How Capacitors Work

Name: _____ Date: _____

Name: _____ Lab Sect.: _____

Name: _____ Lab Instructor: _____

<u>Lab Activity 1: How capacitors store energy</u>

Q1. Describe what you observed during the experiment and sketch (or print and attach) the potential difference across the capacitor vs. time, assuming that you started the experiment at $t = 0$. In the sketch below, indicate when the switch was thrown from position **C** to position **A**. Also indicate the numerical value of the voltage when the capacitor is completely charged.

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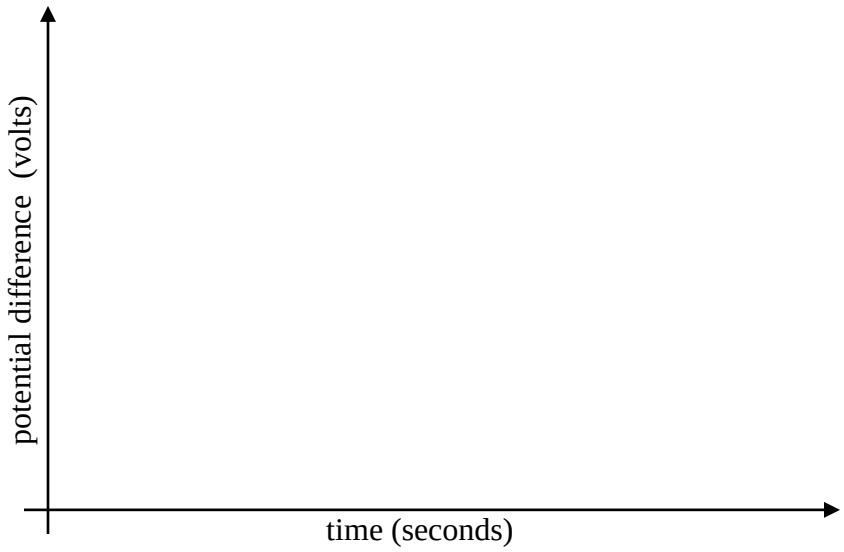


Q2. How much energy was stored in the capacitor when it was fully charged?

Q3. Use the idea of energy conservation to describe the entire process of charging and discharging that you observed. Remember that energy can take on different forms: chemical energy, light, heat, electrical energy (*i.e.*, electric field)…

Lab Activity 2: Capacitors in series

Q4. What is the total capacitance of the two capacitors in series?

Q5. Based on your observations of the bulb, did the capacitors in series become charged more rapidly or more slowly than when you had only a 1-F capacitor in the circuit? (You do not have to explain anything here — just report your empirical observations.)

Q6. What is the final potential difference that you measured across each capacitor?

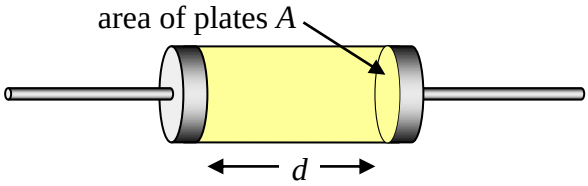
Q7. Use your understanding of capacitors in series to explain your observation in **Q6**.

Q8. Describe intuitively why it makes sense that capacitors in series all have the same charge. It may be helpful to sketch a picture of several capacitors and their plates (with charge) while in series.

Lab Activity 3: How are capacitors designed?

Your goal in this activity is to try to make a model of the 1-μF capacitor.

Q9. First, model the 1-μF capacitor as a parallel plate capacitor, as depicted below. You have to make some intelligent estimates of the distance *d* and the plate area *A* from the external appearance of the capacitor (looking at the 1-μF capacitor on the circuit board *approximately* how long do you think it is and what is its diameter?). How large a dielectric constant is needed to produce the measured capacitance? Is this realistic (compare it to the values in Table 1)?



Here is the equation we used to model this parallel plate capacitor:

Estimated value of *A*: _____

Estimated value of *d*: _____

Based on values of *C*, *A* & *d*, we obtain the following value for the dielectric constant:

_____

_____

Is this reasonable or not? Justify your answer.

_____

_____

_____

Q10. So, you've probably figured out by now that the parallel plate model does not work! Model the capacitor as a cylindrical capacitor instead. This should consist of a solid inner cylinder of

radius R_1, a cylindrical outer shell with radius R_2, both of length L. How large a dielectric constant is needed to produce the measured capacitance? Is this realistic?

Expression used for calculating capacitance of cylindrical capacitor:

Estimated radius of inner cylinder: _____

Estimated radius of outer cylinder: _____

Estimated length of cylinder : _____

Based on the values of C, L, R_1 and R_2, we obtain the following value for the dielectric constant:

_____

Is this reasonable or not? Justify your answer.

_____

_____

Q11. Neither the simple parallel plate nor the cylindrical capacitor schemes seem to work. So, how are these capacitors constructed? Design an alternative scheme that can produce the measured capacitance in the given compact package/geometry. Think creatively but remember that your scheme should be amenable to large-scale manufacturing and hence cannot be extremely intricate! (*Hint:* look at the expression for the capacitance of a parallel plate capacitor. What geometrical factor should you maximize to increase capacitance? What geometrical factor should you minimize to increase capacitance? How would you make a package that is compact but meets these requirements?)

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