

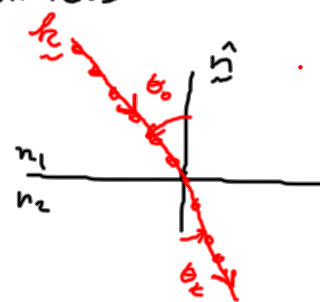
2/25/10 FRESNEL EQUATIONS → POLARIZED LIGHT

(1)

TE, ⊥, S

$$r_{TE} = \frac{n_1 \cos \theta_0 - n_2 \cos \theta_t}{n_1 \cos \theta_0 + n_2 \cos \theta_t}$$

$$t_{TE} = \frac{2n_1 \cos \theta_0}{n_1 \cos \theta_0 + n_2 \cos \theta_t}$$



$$\theta_t = \sin^{-1}\left(\frac{n_1}{n_2} \sin \theta_0\right)$$

TM, ||, P

$$r_{TM} = \frac{n_2 \cos \theta_0 - n_1 \cos \theta_t}{n_2 \cos \theta_0 + n_1 \cos \theta_t}$$

$$t_{TM} = \frac{2n_1 \cos \theta_0}{n_2 \cos \theta_0 + n_1 \cos \theta_t}$$

1/25 - (2)

R = REFLECTANCE \rightarrow RATIO OF REFLECTED TO INCIDENT POWER

$$= (r)^2$$

$$R_{TE} = r_{TE}^2$$

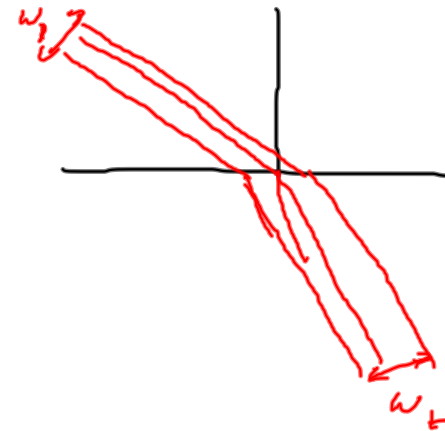
$$R_{TM} = r_{TM}^2$$

T TRANSMITTANCE

$$T = 1 - R$$

~~t_{TE}~~ $T_{TE} = (t_{TE})^2 \cdot \left(\frac{n_2 \cos \theta_2}{n_1 \cos \theta_1} \right)$

$$T_{TM} = (t_{TM})^2 \cdot \left(\frac{n_2 \cos \theta_2}{n_1 \cos \theta_1} \right)$$

