7 Ray optics

Lens

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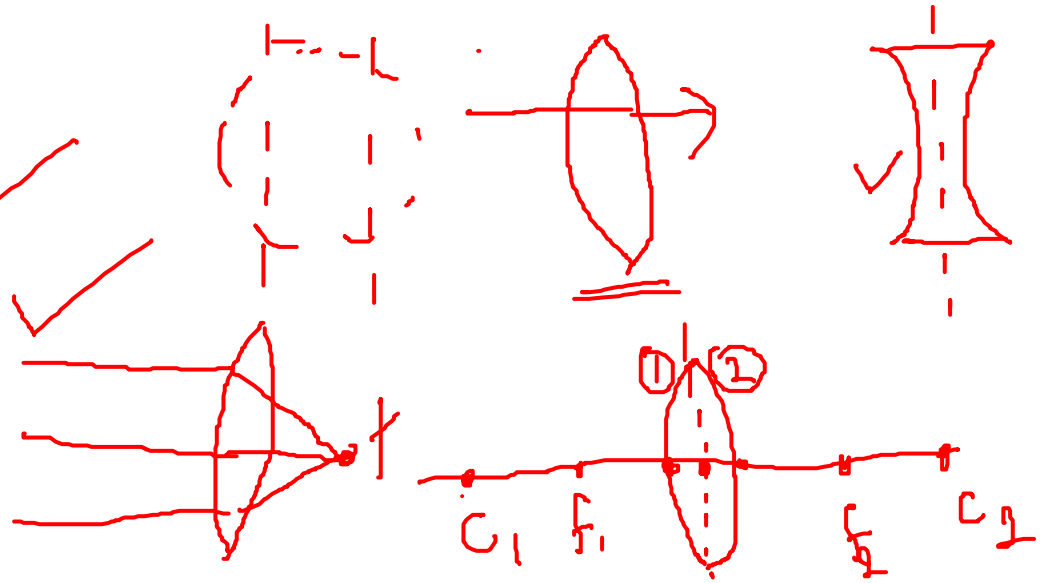
RAY OPTICS-2

BY – SALIL BAJPAI SIR

Lenses

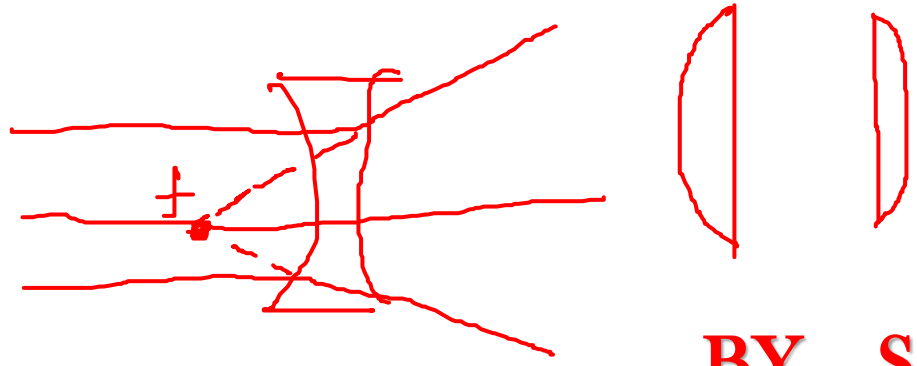
- A lens is a transmissive optical device that focuses or disperses light beams by means of refraction.



- **Types Of Lenses-**

1. **Convex Lens (Converging)**
2. **Concave Lens (Diverging)**

- Compound lenses are those constructed out of a combination of different simple lenses.



- **Lens Formula**
- $1/f = 1/v - 1/u$

BY – SALIL BAJPAI SIR

$f = 20\ m, \quad P = \frac{1}{f} = \frac{100}{20} = 0.05\ D$

- **Power of a Lens**

Power of a lens, (P)= 1/f(metre)

Its unit is diopter (D).

magnify

$P = \frac{1}{f}$ (Focal length)

- **Linear Magnification**

$$m = I/O = v/u$$

$h_o = 7\ cm$, $m = 20$, $h_i = ?$, $h_i = 140$

$m = \frac{h_{iv}}{h_{ov}} = \frac{v}{u}$ → Dist. of image / Dist of obj

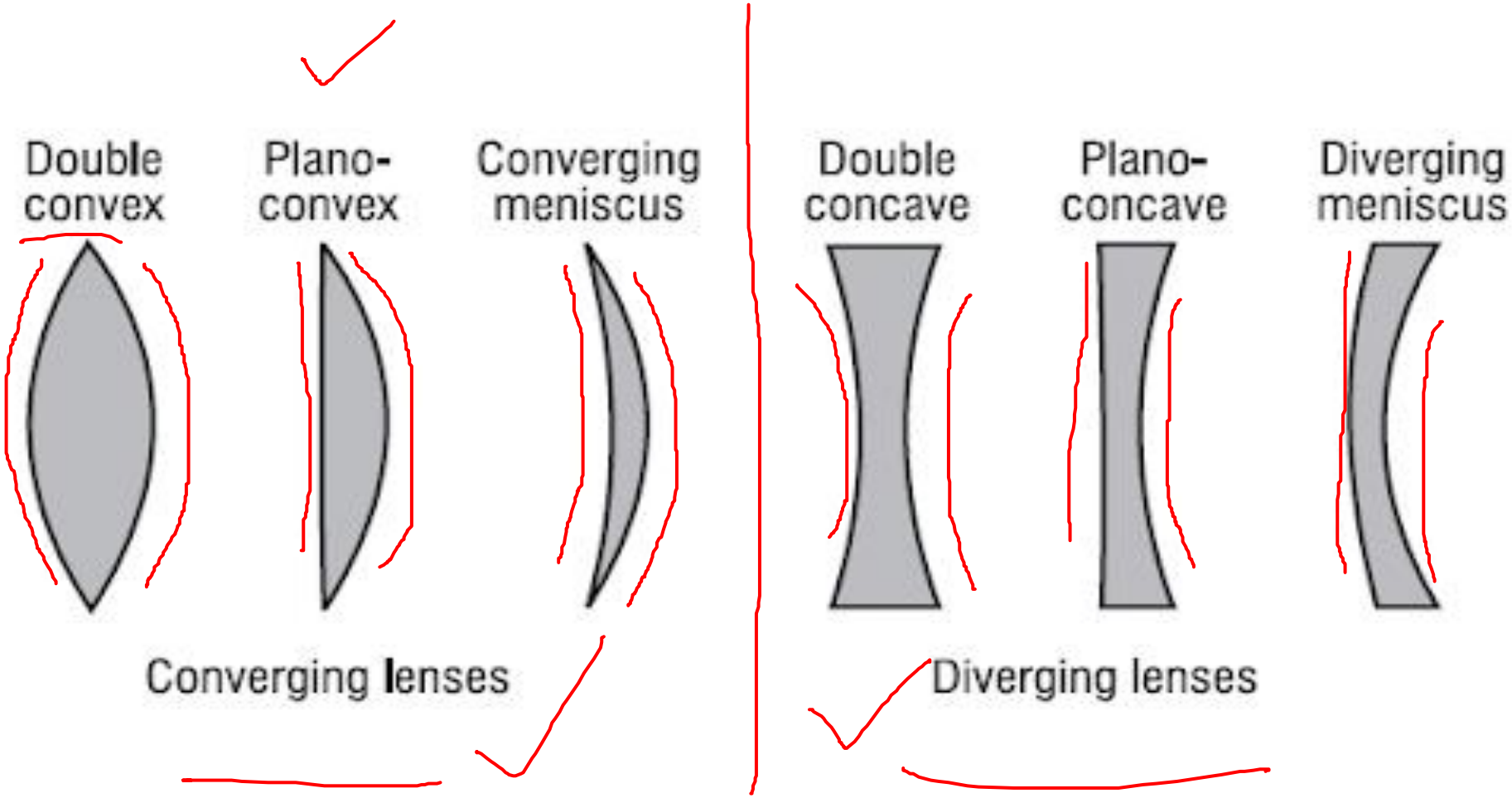
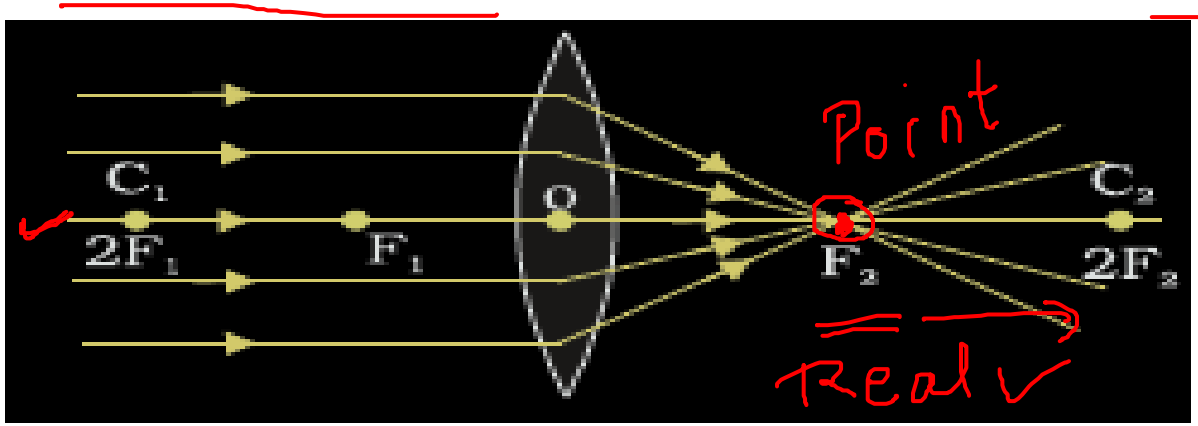

Double convex
Plano-convex
Converging meniscus
Double concave
Plano-concave
Diverging meniscus
Converging lenses
Diverging lenses

