Refraction Of Light

Question 1:

If a ray of light goes from a rarer medium to a denser medium, will it bend towards the normal or away from it ?

Solution :

It will bend towards the normal.

Question 2:

If a ray of light goes from a denser medium to a rarer medium, will it bend towards the normal or away from the normal ?

Solution :

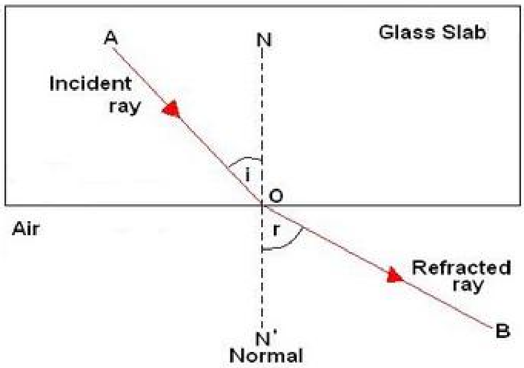
It will bend away from the normal.

Question 3:

A beam of light travelling in a rectangular glass slab emerges into air. Draw a ray-diagram indicating the change in its path.

Solution :

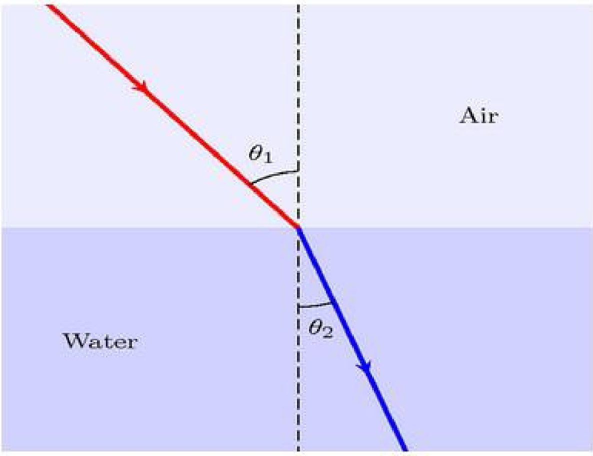
A ray of light travelling from the glass slabs and emerges into the air.



Question 4:

A beam of light travelling in air is incident on water. Draw a ray-diagram indicating the change in its path in water.

Solution :

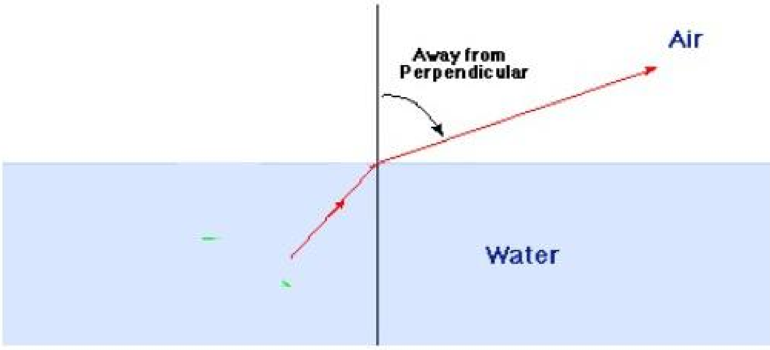


Question 5:

A ray of light travelling in water emerges into air. Draw a ray-diagram indicating the change in its path.

Solution :

A ray of light travelling through water to air.

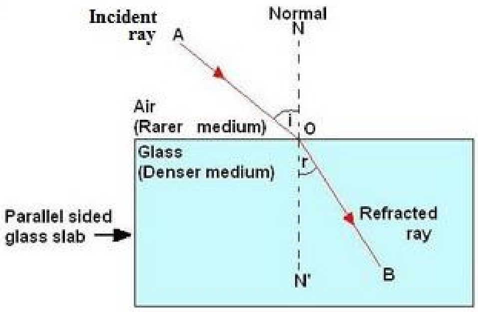


Question 6:

A ray of light travelling in air is incident on a parallel-sided glass slab (or rectangular glass slab). Draw a ray-diagram indicating the change in its path in glass.

Solution :

A ray of light incidence on parallel sided glass slab.



Question 7:

A ray of light travelling in glass emerges into air. State whether it will bend towards the normal or away from the normal.

Solution :

The ray of light will bend away from the normal.

Question 8:

A ray of light travelling in air enters obliquely into water. Does the ray of light bend towards the normal or away from the normal ? Why ?

Solution :

The ray of light bends towards the normal. This is because water is an optically denser medium than air.

Question 9:

A ray of light goes from water into air. Will it bend towards the normal or away from the normal ?

Solution :

It will bend away from the normal.

Question 10:

State two effects caused by the refraction of light.

Solution :

Two effects caused by refraction of light are:

– a pool of water appears to be less deep than it actually is.

– an object placed under water appears to be raised.

Question 11:

Name the phenomenon due to which a swimming pool appears less deep than it really is.

Solution :

This is due to refraction of light.

Question 12:

When a ray of light passes from air into glass, is the angle of refraction greater than or less than the angle of incidence ?

Solution :

Angle of refraction is less than the angle of incidence.

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Question 13:

A ray of light passes from air into a block of glass. Does it bend towards the normal or away from it ?

Solution :

A ray of light travelling from air to glass block, will bend towards the normal.

Question 14:

As light rays pass from water into glass, are they refracted towards the normal or away from the normal ?

Solution :

A ray of light travelling from water into glass will bend towards the normal.

Question 15:

In which material do you think light rays travel faster-glass or air ?

Solution :

Light rays travel faster in air.

Question 16:

Which phenomenon of light makes the water to appear shallower than it really is ?

Solution :

Refraction of light.

Question 17:

State whether the following statement is true or false :

Refraction occurs because light slows down in denser materials.

Solution :

True.

Question 18:

Why does a ray of light bend when it travels from one medium to another ?

Solution :

A ray of light bends when it travels from one medium to another due to the change in the speed of light.

Question 19:

Fill in the following blanks with suitable words :

(a) Light travelling along a normal is………..

(b) Light bends when it passes from water into air. We say that it is…………..

Solution :

(a) not.

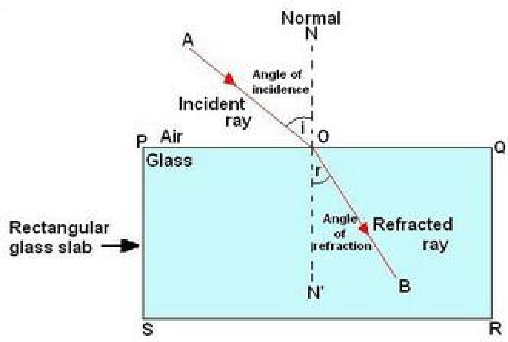
(b) refracted.

Question 20:

What is meant by 'refraction of light' ? Draw a labelled ray diagram to show the refraction of light.

Solution :

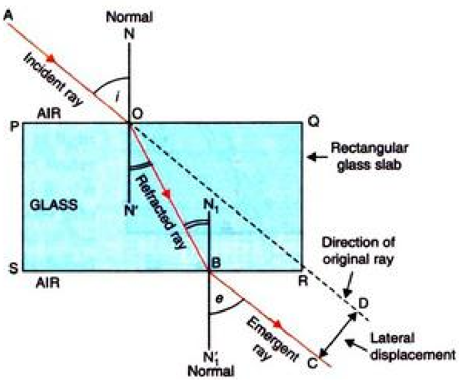
The change in direction of light when it passes from one medium to another obliquely, is called refraction of light.



Question 21:

A ray of light travelling in air is incident on a rectangular glass block and emerges out into the air from the opposite face. Draw a labelled ray diagram to show the complete path of this ray of light. Mark the two points where the refraction of light takes place. What can you say about the final direction of ray of light ?

Solution :



The final direction of the ray of light is same as the incident direction.

Question 22:

Draw a labelled ray diagram to show how a ray of light is refracted when it passes :

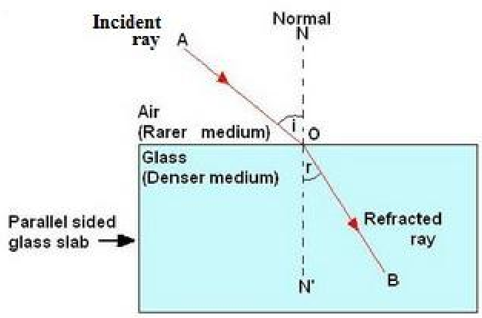
(a) from air into an optically denser medium.

(b) from an optically denser medium into air.

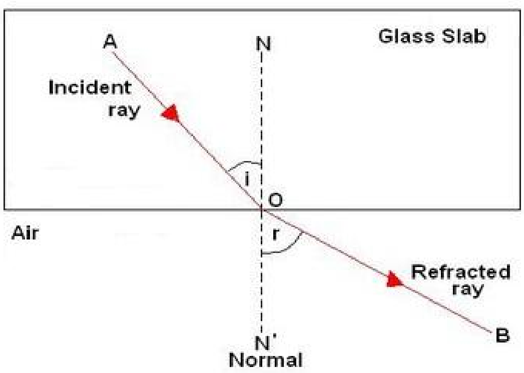
Solution :

(a) Ray of light travelling from air into an optically denser medium.

(a) Ray of light travelling from air into an optically denser medium.



(b) Ray of light travelling from an optically denser medium into air.

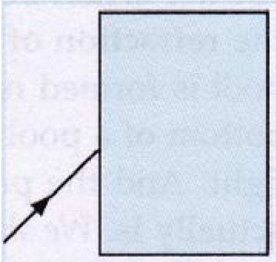


Question 23:

The diagram given alongside shows a ray of light entering a rectangular block of glass.

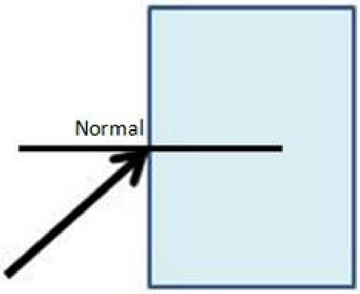
(a) Copy the diagram and draw the normal at the point of entry.

(b) Draw the approximate path of the ray of light through the glass block and out of the other side.

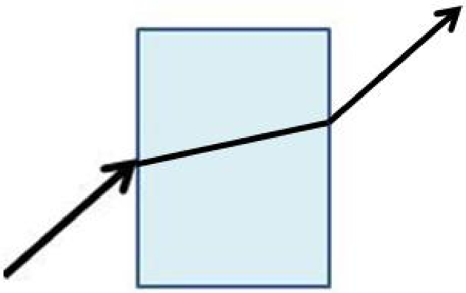


Solution :

(a)



(b)



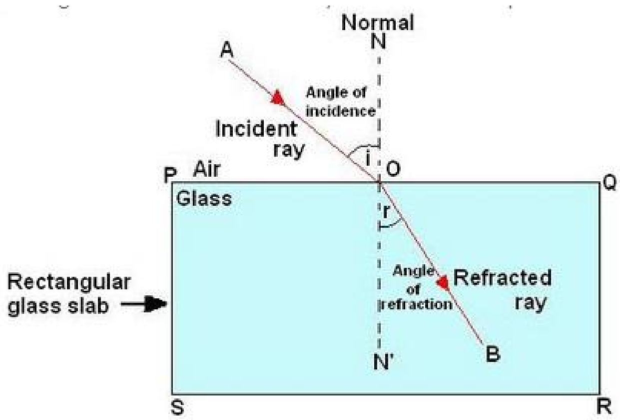
Question 24:

What is meant by the 'angle of incidence' and the 'angle of refraction' for a ray of light ? Draw a labelled ray diagram to show the angle of incidence and the angle of refraction for a refracted ray of light.

Solution :

The angle between the incident ray and normal at the point of incidence is called angle of incidence.

The angle between the refracted ray and normal at the point of refraction is called angle of refraction.



Question 25:

Light travels more quickly through water than through glass.

(a) Which is optically denser : water or glass ?

(b) If a ray of light passes from glass into water, which way will it bend : towards the normal or away from the normal ?

Solution :

(a) Glass is optically denser than the water.

(b) The ray will bend away from the normal.

Question 26:

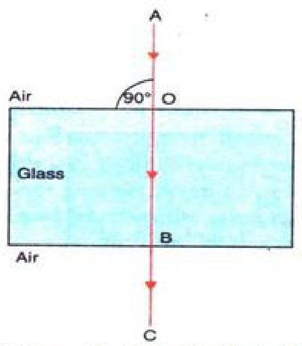
Draw a labelled ray diagram to show how a ray of light passes through a parallel sided glass block :

(a) if it hits the glass block at 90° (that is, perpendicular to the glass block)

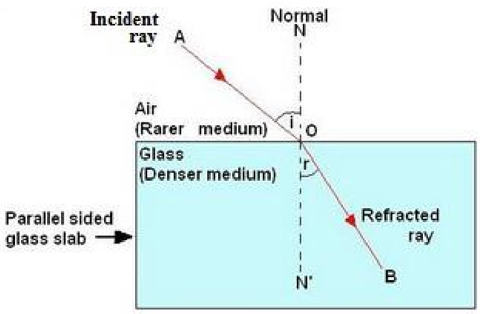
(b) if it hits the glass block at an angle other than 90° (that is, obliquely to the glass block).

Solution :

(a) If ray of light hits the block at 90°



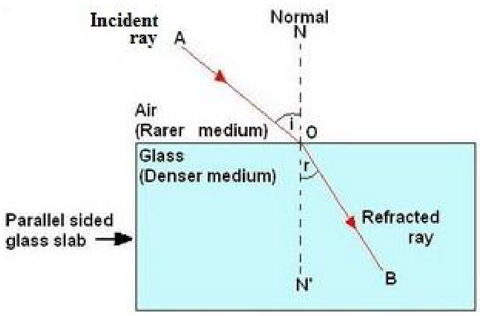
(b) If ray of light hits the block other than the 90°



Question 27:

When a light ray passes from air into glass, what happens to its speed ? Draw a diagram to show which way the ray of light bends.

Solution :



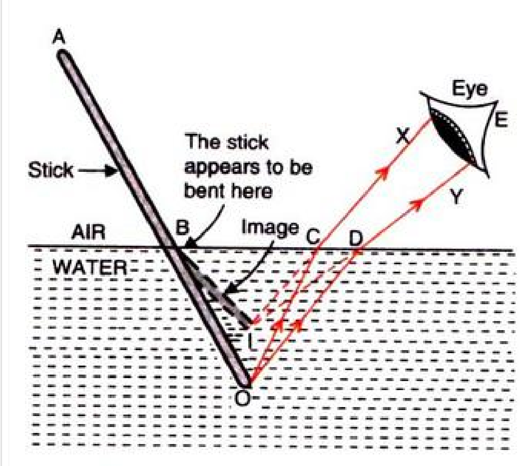
The ray of light bends towards the normal.

Question 28:

(a) Explain why, a stick half immersed in water appears to be bent at the surface. Draw a labelled diagram
to illustrate your answer.
(b) A coin in a glass tumbler appears to rise as the glass tumbler is slowly filled with water. Name the phenomenon responsible for this effect.

