LIGHT
Part 1

Introduction

Light is a form of energy which travels as electromagnetic waves. The branch of physics that deals with the properties and applications of light is called optics. Two types of optics are ray optics and wave optics.

Sources of Light:

1. Natural sources of light
2. Artificial sources of light

- Incandescent Sources (Example: Candle, incandescent lamp)
- Gas Discharge Sources (Example: Neon lamp, Sodium lamp)

Properties of light:

1. Light is a form of energy.
2. Light always travels along a straight line. (Rectilinear propagation of light)-pin hole camera
3. Light does not need any medium for its propagation. It can even travel through vacuum.
4. The speed of light in vacuum or air is, $c = 3 \times 10^8\ ms^{-1}$.
5. Since, light is in the form of waves, it is characterized by a wavelength (λ) and a frequency (v), which are related by the following equation: $c = v\lambda$ (c - velocity of light).
6. Different coloured light has different wavelength and frequency.
7. Among the visible light, violet light has the lowest wavelength and red light has the highest wavelength.
8. When light is incident on the interface between two media, it is partly reflected and partly refracted.

Interaction of light with matter:

Transparent Material - allow light to pass through completely (ex: Eye glasses, clear drinking glass)

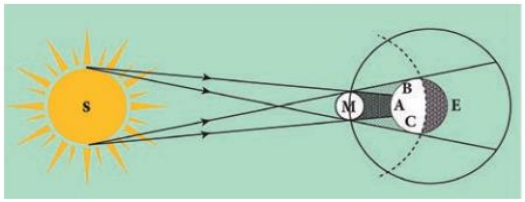
Translucent Material - allow light to pass through partially (ex: a rough window glass)

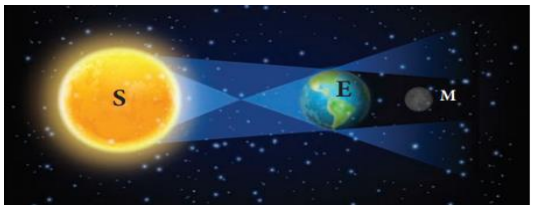
Opaque Material - not able to allow light to pass through (ex: Wall, thick card board, stone, etc.)

Shadows:

Light travels in a straight line and cannot bent according to object that is why we see shadow. Shadow appears in opposite side of light source. It is caused by opaque objects.

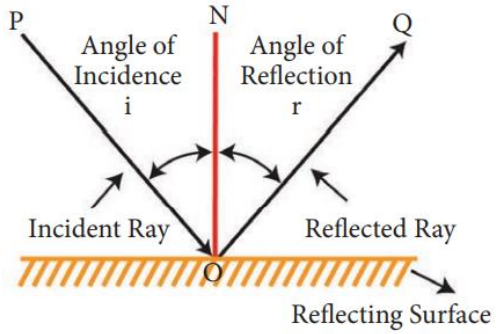
Solar eclipse





Reflection of Light:

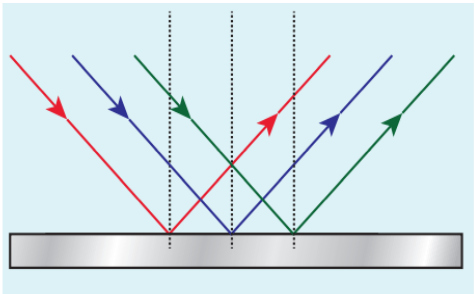
The bouncing back of light into the same medium when it encounters a reflecting surface is called reflection of light.



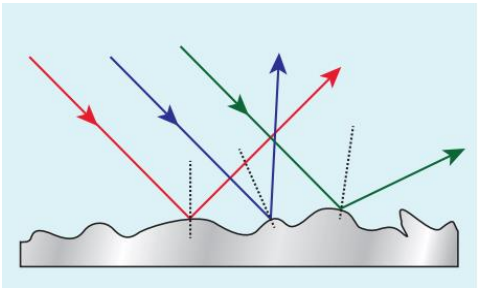
According to law of reflection,

a. The incident ray, reflected ray and normal to the reflecting surface all are coplanar (ie. lie in the same plane).

b. The angle of incidence (i) is equal to the angle of reflection (r). $\angle i = \angle r$.



Regular reflection



Irregular reflection

Periscope:

It is an instrument used for viewing bodies or ships, which are over and around another body or a submarine. It is based on the principle of the law of reflection of light.

