LIGHT- PART 1

REFLECTION OF LIGHT

EDUMAX CLASSES

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Introduction to Light – Reflection & Refraction

Light: Definition

Light is a form of energy that enables us to see things. Light starts from a source and bounces off objects which are perceived by our eyes and our brain processes this signal, which eventually enables us to see.

Nature of Light

Light behaves as a:

- ray, e.g. reflection
- wave, e.g. interference and diffraction
- particle, e.g. photoelectric effect

Laws of Reflection

Light incident on another medium

When light travels from one medium to another medium it either:

- gets absorbed (absorption)
- bounces back (reflection)
- passes through or bends (refraction)

When light is incident on a plane mirror, most of it gets reflected, and some of it gets absorbed in the medium.

Characteristics of light

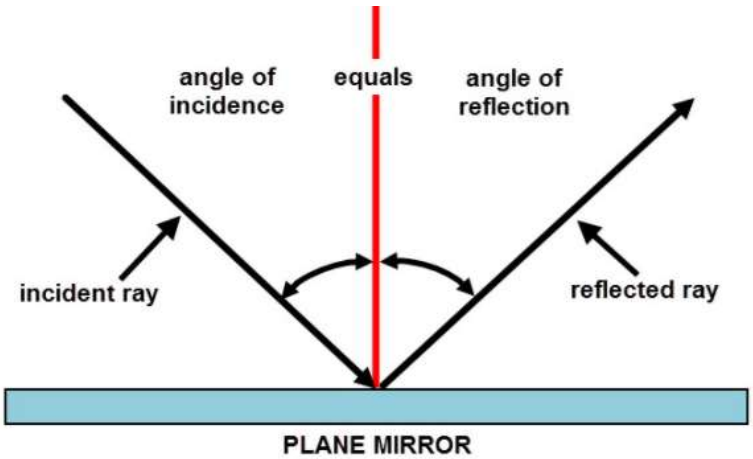
- Speed of light $c=\lambda\times\mu$, where λ is its wavelength and μ is its frequency.
- Speed of light is a constant which is 2.998×10^8 m/s or approximately 3.0×10^8 m/s.

Reflection of light by other media

A medium that is polished well without any irregularities on its surface will cause regular reflection of light. For example, a plane mirror. But even then some light gets absorbed by the surface.

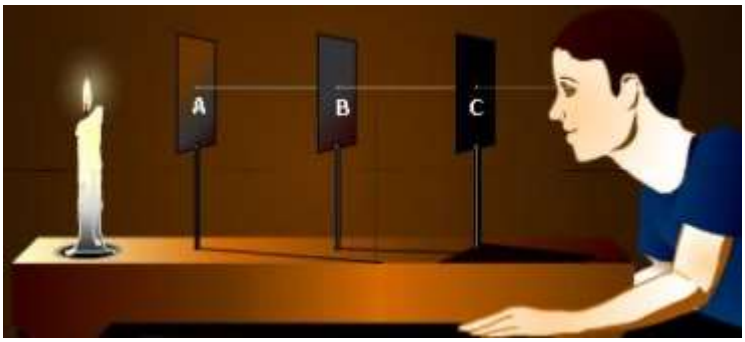
Laws of Reflection

1. The incident ray, reflected ray and the normal all lie in the same plane.
2. Angle of incidence = Angle of reflection [$\angle i=\angle r$]



Propagation of light

Rectilinear propagation of light: Light travels in a straight line between any two points.



Fermat's Theorem

- The principle of least time: Light always takes the quickest path between any two points (which may not be the shortest path).
- Rectilinear propagation of light and the law of reflection [∠i=∠r] can be validated by Fermat's principle of least time.

Plane mirror

Any flat and polished surface that has almost no irregularities on its surface that reflect light is called as a plane mirror.

Virtual and Real image

Image is a point where atleast two light rays actually meet or appear to meet.

Real Image	**Virtual Image**
Formed when light rays actually meet.	Formed when light rays appear to meet.
Can be obtained on screen.	Can't be obtained on screen.
Inverted	Erect
Example: image formed on cinema screen and formed by concave mirror.	Example: image formed by plane mirror or convex mirror.