Solution :

(a) The apparent bending of the stick is due to the refraction of light when it passes from water into air.
A ray of light OC coming from O passes from water into air and gets refracted away from normal (along CX). Another ray OD gets refracted along DY. The two refracted rays CX and DY, when produced backwards, appear to meet at point I. Thus, I is the virtual image of the end O of the stick. So, the stick appears to be bent as shown below.



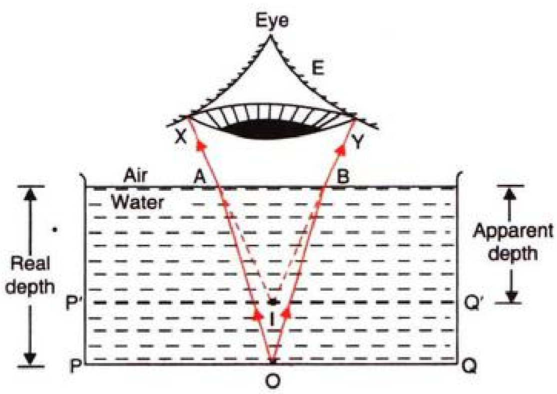
(b) This phenomenon is due to the refraction of light as it comes out from water into air?

Question 29:

(a) With the help of a labelled diagram, explain why a tank full of water appears less deep than it actually is.
(b) Name the phenomenon due to which a pencil partly immersed in water and held obliquely appears to be bent at the water surface.

Solution :

(a) If we look into a tank of water, it appears to be less deep than it really is. This is due to the refraction of light which takes place when light rays pass from the tank of water into air. When we look into the tank, we do not see the actual bottom of the tank, we see a virtual image of the bottom of the pool which is formed by the refraction of light coming from the water into the air.



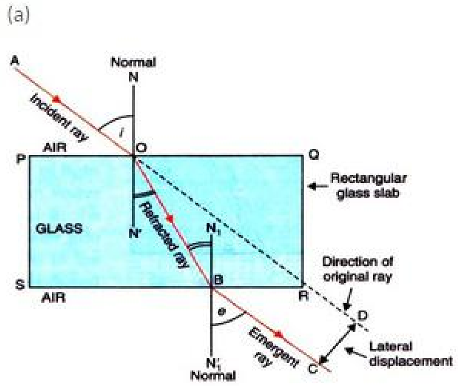
(b) Refraction of light

(b) Refraction of light.

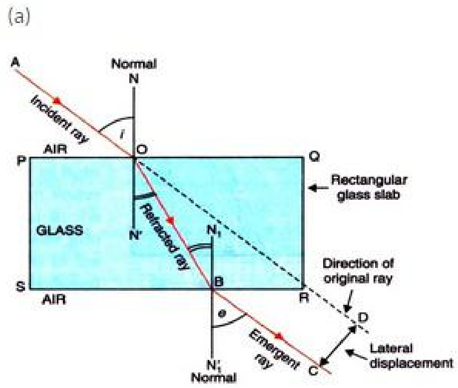
Question 30:

(a) With the help of a diagram, show how when light falls obliquely on the side of a rectangular glass slab,
the emergent ray is parallel to the incident ray.
(b) Show the lateral displacement of the ray on the diagram.
(c) State two factors on which the lateral displacement of the emergent ray depends.

Solution :



(a)



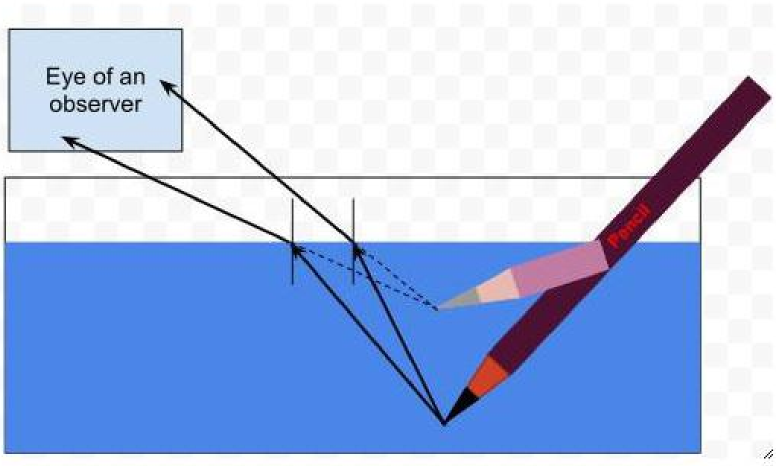
(b) The lateral displacement is shown in the above diagram.
(c) Factors on which the lateral displacement depends are:
(i) Angle of incidence
(ii) Thickness of glass slab
(iii) Refractive index of glass slab

Question 31:

Explain with the help of a labelled ray diagram, why a pencil partly immersed in water appears to be bent at the water surface. State whether the bending of pencil will increase or decrease if water is replaced by another liquid which is optically more dense than water. Give reason for your answer.

Solution :

A pencil placed in water appears to be bent because of refraction of light. The refraction causes an apparent shift in the position of the part of the pencil within the water.



If water is replaced by another liquid which is optically more dense than water, then the bending of the pencil will increase. This is because the optically denser medium will cause more refraction of light rays.

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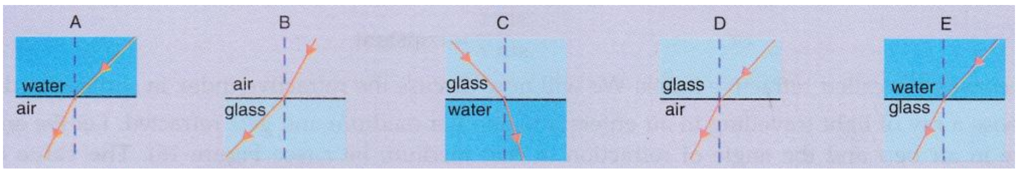
Question 39:

Which of the following diagrams shows the ray of light refracted correctly ?



Solution :

E.

Question 40:

A vertical ray of light strikes the horizontal surface of some water :

(a) What is the angle of incidence ?

(b) What is the angle of refraction ?

Solution :

(a) 0^0

(b) 0^0

Question 41:

How is the reflection of light ray from a plane mirror different from the refraction of light ray as it enters a block of glass ?

Solution :

The angle of reflection is equal to the angle of incidence but the angle of refraction is not equal to the angle of incidence.

Question 42:

How does the light have to enter the glass :

(a) to produce a large amount of bending ?

(b) for no refraction to happen ?

Solution :

(a) Obliquely; making a large angle of incidence.

(b) Perpendicular to the glass surface.

Question 43:

(a) How can you bend light away from the normal ?

(b) How must light travel out of a substance if it is not going to be refracted ?

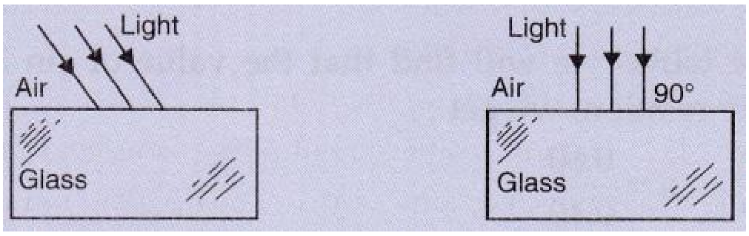
Solution :

(a) By making the light enter from a denser medium to a rarer medium.

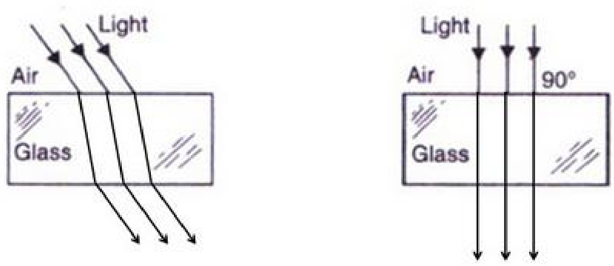
(b) Incidence should be at right angle to the surface of substance.

Question 44:

Draw and complete the following diagrams to show what happens to the beams of light as they enter the glass block and then leave it :



Solution :



Question 45:

Why does a beam of light bend when it enters glass at an angle ? Why does it not bend if it enters the glass at right angles ?

Solution :

A beam of light bends when it enters glass at an angle. This is due to refraction of light. It does not bend if it enters the glass at right angles because no refraction will occur in this case, the angle of incidence in this case is zero and angle of refraction is also zero.

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Question 1:

What name is given to the ratio of sine of angle of incidence to the sine of angle of refraction ?

Solution :

Refractive index.

Question 2:

Write the relation between the angle of incidence and the angle of refraction for a medium.

Solution :

Refractive index= sine of the angle of incidence/sine of the angle of refraction.

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Question 3:

What is the unit of refractive index ?

Solution :

Refractive index has no units.

Question 4:

Which has higher refractive index : water or glass ?

Solution :

Glass has higher refractive index.

Question 5:

Refractive indices of carbon disulphide and ethyl alcohol are 1.63 and 1.36 respectively. Which is optically denser ?

Solution :

Carbon disulphide is more denser than the ethyl alcohol.

Question 6:

The refractive index of diamond is 2.42. What is the meaning of this statement in relation to the speed of light ?

Solution :

This means that the ratio of the speed of light in air to the speed of light in diamond is equal to 2.42.

Question 7:

If the refractive index for light going from air to diamond be 2.42, what will be the refractive index for light going from diamond to air ?

Solution :

$$_{\text{diamond}}n_{\text{air}} = 2.42$$

$$_{\text{air}}n_{\text{diamond}} = \frac{1}{2.42} = 0.41$$

Question 8:

How is the refractive index of a material related to the speed of light in it ?

Solution :

$$\text{Refractive index of a material} = \frac{\text{Speed of light in vacuum}}{\text{speed of light in the material}}$$

Question 9:

Fill in the following blank with a suitable word :

When a ray of light goes from air into a clear material, you see the ray bend. How much the ray bends is determined by the……………………. of the material.

Solution :

Refractive index.

Question 10:

Give three examples of materials that refract light rays. What happens to the speed of light rays when they enter these materials ?

Solution :

Three examples of materials that refract light rays are water, glass and diamond. When light rays (travelling in air) enter these materials, their speed decreases.

Question 11:

Define Snell's law of refraction. A ray of light is incident on a glass slab at an angle of incidence of 60°. If the angle of refraction be 32.7°, calculate the refractive index of glass.

(Given : sin 60° = 0.866, and sin 32.7° = 540).

Solution :

Snell's law: According to the Snell's law of refraction, the ratio of sine of angle of incidence to the sine of angle of refraction is constant for a given pair of media.

$$\text{Refractive index} = \frac{\text{sine of the angle of incidence}}{\text{sine of the angle of refraction}}$$

Given: Angle of incidence=60^{o}

Angle of refraction=32.4^{o}

$$\text{Refractive index} = \frac{\text{sine of the angle of incidence}}{\text{sine of the angle of refraction}}$$

$$\text{Refractive index} = \frac{\sin 60^\circ}{\sin 32.4^\circ}$$

$$\text{Refractive index} = \frac{0.866}{0.540} = 1.603$$

Question 12:

The speed of light in vacuum and in two different glasses is given in the table below :

Medium	*Speed of light*
Vacuum	3.00×10^8 m/s
Flint glass	1.86×10^8 m/s
Crown glass	1.97×10^8 m/s

(a) Calculate the absolute refractive indexes of flint glass and crown glass.

(b) Calculate the relative refractive index for light going from crown glass to flint glass.

Solution :

$$\text{(a) } n_{flint} = \frac{\text{speed of light in vacuum}}{\text{speed of light in flint glass}} = \frac{3 \times 10^8}{1.86 \times 10^8} = 1.61$$

$$n_{crown} = \frac{\text{speed of light in vacuum}}{\text{speed of light in crown glass}} = \frac{3 \times 10^8}{1.97 \times 10^8} = 1.52$$

$$\text{(b) } {}_{crown}n_{flint} = \frac{\text{speed of light in crown glass}}{\text{speed of light in flint glass}} = \frac{1.97 \times 10^8}{1.86 \times 10^8} = 1.059$$

Question 13:

The speed of light in air is 3×10^8 m/s. In medium X its speed is 2×10^8 m/s and in medium Y the speed of light is 2.5×10^8 m/s. Calculate:

(a) air ^{n}x (b) air ^{n}y (c) x^{n}y

Solution :

Given:
Speed of light in air=3.0×10^8m/s
Speed of light in medium X=2.0×10^8m/s
Speed of light in medium Y=2.50×10^8m/s
(a) ${}_{air}n_x$=?

$$ {}_{air}n_x = \frac{\text{speed of light in air}}{\text{speed of light in medium X}} $$
$$ {}_{air}n_x = \frac{3.0\times10^8 m/s}{2.0\times10^8 m/s} $$
$$ = 1.5 $$

(b) ${}_{air}n_y$=?

$$ {}_{air}n_y = \frac{\text{speed of light in air}}{\text{speed of light in medium y}} $$
$$ {}_{air}n_y = \frac{3.0\times10^8 m/s}{2.50\times10^8 m/s} $$
$$ = 1.2 $$

(c) ${}_{x}n_y$=?

$$ {}_{x}n_y = \frac{\text{speed of light in medium X}}{\text{speed of light in medium Y}} $$
$$ {}_{x}n_y = \frac{2.0\times10^8 m/s}{2.50\times10^8 m/s} $$
$$ = 0.8 $$

Question 14:

What is the speed of light in a medium of refractive index $\frac{6}{5}$ if its speed in air is 3,00,000 km/s ?

Solution :

Refractive index of medium=6/5=1.2
Speed of light in air=3,00,000km/s
We know that

$$ \text{Refractive index of the medium} = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}} $$
$$ 1.2 = \frac{300000}{\text{Speed of light in medium}} $$
Speed of light in medium=250000km/s

Question 15:

The refractive index of glass is 1.5. Calculate the speed of light in glass. The speed of light in air is 3.0×10^8 ms^{-1}.

Solution :

Given:-
Refractive index of glass=1.5
Speed of light in air=3.0×10^8m/s
We know that

$$ \text{Refractive index of glass} = \frac{\text{Speed of light in air}}{\text{Speed of light in glass}} $$
$$ 1.5 = \frac{3\times10^8}{\text{Speed of light in glass}} $$
$$ \text{Speed of light in glass} = 2\times10^8 \ m/s $$

Question 16:

The speed of light in water is 2.25×10^8 m/s. If the speed of light in vacuum be 3×10^8 m/s, calculate the refractive index of water.

Solution :

Speed of light in vacuum=3.0×10^8m/s
Speed of light in water=2.25×10^8m/s

Refractive index of water=?
We know that

$$\text{Refractive index of water}=\frac{\text{Speed of light in vacuum}}{\text{Speed of light in water}}$$

$$\text{Refractive index of water} = \frac{3\times10^8}{2.25\times10^8} = 1.33$$

Question 17:

Light enters from air into diamond which has a refractive index of 2.42. Calculate the speed of light in diamond. The speed of light in air is 3.0×10^8 ms^{-1}.

