CHAPTER 22 HINT FOR EXERCISE 3

(a) The magnitudes of the forces acting on the particles are the same, so $m_1 a_1 = m_2 a_2$, where m_1 and m_2 are the masses and a_1 and a_2 are the magnitudes of the accelerations. Solve for m_2.

(b) The magnitude of the force is given by Coulomb's law:

$$F = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2},$$

where r is the separation of the particles. Newton's second law for particle 1 yields

$$\frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2} = m_1 a_1$$

Solve for q.

[ans: (a) 4.9×10^{-7} kg; (b) 7.1×10^{-11} C]

CHAPTER 22 HINT FOR EXERCISE 4

Let q be the charge originally on each of the spheres 1 and 2. The force on 2 has magnitude

$$F = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2} ,$$

where r is the center-to-center separation of the spheres. After 3 is touched to 1, they have equal charge. Since the total charge on 1 and 3 is q, each has charge $q/2$. After 3 is touched to 2, they have equal charge. Since the total charge on 2 and 3 is $q + q/2 = 3q/2$, they each have charge $3q/4$. Since the charge on 1 is $q/2$ and the charge on 2 is $3q/4$, the magnitude of the force between spheres 1 and 2 is now

$$F' = \frac{1}{4\pi\epsilon_0} \frac{3q^2}{8r^2} .$$

Substitute F for $(1/4\pi\epsilon_0)q^2/r^2$. The force is in the same direction as before.

CHAPTER 22 HINT FOR PROBLEM 8

One of the fixed charges must attract and the other must repel q_3, so one is positive and the other is negative. The condition that the net force on q_3 is zero leads to

$$\frac{q_1}{(2d)^2} + \frac{q_2}{d^2} = 0\,.$$

Solve for q_1.

Chapter 22 Hint for Problem 10

The third charge must be located on the same line as the fixed charges, for otherwise the two forces acting on it would not be antiparallel and so could not sum to zero. It cannot be between the fixed charges for then the two forces would be in the same direction. It must be nearer the smaller of the fixed charges for the magnitudes of the two forces to be the same. Place the particle with charge q_1 at the origin, the particle with charge q_2 at $x = d$ ($= 10\,\mathrm{cm}$), and the third particle at $x = d + L$, where L is positive. The condition that the force vanishes leads to

$$\frac{q_1}{(d+L)^2} + \frac{q_2}{L^2} = 0\,.$$

Solve for L.

(a) The relative displacement of q_2 from q_1 has components $\Delta x = x_2 - x_1$ and $\Delta y = y_2 - y_1$. The distance between the charges is $d = \sqrt{(\Delta x)^2 + (\Delta y)^2}$ and the magnitude of the force is

$$F = \frac{1}{4\pi\epsilon_0} \frac{|q_1||q_2|}{d^2}$$

The x component of the force is

$$F_x = F\,\frac{\Delta x}{d}$$

and the y component is

$$F\,\frac{\Delta y}{d}\,.$$

The angle between the force and the positive x axis is given by $\tan\theta = F_y/F_x$. Be sure to pick the proper value so the force is one of attraction.

(b) The third charge must be along the line that joins the first two. Since it is positive and attracts q_2 it must be on the side of q_2 opposite q_1. The magnitude of the force it exerts on q_2 must be the same as the magnitude of the force q_1 exerts on q_2. If it is a distance ℓ from q_2, then

$$\frac{|q_3|}{\ell^2} = \frac{|q_1|}{d^2}\,.$$

Solve for ℓ. The coordinates of q_3 are given by $x_3 = x_2 - \ell\cos\theta$ and $y_3 = y_2 + \ell\sin\theta$.

(a) Since the two charges Q are separated by $\sqrt{2}a$, where a is the edge length of the square, the magnitude of the electrostatic force exerted by one on the other is

$$F = \frac{1}{4\pi\epsilon_0}\frac{Q^2}{2a^2}\,.$$

Each of the charges q exerts a force with magnitude $(1/4\pi\epsilon_0)|q||Q|/a^2$, at 90° to each other and at 45° to the force of Q. For the net force on Q to be 0,

$$\frac{|Q|}{2a^2} = \frac{2|q|\cos 45^\circ}{a^2}\,.$$

Use $\cos 45^\circ = 1/\sqrt{2}$. Since the force of Q is repulsive, the force of each charge q must be attractive and Q and q must have opposite signs.

(b) To make the force on q vanish, the charges must be related by $q = -2\sqrt{2}Q$. This condition and $Q = -2\sqrt{2}q$ cannot be satisfied simultaneously.

Chapter 22 Hint for Exercise 20

A mole contains 6.02×10^{23} molecules and each molecule contains two protons. The charge on a proton is 1.60×10^{-19} C. Divide by 1.00×10^{6} to convert to megacoulombs.

Chapter 22 Hint for Problem 25

The current is the charge per unit time intercepted by Earth. If R is the radius of Earth ($6.37 \times 10^6\,\mathrm{m}$), then $A = 4\pi R^2$ is the area of its surface and $1500A$ is the number of protons that strike Earth, on average, each second. Multiply by the charge on a proton ($1.60 \times 10^{-19}\,\mathrm{C}$) to obtain the current.

$\left[\text{ans:} \quad 0.122\,\mathrm{A}\right]$

Chapter 22 Hint for Problem 28

The total positive charge in a neutral copper penny is

$$Q_+ = (3\times 10^{22}\,\text{atoms})(29\,\text{protons/atom})((1.60\times 10^{-19}\,\text{C/proton}) = 1.39\times 10^{5}\,\text{C}$$

and the total negative charge is $Q_- = -1.39\times 10^5$ C. If the positive charge were greater by a factor of 5.0×10^{-7} and the negative charge were less by the same factor, the net charge on the penny would be $(1.39\times 10^5)(1.0\times 10^{-6}) = 0.139$ C. Use Coulomb's law to find the force of one penny on another, separated by 1.0 m.