ENGINEERING
CHALLENGE

01

GEODESIC DOMES

THE
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FOUNDATION

GEODESIC DOMES

ENGINEERING CHALLENGE 01

Designed by Hannah,
Design engineer at Dyson

The brief

Using jelly sweets and cocktail sticks, make your own geodesic dome.

The method

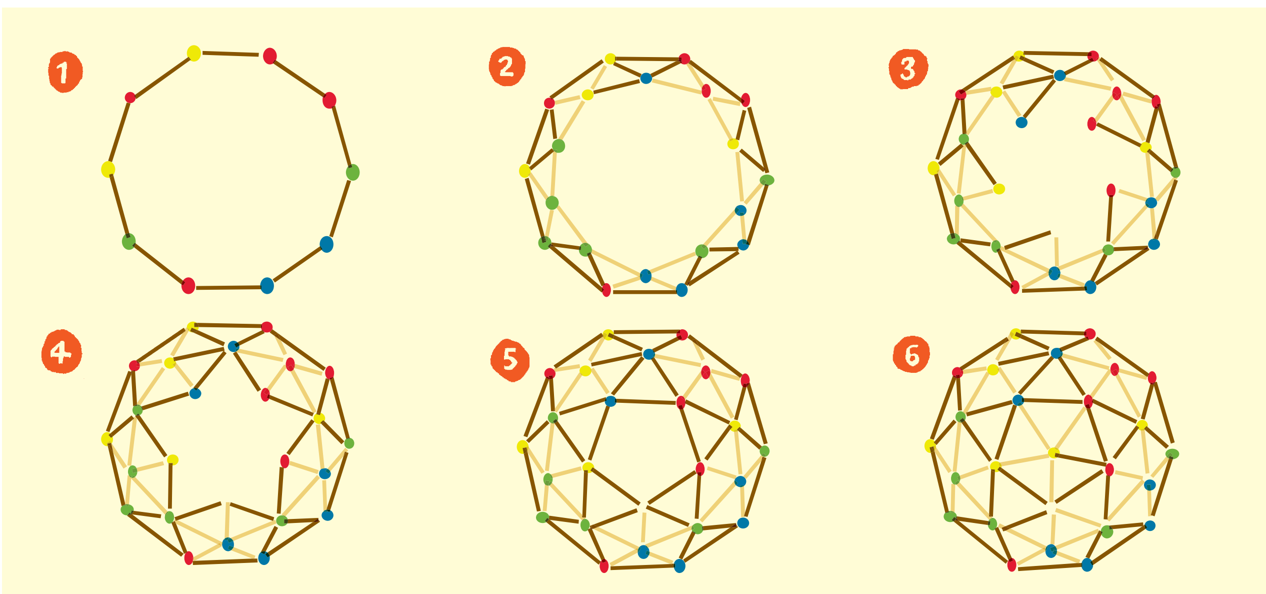
Follow steps 1 – 6 in the diagram below.
Key for cocktail sticks: —— 60mm —— 54mm

Materials

Cocktail sticks: 35 at 60mm long and 30 cut down to 54mm long

Jelly sweets

Scissors
(with adult supervision)



How does it work?

Geodesic domes are extremely rigid. Multiple interlocking triangles form incredibly strong structures.

To deform or buckle a triangle you have to compress or stretch the lengths of the sides, which is hard to do as they support each other.

Design icons

Richard Buckminster Fuller, inventor of the geodesic dome. He was inspired by beehives, fishing nets and other ‘networks’.

Today there are more than 300,000 geodesic domes around the world.

ENGINEERING CHALLENGE

02

MARBLE RUN

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MARBLE RUN

ENGINEERING CHALLENGE 02

Designed by Coco,
Design engineer at Dyson

The brief

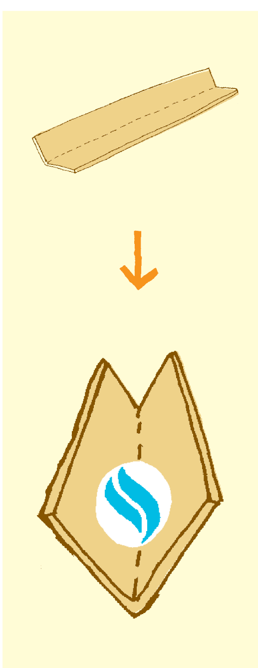
Use a cardboard box and cardboard struts to create a marble run. The marble must run for 60 seconds.

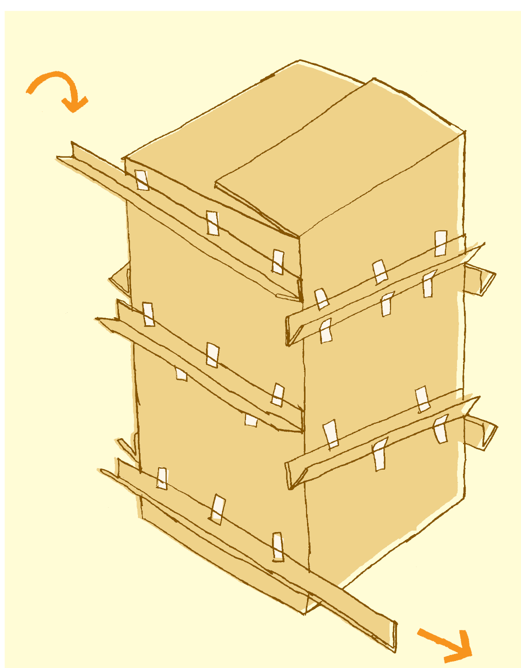
The method

1. Use sticky tape to attach the cardboard struts to the cardboard box, creating a run for the marble.
2. Place the marble at the top of the run and time how long it takes for it to reach the bottom.
3. Keep improving your design until the marble takes exactly 60 seconds to reach the bottom.

Top tip

If you can't find cardboard struts, make your own by folding four inch wide strips of cardboard in half to create a V shape.





Materials

- Large cardboard box
- Cardboard struts
- Sticky tape
- Marbles
- Scissors (with adult supervision)

How does it work?

