Chapter 4. Refraction through lenses and Optical Instruments

Short Answers

Question 1: What is lens?

Answer: A lens is portion of transparent refracting medium having at least one of its two surfaces spherical. One of the surfaces may also be plane.

Question 2: Define 'power of a lens'.

Answer: The power of a lens is the reciprocal of its focal length in metre. It may also be defined as the power of convergence or divergence of a lens. If f is the focal length of a lens in metre and P is the power of the lens. Then:

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

Question 3: What is the difference between a double convex and a bi-convex lens?

Answer: In both cases the two surfaces are convex towards air. In case of double convex lens the two surfaces may have any values for the two radii of curvature of the two surfaces while in bi-convex lens the radii of curvature of the two surfaces, has the same value. Thus, every bi-convex lens is a double convex lens about every double convex may not be bi-convex.

Question 4: Point out difference between a convex lens and a concave lens.

Answer:

Convex Lens	Concave Lens
1. It is thicker at the centre and thin at the ends.	It is thinner at the centre and thick at the ends.
2. It converges rays of light.	It diverges rays of light.
3. It has a real focus.	It has a virtual focus.

Question 5: How will you decide whether a given piece of glass is a concave lens, convex lens or a plane glass plate?

Answer: Hold the given piece of glass over some printed number:
(i) If the letter appear magnified, the given piece is a convex lens.
(ii) If the letters appear diminished, the given piece is a concave lens.
(iii) If the letters appear to be of the same size, then it is a plane glass mirror.

Question 6: Out of the two lenses—one concave and the other convex—state which is a convergent or a divergent type of a lens. Give a reason of your answer.

Answer: The convex lens is a convergent type of a lens since it converges the light rays to a point while the concave lens is a divergent type of lens since it spreads the light rays.

Question 7: How are the distance of object (u), distance of image (v) and focal length (f) of a lens related?

Answer: The distance of object (u), the distance of image (u) and focal length if) of a lens are related as

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

Question 8: What will be the behaviour of a lens, if it is placed in water instead of air?

Answer: Focal length depends upon the refractive index of the material of the lens with respect to the medium surrounding it. Since the surrounding medium changes from air to water, the refractive index decreases and so the focal length of the lens increases.

Question 9: Distinguish between real and virtual images.

Answer: (i) A real image can be obtained on a screen but a virtual image cannot be obtained on screen,
(ii) A real image is formed by the actual intersection of refracted rays, while a virtural image is formed when the refracted rays do not actually meet, but they appear to meet when they are produced backwards.

Question 10: What are conjugate foci?

Answer: Two points lying on the principal axis such that image of an object kept at such point is formed on the other point, are called conjugate foci.

Question 11: Name the subjective property of light related to its wavelength.

Answer: The subjective property of light related to its wavelength is colour.

Question 12: State the position of object, position of image, nature of image when: Convex lens is used as objective lens of astronomical telescope.

Answer: Object is at infinity
Image is formed at F_2 on the other side of lens. Image is real; inverted and almost diminished to a point.

Question 13: State the position of object, position of image, nature of image when: Convex lens is used as objective lens of photographic camera.

Answer: Object is in between infinity and $2F_1$. Image is formed between F_2 and $2F_1$. Image is real; inverted and diminished.

Question 14: State the position of object, position of image, nature of image when: Convex lens is used as an erecting lens in terrestial telescope.

Answer: Object is at $2F_1$. Image is formed at $2F_2$. Image is real; inverted and same size as object.

Question 15: What happens to the image formed by a convex lens if its lower part is blackened?

Answer: Every part of a lens forms a or complete image. If the lower part of the lens is blackened the complete image will be formed but its intensity will decrease.

Question 16: State the position of object, position of image, nature of image when: Convex lens is used in cine projector.

Answer: Object is between F_1 and $2F_1$. Image is between $2F_2$ and infinity. Image is real; inverted and enlarged.

Question 17: State the position of object, position of image, nature of image when: Convex lens is used as in searchlight.

Answer: Object is at F_1. Image is formed at infinity. Image is real; inverted and highly enlarged.

Question 18: State the position of object, position of image, nature of image when: Convex lens is used in observing biological specimens.

Answer: Object is between F_1 and O. Image is formed on the same side of lefts. Image is virtual; erect and magnified.

Question 19: State the nature and position of the object on the principal axis to obtain a real and magnified image.

Answer: Lens is convex; position of the object is between F and 2F.

Question 20: State the nature and position of the object on the principal axis to obtain a virtual and magnified image.

Answer: Lens is convex; object to be placed between F and the lens.

Question 21: State the nature and position of the object on the principal axis to obtain a real image of the same size

Answer: Lens is convex; object to be placed at 2F.

Question 22: We can burn a piece of paper by focussing the sun rays by using a particular type of lens. Name the type of lens used for the above purpose.

Answer: Convex lens.

Question 23: Write the three characteristics of the image formed by a convex lens of focal length 20 cm for the object at distance (i) 10 cm, (ii) 30 cm, (iii) 40 cm, (iv) 60 cm from the lens.

Answer: (i) For the object at distance 10 cm, the image is virtual, upright and enlarged.
(ii) 'For the object at distance 30 cm, the image is real, inverted and enlarged.
(iii) For the object at distance 40 cm, the image is real, inverted and same size.
(iv) For the object at distance 60 cm, the image is real, inverted and diminished.

Question 24: Name the lens. A lens forms an erect, magnified and virtual image of an object.

Answer: Bi-Convex lens—Virtual, erect magnified image.

Question 25: A concave mirror and convex lens are held in water. What changes, if any, do you expect in their focal length?

Answer: The focal lengths of a mirror does not depend upon the nature of the medium in which it is placed whereas the focal length of a lens depends upon the medium in which it is placed. Thus there will be no change in the focal length of the concave mirror whereas the focal length of the convex lens will change.

Question 26: State three characteristics of the image of an extended source, formed by a concave lens.

Answer: Virtual, upright and diminished.

Question 27: Do we expect any change in the position, nature and size of the image (i) formed by a concave lens, (ii) with a change in the position of the object?

Answer: No, the image formed by a concave lens.
(i) Is always formed between the optical centre and the focus of the lens.
(ii) Is always virtual, erect and diminished in size. This is true for all positions of the object on the principal axis.

Question 28: An object is placed infront of a lens between its optical centre and focus. The formed image is virtual, erect and diminished. Name the lens used.

Answer: The lens used is concave lens.

Question 29: State the nature and position of the object on the principal axis to obtain. A virtual and diminished image.

Answer: Lens is concave; object may be at any place on the principal axis between the lens and infinity.

Question 30: Which lens can produce a real and inverted image of an object?

Answer: Convex lens.

Question 31: Ranbir claims to have obtained an image twice the size of the object with a concave lens. Is he correct? Give a reason for your answer.

Answer: No., he is not correct. Because concave lens always forms virtual, erect and diminished image.

Question 32: In sun glasses, both of its surface are curved, yet their behaviour is neither like a convex lens nor like a concave lens. State the reason.

Answer: In sun glasses, the outer surface is convex and the inner surface is concave, hence the power of one surface is positive and that of the other is negative. By making both these powers equal, the effective power of the lens becomes zero. Hence, these lenses are simply like a thin glass having no power, plus or minus.

Question 33: When does a ray of light falling on a lens pass through it undeviated?

Answer: A ray of light falling on the lens passes through it undeviated when it passes through optical centre.

Question 34: A converging lens is used to obtain an image of an object placed in front of it. The inverted image is formed between F_2 and $2F_2$ of the lens. Where is the object placed?

Answer: Object is beyond $2F_1$.

Question 35: Define the term magnifying power of a simple microscope. How does it depend on the focal length of the lens used?

Answer: The magnifying power of a simple microscope is defined as the ratio of the angle subtended by the image at the eye to the angle subtended by the object at the eye if it is assumed to be placed at the least distance of distinct vision.
Shorter the focal length of the lens used, larger is its magnifying power.

Question 36: Name the lens used as a magnifying glass.

Answer: Convex (or converging) lens is used as a magnifying glass.

Question 37: Why is the focal length of the lens, used as magnifying glass, kept short?

Answer: The focal length of the lens used as magnifying glass is kept small to increase its magnifying power.

Question 38: Will the image formed by a magnifying glass be real or virtual?

Answer: The image formed by a magnifying glass will be virtual.

Question 39: Can a normal convex lens behave like a concave lens and vice-versa?

Answer: Yes. If a lens is kept in a medium whose refractive index is more than that of the material of the lens, the normal convex lens starts behaving like a concave lens and vice-versa.

Question 40: What information we seek by linear magnification of the image when it is positive or negative?

Answer: If magnification is positive, then image will be real and inverted and if negative then image will be virtual and erect.

Question 41: Define magnification produced by a lens. State its unit.

Answer: The magnification produced by a lens is defined as the ratio of the size of the image to the size of the object, i.e.,

$$\text{Magnification } (m) = \frac{\text{Size of the image}}{\text{Size of the object}}$$

It has no unit.

