Government of Tamilnadu

Department of Employment and Training

Course : TNPSC Group II Exam

Subject : Physics

Topic : **Light**

LIGHT

LIGHT

Rectilinear Propagation, Shadows and Eclipse :

- Light travels in straight line.
- The kind of shadow depends on the size of the source of light
- Shadow obtained is a region of total darkness called umbra
- Shadow obtained partial darkness called penumbra.
- Lunar eclipse - earth comes between the sun and the moon.
- Solar eclipse - moon comes between the sun and the earth.

Reflection of light

❖ A highly polished surface, such as a mirror, reflects most of the light falling on it.

(i) The angle of incidence is equal to the angle of reflection, and

$$\angle i = \angle r$$

(ii) The incident ray, the normal to the mirror at the point of incidence and the reflected ray, all lie in the same plane.

An image formed in a plane mirror has the following Characteristics.

- The image is of the same size as the object.
- It is as behind the mirror as the object is in front of it.
- It is virtual
- It is laterally inverted.

❖ Light is incident on a rough surface, the reflected rays are scattered in all direction the many surface irregularities. This is called diffuse reflection.

Inclined mirror :

❖ When an object is placed between two inclined mirrors several images of the object one formed

❖ Number of images depends on the angle between the mirror.

$$\textbf{No. of image} = \frac{360^0}{\text{angle between mirrors}}$$

Kaleidoscope :

- It is toy image are formed by two strips of plane mirrors placed at an angle of 60⁰ inside the tube five images are seen.

Refraction :

- Light bends when its travel from one medium to another this called refraction of the lights.
- Different speeds of light in medium different densities.
- Speed of light in vaccum - 3×10^8 m/s.
- When light travels from a rarer medium and enters a denser medium it will be deviated towards to the normal line

  Ex : From air to glass.

- The light will be deviated away from the normal when it passes from a denser into a rare medium

  Ex : Glass to Air.

Atmosphere Refraction

- The density of the atmosphere surrounding the earth decreases with increasing altitude. Thus if light enters the atmosphere from outside it encounters layers of air increasing density and, therefore, bends gradually producing a curved path.

  Ex - Star twinkling, Mirage

Refractive Index

$$\mu = \frac{Sin\ i}{Sin\ r} = \frac{\text{Velocity of light in air}}{\text{Velocity of light in medium}}$$

It has no unit & no dimension

Water	- 1.33
Crown glass	- 1.52
Dense Flint glass	- 1.62
Diamond	- 2.42

Total Internal Reflection :

- Ray or light passes through the denser medium to the rare medium the refracted Ray is bent away from the normal line.
- Angle of incidence increase the angle of refraction also increase.
- At a certain angle of incidence the angle of reflection becomes

The colour of outer edge of rainbow will be red.

90°. This angle is called critical angle (c).

- ❖ If the angle of incidence is more than the critical angle the rays bends inside the denser medium itself. This phenomenon is called **total internal reflection.**

Optical Fibre

- ❖ An optical fibre is a device based on the principle of total internal reflection.
- ❖ Optical fibres are thin, flexible and transparent strands of glass which can carry light along them very easily. A boundle of such thin fibres from a light pipe.

Uses of Optical Fibre

- ❖ Optical fibres are used to transmit communication signals.
- ❖ In medicine, optical fibres are used endoscope and laparoscopes.

Dispersion

- ❖ Separation of light into colours is called dispersion.
- ❖ Seven colours - Violet, Indigo, Blue, Green, Yellow, Orange and Red.
- ❖ Violet Colour Minimium Wave Length and Maximum Frequency.
- ❖ Red Colour - Maximum Wave Length and Minimum Frequency.
- ❖ Vaccum all colours are same speed but different medium and different speed.

The Rainbow

- ❖ The most spectacular illustration of dispersion.
- ❖ Droplets acts as a prism.
- ❖ Rainbow is seen in the sky opposite the sun.
- ❖ Each droplets there is dispersion as well as total internal reflection.

Colour of objects

- ❖ Leaves reflect the green colour the remaining colour are observed.

