Teach Mayurbhanj

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LIGHT – REFLECTION AND REFRACTION

CLASS –X

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LIGHT: REFLECTION AND REFRACTION

- "Light is an electromagnetic ray that travels in a straight line"

- Reflection of Light:
  - When light falls on a surface and is reflected back into the same medium, we say reflection has taken place

- Refraction of Light:
  - When light travels from one medium to another it bends from its original path
  - This phenomenon is called refraction

TERMS RELATED TO REFRACTION OF LIGHT

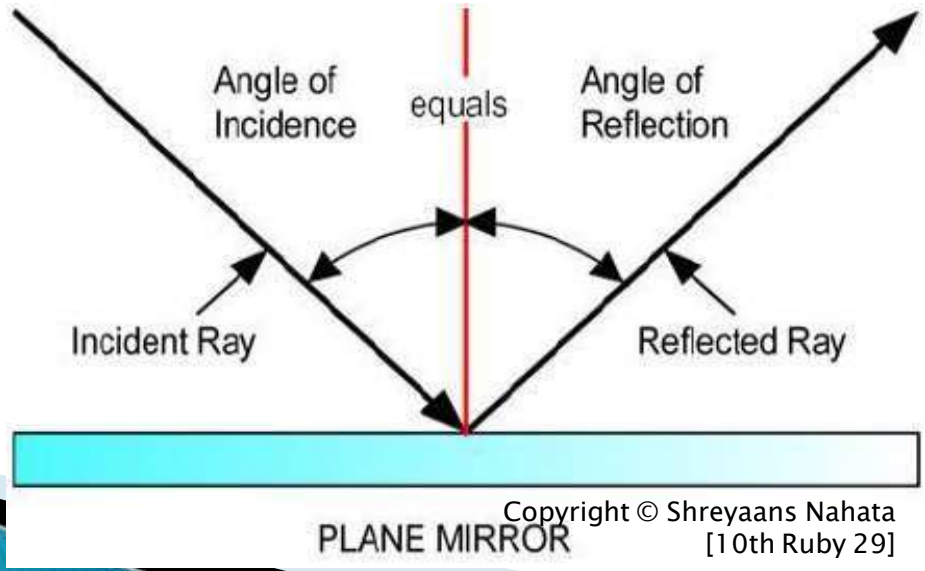
- **Incident Ray:** The ray of light that falls on the reflecting surface
- **Reflected Ray:** The ray of light that is sent back by the reflecting surface
- **Normal:** The normal is a line at right angle to the reflecting surface to the point of incidence
- **Angle of Incidence:** It is the angle made by the incident ray and the normal

TERMS RELATED TO REFRACTION OF LIGHT

- **Angle of Reflection:** It is the angle made by the reflected ray and the normal
- **Object:** It is the "thing" that forms an image on the screen
- **Image:** It is the reflection of the object on the screen
- **Virtual Image:** The image that cannot be obtained on a screen (a surface where image is formed)
- **Real Image:** The image that is formed directly on the screen

LAWS OF REFLECTION OF LIGHT

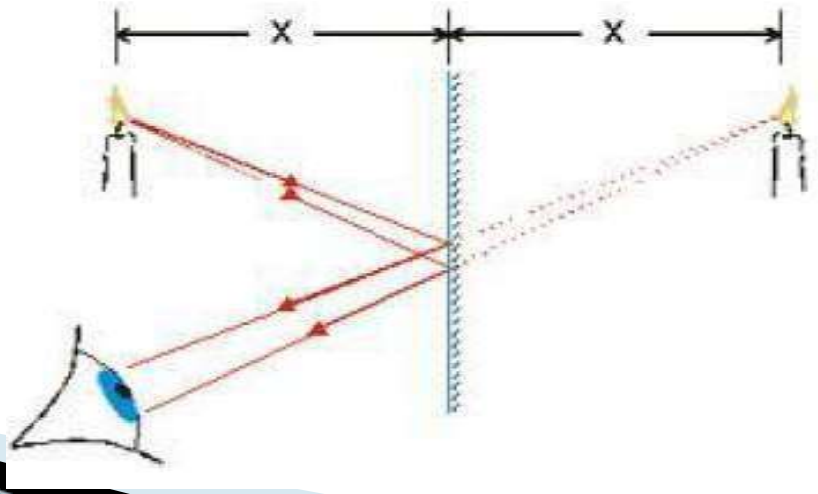
- **Laws of Reflection of light are:**
  - The angle of incidence is equal to the angle of reflection
  - The incident ray, the reflected ray and the normal to the mirror at the point of incidence all lie in the same plane
  - The incident ray and the reflected ray lie on either side of the normal



PROPERTIES OF IMAGE FORMED BY A PLANE MIRROR

- **The image formed in a plane is mirror is…**

  1. Virtual and Erect
  2. Of the same size as of the object
  3. At the same distance from the mirror as the object is in front of it
  4. Laterally inverted

