2021

1.

(a)

$$\angle \frac{E}{H} = 20^\circ \Rightarrow \frac{1}{2}\tan^{-1}(\tan\delta) = 20^\circ \Rightarrow \underline{\tan\delta = 0.8391} \ \#$$

(b)

$$-20\log(1-0.2) = 1.938 \ dB/m \Rightarrow 0.2231 \ Np/m = \alpha$$

$$\gamma = \sqrt{-\omega^2\mu_0\varepsilon_e} = \alpha + j\beta \ , \quad \varepsilon_e = \varepsilon - j\frac{\sigma}{\omega} = \varepsilon\left(1 - j\frac{\sigma}{\varepsilon\omega}\right)$$

$$= j\omega\sqrt{\mu_0}\cdot\sqrt{\varepsilon}\cdot\sqrt{1-j\tan\delta}$$

$$= \omega\sqrt{\mu_0}\cdot\sqrt{\varepsilon}\cdot(0.39 + j1.07)$$

$$\beta = \alpha\cdot\frac{1.07}{0.39} = \underline{0.612 \ rad/m} \ \#$$

(c)

$$\gamma^2 = \alpha^2 - \beta^2 + \underline{j2\alpha\beta} = -\omega^2\mu_0\varepsilon + \underline{j\omega\mu_0\sigma}$$

$$\sigma = \frac{2\alpha\beta}{\omega\mu_0} = \underline{1.73\times10^{-3} \ S/m} \ \#$$

(d)

$$\frac{\sigma}{\varepsilon\omega} = \tan\delta \Rightarrow \varepsilon = \frac{\sigma}{\tan\delta\cdot\omega} = \underline{1.64\times10^{-11} \ F/m} \ \#$$

(e)

$$\eta = \sqrt{\frac{\mu_0}{\varepsilon_e}} = \sqrt{58697.54\angle 40^\circ} = \underline{242 \ \angle 20^\circ \ \Omega}$$

#

2.

(a) $\hat{k} = -0.6\hat{a}_y + 0.8\hat{a}_z$

$$|k| = \omega\sqrt{\mu_0\varepsilon_0} = \sqrt{0.6^2+0.8^2}$$

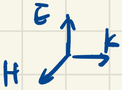
$$\Rightarrow f = 47.7\ \text{MHz}$$ #

(b) $\hat{a}_k = -0.6\hat{a}_y + 0.8\hat{a}_z$ #

(c)

$$\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 120\pi$$

$$|H| = \frac{|E|}{\eta_0} = \frac{10}{\eta_0} = \frac{1}{12\pi}$$

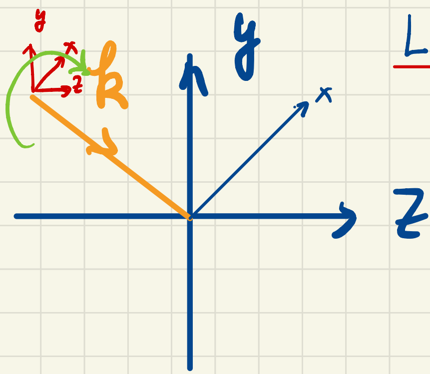


$$\hat{a}_k \times \hat{a}_E = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ 0 & -0.6 & 0.8 \\ 1 & 0.4j & 0.3j \end{vmatrix}$$

$$\hat{a}_H = -0.5j\,\hat{a}_x + 0.8\,\hat{a}_y + 0.6\,\hat{a}_z$$

$$\vec{H} = \frac{1}{12\pi}\left(-0.5j\,\hat{a}_x + 0.8\,\hat{a}_y + 0.6\,\hat{a}_z\right)e^{j(0.6y-0.8z)}$$ #

(d)



LHEP #

3.

(a)

$$\varepsilon_e = \frac{\sigma + j\omega\varepsilon}{j\omega} = \varepsilon - \frac{j\sigma}{\omega} = (4-0.2j)\varepsilon_0$$

$$\gamma_2 = \sqrt{-\omega^2\mu\varepsilon_e} = \sqrt{142497\angle 177.14}$$

$$= 377.49\angle 88.57 = 9.42 + 377.37j$$

$$\delta = \frac{1}{\alpha} = \frac{1}{9.42} = 10.6\ \text{cm}$$ #

$$\lambda = \frac{2\pi}{\beta} = 1.67\ \text{cm}$$ #

(b)

