# Refraction :

Bending of light is called refraction.

### * Reason *

→ when it is moving from one medium to other medium. It's velocity change. So light will bend.

→ Light velocity is different in different mediums.

→ In denser medium light velocity is very less.

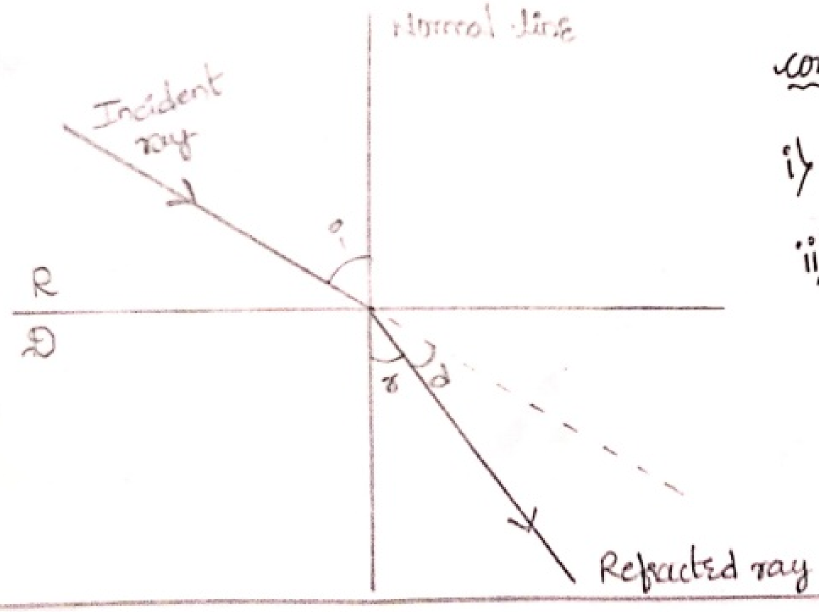
→ In rarer medium light velocity is more.

→ light velocity in vaccum is $3 \times 10^8 m/s$.

### * Types of refraction *

**Rarer to denser**

when light travels from rarer medium to denser medium. It will bend towards normal line.




conditions

i) $\angle i > \angle r$

ii) $i = r + d$

$\boxed{d = i - r}$

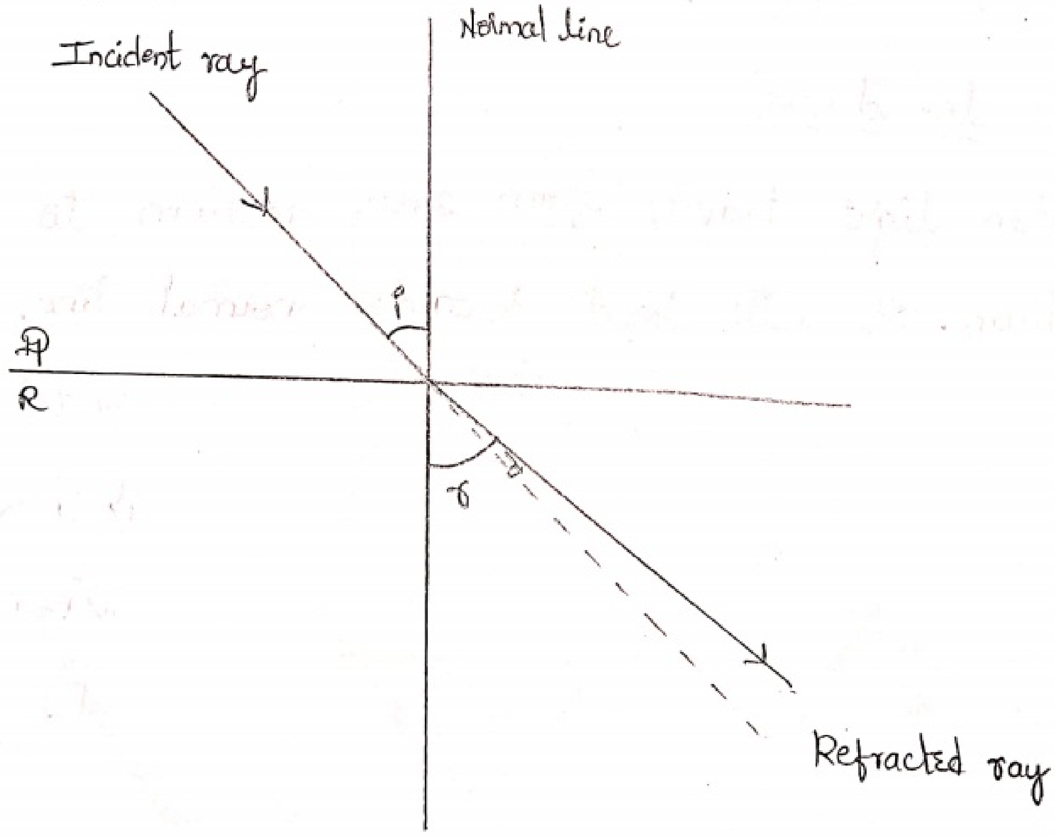
* Application

* If kohli is in water dhoni watching from outside how kohli will appear to dhoni ?

Ans: Kohli will appear shorter to dhoni because the light ray is travelling from rarer medium to denser medium then the light ray will bend towards normal. So, kohli appears shorter to Dhoni.

2. When light ray is travelling from denser to Rarer:

when light ray travels from denser to rarer it bends away from the normal line.



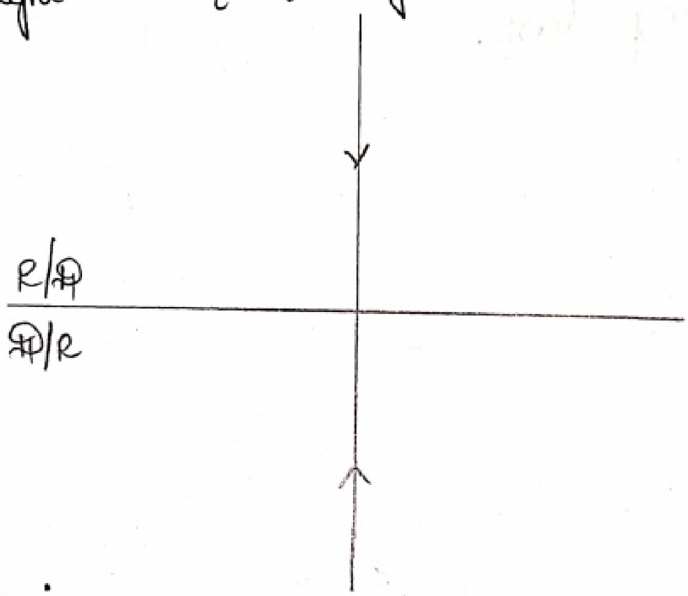
* Application :

* If Kohli is in water Kohli watching dhoni from water how dhoni will appear to kohli.

Ans: Dhoni will appear taller to kohli because the light ray is travelling from denser to rarer then the light ray will bend away from the normal line. So, Dhoni appears taller to kohli.

3. When light ray travelling through normal line :

when light travels through normal line it will not bend.




conditions

i) $\angle i = 0$

ii) $\angle r = 0$

iii) $d = 0$

* Application :

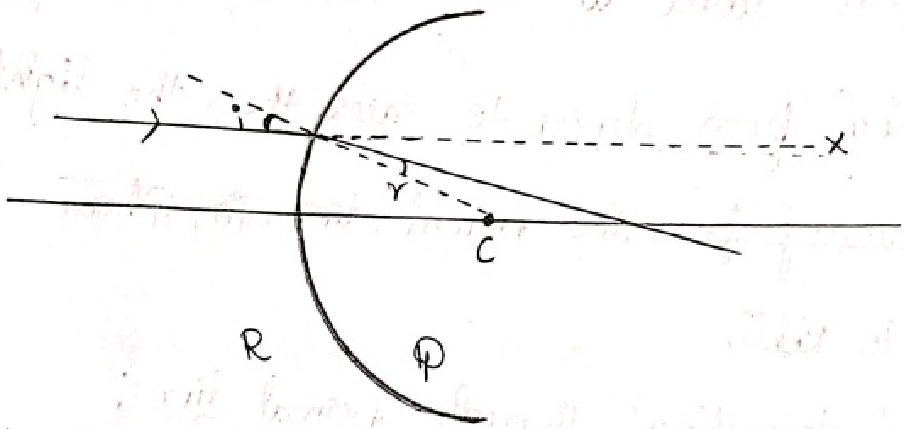
* The King fisher bird if it wants to catch the fish in water how it should travel.

Ans: If king fisher bird wants to catch the fish in water then it should travel through normal line.

# * Refraction through surfaces *

**convex surface :**

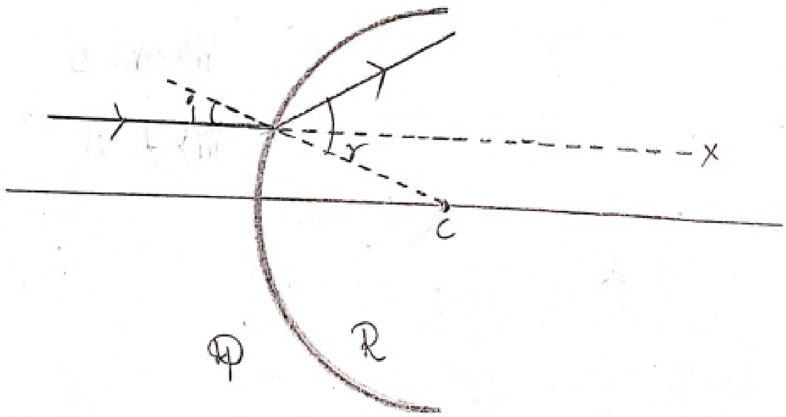
i) Rarer to Denser




→ Light bends towards normal line.

→ It is a converging lens.

ii) Denser to Rarer

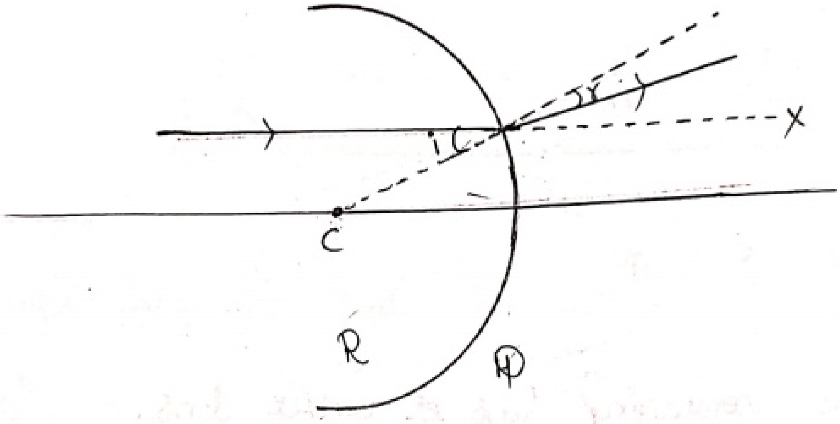



→ If light travels from Denser to Rarer then it bends away from normal.

→ Diverging lens.

concave surface:

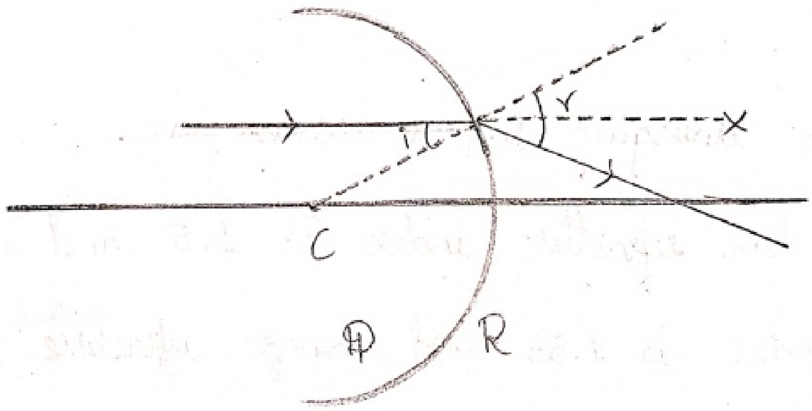
i) Rarer to Denser




⇒ If light travels from rarer to denser it bends towards normal line.

⇒ It acts as diverging lens.

ii) Denser to Rarer

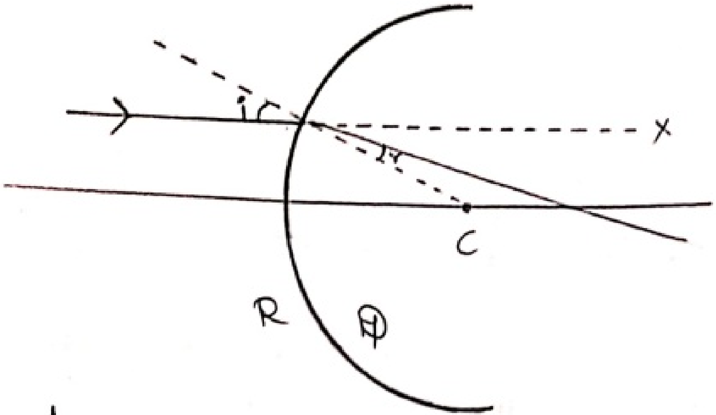



⇒ If light travels from denser to Rarer then it bends away from normal line.

⇒ It acts as converging lens.

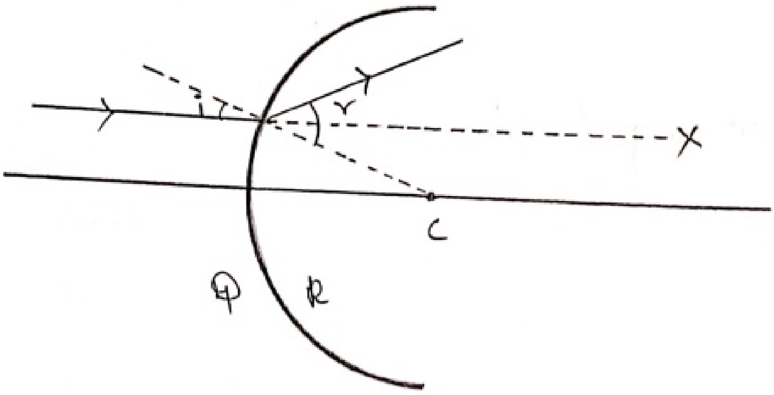
## * Applications

1. How water drop will act in air




It acts as converging lens or convex lens.

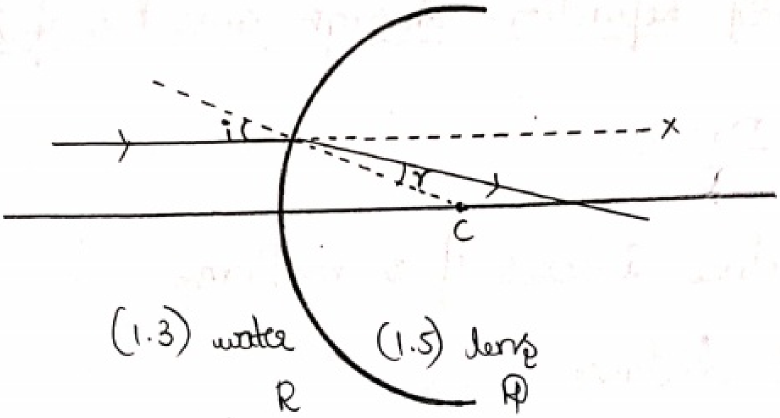
2. How air bubble will act in water.