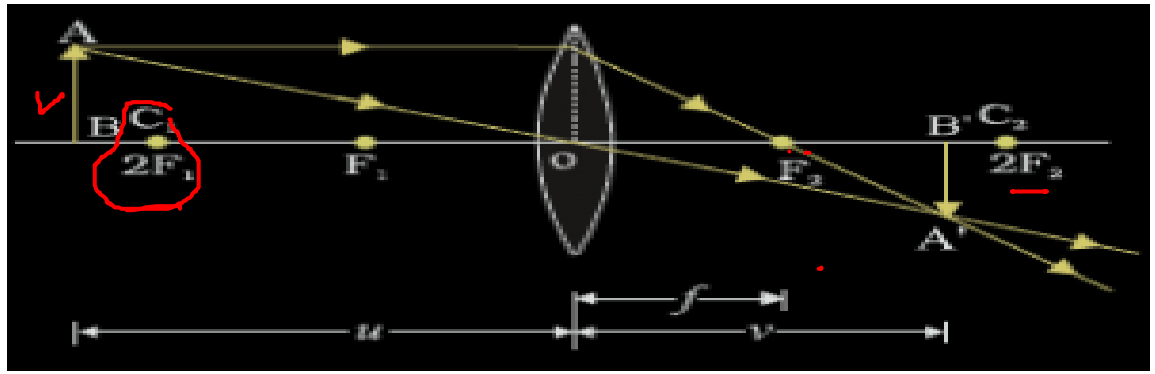
Image Formation by Concave and Convex Lenses:

- **Convex Lenses**

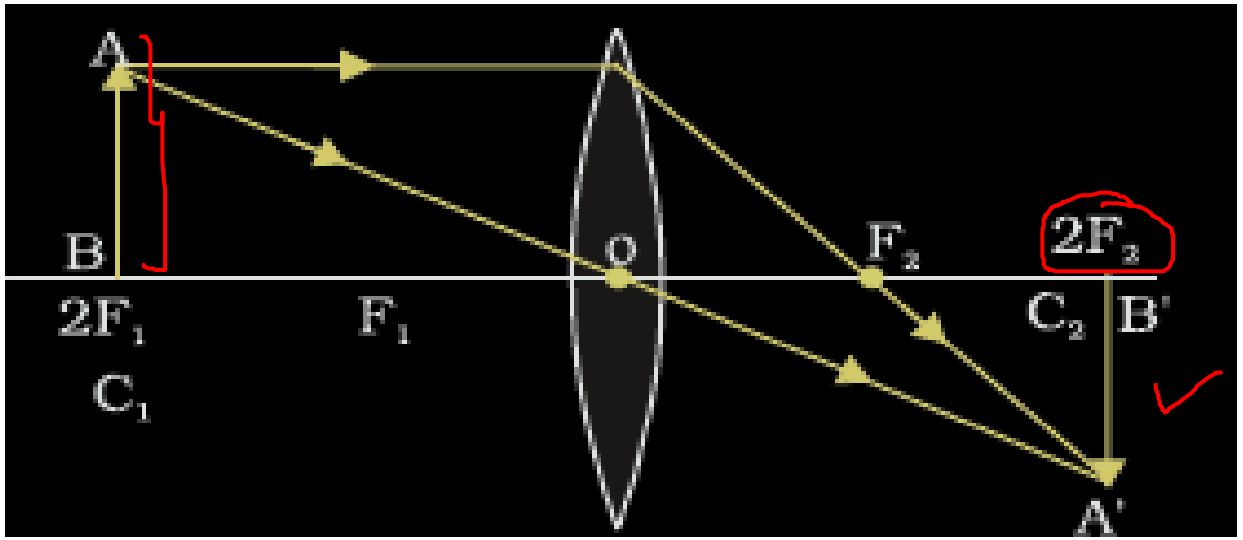
- When an object is placed at infinity, the real image is formed at the focus.



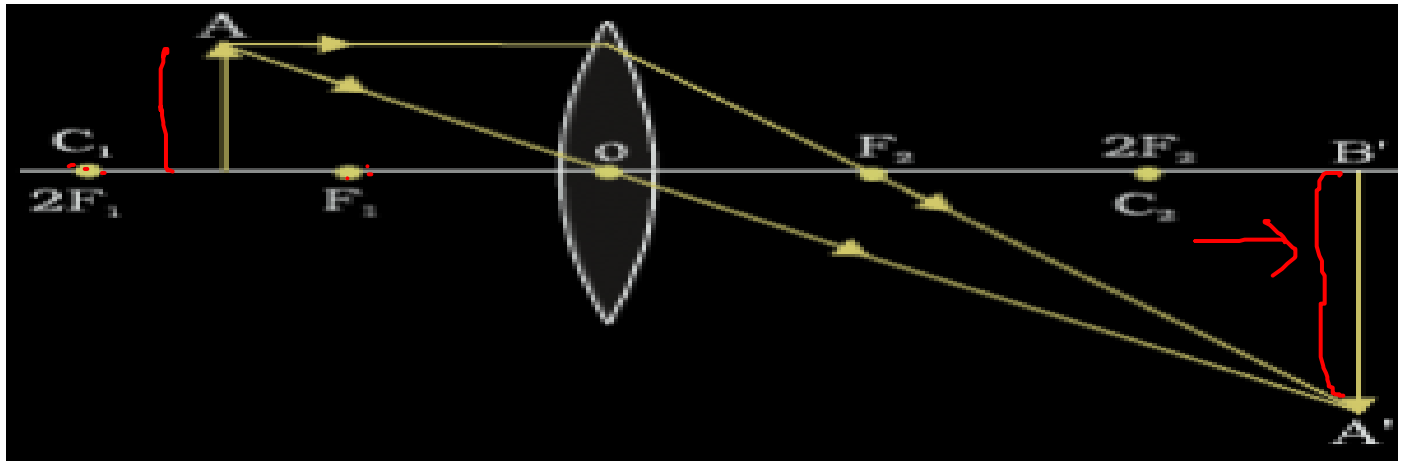
- When an object is placed behind the center of curvature, the real image is formed between the center of curvature and focus.



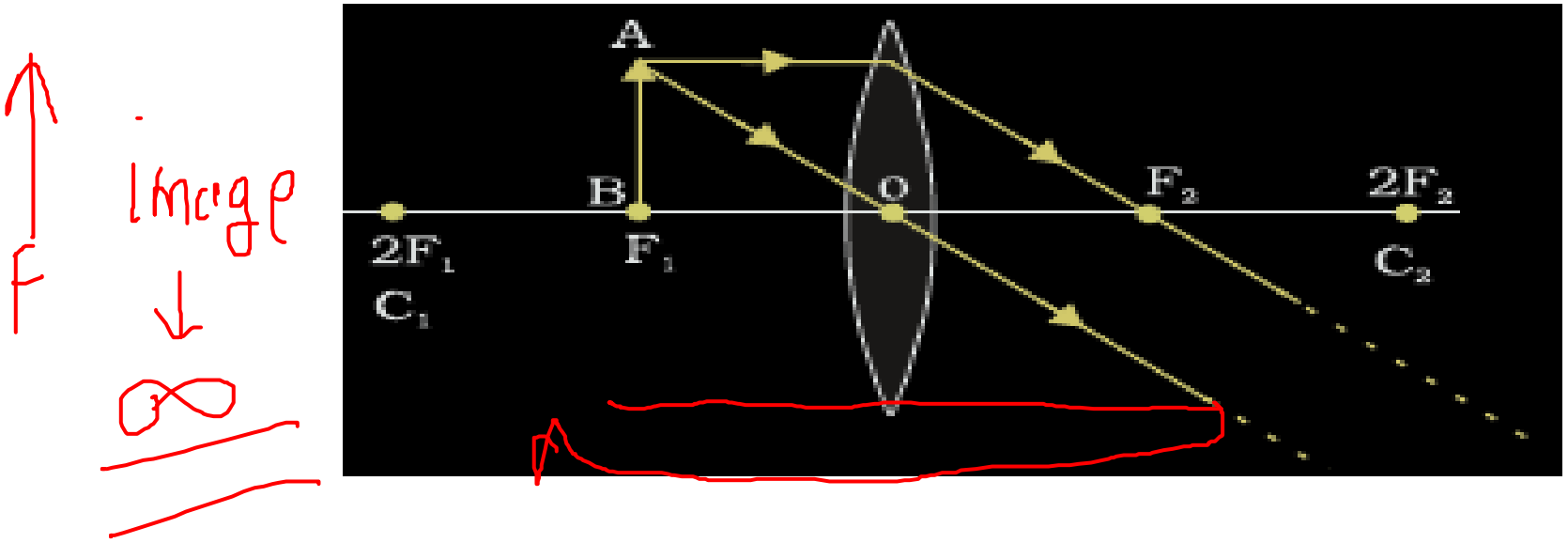
- When an object is at the center of curvature, the real image is formed at the other center of curvature.



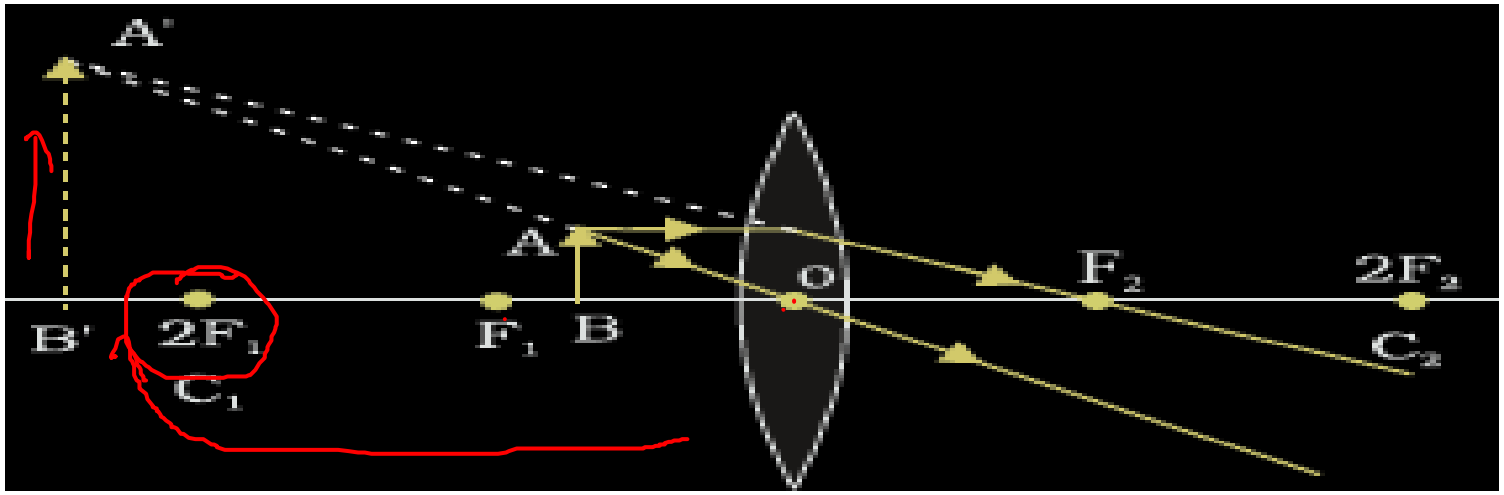
- When an object is placed in between the centre of curvature and focus, the real image is the formed behind the center of curvature.



