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Science Oxford is pleased to present

STEM Busking Booklet

Amazing Demonstrations and Exciting Activities

STEM Club Resource Pack

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Bernoulli Balloons

Equipment needed:

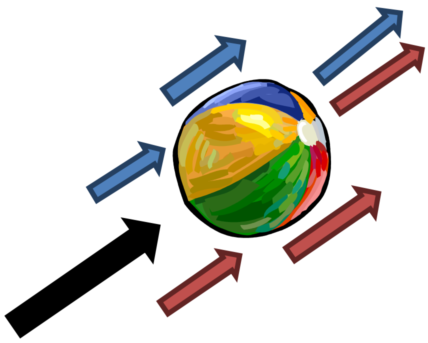
Inflatable beach ball or balloon	Ping pong ball
Hair dryer	Extension cable

Before you start:

Experiment at home with various objects and see if you can find other alternatives that illustrate Bernoulli's principle.

Methodology:

Plug your hair dryer into the extension cable, tilt it upwards and place the beach ball/ping pong ball in the air stream. The ball will float upwards and then hover in the air stream. Tilt the hair drier to the side and the ball will still hover in the air stream, you should be able to hold the hair dryer at a 45° angle before the ball will fall out of the air stream. You can also add a competition element to the demo: place/hold a paper cup at one end of the room and then challenge a volunteer to get the ping pong ball into the cup using just the hair dryer!.



Science Note:

This demo works due to the Bernoulli principle. The air from the hair dryer travels over the top and bottom of the ball concurrently. The air passing under the ball moves slower which creates more pressure. Equally the air passing over the top of the ball moves faster which creates less pressure. This difference in pressure creates a resultant force upwards (lift) which is what keeps the ball in the air. The Bernoulli principle only works with curved surfaces, such as balls or balloons. If you were to try the demo using a cube, it would fall out of the air stream as soon as you tilted the hair dryer.

Extension activities:

Experiment with placing different objects in the air stream, how size, weight and material affect how high they float?

Health and Safety Note:

Be aware that the hair dryer can over heat if you run it for too long, resulting in a blown fuse or tripping the circuit on the extension cable. It also very strongly suggested that you tape down the extension cables to avoid trips. It is also important to remember that if you decide to walk with the hair dryer (around the room for instance) that you are attached to a cable, and therefore there will be limitations in how far you can walk!

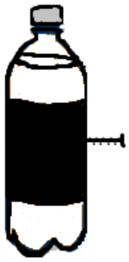
Bottle and Screw

Equipment needed:

100ml plastic water bottle and lid	Water
screw	tray

Before you start:

Make a small hole in the side of the water bottle using the screw. Fill the water bottle up to the top and screw on the lid.



Methodology:

You can perform this like a magic trick- ask for a volunteer to come and stand out front and hold the tray. Bring out the bottle with the screw in, and ask the audience what would happen if you were to remove the screw- most of them will say that the water will come out. Agree and then hold the bottle over the volunteers head and proceed to take the screw out slowly. When you do eventually remove it, no water will come out. Thank your volunteer, send them back to sit down and then ask- how can you make the water come out? Squezzing it, turn it upside down, eventually someone will say 'take the lid off' at which point the water will come out of the hole.

Science Note:

With the lid on the bottle you create a partial vacuum, as no air can get in to replace any water than would be lost. Alternatively if you think about it terms of pressure- there is lots of air pressure outside the bottle, because there is lots of air. Inside the bottle is only a tiny amount of air. So the air pressure inside the bottle plus the weight of the water is not strong as the air pressure pushing from outside over the hole, when you remove the lid, you remove the partial vacuum and the difference in air pressure, as the only force now acting is the weight of the water.

Health and Safety Note:

Take care when piercing the bottle with the screw!

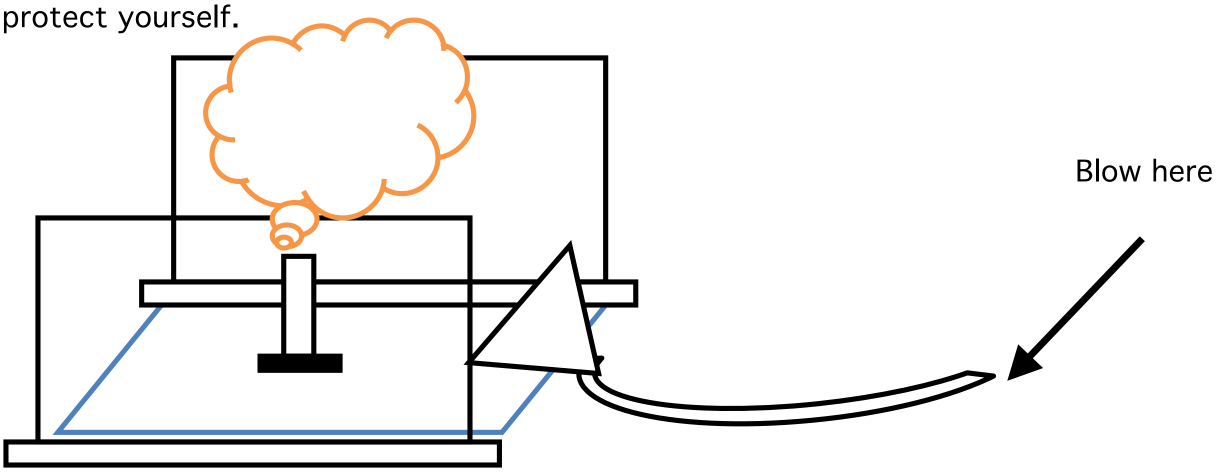
Custard Powder Clouds

Equipment needed:

Custard powder	Safety goggles
funnel	Rubber tubing
Safety screens	Blow torch/Bunsen burner
Heat proof mats	

Before you start:

Set up your safety screens on the desk where you plan to demonstrate this explosion, it is recommended that you use two safety screens and place one in front of the explosion to protect the audience and one behind the demonstration to protect yourself.



Methodology:

Attach the funnel to the end of the rubber tubing. Set up your blow torch or bunsen burner at one end of your desk ontop of a line of heat proof mats. If using a blow torch you will need to secure it in place using a clamp stand. Tip some custard powder into the funnel, hold the funnel to the side of the flame, and keeping your face well back blow through the other end of the rubber tubing. This will create huge fire clouds over your bunsen/blow torch flame.

Science Note:

Custard powder is high in sugar, which is a fuel and will rapidly combust when blown over a flame as it increases its flammability due to the high surface area exposed to oxygen in the atmosphere.

Extension activities:

You can illustrate the effect of surface area on flammability by beginning this demonstration by setting light to a lump of sugar at the start, and showing how much less flammable it is.

Health and Safety Note:

It is recommended that you use safety screens, wear safety goggle and keep hair tied well back

Dissolving Polystyrene

Equipment needed:

Acetone	Tray
Polystyrene cups/boards/beads	

Before you start:

Make sure the room you carry demonstration in is well ventilated, as excessively breathing in Acetone vapours can lead to headaches and dizziness.

Methodology:

There are lots of different ways to present this demonstration- you can put some acetone in a squirty bottle and spray it over your polystyrene and watch as it melts or you can pour some into the bottom of a tray and then push the polystryene shape down into it and watch as it slowly disintegrates.

Science Note:

Polystyrene foam is a polymer of Styrene essentially it is lots and lots of repeating units held in chains with lots of air trapped in between. When added to acetone it rapidly dissolves and looks like it is disappearing. However it is just dissolving the interactions between the polymers chains; the acetone acts as a molecular "lubricant" between the polymer chains, allowing them to slide around each other. The Styrofoam therefore becomes soft releasing the trapped air and the chains clump together and will solidify to form a hard piece of plastic once the acetone dissolves.

Health and Safety Note:

Acetone is highly flammable so should not be used near an open flame. It is also an irritant, so eye protection should be worn when using acetone, the room should be well ventilated to prevent excessive inhalation and prolonged contact with the skin should be avoided wherever possible.

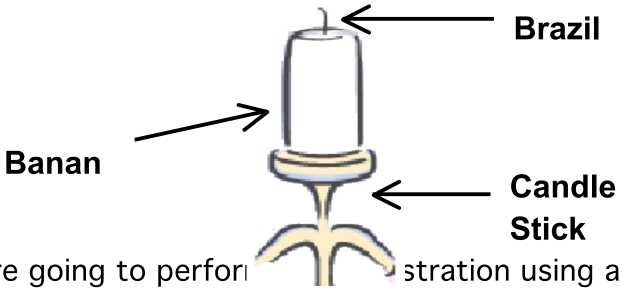
Edible Candle

Equipment needed:

Candle stick holder	Lemon juice
Banana	Sharp Knife
Brazil nut	Lighter

Before you start:

Cut a section of banana and fit it into a candlestick holder. If you thinly slice off the outside layer and ensure that you have a straight section of banana then it will look more realistic. Cover the banana in lemon juice to stop it from going brown. Take a brazil nut and use a sharp knife to shave off the edges until you have a thin sliver of Brazil nut to stick into the top of your banana candle so that it looks like a wick. Light the wick and then blow it out as a blackened end will make it look more realistic.