Characteristics of images

- Images can be real or virtual, erect or inverted, magnified or diminished. A real image is formed by the actual convergence of light rays. A virtual image is the apparent convergence of diverging light rays.

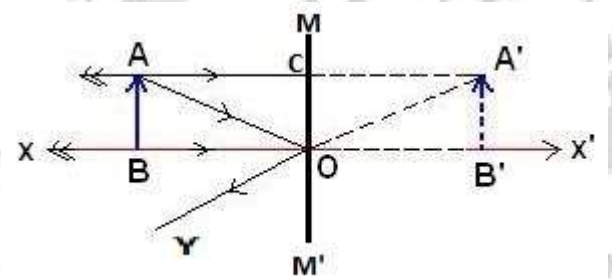
- If an image formed is upside down then it is called inverted or else it is an erect image. If the image formed is bigger than the object, then it is called magnified. If the image formed is smaller than the object, then it is diminished.

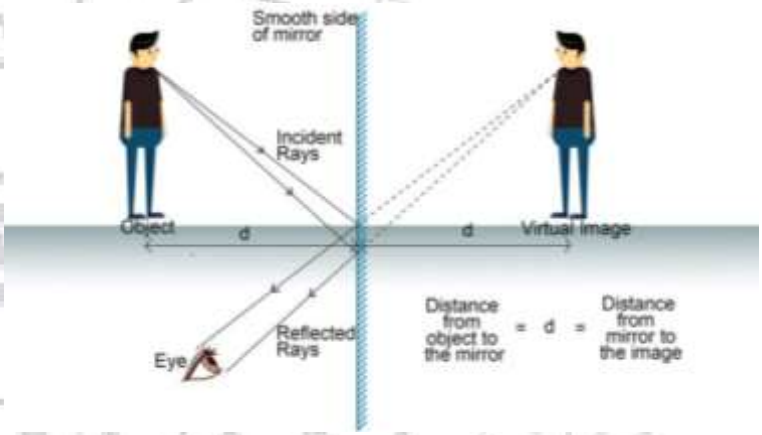
Lateral Inversion: The right side of the object appears left side of the image and vice-versa.

Application of lateral inversion

→ The word AMBULANCE is written in reverse direction so that it can be read correctly in rear view mirror of vehicles going in front of it.

Image formation by a plane mirror

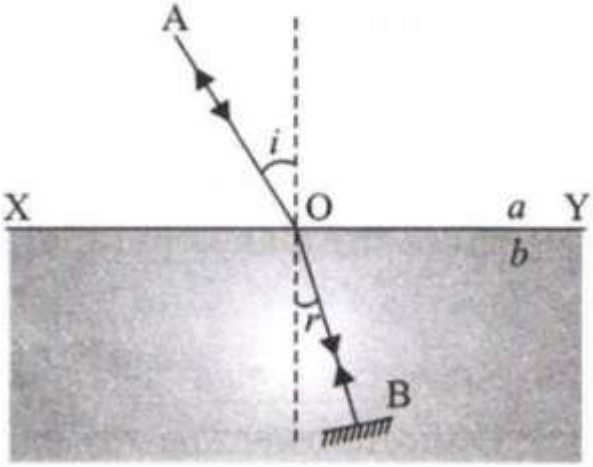




- The image formed by a plane mirror is always virtual and erect.
- Object and image are equidistant from the mirror.

Principle of Reversibility of light

If the direction of a ray of light is reversed due to reflection off a surface, then it will retrace its path.



Spherical Mirrors

Spherical mirror

Consider a hollow sphere with a very smooth and polished inside surface and an outer surface with a coating of mercury so that no light can come out. Then if we cut a thin slice out of the shell, we get a curved mirror, which is called a spherical mirror.

Relationship between focus and radius of curvature

Focal length is half the distance between pole and radius of curvature.

