PHYSICS(II)

Section 1

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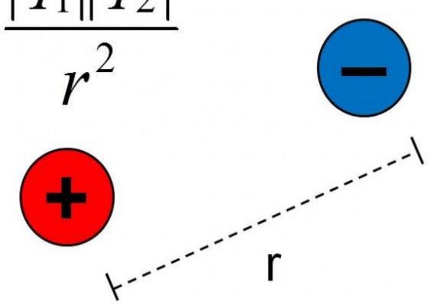
Electric Force

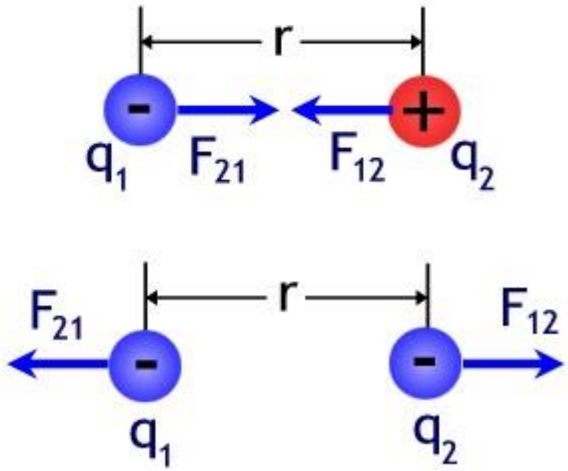
Coulomb's Law

The Force between two point charges is **directly proportional to the product of the CHARGES** and **inversely proportional to the square of their distance apart.**

Coulomb's Law

$$F_e = k\frac{|q_1||q_2|}{r^2}$$





5) (a) Two protons in a molecule are separated by 3.80×10^{-10} m. Find the electric force exerted by one proton on the other.
(b) How does the magnitude of this force compare to the magnitude of the gravitational force between the two protons?
(c) What If? What must be the charge-to-mass ratio of a particle if the magnitude of the gravitational force between two of these particles equals the magnitude of electric force between them?

(a) $$F_e = \frac{k_e q_1 q_2}{r^2} = \frac{(8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2})(1.60 \times 10^{-19}\ \mathrm{C})^2}{(3.80 \times 10^{-10}\ \mathrm{m})^2} = \boxed{1.59 \times 10^{-9}\ \mathrm{N}}\ \text{(repulsion)}$$

(b) $$F_g = \frac{G m_1 m_2}{r^2} = \frac{(6.67 \times 10^{-11}\mathrm{N \cdot m^2/kg^2})(1.67 \times 10^{-27}\ \mathrm{kg})^2}{(3.80 \times 10^{-10}\ \mathrm{m})^2} = \boxed{1.29 \times 10^{-45}\ \mathrm{N}}$$

The electric force is $\boxed{\text{larger by } 1.24 \times 10^{36} \text{ times}}$.

(c) If $k_e \frac{q_1 q_2}{r^2} = G \frac{m_1 m_2}{r^2}$ with $q_1 = q_2 = q$ and $m_1 = m_2 = m$, then

$$\frac{q}{m} = \sqrt{\frac{G}{k_e}} = \sqrt{\frac{6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}}{8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}}} = \boxed{8.61 \times 10^{-11}\ \mathrm{C/kg}}.$$

9) Two identical conducting small spheres are placed with their centers 0.300 m apart. One is given a charge of 12.0 nC and the other a charge of −18.0 nC. (a) Find the electric force exerted by one sphere on the other. (b) What If? The spheres are connected by a conducting wire. Find the electric force between the two after they have come to equilibrium.

