CLASS 10TH MID TERM

SCORE BOOSTER

PHYSICS

LIGHT REFRACTION

ONE SHOT

Refraction of Light

- **Snell's Law**
  - $n = \frac{\sin i}{\sin r} = \frac{Velocity\ of\ light\ in\ medium\ 1}{Velocity\ of\ light\ in\ medium\ 2} = \frac{c}{v}$

Lens

- **Convex: Bulged outward**
- **Concave: Curved inward**

Image Formation

- **Concave lens Always produce virtual and diminished image.**
- **Convex lens can produce virtual as well as real image**

Mirror Equation

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

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Topic	PDF	Link
Real Numbers		
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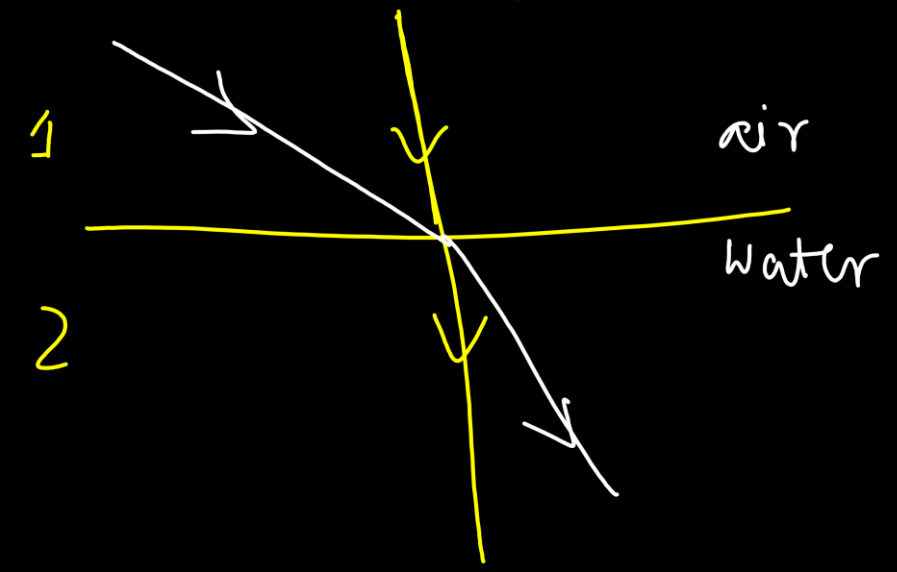
Refraction of light

MCQ 1: Light ray changes its direction as it enters another medium

a) only for oblique incidence
b) only for normal incidence
c) any type of incidence
d) It does not change its direction.



Snell's Law

MCQ 2 : If i is the angle of incidence and r is the angle of refraction, then which of the following is correct? (n=refractive index of the second medium with respect to the first.)

a) $i = r$ ✗

b) $\sin i = \sin r$ ✗

c) ✓ $n = \dfrac{\sin i}{\sin r}$

d) $n = \dfrac{\sin r}{\sin i}$

$\dfrac{\sin i}{\sin r}$ = Constant

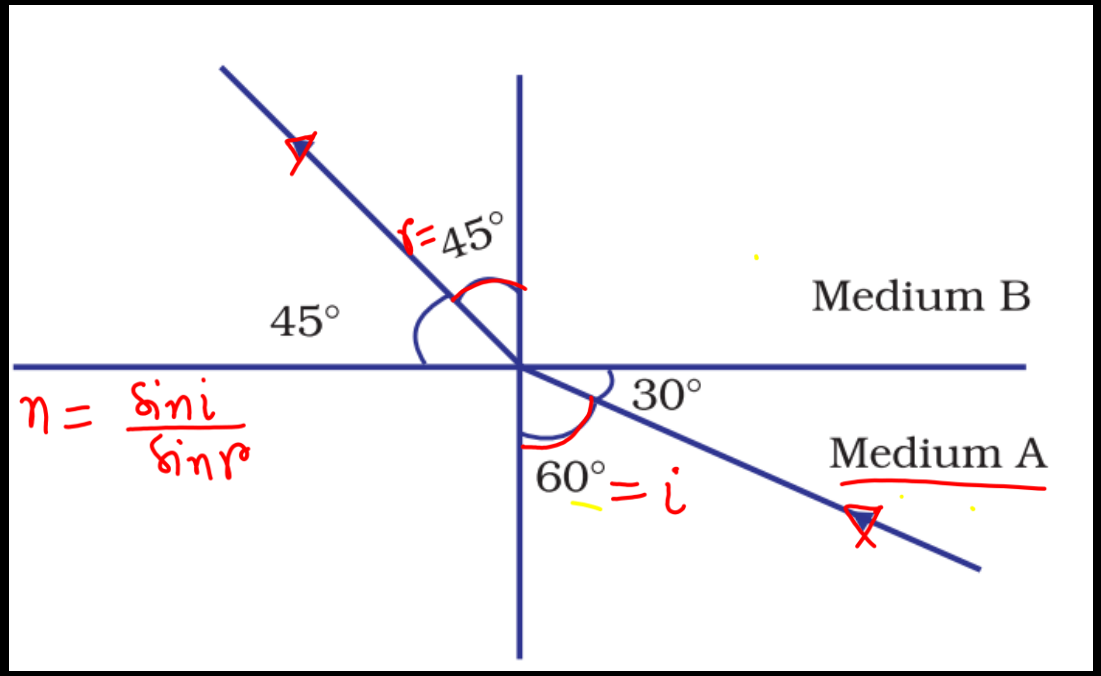
= r. i (n)