It acts as diverging lens or convex lens.

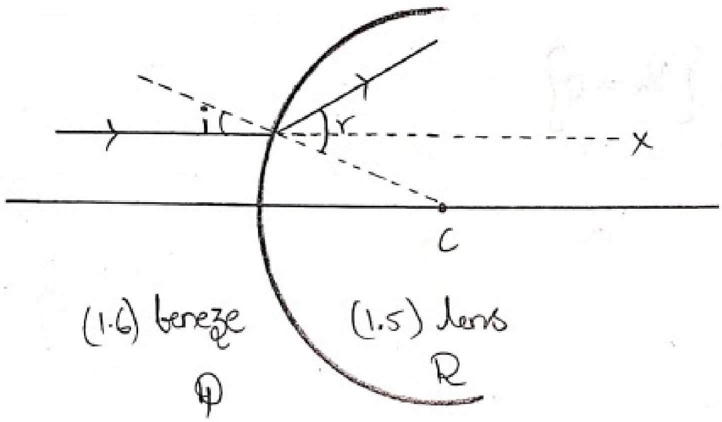
3. The convex lens refractive index is 1.5 and water refractive index is 1.33 and beneze refractive index 1.6 then when lens kept in water and also beneze how it will act.

Ans: When convex lens is kept in water.




when convex lens is kept in water it acts as converging lens.

when convex lens is kept in beneze.




when convex lens is kept in beneze it acts as diverging lens.

## * Image formation by Refraction through curved surface.

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

$n_1, n_2 \Longrightarrow$ Refractive indexes of 2 mediums

$u \Longrightarrow$ object distance

$v \Longrightarrow$ Image distance

$R \Longrightarrow$ Radius of curvature.

## * For plane surface.

$R, F = \alpha$

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{\alpha} \quad \left\{ 1/\alpha = 0 \right\}$$

$$\frac{n_2}{v} - \frac{n_1}{u} = 0$$

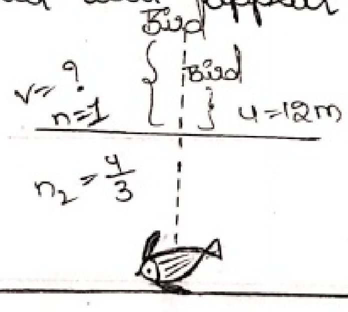
$$\frac{n_2}{v} = \frac{n_1}{u}$$

$$\frac{n_1}{u} = \frac{n_2}{v}$$

## * Applications:

1. A bird flying in the sky at a height of 12m from sea level. If a fish watching the bird through water at what height bird will appear to fish.

Ans:



$\Rightarrow \frac{n_1}{u} = \frac{n_2}{v}$

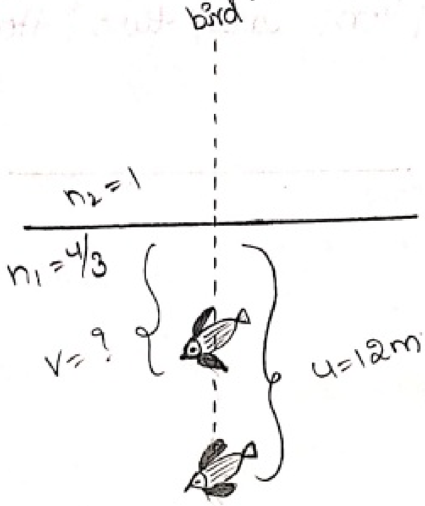
$\frac{1}{12} \times \frac{4/3}{v}$

$v = \cancel{12}^{4} \times 4/\cancel{3}_{1}$

$v = \underline{\underline{16m}}$

2. If a fish is at 12m depth in water when we see from air where does it appears.

Ans:




$\Rightarrow \frac{n_1}{u} = \frac{n_2}{v}$

$\Rightarrow \frac{4/3}{12} \times \frac{1}{v}$

$4/3\, v = 12$

$v = \cancel{12}^{3} \times 3/\cancel{4}_{1}$

$v = 3 \times 3$

$v = \underline{\underline{9m}}$

* Examples :

1. A bird is flying down vertically towards the surface of water in a pond with constant speed. There is a fish inside

the water. If that fish is exactly vertically below the bird, then the bird will appear to the fish to be :

a. farther away than its actual distance.

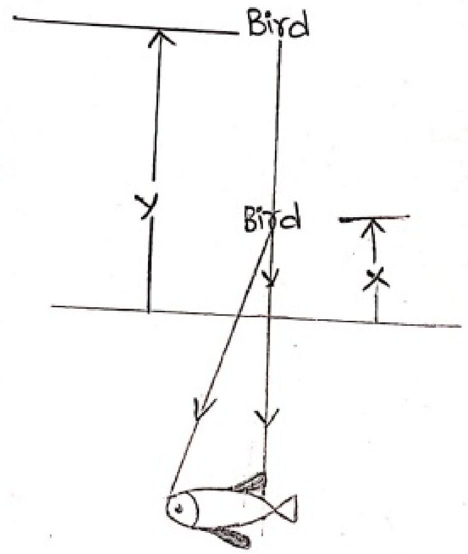
b. closer than its actual distance.

c. moving faster than its actual speed.

d. moving slower than its actual speed.

Which of the four options are true? How can you prove it ?

Ans:




for refraction at a plane surface,

we use $\frac{n_2}{v} = \frac{n_1}{u} \Longrightarrow (1)$

Let $x$ be the height of the bird above the water surface at an instant and $n$ be the refractive index of water.

$n_1$ = refractive index of air,

Then $n_1 = 1$, $n_2 = n$, $u = -x$ and $v = -y$,

Substituting these values in equation (1)

$$\frac{n}{-y} = \frac{1}{-x}$$

$$+y = +nx$$

$$y = nx$$

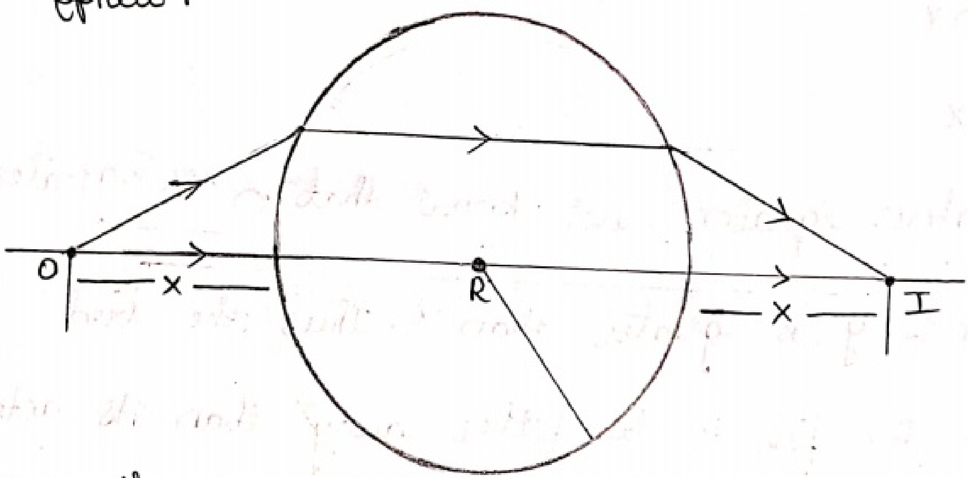
In the above equation, we know that $n$ is greater than 1. Hence $y$ is greater than $x$, Thus the bird appears to the fish to be farther away than its actual distance. We have assumed that bird is flying vertically down with constant speed, for the observer on the ground, bird appears that it has covered $x$ distance for certain time. But for fish, it appears that bird has covered a distance $y$ in the same time. As $y$ is greater than $x$, we can conclude that the speed of the bird, observed by the fish, is greater than its actual speed.

So, options (a) and (c) are correct.

2. A transparent sphere of radius R and refractive index $n$ is kept in air. At what distance from the

surface of the sphere should a point object be placed on the principle axis so as to form a real image at the same distance from the second surface of the sphere.

Ans:-




from the symmetry of figure, the rays must pass through the sphere.

from the figure,

$u = x$, $v = \alpha$ (refracted rays is parallel to the optical axis after refraction first surface).

$n_1 = 1$ and $n_2 = n$ (where $n_1$ is refractive index of air).

using $\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$

$\frac{n}{\alpha} - \frac{1}{-x} = \frac{(n-1)}{R} \Rightarrow \frac{1}{x} = \frac{(n-1)}{R}$

$\Rightarrow x = \frac{R}{(n-1)}$

object distance from the first surface of the sphere is $x = \frac{R}{(n-1)}$.

3. A transparent (glass) sphere has a small, opaque dot at its centre. Does the apparent position of the dot appear to be the same as its actual position when observed from outside?

Ans: Let refractive index of glass $n_1 = n$

refractive index of air $n_2 = 1$

Then $u = -R$ (Radius of sphere) ; Radius of curvature $R = -R$

using $\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$

$$\frac{1}{v} - \frac{n}{-R} = \frac{(1-n)}{-R}$$

After solving this equation, we get

Image distance $v = -R$

Thus we can say that the image distance and object distance are equal and that the apparent position of dot is the same as its actual position.

## * Lens :

A lens is a transparent material which can be prepared by 2 spherical surfaces (atleast 1 spherical surface).

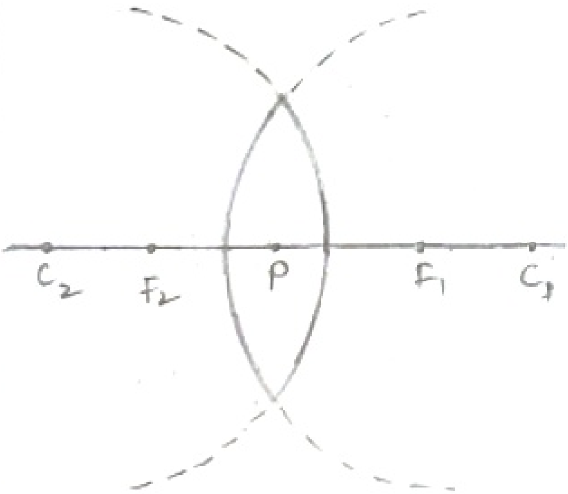
## * Types of Lenses :

1. convex lens :-

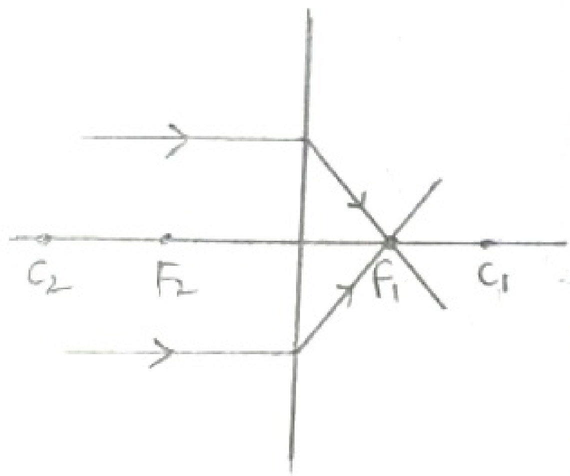
The lens which is thicker at middle and thiner at edges is called convex lens.

It is also called as converging lens and also called as positive lens.

convex lens




Symbol of convex lens




It is also called as double convex lens.

uses of convex lens :

1. It is used to correct hyper - metropia vision defect.

2. It is used as Reading lens {magnifying lens}.

3. It is used as simple microscope.

4. It is used in camera, projector and also in search light.

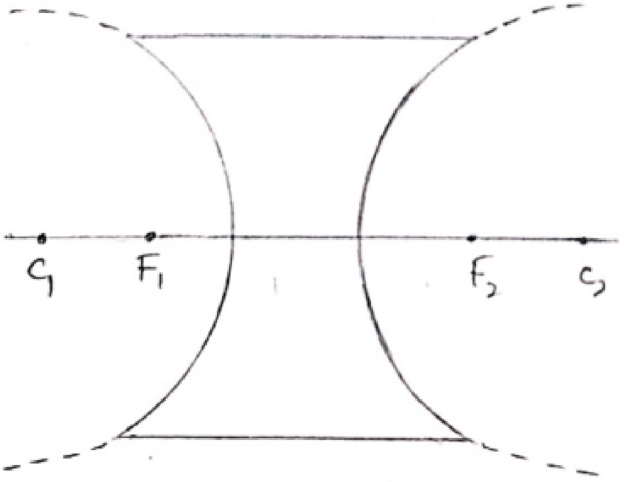
5. It is used as burning lens.

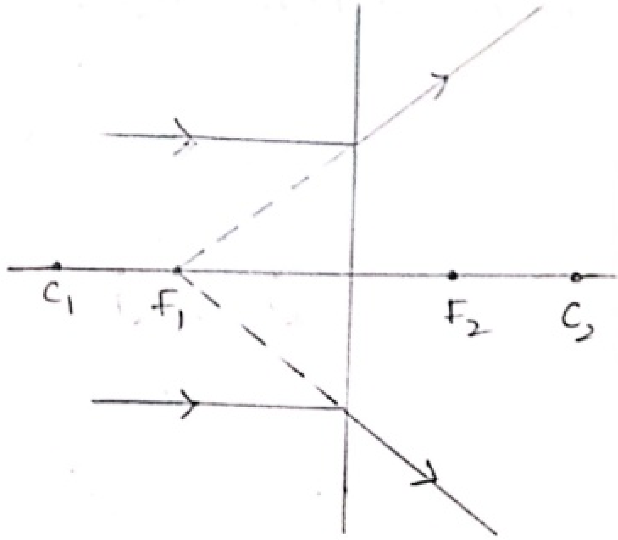
2. concave lens :-

The lens which is thinner at middle and thicker at edges is called concave lens.

It is also called as double concave lens.

It is also called as diverging lens and also called as negative lens.



