17. Consider the electric field at points A, B, and C in Fig. 16–48. First draw an arrow at each point indicating the direction of the net force that a positive test charge would experience if placed at that point, then list the points in order of *decreasing* field strength (strongest first).

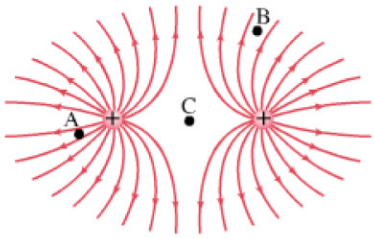

FIGURE 16–48
Question 17.

18. Why can electric field lines never cross?

19. Show, using the three rules for field lines given in Section 16–8, that the electric field lines starting or ending on a single point charge must be symmetrically spaced around the charge.

20. Given two point charges Q and $2Q$, a distance l apart, is there a point along the straight line that passes through them where $E = 0$ when their signs are (*a*) opposite, (*b*) the same? If yes, state roughly where this point will be.

21. Consider a small positive test charge located on an electric field line at some point, such as point P in Fig. 16–31a. Is the direction of the velocity and/or acceleration of the test charge along this line? Discuss.

22. Sketch the electric field lines for a uniform line of charge which is infinitely long. (*Hint*: Use symmetry.) Is the electric field uniform in strength?

* **23.** If the electric flux through a closed surface is zero, is the electric field necessarily zero at all points on the surface? Explain. What about the converse: If $\vec{\mathbf{E}} = 0$ at all points on the surface is the flux through the surface zero?

* **24.** A point charge is surrounded by a spherical gaussian surface of radius r. If the sphere is replaced by a cube of side r, will Φ_E be larger, smaller, or the same? Explain.

Problems

16–5 and 16–6 Coulomb's Law

[$1\text{ mC} = 10^{-3}\text{ C}$, $1\ \mu\text{C} = 10^{-6}\text{ C}$, $1\text{ nC} = 10^{-9}\text{ C}$.]

1. (I) Calculate the magnitude of the force between two 3.60-μC point charges 9.3 cm apart.

2. (I) How many electrons make up a charge of $-30.0\ \mu\text{C}$?

3. (I) What is the magnitude of the electric force of attraction between an iron nucleus ($q = +26e$) and its innermost electron if the distance between them is 1.5×10^{-12} m?

4. (I) What is the repulsive electrical force between two protons 5.0×10^{-15} m apart from each other in an atomic nucleus?

5. (I) What is the magnitude of the force a $+25\ \mu\text{C}$ charge exerts on a +3.0 mC charge 35 cm away?

6. (II) Two charged dust particles exert a force of 3.2×10^{-2} N on each other. What will be the force if they are moved so they are only one-eighth as far apart?

7. (II) Two charged spheres are 8.45 cm apart. They are moved, and the force on each of them is found to have been tripled. How far apart are they now?

8. (II) A person scuffing her feet on a wool rug on a dry day accumulates a net charge of $-42\ \mu\text{C}$. How many excess electrons does she get, and by how much does her mass increase?

9. (II) What is the total charge of all the electrons in 1.0 kg of H_2O?

10. (II) Compare the electric force holding the electron in orbit ($r = 0.53 \times 10^{-10}$ m) around the proton nucleus of the hydrogen atom, with the gravitational force between the same electron and proton. What is the ratio of these two forces?

11. (II) Two positive point charges are a fixed distance apart. The sum of their charges is Q_T. What charge must each have in order to (*a*) maximize the electric force between them, and (*b*) minimize it?

12. (II) Particles of charge +75, +48, and $-85\ \mu\text{C}$ are placed in a line (Fig. 16–49). The center one is 0.35 m from each of the others. Calculate the net force on each charge due to the other two.

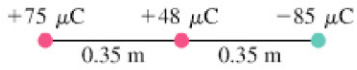

FIGURE 16–49
Problem 12.

13. (II) Three positive particles of equal charge, $+11.0\ \mu\text{C}$, are located at the corners of an equilateral triangle of side 15.0 cm (Fig. 16–50). Calculate the magnitude and direction of the net force on each particle.

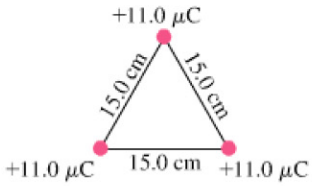

FIGURE 16–50
Problem 13.

14. (II) A charge of 6.00 mC is placed at each corner of a square 0.100 m on a side. Determine the magnitude and direction of the force on each charge.

15. (II) Repeat Problem 14 for the case when two of the positive charges, on opposite corners, are replaced by negative charges of the same magnitude (Fig. 16–51).

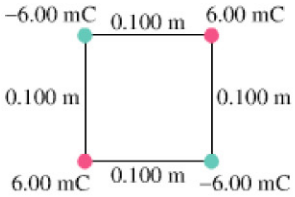

FIGURE 16–51
Problem 15.