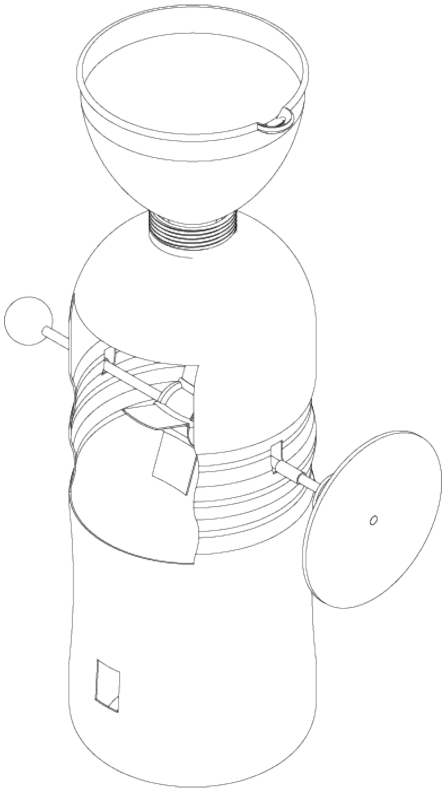


WATER TURBINE WORKSHEET

GETTING STARTED

5-10m

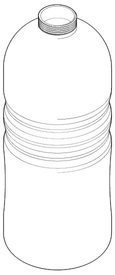
Throughout time, people have used the energy of falling and flowing water to produce power - from water wheels used to grind grain to modern hydroelectric dams to power cities.

Our need for energy is growing, therefore it is incredibly important for engineers and scientists to work to find greener and renewable sources of power to meet our needs in the future.

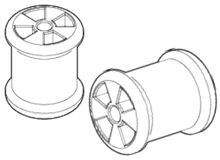
In this project, we are going to show you how to make a water-powered turbine, to allow you to harness the energy of water.

During this process, you will learn about the physics involved and it will hopefully get you thinking about what the future holds for how we produce our energy.

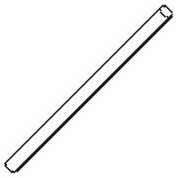
YOU WILL NEED



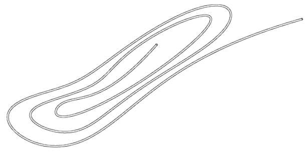
2L plastic bottle
1



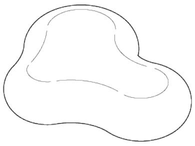
Cotton reels
2



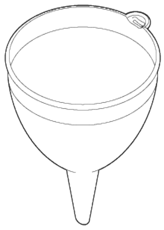
Wooden Dowel
30cm



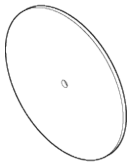
String
1m



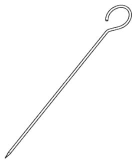
Modelling clay
(small fist size)



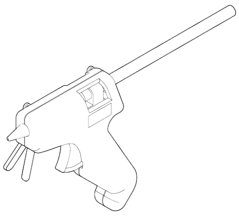
Funnel
1



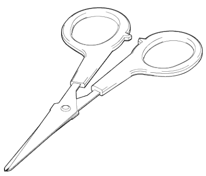
Cardboard Disc
10cm diameter



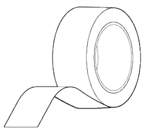
Skewer
1



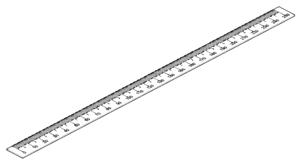
Glue gun
1



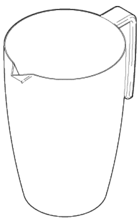
Scissors
1



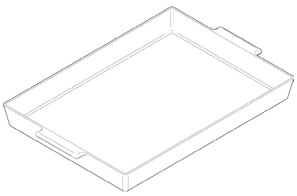
Tape
60cm



Ruler
1



Jug
1



Tray
1

VOCABULARY

Renewable Energy - Energy made from resources that nature will replace. This includes resources such as wind, water and sunshine.

