CHAPTER - 10

LIGHT : REFLECTION AND REFRACTION

Class	**:- X**
Subject	**:- Science**
Name of Teacher	**:- Mr. V. K. Pathak (PGT Physics)**
School	**:- KV RRL Jorhat, Assam**

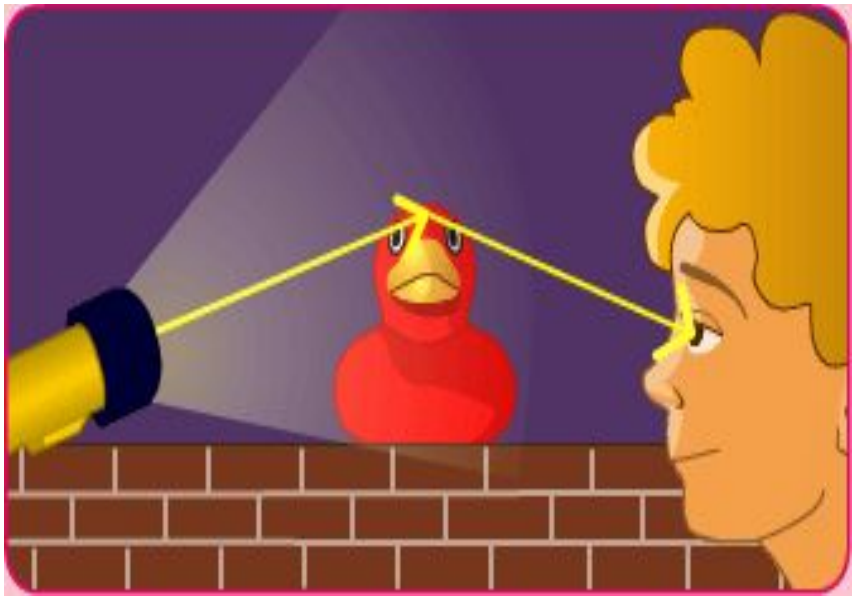
1) Light :-

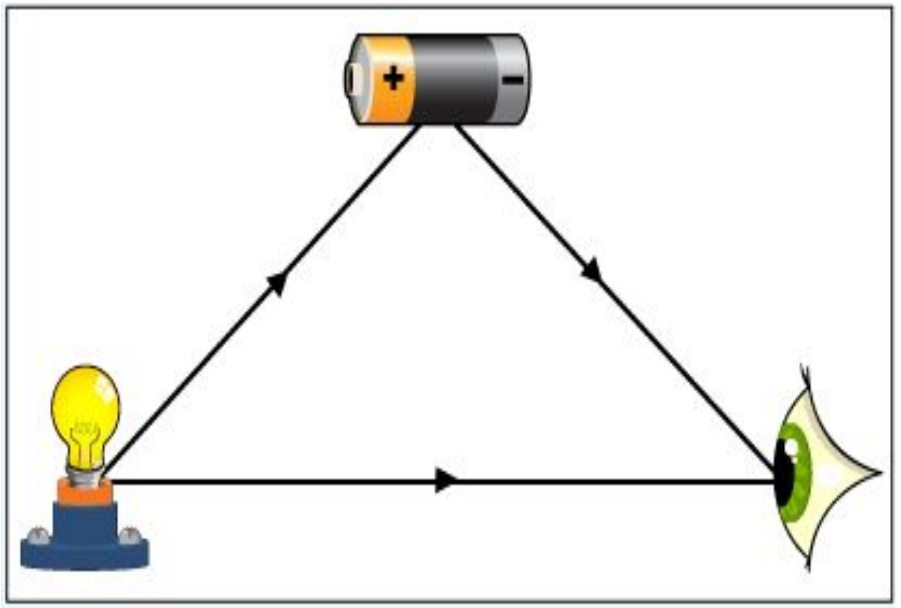
i) Light is a form of energy which helps us to see objects.

ii) When light falls on objects, it reflects the light and when the reflected light reaches our eyes then we see the objects.

iii) Light travels in straight line.

iv) The common phenomena of light are formation of shadows, formation of images by mirrors and lenses, bending of light by a medium, twinkling of stars, formation of rainbow etc.





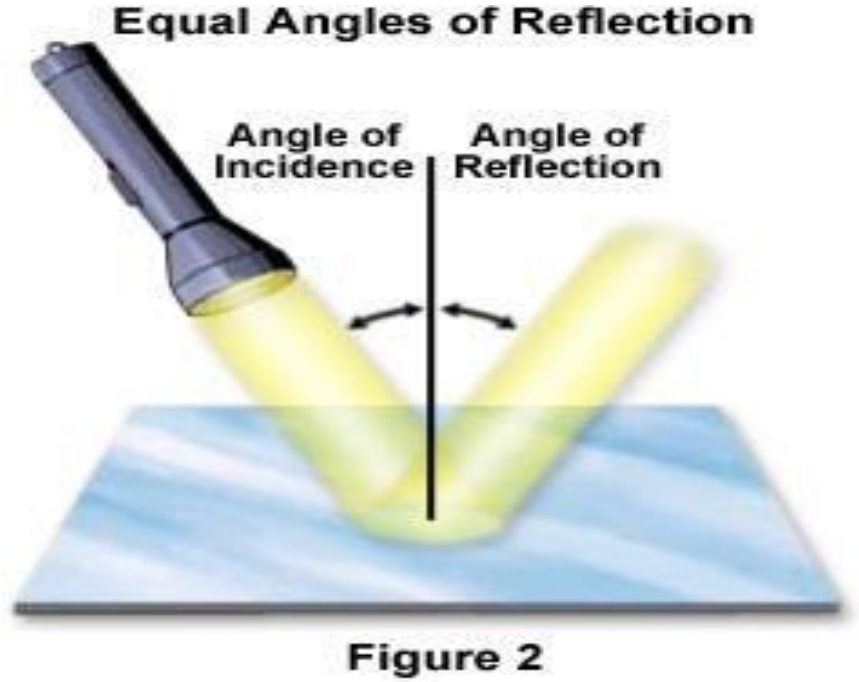

Equal Angles of Reflection
Angle of Incidence
Angle of Reflection

Figure 2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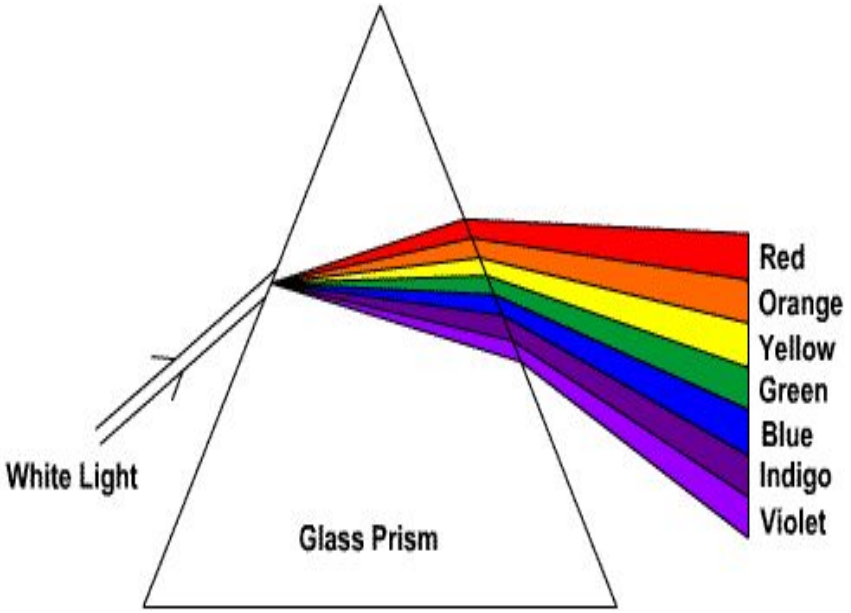

White Light
Glass Prism
Red
Orange
Yellow
Green
Blue
Indigo
Violet

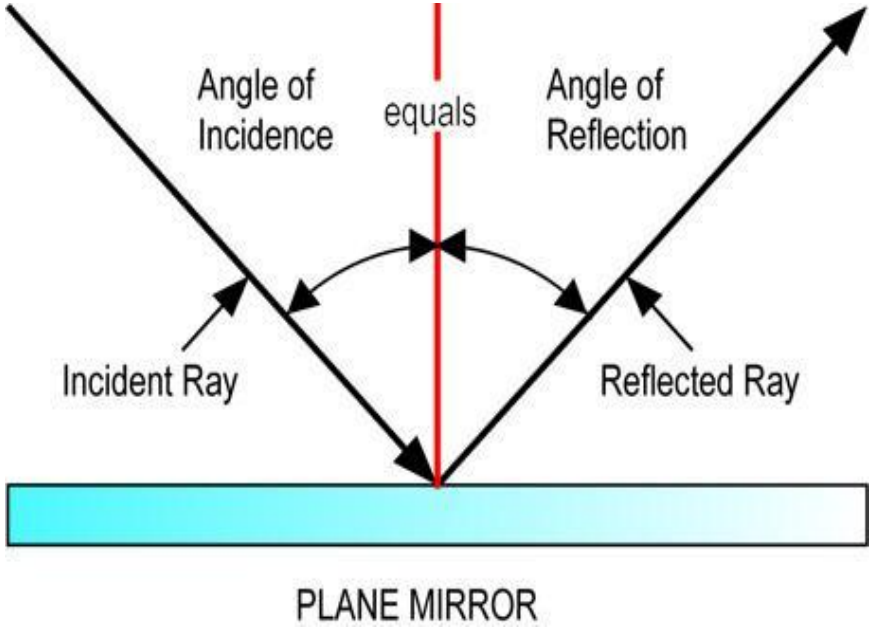
2a) Reflection of light :-

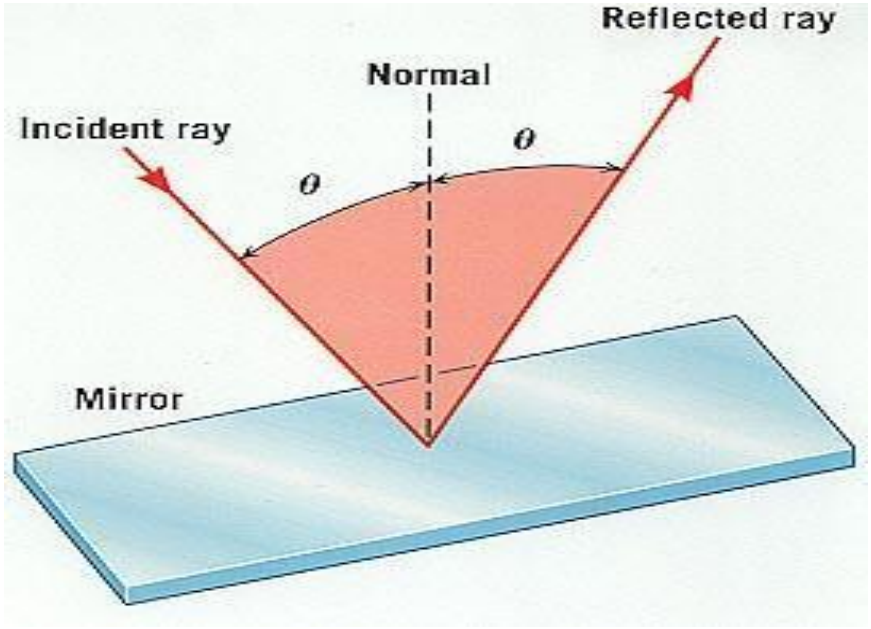
When light falls on a highly polished surface like a mirror most of the light is sent back into the same medium. This process is called reflection of light.

a) Laws of reflection of light :-

i) The angle of incidence is equal to the angle of reflection.

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





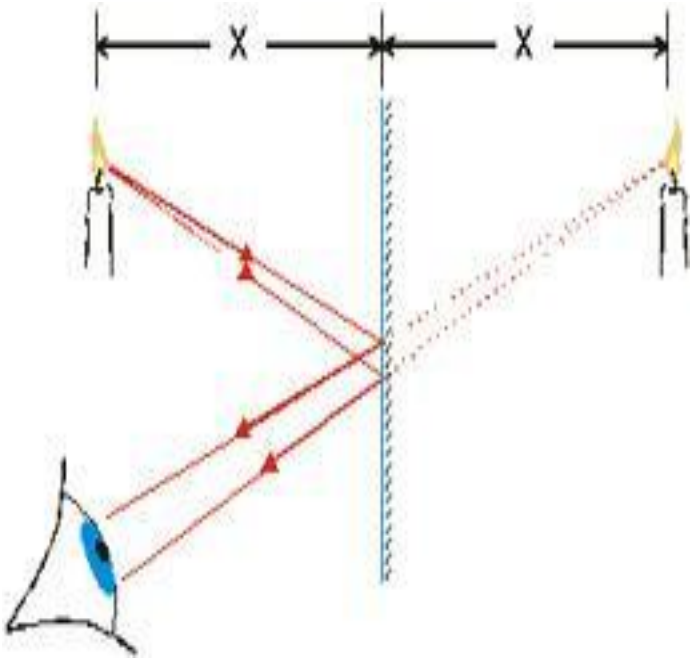
i) The image is erect.

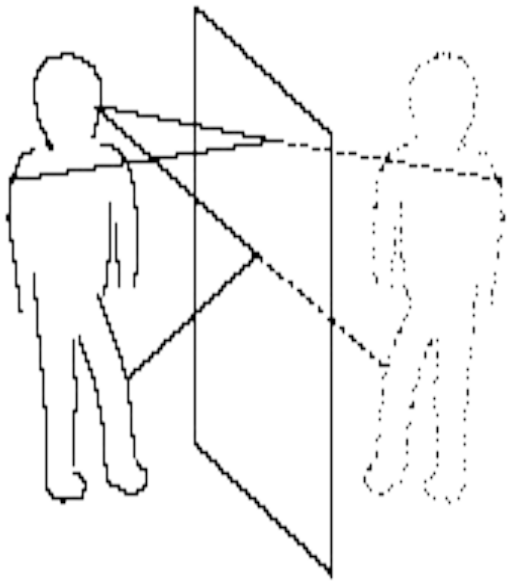
ii) The image is same size as the object.

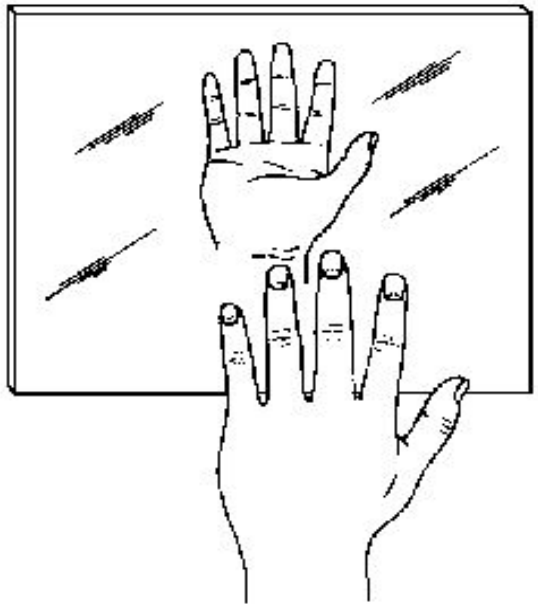
iii) The image is at the same distance from the mirror as the object is in front of it.

iv) The image is virtual (cannot be obtained on a screen).

v) The image is laterally inverted.





