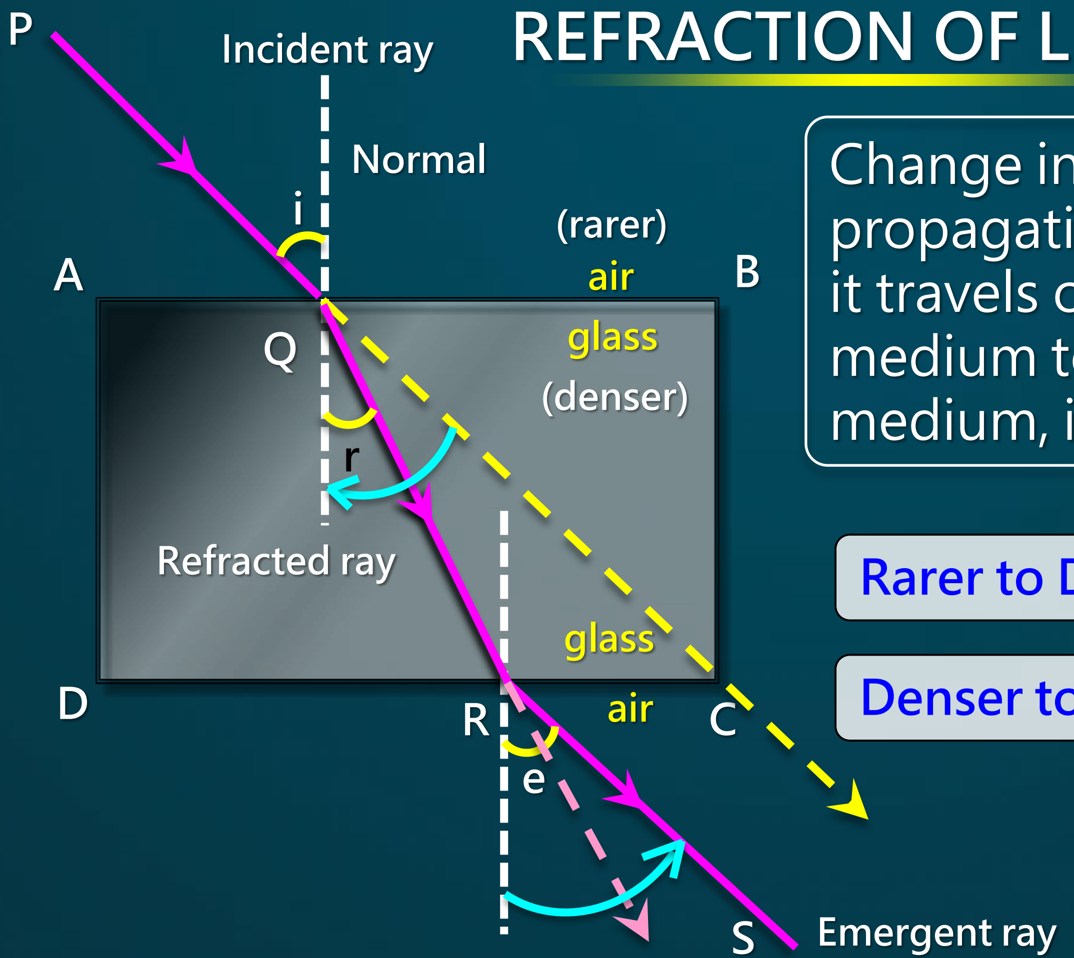
Lec - 6


Light is travelling
in a straight line

REFRACTION OF LIGHT



Change in the direction of propagation of a ray of light, when it travels obliquely from one medium to another transparent medium, is called refraction of light.

Rarer to Denser: towards normal

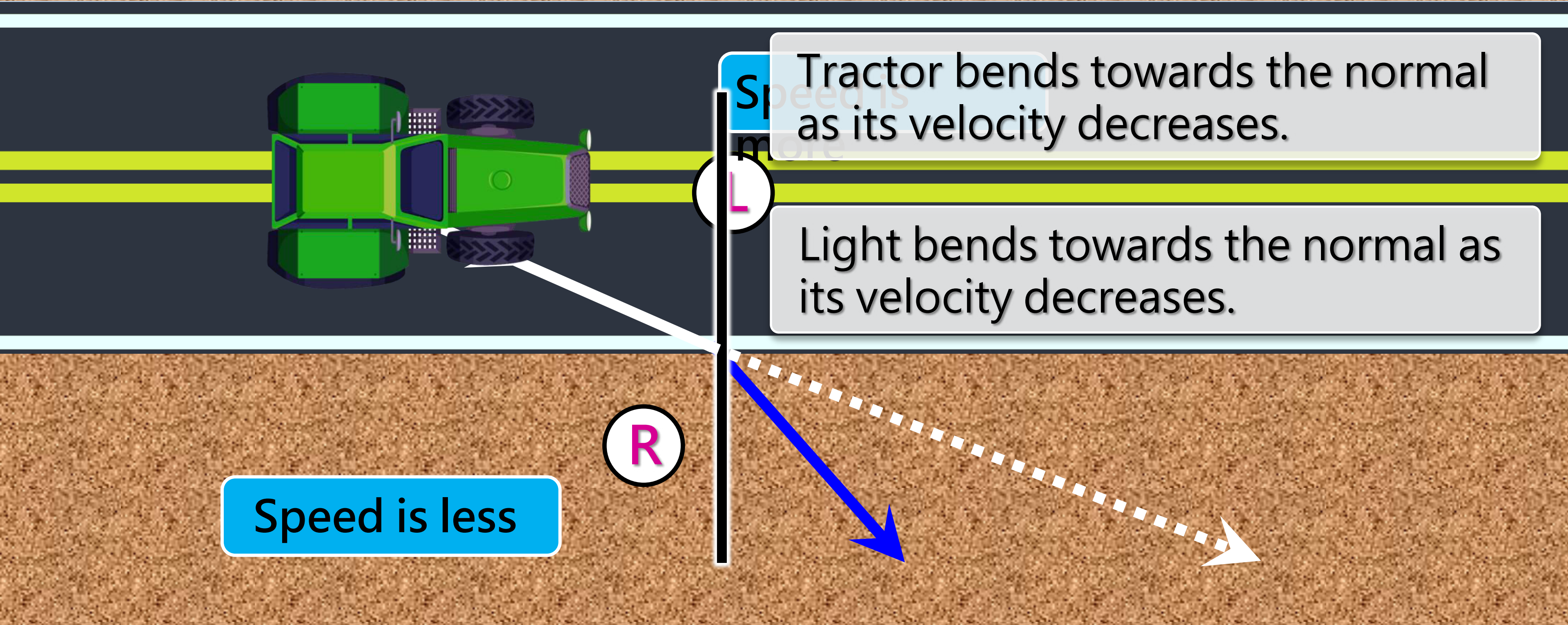
Denser to Rarer: away from normal

Let us understand why does the ray of light bend?

CONCLUSION

Tractor bends towards the normal as its velocity decreases.

Light bends towards the normal as its velocity decreases.



Let us understand why does the ray of light bend?

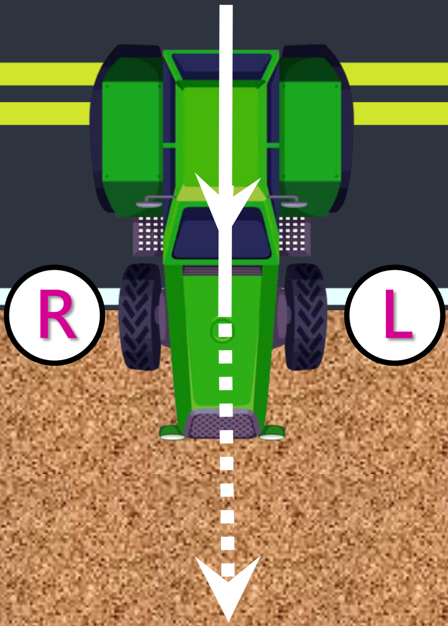
CONCLUSION

Rarer to denser → towards the normal

Denser to rarer → away from the normal

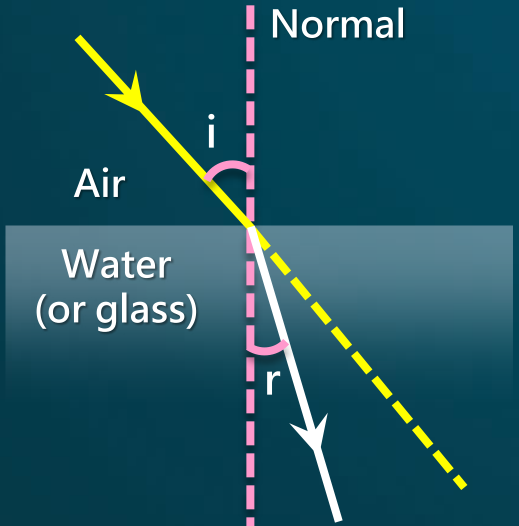
Light travels straight → No deviation

Speed is same



What happens when

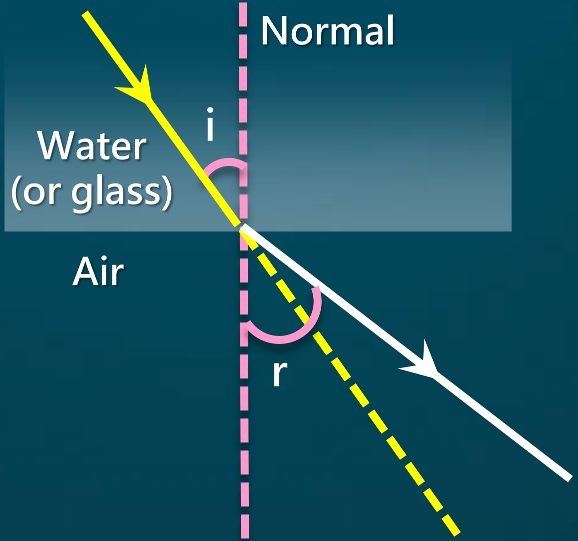
RARER TO DENSER



It bends towards the normal

Velocity Decreases

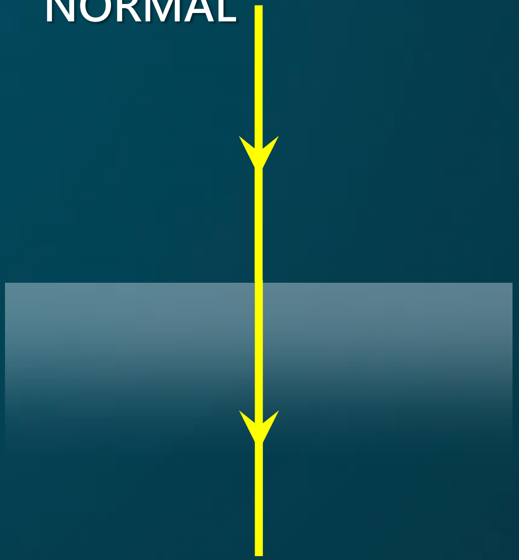
DENSER TO RARER



It bends away from the normal

Velocity increases

ALONG THE NORMAL



It passes undeviated.

Velocity decreases


QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME
QUIZ TIME
QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME

ALL THE BEST !!

IT'S QUIZ TIME

QUIZ TIME

Correct Wrong Cheer Boo Silence

1

2

3

4

5

6

7

8

FINAL QUIZ TIME

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of incidence?

(A) $\angle i = 30°$

(C) $\angle i = 40°$

(B) $\angle i = 60°$

(D) $\angle i = 0°$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of incidence?

(A) $\angle i = 30°$

(C) $\angle i = 40°$

(B) $\angle i = 60°$

(D) $\angle i = 0°$

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab normally. What is the angle of incidence?

(A) $\angle i = 30°$

(C) $\angle i = 40°$

(B) $\angle i = 60°$

(D) $\angle i = 0°$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab normally. What is the angle of incidence?

(A) $\angle i = 30^\circ$

(B) $\angle i = 60^\circ$

(C) $\angle i = 40^\circ$

(D) $\angle i = 0^\circ$

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of emergence?

(A) $\angle e = 30°$

(C) $\angle e = 60°$

(B) $\angle e = 40°$

(D) $\angle e = 0°$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of emergence?

(A) $\angle e = 30°$

(B) $\angle e = 40°$

(C) $\angle e = 60°$

(D) $\angle e = 0°$

QUIZ TIME

Correct Wrong Cheer Boo Silence

FREE POINT

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light strikes a glass slab at an angle of 50° with the normal to the surface of the slab. What is the angle of incidence?

(A) 50°

(C) 40°

(B) 25°

(D) 100°

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light strikes a glass slab at an angle of 50° with the normal to the surface of the slab. What is the angle of incidence?

(A) 50°

(B) 25°

(C) 40°

(D) 100°

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light gets deviated when it passes obliquely from one medium to another medium because ____________

(A) colour of light changes

(B) frequency of light changes

(C) speed of light changes

(D) intensity of light changes

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light gets deviated when it passes obliquely from one medium to another medium because ____________

(A) colour of light changes

(C) speed of light changes

(B) frequency of light changes

(D) intensity of light changes

QUIZ TIME

Correct Wrong Cheer Boo Silence

FREE POINT

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

Rakesh performs the experiment of tracing the path of a ray of light passing through a rectangular glass slab for different angles of incidence. He observes that in all cases __________.

(A) $\angle i > \angle r$ but $\angle i = \angle e$

(B) $\angle i < \angle r$ but $\angle i = \angle e$

(C) $\angle i > \angle e$ but $\angle i = \angle r$

(D) $\angle i < \angle e$ but $\angle i = \angle r$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

Rakesh performs the experiment of tracing the path of a ray of light passing through a rectangular glass slab for different angles of incidence. He observes that in all cases __________.

(A) $\angle i > \angle r$ but $\angle i = \angle e$

(C) $\angle i > \angle e$ but $\angle i = \angle r$

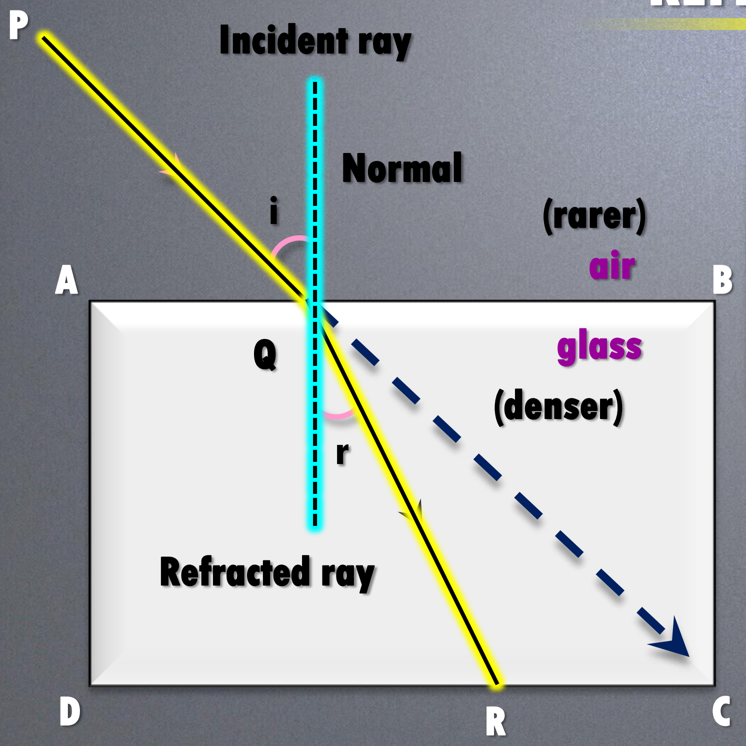
(B) $\angle i < \angle r$ but $\angle i = \angle e$

(D) $\angle i < \angle e$ but $\angle i = \angle r$

QUIZ TIME

Correct Wrong Cheer Boo Silence

REFRACTION OF LIGHT



Change in ... ion of a
ray of ligh ... ly from
on
m

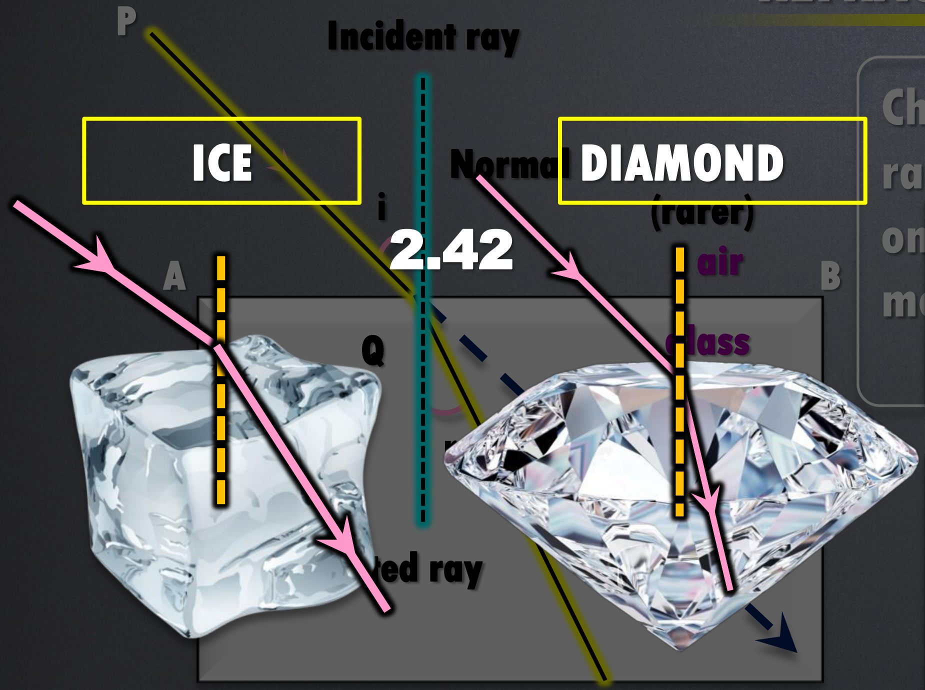
Laws of Refraction

1. 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.

2. The ratio of the sine of angle of incidence to the sine of the angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also know as Snell's law of refraction.

$$\frac{\sin i}{\sin r} = \text{constant} \longrightarrow \text{Refractive index } (n)$$

REFRACTION OF LIGHT



$$\frac{\sin i}{\sin r} = 1.31$$

$$\frac{\sin i}{\sin r} = 2.42$$

Change in ... ion of a ray of ligh... ly from on... m...

Laws of Refraction

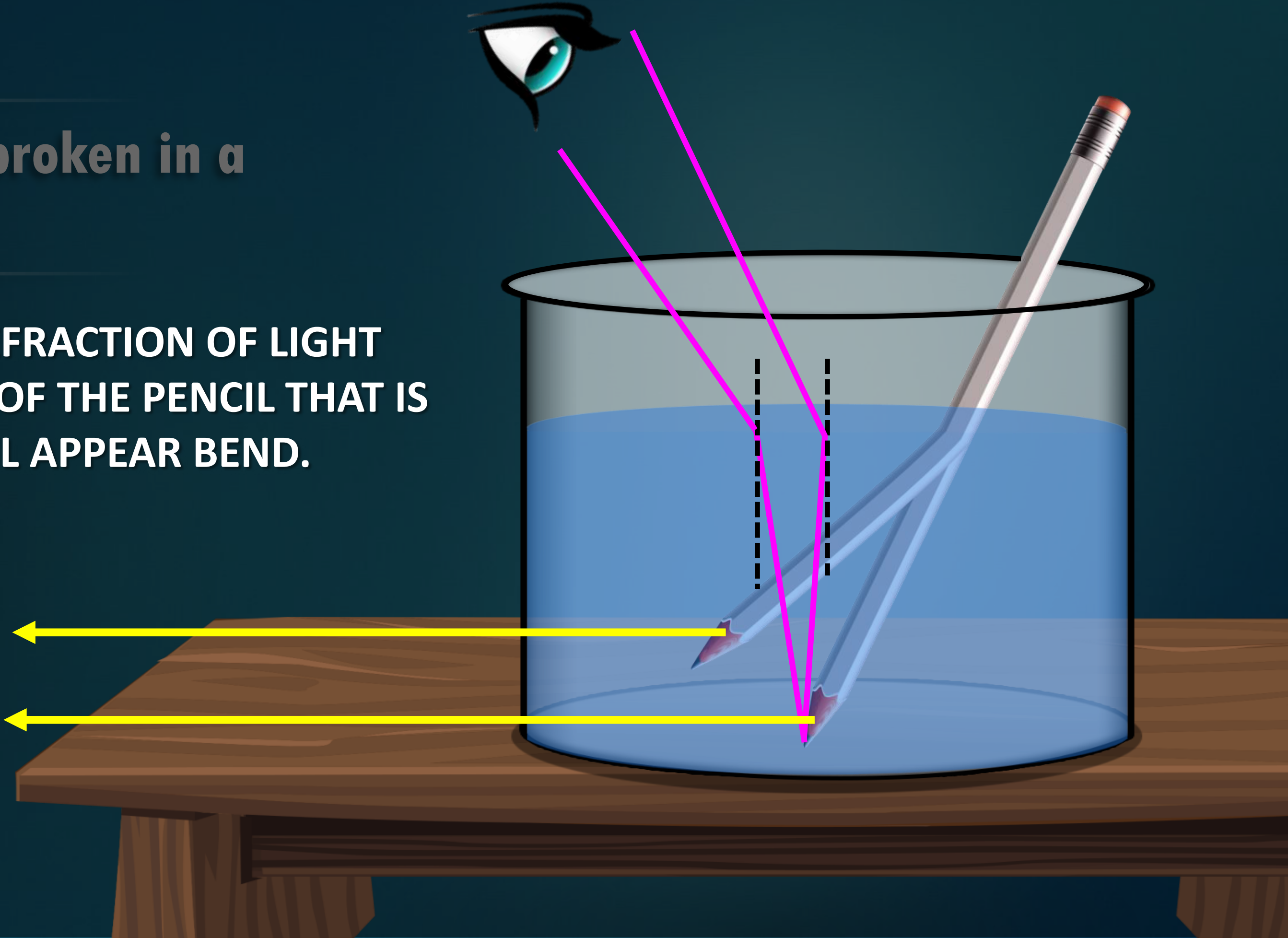
1. The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

2. The ratio of the sine of angle of incidence to the sine of the angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also know as Snell's law of refraction.

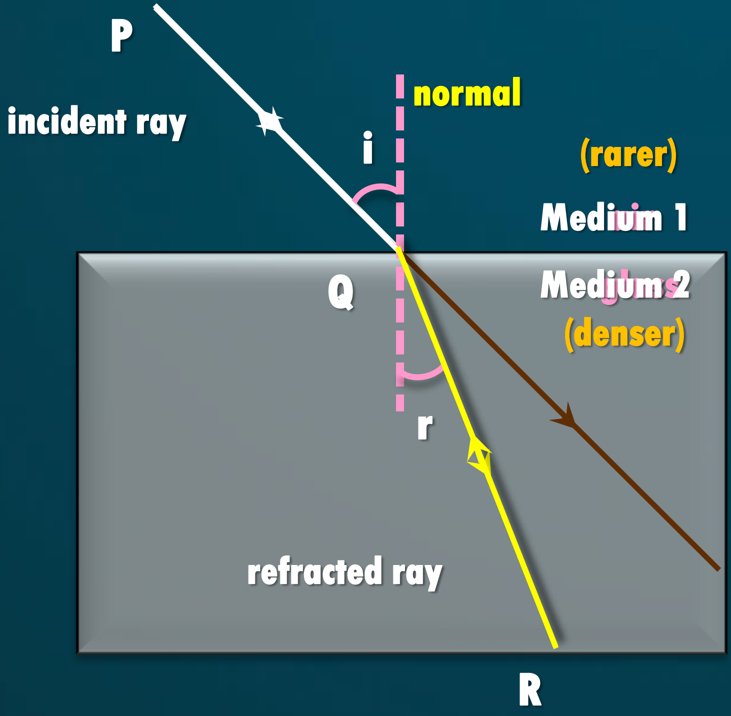
$$\frac{\sin i}{\sin r} = \text{constant} \rightarrow \text{Refractive index (n)}$$

Pencil appears to be broken in a beaker with water

THUS, BECAUSE OF THE REFRACTION OF LIGHT COMING FROM THE PART OF THE PENCIL THAT IS UNDER WATER, THE PENCIL APPEAR BEND.



REFRACTIVE INDEX



We know that

$$\frac{\sin i}{\sin r} = n_{21}$$

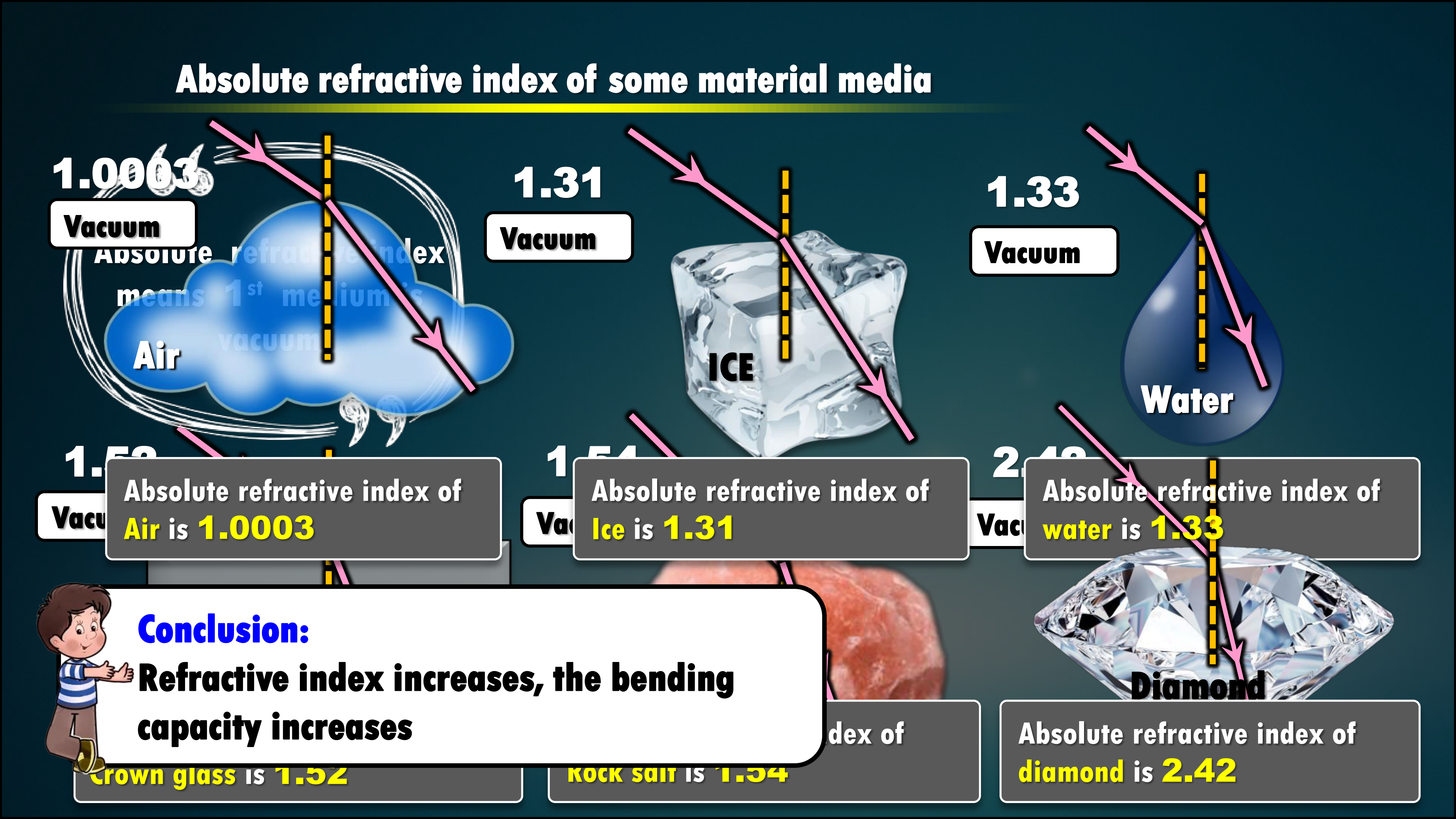
Refractive Index

$$n_{21} = \frac{v_1}{v_2}$$

Reciprocal of each other

$$n_{12} = \frac{v_2}{v_1}$$

$$n_{21} = \frac{1}{n_{12}}$$



Absolute refractive index of some material media
1.0003
Vacuum
Air
1.31
Vacuum
ICE
1.33
Vacuum
Water
Absolute refractive index of
Air is 1.0003
Absolute refractive index of
Ice is 1.31
Absolute refractive index of
water is 1.33
Diamond
Absolute refractive index of
diamond is 2.42
Conclusion:
Refractive index increases, the bending capacity increases
Crown glass is 1.52
Rock salt is 1.54

Q. The refractive index of diamond is 2.42. What is the meaning of this statement?

Ans.

The refractive index of diamond 2.42 suggests that, the speed of light in diamond will reduce by a factor 2.42 as compared to its speed in air.

FRAMING THE FORMULA FOR REFRACTIVE INDEX

$n_{a\,v} = \dfrac{V_v}{V_a}$ → Absolute Refractive index of air

$n_{ice\,a} = \dfrac{V_a}{V_{ice}}$ → Refractive index of ice w.r.t the air

$n_{g\,v} = \dfrac{V_v}{V_g}$ → Absolute Refractive index of glass

$n_{w\,a} = \dfrac{V_a}{V_w}$ → Refractive index of water w.r.t the air

$n_{oil\,a} = \dfrac{V_a}{V_{oil}}$ → Refractive index of oil w.r.t the air

FORMULAE

1. $n_{21} = \frac{V_1}{V_2}$

2. $n_{21} = \frac{1}{n_{12}}$

V_1 = velocity of light in **1**st medium

V_2 = velocity of light in **2**nd medium

Important Points

1. If the first medium is not mentioned, **take 1st medium as Air**
2. If the first medium is Vacuum then refractive index of **2**nd medium is called as **Absolute refractive index**
3. For solving Numerical, Velocity of light in air **=** Velocity of light in vacuum **=** **3×10^8 m/s**

n = Refractive index has no units

1 Light enters into a glass plate having absolute refractive index 1.50. What is the speed of light in glass? (The speed of light in vacuum is 3×10^8 ms^{-1})

Given : Velocity of light in vacuum $(V_v) = 3 \times 10^8$ m/s

Absolute refractive index of glass $(\eta_{gv}) = 1.50$

To Find : Velocity of light in glass $(V_g) = ?$

Formula : $$\eta_{gv} = \frac{V_v}{V_g}$$

Solution : $$\eta_{gv} = \frac{V_v}{V_g}$$

$$\therefore V_g = \frac{V_v}{\eta_{gv}}$$

$$\therefore V_g = \frac{3 \times 10^8}{1.50}$$

$$V_g = 2 \times 10^8 \text{ m/s}$$

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

2 Refractive index of water is $\frac{4}{3}$ and speed of light in air 3×10^8 m/s. Find the speed of light in water.

Given : Refractive index of water $(\eta_{wa}) = \frac{4}{3}$

Speed of light in air $(v_a) = 3 \times 10^8$ m/s

To Find : Speed of light in water (V_w) = ?

Formula : $\eta_{wa} = \frac{V_a}{V_w}$

Solution :

$$\frac{4}{3} = \frac{3 \times 10^8}{V_w}$$

$$V_w = \frac{3 \times 10^8 \times 3}{4}$$

$$V_w = \frac{9 \times 10^8}{4}$$

$$V_w = 2.25 \times 10^8 \text{ m/s}$$

The speed of light in water is 2.25×10^8 m/s

3

If the refractive index of water for light going from air to water is 1.33, then what will be the refractive index for light going from water to air?

Given : Refractive index of water w.r.t. air (η_{wa}) = 1.33

To Find : Refractive index of air w.r.t. water (η_{aw}) = ?

Formula : $$\eta_{aw} = \frac{1}{\eta_{wa}}$$

Solution : $$\eta_{aw} = \frac{1}{\eta_{wa}}$$

$$\eta_{aw} = \frac{1}{1.33}$$

$$\boxed{\eta_{aw} = 0.75}$$

Refractive index of air w.r.t. water (η_{aw}) is 0.75

4 **The refractive index of kerosene, turpentine and water are 1.44, 1.47 and 1.33, respectively. In which of these materials does light travel fastest?**

Solution :

$$\text{Refractive index} = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$$

$$\text{Speed of light in medium} = \frac{\text{Speed of light in air}}{\text{Refractive index}}$$

It is obvious from the above relation that the speed of light will be the maximum in that medium which has the lowest refractive index.

Now out of kerosene, turpentine and water, water has the lowest refractive index of 1.33.

So, the light will have maximum speed in water or light will travel fastest in water.

(i) In which of the given media, light moves the fastest ?

Medium	Refractive index
Water	1.33
Ice	1.31
Alcohol	1.36

(ii) Using above table, calculate the velocity of light in water.

Q.

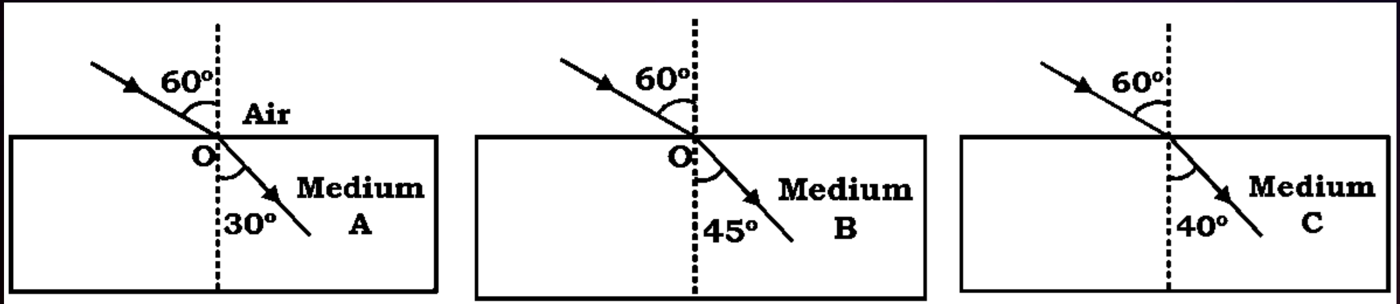
Ans. (i) Light travels fastest through ice which has the lowest refractive index.

(ii) Velocity of light in water $= \dfrac{\text{Velocity of light in air}}{\text{Refractive index of water}}$

$$= \frac{3 \times 10^8 \text{ ms}^{-1}}{1.33}$$

$$= 2.25 \times 10^8 \text{ ms}^{-1}$$

(a) The path of light passing from air to different media A, B, and C for a given angle of incidence is shown below. Study the diagrams and answer the following questions.



(i) Which of the media A, B and C has maximum optical density ?

(ii) Through which of three media, will the speed of light be maximum ?

(iii) Will the light travelling from A to B bend towards or away from the normal ?

Ans. (a) (i) $\sin 30° < \sin 40° < \sin 45° \Rightarrow \eta A > \eta C > \eta B$

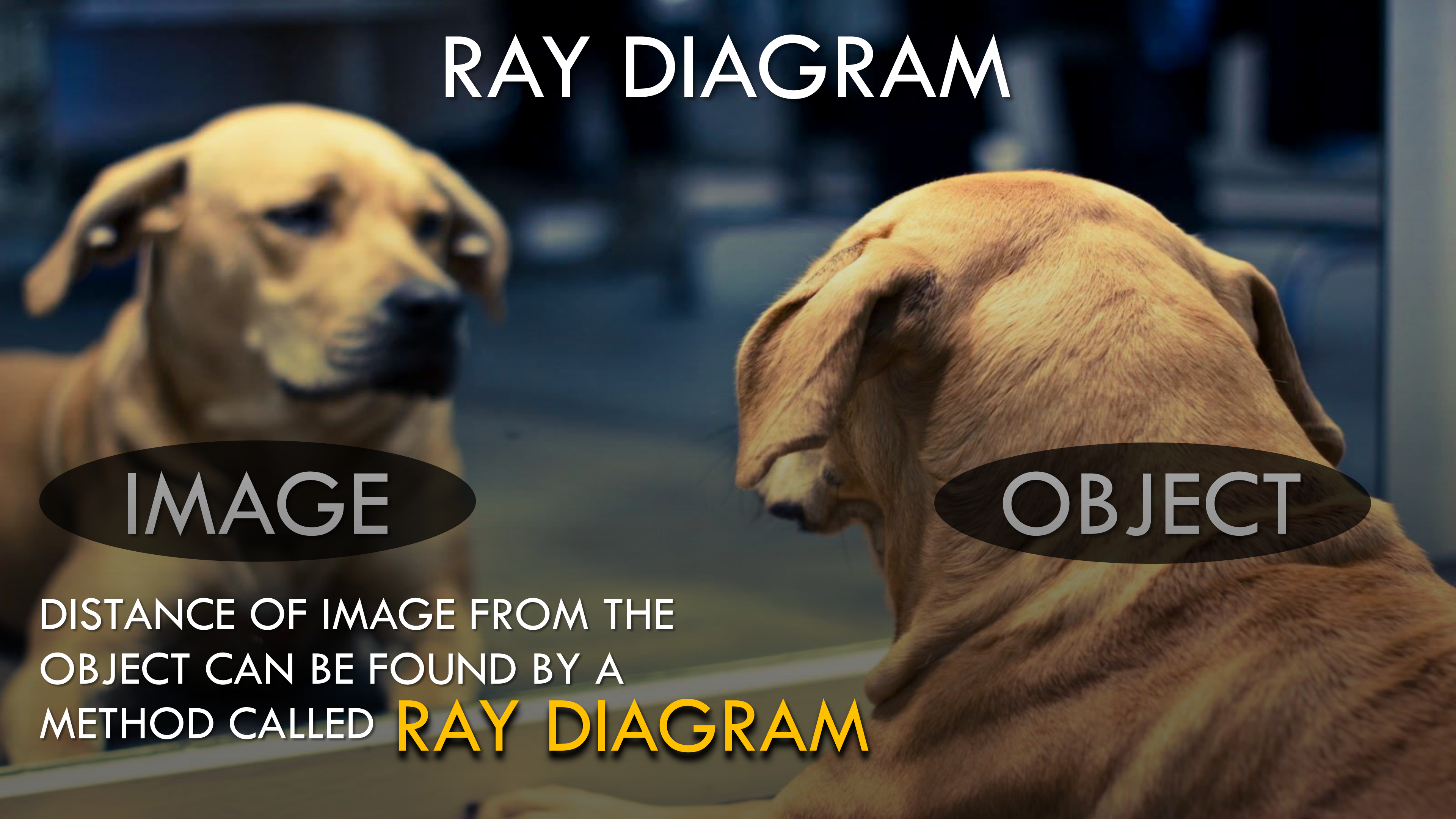
$\therefore$ Medium A has maximum optical density.

