Coulomb's Law

7.2

Vocabulary

electric force (F_E) | Coulomb's constant (k) | superposition principle

Textbook pp. 327–333

MAIN IDEA: According to Coulomb's law, the force between two point charges is directly proportional to the product of the charges, and inversely proportional to the square of the distance between the charges, given as $F_E = \frac{kq_1q_2}{r^2}$. Coulomb's constant $k = 8.99 \times 10^9$ Nm^2/C^2. Coulomb's law applies to point charges, and to charges that can be concentrated equivalently in points located at the centre, when the sizes of the charges are much smaller than their distance of separation. There are similarities between the electric force and the gravitational force.

STUDY TIP

Vector Force Problems
You can simplify many vector force problems by using symmetry, especially when charges are located on the vertices of a regular polygon such as an equilateral triangle or a square.

1. Two charged points experience an electric force F between them. The distance between the points is doubled. What is the electric force after the doubling? Explain your answer. K/U T/I

   (a) $\frac{1}{4}F$
   (b) $\frac{1}{2}F$
   (c) F
   (d) $2F$

   $F_e = \frac{kq_1q_2}{r^2}$

   $F_e = \frac{kq_1q_2}{(2r)^2} = \frac{1}{4}F_e$

2. The electric force and the gravitational force
   (a) can be either attractive or repulsive
   (b) have about the same magnitude over the same distance
   (c) have greatly different magnitudes, with the electric force the weaker of the two
   (d) have greatly different magnitudes with the gravitational force the weaker of the two K/U

3. Two balloons are each given a charge of 2.00 μC, and separated by a distance of 0.500 m between their centres. What is the electric force between the balloons? T/I A

   $r = 0.500$ m
   $q_1 = q_2 = 2.00\,\mu C$
   $= 2.00 \times 10^{-6}$ C
   $F_e = ?$

   $F_e = \frac{kq_1q_2}{r^2}$

   $= \frac{(9.0 \times 10^9\ Nm^2/C^2)(2.00 \times 10^{-6} C)^2}{(0.500 m)^2}$

   $= 0.14$ N

MAIN IDEA: The superposition principle states that the total force acting on a charge q is the vector sum, or superposition, of the individual forces exerted on q by all the other charges in the system.

4. Two point charges Q and $2Q$ are fixed in place and separated by a distance d as shown in **Figure 1**. For what value of x will a small test charge q feel no net force from the two charges? K/U

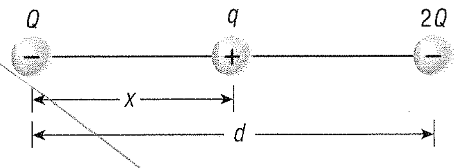

Figure 1

(a) $x = \frac{d}{4}$

(b) $x = \frac{d}{3}$

(c) $x = \frac{d}{2}$

(d) $x = \frac{2d}{3}$

$F_Q = F_{2Q}$

$\frac{kQq}{x^2} = \frac{k2Qq}{(d-x)^2}$

$\frac{1}{x^2} = \frac{2}{(d-x)^2}$

$2x^2 = (d-x)^2$

$\sqrt{2}x = d - x$

$(1+\sqrt{2})x = d$

$x = \frac{d}{1+\sqrt{2}}$

5. **Figure 2** shows three point charges of 15.0 μC each are arranged on the vertices of an equilateral triangle of side length 0.400 m. Determine the vector electric force experienced by charge q_1 due to the other two charges. Draw diagrams to help you. T/I C A

* only vertical matters

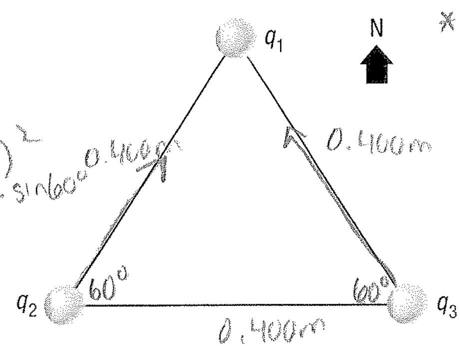

Figure 2

$F_{12} = \frac{kq_1q_2}{r_{12}^2}\sin\theta$

$= \frac{(9.0\times10^9 \text{ Nm}^2/\text{C}^2)(15.0\times10^{-6}\text{ C})^2}{(0.400\text{ m})^2}\sin 60°$

$= 10.96 \text{ N} = F_{13}$

$F = F_{12} + F_{13}$

$= 2(10.96\text{ N})$

$= 21.92\text{ N}$

$= 22\text{ N}$