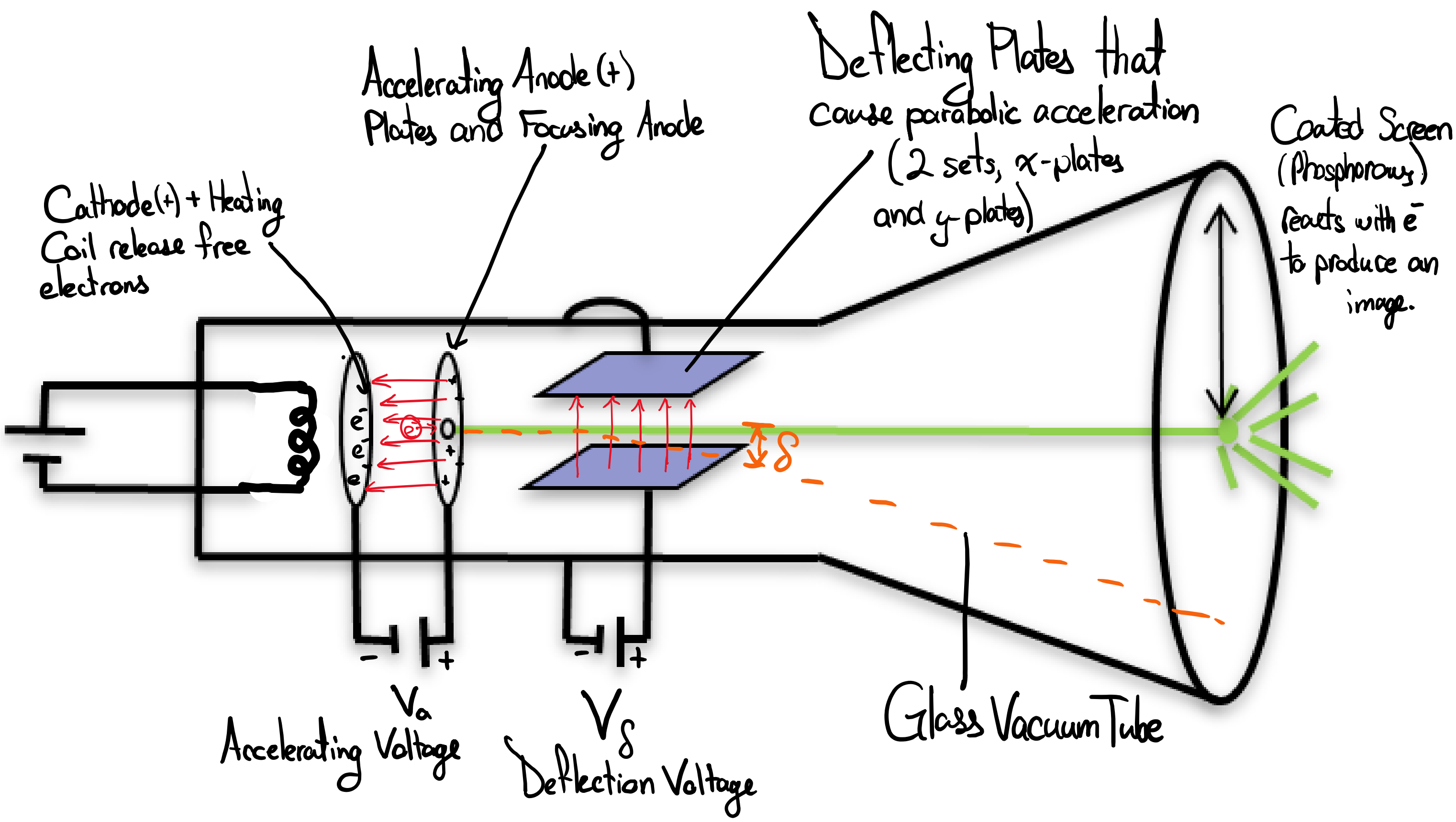
Lesson 6.5 – Cathode Ray Tubes

Unit 6: Electrostatics

The Cathode Ray Tube (CRTs):

Below, make a list of everything you can think of that uses cathode ray tubes. We will use your ideas as discussion points:

https://youtu.be/rjDX5ItsOnQ?si=G3GMj4JXR8343lHd
https://www.thephysicsaviary.com/Physics/Programs/Labs/ThompsonetomLab/



*δ (delta) is the distance of deflection of e^- between the plates

*Vary V_a & V_δ to change deflection

$$\delta \propto V_\delta$$

$$\delta \propto \frac{1}{V_a}$$

$$\therefore \delta = \frac{cV_\delta}{V_a}$$

where c is a constant specific to a specific CRT (length, material, etc.)

