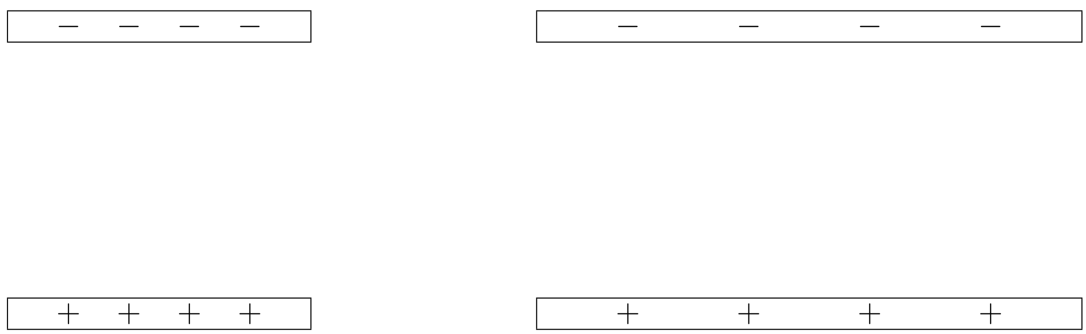
Assignment 4; Phys 186 Name ______________

1. (20 points) Use the rules concerning equipotential lines and electric field lines to figure out what happens when you double the plate area of a parallel plate capacitor. You have a capacitor with plate area A and plate separation d with charges $\pm Q$ on its plates, with a voltage difference of 4.0 V between the plates. You also have a capacitor that is identical in every respect, except that the same charge is distributed throughout double the area, $2A$. What will the voltage reading on the second capacitor be? Draw electric field lines and equipotential lines at 1 V intervals, and explain your reasoning.

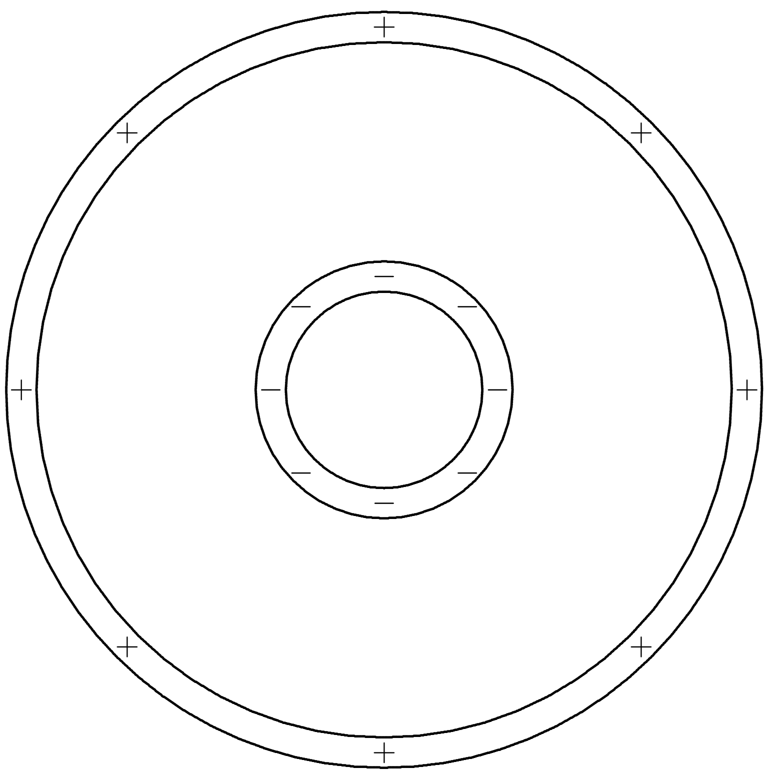
Remember that the the magnitude of the uniform electric field produced by an infinite plane of charge is proportional to the charge density (charge per unit area).



2. (30 points)

(a) You have a parallel plate capacitor. The left plate is set at a potential of 5 V, the right at 0 V. Draw in equipotential lines in between at 1, 2, 3, and 4 V, and the electric field lines. Finally, find an expression for the *total electrical force* by which the plates are attracted toward one another, in terms of the constant ϵ_0, the charge Q on each plate, the plate area A, and the plate separation d.

(b) You now have a cylindrical capacitor: two concentric metal rings with equal and opposite charges. Draw a qualitative map of the equipotential lines and electric field lines for this case. Also include the voltage and electric fields inside the inner ring. What is the total electrical force acting on each ring?



3. (25 points) You have two concentric metal spheres; the inner sphere has a total charge of $-Q$ while the outer sphere has $+2Q$. Draw the electric field lines and equipotential lines all over space: inside the inner sphere, in between the spheres, and outside the outer sphere. To determine the electric field strength, use

$$\text{(Electric flux through a closed surface)} = \frac{1}{\epsilon_0}\text{(Total charge inside that surface)}$$

