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Light ⇒ ① Ray optics → ✓

② Wave optics →

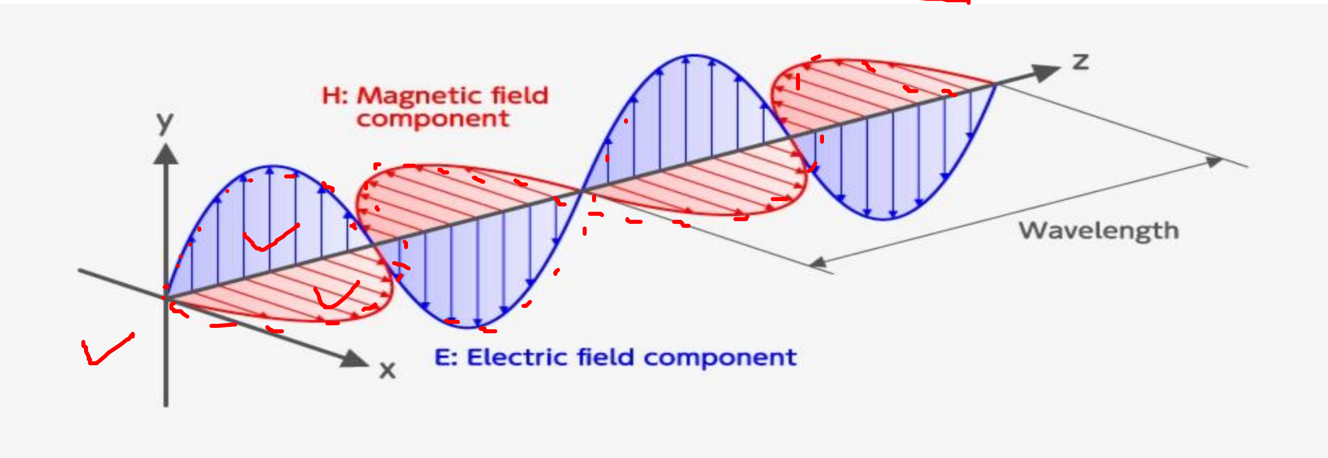
RAY OPTICS

BY - SALIL BAJPAI SIR

LIGHT

प्रकाश

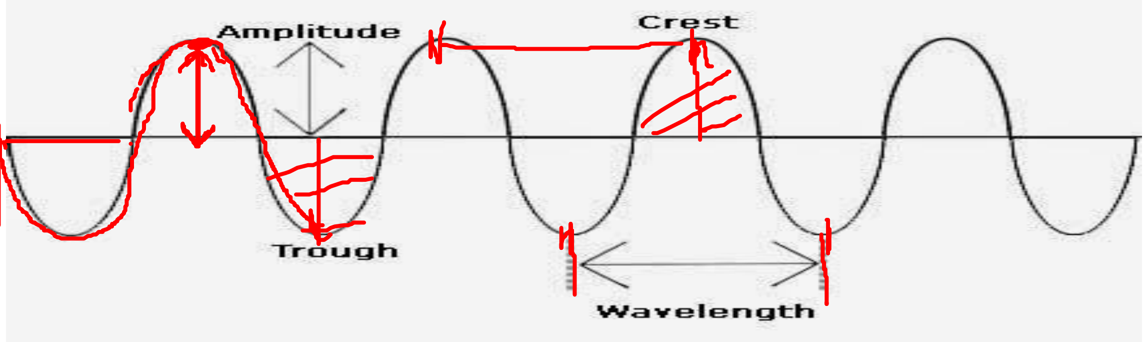
- Light is an electromagnetic radiation that can be detected by the human eye.



- Light is a Transverse wave.
- Light shows wave-particle duality.

तरंग कण

- Light not need any medium to travel. → vacuum



- Fundamental particle in light is – PHOTONS.
- Speed of light is 3×10^8 ms-1 (vacuum)

BY - SALIL BAJPAI SIR

- Wave nature of light explains – DIFFRACTION & INTERFERANCE Phenomenon.

- Light travels through vacuum.

- Transverse nature of light explained by – POLARIZATION.

- Visible Spectrum have range – 400nm to 750nm.

- Shadow created due to rectilinear propagation of light.

Imp

- Eclipse also occurred due to rectilinear propagation of light.

Imp.

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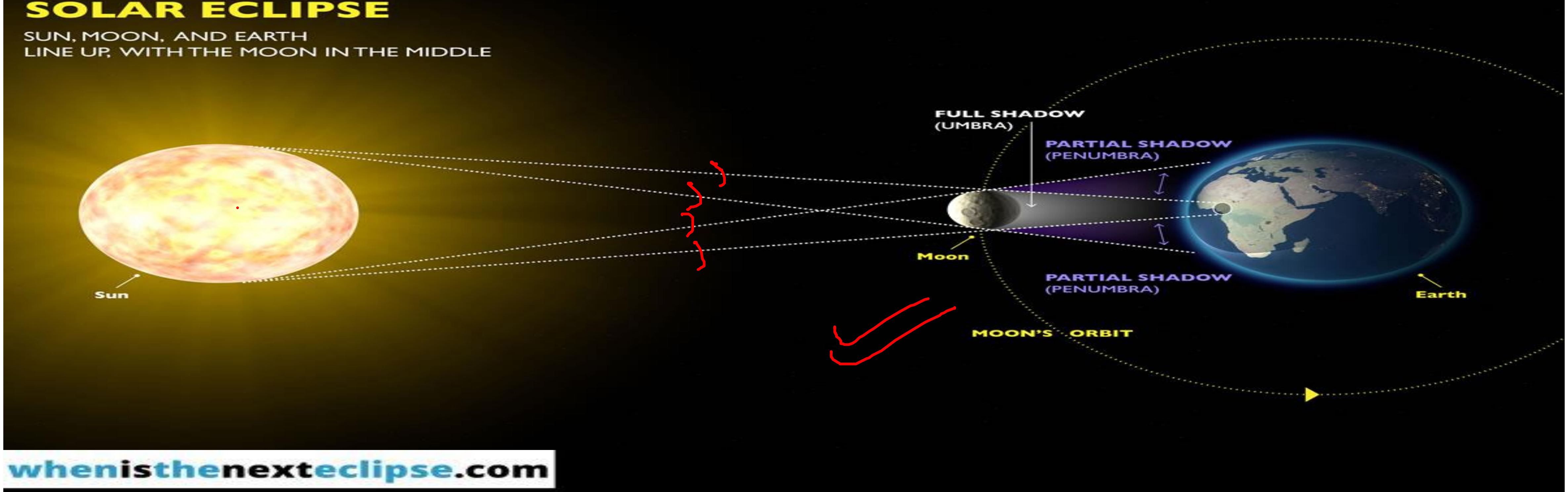

