Exercises

Section 8.1 Coulomb's Law

8.1 Find the force on each charge in each part of Figure 8.14. Draw arrows on the charges to show the directions of the forces on them.

8.2 The force on each of two charges is 2400 N. If the distance between the charges is halved, what is the force on each?

8.3 How far apart would it be necessary to move two 1-C charges in order to reduce the force on each to 1 N?

8.4 A valence electron of the copper atom is approximately 1.2×10^{-10} m from its nucleus. The nucleus contains 29 protons. What is the force of attraction between the electron and the nucleus?

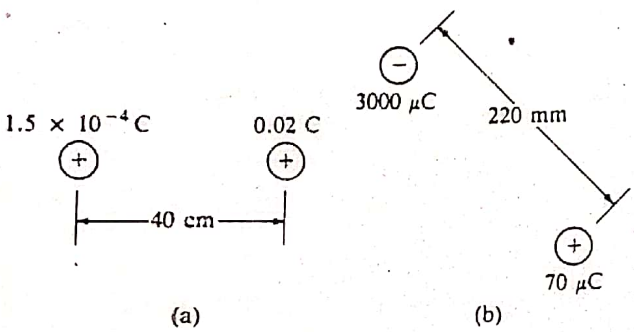

FIGURE 8.14 (Exercise 8.1)

Section 8.2 Electric Fields

8.5 Using your intuitive understanding of the nature of electric field lines, sketch the approximate appearance of the electric field around the fixed charges in each part of Figure 8.15. Include arrows to show the directions of the field lines.

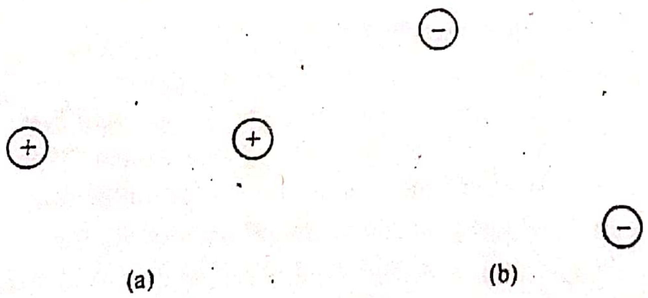

FIGURE 8.15 (Exercise 8.5)

8.6 Repeat Exercise 8.5 for the arrangement of fixed charges shown in Figure 8.16.

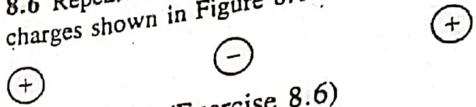

FIGURE 8.16 (Exercise 8.6)

8.7 What is the total flux passing through a 10 cm × 6 cm surface in a region where the electric flux density is 2700 $\mu C/m^2$?

8.8 The flux density between two parallel, charged surfaces is 0.042 C/m^2. If the total flux crossing from the positively charged surface to the negatively charged surface is 77.7 μC, what is the area of each surface?

8.9 How much force would be experienced by a 220-μC point charge if it were placed in an electric field where the intensity is 1.3×10^4 V/m?

8.10 What is the electric field intensity 1 mm away from a single fixed electron? (*Hint:* First find the force on an arbitrary charge placed at that point, say 1 C.)

8.11 At a certain point in a material, the flux density is 0.09 C/m^2 and the electric field intensity is 1.2×10^9 V/m. What is the permittivity of the material?

8.12 Find the flux density in a vacuum at a point 6.42 mm away from a fixed charge of 5000 μC. (*Hint:* Use an approach similar to that in Exercise 8.10.)

8.13 The voltage difference between two parallel, charged surfaces is 9 V and the electric field intensity in the region between them is 1600 V/m. How far apart are the surfaces?

8.14 Two parallel, charged surfaces are separated by 0.8 mm of a material that has a permittivity of 1.25×10^{-10}. The flux density in the material is 50 $\mu C/m^2$. What is the voltage difference between the surfaces?

Section 8.3 Breakdown Strength

8.15 Two parallel, charged surfaces are separated by air and have a potential difference of 250 V across them. At what separating distance will the air between the surfaces break down?

8.16 Mica has a permittivity that is five times greater than that of air. At what value of flux density will mica break down?

