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Introduction

This is a learning as well as an exam preparation video.

At the end of the video are practice assignments for you to attempt.

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MEGA Forte

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Chapter 1: Light- Reflection and Refraction

Chapter 1: Light- Reflection and Refraction

Reflection of Light

- The image formed by a plane mirror is always

o virtual and erect

o of the same size as the object

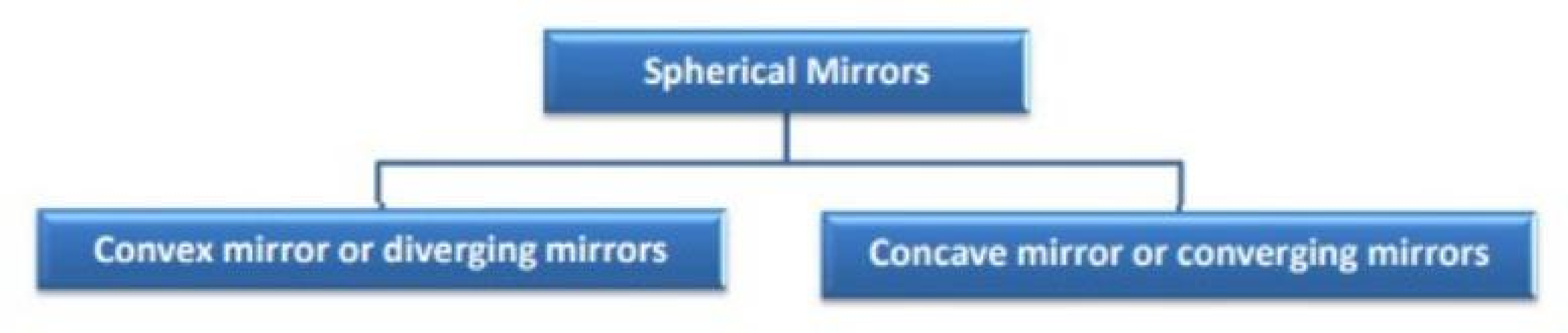
o as far behind the mirror as the object is in front of it

o laterally inverted

Chapter 1: Light- Reflection and Refraction

Reflection of Light

Spherical mirrors are of two types:



Chapter 1: Light- Reflection and Refraction

Reflection of Light

Some terms related to spherical mirrors:

- The centre of curvature (C) of a spherical mirror is the centre of the hollow sphere of glass, of which the spherical mirror is apart.
- The radius of curvature (R) of a spherical mirror is the radius of the hollow sphere of glass, of which the spherical mirror is apart.
- The pole (P) of a spherical mirror is the centre of the mirror.
- The principal axis of a spherical mirror is a straight line passing through the centre of curvature C and pole P of the spherical mirror.

Chapter 1: Light- Reflection and Refraction

Reflection of Light

- The principal focus (F) of a concave mirror is a point on the principal axis at which the rays of light incident on the mirror, in a direction parallel to the principal axis, actually meet after reflection from the mirror.
- The principal focus (F) of a convex mirror is a point on the principal axis from which the rays of light incident on the mirror, in a direction parallel to the principal axis, appear to diverge after reflection from the mirror.
- The focal length (f) of a mirror is the distance between its pole (P) and principal focus(F).
- For spherical mirrors of small aperture, $R = 2f$.

Chapter 1: Light- Reflection and Refraction

Sign Conventions for Spherical Mirrors

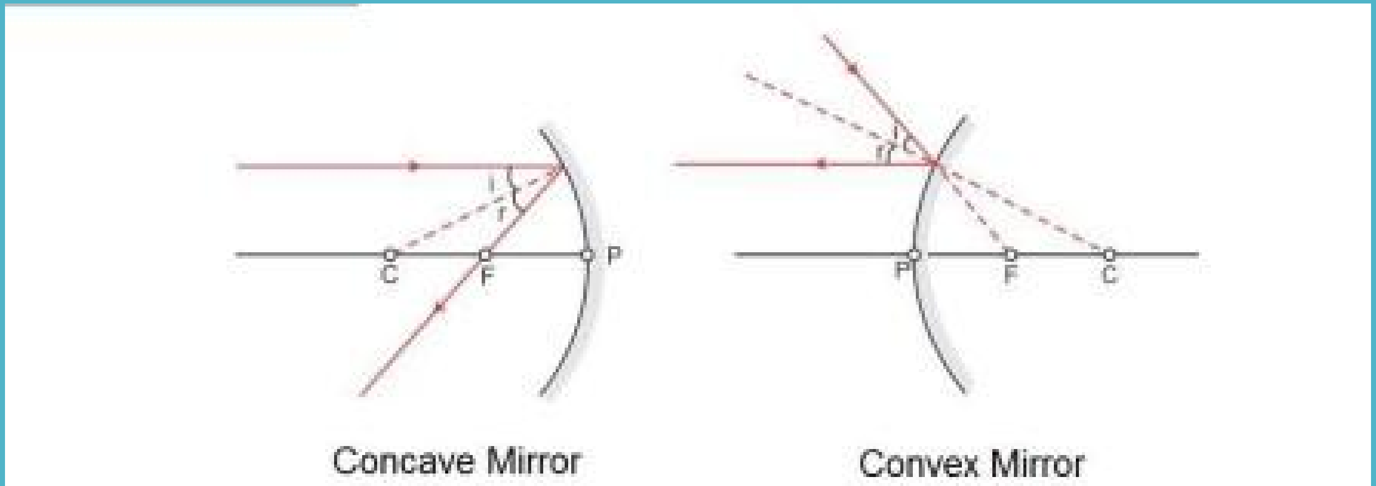
According to New Cartesian Sign Conventions,

- All distances are measured from the pole of the mirror.
- The distances measured in the direction of incidence of light are taken as positive and viceversa.
- The heights above the principal axis are taken as positive and viceversa.

