10 D.C. Circuits

10.1 Practical circuits

Connecting lead	Filament lamp	Fuse
Cell	Voltmeter	Earth
Battery of cells	Ammeter	Alternating signal
Resistor	Switch	Capacitor
D.C. Power supply	Variable resistor	Inductor
Junction of conductors	Microphone	Thermistor
Crossing conductors (no connection)	Loudspeaker	
	Light emitting diode (led)	Light dependant resistor (ldr)
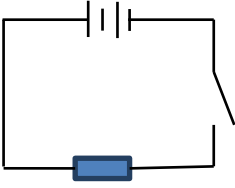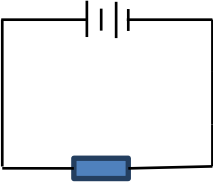
- Candidates must be able to interpret circuit diagrams (refer to IGCSE Chapter 4 Notes (https://www.senpaicorner.com/course-notes)
- Welcome to the big confusion which is e.m.f and potential difference aka Volts!
- There is a very small distinction between the both of them so people often get confused.
- 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 also in 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 greater than the potential difference.
- This voltage difference is due to the potential difference required to drive the current (I) across the internal resistance (r) and the resistance in the circuit.

$$E = V + Ir$$
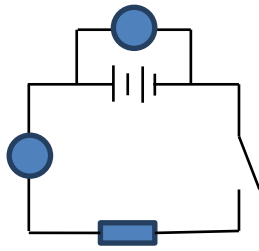
Label the voltmeter and ammeter. The figure above shows an electrical circuit with a 20 Ω resistor.

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

## 10.2 Kirchhoff's laws

Candidates should be able to:

1   recall Kirchhoff's first law and understand that it is a consequence of conservation of charge

2   recall Kirchhoff's second law and understand that it is a consequence of conservation of energy

3   derive, using Kirchhoff's laws, a formula for the combined resistance of two or more resistors in series

4   use the formula for the combined resistance of two or more resistors in series

5   derive, using Kirchhoff's laws, a formula for the combined resistance of two or more resistors in parallel

6   use the formula for the combined resistance of two or more resistors in parallel

7   use Kirchhoff's laws to solve simple circuit problems

- Kirchhoff's first law states that **the sum of the currents entering a junction always equal the sum of the currents out of the junction**
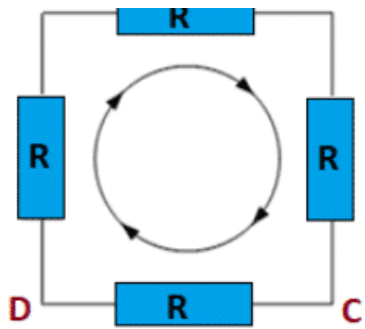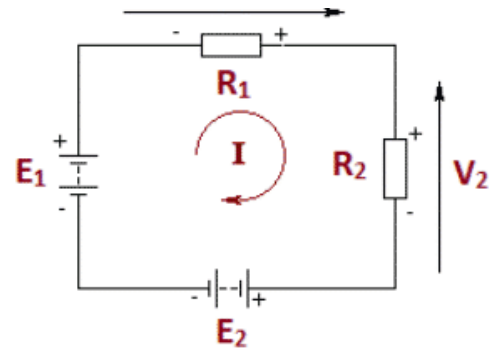
$$I_1 = I_2 + I_3 + I_4$$

- E.g.

$I_2 = 7\ A$

$I_1 = 11\ A$

a

$I_3 = 4\ A$
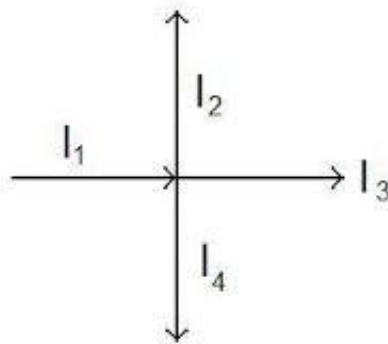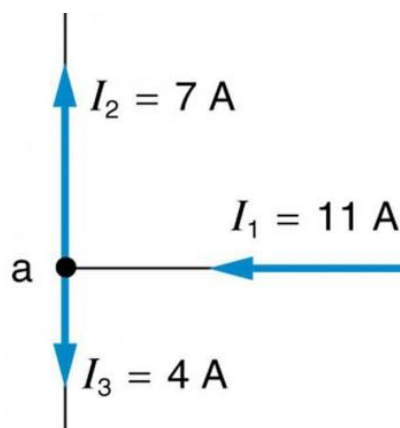
$$I_1 = I_2 + I_3$$

