

Design and build a brush monster



STEM Learning Objectives

- **S**cience – construct a simple series electrical circuit.
- **T**echnology – understand and use electrical systems in products.
- **E**ngineering – build, test and troubleshoot products.
- **M**aths – measure distance and time, calculate average speed.
- Discover how much fun **STEM** can be!

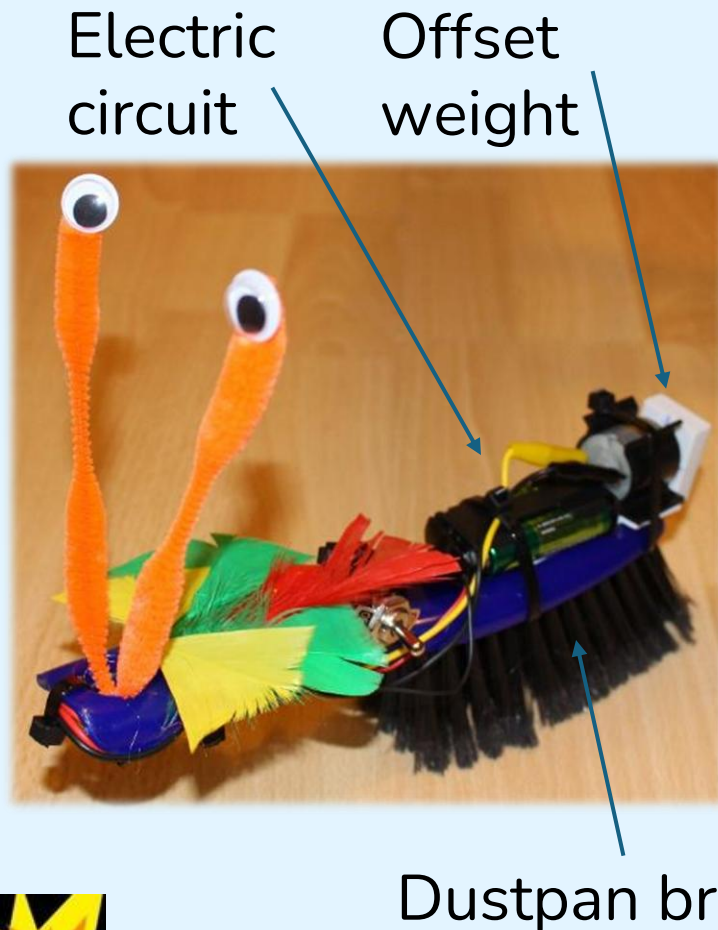


What you are going to make



- You will design, build and test a vibrating brush monster.
- It uses an electric circuit to rotate an offset weight.
- This causes the brush monster to vibrate and move around.

What you will do



- Learn about the forces acting on the brush monster.
- Complete the electric circuit.
- Assemble your brush monster and get it to work.
- Decorate your brush monster.
- Experiment with, improve and race the brush monsters.

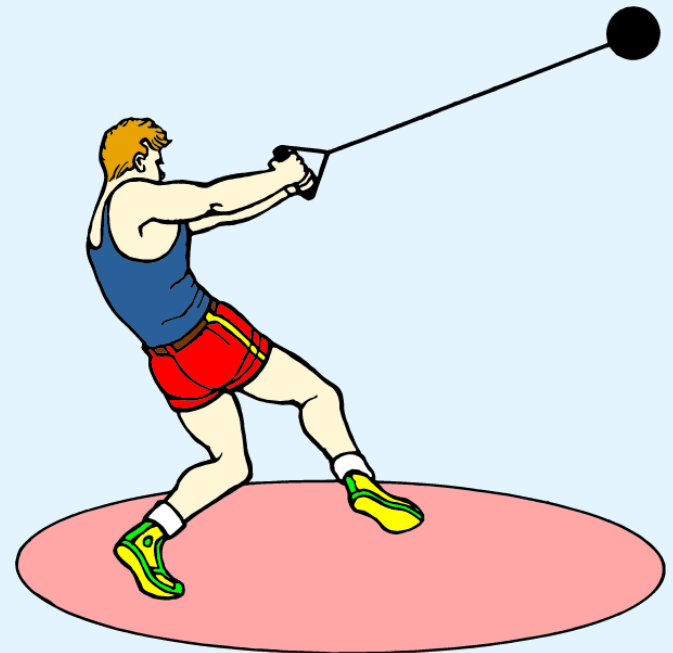
Where offset weights are used

- Here are two examples of objects which use a rotating offset weight to make them vibrate:
- An electric toothbrush
- A mobile phone
- Why are they designed to vibrate?



