LENS - A part of a refracting material

CONVEX LENS
↓
. Thicker at the middle.
. It is a converging lens.

CONCAVE LENS
↓
. Thicker at the edges.
. It is a diverging lens.

 - Double Convex lens

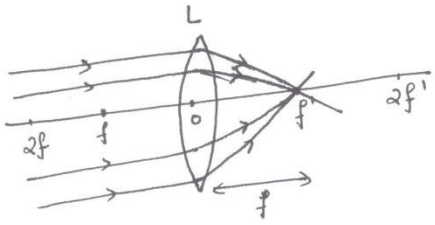
 - Plano Convex lens

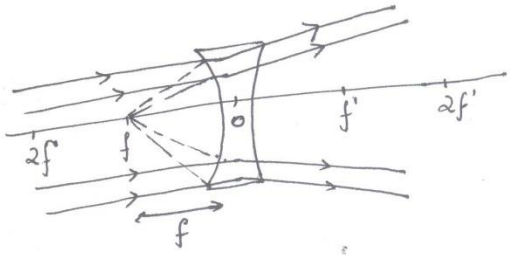
 - Concavo-convex lens

 - Double Concave lens

 - Plano Concave lens

 - Convexo-Concavo lens



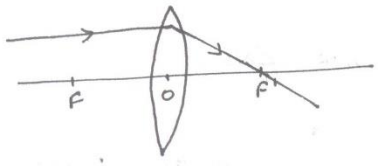


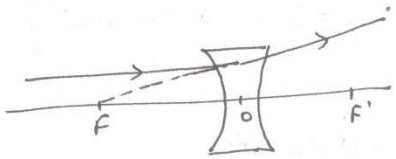
PRINCIPAL FOCUS - A point where all light rays travelling parallel to principal axis actually converge to (in case of Convex lens) or appear to diverge from (in case of Concave lens).

Distance b/w Principal focus and Optical centre is called FOCAL LENGTH.

IMAGE FORMATION BY SPHERICAL LENS

1)





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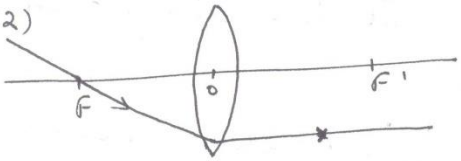

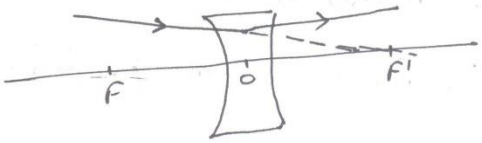

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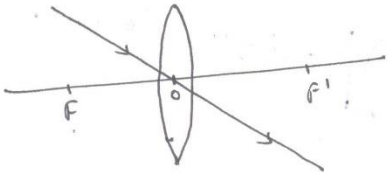


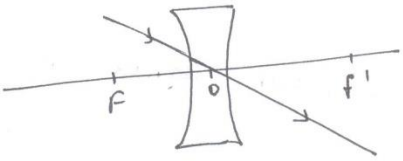
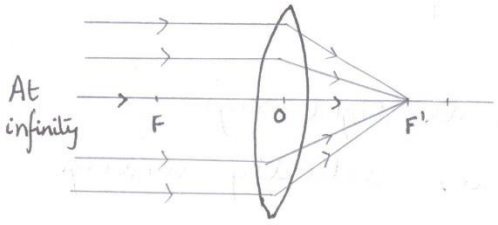
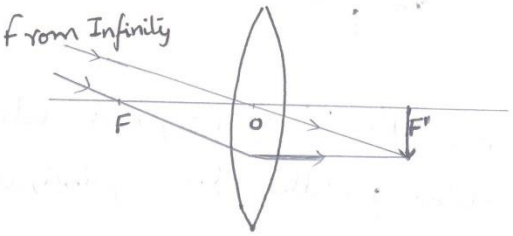


IMAGE FORMATION BY CONVEX LENS

1) When object is at infinity -



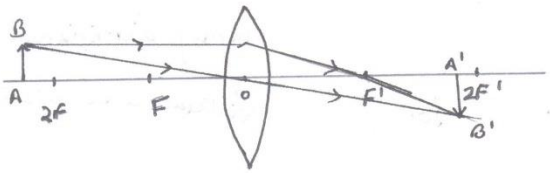


Nature of Image - At F.

Diminished.

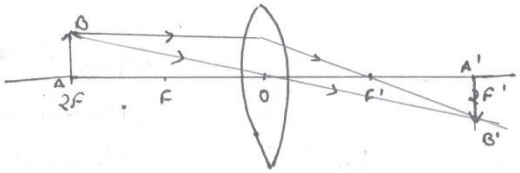
Real and inverted.

2) When an object is beyond 2f.



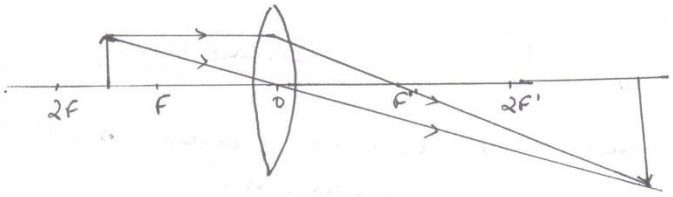
Nature of Image -
Real and inverted
Smaller in size
B/w F' and 2F'.