Angle of deviation due to reflection:

The angle between the incident and deviated light ray is called angle of deviation of the light ray(d).

$$d = 180 - 2i$$

Multiple Reflections: (Kaleidoscope)

Lateral inversion:

Lateral inversion means sidewise inversion. It is the apparent inversion of left and right that occurs in a plane mirror

Image formation in plane mirror:

The image distance inside the plane mirror is equal to the object distance in front of the plane mirror.

By geometry, the height of the mirror needed is only half of the height of the person. (h/2)

The number of images formed is equal to $(360° / \theta) - 1$

The mirror equation : $1/f = 1/v + 1/u$

Real and virtual images:

The images that are obtained on a screen are called 'real image' and that which cannot be obtained on a screen 'virtual image'.

Refraction of light:

When a ray of light travels from one transparent medium into another obliquely, the path of the light undergoes deviation. This deviation of ray of light is called refraction. Refraction takes place due to the difference in the velocity of light in different media. The velocity of light is more in a rarer medium and less in a denser medium. Refraction of light obeys two laws of refraction.

Law of refraction is called Snell's law.

i. The incident ray, the refracted ray and the normal at the point of intersection, all lie in the same plane.
ii. The ratio of the sine of the angle of incidence (i) to the sine of the angle of refraction (r) is equal to the refractive index of the medium, which is a constant

$$\sin i / \sin r = \mu_2/\mu_1$$

Angle of deviation due to refraction

$$d = i - r$$

On the other hand, if light travels from denser to rarer medium it deviates away from normal and if the light travels from rarer to denser medium it moves towards the normal.

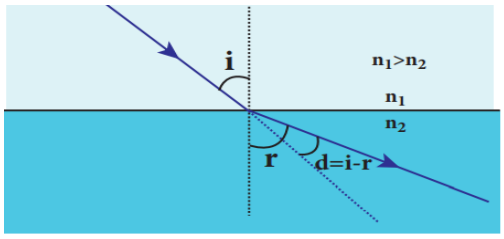


Figure 6.17 Angle of deviation due to refraction from denser to rarer medium

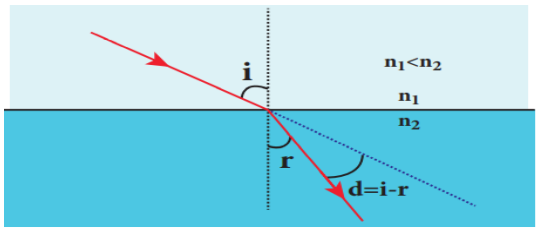


Figure 6.16 Angle of deviation due to refraction from rarer to denser medium

Atmospheric refraction:

Due to refraction of light through different layers of atmosphere which vary in refractive index, the path of light deviates continuously when it passes through atmosphere.

Critical angle and total internal reflection:

The angle of incidence in the denser medium for which the refracted ray graces the boundary is called critical angle (i_c). As angle of incidence i is gradually increased, r rapidly increases and at a certain stage it becomes 90° or gracing the boundary.

If the angle of incidence in the denser medium is increased beyond the critical angle, there is no refraction possible in to the rarer medium. The entire light is reflected back into the denser medium itself. This phenomenon is called total internal (Ex: Optical fibre, glittering of diamond and endoscope).

The two conditions for total internal reflection are,

a) light must travel from denser to rarer medium,
b) angle of incidence in the denser medium must be greater than critical angle (i>ic)

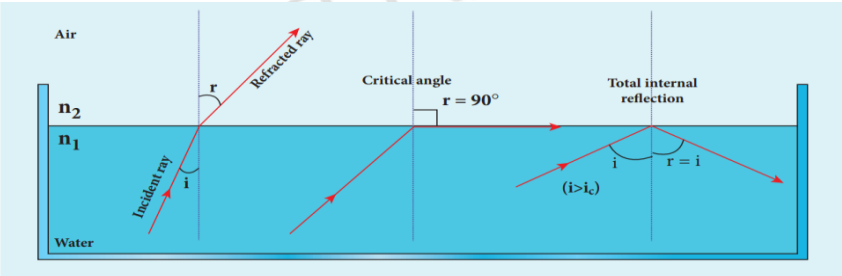


Figure 6.21 Critical angle and total internal reflection

Mirage and looming:

For of the shaky nature of the layers of air, the observer feels as if the object is getting reflected by a pool of water or wet surface beneath the object. This phenomenon is called mirage.

