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EE301 Electricity, Magnetism and Fields
Midterm Examination
Professor Robert E. Johanson

Welcome to the EE301 Midterm. This is a closed book and closed notes examination. A formulae sheet is attached. You may use a calculator. The examination lasts **1:25** hour.

Each problem is worth the same; subparts of a problem might be weighted differently. Show your work and briefly explain what you are doing if appropriate; credit will be given only if the steps leading to the answer are clearly shown. If a symmetry argument is used, it is sufficient to write "By symmetry we know that...". Partial credit will be given for partially correct answers. Be reasonably neat; credit will not be given for illegible answers.

Answer all **4** of the problems.

None of the problems require intricate mathematical manipulations.

Problem 1

A charge of 40 nC is at $(2, 3, 1)$ and a charge of -100 nC is at $(-2, 1, -3)$ (Cartesian coordinates, distances in meters). Answer the following questions.

a) Determine the electric field vector at the point $(1, 1, 0)$.

b) Determine the electric potential at the point $(1, 1, 0)$.

c) If another charge of 10 nC is placed at the point $(1, 1, 0)$, what force acts on this charge and what is the potential energy of the charge?

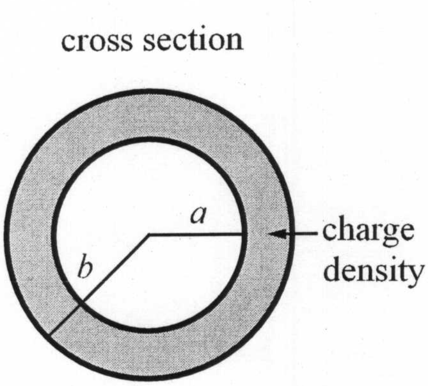
Problem 2

a) A charge distribution expressed in spherical coordinates depends only on the variable r. What does symmetry imply about the electric field $\vec{E}(r, \theta, \phi)$ produced by this charge?

b) There is a constant space charge density ρ_0 for $a < r < b$ (spherical coordinates) and no space charge outside of this region. That is

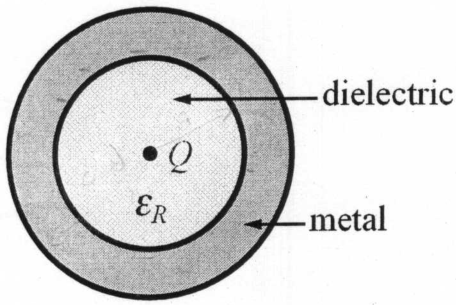
$$\rho_V = \begin{cases} 0 & \text{for } r < a \\ \rho_0 & \text{for } a < r < b \\ 0 & \text{for } r > b \end{cases}$$

Use Gauss's law to calculate the electric field in all three regions.



Problem 3

A hollow metal sphere with inner radius a and wall thickness d contains a dielectric with dielectric constant ϵ_R. At the very center is a charge Q. The metal is not connected to ground.

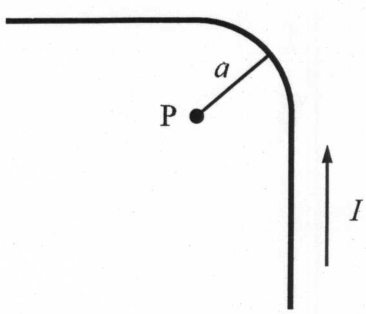


a) Determine the electric field inside the metal, inside the dielectric, and outside the sphere.

b) Determine the electric potential as a function r everywhere. Let the potential at infinity be 0 V.

Problem 4

The middle of an infinitely long wire is bent in a quarter circle as shown; the radius of the bend is a. A current I flows in the wire. Calculate the magnetic field vector at the center of the circular bend, point P.



You might be interested to know that

$$\int_0^\infty \frac{1}{(a^2 + x^2)^{3/2}} dx = \frac{1}{a^2}$$

although if you are really clever you won't need it.