$$\eta_2 = \sqrt{\frac{\mu_0}{\varepsilon_e}} = \sqrt{35437\angle 2.86^\circ}$$

$$= 189\angle 1.43^\circ$$

$$\eta_0 = 120\pi$$

$$\gamma l = 0.5 + 20j$$

$$\tanh(\gamma l) = \frac{\overset{A}{e^{\gamma l}} - \overset{B}{e^{-\gamma l}}}{e^{\gamma l} + e^{-\gamma l}}$$

$$= 1.34 + 0.85j \quad C$$

$$\eta_{in} = \eta_2\,\frac{\eta_0 + \eta_2\tanh(\gamma l)}{\eta_2 + \eta_0\tanh(\gamma l)}$$

$$= 158 - j24.3\ \Omega$$ #

(c)

$$\Gamma = \frac{\eta_{in} - \eta_0}{\eta_{in} + \eta_0} = 0.414\angle -171^\circ$$ #

$$\cosh(\gamma l) = \frac{\overset{A}{e^{\gamma l}} + \overset{B}{e^{-\gamma l}}}{2} = C$$

$$\sinh(\gamma l) = \frac{A-B}{2} = D$$

$$T = \frac{1+\Gamma}{\cosh(\gamma l) + \frac{\eta_2}{\eta_0}\cdot\sinh(\gamma l)} = 0.52\angle -67.2^\circ$$ #

4.

(a)

$k_i = 4\hat{a}_y + 3\hat{a}_z$, $\theta_i = 36.87°$

$|k_i| = w\sqrt{\mu_0\varepsilon} = 5 \Rightarrow w = 10^9$ rad/s

$k_t = w\sqrt{\mu\varepsilon}$

$\Rightarrow k_i \sin\theta_i = k_t \sin\theta_t$

$\Rightarrow \sin\theta_t = \frac{k_i}{k_t}\sin\theta_i = \sqrt{2.25}\sin\theta_i$

$\Rightarrow \theta_t = 64.16°$

TM mode:

$$\begin{cases} \eta_i \cos\theta_i = 201 & A \\ \eta_t \cos\theta_t = 164.2 & B \end{cases} \Rightarrow \Gamma = -0.1$$

$\Rightarrow T = \frac{2\eta_t \cos\theta_i}{A + B} = 1.651$

$|E_r| = 10 \cdot 0.1 = 1$ V/m

$\Rightarrow \vec{E}_r = (-0.6\hat{a}_y - 0.8\hat{a}_z) \cdot \sin(10^9 t + 4y - 3z)$ V/m #

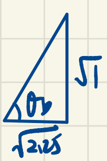
$|E_t| = 10 \times 1.651 = 16.51$ C

$k_t = x\hat{a}_y + 3\hat{a}_z$, $|k_t| = \frac{10}{3}$

$= 1.45\hat{a}_y + 3\hat{a}_z$

$\Rightarrow \vec{E}_t = (-14.86\hat{a}_y + 7.2\hat{a}_z) \cdot \sin(10^9 t - 1.45\hat{a}_y - 3\hat{a}_z)$ V/m #

(b)



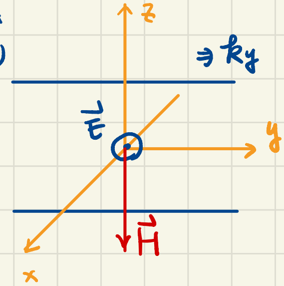
$\theta_b = 33.7°$ #

$\sin\theta_c = \frac{k_t}{k_i}$

$\Rightarrow \theta_c = 41.8°$ #

5.

(a)



$100\pi = \frac{n\pi}{d}$

$\Rightarrow n = 2$

TE_2 #

(b)

$k_y = 120\pi$, $k = w\sqrt{\mu_0\varepsilon_0}$

$k_c = 100\pi$

$k = \sqrt{(120\pi)^2 + (100\pi)^2} = 2\pi f\sqrt{\mu_0\varepsilon_0}$

$\Rightarrow f = 23.4$ GHz #

(c)

$Z_{TE} = \frac{jw\mu}{\gamma} = \frac{jw\mu}{jk_y} = \frac{w\mu_0}{k_y}$

$= 490\ \Omega$ #

(d)

