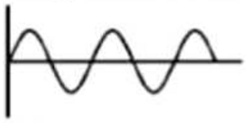
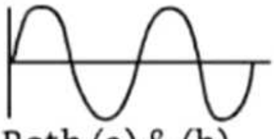
(a) (i) & (iii)
(b) only (iii)
(c) (i), (ii) & (iii)
(d) (i) & (ii)

35. Which of the following are true about speed of sound?
   (i) Sound propagates through a medium at a finite speed.
   (ii) The speed of sound decreases when we go from solid to gaseous state.
   (iii) Speed of sound increases with increase in temp.
   (a) only (i)
   (b) (i) & (iii)
   (c) (i), (ii) & (iii)
   (d) (i) & (ii)

36. Select the odd one out
   (a) S.I. Unit is hertz (Hz)
   (b) Frequency = 1 / Time Period
   (c) Objects vibrating at different frequencies produce same pitch
   (d) Higher the frequency, higher is the pitch

37. Identify the sound wave with low frequency/low pitch.
   (a) 
   (b) 
   (c) Both (a) & (b)
   (d) None of the above

38. Identify the louder sound.
   (a) 
   (b) 
   (c) Both (a) & (b)
   (d) None

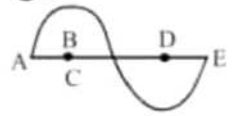
39. A key of a mechanical piano struck gently and then struck again but much harder this time. In the second case
   (a) sound will be louder but pitch will not be different

(b) sound will be louder and pitch will also be higher
(c) sound will be louder but pitch will be lower
(d) both loudness and pitch will remain unaffected

40. Objects of different sizes and conditions vibrate at different
(a) Frequencies to produce sounds of different pitch
(b) Frequencies to produce sound of same pitch
(c) Time intervals
(d) Energy levels

41. When we change feeble sound to loud sound we increase its
(a) frequency
(b) amplitude
(c) velocity
(d) wavelength

42. In the curve (Fig.) half the wavelength is



(a) A B
(b) B D
(c) D E
(d) A E

43. Earthquake produces which kind of sound before the main shock wave begins
(a) ultrasound
(b) infrasound
(c) audible sound
(d) None of the above

44. Before playing the orchestra in a musical concert, a sitarist tries to adjust the tension and pluck the string suitably. By doing so, he is adjusting
(a) intensity of sound only
(b) amplitude of sound only
(c) frequency of the sitar string with the frequency of other musical instruments
(d) loudness of sound

45. Loud and soft sound can have the same
(a) amplitude
(b) frequency

(c) wavelength
(d) None of these

46. The amount of sound energy passing each second through a unit area is called
(a) Loudness or Intensity of sound
(b) Amplitude of sound
(c) Pitch of the sound
(d) Frequency of sound

47. Speed of sound
(a) Decreases when we go from solid to gaseous state
(b) Increases with increase in temperature
(c) Depends upon properties of the medium through which it travels
(d) All these statements are correct

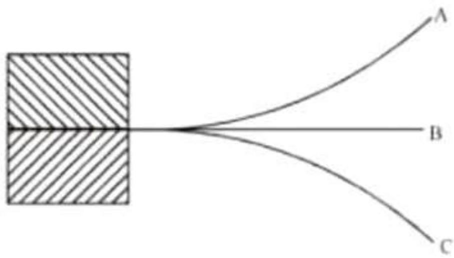
48. The frequency of a source of sound is 100 Hz. How many times does it vibrate in a minute ?
(a) 6000
(b) 2000
(c) 5500
(d) 4500

49. Sound waves have the following frequencies that are audible to human beings –
(a) 5 c/s
(b) 27000 c/s
(c) 5000 c/s
(d) 50,000 c/s

50. A big explosion on the moon cannot be heard on the earth because –
(a) The explosion produces high frequency sound waves which are inaudible
(b) Sound waves required a material medium for propagation
(c) Sound wave are absorbed in the moon's atmosphere
(d) Sound waves are absorbed in the earth's atmosphere

51. Figure shown is of a metal blade fixed at one end. B is the mean position, while A and C are the extreme positions of the blade when it is vibrated. If the frequency of the note produced by the blade is 640 Hz and the velocity of sound in

hair is 320 m/s calculate the wavelength of the sound waves produced.



(a) 0.5 m
(b) 2 m
(c) 1 m
(d) 4 m

52. A person has the audible range from 20 Hz to 20 $\times 10^3$ Hz. Find the wavelength range corresponding to these frequencies. Take velocity sound as 340 m/s.
(a) 15×10^{-3} m
(b) 11×10^{-3} m
(c) 17×10^{-3} m
(d) 15×10^{-8} m

53. How fast will a wave travel in air at a temperature of 15°C?
(a) 220 m/s
(b) 340 m/s
(c) 100 m/s
(d) 150 m/s

54. A wave on a string has a frequency of 440 Hz and a wavelength of 1.3m. How fast does the wave travel ?
(a) 270 m/s
(b) 470 m/s
(c) 520 m/s
(d) 570 m/s

55. The distance between two consecutive crests in a wave train produced in a string is 5 cm. If 2 complete waves pass through any point per second, the velocity of the wave is–
(a) 10 cm/sec
(b) 2.5 cm/sec
(c) 5 cm/sec
(d) 15 cm/sec

56. The frequency of a rod is 200 Hz. If the velocity of sound in air is 340 m/s, the wavelength of the sound produced is –
(a) 1.7 cm
(b) 6.8 cm
(c) 1.7 m
(d) 6.8 m

57. Speed of sound at constant temperature depends on –
(a) pressure
(b) density of gas
(c) both (a) & (b)
(d) None of the above

58. The waves in which the particles of the medium vibrate in a direction perpendicular to the direction of wave motion is known as –
(a) Transverse wave
(b) Longitudinal waves
(c) Propagated waves
(d) None of these

59. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 m/s and in air is 300 m/s. The freqency of sound recorded by an observer who is standing in air is –
(a) 200 Hz
(b) 3000 Hz
(c) 120 Hz
(d) 600 Hz

60. A thunder clap is heard 5.5 second after the lightening flash. The distance of the flash is –
(velocity of sound in air = 330m/s)
(a) 1780 m
(b) 1815 m
(c) 300 m
(d) 3560 m

