Polarization
of light

Significance

- Interference and Diffraction so far tells us that light is a form of wave motion but it does tell nothing about whether these waves are longitudinal or transverse..... **Polarization** is that phenomenon which established beyond doubt that light waves are transverse waves.
- **Polarization** is the phenomenon by which the vibrations in a transverse wave are confined to one particular direction only.
- **Polarization** is exhibited only by transverse waves. As light can be polarized, the phenomenon confirms transverse nature of light.

Overview of light wave

- Light is a transverse wave, an **electromagnetic** wave
- The magnetic field vector B vibrates in a direction perpendicular to that of the electric field vector and to the direction of propagation of the wave
- Light wave can be traced by a point that oscillates sinusoidally in a plane, such that the direction of oscillation is perpendicular to the direction of propagation of the wave.
- The oscillating point can describe the vibration of E

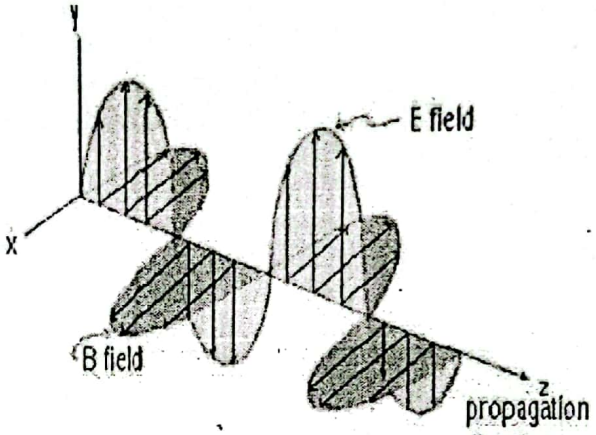
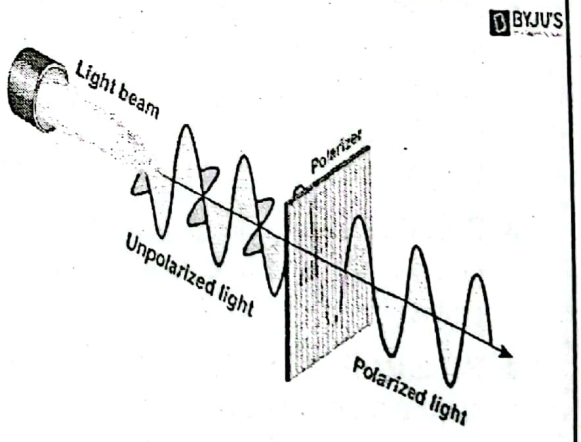


Figure 1 (b) An electromagnetic wave

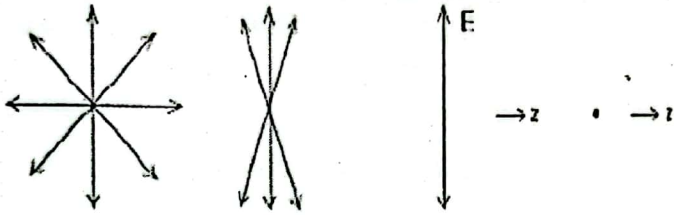
Polarization .....

- Light emitted from an actual/ordinary source (such as the Sun) consists of many such electric field vectors.
- The electric field vectors vibrate randomly in all directions. Such sources of light are **unpolarized.**
- The other kind of light waves in which the vibrations occur in a single plane are polarized light.
- **Polarization is the phenomenon by which the vibrations in a transverse wave are confined to one particular direction only.**
- The process of transforming unpolarized light into polarized light is known as polarization.



Polarization .....

- **Partially polarized** light occurs if the E vectors have a preferred direction of oscillation
- Light is totally **linearly polarized (or plane polarized)** if all the electric field vectors oscillate in the same plane, parallel to a fixed direction referred to as the polarization direction.
- vertically polarized light is represented by a vertical arrow
- horizontally polarized light is represented by a dot indicating that the E vector oscillates into and out of the page



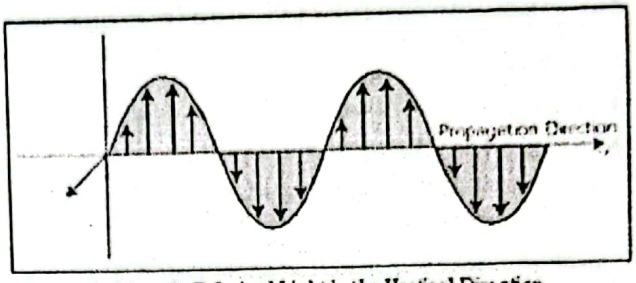
Types of Polarization

- Linear polarization
- Circular polarization
- Elliptical polarization

The behavior of electromagnetic waves can be studied by considering two orthogonal components of the electric field vector. The phase relationship between these two components can explain the different states of polarization.

