

Ray Optics

Question1

A ray of light passes from vacuum into a medium of refractive index n . If the angle of incidence is twice the angle of refraction, then the angle of incidence in terms of refractive index is

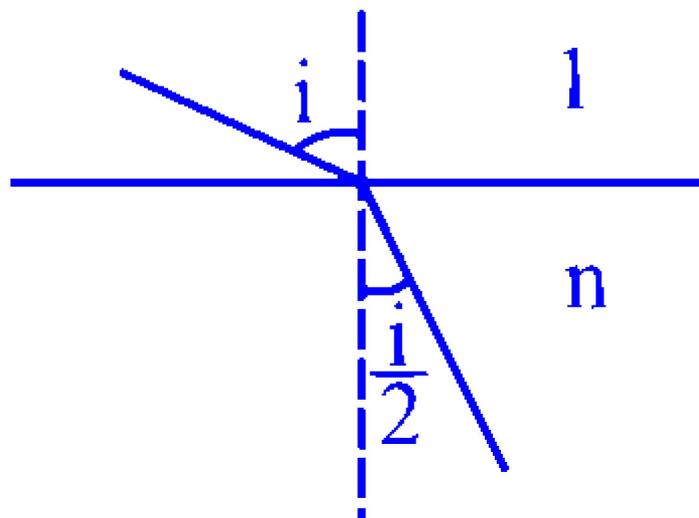
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Options:

- A. $\text{Sin}^{-1} \left(\frac{n}{2} \right)$
- B. $2 \text{Cos}^{-1} \left(\frac{n}{2} \right)$
- C. $2 \text{Sin}^{-1} \left(\frac{n}{2} \right)$
- D. $\text{Cos}^{-1} \left(\frac{n}{2} \right)$

Answer: B

Solution:



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

$$2 \sin \frac{i}{2} \cos \frac{i}{2} = n \sin \frac{i}{2}$$

$$2 \cos \frac{i}{2} = n$$

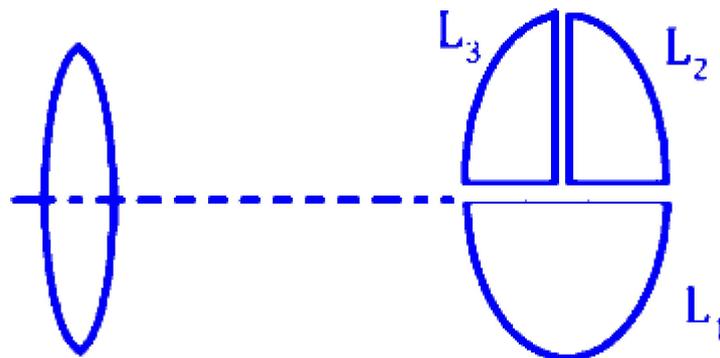
$$\cos \frac{i}{2} = \frac{n}{2}$$

$$\frac{i}{2} = \cos^{-1} \left(\frac{n}{2} \right)$$

$$i = 2 \cos^{-1} \left(\frac{n}{2} \right)$$

Question2

A convex lens has power P . It is cut into two halves along its principal axis. Further one piece (out of two halves) is cut into two halves perpendicular to the principal axis as shown in figure. Choose the incorrect option for the reported lens pieces



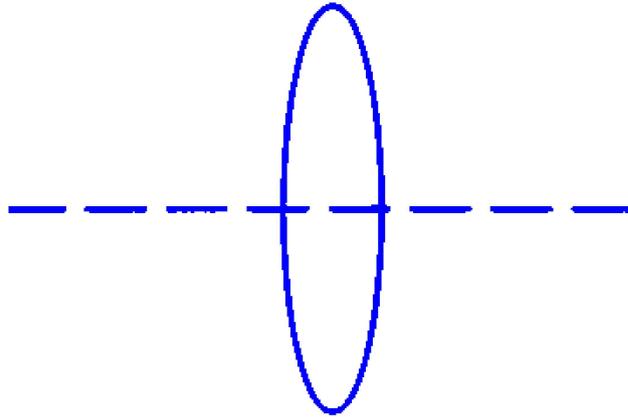
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Options:

- A. Power of L_2 is $\frac{P}{2}$
- B. Power of L_3 is $\frac{P}{2}$
- C. Power of L_1 is P
- D. Power of L_1 is $\frac{P}{2}$

Answer: D

Solution:



$$P_2 \frac{1}{F} = (\mu - 1) \frac{2}{R}$$

$$\text{Power of L1} \nabla \rightarrow P_{L_1} = (\mu - 1) \frac{2}{R} = P$$

Question3

The image formed by an objective lens of a compound microscope is

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Options:

A.

Real and diminished

B.

Real and enlarged

C.

Virtual and enlarged

D.

Virtual and diminished



Answer: B

Solution:

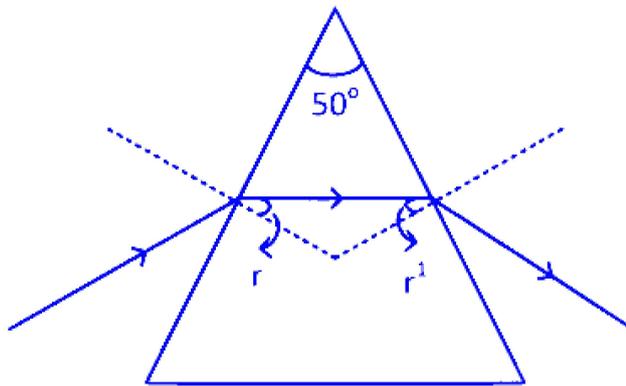
The objective lens of a compound microscope produces a real, inverted and magnified image of the object.

So the correct choice is:

Option B: Real and enlarged

Question4

If r and r^1 denotes the angles inside the prism having angle of prism 50° considering that during interval of time from $t = 0$ to $t = t$, r varies with time as $r = 10^\circ + t^2$. During the time r^1 will vary with time as



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Options:

A. $40^\circ + t^2$

B. $50^\circ - t^2$

C. $50^\circ + t^2$

D. $40^\circ - t^2$

Answer: D



Solution:

In this problem, we are given two angles, r and r^1 , inside a prism with an angle of 50° . The angle r changes with time according to the equation $r = 10^\circ + t^2$.

