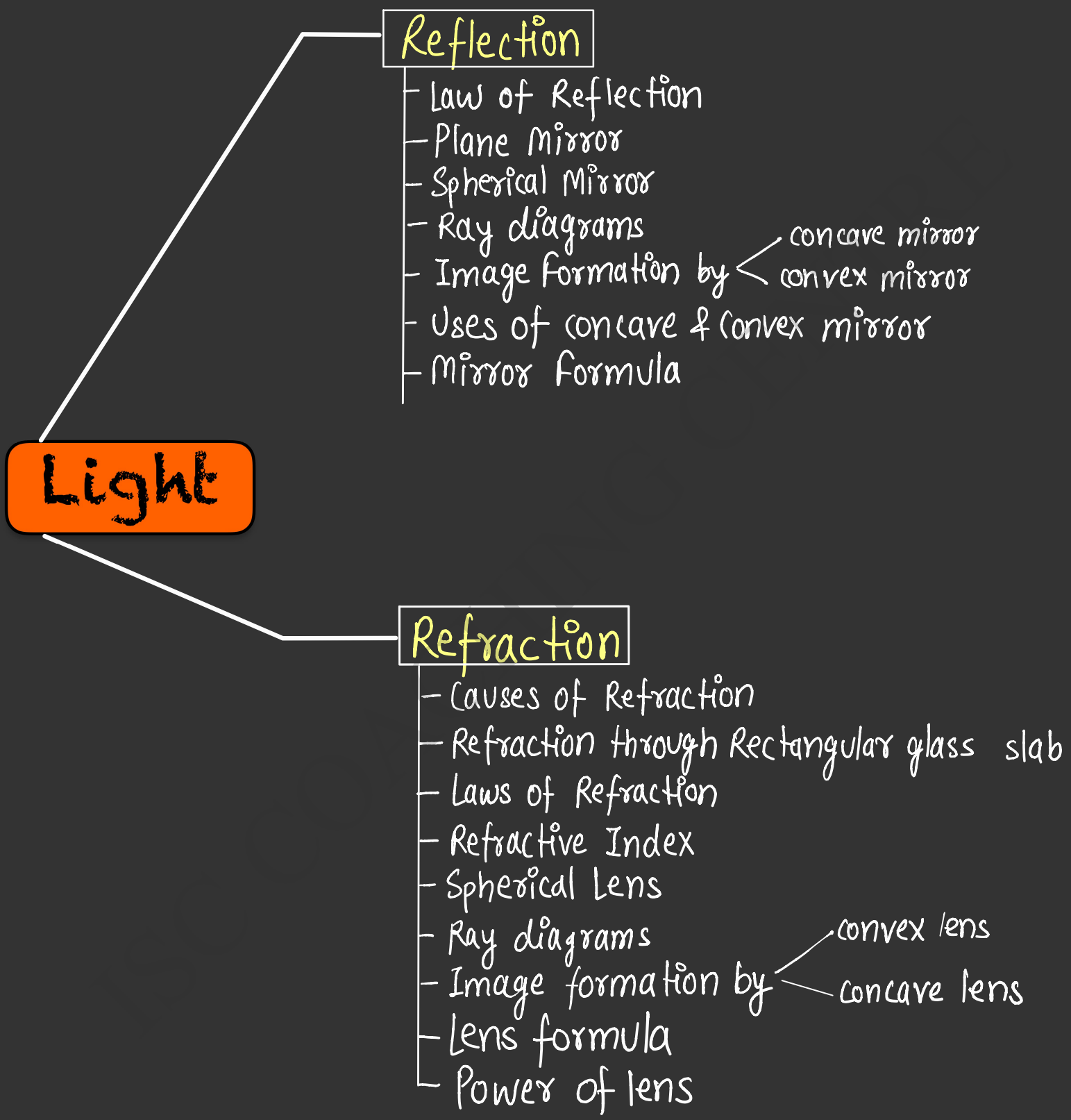
LIGHT


Light
Reflection
Law of Reflection
Plane Mirror
Spherical Mirror
Ray diagrams
Image Formation by
concave mirror
convex mirror
Uses of concave & convex mirror
Mirror formula
Refraction
Causes of Refraction
Refraction through Rectangular glass slab
Laws of Refraction
Refractive Index
Spherical Lens
Ray diagrams
Image formation by
convex lens
concave lens
Lens formula
Power of lens

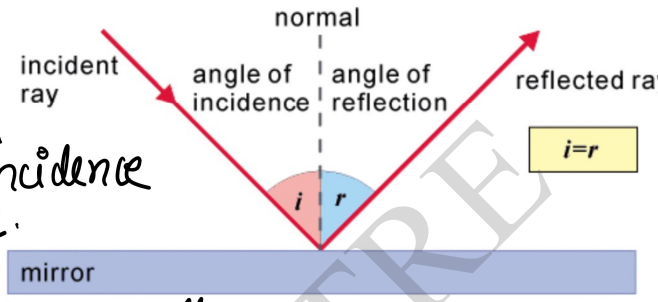
✱ Light travels in a straight line.

REFLECTION

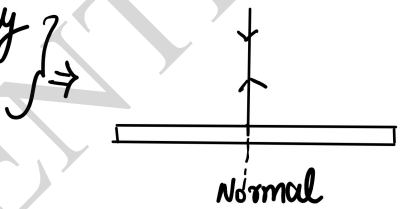
Coming back of light rays to the same medium, when they fall on a surface.

Laws of Reflection:

(i) Angle of incidence ($\angle i$) = Angle of refl. ($\angle r$).
(ii) Incident ray, normal at the point of incidence and reflected ray all lie in the same plane.



K³B ⇒ Any ray of light which is incident normally on a mirror is reflected back along its own path.



- **Object** – Point of intersection of incident ray is called object.
- **Image** – Point of intersection of reflected ray is called image.

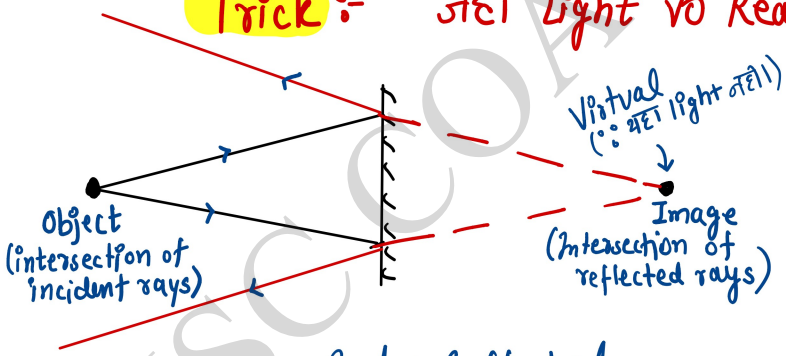
Real Image

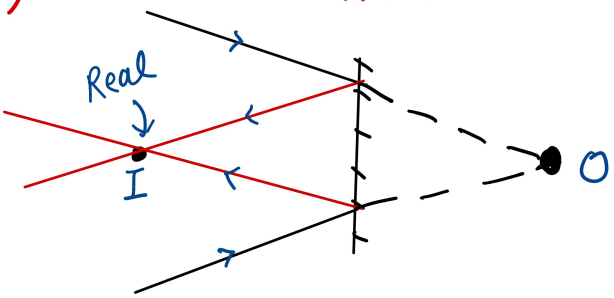
If the light rays coming from a point actually, meet after reflection, then image formed is Real.

