IMPORTANT QUESTIONS CLASS – 12 PHYSICS
CHAPTER – 9 RAY OPTICS AND OPTICAL INSTRUMENTS

Question 1.
A convex lens made up of a glass of refractive index 1.5 is dipped, In turn, In
(a) a medium of refractive index 1.65,
Answer:
When dipped in the medium of refractive index 1.65, it will behave as a concave lens and when dipped in the medium of refractive index 1.33, it will behave as a convex lens.

(b) a medium of refractive index 1.33.
(i) Will it behave as a converging or a diverging lens in the two cases?
Answer:
Its focal length in another medium is given by

$$\frac{f_m}{f_a} = \frac{({}_a\mu_g - 1)}{\left(\frac{{}_a\mu_g}{{}_a\mu_m} - 1\right)} = \frac{1.5 - 1}{\left(\frac{1.5}{1.65} - 1\right)} = \frac{0.5}{-0.09} = -5.5$$

Thus $f_m = -5.5\ f_a$, i.e. focal length increases and becomes negative.

(ii) How will Its focal length change In the two media? (CBSE AI 2011)
Answer:
Similarly

$$\frac{f_m}{f_a} = \frac{({}_a\mu_g - 1)}{\left(\frac{{}_a\mu_g}{{}_a\mu_m} - 1\right)} = \frac{1.5 - 1}{\left(\frac{1.5}{1.33} - 1\right)} = \frac{0.5}{0.15} = 3.3$$

Thus $f_m = 3.3\ f_a$, i.e. focal length increases.

Question 2.
A compound microscope uses an objective lens of focal length 4 cm and an eyepiece lens of focal length 10 cm. An object is placed at 6 cm from the objective lens. Calculate the magnifying power of the compound microscope. Also, calculate the length of the microscope. (CBSE Al 2011)
Answer:
$f_o = 4$ cm, $f_e = 10$ cm, $u_o = -6$ cm, M = ?, L = ?
Using

$$\frac{1}{f_0} = \frac{1}{v_0} - \frac{1}{u_0} \text{ we have}$$

$$\frac{1}{v_0} = \frac{1}{f_0} + \frac{1}{u_0} = \frac{1}{4} + \frac{1}{-6} = \frac{3-2}{12} = \frac{1}{12} \text{ or}$$

$$v_0 = 12 \text{ cm}$$

Hence angular magnification

$$M = \frac{v_0}{u_0} \times \left(1 + \frac{D}{f_e}\right) = \frac{12}{6}\left(1 + \frac{25}{10}\right) = 7$$

$$L = v_0 + u_e$$

$$\text{Now } \frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e} \text{ or}$$

$$\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{10} = \frac{-7}{50} \text{ or}$$

$$u_e = -50/7 \text{ cm}$$

Therefore $L = 12 + 50/7 = 19.1$ cm

Question 3.
A giant refracting telescope at an observatory has an objective lens of focal length 15 m. If an eyepiece lens of focal length 1 cm is used, find the angular magnification of the telescope.
If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens? The diameter of the moon is 3.42×10^6 m and the radius of the lunar orbit is 3.8×10^8 m.
(CBSE AI 2011, Delhi 2015)
Answer:
Given f_o = 15 m, f_e = 1.0 cm = 0.01 m, M = ?
Dm = 3.48×10^6 m, r = 3.8×10^8 m,

Using M = fofe=150.01 = 1500

The angle subtended by the moon at the objective of the telescope

$$\alpha = \frac{D_m}{r} = \frac{3.42 \times 10^6}{3.8 \times 10^8}$$

Therefore angle subtended by the image

$$\beta = M \times \alpha = 1500 \times \frac{3.42 \times 10^6}{3.8 \times 10^8}$$