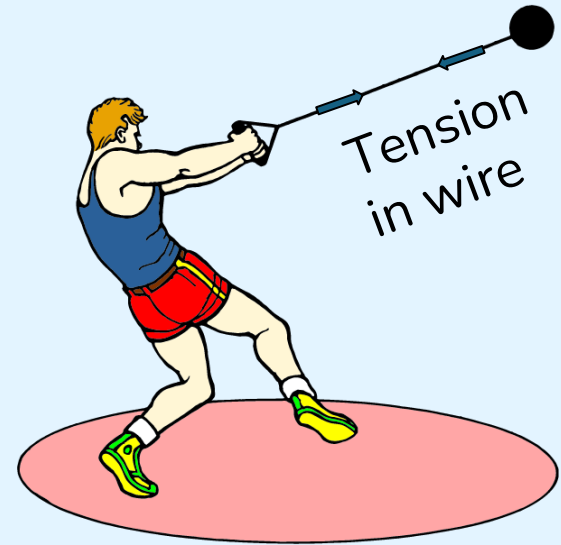
How an offset weight works - 1

- This hammer thrower uses a wire to pull a 'hammer' (heavy metal ball) towards the centre of the circle.
- He spins around several times to build up speed, then releases the hammer which flies off in a straight line.



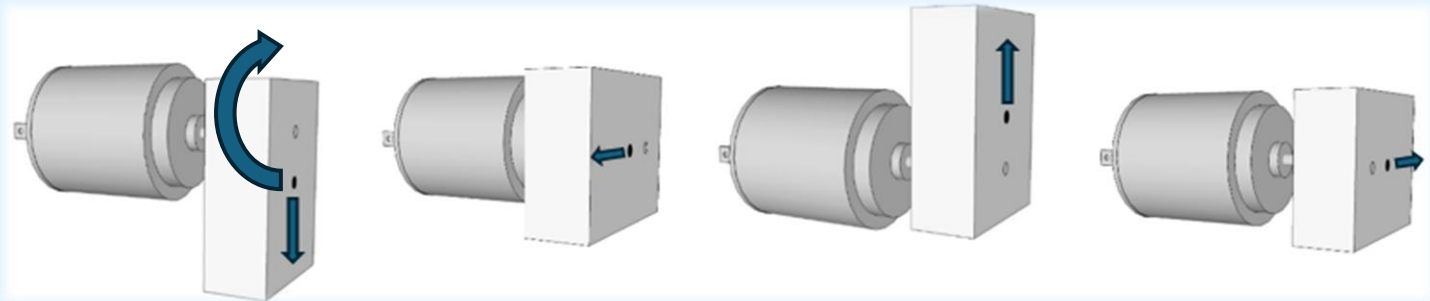
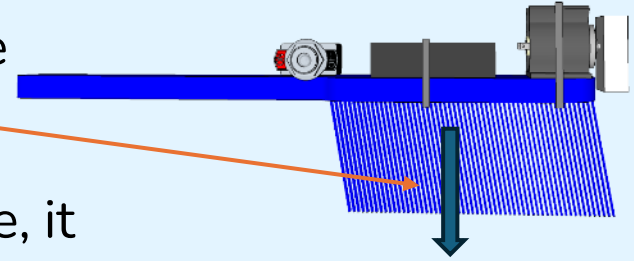
How an offset weight works - 2

- The tension in the wire pulls outwards on the hammer thrower. This tension moves round in a circle as the hammer rotates.
- This is a motor with an offset weight used in an electric toothbrush. As the motor rotates, it spins the weight. This causes a rotating force like the one acting on the hammer thrower, making the toothbrush vibrate.

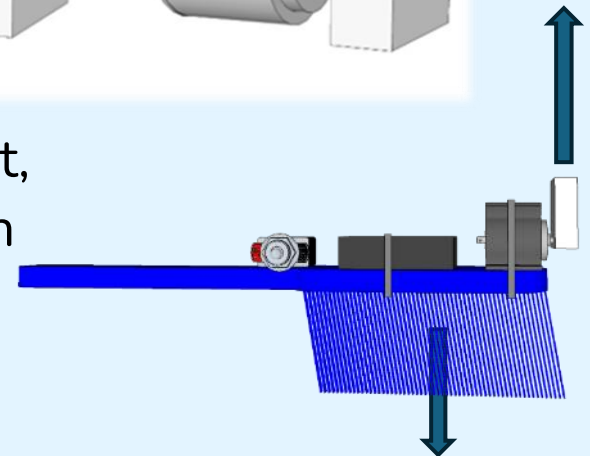


Forces acting on the brush monster

- The force of gravity acts downwards on the brush monster.
- As the offset weight moves round in a circle, it exerts a force on the brush monster; this force also moves round in a circle.

