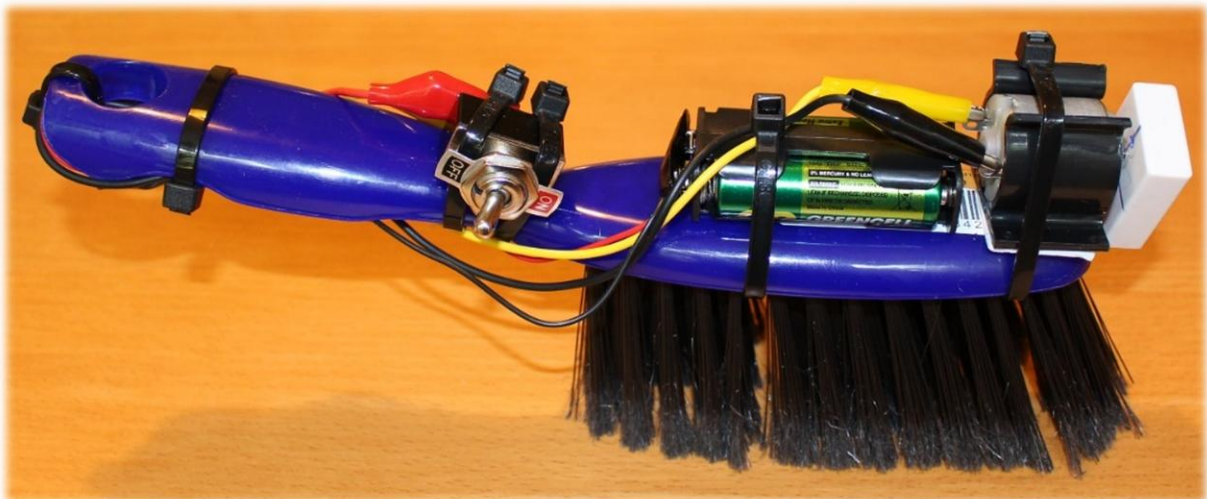


Brush Monsters



Lesson Plan

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Brush Monsters Lesson Plan

- Recommended level – Years 4-6
- Time taken – 5-6 hours
- Pupils to work in groups of 3
- Expectation – each group to create one working brush monster
- Additional adult help is recommended

Skills and Learning

STEM Links

- Science: electrical circuits, forces
- Technology: electrical systems, mechanical systems, designing and making products
- Engineering: build, test and troubleshoot products
- Mathematics: measure distance and time, calculate average speed

Curriculum Learning Objectives – it is recommended to cover these topics prior to the exercise so that the pupils are reinforcing their knowledge and understanding, rather than meeting the topics for the first time.

Science: Electricity

Pupils should be taught to:

- construct a simple series electrical circuit, identifying and naming its basic parts
- recognise that a switch opens and closes a circuit
- recognise some common conductors and insulators, and associate metals with being good conductors
- use their circuits to create simple devices
- represent a simple circuit in a diagram using recognised symbols
- pupils should be taught about precautions for working safely with electricity

Science: Forces

Pupils should be taught to:

- compare how things move on different surfaces
- explore the effects of simple machines on movement

Design and Technology

Through a variety of creative and practical activities, pupils should be taught the knowledge, understanding and skills needed to engage in an iterative process of designing and making.

When designing and making, pupils should be taught to:

- design innovative, functional, appealing products that are fit for purpose
- select from and use a wide range of tools and equipment to perform practical tasks
- select from and use a wide range of materials and components according to their functional properties and aesthetic qualities
- understand and use electrical systems in their products (e.g. series circuits incorporating switches and motors)
- understand and use mechanical systems in their products

Mathematics: Measurement

Pupils should be taught to:

- measure length and record time
- compare duration of events
- calculate average speed

Vocabulary List

- **Battery/cell** – this converts chemical energy into electrical energy. It is used to ‘push’ electricity around a circuit. If you connect cells together you get more ‘push’ – a battery consists of two or more cells.
- **Conductor** – an electrical conductor allows electricity to flow through it. Metals are good conductors.
- **Insulator** – an electrical insulator stops electricity passing through. Plastic, wood, rubber and glass are insulators.
- **Offset** – the distance by which something is not in-line or central.
- **Ratchet** – a mechanical device allowing motion in one direction while preventing reverse movement.
- **Series circuit** – a circuit with only one possible path for the current.
- **Short circuit** – an incorrect route in a circuit which misses out certain components and can cause the circuit to fail.

Associated Resources

- Brush Monsters Presentation – this is to be followed when running the activity in class.
- Brush Monsters Worksheet – this is to be printed out, one for each pupil. Some suggested answers are given at the end of this Lesson Plan.
- Brush Monster Instructions – this is for the teacher to follow to make a sample brush monster.