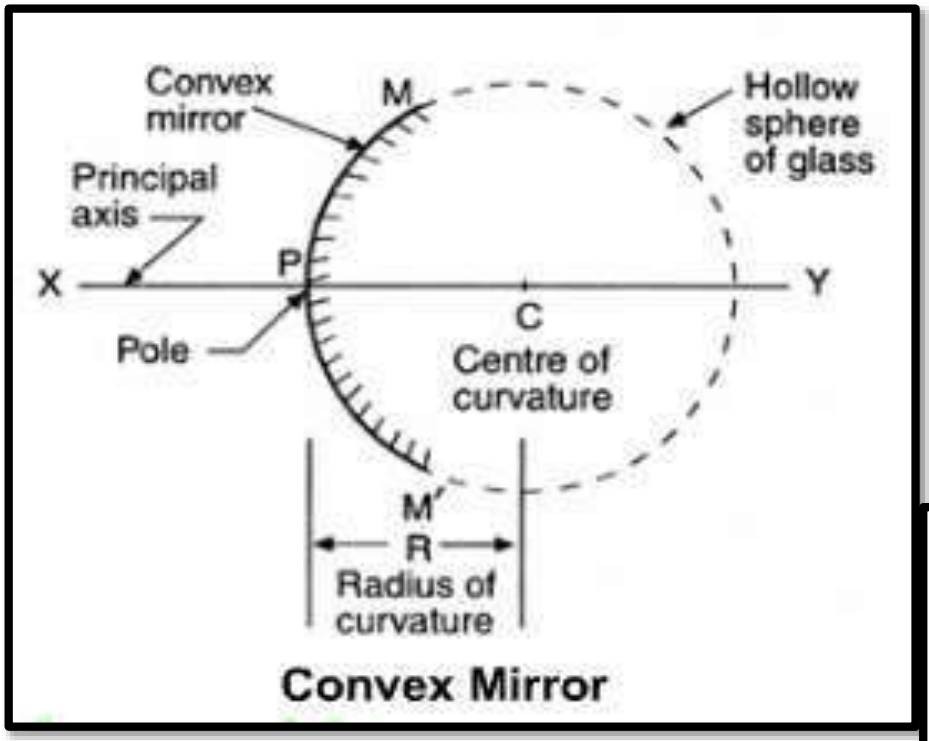


SPHERICAL MIRRORS: CONCAVE AND CONVEX

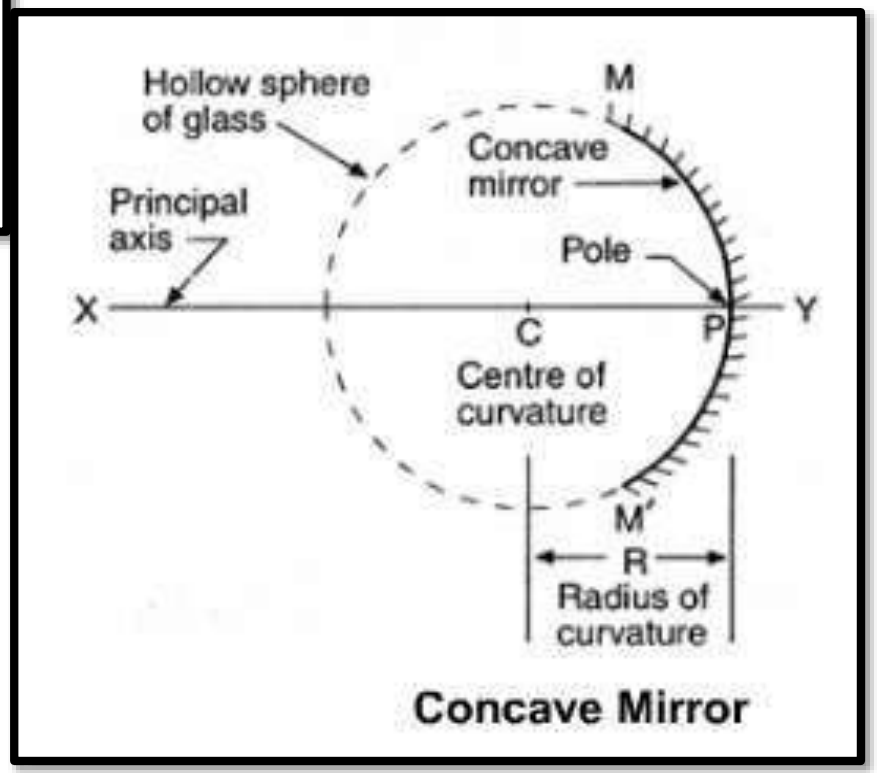
- **Concave Mirror:** A spherical mirror that has its reflecting surface curved inwards
- **Convex Mirror:** A spherical mirror that has its reflecting surface curved outwards
- There are some important terms to be explained first in terms of Spherical mirrors. They are:
  - Centre of Curvature
  - Focus
  - Principal Axis
  - Pole
  - Focal length
  - Radius of Curvature

TERMS USED TO EXPLAIN SPHERICAL MIRRORS

- **Center of curvature (C):** It is the centre of the sphere of which the mirror is a part
- **Radius of curvature (CP):** It is the radius of the sphere of which the mirror is a part
- **Pole (P):** It is the centre of the spherical mirror
- **Principal axis (X-Y):** It is the straight line passing through the centre of curvature and the pole



Convex Mirror

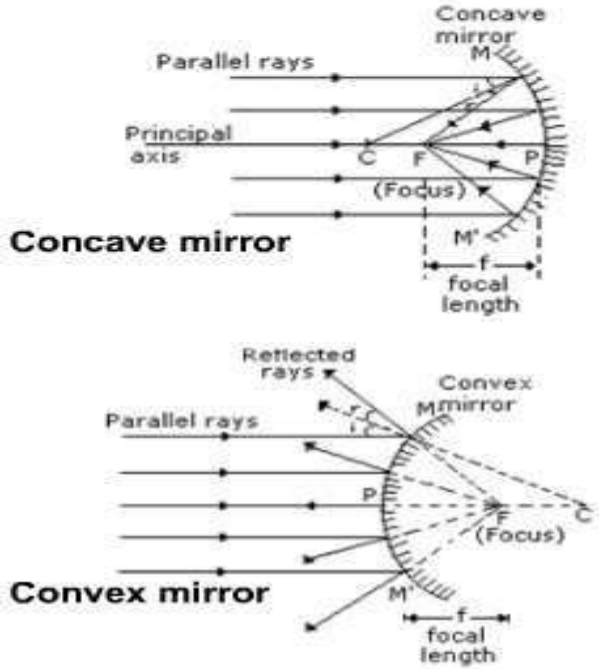


Concave Mirror

FOCUS AND FOCAL LENGTH OF SPHERICAL MIRRORS

- **Principal Focus:**
  - Focus of Concave Mirror: It is a point on the principal axis, where all the rays parallel to the principal axis converge

