271.

Problem 22.5 E (HRW)

Two equally charged particles, held 3.2×10^{-3} m *apart, are released from rest. The initial acceleration of the first particle is observed to be* $7.0\ \text{m s}^{-2}$ *and that of the second to be* $9.0\ \text{m s}^{-2}$. *The mass of the first particle is* 6.3×10^{-7} kg. *We have to find* (a) *the mass of the second particle and* (b) *the magnitude of the charge of each particle.*

Solution:

Let the charge on each particle be q C. Separation between the two charged particles is 3.2×10^{-3} m. According to Coulomb's law the force on each charged particle due to the other will be

$$F=\frac{1}{4\pi\varepsilon_0}\times\frac{q^2}{\left(3.2\times10^{-3}\right)^2}\ \text{N}.$$

We recall

$$\frac{1}{4\pi\varepsilon_0} = 8.99\times10^{9}\ \text{N m}^2\ \text{C}^{-2},$$

and

$$\varepsilon_0 = 8.85\times10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}.$$

Therefore,

$$F = \frac{8.99\times10^{9}\times q^2}{(3.2)^2\times10^{-6}}\ \text{N} = 0.8779\times10^{15}q^2\ \text{N}.$$

The initial acceleration of the first particle is $7.0\ \text{m s}^{-2}$ and its mass is 6.3×10^{-7} kg. From Newton's second law

$$F = ma = 7.0\times6.3\times10^{-7}\ \text{N}.$$

We therefore have the equation

$$F = 0.8779\times10^{15}q^2\ \text{N} = 7.0\times6.3\times10^{-7}\ \text{N},$$

or

$$q = \left(\frac{7.0\times6.3\times10^{-7}}{0.8779\times10^{15}}\right)^{1/2}\ \text{C} = 7.08\times10^{-11}\text{C}.$$

(b)

The initial acceleration of the second particle is $9.0\ \text{m s}^{-2}$. Its mass m_2 can be found by applying the Newton's third law of motion

$m_2 a_2 = m_1 a_1 = 6.3 \times 10^{-7} \times 7.0$ N.

$\therefore\ \mathrm{m}_2 = \dfrac{6.3 \times 10^{-7} \times 7.0}{9.0}$ kg $= 4.9 \times 10^{-7}$ kg.