अभय

CLASS X - SCIENCE

LIGHT - REFLECTION AND REFRACTION - II

PRASHANT KIRAD

PK HITS🔥

अभय

- Numerical:
  - Mirror Formula
  - Lens Formula
  - Power of Lens
- All Ray Diagrams
- Snell's Law

अभय

REFRACTION

अभय

REFRACTION OF LIGHT

The phenomenon of bending of ray of light when it enters from one medium to another

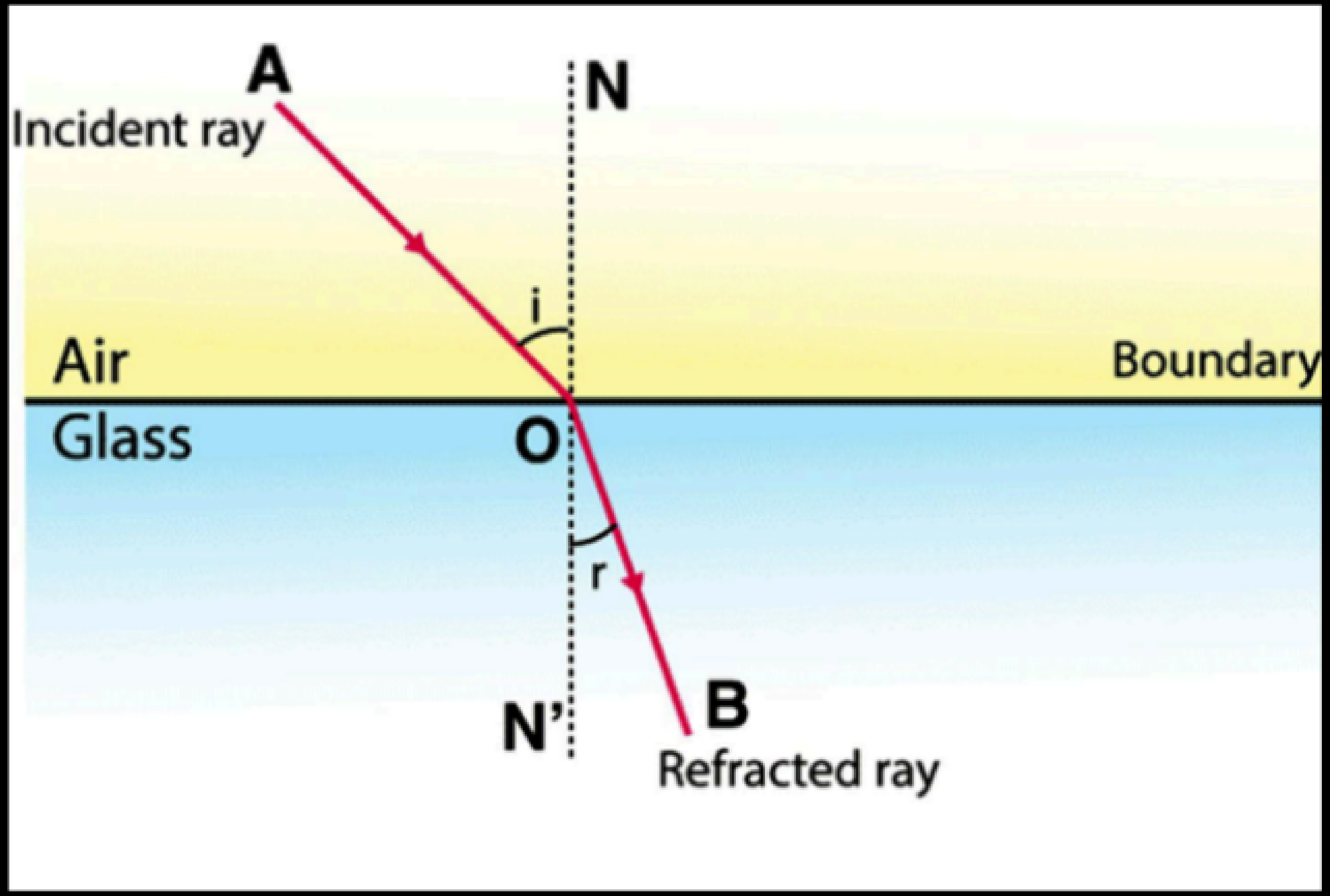
The bending of a light ray during refraction occurs because of a change in the speed of light as it passes from one medium to another with a different refractive index

TRY DOING THIS!

CAUSES OF REFRACTION

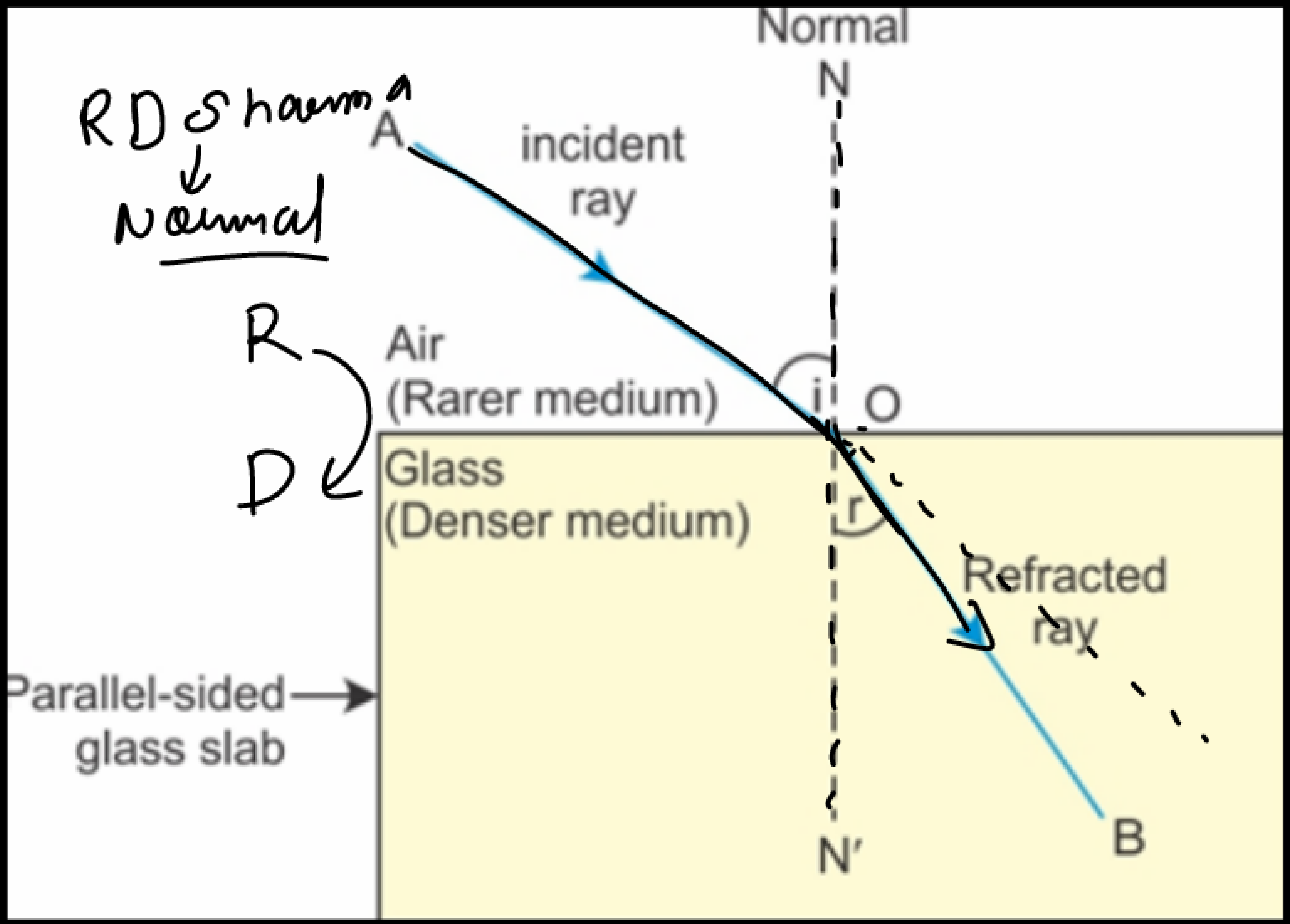
- When the light goes from air into water, it bends towards normal because there is a reduction in its speed.

- When the light goes from water to air, it bends away from normal because there is an increase in the speed of light.



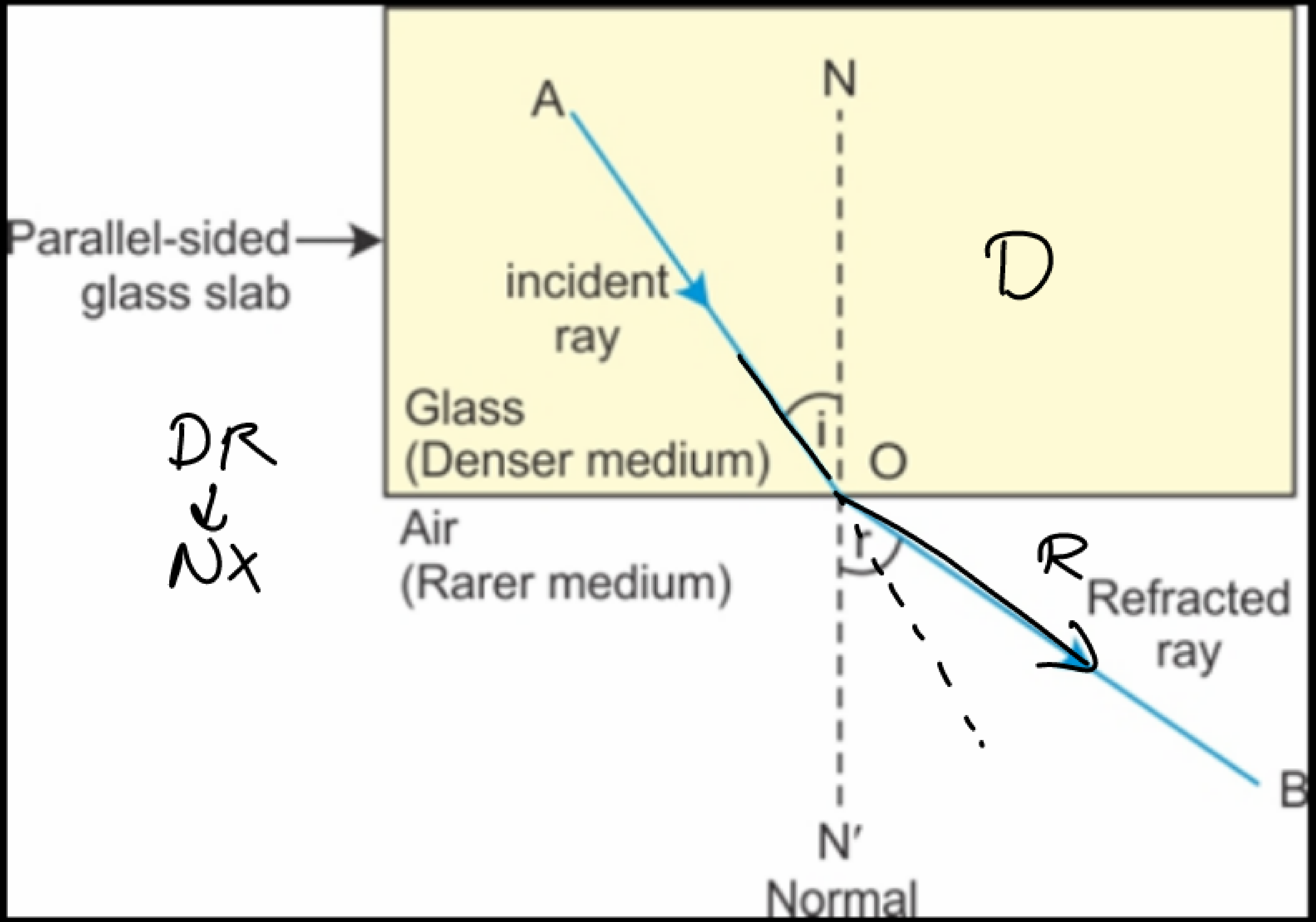
BENDING TENDENCY

- Rarer to denser medium (bends towards normal)



BENDING TENDENCY

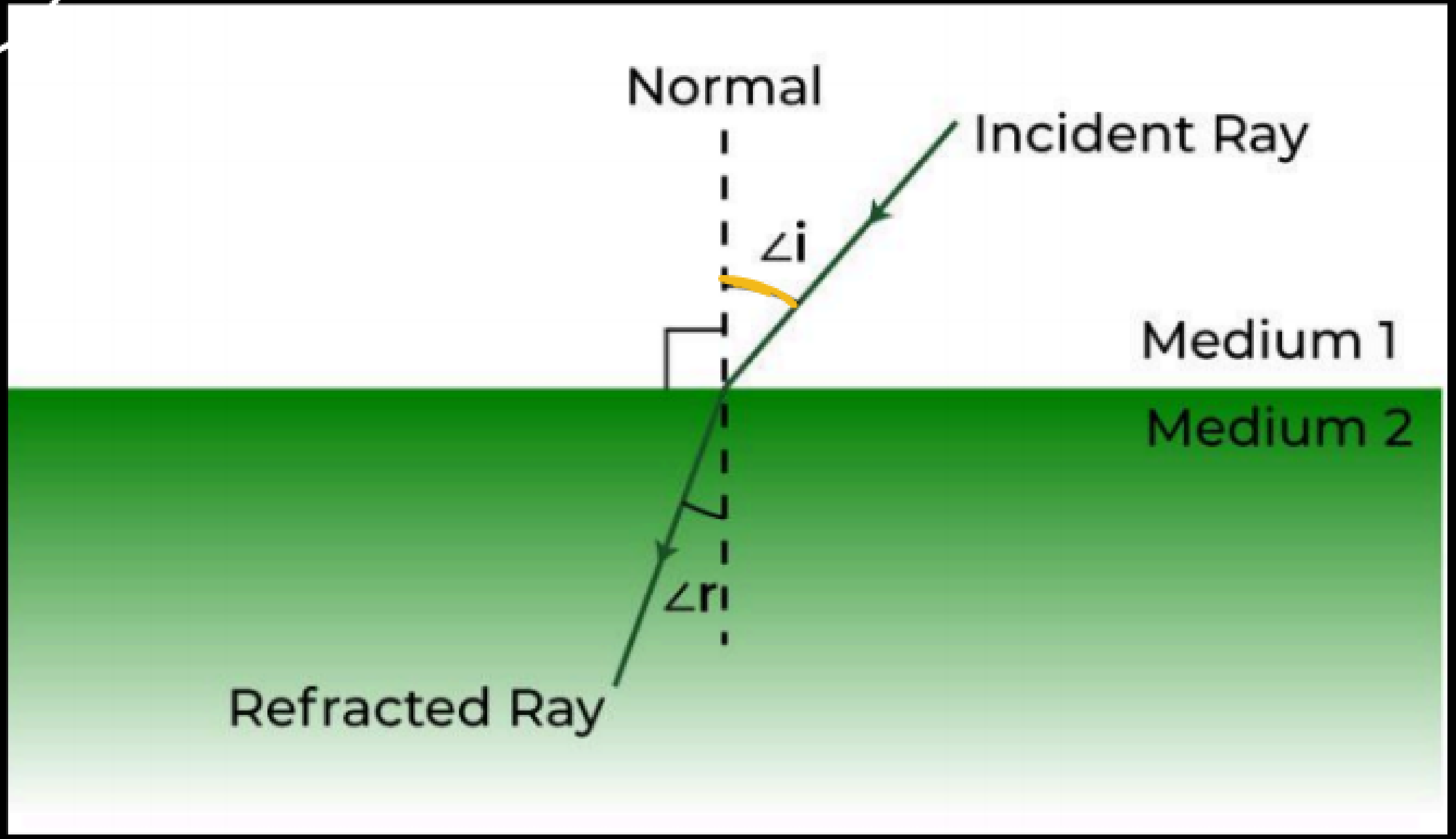
- Denser to rarer medium (bends away from normal)



LAWS OF REFRACTION

- The incident ray, refracted ray, and the normal to the interface of two media at the point of incidence all lie on the same plane.

