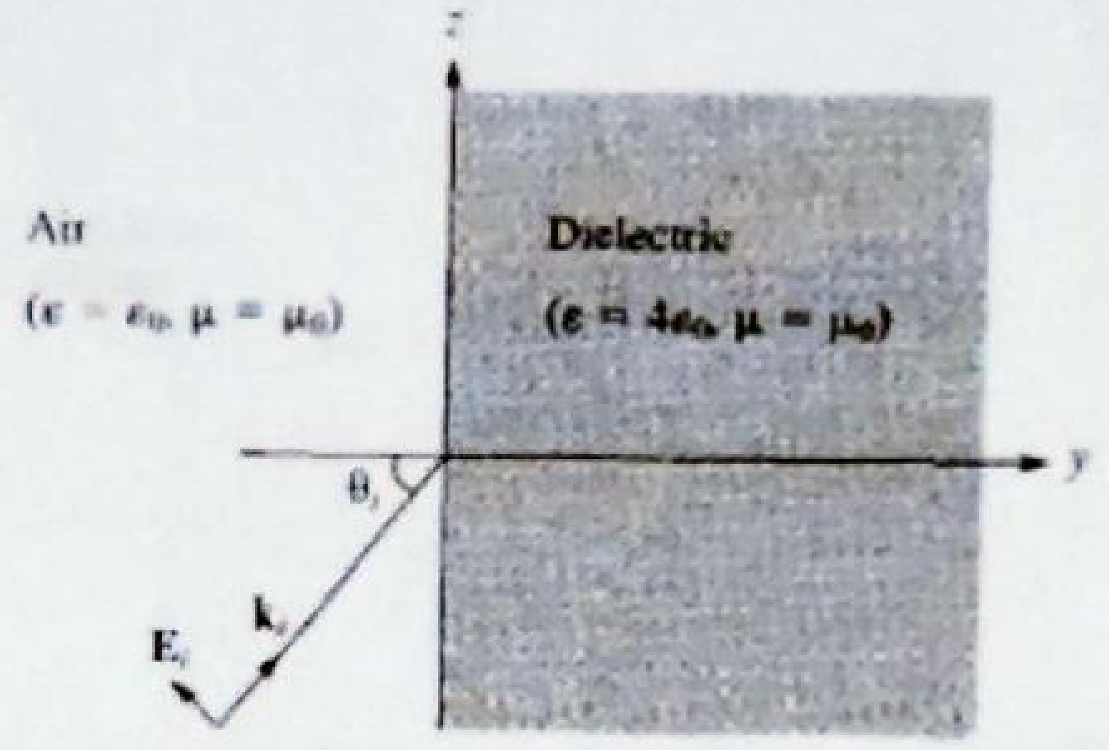
كلية التقنية الالكترونية طرابلس
College of Electronic Technology - Tripoli

القســـم: الاتصالات أسئلة الامتحان النهائي لمادة : كهرومغناطسية 2
لطلبة الفصل: ..السادس رمز المادة ..EM.3.22.... التاريخ 28-9-2019
الفصل الدراسي : ربيع2019 اسم الأستاذ : أ/جمعة عمارة ابوشعفة الزمن : ساعتان

اسم الطالب :.................................. رقم القيد .... المجموعة : ....

Q1/ A parallel polarized wave in air with $E=(8a_x-6a_y)\sin(wt-4y-3z)$ V/m

Impinges a dielectric half-space shown in figure. Find: 1- the incident angle Θ_i
2- the time average in air ($\varepsilon=\varepsilon_0, \mu=\mu_0$) 3- the reflected and transmitted E fields



Q2/ The plan wave $E=50\sin(wt-5x)a_y$ V/m in a lossless medium encounters a lossy medium ($\varepsilon=4\varepsilon_0$, $\mu=\mu_0$, $\sigma=0.2$mhos /m) normal to the X-axis at x=0 . Find 1- Γ ,τ , and S 2- E_r and H_r 3- E_i and H_i 4- The time-average Poynting vectros in both regions

b- The plane wave $E_s=300e^{-jkx}a_y$ V/m is propagating in a material for which μ= 2. 5 μH/M , ε'= 7 PF/m , and ε''= 7.8 PF/m. If w= 64 Mrad/s, find: 1- α 2- β 3- v_p 4- λ 5- η 6- H_s 7- E(3,2,4,10ns).

