Lesson Plan – Making and Testing Motorised Vehicles

Level – Years 5-6
Time taken – 6 hours
Pupils to work individually or in pairs
Additional adult help is recommended
Expectations – to complete working vehicles
Associated resources:
PowerPoint
Design sheet
Pupil worksheet
Suggested answers to worksheet
Blog 'How to make a motorised vehicle'

STEM Links

- Science: electrical circuits, friction, pulleys
- Technology: structures, mechanical systems, electrical systems, designing and making
- Engineering: design, build, test and improve products
- Mathematics: measurement, speed, converting units

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:

- identify the effects of friction that act between moving surfaces
- recognize that some mechanisms including pulleys allow a smaller force to have a greater effect

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 and Technology: Technical knowledge

- apply their understanding of how to strengthen, stiffen and reinforce more complex structures
- understand and use mechanical systems in their products (for example pulleys, wheels and axles)
- understand and use electrical systems in their products (e.g. series circuits incorporating switches and motors)

Mathematics: Measurement

Pupils should be taught to:

- Measure lengths
- Compare duration of events
- Measure angles in degrees
- Calculate average speed

Parts included in class kit:

- Square section wood (50 lengths)
- Wooden wheels 54mm diameter (100)
- Wooden wheels mixed (100)
- Motors (30)
- Rubber bands (454g box)
- Toggle switches (30)
- Motor mounts (30)
- Battery holders (30)
- Snap battery connectors (50)
- Crocodile leads (90)
- Axles supports (500)
- Wooden pulleys 34mm (2 packs of 10)
- Wooden pulleys 54mm (2 packs of 10)
- Small plastic motor pulleys (30)
- Dowel (20 lengths of 60 cm)
- Straws (250)

Check you have received the correct contents in your class kit. Try pushing both the wooden wheels and the wooden pulleys onto the dowel to check they fit tightly. (There can be a slight variation in the diameter of the dowel due to the wood's moisture content. If the wheels are difficult to fit you can sandpaper down the end of the dowel slightly, and if they are slightly loose on the dowel you can glue them on.) Check the plastic motor pulleys are a tight fit on the motor shafts. Check the dowel slides easily inside the straws. Please let TTS know if there are any problems as soon as possible.

Tools and consumables needed:

- Ruler
- Pencil
- Paper
- Calculator
- Pointed scissors
- Low melt glue gun and glue sticks. **Note: High melt temperature glue guns should not be used by pupils, as they can cause nasty burns.**
- Ramp (if you don't have one you can use a length of plywood propped up on some books)
- Junior hacksaw, Vice or bench hook
- Sandpaper
- Cable ties 20 cm long (about 300)
- Balloons and/or old bicycle inner tube from mountain bike or similar
- Tape measure
- Stop watch
- Protractor
- Two sheets of plywood or similar to make a shallow slope for the race track
- Duct tape to join the wood together
- Chalk or masking tape to mark out the race track

Risk assessment

Conduct a risk assessment before undertaking the activity. Some suggestions for inclusion are given below:

Hazard: Pupils burning themselves with the glue guns.
Ways to reduce the risk: Warn the pupils of the dangers; don't switch them on until after the safety briefing; have a responsible adult supervising the glue guns; only use low melt temperature glue guns.

Hazard: Pupils cutting themselves with the junior hacksaws.
Ways to reduce the risk: Explain how to use the hacksaws safely; warn the pupils of the dangers; use only in combination with a vice or bench hook.

Hazard: Pupils cutting themselves with the scissors.
Ways to reduce the risk: make the pupils aware of the dangers; explain how to use the scissors safely.

Hazard: Pupils short circuiting their batteries and burning their fingers.
Ways to reduce the risk: explain how to avoid short circuiting the battery; use zinc chloride batteries (not alkaline or rechargeable ones) so they don't get so hot; if the batteries get hot ask an adult to disconnect them immediately.

