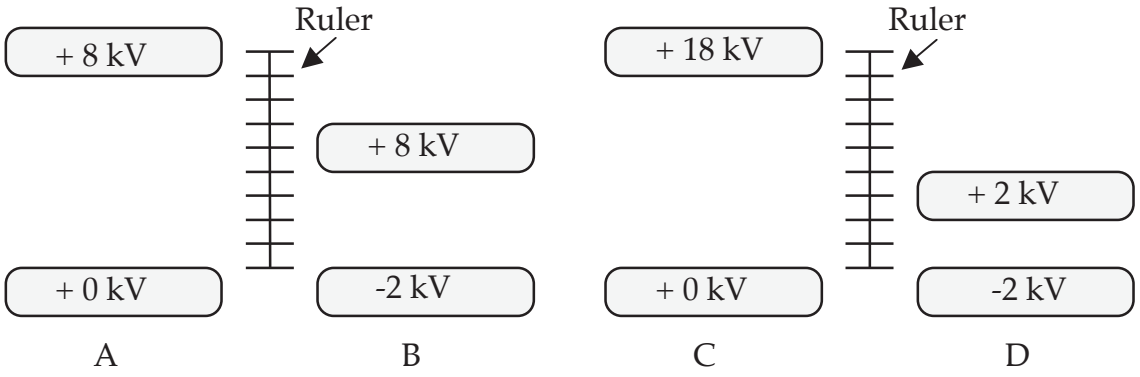
Homework Questions – Section 10

1. The diagram below shows several arrangements of metal plates at different potential differences.

   a. In which situation is a spark most likely to jump?

   b. In which situation is a spark least likely to jump?

   Explain your reasoning.



2. For each of the following charge arrangements, draw an arrow on each dot to show the approximate direction of the electric field at that point.

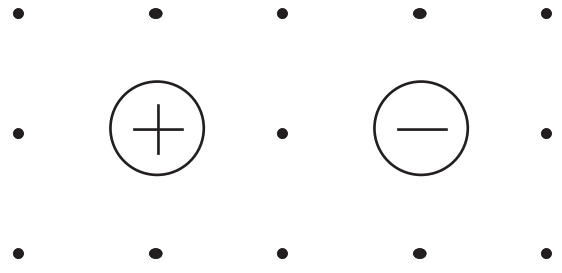


Figure 2a

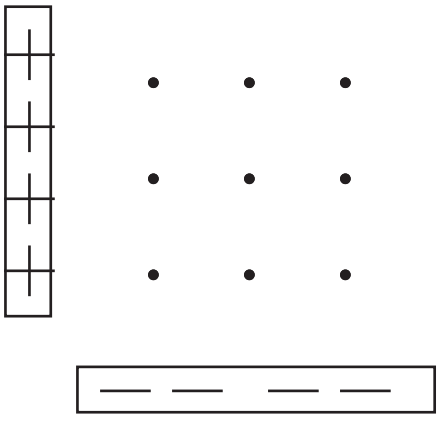
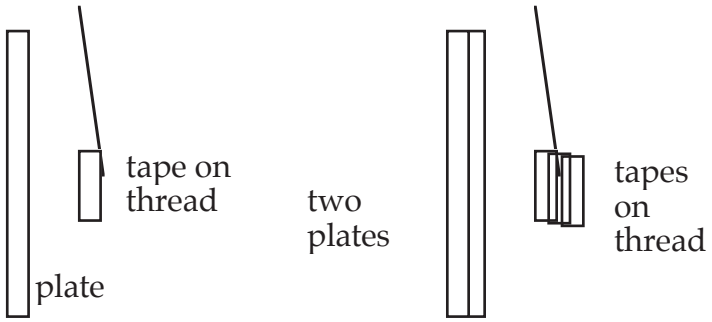


Figure 2b

3. A student is creating an electric field by placing equally charged acrylic plates in a region of space. In one experiment she places a single plate a short distance from a 2 cm length of positively charged tape hanging from a thread and finds that there is a force of 0.15 millinewtons on the tape. She now takes a second equally charged plate and sandwiches it with the first plate to make a doubled plate, sticks two more 2 cm pieces of positively charged tape on the thread, and puts them the same distance away from the plates as before. How much electrical force would there be on the tapes in this new situation?



4. A certain capacitor has 1 microjoule of energy stored in it. A second capacitor with the same insulating material has plates that are twice as long, three times as wide and half as far apart. If the electric field between the plates of the second capacitor is twice that of the first, what is the energy stored in the second capacitor?

5. The first diagram below represents a thundercloud whose base is 2000 meters above the ground. Air requires an electric field strength of about 3 000 000 volts/meter to break down and conduct a spark. If there is a lightning strike between the cloud and the ground, what is the minimum electric potential difference required?

Sketch five lines of equal potential value in between the cloud and ground.
If the value of the electric potential of the ground is zero, label the value of the potential at each line.

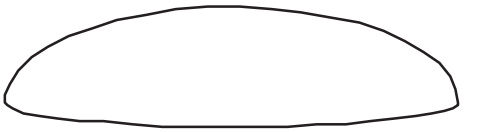
In the second picture there is a hill with a building on it. If ground and building are all at 0 volts potential, sketch the approximate shape of the five lines of equal potential as in the previous picture.

a. Where are the lines most crowded together?

b. Where is the ratio of potential difference to distance the largest?

c. Where is the value of the electric field the largest?

d. Where is the most likely point for lightning to strike?



