MIDTERM 2 Fall-2017

Instructor: Prof. A. LANZARA

TOTAL POINTS: 90

Show all work, and take particular care to explain what you are doing. Partial credit is given. Please use the symbols described in the problems, define any new symbol that you introduce and label any drawings that you make. All answers should be in terms of variables. If you get stuck, skip to the next problem and return to the difficult section later in the exam period.

PROBLEM 1 (Tot 20pts)

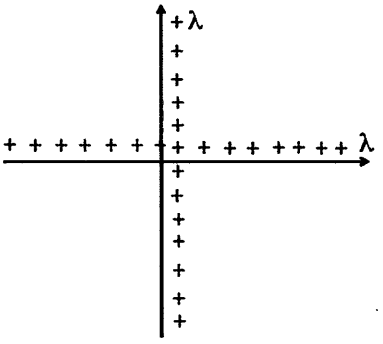
A very long uniform line of charge with positive linear charge density $+\lambda$ lies along the x-axis. An identical line of charge lies along the y-axis.

a) (5pts) Determine the electric field E (x, y) for all points in the x-y plane

b) (5pts) Determine the change in electrostatic potential ΔV between the points (x=a, y=a) and (x=a, y=3a).

c) (5pts) How much work must be done to move a small negative charge –q from the point (x=3a, y=3a) to the point (x= a, y= a)?

d) (5pts) For a very long linear charge distribution we do not define the zero of electrostatic potential to be at infinity. Why not?



PROBLEM 2 (Tot 20pts)

A shell of conducting material has inner radius a and outer radius b. The shell carries a total charge +Q. The coordinate r measures the distance from the center of the shell.

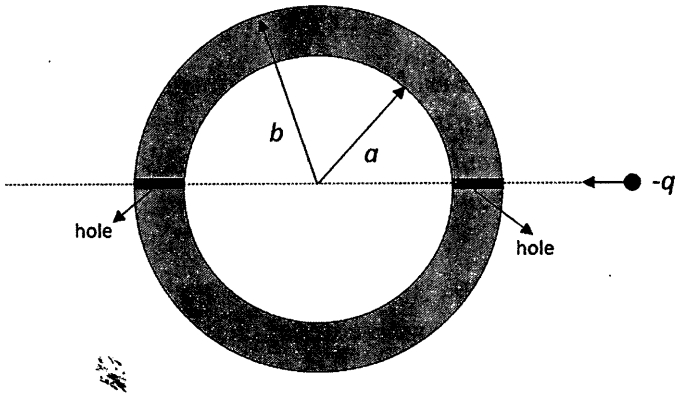
a) (6pts) Determine the electric field **E** everywhere in space. Sketch E(r) vs r

b) (6pts) Determine the electrostatic potential V everywhere in space

Now suppose two small holes are drilled through the shell along a diameter. The holes are small enough that the electric field is not changed significantly. A small negative charge – q of mass m is released from rest a distance 2b from the center of the conducting shell. The charge passes through one hole, through the center of the shell and exits through the hole on the other side.

c) (5pts) Determine the speed at which the charge – q is traveling when it reaches the surface r = *b*

d) (3pts) What acceleration does the charge – q experience in the region $a < r < b$?



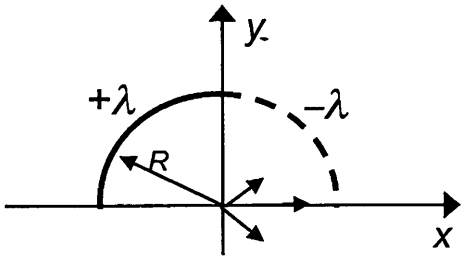
PROBLEM 3 (Tot 15pts)

Consider electric charge distributed along a one-dimensional path in the form shown below. The charge is distributed in two sections, each in the shape of one ¼ of a circle. The circle is centered at the origin with a radius of *R*, and the linear charge density is $+\lambda$ in the left quadrant and $-\lambda$ in the right.

a) (5pts) Find the component of the electric field along the *x*-axis (E_x) at the origin (0,0).

b) (5pts) Find the component of the electric field along the *y*-axis (E_y) at the origin (0,0).

c) (5pts) How are the results from part a) and b) modified if the two charge densities are both $+\lambda$?



PROBLEM 4 (Tot 20pts)

Consider an air-filled parallel-plate capacitor of area A and separation between the plates *x*. The plates are connected to a battery with voltage *V*. While connected to the battery, the plates are pulled apart until they are separated by *2x*.

a) (5pts) What are the initial and final energies stored in the capacitor?

b) (5pts) How much work is required to pull the plates apart?

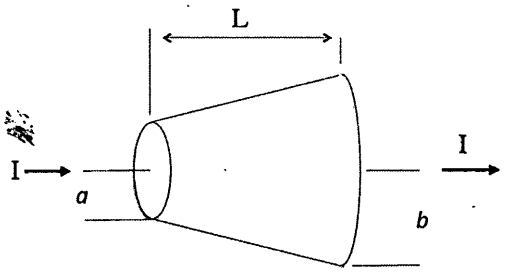
c) (5pts) How much energy is exchanged with the battery?

d) (5pts) If the charged plates of the capacitor are pulled apart *after* being disconnected from the battery, by how much do the initial and final energies stored in the capacitor would differ from a)?

PROBLEM 5 (Tot 15pts)

A resistor is in the shape of a truncated right circular cone. The resistor has resistivity ρ. The end radii are *a* and *b* and the length is L.

a) (6pts) Calculate the resistance of this object.



If the two end surfaces S_1 and S_2 are two different equipotential surfaces, answer qualitatively to the following:

b) (3pts) Through which plane does the greatest current flow?

c) (3pts) Which plane has the greatest electric flux?

d) (3pts) How does the magnitude of the electric field **E** vary along the central axis moving from S_1 to S_2?