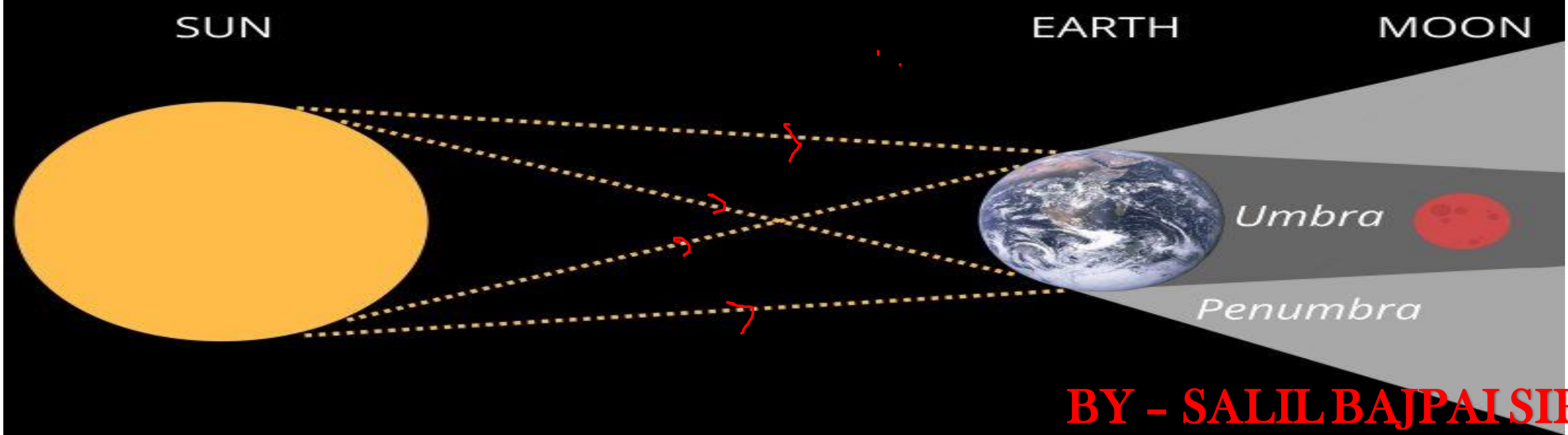

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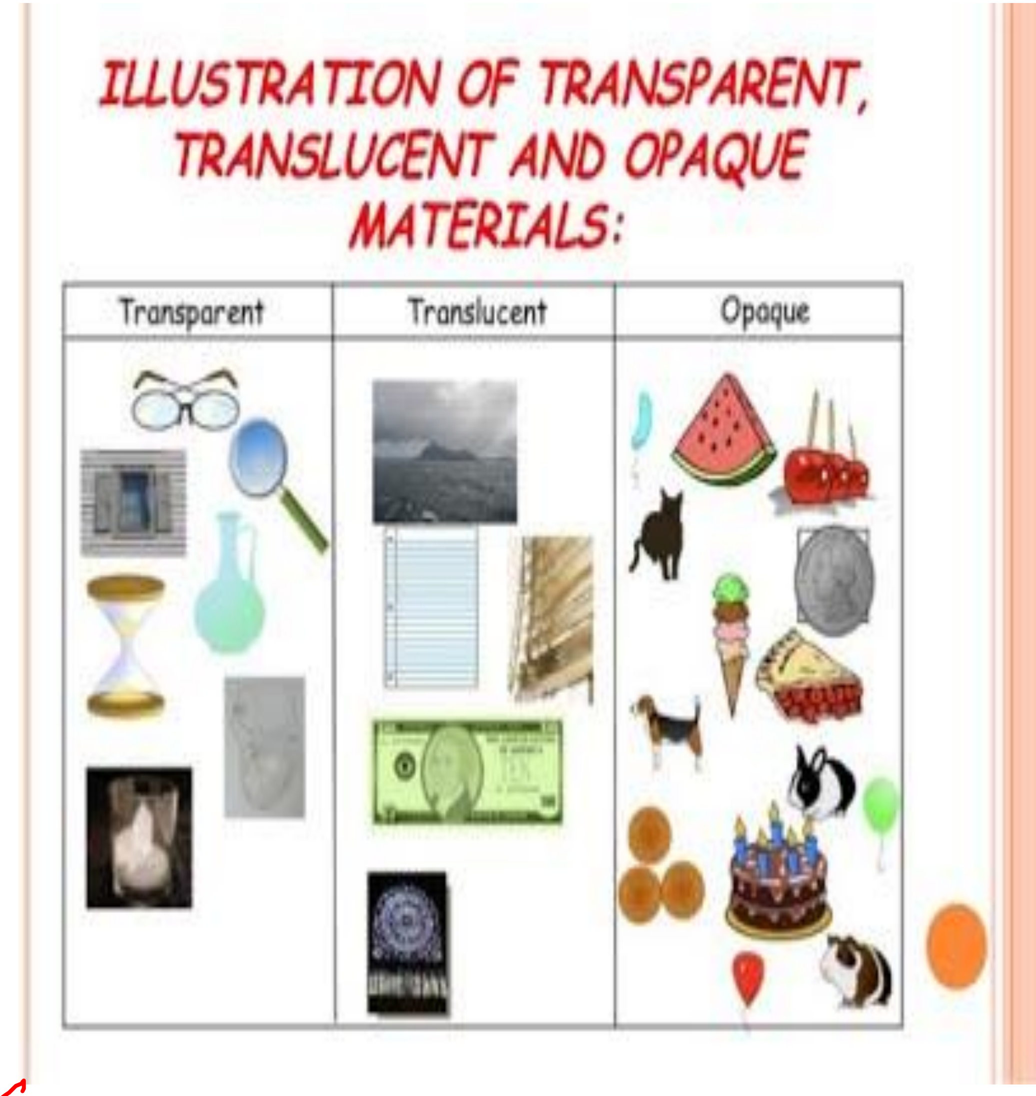
- **Transparent medium:-** It is a medium through which light can be propagated easily.(e.g., sun, candle, electric arc)

- **Translucent medium:-** It is a medium through which light is propagated partially.(e.g., paper, ground, glass)

100%. 80%. 90%.

- **Opaque:-** It is a medium through which light can be propagated. (e.g., wood, iron)



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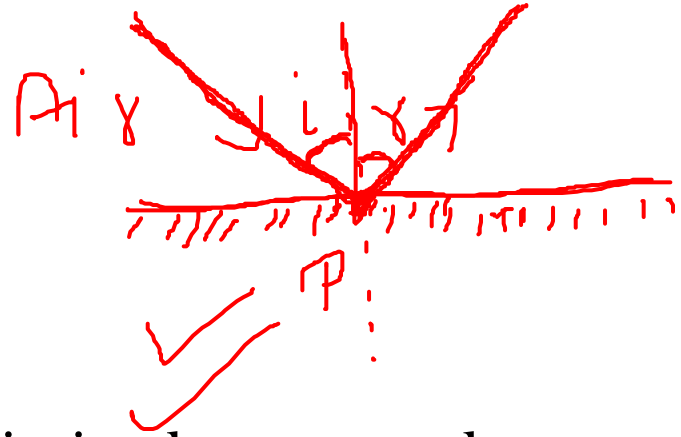
REFLECTION OF LIGHT

BY – SALIL BAJPAI SIR

- When a ray of light approaches a smooth polished surface and the light ray bounces back, it is called the **REFLECTION** of light.

$\angle i = \angle r$

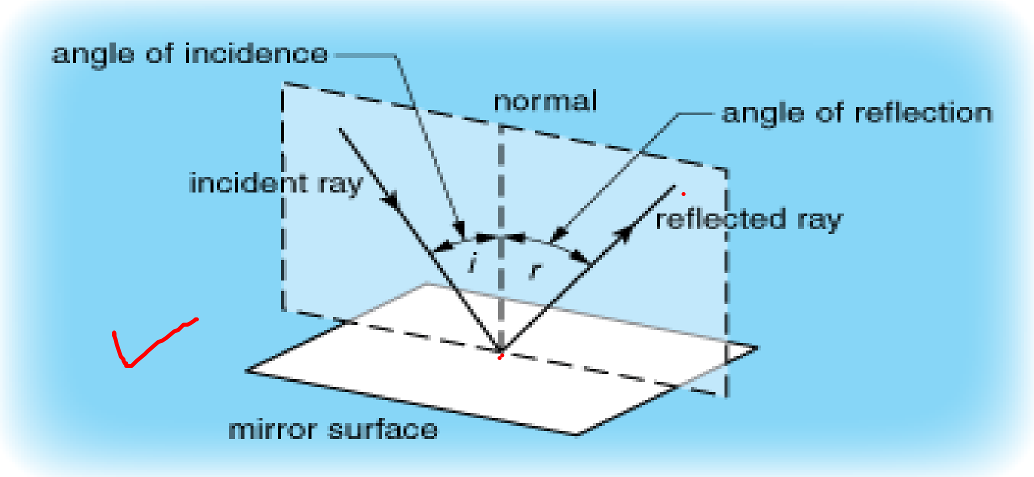


- **Laws of Reflection:**

1. The incident ray, the reflected ray and the normal all lie in the same plane.

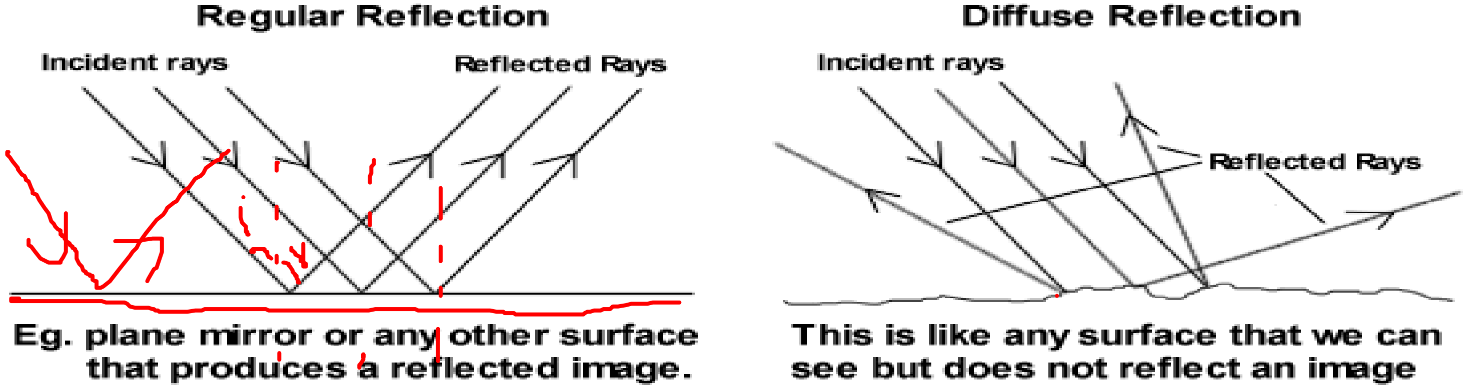
$\angle i = \angle r$

2. The angle of incidence = Angle of reflection.

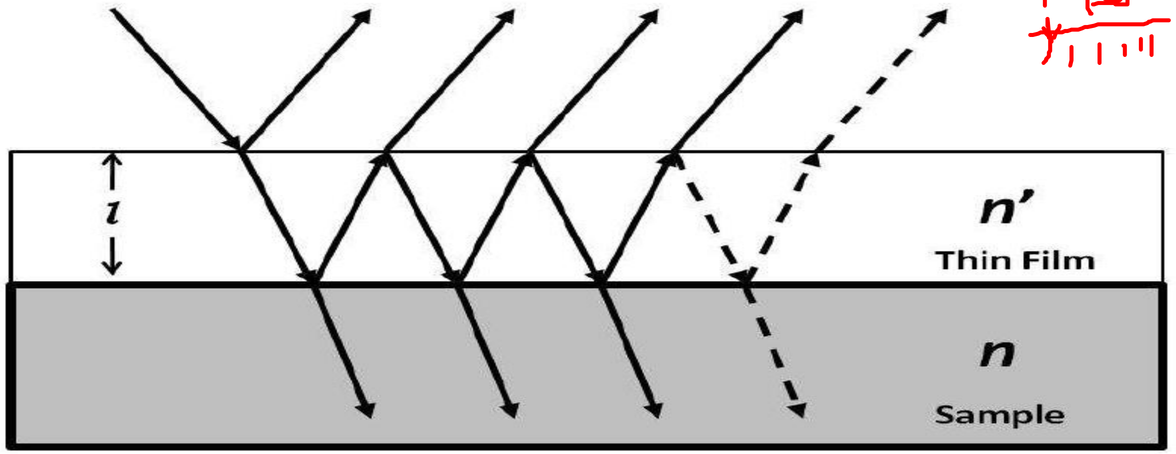


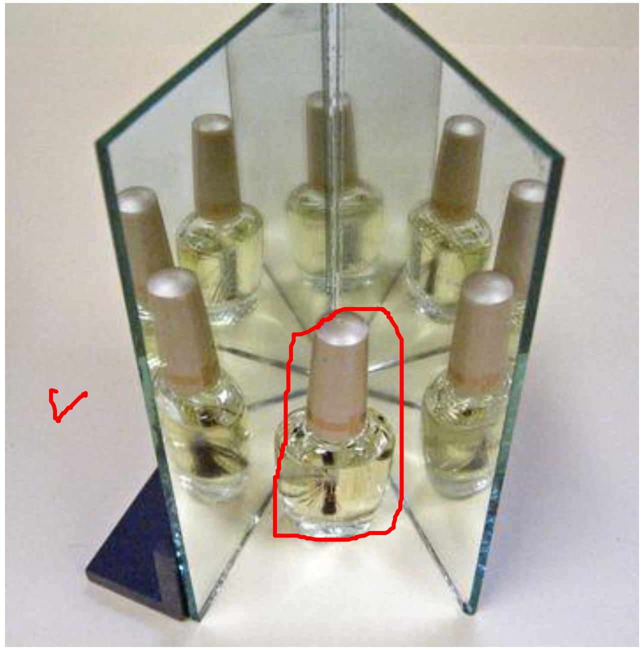
Types of Reflection of Light:

- Regular/ Specular Reflection:



- Diffused Reflection:
- Multiple Reflection
-





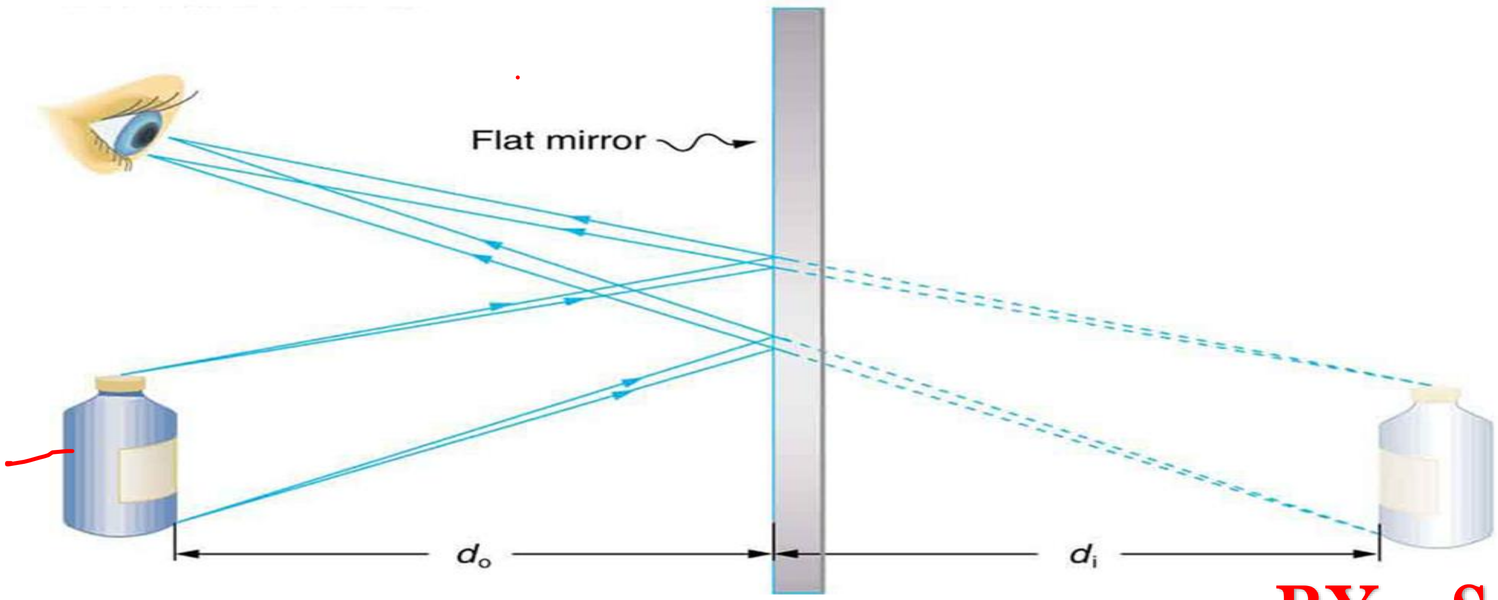
$$Number\ of\ images = \frac{360^\circ}{angle\ between\ mirrors} - 1$$

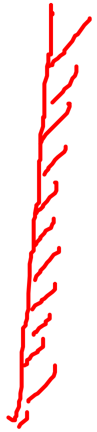
BY - SALIL BAJPAI SIR

MIRROR

3 → ① Plane
② Spherical < Conc / Conv

- A mirror is defined as reflecting surface and can be explained by the law of reflection, which states that when a ray of light is made to fall on the reflecting surface, the reflected ray has its angle of reflection, incident ray, and the reflected ray are normal to the surface at a point of incidence.





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•Types Of Mirror

• **Plane mirror:** The images formed from a plane mirror are the reflected images in their normal proportions but reversed from left to right. These are the most widely used mirrors.

• **Characteristics of the image formed by a plane mirror :**

- It is virtual ✓ (always) ✓
- It is erect and of the same size as the object. ✓
- The distance of the object from the plane mirror is the same as the distance of the image from the plane mirror.
- the image is that it is laterally inverted. (R → L) (L → R)

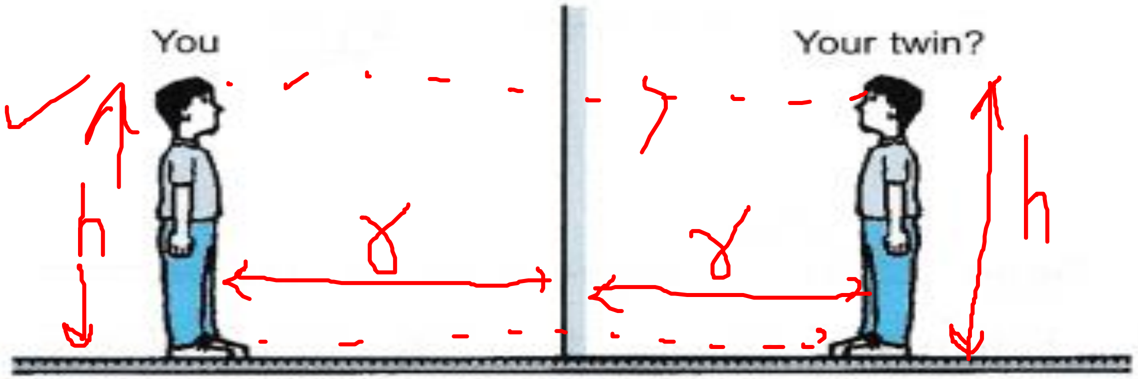
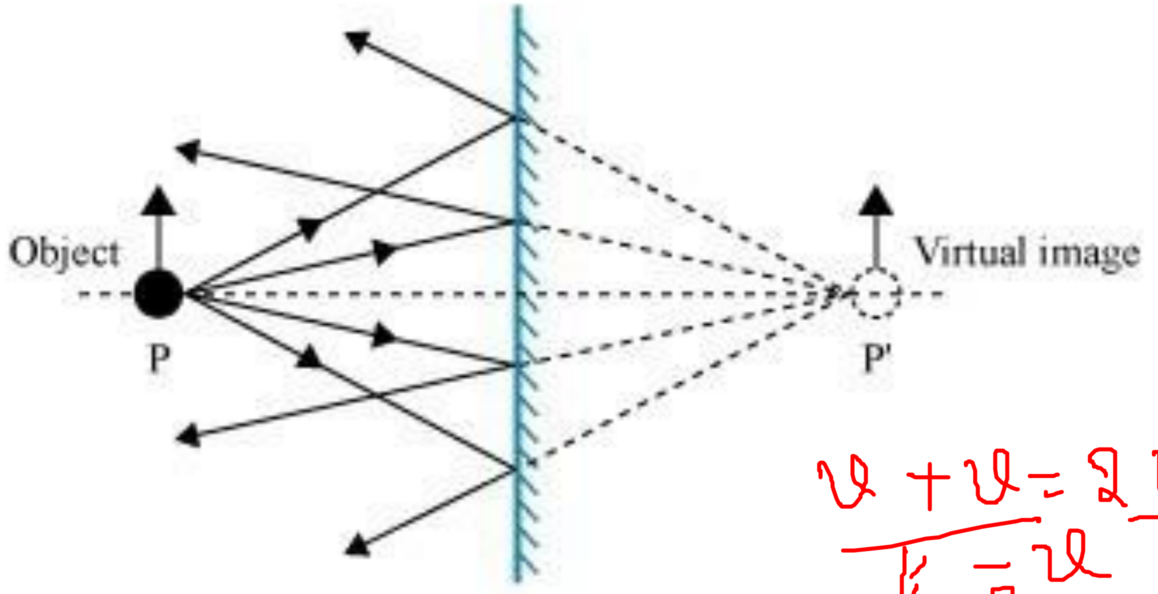


Figure *Your image and you are identical*

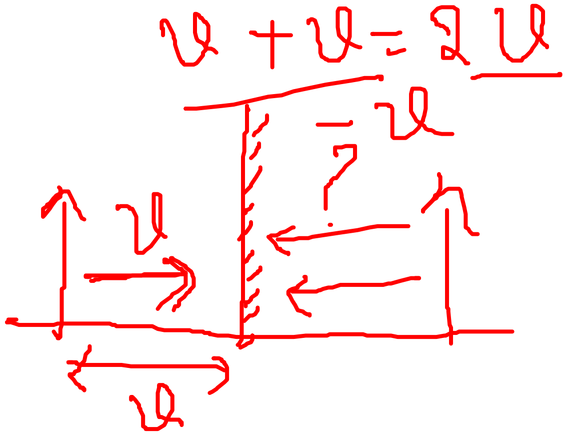
BY - SALIL BAJPAI SIR

• Properties of an image formed by plane mirror

u ⇒ vector ✓



- The image obtained is virtual.
- The image is laterally inverted.
- The image is erect.
- The size of the image is the same as the size of the object.
- The distance between the image obtained is the same as the distance between the object from the mirror.



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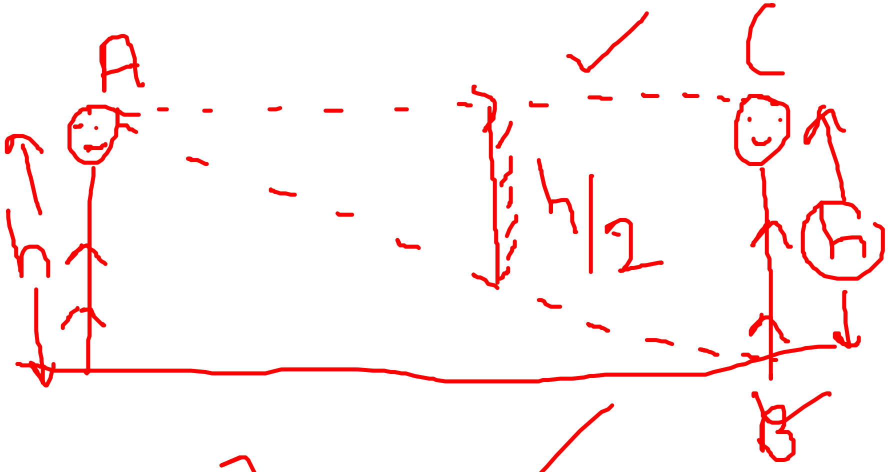
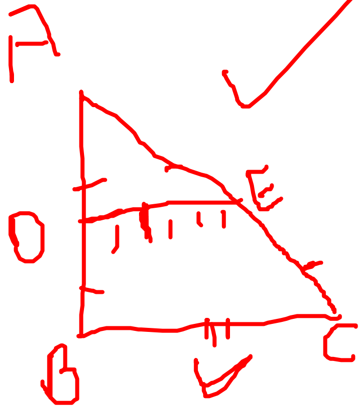
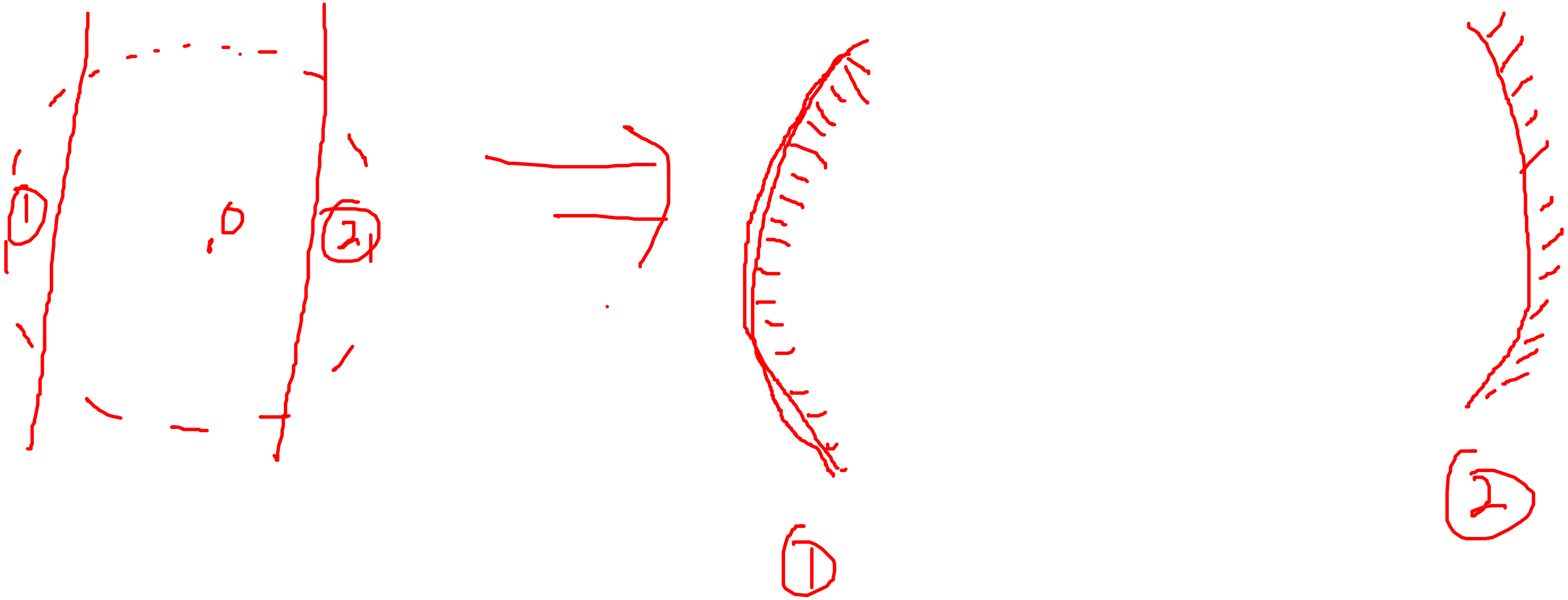