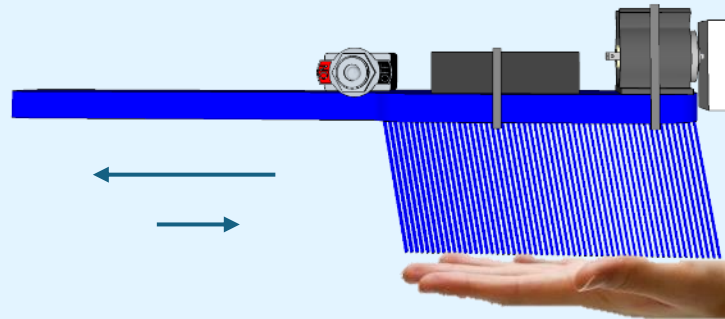


- When the weight moves through its top point, this force is upwards, opposing gravity, which causes the brush monster to give a little hop.



Why the brush monster moves along

- Try sliding the brush along the palm of your hand, then sliding it back the other way. Can you feel that it slides more easily in one direction than the other?

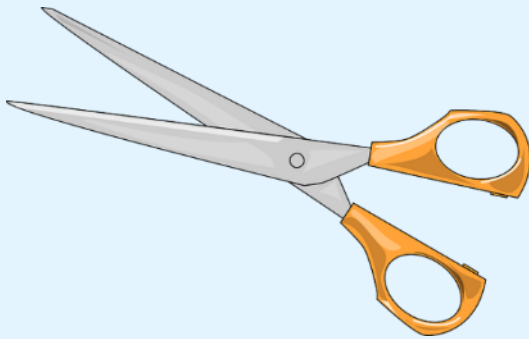


- The bristles of the brush are sloping. When it moves in one direction, the bristles slide easily. When it moves in the other direction the ends of the bristles try to 'dig in' and prevent the brush from moving.
- This is the 'ratchet effect'. A ratchet is a mechanical device with asymmetrical teeth which allows rotation in one direction but not the other.



Safety

Look at the tools and equipment. Can you spot any potential hazards?



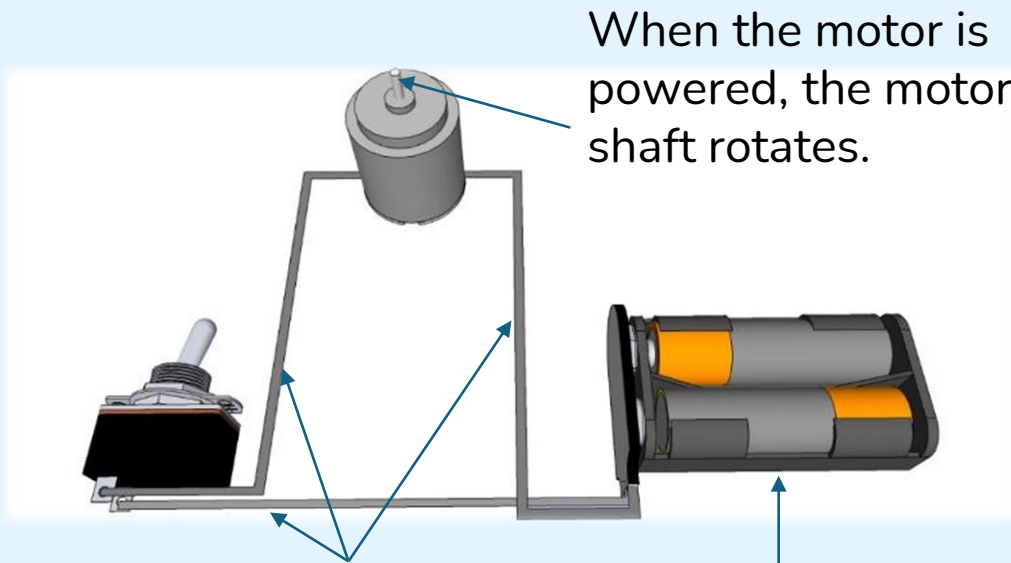
Can you think of ways to reduce the risks?

