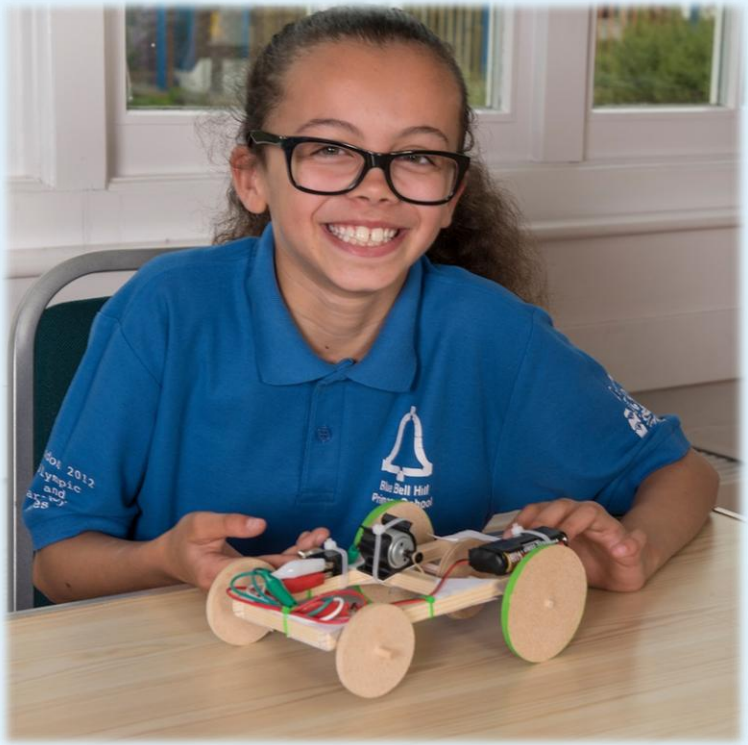
Design a motorised vehicle

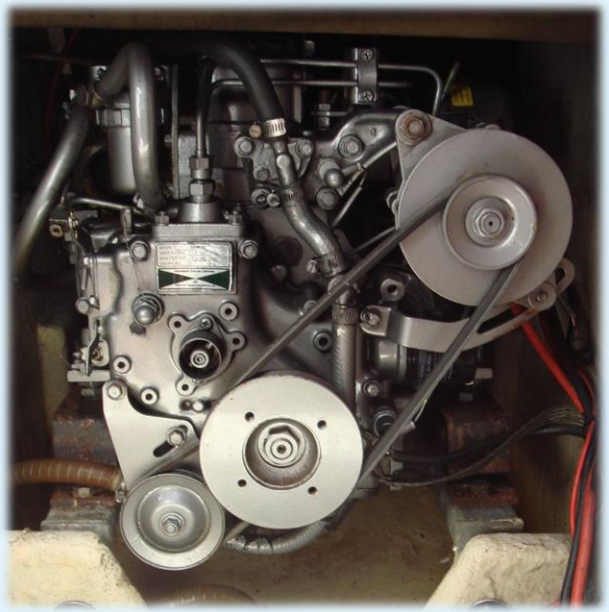


Examples of vehicles

What are these vehicles used for?

Technology for Fun

Examples of pulleys



Do you recognise these? What are the pulleys being used for?

Context

Your school is entering the Formula 24 Electric Car competition, and wants to design the winning car.

The race track is mostly flat with one gentle slope.

All cars have the same motor and battery but the wheels, pulleys, size and shape of vehicle, tyre materials etc vary.

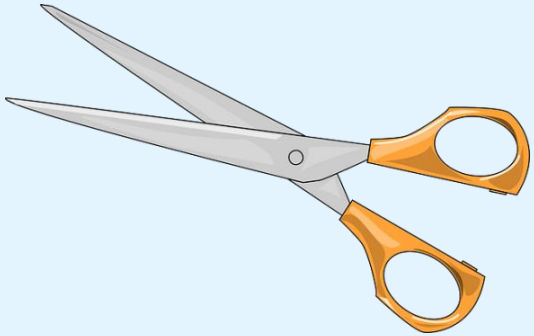
Design and build the fastest prototype you can.

Learning Objectives

- Make and use simple series circuits.
- Understand and use mechanical systems, e.g. pulleys, wheels, axles and bearings
- Build and reinforce structures.
- Measure length and time; calculate average speed.

