1. (15%) A magnetic field is given in the *xz*-plane by $\vec{B} = \sin(x - v_0 t)\vec{a}_y$ Wb/m^2. Consider a regid square loop situated in the *xz*-plane with its vertices at (*x*, 0, 1), (*x*+1, 0, 1), (*x*+1, 0, 2), and (*x*, 0, 2). Find the emf induced around the loop in the sense defined by connecting the above points in succession.

2. (15%) Charge is distributed with uniform density ρ_0 C/m^3 in the spherical region $a<r<2a$. Find the electric displacement field $\vec{D}$ everywhere.

3. (20%) A current distribution is given in cylindrical coordinates by

$$\vec{J} = \begin{cases} J_0 \vec{a}_z & for \quad r < 3a \\ -J_0 \vec{a}_z & for \quad 4a < r < 5a \end{cases}$$

(a) Find the magnetic field everywhere.
(b) Find the energy stored in the magnetic field of the current distribution per unit length in the *z*-direction.

4. (15%)Let us consider the charge distribution given by

$$\rho = \begin{cases} -\rho_0 & for \quad -a < x < 0 \\ 0.5\rho_0 & for \quad a < x < 3a \end{cases}$$

where ρ_0 is a constant. Find the electric displacement field $\vec{D}$ everywhere.

5. (15%) For a uniform plane wave propagating in the -z-direction in a material medium with $\sigma=0$, $\varepsilon=4\varepsilon_0$, $\mu=\mu_0$, the magnetic field intensity in the z=0 plane is given by

$$\vec{H}\Big|_{z=0} = \cos(10^8 t)\vec{a}_y \ \text{A/m}$$

(a) Find the impedance of the medium for the field.
(b) Find the phase velocity of the wave.
(c) Find the associated electric field $\vec{E}(z,t)$.

6. (20%) Consider a structure with three regions, region 1, 2, and 3. Region 1, $x>d$, is free space. Region 2, $0<x<d$, is a perfect dielectric of $\varepsilon = 4\varepsilon_0$ and $\mu = \mu_0$. Region 3, $x<0$, is a perfect conductor. The electric and magnetic fields in the region 2 are given at a particular instant of time by

$$\vec{E} = E_1 \cos \pi x \sin 2\pi z \, \vec{a}_x$$
$$\vec{H} = H_1 \cos \pi x \sin 2\pi z \, \vec{a}_y$$

(a) Find ρ_s and $\vec{J}_S$ on the surface $x=0$.
(b) Find $\vec{E}$ for $x=d^+$, that is, immediately adjacent to the $x=d$ plane and on the free-space side, at that instant of time.

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