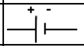
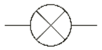
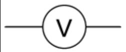
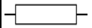
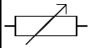
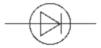
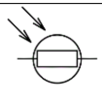
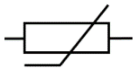
SP10-11 Electricity and Circuits

Kettering Science Academy

Lesson sequence

1. Electrical circuits
2. Current and potential difference
3. Current, charge and energy
4. Current, resistance and potential difference
5. More about resistance
6. Core practical – investigating resistance (CP15)
7. Transferring energy
8. Electrical power
9. Using electricity
10. Electrical safety
11. TRIPLE Charges and static electricity
12. TRIPLE Dangers and uses of static electricity
13. TRIPLE Electric fields

Circuit symbols

Switch	
Cell	
Battery	
Lamp	
Ammeter	
Voltmeter	
Resistor	
Variable resistor	
Diode	
LDR	
****Thermistor**	

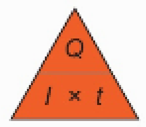
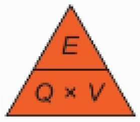
1. Electrical circuits

Delocalised electrons	Electrons that are free to move between many different atoms.
Conventional current	The flow of positive charge from the positive terminal towards the negative terminal (goes in the opposite direction to electrons).
Electron flow	Electrons flow from the negative terminal towards the positive terminal.
Series circuit	A circuit in which there is only one path for the current to flow.
Parallel circuit	A circuit with multiple paths for the current to flow.

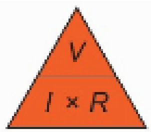
2. Current and Potential Difference

Amperes, A	The unit of measurement for current. Amps for short.
Ammeter	Used for measuring current. Connected in **series** to measure the current **passing through** a component or circuit.
Potential difference	Also called voltage. This is what pushes electrons around a circuit.
Volts, V	The unit of measurement for potential difference.
Voltmeter	Used for measuring potential difference. Connected in **parallel** to measure the potential difference **across** a component or circuit.
Current in series circuits	The **same** at all points in the circuit.
Current in parallel circuits	**Less** on the branches than at the battery. Current on branches adds up to that at the battery.
Potential difference in series circuits	Potential difference is **shared** between the components on a circuit. It adds up to be the same as the battery.
Potential difference in parallel circuits	Potential difference is the **same** across each branch as it is across the battery.

3. Current, charge and energy

Charge	The amount electricity that has flowed through a circuit.
Coulombs, C	The unit of measurement for charge.
Current, I	The number of coulombs of charge that flows past a point each second. 1 amp = 1 coulomb per second
Calculating charge	Charge = current x time $Q = I \times t$ Q is charge (C) I is current (A) T is time = (s) 
Voltage, V	The amount of energy transferred by each coulomb of charge. One volt = 1 joule per coulomb.
Calculating energy	Energy = charge x potential difference $E = Q \times V$ E is energy (J) Q is charge (C) V is potential difference (V) 

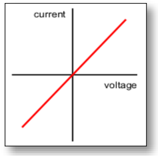
4. Current, resistance and potential difference

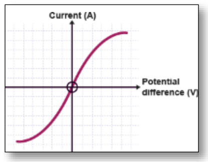
Resistance	The difficulty with which current passes through materials.
Ohms, Ω	The unit of measurement for resistance.
High/low resistance	Higher resistance → better insulator→ lower current Lower resistance →better conductor→ higher current
Changing current	Higher voltage → higher current Higher resistance → lower current
Calculating resistance 	Current = potential difference / resistance $I = V / R$ I is current (A) V is potential difference (V) R Is resistance (Ω) Note: This equation is normally written as $V = IR$.

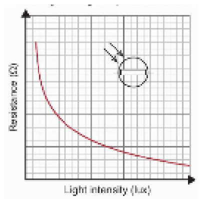
Resistors	Circuit components with differing resistance to control how much current flows to parts of a circuit.
Resistors in series	Total resistance is the sum of all of the resistors.
Voltage and resistors in series	Voltage is shared in proportion to the resistance. The resistor with more resistance takes more of the voltage. Calculate this using V=IR.
Resistors in parallel	Think about each branch of the circuit as a different series circuit. Resistors on different branches do not affect each other. The total resistance of resistors in parallel will always be **less** than resistors in series.