Chapter 1: Light- Reflection and Refraction

Rules for tracing images formed by Spherical Mirrors

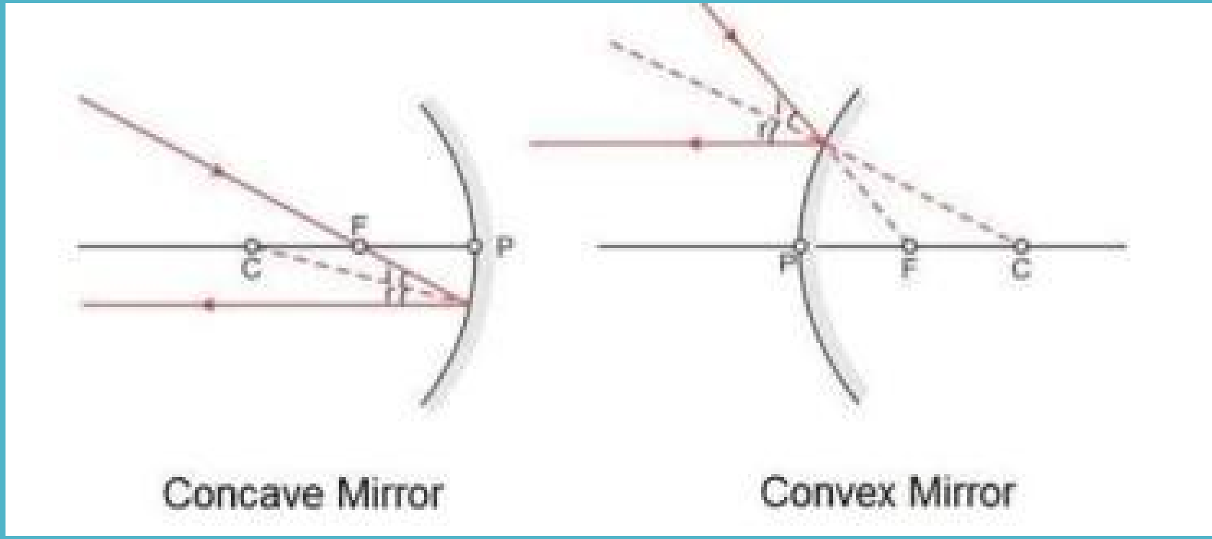
Rule 1: A ray which is parallel to the principal axis after reflection passes through the principal focus in case of a concave mirror or appears to diverge from the principal focus in case of a convex mirror.



Chapter 1: Light- Reflection and Refraction

Rules for tracing images formed by Spherical Mirrors

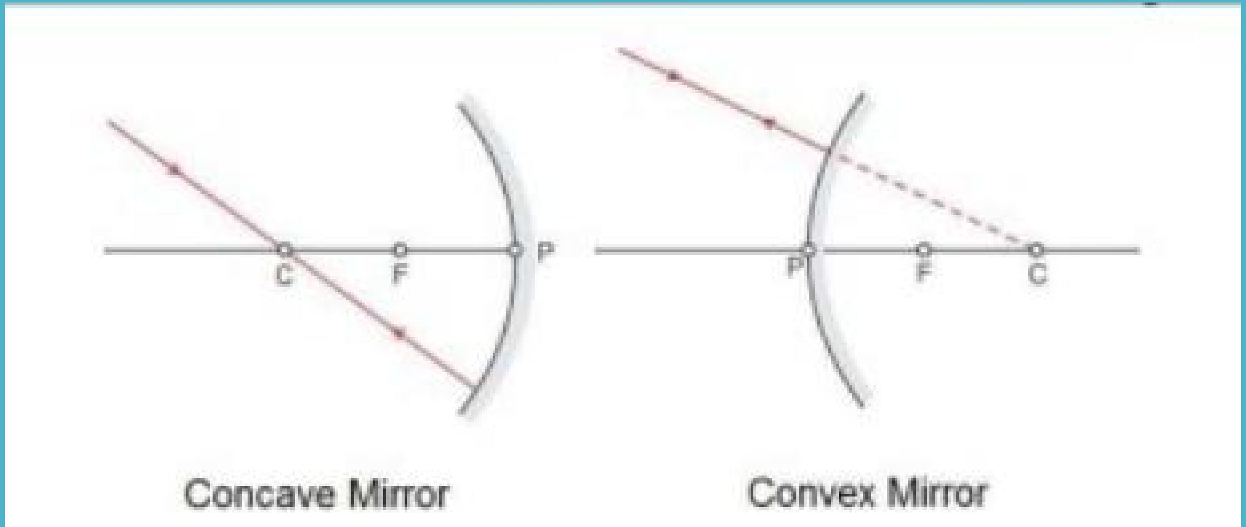
Rule 2: A ray passing through the principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror emerges parallel to the principal axis after reflection.



Chapter 1: Light- Reflection and Refraction

Rules for tracing images formed by Spherical Mirrors

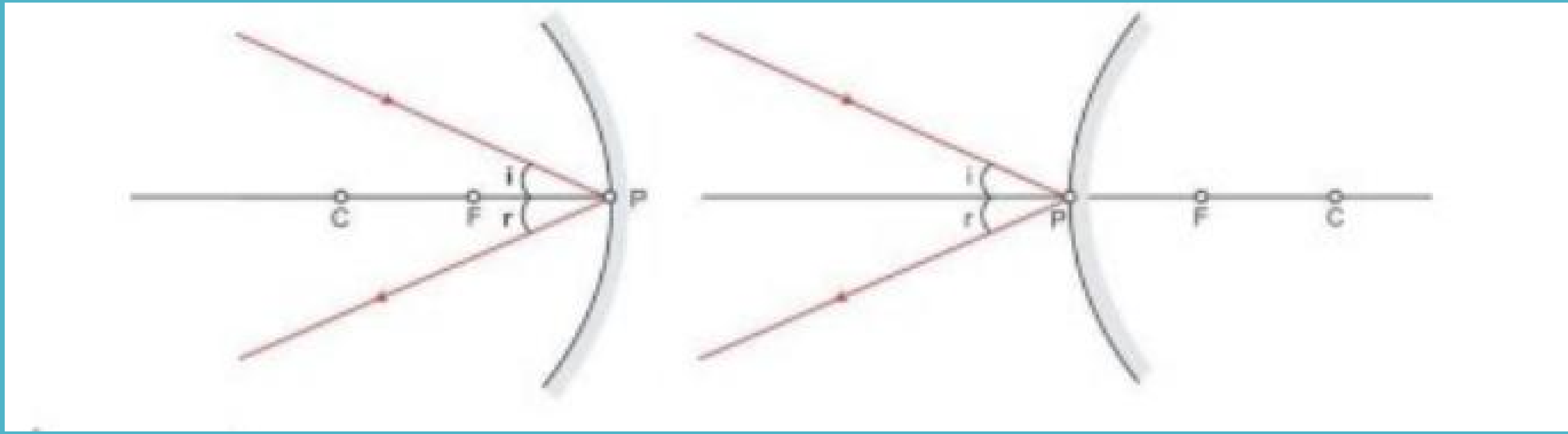
Rule 3: A ray passing through the centre of curvature of a concave mirror or directed towards the centre of curvature of a convex mirror is reflected back along the same path.