- The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. This is also known as Snell's law of refraction



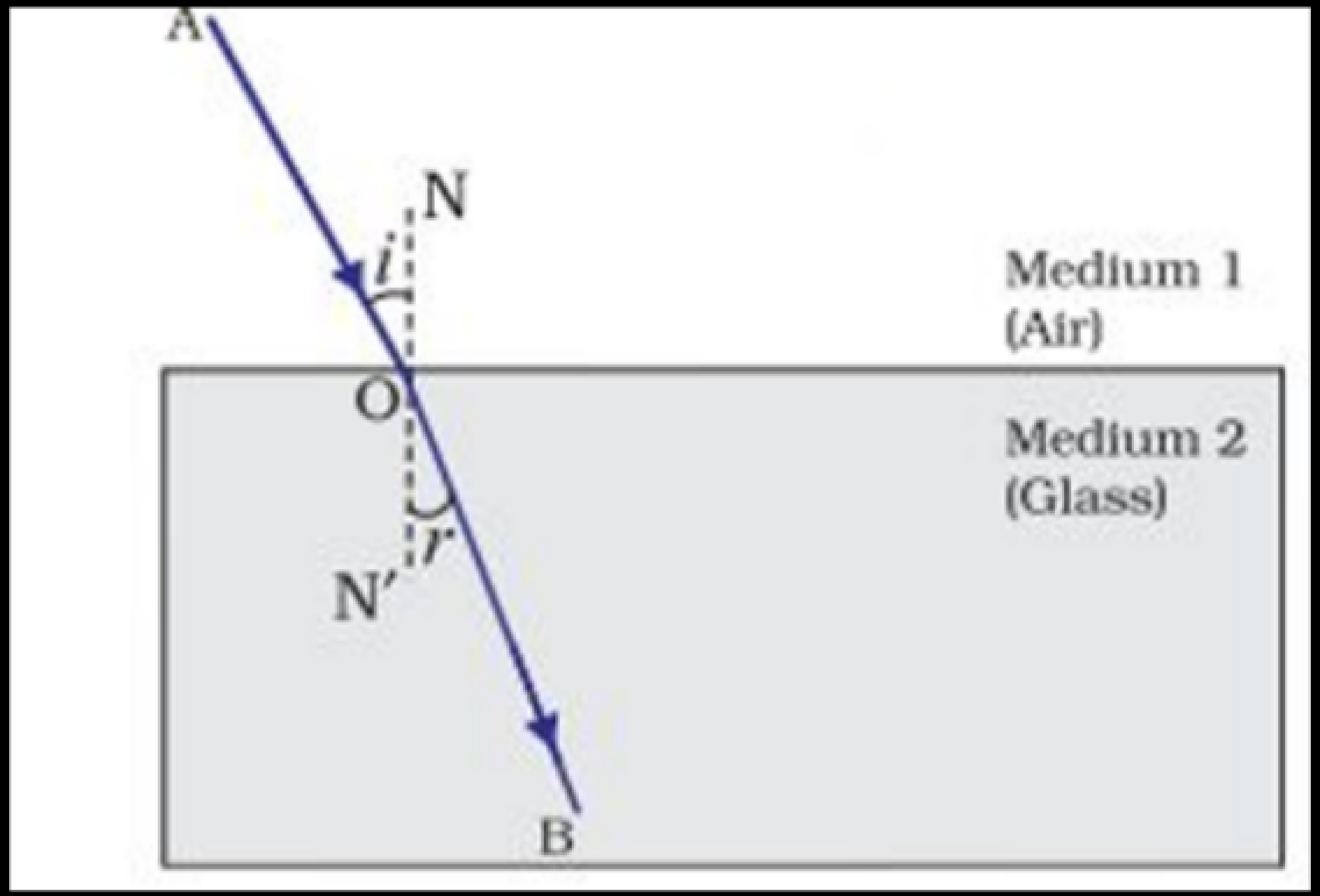
Snell's law

sin i /sin r = constant

REFRACTIVE INDEX

The refractive index is a measure of how much light is bent or refracted when it enters a new medium. It is denoted by the symbol "n."

$$n = \frac{\text{Velocity of light in medium 1}}{\text{Velocity of light in medium 2}}$$



$\eta = 1.4$ ✓

$\eta = 1.5$

↓

Speed? //

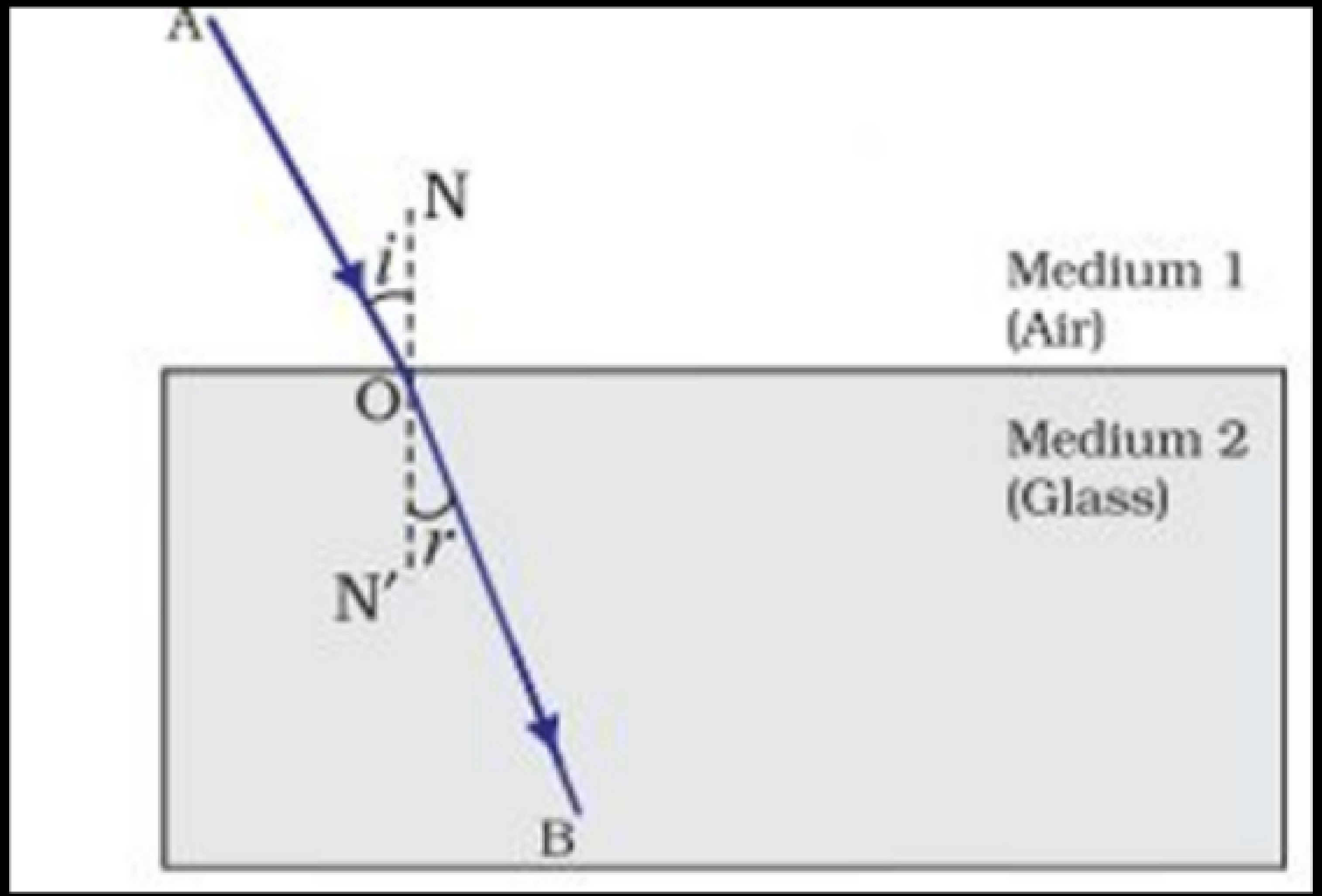
$\eta \propto$ Bending

→ $\propto$ density

→ $\propto \frac{1}{\text{Velocity (Speed)}}$ ✓

REFRACTIVE INDEX

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

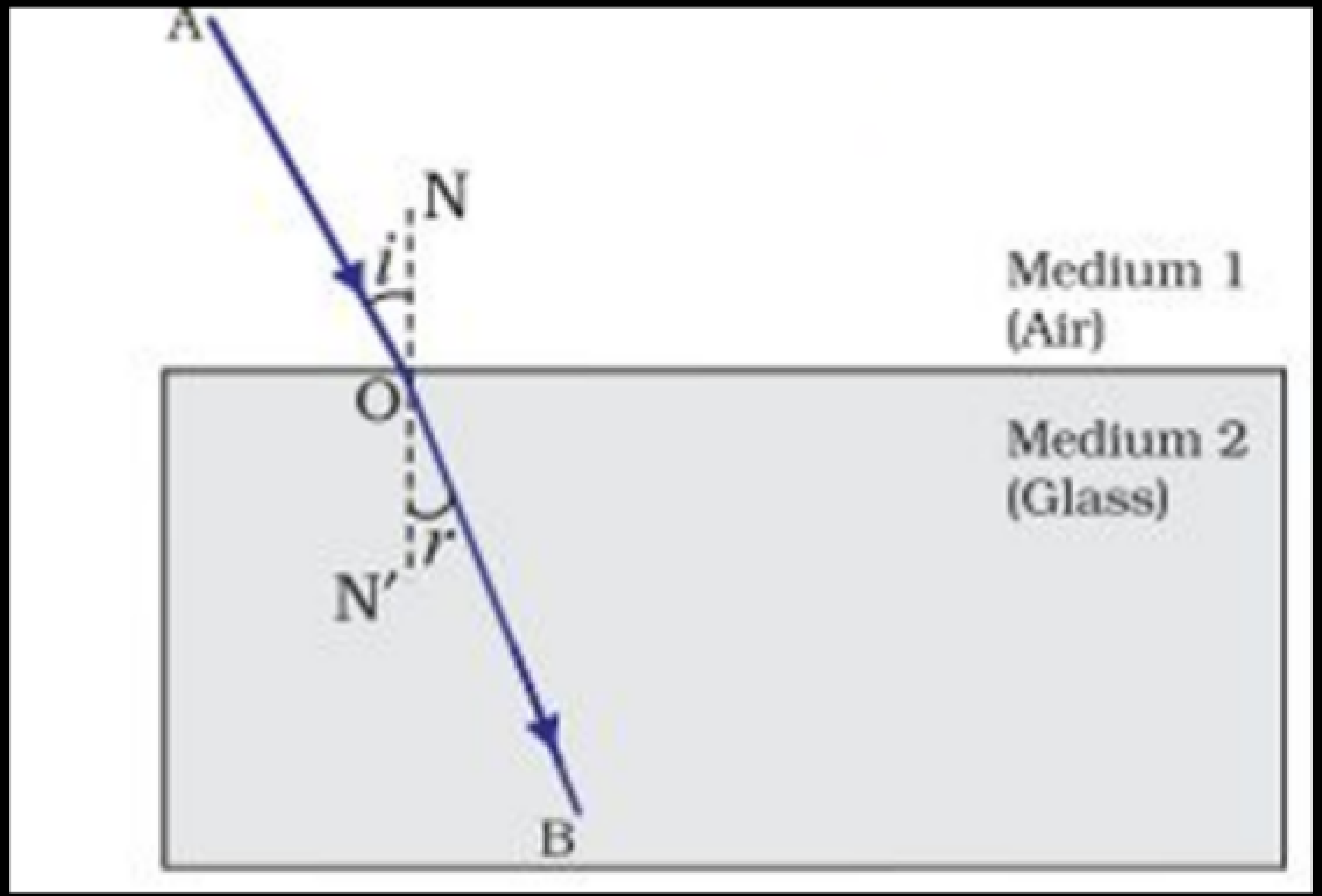


Refractive index of medium 2 with respect to medium 1

ABSOLUTE REFRACTIVE INDEX

अभय

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



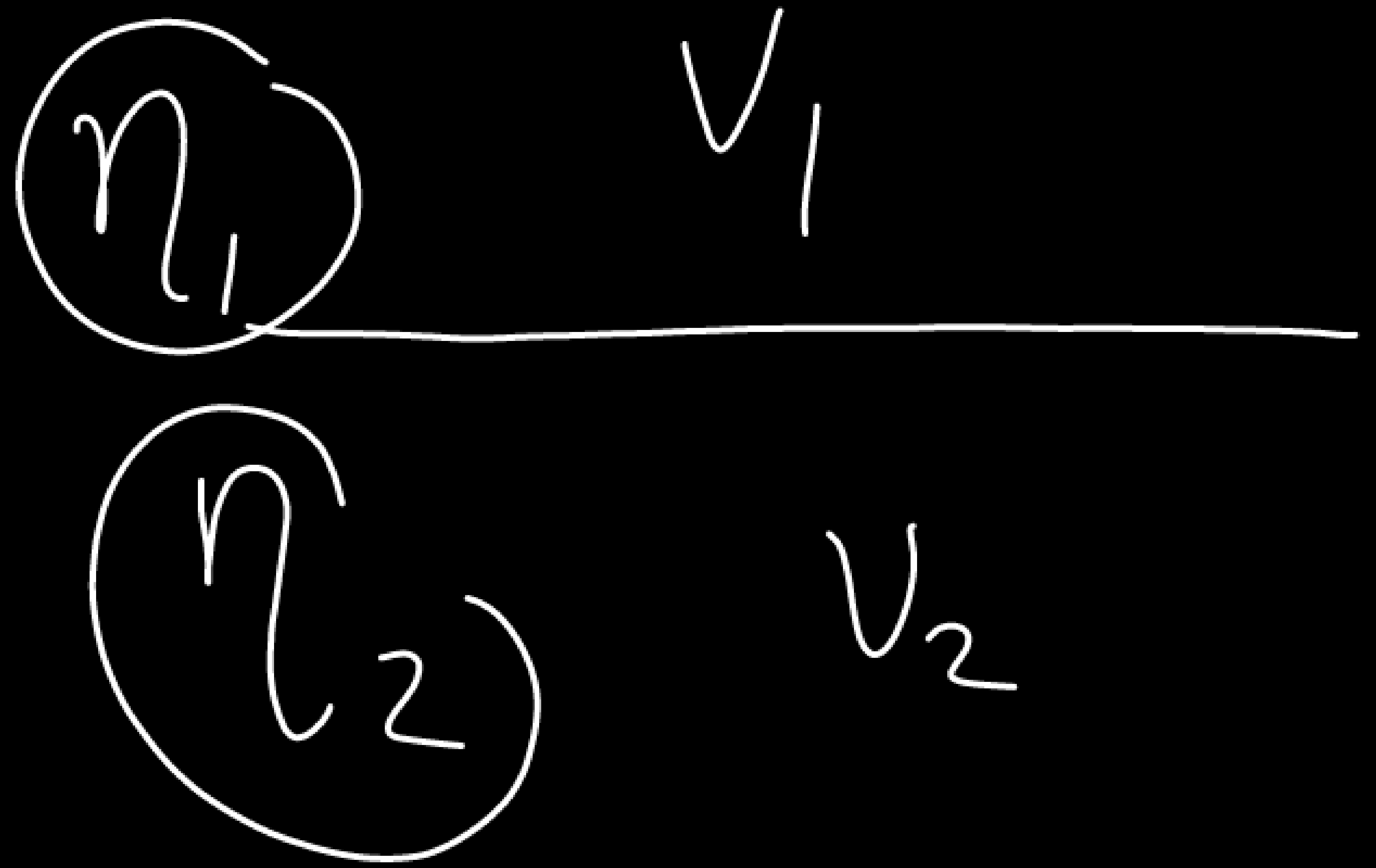
$$n = \frac{c}{v} \quad (3\times10^8)$$

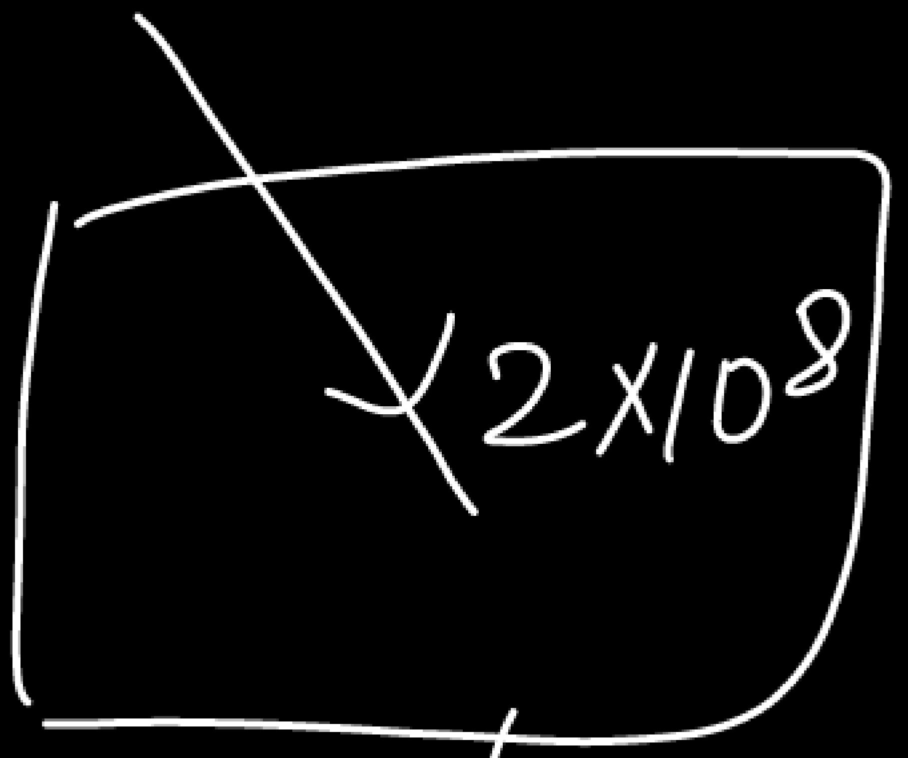
If medium 1 is vacuum or air, then the refractive index of medium m is considered with respect to vacuum. This is called the *absolute refractive index* of the medium.