  - Focus of Convex Mirror: It is a point on the principal axis, where the reflected rays appear to converge

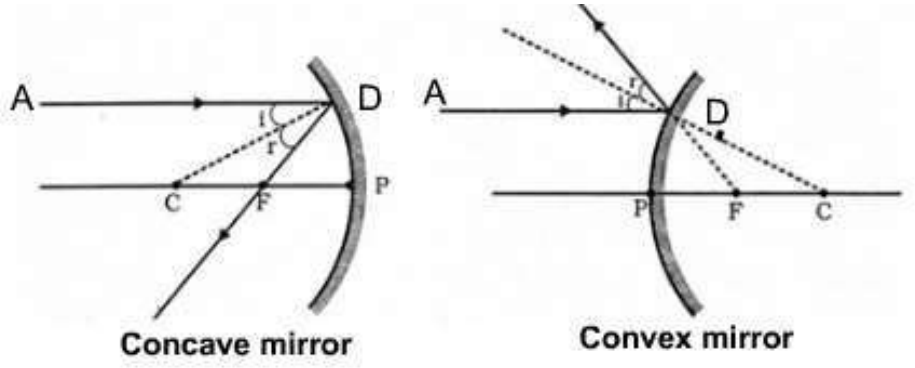


- **Focal length of Spherical Mirrors:**
  - The distance between the pole and the principal focus is called the focal length of the spherical mirror

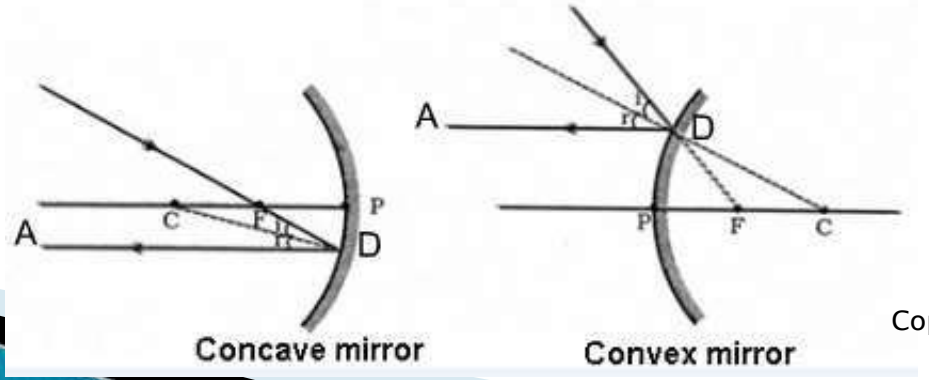
- The Radius of Curvature is two times the Focal Length of any spherical mirror

RULES FOR REFLECTION OF LIGHT THROUGH SPHERICAL MIRRORS

- If in a concave mirror, a ray of light parallel to the principal axis after reflection will pass through the focus or appear to diverge from the focus in case of convex mirror

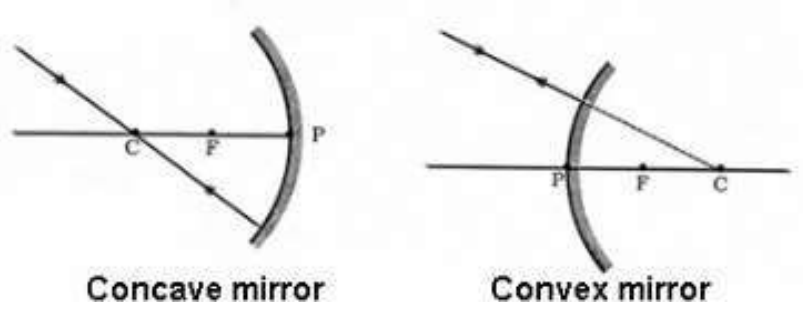


- A ray passing through the focus of a concave mirror, after reflection, will emerge parallel to the principal axis



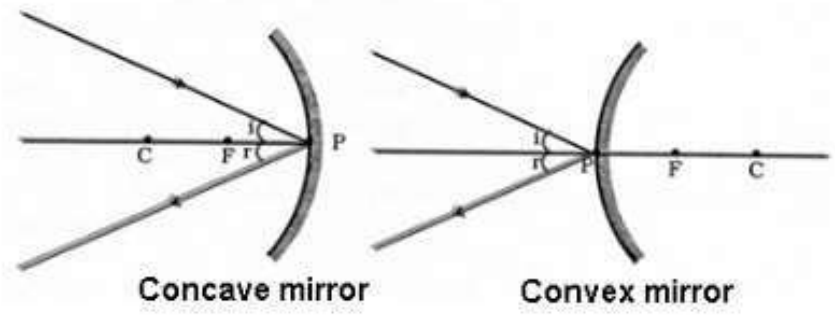
RULES FOR REFLECTION OF LIGHT THROUGH SPHERICAL MIRRORS

- A ray passing through the centre of curvature, after reflection is reflected back along the same path



Concave mirror Convex mirror

- A ray incident obliquely to the principal axis towards the pole on the spherical mirrors is reflected back obliquely