(ii) Speed of light will be maximum in the medium B of lowest refractive index ηB.

(iii) As $\eta A > \eta B$, light travelling from A to B will bend away from the normal

Thank You

Lec - 2


RAY DIAGRAM
IMAGE
OBJECT
DISTANCE OF IMAGE FROM THE OBJECT CAN BE FOUND BY A METHOD CALLED RAY DIAGRAM

RAY DIAGRAM

It is a method of locating the position, size and nature of the image.

ERECT IMAGE

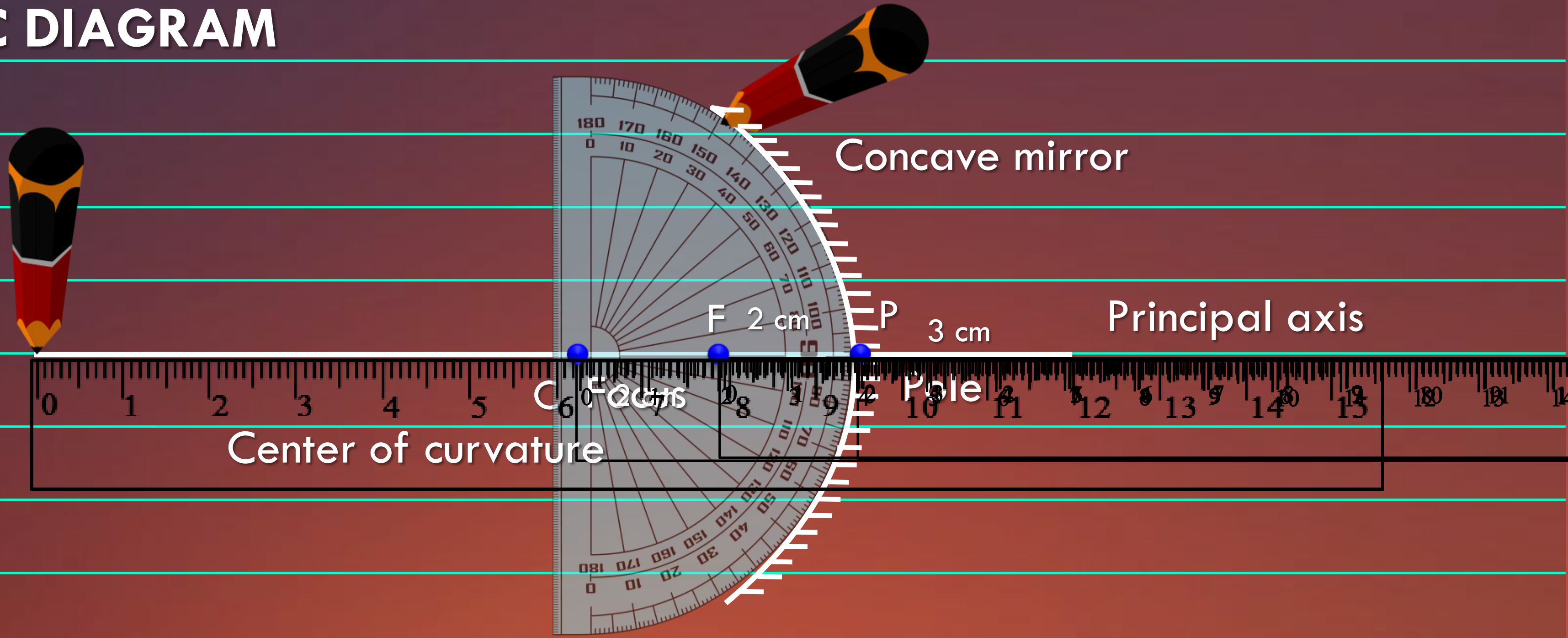
MAGNIFIED IMAGE

INVERTED IMAGE

DIMINISHED IMAGE

RAY DIAGRAM

BASIC DIAGRAM

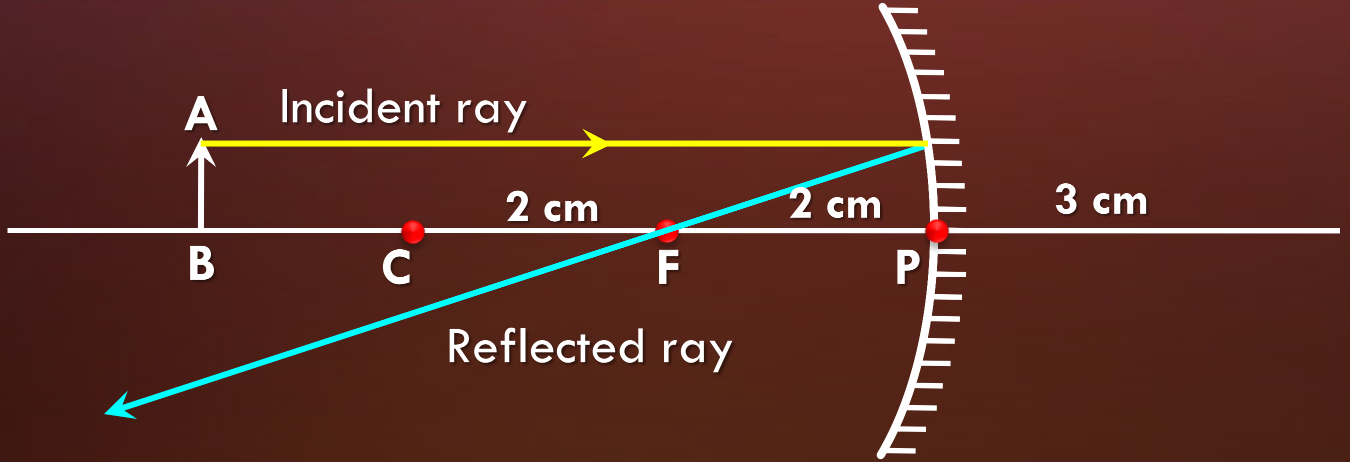


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 1

A ray of light which is parallel to the principle axis of a concave mirror, passes through its focus after reflection from the mirror.

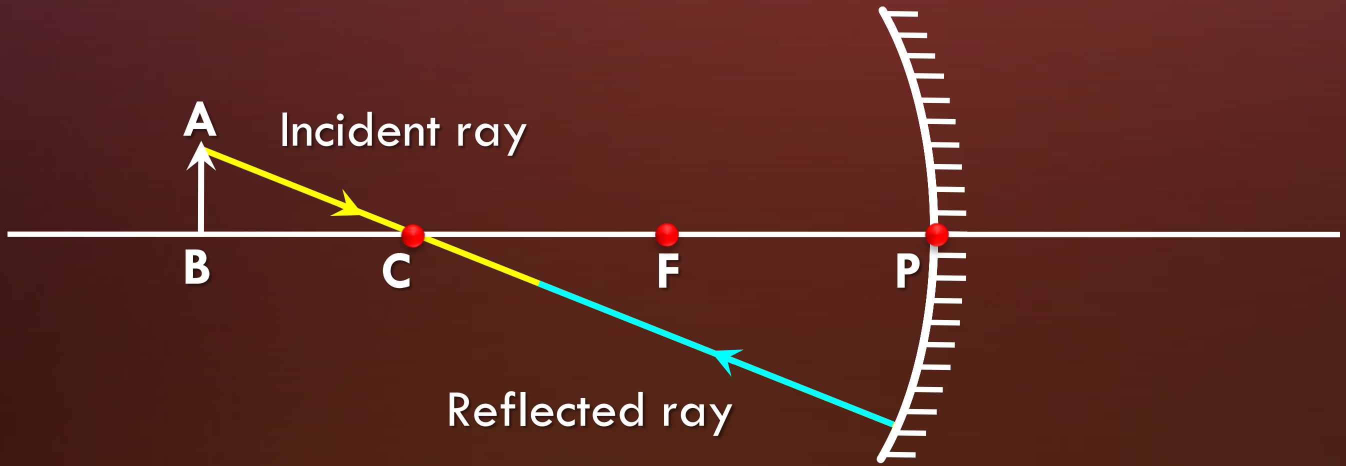


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 2

A ray of light passing through the centre of curvature of a concave mirror, is reflected back along the same path.

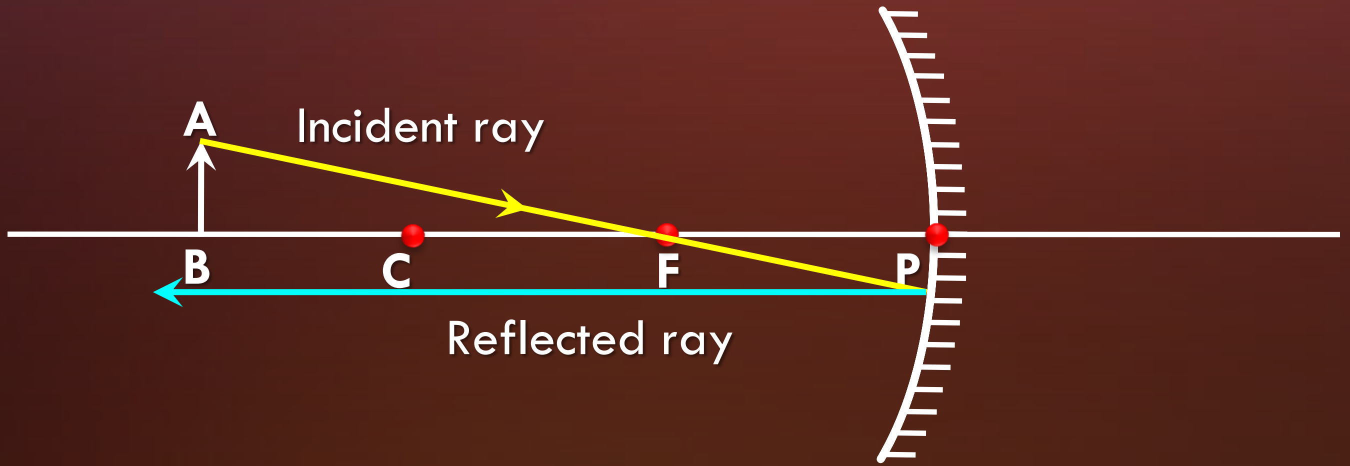


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 3

A ray of light passing through the focus of a concave mirror, becomes parallel to the principal axis after reflection.

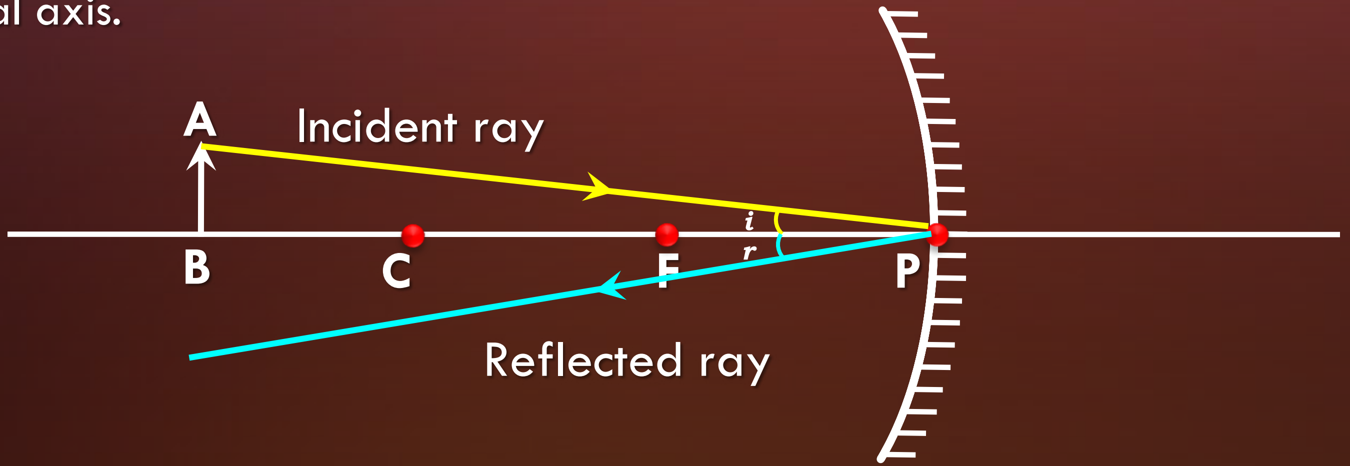


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 4

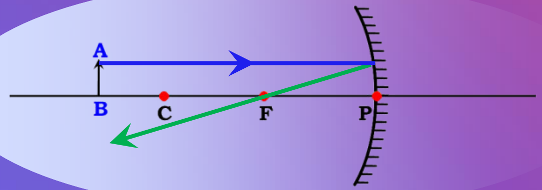
A ray of light which is incident at the pole of a concave mirror, is reflected back making the same angle with the principal axis.



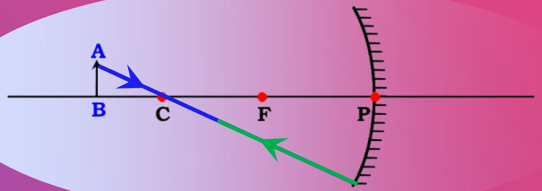
4 RULES FOR MAKING

RAY DIAGRAM

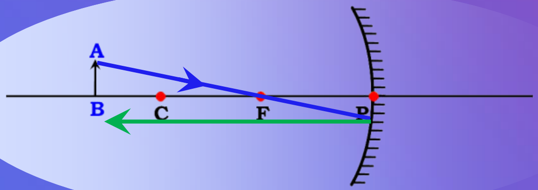
INCIDENT RAY	REFLECTED RAY
Parallel to the principal Axis	Passes through focus



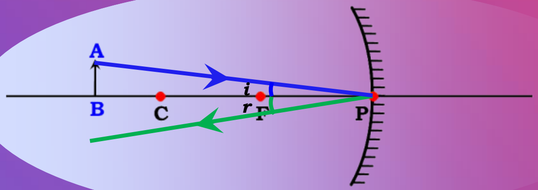
INCIDENT RAY	REFLECTED RAY
Passes through C	Passes through C



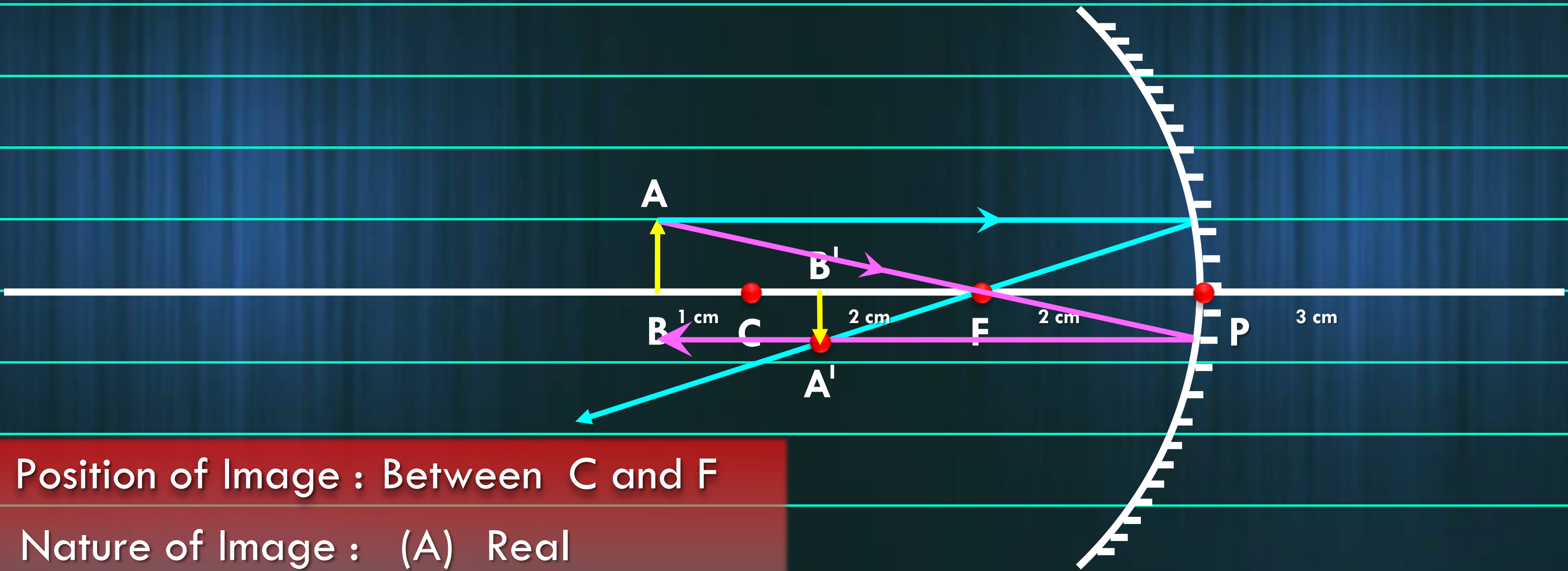
INCIDENT RAY	REFLECTED RAY
Passes through focus	Parallel to the principal Axis



INCIDENT RAY	REFLECTED RAY
Strike the pole at an angle	Makes the same angle with principal axis



OBJECT BEYOND 'C'



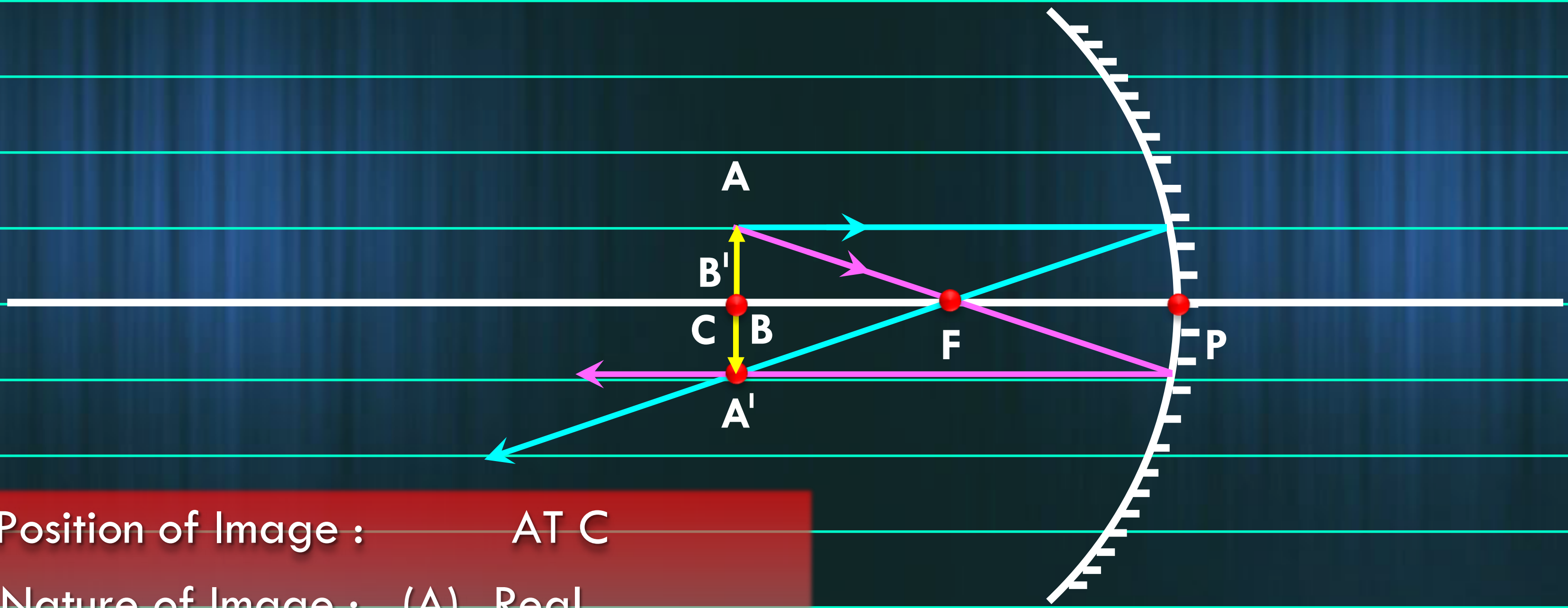
Position of Image : Between C and F

Nature of Image : (A) Real

(B) Inverted

(C) Diminished

OBJECT AT 'C'



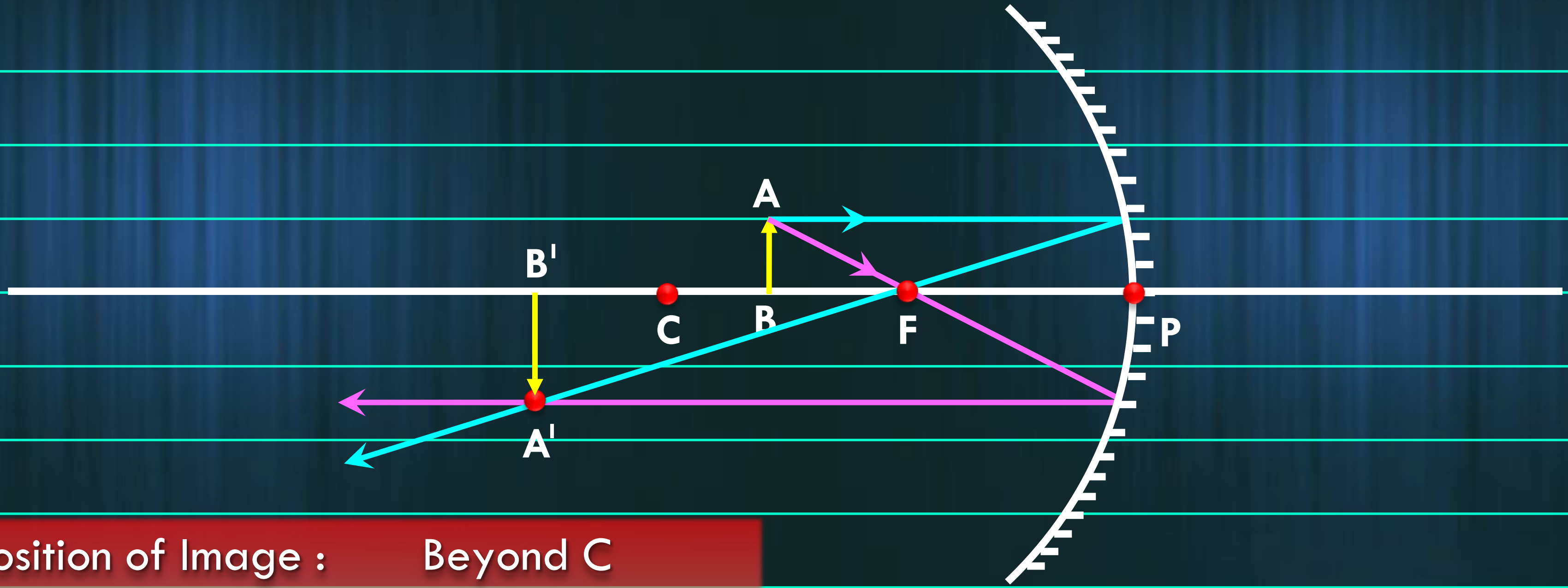
Position of Image : AT C

Nature of Image : (A) Real

(B) Inverted

(C) Same size

OBJECT BETWEEN ‘F’ AND ‘C’



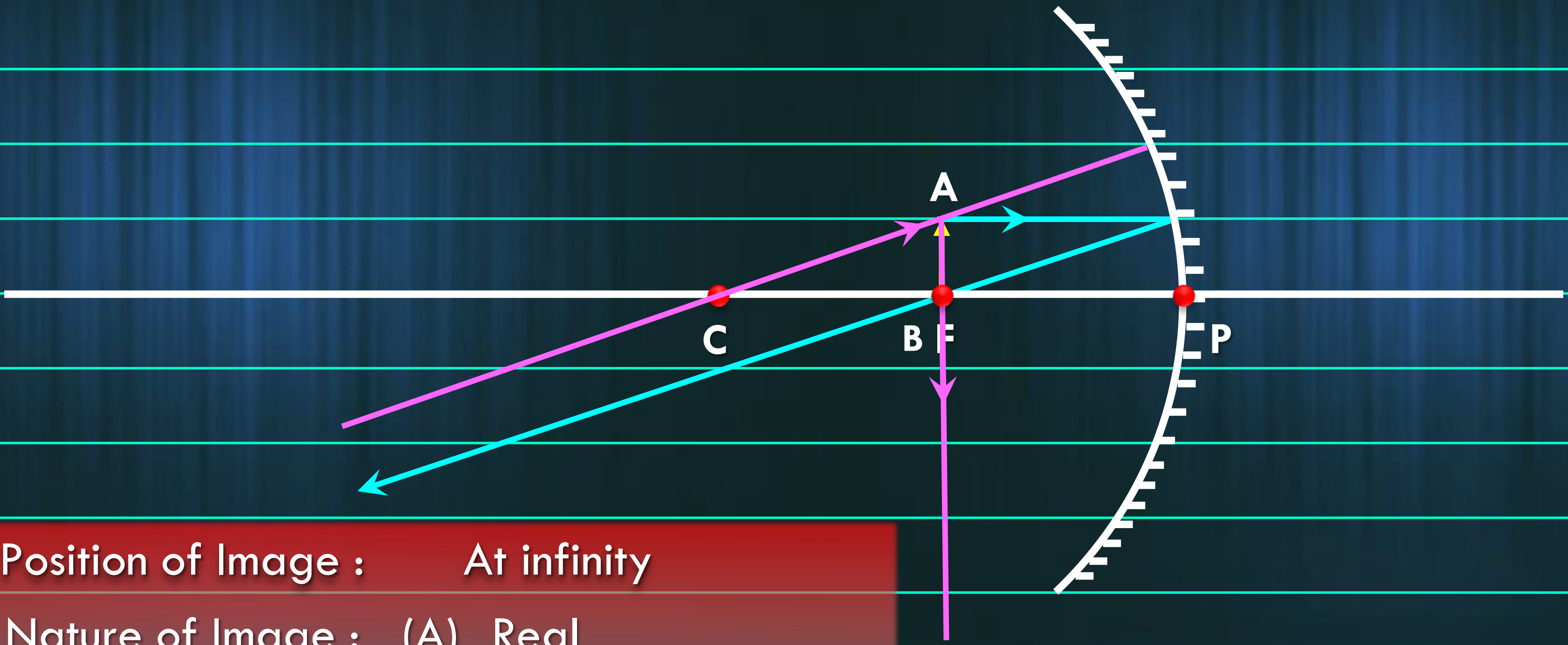
Position of Image : Beyond C

Nature of Image : (A) Real

(B) Inverted

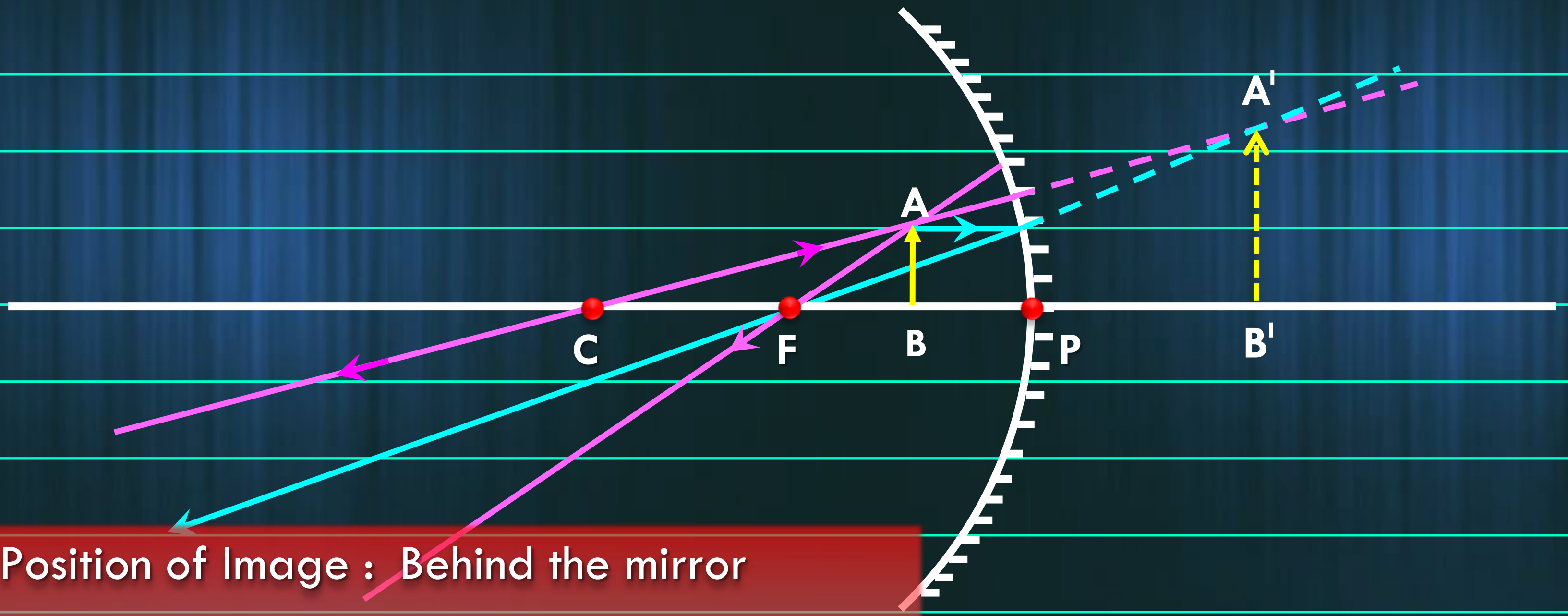
(C) Magnified

OBJECT AT 'F'



Position of Image :		At infinity
Nature of Image :	(A)	Real
	(B)	Inverted
	(C)	Highly Magnified

OBJECT BETWEEN 'P' AND 'F'



Position of Image : Behind the mirror

Nature of Image : (A) Virtual

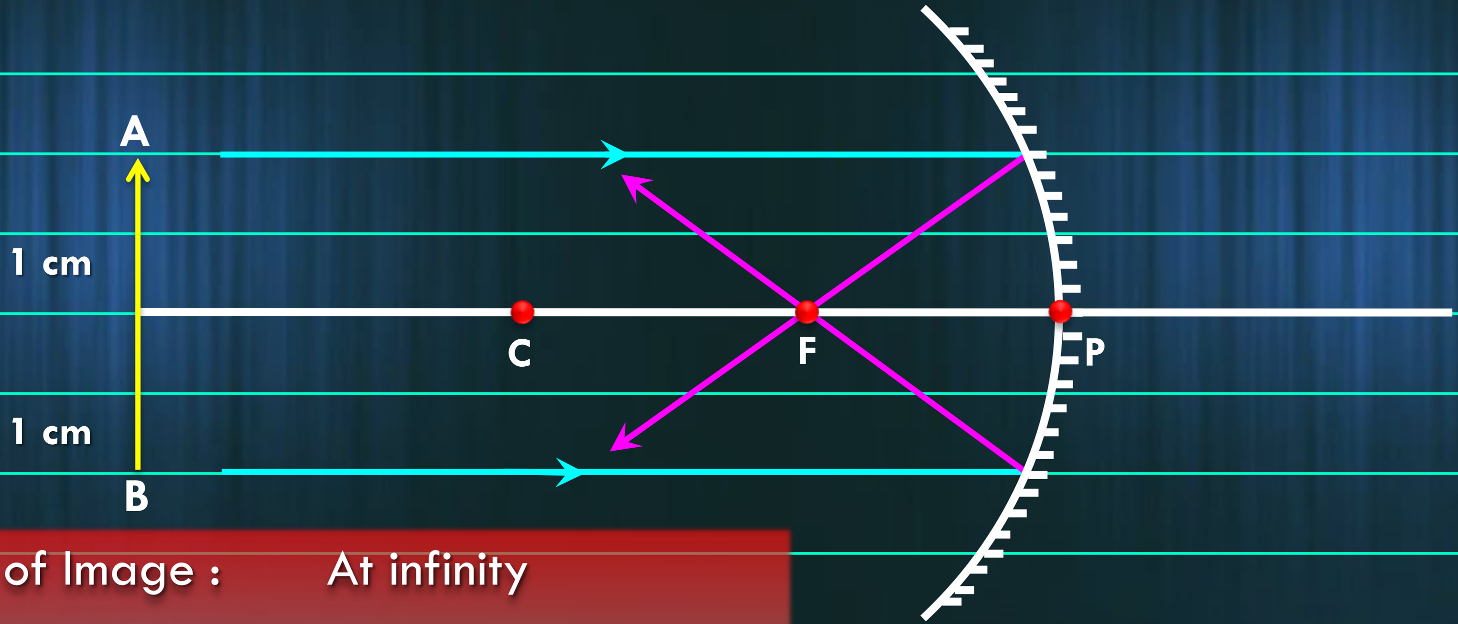
(B) Erect

(C) Magnified

Thank You

Lec - 3

OBJECT AT INFINITY



Position of Image : At infinity

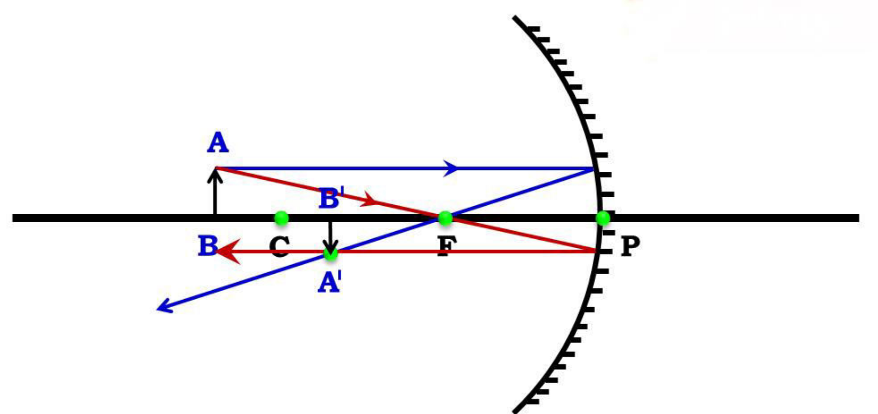
Nature of Image : (A) Real

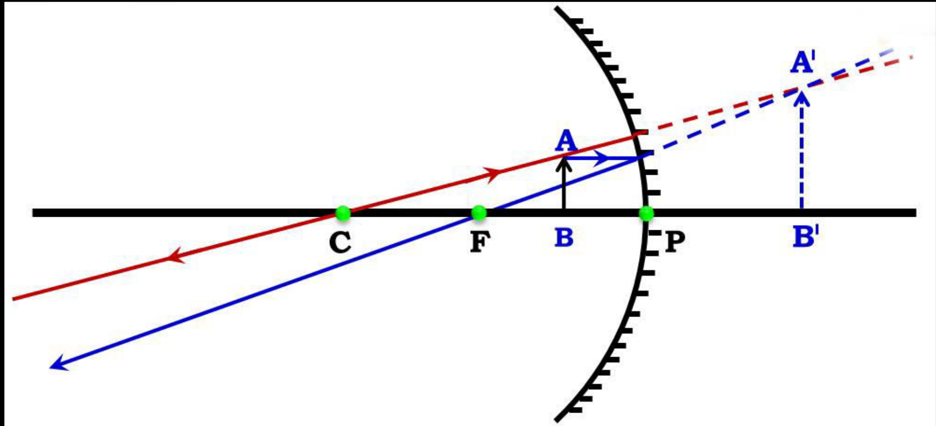
(B) Inverted

(C) Highly Diminished

REVISE ALL LENS RAY DIAGRAMS IN 3 MINUTES

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F	Highly diminished	Real & inverted
At focus F	At infinity	Highly diminished	Real & inverted
Beyond C	Between F & C	Diminished	Real & inverted





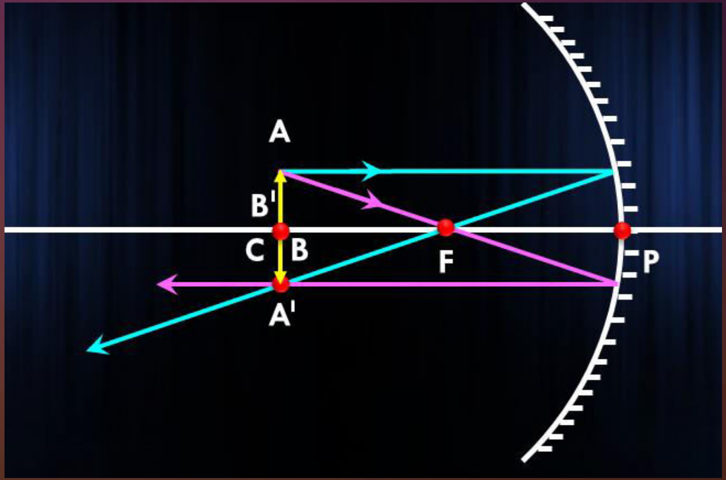
1

A concave mirror has a focal length of 10 cm. Where should an object be placed in front of this concave mirror so as to obtain an image which is real, inverted and same size as the object ?