Relative

$\eta = 1$

$$\frac{\eta_2}{\eta_1} = \frac{v_1}{v_2}$$





$\eta = ?$

$$\frac{c}{v} = \frac{3\times10^8}{2\times10^8} = \boxed{1.5}$$

ABSOLUTE REFRACTIVE INDEX

अभय

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

अभय

Q. Define the term absolute refractive index of a medium. A ray of light enters from vacuum to glass of absolute refractive index 1.5. Find the speed of light in glass. The speed of light in vacuum is 3×10^8 m/s.

$n_g = 1.5$

$n_a = 1$

$1.5 = \frac{3\times10^8}{v}$

$v = 2\times10^8$

The speed of light in glass is 2×10^8 m/s.

R.I of X wrt Y = $\frac{4}{3}$

" " Z wrt Y = $\frac{3}{2}$

" " X wrt Z = ?

$$\frac{\eta_x}{\eta_z} = ?$$

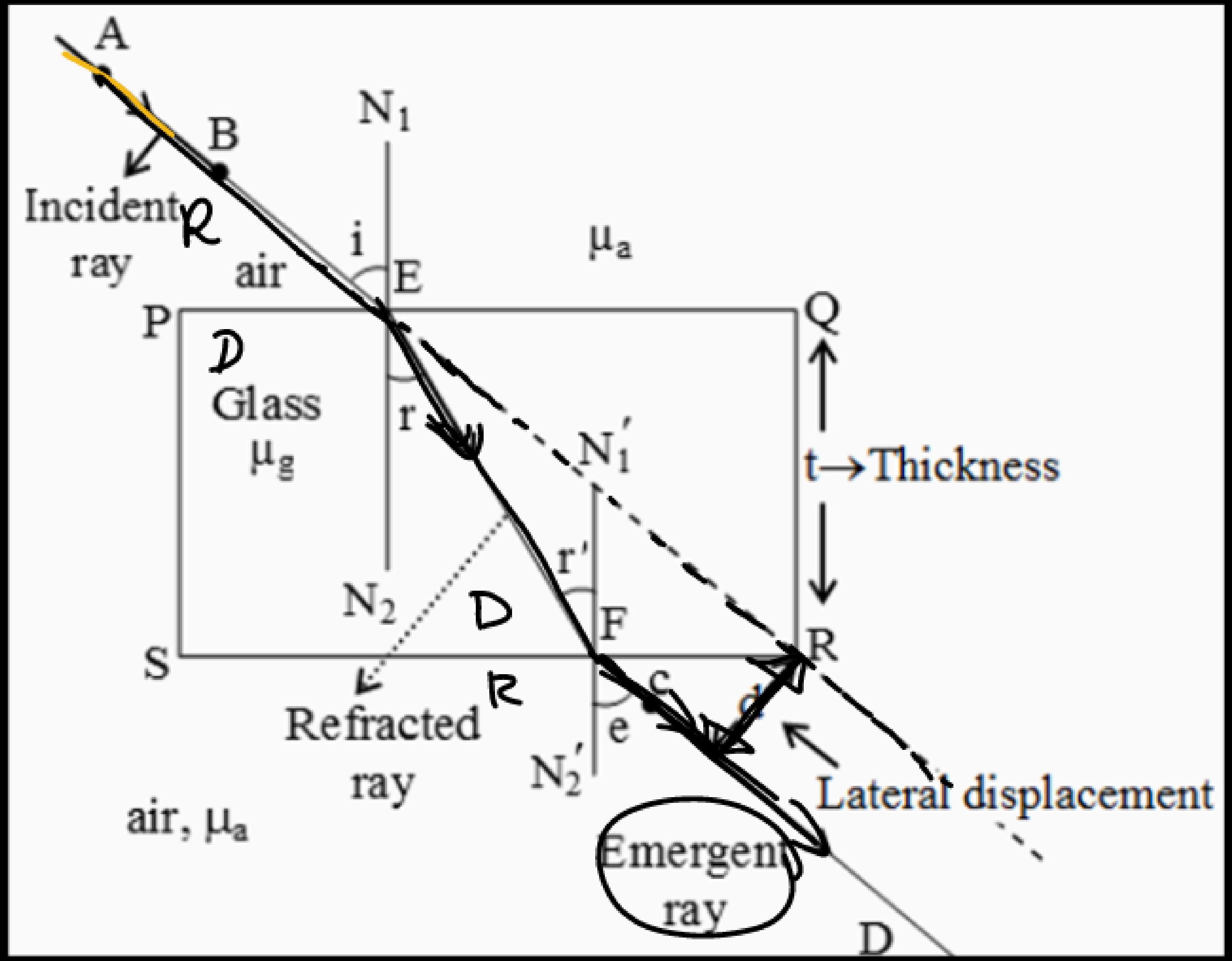
$$\frac{\eta_x}{\eta_z} \leftarrow \frac{\;\frac{\eta_x}{\eta_y} = \frac{4}{3}\;}{\;\frac{\eta_z}{\eta_y} = \frac{3}{2}\;} = \frac{8}{9}$$

REFRACTION THROUGH A RECTANGULAR GLASS SLAB

अभय

When an incident ray enters a glass slab from air, it makes an angle of incidence (*i*) with the normal and bends towards the normal as it moves from a rarer to a denser medium.

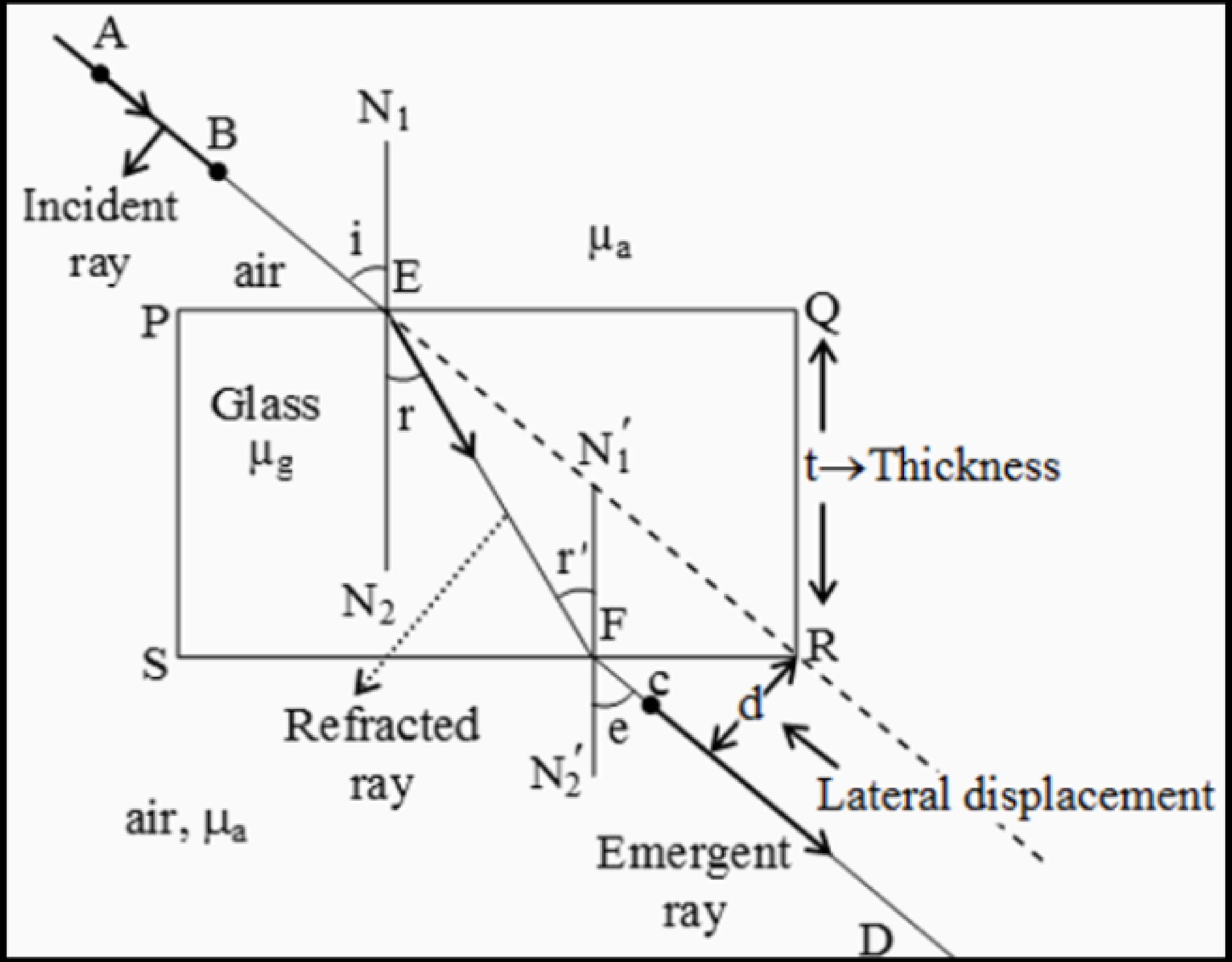
- **After passing through the glass slab, the refracted ray makes an angle of refraction (*r*) at the other surface.**
- **The emergent ray then bends away from the normal as it exits from glass (denser) to air (rarer), forming an angle of emergence (*e*) with the normal.**



REFRACTION THROUGH A RECTANGULAR GLASS SLAB

अभय

When an incident ray enters a glass slab from air, it makes an angle of incidence *(i)* with the normal and bends towards the normal as it moves from a rarer to a denser medium.

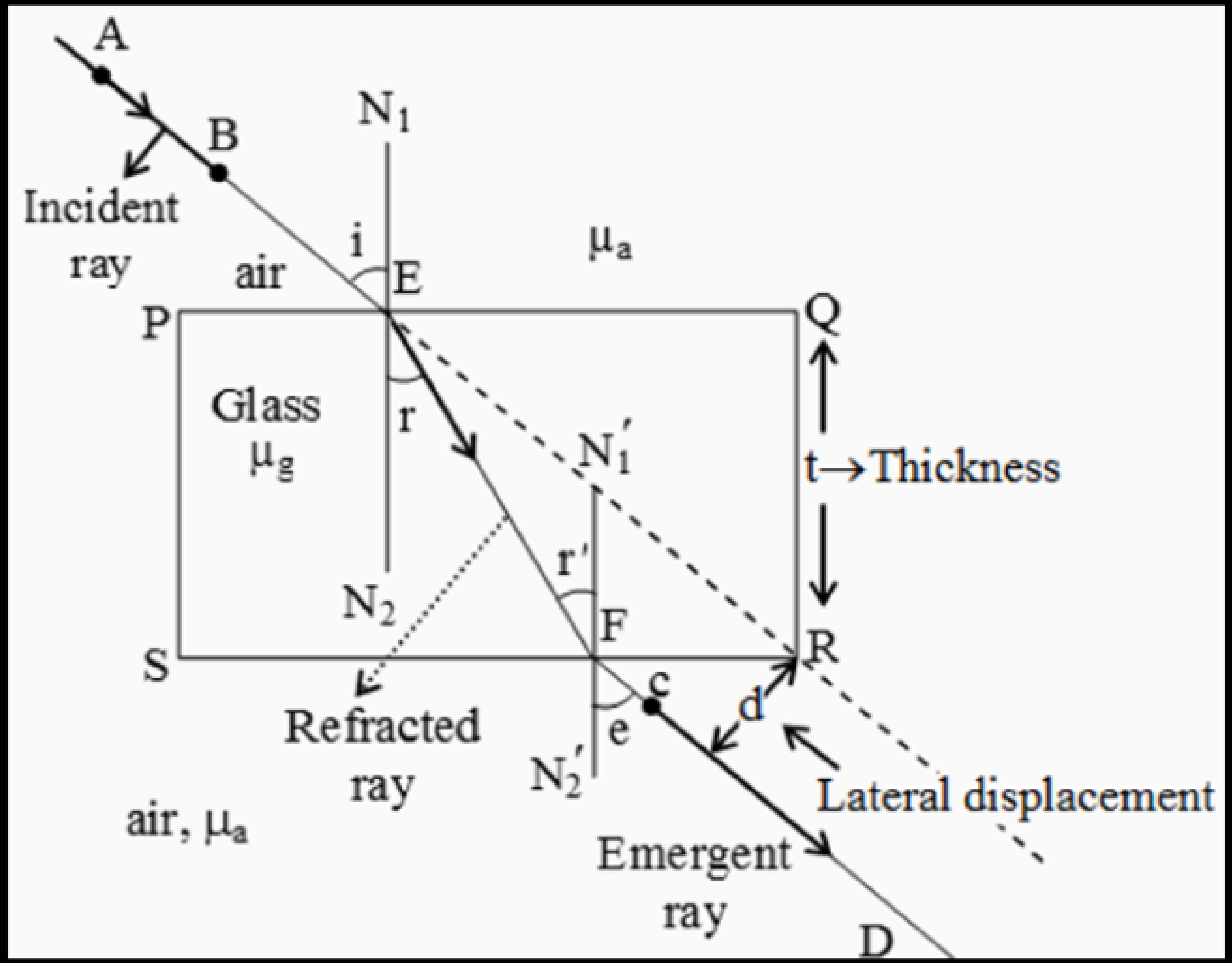


- After passing through the glass slab, the refracted ray makes an angle of refraction *(r)* at the other surface.
- The emergent ray then bends away from the normal as it exits from glass (denser) to air (rarer), forming an angle of emergence *(e)* with the normal.

