5^{th} HOMEWORK
Due April 22, 2009

1. How would you measure the magnetic moment of a compass needle?

2. Consider a closed mathematical surface enclosing one of the poles of a bar magnet. What is the magnetic flux through this surface?

3. You can make a chain of paper clips by touching one end of a clip to the pole of a magnet, then touching the free end to another paper clip, end so on. Expand.

4. Consider a charged sphere of radius R that is rotating around the z axis with an angular momentum L. Assume that the sphere has a mass M distributed uniformly over its volume. What is the magnetic dipole moment of the sphere it it has a total charge Q distributed uniformly over its (i) surface? (ii) volume?

5. The proton has a magnetic moment of $\mu = 1.41 \times 10^{-28} A \cdot m^2$ parallel to the axis of its spin angular momentum. If the proton is in a magnetic field $\vec{B}$ and the magnetic moment makes an angle θ with this field, the torque exerted by this field on the magnetic moment will be $\tau = \mu B \sin\theta$ and the direction of this torque will be perpendicular to μ. Since the proton has a spin angular momentum $\vec{S}$ parallel to the magnetic moment, the torque will cause a precession of the spin about the direction of the magnetic field.

   (a) Show that the precession frequency of the proton is

   $$\omega = \mu B/s$$

   or since $S = \hbar/2 = 0.53 \times 10^{-34} J \cdot s$,

   $$\omega = 2\mu B/\hbar$$

   (b) What is the precession frequency of a proton in a magnetic field of 0.20 T

6. A current of 15 A in a coil produces a magnetic flux of 0.10 Wb through each of the turns of an adjacent coil of 60 turns. What is the mutual inductance?

7. A transmission line consists of two concentric tubes of thin copper sheet metal of radii R_1 and R_2. The current flows to the left along one of the tubes and back along the other, completing a circuit; the current is uniformly distributed over the surface of each tube. Show that the self inductance per unit length of the transmission line is

$$\frac{\mu_0}{2\pi} \ln \frac{R_2}{R_1}$$

8. To measure the self-inductance and the internal resistance of an inductor, a physicist first connects the inductor across a 3.0 V battery. Under these conditions, the final, steady current in the inductor is 24 A. The physicist then suddenly short-circuits the inductor with a thick (resistanceless) wire placed across its terminals. The current then decreases from 24 A to 12 A in 0.22 s. What are the self-inductance and the internal resistance of the inductor? How does the internal resistance of the battery effect your conclusions?