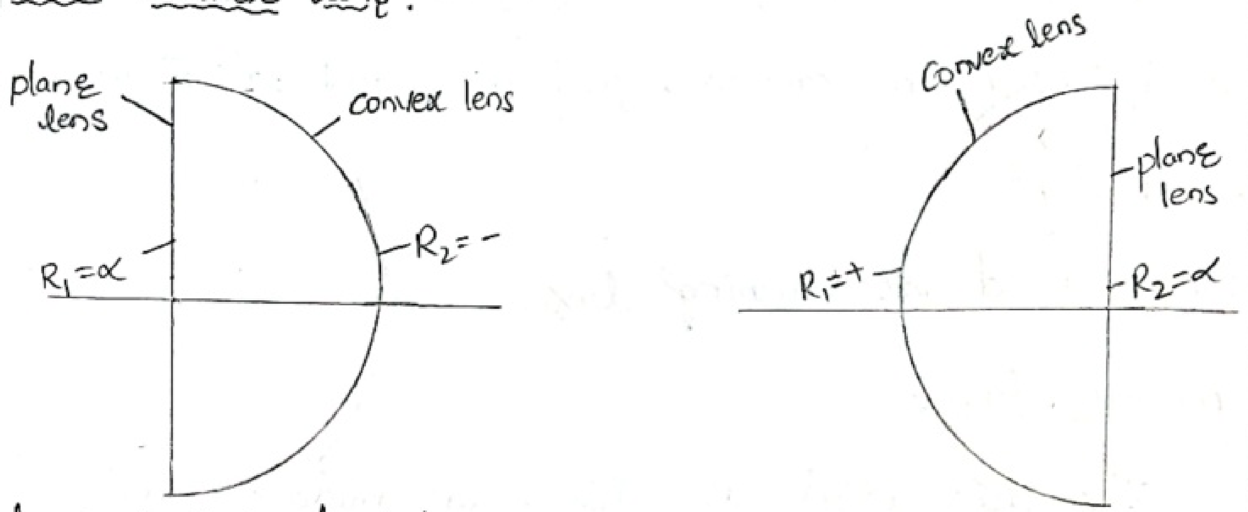



## uses of concave lens :

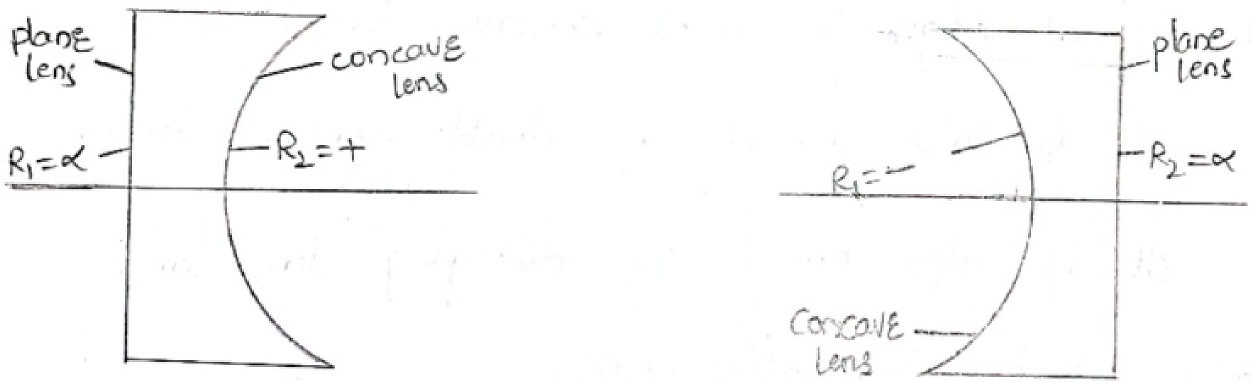
1. It is used to correct myopia vision defect.

2. It is used in gallalio telescope.

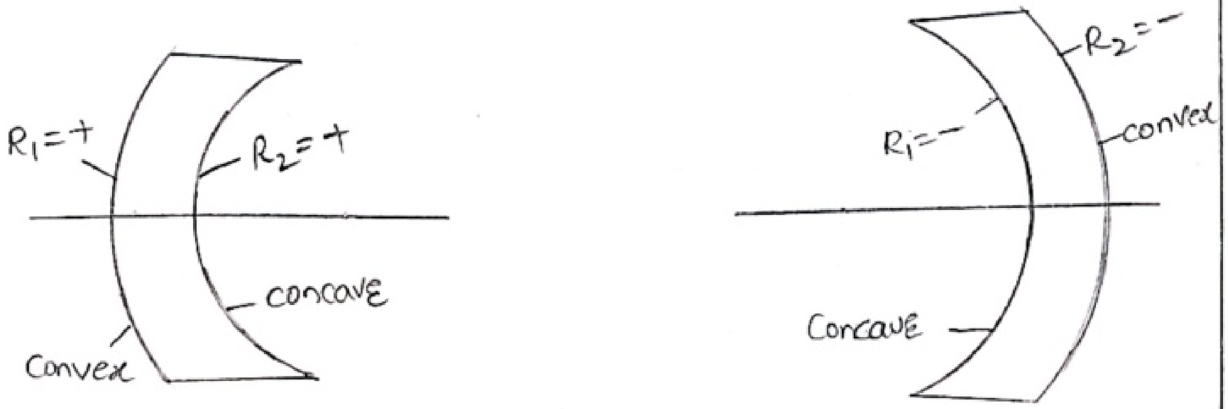
3. plano convex lens :



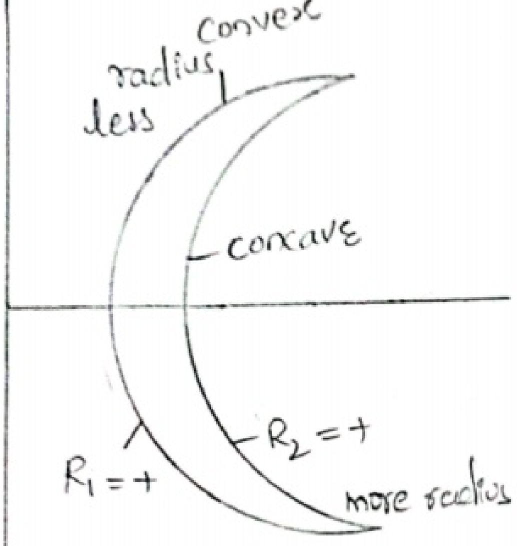

4. plano concave lens :

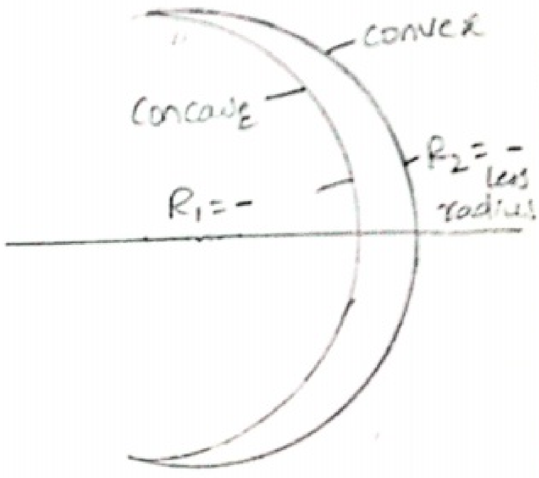



5. convexo concave lens :



6. concavo convex lens :



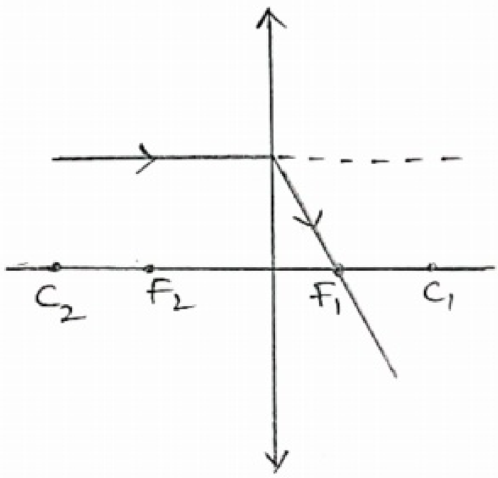



## * Rules for rays diagrams

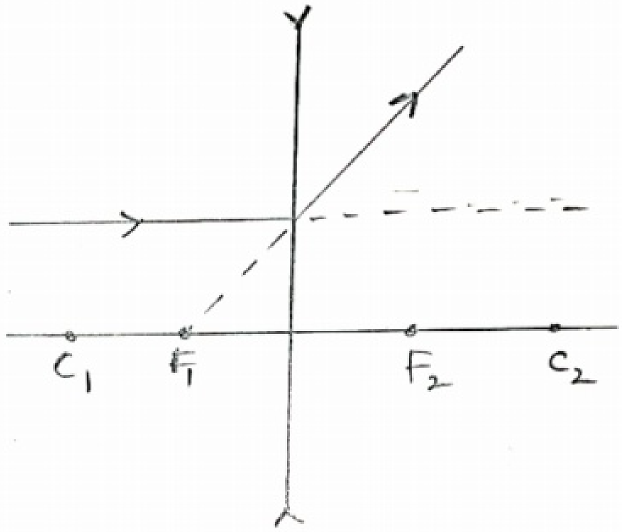
### Rule - 1

If the incident light rays is parallel to principle axis, after refraction it passes {appears to passes} {through focus}.

convex lens



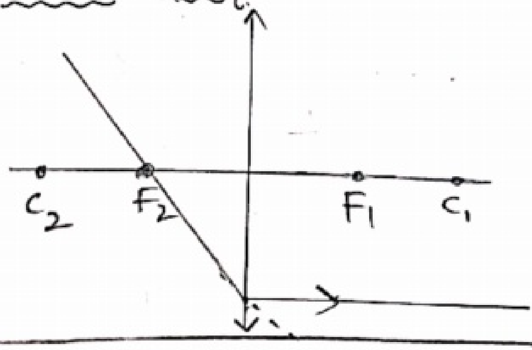

concave lens



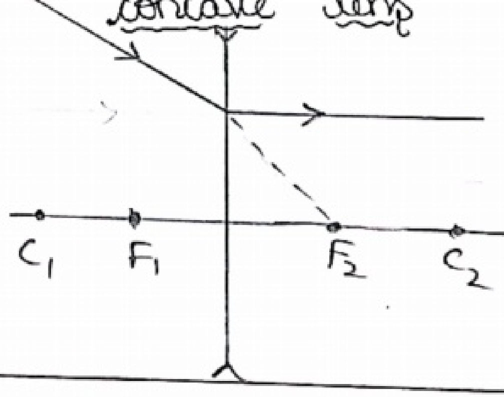

### Rule - 2

If the incident light rays is passes {appears to passes} {through focus} after refraction is parallel to principle axis.

convex lens



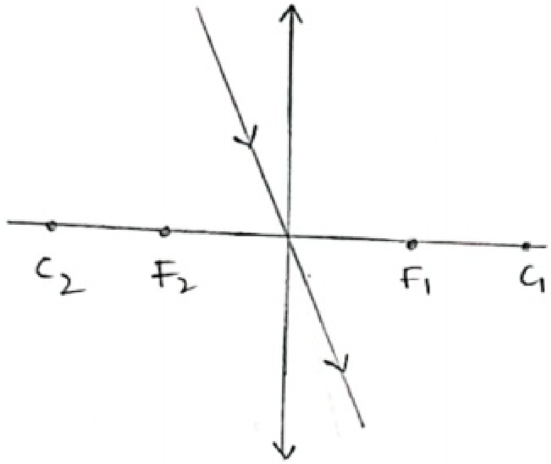

concave lens



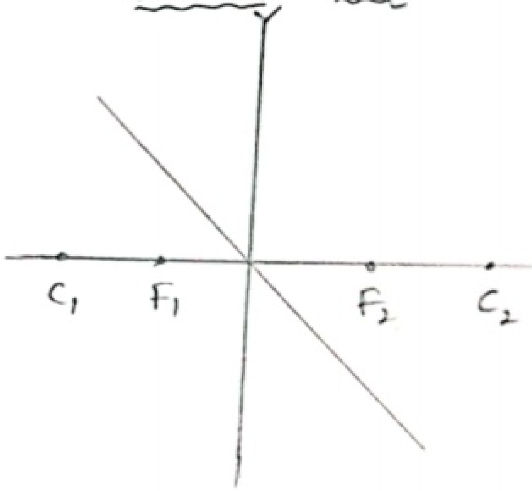
## Rule - 3

If the incident light ray passes {appears to passes} through pole after refraction again it passes {appears to passes} through same pole {P}.