Fossil Fuels - Coal, oil and natural gas, which come from the breakdown of ancient plants and animals over millions of years.

Kinetic Energy - Energy which an object possesses by being in motion.

Gravitational Potential Energy - The energy stored by an object lifted against the force of gravity.

Sustainability - To prevent the depletion of natural resources in order to maintain ecological balance.

Hydroelectric Power Plant - A place where electrical energy is produced through the power of moving water, known as hydropower.

Turbine - An engine that turns fluid movement into energy.

Shaft - A long thin piece of wood or metal.

WARM-UP ACTIVITIES

A

5-10m

Water turbines are used in hydroelectric power plants to produce electricity. Using water to produce electricity is sustainable because it is a renewable resource. Renewable resources help the UK to achieve its target of achieving zero emissions by 2050.

Consider and investigate the following:

- What can we do to try to reduce our emissions?
- What are the pros and cons of using water to produce energy?
- What other sustainable sources of power are there?

Thinking about where our energy comes from will help you understand why sustainability is important.

B

10-15m

Turbines have many different uses; they are even used inside of jet engines to power planes.

Using online resources, investigate some of the uses for turbines and explore the different shapes and designs.

This will help you to understand the variety of uses turbines have and inspire you to engineer your own turbine.

MAIN CHALLENGE

30-40m

Building a model water turbine is a great way to get you thinking about and investigating more sustainable energy sources for the future.

We have provided you with an example of how to build a water turbine and suggested some materials to use, but if you are feeling creative we encourage you to design your own.

Once you have put your turbine together, you can use your imagination to decide what your turbine can power. Perhaps it could be used as a lift for a toy, or to power an optical illusion. You decide!

Every time an engineer is faced with a problem, they approach it using the Engineering Design Process.

Ask - What is the problem?
Imagine - Choose a solution.
Plan - Design and choose materials.
Create - Make it.
Test - Test your creation.
Improve - Redesign as needed.

Using this design process, see if you can create the most efficient water turbine. Good luck!

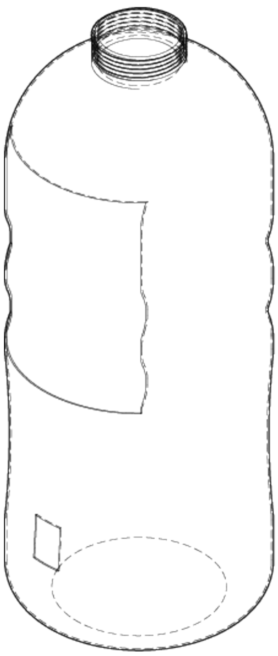
BUILDING THE TURBINE

Follow these steps to build your water turbine!

A

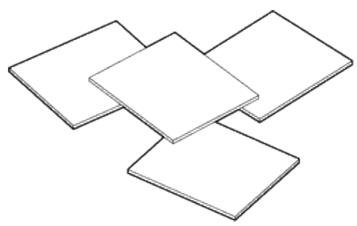
First, cut a tall rectangular hole (about 15cm x 8cm) in the top half of a 2L plastic bottle. This will allow you to place the turbine inside once you have made it. Then mark a smaller hole (about 2cm x 3cm) 4cms below it. This hole will allow the water to flow out of the turbine as it passes through.

To cut these holes, first use a sharp skewer to pierce the bottle, then you can use scissors to enlarge the hole and cut out the rectangle. Ask an adult for help with this step if you need it.