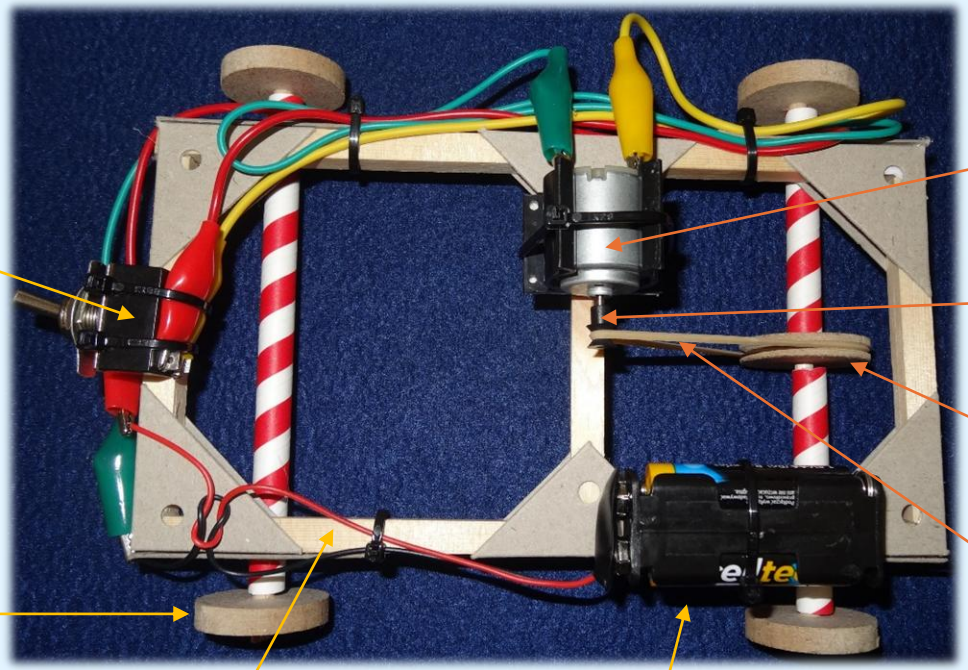
Safety

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

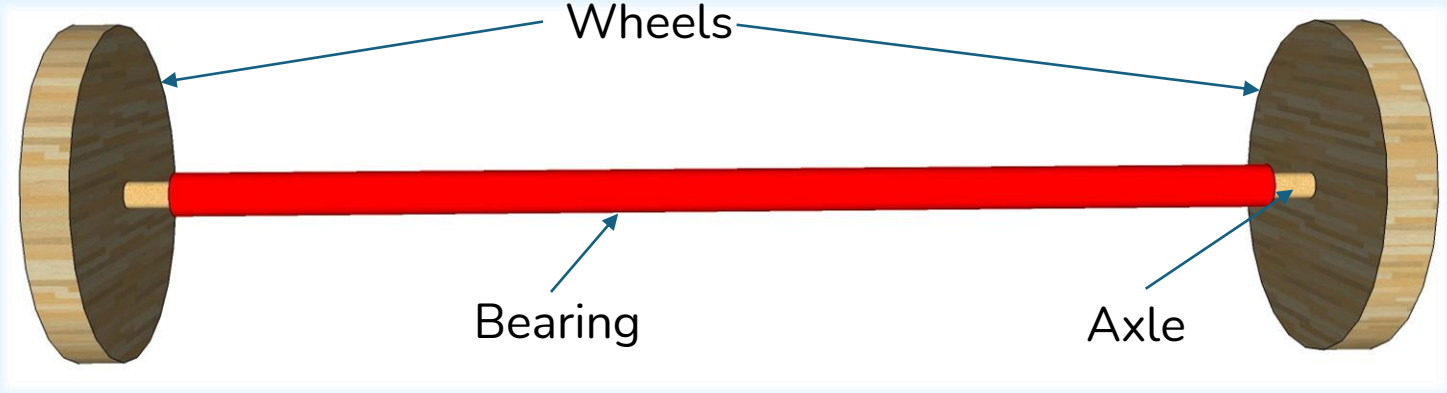


Can you think of ways to reduce the risks?

Parts of the vehicle



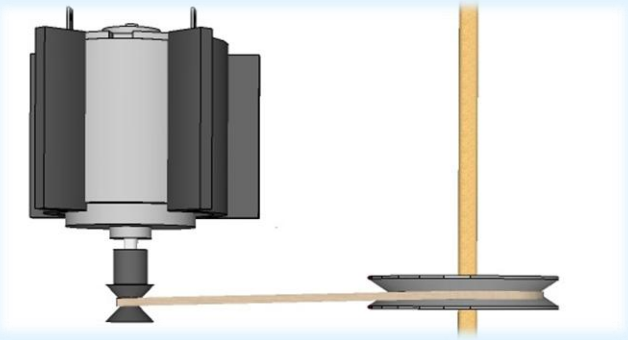
Using wheels, axles and bearings

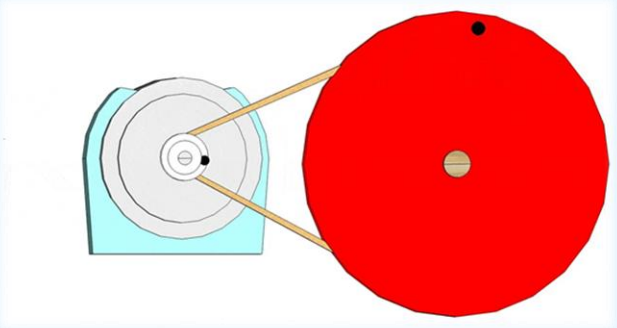


- The wheels support the vehicle, allowing it to move by rolling smoothly over the ground.
- The axles connect the wheels together.
- The bearings support the axles while allowing them to rotate easily.