To find out how r^1 changes with time, we follow these steps:

Since the sum of angles r and r^1 inside the prism must equal the prism's angle, we write:

$$r + r^1 = 50^\circ$$

Substitute the expression for r into the equation:

$$(10^\circ + t^2) + r^1 = 50^\circ$$

Solve for r^1 :

$$r^1 = 50^\circ - 10^\circ - t^2 = 40^\circ - t^2$$

Therefore, during the time interval considered, the angle r^1 varies with time as $40^\circ - t^2$.

Question5

In determining the refractive index of a glass slab using a travelling microscope, the following readings are tabulated

(a) Reading of travelling microscope for ink mark = 5.123 cm

(b) Reading of travelling microscope for ink mark through glass slab = 6.123 cm

(c) Reading of travelling microscope for chalk dust on glass slab = 8.123 cm

From the data, the refractive index of a glass slab is

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Options:

A. 1.500

B. 1.601



C. 1.399

D. 1.390

Answer: A

Solution:

To determine the refractive index of a glass slab using a traveling microscope, we have recorded the following data:

Reading for the ink mark on the table surface: 5.123 cm

Reading for the ink mark viewed through the glass slab: 6.123 cm

Reading for chalk dust on top of the glass slab: 8.123 cm

Using these readings, we calculate the refractive index (n) of the glass slab as follows:

The **real depth** of the glass slab is the difference between the reading for chalk dust on the slab and the reading for the ink mark on the table:

$$\text{Real depth} = 8.123 \text{ cm} - 5.123 \text{ cm} = 3 \text{ cm}$$

The **apparent depth** is the difference between the reading for chalk dust on the slab and the reading for the ink mark viewed through the glass slab:

$$\text{Apparent depth} = 8.123 \text{ cm} - 6.123 \text{ cm} = 2 \text{ cm}$$

The refractive index (n) is calculated by dividing the real depth by the apparent depth:

$$n = \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{3 \text{ cm}}{2 \text{ cm}} = 1.5$$

Therefore, the refractive index of the glass slab is 1.5.

Question6

The final image formed by an astronomical telescope is

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Options:

A. real, erect and diminished

B. virtual, inverted and diminished



C. real, inverted and magnified

D. virtual, inverted and magnified

Answer: D

Solution:

The final image formed by an astronomical telescope is:

Option D

virtual, inverted and magnified

In an astronomical telescope, the objective lens (or mirror) creates a real, inverted image of a distant object at its focal plane. The eyepiece, which functions as a magnifying glass, then takes this real image and forms a virtual image that is also inverted but magnified for the viewer's eye. This is why when you look through an astronomical telescope, the image appears larger and upside down.

Question7

If the angle of minimum deviation is equal to angle of a prism for an equilateral prism, then the speed of light inside the prism is

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Options:

A. $3 \times 10^8 \text{ ms}^{-1}$

B. $2\sqrt{3} \times 10^8 \text{ ms}^{-1}$

C. $\sqrt{3} \times 10^8 \text{ ms}^{-1}$

D. $\frac{\sqrt{3}}{2} \times 10^8 \text{ ms}^{-1}$

Answer: C

Solution:

Given that the angle of minimum deviation δ_m is equal to the angle of the prism A for an equilateral prism, we have:

$$A = 60^\circ, \quad \delta_m = 60^\circ$$

The refractive index μ of the prism can be determined using the formula:

$$\mu = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\frac{A}{2}}$$

Substitute the values:

$$\mu = \frac{\sin\left(\frac{60^\circ+60^\circ}{2}\right)}{\sin\frac{60^\circ}{2}} = \frac{\sin 60^\circ}{\sin 30^\circ} = \frac{\frac{\sqrt{3}}{2}}{1/2} = \sqrt{3}$$

Therefore, if v is the speed of light inside the prism, the relationship with μ is:

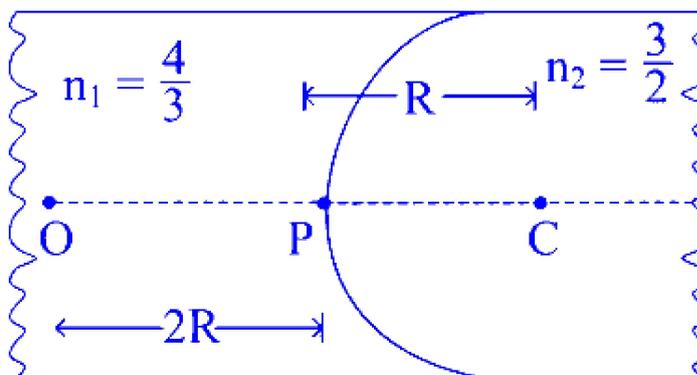
$$\mu = \frac{c}{v}$$

Rearrange to find v :

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

Question 8

A luminous point object O is placed at a distance $2R$ from the spherical boundary separating two transparent media of refractive indices n_1 and n_2 as shown, where R is the radius of curvature of the spherical surface. If $n_1 = \frac{4}{3}$, $n_2 = \frac{3}{2}$ and $R = 10$ cm, the image is obtained at a distance from P equal to



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Options:

- A. 30 cm in the rarer medium
- B. 30 cm in the denser medium

C. 18 cm in the rarer medium

D. 18 cm in the denser medium

Answer: A

Solution:

From the given diagram in question,

$$n_1 = \frac{4}{3}n_2 = \frac{3}{2}$$
$$u = -2R,$$

∴ Using refraction formula through convex spherical surface.

$$\frac{n_2}{v} - \frac{n_1}{\mu} = \frac{n_2 - n_1}{R}$$

$$\Rightarrow \frac{\frac{3}{2}}{v} - \frac{4}{3(-2R)} = \frac{\frac{3}{2} - \frac{4}{3}}{R} \Rightarrow v = -3R$$

