ECE 329 Fall 2018 Tutorial Session

Tutorial 6

October 11, 2018

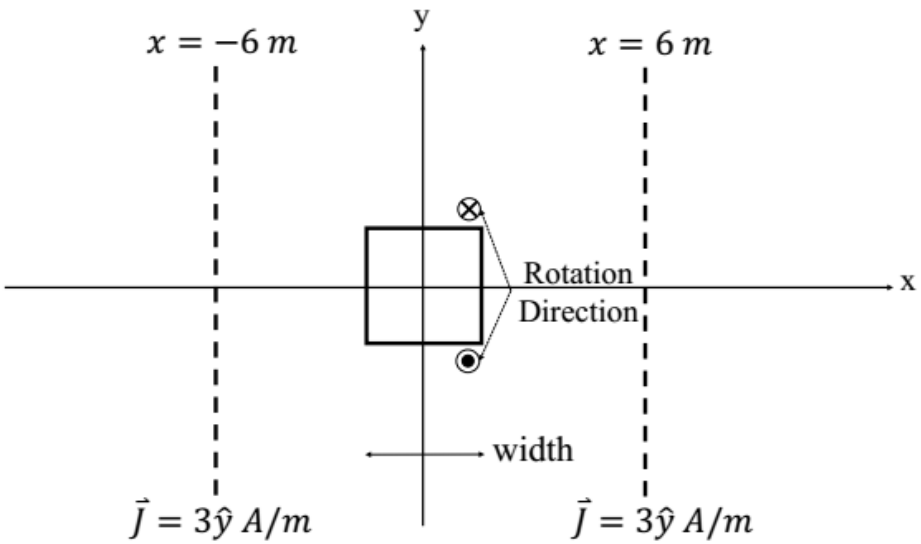
Question 1 (previous exam problem)

In free space, the current density is given by $\vec{J}(x,y,z,t) = \left(tx - tx^2\right)\hat{x} + 2ye^t\hat{y} + 3tz\hat{z}\frac{A}{m^2}$. The charge density at $t = 0$ is given by $\rho(x,y,z,0) = 0\frac{C}{m^3}$

1. Calculate the outward flux of the current $\oint \vec{J} \cdot d\vec{S}$ from a cube with column $V = 27m^3$centered at the origin at time $t = 0$.
2. Determine the charge density implied by $\vec{J}$.
3. Is the positive charge density at point $(1,0,0)$ increasing or decreasing for $t > 0$?

Question 2 (previous exam problem)

Two current sheets are oriented and positioned as shown in the gure below (dashed lines). They are surrounded by free space. A square loop of wire is located at the origin (on the xy− plane) as shown, with resistance of 2Ω. The loop has an area of $1m^2$



1. Determine the magnetic eld strength and magnetic ux density everywhere in space due to the current sheets.

Question 2 cont. (previous exam problem)

2. Determine the induced EMF $\mathcal{E}$ and current on the loop if it is rotated about the x−axis at a rate of 1 revolution per second. Use $\hat{z}$ as the starting direction of the surface vector $d\vec{S}$. Be sure to get the signs correct. The top of the loop is moving into the plane of the paper as shown in the figure.
3. Repeat the above if the loop were instead positioned at $x = 9m$ $(y = 0)$ and still on the xy−plane.
4. Now assume that the currents on the sheets are $J_{x=-6m} = 0\frac{A}{m}$ and $J_{x=6m} = 3\sin\left(2\pi \times 10^8 t\right)\hat{y}\frac{A}{m}$. With the loop positioned at $x = 9m$ $(y = 0)$ and still on the xy−plane, and stationary (not rotating), determine the (non-zero) loop width such that total net magnetic flux passing through the loop at any given time is zero.

Question 3 (previous exam problem)

(a) TRUE FALSE The induced current from a time varying magnetic field $\mathbf{H}$ produces a magnetic field in the opposite direction of $\mathbf{H}$.

(b) TRUE FALSE In magnetostatics, the curl of $\mathbf{H}$ will be zero in regions that the current density $\mathbf{J}$ is zero.

(c) TRUE FALSE The inductance of a structure increases either when the applied current increases or when the magnetic flux linked by the closed current path increases.

(d) TRUE FALSE The continuity equation $\frac{\partial \rho}{\partial t} = -\nabla \cdot J$ is a statement about charge conservation that can be obtained from Maxwell's equations.

(e) TRUE FALSE Diamagnetic materials have a negative magnetic susceptibility, i.e. $\chi_m < 0$.

(f) TRUE FALSE The ratio of the magnetic flux density to the magnetic field intensity is given by the permittivity of the material.

(g) TRUE FALSE Any magnetic field $\mathbf{B}$ can be expressed in terms of a vector potential $\mathbf{A}$ according to: $\mathbf{B} = \nabla \times (\mathbf{A} + \nabla f)$, where f is an arbitrary scalar field.