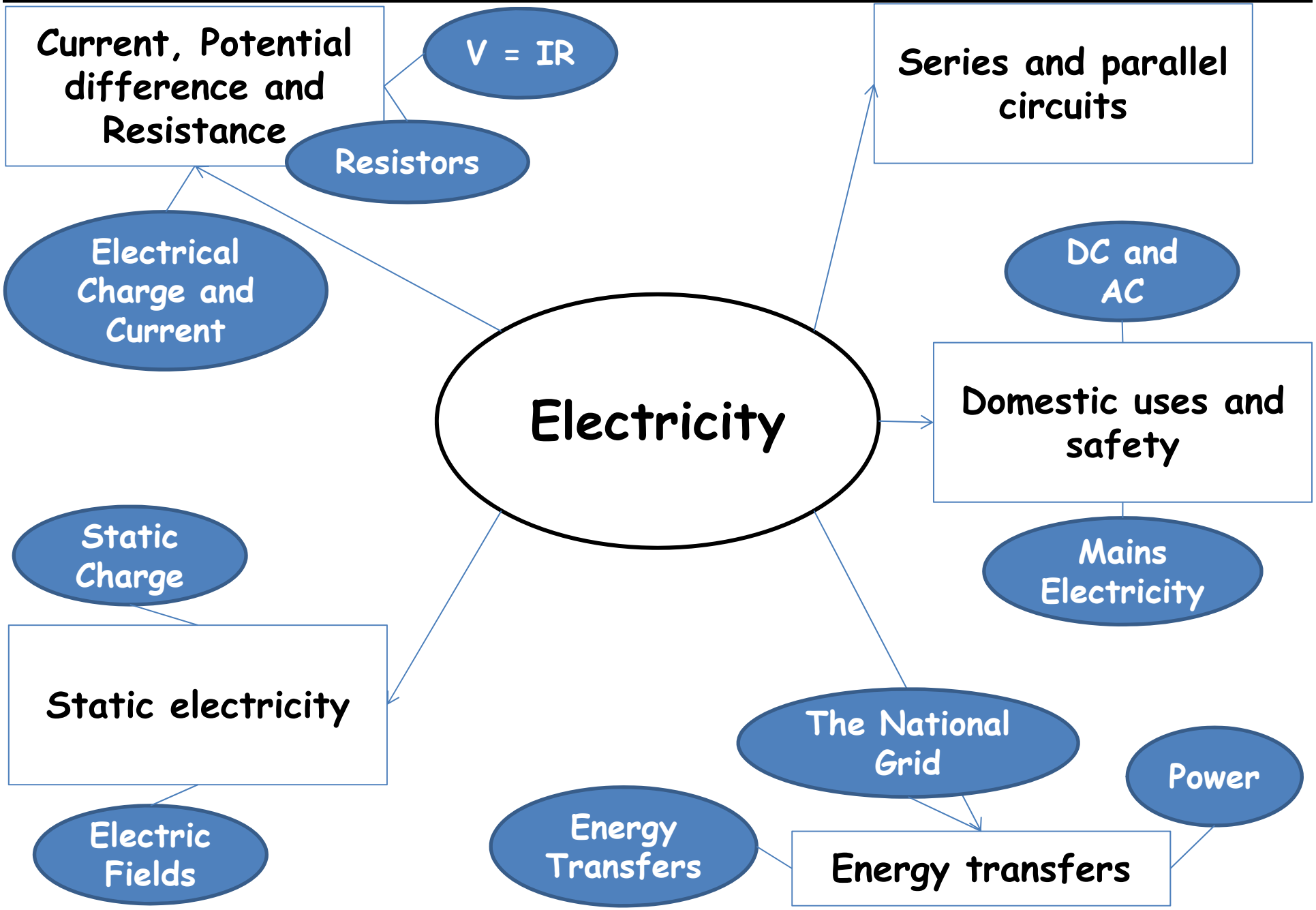
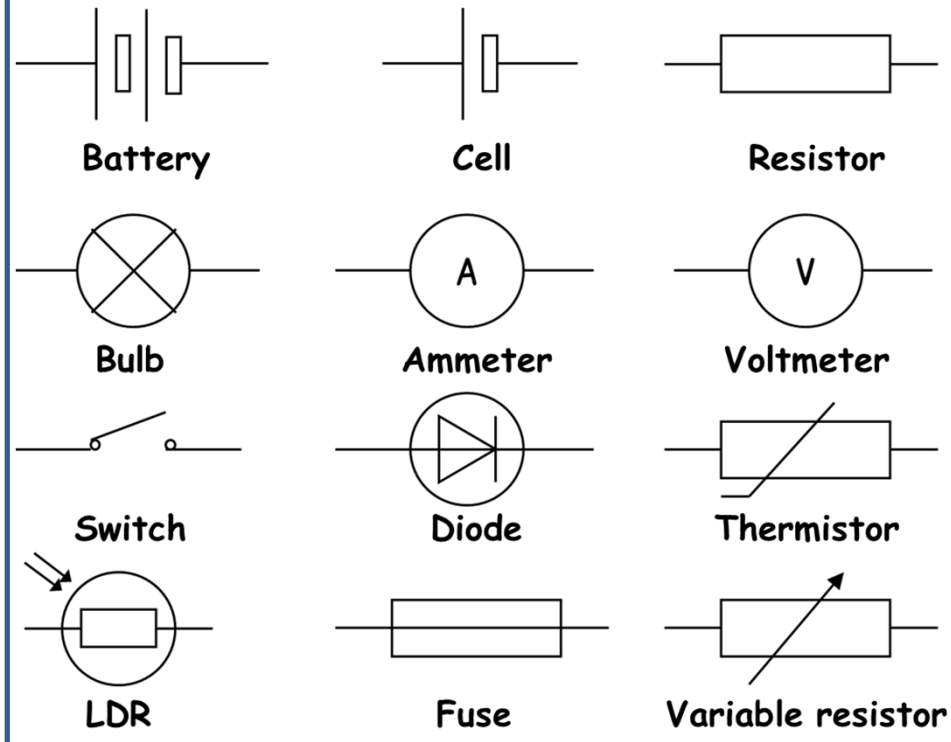
Unit 2: Electricity



Circuit Symbols and Current

You should be able to identify and recall the following symbols in your exam. You may need to label them, or you may need to draw them!

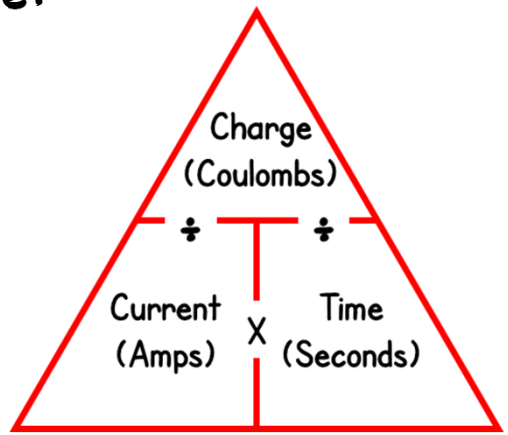


Draw circuit symbols with a ruler and a pencil. All circuits must be closed, so that you can follow all of the wires from start to finish with no breaks!

Current is the amount of charge, in Coulombs, that flows through a given point in a circuit in one second.

Current is measured in amperes (or Amps, A) and can be measured using an ammeter. Ammeters must be connected in series to work.

We can calculate the amount of charge that flows through a point in a circuit using the formula triangle:



What units do we measure each of the following quantities with?	
Charge	
Time	
Current	
Energy	

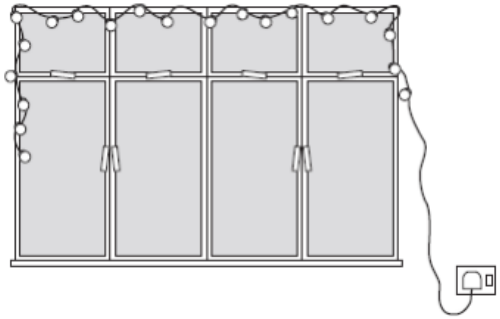
Calculate the charge transferred by each of these circuits:	
A 13A current flowing for 30s	
A 2A current flowing for 2 minutes	
A 2mA current flowing for 15 minutes	
A 0.4kA current flowing for 1 hour	

Calculate the time taken for a current of 2.1A to move a charge of 16C.	
33.6s	7.6ms
131.3ms	7.6s

Which of these factors will increase the charge flowing in a circuit?	
Decreasing the current	Adding more wires
Reducing the number of wires	Increasing the current

What current would transfer 10C of charge in 1 minute?	
10A	0.167A
600A	6A

A set of lights consists of 20 lamps connected in series to the 230 V mains electricity supply.



(a) When the lights are switched on and working correctly, the current through each lamp is 0.25 A.

(i) What is the total current drawn from the mains supply?

.....

(ii) Calculate the charge passing through **one** of the lamps in 5 minutes.

Show clearly how you work out your answer and give the unit.

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.....

