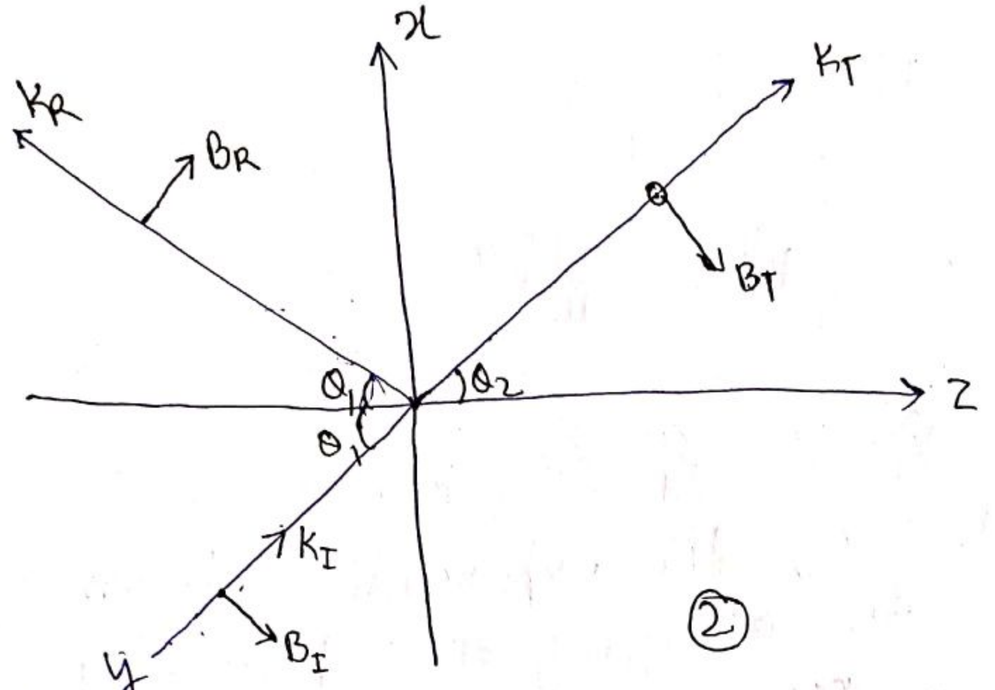
(b) perpendicular polarization:-



When the e.f. is perpendicular to the plane of incidence (x-z plane) i.e. electric field is in y-direction. we have perpendicular polarization

The fields for incidence, reflected & transmitted waves are:

$$\vec{E}_I = \tilde{E}_{0I}\, e^{i(\hat{k}_I \cdot \vec{r} - \omega t)}\, \hat{y}$$

$$\vec{B}_I = \frac{1}{v_1} \tilde{E}_{0I}\, e^{i(\hat{k}_I \cdot \vec{r} - \omega t)} \cdot (-\cos\theta_1 \hat{x} + \sin\theta_1 \cdot \hat{z}) \quad \text{——— (1)}$$

$$\vec{E}_R = \tilde{E}_{0R}\, e^{i(\hat{k}_R \cdot \vec{r} - \omega t)}\, \hat{y}$$

$$\vec{B}_R = \frac{1}{v_1} \tilde{E}_{0R}\, e^{i(\hat{k}_R \cdot \vec{r} - \omega t)} \cdot (\cos\theta_1 \hat{x} + \sin\theta_1 \hat{z}) \quad \text{——— (2)}$$

$$\vec{E}_T = \tilde{E}_{0T}\, e^{i(\hat{k}_T \cdot \vec{r} - \omega t)}\, \hat{y}$$

$$\vec{B}_T = \frac{1}{v_2} \tilde{E}_{0T}\, e^{i(\hat{k}_T \cdot \vec{r} - \omega t)} \cdot (-\cos\theta_2 \hat{x} + \sin\theta_2 \hat{z}) \quad \text{——— (3)}$$

On applying boundary cond^{ns}:-

(i) $\epsilon_1 E_1^{\perp} = \epsilon_2 E_2^{\perp}$

(ii) $B_1^{\perp} = B_2^{\perp}$

(iii) $E_1^{\parallel} = E_2^{\parallel}$ ——— (4)

(iv) $\frac{1}{\mu_1} B_1^{\parallel} = \frac{1}{\mu_2} B_2^{\parallel}$

Since,

$$\hat{K_I} \cdot \vec{r} = \hat{K_R} \cdot \vec{r} = \hat{K_T} \cdot \vec{r} = \omega$$

at $z=0$, the exponential term can be ignored in applying the boundary cond^{ns}.