61. A source produces 50 crests and 50 troughs in 0.5 seconds. What is the frequency of the wave ?
(a) 100 Hz
(b) 150 Hz
(c) 50 Hz
(d) 125 Hz

Hints & SOLUTIONS

1. (d)
2. (c)
3. (c)
4. (d) Sound needs a medium to travel. It cannot travel through vacuum.
5. (a)
6. (c)
7. (a)
8. (a) A particle of the medium in contact with the vibrating object is first displaced from its equilibrium position. It exerts a force on the adjacent particle and displaces it from rest. After displacing the adjacent particle the first particle comes back to its original position.
9. (b)
10. (a)
11. (c)
12. (b) When a vibrating object moves forward, it pushes and compresses the air in front of it creating a region of high pressure called compression.
13. (c)
14. (d)
15. (b)
16. (a) When the vibrating object moves backwards, it creates a region of low pressure called rarefaction.
17. (a)
18. (b)
19. (d)
20. (d) Pressure in the compression or rarefaction is related to the number of particles of the medium in a given volume or the density of particles in the medium.
21. (c)
22. (a)
23. (a)
24. (d) Sound is a mechanical wave or a longitudinal wave.
25. (b)
26. (d)
27. (a)
28. (d) Sound can be characterized by its frequency, amplitude and speed.

29. (c)
30. (d)
31. (a)
32. (d) Valleys represent the rarefactions in density-distance graphs.
33. (c)
34. (d)
35. (c)
36. (c) Objects vibrating at different frequencies produce sounds of different pitch.
37. (a)
38. (b)
39. (a)
40. (a) Objects of different sizes and conditions vibrate at different frequencies to produce sounds of different pitch.
41. (b)
42. (b)
43. (b)
44. (c)
45. (b) Loud and soft sound can have the same frequency, if the sound wave has traveled a large distance.
46. (a) The amount of sound energy passing each second through a unit area is called its loudness or intensity.
47. (d) Speed of sound decreases when we go from solid to gaseous state and increases with increase in temperature. It also depends upon properties of the medium through which it travels.
48. (a) Frequency of source of sound, N = 100 Hz

    Time interval, t = 1 minute = 60s

    Number of vibrations in 1 minute, n = ?

    From relation,

    Number of vibrations = vibrations per second × time

    i.e., n = Vt,

    Putting values, we get,

    n = 100 × 60

    Number of vibrations = 100 × 60 = 6000
49. (c) Audiable range of frequency is 20 Hz to 20000 kHz

50. **(b)** Sound waves required a material medium for propagation.

51. **(a)** $V = f \times \lambda$

Wavelength, $\lambda = \frac{V}{f}$ $\lambda = \frac{320}{640} = 0.5\ \text{m}$

52. **(c)** $\nu_1 = 20\ \text{Hz}$, Velocity = 340 m/s, $\lambda_1 = ?$ and $\lambda_2 = ?$

$V = n\lambda$ or $\lambda = \frac{V}{\nu}$

Substituting the given values, we have

$$\lambda_1 = \frac{340\ (\text{m/s})}{20\ (\text{s}^{-1})} = 17\text{m} \qquad (\because\ 1\ \text{Hz} = 1\ \text{s}^{-1})$$

$$\lambda_2 = \frac{V}{\nu_2} = \frac{340\ (\text{m/s})}{3 \times 10^3 (\text{s}^{-1})} = 17 \times 10^{-3}\ \text{m}$$

53. **(b)** $v_{air} = 331\frac{\text{m}}{\text{s}} + \left(0.6\frac{\text{m}}{\text{s}}\right)(15)$

$v_{air} = 340\ \text{m/s}$

54. **(d)** $v = \lambda f = (1.3\text{m})(440\ \text{Hz}) = 570\ \text{m/s}$

55. **(a)** $v = n\lambda = 2 \times 5 = 10\ \text{cm/sec}$

56. **(c)** $\lambda = \frac{v}{n} = \frac{340}{200} = 1.7\text{m}$

57. **(d)** Speed of sound, doesn't depend on pressure and density of medium.

58. **(a)** In transverse waves medium particles vibrate perpendicular to the direction of propagation of wave.

59. **(d)** Frequency of sound does not change with medium, because it is characteristics of source.

60. **(b)** The lightening flash travels with speed of light which takes negligible time to reach the observer, while sound has finite velocity 330 m/s, it takes time 5.5 seconds.

Distance = velocity of sound × time

$= 330 \times 5.5 = 1815\ \text{m}$

61. **(a)** One crest and the immediate next trough constitute one wave and distance between them = λ.

Frequency ν is the number of waves produced by the source.

Here, the source produces 50 waves in 0.5s.

Therefore, the number of waves produced by the source in one second = $\frac{50}{0.5\text{s}} = 100\text{s}^{-1}$ or $\nu = 100\ \text{Hz}$

Chapter 5

Light-Its Phenomena and Human Eye

LIGHT

- Light may be defined as the radiant energy which produces in us the sensation of sight. Light itself is invisible but makes other objects visible.

Properties of Light

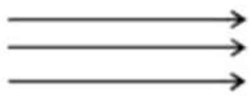
1. Light is a form of energy which does not require any medium to travel.
2. Light can travel in all the 3 media, viz, solid, liquid and gas.
3. Light travels fastest in vacuum. It's speed is 3×10^8 m/sec.
4. The wavelength of light (visible light) is 400 nm to 700 nm.
5. Light consists of small packets of energy called photons.

- **Ray of Light :** A line drawn in the direction of propagation of light is called a ray of light.

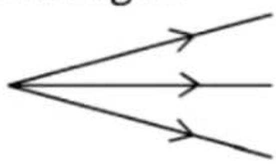
Beam of Light

A group of rays of light emitted by a source of light is called a beam of light. A light beam is of three types.

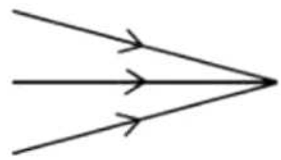
(i) **Parallel beam :-** A group of light rays parallel to each other is known as parallel beam of light



(ii) **Divergent beam :-** A group of light rays spreading out from a source of light is called divergent beam of light.