Total charge = ...

(b) One of the lamps in the set is a fuse lamp. This contains a filament which melts if a fault occurs. A short time after the lights are switched on, a fault causes the filament inside the fuse lamp to melt and all the lamps go out.

The householder cannot find another fuse lamp so connects a piece of aluminium foil across the contacts inside the fuse lamp holder.
When switched on, the nineteen remaining lamps work.
What the householder has done is dangerous.

Explain why.

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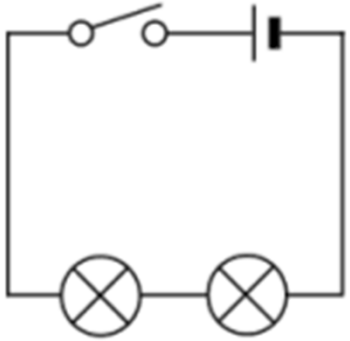
Circuit Symbols and Current: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify and draw circuit symbols			
Identify that current has the same value at any point in a single closed loop			
Identify that components and electrical devices are used to change energy from one store to another			
Describe that current is only able to flow through a closed circuit that has a source of potential difference			
Describe that electrical current is a flow of charge			
Calculate the amount of current that has flowed in a circuit			
Explain that the size of the electric current is the rate of flow of charge			

Series Circuits

Series circuits have all of the components in one main loop. These circuits are useful for simple devices, such as torches.



A disadvantage of using series circuits is that once one components break, the circuit will not work. This is because the circuit does not have a complete loop.

The current in a series circuit is the same all of the way around the circuit. So, if 5A of current is being produced by the battery, 5A of current will pass through each component.

$$I_1 = I_2 = I_3 = I_4 \ldots$$

The potential difference in a series circuit is shared between all of the of the components in the circuit. These always add up to the source PD.

$$V_{Total} = V_1 + V_2 + V_3 + V_4 + \ldots$$

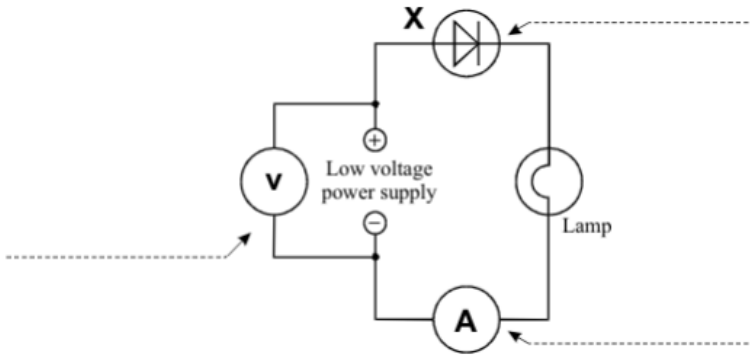
The total resistance in a series circuit is the sum of the individual resistances of each component.

$$R_{Total} = R_1 + R_2 + R_3 + R_4 + \ldots$$

If there is more than 1 battery in series with each other, the total potential difference supplied to the circuit will be the combined PD of the batteries

$$\text{Source PD}_{Total} = \text{Source PD}_1 + \text{Source PD}_2 + \ldots$$

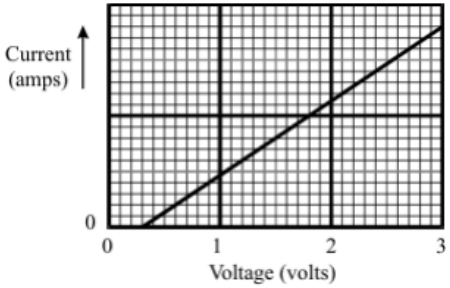
(a) Add the missing labels to the diagram.



(b) Some students use the circuit shown above.

They want to find out how the current through component X changes as they change the voltage.

The graph shows their results.



Describe, as fully as you can, what happens to the current through component X as the students increase the voltage.

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Series Circuits: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify a circuit as being either series or parallel			
Describe that the current at any point in a series circuit is the same			
Describe that the potential difference of the power supply in a series circuit is shared between the components			
Describe that the total resistance of components in series is the sum of the resistance of each component			
Calculate the potential difference, current and resistance values for a series circuit			

Parallel Circuits

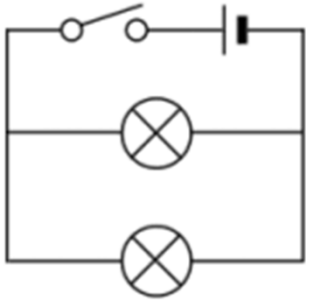
The Current in a parallel circuit is shared between each of the branches in the circuit. The current in each branch adds up to the current that flows through the power source.

$$I_{Total} = I_1 + I_2 + I_3 \ldots$$

The potential difference in a parallel circuit is the same on each branch. So, if 5V of PD is produced on 1 branch, 5V will be produced along every other branch in parallel in the circuit.

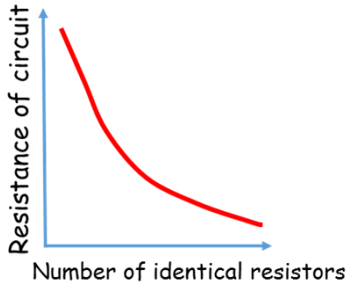
$$V_{Source} = V_1 = V_2 = V_3 = \ldots$$

A parallel circuit has a number of different loops with some components on each. These circuits are more complex, and more useful.



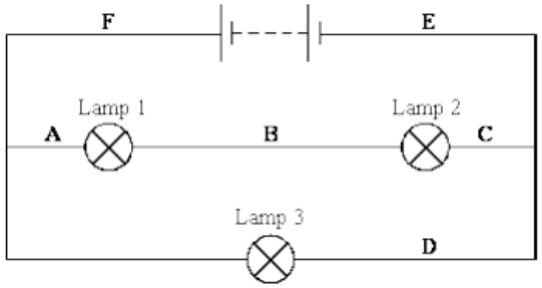
Parallel circuits are useful lots of devices. This is because if one of the components fails, the rest of the circuit will continue to work. The disadvantage is that the additional wire increases the cost of the circuit.

If resistors are placed in parallel with each other, the overall resistance of the circuit will decrease. This is because the current is shared between each of the resistors.



<u>You do not need to know the formula for this.</u>

The circuit contains three identical lamps.



(a) Complete each of the sentences about the circuit, using one of the phrases in the box.

more than	less than	the same as

(i) The current at **A** is ..... .the current at **B**.

(ii) The current at **A** is ..... .the current at **D**.

(iii) The current at **F** is ..... .the current at **E**.

(iv) The current at **F** is ..... .the current at **D**.

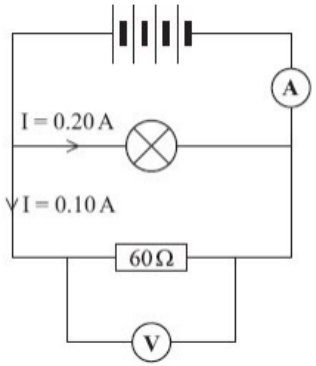
(b) In the circuit, which lamp is brightest?.....

Give a reason for your answer.

.....

.....

A circuit was set up as shown in the diagram.



(a) Each cell provides a potential difference of 1.5 volts.

(i) What is the total potential difference provided by the four cells in the circuit?

.....

Total potential difference = ... volts

(ii) What will be the reading on the voltmeter?

.....

(b) The current through the lamp is 0.20 amps.
The current through the resistor is 0.10 amps.

What is the reading on the ammeter?

.....

Reading on ammeter = ... amps

(c) Use a phrase from the box to complete the following sentence.

greater than	**equal to**	**smaller than**

The resistance of the lamp is ..... 60 Ω.

Give a reason for your answer.

.....

.....

Parallel Circuits: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify a circuit as being either series or parallel			
Describe that the potential difference across each branch in a parallel circuit is the same as the source potential difference			
Describe that the total current through the whole circuit is the sum of the currents through separate branches			
Calculate the potential difference and current values for a parallel circuit			
Explain that the total resistance of two resistors in parallel is less than the resistance of the smallest individual resistor			

A current of 2A flows through two resistors that are connected in series, one with a resistance of 3Ω and one with a resistance of 2.5Ω. What is the total resistance?	
5.5Ω	11Ω
0.5Ω	1Ω

Which 2 of these statements are correct?	
The current is the same at every point in a series circuit	The current is the same at every point in a parallel circuit
The PD is the same across each part of a parallel circuit	The PD is the same across each part of a series circuit

A bulb and a resistor in a series circuit. Complete these sentences to explain what would happen if the resistance of the resistor was increased?	
The brightness of the bulb _____	
The potential difference across the bulb and resistor _____	
The potential difference across the resistor _____	
The current through the circuit _____	

A current of 2A flows through two resistors that are connected in series, one with a resistance of 3Ω and one with a resistance of 2.5Ω. These resistors are placed in parallel. What happens to the total resistance?	
The total resistance is more in the parallel circuit that in the series circuit	The total resistance is less in the parallel circuit that in the series circuit
The total resistance is the same in both circuits	It is not possible to know what the total resistance will be

Series and Parallel Circuits: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify issues in series and parallel circuits by looking at schematic diagrams			
Construct both series and parallel circuits from schematic diagrams			
Describe the key differences between series and parallel circuits			
Explain, without calculation, why adding resistors in series increases the overall resistance, and why adding resistors in parallel decreases the total resistance			
Apply understanding of series and parallel circuits to solve problems for circuits which include resistors in series using the idea of resistance equivalence			

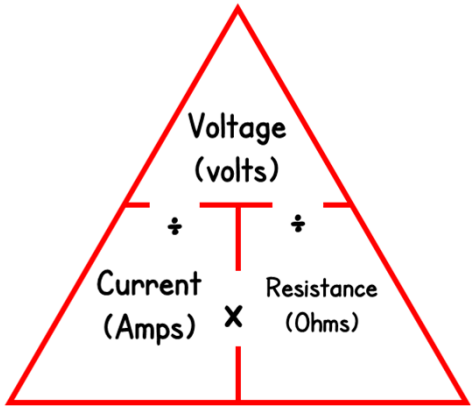
Current, Voltage and Resistance

Resistance is a measure of how easy or difficult it is for electricity to flow around a circuit.