convex lens

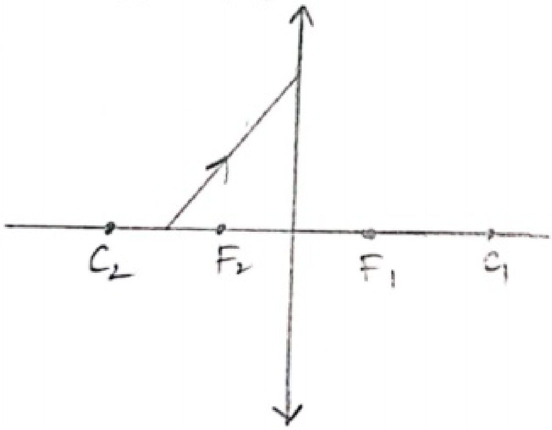


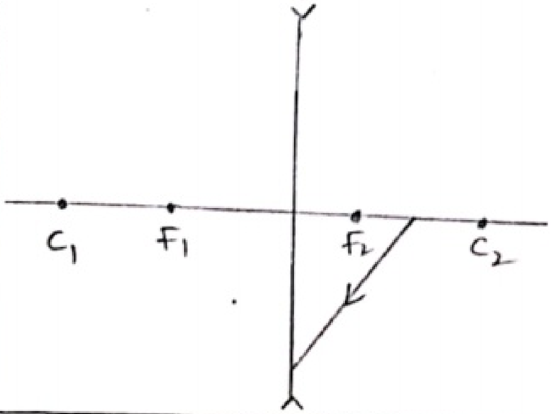

concave lens



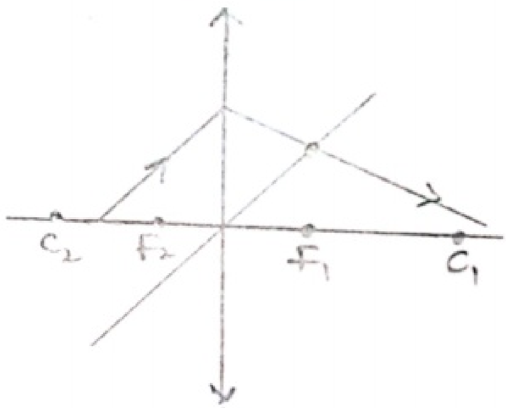

* complete the ray diagrams

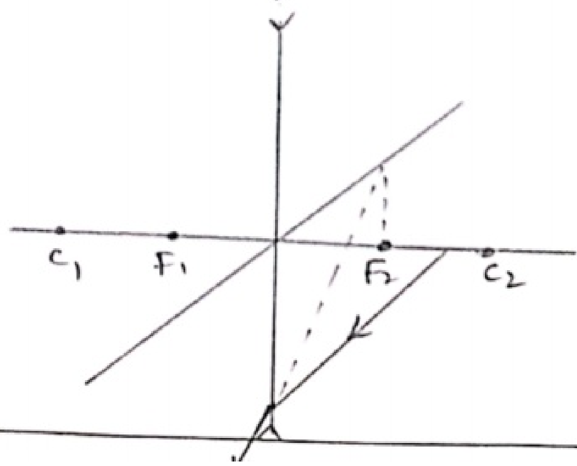
questions

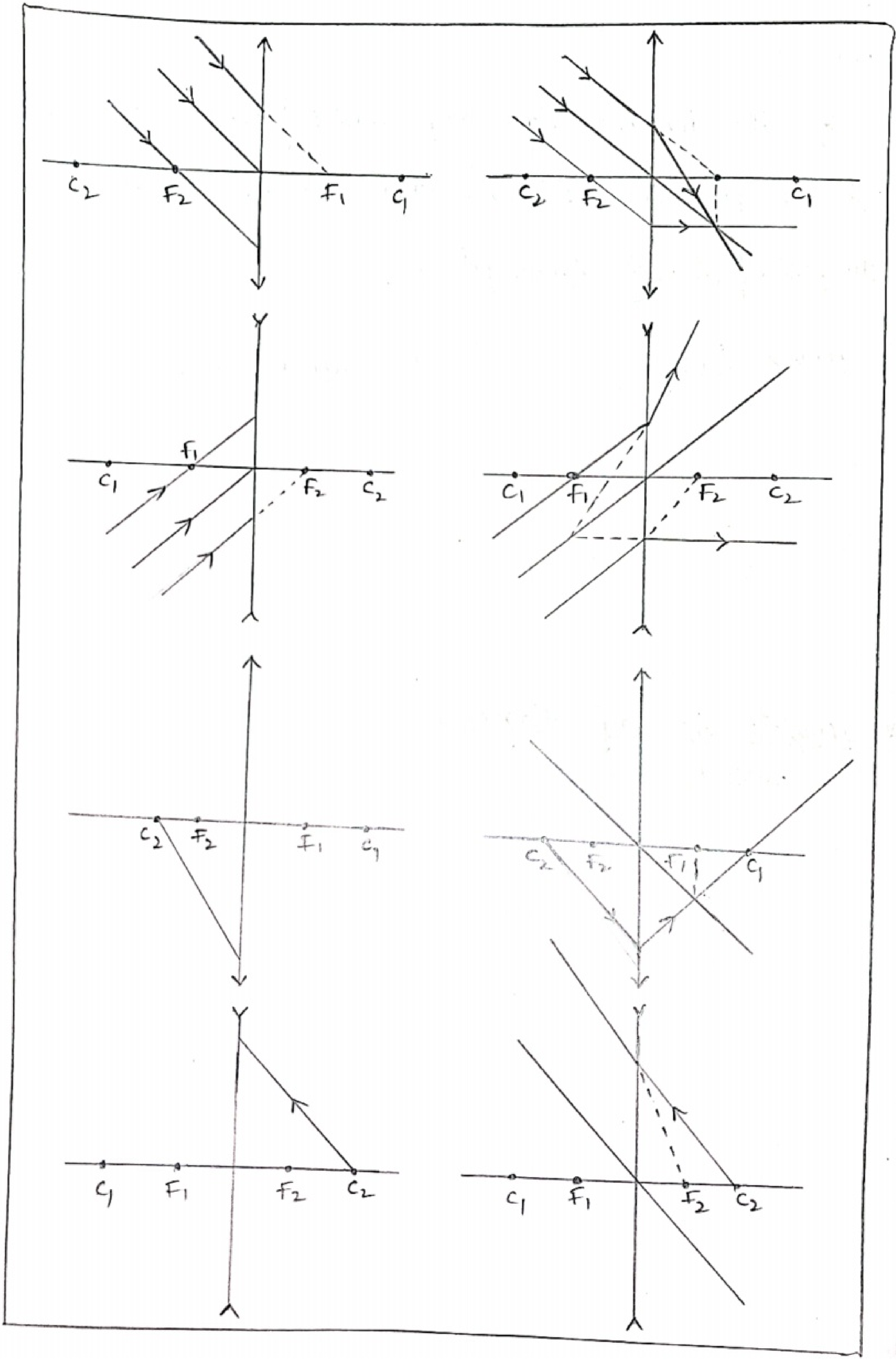



Answers




C2 F2 F1 C1
C2 F2 C1
C1 F1 F2 C2
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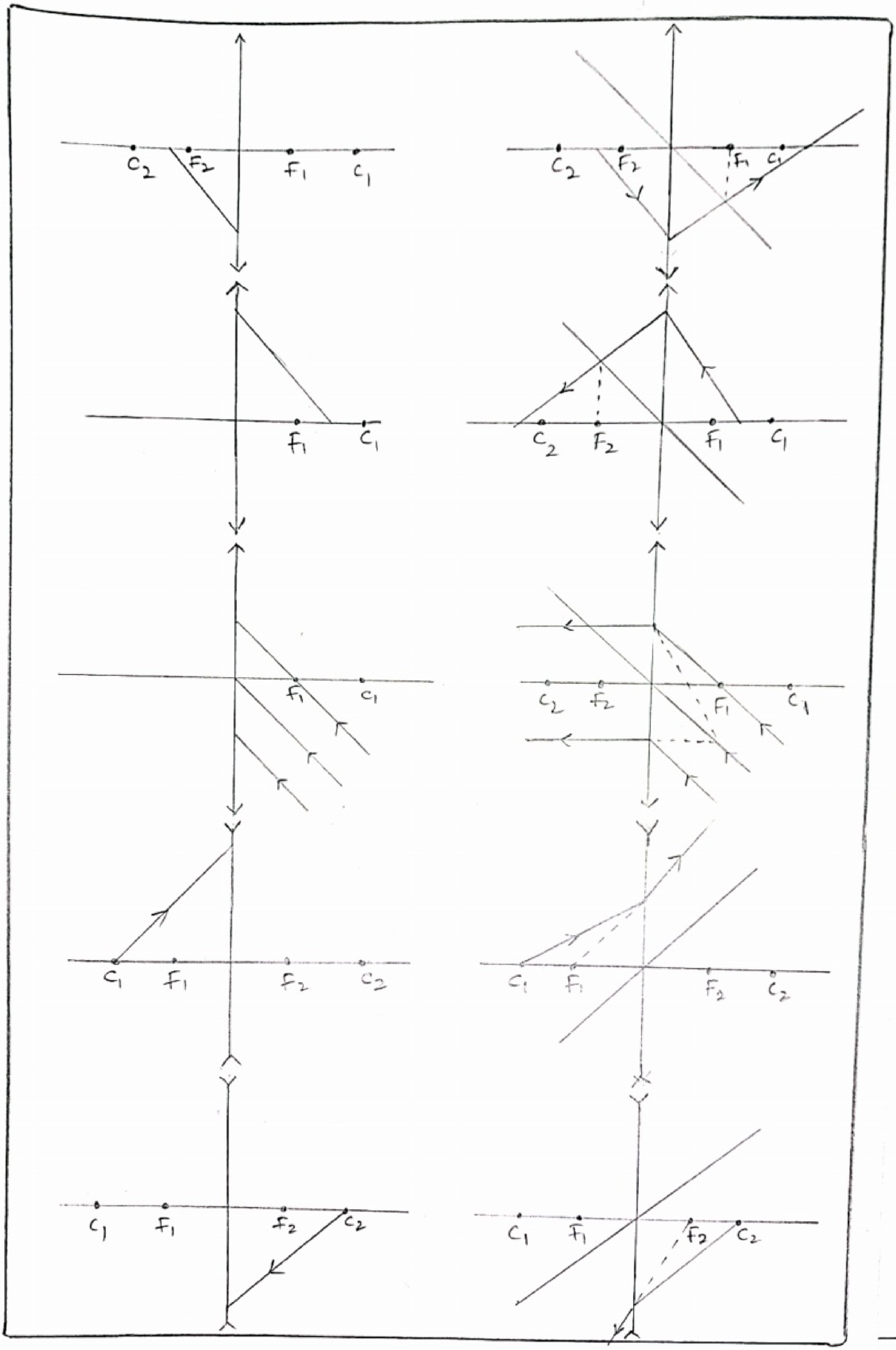
C1 F1 F2 C2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F1 C1
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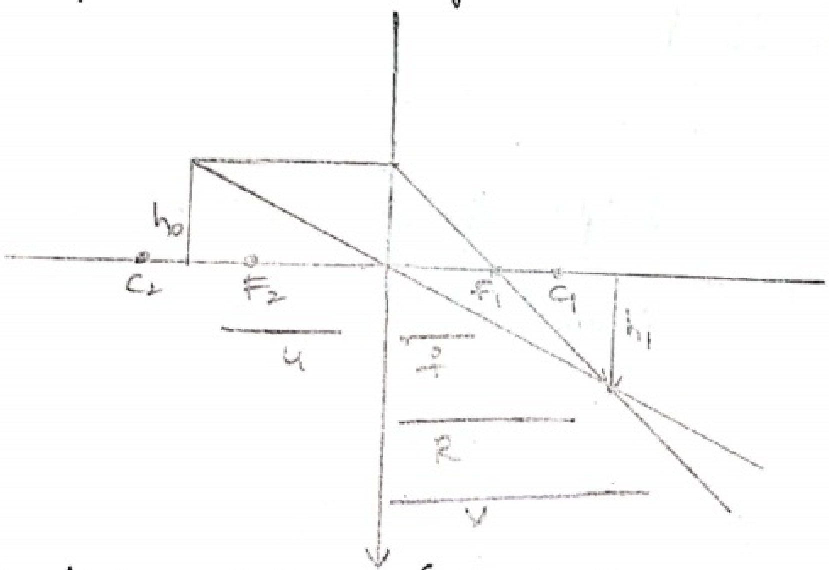
F1 C1
C2 F2 F1 C1
C1 F1 F2 C2
C1 F1 F2 C2
C1 F1 F2 C2
C1 F1 F2 C2

* Sign convention rules

1. All the distances should measured from the pole.
2. If the distances measured in incident light direction. Then taken as positive.
3. If the distances measured opposite to incident light direction taken as negative.
4. If the object or image lies above the principle axis that height taken as positive.
5. If the object or image lies below the principle axis that height taken as negative.

Ex:-

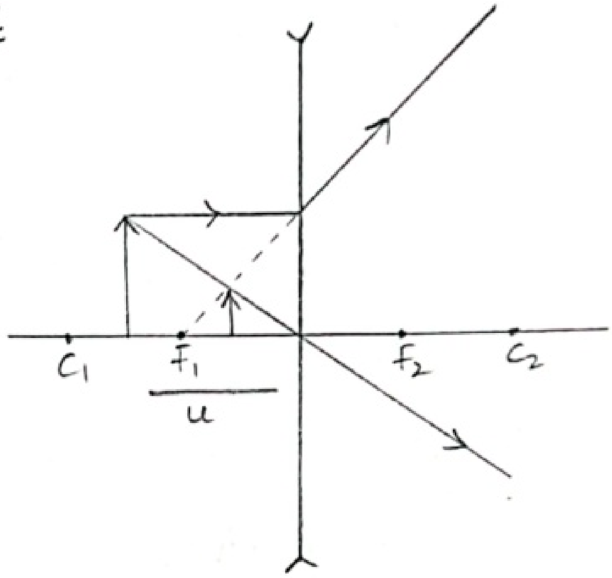



object distance (u) = − {Negative}
Image distance (v) = + {positive}
focal length (f) = + {positive}
height of image (hi) = − {Negative}
height of object (ho) = + {positive}

# * convex lens *

1. object is at infinity (∞)

A. Ray diagram




B. properties

Nature - Real and inverted image

position - on F

size - highly diminished

C. Sign convention

object distance = -    height of the object = -

Image distance = +    height of the image = -

focal length = +

D. Magnification

$M = \frac{-v}{u}$ or $\frac{hi}{ho}$

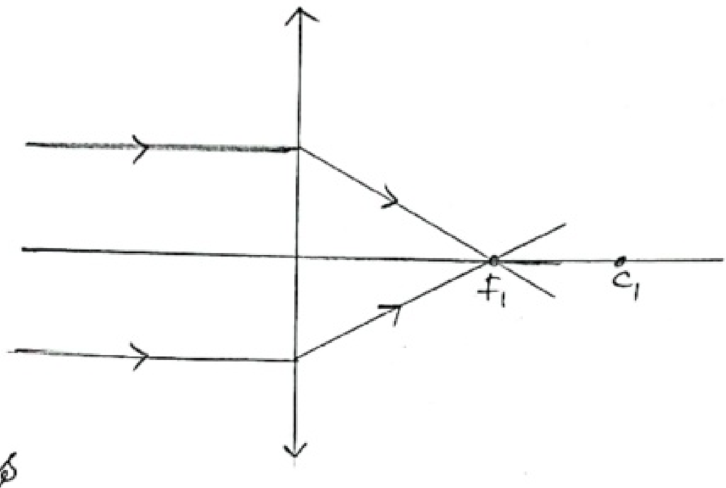
$\boxed{m < -1}$

E. uses

It is used in burning lens.

2: object beyond 'C'.

A. Ray diagram




B. properties

Nature - Real and inverted image

position - between F and C

Size - diminished

C. Sign convention

object distance = -     height of the object = +

Image distance = +     height of the image = -

focal length = +

D. Magnification

$$m = \frac{-v}{u} \text{ or } m = \frac{h_i}{h_o}$$

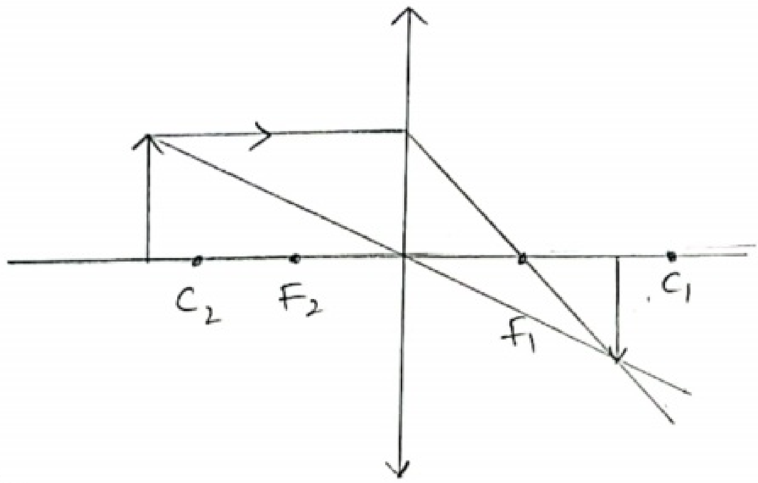
$$\boxed{m < -1}$$

'-' indicates Real and inverted

less than means diminished image.

3. object on 'c'

A. Ray diagram




B. properties

Nature - Real and inverted image

position - on c

size - same

C. sign convention

object distance = -    height of the object = +

Image distance = +    height of the image = -

focal length = +

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_o}$.