Question 42: Do we expect any change in the position, nature and size of the image, formed by a concave lens, with a change in the position of the object?

Answer: No, the image formed by a concave lens is:
(i) Always formed between the optical centre and the focus of the lens.

(ii) Is always virtual, erect and diminished in size. This holds good for all positions of the object.

Question 43: Name the lens for which magnification can be 1. For what position of the object will the magnification be 1?

Answer: The lens for which magnification can be 1 is convex lens. For this, the object must be at 2F (i.e.r at distance twice the focal length, in front of the lens).

Question 44: State one practical use of a magnifying glass.

Answer: A magnifying glass is used by the watch makers to see small screws, etc.

Question 45: Name the lens for which magnification is always less than 1.

Answer: Concave lens.

Question 46: A convex lens produces on a screen an image twice the size of the object. If the position of image and object be interchanged, what will be the magnification then?

Answer: On interchanging the position of image and object, the magnification will be 1/2.

Question 47: How is the magnification (m) produced by a lens related to the object distance (u) and the image distance (v)?

Answer: The magnification produced by a lens = v/u

Question 48: State two applications each of (i) convex lens, and (ii) concave lens.

Answer: (i) A convex lens is used (a) as a magnifying glass, and (b) in spectacles to correct hypermetropia.
(ii) Concave lens is used (a) in spectacles to correct myopia, and (b) as eye lens in terrestrial telescope.

Long Answers

Question 1: Why do we say that the '2F' and 'F' points of a convex lens can be regarded as a sort of 'turning points' as far as the nature of the image formed by it is concerned?

Answer: We know that:
(i) When an object is beyond the 2F point of a convex lens, the image formed by it is real, inverted and diminished in size.
(ii) When the object is in between the '2F' and 'F' points of the convex lens, the image formed by it is real, inverted and enlarged.
(iii) When object is between the 'F' point and optical centre of the convex lens, the image formed by it is virtual, erect and enlarged.
We thus notice that there is a sudden change in the nature of the image formed when an object approaching from infinity, crosses the '2F' and 'F' points of a convex lens. It is for this reason that we regard these two points as a sort of turning points as far as the nature of the image formed by a convex lens is concerned.

Figure Based Short Answers

Question 1: Draw a diagram to show the convergent action of a convex lens by treating it as a combination of glass block and two triangular glass prisms, with the aid of two parallel incident rays.

Answer: The diagram is shown below:
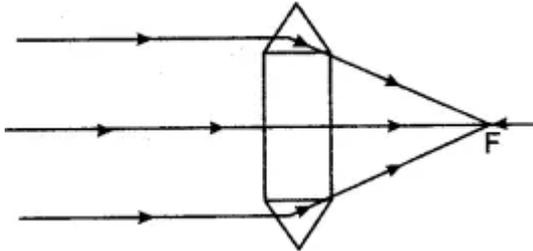
Question 2: What is the path of ray, after refraction, that passes through the first focus of the lens?
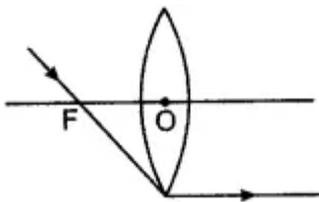
Answer: The ray becomes parallel to the principal axis after refraction through the lens. This is shown in the figure shown alongside.

Question 3: What is optical centre of a thin lens? Draw diagram/diagrams to illustrate it.

Answer:
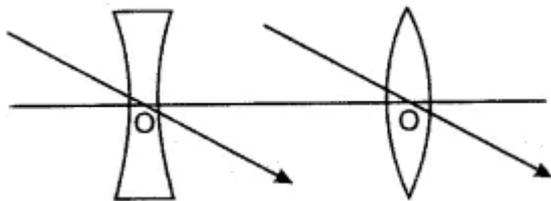
The optical centre of a thin lens is a point O on the principal axis of the lens such that a ray of light directed towards it, passes undeviated and undisplaced from the lens. The diagram illustrating it in a convex and a concave lens are shown alongside.

Question 4: Complete the ray diagram to show how the rays pass into and out of the lens?
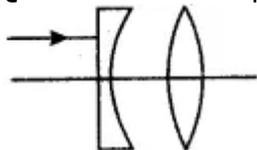
Answer: The path of the ray is shown in the diagram.
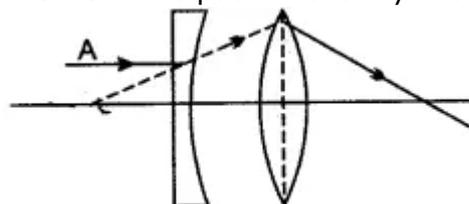
Question 5: From the nature of the refracted rays, shown in diagram [(i) and (ii)] interpret the nature of the lens represented by the dotted line.

(a)　　　　　　　　(b)
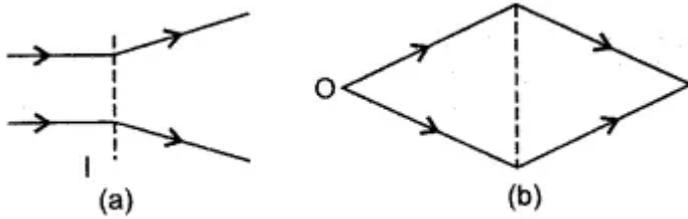
Answer: (i) Since the incident parallel rays are diverging after refraction, the lens represented by the dotted line must be a concave lens.
(ii) Since the rays, starting from the object point 'O', are being made to converge to another point 'I', the lens used must be a convex lens.

Question 6: Draw a diagram to show the refraction of two parallel incident rays by a concave lens by treating it as a combination of a glass block and two triangular glass prisms. What does this diagram illustrate?

Answer: The diagram is shown below. This diagram illustrates the divergent action of concave lens.
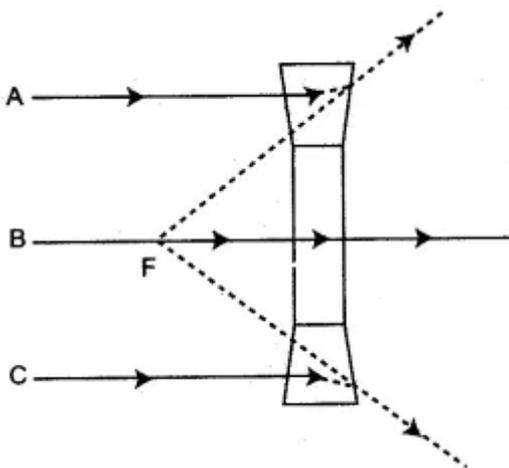
Question 7: Where should an object be placed infront of a convex lens so as to form an inverted and enlarged image? Will the image be real or virtual? Draw a ray diagram to illustrate your answer.
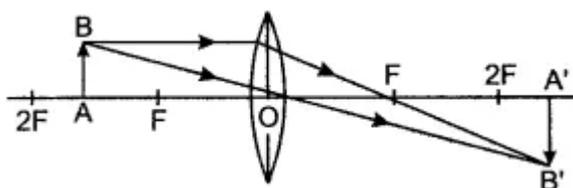
Answer: To form an inverted and enlarged image by a convex lens, the object should be placed between F and 2F infront of the lens.
The image will be real.
The ray diagram is shown in figure. For the object AB, the images is A'B'.

Question 8: Draw a ray diagram to show the formation of an inverted and diminished image of an object by a lens. Name the lens used. State the position of object with respect to the lens used. State one more characteristic of the image.

Answer:
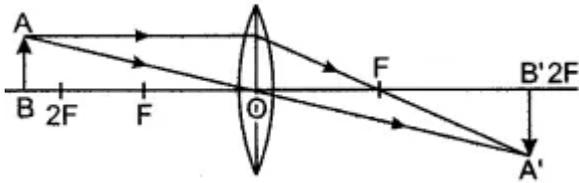
The ray diagram to show the formation of an inverted and diminished image of an object by a lens is shown alongside. In figure A′B′ is the image for the object AB. The lens used is convex (or converging). The object lies beyond 2F in front of the lens. The image is real.

Question 9: A lens forms an upright and diminished image of an object, irrespective of its position. What kind of lens is this? Draw an outline ray diagram to show the formation of image. State the position and one more characteristics of the image.

Answer: A concave (or diverging) lens forms an upright and diminished image of an object irrespective of its position.
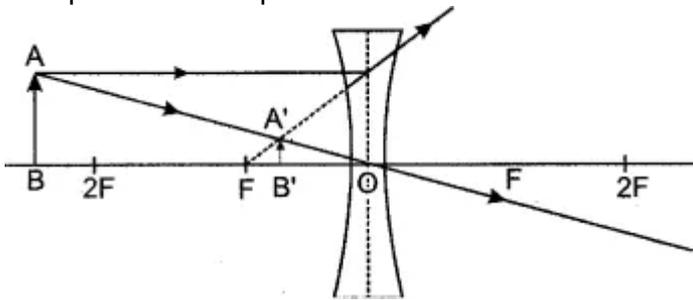
The outline ray diagram showing the formation of image is given in figure. For the object AB, the image is A′B′.
The image is formed between optical centre O and focus F, in front of the lens.
The image is virtual.