- When an object is placed at the focus, a real image is formed at infinity.

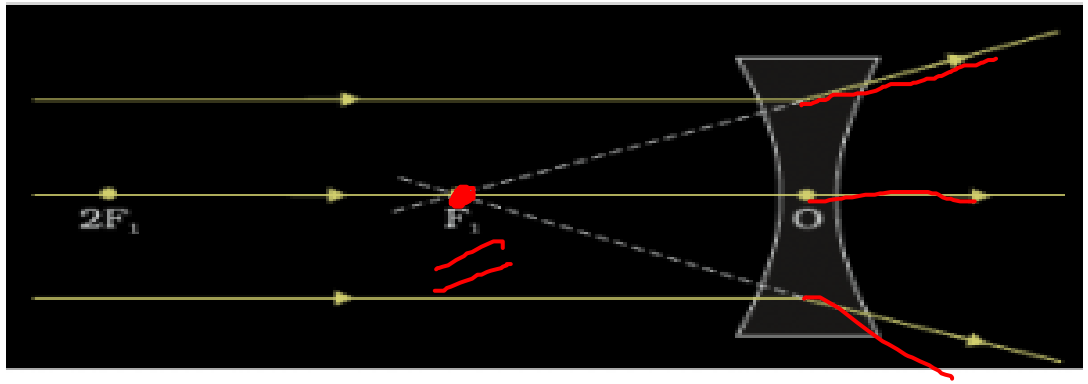


- When an object is placed in between focus and pole, a virtual image is formed.



- # Concave Lenses

- When an object is placed at infinity, a virtual image is formed at the focus.



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

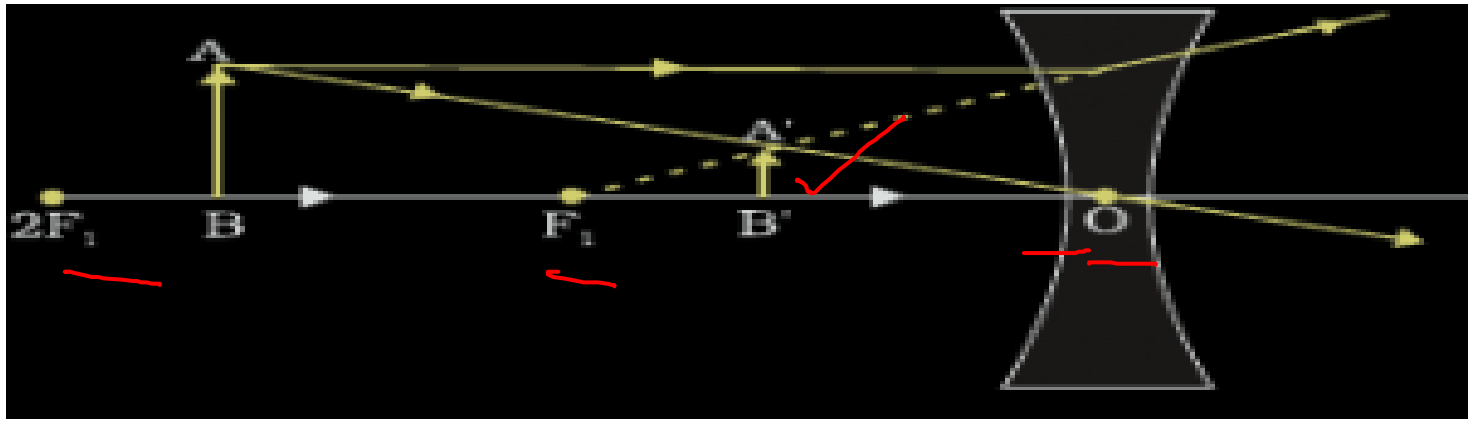


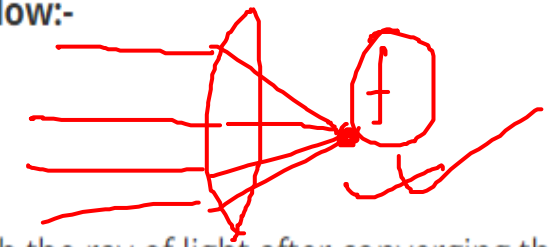
Image formation by Concave Lens			
Object Location	**Image Location**	**Image Nature**	**Image Size**
Infinity	At F2	Virtual and Erect	Highly Diminished
Beyond Infinity and Zero	Between F1 and Optical centre	Virtual and Erect	Diminished

Image formation by Convex Lens			
Object location	**Image location**	**Image nature**	**Image size**
Infinity	At F2	Real and Inverted	Diminished
Beyond 2 F1	Between 2F2 and F2	Real and Inverted	Diminished
Between 2F1 and F1	Beyond 2F2	Real and Inverted	Enlarged
At F1	At infinity	Real and Inverted	Enlarged
At 2 F1	At 2F2	Real and Inverted	Same size
Between F1 and 0	On the same side as the object	Virtual and Erect	Enlarged

Difference between Convex and Concave lenses:-

Basis	Convex Lens	Concave Lens
Other name	A convex lens is called as 'converging lens' or 'positive lens'.	A concave lens is called as 'Diverging lens' or 'Negative lens.
Light rays	When light passes through the lens, it bends the light rays towards each other.	The concave lens spreads out the light when it passes through the lens. An image cannot form on a screen in this case.
Structure	This lens is thick at the center as compared to the edge. It helps to magnify the things and make them look bigger.	A concave lens is exactly opposite to a convex lens. It is thin at the center and thick at the edge.
Parallel rays	As the parallel rays converge, the convex lens is termed as a converging lens.	Similarly, a concave lens is called diverging lenses because they cause parallel rays to diverge.
Curve	The convex lens is curved towards the inside.	The concave lens is curved towards the outside.
Use	It is used to correct long-sightedness or hypermetropia.	It is used to correct short-sightedness or myopia.
For instance	The human eye, camera, telescope, microscope etc. are some examples of the convex lens.	Lights, flashlights, laser, binocular etc. are the examples of the concave lens.
Focal length	It is called positive lens because of its positive focal length nature.	The concave lens is called a negative lens because of its negative length nature.

Some of the uses of the Convex lens are stated below:-



- *Magnifying glasses:*

It is the most common use of the convex lens, in which the ray of light after converging through the convex lens forms an image at the focus point which provides the maximum magnification to the object.

- *Eyeglasses:*

A person can face the problems of farsightedness or nearsightedness due to the failure of the lens of his eye in focusing the light on the retina properly. The convex lens is used to solve the problem of farsightedness or Hypermetropia, by bending the light ray which shortens the focal length and makes the light ray focus on the retina in a proper way.

- *Cameras:*

The convex lens is used in the camera for focusing the image and also for magnifying it. The magnification of the image in the camera is done by adding multiple lenses one after another like a convex lens followed by a concave lens and again followed by a convex lens. The magnification of the image in the camera is controlled by moving the front convex lens.

- *Microscopes:*

Convex lens is used in microscopes to magnify the images of very small objects. Generally, microscopes consist of three lenses in which the end lens generates a magnified and inverted image.

Some uses of the concave lens are stated as follows:-

- • *Telescopes and Binoculars:*

To make a person focus more clearly and see the far objects clearly through telescope or binoculars, a concave lens is used. It is most preferred for these devices as the convex lens helps in seeing a blurry image.

- • *Eyeglasses:*

The concave lens is used to treat the problem of nearsightedness or myopia by diverging the light ray and making the clear image of the object on the retina.

- • *Lasers:*

Small concave lenses are used to widen the laser beam which occupies more area and makes the laser beam producing equipment work properly.

- • *Camera:* The magnification of the image in the camera is done by adding multiple lenses one after another like a convex lens followed by a concave lens and again followed by a convex lens. By combining a concave lens with a convex lens, the undesirable effects are eliminated.

- • *Flashlights:*

To magnify the light produced by the light beam, the concave lens is used which increases the radius of the beam by diverging the light ray falling on the hollowed side to the other side, making the light ray wider and magnified.

- • *Peepholes:*

Peepholes in doors provide the panoramic view of the objects on the other side of the door, works as a security device in which concave lens is used to minimize the proportion of objects providing a wider view of the objects outside the door.