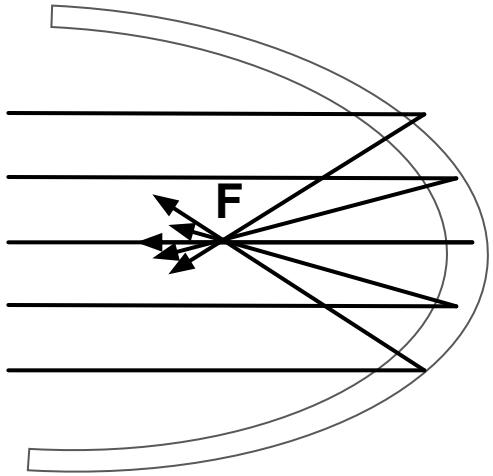


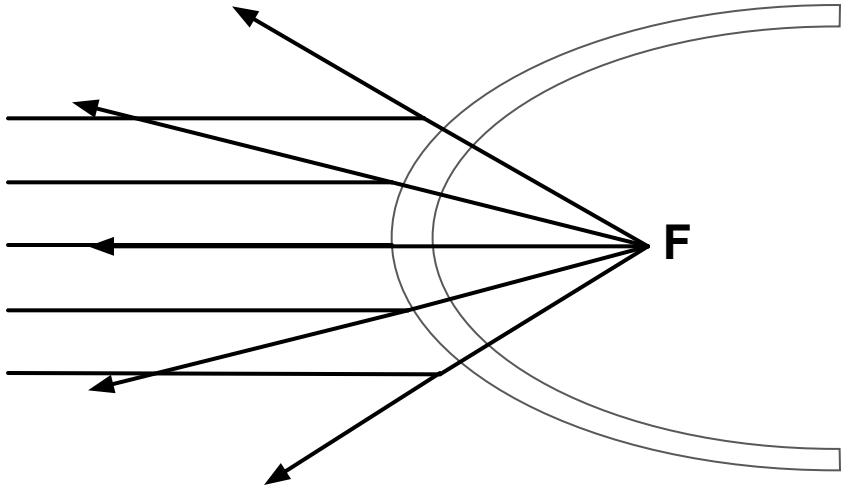
3) Spherical mirrors :-

Spherical mirror is a curved mirror which is a part of a hollow sphere. Spherical mirrors are of two types. They are concave mirror and convex mirror.

i) Concave mirror :- is a spherical mirror whose reflecting surface is curved inwards. Rays of light parallel to the principal axis after reflection from a concave mirror meet at a point (converge) on the principal axis.

ii) Convex mirror :- is a spherical mirror whose reflecting surface is curved inwards. Rays of light parallel to the principal axis after reflection from a convex mirror get diverged and appear to come from a point behind the mirror.





4) Terms used in the study of spherical mirrors :-

i) **Center of curvature** :- is the centre of the sphere of which the mirror is a part (C).

ii) **Radius of curvature** :- is the radius of the sphere of which the mirror is a part (CP).

iii) **Pole** :- is the centre of the spherical mirror (P).

iv) **Principal axis** :- is the straight line passing through the centre of curvature and the pole (X-Y).

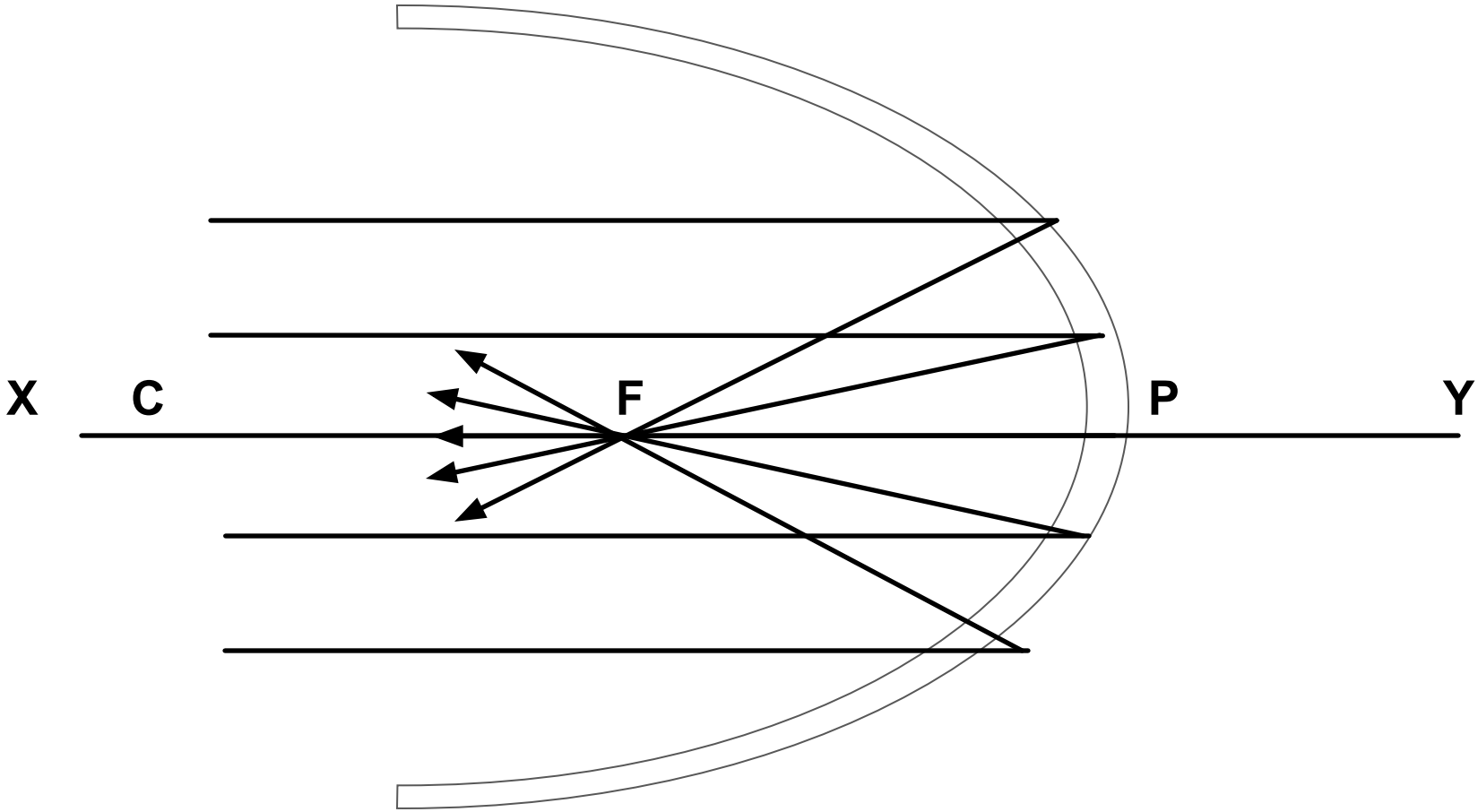
v) **Principal focus** :-

In a concave mirror, rays of light parallel to the principal axis after reflection meet at a point on the principal axis called principal focus(F).

In a convex mirror, rays of light parallel to the principal axis after reflection get diverged and appear to come from a point on the principal axis behind the mirror called principal focus (F).

vi) **Focal length** :- is the distance between the pole and principal focus (f). In a spherical mirror the radius of curvature is twice the focal length.

$$R = 2f \quad \text{or} \quad f = \frac{R}{2}$$



C – centre of curvature

P – pole

F – principal focus

CP – radius of curvature

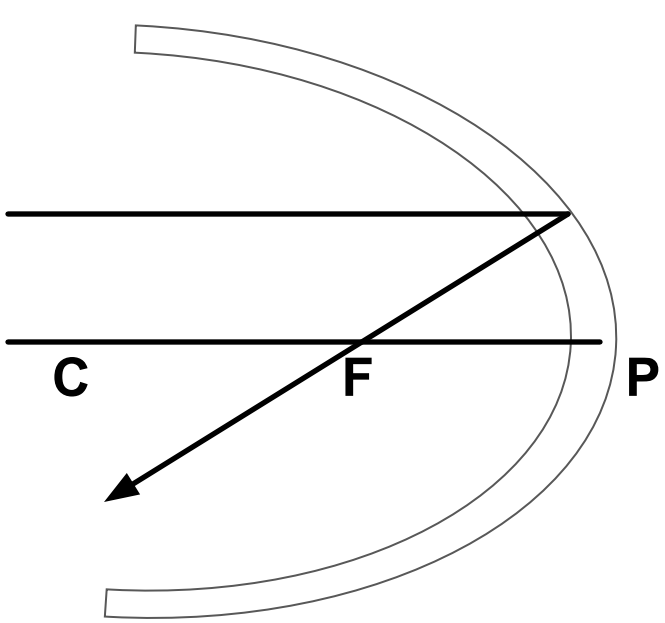
XY – principal axis

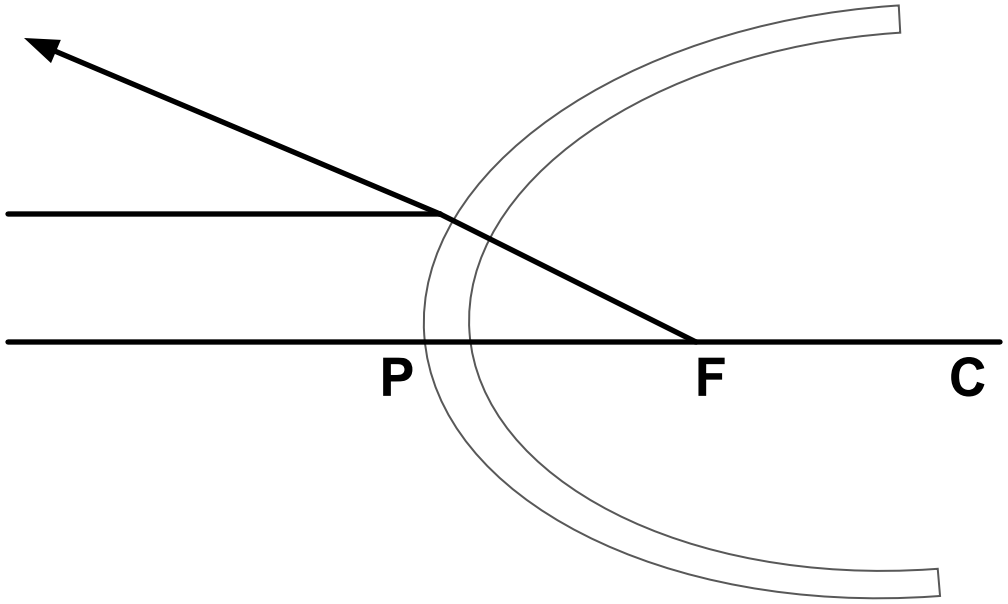
PF – focal length

5) Reflection by spherical mirrors :-

i) In a concave mirror a ray of light parallel to the principal axis after reflection passes through the focus.

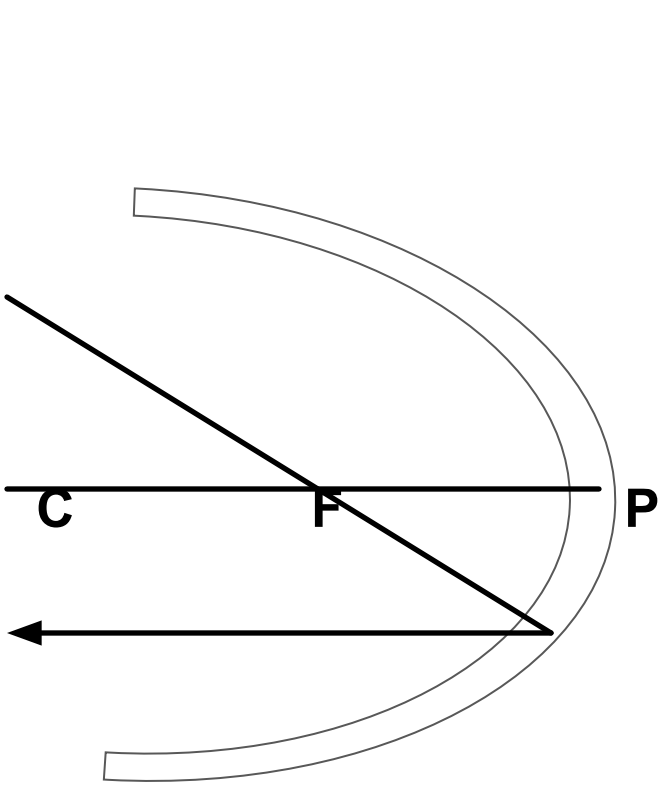
In a convex mirror a ray of light parallel to the principal axis after reflection appears to diverge from the focus.

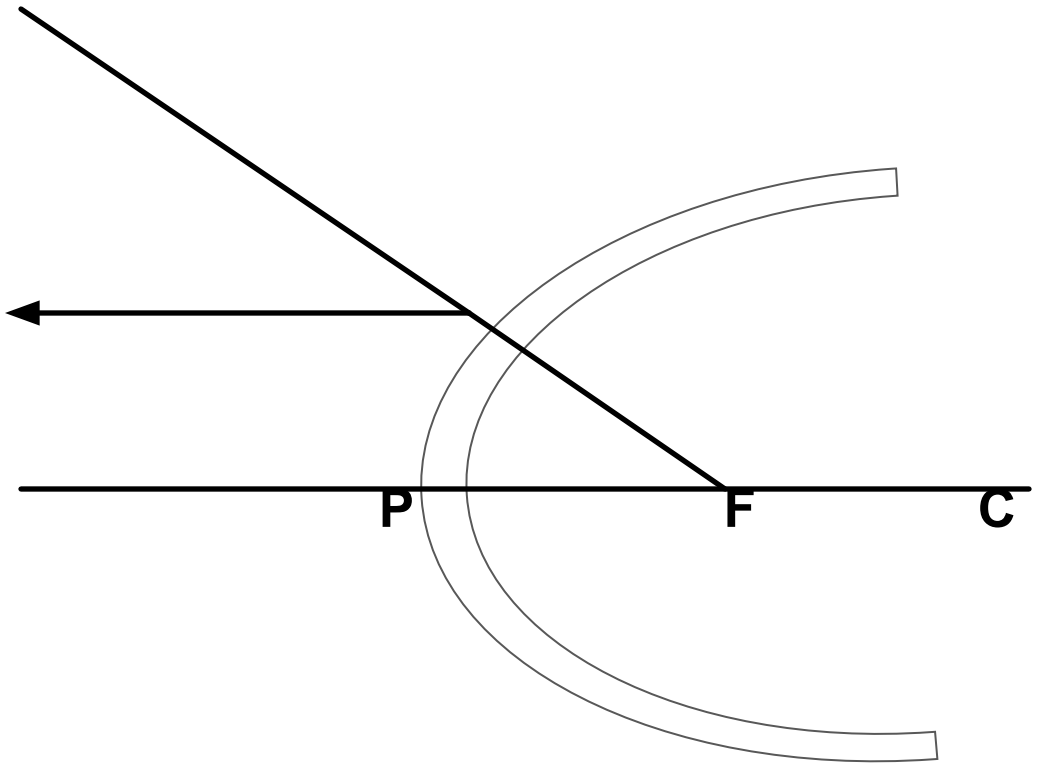




ii) In a concave mirror a ray of light passing through the focus after reflection goes parallel to the principal axis.