Solution :

Given:-
Refractive index of diamond=2.42
Speed of light in air=3.0×10^8m/s
We know that

$$\text{Refractive index of diamond}=\frac{\text{Speed of light in air}}{\text{Speed of light in diamond}}$$

$$2.42 = \frac{3\times10^8}{\text{Speed of light in diamond}}$$

$$\text{Speed of light in diamond} = 1.239\times10^8 \text{ m/s}$$

Question 18:

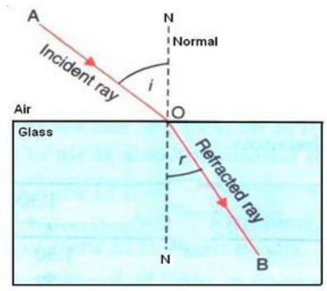
(a) State and explain the laws of refraction of light with the help of a labelled diagram.

(b) What is meant by the refractive index of a substance ?

(c) Light travels through air at 300 million ms^{-1}. On entering water it slows down to 225 million ms^{-1}. Calculate the refractive index of water.

Solution :

(a) Laws of refraction:



First law: According to the first law of refraction, the incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

Second law: According to the second law of refraction, the ratio of the sine of angle of incidence to the sine of angle of refraction is constant for a given pair of media.

(b) Refractive index of substance: The ratio of speed of light in vacuum to the speed of light in a medium, is called the refractive index of that medium.

(c) Speed of light in air =300milion m/sec

Speed of light in water=225milion m/sec

We know that

$$\text{Refractive index of water} = \frac{\text{Speed of light in air}}{\text{Speed of light in water}}$$

$$\text{Refractive index of water} = \frac{300\ \text{million m/s}}{225\ \text{million m/s}} = 1.33$$

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Question 29:

The following table gives the refractive indices of a few media :

	1	2	3	4	5
Medium :	Water	Crown glass	Rock salt	Ruby	Diamond
Refractive index :	1.33	1.52	1.54	1.71	2.42

Use this table to give an example of :

(i) a medium pair so that light speeds up when it goes from one of these medium to another.

(ii) a medium pair so that light slows down when it goes from one of these medium to another.

Solution :

(i) Crown glass to water.

(ii) Water to diamond.

Question 30:

Refractive indices of four media A, B, C and D are given below :

Medium	Refractive index
A	1.33
B	1.44
C	1.52
D	1.65

In which of these four media is the speed of light (i) maximum, and (ii) minimum ?

Solution :

(i) A (It has least refractive index).

(ii) D (It has highest refractive index).

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Question 1:

Name the lens which can concentrate sun's rays to a point and burn a hole in a piece of paper.

Solution :

Converging lens.

Question 2:

Give the usual name for the following :

A point inside a lens through which the light passes undeviated.

Solution :

Optical center.

Question 3:

A 1 cm high object is placed at a distance of 2ƒ from a convex lens. What is the height of the image formed ?

Solution :

1 cm (same as the height of the object).

Question 4:

If the image formed by a convex lens is of the same size as that of the object, what is the position of the image with respect to the lens ?

Solution :

At 2F (At twice the focal length).

Question 5:

If an object is placed at the focus of a convex lens, where is the image formed ?

Solution :

The image is formed at infinity (at very large distance).

Question 6:

Where should an object be placed in order to use a convex lens as a magnifying glass ?

Solution :

Object should be placed at a distance less than focal length.

Question 7:

Where should an object be placed in front of a convex lens so as to obtain its virtual, erect and magnified image ?

Solution :

The object should be placed within focus.

Question 8:

Where should an object be placed in front of a convex lens so as to obtain its real, inverted and magnified image ?

Solution :

Object should be placed between f and 2f.

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Question 9:

For what position of an object a real, diminished image is formed by a convex lens ?

Solution :

Beyond 2F.

Question 10:

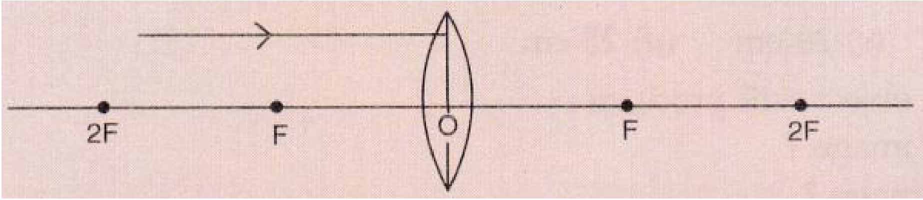
If an object is at a considerable distance (or infinity) in front of a convex lens, where is the image formed ?

Solution :

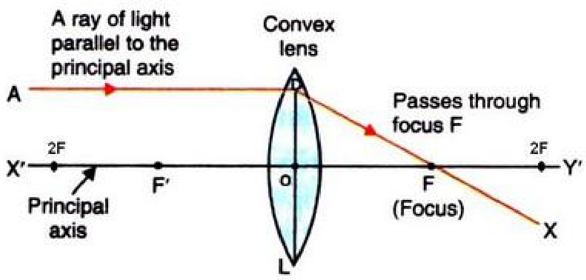
At focus F.

Question 11:

Draw the given diagram in your answer book and complete it for the path of a ray of light after passing through the lens.



Solution :



Question 12:

What type of lens would you use as a magnifying glass ? How close must the object be to the lens ?

Solution :

Convex lens

The object must be withing the focus of the lens.

Question 13:

Name two factors on which the focal length of a lens depends.

Solution :

Focal length of a lens depends on the refractive index of the glass from which it is made, and on the curvature of its two surfaces.

Question 14:

State any two uses of convex lenses.

Solution :

Two uses of convex lenses:-

1. As a magnifying glass.
2. For making a simple camera.

Question 15:

Fill in the following blanks with suitable words :

(a) Parallel rays of light are refracted by a convex lens to a point called the..........

(b) The image in a convex lens depends upon the distance of the............ from the lens.

Solution :

a) focus.

b) object.

Question 16:

What is a lens ? Distinguish between a convex lens and a concave lens. Which of the two is a converging lens : convex lens or concave lens ?

Solution :

A lens is a piece of transparent glass bound by two spherical surfaces.

A convex lens is thicker at the middle as compared to the edges; while a concave lens is thicker at the edges as compared to the middle.

Convex lens is converging lens.

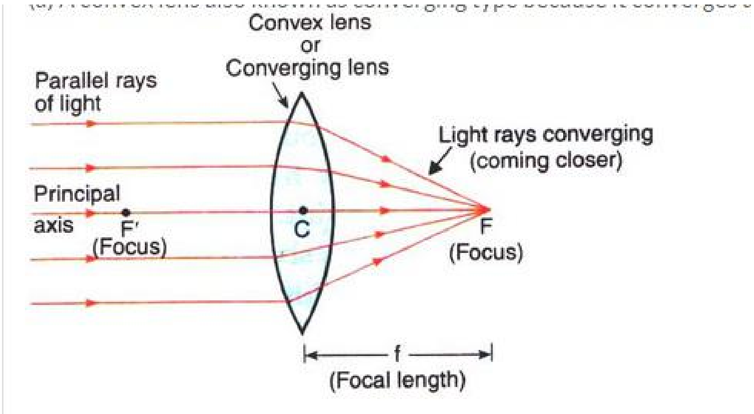
Question 17:

(a) Explain with the help of a diagram, why the convex lens is also called a converging lens.

(b) Define principal axis, principal focus and focal length of a convex lens.

Solution :

(a) A convex lens also known as converging type because it converges a parallel beam of light rays passing through it.



(b) Principle axis: The principal axis of a lens is a line passing throught the optical centre of the lens and perpendicular to both the faces of the lens.

Principle focus: The principal focus of a convex lens is a point on its principal axis to which light rays parallel to the principal axis converge after passing through the lens.

Focal length: The distance of the principle focus from the optical center of a lens is called its focal length.

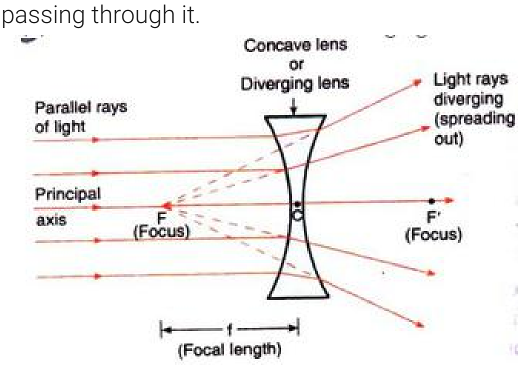
Question 18:

(a) Explain with the help of a diagram, why the concave lens is also called a diverging lens.

(b) Define the principal focus of a concave lens.

Solution :

(a) A concave lens is known as diverging lens because it diverges the parallel rays of light passing through it.



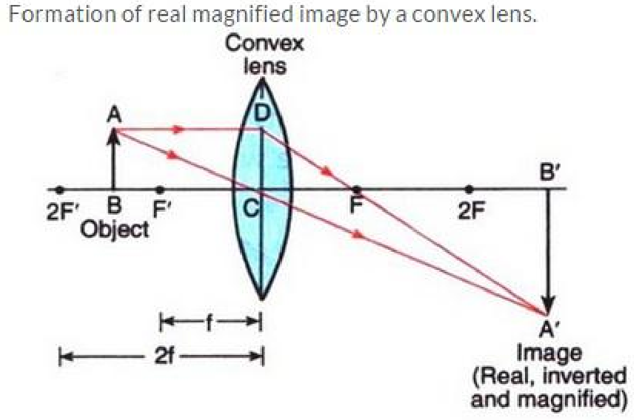
(b) The principal focus of a concave lens is a point on its principal axis from which light rays, originally parallel to the axis, appear to diverge after passing through the lens.

Question 19:

Draw a ray diagram to show the formation of a real magnified image by a convex lens. (In your sketch the position of object and image with respect to the principal focus of lens should be shown clearly).

Solution :

Formation of real magnified image by a convex lens.

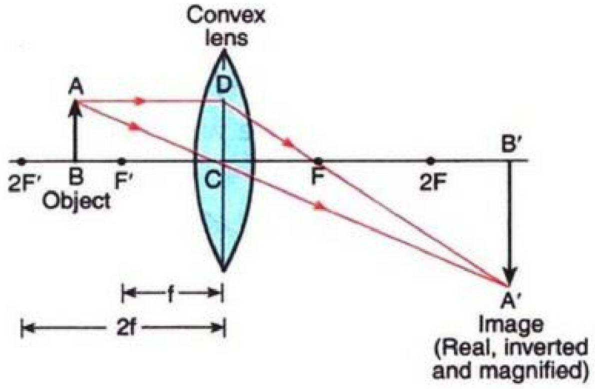


Question 20:

Describe with the help of a ray-diagram, the formation of image of a finite object placed in front of a convex lens between ƒ and 2ƒ Give two characteristics of the image so formed.

Solution :

If object is placed in between f and 2f, the image will form on the other side of the lens beyond 2f as shown below.



Characteristics of image formed:

Image formed is real and inverted.

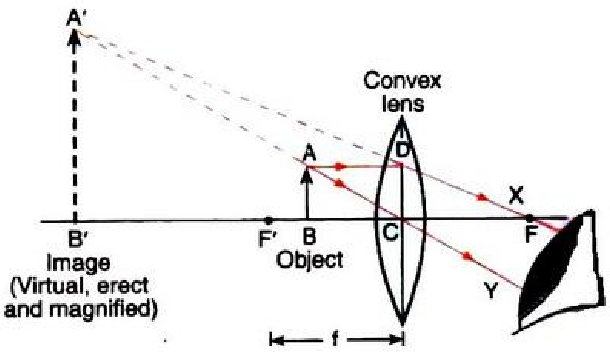
Image formed is magnified.

Question 21:

Describe with the help of a ray diagram the nature, size and position of the image formed when an object is placed in front of a convex lens between focus and optical centre. State three characteristics of the image formed.

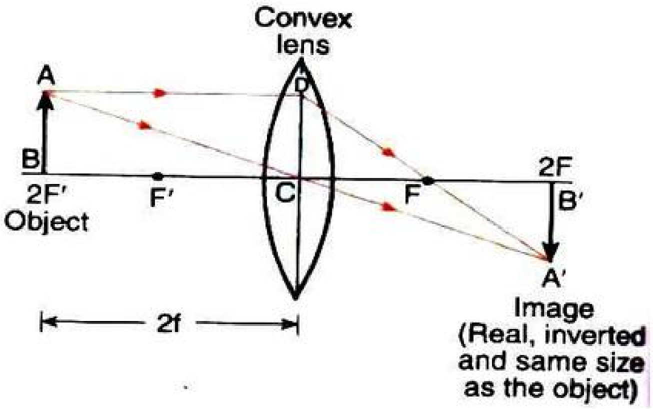
Solution :

In the diagram, the object is placed in front of a convex lens between focus and optical centre. The image is formed on the same side as the object as shown below.



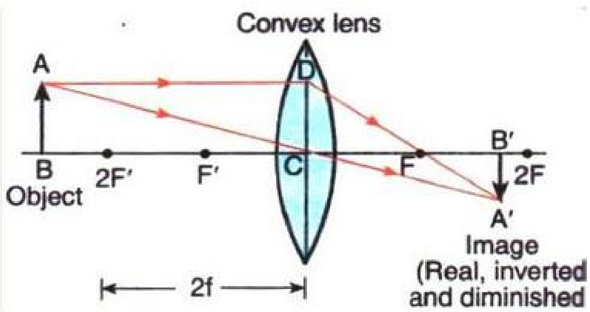
Characteristics of image formed:
Image is virtual and erect.
Image is larger than the object
Image is formed behind the object.

Question 22:
An object is placed at a distance equal to 2ƒ in front of a convex lens. Draw a labelled ray diagram to show the formation of image. State two characteristics of the image formed.
Solution :

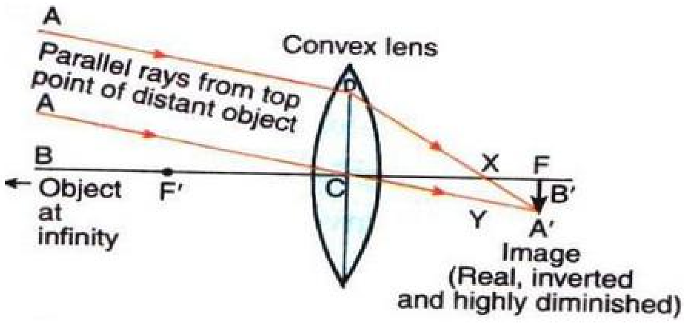


Characteristic of image formed:
Image formed is real and inverted.
Image is of same size as the object

Question 23:
Describe with the help of a ray-diagram, the size, nature and position of the image formed by a convex lens when an object is placed beyond 2f in front of the lens.
Solution :
When an object is placed beyond 2f in front of a convex lens, then the image formed is between f and 2f on the other side of the lens, it is real, inverted and smaller than the object.



Question 24:
Describe with the help of a ray diagram the nature, size and position of the image formed when an object is placed at infinity (considerable distance) in front of a convex lens. State three characteristics of the image so formed.
Solution :
When an object is placed at infinity in front of a convex lens, the image is formed at the focus on the other side of the lens.



Characteristics of image formed:

Image is real.

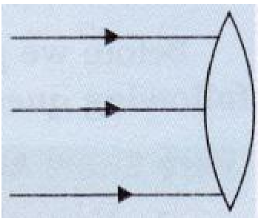
Image is inverted.

Image is highly diminished.