Methodology:

Explain that you are going to perfor stration using a candle. Light the brazil nut, hold the whole candle up for your audience to see. Then, without warning, blow out the candle and eat it. For effect you can use facial expressions to imply that it is not a pleasant experience! Challenge your audience as to what has just happened? How could it be possible to eat a candle? How was it burning, how was it possible to eat that piece of the candle?

Science Note:

The banana is only useful for this demonstration because you can make it look like a candle (especially when put in a candlestick holder) and it is edible. In a real candle the wick is used to hold a small amount of melted wax (the fuel) in place so that it can vapourise and burn (giving rise to the candle flame). In this candle though it is the wick which is also providing the fuel for the flame – Brazil nuts are rich in oil. The flame will go out once the brazil nut wick has burnt, unlike a real candle which will burn for as long as the wick can continue to hold a little melted wax in place.

Extension activities:

What other edible things could have been used as a wick? Some foods contain more stored energy than others and therefore combust more easily and will stay alight longer than others.

Health and Safety Note:

Do not perform this demonstration if you have an allergy to nuts, also be aware that some of your audience may also have a nut allergy, therefore you should be careful not to breath over them or allow them to come into contact with the nuts.

Film Canister Rockets

Equipment needed:

Empty film canisters (with lids)	Tray
Effervescent Vitamin C tablets	Blu tack
Water	Small plastic spoon

Before you start:

Place some protection on the tables if you are worried about them getting messy. You also need to carry out this demonstration under a reasonably high ceiling.

Methodology:

Start by removing the lid from the film canister and attaching one vitamin C tablet to the lid using some blu tack. Add two spoonfulls of water to the container, until it is about one quarter full. Put the lid back on the canister tightly, and quickly put the canister in the tray with the cap upside down. Step back at least 2 metres and wait… After about 10 seconds, you will hear a pop and the film canister will launch into the air. If it does not launch, wait about 30 seconds before examining the canister- usually the cap is not on tight enough.

Science Note:

Effervescent Vitamin C tablets contain sodium bicarbonate and citric acid, added to water they mix and react and one of the products is carbon dioxide gas. As more and more carbon dioxide gas builds up inside the container – a volume that can't increase- the pressure inside the canister rises until the pressure builds up so much that it blows the canister from its lid. The gas rushing out of the end of the canister pushes it in the opposite direction, so that the rocket shoots upwards.

Extension activities:

- Experiment with different quantities of water in the canister using a pipette and the measuring cylinders and time how long it takes to pop. How high does it go? You can also try putting half a Vitamin C tablet, a quarter and three quarters to see whether this makes a difference. Finally, try crushing the Vitamin C tablet into smaller pieces and then larger pieces and time it.
- Vary the temperature of the water, and note if there is any difference in the height to which the Vitamin C rocket shoots.
- Change the 'fuel' used by the rocket. For example, try using a Vitamin C tablet with vinegar instead of water to see whether there is any difference in the way the rocket behaves (warning – vinegar can be quite smelly!)

Health and Safety Note:

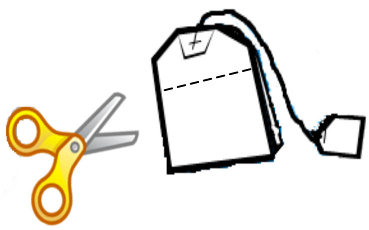
Keep well back from the rocket when launching as the canister can take off with some force. Make sure that you launch from a flat surface, as even the slightest tilt could send the rocket off at an angle as opposed to straight upwards.

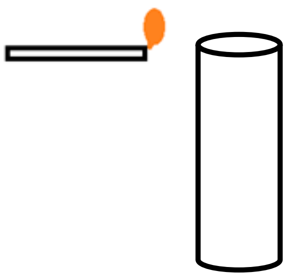
Floating Tea Bag

Kit needed:

Tea bag	Lighter
Scissors	Flat mat or plate

Before you start:
Make sure you have the right sort of tea bag for this trick- It needs to be the type with a staple and tag at top (Twinings are best!)





Methodology:
Cut the top off the tea bag and empty out all the tea, so that an empty tube is left. Balance the tube (end-on) on a flat surface, such as a mat or a plate. Set light to the tea bag tube from the top, and watch as the tea bag burns down and then floats upwards. Ask students to form hypothesis based on their observations.

Science Note:
As the flame burns down the tea bag it heats up the air that surrounds it. As this air becomes warmer, it also becomes less dense and so will rise above the cooler more dense air. As the bag of tea burns down it dissipates, leaving just a delicate ash frame. Since the ash is so lightweight, the force of the rising hot air is strong enough to lift the ash into the air.

Extension activities:
Hot air rising over cooler air, demonstrates the principle of convection currents- which is the driving force beneath hot air balloons. It is possible to make hot air balloons by placing dry cleaning bags over a toaster.

Health and Safety Note:
Use a heat proof surface to place the tea bag on
Remove anything flammable from the area

Gravity Defying Cans

Equipment needed:

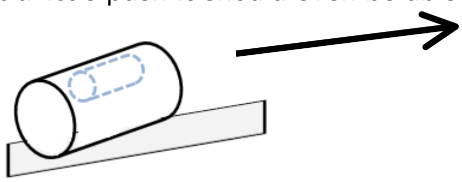
Coke can	Old AA battery
Empty coffee can	Measuring cylinder
Sellotape	Ramp, made from a small plank of wood and a prop

Before you start:

Open the coke can and pour all the coke into a measuring cylinder. Once it is empty pour back in exactly 100ml of coke (or water). Take the lid off the coffee can, and place the battery inside long ways and stick it in place using some sellotape. Then place the lid back on, so the battery is not visible

Methodology:

Tell your audience that you can make a coke can levitate; pick up the can already filled with the 100ml of coke, and hold it at a 45 degree angle on the groove at the bottom of the can, once you have practiced this a few times you will have a feel for it. Take your hands away slowly and wave them around it like you are levitating it for added effect. If you give it a little push it should even be able to spin around on its rim without toppling over



Next pick up the coffee can and place it halfway up the ramp- ask the audience to predict which way it will roll. The majority of the audience will quite sensibly guess that it will roll downwards, however if you place the can so that the battery is tilted to the side facing up the ramp, the can will roll uphill.

Science Note:

The coke can demo balances on a tilt, as having that exact volume of coke, causes the centre of mass to be placed directly above the pivot point on the rim. So when gravity acts on the centre of mass and pulls it downwards, the can balances on the rim rather than toppling over. Because the liquid inside the can is able to move with the can, it will stay balanced even if the can rolls around on its rim.
The coffee can demo works because the extra mass that you tape to the inside edge of the tin changes the centre of mass (sometimes referred to as the centre of gravity) of the tin, which would normally be at the centre of the cylindrical tin. The centre of mass is now much closer to the extra mass on the edge. Gravity acts on the centre of mass and pulls it downwards and this causes the tin to roll up the hill rather than down.

Non-Burning Bank Note

Equipment needed:

Lighter	Water
Bank note or strips of newspaper	Salt
Surgical spirit	tongs
Safety goggles	Small beaker or cup
Measuring cylinder	

Before you start:

Don't do this experiment directly below a smoke detector

Methodology:

Put 25ml of water in with 25ml of surgical spirit and a small quantity of salt in to your beaker, swirl it round so that the liquids mix and the salt dissolves (or partly dissolves). Using your tongs dip in your newspaper/bank note, and completely soak it in the mixture. Hold it out and away from the remaining liquid and set fire to it. The paper will be alight but without burning itself.

Science Note:

This trick works due to the very high heat capacity of water. The surgical spirit burns, but the water absorbs the heat of the flame and therefore protects the paper from burning. Surgical spirit burns with an almost transparent flame, so adding the salt at the start makes the flame burn yellow, which makes it more visible and therefore a more impressive trick.

Extension activities:

This method uses a 50:50 ratio of surgical spirit to water, but you can also experiment with other ratios, see how little water you can get away with before the paper starts burning, or how little surgical spirit you need before the paper won't alight at all! (newspaper as opposed to bank notes would be recommended for these extensions!)

Health and Safety Note:

Surgical spirit is highly flammable; keep the solution and the container well away from the burning note.
Safety goggles and a lab coat are recommended for the demonstrator as is having any loose hair tied well back.
Disposal of surgical spirits is down a foul water drain provided it is diluted to a least a 5% solution first.

Oil and Pyrex

Equipment needed:

Large Pyrex beaker (1L or above)	Other small Pyrex objects
Cooking oil	Paper tissues
Tongs	

Before you start:

This demonstration is very messy, so it is recommended that you use a table covering and have lots of paper tissue to hand. Fill the large beaker with cooking oil and then depending on whether you want to perform this like a magic trick or not hide some small Pyrex objects into the beaker full of oil to then pull out later.

