

# Practice Midterm Examination, ECED 4301

## Problem 1

Given the magnetic field in free space,

$$\mathbf{H} = \mathbf{a}_z H_0 \sin \alpha x \cos(\omega t - \beta y),$$

determine the displacement current density and the corresponding electric field in terms of  $H_0$ ,  $\omega$ , and  $\beta$ .

## Problem 2

In a lossless nonmagnetic medium with  $\epsilon_r = 9$ , a magnetic field  $\mathbf{H}(y, t) = 10\mathbf{a}_x \cos(\omega t + \beta y) + 10\mathbf{a}_z \sin(\omega t + \beta y)$ , mA/m propagates as a plane wave with the frequency of 10MHz.

1. What are the propagation constant, wavelength, and phase velocity of the wave?
2. Determine  $\mathbf{E}(y, t)$ .
3. What is the polarization of the wave? (*you have to justify your answer to get full credit*).

## Problem 3

Given the volume charge density

$$\rho_v(\mathbf{r}, t) = (x^2 + y^2 + z^2) \cos 10^4 t, \quad \mu\text{C}/\text{m}^3$$

in a region of space, find the total current flowing through the surface of a cube of size 1 centered at the origin.

## Problem 4

A plane wave propagates in a good conductor with conductivity  $\sigma = 10 \text{ MS/m}$ . The electric field of the wave is given by

$$\mathbf{E} = 3e^{-10^3 x} \cos(10^3 x - 10^5 t) \mathbf{a}_y, \quad \text{mV}/\text{m}.$$

1. What are the skin depth and complex impedance of the medium?
2. Find the time-averaged power flow through the surface  $x = 0$ ,  $-1 \text{ mm} \leq y \leq 1 \text{ mm}$ ,  $-1 \text{ mm} \leq z \leq 1 \text{ mm}$ .