ST. ANDREWS SCOTS SR. SEC. SCHOOL

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Class X

Subject : Physics

Light : Reflection and Refraction

LIGHT

Light is a form of energy which produces the sensation of vision and helps us to see objects around us. Without light, objects cannot be seen. Light travels in a straight line and can travel through vacuum as well as transparent media.

Examples: sunlight, electric bulb, candle flame, torch light.

Characteristics of Light

Light travels in a straight line.

Light can undergo reflection and refraction.

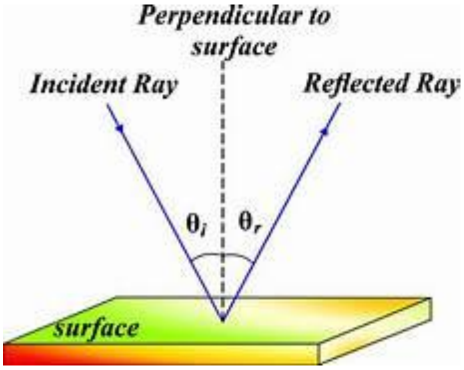
Light travels very fast.

Light can pass through transparent substances.

REFLECTION OF LIGHT

The phenomenon in which light rays bounce back into the same medium after striking a polished or shiny surface is called reflection of light. Reflection enables us to see objects through mirrors and other reflecting surfaces.

Examples: reflection from mirror, reflection from still water, reflection from polished metal surfaces.



LAWS OF REFLECTION

Reflection of light follows two important laws.

First Law of Reflection

The angle of incidence is always equal to the angle of reflection.

Second Law of Reflection

The incident ray, reflected ray and the normal at the point of incidence all lie in the same plane.

MIRROR

A smooth and highly polished reflecting surface is called a mirror. Mirrors are used to form images by reflection of light.

TYPES OF MIRRORS

Mirrors are mainly of two types:

Plane Mirror

A mirror having a flat reflecting surface is called a plane mirror. It forms a virtual, erect and same-sized image.

Examples: dressing mirror, bathroom mirror.

Spherical Mirrors

Mirrors whose reflecting surfaces are curved inward or outward are called spherical mirrors. They are of two types:

Concave Mirror

A spherical mirror whose reflecting surface is curved inward is called a concave mirror. It is also known as a converging mirror because it converges parallel rays of light at one point.

Uses: shaving mirror, dentist mirror, solar furnace, vehicle headlights.

Convex Mirror

A spherical mirror whose reflecting surface bulges outward is called a convex mirror. It is also known as a diverging mirror because it diverges light rays.

Uses: rear view mirrors in vehicles, security mirrors in shops and parking areas.

CONDITIONS OF LIGHT RAYS FALLING ON MIRROR

The following standard rays are used to draw image formation diagrams.

For Concave Mirror

A ray parallel to the principal axis passes through focus after reflection.

A ray passing through focus becomes parallel to principal axis after reflection.

A ray passing through centre of curvature retraces its path after reflection.

A ray striking the pole reflects according to laws of reflection.

For Convex Mirror

A ray parallel to principal axis appears to come from focus after reflection.

A ray directed towards focus becomes parallel to principal axis after reflection.

IMAGE

An image is formed when light rays coming from an object actually meet or appear to meet after reflection or refraction.

TYPES OF IMAGES

Real Image

A real image is formed when reflected or refracted rays actually meet at a point. Real images can be obtained on a screen and are generally inverted.