Devices, like wires, that allow electricity to flow easily through them are called conductors. They have a low resistance.

Other devices, like resistors, that restrict the flow of current in a circuit have a high resistance.

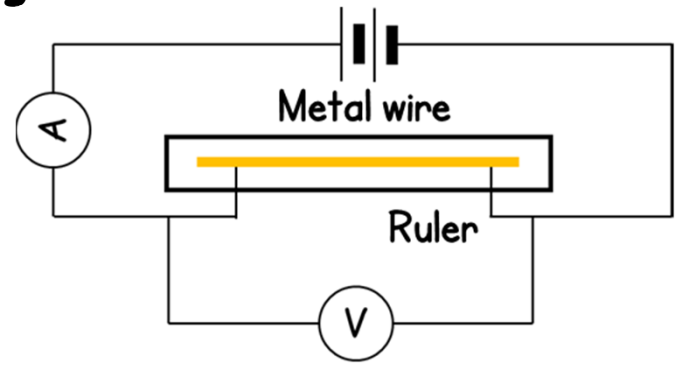
Resistance can be calculated using the equation triangle:



To increase the resistance of a circuit, we could…

- Decreasing the thickness of the wires in the circuit
- Add more components to the circuit
- Increase the potential difference provided from the power pack

You can investigate the resistance of a wire in a circuit by measuring the potential difference across the component and the current flowing through it.



Some components were put into a circuit where the PD across them and the current flowing through them were measured. Calculate the resistance of each component.	
16A of current and 4V PD	
4A of current and 32V PD	
4A of current with 16V PD	
2A of current and 4V PD	

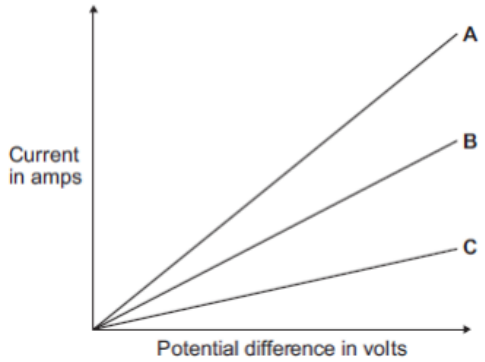
Two resistors of 3Ω and 2Ω are connected in series with a 10V battery. Which of the following is correct?	
The 2Ω resistor has 5A current flowing through it	The 3Ω resistor has 2A current flowing through it
The potential difference is the same across each resistor	The 3Ω resistor has 50% more current flowing through it

Which of the following components has the highest resistance?	
A bulb with 5A of current and 5V of PD	A wire with 2A of current and 3V of PD
A LDR with 10V of PD and 11A current	A thermistor with 33A of current and 99V PD

Which two of these statements are true?	
As resistance is increased on a variable resistor, current in the circuit increases	Two resistors of 5Ω and 3Ω are connected in series so their equivalent resistance is 8Ω
Two resistors of 5Ω and 3Ω are connected in parallel so their equivalent resistance is 8Ω	Two resistors are connected in series. The PD across them is 6V and 2V, so the PD across both is 8V

(a) **Figure 1** shows the current–potential difference graph for three wires, **A**, **B** and **C**.

Figure 1



(i) Using **Figure 1**, how can you tell that the temperature of each wire is constant?

.....

.....

(ii) Which **one** of the wires, **A**, **B** or **C**, has the greatest resistance?

Write the correct answer in the box. ☐

Give a reason for your answer.

.....

.....

.....

(b) A student measured the resistance of four wires.

The table below shows the resistance of, and other data about, each of the four wires, **J**, **K**, **L** and **M**.

Wire	**Type of metal**	**Length in cm**	**Diameter in mm**	**Resistance in ……**
J	copper	50	0.17	0.36
K	copper	50	0.30	0.12
L	copper	100	0.30	0.24
M	constantan	100	0.30	7.00

(i) The last column of the table should include the unit of resistance.

What is the unit of resistance?

.....

(ii) The resistance of a wire depends on many factors.

Look at the table. Which **two** wires from **J**, **K**, **L** and **M** show that the resistance of a wire depends on the **length** of the wire?

Wire ☐ and wire ☐

Give a reason for your answer.

.....

.....

.....

(iii) A student looked at the data in the table and wrote this conclusion:

'The resistance of a wire depends on the type of metal from which the wire is made.'

The student could **not** be certain that her conclusion is true for **all** types of metal.

Suggest what extra data is needed for the student to be more certain that the conclusion is correct

.....

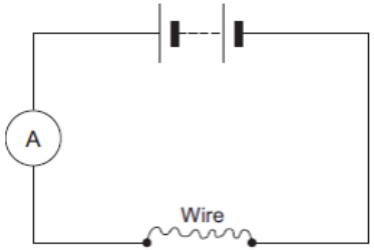
.....

.....

(c) The resistance of a wire can be calculated using the readings from an ammeter and a voltmeter.

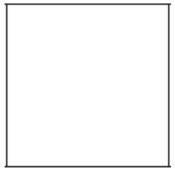
(i) Complete **Figure 2** by drawing a voltmeter in the correct position in the circuit. Use the correct circuit symbol for a voltmeter.

Figure 2



(ii) In a circuit diagram, a wire can be represented by the symbol for a resistor.

In the box below, draw the circuit symbol for a resistor.

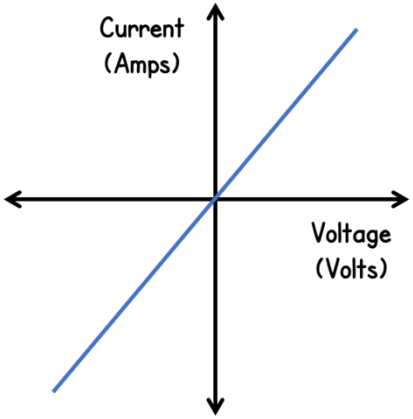


Current, Voltage and Resistance: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Describe that the larger the resistance of a component, the smaller the current for a given potential difference			
Describe how to investigate the factors that affect the resistance in an electrical circuit. This should include the length of a wire and different combinations of resistors			
Describe that work is done when charge flows in a circuit			
Explain that the current that flows through a component depends on the resistance of the component and the potential difference across it			
Calculate the potential difference transferred to, current flowing through and resistance of a component in a circuit			

Ohmic Conductors and Semi-Conductors

For an Ohmic conductor, like a wire or resistor, the resistance will stay the same as long as the temperature does not change. This means that current increases at the same rate as the potential difference.

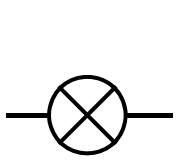


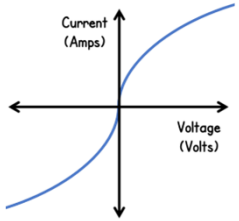
If we plot this data on a graph, we will get a straight line graph – this shows a proportional relationship.

The resistance of a semi-conducting component changes depending on the environment. There are 4 that you need to know about (and in more detail than is below, these are the key points)!

