MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.013 Electromagnetics and Applications

Quiz 1 Solutions

Problem 1. (34/100 points)

$$\bar{E} = 2\,\hat{x}\cos(t+z) \text{ and } \bar{H} = \hat{y}\sin(t+z+\frac{\pi}{2}).$$

a) $\frac{\partial}{\partial t}(t+z) = 0 \Rightarrow$ velocity $\boxed{v = \frac{\partial z}{\partial t} = -1 \text{ [m/s]}}$

b) Wave intensity $I = \left\langle \bar{E} \times \bar{H} \right\rangle = \left\langle 2\cos^2(t) \right\rangle = \boxed{1 \text{ [W/m}^2\text{]}}$

c) $\eta = E/H = 2$. $\mu = \eta/v = \sqrt{\mu/\varepsilon}\sqrt{\mu\varepsilon} = 2\times 1 = \boxed{2 \text{ [H/m]}}$

d) Pressure $P_m = W_m = \frac{1}{2}\mu\left\langle H^2 \right\rangle$ where $|H| = 2$ at $s = \infty$. $P_m = \frac{1}{4}\mu 2^2 = \boxed{2 \text{ [N/m}^2\text{]}}$

Problem 2. (18/100 points)

$f_e = -e(\bar{E} - \bar{v}_m \times \mu_o \bar{H}) = 0 \Rightarrow E_y = -v_m B$. But $V = E_y W \Rightarrow \boxed{\bar{v}_m = -\hat{z}\,E_y/B = -\hat{z}\,V/WB}$

Problem 3. (20/100 points)

$\bar{H}_{//}$ is continuous since $\sigma = 0 \Rightarrow \bar{J}_s = 0$.
When $\mu = \infty$ and μH is finite (finite W_m), $H = 0$, so $\boxed{\bar{H}_{//} = 0.}$

Problem 4. (28/100 points)

a) Ampere's Law: $\pi D H = NI \Rightarrow \boxed{H = NI/\pi D \text{ [A/m]}}$ (points counterclockwise)

b) $L = \Lambda/I$. $\Lambda = NA\mu_o H$. So $\boxed{L = NA\mu_o NI/\pi DI = \mu_o N^2 A/\pi D \text{ [H]}}$

c) $\mu \to 0.01\times 1000\mu_o + 0.99\mu_o = 10.99\,\mu_o$; $A \to A/100$, so $L \to \boxed{L' = 10.99\,\mu_o N^2 A/\pi D \text{ [H]}}$

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