Name _____

Physics 413
Final Exam

Answer 6 out of the 7 following questions. Mark clearly each question you wish to have graded. Each answered question will carry equal weight.

Question 1:

An annular disk (a washer) of inner radius a and outer radius b has uniform surface charge density $\sigma = \sigma_\circ$. The washer spins about its axis with constant frequency $\omega_\circ$.

a. Find the magnetic dipole moment m for the disk.

b. Find the magnetic field on the z-axis for all z.

c. Show that your answer to part b is consistent with the magnetic dipole moment you found for part a.

Question 2:

A long solenoid has current $I(t) = I_\circ$ for time $t < 0$ and $I(t) = I_\circ \exp(-t/t_\circ)$ for time $t > 0$. The solenoid has radius a. A plastic hoop with radius $b > a$ is placed so that its axis coincides with the axis of the solenoid. A charge q with mass m is placed on the plastic hoop.

a. Find the magnetic vector potential $A(t)$. Assume that the current changes very slowly.

b. Find the speed and direction in which the charge moves at large times after the current decays.

Question 3:

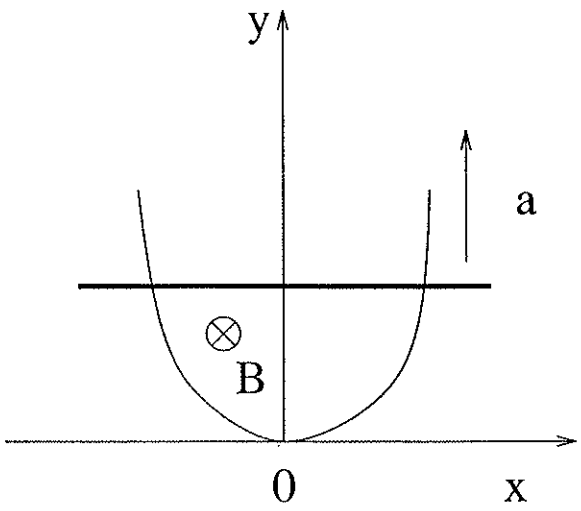
A cylinder of length L and radius R has uniform magnetization parallel to its axis, $\mathbf{M} = M_o\hat{\mathbf{z}}$.

a. Find the bound currents.

b. Find **B** and **H** at the midpoint of the cylinder.

Question 4:

A wire is bent into the shape of a parabola $y = kx^2$, where k is a constant. The wire is located in a uniform magnetic field **B** perpendicular to the x-y plane. At $t = 0$ a metal conducting rod, which is parallel to the x axis, starts sliding upward along the wire (i.e., in the direction of increasing y) from the origin with constant acceleration **a**.



Find an expression for the *emf* induced in the loop. Express your answers in terms of B, y, k and a.

Question 5:

A capacitor with circular parallel plates with radius a and separation d has potential difference V(t).

a. Find the magnetic field on the midplane of the capacitor at radius s from the symmetry axis.

b. Show that **B** is the same as the field of a straight wire carrying current $I = dQ/dt$, where Q is the charge on the capacitor.

c. Find the Poynting vector at s and then find the integral of the Poynting vector over the cylindrical area with radius s and length d. Find the average energy flow into the cylindrical volume defined by s.

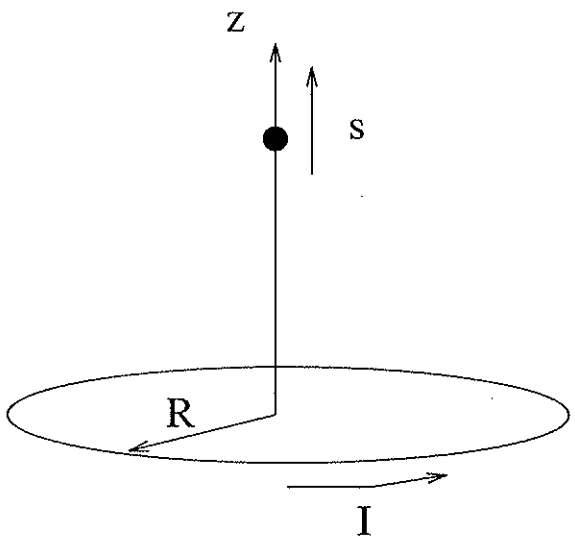
Question 6:

An electron is held on the z-axis at a height h above a circular loop (radius R). The spin of the electron points in the positive z-direction (away from the wire loop). The wire loop carries a steady current I.

a. Find and roughly plot the magnetic field and the gradient of the magnetic field on the z-axis.

b. Make a rough plot of the force on the electron as a function of z.

c. The electron is propelled toward the wire loop with initial speed v_o (down the z-axis). Under what condition will the electron reflect before it reaches $z = 0$? The current in the wire loop is maintained at the value I and the initial height $h \ll R$.



Question 7:

The region between two conducting shells of radii a and b is filled with material of conductivity $\sigma = \mathrm{k}/r^2$. The inner shell is held at potential $V_\circ$ and the the outer shell is held at potential 0.

a. Find the resistance R between the shells.

b. Show that the continuity equation is satisfied.

c. Find the charge distribution between the shells.