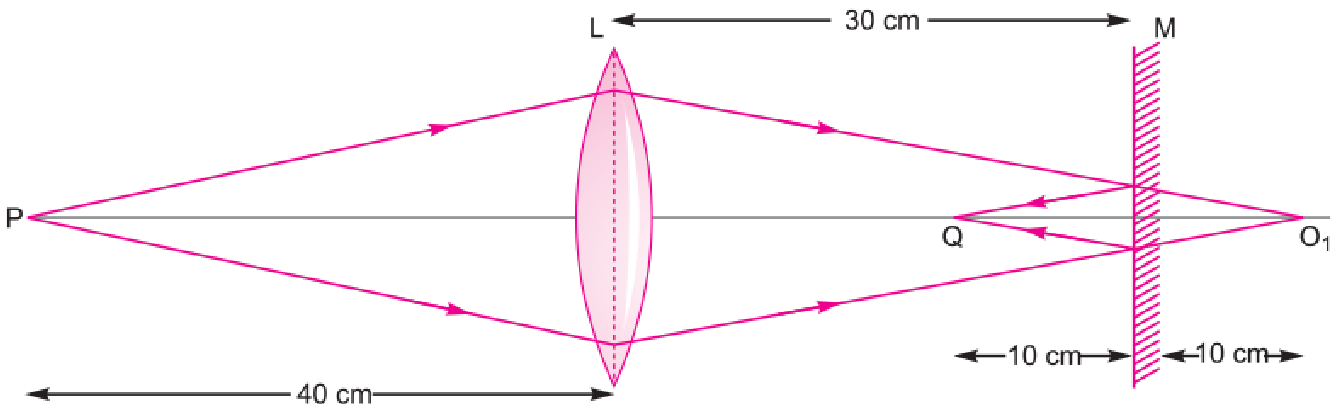
$$\frac{1}{f'} = \frac{1}{4}\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \Rightarrow \quad f' = 40 \ \text{cm}$$

Q. 2. You have learnt that plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances? Explain.

Ans. Yes, plane and convex mirrors can form real images if the object is virtual i.e., rays incident on the mirror is convergent as shown in figs. (i) and (ii).



Q. 3. A convex lens, of focal length 20 cm, has a point object placed on its principle axis at distance of 40 cm from it. A plane mirror is placed 30 cm behind the convex lens. Locate the position of image formed by this combination.



Ans. We first consider the effect of the lens. For the lens, we have

u = – 40 cm and f = + 20 cm

$$\frac{1}{v} - \frac{1}{(-40)} = \frac{1}{20} \quad \Rightarrow \quad v = +40\,cm$$

Had there been the lens only the image would have been formed at Q1. The plane mirror M is at a distance of 30 cm from the lens L. We can, therefore, think of a Q_1 as a virtual object, located at a distance of 10 cm, behind the plane mirror M. The plane mirror therefore forms a real image (of this virtual object Q_1) at Q, 10 cm in front of it. This is show in the figure.

Q. 4. The following data was recorded for values of object distance and the corresponding values of image distance in the experiment on study of real image formation by a convex lens of power + 5D. One of these observations is incorrect. Identify this observation and give reason for your choice:

S.No.	1	2	3	4	5	6

Object distance (cm)	25	30	35	45	50	55
Image distance (cm)	97	61	37	35	32	30

Ans. Power of lens = + 5 D

Focal length of lens,

The observations at serial number (3) i.e., (object distance 35 cm and image distance 37 cm is incorrect), because if the object is placed at a distance between f and 2f its image will be formed beyond 2f, while in this observation the object and image distances, both are between f and 2f.

Q. 5. For a given position of an object, an equiconvex lens forms its real image at a distance of 60 cm from the lens. A convex mirror is now kept in between this image position and the convex lens. The final image formed by this combination coincides with the object when the distance between the convex lens and the convex mirror equals 25 cm. Calculate the radius of curvature of the convex mirror.

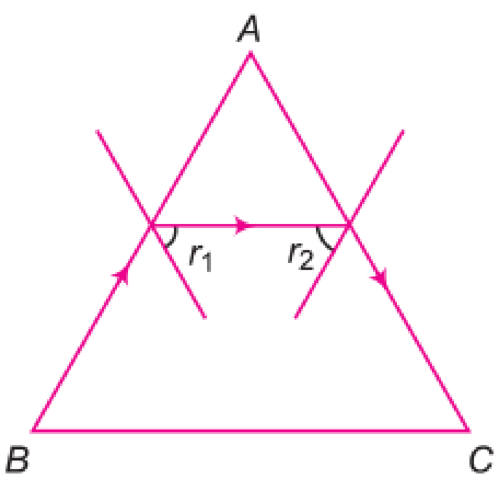
Ans. Given that the image formed by the combination of convex lens and the convex mirror coincides with the object.

