

# L07 - Parallel Plates

## Electricity and Magnetism

$$|\vec{F}_e| = \frac{kq_1q_2}{r^2} \text{ Point Charge}$$

$$\Delta V = \frac{\Delta E}{q} \leftarrow \text{Scalar Energy "Ep"}$$

$$|\vec{E}| = \frac{kq}{r^2} \text{ Point Charge}$$

$$I = \frac{q}{t}$$

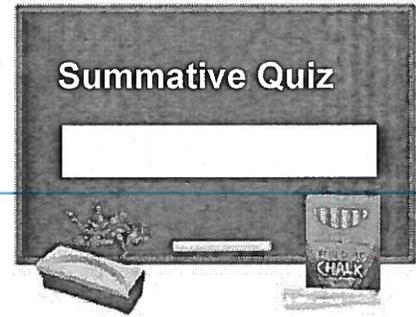
$$\vec{E} = \frac{\vec{F}_e}{q}$$

$$|\vec{F}_m| = \mu_{\perp} |\vec{B}|$$

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

Vector Electric Field

$$|\vec{F}_m| = qv_{\perp} |\vec{B}|$$



$\Delta V =$  Potential Difference "Voltage" (Volts)

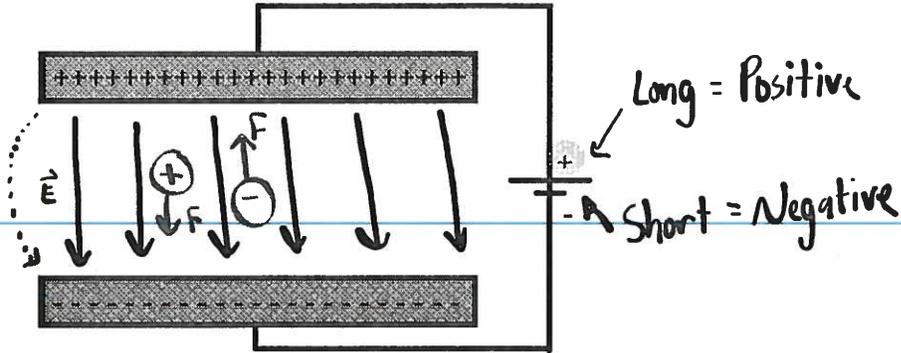
$q =$  charge

$\Delta d =$  Plate separation distance

## Electric Fields in Parallel Plates

On the diagram of the parallel plates, draw the arrows for the electric field lines.

How would you describe the electric field between parallel plates? *Uniform* → *Same strength everywhere.*



If an electron were placed in the electric field, what direction would it go? *Up.*

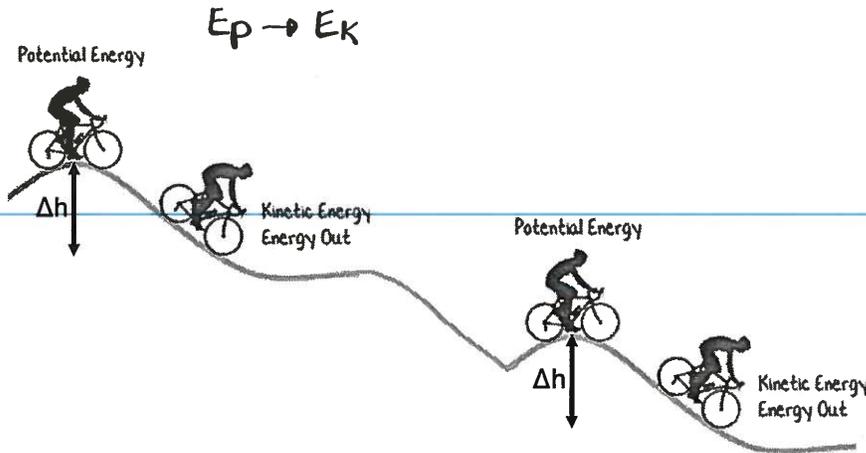
Remember that  $a = F/m$ .

# Electric Potential (Voltage)

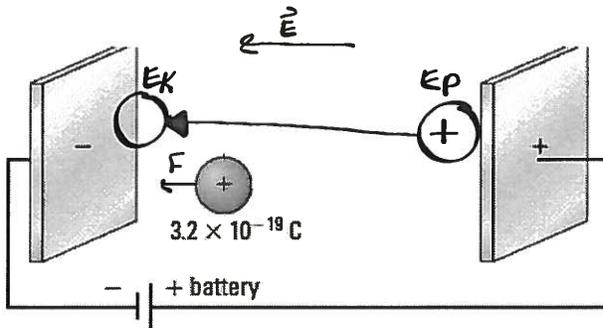
## Gravitational Potential Energy

$$\Delta E_p = mg\Delta h$$

What happens to the  $\Delta E_p$ ?



