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CLASS X - SCIENCE

LIGHT - REFLECTION AND REFRACTION - I

PRASHANT KIRAD

TOPICS TO BE COVERED

- What is light?
- Reflection
- Spherical Mirrors and Its types
- Rules to obtain image
- Image formation by Concave and Convex Mirror
- Sign Convention
- Uses of Spherical Mirrors
- Mirror formula & Magnification

WHAT IS LIGHT?

Light is a form of energy that enables us to see objects around us.

Light itself is not visible otherwise, the universe wouldn't appear dark.

REFLECTION OF LIGHT

Reflection of Light: The phenomenon of bouncing back of light rays when they strike the surface of an object is called reflection of light.

A ray of light is the straight line along which the light traveled and a bundle of light rays is called a beam of light.

Numerical → 2 Q

→ Theory

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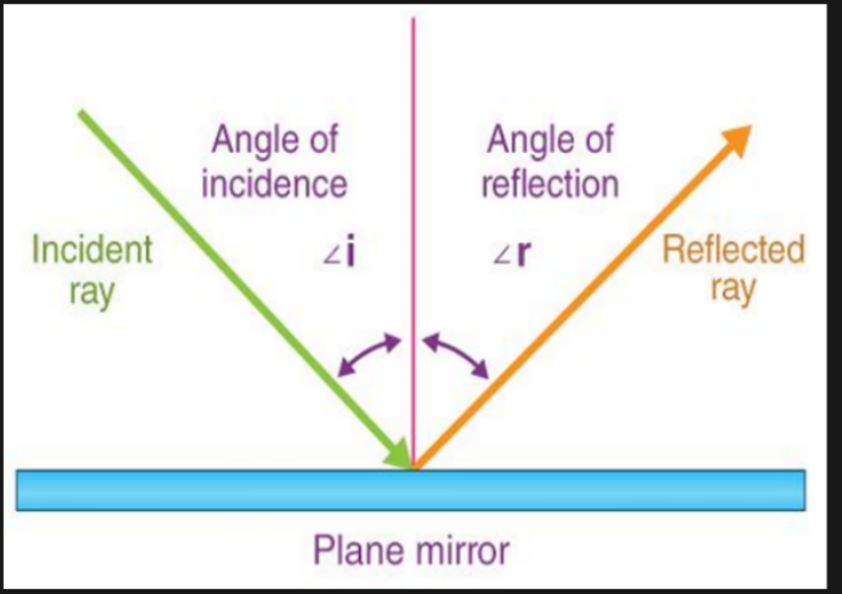
REFLECTION OF LIGHT

Incident Ray: The incoming ray of light that strikes the surface is called the incident ray.

Reflected Ray: The ray that bounces off the surface is called the reflected ray.

Normal: The imaginary line perpendicular to the surface at the point of incidence is called the normal.



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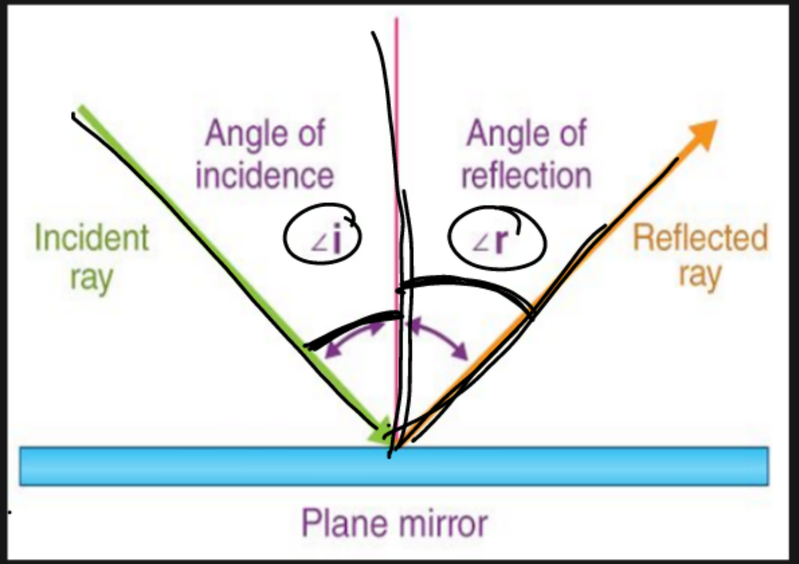
LAW OF REFLECTION

1. **The Angle of incidence (∠i) = The angle of reflection (∠r)**
2. **The incident ray, the reflected ray and the normal to the mirror at the point of incidence all lie in the same plane.**



LATERAL INVERSION

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Phenomenon where an image appears reversed from left to right.

This effect is commonly seen in mirrors, where your right hand appears as the left hand in the mirror image.

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CHARACTERISTICS OF A IMAGE FORMED BY A PLANE MIRROR

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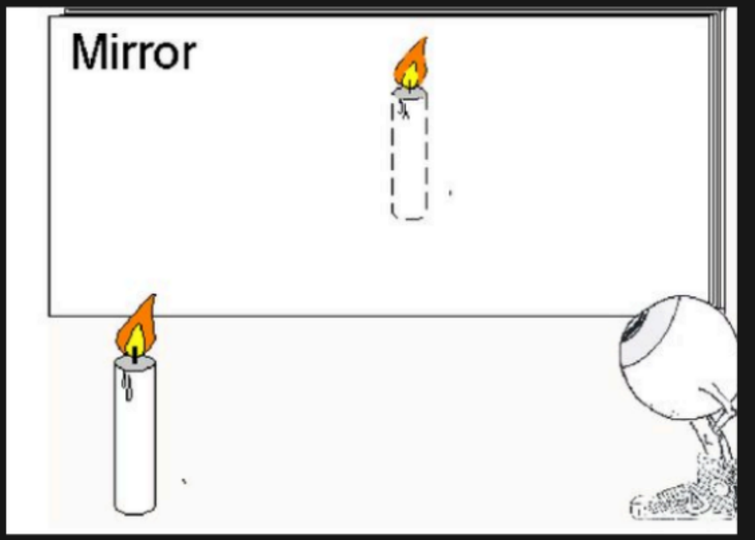
- The image obtained is virtual.
- The image is laterally inverted.
- The image is erect.
- The size of the image is the same as the size of the object.
- The distance between the image obtained from the mirror is the same as the distance between the object from the mirror.