(iii) **Convergent beam :-** A group of light rays meeting at a point is called convergent beam of light.

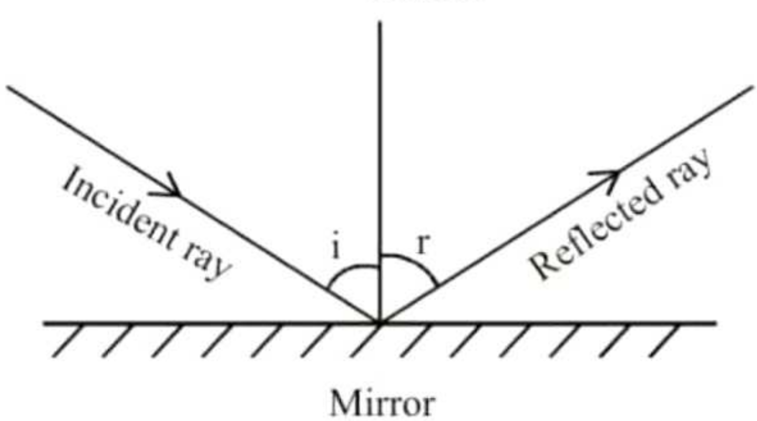


REFLECTION OF LIGHT

There are some surfaces which have ability to send the light back in the same medium when light strikes it. This phenomena of sending the light back in the same medium by a surface is called **reflection of light**.

Laws of Reflection

1. The incident ray, the reflected ray and the normal at the point of incidence, all lie in a same plane.
2. The angle of incidence is always equal to the angle of reflection, $\angle i = \angle r$.



$\angle i$ = Angle of incidence

$\angle r$ = Angle of reflection

- Any smooth, highly polished reflecting surface is called a mirror. A plane mirror is a highly polished plane surface.
- The image formed by a plane mirror is erect and virtual. It is a laterally inverted image. The image formed is of the same size as that

of the object. Also, the image and the object are equidistant from the mirror.

- A spherical mirror is that mirror whose reflecting surface is the part of a hollow sphere of glass. In case of a concave mirror, the reflecting surface is inside while in a convex mirror, the reflecting surface bulges out.
- The centre of a spherical mirror is called its pole. The centre of the imaginary sphere to which the mirror belongs is called the centre of curvature. The centre of curvature of a concave mirror is in front of it but the centre of curvanture of a convex mirror is behind it.
- The radius of the imaginary sphere of which the mirror is a part is called the radius of curvature.
- The straight line passing through the pole and centre of curvature is called the principal axis.
- The principal focus of a spherical mirror is a point on the principal axis of the mirror.
- If r is radius of curvature of the mirror of focal length f, we can write

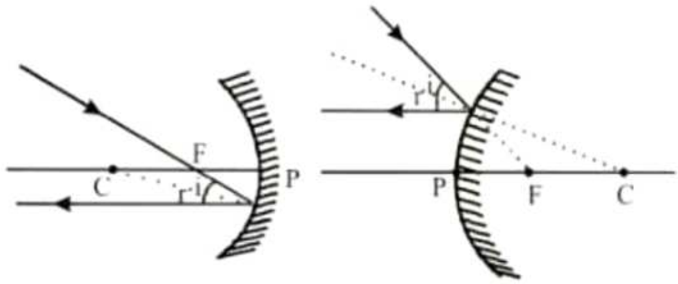
$$r = 2f$$

- Mirror formula is the relation between the focal length f of the mirror, the distance u of the object from the pole of the mirror, and the distance v of the image from the pole.

REPRESENTATION OF IMAGES FORMED BY SPHERICAL MIRRORS USING RAY DIAGRAMS

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

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



(iii) *A ray passing through the centre of curvature* of a concave mirror or directed in the direction of the centre of curvature of a convex mirror, after reflection, is reflected back along the same path.

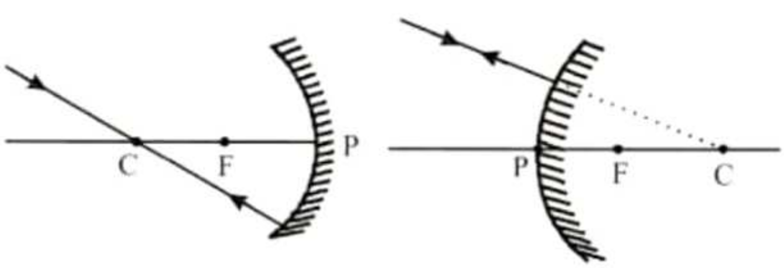


IMAGE FORMATION BY CONCAVE MIRRORS

(i) **Object is between C and F**

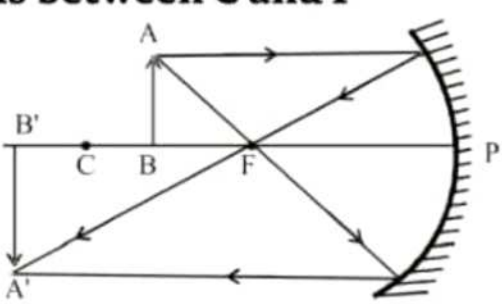


Image is real, inverted and beyond C.

(ii) Object is at F

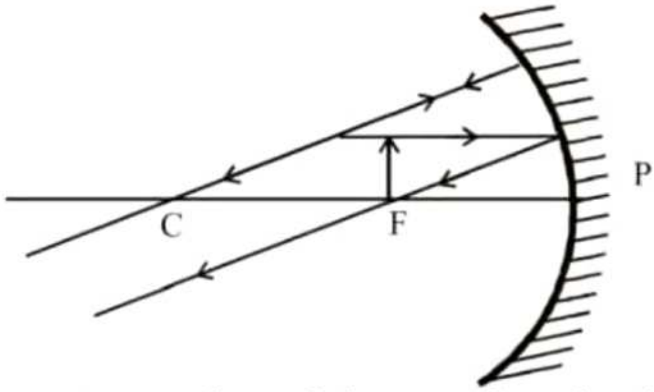


Image is real, inverted and at infinity.