Mixing Coloured Light

- ❖ All colours can be suitable mixture of these three colour. (Red, Blue, Green) Therefore called primary colour, others secondary colour.
- ❖ The colours which give white light when put together, are called complementary colour blue + yellow - complementary colours.

Scattering of light

- Lord Rayleigh was the first to deal with scattering of light by air molecules. The scattering of sunlight by the molecules of the gases in Earth's atmosphere is called Rayleigh scattering. The basic process in scattering is absorption of light by the molecules followed by its re-radiation in different directions. The strength of scattering depends on the wavelength of the light and also the size of the particle which cause scattering. The amount of scattering is inversely proportional to the fourth power of the wavelength. This is known as Rayleigh scattering law.
- Hence, the shorter wavelengths are scattered much more than the longer wavelengths. The blue appearance of sky is due to scattering of sunlight by the atmosphere. According to Rayleigh's scattering law, blue light is scattered to a greater extent than red light. This scattered radiation causes the sky to appear blue.
- At sunrise and sunset the rays from the sun have to travel a larger part of the atmosphere than at noon. Therefore most of the blue light is scattered away and only the red light which is least scattered reaches the observer. Hence, sun appears reddish at sunrise and sunset

Tyndal scattering

- The scattering of light by the colloidal particles is called Tyndal scattering.

Diffraction

- Sound is propagated in the form of waves. Sound produced in an adjoining room reaches us after bending round the edges of the walls. Similarly, waves on the surface of water also bend round the edges of an obstacle and spread into the region behind it. This bending of waves around the edges of an obstacle is called diffraction. Diffraction is a characteristic property of waves. The waves are diffracted, only when the size of the obstacle is comparable to the wavelength of the wave.

The sky appears to be blue because of scattering of light.

- Fresnel showed that the amount of bending produced at an obstacle depends upon the wavelength of the incident wave. Since **the sound waves have a greater wavelength, the diffraction effects are pronounced. As the wavelength of light is very small, compared to that of sound wave and even tiny obstacles have large size, compared to the wavelength of light waves, diffraction effects of light are very small.**

Fresnel and Fraunhofer diffraction

Diffraction phenomenon can be classified under two groups (i) Fresnel diffraction and (ii) Fraunhofer diffraction

Polarisation

The phenomena of reflection, refraction, interference, diffraction are common to both transverse waves and longitudinal waves. But the transverse nature of light waves is demonstrated only by the phenomenon of polarization

The phenomenon of restricting the vibrations into a particular plane is known as polarization (for glass it is 57.5o)

Types of crystals

Crystals like calcite, quartz, ice and tourmaline having only one optic axis are called uniaxial crystals. Crystals like mica, topaz, selenite and aragonite having two optic axes are called biaxial crystals

Polaroids

A Polaroid is a material which polarises light. The phenomenon of selective absorption is made use of in the construction of polariods

Uses of Polaroid

1. Polaroids are used in the laboratory to produce and analyse plane polarised light.
2. Polaroids are widely used as polarising sun glasses.
3. They are used to eliminate the head light glare in motor cars.
4. They are used to improve colour contrasts in old oil paintings.
5. Polaroid films are used to produce

We cannot see during a fog because scattering of light three – dimensional moving pictures.

6. They are used as glass windows in trains and aeroplanes to control the intensity of light. In aeroplane one polaroid is fixed outside the window while the other is fitted inside which can be rotated. The intensity of light can be adjusted by rotating the inner polaroid.
7. Aerial pictures may be taken from slightly different angles and when viewed through polaroids give a better perception of depth.
8. In calculators and watches, letters and numbers are formed by liquid crystal display (LCD) through polarisation of light.
9. Polarisation is also used to study size and shape of molecules

Theories of light

Corpuscular theory

- According to Newton, a source of light or a luminous body continuously emits tiny, massless (negligibly small mass) and perfectly elastic particles called corpuscles. They travel in straight lines in a homogeneous medium in all directions with the speed of light

- **Wave theory**

  According to Huygens, light is propagated in the form of waves, through a continuous medium. Huygens assumed the existence of an invisible, elastic medium called ether, which pervades all space

- **Electromagnetic theory**

  Maxwell showed that light was an electromagnetic wave, conveying electromagnetic energy and not mechanical energy as believed by Huygens

  He also showed that no medium was necessary for the propagation of electromagnetic waves.