- **Prism:** Prism is uniform transparent medium bounded between two refracting surfaces, inclined at an angle.

$$\eta = \frac{\sin\left(\frac{60+30}{2}\right)}{\sin\left(\frac{60}{2}\right)} = \frac{\sin 45}{\sin 30}$$

- **Prism Formula** The refractive index of material of prism

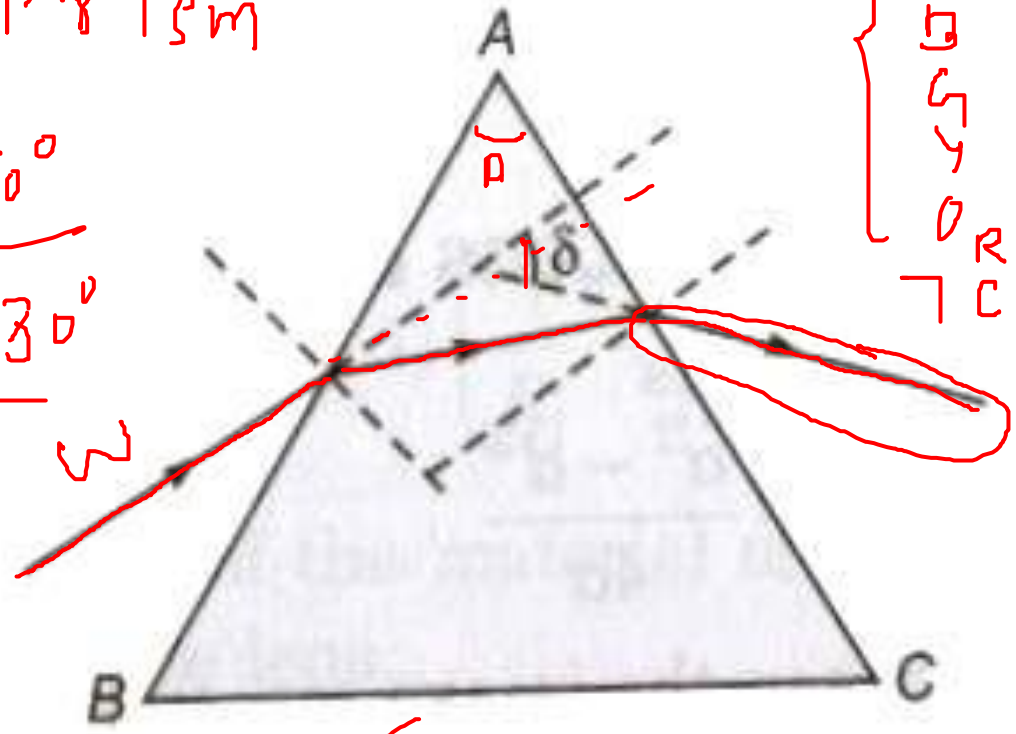
$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

Angle of Prism

$A = 60^\circ$

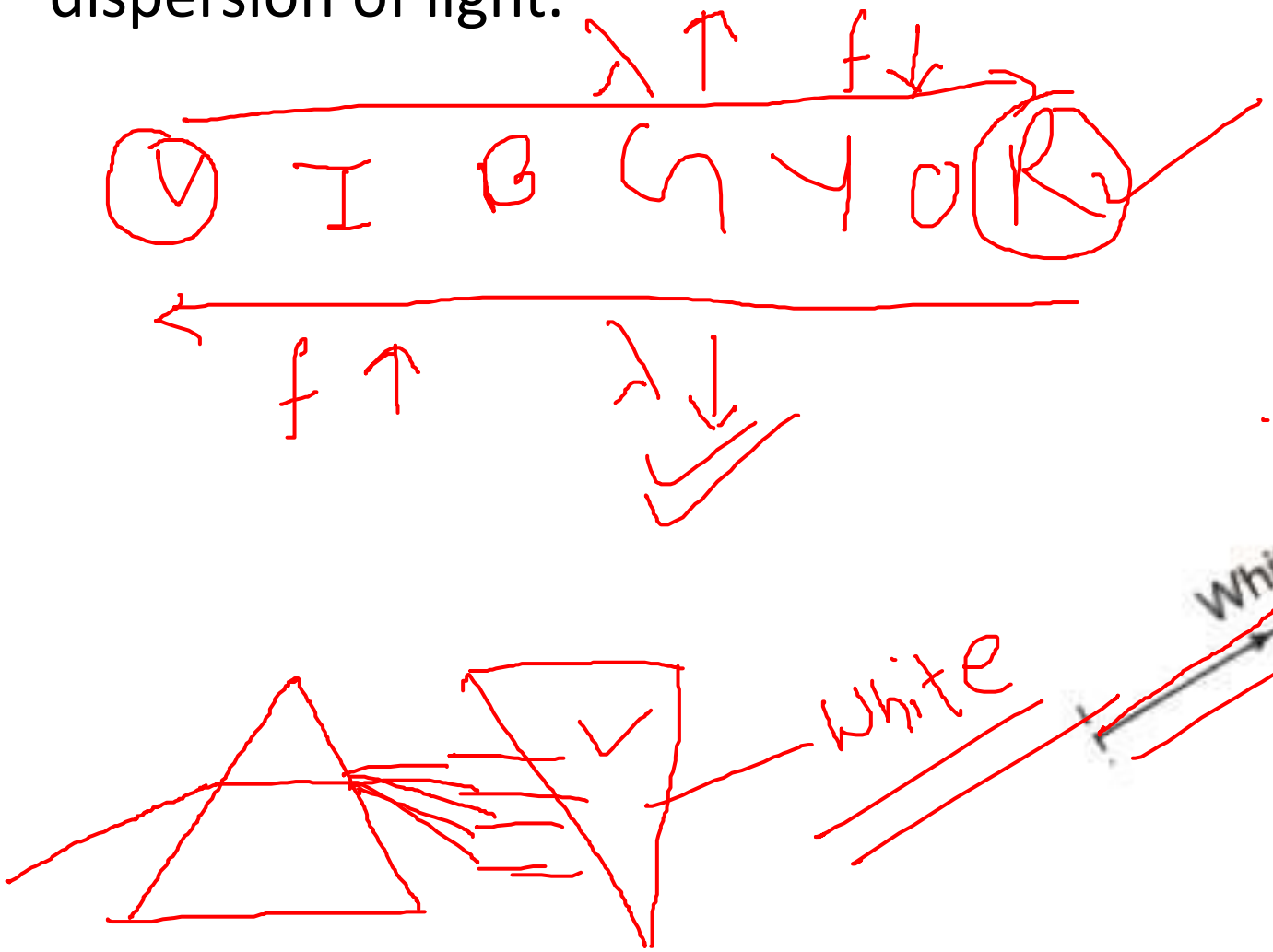
$\delta_m = 30^\circ$

$\eta = ? = \frac{1}{\frac{1}{\sqrt{2}}} = \frac{2}{\sqrt{2}} = \sqrt{2} = 1.41$



VIBGYOR Colors

- **Dispersion of Light** The splitting of white light into its constituent colors in the sequence of VIBGYOR, on passing through a prism. is called dispersion of light.

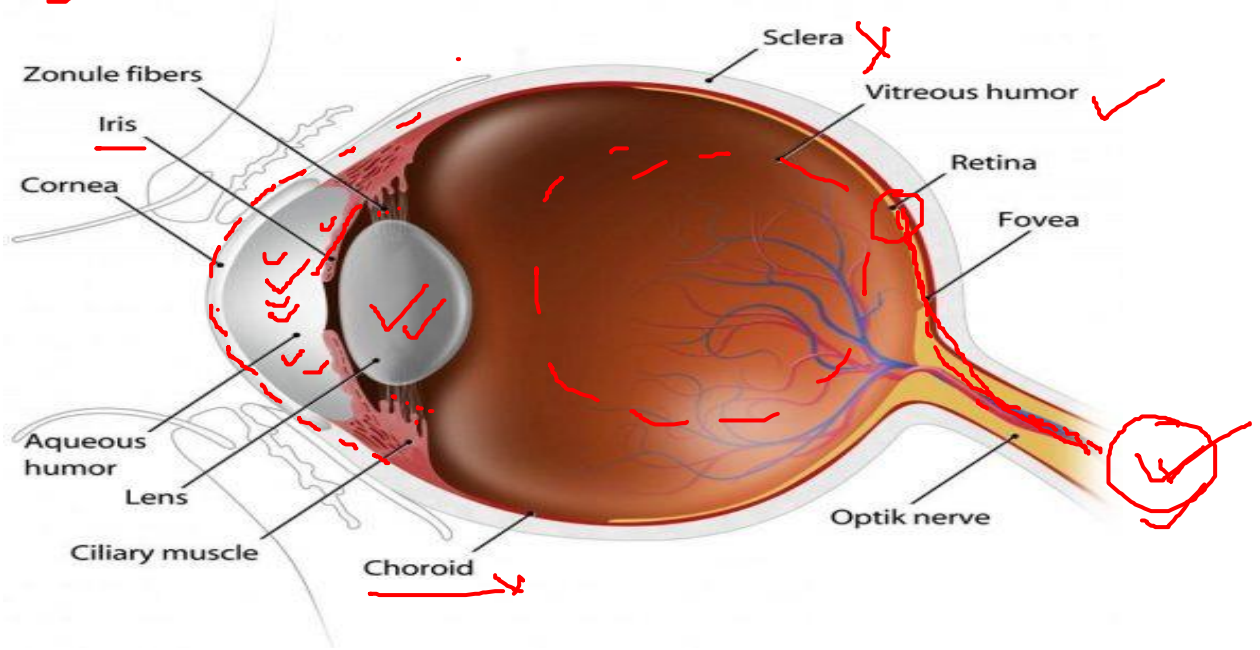


Human Eye

- The human eye is like a camera. Its lens system forms an image on a light-sensitive screen called the retina.

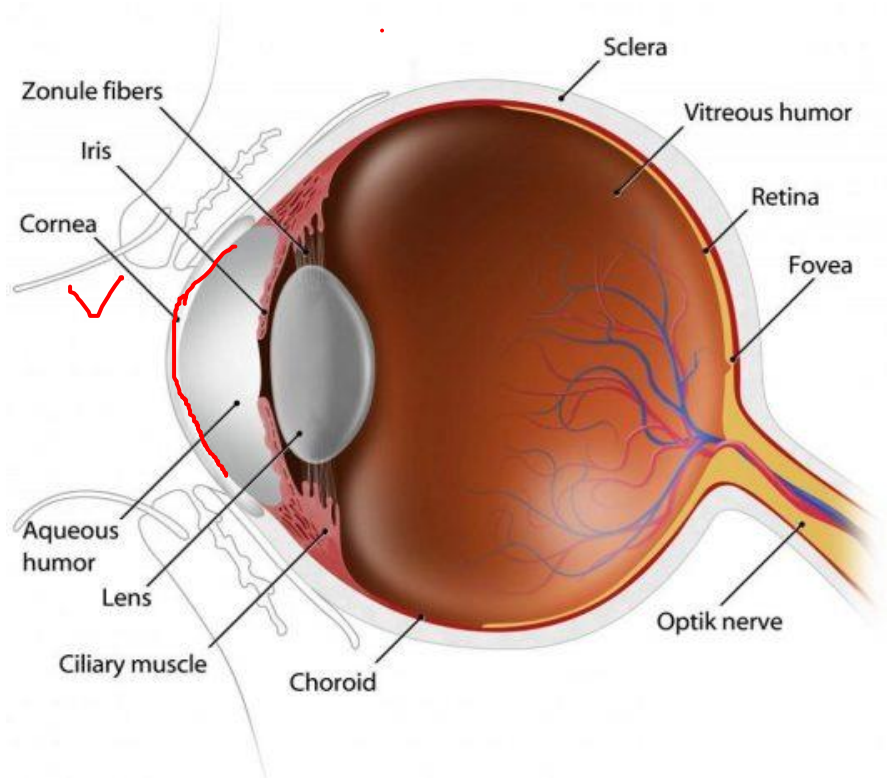
- The eyeball is approximately spherical in shape with a diameter of about 2.3 cm

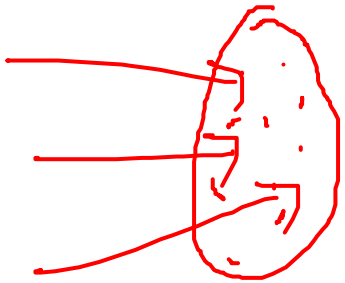
- The eye lens forms an inverted real image of the object on the retina.



