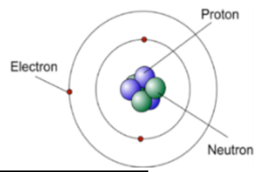
Edexcel GCSE Physics

Topic 10: Electricity and circuits

Notes

(Content in bold is for Higher Tier only)

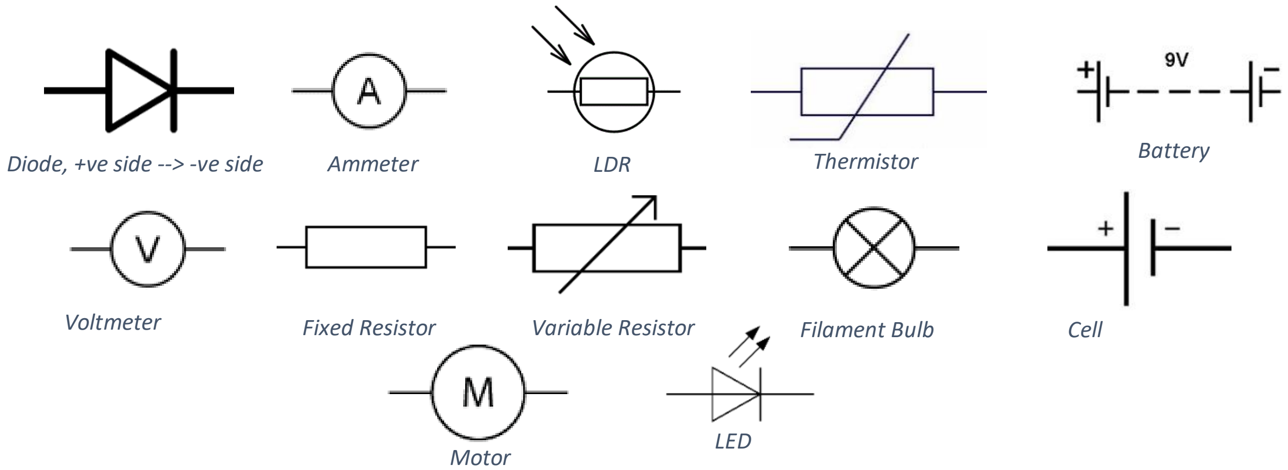
The Structure of the Atom



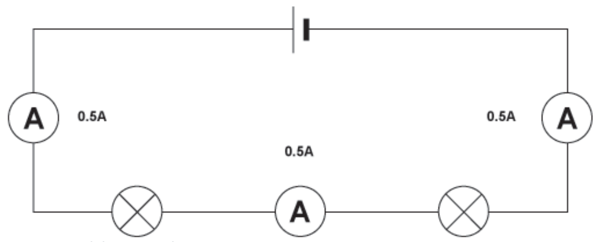
Positively charged nucleus surrounded by negatively charged electrons

Subatomic Particle	Relative Mass	Relative Charge
Proton	1	+1
Neutron	1	0
Electron	0 (0.0005)	-1

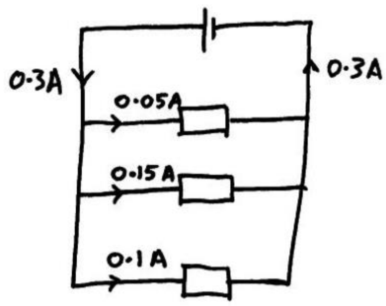
Electricity



Series and Parallel



- Series Circuits
  - Closed circuit
  - The current is the same everywhere
- Parallel Circuits
  - Branched circuit
  - Current splits into multiple paths
  - Total current into a junction = total current in each of the branches
  - Voltage is the same across each "branch"



physicsnet.co.uk

Here the resistors are not all the same hence different amounts of current flow through each branch

Potential Difference represented by 'V'

