ELECTRICITY

Dr Kanzul Iman

AQA A level PHYSICS

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1. **Electric Current**

This is like the flow of tiny particles called "charge" in a wire. It's how much charge flows past a point in a certain amount of time.

"Flow of charge per unit time"

$$I = \Delta Q/\Delta T$$

2. **Potential Difference (V):**

Think of this as the push that makes the charge move. It's how much energy is given to the charge as it goes through a component like a light bulb.

" The energy transferred per unit charge between two points"

$$V = W/Q$$

3. **Resistance (R):**

Imagine walking through a crowd - if it's easy to move through, that's like low resistance. If it's really hard to move through, that's high resistance. Resistance measures how tough it is for charge to go through something.

$$R = V/I$$

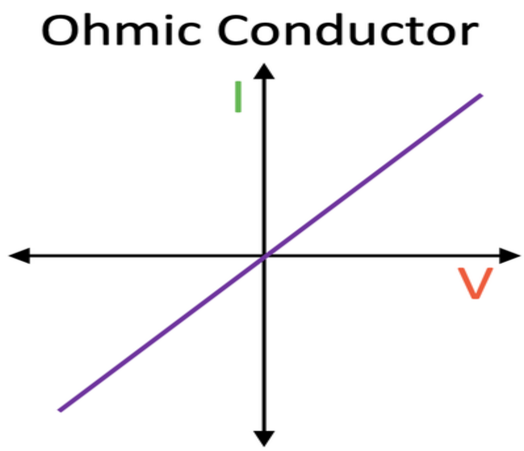
4. **Ohm's Law:**

This is a rule that says, for some things (like most wires), if you push harder (increase the potential difference), more charge will flow (current). It's like saying the more you push a swing, the higher it goes.

5. **Ohmic Conductor:**

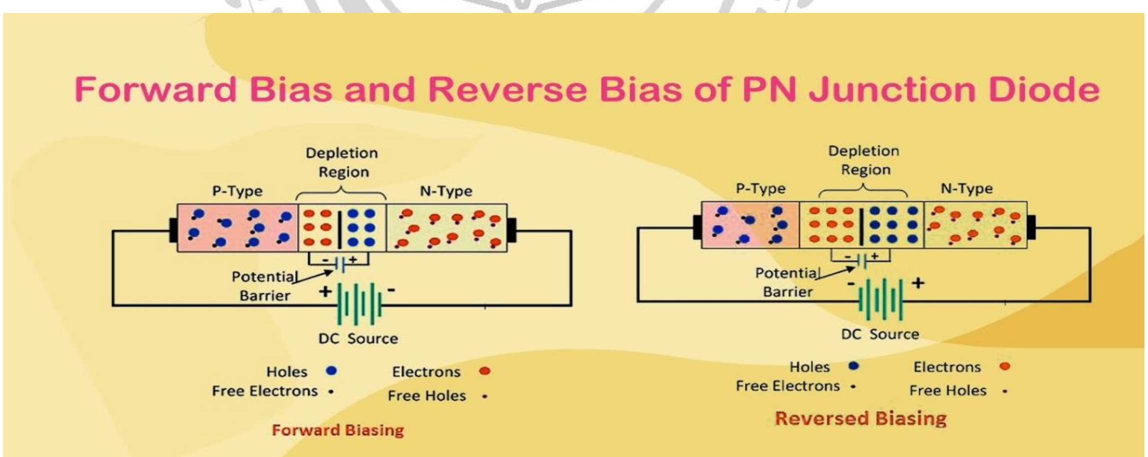
It's like a special path where Ohm's law works perfectly. If you draw a line on a graph of current and voltage, it's a straight line that starts at the zero point.

For an ohmic conductor, current is directly proportional to the potential difference across it, given that physical conditions (e.g temperature) are kept **constant**.



6. **Semiconductor Diode:**

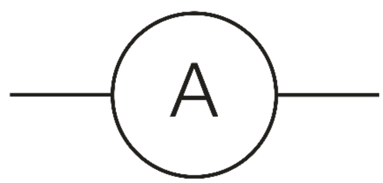
This is like a gate. It only lets charge through in one direction easily (forward bias), and it's really hard for charge to go the other way (reverse bias).



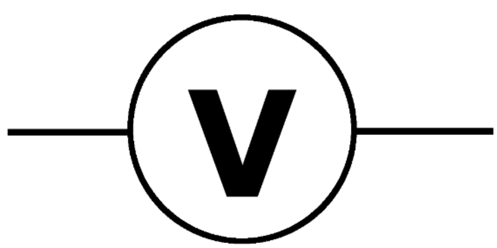
7. **Filament Lamp:**

It's like a light bulb with a special wire inside. When you send more electricity through it, the wire gets really hot and makes it harder for electricity to flow. At low electricity, it behaves like Ohm's law, but as you send more electricity, it starts to act differently because of the heat.