Given : The image formed by a concave mirror is real, inverted and of the same size, then the object must be placed at its centre of curvature (C)

f = 10cm

To Find : Centre of curvature (C) = ?



Formula : C = 2f

Solution : $C = 2 \times f$

$C = 2 \times 10$

$C = 20$

$\boxed{\therefore C = 20 \text{ cm}}$

Thus, the object should be placed at a distance of 20 cm in front of this concave mirror.

We wish to obtain an erect image of an object using a concave mirror of focal length 15 cm.

(a) What should be the range of distance of the object from the mirror?
(b) What is the nature of the image?
(c) Is the image larger or smaller than the object?
(d) Draw a ray-diagram to show the image formation in this case.

Q.

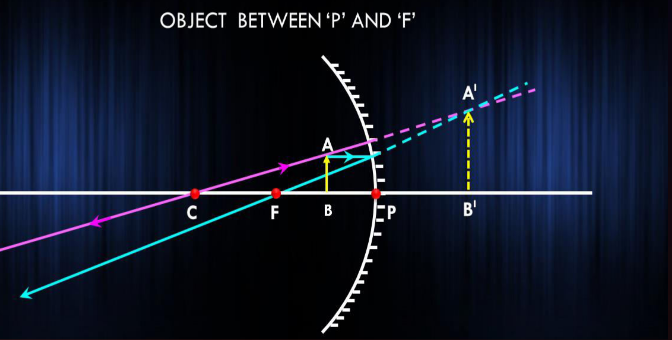
Ans.

a) In order to obtain an erect image of an object with a concave mirror, the object should be at a distance less than its focal length. Here the focal length of concave mirror is 15 cm. The object should be placed at any distance which is less than 15 cm from the mirror.

b) The nature of image will be virtual and erect.

c) The image will be larger than the object.

d)



Sunita takes a mirror which is depressed at the centre and mounts it on a mirror stand. An erect and enlarged image of her face is formed. She places the mirror on a stand along a meter scale at 15 cm mark. In front of this mirror, she mounts a white screen and moves it back and forth along the meter scale till a sharp, well defined inverted image of a distant tree is formed on the screen at 35 cm mark.

Q.

(i) Name the mirror and find its focal length.

(ii) Why does Sunita get sharp image of the distant building at 35 cm mark**?**

Ans.

(i) Concave mirror; $f = 35 - 15$

$= 20$ cm

(ii) Because the incident rays parallel to each other, after reflection from concave mirror, meet at focus and produce sharp image at focus.

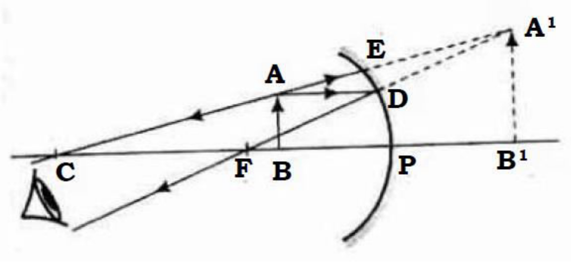
Q. From the given table, showing object distance and focal length of three concave mirrors, answer the following questions.

Sr. No.	Object distance (cm)	Focal length (cm)
1	30	20
2	10	15
3	20	10

(i) Out of three, in which case, the mirror will form the image having same size as an object?
(ii) Draw the ray diagram for Sr. No.(2)

Ans. (i) The mirror will form an image of same size as that of object in case 3.

(ii)



USES OF A CONCAVE MIRROR

1. Concave mirrors are commonly used in torches, search – lights and vehicles headlights to get powerful parallel beams of light.

2. Concave mirrors are used as shaving mirrors to see a larger image of the face.

3. The dentists used concave mirrors to see large images of the teeth.

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

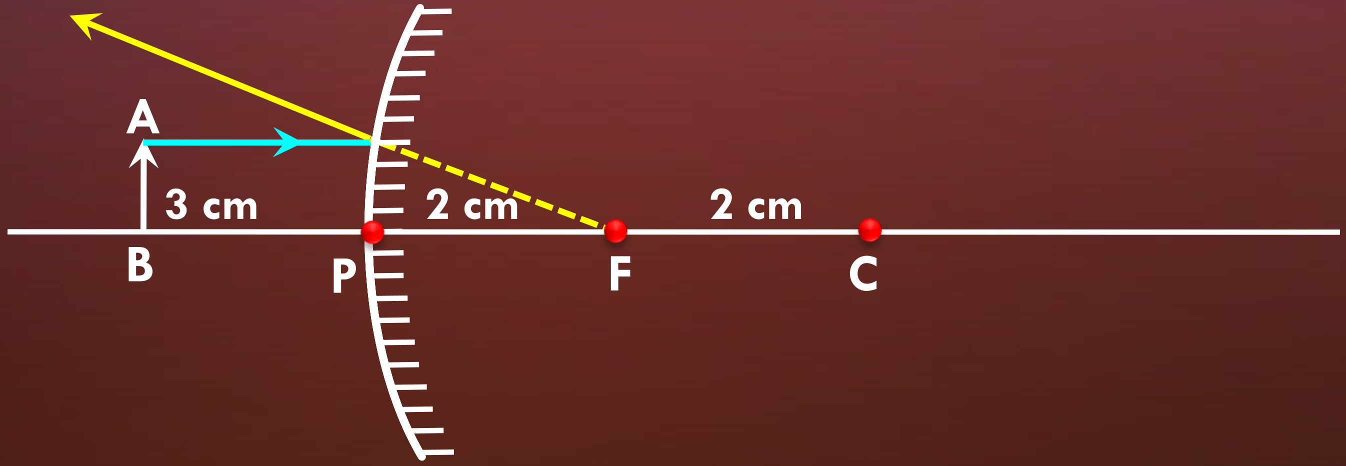
5. Concave mirrors are used in doctor's head mirror to concentrate the light beam on a small area of the body part such as nose, throat, ear, teeth, to be examined

RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 1

A ray of light which is parallel to the principal axis of a convex mirror, appears to diverge from the focus after reflection from the mirror.

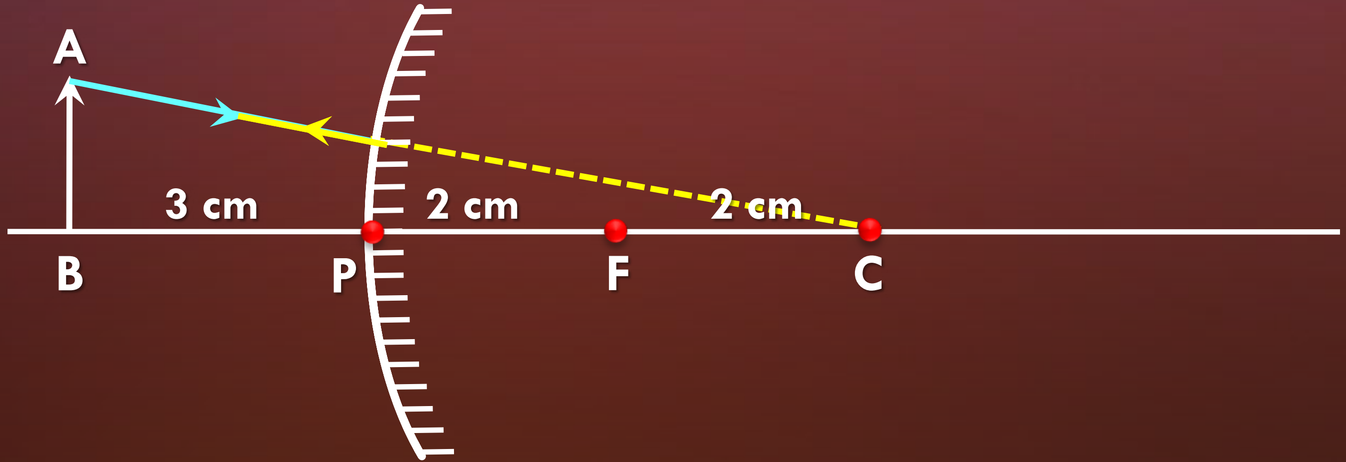


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 2

A ray directed in the direction of the centre of curvature of a convex mirror, is reflected back along the same path.

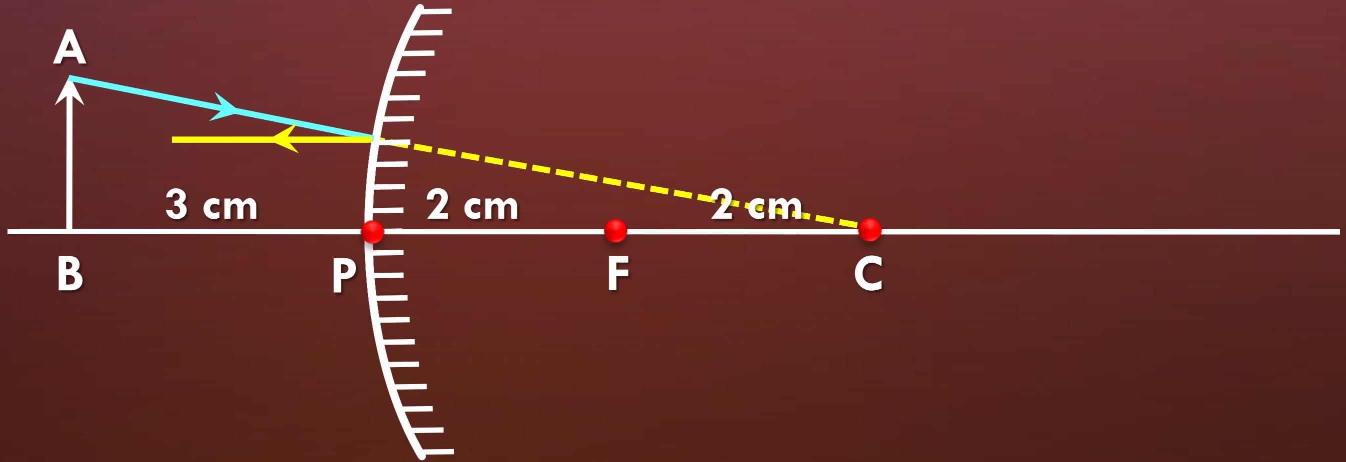


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 3

A ray which is directed towards the principal focus of a convex mirror, becomes parallel to the principal axis after reflection.

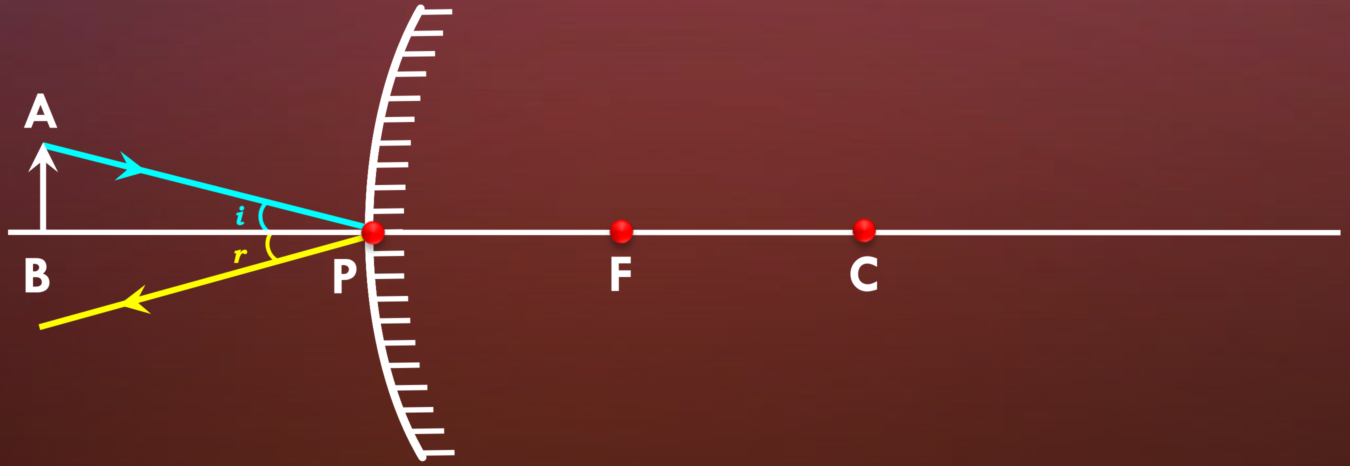


RAY DIAGRAM

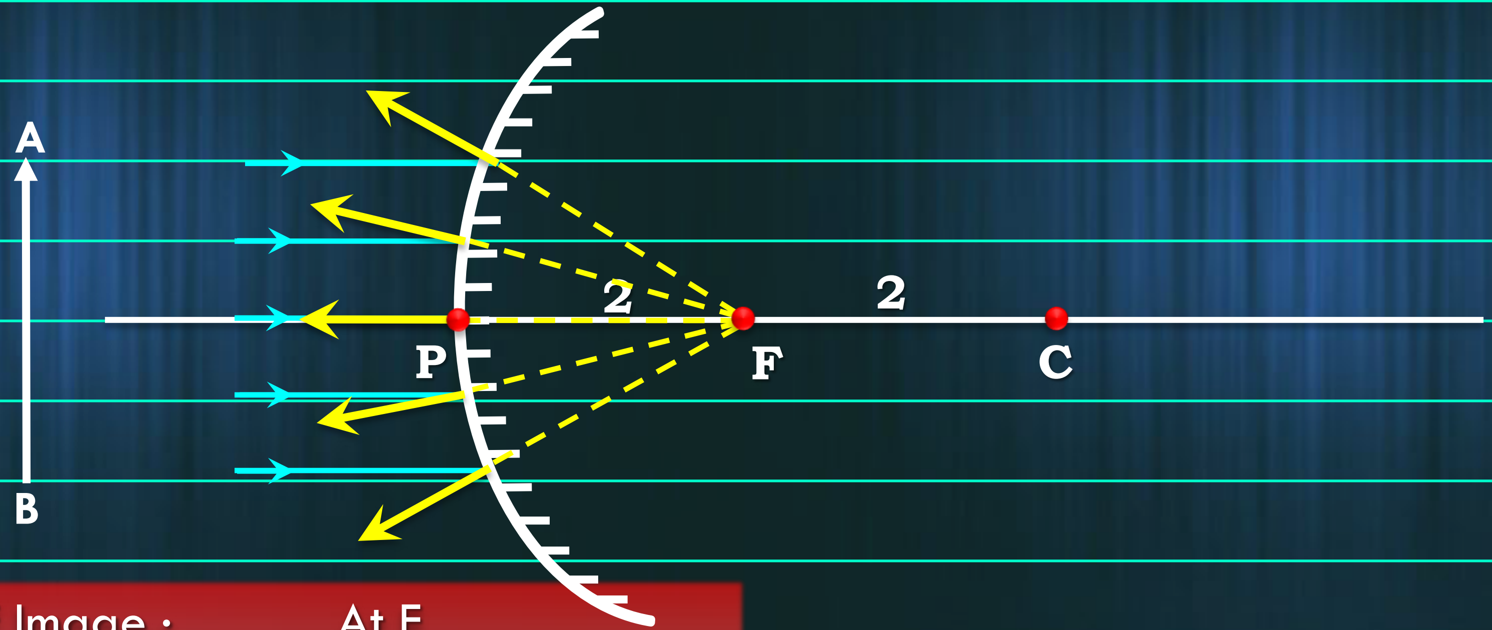
RULES FOR MAKING RAY DIAGRAMS

RULE 4

A ray of light which is incident at the pole of a convex mirror, is reflected back making the same angle with the principal axis.



OBJECT AT INFINITY OF A CONVEX MIRROR



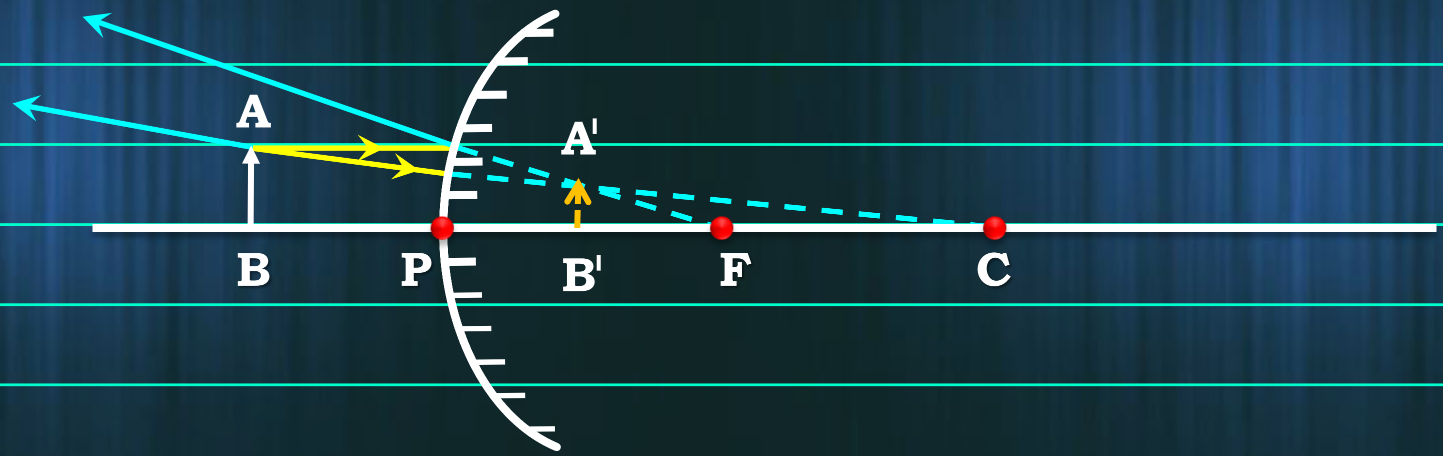
Position of Image : At F

Nature of Image : (A) Virtual

(B) Erect

(C) Highly Diminished

OBJECT BETWEEN INFINITY AND P OF A CONVEX MIRROR



Position of Image : At F

Nature of Image : (A) Virtual

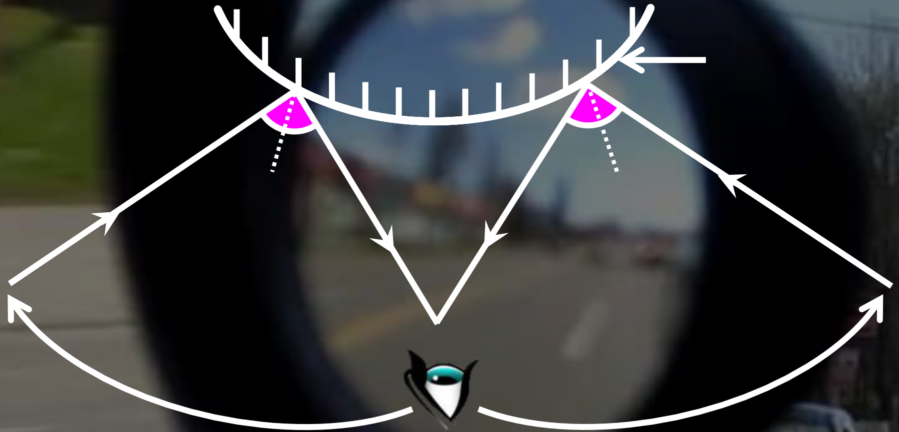
(B) Erect

(C) Diminished


SHOP SECURITY
MIRROR

Why is convex mirror used as rear - view mirror in vehicles ?

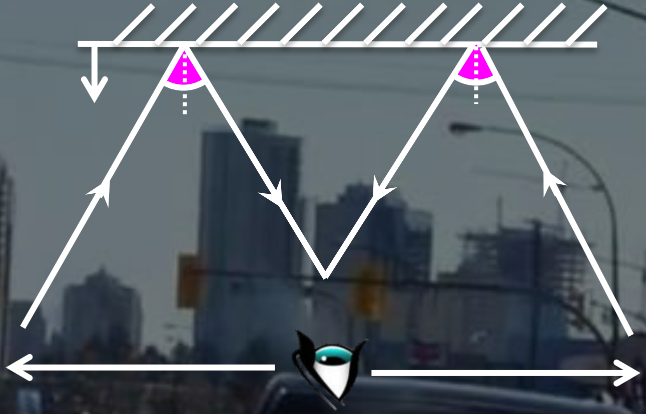
CONVEX MIRROR



Wild field of view

The image formed in a convex mirror is diminished due to which a convex mirror gives a wide field of view

PLANE MIRROR



Narrow field of view

On the other hand a plane mirror gives a narrow field of view

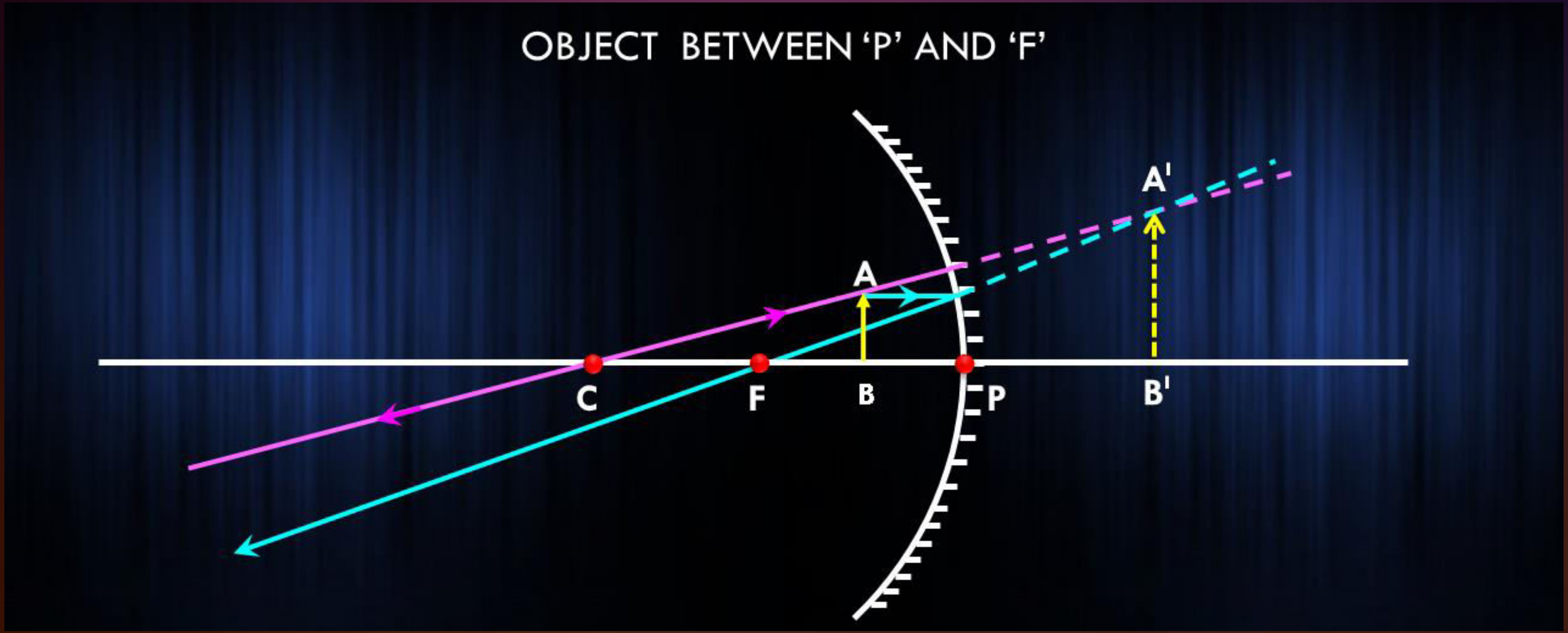
Why is convex mirror used as rear - view mirror in vehicles?

Concave mirror cannot be used in vehicles because it produces inverted images of distant object


Convex mirror produces erect image of distant objects.
Both plane and convex mirror produce erect images of distant objects.

Q. Name a mirror that can give an erect and enlarged image of an object.

Ans : Concave mirror gives an erect and an enlarged image, when the object is between the pole and principal focus.



Thank You

Lec - 4

Difference between a concave and convex mirror

Concave mirror

- It is made by silvering the outer surface of a part of the hollow sphere, so reflection takes
- It converges the light rays incident on it after reflection.
- The image formed by it is real as well as virtual.

Convex mirror

- It is made by silvering the inner surface of the hollow sphere, so reflection takes place from the bulging surface.
- It diverges the light rays incident on it after reflection.
- The image formed by it is always virtual for all positions of the object in front of it.

DISTINCTION BETWEEN A

PLANE MIRROR, CONCAVE MIRROR AND CONVEX MIRROR

CASE 1

If the image is upright, of same size and it does not change in size by moving the mirror towards or away from the object, then **which type of mirror is this?**

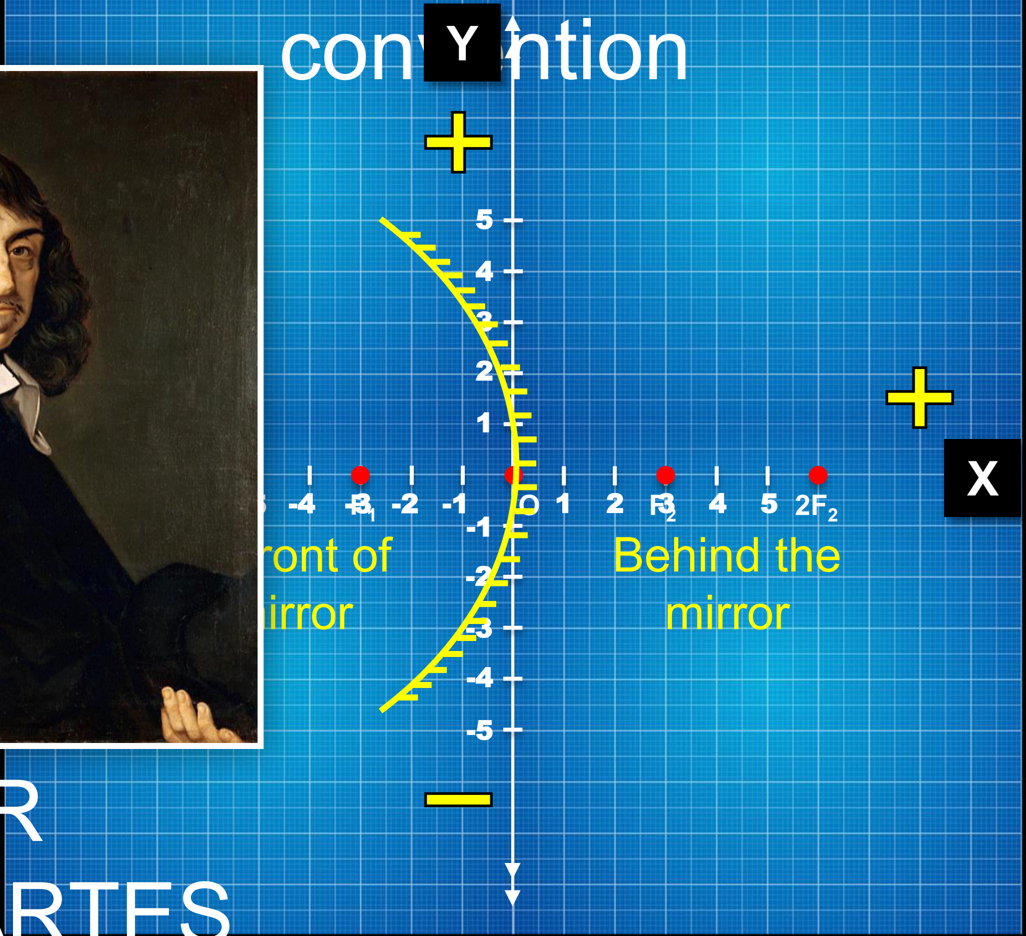
THE MIRROR IS

PLANE


THE MIRROR IS
CONCAVE

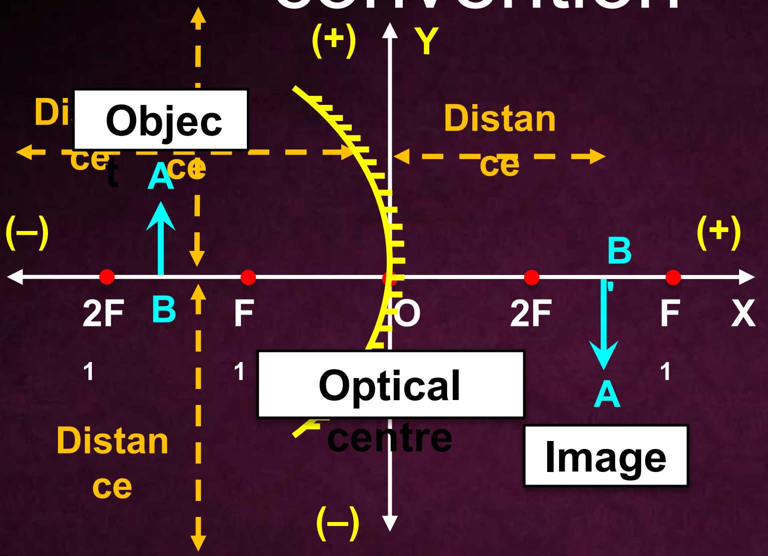

THE MIRROR IS
CONVEX

Cartesian sign convention



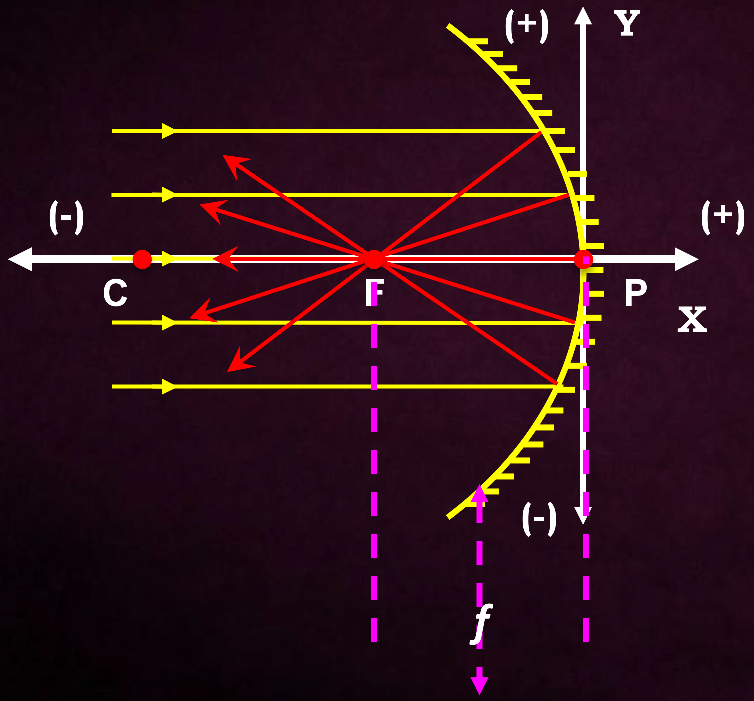
SIR DESCARTES

Cartesian sign convention



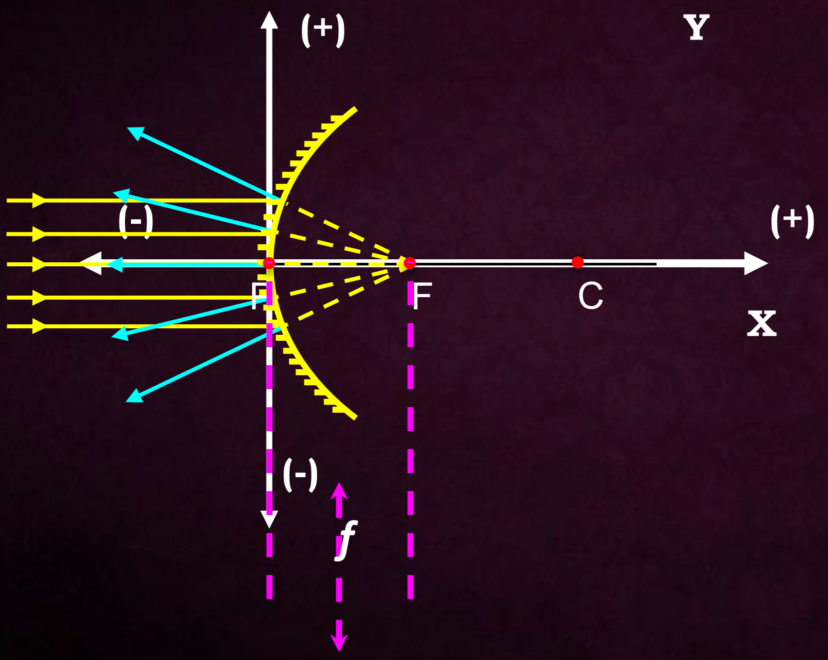
1. Object should be always to the left of the mirror.
2. All distances parallel to principal axis are measured from the optical centre of the mirror.
3. The distances to the right of origin are +ve
   The distances to the left of origin are –ve
4. The distances measured perpendicular to and above the principal axis are +ve
5. The distances measured perpendicular to and below the principal axis are –ve

Cartesian sign convention



1. Object should be always to the left of the mirror.
2. All distances parallel to principal axis are measured from the optical centre of the mirror.
3. The distances to the right of origin are +ve
   The distances to the left of origin are –ve
4. The distances measured perpendicular to and above the principal axis are +ve
5. The distances measured perpendicular to and below the principal axis are –ve
6. Focal length of concave mirror is –ve
   Focal length of convex mirror is +ve

Cartesian sign convention



1. Object should be always to the left of the mirror.
2. All distances parallel to principal axis are measured from the optical centre of the mirror.
3. The distances to the right of origin are +ve
   The distances to the left of origin are –ve
4. The distances measured perpendicular to and above the principal axis are +ve
5. The distances measured perpendicular to and below the principal axis are –ve
6. Focal length of concave mirror is –ve
   Focal length of convex mirror is +ve

Mirror Formula

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

$v \longrightarrow$ **Image distance**

$u \longrightarrow$ **Object distance**

$f \longrightarrow$ **Focal length**

Magnification (M)

$$\text{Magnification} = \frac{\text{size of the image } (h_2)}{\text{size of the object } (h_1)}$$

$$M = \frac{h_2}{h_1} = -\frac{h_2}{h_1}$$

Mirror Formula

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

$v \longrightarrow$ Image distance

$u \longrightarrow$ Object distance

$f \longrightarrow$ Focal length

Magnification (M)

$$\text{Magnification} = \frac{\text{size of the image } (h_2)}{\text{size of the object } (h_1)}$$

$$M = \frac{h_2}{h_1} = -\frac{h_2}{h_1}$$

TYPE - A

PROBLEMS BASED ON THE

FORMULA

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

ALWAYS REMEMBER

u : always -ve

$f_{(convex)}$: +ve

$f_{(concave)}$: -ve

1 **An object is placed at a distance of 36 cm from a concave mirror of focal length 12 cm. Find the image distance.**

Given : Object distance (u) = -36 cm

Focal length (f) = -12 cm

To Find : Image distance (v) = ?