Methodology:

Take your big beaker full of oil, and slowly start to place small Pyrex objects into it, small beakers, glass stirring rods etc, as they fill with oil they will no longer be visible, and it will look like they are disappearing! Pyrex funnels work well for this trick; if you lower then into the oil keeping your finger over the opening,until they are competely submerged, when you release your finger and let the oil displace the air it suddenly disappears. For added effect you can then pull out any objects you secretly hid in the oil earlier.

Science Note:

When light travels from air into a glass object, some of the light reflects straight back into our eyes; however some of the light keeps passing through the object, which causes it to bend slightly. This is known as refraction. We see objects because they both reflect and refract light. When light travels from air to glass it slows down. The measure of how much the light slows down and bends as it passes through an object is known as the index of refraction and every material will have an index of refraction.

Oil and Pyrex have nearly the same index of refraction, which means that the speed at which the light travels when it passes from the oil to the pyrex doesn't really change, so no reflection or refraction take place and it makes it very hard to discern between the two objects. This is why when Pyrex is submerged in oil it looks invisible to our eyes.

Extension activities:

The index of refraction is a function of temperature; therefore this demonstration will work better on some days than others. Alternatively you can experiment with altering the temperature of the oil, either cooling it or heating it, to see if you can find the optimum temperature.

Health and Safety Note:

Obviously handling glassware when slippery can be tricky, so it is recommended that you use tongs to avoid accidentally dropping pieces and causing breakages.

Optical Illusions

Equipment needed:

Sun glasses with one lens missing	Some form of pendulum

Before you start:

You will need Sunglasses (enough for all your audience to have a pair) with one lens missing (see image 1), and some form of pendulum- this can just be a key or other reasonably weighted object tied to a shoe lace or length of string.

Image 1

Methodology:

Ask all your audience to start off not wearing their sunglasses. Swing your pendulum back and forth in front of your arm. Keep swinging your pendulum but ask your audience to place their sunglasses on, to them it will now look as if your pendulum is swinging in a circular motion around your arm, not just back and forth. Now ask your audience to take off their sunglasses and put them back on upside down, (so that opposite eye is now covered) the pendulum will still look as if it is circling your arm, but this time it will look as if the circle has changed direction.

Science Note:

This demo works due to what is called the Pulfrich effect. Covering one eye with a dark filter but not the other creates a relative difference in signal timings between the two eyes. This results in your eyes perceiving lateral motion as having a depth component

Health and Safety Note:

This demo will need to be conducted with sensitivity towards any members of your audience who already have impaired vision for any reason.

UV Hand Prints

Equipment needed:

White paper	Hand cream
Hand held UV torch	Sun cream

Methodology:

Cover the palm of one hand in moisturiser and the palm of the other hand in sun cream. Place both palms down onto your sheet of white paper, so you leave a hand print of both types of cream. Wipe your hand off and then hold the UV torch over the sheet of paper. One hand print will be clearly visible and the other one will not.

Science Note:

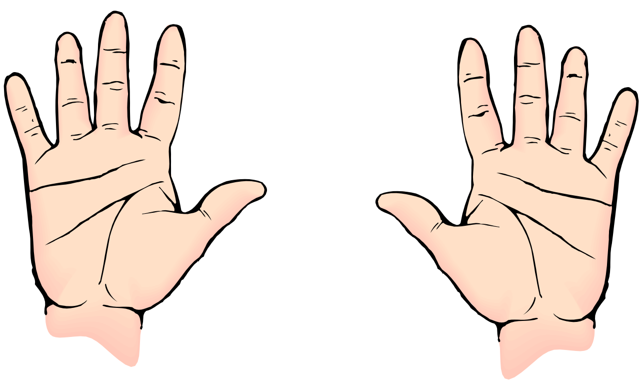
White paper naturally fluoresces in the presence of UV light; sun cream absorbs UV light therefore creating a barrier between the paper and the UV light source, so the sun cream hand print will be visible as it will be the only patch of paper that does not fluoresce when held under the UV torch. The handprint in moisturiser acts as a control and shows how regular moisturiser does not have UV blocking properties.

Extension activities:

Investigate the effectiveness of different factor sun creams using UV beads. Place the same number of UV beads into small zip lock bags, and apply a layer of different factor sun creams to the outside of each. Expose the beads to UV light and time how long it takes to see changes in colour.

Health and Safety Note:

UV light is damaging to both the skin and the eyes. Therefore use of UV torches should be very carefully monitored to ensure the torch is always used pointing away from the eyes.



Water Balloon Fire Trick

Equipment needed:

Lighter	Water
At least two balloons	Safety goggles

Before you start:

Pre-fill a regular balloon with some water, and then blow it up with air as well (easier said than done). The balloons need to be quite heavy duty for this trick, so try it a few times before doing it live in front of an audience!

Methodology:

Blow up a regular balloon live in front of an audience, tie it off, and then hold a flame underneath and ask the question “what will happen next?” The balloon will of course pop, when you bring the flame into contact with it. Next bring out your balloon filled with water and air, hold a flame underneath it and ask the same question again. For extra theatricality you can also ask for a volunteer to come and sit in a chair and then hold the balloon filled with water over their head. (Make sure you hold the flame under a piece of the balloon that is in contact with some water) This time when you bring the flame into contact with the balloon it will not pop.

Science Note:

This trick works due to the very high heat capacity of water. The water inside the balloon absorbs the heat from the flame, which stops the rubber melting and therefore means the balloon does not pop.

Extension activities:

Boil water in a paper bag- pour about 200ml of water into a small paper bag (4-6 inches across) place it on a tripod over an open flame. The conduction of heat through the paper bag will eventually increase the temperature of the water to its boiling point. The heat keeps the water from seeping through the bag and the high heat capacity of the water keeps the paper from igniting!

Health and Safety Note:

Safety goggles and a lab coat are recommended for the demonstrator as is having any loose hair tied well back. Test your balloon filled with water over a flame before doing it in front of an audience, as some rubber balloons are stronger than others. If your balloon does accidentally burst, you will end up with a lot of water over the floor so it is recommended that you have some towels to hand to mop up any spills and so prevent any slip hazards.

Water into Wine

Equipment needed:

3 x medium beakers	Ammonia
1 x large beaker	Phenolphthalein
White vinegar	

Before you start:

Fill the large beaker with a weak colourless ammonia solution (colourless Windex would also work). Of the three small beakers, one needs to be left empty, one needs a few drops of phenolphthalein solution* in the bottom and one needs a small amount of white vinegar in the bottom.

*Phenolphthalein solution can be made by dissolving 3 or 4 non-chocolate Exlax tablets in a bottle of denatured alcohol.

Beaker 1 Weak Ammonia

Beaker 2 Empty

Beaker 3 Few drops of Phenolphthalei

Beaker 4 Small amount of vinegar

Methodology:

A clear liquid from beaker 1 is poured into beaker 2, but becomes pink when poured into beaker 3. The contents of beakers 2 & 3 are then poured back into beaker 1. The liquid in beaker 1 is now pink. The pink liquid is poured into beakers 2 & 3 but turns clear when poured into beaker 4. The contents of beakers 2, 3 & 4 are then all poured back into beaker 1. The liquid becomes clear and the liquid is poured back out into beakers 2, 3 & 4 again.

Science Note:

Phenolphthalein is an indicator that turns pink in the presence of a basic solution (ammonia) but will be colourless in the presence of an acidic solution (vinegar).

Extension activities:

Indicators are a great way of making ‘magic messages’. You can dip Q tips in phenolphthalein solution and then spray with Windex to reveal the message.

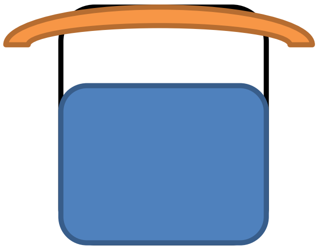
Health and Safety Note:

Phenolphthalein is a low hazard chemical, however it has laxative properties, and so direct skin contact should be avoided as should consumption and inhalation. Phenolphthalein as with ammonia and vinegar can be safely disposed of down the sink.

Water-proof Handkerchief

Equipment needed:

Handkerchief	Water
coaster	Jam jar or drinking glass



Methodology:

This demonstration can be perform this like a magic trick- tell your audience you are going to make the handkerchief water-proof, start off with it draped loosley over the jar and pour some water through it into the jar. Keep pouring until the glass is roughly half full. Pull the handkerchief tight over the jar, keeping the material taught. Place the coaster on top of the jar and tip it all upside down, being careful to keep the handkerchief pulled tight. Ask for a volunteer from the auidence, hold the jar upside down over their head and then remove the coaster- no water comes out!

Science Note:

The reason no water comes out is due to surface tension, with the handkerchief loose the water can pass through gaps in the fabric. When you pull the handkerchief tight- the water molecules can form a single membrane across the handkerchief and this surface tension is sufficient to overcome gravity.

Health and safety

Try and keep your hands dry so that your hands don't accidentally slip on the outside of the jar and drop it on your volunteers head! It might also be a good idea to have some rolls of tissue or a towel to hand, just in case there are any spills!

