University of Alabama
Department of Physics and Astronomy

PH 126 LeClair Fall 2011

Problem Set 2

Instructions:

1. Answer all questions below. All questions have equal weight. Show your work for full credit.
2. All problems are due Friday 2 September 2011 by 11:59pm.
3. You may collaborate, but everyone must turn in their own work.

1. A charge of $1\,\mu C$ is at the origin. A charge of $-2\,\mu C$ is at $x=1$ on the x axis.
(a) Find the point on the x axis where the electric field is zero.
(b) Locate, at least approximately, a point on the y axis here the electric field is parallel to the x axis [a calculator should help].

2. Two long, thin parallel rods, a distance $2b$ apart, are joined by a semicircular piece of radius b, as shown below. Charge of uniform linear density λ is deposited along the whole filament. Show that the field $\vec{\mathbf{E}}$ of this charge distribution vanishes at point C. One way to do this is by comparing the contribution of the element at A to that of the element at B which is defined by the same values of θ and $d\theta$.

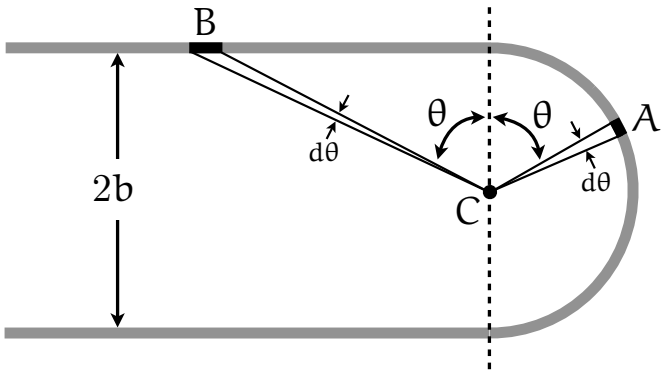
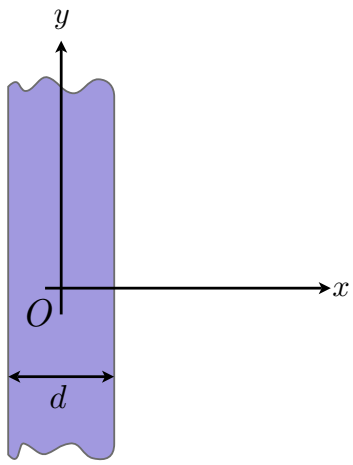


Figure 1: *Problem 2.*



3. A slab of insulating material, infinite in two of its three dimensions, has a uniform positive charge density ρ, shown at left. **(a)** Show that the magnitude of the electric field a distance x from the center and inside the slab is $E = \rho x/\epsilon_0$. **(b)** Suppose an electron of charge $-e$ and mass m_e can more freely within the slab. It is released from rest at a distance x from the center. Show that the electron exhibits simple harmonic motion with a frequency

$$f = \frac{1}{2\pi}\sqrt{\frac{\rho e}{m_e \epsilon_0}}$$

4. Imagine a sphere of radius a filled with negative charge of uniform density, the total charge being equivalent to that of two electrons. Imbed in this jelly of negative charge two protons and assume that in spite of their presence the negative charge distribution remains uniform. Where must the protons be located so that the total force on each of them is zero? (This is a surprisingly realistic model of a hydrogen atom; the magic that keeps the electron cloud in the molecule from collapsing around the protons is explained by quantum mechanics!

5. (a) Twelve equal charges q are situated at the corners of a regular 12-sided polygon (for instance, one on each numeral of a clock face). What is the net force on a test charge Q at the center?
(b) Suppose *one* of the 12 q's is removed (say, the one at 6 o'clock). What is the force on Q? Use superposition . . . and explain your reasoning carefully.

6. (a) Find the electric field a distance z above the center of a flat circular disk of radius R which carries a uniform surface charge σ.
(b) What happens in the limits $R \to \infty$ and $z \gg R$? Comment on the mathematical and physical nature of those limits.

7. Find the electric field inside a sphere which carries a charge density proportional to the distance from the origin, $\rho = kr$, for some constant k. Note: the charge density is not uniform, and you must integrate to get the enclosed charge.

8. Consider an infinite number of identical charges (each of charge q) placed along the x axis at distances $a, 2a, 3a, 4a, \ldots$ from the origin. What is the electric field at the origin due to this distribution?