(iii) Object is between F and P :

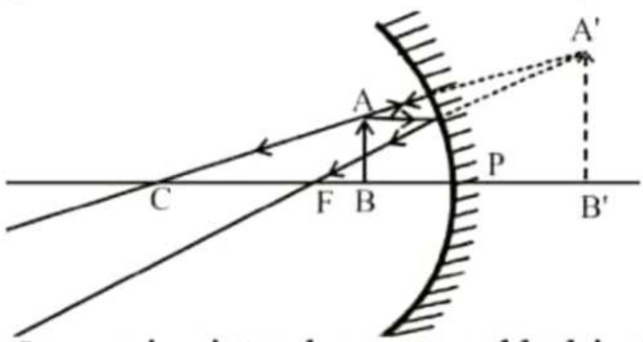
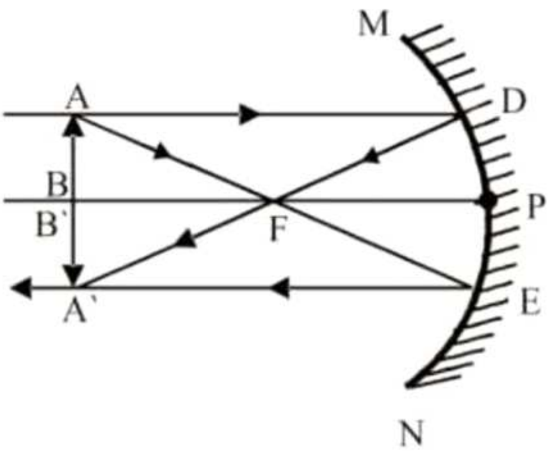


Image is virtual, erect and behind the mirror.

(iv) **Object is at C:**

Image is real, inverted and at C.



(v) **Object is at infinity :**

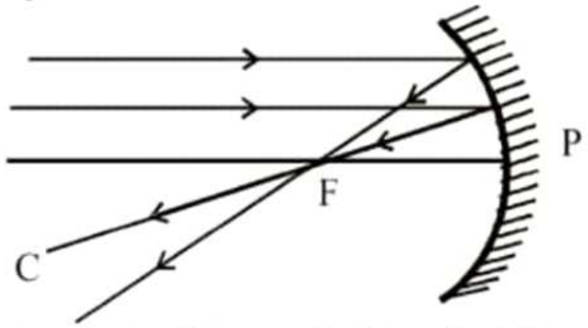


Image is real, inverted and at F.

(vi) **Beyond C**

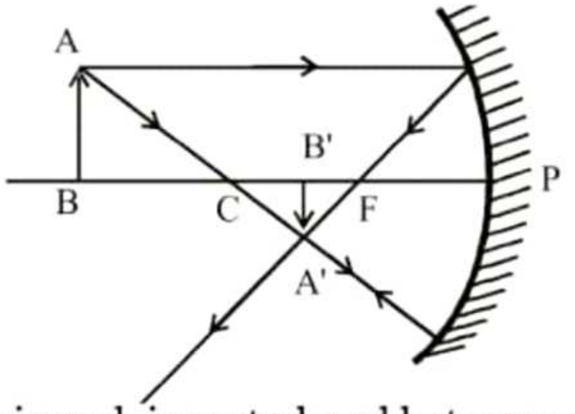


Image is real, inverted and between C & F.

Image Formation by a Concave Mirror for Different Positions of the Object

Position of object	Position of the image	Size of the image	Nature of the image
At infinity	At the focus F	Highly-diminished,point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At in finity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

Image Formation by a Convex Mirror for Different Positions of the Object

Position of the object	Position of the image	Size of the image	Nature of the image
Any where between pole (P)	Between P and F back of	Small	Virtual and erect
and in finity (∞)	the mirror	Very small in size	Virtual and erect
At in finity	At F		

IMAGE FORMATION BY CONVEX MIRRORS

(i) Object is any where between pole and infinity :

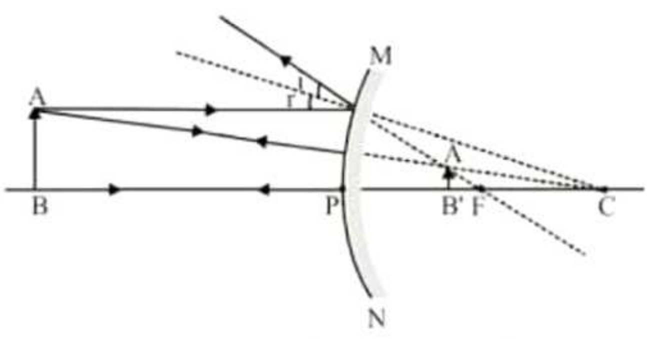


Image is formed between P and F which is virtual, erect and diminished.

(ii) **Object is at infinity :**

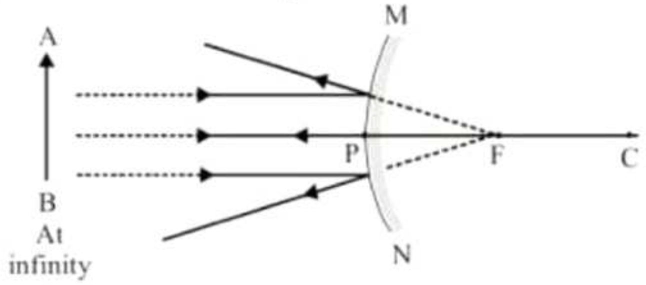


Image is formed at focus behind the mirror which is virtual, erect and highly diminished.

Uses of Concave Mirror

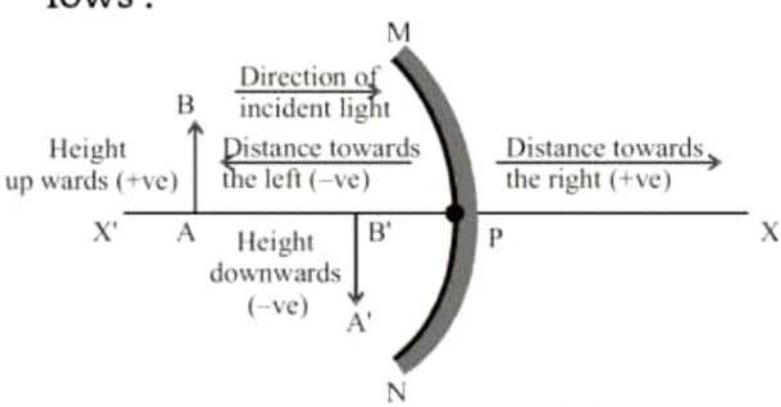
(i) It is used as a shaving mirror.
(ii) It is used in solar heating devices like solar cooker.
(iii) It is used as reflectors in headlights of vehicles, search light, torch, etc.
(iv) It is used by doctors to examine body parts by focusing the light over that part.