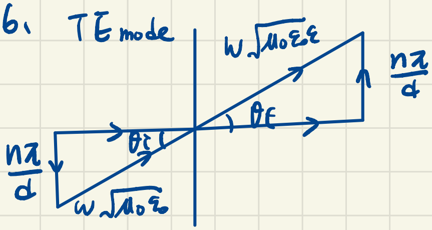
$k > k_c$

$\Rightarrow w\sqrt{\mu_0\varepsilon_0} > \frac{n\pi}{d}$

$\Rightarrow n < \frac{w\sqrt{\mu_0\varepsilon_0}\cdot d}{\pi} = 3.1$

TE_3 #

6. TE mode



$$\theta_i = \sin^{-1}\left(\frac{\frac{n\pi}{d}}{\omega\sqrt{\mu_0\varepsilon_0}}\right) = 36.84 \quad A$$

$$y_1/\cos\theta_i = 470.7\,\Omega \quad B$$

$$\Gamma = \frac{C-B}{C+B} \Rightarrow (C+B)\Gamma = C-B$$

$$\Rightarrow C = \frac{(1+\Gamma)B}{1-\Gamma} = 273.92\,\Omega = y_2/\cos\theta_t \quad D$$

$$\frac{y_2}{\cos\theta_t} = \frac{\sqrt{\frac{\mu_0}{\varepsilon}}\cdot\omega\sqrt{\mu_0\varepsilon}}{\sqrt{\omega^2\mu_0\varepsilon - \frac{n^2\pi^2}{d^2}}} = \frac{\omega\mu_0}{\sqrt{\omega^2\mu_0\varepsilon - \frac{n^2\pi^2}{d^2}}}$$

$\underline{\varepsilon_r = 2.25}$ #

2020

1.

$$\varepsilon_c = \varepsilon - j\frac{\sigma}{\omega} = (81 - j14.4)\varepsilon_0$$

$$\gamma = \sqrt{-\omega^2 \mu_0 \varepsilon_c} = \sqrt{903442\angle 170^\circ}$$

$$= \underbrace{82.84}_{\alpha}\ \text{Np/m} + j\underbrace{946.9}_{\beta}\ \text{rad/m} \quad \#$$

$$\eta = \sqrt{\frac{\mu_0}{\varepsilon_c}} = \sqrt{1725\angle 10.1}$$

$$= 41.53\angle 5^\circ\ \Omega \quad \#$$

$$V_p = \frac{\omega}{\beta} = 0.332\times 10^{8}\ \text{m/s} \quad \#$$

$$l = \frac{1}{\alpha} = 1.21\ \text{cm} \quad \#$$

2.

$\alpha = 0.1$ Np/m, $\beta = 4.2$ rad/m, $\eta_2 = 60\pi\ \Omega$

$$\gamma l = 0.1 + 4.2j$$

$$\tanh(\gamma l) = \frac{\overset{A}{e^{\gamma l}} - \overset{B}{e^{-\gamma l}}}{e^{\gamma l} + e^{-\gamma l}} = 1.4 + 1.71j \quad C$$

$$\eta_{in} = \eta_2 \frac{\eta_1 + \eta_2 \tanh(\gamma l)}{\eta_2 + \eta_1 \tanh(\gamma l)} = 143.87\angle -26.1^\circ \quad D$$

$$\Gamma = \frac{\eta_{in} - \eta_1}{\eta_{in} + \eta_1} = 0.5\angle -158^\circ \quad E$$

$$\therefore |\Gamma|^2 = P_r = 0.25\ \text{W/m}^2 \quad \#$$

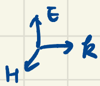
$$\cosh(\gamma l) = C = 0.5\angle -170^\circ$$

$$\sinh(\gamma l) = D = 0.88\angle -93.2^\circ$$

$$T = \frac{1 + \Gamma}{\cosh(\gamma l) + \frac{\eta_2}{\eta_1}\sinh(\gamma l)} = 0.766\angle 115^\circ$$

$$|T|^2 = P_t = 0.587$$

3.



(a)

$$\hat{a}_k = -\hat{a}_z, \quad \hat{a}_E = \hat{a}_x - (1+j)\hat{a}_y$$

$$\hat{a}_E \times \hat{a}_k = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ 1 & -1-j & 0 \\ 0 & 0 & 1 \end{vmatrix} = (-1-j)\hat{a}_x - \hat{a}_y = \hat{a}_H$$

$$\therefore \vec{H} = \frac{1}{10\pi}\left[(-1-j)\hat{a}_x - \hat{a}_y\right] e^{j50\pi z}\ \text{A/m} \quad \#$$

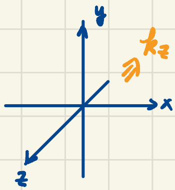
$$\eta = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 120\pi, \quad |H| = \frac{12}{120\pi} = \frac{1}{10\pi}$$

(b)

$$\vec{P}_a = \frac{1}{2}\text{Re}(\vec{E}\times\vec{H}^*) = 0.5\,\text{Re}\begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ 1 & -1-j & 0 \\ -1+j & -1 & 0 \end{vmatrix} \cdot \frac{12}{10\pi} = 0.5\cdot\frac{12}{10\pi}\cdot(-3)\,\hat{a}_z$$