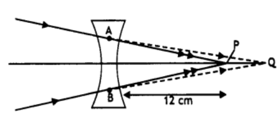
If l be the linear size of the image then

$$l = \beta \times f_e = \frac{3.42 \times 10^6 \times 1500}{3.8 \times 10^8} \times 0.01$$

$$= 13.5 \times 10^{-2} \text{ m}$$

Or l = 13. 5 cm

Question 4.
A beam of light converges at a point P. A concave lens of focal length 16 cm is placed in the path of this beam 12 cm from P. Draw a ray diagram and find the location of the point at which the beam would now converge. (CBSE Delhi 2011C)
Answer:
The ray diagram is shown in the figure. In the absence of the concave lens the beam converges at point P. When the concave lens is introduced, the incident beam of light is diverged and now comes to focus at point Q. Thus for the concave lens P serves as a virtual object giving rise to a real Image at Q.



Here u = + 12 cm, f = – 16 cm, v = ?, Now for a lens

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \text{ or } \frac{1}{v} - \frac{1}{12} = \frac{1}{-16}$$

$$\text{or } \frac{1}{v} = \frac{1}{12} - \frac{1}{16} = \frac{1}{48}$$

Hence v = 48 cm
i. e. the point at which the beam is focused is 48 cm from the lens.

Question 5.
Two convex lenses of focal length 20 cm and 1 cm constitute a telescope. The telescope is focused on a point that is 1 m away from the objective. Calculate the magnification produced and the length of the tube, if the final image Is formed at a distance of 25 cm from the eyepiece.
Answer:
Given f_o = 20 cm, f_e = 1 cm, u = – 100 cm, M =?, y =?

Fora lens 1v−1u=1f
or
1v−1−100=120
or
v = 25cm

Since the eye lens forms the image of the virtual object at the distance of distinct vision for the eye lens
v = – 25 cm, f_e = 1 cm,

Now 1v−1u=1f
or
1−25−1u = 1
or
u = – 2526cm

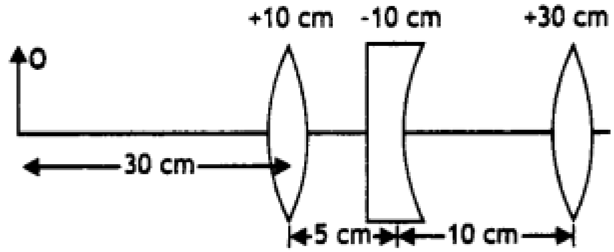
Now magnification produced by the object lens
m_o = vu=−25100=−14

Magnification produced by the eye Lens
m_e = vu=−25−25 × 26 = 26

Hence total magnification
M = m_o × m_e = -1 /4 × 26 = – 6.5

Question 6.
(a) Under what conditions are the phenomenon of total internal reflection of light observed? Obtain the relation between the critical angle of incidence and the refractive index of the medium.
(b) Three lenses of focal lengths +10 cm, -10 cm and +30 cm are arranged coaxially as in the figure given below. Find the position of the final image

formed by the combination.



Answer:
(a) (i) Light travels from a denser medium to a rarer medium.
(ii) Angle of Incidence in the denser medium is more than the critical angle for a given pair of media.
For the grazing incidence n sin i_C = l sin 90°
n = 1sinic

(b) For convex lens f = + 10 cm

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$$

$$\frac{1}{10} = \frac{1}{v_1} - \frac{1}{-30} \Rightarrow v_1 = 15 \text{ cm}$$

Object distance for concave lens u_2 = 15 – 5 = 10 cm

$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$

$$\frac{1}{-10} = \frac{1}{v_2} - \frac{1}{10} \Rightarrow v_2 = \infty$$

For third lens
1f3=1v3−1∞ ⇒ v_3 = 30 cm

Question 7.
A ray of light incident on an equilateral glass prism (μ_g = 3–√) moves parallel to the baseline of the prism inside it. Find the angle of Incidence for this ray.
Answer:
Given A = 60°, μ_g = 3–√, i = ?