Question 25:

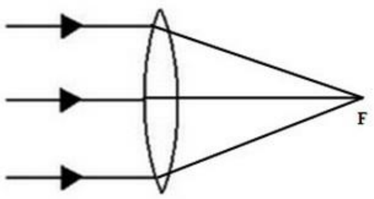
(a) What type of lens is shown in the diagram on the right ? What will happen to the parallel rays of light ? Show by completing the ray diagram.

(b) Your eye contains a convex lens. Why is it unwise to look at the sun ?



Solution :

(a) The lens shown in convex. the parallel rays will converge to a point called focus (F).



(b) It is unwise to look at the sun because the convex lens focusses a lot of sun rays into our eyes and this may damage them.

(b) It is unwise to look at the sun because the convex lens focusses a lot of sun rays into our eyes and this may damage them.

Question 26:

Where must the object be placed for the image formed by a converging lens to be :

(a) real, inverted and smaller than the object ?

(b) real, inverted and same size as the object ?

(c) real, inverted and larger than the object ?

(d) virtual, upright and larger than the object ?

Solution :

a) Beyond 2F

b) At 2F

c) Between F and 2F

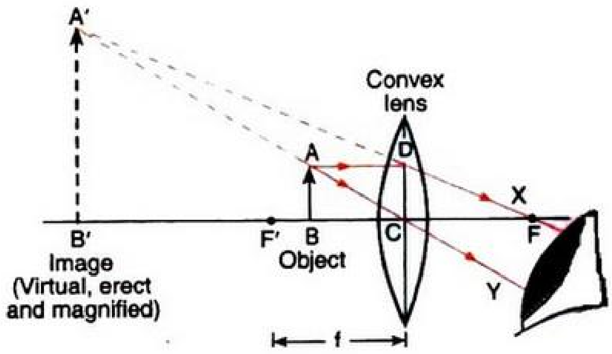
d) Between F and optical centre

Question 27:

Draw a diagram to show how a converging lens held close to the eye acts as a magnifying glass. Why is it usual to choose a lens of short focal length for this purpose rather than one of long focal length ?

Solution :

Converging lens as a magnifying glass:



It is usual to choose a lens of short focal length for this purpose rather than one of long focal length because smaller the focal length of a convex lens, greater will be its magnifying power.

Question 28:

How could you find the focal length of a convex lens rapidly but approximately ?

Solution :

To determine the focal length of a convex lens, we put the convex lens in a holder and keep it in front of a distant object like a window or tree, so that the rays coming from the window pass through it. A cardboard screen is put behind the lens. We change the distance of the screen from the convex lens until a clear inverted image of the window is formed on the screen. Measure the distance of the screen from the lens with a scale. This distance will be the focal length of convex lens.

Question 29:

(a) With the help of a labelled diagram explain how a convex lens converges a beam of parallel light rays.

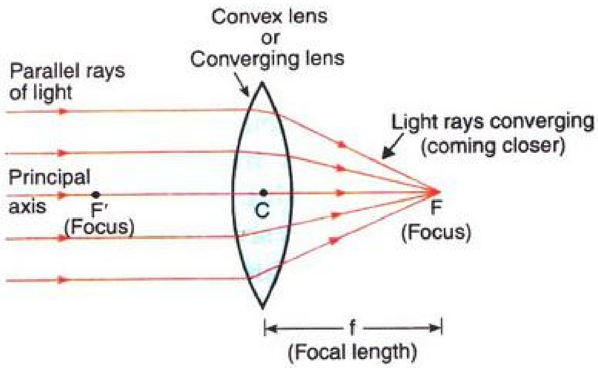
Mark the principal axis, optical centre, principal focus and focal length of the convex lens on the diagram.

(b) State whether convex lens has a real focus or a virtual focus.

(c) List some things that convex lens and concave mirror have in common.

Solution :

(a) When a beam of light rays parallel to one another and also to the principal axis of the convex lens fall on the lens, the incident rays pass through the lens and get refracted according to the laws of refraction. All the rays, after passing through the lens, converge at the same point F (focus) on the other side of the lens.



(b) A convex lens has a real focus.

(c) Both, convex lens and concave mirror, converge parallel rays of light coming from infinity (parallel to the principal axis) at the focus.

Question 30:

(a) With the help of a labelled diagram, explain how a concave lens diverges a beam of parallel light rays.

Mark the principal axis, optical centre, principal focus and focal length of the concave lens on the diagram.

(b) State whether concave lens has a real focus or a virtual focus.

(c) List some things that concave lens and convex mirror have in common.

Solution :

(a)

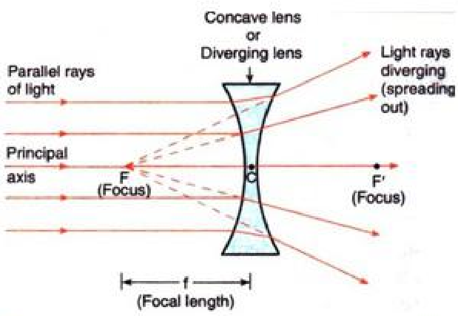


Figure — A concave lens diverges (spreads out) a parallel beam of light rays.

When a beam of light rays parallel to one another and also to the principal axis of the concave lens fall on the lens, the incident rays pass through the lens and get refracted according to the laws of refraction. All the rays spread out after passing through the lens. These diverging rays when produced backwards appear to meet at a point F (focus) on the left side of the lens.

(b) A concave lens has a virtual focus.

(c) Both, concave lens and convex mirror, diverge parallel rays of light coming from infinity (parallel to the principal axis).

Question 31:

Draw ray diagrams to represent the nature, position and relative size of the image formed by a convex lens for the object placed :

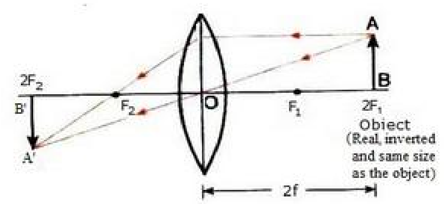
(a) at $2F_1$,

(b) between F_1 and the optical centre O of the lens.

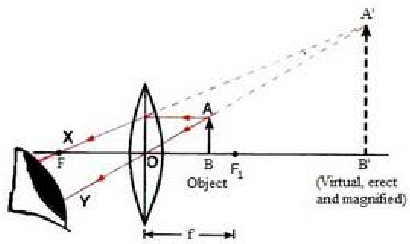
Which of the above two cases shows the use of convex lens as a magnifying glass ? Give reasons for your choice.

Solution :

(a) Object at $2F_1$:



(b) Object between F_1 and the optical centre O of the lens:



The case when object is between F_1 and the optical centre O of the lens shows the use of convex lens as a magnifying glass. This is because here the image formed is erect and magnified.

Question 32:

(a) An object is placed well outside the principal focus of a convex lens. Draw a ray diagram to show how
the image is formed, and say whether the image is real or virtual.
(b) What is the effect on the size and position of the image of moving the object (i) towards the lens, and (ii) away from the lens ?

Solution :

(a).

a)

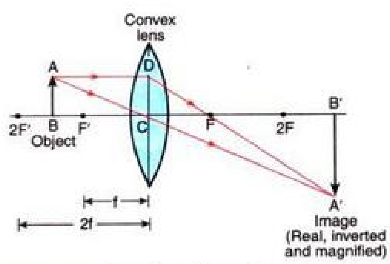


Figure — Formation of image by a convex lens when the object is placed between F' and 2F' (or between *f* and 2*f*)

(b)
(i) If object is moved towards the lens, the image size will keep on increasing till the object reaches focus. After that, the size decreases but the image remains magnified. The image keeps movingvaway from the lens (on the opposite side of the lens) till the object reaches focus; after that the image is formed on the same side of the lens as the object.
(ii) If object is moved away from the lens, the size will keep on decreasing and the image keeps on shifting towards the lens.

Question 33:

(a) Explain what is meant by a virtual, magnified image.
(b) Draw a ray diagram to show the formation of a virtual magnified image of an object by a convex lens. In your diagram, the position of object and image with respect to the principal focus should be shown clearly.
(c) Three convex lenses are available having focal lengths of 4 cm, 40 cm and 4 m

respectively. Which one would you choose as a magnifying glass and why ?

Solution :

(a) A virtual magnified image is the one which cannot be taken on a screen and whose size is larger than that of the object.

(a) A virtual magnified image is the one which cannot be taken on a screen and whose size is larger than that of the object.

(b)

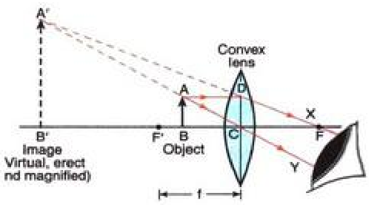


Figure – Formation of image by a convex lens when the object is placed between its optical centre (C) and focus (F').

(c) Convex lens having 4 cm focal length - because it will produce greatest magnification.

Question 34:

(a) Explain why, a real image can be projected on a screen but a virtual image cannot.

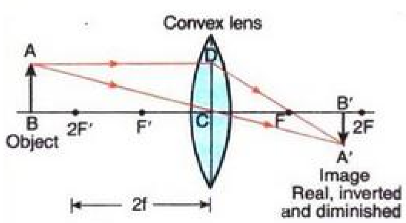
(b) Draw a ray diagram to show the formation of a real diminished image of an object by a convex lens. In your diagram, the position of object and image with respect to the principal focus should be shown clearly.

(c) Name one simple optical instrument in which the above arrangement of convex lens is used.

Solution :

a) A real image can be projected on a screen but a virtual image cannot because a real image is formed when light rays coming from an object actually meet at a point after refraction through a lens while a virtual image is formed when light rays coming from an object only appear to meet at a point when produced backwards (but do not actually meet) after refraction through a lens.

b)



c) A simple camera

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Question 46:

A lens of focal length 12 cm forms an erect image three times the size of the object. The distance between the object and image is :

(a) 8 cm (b) 16 cm (c) 24 cm (d) 36 cm

Solution :

(b) 16 cm

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

$3 = \frac{v}{u}$

$\Rightarrow v = 3u$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{3u} - \frac{1}{u} = \frac{1}{12}$

$\frac{-2}{3u} = \frac{1}{12}$

$\Rightarrow u = -8\text{ cm}$

$v = 3 \times -8 = -24\text{ cm}$

Distance between object and image=u-v=-8-(-24) $= -8 + 24 = 16\text{ cm}$

Question 47:

If an object is placed 21 cm from a converging lens, the image formed is slightly smaller than the object. If the object is placed 19 cm from the lens, the image formed is slightly larger than the object. The approximate focal length of the lens is :

(a) 5 cm (b) 10 cm (c) 18 cm (d) 20 cm

Solution :

(b) 10 cm

The image is slightly smaller than the object when the object lies beyond 2f; and the image is slightly larger than the object when the object between f and 2f. This means that between 21 cm and 19 cm lies 2f. Out of the given options, 20 cm lies between 21 cm and 19 cm.

So, 2f = 20 cm.

f = 10 cm.

Question 48:

An object is placed at the following distances from a convex lens of focal length 15 cm :

(a) 35 cm (b) 30 cm (c) 20 cm (d) 10 cm

Which position of the object will produce :

(i) a magnified real image ?

(ii) a magnified virtual image ?

(iii) a diminished real image ?

(iv) an image of same size as the object ?

Solution :

Here, f=15cm and 2f=30cm

(i) 20 cm (Because a magnified real image is formed when the object is placed between f and 2f).

(ii) 10cm (Because a magnified virtual image is formed when the object is placed between f and the lens).

(iii) 35cm (Because a diminished real image is formed when the object is placed beyonf 2f).

(iv) 30cm (Because an image of same size as the object is formed when the object is placed at 2f).

Question 49:

When an object is placed at a distance of 36 cm from a convex lens, an image of the same size as the object is formed. What will be the nature of image formed when the object is placed at a distance of:

(a) 10 cm from the lens ? (b) 20 cm from the lens ?

Solution :

Here, 2f = 36 cm, f = 18 cm.

(a) When the object is placed at a distance of 10 cm from the lens, the object lies within the

focus. Hence, the image formed is virtual, erect and magnified.
(b) When the object is placed at a distance of 20 cm from the lens, the object lies between f and 2f. Hence, the image formed is real, inverted and magnified.

Question 50:

(a) Draw a diagram to show how a converging lens focusses parallel rays of light.
(b) How would you alter the above diagram to show how a converging lens can produce a beam of parallel rays of light.

Solution :

(a) A converging lens focusses parallel ray of light as shown below:

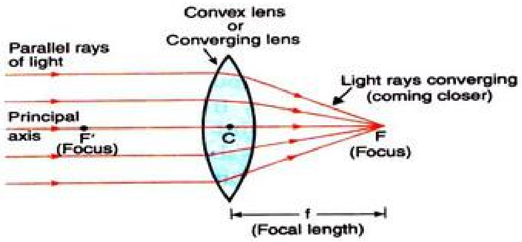

Figure — A convex lens converges (brings closer) a parallel beam of light rays to a point *F* on its other side (right side).

(b) Place a source of light at the focus of the converging lens.

(b) Place a source of light at the focus of the converging lens.

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Question 1:

Write the formula for a lens connecting image distance (υ),object distance (u)and the focal length (ƒ).How does the lens formula differ from the mirror formula ?

Solution :

Formula for a lens connecting image distance (v), object distance (u) and the focal length (f) is:

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

This is the lens formula.
The lens formula has a minus sign (-) between 1/v and 1/u whereas the mirror formula has a plus sign (+) between 1/v and 1/u.
Mirror formula:

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

Question 2:

Write down the magnification formula for a lens in terms of object distance and image distance. How does this magnification formula for a lens differ from the corresponding formula for a mirror ?

Solution :

Magnification (m) fomula for a lens is:

$$m = \frac{v(\text{distance of image})}{u(\text{distacne of object})}$$

Magnification formula for a mirror has a minus sign (-) but the magnification formula for a lens has no minus sign.

Magnification formula for a mirror is:

$$m = -\frac{v(\text{distance of image})}{u(\text{distacne of object})}$$

Question 3:

What is the nature of the image formed by a convex lens if the magnification produced by the lens is +3 ?

Solution :

The image will be virtual and erect, since the magnification has positive value.

Question 4:

What is the nature of the image formed by a convex lens if the magnification produced by the lens is, – 0.5 ?

Solution :

The image will be real and inverted, since the magnification has negative value.

Question 5:

What is the position of image when an object is placed at a distance of 10 cm from a convex lens of focal length 10 cm ?

Solution :

u = -10 cm, f = 10 cm

We have

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

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

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

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

At infinity

Question 6:

Describe the nature of image formed when an object is placed at a distance of 30 cm from a convex lens of focal length 15 cm.

Solution :

Since the object is placed at a distance greater than the focal length of the convex lens, so the image formed is real and inverted.

Question 7:

At what distance from a converging lens of focal length 12 cm must an object be placed in order that an image of magnification 1 will be produced ?

Solution :

$f = 12\,cm$

$m = 1$

$$m = \frac{v}{u} = 1$$

$$\Rightarrow v = u$$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Putting the value of v, u and f,

$$\frac{1}{u} - \frac{1}{-u} = \frac{1}{12} \quad \text{(image distance is negative)}$$

$$\frac{2}{u} = \frac{1}{12}$$

$u = 24\,cm$

The object should be placed at a distance of 24 cm to from the lens (on the left side).

