Physics 106c: Electrodynamics

Problem Set 3

Due: 4pm Friday, April 27, 2012

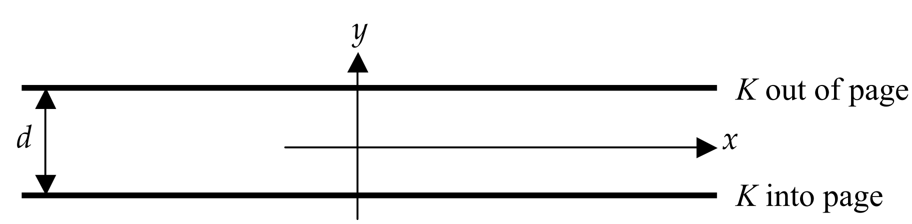
Remember: Late homework will be granted 50% credit up to one week late, unless you have a note from the Dean or a health official.
Reading: Griffiths Chapter 7 and 9.
Problems:

1. Consider a cylindrical copper rod of length L and radius R. At time $t = 0$ a uniform magnetic field $B(t)$ begins to be applied along the symmetry axis of the rod. Assume the magnitude of the field grows linearly with time: $B(t) = \gamma t$, with γ a constant. Calculate the Joule heating generated in the rod as a function of time, keeping in mind the results of Problem 3 from Set 2. To make things concrete, take $L = 30$ cm, $R = 3$ mm, and $\gamma = 0.001$ T/s. Also, take the resistivity of copper (at $B = 0$) to be $1.6 \text{x} 10^{-6}$ ohm-meter, and its free carrier density to be $n = 8.5 \text{ x } 10^{28}$ m^{-3}. Graph your result for $0 < B < 10$ T.

2. Griffiths 7.42

3. Griffiths 7.53

4. Two parallel infinite conducting planes are separated by a distance d along the y – axis. A sheet current density K flows uniformly in the z - direction in one sheet while an opposite current density, $-K$, flows in the other sheet. In cross section:



a) Find the magnetic field **B** everywhere.
b) Assume K increases linearly with time; $K = \alpha t$. Find the electric field **E** everywhere.
c) Evaluate the Poynting vector everywhere. Show that the flux of energy into the region between the plates matches the time rate of change of the energy stored in the electric and magnetic fields between the plates. (Of course the total energy between the plates is infinite, since the plates are. Work with the energy per unit area.)
d) Now suppose that the current density is an arbitrary but slowly varying function of time, $K(t)$. Evaluate the electric and magnetic fields, and the Poynting vector, everywhere, in the quasistatic approximation. Show that the flux of energy into the region between the plates equals the time rate of change of the *magnetic* energy only. What about the electric field energy? Is total energy not being conserved? Explain.