Tip for solving these problems:

- Separate the equation into unchanged (constant) and changed conditions.
- Set the initial changing conditions = the final changed conditions

Example 1: An electron deflects 3 mm with V_a = 620 V. What is the deflection if V_a = 830V and V_δ is unchanged?

$$\delta = \frac{cV_\delta}{V_a}$$

$$\underbrace{\delta V_a}_{\text{changing}} = \underbrace{cV_\delta}_{\text{constant}}$$

$$\delta_1 V_{a1} = \delta_2 V_{a2}$$

↑ Constant. So put w/ c on one side of eq.

$$\delta_2 = \frac{\delta_1 V_{a1}}{V_{a2}}$$

$$\delta_2 = \frac{(3mm)(620V)}{(830V)}$$

$$\boxed{\delta_2 = 2.24mm}$$

Example 2: An electron deflects 8 mm with V_δ = 10 V. What is V_δ for a 5 mm deflection if V_a is constant?

$$\delta = \frac{cV_\delta}{V_a}$$

$$\frac{\delta}{V_\delta} = \frac{c}{V_a}$$ Constant

$$\frac{\delta_1}{V_{\delta 1}} = \frac{\delta_2}{V_{\delta 2}}$$

$$\frac{8}{10} = \frac{5}{V_{\delta 2}}$$

$$\boxed{V_{\delta 2} = 6.25V}$$

Example 3: When V_a = 340 V and V_δ = 20 V the deflection is 7.2 mm. Find the deflection when V_a = 220 V and V_δ = 15 V.

$$\delta = \frac{cV_\delta}{V_a}$$

$$c = \frac{\delta V_a}{V_\delta}$$

$$\frac{\delta_1 V_{a1}}{V_{\delta 1}} = \frac{\delta_2 V_{a2}}{V_{\delta 2}}$$

$$\frac{(7.2)(340)}{20} = \frac{\delta_2 (220V)}{15}$$

$$\boxed{\delta_2 = 8.35mm}$$

Example 4: An electron travelling at 3.5 x 10^6 m/s enters two deflecting plates which are 3.0 mm apart and have 15 V of potential difference between them.

a) Find the net force on the electron.

$* E = \frac{\Delta V}{d}$

$$\vec{F}_e = QE = \frac{Q\Delta V}{d}$$

$$\vec{F}_e = \frac{(1.6\times10^{-19})(15)}{(0.003)}$$

$$\vec{F}_e = 8.0\times10^{-16}\,N$$

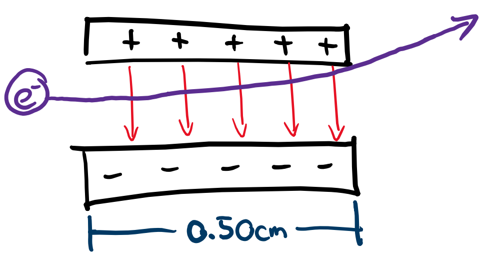
b) Find the acceleration of the electron.

$$\vec{F}_e = m\vec{a}$$

$$\vec{a} = \frac{\vec{F}_e}{m} = \frac{(8.0\times10^{-16})}{(9.11\times10^{-31})}$$

$$= 8.78\times10^{14}\ m/s$$

c) If the plates are 0.50 cm long, find the deflection amount of the electron.



$*$ Kinematics in 2D

x-direction (find time)

$$\vec{V}_x = \frac{d_x}{t}$$

$$t = \frac{d_x}{V_x}$$

$$t = \frac{0.0050\,m}{3.5\times10^6\,m/s}$$

$$\boxed{t = 1.43\times10^{-9}\,s}$$

y-find δ (d_y)

$$\delta = \cancel{V_{oy}t}^{\,0} + \frac{1}{2}\vec{a}_y t^2$$

$$\delta = \frac{1}{2}(8.78\times10^{14})(1.43\times10^{-9})^2$$

$$\delta = 8.96\times10^{-4}\,m$$

$$\boxed{\delta = 0.896\,mm}$$