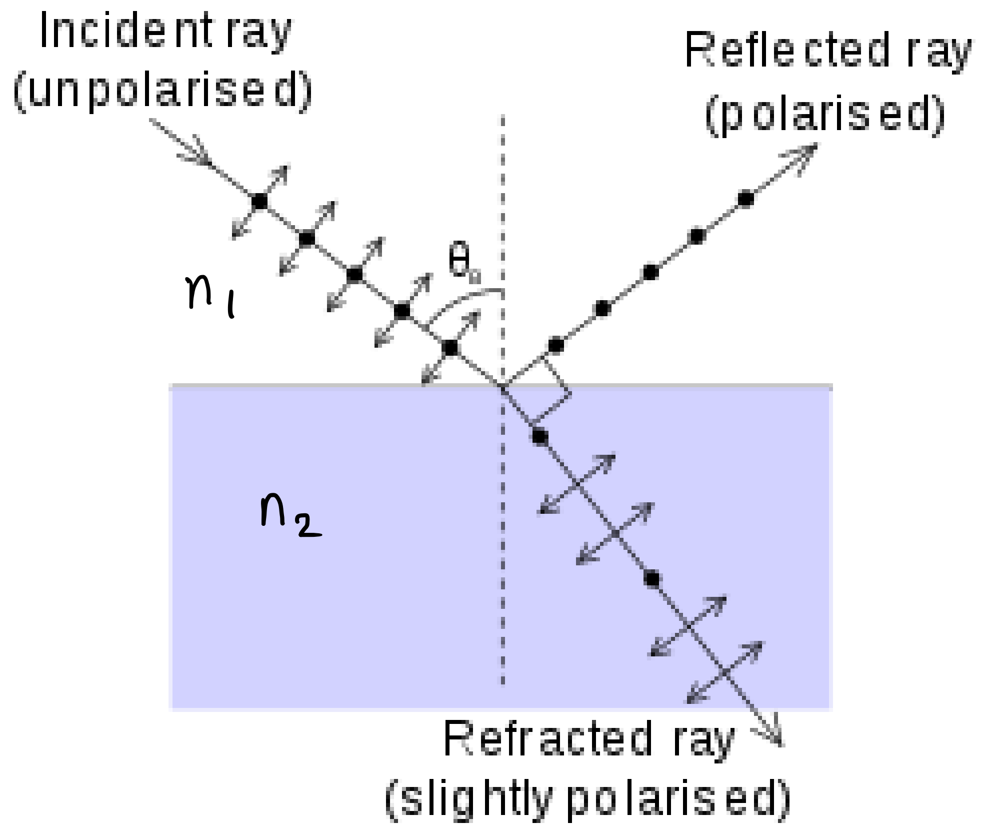
Polarization by Reflection

→ Incidence of an unpolarized beam on a dielectric turns it into a polarized wave