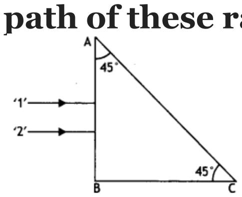
Using the expression μ = sinisinA/2
or

$$\sin i = \mu \times \sin A/2$$

$$\text{Sin } i = \sqrt{3} \times \sin 30 = \frac{\sqrt{3}}{2}$$

Therefore $i = 60°$

Question 8.
Two monochromatic rays of light are incident normally on the face AB of an isosceles right-angled prism ABC. The refractive indices of the glass prism for the two rays '1' and '2' are respectively 1.35 and 1.45. Trace the path of these rays after entering through the prism.



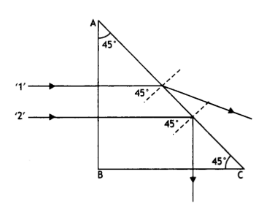
Answer:
The critical angle for the two rays is

$$n_1 = \frac{1}{\sin i_1} \text{ or } \sin i_1 = \frac{1}{1.35} = 0.741$$

Or $i_1 = 47.80$

$$n_2 = \frac{1}{\sin i_2} \text{ or } \sin i_2 = \frac{1}{1.45} = 0.6896$$

Or $i_2 = 43.60$



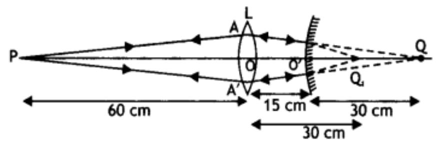
This shows that the angle of Incidence for ray '2' Is greater than the critical angle. Hence it suffers total internal reflection, white ray '1' does not. Hence the path of rays is as shown.

Question 9.

A convex lens of focal length 20 cm is placed coaxially with a convex mirror of radius of curvature 20 cm. The two are kept at 15 cm from each other. A point object lies 60 cm in front of the convex lens. Draw a ray diagram to show the formation of the image by the combination. Determine the nature and position of the image formed. (CBSE AI 2014)

Answer:

The ray diagram is as shown.



For the convex lens, we have

u_1 = – 60 cm, f = + 20 cm, v = ?

Using lens formula we have

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \text{ or } v = \frac{uf}{u+f}$$

$$= \frac{-60 \times 20}{-60 + 20} = \frac{-1200}{-40} = +30 \text{ cm}$$

Had there been only the Lens, the image would have been formed at Q_1, which acts as a virtual object for the convex mirror.

Therefore $u_2 = OQ_1 - OO'$ = 30 – 15 = 15 cm

Using mirror formuLa we have

1v2+1u2=2R

or

1v2+1u15=220

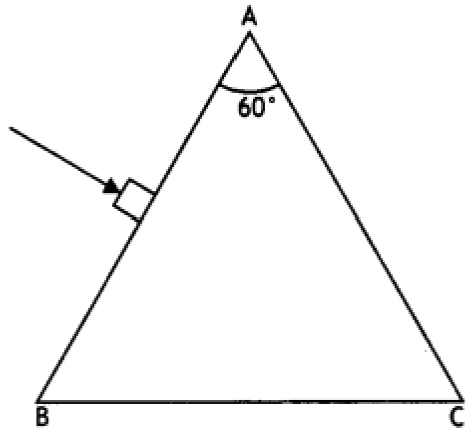
Solving for v_2 we have

v_2 = 30cm

Hence the final image is formed at (Point Q) a distance of 30 cm behind the mirror.

Question 10.

A ray PQ is an incident normally on the face AB of a triangular prism refracting angle of 60°, made of a transparent material of refractive index 2 / 3–√, as shown in the figure. Trace the path of the ray as it passes through the prism. Also, calculate the angle of emergence and angle deviation.



Answer:
Critical angle for glass
μ = 1sinic
or
sin i_c = 1μ=3√2= 0.866
or
i_c = 60°

Now the ray is incident at an angle of 60° which is equal to the critical angle, therefore the ray graces the other edge of the prism

Therefore the angle of emergence is = 90°
Hence δ = 30°