Virtual Image

If light rays coming from a point, after reflection does not meet actually but appear to meet at another point then image formed is virtual.

Trick :- जहाँ Light वो Real, जहाँ नहीं वो Virtual.





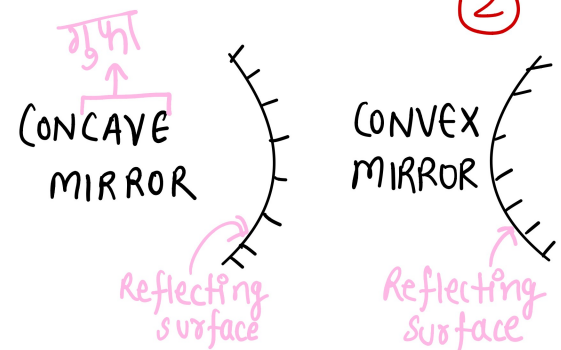
Red → Reflected rays
Black → Incident rays

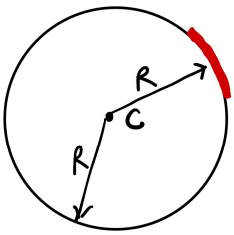
Plane Mirror

- Object and image are equidistant from the plane mirror
- If object is real then image will be virtual and vice-versa.
- Image is laterally inverted i.e. left seems to be right and vice-versa
- Size of image is equal to size of object.
- Uses → looking glass, periscopes etc.

Spherical Mirror

↳ Whose reflecting surfaces are spherical:-
(ये mirror एक sphere के ही Part होते हैं।)

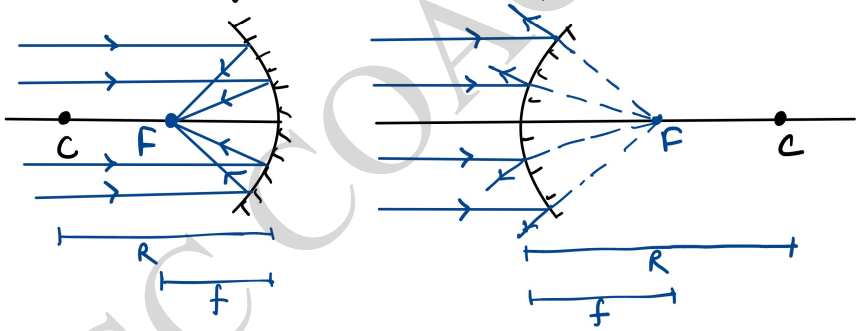




← for example यहा से काट कर निकाल लिया।

↳ तो अब spherical mirror देखते ही एक imaginary sphere दिमाग में ले आना और मान लेना कि उसी sphere से वो mirror बना है।

- **Radius of Curvature:** Radius of curvature of a spherical mirror is the radius of imaginary sphere of which, mirror is part.
- **Centre of Curvature:** Centre of that imaginary sphere of which, mirror is part
- **Pole:** It is the mid-point of its reflecting surface. Symbol → P.
- **Principal Axis:** line joining pole and centre of curvature.
- **Focus (F):** A point on principal axis of the mirror at which the light rays coming parallel to principal axis, after reflection actually meet.



focus of concave → Real
convex → Virtual

focal length (f) → Distance between pole and focus.

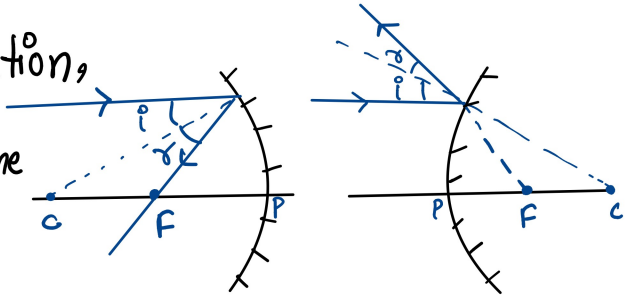
in mirror (only) ⇒ $f = \frac{R}{2}$

- **Aperture:** diameter of reflecting surface of spherical mirror.

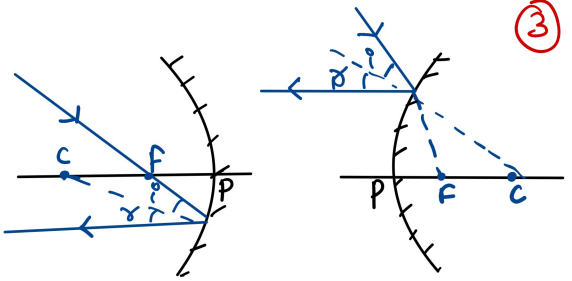
RAY DIAGRAMS

Some Rules:-

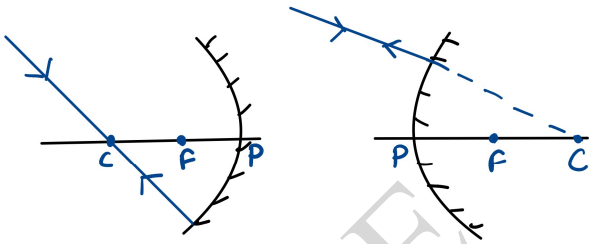
- A ray parallel to principal axis, after reflection, will pass through the principal focus in case of a concave mirror or appear to diverge from the principal focus in case of a convex mirror.



- A ray passing through principal focus of a concave mirror or a ray which is directed towards the principal focus of a convex mirror, after reflection will emerge parallel to principal axis.



- Ray passing through centre of curvature of a concave mirror or directed in the direction of centre of curvature of a convex mirror, after reflection, is reflected back along same path.



- The incident and reflected rays make equal angles with principal axis.

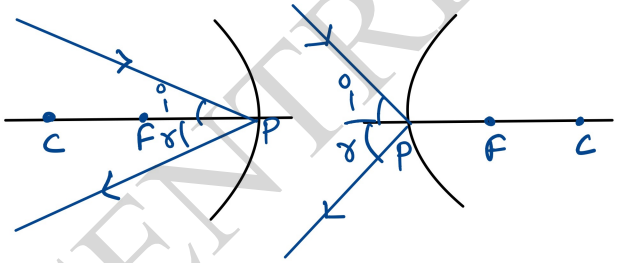
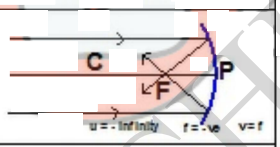
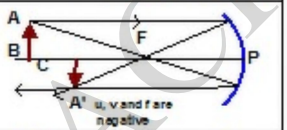
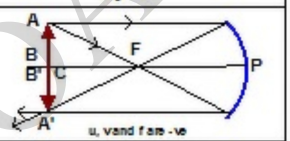
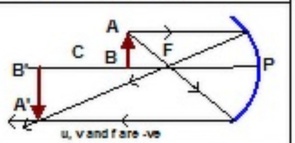
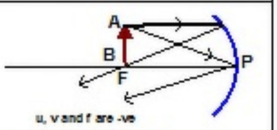
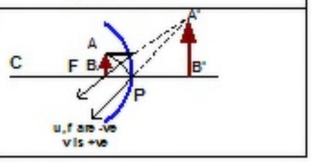


