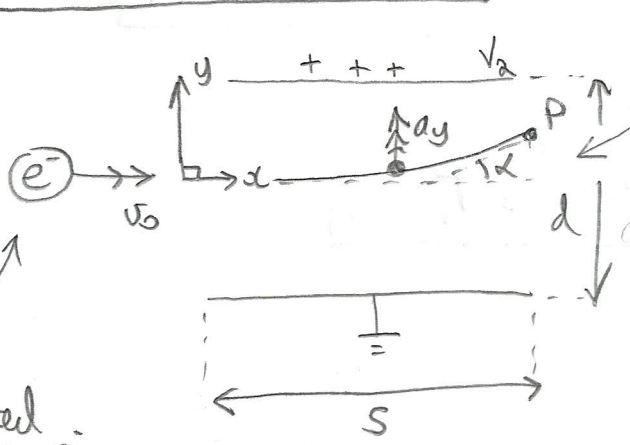


Q2



$$\tan \alpha = \frac{v_y}{v_x} \Big|_P$$



electron accelerated from rest via potential  $V_1$

a) Assume classical physics ( $v_0 \ll c$ )

$$\frac{1}{2} m_e v_0^2 = eV_1$$

kinetic energy gain of electron

work done by horizontal field

mass of electron  
 $m_e = 9.109 \times 10^{-31} \text{ kg}$

charge of electron  
 $e = 1.60 \times 10^{-19} \text{ C}$

$$v_0 = \sqrt{\frac{2eV_1}{m_e}} \quad (i)$$

b) Constant acceleration motion between horizontal plates

Newton II: // x: No acceleration  $\therefore v_x = v_0$

$$// y: m_e a_y = \frac{V_1}{d} e$$

$$\text{if } F_y = eE_y$$

$$E_y = V_1/d$$

$$\therefore a_y = \frac{V_1 e}{m_e d}$$

$\therefore$  Now if  $t$  is the time between the plates

$$v_y = a_y t = \frac{V_1 e}{m_e d} t$$

$$s = v_0 t \quad \therefore t = \frac{s}{v_0}$$

$$\therefore v_y = \frac{V_1 e}{m_e d} \frac{s}{v_0} = \frac{eV_1 s}{m_e v_0 d}$$

$$\therefore \tan \alpha = \frac{v_y}{v_x} = \frac{eV_1 s}{s m_e v_0^2}$$

$$\text{Now } m_e v_0^2 = 2eV_1$$

$$\therefore \tan \alpha = \frac{eV_2}{2eV_1} \frac{s}{d}$$

$$\therefore \boxed{\tan \alpha = \frac{1}{2} \frac{V_2 s}{V_1 d}}$$

$$\therefore \boxed{\alpha = \tan^{-1} \left( \frac{1}{2} \frac{V_2 s}{V_1 d} \right)}$$

(iii)

$$y_e = \frac{1}{2} a_y t^2$$

$$y_e = \frac{1}{2} \frac{\frac{1}{2} e}{m_e d} \left( \frac{s}{v_0} \right)^2 = \frac{1}{2} \frac{V_2 e s^2}{d m_e v_0^2} \leftarrow \text{MS steps here!}$$

Now  $m_e v_0^2 = 2eV_1$

So  $y_e = \frac{V_2 e s^2}{4d e V_1}$

$$\therefore \boxed{y_e = \frac{1}{4} \left( \frac{V_2}{V_1} \right) \left( \frac{s}{d} \right) s}$$

b)  $t = \frac{s}{v_0} \quad v_0 = \sqrt{\frac{2eV_1}{m_e}}$

So  $t = \sqrt{\frac{m_e}{2eV_1}} \times s$

$$\therefore t = \sqrt{\frac{9.109 \times 10^{-31}}{2 \times 1.60 \times 10^{-19} \times 2 \times 10^3}} \times 4 \times 10^{-2}$$

$$\boxed{t = 1.51 \times 10^{-9} \text{ s}}$$

c)

on exiting the horizontal plates, the electron has velocity

$$\begin{pmatrix} v_x \\ v_y \\ 0 \end{pmatrix}$$

$$\boxed{v_x = \sqrt{\frac{2eV_1}{m_e}}}$$

$$v_y = \frac{eV_2}{m_e v_0} \frac{s}{d} \leftarrow \text{from above}$$

$$\therefore \boxed{v_y = \frac{eV_2}{m_e v_0} \frac{s}{d} \sqrt{\frac{m_e}{2eV_1}}}$$

(2)