Electrical parts

Name these electrical components:

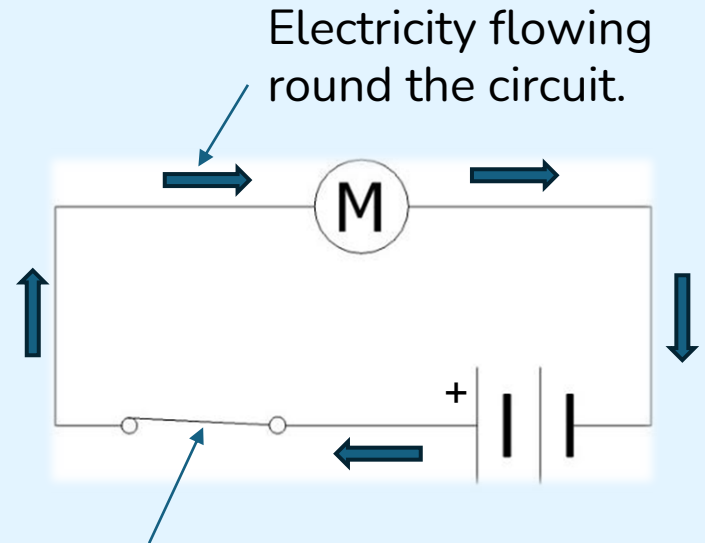


How the electric circuit works



Crocodile leads are used to connect the different electrical components together.

The battery 'pushes' electricity around the circuit.



The switch is used to control the flow of electricity. When it is on, the electricity can flow. When it is off, there is a gap in the circuit and the electricity cannot flow round.

Avoid short circuits

If batteries are 'short-circuited' they can get very hot.

- **The zinc cells provided should be used, not alkaline or rechargeable ones.**
- Do not connect the bare ends of the wires from the battery directly together; they must be connected across the motor.
- Tie the black wire and the red wire from the battery clip in a reef knot to stop the bare ends from touching.

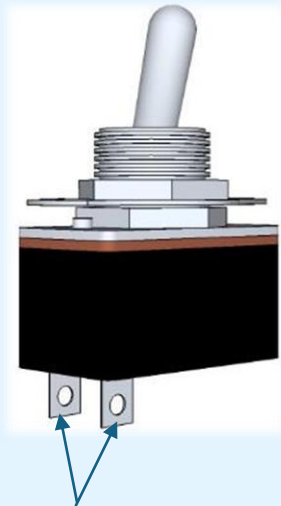


- Make sure the plastic sleeves cover the crocodile clips as shown here, to help prevent short-circuits if the clips touch.

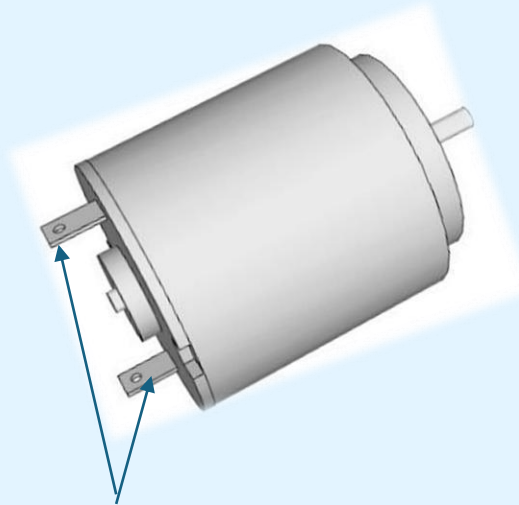


Connecting the crocodile clips

Where to connect the crocodile clips:



Connect to these two contacts on the switch.



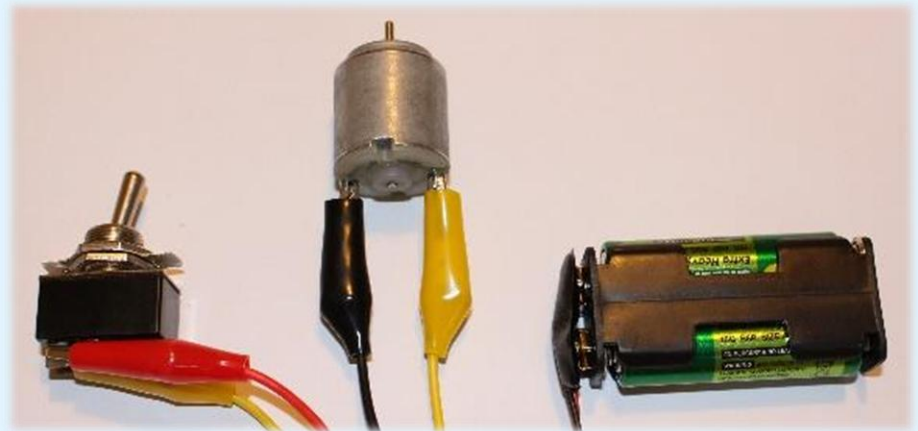
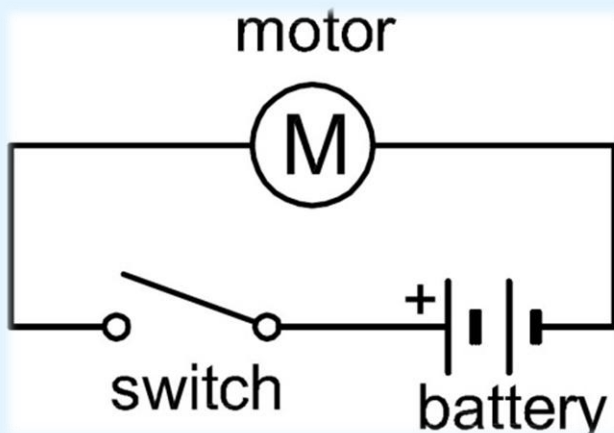
Connect to these two contacts on the motor.



