Light: Reflection & Refraction

Check Point 01

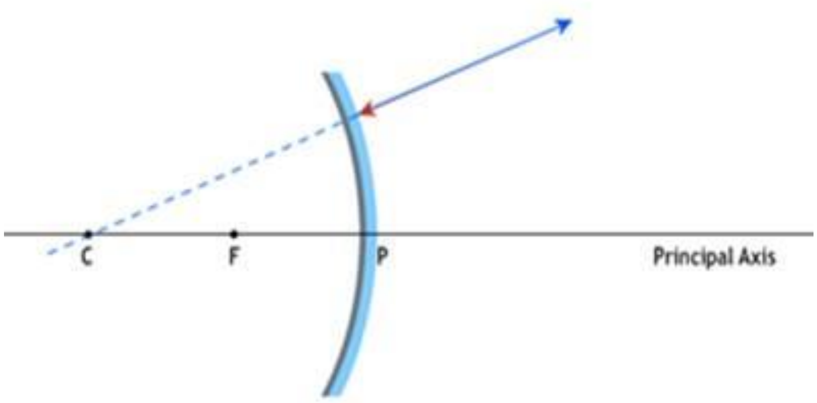
Q. 1. Why does a ray of light passing through the centre of curvature of a concave mirror gets reflected along same path after reflection?

Answer: When ray of light passes through the center of curvature of the concave mirror it strikes along the normal that means it is incident on mirror at 90°.

Thus by the law of reflection which states that the angle of incidence is always equal to the angle of reflection i.e. 90°.

Hence the incident ray coincides with the normal and retraces its path after reflection from the spherical mirror.

The figure below illustrates the above situation.



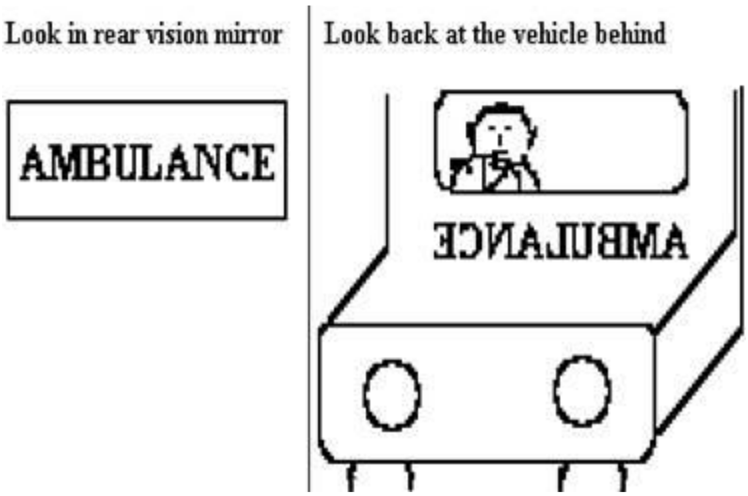
Q. 2. What kind of image is formed on a cinema screen?

Answer: Image formed is real and erect because real image is formed on the screen, and it is not inverted because the object inside the projector is inverted already, therefore its image will come as erect image, hence we are able to produce the image on screen as well as keep it erect.

Q. 3. What do you mean by laterally inverted?

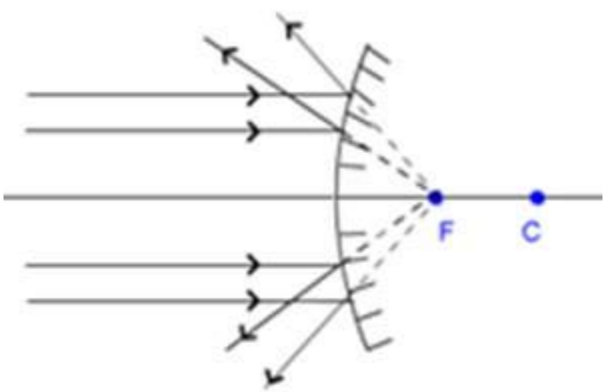
Answer: A mirror forms an image such that its left side is object's right side and its right side is object's left side. This phenomenon of change in object and image sides is known as lateral inversion.

For example, the word AMBULANCE is painted left-right inverted on the ambulance so that when the driver of a vehicle in front looks into his rear-view mirror, he can make out the word AMBULANCE quickly and give way. As shown in the figure below.



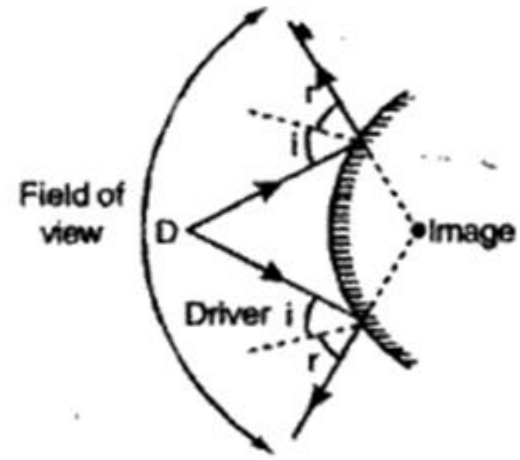
Q. 4. The image formed by a convex mirror is observed to be virtual, erect and extremely diminished than the object, what should be the position of the object?

Answer: Convex mirror always forms virtual, erect and diminished image of an object but when the object is kept at infinity the image is formed at focus and is extremely diminished. As shown in the figure below.



Q. 5. Which type of spherical mirror has a larger field of view?

Answer: Convex mirror has a larger field of view because it is diverging in nature. The light rays incident on it gets diverged following the laws of reflection, the reflected rays form the wider path as shown in the figure below.

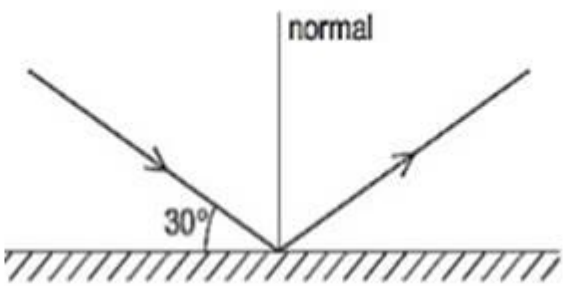


Due to large field of view convex mirrors are used in headlights of vehicles.

Q. 6. If a ray of light is incident on a plane mirror such that it makes an angle of 30with the mirror, then will be the angle of reflection?

Answer: Ray of light strikes the mirror at an angle of 30°.

⇒ It will make an angle of 60° (90° – 30°) with the normal. As shown in the figure below.



∴ Angle of incidence = 60°.

Now, By laws of reflection;

Angle of Incidence = Angle of reflection;

⇒ Angle of reflection = 60°.

Hence Angle of reflection is 60°.

Check Point 02

Q. 1. A spherical mirror has focal length -10 cm. What type of mirror is it likely to be?

Answer: The mirror is likely to be the concave mirror because the focal length of the concave mirror is negative because the focus is on the left-hand side of the mirror which is taken to be negative according to sign convention.

Thus the required spherical mirror is a concave mirror of focal length 10 cm.

Q. 2. If the magnification of an image formed by a mirror is positive, what does it mean?

Answer: Positive magnification means that both the object and the image formed by a spherical mirror (concave or convex) are erect (upright). An erect image is always virtual. Thus, positive magnification indicates that the image formed by a spherical mirror is virtual, erect.

Q. 3. What is the magnification produced by a rear view mirror fitted in vehicles?

Answer: Convex mirrors are used in vehicles for rear view due to their wide field of view. And the convex mirror forms a virtual, erect and diminished image of the object. Therefore, magnification (m) produced by a rear view mirror fitted in vehicles is less than one i.e., m < +1 because

Magnification (m) = $\frac{\text{Image height}}{\text{object height}}$

And image size is less than the object size.

Q. 4. Rays from the sun converge at a point 15 cm in front of a concave mirror. Where an object should be placed, so that its image formed is equal to the size of the object?

Answer: The rays from sun coming from infinity are parallel to principal axis after reflection they converge at a point, known as focus. Therefore, focal length (F) of concave mirror is 15 cm.

And we know that same size, real and inverted image is formed by concave mirror when object is placed at centre of curvature = 2×Focal length (F). So to form same size image object will be placed at 15x2 = 30cm.

Q. 5. An object is placed at a distance of 8 cm form a convex mirror of focal length 12 cm. Find the position of the image formed?

Answer: According to the question;

Focal length (f) = 12cm;

Object distance (u) = -8cm;

By mirror formula;

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

$$\Rightarrow \frac{1}{v}+\frac{1}{-8}=\frac{1}{12}$$

$$\Rightarrow \frac{1}{v}=\frac{1}{8}+\frac{1}{12}$$

$$\frac{1}{v}=\frac{3+2}{24}$$

$$\Rightarrow \frac{1}{v}=\frac{5}{24}$$

$$\Rightarrow v=\frac{24}{5}=4.8\text{cm}.$$

Since v = 4.8cm which is positive hence image is behind the mirror.

The image is formed at the distance of 4.8 cm behind the mirror and is virtual and erect.

Q. 6. If the object distance for a concave mirror is 24 cm and image distance is 12 cm in front of a mirror. Then, find the magnification of the mirror.

Answer: Given that;

Object distance (u) = -24cm;

Image distance (v) = -12cm (image is in front of mirror hence v is negative).

Now;

Magnification = $-\frac{v}{u}$

⇒ Magnification = $-\frac{-12}{-24}= -\frac{1}{2}$

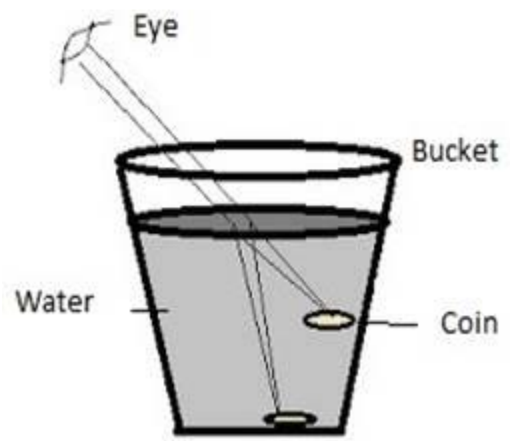
∴ Magnification is -0.5. Which tells that image is real and inverted and half of the size of the object.

Check Point 03

Q. 1. The depth of a bucket filled with water seems to be less than its actual depth. Name the phenomenon responsible for this?

Answer: The depth appears to be less because of refraction of light. Light rays bend as they move from water to the air. When the light ray from water reaches our eye, the eye traces them back as straight lines (shown as dashed lines) which intersect at a higher position than where the actual rays originated. This causes the depth of a bucket to appear higher and we cannot see the actual depth of the bucket.

The figure below illustrates the same.