Q3 A/ Consider a material for which μ_R= 1 , ε'_R=2.25,and the loss tangent is 0.13 . IF these three values are constant with frequency in the range 0.5 MHZ≤f ≤100MHZ.

Calculate a- σ at 1 and 75 MHZ b- λ at 1 and 75MHZ c- v_p at 1 and 75MHZ

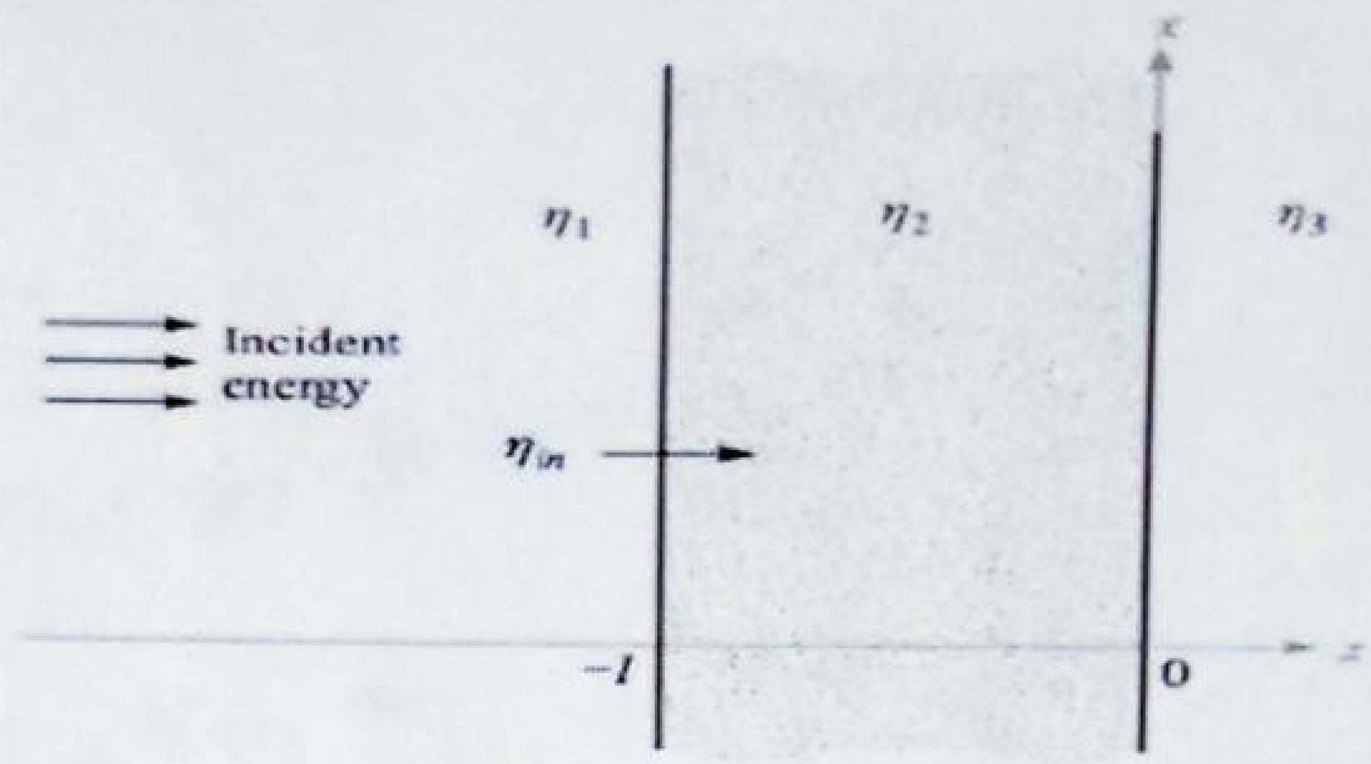
b- Region 1 , z< 0 , and region 2 , z> 0 , are described by the following parameters: ε'_1= 100 pF/m , ε''_1= 0 ,μ_1=35 μH/m , ε'_2= 200 pF/m , μ_2=50 μ H/m, and $\varepsilon_2''/\varepsilon'_2$ = 0.5. If $E^+_1 = 600e^{-\alpha_1 z}\cos(5*10^{10}t-\beta_1 z)\,a_x$ V/m, find 1- α_1 2- β_1
3- E^+_{s1} 4- E^+_{s2} 5- E^-_{s1}/