- **RETINA -> The retina is a delicate membrane having enormous number of light-sensitive cells.**

- **CORNEA -> Light enters the eye through a thin membrane called the cornea. It is the eye's outermost layer. It is the clear, do meshaped surface that covers the front of the eye. It plays an important role in focusing your vision.**

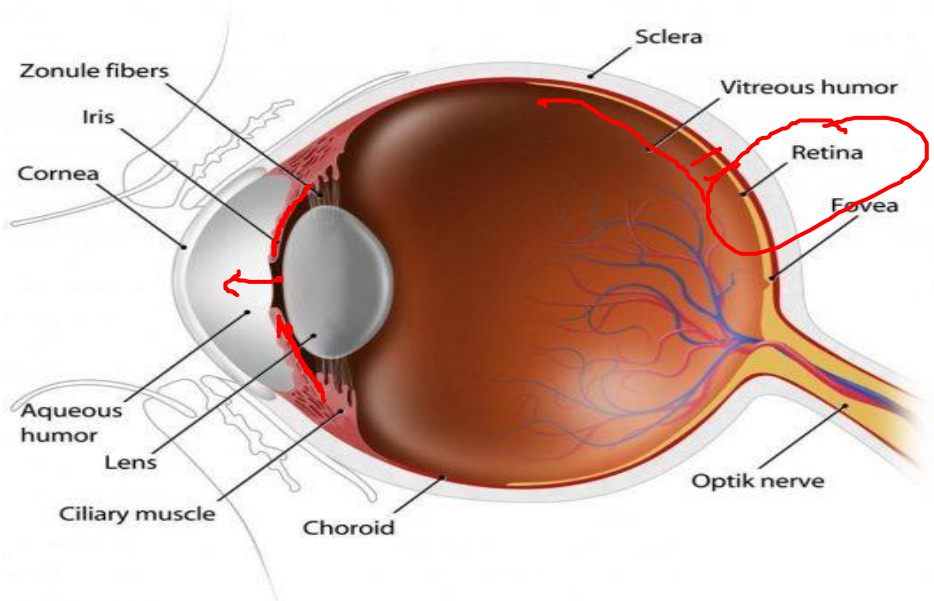




- **PUPIL -> The pupil is a hole located in the centre of the iris of the eye that allows light to strike the retina. The pupil regulates and controls the amount of light entering the eye.**

- **IRIS -> It is a dark muscular diaphragm that controls the size of the pupil and thus the amount of light reaching the retina.**

- **CILIARY MUSCLE -> The ciliary muscle is a ring of smooth muscle in the eye's middle layer . It changes the shape of the lens within the eye, not the size of the pupil.**



- When the light is very bright, the *iris* contracts the *pupil* to allow less light to enter the eye.

- in dim light the *iris* expands the *pupil* to allow more light to enter the eye. Thus, the pupil opens completely through the relaxation of the iris.

- Blind spot : it is the point at which the optic nerve leaves the eye. An image formed at this point is not sent to the brain.

- Aqueous humor : It is clear liquid region between the cornea and the lens.

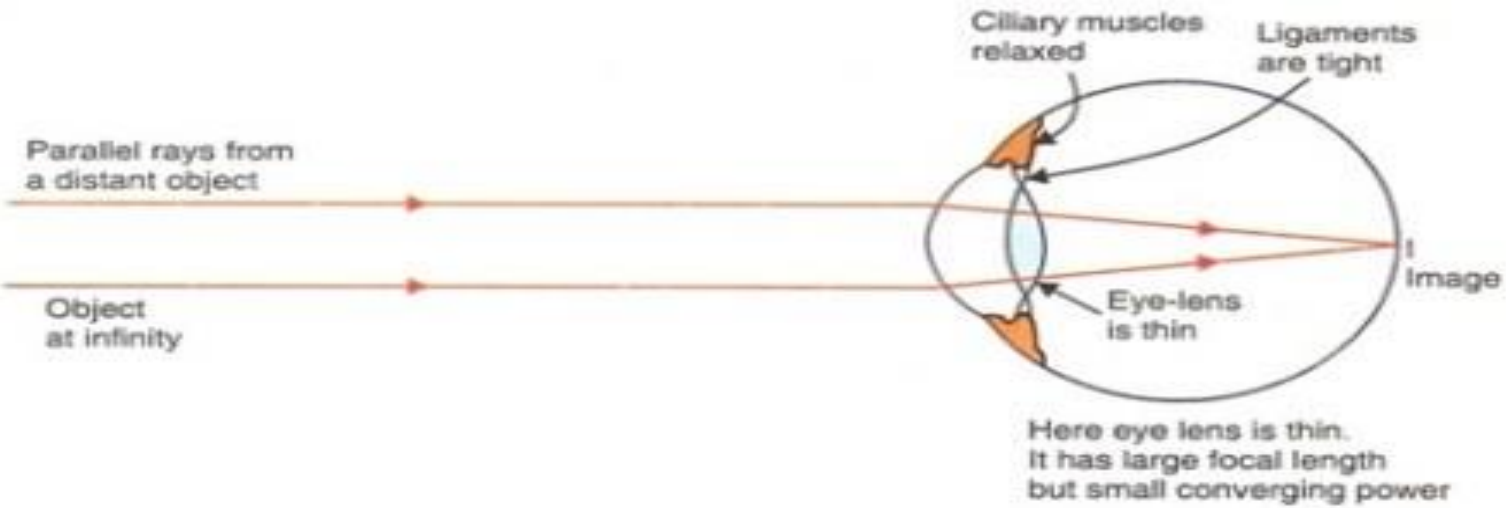
- Vitreous humor : The space between eye lens and retina is filled with another liquid called vitreous humor.

- least distance of distinct vision = D = 25 cm.

- The impression (or sensation) of the object remains on the retina for about (1/16)th of a second, This continuance of the sensation of eye is called the persistence of vision.

$\frac{1}{16}$ of a sec

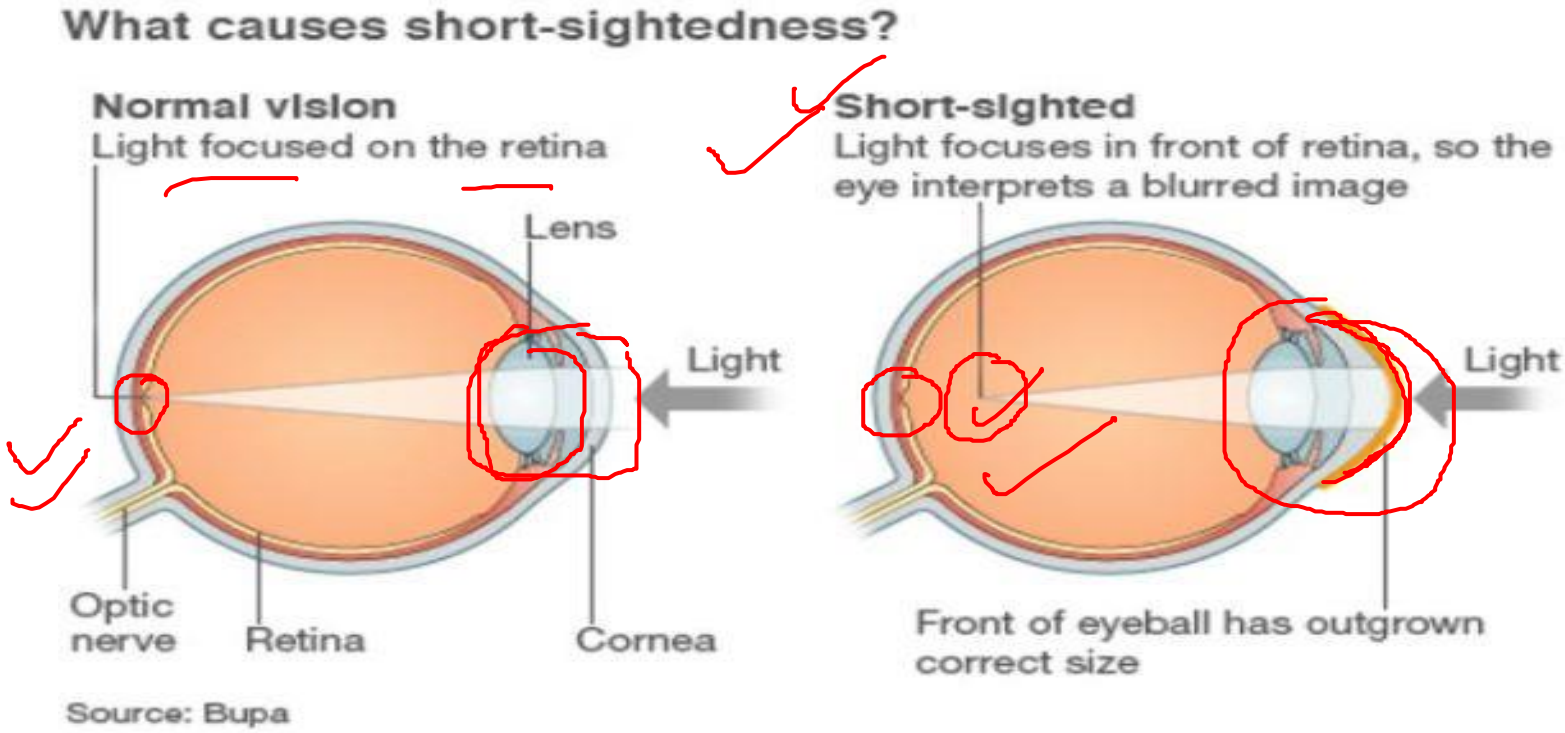
- The rod- shaped cells responds to the intensity of light with different of brightness and darkness were as the cone shaped cells respond to colour