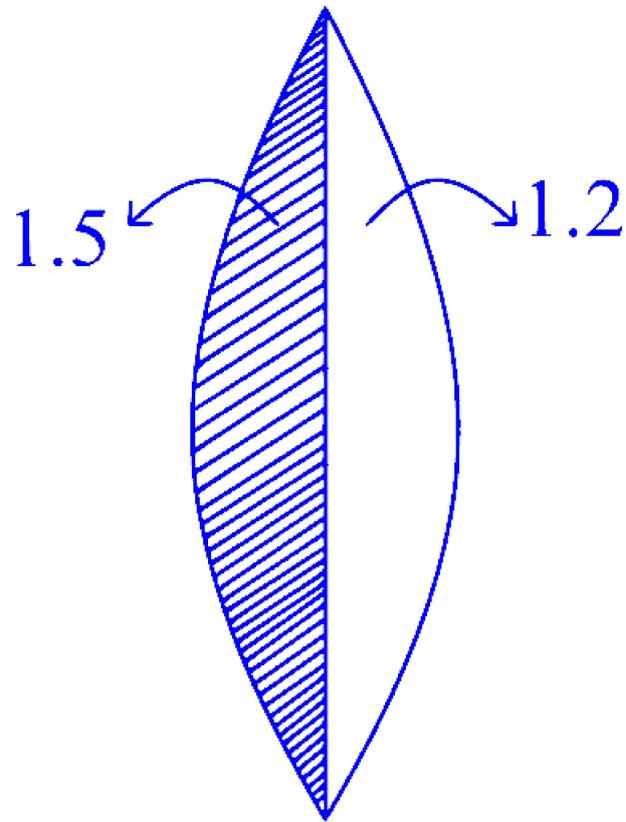
$$= -3 \times 10 \quad [\because R = 10 \text{ cm}]$$
$$= -30 \text{ cm}$$

Since, v is negative, thus image is obtained at a distance from P equal to 30 cm in the rarer medium.

Question9

An equiconvex lens of radius of curvature 14 cm is made up of two different materials. Left half and right half of vertical portion is made up of material of refractive index 1.5 and 1.2 respectively as shown in the figure. If a point object is placed at a distance of 40 cm, calculate the image distance.





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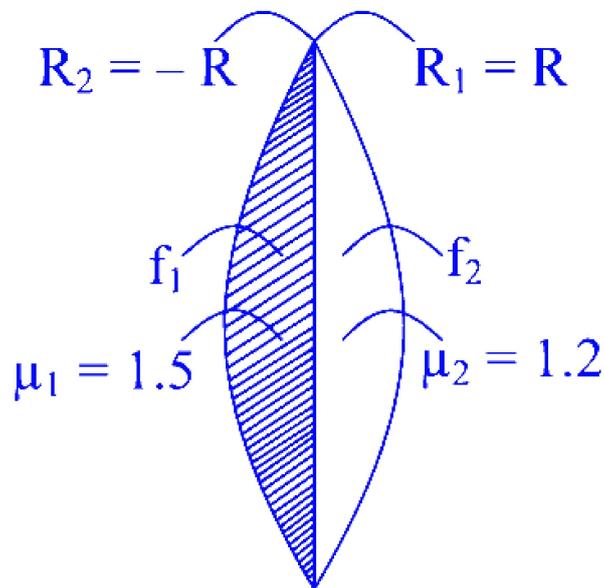
Options:

- A. 25 cm
- B. 50 cm
- C. 35 cm
- D. 40 cm

Answer: D

Solution:





From the diagram,

$$\frac{1}{f_1} = (\mu_1 - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right) = (\mu_1 - 1) \left(\frac{1}{R} - \frac{1}{\infty} \right)$$

$$\frac{1}{f_1} = \frac{\mu_1 - 1}{R} \text{ and } \frac{1}{f_2} = (\mu_2 - 1) \left(\frac{1}{\infty} - \frac{1}{-R} \right)$$

$$\frac{1}{f_2} = \frac{\mu_2 - 1}{R}$$

\therefore Combined focal length,

$$\begin{aligned} \frac{1}{f} &= \frac{1}{f_1} + \frac{1}{f_2} = \frac{\mu_1 - 1}{R} + \frac{\mu_2 - 1}{R} \\ &= \frac{\mu_1 + \mu_2 - 2}{R} = \frac{1.5 + 1.2 - 2}{14} \end{aligned}$$

$$\Rightarrow \frac{1}{f} = \frac{0.7}{14}$$

$$\Rightarrow f = 20 \text{ cm}$$

Again, $v = -40 \text{ cm}$, $v = ?$

\therefore Using lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\therefore \frac{1}{20} = \frac{1}{v} - \frac{1}{(-40)} \Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{40} = \frac{1}{40}$$

$$\Rightarrow v = 40 \text{ cm}$$

Question10

For a point object, which of the following always produces virtual image in air?

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Options:

- A. Concave mirror
- B. Plano-convex lens
- C. Convex mirror
- D. Biconvex lens

Answer: C

Solution:

Convex mirror always produces virtual, erect and diminished image in air.

Question11

For a given pair of transparent media, the critical angle for which colour is maximum?

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Options:

- A. Green
- B. Red
- C. Blue
- D. Violet

Answer: B



Solution:

Red light has the longest wavelength and the smallest refractive index within the visible region. Thus, it bends least when passing from glass to air. As a result, its critical angle is maximum.

Question12

An equiconvex lens made of glass of refractive index $\frac{3}{2}$ has focal length f in air. It is completely immersed in water of refractive index $\frac{4}{3}$. The percentage change in the focal length is

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Options:

- A. 400% increase
- B. 300% decrease
- C. 400% decrease
- D. 300% increase

Answer: D

Solution:

$$\text{Given, } {}^a\mu_g = \frac{3}{2}, f_{\text{air}} = f$$
$${}^a\mu_w = \frac{4}{3}$$

Using lens Maker's formula, when lens is in air,

$$\frac{1}{f_{\text{air}}} = ({}^a\mu_g - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$
$$\Rightarrow \frac{1}{f} = \left(\frac{3}{2} - 1 \right) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$
$$\Rightarrow \frac{1}{f} = \frac{1}{2} \left(\frac{1}{R_1} - \frac{1}{R_2} \right) \dots (i)$$

When lens is immersed in water, then



$$\frac{1}{f_w} = ({}^w\mu_g - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right) \dots \dots \text{(ii)}$$

Dividing Eq. (i) by Eq. (ii), we get

$$\begin{aligned} \frac{f_w}{f} &= \frac{1}{2({}^w\mu_g - 1)} \\ \Rightarrow f_w &= \frac{f}{2\left(\frac{\mu_g}{\mu_w} - 1\right)} = \frac{f}{2\left(\frac{\frac{3}{2}}{\frac{4}{3}} - 1\right)} = \frac{f}{\frac{1}{4}} = 4f \\ \Rightarrow f_w &= 4f \end{aligned}$$

∴ Percentage change in focal length

$$\begin{aligned} &= \frac{f_w - f}{f} \times 100 \\ &= \frac{4f - f}{f} \times 100 = 300\% \end{aligned}$$

Question13

A point object is moving at a constant speed of 1 ms^{-1} along the principal axis of a convex lens of focal length 10 cm. The speed of the image is also 1 ms^{-1} , when the object is at cm from the optical centre of the lens.

