# Fundamentals of Electromagnetic Fields and Waves: I

Fall 2006, EE 30348, Electrical Engineering, University of Notre Dame

## Assignment 3

Due date: **Tuesday, September 19th**.
Please attach this sheet on top of your solutions.

1) **Gauss's Law:**
Iskander: Problem 1.37, Problem 1.38.

2) **Faraday's and Lenz's Law:**
Iskander: Problem 1.39, Problem 1.40, Problem 1.41, Problem 1.42, Problem 1.47.

3) **Ampere's Law & Displacement Current:**
Iskander: Problem 1.43, Problem 1.44, Problem 1.45, Problem 1.46.

4) **Ampere's circuital law & Displacement Current**[1]**:**

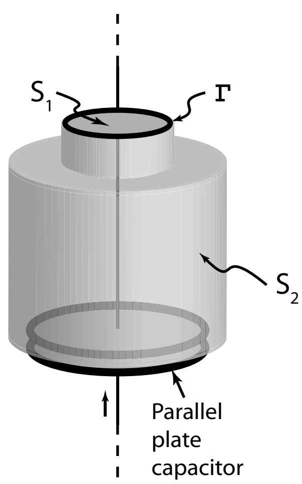


Figure 1: Problem 4.

Consider a long wire carrying a current $I(t) = I_0 cos(\omega t)$, as shown in Figure 1. Neglect the capacitor shown in the figure to begin with.
a) Find the magnetic field $\mathbf{B}(t)$ along the contour $\Gamma$ shown, which is at a distance $\rho$ from the wire. Use the surface $S_1$ and Ampere's law.
b) Now consider the situation when far away from the contour $\Gamma$, a large parallel-plate capacitor (area $A$) is introduced into the path of the wire. Say the capacitance is $C$. Find the charge $Q(t)$ stored in the capacitor as a function of time. Give an argument why the introduction of the capacitor would not change the magnetic field calculated in part (a).
c) If instead of the surface $S_1$, I choose to use the surface $S_2$ which passes through the middle of the parallel plate capacitor, show that the "steady state" Ampere's law $\oint_c \frac{\mathbf{B}}{\mu_0} \cdot d\mathbf{l} = \int_s \mathbf{J} \cdot d\mathbf{S}$ gives an incorrect result for contour $\Gamma$.
d) Maxwell found that he *had* to introduce the displacement current component to make Ampere's law complete. By finding the electric field $\mathbf{E}(t)$ inside the plates of the capacitor, show that adding the displacement term

$$d/dt(\int_s \epsilon_0 \mathbf{E} \cdot d\mathbf{S})$$

to the real current $\int_s \mathbf{J} \cdot d\mathbf{S}$ will give the correct result on surface $S_2$.

[1]Read section 1.9 from Iskander.