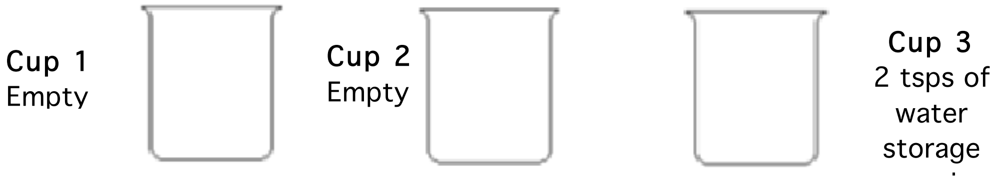
Where's the Water?

Equipment needed:

Water storage granules	Small spoon/scoop
Three identical opaque cups	Jug of water

Before you start:

You will need three identical, opaque plastic cups. Put a small quantity (e.g. two teaspoons) of water storage gel into one of the cups. Place the cups in a row on the table. You will also find it worthwhile to try this experiment before you perform it for students.



Methodology:

You can perform this like a magic trick. Using your jug pour about 100ml of water into Cup 1. Now mix up the cups, making as much of a show of it as you would like to. When you stop moving them ask the pupils to point to which cup they think the water is in. Choose the cup most pupils point to (this usually is the one with the water) and show them that they were right by pouring the water into the other empty cup (cup 2). Repeat, mixing the cups around and ask then guess which cup the water is in- they will usually be right again. This time pour the water into the cup with the water storage gel (cup 3). Repeat. This time the pupils will be wrong-footed – turn the cup upside down to show them that they appear to be wrong. (or over your head if you're feeling brave) Allow them to choose the other two cups too – still wrong!

Science Note:

Water storage gel is an example of a super-absorbent polyacrylamide polymer (sodium polyacrylate). A polymer is a material made from long chain-like molecules. Each granule of water storage gel is able to absorb hundreds of times its own weight in water.

Extension activities:

Water storage gel is often sold in garden centres as something that can be mixed in with soil for hanging baskets or flower beds. It holds the water in the soil and stops it draining away too quickly so that the plants or flowers can make use of it. A similar material can also be found inside disposable nappies! In a related experiment you can show pupils just how much water a disposable nappy is capable of holding. Alternatively you can look at how water storage granules react when mixed with salt and/or sugared water.

Health and Safety Note:

Water storage gel itself is non-toxic, however as it expands so significantly when mixed with water it would be very hazardous if accidentally ingested. Therefore great care should be taken to wash all remains of the powder off your hands before eating anything. In addition water storage granules should **never** be disposed of down the sink as they will cause major blockages. Always place in regular refuse bins.

Balloon Hovercraft

Equipment needed:

Old bottle top with a pop-up valve- these are most common on 'Fruit shoot' or sports bottles	Medium sized balloon
An old CD or DVD	Balloon pump (optional)
Glue gun or strong craft glue	stopwatch

Methodology:

1. Push down the pop-up valve on the bottle top so that it is in the closed position.
2. Attach the bottle top firmly to the middle of the CD using glue. Make sure to seal all around the bottle top and then wait for the glue to harden.
3. Make sure you don't get glue on the bottom of the CD.
4. Ease the neck of the balloon over the rim of the pop-up valve. Open the valve and blow up the balloon through the hole in the CD.
5. If blowing up the balloon attached to the hover craft is too difficult, you can always blow it up separately, pinch the neck and then slip it over the rim of the bottle top.
6. Place the hovercraft on a flat surface and prepare your timer.
7. Start your timer, open the pop up lid, gently push the hovercraft and watch it skim the over the surface.

Science Note:
Hovercrafts work by floating on a cushion of air. The air from the balloon pushing out and downwards creates a small upwards force which is why they float. In addition the air cushion also reduces the friction of the hovercraft allowing it to glide freely over the surface.

Extension activities:
Alter the amount of air in the balloon and time how long your hovercraft stays in the air for.

Health and Safety Note:
If using a glue-gun be careful not to burn yourself as the glue can get very hot.

Bubbles

Equipment needed:

Measuring jugs	Stopwatch
Spoons	Water
Glycerine	Jars/cups
Oil	Pipe cleaners
Maple syrup	Washing up liquid
Straws	

Before you start:

There are lots of potential ways to run this session. You can make up different bubble mix solutions in advance and get pupils to test them and guess which one contains which ingredients. You can give pupils different recipes and get them to make them up, test them and see which the best solution is. Or alternatively you can show the pupils one solution to test and then give them free reign to make up their own recipes. Bubble mix solution is best when made up ~ 24 hours in advance, so if you do plan to bring along some pre-made solution, make it the night before hand.

Methodology:

The ratio 8:1:0.5 works well for water: washing up liquid: additive
Add each liquid together carefully and stir gently to avoid making froth.

Bubble mix solution 1: water & washing up liquid (control)
60ml washing up liquid
480ml water

Bubble mix solution 2: water, washing up liquid & glycerine
60ml washing up liquid
30ml glycerine
480ml water

Bubble mix solution 3: water, washing up liquid & maple syrup
60ml washing up liquid
30ml maple syrup
480ml water

Bubble mix solution 4: water, washing up liquid & vegetable oil
60ml washing up liquid
30ml oil
480ml water

Once you have made the bubble mixture, pour it into your jar/cups and label which formula it is. To blow bubble you can either use a straw, and just dip the end in the solution and blow gently. Or you can make a bubble blower using a pipe cleaner: twist the end of the pipe cleaner into a small loop and dip this loop in the bubble solution and then blow through it gently.

Science Note:

Water is a polar molecule, so when multiple water molecules line up with one another they stick together creating surface tension and this is what holds bubbles together. However surface tension of water on its own is much too strong and rigid to form a bubble, adding detergent to the water, a hydrophobic molecule relaxes the surface tension, by interfering with the interactions between the water molecules therefore making it more elastic and stretchy allowing it to form a skin that will trap air- also known as a bubble!

The different additives suggested above, vegetable oil, maple syrup and glycerine are all greasy hydrophobic molecules that will disrupt the interactions between the water molecules- some will be better at it than others though, and adding too much hydrophobic liquid will just cause it to separate out from the water completely!

Extension activities:

Once you have blown some bubbles and tried out some different bubble wands you can test your bubbles. Blow a bubble and then catch it on the end of your bubble wand. Start the stopwatch and time how long it takes before the bubble pops. Repeat this multiple times for each solution, and this will give you some data to compare different bubble mix solutions.

Health and Safety Note:

Be aware of any allergies or pupils with sensitive skin that might become irritated by excessive contact to detergents.

Crime Scene Chemistry

Equipment needed:

Salt	Water
Cornflour	Universal Indicator paper
Bicarbonate of Soda	Pipettes
Talcum Powder	Vinegar
Iodine	Petri dishes
Beakers	

Before you start:

This is the ideal practical to add a 'back story' to or develop and incorporate in more of a detective theme/feel.

Methodology:

A mystery powder has been found on a crime scene and the pupils have been enlisted to help identify it. It is known to be one of the following four powders
Salt, Cornflour, Bicarbonate of soda, Talcum powder
The powders all look the same- they are all made up of small white grains. Therefore they key to identifying them from one another is to see how they react when mixed with other things. The aim is to observe how each powder reacts in the following 5 tests and then test the mystery powder to see which set of test results it corresponds to.

Test 1: What does the powder look like?

This first test is all about using observation: get pupils to look at the different powders, encourage them to rub the powder around and describe what they look and feel like- are the grains soft or hard, small or big?
Salt and bicarbonate of soda are usually quite hard grains, whereas talcum powder and cornflour are much finer and softer powders.

Test 2: Does the powder react with vinegar?

Put some of each powder into a labelled petri dish, and then carefully add a few drops of vinegar to each. Watch what happens.
Very little will happen for all the powders except bicarbonate of soda, which will fizz and bubble.

Test 3: Does the powder dissolve?

Using measuring cylinder pupils need to measure out 100ml of water and put it into a labelled beaker (so the powders don't get mixed up) then they can add 1 spoonful of the powder to the beaker of water and stir. Then let it sit for a little bit- if all the grains have disappeared and the water looks clear then the powder has dissolved. If the powder does not dissolve the water will look cloudy. For the next test to work well it is important that you put each powder into a **separate** beaker of water.
Salt and bicarbonate of soda will both dissolve whereas cornflour and talcum powder will stay very obviously cloudy.

Test 4: Does the powder change the colour of the indicator paper?

Using the beakers of water from test 3, pupil can now take a small strip of indicator paper and dip

just the end into their watery sample from test 3. They now need to look for a colour change- often because the strip is wet it looks darker than the regular yellow of the dry end, so encourage pupils to let it dry out a bit before looking for a colour change. Compare the colour of the strip to the colour wheel of pHs.

Bicarbonate of soda will turn the indicator strip green (alkali) the other powders will remain yellow (neutral).

Test 5: What happens if you add a few drops of iodine?

Pupils now need to add a few drops of iodine solution to their sample from tests 3&4 and look for a colour change.