In the cold regions like glaciers and frozen lakes and seas, the reverse effect of mirage will happen. Hence, an inverted image is formed little above the surface. This phenomenon is called looming.

Refraction of a composite light dispersion of light:

When a beam of white light or composite light is refracted through any transparent media such as glass or water, it is split into its component colours. This phenomenon is called as 'dispersion of light'.

Prism:

A prism is an object made up of a transparent material, like glass or plastic that has at least two flat surfaces that from an acute angle (less than 90O degrees).

Newton Disc:

Using this disc, one can explain that white is a combination of VIBGYOR

The band of colours is termed as spectrum. This spectrum consists of following colours: Violet, Indigo, Blue, Green, Yellow, Orange, and Red represented by acronym "VIBGYOR".

Angle of refraction is the smallest for red and the highest for violet.

INTERFERENCE: (Dazzling colours on soap bubble)

The phenomenon of addition or superposition of two light waves which produces increase in intensity at some points and decrease in intensity at some other points is called interference of light.

DIFFRACTION:

Diffraction is bending of waves around sharp edges into the geometrically shadowed region.

Refractive Index:

Refractive index is a ratio of two similar quantities (speed) and so, it has no unit.

The smallest value of refractive index is for vacuum, which is 1. For any other medium refractive index is greater than 1. Refractive index is also called as optical density of the medium. Higher the refractive index of a medium, greater is its optical density and speed of light through the medium is lesser and vice versa.

μ = Speed of light in air (c)/ Speed of light in the medium (v)

Refractive index of different media	
Media	**Refractive Index**
Vacuum	1.00
Air	1.0003
Carbon dioxide gas	1.0005
Ice	1.31
Pure water	1.33

Ethyl alcohol	1.36
Quartz	1.46
Vegetable oil	1.47
Olive oil	1.48
Acrylic	1.49
Table salt	1.51
Glass	1.52
Sapphire	1.77
Zircon	1.92
Qubic zirconia	2.16
Diamond	2.42
Gallium phosphide	3.50

Optical Fiber:

Optical fibres consists of inner part called core and outer part called cladding (or) sleeving. Signal in the form of light is made to incident inside the core-cladding boundary at an angle greater than the critical angle. Hence, it undergoes repeated total internal reflections along the length of the fibre without undergoing any refraction.

Acceptance angle ia = $\sin^{-1} \sqrt{(n_1^2 - n_2^2)}$

Optical path:

Optical path of a medium is defined as the distance d' light travels in vacuum in the same time it travels a distance d in the medium. [v= d/t or t= d/v]

$d' = nd$

As n is always greater than 1, the optical path d' of the medium is always greater than d.

Scattering of light:

When sunlight enters the Earth's atmosphere, the atoms and molecules of different gases present in the atmosphere refract the light in all possible directions. This is called as 'Scattering of light'.

Visible light is a spectrum of number of waves with different wavelength range from 400nm to 700nm (1nm = 10^{-9} metre) each wave has a definite wavelength represents a particular color.

Rayleigh scattering:

The scattering of sunlight by the atoms or molecules of the gases in the earth's atmosphere is known as Rayleigh scattering.

Amount of scattering 'S' $\propto 1/ \lambda 4$

Violet colour which has the shortest wavelength gets much scattered during day time. The next scattered colour is blue. As our eyes are more sensitive to blue colour than violet colour the sky appears blue during day time.

Raman scattering:

Raman Scattering is defined as "The interaction of light ray with the particles of pure liquids or transparent solids, which leads to a change in wavelength or frequency."

Mie scattering:

Mie scattering takes place when the diameter of the scatterer is similar to or larger than the wavelength of the incident light. Mie scattering is responsible for the white appearance of the clouds.

Tyndall Scattering:

The scattering of light rays by the colloidal particles in the colloidal solution is called Tyndall Scattering or Tyndall Effect.

Apparent depth:

It is a common observation that the bottom of a tank filled with water appears raised

Part -2

Mirrors:

The mirror is an optical device with a polished surface that reflects the light falling on it. The shape of a mirror determines the type of image it forms. Plane mirrors form the perfect image of an object. Whereas, curved mirrors produce images that are either enlarged or diminished.
Spherical mirrors:

If the curved mirror is a part of a sphere, then it is called a 'spherical mirror'. It resembles the shape of a piece cut out from a spherical surface. One side of this mirror is silvered and the reflection of light occurs at the other side.