IMAGE FORMATION BY CONCAVE MIRROR:-

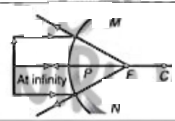
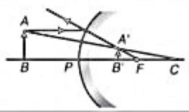
Image formed by Concave Mirror:-

Position of object	Position of image	Nature of image	Ray diagram
(i) At infinity	At focus	Real, Inverted, and diminished	
(ii) Beyond C	Between F and C	Real, Inverted and diminished	
(iii) At C	At C	Real, Inverted and same size	
(iv) Between F and C	Beyond C	Real, Inverted and enlarged	
(v) At F	At Infinity	Real, Inverted and highly enlarged	
(vi) Between F and P	Behind the mirror	Virtual, enlarged and erect image	

Here u = Distance of object
v = Distance of image

Uses of concave mirror:-

↳ Shaving mirror, torch, dentists, in solar furnace.

Position of object	Ray diagram	Position of image	Nature and Size of image
At infinity		At the principal focus	Virtual, erect and extremely diminished
Between infinity and the pole (i.e. at finite distance)		Between the principal focus and the pole	Virtual, erect and diminished

By Convex Mirror:-

↳ Here we consider only two positions of the object. Firstly, when object is at infinity and the second position is, when object is at a finite distance from mirror.

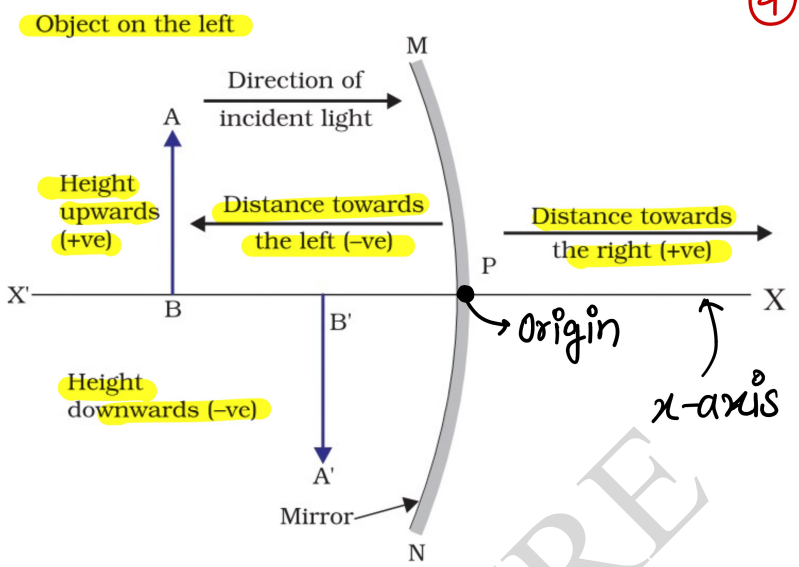
Uses of Convex Mirror:-

- Rear view mirrors in vehicles because they always give an erect image and have wider field of view as they are curved outward
- Big convex mirrors used as shops security mirrors.

गाड़ी का शीशा!

Sign-convention :-

- Pole is origin.
- Principal axis is x-axis



MIRROR FORMULA

$$\frac{1}{V} + \frac{1}{U} = \frac{1}{f}$$

[with sign]

f ⇒ x-cordinate of focus
V ⇒ x-cordinate of image
U ⇒ x-cordinate of object

Magnification (m): Gives the relative extent to which the image of an object is magnified with respect to object size.

$$m = \frac{-V}{U} = \frac{h_I}{h_O}$$

h_I = height of Image
h_O = height of Object

Imp

LP:- An object is placed at a distance of 12cm in front of a concave mirror. It forms a real image four times larger than the object. Calculate the distance of image from the mirror.

K³B ⇒

m = -ve → Inverted.
m = +ve → Erect

object	Image
RO	RI
VO	VI
RO	VI
VO	RI

RO RI या VO VI → Inverted
RO VI या VO RI → Erect.

Trick :- 2 चीज़ें फसने के लिए "same-same inverted"

2 तो दोनों रट लो (Trick है जो काम आएगी)

Solution of (LP) :- Given :- U = -12 cm [as we know object is always on left ∴ -ve sign]

m = 4 times [but m का sign ??]
↳ अब यहाँ Trick लगेगी अपर वाली।

as object is "placed" → ∴ R.O.
& given R.I.
R.O. & R.I. → same-same ⇒ inverted!
and we know for inverted, m = ⊖ve

R.O. - Real object
R.I - Real Image
V.I - Virtual Image
V.O - Virtual object

$\therefore m = -4$

[Red pen वाला part rough में करना, it is not for boards, because ये JEE की Trick है ☺]

as, $m = \frac{-V}{U} \Rightarrow \therefore \frac{-V}{U} = -4$

$\frac{-V}{(+12)} = -4$

$\boxed{V = -48\,cm}$

LP: An object is placed at a distance of 8cm from a convex mirror of focal length 12cm. Find position of image.

Sol: given, $u = -8cm$, $f = +12cm$, $V = ??$

using mirror formula, $\frac{1}{V} + \frac{1}{U} = \frac{1}{f}$

[हमें V का sign की चिंता नहीं करनी वो automatically सही sign आएगा।]

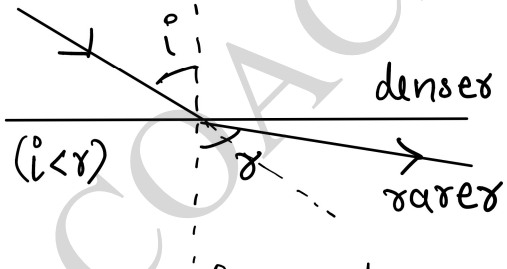
$\Rightarrow \frac{1}{V} + \frac{1}{(-8)} = \frac{1}{12}$

$\Rightarrow \frac{1}{V} = \frac{1}{12} + \frac{1}{8} \Rightarrow \frac{2+3}{24} \Rightarrow \frac{5}{24}$

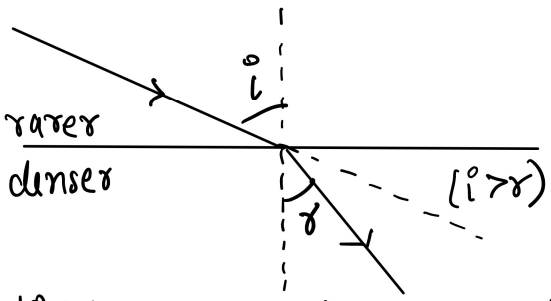
$\Rightarrow \frac{1}{V} = \frac{1}{4.8} \Rightarrow \boxed{V = 4.8\,cm}$

REFRACTION

Change in path of a light ray as it passes from one medium to another medium is called Refraction of light.



When light ray goes from denser to rarer medium, it bends away from normal.