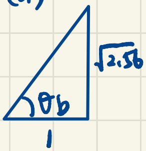
$$= -0.573\,\hat{a}_z\ \text{W/m}^2 \quad \#$$

(c)



LHEP #

4. (a)



$\underline{\theta_b = 58^\circ}$ #

$(\theta_b + \theta_t = 90^\circ)$

TE mode

$\eta_1 / \cos\theta_i \qquad \eta_2 / \cos\theta_t$

$\Downarrow$

$\Gamma = -0.44$

$T = 0.56$

(b)

$k_i = \omega\sqrt{\mu_0 \varepsilon_0} = 88.86$

$k_t = \omega\sqrt{\mu_0 \varepsilon_0 \cdot 2.56}$

$\sin\theta_t = \frac{k_i}{k_t}\sin\theta_b \Rightarrow \underline{\theta_t = 32^\circ}$ #

$\vec{E}_r(x,z) = \hat{a}_y E_0 e^{-j20\pi(x\sin\theta_b - z\cos\theta_b)}$

$= \hat{a}_y \underset{-0.44}{\wedge} E_0 e^{-j20\pi(0.85x - 0.53z)}$ V/m #

$20\pi \times \sqrt{2.56} = 32\pi = |k_t|$

$\vec{E}_t(x,z) = \hat{a}_y E_0 e^{-j32\pi(x\sin\theta_t + z\sin\theta_t)}$

$= \hat{a}_y \underset{0.56}{\wedge} E_0 e^{-j32\pi(0.53x + 0.85z)}$ V/m #

5.

① $\sqrt{2}\sin\theta_2 = 1 \Rightarrow \theta_2 = 45^\circ$

$\sqrt{2}\sin 45^\circ = \sqrt{2.25}\sin\theta_i \Rightarrow \underline{\theta_i = 41.81^\circ}$ #

②

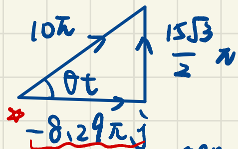
$\sqrt{2.25}\sin\theta_i = \sqrt{2} \Rightarrow \underline{\theta_i = 70.53^\circ}$ #

TM mode:

$\eta_1\cos\theta_i = 40\pi$

$|k_t| = \omega\sqrt{\mu_0\varepsilon_0} = 10\pi$

$k_t = 13\pi\hat{a}_x - 8.3\pi j\hat{a}_z$



$\eta_2\cos\theta_t = \frac{-2487}{25}\pi j$

$\Gamma = e^{-j0.7646}$

$\Rightarrow \vec{E}_r(x,z) = E_0\left(\frac{1}{2}\hat{a}_x + \frac{\sqrt{3}}{2}\hat{a}_z\right)\cdot e^{-j15\pi\left(\frac{\sqrt{3}}{2}\hat{a}_x - \frac{1}{2}\hat{a}_z\right) - j0.7646}$ V/m #

$T = \frac{2\eta_2\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i} = 1.12\angle 68^\circ = 1.12e^{j1.188}$

$\vec{E}_t = E_0\cos\theta_t \cdot 1.12\,\hat{a}_x - E_0\sin\theta_t \cdot 1.12\,\hat{a}_z$

$= E_0(-0.928j\,\hat{a}_x - 1.455\,\hat{a}_z)$

$\vec{E}_t = E_0(-0.928j\hat{a}_x - 1.455\hat{a}_z)\, e^{j1.188} \cdot e^{-j(13\pi\hat{a}_x - 8.3\pi j\hat{a}_z)}$ V/m #

?

6.

$\theta_c = \sin^{-1}\left(\frac{k_t}{k_i}\right) = 41.8^\circ$

$|k_i| = \omega\sqrt{\mu_0\varepsilon} = 15\pi$

$\Rightarrow \begin{cases} \vec{k}_i = 15\pi\left(\frac{\sqrt{3}}{2}\hat{a}_x + \frac{1}{2}\hat{a}_z\right) \\ \vec{E}_i = E_0\left(\frac{1}{2}\hat{a}_x - \frac{\sqrt{3}}{2}\hat{a}_z\right) \end{cases}$

$\Rightarrow \vec{E}_i(x,z) = E_0\left(\frac{1}{2}\hat{a}_x - \frac{\sqrt{3}}{2}\hat{a}_z\right)\cdot e^{-j15\pi\left(\frac{\sqrt{3}}{2}\hat{a}_x + \frac{1}{2}\hat{a}_z\right)}$ V/m #

2019

1.