Filament lamp:

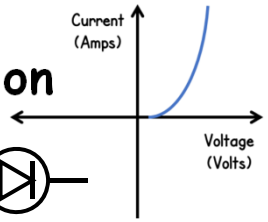
- Filament heats up with increased current
- This increases resistance





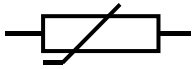
Diode:

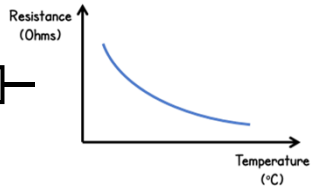
- Current only flows in one direction
- Opposite direction has high resistance



Thermistor:

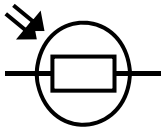
- High temperature gives a low resistance

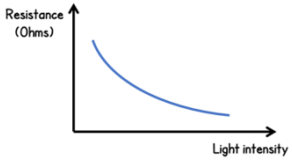




LDR:

- High light intensity, low resistance





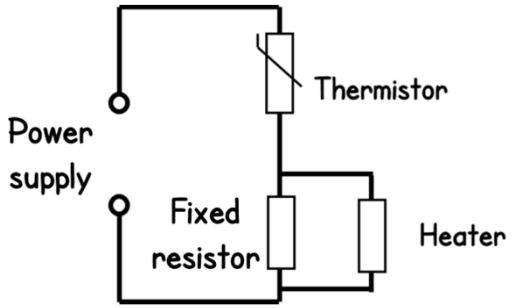
Using Semi-conducting Components

Semi-conducting components can be used as part of a sensor circuit. These types of circuits are used to control devices, such as street lamps and boilers, to turn something on (or off) depending on the environment.

Turning on a heater

The fixed resistor and the heater are in parallel, so will have the same PD across them.

The PD from the power supply is shared between the thermistor and the fixed resistor; the cooler it is, the more PD will be lost over the thermistor, so less PD will be over the fixed resistor and the heater. This will keep the heater off



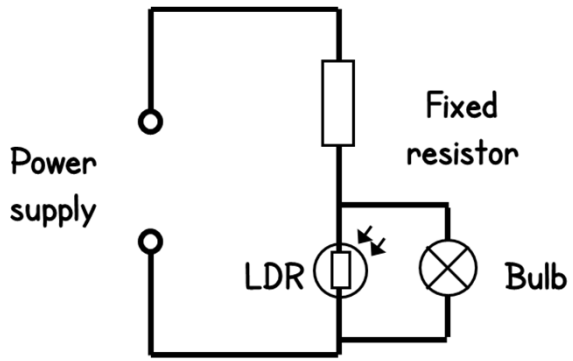
As the temperature rises, the resistance will drop over the thermistor, increasing the PD across the fixed resistor and heater. This will turn the heater on.

Turning on a street lamp

A lightbulb is connected with an LDR, meaning that the PD across both the bulb and the LDR will be the same.

This means that when it is dark, the LDR has a high resistance: the light bulb will have a larger current.

As it gets lighter, the resistance in the LDR decreases, allowing more current to flow through it. This turns the light bulb off!



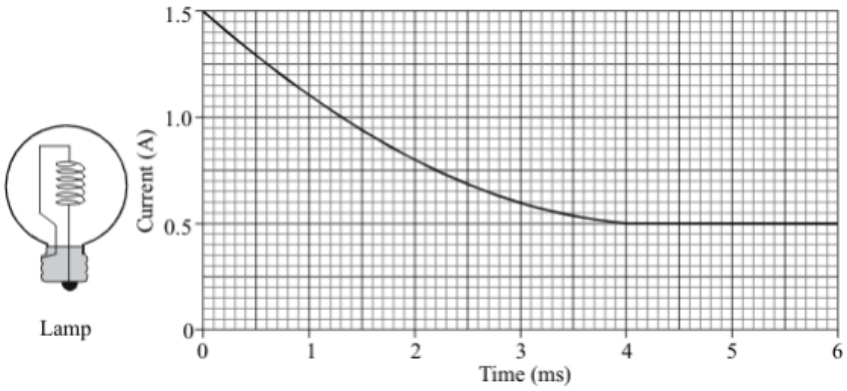
Which of these components could be used to control an oven's temperature?	
Thermistor	LDR
Diode	Filament bulb

A lightbulb is connected to an LDR circuit; the voltage supplied to it is controlled by the intensity of light hitting the LDR. The circuit should be set up so that, as it gets darker, the bulb increases in brightness. Which two of these statements are true?	
The voltage across the LDR decreases with increasing light intensity	The lightbulb should be connected across the LDR
A resistor is required to divide the voltage in the LDR circuit	The current through the bulb in always equal to the current through the LDR

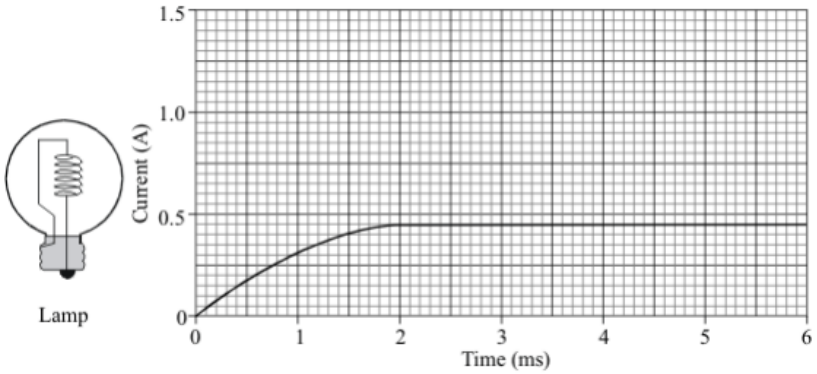
Which of the statements below describe an LDR in the dark?	
High resistance, high current, few free electrons	Low resistance, high current, many free electrons
High resistance, low current, few free electrons	High resistance, low current, many free electrons

A thermistor is used to monitor the temperature of an incubator for new born babies. Which two of the following are required?	
A calibration circuit to match current or voltage readings of the thermistor to the temperature displayed	A variable resistor to control the current when the temperature increases
A power supply to produce a current in the circuit	An LDR to measure light levels in an incubator

A computer is set up to produce a graph of the current through an electric lamp during the first few milliseconds after it is switched on.



The lamp is modified then tested in the same way.



(a) Describe **three** differences in the way the lamp behaves after it has been modified.

1. .....

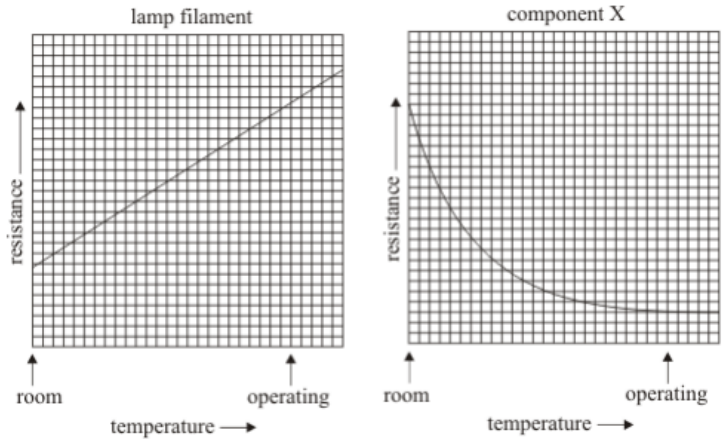
2. .....

3. .....

(b) The current through the modified lamp depends on the total resistance of the filament and component X.

The smaller this total resistance is, the greater the current.

The following graphs show how the resistance of the lamp filament and component X change as the lamp heats up to its operating temperature.



Use the information shown on the graphs to explain the behaviour of the modified lamp.

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Ohmic Conductors and Semiconductors: Checklist

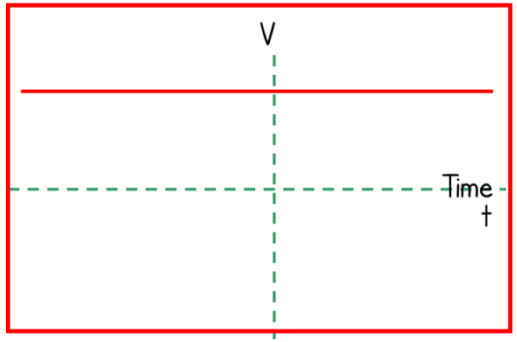
For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify the voltage-current graphs for a resistor, filament bulb, diode, thermistor and LDR			
Identify that a diode only allows current to flow in one direction			
Describe that the current through an Ohmic conductor (at a constant temperature) is directly proportional to the potential difference across the resistor – this means that the resistance stays the same			
Describe that the resistance of lamps, diodes, thermistors and LDR's are not constant, and change with current			
Describe how to investigate the IV characteristics for a range of different circuit components			

Ohmic Conductors and Semiconductors: Checklist

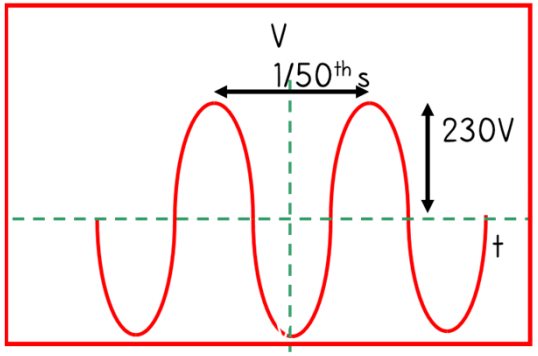
For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Explain why the resistance of a filament lamp increases as the current increases			
Explain that the resistance of a thermistor decreases as the temperature increases			
Explain that the resistance of an LDR decreases as light intensity increases			
Explain the design and use of some circuits for measurements, testing and control purposes			
Explain the design and use of a circuit to measure the resistance of a component by measuring the current through, and potential difference across, the component			
Apply understanding of circuits to explain the applications of LDR's and thermistors in circuits			

AC and DC

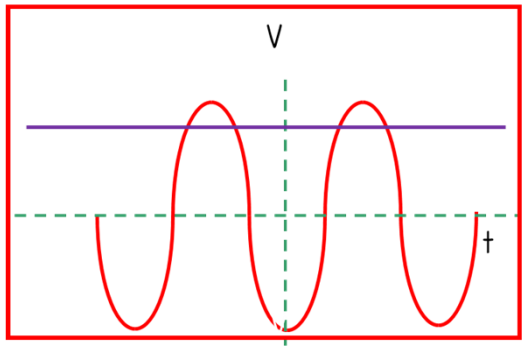
Direct current is the type of current provided by a battery and school power pack. The current flows in one direction.



