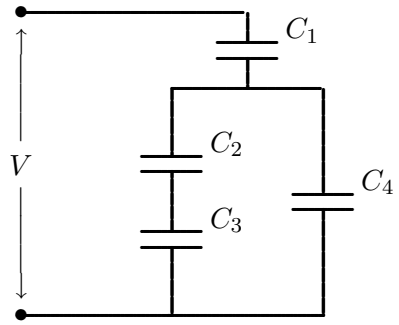
Problems
Chapter 7

1. A parallel plate capacitor is made of two circular plates separated by a distance of 1.0mm. The radius of each plate is 10cm.

   (a) Find the capacitance of the capacitor.

   (b) Find the charge on each plate when a potential difference of 50 V is applied across the capacitor.

2. Find the equivalent capacitance of the following network across the terminals shown. $C_1 = 20.0\mu$F, $C_2 = 10.0\mu$F, $C_3 = 5.00\mu$F and $C_4 = 4.00\mu$F. Also, find the charge in each capacitor if the potential difference across the terminals is $V = 10$V.



3. Two parallel plate capacitors C_a and C_b have the same plate area A. The distance between plates for C_a is a and that for C_b is b. If the two capacitors are connected in series, show that their equivalent capacitance is given by

$$C = \frac{\epsilon_0 A}{a + b}.$$

4. A capacitor of capacitance $C_1 = 5.00\mu$F is charged to a voltage of 20.0 V and then disconnected from the charging battery. Next, another capacitor of unknown capacitance C_2 and zero initial charge is connected in parallel to the already charged capacitor. The final voltage across each capacitor is found to be 10.0 V. Find the unknown capacitance C_2.

5. Two capacitors of capacitance $C_1 = 1.00\mu$F and $C_2 = 2.00\mu$F are connected in parallel and charged such that each has a voltage of 50.0 V. Then, the charging battery is removed and the two capacitors are separated carefully such that they do not lose any charge. Next, the two capacitors are reconnected in parallel but with polarities reversed – that is the negative plate of one is connected to the positive plate of the other and vice versa.

   (a) Find the final voltage across each capacitor.

   (b) Find the final charge in each capacitor.

6. In calm weather, the electric field in a certain part of the atmosphere is found to be of magnitude 150 V/m. Find the the energy due to this field in a volume of one cubic meter.

7. A charged capacitor of capacitance C has 10.0 J of stored energy. The voltage across it is V. When a second capacitor with no initial charge is connected in parallel to it, the voltage across the combination becomes $V/2$.

   (a) Show that the second capacitor has the same capacitance as the first.

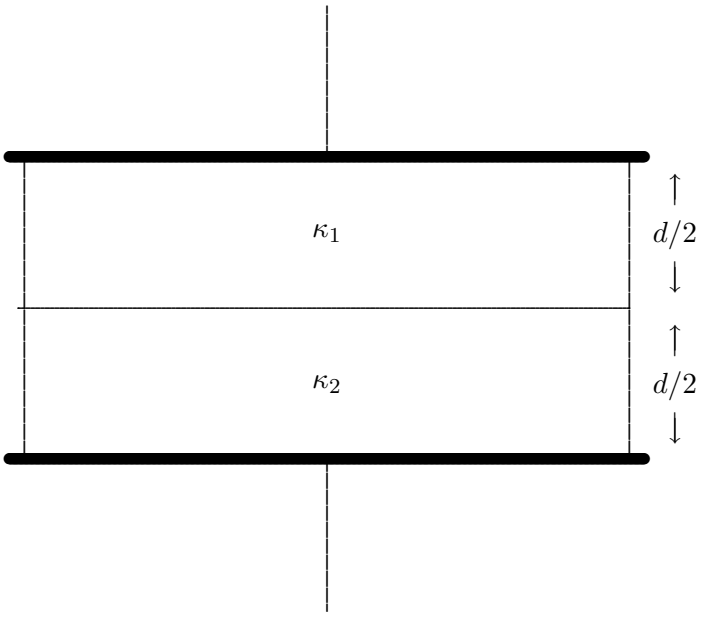
   (b) Show that the two capacitors have the same charge after they are connected.

   (c) Show that the final total energy of the two capacitors is 5.00 J.

   (d) Explain what happens to the other 5.00 J of the initial energy.

8. A parallel plate capacitor has two different dielectric materials in it as shown below. The dielectric constants of the materials are κ_1 and κ_2. The area of each plate is A. The thickness of each material is $d/2$. Show that the capacitance of the capacitor is

$$\frac{\epsilon_0 A}{d}\left(\frac{2\kappa_1\kappa_2}{\kappa_1+\kappa_2}\right).$$



9. A discharging capacitor has a time constant τ.

   (a) Find the time taken (in terms of τ) for the capacitor to lose one-quarter of its intial charge.

   (b) Find the time taken (in terms of τ) for the capacitor to lose three-quarters of its intial charge.

10. A capacitor of capacitance C is initially uncharged. It is connected in series to a battery of emf $\mathcal{E}$ and a resistor of resistance R.

(a) Find the total energy delivered by the battery after a long period of time has elapsed (effectively infinite time).

(b) Show that only half the energy delivered by the battery is stored in the capacitor (after infinite time).

(c) Show that the balance of the energy delivered is dissipated by the resistor.