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Options:

- A. 10
- B. 15
- C. 20
- D. 5

Answer: C

Solution:

Given:

Focal length, $f = 10 \text{ cm}$

Speed of the object, $\frac{du}{dt} = 1 \text{ m/s}$

Speed of the image, $\frac{dv}{dt} = 1 \text{ m/s}$

Using the Lens Formula:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad (\text{i})$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{u-f}{fu} \Rightarrow v = \frac{fu}{u-f} \quad (\text{ii})$$

Differentiating Equation (i) with respect to t :

$$\frac{d\left(\frac{1}{f}\right)}{dt} = \frac{d\left(\frac{1}{u}\right)}{dt} + \frac{d\left(\frac{1}{v}\right)}{dt}$$

Since $\frac{1}{f}$ is a constant, its derivative is zero:

$$0 = -\frac{1}{u^2} \cdot \frac{du}{dt} - \frac{1}{v^2} \cdot \frac{dv}{dt}$$

which simplifies to:

$$\frac{1}{u^2} \cdot \frac{du}{dt} = -\frac{1}{v^2} \cdot \frac{dv}{dt}$$

Further simplifying, we have:

$$-\frac{v^2}{u^2} = \frac{dv}{dt} \cdot \frac{dt}{du}$$

Substitute values from Equation (ii):

$$-\frac{(fu)^2}{(u-f)^2} \cdot \frac{1}{u^2} = \frac{dv}{dt} \cdot \frac{dt}{du}$$

This results in:

$$(u-f)^2 = f^2 \cdot \frac{du}{dt} \cdot \frac{dt}{dv}$$

Substitute the given values into the equation:

$$(u-10)^2 = (10)^2 \cdot 1 \cdot \frac{1}{1} = 10^2$$

$$\text{Thus, } u-10 = 10 \Rightarrow u = 20 \text{ cm}$$

Therefore, the object must be 20 cm from the optical center of the lens for the image to move at the same speed.

Question 14

The power of a equi-concave lens is -4.5D and is made of a material of refractive index 1.6, the radii of curvature of the lens is



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Options:

A. 36.6 cm

B. -266 cm

C. 115.44 cm

D. -26.6 cm

Answer: D

Solution:

The problem involves finding the radii of curvature of an equi-concave lens with a given power and refractive index.

Given:

Power of the lens, $P = -4.5 \text{ D}$

Refractive index, $\mu = 1.6$

Step-by-step Solution:

Calculate the focal length:

The power of a lens is related to its focal length by the equation:

$$f = \frac{1}{P}$$

Substituting the given power:

$$f = \frac{1}{-4.5} \text{ m} = \frac{100}{-4.5} \text{ cm} = \frac{-200}{9} \text{ cm}$$

Use the Lens Maker's Formula:

The lens maker's formula is:

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

Apply conditions for an equi-concave lens:

For an equi-concave lens, $R_1 = -R$ and $R_2 = R$. Substituting these into the formula:

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

Substitute and solve:

Let's substitute the given values into the equation:

$$\frac{9}{200} = (1.6 - 1) \left(\frac{-2}{R} \right)$$

Simplifying gives:

$$\frac{9}{200} = 0.6 \left(\frac{-2}{R} \right)$$

Solving for R :

$$R = \frac{-0.6 \times 2 \times 200}{9} = -26.6 \text{ cm}$$

The radii of curvature for this equi-concave lens is -26.6 cm .

Question15

A ray of light passes through an equilateral glass prism in such a manner that the angle of incidence is equal to the angle of emergence and each of these angles is equal to $\frac{3}{4}$ of the angle of the prism. The angle of deviation is

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Options:

A. 39°

B. 20°

C. 30°

D. 45°

Answer: C

Solution:

In an equilateral glass prism, where the angle of the prism A is 60° , a ray of light passes through such that the angle of incidence (i) is equal to the angle of emergence (e), and both are $\frac{3}{4}$ of the angle of the prism.

This can be calculated as:

$$i = \frac{3}{4}A = \frac{3}{4} \times 60^\circ = 45^\circ$$

Thus, $e = i = 45^\circ$.

For a prism, the relationship between the angle of the prism A , the angle of deviation δ , the angle of incidence i , and the angle of emergence e is given by:



$$A + \delta = i + e$$

Substituting the known values:

$$\delta = i + e - A = 45^\circ + 45^\circ - 60^\circ = 90^\circ - 60^\circ = 30^\circ$$

Therefore, the angle of deviation is 30° .

Question 16

A convex lens of focal length f is placed somewhere in between an object and a screen. The distance between the object and the screen is x . If the numerical value of the magnification produced by the lens is m , then the focal length of the lens is

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Options:

A. $\frac{mx}{(m-1)^2}$

B. $\frac{(m+1)^2x}{m}$

C. $\frac{(m-1)^2x}{m}$

D. $\frac{mx}{(m+1)^2}$

Answer: D

Solution:

Given a convex lens with a focal length f positioned between an object and a screen, the total distance between the object and screen is x . The lens produces a magnification m .

To find the lens' focal length, consider:

Distance Relations:

The equation for distances is $u + v = x$, where u is the object distance and v is the image distance.