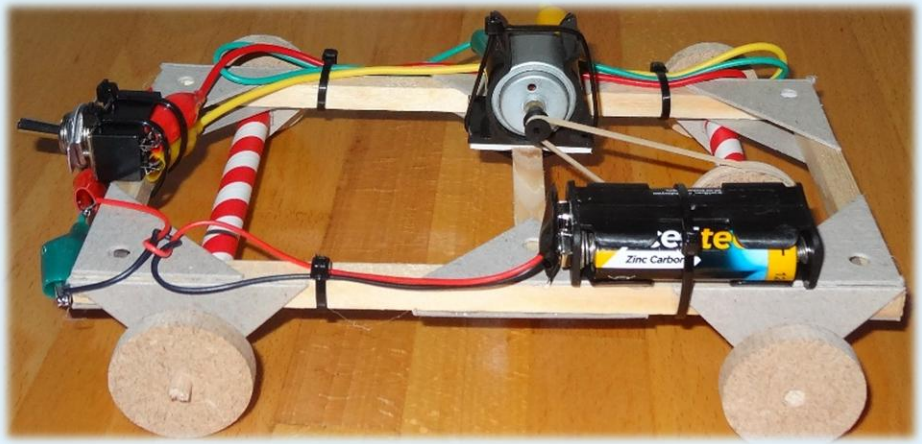
Using a pulley system

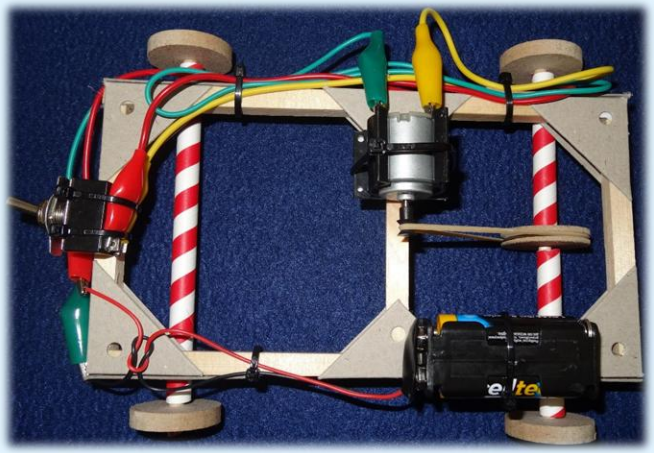
- The motor cannot drive the wheels directly to make the vehicle move, because the motor shaft rotates too fast and does not produce enough ‘turning force’ (torque).
- Instead, a pulley system is used. A motor pulley fitted to the motor shaft uses a rubber band to drive a larger pulley.
- The larger pulley is mounted on an axle connected to the wheels.
- This system reduces the speed of rotation and increases the torque sufficiently to drive the vehicle.





How the vehicle works



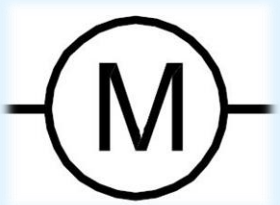


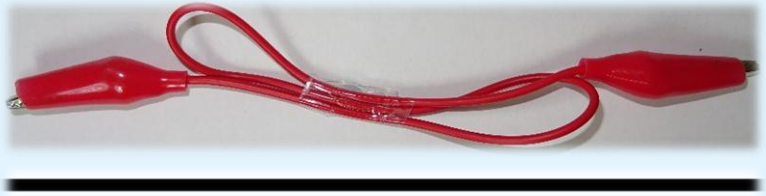
- When the electric circuit is switched on, the motor rotates.
- The driving pulley attached to the motor shaft rotates, driving the drive belt, which in turn rotates the driven pulley.
- The driven pulley is attached to an axle on which the wheels are mounted, so the wheels rotate.