$2 = \sqrt{2} \times \sqrt{2}$

Snell's Law

MCQ 3. Figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is

(a) $\sqrt{3}/\sqrt{2}$
(b) $\sqrt{2}/\sqrt{3}$
(c) $\sqrt{2}$
(d) $1/\sqrt{2}$



$$\eta = \frac{\sin 60^\circ}{\sin 45^\circ}$$

$$= \frac{\sqrt{3}/2}{1/\sqrt{2}}$$

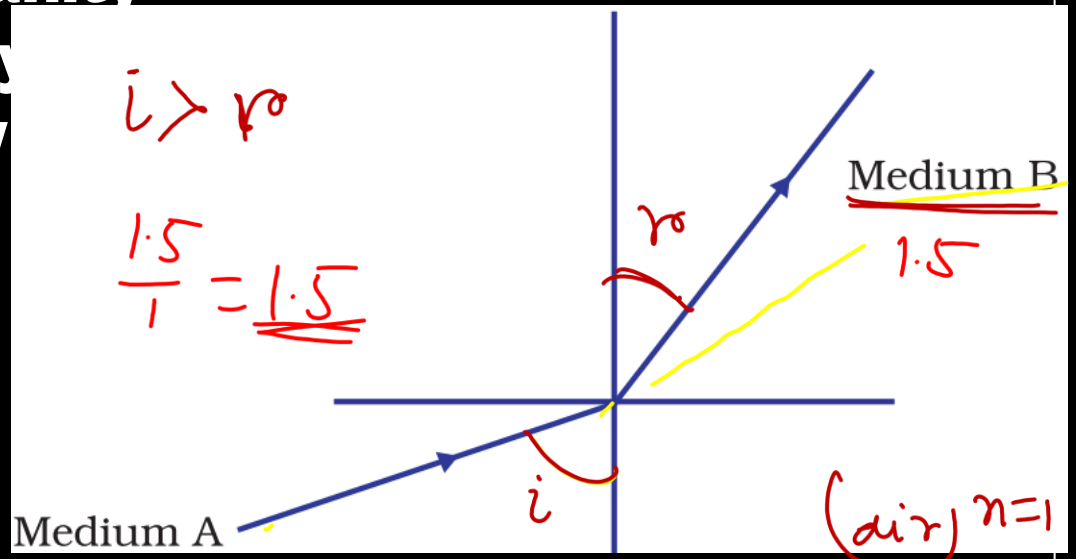
$$= \frac{\sqrt{3} \times \sqrt{2}}{2\sqrt{2}} = \frac{\sqrt{3}}{\sqrt{2}}$$

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

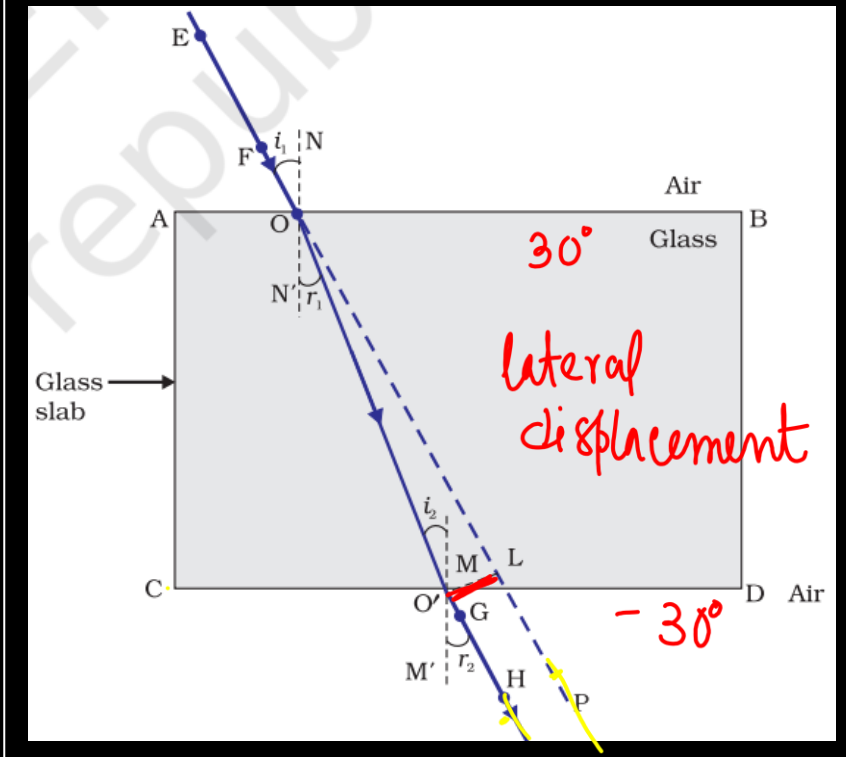
Snell's Law

MCQ 4 A light ray enters from medium A to medium B as shown in Figure 10.2. The refractive index of medium B relative to A will be

(a) greater than unity
(b) less than unity
(c) equal to unity
(d) zero



Refraction Through a Glass Slab



SA 1: Why does a light ray incident on a rectangular glass slab immersed in any medium emerges parallel to itself? Explain using a diagram.

Answer:

The extent of bending of the ray of light at the opposite parallel faces AB (air-glass interface) and CD (glass-air interface) of the rectangular glass slab is equal and opposite. This is why the ray emerges parallel to the incident ray. However, the light ray is shifted sideward slightly. This is known as Lateral displacement.

Refractive Index

SA 2: How is the refractive index of a medium related to the speed of light?
Obtain an expression for refractive index of a medium with respect to another in terms of speed of light in these two media?