Equipment needed (included in the class kit)

- Zinc chloride AA batteries (80)
- Dustpans and brushes (10)
- Motors (10)
- Toggle switches (10)
- Motor mounting clips (10)
- Battery holders 2xAA (10)
- Snap battery connectors (50)
- Crocodile leads (30)
- Erasers (45)
- Cable ties (100)
- Googly eyes (560)
- Pipe cleaners (1 pack)
- Feathers (1 pack)

Check you have received the correct contents in your class kit. Please let TTS know if there are any problems as soon as possible.

Tools and consumables needed (not included in class kit):

- A small plastic bowl for each pupil would be useful, for them to collect their electrical parts. Otherwise, the motors tend to roll off the table and get lost!
- Rulers
- Ball point pens
- Large scissors
- Cool melt glue gun and glue sticks. **Note: High melt temperature glue guns should not be used by pupils, as they can cause nasty burns.**
- Double-sided foam sticky pads can be used to help assemble the brush monsters. It makes them easier to assemble, but slightly harder to disassemble for re-use. These can be found at discount stores or craft shops.
- Tape measures, stop watches and calculators (or a mobile phone) to determine the average speed of the brush monsters.

Suggestions for re-using the class kit:

- It is recommended that the pupils use glue guns sparingly when decorating their brush monsters, as it is difficult to get the glue off when re-using the kit.
- If you need replacement AA cells (batteries), be careful to use zinc cells, not alkaline or rechargeable ones. Zinc ones do not get so hot when accidentally short-circuited. They are cheap and readily available from discount stores.
- If you have problems cutting off the cable ties with scissors, you can use wire cutters.
- Replacement cable ties and decorations can also be found at discount stores. 200mm long cable ties are recommended, preferably narrow (e.g. 2.5mm width).
- In order to store the class kit more efficiently, you can dispose of the dustpans – they can be used for cleaning out rabbit/guinea pig cages, and some charity shops will take them.

Preparation needed

- Build a sample brush monster to explore any pitfalls, and to demonstrate to the pupils what they will be making and how it works. Instructions for building a sample brush monster are given in the Brush Monster Instructions.
- Print out a copy of the worksheet for each pupil.
- Additional adult help is useful; you could invite in some adult helpers.
- The brush monsters work best on a smooth floor. If the classroom floor is carpeted, you could book the school hall for testing the brush monsters. If you only have the classroom available, you can run the brush monsters on tables as long as pupils catch them before they fall on the floor.
- Some method of keeping the brush monsters travelling in a straight line is needed for racing them. For example, you could use lengths of square guttering, benches turned on their sides, or construct a race track from cardboard or bricks. Some examples are shown on slide 26 of the Brush Monster Presentation.

Risk Assessment

Conduct a risk assessment before undertaking the activity. A sample risk assessment is given below; you can use this as a starting point when writing your own. (L=low, M=medium, H=high)

Activity	Identified Hazard	Initial Risk Rating L/M/H	Control Measures	Controlled Risk Rating L/M/H
Use of glue guns	Burns	H	- Children should be supervised by a responsible adult at all times when using the glue guns. - Explain to children how to use the glue guns. - Warn them that the ends are very hot. - Use only low melt temperature glue guns. If burned hold under running water for ten minutes. - Don't switch on the glue guns until after the safety briefing. - In some schools, children wear safety goggles when using glue guns.	M
Accidentally short-circuiting battery	Burns, smoke inhalation	M	- Explain how to avoid short circuits. - Use only zinc chloride cells, not alkaline or re-chargeable ones as these can get very hot if short circuited.	L
Use of scissors	Injury e.g. to fingers	M	- Make the children aware of the dangers. - Do not give out the scissors until after the safety briefing.	L
Use of cable ties	Cable tying fingers and cutting off blood supply	M	Explain the dangers to the pupils. Cut cable ties off fingers immediately.	L
Running extension leads along floor for glue guns	Trip hazard	M	- Avoid using extension leads if possible. - Otherwise make sure extension leads are run where they cannot be tripped over.	L
Damaged extension leads or glue gun leads	Electrocution hazard	H	Conduct a visual check of all electrical items before session, to ensure the leads are undamaged.	L

Teacher notes – referring to the relevant slides in the Brush Monsters Presentation

Slide 3

What you are going to make

- You could demonstrate your sample brush monster to show the pupils what they will be making and how it works.

Slide 5

Where offset weights are used

- The toothbrush vibrates in order to remove plaque and clean teeth.
- The mobile phone vibrates to provide a silent notification of calls, messages etc.

