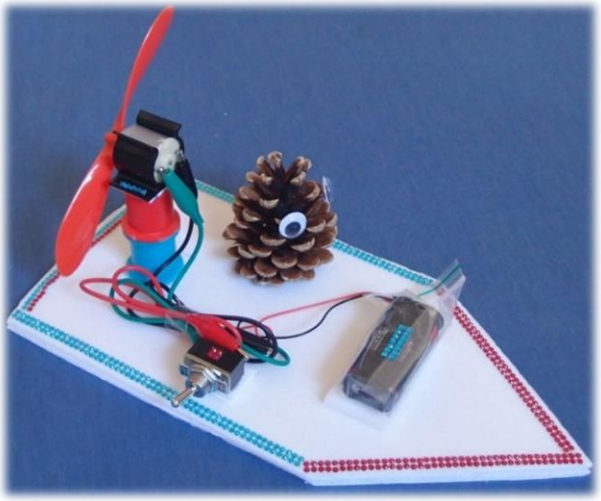
Fan Boats



Lesson Plan

Copyright © Caroline Alliston 2025

Fan Boats Lesson Plan

- Recommended level – Years 4-6
- Time taken – 6 hours
- Expectation – each pupil to complete one working fan boat
- Additional adult help is recommended (you could invite in parent helpers)

Skills and Learning

STEM Links

- Science: electrical circuits, materials, forces
- Technology: mechanical systems, electrical systems, designing and making
- Engineering: design, build, test and improve products, how a fan boat works
- Mathematics: drawing 2-D shapes, measurement

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
- use recognised symbols when representing a simple circuit in a diagram
- pupils should be taught about precautions for working safely with electricity

Science: Materials

Pupils should be taught to:

- identify and compare the suitability of a variety of everyday materials for particular uses
- give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials

Pupils should think about the properties of materials that make them suitable or unsuitable for particular purposes and they should be encouraged to think about unusual and creative uses for everyday materials.

Science: Forces

Pupils should be taught to:

- explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object
- identify the effects of air resistance, water resistance and friction, that act between moving surfaces

Pupils might explore resistance in water by making and testing boats of different shapes.

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:

- develop design criteria to inform the design of 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
- evaluate their ideas and products against their own design criteria and consider the views of others to improve their work

Mathematics: Measurement

Pupils should be taught to:

- measure lengths
- compare duration of events

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 electrical conductors.
Drag – as a boat passes through water, the water exerts a 'drag' force on the boat which acts to slow it down.
Insulator – an electrical insulator stops electricity from passing through it. Plastic, wood, rubber and glass are electrical insulators.
Prototype – an early model used to test out a design idea.
Short circuit – an incorrect route in a circuit which misses out certain components, allowing electricity to flow round it with very little resistance. This will allow the battery to drain quickly and become hot.
Streamlined – a boat which has a streamlined shape will be able to pass through the water more easily and quickly than one which doesn't.
Upthrust / buoyancy – when the boat is floating, the water gives it an upthrust or buoyancy force which supports the boat against the downward pull of gravity.

Associated Resources

- Fan Boats Presentation – this is to be followed when running the activity in class.
- Fan Boats Design Sheet – this is to be printed out, one for each pupil.
- Fan Boats Worksheet – this is to be printed out, one for each pupil. Some suggested answers are given at the end of this Lesson Plan.
- Fan Boats Instructions – this is for the teacher to follow to make a sample fan boat.

Equipment needed per boat (included in class kit)

- 3 half-sheets of polystyrene foam (total 50 sheets)
- 2 zinc chloride AA batteries (total 80)
- 1 motor (total 30)
- 1 toggle switch (total 30)
- 1 motor mounting clip (total 30)
- 1 battery holder 2xAA (total 30)
- 1 snap battery connector (total 50)
- 1 propeller (total 30)
- 3 crocodile leads (total 90)
- 2 cotton reels (total 100)
- 1 pine cone (total 1 box of 500g)
- 2 googly eyes (total 540)
- Rhinestone craft tape (pack of 6 rolls total)

Check you have received all these items in your class kit, and that the propeller fits tightly on the motor shaft. If there are any problems, please let TTS know as soon as possible.