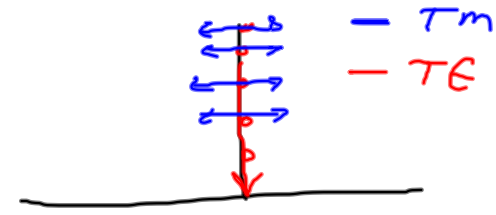


1/25 - ⑤

Normal Incidence

$$\theta_o = \theta_t = 0 \Rightarrow \cos \theta_o = \cos \theta_t = 1$$

$$r_{TE} = \frac{n_1 - n_2}{n_1 + n_2}$$



$$r_{TM} = \frac{n_2 - n_1}{n_2 + n_1} = -r_{TE}$$

RARE TO DENSE

$$n_1 = 1$$

$$n_2 = 1.5$$



$$r_{TE} = \frac{1 - 1.5}{1 + 1.5} = -0.2 = 0.2 \cdot e^{+it\pi}$$



$$r_{TM} = +0.2 \quad R_{TE} = R_{TM} = (0.2)^2 = 4\%$$

Normal Incidence

1/25 - ②

$$t_{TE} = \frac{2n_1}{n_1 + n_2} = \frac{2 \cdot 1}{2.5} = 0.8$$

$$t_{TM} = \frac{2n_1}{n_1 + n_2} = 0.8$$

$$T = t^2 \cdot \frac{n_2}{n_1} = 0.64 \cdot 1.5 = 0.96 = 1 - R$$

DENSE TO RARE $n_1 = 1.5$ $n_2 = 1.0$

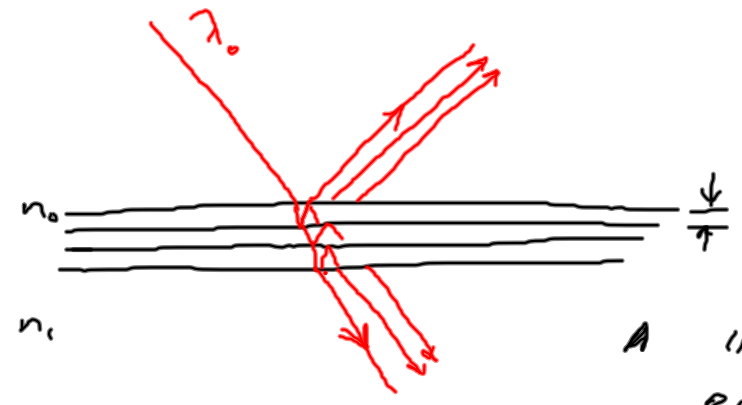
$$r_{TE} = +0.2$$

$$r_{TM} = -0.2$$

$$R_{TE} = R_{TM} = 0.04$$

$$T_{TM} = T_{TE} = 0.96$$

1/25 - 5



A IF PHASES OF TRANSMITTED RAYS "MATCH" \Rightarrow MORE TRANSMITTED LIGHT
ANTI-REFLECTION COATING - AR COAT

Brewster's Angle $r_{TM} = 0 \Rightarrow R_{TM} = 0 \Rightarrow R_{TE} = 1$
 $T_{TM} = 1$

$$r_{TM} = \frac{n_2 \cos \theta_0 - n_1 \cos \theta_t}{n_2 \cos \theta_0 + n_1 \cos \theta_t} = 0$$

$$n_2 \cos \theta_0 = n_1 \cos \theta_t$$

Snell's Law

$$n_1 \sin \theta_0 = n_2 \sin \theta_t$$

$$\boxed{r_{TM} = 0} \Rightarrow \theta_o = \theta_B = \text{BREWSTER'S ANGLE} \quad 1/25 - (6)$$

$$n_2^2 \cos^2 \theta_o = n_1^2 \cos^2 \theta_t \Rightarrow \cos^2 \theta_t = \left(\frac{n_2}{n_1}\right)^2 \cos^2 \theta_o$$

$$n_1^2 \sin^2 \theta_o = n_2^2 \sin^2 \theta_t \Rightarrow \underline{\sin^2 \theta_t = \left(\frac{n_1}{n_2}\right)^2 \sin^2 \theta_o}$$

$$\nabla \cos^2 \theta_t + \sin^2 \theta_t = 1 = \cos^2 \theta_o + \sin^2 \theta_o = \left(\frac{n_2}{n_1}\right)^2 \cos^2 \theta_o + \left(\frac{n_1}{n_2}\right)^2 \sin^2 \theta_o$$

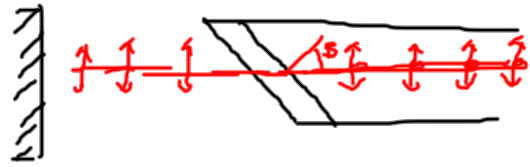
$$\text{DEFINE } \theta_o = \theta_B \text{ IF } r_{TM} = 0$$

$$\cos^2 \theta_B - \left(\frac{n_2}{n_1}\right)^2 \cos^2 \theta_B = \left(\frac{n_1}{n_2}\right)^2 \sin^2 \theta_B - \sin^2 \theta_B$$

$$\cos^2 \theta_B \left(1 - \left(\frac{n_2}{n_1}\right)^2\right) = \sin^2 \theta_B \left(\left(\frac{n_1}{n_2}\right)^2 - 1\right)$$

$$\cos^2 \theta_B \left(\frac{n_1^2 - n_2^2}{n_1^2}\right) = \sin^2 \theta_B \left(\frac{n_1^2 - n_2^2}{n_2^2}\right)$$

$$\frac{\sin^2 \theta_B}{\cos^2 \theta_B} = \left(\frac{n_2}{n_1}\right)^2 \Rightarrow \tan^2 \theta_B = \frac{n_2^2}{n_1^2} \Rightarrow \theta_B = \tan^{-1}\left(\frac{n_2}{n_1}\right)$$