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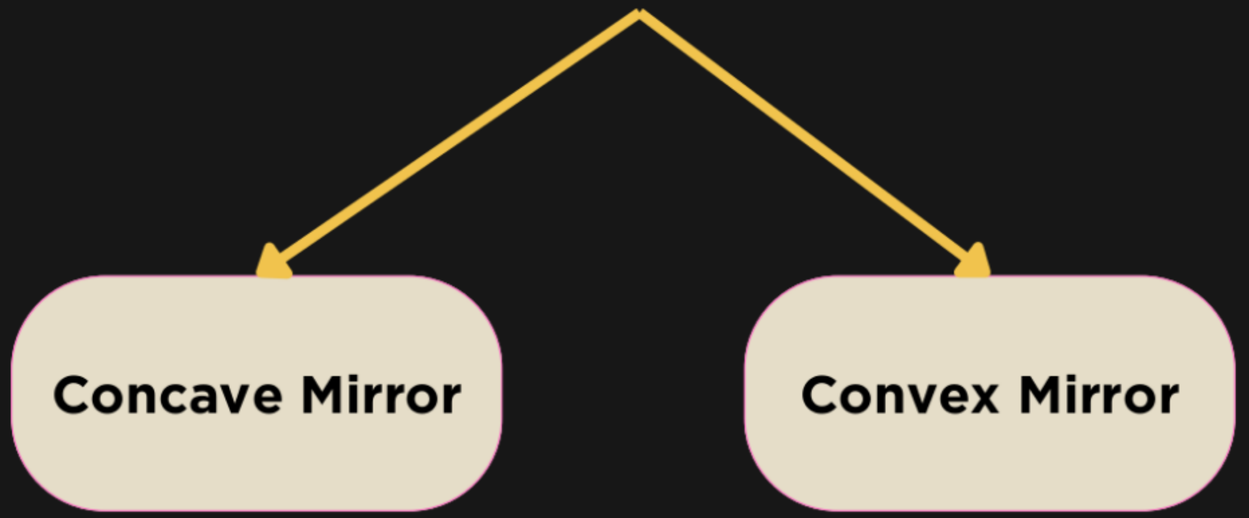
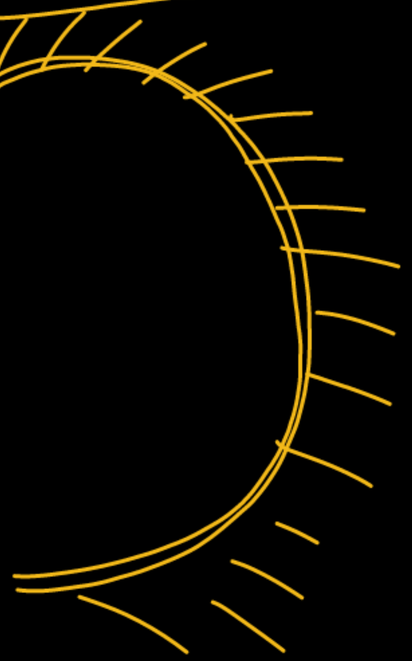
SPHERICAL MIRROR

Spherical mirrors are mirrors whose reflecting surfaces are part of a sphere.

TYPES OF SPHERICAL MIRRORS



Concave



Convex

IMPORTANT TERMS

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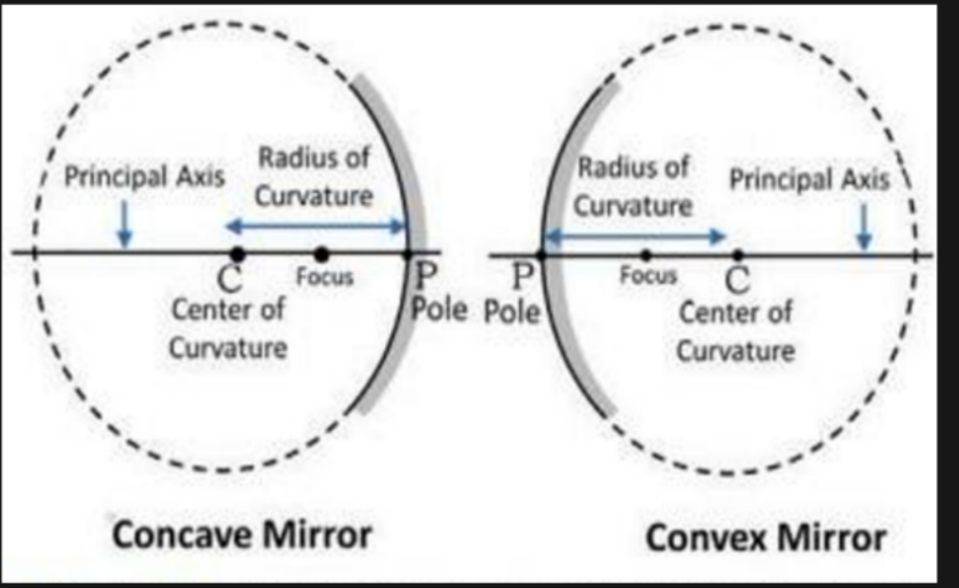
Principal axis: The imaginary line passing through the center of the mirror, the focal point, and the object.

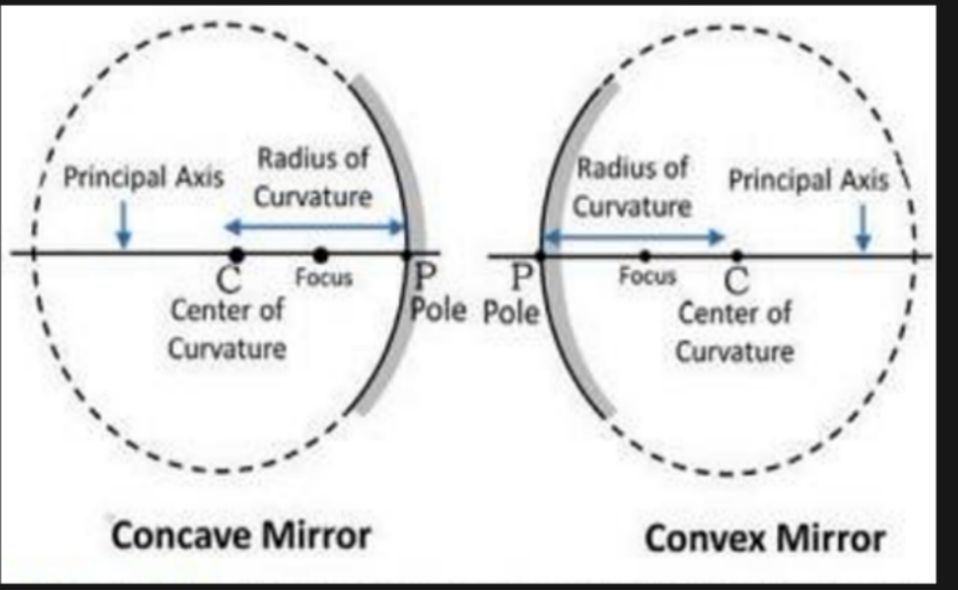
Aperture: is the effective diameter of the mirror's reflecting surface

Pole (P): The point of intersection of the aperture of the mirror and the principal axis is called as the pole of the mirror.



Centre of Curvature (C): The center of the imaginary sphere of which the mirror is a part.

Radius of Curvature: The distance between the center of curvature and pole of the mirror.



Focal point (F): the point where light rays parallel to the principal axis converge (concave mirror) or appear to diverge from (convex mirror).

