EE 303 Final Examination

January 13, 2022

Duration: 160 min

Simple calculators are allowed.

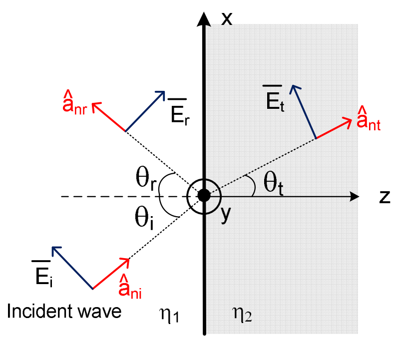
Mobile Phones must be turned off and kept away from you during the exam.

Give your answers neatly showing all necessary DETAILS!

Use proper VECTOR notations! Provide UNITs!

Fresnel Formulas :

E // Plane of Incidence Case

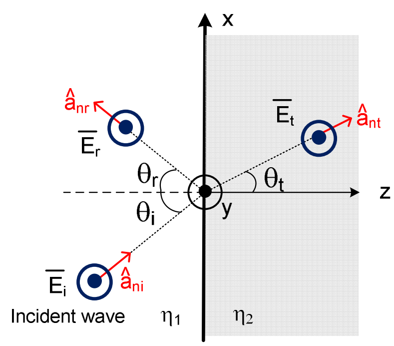


$$\Gamma_{//} = \frac{\eta_2 \cos\theta_t - \eta_1 \cos\theta_i}{\eta_2 \cos\theta_t + \eta_1 \cos\theta_i}$$

$$T_{//} = \frac{\cos\theta_i}{\cos\theta_t}\left(1 + \Gamma_{//}\right)$$

$$\sin\theta_B^{//} = \sqrt{\frac{1-(\varepsilon_1\mu_2/\mu_1\varepsilon_2)}{1-(\varepsilon_1/\varepsilon_2)^2}}$$

E ⊥ Plane of Incidence Case



$$\Gamma_{\perp} = \frac{\eta_2 \cos\theta_i - \eta_1 \cos\theta_t}{\eta_2 \cos\theta_i + \eta_1 \cos\theta_t}$$

$$T_{\perp} = 1 + \Gamma_{\perp}$$

$$\sin\theta_B^{\perp} = \sqrt{\frac{1-(\mu_1\varepsilon_2/\varepsilon_1\mu_2)}{1-(\mu_1/\mu_2)^2}}$$

Lorentz condition in time domain

$$\overline{\nabla}\cdot\overline{A} = -\mu\in\frac{\partial V}{\partial t}$$

Propagation constant and intrinsic impedance of lossy medium

$$\gamma = \sqrt{j\omega\mu\left(\sigma + j\omega\in\right)}$$

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}}$$

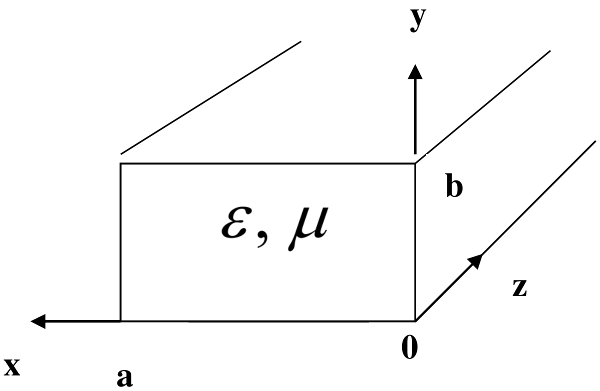
For good conductor

$$\beta \approx \sqrt{\pi f\mu\sigma}$$

For low loss dielectric

$$\beta \approx \omega\sqrt{\mu\epsilon'}$$

Name, Surname:



Wave impedance of WG

$$Z = \frac{E_x}{H_y} = -\frac{E_y}{H_x}$$

Expression of the propagation constant for this rectangular waveguide is given as

$$\gamma = \sqrt{\underbrace{(\frac{m\pi}{a})^2 + (\frac{n\pi}{b})^2}_{h^2} - k^2} = \alpha + \beta j \qquad k \to \omega\sqrt{\varepsilon\mu}$$

Fields for TM modes: → H_z yok

$$E_z = E_o \sin(\frac{m\pi}{a}x)\sin(\frac{n\pi}{b}y)e^{-\gamma z}$$

0 0 olamaz ⇐

$$E_x = -\frac{\gamma}{h^2}(\frac{m\pi}{a})E_o\cos(\frac{m\pi}{a}x)\sin(\frac{n\pi}{b}y)e^{-\gamma z}$$

$$E_y = -\frac{\gamma}{h^2}(\frac{n\pi}{b})E_o\sin(\frac{m\pi}{a}x)\cos(\frac{n\pi}{b}y)e^{-\gamma z}$$

$$H_x = \frac{j\omega\varepsilon}{h^2}(\frac{n\pi}{b})E_o\sin(\frac{m\pi}{a}x)\cos(\frac{n\pi}{b}y)e^{-\gamma z}$$

$$\cancel{H_y = -\frac{j\omega\varepsilon}{h^2}(\frac{m\pi}{a})E_o\cos(\frac{m\pi}{a}x)\sin(\frac{n\pi}{b}y)e^{-\gamma z}}$$

$$\lambda = \frac{2\pi}{k} = \qquad k \to \beta_{mn}$$

$$v_{p_{mn}} = \lambda \cdot f$$

$$\frac{2\pi \cdot f}{\beta_{m,n}} = v_{p_{mn}}$$

$$h^2 = k^2_{c,mn} = \left[\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2\right]$$

Fields for TE modes: → E_z yok

$$H_z = H_o\cos(\frac{m\pi}{a}x)\cos(\frac{n\pi}{b}y)e^{-\gamma z}$$

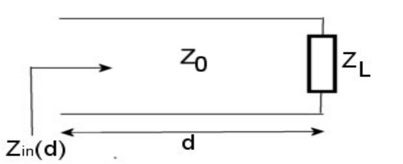
$$H_x = \frac{\gamma}{h^2}(\frac{m\pi}{a})H_o\sin(\frac{m\pi}{a}x)\cos(\frac{n\pi}{b}y)e^{-\gamma z}$$

$$H_y = \frac{\gamma}{h^2}(\frac{n\pi}{b})H_o\cos(\frac{m\pi}{a}x)\sin(\frac{n\pi}{b}y)e^{-\gamma z}$$

$$E_x = \frac{j\omega\mu}{h^2}(\frac{n\pi}{b})H_o\cos(\frac{m\pi}{a}x)\sin(\frac{n\pi}{b}y)e^{-\gamma z}$$

$$E_y = -\frac{j\omega\mu}{h^2}(\frac{m\pi}{a})H_o\sin(\frac{m\pi}{a}x)\cos(\frac{n\pi}{b}y)e^{-\gamma z}$$

TE_{01} and TE_{10} ⇒ mn ⇒ TM mode ‖ den başlıyor



$$Z_{in}(d) = Z_0\frac{Z_L + jZ_0\tan\beta d}{Z_0 + jZ_L\tan\beta d}$$

$$v_{g_{mn}} = \frac{d\omega}{d\beta_{mn}}$$

$$v_{g_{mn}} \cdot v_{p_{mn}} = \frac{1}{\mu.\varepsilon} = c^2$$

For air and free space

$\mu_0 = 4\pi 10^{-7}$ H/m $\varepsilon_0 = \frac{10^{-9}}{36\pi}$ F/m