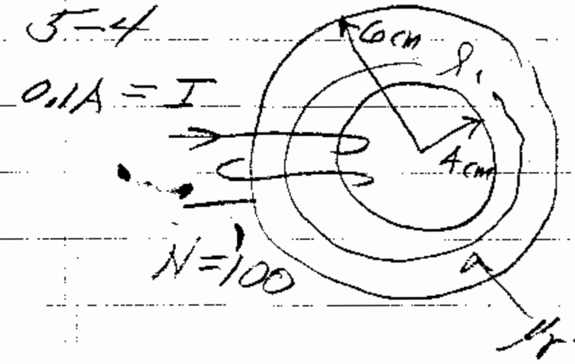
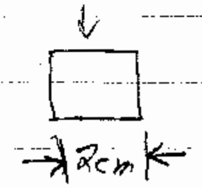
EE 434 Homework 1

5-5
5-16

5-4



cross section



a) $R = \frac{2\pi 5\times10^{-2}}{10^3 \times 4\pi\times10^{-7}\times4\times10^{-4}}$

$R = 0.0625\times10^{7}$

$\therefore \psi = \frac{nI}{A} = B_{ave}A = \mu H_{ave} A$

$\psi = \frac{NI}{R}$

or $H_{ave} = \frac{\psi}{\mu A} = \frac{NI}{\mu A R} = \frac{NI \cancel{\mu A}}{\cancel{\mu A}\, l} = \frac{NI}{l} = \frac{10^{-1}\times10^{2}}{2\pi\times5\times10^{-2}} = \boxed{31.8}$

b) $\oint \bar{H}\cdot d\bar{l} = NI = Hl$ or $\boxed{H = \frac{NI}{l} \text{ as above}}$

With a gap we don't have a path with constant $\bar{H}$ so we can not take $\bar{H}$ outside the line integral and calculate its value

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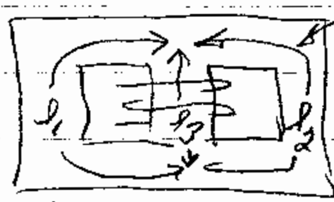
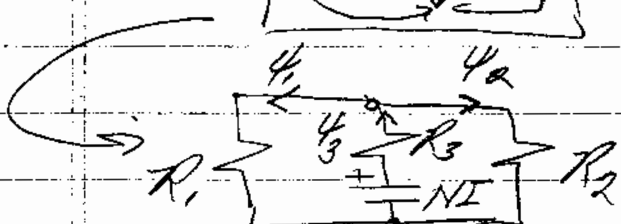
5-5



$\mu_r = 10^4$, $I = 0.1A$, $N = 80$

$l_3 = 4cm$, $l_1 = l_2 = 12cm$

$A = 2cm^2$



$\boxed{\psi_1 = \psi_2 = \frac{\psi_3}{2}}$

$\psi_3 = \frac{NI}{R_3 + \frac{R_1}{2}} = \frac{8}{\frac{4\times10^{-2}}{4\pi\times10^{-7}\times10^{4}\times2\times10^{-4}} + \frac{6\times10^{-2}}{4\pi\times10^{-7}\times10^{4}\times2\times10^{-4}}}$

$\boxed{\psi_3 = 201.6\times10^{-6} = 0.202m \text{ Webers} = 2\psi_{1,2}}$

$B_{AVE_3} = \frac{\psi_3}{A} = \frac{0.202\times10^{-3}}{4\times10^{-4}} \cong 1 \text{ Weber/m2}$

$H_{ave_3} = 2H_{ave_1} = 2H_{ave_2} = \frac{B_{ave_3}}{\mu_0\mu_r} \boxed{\cong 80}$

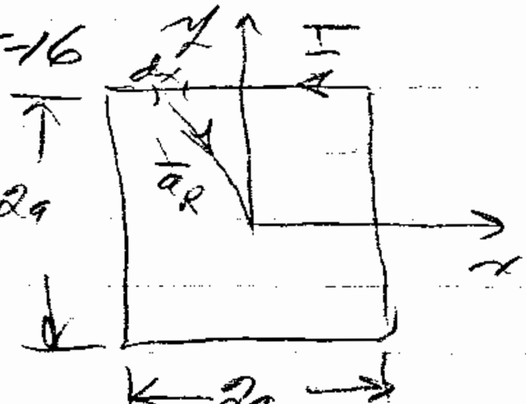
5-5 (continued) $H_{ave_1} l_1 + H_{ave_3} l_3 = nI$?

