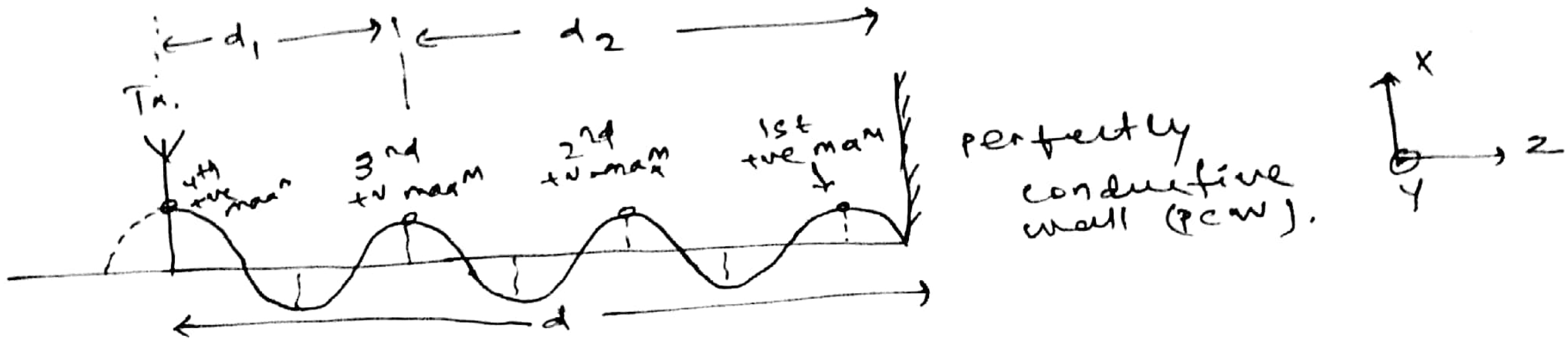
1. From the equ^n of Electric field

$E(z,t) = \hat{y}\, 2E_0 \sin(\beta z) \cdot \sin(\omega t)$ V/m. ——— (1)

(please follow the tutorial-3 material for the derivation of above equ^n.)

According to the equ^n-1 and ~~equ~~ question given, the standing wave pattern



(a) $E(z) = \hat{y}\, 2E_0 \sin(\beta z)$.

$E(z) \rightarrow$ max^M. for

$\beta z = n\pi + \pi/2$.

$\beta = \omega\sqrt{\mu_0 \epsilon_0} = 2\pi/\lambda_0$

$z = \dfrac{(n\pi + \pi/2)\lambda_0}{2\pi}$.

For, $n = 6$, the 4th (+ve) max^M will at the pos^n of antenna.

$z = \dfrac{(6\pi + \pi/2)\lambda_0}{2\pi} = \dfrac{13 \times 12}{4} = 3.25\,(12)$
$= 39$ m.

(b) $\beta z = n\pi$

$z = \dfrac{n\pi}{2\pi}\lambda_0 = \dfrac{12n}{2} = 6n \quad \forall\, n = 1, 2, \ldots, 6$

where the E-field is zero. [Hence, placing a conducting surface will not affect the wave propagation.

(c) from. equn.
for propagation in a low-loss medium.
i.e. $\frac{\sigma}{\omega\epsilon} << 1$

$\epsilon_1 = 4\epsilon_0$, $\epsilon_r = 4$
$\mu_1 = \mu_0$, $\mu_r = 1$.
$\sigma = 10^{-5}$ S/m.
$\alpha = \frac{\sigma}{2}\sqrt{\frac{\mu}{\epsilon}} = 30\pi \times 10^{-5}$ dP/m.

The first +ve maxm. of the E-field to the right of the antenna.

$E. = E_0 e^{-\alpha d_1} + E_0 e^{-\alpha(d+d_2)}$

$= 100 \left[e^{-\alpha d_1} + e^{-\alpha(d+d_2)}\right]$

$d_1 = \lambda = 12$m.
$d = 3.25\lambda = 39$m.
$d_2 = 2.25\lambda = 27$m.