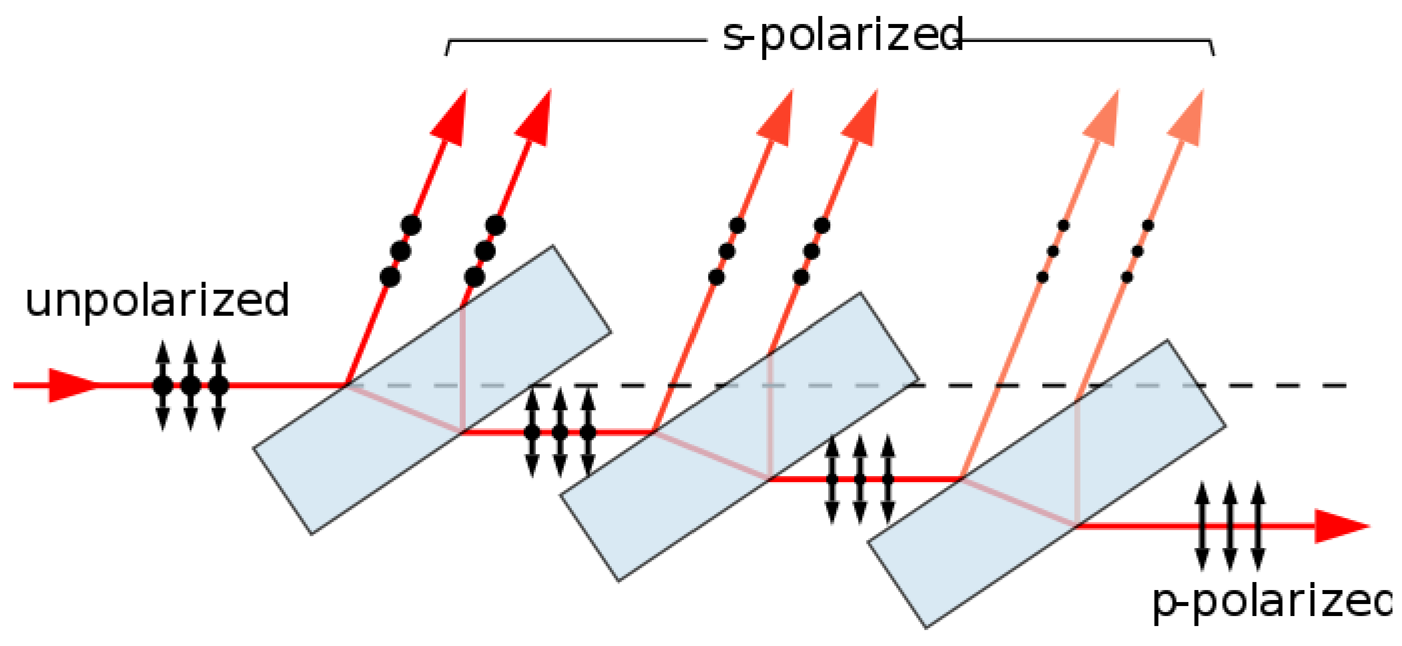
If light is incident at angle

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

→ reflected beam is completely linearly polarized ⊥ plane of incidence

$\theta_P \Rightarrow$ Brewster angle.

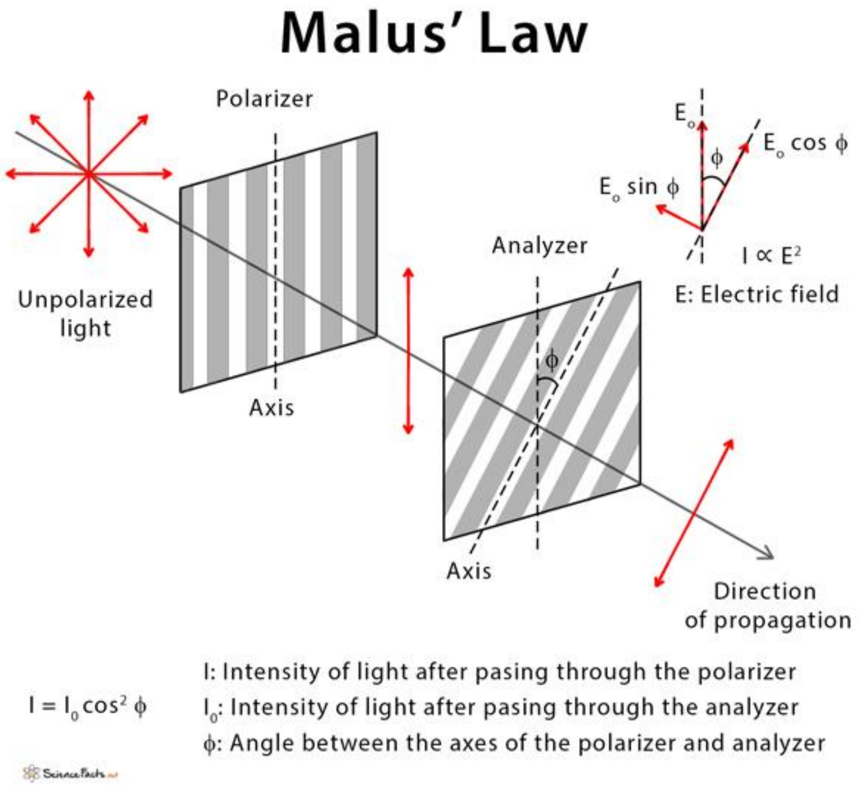
In particular, if light linearly polarized in the plane of ~~so~~ incidence. ~~so~~ is incident on the dielectric at $\angle\theta_P$ reflected beam is completely absent!



→ refraction through a stack of slabs/plates.

glass air, $n_1 = 1$, $n_2 = 1.5$ $\theta_p = 56^\circ$

air water $n_1 = 1$ $n_2 = 1.33$, $\theta_p = 53^\circ$.



Intensity after passing through analyzer

$I = I_0 \cos^2 \phi \longrightarrow$ Malus' Law.

Superposition of two disturbances

Let us consider the propagation of 2 linearly polarized EM waves (both propagating along z-axis)

$$\vec{E_1} = \hat{x}\, a_1 \cos(kz - \omega t + \theta_1)$$

$$\vec{E_2} = \hat{x}\, a_2 \cos(kz - \omega t + \theta_2)$$

Resultant vector $\vec{E_1} + \vec{E_2}$

$$\vec{E} = \hat{x}\, a \cos(kz - \omega t + \theta).$$

$$a = [a_1^2 + a_2^2 + 2 a_1 a_2 \cos(\theta_1 - \theta_2)]$$

→ resultant also linearly polarized wave in $\hat{x}$ direction

Case 1

$$\vec{E_1} = \hat{x}\, a \cos(kz - \omega t)$$
$$\vec{E_2} = \hat{y}\, b \cos(kz - \omega t + \theta)$$

$$\vec{E} = \vec{E_1} + \vec{E_2}$$

for $\theta = m\pi$ $(m = 0, \pm 1, \dots)$ resultant will also be a linearly polarized wave with $\vec{E}$ oscillating along a direction making angle with x axis depending on a, b.

