STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

SPAGHETTI BRIDGES

CHALLENGE 01

THE BRIEF

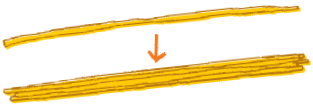
CONSTRUCT A BRIDGE OUT OF SPAGHETTI, STRONG ENOUGH TO SUPPORT A 250G BAG OF SUGAR.

MATERIALS

Spaghetti, small rubber bands or bag ties, sticky tape.

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.

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HOW DOES IT WORK?

Bridges manage two important forces: compression and tension – pushing and pulling.

Too much of either and they buckle or snap.

BE PATIENT

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

DESIGN ICONS


suspension bridge


beam bridge


truss bridge


arch bridge


cantilever bridge


cable stayed bridge

Challenge designed by:
Kristian, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

CHANGING STATES

CHALLENGE 02

THE BRIEF

MAKE AN EGG FIT INTO A BOTTLE WITHOUT BREAKING IT.

MATERIALS

An uncooked egg, a pan of boiling water (with adult supervision), a glass of vinegar, a thick necked bottle.

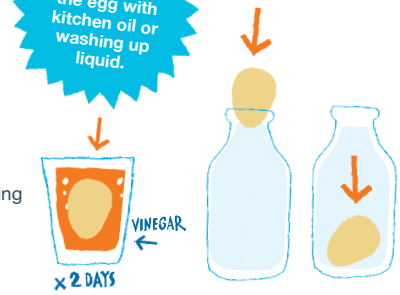
THE METHOD

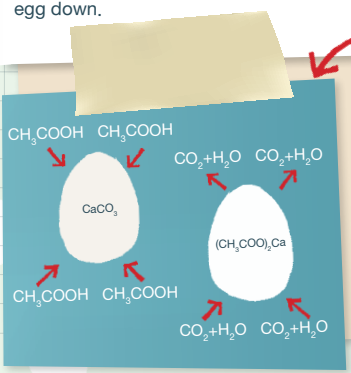
Boil an egg in a pan of water for 10 minutes and carefully remove its shell.

Or, if you fancy a challenge, submerge the egg in a glass of vinegar for up to two days. When you take it out, the shell will have changed state and the egg will be surprisingly rubbery.

Heat the bottle in hot water – use gloves (or a tea towel) when handling the hot bottle. Rest the egg on the neck. As the air inside the bottle cools, it contracts and sucks the egg down.

TOP TIP
Try lubricating the egg with kitchen oil or washing up liquid.





HOW DOES IT WORK?

Eggs are rich in protein. When heat is applied, chemical bonds within the protein molecules are broken, and new bonds are formed between adjacent molecules. This creates a network of inter-connected proteins which causes the egg to go hard.

Vinegar contains acetic acid (CH_3COOH) that dissolves the calcium carbonate ($CaCO_3$) shell but leaves behind the egg's springy membrane.

Challenge designed by:
Charles, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

GEODESIC DOMES

CHALLENGE 03

THE BRIEF

USING JELLY SWEETS AND COCKTAIL STICKS, MAKE YOUR OWN GEODESIC DOME.

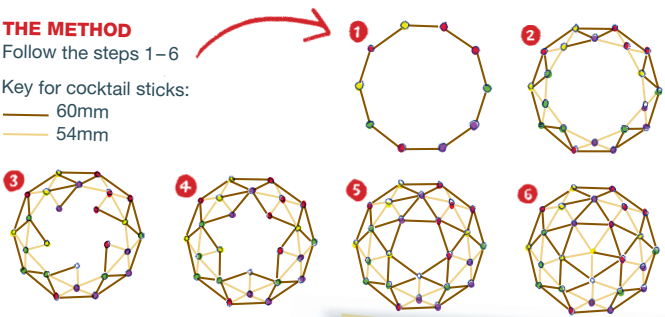
MATERIALS

Cocktail sticks: 35 at 60mm long and 30 cut down to 54mm long, jelly sweets, scissors (with adult supervision).

THE METHOD

Follow the steps 1–6

Key for cocktail sticks:
- 60mm
- 54mm



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.

Richard Buckminster Fuller invented the geodesic dome. He was inspired by beehives, fishing nets and other 'networks'.

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

DESIGN ICONS

Challenge designed by:
Hannah, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

MARBLE RUN

60 SECONDS

CHALLENGE 04.

THE BRIEF

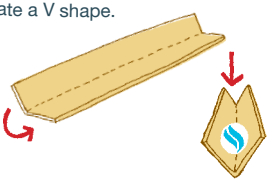
USE A CARDBOARD BOX AND CARDBOARD STRUTS TO CREATE A MARBLE RUN. THE MARBLE MUST RUN FOR 60 SECONDS.

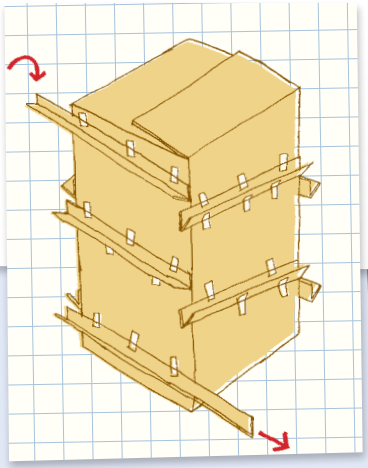
MATERIALS

Large cardboard box, cardboard struts, sticky tape, marbles, scissors (with adult supervision).

THE METHOD

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





HOW DOES IT WORK?

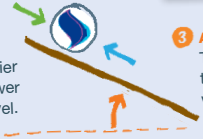
To help you to control the time your marble takes to run its course you'll need to consider a few factors:

1 POTENTIAL ENERGY = MASS x GRAVITY x HEIGHT

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

2 FRICTION

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



3 ANGLE OF THE SLOPE

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

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Challenge designed by:
Coco, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

STRONG AS A DRINKING STRAW

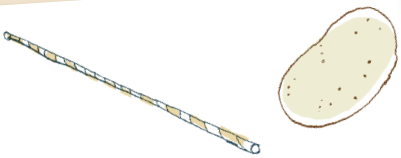
CHALLENGE 05

THE BRIEF

USE A DRINKING STRAW TO PIERCE THROUGH A RAW POTATO.

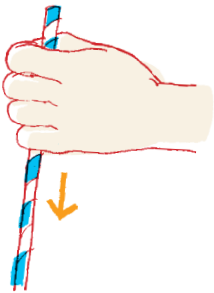
MATERIALS

Two stiff drinking straws, a firm, raw potato.

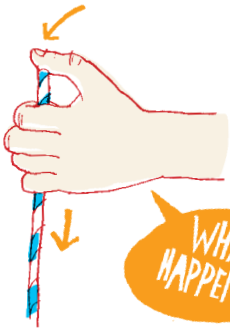


THE METHOD

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.



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.

Challenge designed by:
Phil, design engineer at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☑ ENGINEERING ☑ MATHS ☐

FOUNDATION JAMES DYSON

ELECTRIC MOTOR

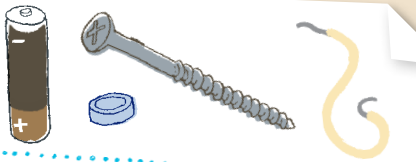
CHALLENGE 06

THE BRIEF

BUILD YOUR OWN ELECTRIC MOTOR.

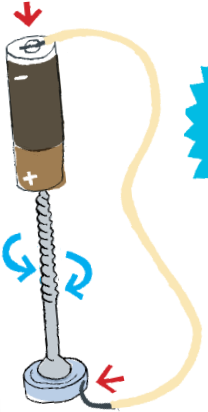
MATERIALS

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



THE METHOD

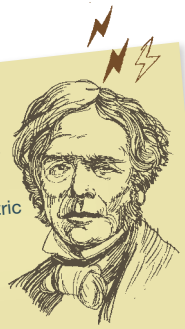
1. Attach the magnet to the head of the screw.
2. Holding the battery in your hand, hang the pointy end of the screw from the positive terminal of the battery.
3. Hold one end of the wire to the negative terminal of the battery.
4. With your other hand, touch the opposite end of the wire to the head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



TOP TIP
What happens if you swap the battery terminals?

DESIGN ICONS

Michael Faraday built the first electric motor in 1821.



HOW DOES IT WORK?

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

Challenge designed by: Mike, design engineer at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

UNDERWATER VOLCANO

CHALLENGE 07

THE BRIEF

CREATE A COLOURFUL UNDERWATER VOLCANO.

MATERIALS

String, scissors (with adult supervision), an empty salt shaker, a large jar, food colouring.

THE METHOD

1. Cut a two foot length of string with a pair of scissors. Tie a knot around the neck of a salt shaker with one end of the string. Double-knot it to ensure the knot is secure. Repeat this process with the other end of the string, resulting in a handle to lower your shaker.
2. Empty and clean a large jar. Fill the clean jar about three quarters full with cold water.
3. Fill the salt shaker with hot water (with adult supervision) – as hot as you can get from your tap – to just below the neck. Add three to four drops of red food colouring.
4. Hold your salt shaker over the mouth of the jar by the string handle. Slowly lower the salt shaker into the jar until the shaker is completely submerged and resting upright on the bottom of the jar. Observe how the coloured water erupts from the shaker into the cold water.

DESIGN ICONS

Hot air balloons use convection currents. As hot air rises, so too does the balloon.

HOW DOES IT WORK?

This shows how convection currents work. A convection current is the way that heat rises and falls in liquids and gases.

Challenge designed by:
Ian, engineering analyst at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

BUILD A CRUMPLE ZONE

CHALLENGE 08

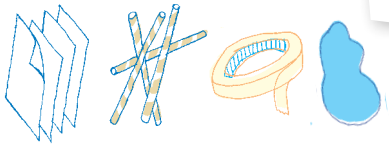
THE BRIEF

BUILD A CRUMPLE ZONE ON THE FRONT OF A TOY CAR THAT WILL PROTECT IT WHEN IT ROLLS DOWN A SLOPE INTO A WALL.

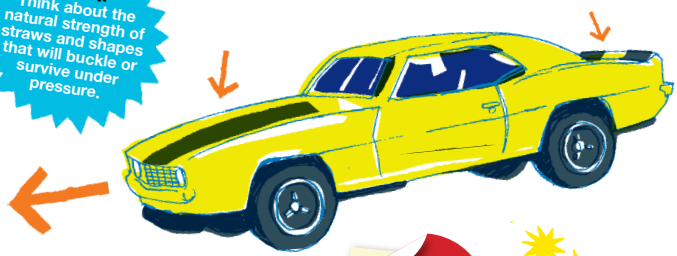
USE BLU TAC™ TO MEASURE HOW WELL YOUR CRUMPLE ZONE PROTECTS PASSENGERS INSIDE THE CAR.