Alternating current is provided by main electricity; this is 230V in the UK. It flows in both directions; this changes 50 times a second in the UK.



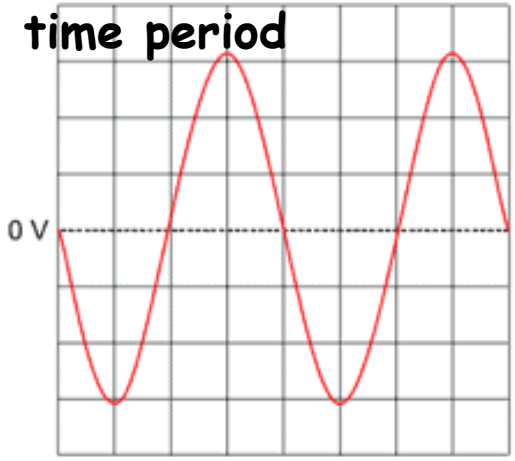
When AC and DC is compared, AC appears to be slightly higher. This is to make up for the AC changing direction.



You will need to be able to read the time period, frequency and peak of an AC supply from an oscilloscope. The x-axis will represent time (each square will represent a given amount of seconds) and the y-axis will show the amplitude and peak voltage. This will be in a given amount of volts.

Frequency = 1 ÷ time period

Be careful with the time scale, as it may be given in ms!



The gradient of a voltage-current graph for a resistor is found to be 0.02. What is its resistance?	
50Ω	20Ω
200Ω	5Ω

What component is being described?	
Measures the amount of charge that flows in a second	
Generates light energy at high temperatures	
Measures the difference in electrical energy per unit charge between two points in a circuit	
Reduces the current in a circuit pathway through electron-ions collisions	

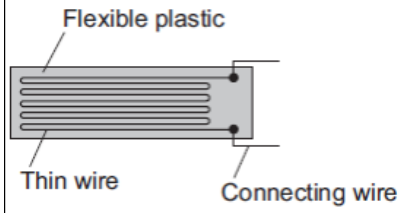
Which component can be used to manually control current flow through a circuit?	
Resistor	Light dependent resistor
Thermostat	Variable resistor

Which two of these statements are true?	
Filament bulbs only produce light when the filament becomes hot	Resistors decrease the current in a circuit when the voltage is increased
Ammeters are connected in parallel	The gradient of an IV graph is a measure of a components conductance

Which of these components would <u>not</u> be required to measure the IV characteristics of a diode?	
Variable resistor	Voltmeter
Thermistor	AC supply

The diagram shows a strain gauge, which is an electrical device used to monitor a changing force.

Applying a force to the gauge causes it to stretch.
This makes the electrical resistance of the wire change.



(a) (i) Using the correct symbols, **add** to the diagram to show how a battery, an ammeter and a voltmeter can be used to find the resistance of the strain gauge drawn above.

(ii) When in use, the strain gauge is always connected to a d.c. power supply, such as a battery.

How is a d.c. (direct current) power supply different from an a.c. (alternating current) power supply?

.....

.....

.....

(b) Before any force is applied, the unstretched gauge, correctly connected to a 3.0 V battery, has a current of 0.040 A flowing through it.

(i) Calculate the resistance of the unstretched gauge.

Show clearly how you work out your answer.

.....

.....

Resistance = ... Ω

(ii) Stretching the gauge causes the current flowing through the gauge to decrease.

What happens to the resistance of the gauge when it is stretched?

.....

.....

(iii) What form of energy is stored in the gauge when a force is applied and the gauge stretches?

.....

AC and DC: Checklist

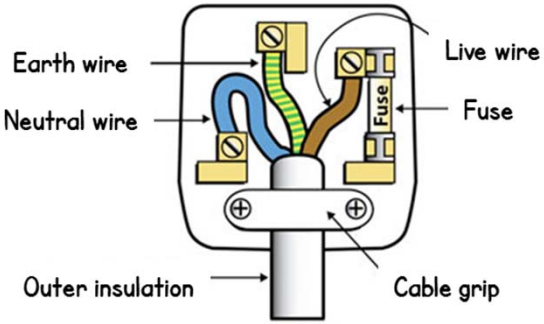
For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify the mains electricity supply in the UK as having 230V and a frequency of 50Hz			
Describe mains electricity as being a supply of alternating current			
Explain the differences between direct and alternating potential difference			

Plugs and the Earth Wire

Most electrical appliances are connected to a mains power supply by 3 core cables. This means they have 3 wires inside of them, each made from copper with a different coloured plastic cover. Each wire has a different job!

The earth wire
This is a green and yellow wire that is used for protecting the device from an excess current. If the fuse breaks, the electricity will flow along the earth wire to prevent the user from receiving an electric shock. The potential difference of this wire is around 0V.

The neutral wire
This is a blue wire that carries the current back to the source. This has a potential difference that is close to 0V.



The cable grip
This is a piece of plastic that is used to help keep everything in place.

The outer insulation
A plastic cover that protects the user against an electric shock.

The live wire
This is a brown wire that provides the alternating potential differences from the mains. This is around 230V.

The fuse
This is a thin piece of wire that is designed to melt when too much current flows through it. This protects the device against current surges.

Which of these is <u>not</u> found in a UK plug?	
Insulating material	Fuse
Earth wire	Battery

Identify a precaution that could be taken to prevent someone from receiving an electric shock	
Loose wire touching metal casing	
Current spikes in the live wire	
Current leakage from wires	
High current in electrical cables	

What is being described in the descriptions?	
Does not conduct electricity, preventing current from passing away from wires	
Melts at high currents to break the circuit	
Provides a pathway for excess charge from metal in faulty appliances to flow to Earth	
Detects differences in current between the live and neutral wires, breaking the circuit when there is a difference	

Alternating current generated in some countries changes direction 120 times in two seconds. What is its frequency?	
2Hz	50Hz
60Hz	120Hz

(a) Describe the difference between an alternating current (a.c.) and a direct current (d.c.).

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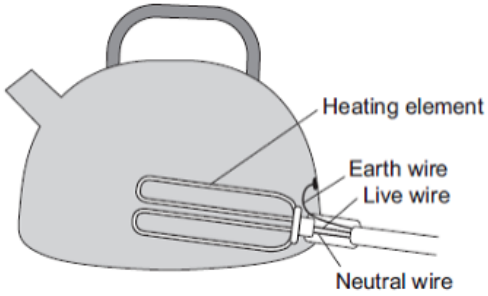
(b) The diagram shows how the electric supply cable is connected to an electric kettle.
The earth wire is connected to the metal case of the kettle.



If a fault makes the metal case live, the earth wire and the fuse inside the plug protect anyone using the kettle from an electric shock.

Explain how.