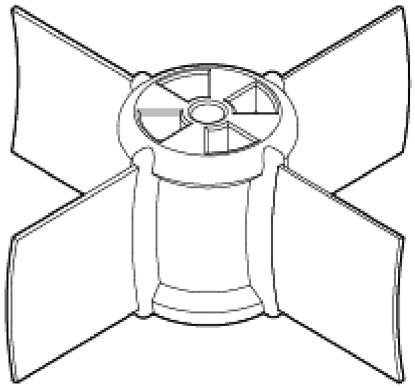
B

Next, take the large rectangle you cut from the bottle and use your ruler to measure four smaller rectangles which are 3cm by 3.5cm. These will form the turbine blades.



C

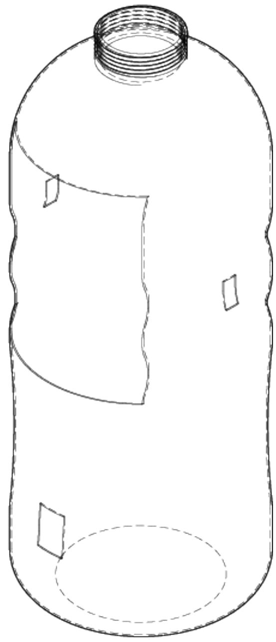
Now, mark quarters onto one of the cotton reels using a marker pen. This will ensure the blades are evenly spaced. Next, glue the turbine blades onto the marked lines using a hot glue gun. You will need to squeeze the two edges of the blade together slightly as you glue it because it is wider than the cotton reel. This will create a scoop shape to catch the water.



D

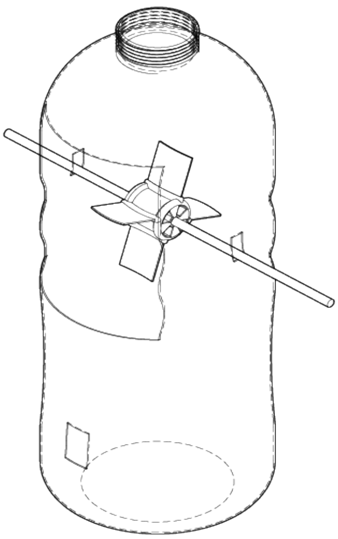
Next, we will make some holes for the dowel. Measure 12cm from the top of the bottle and mark two small 2cm x 1cm slits on opposite sides.

Use your sharp skewer and scissors to cut the slits, like you did in step A.



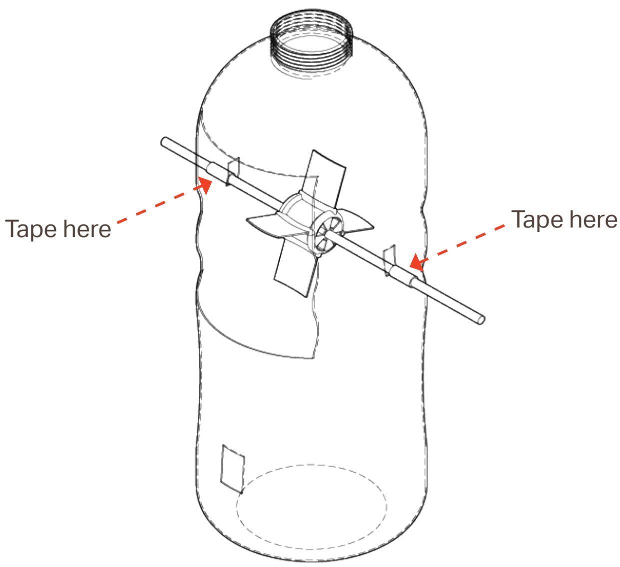
E

Then, hold the turbine inside of the bottle and align the reel between the pair of upper holes and directly below the bottle neck. It is important at this point to make sure the scoop of the turbine blade is facing upwards to collect the water. Put some glue inside the shaft of the cotton reel and insert a dowel through the slits in the side of the bottle and through the cotton reel.