Focal length (f): The distance between the mirror's surface and its focal point OR half of the radius of curvature distance

RULES TO OBTAIN IMAGE

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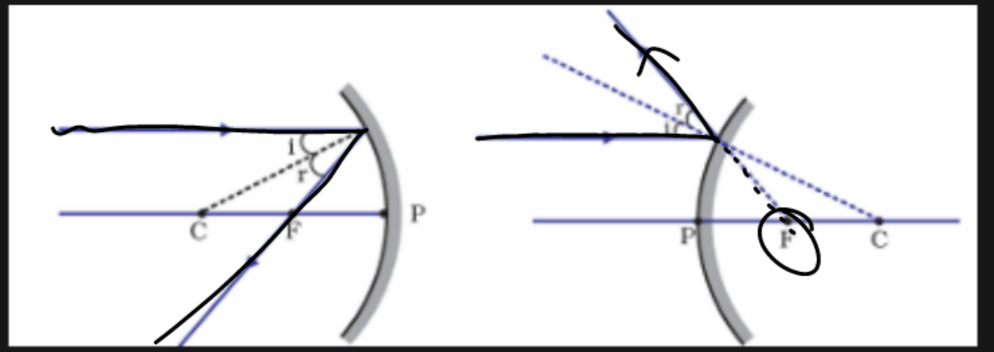
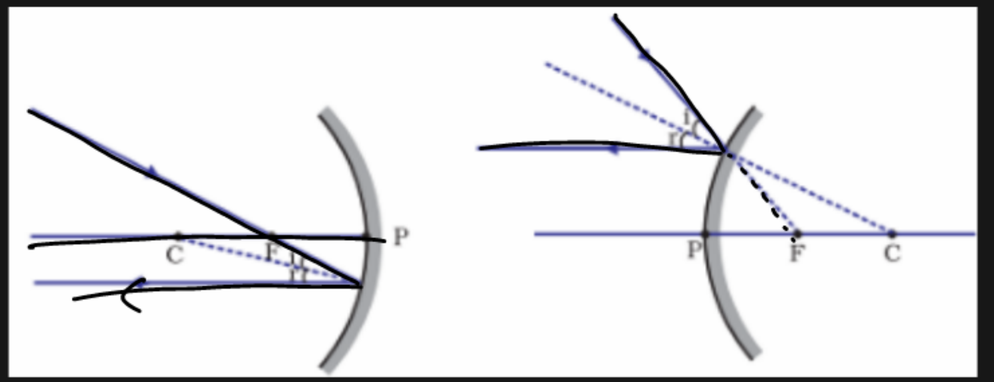
Rule 1: A ray parallel to principal axis will pass through focus after reflection.



Rule 2: A ray passing through the principal focus will become parallel to principal axis after reflection.



RULES TO OBTAIN IMAGE

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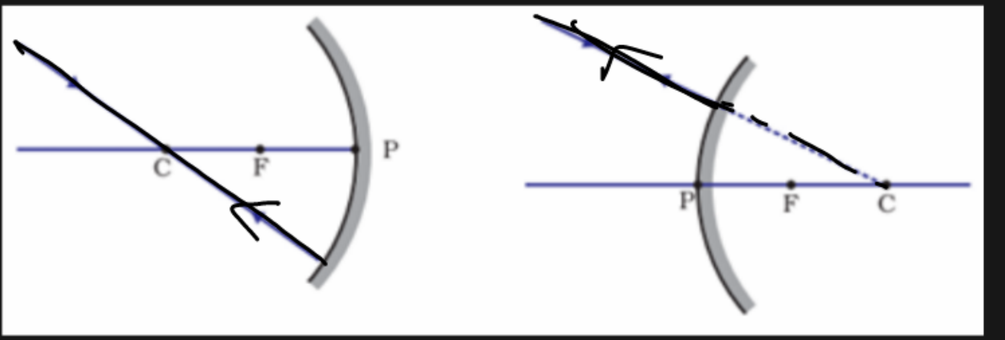
Rule 3: A ray passing through center of curvature will follow the same path back after reflection.



Rule 4: Ray incident at pole is reflected back making same angle with principal axis.

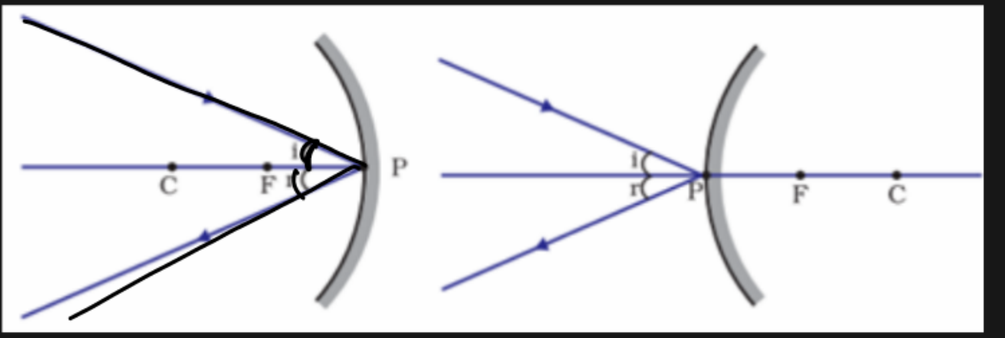


IMAGE FORMATION BY CONCAVE MIRROR

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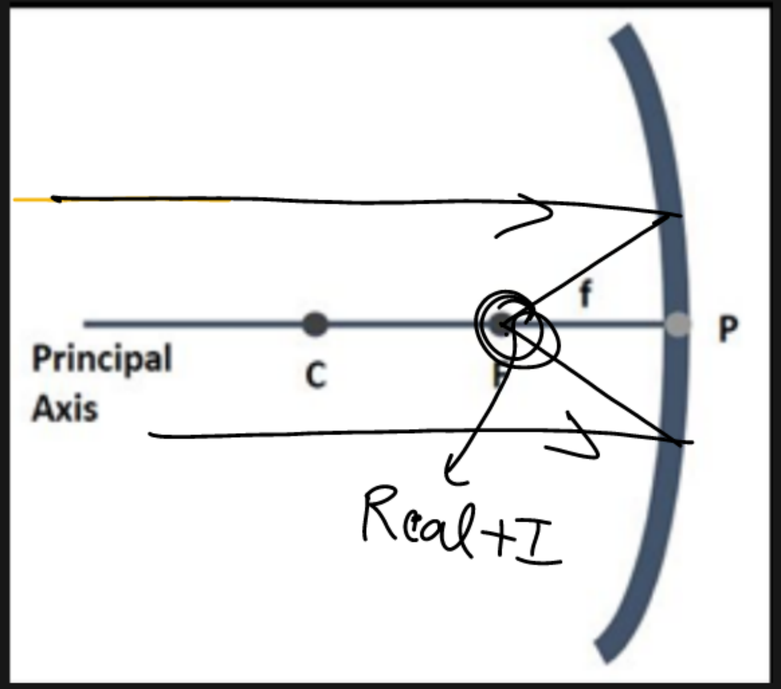
1. Object at Infinity