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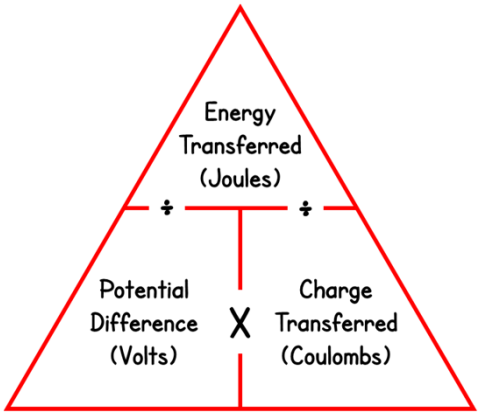
Plugs and the Earth Wire: Checklist

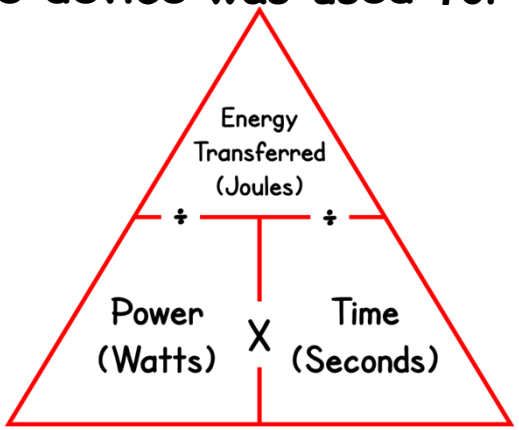
For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify that most electrical appliances are connected to the mains supply using a three core cable			
Identify each colour of wire has a different purpose and operating voltages (blue – neutral wire [0V], brown – live wire [230V], green and yellow – earth wire [0V])			
Describe that the live wire carries the alternating potential difference from the power supply			
Describe that the neutral wire completes the circuit			
Describe that the Earth wire is a safety wire to prevent the appliance becoming live, and only carries current away from the device if there is a fault			
Explain that a live wire is dangerous, even when the circuit is not completed			

Power, Energy and Charge and Fuses

When charge passes through a circuit, it warms up. This is because electrons collide with the atoms that are in the components. The atoms turn their kinetic energy into thermal energy. This shows scientists that energy is being transferred, and work is being done. Energy, PD and Charge are connected with this formula triangle:



When an electrical device is switched on, electrical energy starts to be converted. Different types of energy can be transferred from different devices. The rate that this energy is transferred is dependent on the power rating of the device. You can calculate the energy transferred using the power rating and the time the device was used for:



Using the equations:

$$E = P \times t$$
$$E = V \times Q$$
$$Q = I \times t$$
$$V = I \times R$$

You can form 3 new equations for the power of a device:

$$P = I \times V$$
$$P = V^2/R$$
$$P = I^2 \times R$$

<u>These can be used to find the power of a device, even if we don't know the voltage, current or resistance!</u>

Power, Energy and Charge and Fuses

Most electrical items have an information plate on them. This shows the key information about the device, such as the working voltage and current. This information can be used to decide what size of fuse to put into a device.

This device has a power rating of 2000W when it is using 240V. This is the potential difference supplied by plug sockets in the UK, at a frequency of 50Hz. We can use the equation P = I x V to find the maximum current that can flow through the device.

$$2000W = I \times 240V \rightarrow 2000W/240V = I = 8.33A$$

So the maximum current that can flow through this device is 8.3A. In this device, you would need to use a 13A fuse.

Electrical safety – RCCB's and Fuses

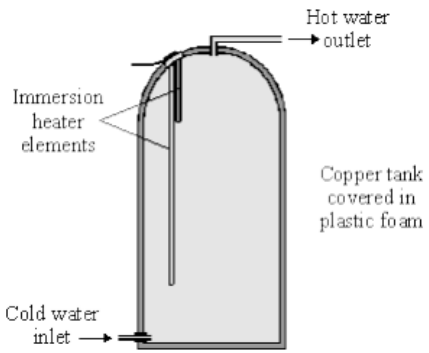
RCCB

- Turns off is there is a large difference between the current entering and current leaving an appliance.
- Can be reused
- Expensive

Fuse

- A wire in the fuse melts if too much current flows through it
- Cheap
- Easily replaced
- Not reusable

The diagram shows a type of electric immersion heater in a hot water tank. These hot water tanks are normally found in airing cupboards.



Information on the immersion heater states:

230 V
10 A

(a) (i) What is the equation which shows the relationship between power, current and voltage?

.....

(ii) Calculate the power of the heater. Show clearly how you get to your answer and give the units.

.....

Power = ...

(b) (i) What rating of fuse should be in the immersion heater circuit?

.....

(ii) There are three wires in the cable to the immersion heater. Two of the wires are connected to the immersion heater. The third wire is connected to the copper tank.

Explain the function of this third wire and the fuse in the circuit.

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(c) (i) What is the equation which shows the relationship between resistance, current and voltage?

.....

(ii) Calculate the resistance of the heater. Show clearly how you get to your answer and give the units.

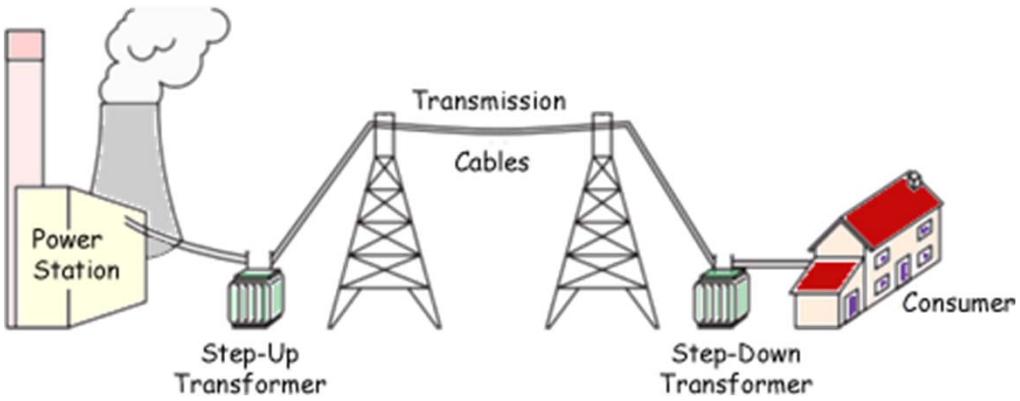
.....

Resistance = ...

Power, Energy and Charge and Fuses: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify that the more powerful a device, the more energy used in a given time			
Describe the relationships between power, potential difference and current			
Describe the relationship between power, current and resistance			
Calculate the amount of energy transferred to a device, using either power and time, or charge and potential difference			
Calculate the power of a device if given the potential difference, current, and/or resistance of a device			
Explain how the power transfer in any circuit device is related to the potential difference across it and the current through it			

The National Grid



The National Grid consists of 3 key parts:

- Transformers
- Cables
- Pylons

Transformers are devices that increase or decrease the potential difference of the electricity supply that leaves the power station.

Step-Up transformer

- Increases potential difference to 400,000V
- Reduces electrical current
- This reduces power loss.

Step-Down Transformer

- Decreases potential difference to 230V
- Increases electrical current
- This makes it safe for us to use in our homes

There is a problem with cables: they get hot! This would mean that lots of energy would be lost as heat as the electricity is transferred.

To reduce the energy loss, the current is kept low, and the potential difference is increased. This means that each electron will have more electrical energy, but will move slower through the cable!

Pylons are used to keep the wires from the ground. This reduces the risk of people being electrocuted, but increases the risk of low flying air craft hitting them

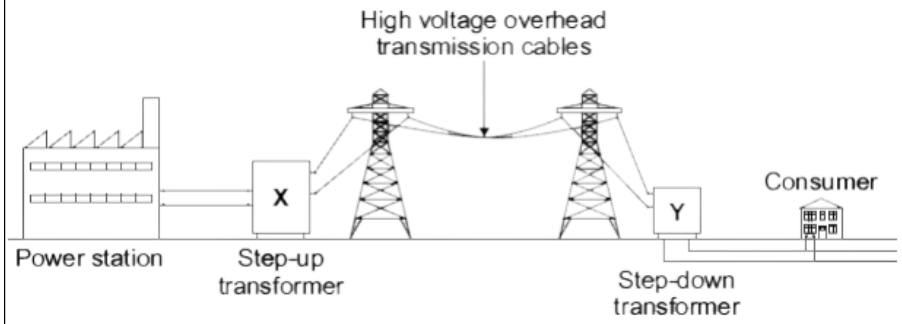
Which of the following would result in electrical energy being lost as thermal energy?	
Higher power	High current
High resistance	High potential difference

Name the part of the National grid that is being described below.	
Reduces current in power lines	
Produces electricity	
Reduces potential difference to a safe level for domestic use	
Provides users with alternative sources of power and routes by which it is delivered	

Why is the UK's power supply set up as a grid?	
To reduce the resistance in the system	To have the capacity to transport higher currents
To have the capacity to transmit more electrical power	To be able to supply power from different sources and using different routes

What two things are step-up transformers designed to do?	
Increase current	Decrease current
Increase electrical power	Increase potential difference

The diagram shows the National Grid system.



(a) The National Grid includes step-up transformers.

Explain why.

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(b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Over the next 10 years, more than 300 kilometres of new high voltage transmission cables are to be added to the National Grid. Most of the new cables will be suspended from pylons and run overhead while the rest will be buried underground.

Outline the advantages and disadvantages of both overhead transmission cables and underground transmission cables.

