

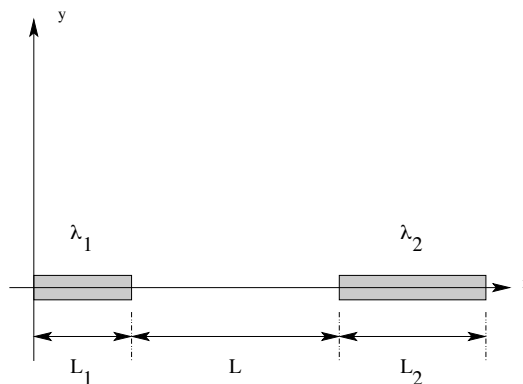
Problem Set 1: Electrostatics

Instructions:

1. Answer all questions below. Show your work for full credit.
2. Due before 5pm, 29 August 2008
3. Email submission: pleclair@ua.edu
4. Hard copies: Gallalee 206 or Beville 228; at the *beginning* of the lab period.
5. You may collaborate, but everyone must turn in their own work

1. At each corner of a square is a particle with charge q . Fixed at the center of the square is a point charge with opposite sign, of magnitude Q . What value must Q have to make the total force on each of the four particles zero? With Q set at that value, the system, in the absence of other forces, is in equilibrium. Do you think the equilibrium is stable?

2. Two thin rigid rods lie along the x axis, 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 the left end of 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:

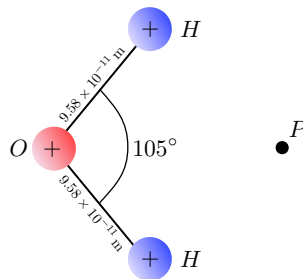
<http://integrals.wolfram.com>

(b) Use a first-order Taylor expansion to show that for $L_2 \gg L_1$ the electrical force on rod 1 is approximately

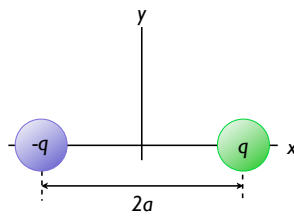
$$\vec{\mathbf{F}}_1 = -\hat{\mathbf{x}}\lambda_1\lambda_2 \ln\left(1 + \frac{L_1}{L}\right)$$

(c) 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?

3. The distance between the oxygen nucleus and each of the hydrogen nuclei in an H_2O molecule is 9.58×10^{-11} m, and the bond angle between hydrogen atoms is 105° . (a) Find the electric field produced by the nuclear charges (positive charges) at the point P a distance 1.2×10^{-10} m to the right of the oxygen nucleus. (b) Find the electric potential at P .



4. Two point charges q and $-q$ are situated along the x axis a distance $2a$ apart as shown below. Show that the electric field at a distant point along $|x| > a$ along the x axis is $E_x = 4k_eqa/x^3$.



5. Suppose three positively charged particles are constrained to move on a fixed circular track. If all the charges were equal, an equilibrium arrangement would obviously be a symmetrical one with the particles spaced 120° apart around the circle. Suppose two of the charges have equal charge q , and the equilibrium arrangement is such that these two charges are 90° apart rather than 120° . What must be the relative magnitude of the third charge?

6. A charge of $100 \mu\text{C}$ is at the center of a cube of side 0.8 m. (a) Find the total flux through each face of the cube. (b) Find the flux through the whole surface of the cube. (c) Would your answers to the first two parts change if the charge were not at the center of the cube?