Chapter 1: Light- Reflection and Refraction

Rules for tracing images formed by Spherical Mirrors

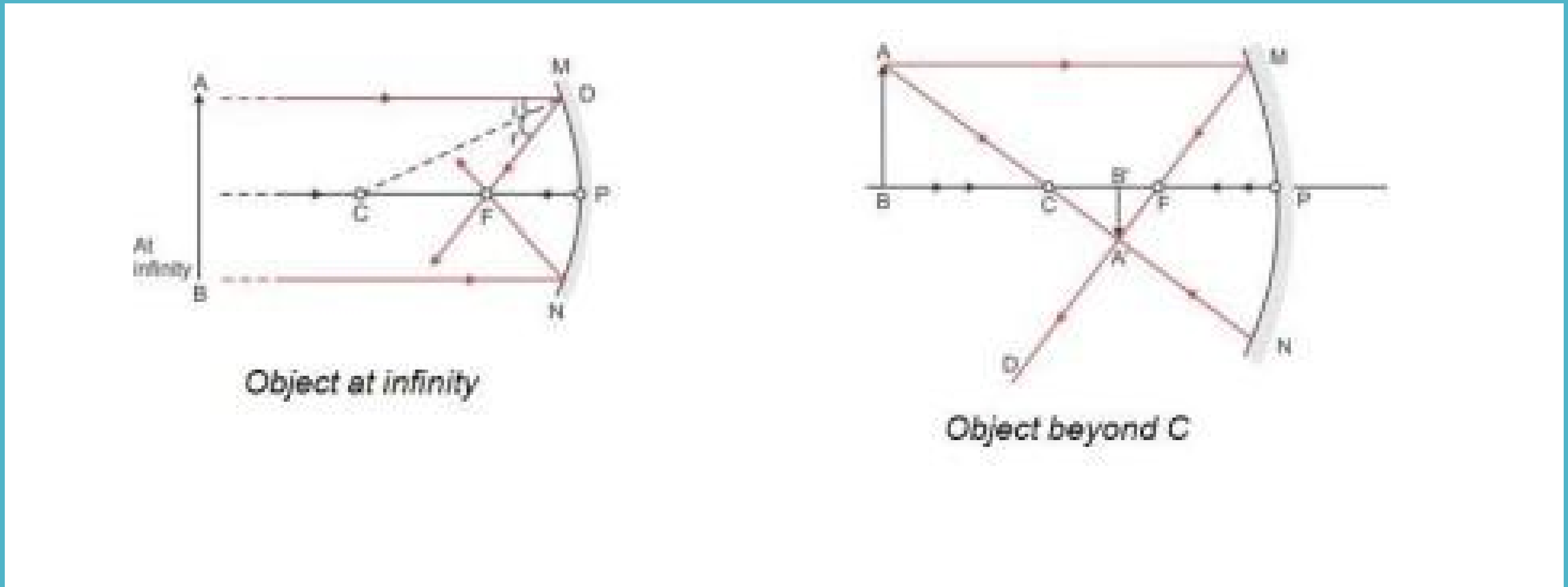
Rule 4: A ray incident obliquely towards the pole of a concave mirror or a convex mirror is reflected obliquely as per the laws of reflection.