Ground

Figure 5a

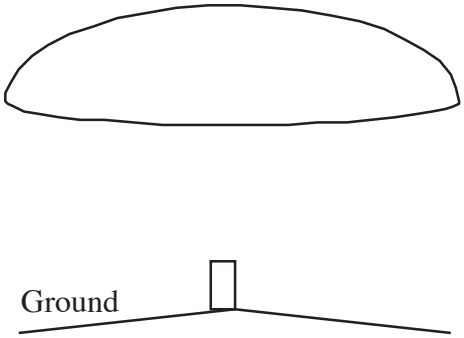


Figure 5b

6. In the circuit below, the voltmeter across the battery reads 8 volts, the battery is connected to four carbon resistors. The resistors in the left hand branch are identical, but the resistors in the right hand branch are different.

Assuming that the connecting wires have almost no resistance, draw and label potential lines at 1 volt intervals in the four resistors, taking the bottom of each of the lower resistors to be at a potential pressure level of 0 volts.

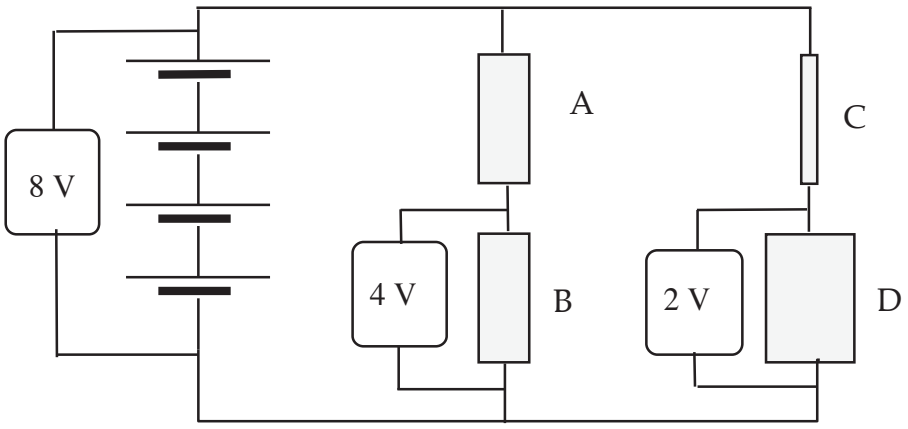
a. Which resistor has the smallest spacing between the lines of equal potential pressure? Which has the largest spacing between the lines of equal potential pressure?

b. Which resistor has the highest value of the electric field in the resistor?

c. Which has the lowest value?

d. Which has an intermediate value?

e. If each resistor has a length of 2 cm, what is the value of the electric field strength in each resistor?



7. Hidden charges. The figures below show the direction that a set of dipoles would point near a pair of two small charged objects hidden under a cover. For each diagram, mark the approximate position and sign of the hidden charges.

In the first two diagrams, the charges are equal. In the third diagram, one charge is twice the other. Indicate which is the larger charge.

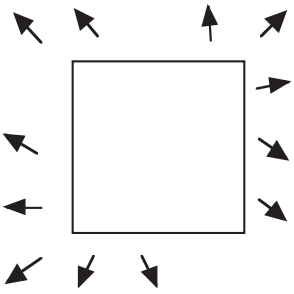


Figure 7a

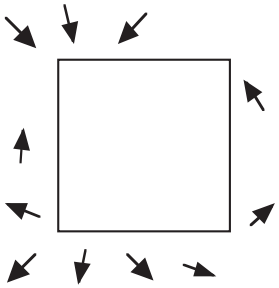


Figure 7b

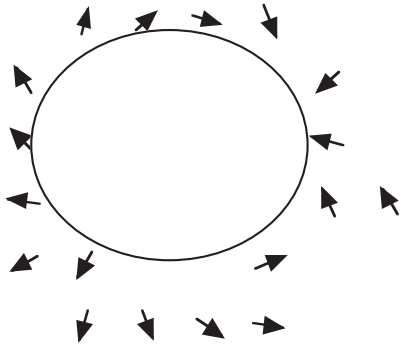


Figure 7c

8. A parallel plate capacitor has a maximum rated voltage of 50 V. Its plates have an area of 0.40 m^2 and are separated by 0.010 cm by a paraffin insulating layer with a dielectric constant of 2.20. If the capacitor is charged to its maximum voltage, how much energy is stored in the electric field?

9. In a television picture tube, an electron gun is used to shoot a beam of electrons toward the screen. The electron gun consists of two parallel plates with a potential difference of about 25 000 volts between them. Each plate has a small hole in it. Electrons "boiled" off a hot wire enter the hole in the first plate and are accelerated by the electric field between the plates, and leave through the hole in the second plate at a high speed.

a. If the separation between the plates is 1.5 millimeters, what is the electric field strength between the plates?

b. The charge on one electron is 1.6 $x10^{-19}$ coulombs. What would be the force on the electron in the electron gun?

c. Newton's second law states that the acceleration of an object is given by the force applied divided by the mass. The mass of an electron is 9.1 x 10^{-31} kg. What is the acceleration of the electron in the electron gun?

d. For an object with acceleration a, starting from rest and traveling a distance x, the final speed v is given by $v = \sqrt{2ax}$. What is the final speed of the electron as it comes out of the electron gun?