EA jnr club

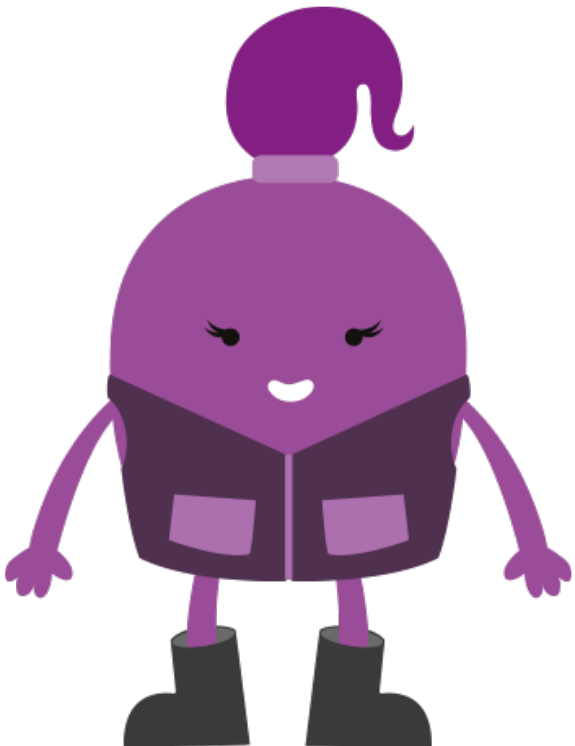
Lower Primary

TEACHER RESOURCE KIT

Construct a water wheel

This guide includes:

- Lesson ideas
- Project instructions
- Simple machines every day
- Tools and machines
- Draw your own water wheel
- Wheels and axles
- Know Want Learnt (KWL) chart
- Think Want Learnt How (TWLH) chart



ENGINEERS AUSTRALIA

Construct a water wheel: *lesson ideas*

Science

- Students to investigate hydroelectric power. What is it? Is a hydroelectric power generator a modern-day interpretation of a water wheel? How do hydroelectric power generators provide energy for the community?

Technologies

- Students to complete the **'Wheels and Axles - Where Else Can We Find Them?'** activity sheet.
- Students to brainstorm as many tools and machines as possible *(e.g. hammer, can opener, screwdriver)*.
- Students to then complete the **'Tools and Machines - Where Do They Belong?'** activity sheet.
- Students to sort and classify several simple machines using the **'Simple Machine Cards'** *(printable cards can be found with the activity sheets)*.
- Students to go for a walk around the school looking for different types of simple machines. Where can they see a wheel and an axle? Students to complete the **'Simple Machines Every Day'** activity sheet.
- Class discussion: Why do we need machines and tools?
- Set up a display table of simple machines *(e.g. egg-beater, screw, hammer, pulley, gear etc.)* in the classroom so students can become familiar with them. Encourage students to bring other simple machines from home.

Mathematics

- Water wheels have 'paddles' that are equally spaced around a circle. Students to practise folding circles of coloured paper into equal sections to show where paddles could be placed.
- Students to use various measuring containers to estimate, and then establish, what constitutes a litre *(e.g. how many cups of water make a litre?)*. Students to record their results. The students can water the school garden when the activity is finished.

English

- Students to brainstorm as many engineering words as possible and then create a page in their Science books on which to record them. Students will add to this as they learn new words. These words could be used to create a class word wall.
- Students to use pictures and key words to create a display in the classroom based on 'simple machines'.
- Students to complete the **'KWL Chart'** or **'TWLH Chart'** activity sheet.
- Students to write a procedure of how to make a water wheel.

Humanities and Social Sciences

History

- There are many examples of water wheels around Australia. Students to view pictures and talk about how they work and discuss their past and present uses.

Geography

- Students to discuss the importance of water as a valuable resource. What would communities do without water? Students to discuss what they can do to ensure that this precious resource is used wisely.