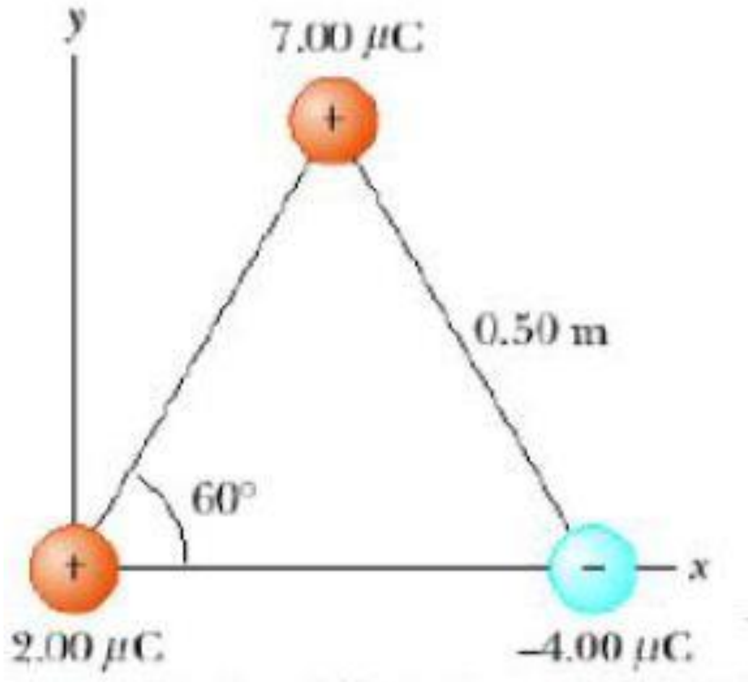
(a) The force is one of $\boxed{\text{attraction}}$. The distance r in Coulomb's law is the distance between centers. The magnitude of the force is

$$F = \frac{k_e q_1 q_2}{r^2} = \left(8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\frac{\left(12.0\times10^{-9}\ \text{C}\right)\left(18.0\times10^{-9}\ \text{C}\right)}{(0.300\ \text{m})^2} = \boxed{2.16\times10^{-5}\ \text{N}}.$$

(b) The net charge of -6.00×10^{-9} C will be equally split between the two spheres, or -3.00×10^{-9} C on each. The force is one of $\boxed{\text{repulsion}}$, and its magnitude is

$$F = \frac{k_e q_1 q_2}{r^2} = \left(8.99\times10^{9}\ \text{N}\cdot\text{m}^2/\text{C}^2\right)\frac{\left(3.00\times10^{-9}\ \text{C}\right)\left(3.00\times10^{-9}\ \text{C}\right)}{(0.300\ \text{m})^2} = \boxed{8.99\times10^{-7}\ \text{N}}.$$

7) Three point charges are located at the corners of an equilateral triangle as shown in Figure below. Calculate the resultant electric force on the 7.00 μC charge



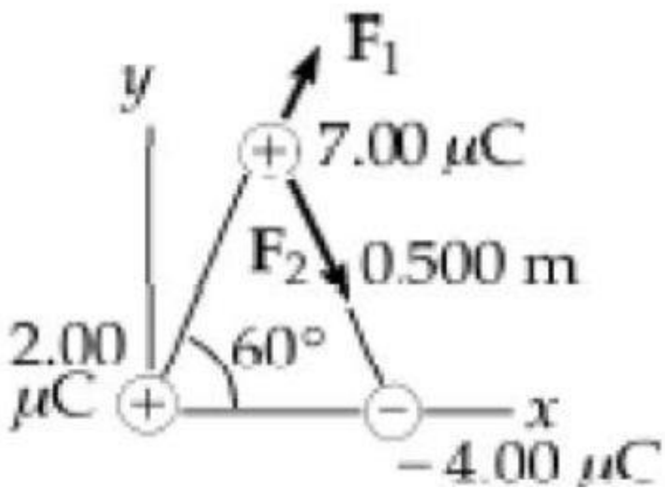
$$F_1 = k_e \frac{q_1 q_2}{r^2} = \frac{(8.99\times10^9\ \mathrm{N\cdot m^2/C^2})(7.00\times10^{-6}\ \mathrm{C})(2.00\times10^{-6}\ \mathrm{C})}{(0.500\ \mathrm{m})^2} = 0.503\ \mathrm{N}$$