- Kirchhoff's second law states that the sum of the e.m.f's in a closed circuit equals the sum of the potential differences.
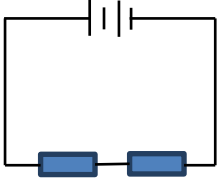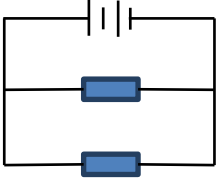

$$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$$

$$E_1 + V_1 - V_2 - E_2 = 0$$
$$E_1 + V_1 = V_2 + E_2$$

- Recall the formulas used to calculate resistance in series and parallel.

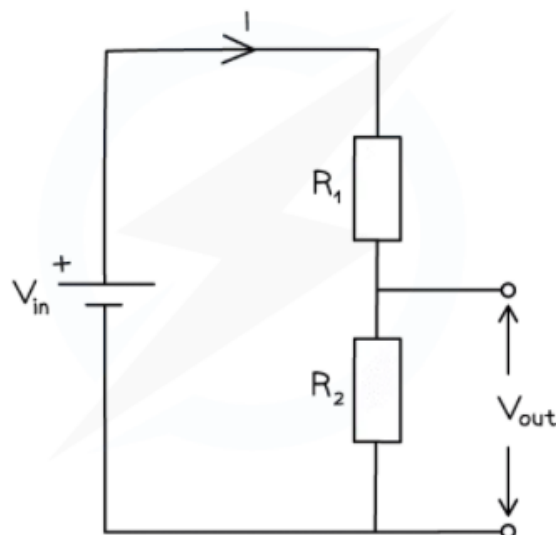| Series	Parallel
COMBINED RESISTANCE IN SERIES $R = R_1 + R_2 + R_3 \ldots$	COMBINED RESISTANCE IN PARALLEL $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$

10.3 Potential dividers

- According to Kirchhoff's Second Law, the potential difference across a power source is divided when two resistors are connected in series.

$$\text{POTENTIAL DIVIDER EQUATION: } V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$

- The larger the resistance the larger the voltage share (the big eater gets more pie!)
- A potential meter is similar to a variable resistor