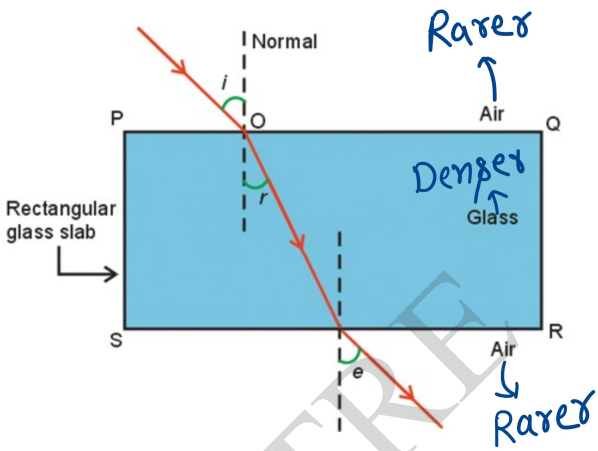


When light rays goes from rarer to denser medium it bends towards the normal.

Cause of Refraction? → As we know speed of light is different in different media, i.e. more in rarer medium and comparatively less in denser medium. So, when light enters a denser medium, its speed reduces and it bends towards the normal and when it enters rarer medium, its speed increases and it bends away from the normal.

Refraction through a Rectangular Glass Slab:-

i = angle of incidence
r = angle of refraction
e = angle of emergence



- Angle of incidence = Angle of emergence, $\angle i = \angle e$
- If the incident ray falls normally to the surface of glass slab, then there is no bending of ray of light; i.e. it goes straight.

LAWS OF REFRACTION:

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

(ii) The ratio of sine of angle of incidence to the sine of angle of refraction for light of given colour is constant for a given pair of media (Snell's Law). It is expressed as:

$$\frac{\sin i}{\sin r} = \mu = \text{constant} \qquad [\mu \rightarrow \text{refractive index}]$$

Refractive Index: The extent of change in direction that takes place in a given pair of media is expressed in terms of refractive index.

${}_1\mu_2$ represents refractive index of medium 2 with respect to medium 1, when light is going from medium 1 to medium 2.

$$\boxed{{}_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r}}$$

- The refractive index of a medium with respect to vaccum is called absolute refractive index of medium.

for glass/water pair $\Rightarrow$ $\boxed{{}_w\mu_g = \frac{{}_a\mu_g}{{}_a\mu_w}}$

[कुछ ना दिया हो तो w.r.t vaccum (a) ही लेंगे।]

- If question is related to speed:

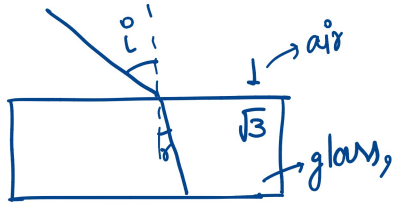
$$\boxed{\mu = \frac{c}{v}}$$

c → speed of light in vaccum/air
v → speed of light in medium

for eg, ${}_a\mu_g = \frac{\text{velocity of light in air}}{\text{velocity of light in glass}} = \frac{c}{v_g}$ or, ${}_a\mu_w = \frac{c}{v_w}$ (water)

LP: Calculate angle of incidence of light ray incident on surface of a plastic slab of refractive index $\sqrt{3}$, if angle of refraction is 30°.

Sol:



given, $\angle r = 30°$

light is going from air to glass

$\therefore \quad {}_aMg = \frac{Mg}{Ma} = \frac{\sin i}{\sin r}$

$\Rightarrow \frac{\sqrt{3}}{1} = \frac{\sin i}{\sin 30°} \left(\frac{1}{2}\right)$

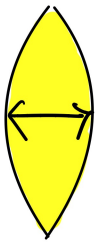
$\Rightarrow \sin i = \frac{\sqrt{3}}{2}$

$\therefore \boxed{i = 60°}$

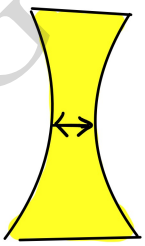
K3B जब speed given होगी तो "speed" वाला formula वरना "sin" वाला।

SPHERICAL LENS

↳ A transparent material bound by two surfaces, of which both surfaces are spherical, forms a lens.

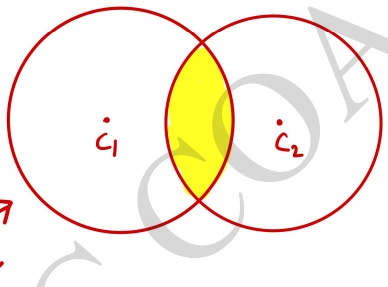


Thick at middle ⇓ Convex / converging lens



Thin at middle ⇓ Concave / Diverging lens

K3B → Lens कैसे बनते हैं?

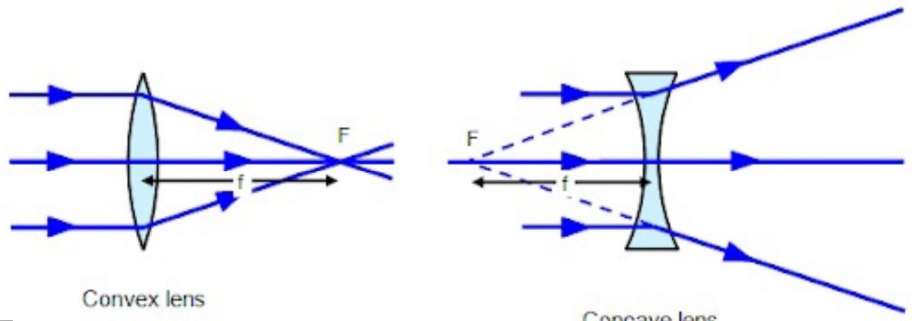


→ दो spheres को जोड़कर बना हुआ मान सकते हैं। (Just an imagination for solving questions easily)

- **Centre of Curvature (C):** A lens has two spherical surfaces. Each surface forms a part of a sphere. The centre of these spheres are called centre of curvature. [या C_1 & C_2] [or $2f_1$ & $2F_2$]
- **Principal Axis:** An imaginary straight line passing through the two centres of curvature of a lens is called its principal Axis.
- **Optical centre (O):** Central point of a lens is called optical centre.
- **Aperture:** Effective diameter of the circular outline of a spherical lens is called its aperture.
- **Principal Focus (F):** The point where the rays parallel to principal axis after

refraction meet is called principal focus. A lens has two principal foci.

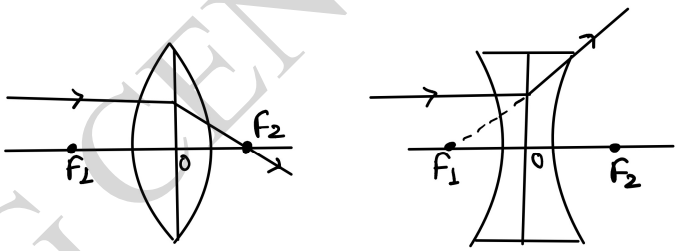
- **Focal Length (f)**: The distance of principal focus from optical centre.



