

Answer on Question #40917, Physics, Electromagnetism

In an oscilloscope, an electron is accelerated from rest through a voltage of 1.14×10^3 V it then passes through deflecting plates 2.00 cm apart, across which there is a voltage of 412 V. Its velocity when it enters the plate is perpendicular to the electric field of the plates. When the electron leaves the plates, what distance will it have moved toward the positive plate?

The length of the plates is 4.00 cm.

Solution

$v_0 = 0$ - initial velocity of an electron, v its velocity when it enters the plate, $V_a = 1.14 \cdot 10^3$ V - accelerating voltage, $V_d = 412$ V - deflecting voltage, $l = 4.00$ cm = $4.00 \cdot 10^{-2}$ m length of the plates, $d = 2$ cm = 0.02 m - distance between the plates, t - time that the electron travel between the plates.

$e = 1.6 \cdot 10^{-19}$ C - charge of an electron, $m = 9.11 \cdot 10^{-31}$ kg - mass of an electron.

The kinetic energy of an electron after accelerating voltage:

$$K = \frac{mv^2}{2} = eV_a \rightarrow v = \sqrt{\frac{2eV_a}{m}}.$$

The time that the electron travel between the plates:

$$t = \frac{l}{v}.$$

The electric field accelerates the electron toward the positive plate:

$$E = \frac{V_d}{d}.$$

The force acting on electron when it travel between the plates:

$$F = eE = e \frac{V_d}{d}.$$

An acceleration of an electron:

$$a = \frac{F}{m} = \frac{eV_d}{md}.$$

The distance that an electron have moved toward the positive plate:

$$x = \frac{at^2}{2} = \frac{1}{2} \frac{eV_d}{md} \left(\frac{l}{v}\right)^2 = \frac{1}{2} \frac{eV_d l^2}{md} \cdot \frac{m}{2eV_a} = \frac{1}{4} \frac{V_d l^2}{V_a d} = \frac{1}{4} \frac{412 \cdot 0.04^2}{1.14 \cdot 10^3 \cdot 0.02} = 7.23 \cdot 10^{-3} \text{ m}.$$

Answer: $7.23 \cdot 10^{-3}$ m.