Connect to the metal ends of the wires from the battery box (not onto the plastic insulation).

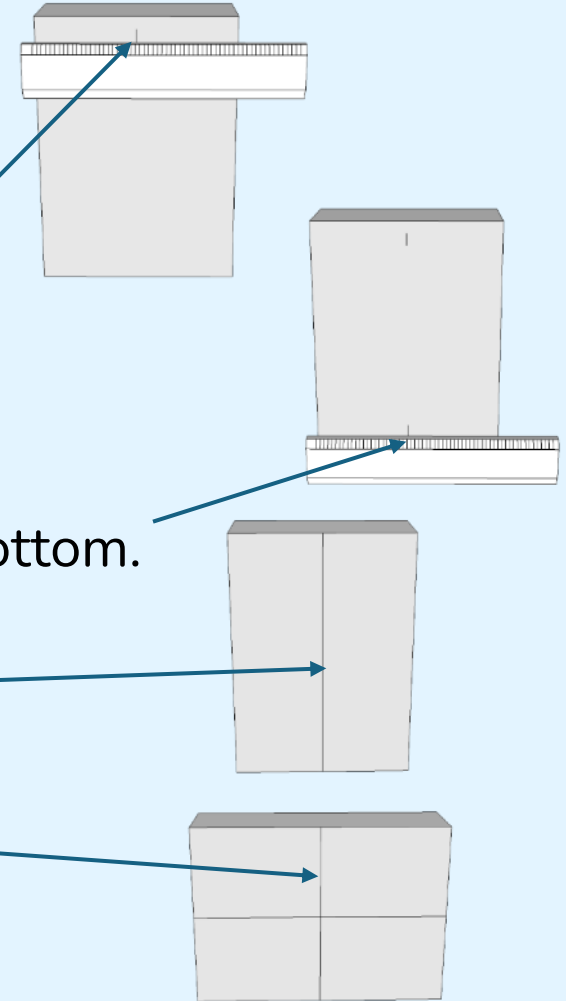
Make your circuit

- Fit the cells into the battery holder (the right way round).
- Push the snap battery connector on firmly.
- Lay out your components in a triangle and make the following circuit, then check it works.



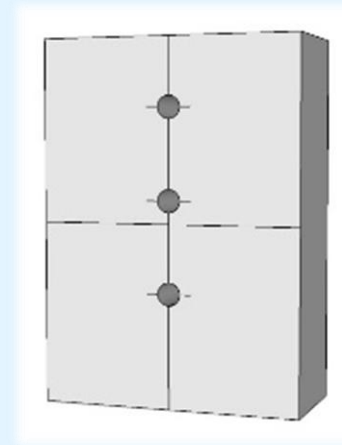
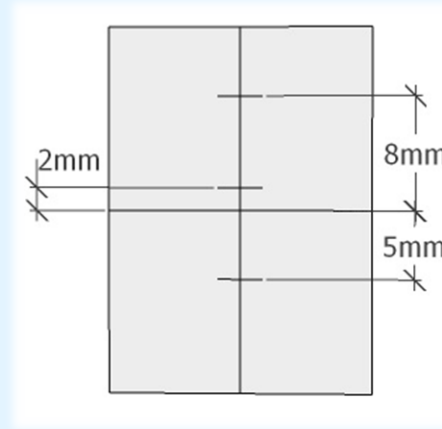
Prepare your eraser - 1

- Draw centre lines on the eraser as follows:
- Measure the width of the eraser and halve it. Use a ball point pen to mark a short line halfway across, near the top.
- Mark a short line halfway across, near the bottom.
- Join the two lines.
- Turn the eraser through 90° and repeat.

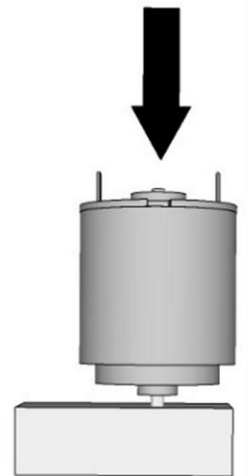


Prepare your eraser - 2

- Mark lines 2mm, 5mm and 8mm from the short centre line as shown.
- Unclip the crocodile clips from your motor.
- Lie the eraser flat and use the motor shaft to make holes at the 3 positions you marked, by pushing down hard on the back of the motor (in the middle, to avoid damaging the motor terminals).