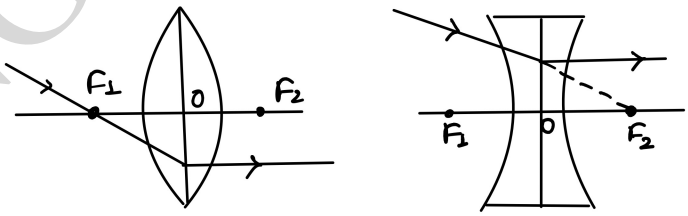
RAY DIAGRAMS

Rules:

- Rays which are parallel to principal axis, after refraction will pass through principal focus in case of convex lens and will appear to be coming from principal focus in case of concave lens.



- Ray passing through or directed to the focus will emerge parallel to principal axis.



- Ray directed to optical centre will emerge out undeviated.

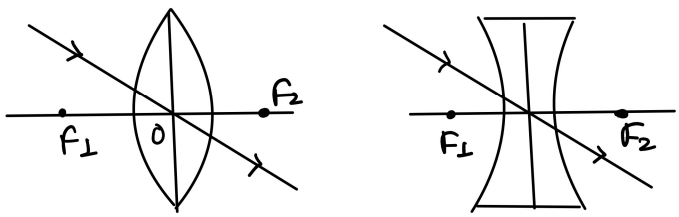
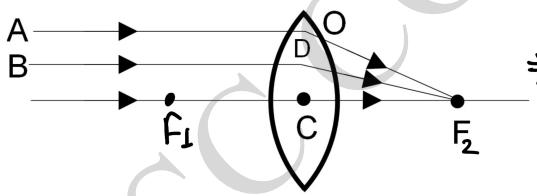
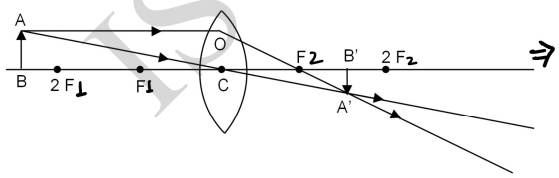


Image formation by Convex Lens

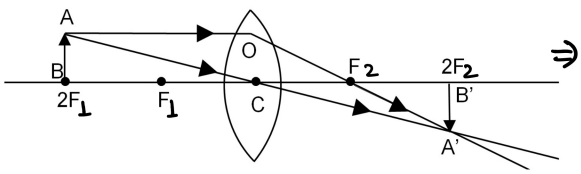


⇒ object → at infinity
image → At F_2
Nature → Real, inverted & diminished

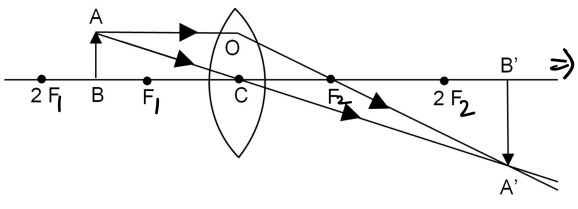


⇒ object → Beyond $2F_1$
image → between F_2 and $2F_2$
nature → real, inverted & diminished

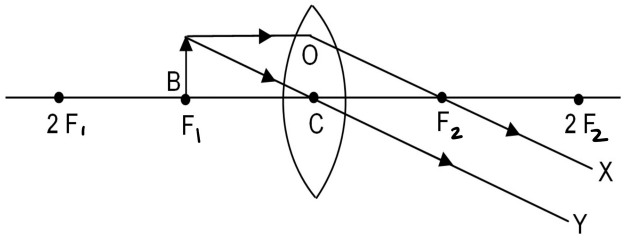
→ $2F_1$ means F_1 का double length.



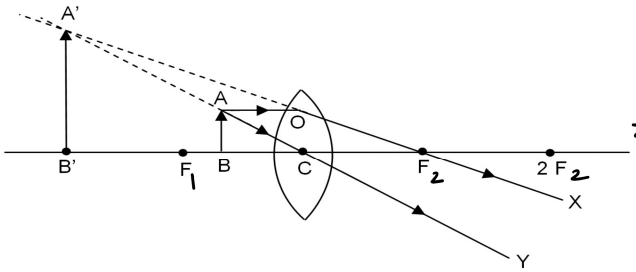
⇒ object → At $2F_1$
image → At $2F_2$
nature → Real, inverted & same size as of object.



⇒ object → Between F_1 and $2f_1$
image → Beyond $2F_2$
nature → Real, inverted & magnified.



⇒ Object → At f_1
image → at infinity
nature → Real, inverted & magnified.

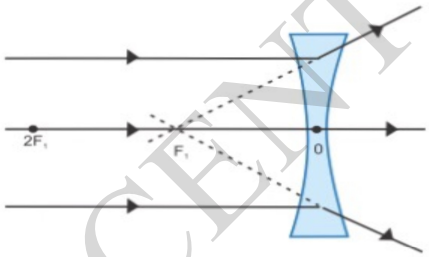


⇒ object → Between lens and f_1
image → On same side of lens as object
nature → virtual, erect and magnified.

Image formation by Concave lens :-

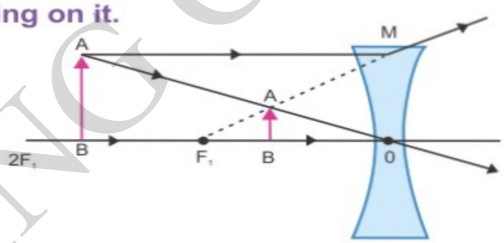
1) When object is placed at infinity

Image is :
- formed at F_1
- virtual and erect
- highly diminished



2) A concave lens diverges all rays falling on it.

Therefore for all positions, image is :
- on the same side of object
- virtual and erect
- diminished



Lens Formula

$$\frac{1}{V} - \frac{1}{U} = \frac{1}{f}$$

(with sign)

sign convention is same as that for mirrors
Also, In convex lens focal length → ⊕ve
and in concave → ⊖ve

$$m = \frac{h_i}{h_o} = \frac{V}{U}$$

h_i = height of image
h_o = height of object
[Pg-(4) की K3B lens पर भी applicable है।]

POWER OF LENS (P) :-

Ability of a lens to converge or diverge light rays is called power(P) of the lens.

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

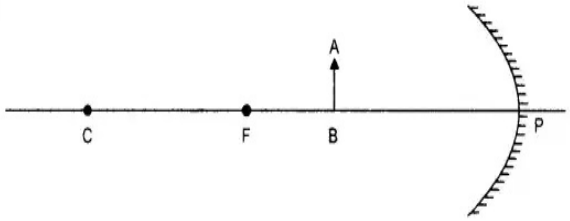
f → focal length in metre
SI Unit ⇒ [D] (called Dioptre = $1m^{-1}$)

Power for
- convex lens → ⊕ve → ∵ f → ⊕ve
- concave lens → ⊖ve → ∵ f → ⊖ve

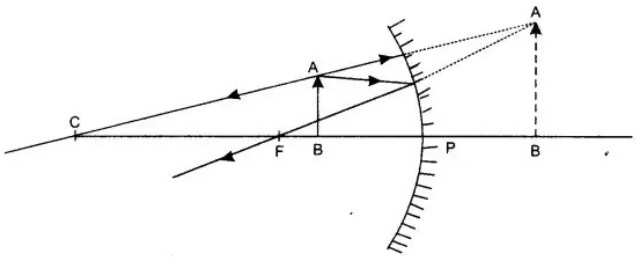
-- PREVIOUS YEAR QUESTIONS --

1 MARK QUESTIONS (INCLUDING MCQs)

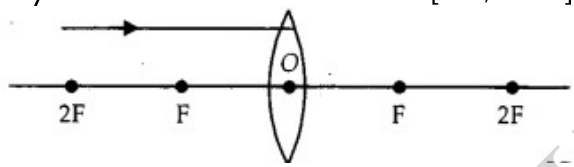
Q1. Draw the following diagram in your answer-book and show the formation of image of the object, AB with the help of suitable rays. [1M,2008]