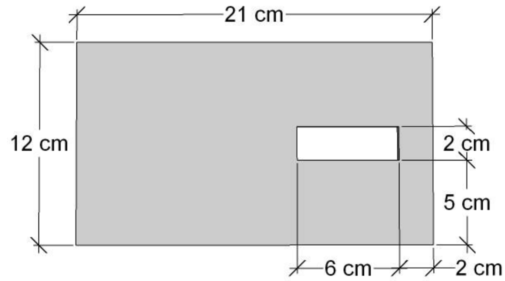
Vocabulary list

Pulley – a grooved wheel over which a drive belt can run
Drive belt – the belt which connects and transfers movement between two pulleys
Axle – a central shaft for rotating wheels
Bearing – this retains the axle in position whilst allowing it to rotate
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

Preparation needed

Build a sample vehicle to explore any pitfalls, and to demonstrate to the pupils what they will be making and how it works. Instructions for building a sample vehicle are given in the blog 'How to make a motorised vehicle'.

If you have pupils with mixed abilities some of them could find this activity quite difficult. In order to help them to complete a working model you could make them a chassis from Corriflute (N.B. Corriflute is not included in the kit) to the dimensions shown here.



The vehicles can be tested either on the school floor or in the playground. You need to lay out a straight race track (with start and finish line) for the vehicles which includes a shallow slope of about 10°, so that the effect of different pulley ratios can be investigated. To construct the slope you can use a sheet of plywood board propped up on some books to go up, then another one to go down again. If you put duct tape across the join it makes it easier for the vehicles to cross from one to the other. The start could be on the slope; otherwise you may need more duct tape between the slope and the floor so the vehicles can get onto the slope. Try out your vehicle on the track to make sure it works – you will probably need rubber tyres (e.g. slices of balloon or bicycle inner tube) to get the wheels to grip.

Once the initial build is complete pupils can test their vehicles on the track. They need to measure the distance and find out how long it takes to complete this. They then divide the distance by the time to calculate the average speed, and convert it to mph. They can then make changes to their car in order to help it go faster. At the end a competition is held in which each car races along the track, and the times are recorded on a leader board. The winning car should be examined closely by the pupils, to try and identify what design features were responsible for its success.

Avoiding pitfalls

It is a good idea to ask the pupils some leading questions before they embark on their designs, to help them avoid a number of common pitfalls. Show them the sample vehicle so that you can point out the issues. Suggested questions include:

1. Why do you need to fit the rubber band onto the pulley before you attach your driven axle? (This is because you can't fit it after you have attached your axle!)

2. What will happen if your driven pulley is touching the frame? (It will rub when it rotates, or may not be able to rotate at all.) How can you avoid this? (Mount your axles holders further away so the pulley doesn't touch.)

3. If your wheels are jammed up hard against the ends of the straws what will happen? (They will rub and slow the vehicle down; that is why you need to leave a gap.)

4. If your straws are jammed up hard against the pulley what will happen? (They will rub and prevent the axle turning as fast.)

5. If your wheels slip on the ground how could you increase the friction? (Add tyres made from slices of balloon or bicycle inner tube.)

6. If your driven axle is able to slide sideways, for example your straws are not glued to the axle holders, or there is a big gap between the straw and pulley, what is likely to happen? (The rubber band is likely to come off the pulley when in use. That is why the gap needs to be very small.)

7. Why might your motor stall? (When your motor stalls it can't rotate. This is usually because you have put too high a load on it, for example by using a driven pulley which is too small, wheels which are too large or by trying to climb too steep a slope.)

8. Why should you keep your wires away from the rotating parts? (The wires could stop get caught and stop the parts moving.)

9. Whereabouts do you want the centre of gravity of your vehicle to help the driven wheels grip the ground? (Keep your centre of gravity near the driven end, for example by mounting your battery that end.)

Extension activity

You could mount a Crumble Controller (not included in the kit) on one of the vehicles and programme it to run the vehicle backwards and forwards and at different speeds. This controller is particularly useful because you can run motors directly from it without needing a separate circuit. It can be programmed using a very simple drag and drop language.

If you have some particularly competent budding engineers in your class you could challenge them to make a steerable vehicle using two separate motors for the two driving wheels, then programme the vehicle to drive around a simple course.