Concave mirror Convex mirror

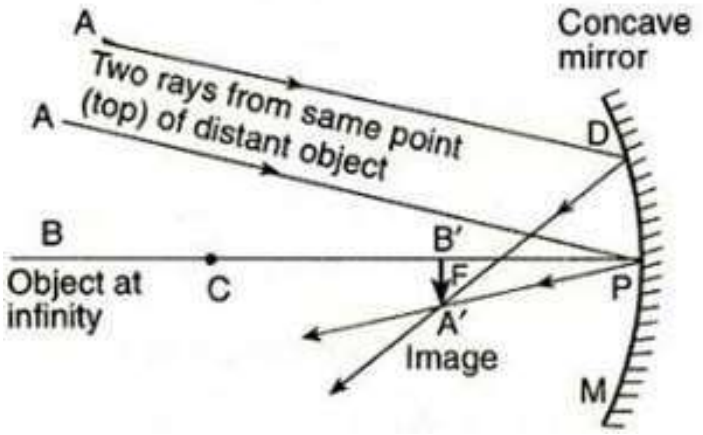
FORMATION OF DIFFERENT TYPES OF IMAGES BY CONCAVE MIRRORS

- We can place the object at six positions from the mirror:
  - At infinity
  - Beyond C
  - At C
  - Between C and F
  - At F
  - Between F and P

FORMATION OF DIFFERENT TYPES OF IMAGES BY CONCAVE MIRRORS

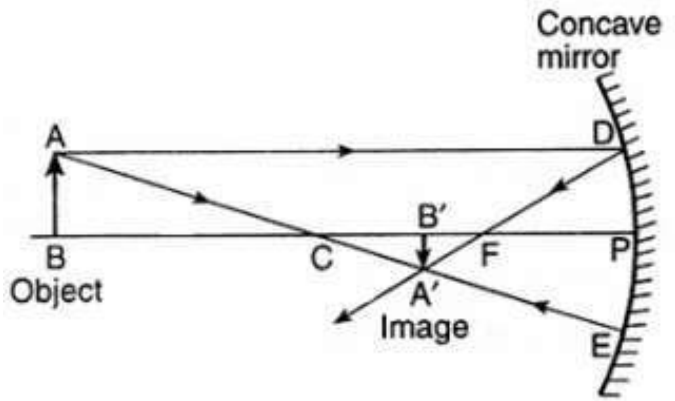
1. At infinity:

- The image formed is:
  - Real and Inverted
  - Highly diminished, Point-sized
  - Formed at F



2. Beyond C:

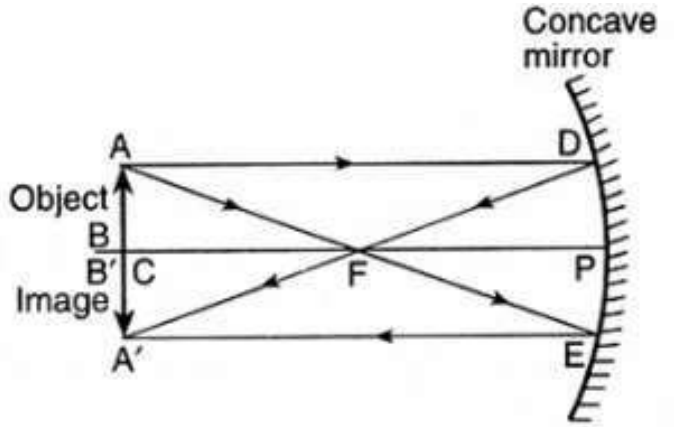
- The image formed is:
  - Real and Inverted
  - Between F and C
  - Diminished



FORMATION OF DIFFERENT TYPES OF IMAGES BY CONCAVE MIRRORS

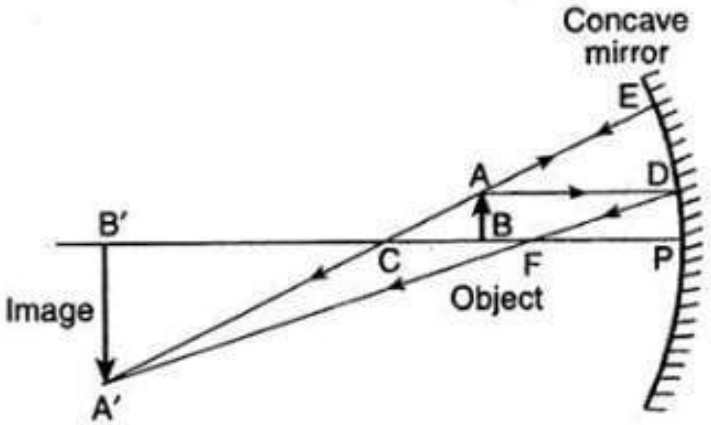
3. At C:

- The image formed is:
  - Real and Inverted
  - At C
  - Of the same size as the object



