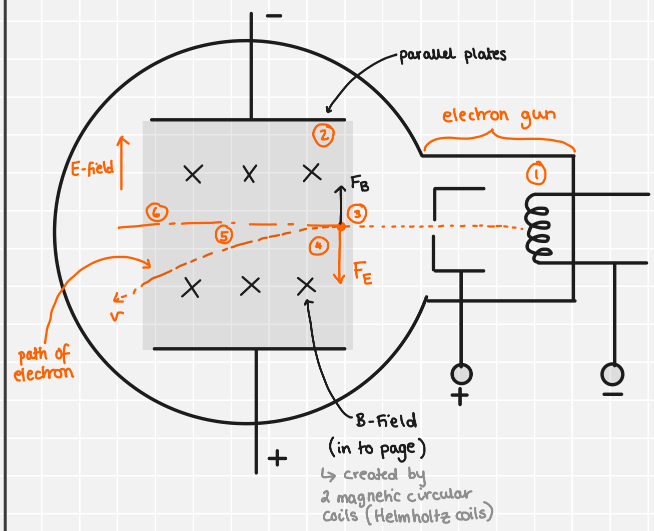
THE SPECIFIC CHARGE OF THE ELECTRON

Method 1: Crossed Fields



1. Electron gun used to create a beam of electrons
2. Beam enters a region with a zinc sulfide coated mica screen: makes beam visible.
3. mica screen is in an area containing:
   - E-field due to plates
   - B-field due Helmholtz coils
4. electrons in beam then experience two forces:
   1. $F_E = e \times E$ — E-field strength
   2. $F_B = BeV$

5. electron follows a parabolic path due to a downwards acceleration caused by F_E
6. it is possible to straighten the path of the e^- beam by altering E and B such that:

$$F_E = F_B$$

Determining $\frac{e}{m}$

- set your system up such that there is no beam deflection:

$$\cancel{e}E = B\cancel{e}v$$

$$v = \frac{E}{B} \quad (A)$$

From our knowledge of the electron gun we know that:

$$eV = \frac{1}{2}mv^2$$

$$\frac{e}{m} = \frac{v^2}{2V} \quad (B)$$

By substituting (A) into (B):

$$\frac{e}{m} = \frac{\left(\frac{E}{B}\right)^2}{2V}$$

$$\boxed{\frac{e}{m} = \frac{E^2}{2VB^2}}$$

specific charge on electron [Ckg^{-1}]

electric field strength [Vm^{-1}]

magnetic field strength [T]

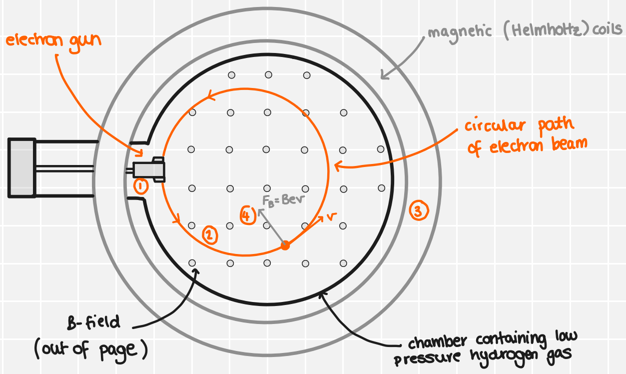
accelerating p.d. of electron gun [V]

Thomson's Conclusions (1897)

1. electrons are indeed particles with mass, charge and momentum
2. specific charge of an electron is $1.7 \times 10^{11} Ckg^{-1}$ (1800 higher than Hydrogen ion)
3. cathode rays are in fact made out of fundamental particles.

THE SPECIFIC CHARGE OF THE ELECTRON

Method 2: Fine Beam Tube (modern method)



1. Electron gun produces a beam of e^-
2. as the e^- pass through the H-gas the collide with the H-atoms causing excitation. H-atoms proceed to quickly de-excite releasing visible photons (allowing e^- path to be observed)
3. Helmholtz coils create a strong magnetic field in bulb
4. B-field creates a force on electrons ($= Bev$) that is always perpendicular to motion (due to LHR)
   → acts as a centripetal force so we can say:

$$\frac{mv^2}{r} = Bev$$

radius of circular path

Determining Specific charge

Starting from our centripetal force equation:

$$\frac{mv^2}{r} = Bev$$

divide through by v

$$\frac{mv}{r} = Be$$

square result:

$$\frac{m^2v^2}{r^2} = B^2e^2$$

sub in $\frac{1}{2}mv^2 = eV$:

$$\frac{m(2\cancel{e}V)}{r^2} = B^2e^{\cancel{2}}$$

rearrange:

$$\boxed{\frac{e}{m} = \frac{2V}{r^2B^2}}$$

accelerating p.d of electron gun [V]

magnetic field strength [T]

radius of circular path [m]