Name:

Physics 51
Homework #15
October 31, 2016

SUP1, SUP2, 38-P3, 34-P6*

SUP1 A parallel plate capacitor has circular plates of radius R and separation d. The capacitor is connected to a battery of voltage V and then disconnected so that the charge ought to remain constant. The air is humid, however, and therefore slightly conducting; thus the stored charge leaks back across the air gap between the capacitor plates at rate i_{leak}. Assume that this leakage current is uniformly distributed across the area of the plates. Find the magnetic field everywhere between the plates.

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SUP2 In a material of non-zero electrical resistivity ρ, the relationship between electric field and current density is $\vec{E} = \rho\vec{j}$. For copper, $\rho = 2 \times 10^{-8}\,\Omega\text{m}$. A copper wire with a circular cross-sectional area of $4\,\text{mm}^2$ carries a current of $40\,\text{A}$.

(a) What is the longitudinal electric field (field along the length of the wire) in the copper?

(b) If the current is changing at a rate of $5000\,\text{A/s}$, at what rate is $\vec{E}$ changing, and what is the resulting displacement current?

(c) Does the displacement current contribute significantly to the magnetic field outside the wire? Explain your answer.

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38-P3 The capacitor in Fig 38-25 consisting of two circular plates with radius $R = 18.2\,\text{cm}$ is connected to a source of emf $\mathscr{E} = \mathscr{E}_m \sin\ \omega t$, where $\mathscr{E}_m = 225\,\text{V}$ and $\omega = 128\,\text{rad/s}$. The maximum value of the displacement current is $i_d = 7.63\,\mu\text{A}$. Neglect fringing of the electric field at the edges of the plates.

(a) What is the maximum value of the current i?

(b) What is the maximum value of $\frac{d\Phi_E}{dt}$, where Φ_E is the electric flux through the region between the plates?

(c) What is the separation d between the plates?

(d) Find the maximum value of the magnitude of $\vec{\mathbf{B}}$ between the plates at a distance $r = 11.0\,\text{cm}$ from the center.

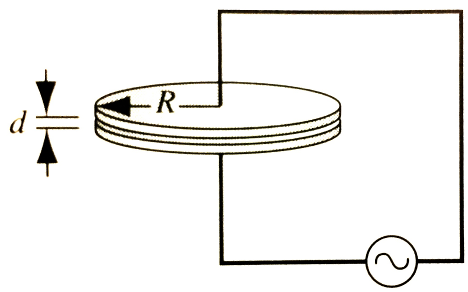

FIGURE 38-25. Problem 3.

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34-P6* Figure 34-57 shows two parallel loops of wire having a common axis. The smaller loop (radius r) is above the larger loop (radius R), by a distance $x \gg R$. Consequently the magnetic field, due to the current i in the larger loop, is nearly constant throughout the smaller loop and equal to the value of the axis. Suppose that x is increasing at the constant rate $\frac{dx}{dt} = v$.

(a) Determine the magnetic flux across the area bounded by the smaller loop as a function of x.

(b) Compute the emf generated in the smaller loop.

(c) Determine the direction of the induced current flowing in the smaller loop.

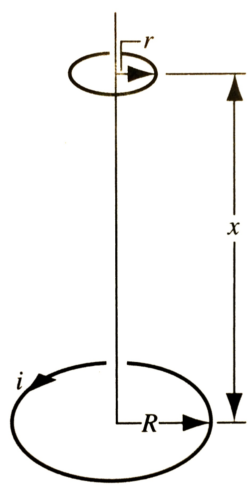

FIGURE 34-57. Problem 6.

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