Chapter 1: Light- Reflection and Refraction

Image formation by a concave mirror

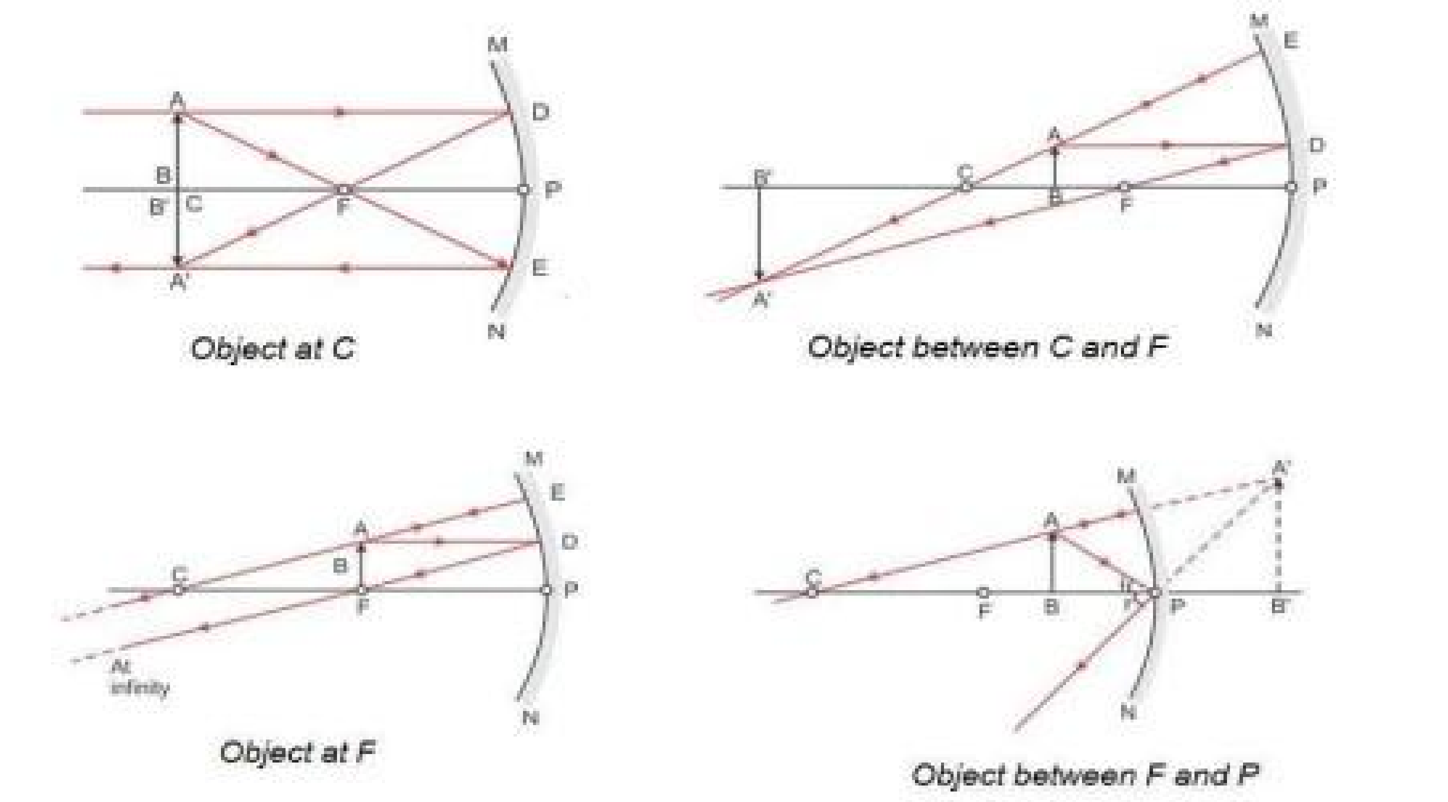
- Ray Diagrams



Chapter 1: Light- Reflection and Refraction

Image formation by a concave mirror

- Ray Diagrams



Chapter 1: Light- Reflection and Refraction

Image formation by a concave mirror

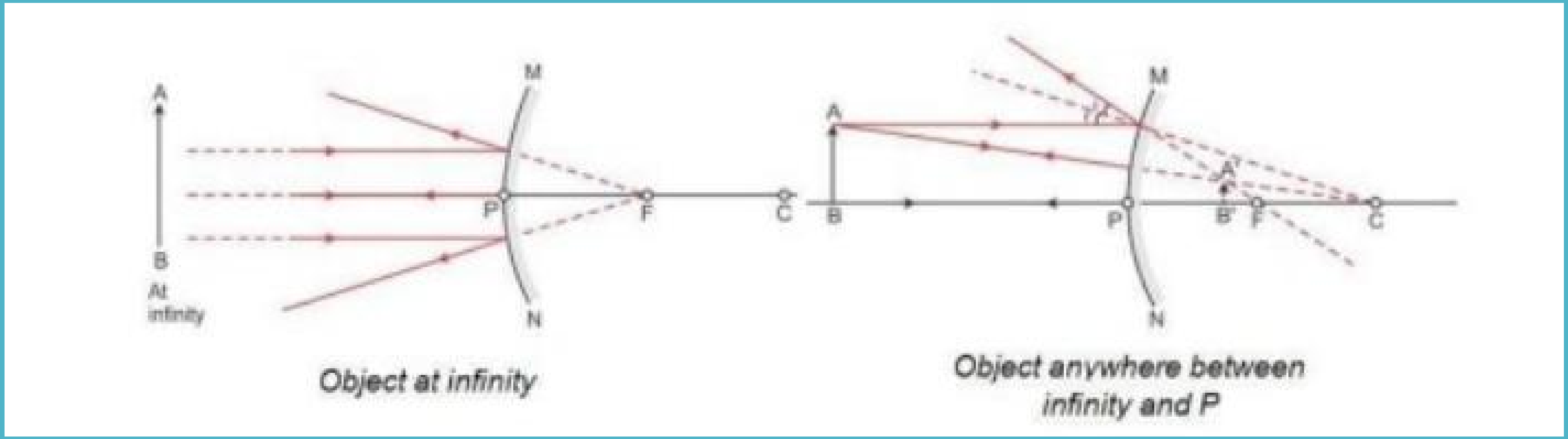
- **Characteristics of images formed**

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

Chapter 1: Light- Reflection and Refraction

Image formation by a convex mirror

- Ray Diagrams



Chapter 1: Light- Reflection and Refraction

Image formation by a convex mirror

- **Characteristics of images formed**

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

Chapter 1: Light- Reflection and Refraction

Sign Convention for Reflection by Spherical Mirrors

While dealing with the reflection of light by spherical mirrors, we shall follow a set of sign conventions called the New Cartesian Sign Convention. In this convention, the pole (P) of the mirror is taken as the origin. The principal axis of the mirror is taken as the x-axis (X’X) of the coordinate system. The conventions are as follows:

- The object is always placed to the left of the mirror. This implies that the light from the object falls on the mirror from the left-hand side.
- All distances parallel to the principal axis are measured from the pole of the mirror.

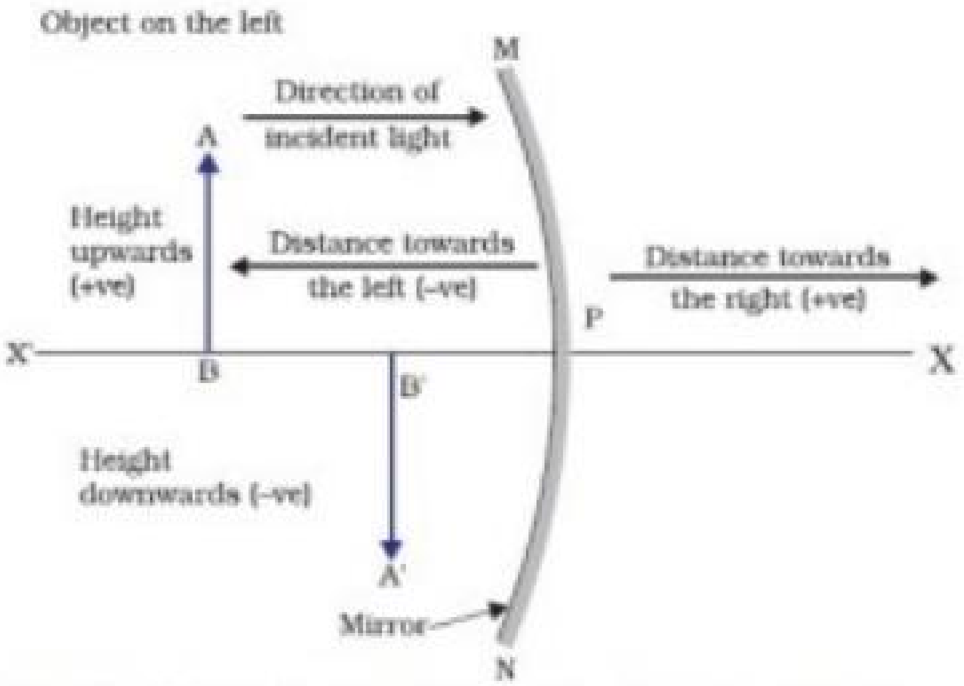
Chapter 1: Light- Reflection and Refraction