$$40 \times 0.12 + 80 \times 0.04 \overset{?}{=} 8$$

$$4.8 + 3.2 \overset{?}{=} 8$$

$$\boxed{8 = 8} \; !$$

5-16



for top of square we have:

$$\overline{dB} = \frac{\mu I \, dx \, \bar{a}_x \times \bar{a}_R}{4\pi (x^2 + a^2)}$$

$$\bar{a}_R = \frac{-x\bar{a}_x - a\bar{a}_y}{\sqrt{x^2 + a^2}}$$

$$\therefore \overline{dB} = \frac{\mu I \, dx \, (-a \bar{a}_z)}{4\pi (x^2 + a^2)^{3/2}}$$

$$B_{z_{top}} = \int_a^{-a} \frac{-\mu I \, dx \, a}{4\pi (x^2 + a^2)^{3/2}} = -\frac{\mu I a}{4\pi} \left\{ \frac{x}{a^2 (x^2 + a^2)^{1/2}} \right\}_a^{-a}$$

$$B_{z_{top}} = \frac{-\mu I}{4\pi} \left\{ \frac{-a}{a\sqrt{2}\,a} - \frac{a}{a\sqrt{2}\,a} \right\}$$

$$B_{z_{top}} = \frac{\mu I}{2\pi a \sqrt{2}} = \frac{\mu I \sqrt{2}}{4\pi a}$$

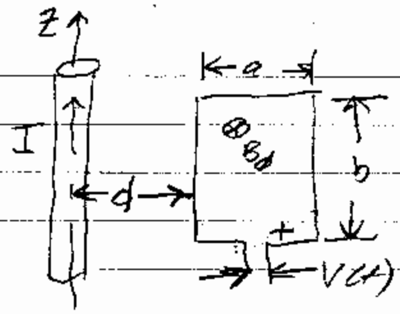
from symmetry all sides contribute the same

$$\boxed{\therefore B_{z_{total}} = \frac{\sqrt{2}\,\mu I}{\pi a}}$$

EE 434 Homework 2

quasi-static

5-19



$I(t) = I_m \sin\omega t$; $\oint \bar{H}\cdot d\bar{l} = I$

a) $H_\phi = \frac{I}{2\pi\rho} = \frac{I_m \sin\omega t}{2\pi\rho}$

clockwise integration

b) $\oint \bar{E}\cdot d\bar{l} = -\frac{d}{dt}\left\{\int_{\rho=d}^{d+a}\int_{z=0}^{b} \frac{\mu_0 I_m \sin\omega t}{2\pi\rho}\, dz\, d\rho\right\}$

$\oint \bar{E}\cdot d\bar{l} = -\frac{d}{dt}\left\{\frac{\mu_0 I_m \sin\omega t}{2\pi}\, b \ln\frac{d+a}{d}\right\} = -\frac{\omega\mu_0 I_m b \ln\left[\frac{d+a}{d}\right]}{2\pi}\cos\omega t$

(right hand terminal positive)

(case A page 282 of text)

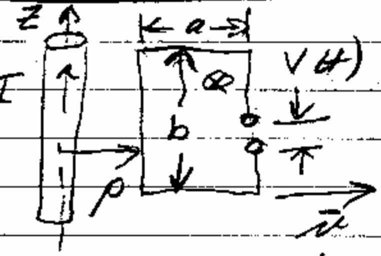
For $I_m = 10A$, $f = 20kHz$, $d = 4\times10^{-3}m$, $a = b = 0.1m$