3) When an object is situated at 2F.



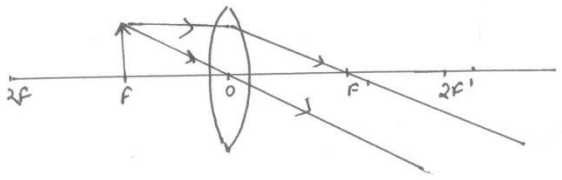
Nature of image -
At C
Same Size
Real and
inverted

4) When an object is b/w F and 2F.



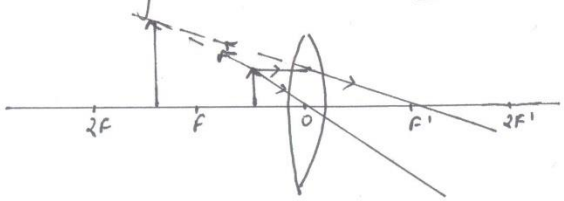
Nature of image -
Beyond 2F'
Real, inverted
Highly enlarged

5) When an object is at F



Nature of image -
At infinity
Real and inverted
Large

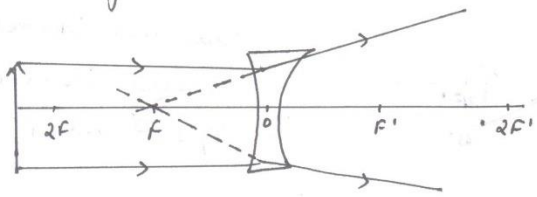
6) When an object is b/w F and Optical centre -



Nature of image -
On the same side of
the lens
Virtual and erect
Enlarged

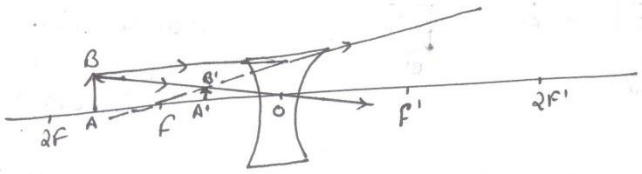
IMAGE FORMATION BY CONCAVE LENS

(a) When object is at infinity



At F
Highly diminished
Virtual and erect

(b) when object is b/w Infinity and O -



B/w F & O
Diminished
Virtual and Erect.

Uses -

Convex lens

1) Small focal length is used as a magnifying glass. Used by watchmakers, jewellers etc.
2) Used to Correct Long sightedness
3) Used in film projectors
4) Used in Searchlights
5) Human eye lens is a Convex lens:
6) Used in microscope and telescope.

Concave lens

1) Used to correct short-sightedness.
2) Used in Galileo's telescope

LENS FORMULA -

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

$$\frac{1}{\text{image distance}} - \frac{1}{\text{object distance}} = \frac{1}{\text{focal length}}$$

Linear Magnification -

$$m = \frac{\text{Ht. of image}}{\text{Ht. of object}} = \frac{H'}{H}$$

$$\boxed{m = \frac{v}{u} = \frac{h'}{h}}$$

NOTE - Negative Sign magnification means image is real and inverted.

Positive Sign magnification means image is virtual and erect.

1) If $m > 1$ means $h' > h$

2) If $m < 1$ means $h' < h$

3) If $m = 1$ means $h' = h$

Magnification of Concave lens is +ve (virtual image)

" of Convex lens is

+ve ⟶ virtual image

-ve ⟶ real and inverted image

POWER -

It is the degree of convergence or divergence of light rays.

$$\text{Power of lens } (P) = \frac{1}{\text{focal length of lens } (f)}$$

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

SI unit -

SI unit of power is dioptre 'D'.

$$P = \frac{1}{(1\text{m focal length})} = 1 \text{ dioptre} = 1\,D$$

$$1\,D = 1\,m^{-1}$$

Power of convex lens is taken as positive (+ve).

Power of concave lens is taken as negative (-ve).

Power of Combination of lenses -

$$P = P_1 + P_2 + \cdots$$

or,
$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \cdots$$

NOTE - If convex lens of power P_1 is placed in contact with concave lens of power P_2, then lens combination behaves as convex lens $\rightarrow$ $P = P_1 - P_2$ $(P_1 > P_2)$

and as a concave lens $\rightarrow$ $P = P_2 - P_1$ $(P_2 > P_1)$

Lens formula -

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

Sign Convention -

Convex Lens

$u = -ve$

$v = +ve$ (real image)

$v = -ve$ (virtual image)

