Electromagnetism

Do two of the following three problems, each on a separate sheet (or sheets). Staple together the sheets for each problem, if using multiple sheets, but do not staple all problems together. Write at the top of the first sheet of each problem your name, subject, and problem number.

Problem 1

A thin insulating disk has a radius a, and carries a total charge Q distributed isotropically about the center but with a charge density varying as r^2. The disk rotates (nonrelativistically) with angular speed ω about its center. Find the magnetic field at the center of the disk in terms of Q, a and ω.

Problem 2

A long straight solenoid of 2,000 turns per meter is wound on an iron core with a radius of 2 cm, and carries a current of 3 amps in the winding. Assume that the relative permeability $k_m = 1,000$ and neglect the end effects.

1. Find **H** inside the iron core.
2. Find the polarization vector **M** inside the iron core.
3. Find the amperian surface current density, **J**, on the surface of the iron.
4. By aid of a diagram show the direction of this current with respect to the real current in the windings.
5. What is the value of the flux in the core?
6. If the iron core were removed, how many turns of wire per meter would have to be employed (still carrying 3 amps) to produce the same value of magnetic flux in the core?

Problem 3

Consider a y-dependent charge density in space

$$\rho = \begin{cases} cy, & y > 0 \\ 0, & y \leq 0, \end{cases}$$

with $c = 2\mu\text{C/m}^4$, independent of x and z. For the cubic volume in the figure below, calculate the following, preferably in the SI system:

(a) The flux of the electric field through the surface of the cube

(b) The divergence of the electric field at the cube's faces parallel to the xz plane