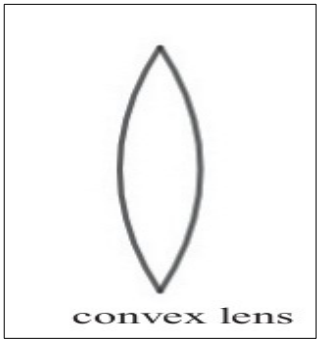
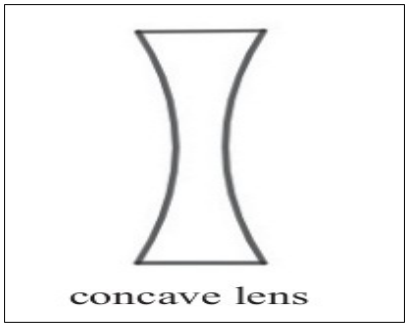


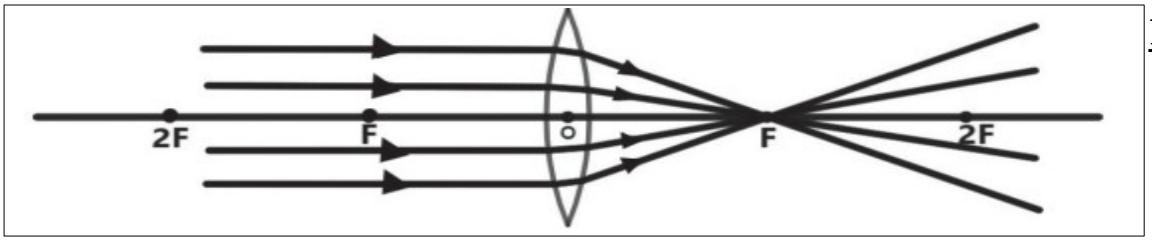
Lenses



Convex lens	Concave lens
• Thicker in the middle • Shows the objects magnified • converge light rays	• Shows the objects diminished • Thicker at the edges • diverge light rays

A lens is a transparent medium in which each refracting surface is part of the spheres.

Optic centre : The midpoint of a lens is the optic centre (O).
Centres of curvature : Each refracting surface of a lens is part of a sphere. The centres of such spheres are the centres of curvature.
Optic axis : The optic axis is the imaginary line passing through the centres of curvature and the optic centre of a lens.
Aperture : The area of the lens through which light passes is called aperture.



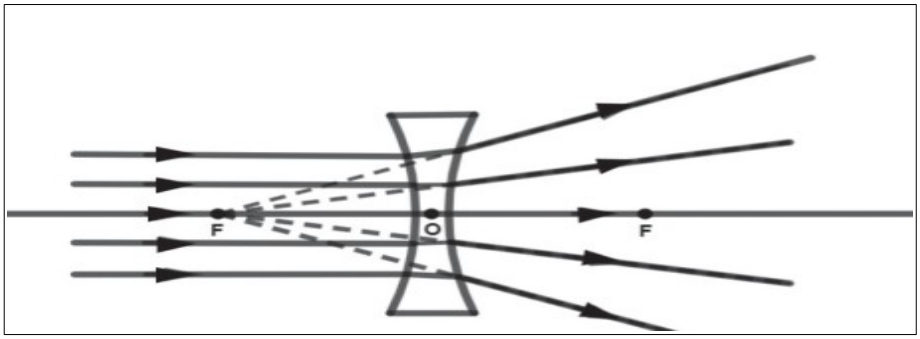
focus

Light rays near and parallel to the optic axis incident on a convex lens,after refraction converge at a point on the optic axis

on the other side of the lens. This point is the principal focus (F) of a convex lens.

Focal length

The focal length (f) is the distance from the optic centre of the lens to the principal focus.



Light rays, near and parallel to the optic axis incident on a concave lens, after refraction appear to diverge from a point on the optic axis on the same side of the lens. This point is the principal focus of a concave lens (F).

Images that can be projected on a screen are real images.