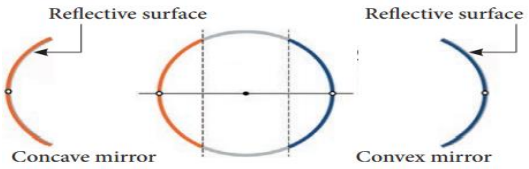


Figure 3.1 Sperical mirrors

Concave mirror:

A spherical mirror, in which the reflection of light occurs at its concave surface, is called a concave mirror. These mirrors magnify the object placed close to them.

Convex mirror:

A spherical mirror, in which the reflection of light occurs at its convex surface, is called a convex mirror. The image formed by these mirrors is smaller than the object.

Parabolic mirrors:

A parabolic mirror, which is in the shape of a parabola, is one type of curved mirror. It has a concave reflecting surface and this surface directs the entire incident beam of light to converge at its focal point. They are also used in solar cookers and solar water heaters.

Terms related to Spherical Mirrors:

Center of Curvature-It is the center of the sphere from which the mirror is made.

Pole-It is the geometric centre of the spherical mirror.

Radius of Curvature-It is the distance between the center of the sphere and the vertex

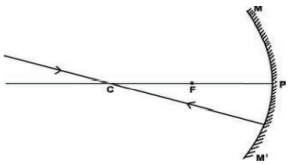
Principal Axis-The line joining the pole of the mirror and its center of curvature

Focus point-When a beam of light is incident on a spherical mirror, the reflected rays converge at or appear to diverge from (convex mirror) a point on the principal axis.

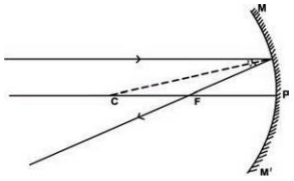
Focal length = radius/2

Rules for the construction of image:

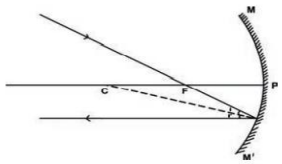
Rule 1: A ray passing through the centre of curvature is reflected back along its own path



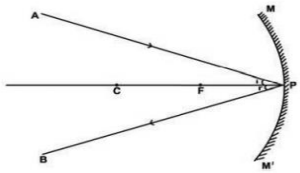
Rule 2: A ray parallel to the principal axis passes through or appears to be coming from the principal focus (in case of convex mirror) after reflection.



Rule 3: A ray passing through the focus gets reflected and travels parallel to the principal axis.



Rule 4: A ray incident at the pole of the mirror gets reflected along a path such that the angle of incidence (APC) is equal to the angle of reflection (BPC).



Lenses:

A lens is an optically transparent medium bounded by two spherical refracting surfaces or one plane and one spherical surface.

Types:

Convex or bi-convex lens-It is a lens bounded by two spherical surfaces such that it is thicker at the centre than at the edges. (converging)
Concave or bi-concave Lens-It is a lens bounded by two spherical surfaces such that it is thinner at the centre than at the edges. (diverging)

Lens formulas:

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

POWER OF A LENS = 1/ f u – Image distance; v- Object distance

Convex mirror	Concave mirror
Concave mirrors are used while applying make-up or shaving	Convex mirrors are used in vehicles as rear-view mirrors because they give an upright image and provide a wider field of view as they are curved outwards.
They are used in torches, search lights and head lights as they direct the light to a long distance	They are found in the hallways of various buildings including hospitals, hotels and schools
They can collect the light from a larger area and focus it into a small spot. Hence, they are used in solar cookers.	They are usually mounted on a wall or ceiling where hallways make sharp turns.
They are used as head mirrors by doctors to examine the eye, ear, nose and throat as they provide a shadow-free illumination of the organ.	They are also used on roads where there are sharp curves and turns.

They are also used in reflecting telescopes.	

Linear magnification (m):

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

height of the image (hiR) ; the height of the object (ho)

Applications of Curved Mirrors:

Polarisation:

The phenomenon of restricting the vibrations of light (electric or magnetic field vector) to a particular direction perpendicular to the direction of propagation of wave is called polarization of light.

Plane polarised light:

A transverse wave which has vibrations in all directions in a plane perpendicular to the direction of propagation of wave is said to be unpolarised light.