Question 10: The following diagram shows the object O and the image I formed by a lens. Copy the diagram and on it mark the positions of the lens LL′ and focus (F). Name the lens.
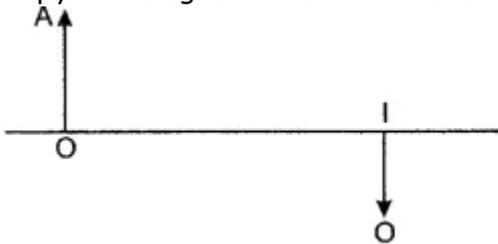
Answer: The complete diagram is shown in figure in which the position of lens has been marked by the letter LL′ and the focus as F. The lens is convex (or converging).
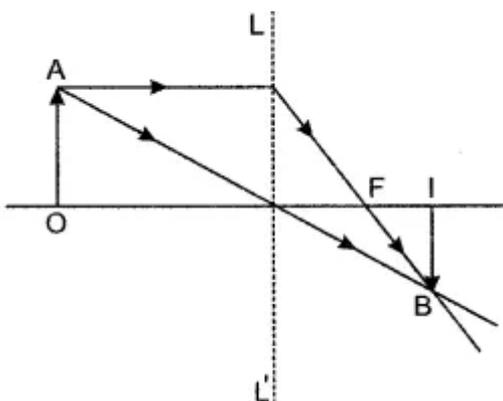
Question 11: In figure give below of thin concave lens, F_1 and F_2 are its foci, complete the path of the given ray of light after it emerges out of the lens.
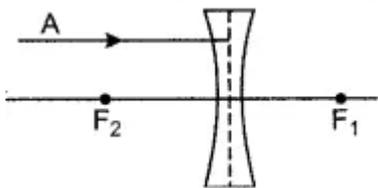
Answer: See figure
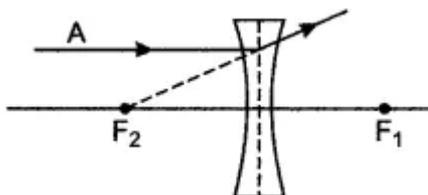
Question 12: Figure shows the transmitted rays through lens kept in a box. Draw the lens and complete the path of rays.
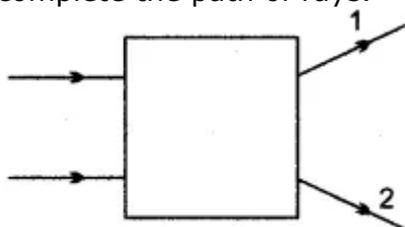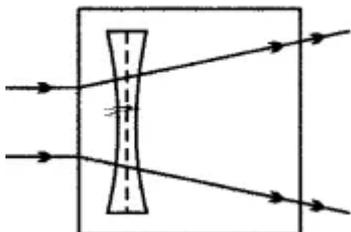
Answer:

Question 13: Copy the following figure and complete it to show the formation of the image of the object AB. Name the lens used in the figure.
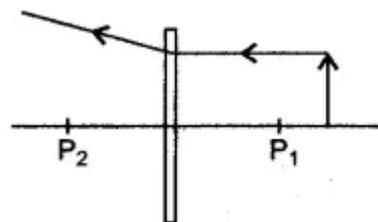
Answer: Since the ray is deviated away from the axis, the lens used is a concave lens. The complete figure showing the image formed is given alongside. The image is virtual, erect and diminished.
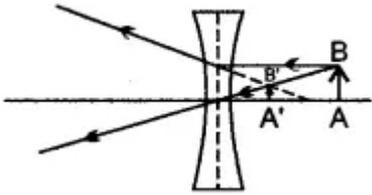
Question 14: In the figure given below L is a convex lens, M is a plane mirror and S is a point source of light. Rays of light from the source S return to their point of origin. Complete the ray diagram to show this. What is the point S called?
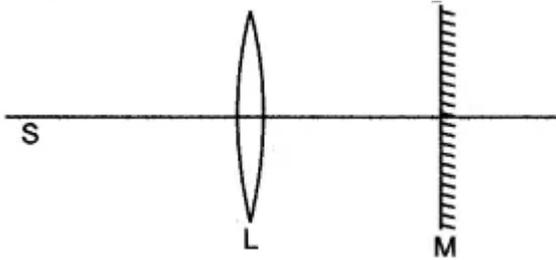
Answer: The complete ray diagram is shown below:
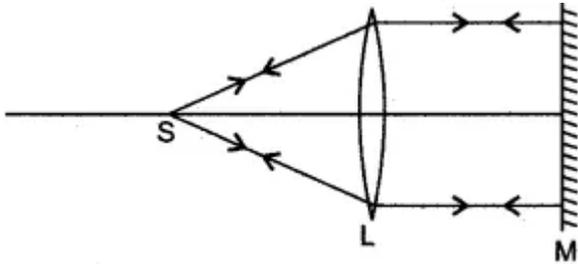
The point S is called focus of the lens.

Question 15: An object is placed in front of a lens between its optical centre and the focus and forms a virtual, erect and diminished image. Draw a ray diagram to show the formation of the image with the above stated characteristics.

Answer:

Concave lens
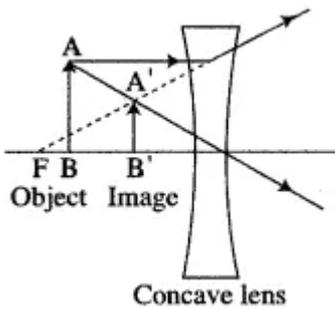
Question 16: A candle is placed between f and 2f a convex lens. Draw a ray diagram showing position of the image.

Answer:
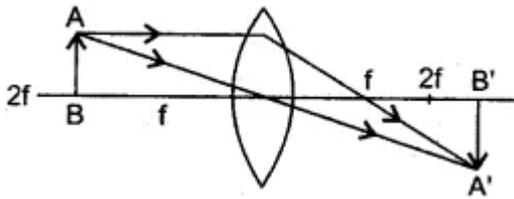
Question 17: Draw a ray diagram to illustrate the determination of the focal length of a convex lens using an auxiliary plane mirror.

Answer:
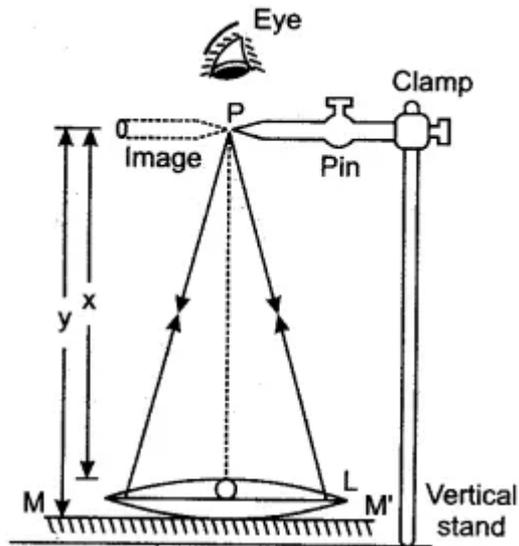
Question 18: Draw the ray diagrams of a converging lens, when the object is placed at a distance greater than twice the focal length of the lens.

Answer:
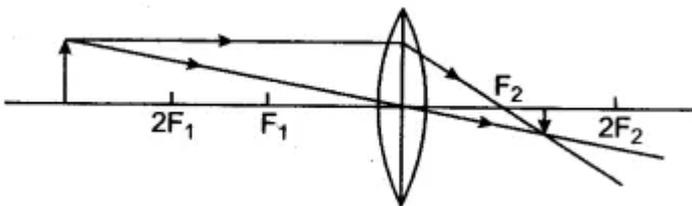
Object placed beyond 2F.
Image Nature: Real and inverted.
Size: Diminished.
Position: Between F and 2F.

Question 19: Draw the ray diagrams of a converging lens, when the object is placed at 2F on the principal axis. Write down the nature, position and size of the image in both cases. Use only two rays in the diagrams.

Answer:
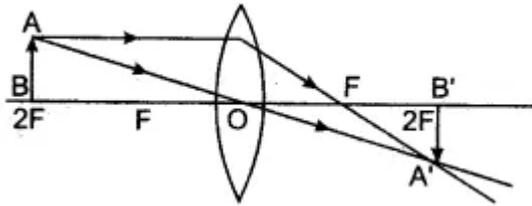
Object placed at 2F.
Image Nature: Real and inverted.
Size: Same (equal).
Position: At 2F.

Question 20: Write down the characteristic of the image formed when the object is between F and 2F?

Answer:
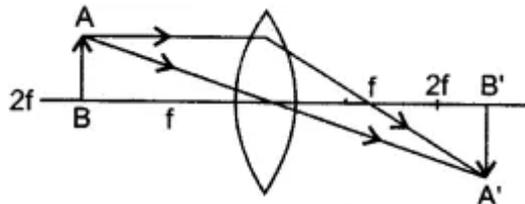
Object is between F and 2F.
Nature: Real and inverted.
Size: Magnified.
Position: Beyond 2F.

