4^{th} HOMEWORK
Due April 15, 2009

1. At an initial time, a charged particle is at some point P in a magnetic field and it has an initial velocity. Under the influence of the magnetic field, the particle moves to a point P'. If you now reverse the velocity of the particle, will it trace its orbit and return to the point P?

2. (a) Prove that the magnetic force can be expressed as

$$\vec{F} = \frac{\mu_0}{4\pi}\frac{qq'}{r^2}\left(\vec{v}'\hat{r}\cdot\vec{v} - \hat{r}\vec{v}\cdot\vec{v}'\right)$$

   (b) Show that the magnetic field of a point charge q' moving with a velocity $\vec{v}'$ can be written in terms of the electric field of this point charge as $\vec{B} = \mu_0\epsilon_0\vec{v}'\times\vec{E}$.

3. (a) A long solenoid has 300 turns of wire per meter and it has a radius of 3.0 cm. If the current in the wire is increasing at the rate of 50 ampere per second, at what rate does the strength of the magnetic field in the solenoid increase?

   (b) The solenoid is surrounded by a coil of wire with 120 turns. The radius of this coil is 6.0 cm. What induced emf will be generated in this coil while the current in the solenoid is increasing?

4. A square loop of dimension $l\times l$ is moving at speed v toward a straight wire carrying a current I. The wire and the loop are in the same plane and two of the sides of the loop are parallel to the wire. What is the induced emf of the loop as a function of the distance d between the wire and the nearest side of the loop?

5. A disk of metal of radius R rotates about its axis with a frequency ν. The disk is in a uniform magnetic field B, parallel to the axis of the disk.

   (a) find the induced emf between the center of the disk and a point on the disk at a radial distance r (where $r < R$)

   (b) Find the strength of the induced electric field at this point.

6. A loop of wire carrying a current of 100 A generates a magnetic flux of 50 Wb through the area bounded by the loop.

   (a) What is the self-inductance of the loop?

   (b) If the current is decreased at the rate $dI/dt = 20\ A/s$, what is the induced emf.

7. The field of a fixed magnetic dipole located at the origin and oriented parallel to the z axis has the following components as a function of z and x in the plane $y = 0$:

$$\begin{aligned} B_x &= \frac{\mu_0 \mu}{4\pi} \frac{3zx}{(x^2+z^2)^{5/2}}, \quad B_y = 0 \\ B_z &= -\frac{\mu_0 \mu}{4\pi} \left(\frac{1}{(x^2+z^2)^{3/2}} - \frac{3z^2}{(x^2+y^2)^{5/2}} \right) \end{aligned} \tag{1}$$

   Suppose that a second magnetic dipole of moment μ' is located at the point $x,\ z$(with $y = 0$); this dipole is free to rotate in the $x - z$ plane.

   (a) What is the orientation of least magnetic energy of this second dipole in the field of the first dipole, i.e., what is the angle that the second dipole will make with the z-axis?

   (b) What is the numerical value of the angle in the case $x = 0$, $z = r$? In the case $x = r$, $z = 0$? In the case $x = z = r/\sqrt{2}$?