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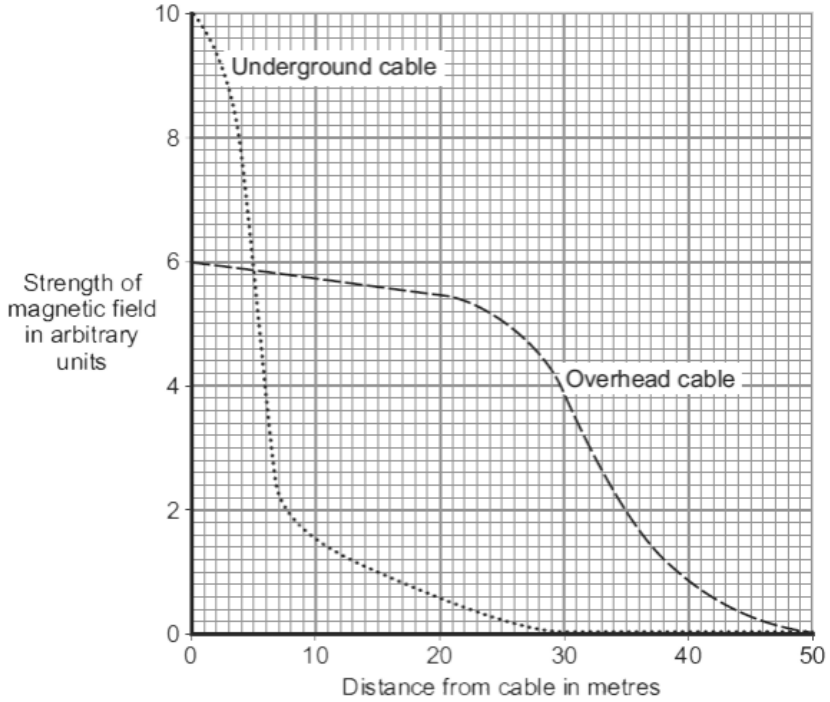
(c) When an electric current flows through a transmission cable, a magnetic field is produced.

The graph shows how the strength of the magnetic field varies with distance from both overhead and underground transmission cables that carry the same current.



What conclusions may be drawn from this graph?

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(d) Some people think that, because of the magnetic fields, living close to transmission cables is dangerous to health. Laboratory studies on mice and rats exposed to magnetic fields for two or more years found that the magnetic fields had no effect on the animals' health.

Draw a ring around the correct answer in the box to complete the sentence.

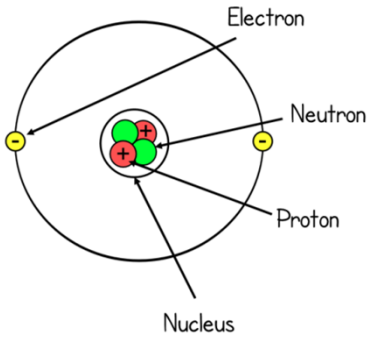
Using animals in scientific research raises [economic / environmental / ethical] issues.

The National Grid: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify the key parts that make up the National Grid			
Describe that electrical power is transferred from power stations to consumers and businesses using the National Grid			
Explain the purpose of step-up and step-down transformers			
Explain why the National Grid system is an efficient way to transfer energy			

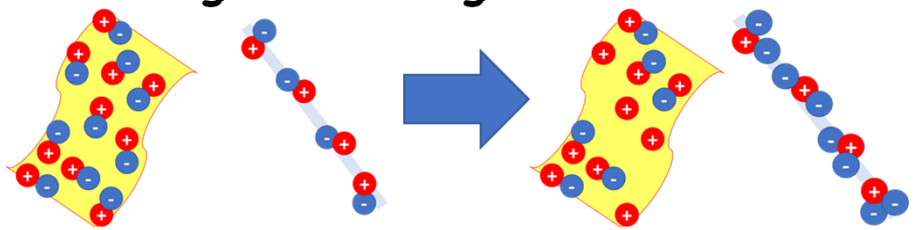
Static Electricity and its Uses – Physics Only

Atoms are made up of protons, electrons and neutrons. Electrons can be transferred easily from atom to atom as they are on the outside.

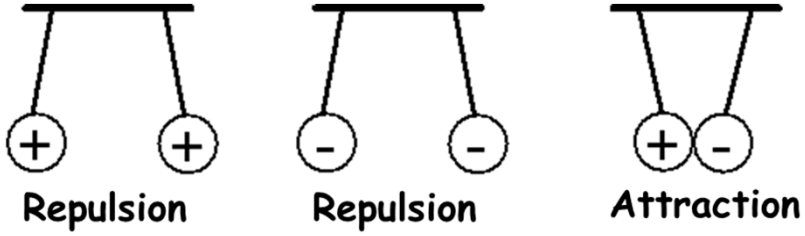


	Charge	Mass
Proton	+1	1
Neutron	0	1
Electron	-1	1/2000

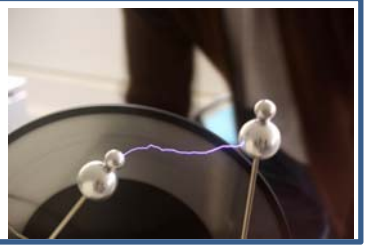
Most objects have an equal amount of positive an negative charge. When insulating materials are rubbed together, electrons are transferred. This leaves one object with an overall positive charge, and the other with an overall negative charge



If two objects are brought together with similar charges, they will repel; if two objects are brought together with opposing charges, they will attract.



After electrons have built up on an object, a potential difference builds up between the object an Earth, or 0V. When this potential difference gets big enough, electrons can jump from the object to Earth. We see this as a spark.



Static Electricity and its Uses – Physics Only

Aircraft Refuelling

When aircraft are being refueled, there is a risk of static building up.

There are large rubber tubes that transport the fuel to the aircraft. Because rubber is an insulator, there is a risk that static charge can build up on the fuel line.

To prevent this from happening, an earth wire (a path of low resistance for static electricity to travel along) is attached to the wing. This directs any static charge away from the aircraft.

A build up of static that is released near the fuel could cause the fuel to ignite and explode.

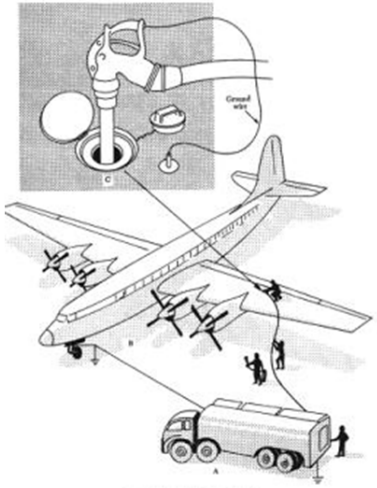
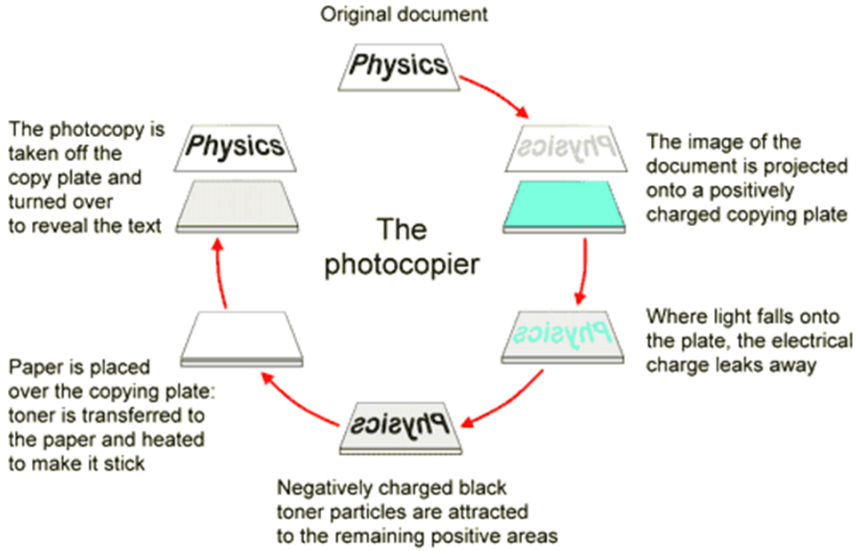


FIGURE 11-2. Refueling an aircraft.

Photocopiers



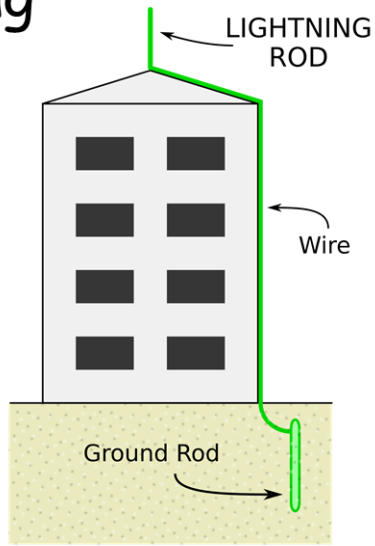
Lightning

Lightning is caused when ice and water particles in a cloud rub together. This causes a transfer of electrons between these materials and an overall charge on a part of a cloud.

This can cause a lot of damage to buildings that contain electrical equipment, as a surge of electricity can cause electrical items to explode.

On the top of buildings, large spikes that are made out of a conducting material are installed to take the electrical charge away from the building.

The charge will pass along the conducting rod, into the ground. This causes a large flash.



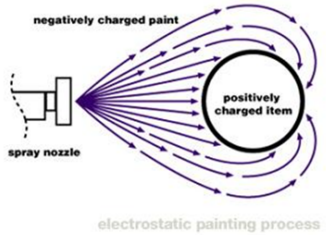
Paint Spraying

Car manufacturers can save money by using charged paint spray guns. They work because like charges repel and unlike charges attract.