$f = +ve$

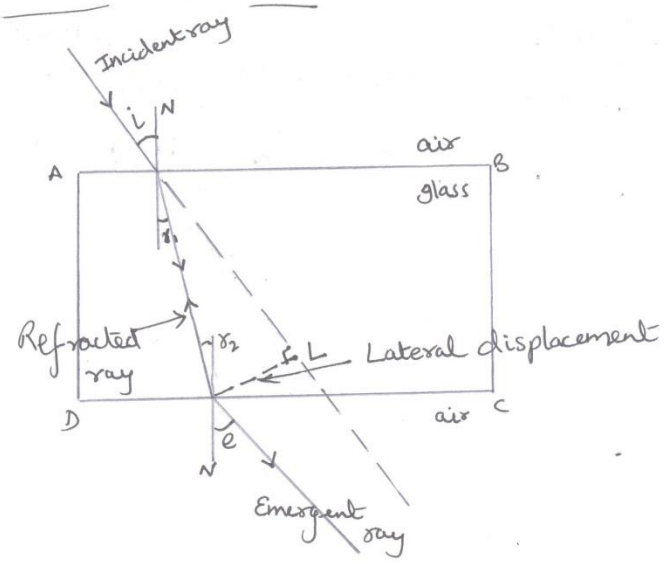
Concave Lens

$u = -ve$

$v = -ve$ (virtual image)

$f = -ve$

Refraction through a Glass Slab -



Lateral Displacement -

Distance b/w produced incident ray and the emergent ray

$L r_1 = L r_2$

$L i = L e$

Examples of Refraction of light -

1) A pencil partly immersed in water in a glass tumbler appears to be displayed at interface of air and water.

2) If a coin is placed at bottom of a tumbler filled with water, the apparent depth of coin appears to be less than its true depth.

$$\text{Refractive index of water wrt air } \mu_{wa} = \frac{\text{Real depth}}{\text{Apparent depth}}$$

3) When thick glass slab is placed over some printed matter, it appears to (the letters) be raised when viewed from glass slab.

Numericals -

1) A convex mirror of radius of curvature 1.6m has an object placed at a distance of 1m from it. Find position of image and magnification.

(Ans: $v = \frac{4}{9}$ m, $m = \frac{4}{9}$)

2) A converging lens is to project image of a lamp 4 times the size of the lamp on a wall at a distance of 10m from the the lamp. Find focal length of the lens.

(Ans: $f = \frac{8}{5}$ m)

3) What is the focal length of combination of lenses formed with lenses having powers of +2.50D and −3.75D?

(Ans: $f = -0.8$ m or 80cm)

4) A convex lens of focal length 20cm is placed in contact with a concave lens of focal length 30cm. Calculate focal length of combination. What is its power? (Ans: $f = +60$cm, $P = 1.67$D)

NUMERICAL-BASED WORKSHEET

G. Solve the Following Numerical Problems

1. A light ray is incident on a plane mirror inclined at an angle of 60° from the surface of the mirror. Find the values of angle of incidence and angle of reflection.
2. An object is situated at a distance of 18 cm from a plane mirror. What is the distance between the object and its image formed by the mirror?
3. The radius of curvature of a convex mirror is 48 cm. What is its focal length?
4. The focal length of a concave mirror is 12.5 cm. Find the value of its radius of curvature.
5. An object is placed at a distance of 30 cm from the pole of a concave lens of focal length 15 cm. Find the position of the image. What is its magnification?
6. Find the position, nature and size of the image of an object of length 2 cm placed at a distance of 18 cm from a concave mirror of focal length 12 cm.
7. Three times magnified real image of an object is formed by a concave mirror when the object is placed 20 cm from it. Where is the image formed? Also, calculate the focal length of the given mirror.
8. A concave mirror has a radius of curvature of 1.2 m and a person stands in front of it at a distance of 40 cm from the mirror. Where is the image of the person formed?
9. An object is placed at a distance of 40 cm in front of a convex mirror of radius of curvature 20 cm. Calculate the position and magnification of the image.
10. A light ray travelling in air is incident on the surface of a dense flint glass slab. If angles of incidence and refraction are 60° and 30° respectively, then calculate the refractive index of dense flint glass w.r.t. air.
11. Refractive index of a transparent fluid w.r.t. air is 1.40. Calculate the refractive index of air w.r.t. that fluid.
12. Find the speed of light in a transparent medium of refractive index 1.36, if the speed of light in air is 3×10^8 m s^{-1}.
13. Speeds of light in air and a given transparent medium are 3.0×10^8 m s^{-1} and 2.1×10^8 m s^{-1} respectively. Calculate the refractive index of the given medium.
14. An object 5 cm high is placed at a distance of 20 cm from a converging lens of focal length 10 cm. Find the position, nature and size of the image.
15. When an object of height 2 cm is placed at 12 cm from a convex lens, its erect and three times magnified image is formed by the lens. Find the focal length of the lens.
16. Find the position of an object held in front of a convex lens of focal length 12 cm so as to form a real and 4 times magnified image.
17. A concave lens of focal length 24 cm forms a virtual and erect image of an object. If the image is formed 8 cm away from the lens, then find the distance of the object from the lens.
18. A 5.0 cm tall object is held at a distance of 50 cm from a concave lens of focal length 20 cm. Find the position, nature and height of the image.
19. Focal length of a diverging lens is 25 cm. What is its power?
20. Power of a converging lens is +0.50 D. What is the focal length of the given lens?
21. A convex lens has a power of +1.5 D. Lens of what power should be combined with it so that the net power of the lens combination is +1.75 D?