Q. 2. A light ray is incident on a rectangular glass slab at an angle of 60°. What is the angle between the ray coming out of the slab and the normal to the face of rectangular slab from which it comes out?

Answer: Ray of light strikes the mirror at an angle of 60o.

⇒ It will make an angle of 300 (900 – 600) with the normal.

∴ Angle of incidence = 300.

Now, By laws of refraction;

$$\mu = \frac{\text{Sin i}}{\text{Sin r}}$$

Angle of incidence is 60°

Refractive index of glass slab is 1.5

Putting the value in the above equation, we get

$$1.5 = \frac{0.866}{\sin r}$$

On solving the above equation, we get

$$\sin r = \frac{0.866}{1.5}$$

Angle of refraction, r= 35.26°

Thus the angel of refraction is 35.26° from the normal.

Q. 3. How is the refractive index of a medium related to the speed of light? Give an expression for refractive index of a medium with respect to another in terms of speed of light in these two media?

Answer: Refractive index compares the speed of light in a particular medium with the speed of light in vacuum

Relation between refractive index and speed of light:

Refractive index (μ) = $\frac{\text{c (speed of light in vaccum)}}{\text{v(speed of light in any medium)}}$

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

Let the refractive index of medium 1 be μ1 and the speed of light in medium 1 is v1.

$\Rightarrow \mu_1 = \frac{c}{v_1}$ …………………. (1)

Similarly;

Let the refractive index of medium 2 be μ2 and the speed of light in medium2 is v2.

$\Rightarrow \mu_2 = \frac{c}{v_2}$ …………………. (2)

Dividing (1) by (2) $\frac{\mu_1}{\mu_2} = \frac{\frac{c}{v_1}}{\frac{c}{v_2}} = \frac{c}{v_1} \times \frac{v_2}{c}$

$$\Rightarrow \frac{\mu_1}{\mu_2} = \frac{v_2}{v_1}$$

Hence refractive index of a medium is inversely proportional to the speed of light in that medium.

Q. 4. For the same angle of incidence, the angle of refraction in three different media A, B and C 10°, 25° and 40°, respectively. In which medium the velocity of light will be maximum?

Answer: Refractive index (μ) = $\frac{c\ (\text{speed of light in vaccum})}{v(\text{speed of light in any medium})}$ ……(1)

Hence refractive index of a medium is inversely proportional to the speed of light in that medium.

Also μ = $\frac{\sin i}{\sin r}$ …………….. (2)

⇒ Refractive index is inversely proportional to the angle of refraction.

From (1) and (2)

Velocity of light is directly proportional to the angle of refraction.

Thus velocity of light is maximum in medium C because angle of refraction is 40° is maximum.

Q. 5. Calculate the angle of incidence of light ray incident of surface of a plastic slab of refractive index √3, if the angle of refraction is 30°.

Answer: Given;

Angle of refraction(r) = 30°.

Angle of incidence = i.

Refractive index (μ) = √3.

Refractive index (μ) = $\frac{\sin i}{\sin r}$

$$\Rightarrow \sqrt{3} = \frac{\sin i}{\sin 30} = \frac{\sin i}{\frac{1}{2}}$$

⇒ $\sqrt{3} = 2 \times \sin i$

⇒ $\sin i = \frac{\sqrt{3}}{2}$

⇒ $i = 60^0.$

Hence angle of incidence is 60°.

Q. 6. If a ray of light enters from alcohol to air. The refractive index of alcohol is 1.36. Calculate the speed of light in alcohol with respect to air.

Answer: Given;

Refractive index of alcohol (μ) = 1.36.

Speed of light in vacuum = 3×10^8m/s.

Refractive index (μ) = $\frac{\text{c (speed of light in vaccum)}}{\text{v(speed of light in alcohol)}}$

⇒ 1.36 = $\frac{3 \times 10^8}{\text{speed of light in alcohol}}$

⇒ $\text{speed of light in alcohol} = \frac{3 \times 10^8}{1.36}$

∴ Speed of light in alcohol = 2.21×10^8m/s

Speed of light in alcohol with respect to air is 2.21×10^8 ms-1

Q. 7. The refractive index of glass with respect to air is $\frac{3}{2}$ and refractive index of water with respect to air is $\frac{4}{3}$. What will be the refractive index of water with respect to glass?

Answer: Refractive index of air, μair = 1;

Given;

Refractive index of water w.r.t air, aμw $= \frac{4}{3}$

Refractive index of glass w.r.t air, aμg $= \frac{3}{2}$

Refractive index of water w.r.t glass = gμw = $\frac{{}^a\mu_w}{{}^a\mu_g} = \frac{\frac{4}{3}}{\frac{3}{2}}$

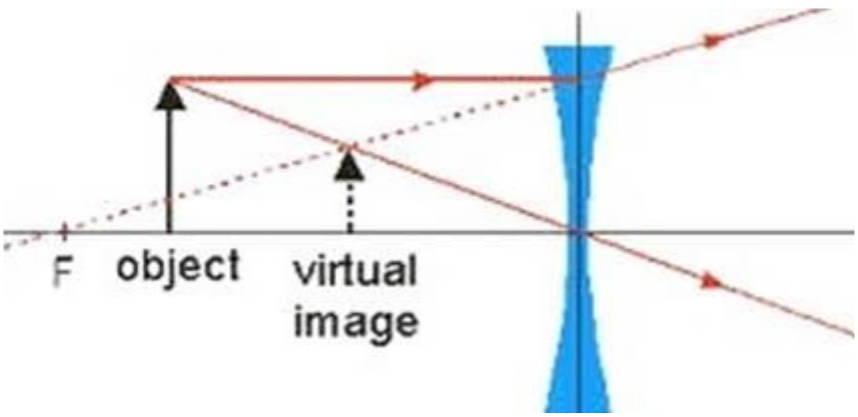
⇒ gμw = $\frac{4 \times 2}{3 \times 3} = \frac{8}{9}$

∴ Refractive index of water w.r.t glass is $\frac{8}{9}$.

Check Point 04

Q. 1. Name the lens which always forms a virtual image of an object.

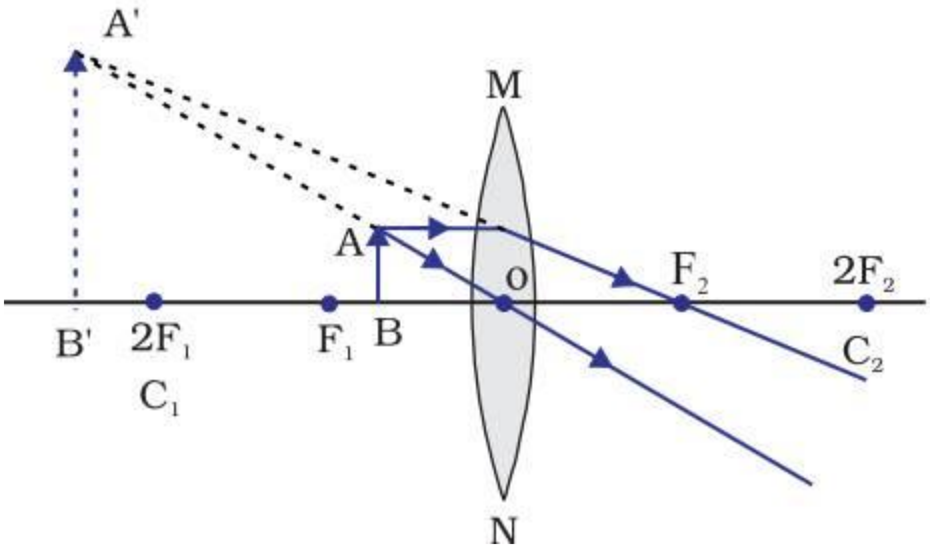
Answer: A concave lens always forms the virtual image of an object because it is diverging lens. The image formed is erect as shown in the figure below.



Q. 2. Discuss the case when a convex lens forms a virtual and enlarged image.

Answer: A virtual, erect and enlarged image is formed at the same side of lens, when an object is placed between principal focus, F1 and optical centre, O of a convex lens.

Figure below shows the image formation.



Q. 3. Which lens would you prefer to use while reading small letters from a dictionary?

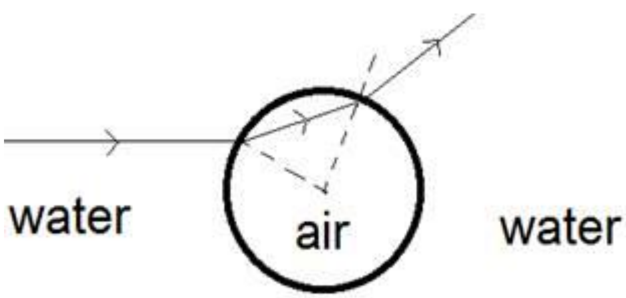
Answer: I would prefer convex lens because it gives the magnified image of an object when an object is placed between the radius of curvature and focal length. Also the magnification is more for the convex lenses having shorter focal length.

Hence for reading, a convex lens of focal length 5 cm should be used.

Q. 4. What type of lens is an air bubble inside the water?

Answer: When the light ray passes from a rarer medium to a denser medium it bends away from the normal. Thus light ray get diverge when it emerges out from the air bubble.

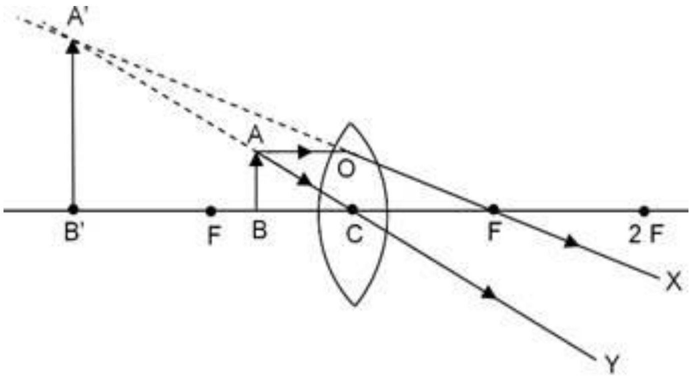
Thus the air bubble inside the water acts as Concave lens.



Q. 5. A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?

Answer: Yes the above statement is correct.

A magnified virtual image can be obtained when the object is placed between optical centre and principal focus of the lens means the object is placed at distance less than 20 cm from the centre of the lens. Figure below illustrates it.