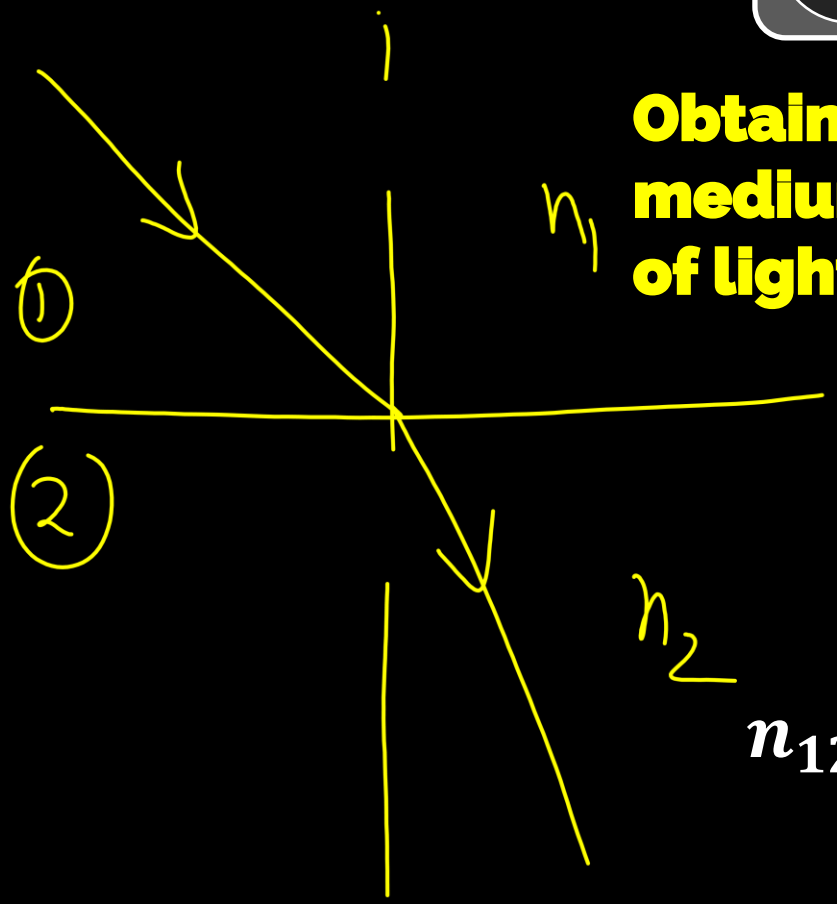
Answer:

The relationship between refractive index of a medium and speed of light is given by:

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

$c = 3 \times 10^8$ m/s = speed of light in air

Refractive Index



Obtain an expression for refractive index of a medium with respect to another in terms of speed of light in these two media?

$$n_{21} = \frac{n_2}{n_1} = \frac{\frac{c}{v_2}}{\frac{c}{v_1}} = \frac{v_1}{v_2} = \frac{\text{speed of light in } 1^{st}}{\text{speed of light in } 2^{nd}}$$

$$n_{12} = \frac{Speed\ of\ light\ in\ second\ medium}{Speed\ of\ light\ in\ first\ medium}$$

Refractive Index

SA 3: Refractive index of diamond with respect to glass is 1.6 and absolute refractive index of glass is 1.5. Find out the absolute refractive index of diamond.

$n_g = \frac{c}{v_g}$, $n_d = \frac{c}{v_d}$

$n_{dg} = 1.6$ $\quad n_g = 1.5$

$n_{dg} = \frac{n_d}{n_g} = 1.6$

$= \frac{n_d}{1.5}$

$n_d = 1.6 \times 1.5$

$= 1.6 \times \frac{3}{2}$

$= 2.4$

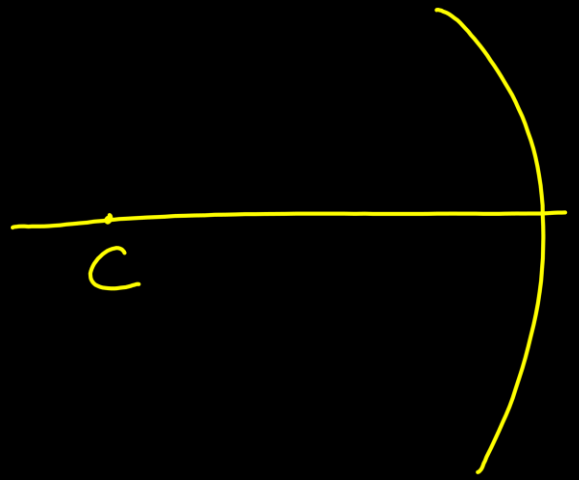
Refractive Index

MCQ 5: You are given water, mustard oil, glycerine and kerosene. In which of these media a ray of light incident obliquely at same angle would bend the most?