REFRACTION THROUGH A RECTANGULAR GLASS SLAB

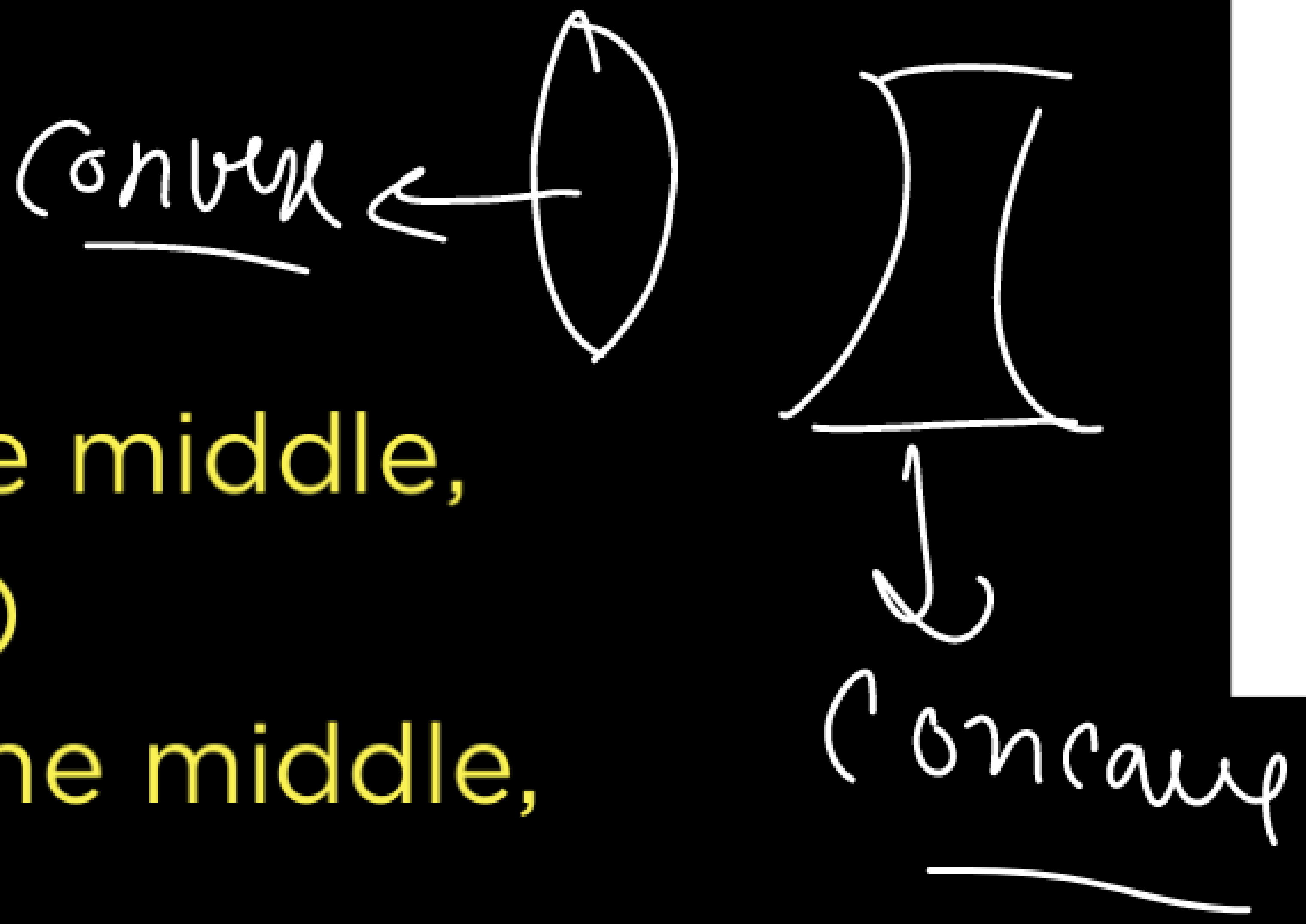
अभय

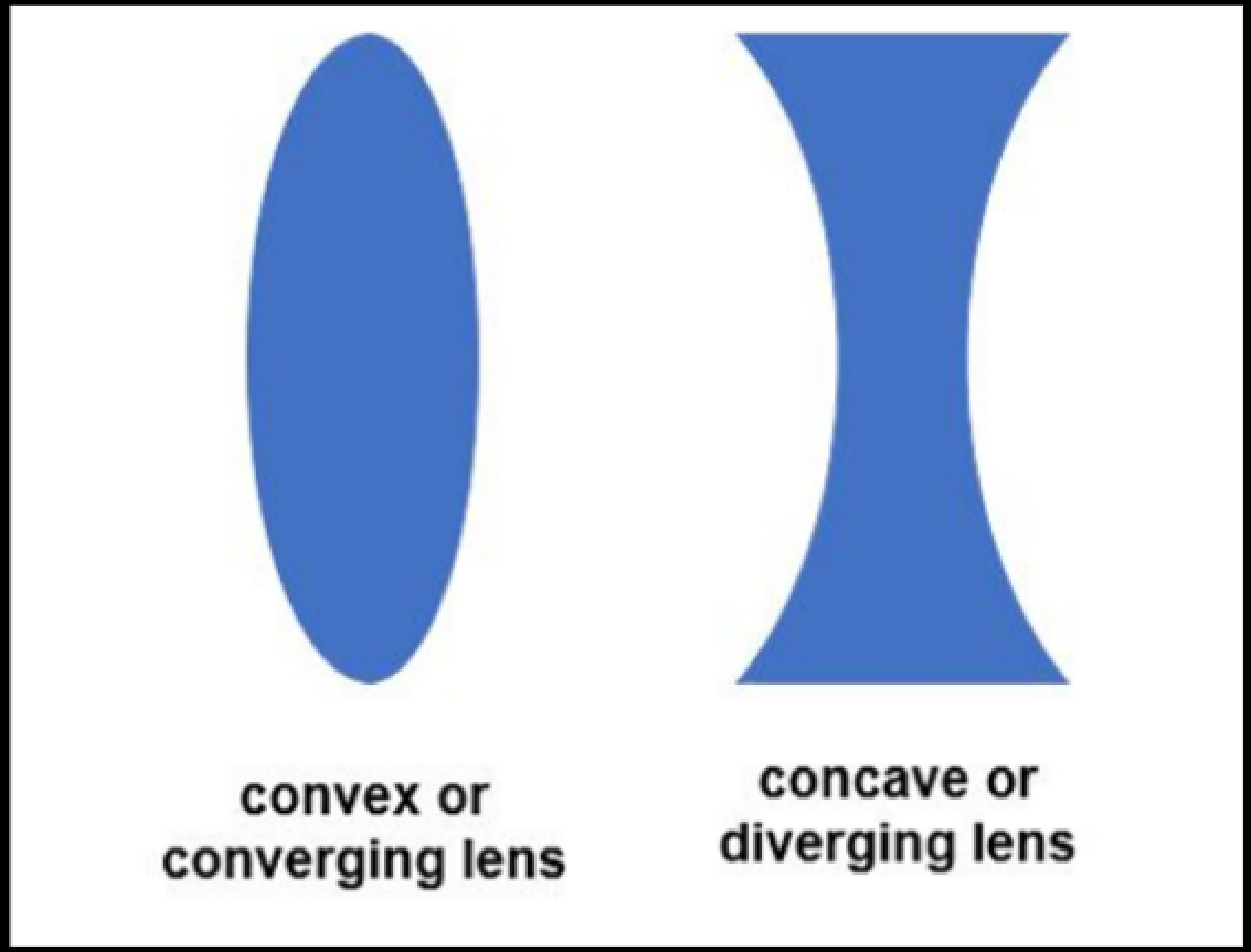
- The *emergent ray is parallel to the incident ray*, with the perpendicular distance between them known as ***lateral displacement***.
- Since the angle of incidence equals the angle of emergence, *the emergent ray remains parallel to the incident ray.*
- In a glass slab, light is refracted twice: first from a rarer to a denser medium, and then from denser to rarer.
- *This refraction causes the lateral displacement of the emergent ray.*



SPHERICAL LENS

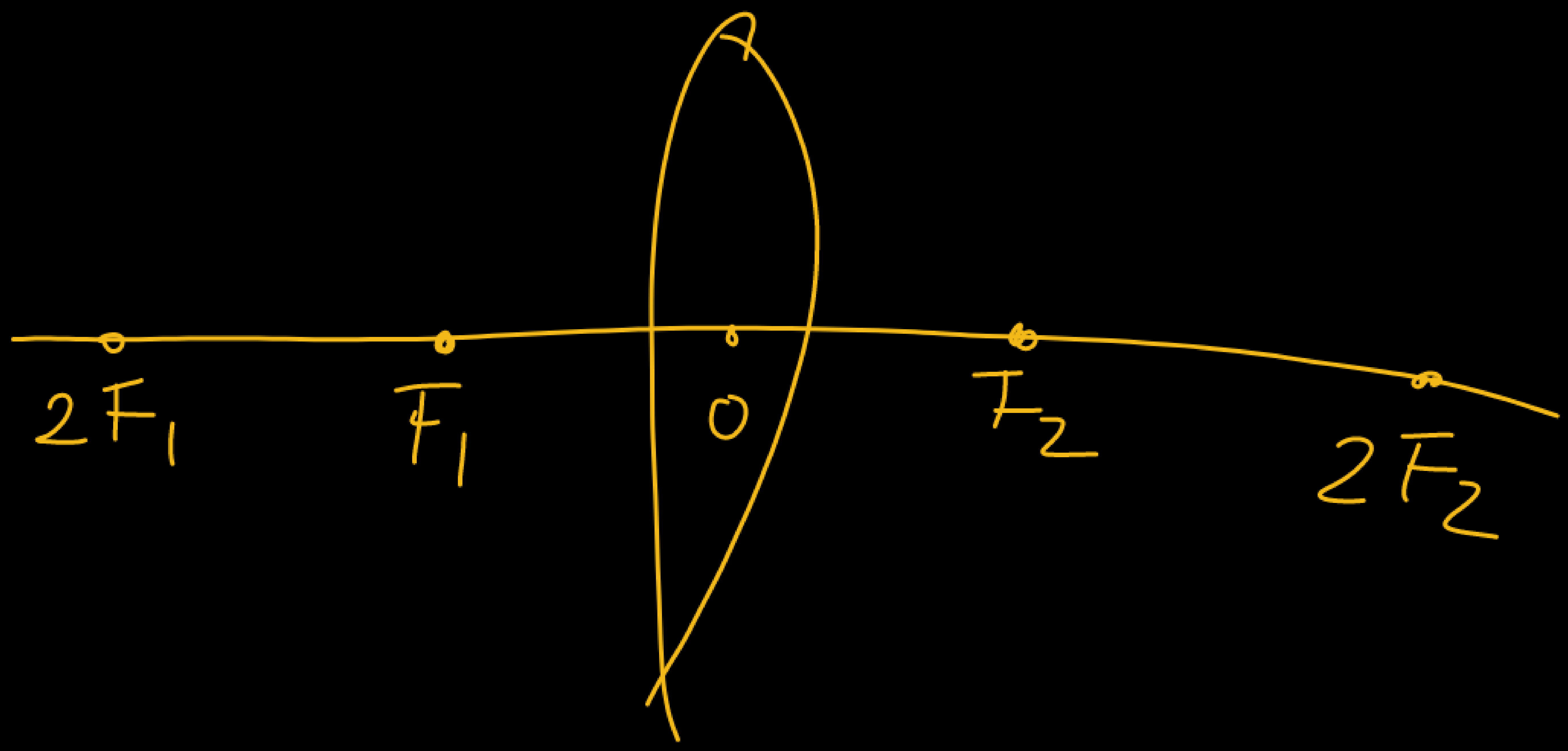
Spherical lenses are lenses with surfaces that are part of a sphere.





Types of lenses

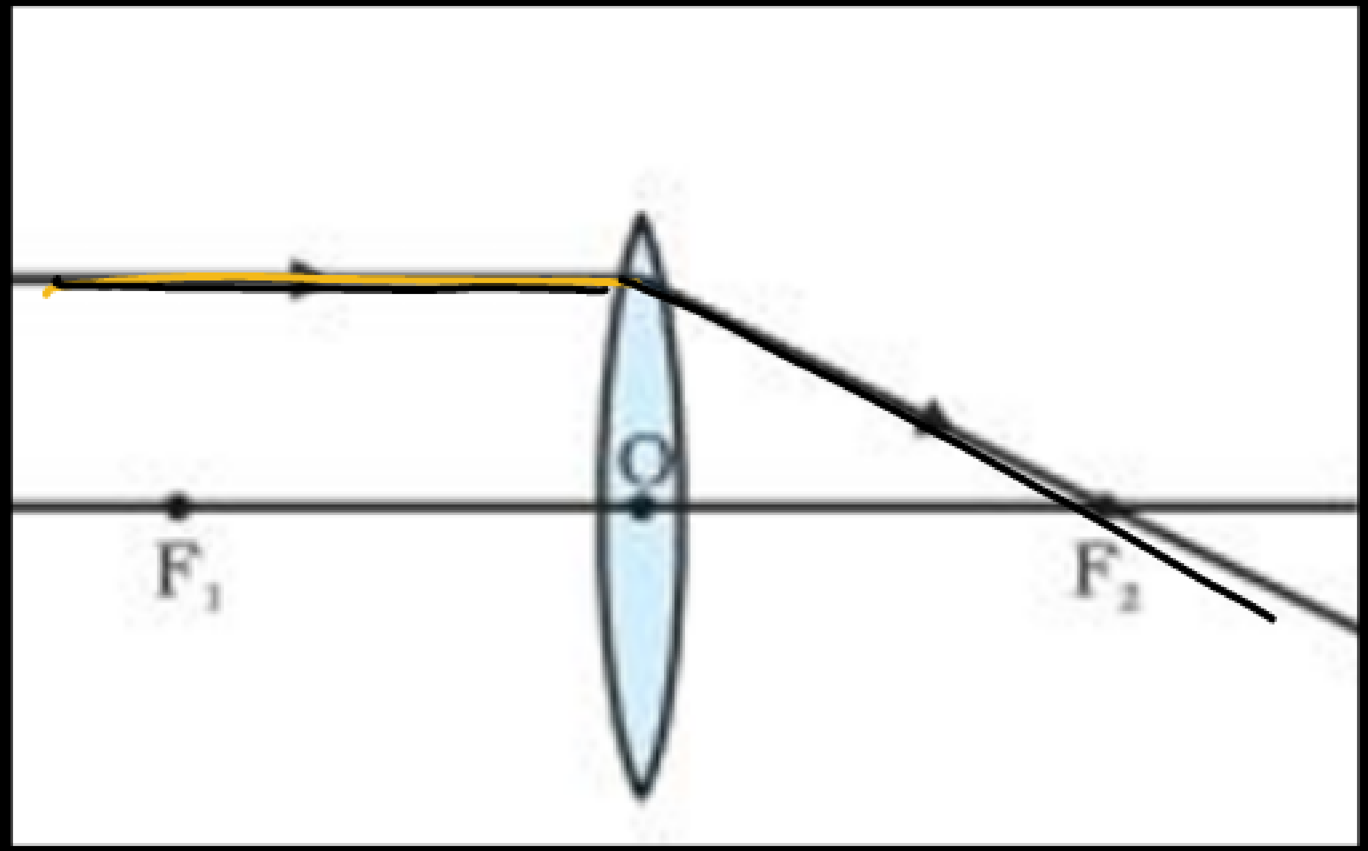
- ***Convex*** (thicker in the middle, converging light rays)
- ***Concave*** (thinner in the middle, diverging light rays).


2F1
F1
O
F2
2F2

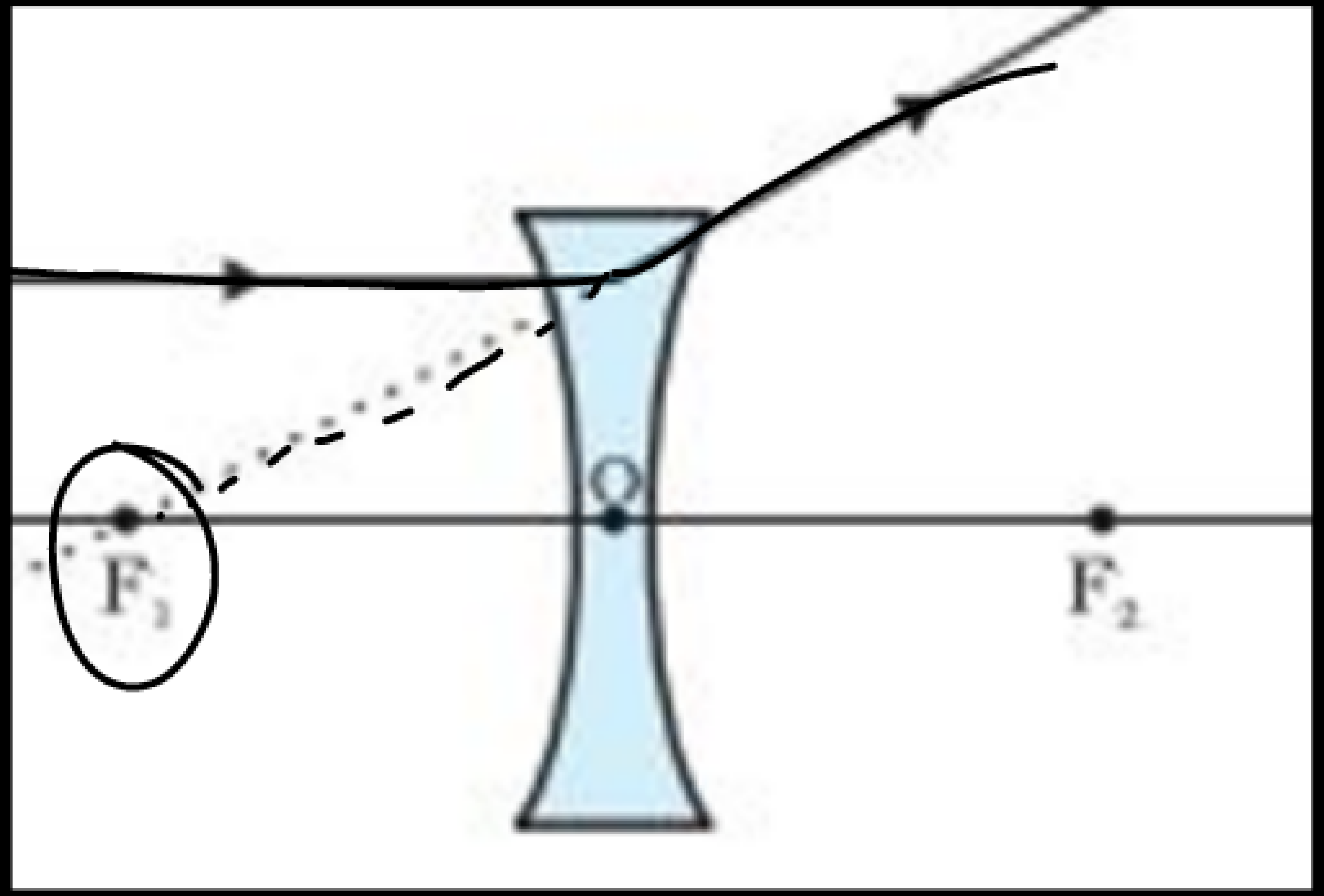
RULES TO OBTAIN IMAGE

अभय

Rule 1: A ray of light from the object, parallel to the principal axis, after refraction from a convex lens, passes through the principal focus on the other side of the lens.



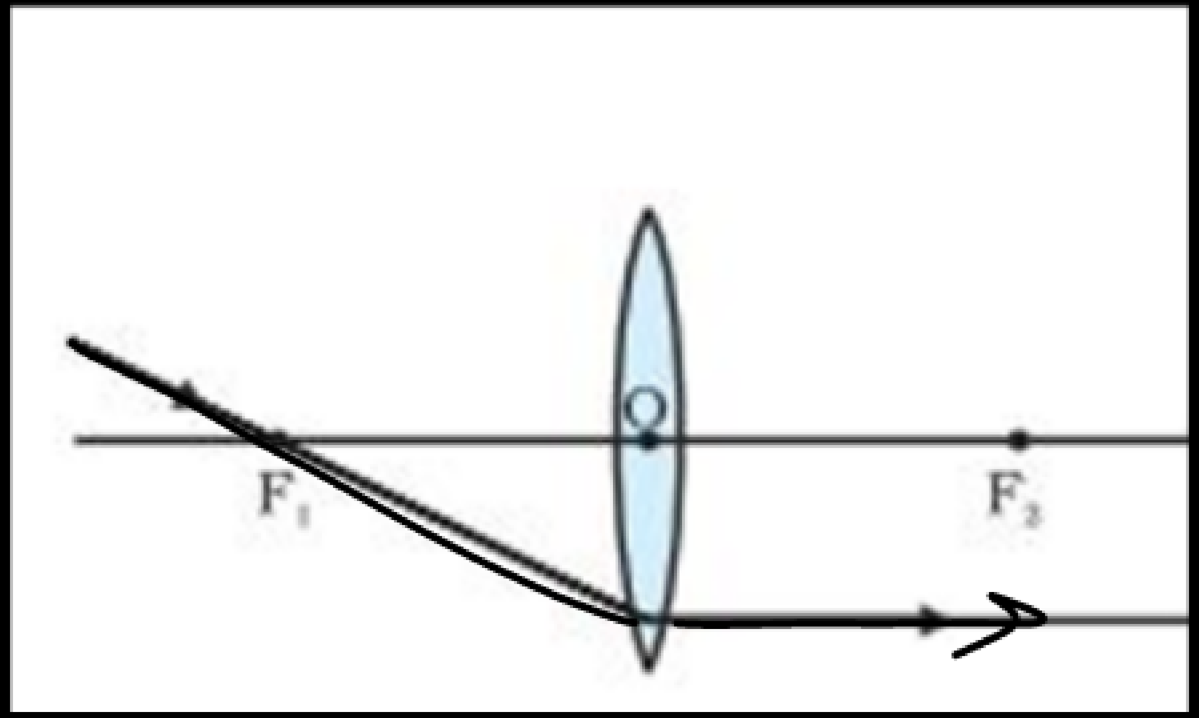
In case of a concave lens, the ray appears to diverge from the principal focus located on the same side of the lens.