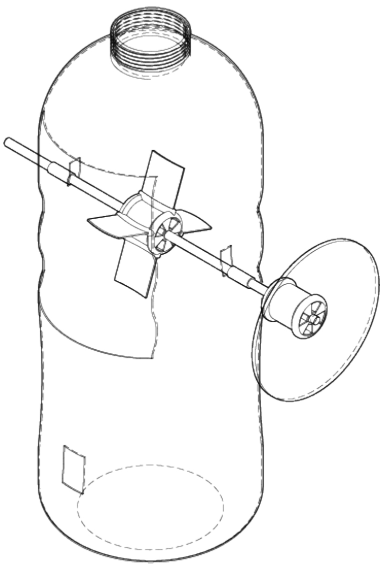
F

To keep the dowel in place, wrap tape around the dowel where it sits outside of the bottle to keep it from moving sideways.



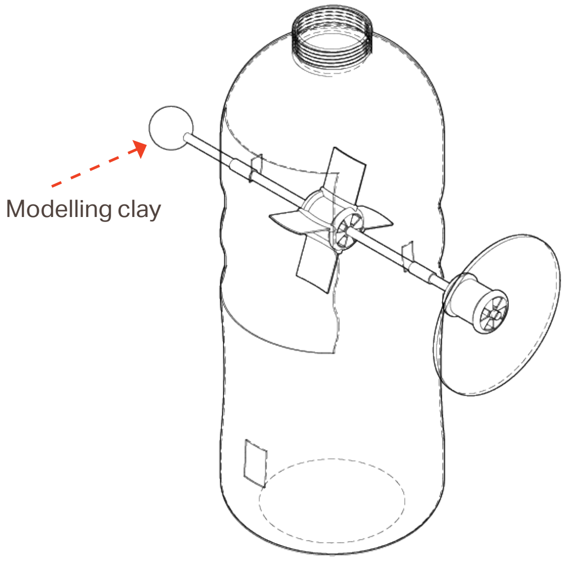
G

Next, place glue inside of the central shaft of the other cotton reel and place the reel over one end of the dowel. Then glue the card disc to the end of the cotton reel. You could decorate the disc using one of the patterns on the worksheet to create an optical illusion as it spins!



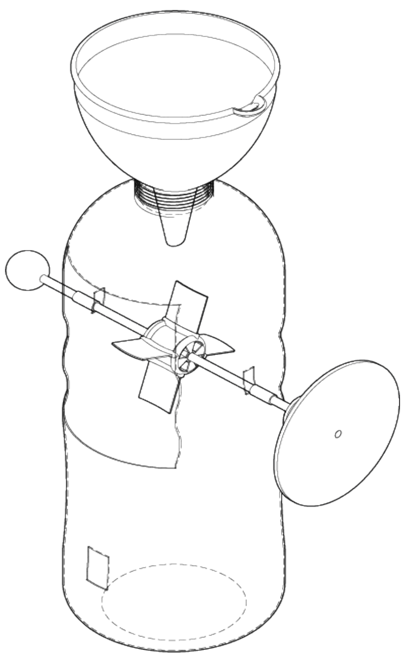
H

Stick modelling clay onto the other end of the dowel to straighten it by balancing the weight of the card disc.



