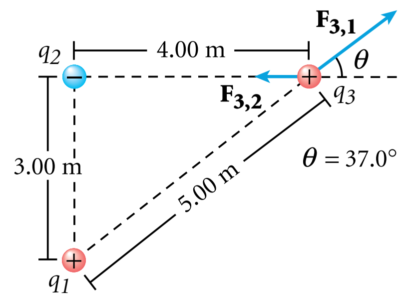
SAMPLE PROBLEM B

STRATEGY The Superposition Principle

PROBLEM

Consider three point charges at the corners of a triangle, as shown at right, where $q_1 = 6.00 \times 10^{-9}$ C, $q_2 = -2.00 \times 10^{-9}$ C, and $q_3 = 5.00 \times 10^{-9}$ C. Find the magnitude and direction of the resultant force on q_3.



SOLUTION

1. Define the problem, and identify the known variables.

Given: $q_1 = +6.00 \times 10^{-9}$ C $\quad r_{2,1} = 3.00$ m

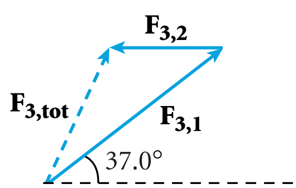
$q_2 = -2.00 \times 10^{-9}$ C $\quad r_{3,2} = 4.00$ m

$q_3 = +5.00 \times 10^{-9}$ C $\quad r_{3,1} = 5.00$ m

$\theta = 37.0°$

Unknown: $\mathbf{F}_{3,tot} = ?$

Diagram:



2. Determine the direction of the forces by analyzing the charges.

The force $\mathbf{F}_{3,1}$ is repulsive because q_1 and q_3 have the same sign.
The force $\mathbf{F}_{3,2}$ is attractive because q_2 and q_3 have opposite signs.

3. Calculate the magnitude of the forces with Coulomb's law.

$$F_{3,1} = k_C \frac{q_3 q_1}{(r_{3,1})^2} = (8.99 \times 10^9\ \mathrm{N \bullet m^2/C^2})\left(\frac{(5.00 \times 10^{-9}\ \mathrm{C})(6.00 \times 10^{-9}\ \mathrm{C})}{(5.00\ \mathrm{m})^2}\right)$$

$$F_{3,1} = 1.08 \times 10^{-8}\ \mathrm{N}$$

$$F_{3,2} = k_C \frac{q_3 q_2}{(r_{3,2})^2} = (8.99 \times 10^9\ \mathrm{N \bullet m^2/C^2})\left(\frac{(5.00 \times 10^{-9}\ \mathrm{C})(2.00 \times 10^{-9}\ \mathrm{C})}{(4.00\ \mathrm{m})^2}\right)$$

$$F_{3,2} = 5.62 \times 10^{-9}\ \mathrm{N}$$

4. Find the *x* and *y* components of each force.

At this point, the direction of each component must be taken into account.

For $\mathbf{F}_{3,1}$: $F_x = (F_{3,1})(\cos 37.0°) = (1.08 \times 10^{-8}\ \mathrm{N})(\cos 37.0°) = 8.63 \times 10^{-9}\ \mathrm{N}$

$F_y = (F_{3,1})(\sin 37.0°) = (1.08 \times 10^{-8}\ \mathrm{N})(\sin 37.0°) = 6.50 \times 10^{-9}\ \mathrm{N}$

For $\mathbf{F}_{3,2}$: $F_x = -F_{3,2} = -5.62 \times 10^{-9}\ \mathrm{N}$

$F_y = 0\ \mathrm{N}$

5. Calculate the magnitude of the total force acting in both directions.

$$F_{x,tot} = 8.63 \times 10^{-9}\ \mathrm{N} - 5.62 \times 10^{-9}\ \mathrm{N} = 3.01 \times 10^{-9}\ \mathrm{N}$$

$$F_{y,tot} = 6.50 \times 10^{-9}\ \mathrm{N} + 0\ \mathrm{N} = 6.50 \times 10^{-9}\ \mathrm{N}$$

continued on next page

TIP *According to the superposition principle, the resultant force on the charge q_3 is the vector sum of the forces exerted by q_1 and q_2 on q_3. First, find the force exerted on q_3 by each, and then add these two forces together vectorially to get the resultant force on q_3.*