Size of Image - Highly diminished, point-sized

Nature of Image - Real and Inverted

IMAGE FORMATION BY CONCAVE MIRROR

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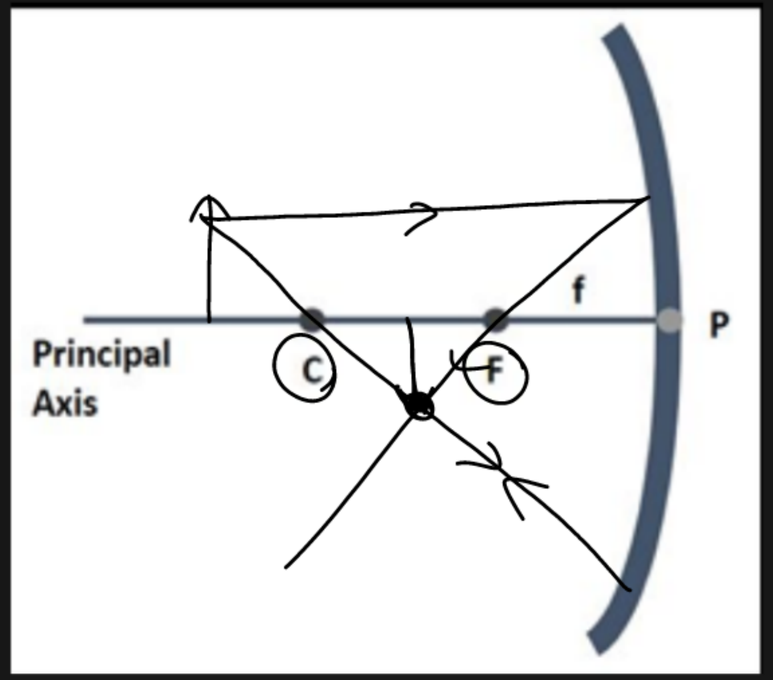
2. Object beyond C



Size of Image - Diminished

Nature of Image - Real and Inverted

IMAGE FORMATION BY CONCAVE MIRROR

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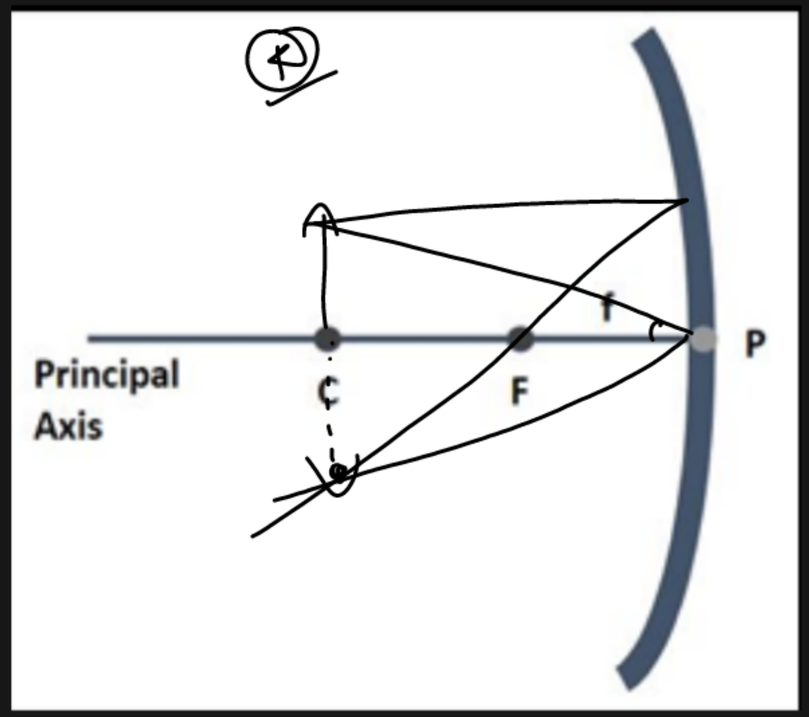
3. Object at C



Size of Image - Same size

Nature of Image - Real and Inverted

IMAGE FORMATION BY CONCAVE MIRROR

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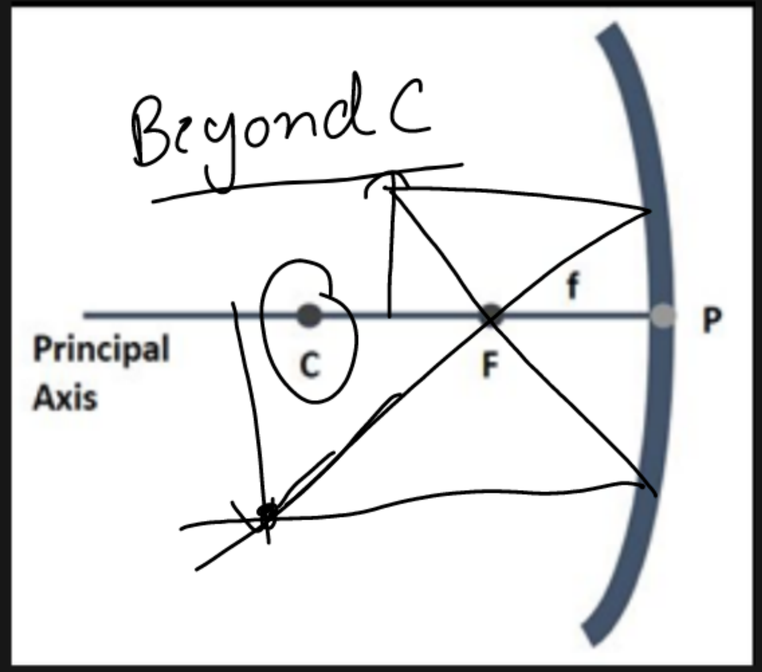
4. Object between C and F



Size of Image - Enlarged

Nature of Image - Real and Inverted

IMAGE FORMATION BY CONCAVE MIRROR

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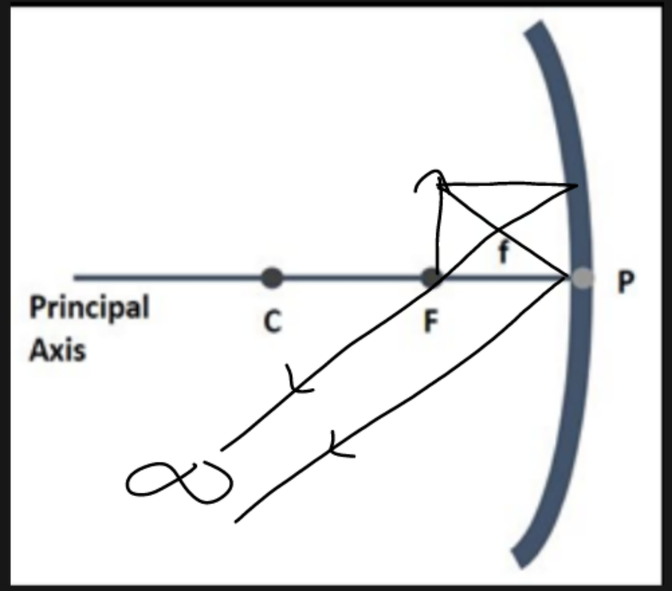
5. Object at F