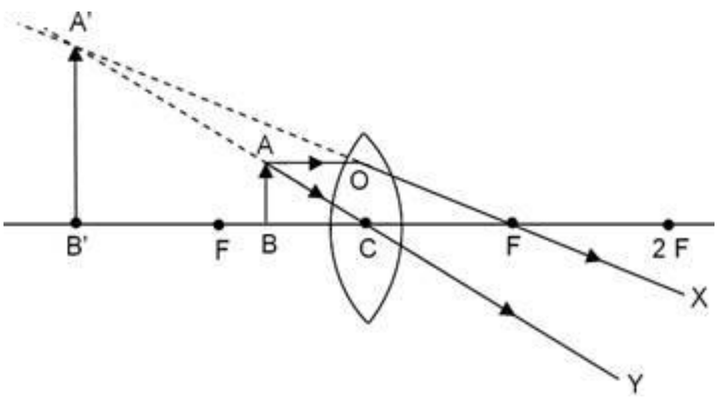


Real image of various sizes can be obtained when the object is placed beyond the principal focus.

Q. 6. A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?

Answer: Yes the above statement is correct.

A magnified virtual image can be obtained when the object is placed between optical centre and principal focus of the lens means within 20cm. Figure below illustrates it.



Real image of various sizes can be obtained when the object is placed beyond the principal focus.

Check Point 05

Q. 1. A student uses a lens of focal length- 50 cm. What is the nature of the lens and its power?

Answer: Since the focal length is negative, therefore the lens is concave lens because the focal length of concave lens is negative.

P (in diopter) = $\frac{1}{\text{f(in meters)}}$

F = -50cm = -0.5m (1m = 100cm)

⇒ P = $-\frac{1}{0.5} = -2\ \text{D}$

Hence power of lens is -2 Dioptre.

Q. 2. You are provided with two lenses of focal length 20 cm and 30 cm, respectively. Which lens will you use to obtain more convergent light?

Answer: We know that Power of lens is defined as the efficiency with which a lens can converge or diverge the light ray.

Also P (in diopter) = $\frac{1}{\text{f(in meters)}}$

Hence power is inversely proportional to the focal length

Therefore the lens with focal length 20cm will have more power than the lens with focal length 30cm. Therefore the lens with focal length 20cm will give more convergent light.

Q. 3. A lens has power 4 D. Find the focal length that lens.

Answer: Given Focal length (f) = 4D

P (in diopter) = $\frac{1}{\text{f(in meters)}}$

⇒ 4 = $\frac{1}{\text{f(in meters)}}$

⇒ $\text{f(in meters)} = \frac{1}{4} = 0.25\text{m}$

Now 1m = 100cm

⇒ 0.25m = 25cm

Hence the focal length of lens is 25cm.

Q. 4. Two lenses of power -3.5 D and + 1 D are placed in contact. Find the total power of the combination of lens. Calculate the focal length of this combination.

Answer: Power P1 = -3.5D; P2 = +1D

Total power = P1 + P2 = -3.5D + 1D

⇒ Total power (P) = -2.5D.

Now;

P (in diopter) = $\frac{1}{\text{f(in meters)}}$

⇒ -2.5 = $\frac{1}{\text{f(in meters)}}$

⇒ $\text{f(in meters)} = \frac{-1}{2.5} = \frac{-1}{\frac{5}{2}}$

⇒ $\text{f(in meters)} = -\frac{2}{5} = -0.4\text{m}$

Now 1m = 100cm

⇒ -0.4m = -40cm

Hence the focal length of lens is -40cm.

Q. 5. If two lenses (convex) are in contact with each other, what happens to the ray after refraction?

Answer: If the two lenses are kept in contact than their power is added

⇒ Power (P) = $P_1 + P_2$.

Hence the power of combination is increased which means that the converging capacity is increased. And the focal length is decreased (because focal length is inversely proportional to the power of lens).

Therefore the ray after refraction will converge at point close to lens than earlier.

Q. 6. A lens is cut into two equal halves

(i) along the principal axis
(ii) Perpendicular to principal axis. What will be the focal length of each half?

Answer: (i) If the lens is cut along the principal axis than there will be no change in the focal length of the lens because the radius of curvature will remain the same, hence the focal length will remain unchanged.

(ii) If the lens is cut perpendicular to the principal axis than the focal length will change it will be twice the focal length of the original lens because the radius of curvature will increase and R = 2F.

Chapter Exercise

Q. 1. What is the radius of curvature of a plane mirror?

Answer: A plane mirror can be considered as a spherical mirror of infinite radius of curvature where the radius is infinitely large hence the aperture is straight. Therefore the radius of curvature of a plane mirror is infinite

Q. 2. What is the power of sun glasses?

Answer: The sunglasses are not used for magnification they are used to protect our eyes from the sun rays. The sun glass is the plain glass with thin polarizing film, therefore it does not have focus or the focus is at infinity.

∴ Power = $\frac{1}{\text{focal length}}$

Power = $\frac{1}{\infty} = 0$

Hence the power of sun glasses is zero.

Q. 3. What is the value of speed of light in free space?

Answer: The refractive index of free space is 1, hence μ = 1.

⇒ $\mu = \frac{c}{v} = 1$

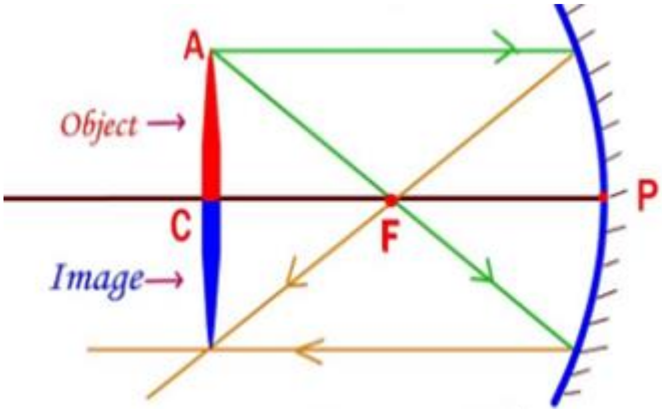
⇒ Speed of light = c

Therefore speed of light in free space is 3×10^8m/s.

Q. 4. For what position of an object, a concave mirror forms a real image equal in size to the object?

Answer: When an object is kept at the centre of curvature of the concave mirror than the image formed is real, inverted and equal to the size of the object.

The figure below shows the ray diagram.



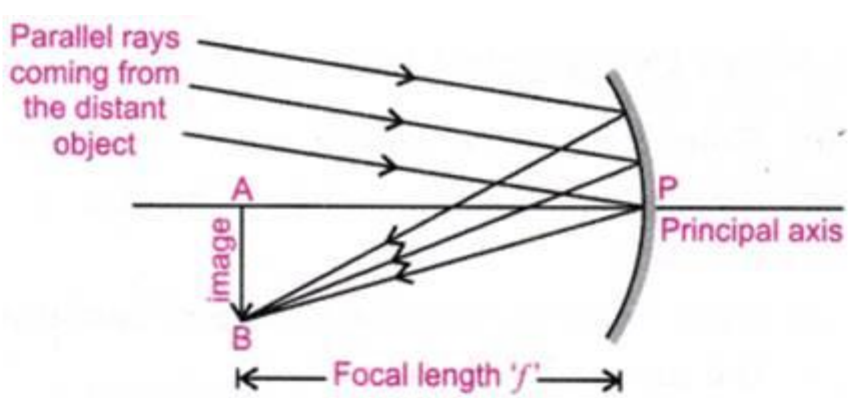
Q. 5. Does the value of speed of light change with medium?

Answer: Yes it does change with the change in medium because different mediums have different optical densities. Some are optically denser(higher refractive index) like oil, diamond etc in which the light travels at a slower speed and bends towards the normal, whereas some other materials can be optically rarer(lower refractive index) like air, water in which light speeds up and bends away from the normal.

Q. 6. A concave mirror forms sharp image of a distant tree. What is the separation between the mirror and the screen called?

Answer: When an object is kept at infinity or larger distances than the image is formed at the focus. Therefore the image of the distant tree will be formed at the focus of the concave mirror. So the screen will be placed at the focus to obtain the image And the distance between the mirror and the screen will be the focal length.

Figure below shows the ray diagram for the same.



Q. 7. Does refractive index change with color of light?

Answer: Yes the refractive index changes with the color of the light because refractive index changes with the change in the wavelength and different colors have different wavelength. Due to it refractive index of violet color is highest and of red color is lowest.

Q. 8. Magnification produced by a concave mirror of a body 4.0 cm in size is 0.16 what is the size of image?

Answer: Given;

Magnification (m) = 0.16;

Size of object = 4cm;

Size of image =?

We know that;

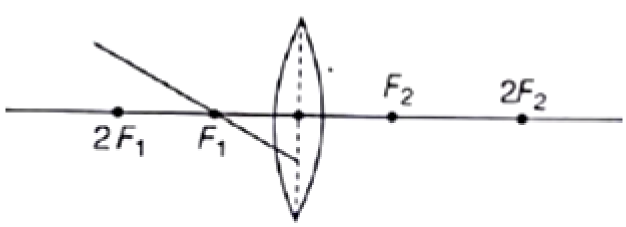
$$\text{Magnification} = \frac{\text{Size of image}}{\text{Size of object}}$$

$\Rightarrow 0.16 = \frac{\text{Size of image}}{4}$

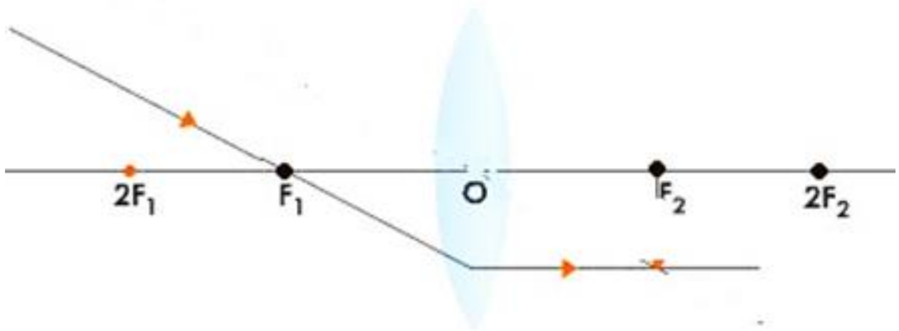
⇒ Size of image = 0.16×4 = 0.64cm.

Hence size of image is 0.64cm.

Q. 9. Redraw the ray diagram given below in your answer book and completer the path of ray.



Answer: When the ray of light passes through the focus of the convex lens it becomes parallel to the principal axis as shown in the figure below.



Q. 10. The refractive index of water is 1.33 and the speed of light in air 3 × 108 ms–1. Calculate the speed of light in water.

Answer: Given that;

Refractive index (μ) = 1.33 $= \frac{4}{3}$

Speed of light in air(c) = 3 x 108;

Speed of light in water =?