Uses of Convex Mirror

(i) It is used as rear view mirror in automobiles.
(ii) It is also used in street lights.

Sign Conventions

The new sign convention is described as follows :



1. All distances are measured from the pole.
2. All distances which are measured in the direction of incident ray are taken as positive.
3. All distances which are measured in the direction opposite to incident ray are taken as negative.
4. Upward direction which is perpendicular to principal axis is taken as positive and downward as negative.

Results :

1. Distance of object i.e., 'u' is always negative.
2. Focal length of concave mirror is always negative whereas focal lenght of convex mirror is always positive.

3. Size of object is always taken as positive.
4. If image is real, v is negative and if image is virtual, v is positive.

- **Mirror Formula :** It is a relation between distance of object, distance of image from the pole of the mirror and it's focal length, i.e., relation between 'u', 'v' and 'f '. It is given by

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

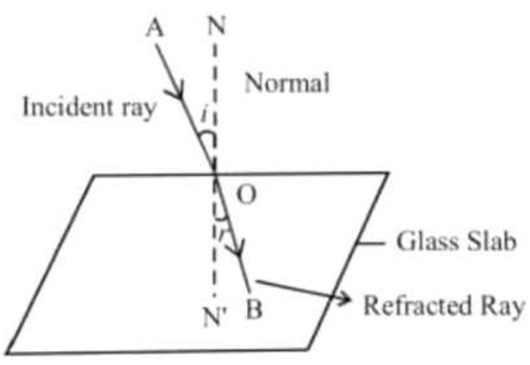
- **Magnification :** It is defined as the ratio of height of image to the height of the object. It is denoted by letter m.

$$m=\frac{\text{height of image (I)}}{\text{height of object (O)}}$$

m = + ve for virtual images
m = – ve for real images

REFRACTION OF LIGHT

The bending of ray of right when it passes from one medium to another is called refraction of light.



When a ray of light goes from an optically less dense medium to a more dense medium, it bends towards the normal. On the other hand, a ray of light going from an optically more dense medium to a less dense medium, will bend away from the normal.

Laws of Refraction

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

(ii) When a ray of light undergoes refraction then the ratio of sine of angle of incidence to the sine of angle of refraction is constant i.e., for two particular media, is always con- $\frac{\sin i}{\sin r}$ stant. This law is known as Snell's law. This constant is also known as refractive index of the second medium with respect to the first i.e., $\mu = \frac{\sin i}{\sin r}$

- If c is velocity of light in air or vacuum and v that in the medium, then

$$\mu = \frac{\text{Velocity of light in vacuum or air}}{\text{Velocity of light in the medium}} = \frac{c}{v}$$

The refractive index of a medium c with respect to a medium a, when the refractive index of medium b with respect to a and that of c with respect to b are given, can be found by the following relation :

$$^{a}\mu_{c} = {}^{a}\mu_{b} \times {}^{b}\mu_{c}$$

Critical Angle (c)

It is the angle of incidence in a denser medium corresponding to which the refracted ray just grazes the surface of separation (angle of refraction is 90°)

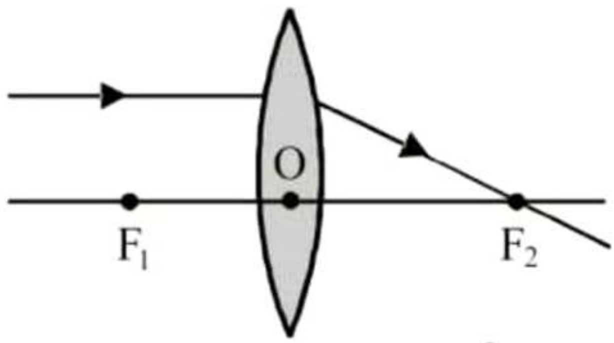
$$^{\text{denser}}\mu_{\text{rarer}} = \frac{\sin c}{\sin \pi/2} = \sin c \quad \text{or} \quad \mu = \frac{1}{\sin c}$$

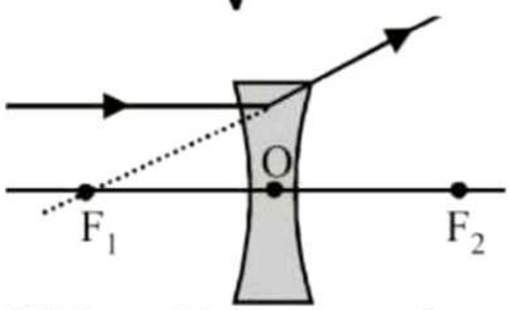
- A lens is a piece of transparaent glass which isn bounded by two spherical surfaces. A convex lens is thick at the centre but thinner at the edges.
- The lens formula or lens equation is given by

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

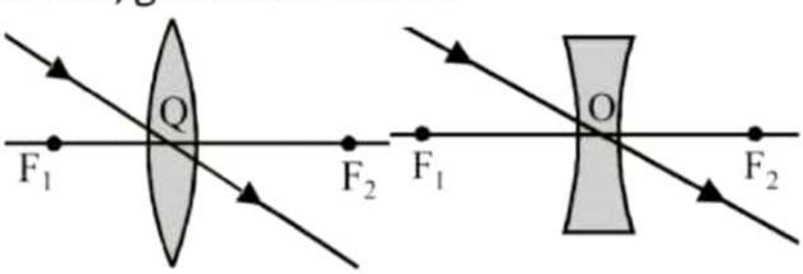
IMAGE FORMATION IN LENSES

(i) A ray of light which is parallel to principal axis, passes through focus after refraction in case of a convex lens or concave lens appears to diverge from the principal focus.





(ii) A ray of light which passes through optical centre, goes undeviated.



(iii) A ray of light which passes through focus or appears to meet at the principal focus becomes parallel to the principal axis after refraction.