minimum
H. of plane
mirror = ?



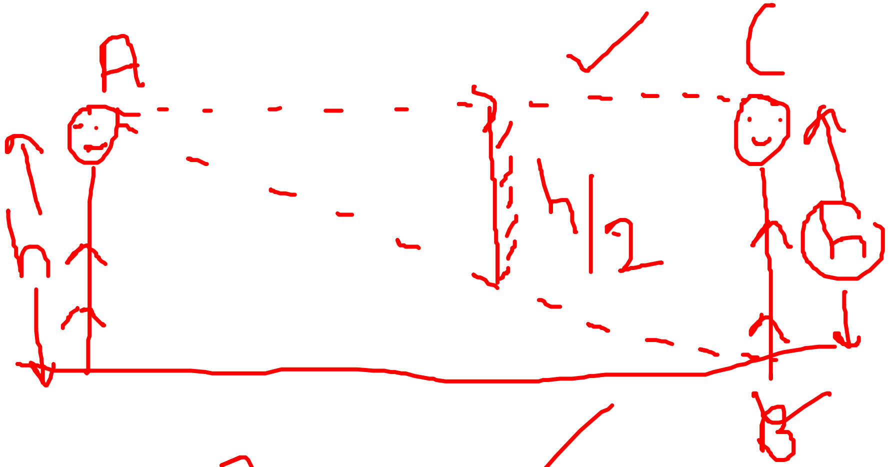
9/h

Spherical mirror

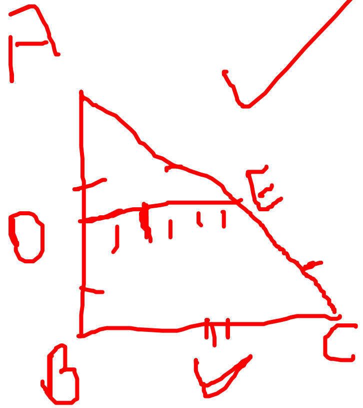


Convex

Concave



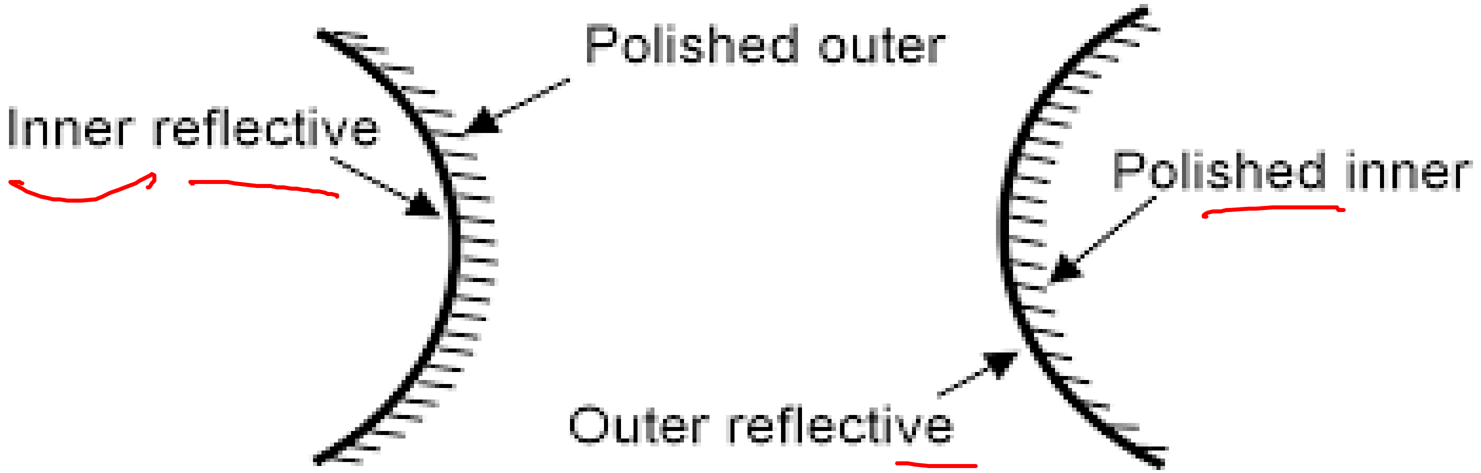
minimum
H. of plane
mirror = ?



9th

- **<u>Concave mirrors:</u>** These are the spherical mirror that is curved inward and the image obtained from these mirrors depend on the placement of the object.

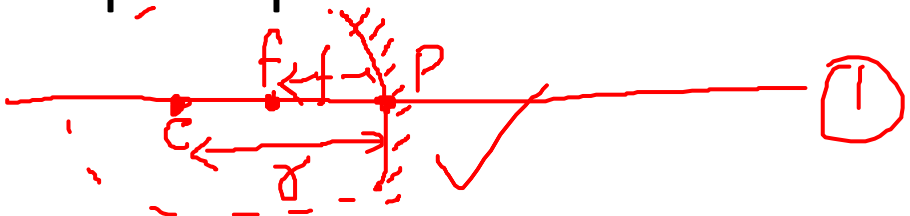
- **<u>Convex mirror:</u>** These are the spherical mirror that is curved outward and the image obtained is virtual, diminished and erect for a real object.

