

7th HOMEWORK

Due May 1, 2008

1. (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?
2. 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?
3. 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.
4. 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.
5. 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 $y = 0$:

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

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 $x = z = r/\sqrt{2}$?

6. A current of 25 A flows in a long solenoid of 1500 turns per meter.
- (a) If the interior of this solenoid is empty (a vacuum), what is the strength of the magnetic field?
 - (b) If the interior is filled with liquid oxygen while the current stays constant, what will be the percentage change in the magnetic field?
7. In iron, two of the electrons of each atom participate in the alignment of spins that causes magnetization. Suppose that a cylindrical piece of iron, of radius 1.0 cm and length 8.0 cm , is completely magnetized along its axis, all the available electrons being in perfect alignment.
- (a) What is the number of aligned electrons?
 - (b) The dipole moment of each electron is $9.27 \times 10^{-24}\text{ Am}^2$. What is the total dipole moment of all the aligned electrons?
 - (c) What surface current running around the surface of the cylinder will give the same total dipole moment?
 - (d) What magnetic field does this surface current produce in the interior of the iron?