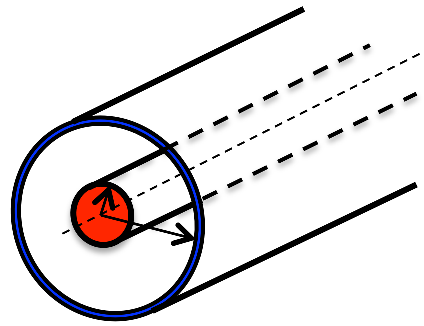
26-Series Problem (Capacitors)

26.1) You are given a $4.00\ \mu F$ capacitor. You connect it to a 12.0-volt battery.

a.) How much charge will end up on each plate?

b.) You then connect it to a 1.50 volt battery. How much charge is stored?

26.5) A coaxial cables, being made up of multiple metal layers, has capacitance. A 50.0 meter long coaxial cable is made up of an inside conducting line of radius 1.29 mm and an outside conducting cylindrical shell whose inner radius is 3.635 mm. The inner line has $8.10\ \mu C$'s worth of charge on it while the outer shell has $-8.10\ \mu C$'s worth of charge on it. If the region between the conductors is air:



a.) What is the cable's capacitance?

b.) Determine the potential difference between the "plates" of the capacitor.

26.11) Two metal plates, each of area $7.60\ cm^2$, are positioned parallel to one another so as to be a distance 1.80 mm apart. Called a *parallel plate capacitor,* 20.0 volts is applied between the plates.

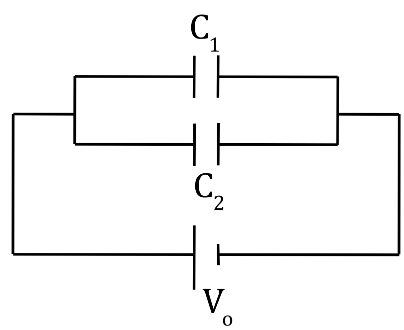
a.) Derive an expression, then calculate the electric field between the plates.

b.) Determine the surface charge density on each plate.

c.) Determine the capacitance of the capacitor.

d.) Determine the charge on each plate.

26.13) A parallel circuit of caps is shown to the right. If $C_1 = 5.00\ \mu F$, $C_2 = 12.0\ \mu F$ and the battery voltage is 9.00 volts:

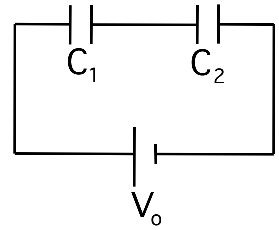


a.) Determine the equivalent capacitance for the combination.

b.) Determine the potential difference across each capacitor.

c.) Determine the charge on each capacitor.

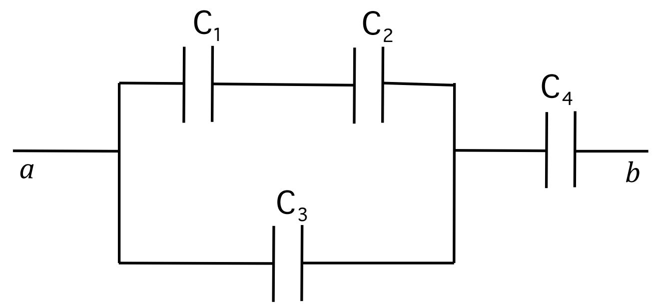
26.16) A series combination of capacitors across a battery is shown to the right. A parallel combination is shown in Problem 26.13. If the new battery voltage in each case is 6.00 volts, and if $C_1 = 2.50\ \mu F$ and $C_2 = 6.25\ \mu F$:



a.) Determine the charge on each capacitor if the caps are in series.

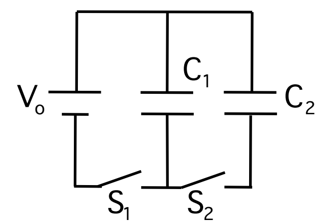
b.) Determine the charge on each capacitor if the caps are in parallel.