The Arts

- Students to complete the **'Draw Your Own Water Wheel'** activity sheet. Following are some easy instructions to give your students to help them draw their water wheels.
    - **Step 1 -** Draw a house shape *(the 'mill house')* with a small arched window at the top. Then draw a large circle for the wheel, with a smaller one in its centre to represent the axle.
    - **Step 2 -** Draw the roof and then a small arc around the left side of the water wheel to give it some depth.
    - **Step 3 -** Draw the paddles on the water wheel as equally-spaced black rectangles around the circumference of the large circle. It does not really matter how many, as long as they are roughly an equal distance from one another.
    - **Step 4 -** Add a straight line for the ground and a wavy line for the water, taking care that the waterline crosses the lower paddles of the water wheel, to show how flowing water pushes the paddles around. Your students could also decorate the building, or even draw some hills and trees in the background.
- Students to paint pictures of water wheels.
- Students to cut out pictures from magazines of machines and tools. Paste onto a large piece of paper to create a class collage on the topic.

Health and Physical Education

- Students to brainstorm ways in which simple machines have helped human beings.
- Students to learn about water safety. What are some key things to remember when you are near or around water? Students to produce a class poster about water safety.
- Students to work in small groups to create a water wheel with their bodies. They can make the sounds of each part of the water wheel.

Languages

- Students to investigate the origin of the word 'engineer'.
- Students to learn how to say and write 'water wheels' in various languages.

Construct a water wheel: *Project instructions*

Important safety information

Allow plenty of time to discuss any safety precautions that are essential when assembling and testing water wheels. This could include not using water near electrical equipment or outlets, avoiding the slip hazards of spilt water, and the safe use of any tools that might be needed for the activity.

As a class, discuss how students can keep themselves and others safe. These ideas should be presented on a class poster and displayed in the classroom. All students should agree with these rules before starting and the safety precautions and guidelines should always be observed.

Getting started - research activities

- Students to participate in the **'Construct a water wheel'** lessons and complete the associated activity sheets.
- Students to research the applications of various simple machines, and the combinations of simple machines they might use to build a working model of a water wheel.

The design stage

These are some of the design elements that students may need to consider in planning their water wheel.

- The size *(diameter)* of the wheel and the number of buckets or paddles that are to be fitted around it.
- How to arrange the buckets or paddles evenly around the wheel.
- The axle, and the hole through the centre of the wheel through which it will pass.
- How the axle will be supported at each end to allow the wheel to rotate freely.

Note: Due to the weight of water flowing over students' water wheels, the wheels need to be well constructed in order to be able to turn without falling apart.

Students to construct a simple water wheel model that turns by the flow of water. The water wheel will need an axle on which to turn, and a stand of some sort to support the axle and the wheel. The water to drive the wheel *(the 'head race')* could be poured *(e.g. from a jug or other container)*, or perhaps delivered through a plastic tube or hose.

Students *(with teacher assistance)* could consider some of the factors that will affect the 'power' of their water wheel. These could include factors such as the rate of flow of water entering the wheel, the speed of the water flow, the diameter of the wheel and the size and number of the buckets or paddles mounted on the wheel.

Project limitations

- The water wheel is to be constructed from readily available or 'found' materials, or items that can be easily and cheaply purchased in a hardware store or supermarket.
- The water wheel diameter should be no larger than 30cm, and the base of the supporting structure no larger than 35cm^2. Any 'head race' or flume that brings the water to the wheel is to be no longer than 60cm.
- As the operation of the water wheel will involve the use of water, it is clear that a wet area will be required for testing.

Water conservation and efficiency

EA Junior Club encourages all participants to be 'water wise' and conserve water. Accordingly it is likely that 'overshot' water wheel designs will be more effective than 'undershot' ones. This could lead to a class discussion on the importance of water conservation and the most efficient use of water.

The construction stage

Materials

Students are to create their water wheels out of recycled or household items, or materials that can be purchased cheaply from a hardware store or supermarket.

In choosing their construction materials, students will need to consider the properties of different materials and select those that are most appropriate.

Some considerations about the properties of materials could include the following:

- Strength: The structure needs to be strong enough to support its weight and to work without breaking.
- Water absorbency: Some materials such as cardboard will absorb water and become soft and weak. If they are used, they will need to be coated to make them waterproof.
- Available materials: For example, the axle will need to be round in cross section so as to turn smoothly in the bearings.