$\Rightarrow E = 100 \left[e^{-30\pi\times10^{-5}\times12} + e^{-30\pi\times10^{-5}(39+27)}\right]$.

$= 192.84$ V/m.

2. $P_r = 10$ mW/m²
$f = 10$ GHz.
body property $\sigma = 0.01$ S/m.
$\mu = \mu_0$.
$\epsilon = 24\epsilon_0$.

body impedance $\eta_b = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\epsilon}}$

$\frac{\sigma}{\omega\epsilon} << 1$, $\eta_b = \sqrt{\mu/\epsilon}$

Reflection from body.

$$\Gamma_b = \frac{\eta_b - \eta_0}{\eta_b + \eta_0} = \frac{1-\sqrt{24}}{1+\sqrt{24}} = -0.66 .$$

Total power absorbed by the body.

$= P_r (1 - |\Gamma|^2) \cdot$ effective area

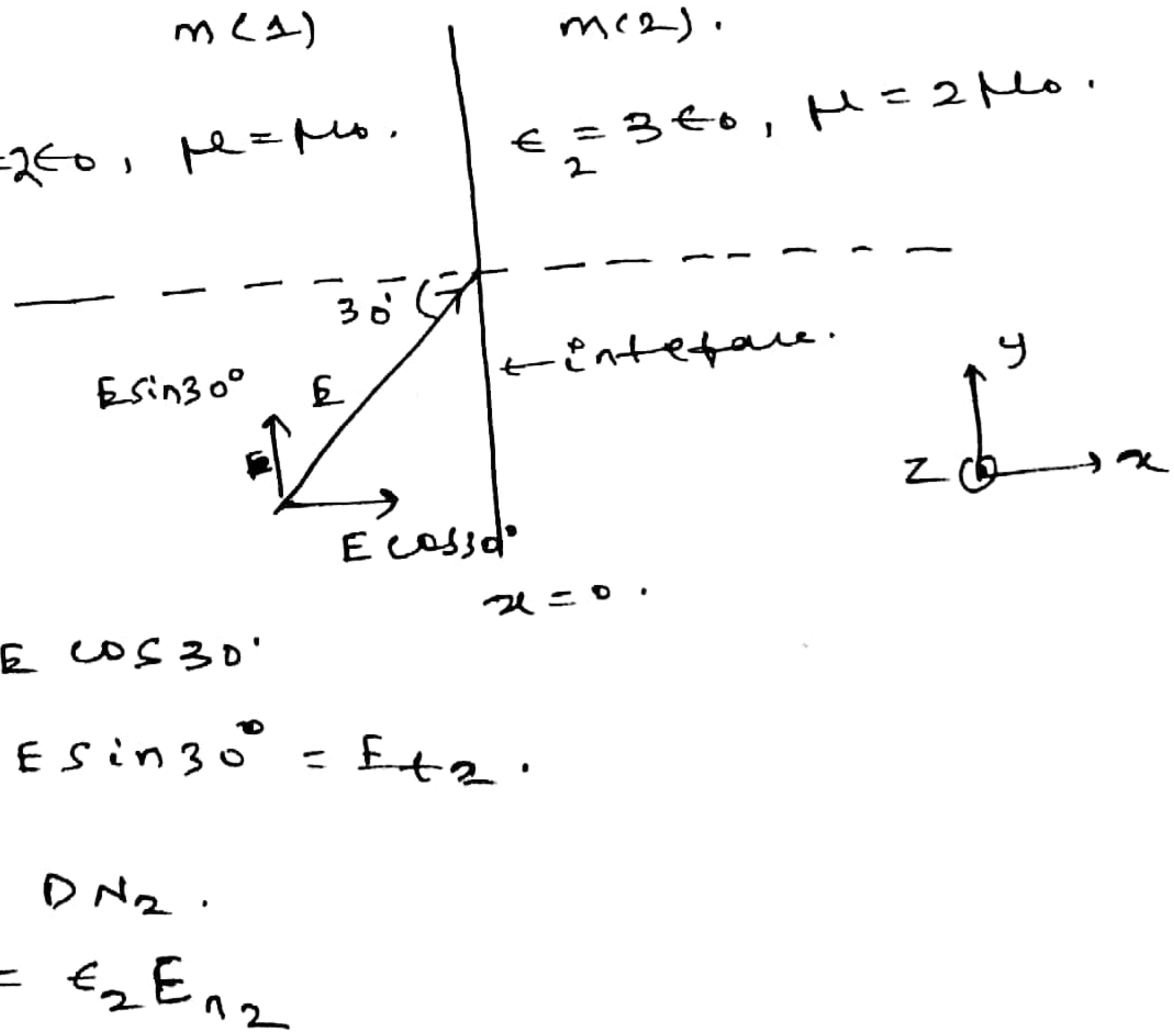
$= 10 \frac{mW}{cm^2} (1 - 0.66^2) \cdot 1.5 \times 100^2 \ cm^2 .$