To help you to control the time your marble takes to run its course you'll need to consider a few factors:

Potential energy = mass x gravity x height

The heavier your marble and higher your slope, the more energy your marble will have.

Friction

The rougher or stickier the surface, the slower your marble will travel.

Angle of the slope

The less steep the angle of the slope, the longer the marble will take to reach the bottom.

ENGINEERING
CHALLENGE

03

SPAGHETTI BRIDGES

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SPAGHETTI BRIDGES

ENGINEERING CHALLENGE 03

Designed by Kristian,
Design engineer at Dyson

The brief

Construct a free standing bridge out of spaghetti, strong enough to support a 250g bag of sugar.

The method

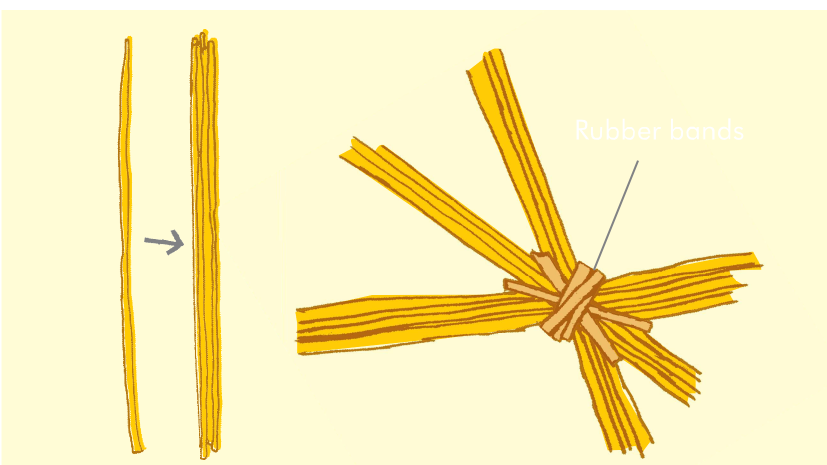
Think about bracing strands together for strength. Some shapes are better at absorbing loads – triangles are particularly strong. Rubber bands make for good junctions.

Top tip

Be patient. Through trial and error, you'll become proficient at working with spaghetti.

Materials

- Spaghetti
- Small rubber bands or bag ties
- Sticky tape
- 250g bag of sugar

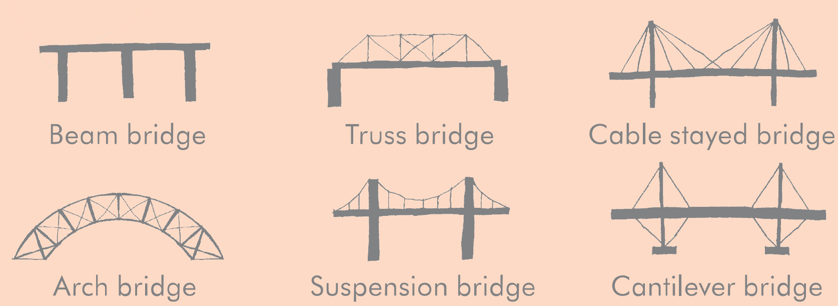


How does it work?

Bridges manage two important forces: compression and tension – pushing and pulling. Too much of either and they buckle or snap.

Design icons

Why not take inspiration from these iconic bridge designs?



ENGINEERING
CHALLENGE

04

STRONG AS A DRINKING STRAW

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STRONG AS A DRINKING STRAW

ENGINEERING CHALLENGE 04

Designed by Phil,
Design engineer at Dyson

The brief

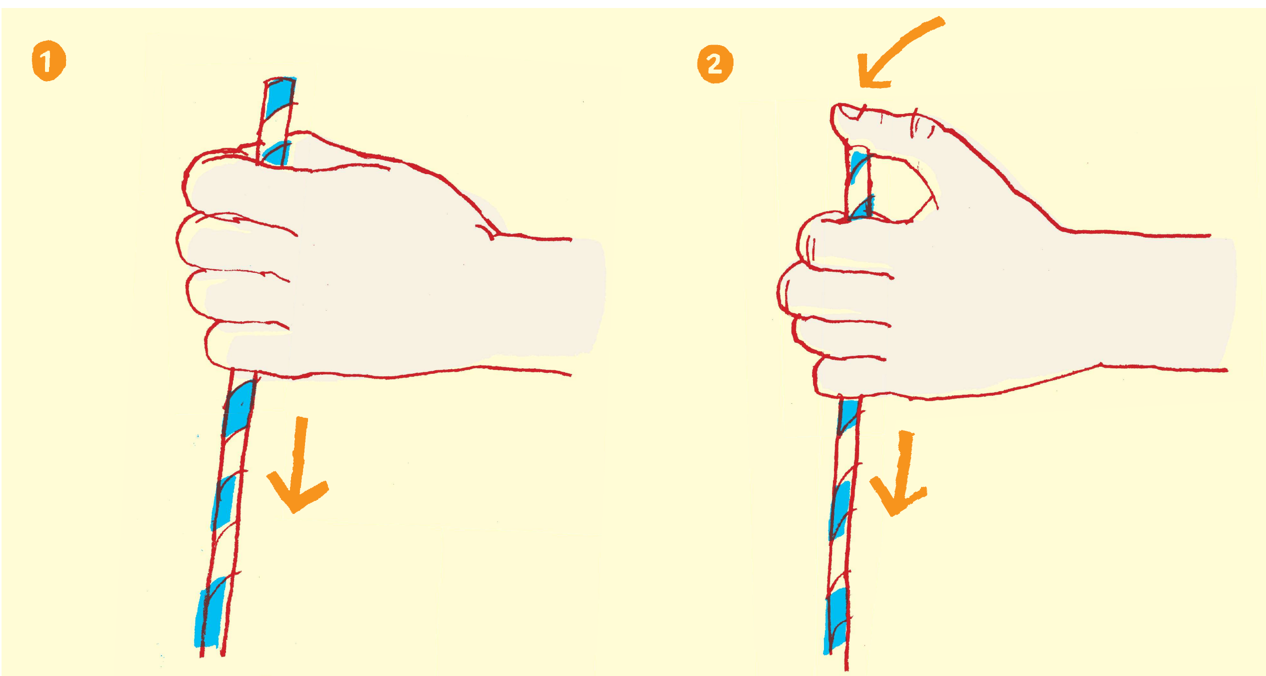
Use a drinking straw to pierce through a raw potato.