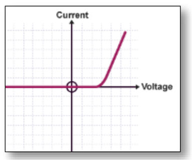
5. More about resistance

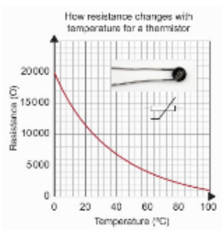
LDR	Light-dependent resistor. High resistance in dark, low resistance in light.
Thermistor	High resistance when cold, low resistance when hot.
Diode	High resistance in one direction, low resistance in the other.
Filament lamp	High resistance causes the filament to heat up, producing light.
Resistor graph	Current increases in direct proportion to voltage (straight line going through the origin (0,0)).
Filament lamp graph	Current increases as voltage increases, but levels out eventually as resistance increases with temperature.
Diode graph	Graph slopes up with a positive voltage but stays at 0 with a negative voltage.











6. Core practical CP15 Investigating resistance

CP15 - Aim	To explore how resistance changes in different circuits.
CP15 - Investigating resistance	Set up a circuit with an ammeter, resistor and voltmeter across the resistor. Vary the voltage and record voltage and current.
CP15 - Investigating series circuits	Set up a series circuit with an ammeter, two bulbs and voltmeters across each bulb and the power supply. Vary the voltage and record all readings
CP15 - Investigating parallel circuits	Set up a parallel circuit with two bulbs and ammeters on each branch and by the power supply, and voltmeters across each bulb and the powers supply. Vary voltage, record all readings.
CP15 - Results	Resistor – doubling voltage doubles current Series circuit – voltage at bulbs half of that at power supply Parallel circuit – voltage at bulbs equal to power supply, current half that at power supply

7. Transferring energy

Calculating energy transfer	Energy = current x potential difference x time E = I x V x t Energy (J) Current (A) Potential difference (V) Time (s)
Resistance and energy transfer	Electrons flowing through wires collide with atoms and lose energy. This energy is transferred to heat.

Electrical energy dissipation	When electrical energy is transferred to the surroundings as wasted heat energy by resistance.
How to reduce resistance	Use thicker wires, use shorter wires, use lower-resistance metals, reduce the temperature.

8. Electrical power

Power	The rate of energy transfer.
Watts, W	The unit of power: 1 W = 1 joule per second
Power and work done	$P = \frac{E}{t}$ P is power (W) E is work done (J) t is time (s)
Power, current and voltage	$P = I \times V$ P is power (W) I is current (A) V is the potential difference (V)
Power, current and resistance	$P = I^2 \times R$ P is power (W) I is current (A) R is resistance (Ω)

9. Using electricity

Mains electricity	The electricity supplied from wall sockets.
National grid	The systems of power lines and sub-stations that distributes electricity from power stations to homes and businesses.
Heaters	Transfer energy from electrical to thermal.
Motors	Transfer energy from electrical to kinetic.
Direct current	Current that flows in one direction.
Alternating current	Current that switches direction many times each second.
Frequency of mains current	Mains current alternates (switches direction) 50 times each second. The frequency is 50 Hz.

10. Electrical safety

Live wire	Brown, bottom right, 230 V, connects the appliance to the power station.
Neutral wire	Blue, bottom left, 0 V, completes the circuit.
Earth wire	Green and yellow, top, 0 V. Connects the appliance to the ground so current can flow there in the event of a short circuit.
Fuse	A thin metal wire that melts and breaks the circuit if there is too much current.
Circuit breaker	Breaks the circuit if too much current flows.
Advantages of circuit breakers	Quicker than fuses, just need switching - not replacing.