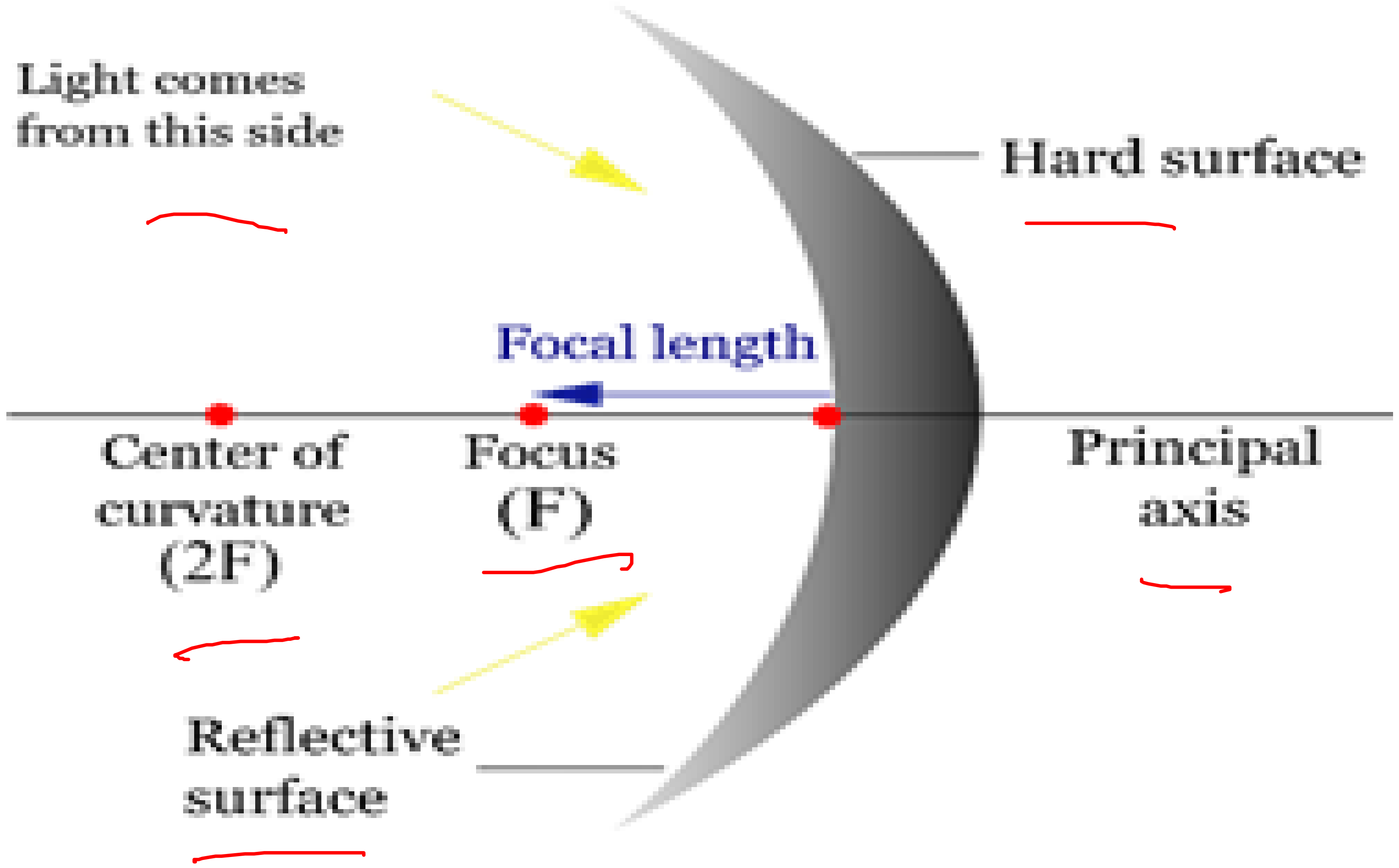


(a) A concave mirror (b) A convex mirror

• Important Terms

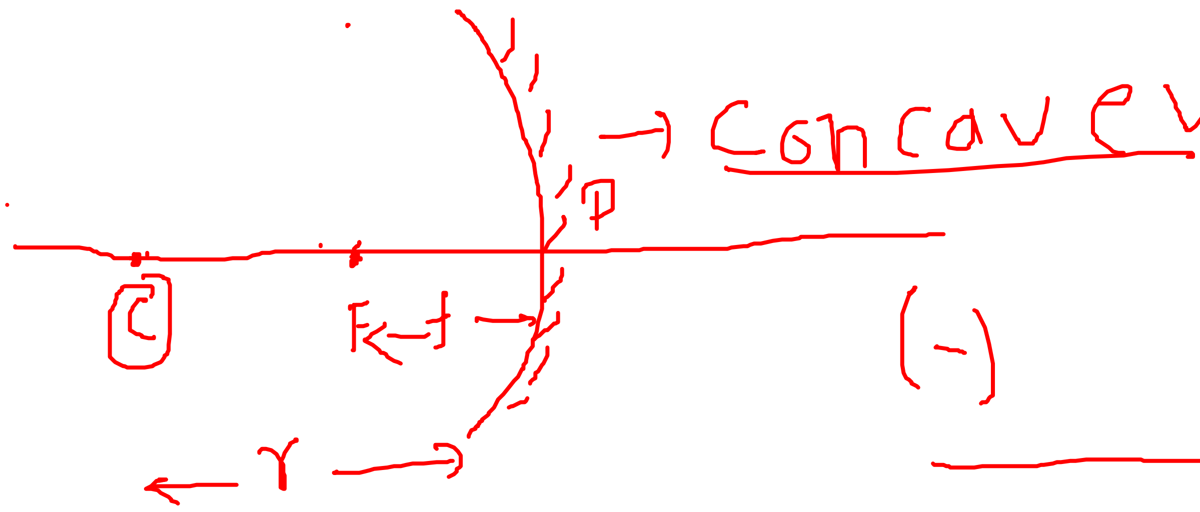
- **Pole:** it is the centre of the reflecting surface of a spherical mirror. It lies on the surface of the mirror and it is usually denoted by P.
- **Centre of curvature:** the centre of the sphere formed by the reflecting part of a spherical mirror is called centre of curvature. It is generally denoted by C. **The**
- **radius of curvature:** it is the radius of the sphere formed by the reflecting part of the sphere. It is represented by R.
- **Principal axis:** it is the straight line passing through the pole and centre of curvature of the spherical mirror. This is normal to the mirror at its pole.
- **Principal focus:** the incident rays coming parallel to the principal axis after reflection appear to converge to a common point on the principal axis, this point is called the principal focus of a concave mirror. It is usually denoted by F.
- **Focal length:** it is the distance between the pole and principal focus of the concave mirror. It is denoted by f.



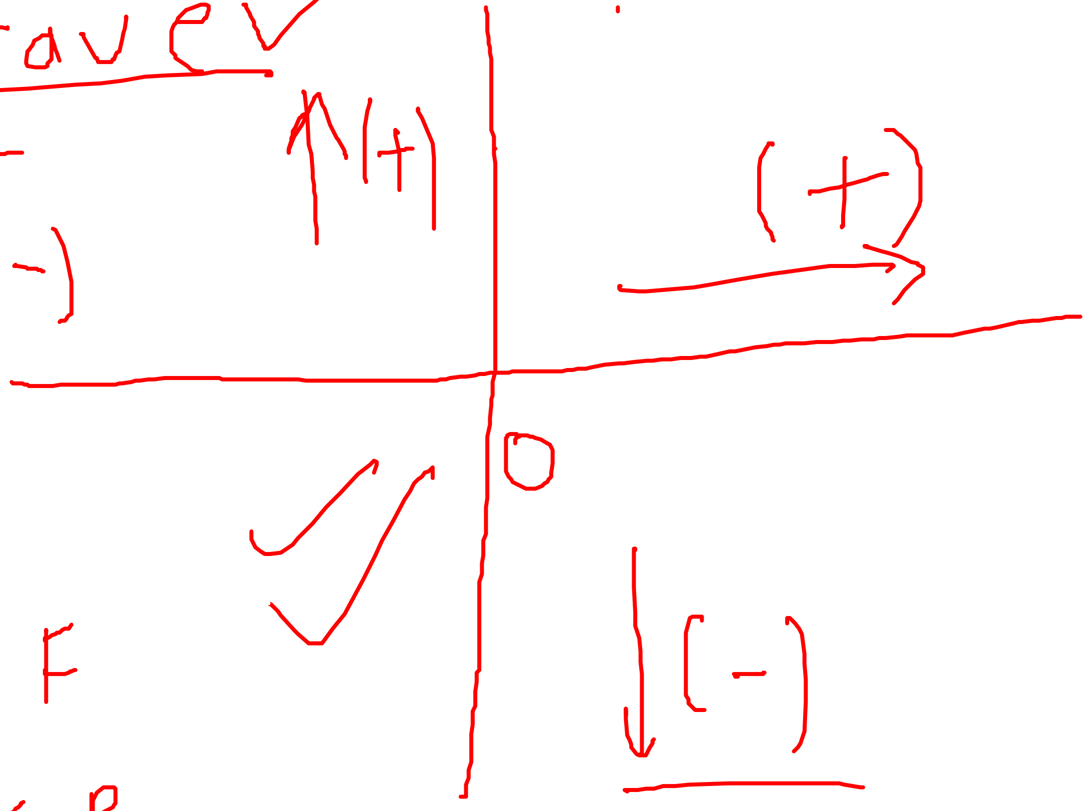

Light comes from this side
Hard surface
Focal length
Center of curvature (2F)
Focus (F)
Principal axis
Reflective surface

Sign Conventions

1. infinite
2. Behind C



3. at C
4. b/w C & F
5. at F
6. F & P



Concave Mirror Ray Diagrams

- a) A ray parallel to the principal axis, after reflection, will pass through the principal focus of a concave mirror.

- b) A ray which is passing through the principal focus of a concave mirror, after reflection, will emerge parallel to the principal axis.

- c) A ray passing through the centre of curvature of a concave mirror, after reflection, is reflected along the same path. The light rays come back along the same path because the incident rays fall on the mirror along the normal to the reflecting surface.

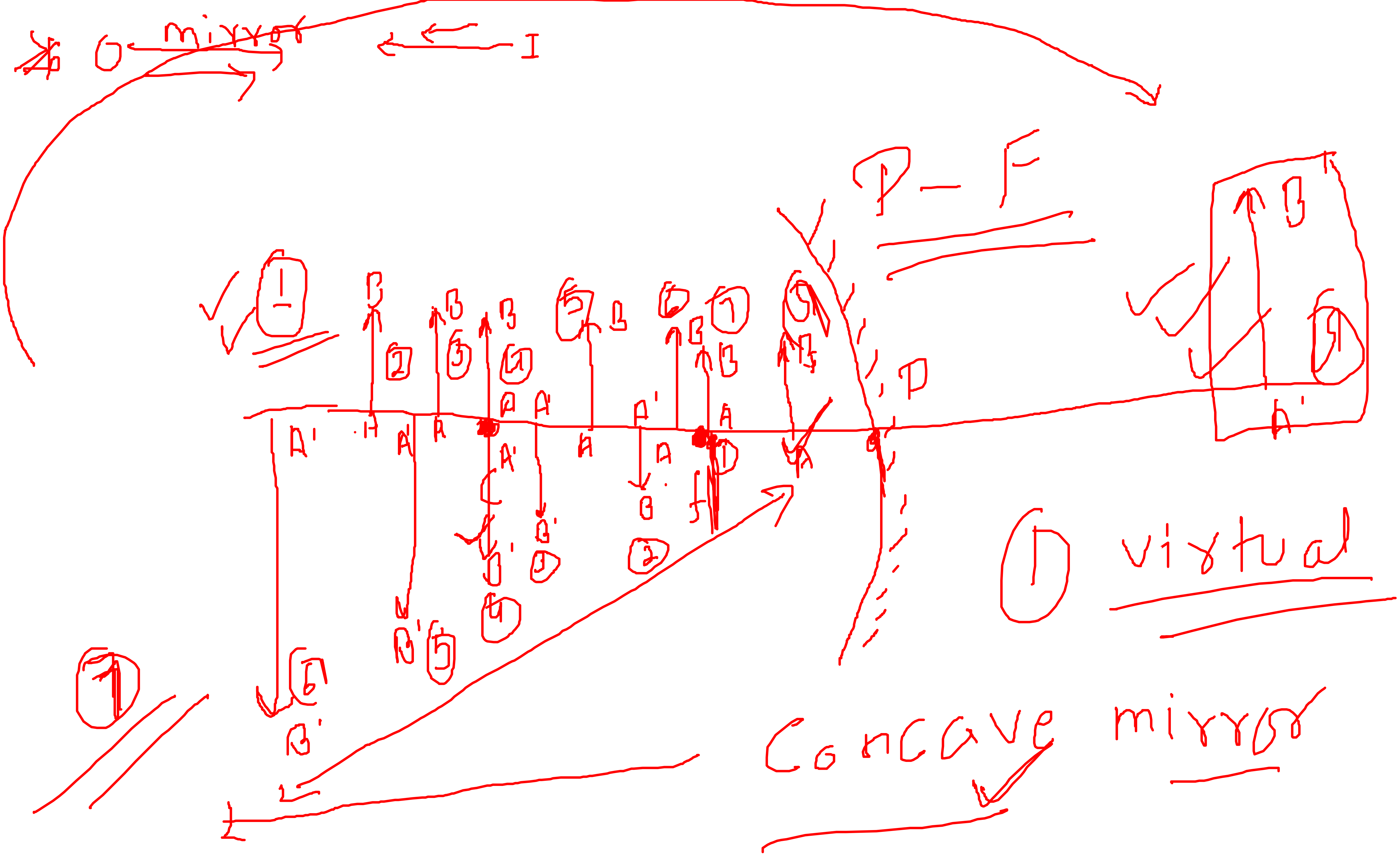

O mirror I
P-F
virtual
Concave mirror

Image Formation

Position of the object	Position of the image	Size of the image	Nature of the image
At infinity	At focus, F	Highly diminished and pointed in size	Inverted and Real
Beyond C	Between F and C	Diminished	Inverted and Real
At C	At C	Same size	Inverted and Real
Between C and F	Beyond C	Enlarged	Inverted and Real
At F	At infinity	Highly enlarged	Inverted and Real
Between F and P	Behind the mirror	Enlarged	Erect and virtual

• Uses of Concave Mirrors

- Torches, search-lights and vehicles headlights use concave mirrors to get powerful parallel beams of light.
- Shaving mirrors used are usually concave mirrors to get a magnified image of the face.
- To see large images of the teeth of patient’s, dentists use concave mirrors.
- Concave mirrors are also used in reflecting telescopes.
- Concave mirrors are used to form optical cavities, which are important in the construction of laser.
- For concentrating sunlight to produce heat in solar furnaces large concave mirrors are used.
- Concave mirrors are used as the mirror landing aid system of modern aircraft carriers.