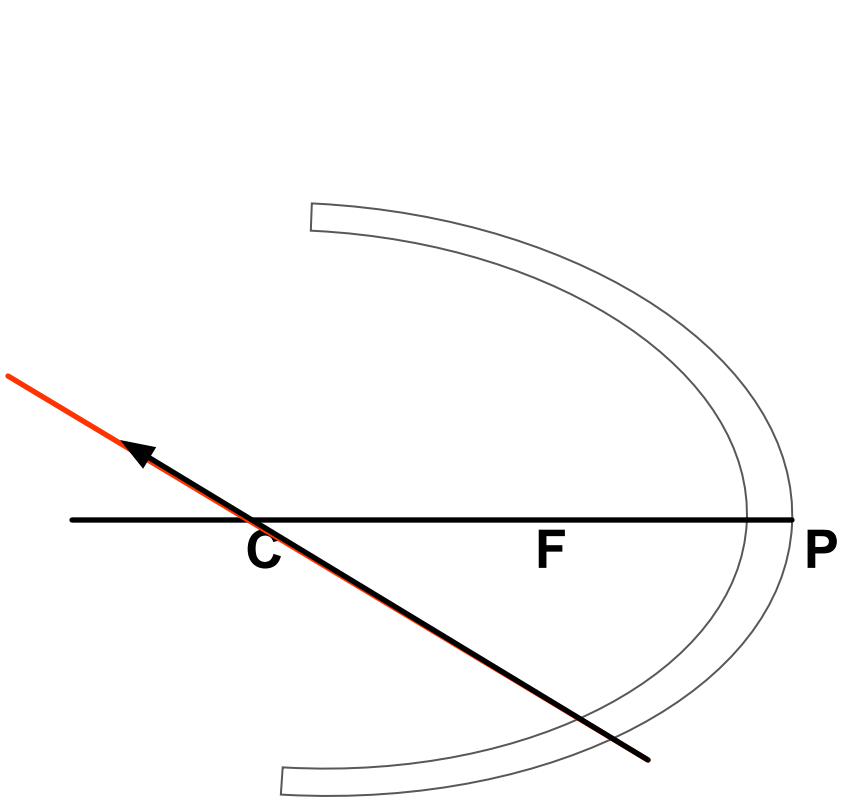
In a convex mirror a ray of light directed towards the focus after reflection goes parallel to the principal axis.

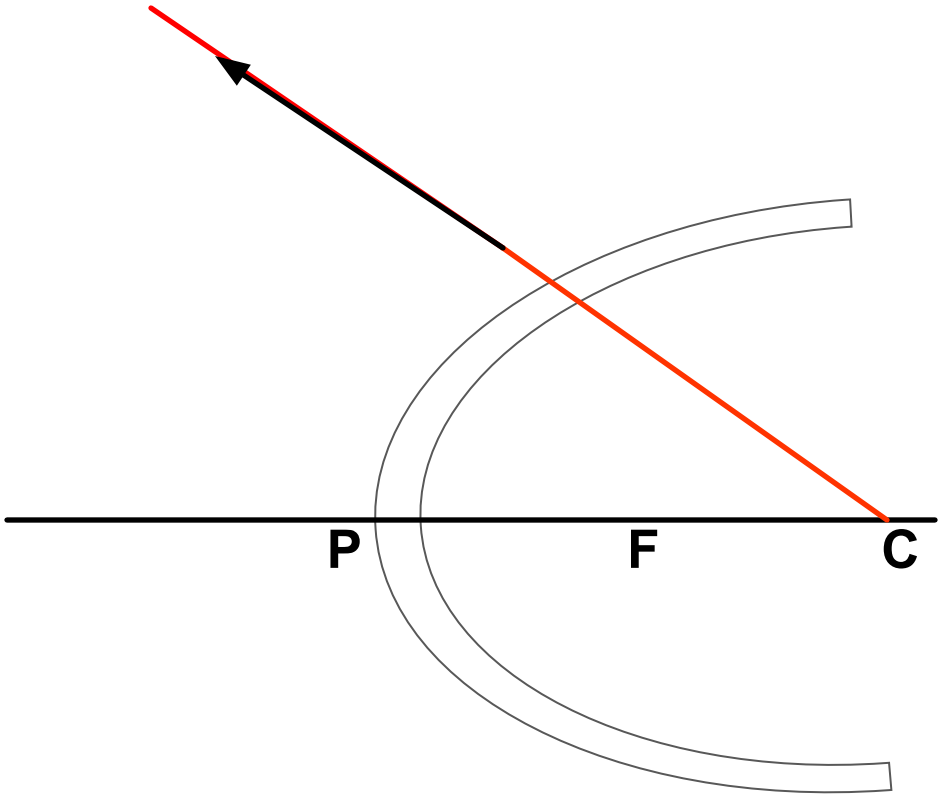




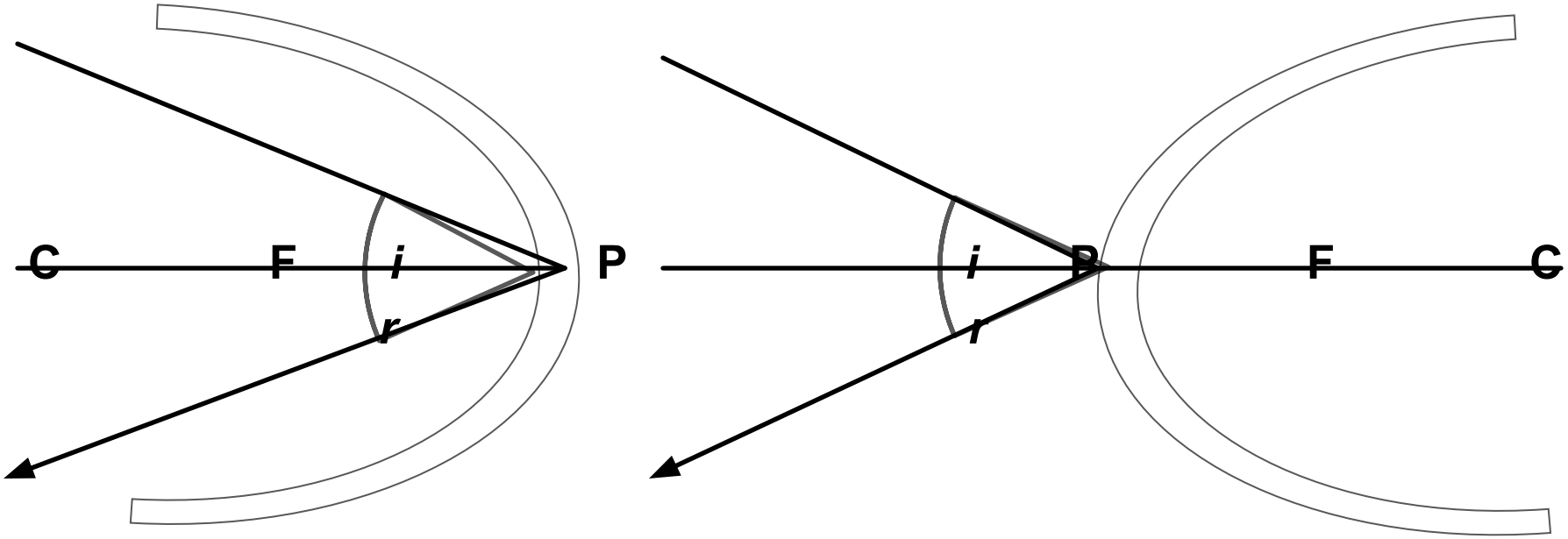
iii) In a concave mirror a ray of light passing through the centre of curvature after reflection is reflected back along the same direction.

In a convex mirror a ray of light directed towards the centre of curvature after reflection is reflected back along the same direction.



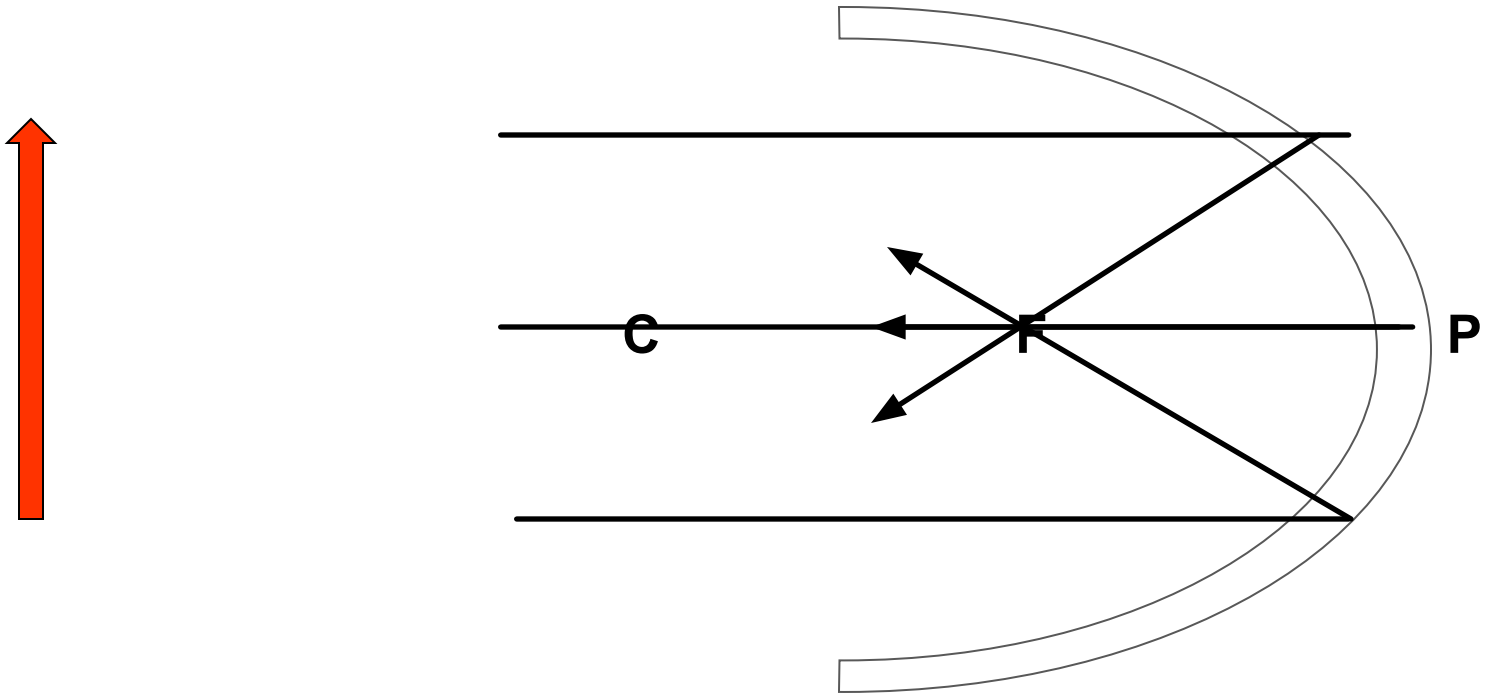


iv) In a concave or a convex mirror a ray of light directed obliquely at the pole is reflected obliquely making equal angles with the principal axis.

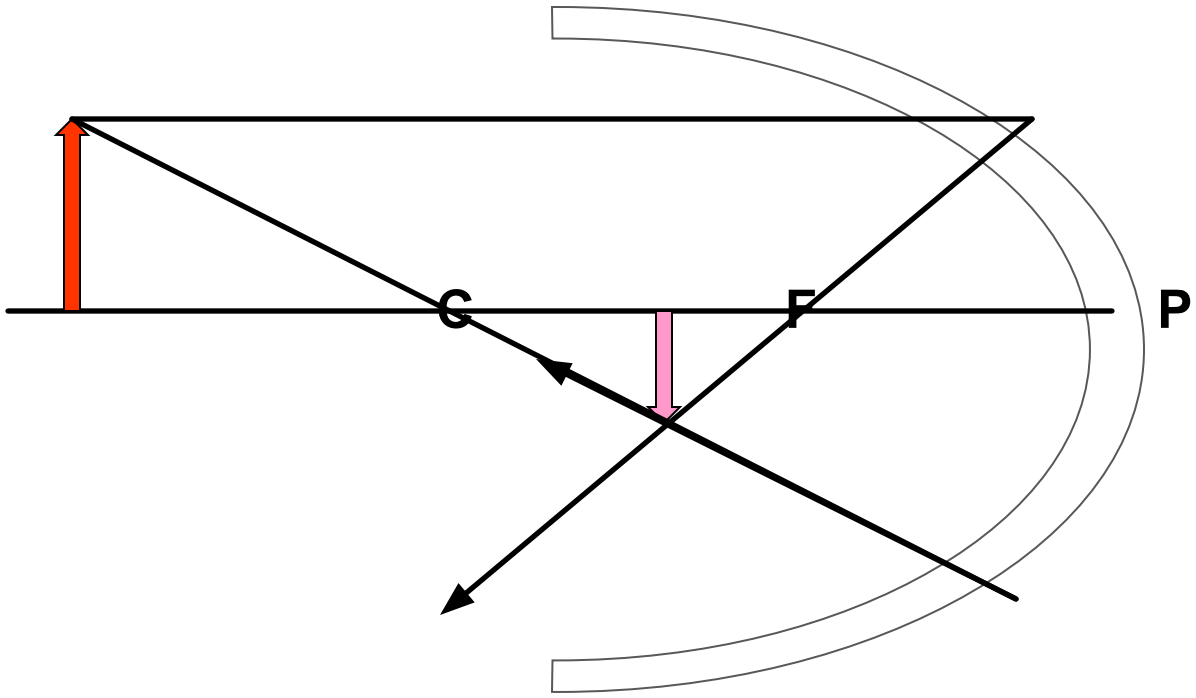


6) Images formed by concave mirror :-

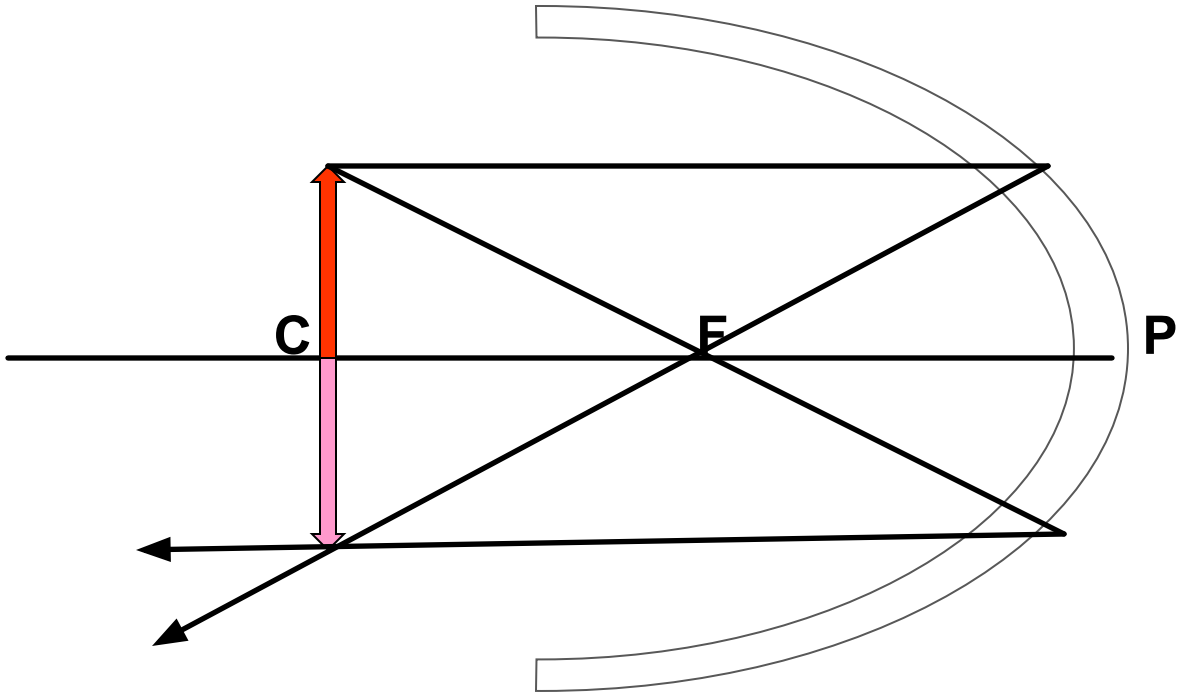
i) When the object is at infinity the image is formed at the focus, it is highly diminished, real and inverted.