The method

1. Hold the straw by its sides, without covering the hole at the top and try quickly stabbing the potato.
2. Repeat the experiment with a new straw but this time place your thumb over the top, covering the hole.

Materials

- Two stiff drinking straws
- A firm, raw potato



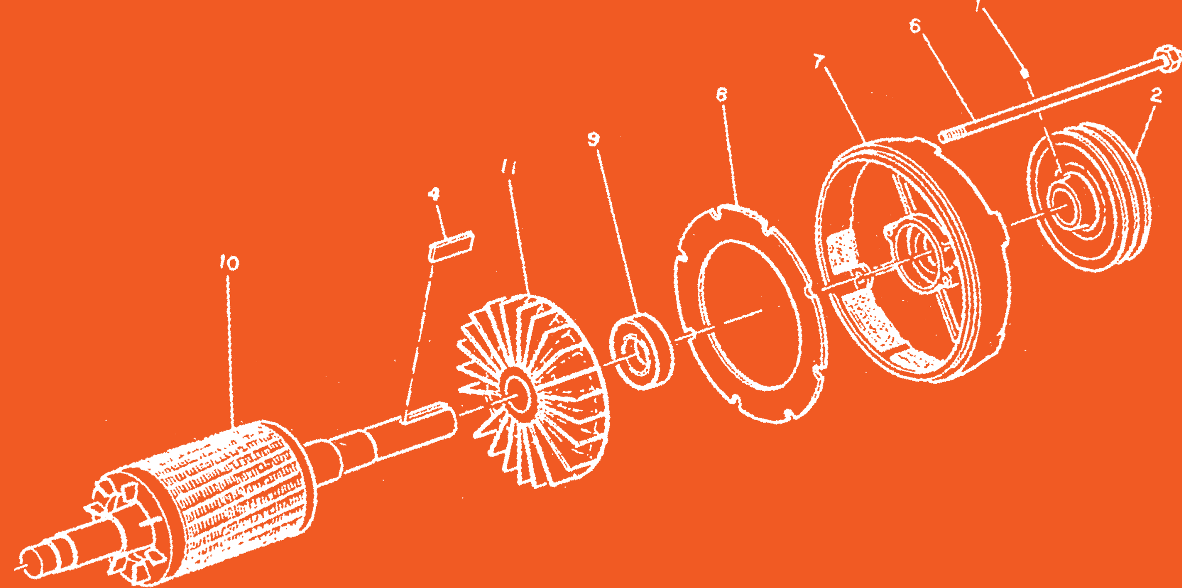
How does it work?

Covering the top of the straw with your thumb traps air inside, forcing it to compress as you stab the straw through the potato skin. This creates enough rigidity within the straw to pierce the potato.

ENGINEERING
CHALLENGE

05

ELECTRIC MOTOR



THE JAMES DYSON FOUNDATION

ELECTRIC MOTOR

ENGINEERING CHALLENGE **05**

Designed by Mike,
Design engineer at Dyson

The brief

Build your own electric motor.

The method

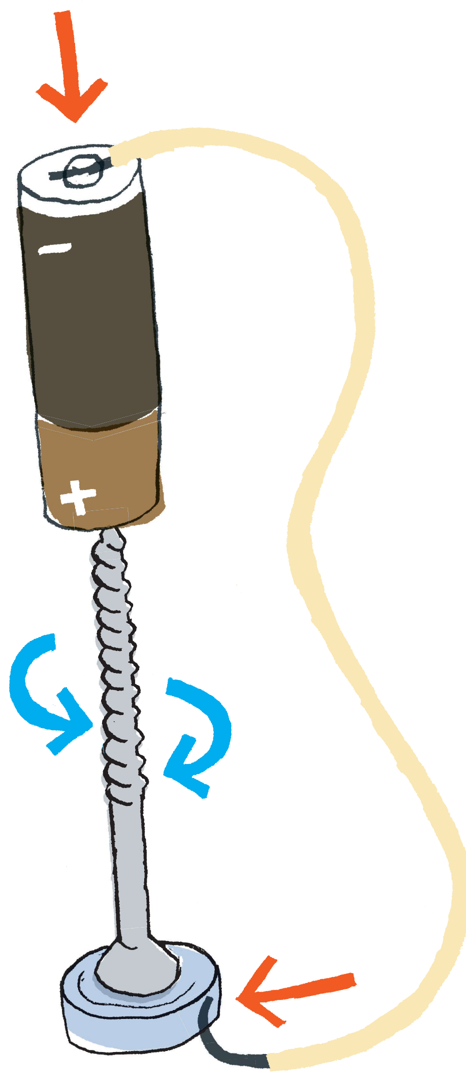
1. Attach the magnet to the head of the screw.
2. Holding the battery in your hand, hang the pointy end of the screw from the positive terminal of the battery. Hold one end of the wire to the negative terminal of the battery.
3. With your other hand, touch the opposite end of the wire to the head of the screw and watch it spin.

Top tip

What happens if you swap the battery terminals?

Materials

- An AA battery
- A screw
- A small, round neodymium magnet (approx. 6mm diameter)
- A wire



How does it work?

The electric current passing through the screw when the circuit is completed by the wire is subject to the Lorentz force. This force creates torque, which turns the screw.