Eg:Image that is captured on a camera

Image that is formed on a cinema screen

Position of the object	Position of the image	Characteristics of the image
Beyond 2F	Between F and 2F	Diminished, inverted, real
At 2F	The image is formed at 2F on the other side	real, inverted, and the same size as the object.
Between F and 2F	The image is formed beyo nd 2F on the other side	real, inverted, and magnified
At F	At infinity (Far away)	Magnified, inverted, real
Between F and lens	same side f the lens	virtual, erect, and magnified.

when the object is placed betweenb the focus (F) and the optic centre (O).Characteristics of the image :Erect, Virtual.
Images that cannot be captured on a screen, but can only be seen are virtual images.

Position of the object	Position of the image	Characteristics of the image		
		Real/ Virtual	Inverted/ Erect	Magnified/ diminished
Between F and 2F	same side	virtual	erect	diminished
Between F and the Lens	F and lens	virtual	erect	diminished

Cartesian sign convention

All distances should be measured from the optic centre of the lens.
Distances measured in the same direction as the incident ray should be considered positive and those in the opposite direction should be considered negative.
Distances measured above the optic axis should be considered positive and those below should be considered negative.

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

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

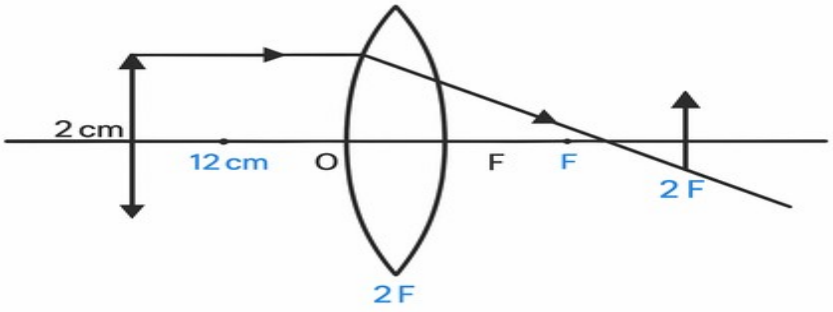
Magnification is the ratio of the height of the image to the height of the object. It has no unit.

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

An object of height 2 cm is placed on the optic axis at a distance of 12 cm from the optic centre of a convex lens. Focal length of the convex lens is 6 cm.

a) Draw a ray diagram based on the given measurements and write down the characteristics of the image.

b) Calculate the magnification by measuring the height of the image



real,inverted, same size,

Lens formula:

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

Substitute values:

$$\frac{1}{6} = \frac{1}{v} - \frac{1}{(-12)}$$

$$\frac{1}{6} = \frac{1}{v} + \frac{1}{12}$$

$$\frac{1}{v} = \frac{1}{6} - \frac{1}{12} = \frac{1}{12} \Rightarrow v = 12 \text{ cm}$$

Magnification formula:

$$M = \frac{h_i}{h_o} = \frac{v}{u} = \frac{12}{-12} = -1$$

So:

- **Image height (h_i)** = −2 cm
  (negative sign indicates inverted image)

A concave lens has a focal length of 20 cm. An object of height 2 cm is placed at a distance 30 cm from the lens on the optic axis.
a) Calculate the distance from the lens to the image.
b) How much will the magnification be? What are the characteristics of the image?

Use the **lens formula**:

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

Substitute the known values:

$$\frac{1}{-20} = \frac{1}{v} - \frac{1}{(-30)} = \frac{1}{v} + \frac{1}{30}$$

$$\frac{1}{v} = \frac{1}{-20} - \frac{1}{30} = \frac{-3-2}{60} = \frac{-5}{60} = \frac{-1}{12}$$

$$\Rightarrow v = -12 \text{ cm}$$

So, the **image is formed 12 cm on the same side** of the lens (i.e., **virtual**).

Magnification formula:

$$M = \frac{v}{u} = \frac{-12}{-30} = \frac{2}{5} = 0.4$$

$$\text{Image height } h_i = M \times h_o = 0.4 \times 2 = 0.8 \text{ cm}$$

Image Characteristics:

- **Position**: 12 cm on the same side as the object
- **Nature**: Virtual and upright
- **Size**: Smaller (0.8 cm)
- **Orientation**: Erect
- **Type**: Virtual, Upright, Diminished

Which are the instruments where lenses are

used?
Spectacles, simple microscope, compound microscope and telescope.