(a)

$\eta_0 = 120\pi$

$\eta_1 = \sqrt{\frac{\mu_0}{\varepsilon}} = \sqrt{9524.7\angle 6.67^\circ}$

$= 97.6\angle 3.33^\circ$

$\Gamma = 0.59\angle 178.1^\circ$

$|\Gamma|^2 = 0.347 \Rightarrow \underline{34.7\%}$ #

(b)

$\gamma = \sqrt{-\omega^2\mu_0\varepsilon} = \sqrt{6545.26\angle 173.33^\circ}$

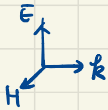
$= 80.9\angle 86.67^\circ = 4.699 + 80.76j$

$l = \frac{1}{4.699} = \underline{21.28\,cm}$ #

2.

$\gamma = (1+j)\sqrt{\frac{\omega\mu_0\sigma}{2}}$

$\alpha = 12$, $\underline{\sigma = 36.5\ S/m}$ #



$\hat{a}_E = \hat{a}_H \times \hat{a}_k = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{vmatrix} = -\hat{a}_x$

$\eta = \sqrt{\frac{j\omega\mu}{\sigma}} = 0.465\angle 45^\circ$

$|E| = 0.465 \times 20 = 9.3$

$\underline{\vec{E} = -9.3\, e^{12z} \cos(2\pi\times 10^6 t + 12z + 45^\circ)\hat{a}_x\ mV/m}$ #

3. (a)

$\underline{RHEP}$ #

(b)

$\sqrt{1}\sin 60^\circ = \sqrt{4}\sin\theta_t \Rightarrow \theta_t = 25.66^\circ$

TE :

$\frac{\eta_1}{\cos\theta_i} = \overset{A}{753.46}\,\Omega$, $\frac{\eta_2}{\cos\theta_t} = \overset{B}{208.97}\,\Omega$

$\underline{\Gamma = -0.566}$ #

TM:

$\eta_1\cos\theta_i = \overset{A}{188.37}\,\Omega$, $\eta_2\cos\theta_t = \overset{B}{169.79}\,\Omega$

$\underline{\Gamma = -0.052}$ #

(c)

$T_{TE} = 1 + \Gamma_{TE} = 0.434$

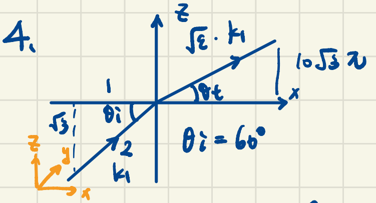
$T_{TM} = \frac{2\eta_2\cos\theta_i}{\eta_1\cos\theta_i + \eta_2\cos\theta_t} = 0.526$

$\vec{E}_t = 0.434\,\hat{a}_y\, e^{-j2\beta_1(0.433x + 0.9z)}$

$+ j(0.9\hat{a}_x - 0.433\hat{a}_z)\, e^{-j2\beta_1(0.433x+0.9z)}$ V/m

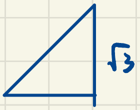
#

4.



$\theta_i = 60^\circ$

brewsters angle 反射為 linearly



$\theta_i = \theta_b = 60^\circ$

$k = \omega\sqrt{\mu_0 \varepsilon_0} = 20\pi \Rightarrow \varepsilon_0 = 1\varepsilon_0$

$\therefore\ \underline{\varepsilon_{r_2} = 3}$ #

5.

(a)

$\sqrt{\varepsilon_r}\,\sin\theta_i = 1,\ \theta_i = 60^\circ$

$\underline{\varepsilon_r = \frac{4}{3}}$ #

(b)

$\sqrt{\frac{4}{3}}\cdot\sin 30^\circ = \sin\theta_t \Rightarrow \underline{\theta_t = 35.26^\circ}$ #

6.

(a) $f = 1.2 f_c \Rightarrow f_c = 5000\ MHz$

$k > k_c \Rightarrow \omega\sqrt{\mu\varepsilon} > \frac{n\pi}{d}$

$\Rightarrow f_c = \frac{n}{2d\sqrt{\mu\varepsilon}},\ n = 1$

$\Rightarrow \underline{a = 1\ cm}$ #

(b)