Cornflour will turn a dark purple (starch containing) the other powders will show no change or just a slight brown tinge.

Testing a mystery powder

Now that all the tests are completed you can hand out the mystery white powder, and challenge pupils to use all they have learnt from the previous test to work out what it is.

Science Note:

Test 1 is purely observational, but very useful, as the powders do all look slightly different

Test 2 is an Acid- Base reaction. The bicarbonate of soda and vinegar react and release carbon dioxide, which is what the fizzing is.

Test 3 looks at solubility – some solids are soluble and some are insoluble.

Test 4 is a pH test, all of the powders give neutral solutions in water except bicarbonate of soda which is basic and therefore gives a weakly alkaline solution.

Test 5 is a test for starch, iodine reacts with starch and changes colour. Cornflour is the only starch containing powder

Extension activities:

If you really want to challenge pupils you could ask them to design their own science tests to identify the differences between substances.

Health and Safety Note:

Iodine solution is harmful and should be used at low concentrations (less than 1 mol dm^{-3}) eye protection and disposable gloves should be worn when handling iodine solution.

Crystal Growing

Equipment needed:

Borax powder	Water	String
Thermometer	Scissors	Jam jar or beaker
Pencil	Spoon	Kettle
Clingfilm	Disposable gloves	

Before you start:

Measure out and cut off a piece of string so that when it is tied around the pencil and the pencil is placed over the jam jar, the string hangs down to just above the bottom of the jar.

Methodology:

1. Measure out enough water to fill the jar/beaker three quarters full. Add this water to the kettle and boil it.
2. Pour the boiled water into the jar and then add 1 tablespoon of Borax to the water, and stir until it dissolves.
3. Continue to add more Borax, 1 tablespoon at a time, until no more Borax will dissolve.
4. Once no more Borax will dissolve you have a saturated solution.
5. Lay your pencil across the top of the jar so that the string hangs into the saturated solution.
6. Cover the top of the jar with cling film and leave the jar alone for at least 5 hours (preferably overnight)
7. Pull the pencil out of the jar and observe the crystals on the string.

Science Note:

Crystal growing involves dissolving a soluble substance in hot water and then allowing it to slowly recrystallize and 'fall' out of solution as the water cools.
The solubility of the borax (and most solids) is greater in a hotter solution than a cooler one, but as the liquid cools there is suddenly more solid in the solution than can normally be contained by the cooler water and so small bits of the solid 'fall out' of the solution, as they fall out they bump into one another and stick together and from larger pieces of solid known as crystals.

Extension activities:

Different sizes and different numbers of crystals will form dependent on a number of different variables. How fast or slowly the solution is cooled will affect the size and amount of crystals vastly. Try setting up multiple jars and placing them in different mediums – for example in the fridge/freezer or on a windowsill near a radiator etc.
It is also possible to compare Borax to other dissolvable solids- such as salt/sugar and see which makes the 'best' crystals

Health and Safety Note:

Borax is a mild irritant to the skin; therefore it is recommended that you wear gloves when handling the Borax. Borax is also a potential mutagen (may cause harm to an unborn child) so it is recommended that no pregnant women take part in this activity.

Domino Theory

Equipment needed:

Dominoes	Metre ruler
Stop watch	Protractor
Calculator	

Before you start:

You will need a large clear, flat space for this investigation as well as a lot of domino blocks!

Methodology:

The aim of this project is to investigate what will make a line of dominoes fall the fastest.

1. Set up a line of dominoes that covers 1.5 metres, spacing the dominoes at 2cm increments.
2. Set the dominoes off and time how long the line takes to fall over.
3. Now set up a new domino line still covering 1.5 metres, but this time using either smaller or larger spacing increments.
4. Conduct multiple tests at each spacing and determine an average result.
5. At which spacing do the dominoes fall the fastest?
6. To extend the challenge, try curved lines as opposed to straight lines and work out the optimum angle you can place dominoes at and still have them knock one another over.

Science Note:

In the described methodology your controlled variable is the length of the line of dominoes not the number of dominoes, therefore as your spacing increments get smaller, the number of dominoes per line will get larger.

Obviously the smaller the increments of spacing between dominoes the less distance a domino will have to fall in order to hit the next one in the line, which will initially speed up the total time for the line to fall, however there will be more dominoes to topple within the whole line, which will eventually slow down the overall time for the line to fall. If you continue to decrease the increments of spacing so that the dominoes are really close together, they will end up propping each other up rather than knocking each other down, so that the line does not topple over continuously.

As the increment of spacing between dominoes gets larger, the dominoes will have further to fall before they hit the next domino, however each domino will have more momentum when it hits the next one. As the increment spacing increases to greater than the height of the dominoes, the dominoes will cease to hit one another at all, and the line will not topple at all.

Egg Drop Challenge

Equipment needed:

Bags of assorted stationery resources (explained below)	Rubber eggs (optional, but good to hand out for practising)
Scissors	Bin liners
Raw eggs contained in zip lock bags	trays

Before you start:

You will need somewhere to drop the eggs from- a balcony, play equipment, second floor, step ladder or wall bars. Put the raw eggs into zip-lock bags in advance, this ensures less mess at the end and solves the problem of allergies.

Methodology:

The objective is to make a device or package that will allow a raw egg to be dropped from height onto a target on the floor without breaking the egg.
This can be run as a competition with pupils working in small teams or individually. Each team will be given the same resources:

In a plastic bag each team will receive:

- A balloon
- An envelope
- 4 x sheets of A4 paper
- 1 x sheet of card
- 2m of string
- 1x sheet of sticky labels
- 1 x sheet of newspaper

Often it is a good idea not to hand out the raw eggs at the start as they will get broken. Having a few rubber eggs is a good alternative as it allows pupils to test their contraptions for size and stability without the risk of using a real egg.

You need to set a time limit for construction- depending on how old the pupils are and how many there are in each team you can adjust this accordingly, but usually a minimum of 30 minutes is a good length of time.

It is often good to set a few ground rules or at last minute pieces of advice, such as:

- Once the balloon has been blown up and tied it is really hard to untie
- Once a material has been cut, its cut, you can't them change your mind and ask for a replacement
- You don't have to use all the stuff in the bags
- They don't have to build a parachute- it could be another type of contraption, as long as the egg is kept safe.
- You can use the plastic bags for construction, although it is best not to give this away straight away at the start.

Once the construction phase is over, the drop phase commences. Hand out the eggs and get the pupils to place them into their devices. Drop each device one at a time from the designated dropping area (balcony, play equipment, wall bars etc.) after each device is dropped, check to see if the egg is broken.

Once all contraptions have been dropped you can move onto a reflective phase- as a whole group look at which contraptions were successful in the challenge and which were not. What did the successful contraptions have in common? Ask the teams if they were to do the challenge again what they would do differently?

Science Note:

This challenge looks at a combination of different science, design and engineering themes.
Once the egg is dropped the main force acting on it is gravity, which it is pulling it downwards towards the earth. However there is also a drag force acting in the opposite direction to gravity which will slow down the egg. The drag force is also called air resistance, which is effectively air pushing against a moving object. The air pushes on the object as it moves to get out of the way and let the object through. The larger an object, the more air resistance there will be as there will be more air in contact with the object, pushing on it as it falls. Therefore the larger the object the more air resistance it will have. However the larger the object the more gravity will act on it as well, the key to slowing down an object is to use a material that has a large surface area but a relatively small mass, as this will cause an increase in air resistance without overly increasing the gravity acting downwards- hence the invention of parachutes!

The other engineering principle that will work to prevent the egg from smashing is building some form of shock absorber- this is usually just in the form of padding surrounding the egg within the contraption. Some form of padding that can crumple or squash (especially if it contains air) will absorb the kinetic energy gained when the egg falls and slow the speed at which it hits the ground therefore meaning it hits the ground at less speed and with less energy and is therefore less likely to smash.

Extension activities:

Try the naked egg drop challenge- this is a variation where you drop an exposed egg into a container below that must catch the egg and keep it from breaking. Therefore the challenge is to turn the container into a suitable crash pad.

Health and Safety Note:

Place all eggs in zip-lock bags before handing them out to pupils, this will minimise the amount of mess at the end of broken eggs and therefore slip hazards. It is also more hygienic and will be safer if there are any participants with allergies to eggs. It is also recommended that an adult drops all the eggs, especially if it involves climbing some form of wall bars or a step ladder.

Egg Tower Challenge

Equipment needed:

Sticky labels	Standard A4 scrap paper
Rubber eggs	Standard A4 card
Timer	Scissors
Small Plastic Trays	Old Newspapers
Tape measure	

Before you start:

The materials needed for this activity are very simple- you could always set up a scrap paper box in the staff room/office for a few weeks before hand.

