University of Alabama
Department of Physics and Astronomy

PH 126 / LeClair Fall 2009

Problem Set 2: Electrostatics

Instructions:

1. Answer all questions below.
2. Some problems have different due dates!
3. You may collaborate, but everyone must turn in their own work

The following two problems are due Wed 2 September 2009

1. A thin plastic rod bent into a semicircle of radius R has a charge of Q, in coulombs, distributed uniformly over its length. Find the strength of the electric field at the center of the semicircle.

2. A charge of 1 C sits at the origin. A charge of -2 C is at $x=1$ on the x axis.

(a) Find a point on the x axis where the electric field is zero.
(b) Locate, at least approximately, a point on the y axis where the electric field is parallel to the x axis.

3. The neutral hydrogen atom in its normal state behaves in some respects like an electric charge distribution which consists of a point charge of magnitude e surrounded by a distribution of negative charge whose density is given by

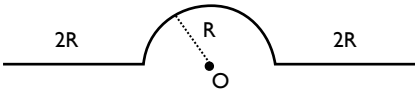
$$-\rho(r) = Ce^{-2r/a_o}$$

Here a_o is the *Bohr radius*, 0.53×10^{-10} m, and C is a constant with the value required to make the total amount of negative charge exactly e.

(a) What is the net electric charge inside a sphere of radius a_o?
(b) What is the electric field strength at this distance from the nucleus?
(c) What is C?

4. A plastic spherical shell has inner radius a and outer radius b. Electric charge is uniformly distributed over the region $a<r<b$, where r is the distance from the center of the spherical shell. The amount of charge is ρ coulombs per cubic meter. Find the electric field for regions $r \leq a$, $a \leq r \leq b$, and $r \geq b$.

5. A wire having uniform linear charge density λ is bent into the shape shown below. Find the electric potential at O.



The following two problems are due Fri 4 September 2009

6. A thin rod extends along the z axis from $z=-d$ to $z=d$. The rod carries a charge uniformly distributed along its length with a linear charge density λ. By integrating over this charge distribution calculate the potential at point P_1 on the z axis with coordinates $(0, 0, 2d)$. By another integration, find the potential at the point P_2 on the x axis and locate this point to make the potential equal to the potential at P_1.

7. Three protons and three electrons are to be placed at the vertices of a regular octahedron of edge length a. We want to find the potential energy of the system, or the work required to assemble it starting with the particles infinitely far apart. There are essentially two different arrangements possible. What is the energy of each? Symbolic answer, please.

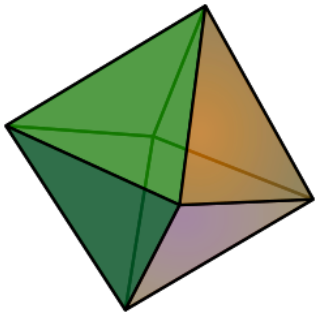


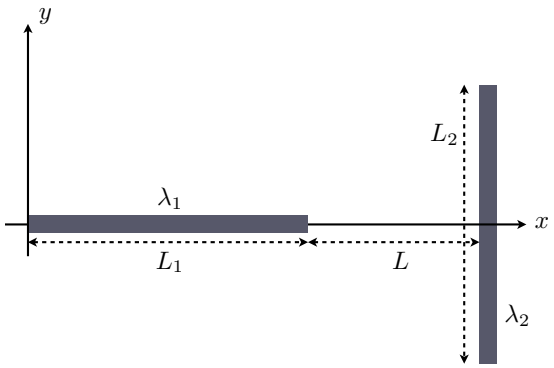
Figure 1: *An octahedron. It has eight faces and six vertices.*

8. An interstellar dust grain, roughly spherical with a radius of 3×10^{-7} m, has acquired a negative charge such that its electric potential is -0.15 Volts.

(a) How many extra electrons has it picked up?
(b) What is the strength of the electric field at its surface?

9. Find the electric field at a height z above the center of a square sheet (side a) carrying a uniform surface charge σ. Check your result for the limiting cases $a \to \infty$ and $z \gg a$.

10. Two thin rigid rods lie along the x axis at right angles to one another, as shown below. Both rods are uniformly charged. Rod 1 has a length L_1 and a charge per unit length λ_1. Rod 2 has a length L_2 and a charge per unit length λ_2. The distance between the right end of rod 1 and rod 2 is L.



(a) Give an exact expression for the electrical force between the two rods, i.e. the force that one rod exerts on the other. If you get really stuck on the integral, you should always feel free to consult an integral table or try:

`http://integrals.wolfram.com`

(b) Show that in the limit $L \gg L_1$ and $L \gg L_2$ your expression for the force between the rods reduces to the Coulomb force between two point charges. What are the magnitudes Q_1 and Q_2 of the point charges?