**FORM 5 SPM PHYSICS** SHORTHAND NOTES
**Chapter 3 Electricity**
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## 1.0 Basic Terminology

**Electrical charge**, $Q$ consist of either '+' or '-' charge. The SI unit for charge is in coulomb. Like charges repel each other while opposite charges attract. Electrons are the cause of the charge. Remember that electrons are negatively charged. Each electron has a charge of $1.6 \times 10^{-19}$ C. When electrons flow into a neutral object, the object becomes negatively charged. Likewise when electrons are removed from a neutral object it becomes more positively charged.

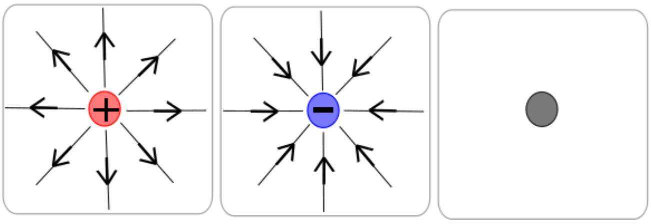
Current, $I$ is defined as the rate of charge flow in a circuit.

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

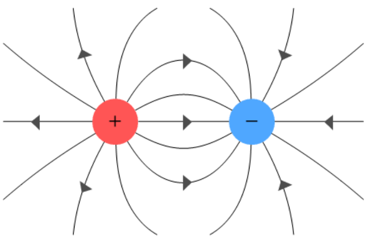
Where $I$ is the electric current measured in ampere (A), $Q$ is the charge (C) and $t$ is the time is seconds.

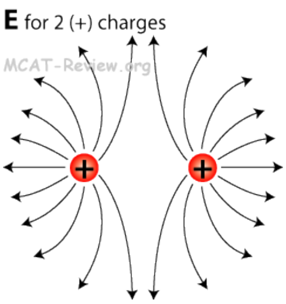
*Note: The current always flows in the opposite direction of the electron.*

An **electric field** is a region where electrical charges experience electric force. They are usually represented by arrow lines. '+' charges have arrows that are pointing outwards while '-' charges have arrows that are pointing inwards (see below). Also a stronger electric field is indicated by more lines. The field is also stronger at the source and vice versa.

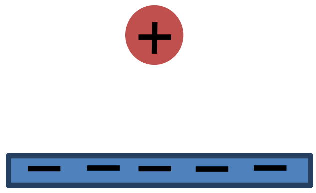


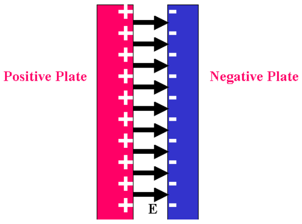
You can combine '+' and '-' fields to get more exotic shapes (see below).






$1.25 \times 10^{18}$ electrons flow through a conductor in 5 seconds. Calculate the current flowing in the conductor.






**Potential difference** is defined as the work done to transfer one unit of charge across two points of different potential (charge).

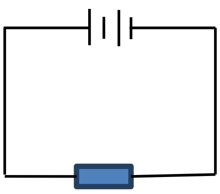
$$V = \frac{W}{Q}$$

Here *V* is the potential difference in volts (V), *W* is the work done in ___ ______ and *Q* is the charge in ____________.

**Resistance**, R of a conductor is the opposition to an electrical current. The higher the resistance of a conductor the more work needs to be applied to push the same amount of current through a conductor (Think friction when pushing a box). Resistance is measured in ohms, **Ω**. Ohm's Law states that the potential difference, V is directly proportional to the current, I that flows through a conductor. This law is only obeyed provided that the temperature and other physical properties remain constant and that the conductor is ohmic. Ask me what is the difference between an ohmic and non-ohmic conductor.

Mathematical explanation,

$$R = \frac{V}{I}$$



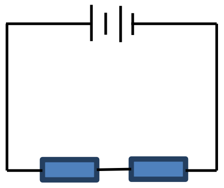
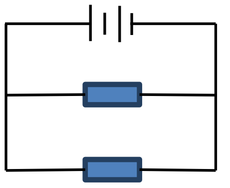
Several factors affect the resistance of a conductor:

1) *The length of the conductor*: The longer the length of the conductor, the
_______________ its resistance.
2) *Diameter or area of the conductor*: The bigger the area of the conductor, the _________________ its resistance.
3) *Temperature of the conductor*: The higher the temperature of the conductor, the __________________its resistance.
4) *The type of material of a conductor*: depends on material type (conductive or insulative type).

The potential difference across a conductor is 240 V. What is the work done to transfer 20 C of charge across a conductor?

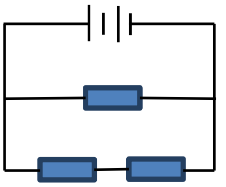
The potential difference across two metal plates is 120 V. What is the number of electrons transferred across the plate if 960 J of energy is dissipated during the process?

## 2.0 Electrical Circuits

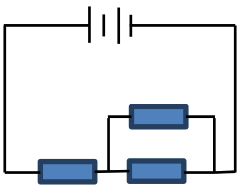
| Series | Parallel |
| --- | --- |
|  |  |
| I = | I = |
| V = | V = |
| R = | R = |
| | |

What if I combined the circuits?