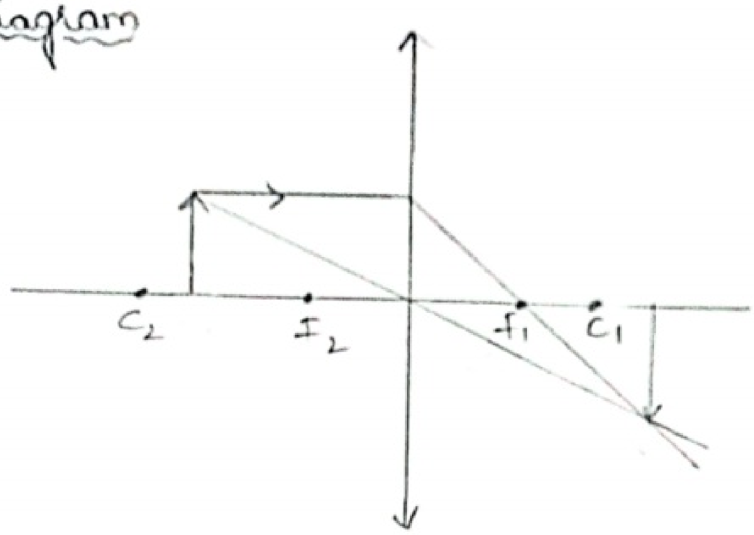
$\boxed{m = -1}$

'–' means Real and ~~xxx~~ inverted image

is equals to means same size or equal size.

4. object between 'F' and 'C'.

A. Ray diagram




B. properties

Nature - Real and inverted image

position - beyond C

size - magnified

C. Sign convention

object distance = - height of the object = +

Image distance = + height of the image = -

focal length = +

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_o}$

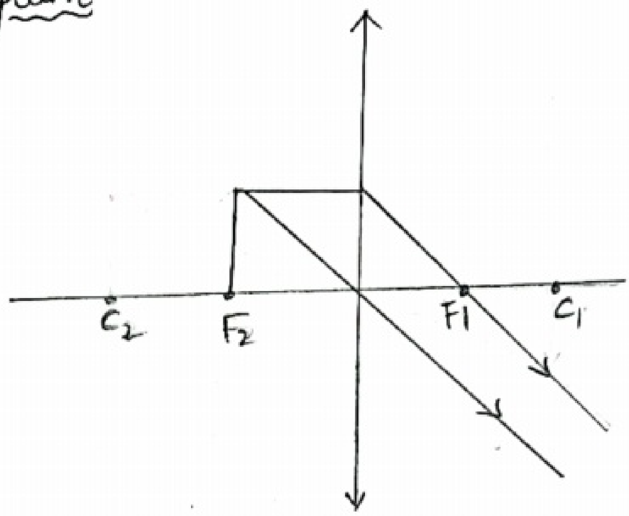
$\boxed{m > -1}$

-, means Real and inverted

Greater than means magnified image.

15. object on 'F'

A. Ray diagram




B. properties

Nature - Real and inverted image

position - beyond 'C'

Size - highly magnified

C. Sign convention

object distance = −  height of the object = +

Image distance = +  height of the image = −

focal length = +

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_o}$

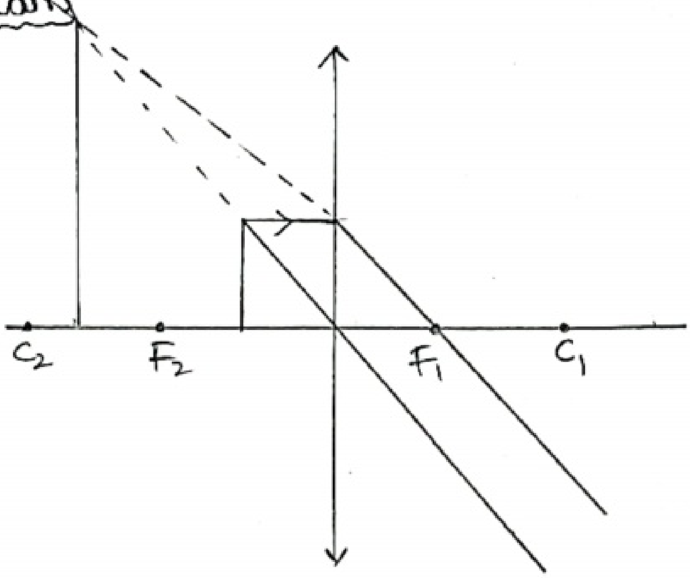
$\boxed{m > -1}$

'−' indicates Real and inverted

Greater than means magnified.

6. object is between 'P' and 'F'

A. Ray diagram




B. properties

Nature - virtual and erect image

position - same side of the object

size - magnified

C. sign convention

object distance = -

Image distance = -

focal length = +

height of the object = +

height of the Image = +

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_o}$

$\boxed{m > 1}$

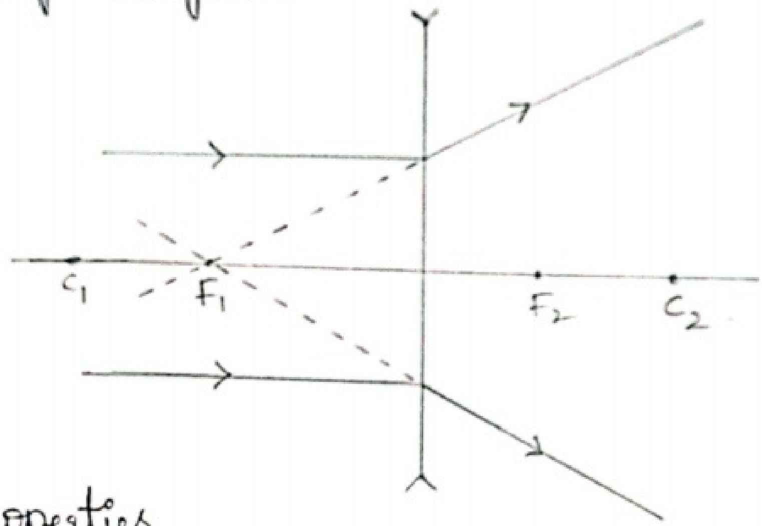
'+' indicates virtual and erect image

Greater than means magnified.

## * concave lens

1. object is at infinity (∞)

A. Ray diagram




B. properties

Nature - virtual and erect image

position - on 'F'

size - highly diminished

C. sign convention

object distance = -

Image distance = -

focal length = -

D. Magnification

$$m = \frac{-v}{u} \text{ or } m = \frac{h_i}{h_o}$$

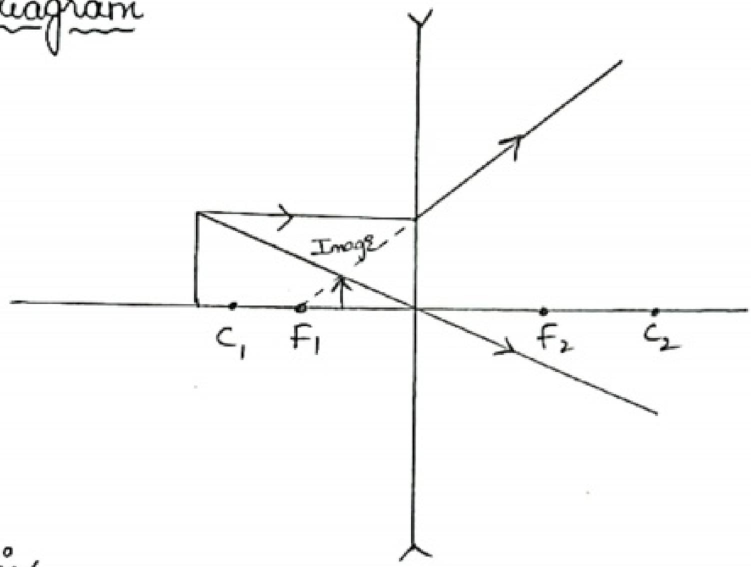
$$\boxed{m<1}$$

'+' means virtual and erect image

less than means smaller image.

2. object beyond 'C'

A. Ray diagram




B. properties

Nature - virtual and erect image

position - same side of the object

size - dimnished

C. sign convention

object distance = -

Image distance = -

focal length = -

height of the object = +

height of the image = +

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_o}$

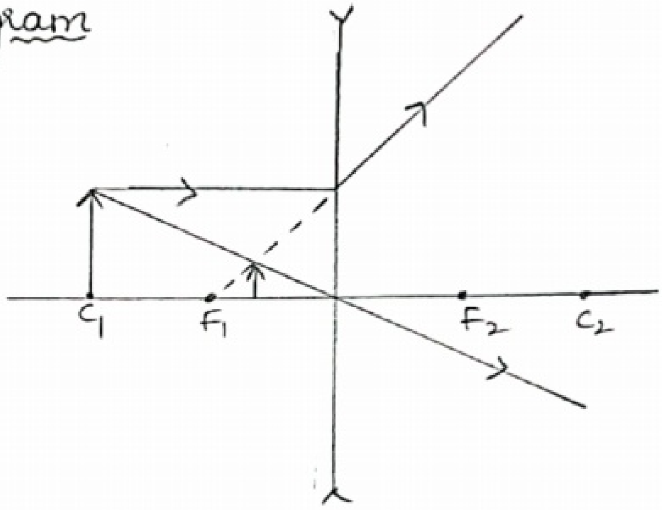
$\boxed{m<1}$

'+' indicates virtual and erect image.

less than means dimnished image.

3. object on 'c'

A. Ray diagram




B. properties

Nature - virtual and erect image

position - same side of the object

size - diminished

C. sign convention

object distance = -

height of the object = +

Image distance = -

height of the Image = +

focal length = -

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_o}$

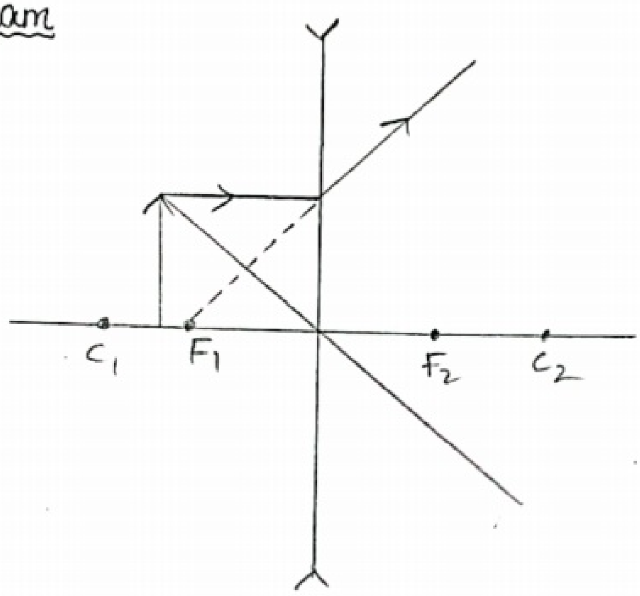
$\boxed{m < 1}$

'+' indicates virtual and erect image

less than means diminished image.

4. object between 'f' and 'c'

A. Ray diagram




B. properties

Nature - virtual and erect image

position - same side of the object

size - diminished

C. sign convention

object distance = -   height of the object = +

Image distance = -   height of the Image = +

focal length = -

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_o}$

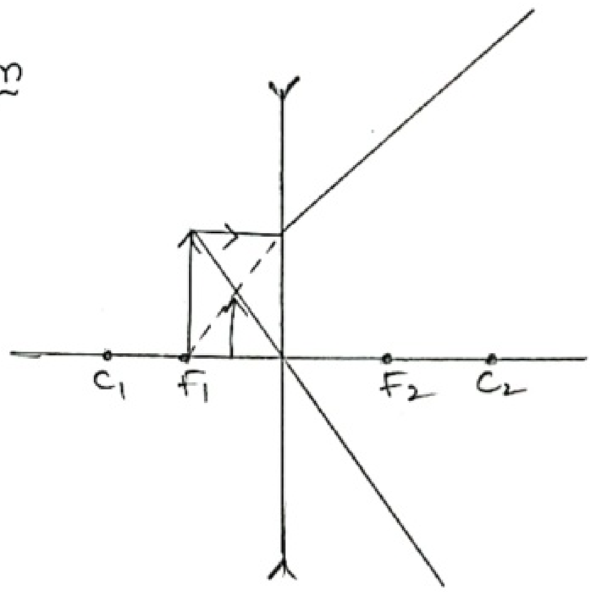
$\boxed{m<1}$

'+' indicates virtual and erect image

less than means diminished image.

5. object on 'F'

A. Ray diagram




B. properties

Nature - virtual and erect image

position - same side of the object

size - dimnished

C. sign convention

object distance = -   height of the object = +

Image distance = -   height of the Image = +

focal length = -

D. Magnification

$$m = \frac{-v}{u} \text{ or } m = \frac{hi}{ho}$$

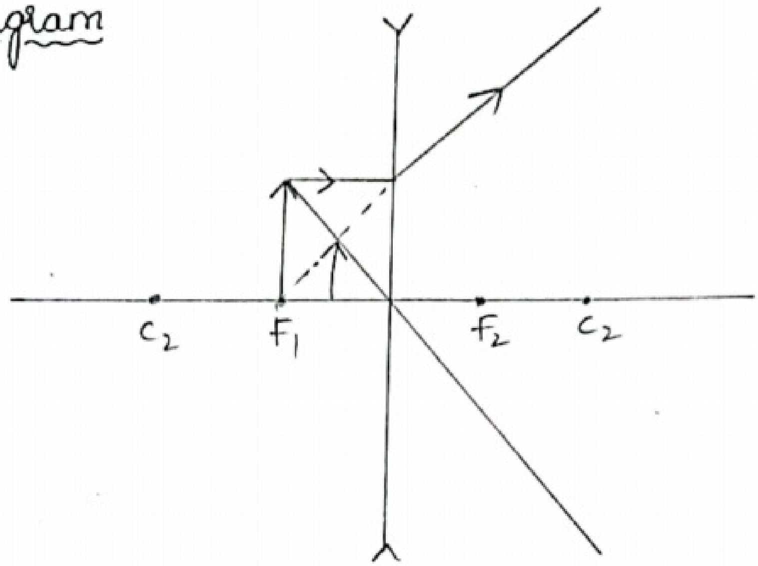
$$\boxed{m < 1}$$

'+' indicates virtual and erect image

less than means dimnished image.

6. object between 'F' and 'P'

A. Ray diagram




B. properties

Nature - virtual and erect image

position - same side of the object

size - dimnished

C. sign convention

object distance = -   height of the object = +

Image distance = -   height of the Image = +

focal length = -

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{hi}{ho}$

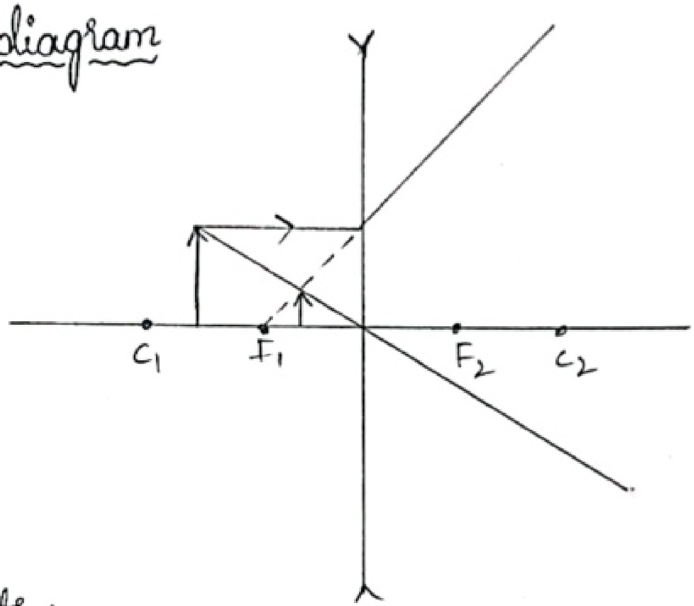
$\boxed{m<1}$

'+' indicates virtual and erect image

less than means dimnished image.