We know that

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

$$\frac{4}{3} = \frac{3 \text{ x } 10^8}{v}$$

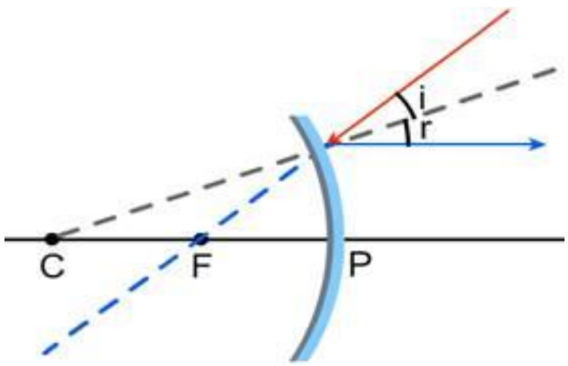
$$\Rightarrow v = \frac{3 \times 3 \times 10^8}{4} = \frac{9 \times 10^8}{4}$$

⇒ v= 2.25 × 10^8m/s.

Hence speed of light in water is 2.25 × 10^8m/s.

Q. 11. Draw a ray diagram to show the path of the reflected ray corresponding to an incident ray of light parallel to the principal axis of a convex mirror and show the angle of incidence and angle of reflection on it.

Answer: A ray of light parallel to the principal axis after reflection appears to come from the focus of the convex mirror as shown in the figure below.



Q. 12. How do we say a medium to be rarer or denser? Give two reasons.

Answer: A medium can be classified as rarer or denser by following ways.

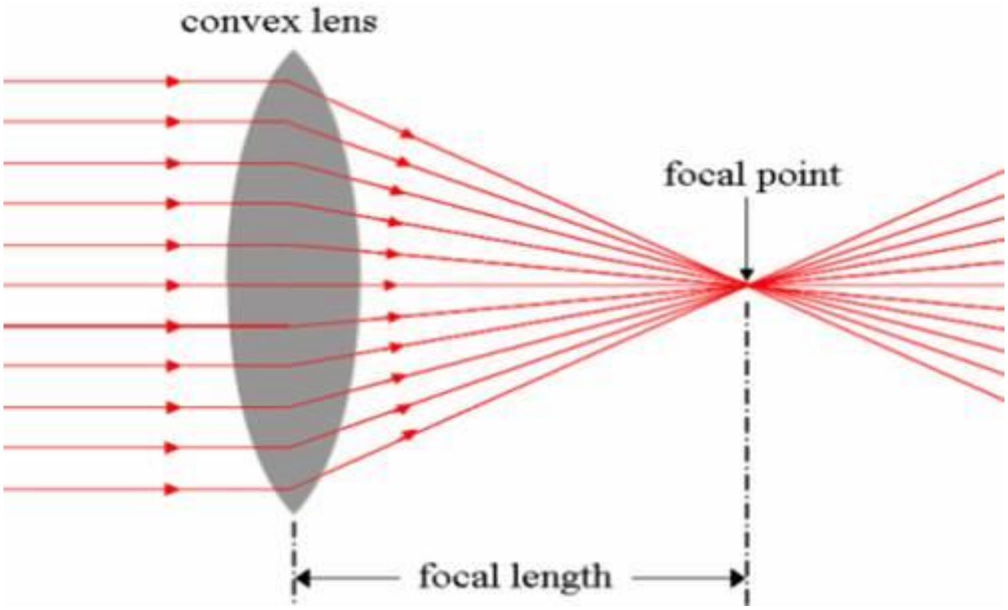
Rarer medium has less refractive index ex-water (1.33) while denser medium has higher refractive index ex-diamond (2.42).

When light goes from rarer medium to denser medium it bends towards the normal but when light goes from denser to rarer medium it goes away from the normal.

Q. 13. When we focus sunlight using a convex lens at the tip of a matchstick, what will happen? Why?

Answer: The matchstick will burn because convex lens is the converging lens. The rays of sun coming from large distance (infinity) will be converged at the focus of the convex lens, due to which too much energy will be produced and this energy will burn the matchstick kept at focus of the convex lens.

Figure below shows the ray diagram for the same.



Q. 14. A dentist uses a mirror in front of a decayed tooth at a distance of 4 cm from the tooth to get four times magnified image in the mirror. Use mirror formula to find the focal length and nature of the mirror used.

Answer: Given;

Magnification (m) = 4;

Object distance (u) = -4cm;

Image distance = v;

Magnification (m) = $-\frac{v}{u}$

⇒ $4 = -\frac{v}{-4}$

⇒ v = 4 × 4 = 16cm

Image distance = 16cm.

By mirror formula;

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

⇒ $\frac{1}{16} - \frac{1}{4} = \frac{1}{f}$

$\Rightarrow \frac{1-4}{16} = \frac{1}{f}$

$\Rightarrow -\frac{3}{16} = \frac{1}{f}$

$\Rightarrow f = -\frac{16}{3} = -5.33 \text{ cm}$

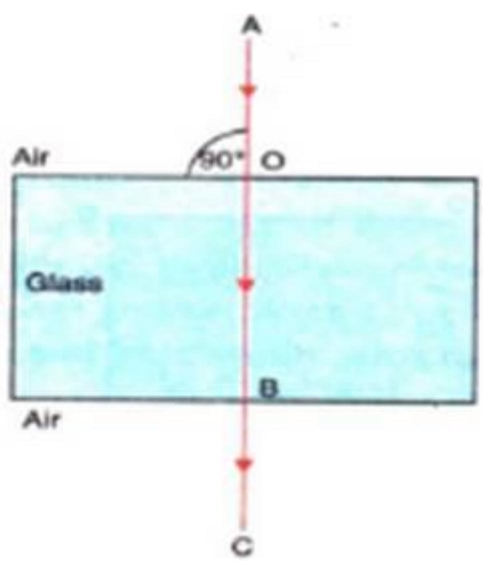
Hence the focal length is -5.33cm. Since the focal length is negative therefore the mirror is concave.

Q. 15. A ray of light strikes the glass slab at an angle of 90°. What are the angle of incidence and the angle of refraction?

Answer: Since the ray strikes the glass slab at an angle of 90°. Therefore

Angle of incidence = 00.

Thus the ray of light will pass straight without any deviation as shown in the figure below.



Laws of Refraction of light;

$$\mu = \frac{\text{Sin i}}{\text{Sin r}}$$

Refractive index=1.5

Thus angle of refraction is given by

$$1.5 = \frac{0}{\sin r}$$

On solving, we get

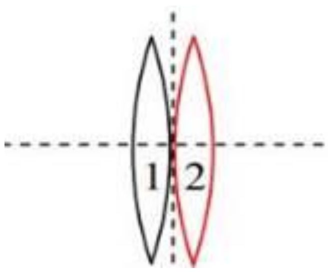
$$\sin r = 0$$

Thus the angle of refraction is 0°

Thus the refracted ray is perpendicular to the surface of the glass slab as shown in the above diagram.

Q. 16. When two or more lenses are placed in contact, what will be their combined power?

Answer: When two or more lenses each of power P_1, P_2, P_3, P_4… P_n. are placed in contact with each other as shown in the figure below.



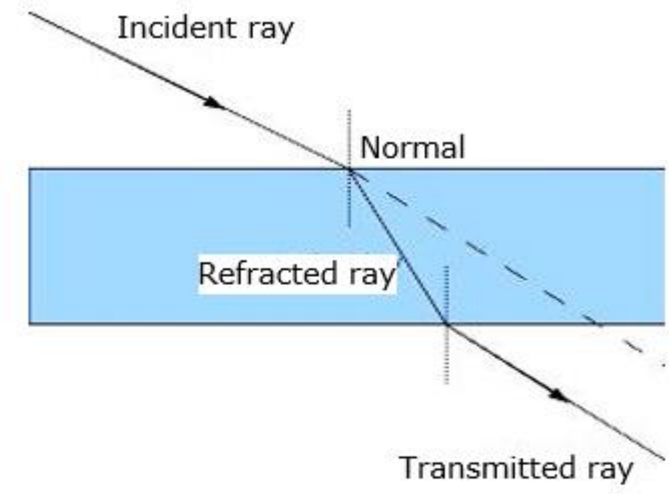
Then the combined power of the combination is the sum of all individual powers.

$\Rightarrow P = P_1 + P_2 + P_3 + P_4 + \ldots..+ P_n$

Q. 17. A ray of light incident on one face of a rectangular glass slab emerges from the opposite face of the slab parallel to the direction of the incident ray. Why does it happen so?

Answer: It happens so due to the refraction in glass Slab. The incident ray bends towards the normal as the refracted ray when it enters the glass slab, and bends away from the normal as it comes out of the slab as the emergent ray. Because of the displacement between the incident ray of light and the emergent ray of light. The displacement between emergent and incident ray is called as lateral displacement.

The figure below illustrates the above situation.

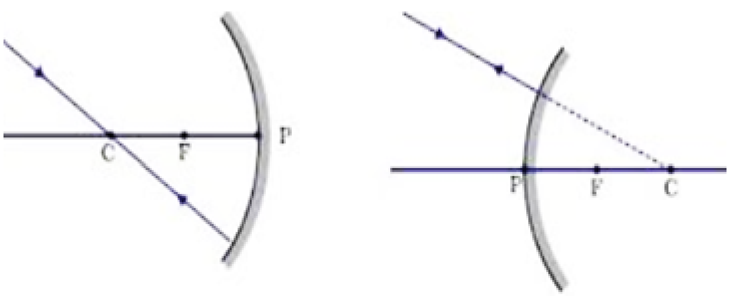


Q. 18. A ray passing through the centre of curvature of a spherical mirror after reflection returns along the same path. Why?

Answer: When ray of light passes through the centre of curvature of the spherical mirror it strikes along the normal that means it is incident on mirror at 900. Hence the incident ray coincides with the normal and retraces its path. Therefore angle of incidence = 0 so, According to law of reflection;

Angle of reflection = 0, hence the angle of reflection to become zero degrees, thus ray of light retraces its path.

The figure below illustrates the above situation.



Q. 19. Why does a ray of light bend from its path when it travels from one medium to other?

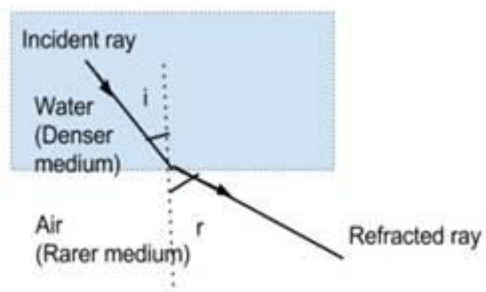
Answer: Bending of the light ray as it travels from one medium to another is due to the refraction of light. Refraction takes place because there is change in velocity as the light travels from one medium to another. Also the light always takes the shortest path between the two given points, due to this property the light gets bend.

Q. 20. A ray of light traveling from a medium x enters obliquely into another medium Y. If it bends away from the normal, then state which one of the two is relatively optically denser. Why?

