MODULE P5: ELECTRIC CIRCUITS

P5.1 Electric current - a flow of what?

1. explain that when two objects are rubbed together and become charged, electrons are transferred from one object to the other;
2. recall that there are repulsive forces between objects with similar charges, and attractive forces between objects with opposite charges;
3. explain simple electrostatic effects in terms of attraction and repulsion between charges;
4. recall that electrons are negatively charged;
5. recall that electric current is a flow of charge;
6. recall that electric current is measured in amperes;
7. explain that in an electric circuit the components and wires are full of charges that are free to move;
8. explain that when a circuit is made the battery causes these free charges to move, and that they are not used up but flow in a continuous loop;
9. recall that in metallic conductors an electric current is a movement of free electrons;
10. explain that in metal conductors there are lots of charges free to move but in an insulator there are few charges free to move.

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P5.2 What determines the size of the current in an electric circuit?

1. recall that the larger the voltage of the battery in a given circuit, the bigger the current;
2. explain that components (for example resistors, lamps, motors) resist the flow of charge through them;
3. recall that the larger the resistance in a given circuit, the smaller the current will be;
4. recall that the resistance of connecting wires is so small that it can usually be ignored;
5. recall that resistors get hotter when electric current passes through them, **and that this heating effect is caused by collisions between the moving charges and stationary atoms in the wire;**
6. recall that this heating effect makes a lamp filament hot enough to glow;
7. describe how the resistance of an LDR varies with light intensity;
8. describe how the resistance of a thermistor (ntc only) varies with temperature;
9. recognise and use the electrical symbols for a cell, power supply, filament lamp, switch, LDR, fixed and variable resistor, thermistor, ammeter and voltmeter;
10. explain that two (or more) resistors in series have more resistance than one on its own, because the battery has to push charges through both of them;
11. explain that two (or more) resistors in parallel provide more paths for charges to flow along than one resistor on its own, so the total resistance is less and the current is bigger;
12. use the equation:
    - $\text{resistance (ohm, }\Omega) = \dfrac{\text{voltage (volt, V)}}{\text{current (ampere, A)}}$

ⓘ **Rearrangement of the equation is expected only on higher tier.**

13. describe in words, or using a sketch graph, how the current varies with voltage in components whose resistance stays constant.

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P5.3 How do parallel and series circuits work?

1. describe how a voltmeter should be connected to measure the potential difference between any two chosen points;
2. recall that the voltage of a battery (measured in V) provides a measure of the ‘push’ of the battery on the charges in the circuit;
3. recall that potential difference is another term for voltage;
4. relate the potential difference between two points in the circuit to the energy transferred to, or from, a given amount of charge as it moves between these points;
5. describe the effect on voltage and current of adding further batteries in series **and in parallel** with original one;
6. understand that when several components are connected in series to a battery:
   - the current through each component is the same;
   - the potential differences across the components add up to the potential difference across the battery **(because the total energy transferred to each unit of charge by the battery must equal the amount transferred from it to other components);**
   - the potential difference is largest across the component with the greatest resistance, **because more energy is transferred by the charge flowing through a large resistance than through a small one;**
7. recall that when several components are connected in parallel directly to a battery:
   - **the potential difference (voltage) across each component is equal to the potential difference of the battery;**
   - **the current through each component is the same as if it were the only component present;**
   - the total current from (and back to) the battery is the sum of the currents through each of the parallel components;
   - the current is smallest through the component with the largest resistance, **because the same battery voltage causes more current through a smaller resistance than a bigger one.**

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P5.4 How is mains electricity produced?

Candidates will be assessed on their ability to:

1. recall that mains electricity is produced by generators;
2. recall that generators produce a voltage by a process called electromagnetic induction;
3. recall that when a magnet is moving into a coil of wire a voltage is induced across the ends of the coil;
4. recognise that if the ends of the coil are connected to make a closed circuit, a current will flow round the circuit;
5. recall that if the magnet is moving out of the coil, or the other pole of the magnet is moving into it, there is a voltage induced in the opposite direction;
6. explain that a changing magnetic field caused by changes in the current in one coil of wire can induce a voltage in a neighbouring coil;
7. describe the construction of a transformer as two coils of wire wound on an iron core;
8. recall that a transformer can change the size of an alternating voltage;
9. **be able to use the equation:**

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

10. describe how, in a generator, a magnet or electromagnet is rotated within a coil of wire to induce a voltage across the ends of the coil;
11. understand that the size of this induced voltage can be increased by:
    - increasing the speed of rotation of the magnet or electromagnet;
    - increasing the strength of its magnetic field;
    - increasing the number of turns on the coil;
    - placing an iron core inside the coil;
12. **describe how the induced voltage across the coil of a generator changes during each revolution of the magnet or electromagnet and explain that the current produced in an external circuit is an alternating current (a.c.);**
13. understand that the current from a battery is always in the same direction: it is a direct current (d.c.);
14. recall that mains electricity is an a.c. supply;
15. **explain that a.c. is used because it is easier to generate than d.c., and can be distributed more efficiently;**
16. recall that the mains supply voltage to our homes is 230 volts.

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P5.5 How much electrical energy do we use at home?

1. explain that when electric charge flows through a component (or device), energy is transferred to the component;
2. recall that the power (in watt, W) is a measure of the rate at which an appliance or device transfers energy;
3. use the following equation to calculate energy transfer in joules and kilowatt-hours:

   - energy transferred = power x time
     (joule, J) (watt, W) (second, s)
     (kilowatt hour, kWh) (kilowatt, kW) (hour, h)

4. use the equation:

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

ⓘ **Transformation of these equations is only required on the higher tier.**

5. know that a joule is a very small amount of energy, so a domestic electricity meter measures the energy transfer in kilowatt hours;
6. calculate the cost of electrical energy given the power, the time and the cost per kilowatt hour;
7. use the following equation in the context of different electrical appliances:

   - $\text{efficiency} = \frac{\text{energy usefully transferred}}{\text{total energy supplied}} \times 100\%$