Chapter 18

Problems & Exercises

1.

(a) 1.25×10^{10}

(b) 3.13×10^{12}

3.

-600 C

5.

1.03×10^{12}

7.

9.09×10^{-13}

9.

1.48×10^{8} C

11.

(a) 0.263 N

(b) If the charges are distributed over some area, there will be a concentration of charge along the side closest to the oppositely charged object. This effect will increase the net force.

13.

The separation decreased by a factor of 5.

17.

$$\begin{aligned} F &= k\frac{|q_1 q_2|}{r^2} = ma \Rightarrow a = \frac{kq^2}{mr^2} \\ &= \frac{\left(9.00\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\left(1.60\times10^{-19}\ \text{m}\right)^2}{\left(1.67\times10^{-27}\ \text{kg}\right)\left(2.00\times10^{-9}\ \text{m}\right)^2} \\ &= 3.45 \times 10^{16}\ \text{m/s}^2 \end{aligned}$$

18.

(a) 3.2

(b) If the distance increases by 3.2, then the force will decrease by a factor of 10 ; if the distance decreases by 3.2, then the force will increase by a factor of 10. Either way, the force changes by a factor of 10.

20.

(a) 1.04×10^{-9} C

(b) This charge is approximately 1 nC, which is consistent with the magnitude of charge typical for static electricity

23.

1.02×10^{-11}

25.

a. 0.859 m beyond negative charge on line connecting two charges
b. 0.109 m from lesser charge on line connecting two charges

28.

8.75×10^{-4} N

30.

(a) 6.94×10^{-8} C

(b) 6.25 N/C

32.

(a) 300 N/C (east)

(b) 4.80×10^{-17} N (east)

42.

(a) 2.12×10^{5} N/C

(b) one charge of $+q$

44.

(a) 0.252 N to the left

(b) $x = 6.07\ cm$

46.

(a)The electric field at the center of the square will be straight up, since q_a and q_b are positive and q_c and q_d are negative and all have the same magnitude.

(b) 2.04×10^{7} N/C (upward)

48.

0.102 N, in the $-y$ direction

50.

(a) $\vec{E} = 4.36 \times 10^{3}$ N/C, 35.0, below the horizontal.

(b) No

52.

(a) 5.58×10^{-11} N/C

(b)the coulomb force is extraordinarily stronger than gravity

54.

(a) -6.76×10^{5} C

(b) 2.63×10^{13} m/s^2 (upward)

(c) 2.45×10^{-18} kg

56.

The charge q_2 is 9 times greater than q_1.

69.

(a) The forces are balanced in the x-direction, so the net force is vertical. It is composed of the sum of the vertical components of the Coulomb force and the gravitational force. $\cos 45^\circ = -4.36 \times 10^{-9}$ N

$$\mathbf{F}_y = -2\left(\frac{kq_1q_2}{r^2} + G\frac{m_1m_2}{r^2}\right)\cos 45^\circ =$$
$$-2\left(\frac{8.99\times10^9(1.00\times10^{-9})(2.00\times10^{-9})}{8} + 6.67\times10^{-11}\frac{(10.0)(10.0)}{8}\right)$$

(b) No, it is in a metastable position. Since it cannot move horizontally, it cannot traverse any part of the track.

$$\mathbf{F}_x = -\left(\frac{kq_1q_2}{4} + G\frac{m_1m_2}{4}\right)\frac{1}{2} + \left(\frac{kq_1q_2}{12} + G\frac{m_1m_2}{12}\right)\frac{\sqrt{3}}{2} =$$
$$-\left(\frac{8.99\times10^9(-1.00\times10^{-9})(2.00\times10^{-9})}{4}\frac{1}{2} - 6.67\times10^{-11}\frac{(10.0)(10.0)}{4}\frac{1}{2}\right)$$
(c) $$+\left(\frac{8.99\times10^9(-1.00\times10^{-9})(2.00\times10^{-9})}{12}\frac{\sqrt{3}}{2} - 6.67\times10^{-11}\frac{(10.0)(10.0)}{12}\frac{\sqrt{3}}{2}\right)\text{N} = 2.60\times10^{-9}\text{ N}$$
$$\mathbf{F}_y = -\left(\frac{kq_1q_2}{4} + G\frac{m_1m_2}{4}\right)\frac{\sqrt{3}}{2} - \left(\frac{kq_1q_2}{12} + G\frac{m_1m_2}{12}\right)\frac{1}{2} = -2.08\times10^{-9}\text{ N}$$
$$-\left(\frac{8.99\times10^9(1.00\times10^{-9})(2.00\times10^{-9})}{4}\frac{\sqrt{3}}{2} - 6.67\times10^{-11}\frac{(10.0)(10.0)}{4}\frac{\sqrt{3}}{2}\right)$$
$$-\left(\frac{8.99\times10^9(1.00\times10^{-9})(2.00\times10^{-9})}{12}\frac{1}{2} + 6.67\times10^{-11}\frac{(10.0)(10.0)}{12}\frac{1}{2}\right)\text{N} = -6.36\times10^{-9}\text{ N}$$

(d) Yes.

(e) It will reach $(1, -\sqrt{3})$ before it will change direction.

(f) The metastable positions where there is no component in one direction are $(0, 0)$, $(4, 0)$, $(2, 2)$, and $(2, -2)$. They number 4.