Department of Physics, IIT-Kanpur

Instructors: TKG & DpC PHY103A (2014-15, II-SEM) Problem Set 4

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1. The electric field near the surface of the earth is roughly 100 V/m, pointing towards the center of the earth. As you move up into the space, the field vanishes beyond some distance above the surface of the earth. Assuming (a) the field does not extend beyond 10 km (b) the atmosphere has a uniform charge density up to that point, calculate the potential of the earth surface with respect to a reference point at infinity. Also estimate the total charge on earth (excluding the atmosphere). What is the energy stored in the electric field?

2. A metal sphere of radius R carries a total charge Q. What is the force of repulsion between the northern and southern hemispheres?

3. Two non-intersecting spherical cavities of radii a and b are hollowed out from the interior of a neutral conducting sphere of radius R. At the center of each cavity, a point charge is kept - call them q_a and q_b. i) Find the surface charge densities on all the surfaces. ii) Calculate the electric field outside the conductor and inside each cavity. iii) What is the force on q_a and q_b? iv) Which of these answers would change if a third charge Q were brought near the conductor?

Exercises

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1. The electrostatic force is responsible for the stability of ionic crystals like NaCl, KCl etc. In such ionic crystals, ions are arranged in a periodic manner in three dimensional space: the positive and negative ions repeating alternatively in all the directions. For simplicity, consider an infinitely long chain of alternating positive and negative ions separated by a distance R. Find the electrostatic energy of an ion.

2. A thick metallic shell of inner radius a and outer radius b has a charge Q on it. A point charge q is kept at the center of the shell. Calculate charge on each surface of the shell. Also, calculate electric field and potential everywhere.

3. Find the net force that the southern hemisphere of a uniformly charged sphere exerts on the northern hemisphere.