If the vibrations of a wave are present in only one direction in a plane perpendicular to the direction of propagation of wave is said to be polarised or plane polarised light.

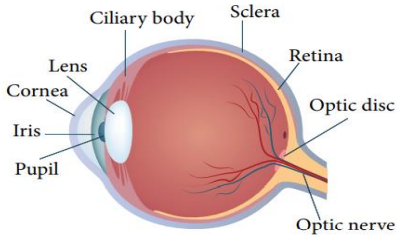
Polarisation Techniques:

The unpolarised light can be polarised by several techniques. Here, we are discussing the following four methods,

i. polarisation by selective absorption - polaroids or polarisers
ii. polarisation by reflection
iii. polarisation by double refraction - Nicol prism
iv. polarisation by scattering – sunlight

The eye:

Eye is a natural optical instrument given by God to the human beings. The diameter of eye for a normal adult is about 2.5 cm.



Cornea: This is the thin and transparent layer on the front surface of the eyeball. It is the main refracting surface.

Iris: It is the coloured part of the eye. It may be blue, brown or green in colour. Iris controls amount of light entering into the pupil like camera aperture.

Pupil: It is the centre part of the Iris. It is the pathway for the light to retina
Retina: This is the back surface of the eye. It is the most sensitive part of human eye, on which real and inverted image of objects is formed.

Eye Lens – It is the important part of human eye. It is convex in nature.

Ciliary muscles – Eye lens is fixed between the ciliary muscles. It helps to change the focal length of the eye lens according to the position of the object.

Power of Accommodation

The ability of the eye lens to focus nearby as well as the distant objects is called power of accommodation of the eye. This is achieved by changing the focal length of the eye lens with the help of ciliary muscles.

Persistence of vision:

If the time interval between two consecutive light pulses is less than 116 second, human eye cannot distinguish them separately. It is called persistence of vision.

The far point and near point of the human eye:

Near point is 25 cm for normal human eye. Far point is infinity for normal eye.

Common defects of vision in the eye:

- Near sightedness (myopia)- This defect can be corrected using a concave lens
- Far sightedness (hypermetropia) - This defect can be corrected using a convex lens
- Presbyopia (eye loses its power of accommodation) - This can be corrected by 'bifocal lenses'.
- Astigmatis (eye cannot see parallel and horizontal lines clearly)-It can be corrected by using cylindrical lenses.

OPTICAL INSTRUMENTS:

Simple microscope:

A simple microscope is a single magnifying (converging) lens of small focal length. The idea is to get an erect, magnified and virtual image of the object.

Compound microscope:

The lens near the object, called the objective, forms a real, inverted, magnified image of the object. This serves as the object for the second lens which is the eyepiece. Eyepiece serves as a simple microscope that produces finally an enlarged and virtual image.

Telescope:

Telescope is an optical instrument to see the distant objects.

Types of telescopes:

Astronomical telescope:

An astronomical telescope is used to get the magnification of distant astronomical objects like stars, planets, moon etc. The image formed by astronomical telescope will be inverted. It has an objective of long focal length and a much larger aperture than the eyepiece.

Terrestrial telescope:

A terrestrial telescope is used to see object at long distance on the surface of earth. Hence, image should be erect. A terrestrial telescope has an additional erecting lens to make the final image erect.

Reflecting telescope:

Telescopes with mirror objectives are called reflecting telescopes.

Spectrometer:

The spectrometer is an optical instrument used to study the spectra of different sources of light and to measure the refractive indices of materials. It consists of basically three parts. They are (i) collimator (ii) prism table and (iii) Telescope.

Important formulas:

1. f=R/2 (R- radius of curvature of the mirror, f – focal lenght)
2. Mirror equation $1/f = (1/v) + (1/u)$
3. Magnification: m = height of image(h_2)/ height of object(h_1)
4. Reflection law $\angle i = \angle r$
5. Refraction law $\sin i / \sin r = \mu$
6. Critical angle $i_c = 90$ degree
7. power of lens $p = 1/f$
8. focal length of the required convex lens is $f = dD/(d-D)$
9. focal length of the required concave lens is, $f = xy/(x-y)$ (x- seen distance; y- wishing distance)
10. No of images formed when an object is placed in particular angle between two mirrors
    $n = (360^\circ/\theta) - 1$

Previous Year Questions

1. Match the following:

A. Myopia	1. Bifocal lens
B. Hyper Metropia	2. Cylindrical lens
C. Presbyopia (above 45yrs of age)	3. Concave lens
D. Astigamatism	4. Convex lens

பொருத்துக.