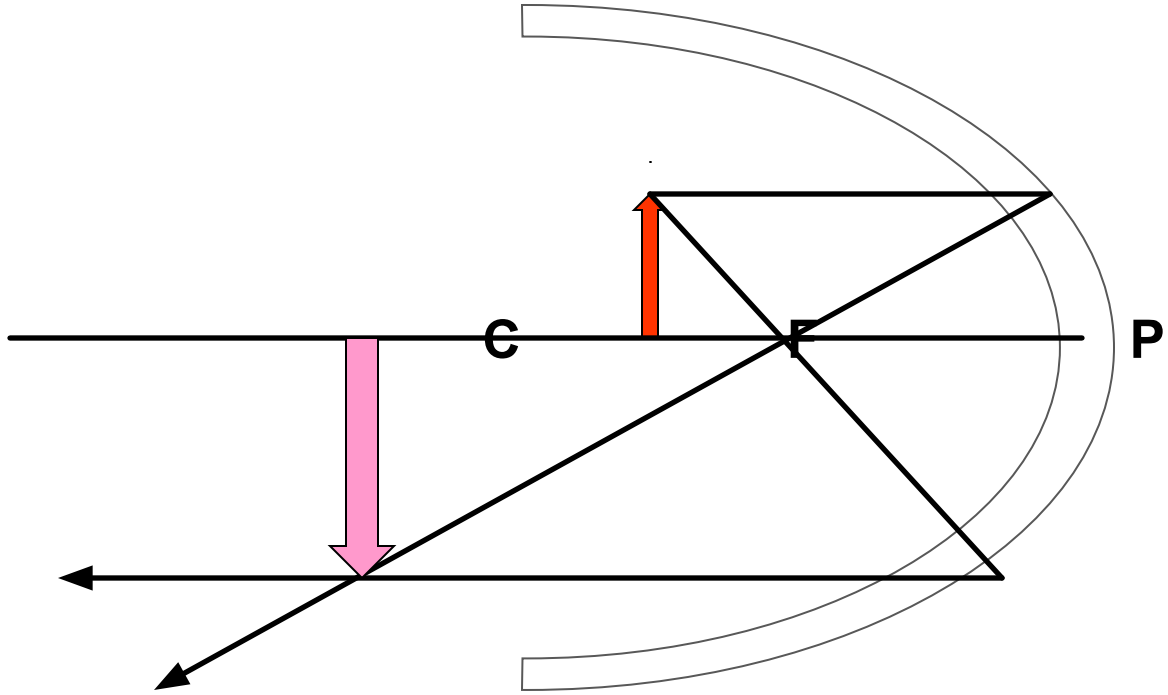
ii) When the object is beyond C, the image is formed between C and F, it is diminished, real and inverted.



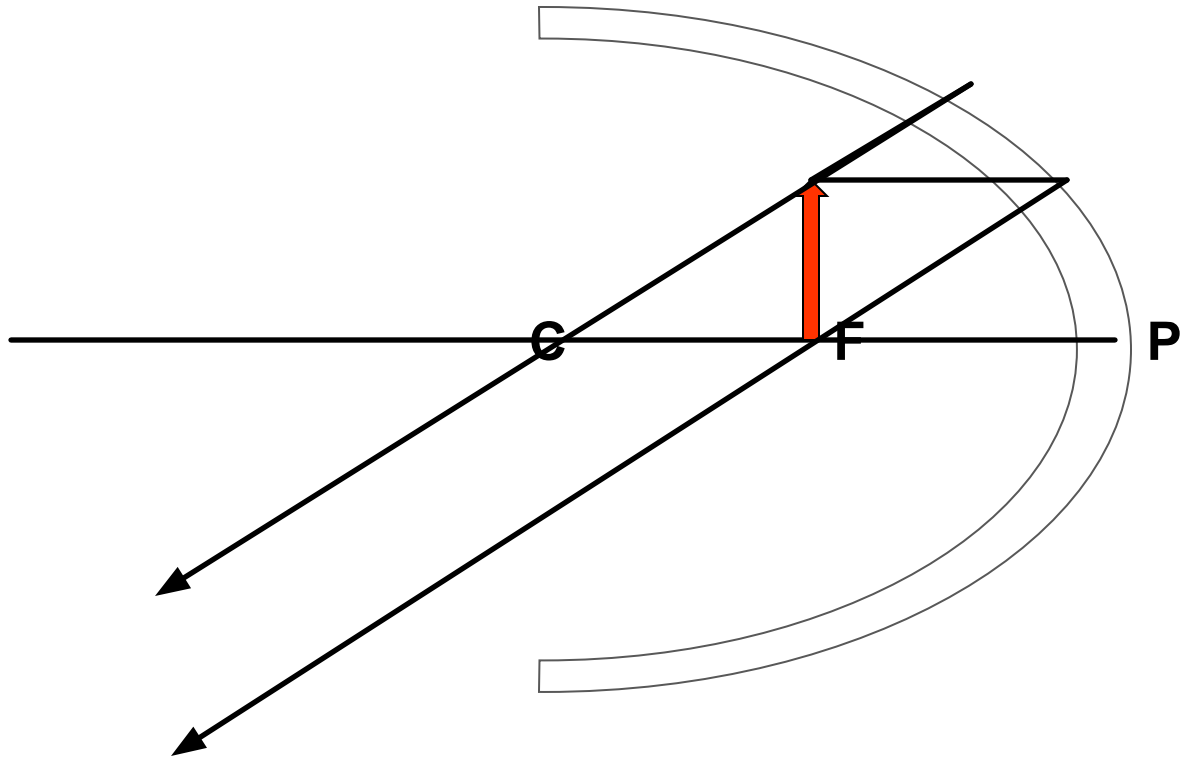
iii) When the object is at C, the image is formed at C, it is same size as the object, real and inverted.



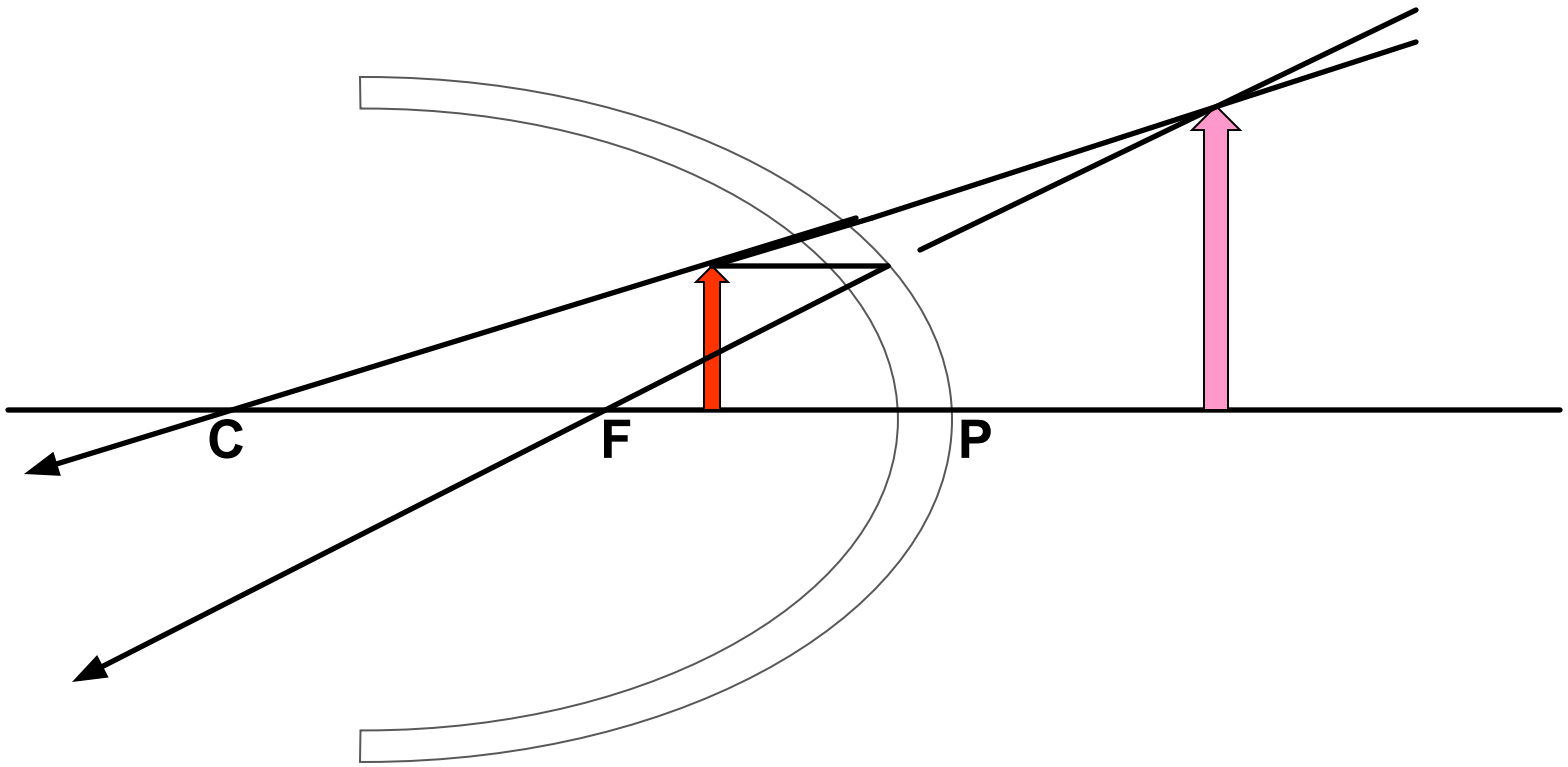
iv) When the object is between C and F, the image is formed beyond C, it is enlarged, real and inverted.



v) When the object is at F, the image is formed at infinity, it is highly enlarged, real and inverted.

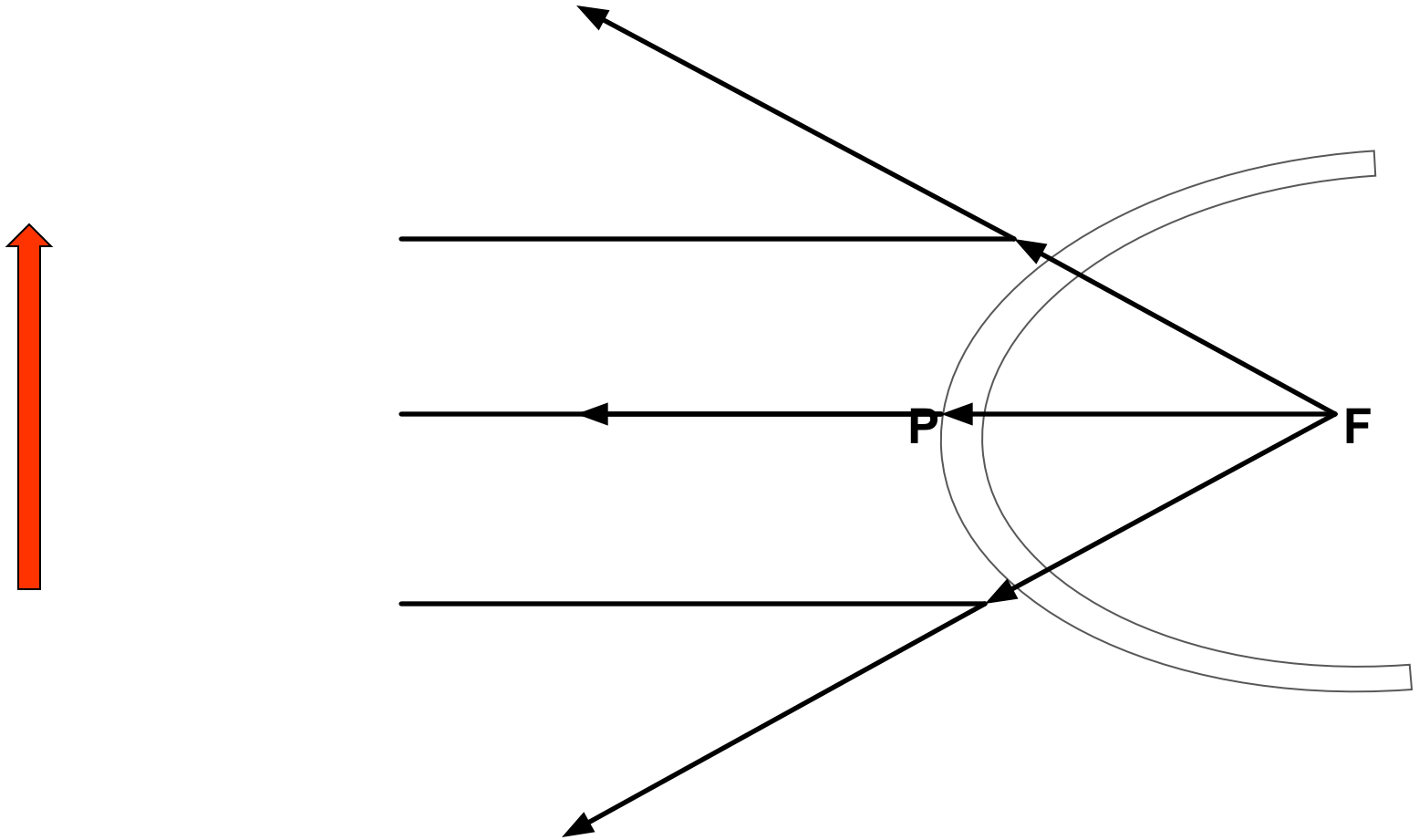


vi) When the object is between F and P, the image is formed behind the mirror, it is enlarged, virtual and erect.