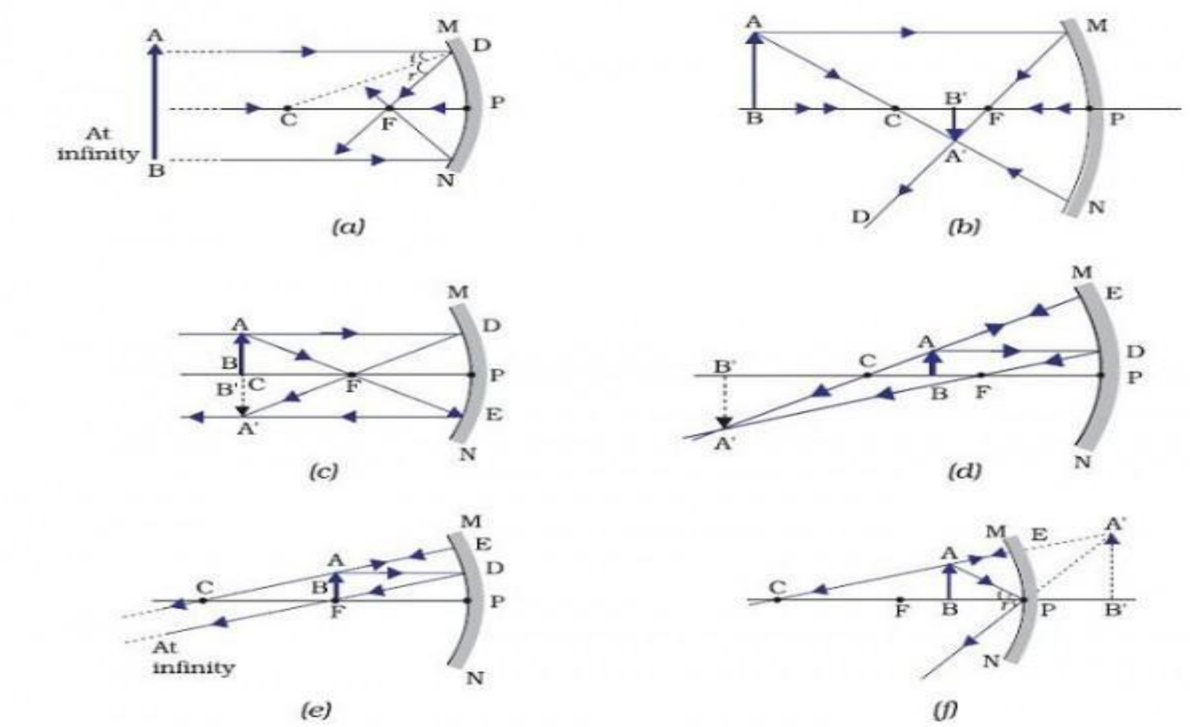
Example: image formed on cinema screen.

Virtual Image

A virtual image is formed when rays appear to meet at a point. Virtual images cannot be obtained on a screen and are generally erect.

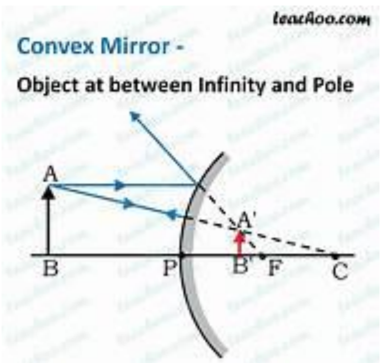
Example: image formed by plane mirror.

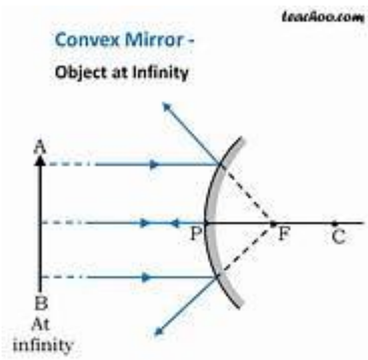
IMAGE FORMATION BY CONCAVE MIRROR



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

IMAGE FORMATION BY CONVEX MIRROR





Position of the object	Position of the image	Size of the image	Nature of the image
Anywhere between P and infinity	Behind the mirror between P and F	Diminished	Virtual and erect
At infinity	Behind the mirror at focus	Highly diminished	Virtual and erect

MIRROR FORMULA

Mirror's Formula

The relation between object's distance, image distance and focal length of mirror is known as mirror's formula.

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

u → object distance

v → image distance

f → focal length of mirror

MAGNIFICATION FOR MIRROR

Linear Magnification, m

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

or

$$m = -\frac{\text{image distance}}{\text{object distance}} = -\frac{v}{u}$$

$$m = \frac{h'}{h} = -\frac{v}{u} \quad \text{or} \quad m = \left|\frac{v}{u}\right|$$

Nature of Magnification

Positive magnification indicates virtual and erect image.

Negative magnification indicates real and inverted image.

REFRACTION OF LIGHT

The bending of light when it passes from one transparent medium to another is called refraction of light. Refraction occurs due to change in speed of light in different media.

Examples: bending of pencil in water, twinkling of stars, apparent depth of water.

CONDITIONS NECESSARY FOR REFRACTION

Light must travel from one medium to another.

The two media should have different optical densities.

Light should strike the surface obliquely.

RARER AND DENSER MEDIUM

Optically Rarer Medium

A medium in which light travels faster is called optically rarer medium.