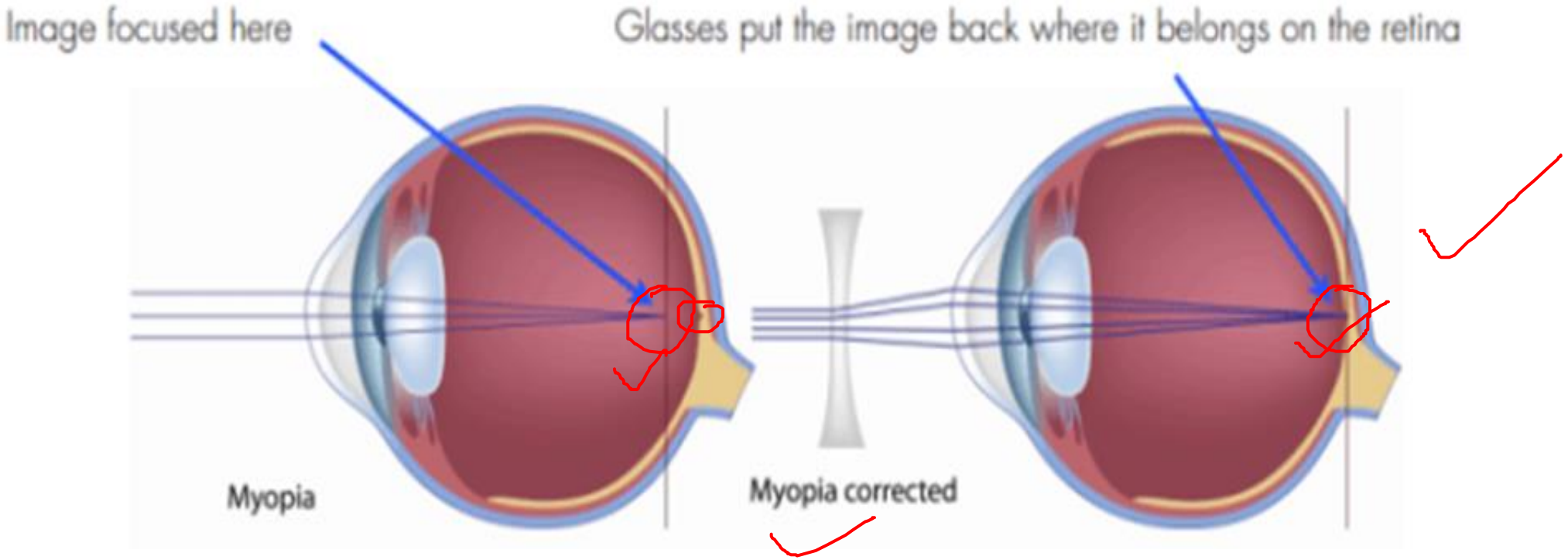
An eye focused on a distant object (at infinity).

Short Sightedness (or Myopia):

- This defect occurs if a person's eyeball is larger that the usual diameter.
-



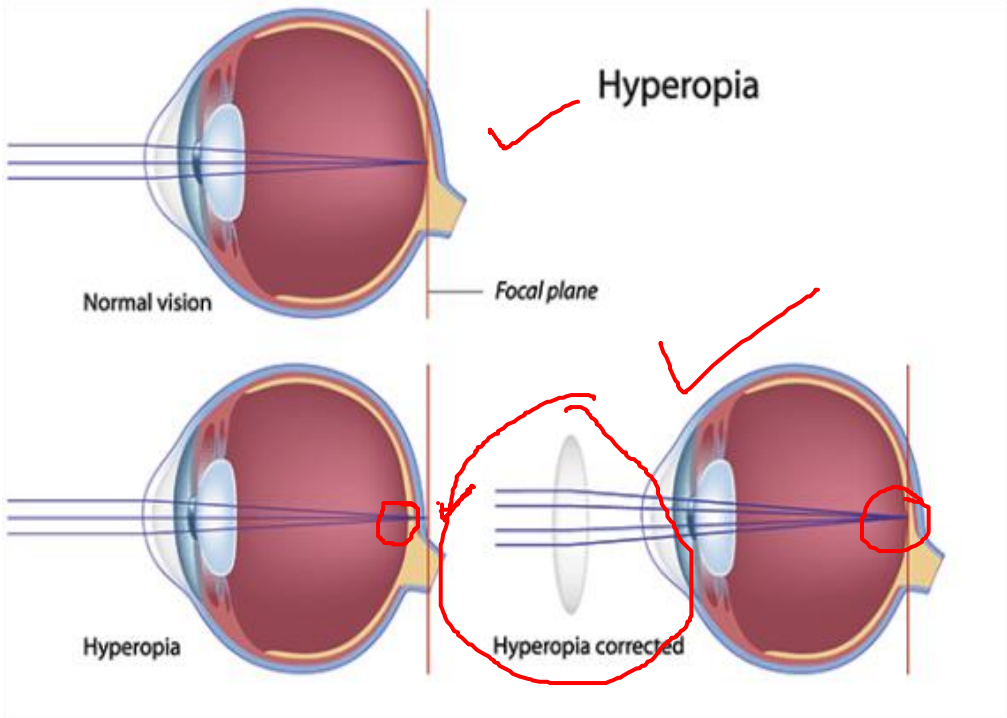
- To correct short-sighted vision, a diverging lens (concave lens) of suitable focal length is place din front of the eyes.



Far Sightedness (or Hyperopia or Hypermetropia)

- This defect may occur if the diameter of person's eyeball is smaller than the usual or if the lens of the eye is unable to curve when ciliary muscle contract.

- A farsighted person has the normal far point but needs a converging lens in order to focus objects which are as close as 25 cm.



Prsbyopia

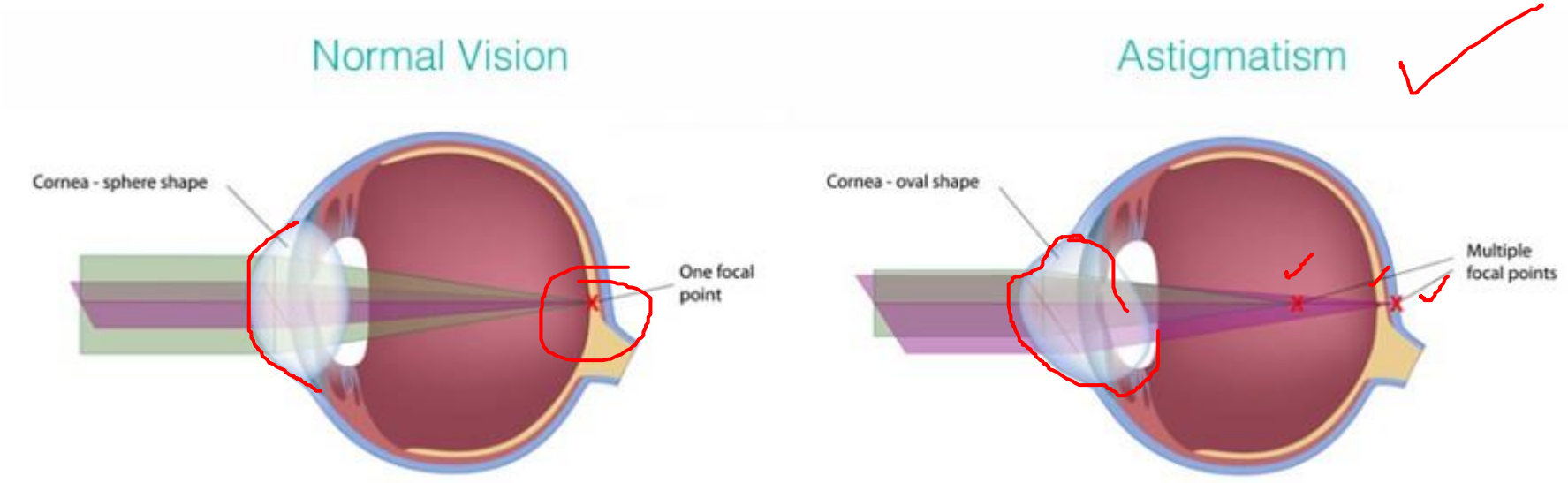
- This defect arises with aging. A person suffering from this defect can see neither nearby objects nor distant objects clearly/distinctly.

- This defect can be corrected by using bi-focal lenses.

Astigmatism

- A person suffering from this defect cannot simultaneously focus on both horizontal and vertical lines of wire gauze.

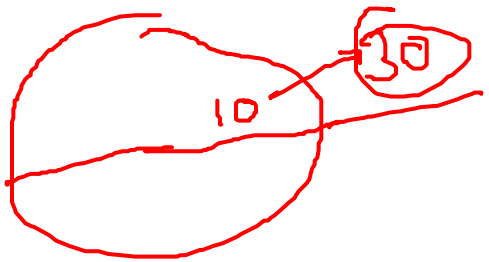
- This defect can be corrected by using cylindrical lenses.



- **f-Number for a Camera:** The f-number represent the size of the aperture.

f-number =Focal length of the lens (F) / Diameter of the lens(d)

Generally 2, 2.8, 4, 5.6, 8, 11, 22, 32 are f-numbers.