F = R/2

Curved Mirror

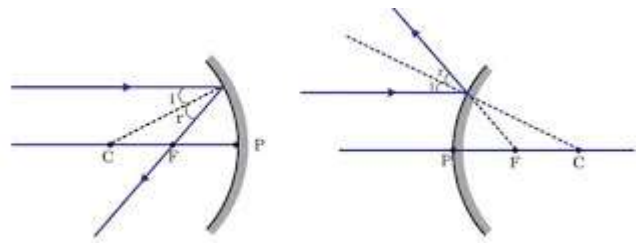
A mirror (or any polished, reflective surface) with a curvature is known as a curved mirror.

Important terms related to spherical mirror

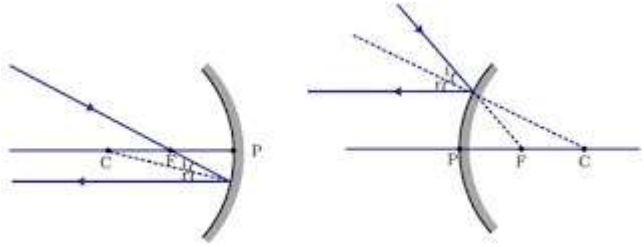
- Pole (P): The midpoint of a spherical mirror.
- Centre of curvature (C): The centre of the sphere that the spherical mirror was a part of.
- The radius of curvature (r): The distance between the centre of curvature and the spherical mirror. This radius will intersect the mirror at the pole (P).
- Principal Axis: The line passing through the pole and the centre of curvature is the main or principal axis.
- Concave Mirror: A spherical mirror with the reflecting surface that bulges inwards.
- Convex Mirror: A spherical mirror with the reflecting surface that bulges outwards.
- Focus (F): Take a concave mirror. All rays parallel to the principal axis converge at a point between the pole and the centre of curvature. This point is called as the focal point or focus.
- Focal length: Distance between pole and focus.

Rules of ray diagram for representation of images formed

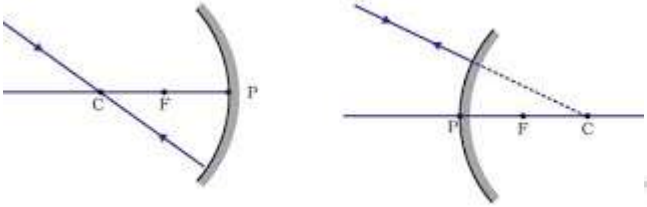
(i) A ray parallel to the principal axis, after reflection, will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.



(ii) 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, after reflection, will emerge parallel to the principal axis.



(iii) A ray passing through the centre of curvature of a concave mirror or directed in the direction of the centre of curvature of a convex mirror, after reflection, is reflected back along the same path.



(iv) A ray incident obliquely to the principal axis, towards a point P (pole of the mirror), on the concave mirror or a convex mirror, is reflected obliquely. The incident and reflected rays follow the laws of reflection at the point of incidence (point P), making equal angles with the principal axis.

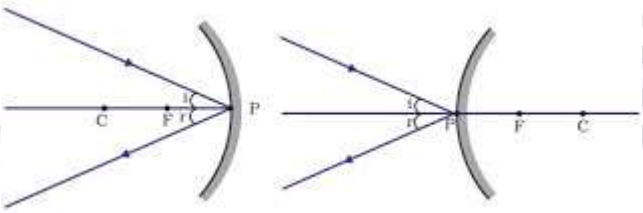


Image formation by spherical mirrors

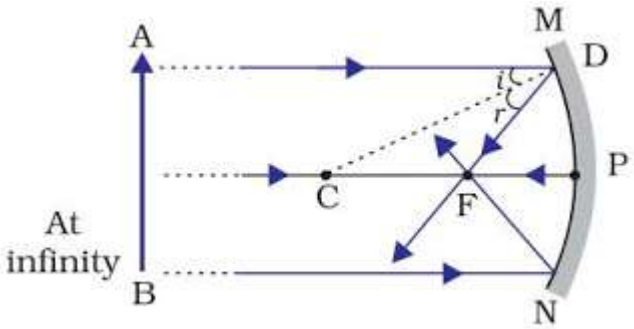
For objects at various positions, the image formed can be found using the ray diagrams for the special two rays. The following table is for a concave mirror.