Power is the reciprocal of focal length. The lower the focal length, the higher the power of the lens. Power $P = \frac{1}{f}$

The SI unit of power is dioptre. It is denoted by the letter D.

Increasing the focal length of the objective lens will not be beneficial in thecompound microscope. What is the reason?
If the focal length of the objective lens is longer, the size of image will besmaller. That means the magnification will be lesser. So the objective lens should have a shorter focal length.
The main parts of the telescope are objective and eyepiece.

Let's see how the image is formed in the telescope.
• Where is the position of the object?
(far away / nearby)..far away
Focal length of the objective is
(lesser / greater)...greater
What are the characteristics of the image formed by the objective?
(small and real / large and virtual)..small and real.
Which of the lenses use this image as its object?
(objective / eyepiece)...eyepiece.
Through which lens is the image viewed?
(objective / eyepiece)...eyepiece
The image we see through the eyepiece is
(real / virtual)...virtual.

Let's Assess

1)The focal length of a convex lens is 20 cm. An object of height 3 cm is located at a distance of 60 cm from its optic centre on the optic axis.

a) Calculate the height of the image.

b) What are the characteristics of the image obtained?

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

$$\frac{1}{20} = \frac{1}{v} - \frac{1}{(-60)} = \frac{1}{v} + \frac{1}{60}$$

$$\frac{1}{v} = \frac{1}{20} - \frac{1}{60} = \frac{3-1}{60} = \frac{2}{60} = \frac{1}{30}$$

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

$$M = \frac{v}{u} = \frac{30}{-60} = -0.5$$

$$\text{Image height } h_i = M \times h_o = -0.5 \times 3 = -1.5 \text{ cm}$$

- **Nature**: **Real** (since image distance is positive)
- **Orientation**: **Inverted** (because magnification is negative)
- **Size**: **Smaller than object** (image height = 1.5 cm < 3 cm)
- **Type**: **Real, inverted, diminished**

2)The focal length of a lens is 20 cm.

a) An object is placed 30 cm away from the lens. Calculate how far the screen should be placed to get a clear image.

b) If the height of the object is 1.2 cm, what will be the height of the image appearing on the screen?

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

$$\frac{1}{20} = \frac{1}{v} - \frac{1}{(-30)} = \frac{1}{v} + \frac{1}{30}$$

$$\frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{3-2}{60} = \frac{1}{60} \Rightarrow v = 60 \text{ cm}$$

$$M = \frac{v}{u} = \frac{60}{-30} = -2$$

$$h_i = M \times h_o = -2 \times 1.2 = -2.4 \text{ cm}$$

The screen should be placed **60 cm from the lens** to get a clear image.

3)The focal length of a convex lens is 100 mm. An object of height 15 mm is located 60 mm from the optic centre on its optic axis.
a) Draw its ray diagram on a graph paper and find the position and height of the image.
b) Calculate the magnification if the distance to the object is 20 mm

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

$$\frac{1}{100} = \frac{1}{v} - \frac{1}{(-60)} = \frac{1}{v} + \frac{1}{60}$$

$$\frac{1}{v} = \frac{1}{100} - \frac{1}{60} = \frac{3-5}{300} = \frac{-2}{300} = \frac{-1}{150} \Rightarrow v = -150 \text{ mm}$$

