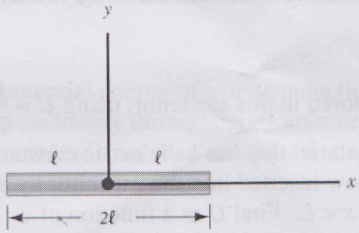
University of California, Berkeley
Physics 7B, Lecture 001, Spring 2012 (*Xiaosheng Huang*)

Midterm 2
Monday, 4/2/2012
7:00 – 9:00 PM

Total Points: 100

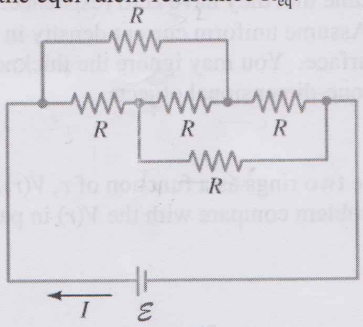
Note: *You are allowed one handwritten formula card (3½" by 5", double sided). No calculators or any other electronic devices are permitted. Show all work, and take particular care to explain what you are doing. Please use the symbols described in the problems, define any new symbols that you introduce, and label any drawings that you make.*

1. (18 pts.) **Electric Potential and Electric Field** [Homework "Practice Exam Problem"]
A thin rod of length $2l$ is centered on the axis as shown in the figure. The rod carries a uniformly distributed charge Q.

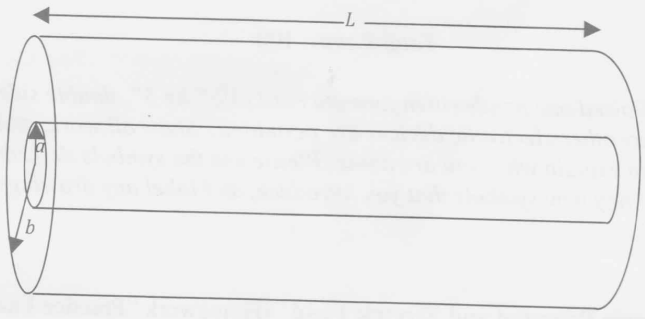


a) Determine the potential V as a function of y for points along the y axis. Let $V = 0$ at infinity.
b) Find the direction and the magnitude of the electric field as a function of y along the y axis.

2. (15 pts.) **DC Circuit**
A network of five equal resistors R is connected to a battery with EMF $\mathcal{E}$ as shown in the figure below. Determine the equivalent resistance R_{eq}.



3. (22 pts.) **Cylindrical Capacitor**
Consider two concentric cylindrical conductors. The radius of the inner cylinder is a, and that of the outer cylinder is b. The length of both cylinders is L, and $L \gg a, b$. The amount of charge on the outer cylinder is Q and, on the inner cylinder, $-Q$. Ignore fringe effects of the electric field in this problem.



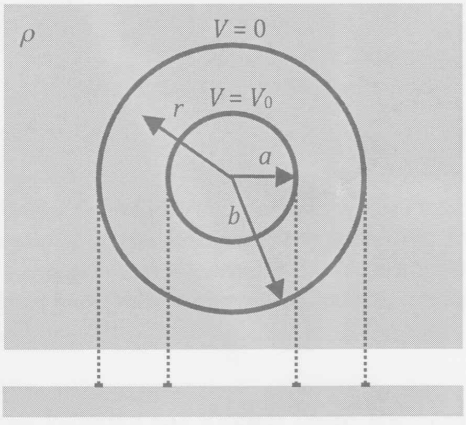
a) Find the direction and magnitude of the electric field in the space between the two cylinders.
b) Find the electric potential as a function of r between the two cylinders, $V(r)$. Assume $V = 0$ on the outer cylinder.
c) Find the capacitance.

d) Find the electric potential energy stored in this capacitor, using $U = \frac{1}{2}QV$.

e) A cylindrically shaped dielectric material that has a dielectric constant K and fits snugly between the two cylinders is now inserted into the capacitor by an experimenter from the left end to a depth of x, with $x < L$. Find U as a function of x. Assume the dielectric material has a length that is greater than L.
f) When the dielectric material is inserted from the left end to a depth of $x = L/2$, the experiment let go of it. Which way would it move, to the left or to the right? Why?

4. (20 pts.) **Current and Voltage between Two Concentric Conducting Rings**
Referring to the figure on the next page: As in one of your labs, two concentric conducting rings painted on carbon paper were connected to a battery with voltage, V_0. You were asked to measure the voltage between the rings. The conducting rings have radii a and b and you may assume that they have zero resistance. The carbon paper has resistivity ρ and thickness d. Assume uniform current density in the carbon paper from its top surface to the bottom surface. You may ignore the thickness of the rings; that is, you may assume the rings are one-dimensional objects.

a) Find the total current.
b) Find the voltage between the two rings as a function of r, $V(r)$.
c) How does the $V(r)$ in this problem compare with the $V(r)$ in part (3.b)?



Top View

Cross sectional View

5. (25 pts) **Electric Potential Energy**
For the following two charge distributions, use the electric field energy density $u = \frac{1}{2}\varepsilon_0 E^2$ to find

a) the total electric potential energy of a nonconducting sphere of radius R carrying a total charge Q distributed uniformly throughout its volume;
b) the total electric potential energy of a conducting sphere of radius R carrying the same total charge Q.

c) Please explain how the calculation in this problem helps you understand, from the energy perspective, the distribtuion of charge that a conducting sphere carries.

The End