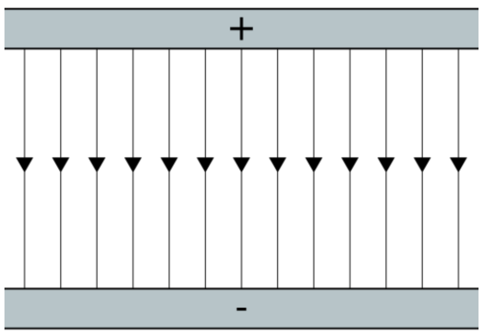
Lesson 6.4- Electric Fields and Parallel Plates

Unit 6: Electrostatics

Uniform Electric Fields and Voltage Between Plates:

A uniform electric field exists between oppositely charged plates.



Work is required to move a positive charge from the negative plate to the positive plate.

The potential difference (voltage) between the plates is the work per unit charge.

$$V = \frac{W}{Q} = \frac{\Delta Ep}{Q}$$

FOR PROOF OF UNIFORM FIELDS BETWEEN PARALLEL PLATES, SEE PG. 195.

For Parallel Plates:

$$\Delta V = \frac{W}{Q}$$

$$\Delta V = \frac{Fd}{Q}$$

$$\Delta V = \frac{QEd}{Q}$$

$$\Delta V = Ed$$

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

Recall Potential difference is dimensionally "Energy per unit charge" (J/C)

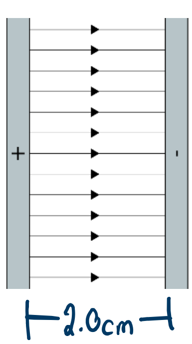
We use Volts (V) for this

If $E = \frac{\Delta V}{d}$ has units (V/m) we can relate:

$$1\,\frac{V}{m} = 1\,\frac{J/C}{m} = 1\,\frac{N\cancel{m}}{\cancel{m}C} = 1\,N/C$$

$$* \;\frac{V}{m} = \frac{N}{C}$$

Example 1: Find the voltage between parallel plates 2.0 cm apart with a 2.0 N/C field between them.



$\Delta V = ?$

$d = 0.02m$

$E = 2.0 N/C$

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

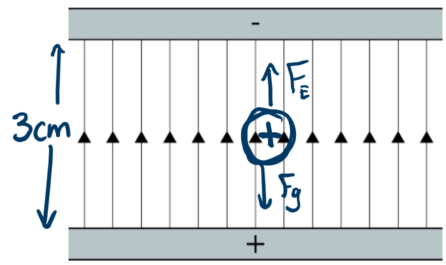
$\Delta V = Ed$

$= (2.0 N/C)(0.02m)$

$\boxed{= 0.040V}$

balanced forces.

Example 2: A pith ball of charge +2.3 μC is suspended between two charged horizontal plates 3.0 cm apart with a potential difference of 6.0 V. Find the mass of the ball.



FBD:

$\Delta V = 6.0V$
$d = 0.03m$
$Q = 2.3 \times 10^{-6} C$

$\sum \vec{F_y} = 0$

$F_g = F_e$

$mg = QE \leftarrow * \; E = \frac{\vec{F_e}}{Q} \therefore \vec{F_e} = QE$

$mg = Q\frac{\Delta V}{d} \leftarrow * \; E = \frac{\Delta V}{d}$

$m = \frac{Q\Delta V}{gd} = \frac{(2.3\times10^{-6})(6)}{(9.8)(0.03)}$

$\boxed{= 4.69 \times 10^{-5} kg}$

Example 3 – Considering Work with Kinetic Energy: An electron is accelerated from rest between two charged parallel plates with voltage 220 V. Find the final speed of the electron.

*A change in energy means work done.

$V_o = 0$
$V = ?$
$\Delta V = 220V$
$Q_{e^-} = -1.6 \times 10^{-19} C$
$m_{e^-} = 9.11 \times 10^{-31} kg$

$W = \Delta E_k$

*Recall $\Delta V = \frac{W}{Q} \Rightarrow W = \Delta VQ$

$\Delta VQ = E_k - \cancel{E_{ko}}^{\,0}$

$\Delta VQ = \frac{1}{2}mv^2$

$\vec{V} = \sqrt{\frac{2\Delta VQ}{m}}$

$\vec{V} = \sqrt{\frac{2(220)(-1.6\times10^{-19})}{(9.11\times10^{-31})}}$

$\boxed{\vec{V} = 8.79 \times 10^6 \, m/s}$