Answer: When the ray of light travels from denser medium to the rarer medium than it bends away from the normal.

Therefore medium x is optically denser than medium y because the ray of light bends away from the normal when it travels from the medium x to medium y.

Figure below shows the situation.



Q. 21. Why is the refractive index of atmosphere different at different altitudes?

Answer: As we move above the earth surface the density of air goes on decreasing because the amount of air present at high altitudes is less. Thus due to the decrease in the density of the air, the refractive index gradually increases from the atmosphere to the earth's surface. Therefore the refractive index of the atmosphere is different at different altitudes.

Q. 22. For the same angle of incidence in medium P, Q and R, the angles refraction are $45°$, $35°$ and $15°$ respectively. In which medium will the velocity of light be minimum? Give reason for your answer.

Answer: Refractive index, $\mu = \frac{\text{c (speed of light in vaccum)}}{\text{v(speed of light in any medium)}}$ ……(1)

Hence refractive index of a medium is inversely proportional to the speed of light in that medium.

Also μ = $\frac{\sin i}{\sin r}$ …………….. (2)

⇒ Refractive index is inversely proportional to the angle of refraction.

From (1) and (2)

Velocity of light is directly proportional to the angle of refraction.

Thus velocity of light is minimum in medium R because angle of refraction is 150 is minimum.

Q. 23. What is meant by refractive index? If the speed of light in a medium is 2/3rd of the speed of light in vacuum, find the refractive index of that medium.

Answer: Refractive index is the measure of bending of ray of light as it passes from one medium to another. It is also defined as the ratio of the speed of light in vacuum to the speed of light in any medium.

Refractive index (μ) = $\frac{\text{c (speed of light in vaccum)}}{\text{v(speed of light in any medium)}}$

Given

Speed of light in a medium (v) = $\frac{2c}{3}$

⇒ $\mu = \frac{c}{\frac{2c}{3}}$

⇒ μ = $\frac{3c}{2c}$

⇒ μ = $\frac{3}{2} = 1.5$

Hence Refractive index of medium is 1.5.

Q. 24. The radius of curvature of a concave mirror is 50 cm. Where should an object be placed in the mirror, so as to form its image at infinity? Justify your answer.

Answer: Given;

Radius of Curvature(R) = 50cm;

R = 2f

⇒ 50 = 2f

⇒ $f = \frac{50}{2} = 25 \text{ cm}$

Focal length = 25cm.

When an object is kept at the focus of the concave mirror then the image is formed at infinity.

This can be shown as below:

The Mirror formula is given by:

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

Where, F is the focal length of the mirror

v is the image distance from the pole of the mirror

u is the object distance from the pole of the mirror

On solving for v, we get

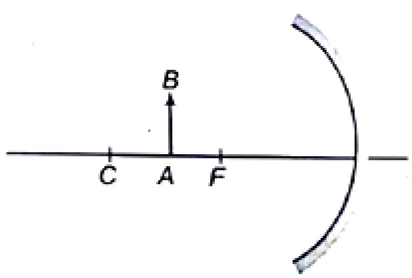
$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

If F=u=25 cm, we get

$$\frac{1}{v} = 0 \text{ or } v = \frac{1}{0} = \infty$$

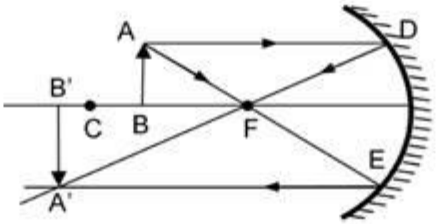
Therefore the object should be placed at 25cm from the pole of the concave mirror to get an image at infinity.

Q. 25. Draw the ray diagram in your answer book and show the formation of image of object AB with suitable rays. Mention the position and nature of image.



Answer: The mirror is the concave mirror and the object is kept between Centre of curvature and focus.

Thus the real, inverted and enlarged image will be formed beyond the center of curvature. Below is the ray diagram for it.



Q. 26. How far should an object be placed from a convex lens of focal length 20 cm to obtain its image at a distance of 30 cm from the lens? What will be the height of the image, if the objects is 6 cm tall?

Answer: According to the question;

Object distance = u;

Image distance (v) = 30cm;

Focal length = 20cm

By lens formula;

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

$$\Rightarrow \frac{1}{30} - \frac{1}{u} = \frac{1}{20}$$

$$\Rightarrow \frac{1}{u} = \frac{1}{30} - \frac{1}{20}$$

$$\Rightarrow \frac{1}{u} = \frac{20 - 30}{600} = \frac{-10}{600}$$

$$\Rightarrow \frac{1}{u} = \frac{-1}{60}$$

⇒ u = -60cm.

Therefore object is placed at 60 cm in front of lens.

Now;

Height of object h1= 6cm;

Magnification = $\frac{h_2}{h_1} = \frac{v}{u}$

Putting values of v and u

Magnification = $\frac{h_2}{6} = \frac{30}{-60}$

$\Rightarrow \frac{h_2}{6} = -\frac{1}{2}$

$\Rightarrow h_2 = -\frac{6}{2} = -3$

Height of image is 3 cm.

Negative sign means image is real and inverted.

Q. 27. An object of size 7.0 cm is placed at a distance of 27 cm in front of concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed so that a sharply focused image can be obtained? Find the size and the nature of the image.

Answer: According to the question;

Object distance (u) = -27cm;

Focal length (f) = -18cm;

Image distance = v;

By mirror formula;

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

$$\Rightarrow \frac{1}{v} + \frac{1}{-27} = \frac{1}{-18}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{27} - \frac{1}{18}$$

$$\Rightarrow \frac{1}{v} = \frac{-3+2}{54}$$

$$\Rightarrow \frac{1}{v} = -\frac{1}{54}$$

⇒ v = -54cm.

Thus, screen should be placed 54cm in front of the mirror to obtain the sharp focused image.

Height of object h1= 7cm;

Magnification = $\frac{h_2}{h_1} = -\frac{v}{u}$

Putting values of v and u

Magnification = $\frac{h_2}{7} = -\frac{-54}{-27}$

$$\Rightarrow \frac{h_2}{7} = -2;$$

⇒ h2 = 7 ×-2 = -14.

Height of image is 14 cm.

Negative sign means image is real and inverted.

Thus real, inverted image of 14cm size is formed.

Q. 28. A 5.0 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. The distance of the object from the lens is 30 cm By calculation determine

(i) The position and
(ii) The size of the image formed.

Answer: According to the question;

Object distance = -30 cm;

Image distance = v cm;

Focal length = 20 cm

By lens formula;

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

$$\Rightarrow \frac{1}{v} - \frac{1}{-30} = \frac{1}{20}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{20} - \frac{1}{30}$$

$$\Rightarrow \frac{1}{v} = \frac{30 - 20}{600} = \frac{10}{600}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{60}$$

⇒ v = 60cm.

Therefore image is formed at 60 cm in right of lens.

Now;

Height of object h_1= 5cm;

Magnification = $\frac{h_2}{h_1} = \frac{v}{u}$

Putting values of v and u

Magnification = $\frac{h_2}{5} = \frac{60}{-30}$

$\Rightarrow \frac{h_2}{5} = -2$

⇒ h_2 =-2 ×5=10

Height of image is 10 cm.

Negative sign means image is real and inverted.

Q. 29. An object placed 45 cm from a lens forms an image on a screen place 90 cm on the other side of the lens. Identify the type of the lens and find its focal length.

Answer: According to the question;

Object distance, u= -45cm;

Image distance, v= 90 cm;

Focal length, f=?

By lens formula;

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

$$\Rightarrow \frac{1}{90} - \frac{1}{-45} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{90} + \frac{1}{45}$$

$$\Rightarrow \frac{1}{f} = \frac{1+2}{90} = \frac{3}{90}$$

$$\Rightarrow f = \frac{90}{3}$$

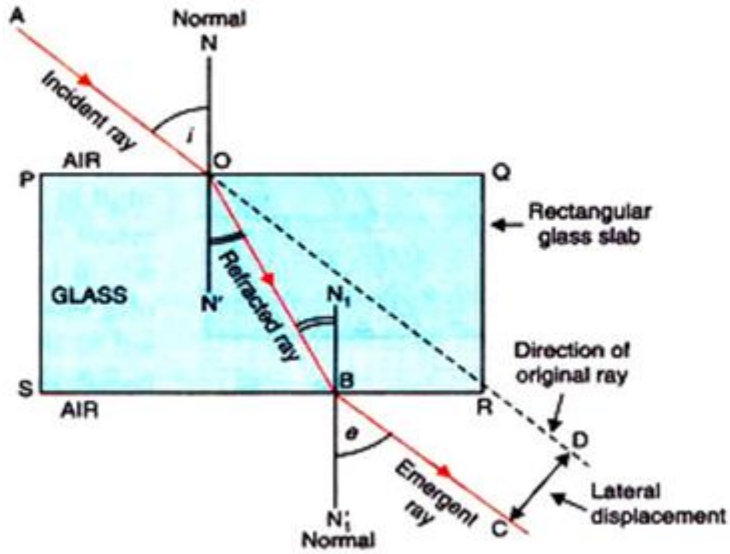
⇒ f = 30cm.

Since the focal length is positive, therefore the lens is convex lens of focal length 30cm.

Q. 30. Does the incident and emergent ray coincide in the process of refraction through glass slab? Give reason.

Answer: The incident ray and the emergent ray do not coincide they are parallel to each other. The emergent ray is shifted by some distance from the incident ray while passing through the glass slab which is called the lateral displacement.

The figure below illustrates it.



Q. 31. A ray of light enters a diamond from air. If the refractive index of diamond is 2.42, what % (percentage) is speed of light in diamond with that of speed in air?

Answer: Refractive index (μ) = $\frac{\text{c (speed of light in vaccum)}}{\text{v(speed of light in any medium)}}$

Given μ = 2.42, c = 3 × 10^8.

Putting the value in the above formula, we get

⇒ $2.42 = \frac{3 \times 10^8}{v}$

⇒ $\mathbf{v} = \frac{3 \times 10^8}{2.42}$

⇒ v = 1.23 × 10^8 m/s.

Speed of light in diamond is 1.23 × 10^8 m/s

% of speed in diamond = $\frac{1.23 \times 10^8}{3 \times 10^8} \times 100 = 0.41 \times 100 = 41\%$

Thus there is 41% decrease in the speed of light in diamond than in air.

Q. 32. The image of an object place at 60 cm in front of a lens is obtained on a screen at a distance of 120 cm from it. Find the focal length of the lens. What would be the lens? What would be the height of the image? If the object is 5 cm high?

