Chapter 5 Problem 64 †

Given
$k = 8.99 \times 10^9 \ \frac{Nm^2}{C^2}$
$q_1 = 10 \ \mu m = 1.0 \times 10^{-5} \ C$
$q_2 = -30 \ \mu m = -3.0 \times 10^{-5} \ C$
$\vec{r}_1 = 3.0\hat{\imath} - 4.0\hat{\jmath} \ m$
$\vec{r}_2 = 9.0\hat{\imath} + 6.0\hat{\jmath} \ m$

Solution
Find the force that q_2 exerts on q_1.

The electric force between the two spheres is given by Coulomb's law. The subscript notation is the force on 1 due to 2.

$$\vec{F}_{12} = k\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$$

Now $\vec{r}_{21}$ is a vector that starts at $\vec{r}_2$ and ends at $\vec{r}_1$. To find this vector, just subtract the r_2 from r_1.

$$\vec{r}_{12} = \vec{r}_1 - \vec{r}_2 = (3.0\hat{\imath} - 4.0\hat{\jmath} \ m) - (9.0\hat{\imath} + 6.0\hat{\jmath} \ m) = \{-6.0\hat{\imath} - 10.0\hat{\jmath}\} \ m$$

The magnitude of this vector is

$$r_{12} = \sqrt{(-6.0)^2 + (-10.0)^2} \ m = 11.7 \ m$$

The unit vector is then

$$\hat{r}_{12} = \frac{\vec{r}_{12}}{r_{12}} = \frac{\{-6.0\hat{\imath} - 10.0\hat{\jmath}\} \ m}{11.7 \ m} = -0.513\hat{\imath} - 0.855\hat{\jmath}$$

Substitute these values into Coulomb's law gives

$$\vec{F}_{12} = (8.99 \times 10^9 \ \tfrac{Nm^2}{C^2})\frac{(1.0 \times 10^{-5} \ C)(-3.0 \times 10^{-5} \ C)}{(11.7 \ m)^2}\{-0.513\hat{\imath} - 0.855\hat{\jmath}\}$$

$$\vec{F}_{12} = -1.97 \times 10^{-2} \ N\{-0.513\hat{\imath} - 0.855\hat{\jmath}\}$$

$$\vec{F}_{12} = (1.01\hat{\imath} + 1.68\hat{\jmath}) \times 10^{-2} \ N$$

The magnitude of the force is $1.97 \times 10^{-2} \ N$ and the diretion is

$$\theta = \tan^{-1}\left(\frac{1.68 \times 10^{-2} \ N}{1.01 \times 10^{-2} \ N}\right) = 59.0°$$

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†Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)