A simple water wheel model

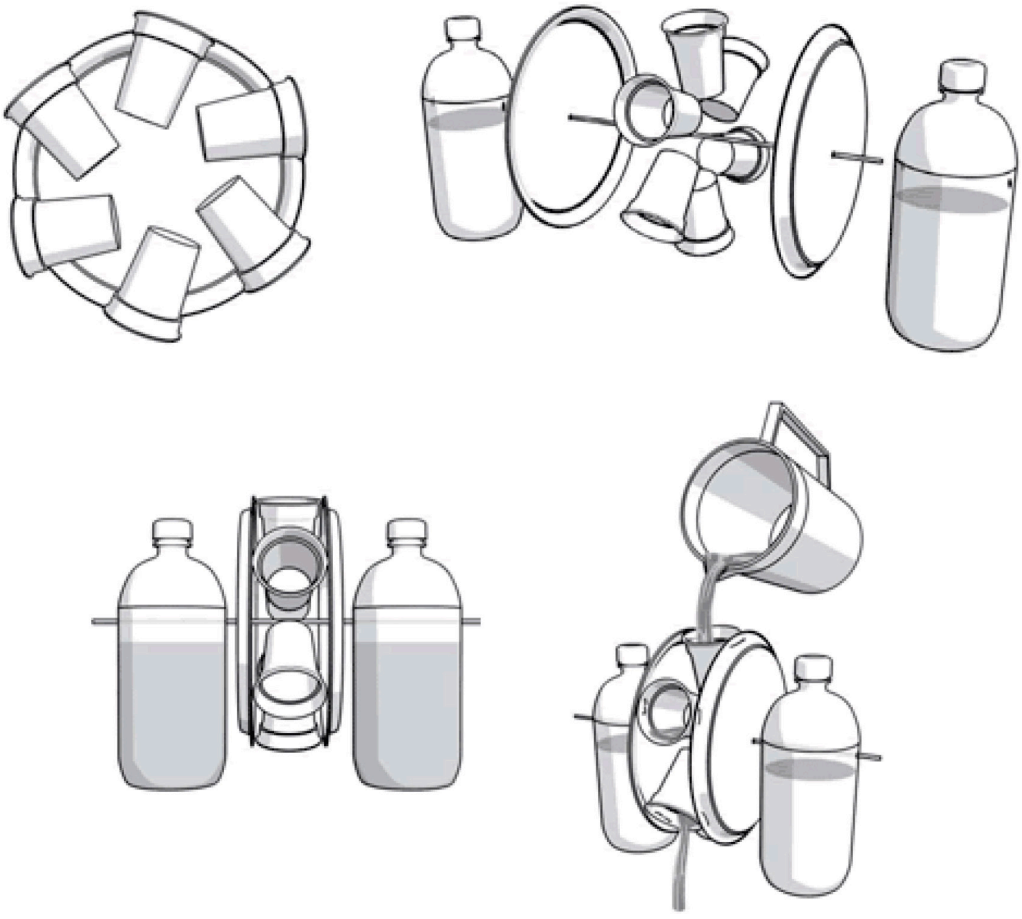
Here are the instructions for a simple water wheel. Students can follow this design or create one of their own.

What you will need:

- 2 x disposable plastic dinner plates *(260mm in diameter)*
- 6 x 240ml capacity disposable plastic drinking cups
- stapler
- 2 x 2L soft drink bottles half filled with water or sand
- wooden skewer *(extra long, or two taped together)* or a long piece of dowel
- hand drill or a sharp object to make a small hole in the soft drink bottles
- pencil
- protractor
- ruler
- jug
- water
- sink or wet area to test the models

What to do:

- Begin by using the protractor and pencil to find the centre of each disposable plate *(see 'Mathematical skills' below for more ideas on how to do this).*
- Poke the wooden skewer through the centre of each plate to make a hole. Remove the skewer while you attach the cups.
- Mark out six equal segments on one plate *(see 'Mathematical skills').*
- Use the stapler to attach the cups to the plate at an angle, ensuring that the open end of the cup is facing up *(see diagram).*
- Once the cups are in place, staple them to the other plate to make the 'wheel'.
- Thread the skewer through the two plates to make an 'axle'.
- Make a hole in each of the soft drink bottles *(using a hand drill or sharp object)* and push the skewer through to support the wheel (see diagram). Try to ensure these holes are at equal heights.
- Fill the jug with water and pour it into one of the cups to begin the water wheel process.
- Mathematical skills *(Depending on the abilities of the students, the measuring of the hole and angles may need to be undertaken by an adult.)*



The wheel will need a hole in the centre for the axle to pass through and the buckets *(disposable cups)* will need to be arranged at equal distances around the edge of the wheel.