The spray gun is **charged positively**, which causes every paint particle to become positively charged. Like charges repel and the paint particles spread out.

The object to be painted is given a **negative charge** and so attracts the paint particles.

The advantages of using this system are that less paint is **wasted**, the object receives an **even coat** and the paint covers awkward 'shadow' surfaces that the operator cannot see.



Which one of these groups does <u>not</u> contain any insulators?	
Steel, Ceramic, Perspex	Cotton, Graphite, Copper
Wood, Cardboard, Rubber	Iron, Copper, Steel

A van der Graff generator is a machine that can build up a large static charge on a globe at the top. When it is switched of, a pupil steps onto a plastic box and places their hands onto the globe. What happens when the generator is switched on?	
A static charge will build up in the student	The student will instantly receive a painful shock
The globe will be discharged if the student touches an object or person that is earthed	A spark will immediately jump from the student to the nearest metal object

Why does rubbing a metal spoon with a duster <u>not</u> cause a static charge to build up?	
Metals are conductors which allow an electric charge to flow so charge will always spread out	Metals are reflective so reflect the charge away
Metals allow an electric charge to transfer to the air	Metals do not transfer electrons to other materials

Complete the sentences:	
Like charges _____ each other	
Insulators _____ charge to flow through them	
Conductors _____ charge to flow through them	
Unlike charges _____ each other	

A student did an experiment with two strips of polythene. She held the strips together at one end. She rubbed down one strip with a dry cloth. Then she rubbed down the other strip with the dry cloth. Still holding the top ends together, she held up the strips.

(a) (i) What movement would you expect to see?

.....

.....

(ii) Why do the strips move in this way?

.....

(b) Complete the **four** spaces in the passage.

Each strip has a negative charge. The cloth is left with a.....

charge. This is because particles called ..... have been transferred

from the ..... to the ..... .

(c) The student tried the experiment using two strips of aluminium. The strips did not move.

Complete **each** of the sentences.

(i) Materials, such as aluminium, which electricity will pass through easily, are

called ..... .

(ii) Materials, such as polythene which electricity will **not** pass through easily, are

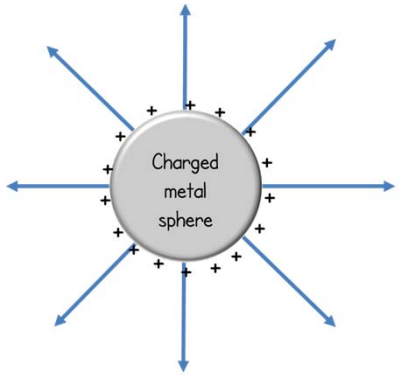
called ..... .

Static Electricity and its Uses – Physics Only: Checklist

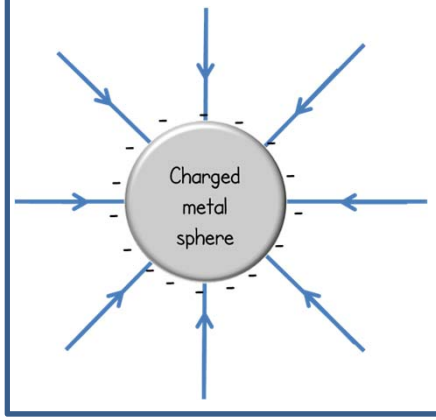
For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify the charges on the key parts of an atom			
Describe how an object becomes charged			
Describe what happens when two charged objects are brought towards each other			
Describe the production of both static electricity and sparking			
Describe evidence that charged objects exert forces of attraction or repulsion on one another when not in contact			
Explain how the transfer of electrons between objects can explain the idea of static electricity			

Electric Fields – Physics Only

Charged objects exerts forces on other charged objects from a distance (they do not have to touch to feel a force). This happens because a charged object creates an electric field around itself. Any other charged object that moves into this field will then feel a force.



A positively charged surface would have field lines that point away from the surface of the object.
This shows the force that would be applied to a positive charge that was moved into the field of this object.

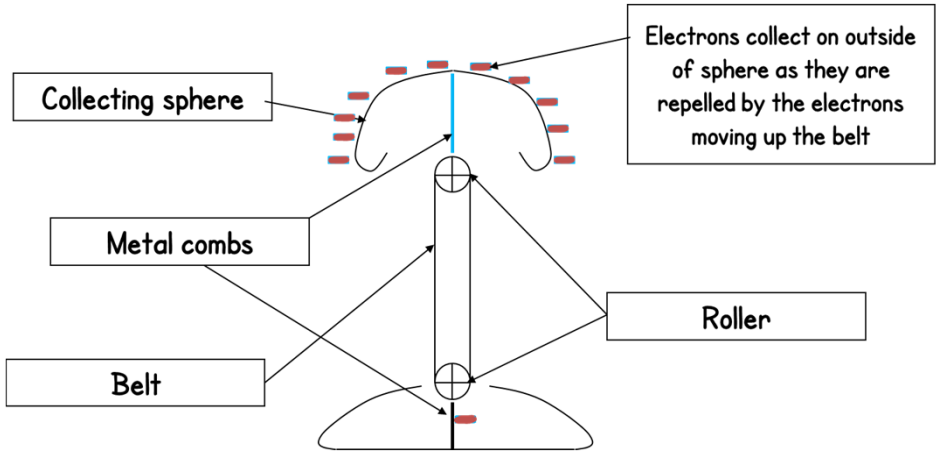


A negatively charged surface would have field lines that point towards the surface of the object.
This shows the force that would be applied to a positive charge that was moved into the field of this object.

Field lines are always drawn at 90° to the surface of the charged object.

Electric Fields – Physics Only

The van der Graaf generator



A van de Graaff generator works by rubbing together two insulating materials. The electrons transferred to the roller are moved to the sphere at the top of the van de Graaff.

On the sphere, the electrons will want to spread out as much as possible, as they have similar charges so repel. This gives the sphere an even charge all over.

From here, the electrons will try to find a way to the earth as quickly as possible. This will show as a spark.

Why does your hair stand on end when using a van de Graaff?

We know that the electrons try to spread out as much as possible, because similar charges repel. This causes the electrons to spread out onto you.

The charges eventually spread to your hair. The force of the electrons repelling is greater than the weight of your hair, causing it to stand on end!

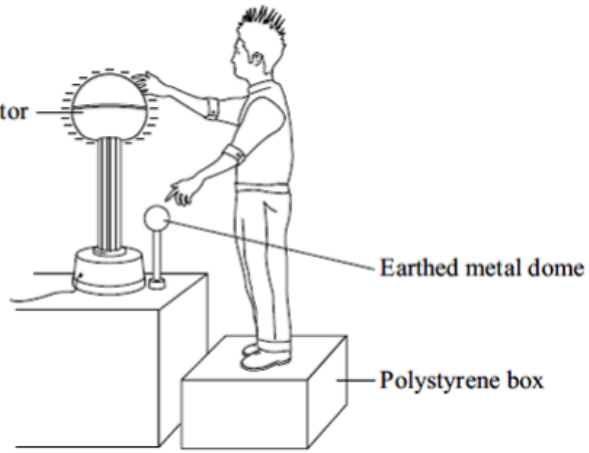
Two positive charges are brought closer together. What happens to the force between these charges?	
It decreases	It increases
It changes direction	It stays the same

Complete these sentences.	
A _____ charged particle will experience a force in the direction of the arrows on electric field lines	
A _____ charged particle will experience a force in the opposite direction to the arrows on electric field lines	
Electric field lines point away from a _____ charge	
Electric field lines point towards a _____ charge	

Which of the following statements are correct?	
An electric field is only found around positive charges	An electric field is only found around negative charges
An electric field is the region in which an electric charge will experience a force	An electric field is weaker as you move closer to a charged particle

Electric fields explain how charged particles can exert a force at a distance. Which 2 of these statements are <u>false</u>?	
The arrows on field lines show the direction off the force on a negative charge	The density of field lines is unrelated to how strong the force is
This type of force is known as a non-contact force	When drawing field lines, they never overlap

(a) The diagram shows a student touching the metal dome of a Van de Graaff generator. When the generator is switched on, the metal dome becomes negatively charged.



Explain why the student's hair stands on end when the generator is switched on.

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(b) When the potential difference between the student and a nearby earthed metal dome reached 15 kV, a spark jumped between the student and the earthed dome. The spark transformed 30 mJ of energy into heat, light and sound. (1 mJ = 0.001 J)

Calculate the charge carried by the spark.

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Charge transferred =..... coulombs

(c) What name is given to the rate of flow of charge?

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Electric Fields – Physics Only: Checklist

For your exam, you must be able to…	I have looked at this once	I have reviewed this	I have mastered this
Identify the pattern of field lines that form around a charged object			
Describe how the strength of an electric field changes with the distance from the object			
Describe what happens to a charged object when it is placed into a field of another charged object			
Explain the idea of an electric field			
Explain how electric fields can be used to explain the forces felt between charged objects and sparking			