$= 84.66$ W.

Energy absorbed during maximum exposure.

$= 84.66 \times 6$ hr. $= 507.96$ W.h.

4.



(a) $E_{n_1} = E \cos 30°$

$E_{t_1} = E \sin 30° = E_{t_2} .$

$D_{N_1} = D_{N_2} .$

$\Rightarrow \epsilon_1 E_{n_1} = \epsilon_2 E_{n_2}$

$\Rightarrow E_{n_2} = \frac{\epsilon_1}{\epsilon_2} E_{n_1} = \frac{2}{3} E \cos 30°$

$\vec{E}_1 = \vec{E}_{t_1} + \vec{E}_{n_1} = E \sin 30° \ \hat{y} + E \cos 30° \ \hat{x}$

$= \frac{5}{2} \hat{y} + \hat{x} \cdot \frac{5 \cdot \sqrt{3}}{2} .$

$|\vec{E}_1| = \sqrt{\left(\frac{5}{2}\right)^2 + \left(\frac{5\sqrt{3}}{2}\right)^2} = 5$ V/m.

$|\vec{D}_1| = 2|\vec{E}_1| = 10 \; C/m^2.$

$\vec{E}_2 = \vec{E}_{t2} + \vec{E}_{n2}$

$= E \sin 30 \, \hat{y} + \frac{2}{3} E \cos 30^\circ \, \hat{x}$

$= \frac{5}{2} \hat{y} + \frac{2}{3} \times 5 \cdot \frac{\sqrt{3}}{2} \hat{x}$

$|\vec{E}_2| = 3.81 \; V/m.$

$|\vec{D}_2| = 3 \times (3.81) = 11.45 \; C/m^2.$

(b) The wave is LP on each side of interface.

5. $\omega = 6 \times 10^8$ rad/s.

$L = 0.35 \; \mu H/m$

$C = 40 \; pF/m.$

$G = 75 \; \mu s/m.$

$R = 17 \; \Omega/m.$

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}} = \left(\frac{17 + j \, 6 \times 10^8 \times 0.35 \times 10^{-6}}{75 \times 10^{-6} + j \times 6 \times 10^8 \times 40 \times 10^{-12}} \right)^{1/2}$$

$= 93.623 - j \, 3.63$ or $93.694 \angle -2.224 \; \Omega.$

$$\gamma = \left[(R + j\omega L)(G + j\omega C) \right]^{1/2}$$

$= 0.094 + j \, 2.246$ or $2.248 \angle 87.596.$

$u_p = \frac{\omega}{\beta} = \frac{6 \times 10^8}{2.246} = 2.671 \; m/s.$

$\lambda = \frac{2\pi}{\beta} = 2.797 \; m.$

PTO

P.T.O.

$10 \log(A) = -20.$

$\Rightarrow A = 10^{-2}$

$e^{-2\alpha d} = 10^{-2}.$

$\Rightarrow 2\alpha d = 4.605$

$\Rightarrow d = \frac{4.605}{2 \times 0.094} \simeq 24.5 \text{ m}.$

3.