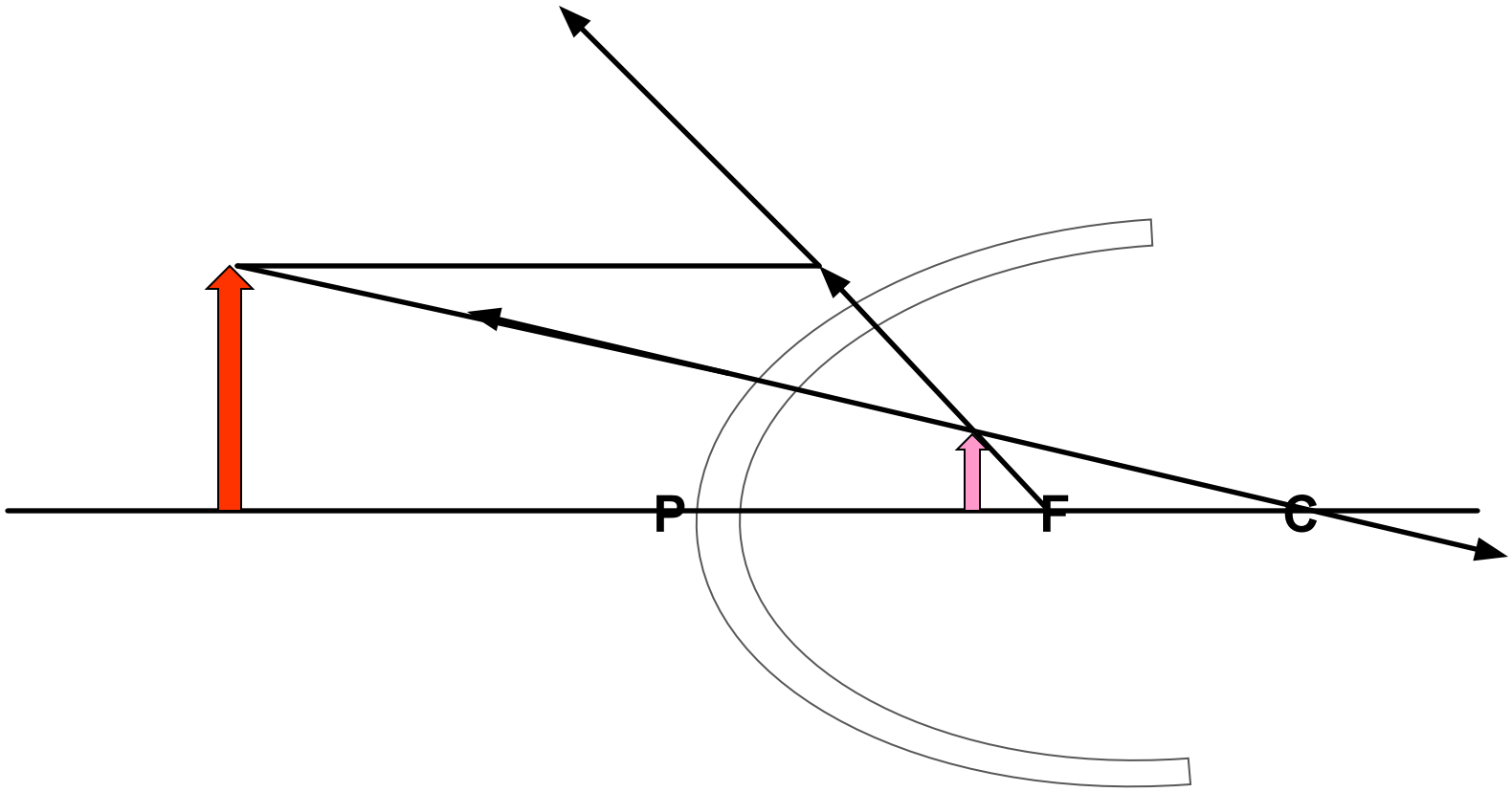


7) Images formed by convex mirror :-

i) When the object is at infinity, the image is formed at F behind the mirror, it is highly diminished, virtual and erect.



ii) When the object is between infinity and pole, the image is formed behind the mirror, it is diminished, virtual and erect.



8) Uses of spherical mirrors :-

a) Concave mirrors :-

Concave mirrors are used in torches, search lights and head lights of vehicles to get parallel beams of light.

They are used as shaving mirrors to see larger image of the face.

They are used by dentists to see larger images of the teeth.

Large concave mirrors are used to concentrate sunlight to produce heat in solar furnaces.

b) Convex mirrors :-

Convex mirrors are used as rear-view mirrors in vehicles. Convex mirrors give erect diminished images of objects. They also have a wider field of view than plane mirrors.

9) New Cartesian sign convention for spherical mirrors :-

i) The object is always placed on the left of the mirror and light from the object falls from the left to the right.

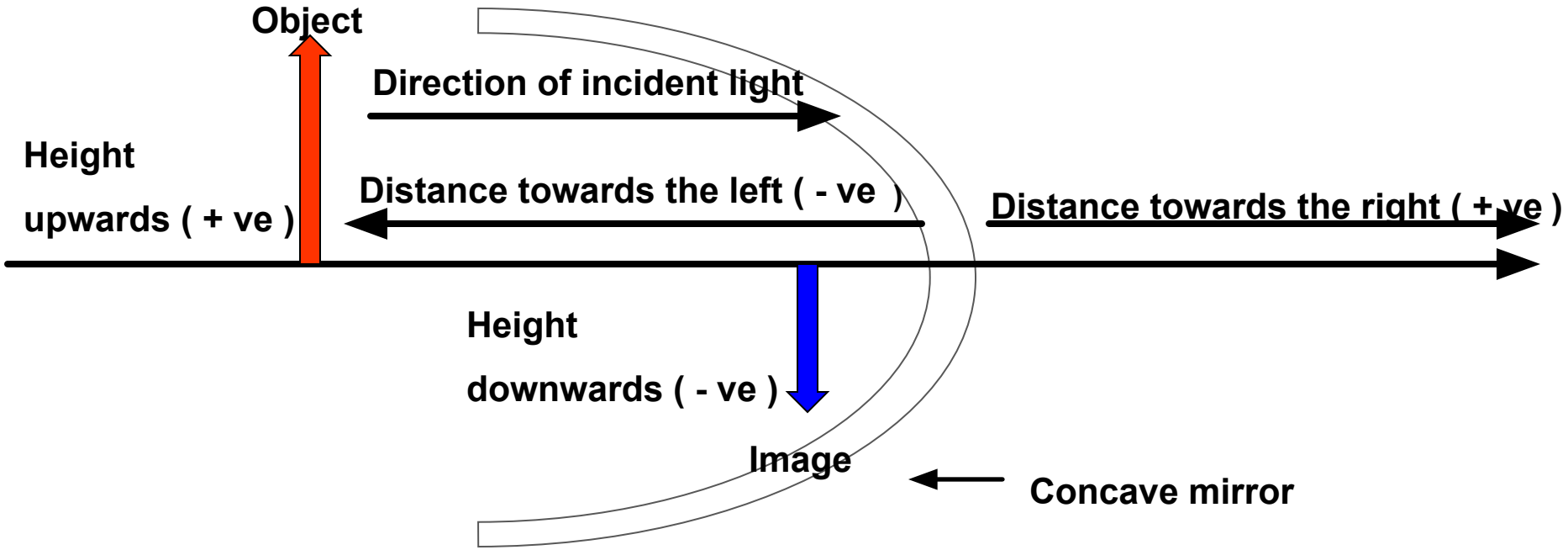
ii) All distances parallel to the principal axis are measured from the pole.

iii) All distances measured to the right of the pole are taken as + ve.

iv) All distances measured to the left of the pole are taken as – ve.

v) The height measured upwards perpendicular to the principal axis is taken as + ve.

vi) The height measured downwards perpendicular to the principal axis is taken as – ve.



10a) Mirror formula for spherical mirrors :-

The mirror formula for spherical mirrors is the relationship between the object distance (u), image distance (v) and focal length (f).

The mirror formula is expressed as :-

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

b) Magnification for spherical mirrors :-

Magnification for spherical mirrors is the ratio of the height of the image to the height of the object.

$$\text{Magnification} = \frac{\text{Height of the image}}{\text{Height of the object}} \qquad m = \frac{h^i}{h^o}$$

The magnification is also related to the object distance and image distance. It is expressed as :-

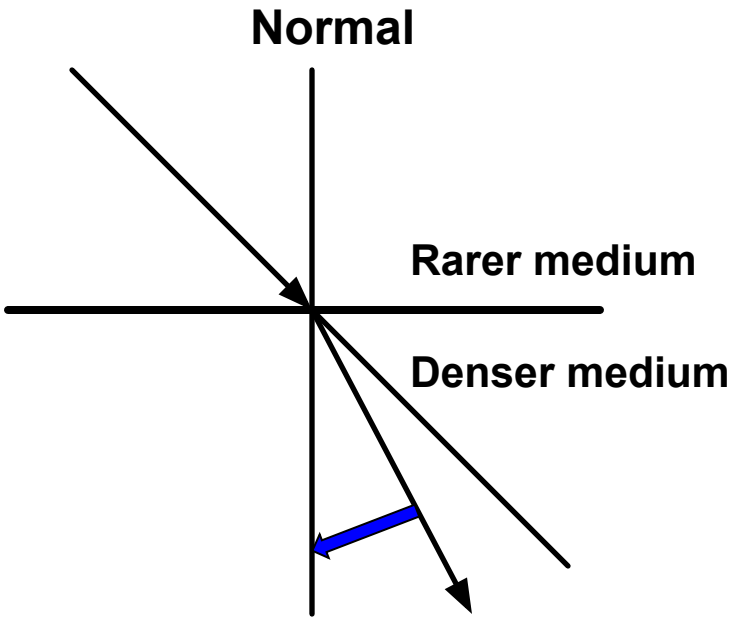
$$\text{Magnification} \quad m = \frac{h^i}{h^o} = -\frac{v}{u}$$

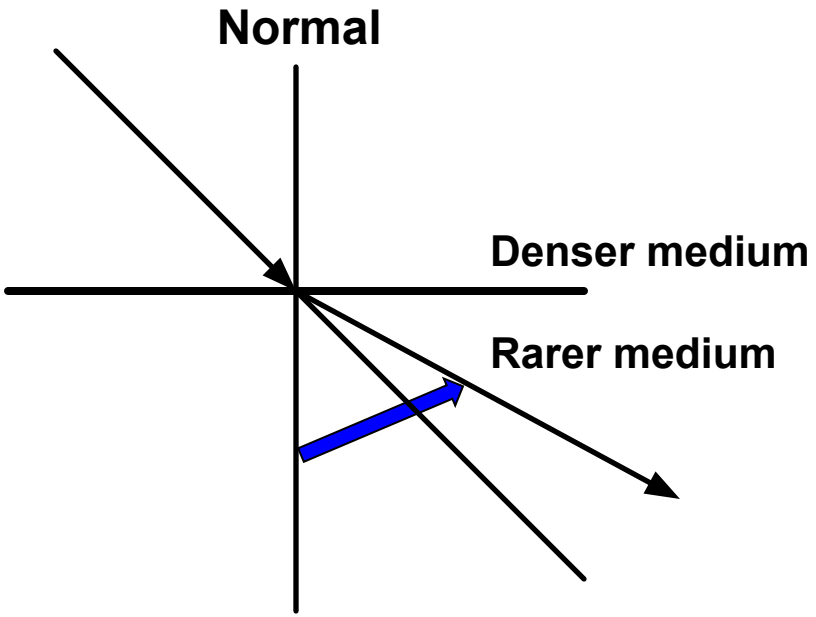
11a) Refraction of light :-

When light travels obliquely from one transparent medium into another it gets bent. This bending of light is called refraction of light.

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

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

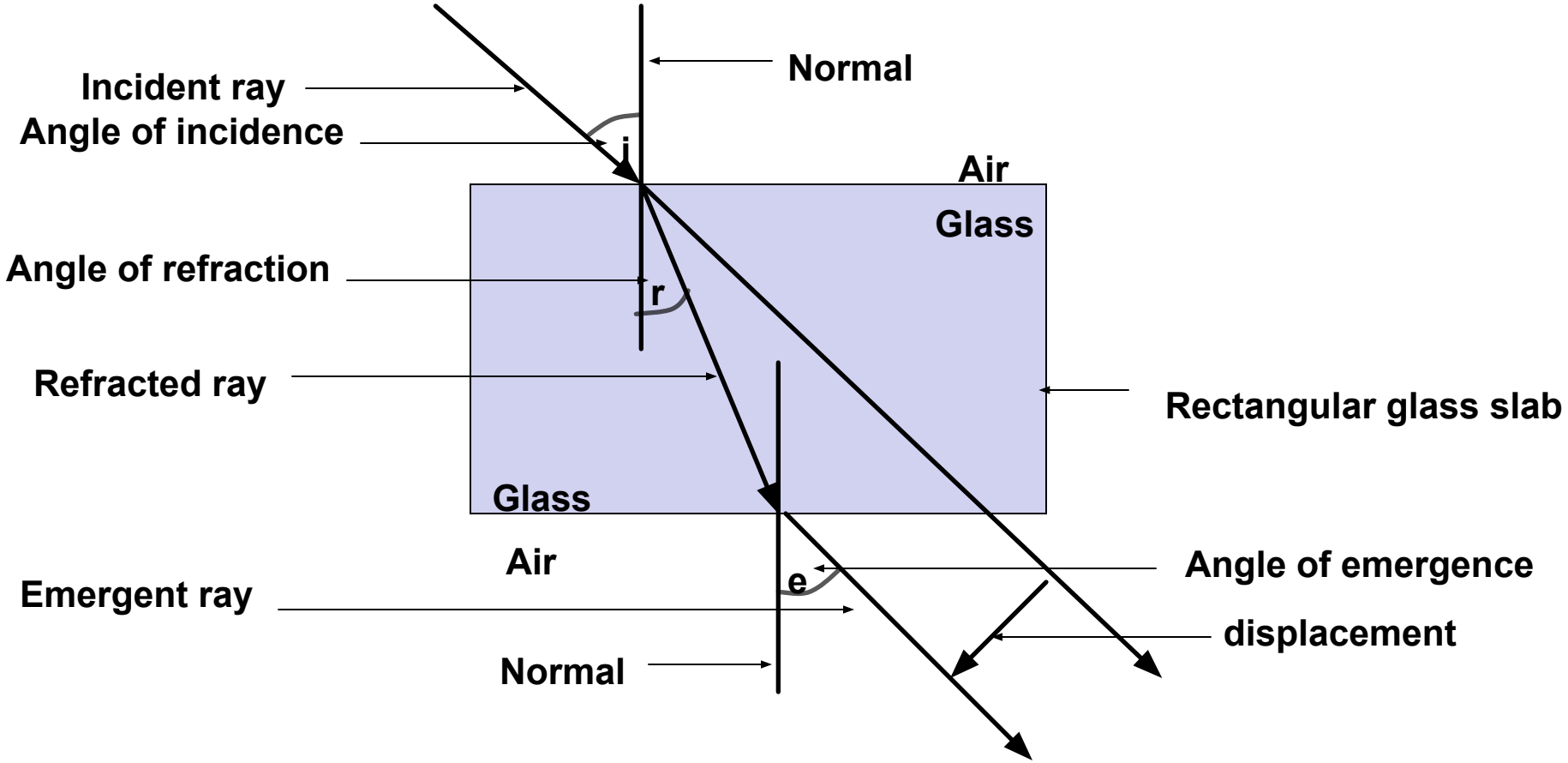




b) Refraction of light through a rectangular glass slab :-

When a ray of light passes through a rectangular glass slab, it gets bent twice at the air- glass interface and at the glass- air interface.