Magnification Equation:

$$\text{Magnification } m = \frac{v}{u}.$$

Expressing Distances Using Magnification:



Using the magnification equation, express the distances:

For object distance, we solve $u + mu = x$ giving $u(m + 1) = x$. Hence,

$$u = \frac{x}{m+1}$$

For image distance, we solve $\frac{v}{m} + v = x$, leading to

$$v = \frac{mx}{m+1}$$

Lens Formula Application:

The lens formula is given by

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Substituting the values of u and v from above:

$$\frac{1}{f} = \frac{1}{\left(\frac{mx}{m+1}\right)} - \frac{1}{\left(\frac{x}{m+1}\right)}$$

Simplify:

$$\frac{1}{f} = \frac{m+1}{mx} + \frac{m+1}{x}$$

$$= \frac{m+1}{x} \left[\frac{1}{m} + 1 \right]$$

$$= \frac{m+1}{x} \cdot \frac{m+1}{m}$$

Resulting in:

$$= \frac{(m+1)^2}{mx}$$

Therefore, the focal length f is:

$$f = \frac{mx}{(m+1)^2}$$

This formula provides the focal length of the lens based on the given distances and magnification.

Question17

Focal length of a convex lens will be maximum for

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Options:

A. yellow light



B. green light

C. red light

D. blue light

Answer: C

Solution:

The focal length of a convex lens depends on the refractive index of the material from which the lens is made. The relationship given by the lens maker's formula is:

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

where f is the focal length, μ is the refractive index, and R_1 and R_2 are the radii of curvature of the lens surfaces.

The focal length f is inversely related to the factor $(\mu - 1)$:

$$\frac{1}{f} \propto (\mu - 1) \Rightarrow f \propto \frac{1}{(\mu - 1)} \quad \dots (i)$$

The refractive index μ itself is inversely related to the wavelength λ of the light:

$$\mu \propto \frac{1}{\lambda} \quad \dots (ii)$$

Combining these relationships from equations (i) and (ii), we find:

$$f \propto \lambda$$

This tells us that the focal length is directly proportional to the wavelength of the light. Since red light has the longest wavelength among the visible spectrum components, the focal length of a convex lens will be maximum for red light.

Question18

Consider a glass slab which is silvered at one side and the other side is transparent. Given the refractive index of the glass slab to be 1.5. If a ray of light is incident at an angle of 45° on the transparent side, then the deviation of the ray of light from its initial path, when it comes out of the slab is

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Options:

A. 180°

B. 120°

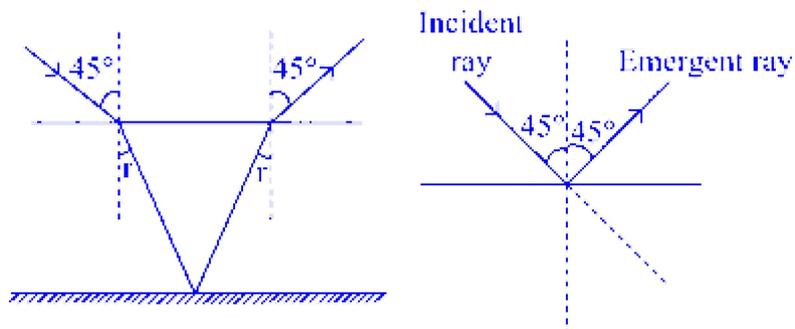
C. 45°

D. 90°

Answer: D

Solution:

The ray diagram for the given situation is shown below



Hence, emergent rays comes out at angle of 90° from incident ray.

Question19

In refraction, light waves are bent on passing from one medium to second medium because, in the second medium

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Options:

A. frequency is different

B. speed is different

C. coefficient of elasticity is different

D. amplitude is smaller



Answer: B

Solution:

The bending of light as it passes from one medium to another is due to the refractive index of the second medium relative to the first. The refractive index is determined by the speed of light in the two media and is expressed by the equation:

$${}_1\mu_2 = \frac{\text{Speed of light in first medium}}{\text{Speed of light in second medium}}$$

Therefore, when light transitions from one medium to another, it is the change in the speed of light that causes its path to bend.

Question20

If the refractive index from air to glass is $\frac{3}{2}$ and that from air to water is $\frac{4}{3}$, then the ratio of focal lengths of a glass lens in water and in air is

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Options:

A. 1 : 2

B. 2 : 1

C. 1 : 4

D. 4 : 1

Answer: D

Solution:

Given:

Refractive index from air to glass: ${}_a\mu_g = \frac{3}{2}$

Refractive index from air to water: ${}_a\mu_w = \frac{4}{3}$

Using the Lens Maker's Formula:



$$\frac{1}{f} = ({}_1\mu_2 - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

The ratio of the focal lengths of the glass lens in water and in air is given by:

$$\frac{f_{\text{water}}}{f_{\text{air}}} = \frac{({}_a\mu_g - 1)}{\left(\frac{{}_a\mu_g}{{}_a\mu_w} - 1 \right)}$$

Substituting the provided values:

$$\frac{f_{\text{water}}}{f_{\text{air}}} = \frac{\left(\frac{3}{2} - 1 \right)}{\left(\frac{\frac{3}{2}}{\frac{4}{3}} - 1 \right)}$$

Simplify:

$$= \frac{1/2}{\left(\frac{3}{2} \times \frac{3}{4} - 1 \right)} = \frac{1/2}{\left(\frac{9}{8} - 1 \right)}$$

This further simplifies to:

$$= \frac{1}{2} \times \frac{8}{1} = \frac{4}{1}$$

Therefore, the ratio of the focal lengths is 4 : 1.

Question21

Two thin biconvex lenses have focal lengths f_1 and f_2 . A third thin biconcave lens has focal length of f_3 . If the two biconvex lenses are in contact, then the total power of the lenses is P_1 . If the first convex lens is in contact with the third lens, then the total power is P_2 . If the second lens is in contact with the third lens, the total power is P_3 , then

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Options:

A. $P_1 = \frac{f_1 f_2}{f_1 - f_2}$, $P_2 = \frac{f_1 f_3}{f_3 - f_1}$ and $P_3 = \frac{f_2 f_3}{f_3 - f_2}$

B. $P_1 = \frac{f_1 - f_2}{f_1 f_2}$, $P_2 = \frac{f_3 - f_1}{f_3 + f_1}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$

C. $P_1 = \frac{f_1 - f_2}{f_1 f_2}$, $P_2 = \frac{f_3 - f_1}{f_1 f_3}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$

D. $P_1 = \frac{f_1 + f_2}{f_1 f_2}$, $P_2 = \frac{f_3 - f_1}{f_1 f_3}$ and $P_3 = \frac{f_3 - f_2}{f_2 f_3}$

Answer: D

Solution:

To understand the powers of the combined lenses, consider the following:

The focal length of the first biconvex lens is f_1 .