Tools and consumables needed per boat unless otherwise specified (not included in class kit):

- A small plastic bowl is recommended for pupils to collect their electrical parts. Otherwise, the motors tend to roll off the table and get lost!
- Ruler
- Pencil
- Felt tip pen
- Sheet of A4 card
- Large scissors
- Sellotape dispenser (1 per table)
- 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.
- Water tray, paddling pool or plastic box big enough to try out the boats, half filled with water.
- Blue roll or cloth for mopping up water spills.
- Note: If you need to replace the cells, it is very important to use zinc type of cells, not alkaline or rechargeable ones. If pupils accidentally short circuit their battery (which often happens) then alkaline or rechargeable cells can get extremely hot and cause burns. Zinc cells are cheap and easily available (e.g. from discount stores).

Recommended resources for flotation exercise per class (not included)

- 1 metal coin
- 1 wooden lolly stick
- 1 piece of plastic K'nex
- 1 glass marble
- 1 small piece of polystyrene foam
- 1 pebble

Preparation needed

- Build a sample boat to explore any pitfalls, and to demonstrate to the pupils what they will be making and how it works. Instructions are given in the 'Fan Boat Instructions' provided.
- Cut the polystyrene foam sheet neatly in half before giving it to the pupils. They will need a double-thickness base to support the weight of their electrical parts. Allow three half-sheets per boat – two for the base and one for sides, fins, motor houses, rudders and other variations.
- Print out one 'Fan Boats Design Sheet' per pupil.
- Print out one 'Fan Boats Worksheet' per pupil. Sample answers to the questions are given later in this document.

Suggested schedule (depending on the timings of the school day)

- 08:30-09:00 Introduction and safety briefing
- 09:00-09:20 Flotation exercise
- 09:20-09:30 Forces
- 09:30-10:15 Select design criteria, draw your design, make card prototype
- Break
- 10.30-11.00 Electrical circuits
- 11.00-12.00 Make boats. Test the electric circuit works on the assembled boat (in the dry).
- Lunch
- 1.00-2.00 Finish off boats. Test them in the water trays and see what you can learn.
- 2.00-2.30 Decorate and improve boats then re-test.
- 2:30-3.00 Tidy up and plenary.
- Following day: Complete worksheets.

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 before 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 before the safety briefing.	L
Use of Sellotape dispensers	Injury, e.g. to fingers	M	• Make the children aware of the dangers. • Do not give out the Sellotape dispensers before the safety briefing.	L
Putting rotating fan too close to eye or putting finger in way	Bruising or damage	M	• Make the pupils aware of the dangers.	L
Water spillages	Slip hazard	M	• Use water trays outside where possible. • Warn people of hazard. • Wipe up water spillages	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 Fan Boats Presentation

Slide 3

Plan for the day

- It is recommended to start promptly and keep the pace up to complete the activity in one school day.

Slide 5

Learning objectives

- STEM stands for Science, Technology, Engineering and Maths.

Slide 6

Boats and ships from past to present

- The oldest boat found is a canoe made from a log and is about 10,000 years old. Canoes are paddled by humans.
- Sailing boats have been used from about 4,000 years ago. They are blown along by the wind.

- The first steam ship was made in 1705. It burned coal to produce steam which powered the paddles.
- Most modern ships use engines which burn diesel oil to power propellers which drive the ship.

Slide 7

How are boats and ships used?

- Passenger ships, e.g. ferries and cruise liners
- Cargo ships e.g. bulk carriers, oil tankers and container ships
- Naval ships e.g. destroyers, submarines and aircraft carriers
- Leisure boats e.g. sailing boats, rowing boats, speed boats and luxury yachts
- Boats for other uses such as fishing boats, tugs and dredgers

Slide 8

Working safely

- 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.
- Don't injure yourself with the spinning propeller.
- Long hair can also get tangled in the propeller – it could be tied back to avoid this.

Slide 10

Flotation exercise

- Ask the pupils to identify which of the items are made of metal, glass, wood, rock or plastic, and predict which items will float and which will sink. You can pass the items around so they can feel the weight. Place the items in the water and check whether they behave as predicted.

- Question - which of the materials could you use to make your boat, and why? You could use the polystyrene foam because it floats, it is easy to cut and join, it is cheap and you have plenty of it. You could potentially use lolly sticks, which also float.

- Question - which of the materials would you not use to make your boat, and why not? The metal, glass and rock sink, are difficult to cut and join, and you would have to trap air in them to make them float.