Technology for Fun

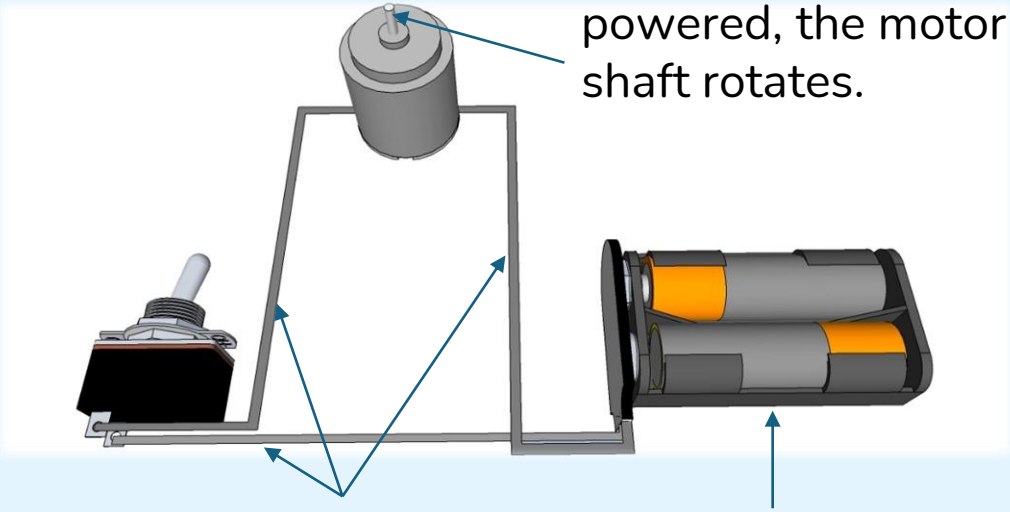
Electrical parts

Name these electrical components:





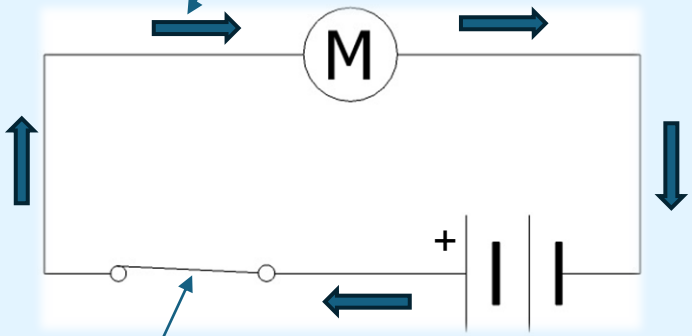
How the electric circuit works



When the motor is powered, the motor shaft rotates.

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

The battery ‘pushes’ electricity around the circuit.



Electricity flowing round 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

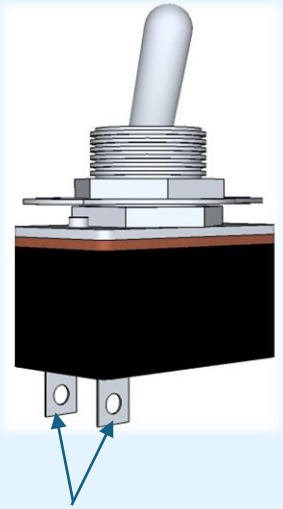
If batteries are ‘short-circuited’ they can get very hot.

- **Do not use alkaline or rechargeable batteries.**
- 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.

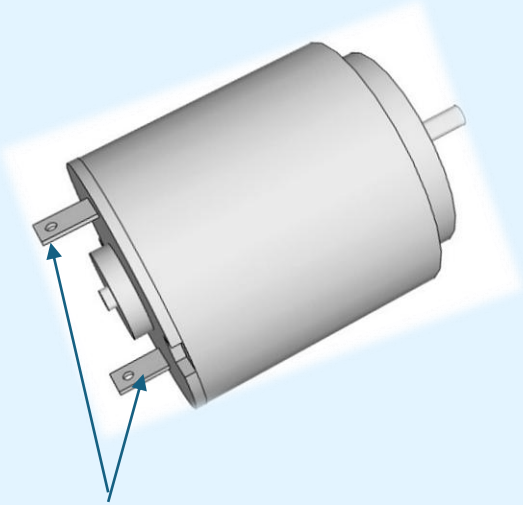
- Make sure the plastic sleeves cover the crocodile clips as shown here, to help prevent short-circuits if the clips touch.

Connecting the crocodile clips

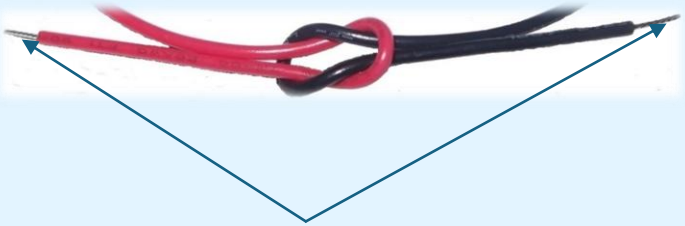
Where to connect the crocodile clips:



Connect to these two contacts on the switch.