7. object between infinity and pole

A. Ray diagram




B. properties

Nature - virtual and erect image

position - same side of the object

size - diminished

C. sign convention

object distance = -   height of the object = +

Image distance = -   height of the image = +

focal length = -

D. Magnification

$m = \frac{-v}{u}$ or $m = \frac{h_i}{h_0}$

$\boxed{m<1}$

'+' indicates virtual and erect image

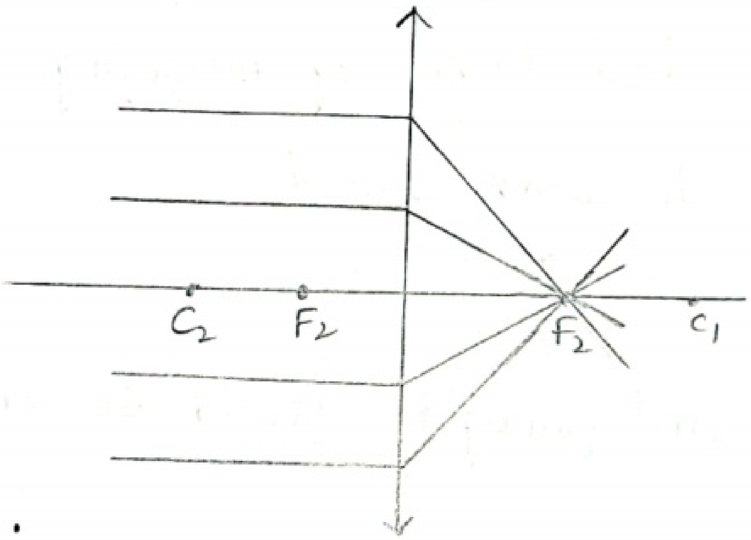
less than means diminished image.

# * Experiment - 1 *

**Aim** : To find the focal length of convex lens.

**Materials required** : 1. sunlight

2. convex lens
3. V- stand
4. scale
5. screen / paper




**procedure** :

1. Take a convex lens and place it opposite to sunlight.
2. The sunlight will converse to a point.
3. Now adjust the screen to get a bright and sharp image.
4. Now measure the distance between lens and sharp and bright image formed to find the focal length (f).

observation :

1. while doing this experiment I observed that while I am adjusting the screen I got a sharp and bright image. That point is called focus.

2. If I move screen other than focus the image is blured.

conclusion :

I can find the focal length by measuring the distance from lens to image formed.

precautions :

Mirror, screen and sunlight should lie on same line.

# * Experiment - 2 *

**Aim:** To find the focal length of convex lens by using candle.

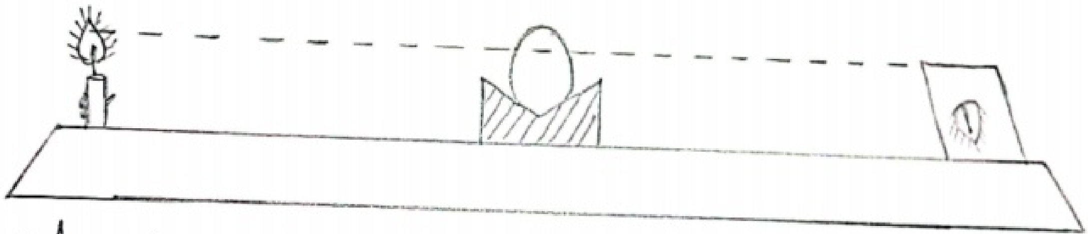
**Materials required:** 1. candle

2. convex lens

3. V- stand

4. meter scale

5. screen / paper



**procedure:**

1. Arrange the material as shown in the figure.
2. Keep the candle away from the lens.
3. Adjust the screen to get a sharp and bright image.
4. Record your observations of object distance, image distance in the given table.
5. change the object distance and adjust the screen to get a sharp and bright image. and Record

your observations in the given table.

6. Repeat the same experiment by changing the object distance & Adjusting the screen to get a bright and sharp image and Record your observations in the given table for the 3, 4, 5 times.

| Sl.No | object distance | Image distance | focal length $= \left\{\frac{1}{f} = \frac{1}{v} - \frac{1}{u}\right\} \left\{f = \frac{uv}{u-v}\right\}$ |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |

observation :

1. from this experiment I observed that while changing the object distance, Image distance is also changes.
2. I observed that focal length in all the cases was same.

conclusion :

By using lenses formula $\left\{\frac{1}{f} = \frac{1}{v} - \frac{1}{u}\right\}$ we can find the focal length of convex lens.

precautions :

1. While doing this experiment we should set candle and lens on the same line.
2. we should take the readings accurately.

# * Experiment - 3 *

**Aim** : To observe the types of images formed by convex lens.

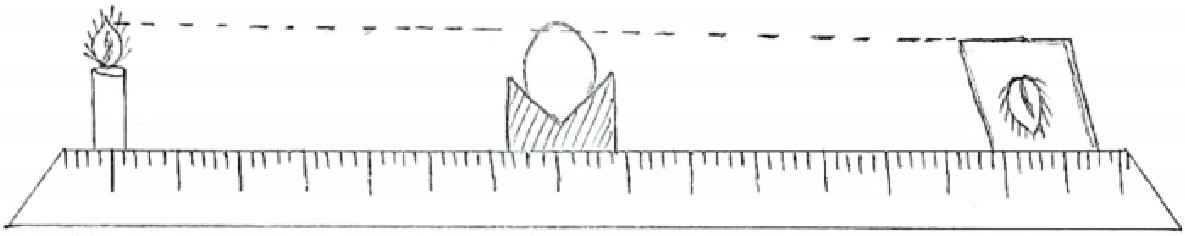
**Materials required** : 1. candle

2. convex lens [known focal length]

3. V- stand

4. Meter scale

5. screen / paper



**procedure** :

1. Arrange the materials as shown in the figure.
2. Keep the candle more distance from the lens.
3. Adjust the screen to get a sharp and bright image.
4. Record the observations of object distance, Image distance, position, nature and size of the image in the given table.
5. change the object distance, adjust the screen to

get a bright and sharp image and record the obser-vation of object distance, image distance, nature, position and size of the image.

6. Repeat the same experiment by changing the object distance, adjusting the screen to get a bright and sharp image and record the observations of object distance, image distance, position, Nature and size of the image for the next 3, 4, 5, 6 times.

| Sl.No | object distance | Image distance | focal length $\left\{\frac{1}{f} = \frac{1}{u} - \frac{1}{v}\right\}$ $\left\{f = \frac{uv}{u-v}\right.$ |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |
| 6. | | | |

| S.No | object distance | Image distance | Real (or) virtual | Magnified (or) diminished |
|---|---|---|---|---|
| 1. | Infinity | at focus | Real | diminished |
| 2. | beyond 'c' | b/w F and c | Real | diminished |
| 3. | on 'c' | on 'c' | Real | So same |
| 4. | b/w F and c | beyond 'c' | Real | Magnified |
| 5. | on 'F' | Infinity | Real | Magnified |
| 6. | b/w P and F | Same side of the object | Real | Magnified |

Observation :

1. I observed that when object distance changes image distance also changes.
2. But the focal length is constant in all the cases.
3. I observed that sometimes the image smaller than object, same size of object and bigger size than object at different positions.
4. I observed that when the candle is very close to the mirror I did not get any image on the screen because it forms virtual image inside the lens.

conclusion :

I conclude that by this experiment convex lens can form different types of images.

precautions :

1. while doing this experiment we should set candle and mirror on a same line.
2. we should take the readings accurately.

## * Experiment - 4 *

**Aim** : How can you prove that the focal length of lens can change with medium.

{or}

Show the focal length of lens increased when kept in water.

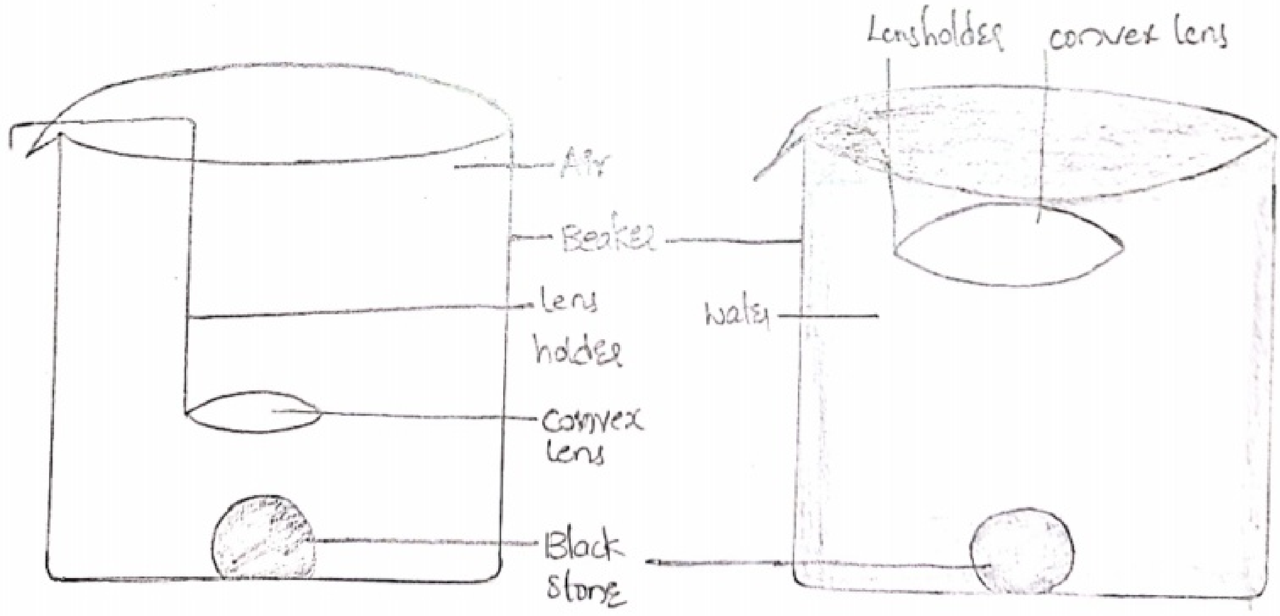
**Apparatus** : 1. Beaker

2. water

3. convex lens

4. lens holder

5. black stone



procedure :

1. Arrange the apparatus as shown in the figure.
2. Take a known focal length of convex lens.
3. fill the beaker with $\frac{3}{4}^{th}$ of water and keep the stone at bottom of the beaker.
4. See that the beaker length must be 4 times greater than the focal length.
5. Dip the lens in water with lens holder.
6. Keep lens distance than focal length and observe ~~of~~ the image of the stone.
7. Keep more distance than the focal length and observe the image of the stone.

observations :

1. I observed that when I kept the lens close to the stone. stone will appear.
2. when I kept the lens more distance its focal length {Increased the distance} even we can see the stone clearly?

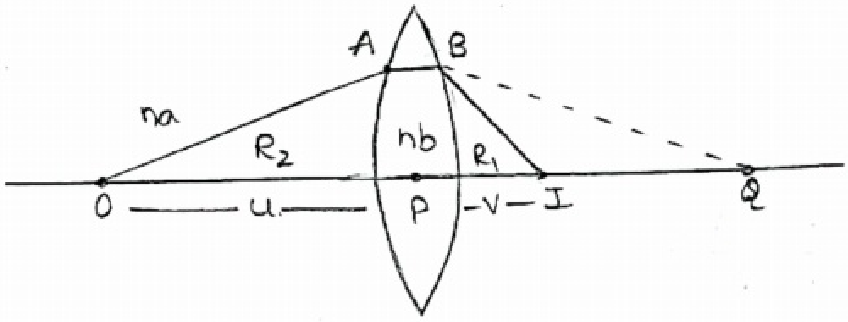
3. Because in water the focal length will increase.

conclusion :

By this experiment we can conclude that the focal length of lens increase even kept in water.

precautions :

1. The water should be transparent.
2. The height of the beaker should be 4 times greater than the focal length of lens.




for 'A' refraction

$n_1 = n_a$

$n = n_b$

$R = R_1$

object $= -u$

Image $= x$

for 'B' refraction

$n_1 = n_b$

$n_2 = n_a$

$R = R_2$

object distance $= x$

Image distance $= v$

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

for 'A'

$$\frac{n_b}{x} - \frac{n_a}{-u} = \frac{n_b - n_a}{R_1}$$

$$\frac{n_b}{x} + \frac{n_a}{u} = \frac{n_b - n_a}{R_1} \Longrightarrow (1)$$

for 'B'

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 + n_1}{R}$$

$$\frac{n_a}{v} - \frac{n_b}{x} = \frac{n_a - n_b}{-R_2}$$

$$\frac{n_a}{v} - \frac{n_1}{x} = +\frac{(n_b - n_a)}{+R_2}$$

$$\frac{n_a}{v} - \frac{n_b}{x} = \frac{n_b - n_a}{R_2} \Longrightarrow (2)$$

add eq (1) and eq (2)

$$\cancel{\frac{n_b}{x}} + \frac{n_a}{u} + \frac{n_a}{v} - \cancel{\frac{n_b}{x}} = \frac{n_b - n_a}{R_1} + \frac{n_b - n_a}{R_2}$$

$$\frac{n_a}{u} + \frac{n_a}{v} = (n_b - n_a)\left(\frac{1}{R_1} + \frac{1}{R_2}\right) \Longrightarrow (3)$$

divide eq (3) with $n_a$

$$\frac{\cancel{n_a}}{u} \times \frac{1}{\cancel{n_a}} + \frac{\cancel{n_a}}{v} \times \frac{1}{\cancel{n_a}} = \left(\frac{n_b - n_a}{n_a}\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\frac{1}{u} + \frac{1}{v} = \left(\frac{n_b}{n_a} - 1\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Sign convention

$$\frac{1}{v} - \frac{1}{u} = \left(\frac{n_b}{n_a} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\boxed{\frac{1}{f} = \left\{\frac{nb}{na} - 1\right\}\left\{\frac{1}{R_1} - \frac{1}{R_2}\right\}}$$ $\left\{\frac{1}{f} = \frac{1}{v} - \frac{1}{u}\right\} \Rightarrow$ lens formula

$nb$ = lens refractive index

$na$ = medium refractive index

But we know

$$\frac{nb}{na} = nba = nb$$

$$= n$$

$n$ = Refractive index

$R_1$ = Radius of curvature 1

$R_2$ = Radius of curvature 2

$f$ = focal length

$$\boxed{\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}$$

## * formulas

1. Image formed by refraction

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

2. lens formula

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

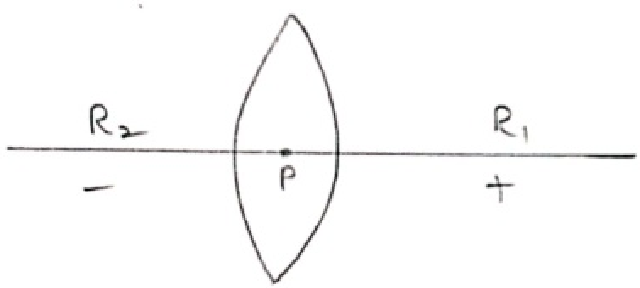
3. lens makers formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

for IIT

$$\frac{1}{f} = \left(\frac{n_b}{n_a} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

1. A converging lens of radius of curvature 30cm and 60cm Refractive index is 1.5. find the focal length.




Given data:

i) $I^{st}$ Radius of curvature = $(R_1) = 30$

ii) $II^{nd}$ Radius of curvature = $(R_2) = -60$

iii) Refractive index = $(n) = 1.5$

iv) focal length = $(f)$ = ?