Slide 11

Forces exercise

- Place your sample boat on the water and ask the questions about forces pulling it down and pushing it up. Then switch on.

- Question - can you explain why the boat moves across the water? When the propeller pushes the air backwards, the opposing force [of the air pushing the propeller] pushes the

boat forwards.

- Question - what is the main force opposing the boat moving? The main force opposing the boat moving is the resistance of the water, known as 'drag'. The air resistance acting on the boat is very small compared with the resistance of the water.

Slide 12

Some examples of boat designs

- This slide shows various designs which have performed successfully.
- They include a catamaran (top right) and an aircraft carrier (bottom left)!
- Note that all these designs worked.
- Encourage the pupils to see the range of models that can be made.

Slide 14

Where to put your electrical parts

- If the centre of gravity is too near the front then the nose is likely to dip and the boat ship water as it goes along. (It is better for the centre of gravity to be slightly back rather than forward of centre, because the propulsion force acts quite high up so it also tends to make the nose dip.)
- If it is too near the back then the back will end up under water and slow the boat down.
- If it is over to one side then the boat is likely to turn to one side or possibly to capsize.

Slide 15

Design your boat

Ask the pupils to come up with a design of boat which they think will fit their design criteria, and make a prototype using the A4 card. Make sure the prototypes are large enough to be used as a template when creating their models. They don't have to be the shape shown in the diagram. They should try to imagine the resistance of the water and think of a shape which would cut through the water easily. Also, they need to work out where their electrical parts will be mounted; the centre of gravity should be near the middle of the boat, and the wires shouldn't get tangled in the propeller.

The propeller will work facing either forwards or backwards. It can be mounted either way round on the motor shaft. It will work much better one way than the other; they may be able to work out which way round to fit it, as it is curved to 'scoop up' the air as it turns. Otherwise, they can try it both ways and find out which works best.

You could ask the pupils to suggest what might happen if:

- the base is too small (it might sink)
- the base it too narrow (it might capsize)
- the base is too wide (it might go slowly)
- the cotton reel stack is too short (the propeller blades would rub on the base)
- there is no gap between the propeller blades and cotton reels (the propeller won't go round and the motor might get hot and stop working)
- the crocodile leads get tangled in the propeller (it won't go round)
- the batteries get wet (they might stop working)
- the switch gets wet (it might stop working)

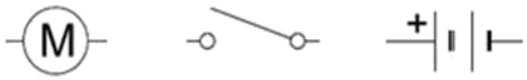
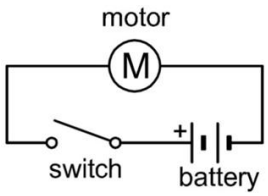
	• the crocodiles get wet (they might go rusty and stop working) • the centre of gravity is not in the middle (the boat might go round in circles, or even capsize) • you put on lots of heavy decorations (the boat might sink) • the boat doesn't go in a straight line (you could improve the balance, make sure the motor is attached straight, and perhaps add fins, an air rudder or a keel, or turn it into a catamaran)
Slide 16	**Electrical parts** • The electrical parts are a motor, switch, battery, crocodile lead or wire.
Slide 18	**Avoid short circuits** • If you need to replace the batteries, be careful not to use alkaline or rechargeable cells, as these can get very hot if you accidentally short circuit them, which is easily done. Make sure you use zinc cells, which don't get as hot.
Slide 19	**Make your circuit** • It is a good idea to have bowls for the pupils to collect their electrical parts so they don't lose them. • They need a motor, motor mount, switch, battery holder, battery connector, two cells and three crocodile leads (preferably different colours). • Slide the motor into its mount from the end rather than above to avoid snapping the mount This is to stop the motor from rolling off the table. • Demonstrate how to connect up the circuit before the pupils start. Show them the reef knot, where to connect the crocodile leads onto the components and explain that they need to clip onto the metal ends of the battery wires, not the plastic insulation! • Some pupils are better at tying reef knots than others. You could get them to help one another. • You could check the circuits to make sure they are connected up correctly before the pupils fits the cells. • Get the pupils to put their circuits back in their bowls once they are complete, checked and switched off.
Slide 20	**Make your boat base** • It is a good idea to retrieve the pencils and the scissors before giving out the polystyrene foam, and give out felt tip pens instead. The pencils indent the foam, so that mistakes are more difficult to correct. • A double thickness of foam is needed to support the heavy electrical parts. The two parts should be glued together only after cutting to shape. • Check that the pupils have come up with a feasible (big enough) prototype before handing out the foam sheet. A minimum width of 14cm and a minimum length of 25cm is recommended. The most common mistake is making the boats too small.

