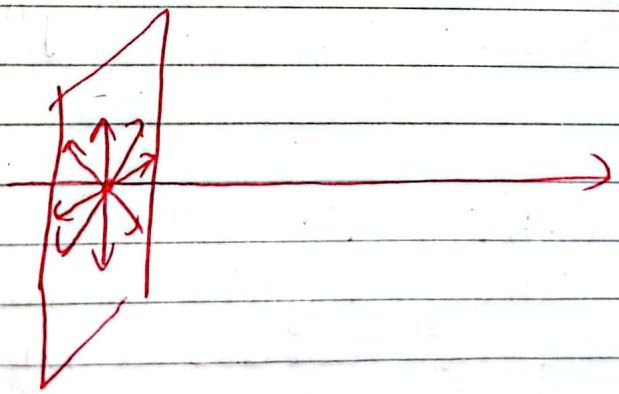
Polarization of light

The phenomenon of restriction of light to vibrate in a single direction is called polarisation of light.

Unpolarized light

Ordinary light, the vibration of electric field $\vec{E}$ occurs symmetrically in all direction in a plane perpendicular to the propagation of light.

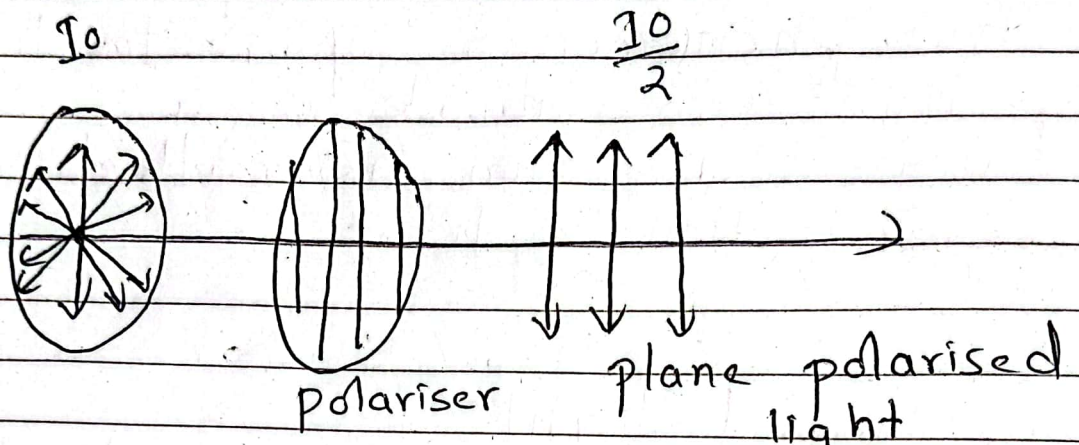


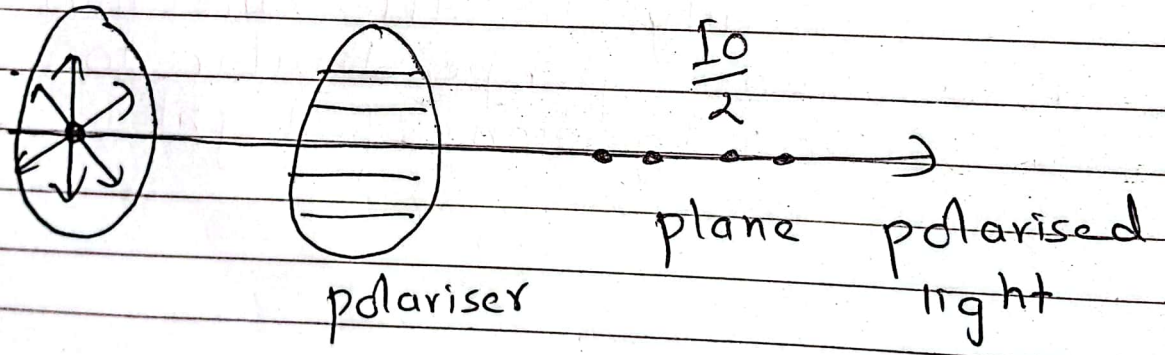
Polaroid / Polariser

→ Device used to produce plane polarised light

→ It consists of long chain of molecules aligned in a particular direction

Eg tourmaline crystal, Nicole prism.