Slide 10

Safety

- First ask the pupils to identify possible hazards and possible ways to reduce the risk.
- Don't burn yourself with the glue gun. You could ask an adult to supervise the gluing station.
- Be careful not to cut yourself with the scissors.
- Don't cable-tie your fingers.

Slide 11

Electrical parts

- You can hold up each part in turn and ask the pupils to name it.
- They are: motor, switch, battery and wires or crocodile leads.
- Point out the circuit symbol (shown below each component) which relates to each of the components.
- Explain that these are used to represent the components on a circuit diagram; they are much easier to draw than the actual components!

Slide 12

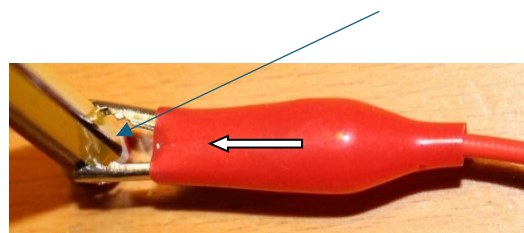
How the electric circuit works

- Explain that the diagram on the right is the circuit diagram. It is a representation of a circuit, and can be used when designing or trouble-shooting an electric circuit.

Slide 13

Avoid short circuits

- It is very common for pupils to accidentally short circuit their batteries whilst wiring up their circuits.
- This will drain the battery quickly. However, as long as you are using zinc cells it should not get too hot. Alkaline or rechargeable batteries should not be used as they can get very hot if short-circuited.
- The point of the knot is to make the bare ends of the wires face away from one another. The actual type of knot used is not that important.
- Pupils often slide the sleeves back off the crocodiles when connecting their crocodile clips. This should be discouraged. If you have problems sliding the sleeves back over the crocodile clips again, you can first clip the crocodile onto a pencil as shown below – this makes it easier.



Connecting the crocodile clips

Slide 14

- Pupils often clip the crocodile leads onto the plastic insulation on the wires from the battery, instead of onto the bare metal ends.
- Explain to the pupils why the crocodile clips must be connected to the metal ends of the wires.
 - Metal is a good conductor of electricity, allowing the current to flow round the circuit.
 - Plastic is an insulator, and does not allow the current to flow.
- Pupils sometimes clip the crocodile leads onto the motor shaft instead of the motor contacts.
- Pupils sometimes clip the crocodile leads onto the switch toggle instead of the switch contacts.

Make your circuit

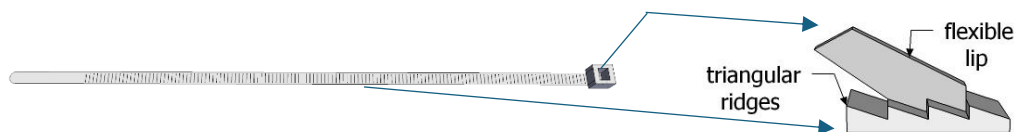
Slide 15

- You could ask pupils to come up and collect their parts in a small bowl, to save you having to hand them out.
- It is recommended for pupils to have three different coloured crocodile leads, as they are less likely to get them mixed up and create a short circuit.
- Some pupils may need help pushing on the snap battery connectors, as they can be quite hard to fit.
- If pupils are not familiar with connecting up a circuit, it is a good idea to demonstrate how to do it, including showing the pupils which way round to fit the cells. The flat end of the cell should be pushed up against the spring in the battery holder.
- Pupils could lay their components out in a triangle, then connect one wire from the switch to the motor, one from the motor to the battery and one from the battery to the switch.
- To check the circuit works, switch on and feel whether the motor shaft is going round, then switch off to preserve the battery life. If it is very quiet you might be able to hear the motors.

Attach your motor firmly

Slide 20

- Some pupils use their ruler to separate the bristles, to help them to fit the cable tie without distorting the bristles too much.
- Explain to the pupils that cable ties only work one way up. You should be able to hear or feel a cable tie 'zip' up – if not then it may be upside down. You could mention to the pupils that a cable tie is another example of the 'ratchet effect'.



Attach your battery

Slide 21

- If you have double-sided foam sticky pads, pupils can use them to hold the battery onto the brush when attaching it. This makes it easier to assemble, but slightly harder to take apart when re-using the class kit.

Prepare your switch

Slide 22

- Normally the nuts on the switches are quite loose, and can be undone easily.

- If they are too tight, you may need to help the pupils to unscrew them, or use a spanner or pliers.
- If the pupils collected their parts in a small bowl, you could ask them to put the nut and label in the bowl to stop them from getting lost.

Slide 23

Attach your switch

- If you have double-sided foam sticky pads, these can be used to hold the switch in position while attaching it.
- It is important to keep the top nut flat relative to the top of the switch when screwing it back on; otherwise, it can become cross-threaded and jam.