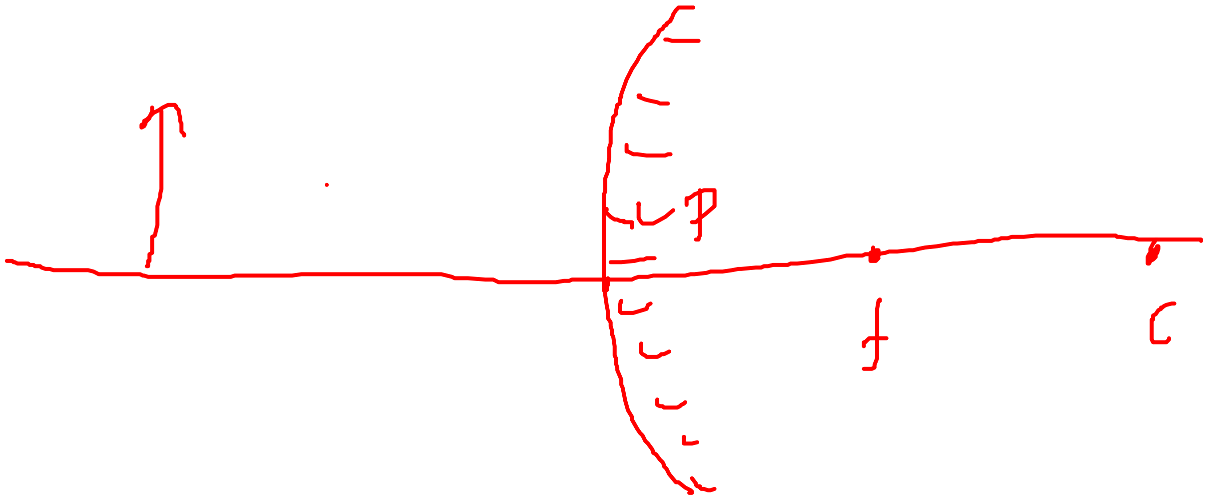
•Image Formation By Convex Mirror

- When an object is placed at infinity, a virtual image is formed at the focus. The size of the image is much smaller than compared to that of the object.

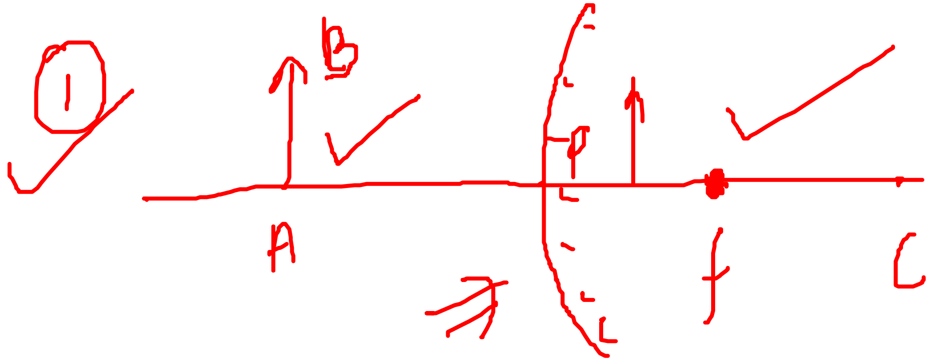
- When an object is placed at a finite distance from the mirror, a virtual image is formed between the pole and the focus of the convex mirror.

G

1



2 1 infinite
2 b/w I & P



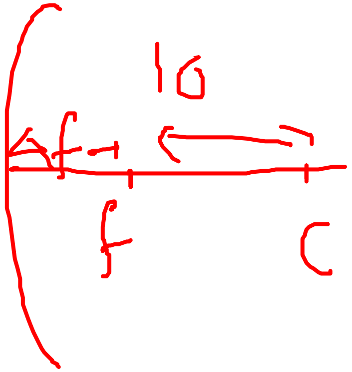
S. No	Position Of Object	Position of Image	Size of Image	Nature of Image
1	At Infinity	At the focus F, behind the mirror	Highly diminished	Virtual and Erect
2	Between Infinity and the Pole	Between P and F, behind the mirror	Diminished	Virtual and Erect

Uses of ~~Concave~~ Mirrors

Convex

- Inside buildings
- Vehicle mirrors
- Magnifying glass
- Security purposes

- **Relation Between Radius of Curvature and Focal Length**



$$R = 2f \Rightarrow f = R/2$$

- **Mirror Equation**

$$\Rightarrow \left\{ \frac{1}{v} + \frac{1}{u} = \frac{1}{f} \right\}$$

Dist of image from mirror

Dist of obj from mirror

Focal Length

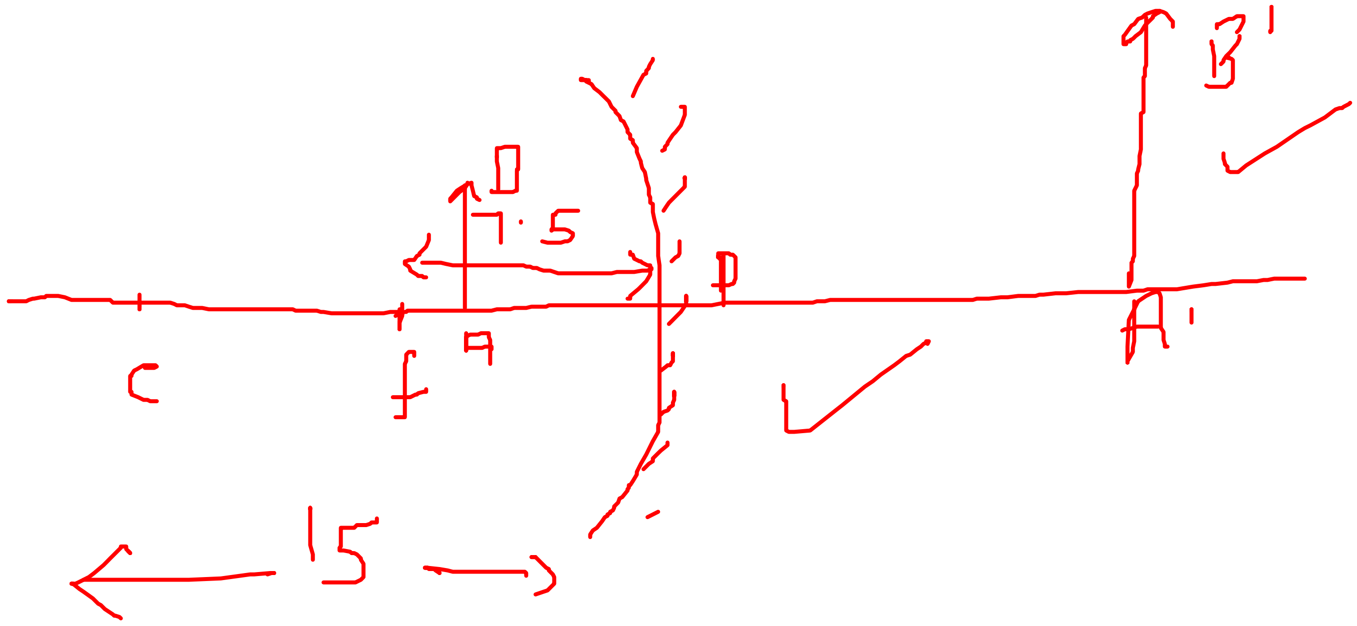
- **Linear Magnification (m):** Linear magnification (m) is the ratio of the height of the image (h’) to the height of the object (h).

m Imp.

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

$h \rightarrow h'$

- 1. An object is found to be 5cm in front of a concave mirror of radius of curvature 15 cm. Determine the position, nature, and magnification of the image in each case.



Refraction of Light (अपवर्तन)

- Refraction is the change in the direction of a wave passing from one medium to another or from a gradual change in the medium.

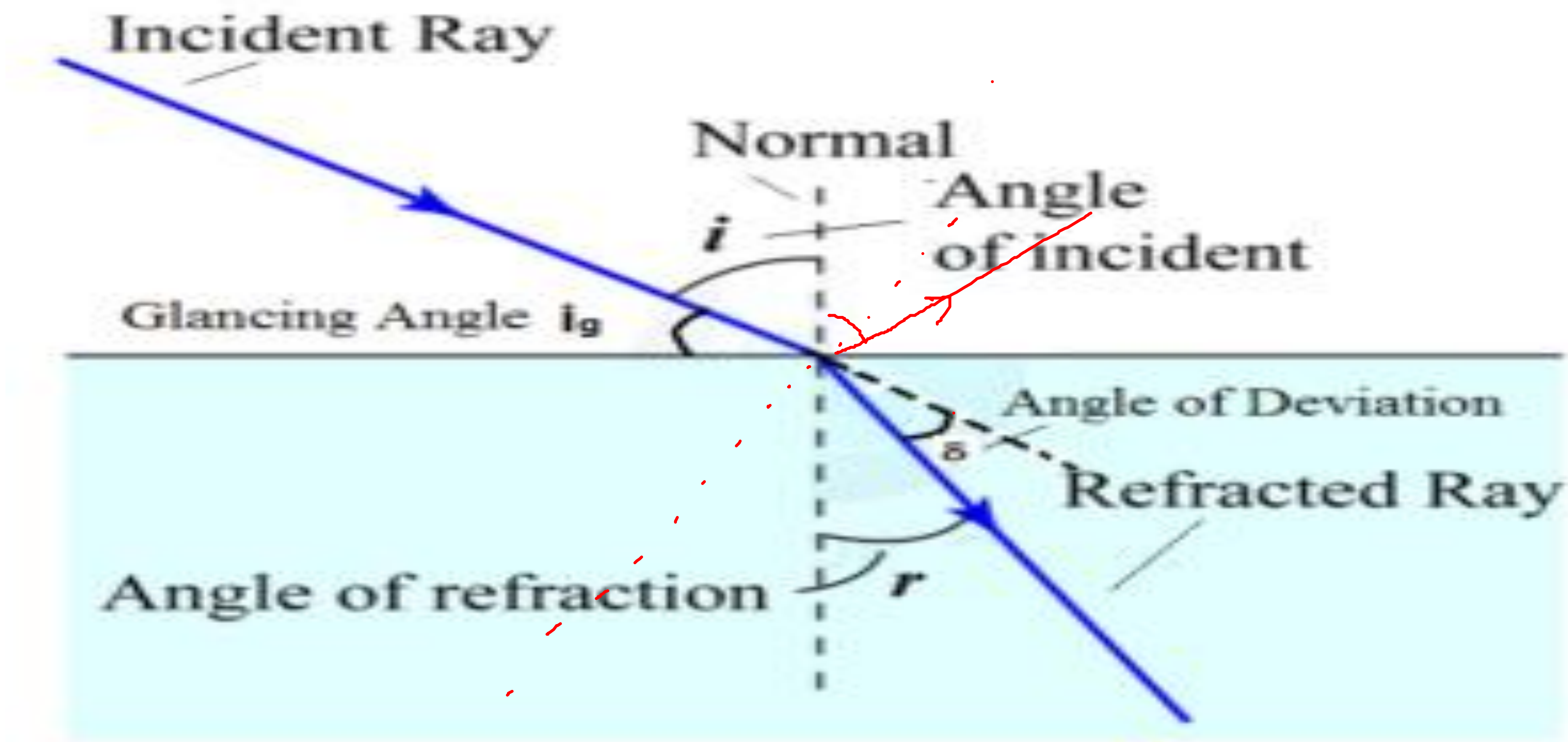
- **Laws of Refraction of Light:**
- The incident ray refracted ray, and the normal to the interface of two media at the point of incidence all lie on the same plane.

