1. (15%) Find the induced emf around the rectangular closed path C connecting the point (0,0,0), (a,0,0), (a,b,0),(0,b,0), and (0,0,0), in that order, for the magnetic field given by

$$\vec{B} = \sin(\frac{\pi x}{2a})\cos\omega t\,\vec{a}_z \quad \text{Wb/m}^2$$

2. (15%) A current density due to flow of charges is given by

$$\vec{J} = -(x\vec{a}_x + y\vec{a}_y + z^2\vec{a}_z) \ \text{A/m}^2$$

Find the displacement current emanating from the surface of the cylindrical box bounded by the surfaces $r = 1$, $z = 0$, and $z = 2$.

3. (15%) Charge is distributed with density $\rho = \rho_0(r/a)$ C/m^3 in the cylindrical region $r < a$. Find $\vec{D}$ everywhere.

4. (15%) Let us consider the current distribution given by $\vec{J} = J_0\vec{a}_x$ for $-a<z<a$, where J_0 is a constant. Find the magnetic field everywhere.

5. (20%) The magnetic field of a uniform plane wave propagating in free space is given by

$$\vec{H} = \cos(3\times10^7 t + 0.1y)\vec{a}_x \ \text{A/m}$$

(a) Find the associated electric field $\vec{E}$.
(b) Find the instantaneous Poynting vector.
(c) Find the direction of propagation of the wave.
(d) Find the instantaneous power flow across a surface of area 2m^2 in the y=0 plane at t=0.

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6. (20%) The rectangular cavity resonator is a box consisting of the region $0 < x < a$, $0 < y < b$, and $0 < z < d$, and bounded by perfectly conducting walls on all of its six sides. The time-varying electric and magnetic fields inside the resonator are given by

$$\vec{E} = E_0 \sin(\frac{\pi x}{a})\sin(\frac{\pi z}{d})\cos\omega t\,\vec{a}_y \quad \text{V/m}$$

$$\vec{H} = H_{01}\sin(\frac{\pi x}{a})\cos(\frac{\pi z}{d})\cos\omega t\,\vec{a}_x - H_{02}\cos(\frac{\pi x}{a})\sin(\frac{\pi z}{d})\cos\omega t\,\vec{a}_z \quad \text{A/m}$$

where E_0, H_{01}, and H_{02} are constants. The medium inside the box is a perfect dielectric of $\varepsilon = 4\varepsilon_0$.

(a) Find the charge density and current density on the wall of $x = 0$

(b) Find the charge density and current density on the wall of $y = 0$

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