$V(t) = -\frac{2\pi\times2\times10^4\times4\pi\times10^{-7}\times10\times10^{-1}}{2\pi}\ln\left[1+\frac{0.1}{4\times10^{-3}}\right]\cos(2\pi\times2\times10^4 t)$

or $V(t) = -81.9\cos(4\pi\times10^4 t)\ mV$

c) 2 times above result with opposite polarity

5-21



$\oint \bar{E}\cdot d\bar{l} = \oint \bar{v}\times\bar{B}\cdot d\bar{l}$

$\bar{B} = \frac{\mu_0 I}{2\pi\rho}\bar{a}_\phi$ (integrate clockwise)

$\oint \bar{E}\cdot d\bar{l} = \int \bar{v}\times\bar{B}\cdot d\bar{l} = \int_0^b v\,\bar{a}_\rho\times\frac{\mu_0 I}{2\pi\rho}\bar{a}_\phi\cdot dz\,\bar{a}_z + \int_b^0 v\,\bar{a}_\rho\times\frac{\mu_0 I}{2\pi(\rho+a)}\bar{a}_\phi\cdot dz\,\bar{a}_z$

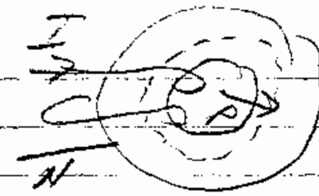
$\oint \bar{E}\cdot d\bar{l} = \frac{v\mu_0 I}{2\pi}\left\{\frac{b}{\rho} - \frac{b}{\rho+a}\right\}$

$\bar{E}$ +

(top terminal positive)

EE 434 Homework 2 (page 2)

5-23 $U_m = \frac{1}{2}\int_{vol} \bar{B}\cdot\bar{H}\,dv$



a) $\oint \bar{H}\cdot d\bar{l} = NI \quad \therefore \quad H_\phi = \frac{NI}{2\pi\rho}$

so $U_m = \frac{1}{2}\int_{z=0}^{d}\int_{\rho=a}^{b}\int_{\phi=0}^{2\pi} \frac{\mu N^2 I^2}{4\pi^2\rho^2}\,\rho\,d\rho\,d\phi\,dz$

$$U_m = \frac{\mu N^2 I^2\, 2\pi d}{2\times 4\pi^2}\ln\left(\frac{b}{a}\right) = \frac{1}{2}LI^2$$

$$\therefore L = \frac{2U_m}{I^2} = \frac{2\mu N^2 I^2 d\ln\left(\frac{b}{a}\right)}{4\pi I^2}$$

$$\text{or } L = \frac{\mu d N^2}{2\pi}\ln\left(\frac{b}{a}\right)$$

b) $I = 2$, $\mu_r = 4\times10^3$, $a = 10^{-2}$, $b = 3\times10^{-2}$, $d = 2\times10^{-2}$

$N = 150$

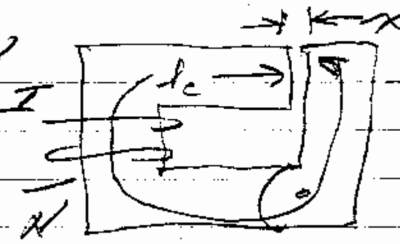
$$\boxed{U_m = 79.1\times10^{-2}\ J}$$

$$\boxed{L = \frac{2U_m}{I^2} = 0.395\ H}$$

c) if $\mu_r = f(I)$ or $f(H)$ which would be true for ferromagnetic material!

EE 434 Homework 3

5-48



a) $\phi_m = \dfrac{NI}{R_{iron} + R_{gap}}$

b) $L = \dfrac{\lambda}{I} = \dfrac{N\phi_m}{I} = \dfrac{N^2}{R_{total}} \leftarrow$

$\therefore U_m = \frac{1}{2} L I^2 = \frac{1}{2} \dfrac{N^2 I^2}{R_{total}} \leftarrow$

in general $F_x = \dfrac{\partial U_m}{\partial x} = \dfrac{I^2}{2}\dfrac{\partial L}{\partial x} = -\dfrac{\phi_m^2}{2}\dfrac{\partial R}{\partial x} \leftarrow$

$\left\{ \begin{array}{l} \text{for } l_c = 0.12,\ A_c = 4\times10^{-4},\ x = 1.5\times10^{-3},\ I = 1.25A,\ N = 200; \\ \mu = 10^5 \mu_0 \end{array} \right.$