$$\theta_B \text{ if } n_1 = 1, n_2 = 1.5$$

$$\theta_B = \text{TAN}^{-1}(1.5) = 56.3^\circ$$

$$\theta_B = \text{TAN}^{-1}\left(\frac{1}{1.5}\right) \approx 36^\circ$$

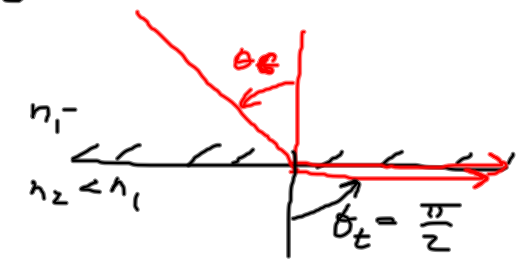
1/25 =

CRITICAL ANGLE DENSE TO RARE

$$r_{TM} = \frac{n_2 \cos \theta_o - n_1 \cos \theta_t}{n_2 \cos \theta_o + n_1 \cos \theta_t}$$

$$\theta_t = \frac{\pi}{2} \Rightarrow \cos \theta_t = 0$$

$$r_{TM} = \frac{n_2 \cos \theta_o}{n_2 \cos \theta_o} = 1$$



$$n_1 \sin \theta_o = n_2 \sin \theta_t = n_2 \cdot 1$$

$$n_1 \sin \theta_c = n_2 \Rightarrow \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

1/25-8

BROWSTER'S ANGLE $\theta_B = \tan^{-1}\left(\frac{n_2}{n_1}\right)$

(DENSE-TO-RARE AND RARE-TO-DENSE)

CRITICAL ANGLE $\theta_C = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

FOR DENSE-TO-RARE \Rightarrow ~~NO~~ NO TRANSMITTED RAY

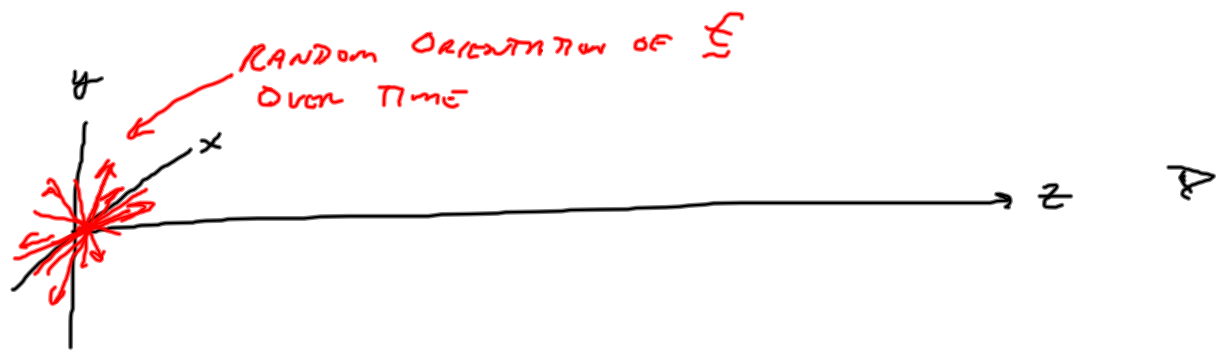
\Rightarrow 100% REFLECTANCE

\Rightarrow TOTAL INTERNAL REFLECTION



POLARIZED LIGHT

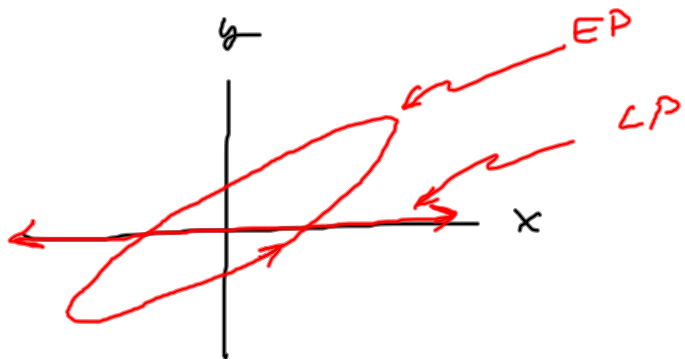
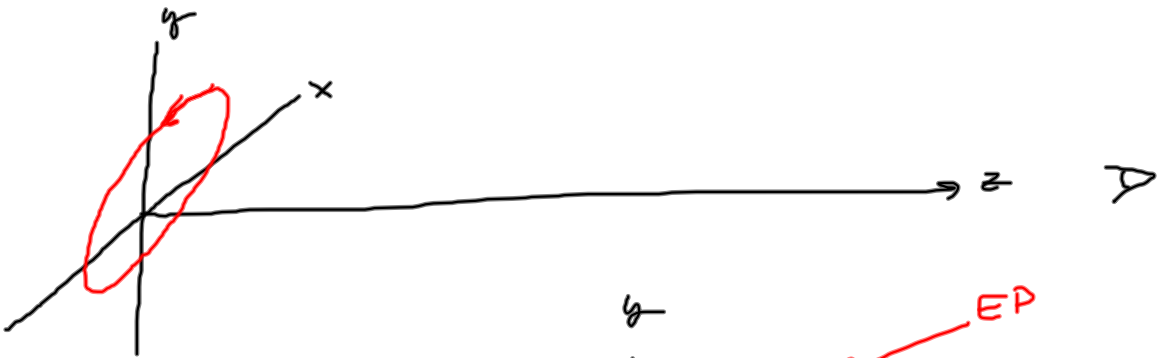
DOMINANT ~~SEE~~ ORIENTATION OF E VECTOR