Answer: According to the question;

Object distance (u) = -60cm;

Image distance (v) = 120cm;

Focal length = f

By lens formula;

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

$$\Rightarrow \frac{1}{120} - \frac{1}{-60} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{1}{120} + \frac{1}{60}$$

$$\Rightarrow \frac{1}{f} = \frac{1+2}{120} = \frac{3}{120}$$

$$\Rightarrow f = \frac{120}{3}$$

⇒ f = 40cm.

Therefore Focal length of lens is 40 cm.

Since the focal length is positive. Therefore the lens is convex lens of focal length 40cm.

Now;

Height of object h1= 5cm;

Magnification = $\frac{h_2}{h_1} = \frac{v}{u}$

Putting values of v and u

Magnification = $\frac{h_2}{5} = \frac{120}{-60}$

$\Rightarrow \frac{h_2}{5} = -2$

$\Rightarrow$ h2 = -2 × 5= -10 cm

Height of image is 10 cm.

Negative sign means image is real and inverted.

Q. 33.A. Two lenses have power of (a) + 2D (b) – 4D. What is the nature and focal length of each lens?

Answer: Power P_1 = 2D;

Since Power is positive. Therefore, the lens is convex lens.

$$\text{Power} = \frac{1}{\text{focal length(in meters)}}$$

$\Rightarrow 2 = \frac{1}{f}$

$\Rightarrow f = \frac{1}{2} = 0.5m$

1m = 100cm

$\Rightarrow$ 0.5m = 50cm.

Hence the focal length is 50cm

P_2 = -4D.

Since the power is negative. Therefore, the lens is concave lens.

$$\text{Power} = \frac{1}{\text{focal length(in meters)}}$$

$\Rightarrow -4 = \frac{1}{f}$

$\Rightarrow f = \frac{1}{-4} = -0.25m$

1m = 100cm

$\Rightarrow$ 0.25m = 25cm.

Hence the focal length is -25cm

Q. 33.B. An object is kept at a distance of 100 cm from each of the above lenses.

Calculate the

(a) image distance and
(b) magnification in each of two cases.

Answer: (a) Given

Object distance (u) = -100cm

Focal length (f) = 50cm

Image distance = v

By lens formula;

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

$$\Rightarrow \frac{1}{v} - \frac{1}{-100} = \frac{1}{50}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{50} - \frac{1}{100}$$

$$\Rightarrow \frac{1}{v} = \frac{2-1}{100} = \frac{1}{100}$$

$\Rightarrow$ v=100cm

Hence the image is formed at 100 cm behind the lens.

Object distance (u) = -100cm

Focal length (f) = -25cm

Image distance = v

By lens formula;

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

$$\Rightarrow \frac{1}{v} - \frac{1}{-100} = \frac{-1}{25}$$

$$\Rightarrow \frac{1}{v} = \frac{-1}{25} - \frac{1}{100}$$

$$\Rightarrow \frac{1}{v} = \frac{-4-1}{100} = \frac{-5}{100}$$

$\Rightarrow$ v = $-\frac{100}{5}$

$\Rightarrow$ v= -20cm

Hence the image is formed at 20cm in front of the lens.

(b) For 1st case

Object distance (u) = -100cm

Image distance (v) = 100cm.

By Magnification Formula

Magnification (m) = $\frac{v}{u}$

$\Rightarrow$ Magnification = $\frac{100}{-100}$

Therefore, Magnification for the 1st case is -1. The negative sign means the image is real and inverted.

For 2nd case

Object distance (u) = -100cm

Image distance (v) = -20cm.

By Magnification Formula

Magnification (m) = $\frac{v}{u}$

⇒ Magnification = $\frac{-20}{-100} = \frac{1}{5} = 0.2$

Therefore, Magnification for 2nd case is 0.2. The positive sign means the image is erect and virtual.

Q. 34. List the sign conventions for reflection of light by spherical mirror. Draw a diagram and apply these conventions in the determination of focal length of a spherical mirror which forms three times magnified real image of an object placed. 16 cm in front of it.

Answer: Pole (P) of the mirror is taken as the origin and the Principal axis is taken as the horizontal X- axis. The sign conventions are as follows:

The object is always placed on the left side of the mirror.

All the distances measured to the right side of the origin are taken as positive, while the distances measured to the left side of the origin are taken as negative.

The object distance is always negative.

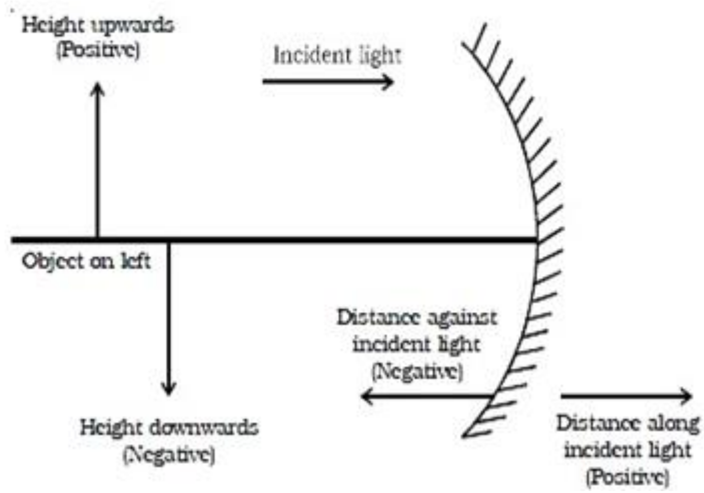
All the distances parallel to the principal axis of the mirror are measured from the pole of the mirror.

Distances measured vertically upwards from the principal axis of the mirror are taken as positive.

Distances measured vertically downwards from the principal axis of the mirror are taken as negative.

The focal length of Concave mirror is negative while that of convex mirror is positive.

The figure below illustrates the conventions used.

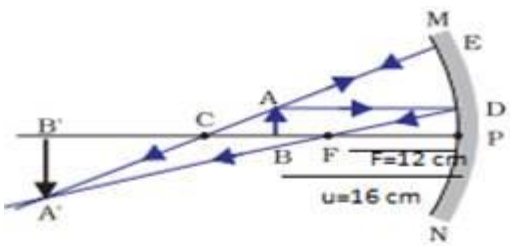


Given;

Magnification (m) = -3 (real image is inverted always).

Object distance (u) = -16cm.

Ray diagram can be shown as below



By Magnification Formula;

Magnification, $m = -\frac{v}{u}$

Where,

v is the image distance

u is the object distance

$\Rightarrow -3 = -\frac{v}{-16}$

$\Rightarrow$ v = -3 × 16 = -48cm.

∴ Image distance (v) = -48cm.

By mirror formula;

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

$$\Rightarrow \frac{1}{-48} + \frac{1}{-16} = \frac{1}{f}$$

$$\Rightarrow f = \frac{-48}{4} = -12$$

Therefore the focal length is -12 cm. Since the focal length is negative, therefore the mirror is concave mirror.

Q. 35. List the new Cartesian sign convention for reflection of light by spherical mirrors. Draw a diagram and apply these conventions for calculating the focal length and nature of a spherical mirror which forms 1/3 times magnified virtual image of an object placed 18 cm if front of it.

Answer: According to the new Cartesian system the Pole (P) of the mirror is taken as the origin and the Principal axis is taken as the horizontal X- axis. The sign conventions for it are as follows:

The object is always placed on the left side of the mirror.

All the distances measured to the right side of the origin are taken as positive, while the distances measured to the left side of the origin are taken as negative.

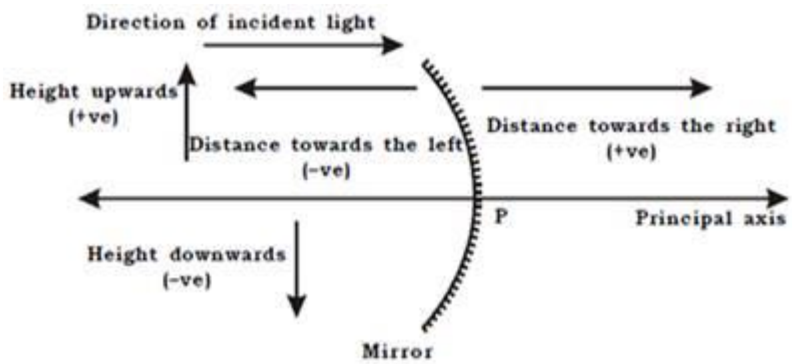
All the distances parallel to the principal axis of the mirror are measured from the pole of the mirror.

Distances measured vertically upwards from the principal axis of the mirror are taken as positive.

Distances measured vertically downwards from the principal axis of the mirror are taken as negative.

The focal length of Concave mirror is negative while that of convex mirror is positive.

The figure below illustrates the conventions used.



Given;

Magnification (m) = $= \frac{1}{3}$ (virtual image is always erect).

Object distance (u) = -18cm.

By Magnification Formula;

Magnification, $m = -\frac{v}{u}$

Where,

v is the image distance

u is the object distance

$\Rightarrow \frac{1}{3} = -\frac{v}{-18}$

$\Rightarrow v = \frac{18}{3} = 6$

⇒ v= 6cm.

∴ Image distance (v) = 6cm.

By mirror formula;

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

$$\Rightarrow \frac{1}{6} + \frac{1}{-18} = \frac{1}{f}$$

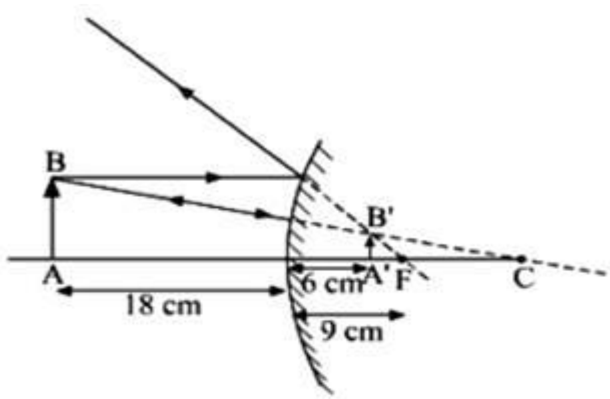
$$\Rightarrow \frac{1}{6} - \frac{1}{18} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{3-1}{18} = \frac{2}{18}$$

$$\Rightarrow f = \frac{18}{2} = 9\ \text{cm}$$

Therefore, the focal length is 9 cm. Since the focal length is positive, therefore the mirror is convex mirror.

Figure below shows the ray diagram for the same.



Q. 36.A. State and define the SI unit of power of a lens.

Answer: The reciprocal of focal length of the lens is called the power of the lens (P).

P (in dioptre) = $\frac{1}{f(\text{in meters})}$

The S.I unit of power of lens is diopter denoted by D.

From the formula of power of lens.

$$1\ D = \frac{1}{1\ m} = 1\ m^{-1}.$$

Thus 1 Dioptre is the power of the convex lens having focal length of 1m.