Question 21: Write down the characteristic of the image formed when object is between F and the lens?

Answer:
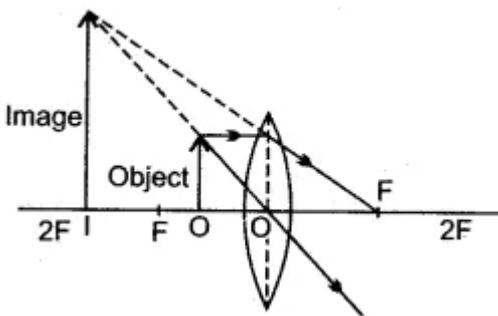
Object is between F and the lens.
Nature: Virtual and upright.

Size: Magnified.
Position: Towards object side.

Question 22: (i) Show with the help of a ray diagram, the path of the ray when incident normally on the first surface of the glass block, through the block and the liquid.
(ii) Show, using a ray diagram, how a converging lens can be used to form a virtual image.

Answer: (i) We are assuming that the glass block is bounded by parallel plane refracting surfaces.
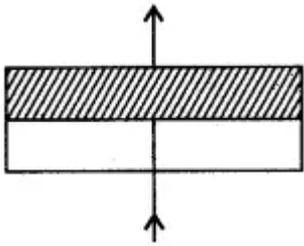
(ii) The ray diagram is given below.
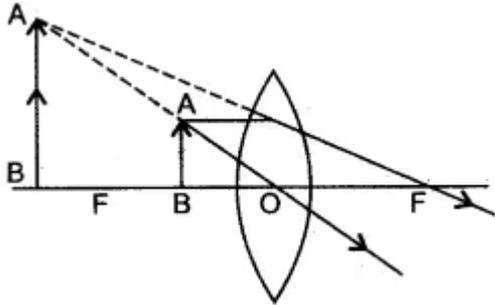
Question 23: A stick partly immersed in water appears to be bent. Draw a ray diagram to show the bending of the stick when placed in water and viewed obliquely from above.

Answer:
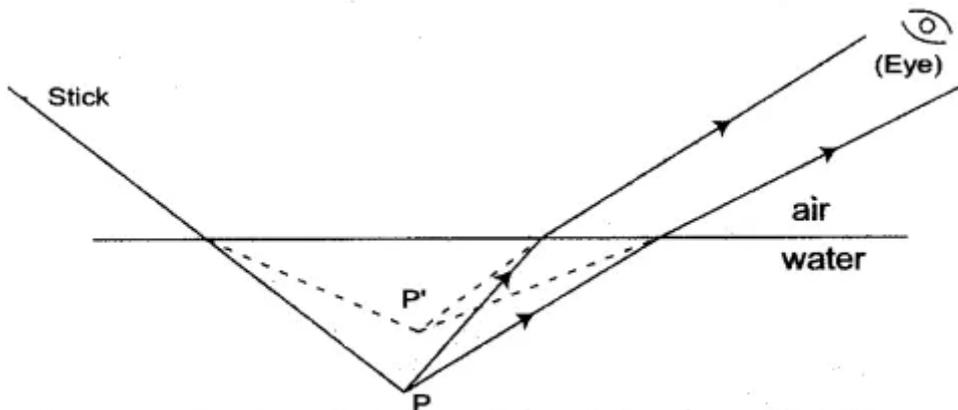
Ray diagram showing the bend of the stick when placed in water

Question 24: Draw a neat diagram to explain the action of a convergent (convex) lens as a reading glass (or magnifying glass). State the characteristics of the image formed.

Answer:

A Magnifying or Reading Lens
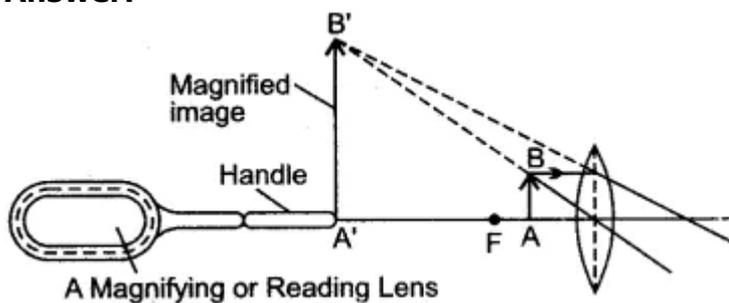
The object to be seen must be placed from the convex lens at a distance less than its focal length.
Characteristics of the image so formed are:
(i) It is virtual and upright.
(ii) It is magnified.
(iii) The image is formed towards the object side.

Question 25: An object is placed in front of a convex lens such that the image formed has the same size as that of the object. Draw a ray diagram to illustrate this.

Answer:
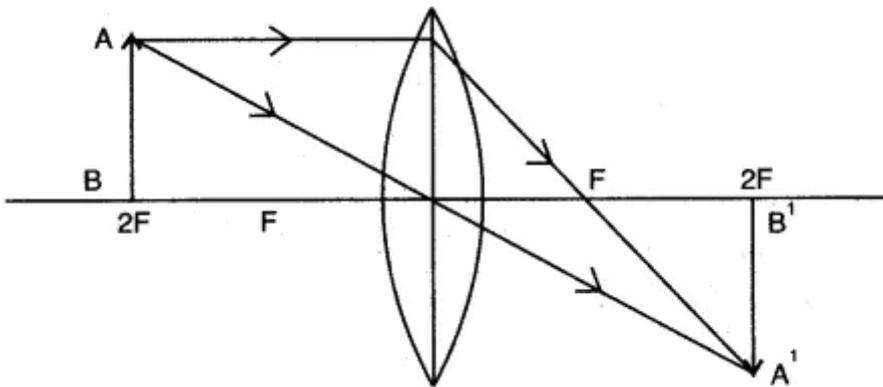
Question 26: What is a simple microscope or a magnifying glass? Draw a ray diagram to show its function.

Answer:
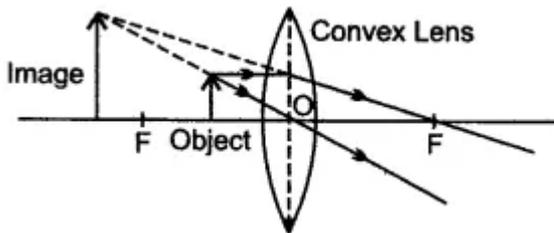
A convex lens works as a simple microscope or a magnifying glass when an object is kept between its optical centre and the focus. The image of the object so obtained is virtual, upright and magnified.

Question 27: We can burn a piece of paper by focussing the sun rays by using a particular type of lens. Name the type of lens used for the above purpose. Draw a ray diagram to support your answer.

Answer:
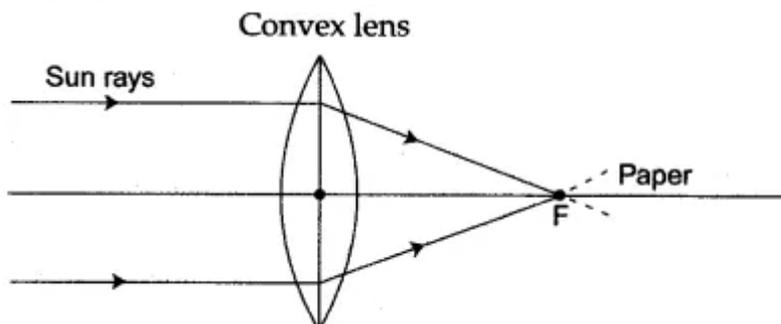
Figure Based Long Answers

Question 1: Name the types of lens.

Answer: There are two types of lenses:
(i) Concave or diverging lens which may be either double-concave, piano-concave or convexo-concave.

Convexo concave   Plano concave   BI-Concave
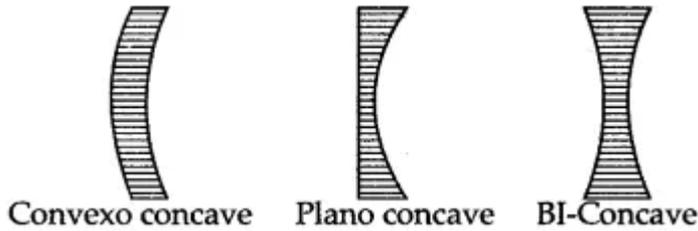
(ii) Convex or converging lens which may be either double convex, piano-convex, or concavo-convex

BI-Concave   Plano concave   Convexo concave
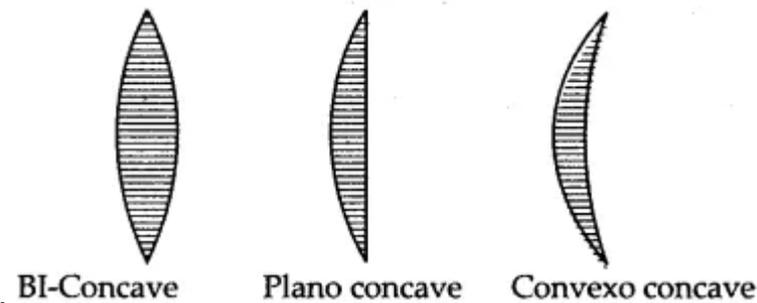
Question 2: Define (i) Principal axis, and (ii) Optical centre of a lens.