تمنياتي للجميع بالتوفيق
أستاذ المادة : أ.جمعة أبو شعفة

كلية التقنية الالكترونية طرابلس
College of Electronic Technology - Tripoli

القســـم: الاتصالات أسئلة الامتحان النهائي لمادة : كهرومغناطسية 2
لطلبة الفصل: ..السادس رمز المادة.CM 322...... التاريخ 28-9-2019
الفصل الدراسي : ربيع2019 اسم الأستاذ : أ/جمعة عمارة ابوشعفة الزمن : ساعتان
اسم الطالب :................................... رقم القيد .... المجموعة : ....

Q4A/ Let $\eta_1=\eta_3= 377\Omega$, and $\eta_2= 0.4\ \eta_1$. A uniform plane wave is normally incident from the left. As shown.Plot a curve of the standing wave ratio in region to the left 1- as function of L if f = 2.25GHZ



B- Which of the following media may be treated as conducting at 10 MHZ?

1- Wet marshy soil ($\varepsilon=15\ \varepsilon_0$, $\mu=\mu_0$, $\sigma=10^{-2}$ S/m)

2- Intrinsic germanium ($\varepsilon=16\ \varepsilon_0$, $\mu=\mu_0$, $\sigma=0.0\ 25$ S/m)

3- Sea water ($\varepsilon=81\ \varepsilon_0$, $\mu=\mu_0$, $\sigma=25$ S/m)

تمنياتي للجميع بالتوفيق
أستاذ المادة : أ.جمعة أبو شعفة

صفحة 2 من 2

إجابة أسئلة النهائي ٢ مادة / كهرومغناطيسية II الفصل السادس
قسم الاتصالات
ربيع 2019

Q1 ① $K_i = 4a_y + 3a_z \longrightarrow K_i \cdot a_n = K_i \cos\theta_i$

(6.5)

$\cos\theta_i = 4/5 \rightarrow \theta_i = 36.87^\circ$

② $P_{ave} = \frac{1}{2} Re[E_s \times H_s^*] = \frac{E_o^2}{2\eta} a_k = \frac{\sqrt{(8^2+6^2)}^2}{2 \times 120\pi} \frac{(3a_y + 4a_z)}{5}$

$= 79.58 a_y + 106.1 a_z \; mW/m^2$

(6.5)

③ let $\theta_r = \theta_i = 36.87^\circ$

$E_r = (E_{ry} a_x + E_{rz} a_z) \sin(wt - k_r \cdot r)$

$K_r = K_{rz} a_z - K_{ry} a_y$

$K_r = K_i = 5$

$K_{rz} = K_r \sin\theta_r = 5(3/5) = 3$, $K_{ry} = K_r \cos\theta_r = 5(4/5) = 4$

(7 درجات)

$K_r = -4a_y + 3a_z$

$\sin\theta_r = \frac{n_1}{n_2} \sin\theta_t = c\sqrt{\frac{\mu_1 \epsilon_1}{\mu_2 \epsilon_2}} \sin\theta_t = \frac{3/5}{\sqrt{4}} = 0.3$

$\theta_t = 17.46 \quad \cos\theta_i = 0.9539$, $\eta_1 = \eta_o = 120\pi$
$\eta_2 = \eta_o/2 = 60\pi$