Question 8:

State and explain the New Cartesian Sign Convention for spherical lenses.

Solution :

New Cartesian Sign Convention for spherical lenses:

(i) All the distances are measured from the optical centre of the lens.

(ii) The distances measured in the same direction as that of incident light are taken as positive.

(iii) The distances measured against the direction of incident light are taken as negative.
(iv) The distances measured upward and perpendicular to the principal axis are taken as positive.
(v) The distances measured downward and perpendicular to the principal axis are taken as negative.

Question 9:

An object 4 cm high is placed at a distance of 10 cm from a convex lens of focal length 20 cm. Find the position, nature and size of the image.

Solution :

$$u = -10\text{cm}$$
$$h_1 = 4\text{cm}$$
$$f = 20\text{cm}$$
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} - \frac{1}{-10} = \frac{1}{20}$$
$$\frac{1}{v} = \frac{1}{20} - \frac{1}{10} = -\frac{1}{20}$$
$v = -20\text{cm}$ (Image is 20cm in front of the convex lens)
$$m = \frac{v}{u} = \frac{20}{-10} = -2$$
$$m = \frac{h_2}{h_1} = -2$$
$$\frac{h_2}{4} = -2$$
$$h_2 = -8\text{cm}$$
Image is 8cm in size and is real and inverted.

Question 10:

A small object is so placed in front of a convex lens of 5 cm focal length that a virtual image is formed at a distance of 25 cm. Find the magnification.

Solution :

$$f = 5\text{cm}$$
$v = -25\text{cm}$ (Virtual image)
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{-25} - \frac{1}{u} = \frac{1}{5}$$
$$\frac{1}{u} = -\frac{1}{25} - \frac{1}{5} = -\frac{6}{25}$$
$$u = -\frac{25}{6}\text{cm}$$
Magnification, $m = \frac{v}{u} = \frac{-25}{-25/6} = +6$

Question 11:

Find the position and nature of the image of an object 5 cm high and 10 cm in front of a convex lens of focal length 6 cm.

Solution :

$h_1 = 5\,cm$
$u = -10\,cm$
$f = 6\,cm$

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

$$\frac{1}{v} - \frac{1}{-10} = \frac{1}{6}$$

$$\frac{1}{v} = \frac{1}{6} - \frac{1}{10} = \frac{2}{30} = \frac{1}{15}$$

$v = 15\,cm$

Image is formed 15cm behind the convex lens and it is real and inverted.

Question 12:

Calculate the focal length of a convex lens which produces a virtual image at a distance of 50 cm of an object placed 20 cm in front of it.

Solution :

$v = -50\,cm$ (Virtual image)
$u = -20\,cm$

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

$$\frac{1}{-50} - \frac{1}{-20} = \frac{1}{f}$$

$$\frac{-2+5}{100} = \frac{1}{f}$$

$$\frac{3}{100} = \frac{1}{f}$$

$f = 33.3\,cm$

Question 13:

An object is placed at a distance of 100 cm from a converging lens of focal length 40 cm.

(i) What is the nature of image ?

(ii) What is the position of image ?

A convex lens produces an inverted image magnified three times of an object placed at a distance of 15 cm from it. Calculate focal length of the lens.

Solution :

(i) Since the object is placed at a distance greater than the focal length of the lens, so the image formed is real and inverted.

(ii) $u = -100\,cm$, $f = 40\,cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$$\frac{1}{v} - \frac{1}{-100} = \frac{1}{40}$$

$$\frac{1}{v} = \frac{1}{40} - \frac{1}{100}$$

$$\frac{1}{v} = \frac{5-2}{200} = \frac{3}{200}$$

$v = 66.6\,cm$

Image is formed 66.6 cm behind the convex lens.

Question 14:

A convex lens produces an inverted image magnified three times of an object placed at a distance of 15 cm from it. Calculate focal length of the lens.

Solution :

$m = -3$ (Inverted image)
$u = -15cm$

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

$-3 = \frac{v}{-15}$

$v = 45cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{45} - \frac{1}{-15} = \frac{1}{f}$

$\frac{1+3}{45} = \frac{1}{f}$

$f = \frac{45}{4}cm$

$f = 11.25cm$

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Question 15:
A converging lens of focal length 5 cm is placed at a distance of 20 cm from a screen. How far from the lens should an object be placed so as to form its real image on the screen ?
Solution :

$f = 5cm$
$u = -20cm$
$v = +v$ (since image is real)

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-20} = \frac{1}{5}$

$\frac{1}{v} = \frac{1}{5} - \frac{1}{20} = \frac{4-1}{20} = \frac{3}{20}$

$v = 6.66$

Question 16:
An object 5 cm high is held 25 cm away from a converging lens of focal length 10 cm. Find the position, size and nature of the image formed. Also draw the ray diagram.
Solution :

$h_1 = 5\,cm$
$u = -25\,cm$
$f = 10\,cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-25} = \frac{1}{10}$

$\frac{1}{v} = \frac{1}{10} - \frac{1}{25} = \frac{5-2}{50} = \frac{3}{50}$

$v = 16.6$

Image is 16.6 cm behind the convex lens.

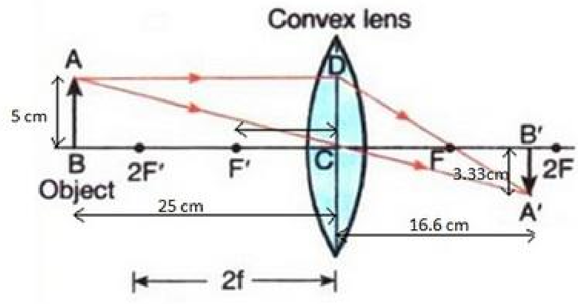
$m = \frac{v}{u} = \frac{50/3}{-25} = -\frac{2}{3}$ (Image is real and inverted)

$m = \frac{h_2}{h_1}$

$-\frac{2}{3} = \frac{h_2}{5}$

$h_2 = \frac{-10}{3} = -3.33\,cm$

Image is 3.33 cm in size and is real and inverted.



Question 17:

At what distance should an object be placed from a convex lens of focal length 18 cm to obtain an image at 24 cm from it on the other side ? What will be the magnification produced in this case ?

Solution :

$f = 18\,cm$
$v = 24\,cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{24} - \frac{1}{u} = \frac{1}{18}$

$\frac{1}{u} = \frac{1}{24} - \frac{1}{18}$

$\frac{1}{u} = \frac{3-4}{72} = \frac{-1}{72}$

$u = -72\,cm$

$m = \frac{v}{u} = \frac{24}{-72} = -\frac{1}{3}$

Question 18:

An object 2 cm tall is placed on the axis of a convex lens of focal length 5 cm at a distance of 10 m from the optical centre of the lens. Find the nature, position and size of the image formed. Which case of image formation by convex lenses is illustrated by this example ?

Solution :

$h_1 = 2\text{cm}$
$f = 5\text{cm}$
$u = -10\text{m} = -1000\text{cm}$
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-1000} = \frac{1}{5}$
$\frac{1}{v} = \frac{1}{5} - \frac{1}{1000} = \frac{200-1}{1000} = \frac{199}{1000}$
$v = 5.02\text{cm}$
The image is formed 5.02 cmbehind the convex lens and is real and inverted.
$m = \frac{v}{u} = \frac{5.02}{-1000} = -0.005$
$m = \frac{h_2}{h_1} = -0.005$
$\frac{h_2}{2} = -0.005$
$h_2 = -0.01\text{cm}$

Since the object distance is much greater than the focal length, this example illustrates the case when the object is place

Question 19:

The filament of a lamp is 80 cm from a screen and a converging lens forms an image of it on a screen, magnified three times. Find the distance of the lens from the filament and the focal length of the lens.

Solution :

$-u + v = 80\text{cm}\ \ -----(1)$
$m = -3$ (The image is real, since it forms on a screen)
$m = \frac{v}{u} = -3$
$v = -3u$
Put in eq (1),
$-u - 3u = 80$
$-4u = 80$
$u = -20\text{cm}$
Distance of lens from filament is 20cm.
$v = -3u = 60\text{cm}$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{60} - \frac{1}{-20} = \frac{1}{f}$
$\frac{1}{f} = \frac{1+3}{60} = \frac{4}{60}$
$f = 15\text{cm}$

Question 20:

An erect image 2.0 cm high is formed 12 cm from a lens, the object being 0.5 cm high. Find the focal length of the lens.

Solution :

$h_2 = 2\text{cm}$ (Erect image)
$v = -12\text{cm}$ (Erect image)
$h_1 = 0.5\text{cm}$
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{-12}{u} = \frac{2}{0.5}$
$u = -3\text{cm}$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{-12} - \frac{1}{-3} = \frac{1}{f}$
$\frac{-1+4}{12} = \frac{1}{f}$
$f = 4\text{cm}$

Question 21:

A convex lens of focal length 0.10 m is used to form a magnified image of an object of height

5 mm placed at a distance of 0.08 m from the lens. Calculate the position, nature and size of the image.

Solution :

$f = 0.10\,m$
$h_1 = 5\,mm = 0.005\,m$
$u = -0.08\,m$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-0.08} = \frac{1}{0.10}$
$\frac{1}{v} = \frac{1}{0.10} - \frac{1}{0.08}$
$v = -0.4\,m$
Image is formed 0.40 m in front of the convex lens.
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{-0.4}{-0.08} = \frac{h_2}{0.005}$
$h_2 = 0.025\,m = 25\,mm$
Size of image is 25 mm.
Image is virtual and erect.

Question 22:

A convex lens of focal length 6 cm is held 4 cm from a newspaper which has print 0.5 cm high. By calculation, determine the size and nature of the image produced.

Solution :

$f = 6\,cm$
$u = -4\,cm$
$h_1 = 0.5\,cm$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-4} = \frac{1}{6}$
$\frac{1}{v} = \frac{1}{6} - \frac{1}{4} = \frac{2-3}{12}$
$v = -12\,cm$
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{-12}{-4} = \frac{h_2}{0.5}$
$h_2 = 1.5\,cm$
Image is 1.5 cm high, virtual, erect and magnified.

Question 23:

Determine how far an object must be placed in front of a converging lens of focal length 10 cm in order to produce an erect (upright) image of linear magnification 4.

Solution :

$f = 10\,cm$
$m = +4$ (upright image)
$m = \frac{v}{u} = 4$
$v = 4u$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{4u} - \frac{1}{u} = \frac{1}{10}$
$\frac{-3}{4u} = \frac{1}{10}$
$u = -7.5\,cm$
The object must be placed 7.5 cm in front of the converging lens.

Question 24:

A lens of focal length 20 cm is used to produce a ten times magnified image of a film slide on a screen. How far must the slide be placed from the lens ?

Solution :

$f = 20cm$
$m = -10$ (Image is real)
$u = ?$
$m = \frac{v}{u} = -10$
$v = -10u$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{-10u} - \frac{1}{u} = \frac{1}{20}$
$\frac{-1-10}{10u} = \frac{1}{20}$
$\frac{-11}{10u} = \frac{1}{20}$
$u = -22cm$
$v = -10 \times -22 = 220\,cm$

Question 25:

An object placed 4 cm in front of a converging lens produces a real image 12 cm from the lens.

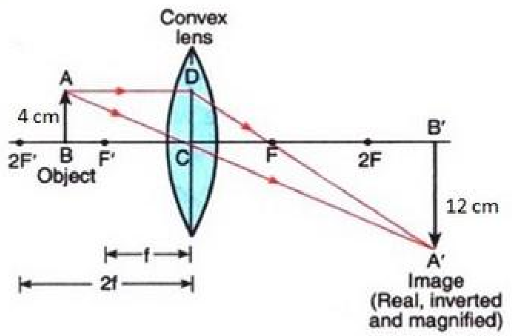
(a) What is the magnification of the image ?

(b) What is the focal length of the lens ?

(c) Draw a ray diagram to show the formation of image. Mark clearly F and 2F in the diagram.

Solution :

$u = -4\,cm$
$v = 12\,cm$ (Real image)
(a) $m = \frac{v}{u} = \frac{12}{-4} = -3$
(b) Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{12} - \frac{1}{-4} = \frac{1}{f}$
$\frac{1+3}{12} = \frac{1}{f}$
$f = 3\,cm$
(c)



Question 26:

(a) An object 2 cm tall stands on the principal axis of a converging lens of focal length 8 cm. Find the position, nature and size of the image formed if the object is :

(i) 12 cm from the lens

(ii) 6 cm from the lens

(b) State one practical application each of the use of such a lens with the object in position (i) and (ii).

Solution :

(a) $h_1 = 2$ cm
$f = 8$ cm
(i) $u = -12$ cm
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-12} = \frac{1}{8}$
$\frac{1}{v} = \frac{1}{24}$
$v = 24$ cm
Image is 24 cm behind the lens.
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{24}{-12} = \frac{h_2}{2}$
$h_2 = -4$ cm
Image is 4 cm high, real and inverted.
(ii) $u = -6$ cm
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-6} = \frac{1}{8}$
$\frac{1}{v} = -\frac{1}{24}$
$v = -24$ cm
Image is 24 cm in front of the lens.
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{-24}{-6} = \frac{h_2}{2}$
$h_2 = 8$ cm
Image is 8 cm high, virtual and erect.

(b) (i) Used in film projector.
(ii) Used as a magnifying glass.

Question 27:
(a) An object 3 cm high is placed 24 cm away from a convex lens of focal length 8 cm. Find by calculations, the position, height and nature of the image.
(b) If the object is moved to a point only 3 cm away from the lens, what is the new position, height and nature of the image ?
(c) Which of the above two cases illustrates the working of a magnifying glass ?
Solution :

(a) $h_1 = 3cm$
$u = -24cm$
$f = 8cm$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{v} - \frac{1}{-24} = \frac{1}{8}$$
$$\frac{1}{v} = \frac{1}{12}$$
$v = 12cm$
Image is formed 12 cm behind the lens.
$$m = \frac{v}{u} = \frac{h_2}{h_1}$$
$$\frac{12}{-24} = \frac{h_2}{3}$$
$h_2 = -1.5cm$
Image is 1.5cm high, real and inverted.

(b) u=-3cm
$h_1 = 3cm$
$f = 8cm$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$$\frac{1}{v} - \frac{1}{-3} = \frac{1}{8}$$
$$\frac{1}{v} = -\frac{5}{24}$$
$v = -4.8cm$
Image is formed 4.8 cm in front of the lens.
$$m = \frac{v}{u} = \frac{h_2}{h_1}$$
$$\frac{-4.8}{-3} = \frac{h_2}{3}$$
$h_2 = +4.8cm$
Image is 4.8cm high, virtual and erect.

(c) Case (b)

Question 28:

(a) Find the nature, position and magnification of the images formed by a convex lens of focal length 0.20 m if the object is placed at a distance of :

(i) 0.50 m (ii) 0.25 m (iii) 0.15 m

(b) Which of the above cases represents the use of convex lens in a film projector, in a camera, and as a magnifying glass ?

Solution :

(a) f=0.20 m

(i) u=-0.50 m

Lens formula: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$\frac{1}{v}-\frac{1}{-0.50}=\frac{1}{0.20}$

$\frac{1}{v}=\frac{1}{0.20}-\frac{1}{0.50}$

$v=0.33\,m$

Image is formed 0.33 m behind the lens.

