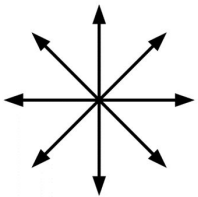
Lecture 5-6: Optics – Polarization
Optics by Ajoy Ghatak, 6E
Chapter 22, Polarization and Double Refraction
22.1 Introduction
22.2 Malus' law
22.3 Production of Polarized light

What is polarization?

Two types of light

based on the orientation of electric field vibrations light

Unpolarized light



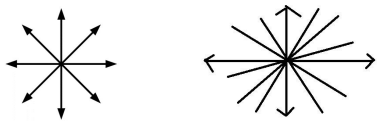
Polarized light

Unpolarized light

refers to light in which the electric field vectors vibrate in all possible directions perpendicular to the direction of propagation of the light

Electric field vibrates randomly in all possible planes

Sun or Incandescent bulbs emit unpolarized light.



Polarized light

refers to light in which the electric field vectors vibrate in a specific direction or plane

Electric field oscillates in well-defined direction

Polarization can occur through reflection, transmission, scattering, or filtering

The process of transforming unpolarized light into polarized light is called polarization.

Types of polarized light

Linear

Electric field is confined to a single plane along the direction of the propagation of light

Elliptical

Two linear components do not have the same amplitude and /or phase difference

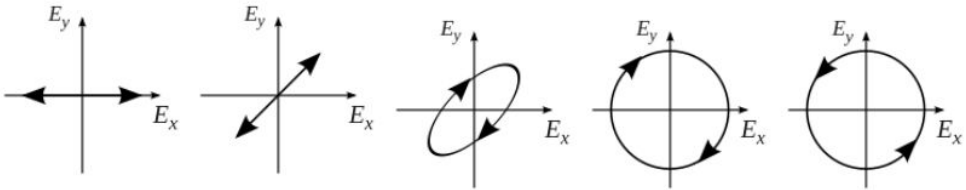
Resultant electric field propagates along an elliptical path

Circular

Electric field has two linear components that are,

- perpendicular to each other
- have identical amplitudes,
- phase difference is $\pi/2$

Resultant electric field propagate along a circular path



For circular polarized light:
Phase difference of π／2 between two components (Ex & Ey)

1

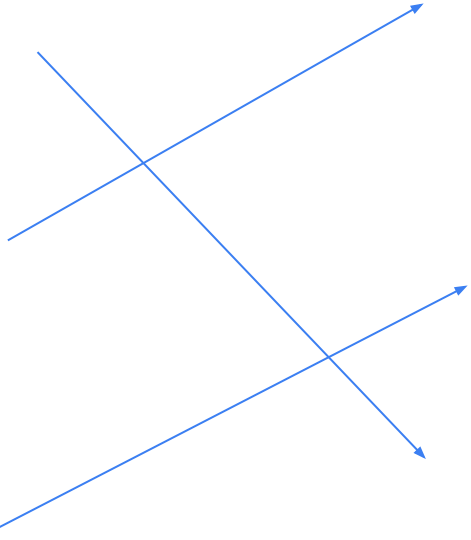
$$x(z,t) = a\cos(kz - \omega t - \phi_1)$$
$$y(z,t) = 0$$

2

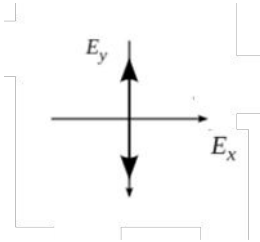
$$x(z,t) = 0$$
$$y(z,t) = a\cos(kz - \omega t - \phi_2)$$

3

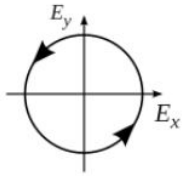
$$x(z,t) = a\cos(kz - \omega t - \phi)$$
$$y(z,t) = -a\sin(kz - \omega t - \phi)$$



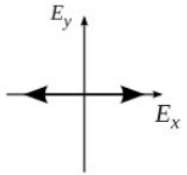
A



B



C



What kind of waves can be polarized?

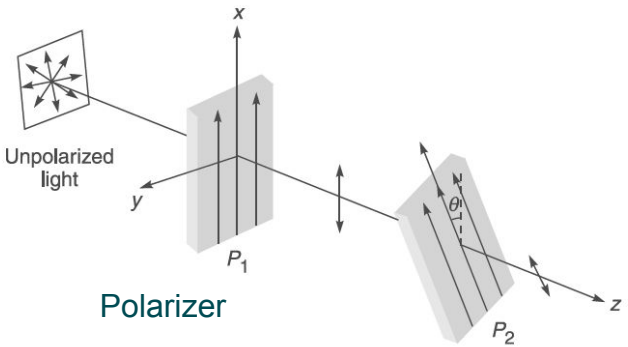
- Light
- Wave in a string

Polarizer (Polaroid)

Polarizer is an optical filter that lets light of a specific polarization pass through while blocking light of other polarizations

Polariod are polarizing materials made up of molecules that are oriented in a specific direction.

What is the relationship between the intensity of the transmitted light through Analyzer?



Polarizer

Analyzer

Polarizer sheets

Malus' law

$$I = I_0 \cos^2 \phi$$

How to produce polarized light?

- Polarizer and the Polaroid
- Polarization by Reflection
- Polarization by Double Refraction
- Polarization by Scattering

1. Polarization by Polarizer and Polaroid:

When the unpolarized light travels through a polaroid, it becomes polarized

2. Polarization by Reflection:

If angle of incidence is θ is such that,

$$\theta = \theta_p = \tan^{-1}\left(\frac{n_2}{n_1}\right)$$

then no reflection of light

θ_p: Brewster's angle

p-polarized: light's electric field polarized parallel to plane of incidence
s-polarized: light's electric field polarized perpendicular to plane of incidence

If an unpolarized beam is incident at Brewster's angle, then the reflected beam is linearly s-polarized

p-polarized: light's electric field polarized parallel to plane of incidence
s-polarized: light's electric field polarized perpendicular to plane of incidence

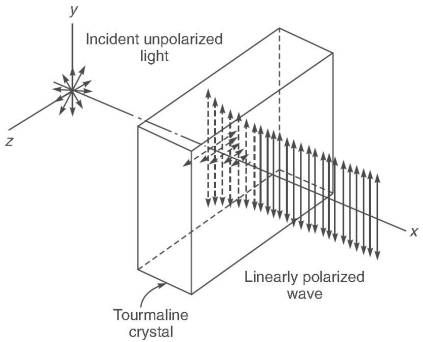
2. Polarization by Double Refraction:

When an unpolarized light enters an anisotropic crystal like calcite, it splits up into two linearly polarized beams.

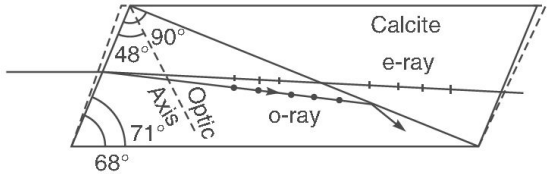
If one of the beam is eliminated, we can get linearly polarized light.

Two methods for elimination:

1. Selective absorption



2. Total internal reflection



2. Polarization by Scattering:

If the unpolarized beam is allowed to fall on a gas, then the beam scattered at 90^o to the incident beam in linearly polarized.