Conditions (iii) gives:

$$\frac{1}{v_1} \cdot \tilde{E}_{0I} \sin\theta_1 + \frac{1}{v_1} \cdot \tilde{E}_{0R} \sin\theta_1 = \frac{1}{v_2} \tilde{E}_{0T} \sin\theta_2$$

$$\tilde{E}_{0I} + \tilde{E}_{0R} = \frac{v_1 \sin\theta_2}{v_2 \sin\theta_1} \tilde{E}_{0T}$$

$$\boxed{\tilde{E}_{0I} + \tilde{E}_{0R} = \tilde{E}_{0T}} \quad \text{——— (5)}$$

Cond^{ns} (iv) gives -

$$\frac{1}{\mu_1}\left[\frac{1}{v_1} \tilde{E}_{0I}(-\cos\theta_1) + \frac{1}{v_1} \tilde{E}_{0R} \cos\theta_1\right] = \frac{1}{\mu_2}\left(\frac{1}{v_2} \tilde{E}_{0T}\right)(-\cos\theta_2)$$

or,

$$\tilde{E}_{0I} - \tilde{E}_{0R} = \left(\frac{\mu_1 v_1 \cos\theta_2}{\mu_2 v_2 \cos\theta_1}\right) \tilde{E}_{0T}$$

or,

$$\boxed{\tilde{E}_{0I} - \tilde{E}_{0R} = \alpha\beta\, \tilde{E}_{0T}} \quad \text{——— (6)}$$

where, $\alpha = \frac{\cos\theta_2}{\cos\theta_1}$ & $\beta = \frac{\mu_1 v_1}{\mu_2 v_2}$

Solving eqⁿ ⑤ & ⑥, we get

$$\boxed{\begin{aligned} \tilde{E}_{0R} &= \left(\frac{1-\alpha\beta}{1+\alpha\beta}\right)\tilde{E}_{0I} \\ \& \quad \tilde{E}_{0T} &= \left(\frac{2}{1+\alpha\beta}\right)\tilde{E}_{0I} \end{aligned}} \qquad \text{———} (7)$$

These are Fresnel's equations for polarization perpendicular to plane of incidence.

Since, α & β are positive the quantity $\frac{2}{1+\alpha\beta}$ is also positive. Hence, transmitted waves is in phase with the incident wave. the reflected wave is "in phase" if α, β is less than 1 and 180° "out of phase" if α, β greater than 1.

I, The Reflection & transmission Coeff. are given by:

$$'R' = \left(\frac{\tilde{E}_{0R}}{\tilde{E}_{0I}}\right)^2 = \left(\frac{1-\alpha\beta}{1+\alpha\beta}\right)^2$$