4. Between F and C:

- The image formed is
  - Real and Inverted
  - Beyond C
  - Magnified



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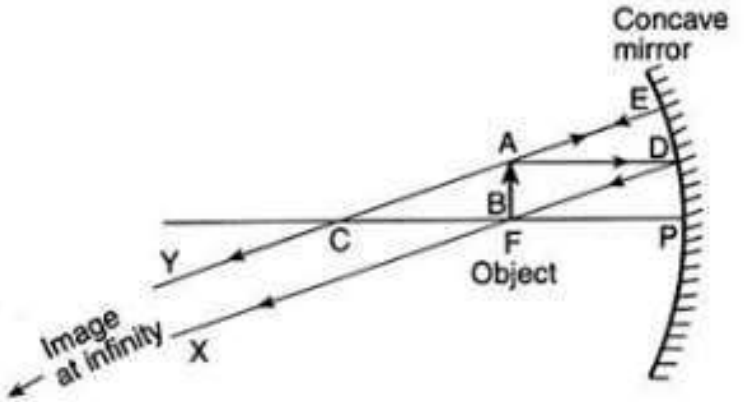
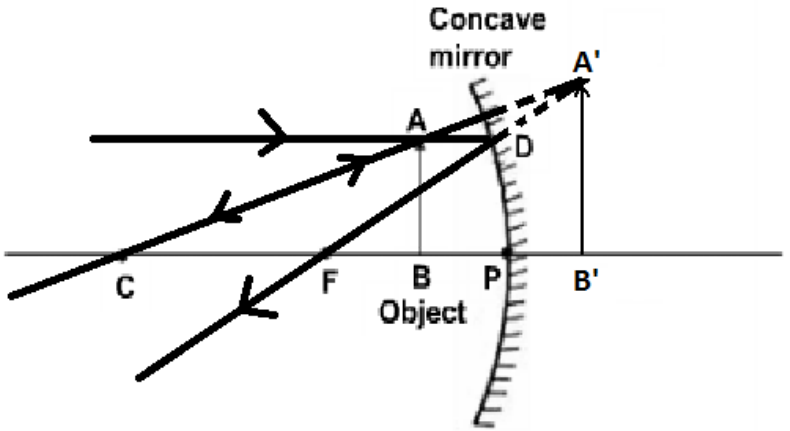
FORMATION OF DIFFERENT TYPES OF IMAGES BY CONCAVE MIRRORS

5. At F:

- The image formed is:
  - Real and Inverted
  - At infinity
  - Highly magnified



6. Between F and P:
   - Virtual and Erect
   - Behind the mirror
   - Magnified



FORMATION OF DIFFERENT TYPES OF IMAGES BY CONCAVE MIRRORS

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

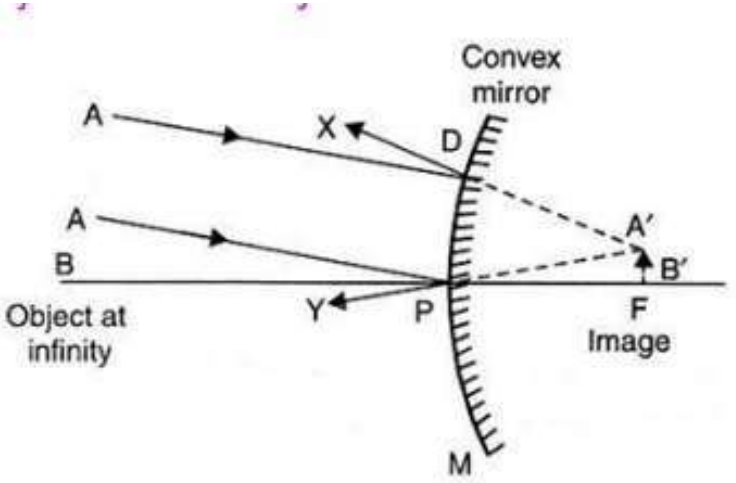
USES OF CONCAVE MIRRORS

- Concave mirrors are used as:
  - Shaving mirrors
  - Torches, search lights, and vehicle headlights
  - Used by dentist to get large images of patient's teeth
  - In solar furnaces to concentrate heat

IMAGE FORMATION BY CONVEX MIRROR

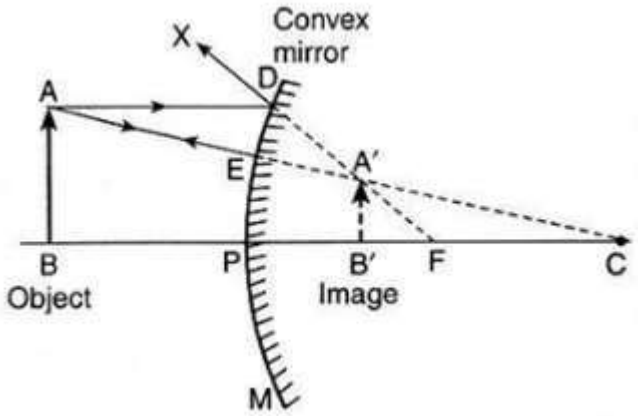
1. At Infinity:

- The image formed is
  - Virtual and Erect
  - Behind the mirror (at F)
  - Highly diminished



2. Between Infinity and P:

- The image formed is:
  - Virtual and Erect
  - Behind the mirror (between P and F)
  - Diminished

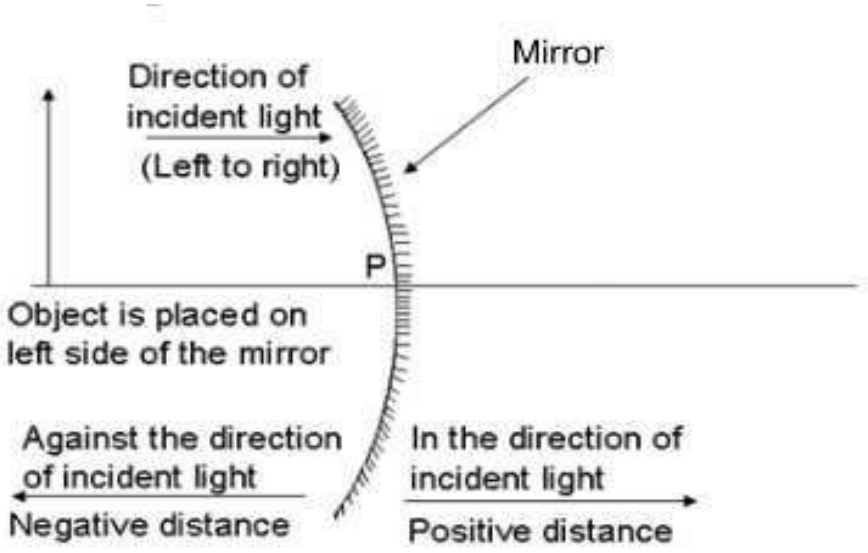


USES OF CONVEX MIRRORS

- Convex mirrors are used in:
  - Vehicles as rear-view mirrors to see traffic at the rear-side
  - Used as a device to check thefts in shops