$\Gamma_{11} = \frac{E_{ro}}{E_{to}} = \frac{\eta_2 \cos\theta_t - \eta_1 \cos\theta_i}{\eta_2 \cos\theta_t + \eta_1 \cos\theta_i} = \frac{\frac{\eta_o}{2}(0.9539) - \eta_o(0.8)}{\frac{\eta_o}{2}(0.9539) + \eta_o(0.8)}$

$E_{ro} = \Gamma_{11} E_{to}$ $\boxed{\Gamma_{11} = -0.253}$

$= -0.253(10) = -2.53$

But $(E_{ry} a_y + E_{rz} a_z) = E_{ro}(\sin\theta_r a_y + \cos\theta_r a_z) = -2.53\left(\frac{3}{5}a_y + \frac{4}{5}a_z\right)$

$E_r = -(1.518 a_y + 2.02 a_z) \sin(wt + 4y - 3z) \; V/m$

III

② Q1 E.V

$E_t = (E_{ty} a_y + E_{tz} a_z) \sin(\omega t - k_t \cdot r)$

$k_t = \beta_2 = \omega\sqrt{\mu_2 \epsilon_2} = \omega\sqrt{4\mu_0\epsilon_0}$

$k_i = \beta_i = \omega\sqrt{\mu_0\epsilon_0}$

$\frac{k_t}{k_i} = 2 \rightarrow k_t = 2k_i = 2\times5 = 10$

$k_{ty} = k_t \cos\theta_t = 9.539$, $k_{tz} = k_t \sin\theta_t = 3$

$k_t = 9.539 a_y + 3 a_z$

$k_{iz} = k_{rz} = k_{tz} = 3$

$\tau_{\parallel} = \frac{E_{to}}{E_{ro}} = \frac{2\eta_2 \cos\theta_i}{\eta_2 \cos\theta_t + \eta_1 \cos\theta_r}$

$= \frac{\eta_0 (0.8)}{\frac{\eta_0}{2}(0.9539) + \eta_0(0.8)} = 0.6265$

$E_{to} = \tau_{\parallel} E_{ro} = 0.265$

But $(E_{ty} a_y + E_{tz} a_z) = E_{to}(\sin\theta_t a_y - \cos\theta_t a_z) = 0.256(0.3 a_y - 0.9539 a_z)$

$E_t = (1.877 a_y - 5.968 a_z) \sin(\omega t - 9.539y - 3z)$ V/m

Q2 a/ (1) $\eta_1 = 120\pi\sqrt{\frac{1}{4}} = 60\pi$

$$\eta_2 = \frac{\sqrt{\frac{\mu_0\mu_r}{\varepsilon_0\varepsilon_r}}}{\left[1+\left(\frac{\sigma}{\omega\varepsilon}\right)^2\right]^{\frac{1}{4}}} = \frac{120\pi\sqrt{\frac{1}{4}}}{\left[1+\frac{0.2}{7.5\times10^{8}\times4\times8.85\times10^{-12}}\right)^2\Big]^{\frac{1}{4}}}$$

$\eta_2 = 68.37$

$\eta_{2\theta} = \frac{1}{2}\tan^{-1}\left(\frac{\sigma}{\varepsilon\omega}\right) = \angle 41.7$

(zero 2.5)

$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = 0.59\angle 151.17^\circ$

$\tau = 1 + \Gamma = 0.56\angle 30.57^\circ$

$S = 3.878$

(2.5) (2) $\frac{E_r}{E_i} = \Gamma \Rightarrow E_r = 50\times0.59\sin(\omega t + 5x + 151.17)\vec{a}_y$

$H_r = 156\sin(\omega t + 5x + 151.12)a_z$

(2.5) (3) $E_i = 50\sin(\omega t - 5x)\vec{a_y}$

$H_i = \frac{E_i}{\eta}\sin(\omega t - 5x)a_z$

(2.5) (4) $\vec{P} = \frac{E_0^2}{\eta}\sin^2(\omega t - 8x)\vec{a_y}$

$= \frac{50^2}{60\pi}(-\vec{a_y}) + \frac{29.5^2}{60\pi}a_y$

Q3/(b) ① $\alpha_1 = 0$ (2) [Arabic annotation] (4)