$\boxed{\sin i \propto \sin r}$

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

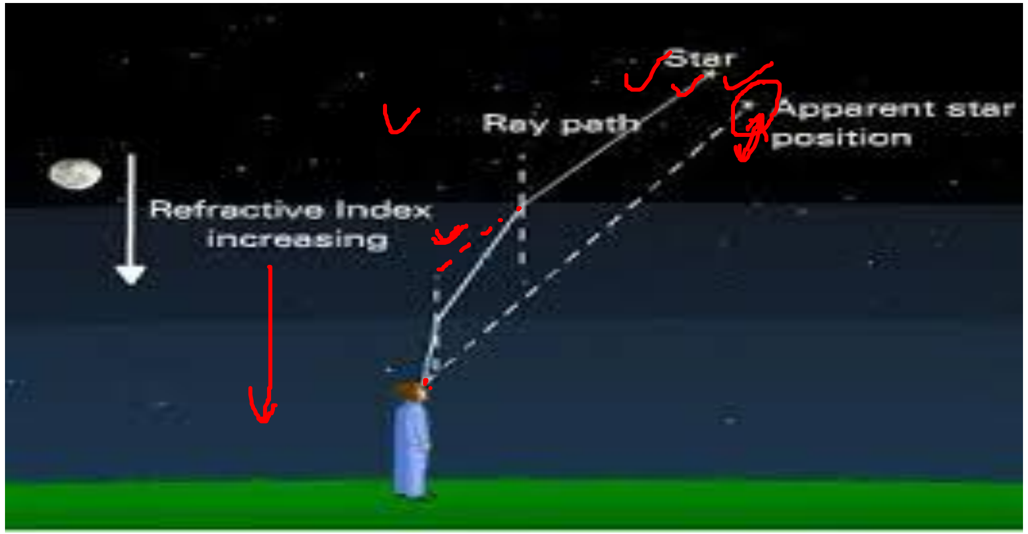
$$\left\{ \frac{Sin\ i}{Sin\ r} = Constant \right\}$$

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

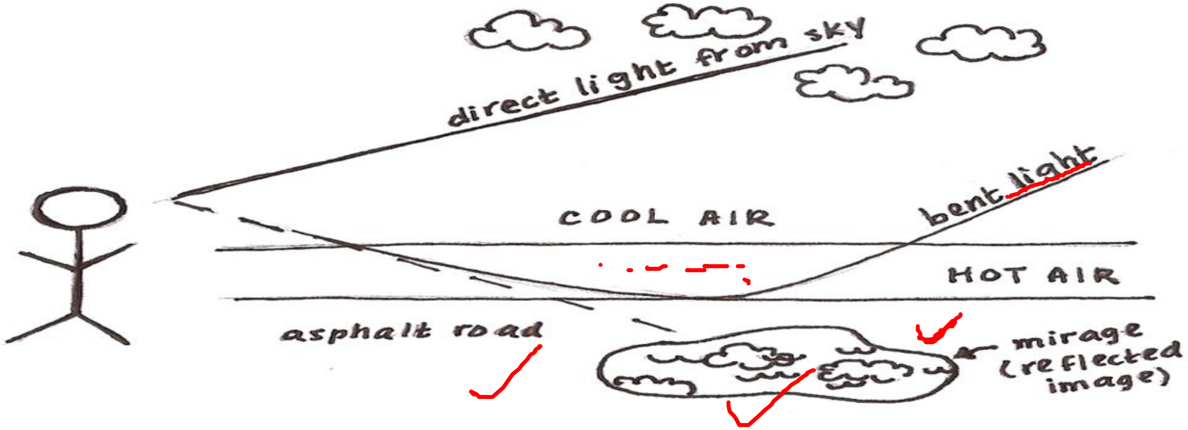

Incident Ray
Normal
Angle
of incident
i
Glancing Angle i_g
Angle of Deviation
δ
Refracted Ray
Angle of refraction
r

Effects of Refraction:

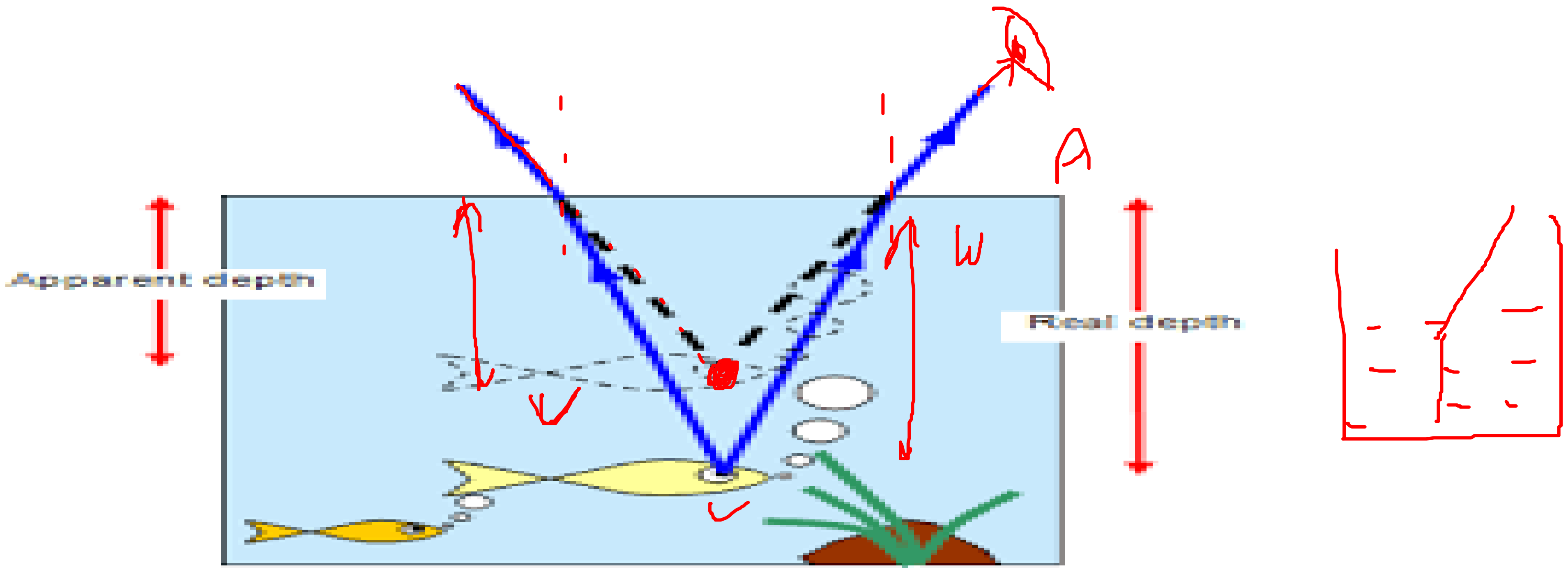
- Twinkling of stars is due to refraction of light.



- Mirage and looming are optical illusions which are a result of refraction of light.

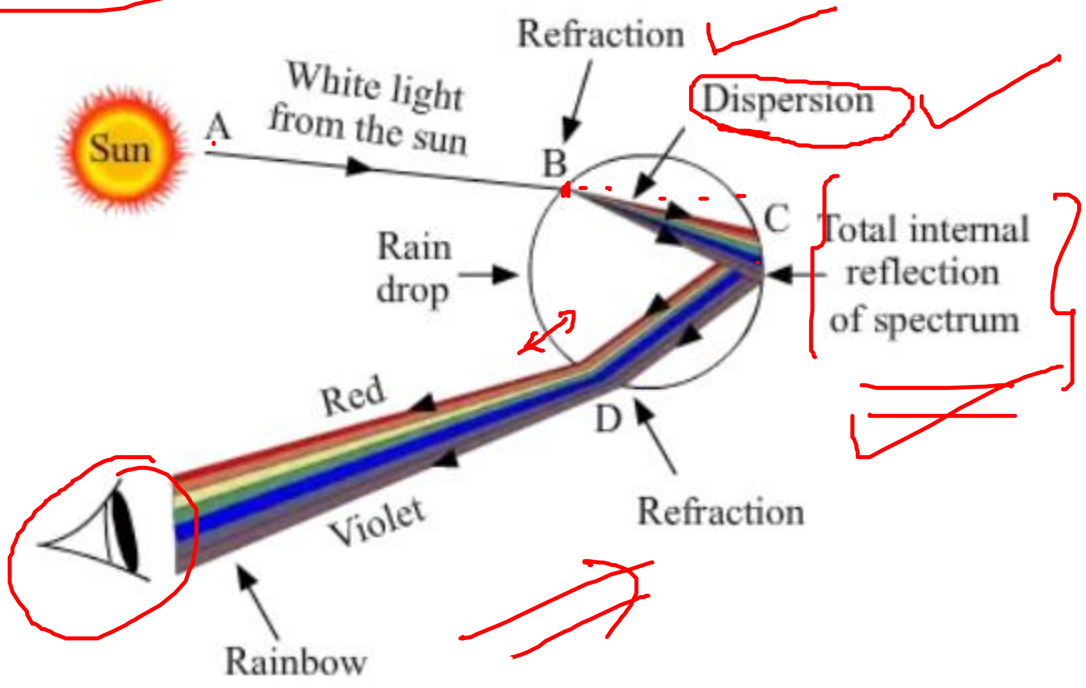


- A swimming pool always looks shallower than it really is because the light coming from the bottom of the pool bends at the surface due to refraction of light.