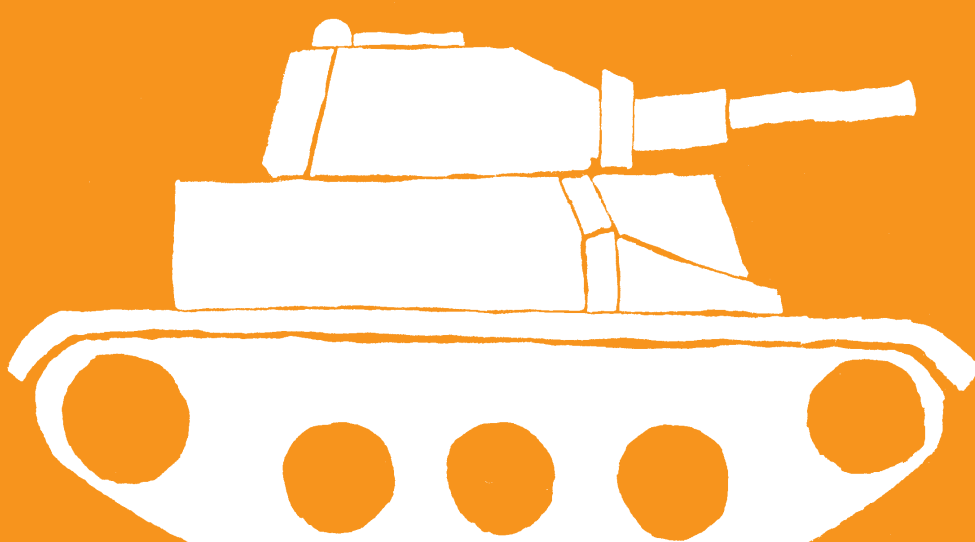
Design icons

Michael Faraday built the first electric motor in 1821.

ENGINEERING
CHALLENGE

06

COTTON REEL TANK



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COTTON REEL TANK

ENGINEERING CHALLENGE 06

Designed by Neil,
Electronics engineer at Dyson

The brief

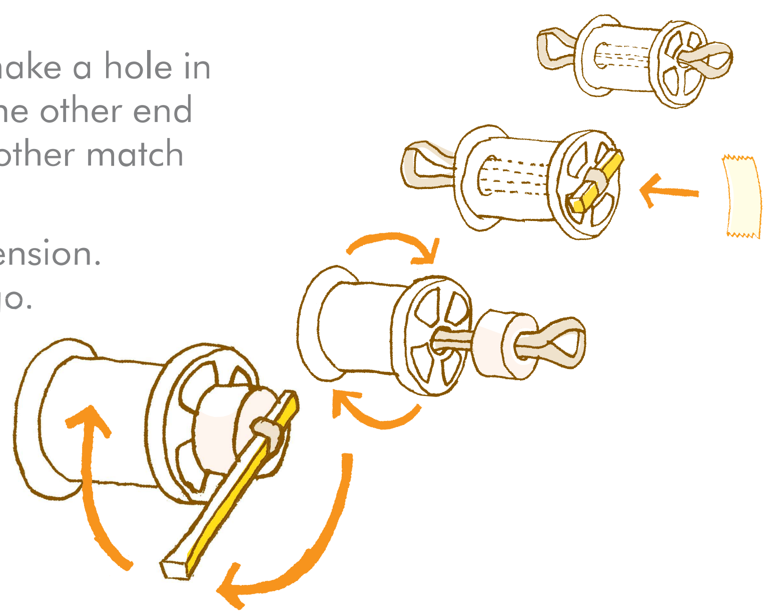
Build a tank out of a cotton reel.

The method

1. Thread the rubber band through the cotton reel.
2. Break one matchstick in half. Tie one end of the rubber band around the half matchstick and secure it to the end of the cotton reel using sticky tape.
3. Cut 2cm and use a pencil to make a hole in the middle of it. Thread onto the other end of the rubber band. Place the other match through the loop of the band.
4. Wind up the match to create tension. Place it on the floor and let it go.

Materials

- A cotton reel
- A long white candle
- A rubber band
- Sticky tape
- Two matchsticks, with their heads removed



How does it work?

Winding up the rubber band creates potential energy. When the band is released this stored energy converts into kinetic energy, causing the tank to move.

Design icons

In a car, potential energy exists in the form of liquid gasoline. It is converted into kinetic energy as the fuel is ignited in the engine's combustion chamber.

ENGINEERING
CHALLENGE

07

CARDBOARD BOAT

THE
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FOUNDATION

CARDBOARD BOAT

ENGINEERING CHALLENGE 07

Designed by Ben,
Design engineer at Dyson

The brief

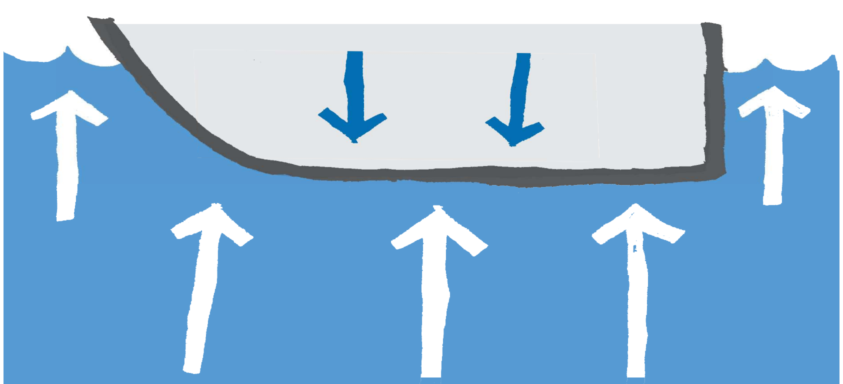
Construct a boat to support up to 250g without sinking.

The method

1. Draw out the basic shape of your boat on the cardboard, and cut it out.
2. Create walls for your boat from more cardboard.
3. Stick the bottom of the boat and the walls together with tape or glue.
4. Back everything with wax paper or foil – be careful not to leave any gaps where the water can get in.
5. Place the 250g weight in the boat.
6. Set your boat afloat.

Top tip

Think about stability. Some shapes are more stable than others when a load is applied.



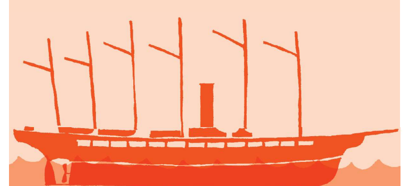
How does it work?

