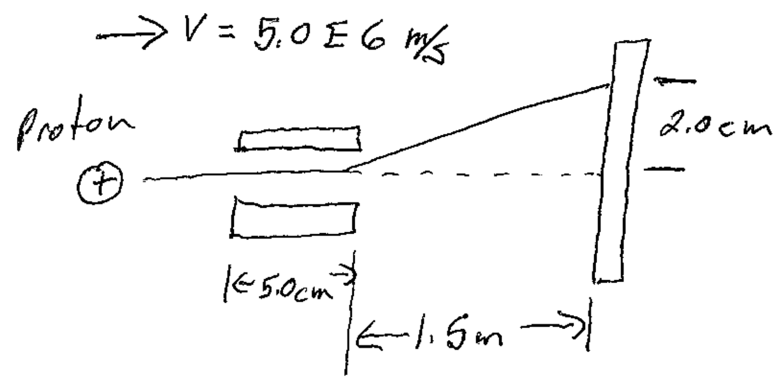
You are to design a machine to direct protons at a targeted area of the body for cancer treatment. Suppose one possibility is shown below. Determine the acceleration required between the plates to provide a 2.0 cm deflection as indicated

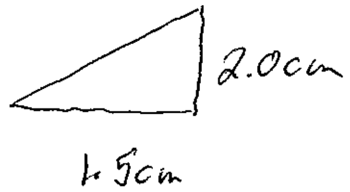


Solution

To solve note that before entering the 5.0 cm directing region the proton does not have a y-velocity.

1) Determine final y-velocity component
2) Find the time it takes to move through the 5.0 cm directing region.
3) Solve for average acceleration in directing region.

After directing Region



$V_x = 5.0\,E6\,m/s$ $\qquad V_y = ?$

$x_0 = 0$ $\qquad y_0 = 0$

$x = 1.5\,E\text{-}2\,m$ $\qquad y = 2.0\,cm$

$\Delta t = ?$ ⟶ Δt

x-part

$x = x_0 + V\Delta t$

$$\Delta t = \frac{x - x_0}{V} = \frac{1.5\,E\text{-}2\,m}{5.0\,E6\,m/s} = 3.0\,E\text{-}9\,s$$

y-part

$y = y_0 + V\Delta t$

$$V = \frac{y - y_0}{\Delta t} = \frac{2.0\,E\text{-}2\,m}{3.0\,E\text{-}9\,s} = 6.67\,E6\,m/s$$

within directing region

x - parts

$V = 5.0E6\,m/s$

$x = 5.0E{-2}\,m$

$x_0 = 0$

$\Delta t = ?$ ⟶ Δt

y - parts

$V_0 = 0$

$V = 6.67E6\,m/s$

$a = ?$

x-part

$$x = x_0 + v\Delta t$$

$$\Delta t = \frac{x - x_0}{v} = \frac{5.0E{-2}\,m}{5.0\,E6\,m/s} = 1.0\,E{-8}\,s$$

y-part

$$v = v_0 + a\Delta t$$

$$a = \frac{v - v_0}{\Delta t} = \frac{6.67\,E6\,m/s}{1.0E8\,s}$$

$$= 6.67\,E14\,m/s$$

$$\boxed{6.7E14\,m/s}$$