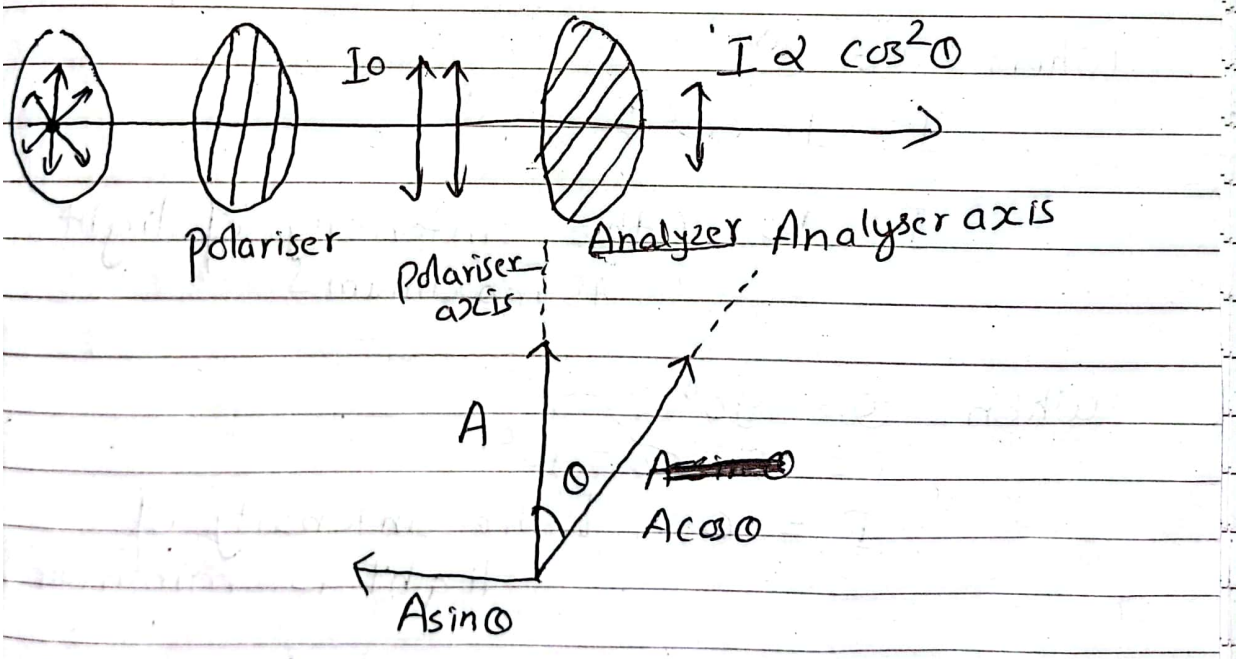


Polarised light

It is the light in which vibration of $\vec{E}$ occurs in only one direction in a plane perpendicular to the propagation of wave.

Malus law

According to malus, when plane polarized light is incident on the analyzer, the intensity 'I' of the transmitted light is directly proportional to the square of the cosine of angle between transmission axis of the analyzer and polariser ie $I = I_0 \cos^2\theta$



Suppose 'θ' be the angle between analyzer and polariser axis
If A is the amplitude of the electric vector transmitted by polariser then Io of the light comming from polariser

$I_0 \propto A^2$

$I_0 = A^2$ (1)

A can be resolved into two component ie $A\cos\theta$ and $A\sin\theta$
the analyzer will transmit only the component $A\cos\theta$ which is parallel to transmission axis

Hence

$$I \propto (A\cos\theta)^2$$

$$I = A^2\cos^2\theta$$

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

$$\boxed{I \propto \cos^2\theta}$$

When $\theta = 0^0$

$$I = I_0\cos^2 0$$

$I = I_0$ (the intensity of light is maximum)