Section 8.4 Voltage

8.17 Find the voltage V_{xy} between points x and y in a circuit if

(a) 23 J of work must be performed on a 0.025-C negative charge to move it from point x to point y

(b) 147 mJ of energy is required to move a 300-μC positive charge from y to x

(c) 64 J of work must be performed on a 16-C negative charge to move it from y to x

8.18 Find the amount of work that must be performed

(a) to move a 400-μC negative charge from x to y if $V_{xy} = 250$ V

(b) to move a 0.33-C positive charge from x to y if $V_{xy} = -20$ V

(c) to move a 1000-μC negative charge from x to y if $V_{yx} = 52$ V

Section 8.5 Resistance of Conductors

8.19 Find the resistance between surfaces A and B of the bar shown in Figure 8.17, assuming that it is made of copper.

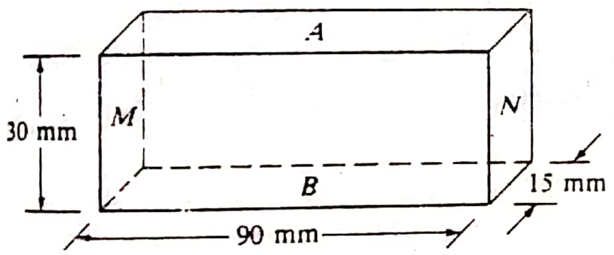

FIGURE 8.17 (Exercise 8.19)

8.20 Find the resistance between surfaces M and N of the bar shown in Figure 8.17, assuming that it is made of nickel.

8.21 The tungsten bar shown in Figure 8.18 has a square cross section ($d \times d$). If the current through the bar is to be 20 mA when the 3-V source is connected as shown, what should be dimension d?

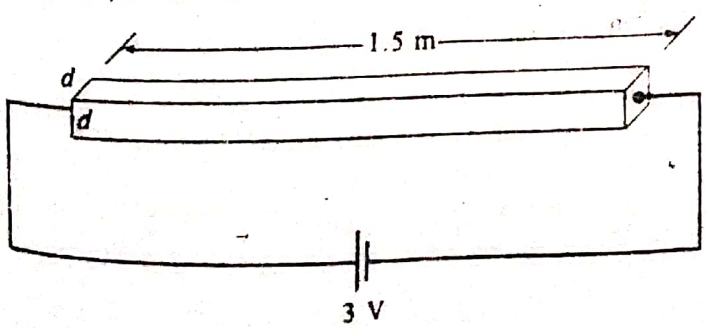

FIGURE 8.18 (Exercise 8.21)

8.22 A heater element is to be constructed from nichrome wire having a diameter of 3 mm. If the element is to dissipate 200 W when a 24-V source is connected between its ends, how long should the wire be?

8.23 Find the resistance of 250 ft of copper wire whose diameter is 0.08 in.

8.24 What is the radius of an aluminum cable if a 2000-ft length of it has a resistance of 212.5 mΩ?

8.25 An AWG standard wire size is to be selected for an application in which 20 A must be conducted over a 1000-ft distance. If the wire is copper and the power loss in it cannot exceed 70 W, what is the smallest size that can be used?

8.26 The resistance of a 6-in. length of AWG No. 35 wire is measured to be 1.174 Ω. Of what material is the wire made?

Section 8.6 Resistance of Semiconductors

8.27 A silicon bar is 2 mm long and has a cross-sectional area of 0.5×10^{-7} m^2. If the conductivity of the silicon is 800 S/m, what is the resistance of the bar?

8.28 If the thickness of the bar in Exercise 8.27 is 0.1 mm, what is its aspect ratio? What is its sheet resistivity?

8.29 A 500-Ω semiconductor resistor is to be designed using silicon whose sheet resistivity is 200 Ω/square. If the width of the resistor is 20 microns, how long should it be?

8.30 An 800-Ω semiconductor resistor is to be constructed using silicon whose conductivity is 2000 S/m. If the resistor is to be 6 mm long by 1 mm wide, how thick should the silicon layer be, in microns?

Section 8.7 Temperature Dependence of Resistance

8.31 An aluminum conductor has resistance 12 Ω at 50°C. Find its resistance at

(a) 85°C

(b) −5°C

8.32 A copper conductor has resistance 3.5 Ω at 30°C. At what temperature would its resistance be 3.7 Ω?

8.33 Using the temperature coefficient of resistance, find the resistance of a nichrome wire at 200°C if its resistance at 20°C is 300 Ω.