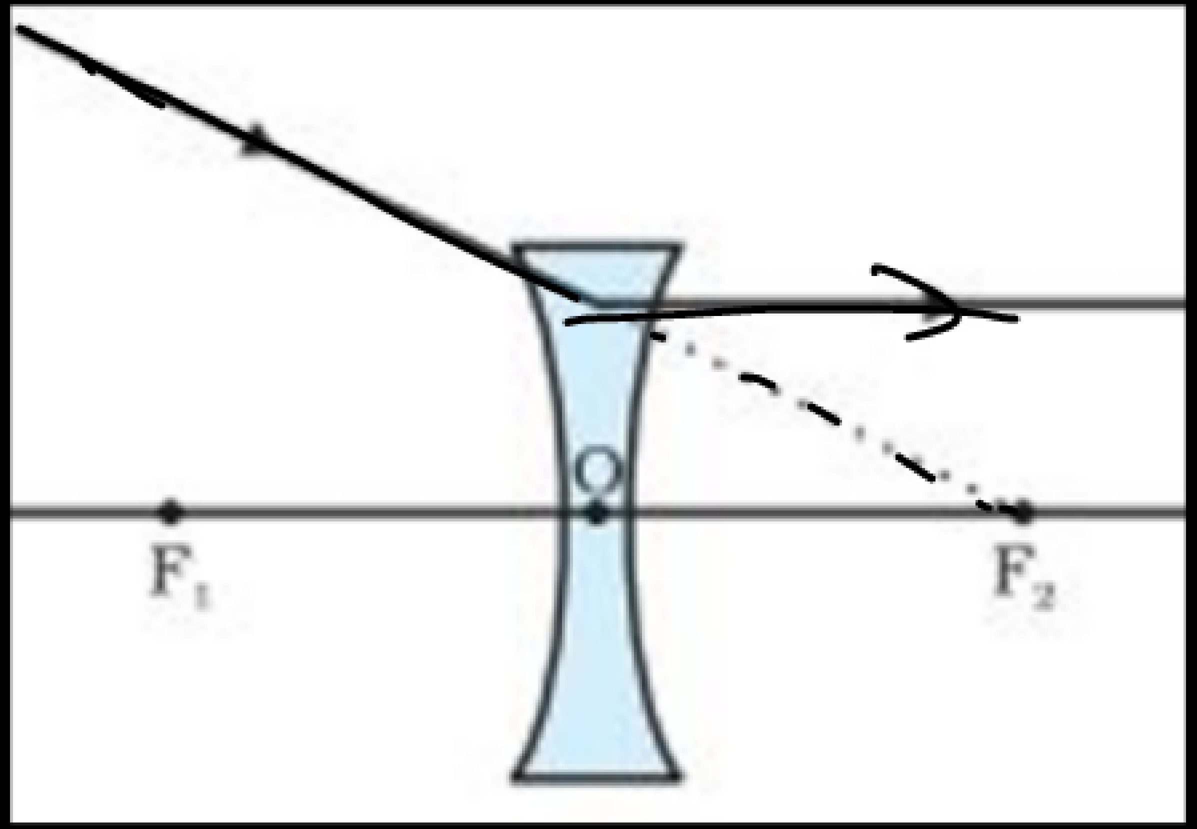
RULES TO OBTAIN IMAGE

अभय

Rule 2: A ray of light passing through a principal focus, after refraction from a convex lens, will emerge parallel to the principal axis.



A ray of light appearing to meet at the principal focus of a concave lens, after refraction, will emerge parallel to the principal axis.



RULES TO OBTAIN IMAGE

Rule 3: A ray of light passing through the optical centre of a lens will emerge without any deviation.