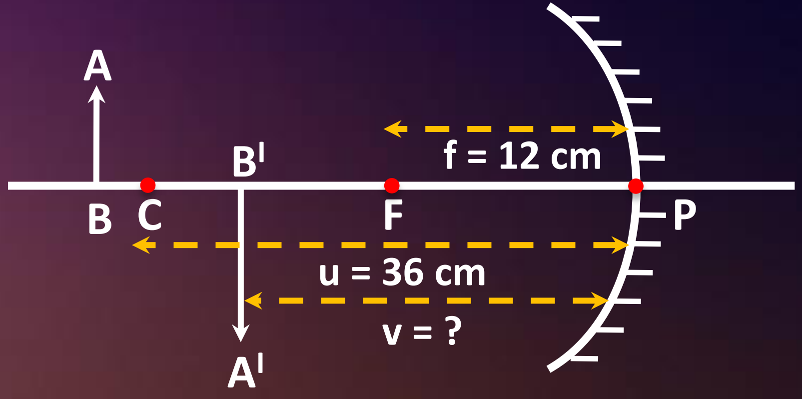
Formula : $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

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

$\therefore \frac{1}{v} = \frac{1}{-12} - \frac{1}{-36}$

$\therefore \frac{1}{v} = \frac{-1}{12} + \frac{1}{36}$ $\therefore \frac{1}{v} = \frac{-2}{36}$

$\therefore \frac{1}{v} = \frac{-3+1}{36}$ $\therefore \frac{1}{v} = \frac{1}{-18}$



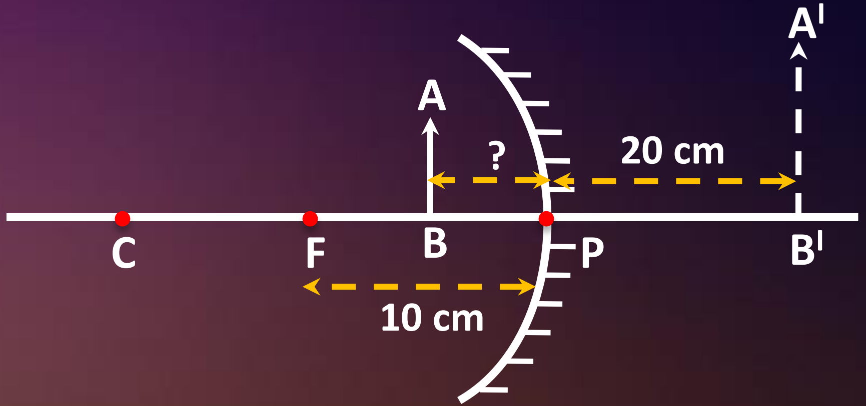
The image is formed at a distance of 18 cm in front of the mirror.

2 At what distance from a concave mirror of focal length 10 cm should an object be placed, so that image is formed 20 cm behind the mirror.

Given : Focal length (f) = -10 cm

Image distance (v) = 20 cm

To Find : Object distance (u) = ?



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

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

$\therefore \frac{1}{u} = \frac{1}{-10} - \frac{1}{20}$

$\therefore \frac{1}{u} = \frac{-2 - 1}{20}$

$\therefore \frac{1}{u} = \frac{-3}{20}$

$\therefore u = \frac{-20}{3}$

$\boxed{\therefore u = -6.67 \text{ cm}}$

The object is placed at a distance of 6.67 cm in front of the concave mirror.

3 An object placed 20 cm in front of a convex mirror is found to have an image 15 cm behind the mirror. Find the focal length of the mirror.

Given : Object distance (u) = -20 cm

Image distance (v) = 15 cm

To Find : Focal length (f) = ?

Formula : $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$

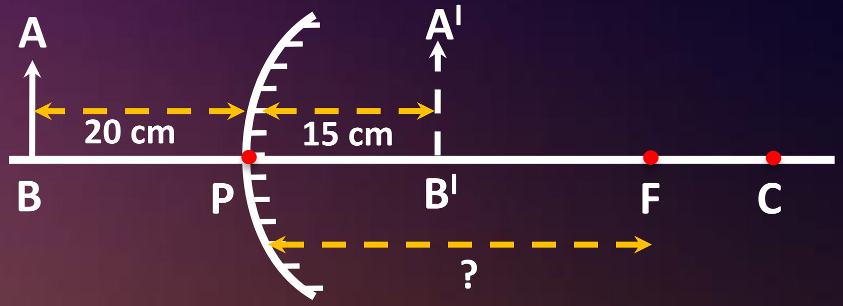
Solution : $\dfrac{1}{15} + \dfrac{1}{(-20)} = \dfrac{1}{f}$

$\therefore \dfrac{1}{15} - \dfrac{1}{20} = \dfrac{1}{f}$

$= \dfrac{4-3}{60} = \dfrac{1}{f}$

$\therefore \dfrac{1}{60} = \dfrac{1}{f}$

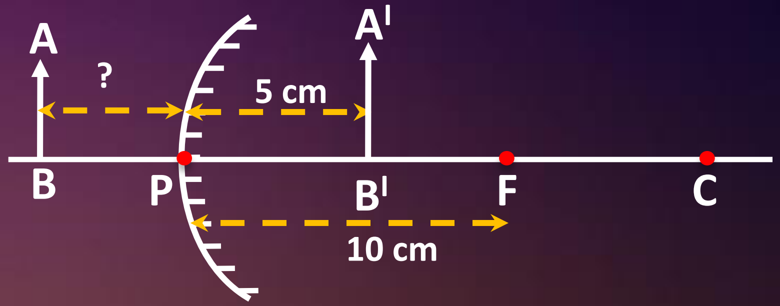
$\boxed{\therefore f = 60 \text{ cm}}$



The focal length of the convex mirror is 60 cm.

4

An image is formed 5 cm behind a convex mirror of focal length 10 cm. At what distance is the object placed from the mirror ?



Given : Image distance (v) = 5 cm

Focal length (f) = 10 cm

To Find : Object distance (u) = ?

Formula : $\dfrac{1}{v} + \dfrac{1}{u} = \dfrac{1}{f}$

Solution : $\dfrac{1}{u} = \dfrac{1}{f} - \dfrac{1}{v}$

$\therefore \dfrac{1}{u} = \dfrac{1}{10} - \dfrac{1}{5}$

$\therefore \dfrac{1}{u} = \dfrac{1 - 2}{10}$

$\therefore \dfrac{1}{u} = \dfrac{-1}{10}$

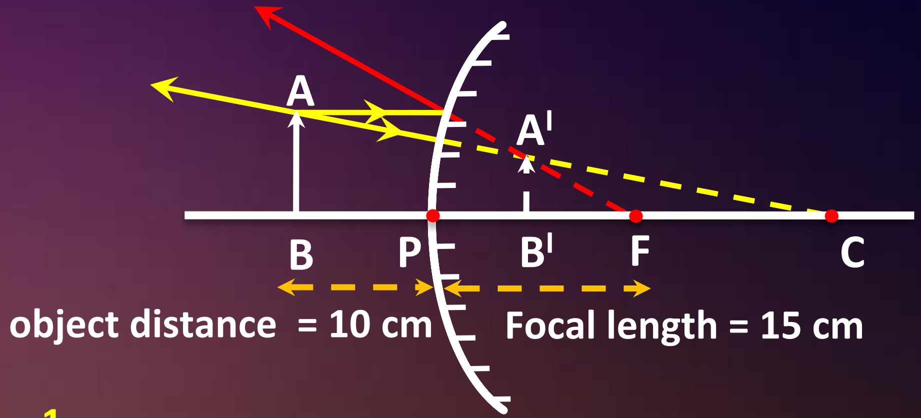
$\boxed{\therefore u = -10 \text{ cm}}$

The object is placed in front of the convex mirror at a distance of 10 cm.

***5** 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.

Given : Object distance (u) = -10 cm

Focal length (f) = 15 cm



To Find : Image position and nature

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

Solution : $\frac{1}{v} + \frac{1}{-10} = \frac{1}{15}$

$\therefore \frac{1}{v} - \frac{1}{10} = \frac{1}{15}$

$\therefore \frac{1}{v} = \frac{1}{(15)} + \frac{1}{10}$

$\therefore \frac{1}{v} = \frac{10 + 15}{15 \times 10}$

$\therefore \frac{1}{v} = \frac{\overset{1}{\cancel{\overset{5}{\cancel{25}}}}}{\underset{3}{\cancel{15}} \times \underset{2}{\cancel{10}}}$

$\therefore \frac{1}{v} = \frac{1}{6}$

$\boxed{\therefore v = 6 \text{ cm}}$

Since image distance 6 cm which is positive, image is formed behind the mirror. Thus nature is virtual and erect

6

An arrow is placed at a distance of 25 cm from a diverging mirror of focal length 20 cm. Find the image distance.

$$\boxed{\therefore v = 11.1 \text{ cm}}$$

Thank You

Lec - 5

TYPE - B

PROBLEMS BASED ON THE

FORMULA

$$M = \frac{h_2}{h_1} = \frac{-v}{u}$$

h_1 ⇨ *Object height*

h_2 ⇨ *Image height*

u ⇨ *Object distance*

v ⇨ *Image distance*

HOW TO READ MAGNIFICATION

$$M = +1$$

$+$: erect (Virtual)

$-$: inverted (Real)

$= 1$: same size

>1 : magnified

<1 : diminished

$M = -0.5$

$-$: inverted (Real)

<1 : diminished

1

The magnification produced by a plane mirror is +1. What does this mean ?

Solution : **Erect, Virtual and same size**

2

What is the nature of the image formed by a concave mirror if the magnification produced by the mirror is +3 ?

Solution : **Erect, Virtual and Magnified**

3

What is the nature of the image formed by a concave mirror if the magnification produced by the mirror is, – 0.75 ?

Solution : **Inverted, Real and Diminished**

Light – Reflection and Refraction

- **Type B Numericals 1 and 2**

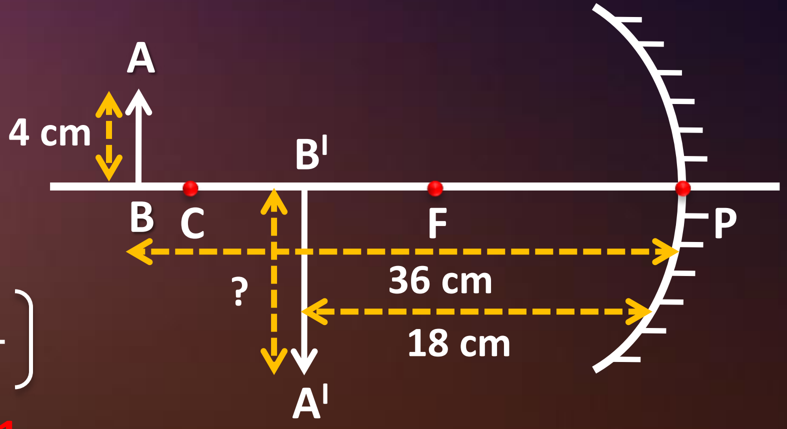
1 An object 4 cm in height is placed at a distance of 36 cm from a concave mirror. The image is formed 18 cm in front of the mirror. Find the height of the image.

Given : Object height (h_1) = 4 cm

Object distance (u) = - 36 cm

To Find : Image distance (v) = - 18 cm

Formula : Height of image (h_2) = ?



Solution : $M = \frac{h_2}{h_1} = \frac{-v}{u}$

$$h_2 = -\left(\frac{v \times h_1}{u}\right)$$

$$\therefore \quad h_2 = -\left(\frac{-\cancel{18}^{\,1} \times 4}{-\cancel{36}_{\,2}}\right)$$

$$\therefore \quad h_2 = -\left(\frac{\cancel{4}^{\,2}}{\cancel{2}_{\,1}}\right)$$

$$\boxed{\therefore h_2 = -2 \text{ cm}}$$

The height of the image is 2 cm and it is real and inverted.

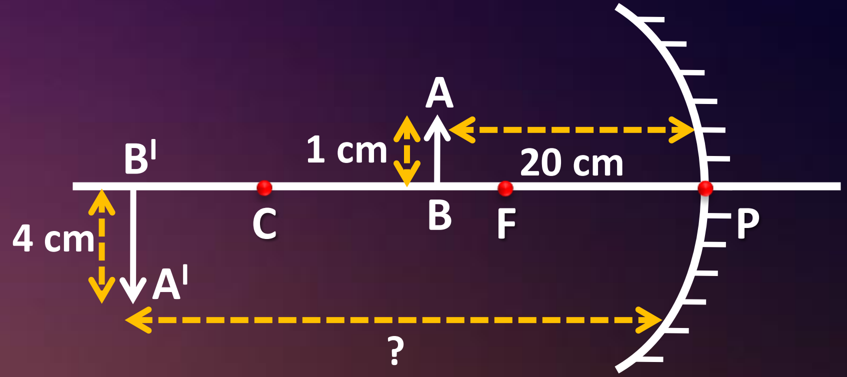
2 A converging mirror forms a real image of height 4 cm of an object of height 1 cm placed 20 cm away from the mirror. Find the image distance.

Given : Height of image (h_2) = -4 cm

Object height (h_1) = 1 cm

Object distance (u) = -20 cm

To Find : Image distance (v) = ?



Formula : $M = \frac{h_2}{h_1} = \frac{-v}{u}$

Solution : $-v = \left(\frac{u \times h_2}{h_1}\right)$

$\therefore \quad -v = \left(\frac{u \times h_2}{h_1}\right)$

$\therefore \quad v = -\left(\frac{-20 \times -4}{1}\right)$

$\therefore \quad v = \frac{-80}{1}$

$\boxed{\therefore v = -80 \text{ cm}}$

The image distance is 80 cm and is in front of the mirror.

***3** (a) A concave mirror produces three times enlarged image of an object placed at 10 cm in front of it. Calculate the focal length of the mirror.
(b) Show the formation of the image with the help of a ray diagram when object is placed 6 cm away from the pole of a convex mirror.

Ans. (a) $u = -10$ cm

$$m = \frac{-v}{u} = -3$$ (–ve sign as image is formed in front of the mirror.)

$$\frac{v}{u} = 3$$

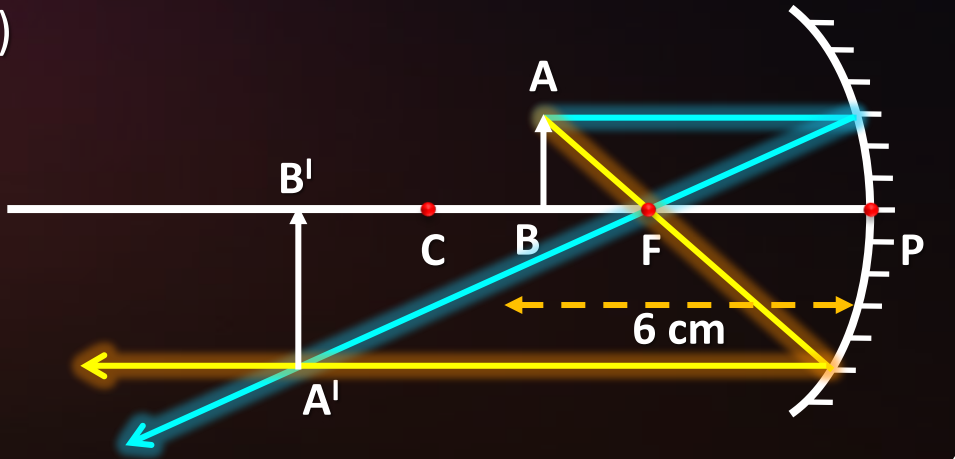
$v = 3u$ or $v = 3 \times -10 = -30$ cm

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

$$-\frac{1}{30} - \frac{1}{10} = \frac{1}{f}$$

$$\boxed{\therefore f = -7.5 \text{ cm}}$$

(b)

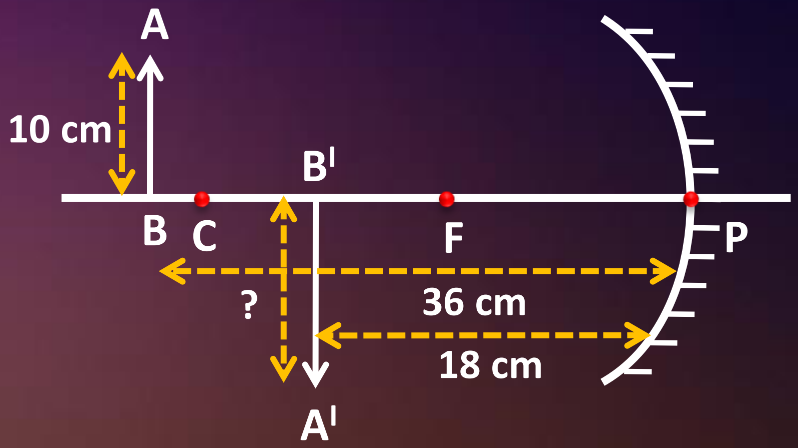


4 An object 10 cm in height is placed at a distance of 36 cm from a concave mirror. If the image is formed 18 cm in front of the mirror. Find the height of the image.

Given : Object height (h_1) = 10 cm

Object distance (u) = - 36 cm

Image distance (v) = - 18 cm



To Find : Height of image (h_2) = ?

Formula : $M = \frac{h_2}{h_1} = \frac{-v}{u}$

Solution : $h_2 = -\left(\frac{v \times h_1}{u}\right)$

$\therefore \quad h_2 = -\left(\frac{-\cancel{18}^{1} \times 10}{-\cancel{36}_{2}}\right)$

$\therefore \quad h_2 = -\left(\frac{\cancel{10}^{5}}{\cancel{2}_{1}}\right)$

$\boxed{\therefore h_2 = -5 \text{ cm}}$

The height of the image is 5 cm and it is inverted.

5 An object 2cm high is placed at a distance of 16 cm from a concave mirror which produces a real image 3 cm high. Find the image distance.

Given :

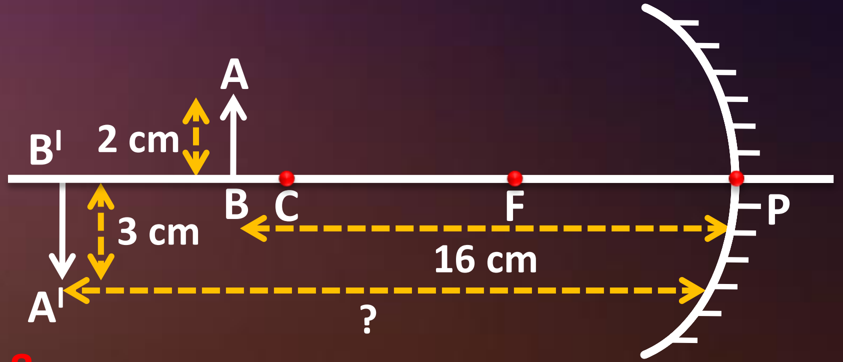
Object height (h_1) = 2 cm

Object distance (u) = - 16 cm

Height of image (h_2) = - 3 cm

To Find :

Image distance (v) = ?



Formula :

$$M = \frac{h_2}{h_1} = \frac{-v}{u}$$

Solution :

$$-v = \left(\frac{u \times h_2}{h_1}\right)$$

$$-v = -\left(\frac{u \times h_2}{h_1}\right)$$

$$\therefore \quad v = -\left(\frac{-\cancel{16}^{\,8} \times -3}{\cancel{2}}\right)$$

$$\boxed{\therefore v = -24 \text{ cm}}$$

The image is formed at a distance of 24 cm in front of mirror.

Light – Reflection and Refraction

- Type B Numericals 3 and 4

6

For a convex mirror the object distance u = 30 cm to the left, image distance v = 12 cm to the right of the mirror and height of object = 5 cm. Find the height of image.

$\therefore h_2 = 2$ cm

The height of the image is 2 cm and it is erect.

7

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 ?

$\therefore v = -30$ cm

The image distance is 30 cm and is in front of the mirror.

Light – Reflection and Refraction

- **Type C Numericals - 1**

TYPE - C

PROBLEMS BASED ON THE

FORMULA

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

$$M = \frac{h_2}{h_1} = -\frac{v}{u}$$

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

$$\therefore \frac{1}{v} = \frac{1}{(-12)} - \frac{1}{(-20)}$$

$$\therefore \frac{1}{v} = \frac{-1}{12} + \frac{1}{20}$$

$$\therefore \frac{1}{v} = \frac{-5 \;\; + 3}{60}$$

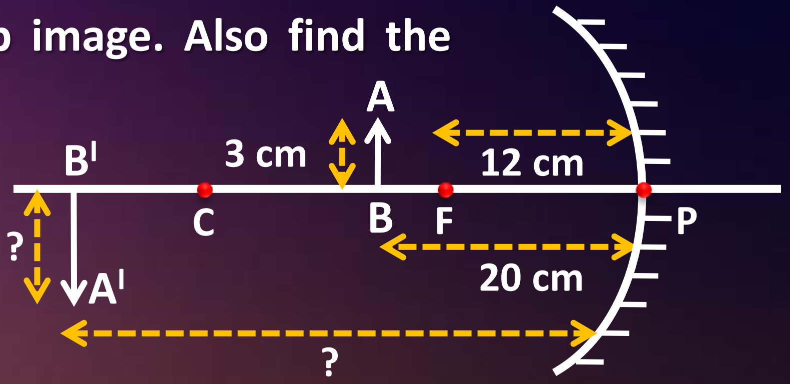
$$\therefore \frac{1}{v} = \frac{-2}{60}$$

$$\therefore \frac{1}{v} = \frac{-1}{30}$$

$$\therefore v \;\; = -30 \text{ cm}$$

The screen should be placed at 30 cm from the mirror. The image is real.

in front of a concave mirror
e from the mirror should a
sharp image. Also find the



To Find : Image distance (v) = ?

Image Size (h_2) = ?

Formulae :

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

$$M = \frac{h_2}{h_1} = \frac{-v}{u}$$

Solution :

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

$$\therefore \frac{1}{v}$$

$$\therefore \frac{1}{v}$$

$$\therefore \frac{1}{v}$$

$$\therefore \frac{1}{v}$$

$$M = \frac{h_2}{h_1} = \frac{-v}{u}$$

$$\therefore h_2 = -\left(\frac{v \times h_1}{u}\right)$$

$$\therefore h_2 = -\left(\frac{(-\cancel{30}^{\,3}) \times (3)}{-\cancel{20}_{\,2}}\right)$$

$$\boxed{\therefore h_2 = -4.5 \text{ cm}}$$

Height of the image is 4.5 cm. It is an inverted and enlarged image.

*2 An object of size 7.0 cm is placed at a distance of 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed so that a sharp image can be obtained? Find the size and nature of image.

Ans. $h_1 = 7$ cm, $u = -27$ cm, $f = -18$ cm

using mirror formula,

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

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

$$= \frac{1}{-18} - \frac{1}{-27}$$

$$= -\frac{1}{18} + \frac{1}{27}$$

$$= \frac{-3+2}{54}$$

$$\therefore \frac{1}{v} = \frac{-1}{54}$$

$$\boxed{\therefore v = -54 \text{ cm}}$$

The image is formed 54 cm in front of the mirror. Thus, the screen should be held 54 cm in front of the mirror.

$$m = \frac{h_2}{h_1} = \frac{-v}{u}$$

$$\therefore h_2 = -\frac{v \times h_1}{u}$$

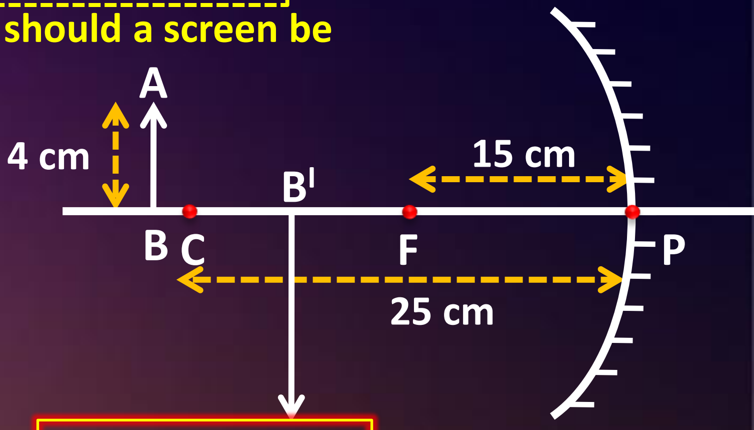
$$\therefore h_2 = -\frac{(-54) \times 7}{-27}$$

$$\boxed{\therefore h_2 = -14 \text{ cm}}$$

∴ The image is real, inverted and magnified ($h_2 > h_1$).

3

An object, 4cm in size, is placed at 25cm in front of a concave mirror of focal length 15cm. At what distance from the mirror should a screen be placed in order to obtain a sharp image?
Find the nature and the size of the image.



Given :

Object size	$h = +4cm$
Object distance	$u = -25cm$
Focal length,	$f = -15cm$

To Find :

Image distance	$v = ?$
Image size,	$h_2 = ?$

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

Solution : $$\therefore \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$\frac{1}{-15} - \frac{1}{-25}$$

$$= \frac{1}{-15} + \frac{1}{25}$$

$$= \frac{25-15}{-15 \times 25} = \frac{10}{-375}$$

$$\boxed{\therefore v = -37.5 \text{ m}}$$

The screen should be placed at 37.5 cm from the mirror. The image is real.

$$M = \frac{h_2}{h_1} = -\frac{v}{u} \qquad h_2 = -\frac{vh_1}{u}$$

$$= -\frac{(-37.5) \times 4}{(-25)} = -\frac{150}{25} = -6 \text{ cm}$$

Image distance is 37.5 cm and height of the image is 6 cm, Thus image is enlarged and inverted

Light – Reflection and Refraction

- **Type C Numericals - 2**

$$\therefore \frac{1}{v} = \frac{1}{20} + \frac{1}{25}$$

$$\therefore \frac{1}{v} = \frac{5+4}{100}$$

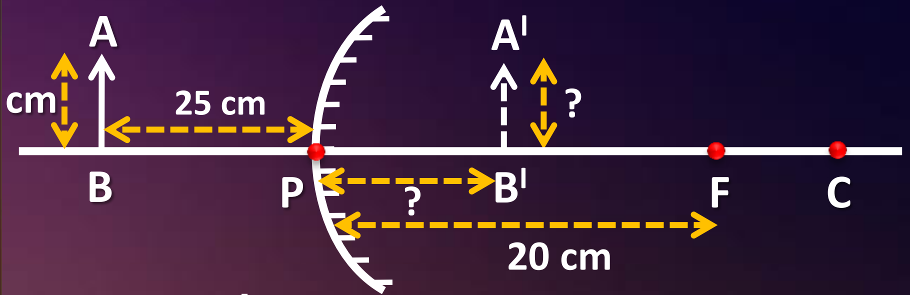
$$\therefore \frac{1}{v} = \frac{9}{100}$$

$\boxed{\therefore v = 11.1\ \text{cm}}$

$$\therefore v = \frac{100}{9}$$

The image is formed at a distance of 11.1 cm behind the mirror.

tance of 25 cm from a diverging mirror
tion and size of the image formed.



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

$$M = \frac{h_2}{h_1} = \frac{-v}{u}$$

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

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

$$\therefore \frac{1}{v} = \frac{1}{20} - \frac{1}{(-25)}$$

$$M = \frac{h_2}{h_1} = \frac{-v}{u}$$

$$\therefore h_2 = -\left(\frac{v \times h_1}{u}\right)$$

$$\therefore h_2 = -\left(\frac{11.1 \times 2.5}{-25}\right)$$

$$\therefore h_2 = -$$

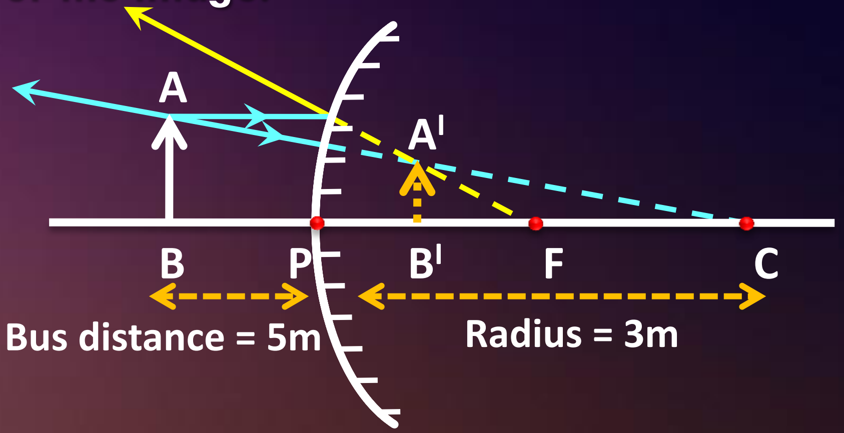
$$\therefore h_2 = -\left(\frac{111 \times \cancel{25}}{-\cancel{25} \times 10 \times 10}\right)$$

$$\therefore h_2 = -\left(\frac{111}{-100}\right)$$

$$\therefore h_2 = \frac{111}{100}$$

Height of the image is 1.11 cm. It is a virtual, erect and diminished image.

***5** A convex mirror used for rear-view on an automobile has a radius of curvature of 3 m. If a bus is located at 5 m from this mirror, find the position, nature and size of the image.



Given :

Radius of curvature $R = 3\ m$

Object distance $u = 5\ m$

To Find :

Image distance $v = ?$

Height of the image $h_2 = ?$

Formula :

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

Solution :

$$f = \frac{R}{2} = \frac{3\ m}{2} = 1.5m$$

$$\because \frac{1}{v} + \frac{1}{u} = \frac{1}{f} \quad \therefore \frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

$$= \frac{1}{1.5} - \frac{1}{(-5)} = \frac{1}{1.5} + \frac{1}{5} = \frac{5 + 1.5}{7.5}$$

$$= \frac{7.5}{6.5} \quad \boxed{\therefore v = 1.15\ m}$$

The image is 1.15 m at the back of the mirror.

$$M = \frac{h_2}{h_1} = -\frac{v}{u} = -\frac{1.15m}{-5.00m} \quad \boxed{= +0.23}$$

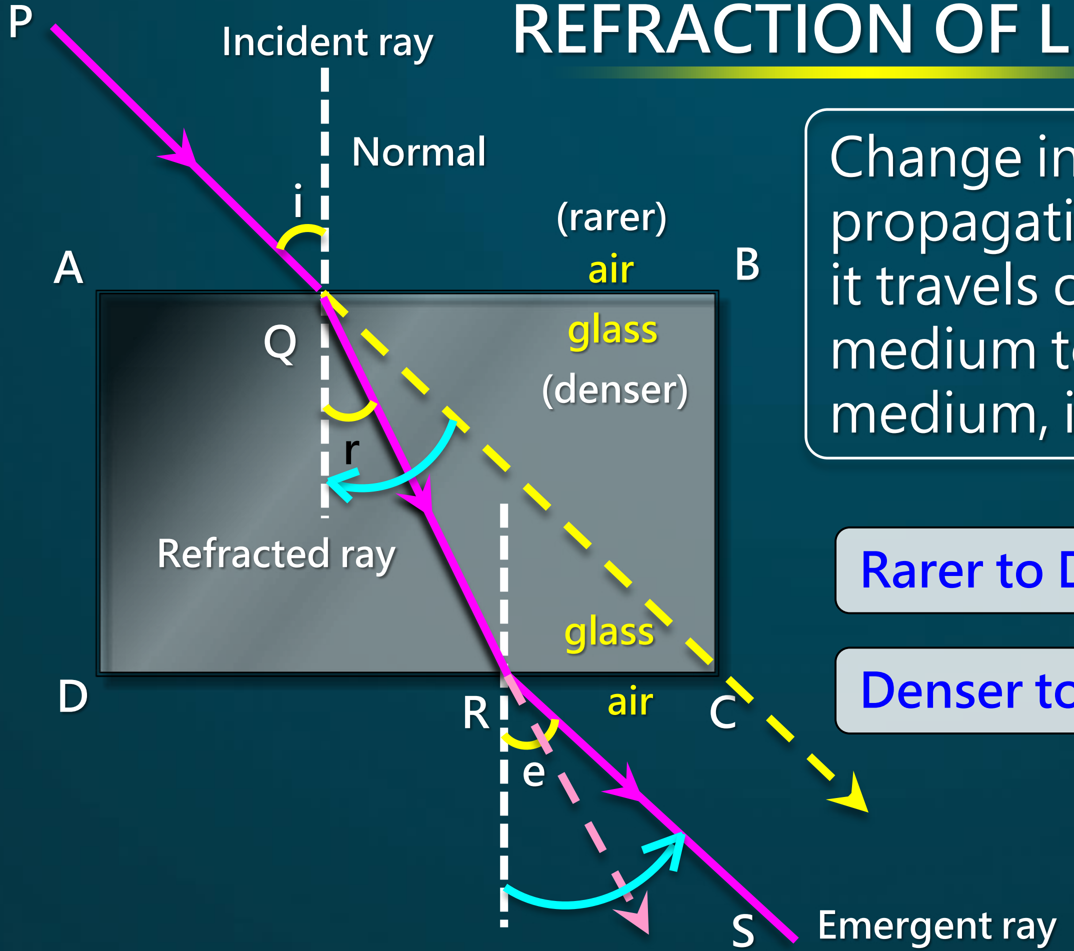
The image distance is 1.15 m and it is virtual, erect and smaller in size by a factor of 0.23

Thank You

Lec - 6


Light is travelling
in a straight line

REFRACTION OF LIGHT



Change in the direction of propagation of a ray of light, when it travels obliquely from one medium to another transparent medium, is called refraction of light.

Rarer to Denser: towards normal

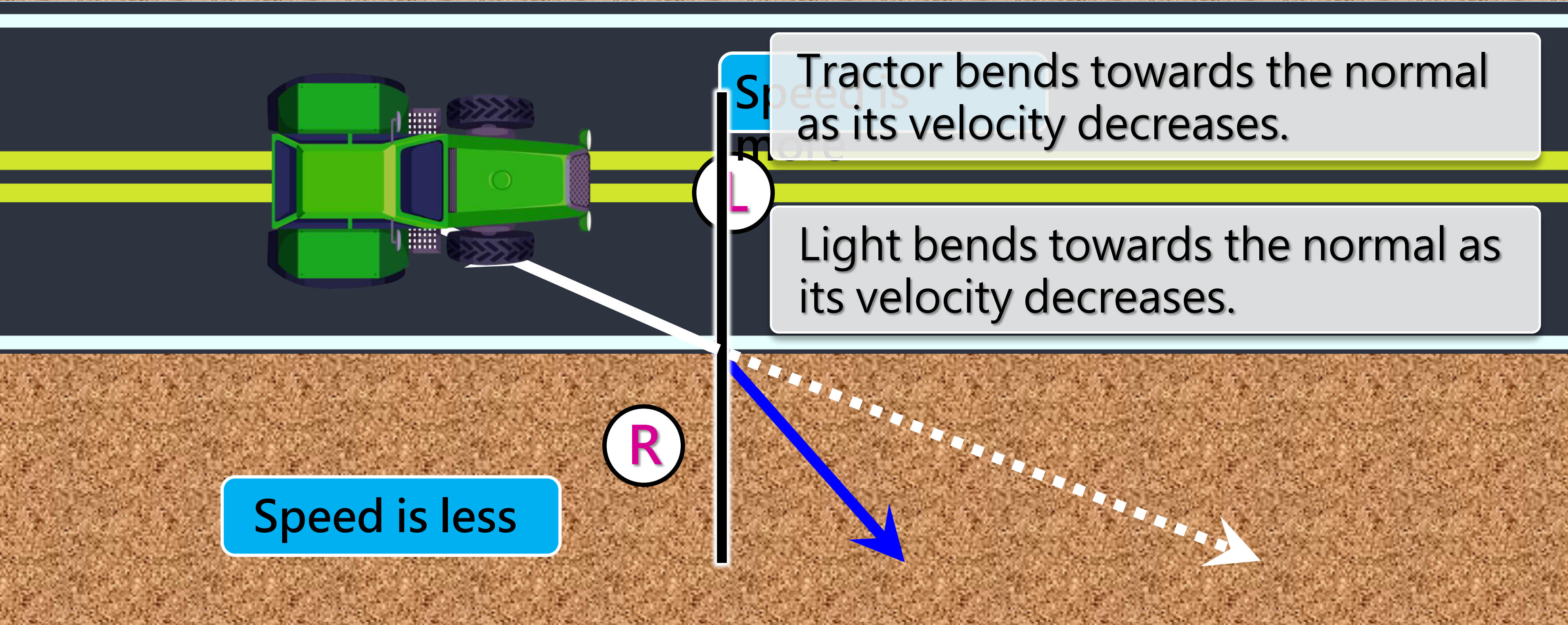
Denser to Rarer: away from normal

Let us understand why does the ray of light bend?

CONCLUSION

Tractor bends towards the normal as its velocity decreases.

Light bends towards the normal as its velocity decreases.



Let us understand why does the ray of light bend?