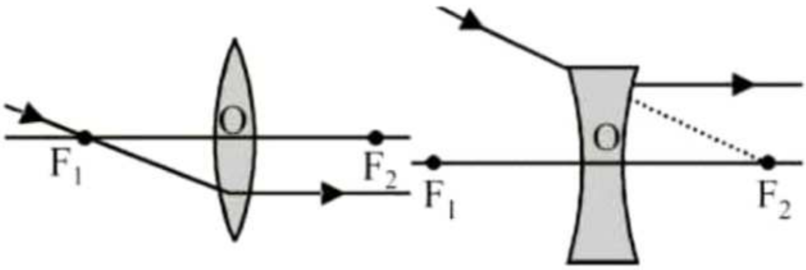
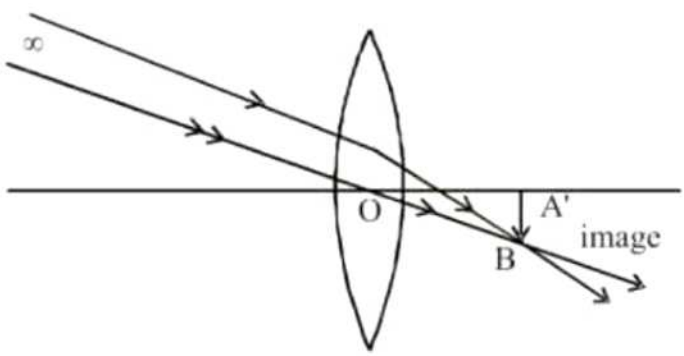


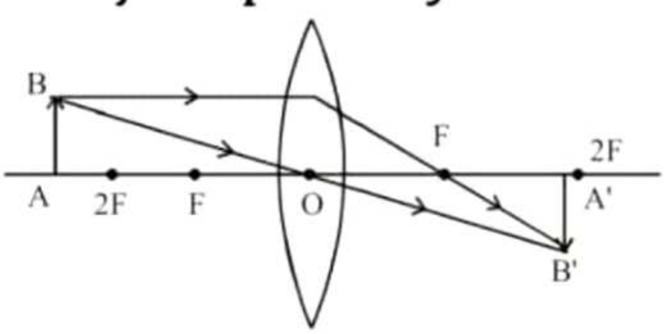
Image Formed By A Convex Lens

(i) **When object is placed at infinity :-**



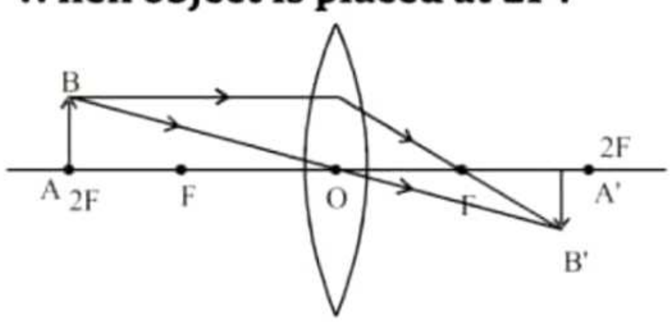
real, inverted, diminished at F

(ii) **When object is placed beyond 2F :-**



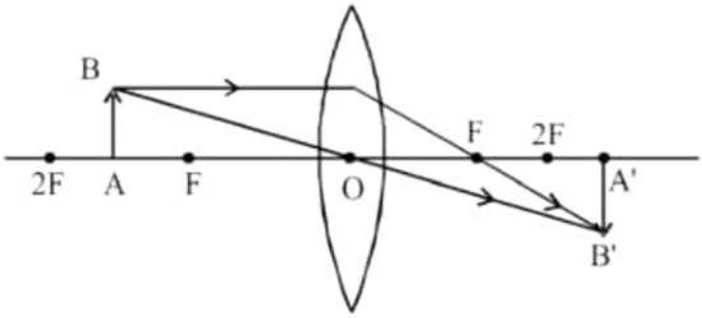
real, inverted diminished between F and 2F

(iii) **When object is placed at 2F :-**



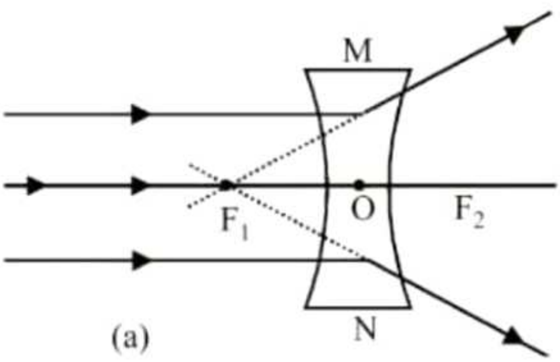
real, inverted, same size and at 2F

(iv) **When object is placed between F and 2F :-**

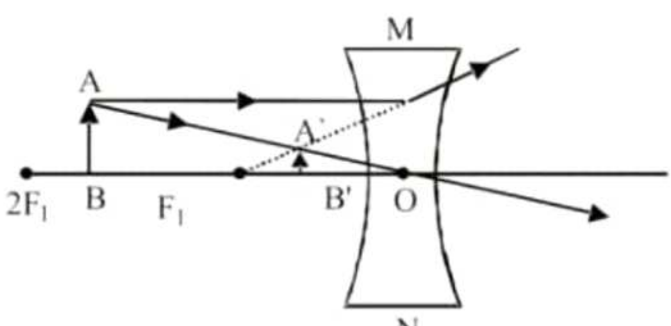


real, inverted, enlarged and beyond 2F

Image Formed by a Concave Lens



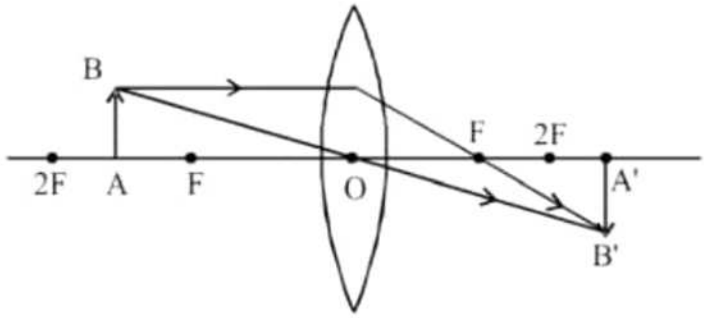
(a)



