IGCSE/GCE O-LEVEL

Electric Cuircuts

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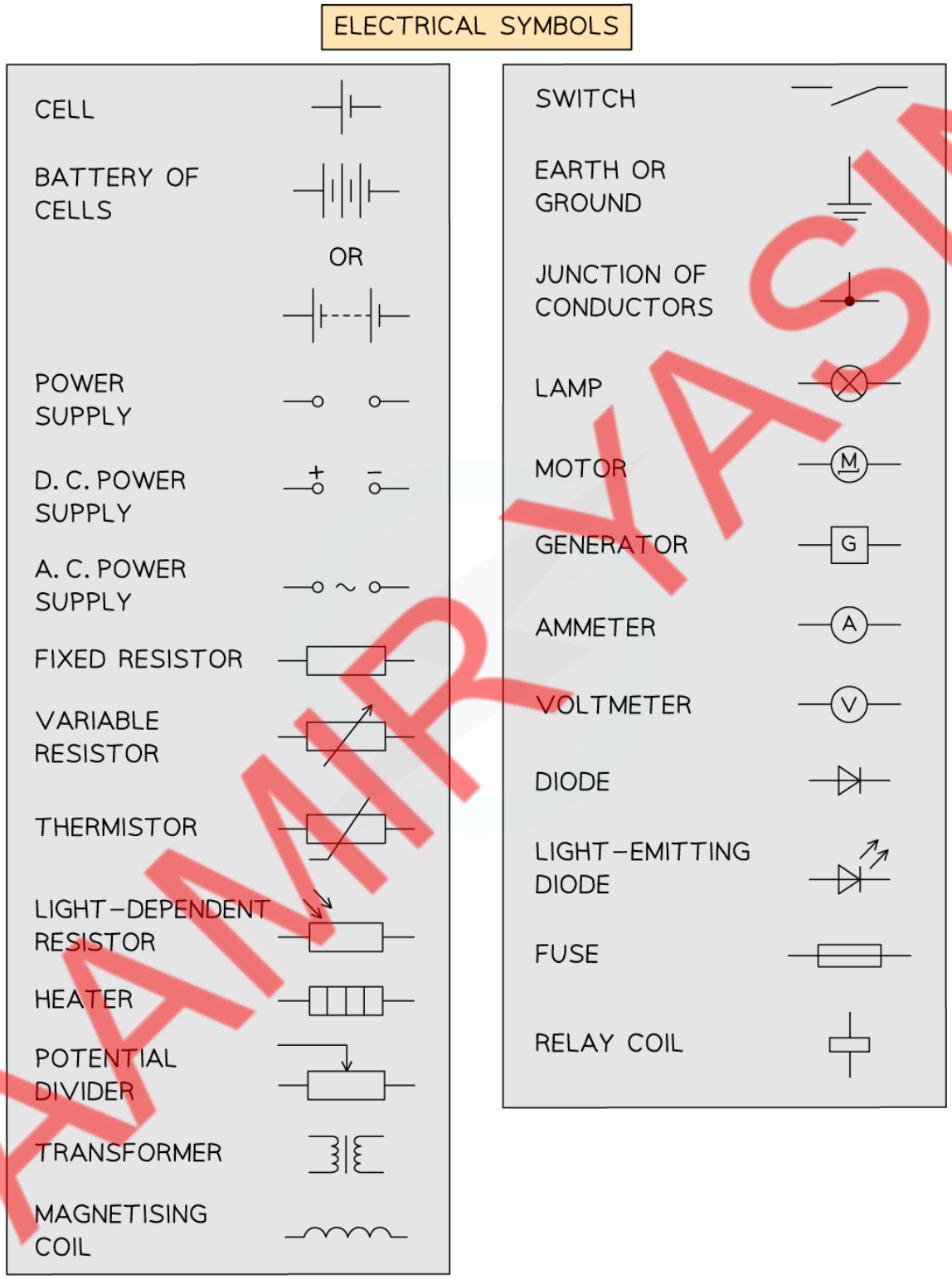
Circuit Components