8. **Ammeters:** These are like super-accurate counters for electricity. They don't slow down or affect the flow of electricity in a circuit at all.



9. **Voltmeters:** These are like super-sensitive measuring tools for how strong the push (voltage) is in a circuit. They don't let any electricity flow through them, so they give you an exact measurement of voltage.



10. **Resistivity:**

It's like a special property of materials that tells you how easily electricity can move through them. It depends on the material's size and shape, but it can also change if the material gets hotter, making it harder for electricity to pass through. So, when things get hot, their resistivity goes up, and it's like they resist electricity more.

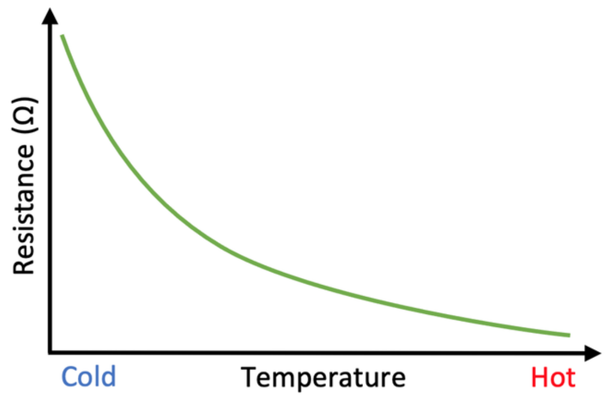
Product of resistance and cross-sectional area, divided by the length of the material. Resistivity will give the value of resistance through a material of length 1 m and cross-sectional area 1 m^2 which is useful when you need to compare materials even though they may not be the same size, however resistivity is also dependent on environmental factors, such as temperature.

$$\rho = \frac{RA}{L}$$

Thermistors:

These are like special temperature sensors. When it gets warmer, they become more conductive, meaning electricity can flow through them more easily. So, if you want to know when it's too hot or cold, you can use a thermistor to trigger things like turning on the heat when it gets chilly.

As the temperature of a thermistor increases, its resistance decreases. This is because increasing the temperature of a thermistor causes electrons to be emitted from atoms, therefore the number of charge carriers increases and so current increases causing resistance to decrease.Temperature-resistance graph of thermistor:



One application of a thermistor in circuits is a temperature sensor, which can trigger an event to occur once the temperature drops or reaches a certain value.

Superconductors:

These are materials that become super special when they're very, very cold. They allow electricity to flow through without any resistance, like a super-fast train with no brakes. People use them for things like making power cables that don't waste energy as heat and for creating strong magnetic fields, which can be used in things like super-fast trains and some medical equipment. However, they need to be extremely cold to work this way.

A superconductor is a material which, below a certain temperature, known as the critical temperature, has zero resistivity. The critical temperature of a superconductor depends on the material it is made out of, and most known superconductors have an extremely low critical temperature which lie close to 0 K (-273°C).

Applications of superconductors include:

- Power cables, which would reduce energy loss through heating to zero during transmission.
- Strong magnetic fields, which would not require a constant power source. These could be used in maglev trains, where there would be no friction between the train and rail, and in certain medical applications.

Power:

This is how fast energy is used or transferred. Imagine it's like how quickly your toy car uses up its battery. More powerful toys use up the battery faster.

$$P = IV$$

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

$$P = I^2R$$

Energy (E):

This is the total amount of "work" done or transferred. It's like the total distance your toy car travels before the battery runs out.

Now, here's how they're related:

Power (P) = Energy (E) / Time (t):

- This tells you how fast something is using energy. It's like saying, "How quickly is the toy car using up its battery?
-

Power (P) = Voltage (V) x Current (I):

This is a way to figure out power using voltage and current. Voltage is like the push, and current is like the flow of electricity.

Energy (E) = Voltage (V) x Current (I) x Time (t):

This helps you find the total energy used. It's like calculating how much distance the toy car can travel by considering how fast it's going and for how long.

Lamp example:

- The lamp uses 60 watts (W) of power, and you want to find how much energy it uses in 2 minutes (which is 120 seconds). So, it's like asking, "How much distance can the toy car travel in 2 minutes?"
- To find the current (I), you use the formula: Current (I) = Power (P) / Voltage (V). It's like asking, "How fast is the toy car using its battery if it has a 240-volt push?"

- You find that the lamp uses 7200 joules (J) of energy (work), and the current in the lamp is 0.25 amperes (A).

In a series circuit:

- The same amount of current flows everywhere. It's like all the toy cars in a race moving at the same speed.
- The voltage from the battery gets shared across all the parts in the circuit. It's like each toy car in the race getting the same push from the same battery. So, if you add up the distances each toy car travels, it's equal to the total distance they could travel with the battery's push.

