Physics 106c: Electrodynamics

Problem Set I

Due: 4pm, Friday, April 10, 2009

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. Homework should be turned into the box outside 114 Sloan Annex.

Reading: Griffiths Chapters 5 and 6
Problems:

1. Consider a circular wire loop of radius R which carries a current I. Evaluate the magnetic field on the symmetry axis. Away from the loop $\nabla \times \mathbf{B} = 0$ and so we may construct a *scalar* potential ϕ such that $\mathbf{B} = \nabla \phi$. Evaluate ϕ on the symmetry axis. Then, based on your knowledge from last term, determine $\mathbf{B}$ off the symmetry axis (confining your results to distances large compared to R and only the first 3 non-vanishing terms in the series). Show that at large distances the magnetic field is that of a simple dipole.

2. In class we found that if $\nabla \cdot \mathbf{A} = 0$ then we could deduce $\mathbf{A}$ from the current density $\mathbf{J}$ via

$$\mathbf{A} = \frac{\mu_0}{4\pi} \int \frac{\mathbf{J}}{\mathscr{r}} \, d\tau$$

Show, by direct calculation that this formula does indeed produce $\nabla \cdot \mathbf{A} = 0$ when magnetostatics prevails and the current distribution is localized.

3. Consider a solenoid of radius R and length L. Let the number of turns per unit length be n. Find the magnetic field everywhere along the symmetry axis. Express your answer compactly in terms of the angles subtended by the ends of the solenoid as observed at the point where the field is being evaluated.

4. Griffiths 5.57

5. Griffiths 6.12

6. Griffiths 6.13