NEW CARTESIAN SIGN CONVENTION

- Object is placed left to the mirror and the pole is taken as the origin
- Distance to the right of origin **(+ve X-axis)** is positive while that to its left **(-ve X-axis)** is negative
- Distances above the principal axis **(+ve Y-axis)** are positive while those below it **(-ve Y-axis)** are negative



Sign convention for mirror

MIRROR FORMULA FOR SPHERICAL MIRRORS

- The mirror formula is:

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

Where, **u**= Object distance

v= Image distance

f= Focal length

	Convex Mirror	Concave Mirror
u	Negative	Negative
v	positive	Positive or Negative
f	positive	Negative

MAGNIFICATION

$$Magnification\ (m) = \frac{height\ of\ image\ (h_2)}{height\ of\ object\ (h_1)} = \frac{-Image\ distance\ (-v)}{Object\ distance\ (u)}$$

- For Virtual image, ***m*** is positive
  Real image, ***m*** is negative

- If **m>1**, image is bigger than the object
- If **m=1**, image is of the same size as of the object
- If **m<1**, image is smaller than the object

- If ***m*** is positive, then the image is virtual and erect
- If ***m*** is negative, then the image is real and inverted

REFRACTION OF LIGHT

- The phenomenon of bending of light when it travels from one medium to another is called as 'refraction'

- Laws of refraction of light:
  - The incident ray, the normal and the refracted ray, all lie in the same plane

  - $\frac{\sin i}{\sin r} = constant$ where, i= Angle of incidence
    r= Angle of reflection
    constant= Refractive index

REFRACTIVE INDEX

- The refractive index of a medium gives an indication of light bending ability of that medium

$$n_{21} = \frac{\text{Speed of light in medium 1}}{\text{Speed of light in medium 2}} = \frac{v_1}{v_2}$$

$$n_{12} = \frac{\text{Speed of light in medium 2}}{\text{Speed of light in medium 1}} = \frac{v_2}{v_1}$$

$$n_m = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}} = \frac{c}{v}$$

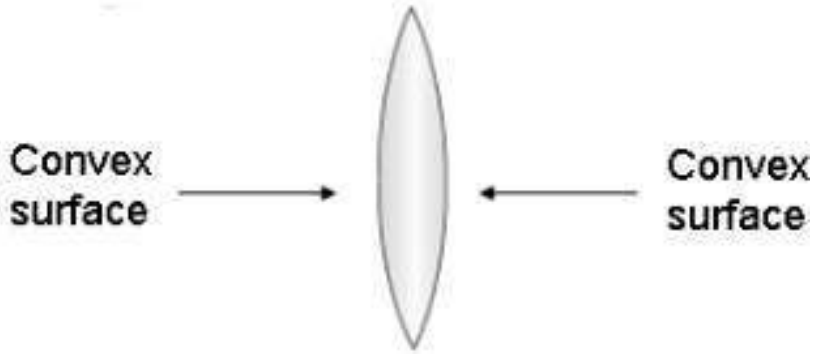
- Where n_{21} is the refractive index of medium 2 with respect to medium 1

REFRACTIVE INDEX

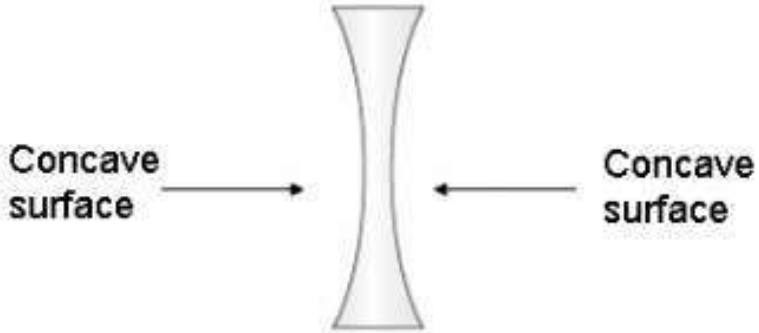
Material medium	Refractive index	Material medium	Refractive index
Air	1.0003	Crown glass	1.52
Ice	1.31	Canada Balsam	1.53
Water	1.33	Rock salt	1.54
Alcohol	1.36	Carbon disulphide	1.63
Kerosene	1.44	Dense flint glass	1.65
Fused Quartz	1.46	Ruby	1.71
Turpentine Oil	1.47	Sapphire	1.77
Benzene	1.50	Diamond	2.42

REFRACTION BY SPHERICAL LENSES

- There are two types of lenses:
  - Convex Lens:

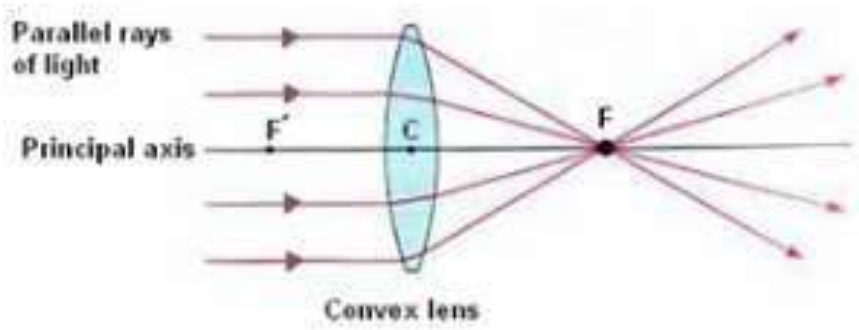


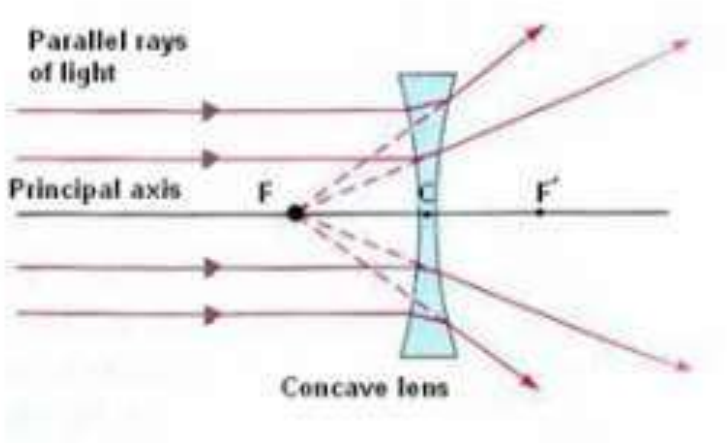
  - Concave Lens:



OPTICAL FOCUS, PRINCIPAL AXIS, FOCUS

- The centre point of a lens is known as its Optical Focus
- A line passing through the optical centre is the Principal Axis
- Focus is the point where rays converge (or appear to) after refraction in lens





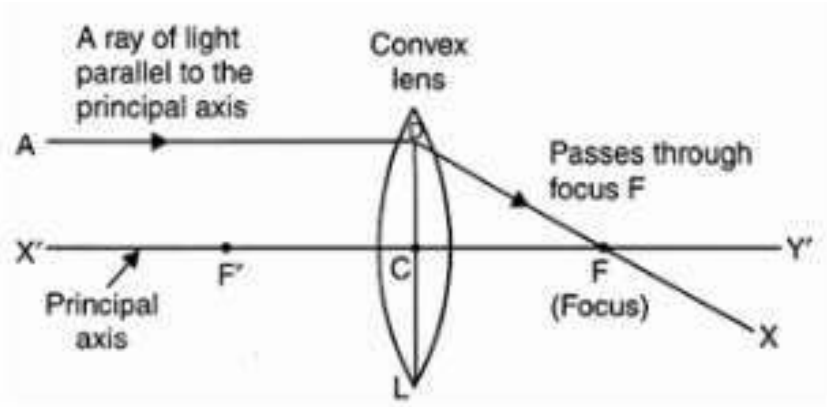
RULES FOR DRAWING RAY DIAGRAMS

1. A ray of light parallel to the principal axis passes through the focus after refraction

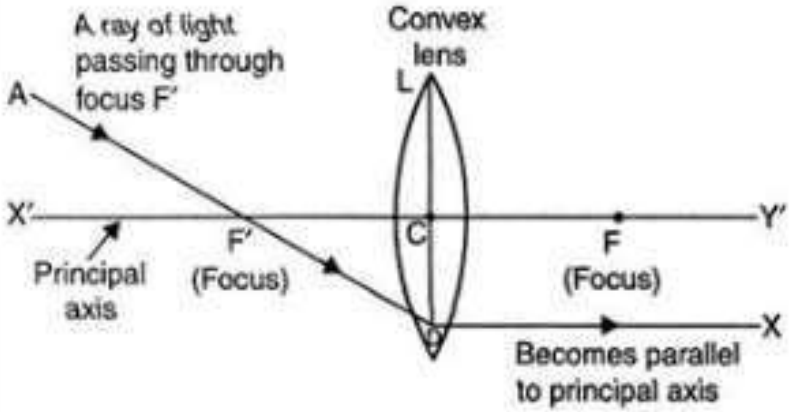
2. A ray of light passing through the focus becomes parallel to the principal axis after refraction