Size of Image - Highly enlarged

Nature of Image - Real and Inverted

IMAGE FORMATION BY CONCAVE MIRROR

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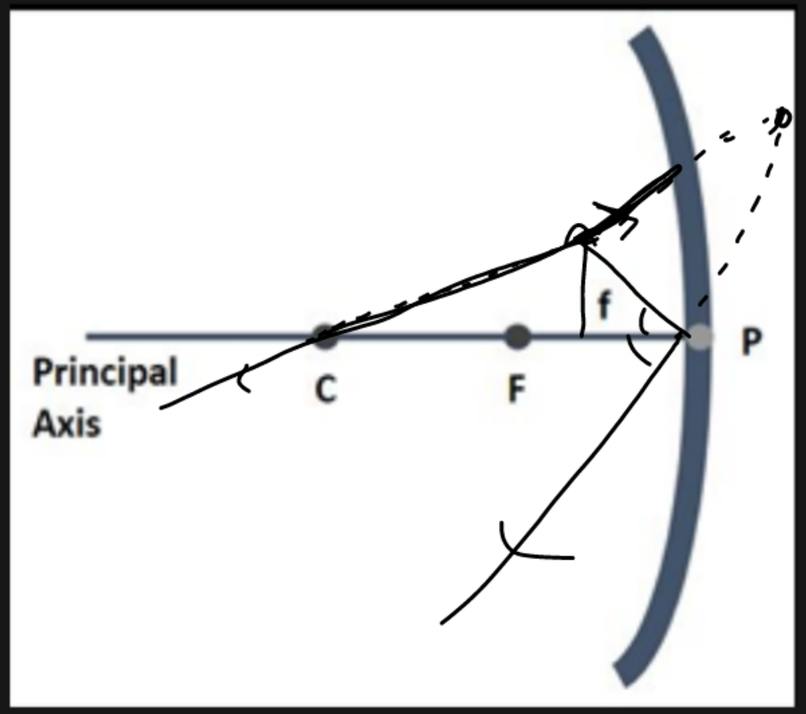
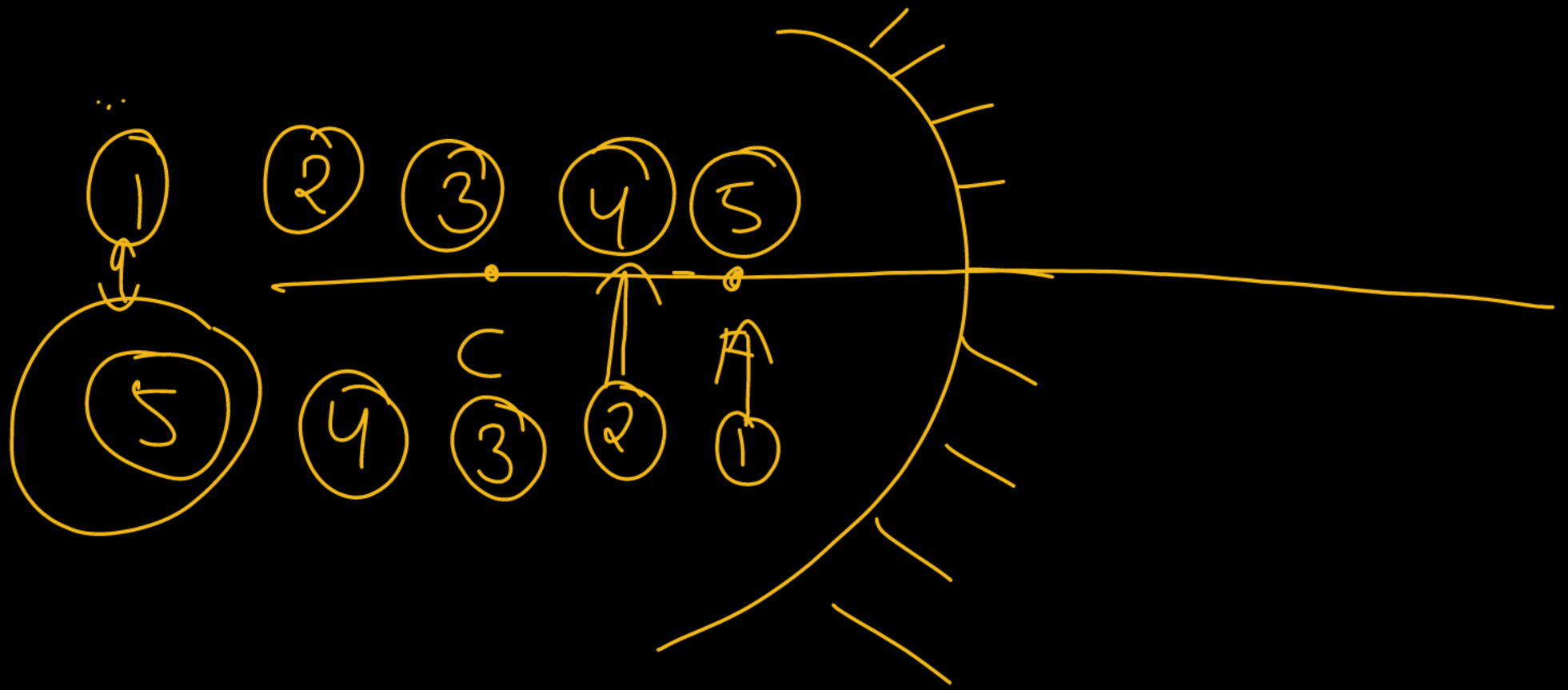
6. Object between F and P



Size of Image - Enlarged

Nature of Image - Virtual and Erect


1
2
3
4
5
5
4
3
2
1

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USES OF CONCAVE MIRROR

Shaving mirror

At dentist's

Search lights

IMAGE FORMATION BY CONVEX MIRROR

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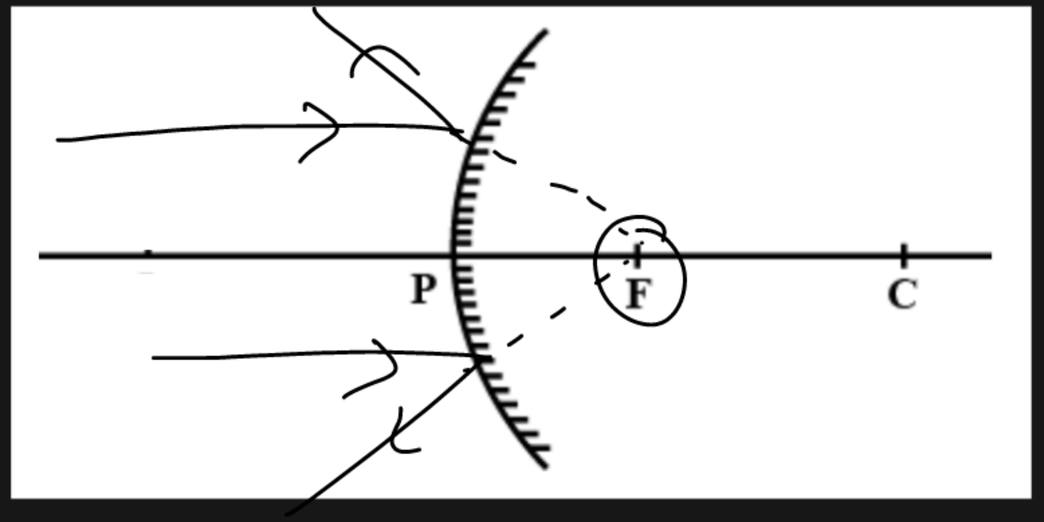
1. Object at Infinity