Sign Convention for Reflection by Spherical Mirrors

- All the distances measured to the right of the origin (along + x-axis) are taken as positive while those measured to the left of the origin (along – x-axis) are taken as negative.
- Distances measured perpendicular to and above the principal axis (along + y-axis) are taken as positive.
- Distances measured perpendicular to and below the principal axis (along –y-axis) are taken as negative.

Chapter 1: Light- Reflection and Refraction

Sign Convention for Reflection by Spherical Mirrors



The New Cartesian Sign Convention for spherical mirrors

Chapter 1: Light- Reflection and Refraction

Sign Convention for Reflection by Spherical Mirrors

- **Mirror Formula**

The object distance (u), image distance (v) and focal length (f) of a spherical mirror are related as

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

Chapter 1: Light- Reflection and Refraction

Sign Convention for Reflection by Spherical Mirrors

- **Linear Magnification (m)**

The magnification produced by a spherical mirror indicates the extent to which an object's image is magnified in relation to the object size.

Magnification is defined as the ratio of the image's height to the object's height. The letter m is commonly used to represent it.

Chapter 1: Light- Reflection and Refraction

Sign Convention for Reflection by Spherical Mirrors

If h is the object's height and h' is the image's height, then the magnification m produced by a spherical mirror can be written as:

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

m is negative for real images and positive for virtual images.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- The phenomenon of change in the path of a beam of light as it passes from one medium to another is called refraction of light.
- The cause of refraction is the change in the speed of light as it goes from one medium to another.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- **Laws of Refraction**

o **First Law:** The incident ray, the refracted ray and the normal to the interface of two media at the point of incidence, all lie in the same plane.

o **Second Law:** The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for a given pair of media.

$$\frac{\sin i}{\sin r} = constant = {}^{1}n_{2}$$

This law is also known as Snell's law.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

The constant, written as 1n2 is called the refractive index of the second medium (in which the refracted ray lies) with respect to the first medium (in which the incident ray lies).

- Absolute refractive index (n) of a medium is given as

$$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in the medium}} = \frac{C}{V}$$

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- When a beam of light passes from medium 1 to medium 2, the refractive index of medium 2 with respect to medium 1 is called the relative refractive index, represented by 1n ,where

$$ {}^{1}n_{2} = \frac{n_2}{n_1} = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2} $$

Chapter 1: Light- Reflection and Refraction

Refraction of Light

Similarly, the refractive index of medium 1 with respect to medium 2 is

$$^{2}n_{1} = \frac{n_1}{n_2} = \frac{cv_1}{cv_2} = \frac{v_2}{v_1}$$

$$\Rightarrow {}^{1}n_{2} \times {}^{2}n_{1} = 1$$

$$\text{or, } {}^{1}n_{2} = \frac{1}{^{2}n_{1}}$$

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- While going from a rarer to a denser medium, the ray of light bends towards the normal. While going from a denser to a rarer medium, the ray of light bends away from the normal.
- Conditions for no refraction

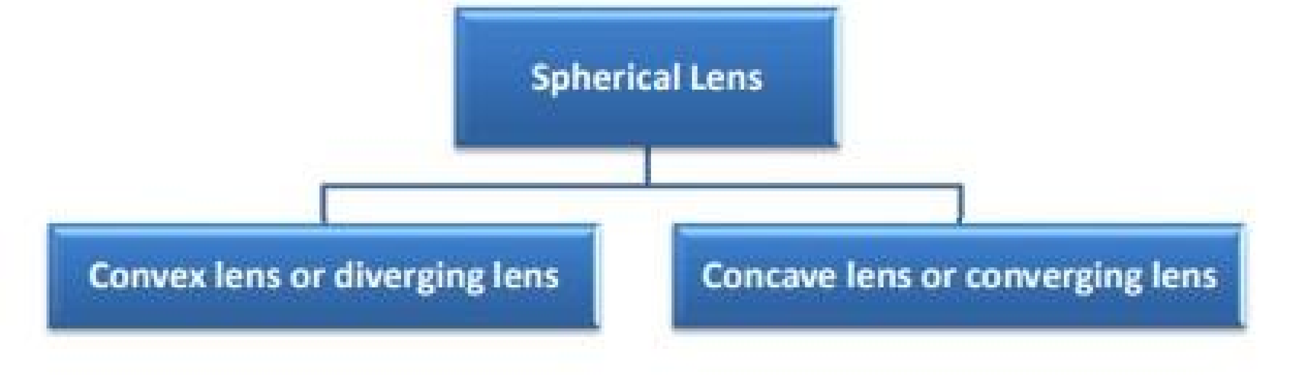
o When light is incident normally on a boundary.

o When the refractive indices of the two media are equal.

- In the case of a rectangular glass slab, a ray of light suffers two refractions, one at the air–glass interface and the other at the glass–air interface. The emergent ray is parallel to the direction of the incident ray.

