67. A point charge ($m = 1.0\,\text{g}$) at the end of an insulating string of length 55 cm is observed to be in equilibrium in a uniform horizontal electric field of 12,000 N/C, when the pendulum's position is as shown in Fig. 16–66, with the charge 12 cm above the lowest (vertical) position. If the field points to the right in Fig. 16–66, determine the magnitude and sign of the point charge.
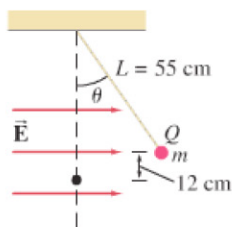

FIGURE 16–66
Problem 67.

68. A point charge of mass 0.210 kg, and net charge $+0.340\,\mu\text{C}$, hangs at rest at the end of an insulating string above a large sheet of charge. The horizontal sheet of uniform charge creates a uniform vertical electric field in the vicinity of the point charge. The tension in the string is measured to be 5.67 N. Calculate the magnitude and direction of the electric field due to the sheet of charge (Fig. 16–67).
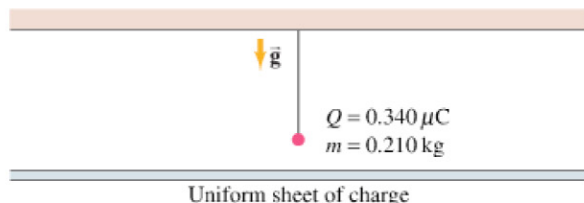

Uniform sheet of charge

FIGURE 16–67   Problem 68.

69. What is the total charge of all the electrons in a 15-kg bar of aluminum? What is the net charge of the bar? (Aluminum has 13 electrons per atom and an atomic mass of 27 u.)

70. Two small, identical conducting spheres A and B are a distance R apart; each carries the same charge Q. (a) What is the force sphere B exerts on sphere A? (b) An identical sphere with zero charge, sphere C, makes contact with sphere B and is then moved very far away. What is the net force now acting on sphere A? (c) Sphere C next makes contact with sphere A and is then moved far away. What is the force on sphere A in this third case?

71. Given the two charges shown in Fig. 16–68, at what position(s) x is the electric field zero? Is the field zero at any other points, not on the x axis?
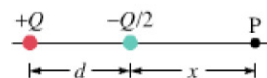

FIGURE 16–68   Problem 71.

72. Two point charges, $+Q$ and $-Q$ of mass m, are placed on the ends of a massless rod of length L, which is fixed to a table by a pin through its center. If the apparatus is then subjected to a uniform electric field E parallel to the table and perpendicular to the rod, find the net torque on the system of rod plus charges.

73. Four equal positive point charges, each of charge $8.0\,\mu\text{C}$, are at the corners of a square of side 9.2 cm. What charge should be placed at the center of the square so that all charges are at equilibrium? Is this a stable or unstable equilibrium (Section 9–4) in the plane?

Answers to Exercises

A: Opposite.

B: 5 N.

C: 1.2 N, to the right.

D: 0.32 m.

E: (a) No; (b) yes, midway between them.

F: 9.0×10^4 N/C, vertically down.

G: (a) $\vec{E}_1$ right; $\vec{E}_2$ left; $\vec{E}$ right;
(b) $\vec{E}_1$ left; $\vec{E}_2$ right; $\vec{E}$ right.

H: $\sum E_\perp \, \Delta A = E \sum \Delta A = E(2\pi rL) = \dfrac{Q_{\text{encl}}}{\epsilon_0}$,

so $E = \dfrac{1}{2\pi\epsilon_0\, r}\dfrac{Q}{L}$.