The emergent ray is parallel to the incident ray and is displaced through a distance.



c) Laws of refraction of light :-

i) The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

II) The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant, for the light of a given colour and for the given pair of media.(This law is also known as Snell`s law of refraction.)

$$\frac{\text{sine } i}{\text{sine } r} = \text{constant}$$

d) Refractive index :-

The absolute refractive index of a medium is the ratio of the speed light in air or vacuum to the speed of light in medium.

$$\text{Refractive index} = \frac{\text{Speed of light in air or vacuum}}{\text{Speed of light in the medium}} \qquad n = \frac{c}{v}$$

The relative refractive index of a medium 2 with respect to a medium 1 is the ratio of the speed of light in medium 1 to the speed of light in medium 2.

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

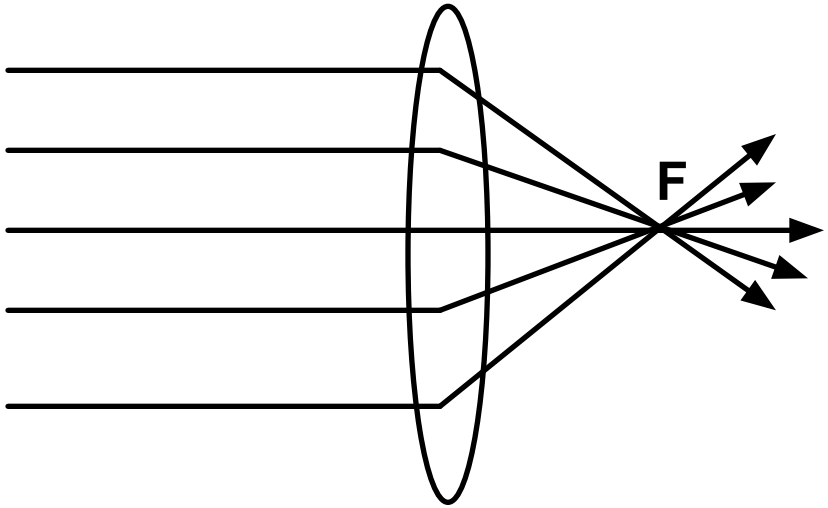
12) Spherical lenses :-

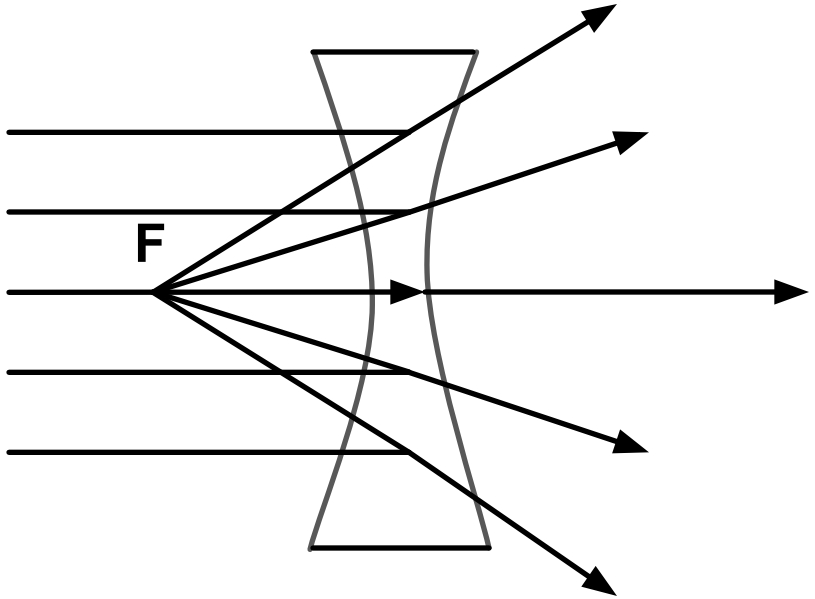
A spherical lens is a transparent material bounded by two surfaces one or both of which are spherical.

Spherical lenses are of two main types. They are convex and concave lenses.

i) Convex lens :- is thicker in the middle and thinner at the edges. Rays of light parallel to the principal axis after refraction through a convex lens meet at a point (converge) on the principal axis.

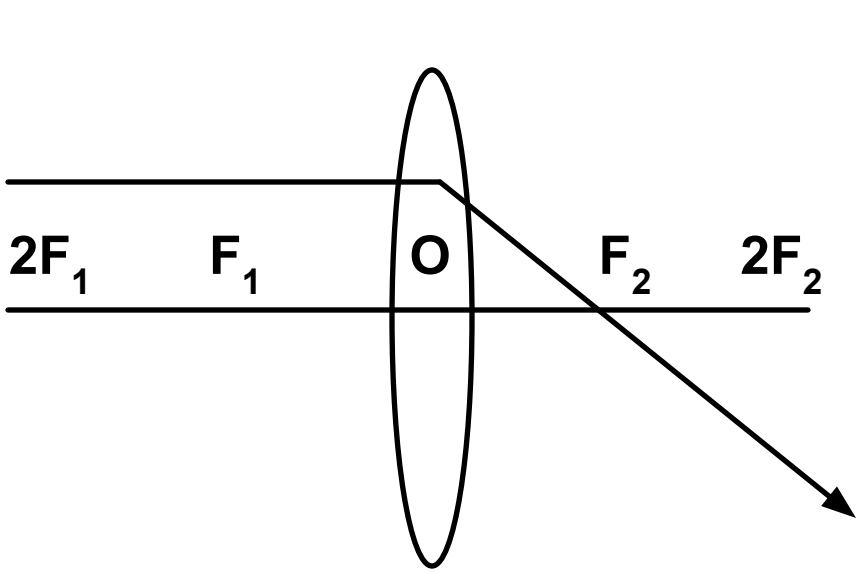
ii) Concave lens :- is thinner in the middle and thicker at the edges. Rays of light parallel to the principal axis after refraction get diverged and appear o come from a point on the principal axis on the same side of the lens.

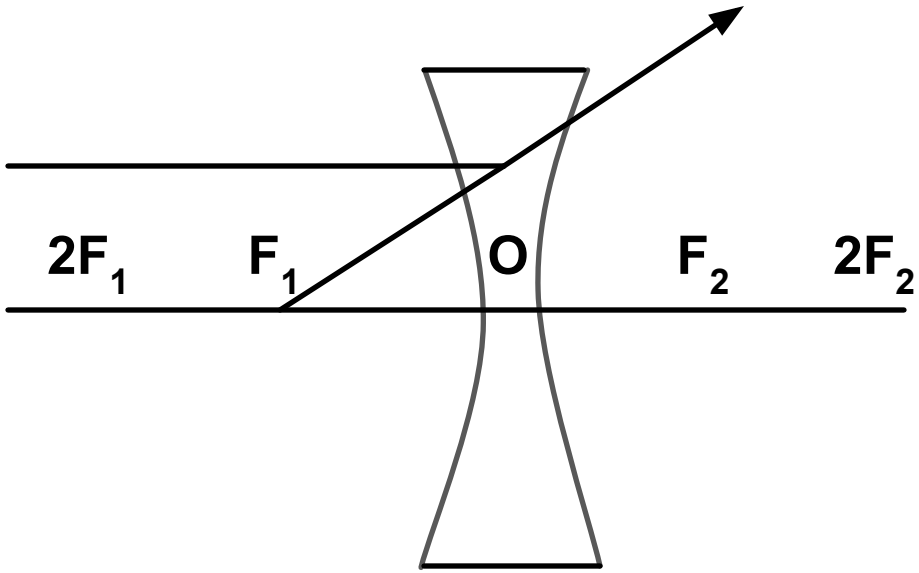




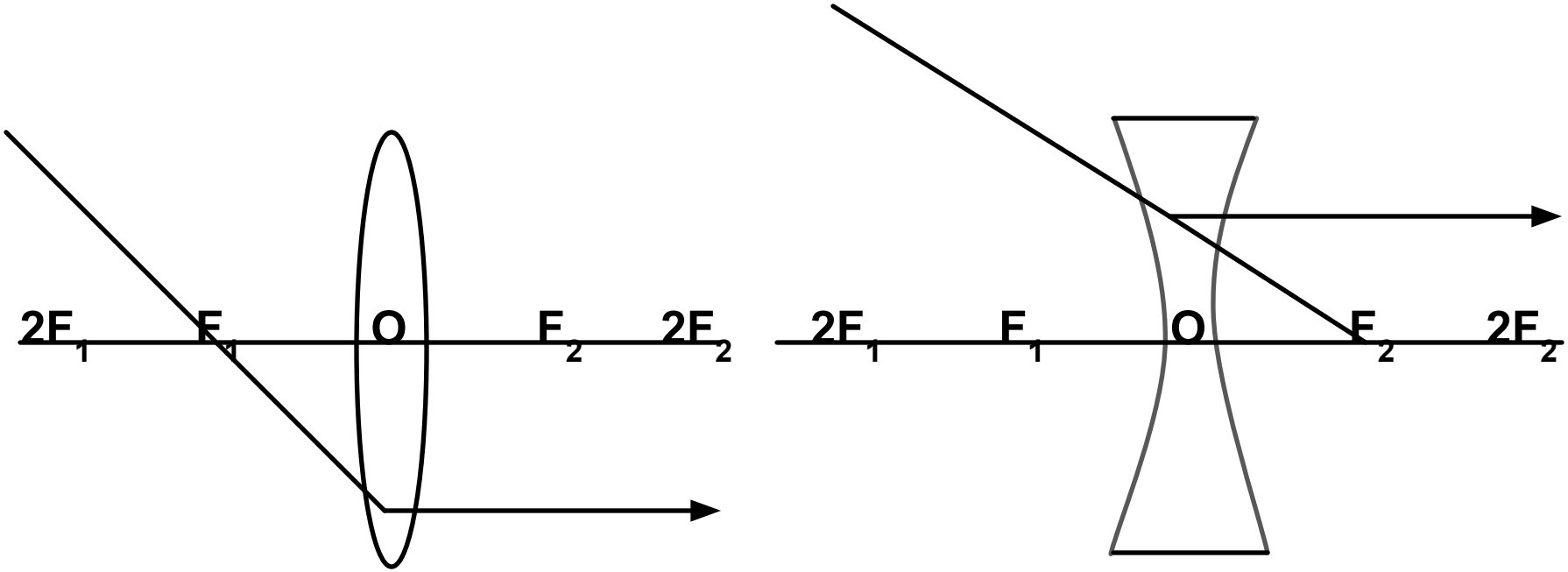
13) Refraction by spherical lenses :-

i) In a convex lens a ray of light parallel to the principal axis after refraction passes through the focus on the other side of the lens. In a concave lens it appears to diverge from the focus on the same side of the lens.

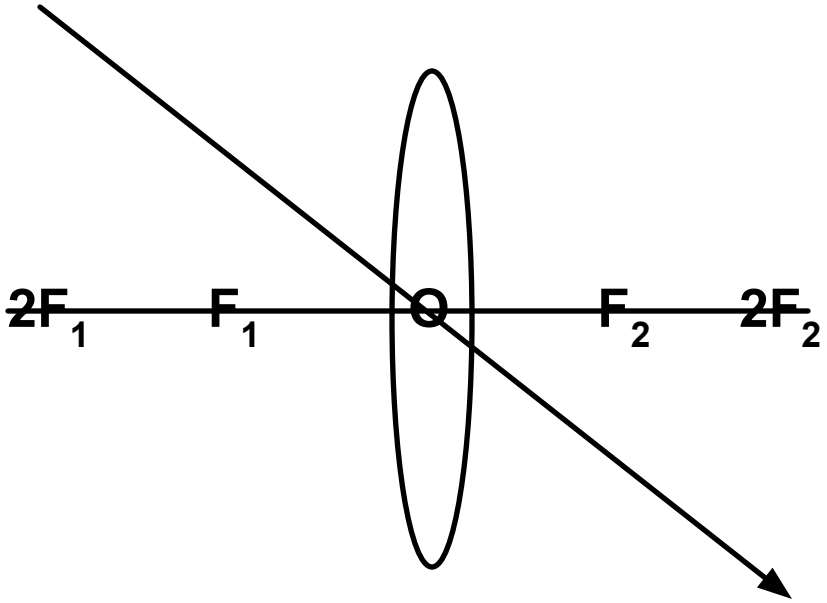


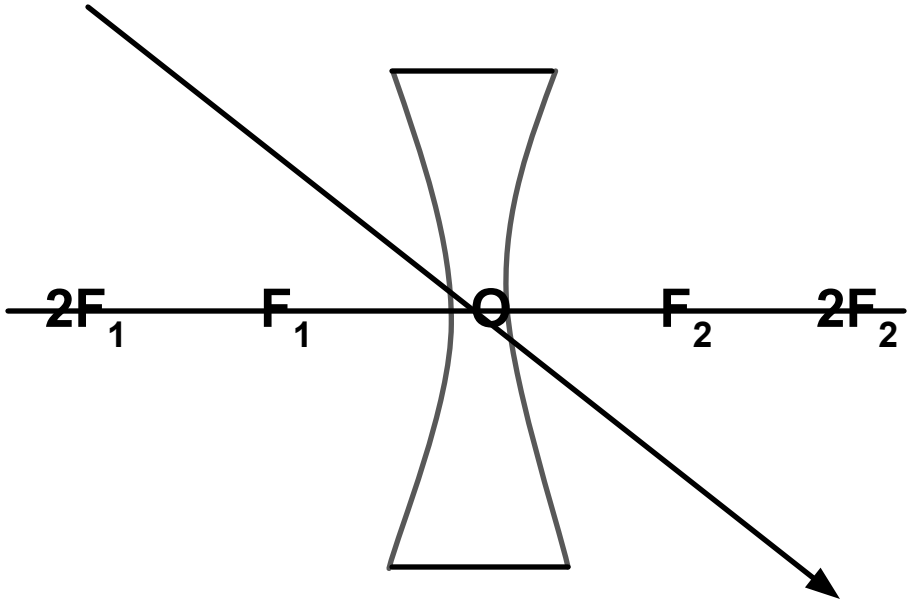


ii) In a convex lens a ray of light passing through the focus after refraction goes parallel to the principal axis. In a concave lens a ray of light directed towards the focus after refraction goes parallel to the principal axis.