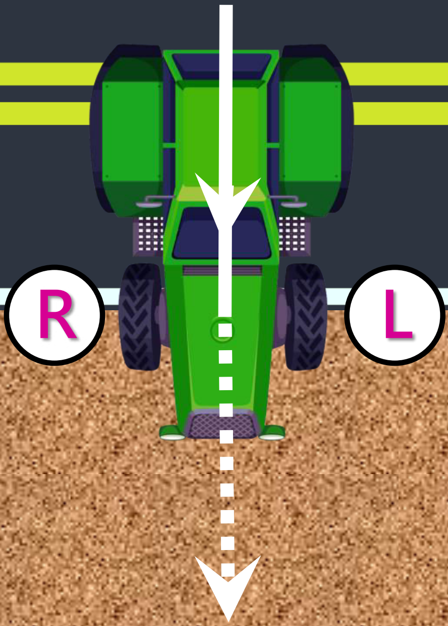
CONCLUSION

Rarer to denser → towards the normal

Denser to rarer → away from the normal

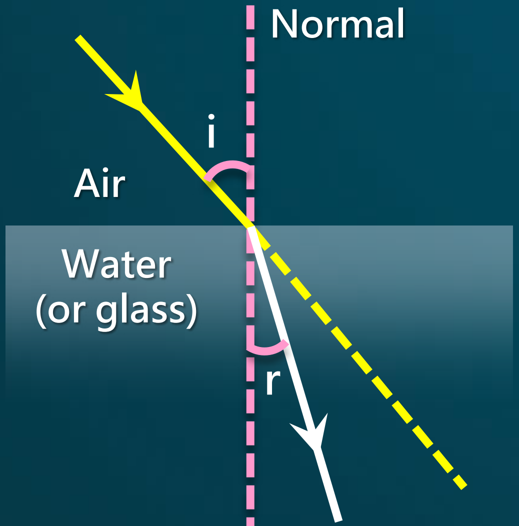
Light travels straight → No deviation

Speed is same



What happens when

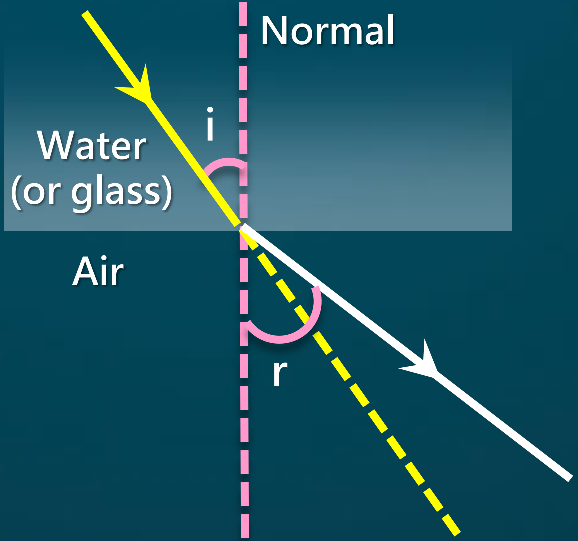
RARER TO DENSER



It bends towards the normal

Velocity Decreases

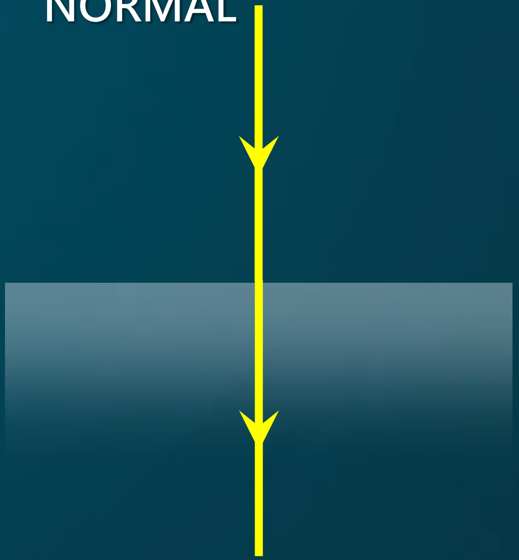
DENSER TO RARER



It bends away from the normal

Velocity increases

ALONG THE NORMAL



It passes undeviated.

Velocity decreases

QUIZ TIME

QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME QUI

IME QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME QUIZ TIME

ALL THE BEST !!

IT'S QUIZ TIME

QUIZ TIME

Correct Wrong Cheer Boo Silence

1

2

3

4

5

6

7

8

FINAL QUIZ TIME

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of incidence?

(A) $\angle i = 30°$

(C) $\angle i = 40°$

(B) $\angle i = 60°$

(D) $\angle i = 0°$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of incidence?

(A) $\angle i = 30°$

(C) $\angle i = 40°$

(B) $\angle i = 60°$

(D) $\angle i = 0°$

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab normally. What is the angle of incidence?

(A) $\angle i = 30°$

(C) $\angle i = 40°$

(B) $\angle i = 60°$

(D) $\angle i = 0°$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab normally. What is the angle of incidence?

(A) $\angle i = 30°$

(C) $\angle i = 40°$

(B) $\angle i = 60°$

(D) $\angle i = 0°$

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of emergence?

(A) $\angle e = 30°$

(B) $\angle e = 40°$

(C) $\angle e = 60°$

(D) $\angle e = 0°$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

If a ray of light strikes the glass slab at 30°. What is the angle of emergence?

(A) $\angle e = 30°$

(B) $\angle e = 40°$

(C) $\angle e = 60°$

(D) $\angle e = 0°$

QUIZ TIME

Correct Wrong Cheer Boo Silence

FREE POINT

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light strikes a glass slab at an angle of 50° with the normal to the surface of the slab. What is the angle of incidence?

(A) 50°

(B) 25°

(C) 40°

(D) 100°

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light strikes a glass slab at an angle of 50° with the normal to the surface of the slab. What is the angle of incidence?

(A) 50°

(C) 40°

(B) 25°

(D) 100°

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light gets deviated when it passes obliquely from one medium to another medium because ____________

(A) colour of light changes

(B) frequency of light changes

(C) speed of light changes

(D) intensity of light changes

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

A ray of light gets deviated when it passes obliquely from one medium to another medium because ___________

(A) colour of light changes

(C) speed of light changes

(B) frequency of light changes

(D) intensity of light changes

QUIZ TIME

Correct Wrong Cheer Boo Silence

FREE POINT

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

Rakesh performs the experiment of tracing the path of a ray of light passing through a rectangular glass slab for different angles of incidence. He observes that in all cases ___________.

(A) $\angle i > \angle r$ but $\angle i = \angle e$

(C) $\angle i > \angle e$ but $\angle i = \angle r$

(B) $\angle i < \angle r$ but $\angle i = \angle e$

(D) $\angle i < \angle e$ but $\angle i = \angle r$

Start Timer

GO TO RESPONSE

QUIZ TIME

Correct Wrong Cheer Boo Silence

Rakesh performs the experiment of tracing the path of a ray of light passing through a rectangular glass slab for different angles of incidence. He observes that in all cases __________.

(A) $\angle i > \angle r$ but $\angle i = \angle e$

(C) $\angle i > \angle e$ but $\angle i = \angle r$

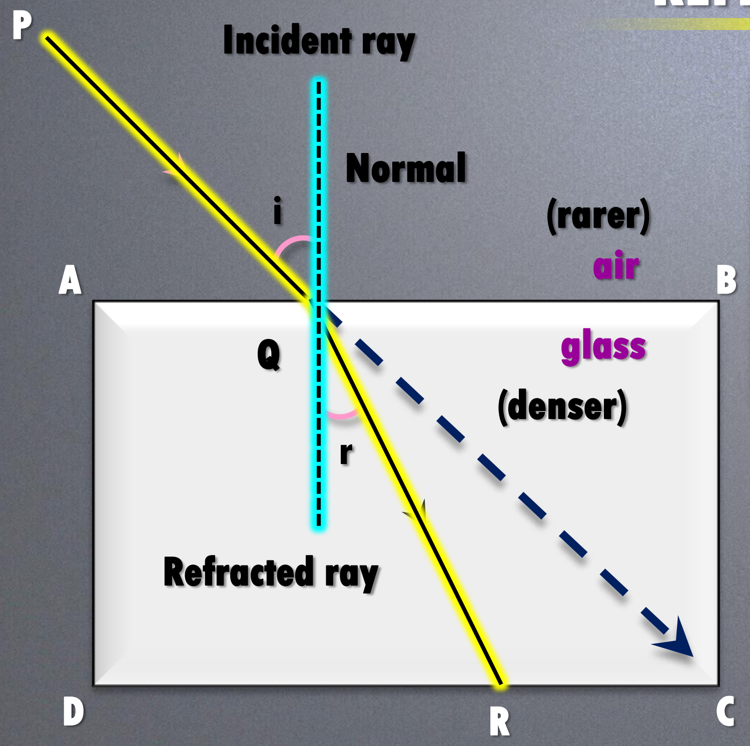
(B) $\angle i < \angle r$ but $\angle i = \angle e$

(D) $\angle i < \angle e$ but $\angle i = \angle r$

QUIZ TIME

Correct Wrong Cheer Boo Silence

REFRACTION OF LIGHT



Change in ... ion of a
ray of ligh ... ly from
on
m

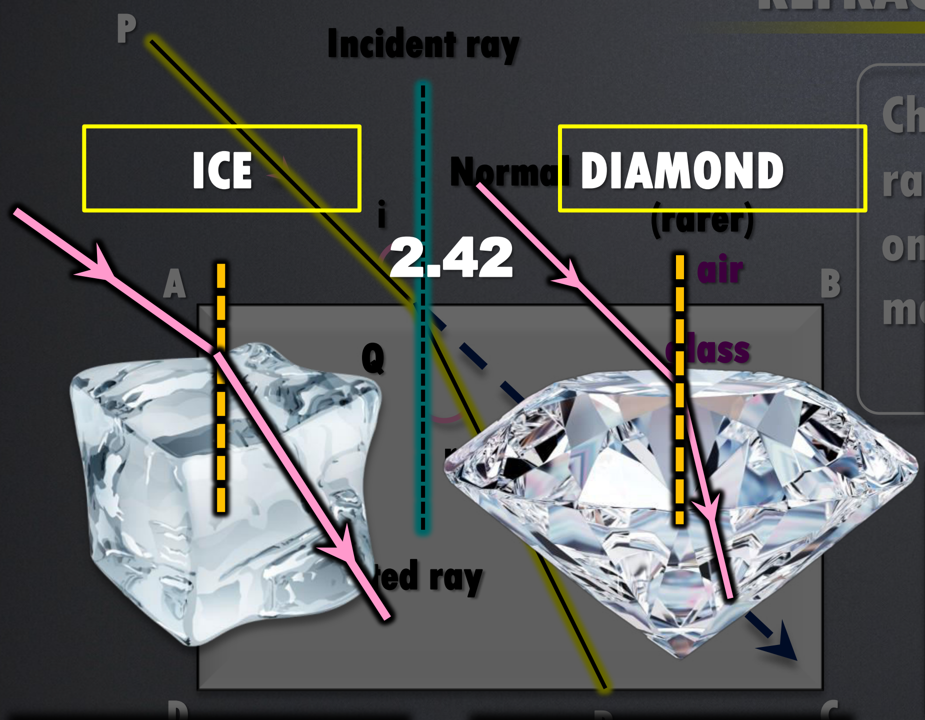
Laws of Refraction

1. 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.

2. The ratio of the sine of angle of incidence to the sine of the angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also know as Snell's law of refraction.

$$\frac{\sin i}{\sin r} = \text{constant} \longrightarrow \text{Refractive index } (n)$$

REFRACTION OF LIGHT



$$\frac{\sin i}{\sin r} = 1.31$$

$$\frac{\sin i}{\sin r} = 2.42$$

Laws of Refraction

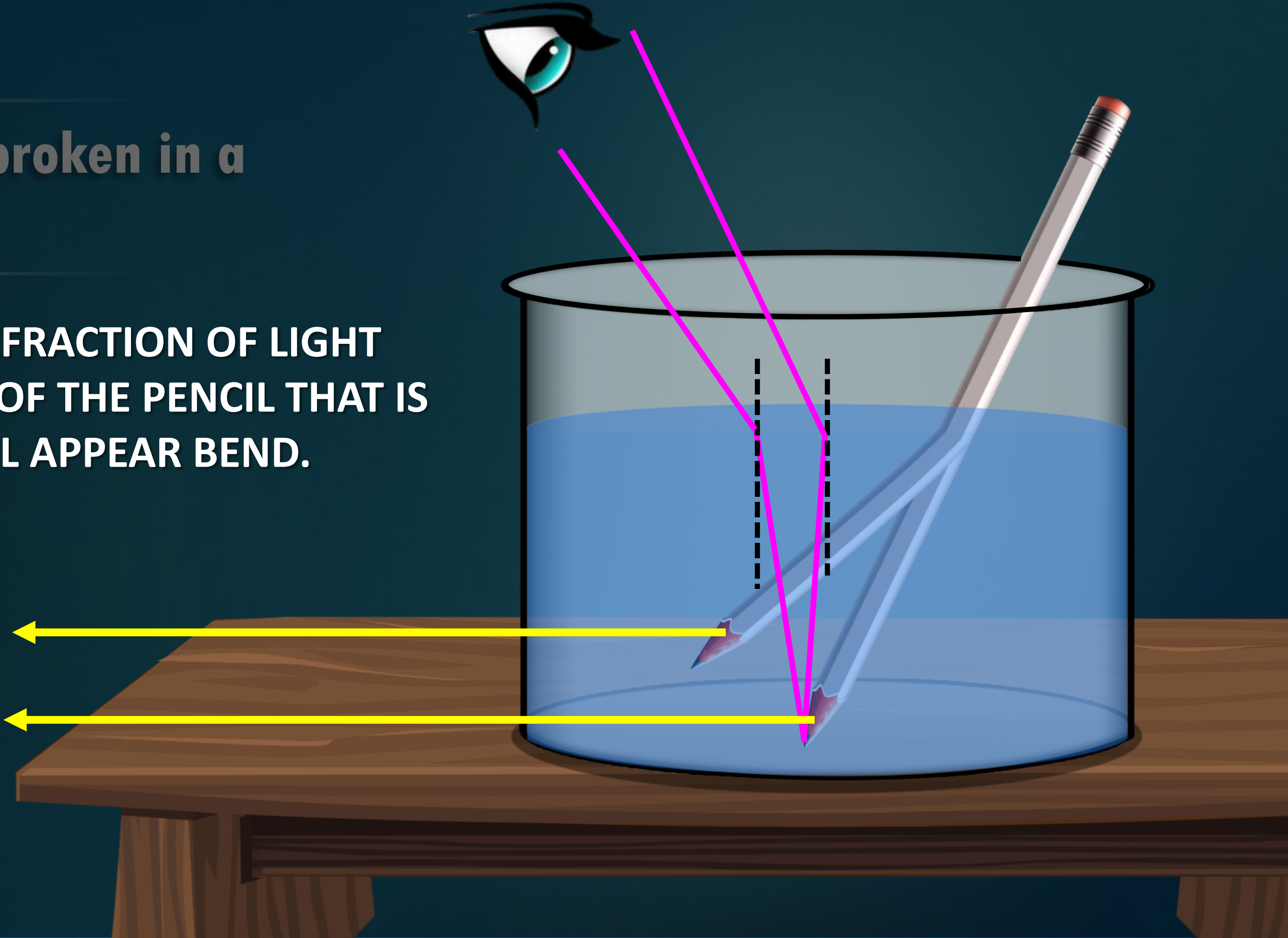
1. The incident ray, the refracted ray and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.

2. The ratio of the sine of angle of incidence to the sine of the angle of refraction is a constant, for the light of a given colour and for the given pair of media. This law is also know as Snell's law of refraction.

$$\frac{\sin i}{\sin r} = \text{constant} \rightarrow \text{Refractive index (n)}$$

Pencil appears to be broken in a beaker with water

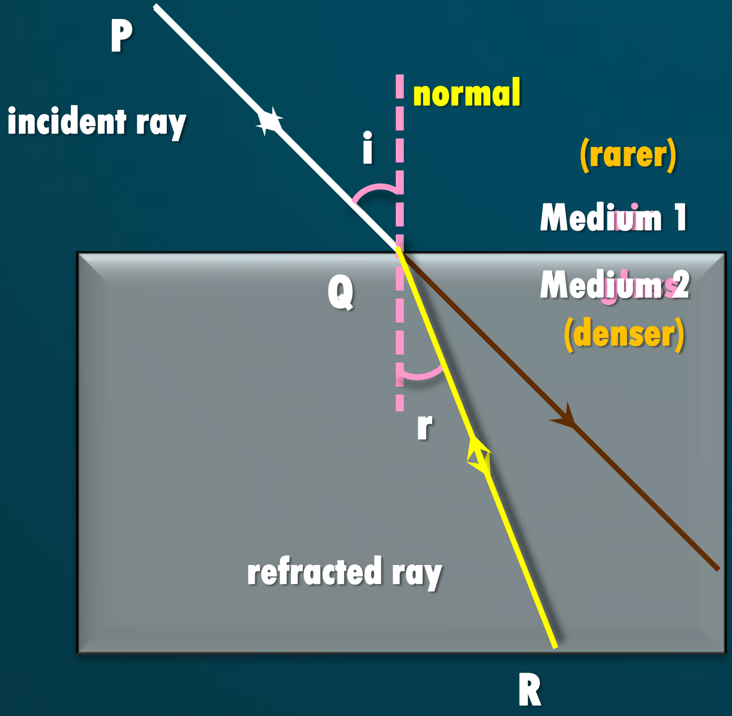
THUS, BECAUSE OF THE REFRACTION OF LIGHT COMING FROM THE PART OF THE PENCIL THAT IS UNDER WATER, THE PENCIL APPEAR BEND.



Apparent Position

Actual position

REFRACTIVE INDEX



We know that

$$\frac{\sin i}{\sin r} = n_{21}$$

Refractive Index

$$n_{21} = \frac{v_1}{v_2}$$

Reciprocal of each other

$$n_{12} = \frac{v_2}{v_1}$$

$$n_{21} = \frac{1}{n_{12}}$$

Absolute refractive index of some material media

1.0003
Vacuum
Absolute refractive index means 1st medium is vacuum
Air

1.31
Vacuum
ICE

1.33
Vacuum
Water

Absolute refractive index of Air is 1.0003

Absolute refractive index of Ice is 1.31

Absolute refractive index of water is 1.33

Conclusion:
Refractive index increases, the bending capacity increases

crown glass is 1.52

Rock salt is 1.54

Diamond

Absolute refractive index of diamond is 2.42

Q. The refractive index of diamond is 2.42. What is the meaning of this statement?

Ans.

The refractive index of diamond 2.42 suggests that, the speed of light in diamond will reduce by a factor 2.42 as compared to its speed in air.

FRAMING THE FORMULA FOR REFRACTIVE INDEX

$$n_{a\,v} = \frac{V_v}{V_a}$$ → Absolute Refractive index of air

$$n_{ice\,a} = \frac{V_a}{V_{ice}}$$ → Refractive index of ice w.r.t the air

$$n_{g\,v} = \frac{V_v}{V_g}$$ → Absolute Refractive index of glass

$$n_{w\,a} = \frac{V_a}{V_w}$$ → Refractive index of water w.r.t the air

$$n_{oil\,a} = \frac{V_a}{V_{oil}}$$ → Refractive index of oil w.r.t the air

FORMULAE

1. $n_{21} = \frac{V_1}{V_2}$

2. $n_{21} = \frac{1}{n_{12}}$

V_1 = velocity of light in **1**st medium

V_2 = velocity of light in **2**nd medium

Important Points

1. If the first medium is not mentioned, **take 1st medium as Air**
2. If the first medium is Vacuum then refractive index of **2**nd medium is called as **Absolute refractive index**
3. For solving Numerical, Velocity of light in air **=** Velocity of light in vacuum **=** **3×10^8 m/s**

n = Refractive index has no units

1 Light enters into a glass plate having absolute refractive index 1.50. What is the speed of light in glass? (The speed of light in vacuum is $3 \times 10^8\ ms^{-1}$)

Given : Velocity of light in vacuum $(V_v) = 3 \times 10^8$ m/s

Absolute refractive index of glass $(\eta_{gv}) = 1.50$

To Find : Velocity of light in glass $(V_g) = ?$

Formula : $\eta_{gv} = \dfrac{V_v}{V_g}$

Solution : $\eta_{gv} = \dfrac{V_v}{V_g}$

$$\therefore\ V_g = \frac{V_v}{\eta_{gv}}$$

$$\therefore\ V_g = \frac{3 \times 10^8}{1.50}$$

$$\boxed{V_g = 2 \times 10^8 \text{ m/s}}$$

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

2 Refractive index of water is $\frac{4}{3}$ and speed of light in air 3×10^8 m/s. Find the speed of light in water.

Given : Refractive index of water $(\eta_{wa}) = \frac{4}{3}$

Speed of light in air $(v_a) = 3 \times 10^8$ m/s

To Find : Speed of light in water (V_w) = ?

Formula : $\eta_{wa} = \frac{V_a}{V_w}$

Solution : $\frac{4}{3} = \frac{3 \times 10^8}{V_w}$

$$V_w = \frac{3 \times 10^8 \times 3}{4}$$

$$V_w = \frac{9 \times 10^8}{4}$$

$$\boxed{V_w = 2.25 \times 10^8 \text{ m/s}}$$

The speed of light in water is 2.25×10^8 m/s

3

If the refractive index of water for light going from air to water is 1.33, then what will be the refractive index for light going from water to air?

Given : Refractive index of water w.r.t. air $(\eta_{wa}) = 1.33$

To Find : Refractive index of air w.r.t. water $(\eta_{aw}) = ?$

Formula : $$\eta_{aw} = \frac{1}{\eta_{wa}}$$

Solution : $$\eta_{aw} = \frac{1}{\eta_{wa}}$$

$$\eta_{aw} = \frac{1}{1.33}$$

$$\boxed{\eta_{aw} = 0.75}$$

Refractive index of air w.r.t. water (η_{aw}) is 0.75

4 **The refractive index of kerosene, turpentine and water are 1.44, 1.47 and 1.33, respectively. In which of these materials does light travel fastest?**

Solution : Refractive index $= \dfrac{\text{Speed of light in air}}{\text{Speed of light in medium}}$

$$\text{Speed of light in medium} = \frac{\text{Speed of light in air}}{\text{Refractive index}}$$

It is obvious from the above relation that the speed of light will be the maximum in that medium which has the lowest refractive index.

Now out of kerosene, turpentine and water, water has the lowest refractive index of 1.33.

So, the light will have maximum speed in water or light will travel fastest in water.

Q.

(i) In which of the given media, light moves the fastest ?

Medium	Refractive index
Water	1.33
Ice	1.31
Alcohol	1.36

(ii) Using above table, calculate the velocity of light in water.

Ans. (i) Light travels fastest through ice which has the lowest refractive index.

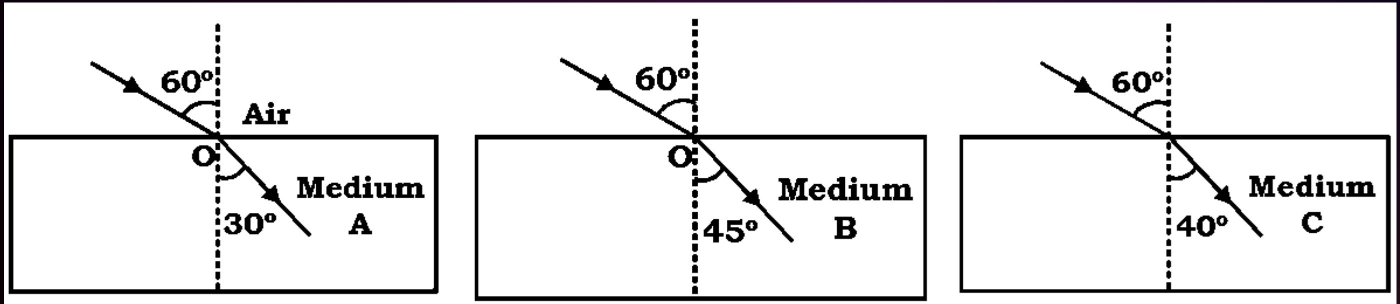
(ii) Velocity of light in water = $\dfrac{\text{Velocity of light in air}}{\text{Refractive index of water}}$

$$= \frac{3 \times 10^8 \text{ ms}^{-1}}{1.33}$$

$$= 2.25 \times 10^8 \text{ ms}^{-1}$$

Q.

(a) The path of light passing from air to different media A, B, and C for a given angle of incidence is shown below. Study the diagrams and answer the following questions.



(i) Which of the media A, B and C has maximum optical density ?

(ii) Through which of three media, will the speed of light be maximum ?

(iii) Will the light travelling from A to B bend towards or away from the normal ?

Ans. (a) (i) $\sin 30° < \sin 40° < \sin 45° \Rightarrow \eta A > \eta C > \eta B$

$\therefore$ Medium A has maximum optical density.

(ii) Speed of light will be maximum in the medium B of lowest refractive index ηB.

(iii) As $\eta A > \eta B$, light travelling from A to B will bend away from the normal

Thank You

Lec - 7

LENS

Magnifying glass

Spectacles

Contact lens

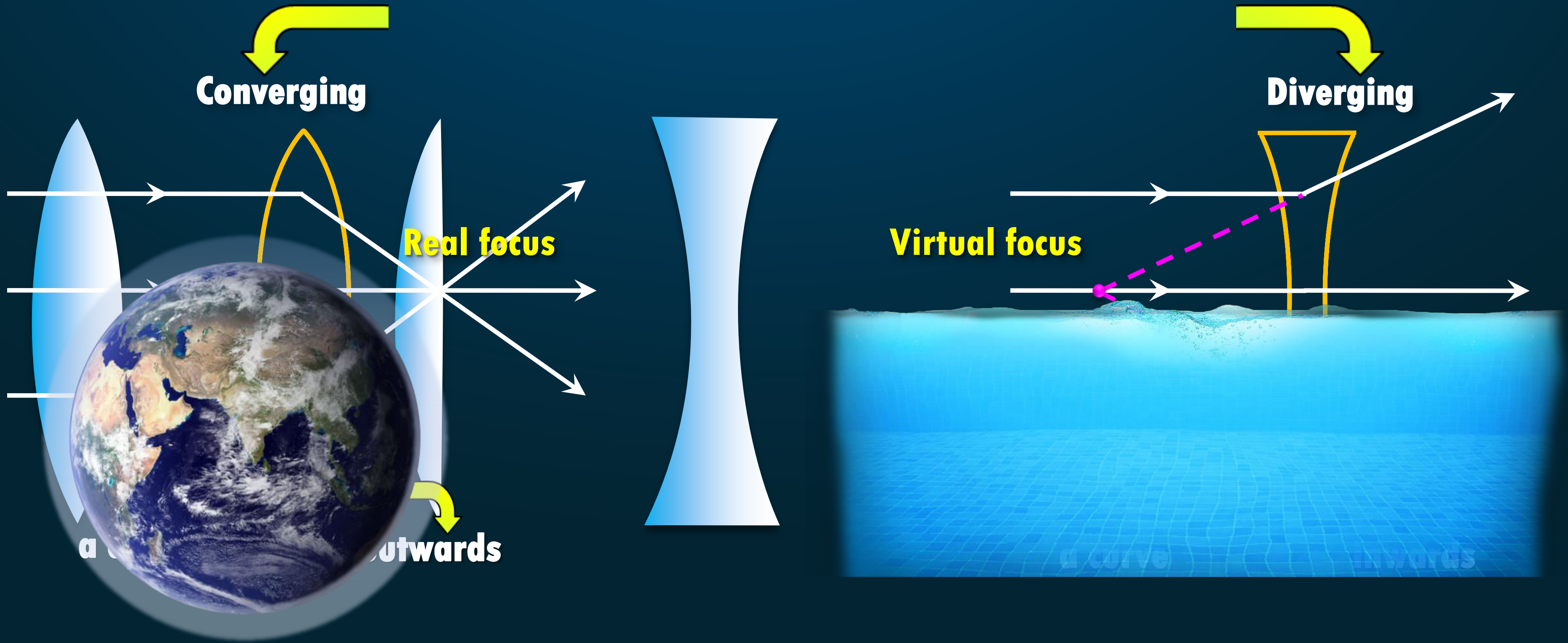
Binoculars

Microscope

Telescope

LENS

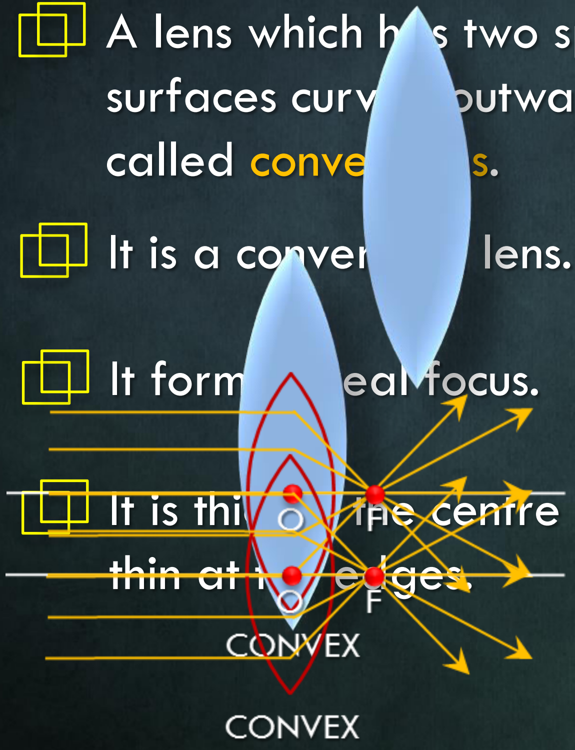
A lens is a transparent medium bound by two surfaces.



Distinguish between Convex and Concave lens

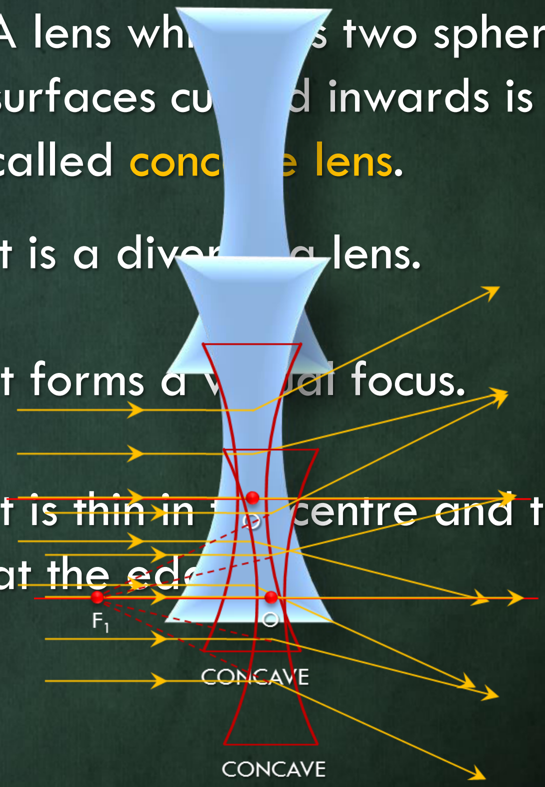
Convex

- A lens which has two spherical surfaces curved outwards is called convex lens.
- It is a converging lens.
- It forms a real focus.
- It is thick in the centre and thin at the edges.



Concave

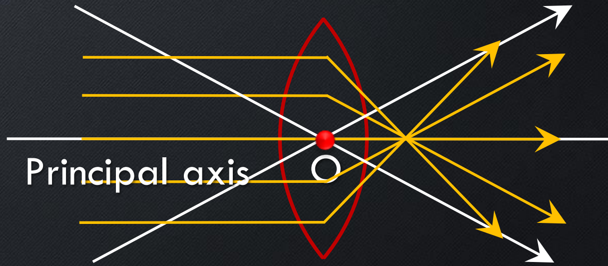
- A lens which has two spherical surfaces curved inwards is called concave lens.
- It is a diverging lens.
- It forms a virtual focus.
- It is thin in the centre and thick at the edges.



Common Terms

Centre of curvature (C)

The centres of the spheres whose parts form surfaces of the lenses are called centres of curvatures of the lenses. C_1 and C_2



Centre of curvature (C)

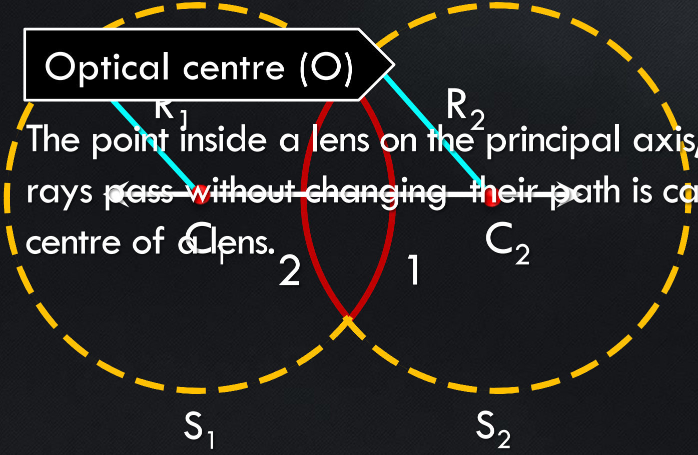
The radius of the spheres whose parts form surfaces of the lenses are called radii of curvature of the lenses. R_1 and R_2

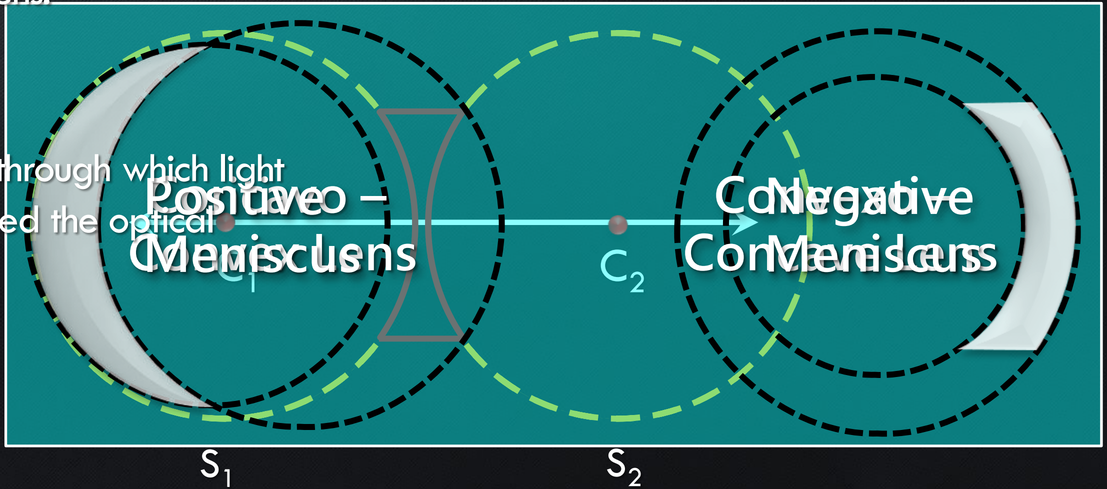
Principal axis

The imaginary line passing through both centres of curvature is called the principal axis of the lens.

Optical centre (O)

The point inside a lens on the principal axis, through which light rays pass without changing their path is called the optical centre of a lens.





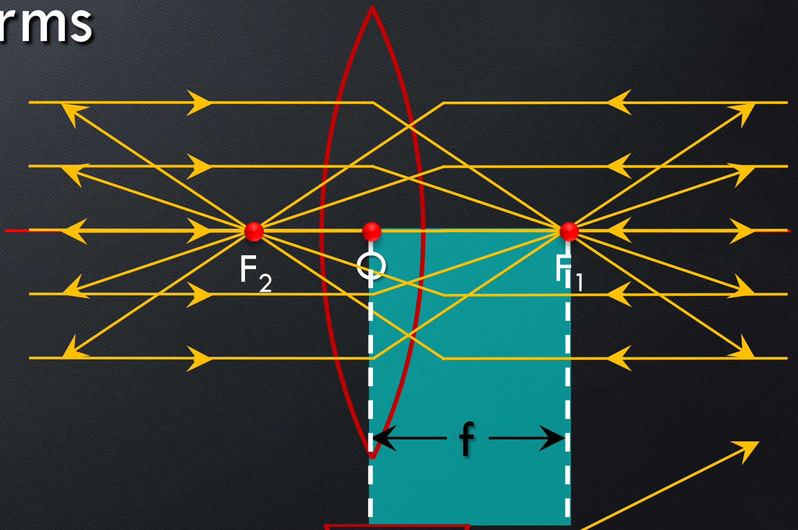
Common Terms

Principal focus (F)

Convex Lens → **(real focus)**

When light rays parallel to the principal axis are incident on a convex lens, they converge to a point on a principal axis. This point is called the principal focus of the lens.