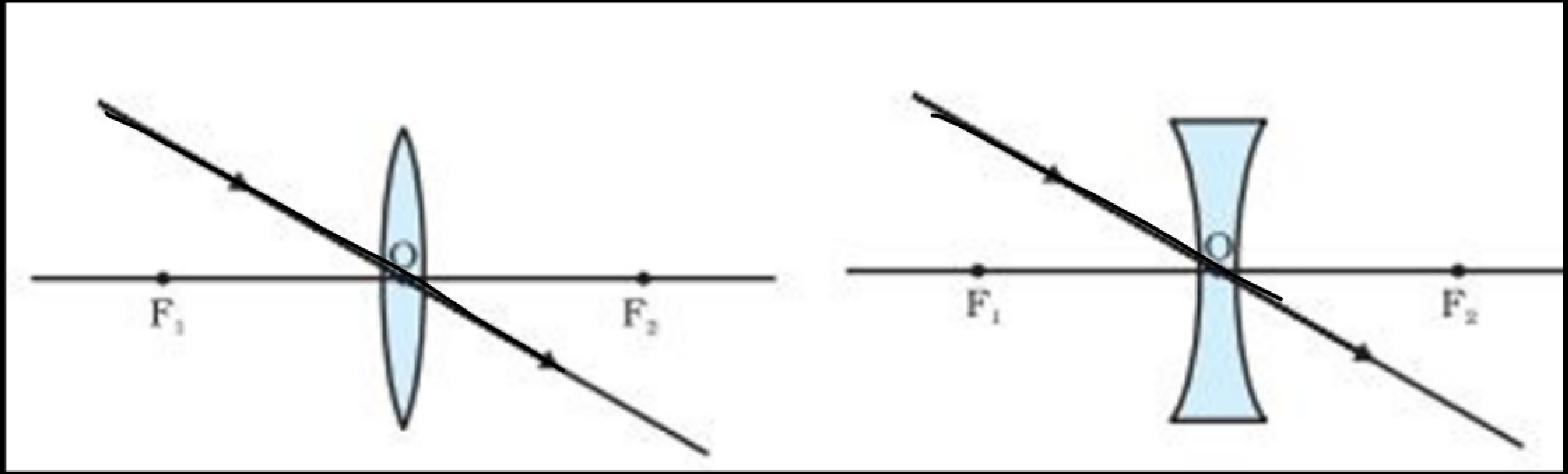


IMAGE FORMATION BY CONVEX LENS

1. Object at Infinity

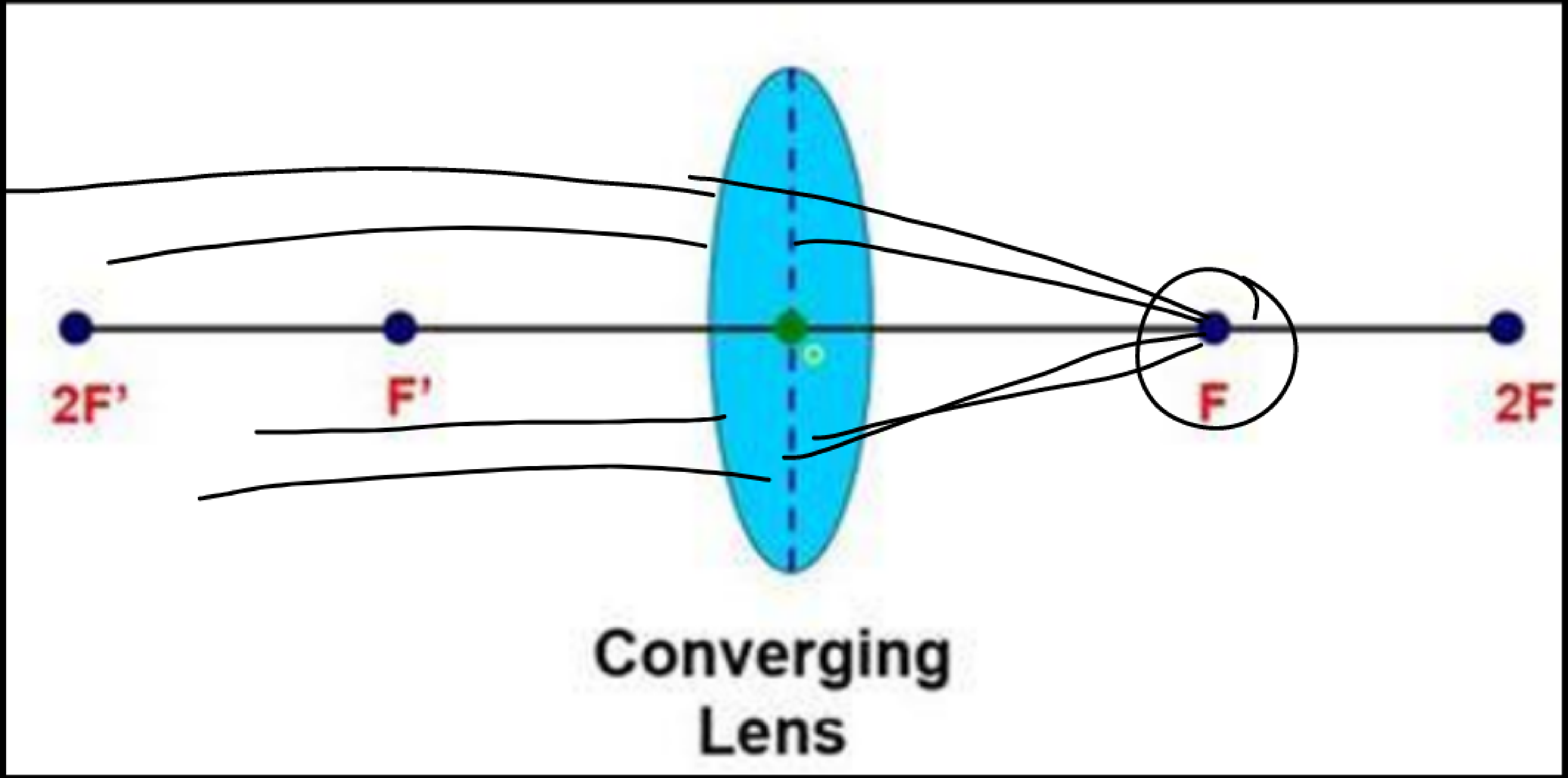


IMAGE FORMATION BY CONVEX LENS

अभय

2. Object beyond 2F1

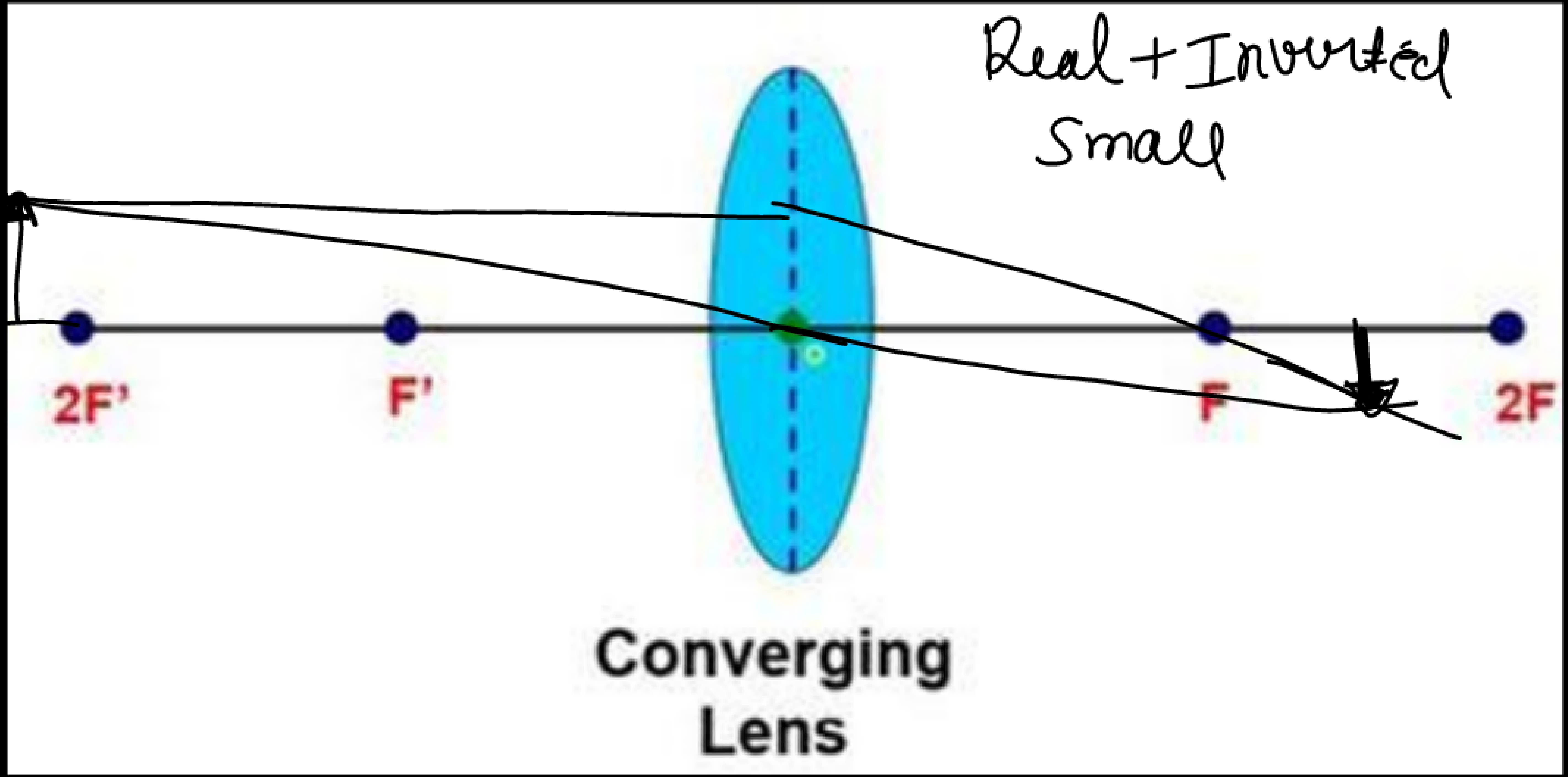


IMAGE FORMATION BY CONVEX LENS

अभय

3. Object at 2F1

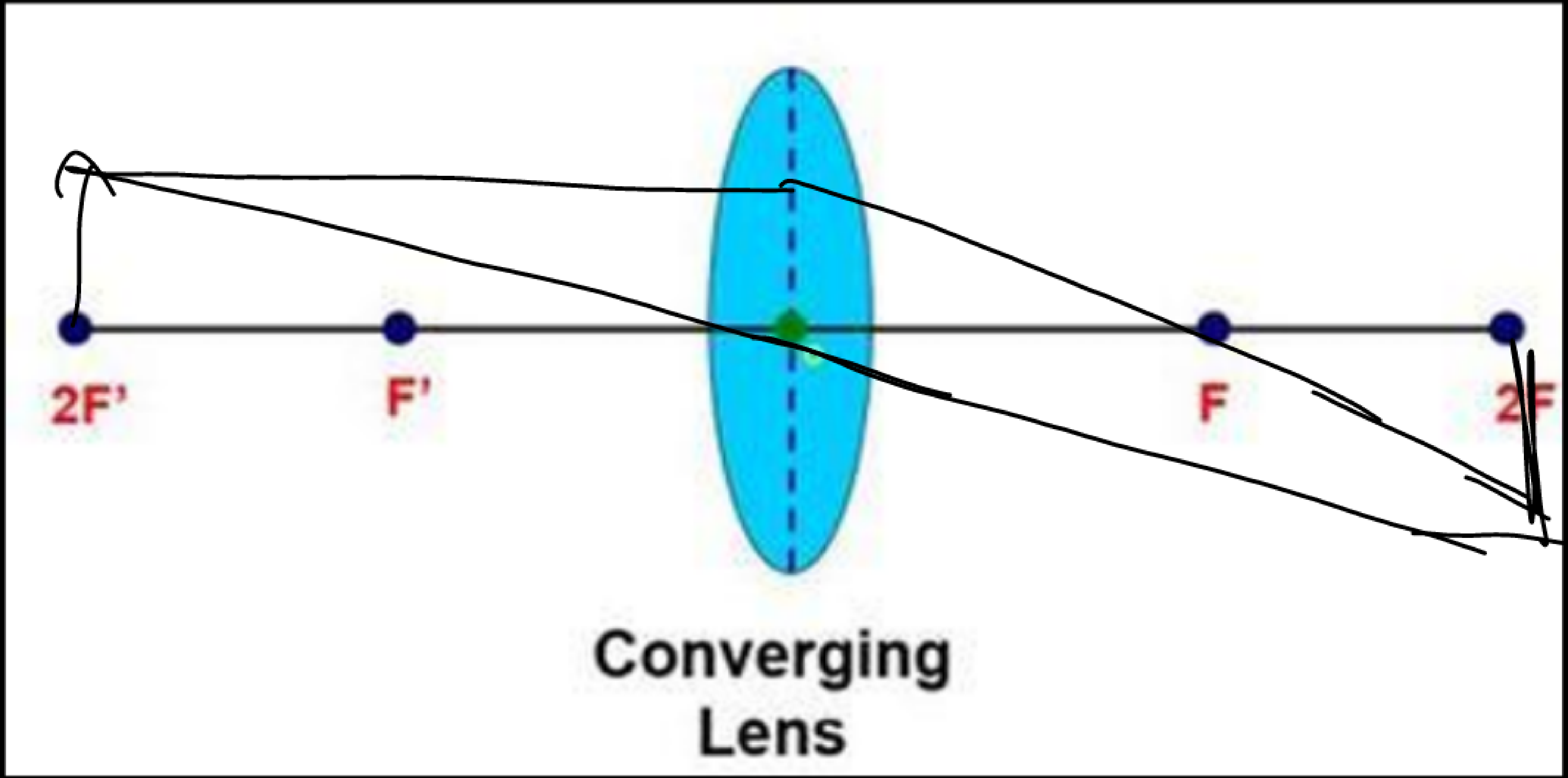


IMAGE FORMATION BY CONVEX LENS

अभय

4. Object between 2F1 and F1

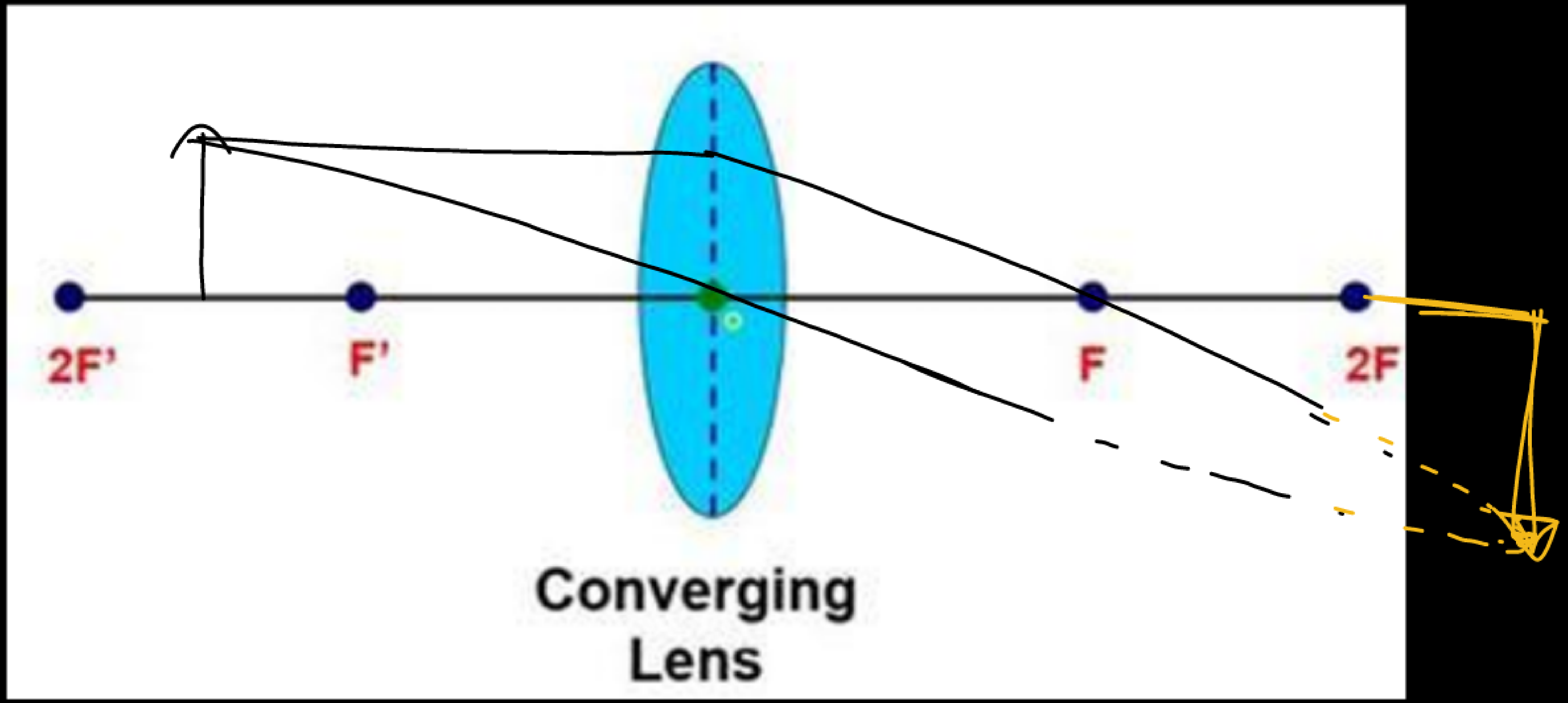


IMAGE FORMATION BY CONVEX LENS

5. Object at F1

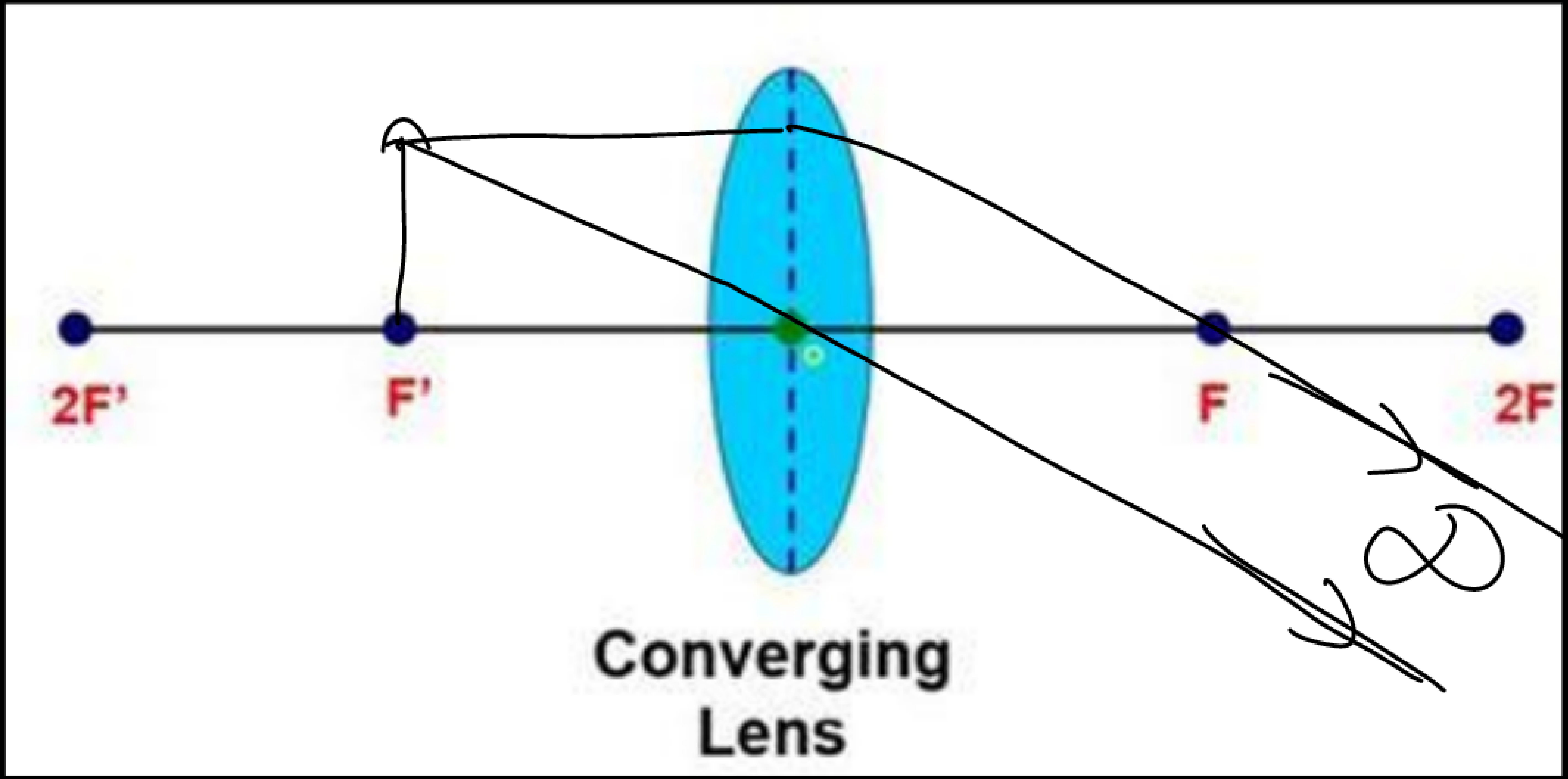
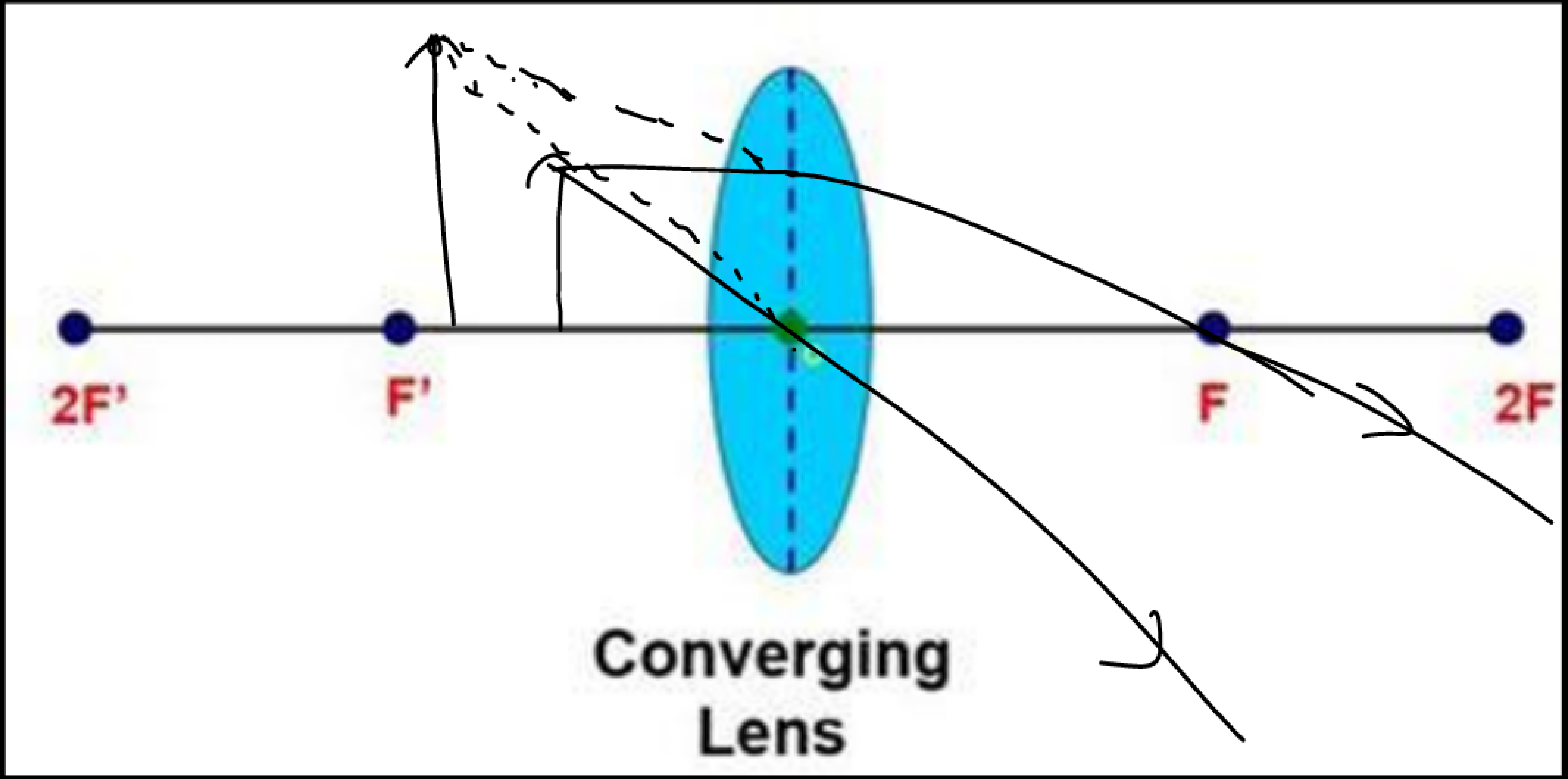
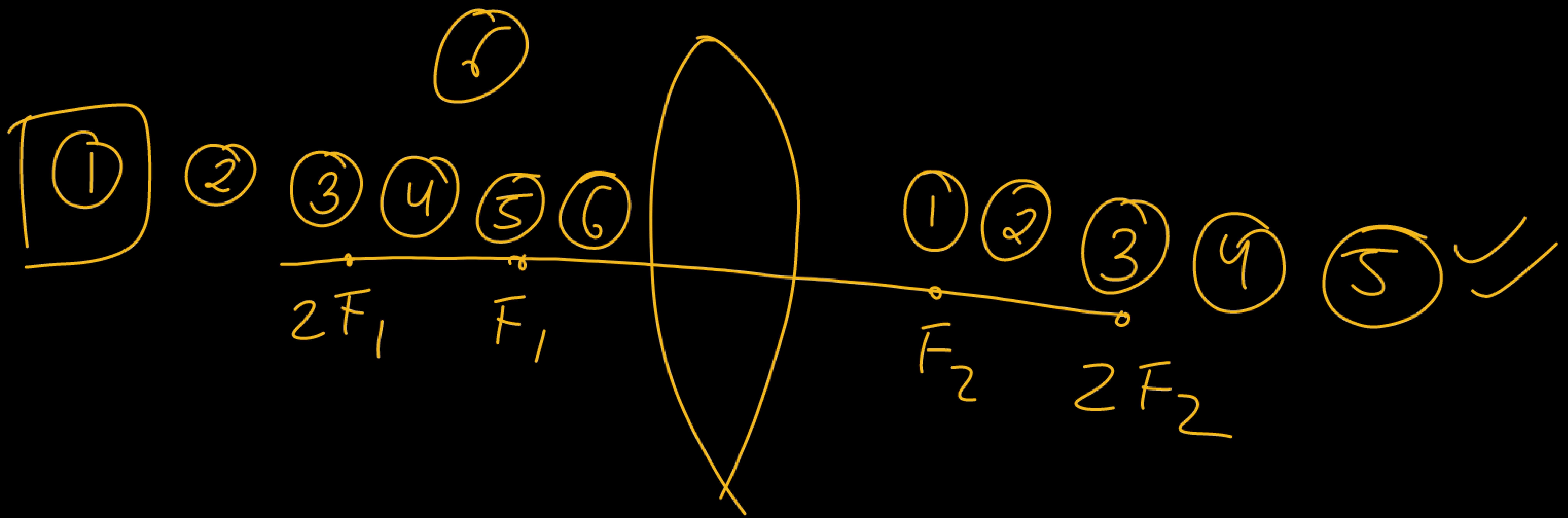