Answer:

(i) Principal axis: It is the straight line passing through both the centres of curvatures, C_1 and C_2 and also through its optical centre O.
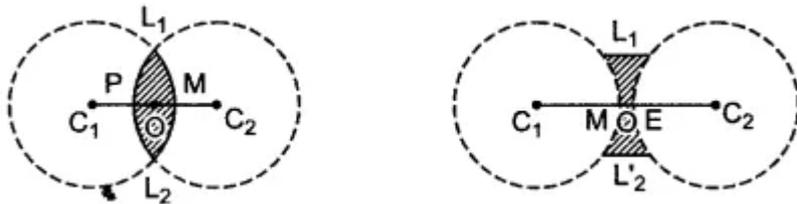
(ii) Optical centre: It is the centre of the lens through which the principal axis passes. Any ray of light passes through it undeviated, provided the lens is thin.

Question 3: Define the Principal focus of a (i) Convex lens and (ii) Concave lens.

Answer: (i) For a convex lens, principal focus is a point on the principal axis of a convex lens at which the rays of light originally parallel and close to the principal axis of the lens pass through it after refraction by the lens.
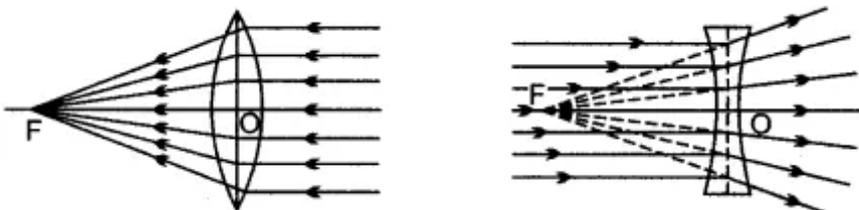
(ii) For a concave lens, principal focus is a point on its principal axis at which the rays of light originally parallel to the principal axis, appear to come from it after refraction by the lens.

Question 4: (i) Copy and complete the following ray diagrams.
(ii) Define focal length.

(i)   (ii)
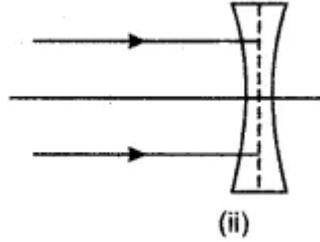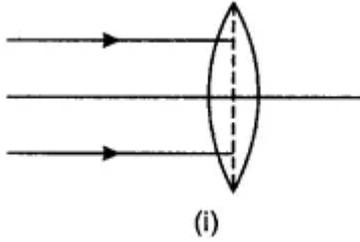
Answer: (i) See figure.
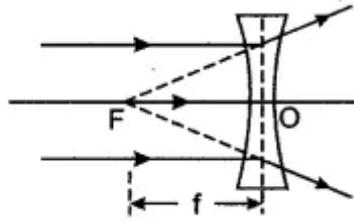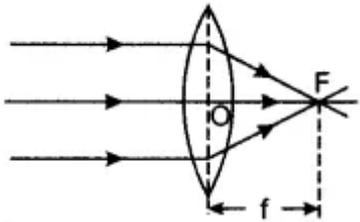
(ii) **Focal length:** It is the distance of the principal focus of the lens from its centre.

Question 5: The diagram shown a lens as a combinations of one glass block and two prisms. Complete the ray diagram and show the part of the incident ray AB after passing through the lens.
(i) Name of the lens formed by the combination.
(ii) What is the line XX' called?
(iii) Mark the focus F.
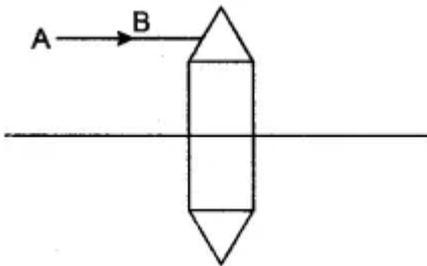
Answer: The completed ray diagram is shown.
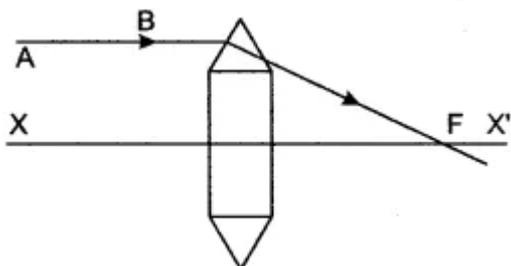
(i) The lens formed by the combination is the convex lens.
(ii) The line XX' is called the principal axis.
(iii) The focus has been marked by the letter F in the diagram.

Question 6: Complete the following diagram and state what happens to the ray of light after refraction through the lens.

(i)

(ii)

(iii)
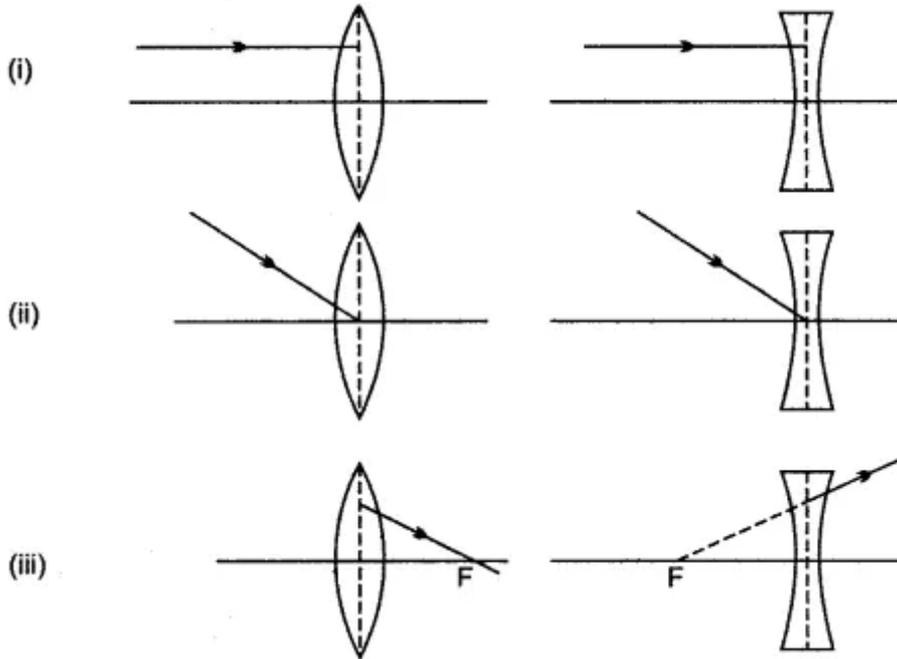
Answer:
(i) A ray of light parallel to the principal axis, after refraction by the lens either passes through its principal focus or appear to pass through its principal focus.
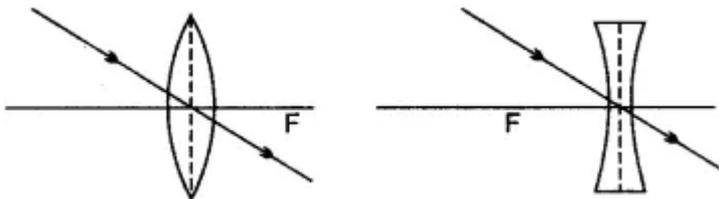
(ii) A ray of light goes undeviated through the optical centre of a lens, whether convex or concave.
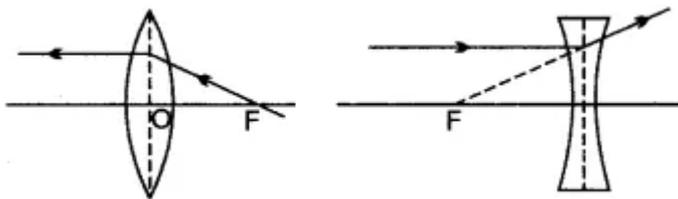
(iii) A ray of light that passes through the principal focus or appears to pass through the principal focus, goes parallel to its principal axis.
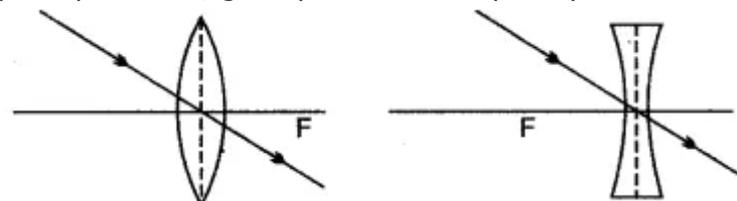
Question 7: The given ray diagram illustrates the experimental set up for the determination of the focal length of a converging lens using a plane mirror.
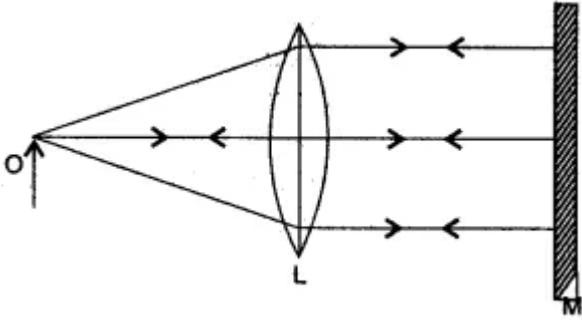
(i) State the magnification of the image formed.
(ii) Write two characteristics of the image formed.
(iii) What is the name given to the distance between the object and optical centre of the lens in the above diagram?