(i) When object is at infinity

Image Position − At 'F'

Nature of image – Real, inverted

Size – Point sized or highly diminished

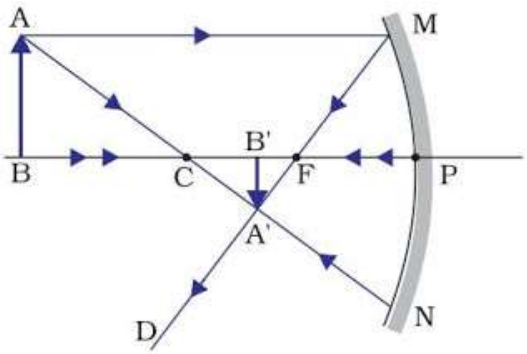


(ii) When object is beyond 'C'

Image Position – Between 'F' and 'C'

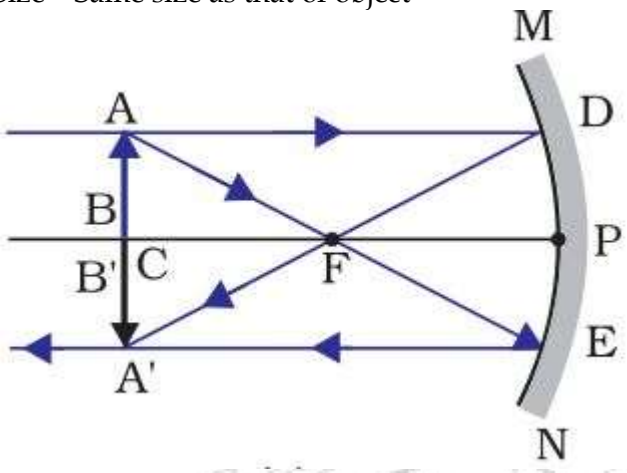
Nature of image – Real, inverted

Size – Diminished



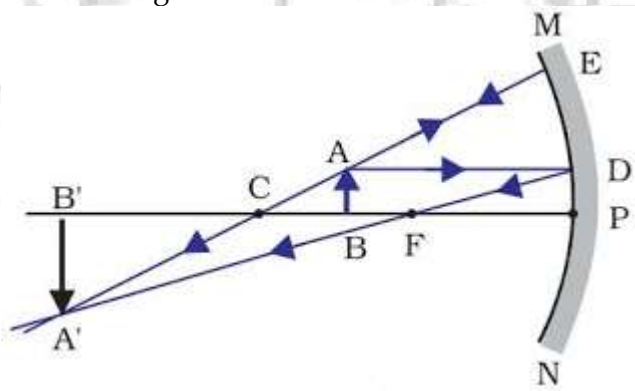
(iii) When object is at 'C'

Image Position – At 'C'
Nature of image – Real, inverted
Size – Same size as that of object



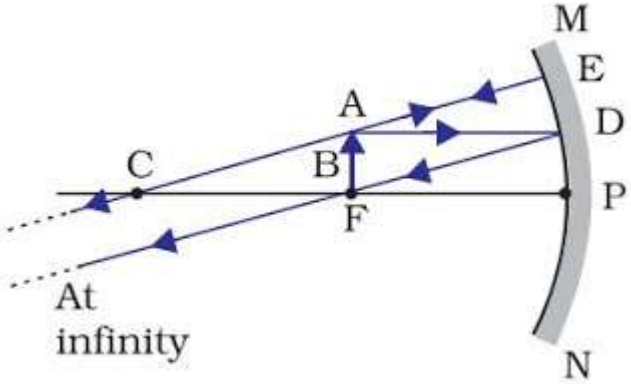
(iv) When object is placed between 'F' and 'C'