② $\beta_1 = \omega\sqrt{\mu_1\epsilon_1} = 5\times10^{10}\sqrt{35\times10^{-6}\times100\times10^{-12}} = \sqrt{35\times10^{-16}}\times5\times10^{10}$ $= 2.9\times10^{3}$ rad/m (2)

$E_{s1}^{+} = 600\, e^{-j\beta_1 z}\, a_x$ V/m $= 600\, e^{-j2.9\times10^{3}z}\, a_x$ V/m

$E_{s1}^{-} \rightarrow \eta_1 = \sqrt{\mu_1/\epsilon_1} = \sqrt{\frac{35\times10^{-6}}{100\times10^{-12}}} = 10^{2}\sqrt{35} = 591.61$ (2)

$\Gamma = \frac{\eta_2-\eta_1}{\eta_2+\eta_1} = \frac{460+j109-591.61}{460+j109+591.61} =$

$\eta_2 = \sqrt{\frac{\mu_2}{\epsilon_2'}}\frac{1}{\sqrt{1-j(\epsilon_2''/\epsilon_2')}} = \sqrt{\frac{50\times10^{-6}}{2\times10^{-10}}}\frac{1}{\sqrt{1-j0.5}}$

$\eta_2 = 460+j109$

$\Gamma =$

$E_{s1}^{-} = 71.8\, e^{j}\, e^{j2.9\times10^{3}z}$ V/m (2)

$E_{s2}^{+} \rightarrow \alpha_2 = \omega\sqrt{\frac{\mu_2\epsilon_2}{2}}\left[\sqrt{1+\left(\frac{\epsilon_2''}{\epsilon_2'}\right)^2}-1\right]^{\frac{1}{2}}$ (2)

$= 5\times10^{10}\sqrt{\frac{50\times10^{-6}(200\times10^{-12})}{2}}\left[\sqrt{1+(0.5)^2}-1\right]^{\frac{1}{2}}$

$= 1.21\times10^{3}$ Np/m

$\beta_2 = \omega\sqrt{\frac{\mu_2\epsilon_2}{2}}\left[\sqrt{1+\left(\frac{\epsilon_2''}{\epsilon_2'}\right)^2}+1\right]^{\frac{1}{2}} = 5.15\times10^{3}$ rad/m

$\tau = 1+\Gamma = 1 - \frac{-131.61+j109}{1051.61+j109}$

$E_{s2}^{+} = 587\, e^{-1.21\times10^{3}z}\, e^{j}\, e^{-j5.15\times10^{3}z}$ V/m

Q2/ (b) $E_s = 300 e^{-jKx} a_y$ V/m (5)

$$\alpha = \omega \sqrt{\frac{\mu \epsilon'}{2}} \left[\sqrt{1 + \left(\frac{\epsilon''}{\epsilon'}\right)^2} - 1 \right]^{\frac{1}{2}}$$ (1.5)

$$\alpha = (64 \times 10^6) \sqrt{\frac{(2.25 \times 10^{-6})(9 \times 10^{-12})}{2}} \left[\sqrt{1 + (0.867)^2} - 1 \right]^{\frac{1}{2}}$$

$$\boxed{\alpha = 0.116 \text{ NP/m}}$$

$$\beta = \omega \sqrt{\frac{\mu \epsilon'}{2}} \left[\sqrt{1 + \left(\frac{\epsilon''}{\epsilon'}\right)^2} + 1 \right]^{\frac{1}{2}} = 0.311 \text{ rad/m}$$ (1.5)

$$v_p = \omega/\beta = (64 \times 10^6)(0.311) = 2.06 \times 10^8 \text{ m/s}$$ (1.5)

$$\lambda = 2\pi/\beta = \frac{2\pi}{0.311} = 20.2 \text{ m}$$ (1.5)

$$\eta = \sqrt{\frac{\mu}{\epsilon'}} \frac{1}{\sqrt{1 - j(\epsilon''/\epsilon')}} = \sqrt{\frac{2.25 \times 10^{-6}}{9 \times 10^{-12}}} \frac{1}{\sqrt{1 - j(0.687)}} = 407 + j152$$

