Mock Semester exam chapters 7.

PHYS4315

 Two small circular loops of wire (of radii a and b) lie at two different points on the z-axis. Assume that both loops have their normal parallel to the z-axis. What is the mutual inductance between the loops if the distance r is sufficiently large that the dipole approximation may be used?



- 2. At the National High Magnetic Field Laboratory in Los Alamos, explosive techniques are used to create huge magnetic fields. Consider a ring with radius a that is situated in a homogeneous magnetic field B perpendicular to the plane that contains the ring. Now assume that explosives are used to decrease the radius of the ring to a radius a/10. This reduction in radius happens during a very short interval Δt . Assume that during this compression the ring is not destroyed and stays a conducting magnetic circuit.
 - a. Calculate the induced emf in the ring.
 - b. Find an expression for the maximum magnetic field during compression of the ring in the center of the ring.
- 3. In a perfect conductor, the conductivity is infinite, so E=0 and any net charge resides on the surface.
 - a. Show that the magnetic field is constant ($\frac{\partial B}{\partial t} = 0$), inside a perfect conductor.
 - b. Show that the magnetic flux through a perfectly conducting loop is constant.

A superconductor is a perfect conductor with the additional property that the (constant) B inside is in fact zero. (This "flux exclusion" is known as the Meissner effect.

- c. Show that the current in a superconductor is confined to the surface.
- d. Superconductivity is lost above a certain critical temperature (T_c), which varies from one material to another. Suppose you had a sphere (radius a) above its critical temperature,

and you held it in a uniform magnetic field $B_o \hat{z}$ while cooling it below T_c. Find the induced surface current density **K**, as a function of the polar angle θ .

4. Assume a coaxial cable of 1 meter length with an inner wire radius of a and an outer radius of b. The space between the electrodes is filled with a weakly conducting material whose conductivity is inhomogeneous and depends on the distance of the material to center axis of the coaxial system, i.e.

 $\sigma = 3s$

- a. If the electrodes are maintained at a potential difference V, what current flows from the inner electrode to the outer electrode?
- b. Determine an expression for the resistance of the device.