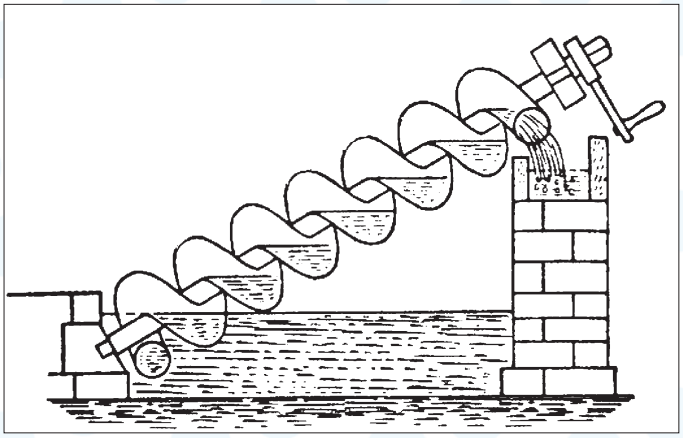
DESIGN AND MAKE A WATER PUMP – AN ARCHIMEDES' SCREW

Equipment

Per group of children:
Plastic drinks bottle (1Litre), narrow plastic tubing (approximately 1.5 metres, 4-7mm diameter), two bowls or basins, waterproof tape (e.g. duct tape), water, food colouring, book or something to raise one bowl.
For follow-up activities:
Measuring jug/graduated cylinder; various lengths of pipe and diameters of plastic tubing would be useful.



Suggested class level

Senior classes

Preparation

This is a wet activity, so plastic sheeting to protect surfaces is important.

Background information

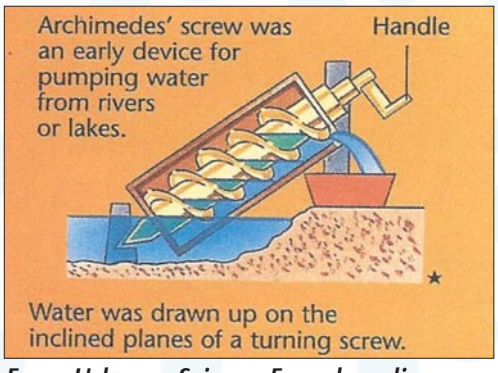
Water normally falls downwards due to gravity. If you want water to go in another direction you have to apply pressure to it.

There are different ways of sending water under pressure in other directions, e.g. if you put your thumb to the tap when it is running you can squirt water up and across the room!

Water from rivers and lakes is pumped under pressure to our homes. An Archimedes' screw is a simple machine (a type of pump) which lifts water up when it is turned. It has been used since ancient times. It is used mainly for lifting water from a lower to higher level, such as rivers or lakes, to irrigate fields, and also for draining water out of mines. Its name is from the person who is said to have invented it, Archimedes (287-212 BC). Archimedes was a scientist/engineer/mathematician from Sicily, who studied in Alexandria, Egypt. He is famous for many inventions and discoveries (including Archimedes' Principle – well-known in second level science classes!).

Even though the Archimedes' screw was invented in ancient times, it has been adapted throughout time. Due to the simplicity of how it works, the Archimedes' screw can be environmentally friendly by being powered by a windmill.

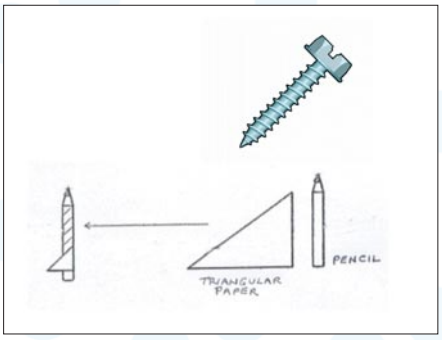
The lowest portion of the screw just dips into the water, and as it is turned a small quantity of water is scooped up into the tube. As the screw turns, the water slides along the tube. Meanwhile more water is scooped up at the end of the tube and then it slides along, and so on until the water comes out the top of the tube.



From Usborne Science Encyclopedia.

TRIGGER QUESTIONS

How does a screw work?
It works like a spiral staircase. You have to turn a screw round and round to get it into wood or a wall, but this is easier than pushing it straight in.



If you opened it out what would it look like?
A triangle. It's a bit like a ramp going round in a spiral shape. This could lead to a discussion on going up steep hills by using a more gradual path, but going a longer distance while you are doing so, e.g. ramps, zig-zagging up steep hills, etc. Similarly, your hand moves a far greater distance compared with the tip of the screw. In an Archimedes' screw the water goes up in a spiral path, rather that straight up; that is why it is called a screw.

What is a pump?
A machine for raising or transferring liquids or gases.

When would you use a pump for transferring air?
For pumping air into tyres.

What way does water normally flow?
Downwards.

Why?
Gravity.

Do we ever need to get it up high?
Yes, to upstairs of houses – bathrooms, etc.

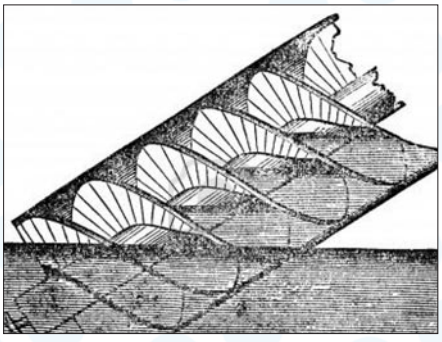
How does it get up high?
By using high pressure on the water.