Connect to these two contacts on the motor.

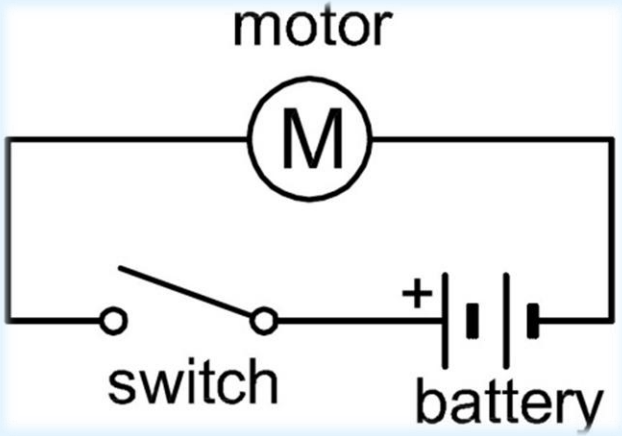


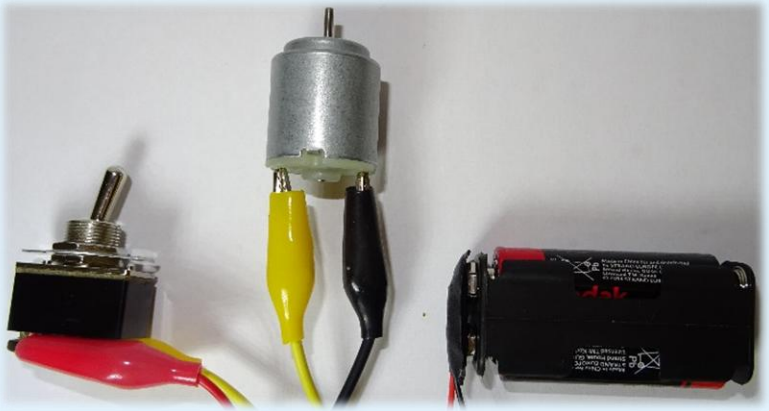
Connect to the metal ends of the wires from the battery box (not onto the plastic insulation).

Technology for Fun

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.

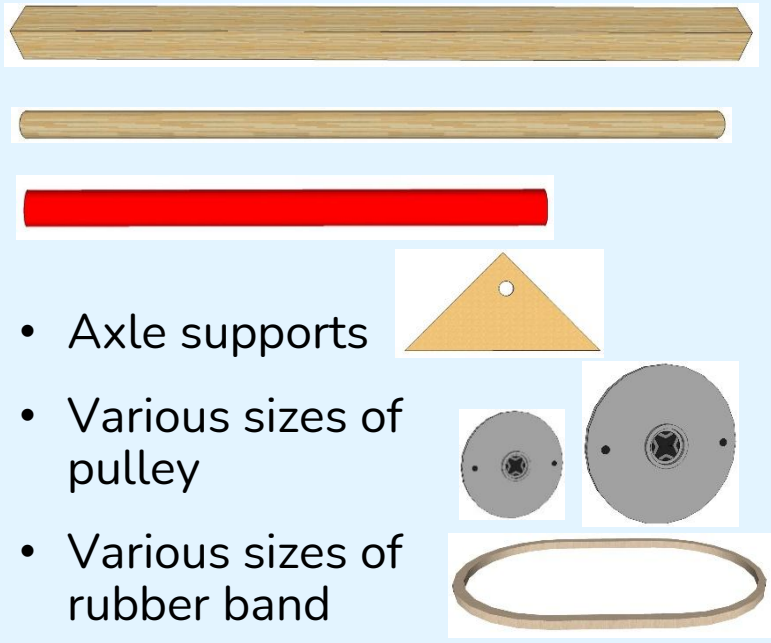




Materials available for your vehicle

Apart from the electric circuit, you have the following materials to make your vehicle:

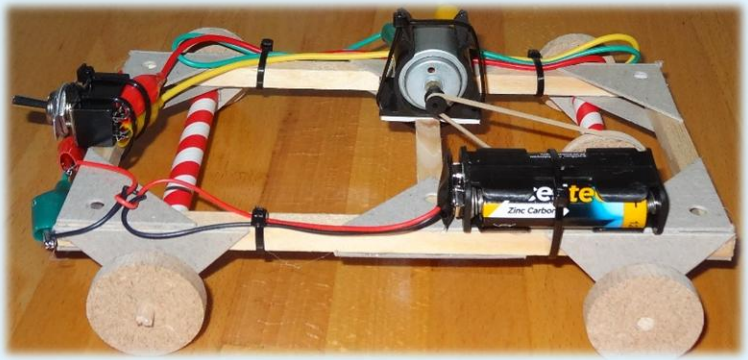
- Square section wood (to make the frame)
- Wooden dowel (to make axles)
- Straws (to make bearings)
- Card triangles (to reinforce the frame)
- Various sizes of wheel
- Motor pulley or gear
- Cable ties



- Axle supports
- Various sizes of pulley
- Various sizes of rubber band

Design your vehicle

- Think of a design for your vehicle and sketch it on your design sheet. Here is an example to help you (this frame is 11cm x 20cm).