Methodology:

The objective is to make the tallest tower possible out of the provided materials that will support a rubber egg for at least ten seconds. At the end of the session, the height of the towers will be measured from the ground level to the bottom of the egg. This challenge works best when run as a competition with pupils working in small teams or individually. Each team will be given the same resources:

- 1 x plastic tray
- 10 x sheets of scrap paper
- 3 x sheets of card
- 1 x sheet of newspapers
- 1 x pair of scissors
- 1 x sheet of sticky labels (which they can cut using the scissors)
- 1 x rubber egg

It is also possible to use real eggs for this challenge; however it is obviously a lot more risky! Pupils can use the tray whatever way they want - they can stick things to it, flip it over, etc. However, they are not allowed to stick their tower to any objects such as walls or tables to help it stand up. They are also not allowed to stick the egg to their towers – it must be carefully placed at the top of their tower by at the end with everyone else. Try doing a group count down at the end of the session or having a leader board!

Science Note:

This activity encourages children to work together to achieve a common goal. Pupils can discuss their ideas, and use their prior knowledge on shapes and structures to come to conclusions about the design and construction of their tower. It allows them to test and retest their solutions, providing time for them to build upon their designs and increased knowledge base.

Other key learning points:

- Some shapes and materials are stronger than others.
- Even weak materials can be made stronger with good design techniques.
- Distribution of mass is an important consideration when building a tower.
- Mass can affect balance.
- The tallest tower is not necessarily the strongest.
- How science works – how the creative application of scientific ideas can bring about developments and changes.

Extension activities:

Try other similar construction challenges:

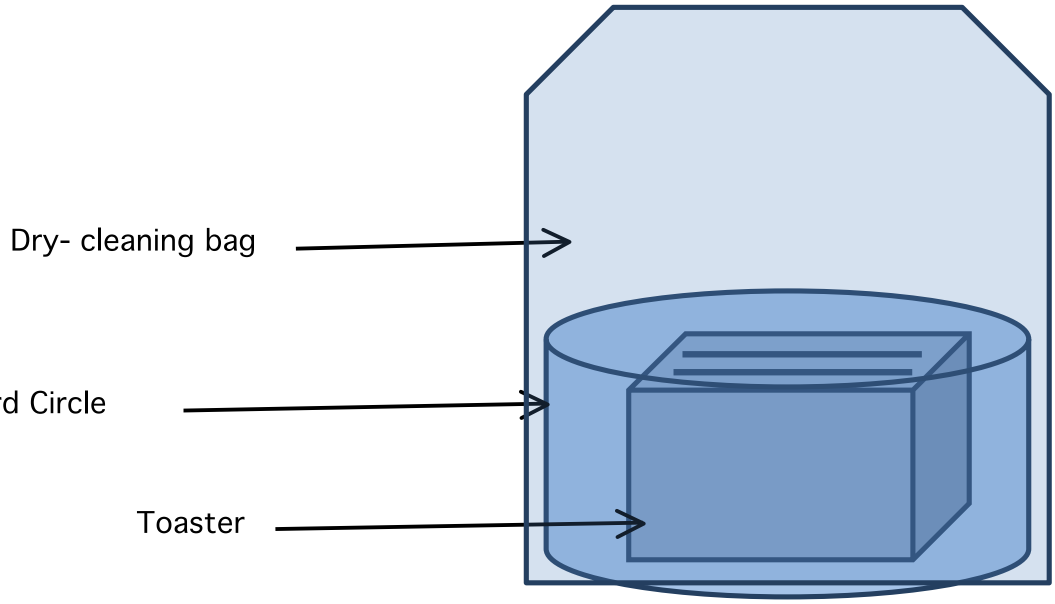
1. **The spaghetti and marshmallow challenge.** Pupils must work as a team to build the highest tower possible out of dried spaghetti and marshmallows. This investigation can cause some mess, so have cleaning materials and black bin bags available for clearing up afterwards. If you cut open bin liners you can use them as tablecloths or floor mats and this will enable you to roll up the mess ready for the bin at the end of the activity. If you don't want to use spaghetti or marshmallows you could try some of the other materials such as grapes/raisins with blunt cocktail sticks/skewers.

2. **Straws and tape.** Plastic drinking straws are cheap and easy for students to manipulate. Pupils can make a stable tower using straws positioned in right triangles. The triangles create stable building blocks to ensure the tower will not fall under its own weight.

Hot Air Balloons

Equipment needed:

Large stiff card	Sellotape
Toaster	Dry-cleaning bags
scissors	Ruler
Extension cable	Post it notes
Stopwatch	



Methodology:

1. Plug the toaster into an extension cable and tape down the extension cable so that there are no trip hazards.
2. Placing the toaster on the floor will give your balloon (dry cleaning bag) more space to fly
3. Circle the card around the toaster so that it leaves about 5 centimetres of space between the toaster and the paper.
4. Tape the edges of the card together to make an oval shape. This will protect the balloon from direct contact with the heat and prevent it melting.
5. Place the dry-cleaning bag over the toaster and on the **outside** of the card ring.
6. Hold the plastic bag up slightly so that the hot air can fill it
7. Turn on the toaster and wait.
8. Once the bag is fully inflated let it go and watch the flight.
9. The post it notes are in case the dry-cleaning bag starts to tip and spill out its hot air.

Science Note:

The toaster causes the air inside the bag to heat up. As the air heats up it also expands and takes up more room, pushing air out of the opening in the bottom of the balloon as it continues to expand. As more and more air expands and gets pushed out of the balloon, the remaining air inside the balloon becomes lighter than the surrounding air on the outside of the balloon (simply because there is less of it) this gives the balloon buoyancy (a lifting force). The balloon is able to leave the ground when the weight of air that has been pushed out of the balloon equals the weight of the balloon itself, plus the air inside the balloon.

Extension activities:

You can investigate the correlation between the size/volume of the bag in relation to the time of flight/how long it takes to fully inflate.

Health and Safety Note:

Be aware of trip hazards when using power cables- it is recommended that you tape them to the floor before you start. It also possible after extended use that the toaster could over heat. So if you plan on repeating this investigation multiple times it might be best to have multiple toasters available for use. In addition it is also recommended that you clean the toaster out of all crumbs before you use it, as it will get hot during use and the crumbs could start to burn. Also great care needs to be taken that the dry cleaning bag does not melt, so it is important that it doesn't directly touch any part of the toaster.

How salty does the sea have to be for an egg to float?

Equipment needed:

Eggs	Measuring cylinder
Rock salt	Tall glasses/jars/beakers
Spoon	Kettle
Water	Scales (optional)

Before you start:

Make up a saturated salt water solution.

Methodology:

Have two pint glasses at the front of the room, one filled with tap water, and one filled with concentrated salt solution. Pass the egg around the class so that all pupils can all see that it is in fact a real egg. Then place it first in the glass filled with tap water and then in the glass filled with salt water. Ask the pupils if they can guess why it floats in one, but not in the other. They may or may not guess that one is salt water and one is tap water.

Following on from your demonstration, challenge the pupils to investigate exactly how much salt you need to dissolve in water for an egg to float, is it a case of all or nothing? Will the egg float halfway up the glass? Does the water temperature make a difference?

Suggested procedure:

1. Take 6 glasses and label them 1-6.
2. Fill the kettle and set it to boil
3. Leave glass 1 empty
4. Put one heaped spoonful of salt in glass 2
5. Put two heaped spoonfuls of salt in glass 3
6. Put four heaped spoonfuls of salt in glass 4
7. Put eight heaped spoonfuls of salt in glass 5
8. Put sixteen heaped spoonfuls of salt in glass 6
9. If you would like to you can weigh each spoonful so that you can calibrate exactly how much salt you add to each glass.
10. Fill each glass with 500ml of water and stir so that the salt dissolves.
11. Take your egg and place it in each glass in turn and make a note of whether it floats, sinks or hovers somewhere in between.
12. Once you have a range between which it sinks, e.g. between eight-sixteen spoonfuls of salt. You can, empty out your glasses, and make up new solutions between your isolated range looking at more precise increments, until you narrowed down the amount of salt to the spoonful/gram.

Science Note:

The egg floats on salty water but not tap water due to density. Density is the mass of a material per unit volume. When you dissolve salt in water you effectively add a lot more mass to the water but without changing the volume, therefore making it a lot denser. The egg which was already quite light anyway is now a lot less dense than the water and will float on top of it.

Also make sure the eggs you give out for testing are fresh eggs- as rotten eggs float, which would confuse the results!

Extension activities:

Try experimenting with different types of salt: rock salt, table salt, kosher salt or laboratory grade sodium chloride- is one type better than the other? You could also try experimenting with different water types: tap water, bottled water, mineral water or distilled water.

Health and Safety:

Be careful of scalding when boiling the kettle, check for allergies before handing out eggs. Also glass has a tendency to crack when filled with boiling water, so use Pyrex glassware if available or add hot water slowly to glassware so that it can heat up slowly and is less likely to crack.

Iodine Clock Reaction

Equipment needed:

3 x Clear plastic cups/beakers	Soluble Starch
Vitamin C tablets	Safety Goggles
Tincture of Iodine (2%)	Measuring cylinder
Hydrogen Peroxide (3%)	Stop watch
Water	Plastic bag & rolling pin or Mortar & pestle
Stirrer/spoon	

Before you start:

This is a popular well known reaction that can be done with laboratory grade chemicals. However it can also be done with less concentrated equivalents available to buy over the pharmacy counter. Therefore in advance you will need to purchase, tincture of iodine (2%), hydrogen peroxide (3%), soluble starch and vitamin C tablets.