(a) Kerosene
(b) Water
(c) Mustard oil
(d) Glycerine

$\mu_k = 1.44$
$\mu_w = 1.33$
$\mu_m = 1.47$
$\mu_g = 1.473$

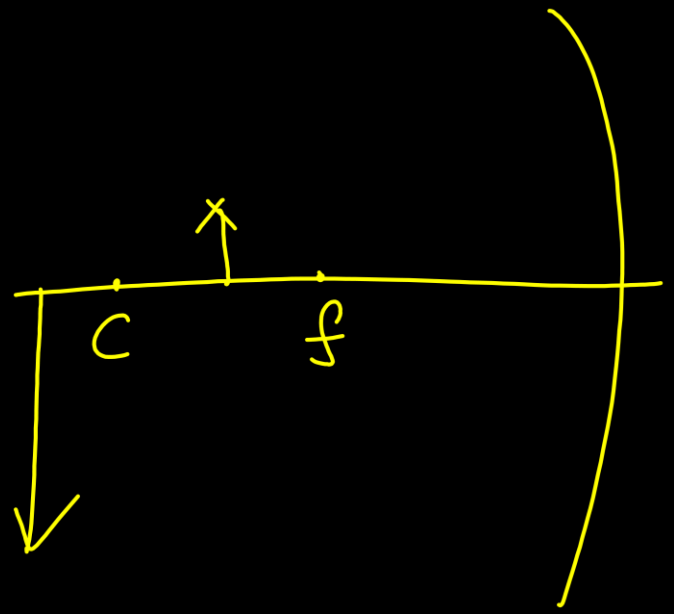
Homework



MCQ: At What distance from a concave mirror should an object be placed to get an image of the same size as the object? (1)

a) Beyond the centre of curvature of the mirror
b) At the principal focus of the mirror
c) At the centre of curvature of the mirror
d) Between the focus and pole of the mirror

Homework



MCQ: At What distance from a concave mirror should an object be placed to get an inverted and magnified image? (1)

a) Beyond the centre of curvature of the mirror
b) At the principal focus of the mirror
c) At the centre of curvature of the mirror
d) Between the focus and centre of curvature of the mirror

Homework

SA 1: 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. (2)

SA 2: State laws of reflection of light. (2)

SA 1

$$m = -\frac{v}{u} = +\frac{v}{+10} = -3 \Rightarrow \frac{v}{10} = -3$$

$$\Rightarrow v = -30 \text{ cm}$$

$v = 30$ cm on the same side as the object. (left side)

Homework

LA 1: An object of height 5·0 cm is placed at 15 cm in front of a concave mirror of focal length 10 cm. At what distance from the mirror should a screen be placed, so that a focussed image is obtained on it ? Find the nature and the height of the image. (5)

$u = -15$ cm

$f = -10$ cm

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

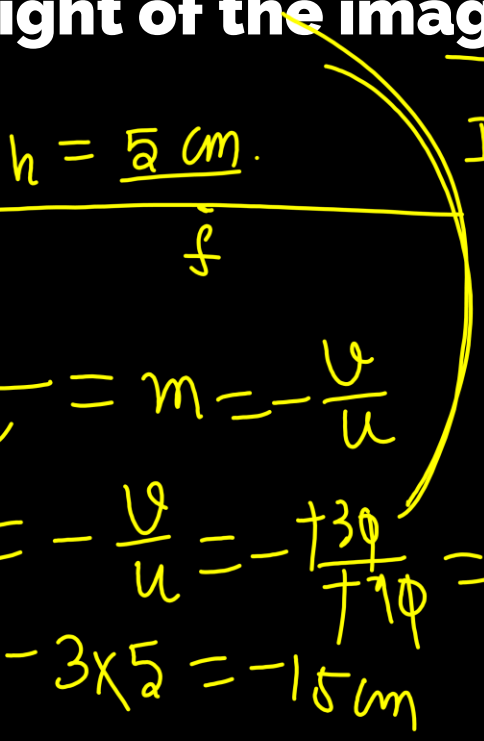
$$\Rightarrow \frac{1}{v} + \frac{1}{-15} = \frac{1}{-10}$$

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

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

$v = -30$ cm

Real image



-ve sig

Image is inverted.

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

$$h' = -\frac{v}{u} = -\frac{+30}{+10} = -3 \times h$$

$$h' = -3 \times 5 = -15 \text{ cm}$$

Homework

LA 2: Study the data given below showing the focal length of three concave mirrors A, B and C and the respective distances of objects placed in front of the mi

Case	Mirror	Focal Length (cm)	Object Distance (cm)
1	A	20	45
2	B	15	30
3	C	30	20

A

i) In which cases, the mirror will form a diminished image of the object? Justify your answer. (1)

ii) List two properties of image formed in case 2. (2)

iii) What is the nature and size of the image formed by mirror c? Draw ray diagram to justify your answer. (2)

Homework

ii) $u = 2f = R$ → 1) The size of the image is same as the size of the object.

2) Imag is inverted and real.

iii) $u < f$ image virtual, erect and magnified.

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Refraction by Spherical Lenses

SA 4: A Lens forms a virtual, erect and diminished image of an object. Identify the type of this lens. Draw a ray diagram to show the image formation in this case?

Answer:

Concave Lens

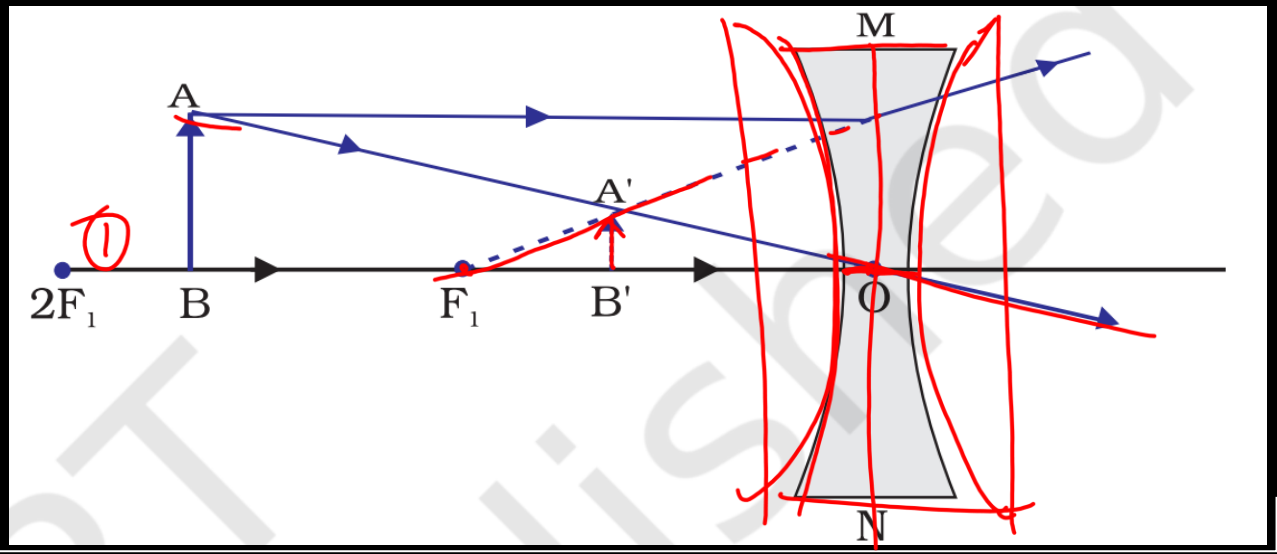


Image formation by a Concave Lens

Position of the object	Position of the image	Size of the image	Nature of the image
At Infinity	At the focus F, behind the lens (left hand side)	Highly diminished, Point sized	Virtual and erect
Between infinity and the pole P of the lens	Between P and F, Behind the lens (LHS)	Diminished	Virtual and erect

Image formation by a Convex Lens

LA 1: A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?

Answer:

A convex lens can produce a magnified real image when it is placed at a distance between f and 2f and if the distance is less than the focal length, it produces a magnified virtual image. Thus, the statement is correct.

Image formation by a Convex Lens

LA 1: A convex lens of focal length 20 cm can produce a magnified virtual as well as real image. Is this a correct statement? If yes, where shall the object be placed in each case for obtaining these images?

Answer:

Magnified virtual image: Between 0 to 20 cm

Magnified real image: Between 20 cm to 40 cm

Convex Lens: Summery

Position of the object	Position of the image	Size of the image	Nature of the image
At Infinity	At the focus F	Highly diminished, Point sized	Real and Inverted
Beyond 2F	Between F and 2F	Diminished	Real and Inverted
At 2F	At 2F	Same size	Real and Inverted
Between 2F and F	Beyond 2F	Enlarged	Real and Inverted
At F	At Infinity	Highly enlarged	Real and Inverted
Between P and F	Behind the lens	Enlarged	Virtual and erect

Example

MCQ 6:

At what distance from a convex lens should an object be placed to get an image of the same size as that of the object on a screen ?

(a) Beyond twice the focal length of the lens.

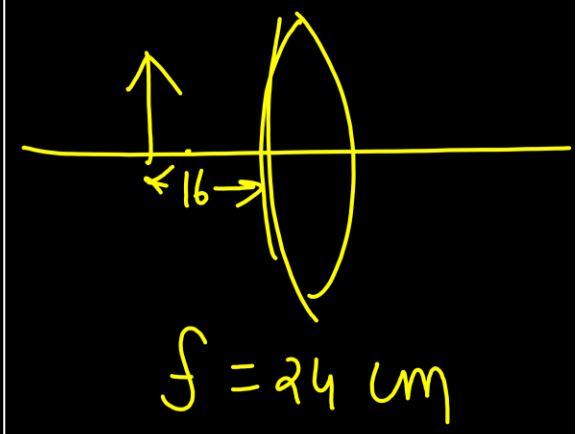
(b) At the principal focus of the lens.

(c) At twice the focal length of the lens. (2f)

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

Example

LA 2:

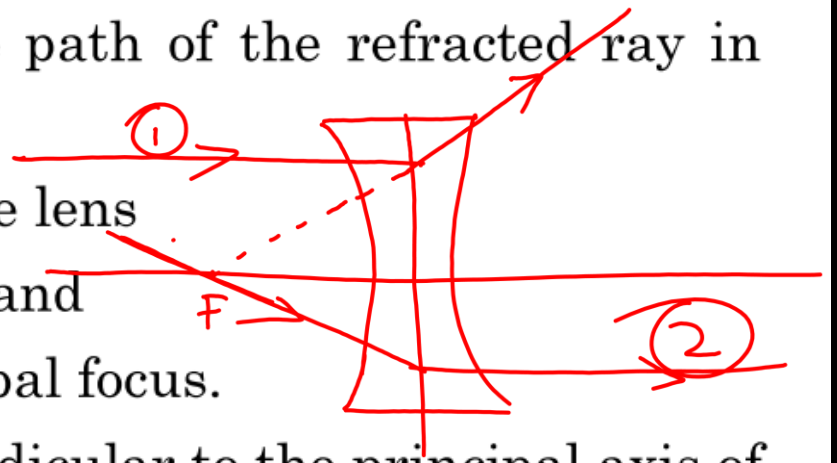


(i) Draw a ray diagram to show the path of the refracted ray in each of the following cases :

A ray of light incident on a concave lens

(1) parallel to its principal axis, and

(2) is directed towards its principal focus.