$R_{total} = \dfrac{0.12}{10^5 \times 4\pi\times10^{-7} \times 4\times10^{-4}} + \dfrac{x}{4\pi\times10^{-7}\times4\times10^{-4}} = 2.387\times10^3 + 19.89\times10^8 x$

for the above x $R_{total} = 2.387\times10^3 + 1.989\times10^8 \times 1.5\times10^{-3}$

$\therefore \phi_m = \dfrac{200\times1.25}{29.84\times10^5} = 8.37\times10^{-5}$ Webers $\leftarrow$

so $F_x = -\frac{1}{2}(8.37\times10^{-5})^2 \times 19.89\times10^8 = \boxed{-6.97 \text{ Newtons}} \leftarrow$

$B_{ave} = \dfrac{\phi_m}{A} = \boxed{0.21\ W/m^2} \leftarrow$

$H_{ave_{gap}} = \dfrac{B_{ave}}{\mu_0} = \boxed{1.67\times10^5}$

$H_{ave_{iron}} = \dfrac{0.21}{4\pi\times10^{-7}\times10^5} = \boxed{1.67}$

$L = \dfrac{N^2}{R_{total}} = \dfrac{4\times10^4}{2.98\times10^6} \cong \boxed{13mH}$

$U_m = \frac{1}{2} L I^2 =$ [illegible] J

if $x = 0.75mm$ $R_{new} = \dfrac{R_{total}}{2}$; $\phi_{m_{new}} = 2\phi_{m_{old}}$ so $\boxed{F_{x_{new}} = 4F_x} \leftarrow$

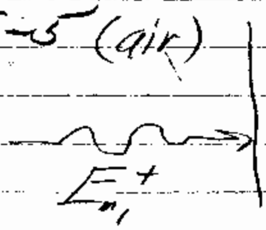
5.48 (continued) if $x \to 0$ $\frac{\partial \mathcal{R}}{\partial x}$ is the same

but $\mathcal{R} = \mathcal{R}_{iron} = 2.387 \times 10^{8}$

$$\text{so } \phi_m = \frac{2.5 \times 10^{8}}{2.387 \times 10^{8}} = 1.047 \times 10^{-1}$$

$$F_x = -\frac{1}{2}(1.047 \times 10^{-1})^2 \times 1.99 \times 10^{9} = \boxed{-1.09 \times 10^{7}\ N}$$

6-5 (air)



$$\epsilon = \epsilon_r \epsilon_0 \qquad \frac{\hat{E}_{m_2}^{+}}{\hat{E}_{m_1}^{+}} = \frac{2\eta_2}{\eta_1 + \eta_2} = \frac{2\eta_0 \frac{1}{\sqrt{\epsilon_r}}}{\eta_0 + \eta_0 \frac{1}{\sqrt{\epsilon_r}}}$$

$$\text{so } \boxed{\frac{\hat{E}_{m_2}^{+}}{\hat{E}_{m_1}^{+}} = \frac{2}{1+\sqrt{\epsilon_r}}}$$

$$\frac{\hat{E}_{m_1}^{-}}{\hat{E}_{m_1}^{+}} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \boxed{\frac{1-\sqrt{\epsilon_r}}{1+\sqrt{\epsilon_r}}}$$

b) $\hat{E}_{m_1}^{+} = 100$, $\epsilon_r = 2.25$, $\sqrt{\epsilon_r} = 1.5$

$$\text{so } \hat{E}_{m_2}^{+} = 100 \frac{2}{2.5} = \boxed{80}$$

$$\hat{E}_{m_1}^{-} = 100 \frac{-0.5}{2.5} = \boxed{-20}$$

c) $\epsilon_r = 81$; $\sqrt{81} = 9$

$$\text{so } \hat{E}_{m_2}^{+} = \frac{100 \times 2}{10} = \boxed{20 \frac{V}{m}}$$

$$\hat{E}_{m_1}^{-} = (100 \times -8)/10 = \boxed{-80\ V/m}$$

EE 434 Homework 4

6-17 γ_1, η_1 | μ_2, ϵ_2, $\sigma_2 = 0$ | γ_3, η_3

$z=0$ $\quad z = d = \lambda_2/4$

$\gamma_2 = j\beta_2$

$e^{\gamma_2 d} = e^{j\beta_2 d} = e^{j\frac{2\pi}{\lambda_2}\cdot\frac{\lambda_2}{4}} = j$