26.23) Consider the four capacitors shown to the right. Assume $C_1 = 15.0\ \mu F, C_2 = 3.00\ \mu F, C_3 = 6.00\ \mu F$ and $C_4 = 20.0\ \mu F$.



- a.) Derive an expression, then determine the equivalent capacitance of the combination.
- b.) Assuming 15.0 volts across *a-b*, how much charge is on each capacitor?

26.24) Consider the capacitor and switch combinations shown to the right. Assuming $C_1 = 6.00\ \mu F, C_2 = 3.00\ \mu F$ and $V_o = 20.0$ V. Both switches are initially open and both caps are uncharged. At t = 0, switch S_1 is closed charging C_1. Switch S_1 is then opened and C_1 is connected to C_2 by closing S_2. By the time you are done, an "initially" charged C_1 is connected in parallel to an "initially" uncharged C_2.



- a.) Determine how much charge was initially on C_1.
- b.) Determine the final charge on each cap.

26.31) 54 μC's of charge is stored in a capacitor hooked to a 12 volt battery. How much energy is stored in the cap?

26.33) In dry weather, a person can accumulate charge on his or her body. When the excess charge produces a voltage that is great enough, the individual can jettison the excess charge via a spark. Typically, a body that is isolated from ground has a capacitance of 150 pF.

- a.) A body potential of 10 kV will be generated by what excess charge?
- b.) Electronic devices can be destroyed by electric discharge from people (this is why there used to be instructions on the back of computers saying "Do not open"). If a device's threshold for destruction is $250\ \mu J$, to what voltage would a person have to charge to effect the device's demise through electric discharge?

26.34) A 12.0 volt battery is connected across two capacitors in series. If the capacitances are $C_1 = 18.0\ \mu F$ and $C_2 = 36.0\ \mu F$:

- a.) What is the equivalent capacitance for the combination?
- b.) How much energy is stored in the equivalent capacitance?
- c.) How much energy is stored in each individual capacitor?
- d.) Is the sum of the two individual energies the same as the energy stored in the equivalent capacitance? Justify your response with numbers.

e.) Is this always the case, or does it matter how many caps are involved (or on what configuration they are in)?

f.) If you wanted the same energy stored in the system, but the caps were in parallel, what potential difference would be required?

g.) Which cap would you expect to store more energy? Which one did?

26.37) Two individual, $10.0\ \mu F$, parallel plate capacitors are charged to 50 volts. Once disconnected from their battery, they are connected to one another in parallel with their positive terminals in contact with one another. At this point, the separation of the plates in one of the caps is doubled.

a.) How much energy existed in the system *before* the plate separation was doubled?

b.) Determine the voltage across each cap *after* the plate separation was doubled.

c.) How much energy existed in the system *after* the plate separation was doubled?

d.) Use *conservation of energy* to explain the difference in the answers to *Part a* and *Part c*.

26.42) An air-filled parallel plate capacitor is connected to a battery and charged up to 85 volts. It is then disconnected from the battery. A dielectric is then placed between the plates, completely filling the space, whereupon the voltage across the plates drops to 25 volts.

a.) Determine the dielectric's *dielectric constant*.

b.) From the dielectric constant, determine what the material is (you might want to use the Internet for this)?

c.) Let's say the dielectric did not fill the space completely. What might you expect the voltage across the plates to do in that case?

26.46) One way dielectrics are useful, aside from increasing capacitance out of hand, is that their insertion between cap plates allows the plates to be situated *very close* without touching AND allows for miniaturization (if you are clever, you can roll up a thin set of plates with a dielectric in between). So let's say you decide to make two capacitor plates out of 7.00 cm wide strips of aluminum foil, and snug in-between the plates you intend to put a 7.00 cm wide strip of paraffin-coated paper. If the foil is 0.004 mm thick and the paper is 0.025 mm thick, and if the paper has a dielectric constant of 3.70, how long would the plates have to be if you wanted a capacitance of 95.0 nF. (Note, for the sake of amusement--and not something you need for this problem, but—adding another piece of paper and rolling the assembly will effect the miniaturization as well as doubling the capacitance as charge will now be able to be stored on *both* sides of each foil strip—clever, eh?)