## Electric Potential Energy



$$\Delta V = \frac{\Delta E_p}{q} \Rightarrow \boxed{E_p = q\Delta V}$$

$$\Downarrow$$

$$\boxed{E_k = \frac{1}{2}mv^2}$$

Where would the particle have the most energy? *Most  $E_p$  at positive plate.  
Most  $E_k$  at negative ( $E_p \rightarrow E_k$ )*

Where would it have the least energy? *Same  $E_m$  everywhere!*

# Definitions and Equations

$$|\vec{E}| \neq E_p \quad \Delta V \neq v$$

Electric Potential Energy -

Energy stored in a system of two charges a certain distance apart; change in electric potential energy equals work done to move a small charge ( $\Delta E_p = W$ )

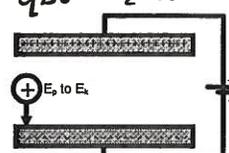
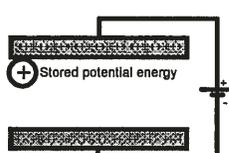
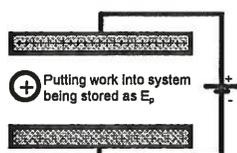
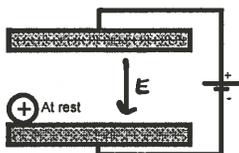
$$W = Fd$$

$$W = \Delta E$$

$$E_p = q\Delta V$$

$$E_p \rightarrow E_k$$

$$q\Delta V \rightarrow \frac{1}{2}mv^2$$



Electric Potential -

Electric potential energy stored per unit charge at a given point in an electric field.

$$V = \frac{E_p}{q}$$

Electric Potential Difference -

Change in electric potential experienced by a charge moving between two points in an electric field.

$$\Delta V = \frac{\Delta E_p}{q}$$

## Alternate Units for Electric Field

$$|\vec{E}| = \frac{|\vec{F}|}{q}$$

Times by  $\frac{\Delta d}{\Delta d}$

$$|\vec{E}| = \frac{|\vec{F}| \Delta d}{q \Delta d}$$

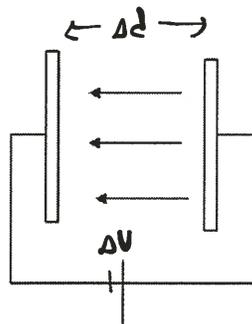
Remember that  $W = F \cdot d$  and  $W = \Delta E$

$$|\vec{E}| = \frac{\Delta E}{qd}$$

And we defined  $\Delta V = \frac{\Delta E}{q}$

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

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



$$|\vec{E}| = \frac{\Delta V}{\Delta d}, \text{ Units (N/C) or (V/m)}$$

## Alternate Units for Energy - Electron Volts

Often energy is in the magnitude of  $\times 10^{-19}$  J, so physicists often convert the units to electron volts from Joules. The conversion is  $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$ .

Coulomb's Law Constant ..  $k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$

~~Electron Volt .....  $1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$~~

Index of Refraction of Air.  $n = 1.00$

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Q1: A small charge of  $3.2 \times 10^{-19} \text{ C}$  is moved between two parallel plates from a position of  $2.0 \times 10^3 \text{ V}$  to  $4.0 \times 10^3 \text{ V}$ .

- a) What is the potential difference between the two positions?  $\Delta V = 2.0 \times 10^3 \text{ V}$   
 b) What the electric potential energy gained in J and eV?

Electricity and Magnetism

$$|\vec{F}_e| = \frac{kq_1q_2}{r^2} \quad \Delta V = \frac{\Delta E}{q}$$

$$|E| = \frac{kq}{r^2} \quad I = \frac{q}{t}$$

$$E = \frac{\vec{F}_e}{q} \quad |\vec{F}_m| = I|\vec{B}|$$

$$|E| = \frac{\Delta V}{\Delta d} \quad |\vec{F}_m| = qv|\vec{B}|$$

(B-1)  $\Delta V = \frac{\Delta E_p}{q}$

$$2.0 \times 10^3 \text{ V} = \frac{\Delta E_p}{3.2 \times 10^{-19} \text{ C}}$$

$$\Delta E_p = 6.4 \times 10^{-16} \text{ J}$$

$$\frac{6.4 \times 10^{-16} \text{ J}}{1} \times \frac{1 \text{ eV}}{1.60 \times 10^{-19} \text{ J}} = 4000 \text{ eV}$$

(B-2)  $3.2 \times 10^{-19} \text{ C} = 2e$

$$\begin{aligned} \Delta E_p &= q\Delta V \\ &= (2e)(2000 \text{ V}) \\ &= 4000 \text{ eV} \end{aligned}$$

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**Q2:** A cathode ray tube accelerates electrons between charged parallel plates. These electrons are then directed toward a screen and create an image. If the plates are  $1.2 \times 10^{-2} \text{ m}$  apart and have a potential difference of  $2.5 \times 10^4 \text{ V}$  between them, determine the magnitude of the electric field between the plates.

Electricity and Magnetism

$$|\vec{F}_e| = \frac{kq_1q_2}{r^2} \quad \Delta V = \frac{\Delta E}{q}$$

$$|E| = \frac{kq}{r^2} \quad I = \frac{q}{t}$$

$$E = \frac{\vec{F}_e}{q} \quad |\vec{F}_m| = Il_{\perp}|\vec{B}|$$

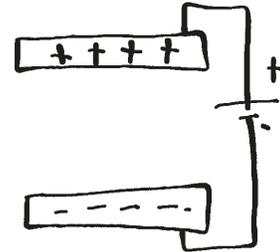
$$|E| = \frac{\Delta V}{\Delta d} \quad |\vec{F}_m| = qv_{\perp}|\vec{B}|$$

$$q = 1.60 \times 10^{-19} \text{ C}$$

$$\Delta d = 1.2 \times 10^{-2} \text{ m}$$

$$\Delta V = 2.5 \times 10^4 \text{ V}$$

$$|\vec{E}| = ?$$



$$\hookrightarrow |\vec{E}| = \frac{2.5 \times 10^4 \text{ V}}{1.2 \times 10^{-2} \text{ m}} = 2.08\bar{3} \times 10^6 \frac{\text{N}}{\text{C}} \text{ or } \frac{\text{V}}{\text{m}}$$