When a boat is placed in water, it displaces an amount of water equal to the boat's weight – as long as the object is less dense than the water, it will float.

Materials

- Cardboard
- Wax paper
- Tape or glue
- Rubber bands
- Foil
- Scissors (with adult supervision)
- Craft knives (with adult supervision)
- A 250g weight

Design icons



The SS Great Britain was the first iron steamer to cross the Atlantic. Designed by Isambard Kingdom Brunel in 1845, it was the first ship to combine an iron body with a screw propeller.

ENGINEERING
CHALLENGE

08

CARDBOARD CHAIR

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CARDBOARD CHAIR

ENGINEERING CHALLENGE 08

Designed by Andy,
Design engineer at Dyson

The brief

Construct a chair that you can sit on using only cardboard. No glue, tape or other fixing materials allowed.

The method

1. Write down or sketch some ideas as to how you will construct the chair.
2. When you are planning, think about using cones, interlocking sheets, spirals, tubes – or even using strips of card like sewing thread.
3. Use the materials to create a chair made from cardboard.
4. If your first design doesn't work, evaluate what went wrong and try again.

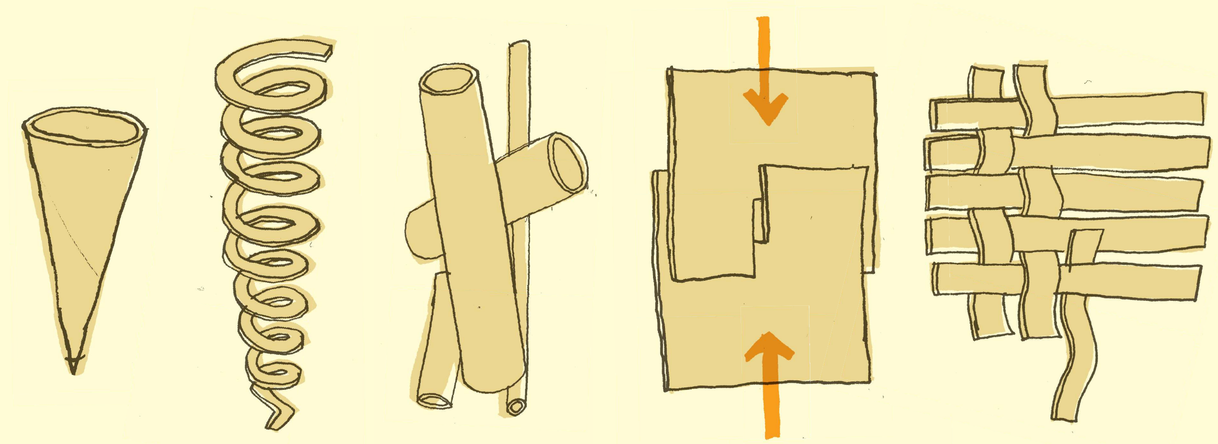
Top tip

Think about structure.

Materials

- Cardboard
- Cutting equipment (with adult supervision)
- Rulers
- Pencils

Examples of different structures:



ENGINEERING
CHALLENGE

09

BOAT POWERED BY A CHEMICAL REACTION

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BOAT POWERED BY A CHEMICAL REACTION

ENGINEERING CHALLENGE 09

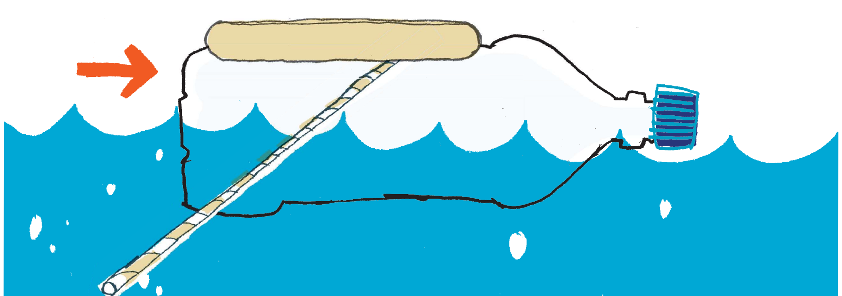
Designed by Rob,
Engineering reliability manager at Dyson

The brief

Build a boat powered by a chemical reaction.

The method

1. Tape the cork and ice lolly sticks together to form a triangle.
2. Tape the triangle to the middle of one side of the bottle.
3. Make a hole in the end of the bottle, at the opposite side to the triangle, so it will sit below the water.
4. Push the drinking straw through the hole so the end inside the bottle touches the inside wall.
5. Pour in vinegar and add bicarbonate of soda. Screw the bottle top back on tightly.
6. With a thumb covering the end of the drinking straw, shake the bottle.
7. Once the reaction starts, drop the boat in the water and watch it propel forward.



How does it work?

When the vinegar and bicarbonate of soda come into contact, a chemical reaction occurs and carbon dioxide is released. This causes pressure to build, gas to be forced down the straw and the boat to be propelled across the water.

Materials

- Small plastic bottle
- Sticky tape
- A cork
- Two ice lolly sticks
- Scissors (with adult supervision)
- A drinking straw
- Vinegar
- Bicarbonate of soda
- Somewhere to sail it – such as a bath tub or sink

