
Fundamentals of Electromagnetic Fields and Waves: I

Fall 2005, EE 30348, Electrical Engineering, University of Notre Dame

Mid Term Exam

Please show your steps clearly and sketch figures wherever necessary. Points will be awarded for correct steps shown in the solutions.

Fundamental constants: $\epsilon_0 \approx \frac{1}{36\pi} \times 10^{-9} \text{F/m}$, $\mu_0 = 4\pi \times 10^{-7} \text{H/m}$.

Problem 1

Answer the following short questions.

- a) (1 Point) What fundamental law is violated if displacement current is not included in Maxwell's equations?
- b) (1 Point) Can the vector $\mathbf{A} = 3x\mathbf{a}_x + 2y\mathbf{a}_y - 5z\mathbf{a}_z$ represent a magnetic field?

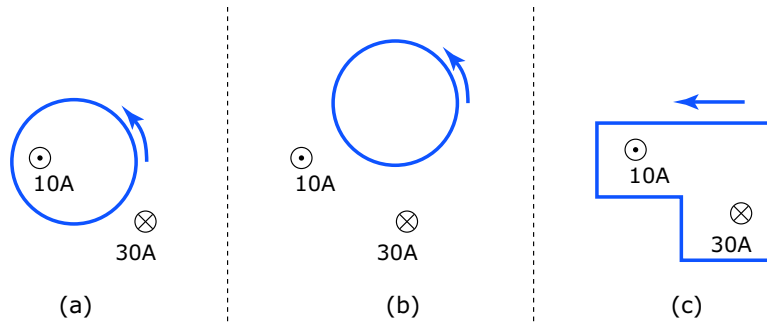


Figure 1: Problem 1 c)

- c) (3 Points) Refer to Figure 1 for this part. Evaluate the line integrals $\oint_c (\mathbf{B}/\mu_0) \cdot d\mathbf{l}$ for the three cases, where the directions of the lines in blue are indicated by arrows.
- d) (3 Points) The electric field intensity of a uniform plane wave is given by

$$\mathbf{E} = 20 \cos(\pi \times 10^9 t - \pi z) \mathbf{a}_x$$

in V/m. Find the direction of propagation, the frequency, and the wavelength of the plane wave. Also find the direction and magnitude of the magnetic field.

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Problem 2 (6 Points)

Refer to Figure 2. A square loop of side a is placed near an infinitely long wire carrying a current I . The loop has a resistance R_0 . The loop moves with a velocity v_0 away from the wire as shown. Find the current that flows through the loop as a function of the distance ρ from the infinite wire.

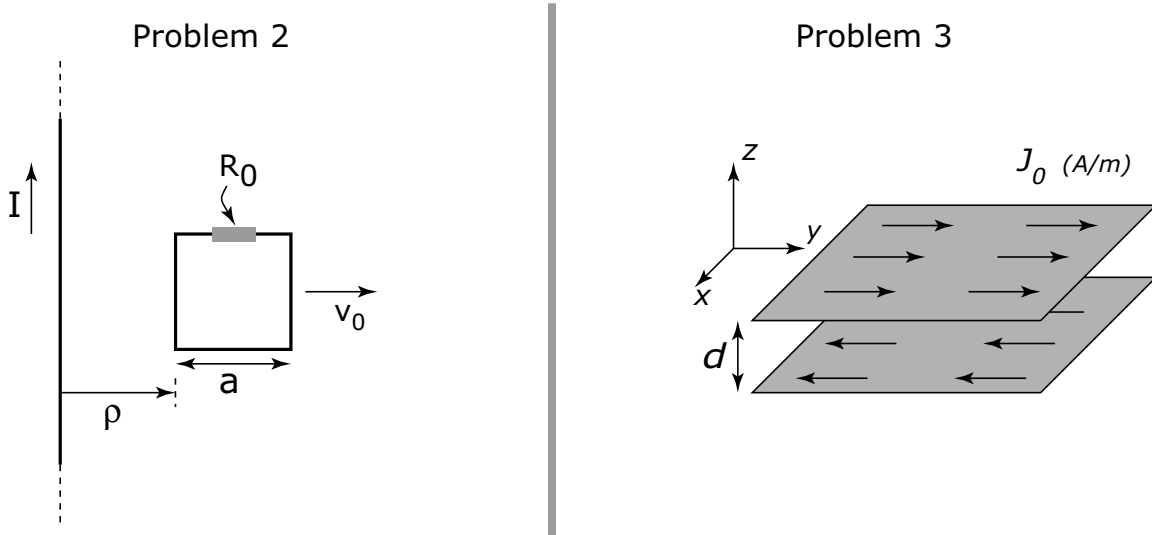


Figure 2: Problems 2 & 3.

Problem 3 (6 Points)

Refer to Figure 2. Two infinitely large sheets carry currents with linear current densities $\pm J_0 \mathbf{a}_y$ in A/m respectively, as shown. Find the magnetic field \mathbf{B} this generates between the sheets, and outside them. Indicate the direction of the field, and plot its magnitude as a function of z .

(Hint: It might be easier if you solve the problem for one sheet first, and then use the superposition principle. Apply symmetry arguments and the right hand rule, and use Ampere's law in the integral form by choosing a reasonable contour.)