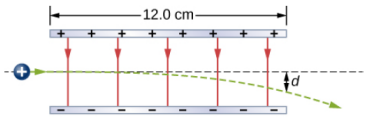
Chapter 5 Problem 94 [†]



Given

$E = 4.0 \times 10^5\ N/C$
$\vec{v}_0 = 1.5 \times 10^7 \hat{i}\ m/s$
$\Delta x = 12.0\ cm = 0.120\ m$
$q_p = 1.60 \times 10^{-19}\ C$
$m_p = 1.67 \times 10^{-27}\ kg$

Solution

What distance is the proton deflected downward?

The electric force is in the negative y-directon.

$$F = qE$$

The acceleration of the proton is then

$$a_p = \frac{F_p}{m_p} = \frac{qE}{m_p} = \frac{(1.60 \times 10^{-19}\ C)(4.0 \times 10^5\ N/C)}{1.67 \times 10^{-27}\ kg}$$

$$a_p = 3.83 \times 10^{13}\ m/s^2$$

The proton is moving in the x-direction at a constant speed, so the time in the chamber is

$$\Delta x = v_0 t$$

$$t = \frac{\Delta x}{v_0} = \frac{0.120\ m}{1.5 \times 10^7\ m/s} = 8.0 \times 10^{-9}\ s$$

With no initial velocity in the y-direction, the displacement by the time it leaves the chamber is

$$y = \tfrac{1}{2} a t^2 = \tfrac{1}{2}(3.83 \times 10^{13}\ m/s^2)(8.0 \times 10^{-9}\ s)^2$$

$$y = 1.23 \times 10^{-3}\ m = 1.23\ mm$$

[†]Problem from Univesity Physics by Ling, Sanny and Moebs (OpenStax)