MATERIALS

A few sheets of paper, some plastic straws, sticky tape, a ball of Blu-Tac™ (to act as the 'passenger') and a toy car.



TOP TIP
Think about the natural strength of straws and shapes that will buckle or survive under pressure.



HOW DOES IT WORK?

Crumple zones absorb crash energy within the outer parts of the vehicle, preventing the force of the crash from being directly transmitted to the occupants.

DESIGN ICONS

Béla Barényi introduced an early crumple zone concept in 1953, whilst working as an engineer at Mercedes-Benz. Now, all cars must have a crumple zone for safety.

Challenge designed by:
James, engineering analyst at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

FOUNDATION JAMES DYSON

COTTON REEL TANK

CHALLENGE 09

THE BRIEF

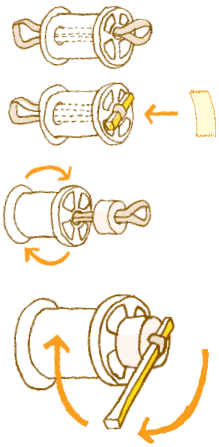
BUILD A TANK OUT OF A COTTON REEL.

MATERIALS

A cotton reel, a long white candle, a rubber band, sticky tape, two matchsticks, with head removed.

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 of the candle off and use a pencil to make a hole in the middle of it. Thread this 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.



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.

HOW DOES IT WORK?

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

Challenge designed by:
Neil, electronics engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

FLOATING PING-PONG BALLS

CHALLENGE 10

THE BRIEF

MAKE TWO PING-PONG BALLS FLOAT IN THE AIR FLOW OF A HAIR DRYER AT THE SAME TIME, WITHOUT HITTING EACH OTHER.

TOP TIP
Use the Blu-Tac™ to add weight to one of the ping-pong balls.

MATERIALS

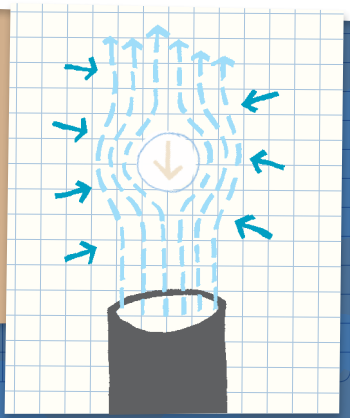
Two ping-pong balls, a hairdryer (on cool setting), Blu-Tac™.

1. Switch on your hairdryer, making sure it is on the cool setting.
2. Hold it with the nozzle pointing upwards.
3. Place one of the ping-pong balls into the stream of air.
4. Try and place another ball into the same stream of air.

HOW DOES IT WORK?

The hair dryer produces a high velocity stream of air with low pressure. The surrounding air is at a higher pressure which keeps the ball inside the stream.

When the upward force of the air equals the weight of the ping-pong ball the ball is said to be in 'equilibrium'. The theory at work here is Bernoulli's principle. This is an equation linking air pressure, velocity and density with particle weight.



Challenge designed by:
Alex, design engineer at Dyson

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STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

LIGHTS OUT

CHALLENGE 11

THE BRIEF

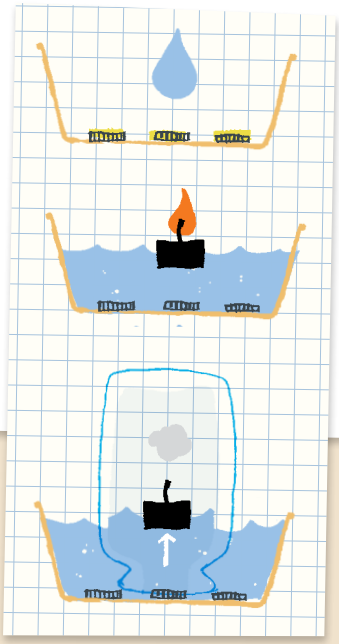
LEARN HOW FLAMES USE UP OXYGEN IN AN ENCLOSED SPACE AND CREATE A VACUUM.

MATERIALS

A large empty margarine tub, a clean jam jar, a tea light, a match, three coins.

THE METHOD

1. Place the three coins in the margarine tub to act as a stand for the jar.
2. Fill the tub with water.
3. Carefully, and with adult supervision, light the tea light.
4. Place it on the water, it should float.
5. Turn the jar upside down and place over the tea light, onto the three coins.
6. As the oxygen is used up, the flame will extinguish and the water level will rise.



HOW DOES IT WORK?

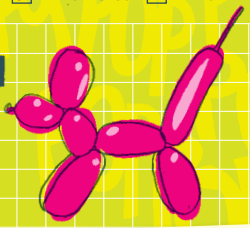
The flame heats the air in the jar and this hot air expands. Some of the expanding air escapes out from under the jar – you might see some bubbles. When the flame goes out, the air in the jar cools down and the cooler air contracts. This creates a vacuum and the water is then sucked into the jar.

Challenge designed by:
Luke, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

BALLOON KEBABS



CHALLENGE 12

THE BRIEF

PUSH A WOODEN SKEWER THROUGH A BALLOON WITHOUT POPPING IT, CREATING A "BALLOON KEBAB".

MATERIALS

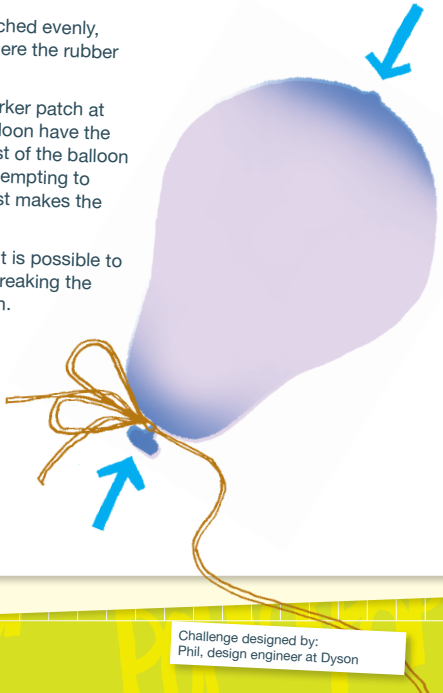
A balloon inflated until ¾ full, a wooden skewer, cooking oil.

HOW DOES IT WORK?

Most of the balloon is stretched evenly, but there are two points where the rubber is least stretched.

The tied section and the darker patch at the opposite side of the balloon have the lowest surface tension. Most of the balloon is under high tension, so attempting to push the skewer through just makes the balloon pop.

At the low tension sections it is possible to make a small hole without breaking the overall surface of the balloon.



TOP TIP
Think about where the rubber is least stretched in the balloon. Use cooking oil to lubricate your skewer.

Challenge designed by:
Phil, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

CARDBOARD BOAT

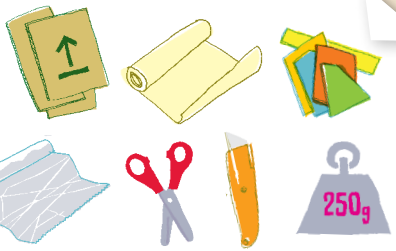
CHALLENGE 13

THE BRIEF

CONSTRUCT A BOAT TO SUPPORT UP TO 250G WITHOUT SINKING.

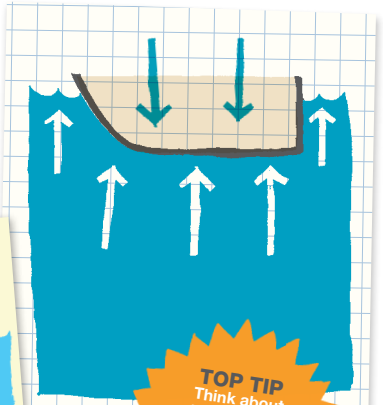
MATERIALS

Cardboard, wax paper, plastic, tape, glue, rubber bands, foil, scissors, craft knives (with adult supervision) and a 250g weight.



HOW DOES IT WORK?

For an object to float, the upward push of the water must be the same as the weight of the water being displaced by the object. To cause an object to float, the density of the object must be adjusted to equal the density of the water being displaced.



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

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.

Challenge designed by:
Ben, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

MULTI SHAPE

CHALLENGE 14

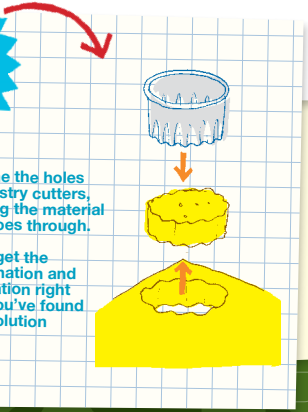
THE BRIEF

DESIGN ONE SHAPE THAT WILL FIT PERFECTLY, WITH NO GAPS, THROUGH A SQUARE, TRIANGULAR AND ROUND HOLE.

MATERIALS

Paper and a pencil, scissors (with adult supervision), some plasticine to make the shape. An old margarine tub with a square, triangular and round shape cut out of the lid.

TOP TIP
Think about the orientation of the shape as it goes through the holes.



HOW DOES IT WORK?

To complete this task you'll need to think laterally and visualise the spaces you need to fill. Modelling skills are vital to being a good design engineer. A prototype is the best way to communicate your idea.

Challenge designed by:
Andy, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

CARDBOARD CHAIR

CHALLENGE 15

THE BRIEF

CONSTRUCT A CHAIR THAT YOU CAN SIT ON USING ONLY CARDBOARD. NO GLUE, TAPE OR OTHER FIXING MATERIAL ALLOWED.

MATERIALS

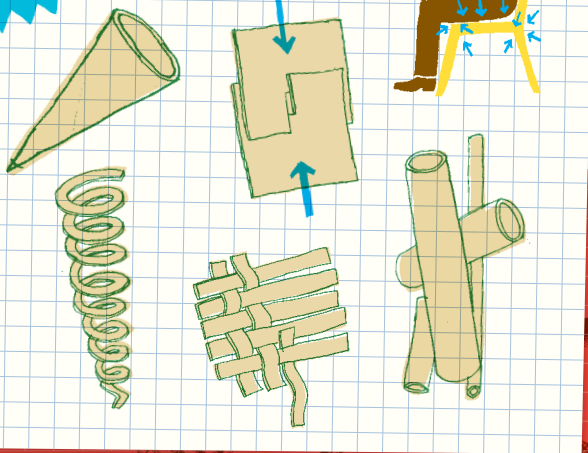
Cardboard, cutting equipment (with adult supervision), rulers, pencils.

TOP TIP

THINK ABOUT STRUCTURE

The best designs use the weight of the person sitting on it to force the joints together making the structure stronger.