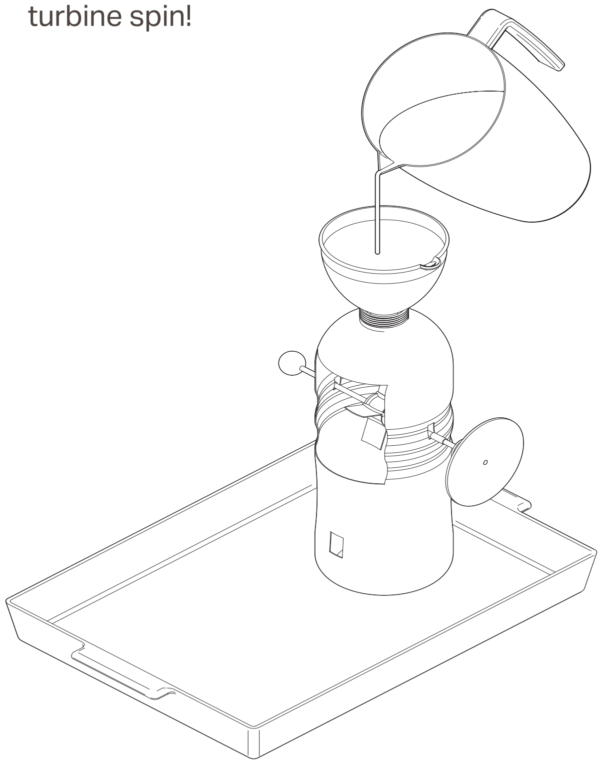
I

Place a funnel in the neck of the bottle and secure with modelling clay.



J

Finally, place the model into a tray so any water flowing from the lowest hole falls into the tray. Pour water through the funnel so that it strikes the scooped side of the turbine blades and makes the turbine spin!



EXTENSION ACTIVITY

Can you use your investigation skills to improve the design of the turbine and increase the speed?

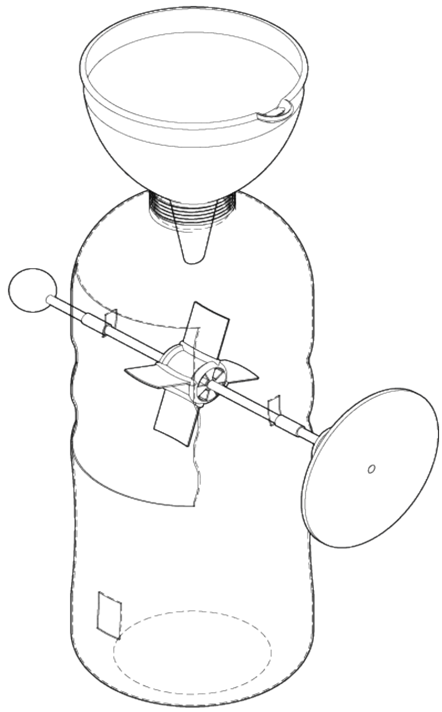
For example you could:

- Change the height of the dowel.
- Change the size of the blades.
- Use different materials.

You can replicate how the energy is generated from water to power a mechanism by attaching a 1 metre length of string to the cotton reel. You can then time how long it takes for the blades to turn and wind the thread. This will give you results you can compare to help you to come to a conclusion.

DID YOU KNOW?

The turbine was the first step towards a world in which machines work for us and relieve both people and animals of physical labour. The Romans used water wheels to power grindstones in flour mills.



WATER TURBINE

POWER THROUGH WATER

10-15m

KS2 UNDERSTAND THE SCIENCE

All work requires energy. In fact, everything we do uses energy - even sleeping! Maybe you thought that energy could only be found in food or in fuel, such as petrol, but did you know that everything in the world contains energy? It comes in many forms. Light, sound, heat, movement, electric - are all different kinds of energy. Energy cannot be created or destroyed, but it can be changed from one form into another.

In the STEM at Home water turbine activity video we referred to **kinetic** and **gravitational potential** energy so let us look at those in more detail.

Kinetic Energy

Anytime something is in motion it is said to have kinetic energy. This could be you when you are running down the street, a bicycle when it is moving or even the wind and water in the sea.

When an object collides with another object, for example a tennis racket hitting a ball, it will transfer its kinetic energy to the alternate object. The tennis racket transfers its kinetic energy to the ball and the ball then moves in a different direction, containing all of the kinetic energy.

DID YOU KNOW?

The word 'kinetic' comes from the Ancient Greek word 'kinesis', which translates to 'motion'.