The focal length of the second biconvex lens is f_2 .

The focal length of the third biconcave lens, due to Cartesian sign conventions, is $-f_3$.

Power of Combined Lenses

Combination of the First and Second Biconvex Lenses:

The reciprocal of the combined focal length is given by:

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

Therefore, the power of the combination of the first and second lenses, P_1 , is:

$$P_1 = \frac{1}{f} = \frac{f_1 + f_2}{f_1 f_2}$$

Combination of the First Biconvex and Third Biconcave Lens:

The reciprocal of the combined focal length is:

$$\frac{1}{f} = \frac{1}{f_1} - \frac{1}{f_3}$$

Thus, the power of this combination, P_2 , is:

$$P_2 = \frac{1}{f} = \frac{f_3 - f_1}{f_1 f_3}$$

Combination of the Second Biconvex and Third Biconcave Lens:

The reciprocal of the combined focal length is:

$$\frac{1}{f} = \frac{1}{f_2} - \frac{1}{f_3}$$

Therefore, the power of the second and third lens combination, P_3 , is:

$$P_3 = \frac{1}{f} = \frac{f_3 - f_2}{f_2 f_3}$$

These calculations show how we derive the combined power of lenses using their individual focal lengths and considering the sign convention for convex and concave lenses.

Question22

The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30 cm is 2 cm. If a concave lens of focal

length 20 cm is placed between the convex lens and the image at a distance of 26 cm from the lens, the new size of the image is

KCET 2021

Options:

A. 1.25 cm

B. 2.5 cm

C. 1.05 cm

D. 2 cm

Answer: B

Solution:

Given:

Focal length of the convex lens, $f_1 = 30$ cm

Focal length of the concave lens, $f_2 = -20$ cm

Original image height, $h_o = 2$ cm

Distance from the convex lens to the concave lens, $u_2 = (30 - 26) = 4$ cm

To find the new size of the image:

Use the lens formula for the concave lens:

$$\frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{u_2} = -\frac{1}{20} + \frac{1}{4} = \frac{4}{20} = \frac{1}{5}$$

Solving gives:

$$v_2 = 5 \text{ cm}$$

Calculate the magnification (m) of the concave lens:

$$m = \frac{v_2}{u_2} = \frac{5}{4} = 1.25$$

Determine the new image height (h_i):

$$m = \frac{h_i}{h_o} = 1.25$$

Therefore, the new size of the image is:

$$h_i = h_o \times 1.25 = 2 \times 1.25 = 2.5 \text{ cm}$$



Thus, the new size of the image upon adding the concave lens is 2.5 cm.

Question23

An object approaches a convergent lens from the left of the lens with a uniform speed 5 m/s and stops at the focus, the image

KCET 2020

Options:

- A. moves away from the lens with an uniform speed 5 m/s
- B. moves away from the lens with an uniform acceleration
- C. moves away from the lens with a non- uniform acceleration
- D. moves towards the lens with a non-uniform acceleration

Answer: C

Solution:

To understand the behavior of the image as an object approaches a converging lens, we begin with the lens formula:

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

where f is the focal length, v is the image distance, and u is the object distance.

By differentiating this equation with respect to time, we obtain:

$$0 = -\frac{1}{v^2} \frac{dv}{dt} + \frac{1}{u^2} \frac{du}{dt}$$

This implies:

$$\frac{dv}{dt} = \left(\frac{v^2}{u^2} \right) \frac{du}{dt}$$

Here, $\frac{dv}{dt}$ is the speed of the image (v_i), and $\frac{du}{dt}$ is the speed of the object ($v_0 = 5$ m/s). Additionally, m represents the magnification. So, we derive:

$$v_i = m^2 v_0 \quad \dots (i)$$

For acceleration, we differentiate with respect to time again:



$$\frac{d^2v_i}{dt^2} = v_0 \cdot 2m \cdot \frac{dm}{dt}$$

This gives:

$$a_i = 2mv_0 \frac{dm}{dt} \quad \dots \text{ (ii)}$$

where a_i is the acceleration of the image.

When the object approaches the lens with a constant speed of 5 m/s and stops at the focus, equations (i) and (ii) indicate that the image will move away from the lens with a non-uniform acceleration. The variability in acceleration arises because $\frac{dm}{dt}$ changes as the object moves, resulting in non-uniform motion of the image.

Question24

The refracting angle of prism is A and refractive index of material of prism is $\cot \frac{A}{2}$. The angle of minimum deviation is A

KCET 2020

Options:

A. $180^\circ - 3A$

B. $180^\circ + 2A$

C. $90^\circ - A$

D. $180^\circ - 2A$

Answer: D

Solution:

Given:

Angle of the prism A

Refractive index of the prism material $\mu = \cot \frac{A}{2}$

We know that the refractive index μ is related to the angle of minimum deviation δ_m as follows:

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Substitute the given refractive index:



$$\cot \frac{A}{2} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

This simplifies to:

$$\frac{\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Therefore:

$$\sin\left(90^\circ - \frac{A}{2}\right) = \sin\left(\frac{A+\delta_m}{2}\right)$$

Equating the angles, we get:

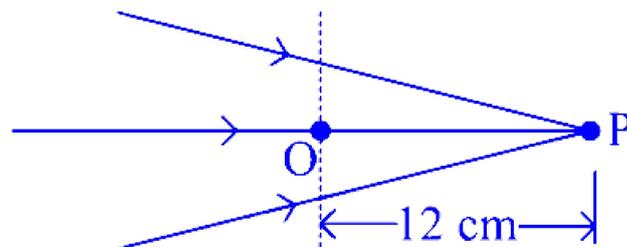
$$\frac{180^\circ - A}{2} = \frac{A + \delta_m}{2}$$

Solving for δ_m gives:

$$\delta_m = 180^\circ - 2A$$

Question25

The following figure shows a beam of light converging at point P . When a concave lens of focal length 16 cm is introduced in the path of the beam at a place shown by dotted line such that OP becomes the axis of the lens, the beam converges at a distance x from the lens. The value of x will be equal to



KCET 2020

Options:

- A. 12 cm
- B. 24 cm
- C. 36 cm
- D. 48 cm

Answer: D



Solution:

When the beam of light converges at point P , it acts as a virtual object for the concave lens.