When $\theta = 90^0$

$$I = I_0\cos^2 90^0$$

$I = 0$ [the intensity of light is minimum]

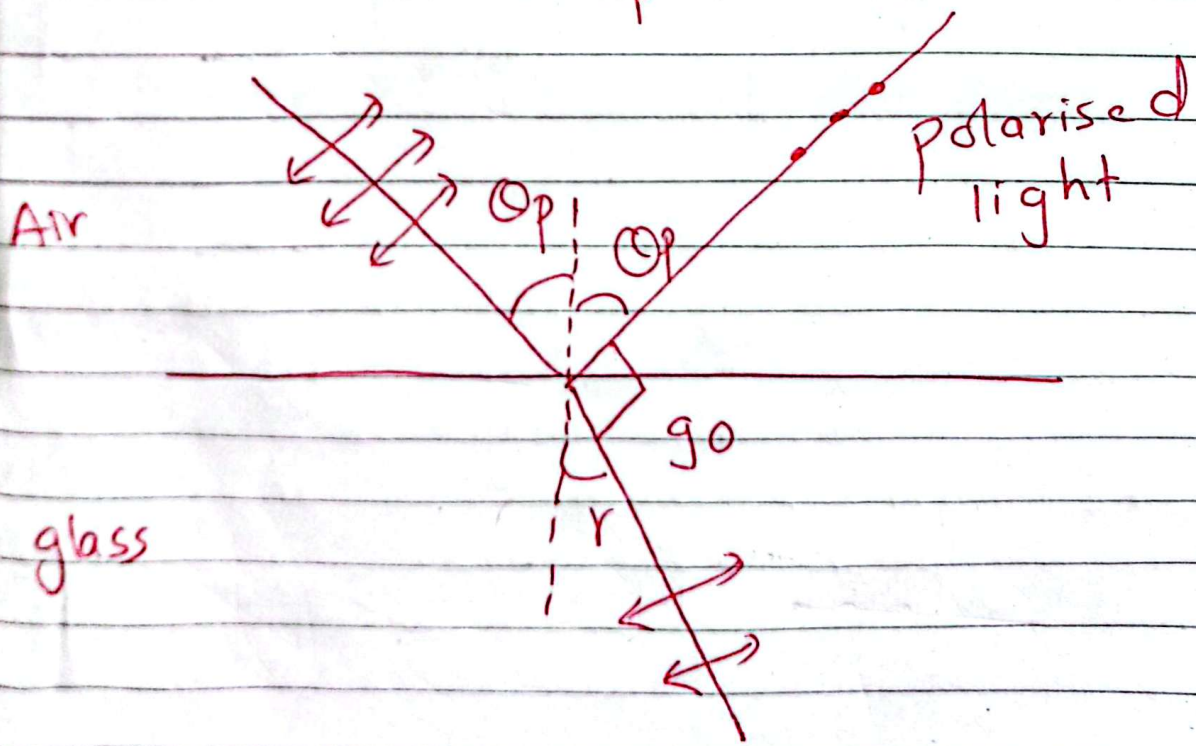
Brewster's law

The degree of polarisation of reflected light depends upon angle of incidence

At a particular angle of incidence when reflected ray is ⊥r to refracted ray then Reflected ray is plane polarised
This angle of incidence is called Brewster's angle or polarising angle (θ_p)

Statement: the tangent of angle of polarisation is equal to the refractive index.

$\mu = \tan \theta_p$



Here,

$\theta_p + 90 + r = 180^0$

$\theta_p + r = 90^0$

$r = 90 - \theta_p$ — (1)

Also,
from snell's law,

$$\mu = \frac{\sin i}{\sin r}$$

$$\mu = \frac{\sin \theta_p}{\sin (90 - \theta_p)} \quad [\because i = \theta_p]$$

$$\mu = \frac{\sin \theta_p}{\cos \theta_p}$$

$$\boxed{\mu = \tan \theta_p} \text{ — (2)}$$

proved