1. **Parallel Circuits:** Imagine you have different paths for the electricity to travel. In a parallel circuit, the total electricity going into the paths is the same as the total coming out. It's like a big river splitting into smaller streams, and then those smaller streams coming back together to form the river again. The push (voltage) is the same for all the paths.

- The sum of the currents in each parallel set of branches is equal to the total current.
- The potential difference across each branch is the same.

2. **Series Circuits:** Now, picture a string of Christmas lights. In a series circuit, all the electricity has to go through one path. It's like the lights are connected end-to-end. The total push (voltage) is the sum of the pushes needed to get through each light.

- The **current is the same** everywhere in the circuit.

- The battery p.d is shared across all elements in the circuit, therefore the **total sum of the voltages across all elements is equal to the supply p.d.**

When joined in series, the total voltage across the cells is equal to the sum of the individual voltages of the cells:

$$V_T = V1 + V2 + V3 + ...$$

3. **Joining Battery Cells:** When you connect batteries together, you can do it in two ways. If you connect them in series, you add up the voltages of each battery. It's like stacking toy cars on top of each other, and the more you stack, the higher the "push" gets. But if you connect them in parallel, it's like putting them side by side, and the "push" stays the same because they share it equally.

4. **Kirchhoff's Laws:** These are like rules to make sure we don't lose electricity or energy in a circuit. The first law says that the total electricity going into a place (junction) is the same as what comes out. It's like saying that no cars go missing in a traffic circle. The second law says that all the "pushes" in a series circuit (like the sum of all the toy cars' pushes) is equal to the battery's "push." It's like making sure all the energy you put into a game is still there when you finish playing.

Kirchoff's first law - the total current flowing into a junction is equal to the current flowing out of that junction. This shows that no charge is lost at any point in the circuit.

Kirchoff's second law - the sum of all the voltages in a series circuit is equal to the battery voltage. This shows that no energy is lost at any point in a circuit.

5. **Potential Divider:**

This is a special setup of resistors connected to a power source. It's like having different-sized pipes connected to a water tank. You can control how much water flows out by changing the size of the pipes. By using variable resistors (like a volume knob on a radio), you can adjust how much "push" (voltage) is available to different parts of the circuit.

A potential divider is a circuit with several resistors in series connected across a voltage source, used to produce a required fraction of the source potential difference, which remains constant.

A light dependent resistor's resistance decreases as light intensity increases.

6. **Internal Resistance and EMF**

Internal Resistance (r):

Think of it as a tiny obstacle inside a battery. When electricity flows through the battery, some of its energy is lost because the electricity bumps into this obstacle. It's like a bumpy road where your toy car loses some speed.

Electromotive Force (EMF or ε):

This is like the "push" that the battery gives to make electricity flow. It's the force that makes your toy car move.

Total Resistance (RT):

In a circuit with a battery, there's not only the internal resistance but also the resistance of the components in the circuit (like a light bulb or a toy). The total resistance is the sum of these resistances.

Voltage (V) and Current (I):

Voltage is like the "push" that makes electricity flow (like how hard you push your toy car). Current is how fast the electricity is actually moving (like how fast your toy car is going).

Examples:

EMF (ε) of the battery is 5 volts.

Lost volts (v) due to internal resistance is 2 volts.

Resistance of component (R) in the circuit is 10 ohms.

To find the current (I) in the circuit, you can use the formula $V = IR$. First, find the total voltage (V) by adding the EMF and the lost volts: $V = \varepsilon + v = 5\ V + 2\ V = 7\ V$. Then, you can use $V = IR$ to find I, which is current. $I = V / R = 7\ V / 10\ \Omega = 0.7\ A$.

Second Example:

EMF (ε) of the battery is 10 volts.

Current (I) in the circuit is 2 amperes.

Resistance of one component (R1) in the circuit is 3.5 ohms, and the resistance of another component (R2) is 0.5 ohms.

To find the lost volts (v), you can use the formula $\varepsilon = V + v$, where V is the total voltage. Since $V = IR$, for R1: $V1 = I * R1 = 2\ A * 3.5\ \Omega = 7\ V$. For R2: $V2 = I * R2 = 2\ A * 0.5\ \Omega = 1\ V$. So, the total voltage (V) is $V1 + V2 = 7\ V + 1\ V = 8\ V$. Now, you can find the lost volts: $v = \varepsilon - V = 10\ V - 8\ V = 2\ V$.

To find the internal resistance (r), you can use $v = Ir$. Since v is 2 V and I is 2 A, you can rearrange the formula: $r = v / I = 2\ V / 2\ A = 1\ \Omega$