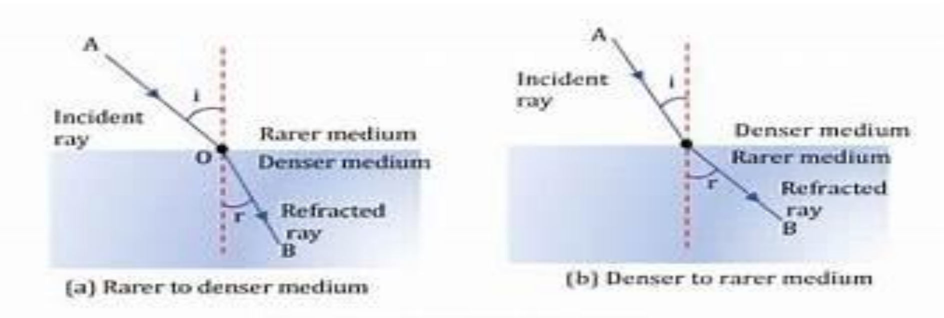
Examples: air, vacuum.

Optically Denser Medium

A medium in which light travels slower is called optically denser medium.

Examples: glass, water.

Behaviour of Light



Characteristics of refraction of light

When light travels from rarer to denser medium, it bends towards the normal.

When light travels from denser to rarer medium, it bends away from the normal.

LAWS OF REFRACTION

Refraction of light follows two laws known as Snell's laws.

First Law

The incident ray, refracted ray and normal at the point of incidence lie in the same plane.

Second Law

For a given pair of media, the ratio of sine of angle of incidence to sine of angle of refraction remains constant.

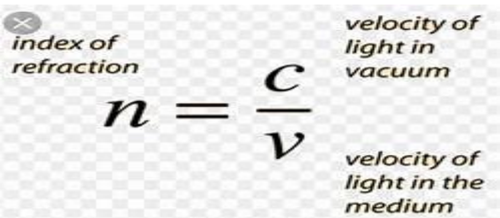
This constant is called refractive index.

REFRACTIVE INDEX

The refractive index of a medium is a measure of how much the medium bends light.

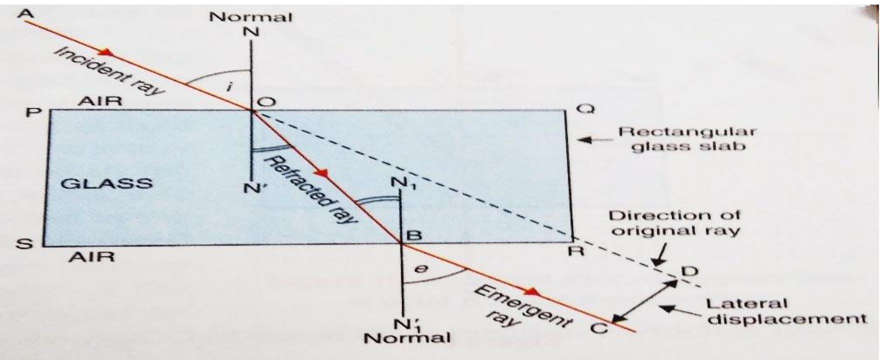
ABSOLUTE REFRACTIVE INDEX

The absolute refractive index of a medium is defined as the ratio of speed of light in vacuum to the speed of light in that medium.



REFRACTION THROUGH A RECTANGULAR GLASS SLAB

When light enters a rectangular glass slab, it bends towards the normal because glass is optically denser than air. When the ray emerges from the slab into air, it bends away from the normal. The emergent ray becomes parallel to the incident ray but is slightly shifted sideways. This sideways shift is called lateral displacement.



LENS

A transparent refracting medium bounded by two curved surfaces is called a lens.

TYPES OF LENSES

Convex Lens

A lens thicker at the centre and thinner at the edges is called convex lens. It converges parallel rays of light at one point and is therefore called converging lens.

Uses: magnifying glass, microscope, camera, human eye.

Concave Lens

A lens thinner at the centre and thicker at the edges is called concave lens. It diverges parallel rays of light and is therefore called diverging lens.

Uses: spectacles for myopia, door viewers.

IMAGE FORMATION BY CONVEX LENS

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_2	Highly diminished, point-sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Infinitely large or highly enlarged	Real and inverted
Between focus F_1 and optical centre O	On the same side of the lens as the object	Enlarged	Virtual and erect