∴ from 6-99a $Z(0) = \eta_2 \dfrac{j(\eta_3+\eta_2)+j(\eta_2-\eta_3)}{j(\eta_3+\eta_2)+j(\eta_3-\eta_2)} = \dfrac{2\eta_2^2}{2\eta_3} = \dfrac{\eta_2^2}{\eta_3}$

6-18 $\epsilon_{r_3} = 2.56$ in the above problem we need $Z(0) = \eta_1$

∴ $\eta_2 = \sqrt{\eta_1 \eta_3}$ assuming $\mu_1 = \mu_2 = \mu_3 = \mu_0$

this becomes $\dfrac{1}{\epsilon_2} = \dfrac{1}{\sqrt{\epsilon_1 \epsilon_3}}$; $\epsilon_{r_2} = \sqrt{\epsilon_{r_1}\epsilon_{r_2}}$

$$\boxed{\epsilon_{r_2} = \sqrt{2.56} = 1.6}$$

reciprocal because we obtain the same value of η_2 if η_1 and η_3 are interchanged!

6-20 problem 6-17 with $d = \frac{\lambda}{2}$; $e^{j\beta_2 d} = e^{j\frac{2\pi}{\lambda_2}\frac{\lambda_2}{2}} = -1$

∴ $Z_0 = \eta_2 \dfrac{-\eta_3 - \eta_2 - \eta_3 + \eta_2}{-\eta_3 - \eta_2 + \eta_3 - \eta_2} = \dfrac{\eta_2(-2\eta_3)}{-2\eta_2} = \boxed{\eta_3}$

same result whenever $e^{j\frac{2\pi}{\lambda_2}d} = -1$

or $d = n\dfrac{\lambda_2}{2} \Rightarrow e^{j\frac{2\pi}{\lambda_2}\frac{n\lambda_2}{2}} = e^{jn\pi}$

→ n odd.

EE 434 Homework 4 (page 2)

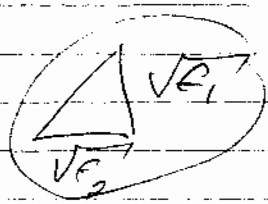
6-35 ① | ②

μ_0, ϵ_0 | $\mu_0, 3\epsilon_0$ $\qquad \theta_i^{\circ} = \tan^{-1}\sqrt{\frac{\epsilon_2}{\epsilon_1}}$

so from ① → ② $\theta_i^{\circ} = \tan^{-1}\sqrt{3} = 60^{\circ}$

from ② → ① $\theta_i^{\circ} = \tan^{-1}\sqrt{\frac{1}{3}} = 30^{\circ}$

must be ∥ polarized {there is no Brewster angle for ⊥ polarization}

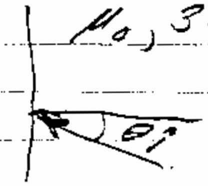


$$\Rightarrow \tan^{-1}\sqrt{\frac{\epsilon_1}{\epsilon_2}} = 90^{\circ} - \tan^{-1}\sqrt{\frac{\epsilon_2}{\epsilon_1}}$$