fix attention to $z=0$ plane.

$$E_x = a \cos \omega t$$
$$E_y = (-1)^m b \cos \omega t$$

$$\boxed{\frac{E_x}{E_y} = \pm \frac{a}{b}}$$

$+$ m even
$-$ m odd

st line in E_x E_y plane

$\phi = \tan^{-1}(\pm a/b)$ with E_y axis for $\theta \neq m\pi$, resultant will not be linearly polarized

<u>Case 2</u>

$a = b$, $\theta = \pi/2$

$E_x = a\cos\omega t$

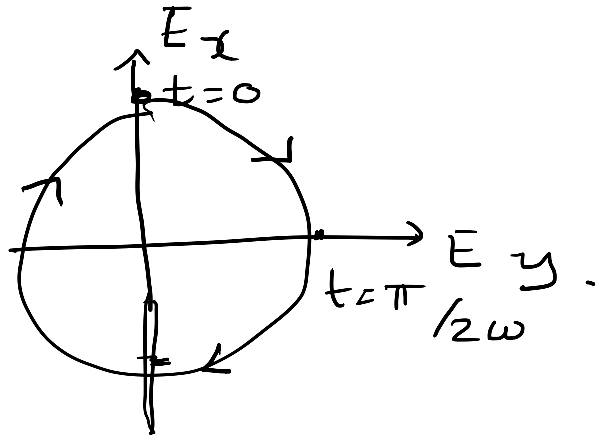
$E_y = a\sin\omega t$

$t = 0$, $E_x = a$, $E_y = 0$

$t = \frac{\pi}{2\omega}$ $E_x = 0$, $E_y = a$

$t = \frac{\pi}{\omega}$, $E_x = -a$, $E_y = 0$

$t = \frac{3\pi}{2\omega}$, $E_x = 0$, $E_y = 0$



tip moving on a circle clockwise

$\downarrow$

Right circularly polarized wave

RCP.

Case 3

$a = b$, $\theta = 3\pi/2$

$E_x = a\cos\omega t$

$E_y = -a\sin\omega t$

↳ LCP.

Case 4 :

$\theta \neq n\pi/2 \longrightarrow$ elliptical polarization

say $b = a$, $\theta = \pi/3$. $E_x = a\cos\omega t$, $E_y = a\cos(\omega t - \pi/3)$

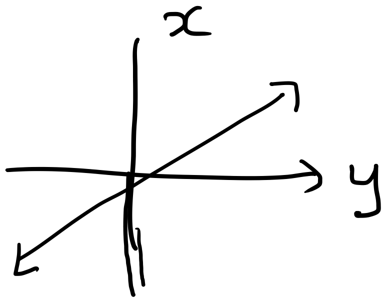
↓ Tip of resultant vector will rotate on ellipse clockwise

REP.

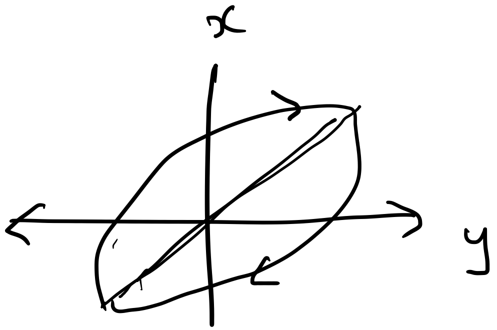
Case 5

$b = a$, $\theta = 2\pi/3$ $\longrightarrow$ ~~b~~ REP.

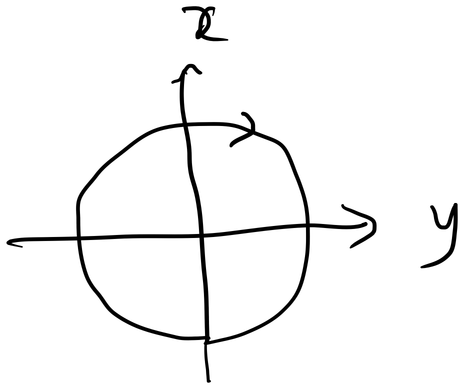
$a = b$



$\theta = 0$ LP



$\theta = \pi/3$ REP



$\theta = \pi/2$ RCP.

$\theta = 2\pi/3$
REP

$\theta = \pi$
LP

$\theta = 4\pi/3$
LEP

$\theta = 3\pi/2$
LCP

$\theta = 5\pi/3$
LEP

$\theta = 2\pi$
LP.

For $a=b$, the major/minor axis of ellipse makes an angle 45° with y-axis

when $a \neq b$ the major axis will make a diff angle with the y axis,

↓ In general elliptical polarization

but for $\theta = m\pi$ will degenerate into a st. line

linear polarization.