Q. 36.B. A convex lens of focal length 25 cm and a concave lens of focal length 10 cm are placed in close contact with each other. Calculate the lens power of this combination.

Answer: Given

f_1 = 25cm (Focal length of convex lens is positive)

⇒ f_1 = 0.25m (1m = 100cm)

P (in dioptre) = $\frac{1}{f(\text{in meters})}$

⇒ Power of convex lens,(F=25 cm) P1 = $\frac{1}{f_1}$

$$\Rightarrow P_1 = \frac{1}{0.25} = \frac{1}{\frac{1}{4}}$$

$$\therefore P_1 = 4D$$

f_2 = -10cm (Focal length of concave lens is negative)

⇒ f_2 = -0.1m (1m = 100cm)

⇒ Power of the concave lens (F=10 cm), P2 = $\frac{1}{f_2}$

$$\Rightarrow P2 = -\frac{1}{0.1} = \frac{1}{\frac{1}{10}}$$

∴ P2 = -10D.

Power of combination = $P_1 + P_2$.

P = 4D – 10D = -6D.

Lens power of the combination is -6D. Since it is negative therefore the new lens will behave like concave lens having a focal length of 16.6cm.

Q. 37. List the sign conventions that are followed in case of refraction of light through spherical lenses. Draw a diagram and apply these conventions in determining the nature and focal length of a spherical lens which forms three times magnified real image of an object placed 16 cm from the lens.

Answer: Sign convention for the refraction of light is as follows.

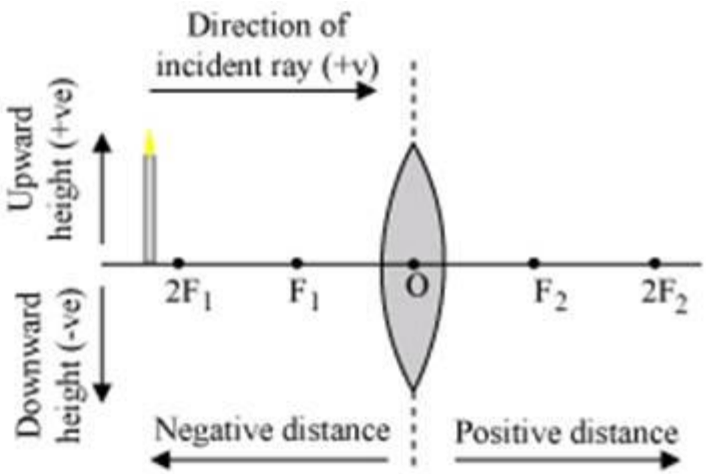
1. All the distances are measured from the optical centre of the lens.

2. All the distances which are measured in the same direction of the incident light ray (left hand side of lens) will be taken as positive.

3. All the distances which are measured against the direction of incident light (right hand side) are taken as negative.

4. The perpendicular distances to principal axis in upward direction will be positive and those in downward direction will be taken as negative.

Figure below illustrates the conventions more clearly.



According to the question.

Magnification (m) = -3 (real image is always inverted).

Object distance (u) = -16cm.

By Magnification Formula;

Magnification, $m = \frac{v}{u}$

Where,

v is the image distance,

u is the object distance

⇒ $-3 = \frac{v}{-16}$

⇒ v= -16 × -3

⇒ v= 48cm.

∴ Image distance (v) = 48cm.

By lens formula;

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

$$\Rightarrow \frac{1}{48} - \frac{1}{-16} = \frac{1}{f}$$

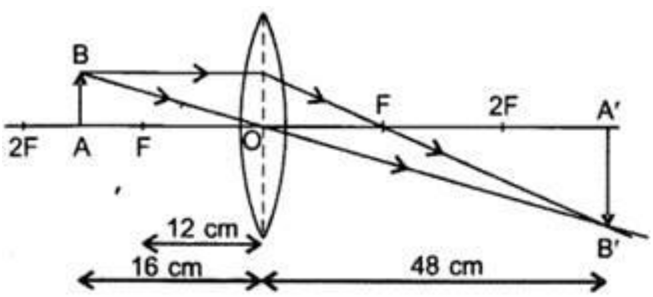
$$\frac{1}{48} + \frac{1}{16} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{f} = \frac{1+3}{48} = \frac{4}{48}$$

$$\Rightarrow f = \frac{48}{4} = 12$$

Therefore the focal length is 12 cm. Since the focal length is positive, therefore the lens is convex lens.

Figure below shows the ray diagram for the same.

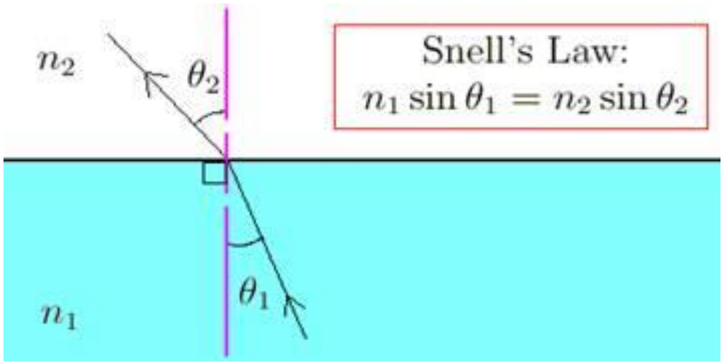


Q. 38.A. State the laws of refraction of light. Write an expression to relate absolute refractive index of a medium with speed of light in vacuum.

Answer: The refraction of light occurs according to the following laws which are as follows.

1. The incident ray refracted ray, and the normal to the surface separating two media at the point of incidence all lie in the same plane.

2. The ratio of sine of angle of incidence and sine of angle of refraction remains constant ($\frac{\sin i}{\sin r}$ = constant) subject to certain conditions. This law is called Snell's law of refraction.



Refractive index of a medium (μ) = $\frac{\text{Speed of light in a vacuum(c)}}{\text{Speed of light in a medium(v)}}$

⇒ μ = $\frac{c}{v}$

Q. 38.B. The refractive index of a medium x with respect to y is 2/3 and the refractive index of medium y with respect to z is 4/3 Calculate the refractive index of medium z with respect to medium x

Answer: Refractive index of air, μair = 1;

Given;

Refractive index of medium x w.r.t medium y, μxy $= \frac{2}{3}$

Refractive index of medium y w.r.t medium z, μyz $= \frac{4}{3}$

Refractive index of medium z w.r.t medium x = μzx = $\frac{\mu_z}{\mu_x} = \frac{\mu_z}{\mu_y} \times \frac{\mu_y}{\mu_x}$

$$\Rightarrow \mu zx = \frac{1}{\frac{\mu_y}{\mu_z}} \times \frac{1}{\frac{\mu_x}{\mu_y}}$$

$$\Rightarrow \mu zx = \frac{1}{\mu_{yz}} \times \frac{1}{\mu_{xy}}$$

$$\Rightarrow \mu zx = \frac{1}{\frac{4}{3}} \times \frac{1}{\frac{2}{3}}$$

$$\Rightarrow \mu zx = \frac{3}{4} \times \frac{3}{2}$$

$$\Rightarrow \mu zx = \frac{9}{8}$$

∴ Refractive index of medium z w.r.t medium x is $\frac{9}{8}$.

Q. 39. Varun's mom is finding it difficult to cook in the kitchen as there was power cut and she was complaining about it to Varun. He immediately took a plane mirror from his shelf made it stand against a wall such that sun's rays were focused into the kitchen directly on the cook top, due to the reflection of the mirror. There was some light now and his mother was able to finish her work.

(i) What are the characteristic of the image formed by a plane mirror?
(ii) What values did Varun display?

Answer:

(i) Image formed by plane mirror is of the same size as of the object.

Positive value of magnification indicates that image formed by plane mirror is erect.

Image formed by plane mirror is at same distance as the object but behind the mirror.

Magnification of image is +1.

The image is virtual.

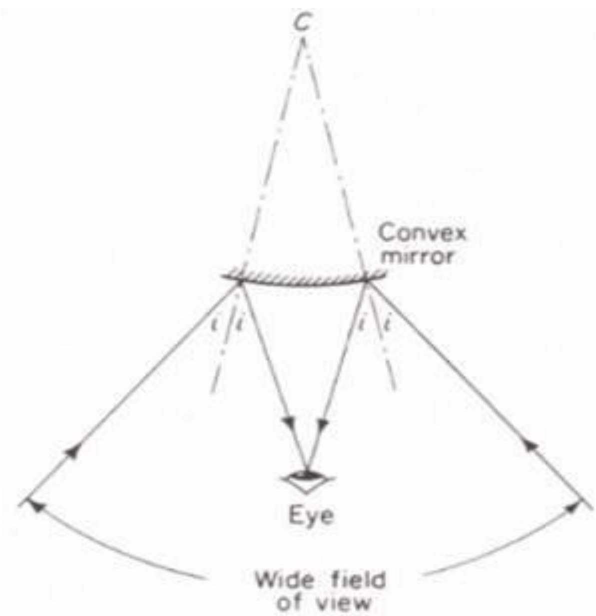
(ii) Varun made an arrangement for the light so that his mother could finish the work easily this shows that Varun is caring and responsible towards his mother. Also, he has used his knowledge of plane mirrors to get the light this shows that he is also quite clever and intelligent also he is the serious student who focuses on the practical aspect of things taught in class and applies them in a day to day use.

In other words, Varun had put the science to the real use.

Q. 40. Mr. Raghav, grade 6 teacher find that his students do not draw when he draws on the board. Every time he had to turn towards them to see whether they draw and label the diagrams. Arav, one of his student fixed two big convex mirrors at the two sides of the black board. With this Mr. Raghav was able to draw and also supervise his students through the mirror. All the students started doing their work property.

(i) Which characteristics of convex lens, let Mr. Raghav to do both his job at the same time?
(ii) What value did Arav and Mr. Raghav show?

Answer: (i) The convex mirrors are diverging in nature and they have the wide field of view due to which we can see the image of large area in the mirror. The light rays incident on it gets diverged following the laws of reflection, the reflected rays forms the wider path as shown in the figure below.



(ii) Mr. Raghav every time look to see whether students are drawing the diagram or not this shows that he is a responsible and caring teacher who does his job passionately. Arav puts two convex mirrors so that Mr. Raghav will not have to turn every time this shows that Arav is helpful, caring and respectful towards his teacher. Also he had used the property of convex mirrors thus he is quite intelligent and serious student who puts the practical use of concepts in day to day life use.

Challengers

Q. 1. A virtual image three times the size of the object is obtained with a concave mirror of radius of curvature 36 cm. The distance of the object from the mirror is

A. 20cm
B. 10cm
C. 12cm
D. 5cm

Answer: Given:

Magnification (m) = 3 (virtual image is erect).