so we see that θ_i°'s from opposite directions are always compliments

EE 434 Homework 5

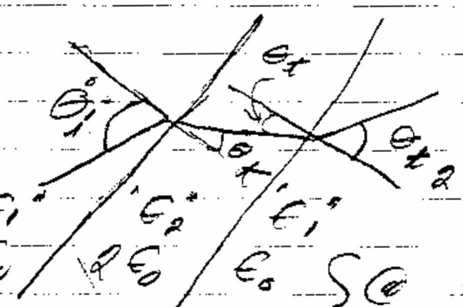
6-36 μ_0, ϵ_0



$\theta_{i_{critical}} = \sin^{-1}\sqrt{\frac{1}{3}} = 35.26°$

polarization not a factor

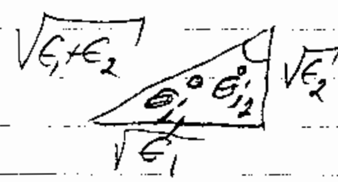
6-37



$\theta_i^{\circ} = \tan^{-1}\sqrt{\frac{\epsilon_2}{\epsilon_1}}$

$\frac{\sin\theta_t}{\sin\theta_i} = \sqrt{\frac{\epsilon_1}{\epsilon_2}}$

@ first interface
$\sin\theta_t = \sin\theta_{i_1}\sqrt{\frac{\epsilon_1}{\epsilon_2}}$ — (1)



this θ_t is the angle of incidence at the second interface

$$\therefore \frac{\sin\theta_{t2}}{\sin\theta_i\sqrt{\frac{\epsilon_1}{\epsilon_2}}} = \sqrt{\frac{\epsilon_2}{\epsilon_1}}$$

or $\boxed{\sin\theta_{t_2} = \sin\theta_i}$ $\boxed{\theta_{t_2} = \theta_1}$

Must show that $\theta_t = \theta_{i_2}^{\circ} = \tan^{-1}\sqrt{\frac{\epsilon_1}{\epsilon_2}}$

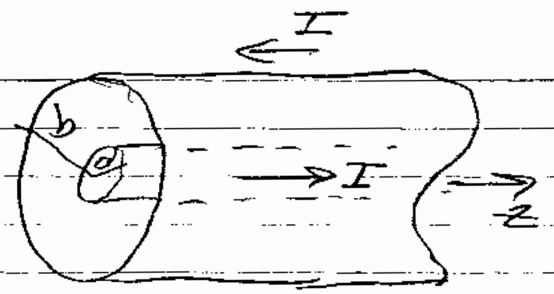
from (1) and the triangle shown above:

$$\sin\theta_t = \sin\theta_1\sqrt{\frac{\epsilon_1}{\epsilon_2}} = \frac{\sqrt{\epsilon_2}}{\sqrt{\epsilon_1+\epsilon_2}}\sqrt{\frac{\epsilon_1}{\epsilon_2}} = \sqrt{\frac{\epsilon_1}{\epsilon_1+\epsilon_2}}$$

or $\sin\theta_t = \sin\theta_{i_2} \Rightarrow \theta_t = \theta_{i_2}$

So there is no reflection from the 2^{nd} surface

EE 434 Homework 6



7-2

in outer conductor

$$E_z = -\frac{J_z}{\sigma}$$

$$J_z = \frac{I}{\pi c^2 - \pi b^2}$$

$H_\phi = \frac{I}{2\pi\rho}$ ← for $a<\rho<b$ (found many times)

$$\overline{E}\times\overline{H}\Big|_{@\rho=b} = \frac{J_z}{\sigma}\cdot\frac{I}{2\pi b}\,\overline{a}_\rho = \frac{I^2}{2\pi^2 b\sigma(c^2-b^2)}\,\overline{a}_\rho$$

in general $R = \frac{L}{\sigma A}$

$$P_{\text{into outer conductor / length } L} = \int_{z=0}^{L}\int_{\phi=0}^{2\pi}\frac{I^2\,\overline{a}_\rho\cdot b\,d\phi\,dz}{2\pi^2 b\sigma(c^2-b^2)} = \frac{I^2 L}{\pi\sigma(c^2-b^2)} = I^2R \leftarrow$$

7-13 $\hat{E}_x = \hat{E}_m^+ e^{-j\beta z}[1+\Gamma]$; $\hat{H}_y = \frac{\hat{E}_m^+}{\eta}e^{-j\beta z}[1-\Gamma]$

$$\overline{P}_{ave} = \frac{1}{2}\mathrm{Re}\{\hat{E}\times\hat{H}^*\} = \frac{1}{2}\mathrm{Re}\left\{\frac{|\hat{E}_m^+|^2}{\eta}(1+\Gamma)(1-\Gamma^*)\right\}\overline{a}_z$$

$$\overline{P}_{ave} = \frac{|\hat{E}_m^+|^2}{2\eta}\mathrm{Re}\{1+\underbrace{\Gamma-\Gamma^*}_{2j\Gamma_{imaginary}}-|\Gamma|^2\}\overline{a}_z$$

$$\therefore\ \overline{P}_{ave} = \frac{|\hat{E}_m^+|^2}{2\eta}\{1-|\Gamma|^2\}\overline{a}_z = \overline{P}_{ave}^+ + \overline{P}_{ave}^- \leftarrow$$