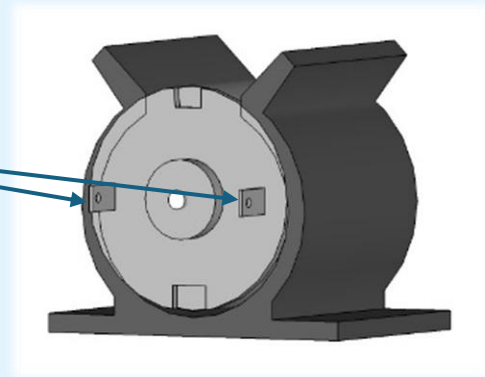
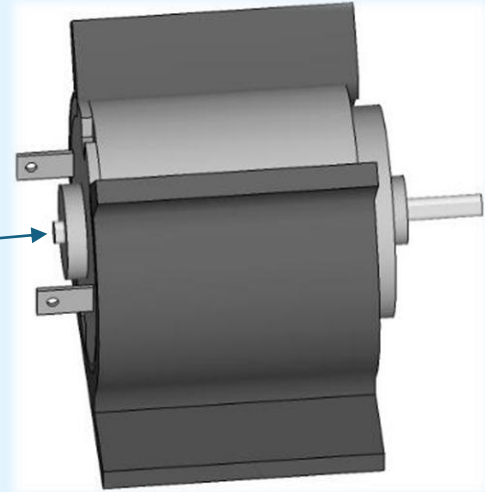
push down



Prepare your motor

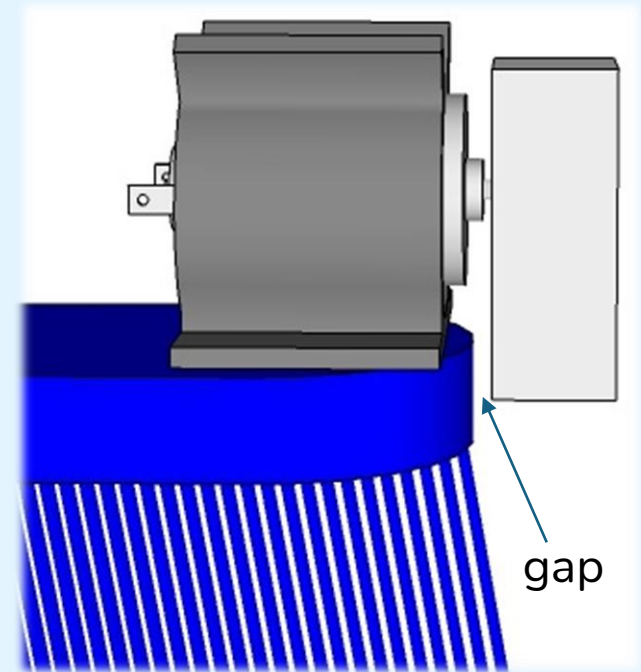
- Remove the eraser and push the motor forwards into the motor mount (not from above as it can snap the motor mount).
- Make sure the back of the motor lines up and the front sticks out a little.
- Rotate your motor in its mount until the two terminals are at roughly the same height.

push in
this way



Fit your motor onto your brush

- Push the motor shaft into one of the holes in the eraser.
- Remove the plastic film from the bottom of the motor mount and stick the mount onto the end of the brush.
- Make sure there is a gap between the eraser and the brush as shown.
- Turn the eraser all the way round with your finger.
- What would happen if the eraser hits the brush?

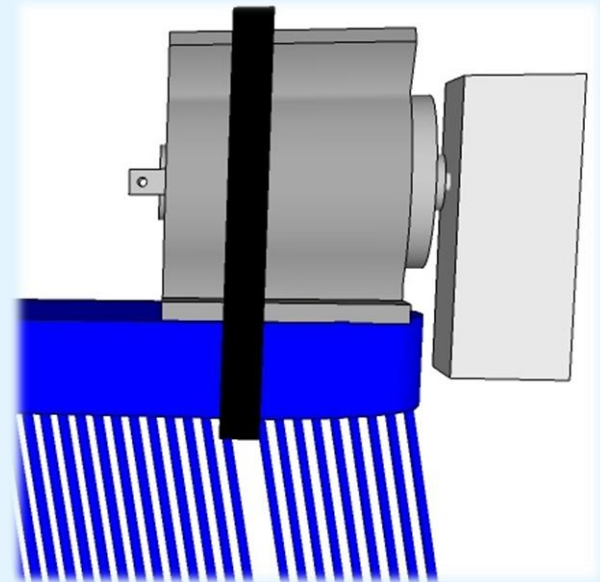


Attach your motor firmly

- Your components will be subject to a lot of vibration, so if they aren't firmly attached, they will work loose.
- Carefully feed a cable tie through the brush between the bristles as shown.