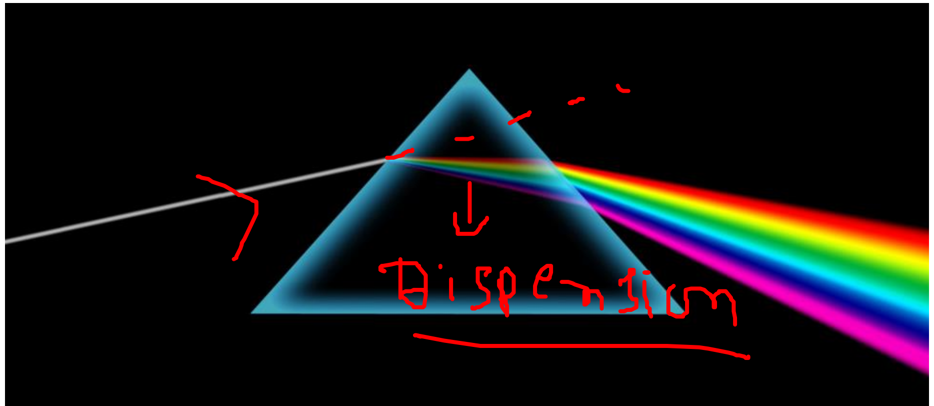


•Refraction Examples

- Formation of a rainbow is an example of refraction as the sun rays bend through the raindrops resulting in the rainbow.



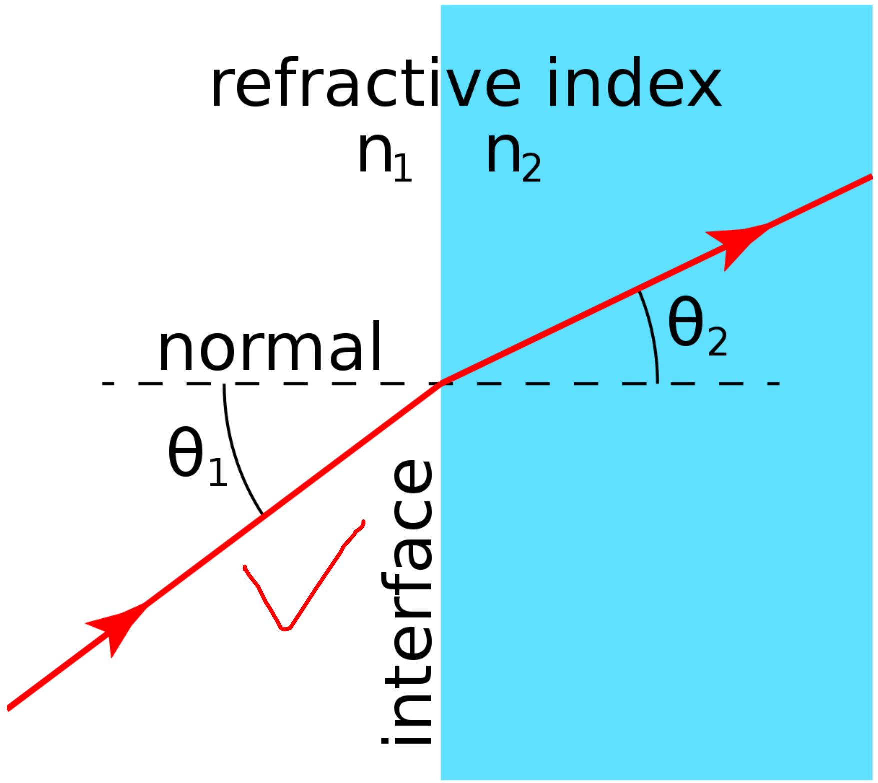
- Prism is also an example of refraction.



•Refractive Index:

अपवर्तनांक

- Refractive index also called the index of refraction describes how fast light travels through the material.



$$n = \frac{c}{v}$$

c (vaccum) v → change (in a medium)

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

(unitless)

MATERIAL	INDEX OF REFRACTION (n)
Vacuum	1.000
Air	1.00027 ($\simeq 1$)
Water	1.333
Ice	1.31
Glass	1.5
Diamond	2.417

${}_{a}n_{w}$, ${}_{a}n_{g}$, ${}_{w}n_{g}$

- What is the refractive index of the medium in which the speed of light is 1.5×10^8 m/s?

$n = ?$ $\quad v = 1.5 \times 10^8$ m/s

$c = 3 \times 10^8$ m/s

$n =$ $\boxed{n = 2}$

- The speed of light in an unknown medium is 1.76×10^8 m/s. Calculate the refractive index of the medium.

$$n = \frac{3\cancel{00} \times \cancel{10^8} \text{ m/s}}{1\cancel{.}76 \times \cancel{10^8} \text{ m/s}}$$

$n = 1.704$

- The angle of incidence in air for a ray of light is 40° .If the ray travels through water of refractive index 4/3, find the angle of refraction.

Snell's Law:-

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

$$\sin r = \frac{\sin 40^\circ}{4/3}$$

$$= \frac{3 \times 0.6}{4/3}$$

Ans

- The refractive index of water is 4/3 and of glass is 3/2. What is the refractive index of glass with respect to water ?

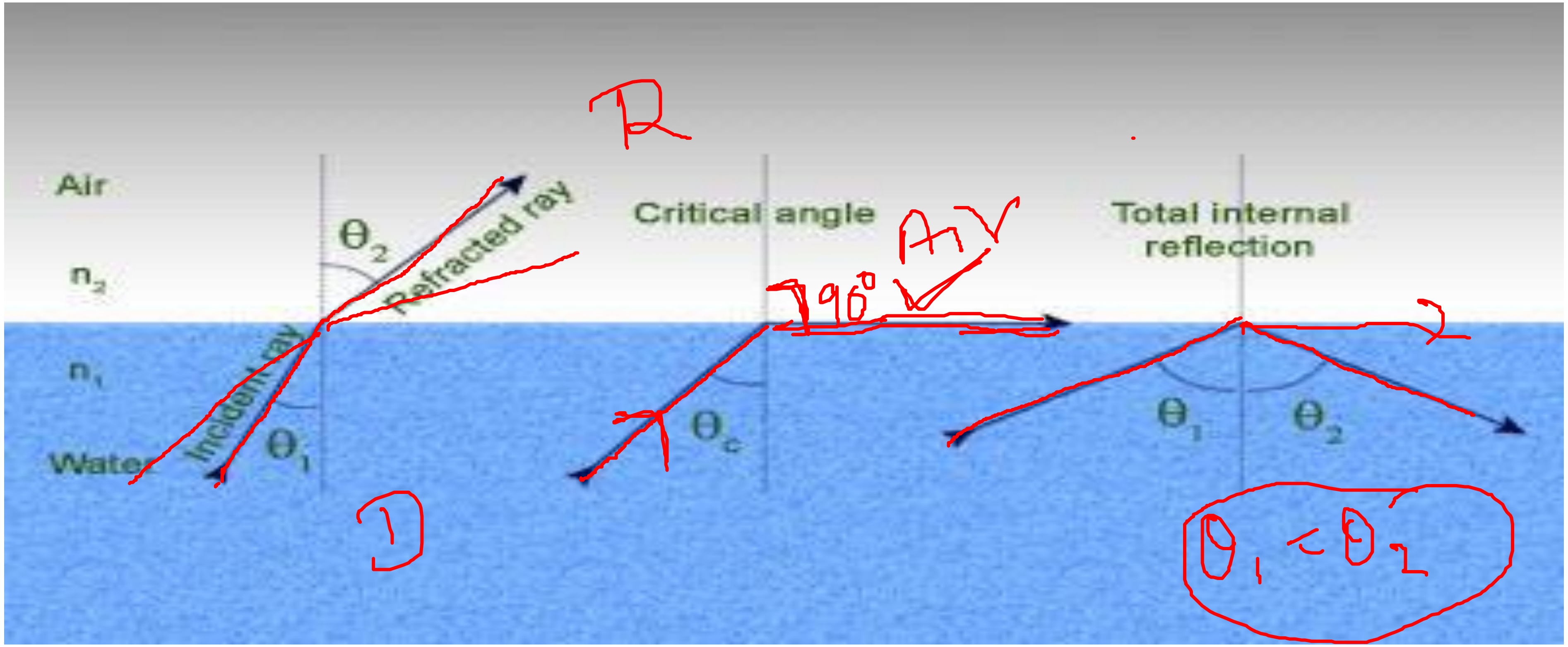
$${}_a n_w = \frac{4}{3}, \quad {}_a n_g = \frac{3}{2}$$

$${}_w n_g = \frac{{}_a n_g}{{}_a n_w}$$

$$= \frac{3/2}{4/3} = 9/8$$

• Total Internal Reflection

- The phenomenon which occurs when the light rays travel from a more optically denser medium to a less optically denser medium.



① Denser to Rarer
② incident angle
critical angle

Total internal reflection	$\frac{n_1}{n_2} = \frac{sin r}{sin i}$
Critical angle, θ	$sin\Theta = \frac{n_2}{n_1}$ 1

Find the refractive index of the medium whose critical angle is 40°.

$n = \frac{1}{\sin\theta} = \frac{1}{\sin 40^\circ}$ $\sin\theta = \frac{1}{n}$

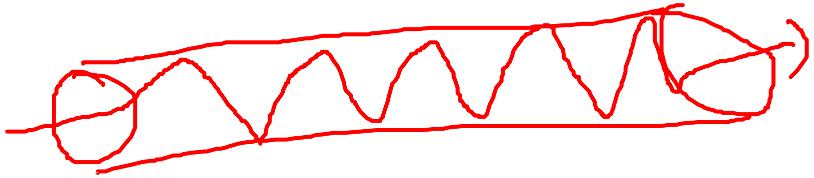
$n = 1.6$

The Examples of Total Internal Reflection

- Diamond: The critical value of the diamond is $\boxed{23°}$.

- Mirage:Mirage is an example of total internal reflection which occurs due to atmospheric refraction.

- Optical fibre: When the incident ray falls on the cladding, it suffers total internal reflection as the angle formed by the ray is greater than the critical angle.



Two Conditions of Total Internal Reflection

- The light ray moves from a more dense medium to less dense medium.

- The angle of incidence must be greater than the critical angle

Lens

wave

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