Think about using cones, interlocking sheets, spirals, tubes or even strips of card like a sewing thread.



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Challenge designed by:
Andy, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☑ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

DECODE A MESSAGE

CHALLENGE 16

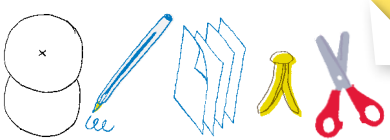
THE BRIEF

DECODE THE FOLLOWING:

WKHUH DUH ORWV RI GLIIHUHQW FRGHV.

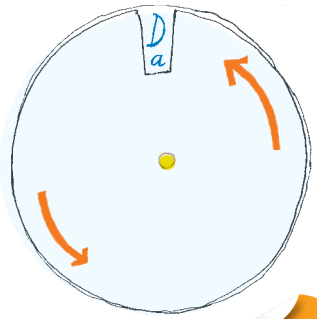
MATERIALS

Two paper disks, a pen, scrap paper, a split pin, scissors (with adult supervision).



THE METHOD

1. Around the edge of one disk, write the alphabet in capitals, clockwise.
2. Under "D", start again at "a" and write the alphabet again, clockwise, in lowercase, under the capital letters.
3. Place the other disk over the first and cut a slit in the edge, so you can see one capital letter and the other letter underneath it.
4. Fix the two disks together with the split pin.
5. For each code letter, find it in capitals by turning the top disk and write the lower case letter you see on your scrap paper.



HOW DOES IT WORK?

This code disk has the code letters in capitals and the real letters in lower case. You can use it to decode messages or write your own codes. This code is called the Caesar Shift, because you shift your alphabet along, and is one of the oldest used.

DID YOU KNOW?

Mary Queen of Scots used codes to tell people to kill Queen Elizabeth I – these were decoded and used to sentence her to execution.

Challenge designed by: Robyn, analyst at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

CLEVER EGG BOX

1m

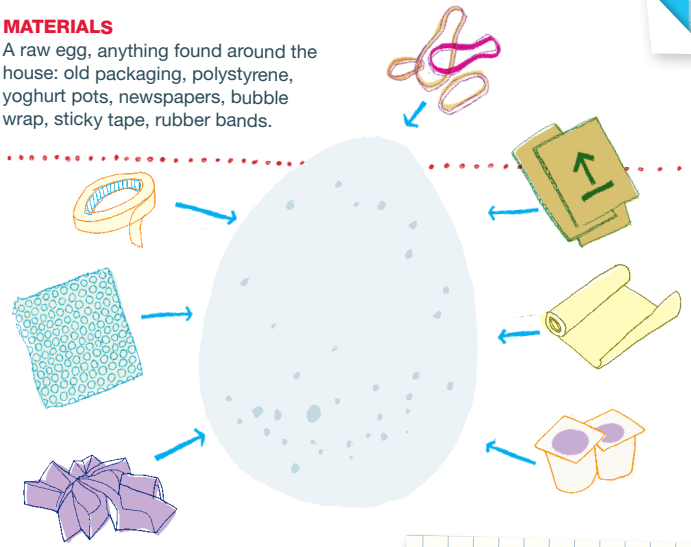
CHALLENGE 17

THE BRIEF

PACKAGE AN EGG SO THAT IT SURVIVES A DROP FROM 1 METRE. NO PARACHUTES ALLOWED.

MATERIALS

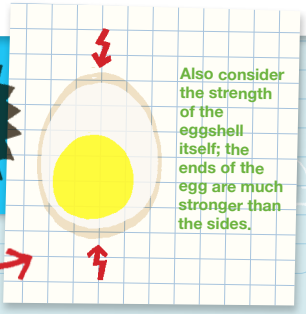
A raw egg, anything found around the house: old packaging, polystyrene, yoghurt pots, newspapers, bubble wrap, sticky tape, rubber bands.



HOW DOES IT WORK?

Outer packaging acts as a crumple zone. Crumple zones absorb the energy from the crash landing preventing it from being directly transmitted to the egg.

TOP TIP
Think of packaging that deforms and absorbs the impact.



Also consider the strength of the eggshell itself; the ends of the egg are much stronger than the sides.

Challenge designed by:
Ian, design engineer at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☑

JAMES DYSON FOUNDATION

LIQUID DENSITIES

CHALLENGE 18

www.jamesdysonfoundation.com

THE BRIEF

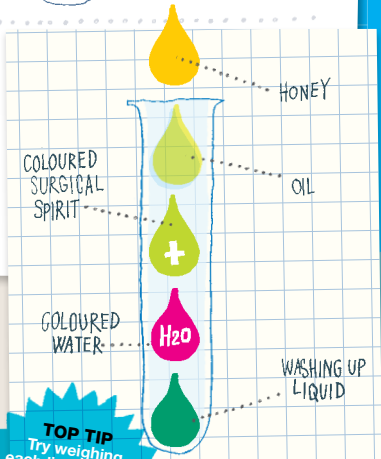
LAYER DIFFERENT LIQUIDS IN A TUBE AND DISCOVER HOW AND WHY THEY SETTLE IN A CERTAIN ORDER.

MATERIALS

Honey, oil, washing up liquid, surgical spirit, water, two shades of food colouring and a test tube.

THE METHOD

1. Start by adding food colouring to the surgical spirit and to the water – using a different shade for each. This will allow you to identify each liquid.
2. Measure out equal quantities of each liquid. Add them to the tube, one by one.



HOW DOES IT WORK?

Different liquids have different densities and therefore, different weights. The heaviest liquids will sink, the lighter liquids will rise to the top.

Density is a comparison between an object's mass and volume. Remember the equation:

$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}}$$

Based on this, if the weight – or mass – of something increases but the volume stays the same, the density has to go up. Lighter liquids, like water, are less dense than heavy liquids, like honey, and so float on top of the more dense layers.

TOP TIP
Try weighing each liquid before you add it in and predict which order the liquids will settle in.

BE PATIENT...

The layers may be a little mixed at first. Allow the jar to settle for a moment and watch the layers start to define.

Challenge designed by:
Ben, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

EXPANDING GASES

CHALLENGE 19

THE BRIEF

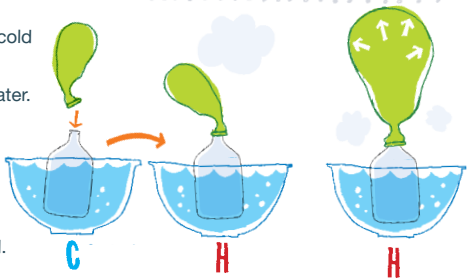
FIND OUT WHAT HAPPENS WHEN GASES ARE HEATED UP OR COOLED DOWN.

MATERIALS

Two bowls, cold water, hot water (with adult supervision), sturdy plastic bottle and a balloon.

THE METHOD

1. Fill two bowls – one with cold the other with hot water.
2. Put the bottle into cold water.
3. Fit a balloon to the neck of the bottle.
4. Now place the bottle into the hot water.
5. Watch the balloon expand.



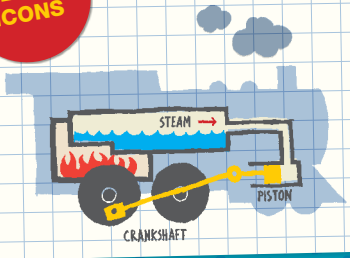
HOW DOES IT WORK?

Gas expands when it is heated. This is known as Charles' Law. The rule is, if the pressure of a gas remains constant, the volume of the gas will increase as the temperature increases. So if the temperature increases, the gas takes up more space.

The principle was first formulated by the French physicist **Jacques Alexandre Cesar Charles** in 1787.

DESIGN ICONS

STEAM ENGINES heat up air and allow it to expand in cylinders to drive wheels.



Challenge designed by:
David, senior mechanical engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

TORNADO IN A BOTTLE

CHALLENGE 20

THE BRIEF

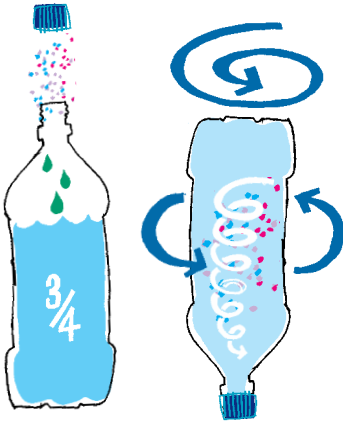
CREATE A WATER VORTEX IN A BOTTLE.

MATERIALS

Water, a clear plastic bottle, glitter, washing up liquid.

THE METHOD

1. Fill the plastic bottle with water until it reaches around three quarters full.
2. Add a few drops of washing up liquid.
3. Sprinkle in a few pinches of glitter (this will make your tornado easier to see).
4. Put the cap on tightly.
5. Turn the bottle upside down and hold it by the neck. Quickly spin the bottle in a circular motion for a few seconds. Stop and look inside to see if you can see a mini tornado forming in the water. You might need to try it a few times before you get it working properly.

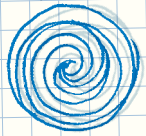


HOW DOES IT WORK?

The water is rapidly spinning around the center of the vortex due to centripetal force. This is an inward force directing an object or fluid such as water towards the center of its circular path.

DID YOU KNOW ?

Vortexes found in nature include tornadoes, hurricanes and waterspouts.



Challenge designed by:
Adam, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

NON-NEWTONIAN FLUID

CHALLENGE 21

THE BRIEF

CREATE A LIQUID THAT TURNS INTO A SOLID WHEN TAPPED.

MATERIALS

60g corn starch, 60ml water, a spoon, a bowl for mixing.

THE METHOD

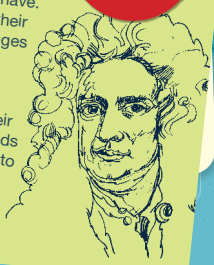
1. Add the corn starch to the bowl.
2. Add water slowly to the mixture, stirring in one tablespoon at a time, until all of the powder is wet.
3. Continue to add water until the corn starch acts like a liquid when you stir it slowly – but when you tap it with your finger it becomes hard.
4. Scoop the mixture into your hand and slowly work it into a ball.
5. As long as you keep pressure on it by rubbing it between your hands, it stays solid. Stop rubbing, and it melts into a puddle in your palm.

HOW DOES IT WORK?

Non-Newtonian fluids change their viscosity or flow behaviour under stress. The sudden application of stress can cause them to get thicker and act like a solid, or in some cases it results in the opposite behaviour and they may get runnier than they were before. Remove the stress and they will return to their earlier state.

DESIGN ICONS

Sir Isaac Newton described how 'normal' liquids or fluids behave. He observed that their viscosity only changes with variations in temperature or pressure. In non-Newtonian fluids their viscosity also depends on the force applied to the liquid.