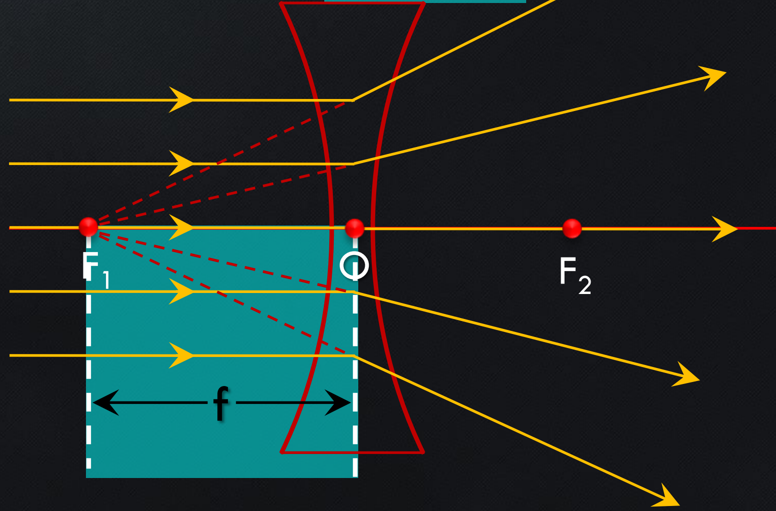
F_1 and F_2 are the principal foci of the convex lens.



Concave Lens → **(virtual focus)**

When light rays parallel to the principal axis are incident on a concave lens, they diverge and appear to be coming from a point on the principal axis. This point is called the principal focus of the lens.

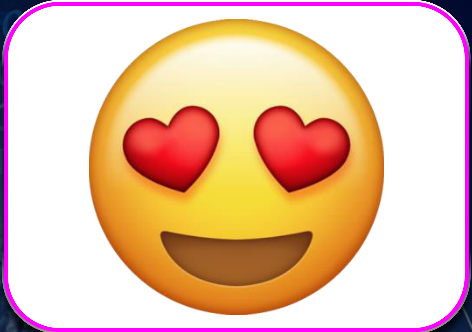
F_1 and F_2 are the principal foci of the concave lens.

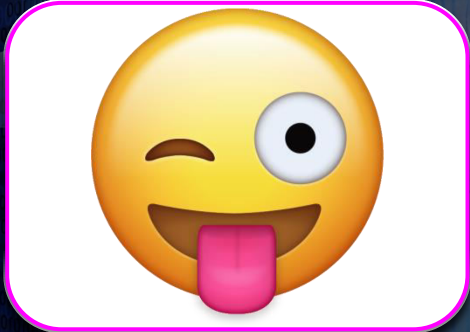
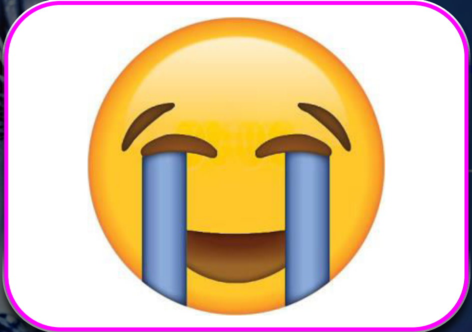


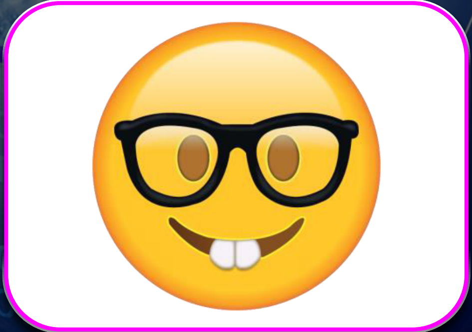
Focal length (f)

The distance between the optical centre and principal focus of a lens is called its focal length.





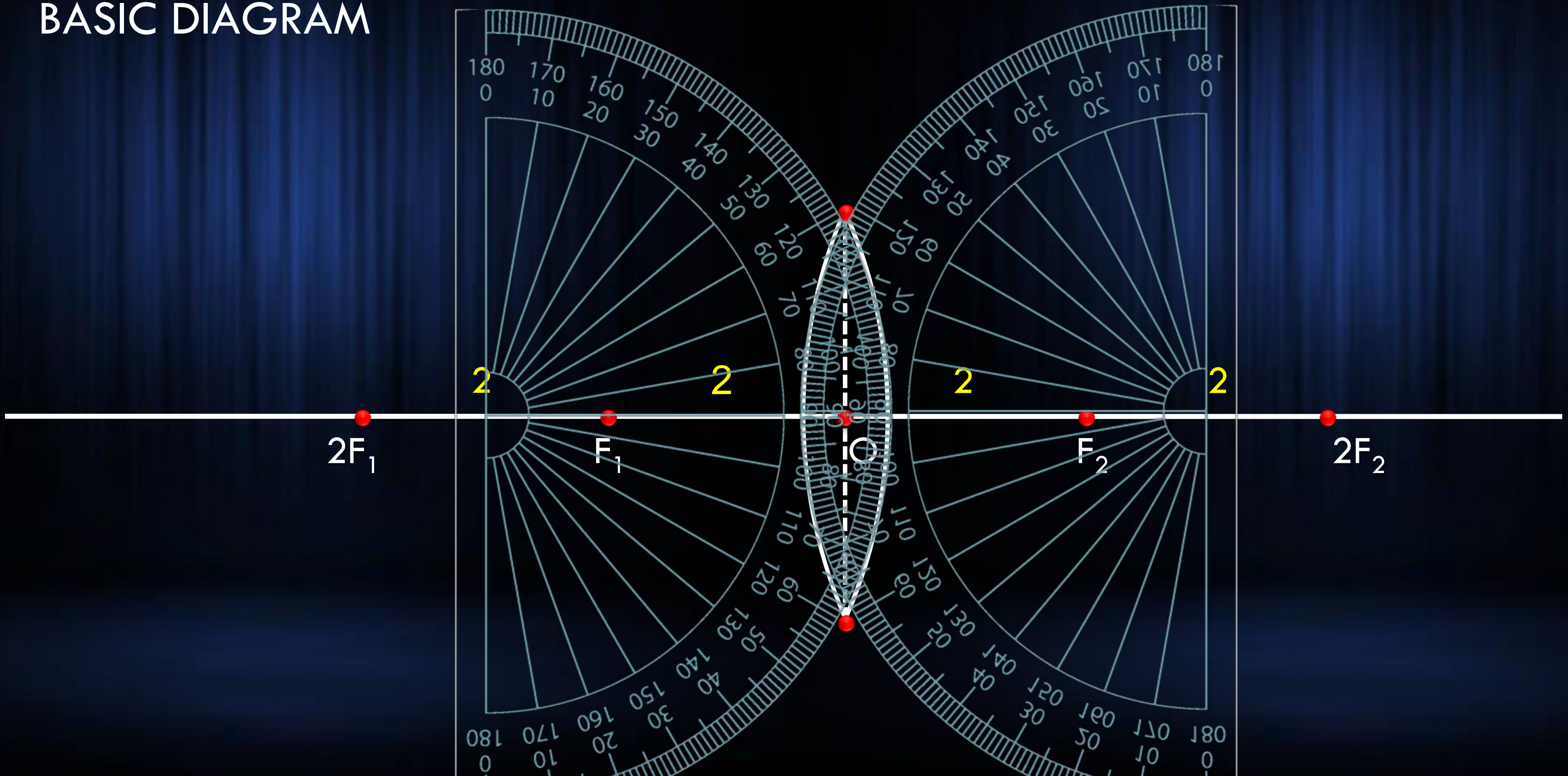
RAY DIAGRAM

Lens showing a diminished and inverted image

But at what distance is it formed?

RAY DIAGRAM

BASIC DIAGRAM

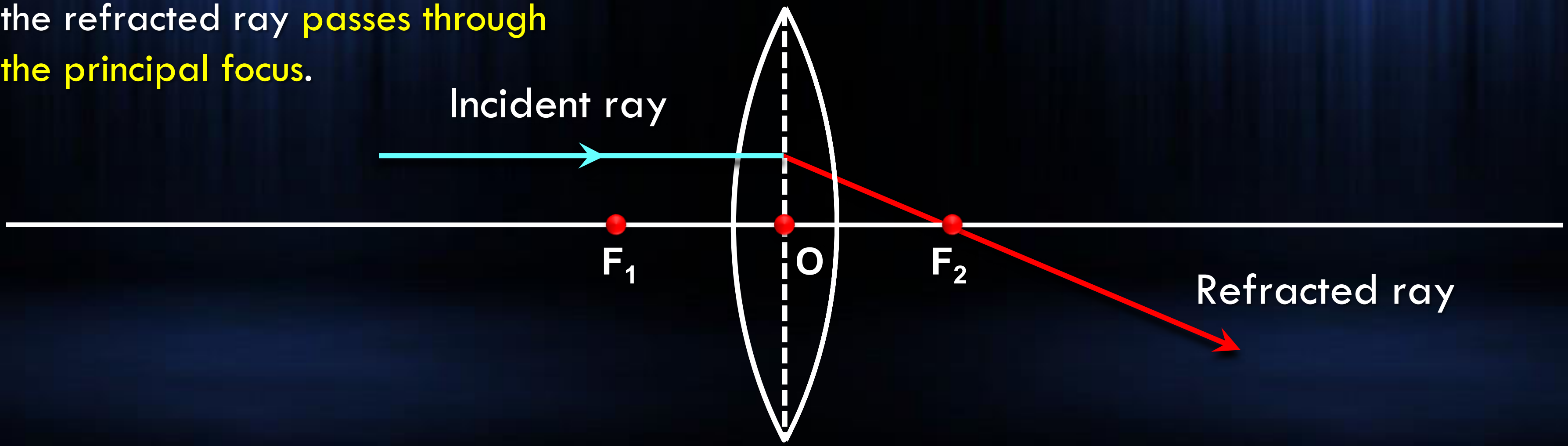


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 1

When the incident ray is parallel to the principal axis, the refracted ray passes through the principal focus.

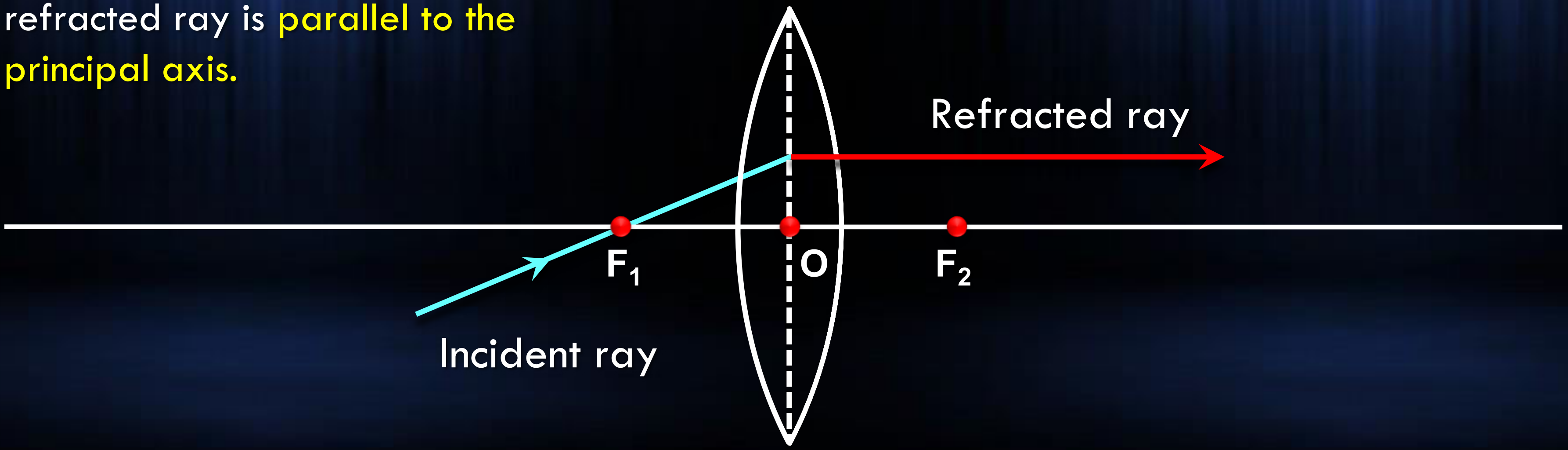


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 2

When the incident ray passes through the principal focus, the refracted ray is parallel to the principal axis.

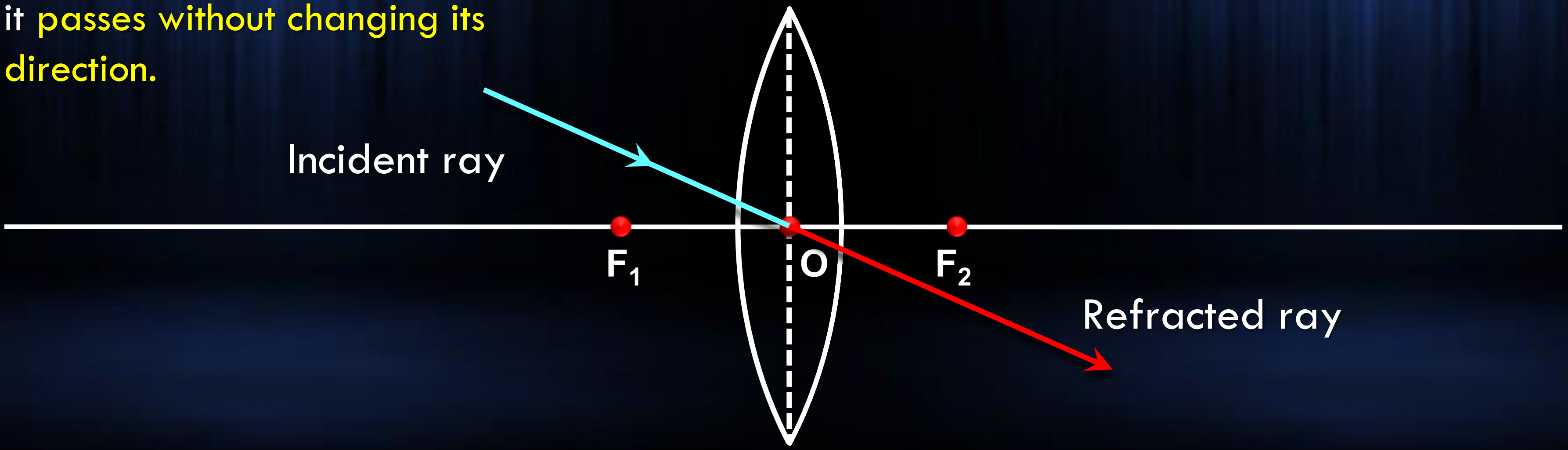


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

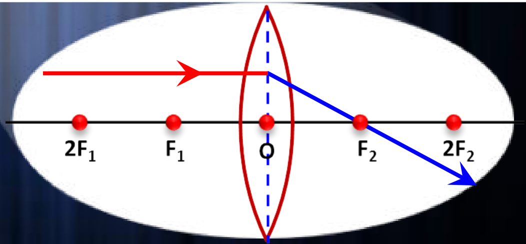
RULE 3

When the incident ray passes through the optical centre, it passes without changing its direction.

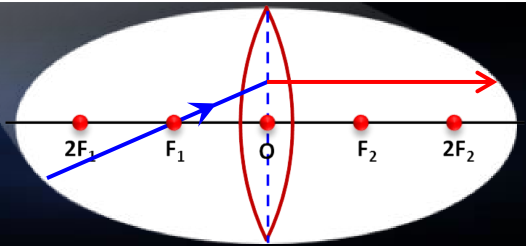


RULES FOR MAKING RAY DIAGRAM

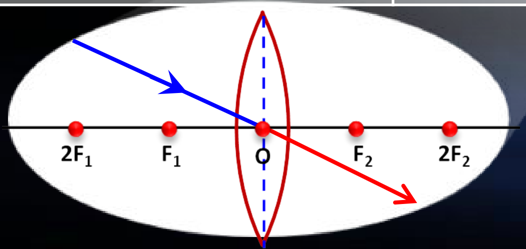
INCIDENT RAY	REFRACTED RAY
Parallel to the principal Axis	Passes through focus



INCIDENT RAY	REFRACTED RAY
Passes through focus	Parallel to the principal Axis



INCIDENT RAY	REFRACTED RAY
Passes through O	Does not change direction



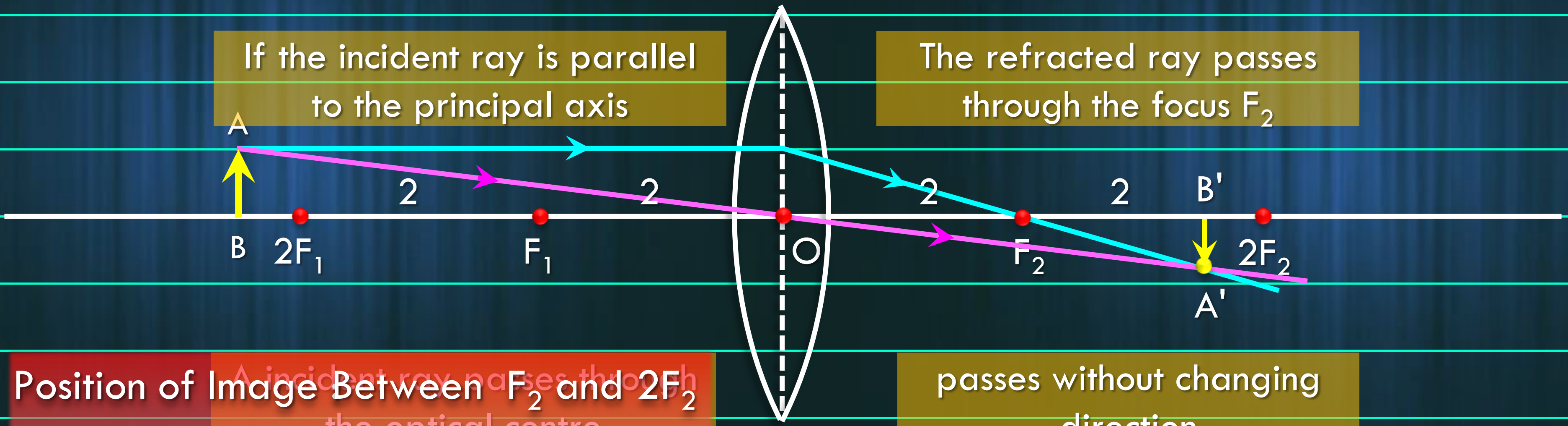
Thank You

Lec - 8

Object beyond $2F_1$

If the incident ray is parallel to the principal axis

The refracted ray passes through the focus F_2



A incident ray passes through the optical centre

passes without changing direction

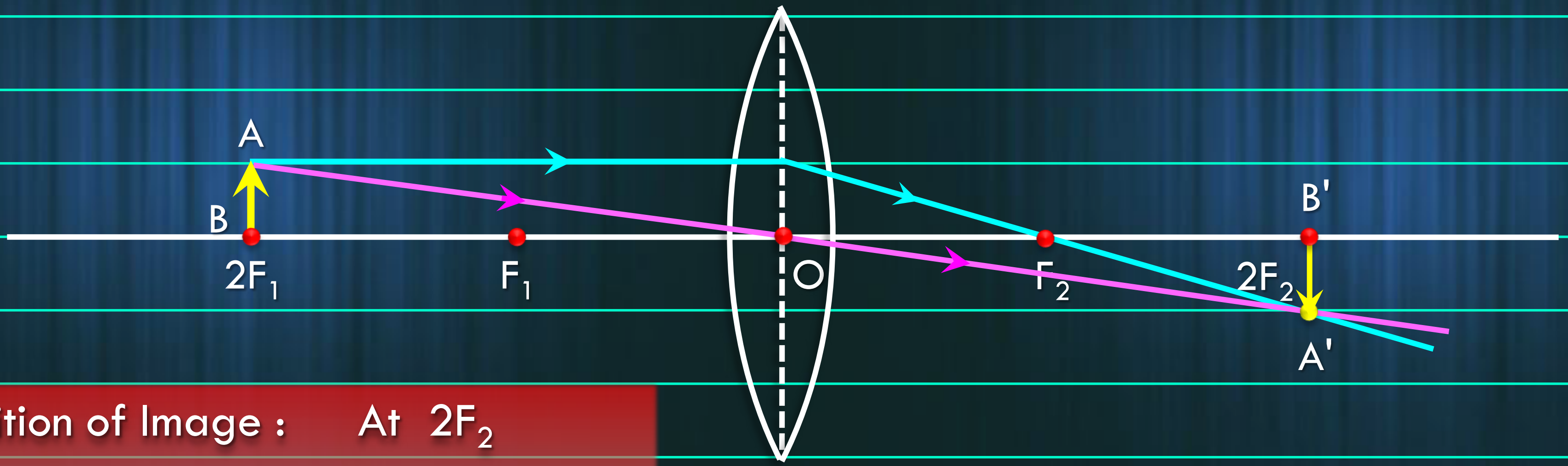
Position of Image Between F_2 and $2F_2$

Nature of Image : (A) Real

(B) Inverted

(C) Smaller

Object at $2F_1$



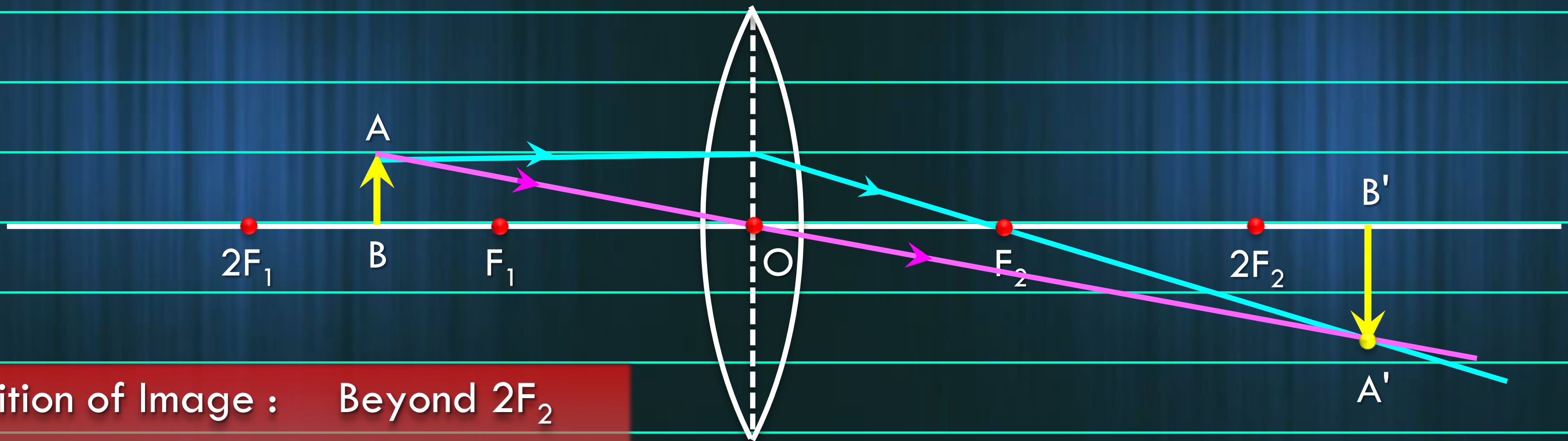
Position of Image : At $2F_2$

Nature of Image : (A) Real

(B) Inverted

(C) Same size

Object between F_1 and $2F_1$



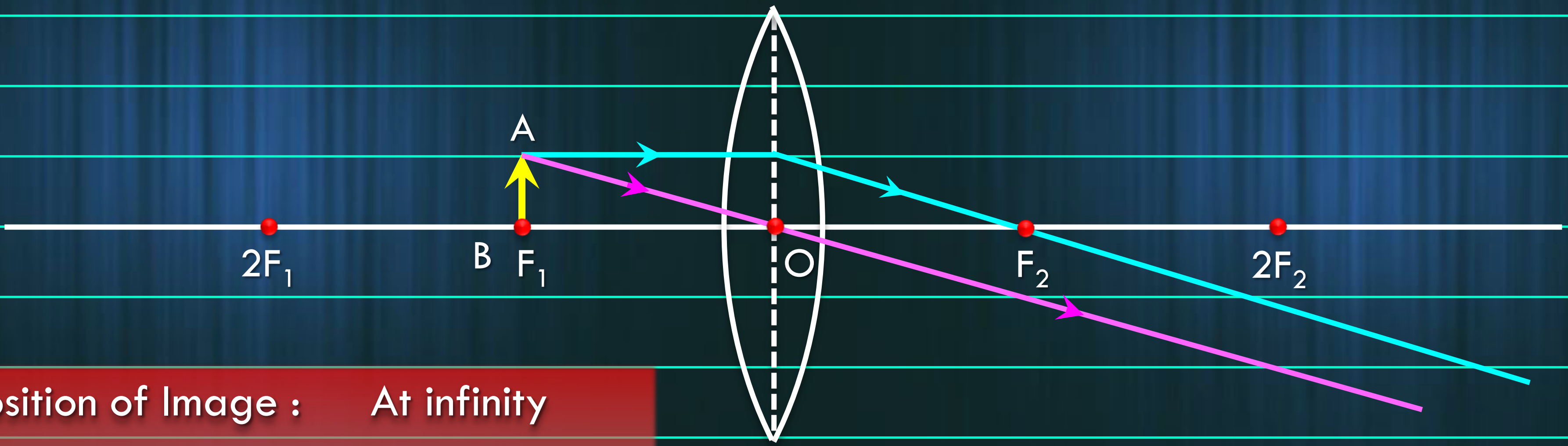
Position of Image : Beyond $2F_2$

Nature of Image : (A) Real

(B) Inverted

(C) Larger

Object at F_1



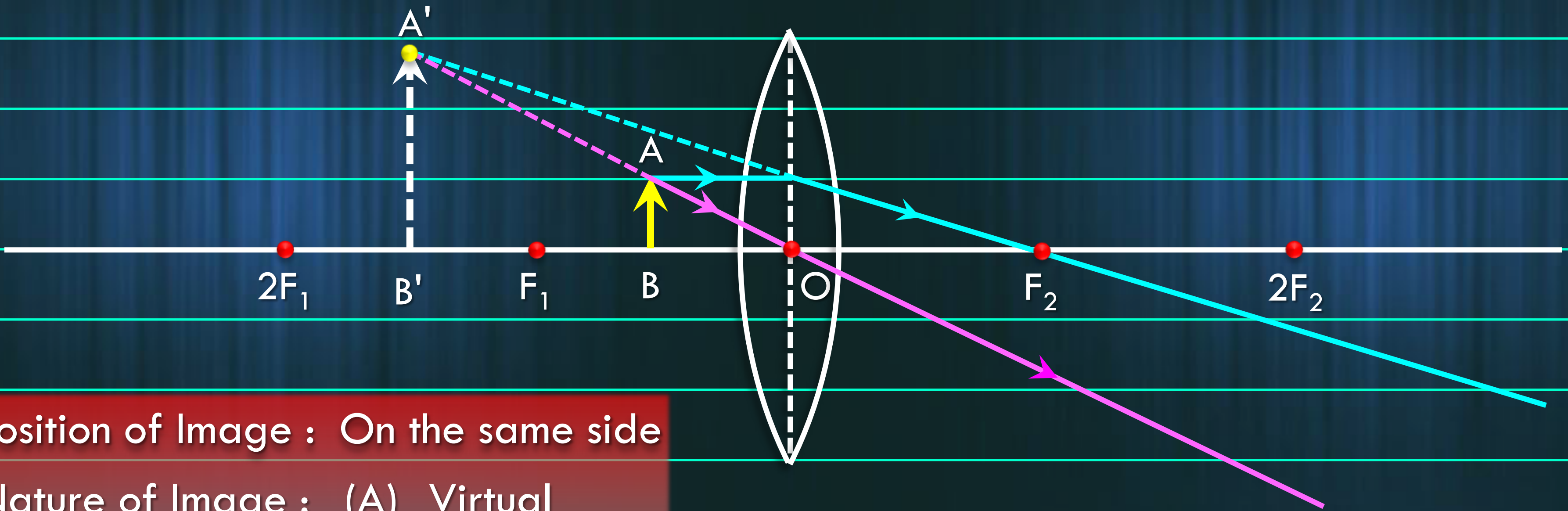
Position of Image : At infinity

Nature of Image : (A) Real

(B) Inverted

(C) Very large

Object between F_1 and O



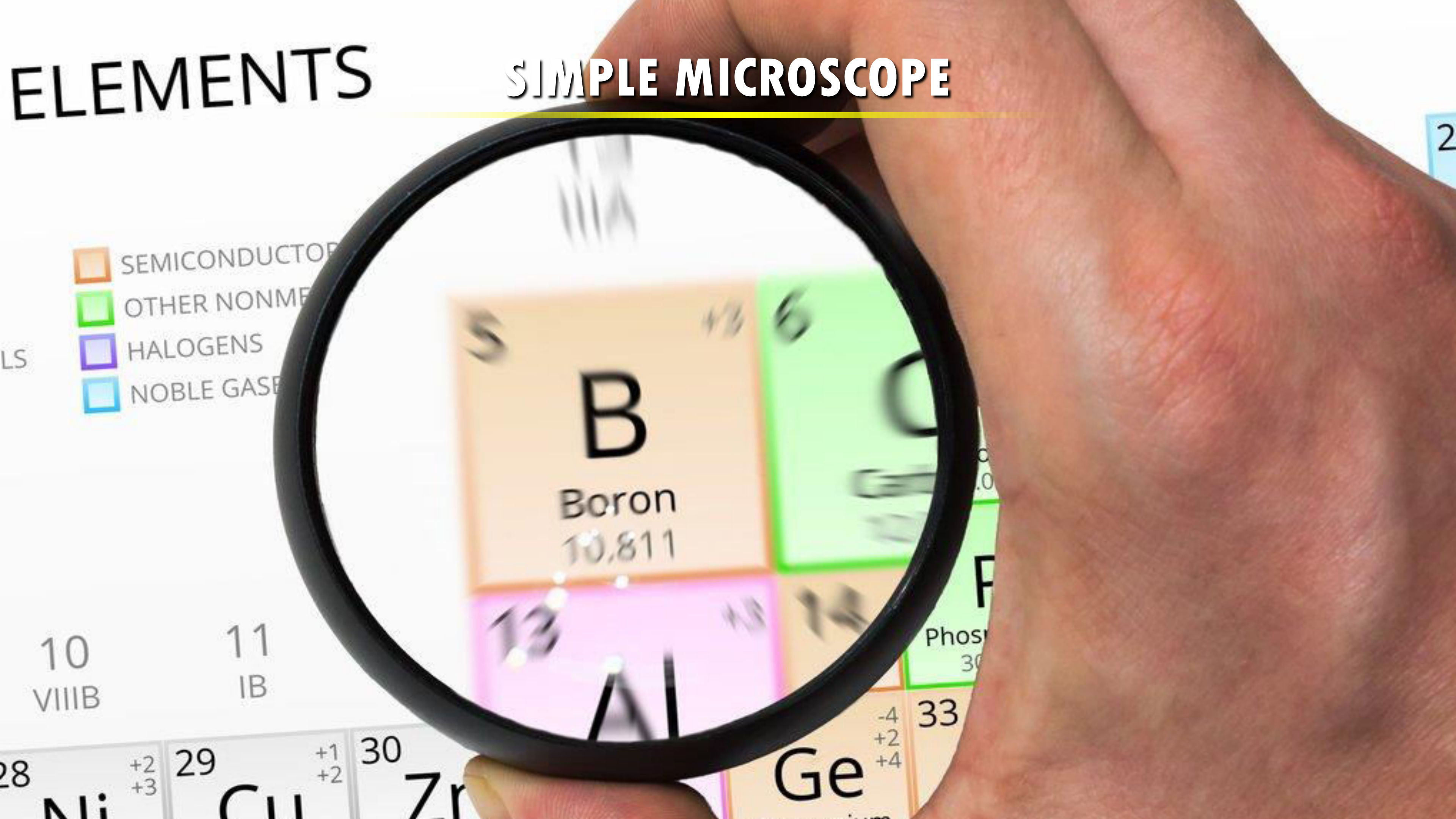
Position of Image : On the same side

Nature of Image : (A) Virtual

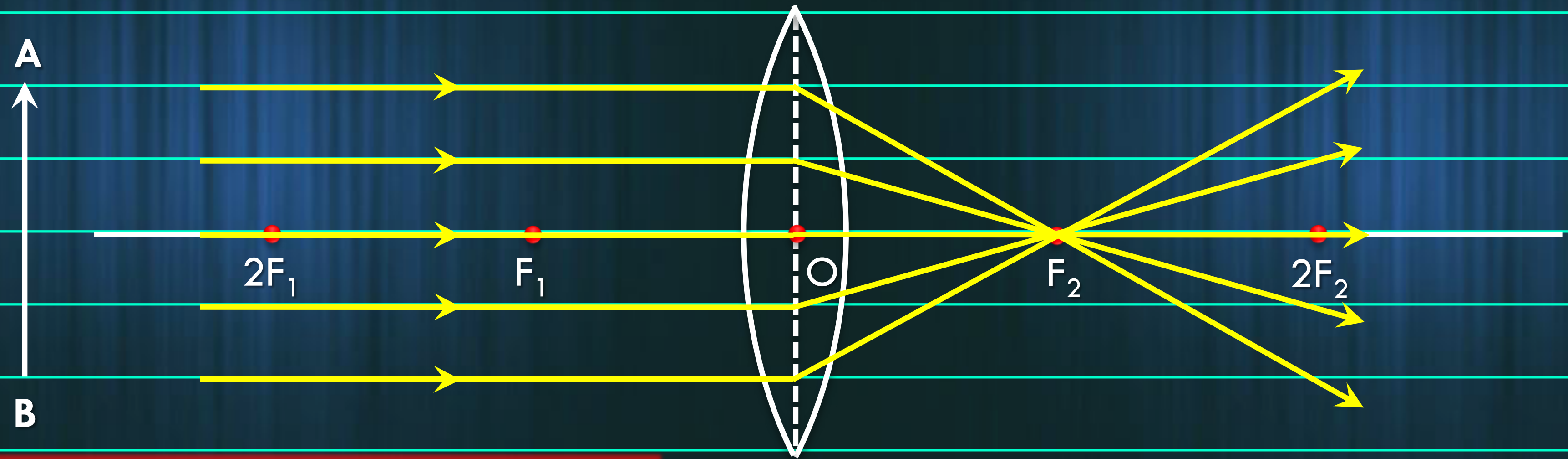
(B) Erect

(C) Large

SIMPLE MICROSCOPE



Object at infinity



Position of Image :		At focus
Nature of Image :	(A)	Real
	(B)	Inverted
	(C)	Point image

Q.

Where should an object be placed in front of a convex lens to get a real image of the size of the object?

(a) At the principal focus of the lens

(b) At twice the focal length

(c) At infinity

(d) Between the optical centre of the lens and its principal focus.

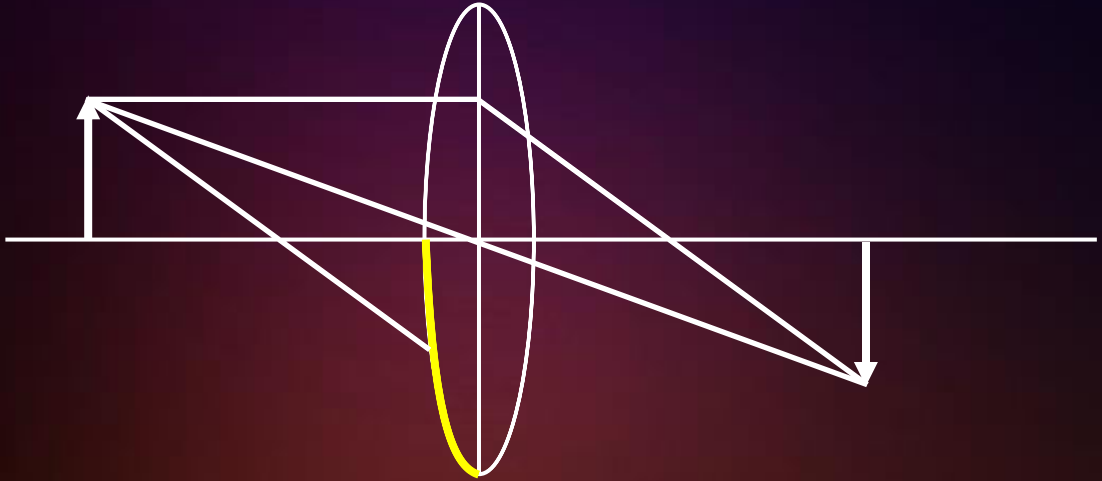
Ans.

(b) At twice the focal length

Q.

One half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Justify your answer.

Ans.

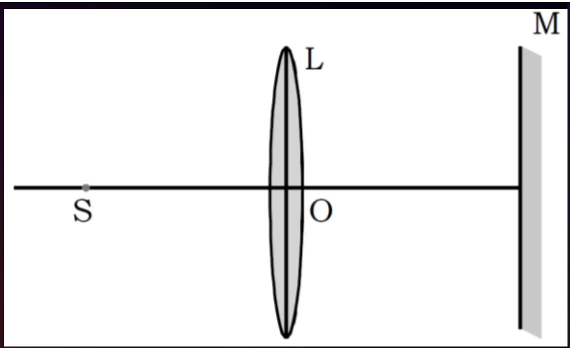


Lens will produce a complete image of the object.
Intensity of the image is reduced because rays from the top portion of the lens only are refracted and forms the image.