Let's try and raise water up using a kind of pump called an Archimedes' Screw.

Content

SCIENCE: Forces

MATHS: Operations
Shape and Space: 3-D shapes (spiral), lines and angles
Measures: Length, capacity, time



Skills

Experimenting, predicting, estimating, measuring, recording
Designing and making

Cross-curricular Links

HISTORY: Irrigation – Egyptians and Nile

GEOGRAPHY: Netherlands – removal of water from polders using Archimedes' Screw to create dry land below sea level.

Activity

Making the Archimedes' Screw

Using the duct tape, tape one end of the narrow tubing onto one end of the plastic bottle, leaving about 1 cm hanging out over the end.

Carefully wrap the tubing around the bottle at regular intervals in a spiral shape until you reach the other end. (You will probably need to use pieces of duct tape to tape down the tubing at intervals as you go along).

Cut off the tubing, leaving about 1 cm. hanging out over this end also. Tape down the narrow tube to the bottle at this end also.
There should be about 1 cm. of tubing hanging off both ends, past the part that you have taped down.

Preparing the Bowls

Mix a few drops of food colouring with one cup of water in one of the bowls.
Place the other (empty) bowl on a book (or anything to raise it up). Place it where it will catch the water which comes out the top of the tube.

Operating the Screw

Place one end of the screw in the bowl of coloured water, with the other end resting on the higher bowl.
Turn the screw slowly.

What do you see?

Water goes into the tube.

Keep turning the screw.

What happens after a while?

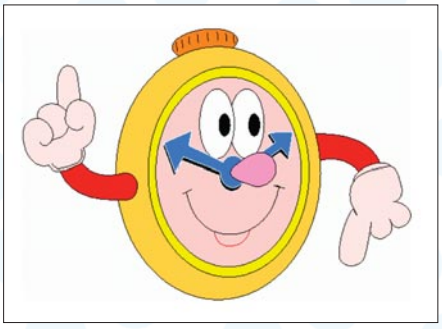
Water comes out the top of the tube and falls into the bowl.

The children should be asked to turn the screw in one direction, and then the other.

Does the direction make any difference?

(It does! The screw only works when it is turned in one direction - in the opposite direction to the winding of the tubing. Otherwise the water will not get scooped up).

Maths



1. How much water can the children move from the lower bowl to the higher one in a certain length of time, say 2 minutes? They should first predict how much, then carry out the activity, then estimate the amount of water in the higher bowl, then measure the amount.
   They can then calculate the rate, i.e. the number of millilitres (ccs.) per minute.
   They could then repeat, and take their average rate.
2. Time how long it takes to move say half a cup of water from the lower bowl to the higher bowl.

3. Can the children work out how to find out how many turns it takes to move half a cup of water up to the top bowl? (Hint: put a mark – using a permanent marker - why a permanent marker? - put a mark on top of the tubing somewhere near the middle, just as the lower end of the tubing is about to enter the water. When this mark comes round to the top again, that counts as one turn).

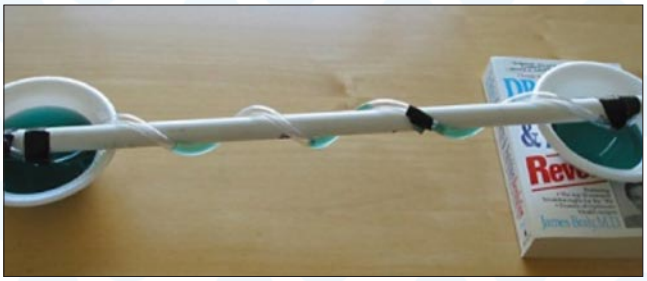
Safety

Careful with cutting the tubing

Follow-up activities

Children can design and make their own Archimedes' Screws and investigate whether the following make any difference to the rate at which the water comes out the top of the screw:

The length of the screw
The diameter of the tubing
The number of turns of the tubing
The angle at which the screw is placed in the water
they should estimate the angle, and then measure it if possible)



The rate at which the screw is turned (if turned too fast the water does not have time to get into the tubing).

Children could try to fit a handle to the cap of the bottle, in order to make it easier to rotate the bottle.

Evaluation

The children should evaluate their activity, e.g.
How could they make a better screw? Would they do it differently next time?
What is the best way to operate the screw in order to increase the efficiency
***i.e. raise the most water in the shortest time*?**

Did You Know?

Archimedes' Screws are used for moving grain inside some combine harvesters.

In the Netherlands, Archimedes' Screws are used to remove water from polders to create dry land areas below sea level. The screw is turned usually by a windmill or by manual labour. As the shaft turns, the bottom end scoops up a volume of water. This water will slide up in the spiral tube, until it finally pours out from the top of the tube.

An Archimedes' Screw was used by British engineer John Burland in 2001 to stabilize the Leaning Tower of Pisa, which was leaning too much! Small amounts of extremely wet subsoil were removed from far below one side of the Tower, so that the weight of the tower shifted back towards the centre.

Archimedes' Screws are sometimes used as 'fish ladders' (called PESCALATORS!). Fish can be lifted safely from ponds and brought to another place, say in fish farms, without damaging them by taking them out of the water.