Chapter 1: Light- Reflection and Refraction

Refraction of Light



- Convex lens or converging lens which is thick at the centre and thin at the edges.
- Concave lens or diverging lens which is thin at the centre and thick at the edges.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- Some terms related to spherical lenses:
  - The central point of the lens is known as its optical centre(O).
  - Each of the two spherical surfaces of a lens forms a part of a sphere. The centres of these spheres are called centres of curvature of the lens. These are represented as C1andC2.
  - The principal axis of a lens is a straight line passing through its two centres of curvature.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- The principal focus of a convex lens is a point on its principal axis to which light rays parallel to the principal axis converge after passing through the lens.
- The principal focus of a concave lens is a point on its principal axis from which light rays, originally parallel to the principal axis appear to diverge after passing through the lens.
- The focal length (f) of a lens is the distance of the principal focus from the optical centre.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

Sign Conventions for Spherical Lenses

According to New Cartesian Sign Conventions,

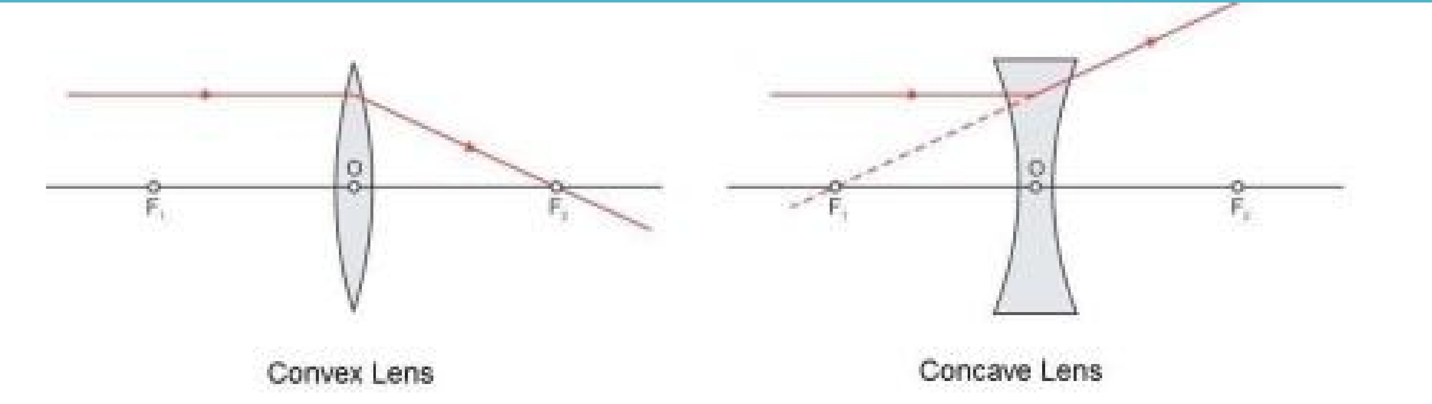
- All distances are measured from the optical centre of the lens.
- The distances measured in the direction of incidence of light are taken as positive and viceversa.
- The heights above the principal axis are taken as positive and viceversa.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

Rules for tracing images formed by spherical lens

Rule 1: A ray which is parallel to the principal axis, after refraction passes through the principal focus on the other side of the lens in case of a convex lens or appears to diverge from the principal focus on the same side of the lens in case of a concave lens.

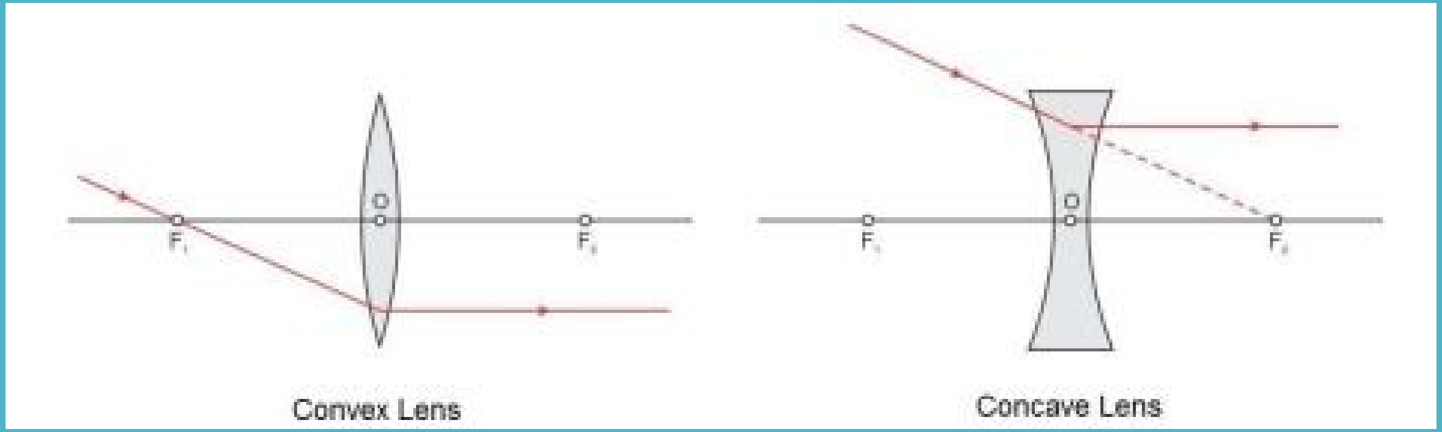


Chapter 1: Light- Reflection and Refraction

Refraction of Light

Rules for tracing images formed by spherical lens

Rule 2: A ray passing through the principal focus of a convex lens or appearing to meet at the principal focus of a concave lens after refraction emerges parallel to the principal axis.