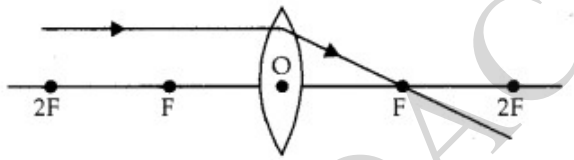
Ans. 1



Q2. Draw the given diagram in your answer book and complete it for the path of ray of light beyond the lens. [1 M,2009]



Ans. 2



Q3. Explain why a ray of light passing through the centre of curvature of a concave mirror gets reflected along the same path. [1M,2010]

Ans 3. A ray of light passing through the centre of curvature of a concave mirror falls on the mirror along the normal to the reflecting surface. Hence, it gets reflected along the same path following the laws of reflection.

Q4. Why does a ray of light bend when it travels from one medium into another? [1M,2009]

Ans 4. Light has different speeds in different media and it takes such a path of propagation for which time taken is minimum.

Q5. What is the nature of the image formed by a concave mirror if the magnification produced by the mirror is +3? [1M,2010]

Ans 5. The nature of the image formed by a concave mirror if the magnification produced by the mirror is +3 is virtual, erect and magnified.

Q6. To find the focal length of a concave mirror, Sita should choose which one of the following

(a) A mirror holder and screen holder
(b) A screen holder and a scale
(c) A mirror holder, a screen holder and a scale
(d) A screen, a mirror, holders for them and a scale [1M,2011]
Ans 6. A screen, a mirror, holders for them and scale are needed to find the focal length of a concave mirror

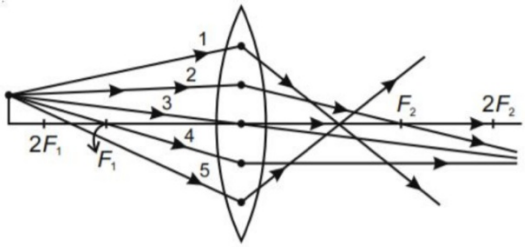
Q7. For a ray of light passing through a glass slab, the lateral displacement was correctly measured as : [1M,2011]
Ans 7. Answer (c)
Lateral displacement is the sideways shift of the emergent ray from the direction of the incident ray.

Q8. By using a convex lens, a student obtained a sharp image of his classroom window grill on a screen. In which direction should he move the lens to focus a distant tree instead of the grill?
(a) Towards the screen
(b) Away from the screen
(c) Very far away from the screen
(d) Behind the screen [1M,2011, 2016, 2017]
Ans 8. Answer (a) The lens should be moved towards the screen because the distant tree can be considered an object at infinity whose image will be formed at the focus, while earlier the image of nearer grill was formed at a distance farther than the focal length.

Q9. A student obtained a sharp image of the grills of a window on a screen using a concave mirror. His teacher remarked that for getting better results a well lit distance object (preferably the Sun) should be focused on the screen. What should be done for this purpose? [1M,2012, 2013]
Ans 9. Answer (c) The screen is moved away from the mirror so as to focus the object for a fixed position of the mirror and the object.

Q10. An object is placed at a distance of 15 cm from a concave lens of focal length 30 cm. List four characteristics (nature, position, etc.) of the image formed by the lens. [1M,2017]
Ans 10. Given, u =-15 cm (It is to the left of the lens)
f =-30 cm (It is a concave lens)
Using the lens formula
1/v-1/u= 1/f
v =-10cm
The negative sign of the image distance shows that the image is formed on the left side of the concave mirror. Thus, the image formed by a mirror is virtual, erect and on the same side as the object.

Q11. Out of the five incident rays shown in the figure find the three rays which are obeying the laws of refraction and may be used for locating the position of the image formed by a convex lens: [1M,2013, 2014]



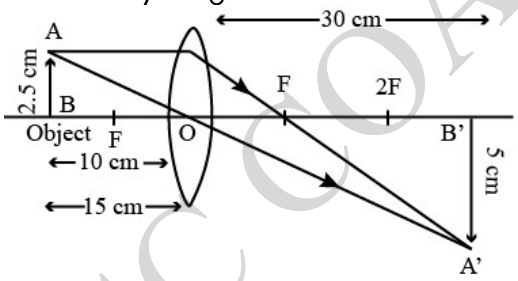
(a) 1, 2 and 3 (b) 2, 3 and 4
(c) 3, 4 and 5 (d) 1, 2 and 4
Ans 11. Answer (b)
Ray (2) is parallel to the principal axis and passes through the second focus of the lens.
Ray (3) passes through the optical centre and does not deviate.
Ray (4) passes through the first focus of the lens and goes parallel to the principal axis.

Q12. Write two different uses of concave mirrors. [1M,2017]
Ans 12. Concave mirrors are used in reflecting telescopes. They are also used to provide a magnified image of the face for applying make-up or shaving.

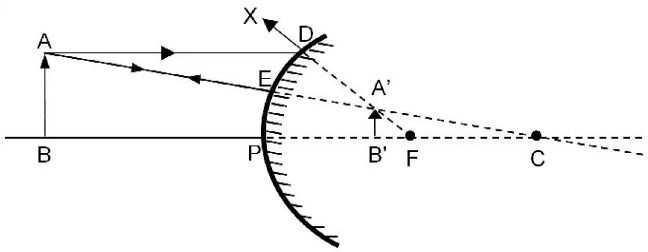
Q13. What is the range of wavelength of visible light? [1M, 2018]
Ans 13. 380 to 700 nanometers

Q14. What makes things visible? [1M]
Ans 14. Objects are visible due to reflection. Light gets reflected from the object and makes it visible.

2 MARKS QUESTIONS
Q15. An object of height 2.5 cm is placed at a distance of 15 cm from the optical centre 'O' of a convex lens of focal length 10 cm. Draw a ray diagram to find the position and size of the image formed. Mark optical 'O', principal focus F and height of the image on the diagram.
[2M,2016, 2018]
Ans 15. Ray diagram :



Q16. If the image formed by a spherical mirror for all positions of the object placed in front of it is always erect and diminished, what type of mirror is it? Draw a labelled ray diagram to support your answer. [2M,2018]
Ans 16. Convex mirror always forms a virtual, erect and diminished image of the object placed at any position in front of the mirror.



Q17. List four precautions which a student should observe while determining the focal length of a given convex lens by obtaining an image of a distant object on a screen. [2M,2019]
Ans 17. (i) The lens should be held in vertical position with its face parallel to the screen.
(ii) A clear and sharpest image of the distant object should be obtained by suitably adjusting the position of the lens.
(ii) At least three observations should be taken.
(iv) Measure the distance between the convex lens and the screen carefully.