Size of Image - Highly diminished, point-sized

Nature of Image - Virtual and erect

IMAGE FORMATION BY CONVEX MIRROR

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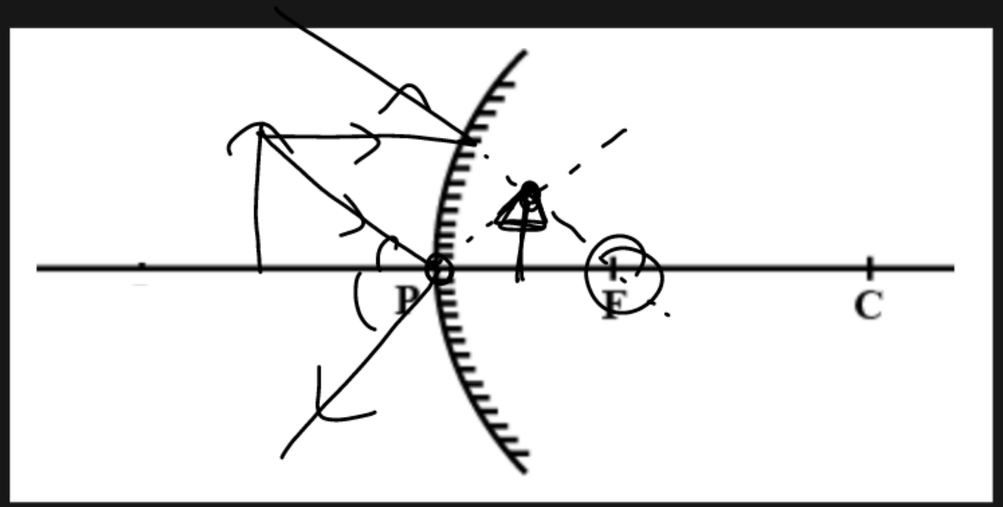
2. Object at finite distance



Size of Image - Diminished

Nature of Image - Virtual and erect

IMAGE FORMATION BY CONVEX MIRROR

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Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F, behind the mirror	Highly diminished, point-sized	Virtual and erect
Between infinity and the pole P of the mirror	Between P and F, behind the mirror	Diminished	Virtual and erect

USES OF CONVEX MIRROR

Rear-view mirror

Security mirror

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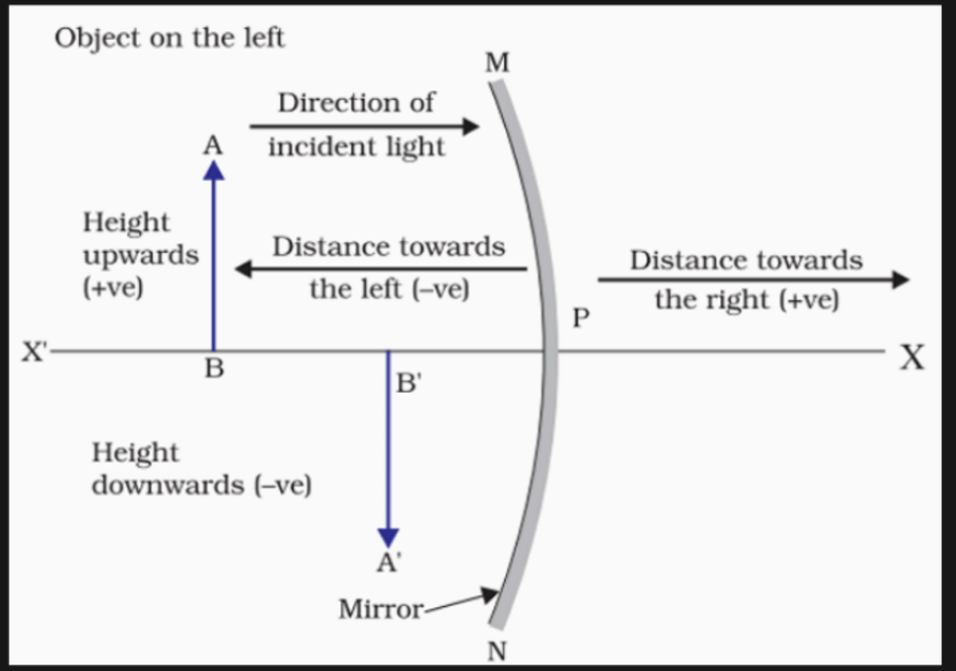
SIGN CONVENTION

(i) The object is placed to **the left of the mirror.**

(ii) All distances parallel to the principal axis are measured **from the pole of the mirror**.

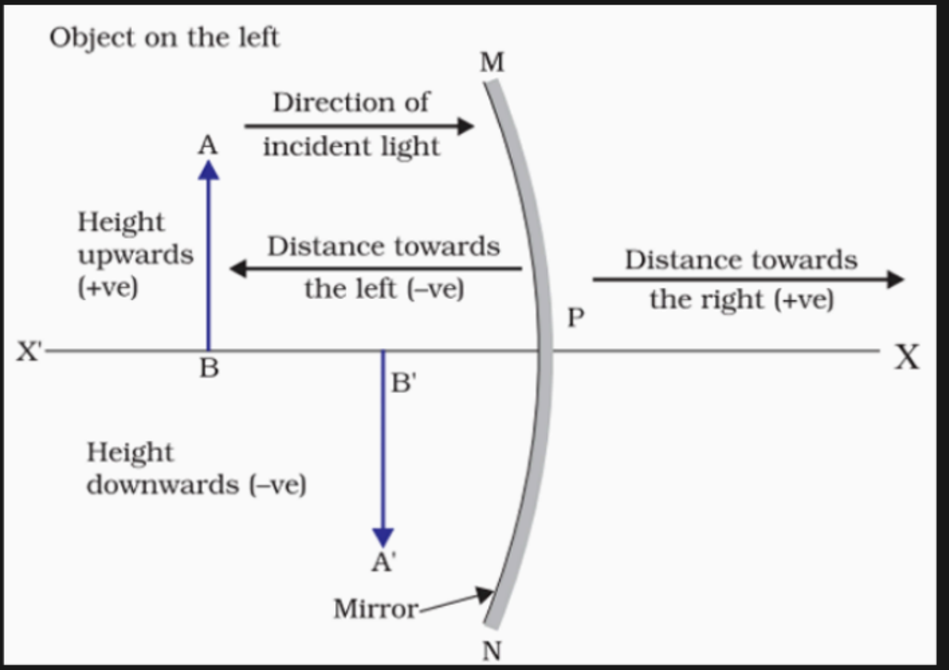
(iii) All distances measured in the *direction of incident ray (along + X-axis) are taken as positive* and those measured against the *direction of incident ray (along – X-axis) are taken as negative.*



SIGN CONVENTION

(iv) Distance measured perpendicular to and above the principal axis are taken as ***positive***.

(v) Distances measured perpendicular to and below the principal axis are taken as ***negative.***



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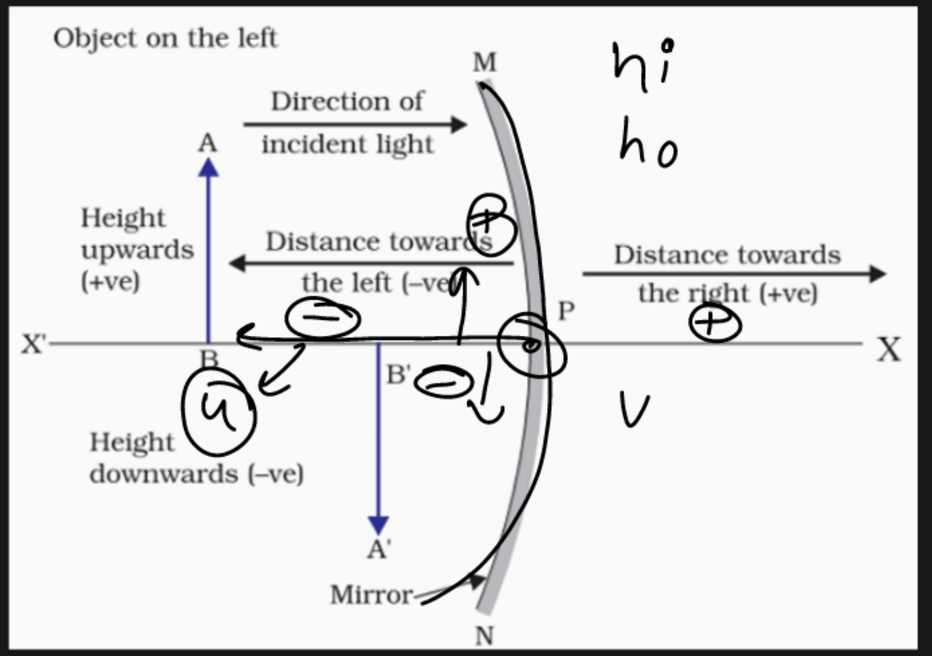
SIGN CONVENTION

