1 Theory

State Coulomb's Law in words.

SOLUTION

The magnitude of the electric force between two charged bodies is proportional to the product of their charges and inversely proportional to the square of the distance between them.

2 Practice

(a) Beginning at the origin, three point charges of 1 μC each are lined up along the x-axis at equal spacings of 10 cm between them. What is the magnitude and direction of the electric force on the charge at the origin?

(b) A fourth 1-μC charge is placed on the y-axis, 10 cm above the x-axis. Now what is the magnitude and direction of the electric force on the charge at the origin? Express your answer in component form.

(c) For extra credit: what angle does the resultant vector make with the x-axis?

SOLUTION

The charges are set up as depicted in Figure 1. Since all charges are positive, all forces between them will be repulsive. We begin by calculating the magnitude of each force. The force on the charge located at the origin due to its nearest neighbor along the x-axis is

$$F = k\frac{qq'}{r^2} \tag{1}$$

$$= (9 \times 10^9)\frac{(10^{-6})(10^{-6})}{(0.1)^2} \tag{2}$$

$$= 0.9 \text{ N}. \tag{3}$$

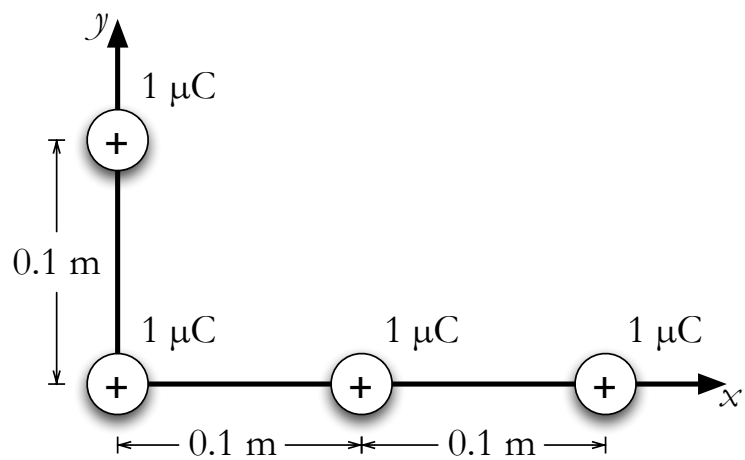

Figure 1: Setup of charges for Question 2

The force due to the more distant charge is

$$F = k\frac{qq'}{r^2} \tag{4}$$

$$= (9 \times 10^9)\frac{(10^{-6})(10^{-6})}{(0.2)^2} \tag{5}$$

$$= 0.225 \text{ N}. \tag{6}$$

Superposition allows us to sum these to arrive at a total force of 1.13 N. Since the force is repulsive, it is directed in the $-x$ direction, or

$$\boxed{F = -1.13 \text{ N } \mathbf{i}}. \tag{7}$$

For part (b), we add to the above result a downward directed force of 0.9 N, and we have

$$\boxed{F = -1.13 \text{ N } \mathbf{i} - 0.9 \text{ N } \mathbf{j}}. \tag{8}$$

Part (c) asks the angle this vector makes with the x-axis. For a force whose x and y

components are of magnitude F_x and F_y respectively, this is given by

$$\begin{aligned}
\theta &= \tan^{-1}\left(\frac{F_y}{F_x}\right) && (9)\\
&= \tan^{-1}\left(\frac{0.9}{1.13}\right) && (10)\\
&= \tan^{-1}(0.8) && (11)\\
&= 0.673 && (12)\\
&\approx 39^\circ, && (13)
\end{aligned}$$

which the resultant vector makes with the $-x$ axis.