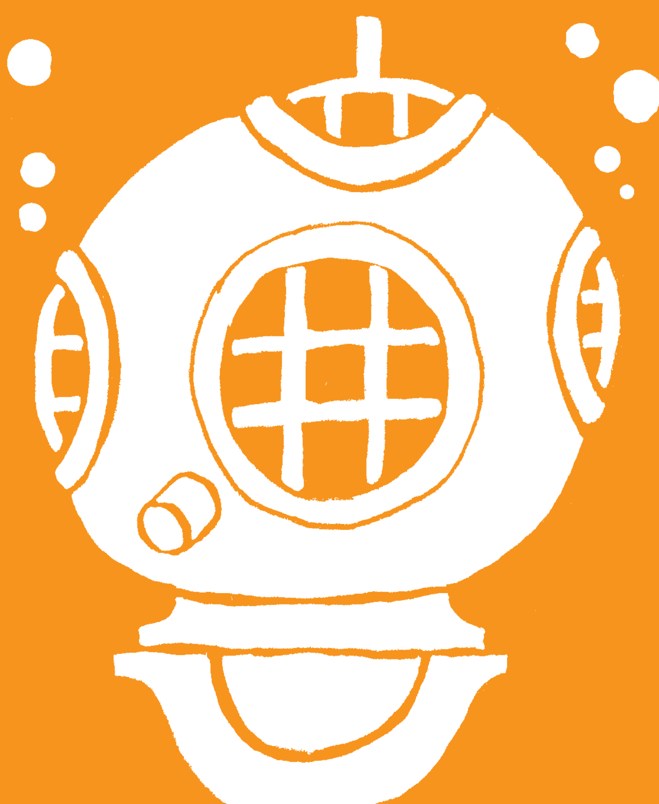
Design icons

Rockets use a chemical reaction during lift off. Combining fuel and oxygen causes combustion and exhaust gases are released. These gases exit the engine nozzle at high speed and push the rocket skyward.

ENGINEERING CHALLENGE

10

CARTESIAN DIVER



THE JAMES DYSON FOUNDATION

CARTESIAN DIVER

ENGINEERING CHALLENGE 10

Designed by Daryl,
Design engineer at Dyson

The brief

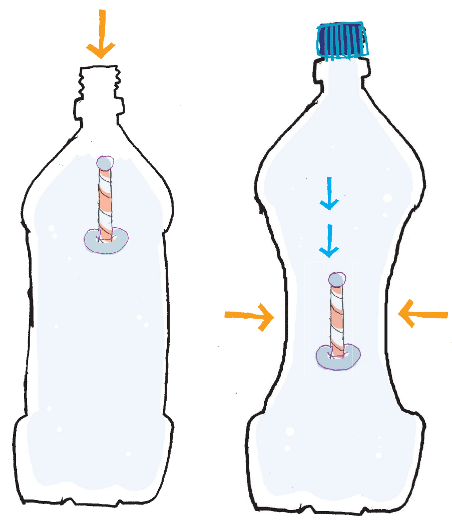
Build a Cartesian diver.

The method

1. Put a small ball of plasticine on the top of the straw to seal it.
2. Roll a sausage of plasticine and wrap it around the bottom of the straw, leaving the bottom open. This is your diver.
3. Now attempt to balance the diver so that it stays upright.
4. Place the diver vertically in the drinking glass. Add or remove weight from the base or top so that when you push it down, it just about bobs back up to the surface (and stays upright).
5. Once you are happy, place the completed diver in the two litre bottle filled to the top with water. Screw on the lid. Squeeze the bottle, and the diver will drop down to the bottom of the bottle. Release it and it floats back to the surface.

Materials

- Drinking straw cut to 30mm in length
- Plasticine
- A two litre bottle
- A drinking glass and water



How does it work?

This is all about density. When the diver floats, there is a volume of air trapped inside, when the bottle is squeezed, the air is compressed but the water is not.

The volume of air trapped decreases, and the displaced water reduces. The diver loses buoyancy, and sinks. When the pressure on the bottle is released, the air expands, displaces the water and the diver floats.

Design icons

Submarines are surrounded by ballast tanks, which help control their buoyancy. When filled with water, the tanks increase the density of the submarine and it sinks. When the submarine needs to rise, the water in the ballast tanks is replaced with compressed air.

ENGINEERING
CHALLENGE

11

BALLOON CAR RACE

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BALLOON CAR RACE

ENGINEERING CHALLENGE 11

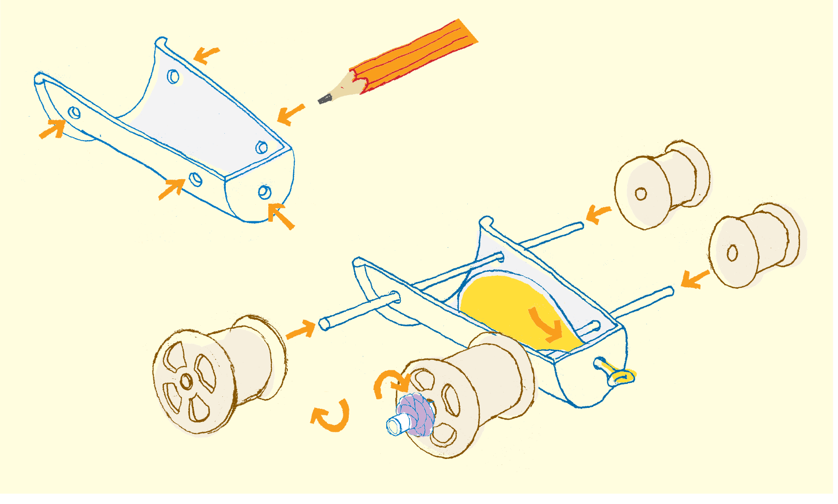
Designed by Caroline,
Engineer at Dyson

The brief

Make and race a balloon powered car.

The method

1. Using scissors, carefully cut the cup in half lengthways, to create the car body.
2. Using a pencil, poke two sets of holes through the length of the cup. One set near the top of the cup, and one set near the bottom. Poke another hole through the bottom of the cup.
3. Insert a straw through each set of holes. Then, slide the cotton reels or lid wheels on to each end of the straws.
4. Wrap a rubber band around the end of each straw; these will keep the wheels from sliding off.
5. Push the neck of the balloon through the hole in the bottom of the cup. The balloon should be lying inside the cup. Make sure the hole is big enough to let the air out.
6. Blow up the balloon, place on a hard surface and release.



Materials

- A balloon
- A paper cup
- Two plastic drinking straws
- Four cotton reels (or drink lids with holes in them)
- Four small rubber bands
- Scissors (with adult supervision)
- A pencil

How does it work?

The balloon powered car is a good example of Newton's Third Law. If object A pushes on object B, object B pushes back on object A with the same amount of force. The force of the air leaving the balloon pushes the car forward.