IMAGE FORMATION BY CONVEX LENS

अभय

6. Object between F1 and O




1
2
3
4
5
6
7
2F1
F1
1
2
3
4
5
F2
2F2

अभय

IMAGE FORMATION BY CONCAVE MIRROR

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

USES OF CONVEX LENS

Microscope

Telescope

Magnifying glass

IMAGE FORMATION BY CONCAVE LENS

1. Object at Infinity

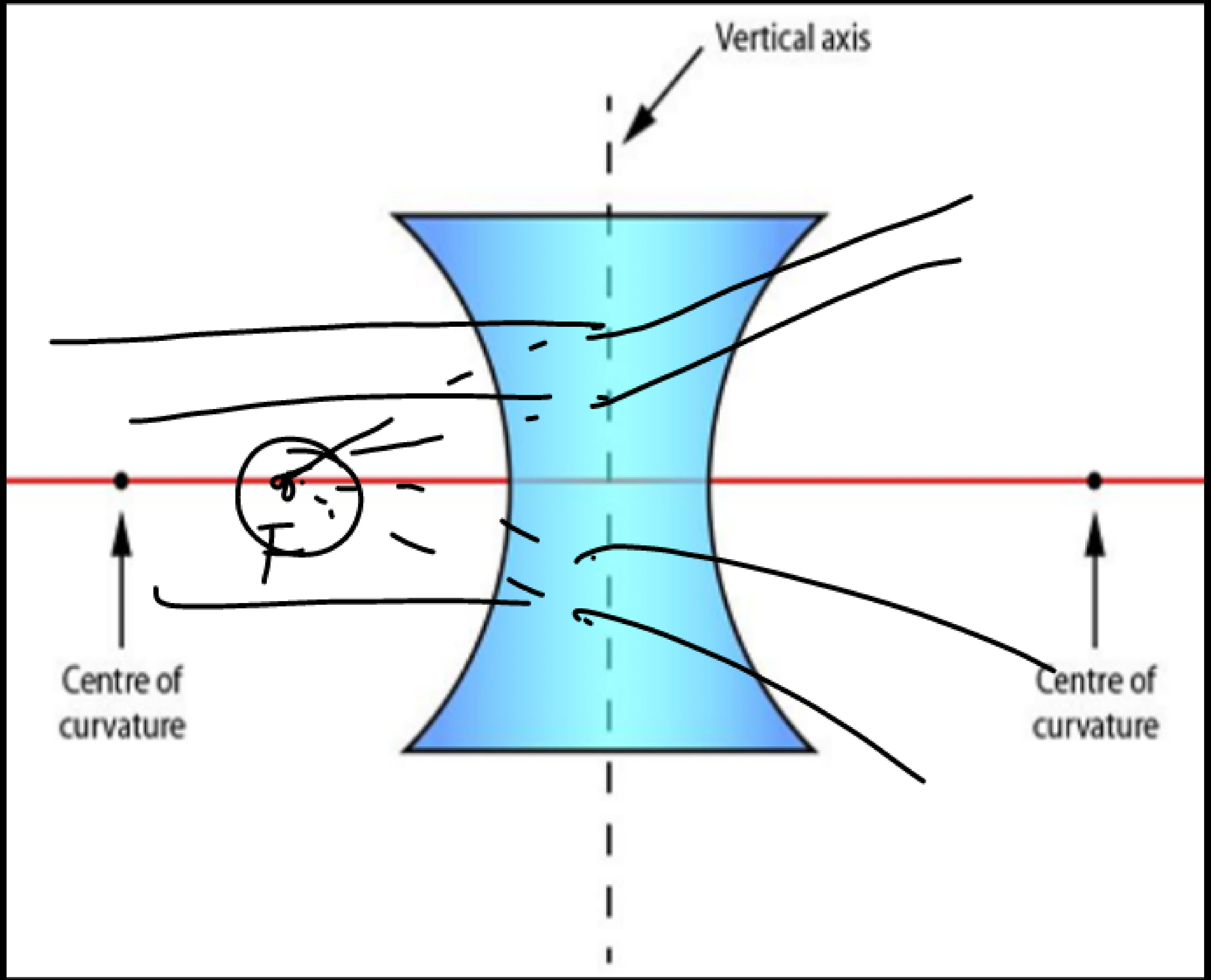


IMAGE FORMATION BY CONCAVE LENS

2. Object at finite distance

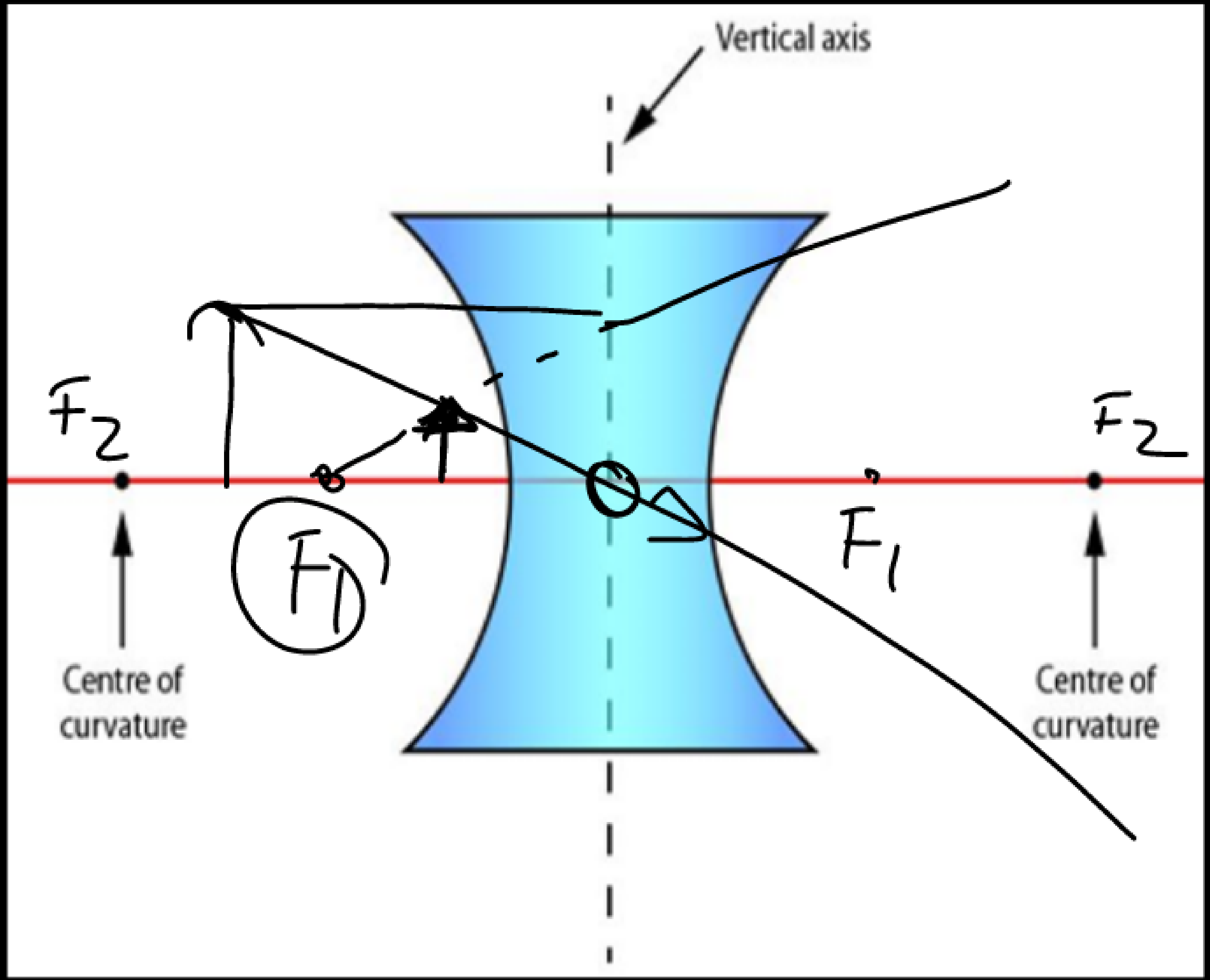


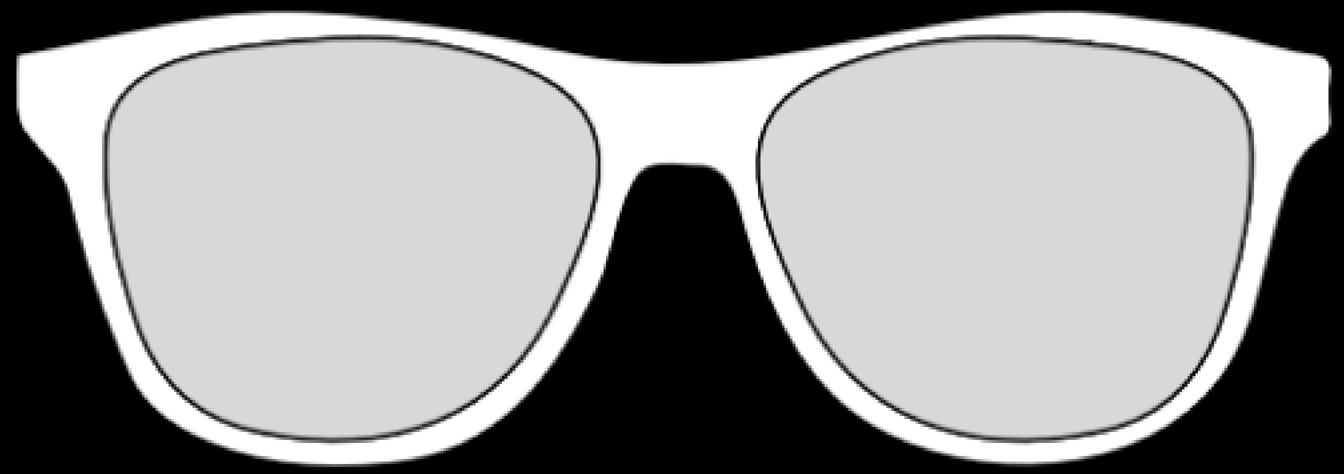
IMAGE FORMATION BY CONCAVE LENS

अभय

Position of the object	Position of the image	Relative 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

USES OF CONVEX LENS

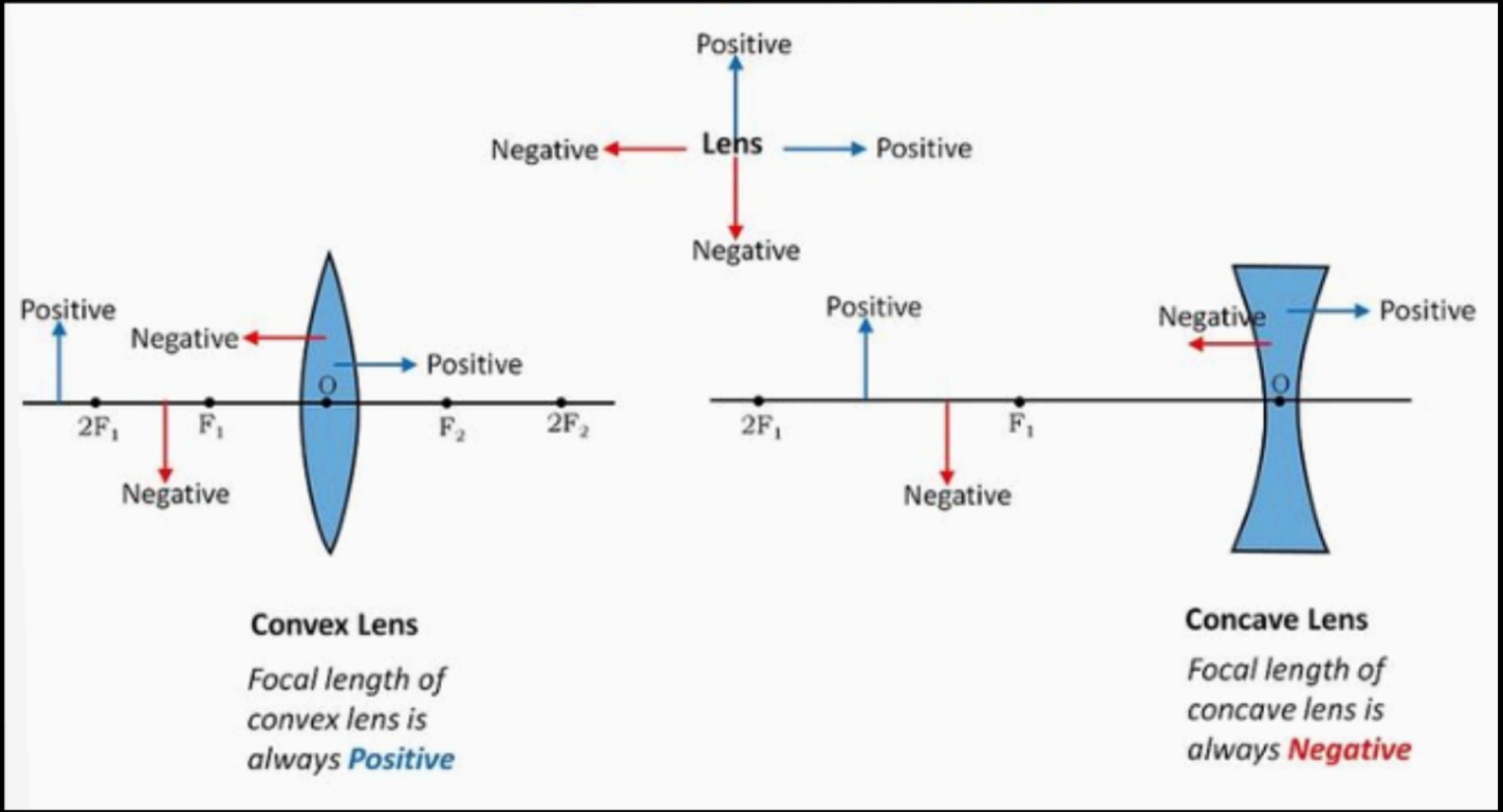
Binoculars



Eye glasses

Torches

SIGN CONVENTION



LENS FORMULA

अभय

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

The lens formula relates the object distance (u), image distance (v), and focal length (f) of a lens.

This formula applies to both convex and concave lenses.

अभय

Q. An object is placed at a distance of 60 cm from a concave lens of focal length 30 cm. Use lens formula to find the distance of the image from the lens

$f = -30\,cm$ $= \ominus$

$u = -60\,cm$

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

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

$= -\frac{1}{30} - \frac{1}{60} = \frac{-3}{60} = -\frac{1}{20} = -20\,cm$

$m = \frac{v}{u} = \frac{-20}{-60} = +\frac{1}{3}$

Virtual
+ve

अभय

Q. An object is placed at a distance of 60 cm from a concave lens of focal length 30 cm. Use lens formula to find the distance of the image from the lens

Given: $f = -30\,\text{cm}, u = -60\,\text{cm}$

Lens formula:

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

$$\frac{1}{-30} = \frac{1}{v} + \frac{1}{60}$$

$$\frac{1}{v} = \frac{-1}{60}$$

$$v = -60\,\text{cm}$$

Image distance: $-60\,\text{cm}$.

MAGNIFICATION

अभय

It gives us information about the image in terms of how large or small is the image formed.

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

$= \frac{v}{u}$

$$m = \frac{Height\ of\ image\ (h')}{Height\ of\ object\ (h)}$$

$$= \frac{h'}{h} = \frac{v}{u}$$

Magnification refers to the *ratio of the height of an image to the height of an object*.

It is denoted by m.

MAGNIFICATION

- If m>1, the Image size is enlarged.
- If 0<m<1, the image size is diminished.
- If m = 1, the image size is equal to the object size.
- If m is negative, the image formed is real and inverted.
- If m is positive, the image formed is virtual and erect.

$$m = \frac{Height\ of\ image\ (h')}{Height\ of\ object\ (h)} = \frac{h'}{h} = \frac{v}{u}$$

POWER OF LENS

अभय

The power of a lens indicates its ability to converge or diverge light, measured in diopters (D) or m^{-1}

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

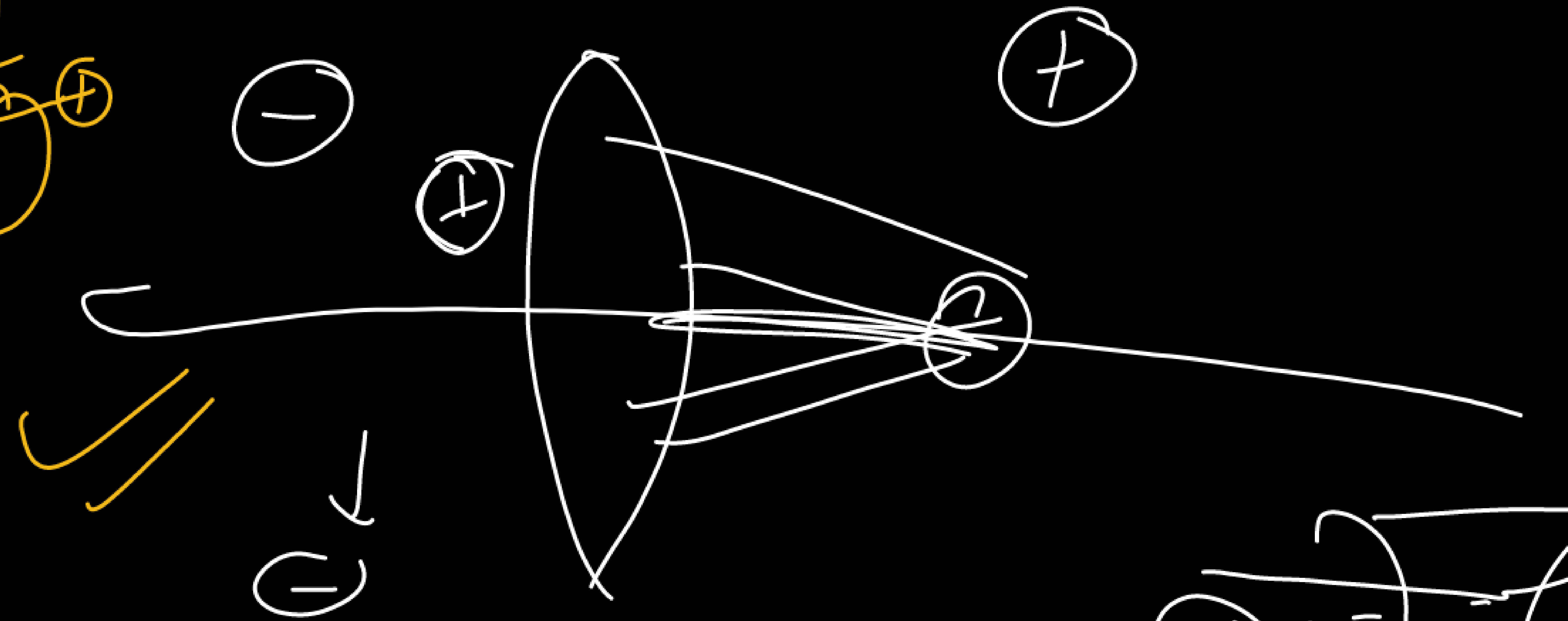
Power for convex lens : Positive as focal length for convex lens is also positive.