Radius of the curvature, R =36 cm

Focal Length (f) = $\frac{R}{2}$ = = -18cm (Negative for concave mirror).

Now by formula,

1. Magnification, $m = \frac{-v}{u}$

Where,

v is the image distance,

u is the object distance,

Putting the values in the above formula, we get

$$3 = \frac{-v}{u} \; or \; v = -3u$$

2. Mirror formula

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

Where f is the focal length of the mirror v is the image distance from the mirror u is the object distance from the mirror Thus, putting the values in the equation, we get

$$\frac{-1}{18} = \frac{-1}{3u} + \frac{1}{u} = \frac{2}{3u}$$

Thus, on solving the above equation, we get $\frac{-1}{36} = \frac{1}{3u}$

u=-12 cm

Hence the distance of the object from the mirror is 12 cm.

Q. 2. A convex mirror of focal length f forms an image $\frac{1}{n^{th}}$ of the size of the object. The distance of the object from the mirror is

A. $\frac{n+1}{n}f$

B. $(n+1)f$

C. $(n-1)f$

D. $\frac{n-1}{n}f$

Answer: According to the question

Magnification (m) = $\frac{1}{n}$ (image is of $\frac{1}{n^{th}}$ the size of object).

Focal length = f (positive for convex mirror).

Object distance = -u.

Now By formula.

$$m = \frac{f}{f-u}$$

$\Rightarrow \frac{1}{n} = \frac{f}{f+u}$

$\Rightarrow$ f + u = nf

$\Rightarrow$ u = nf – f

$\Rightarrow$ u = (n-1)f.

Therefore the object distance from the mirror is (n-1) f. Hence the option C is correct.

Q. 3. A perfecting reflecting mirror has an area of 1cm^2. Light energy is allowed to fall on it for an hour at the rate of 10 Wcm-2. The force that acts on the mirror is

A. 3.35×10^{-7}N

B. 6.7×10^{-7}N

C. 3.35×10^{-8}N

D. 6.7×10^{-8}N

Answer: Given: -

Area of the mirror = 1 cm^2,

Power transmitted to the mirror = 10 Wcm^{-2},

Calculations: -

The average force is given by $\frac{\Delta p}{\Delta t}$

Since the surface is perfectly reflecting we can write $\Delta p = 2\frac{\Delta t}{c}$

So $F = 2\left(\frac{\Delta E}{c\Delta t}\right) = 2\frac{p}{c}$

$$= 2 . \frac{10 \times 10^4 \times 1 \times 10^{-4}}{3 \times 10^8}$$

$$= \frac{20}{3} \times 10^{-8} \text{ N}$$

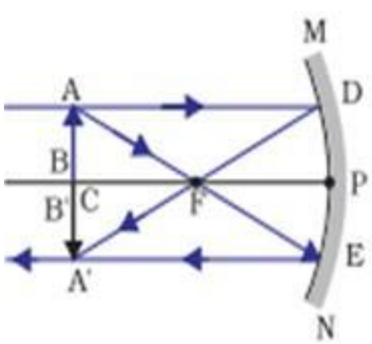
= 6.7×10^{-8} N

Q. 4. An object is placed at the centre of curvature of a concave mirror. The distance between its image and the pole is

A. equal to f
B. between f and 2f
C. equal to 2f
D. greater than 2f

Answer: When an object is placed at centre of curvature of concave mirror than the real, inverted image of size same as that of object is formed at the center of curvature.

Therefore the image distance = Centre of curvature = 2f. Hence the correct option is C



Q. 5. The refractive index of lens flint glass is 1.65 and for alcohol, it is 1.36 with respect to air, then the refractive index of the dens flint glass with respect to alcohol is

A. 1.31
B. 1.21
C. 1.11
D. 1.01

Answer: Refractive index of air, $\mu_{air} = 1$;

Given;

Refractive index of flint glass w.r.t air, $^{air}\mu_{glass} = 1.65$;

Refractive index of alcohol w.r.t air, $^{air}\mu_{alcohol} = 1.36$;

Refractive index of flint glass w.r.t alcohol = $^{alcohol}\mu_{glass} = {}^{air}\mu_{glass} / {}^{air}\mu_{alcohol} = \frac{1.65}{1.36}$

⇒ $^{alcohol}\mu_{glass} = 1.213$

Hence the refractive index of flint glass w.r.t alcohol is 1.213.

Q. 6. Refractive index of diamond with respect to glass is 1.6. If the absolute refractive index of glass is 1.5, then the absolute refractive index of diamond is

A. 1.4
B. 2.4
C. 3.4
D. 4.4

Answer: Absolute refractive index of glass = $\frac{\text{Refractive index of glass}}{\text{Refractive index of air}} = \frac{\mu_{glass}}{\mu_{air}} = 1.5$

Refractive index of diamond w.r.t glass is

$$\frac{\mu_{diamond}}{\mu_{glass}} = 1.6$$

⇒ μdiamond = 1.6 × μglass

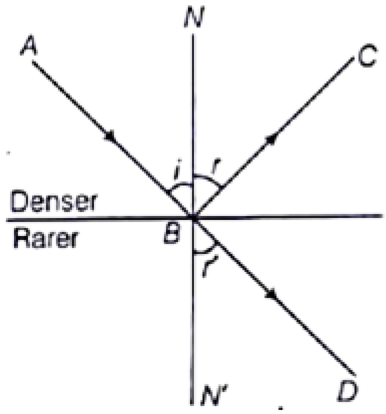
⇒ μdiamond = 1.6 × 1.5 (μglass = 1.5).

⇒ μdiamond = 2.4

Hence the absolute refractive index of diamond is 2.4. Therefore the option B is correct.

Q. 7. A ray of light from a denser medium strikes a rarer medium at an angle incidence as shown in figure. The reflected and refracted rays make an angle of

90° with each other. The angles of reflection and refraction and r and r1. The critical angle is



A. $\sin^{-1}$ (tan r)

B. $\sin^{-1}$ (tan i)

C. $\sin^{-1}$ (tan r^1)

D. $\tan^{-1}$(tan i)

Answer: According to Snell's law

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

But I + r=90° (Reflected and refracted rays are at an angle of 900).

$$\Rightarrow \mu = \frac{\sin 90 - r}{\sin r} = \frac{\cos r}{\sin r}$$

$$\Rightarrow \mu = \cot r.$$

$$\Rightarrow \mu = \frac{1}{\tan r}$$

$$\Rightarrow \frac{1}{\mu} = \tan r$$

$$\text{Critical angle} = \mu = \frac{1}{\sin i_c}$$

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

$\Rightarrow \sin i_c = \tan r$

$\Rightarrow i_c = \sin^{-1} (\text{Tan } r)$

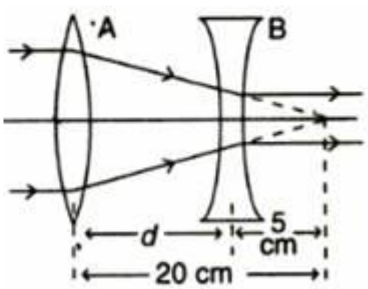
Therefore, the critical angle $i_c = \sin^{-1}(\tan r)$

Hence the option A is correct.

Q. 8. A convex lens A of focal length 20 cm and a concave lens B of focal length 5 cm are kept along the same axis with a distance d between them. If a parallel beam of light falling on A leaves B as a parallel beam, then the distance d in cm will be

A. 25
B. 15
C. 30
D. 50

Answer: According to the question following is the ray diagram.



As the incident ray is parallel to the principal axis. Therefore in absence of concave lens it will form an image at focus of convex lens.

∴ v = 20cm = f

Distance of Image I from the concave lens B will be = u = 20 – d

Now, the image I will act as object for the concave lens.

Since image object (image I) is at focus of concave lens. Therefore, Image will be formed at infinity

$\Rightarrow v = \infty$

Focal length = -5cm.

By Lens Formula.

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

$$\Rightarrow \frac{1}{\infty}-\frac{1}{20-d}=\frac{1}{-5}$$

$$\Rightarrow 0-\frac{1}{20-d}=\frac{1}{-5}$$

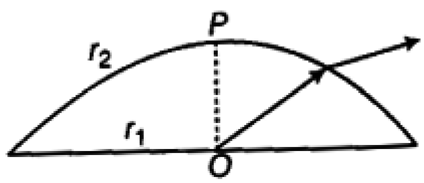
$$\Rightarrow \frac{1}{20-d}=\frac{1}{5}$$

⇒ 20 – d = 5

⇒ d = 20 – 5 = 15cm.

Therefore, the distance d will be 15cm. Hence the option B is correct.

Q. 9. A thick plane-convex lens made of crown glass (refractive index 1.5) has thickness of 3 cm at its centre. The radius of curvature of the spherical surface is 5 cm.



An link mark made at the centre of its plane face, when viewed normal through the curved face, appears to be at a distance x from the curved face. Then, x is equal to

A. 2cm
B. 2.1cm
C. 2.3cm
D. 2.5cm

Answer: Given:

Radius of curvature, R=-5 cm

Object distance, u=-3 cm

The refractive indices n_1=1.5 (glass), n_2=1.0(air)

We have , $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ (The Lensmaker's formula)

$$\frac{1}{v} - \frac{1.5}{-3} = \frac{1 - 1.5}{-5}$$

$$\frac{1}{v} = \frac{0.5}{5} - \frac{1.5}{3} = -\frac{2}{5}$$

v= -2.5 cm

Then the image will appear at distance of 2.5 cm from the plane surface of the mirror

Hence D is the correct option.

Q. 10. An object is placed in front of a screen and a convex lens is placed at a position such that the size of the image formed is 9cm. when the lens is shifted through a distance of 20 cm, the size of the image becomes 1 cm. The focal length of the lens and the size of the object are respectively.

A. 7.5 cm and 3.5 cm
B. 7.5 cm and 4.5 cm

C. 6 cm and 3 cm
D. 7.5 cm and 3 cm

Answer: If h_1 and h_2 are the sizes of the images formed in two conjugate positions, then, the size of object is given as $h = \sqrt{h_1 h_2} = \sqrt{9 \times 1} = 3$cm.

The size of the image in the two conjugate positions is

In the first case, if the image is formed, the magnification is given as

In the first case, if the image is formed, the magnification is given as $\frac{v}{u} = \frac{9}{3}$ Such that, v = 3u

Also, v = 20+u, since "v" and "u" interchange the conjugate positions.

∴ 3u = 20 + u

Or 2u = 20

Or u = 10

And, v = 20+ u = 20+10 = 30 cm

Now, focal length is calculated as:

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

$$= \frac{1}{30} + \frac{1}{10}$$

$$= \frac{10 + 30}{300}$$

$$= \frac{40}{300} = 7.5$$

Thus, correct answer is option (d)