Students may need to learn how to locate the centre of a circle in order to make the hole for the axle. There are multiple methods for doing this such as the 'square' method or the 'chord' method.

Students will need to divide a circle into a number of equal segments *(e.g. 6, 8 or 10)* to accurately calculate the placement of the buckets *(cups)* around the edge of the wheel. They can do this by dividing the 360 degrees of a circle by the number of buckets. This will determine how many degrees apart each one needs to be. For example, if there are to be six buckets, 360 will be divided by 6 and the buckets will be spaced at 60 degree intervals.

Testing the water wheel

Students should test their water wheel and measure the rate at which it turns. They should be encouraged to offer suggestions as to how this can be measured.

One simple method is to place a mark at one point on the edge of the wheel that can be seen as it rotates, and to count how many times the wheel rotates in a given time. This can be calculated and recorded as 'revolutions per minute' *(rpm)*.

Recording the results

Students should be encouraged to record their results in a meaningful way. Students could reflect on their water wheel by drawing pictures/taking photographs or videos and writing a paragraph about it when completed.

Critiquing the designs

Having attempted a design, completed construction, and tested it to see whether it works, the student teams should be given opportunities to critique their designs, plan and carry out any modifications, then test their new designs. All of these steps should be recorded in a journal.

Obviously there is a limit to how many of these critique and modify cycles can be built into a school program, but it does need to be recognised that the capacity to critique a design and its performance, and consequently modify and test it again, is an important basic engineering principle.

Aspects to be critiqued could include:

- The construction and balance of the water wheel.
- How freely the wheel turns.
- The flow rate of the water.
- The angle of the 'head race'.
- How and where the water strikes the water wheel.
- The angle of the buckets on the wheel.

Explaining the water wheel

Having constructed a working model of a water wheel, the students should then be guided through a process of explaining how their machine works. The expected outcomes of this work will of course depend on the ages and abilities of the particular students.

Some aspects that might be appropriate are:

- The energy of movement *(kinetic energy)* of the running water.
- The diameter of the wheel. *(The greater the diameter of the water wheel, the longer the 'lever' effect of the falling water, and the greater the turning effect on the wheel.)*

Building on this understanding

Having constructed and tested a working model, critiqued and refined the design, and tested it again, there are further opportunities for student learning.

These include:

- What other design changes might lead to improved performance of the machine?
- How could these be tested?

Note: This leads into 'Working Scientifically', the concept of variables, and the need to vary only one variable at a time whilst keeping everything else the same, in order to conduct a 'fair test'.

What other machines *(both past and present)* work on similar principles to the water wheel?

Assessing the projects

Upon completing the construction and testing of their water wheels, students should be engaged in assessing the successes of their projects. They should consider:

- Which particular designs were more successful? Why?
- What have they learned whilst doing the project?
- What else would they like to learn about energy and the power of water?
- What would they do differently if they undertook the project again?

Simple machines every day

Name: _____

You see simple machines every day! But where?

Draw three simple machines you have seen around your school in the boxes below.

Tools and machines - Where do they belong?