Answer: (i) Image is highly enlarged.
(ii) (a) Real. (b) Formed at infinity on the other side of the lens.
(iii) Focal length of the lens.

Question 8: Figure show the incident rays through lens kept in a box. Draw the lens and complete the path of rays.
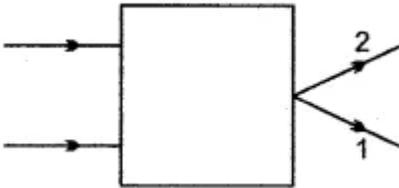
Answer: See the diagram.
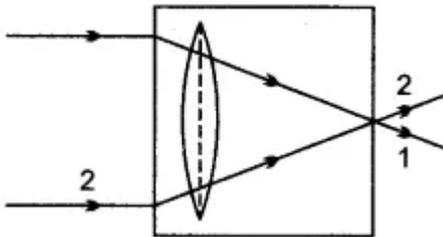
Question 9: Complete the diagram to show the formation of image of the object AB.
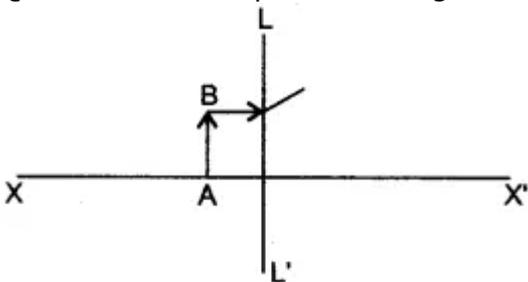
(i) Name the Lens LL'.
(ii) Where is the image of the object AB formed?
(iii) State three characteristics of the image.

Answer: (i) The lens is diverging (or concave) lens.
(ii) The image of the objects is A'B' which is formed between the optical centre and focus of the lens, in front of it.
(iii) The image is (a) virtual, (b) upright, and (c) diminished.
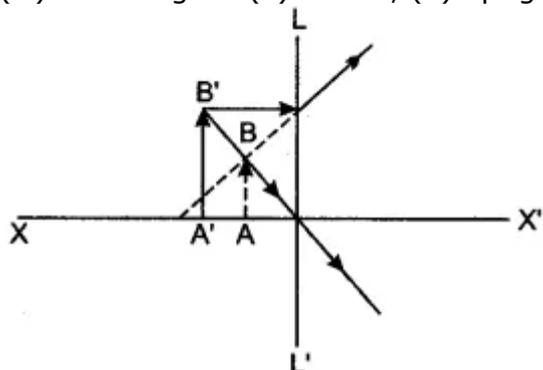
Question 10: Draw a ray diagram to illustrate the formation of an enlarged and upright image of an object by a lens. Name the lens used. Where should the object be placed relative to the lens? Will the image be real or virtual? Name a device where this action of lens is used.
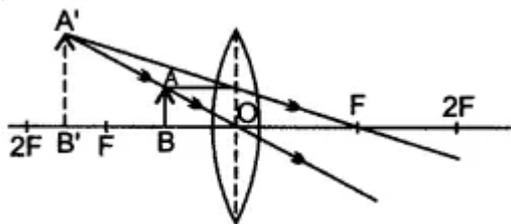
Answer: The ray diagram showing the formation of an enlarged and upright image of an object by a lens is shown in the figure alongside. For the object AB, the image is A'B'. The lens used is convex (converging).

The object should be placed between optical centre O and focus F of the lens, infront of it.
The image is virtual.
This action of lens is used in a simple magnifier (or a reading glass).

Question 11: An object 5 cm high is held 25 cm away from a converging lens of focal length f = 10 cm. Draw a suitable scale diagram and find the position and size of me image formed is the image real or virtual?

Answer: First of all we should note that a converging lens is a convex lens. Since the distance given in this problem are quite large and inconvenient to draw in the note-book, so we have to choose a suitable scale. Let 1 cm represent a distance of 5 cm.
On this scale:
(i) A 5 cm high object can be represented by 1 cm.
(ii) Object distance of 25 cm can be shown by 5 cm.
(iii) Focal length of 10 cm can be represented by 2 cm.
Keeping these distances in mind, we will draw the ray-diagram now.
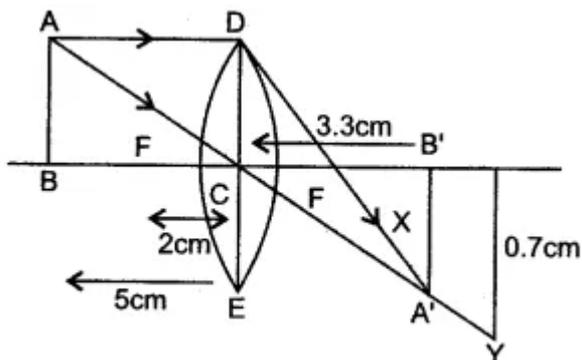
First of all draw a horizontal line to represent the principal axis of the convex lens. A convex lens is then drawn with its optical centre C on the axis. The (centre line) aperture of the convex lens has been shown by the line DE. We assume that the refraction of light takes place at the aperture. The focal length of this lens is 2 cm, so we mark its two focal F' and F at a distance of 2 cm on both the sides of the lens. And to represent the object, we draw and arrow AB, 1 cm high at a distance of 5 cm from the centre C of the lens on its left side.

In order to find out the position of image, we draw two rays of light starting from the top point A of the object. The line AD is drawn parallel to the principal axis to represent a parallel ray of light. This ray cuts the aperture at a point P. Now this parallel ray of light will pass through the focus F. So we join D and F by a straight line and produce this line further towards X. Thus, DX represent the first refracted ray. We now draw a second ray of light passing through the optical centre C of the lens which goes straight without any deviation.
For this purpose we join AC and produce it further downwards towards Y. Now, CY represents the second refracted ray The two refracted rays DX and CY meet at point A'. We draw A'B' perpendicular to the principal axis. Now A'B' represents the real and inverted image of the object AB.
(i) To find the position of image, we measure the distance CB'. It is found to be 3.3 cm. And to obtain the actual position of image we have to multiply this distance by 5. Since 1 cm represents a distance of 5 cm. Thus the position of image is 3.3 × 5 = 16.5 cm from the convex lens on the opposite side of the object.
(ii) If we look at the image formed in the figure, we find that the nature of image is—real and inverted.
(iii) And to find the size of the image, we measure the height A'B' in the figure. It is found to be

0.7 cm. For obtaining the actual size of image, we have to multiply it by 5. Thus, the size of image is 0.7 × 5 = 3.5 cm. So, the image is smaller than the object i.e., diminished.

Question 12: The diagam on right shows a ray of white light AB incident on a rectangular glass block, which is silvered at lower surface. This rays is partly reflected and partly refracted.
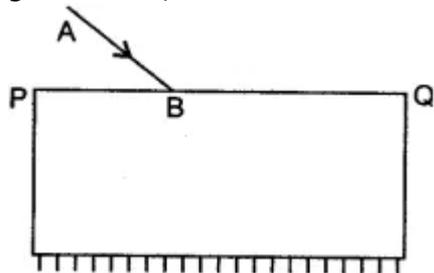
(i) Copy the diagram and trace the path of the refracted and reflected ray. Show at least two rays emerging from the surface 'PQ'
(ii) How many images are formed in the above case? Which image is the brightest?

Answer: (i)

Silvered
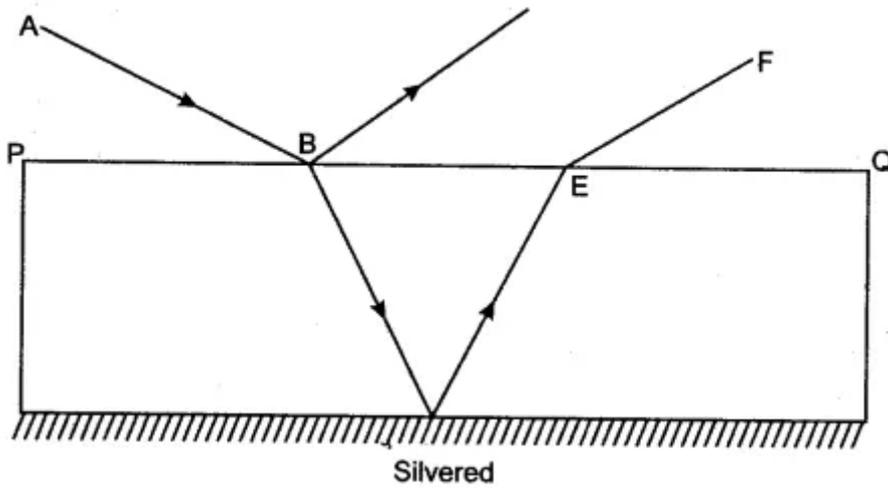
(ii) Two images formed are: (a) on account of reflection from the upper surface, and (b) due to reflection from the lower surface. The second image is brighter.