- Potential difference is measured in Volts
- Energy transferred per unit charge, Joule per Coulomb
  - Measured across two points, as it is the amount of energy per unit charge to move from one point to the next
- Measured with a voltmeter, placed in parallel across a component
- There can be a voltage across a component, in a closed or open circuit
- When it is in a closed circuit, and there is a potential difference (voltage), current will always flow

$$E = QV$$

Energy transferred (joule, J) = charge moved (coulomb, C) × potential difference (volt, V)

Current, represented by 'I'

- Current is measured in amps
- Rate of flow of charge (the flow of electrons in the wires)
    - Measured at any single point on the circuit
- Measured with ammeter which is placed in series
    - $V = IR$
- Potential difference (volt, V) = current (ampere, A) × resistance (ohm, Ω)

Resistance

- Greater resistance, the harder it is for charge to flow through the component, therefore the current is smaller
- Variable resistor changes the amount of resistance of the component, changing the amount of current that flows in the circuit

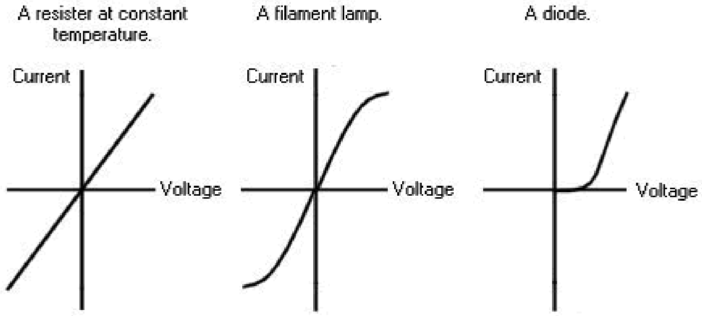
Series

- Components are connected end to end
- All the current flows through all the components
- Can only switch them all off at once
    - PD (potential difference) is shared across the whole circuit
        - PD of power supply = sum of PD across each component
    - Current is the same through all parts of the circuit
        - Current at one point = current at any other point
    - Total Resistance is the sum of the resistance in each component $R_1 + R_2 = R$
        - Resistance of two components is bigger than just one of them, because the charge has to push through both of them when flowing round the circuit

Parallel

- Components are connected separately to the power supply
- Current flows through each one separately
- You can switch each component off individually
    - PD is the same across all branches
        - PD of power supply = PD of each branch
        - Because charge can only pass through any one branch
    - Current is shared between each of the branches
        - Current through source = sum of current through each branch
    - Total resistance is less than the branch with the smallest resistance
        - Two resistors in parallel will have a smaller overall resistance than just one – $1/R1 + 1/R2 = 1/R$
        - Because charge has more than one branch to take, so only some charge will flow along each branch

Device Characteristics



inteleducationresources.intel.co.uk – gradient of each is 1/resistance, so a sharper gradient means a lower resistance

How resistance changes

- With current
    - As current increases, electrons (charge) has more energy
    - When electrons flow through a resistor, they collide with the ions in the resistor
    - The current here is doing work against the resistance
    - This transfers energy to the ions, causing them to vibrate more (heating resistor)
    - This makes it more difficult for electrons to flow through the resistor
        - So resistance increases, and current decreases
    - This may be a benefit, as some appliances like a toaster use heating filaments that have a high resistance to get hot easily.
- With temperature
    - Normal wires - See above, the same process occurs as atoms vibrate when hot
    - THERMISTOR ONLY
        - Hotter temperatures, resistance is lower
        - Used in temperature detectors/thermostats
- With Length
    - Greater length, the more resistance, and the lower the current
    - Electrons make their way through more resistor atoms, so it is harder to get through than if you were using a shorter wire
- With Cross Sectional Area
    - Thinner wires give greater resistance
    - Because less overall room for electrons to pass through between atoms
- With Light
    - LDR (Light Dependent Resistor) ONLY
        - Greater the intensity of light, the lower the resistance
            - So resistance greatest when dark
        - Used in automatic night lights
- With Voltage
    - DIODE ONLY
        - Diode allows current to flow freely in one direction
        - In the opposite direction, it has a very high resistance, so no current can flow