Q18. The refractive indices of glass and water with respect to air are 3/2 and 4/3. If respectively. If speed of light in glass is 2 x 108 m/s, find the speed of light in water. [2M,2016]
Ans 18. Given: Refractive index of glass with respect to air ng=3/2
Refractive index of water with respect to air n_w = 4/3
Speed of light in glass = 2 x 108m/s
When we apply the formula:

$$\text{Refractive index of glass,} \eta_g = \frac{3}{2}$$

$$\text{Refractive index of water,} \eta_w = \frac{4}{3}$$

$$\text{Refractive index of glass,} \eta_g = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in glass}}$$

$$\frac{3}{2} = \frac{\text{Speed of light in vacuum}}{2 \times 10^8}$$

$$\text{Speed of light in vacuum} = \frac{3 \times 2 \times 10^8}{2} = 3 \times 10^8 \text{m/s}$$

$$\text{Refractive index of water, } \eta_w = \frac{4}{3}$$

$$\eta_w = \frac{\text{Speed of light in vacuum}}{\text{Speed of light in water}}$$

$$\frac{4}{3} = \frac{3 \times 10^8}{\text{Speed of light in water}}$$

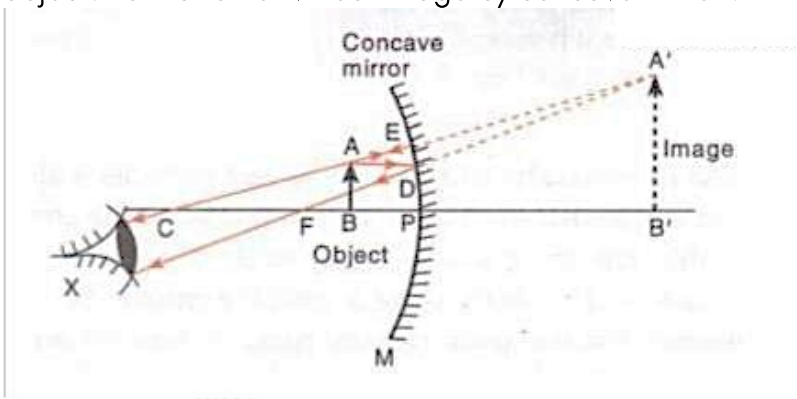
$$\text{Speed of light in water} = \frac{3 \times 3 \times 10^8}{4}$$

$$\text{Speed of light in water} = 2.25 \times 10^8 \text{m/s}$$

Q19. List four properties of the image formed by a concave mirror when an object is placed between the focus and pole of the mirror. [2M,2012]
Ans 19. When an object is placed between the focus and the pole of a concave mirror, the image formed is
(i) Virtual

(ii) Enlarged
(i) Behind the mirror
(iv) Erect

Q20. What is the minimum number of rays required for locating the image formed by a concave mirror for an object? Draw a ray diagram to show the formation of a virtual image by a concave mirror. [2M,2009]
Ans 20. At least two rays are required for locating the image formed by a concave mirror for an object. Formation of virtual image by concave mirror :



Q21. A ray of light travelling in air enters obliquely into water. Does the light ray bend towards the normal or away from the normal. Why? [2M]
Ans 21. The ray of light bends towards the normal. When a ray of light enters from an optically rarer medium (having low refractive index) to an optically denser medium (having high refractive index), its speed slows down and it bends towards the normal. Since water is optically denser than air, a ray of light entering from air into water will bend towards the normal.

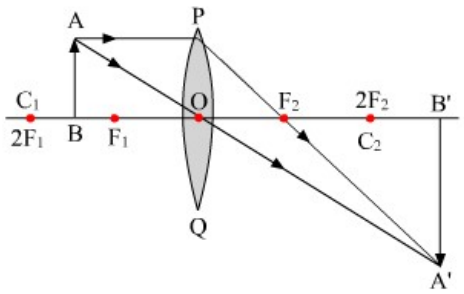
Q22. Differentiate a real image from a virtual image giving two points of difference. [2M]
Ans 22.

Real Image	Virtual Image
1. A real image is formed due to actual intersection of the reflected rays. 2. A real image can be obtained on a screen 3. A real image is inverted with respect to the object. E.g. The image of a distance object formed by a concave mirror.	1. A virtual image is formed when the reflected rays meet if they are produced backwards. 2. A virtual image cannot be obtained on a screen. 3. A virtual image is erect with respect to the object. E.g. The image of an object formed by a plane mirror or by a convex mirror.

Q23. Name the type of mirror used in the design of solar furnaces. Explain how high temperature is achieved by this device. [2M,2016]
Ans 23. (i) Concave mirror/ converging mirrors
(ii) When a solar furnace is placed at the focus of a large concave mirror/ reflector, it focuses a parallel beam of light on the furnace, consequently a high temperature is achieved after some time.

3 MARKS QUESTIONS

Q24. Convex lens can form a magnified erect image as well as a magnified inverted image of an object placed in front of it. [3M,2017]
Ans 24. Convex lens can form a magnified erect image as well as a magnified inverted image of an object placed in front of it.



Q25. State the laws of refraction of light. Explain the term 'absolute refractive of a medium' and write an expression to relate it with the speed of light in vacuum. [3M,2018]
Ans 25. Laws of Refraction of light : Refraction of light follows the following two laws :
First Law : The incident ray, the normal to the transparent surface at the point of incidence and the refracted ray, all lie in one and the same plane.
Second Law : The ratio of sine of the incidence angle to the sine of the refracted angle of the medium is called refractive index. It is denoted by n.
i.e., sin i/sin r = n
Refractive index of the second medium with respect to the first medium is denoted by $_2n_1$. Thus, eq. (i) can be written as
$_2n_1$ = sin i/sin r
This law is called Snell's law as it was stated by Prof. Willebrord Snell (Dutch mathematician and astronomer).
Absolute Refractive index : Absolute refractive index of a medium is defined as the ratio of the speed of light in vacuum or air to the speed of light in the medium. It is denoted by n.
Then, n = c/v
It has no unit.

Q26. The image formed by a spherical mirror is real, inverted and is of magnification '-2'. If the image is at a distance of 30 cm from the mirror, where is the object placed? Find the focal length of the mirror. List two characteristics of the image formed if moved 10 cm towards the mirror [3M,2016]
Ans 26.

Given: Magnification, m = -2

Distance of the image, v = -30 cm

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

$\therefore u = -\frac{v}{m} = -\frac{(-30)}{(-2)}$

∴u = -15 cm

Substituting these values in the mirror formula

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

$= \frac{1}{(-30)} + \frac{1}{(-15)}$

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

∴f = 10 cm

When the object is moved 10 cm towards the mirror the new position of the object is

u' = -(15-10) = 5 cm

Substituting the new value in the mirror formula

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

$\frac{1}{v'} = \frac{1}{f} - \frac{1}{u} = \frac{1}{10} - \frac{1}{(-5)}$

$\frac{1}{v'} = \frac{1}{10}$

∴v' = 10 cm

Thus, the image is located 10 cm behind the mirror.

And magnification, $m' = \frac{v'}{u'} = -\frac{10}{(-5)}$

m' = 2

Since magnification is positive the image is erect and virtual.