Challenge designed by: Rory at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

BRIGHT AS A NEW PENNY

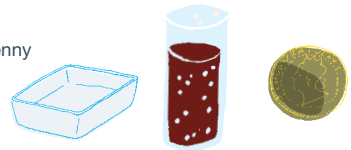
CHALLENGE 22

THE BRIEF

CLEAN A PENNY USING COLA.

MATERIALS

Shallow container, cola and a penny – the older and dirtier the better.



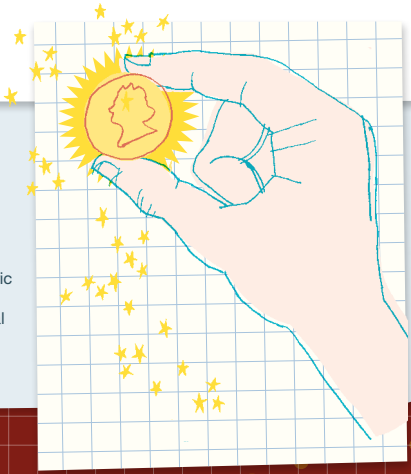
THE METHOD

1. Place the penny in the container.
2. Add enough cola so the penny is covered.
3. Leave overnight.
4. In the morning, you should find that your penny is clean.

HOW DOES IT WORK?

Pennies have a copper coating. As the copper gets older, it reacts with the oxygen in the air and begins to form a copper-oxygen compound. This compound is what makes the penny look dull.

Meanwhile, cola contains phosphoric acid. This acid breaks down the copper-oxygen compound chemical bonds allowing a fresh, unoxidized layer of copper to be exposed.



Challenge designed by:
Roy, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

GROW A PLANT IN A JAR

CHALLENGE 23

THE BRIEF

GROW A PLANT IN A JAR TO SEE ITS ROOT SYSTEMS.

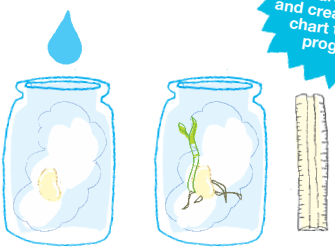
MATERIALS

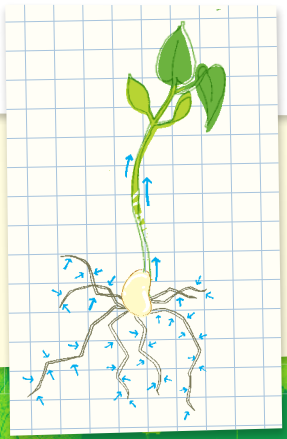
A glass jar, a butter bean, some cotton wool and water.

TOP TIP
Check on your plant every day. Measure the plant and create a bean chart to track progress.

THE METHOD

1. Fill the jar ¾ full with cotton wool.
2. Place the bean on one side of the jar so you can easily see it.
3. Pour water into the jar until the cotton wool is damp but not wet.
4. Place the jar on the windowsill, or somewhere it has access to sunlight.
5. Once your plant has sprouted leaves and is beginning to outgrow the jar, remove it and examine the roots.





HOW DOES IT WORK?

The roots of plants provide two main functions: they anchor the plant, and they absorb water and minerals from the soil. In this case, there's no soil – so the plant draws all the minerals it can get from the water.

The stem of the plant conducts water and minerals from the soil to the rest of the plant.

Challenge designed by:
Karen, microbiologist at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☑ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

BOAT POWERED BY A CHEMICAL REACTION

CHALLENGE 24

www.jamesdysonfoundation.com

THE BRIEF

BUILD A BOAT POWERED BY A CHEMICAL REACTION.

MATERIALS

Small plastic bottle, sticky tape, two ice lolly sticks, two corks, scissors (with adult supervision), drinking straw, vinegar, baking soda. Somewhere to sail it – such as a bath tub or sink.

THE METHOD

Tape the corks and ice lolly sticks together to form a rectangle.

Tape the bottle to the middle of the rectangle so it hangs down between the corks.

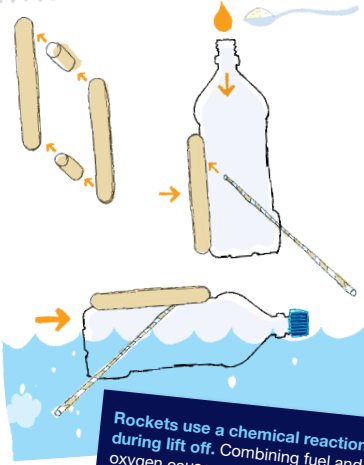
Make a hole in the end of the bottle so it will sit below the water.

Push the drinking straw through the hole so the end inside the bottle touches the inside wall.

Pour in vinegar and add bicarbonate of soda. Screw the bottle top back on tightly.

With a thumb covering the end of the drinking straw, shake the bottle.

Once the reaction starts, drop the boat in the water and watch it propel forward.



HOW DOES IT WORK?

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

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.

DESIGN ICONS

Challenge designed by:
Rob, engineering reliability manager at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☑

JAMES DYSON FOUNDATION

LENZ'S LAW

CHALLENGE 25

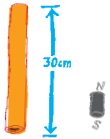
THE BRIEF

DISCOVER A WORKING DEMONSTRATION OF LENZ'S LAW.

MATERIALS

A 30cm long domestic copper plumbing tube.

Strong magnet that fits freely – but closely into the tube.



THE METHOD

Drop the magnet into the tube and watch what happens.

HOW DOES IT WORK?

As the magnet falls down the tube it demonstrates Lenz's law. The magnet induces a current in the tube, this current then opposes the change in flux. The magnet is not attracted to the copper – and it does not stick to it. You should see it slide straight through the tube.

DESIGN ICONS

Rollercoasters

This system is similar to how electromagnetic brakes work on rollercoasters. The wheel is the tube, and the magnet is attached to the chassis of the train. The movement of the train is slowed without any friction parts to wear out.

Challenge designed by:
Tom, design engineer at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

CARTESIAN DIVER

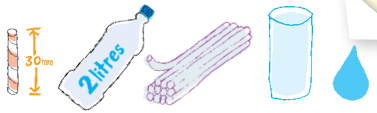
CHALLENGE 26

THE BRIEF

BUILD A CARTESIAN DIVER.

MATERIALS

Drinking straw cut to 30mm in length, plasticine, a two litre bottle, a drinking glass and water.



THE METHOD

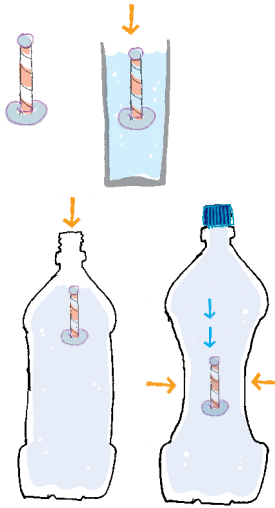
Put a small ball of plasticine on the top of the straw to seal it.

Roll a sausage of plasticine and wrap it around the bottom of the straw, leaving the bottom open. This is your diver.

Now attempt to balance the diver so he stays upright.

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).

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.



DESIGN ICONS

Buoyancy is all about making things float. **Isambard Kingdom Brunel** designed the SS Great Britain in 1843. It was made of iron but was able to float thanks to the upward force of the water equalling the weight of the water displaced.

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.

Challenge designed by:
Daryl, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

INERTIAL EGGS

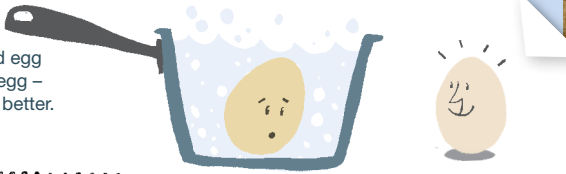
CHALLENGE 27

THE BRIEF

USE EGGS TO FIND OUT ABOUT MOMENTUM AND CHANGING DIRECTION.

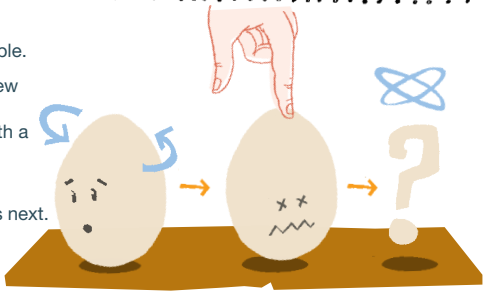
MATERIALS

One hardboiled egg and one fresh egg – the fresher the better.



THE METHOD

1. Spin each egg on a table.
2. Leave it to spin for a few seconds then abruptly stop it momentarily with a finger on top.
3. Release the egg and observe what happens next.

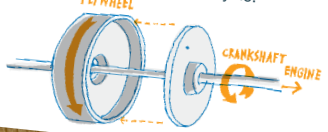


HOW DOES IT WORK?

One of the eggs will start to spin again when the finger is released, while the other will remain at a dead stop. The fresh egg has egg fluid and yolk inside it which gains momentum. When the egg is momentarily stopped, the yolk continues to turn inside the shell. When it is released, the viscosity of the fluid between the still spinning yolk and the shell causes the shell to spin again.

DESIGN ICONS

Inertia is the tendency of a moving object to remain moving or a stopped object to remain stopped. In engineering, flywheels are big heavy wheels that are spun to gain inertia. The energy is stored and released to smooth out the operation of engines that have a short burst of power during their running cycle.



Challenge designed by:
Tom, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☑

JAMES DYSON FOUNDATION

100+100=192? CHALLENGE 28

THE BRIEF

ADD WATER TO ETHANOL AND FIND OUT WHY IT DOESN'T ADD UP.

MATERIALS

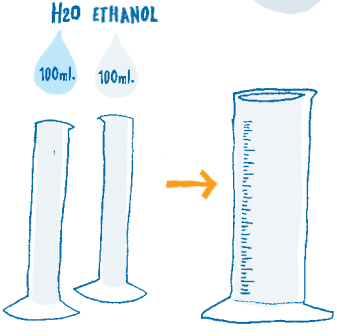
100ml of water, 100ml of ethanol (with adult supervision) and three measuring cylinders – two smaller to measure out the liquids, and one larger to mix and read off the resulting volume.

TOP TIP
When measuring the liquids, practice your lab skills and get down to eye level to measure to the meniscus.

Make sure you get every last drop, and monitor your mixture to see if any gas is given off.