Like this



Or…… Like this



Electromotive force (e.m.f) vs potential difference.

Welcome to the big confusion which is e.m.f and potential difference aka Volts! There is a very small distinction between the both of them so people often get confused. So pay attention…..

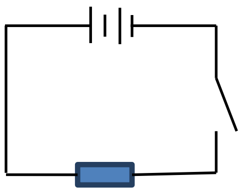
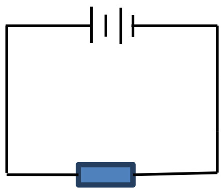
As you know (you should at this point…) the potential difference, V is defined as the work done to move a unit of charge across a component (i.e. resistors, capacitors, inductors, wires, etc.). Potential difference is measured in volts.

The definition for electromotive force or e.m.f of a cell is defined as the work done by the cell to drive a unit of charge around a complete circuit.

$$E.m.f, E = \frac{work\ done\ by\ the\ cell}{charge}$$

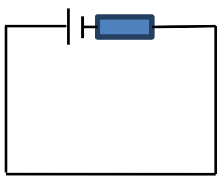
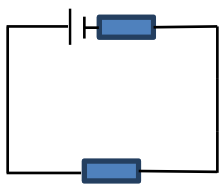
The units for e.m.f is wait for it……… also volts…………..

The difference between the both of them is best illustrated below

| e.m.f | Potential difference |
|---|---|
|  |  |

Common sense dictates that if I attach a voltmeter (in parallel) to both battery sources I should get the same reading. Right? However in actual experiments, the voltage on the left is bigger than the right. The answer to this is due to the internal resistance of the battery. Yes you read that right. The battery itself has a resistance, however for the sake of simplicity we have ignored it, up till now…. The *internal resistance* of battery/ cell is caused by the resistance against the moving charge by

the electrolyte in the cell. Again lets illustrate this

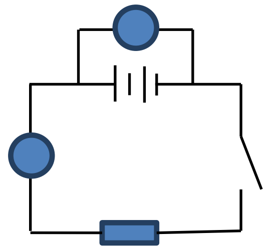
| e.m.f | Potential difference |
|---|---|
|  |  |

You can see here why e.m.f is always greeter than the potential difference. This voltage difference is due to the potential difference required to drive the current, *I*

across the internal resistance and the resistance in the circuit.

$$E = V + Ir$$

I can play around with this equation



Label the voltmeter and ammeter. The figure above shows an electrical circuit with a 20 Ω resistor. When the switch is open the voltmeter gives a reading of 3V. When the switch is closed, the voltmeter gives a reading of 2.8V.

i) Calculate the reading of the ammeter when the switch is closed
ii) The internal resistance of the battery

## 3.0 Electricity as Energy and Power

Recall that

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

and

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

and Ohm's law where

$$\frac{V}{I} = R$$

By playing around with both equations I can come up with different equations:

$$W = VIt$$

Proof:

$$W = I^2Rt$$

Recall that power is the rate of word done or rate of energy transferred i.e.

$$P = \frac{W}{t}$$

Depending on the info given in the question, the above equation can be written in many forms eg.

$$P = \frac{QV}{t}$$

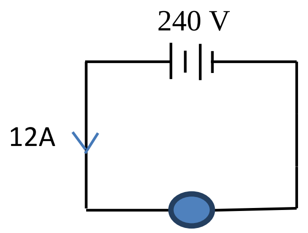
$$P = VI$$

$$P = I^2R$$

Try proving

$$W = \frac{V^2}{R}t$$

$$P = \frac{V^2}{R}$$




Calculate the amount of energy dissipated after 5 minutes.

$3.125x10^{19}$ electrons flow through a light bulb in 2.5 seconds when a battery with potential difference 3V is connected to the bulb. If the charge of electron is $1.6x10^{-19}$C, calculate

a) the energy dissipated
b) the electrical power

## 4.0 Power Rating and Energy Consumption

So far you have seen electrical appliances with power rating labels. For example an iPad charger is rated at 5.1 volts, 2.1 Amps and 12 Watts. A typical AC unit is also around 1000 kW. The idea behind this is that the higher the wattage (power) of the device, the higher the power consumption. Also, if two appliances have the same wattage, the one running longer will consume more electricity.

$$E = Pt$$

In Malaysia TNB is the sole PP. They charge electricity usage based on the how many units of electricity is consumed. 1 unit of electricity is 1kWh or the amount of energy used in 1 hour.

$$E = Pt$$

$$E = kW x 1\text{hr}$$

Efficiency of an electrical appliance refers to how effective the electrical appliance works. Efficiency is calculated as

$$Energy = \frac{output\ power}{input\ power} x100\%$$

Calculate the cost per year.

Perform the same calculations for the refrigerator.

Calculated the amount of energy consumed by an iPad a day assuming charging hours is 4 hours.

Calculate the electricity cost for a day assuming the tariff is RM 0.25 per kWh.