- **Quantum theory**

  1900, Planck had suggested that energy was emitted and absorbed, not continuously but in multiples of discrete pockets of energy called Quantum which could not be subdivided into smaller parts. In 1905, Einstein extended this idea and suggested

The full shape of a rainbow is Parabola that light waves consist of small pockets of energy called photons. The energy associated with each photon is E = hν, where h is Planck's constant (h = 6.626 × 10^{-34}Js) and ν is the frequency of the electromagnetic radiation. It is now established that photon seems to have a dual character. It behaves as particles in the region of higher energy and as waves in the region of lower energy

Mirror and Lens

Focal Length : - The distance between the pole and the principal focus of a special mirror is called the focal length. (F)

Pole : - The centre of the reflecting surface of a spherical mirror is a point called the pole. It is represented by the letter P.

Radius of Curvature

The radius of the sphere of which the reflecting surface of a spherical mirror forms a part is called the radius of curvature of the mirror (R).

Spherical mirrors of small apertures the radius of curvature is found to be equal to twice the focal length.

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

Principal Axis :

Imagine a straight line passing through the pole and the centre of curvature of a spherical mirror. This line is called the principal axis.

Lens Mirror	Nature of the image	Size of the Image
Cancave mirror Convex Lens	Real and inverted image. Virtual and erect image.	Diminished and enlarged image.
Cancave lens convex mirror	Erect virtual	Small image

Uses of Convex Mirrors

1. Rear view mirrors in vehicles, CCTV Camera

Uses of Concave mirrors

1. Tourch Light
2. Street Light

Light is propagated in the form of transverse waves.

3. Vehicles head lights
4. Shaving mirrors
5. Dentists use to see large images of the teeth of patients.
6. Used to concentrate sun light to produce heat in solar turnaces.

Mirror Formula

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

- f = focal length
- u = object distance
- v = image distance

<u>Example - 1</u>

A convex mirror used for rear-view on an automobile has a radius of curvature of 3 m. If a bus is located at 5 m from this mirror, find the position and nature of the image.

Solution:

Radius of curvature, R = +3.00 m

Object distance u = - 5.00 m

Image distance v = ?

We know,

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

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

$$\frac{1}{v} + \frac{1}{1.5} - \frac{1}{-5} = \frac{1}{1.5} + \frac{1}{5} = \frac{15+1.5}{7.5} = \frac{6.5}{7.5}$$

$$= v = \frac{7.5}{6.5} = 1.15 \text{ m}$$

The image is 1.15 m at the back of the mirror. The image is virtual.

Lens formula

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

Example :

A concave lens has focal length of 15 cm. At what distance should the object from the lens be placed so that it forms an image 10 cm from the lens?

Solution:

v = −10 cm, f = − 15 cm, u = ?

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

$$\frac{1}{u} = \frac{1}{-10} - \frac{1}{-15}$$

$$\frac{1}{u} = \frac{1}{-10} + \frac{1}{15}$$

$$\frac{1}{u} = \frac{-3+2}{30}$$

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

u = 30 cm.

Magnification

The magnification produced by a lens is defined as the ratio of the height of the image to the height of the object.

$$\boxed{M = \frac{v}{u}}$$

In fluorescent tube light ultraviolet light is converted into visible light.

Example:

An object is placed at a distance of 30 cm from a concave lens of focal length 15 cm. An erect and virtual image is formed at a distance of 10 cm from the lens. Calculate the magnification.

Solution:

Object distance, u = $-$ 30 cm

Image distance, v = $-$ 10 cm

Magnification, m = v/u

$$m = \frac{-10}{-30}$$

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

$m_2 + 0.33$ cm

Power of Lens

The power of lens is defined as the reciprocal of its focal length.

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

The S.I unit power of a lens is dioptre. It is denote by the letter D.

Example:

The focal length of a concave lens is 2m. Calculate the power of the lens.

Solution:

Focal length of concave lens, f = $-$ 2 m

Power of the lens,

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

$$p = \frac{1}{-2}$$

p = $-$ 0.5 dioptre