To determine the convergence distance x from the lens:

The object distance u is given as 12 cm.

The focal length f of the concave lens is -16 cm (negative because it's a concave lens).

Using the lens formula:

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

Substitute the known values into the formula:

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = -\frac{1}{16} + \frac{1}{12} = \frac{-3+4}{48} = \frac{1}{48}$$

Solving for v :

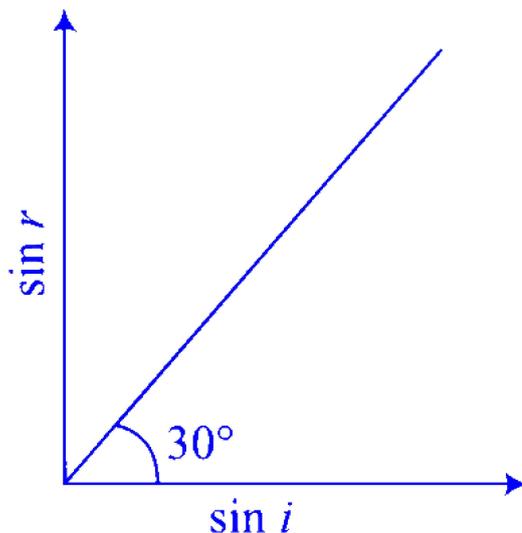
$$v = 48 \text{ cm}$$

Given that $v = x$, we find:

$$x = 48 \text{ cm}$$

Question26

A transparent medium shows relation between i and r as shown. If the speed of light in vacuum is c , the Brewster angle for the medium is



KCET 2019

Options:



A. 30°

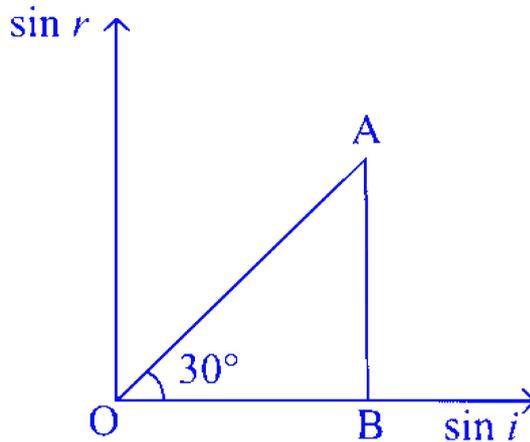
B. 45°

C. 60°

D. 90°

Answer: C

Solution:



From figure $\tan 30^\circ = \frac{AB}{OB}$

$$\frac{1}{\sqrt{3}} = \frac{\sin r}{\sin i} \Rightarrow \frac{\sin i}{\sin r} = \sqrt{3}$$

\Rightarrow By Snell's law

Refractive index,

$$\mu = \frac{\sin i}{\sin r} = \sqrt{3}$$

$$\mu = \sqrt{3}$$

But, by Brewster's law

$$\Rightarrow \mu = \tan i_p \quad [i_p \rightarrow \text{Brewster angle}]$$

$$\Rightarrow \sqrt{3} = \tan i_p$$

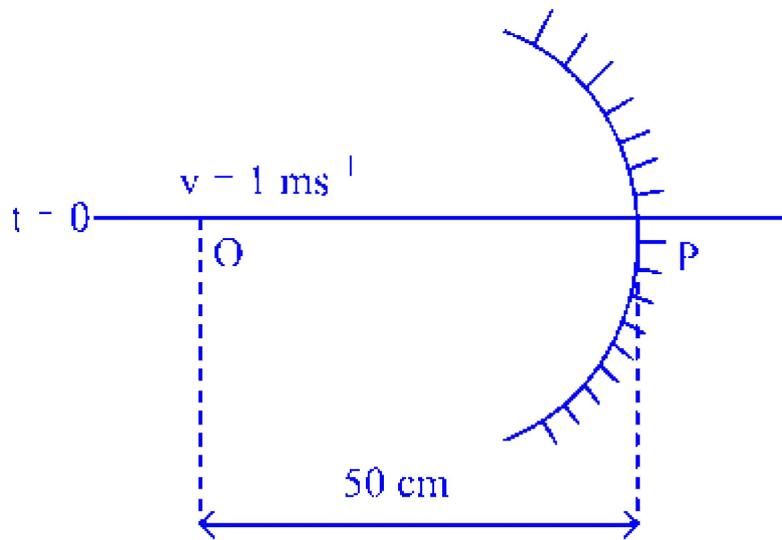
$$\Rightarrow \tan 60^\circ = \tan i_p$$

$$\Rightarrow i_p = 60^\circ$$

Question27

A point object is moving uniformly towards the pole of a concave mirror of focal length 25 cm along its axis as shown below. The speed of the object is 1 ms^{-1} . At $t = 0$, the distance of the object from the mirror is 50 cm. The average velocity of the image formed





KCET 2019

Options:

- A. 40 cm s^{-1}
- B. 20 cm s^{-1}
- C. zero
- D. infinity

Answer: D

Solution:

(i) At $t = 0$, $u = -50 \text{ cm}$

$$f = -25 \text{ cm} \Rightarrow u = 2f \cdot (\text{at C})$$

so image is also at C $\Rightarrow v = -50 \text{ cm}$

(ii) at $t = 0.25 \text{ s}$, distance covered by object $s = vt$

$$= 1 \times 0.25 = 0.25 \text{ m} = 25 \text{ cm}$$

so new distance of object from mirror

$$= (50 - 25) \text{ cm} = 25 \text{ cm}$$

i.e. $u = -25 \text{ cm} (= f)$

when $u = f$, then $v = \infty$

so velocity of image,

$$v_{\text{image}} = \frac{\text{distance travelled by image}}{\text{time}} = \frac{\infty}{0.25}$$
$$= \infty \text{ (infinity)}$$

Question28

A certain prism is found to produce a minimum deviation of 38° . It produce a deviation of 44° when the angle of incidence is either 42° or 62° . What is the angle of incidence when it is undergoing minimum deviation?

