Rutgers Physics 385 Electromagnetism I (Fall'11/Somalwar)

Final Exam - Dec. 19, 2011

This is a closed book/notes exam. A one-sided 8.5x11 sheet with only formulae is allowed. Please attach the sheet to your solutions. Calculators are not needed. Indicate explicitly which problems should be graded. Indicate your reasoning clearly and step-by-step. Exam duration - Noon to 300PM. Total credit 40 points.

SECTION 1 - DO ANY 2 OUT OF 3 PROBLEMS, TOTAL 16 POINTS

A1. A sphere of linear dielectric material of radius R and dielectric constant k also has a uniform free charge density ρ. Find D,P and E inside and outside the sphere.

A2. An infinitely large parallel plate capacitor has uniform surface charge density σ on its upper plate and $-\sigma$ on the lower plate. The plates are parallel to the xy plane, and are separated by a distance d. The entire capacitor is set moving with a constant speed v along the x axis. Find the magnetic field everywhere. (Hint: The surface current density for the positive plate would be $+\sigma v$ along the x-axis, for example. The rest is just Ampere's law.)

A3. A long straight wire of radius R carries a current density that rises linearly as a function of radius, $J(r) = \alpha r$. What is the total current? The wire is made up of a linear material with susceptibility χ_m. Use the appropriate versions of the Ampere law to find the magnetic fields H, B and M inside the wire.

SECTION 2 - DO ANY 6 PROBLEMS, TOTAL 24 POINTS

B1. Find the energy stored in a thin spherical shell of radius R and charge Q by integrating E^2 and also by bringing in the total charge in increments of dq.

B2. Find the capacitance per unit length of two coaxial metal cylindrical tubes (inner radius a and outer radius b), filled with a linear dielectric with dielctric constant k.

B3. A uniform line charge λ is placed on an infinite straight wire, a distance d above a grounded conducting plane. Find the electric field as a function of distance from the wire

ONLY in the plane formed by the wire and its image.

B4. Find the potential everywhere for a spherical shell (radius R) that carries a constant surface charge density $\sigma(\theta)) = k$ using Laplace's equation formalism. Make sure that the answers are the same as what you would get using Coulomb's law.

B5. Compute the monopole and dipole terms for the potential V for a thin disk with radius R and carrying a constant surface charge density σ. Assume the origin to be at the center of the disk.

B6. Calculate the force of attraction per unit length between two infinitely long parallel wires, each carrying current I, and spaced a distance d apart.

B7. Evaluate the B field corresponding to the vector potential $\vec{A}_1 = z\hat{i}$. Then do the same for $\vec{A}_2 = (z\hat{i} - x\hat{k})/2$. What can you conclude about the difference of the two $\vec{A}$ potentials? (Hint - evaluate the gradient of xz). Please be very specific.

B8. Write down the boundary conditions for E and B (don't worry about the signs and constants). Attach the relevant Maxwell's equation to each boundary condition.

B9. A square loop of wire (side a) lies in the xy plane centered at the origin, and carries a current I counterclockwise as viewed from the positive z axis. Calculate the magnetic dipole moment and the approximate $\vec{A}$ at points far from the origin.