The diagram below shows the circuit symbols that could be used in circuit diagrams



Power supplies

Cells, batteries, power supplies and generators all **supply current** to the circuit

Resistors

Potential dividers, fixed and variable resistors, thermistors and light-dependent resistors (LDRs) are all used to **control current**

Meters

Ammeters and voltmeters are used to measure the current and potential difference

- Ammeters are always connected in series whilst voltmeters are always connected in parallel

Electromagnetic Components

Magnetizing coils, relays and transformers use electromagnetic effects

- Relays use a small current in one circuit to switch on a much larger current in another
- Transformers 'step up' and 'step down' current and potential difference

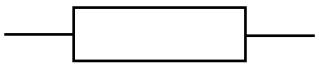
Fuses

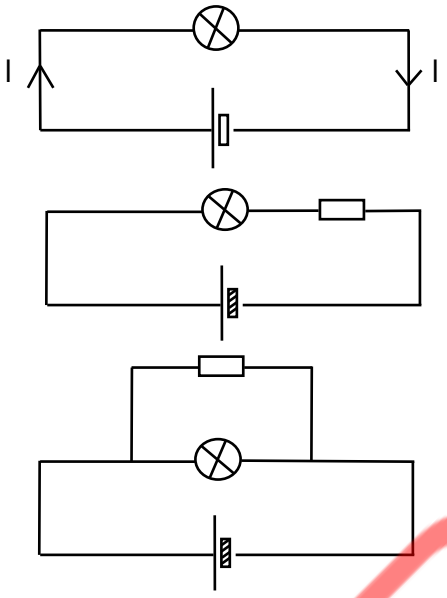
Protect expensive components from current surges and act as a safety measure against fire

Resistor

A device which produces resistance to control the current is called a resistor.

Symbol





A bulb is connected to a cell. Therefore current pass through the bulb.

If we connect a resistor in series with the cell then current passing through bulb will decrease.

If we connect a resistor across (parallel) the bulb then current passing through bulb will increase.

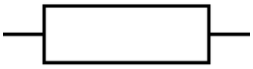
By connecting resistor in electric circuit we can increase or decrease the magnitude of current passing through the electric component or by connecting a resistor in an electric circuit we can control the current passing through the electrical component.

Fixed Resistor

A resistor whose resistance remains constant is called fixed resistor.

Example:

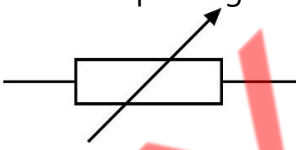
- Carbon film resistor
- Graphite resistor
- Wire – wound resistor



Variable Resistor

A resistor whose resistance can be changed is called variable resistor.

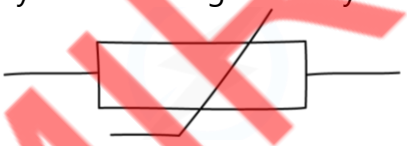
- It is used change the amount of current passing through the conductor.



Thermistor

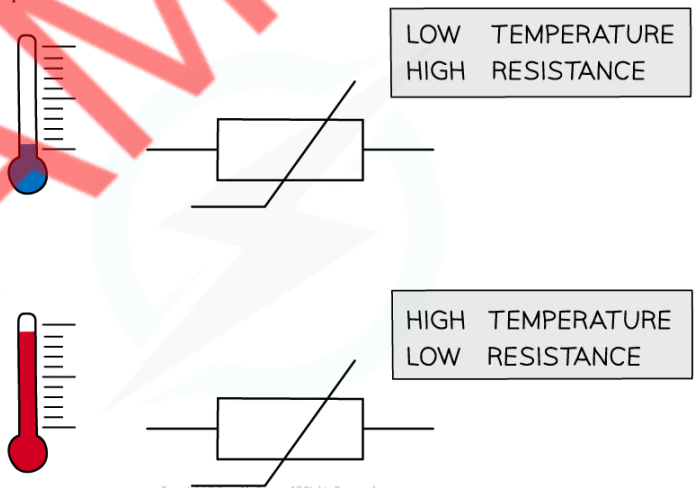
A resistor whose resistance inversely depends upon temperature is called Thermistor.