(ii) A 4 cm tall object is placed perpendicular to the principal axis of convex lens of focal length 24 cm. The distance of object from the lens is 16 cm. Find the position and size of image formed.

h = 4 cm,

Example

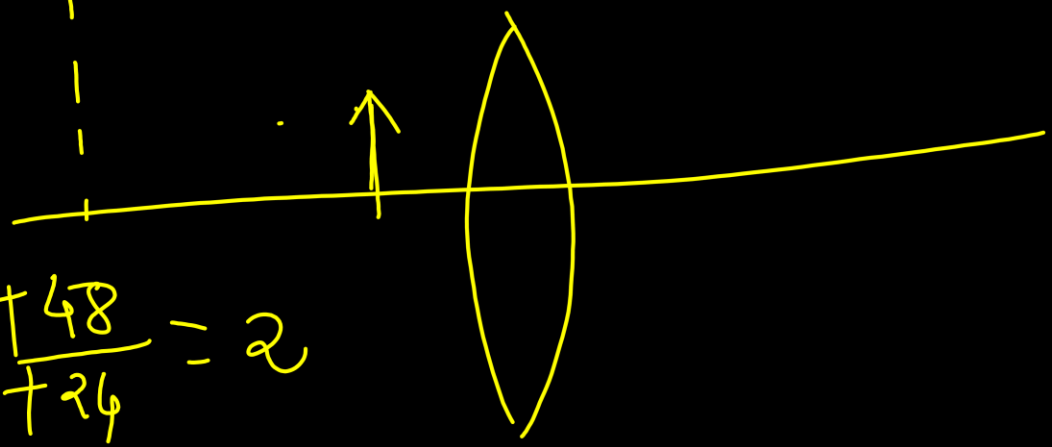
LA 2:

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

$$\frac{1}{v} - \frac{1}{-16} = \frac{1}{24}$$

$$\frac{1}{v} = \frac{1}{24} - \frac{1}{16} = \frac{2-3}{48} = \frac{-1}{48}$$

$$v = -48\ \text{cm}$$



$$m = +\frac{v}{u} = +\frac{+48}{+24} = 2$$

Example

LA 2:

Image formation by a Convex Lens

Object Beyond 2F: Common case

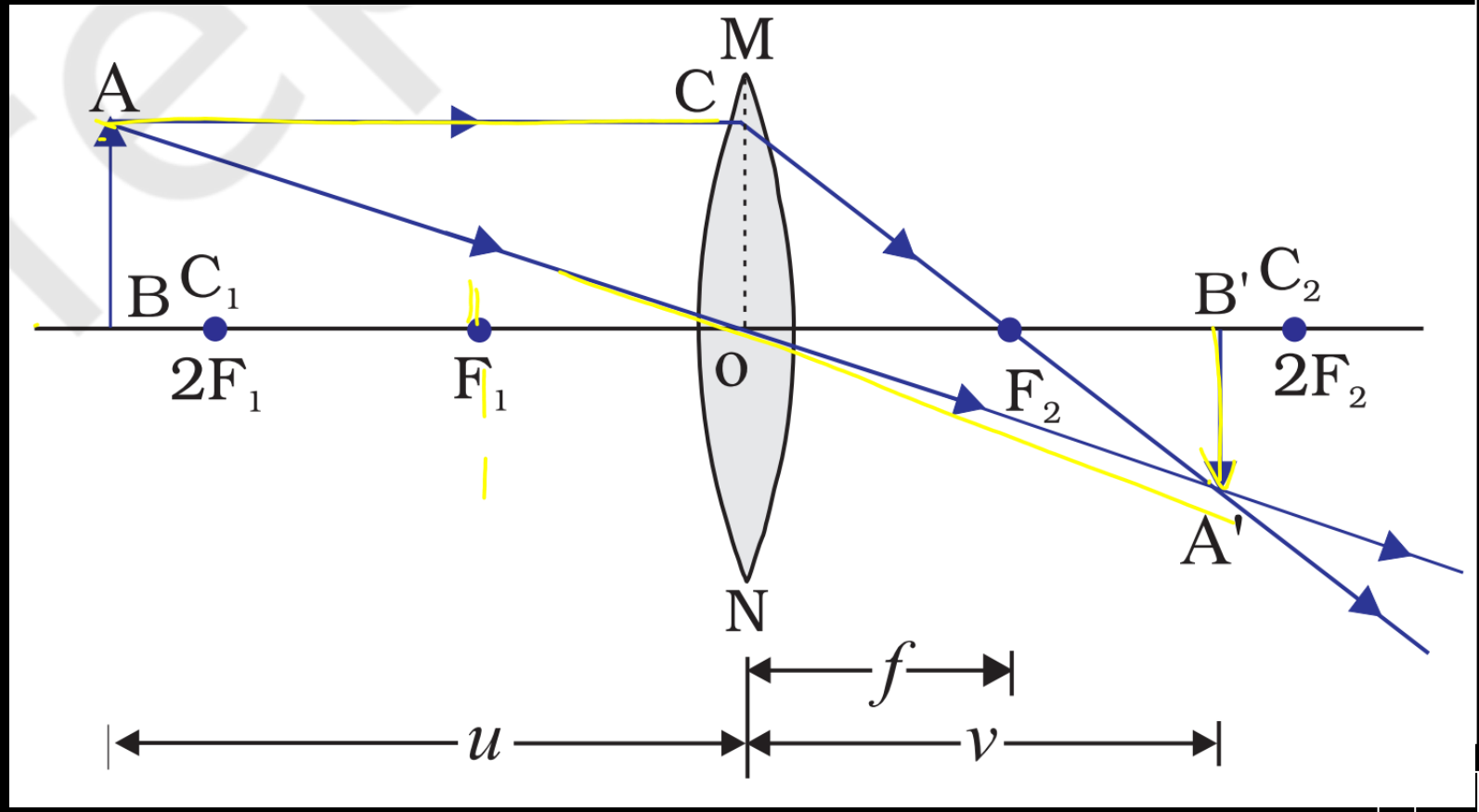
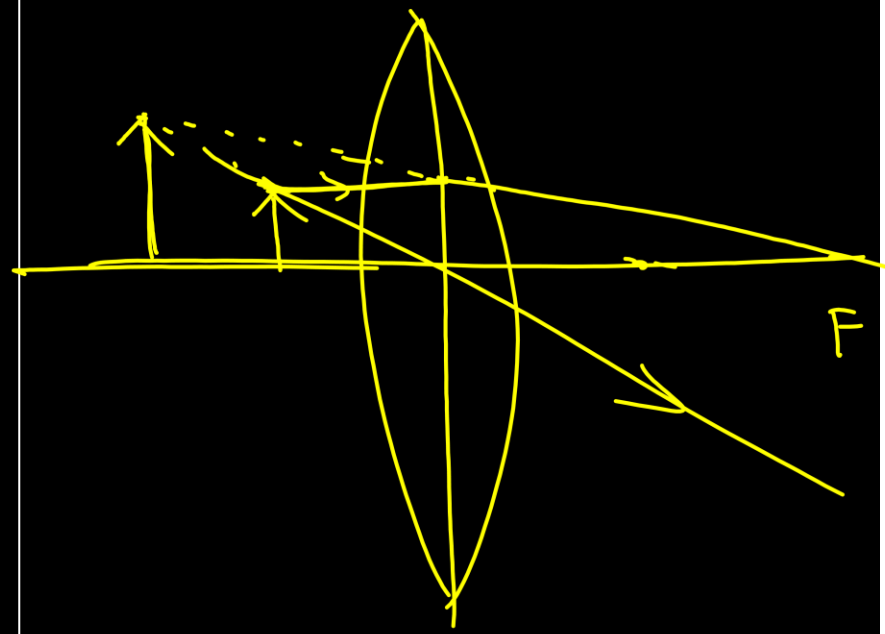
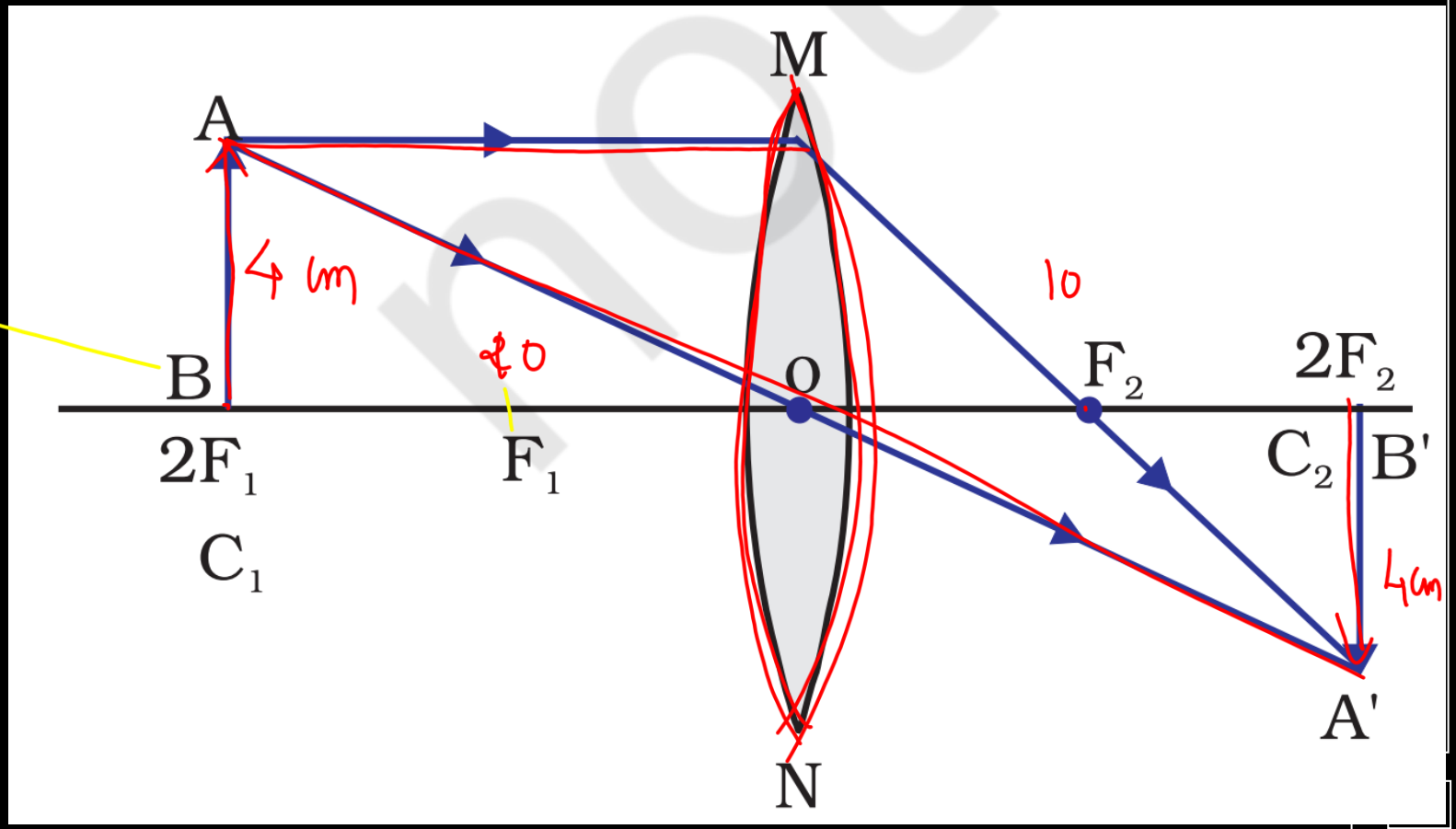


Image formation by a Concave Mirror

Object at 2F: Special case





Lens Formula

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

This formula is valid in all situations for all spherical mirrors for all positions of the object.