THE METHOD

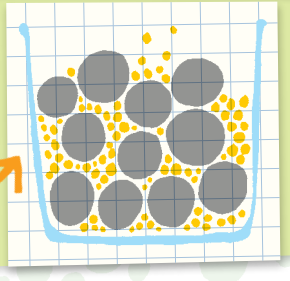
1. Measure out exactly 100ml of water and 100ml of ethanol.
2. Add the two solutions together in the large measuring cylinder and look at the measurements.
3. You would expect the resulting solution to measure exactly 200ml, however it should actually give a volume of around 192ml.
4. Where has the other 8ml gone?



HOW DOES IT WORK?

Ethanol molecules are smaller than water molecules, so when the two liquids are mixed together the ethanol falls between the spaces left by the water.

It's similar to what happens when you mix a litre of sand and a litre of rocks.



Challenge designed by:
Chloe, research engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☑

JAMES DYSON FOUNDATION

MEASURE THE SPEED OF LIGHT

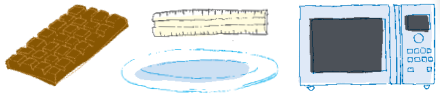
CHALLENGE 29

THE BRIEF

MEASURE THE SPEED OF LIGHT USING CHOCOLATE AND A MICROWAVE OVEN.

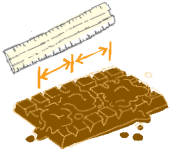
MATERIALS

A large bar of chocolate, a microwave (with adult supervision), a large ceramic plate and a ruler.



THE METHOD

1. Remove the glass plate in the base of the microwave and replace with an upturned ceramic plate. You want your chocolate to stay still in this experiment.
2. Place the chocolate in the middle of the plate.
3. Turn on the microwave and heat the chocolate until it melts in 2 or 3 places. This should take about 20 seconds.
4. Using gloves, and with adult supervision, carefully remove the plate from the microwave.
5. Measure the distance, in metres, between the melted spots on the chocolate bar.

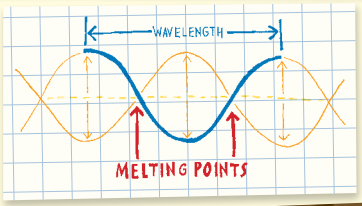


NOW COMES SOME MATHS!

The distance you measured is half a wavelength. Multiply this number by two and then by the frequency of the microwave you are using. This can be found on the outside of the machine. **This number is the speed of light in metres per second.**

HOW DOES IT WORK?

Microwaves work by creating standing waves inside the microwave oven. The water molecules in the chocolate try to align themselves with the rapidly changing standing wave, creating heat. The distance between the two melted spots is half a wavelength. You can now calculate the speed of light, because **speed = wave length x frequency**.



Challenge designed by:
Joe, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☑ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

WEATHER BALLOON

CHALLENGE 30

THE BRIEF

MAKE A BAROMETER AND PREDICT THE WEATHER.

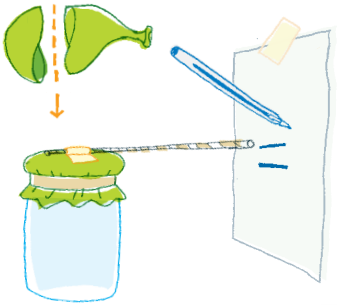
MATERIALS

A glass jar, a balloon, a rubber band, scissors (with adult supervision), a straw, sticky tape, some paper and a pen.

THE METHOD

Take the balloon and cut the bottom half off. Take the top half and pull it tight over the jam jar. Use the rubber band to keep the balloon tight over the jar. Fix the straw to the centre of the balloon skin using a piece of sticky tape. Place the paper so that it is lined up against the straw. Draw a line at this position. Above the line write the word “high” and below the line write “low”.

Try noting down the pressures each day to see if you can notice a pattern between your air pressure readings and the weather outside.

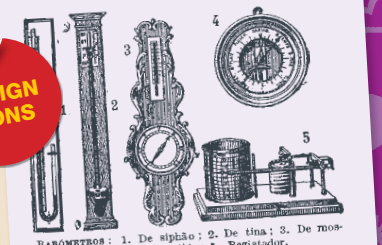


HOW DOES IT WORK?

As the air is sealed inside the jar, any changes to the air pressure outside the jar will result in direct movement of the balloon rubber. As the outside air pressure increases, the rubber will be forced down into the jar. The straw pivoting on the glass will rise upward. The opposite is true when the pressure decreases.

DESIGN ICONS

BAROMETERS are used by weather forecasters to help predict the weather.



Barómetros: 1. De sipháo; 2. De tina; 3. De mostrador; 4. Aneróide; 5. Registador.

Challenge designed by:
Chris, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

FLOATING PAPER CLIP

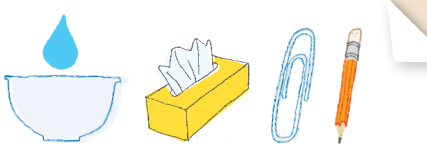
CHALLENGE 31

THE BRIEF

MAKE A PAPER CLIP FLOAT ON WATER.

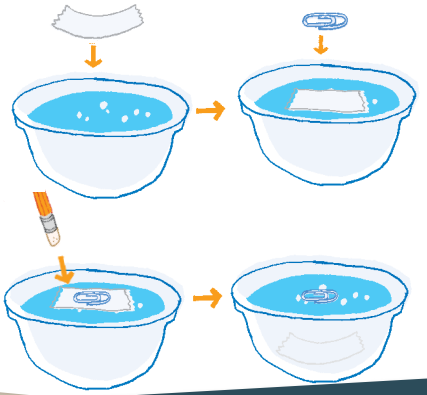
MATERIALS

Water, a bowl, tissue paper, a paper clip, a pencil with a rubber on the end.



THE METHOD

1. Fill the bowl with water.
2. Tear off some tissue paper (around 10cm x 5cm).
3. Gently place the tissue paper onto the surface of the water so that it floats.
4. Place the dry paper clip on top of the tissue.
5. Use the rubber end of the pencil to carefully poke until the tissue sinks and the paperclip is left floating.

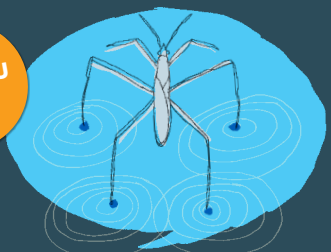


HOW DOES IT WORK?

The paper clip is held afloat by the surface tension of the water. Water molecules are polar, so the molecules pull on each other. This creates a tension – like a thin, flexible membrane on the surface – which helps hold the needle afloat. The tissue paper allows you to lower the paperclip onto the water gently, without breaking the surface tension.

DID YOU KNOW ?

Insects such as **pond skaters** use water tension to appear to walk on water.



Challenge designed by:
Nor, test engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☑ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

BALLOON CAR RACE

CHALLENGE 32

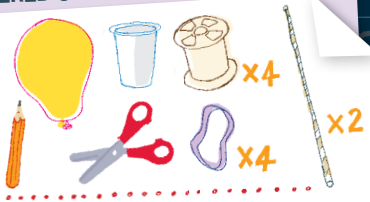
www.jamesdysonfoundation.com

THE BRIEF

MAKE AND RACE A BALLOON POWERED CAR.

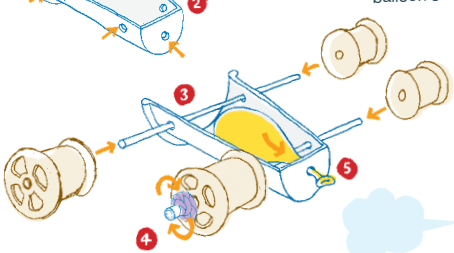
MATERIALS

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) and a pencil.



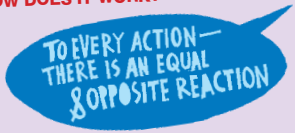
THE METHOD

1. Using scissors, carefully cut out half of the cup, to create the car body.
2. Using a pencil, poke two sets of holes through the length of the cup for the axles and one through the cup bottom.
3. Insert the straws through the holes on the side of the cup. Then, slide the cotton reel or lid wheels on each end of the straws.
4. Wrap the rubber bands 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.



6. Blow up the balloon. Then put your car on the ground, and let the balloon go.

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.

Challenge designed by:
Caroline, engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

DESIGN AND BUILD A HELICOPTER

CHALLENGE 33

THE BRIEF

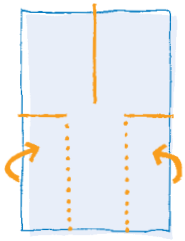
DESIGN AND BUILD A HELICOPTER USING ONLY PAPER AND PAPERCLIPS.

MATERIALS

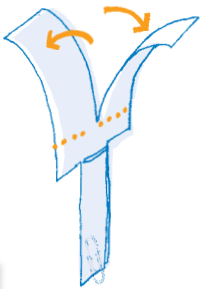
A4 sheet of paper, paper clips and scissors (with adult supervision).

THE METHOD

1. Take a piece of paper and make three cuts. Then fold the paper in on itself at the bottom half.



2. Fold the helicopter blades on opposite sides and use a paperclip to keep the sides together.



3. Stand carefully on a chair and drop your helicopter, making sure it stays upright as you let go!

Leonardo da Vinci's Aerial Screw.

DESIGN ICONS

Juan de la Cierva's Cierva C.8.

Challenge designed by:
Ahmed, design engineer at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

WATER CLOCK

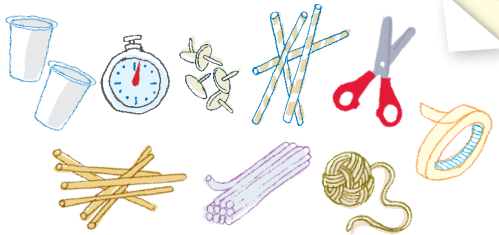
CHALLENGE 34

THE BRIEF

CREATE A WATER CLOCK THAT TIMES EXACTLY ONE MINUTE WITH 200ML OF WATER.

MATERIALS

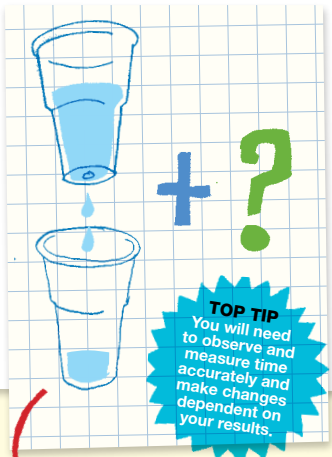
Plastic cups, straws, plasticine, string, a timer, wooden doweling or similar to act as a stand, scissors (with adult supervision), tape and drawing pins.



THE METHOD

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.

Additional cups, string, straws, etc. can also be used to create more elaborate examples or to help slow the water if necessary.



TOP TIP
You will need to observe and measure time accurately and make changes dependent 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.