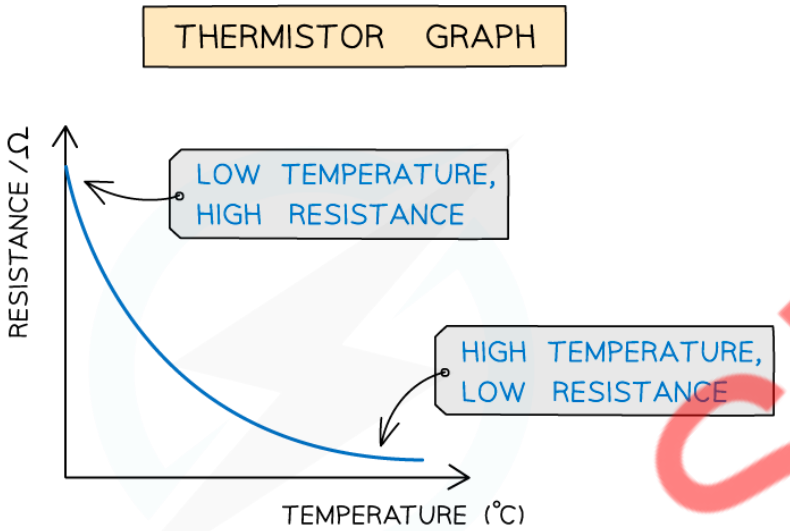
- Thermistor is also called Heat Dependent Resistor and it is abbreviates as HDR.
- A **thermistor** is a **temperature-dependent** resistor
- It is represented by the following circuit symbol:



The resistance of a thermistor changes depending on its **temperature**

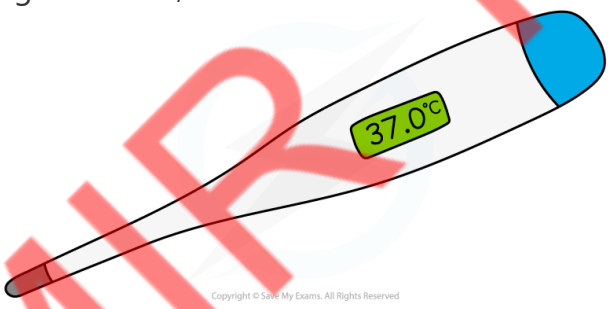
- As the temperature **increases** the resistance of a thermistor **decreases** and vice versa





Thermistors are temperature sensors and are used in circuits in ovens, fire alarms and digital thermometers

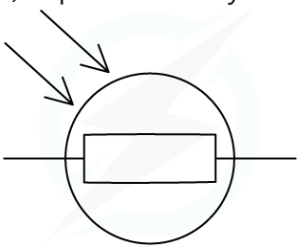
- As the thermistor gets **hotter**, its resistance **decreases**
- As the thermistor gets **cooler**, its resistance **increases**



Light Dependent Resistor (LDR)