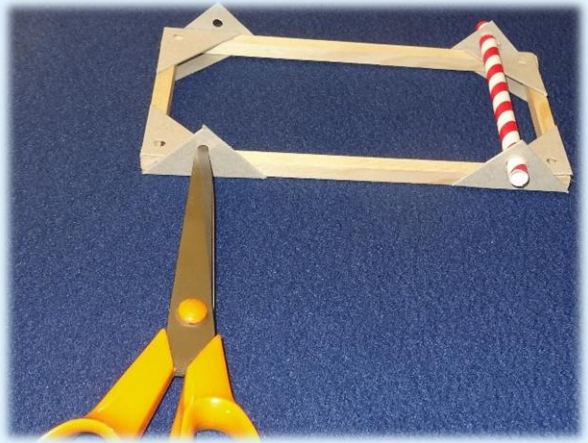
- Select which driven pulley to use. A smaller pulley should go faster on the flat, and a larger pulley should go better up hill.
- Select which wheels to use initially. It should go faster with larger driven wheels, but if they go too fast, they can slip. You can always change them at the end if you need to.
- Work out where your electrical parts will go.

Make your outer frame

- Mark out and cut your wood. Smooth the ends with sandpaper.
- Glue together the outer frame, then reinforce with cardboard triangles on the top and bottom.
- Glue four axle holders on to the frame. Try to make them symmetrical. Make sure you position the axle holders so the pulley doesn't touch the frame.

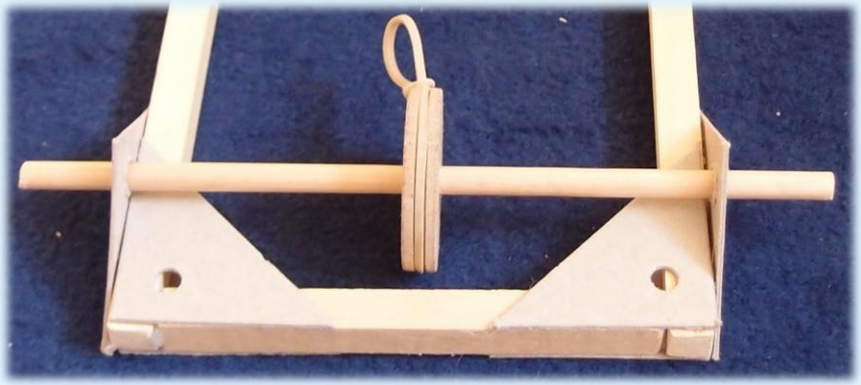
Fit your non-driven axle

- Cut a length of straw 2cm longer than your frame width. Round out the cut end with a pencil.
- Enlarge both the front and back axle holder holes to just fit the straw. Slide the straw in; it should be a tight fit. You could glue it to the axle holders.
- Cut and fit an axle 2cm longer than the straw. Push on the wheels until they nearly touch the straw. Check the axle spins freely.



Fit your driven axle

- Cut an axle 4cm longer than the width of your frame.
- Smooth the ends and check the wheels fit.
- Slide the wooden pulley to the middle; it should be a tight fit.
- Fit the rubber band over the pulley. You can tie a slip knot to hold it in place.
- Slide the axle into the axle holders.



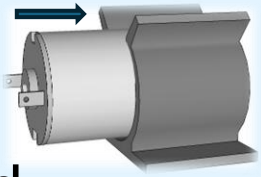
Fit your bearings

- Cut a length of straw 2cm shorter than your axle. Cut the length of straw in half. Slide the two halves onto the axle.
- Fit the wheels. Adjust until there is roughly a 1mm gap between pulley and straw, and between straw and wheel.
- Glue the straws to the axle holders. Don't get glue on the wheels or axles. Undo the slipknot and check the axle rotates freely.