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.

www.jamesdysonfoundation.com

Challenge designed by:
Sam, teacher and D&T enthusiast at Malmesbury Primary School

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☑ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

METAL ETCHING

CHALLENGE 35

THE BRIEF

ETCH A PATTERN INTO A SHEET OF METAL USING ONLY THINGS FOUND IN YOUR HOME.

MATERIALS

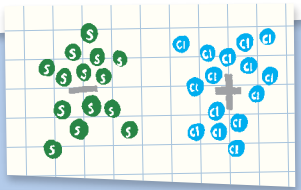
Table salt, water, plastic or glass bowl, two pieces of sheet metal – mild steel, copper or brass, 9v battery, two crocodile clip cables, nail varnish remover and a permanent marker.

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 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 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.

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.



Challenge designed by:
Ed, Design and Technology student and JDF ambassador at Malmesbury School

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

FIRE EXTINGUISHER

CHALLENGE 36

THE BRIEF

CREATE YOUR OWN INVISIBLE FIRE EXTINGUISHER.

MATERIALS

Baking soda, vinegar, candle, matches (with adult supervision) and a jam jar.

THE METHOD

With the help of an adult, light the candle.

Mix a little baking soda and vinegar together in the jar to make a frothing mixture.

Tip the jar over the candle so only the gas from the reaction comes out. Be careful not to tip the mixture out.

The flame will be extinguished.

www.jamesdysonfoundation.com

DESIGN ICONS

Certain types of fire extinguishers use a similar method to extinguish fires.

Dry chemical extinguishers are filled with powder, which is usually sodium bicarbonate or baking soda. When released over the fire, the powder decomposes at 70°C releasing CO_2, smothering the fire.

HOW DOES IT WORK?

The mixture of bicarbonate of soda and vinegar creates carbon dioxide. CO_2 is heaver than air so it sits at the bottom of the glass. When you tip up the glass, the CO_2 comes out and suffocates the candle.

Challenge designed by:
Liam, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

SCARED PEPPER

CHALLENGE 37

THE BRIEF

MOVE PEPPER AWAY FROM YOU WITHOUT TOUCHING IT.

MATERIALS

Ground black pepper, bowl, water and washing up liquid or soap.

THE METHOD

Fill the bowl with water.

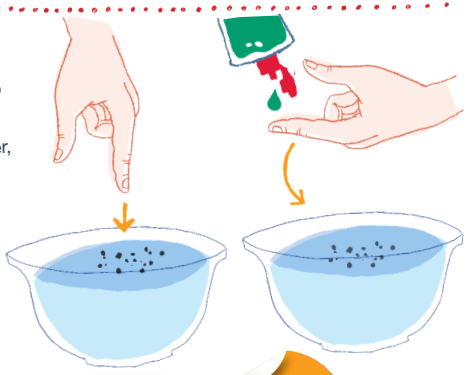
Add some pepper to the top of the water, do not stir it in.

Dip your finger into the water, note down what happens.

Put a small amount of soap on your finger.

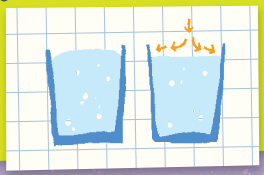
Dip it back into the water.

What happens to the pepper?



HOW DOES IT WORK?

Water normally bulges up a bit. You can see this by looking at a raindrop or by filling a glass slightly over the rim – the water will not spill out. When soap is added to water, surface tension is lowered. The water tries to spread out. As the top of the water flattens out, the pepper on the surface is carried to the edge of the bowl.



DID YOU KNOW?

In the cosmetics industry they regularly change the surface friction and consistency of various liquids in order to make them easier to pour or spray.

Challenge designed by:
Cianan, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

JELLY AND OIL

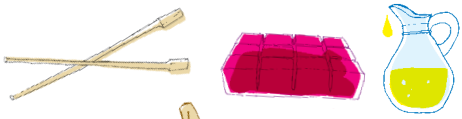
CHALLENGE 38

THE BRIEF

TRY TO MOVE JELLY CUBES FROM ONE PLACE TO ANOTHER – USING CHOPSTICKS.

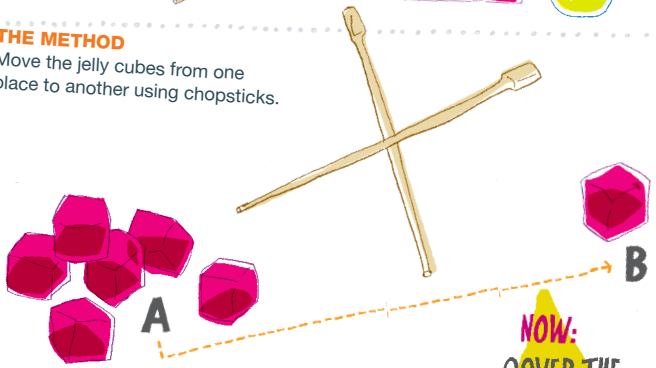
MATERIALS

Jelly cubes, chopsticks and olive oil.



THE METHOD

Move the jelly cubes from one place to another using chopsticks.



NOW: COVER THE CUBES IN OIL – AND TRY AGAIN!

DID YOU KNOW?

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

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, which is why they become slippery.

Challenge designed by: Sophie, at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

DANCING RAISINS

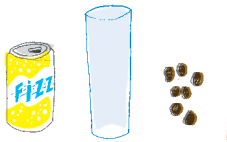
CHALLENGE 39

THE BRIEF

MAKE RAISINS DANCE UP AND DOWN A GLASS OF FIZZY DRINK.

MATERIALS

A can of clear fizzy drink (e.g. lemonade), a tall, clear glass and a handful of raisins.



THE METHOD

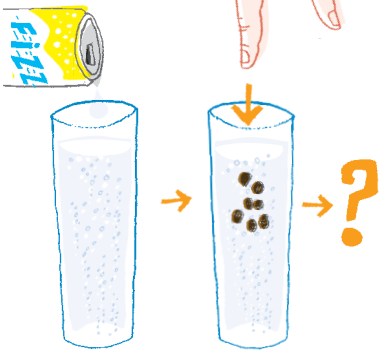
Pour the can of drink into the tall glass.

Notice the bubbles coming up from the bottom of the glass. The bubbles are carbon dioxide gas released from the liquid.

Drop a few raisins into the glass. Watch the raisins for a few seconds. Describe what is happening to the raisins.

Do they sink or float?

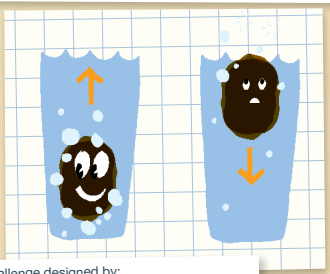
KEEP WATCHING. WHAT HAPPENS?



HOW DOES IT WORK?

Raisins have a higher density than the liquid in the glass, so they sink to the bottom. Carbon dioxide bubbles attach themselves to the raisins and act like little life jackets that make the raisins more buoyant by increasing their volume. Once the raisins reach the top of the glass the carbon dioxide escapes and the raisins sink again.

After a while, the drink will run out of fizz and it will no longer lift the raisins.



Challenge designed by:
Danya, James Dyson Foundation executive

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

A TOUGH NUT TO CRACK

CHALLENGE 40

THE BRIEF

USING BRAZIL NUTS AND A NUT CRACKER, CRACK OPEN THE SHELL WITHOUT DAMAGING THE NUT.

TOP TIP
You should try cracking the nut in different ways to find out the best way to crack the shell without damaging the nut.

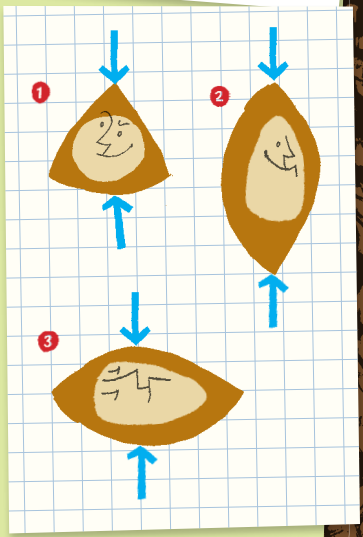
MATERIALS

Brazil nuts in their shell and a nut cracker.

HOW DOES IT WORK?

The cross section of a brazil nut is roughly an equilateral triangle.

1. Cracking the nut across the centre with one flat side aligned with the nut cracker face will transfer all the force directly through into the nut. Most of the time, this will cause the nut to shatter.
2. Cracking the nut end to end is nearly impossible.
3. Instead, apply the force across one of the sides. The side should buckle and most of the time this breaks the shell and not the nut.



THINK ABOUT how the shell protects the nut when it falls from the tree. Investigate this with other nuts and discuss which nuts have the most protective shell.

Challenge designed by:
Sioned, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

BURNING CUSTARD

CHALLENGE 41

THE BRIEF

USE CUSTARD TO FIND OUT HOW THE SURFACE AREA OF FUEL AFFECTS HOW IT BURNS.

MATERIALS

Custard powder, a funnel, 1m length of hosepipe, Bunsen burner (with adult supervision) and goggles.

THE METHOD

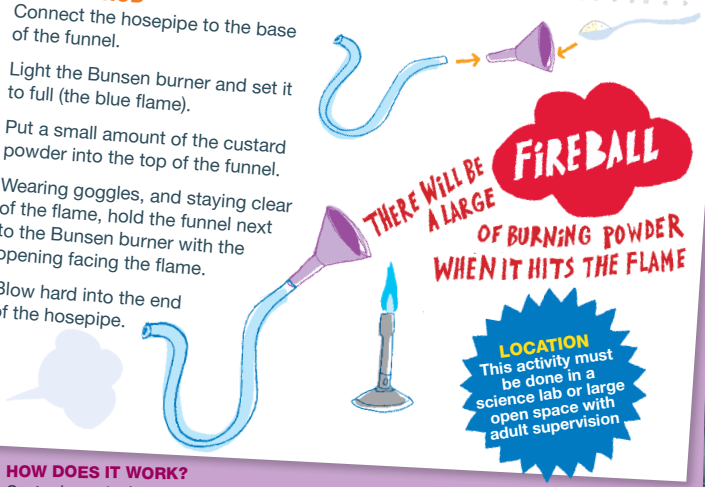
Connect the hosepipe to the base of the funnel.

Light the Bunsen burner and set it to full (the blue flame).

Put a small amount of the custard powder into the top of the funnel.

Wearing goggles, and staying clear of the flame, hold the funnel next to the Bunsen burner with the opening facing the flame.

Blow hard into the end of the hosepipe.



HOW DOES IT WORK?