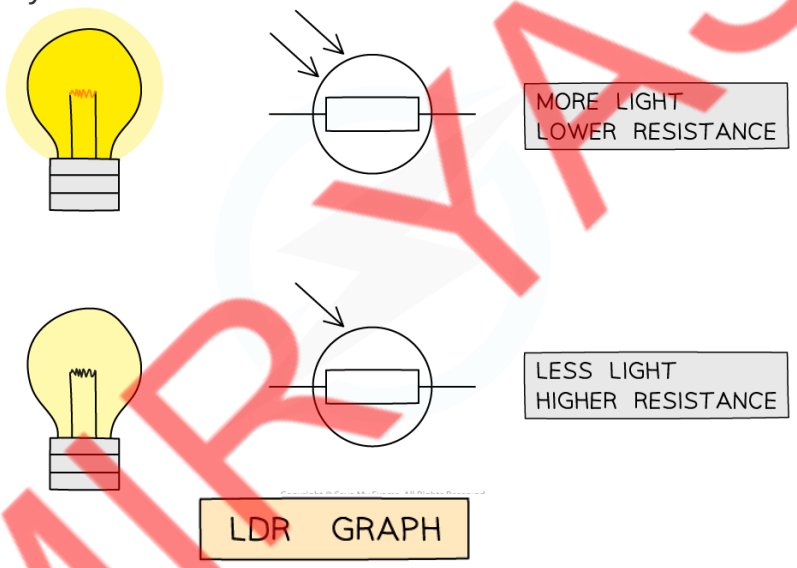
A resistor whose resistance inversely depends upon light intensity is called Light Dependent Resistor.

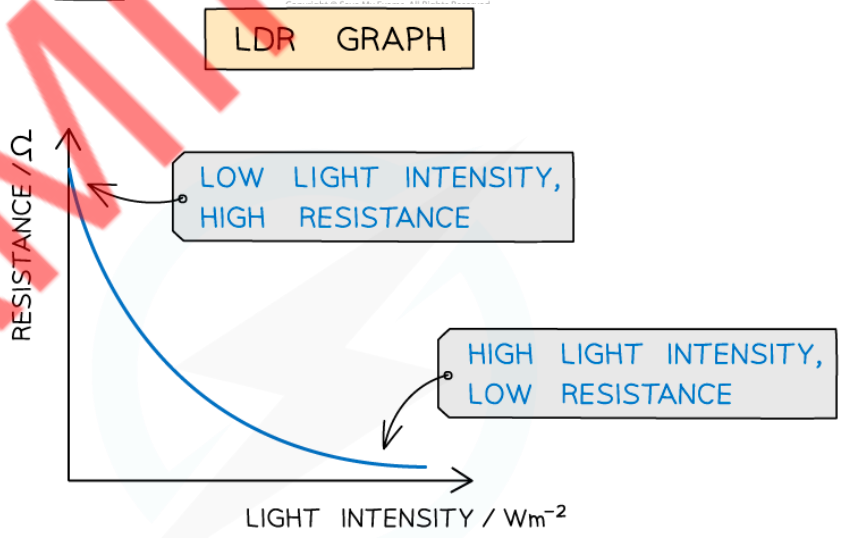
- It is abbreviation as LDR.
- A light-dependent resistor (LDR) represented by the following circuit symbol:



The resistance of an LDR changes depending on the **light intensity** on it

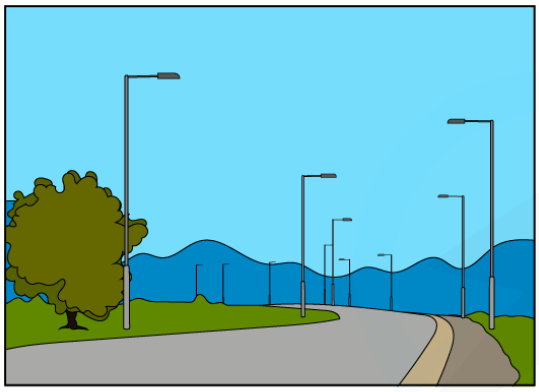
- As the light intensity **increases** the resistance of an LDR **decreases** and vice versa





LDRs can be used as light sensors, so, they are useful in circuits which automatically switch on lights when it gets dark, for example, street lighting and garden lights

- In the dark, its resistance is very large (millions of ohms)
- In bright light, its resistance is small (tens of ohms)