Remember

Object distance = 'u' is always positive

Focal length of concave mirror = Negative

Focal length of convex mirror = Positive



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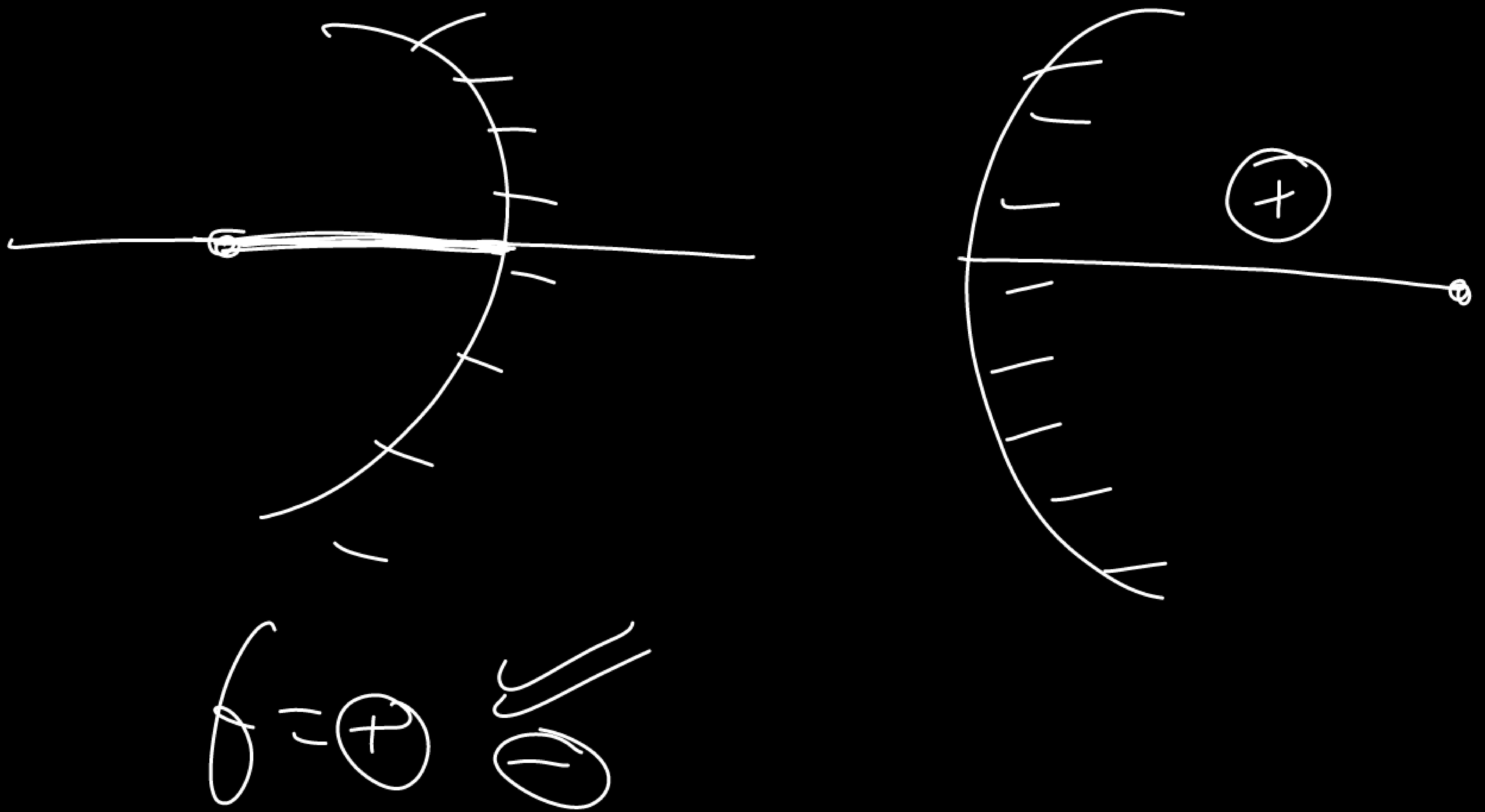
MIRROR FORMULA

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

Focal

The mirror formula relates the object distance (u), image distance (v), and focal length (f) of a spherical mirror.

This formula applies to both concave and convex mirrors.


+
f = +
−

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Q.A student has a concave mirror of 20 cm focal length and he wants to see an erect image of his face in the mirror. What should be the range of distance of the mirror from his face? State the nature and size of the image he is likely to observe.

20 ⟷ 0

θ ⟶ P

less than 20 cm

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Q. An object is placed 25 cm from a concave mirror and the image is formed at 50 cm from the mirror. Calculate the focal length

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

$= -\frac{1}{25} + \left(-\frac{1}{50}\right)$

$= -\frac{(2+1)}{50}$

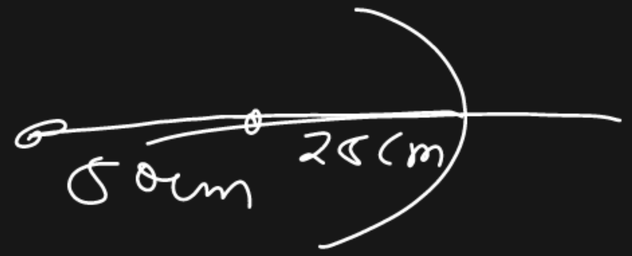
$= -\frac{3}{50}$

$f = -\frac{50}{3}$ cm

$\theta = 0$

$u = -25$

$v = -50$ cm



5	50, 25
5	10, 5
2	2, 1
	1, 1
	1

$h_0 = 10\,cm$

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Q. An object is placed 12 cm in front of a concave mirror of focal length 8 cm. Where is the image formed? Is it real or virtual?

4	12, 8
2	3, 2

$u = -12\,cm$

$f = -8\,cm$

$v = -24$

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

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

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

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

$$\frac{-1}{24} = \frac{1}{v}$$

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

$$= -\left[\frac{-24}{-12}\right]$$

$$= \boxed{-2}$$

$$\frac{h_i}{h_0} = -2 \Rightarrow \boxed{-20\,cm}$$

Q → $m = -2$

$u = -10\,cm$

$$m = -\frac{v}{u} \Rightarrow -2 = -\left[\frac{v}{10}\right]$$

$$-20 = v$$

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

$$= -\frac{1}{20} - \frac{1}{10}$$

$$= \frac{-1-2}{20} = \frac{-3}{20}$$

$$-\frac{20}{3}$$

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MAGNIFICATION

It gives us information about the image in terms of how large or small is the image formed.