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{30} - \frac{1}{-60}\right)$$

$$\frac{1}{f} = \frac{1}{2}\left(\frac{2+1}{60}\right)$$

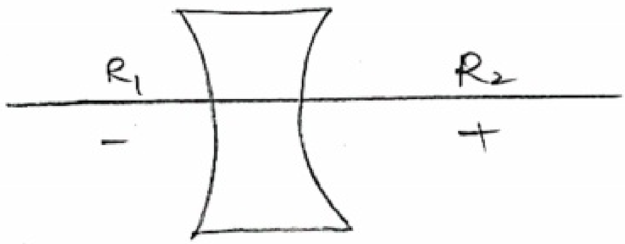
$$\frac{1}{f} = \frac{1}{2}\left(\frac{\cancel{3}}{\underset{20}{\cancel{60}}}\right)$$

$$\frac{1}{f} = \frac{1}{40}$$

$$\boxed{f = 40}$$

∴ The focal length is 40cm.

2. A Diverging lens of radius of curvature 300cm and 60cm Refractive index is 1.5. find the focal length.




Given data:

i) $I^{st}$ Radius of curvature $(R_1) = -30$

ii) $II^{nd}$ Radius of curvature $(R_2) = 60$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{-30} - \frac{1}{60}\right)$$

$$\frac{1}{f} = \frac{1}{2}\left(\frac{-2-1}{60}\right)$$

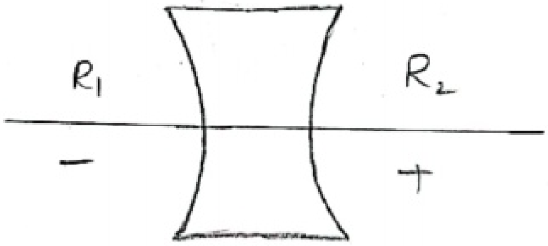
$$\frac{1}{f} = \frac{1}{2}\left(\frac{\overset{1}{\cancel{-3}}}{\underset{20}{\cancel{60}}}\right)$$

$$\frac{1}{f} = \frac{-1}{40}$$

$$\boxed{f = -40}$$

∴ The focal length is 40cm.

5. A symmetric diverging lens of radius of curvature 30 cm refractive index is 1.5. find focal length symmetric means $R_1$ and $R_2$ are same.




Given data:

i) $I^{st}$ Radius of curvature $(R_1) = -30$

ii) $II^{nd}$ Radius of curvature $(R_2) = 30$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{-30} - \frac{1}{30}\right)$$

$$\frac{1}{f} = \frac{1}{2}\left(\frac{-1-1}{30}\right)$$

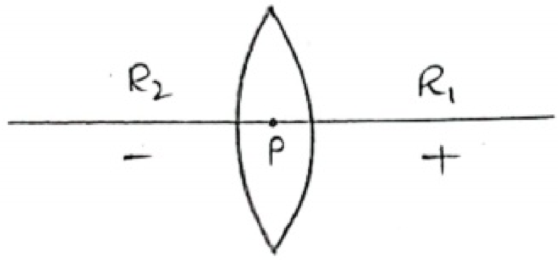
$$\frac{1}{f} = \frac{1}{\cancel{2}}\left(\frac{-\cancel{2}}{30}\right)$$

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

$$\boxed{f = -30}$$

∴ The focal length is 30 cm.

4. A symmetric converging lens of radius of curvature 30cm and refractive index is 1.5. find its focal length.




Given data:

i) $I^{st}$ Radius of curvature $(R_1) = 30$

ii) $II^{nd}$ Radius of curvature $(R_2) = -30$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{30} + \frac{1}{+30}\right)$$

$$\frac{1}{f} = \frac{1}{2}\left(\frac{1+1}{30}\right)$$

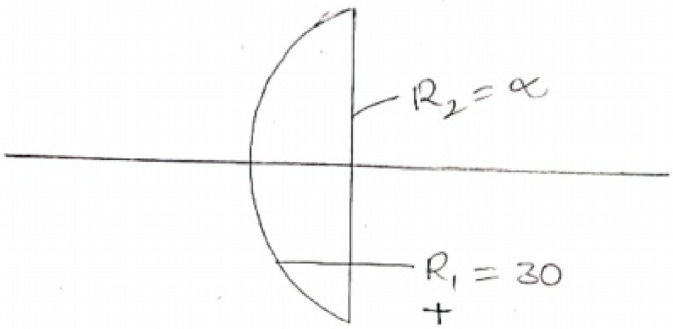
$$\frac{1}{f} = \frac{1}{\cancel{2}}\left(\frac{\cancel{2}}{30}\right)$$

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

$$\boxed{f = 30cm}$$

∴ The focal length is 30cm.

5. A plano convex lens has radius of curvature 30cm and refractive index is 1.5. find the focal length.




Given data :

i) $I^{st}$ Radius of curvature $(R_1) = 30$

ii) $II^{nd}$ Radius of curvature $(R_2) = \alpha$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5)\left(\frac{1}{30} - \frac{1}{\alpha}\right)$$

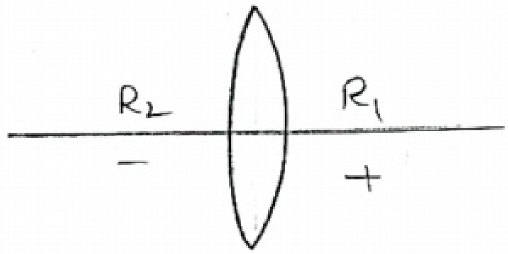
$$\frac{1}{f} = \frac{1}{2}\left(\frac{1}{30}\right)$$

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

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

$\therefore$ The focal length is 60cm.

6. A symmetric converging lens of radius of curvature and the focal length is also equal to Radius of curvature. find the refractive index.




Given data :

i) $I^{st}$ Radius of curvature $(R_1) = R$

ii) $II^{nd}$ Radius of curvature $(R_2) = -R$

iii) Refractive index $(n) = ?$

iv) focal length $(f) = R$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} , \frac{1}{R_2}\right)$$

$$\frac{1}{R} = (n-1)\left(\frac{1}{R} + \frac{1}{+R}\right)$$

$$\frac{1}{R} = (n-1)\left(\frac{1+1}{R}\right)$$

$$\frac{1}{\cancel{R}} = \frac{(n-1)\,2}{\cancel{R}}$$

$$1 = (n-1)\,2$$

$$1 = 2n-2$$

$$1+2 = 2n$$

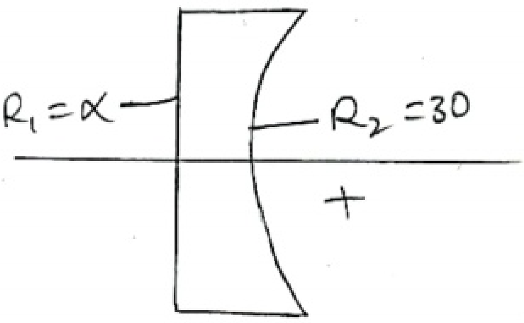
$$3 = 2n$$

$$\frac{\cancel{3}^{1.5}}{\cancel{2}_1} = n$$

$$\boxed{n = 1.5}$$

∴ Refractive index is 1.5.

7. A plano concave lens has radius of curvature 30cm and refractive index 1.5. find its focal length.




Given data:

i) I<sup>st</sup> Radius of curvature $(R_1) = \alpha$

ii) II<sup>nd</sup> Radius of curvature $(R_2) = 30$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{\alpha} - \frac{1}{30}\right)$$

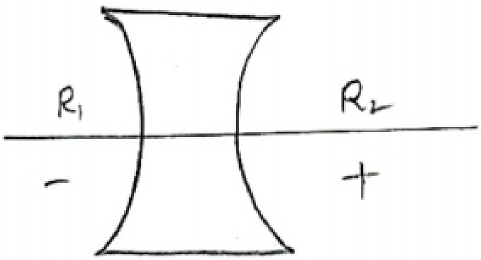
$$\frac{1}{f} = \frac{1}{2}\left(\frac{-1}{30}\right)$$

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

$$\boxed{f = -60cm}$$

∴ The focal length is 60cm.

8. A symmetric diverging lens of radius of curvature is R and the focal length is also equal to Radius of curvature. find the refractive index.




Given data:

i) $I^{st}$ Radius of curvature $(R_1) = -R$

ii) $II^{nd}$ Radius of curvature $(R_2) = R$

iii) Refractive index $(n) = ?$

iv) focal length $(f) = R$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{R} = (n-1)\left(\frac{1}{-R} - \frac{1}{R}\right)$$

$$\frac{1}{R} = (n-1)\left(\frac{-1-1}{R}\right)$$

$$\frac{1}{R} = (n-1)\left(\frac{-2}{R}\right)$$

$$\frac{1}{\cancel{R}} = \frac{(n-1)2}{\cancel{R}}$$

$$1 = 2n - 2$$

$$1 + 2 = 2n$$

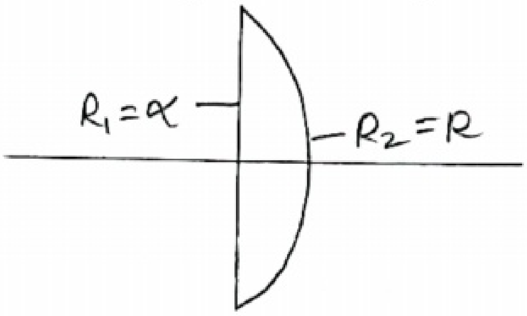
$$3 = 2n$$

$$n = \frac{\cancel{3}^{1.5}}{\cancel{2}_1}$$

$$\boxed{n = 1.5}$$

$\therefore$ Refractive index is 1.5.

9. A plano convex lens has radius of curvature 'R' and refractive index 1.5. find its focal length.




Given data :

i) $I^{st}$ Radius of curvature $(R_1) = \alpha$

ii) $II^{nd}$ Radius of curvature $(R_2) = -R$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{\alpha} + \frac{1}{+R}\right)$$

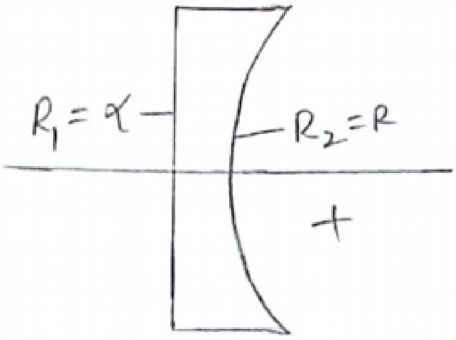
$$\frac{1}{f} = \frac{1}{2}\left(\frac{1}{R}\right)$$

$$\frac{1}{f} = \frac{1}{2R}$$

$$\boxed{f = 2R}$$

$\therefore$ The focal length is 2R.

10. A plano concave lens has radius of curvature 'R' and refractive index 1.5. find its focal length.




Given data:

i) $I^{st}$ Radius of curvature $(R_1) = \alpha$

ii) $II^{nd}$ Radius of curvature $(R_2) = R$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{\alpha} - \frac{1}{R}\right)$$

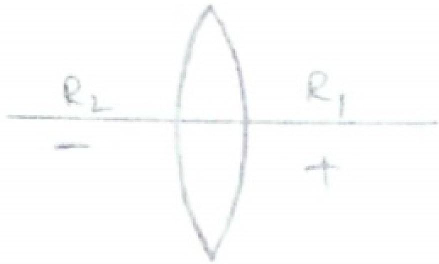
$$\frac{1}{f} = \frac{1}{2}\left(\frac{-1}{R}\right)$$

$$\frac{1}{f} = \frac{-1}{2R}$$

$$\boxed{f = -2R}$$

$\therefore$ The focal length is $2R$.

11. A double convex lens has 2 surfaces of equal radii that is 'R' and refractive index is 1.5. find focal length.




Given that:

i) $I^{st}$ Radius of curvature $(R_1) = R$

ii) $II^{nd}$ Radius of curvature $(R_2) = -R$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{R} + \frac{1}{+R}\right)$$

$$\frac{1}{f} = \frac{1}{2}\left(\frac{1+1}{R}\right)$$

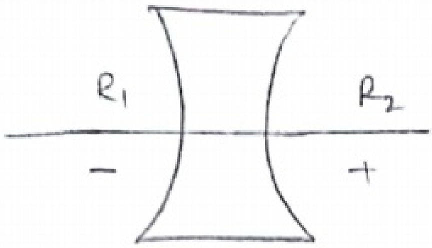
$$\frac{1}{f} = \frac{1}{\cancel{2}}\left(\frac{\cancel{2}}{R}\right)$$

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

$$\boxed{f = R}$$

∴ The focal length is R

12. A double concave lens has 2 surfaces of equal radii that is 'R' and refractive index is 1.5. find its focal length.




Given data:

i) $I^{st}$ Radius of curvature $(R_1) = -R$

ii) $II^{nd}$ Radius of curvature $(R_2) = R$

iii) Refractive index $(n) = 1.5$

iv) focal length $(f) = ?$

formula

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{-R} - \frac{1}{R}\right)$$

$$\frac{1}{f} = \frac{1}{2}\left(\frac{-1-1}{R}\right)$$

$$\frac{1}{f} = \frac{1}{\cancel{2}}\left(\frac{-\cancel{2}}{R}\right)$$

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

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

$$\boxed{f = -R}$$

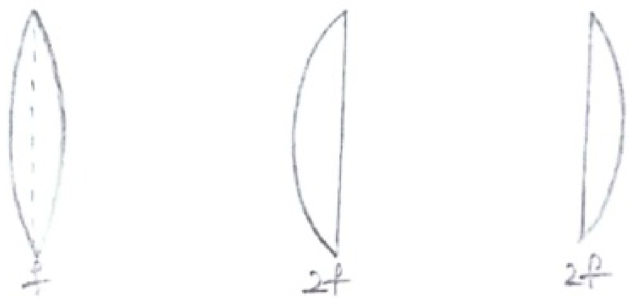
$\therefore$ The focal length is R.

## * About focal length

i) The focal length of lens depends on surrounding medium and also if it breaks the focal length will change.