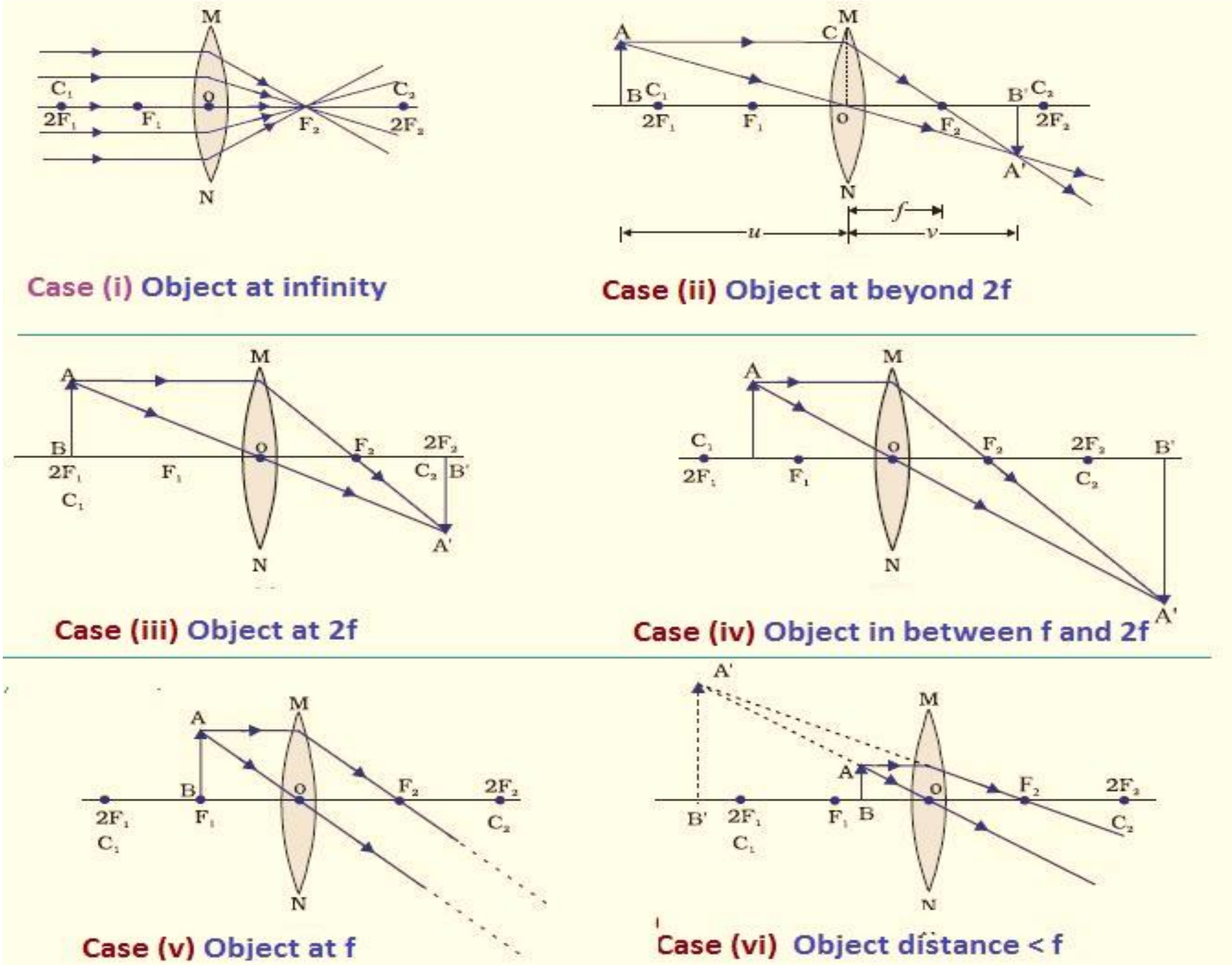
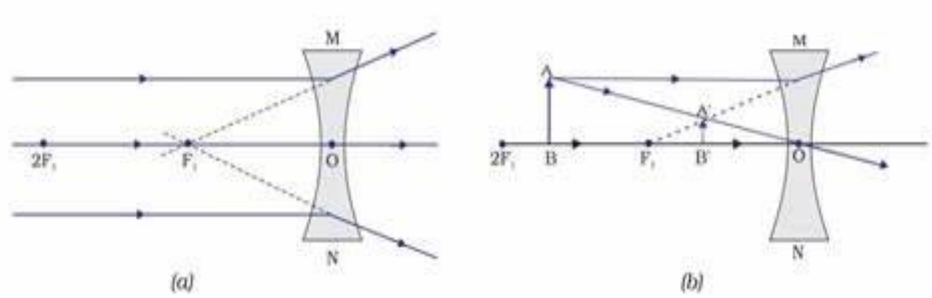