(b)

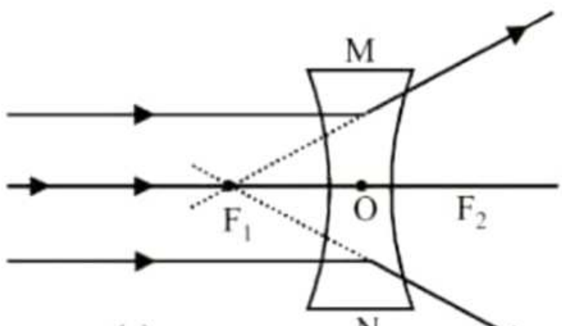
Nature, position and relative size of the image formed by a convex lens for various positions of the object

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_2	Highly-diminished,point-sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted

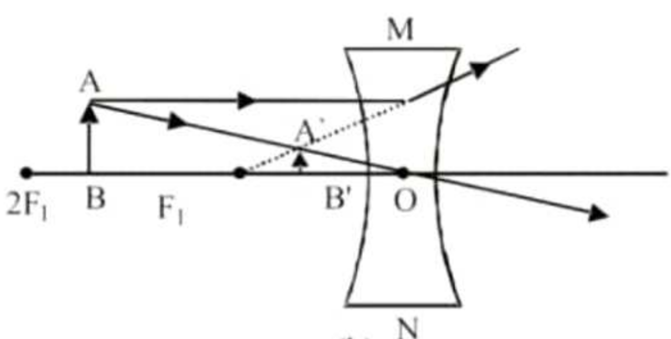


real, inverted, enlarged and beyond 2F

Image Formed by a Concave Lens



(a)



(b)

Nature, position and relative size of the image formed by a convex lens for various positions of the object

Position of the object	Position of the image	Relative size of the image	Nature of the image
At infinity	At focus F_2	Highly-diminished,point-sized	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted

At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At Focus F_1	At infinity	Infinitely large or highly enlarged	Real and inverted
Between F_1 and Optical centre O	On the same side of the lens as the object	Enlarged	Virtual and erect

- **Magnification** : Magnification, $m = \frac{h_2}{h_1}$ i.e.,

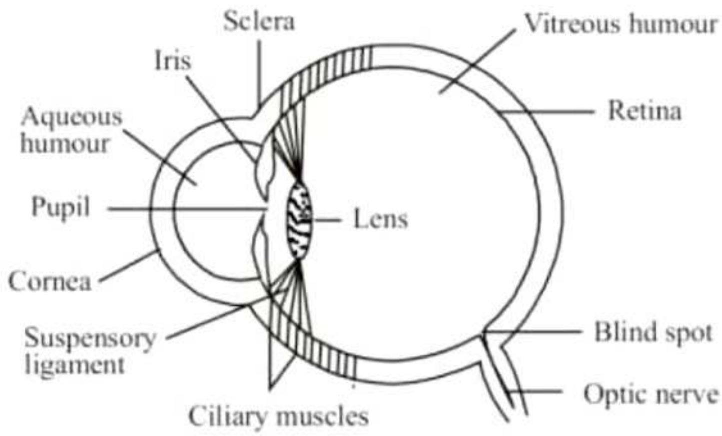
Ratio of height of image to the height of object.

It is also given by $\frac{v}{u}$ i.e., Ratio of distance of image to the distance of object.

- **Power of a lens** : The ability of lens to converge or diverge a beam of light is known as the **power of lens**. It is the degree of measure of converging or diverging ability of a lens. Power of lens is also defined as reciprocal of focal length i.e., P = 1/f where f is in metre. The SI unit of power of a lens is dioptre. It is denoted by *D*.

THE HUMAN EYE

It is a natural optical instrument which is used to see the objects by human beings. It is like a camera which has lens and screen system.



THE EYE

Working of Human Eye

When you look at an object, light rays from the object enter into the eye through cornea by aqueous humour which also acts as lens to refract maximum light. This light then passes through pupil which allows the required amount of light to pass through it. This light falls on eye lens which makes an image on retina. This is a real and inverted image. This image is sent to the brain through optical nerves in the form of electric signal and brain interpret the image into erect image.

Accomodation Power

The ability of eye to change the focal length of eye lens with the help of ciliary muscles to get the clear view of nearby objects (about 25 cm) and far distant objects (at infinity).

Near and Far Point of Human Eye

Near point is Minimum Distance at which objects seen most distinctly without strain. For a young adult normal vision, it is about 25cm. Far point is the maximum distance at which eye can see the things clearly. It is infintiy.

Persistence of Vision

Image formed at retina is not permanent. Its sensation remains on the retina for about 1/16th of a second even after removal of object. This continuance of sensation of the eye is called persistence of vision.

Colour Blindness

Some people do not possess some cone cells that respond to certain specific colours due to genetic disorder. The persons who can not distinguish between colours but can see the objects clearly are said to be colour blind.

Defects of Vision

Human eye with normal vision can accomodate for all distance from 25cm to infinity. Some times the eye of person gradually loses its power of accomodation. In such conditions he cannot see the objects clearly and comfortably. The vision becomes defective due to optical defects of eye.

(i) **Myopia (Short sightedness) :** It is a kind of defect in human eye due to which a person can see near objects clearly but he can not see the distant objects clearly. Myopia is due to

   (i) excessive curvature of cornea.

   (ii) elongation of eye ball.

   Due to these two reasons focal length of eye lens decreases and so the power increases so that image is formed in front of retina i.e., object is not visible properly.

   This defect can be corrected by using a diverging lens i.e., a concave lens.

(ii) **Hypermetropia (Long sightedness) :** It is a kind of defect in human eye due to which a person can see distant objects properly but cannot see the nearby objects clearly. It happens due to

(i) decrease in power of eye lens i.e., increase in focal length of eye lens.
(ii) shortening of eye ball.

Due to these two reasons, light rays coming from nearby objects get less converged and the image is formed behind the retina i.e., object is not visible properly.

This defect can be corrected by using a converging lens i.e., a convex lens due to which the converging power (combined) increases as the image is formed at retina.