Image Position – Beyond 'C'
Nature of image– Real, inverted
Size – Enlarged



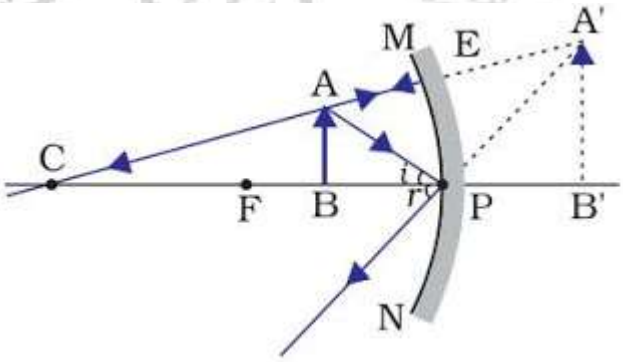
(v) When object is placed at 'F'

Image Position – At Infinity
Nature of image – Real, inverted
Size – Highly enlarged



(vi) When object is between 'P' and 'F'

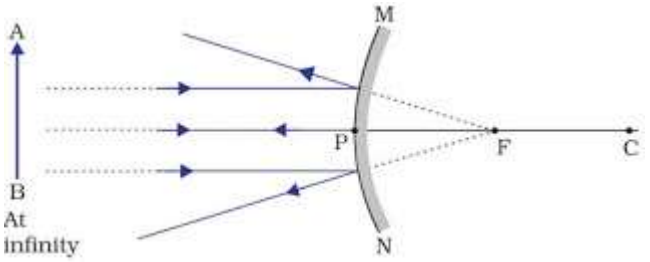
Image Position – Behind the mirror
Nature of image – Virtual, erect
Size – Enlarged



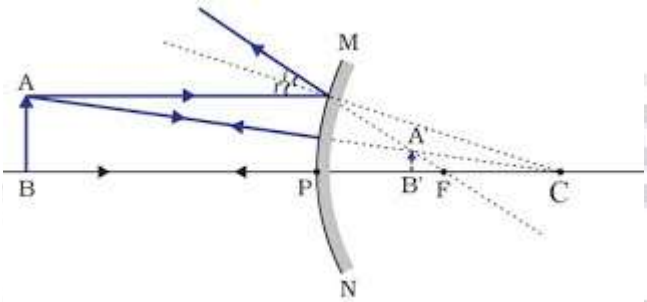
Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At focus F	Highly diminished, point sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At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

Ray diagrams of images formed by convex mirror

(i) When object is placed at infinity
Image Position − At 'F'
Nature of image – Virtual, erect
Size – Point sized



(ii) When object is placed between pole and infinity
Image Position – Between 'P' and 'F'
Nature of image– Virtual, erect
Size – Diminished



A full length image of a tall building/tree can be seen in a small convex mirror.

Uses of spherical mirror based on the image formed

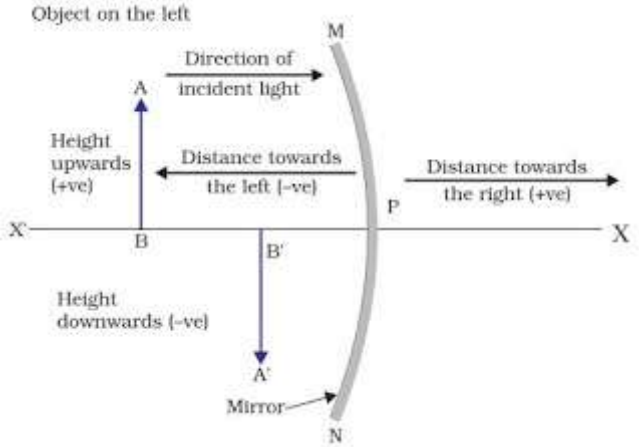
Uses of Concave Mirror
(i) Used in torches, search lights and vehicles headlights to get powerful parallel beam of light.
(ii) Concave mirrors are used by dentists to see large image of teeth of patients. (Teeth have to be placed between pole and focus).
(iii) Concave mirror is used as shaving mirror to see a larger image of the face.
(iv) Large concave mirrors are used to concentrate sunlight to produce heat in solar furnace.