P_{ave} through area A $= \overline{P}_{ave}A = P_{ave}^+ + P_{ave}^-$

$$\therefore\ \frac{|P_{ave}^-|}{|P_{ave}^+|} = |\Gamma|^2 \leftarrow$$

$$\boxed{\text{return loss} = 10\log_{10}|\Gamma|^2}$$

a) 7-17 $\mathcal{P}_{ave} = \frac{1}{2} Re \left\{ \frac{|\hat{E}_m^+|^2 e^{-2\alpha z}}{\eta} e^{+j\theta} [1+\Gamma^*][1-\Gamma] \right\}$

$$\mathcal{P}_{ave} = \frac{|\hat{E}_m^+|^2 e^{-2\alpha z}}{2\eta} Re\left\{[\cos\theta + j\sin\theta][1 + \cancel{\Gamma_r} + j\Gamma_i - \cancel{\Gamma_r} + j\Gamma_i - |\Gamma|^2]\right\}$$

$$\Rightarrow \mathcal{P}_{ave} = \frac{|\hat{E}_m^+|^2 e^{-2\alpha z}}{2\eta} \left\{\cos\theta [1 - |\Gamma|^2] - \sin\theta [2\Gamma_i]\right\} \leftarrow (1)$$

b) for $\Gamma = 0$ this becomes $\mathcal{P}_{ave} = \frac{|\hat{E}_m^+|^2 e^{-2\alpha z}}{2\eta} \cos\theta$

and for a lossless region $\alpha = 0, \theta = 0$

so $\boxed{\mathcal{P}_{ave} = \frac{|\hat{E}_m^+|^2}{2\eta}}$ (Eq. 7-59 in text)

c) $\mathcal{P}_{ave}$ positive wave only $= \frac{1}{2} Re\left\{ \frac{\hat{E}_m^+ e^{-\alpha z} \cancel{e^{-j\beta z}} e^{+j\theta} \hat{E}_m^{+*} e^{-\alpha z} \cancel{e^{+j\beta z}}}{\eta} \right\} = \boxed{\frac{|\hat{E}_m^+|^2 e^{-2\alpha z}}{2\eta} \cos\theta}$

$\mathcal{P}_{ave}$ negative wave only $= \frac{1}{2} Re\left\{ \frac{\hat{E}_m^+ e^{-\alpha z} \cancel{e^{-j\beta z}} \Gamma \hat{E}_m^{+*} e^{-\alpha z} \cancel{e^{+j\beta z}} (-\Gamma^*)}{\eta e^{j\theta}} \right\} = \boxed{\frac{-|\hat{E}_m^+|^2 e^{-2\alpha z}}{2\eta} |\Gamma|^2}$

{ Summing the above two results would miss the $-\sin\theta [2\Gamma_i]$ term in equation (1) above ? }

EE 434 Homework 7

7-21 $P_{ave\ sun\ @\ earth} = 1340\ W/m^2$

assuming a single frequency wave we have:

$$P_{ave} = \frac{|\hat{E}_m^+|^2}{2\eta} \quad \text{or} \quad |\hat{E}_m^+| = \sqrt{2 \times 377 \times 1340} = \boxed{1 \times 10^3\ V/m}$$

$$\text{and } |\hat{H}_m^+| = \frac{|\hat{E}_m^+|}{\eta} = \boxed{2.65\ A/m}$$

$$P_{ave\ total\ from\ sun} = 4\pi (1.48 \times 10^{11})^2 \times 1.34 \times 10^3 = \boxed{36.88 \times 10^{25}\ Watts}$$