$J_0 = 1 \text{ A/m}.$

$f = 100 \text{ MHz}$

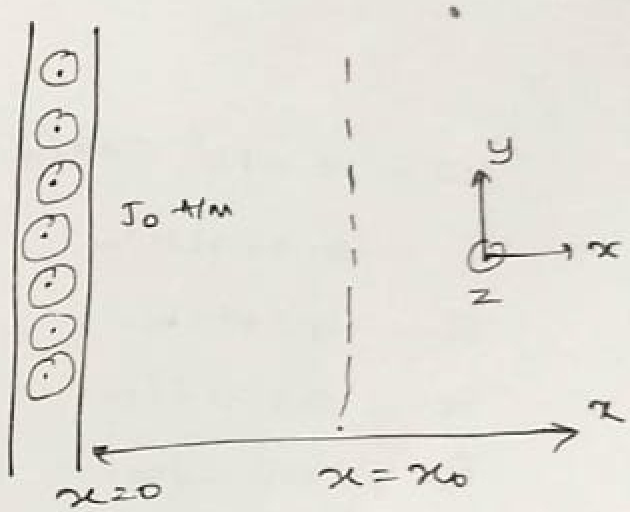
$\sigma = 4 \text{ S/m}.$

$\epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}.$

$\epsilon_r = 80$

$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}.$

$x_0 = 1 \text{m}.$



$$\gamma = \sqrt{j\omega\mu(\sigma + j\omega\epsilon)}$$

$$= \left\{ j \times 2\pi \times 10^8 \times 4\pi \times 10^{-7} \left[4 + (j \times 2\pi \times 10^8 \times 80 \times 8.854 \times 10^{-12}) \right] \right\}^{1/2}$$

$= 37.592 + j\, 42.006$

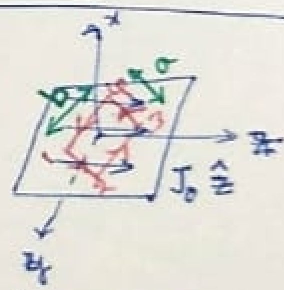
$\alpha = 37.592 \text{ NP/m}.$

$\beta = 42.006 \text{ rad/m}.$

From Ampere's law

$\oint \vec{H} \cdot \vec{dl} = I_{Enc} = J_0 b \rightarrow ①$

$H = \begin{cases} H_0 \hat{a}_y & x > 0 \\ -H_0 \hat{a}_y & x < 0 \end{cases}$



$\oint \vec{H} \cdot \vec{dl} = \left(\int_1^2 + \int_2^3 + \int_3^4 + \int_4^1 \right) H \cdot dl$

$= 0(-a) + (-H_0)(-b) + 0(a) + H_0(b)$

$= 2H_0 b \rightarrow ②$

from ① & ② $H_0 = \frac{1}{2} J_0$

$\boxed{H = \begin{cases} J_0/2\, \hat{a}_y & x > 0 \\ -J_0/2\, \hat{a}_y & x < 0 \end{cases}}$

$\vec{J} = \hat{z}\ 1 \text{ A/m}.$

$\vec{H} = \hat{y}\ \frac{J_s}{2} e^{-\gamma x}$

$= \hat{y}\ \frac{1}{2} \cdot e^{-\alpha x} \cdot e^{-j\beta x}$

$\vec{H}\Big|_{x=1\text{m}} = \hat{y}\ \cancel{\cos}\ 0.5 \times e^{-37.592} \cdot e^{-j42.006},$

$= \hat{y}\ 2.36 \times 10^{-17}\ e^{-j42.006} \text{ A/m}.$

$$\vec{E} = -\hat{z}\,\eta|\vec{H}|\,e^{-\gamma x}$$

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

$$= \left[\frac{j\,2\pi \times 10^{8} \times 4\pi \times 10^{-7}}{4 + j\,2\pi \times 10^{8} \times 80 \times 8.854 \times 10^{-12}}\right]^{1/2}.$$

$$= 10.437 + j9.34 \quad \text{or} \quad 14.006\angle 41.825\ \Omega.$$

$$\vec{E}\Big|_{x_0} = -\hat{z}\quad 3.3\angle 41.82 \times 10^{-16}\,e^{-j42}\ \text{V/m}.$$

$$\text{or}\ (24.631 + j\,22.042) \times 10^{-17} \cdot e^{-j42}\ \text{V/m}.$$