This means that the position of the image formed by the convex lens alone corresponds to the position of centre of curvature of the convex mirror.

Hence, the distance between the convex mirror and this image (formed by the lens) which is equal to 60–25 represents radius of curvature of the mirror.

Thus, radius of curvature of the mirror = 35 cm.

Q. 6. A light ray incident at grazing angle on the face AB of a prism ABC, follows the path shown in the figure. Obtain the relation between the angle of prism A and the refractive index μ of its material.



Ans. For grazing incidence at the first face

$$\mu = \frac{\sin \pi/2}{\sin r_1} = \frac{1}{\sin r_1} \quad \Rightarrow \quad r_1 = \sin^{-1}\left(\frac{1}{\mu}\right)$$

$\ldots(i)$

At the second face,

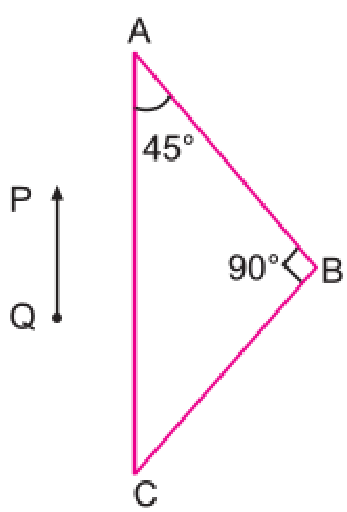
$$\frac{1}{\mu} = \frac{\sin r_2}{\sin \pi/2} = \frac{\sin r_2}{1} \quad \Rightarrow \quad r_2 = \sin^{-1}\left(\frac{1}{\mu}\right)$$

$\ldots(ii)$

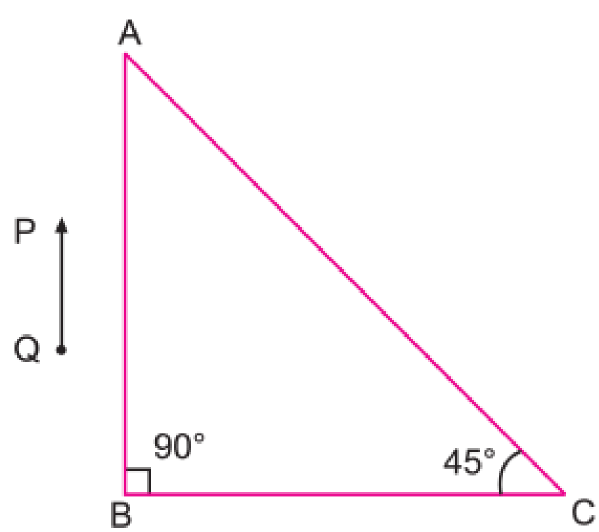
Also

$$A = r_1 + r_2 = 2\sin^{-1}\left(\frac{1}{\mu}\right)$$

Q. 7. A right-angled crown glass prism with critical angle 41° is placed before an object, PQ in two positions as shown in the figures (i) and (ii). Trace the paths of the rays from P and Q passing through the prisms in the two cases.

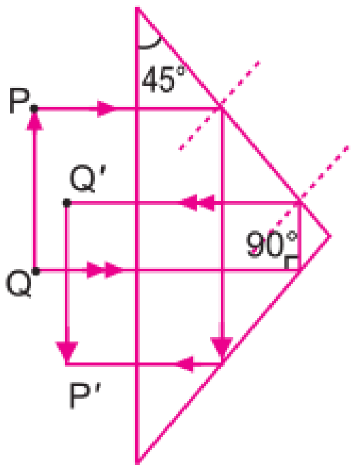


(i)

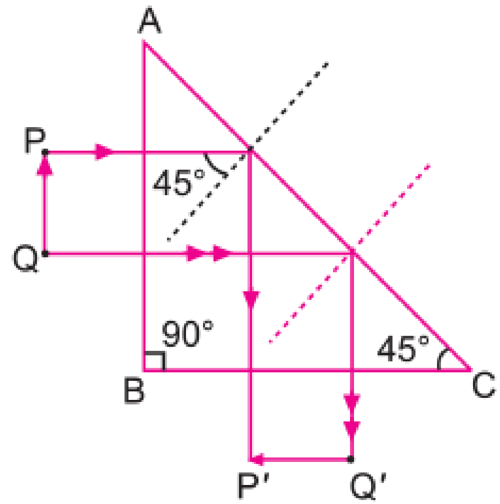


(ii)

Ans. The formation of images is shown in figures (i) and (ii).



(i) image P′ Q′ is inverted, rays suffer 180° deviation



(ii) Image in P′ Q' rays suffer 90° deviation