Try to find a gap to avoid distorting the bristles too much.

- (N.B. If the cable tie is placed too near the end of the brush it will slide off.)
- Use the cable tie to attach the motor assembly firmly to the brush, pull it very tight then cut off the loose end with scissors.



Attach your battery

- Clip the crocodile leads back onto the motor terminals. Switch on and check that the eraser rotates, then switch off.
- Place your battery holder on your brush, close to the motor mount, allowing enough space for the crocodile clips on the motor terminals.
- Ask a classmate to hold the battery holder and crocodile leads on while you cable tie them both firmly to the brush, trying not to distort the bristles too much.

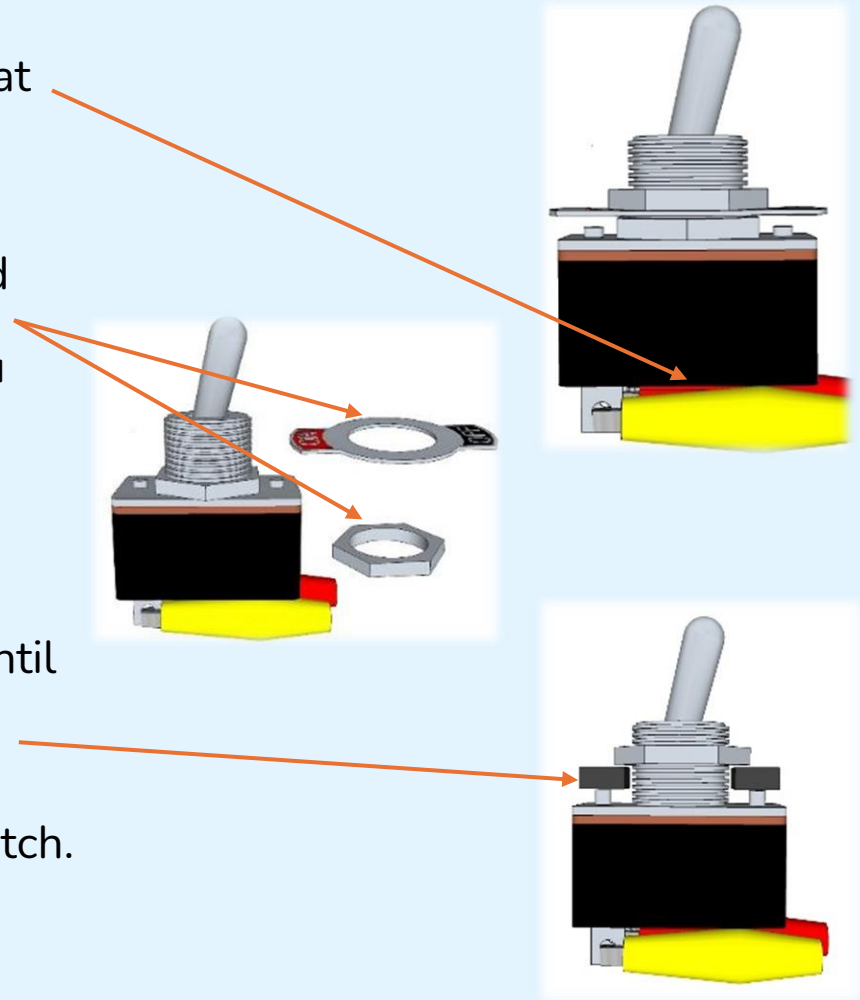
Note: cable tie on both the battery and crocodile leads together.



Put the battery close to the motor mount.

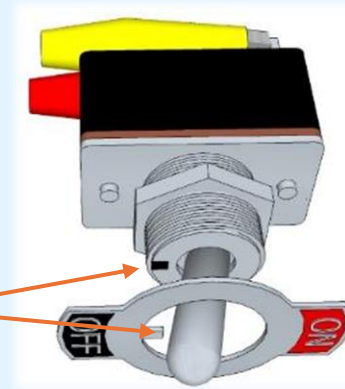
Prepare your switch

- Make sure the crocodile clips are lying flat along the bottom of the switch.
- Unscrew the top nut from the switch and remove the label. Don't lose these. If you have difficulties loosening the nut, you could ask an adult to help.
- Unscrew the second nut on the switch until there is enough space to fit a cable tie in between the nut and the body of the switch.