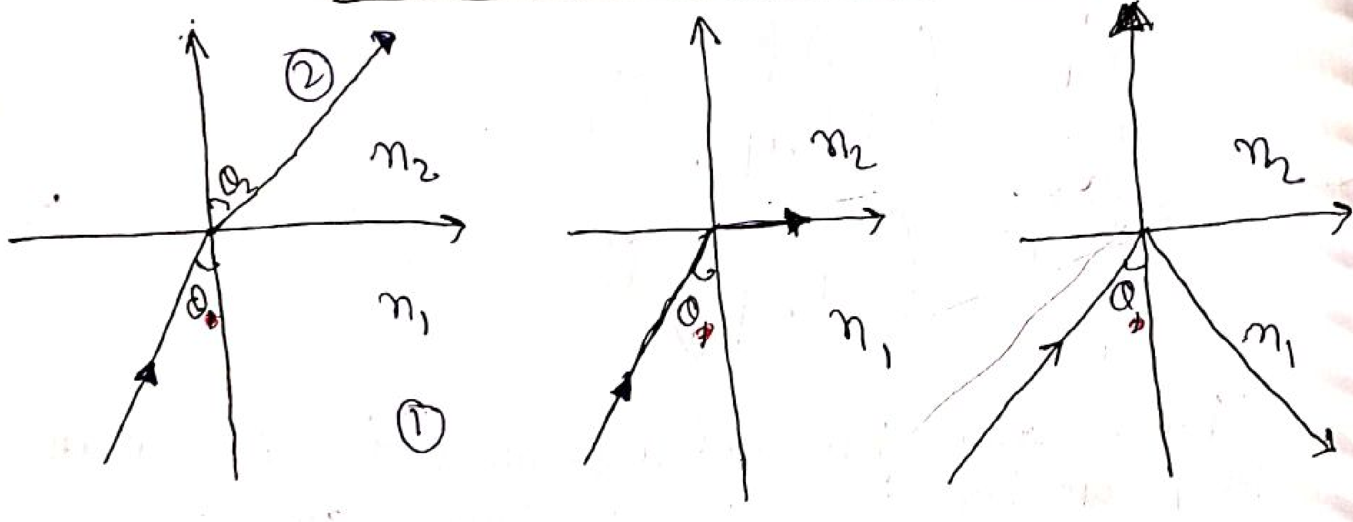
$$'T' = \left(\frac{\tilde{E}_{0T}}{\tilde{E}_{0I}}\right)^2 \cdot \frac{\epsilon_2 v_2}{\epsilon_1 v_1} \frac{\cos\theta_2}{\cos\theta_1}$$

$$= \alpha\beta \cdot \left(\frac{2}{1+\alpha\beta}\right)^2 \qquad \left\{\alpha = \frac{\cos\theta_2}{\cos\theta_1}\right\}$$

& add both of them,

$$\boxed{R+T=1}$$

Total Internal Reflection



$\theta < \theta_c$ $\qquad$ $\theta = \theta_c$ $\qquad$ $\theta > \theta_c$

When light travels from an optically dense medium of refractive index n_1 to a less dense medium of a refractive index n_2 $(n_1 > n_2)$ Then refraction occurs. Since, angle of Refraction is greater than angle of incidence.

With increase in angle of incidence the angle of Refraction also increases and at a particular angle of incidence the refracted ray grazes the interface. This angle of incidence is called Critical angle. $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

When, angle of incidence is further increased the ray is reflected back in medium ① this pheomenon is called total internal reflection. but the fields are not zero in medium ②. Such

(a wave is called 'evanescent wave'. which is rapidly attenuated and transport no energy in medium.)

Polarization

polarization of plane e.m. waves is defined as the time varying behaviour of e.f vector $\vec{E}$ at some fixed point in space along the direction of propogation. There are three types of polarization:-

(i) Linear polarization
(ii) Circular polarization
(iii) eliptical polarization

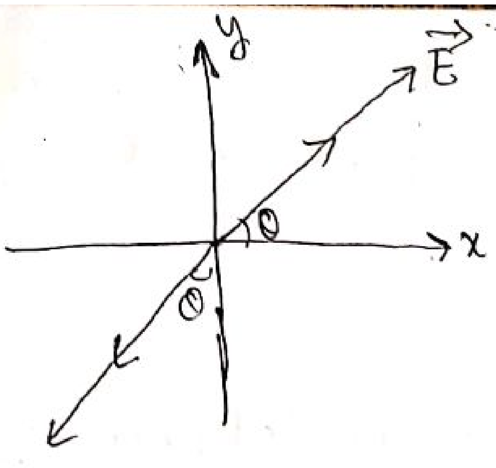
Let us, Consider a plane wave travelling in z-direction the field vectors $\vec{E}$ & $\vec{H}$ lies in xy-plane, which is perpendicular to the direction of propogation

Linear polarization:- Let the e.f. $\vec{E}$ has only x-comp and y comp of $\vec{E}$ is zero then wave is said to be linearly polarized in x-direction and vice versa.

If both comp. of $\vec{E}$ are present and in phase but having different amplitudes the angle made by $\vec{E}$ with x-axis is

$$\theta = \tan^{-1}\left(\frac{E_y}{E_x}\right)$$

this angle is constant w.r. to time, i.e. resultant vector $\vec{E}$ is oriented in a direction



which is constant in time. Therefore, when components E_x and E_y are in phase with either equal or unequal amplitudes for a plane wave travelling in z- direction.

The polarization is linear