

15.1 Electric Charge

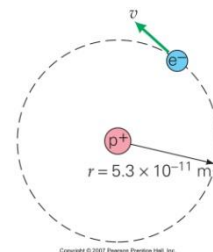
- MC** A combination of two electrons and three protons would have a net charge of (a) $+1$, (b) -1 , (c) $+1.6 \times 10^{-19}$ C, (d) -1.6×10^{-19} C.
- MC** An electron is just above a fixed proton. The direction of the force on the electric proton is (a) up, (b) down, (c) zero.
- MC** In Exercise 2, which one feels the bigger size force: (a) The electron, (b) proton, or (c) both feel the same size force?
- What is the net charge of an object that has 1.0 million excess electrons?
- In walking across a carpet, you acquire a net negative charge of $50 \mu\text{C}$. How many excess electrons do you have?
- An alpha particle is the nucleus of a helium atom with no electrons. What would be the charge on two alpha particles?
- IE** ●● A rubber rod rubbed with fur acquires a charge of -4.8×10^{-9} C. (a) Is the charge on the fur (1) positive, (2) zero, or (3) negative? Why? (b) What is the charge on the fur, and how much mass is transferred to the rod? (c) How much mass has the rubber rod gained?

15.2 Electrostatic Charging

- MC** A rubber rod is rubbed with fur. The fur is then quickly brought near the bulb of an uncharged electroscope. The sign of the charge on the leaves of the electroscope is (a) positive, (b) negative, (c) zero.
- MC** A stream of water is deflected toward a nearby electrically charged object that is brought close to it. The sign of the charge on the object (a) is positive, (b) is negative, (c) is zero, (d) can't be determined by the data given.
- MC** A balloon is charged and then clings to a wall. The sign of the charge on the balloon (a) is positive, (b) is negative, (c) is zero, (d) can't be determined by the data given.

15.3 Electric Force

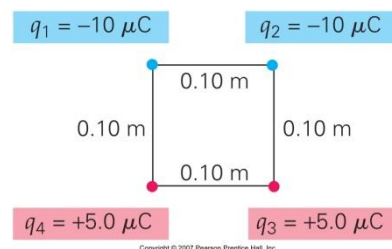
- MC** How does the magnitude of the electric force between two point charges change as the distance between them is increased? The force (a) decreases, (b) increases, (c) stays the same.
- MC** Compared with the electric force, the gravitational force between two protons is (a) about the same, (b) somewhat larger, (c) very much larger, (d) very much smaller.
- CQ** The Earth attracts us by its gravitational force, but we have seen that the electric force is much greater than the gravitational force. Why don't we experience an electric force from the Earth?
- Two identical point charges are a fixed distance apart. By what factor would the magnitude of the electric force between them change if (a) one of their charges were doubled and the other were halved, (b) both their charges were halved, and (c) one charge were halved and the other were left unchanged?
- The distance between neighboring singly charged sodium and chlorine ions in crystals of table salt (NaCl) is 2.82×10^{-10} m. What is the attractive electric force between the ions?
- Two point charges of $-2.0 \mu\text{C}$ are fixed at opposite ends of a meterstick. Where on the meterstick could (a) a free electron and (b) a free proton be in electrostatic equilibrium?
- Two point charges of $-1.0 \mu\text{C}$ and $+1.0 \mu\text{C}$ are fixed at opposite ends of a meterstick. Where could (a) a free electron and (b) a free proton be in electrostatic equilibrium?
- On average, the electron and proton in a hydrogen atom are separated by a distance of 5.3×10^{-11} m (Fig. 15.24>). Assuming the orbit of the electron to be circular, (a) what is the electric force on the electron? (b) What is the electron's orbital speed? (c) What is the magnitude of the electron's centripetal acceleration in units of g ?