UNPOLARIZED LIGHT \Rightarrow NATURAL LIGHT



LINEAR POLARIZATION
= PLANE POLARIZATION



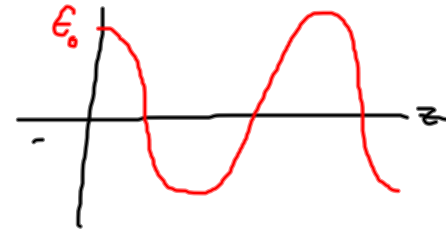
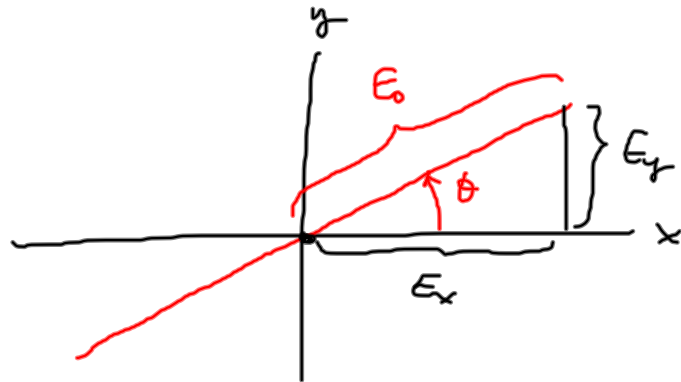
PLANE WAVE
 PROPAGATE DOWN Z \Rightarrow OSCILLATIONS IN X AND/OR Y

$$\begin{aligned}
 \underline{E}(x, y, z, t) &= \left(\hat{x} E_x + \hat{y} E_y \right) \cos(k_0 z - \omega_0 t + \phi_0) \\
 &= \left(\hat{x} E_x + \hat{y} E_y \right) \cos\left(2\pi\left(\frac{z}{\lambda_0} - \nu_0 t\right) + \phi_0\right)
 \end{aligned}$$

↑
IGNORE

1/25 (11)