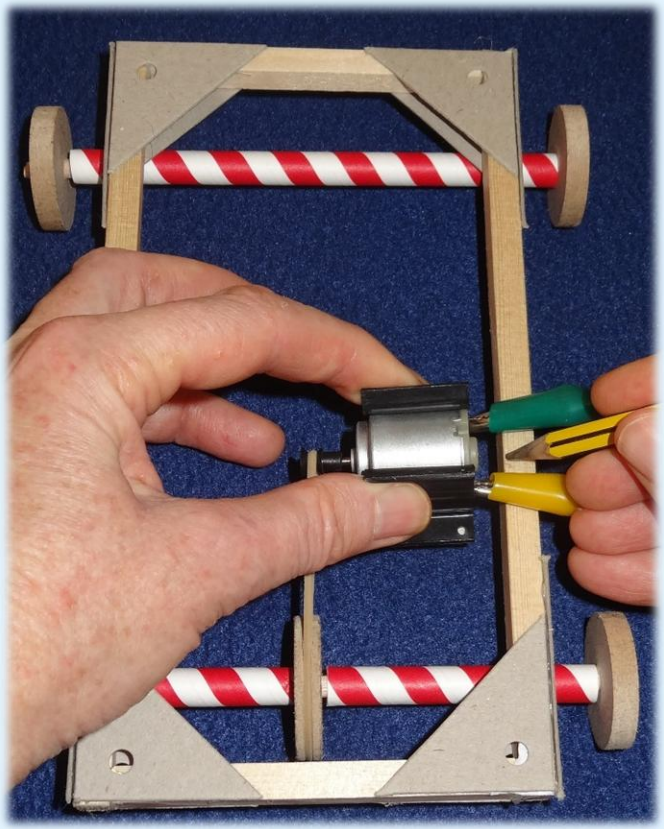
(This straw is in two halves.)

Fit your motor

- Press the driving pulley onto the motor shaft.

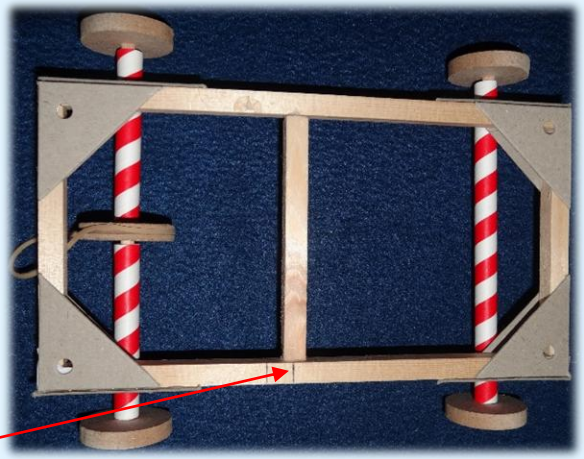


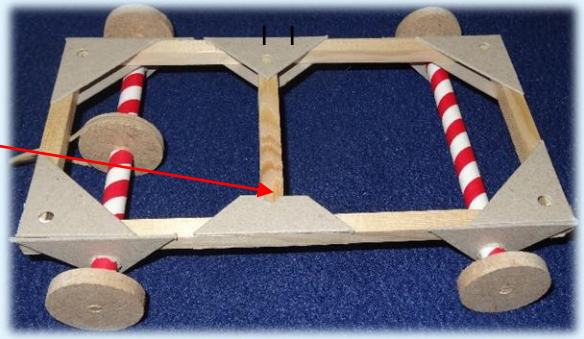
- Push the motor into the motor mount from the end.
- Fit the rubber band onto the driving pulley. Position the motor so that the rubber band is just tight but not stretched, as shown.
- Mark the centre line of the motor on the wooden frame.



Fit your motor (cont.)

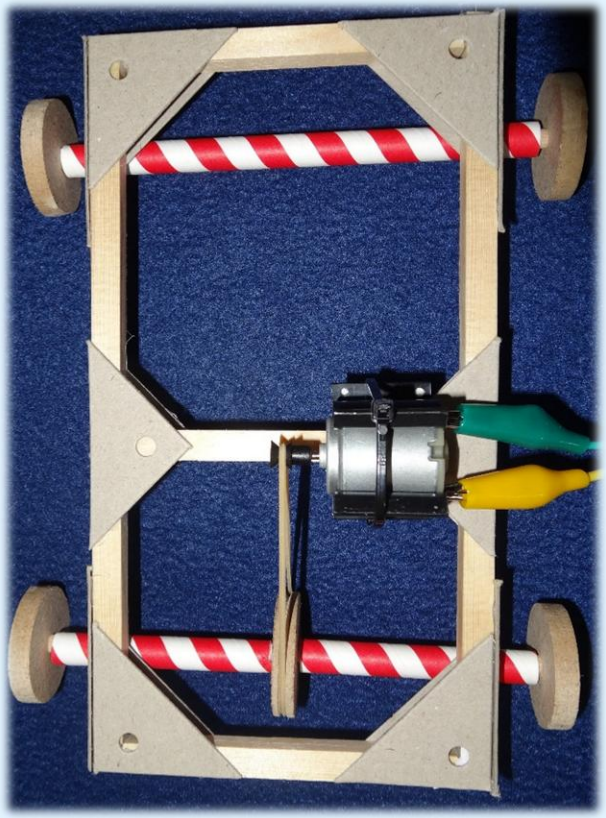
- Make a 2nd mark 1cm further along the frame, as you will need to tension (i.e. stretch) the rubber band.
- Measure, mark, cut and attach a length of wood to fit across the frame with the centre in line with your 2nd mark.
- Reinforce with card triangles. Cut the nose off one card triangle, so that the motor can mount directly on the wood.