15.4 Electric Field

- MC** How is the magnitude of the electric field due to a point charge reduced when the distance from that charge is tripled: (a) It stays the same, (b) it is reduced to one third of its original value charge, (c) it is reduced to one ninth of its original value charge, or (d) it is reduced to one twenty-seventh of its original value charge?

42. **MC** The SI units of electric field are (a) C, (b) N/C, (c) N, (d) J.
43. **MC** At a point in space, an electric force acts vertically upward on an electron. The direction of the electric field at that point is (a) down, (b) up, (c) zero, (d) undetermined by the data.
44. **CQ** How is the relative magnitude of the electric field in different regions determined from a field vector diagram?
45. **CQ** How can the relative magnitudes of the field in different regions be determined from an electric field line diagram?
52. ● What is the magnitude and direction of the electric field at a point 0.75 cm away from a point charge of $+2.0 \mu\text{C}$?
58. ●● Two charges of $+4.0 \mu\text{C}$ and $+9.0 \mu\text{C}$ are 30 cm apart. Where on the line joining the charges is the electric field zero?
61. ●●● What is the electric field at the center of the square in Fig. 15.26>?



15.5 Conductors and Electric Fields

67. **MC** In electrostatic equilibrium, is the electric field just below the surface of a charged conductor (a) the same value as the field just above the surface (b) zero, (c) dependent on the amount of charge on the conductor, or (d) given by kq/R^2 ?
68. **MC** An uncharged thin metal slab is placed in an external electric field that points horizontally to the left. What is the electric field inside the slab: (a) zero, (b) the same value as the original external field but oppositely directed, (c) less than the original external field value but not zero, or (d) depends on the magnitude of the external field?
69. **MC** The direction of the electric field at the surface of a charged conductor under electrostatic conditions (a) is parallel to the surface, (b) is perpendicular to the surface, (c) is at a 45° angle to the surface, or (d) depends on the charge on the conductor.
72. **CQ** Tall buildings have lightning rods to protect them from lightning strikes. Explain why the rods are pointed in shape and taller than the buildings.
73. **IE** ● A solid conducting sphere is surrounded by a thick, spherical conducting shell. Assume that a total charge $+Q$ is placed at the center of the sphere and released. (a) After equilibrium is reached, the inner surface of the shell will have (1) negative, (2) zero, (3) positive charge. (b) In terms of Q , how much charge is on the interior of the sphere? (c) The surface of the sphere? (d) The inner surface of the shell? (e) The outer surface of the shell?
74. ● In Exercise 73, what is the electric field direction (a) in the interior of the solid sphere, (b) between the sphere and the shell, (c) inside the shell, and (d) outside the shell?

*15.6 Gauss's Law for Electric Fields: A Qualitative Approach

78. **MC** A Gaussian surface surrounds an object with a net charge of $-5.0 \mu\text{C}$. Which of the following is true? (a) More electric field lines will point outward than inward. (b) More electric field lines will point inward than outward. (c) The net number of field lines through the surface is zero. (d) There must be only field lines passing inward through the surface.
79. **MC** What can you say about the net number of electric field lines passing through a Gaussian surface located completely within the region between a set of oppositely charged parallel plates? (a) The net number point outward. (b) The net number point inward. (c) The net number is zero. (d) The net number depends on the amount of charge on each plate.
80. **MC** Two concentric spherical surfaces enclose a charged particle. The radius of the outer sphere is twice that of the inner one. Which sphere will have more electric field lines passing through its surface? (a) The larger one. (b) The smaller one. (c) Both spheres would have the same number of field lines passing through them. (d) The answer depends on the amount of charge on the particle.
86. A negatively charged pith ball (mass 6.00×10^{-3} g, charge -1.50 nC) is suspended vertically from a light nonconducting string of length 15.5 cm. This apparatus is then placed in a horizontal uniform electric field. After being released, the pith ball comes to a stable position at an angle of 12.3° to the left of the vertical. (a) What is the direction of the external electric field? (b) Determine magnitude of the electric field.