Linear Polarization

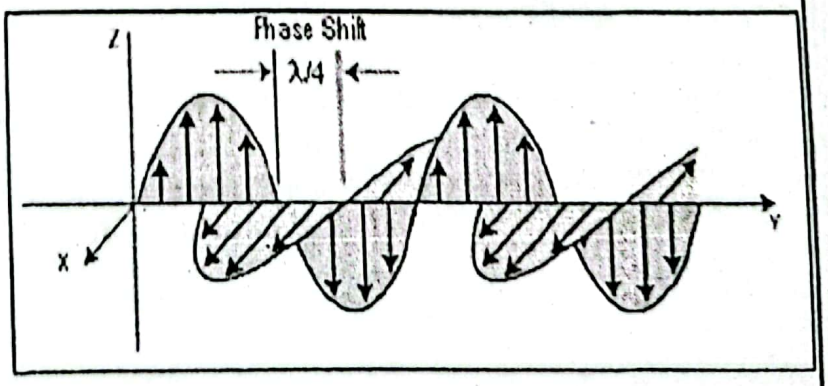
- In linear polarization, the electric field of light is limited to a single plane along the direction of propagation.
- If there is no amplitude in x (Eox = 0), there is only one component, in y (vertical).
- If there is no phase or difference or the phase difference is 180 degrees, the light is linearly polarized



A. Linearly Polarized Light in the Vertical Direction

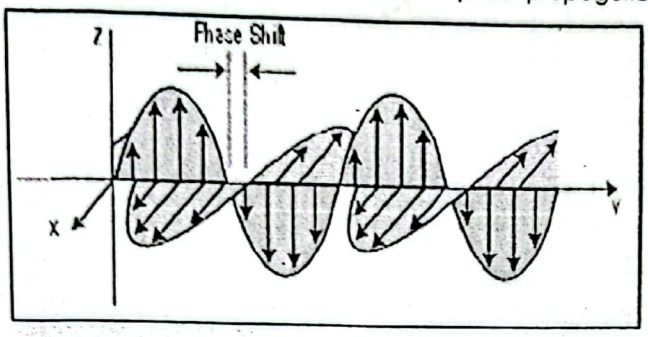
Circular Polarization

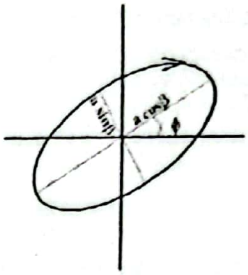
- If the phase difference is 90 or 270 degrees and both components have the same amplitude, the light is circularly polarized.
- The propagation of the occurring electric field will be in a circular motion.



Elliptical Polarization

- If a constant phase difference other than 0, 90, 180 or 270 degrees exists and/or the amplitudes of the components are not equal, then the light is elliptically polarized.
- The electric field of light follows an elliptical propagation. T





In case of circular or elliptical polarization, the plane of polarization rotates, in contrast to linear polarization where the plane of polarization is fixed.

Linear polarizers

- Certain materials have the property of transmitting an incident unpolarized light in only one direction. Such materials are called dichroic.
- Polarizing sheets transmits the only component of the electric field vector, parallel to its transmission axis. The component perpendicular to the transmission axis is completely absorbed.
- Light emerging from the polarizer is linearly polarized in the direction parallel to the transmission axis.
- polarizers reduce the intensity of the incident light beam to some extent.

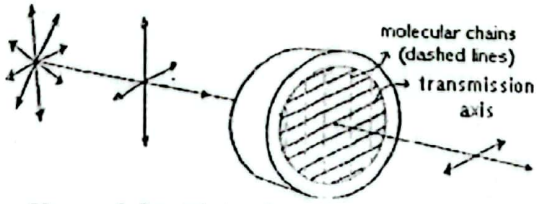


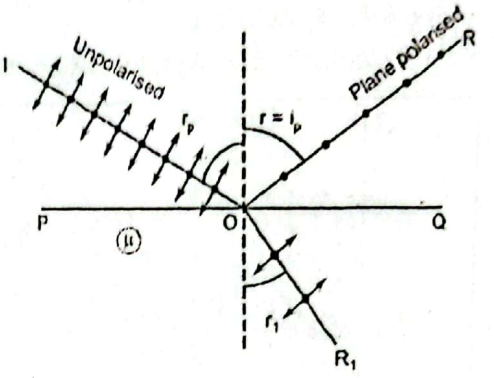
Figure 3 Transmission through a linear polarizer

Polarization by reflection

- Unpolarized monochromatic light I incident on a transparent refracting surface PQ with refracting index μ.
- The electric vector in incident light has two components,

1. one parallel to the plane of incidence (arrows)
2. another normal to the plane of incidence (dots).

- Dot components are always parallel to the reflecting surface PQ so, they are irrespective on the value of angle of incidence.
- Arrow components make different angles with PQ so their condition for reflection and refraction change.
- For a specific value of $\angle i = ip$ (called polarizing angle), the arrow components get totally transmitted
- hence the reflected light contain only the dot components
- i.e; the reflected light is completely polarized for the angle ip called polarizing angle



Brewster's Law

- Brewster performed several experiments on polarization of light by reflection from different surfaces
- He found that ordinary light becomes completely polarized when it is reflected from a transparent medium at a particular angle (polarizing angle)
- and also proved that

$$\mu = \tan ip$$

- Where reflected and refracted rays are at right angles to each other.