$$H_s = \frac{E_s}{\eta} a_z = \frac{300}{407 + j152} e^{-jKx} a_z = 0.69 e^{-j\beta x} e^{-\alpha x} e^{-j0.36} a_z$$ (1.5)

$$\boxed{H_s = 0.69 e^{-0.116x} e^{-j0.311x} e^{-j0.36} a_z \text{ A/m}}$$ (1.5)

$$E(3,2,4,10\text{ns}) \Rightarrow E(x,y,z,t) = Re\{E_s e^{j\omega t}\} = 300 e^{-\alpha x} \cos(\omega t - \beta x) a_y$$

$$E(3,2,4,10\text{ns}) = 300 e^{-0.116(3)} \cos[(64 \times 10^6)(10^{-8}) - 0.311(3)] a_y$$

$$= 203 \text{ V/m}$$ (1)

electromagnetic

(6)

Q4b/ $\beta = \omega\sqrt{\mu\epsilon} = \frac{\omega}{c}\sqrt{\mu_r\epsilon_r} = \frac{2\pi\times10^8}{3\times10^8}(10) = 2.093$ rad/m

(1) ~~for go~~ for a good conductor

$\frac{\sigma}{\omega\epsilon} >> 1$, say $\frac{\sigma}{\omega\epsilon} \geq 100$

$\frac{\sigma}{\omega\epsilon} = \frac{10^{-2}}{2\pi\times10^{7}\times15\times\frac{10^{-9}}{36\pi}} = \frac{10^{-2}}{0.08333}$

$= 0.12$ lossy

No, not conducting

3.5

(2) $\frac{\sigma}{\omega\epsilon} = \frac{0.025}{2\pi\times10^{7}\times16\times\frac{10^{-9}}{36\pi}} = \frac{2.8274}{1.0053}$

$= 2.8125 \longrightarrow$ lossy

No, not conducting

3.5

(3) $\frac{\sigma}{\omega\epsilon} = \frac{25}{2\pi\times10^{7}\times81\times\frac{10^{-9}}{36\pi}} = \frac{2827.433}{5.0893}$

$= 555.56$ conducting

Yes, Conducting

3

Q4/A $\eta_1 = \eta_3 = 377\Omega$ and $\eta_2 = 0.4\eta_1$

① as a function of L if $f = 2.25\,GHz$.

$$\eta_1 = \eta_3 = \eta_0 \;,\; \eta_2 = 0.4\eta_0$$

$$\eta_{in} = 0.4\eta_0 \left[\frac{\cos(\beta L) + j0.4\sin(\beta L)}{0.4\cos(\beta L) + j\sin(\beta L)} \right] \times \left[\frac{0.4\cos(\beta L) - j\sin(\beta L)}{0.4\cos(\beta L) - j\sin(\beta L)} \right]$$

(= 6/5)

$$= \eta_0 \left[\frac{1 - j1.05\sin(2\beta L)}{\cos^2(\beta L) + 6.25\sin(\beta L)} \right]$$

$$\Gamma = \frac{\eta_{in} - \eta_0}{\eta_{in} + \eta_0} \rightarrow |\Gamma| = \sqrt{\Gamma\Gamma^*}$$

$$|\Gamma| = \left[\frac{(1 - \cos^2(\beta L) - 6.25\sin^2(\beta L))^2 + (1.05)^2\sin^2(2\beta L)}{(1 + \cos^2(\beta L) + 6.25\sin^2(\beta L))^2 + (1.05)^2\sin^2(2\beta L)} \right]^{\frac{1}{2}}$$

$$S = \frac{1 + |\Gamma|}{1 - |\Gamma|} \rightarrow \beta = \omega\sqrt{\mu\epsilon} = n\omega/c$$

