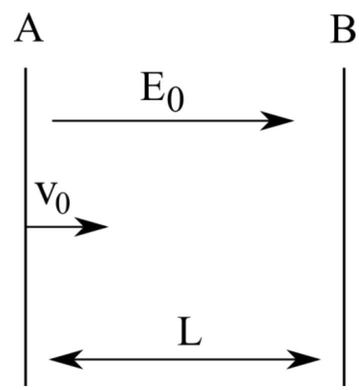
Answer on Question 68385, Physics, Atomic and Nuclear Physics

Question:

A pair of charged conducting plates produces a uniform field of $E_0 = 10859\ N/C$ directed to the right, between the plates. The separation of the plates is $L = 37\ mm$. In Figure, an electron ($e = -1.6 \cdot 10^{-19}\ C$; $m_e = 9.1 \cdot 10^{-31}\ kg$) is projected from the plate A, directly toward the plate B, with an initial velocity of $v_0 = 2.1 \cdot 10^7\ m/s$. The velocity of the electron (expressed in general form as a whole number) as it strikes plate B is what?

Solution:



We can find the velocity of the electron as it strikes the plate B from the work-kinetic energy theorem (the work done by the electric field against the electron is equal to the change in the kinetic energy):

$$W = KE_{final} - KE_{initial},$$

$$F_e L = \frac{1}{2} m_e v^2 - \frac{1}{2} m_e v_0^2,$$

here, $F_e = eE_0$ is the electric force acting on the electron, v_0 is the initial velocity of the electron, v is the velocity of the electron as it strikes plate B, e is the charge of the electron, m_e is the mass of the electron, E_0 is the magnitude of the uniform electric field, L is the separation of the plates.

Then, we can write:

$$eE_0 L = \frac{1}{2} m_e v^2 - \frac{1}{2} m_e v_0^2,$$

$$2eE_0 L = m_e v^2 - m_e v_0^2,$$

$$v^2 = v_0^2 + \frac{2eE_0L}{m_e},$$

$$v = \sqrt{v_0^2 + \frac{2eE_0L}{m_e}} = \sqrt{\left(2.1 \cdot 10^7\ \frac{m}{s}\right)^2 + \frac{2 \cdot (-1.6 \cdot 10^{-19}\ C) \cdot 10859\ \frac{N}{C} \cdot 0.037\ m}{9.1 \cdot 10^{-31}\ kg}}$$
$$= 1.73 \cdot 10^7\ \frac{m}{s}.$$

Answer:

$$v = 1.73 \cdot 10^7\ \frac{m}{s}.$$