A. அண்மைப்பார்வை	1. இருமுகப்பு வில்லை
B. தூரப்பார்வை	2. உருளை வில்லை
C. தூரப்பார்வை (45 வயதுக்கு மேல்)	3. குழி வில்லை
D. உருட்சிப்பிழை	4. குவி வில்லை

	A	B	C	D
a.	4	3	1	2
b.	**3**	**4**	**1**	**2**
c.	2	4	1	3
d.	1	2	3	4

2. A doctor Prescribe spectacles to a patient with a combination of a convex lens focal length 40 cm, and concave lens of focal length 25 cm, then the power spectacles will be

a. – 6.5 D b. 1.5 D c. -1.5 D d. -8.5 D

ஒரு கண் மருத்துவர் நோயாளி ஒருவருக்கு 40 செ.மீ குவியத் தொலைவுள்ள குவிலென்சையும் 25 செ.மீ குவியத் தொலைவுள்ள குழிலென்சையும் இணைத்து மூக்கு கண்ணாடி அணிய பரிந்துரைக்கிறார். அந்த மூக்கு கண்ணாடியின் திறன் என்ன?

a. – 6.5 D b. 1.5 D c. -1.5 D d. -8.5 D

3. Focal length of a convex mirror whose radius of curvature 40 cm is

A. 20 cm B. 40 c, C. 80 cm D. infinity

40 செ.மீ வளைவு ஆரம் உடைய குவியாடி ஒன்றின் குவியத் தொலைவு

A. 20 செ.மீ B. 40 செ.மீ C. 80 செ.மீ D. முடிவிலி

4. If the focal length of a concave lens is 2 m, then the power of the lens is

A. 2 dioptre B. 1 dioptre C. 0.5 dioptre**D. -0.5 dioptre**

2 மீ குவியத்தொலைவு உடைய குழிலென்சின் திறன்

A. 2 டையாப்டர் B. 1 டையாப்டர் C. 0.5 டையாப்டர் D. – 0.5 டையாப்டர்

5. If the power of a lens is +5 D, then its focal length is

ஒரு வில்லையின் திறன் +5D, அதன் குவிய நீளம் என்ன?

a. +0.2cm b. -0.2cm **c. +20 cm** d. -20cm

6. An Achromatic lens produces

a. Coloured Image b. Enlarged Image

c. Black and white image **d. Unaffected clear image**

நிறப்பிறழ்ச்சி நீக்கிய வில்லைகள் கொடுக்கும் பிம்பம்

a. பல நிறப்பட்ட பிம்பம் b. உருவத்தில் பெரிய பிம்பம்

c. கறுப்பு – வெள்ளை நிறம் பிம்பம் **d.** தெளிவான பிம்பம்

7. The mirror used in astronomical telescope and search light is

a. Convex mirror b. Plane mirror

c. Cylindrical mirror **d. Parabolic mirror**

வானியல் தொலைநோக்கி மற்றும் கலங்கரை விளக்குகளில் பயன்படும் ஆடி

a. குவி ஆடி b. சமதள ஆடி c. உருளை ஆடி d. பரவளைய ஆடி

8. If light waves emitted by two coherent sources have wavelengths λ_1 and $\lambda_2$then

A. $\lambda_1 = \lambda_2$ B. $\lambda_1 > \lambda_2$ C. $\lambda_1 < \lambda_2$ D. $\lambda_1\lambda_2 = 1$

இரண்டு ஒரியல் மூலங்களில் இருந்து வெளி வரும் ஒளி அலைகளின் அலை நீளம் மற்றும் என்ன?

A. $\lambda_1 = \lambda_2$ B. $\lambda_1 > \lambda_2$ C. $\lambda_1 < \lambda_2$ D. $\lambda_1, \lambda_2 = 1$

9. Blue colour of sky is due to

A. refraction of light B. reflection of light

C. interference of light **D. scattering of light**

வானம் நீல நிறமாகத் தோன்றுவதன் காரணம்

A. ஒளி விலகலால் B. ஒளி எதிரொளித்தலால்

C. ஒளியின் குறுக்கீட்டு விளைவினால் D. ஒளி சிதறல் அடைவதால்