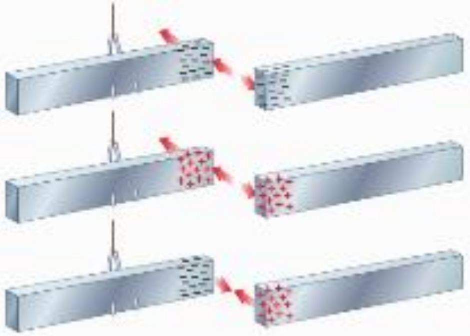
Lesson	Memorised?
Circuit symbols	
1.Electrical circuits	
2. Current and potential difference	
3. Current, charge and energy	
4. Current, resistance & potential difference	
5. More about resistance	
6. Core practical CP15 investigating resistance	
7. Transferring energy	
8. Electrical power	
9. Using electricity	
10. Electrical safety	

6a. Reducing resistance (HIGHER AND TRIPLE ONLY)

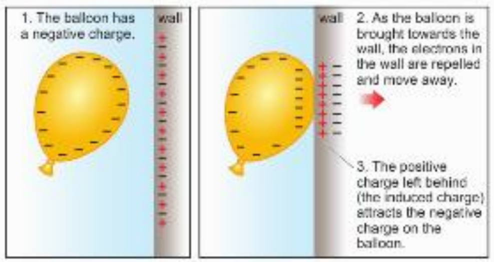
Reducing resistance	Use a low resistance metal for the wires. Make the wire thicker. Cool the wires so ions do not vibrate as much.

11. Charges and static electricity (TRIPLE ONLY)

insulators	Materials that can collect a charge because they do not allow charge to flow through them into other materials.
static electricity	Builds up on an insulating material when charge is unable to flow away into the surroundings.
(charging by) induction	When an object is charged by bringing another charged object near to it.



A Hanging rods with opposite charges attract each other and will move towards one another due to the force between them. Rods with the same charges repel.

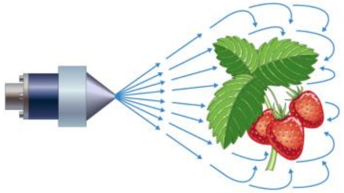


12. Dangers and uses of static electricity (TRIPLE ONLY)

discharging or earthing	When electrons flow from a charged object or person to earth to remove the excess charge. This sometimes causes a spark or an electric shock.
lightning	Static electricity builds up in clouds due to friction between particles of ice or water moved by air currents. When the charge is large enough, charged particles travel between the cloud and the earth, causing both lightning and thunder.
Refuelling aircraft	A charge can build up when fuel flows through a pipe. To prevent a spark, a bonding line is connected from the aircraft to earth before refuelling begins.
Petrol stations	At petrol stations the storage tanks, pipes and hoses are earthed. Cars are earthed through their tyres, which contain a type of carbon to make them conducting. People are earthed when they touch the metal car or pumps.
Electrostatic spraying	e.g. Paint spraying or spraying crops with insecticide. Charged droplets repel each other and spread out, coating the plant or object all around and underneath.

A Lightning conductors are an important way of earthing buildings and protecting them from lightning.

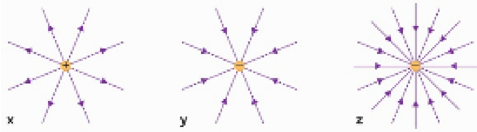
B The bonding line is attached while this aircraft is refuelled.



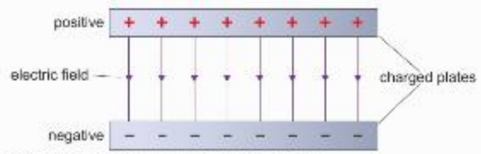
D Static electricity makes the droplets of insecticide spread out.

13. Electric fields (TRIPLE ONLY)

force field	The volume of space around an object in which another object can experience a force.
electric field (electrostatic field)	The force field around a charged object. Another charged object placed in this field will experience a force.
point charge	A single point that represents the charge on an object.
field lines	Lines that represent force fields.
field line rules	The rules are that field lines; *Never cross *Show where the field lines are strongest (where the lines are closest together) *Show the direction of the force on a charge in the field *Start on a positively charged object and end on a negatively charged object *If there is only one object, the lines keep going and become more widely spaced.



A an electric field around positive and negative point charges



C The electric field between two parallel plates is uniform.