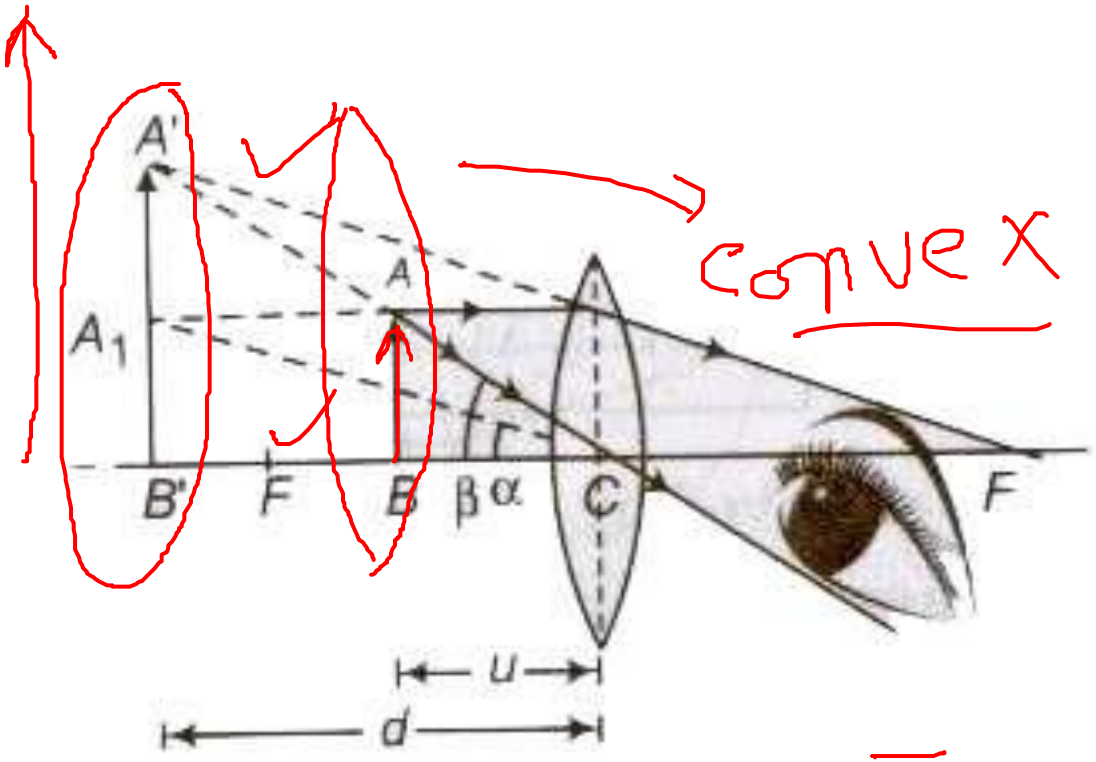
- **Simple Microscope** It is used for observing magnified images of objects. It is consists of a converging lens of small focal length.

- **Magnifying Power**

(i) When final image is formed at least distance of distinct vision (D), then M=1+d/f where, f= focal length of the lens.

(ii) When final image is formed at infinity,

then M = D/f



Scattering of Light

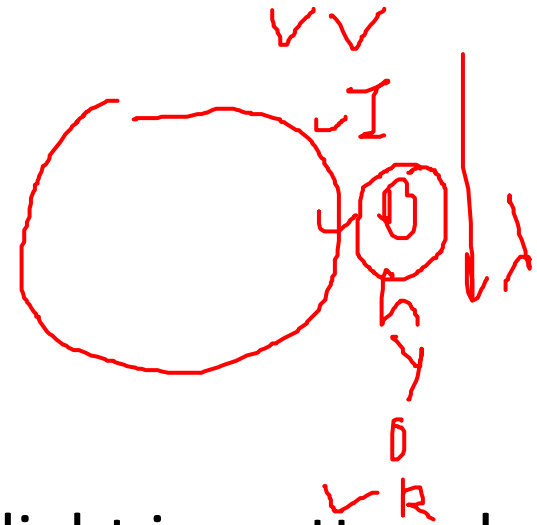
- When light passes through a medium in which particles are suspended whose size is of the order of wavelength of light, then light on striking these particles, deviated in different directions. These phenomena is called scattering of light.

- According to the Lord Rayleigh, the intensity of scattered light

$I \propto 1/\lambda^4$

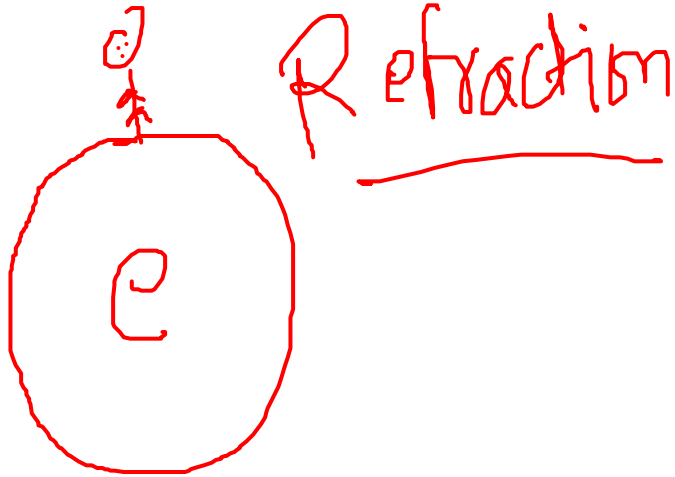
$I \propto 1/\lambda^4$

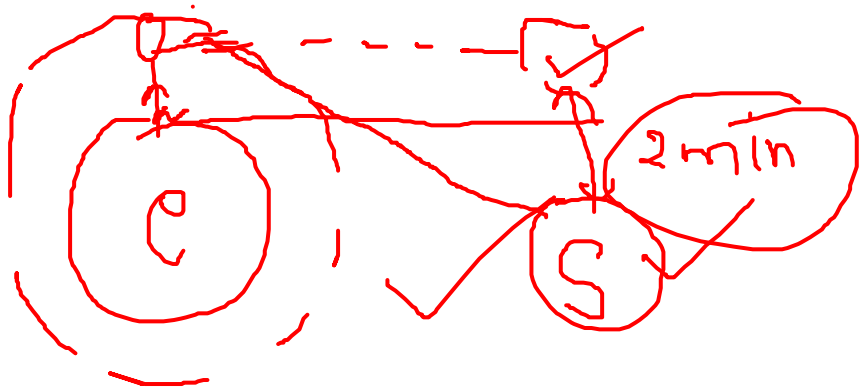
$\frac{I_1}{I_2} = \frac{\lambda_2^4}{\lambda_1^4}$



- Therefore, red color of light is scattered least and violet color of light is scattered most.

- **Daily Life Examples of Scattering of Light**
- 1. Blue color of sky.
- 2. Red color of signals of danger.
-
- 3. Black color of sky in the absence of atmosphere
- 4. Red color of the time of sun rise and sun set.
- 5. The human eye is most senstive to yellow color.

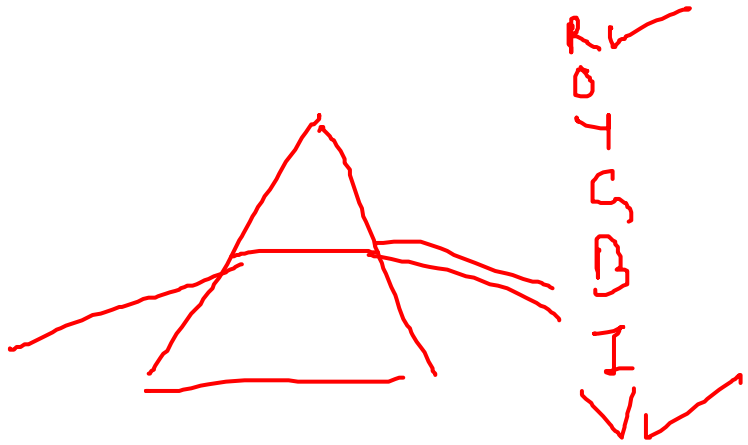




- The focal length of eye lens controlled by-

(A) Iris
(B) Cornea
(C) Ciliary muscles
(D) Optic nerve

- A white lights falls on a glass prism, the least deviated colour is –
  (A) Violet
  (B) Orange
  (C) Red
  (D) Yellow



- Blue colour of sky is due to –
  (A) dispersion of light
  (B) scattering of light
  (C) refraction of light
  (D) reflection of light

- Rainbow is formed due to –
  (A) reflection and dispersion of light through a water droplet
  (B) Total internal reflection, refraction and dispersion of light through a water droplet
  (C) only dispersion of light
  (D) only refraction of light

- Power of accommodation (max. variation in power of eye lens) of a normal eye is about –
  (A) 1D
  (B) 2D
  (C) 3D
  (D) 4D

- Dispersion of light by a prism is due to the change in –
  (A) frequency of light
  (B) speed of light
  (C) scattering
  (D) none of these

{Refractive Index}

- Least distance of distinct vision of a long-sighted man is 40 cm. He wish to reduce it to 25 cm by using a lens, the focal length of the lens is –
  (A) + 200/3 cm
  (B) – 200/3 cm
  (C)+200cm
  (D)–200cm

$\frac{1}{v} \quad \frac{1}{u} \quad \frac{1}{f}$

- Which of the following colour has the least wave length ?
  (A) red
  (B) orange
  (C) violet ✓
  (D) Blue

- Convex lens of suitable focal length can correct –
  (A) short sightedness
  (B) long sightedness ✓
  (C) presbyopia
  (D) astigmatism

WAVE OPTICS

• Huygen's Wave Theory

Light

- Light travel in a medium in the form of wavefront.

- Amplitude (A) is inversely proportional to distance (x) i.g., $A \propto 1/x$.
- ∴ Intensity (I) ∝ (Amplitude)2.

