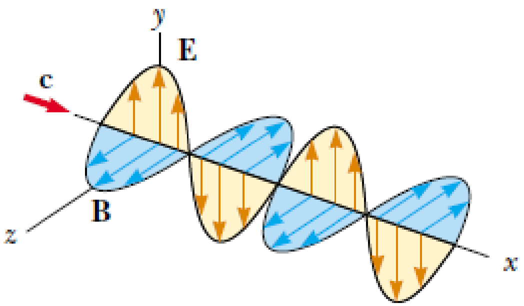
PHY 203- PHYSICS III

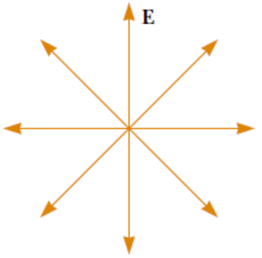
Polarization

Polarization of Light Waves

The *direction of polarization* of each individual wave is defined to be the direction in which the electric field is vibrating.
Schematic diagram of an electromagnetic wave propagating at velocity c in the *x* direction. The electric field vibrates in the *xy* plane, and the magnetic field vibrates in the *xz* plane.

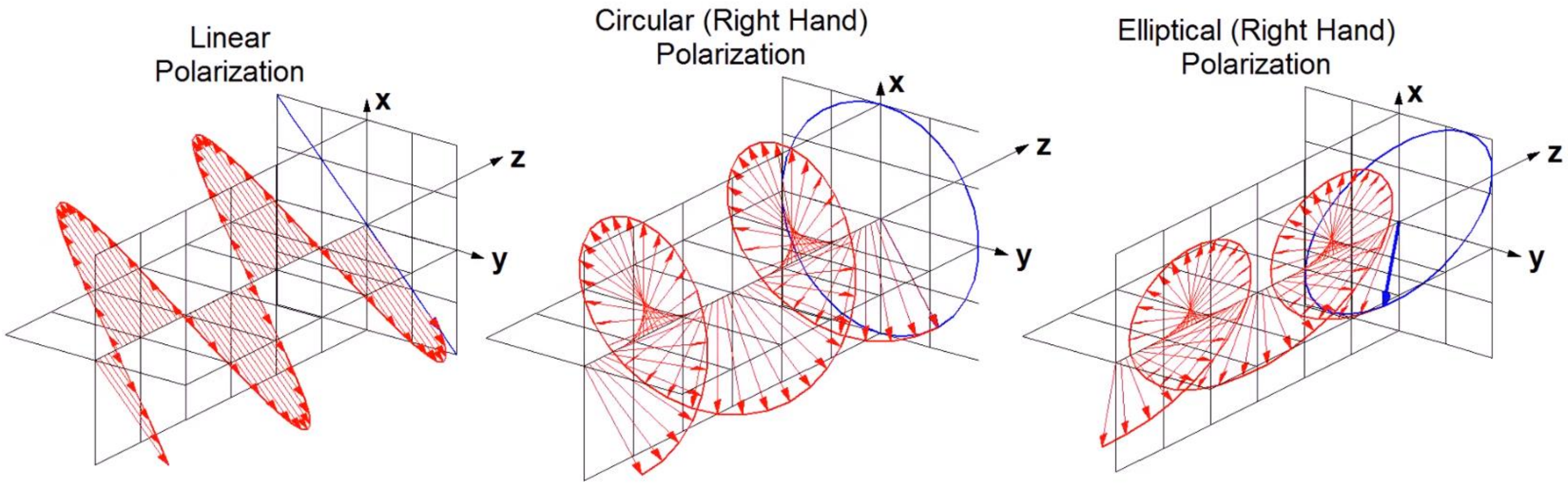


(a) A representation of an unpolarized light beam viewed along the direction of propagation (perpendicular to the page). The transverse electric field can vibrate in any direction in the plane of the page with equal probability. (b) A linearly polarized light beam with the electric field vibrating in the vertical direction.



(a) (b)

Linear, circular and elliptic pollarization



Circular Pollarization

- A right-handed/clockwise circularly polarized wave as defined from the point of view of the source. It would be considered left-handed if defined from the point of view of the receiver

- A left-handed/counter-clockwise circularly polarized wave as defined from the point of view of the source. It would be considered right-handed if defined from the point of view of the receiver.

Polarization by Reflection

- When an unpolarized light beam is reflected from a surface, the reflected light may be
- completely polarized, partially polarized, or unpolarized, depending on the angle of
- incidence.

- ⍰= 0˚ ⍰ the reflected beam is unpolarized
- ⍰≠ 0˚ ⍰ the reflected light is polarized to some extent
- ⍰= ⍰p⍰ the reflected light is completely polarized.
- When unpolarized light is incident on a reflecting surface, the reflected and refracted beams are partially polarized.
- The reflected beam is completely polarized when the angle of incidence equals the polarizing angle ⍰p, which satisfies the equation n = tan⍰p . At this incident angle, the reflected and refracted rays are perpendicular to each other.

Polarization by Scattering

- When light is incident on any material, the electrons in the material can absorb and reradiate part of the light. Such absorption and reradiation of light by electrons in the gas molecules that make up air is what causes sunlight reaching an observer on the Earth to be partially polarized.
- When light of various wavelengths λ is incident on gas molecules of diameter *d*:

- $d << \lambda \rightarrow I \propto 1/\lambda$

- $d << \lambda \rightarrow$ scattering from oxygen (O2) and nitrogen (N2) molecules in the atmosphere, whose diameters are about 0.2 nm.

- Hence, short wavelengths (blue light) are scattered more efficiently than long wavelengths (red light). Therefore, when sunlight is scattered by gas molecules in the air, the short-wavelength radiation (blue) is scattered more intensely than the long- avelength radiation (red).

Optical Activity

- Optical rotation (optical activity) is the turning of the plane of linearly polarized light about the direction of motion as the light travels through certain materials.

- The angle depends on the length of the path through the material and on concentration if the material is in solution. One optically active material is a solution of the common sugar dextrose. A standard method for determining the concentration of sugar solutions is to measure the rotation produced by a fixed length of the solution.

- The liquid crystal displays found in most calculators have their optical activity changed by the application of electric potential across different parts of the display. Try using a pair of polarizing sunglasses to investigate the polarization used in the display of your calculator.