ENGINEERING
CHALLENGE

12

DESIGN AND BUILD A HELICOPTER

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DESIGN AND BUILD A HELICOPTER

ENGINEERING CHALLENGE 12

Designed by Ahmed,
Design engineer at Dyson

The brief

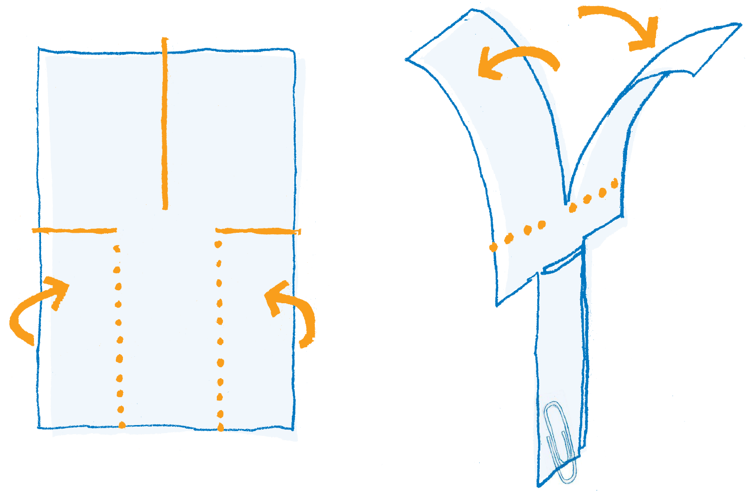
Design and build a helicopter using only paper and paperclips.

Materials

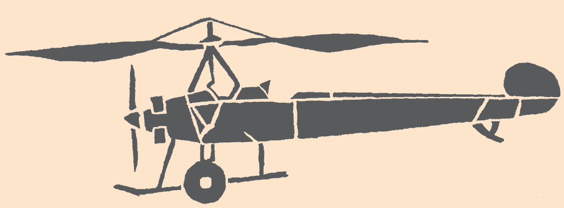
- A4 sheet of paper
- Paper clips
- Scissors (with adult supervision)

The method

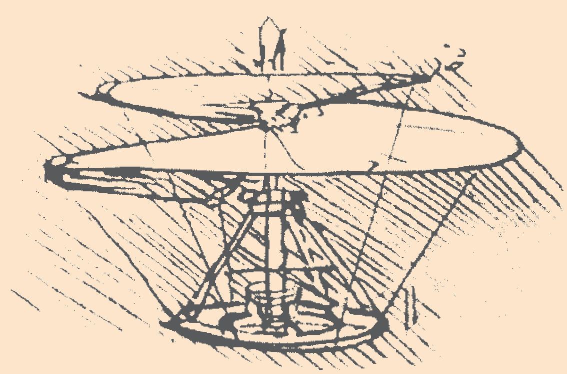
1. Take a piece of paper and make three cuts as shown in the illustration. Then fold the paper in on itself at the bottom half – use a paper clip to keep the sides together.
2. Fold the two halves of the remaining paper away from each other, to form the helicopter blades.
3. Stand carefully on a chair and drop your helicopter, making sure it stays upright as you let go!



Design icons



Juan de la Cierva's Cierva C.8.



Leonardo da Vinci's Aerial Screw.

ENGINEERING
CHALLENGE

13

WATER CLOCK

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WATER CLOCK

ENGINEERING CHALLENGE 13

Designed by Sam,
Teacher and Design
and Technology enthusiast
at Malmesbury Primary School

The brief

Create a water clock that times exactly one minute with 200ml of water.

The method

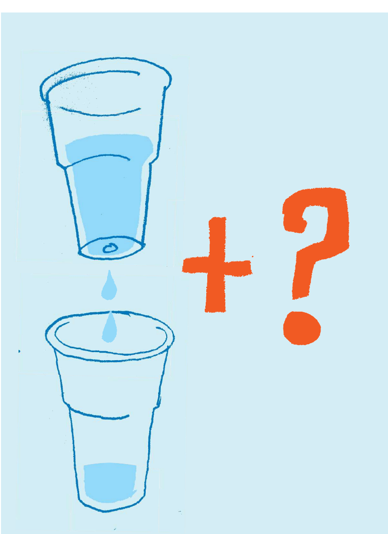
1. A simple water clock could consist of two plastic cups fixed one above the other with a hole in the top cup to allow water to pass from one to the other.
2. Additional cups, string, straws, plasticine, etc. can also be used to create more elaborate examples or to help slow the water if necessary.

Top tip

You will need to use a timer to observe and measure time accurately and make changes depending on your results. The size and position of the holes, the number of cups the water passes through, the angle of straws and flow rates will all affect your design.

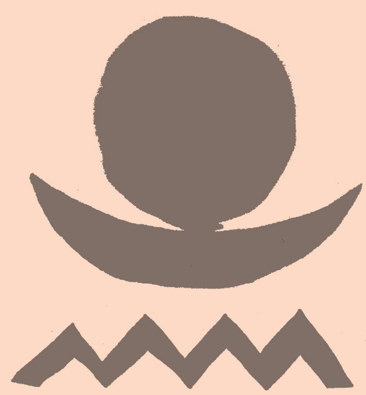
Materials

- Plastic cups
- Straws
- Plasticine
- String
- A timer
- Wooden doweling or similar to act as a stand
- Scissors (with adult supervision)
- Tape
- Drawing pins