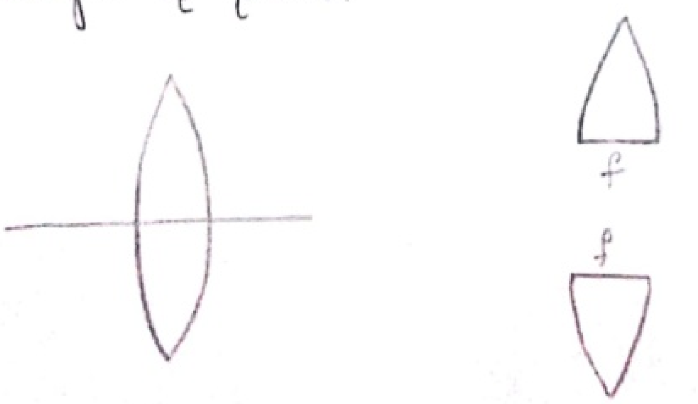
ii) But the focal length of mirror does not change if it breaks and also even medium change.

iii) If lens cut into '2' equal parts vertically each part focal length is double.

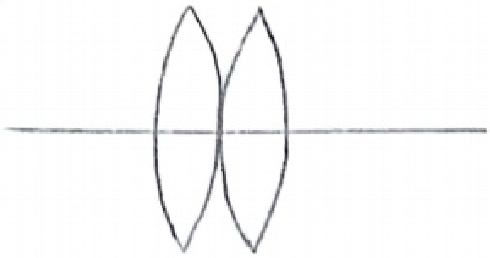



Ex: $f = 20 \Rightarrow f_1 = 40cm$ , $f_2 = 40cm$

iv) If lens cut into 2 equal parts horizontally each part focal length is same.

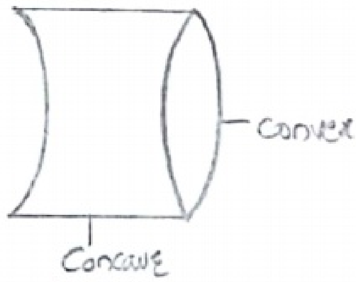


v) If '2' lenses are in contact the resultant focal length is $\frac{1}{f_1} + \frac{1}{f_2}$.



$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

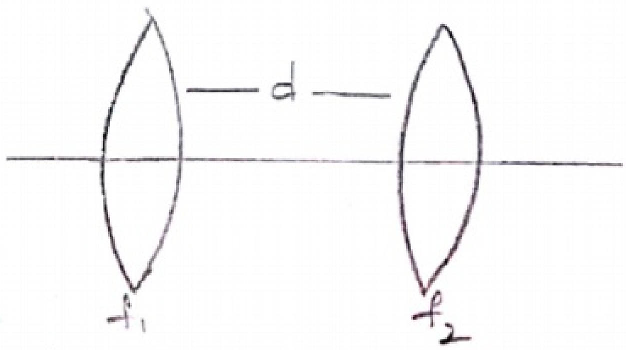
power = $P = P_1 + P_2$




$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

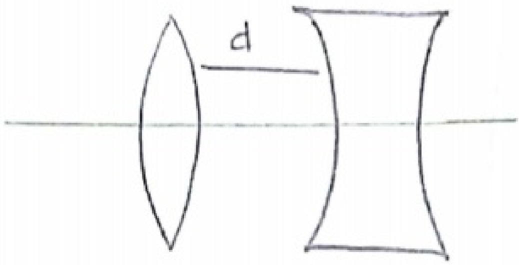
$$P = -P_1 + P_2$$

vi) If lenses are placed at D distance




$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$P = P_1 + P_2 - dP_1P_2$

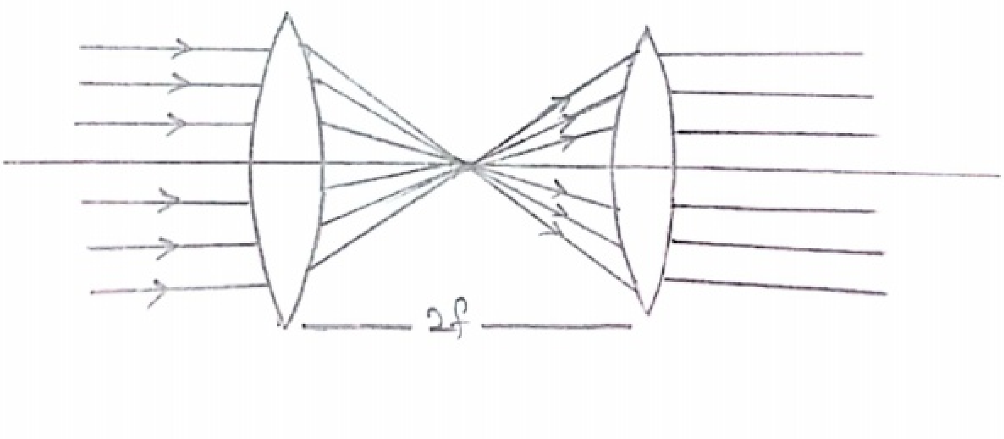



$$\frac{1}{f} = \frac{1}{f_1} - \frac{1}{f_2} - \frac{d}{f_1 \times -f_2}$$

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{-f_2} + \frac{d}{f_1 f_2}$$

$P = P_1 - P_2 + d \times P_1P_2$

vii) If '2' convex lenses of same focal length placed at 2f distance if parallel of light falls on first lens how it will emergent through second lens.



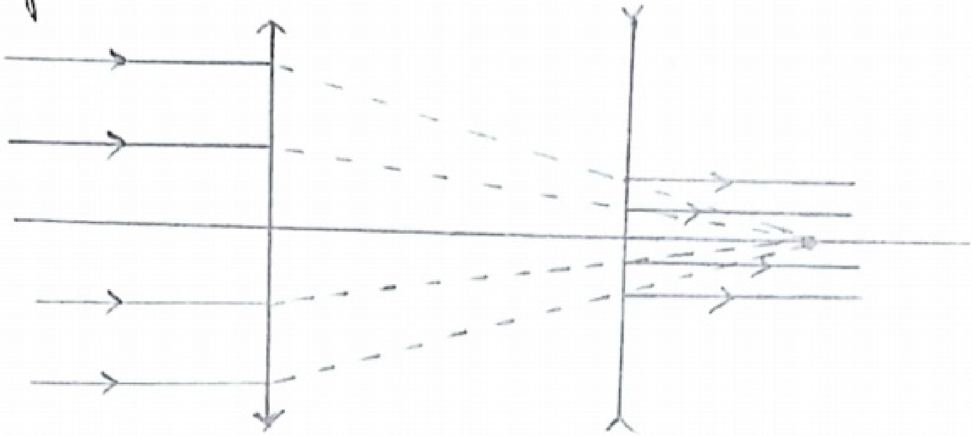
viii) If lens kept in 2 medium then focal length formula.

$$\boxed{\frac{f_2}{f_1} = \frac{\frac{n_b - n_1}{n_1}}{\frac{n_b - n_2}{n_2}}}$$

$$\boxed{\frac{f_2}{f_1} = \frac{\left(\frac{n_b}{n_1} - 1\right)}{\left(\frac{n_b}{n_2} - 1\right)}}$$

vi

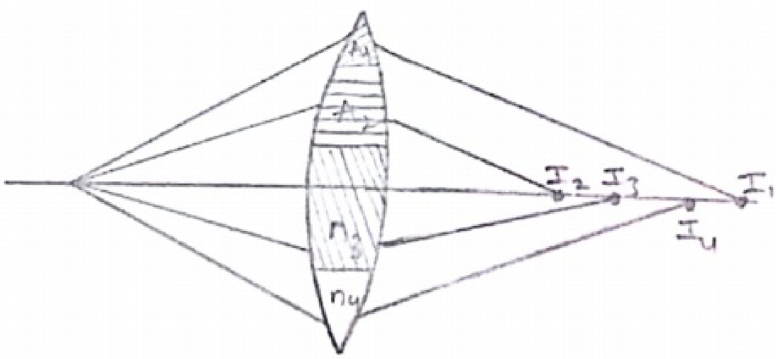
* A convex lens of focal length 30cm and a Concave lens of focal length 10cm where we should place the '2' lenses so that we get some parallel of light rays.



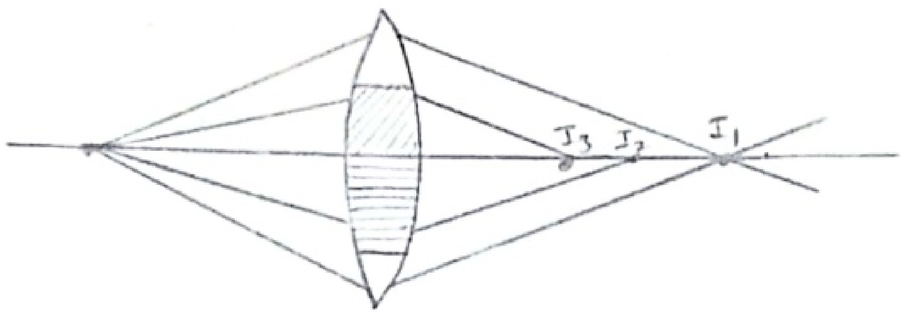
Number of images

If lens prepared by 3 different materials then three images will form.

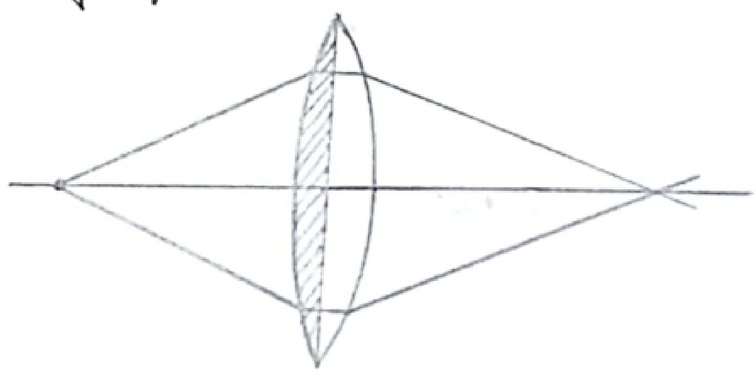
A.



B.

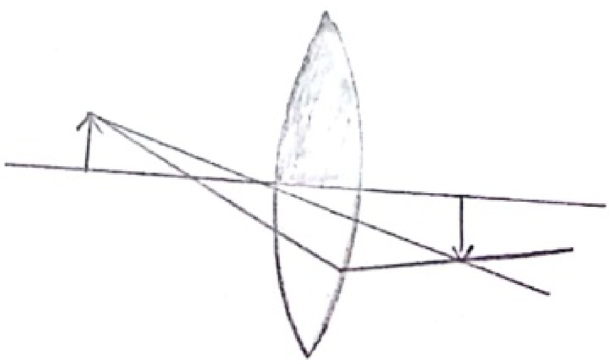



If lens prepared by 2 different materials vertically only 1 image forms.



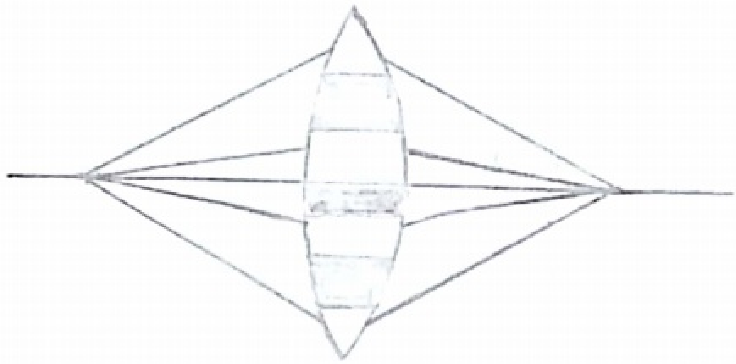
If lens covered half part with black paper how many images will form.

Ans: 1 complete image will form.



* A photo grapher wants to take Zebra photo but he has white donkey so that he planned arrange a lens with black and white strips then he has taken the photo can be get white donkey or Zebra.

Ans:- white donkey will form



Note:

Each part of a lens can form 1 full image.

1. lens has a focal length of -25cm than the power is

$$\text{power} = \frac{100}{\text{focal length(cm)}}$$

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

$$P = \frac{\cancel{100}^{4}}{\cancel{-25}_{1}}$$

$$P = -4D$$

$\therefore$ The power is 4.

2. when lens of power 'P' is cut into 2 pieces along its axis (horizantly) what is the power of each part.

The power of the lens = P

Because when a lens cut into 2 pieces Horizantally then the focal length of the lens will not change.

3. If $x_1$ and $x_2$ are the distances of object and real image formed by convex lens then the focal length.

Ans:- object distance (u) = $x_1$

Image distance (v) = $x_2$

Scanned with OKEN Scanner

focal length (f) = ?

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

$$\frac{1}{f} = \frac{1}{x_2} +_{+} \frac{1}{x_1}$$

$$\frac{1}{f} = \frac{1}{x_2} + \frac{1}{x_1}$$

$$\frac{1}{f} = \frac{x_2 + x_1}{x_1 x_2}$$

4. If a convex lens has its object and image distances are equal that is x then what is the focal length.

Ans: Given data

object distance (u) = $-x$

Image distance (v) = $x$

focal length (f) = ?

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

$$\frac{1}{f} = \frac{1}{x} + \frac{1}{x}$$

$$\frac{1}{f} = \frac{1+1}{x}$$

$$\frac{1}{f} = \frac{2}{x}$$

Scanned with OKEN Scanner

$f = \frac{x}{2}$

$\therefore$ The focal length is $\frac{x}{2}$.

5. A concave lens of focal length f forms an image which is 'n' times the objective then find the objective distance from the lens.

Ans: Given data

Image distance is n times the object distance

$\{u\} = ?$

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

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

$$nf + nu = f$$

$$nu = f - nf$$

$$u = \frac{f - nf}{n}$$

$$u = \frac{f(n-1)}{n}$$

6. 2 lenses have the magnitude of their focal lengths are in the ratio 2 : 3 then find the ratio

of their powers.

Ans:- Given

$f_1 : f_2 = 2 : 3$

$P_1 : P_2 = ?$

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

$P_1 = \frac{1}{f_1}$

$P_1 = \frac{1}{2}$

$P_2 = \frac{1}{f_2}$

$P_2 = \frac{1}{3}$

$\frac{P_1}{P_2} = \frac{\frac{1}{2}}{\frac{1}{3}}$

$\frac{P_1}{P_2} = \frac{3}{2}$

$P_1 : P_2 = 3 : 2$

$\therefore$ The ratio of the power is 3:2.

7. The power of glass slab is __'0'__ .

The power of glass slab is 'zero'.

8. An object light at a distance of 2f from a concave lens of a focal length f then the image distance in terms of f.

Ans:- Given data

object distance (u) = -2f

Image distance (v) = ?

focal length (f) = -f

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

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{+2f}$$

$$\frac{1}{-f} = \frac{1}{v} + \frac{1}{2f}$$

$$\frac{1}{-f} - \frac{1}{2f} = \frac{1}{v}$$

$$\frac{-2-1}{2f} = \frac{1}{v}$$

$$\frac{-3}{2f} = \frac{1}{v}$$

$$\frac{-3}{2f} = \frac{1}{v}$$

$$\frac{-2f}{3} = v$$

$$\boxed{v = \frac{-2f}{3}}$$