$k = \omega\sqrt{\mu\varepsilon} = 377.25$

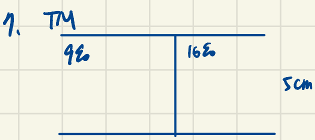
$k_c = \frac{1\cdot\pi}{0.01} = 100\pi$

$k_z = 208.86$

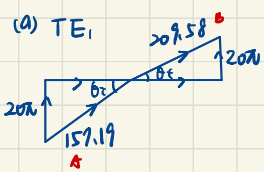
$V_p = \frac{\omega}{k_z} = \underline{180\times 10^6\ m/s}$ #

$V_p \cdot V_g = \frac{1}{\mu\varepsilon} \Rightarrow \underline{V_g = 55.48\times 10^6\ m/s}$ #

7. TM



(a) TE_1

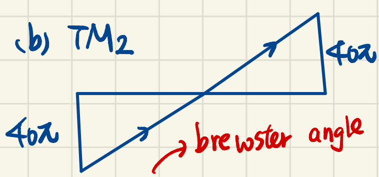


$\theta_i = 23.56^\circ,\ \theta_t = 17.445^\circ$

$\frac{\eta_1}{\cos\theta_i} = C,\ \frac{\eta_2}{\cos\theta_t} = D$

$\Gamma = -0.162 \Rightarrow \underline{|\Gamma|^2 = 0.026}$ #

(b) TM_2



$\theta_i = 53.1^\circ,\ \theta_t = 36.84^\circ$

$\eta_1\cos\theta_i = C \quad \eta_2\cos\theta_t = D$

$\Gamma = 0 = \underline{|\Gamma|^2 = 0}$ #

2018

1.

(a) good dielectric #

(b) $\varepsilon_e = \varepsilon - j\frac{\sigma}{\omega} = (5 - j0.018)\varepsilon_0$

$\gamma = \sqrt{-\omega^2 \mu \varepsilon_e} = \sqrt{164.72 \angle 179.8^\circ}$

$= 12.83 \angle 89.9^\circ = 0.0224 + 12.83j \ m^{-1}$ #

(c)

$l = \frac{1}{\alpha} = 44.64\ m$ #

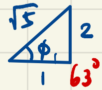
(d)

$\eta = \sqrt{\frac{\mu}{\varepsilon}} = \sqrt{21288721 \angle 0.206^\circ}$

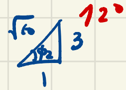
$= 4614 \angle 0.103^\circ\ \Omega$ #

2.

I (a)



$\phi_2 > \phi_1$



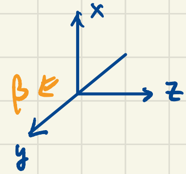
$\sqrt{5}\left[\frac{2}{\sqrt{5}}\cos\theta - \frac{1}{\sqrt{5}}\sin\theta\right]\hat{a}_x + \sqrt{10}\left[\frac{3}{\sqrt{10}}\cos\theta + \frac{1}{\sqrt{10}}\sin\theta\right]\hat{a}_z$

$= \sqrt{5}\sin(\phi_1 - \theta)\,\hat{a}_x + \sqrt{10}\sin(\phi_2 + \theta)\,\hat{a}_z$

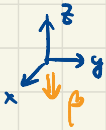
$= \sqrt{5}\sin(\theta - \phi_1 + 180^\circ)\hat{a}_x + \sqrt{10}\sin(\theta + \phi_2)\,\hat{a}_z$

x lad z

LHEP #



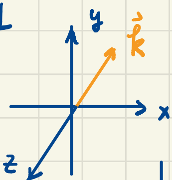
(b)

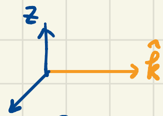


LP #

II

RHCP $\vec{k} = 0.6\hat{a}_x + 0.8\hat{a}_y$



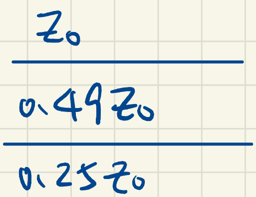


$$\vec{k} \times \vec{z} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ 0.6 & 0.8 & 0 \\ 0 & 0 & 1 \end{vmatrix} = 0.8\hat{a}_x - 0.6\hat{a}_y$$

$$\vec{E} = 1 \cdot \left[j\hat{a}_z + (0.8\hat{a}_x - 0.6\hat{a}_y) \right] e^{-j(0.6x + 0.8y)} \ \ V/m$$ #

3.

$\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon}}$



$\frac{\frac{\lambda}{2.64}}{4} = 0.49\ \mu m$ #

$Z_{in} = \frac{0.49^2}{0.25} = 0.9604$

$\Downarrow$

$\Gamma = -0.02$ #

$Z_{in} = \frac{Z_0^{\ 2}}{Z_L}$

4.

