PC3231

Tutorial 1: Fields in Matter

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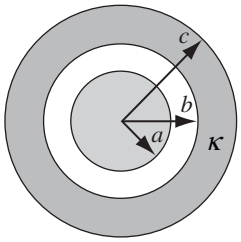
1. A sphere of radius R carries a polarization $\boldsymbol{P}(\boldsymbol{r}) = kr\hat{\boldsymbol{r}}$ where k is a positive constant. Find the electrostatic field inside and outside the sphere by two different methods:

   (a) Locate all the polarization charges and use Gauss's law to calculate the electrostatic field they produce.

   (b) Use Gauss's law to calculate the electrostatic auxiliary field and then calculate the electrostatic field.

2. A coaxial cable consists of a copper wire, radius a, surrounded by a concentric copper tube of inner radius c. The space between is partially filled (from b out to c) with linear isotropy homogeneous material of dielectric constant κ.

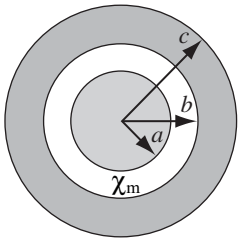


   Find the capacitance per unit length of this cable.

   Note: A capacitor consists of two oppositely-charged (but equal in magnitude) conductors, separated by a dielectric material. The capacitance of the capacitor is defined as the ratio of the positive charge to the voltage difference between the two conductors.

3. A long straight wire of circular cross section with radius a carries current I in the $+z$ direction and is immersed in a large volume of linear isotropy homogeneous material of magnetic susceptibility χ_m. Calculate the magnetization in the magnetic material. What is the magnetization current density for $s > a$? Calculate the total current.

4. A long coaxial cable consists of an inner cylindrical conductor of radius a and an outer cylindrical shell (inner radius b and outer radius c).



A current I flows along the $+z$ axis in the inner conductor and returns along the outer one. The currents are distributed uniformly in the conductors. The region between the conductors is filled with a linear magnetic material of susceptibility χ_m. Find magnetostatic field, magnetostatic auxiliary field and magnetization in each region, and distribution of magnetization current.