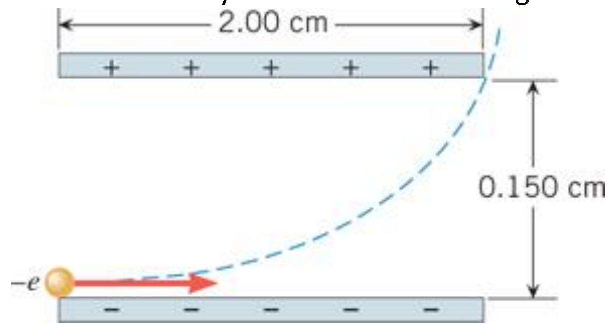
24. The drawing shows an electron entering the lower left side of a parallel plate capacitor and exiting at the upper right side. The initial speed of the electron is 7.00 x 10^6 m/s. The capacitor is 2.00 cm long, and its plates are separated by 0.150 cm. Assume that the electric field between the plates is uniform everywhere and find its magnitude.



The electric field provides the force which creates an acceleration in the y direction. The acceleration in the y direction can act only for the time it takes the electron to travel 2.00 cm in the x direction.

$$E = \frac{F}{q} = \frac{m_e a}{e}$$

$$y = v_{0y}t + \frac{1}{2}at^2 = \frac{1}{2}at^2$$

Solve for a

$$a = \frac{2y}{t^2}$$

Time comes from x motion

$$x = v_{0x}t + \frac{1}{2}a_x t^2 = v_{0x}t$$

So t is

$$t = \frac{x}{v_{0x}}$$

So E is

$$E = \frac{m_e a}{e} = \frac{m_e}{e}\frac{2y}{t^2} = \frac{m_e}{e}2y\frac{1}{t^2} = \frac{m_e}{e}2y\frac{1}{\left(\frac{x}{v_{0x}}\right)^2} = \frac{m_e}{e}2y\left(\frac{v_{0x}}{x}\right)^2$$

$$E = \frac{m_e}{e}2y\left(\frac{v_{0x}}{x}\right)^2$$

$$E = \left(\frac{9.11 \, x \, 10^{-31} kg}{1.6 \, x \, 10^{-19} C}\right) 2(0.15 \, x \, 10^{-2} m)\left(\frac{7.00 \, x \, 10^6 \, m/s}{2.00 \, x \, 10^{-2} m}\right)^2$$

$$E = \left(5.694\ x\ 10^{-12}\ {}^{kg}/_{C}\right)(0.30\ x\ 10^{-2} m)\left(3.500\ x\ 10^{8}\ {}^{1}/_{s}\right)^2$$

$$E = \left(1.708\ x\ 10^{-14}\ {}^{kg\ m}/_{C}\right)\left(1.225\ x\ 10^{17}\ {}^{1}/_{s^2}\right) = 2.092\ x\ 10^{3}\ {}^{N}/_{C}$$

$$\boxed{E = 2.09\ x\ 10^{3}\ {}^{N}/_{C} = 2090\ {}^{N}/_{C}}$$

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Please send any comments or questions about this page to ddonovan@nmu.edu

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