(a)

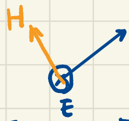
$|k_i| = \omega\sqrt{\mu_0\varepsilon} = 40\sqrt{6}$

$\Rightarrow \varepsilon = 4\varepsilon_0$ #

$\hat{a}_{k_i} = \hat{a}_x + \hat{a}_z \Rightarrow \theta_i = 45^\circ$ #

(b)

$\eta_1 = \sqrt{\frac{\mu}{\varepsilon}} = 60\pi$



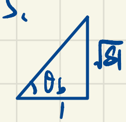
$\vec{H}_i = \frac{E_0}{\eta_1}\left(-\frac{1}{\sqrt{2}}\hat{a}_x + \frac{1}{\sqrt{2}}\hat{a}_z\right)\cos[\ \_\_\_\_\ ]$ A/m #

(c) TE mode

$2\sin 45^\circ = \sqrt{3}\sin\theta_t \Rightarrow \theta_t = 54.74^\circ$

$\Gamma = 0.172 \Rightarrow |T|^2 = 97\%$ #

5.



$\Rightarrow \theta_b = 83.66^\circ$ #

$\theta_t = 6.34^\circ$

TE mode:

$\eta_1/\cos\theta_i = A$ $\quad$ $\eta_2/\cos\theta_t = B$

$\Gamma = -0.9756$ #

$T = 0.024$ #

$\theta_i = 60$

TE mode:

$\eta_1/\cos\theta_i = A$ $\quad$ $\eta_2/\cos\theta_t = B$

$\Gamma = 1\angle 90^\circ$ #

6.

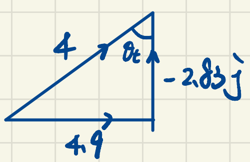
(a)

$\sqrt{2}\sin\theta_c = 1 \Rightarrow \theta_c = 45^\circ$ #

(b)

$\omega = 2\pi\frac{3\times10^8}{\frac{\pi}{2}} = 12\times10^8$ rad/s

$\vec{k}_i = 5.66\left(\frac{\sqrt{3}}{2}\hat{a}_x + \frac{1}{2}\hat{a}_z\right)$



$\vec{k}_t = 4.9\hat{a}_x - 2.83j\,\hat{a}_z$ #

7.

(a)

$k > k_c \Rightarrow \omega\sqrt{\mu\varepsilon} > \frac{3\pi}{a} \Rightarrow f_c = \frac{3}{2a\sqrt{\mu_0\varepsilon}}$ #

(b)

$k < k_c$,

$\sqrt{k_c^2 - k^2} = \sqrt{\left(\frac{3\pi}{a}\right)^2 - (2\pi f)^2\mu\varepsilon} = \pi\sqrt{\frac{9}{a} - 4f^2\mu\varepsilon}$ #

2017

1.

$\varepsilon_e = \varepsilon - j\frac{\sigma}{\omega} = \varepsilon(1 - j\frac{\sigma}{\varepsilon\omega})$

$= 4\varepsilon_0(1 - j\,0.07)$

$\gamma = \sqrt{-\omega^2 \mu_0 \varepsilon_e} = \sqrt{0.0634 \angle 176^\circ}$

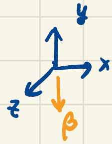
$= 0.252 \angle 88^\circ = 8.79\times10^{-3} + 0.252j$

$l = \frac{1}{\alpha} = \underline{113.8\ m}$ #

$V_p = \frac{2\pi}{\beta}\cdot f = \underline{1.5\times10^8\ m/s}$ #

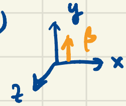
2.

(a) $\sin(\omega t+\beta y) = \cos(\omega t+\beta y-\frac{\pi}{2})$



RHCP #

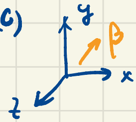
(b)



$-\sin(\omega t-\beta y) = \cos(\omega t-\beta y+\frac{\pi}{2})$

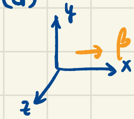
RHEP #

(c)



LP #

(d)



RHEP #

3.