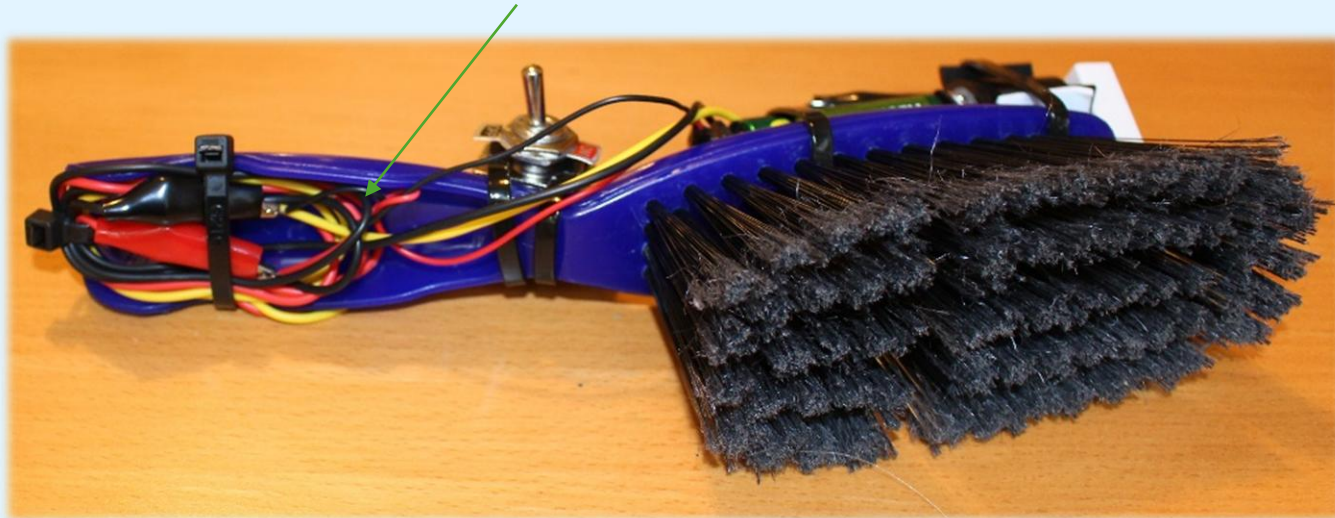
Attach your switch

- Place the switch flat on top of the brush, where it narrows between the bristle end and the handle. Ask a classmate to hold it in position while you cable-tie on the switch and crocodile clips as shown.
- Trim off the ends of the cable ties, being careful not to cut the wires.
- Put back the label, making sure the lug on the 'off' side lines up with the notch in the side of the switch. Screw the top nut back on.



Tidy up the crocodile leads

- Check there is still a gap between the eraser and brush end.
- Switch on and check the eraser rotates, then switch off.
- Tidy up the crocodile leads and wires, and cable tie them in position. You could lay them along the underside of the brush handle as shown.



Try out your brush monster

- Try out your brush monster on a flat smooth floor. Does it work better on a smooth floor or on carpet?
- Does it go in a straight line or round in a circle? How could you get it to travel in a straight line?
- What is the effect of mounting the eraser using a different hole?
- How can you reverse the direction of rotation of the motor?



Decorate your brush monster

- Decorate your brush monster and give it a name.
- You can glue on eyes, pipe cleaners and feathers and make shapes from card.
- You could turn your dustpan into a bed for your brush monster when it gets tired!



Try racing the brush monsters

- Have a go at racing the brush monsters. How will you make them travel in a straight line?
- You could time your brush monster over a known distance, e.g. 1 m. Divide the distance by the time to calculate the average speed.
- Which brush monsters are faster? Can you spot any characteristics which could account for this?



Fix and improve your brush monster

- If your brush monster stops working, can you work out why?
- Could any crocodile clips have come off their contacts?
- Could your motor have moved back in its mount so that the eraser is jammed against the brush?
- Does the eraser fly off? Can you think of ways to prevent this?
- What could be easily changed on your brush monster?
- Could you get your brush monster to go faster?
- Does it need any more decorations?
- Could you get it to go round in a circle, or in a straight line?
- Can it go up or down a shallow slope?
- How could you make extra holes in your eraser?



What did you learn?

- Discuss how the activity went and what you have learnt.
- Why is the eraser mounted on an offset hole?
- How does the brush monster move along?
- Does it work better on a smooth floor or carpet? Why?
- What have you learnt about electric circuits?
- What difficulties did you encounter; how did you overcome them?
- What changes did you make to improve your brush monster?
- What did you enjoy most about the activity?



Fun TTS STEM class kits

Fan boats



Crumble controlled models



Build-a-house



Make your own light



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