	• Pupils can draw round their prototype on the foam if they like. Check the design marked on the foam is big enough before handing out the scissors.
Slide 21	**Make your boat** • If the motor is at the front, it is recommended to mount it facing forwards. If it is at the back it is recommended to mount it facing backwards. The reason for this is so that the wires don't get in the way of the propeller as it turns. If you mount it the other way you have to be really careful with the routing of the wires.
Slide 23	**Assemble your fan** • A common problem is for the motor to get pushed back in its mount so that the propeller is jammed against the cotton reels. If this happens you need to slide it forwards in its mount again so that there is a gap.

Slides 25-26	**Test and improve your boat**
	1. If the boat goes backwards instead of forwards, then try swapping over the crocodile clips attached to the motor terminals, as this will make the motor turn the other way and push the air in the opposite direction.
	2. If the propeller stops going round then it could be catching on the cotton reels, or one of the crocodile clips may have come off.
	3. If the boat is going very slowly then you could try fitting the propeller the opposite way round on the motor shaft. Check the airflow isn't blocked by features on the boat.
	4. If the boat isn't moving even though the propeller is turning, it might be touching the bottom of the water tray.
	5. Can the pupils spot any differences in design between the boats which go faster and those which go slower?
	6. If the boat turns to one side when you want it to go in a straight line you could try:
	  • Moving the battery so that the centre of gravity is not over to one side or the other.
	  • Trimming the boat to make it more symmetrical or pointed at the front.
	  • Adjusting the motor direction if it isn't straight.
	  • Adding an air rudder, fins along the sides or a shallow keel or rudder to help it go straight.
	7. Try out the boat after making any modifications to see if they have made any difference to its operation.

Fan Boats Worksheet - suggested answers

<table>
<tr><th colspan="2">SCIENCE: ELECTRICITY</th></tr>
<tr><td colspan="2">Name these electrical parts:

Motor Switch Battery Crocodile lead (or wire)</td></tr>
<tr><td>Draw your circuit using these circuit symbols, using lines to represent the wires. Label the components.
  </td><td>  </td></tr>
<tr><td>Is metal an insulator or a conductor?</td><td>A conductor</td></tr>
<tr><td>Is plastic an insulator or a conductor?</td><td>An insulator</td></tr>
<tr><td>What could happen if you short circuit your battery?</td><td>I could heat up or melt your battery holder and possibly burn my fingers.</td></tr>
<tr><td>What will happen if you leave the circuit switched on for a long time?</td><td>I will drain the battery.</td></tr>
<tr><th colspan="2">SCIENCE: MATERIALS</th></tr>
<tr><td>Which items floated?</td><td>The lolly stick and the piece of polystyrene foam should have floated.</td></tr>
<tr><td>Which items sank?</td><td>The coin, the marble, the stone and the K’nex should have sunk.</td></tr>
<tr><td>Solid polystyrene is denser than water. Why did the piece of polystyrene foam float?</td><td>It has lots of little air bubbles trapped in it, and air is very light.</td></tr>
<tr><th colspan="2">SCIENCE: FORCES</th></tr>
<tr><td>What force pulls the boat down onto the water?</td><td>The boat is pulled downwards because of the gravitational attraction between it and the Earth.</td></tr>
<tr><td>What opposing force pushes the boat up?</td><td>The ‘upthrust’ or buoyant force pushes the boat up.</td></tr>
<tr><td>Which is the main force opposing the boat moving?</td><td>The main force opposing the boat moving is the resistance of the water, known as ‘drag’.</td></tr>
<tr><th colspan="2">DESIGN & TECHNOLOGY</th></tr>
<tr><td>Did your design meet your design criteria?

Did you make any modifications?</td><td></td></tr>
</table>

EXTENSION QUESTION	
Explain why the fan boat moves across the water.	The propeller pushes the air backwards; the opposing force on the propeller pushes the fan boat forwards across the water.