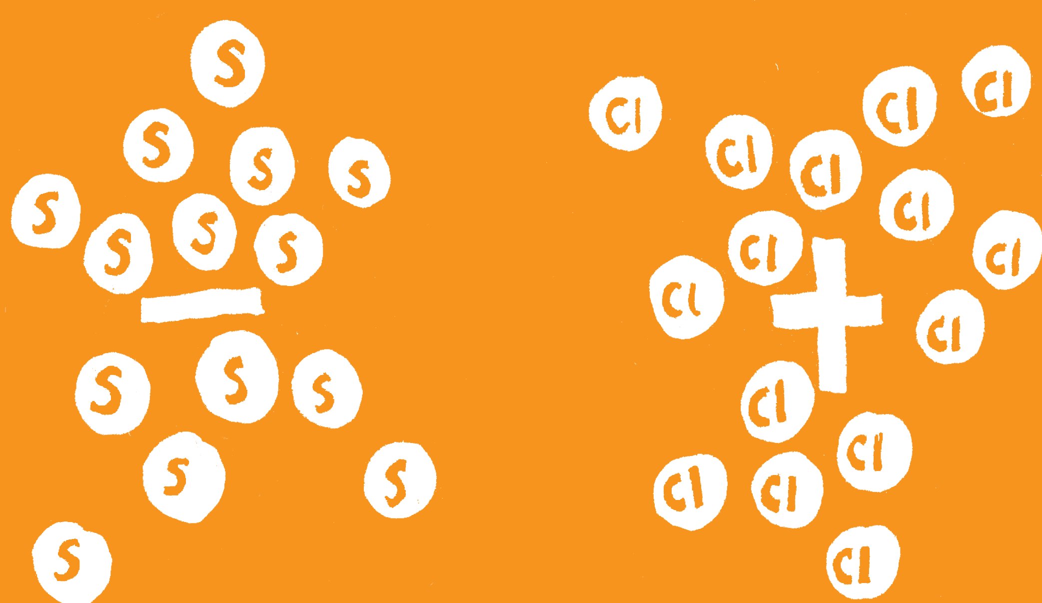
Design icons

Water clocks are among the most ancient of time pieces, with known examples from Egypt dating to the 16th Century BC. Examples with gears and feedback systems were developed during the Greek and Roman periods.



ENGINEERING
CHALLENGE

METAL ETCHING



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METAL ETCHING

ENGINEERING CHALLENGE 14

Designed by Ed,
Design and Technology student and JDF ambassador at Malmesbury School

The brief

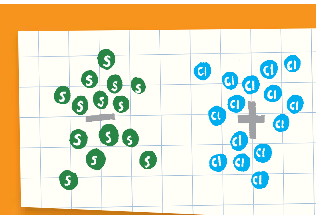
Etch a pattern into a sheet of metal using only things found in your home.

The method

1. Fill the bowl with 4cm of water.
2. Mix salt with the water until no more can be dissolved.
3. Draw a pattern using the permanent marker on one sheet of metal.
4. Connect one crocodile clip to the metal on which you have drawn the pattern and the other to the spare piece of blank metal.
5. Place both pieces of metal in the salty water. Make sure they're as far apart as possible – don't let them touch.
6. Connect the patterned metal to the positive terminal of the battery and the plain metal to the negative terminal. The water will begin to fizz.
7. Wait about 10 minutes, then disconnect the battery and remove the patterned metal.
8. Clean it with water and nail varnish remover to remove the permanent marker. You should see that the pattern you drew is now permanently etched into the surface of the metal.

Materials

- Table salt
- Paper clips
- Scissors (with adult supervision)
- Two pieces of sheet metal – mild steel
- Copper or brass
- 9v battery
- Two crocodile clip cables
- Nail varnish remover
- A permanent marker



How does it work?

This process is called electrolysis. When you place electrodes into the salt water and apply electricity, chloride ions move towards the positive electrode and the sodium ions move towards the negative electrode. The reaction causes metal to be transferred from the positive side into the solution, etching away its surface.

ENGINEERING
CHALLENGE

15

JELLY AND OIL

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JELLY AND OIL

ENGINEERING CHALLENGE 15

Designed by Sophie,
Design engineer at Dyson

The brief

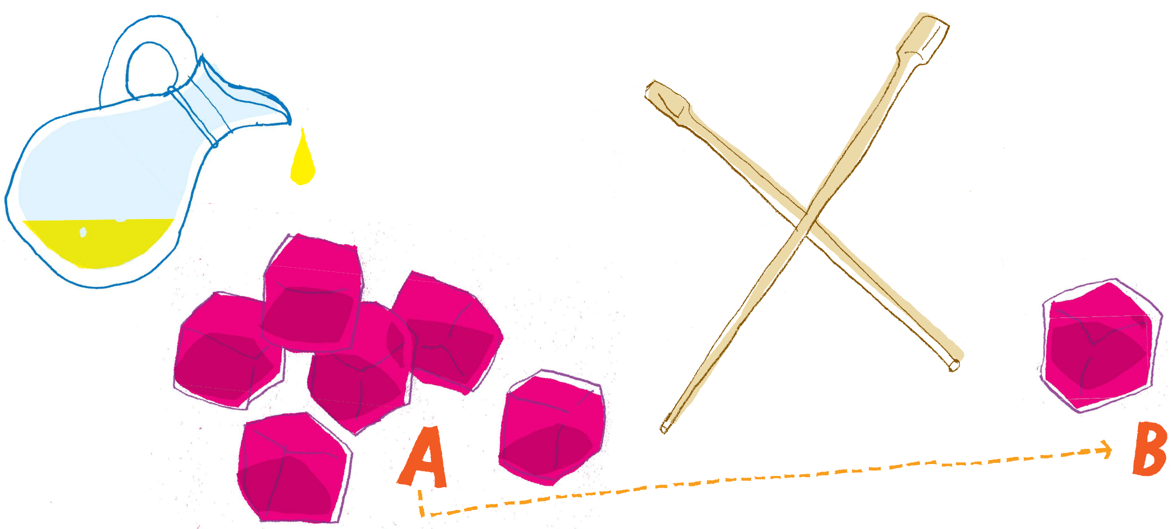
Try to move jelly cubes from one place to another using chopsticks.

Materials

- Jelly cubes
- Chopsticks
- Olive oil

The method

1. Try to move jelly cubes from one place to another using chopsticks.
2. Now cover the cubes in oil and try again.



How does it work?

In order to grip an object, you need friction. When a lubricant like oil or water blocks the force of friction it becomes very difficult for two objects to make contact with each other.

Did you know?

Oil is used in engines to allow moving parts to slide past one another with ease – avoiding wear and tear.