$$M = \frac{v}{u} = \frac{-150}{-60} = 2.5$$

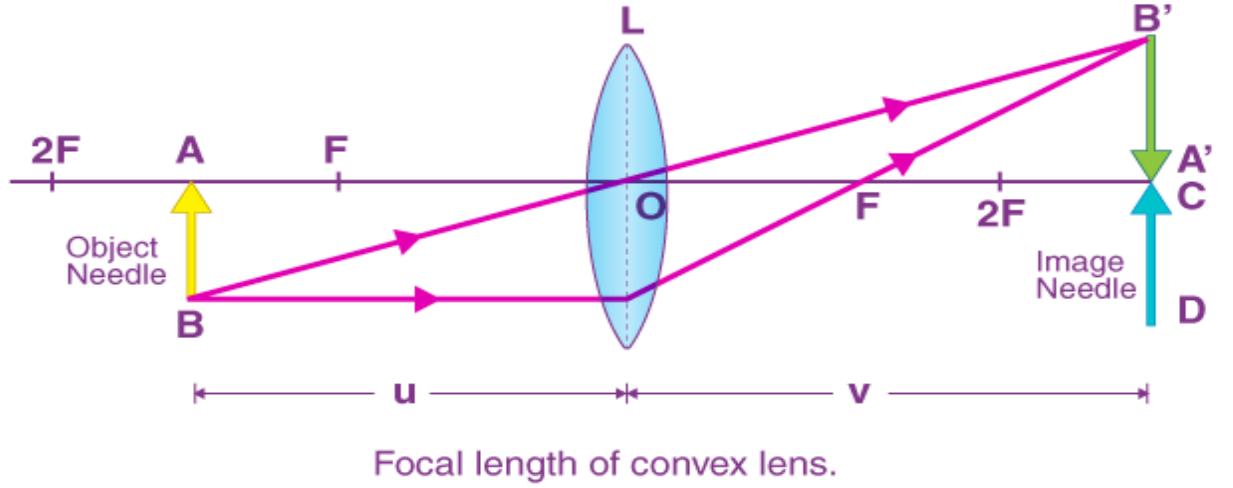
$$h_i = M \times h_o = 2.5 \times 15 = 37.5 \text{ mm}$$

Now, let's calculate magnification.

- **f** = +100 mm
- **u** = –20 mm

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \Rightarrow \frac{1}{100} = \frac{1}{v} + \frac{1}{20} \Rightarrow \frac{1}{v} = \frac{1}{100} - \frac{1}{20} = \frac{1-5}{100} = \frac{-4}{100} = -\frac{1}{25} \Rightarrow v = -25 \text{ mm}$$

$$M = \frac{v}{u} = \frac{-25}{-20} = 1.25$$



Focal length of convex lens.

4)Four statements are given regarding the image formed by a concave lens. Find and choose the correct answer.

i. It will be diminished and inverted

ii. It will be diminished and virtual

iii. It will be magnified and virtual

iv. It will be diminished and erect

a) Only the second statement is true

b) Only the first statement is true

c) Second statement and fourth statements are true

d) Only the third statement is true

Concave lenses always form images that are smaller (diminished) and virtual(ii)

5)A concave lens has a focal length of 50 cm. What will be its power?

a) +2 D
b) +0.5 D
c) −2 D
d) −0.5 D

- Focal length, $f = -50\,\text{cm}$

$$P = \frac{100}{-50} = -2\,\text{D}$$

6)Find the most appropriate statement related to a telescope.

a) The objective lens has a shorter focal length and the eyepiece lens has a longer focal length.
b) The objective lens has a longer focal length and the eyepiece has a shorter focal length.
c) Objective lens and eyepiece lens are concave lenses.
d) Objective lens will be concave lens and eyepiece lens will be convex lens.

Ans:The objective lens has a longer focal length and the eyepiece has a shorter focal length.

7)When an object is placed in front of a lens, the image formed is inverted.

a) Is it real or virtual?
b) What will you do if you want another image of this obtained image to be real, erect and of the same size?

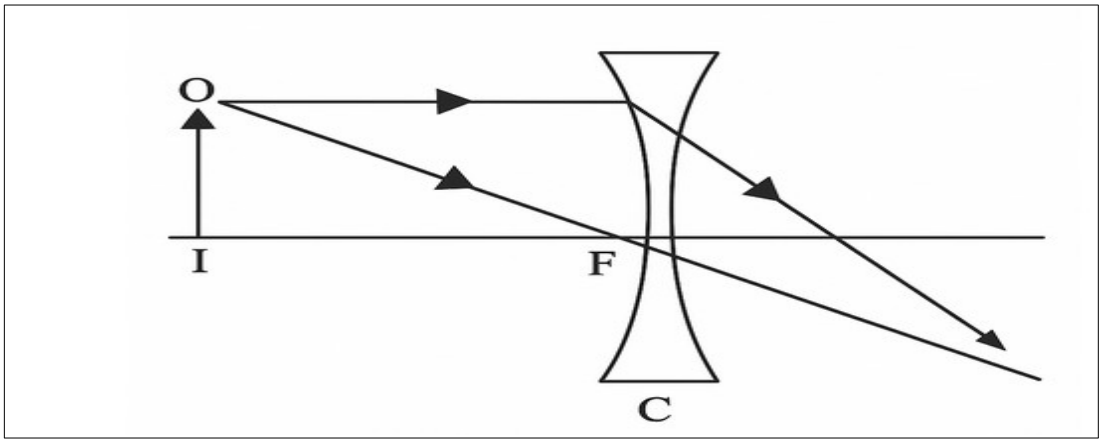
Ans:a)virtual b)Use a **plane mirror** to reflect the inverted real image, so the reflected image becomes **real, erect, and of the same size**.