(a)

$\eta_1 = 120\pi,\ \eta_2 = 60\pi$

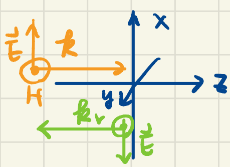
$\Gamma = \frac{1-2}{1+2} = \underline{\frac{-1}{3}}$ #

$T = \underline{\frac{2}{3}}$ # $\quad SWR = \frac{1+\frac{1}{3}}{1-\frac{1}{3}} = \underline{2}$ #

(b)

$k = 1 = \omega\sqrt{\mu\varepsilon} \Rightarrow \omega = 3\times10^8\ rad/s$

$\vec{E} = -10\cos(3\times10^8 t + z)\,\hat{a}_x\ \ V/m$ #



$\eta = 120\pi \Rightarrow |H| = \frac{|E|}{120\pi} = \frac{1}{12\pi}$

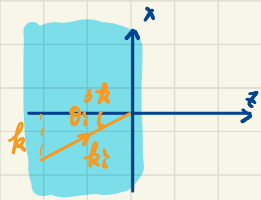
$\vec{H} = \frac{1}{12\pi}\cos(3\times10^8 t + z)\,\hat{a}_y\ \ A/m$ #

4.

(a)

$\theta_i = \tan^{-1}\frac{1}{3} = \underline{18.43 = \theta_r}$ #

$2\sin\theta_i = \sin\theta_t \Rightarrow \underline{\theta_t = 39.22^\circ}$ #

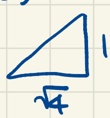


(b)

$|k_i| = \omega\sqrt{\mu\varepsilon} = 6.67$

$k = \frac{6.67}{\sqrt{10}} = \underline{2.11}$ #

(c)



$\underline{\theta_b = 26.57^\circ}$ #

(d)

$2\sin\theta_c = 1 \Rightarrow \underline{\theta_c = 30^\circ}$ #

5.

(a)

$|k_i| = \omega\sqrt{\mu_0\varepsilon_0} = 31.44$

$\vec{k}_i = 27.23\,\hat{a}_y + 15.72\,\hat{a}_z$ #

$\hat{a}_E = -\frac{1}{2}\hat{a}_y + \frac{\sqrt{3}}{2}\hat{a}_z$ #

(b)

$\sin 30° = 2\sin\theta_t \Rightarrow \theta_t = 14.48°$

$\eta_1\cos\theta_i = A \quad \eta_2\cos\theta_t = B$

$\Gamma = -0.283 \Rightarrow |\Gamma| = 0.283$ #

$T = 0.64$ #

(c)

$E_i = E_{i0}\left(\frac{-1}{2}\hat{a}_y + \frac{\sqrt{3}}{2}\hat{a}_z\right)\cos(9.4\times10^9 t - 27.23y - 15.72z)$ V/m #

$E_r = 0.283E_{i0}\left(\frac{-1}{2}\hat{a}_y - \frac{\sqrt{3}}{2}\hat{a}_z\right)\cdot\cos(9.4\times10^9 t + 27.23y - 15.72z)$ V/m #

$E_t = 0.64E_{i0}(-0.25\hat{a}_y + 0.97\hat{a}_z)\cdot\cos(9.4\times10^9 t - 60.88y - 15.72z)$ V/m #

$|k_t| = 62.88^{A}$

6.

X

2016

1.
$$\varepsilon_e = \varepsilon - j\frac{\sigma}{\omega} = \varepsilon_0(1-j10^{10})$$

$$\gamma = \sqrt{-\omega^2\mu_0\varepsilon_e} = \sqrt{4.39\times10^{10}\angle 90^\circ}$$

$$= 148155 + 148155j$$

$$l = \frac{1}{\alpha} = \underline{6.7\times10^{-6}\ m}\ \#$$

$R = ?\quad f = ?$

3.
(a)
$$\tan\delta = \frac{\sigma}{\omega\varepsilon} = \underline{200}\ \#$$

(b)
$$\varepsilon_e = \varepsilon(1 - j\tan\delta)$$

$$\gamma = \sqrt{-\omega^2\mu\varepsilon_e} = \sqrt{158.13\angle 90^\circ}$$

$$= \underline{8.89 + 8.89j}\ \#$$

$$\eta = \sqrt{\frac{\mu_0}{\varepsilon_e}} = \sqrt{9.86\angle 89.7^\circ} = \underline{3.14\angle 44.85^\circ\ \Omega}$$

$$V_p = \frac{\omega}{\beta} = \underline{3.53\times10^{6}\ m/s}\ \#$$

$$\lambda = \frac{V_p}{f} = \underline{0.707\ m}\ \#$$

$$\delta = \frac{1}{\alpha} = \underline{0.112\ m}\ \#$$

6. TM

(a)
$$\lambda = \frac{2d}{n} = \underline{10\ cm}\ \#$$

(b)
$$k_z = \sqrt{k^2 - \left(\frac{n\pi}{d}\right)^2}$$

$$= \underline{144}\ \#$$

(c)
$$\lambda_z = \frac{2\pi}{k_z} = 0.0436\ m$$

(d)