Question 13: How does a convex lens acts as a 'converging lens'?

Answer:
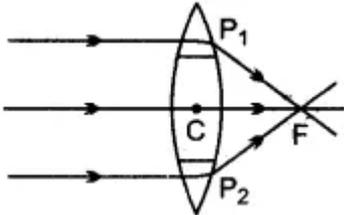
Convex lens may be considered as being made of a large number of prisms, such that in its upper half, prisms have their bases down wards and in its lower half, the prisms have their bases upwards, Due to this, the upper half part deviates the rays of light downwards and the lower half deviates the rays of light upwards while the central part of the lens acts as a glass

block allowing the light to pass undeviated. So, any parallel beam of light incident on it converges to a point F.

Question 14: How will you determine the focal length of a convex lens by the plane mirror method?

Answer:
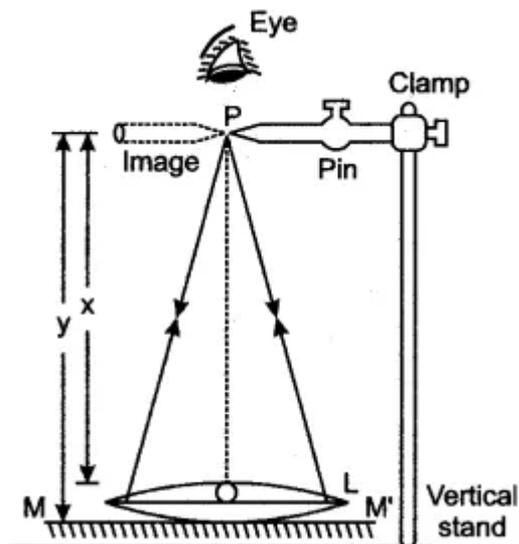
A Set-up the apparatus as shown in the figure. M is a rectangular sheet of plane mirror fixed in a vertical position in a stand and convex lens L is mounted on a lens stand. P is a pin, set up vertically in a pin stand. Mirror M is placed at the back of the lens. Now the pin P is adjusted by moving it backward and forward so that a real and inverted image of the pin is formed after reflection from the plane mirror M. The position of the pin is carefully adjusted so that there is no parallax between the upper tip of the pin and its inverted image. The distance between the needle and the lens gives the focal length of the lens. In this position rays of light starting from the tip of the pin go parallel to the principal axis and strike the reflecting surface of the mirror M normally. The parallel beam of light is reflected back along the same path and forms the image P' of the tip P at the focus of the lens.

Question 15: Define the terms principal foci and focal lengths as applied to a convex lens, and show them with the help of proper diagrams.

Answer: A convex lens has two principal foci: (i) first focus, and (ii) second focus.

First focus: First focus of a convex lens is a point F_1 on the principal axis of the lens such that the rays of light starting from it after refraction from the lens become parallel to the principal axis. This is shown in figure. The distance of first focal point Fj from the optical centre O is called first focal length. In figure, it has been labelled by f_1 (i.e., $OF_1 = f_1$)

Second focus: Second focus of a convex lens is a point F_2 on the principal axis of the lens such that the rays of light incident parallel to the principal axis of the lens, after refraction from the lens pass through it. This is shown in figure. The distance of second focal point F_2 from the optical centre O is called second focal length. In figure it has been labelled by f_2 (i.e., $OF_2 = f_2$).

Question 16: Diagram shows an object AB placed on the principal axis B of a convex lens placed in air. F_1 and F_2 are the two foci of the lens.
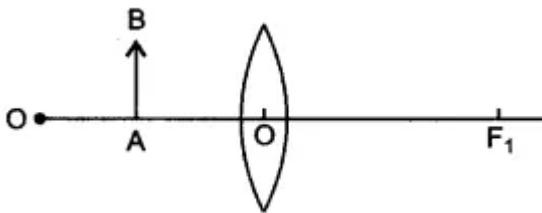
Copy the diagram:
(i) Draw a ray of light starting from B and passing through O. Show the same ray after refraction by lens.
(ii) Draw another ray from B which passes through F_2 after refraction by the lens.
(iii) Locate the final image.
(iv) Is the image real or virtual?
Answer: (i), (ii), (iii) see the diagrams given below.

Eye
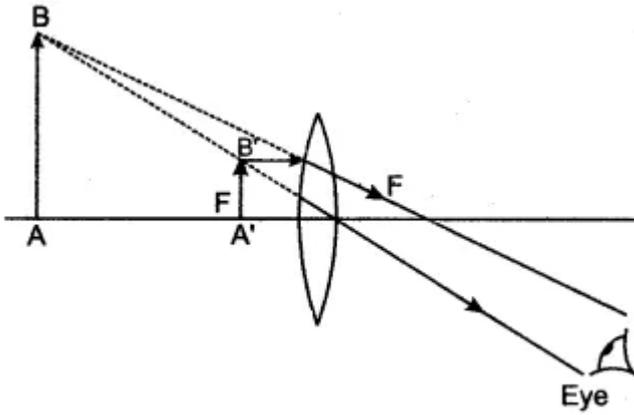
(iv) Image is virtual.

Question 17: In the following diagram L_1 and L_2 are the two convex lense placed at separation equal to the sum of focal lengths of the two lenses. A and B are the two rays of light incident on the lens L_1. Complete the path of rays till they emerge out of the lens L_2.
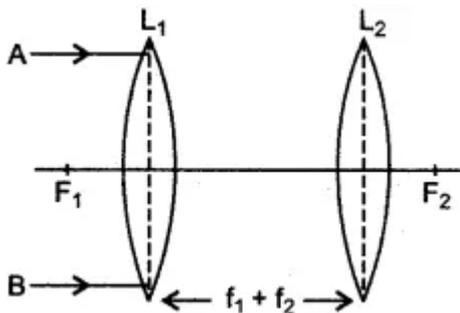
What principles have you used in completing the diagram?

Answer: The complete ray diagram is shown below.
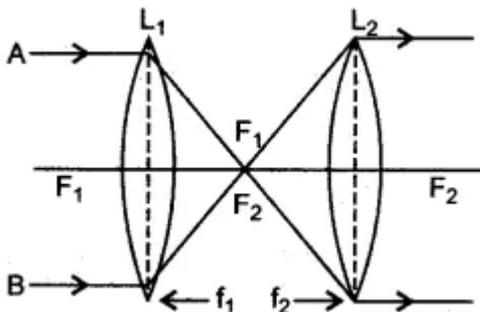
The following two principles have been used in completing the diagram:
(i) A ray of light incident parallel to the principal axis, after refraction from the convey lens passes through the focus.
(ii) A ray of light incident on the convex lens through its focus after refraction becomes parallel to the principal axis of the lens.

Question 18: An erect, magnified and virtual image is formed, when an object is placed between the optical centre and principal focus of a lens.
(i) Name the lens.
(ii) Draw a ray diagram to show the formation of the image with the above stated characteristics.

Answer: (i) The lens is convex.

(ii)

Ray diagram of image formation
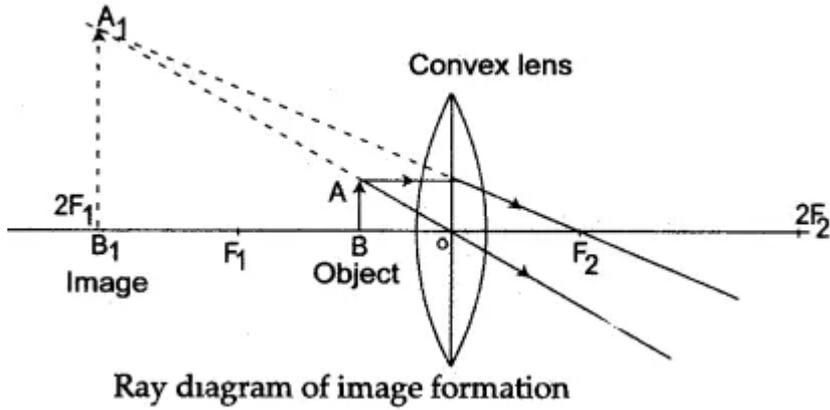
Question 19: An object AB is placed between $2F_1$ and F_1 on the principal axis of a convex lens as shown in the diagram. Copy the diagram and using three rays starting from point A, obtain the image of the object formed by the lens.
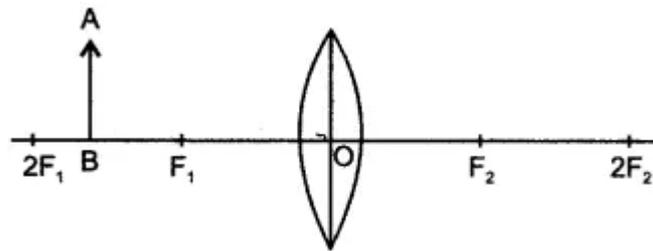
Answer:
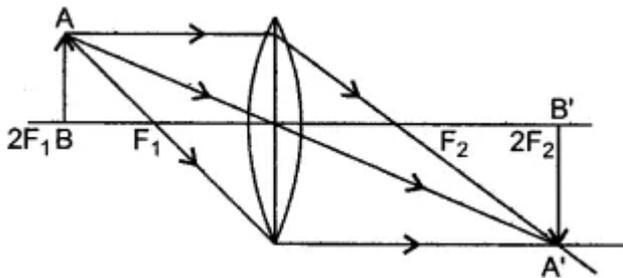
Question 20: How does a concave lens acts as a 'diverging lens'?
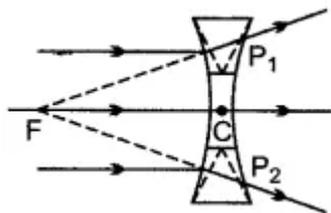
Answer:

In a concave lens, the upper half of the lens has the bases of the prisms upwards and the lower half of the lens has the bases of the prisms down wards. Therefore in this lens, the rays of light suffer divergence in the upwards direction and in the lower half, the rays diverge in the downward direction. On being produced backwards by dotted lines, these rays appear to diverge from a point F.

Question 21: Define the term principal foci as applied to a concave lens. Illustrate your answer with the aid of proper diagrams. Show the focal length of the lens in diagram.

Answer: A concave lens has two principal foci: (i) first focus and (ii) second focus.
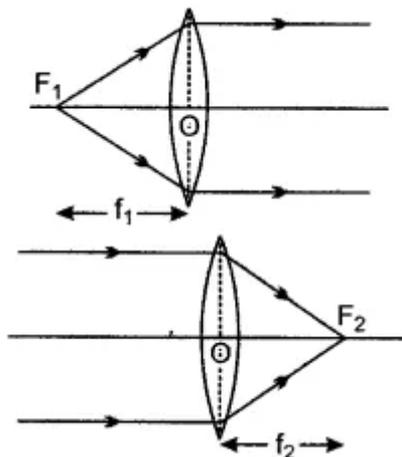
(i) First focus: First focus of a concave lens is the point F_1 on the principal axis of the lens such that the rays of light appearing to meet at it, after refraction from the lens becomes parallel to the principal axis. This is shown in figure. The distance of first point F_1 from the optical centre O of the lens (i.e., OF_1) is the first focal length f_1.

(ii) Second focus: Second focus of a concave lens is the point F_2 on the principal axis of the lens such that the rays of light incident parallel to the principal axis of the lens, after refraction from the lens appear to be coming from it. This is shown in figure. The distance of second focal point F_2 from the optical centre O of the lens (i.e., OF_2) is called the second focal length f_2.

Question 22: Draw images in case of a concave lens when the object is (i) at infinity and (ii) at any point on the principal axis between the lens and infinity.

Answer: (i) When object is at infinity, the incident ray are taken parallel to the principal axis. As shown in the figure, the image is virtual and is formed at the focus F_1 It is diminished (small) in size.
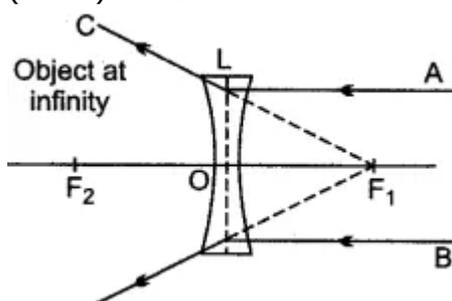
(ii) Here the object AB is between the concave lens L and infinity and is at the principal axis. Two incident rays A and B are taken, A after refraction goes in the direction CD while the other ray B goes straight through the optical centre O. DC' when produced backwards meets the ray B at P', which is the virtual image of P'Q' is the image of the object PQ. The image is virtual, upright and diminished and is on the side of the object PQ.
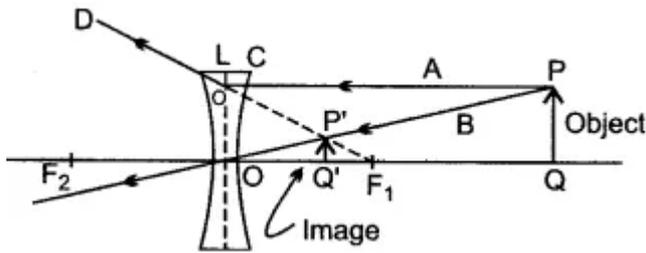
Question 23: Can one bum a piece of paper in daylight by just using a convex lens instead of a match or any direct flame ? Support your answer with the help of an appropriate ray diagram.

Answer: Yes, it is possible to burn a piece of paper, in daylight, by using a convex lens instead of a match or any other direct flame.
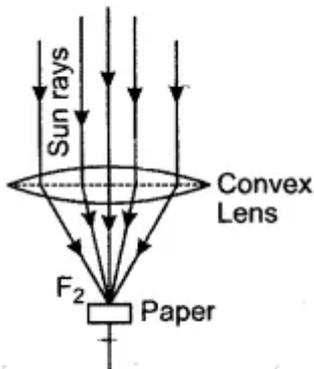
We know that a convex lens brings a beam of parallel incident rays to a focus at its focal point. The rays of the sun (practically an infinite distance source) form a parallel incident beam. When they are allowed to fall on a convex lens, they get focussed at its focal point. If a piece of paper is kept at this focal point, all the (large) heat energy of this parallel beam gets concentrated at

this point. This (concentrated heat energy) is often sufficient to burn the piece of paper. The required ray diagram is as shown in figure.

Question 24: What is a magnifying glass (or a simple microscope)? Draw a ray diagram to show how a convex lens may be used as a magnifying glass. Where should the object be placed? State three characteristics of the image formed.

Answer: A magnifying glass is convex (or converging) lens of B short focal length mounted in a plastic or wooden frame provided with a handle. It is used to see small objects or to read small letters.
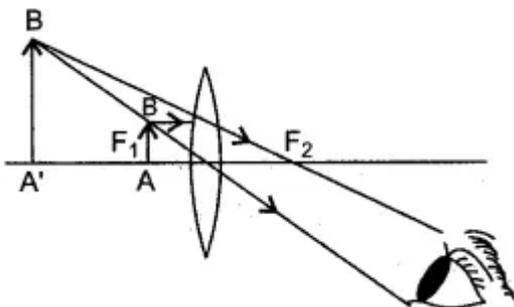
The ray diagram showing the use of a convex lens as a magnifying glass is given in figure. The object should be placed infront of the lens between its optical centre and focus.

Question 25: (i) Draw a ray diagram to show how lens can be used as a 'magnifying glass'? State the nature of the lens.
(ii) In what respect does the image in (i) above different from the image formed by a concave lens?

Answer: (i) The nature of the lens used is convex. The image formed is magnified, virtual and upright. In this case, a convex lens is said to be used as a 'magnifying glass.'
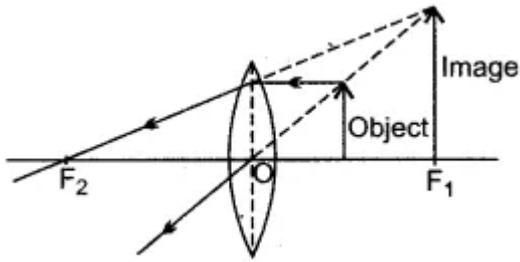
(ii) Image formed by a concave lens differs from the image in size. It is much smaller in size.

Short Numericals

Question 1: A convex lens is of focal length 20 cm. Find its power.

Solution: Given: Focal length f = 20cm = 0.2 m.

Given : Focal length $f = 20cm = 0.2$ m.

$$\text{Power} = \frac{1}{\text{Focal length in m}} = \frac{1}{0.2} = 5D$$

Question 2: If lens is of focal length 25 cm. Calculate the power of the lens.

Solution:

$$f_l = 25 \text{ cm} = 0.25 \text{ m}$$
$$P = \frac{1}{0.25} = 4D$$

Long Numericals

Question 1: If there is a convex lens of focal length 75 cm and concave lens of focal length 40 cm, then calculate their combined power and combined focal length.

Solution:

$$\text{Power of convex lens} = \frac{100}{f\,(cm)} = \frac{100}{75} = +1.33 \text{ D.}$$

$$\text{Power of concave lens} = \frac{100}{f(cm)}$$

$$= \frac{100}{40} = -2.5 \text{ D.}$$

$$\text{Their combined power P} = +1.33 \text{ D} + (-2.5 \text{ D})$$
$$P = -1.17 \text{ D.}$$

$$\text{Their combined focal length } \vec{F} = \frac{100}{P} = \frac{100}{-1.17}$$
$$F = -85.47 \text{ cm.}$$

Negative sign indicates that the nature of their combination is concave.