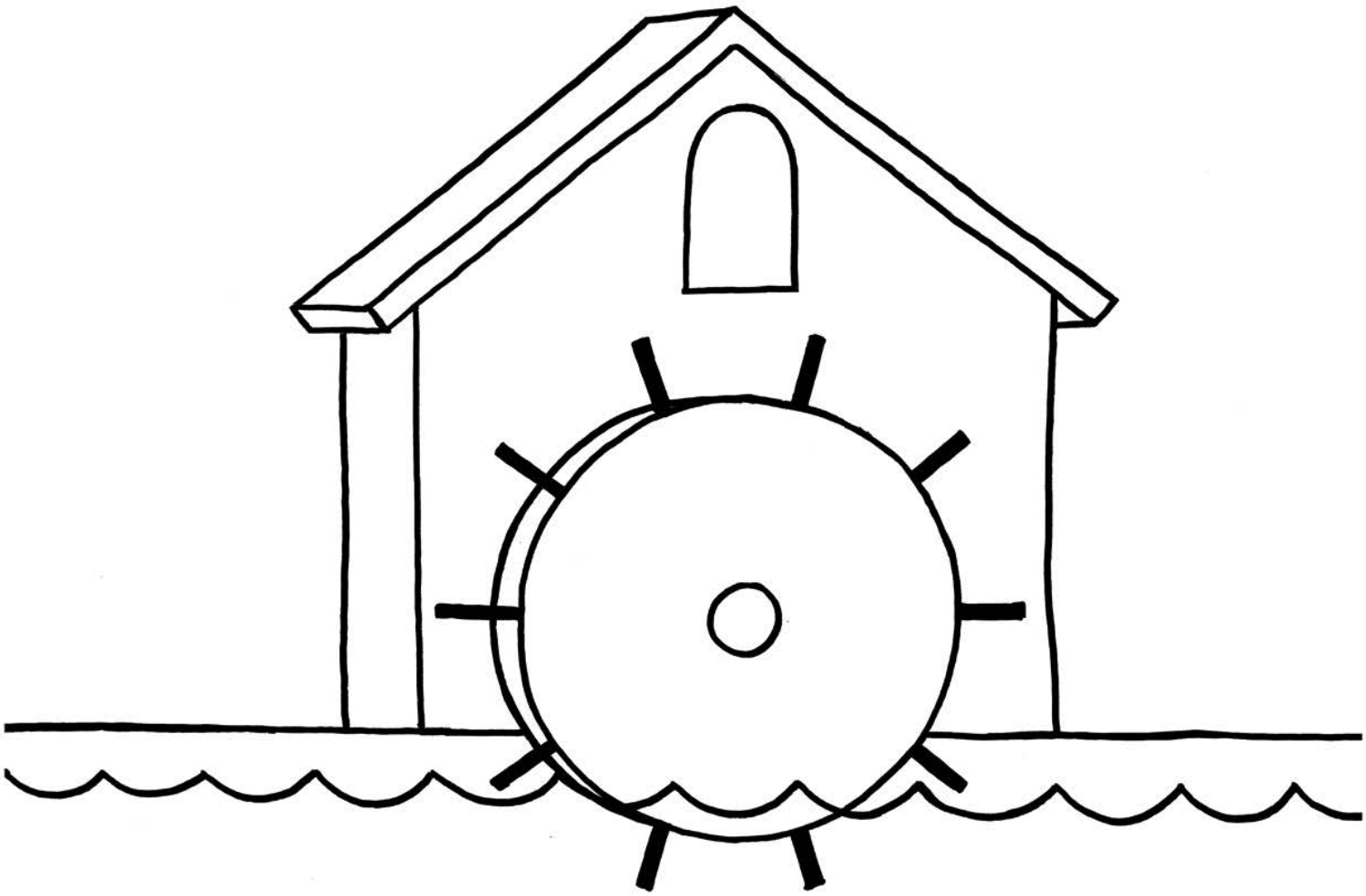
Name: _____

Simple machine	Put the tools and machines (from your brainstorm) into the correct group
Pulley	
Lever	
Wheel and axle	
Inclined plane	
Wedge	
Gear	
Screw	

Draw your own water wheel

Name: _____

Below is a drawing of a water wheel.



Draw your own water wheel

Name: _____

Draw your own water wheel here.

Wheels and axles - Where else can we find them?

Name: _____

Your water wheel needs a wheel and axle to work. Where else have you seen wheels and axles? Draw and label them in the boxes below.

My water wheel	

Know Want Learnt (KWL) Chart

Name: _____

What I **KNOW** about hydropower	What I **WANT** to know about hydropower	What I have **LEARNT** about hydropower

Think Want Learnt How (TWLH) Chart

Name: _____

What we **THINK** we know about hydropower	What we **WANT** to know about hydropower	What we have **LEARNT** about hydropower	**HOW** we learnt it