3. A ray of light passing through the optical centre goes straight without changing its path

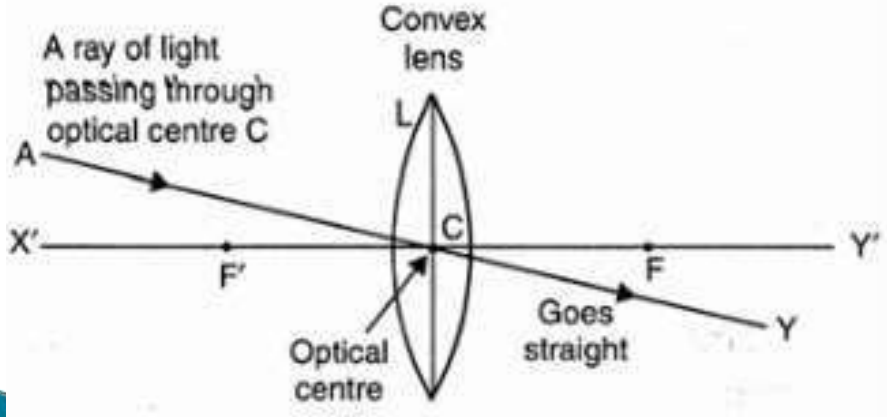
RULES FOR DRAWING RAY DIAGRAMS



Rule 1



Rule 2

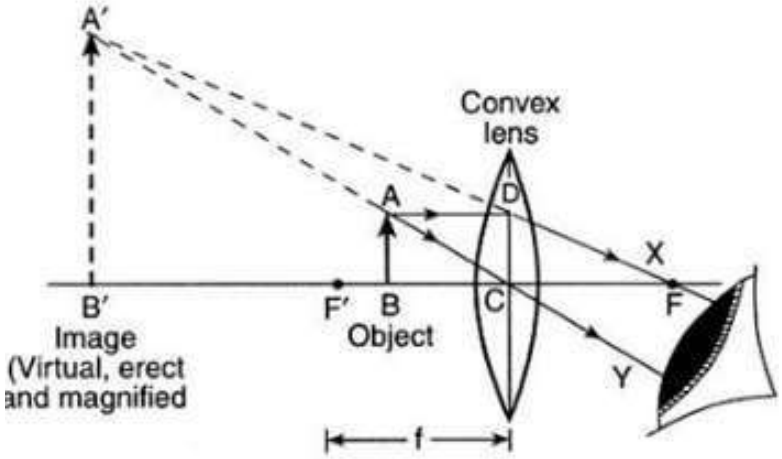


Rule 3

IMAGE FORMED BY CONVEX LENS

1. Between O and F:

- Image formed is:
  - Virtual and Erect
  - Behind the object (on the left side)
  - Magnified



2. Between F and 2F:

- Image formed is:
  - Real and Inverted
  - Beyond 2F
  - Magnified

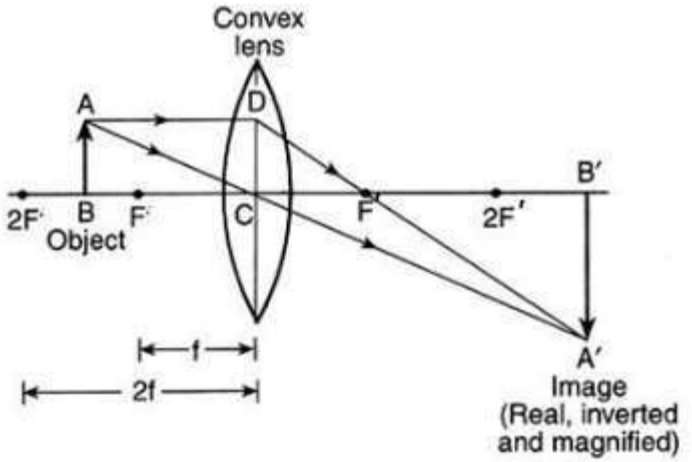


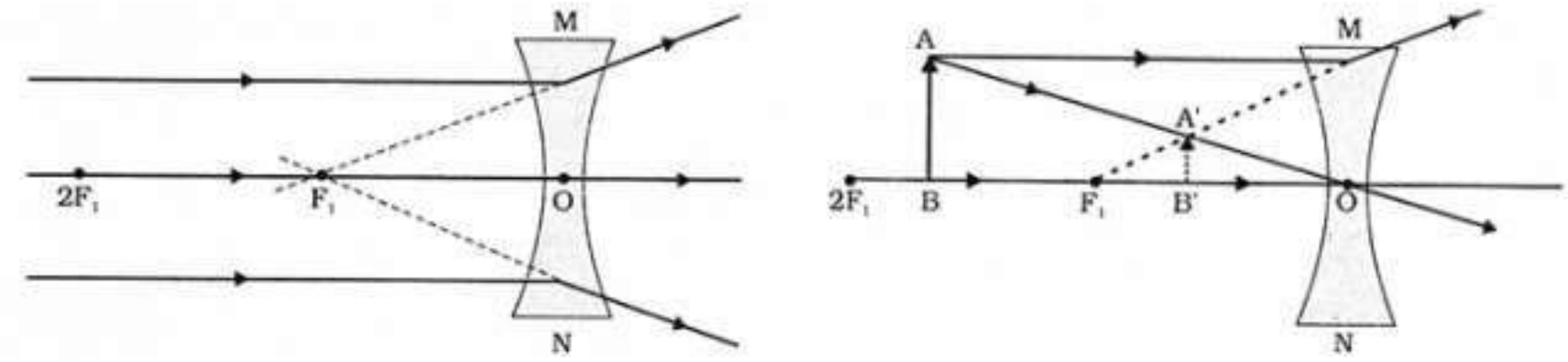
IMAGE FORMED BY CONVEX LENS

Position of the object	Position of the image	Size of the image	Nature of the image
Between f and lens	On the same side as object	Enlarged	Virtual and Erect
At F' (focus)	At infinity	Highly enlarged	Real and Inverted
Between F' and 2F'	Beyond 2F	Enlarged	Real and Inverted
At 2F'	At 2F	Same size as object	Real and Inverted
Beyond 2F'	Between F and 2F	Diminished	Real and Inverted
At infinity	At F (focus)	Highly diminished	Real and Inverted

C

IMAGE FORMED BY CONCAVE LENS

Position of the object.	Position of the image	Size of the image	Nature of the image
At infinity	At focus F_1	Highly diminished, point-sized	Virtual and Erect
Between infinity and optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and Erect



Nature, Position and Relative size of the image formed by a convex lens

SIGN CONVENTIONS FOR LENSES

- The sign conventions for lenses are same as those for spherical mirrors except all the distances are measured from the optical centre
- Distance to the right of origin **(+ve X-axis)** is positive while that to its left **(-ve X-axis)** is negative
- Distances above the principal axis **(+ve Y-axis)** are positive while those below it **(-ve Y-axis)** are negative

C

LENS FORMULA AND MAGNIFICATION

$$\text{Lens Formula is } \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

Magnification:

$$m = \frac{\text{Height of the image}}{\text{Height of the object}} = \frac{h'}{h}$$

$$\text{Also, } m = \frac{h'}{h} = \frac{v}{u}$$

Where

u = object distance

v = image distance

POWER OF A LENS

- The power of a lens is the reciprocal of its focal length, i.e.

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

- S.I. unit for power of lens is called Dioptre (D)

C