Power for concave lens : Negative as focal length for concave lens is also negative

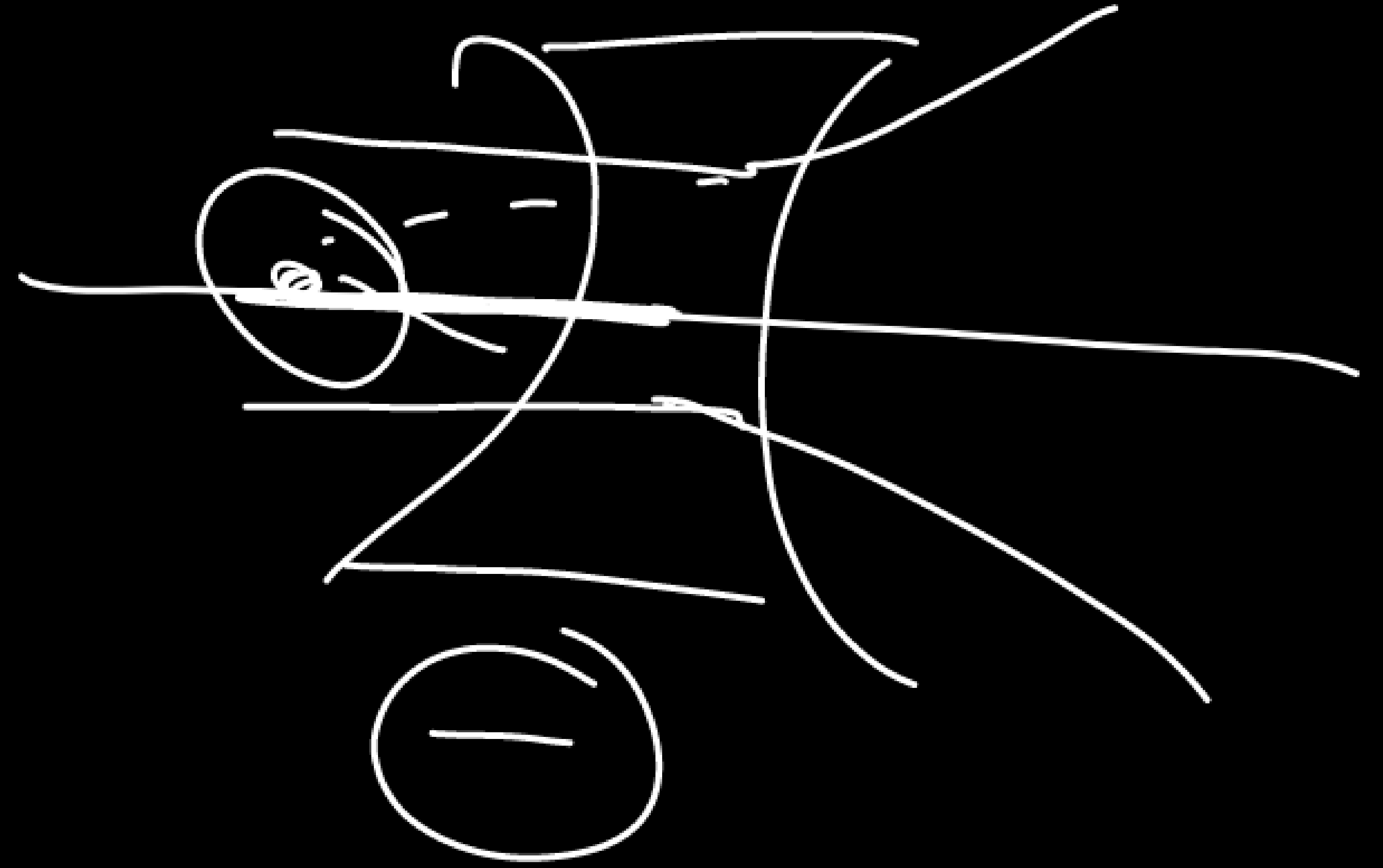
$$P = \frac{1}{f(m)}$$

$$\frac{100}{f}$$

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



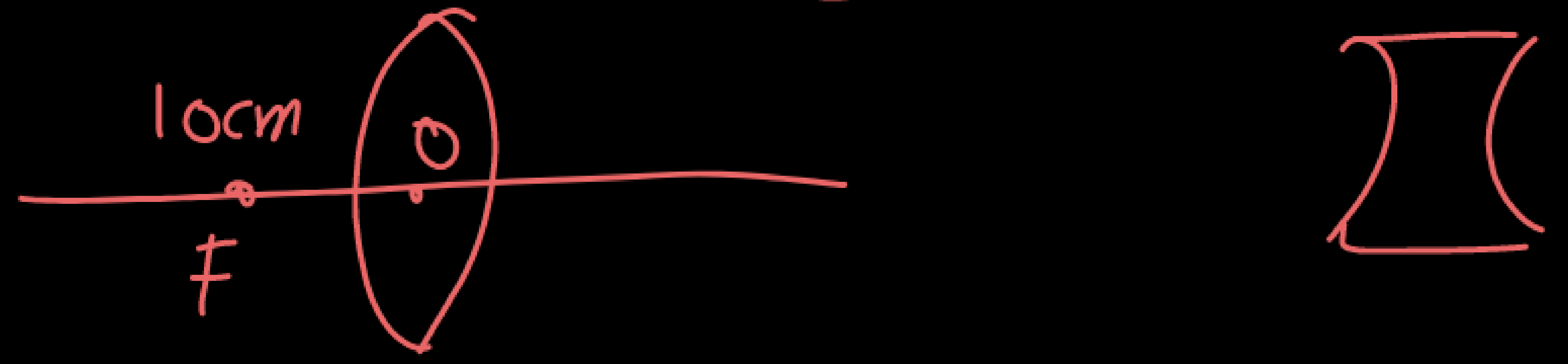
Convex

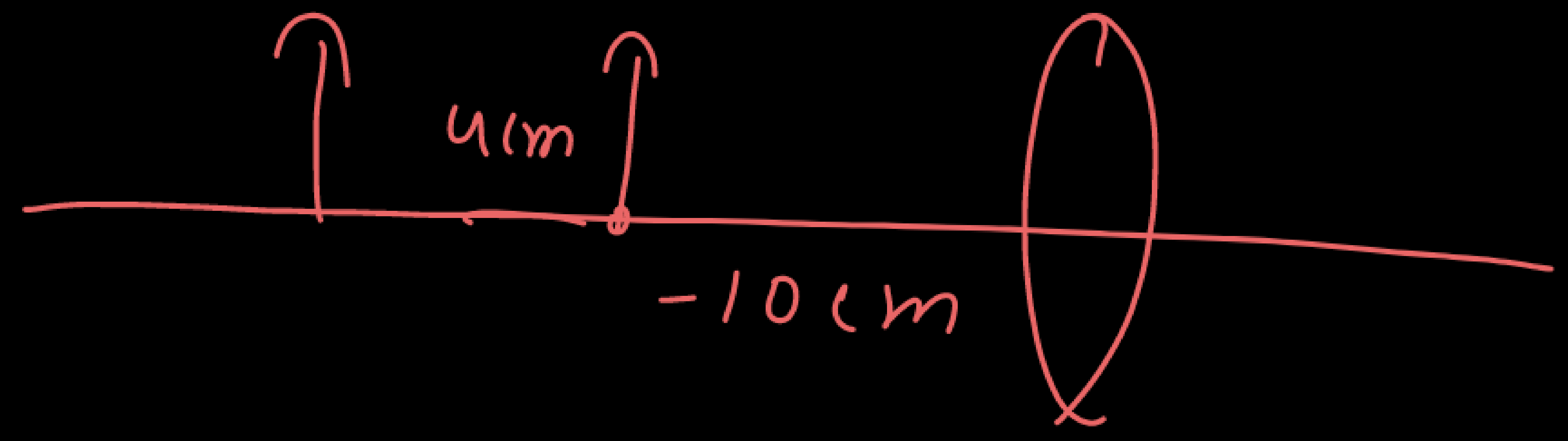


Q. A convex lens has a focal length of 50 cm. Find its power.

$$P = \frac{1}{f} = \frac{100}{f} = \frac{100}{50} = +2\,D$$

Q. You have two lenses A and B of focal lengths + 10 and -10 cm respectively. State the nature and power of each lens. Which of the two lenses will form a virtual and magnified image of an object placed 8 cm from the lens?





$m = \frac{h_i}{h_o} = \frac{16}{4} = \boxed{4}$

$4 = \frac{v}{u}$

$\boxed{-40 = v}$

$h_i = 16\text{cm}$ (virtual)

$f = ?$

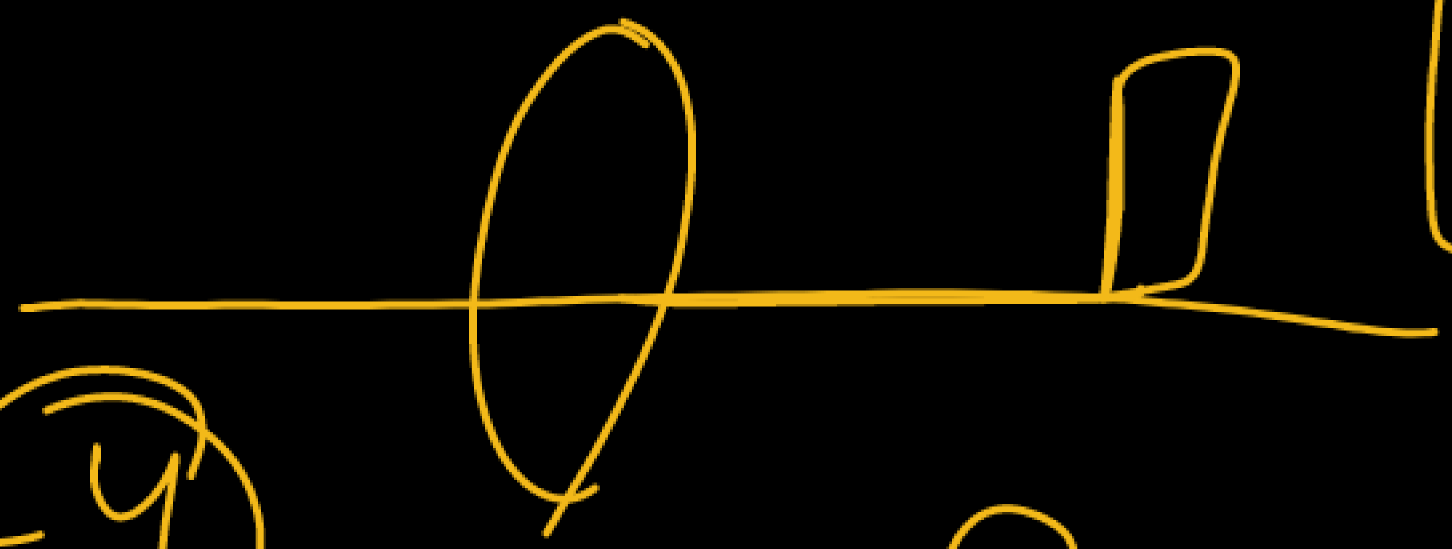
$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$-\frac{1}{40} - \left(-\frac{1}{10}\right) = \frac{1}{f}$

$\frac{-1+4}{40} = \frac{1}{f} \rightarrow \frac{3}{40} \rightarrow \frac{40}{3}\text{cm}$

Real

$m = -4$



$[v = ?]$

$[f = 10\,cm]$

$$\frac{1}{v} + \frac{4}{v} = \frac{1}{10} \rightarrow \frac{5}{v} = \frac{1}{10}$$

$$v = 50\,cm$$

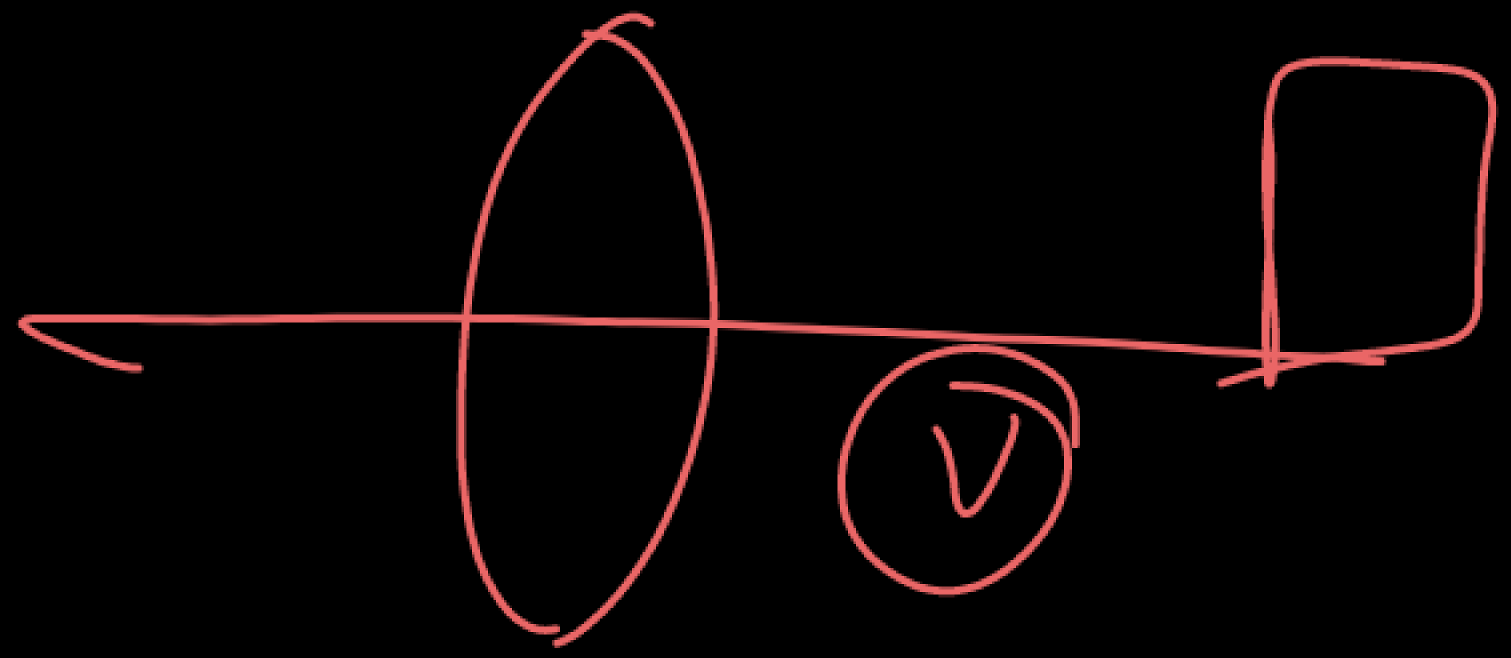
$$m = \frac{v}{u} = -4$$

$$v = -4u$$

$$-\frac{v}{4} = u$$

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

$$\frac{1}{v} - \left[-\frac{1}{v/4}\right] = \frac{1}{10}$$


v

Q. You have two lenses A and B of focal lengths + 10 and -10 cm respectively. State the nature and power of each lens. Which of the two lenses will form a virtual and magnified image of an object placed 8 cm from the lens?

Lens A:
Focal length f = +10 cm (convex lens).
Nature: Converging lens.
Power: P = 100\f = 100\10 = +10 D
Lens B:
Focal length f = −10 cm (concave lens).
Nature: Diverging lens.
Power: Power: P = 100\f = 100\-10 = -10 D.
For the virtual and magnified image:
Lens A (convex lens) will form a virtual and magnified image when the object is placed within its focal length (u<f).
Given u = 8 cm<f=10 cm, lens A will satisfy the condition.

अभय

Abhay Premier League

1.A student conducts an experiment using a convex lens. He places the object at a distance of 60 cm in front of the lens and observes that the image is formed at a distance of 30 cm behind the lens. What is the power of the lens?

(a) 0.005 dioptre

(b) 0.05 dioptre

(c) 5 dioptre ✓

(d) 50 dioptre

$u = -60\,cm$

$v = 30\,cm$

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

$\frac{1}{30} + \frac{1}{60} = \frac{3}{60} = \frac{1}{20}$ → 20 cm

$P = \frac{100}{f} = \frac{100}{20}$ = 5

Abhay Premier League

अभय

2.An image of an object produced on a screen which is about 36 cm using a convex lens. The image produced is about 3 times the size of the object. What is the ~~size~~ distance of the object?

(a) 12 cm
(b) 33 cm
(c) 39 cm
(d) 108 cm

$V = 36\,cm$

$m = -3$ ($h_o = ?$)

$-3 = m = \frac{h_i}{h_o} = \frac{v}{u}$, $v = 36$

$u = -12$

अभय

Abhay Premier League

3.A student studies that a convex lens always forms a virtual image irrespective of its position. What causes the convex ~~mirror~~ Lens to always form a virtual image?

(a) Because the reflected ray never intersects

(b) Because the reflected ray converges at a single point

(c) Because the incident ray traces its path back along the principal axis

(d) Because the incident ray of a convex mirror gets absorbed in the mirror

Abhay Premier League

4.The focal length of four convex lens P, Q, R and S are 20 cm, 15 cm, 5 cm and 10 cm, respectively. The lens having the greatest power is

(a) P

(b) Q

(c) R

(d) S

अभय

Abhay Premier League

5.The phenomenon of the bending of light as it passes from one medium to another is called:

a) Reflection

b) Refraction

c) Diffraction

d) Dispersion

अभय

Chapter ka gyaan

Reflect positivity, absorb knowledge, and scatter joy .

—Light