8)When an object is placed at the principal focus of a lens, an image that is erect and diminished is obtained.

a) What kind of lens is this?
b) Draw the ray diagram of the image formation.

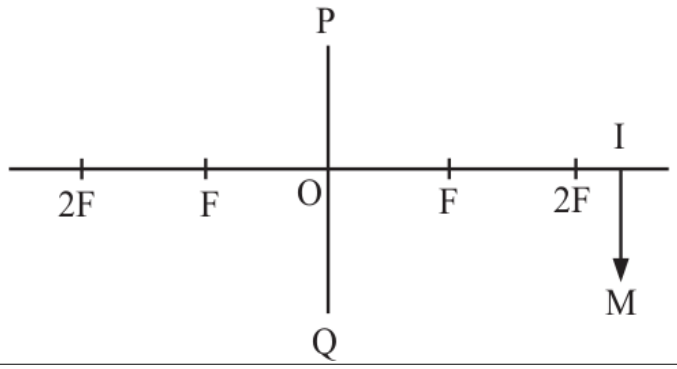
a) Concave lens

b)



9)

The image (IM) obtained when an object is placed in front of a lens is depicted.

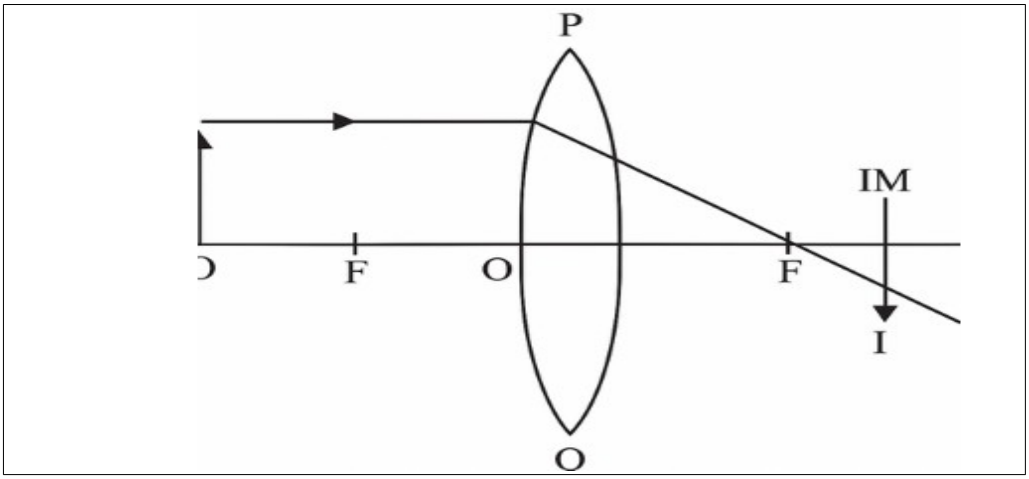


a) If PQ is a lens in the figure, what type of lens does PQ represent?

b) Complete the ray diagram and find the position of the object.

c) The height of the object is ..... than the height of the image (greater / lesser).

a)Convex lens
b)Object is placed between F and 2F
c) Greater



10)

Match the items in the columns A, B and C appropriately.

A	B	C
Magnification	$\frac{1}{f}$	h_i negative
Power of lens	Inverted image	$\frac{v}{u}$
Real image	$\frac{h_i}{h_o}$	h_i positive
	Erect image	dioptre