P_{max} for X-band waveguide @ 10 GHz

$$\hat{E}_y = E_{y_{max}} \sin \frac{\pi}{a} x \quad ; \quad \hat{H}_x = -E_{y_{max}} \sqrt{\frac{\epsilon}{\mu}} \sqrt{1 - \left(\frac{f_c}{f}\right)^2} \sin \frac{\pi}{a} x$$

$$\bar{\mathcal{P}}_{ave} = \frac{1}{2} \mathcal{R}e \{ \hat{\bar{E}} \times \hat{\bar{H}}^* \} = \frac{1}{2} \mathcal{R}e \left\{ \bar{a}_z E_{y_{max}}^2 \sin^2\left(\frac{\pi}{a} x\right) \sqrt{\frac{\epsilon}{\mu}} \sqrt{1 - \left(\frac{f_c}{f}\right)^2} \right\}$$

$$P_{ave} = \frac{1}{2} E_{y_{max}}^2 \sqrt{\frac{\epsilon}{\mu}} \sqrt{1 - \left(\frac{f_c}{f}\right)^2} \int_{y=0}^{b} \int_{x=0}^{a} \underbrace{\sin^2\left(\frac{\pi}{a} x\right)}_{\frac{1}{2}\left[1 - \cos\left(\frac{2\pi x}{a}\right)\right]} dx\, dy$$

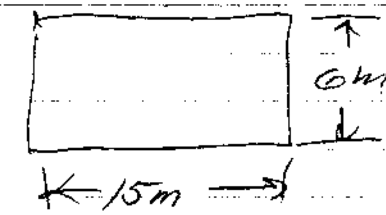
$$P_{ave} = \frac{1}{2} E_{y_{max}}^2 \sqrt{\frac{\epsilon}{\mu}} \sqrt{1 - \left(\frac{f_c}{f}\right)^2} \frac{ba}{2} \quad . \text{ (Equation 8-90)}$$

$$\text{or } P_{ave} = 1.16 \times 10^{-7} E_{y_{max}}^2$$

For air filled waveguide $E_{max} \cong 3 \times 10^6\ V/m$

$$\therefore P_{ave_{max}} = 1.16 \times 10^{-7} \times 9 \times 10^{12} = \boxed{1.04 \times 10^6\ Watts}$$

8-27



TE_{10} mode

$$\boxed{f_c = \frac{1}{2\sqrt{\mu\epsilon}\,15} = \frac{3\times10^8}{30} = 10\,MHz}$$

$\boxed{\text{Vertical polarization}}$

AM will not propagate $535 \Rightarrow 1605$ KHz

FM will propagate $88 \Rightarrow 108$ MHz

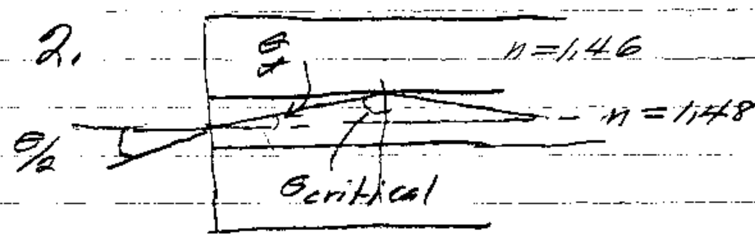
EE 434 Homework 8

1. 1" radius circular waveguide

TE_{11} cutoff frequency $f_c = \frac{3\times10^8 \times 10^2}{2\pi\times 2.54} P'_{1,1}$

$$f_c = \frac{3\times10^{10}}{2\pi\times2.54}\times1.841 = \boxed{3.46\times10^9\ Hz}$$

2.



$\theta_c = \sin^{-1}\left(\frac{1.46}{1.48}\right) = 80.57^\circ$

$\therefore \theta_t = 90 - \theta_c = 9.43^\circ$

$\sin\theta_t = \sqrt{\frac{\epsilon_1}{\epsilon_2}}\sin\left(\frac{\theta}{2}\right)$; $\sin\frac{\theta}{2} = \sqrt{\frac{\epsilon_2}{\epsilon_1}}\sin\theta_t = 1.48\sin 9.43^\circ = 0.2425$

so $\theta = 2\sin^{-1}(0.2425) = 28^\circ$