Q.

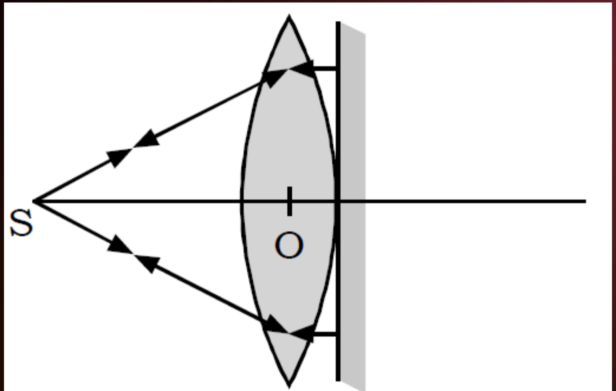
Figure below shows a point source of light S, a convex lens L and a plane mirror M. The three are placed such that rays of light from S return to it after reflection from M.

(i) What is the distance OS called (ii) To which point (left of S, on S or right of S) will the rays returns if M is moved to the left and brought in contact with L ?



Ans. (i) The distance OS is called the focal length of the lens.

(ii) The rays will still return to the same point S. The ray diagram of the situation is as shown below:



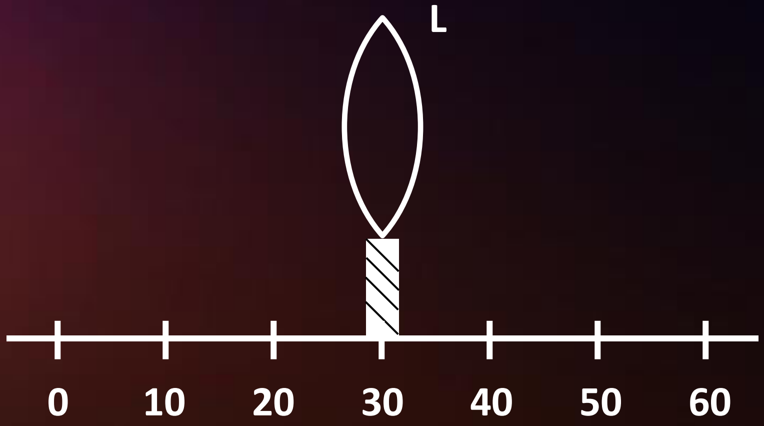
Q.

A student set up the apparatus for determining the focal length of a convex lens as shown below. She told her friend that the approximate focal length of lens was 10 cm. She asked him to place the screen, so that the image of a distant object is obtained on it by slight adjustment. He placed the screen at a mark of

(a) 10 cm (b) 40 cm (c) 50 cm (d) 45 cm

Ans. $= 30cm + f$

$= 40\ cm$

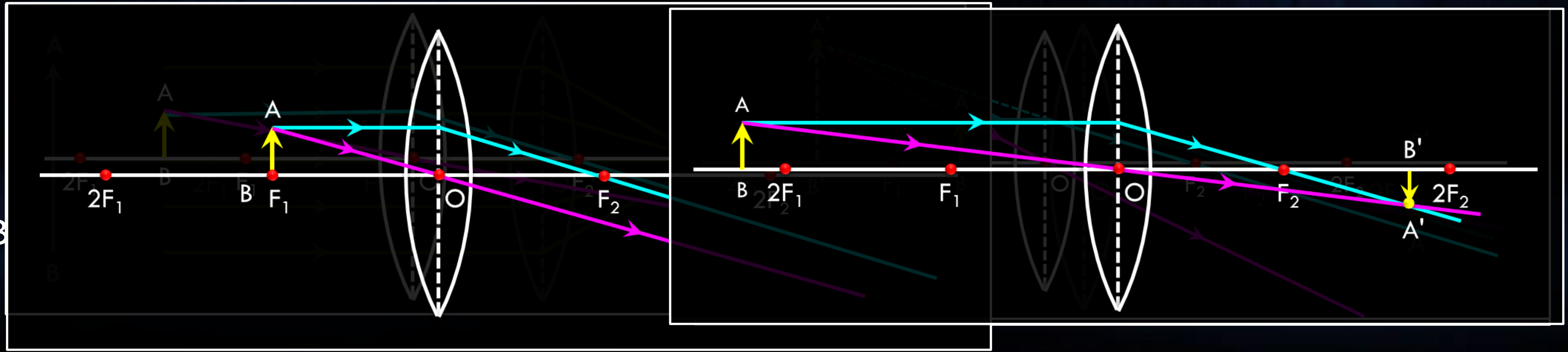


Thank You

Lec - 9

Position of object	Position of image	Size of image	Nature of image
At infinity	At focus F_2	Point image	Real & inverted
At focus F_1	At infinity	Very large	Real & inverted
Between F_1 & $2F_1$	Beyond $2F_2$	Larger	Real & inverted

REVISE ALL LENS RAY DIAGRAMS IN 3 MINUTES



USES OF A CONVEX LENSES

1. Making microscope, telescope and slide projectors.

2. Making a simple camera.

3. As a magnifying lens by watchmakers.

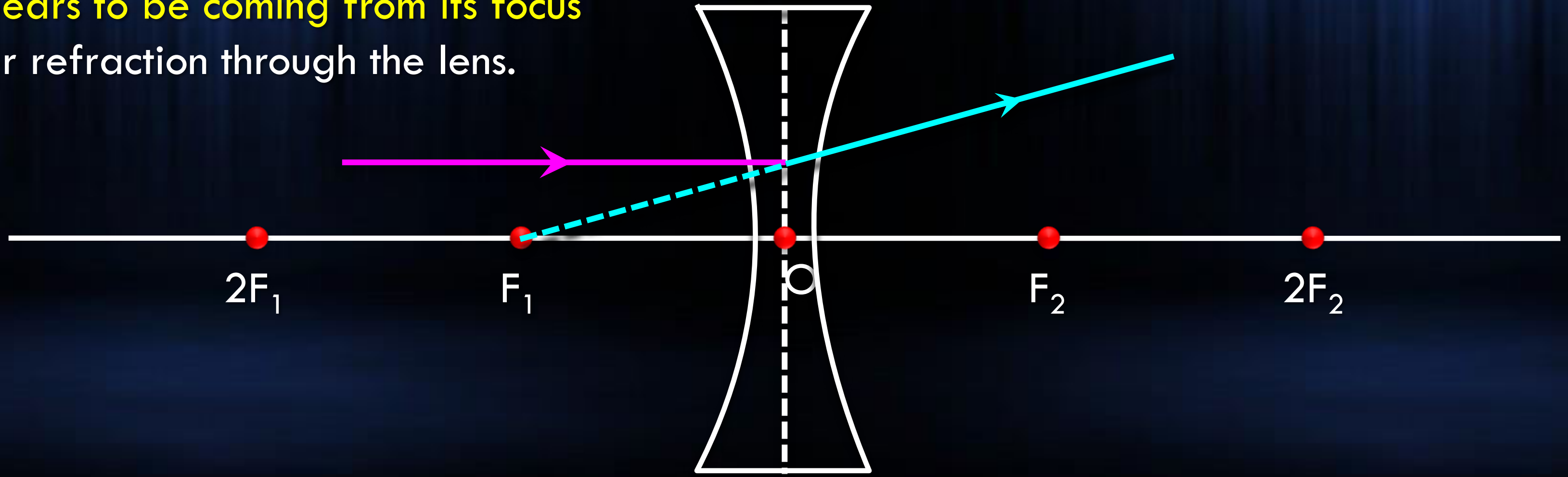
4. Used in spectacles to correct the defect of vision called hypermetropia.

RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 1

A ray of light which is parallel to the principal axis of a concave lens, appears to be coming from its focus after refraction through the lens.

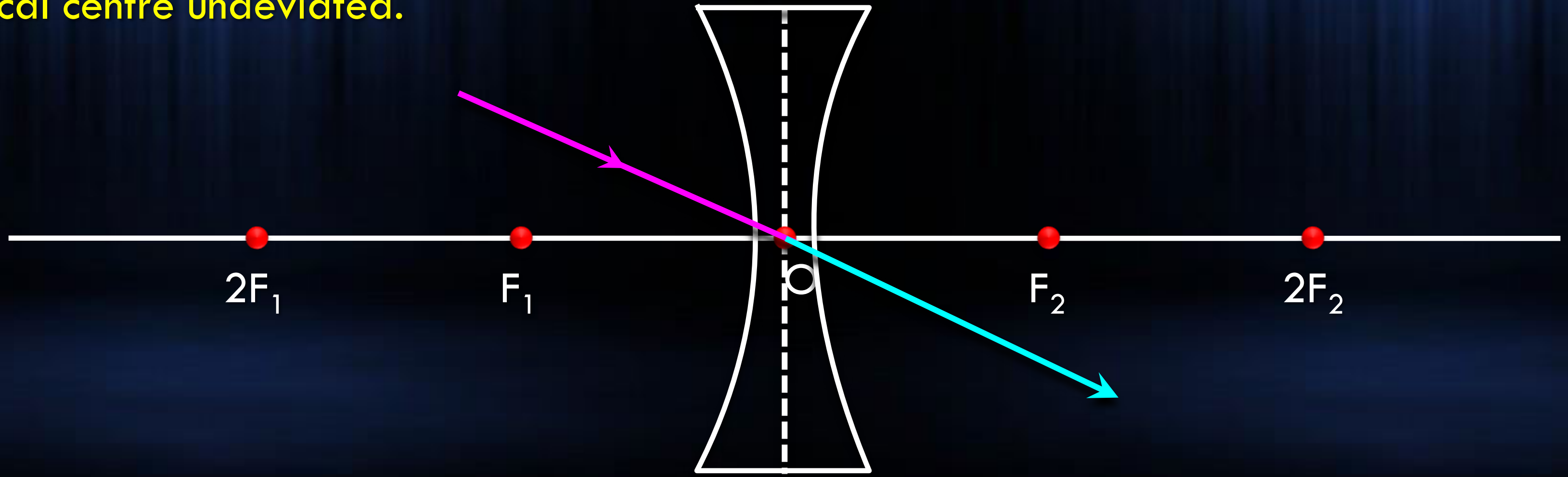


RAY DIAGRAM

RULES FOR MAKING RAY DIAGRAMS

RULE 2

A ray of light passing through the optical centre passes through the optical centre undeviated.

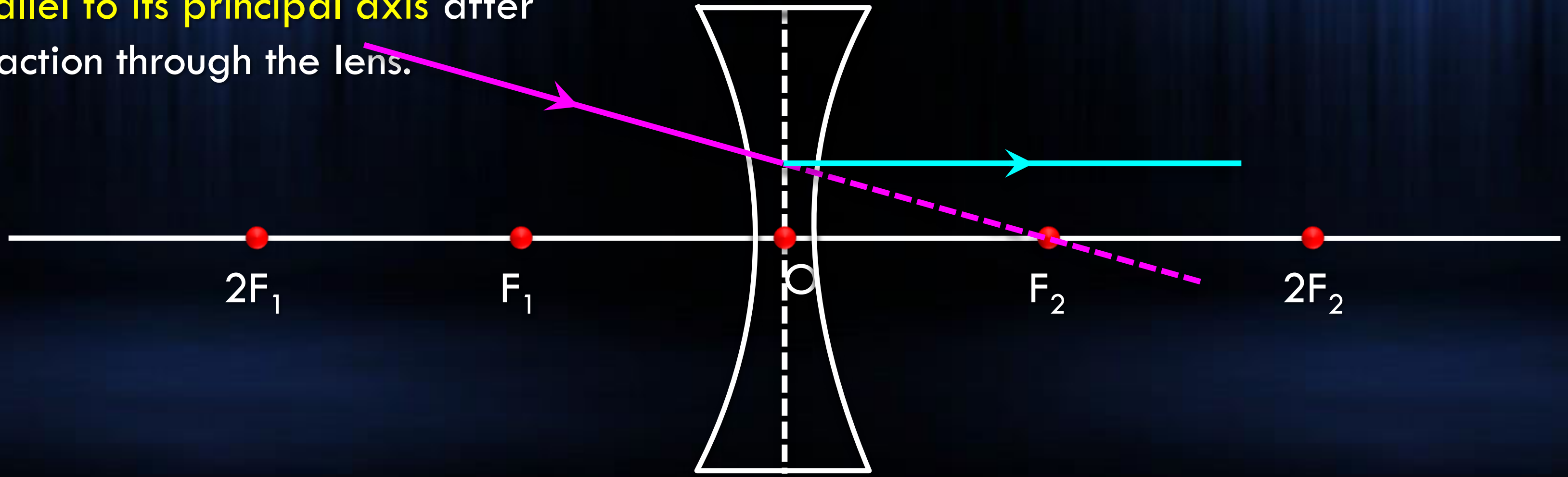


RAY DIAGRAM

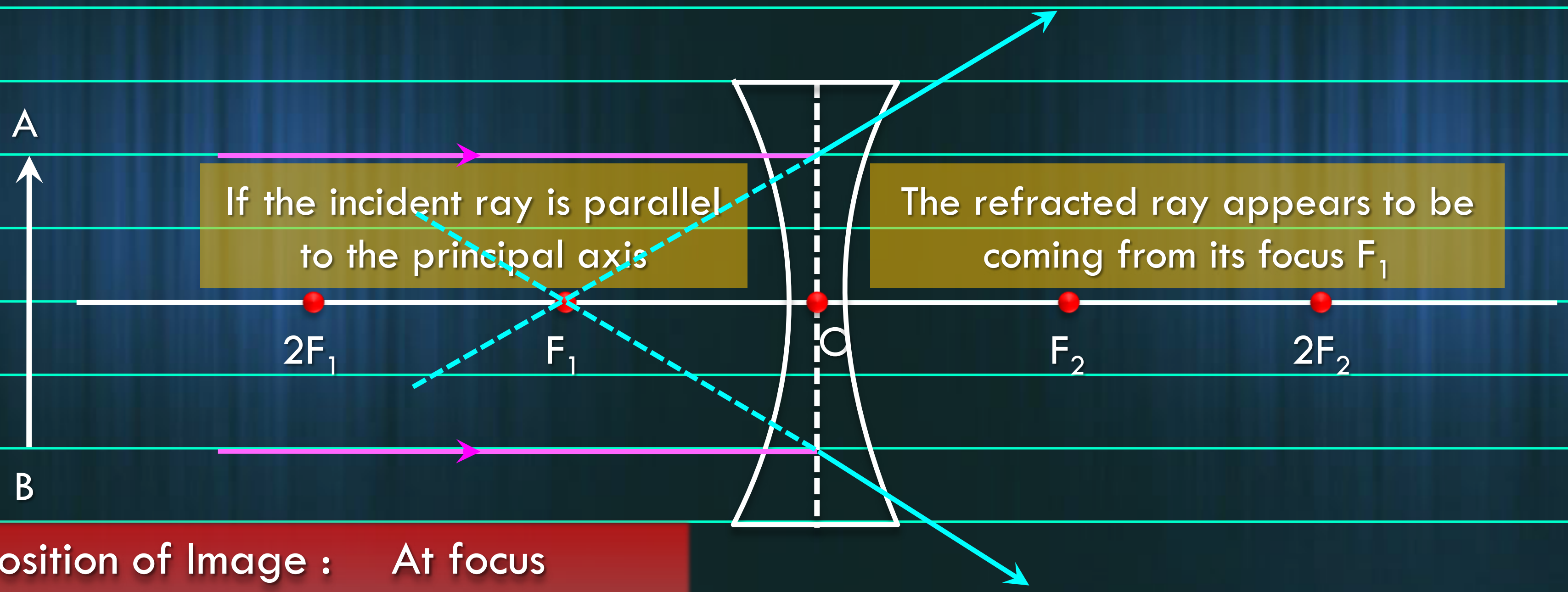
RULES FOR MAKING RAY DIAGRAMS

RULE 3

A ray of light going towards the focus of a concave lens, becomes parallel to its principal axis after refraction through the lens.



Object at infinity



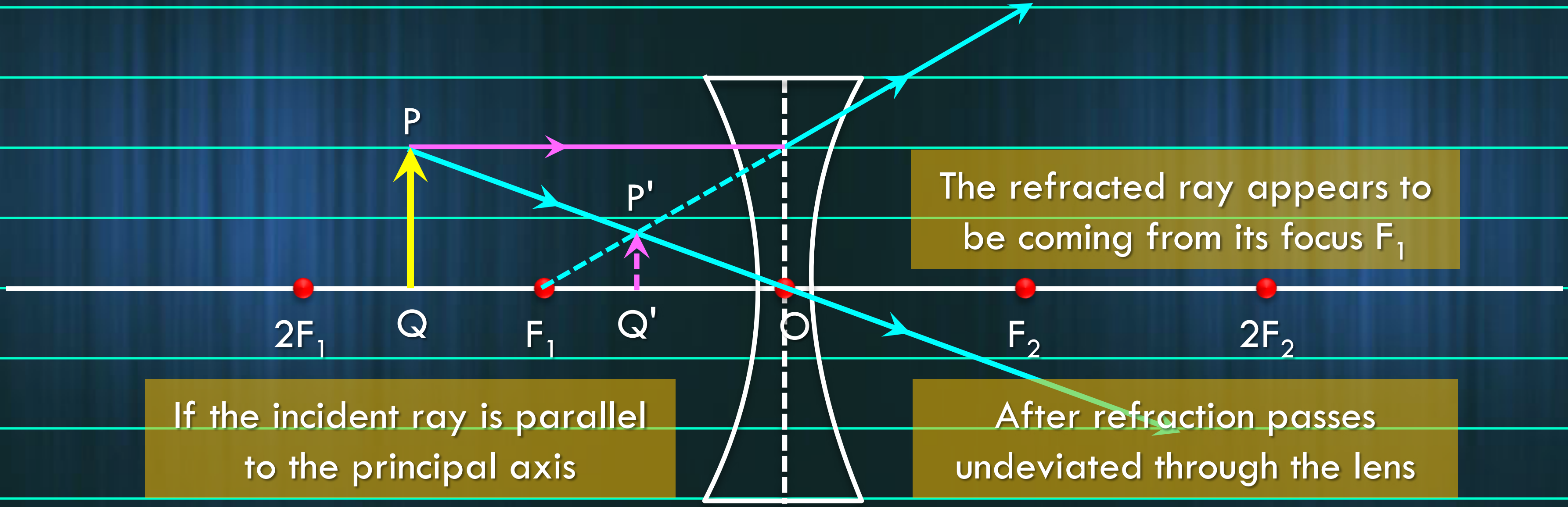
Position of Image : At focus

Nature of Image : (A) Virtual

(B) Erect

(C) Point image

Object between $2F_1$ and F_1



Position of Image : At focus

Nature of Image : (A) Virtual

(B) Erect

(C) Smaller

USES OF A
CONCAVE LENSES

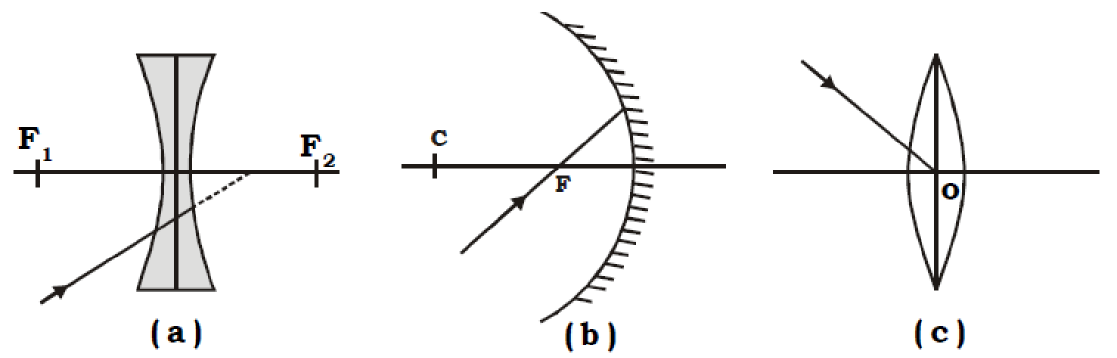
1. Used as eye-lens in Galilean telescope.

2. Used in combination with convex lenses to make high quality lens systems for optical instruments.

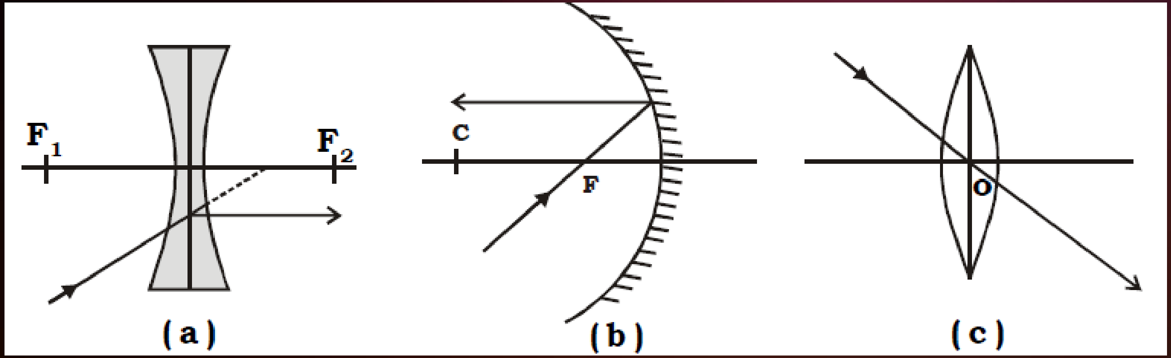
3. Used in wide angle spyhole in doors.

4. Used in spectacles to correct the defect of vision called myopia

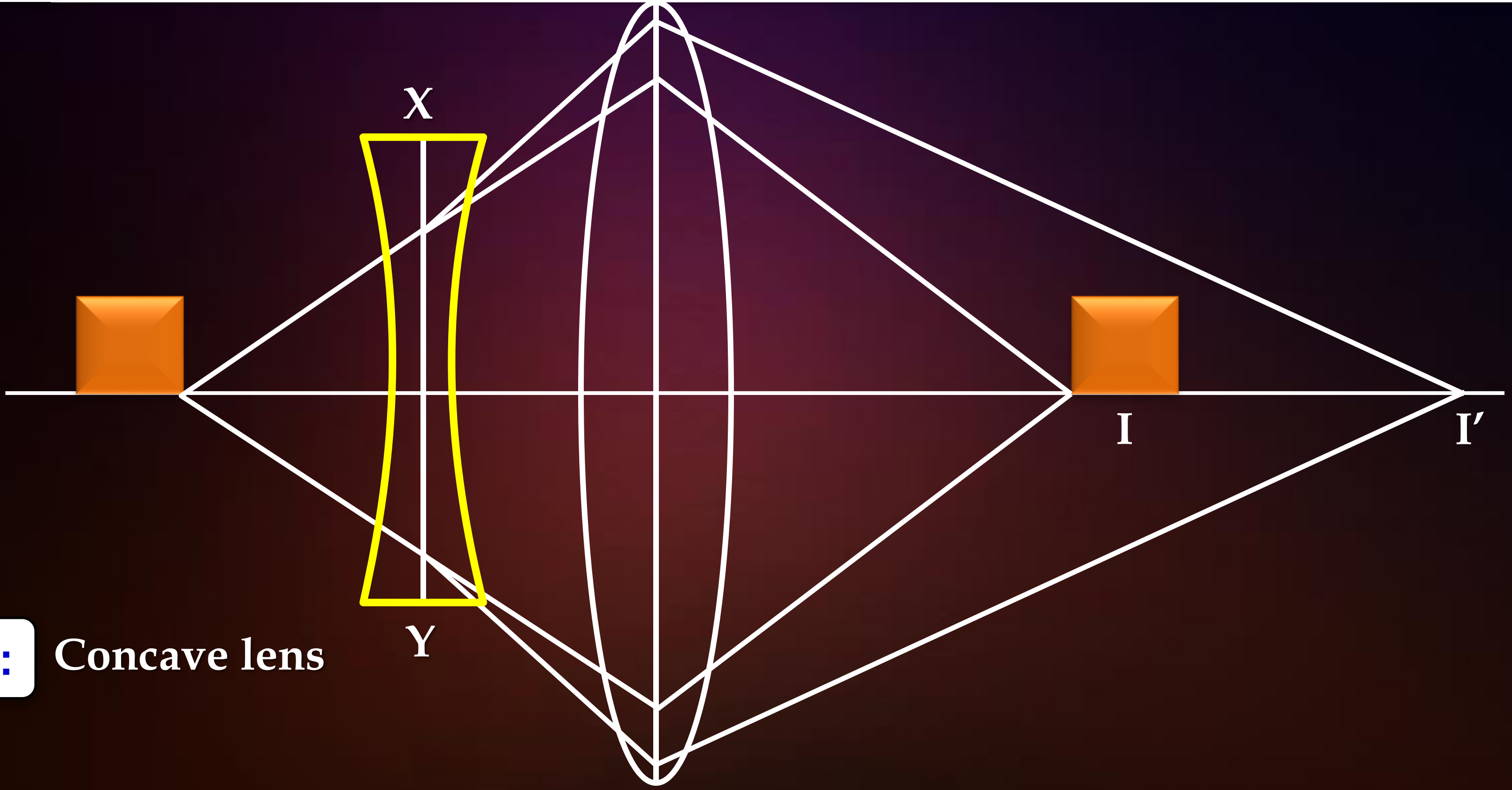
Q. Draw the pathway of light after its incidence on the lens/mirror in the following figures :



Ans.



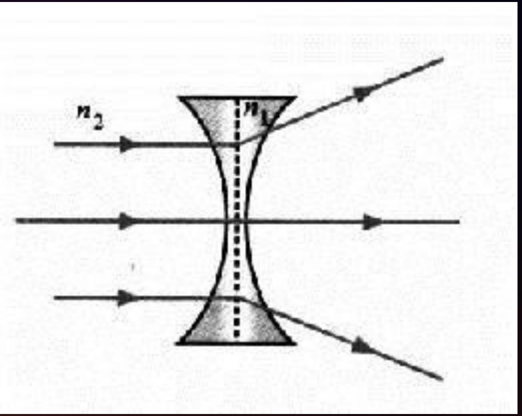
Q. What type of lens must be placed at XY so that image I shifts to I'



Sol : Concave lens

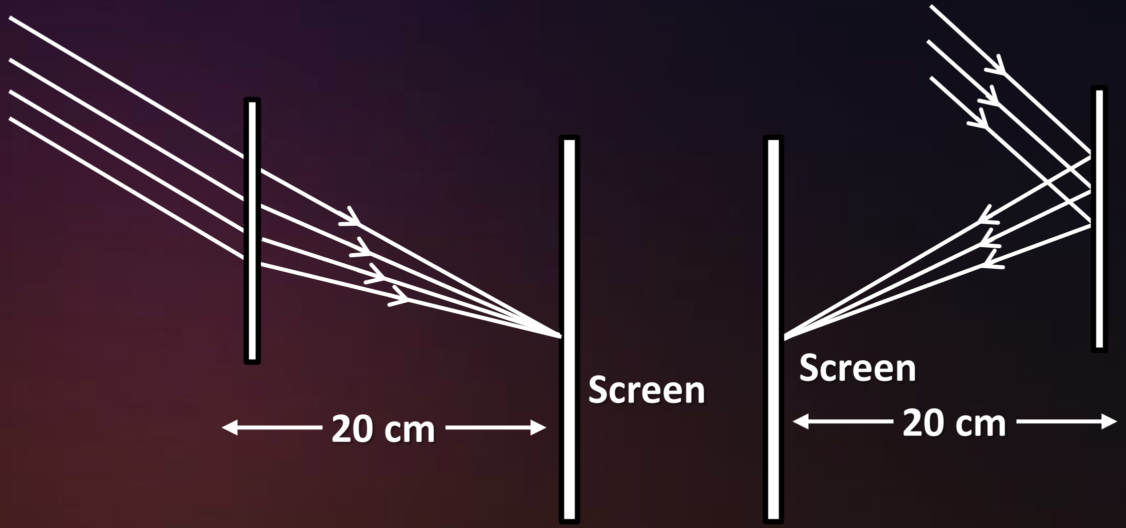
Q. A concave lens made of a material of refractive index n_1 is kept in a medium of refractive index n_2. A parallel beam of light is incident on the lens. Complete the path of rays of light emerging from the concave lens if (i) $n_1 > n_2$

Ans. When $n_1 > n_2$. light goes from rarer to denser medium, Therefore, in passing through a concave lens, it diverges.



Q.

Study the given ray diagrams and name the devices X and Y and their focal lengths respectively.



Ans.

Device X is a convex lens of focal length 20 cm.

Device Y is a concave mirror of focal length 20 cm.

Q.

Which of the following lenses would you prefer to use while reading small letters found in a dictionary?

(a) A convex lens of focal length 50 cm.

(b) A concave lens of focal length 50 cm.

(c) A convex lens of focal length 5 cm.

(d) A concave lens of focal length 5 cm.

Ans.

(c) A convex lens of focal length 5 cm.

EXTRA QUESTION

Q.

(ii) You have three lenses L_1, L_2 and L_3 of powers +10D, +5D and -10D respectively. State the nature and focal length of each lens.

(iii) Explain which of the three lenses will form a virtual and magnified image of an object placed at 15 cm from the lens.

Ans. (ii) Lens L_1 : $f_1 = \dfrac{100}{P_1} = \dfrac{100}{+10} = +10$ cm ; Convex lens

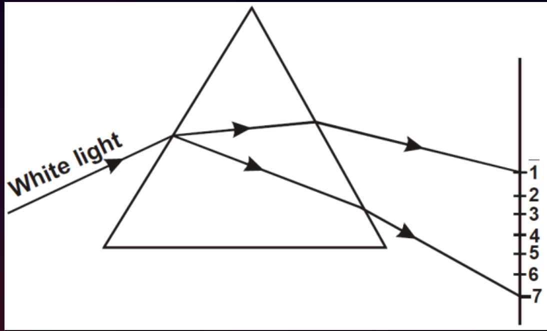
Lens L_2 : $f_2 = \dfrac{100}{P_2} = \dfrac{100}{+5} = +20$ cm ; Convex lens

Lens L_3 : $f_3 = \dfrac{100}{P_3} = \dfrac{100}{-10} = -10$ cm ; Concave lens

(iii) Lens L_2 will form a virtual and magnified image of an object placed at 15 cm from the convex lens because concave lens can never form virtual and magnified image of an object and convex lens form such image only when the object is placed between the optical centre and principle focus of the convex lens.

Q. A beam of white light falling on a glass prism gets split up into seven colours marked 1 to 7 as shown in the diagram. A student makes the following statements about the spectrum observed on the screen.

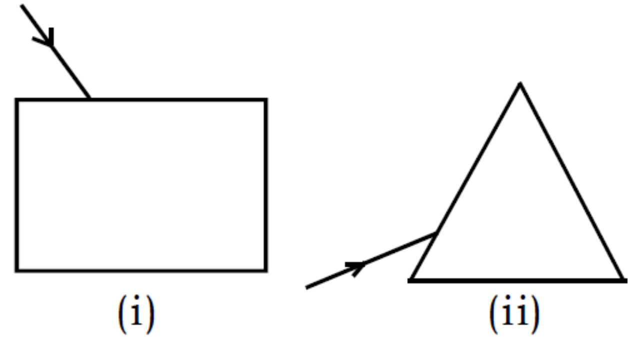
(a) The colours at position marked 3 and 5 are similar to the colour of the core of a hard–boiled egg colour and the colour of the sky respectively.
Is the statement made by the student correct or incorrect? justify.
b) Which of the two positions correspond closely to the colour of
(i) a solution of potassium permanganate,
(ii) Danger or stop signal light ?
c) State and define the phenomenon observed.



Ans. (a) 3 and 5 are yellow and blue respectively. The student has identified them as yellow (colour of the core of a hard – boiled egg) and blue (i.e., colour of sky) respectively. Hence, the statement is correct.
(b) (i) Position 7 is the position of violet colour.
(ii) Position 1 is the position of red colour.
(c) (i) The phenomenon observed here is dispersion of light.
(ii) The splitting of while light into its constituent colours,when passed through a prism, is called dispersion of light.

Q.

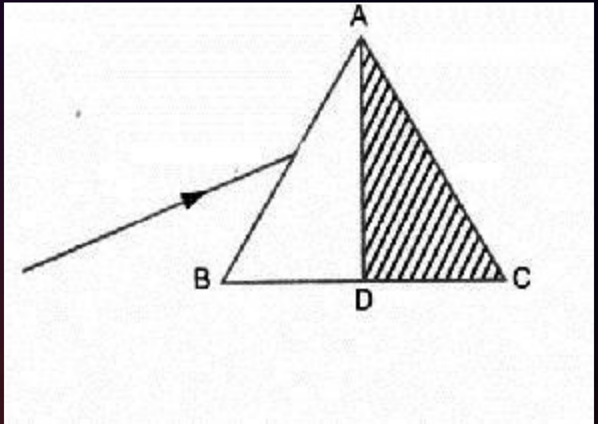
(a) A very thin narrow beam of white light is made incident on two glass objects shown below. Comment on the nature and behavior of the emergent light in all the cases.



Ans. (a) In (i) emergent beam is white, laterally displaced.

In (ii) emergent beam is a spectrum of seven colours bent by different angles.

Q. A ray of light is incident on a prism in the minimum deviation position as shown and it suffers a deviation of 40°.
What will be the deviation suffered if the shaded half of the prism is removed?



Ans. A ray of light which suffers minimum deviation always passes parallel to the base. It thus is incident on the face normally and suffers no further deviation.
Thus, the deviation is halved i.e. 20°.

Q.

A glass slab is placed over a page on which the word VIBGYOR is printed with each letter in its corresponding colour.

(i) Will the image of all the letters be in the same plane?

(ii) If not, state which letter will be raised to the maximum.

Ans. (i) No, the images of letters of different colours will be raised by slightly different heights.

(ii) The letter, V, corresponding to the violet colour will be raised to the maximum. This is because, Apparent depth = real depth / n

Now, n is maximum for the violet colour. Its apparent depth would, therefore, be the least.

Hence, the violet colour (letter V) would be raised to the maximum.

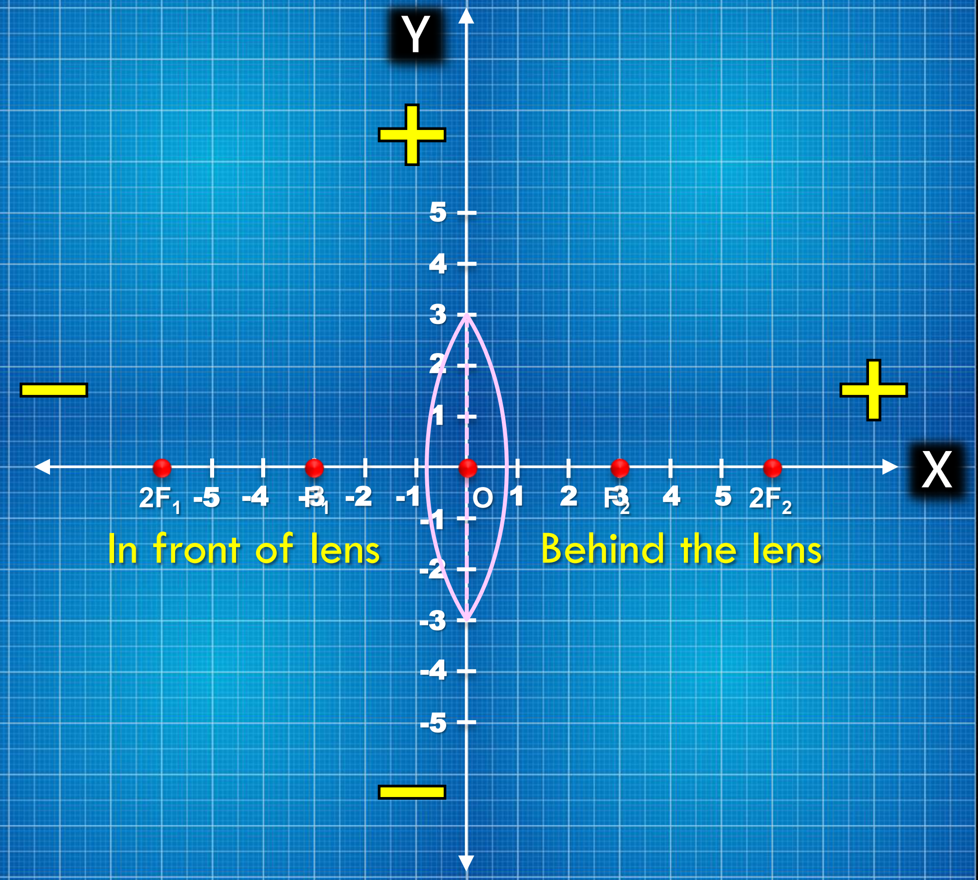
Q. The image of a candle flame formed by a lens is obtained on a screen placed on the other side of the lens. If the image is three times the size of the flame and the distance between lens and image is 80 cm, at what distance should the candle be placed from the lens?
What is the nature of the image at a distance of 80 cm and what is the type of lens?

