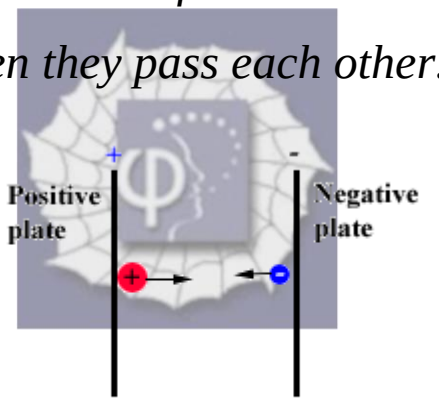
304.

Problem 28.42 (RHK)

Two large copper plates are 5.00 cm *apart and have a uniform electric field between them as shown in the figure. An electron is released from the negative plate at the same time that a proton is released from the positive plate. Neglecting the force of the particles on each other we have to find their distance from the positive plate when they pass each other.*



Solution:

We will use the following data:

Mass of proton, $m_P = 1.67 \times 10^{-27}$ kg,

Mass of electron, $m_e = 9.11 \times 10^{-31}$ kg.

Magnitudes of charge of a proton and that of an electron are equal, $|e| = 1.6 \times 10^{-19}$ C.

Let the distance from the positive plate when the electron and the proton cross each other be *x* cm. Let *t* be the lapse of time between when they when they cross each other and when they left the plates. Let *E* be the electric field between the plates. Accelerations of the proton and the electron will be given by the relations

$$a_P = \frac{|e|E}{m_P} ,$$

$$a_e = \frac{|e|E}{m_e} .$$

As the proton and the electron move with constant accelerations, we can write the following two equations from the kinematics:

$$x = \frac{1}{2} \times \frac{|e|Et^2}{m_P} ,$$

And

$$(5 - x) = \frac{1}{2} \times \frac{|e|Et^2}{m_e} .$$

Therefore, we have the equation

$$\frac{5-x}{x} = \frac{m_P}{m_e} = \frac{1.67 \times 10^{-27}}{9.11 \times 10^{-31}} = 1833.$$

Solving this linear equation, we get

$$x = \frac{5}{1834}\ \text{cm} = 2.73 \times 10^{-3}\ \text{cm} = 27.3\ \mu\text{m}.$$