Thus, the image is erect,virtual and magnified in nature.

Q27. An object of height 5 cm is placed perpendicular to the principal axis of a concave lens of focal length 10 cm. If the distance of the object from the optical centre of the lens is 20 cm, determine the position, nature and size of the image formed using the lens formula. [3M,2015]
Ans 27.

Given:-

Height of the object = h = 5 cm

Focal length of the concave lens = f = −10 cm

Object distance = u = −20 cm

Using the lens formula, we get

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

$$\therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{-10} - \frac{1}{20} = \frac{-2-1}{20} = \frac{-3}{20}$$

$$\therefore v = -6.67cm$$

Hence, the image is formed 6.67 cm in front of the lens on the same side as the object.

Because v is negative, we can say that the image is virtual.

From the magnification formula for the lens, we get

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

$$\therefore h' = \frac{vh}{u} = \frac{-6.67 \times 5}{-20} = 1.67cm$$

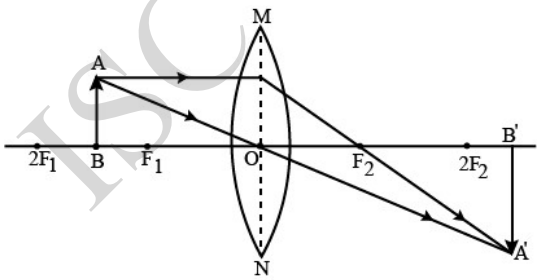
Hence, the size of the image is h' = 1.67 cm.

Because the height of the image is positive and smaller than the height of the object, the image is erect and diminished.

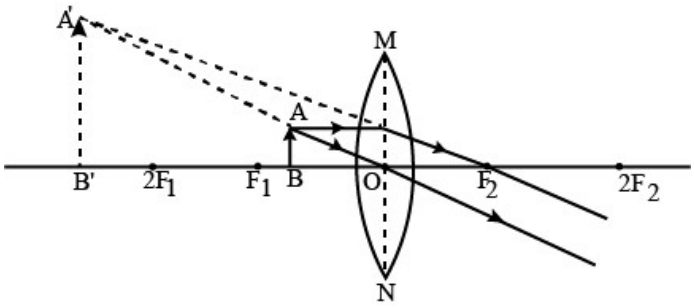
So, we can conclude that the image is virtual, erect and diminished.

Q28. Draw ray diagrams to show the formation of three times magnified (a) real and (b) virtual image of an object by a converging lens. Mark the positions of O, F and 2F in each diagram. [3M,2017]

Ans 28. (a) To get three times magnified real image of the object, the object is placed between F1 & 2F2



(b) To get three times magnified virtual image of the object, the object is placed between the F1 and optical centre O.



5 MARKS QUESTIONS

Q29. List the sign conventions for reflection of light by spherical mirrors. Draw a diagram and apply these conventions in the determination of focal length of a spherical mirror which forms a three times magnified real image of an object placed 16 cm in front of it. [5M,2012]

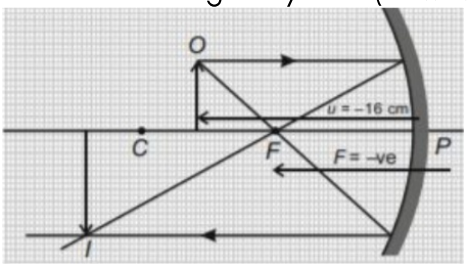
Ans 29. Sign conventions of spherical mirror :

(i) Object is always placed to the left of the mirror.

(ii) All distances are measured from the pole of the mirror.

(iii) Distances measured in the direction of the incident ray are positive and the distances measured in the direction opposite to that of the incident ray are negative.

(iv) Distances measured along the y-axis (upwards) above the principal axis are positive and that measured along the y-axis (downwards) below the principal axis are negative.



Given that: u =-16cm and m = 3

We know that magnification for a spherical

But $m = -\frac{v}{u} = -3$

$\Rightarrow \quad v = 3u = 3(-16) = -48$ cm.

Using mirror formula,

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

We get, $\frac{1}{f} = \frac{1}{-48} + \frac{1}{-16}$

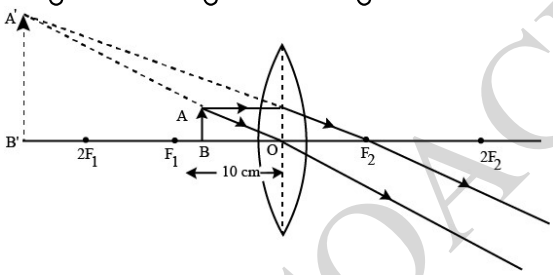
$$= \frac{1}{-48} - \frac{1}{16} = \frac{-1-3}{48} = \frac{-4}{48} = \frac{-1}{12}$$

or $f = -12$ cm

Negative sign of focal length implies that the focal length is being measured against the direction of incident light and it is a concave mirror.

Q30. What is meant by power of a lens? Define its SI unit. You have two lenses A and B of focal lengths +10 cm and-10 cm, respectively. State the nature and power of each lens. Which of the two

lenses will form a virtual and magnified image of an object placed 8 cm from the lens? Draw a ray diagram to justify your answer. [5M,2015, 2018]
Ans 30. The power of a lens is defined as the reciprocal of its focal length. It is represented by the letter p.
The power p of a lens of focal length f is given as
p= 1/f
The SI unit of power is dioptre (D).
Given:
Power of a lens is defined as the ability of less to converge or to diverge a beam of light. It is also defined as reciprocal of focal length in metres.
Let f_A be focal length of lens A and P_A be the power of lens A.
For lens A:
f_A = + 10 cm = 0.1 m
Since the focal length is positive, it is a convex lens.
Now, PA= $1/f_A$=1/0.1=+10D.
For lens B : f_B = -10 cm = - 0.1 m
Let fB be focal length of lens A and P_B be the power of lens B.
Since the focal length is negative, it is a concave lens.
PB=$1/f_B$=1/-0.1=-10D.
The negative sign indicates that it is a diverging or concave lens.
In a convex lens, when the object is placed between the pole and focus, the image formed is always virtual and magnified.
On the other hand, a concave lens produces a virtual, erect but diminished image. Here the object is placed 8 cm from the lens which is at a distance less than the focal length, i.e. less than 10 cm. Thus, the 8 cm position of the object placed in front of the convex lens will produce a virtual and magnified image. The diagram for the same is as shown below :



Q31. An object is placed at a distance of 60 cm from a concave lens of focal length 30 cm.
(a) Use lens formula to find the distance of the image from the lens.
(b) List four characteristics of the image (nature, position, size, erect/inverted) formed by the lens in this case.
(c) Draw ray diagram to justify your answer of part (b) [5M,2019]
Ans 31.
u=-60cm, f=-30cm
(i) Lens formula, 1/f = 1/v-1/u
1/v=1/f+1/u
1/v= 1/(-30) + 1/(-60) =-20cm
The image is at a distance of 20 cm from the lens.
(b) Characteristics of image formed. The image is
1 . Virtual and erect
2. On the same side of the object

3. In front of the lens between 'O' and 'F'
4. Diminished.