Slide 24

Tidy up the crocodile leads

- Tidying the crocodile leads can be the most fiddly part of the build process!

Slide 25

Try out your brush monster

- The brush monsters work best on a smooth floor. They don't normally run on carpet because the bristles get stuck in the carpet fibres.
- Most brush monsters tend to move round in a circle rather than in a straight line. To get them to go in a straight line, they need to be constrained in some kind of race track.
- Mounting the eraser using a hole further from the centre makes the brush monster vibrate more, and vice versa. The brush monsters are more likely to go in a straight line if the eraser is mounted on the hole nearest its centre.
- You can reverse the direction of motion of the motor by swapping over the crocodile clips attached to the motor terminals, which reverses the flow of electricity through the motor.

Slide 26

Decorate your brush monster

- It is a good idea to ensure that the glue guns are used sparingly when decorating the brush monsters, as it can be very hard work getting the glue off in order to re-use the class kit.
- If the pupils want to make spiral shapes from the pipe cleaners, they can coil them round a pencil.

Slide 27

Try racing the brush monsters

- You could have elimination races, or calculate average speed and have a leader board, or both.
- Some pupils dislike competition, and may prefer not to enter their brush monsters in the races.
- If you are celebrating winners, you could also include some other categories, such as the most creative design, best looking brush monster and best build quality.
- It is not always obvious why one brush monster goes faster than another. Brushes which are unbalanced, have very distorted bristles or are heavily laden with decorations may go more slowly. Mounting the eraser further from the centre to create more vibration is not

necessarily a winning strategy, as the brush may then be less inclined to go in a straight line.

- You can also mark out a square on the floor using masking tape and have a 'last man standing' competition, or have a tug of war between brush monsters by facing them in opposite directions in the race track and tying a piece of string between them.

Slide 28

Fix and improve your brush monster

- If the eraser flies off, you can try pushing it further onto the motor shaft, mounting it on a different hole, making additional holes with a spare motor or turning the eraser over and making a complete new set of holes.
- The brush monsters will go down a slope easily, but can only climb a very shallow slope. If you have square guttering for your race tracks, you can prop up one end on some books to make a slope, for example. Otherwise, you can try running the brush monster on a tilted table, and catching it before it falls on the floor.
- It is recommended to use a spare motor to make additional holes in the eraser, to ensure that the holes are the right size.

Brush Monsters Worksheet - suggested answers

Name these electrical parts:



Motor



Switch

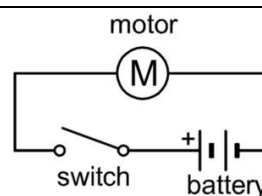


Battery



Crocodile lead (or wire)

Draw your circuit using these circuit symbols, using lines to represent the wires. Label the components.



Is metal an insulator or a conductor?

A conductor

Is plastic an insulator or a conductor?

An insulator

Why do you need to attach the crocodile clips onto bare metal, not onto plastic insulation?

I need to attach the crocodile clips onto bare metal, not onto plastic insulation, in order to allow the electricity to flow round the circuit.

What could happen if you short circuit your battery?

The battery could drain quickly. It could also get hot.

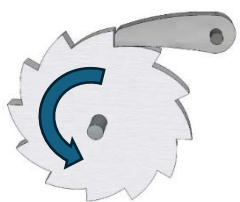
If you measure a time T to travel a distance D, how do you calculate the average speed?

Average speed = distance D / time T

What was the average speed of your brush monster?

Which force acts downwards on the brush monster?

Gravity acts downwards on the brush monster.

Why do you need an offset hole in your eraser, instead of a central one?	I need an offset hole in my eraser in order to create an offset weight to cause vibrations and make the brush monster move.
What could happen if the eraser is pushed up against the end of the brush? How could you fix this?	If the eraser is pushed up against the end of the brush it will jam and not be able to turn. I could fix this by moving the motor forward in its mount, to give a gap between the eraser and the brush.
Does the brush monster work on carpet? Explain your findings.	The brush monster does not work on carpet. This is because the bristles get stuck in the carpet fibres.
Extension Questions	
Suggest two products where offset weights are used to cause vibrations.	Two products where offset weights are used to cause vibrations are mobile phones and electric toothbrushes.
What does a ratchet do? 	A ratchet allows movement in one direction but not in the other.
Which joining methods did you use when creating your brush monster?	The eraser was a tight push fit on the motor shaft. The motor was clipped into the motor mount. The crocodile leads were clipped onto the electrical terminals. The motor mount was attached to the brush with a foam sticky pad. All electrical components were attached firmly to the brush using cable ties. The decorations were glued on.