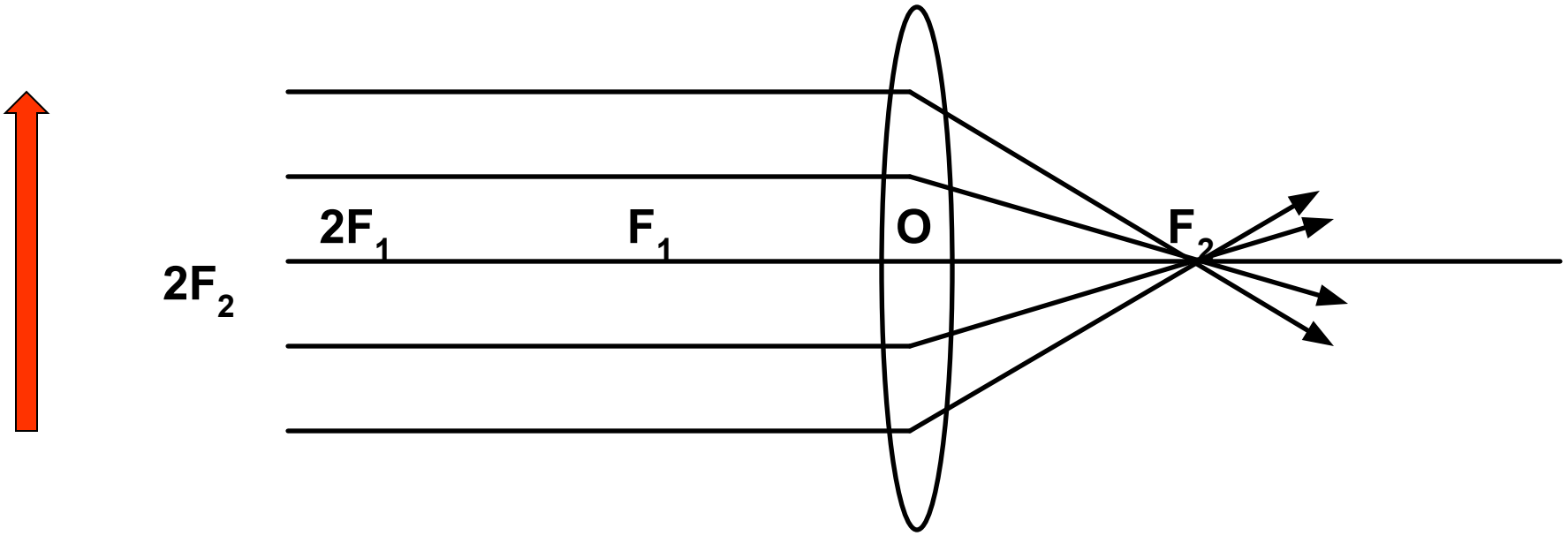
iii) In a convex lens and concave lens a ray of light passing through the optical centre goes without any deviation.



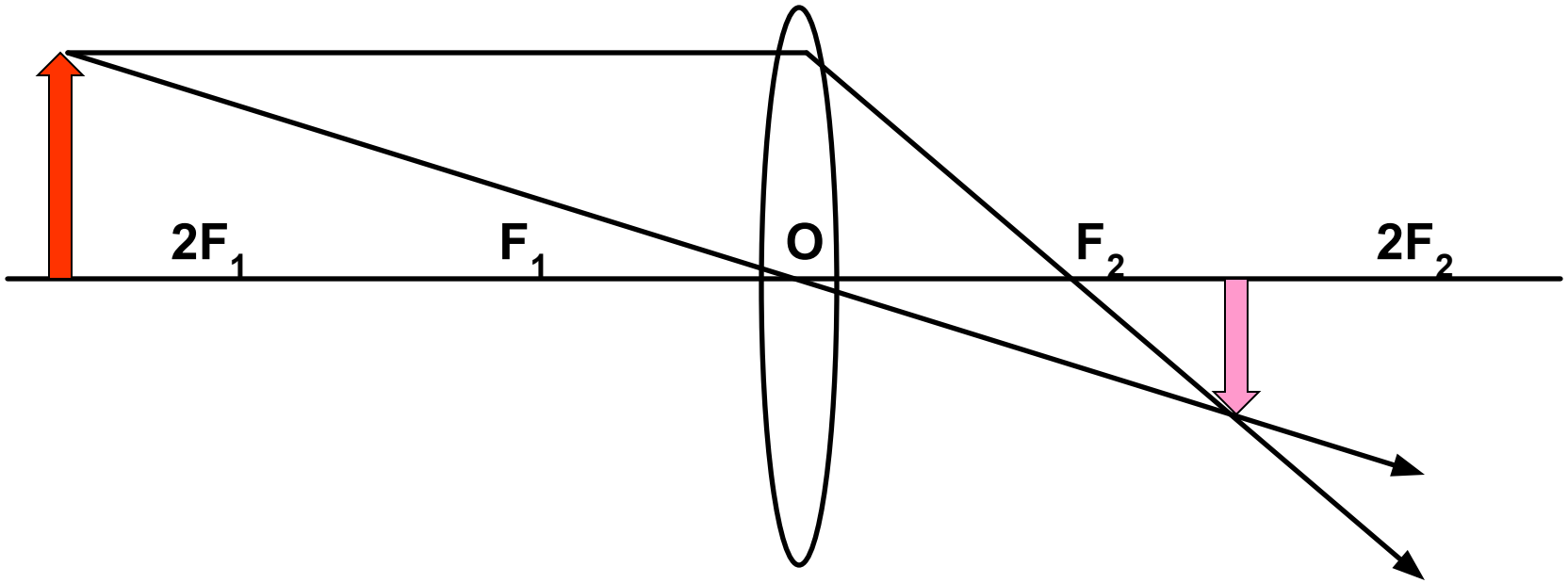


14) Images formed by convex lens :-

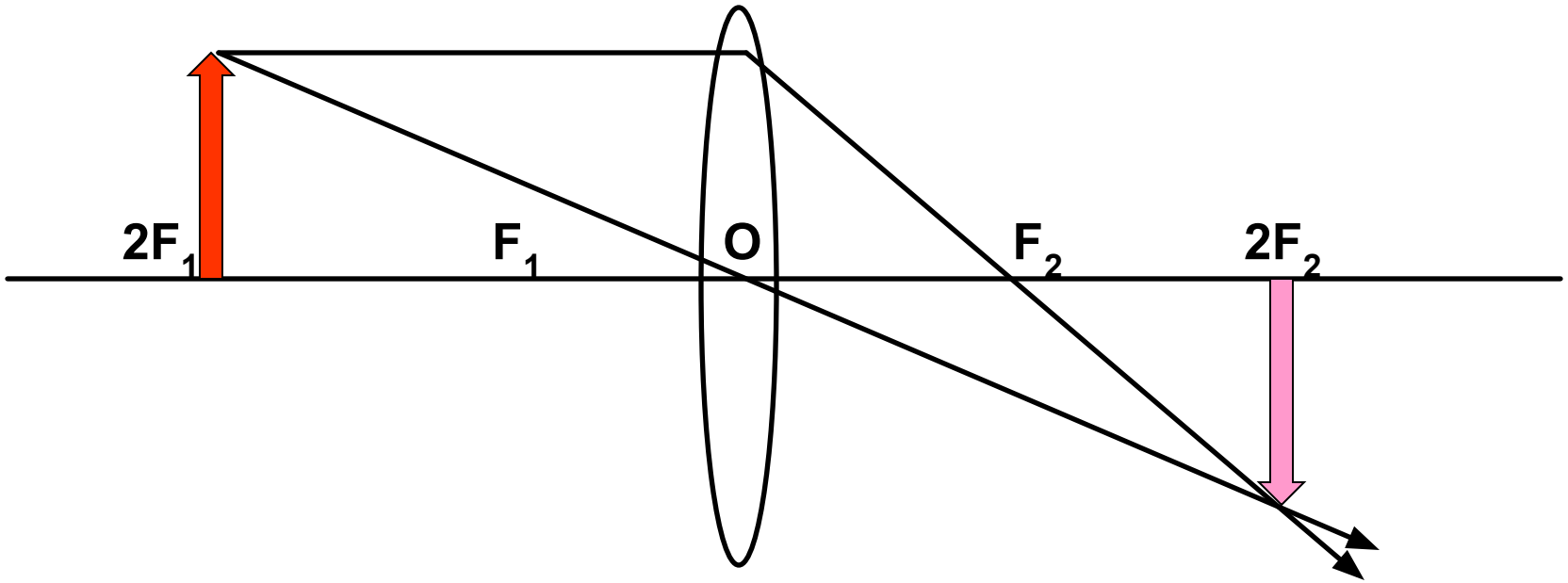
i) When the object is at infinity the image is formed at the focus F_2, it is highly diminished, real and inverted.



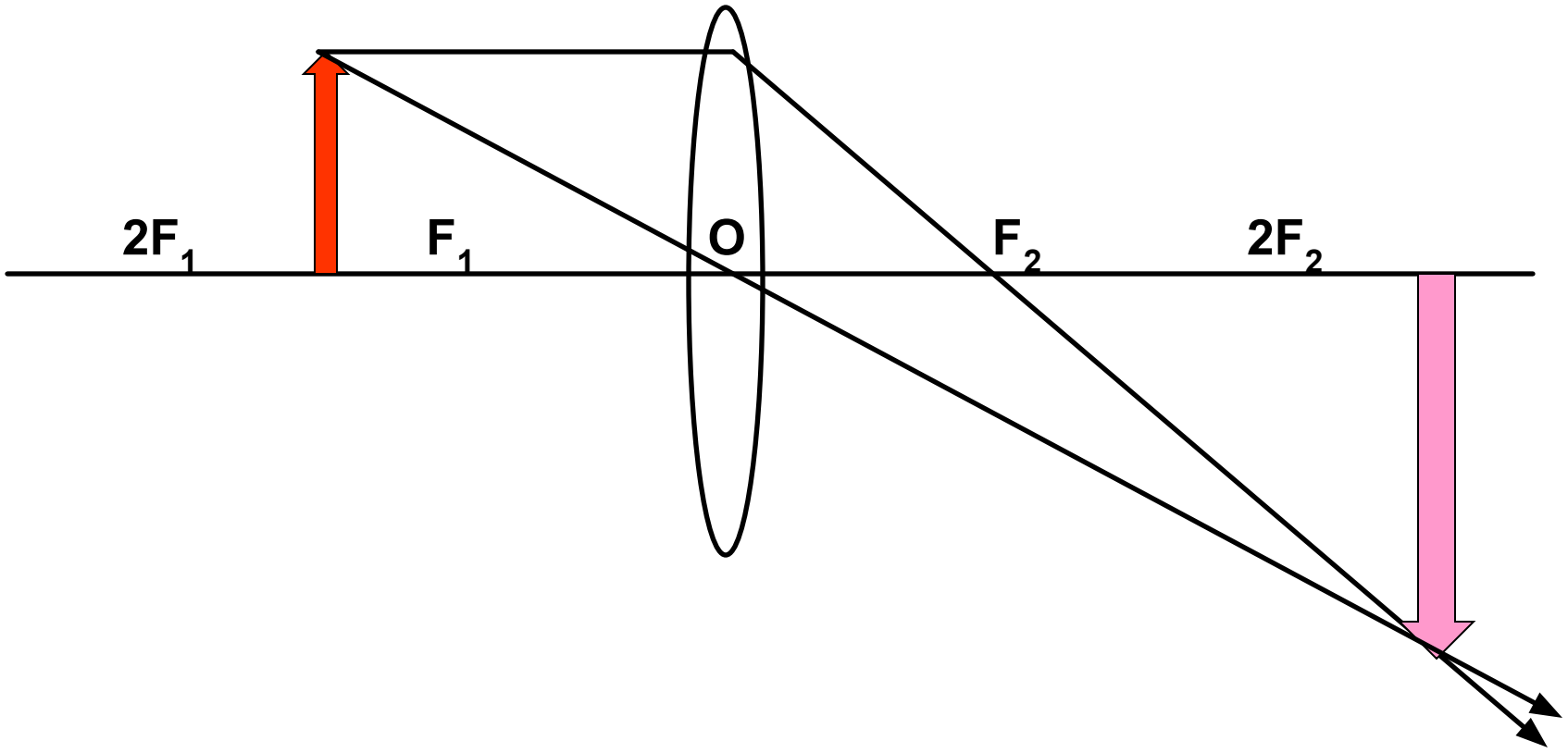
ii) When the object is beyond $2F_1$, the image is formed between F_2 and $2F_2$, it if diminished, real and inverted.



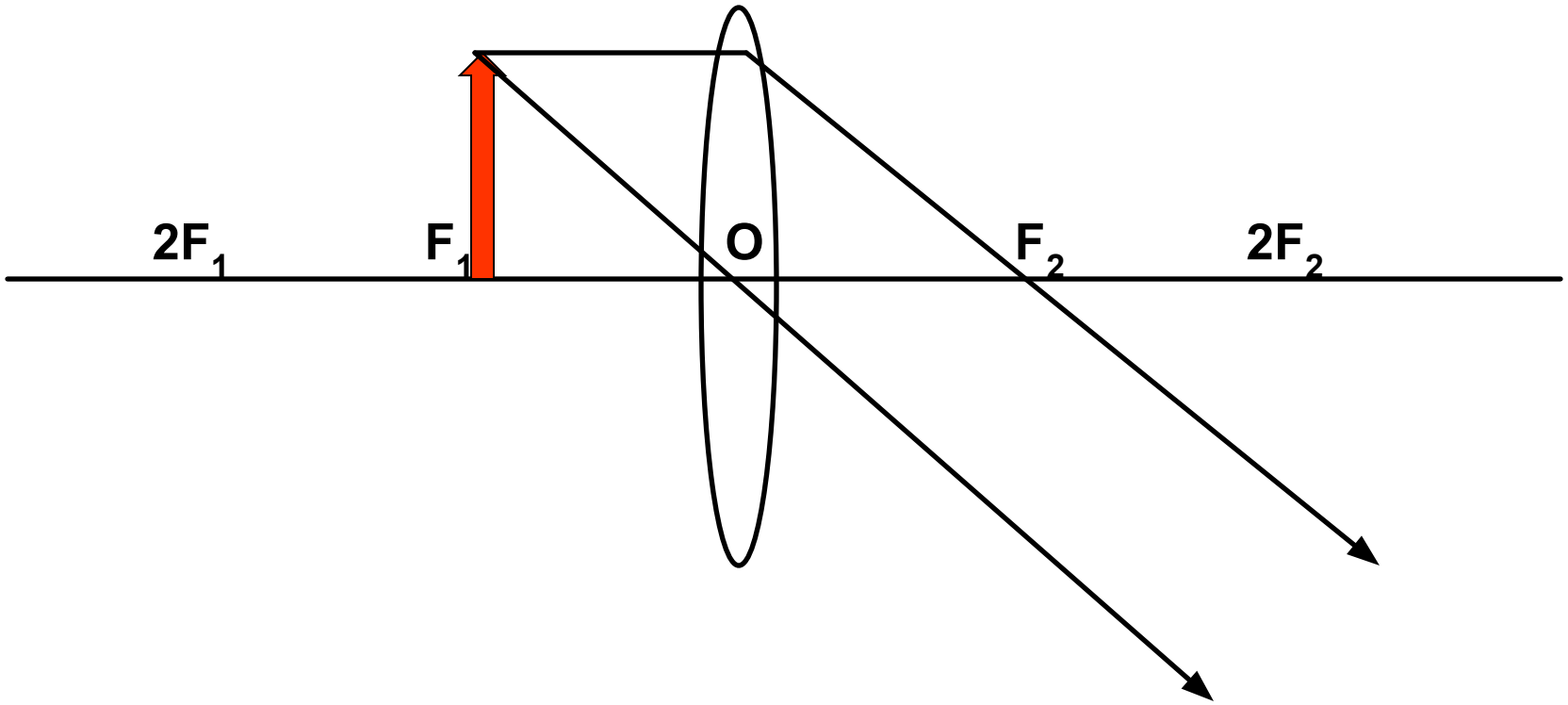
iii) When the object is at $2F_1$, the image is formed at $2F_2$, it is the same size as the object, real and inverted.