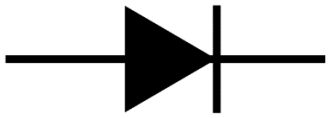
DAYTIME HAS HIGH LIGHT INTENSITY → LDR KEEPS LIGHTS TURNED OFF

AT NIGHT, THERE IS LOW LIGHT INTENSITY → LDR SWITCHES LIGHTS ON

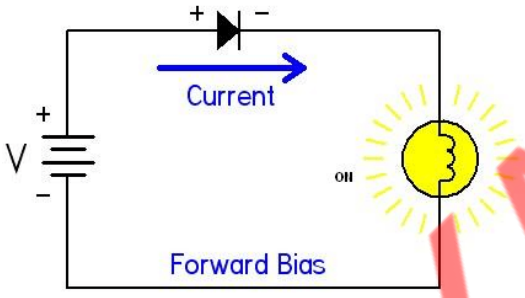
Diode

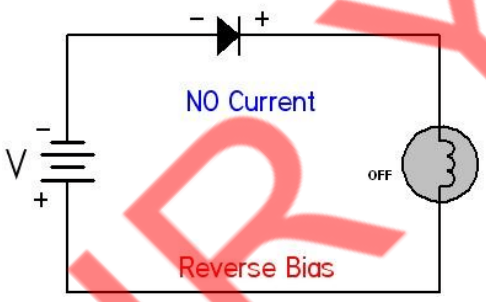
A device which allows the current to pass (flow) in only one direction is called a diode.

- This is symbol of diode.

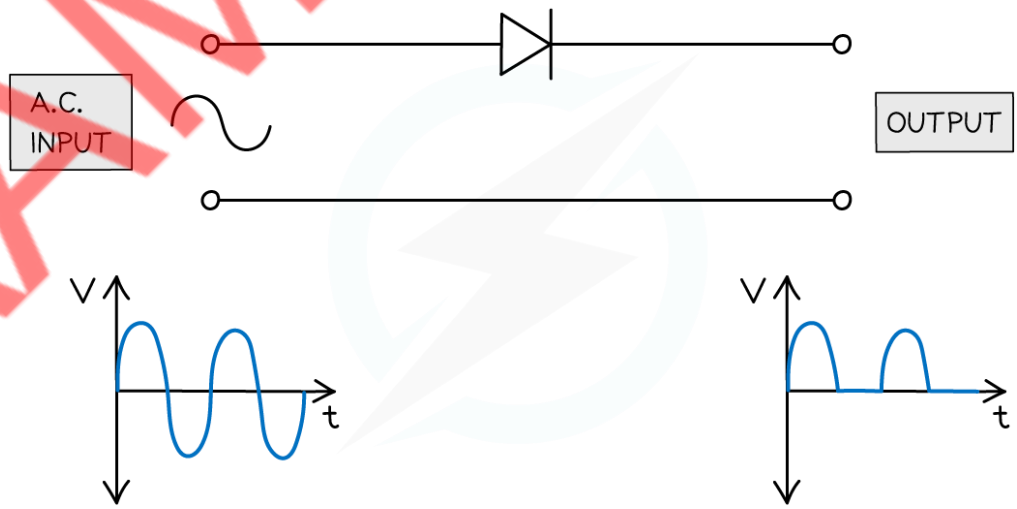


- Arrow head represents the direction of flow of current whereas bar shows that current will be stopped if it tries to flow in opposite direction.





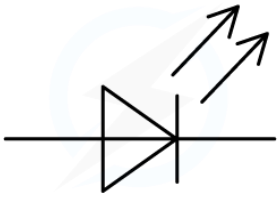
- If a diode is connected to an A.C. (alternating current) power supply, it will only allow a current half of the time.
- This is called rectification.



Light Emitting Diode (LED)

A diode which produces light when current passes through it called light emitting diode.

- It is represented by the following symbol.



