340.

Problem 30.11 (RHK)

A particle of charge q is kept in a fixed position at a point P and a second particle of mass m, having the same charge q, is initially held at rest a distance r_1 *from P. The second particle is then released and is repelled from the first one. We have to determine its speed at the instant it is a distance* r_2 *from P. Let* $q = 3.1\ \mu\text{C}$, $m = 18\ \text{mg}$, $r_1 = 0.90\ \text{mm}$, *and* $r_2 = 2.5\ \text{mm}$.

Solution:

It is given that a particle of charge q is kept in a fixed position at a point P. A second particle of mass m, having the same charge q, is initially held at rest a distance r_1 from P. In this situation the total energy of the two particle system is

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{q^2}{r_1}.$$

The second particle is then released and is repelled from the first one. When the second particle is at a distance r_2 from P its speed v can be determined from the equation

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{q^2}{r_1} = \frac{1}{2} m v^2 + \frac{1}{4\pi\varepsilon_0} \times \frac{q^2}{r_2},$$

or

$$\frac{1}{2} m v^2 = \frac{1}{4\pi\varepsilon_0} \times q^2 \times \left(\frac{r_2 - r_1}{r_1 r_2} \right).$$

Data of the problem are

$q = 3.1\ \mu\text{C},$

$m = 18\ \text{mg},$

$r_1 = 0.90\ \text{mm}$, and $r_2 = 2.5\ \text{mm}.$

$$v^2 = \frac{2}{4\pi\varepsilon_0 m} \times q^2 \times \left(\frac{r_2 - r_1}{r_1 r_2} \right)$$

$$= \frac{2 \times 8.99 \times 10^9 \times \left(3.1 \times 10^{-6}\right)^2}{18 \times 10^{-6}} \times \left(\frac{2.5 - 0.9}{2.5 \times 0.9 \times 10^{-3}} \right) \left(\text{m s}^{-1}\right)^2$$

$$= 6.826 \times 10^6 \left(\text{m s}^{-1}\right)^2.$$

And

$v = 2.61\ \text{km s}^{-1}.$