

UTA EE5306 PhD Diagnosis Exam (Fall 2011) Electromagnetics

Instructions:

- Verify that your exam contains 7 pages (including the cover sheet).
- Some space is provided for you to show your work. Only if more space is needed, you may show your work on the back of the exam sheet.
- The point values listed on this exam serve only as a guideline. The Department reserves the right to make modifications to the weighting of the problems.
- You may use a calculator.

I Choose to work on Problems _____ and _____ (Choose only 2 from the 3 problems).

Problem	Possible Points	Scores
1	50	
2	50	
3	50	
Total Score (Choose 2 Problems)	100	

1. (50 points) There is an infinitely large plate made of perfect conductor and located at $z = 0$. To the left of $z = 0$, there is only air. An incident plane wave traveling in the region $z < 0$ has electric field

$$\mathbf{E}^i(\mathbf{r}) = (\sqrt{2}\hat{x} + 2j\hat{y} + E_{z0}\hat{z})e^{-j\omega\sqrt{\epsilon_0\mu_0}(z+x)/\sqrt{2}} \text{ (V/m)}.$$

- Find E_{z0} .
- What is the polarization of the incident plane wave?
- When this incident wave hits the conducting plate, what is the electric field associated with the reflected wave?
- What is the polarization of the reflected wave?

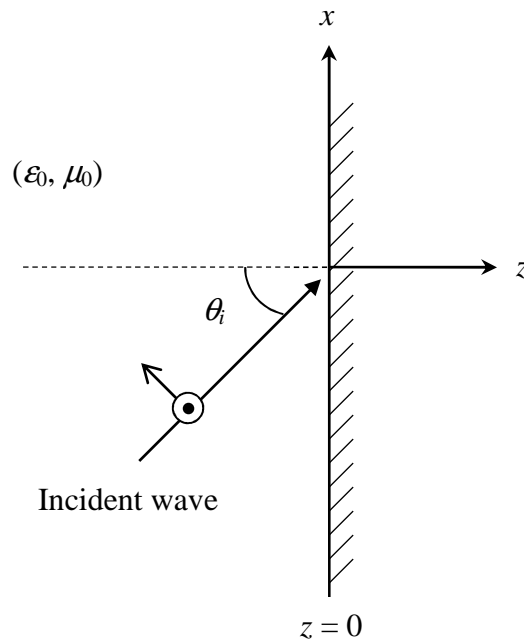


Figure for the problem

2. (50 points) In an air-filled rectangular waveguide with dimensions $a = 3\sqrt{2}$ cm and $b = a/2$, the guided wave is given by

$$\vec{\mathcal{E}}(x, y, z, t) = \hat{y}E_0 \sin\left(\frac{\pi}{a}x\right) \sin\left(\omega t - \frac{\pi}{a}z\right)$$

$$\vec{\mathcal{H}}(x, y, z, t) = \hat{x}H_0 \sin\left(\frac{\pi}{a}x\right) \sin\left(\omega t - \frac{\pi}{a}z\right) + \hat{z}H_0 \cos\left(\frac{\pi}{a}x\right) \cos\left(\omega t - \frac{\pi}{a}z\right)$$

where E_0 and H_0 are real constants.

- What is the mode of this wave? Indicate TE_{mn} or TM_{mn} and the mode numbers m and n .
- Determine the frequency of this wave.
- Determine the phase velocity in \hat{z} direction in terms of the light speed c .
- Determine the cut-off frequency of this mode.

3. (50 points) A Hertzian dipole is made of two opposite charges $\pm q$ separated by an infinitesimally small distance l . The electric field $\vec{\mathcal{E}}$ and magnetic field $\vec{\mathcal{H}}$ of a Hertzian at a very large distances ($kr \gg 1$) in free-space are

$$\vec{\mathcal{E}}(r,t) = -\hat{\theta} \frac{k^2 ql}{4\pi\epsilon_0 r} \sin\theta \cos(\omega t - kr)$$

$$\vec{\mathcal{H}}(r,t) = -\hat{\phi} \frac{\omega k ql}{4\pi r} \sin\theta \cos(\omega t - kr)$$

- (a) Find the Poynting vector $\vec{\mathcal{S}}$ in time domain, and determine the time-averaged power density vector $\langle \vec{\mathcal{S}} \rangle$.
- (b) Determine the average power P radiated by the Hertzian dipole.
- (c) Consider a radio station 15 km away from the city. The transmitting antenna tower may be modeled as a Hertzian dipole antenna of dipole moment ql . Determine the radiation power P_t needed to maintain a 25 mV/m field strength in the city.