① Vcc

② Output

③ GND

Voltage Supply

1

R_1

R

2 +

R_2

V_{OUT}

3

$R = R_1 + R_2$ 1,2,3 - Terminals
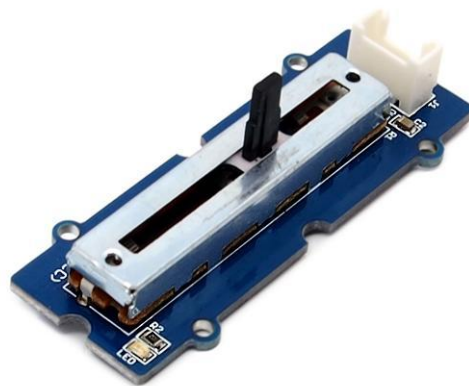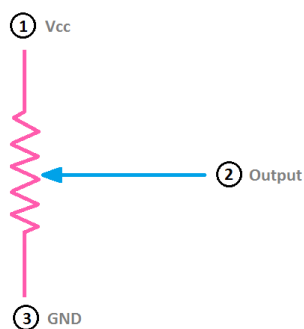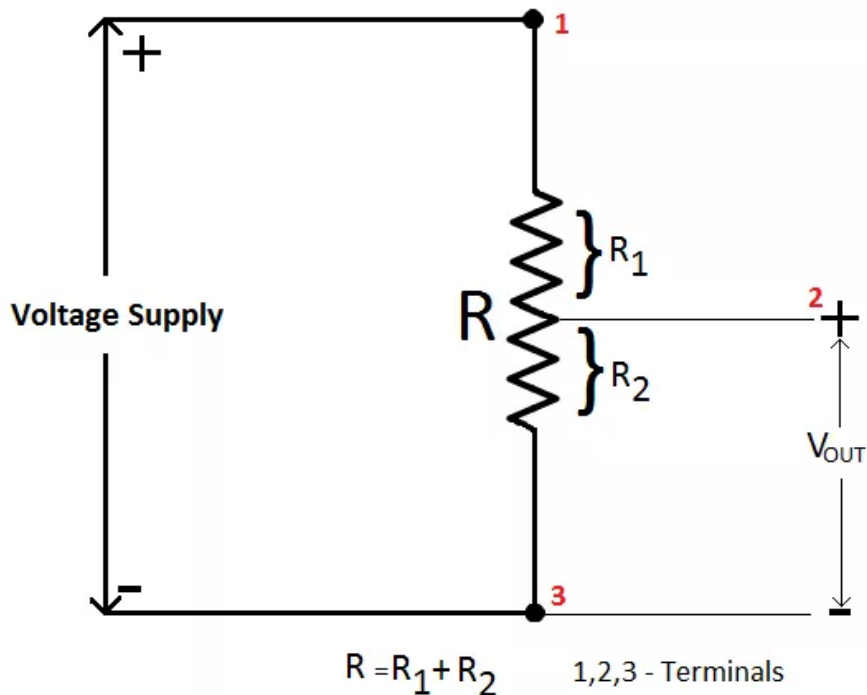
- In the diagram above, the total resistance of the potentiometer is R.
- When the slider is moved it divides R into R_1 and R_2
- If the slider is moved further to the top, R_2 becomes bigger because it becomes longer (big eater!)
- The opposite is true, if the slider is moved further down, R_1 becomes longer and bigger.
- A Galvanometer is a type of ammeter
- It is used to measure current.

G

Ω∠☆2.5

100Ω   2.4K

G0   G1

- The arrow on a galvanometer deflects depending on the amount of current passing through.

- When the arrow is facing directly upwards, there is no current.
- This is called null deflection.
- Recall that Light Dependent Resistors (LDR) and thermistors are special resistors called sensory resistors.

| LDR POTENTIAL DIVIDER CIRCUIT | THERMISTOR POTENTIAL DIVIDER CIRCUIT |
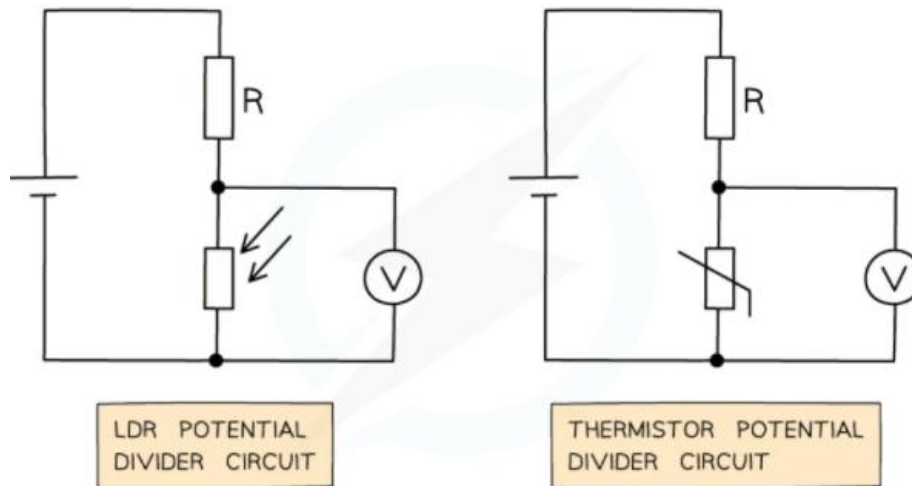
- The higher the light intensity, the lower the resistance of the LDR.
- The hotter the thermistor, the lower the resistance and vice versa.