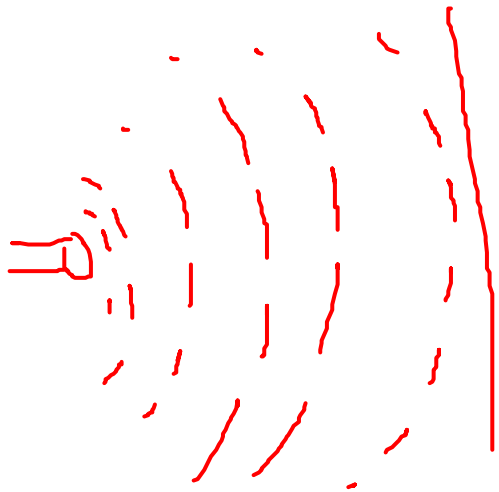
$$\frac{I_1}{I_2} = \left(\frac{A_1}{A_2}\right)^2$$

$I_1 =$

$I_2 =$

$A_1 = 2$

$A_2 = ?$



• Maxwell's Electromagnetic Wave Theory

- (i) Light waves are electromagnetic waves which do not require a material medium for their propagation.
- (ii) Due to transverse nature, light wave undergo polarisation.
- (iii) The velocity of electromagnetic wave in vacuum is $c = 1 / \sqrt{\mu_o \varepsilon_o}$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \text{ m/s}$$

•Polarisation

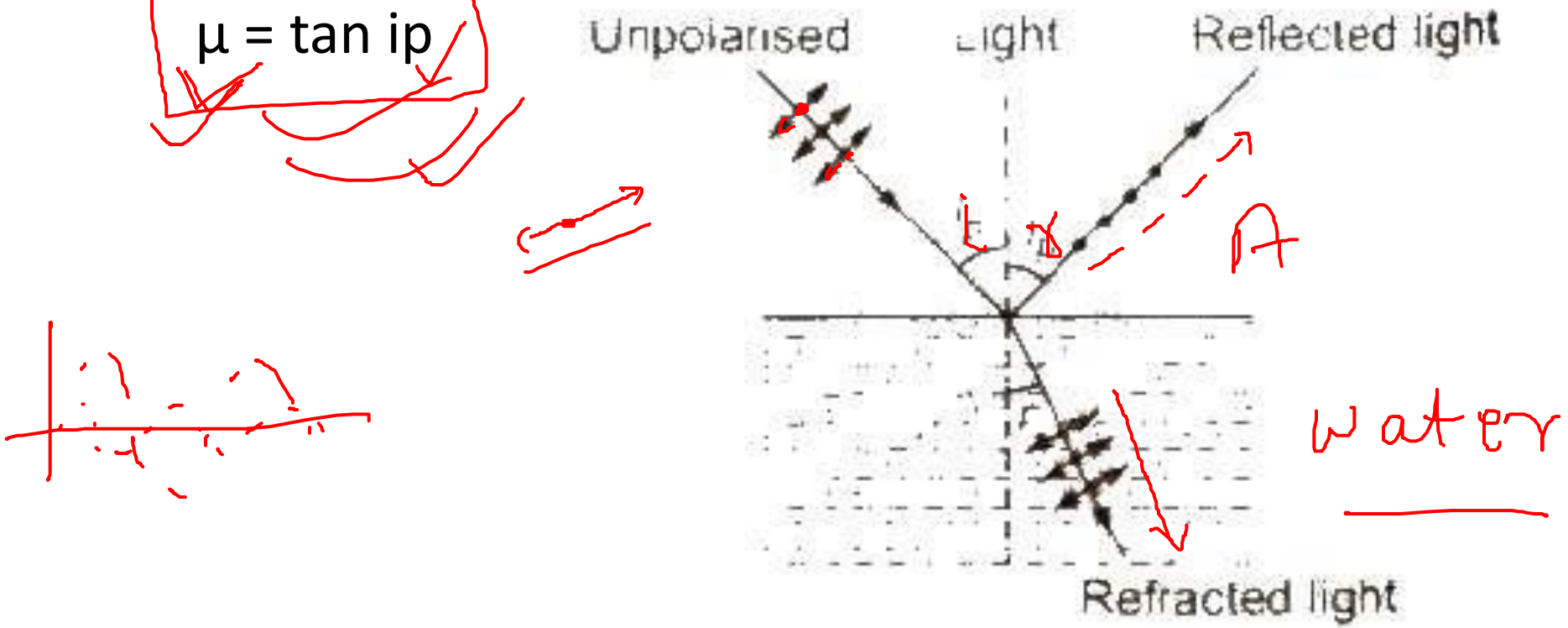
- The phenomena of restructuring of electric vectors of light into a single direction is called **polarisation.**

• Brewster's Law

Imp

- When unpolarised light is incident at an angle of polarisation (ip) on the interface separating air
- from a medium of refractive index μ, then reflected light becomes fully polarised, provided

$$\mu = \tan i_p$$



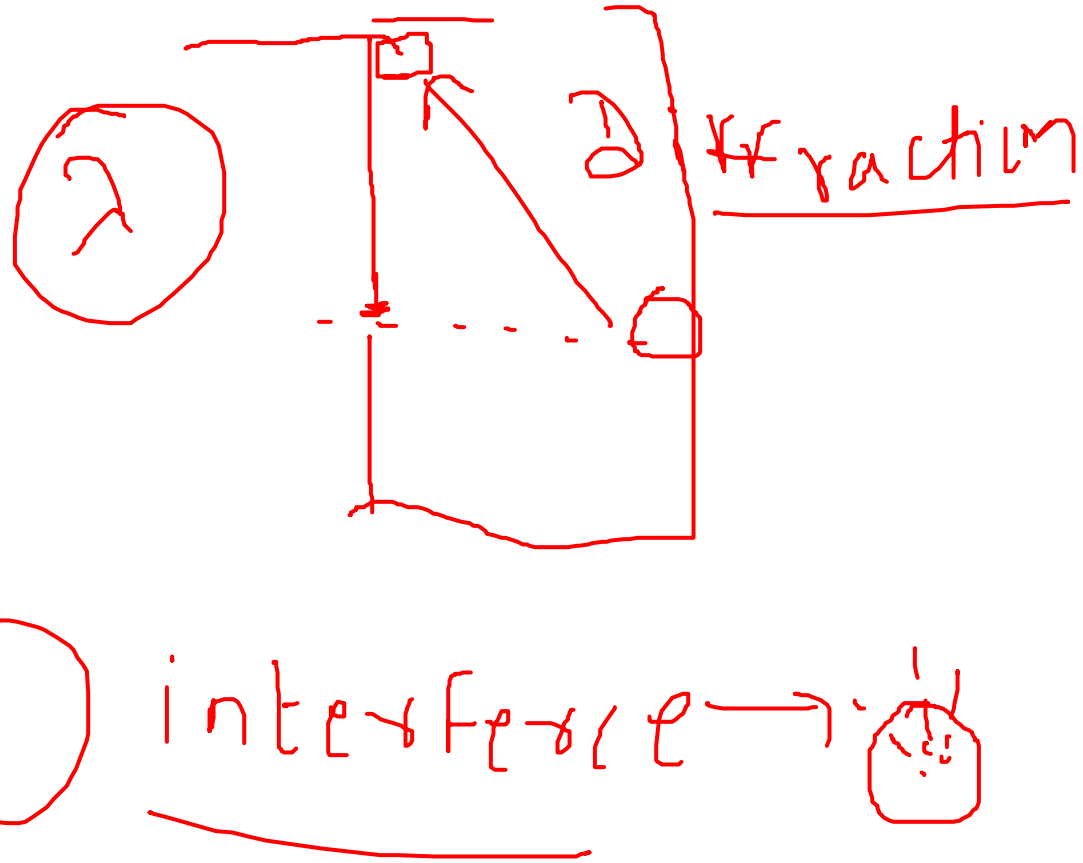
- **Uses of Polaroid**
- (i) Polaroids are used in sun glasses. They protect the eyes from glare.

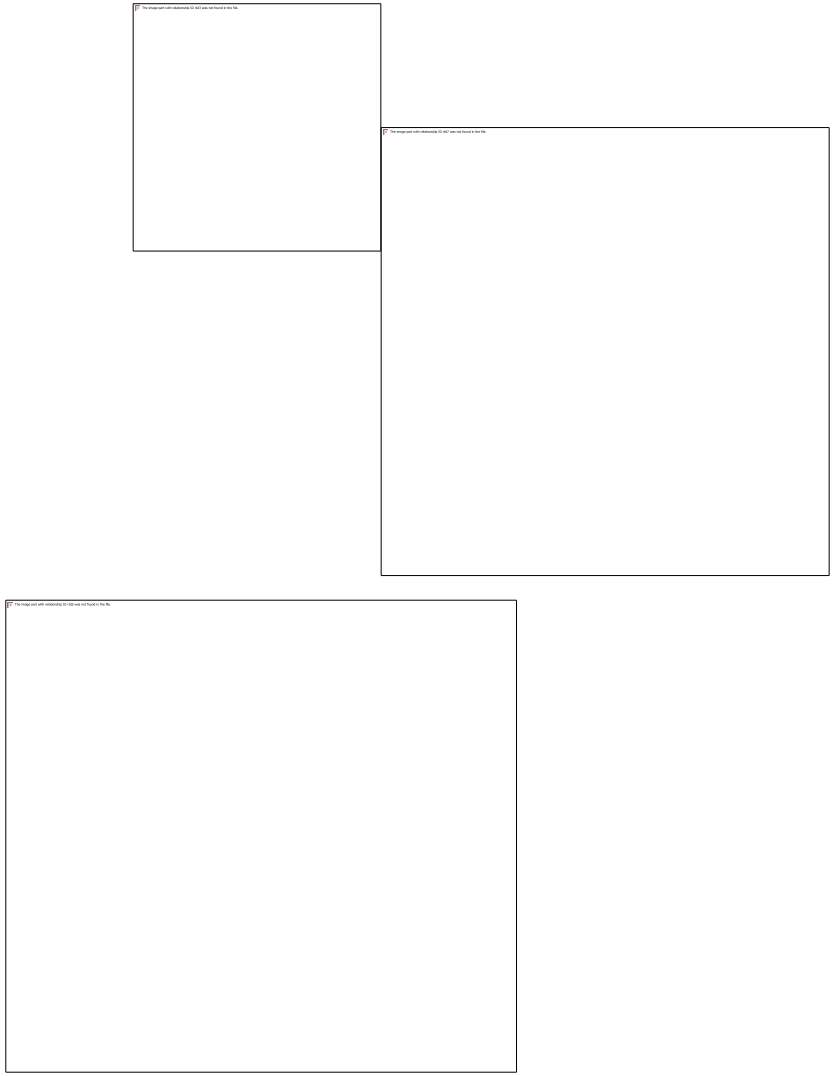
- (ii) The polaroids are used in window panes of a train and especially of an aeroplane. They help to control the light entering through the window.

- (iii) The pictures taken by a stereoscopic camera. When seen with the help of polarized spectacles, create three dimensional effect.

- (iv) The windshield of an automobile is made of polaroid. Such a mind shield protects the eyes of the driver of the automobile from the dazzling light of the approaching vehicles.

- **Examples and applications of diffraction:**
- CD reflecting rainbow colours: So almost all of you have seen a rainbow formation on rainy days. ...
- Holograms: ...
- Sun appears red during sunset: ...
- From **the** shadow of an object: ...
- Bending of light at **the** corners of **the** door: ...
- Spectrometer: ...
- X-ray **diffraction**: ...
- To separate white light:





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