IMAGE FORMATION BY CONCAVE LENS

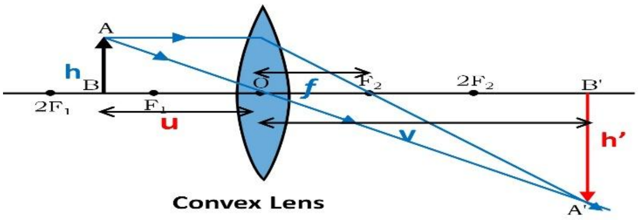


Nature, position and relative size of the image formed by a concave lens

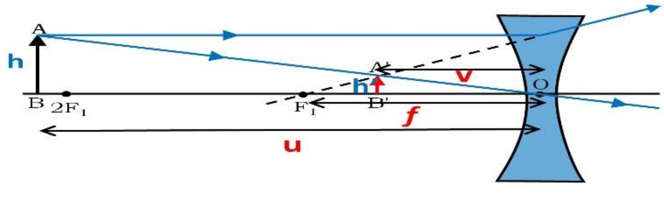
Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F_1	Highly diminished, point-sized	Virtual and erect
Between infinity and optical centre O of the lens	Between focus F_1 and optical centre O	Diminished	Virtual and erect

LENS FORMULA

Lens Formula and Magnification



Convex Lens



Concave Lens

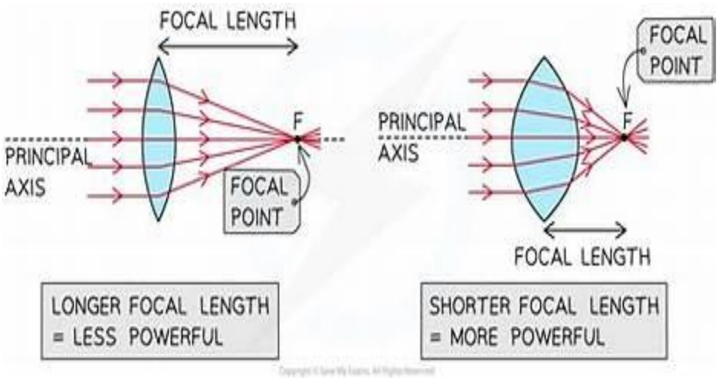
Lens Formula: $$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

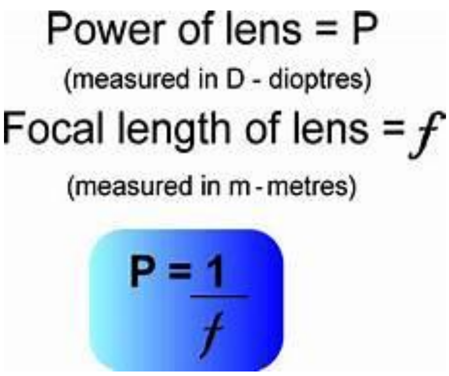
Magnification $$m = \frac{Height\ of\ image}{Height\ of\ Object}$$

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

POWER OF LENS

The power of a lens is the ability of the lens to converge or diverge light rays. The SI unit of power is dioptre (D).

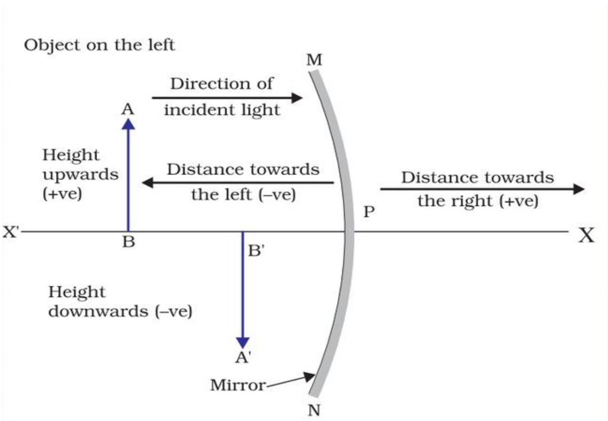


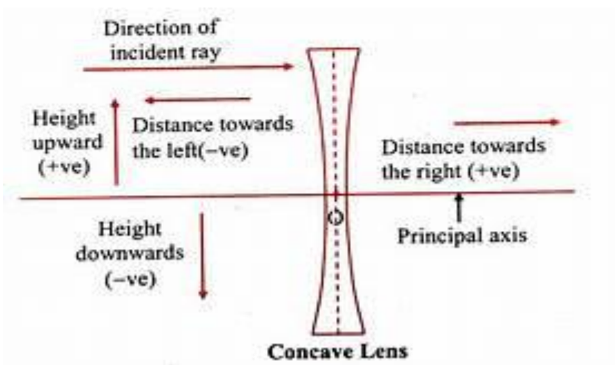


Convex lens has positive power.

Concave lens has negative power.

SIGN CONVENTION





According to Cartesian sign convention:

All distances are measured from pole or optical centre.

Distances measured in direction of incident light are positive.

Distances measured opposite to direction of incident light are negative.

Heights above principal axis are positive.

Heights below principal axis are negative.