Gravitational Potential Energy

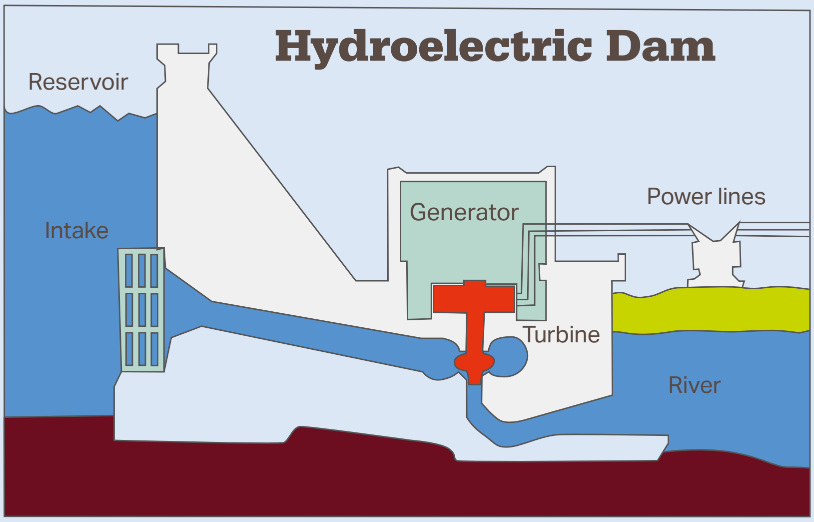
An object has gravitational potential energy when it is moved against the force of gravity to a higher position. For example, a book being held above a table has higher gravitational potential than a book sitting on the table.

Imagine riding your bike up a hill. The energy you use moving up the hill is changed into gravitational potential energy. When you come back down again, the gravitational potential energy is turned back into kinetic energy. That is why riding your bike up a steep hill is very hard, but when you are coming back down, you will not need to pedal at all – you are being powered by the gravitational potential energy that you stored when you rode up the hill.

KS3 DEEPER LEARNING

Hydroelectric Power

Hydroelectric power plants produce electricity from the flow of water through a dam. When the water reaches the turbines, it is traveling fast and therefore the flow contains a lot of **kinetic energy.** The water gets this **kinetic energy** because of a drop in elevation from the reservoir to the intake. This drop in height converts the water's **potential energy** into **kinetic energy.**



Inside the dam, the water is also sped up by forcing the flow through a smaller opening. This decreases the area of the flow of the water, and to make up for the decrease in area, the water flows faster (in keeping with the law of conservation of mass).

Once it has travelled through the smaller opening, the water strikes the turbine blades and spins the turbine, which is connected to a generator with a shaft. The shaft turns the generator causing it to produce a current. The electricity generated is sent through long distance power lines to where it is needed. Not all the water's energy transfers into electrical energy; during the transfer, some energy is lost through **friction** between the shaft and generator, and between water and the blades.

It is possible to calculate the energy produced in a few mathematical steps:

If you measure the difference in the height of the water, then the potential energy of the water in the reservoir is equal to:

$$PE = mgh$$

where **PE** is the potential energy, **m** is the mass of the water, **g** is the acceleration due to gravity (9.8 m/s2), and **h** is the difference in height of the water.

This potential energy can be transferred into kinetic energy using the following equation:

$$KE = \tfrac{1}{2}mv^2$$

Where **v** is the velocity of the water. Since energy can never be created or lost (law of conservation of energy), the potential energy is equal to the kinetic energy of the system. You can use the kinetic energy to determine the velocity of the water flowing through the turbine.

QUIZ

15-20m

What were some of the first turbines used for?

....

....

Name some devices that incorporate a turbine.

....

....

Why is water a sustainable resource?

....

....

Name some other sustainable resources.

....

....

Name some types of energy.

....

....

QUIZ

What type of energy do you have at the top of a slide?

....

....

Can energy be destroyed?

....

....

How can some energy be lost during the hydroelectric power production process?

....

....

What are the steps in the Engineering Design Process?

....

....

Why are the steps in the Engineering Design Process important?

....

....