You must use the New Cartesian Sign Convention while substituting numerical values for u, v, f, and R in the mirror formula for solving problems.

Magnification

MCQ 6: An object is kept at a distance u in front of a spherical lens. An image is formed at distance v from the mirror. What is the magnification of image?

a) $+\frac{v}{u}$

b) $-uv$

c) $-\frac{u}{v}$

d) It depends on the type of the lens

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

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

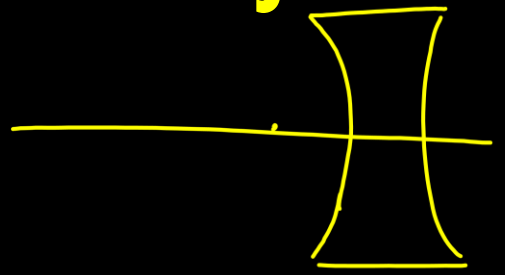
Example

LA 3: 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.

Answer:

$f = -15$ cm.

$v = -10$ cm



$$\frac{1}{u} = \frac{1}{15} - \frac{1}{10}$$

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

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

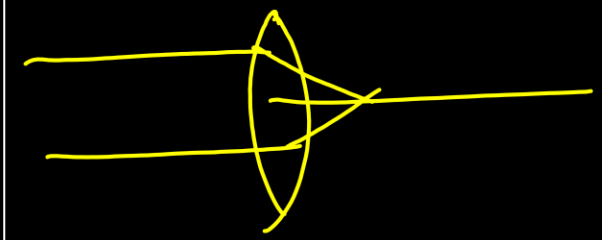
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

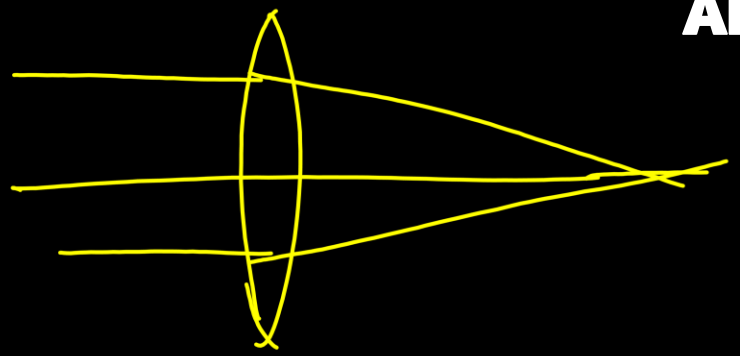
$$\Rightarrow \frac{1}{-10} - \frac{1}{u} = \frac{1}{-15} \Rightarrow \frac{1}{10} + \frac{1}{u} = \frac{1}{15}$$

$$m = \frac{v}{u} = \frac{-10}{-30} = \frac{1}{3} = 0.33$$

Example

Power of a Lens





LA 4: How are power and focal length of a lens related? You are provided with two lenses of focal length 20 cm and 40 cm respectively. Which lens will you use to obtain more convergent light

Answer:

$$P = \frac{1}{f} \qquad f \rightarrow m.$$

$$P = \frac{100}{f} \qquad f \rightarrow cm$$

$$P_{20} = \frac{100}{20} = +5 \text{ D}$$

$$P_{40} = \frac{100}{40} = +2.5 \text{ D}$$

Homework

MCQ 1: Absolute refractive index of glass and water is 2 3 and 3 4 respectively. If the speed of light in glass is 2 108 m/s, the speed of light in water is :

(A) $\frac{9}{4} \times 10^8$ **m/s**

(B) $\frac{5}{2} \times 10^8$ **m/s**

(C) $\frac{7}{3} \times 10^8$ **m/s**

(D) $\frac{16}{9} \times 10^8$ **m/s**

Homework

MCQ 2: How will the image formed by a convex lens be affected, if the upper half of the lens is wrapped with a black paper ?

(A) The size of the image formed will be one-half of the size of the image due to complete lens.

(B) The image of upper half of the object will not be formed.

(C) The brightness of the image will reduce.

(D) The lower half of the inverted image will not be formed.

Homework

SA 1: Sudha finds out that the sharp image of the window pane of her science laboratory is formed at a distance of 15 cm from the lens. She now tries to focus the building visible to her outside the window instead of the window pane without disturbing the lens. In which direction will she move the screen to obtain a sharp image of the building? What is the approximate focal length of this lens?

SA 2: How are power and focal length of a lens related? You are provided with two lenses of focal length 20 cm and 40 cm respectively. Which lens will you use to obtain more convergent light?

Homework

LA 1: 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 the lens?

Homework

LA 2: A student focussed the image of a candle flame on a white screen using a convex lens. He noted down the position of the candle screen and the lens as under Position of candle = 12.0 cm Position of convex lens = 50.0 cm Position of the screen = 88.0 cm

(i) What is the focal length of the convex lens?

(ii) Where will the image be formed if he shifts the candle towards the lens at a position of 31.0 cm?

(iii) What will be the nature of the image formed if he further shifts the candle towards the lens?

(iv) Draw a ray diagram to show the formation of the image in case (iii) as said above.

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