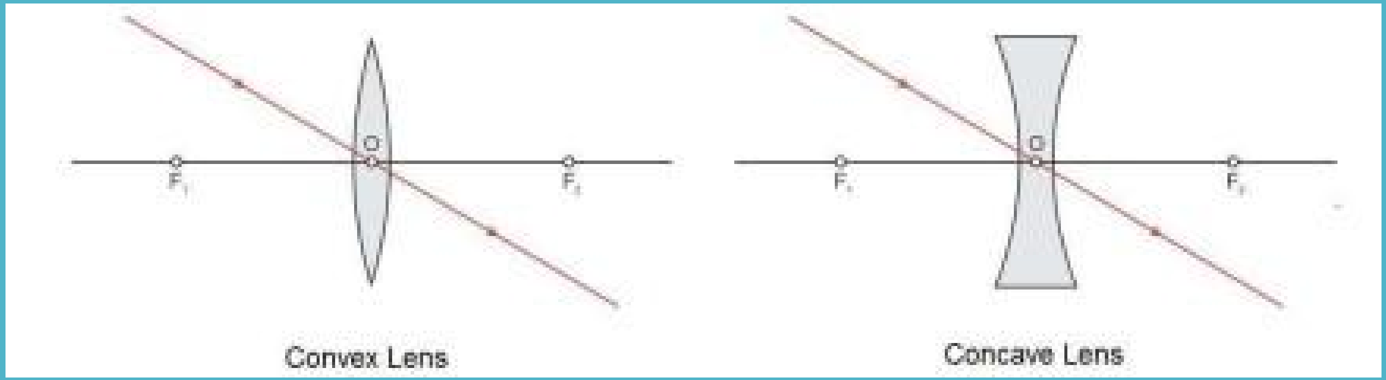


Chapter 1: Light- Reflection and Refraction

Refraction of Light

Rules for tracing images formed by spherical lens

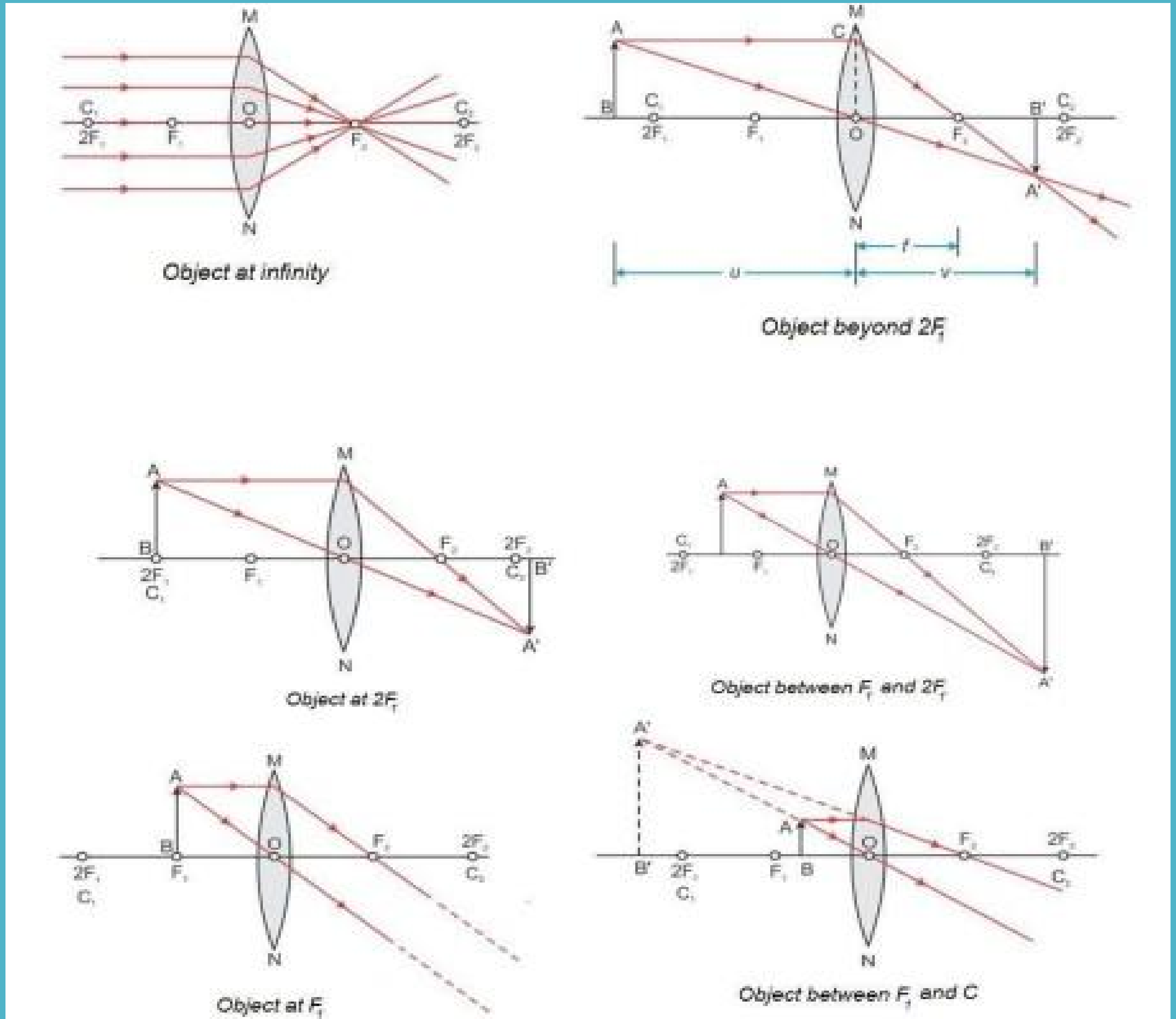
Rule 3: A ray passing through the optical centreof a convex lens or a concave lens emerges without any deviation.



