**275.**

**Problem 27.11 (RHK)**

*Two identical conducting spheres, having charges of opposite sign, attract each other with a force of* 0.108 N *when separated by* 50.0 cm. *The spheres are suddenly connected by a thin conducting wire, which is then removed, and thereafter spheres repel each other with a force of* 0.0360 N. *We have to find the initial charges on the spheres.*

**Solution:**

Let the initial charges on the two conducting spheres be $q_1$ and $q_2$, respectively. Each conducting sphere will attract the other with a force of magnitude

$$F_i = \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 |q_2|}{0.5^2} \text{ N.}$$

It is given that

$$F_i = 0.108 \text{ N.}$$

$$\therefore \quad \frac{1}{4\pi\varepsilon_0} \times \frac{q_1 |q_2|}{0.5^2} = 0.108,$$

and

$$q_1 |q_2| = \frac{0.108 \times 0.5^2}{8.99 \times 10^9} \text{ C}^2 = 3.0 \times 10^{-12} \text{ C}^2.$$

Let $q_1 > |q_2|$ .

When the conducting spheres are connected by a thin conducting wire, charge will flow from one to the other till the charge on each conducting sphere becomes $(q_1 - |q_2|)/2$.

It is given that when the conducting wire is removed, the two conducting spheres repel each other with a force $F_f = 0.0360$ N.

From the Coulomb's law, we have the equation

$$\frac{1}{4\pi\varepsilon_0} \times \frac{(q_1 - |q_2|)^2}{4 \times 0.5^2} = 0.0360,$$

or

$$(q_1 - |q_2|)^2 = \frac{3.6 \times 10^{-2} \times 4 \times 0.5^2}{8.99 \times 10^9} \text{ C}^2 = 4.0 \times 10^{-12} \text{C}^2.$$

We find

$$q_1 - |q_2| = 2.0 \times 10^{-6} \text{ C}.$$

We have also found that

$q_1|q_2| = 3.0\times10^{-12}\ \text{C}^2.$

Using the identity

$$\left(q_1+|q_2|\right)^2 = \left(q_1-|q_2|\right)^2 + 4q_1|q_2|,$$

We get

$$\left(q_1+|q_2|\right)^2 = \left(4.0\times10^{-12}+12\times10^{-12}\right)\ \text{C}^2,$$

and

$$q_1+|q_2| = 4.0\times10^{-6}\ \text{C}.$$

From the above results, we get

$q_1 = 3.0\ \mu\text{C}$, and $q_2 = -1.0\ \mu\text{C}$.