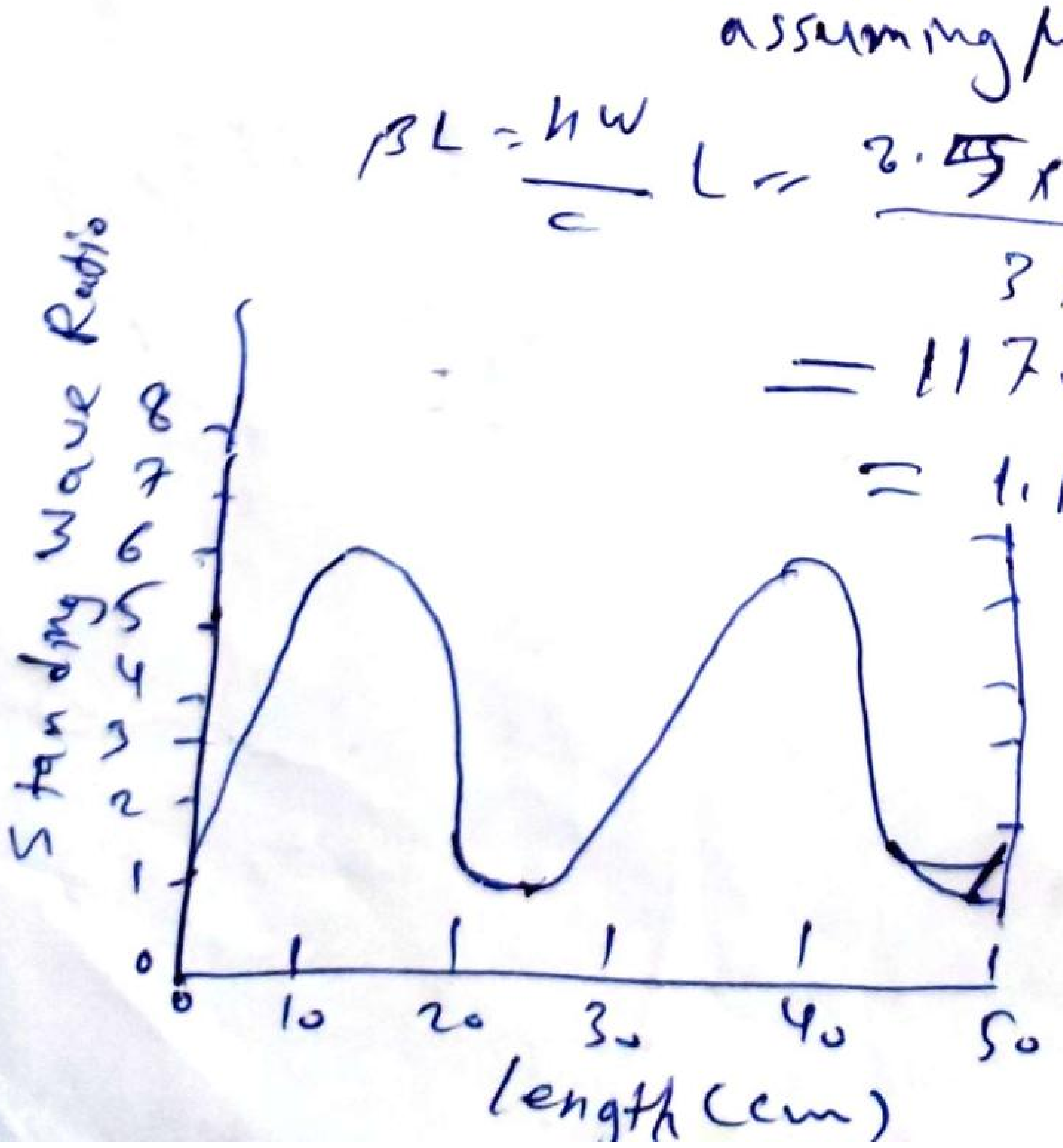
$$\eta_2 = 0.4\eta_0 = \eta_0/n \longrightarrow n = 2.5$$

assuming $\mu = \mu_0$

$$\beta L = \frac{n\omega}{c} L = \frac{2.5 \times 2\pi \times 2.25 \times 10^9}{3 \times 10^8}$$

$$= 117.8L \quad (L \text{ in } m)$$

$$= 1.178L \quad (L \text{ in } cm)$$



(= 6/5)