Ans. Given, $m = -3$, $v = 80$, cm, $u = ?$
Using the expression
$m = v/u$, we have $-3 = 80/u$
or $u = -80/3 = 26.67$ cm
The image is real and the lens is a convex lens.

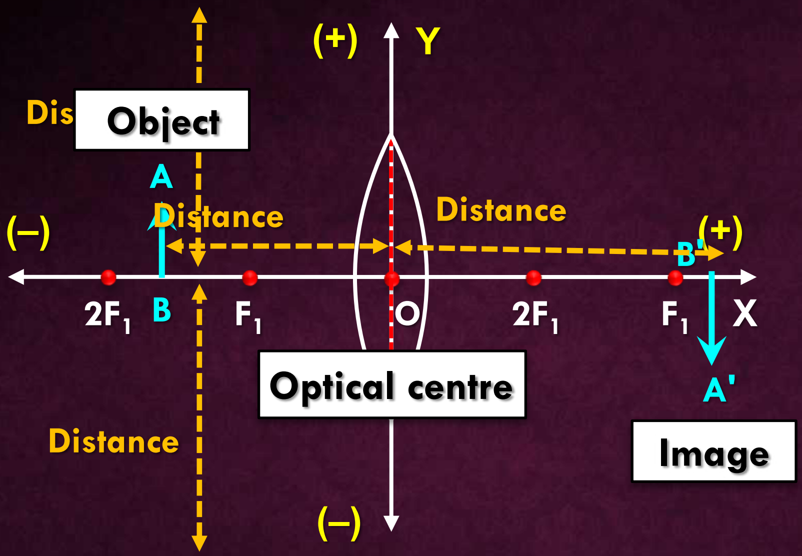
Thank You

Lec - 10

Cartesian sign convention

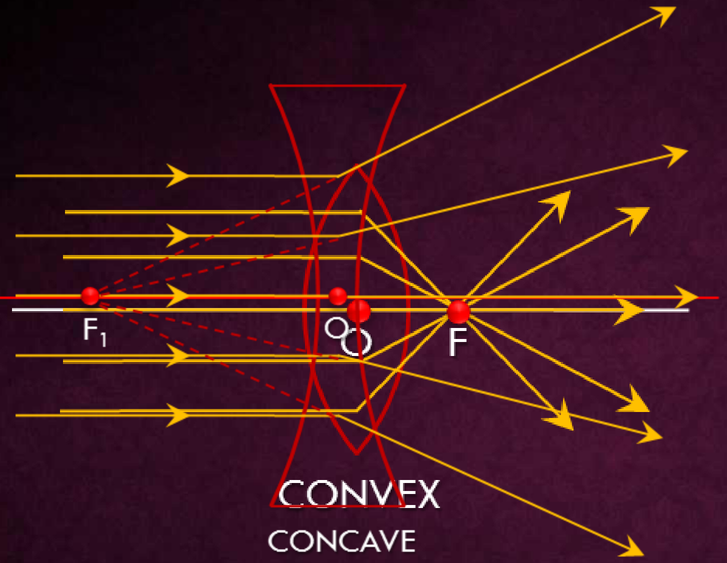


Cartesian sign convention



1. Object should be always to the left of the lens.
2. All distances parallel to principal axis are measured from the optical centre of the lens.
3. The distances to the right of origin are +ve
   The distances to the left of origin are –ve
4. The distances measured perpendicular to and above the principal axis are +ve
5. The distances measured perpendicular to and below the principal axis are –ve

Cartesian sign convention



1. Object should be always to the left of the lens.
2. All distances parallel to principal axis are measured from the optical centre of the lens.
3. The distances to the right of origin are +ve
   The distances to the left of origin are –ve
4. The distances measured perpendicular to and above the principal axis are +ve
5. The distances measured perpendicular to and below the principal axis are –ve
6. Focal length of convex lens is +ve
   Focal length of concave lens is –ve

Lens Formula

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

$v \longrightarrow$ **Image distance**

$u \longrightarrow$ **Object distance**

$f \longrightarrow$ **Focal length**

If $M > 1$, image is magnified

If $M < 1$, image is diminished

If $M = 1$, image is of the same size

Magnification (M)

$$\text{Magnification} = \frac{\text{size of the image } (h_2)}{\text{size of the object } (h_1)}$$

M = 1/2 i
than 1

If size of Image is 4

M = 1

$$\mathcal{M} = \frac{4h_2}{4h_1} = \frac{v}{u}$$

size of object is 4

TYPE - A

PROBLEMS BASED ON THE

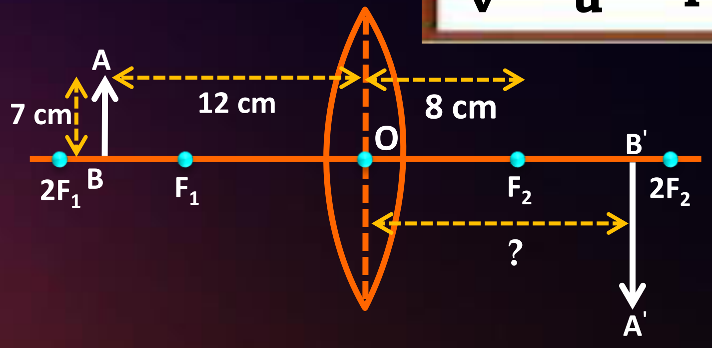
FORMULA

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

1

If an object of 7 cm height is placed at a distance of 12 cm from a convex lens of focal length 8 cm, find the position of the image.

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



Given : Object distance (u) = 12 cm

Focal length (f) = 8 cm

To find : Image distance (v) = ?

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

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

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

$\therefore \frac{1}{v} = \frac{1}{8} + \frac{1}{(-12)}$

$\therefore \frac{1}{v} = \frac{1}{8} - \frac{1}{12}$

$\therefore \frac{1}{v} = \frac{3-2}{24}$

$\therefore \frac{1}{v} = \frac{1}{24}$

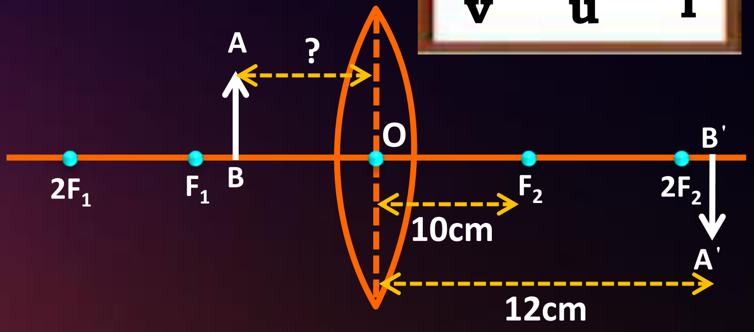
$\therefore v = \frac{24}{1}$

$\boxed{\therefore v = 24 \text{ cm}}$

The image is formed at a distance of 24 cm on the other side of the convex lens.

2 A convex lens of focal length 10 cm is placed at a distance of 12 cm from a wall. How far from the lens should an object be placed so as to form its real image on the wall ?

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



Given : Image distance (v) = + 12 cm

Focal length (f) = 10 cm

To find : Object distance (u) = ?

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

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

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

$\therefore \frac{1}{12} - \frac{1}{10} = \frac{1}{u}$

$\therefore \frac{1}{u} = \frac{5-6}{60}$

$\therefore \frac{1}{u} = \frac{-1}{60}$

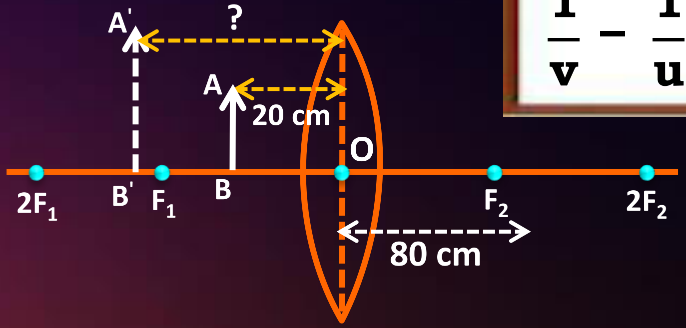
$\therefore u = \frac{-60}{1}$

$\boxed{\therefore u = -60 \text{ cm}}$

The object should be placed at a distance of 60 cm from the lens to form a real image on the wall.

3

A boy was standing at a distance of 20 cm from a convex lens. If the focal length of the lens is 80 cm, find at what distance will the image of the boy be formed ?



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

Given : Object distance (u) = - 20 cm

Focal length (f) = 80 cm

To find : Image distance (v) = ?

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

Solution :

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

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

$$\therefore \frac{1}{v} = \frac{1}{80} + \frac{1}{-20}$$

$$\therefore \frac{1}{v} = \frac{1}{80} - \frac{1}{20}$$

$$\therefore \frac{1}{v} = \frac{1-4}{80}$$

$$\therefore \frac{1}{v} = \frac{-3}{80}$$

$$\therefore v = \frac{-80}{3}$$

$$\boxed{\therefore v = -26.67 \text{ cm}}$$

The image of the boy is formed at a distance of 26.67 cm on the same side of the lens.

4

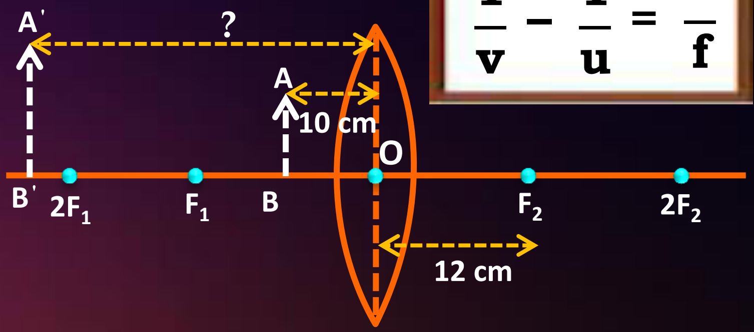
An object is placed at a distance of 10 cm from a convex lens of focal length 12 cm. Find the position and nature of the image.

Given : Object distance (u) = 10 cm

Focal length (f) = 12 cm

To find : Image Position (v) = ?

Nature of Image = ?



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

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

Solution :

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

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

$$\therefore \frac{1}{v} = \frac{1}{12} + \frac{1}{-10}$$

$$\therefore \frac{1}{v} = \frac{1}{12} - \frac{1}{10}$$

$$\therefore \frac{1}{v} = \frac{5-6}{60}$$

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

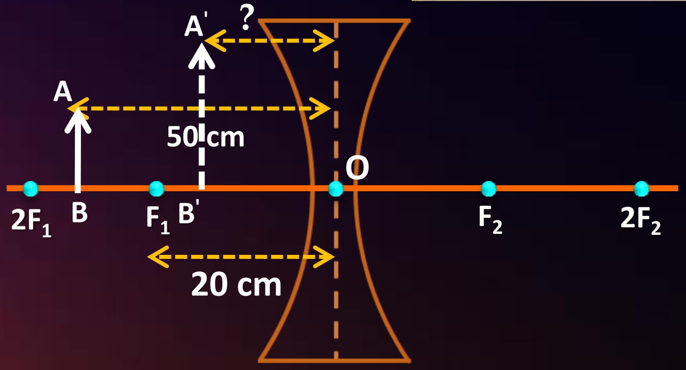
$$\therefore v = \frac{-60}{1}$$

$$\boxed{\therefore v = -60 \text{ cm}}$$

The image is formed at a distance of 60 cm on the same side of the lens, it is a virtual and erect image.

5 An object is placed at a distance of 50 cm from a concave lens of focal length 20 cm. Find the nature and position of the image.

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



Given : Object distance (u) = - 50 cm

Focal length (f) = - 20 cm

To find : Image distance (v) = ?

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

Solution :

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

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

$$\therefore \frac{1}{v} = \frac{1}{(-20)} + \frac{1}{(-50)}$$

$$\therefore \frac{1}{v} = \frac{1}{-20} - \frac{1}{50}$$

$$\therefore \frac{1}{v} = \frac{-5-2}{100}$$

$$\therefore \frac{1}{v} = \frac{-7}{100}$$

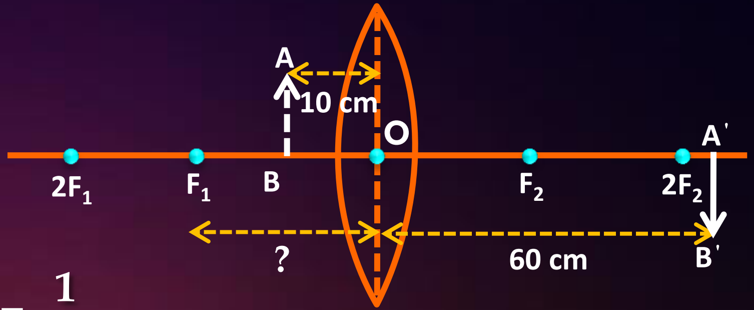
$$\therefore v = \frac{-100}{7}$$

$$\boxed{\therefore v = -14.28 \text{ cm}}$$

The image is formed at a distance of 14.28 cm on the same side of the concave lens.

6

An image was formed at a distance of 60 cm on the other side of the lens. If the object distance is 10 cm, find the focal length of the lens.



Given : Image distance (v) = 60 cm

Object distance (u) = - 10 cm

To find : Focal length (f) = ?

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

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

$\therefore \frac{1}{60} - \frac{1}{-10} = \frac{1}{f}$

$\therefore \frac{1}{60} + \frac{1}{10} = \frac{1}{f}$

$\therefore \frac{1+6}{60} = \frac{1}{f}$

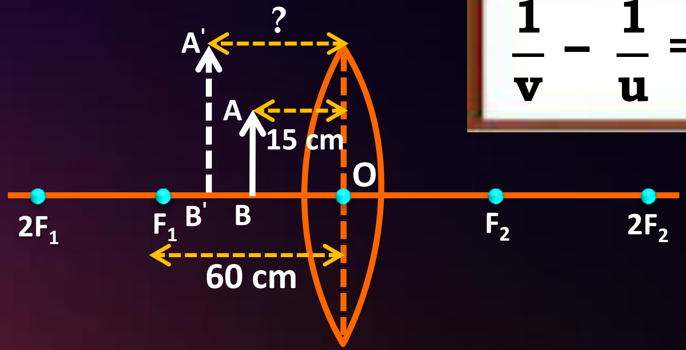
$\therefore \frac{7}{60} = \frac{1}{f}$

$\therefore \frac{60}{7} = f$

$\boxed{\therefore f = 8.57 \text{ cm}}$

The focal length of the lens is 8.57 cm.

7 An object is placed at a distance of 15 cm from a convex lens. If the focal length of the lens is 60 cm. Find the image distance.



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

Given : Object distance (u) = - 15 cm

Focal length (f) = 60 cm

To find : Image distance (v) = ?

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

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

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

$\therefore \frac{1}{v} = \frac{1}{60} + \frac{1}{(-15)}$

$\therefore \frac{1}{v} = \frac{1}{60} - \frac{1}{15}$

$\therefore \frac{1}{v} = \frac{1-4}{60}$

$\therefore \frac{1}{v} = \frac{-3}{60}$

$\therefore \frac{1}{v} = \frac{-1}{20}$

$\boxed{\therefore v = -20 \text{ cm}}$

The image of the boy is formed at a distance of 20 cm on the same side of the lens.

Thank You

TYPE - B

PROBLEMS BASED ON THE

FORMULA

$$m = \frac{h_2}{h_1} = \frac{v}{u}$$

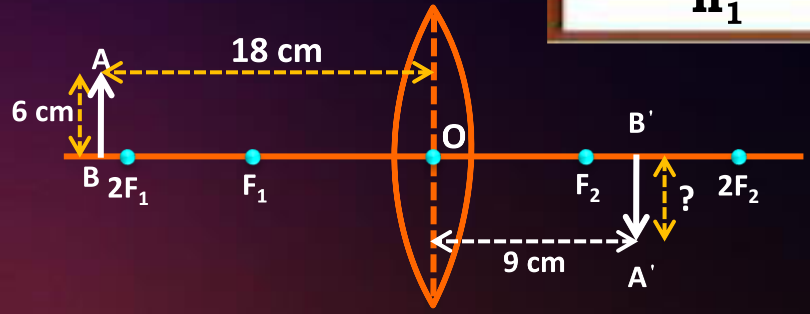
1

An object 6 cm tall is placed in front of a convex lens at a distance of 18 cm. If the image is formed at a distance of 9 cm on the other side of lens. Find the height of the image.

$$M = \frac{h_2}{h_1} = \frac{v}{u}$$

Given : Object height (h_1) = 6 cm
Object distance (u) = -18 cm
Image distance (v) = 9 cm

To find : Image height (h_2) = ?
Nature of the image = ?



Formula : $M = \frac{h_1}{h_2} = \frac{v}{u}$

Solution : $h_2 = \frac{v \times h_1}{u}$

$\therefore \quad h_2 = \frac{\cancel{9}^{1} \times 6}{-\cancel{18}_{2}}$

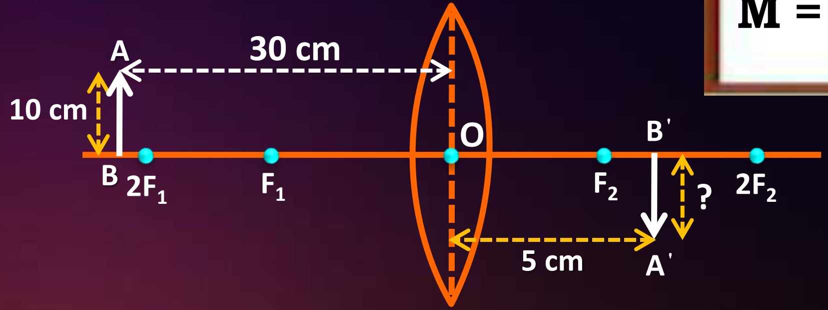
$\therefore \quad h_2 = \frac{6}{-2}$

$\boxed{\therefore \; h_2 = -3 \text{ cm}}$

The image height is 3 cm and it is inverted.

2 An object 10 cm tall is placed in front of a convex lens at a distance of 30 cm. If the image is formed at a distance of 5 cm on the other side of lens. Find the height of the image.

$$M = \frac{h_2}{h_1} = \frac{v}{u}$$



Given : Object height (h_1) = 10 cm

Object distance (u) = - 30 cm

Image distance (v) = 5 cm

To find : Image height (h_2) = ?

Nature of the image = ?

Formula : $M = \frac{h_1}{h_2} = \frac{v}{u}$

Solution : $h_2 = \frac{v \times h_1}{u}$

$\therefore \quad h_2 = \frac{5 \times \cancel{10}^{\,1}}{-\cancel{30}_{\,3}}$

$\therefore \quad h_2 = \frac{5}{-3}$

$\boxed{\therefore \; h_2 = -1.67 \text{ cm}}$

The image height is 1.67 cm and it is inverted.

TYPE - C

PROBLEMS BASED ON THE

FORMULA

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

$$m = \frac{h_2}{h_1} = \frac{v}{u}$$

1

A 5 cm tall object is placed perpendicular to principal axis of a convex lens of focal length 50 cm. The distance of the object from the axis is 10 cm. Find the nature, position and size of the image. Also find its magnification.

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

$$M = \frac{h_2}{h_1} = \frac{v}{u}$$

Given :

Object height (h_1) = 5 cm

Focal length (f) = 50 cm

Object distance (u) = -10 cm

To find :

Image Position (v) = ?

Height of Image (h_2) = ?

Nature of Image = ?

Magnification = ?

Formulae :

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

$$M = \frac{h_1}{h_2} = \frac{v}{u}$$

Solution :

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

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

$$\therefore \frac{1}{v} = \frac{1}{50} + \frac{1}{(-10)}$$

$$\therefore \frac{1}{v} = \frac{1}{50} - \frac{1}{10}$$

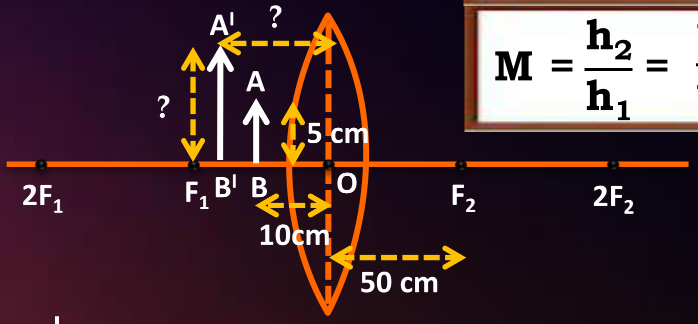
$$\therefore \frac{1}{v} = \frac{1-5}{50}$$

$$\therefore \frac{1}{v} = \frac{-4}{50}$$

$$\therefore v = \frac{-50}{4}$$

$$\boxed{\therefore v = -12.5 \text{ cm}}$$

The image is formed at 12.5 cm on the same side of the lens.



1

A 5 cm tall object is placed perpendicular to principal axis of a convex lens of focal length 50 cm. The distance of the object from the axis is 10 cm. Find the nature, position and size of the image. Also find its magnification.

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

$$M = \frac{h_2}{h_1} = \frac{v}{u}$$

Given :

Object height (h_1) = 5 cm

Focal length (f) = 50 cm

Object distance (u) = -10 cm

To find :

Image Position (v) = ?

Height of Image (h_2) = ?

Nature of Image = ?

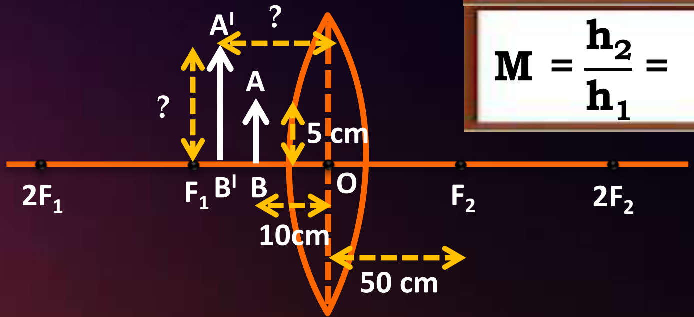
Magnification = ?

Formulae :

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

$$M = \frac{h_1}{h_2} = \frac{v}{u}$$

Solution :



$$\therefore \quad M = \frac{h_2}{h_1} = \frac{v}{u}$$

$$\therefore \quad h_2 = \frac{v \times h_1}{u}$$

$$\therefore \quad h_2 = \frac{-12.5 \times \cancel{5}^{\,1}}{-\cancel{10}_{\,2}}$$

$$\therefore \quad h_2 = \frac{-12.5}{-2}$$

$$\therefore \quad h_2 = 6.25 \text{ cm}$$

The image height is 6.25 cm and it is erect.

$$M = \frac{v}{u} = \frac{-12.5}{-10} = 1.25$$

The image is formed at 12.5 cm on the same side of the lens.

The image is magnified.

2

A 3 cm tall object is placed perpendicular to principal axis of a convex lens of focal length 15 cm. The distance of the object from the axis is 18 cm. Find the nature, position and size of the image. Also find its magnification.

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

$$M = \frac{h_2}{h_1} = \frac{v}{u}$$

Given :

Object height (h_1) = 3 cm

Focal length (f) = 15 cm

Object distance (u) = -18 cm

To find :

Image Position (v) = ?

Height of Image (h_2) = ?

Nature of Image = ?

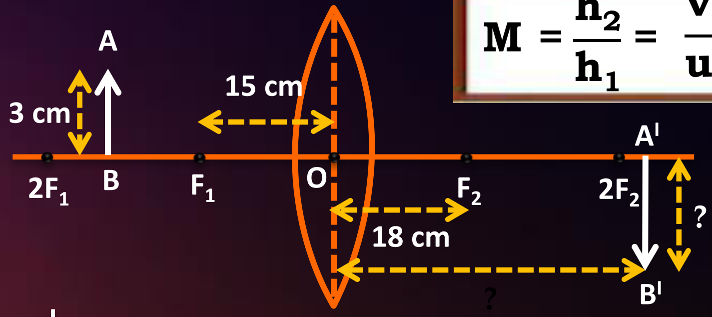
Magnification = ?

Formula :

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

$$M = \frac{h_1}{h_2} = \frac{v}{u}$$

Solution :



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

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

$$\therefore \frac{1}{v} = \frac{1}{15} + \frac{1}{(-18)}$$

$$\therefore \frac{1}{v} = \frac{1}{15} - \frac{1}{18}$$

$$\therefore \frac{1}{v} = \frac{6-5}{90}$$

$$\therefore \frac{1}{v} = \frac{1}{90}$$

$$\boxed{\therefore v = -90 \text{ cm}}$$

The image is formed at 90 cm on the other side of the lens.

2

A 3 cm tall object is placed perpendicular to principal axis of a convex lens of focal length 15 cm. The distance of the object from the axis is 18 cm. Find the nature, position and size of the image. Also find its magnification.

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

$$M = \frac{h_2}{h_1} = \frac{v}{u}$$

Given :

Object height (h_1) = 3 cm

Focal length (f) = 15 cm

Object distance (u) = -18 cm

To find :

Image Position (v) = ?

Height of Image (h_2) = ?

Nature of Image = ?

Magnification = ?

Formula :

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

$$M = \frac{h_1}{h_2} = \frac{v}{u}$$

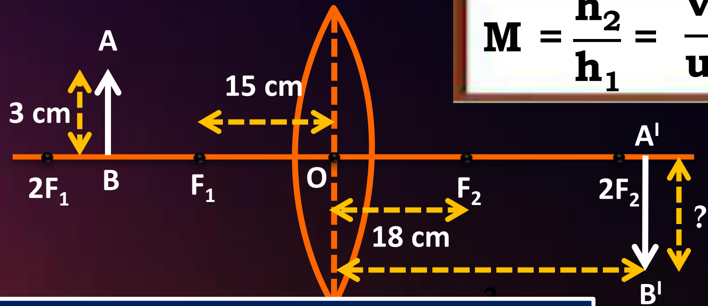
Solution :

$$\therefore \quad M = \frac{h_1}{h_2} = \frac{v}{u}$$

$$\therefore \quad h_2 = \frac{v \times h_1}{u}$$

$$\therefore \quad h_2 = \frac{\overset{5}{\cancel{90}} \times 3}{-\underset{1}{\cancel{18}}}$$

$$\therefore \quad h_2 = -15 \text{ cm}$$



The image height is 1.67 cm and it is inverted.

$$\therefore \quad M = \frac{v}{u} = \frac{90}{-18} = -5$$

The image is five times magnified. The negative sign shows that image is inverted.

The image is formed at 90 cm on the other side of the lens.

Q. An object 5 cm high is held 25 cm away from a converging lens of focal length 10 cm. Find the position, size and nature of the image formed. Also draw the ray diagram.

Ans. $h_1 = +5$ cm, $u = -25$ cm, $f = +10$cm,

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

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

$$= \frac{1}{10} + \frac{1}{(-25)}$$

$$= \frac{1}{10} - \frac{1}{25}$$

$$= \frac{5-2}{50}$$

$$= \frac{3}{50}$$

$$\boxed{\therefore v = 16.67\text{cm}}$$

The image is formed at a distance of 16.67cm on the other side of the lens.

$$m = \frac{h_2}{h_1} = \frac{v}{u}$$

$$\therefore h_2 = \frac{vh_1}{u}$$

$$h_2 = \frac{16.67 \times 5}{25}$$

$$\boxed{\therefore h_2 = -3.33 \text{ cm}}$$

∴ The image is 3.33 cm high.

Nature of image : Real and inverted.

Q. A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image at 10 cm from the lens? Also, find the magnification produced by the lens.

Ans. A concave lens always forms a virtual, erect image on the same side of the object.

v = -10 cm, f = –15 cm, u = ?

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

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

$$= \frac{1}{-10} + \frac{1}{(-15)} = -\frac{1}{10} + \frac{1}{-15}$$

$$= \frac{-3+2}{30} = \frac{1}{-30}$$

$$\boxed{\therefore u = -30 \text{ cm}}$$

Thus, the object distance is 30 cm

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

$$m = \frac{-10 \text{ cm}}{-30 \text{ cm}} = \frac{1}{3} = +0.33$$

The positive sign shows that the image is erect and virtual. The image is one-third of the size of the object.

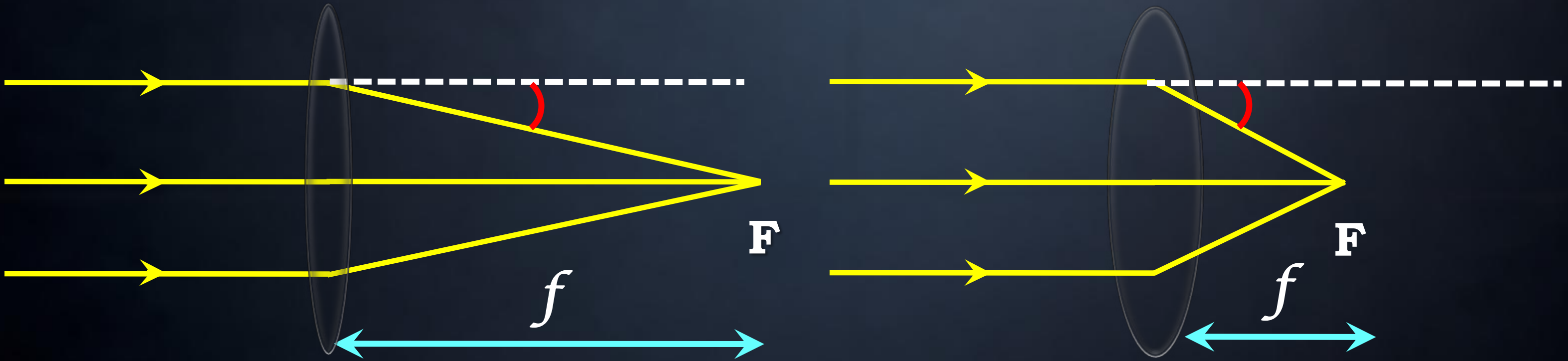
Thank You

Lec - 12

POWER OF A LENS

The power of a lens is a measure of the degree of convergence or divergence of light rays falling on it.

The power of a lens is defined as the reciprocal of its focal length in metres.



Power of a lens = $\frac{1}{f \text{ (in metres)}}$

P = $\frac{1}{\text{focal length of the}}$

A convex lens has a positive focal length, so **the power of a convex lens is positive.**

SI unit : "dioptre" (D)

A concave lens has a negative focal length, so **the power of a concave lens is negative**

POWER OF A

COMBINATION OF LENSES

If a number of lenses are placed in close contact, then the power of the combination of lenses is equal to the algebraic sum of the powers of individual lenses.

Thus, if two lenses of powers p_1 and p_2 are placed in contact with each other, then their resultant power P is given by:

$$P = p_1 + p_2$$

∴ **For n number of lenses**

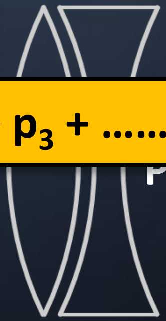
$$P = p_1 + p_2 + p_3 + \ldots\ldots + p_n$$

$P = +4D$

Convex lens

$P = -10D$

Concave lens



$P = -6D$

Combination of convex & Concave lens

$$\begin{aligned} P &= p_1 + p_2 \\ &= +4 + (-10) \\ &= 4 - 10 \\ &= -6\ D \end{aligned}$$

TYPE - D

PROBLEMS BASED ON THE

FORMULA

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

1 A convex lens is of focal length 10 cm. What is its power?

Given : Focal length (f) = 10 cm = $\frac{10}{100}$ = 0.1 m

To find : Power of lens (P) = ?

Formula : $P = \frac{1}{f(\mathrm{m})}$ dioptre

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

$\therefore \quad P = \frac{1}{0.1}$

$\therefore \quad P = \frac{1 \times 10}{1}$

$\boxed{\therefore\ P = 10 \text{ dioptre}}$

The power of this convex lens is +10 dioptres

2

Calculate the power of a convex lens of focal length 20 cm.

Given : Focal length (f) $= 20 \text{ cm} = \dfrac{20}{100} = 0.2 \text{ m}$

To find : Power of lens (P) $= ?$

Formula : $P = \dfrac{1}{f(\text{m})}$ dioptre

Solution : $P = \dfrac{1}{f}$

$\therefore \quad P = \dfrac{1}{0.2}$

$\therefore \quad P = \dfrac{10}{2}$

$\boxed{\therefore P = 5 \text{ dioptre}}$

The power of the lens is 5 dioptre

3 Find the power of a concave lens of focal length 2 m.

Given : Focal length (f) = – 2 m

To find : Power of lens (P) = ?

Formula : $P = \dfrac{1}{f(\text{m})}$ dioptre

Solution : $P = \dfrac{1}{f}$

$\therefore \quad P = \dfrac{1}{-2}$

$\boxed{\therefore\ P = -0.5 \text{ dioptre}}$

The power of this concave lens is – 0.5 dioptre.

4 A thin lens has a focal length of, –25 cm. What is the power of the lens and what is its nature?

Given : Focal length (f) $= -25 \text{ cm} = -\dfrac{25}{100} = -0.25 \text{ m}$

To find : Power of lens (P) $= ?$

Formula : $P = \dfrac{1}{f(\text{m})}$ dioptre

Solution : $P = \dfrac{1}{f}$

$\therefore \quad P = \dfrac{1}{-0.25}$

$\therefore \quad P = -\dfrac{1 \times 100}{25}$

$\boxed{\therefore\ P = -4 \text{ dioptre}}$

The power of this concave lens is – 4 dioptres
The minus sign with the power indicates that it is a concave lens.

5

A person having a myopic eye uses a concave lens of focal length 50 cm. What is the power of the lens?

Given : Focal length (f) $= -50\text{ cm} = -\dfrac{50}{100} = -0.5\text{ m}$

To find : Power of lens (P) $= ?$

Formula : $P = \dfrac{1}{f(\text{m})}$ dioptre

Solution : $P = \dfrac{1}{f}$

$\therefore \quad P = \dfrac{1}{-0.5}$

$\therefore \quad P = -\dfrac{1 \times 10}{5}$

$\boxed{\therefore P = -2 \text{ dioptre}}$

The power of this convex lens is – 2 dioptres

6 The power of a lens is + 2.5 D. What kind of lens it is and what is its focal length?

Given : Power of lens = 2.5 D

To find : Focal length (f) = ?

Formula : $P = \frac{1}{f(\text{m})}$ dioptre

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

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

$\therefore \quad f = \frac{1}{2.5}$

$\therefore \quad f = \frac{1 \times 10}{25}$

$\boxed{\therefore\ f = 0.4\ \text{cm}}$

The power of this lens has positive sign, so it is a convex lens.

The focal length of the lens is 0.4 m.

7 Two thin lenses of power, + 3.5 D and, -2.5 D placed in contact. Find the power and focal length of the lens combination

Given :

$p_1 = +3.5\text{ D}$

$p_2 = -2.5\text{ D}$

To find : Power of combination of lens (P) = ?

Focal length of combination of lens (f) = ?

Formula : $P = p_1 + p_2$ $\quad P = \dfrac{1}{f(\text{m})}$ dioptre

Solution :

$P = p_1 + p_2$

$P = +3.5 + (-2.5)$

$P = +3.5 - 2.5$

$\boxed{\therefore P = +1.0\text{ D}}$

The power of this combination of lenses is, +1.0 dioptre.

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

$+1 = \dfrac{1}{f}$

$\boxed{\therefore f = +1\text{ m}}$

Focal length of this combination of lenses is, +1 metre

8

A convex lens forms a real and inverted image of a needle at a distance of 50 cm from the lens. If the image is of the same size as the needle, where is the needle placed in front of the lens? Also, find the power of the lens.

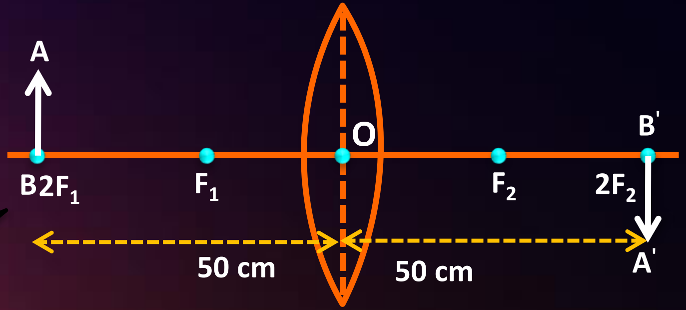
Given : Focal length (f) $= 25\text{ cm} = \frac{25}{100} = 0.25\text{ m}$

To find : Power of lens (P) = ?

Formula

Solution

When the image formed by a convex lens is of the same size as the needle, then the distan... of needl...



Since the image is real, inverted and of same size as the needle. Thus, the needle is placed at a distance of 50 cm from lens in the front.

$\therefore \quad P = +4\text{ D}$

The power of this convex lens is + 4.0 dioptres.

Q. Which one of the following materials cannot be used to make a lens?

(a) Water **(b) Glass** **(c) Plastic** **(d) Clay**

Ans.

Clay. Because it is not transparent.

Thank You