Custard powder burns rapidly because it has a high total surface area to volume ratio, which allows oxygen in the air to come into contact with the fuel easily. When you have a large lump of wood, the oxygen can only touch the outside and so it burns from the outside in. If you turned that lump of wood into sawdust, the surface area would be greatly increased. This increase in surface area allows the oxygen to reach more places at once and so burn quicker when on fire.

Challenge designed by: Hannah, at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☑ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

COPPER PLATING

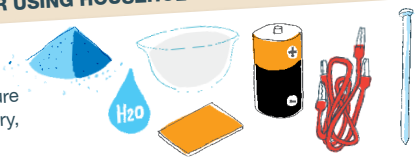
CHALLENGE 42

THE BRIEF

COAT A NAIL IN COPPER USING HOUSEHOLD ITEMS.

MATERIALS

Copper sulphate, water, a glass bowl, a piece of pure copper, nail, a D-cell battery, wires, and crocodile clips.



THE METHOD

Fill the bowl with about 4cm of water.

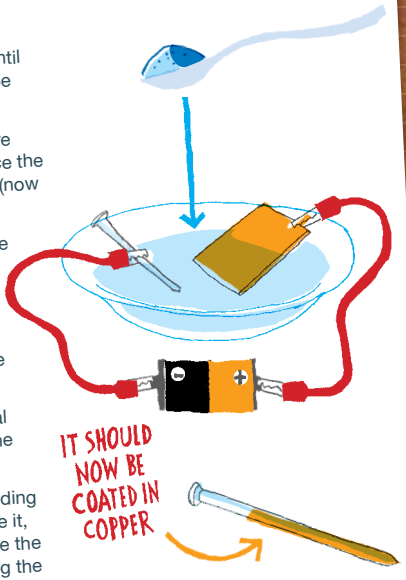
Mix copper sulphate with the water until no more can be dissolved, it should be dark blue.

Connect one crocodile clip to the pure copper and the other to the nail. Place the copper (now the anode) and the nail (now the cathode) into the water.

Don't let the crocodile clips touch the water – as they will become coated in copper too. Make sure to keep the anode and the cathode as far away from each other as possible. They must not touch as it can cause the battery to overheat.

Connect the anode to the + terminal of the battery and the cathode to the – terminal.

You should start to see copper building up on the nail. The longer you leave it, the thicker it will get. After you have the desired thickness of copper, unplug the battery and remove the nail.



HOW DOES IT WORK?

The copper sulphate solution is an electrolyte, conducting electricity from the anode to the cathode. When the current is flowing, oxidation (loss of electrons) happens at the copper anode, adding copper to the solution. The ions are then carried on the electric current to the cathode, where reduction (gain of electrons) happens, plating the nail in copper ions.

Challenge designed by:
Cianan, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

BUILD A COMPASS

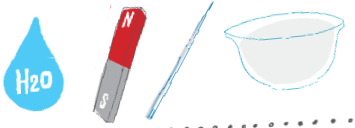
CHALLENGE 43

THE BRIEF

BUILD A COMPASS.

MATERIALS

Water, straight bar magnet, steel needle and a bowl.

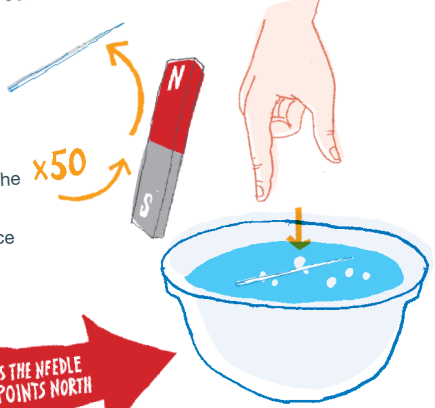


THE METHOD

Fill the bowl with water.

Magnetise the needle by stroking it over the bar magnet about 50 times. Make sure the needle is orientated with the needle pointing to the north of the bar magnet on each stroke.

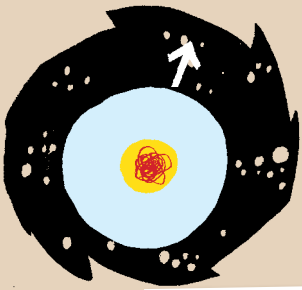
Drop the needle onto the surface of the water – from as close as you can – to let it rest on the surface tension.



HOW DOES IT WORK?

Once the needle is magnetised it naturally wants to align with the Earth's stronger magnetic field.

This field, called the magnetosphere, is created by electrical currents that are generated by a churning molten iron core deep inside the planet. The Earth acts as if it has a bar magnet running through it with the magnet's south pole located near the planet's geographic north. Since opposites attract, the north pole of a magnetised needle is attracted towards it.



Challenge designed by:
Adam, design engineer at Dyson

www.jamesdysonfoundation.com

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☑

JAMES DYSON FOUNDATION

FINGER CALCULATOR

CHALLENGE 44

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THE BRIEF

USE YOUR HANDS TO MULTIPLY ANY COMBINATION OF 6, 7, 8, 9 & 10 TOGETHER.

MATERIALS

x2 HANDS that's it!

THE METHOD

Imagine your fingers and thumbs are numbered 6 to 10 on each hand.

Use 7 x 8 as an example.

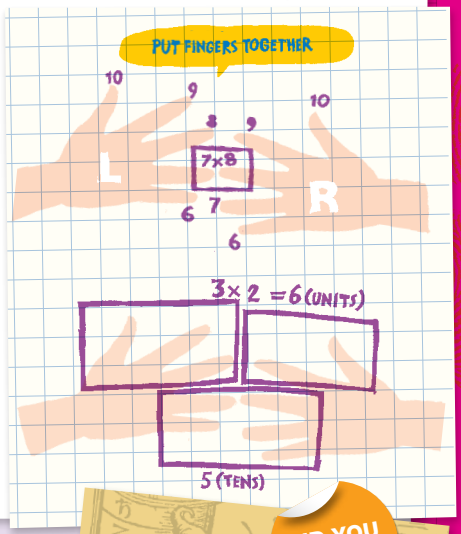
Take the finger representing 7 on the left hand and touch it to the finger representing 8 on the right hand.

The fingers above the touching fingers are multiplied. Here, 3 on the left and 2 on the right make 6.

The touching fingers, and the fingers below them are all 10s. So in this case, 5 fingers is 50.

Add the two numbers together to reach your answer.

50+6 = 56
7x8 = 56



HOW DOES IT WORK?

The times tables from 1 to 5 are easy to learn, but 6 onwards can get tricky.

This method allows you to check you've done it right.

DID YOU KNOW ?

This method of calculating was widely used in Medieval Europe. Today it's a handy way to check you've remembered your times tables correctly.

Challenge designed by:
David, technical manager at Dyson

STEM SUBJECTS: SCIENCE TECHNOLOGY ENGINEERING MATHS

FOUNDATION JAMES DYSON

HOMEMADE WATER BOMB

CHALLENGE 45

THE BRIEF

MAKE YOUR OWN WATER BOMB OUT OF PAPER.

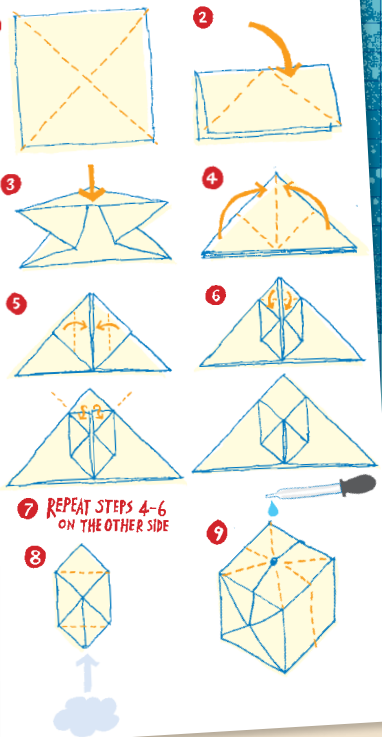
MATERIALS

Square piece of paper, water and a pipette.

THE METHOD

Take a square piece of paper.

1. Fold the paper in half diagonally to create a crease and unfold. Repeat in the opposite direction so you have an 'x' shape.
2. Flip the paper in half and fold top to bottom.
3. Flip the paper over again and press down in the middle, while folding the flaps on the side. You should get a triangle.
4. Take the flaps on the front side and fold them up to the middle.
5. Fold the side corners to the middle line. This should create little pockets.
6. Take the flaps above the pockets and push them in.
7. Repeat steps 4 – 6 on the other side.
8. Blow in the little hole in the bottom to inflate.
9. Use the pipette to fill your water bomb.



DESIGN ICONS

Christchurch Cathedral in New Zealand is made from 98 giant cardboard tubes and designed to last for up to 50 years. The tubes are coated with three layers of waterproof polyurethane.

The cathedral was designed by Shigeru Ban, a Japanese architect who has been building with cardboard since 1986. The new cathedral is earthquake-proof, fireproof and won't get soggy in the rain.

Challenge designed by: Louis, design engineer at Dyson

HOW DOES IT WORK?

Folding paper makes it more rigid.

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STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

HOW TO MAKE A LAVA LAMP

CHALLENGE 46

THE BRIEF

MAKE YOUR OWN LAVA LAMP.

MATERIALS

Empty water bottle, a large bottle of vegetable oil, food colouring, Alka-Seltzer® tablets (with adult supervision), water and a torch.

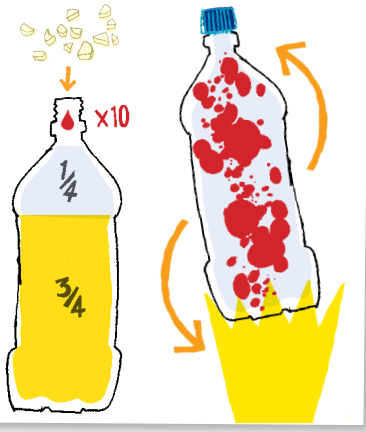
THE METHOD

Take an empty water bottle.

Fill the bottle 3/4 full with vegetable oil, then top it off with water and about 10 drops of food colouring (or enough to make the solution appear fairly dark).

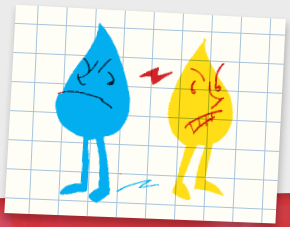
Cut an Alka-Seltzer tablet into pieces. Add pieces of the tablet to the bottle – this will cause the mixture to bubble. Put the cap on and tip the bottle back and forth. The tiny droplets of coloured water will start to move around inside the oil and join together, making bigger lava blobs.

Place a strong torch under the bottle. This will illuminate the bubbles.



HOW DOES IT WORK?