KCET 2019

Options:

- A. 30°
- B. 40°
- C. 49°
- D. 60°

Answer: C

Solution:

To find the angle of incidence when the prism undergoes minimum deviation, we have been provided the following data:

Minimum deviation, $\delta_{\min} = 38^\circ$

Deviation, $\delta = 44^\circ$, for angles of incidence $i_1 = 42^\circ$ and $i_2 = 62^\circ$

We use the formula for deviation:

$$\delta = (i_1 + i_2) - A$$

Rearranging to find A (the angle of the prism), we have:

$$A = (i_1 + i_2) - \delta = (42^\circ + 62^\circ) - 44^\circ = 60^\circ$$

With $A = 60^\circ$, the angle of incidence for minimum deviation is given by:

$$i = \frac{A + \delta_{\min}}{2} = \frac{60^\circ + 38^\circ}{2} = 49^\circ$$



Thus, the angle of incidence when the prism experiences minimum deviation is 49° .

Question29

An object is placed at the principal focus of a convex mirror. The image will be at

KCET 2018

Options:

- A. centre of curvature
- B. principal focus
- C. infinity
- D. no image will be formed

Answer: C

Solution:

A convex mirror forms images using the mirror equation :

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Where :

- f is the focal length of the mirror (for a convex mirror, f is taken as negative in sign convention, but its magnitude is what matters here).
- u is the object distance.
- v is the image distance.

For a convex mirror, when an object is placed at its principal focus, the distance of the object is :

$$u = f$$

Substitute this into the mirror equation :

$$\frac{1}{f} = \frac{1}{f} + \frac{1}{v}$$

Subtract $\frac{1}{f}$ from both sides :

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{f} = 0$$

This means :

$$v = \infty$$

Thus, the image is formed at infinity.

So the correct answer is :

Option C: infinity.

Question30

An object is placed at a distance of 20 cm from the pole of a concave mirror of focal length 10 cm . The distance of the image formed is

KCET 2018

Options:

A. +20 cm

B. +10 cm

C. -20 cm

D. -10 cm

Answer: C

Solution:

To find the distance of the image formed by the concave mirror, we can use the mirror formula:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Where:

f is the focal length of the mirror,

u is the object distance, and

v is the image distance.

Given:

Focal length, $f = 10$ cm

Object distance, $u = -20$ cm (The negative sign indicates that the object is placed on the side of the mirror where light is coming from, as per the sign convention for concave mirrors.)

Substitute these values into the mirror formula:



$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\frac{1}{v} = \frac{1}{10} - \frac{1}{-20}$$

Solving this gives:

$$\frac{1}{v} = \frac{-1}{10} + \frac{1}{20}$$

To find a common denominator:

$$\frac{1}{v} = \frac{-2}{20} + \frac{1}{20} = \frac{-1}{20}$$

Thus:

$$v = -20 \text{ cm}$$

Therefore, the image is formed at a distance of -20 cm from the pole of the concave mirror. The negative sign indicates that the image is formed on the same side of the mirror as the object, which is typical for a real image in concave mirrors.

Question31

A candle placed 25 cm from a lens forms an image on a screen placed 75 cm on the other side of the lens. The focal length and type of the lens should be

KCET 2018

Options:

- A. +18.75 cm and convex lens
- B. -18.75 cm and concave lens
- C. +20.25 cm and convex lens
- D. -20.25 cm and convex lens

Answer: A

Solution:

To determine the focal length and type of lens used, we have the following information:

Object distance, $u = -25$ cm (negative because it's on the opposite side of the light's direction),

Image distance, $v = +75$ cm.

To find the focal length f , we use the lens formula:

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Substitute the given values:

$$\frac{1}{f} = \frac{1}{75} - \frac{1}{-25}$$

Simplify the equation:

$$\frac{1}{f} = \frac{1}{75} + \frac{1}{25}$$

Convert $\frac{1}{25}$ to a denominator of 75:

$$\frac{1}{25} = \frac{3}{75}$$

Now, add the fractions:

$$\frac{1}{f} = \frac{1}{75} + \frac{3}{75} = \frac{4}{75}$$

To find f , take the reciprocal:

$$f = \frac{75}{4} = 18.75 \text{ cm}$$

Since the focal length f is positive, the lens is a convex lens.

Question32

According to cartesian sign convention, in ray optics

KCET 2017

Options:

- A. all distance are taken negative
- B. all distances in the direction of incident ray are taken positive
- C. all distances are taken positive
- D. al distances in the direction of incident ray are taken negative

Answer: B

Solution:

According to cartesian sign convention, in ray optics all distance in the direction of incident ray are taken positive.



Question33

A linear object of height 10 cm is kept in front of a concave mirror of radius of curvature 15 cm , at a distance of 10 cm . The image formed is

KCET 2017

Options:

- A. magnified and erect
- B. magnified and inverted
- C. diminished and erect
- D. diminished and inverted

Answer: B

Solution:

Given:

Height of object, $h_0 = 10$ cm

Radius of curvature, $R = 15$ cm

Distance of object, $u = -10$ cm

First, calculate the focal length of the concave mirror using:

$$f = \frac{R}{2} = \frac{15}{2} \text{ cm}$$

According to the mirror formula:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Substituting the known values:

$$\frac{1}{-\frac{15}{2}} = \frac{1}{-10} + \frac{1}{v}$$

Solving for $\frac{1}{v}$:

$$\frac{1}{v} = \frac{-2}{15} + \frac{1}{10}$$

$$\Rightarrow \frac{1}{v} = \frac{-4+3}{30}$$

$$\Rightarrow \frac{1}{v} = \frac{-1}{30}$$



$$\Rightarrow v = -30 \text{ cm}$$

Now, calculate the magnification (m) using the formula:

$$m = \frac{h_i}{h_o} = \frac{-v}{u}$$

Thus:

$$\frac{h_i}{10} = \frac{-(-30)}{-10}$$

$$\Rightarrow h_i = -3$$

Therefore, the image will be magnified and inverted.