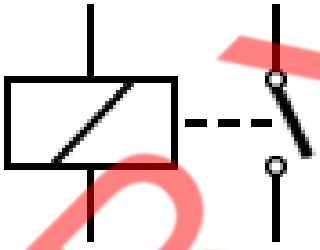
Rectifier

A device which converts A.C in to D.C is called rectifier.

- Diode is used in a rectifier.

Relay

A device which is operated on small current and is used to automatically Switch on / switch off another device which is operated on large current.

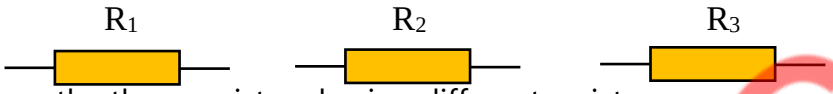


Combination of Resistors

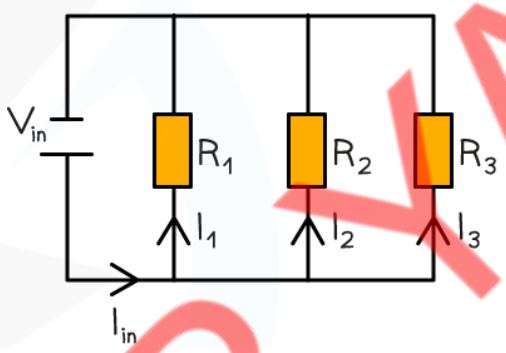
Resistors (electric components) can be connected in

- Parallel Combination
- Series Combination

Parallel Combination



R_1, R_2 and R_3 are the three resistors having different resistance.
These resistors are connected in parallel and then their parallel combination is connected to the cell.



Properties

In parallel combination:

- Potential difference across all the resistor is same and is equal to EMF of a cell.
- Current passing through each resistor is different and magnitude of current passing through the resistor inversely depends upon the resistance of resistor.
- Sum of current passing through all the resistor is equal to total current coming out of cell i.e.

$$I = I_1 + I_2 + I_3$$

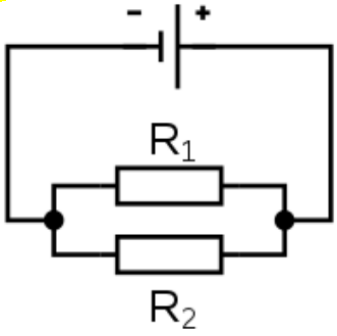
$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{V}{R} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

- Reciprocal of effective resistance is equal to sum of reciprocals of resistance of all the resistors.
- Effective resistance is less than the least resistance of the combination.

Direct Method



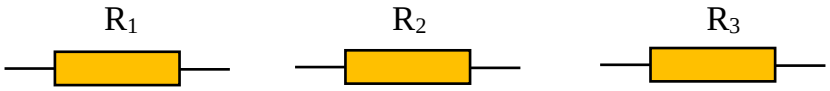
$$\frac{1}{R} = \frac{1}{R1} \quad \frac{1}{R2}$$

$$\frac{1}{R} = \frac{R2+R1}{R1xR2}$$

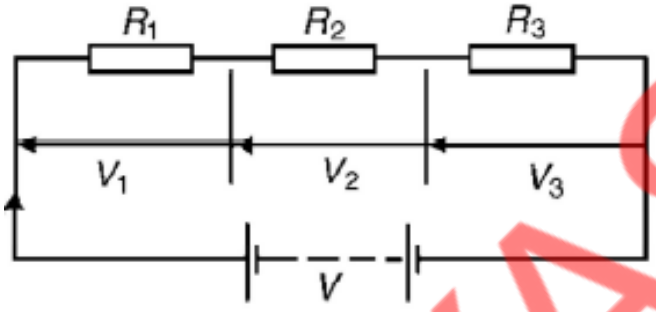
$$R = \frac{R1R2}{R1+R2}$$

Effective resistance = Product of Resistance / Sum of Resistance

Series Combination



R_1, R_2 and R_3 are the three resistors having different resistance.
These resistors are connected in Series and then their Series combination is connected to the cell.