Oil is hydrophobic – it will not mix with water – even if you try to really shake the bottle. The Alka-Seltzer tablet reacts with the water to make tiny bubbles of carbon dioxide which are lighter than water. They attach themselves to the blobs of coloured water, causing them to float to the surface. When the bubbles pop, the colour blobs sink back to the bottom of the bottle.



Challenge designed by:
Fiona, James Dyson Foundation executive

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☑ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

POTATO POWER!

CHALLENGE 47

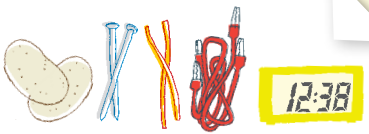
TOP TIP
Try other fruits and vegetables, such as citrus fruits, avocados and bananas.

THE BRIEF

MAKE YOUR OWN POTATO CLOCK.

MATERIALS

Two large clean potatoes, two galvanized zinc nails, two copper wires, three jumper wires (with crocodile clips on each end) and a battery operated LCD clock.



THE METHOD

Label one potato 'A' and the other 'B'.

Place one galvanized nail in each potato.

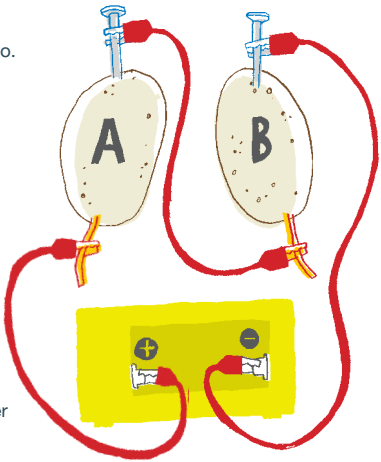
Place one copper wire piece into each potato (placing it as far away from the galvanized nail as you can).

Open the battery compartment of the clock and remove the battery.

Connect the first jumper wire from the copper wire of potato A to the positive terminal of the clock.

Connect the second jumper wire from the galvanized nail of potato B to the negative terminal of the clock.

Connect the third jumper wire from the galvanized nail of potato A to the copper wire of potato B.



Check the clock. It should now be running on potato power.

HOW DOES IT WORK?

Each potato works as a galvanic cell, releasing electrical energy through chemical reactions.

The potato juice acts as the electrolyte, in which charged atoms and molecules, called ions, dissolve and can flow over time. Wiring the potato cells end-to-end makes a series circuit, pulling the stream of electrons through the clock.

Challenge designed by: Sarah, at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

IVORY SOAP®

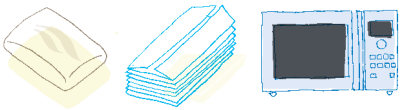
CHALLENGE 48

THE BRIEF

CREATE A BIG SOAPY MARSHMALLOW OUT OF IVORY SOAP.

MATERIALS

Ivory soap®, paper towels, a microwave (with adult supervision) and a plate.



THE METHOD

Place the bar in the middle of a plate covered with a paper towel and place in the centre of the microwave oven.

Cook the bar of soap on high for two minutes.

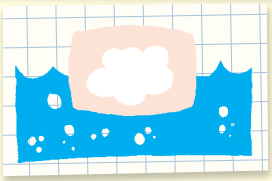
Watch the bar of soap as it begins to expand and erupt into puffy clouds. Be careful not to overcook it.

Allow the soap to cool for a minute.

HOW DOES IT WORK?

Ivory soap® floats because it has air pumped into it during manufacturing. When the air inside the soap heats up, the air expands and reacts with the water inside. The expanding gases push on the softened soap, creating foam.

This effect is a demonstration of Charles' Law. Charles' Law states that as the temperature of a gas increases, so does its volume.



Challenge designed by:
Lydia, James Dyson Foundation manager

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☑ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

MAKE A PERISCOPE

CHALLENGE 49

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THE BRIEF

DESIGN AND BUILD YOUR OWN PERISCOPE TO SEE AROUND CORNERS.

MATERIALS

Shoebox, two small mirrors, a pencil, scissors (with adult supervision), tape and PVA glue.

THE METHOD

Remove the box lid.

Place one mirror on the side and near the bottom of the shoebox and trace around it. Place the second mirror at the opposite end of the shoe box and trace around that too.

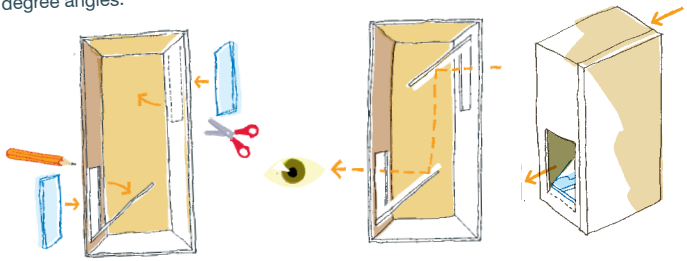
Cut out the traced sections to make a door flap. Slant the doors at 45 degree angles.

Tape the mirrors onto the slanted doors.

Adjust the mirrors. Keep moving them into place until you can see out of the top hole when you look in through the bottom hole.

Seal the mirrors into place using PVA glue.

Glue the shoebox lid back on.



HOW DOES IT WORK?

Light reflects away from a mirror at the same angle that it hits the mirror. In your periscope, light hits the top mirror at a 45 degree angle and reflects away at the same angle, which bounces it down to the bottom mirror. The reflected light hits the second mirror at a 45 degree angle and reflects away at the same angle, into your eye.

Challenge designed by:
Guy, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

COLOURED CARNATIONS

CHALLENGE 50

THE BRIEF

CREATE MULTI-COLOURED FLOWERS.

MATERIALS

White carnations, two colours of food dye, plastic cups, water and scissors (with adult supervision).

THE METHOD

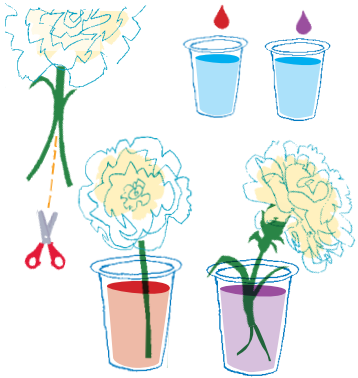
Use the scissors to cut the stem of the carnation in half lengthways.

Take two cups and fill them with water. Add a different coloured food dye to each cup.

Put the split stems of the carnation into the cups and leave overnight.

The next morning you should find that your flower has changed colour.

What do you notice about the petals?

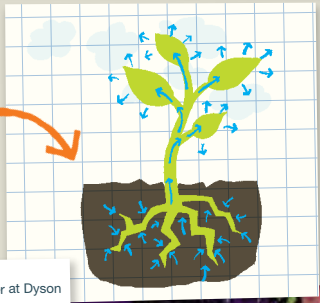


HOW DOES IT WORK?

Plants need a transport system to move food, water and minerals around.

There are two things that combine to move water through plants – **transpiration** and **cohesion**.

Water evaporating from the leaves (transpiration) draws water up the stem of the plant to replace what is lost. This works in the same way as sucking on a straw. Water that evaporates from the leaves "pulls" (cohesion) other water behind it up to fill the space left by the evaporating water.



Challenge designed by:
Adam, science teacher and former design engineer at Dyson

STEM SUBJECTS: SCIENCE ☐ TECHNOLOGY ☑ ENGINEERING ☑ MATHS ☐

JAMES DYSON FOUNDATION

ATTRACTIVE NAILS!

CHALLENGE 51

THE BRIEF

MAKE YOUR OWN ELECTROMAGNET.

MATERIALS

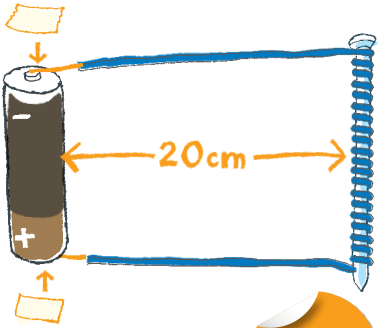
Insulated copper wire – thin insulation is best, tape, a battery, an iron nail and iron filings or paper clips.

THE METHOD

Wrap the insulated copper wire around the iron nail, leaving 20cm of loose wire at either end.

Remove 3cm of insulation from the ends of the copper wire and attach to either end of the battery with tape.

You now have an electromagnet. The nail should attract the iron filings and paper clips.



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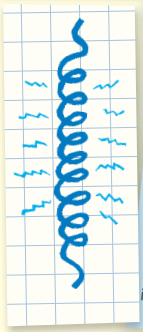
HOW DOES IT WORK?

Most magnets cannot be turned off.

When electric current runs through a wire it creates a magnetic field – and that's why electromagnets can be turned on and off.

Running current through a wire produces a weak magnetic field. But this is usually too weak to give us visible results. By coiling the wire closely you amplify the magnetic influence which gives visible results.



DID YOU KNOW ?

Many objects around you contain electromagnets.

They are found in electric motors and loudspeakers. Very large and powerful electromagnets are used as lifting magnets in scrap yards to pick up then drop old cars and other scrap iron and steel.

Challenge designed by:
Lathiif, design engineer at Dyson

STEM SUBJECTS: SCIENCE ☑ TECHNOLOGY ☐ ENGINEERING ☐ MATHS ☐

JAMES DYSON FOUNDATION

INVISIBLE INK

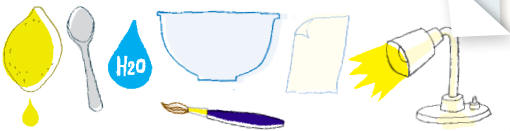
CHALLENGE 52

THE BRIEF

WRITE YOUR OWN SECRET MESSAGE IN AN INVISIBLE INK SOLUTION.

MATERIALS

Lemon juice, a bowl, a spoon, water, a paint brush, white paper and a small lamp.



THE METHOD

Squeeze lemon juice into the bowl and add a few drops of water. Stir with the spoon.

Dip the paint brush into the juice mixture and write a message on the paper.

Allow the paper to dry completely. Your message should become invisible.

Hold the paper very close to the light bulb to heat up the message area (adult supervision required). Watch your message appear.

HOW DOES IT WORK?

The lemon juice is an organic substance which reacts with oxygen in the surrounding air, oxidises and turns brown. By placing the paper right next to the lamp we speed up the oxidisation process. The heat from the lamp causes the chemical bonds to break down.

DID YOU KNOW ?

OXIDISATION

This is the interaction between oxygen molecules and all the different substances they may contact, from metal to living tissue. A freshly-cut apple that turns brown, a bicycle that becomes rusty or a copper penny that turns green. Not all oxidation is bad – but think about choosing the right materials when designing a product for a particular use.

Challenge designed by:
Jack, design engineer at Dyson