Cup 1
60ml of warm water & 1 x crushed Vitamin C tablet

Cup 2
60ml of warm water + 5ml of iodine + 5ml of **Cup 1** liquid

Cup 3
60ml of water + 15ml of hydrogen peroxide + 5g of starch

Methodology:

1. Crush up 1 x 1g vitamin C tablet by placing it in a plastic bag and beating it with a rolling pin or by using a pestle and mortar. Once it is a fine powder, dissolve it in 60ml of warm water in Cup 1.
2. Add 5ml (1 teaspoon) of your dissolved Vitamin C tablet water to Cup 2 and add another 60ml of warm water and 5ml (1 teaspoon) of the iodine tincture. The iodine should turn from brown to clear.
3. In Cup 3 mix 60ml of warm water with 15ml (1 tablespoon) of hydrogen peroxide and 5g of starch, stir well so that the starch dissolves.
4. Now add the contents of Cup 2 to Cup 3 and wait, it will stay clear for a few moments and then suddenly turn a dark blue.

Science Note:

There are several reactions taking place in this investigation, some of them oppose one another.

Tincture of Iodine is a mixture of Potassium Iodide (KI) in solution with Iodine (I_2), therefore it complexes and forms the triiodide ion (I_3^-) (**Cup 2**):

$$I_2 + I^- \longleftrightarrow I_3^-$$

Iodine + Iodide → Triiodide complex

When you add some of the **Cup 1** liquid to **Cup 2** the Triiodide ion (I_3^-) oxidises Vitamin C (ascorbic acid $C_6H_8O_6$) to form dehydroascorbic acid ($C_6H_6O_6$) and convert the triiodide ion (I_3^-) back to the iodide ion (I^-)

$$C_6H_8O_6 + I_3^- + H_2O \longrightarrow C_6H_6O_6 + 3I^- + 2H^+$$

When you add **Cup 2** to **Cup 3** the iodide ions (I^-) react with the hydrogen peroxide (H_2O_2) to form iodine (I_2) you then have a mixture of iodine and iodide ions once more, which will form a triiodide complex, and it is the triiodide complex which reacts with starch to give the blue colour.

$$H_2O_2 + 2I^- + \cancel{2H^+} \longrightarrow I_2 + 2H_2O$$

- I_2 = Iodine
- I^- = Iodide ion
- I_3^- = Triiodide complex
- $C_6H_8O_6$ = Ascorbic acid (Vitamin C)
- $C_6H_6O_6$ = Dehydroascorbic acid (oxidised vitamin C)
- H_2O = Water
- H^+ = a proton

The oxidisation of Vitamin C to form Iodide ions and the reaction of hydrogen peroxide with Iodide ions to form Iodine, happen in parallel with one another, and are effectively ‘competing’ over the concentration of iodine/iodide ions in solution.

The reaction will finally turn blue when all of the Vitamin C has been oxidised. Therefore in order to speed up the reaction you need a higher concentration of Hydrogen Peroxide and to slow down the reaction you need a greater concentration of Vitamin C.

Extension activities:

This reaction is called the Iodine Clock reaction, because by altering the concentrations of the reagents you can alter the amount of time the colour change takes to occur. Set your pupils the challenge of making the reaction happen in a set amount of time (e.g. one minute). Challenge them to work out which are the rate limiting steps in the reaction.

Health and Safety Note:

Both Iodine and Hydrogen peroxide at low concentration are low hazard, however you should still avoid contact with the eyes, and so safety goggles are recommended.

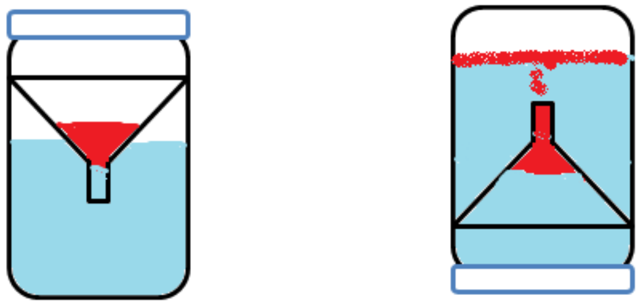
Liquid Timers

Equipment needed:

Clear plastic funnel	Clear oil: baby oil, almond, olive or vegetable
Clear plastic/glass jar with a water tight lid	Food colouring
Measuring cylinder	Pipette
Hot glue	Hole punch
scissors	Bowl

Before you start:

Source a selection of tall jars with screw lids that are water tight. The size of funnels you need will depend on the size of your jar, but they can always be trimmed down to fit.



Methodology:

1. Cut off the end of the funnel, so that it is about half of its original length. You may also need to trim down some of the rim if it is too wide to fit into the jar.
2. Using the hole punch, make holes around the rim of the funnel, as this will give the bubbles a way to pass back through.
3. Put the funnel in the top of the jar; the rim of the funnel should sit against the inside wall of the jar, and not impede the lid fitting back on. Use hot glue to secure the funnel in place.
4. Once the glue has dried, fill the jar with water so that the bottom half of the funnel is submerged.
5. In a separate bowl pour in 10ml of oil and 20 drops of food colouring and stir, until all the colouring is mixed in with the oil.
6. Slowly pour the coloured oil into the jar, so that it sits on top of the water in the funnel.
7. Screw on the lid tightly and then turn the timer upside down. The coloured oil will slowly bubble up through the funnel so that it is sitting on top of the water again.

Science Note:

Oil and water are immiscible liquids- water is a polar molecule whereas oil is hydrophobic. Essentially what this means is that the attractions between the molecules of the same liquid are greater than the force of attraction between the two different liquids. So mixing the two liquids would break up favourable interactions between the molecules of the same liquid and form unfavourable interactions between the different liquids.

Oil floats on water because it is less dense than water; it has less mass per unit volume, which makes it lighter than the water so it floats on top. When you invert the jar, the oil wants to float on top of the water, therefore it will slowly bubbles its way back up to the top, until the two have completely separated out.

Extension activities:

Challenge pupils to design and make a timer that will time an allotted period of time (e.g. 5 minutes, 10 minutes, 30 minutes). They could try different types of oil, different temperatures of water and different ratios of oil to water.

Health and Safety Note:

If using a glue-gun be careful not to burn yourself as the glue can get very hot.

Plastic Milk

Equipment needed:

Microwave	Thermometer
Masking tape	Spoons
Permanent pen	Jay cloths
White vinegar	Rubber bands
Milk	Mug or other heat-resistant cup
Glitter (optional)	Food-dye (optional)

Before you start:

You will need a microwave or some other way to heat up the milk.

Methodology:

1. Fill the cup with milk and heat it up in the microwave (you can also heat it in a pan over a stove).
2. Heat the milk until it is about 49°C
3. Add 4 teaspoons of white vinegar to the mug of hot milk and stir, the milk will now start to curdle and go lumpy.
4. Place a jay cloth over the mouth of a new clean mug and secure in place with a rubber band.
5. Pour the curdling milk over the jay cloth into the new mug.
6. The curds will collect in the cloth and the liquid will filter off into the mug
7. Gather up the jay cloth and squeeze out any remaining liquid.
8. Rinse the curds under a tap with cold water and push them together.
9. Now you can mould the curds or dye them using food colouring or add glitter if you like, as the curd dries it will harden and set (~48 hours).

Science Note:

Milk contains a protein called Casein. When you add vinegar to milk you cause the proteins to unfold and break down from their original structure, they separate out of the milk and clump together forming new long chains of molecules, called a polymer, these polymers are similar to a plastic.

Extension activities:

Try using different milks: full fat, semi skimmed, fully skimmed- which gives you the best yield of plastic? You can also try experimenting with different ratios of milk to vinegar- how does it alter the amount of yield you get?

Health and Safety Note:

Be careful when heating the milk at the start and when straining it as it will still be very hot. Use appropriate protection such as oven gloves when handling the hot containers.

Water Absorbing Beads

Equipment needed:

Water absorbing beads	Water
Measuring Cylinder	Sugar
Salt	Petri dish
Stopwatch	Measuring scoop/spoon
Jug	Clear glass/plastic bowls

Before you start:

You will need to purchase some water absorbing beads, they are readily available online. They can take about 3 hours to swell to full size so if you pre-soak some they will be ready to experiment with. NB leave some un-soaked is also good for experimenting and to show what the size difference is like before absorbing any water.

Methodology:

There are lots of different investigations you can do with water absorbing beads.

Index of refraction

1. Place some pre-expanded clear water absorbing beads in a bowl. Slowly pour some water over the top until the beads are completely covered. As the water covers the beads they will seem to disappear before your eyes!
2. Write a message on a piece of paper, and place it under a bowl of pre-expanded water absorbing beads. Slowly pour some water over the top of the beads, as the beads start to disappear the message under the bowl will become visible.