Properties

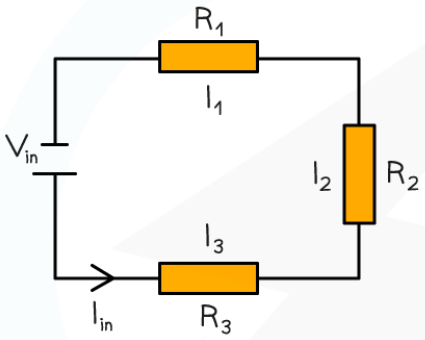
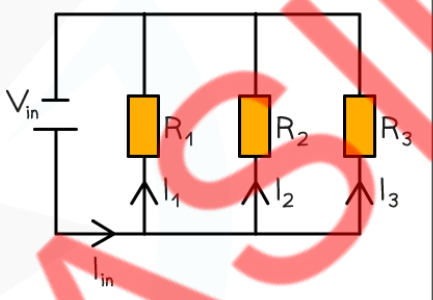
- Current passing through each resistor is the same and is equal to total current coming out of the cell.
- Potential difference across each resistor is different and P.D across the resistor is directly proportional to the resistance of the resistor.
- Sum of potential difference across all the resistors is equal to EMF of the cell i.e.

$$V = V_1 + V_2 + V_3$$
$$IR = IR_1 + IR_2 + IR_3$$
$$IR = I(R_1 + R_2 + R_3)$$
$$\mathbf{R = R_1 + R_2 + R_3}$$

- Effective resistance is equal to the sum of resistance of all the resistors.
- Effective resistance is greater than greatest resistance of the combination.

Summary

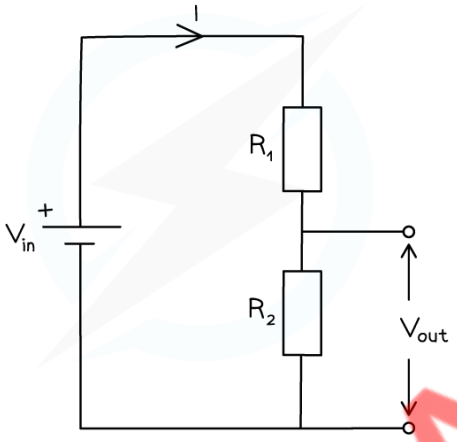
- A summary of the current, voltage and resistance within a series and parallel circuit are summarized below:

	Series	Parallel
Circuit		
Voltage	$V_{in} = V_1 + V_2 + V_3$	$V_{in} = V_1 = V_2 = V_3$
Current	$I_{in} = I_1 = I_2 = I_3$	$I_{in} = I_1 + I_2 + I_3$
Resistance	$R_{total} = R_1 + R_2 + R_3$	$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Series Circuit	Parallel Circuit
In a series circuit, same current flows through all the components.	In a parallel circuit, the current can have more than one path.
All the components are connected in an end-to-end fashion with only one common point between the components.	One end of all the components in a parallel is connected to a common point and the other end to another common point. So, parallel circuit has two common points.
Voltage across the components is not the same and is dependent on the individual resistance.	Voltage across all the components in a parallel circuit is same and is equal to the supply voltage.
If one component fails in a series circuit, then the entire circuit stops functioning as there is only one current path.	Even if one of the parallel branches fail, the rest of the branches continue to work normally.
The current is same in all the components and the sum of individual voltages is equal to the supply voltage.	The voltage is same across all the components in parallel and the sum of individual currents is equal to the total current in the circuit.
If we have three resistors connected in series, then the equivalent resistance is the sum of individual resistances ($R = R_1 + R_2 + R_3$).	If we connected three resistors in parallel, then the inverse of the equivalent resistance is equal to the sum of the inverse of individual resistances ($1/R = 1/R_1 + 1/R_2 + 1/R_3$)

Potential Divider

An arrangement which is used to split or divide total voltage of cell into two smaller values is called potential divider.