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

$$m = \frac{Height\ of\ image\ (h')}{Height\ of\ object\ (h)}$$

$$= \frac{h'}{h} = -\frac{v}{u}$$

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

Magnification refers to the *ratio of the height of an image to the height of an object*.
It is denoted by m.

Real Large

$m = 1 \rightarrow$ Large

$m = > 1 \rightarrow$ Small

$m = -\ \rightarrow$ Real + I

$m = +\ \rightarrow$ Virtual + ϵ

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MAGNIFICATION

- If m>1, the Image size is greater than that of the object
- If m<1, the image size is less than the object size.
- If m is negative, the image formed is real and inverted.
- If m is positive, the image formed is virtual and erect.

$$m = \frac{Height\ of\ image\ (h')}{Height\ of\ object\ (h)}$$

$$= \frac{h'}{h} = -\frac{v}{u}$$

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Q. The magnification produced by a spherical mirror is -3. List four information's you obtain from this statement about the mirror/ image

$m = -3$ → 2 angle

→ 3 times

Real

Inverted

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

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1. The focal length of a plane mirror is

(a) 0

(b) infinite

(c) 25 cm

(d) -25 cm

Let's do this!

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C

2. An object is placed at a distance of 40cm in front of a concave mirror of a focal length of 20 cm. The image produced is:

(a) virtual and inverted

(b) real and erect

(c) real, inverted and of the opposite size as that of the object

(d) real, inverted and of the same size as that of the object

Let's do this!

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3. The angle of incidence is 30°. What is the angle of reflection?

(a) 60°

(b) 30°

(c) 0°

(d) 90°

Let's do this!

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4. A concave mirror forms a virtual image when the object is placed:

(a) At infinity

(b) Beyond the center of curvature

(c) Between focus and pole

(d) At the center of curvature

Let's do this!

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5. If the magnification produced by a mirror is +2, the image formed is:

(a) Real and inverted

(b) Real and erect

(c) Virtual and erect

(d) Virtual and inverted

V + E

Let's do this!

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6. An object is placed 20 cm from a convex mirror of focal length 10 cm. The image distance is:

(a) 6.67 cm

(b) -10 cm

(c) -13.33 cm

(d) -15 cm

$u = -20$

$f = +10$

$\frac{1}{10} = \frac{1}{v} - \frac{1}{20}$

$\frac{1}{10} + \frac{1}{20} = \frac{1}{v}$

$\frac{3}{20}$

$\boxed{\frac{20}{3}}$

Let's do this!

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7. An object is placed at a distance of 30 cm in front of a convex mirror of focal length 15 cm. Write four characteristics of the image formed by the mirror.

Answer. (i) Small in size.

(ii) Image is always erect.

(iii) Always forms behind the mirror between focus and pole.

(iv) Virtual.

Let's do this!

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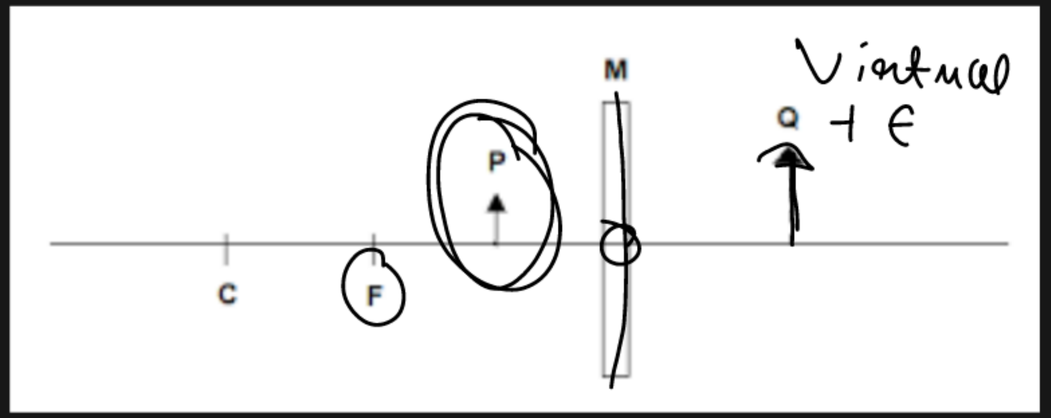
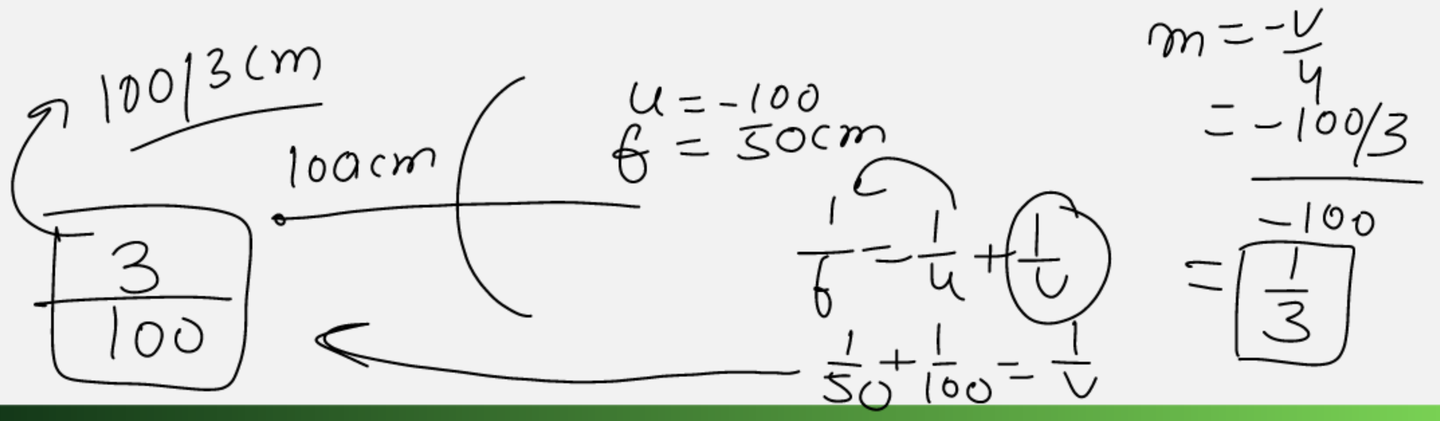
8. (a) Define the following terms in the context of spherical mirror:
Pole, Centre of curvature, Principal axis, Principal focus
(b) Draw ray diagrams to show the principal focus of a:
(i) Concave mirror (ii) Convex mirror
(c) Consider the following diagram in which M is a mirror and P is an object and Q is its magnified image formed by the mirror.
State the type of the mirror M and one characteristic property of the image Q.

CBQ





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9. An object is placed 100 cm from a convex mirror with a focal length of 50 cm. Calculate the image distance and the magnification.

Using the mirror formula: 1/f = 1/v + 1/u
1/50 = 1/v + 1/(-100)
1/v = 3/100
v = +33.3 cm (virtual, upright)
Magnification (m) = -v/u = -33.3/-100 = +0.33 (image is smaller than the size as the object)

Let's do this!