$m=\frac{v}{u}=\frac{0.33}{-0.50}=-0.66$

Image is real and inverted.

(ii) u=-0.25 m

Lens formula: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$\frac{1}{v}-\frac{1}{-0.25}=\frac{1}{0.20}$

$\frac{1}{v}=\frac{1}{0.20}-\frac{1}{0.25}$

$v=1\,m$

Image is formed 1 m behind the lens.

$m=\frac{v}{u}=\frac{1}{-0.25}=-4$

Image is real and inverted.

(iii) u=-0.15 m

Lens formula: $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$\frac{1}{v}-\frac{1}{-0.15}=\frac{1}{0.20}$

$\frac{1}{v}=\frac{1}{0.20}-\frac{1}{0.15}$

$v=-0.60\,m$

Image is formed 0.60 m in front of the lens.

$m=\frac{v}{u}=\frac{-0.6}{-0.15}=+4$

Image is virtual and erect.

(b) Film projector: Case (ii)

Camera: Case (i)

Magnifying glass: Case (iii)

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Question 41:

A student did an experiment with a convex lens. He put an object at different distances 25 cm, 30 cm, 40 cm, 60 cm and 120 cm from the lens. In each case he measured the distance of the image from the lens. His results were 100 cm, 24 cm, 60 cm, 30 cm and 40 cm, respectively. Unfortunately his results are written in wrong order.

(a) Rewrite the image distances in the correct order.

(b) What would be the image distance if the object distance was 90 cm ?

(c) Which of the object distances gives the biggest image ?

(d) What is the focal length of this lens ?

Solution :

(a) 100 cm; 60 cm; 40 cm; 30 cm; 24 cm

(b) When u=-25 cm, v=100 cm

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$
$$\frac{1}{100}-\frac{1}{-25}=\frac{1}{f}$$
$$\frac{1}{f}=\frac{5}{100}$$
$$f=20\,cm$$

When u=-90 cm, v=?

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$
$$\frac{1}{v}-\frac{1}{-90}=\frac{1}{20}$$
$$\frac{1}{v}=\frac{1}{20}-\frac{1}{90}$$
$$\frac{1}{v}=\frac{7}{180}$$
$$v=25.7\,cm$$

(c) 25 cm

(d) 20 cm (As calculated in part (b))

Question 42:

A magnifying lens has a focal length of 100 mm. An object whose size is 16 mm is placed at some distance from the lens so that an image is formed at a distance of 25 cm in front of the lens.

(a) What is the distance between the object and the lens ?

(b) Where should the object be placed if the image is to form at infinity ?

Solution :

$$f=100\,mm$$
$$h_1=16\,mm$$
$$v=-25cm=-250mm$$

(a) $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{-250}-\frac{1}{u}=\frac{1}{100}$$
$$\frac{1}{u}=-\frac{7}{500}$$
$$u=-71.4\,mm=-7.14cm$$

Distance between object and lens is 7.14 cm.

(b) The object should be placed at the focus so that the image is formed at infinity.

So, u = -100 mm = -10 cm

The object should be placed 10 cm in front of the lens.

Question 43:

A lens forms a real image 3 cm high of an object 1 cm high. If the separation of object and image is 15 cm, find the focal length of the lens.

Solution :

$h_2 = -3\text{cm}$ (Real image)
$h_1 = 1\text{cm}$
$-u + v = 15\text{cm}$
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{15+u}{u} = \frac{-3}{1}$
$15 + u = -3u$
$u = -3.75\text{cm}$
$v = 15+u = 15+(-3.75) = 11.25\text{cm}$
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{11.25} - \frac{1}{-3.75} = \frac{1}{f}$
$f = 2.82\text{cm}$

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Question 44:

An object 50 cm tall is placed on the principal axis of a convex lens. Its 20 cm tall image is formed on the screen placed at a distance of 10 cm from the lens. Calculate the focal length of the lens.

Solution :

$h_1 = 50\text{cm}$
$h_2 = -20\text{cm}$ (Real image)
$v = 10\text{cm}$
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{10}{u} = \frac{-20}{50}$
$u = -25\text{cm}$
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{10} - \frac{1}{-25} = \frac{1}{f}$
$f = \frac{50}{7} = 7.14\text{cm}$

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Question 1:

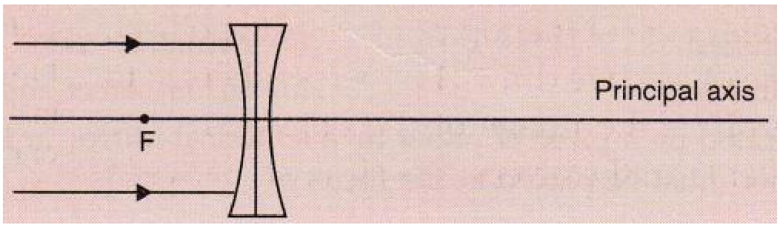
If the image formed by a lens is always diminished and erect, what is the nature of the lens ?

Solution :

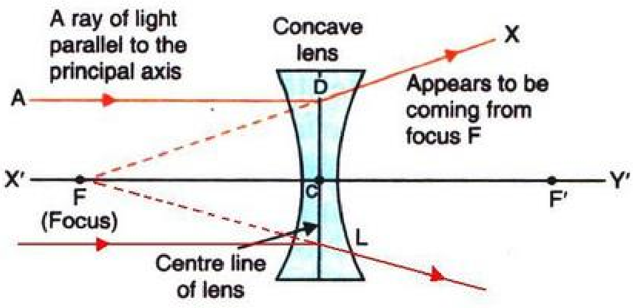
Concave lens.

Question 2:

Copy and complete the diagram below to show what happens to the rays of light when they pass through the concave lens :



Solution :



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Question 3:

Which type of lenses are :

(a) thinner in the middle than at the edges ?

(b) thicker in the middle than at the edges ?

Solution :

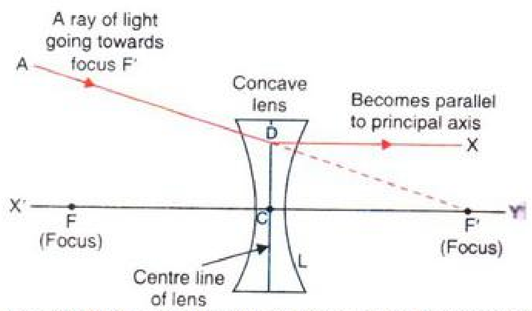
(a) Concave lenses.

(b) Convex lenses.

Question 4:

A ray of light is going towards the focus of a concave lens. Draw a ray diagram to show the path of this ray of light after refraction through the lens.

Solution :



Ray of light going towards the focus of a concave lens.

Question 5:

(a) What type of images can a convex lens make ?

(b) What type of image is always made by a concave lens ?

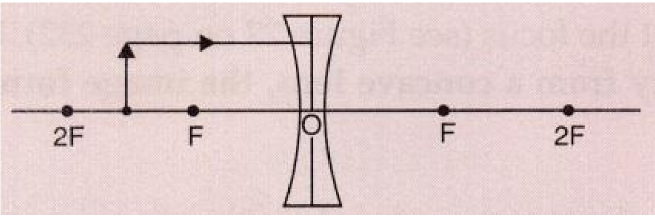
Solution :

(a) Real and virtual.

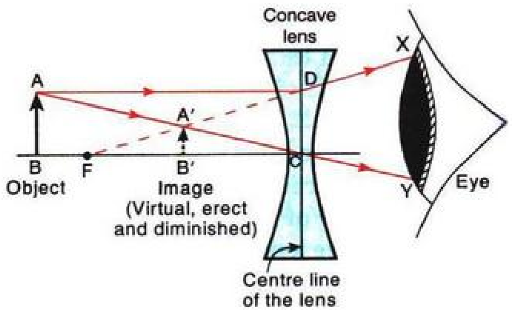
(b) Virtual.

Question 6:

Take down this figure into your answer book and complete the path of the ray.



Solution :



Question 7:

Fill in the following blanks with suitable words :

(a) A convex lens……. rays of light, whereas a concave lens………. rays of light.

(b) Lenses refract light to form images : a……… lens can form both real and virtual images, but a diverging

lens forms only………. images.

Solution :

(a) converges; diverges

(b) converging; virtual

Question 8:

Things always look small on viewing through a lens. What is the nature of the lens ?

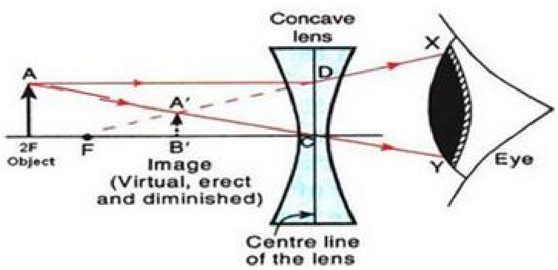
Solution :

Concave lens.

Question 9:

An object lies at a distance of 2ƒ from a concave lens of focal length ƒ. Draw a ray-diagram to illustrate the image formation.

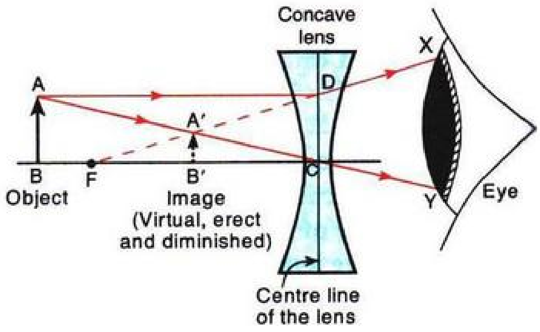
Solution :



Question 10:

Show by drawing a ray-diagram that the image of an object formed by a concave lens is virtual, erect and diminished.

Solution :



Question 11:

Give the position, size and nature of image formed by a concave lens when the object is placed :

(a) anywhere between optical centre and infinity.

(b) at infinity.

Solution :

(a) When the object is placed anywhere between optical centre and infinity, the image is formed between optical centre and focus. It is diminished, virtual and erect.

(b) When the object is placed at infinity, the image is formed at focus. It is highly diminished, virtual and erect.

Question 12:

Which type of lens is : (a) a converging lens, and which is (b) a diverging lens ? Explain your answer with diagrams.

Solution :

(a) A convex lens is a converging lens because it converges a parallel beam of light rays passing through it at its focus.

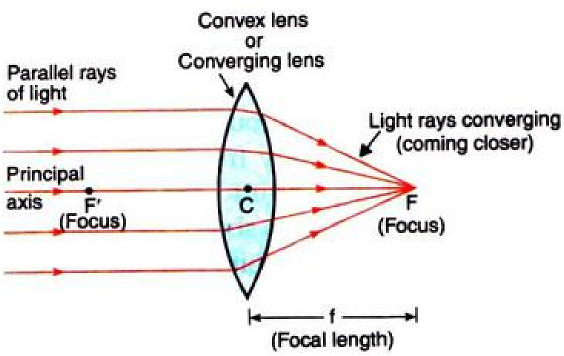


Figure — A convex lens converges (brings closer) a parallel beam of light rays to a point F on its other side (right side).

(b) A concave lens is a diverging lens because it diverges the parallel beam of rays passing through it.

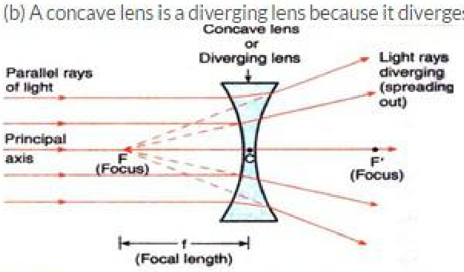


Figure — A concave lens diverges (spreads out) a parallel beam of light rays.

Question 13:

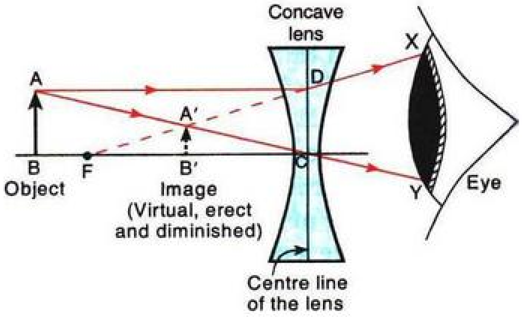
With the help of a diagram, explain why the image of an object viewed through a concave lens appears smaller and closer than the object.

Solution :

(a) Smaller.

(b) Bigger.

Image is virtual in both the cases.



As shown by the diagram, the image of an object viewed through a concave lens appears smaller and closer than the object.

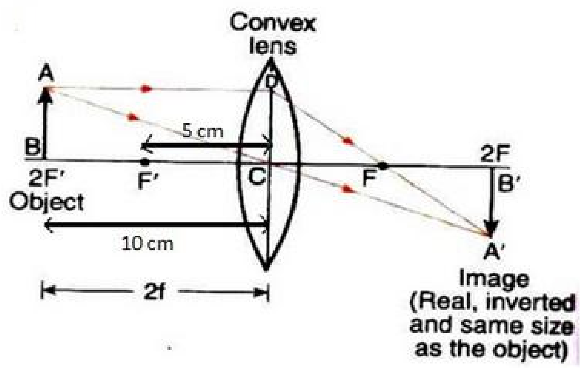
Question 14:

How would a pencil look like if you saw it through (a) a concave lens, and (b) a convex lens ? (Assume the pencil is close to the lens). Is the image real or virtual ?

Solution :

(a)

(a)
(i)



(ii)

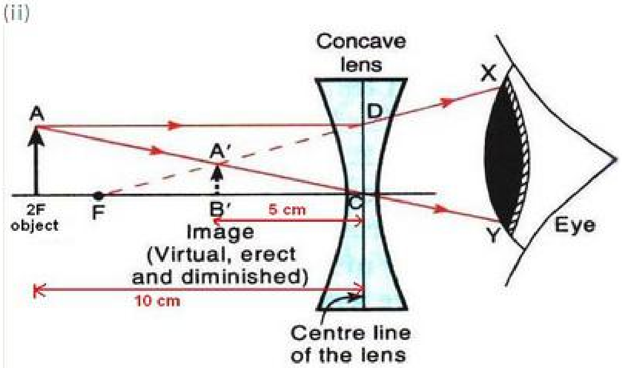


Fig - Formation of image when image is at 2F

(b) Use of convex mirror: As rear-view mirror in vehicles

Use of concave mirror: As shaving mirrors

Use of convex lens: For making simple camera

Use of concave lens: As eye-lens in Galilean telescope

Question 15:

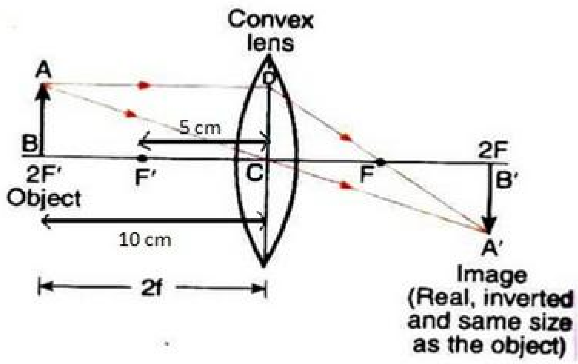
(a) An object is placed 10 cm from a lens of focal length 5 cm. Draw the ray diagrams to show

the formation
of image if the lens is (i) converging, and (ii) diverging.