Rate of absorption

1. Get out three petri dishes; and label them, one for pure water, one for salt water and one for sugared water. Fill each with the same number of dry water absorbing beads (i.e. ones that have not been pre-soaked).
2. Make up a saturated solution of salt water and a saturated solution of sugared water. Add 50ml of each solution of water to the corresponding petri dish and start the timer.
3. You can either time for a set amount of time (~20 minutes) and then measure the average size of one of the beads. Or you can time how long it takes each of the samples to reach a particular bead diameter (e.g. 1 cm- exact bead diameters will depend on what size beads you buy!)

Other investigations

1. What is the quickest way to dry out a water absorbing bead?
2. How can you dye a water absorbing bead?
3. How do water absorbing beads react when placed on/in water containing foods?

Science Note:

Water absorbing beads are an example of a super-absorbent polyacrylamide polymer (sodium polyacrylate). A polymer is a material made from long chain-like molecules. Each granule of water storage gel is able to absorb hundreds of times its own weight in water.

When light travels from air into a glass object, some of the light reflects straight back into our eyes; however some of the light keeps passing through the object, which causes it to bend slightly. This is known as refraction. We see objects because they both reflect and refract light. When light travels from air to glass it slows down. The measure of how much the light slows down and bends as it passes through an object is known as the index of refraction and every material will have an index of refraction.

When the beads are completely hydrated they are made up mostly of water and water has the same refractive index as air, so when the beads are completely submerged in water they appear invisible.

Water absorbing beads absorb very large quantities of water, however if the water is saturated with an electrolyte, like salt you will create an equilibrium whereby the water will want to remain in the region of higher solute concentration, which will be outside of the beads.

Health and Safety Note:

Water absorbing beads are non-toxic, however as they expands so significantly when mixed with water they would be very hazardous if accidentally ingested. Therefore great care should be taken to wash all remains of the gel off your hands before eating anything. In addition water absorbing beads should **never** be disposed of down the sink as they will cause major blockages. Always place in regular refuse bins

Slime

Equipment needed:

PVA glue	Plastic bowls
Borax powder	Food colouring
Plastic spoons	Water
Wooden stirring spoons (lollipop sticks)	Disposable gloves
Safety glasses	

Before you start:

This is a messy activity, so cover the table you are using if it needs protection. Set the table so that you have all the liquids within reach. Each child/pair need a bowl and a spoon. It is really important to try making some slime just before you start to check that it is the right consistency.

You will also need to make the Borax solution up in advance. Add 3 spoonfuls of Borax powder to 300ml of warm water and stir/shake the container. Borax is not particularly soluble, so it will not all dissolve, but as long as you keep shaking/stirring the solution in between use it should work fine.

Methodology:

This activity can be done either individually or in pairs. Start by allocating a bowl and a stirrer per pair/individual.

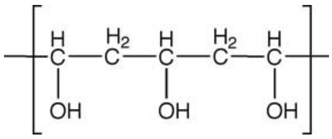
1. Put two spoonfuls of water into the bowl
2. Add two spoonfuls of PVA glue to the bowl and stir
3. Add two drops of food colouring to the bowl and stir (excessive food colouring will interfere with the slime interactions and give you an excessively sticky blob at the end that will hold no shape)
4. Shake/stir the borax solution and then add two spoonfuls of borax solution to the bowl, stir
5. The slime will now start to change consistency and clump together. Once it is all collected into a ball you can take it out and roll it around in your hands.
6. Often the slime is excessively sticky when you first handle it, but it will become a bit drier and less sticky the more it is handled. Do not worry if there is a little liquid left in the bottom of the bowl.

If your slime is excessively sticky even after being handled for a while, add a little bit of extra borax solution and re-mix. If after this it is still too sticky throw it away and create a new batch. If your slime is too dry rub a little bit of water into it- or sometimes, using PVA glue that is quite old or has dried out a bit results in this. So try making a new batch with some fresh PVA glue. The slime will dry out naturally and stiffen over time as the water evaporates, but it can be preserved a bit longer (and taken home) if stored in a little zip lock bag.

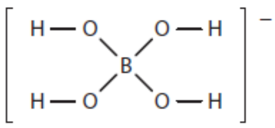
Science Note:

PVA glue contains the polymer polyvinyl alcohol, adding Borax solution (hydrated sodium tetraborate $Na_2B_4O_7.10H_{2}0$) creates crosslinks between polymer chains resulting in what is known as a non-Newtonian fluid. It is known as a dilatant material - something that reacts differently when placed under stress.

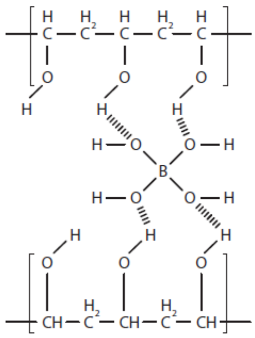
PVA glue contains the polymer polyvinyl alcohol and has the structure:



Borax (hydrated sodium tetraborate $Na_2B_4O_7.10H_{2}0$) forms the borate ion when in solution. This ion has the structure:



The borate ion can make weak bonds with the OH groups in the polymer chains so it can link the chains together as shown below. This is called cross-linking.



Images used with permission from RSC PVA polymer slime manual 2008

Extension activities:

Investigate the extent of the non-newtonian fluid properties- how it reacts when being placed under certain stresses. E.g. dropping, squashing, stretching etc.

Alter the concentration of the reactants: the methodology at the start uses a 1:1:1 ratio of borax solution: PVA glue: Water. Try changing the concentrations and look at how it affects the product.

Experiment with adding acid/alkali to your slime- acid should break down the crosslinks between the borax and PVA resulting in a liquid with lower viscosity (more fluid). Add alkali reverses the effect of the acid and will regenerate the slime back to its original state.

Health and Safety Note:

Borax is a mild irritant to the skin; therefore it is recommended that you wear gloves when handling the slime as well as eye protection. Samples of slime should not be taken home. Borax is also a potential mutagen (may cause harm to an unborn child) so it is recommended that no pregnant women take part in this activity.

Testing Water Hardness

Equipment needed:

Jam jars/cups or bottles **with lids**	Washing – up liquid
Distilled water or battery top up water (available from auto centres)	Stopwatch
Bottled mineral water	Pipette
Tap water	Measuring cylinder
Permanent marker pen	

Before you start:

Label your glass jars with a marker pen, so you can keep track of which water is inside which jar.

Methodology:

In this experiment you will be testing the hardness of three different types of water: distilled, mineral and tap water.

Hard water interferes with or reduces lathering when mixed with soap; this means harder water makes less soapy lather. Therefore it is possible to compare the hardness of different water samples by measuring how much foam is produced when mixed with detergent.

1. Label three jars with the names of the different water types they are testing
2. Fill each jar about 1/5 full with the type of water they are testing.
3. Draw a line across each jar using the permanent marker pen to mark the water height before adding the detergent.
4. Using a pipette, add 2 drops of washing up liquid
5. Screw the lids on the jars and shake each jar for the same amount of time, usually between 15-30 seconds works well.
6. When the time is up, set the jar on a flat surface and measure the distance from the initial water line you made to the top of the bubbles.
7. If your bubbles reach the top of the jar, or are over flowing, you will need to restart your experiment from the beginning and reduce either the original amount of water you placed in the jar or the number of washing up liquid drops used or the time for which the jars were shaken.
8. You can repeat these tests multiple times and take an average height for the amount of bubbles produced, and then from your results work out which water is the hardest and which is the softest.

Science Note:

Water hardness is caused when water travels through mineral deposits containing calcium and magnesium such as limestone or chalk. Some of the minerals dissolve into the water in an ionic (charged) form. The effect of these ions within the water reduces the formation of lather when mixed with soap. This is because positive cations in the water, calcium or magnesium react with sodium stearate, the main component of soap, to produce calcium stearate, which is a white precipitate commonly known as soap scum.

$$2C_{17}H_{35}COO^{-}{}_{(aq)} + Ca^{2+}{}_{(aq)} \longrightarrow (C_{17}H_{35}COO)_2Ca_{(s)}$$

Sodium Stearate + Calcium ions → Calcium Stearate

Water is a polar molecule, so when multiple water molecules line up with one another they stick together creating surface tension and this is what holds bubbles together. However the surface tension of water on its own is much too strong and rigid to form a bubble, adding detergent to the water, a hydrophobic molecule relaxes the surface tension, by interfering with the interactions between the water molecules therefore making it more elastic and stretchy allowing it to form a skin that will trap air- also known as a bubble!

However when hard water mixes with detergent, the more reactive calcium ions react with the soap and produce Calcium stearate instead, soap scum. This reaction prevents the soap from acting as a surfactant, and therefore much less bubbles are produced.

Extension activities:

Test even more types of water- rainwater, river water, water samples from different sides of the country. Test different types of detergents- some modern day detergents are specially formulated to have lathering agents in, so they will produce bubbles regardless of the water type.

Health and safety note:

Be careful when shaking different detergent samples especially if you are shaking the jar anywhere near your face- consider wearing eye protection.