(iii) **Presbyopia** : It is a kind of defect in human eye which occurs due to ageing. It happens due to

(i) decrease in flexibility of eye lens.
(ii) gradual weakening of cilliary muscles.

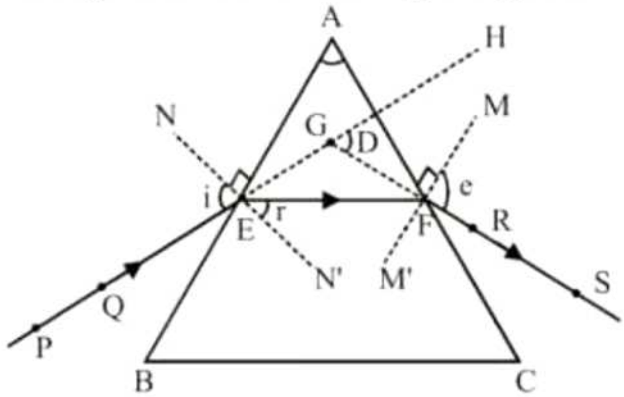
Due to this defect, the person cannot read comfortably and clearly without eye glasses. Sometime a person may suffer from both myopia and hypermetropia which is corrected by using bi-focal lens. The lower portion of these bio-focal lens is convex which is used for reading purpose and the upper portion is a concave lens which is used to see the far distant objects.

(iv) **Astigmatism:** It is a kind of defect in human eye due to which a person cannot see (focus) simultaneously horizonatal and vertical lines both. This defect occurs due to irregularities in surface of cornea which is not perfectly spherical. That's why it has different radii of curvature in different direction i.e., vertical and horizontal plane due to which if he tries to focus one plane (horizontal or vertical) the other becomes out of focus.

This defect can be corrected by using cylinderical lenses.

REFRACTION OF LIGHT THROUGH A PRISM

A glass prism is a transparent surface made up of glass. A triangular prism has two triangular bases and three rectangular lateral surfaces. The angle between its two lateral surfaces is called the angle of the prism. The refraction of light through a triangular prism can be studied with the help of the following diagram.



Here,

PE – Incident ray ∠i – Angle of incidence

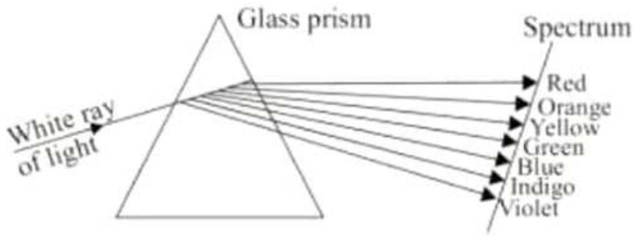
EF – Refracted ray ∠r – Angle of refraction

FS – Emergent ray ∠e – Angle of emergence

∠A – Angle of the prism ∠D – Angle of deviation

DISPERSION OF WHITE LIGHT BY A GLASS PRISM

The phenomenon of splitting of white light into its seven constituent colours when it passes through a glass prism is called dispersion of white light. The various colours seen are Violet, Indigo, Blue, Green, Yellow, Orange and Red. The sequence of colours remember as VIBGYOR.



The Rainbow

A rainbow is a spectrum of white light from the sun. This is a phenomenon due to combined effect of dispersion, refraction and reflection of sunlight by spherical water droplets of rain.

(i) **Primary rainbow:** It is formed due to two refractions and one total internal reflection of the light incident on the droplet. Sunlight is first refracted as it enters a raindrop which cause different colours of light to separate. The observer sees a rainbow with red colour on the top and violet on the bottom.

(ii) **Secondary rainbow:** It is formed due to two refractions and two total internal reflection of light incident on the water droplet. It is due to four - step process. The intensity of light is reduced at the second reflection and hence the secondary rainbow is fainter than the primary rainbow.

ATMOSPHERIC REFRACTION

The refraction of light caused by the earth's atmosphere (having air layers of varying optical densities) is called atmospheric refraction.

Twinkling of Stars

The twinkling of star is due to atmospheric refraction of star light. The light of star undergoes refraction when it enters in the earth's atmosphere. Because of the changing refractive index in the medium, the star light bends towards the normal so that the apparent position of the star is slightly different from its actual position. The star appears slightly higher than its actual position.

Advance Sunrise and Delayed Sunset

Actual sun rise happens when it is below the horizon in the morning. The rays of light from the sun below the horizon reach our eyes because of refraction of light. These rays appear to come from the apparent position of the sun which is above the horizon, hence we can see the sun for few minutes (2 min.) before actual sun rise. Similarly, the sun can be seen about 2 minutes after the actual sun set. Thus the duration of day time will increase by 4 minutes.

The molecules of air and other fine particles in the atmosphere have size smaller than the wavelength of visible light. These are more effective in scattering light of shorter wavelengths at the blue end than light of longer wavelengths at the red end. The red light has a wavelength about 1.8 times greater than blue light. Thus, when sunlight passes through the atmosphere, the fine particles in air scatter the blue colour (shorter wavelengths) more strongly than red. The scattered blue light enters our eyes. If the earth had no atmosphere, there would not have been any scattering. Then, the sky would have looked dark.

SCATTERING OF LIGHT

As sunlight travels through the earth's atmosphere it gets scattered by the small particles present in the atmosphere.

According to **Rayleigh law**, the amount of scattering is inversely proportional to the fourth power of the wavelength $\left(\frac{1}{\lambda^4}\right)$.

Phenomenon Based on Scattering of Light

(i) **Blue colour of sky:** Blue colour has a shorter wavelength than red colour therefore blue colour is scattered strongly. Hence the bluish colour predominates in a clear sky.

(ii) **White colour of clouds:** Clouds contain large dust particles, water droplets or ice particles. These large sized Particles do not obey Rayleigh law of scattering. All wavelengths are scattered nearly equally. Hence clouds are generally white.

(iii) **Sun looks reddish at the Sunset or Sunrise:** At sunset or sunrise, the sun's rays have to pass through a larger distance in the atmosphere. Most of the blue and other shorter wavelengths are scattered. The least scattered light reaching our eyes, therefore the sun looks reddish.