(b) State one practical use each of convex mirror, concave mirror, convex lens and concave lens.

Solution :

(a)
(i)



(ii)

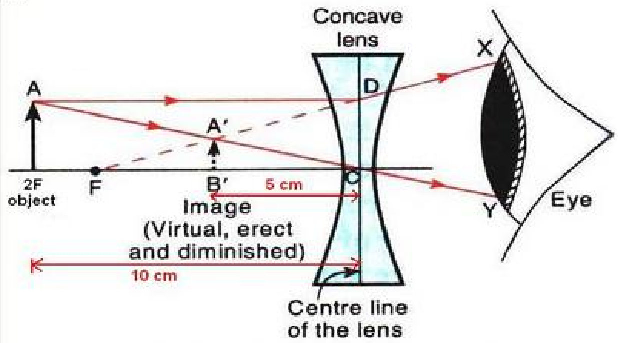


Fig - Formation of image when image is at 2F

(b) Use of convex mirror: As rear-view mirror in vehicles
Use of concave mirror: As shaving mirrors
Use of convex lens: For making simple camera
Use of concave lens: As eye-lens in Galilean telescope

Question 16:

(a) Construct ray diagrams to illustrate the formation of a virtual image using (i) a converging lens, and

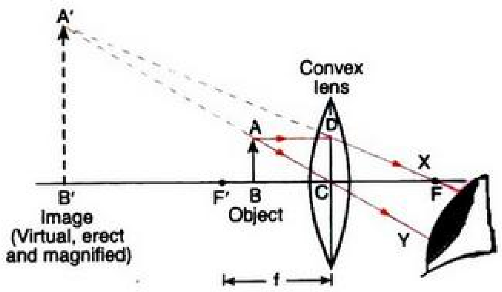
(ii) a diverging lens.

(b) What is the difference between the two images formed above ?

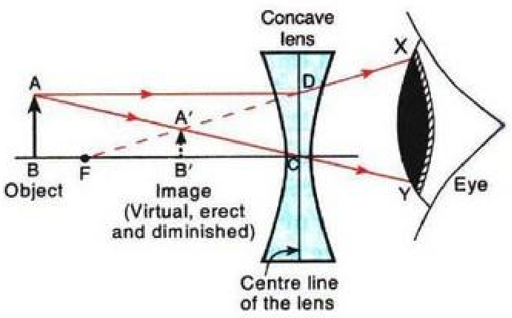
Solution :

(a)

(i) Formation of virtual image using a converging lens:



(ii) Formation of virtual image using a diverging lens:



(b) The virtual image formed by a converging lens is magnified whereas that formed by a diverging lens is diminished.

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Question 23:

When an object is placed 10 cm in front of lens A, the image is real, inverted, magnified and formed at a great distance. When the same object is placed 10 cm in front of lens B, the image formed is real, inverted and same size as the object.

(a) What is the focal length of lens A ?

(b) What is the focal length of lens B ?

(c) What is the nature of lens A ?

(d) What is the nature of lens B ?

Solution :

(a) The object is placed at focus, so f=10 cm.

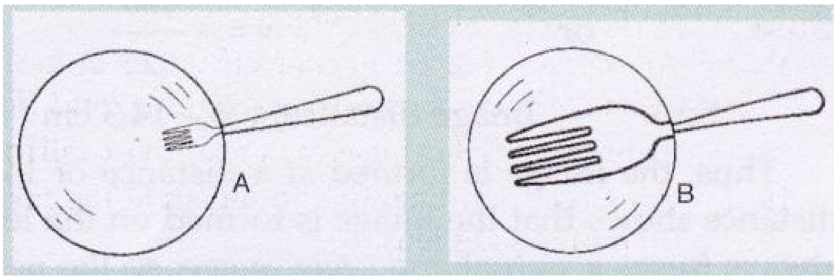
(b) the object is placed at a distance twice the focallength, so f=5 cm.

(c) Convex lens (since image is real).

(d) Convex lens (since image is real).

Question 24:

When a fork is seen through lenses A and B one by one, it appears as shown in the diagrams. What is the nature of (i) lens A, and (ii) lens B ? Give reason for your answer.



Solution :

(i) Concave lens because of negative magnification.

(ii) Convex lens because of positive magnification.

Question 25:

What kind of lens can form :

(a) an inverted magnified image ?

(b) an erect magnified image ?

(c) an inverted diminished image ?

(d) an erect diminished image ?

Solution :

(a) Convex lens.

(b) Convex lens.

(c) Convex lens.

(d) Concave lens.

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Question 1:

The lens A produces a magnification of, – 0.6 whereas lens B produces a magnification of + 0.6.

(a) What is the nature of lens A ?

(b) What is the nature of lens B ?

Solution :

(a) Convex lens (since image is real, inverted and diminished).

(b) Concave lens (since image is virtual, erect and diminished).

Question 2:

A 50 cm tall object is at a very large distance from a diverging lens. A virtual, erect and diminished image of the object is formed at a distance of 20 cm in front of the lens. How much is the focal length of the lens ?

Solution :

When an object is placed at a very large distance from a diverging lens, then image is formed at the focus of the lens.

Therefore, the focal length of the lens is 20 cm.

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Question 3:

An object is placed at a distance of 4 cm from a concave lens of focal length 12 cm. Find the position and nature of the image.

Solution :

$u = -4\,\text{cm}$

$f = -12\,\text{cm}$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} - \frac{1}{-4} = \frac{1}{-12}$

$\frac{1}{v} = -\frac{1}{12} - \frac{1}{4}$

$\frac{1}{v} = \frac{-4}{12}$

$v = -3\,\text{cm}$

Image is formed 3 cm infront of the concave lens.

Image is virtual and erect.

Question 4:

A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens ? Draw the ray-diagram.

Solution :

$f = -15\,cm$

$v = -10\,cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

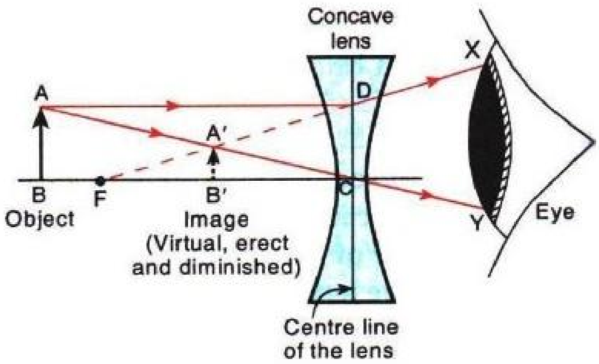
$$\frac{1}{-10} - \frac{1}{u} = \frac{1}{-15}$$

$$\frac{1}{u} = -\frac{1}{10} + \frac{1}{15}$$

$$\frac{1}{u} = \frac{-2}{60}$$

$u = -30\,cm$

Object is at 30 cm from the concave lens (on left side).



Here, OB=30cm
OF=15cm
OB'=10cm

Question 5:

An object 60 cm from a lens gives a virtual image at a distance of 20 cm in front of the lens. What is the focal length of the lens ? Is the lens converging or diverging ? Give reasons for your answer.

Solution :

$u = -60\,cm$

$v = -20\,cm$ (Virtual image)

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

$$\frac{1}{f} = \frac{1}{-20} - \frac{1}{-60}$$

$$= \frac{-2}{60}$$

$f = -30\,cm$

The lens is diverging because the focal length is negative.

Question 6:

A concave lens of 20 cm focal length forms an image 15 cm from the lens. Compute the object distance.

Solution :

$f = -20\,cm$
$v = -15\,cm$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{-15} - \frac{1}{u} = \frac{1}{-20}$
$\frac{1}{u} = -\frac{1}{15} + \frac{1}{20}$
$\frac{1}{u} = \frac{-1}{60}$
$u = -60\,cm$
Object distance is 60 cm towards the left of the lens.

Question 7:

A concave lens has focal length 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens ? Also find the magnification produced by the lens.

Solution :

$f = -15\,cm$
$v = -10\,cm$
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{-10} - \frac{1}{u} = \frac{1}{-15}$
$\frac{1}{u} = -\frac{1}{10} + \frac{1}{15}$
$\frac{1}{u} = \frac{-1}{30}$
$u = -30\,cm$
Object should be placed at a distance of 60 cm on the left side of the lens.
$m = \frac{v}{u} = \frac{-10}{-30} = +0.33$

Question 8:

Calculate the image distance for an object of height 12 mm at a distance of 0.20 m from a concave lens of focal length 0.30 m, and state the nature and size of the image.

Solution :

$v = ?$
$h_1 = 12\,mm = 0.012\,m$
$u = -0.20\,m$
$f = -0.30\,m$
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-0.20} = \frac{1}{-0.30}$
$\frac{1}{v} = \frac{-1}{0.30} - \frac{1}{0.20}$
$v = -0.12\,m$
Image is virtual and erect.
$m = \frac{h_2}{h_1} = \frac{v}{u}$
$\frac{h_2}{0.012} = \frac{-0.12}{-0.20}$
$h_2 = 0.0072\,m = 7.2\,mm$
Image is 7.2 mm high.

Question 9:

A concave lens has a focal length of 20 cm. At what distance from the lens a 5 cm tall object be placed so that it forms an image at 15 cm from the lens ? Also calculate the size of the image formed.

Solution :

$f = -20\,\text{cm}$
$h_1 = 5\,\text{cm}$
$v = -15\,\text{cm}$ (Concave lens forms virtual image)

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{-15} - \frac{1}{u} = \frac{1}{-20}$$
$$\frac{1}{u} = -\frac{1}{15} + \frac{1}{20}$$
$$\frac{1}{u} = \frac{-1}{60}$$
$$u = -60\,\text{cm}$$

Object should be placed 60 cm to the left of the lens.

$$m = \frac{v}{u} = \frac{h_2}{h_1}$$
$$\frac{-15}{-60} = \frac{h_2}{5}$$
$$h_2 = 1.25\,\text{cm}$$

Image formed is 1.25 cm high.

Question 10:

An object is placed 20 cm from (a) a converging lens, and (b) a diverging lens, of focal length 15 cm. Calculate the image position and magnification in each case.

Solution :

$u = -20\,\text{cm}$
(a) $f = 15\,\text{cm}$ (for converging lens)

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} - \frac{1}{-20} = \frac{1}{15}$$
$$\frac{1}{v} = \frac{1}{15} - \frac{1}{20}$$
$$\frac{1}{v} = \frac{1}{60}$$
$$v = 60\,\text{cm}$$
$$m = \frac{v}{u} = \frac{60}{-20} = -3$$

(b) $f = -15\,\text{cm}$ (for diverging lens)

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$
$$\frac{1}{v} - \frac{1}{-20} = \frac{1}{-15}$$
$$\frac{1}{v} = -\frac{1}{15} - \frac{1}{20}$$
$$\frac{1}{v} = \frac{-7}{60}$$
$$v = -8.57\,\text{cm}$$
$$m = \frac{-v}{u} = \frac{-8.57}{-20} = +0.42$$

Question 11:

A 2.0 cm tall object is placed 40 cm from a diverging lens of focal length 15 cm. Find the position and size of the image.

Solution :

$h_1 = 2\,cm$
$u = -40\,cm$
$f = -15cm$
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-40} = \frac{1}{-15}$
$\frac{1}{v} = -\frac{1}{15} - \frac{1}{40}$
$\frac{1}{v} = \frac{-11}{120}$
$v = -10.90\,cm$
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{-10.90}{-40} = \frac{h_2}{2}$
$h_2 = 0.54cm$

Question 12:

(a) Find the position and size of the virtual image formed when an object 2 cm tall is placed 20 cm from :

(i) a diverging lens of focal length 40 cm.

(ii) a converging lens of focal length 40 cm.

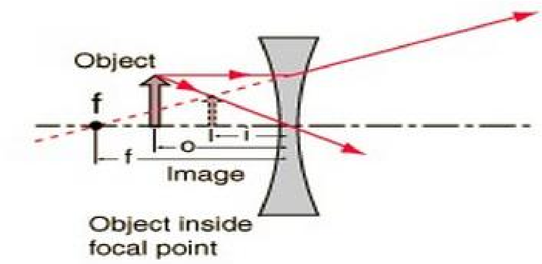
(b) Draw labelled ray diagrams to show the formation of images in cases (i) and (ii)above (The diagrams may not be according to scale).

Solution :

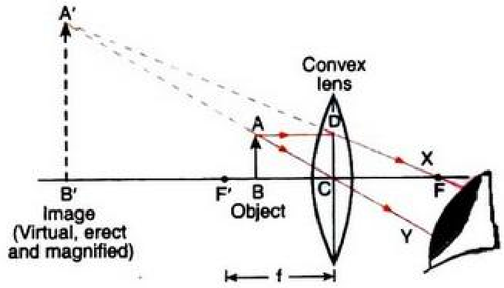
(a) $h_1 = 2cm$
$u = -20cm$
(i) f=-40cm (Diverging lens)
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-20} = \frac{1}{-40}$
$\frac{1}{v} = -\frac{1}{40} - \frac{1}{20}$
$\frac{1}{v} = \frac{-3}{40}$
$v = -13.33cm$
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{-13.33}{-20} = \frac{h_2}{2}$
$h_2 = 1.33cm$

(ii) f=40 cm (Diverging lens)
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
$\frac{1}{v} - \frac{1}{-20} = \frac{1}{40}$
$\frac{1}{v} = \frac{1}{40} - \frac{1}{20}$
$\frac{1}{v} = \frac{-1}{40}$
$v = -40cm$
$m = \frac{v}{u} = \frac{h_2}{h_1}$
$\frac{-40}{-20} = \frac{h_2}{2}$
$h_2 = 4cm$

(b) Formation of image in case (i):



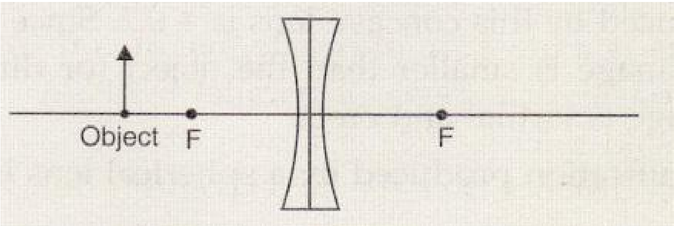
Formation of image in case (ii):



Question 13:

(a) A small object is placed 150 mm away from a diverging lens of focal length 100 mm.

(i) Copy the figure below and draw rays to show how an image is formed by the lens.



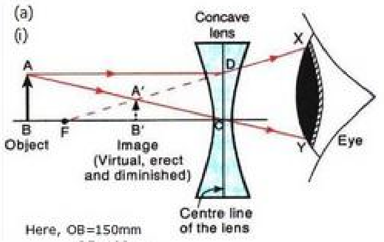
(ii) Calculate the distance of the image from the lens by using the lens formula.

(b) The diverging lens in part (a) is replaced by a converging lens also of focal length 100 mm. The object remains in the same position and an image is formed by the converging lens. Compare two properties of this image with those of the image formed by the diverging lens in part (a).