Uses of Convex Mirror
(i) Convex mirrors are used as rear view mirrors in vehicles because
→ they always give an erect though diminished image.
→ they have a wider field of view as they are curved outwards.
(ii) Convex mirrors are used at blind turns and on points of merging traffic to facilitate vision of both side traffic.
(iii) Used in shops as security mirror.

Mirror Formula and Magnification

Sign Convention for Reflection by Spherical Mirror

(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.
(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.



• Object distance = 'u' is always negative.
• Focal length of concave mirror = Negative
• Focal length of convex mirror = Positive

Mirror Formula

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

where, v = Image distance
u = Object distance
f = Focal length

Magnification of Spherical Mirrors
It is the ratio of the height of image to the height of object.

$$m = \frac{height\ of\ image}{height\ of\ object} = \frac{h_i}{h_o} = -\frac{v}{u}$$

→ If 'm' is negative, image is real.
→ If 'm' is positive, image is virtual.
→ If $h_i = h_o$ then m = 1, i.e., image is equal to object.
→ If $h_i > h_o$ then m > 1 i.e., image is enlarged.
→ If $h_i < h_o$ then m < 1 i.e., image is diminished.

• Magnification of plane mirror is always + 1.
'+' sign indicates virtual image.
'1' indicates that image is equal to object's size.
• If 'm' is '+ve' and less than 1, it is a convex mirror.
• If 'm' is '+ve' and more than 1, it is a concave mirror.
• If 'm' is '-ve', it is a concave mirror.

Fill in the blanks

1. Image formed by a plane mirror is always _____ and _____.
2. A spherical mirror, whose reflecting surface is curved inwards, that is,faces towards the centre of the sphere, is called a _____.
3. The focal length of a spherical mirror is equal to _____ its radius of curvature.
4. Speed of light is _____.
5. Light rays always travels in _____.

One marks questions

1. State the laws of reflection of light.
2. A concave mirror produces three times magnified (enlarged) real image of an object placed at 10 cm in front of it. Where is the image located?
3. The magnification produced by a plane mirror is +1. What does this mean?
4. An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.
5. Define the principal focus of a concave mirror.

Three marks questions

1. Draw ray diagrams showing the image formation by a convex mirror when an object is placed at infinity
2. Under what condition in an arrangement of two plane mirrors, incident ray and reflected ray will always be parallel to each other, whatever may be angle of incidence. Show the same with the help of diagram.
3. A 10 mm long awl pin is placed vertically in front of a concave mirror. A 5 mm long image of the awl pin is formed at 30 cm in front of the mirror. Find the focal length of this mirror.
4. Name the type of mirror used in the following situations.
(a) Headlights of a car.
(b) Side/rear-view mirror of a vehicle.
(c) Solar furnace.
Support your answer with reason.
5. A convex mirror used for rear-view on an automobile has a radius of curvature of 3.00 m. If a bus is located at 5.00 m from this mirror, find the position, nature and size of the image.

Five marks questions

1. Draw ray diagrams showing the image formation by a concave mirror when an object is placed
(a) between pole and focus of the mirror
(b) between focus and center of curvature of the mirror
(c) at center of curvature of the mirror
(d) at infinity

2. Size of image of an object by a mirror having a focal length of 20 cm is observed to be reduced to 1/ 3rd of its size. At what distance the object has been placed from the mirror? What is the nature of the image and the mirror?

3. A student has three concave mirrors A, B and C of focal lengths 20 cm, 15 cm and 10 cm respectively. For each concave mirror he performs the experiment of image formation for three values of object distance of 30 cm, 10 cm and 20 cm.
Giving reason answer the following:
(a)For the three object distances, identify the mirror which will form an image equal in size to that of object. Find at least one value of object distance.
(b)Out of the three mirrors, identify the mirror which would be preferred to be used for shaving purpose.
(c)For the mirror B, draw ray diagram for image formation for any two given values of object distance.