$$F_2 = k_e \frac{q_1 q_2}{r^2} = \frac{(8.99\times10^9\ \mathrm{N\cdot m^2/C^2})(7.00\times10^{-6}\ \mathrm{C})(4.00\times10^{-6}\ \mathrm{C})}{(0.500\ \mathrm{m})^2} = 1.01\ \mathrm{N}$$

$$F_x = 0.503\cos 60.0° + 1.01\cos 60.0° = 0.755\ \mathrm{N}$$

$$F_y = 0.503\sin 60.0° - 1.01\sin 60.0° = -0.436\ \mathrm{N}$$

$$\mathbf{F} = (0.755\ \mathrm{N})\hat{\mathbf{i}} - (0.436\ \mathrm{N})\hat{\mathbf{j}} = \boxed{0.872\ \mathrm{N\ at\ an\ angle\ of\ 330°}}$$



25. A small charge of $-2.0 \times 10^{-8}\ C$ is at the point $x = 2\ m, y = 0$ on the x-axis. A second small charge of $-3.0 \times 10^{-6}\ C$ is at the point $x = 0, y = 3\ m$ on the y-axis (see Fig. 22.19). What is the electric force that the first charge exerts on the second? What is the force that the second charge exerts on the first? Express your answers as vectors, with x and y components.

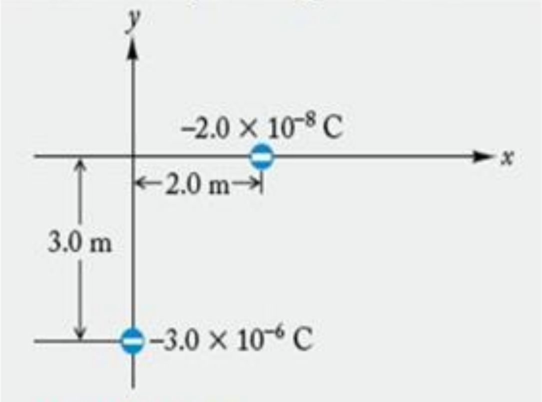


FIGURE 22.19 Two pointlike charges.

Answer:

The force that the first charge exerts on the second charge is:

$$F = \frac{kq_1q_2}{r^2} = \frac{9 \times 10^9 \times 2 \times 10^{-8} \times 3 \times 10^{-6}}{13} = 4.2 \times 10^{-5}\ N$$

$$\mathbf{F} = -2.3 \times 10^{-5}\, i - 3.5 \times 10^{-5}\, j\ N$$

The force that the second charge exerts on the first charge is:

$$\mathbf{F} = 2.3 \times 10^{-5}\, i + 3.5 \times 10^{-5}\, j\ N$$

MCQ:

To make an uncharged object have a negative charge we must:

A. remove some electrons
B. remove some atoms
C. add some electrons
D. add some protons

Ans: C

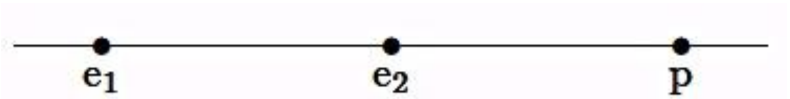
Two small charged objects attract each other with a force F when separated by a distance d. If the charge on each object is reduced to one-fourth of its original value and the distance between them is reduced to d/2 the force becomes:

A. F/4
B. F/16
C. F/8
D. F

Ans: A

Two electrons (e_1 and e_2) and a proton (p) lie on a straight line, as shown. The directions of the force of e_2 on e_1, the force of p on e_1, and the total force on e_1, respectively, are:

A. $\longrightarrow, \longleftarrow, \longrightarrow$
B. $\longleftarrow, \longrightarrow, \longrightarrow$
C. $\longrightarrow, \longleftarrow, \longleftarrow$
D. $\longleftarrow, \longrightarrow, \longleftarrow$
E. $\longleftarrow, \longleftarrow, \longleftarrow$



Ans: D