Solution :

(a)

(i)



Here, OB=150mm
OF=100mm

(ii) u=-150mm

f=-100mm

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

$$\frac{1}{v}-\frac{1}{-150}=\frac{1}{-100}$$

$$\frac{1}{v}=-\frac{1}{100}-\frac{1}{150}$$

$$\frac{1}{v}=\frac{-5}{300}$$

v = −60mm

(b) u=-150mm

f=100mm

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

$$\frac{1}{v}-\frac{1}{-150}=\frac{1}{100}$$

$$\frac{1}{v}=\frac{1}{100}-\frac{1}{150}$$

$$\frac{1}{v}=\frac{1}{300}$$

v = +300mm

The image formed by converging lens is real, inverted and magnified (2 times). It is formed behind the converging lens. On the other hand, the image formed by diverging lens is virtual, erect and diminished. It is formed in front of the diverging lens.

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Question 18:

A camera fitted with a lens of focal length 50 mm is being used to photograph a flower that is 5 cm in diameter. The flower is placed 20 cm in front of the camera lens.

(a) At what distance from the film should the lens be adjusted to obtain a sharp image of the flower ?

(b) What would be the diameter of the image of the flower on the film ?

(c) What is the nature of camera lens ?

Solution :

(a) u=-20 cm=-200 mm

f=50 mm

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

$$\frac{1}{v}-\frac{1}{-200}=\frac{1}{50}$$

$$\frac{1}{v}=\frac{1}{50}-\frac{1}{200}$$

$$\frac{1}{v}=\frac{3}{200}$$

v = 66.6 mm = 6.66 cm

The film should be at a distance of 6.66 cm behind the camera lens.

(b) d_1 = 5 cm = 50 mm

$$m=\frac{v}{u}=\frac{d_2}{d_1}$$

$$\frac{66.6}{-200}=\frac{d_2}{50}$$

d_2 = 16.65 mm = 1.66 cm

(c) It is a convex lens.

Question 19:

An object is 2 m from a lens which forms an erect image one-fourth (exactly) the size of the object. Determine the focal length of the lens. What type of lens is this ?

Solution :

$u = -2\,m$

$m = +\frac{1}{4}$ (Erect image)

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

$\frac{1}{4} = \frac{v}{-2}$

$v = -0.5\,m$

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

$\frac{1}{-0.5} - \frac{1}{-2} = \frac{1}{f}$

$f = -0.666\,m = -66.6\,cm$

It is a concave lens.

Question 20:

An image formed on a screen is three times the size of the object. The object and screen are 80 cm apart when the image is sharply focussed.

(a) State which type of lens is used.

(b) Calculate focal length of the lens.

Solution :

(a) Since the image is formed on a screen, it must be a real image.
Hence, the lens should be a convex lens.

(b) m=-3 (Real and inverted image)

-u+v=80cm

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

$-3 = \frac{80+u}{u}$

$-3u = 80+u$

$u = -20\,cm$

$v = 80+u = 80+(-20) = 60\,cm$

Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{60} - \frac{1}{-20} = \frac{1}{f}$

$\frac{1}{f} = \frac{4}{60}$

$f = +15\,cm$

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Question 1:

The lens A has a focal length of 25 cm whereas another lens B has a focal length of 60 cm. Giving reason state, which lens has more power : A or B

Solution :

Lens A has more power because of its shorter focal length.

Question 2:

Which causes more bending (or more refraction) of light rays passing through it: a convex lens of long focal length or a convex lens of short focal length ?

Solution :

Convex lens of short focal length causes more bending of light rays passing through it.

Question 3:

Name the physical quantity whose unit is dioptre.

Solution :

Power of a lens.

Question 4:

Define 1 dioptre power of a lens.

Solution :

1 diopter is the power of a lens whose focal length is 1 metre.

Question 5:

Which typie of lens has (a) a positive power, and (b) a negative power ?

Solution :

a) Positive power – Convex lens.

b) Negative power – Concave lens.

Question 6:

Which of the two has a greater power : a lens of short focal length or a lens of large focal length ?

Solution :

Lens of short focal length.

Question 7:

How is the power of a lens related to its focal length ?

Solution :

Power of lens is reciprocal of its focal length in metres.

Question 8:

Which has more power : a thick convex lens or a thin convex lens, made of the same glass ? Give reason for your choice.

Solution :

Thick convex lens has more power because of its shorter focal length.

Question 9:

The focal length of a convex lens is 25 cm. What is its power ?

Solution :

f = 25 cm = 0.25 cm.

P = 1/f = 1/0.25 = +4 D.

Question 10:

What is the power of a convex lens of focal length 0.5 m ?

Solution :

f = 0.5 m

P = 1/f = 1/0.5 = +2 D.

Question 11:

A converging lens has a focal length of 50 mm. What is the power of the lens ?

Solution :

f = 50 mm = 0.05 m

P = 1/f = 1/0.05 = +20 D.

Question 12:

What is the power of a convex lens whose focal length is 80 cm ?

Solution :

f = 80 cm = 0.8 m.

P = 1/f = 1/0.8 = +1.25 D.

Question 13:

A diverging lens has a focal length of 3 cm. Calculate the power.

Solution :

Here, f = -3 cm = -0.03 m (Diverging lens)

P = 1/f = 1/(-0.03) = -33.33 D.

Question 14:

The power of a lens is + 0.2 D. Calculate its focal length.

Solution :

P = +0.2 D.

P = 1/f.

f = 1/P = 1/0.2 = +5 m.

Question 15:

The power of a lens is, – 2D. What is its focal length ?

Solution :

P = -2 D.

P = 1/f.

f = 1/P = 1/(-2) = -0.5 m = -50 cm.

Question 16:

What is the nature of a lens having a power of + 0.5 D ?

Solution :

Convex lens.

Question 17:

What is the nature of a lens whose power is, – 4 D ?

Solution :

Concave lens.

Question 18:

The optician's prescription for a spectacle lens is marked + 0.5 D. What is the :

(a) nature of spectacle lens ?

(b) focal length of spectacle lens ?

Solution :

(a) Convex lens

(b) P = +0.5 D.

P = 1/f.

f = 1/P = 1/0.5 = 2 m.

Question 19:

A doctor has prescribed a corrective lens of power, -1.5 D. Find the focal length of the lens. Is the prescribed lens diverging or converging ?

Solution :

P = -1.5 D

P = 1/f.

f = 1/P = 1/(-0.5) = -0.66 m = -66.6 m.

Since focal length is negative, it is a diverging lens.

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Question 20:

A lens has a focal length of, -10 cm. What is the power of the lens and what is its nature ?

Solution :

f = -10 cm = -0.1 m

P = 1/f = 1/(-0.1) = -10 D

It is a concave lens.

Question 21:

The focal length of a lens is +150 mm. What kind of lens is it and what is its power ?

Solution :

f = +150 mm = +0.15 m

It is a convex lens since its focal length is positive.

P = 1/f = 1/0.15 = +6.66 D

Question 22:

Fill in the following blanks with suitable words :

(a) The reciprocal of the focal length in metres gives you the……….. of the lens, which is measured in

(b) For converging lenses, the power is……… while for diverging lenses, the power is…………

Solution :

(a) power, dioptres.

(b) positive, negative.

Question 23:

An object of height 4 cm is placed at a distance of 15 cm in front of a concave lens of power, -10 dioptres. Find the size of the image.

Solution :

$h = 4cm$
$u = -15cm$
$P = -10D$
$P = \frac{1}{f}$
$f = \frac{1}{P}$
$= \frac{1}{-10}$
$= -0.1\,m$
$= -10\,cm$
Using Lens formula,
$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$
$= \frac{1}{-10} + \frac{1}{-15}$
$= \frac{-5}{30}$
$v = -6\,cm$

Magnification, $m = \frac{h'}{h} = \frac{v}{u}$
$\frac{h'}{4} = \frac{-6}{-15}$
$h' = 1.6\,cm$

Question 24:

An object of height 4.25 mm is placed at a distance of 10 cm from a convex lens of power +5 D. Find (i) focal length of the lens, and (ii) size of the image.

Solution :

$h = 4.25\,mm = 42.5\,cm$
$u = -10cm$
$P = +5D$
(i) $P = \frac{1}{f}$
$f = \frac{1}{P} = \frac{1}{5} = 0.2\,m = 20\,cm$
(ii) $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$
$= \frac{1}{20} + \frac{1}{-10}$
$= \frac{-1}{20}$
$v = -20\,cm$

$m = \frac{h'}{h} = \frac{v}{u}$
$\Rightarrow \frac{h'}{42.5} = \frac{-20}{-10}$
$h' = 85\,cm = 8.5\,mm$

Question 25:

A convex lens of power 5 D and a concave lens of power 7.5 D are placed in contact with each other. What is the :

(a) power of this combination of lenses ?

(b) focal length of this combination of lenses ?

Solution :

$P_1 = +5D,\ P_2 = -7.5D$

(a) Power of combination:

$P = P_1 + P_2 = +5D + (-7.5D) = -2.5D$

(b) Focal length of the combination:

$$f = \frac{1}{P} = \frac{1}{-2.5} = -0.4\,m = -40\,cm$$

Question 26:

A convex lens of focal length 25 cm and a concave lens of focal length 10 cm are placed in close contact with one another.

(a) What is the power of this combination ?

(b) What is the focal length of this combination ?

(c) Is this combination converging or diverging ?

Solution :

$$f_1 = 25\,cm = 0.25\,m$$

$$P_1 = \frac{1}{f_1} = \frac{1}{0.25} = 4D$$

$$f_2 = -10\,cm = -0.1\,m$$

$$P_2 = \frac{1}{f_2} = \frac{1}{-0.1} = -10D$$

(a) Power of the combination:

$$P = P_1 + P_2$$
$$= 4D + (-10D)$$
$$= -6D$$

(b) Focal length of the combination:

$$f = \frac{1}{P} = \frac{1}{-6} = -0.1666\,m = -16.66\,cm$$

(c) The combination has negative focal length, so it is diverging.

Question 27:

The power of a combination of two lenses X and Y is 5 D. If the focal length of lens X be 15 cm :

(a) calculate the focal length of lens Y.

(b) state the nature of lens Y.

Solution :

(a) $P = P_X + P_Y$

$$P = \frac{1}{f_X} + \frac{1}{f_Y}$$

$$5 = \frac{100}{15} + \frac{1}{f_Y}$$

$$\frac{1}{f_Y} = 5 - \frac{100}{15}$$

$$= \frac{-25}{15}$$

$$f_Y = -0.6\,m = -60\,cm$$

(b) Lens Y is a concave lens since it has negative focal length.

Question 28:

Two lenses A and B have focal lengths of + 20 cm and, -10 cm, respectively.

(a) What is the nature of lens A and lens B ?

(b) What is the power of lens A and lens B ?

(c) What is the power of combination if lenses A and B are held close together ?

Solution :

$f_A = +20\,cm = +0.2\,m$
$f_B = -10\,cm = -0.1\,m$

(a) Lens A is a convex lens (positive focal length) and lens B is a concave lens (negative focal length).

(b) $P_A = \frac{1}{f_A} = \frac{1}{+0.2} = +5D$

$P_B = \frac{1}{f_B} = \frac{1}{-0.1} = -10D$

(c) Power of combination
$P = P_A + P_B = +5D + (-10D) = -5D$

Question 29:

(a) What do you understand by the power of a lens ? Name one factor on which the power of a lens depends.

(b) What is the unit of power of a lens ? Define the unit of power of a lens.

(c) A combination of lenses for a camera contains two converging lenses of focal lengths 20 cm and 40 cm and a diverging lens of focal length 50 cm. Find the power and focal length of the combination.

Solution :

(a) Power of a lens is a measure of the degree of convergence or divergence of light rays falling in it.

Power of a lens depends on its focal length.

(b) Unit of power of a lens is dioptre.

One dioptre is the power of a lens whose focal length is 1 metre.

(c) $f_1 = 20\,cm = 0.2\,m$

$P_1 = \frac{1}{f_1} = \frac{1}{0.2} = +5D$

$f_2 = 40\,cm = 0.4\,m$

$P_2 = \frac{1}{f_2} = \frac{1}{0.4} = +2.5D$

$f_3 = -50\,cm = -0.5\,m$

$P_3 = \frac{1}{f_3} = \frac{1}{-0.5} = -2D$

Power of the combination

$P = P_1 + P_2 + P_3$
$= +5D + 2.5D + (-2D)$
$= +5.5D$

Focal length of thr combination

$f = \frac{1}{P} = \frac{1}{+5.5} = +0.1818\,m = +18.18\,cm$

Question 30:

(a) Two lenses A and B have power of (i) + 2 D and (ii) – 4 D respectively. What is the nature and focal length of each lens ?

(b) An object is placed at a distance of 100 cm from each of the above lenses A and Calculate (i) image distance, and (ii) magnification, in each of the two cases.

Solution :

(a) $P_A = +2D$

$f_A = \frac{1}{P_A} = \frac{1}{2} = +0.5\,m = +50\,cm$

Lens A is a convex lens.

$P_B = -4D$

$f_B = \frac{1}{P_B} = \frac{1}{-4} = -0.25\,m = -25\,cm$

Lens B is a concave lens.

(b) Case 1: For lens A

$f_A = +50\,cm$

$u_A = -100\,cm$

$$\frac{1}{f_A} = \frac{1}{v_A} - \frac{1}{u_A}$$

$$\frac{1}{v_A} = \frac{1}{f_A} + \frac{1}{u_A}$$

$$= \frac{1}{50} + \frac{1}{-100}$$

$$= \frac{1}{100}$$

Image distance, $v_A = 100\,cm$

Magnification, $m_A = \frac{v_A}{u_A} = \frac{100}{-100} = -1$

Case 1: For lens B

$f_B = -25\,cm$

$u_B = -100\,cm$

$$\frac{1}{f_B} = \frac{1}{v_B} - \frac{1}{u_B}$$

$$\frac{1}{v_B} = \frac{1}{f_B} + \frac{1}{u_B}$$

$$= \frac{1}{-25} + \frac{1}{-100}$$

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

Image distance, $v_B = -20\,cm$

Magnification, $m_B = \frac{v_B}{u_B} = \frac{-20}{-100} = +0.2$

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Question 39:

The optical prescription for a pair of spectacles is :

Right eye : – 3.50 D Left eye : – 4.00 D

(a) Are these lenses thinner at the middle or at the edges ?

(b) Which lens has a greater focal length ?

(c) Which is the weaker eye ?

Solution :

(a) These lenses have negative powers and hence negative focal lengths, so they are concave lenses.

Concave lenses are thinner in the middle.

(b) Lens of lower power has greater focal length.

So, -3.50 D lens has greater focal length.

(c) Left eye is the weaker one because it needs a lens of greater power for its correction.

Question 40:

A person got his eyes tested by an optician. The prescription for the spectacle lenses to be made reads :

Left eye : + 2.50 D Right eye : + 2.00 D

(a) State whether these lenses are thicker in the middle or at the edges.

(b) Which lens bends the light rays more strongly ?

(c) State whether these spectacle lenses will converge light rays or diverge light rays.

Solution :

(a) These lenses have positive powers and hence positive focal lengths, so they are convex lenses.

Convex lenses are thicker in the middle.

(b) Lens of greater power bends light rays more quickly.

So, +2.50 D lens bends light rays more quickly.

(c) These spectacle lenses will converge the light rays because these are convex lenses.