Efficiency – low resistance wires means less energy loss as current flows through the circuit

Testing Relationships:

- Points for All
  - Make sure component(s) do not overheat, leave to cooldown between each reading
  - Repeats and take average
- Varied wire resistance
  - Wires ranging in resistance from 1Ω to 10Ω
  - Connected to DC of 2, 4, 6, …, 10, 12V
  - Connected in series to an Ammeter, parallel to Voltmeter
  - Make sure all the other wires used have negligible resistance
  - Measure the current for each voltage for each wire
  - Plot a graph to show the relationship between the pd and current
- Filament Lamps
  - Connected to DC of 2, 4, 6, …, 10, 12V
  - Connect the filament lamp to Ammeter in series and Voltmeter in parallel,
  - Measure the current for each voltage
  - Plot a graph to show relationship between the pd and current
  - Non-linear shows R varies
- Diodes
  - Connected to DC of 1, 1.5, 2, 4, 6, …, 10, 12V
  - Connect to an Ammeter in series and Voltmeter in parallel,
  - Measure the current for each voltage
  - Switch the diode the other way round to record current for -1, -1.5, -2, -4V
  - Plot graph for the positive and negative potential differences to show the relationship
- LDR
  - Constant voltage of 12V
  - Connect to ammeter
  - Shine lamp immediately onto LDR and measure current
  - Move the lamp ~10cm away and measure current
  - Keep doing this until 50cm
  - Calculate resistance at each light intensity
  - Plot graph of resistance against light intensity
- Thermistor
  - Constant voltage of 12V
  - Connect to an Ammeter
  - Place in ice water with thermometer
  - Measure current at 0 degrees.
  - Add hot water and stir, measuring current at 10, 20, …, 60 degrees
  - Calculate the resistance
  - Plot a graph of resistance against temperature

Power

- Energy transferred (joule, J) = current (ampere, A) × potential difference (volt, V) × time (second, s)

$$E = I\,V\,t$$

- Power is energy transferred per second $P = \frac{E}{t}$
  - Power is directly proportional to current and voltage, so doubling current doubles power

$$P = IV$$

- Electrical power (watt, W) = current (ampere, A) × potential difference (volt, V)

$$P = I^2R$$

- Electrical power (watt, W) = current squared (ampere^2, A^2) × resistance (ohm, Ω)
- Power loss is proportional to resistance, and to current squared
- Energy is transferred from chemical potential in batteries to electrical energy in wires to any form of useful energy in the devices they power

AC/DC

- AC is alternating current, which comes from the mains
  - Current continuously varies, from positive to negative (charge changes direction)
- DC, direct current, is the movement of charge in one direction only
  - Cells and batteries supply direct current
- In the UK, mains supply is at 50Hz and 230V

Plug

- In a plug there are 3 different wires
- Live wire
  - This is a brown colour
  - It carries voltage from mains to appliance
  - This may be dangerous even if mains circuit is off, as current may still be flowing through it
- Neutral Wire
  - This is a blue colour
  - Completes the circuit
- Earth wire
  - This has green and yellow stripes
  - It is the safety wire used to stop the appliance becoming live
  - It is connected to the earth and to the casing
  - If the live wire touches the metal casing of the appliance, it will become live (you'll get a serious electric shock if you touch it, as current flows through you to the ground)
  - The earth wire is connected to the metal casing, and its low resistance means the current will go from the casing through the earth wire and to the ground
- Fuse
  - Connected to the live wire
  - If a large current passes through live wire, fuse heats up and melts, breaking the circuit – preventing a fire or damage

Power Rating – the power of the appliance when in use

- Greater power rating, greater energy consumption per second
  - So uses more energy in a given time