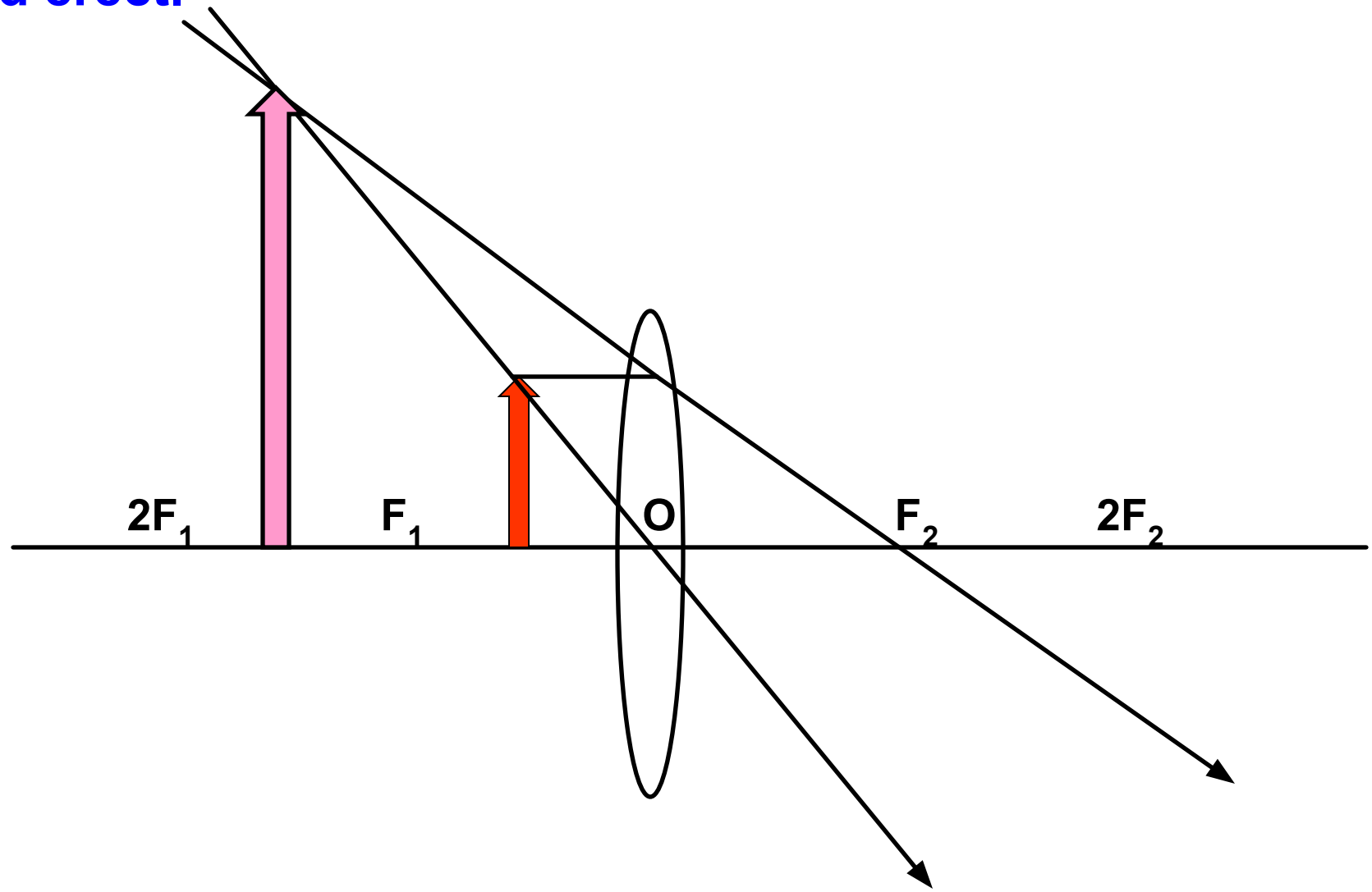
iv) When the object is between $2F_1$ and F_1, the image is formed beyond $2F_2$, it is enlarged, real and inverted.



v) When the object is at F_1 the image is formed at infinity, it is highly enlarged, real and inverted.

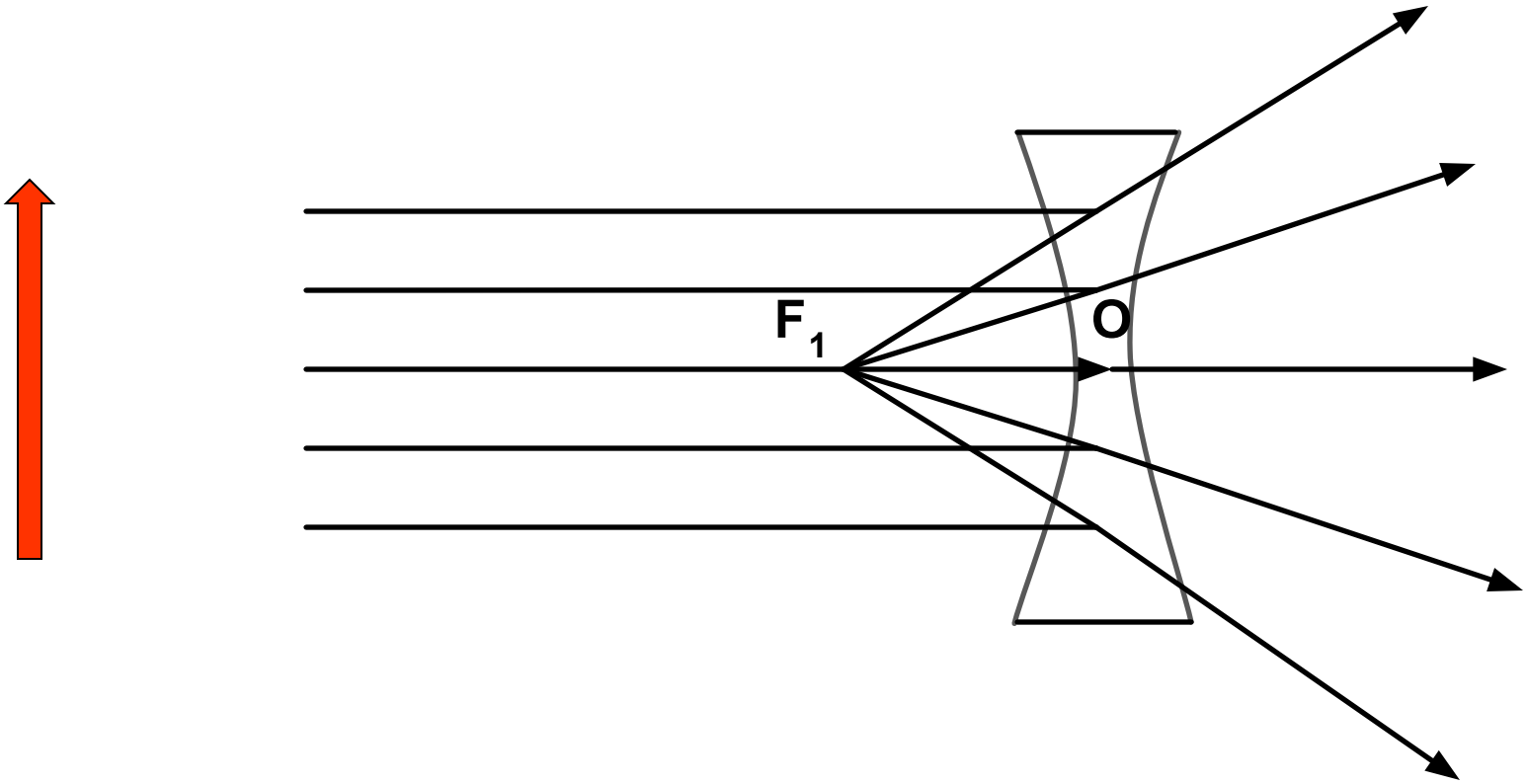


vi) When the object is between F_1 and O, the image is formed on the same side of the lens, it is enlarged, virtual and erect.

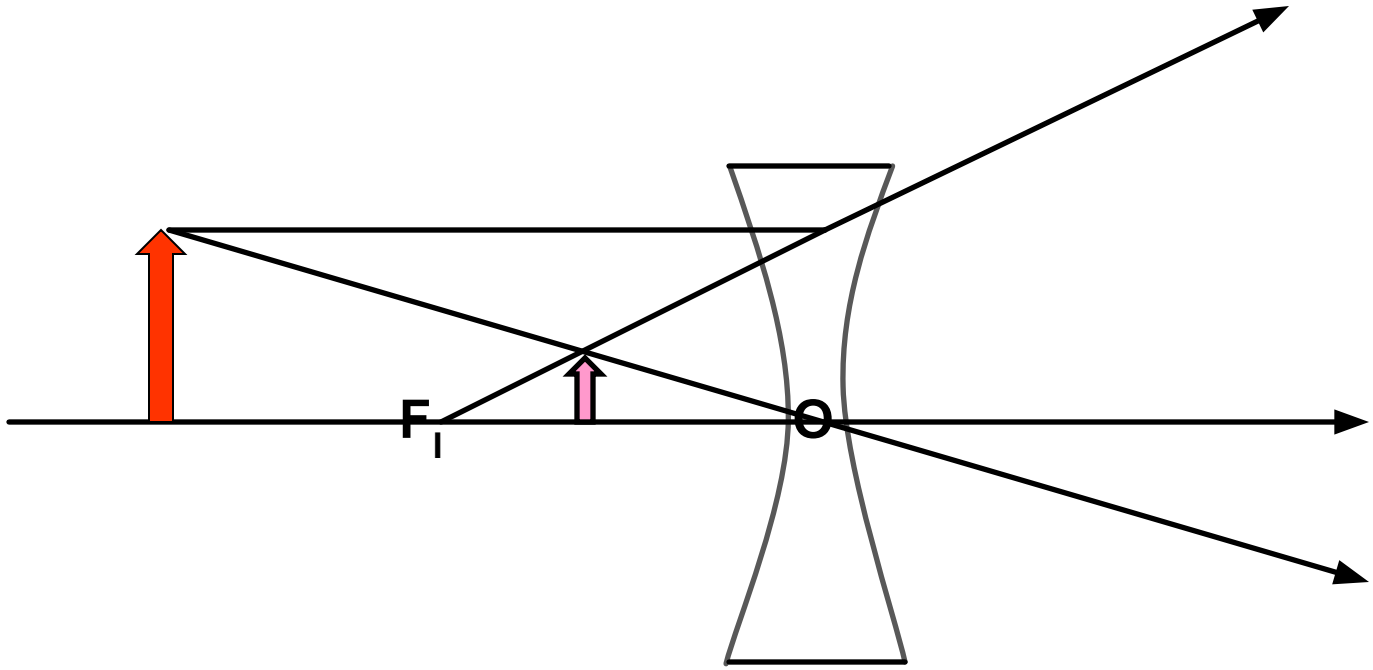


15) Images formed by concave lens :-

i) When the object is at infinity, the image is formed at the focus F_1 on the same side of the lens, it is highly diminished, virtual and erect.



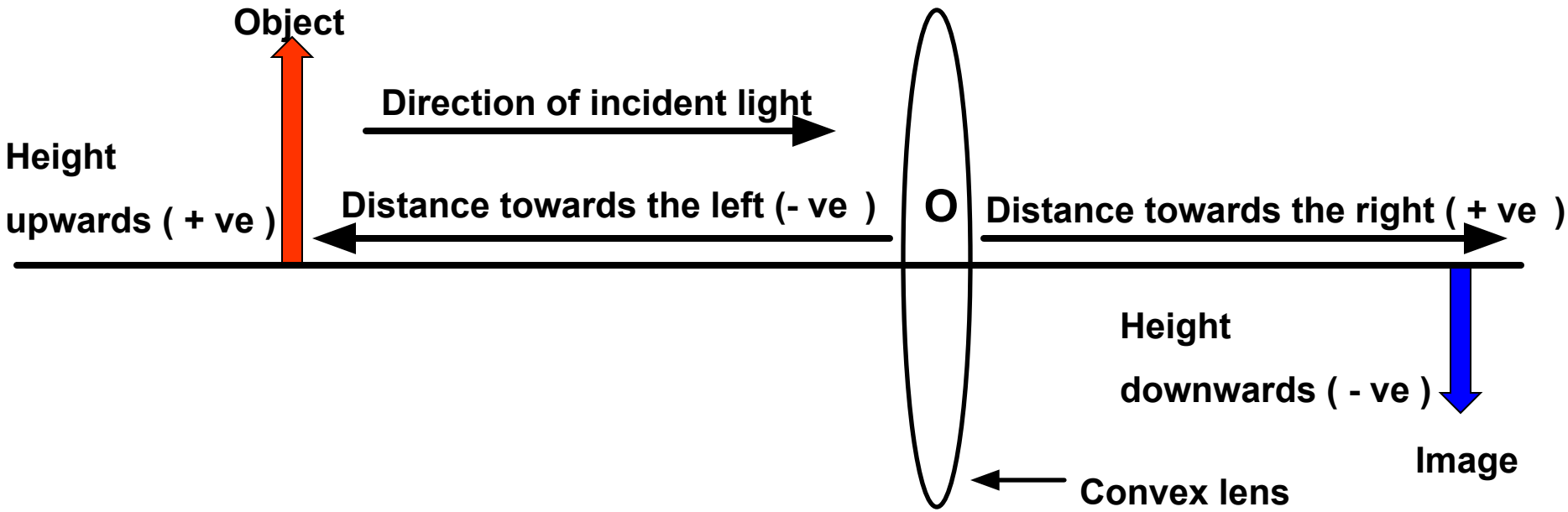
ii) When the object is between infinity and F_1, the image is formed between F_1 and O on the same side of the lens, it is diminished, virtual and erect.



16) Sign convention for spherical lenses :-

The sign convention for spherical lenses is the same as in spherical mirrors except that the distances are measured from the optical centre (O).

The focal length of a convex lens is positive (+ ve) and the focal length of a concave lens is negative (- ve).



17a) Lens formula for spherical lenses :-

The lens formula for spherical lenses is the relationship between the object distance (u), image distance (v) and focal length (f).

The lens formula is expressed as :-

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

b) Magnification produced by spherical lenses :-

Magnification for spherical lens is the ratio of the height of the image to the height of the object.

$$\text{Magnification} = \frac{\text{Height of the image}}{\text{Height of the object}} \qquad m = \frac{h^i}{h^o}$$

The magnification is also related to the object distance and image distance. It can be expressed as :-

$$\text{Magnification} \quad m = \frac{h^i}{h^o} = \frac{v}{u}$$

18) Power of a lens :-

The power of a lens is the reciprocal of its focal length (in metres).

$$P = \frac{1}{f\ (m)} \qquad \text{or} \qquad f = \frac{1}{P}$$

The SI unit of power is dioptre (D).

1 dioptre is the power of a lens whose focal length is 1 metre.

The power of a convex lens is positive (+ ve) and the power of a concave lens is negative (- ve).