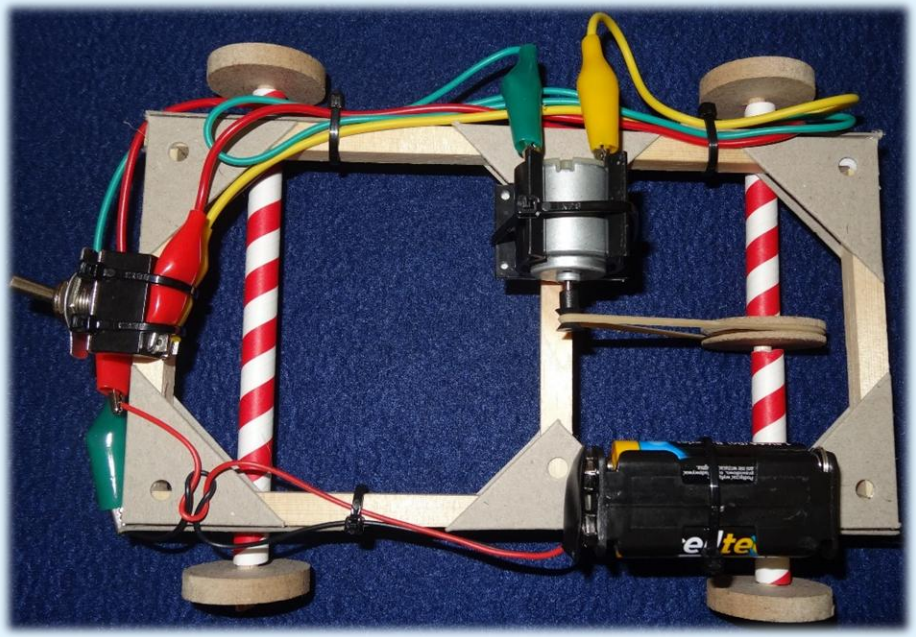
Fit your motor (cont.)

- Make sure your motor chassis is the right way up (i.e. the wheels are on the bottom).
- Stick your motor assembly to the top of your crosspiece so that the two pulley centres are exactly in line as shown.
- Cable tie it firmly in place.
- Fit the rubber band onto the pulley.



Complete your vehicle

- Work out where to attach your battery and switch, making sure nothing will interfere with the rotating parts.
- Glue and cable tie them firmly to the frame.
- Tidy up your wires, making sure the metal ends of the crocodile clips don't touch. Cable tie the wires and trim off the ends of the cable ties.



Test your vehicle

- Try out your motorised vehicle on different surfaces. You may find the driving wheels slip on a smooth surface; you can cut sections of balloon or bicycle inner tube and fit them as tyres.
- Time your vehicle over a measured distance to calculate the speed.
- Use a ramp to find out how steep a slope it can climb.
- You could try different wheel sizes and compare the performance of the vehicle.
- To make your vehicle to go in the opposite direction, swap over the crocodile clips on the back of the motor.

Race the vehicles

- When everyone has finished improving their vehicles race them along the track to find out which is the fastest.
- Have a good look at the winning vehicle to try and understand what features are responsible for its success.
- Tidy up thoroughly.
- Complete your worksheet.

What did you learn?

Discuss how the activity went and what you have learnt.

- What difficulties did you encounter; how did you overcome them?
- Which vehicle was the fastest?
- Can you explain why?
- Why do cars have rubber tyres?

- What have you learnt about:
  - Electric circuits?
  - Pulleys, axles, bearings and wheels?
  - Calculating speed?

- What did you enjoy most about the activity?

Fun TTS STEM class kits

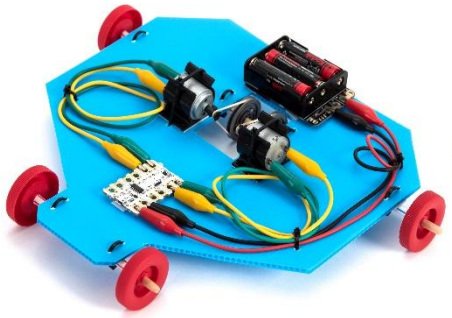
Fan boats

Crumble controlled models

D&T vehicles

Make your own light

Fairground rides



Crumble robotic vehicles