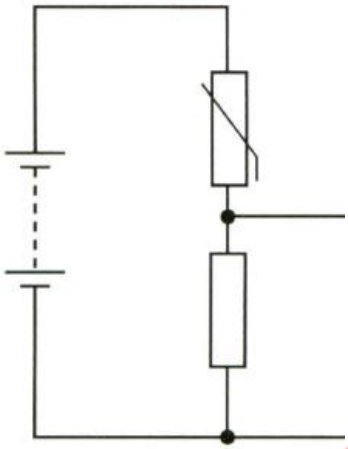
- It consists of two resistors which are connected in series and then series combination is connected to the cell.
- Let say P.D across the resistors R_1 is V_1 and R_2 is V_2 respectively.
- We can find V_1 and V_2 using following expression

$$V_1 = \left(\frac{R_1}{R_1 + R_2}\right) V_{in}$$

$$V_2 = \left(\frac{R_2}{R_1 + R_2}\right) V_{in}$$

Fire Alarm

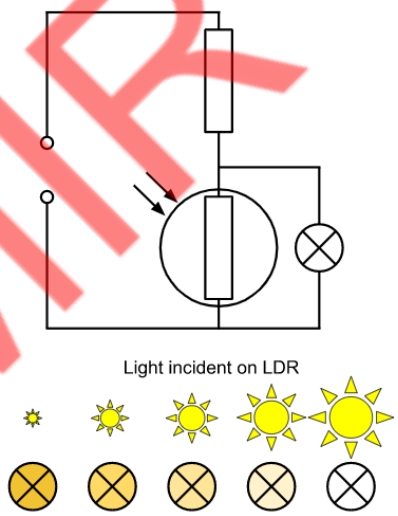
If one of resistor of potential divider is replaced by a thermistor then arrangement can be used as fire alarm.

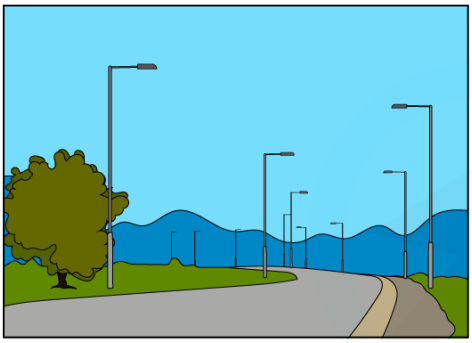


By connecting electric bell across the fixed resistor we can use above arrangement as fire alarm,

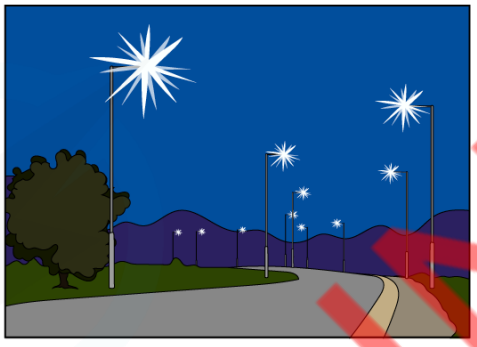
Automatic Street Light

If one of resistor of potential divider is replaced by LDR then arrangement can be used as Automatic Street Light.





DAYTIME HAS HIGH LIGHT INTENSITY → LDR KEEPS LIGHTS TURNED OFF

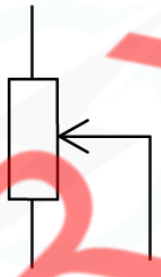


AT NIGHT, THERE IS LOW LIGHT INTENSITY → LDR SWITCHES LIGHTS ON

The Potentiometer

A device used to give a continuously variable output voltage is called potentiometer.

- Following symbol is used to represent potentiometer



- We can charge the length of wire through which current is flowing by moving sliding contact along the wire.
- When length of wire through which current is flowing is charged then resistance changes.
- With change in resistance, potential difference also changes