LP $\hat{x} E_x + \hat{y} E_y$ IN SAME PLANE



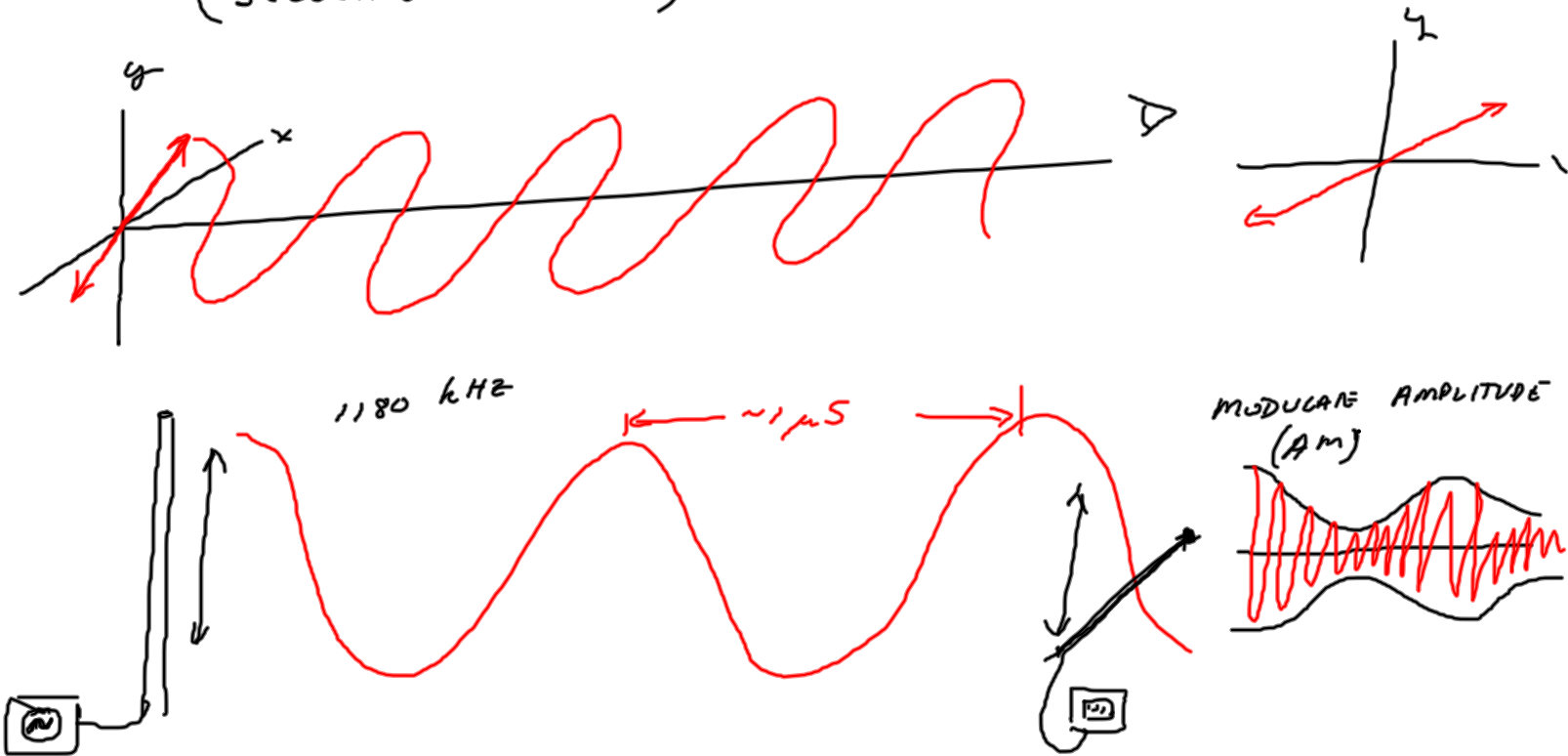
$$\left. \begin{aligned} E_x &= E_0 \cos \theta \\ E_y &= E_0 \sin \theta \end{aligned} \right\} \theta = \text{"ANGLE OF POLARIZATION"} \\ &= \text{TAN}^{-1} \left[\frac{E_y}{E_x} \right]$$

E_x AND E_y ARE "IN PHASE"

1/25 - (2)

GENERATION OF LP

(1) CONSTRAIN ELECTRON DIRECTION OF MOTION AT SOURCE
("SELECTIVE EMISSION")



1/25/13



TOP VIEW

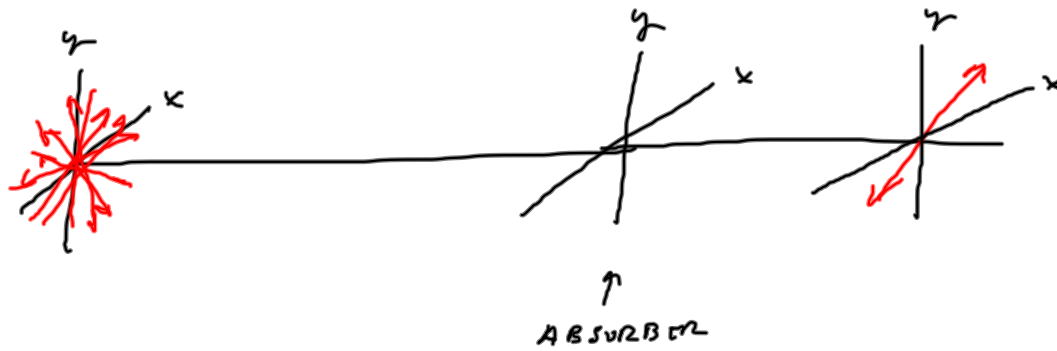
POLARIZED
"LIGHT"



LITTLE SIGNAL
MORE SIGNAL

1/25 - (14)

② SELECTIVE ABSORPTION



EDMUND LAND → POLAROID



③ SELECTIVE REFLECTION

BREWSTER'S ANGLE

$r_{TM} = 0$ AT BREWSTER'S ANGLE

ONLY TE IS REFLECTED

④ POLARIZATION BY SCATTERING