Chapter 1: Light- Reflection and Refraction

Image formation by a convex lens

Ray Diagrams



Chapter 1: Light- Reflection and Refraction

Image formation by a convex lens

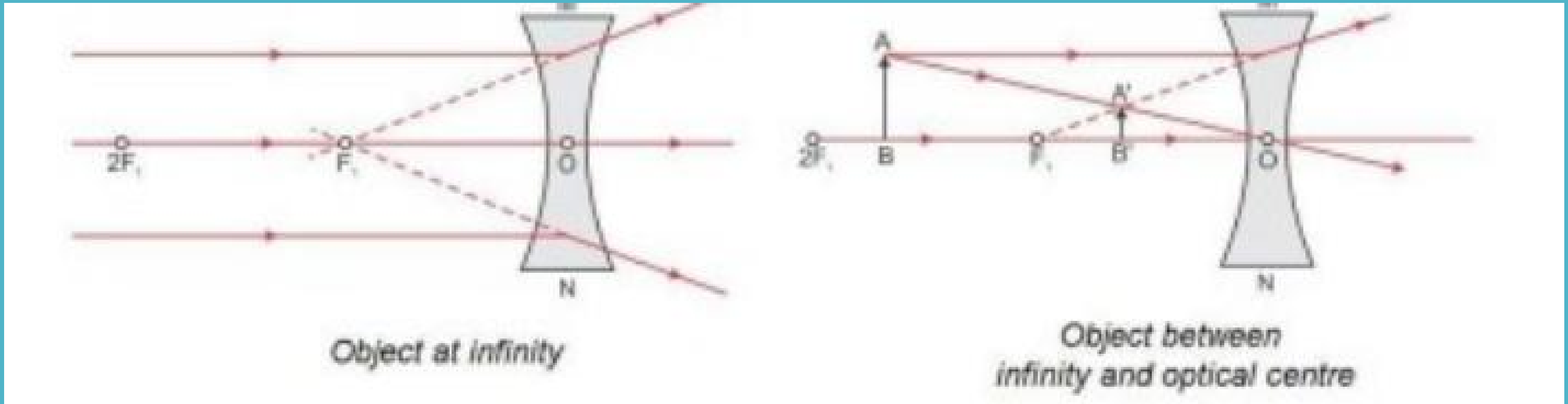
Characteristics of images formed

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F_2	Highly diminished	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Equal to size of object	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Highly enlarged	Real and inverted
Between F_1 and O	Beyond F_1 on the same side as the object	Enlarged	Virtual and erect

Chapter 1: Light- Reflection and Refraction

Image formation by a concave lens

Ray Diagrams



Chapter 1: Light- Reflection and Refraction

Image formation by a concave lens

Characteristics of images formed

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F_1	Highly diminished	Virtual and erect
Between infinity and O	Between focus F_1 and O	Diminished	Virtual and erect

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- **Lens Formula**

Object distance (u), image distance (v) and focal length (f) of a spherical lens are related as

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

- **Linear Magnification (m) produced by a spherical lens is**

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

m is negative for real images and positive for virtual images.

Chapter 1: Light- Reflection and Refraction

Refraction of Light

- Power of a lens
- Power of a lens is the reciprocal of the focal length of the lens. Its S.I. unit is dioptre (D).

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

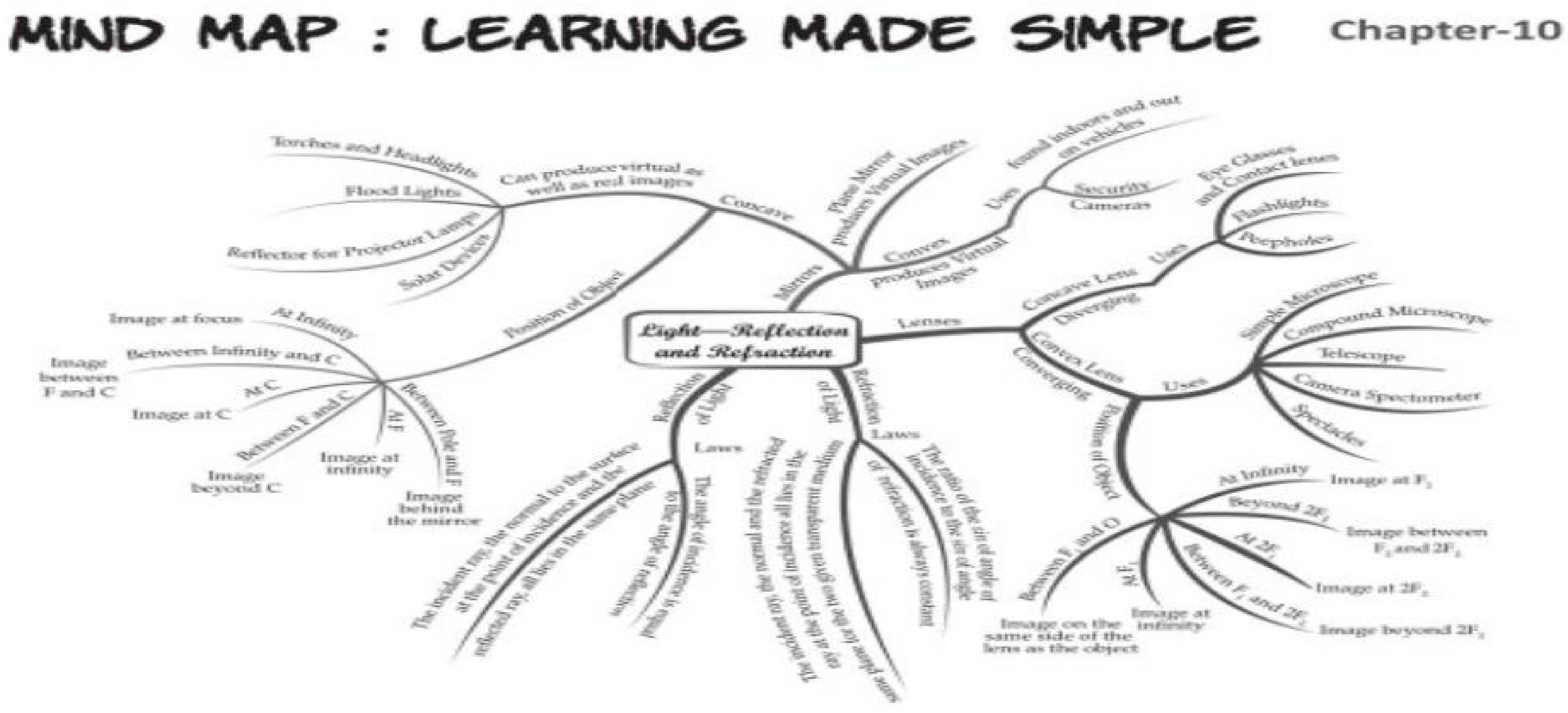
Chapter 1: Light- Reflection and Refraction

Refraction of Light

- Power of a convex lens is positive and that of a concave lens is negative.
- When several thin lenses are placed in contact with one another, the power of the combination of lenses is equal to the algebraic sum of the powers of the individual lenses.

$$P = P_1 + P_2 + P_3 + P_4 + \ldots$$

Chapter 1: Light- Reflection and Refraction



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