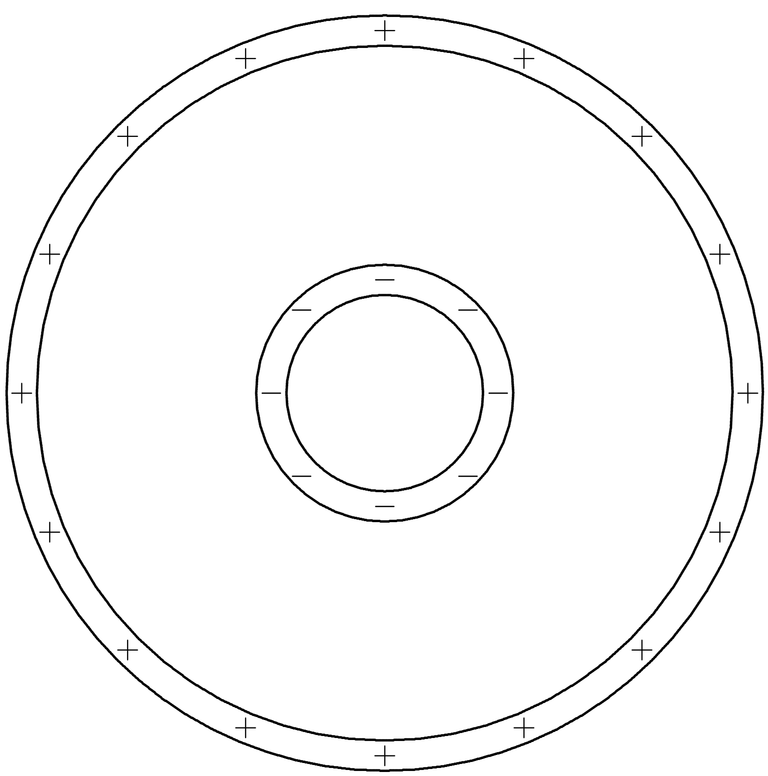
$$\sum E_\perp A = \frac{Q_{\text{in}}}{\epsilon_0}$$

$$\int_{\partial S} \vec{E} \cdot d\vec{A} = \frac{Q_{\text{in}}}{\epsilon_0}$$

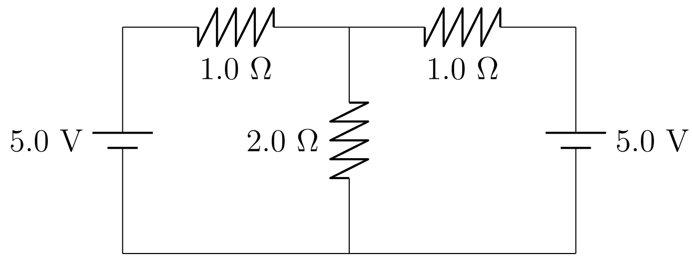
These equations are all the same thing, in increasing order of mathematical propriety. What you care about is that if $\vec{E}$ is always constant and perpendicular to a closed surface,

$$EA = \frac{Q_{\text{in}}}{\epsilon_0}$$

where E is the outward electric field strength at the enclosing surface you choose, and A is the area of the surface. (I suggest figuring out E before drawing the lines. Check with me to see how you're doing.)



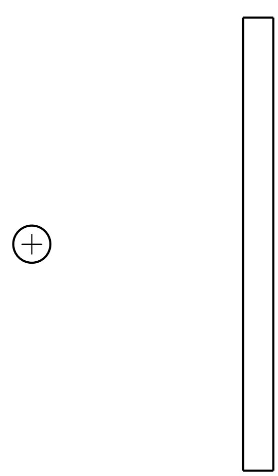
4. (25 points) You have the following circuit. Calculate the voltage across, the current through, and the power dissipated by each resistor.



Extra Problems (not graded)

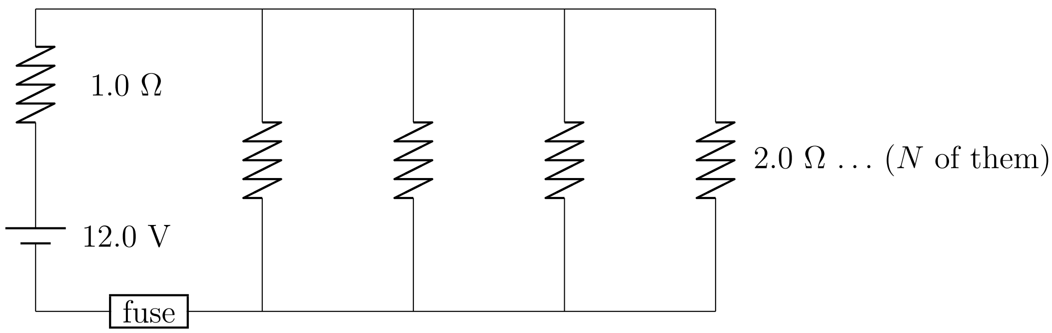
5. (0 points) First, draw equipotential lines and electric field lines for a dipole-like arrangement you investigated in the lab. The low-voltage point in the water is at $-3\,\mathrm{V}$, and the high-voltage point is at $+3\,\mathrm{V}$. Draw the equipotential lines at $1\,\mathrm{V}$ intervals.

Then, draw equipotential lines at $1\,\mathrm{V}$ intervals and electric field lines for the case where you have a point at $+3\,\mathrm{V}$ and a plate at $0\,\mathrm{V}$. Only draw what is happening on the left side; you can ignore the right side of the plate. Also draw some appropriate charges on the plate to give a qualitative idea of the charge distribution on the plate. Explain your reasoning.



How are your two graphs related—how did drawing the dipole first help you draw the second graph with the plate?

6. (0 points) You have a circuit with a fuse in it to limit the current drawn from the battery, which supplies power to N 2.0 Ω resistors connected in parallel. The 1.0 Ω resistor represents the internal resistance of the battery. The fuse acts like an ideal wire until a maximum current goes through it, at which point it burns up and breaks the circuit.



(a) Write down the junction, loop, and resistor equations for the circuit. Note that this is not as complicated as it looks, since many of your equations will be simplified to become identical. Ask me what I mean if you're confused.

(b) If the fuse blows when the current through it is more than 10.0 A, what is the maximum number $N_{\max}$ of 2.0 Ω resistors that can be hooked up in this circuit?

(c) Could you increase $N_{\max}$ by hooking up a capacitor in series with the 1.0 Ω resistor? In parallel? Explain.

(d) What does this problem tell you about the consequences of hooking up lots of appliances to a single wall socket by using extension cords?