



Physics Tricks



Physics Tricks

This section describes recipes for 20 physics-based tricks. It is aimed at providing a resource for IoP members to use when trying to engage non-physicists with the subject.

Selection Criteria

The 20 tricks included here have been tried and tested and chosen according to specific criteria:

- The trick ingredients are familiar to most audiences and commonly available, as well as relatively inexpensive.
- Reliability and simplicity of operation are key features.
- Very little construction or pre-preparation is necessary.
- The chosen tricks cover a range of audience ages and sizes, as well as potential venues (e.g. indoors or outside; different types of 'generic' venues such as pubs, supermarkets etc.).
- A range of physical principles is covered by the selected tricks.

Further Resources

Those members interested in obtaining further information may find the following resources useful:

- The Little Book of Experiments by Planet Science
www.planet-science.com/sciteach/index.html?page=/experiment/
- SciZmic – the Science Discovery Clubs network www.scizmic.net
- The Exploratorium www.exploratorium.edu
- British Interactive Group www.big.uk.com
- Professor Shakhashiri scifun.chem.wisc.edu
- Steve Spangler Science www.stevespanglerscience.com/experiments
- Planet Science's Wired Science Magic Box
www.scienceyear.com/wired/index.html?page=/wired/magicbox
- The Surfing Scientist by the Australian Broadcasting Corporation
www.schoolscience.co.uk/teachers/chemclub/index.html
- Krampf Experiment of the Week www.krampf.com/news.html

There are plenty more demonstrations available, and we would encourage IoP members to develop their own personalised tricks to demonstrate their particular area of interest.

Physics Busking

The tricks included in this Pack will all work well with public audiences of various sorts. However, a little thought about the order of the tricks, and careful selection of which ones are most appropriate to your venue, will maximize the success of your event. One possible running order for 'physics busking' – attracting a crowd in a public venue using physics tricks – is outlined below for guidance. Of course this list is not prescriptive: adapt your own shows to reflect your venue, audience, and personal preferences.

Possible Running Order

1. Balloon Kebabs
2. Straw Oboes
3. Potato Straw
4. Lifting Lemon
5. Water-Proof Hanky
6. Alka-Seltzer Rocket

Start with an attention-seeking demonstration – something visual or noisy usually works best. Targeting children first (using a demonstration that particularly appeals to them, such as balloon kebabs) is a very effective way of attracting an audience. The adults will drift along after the children to see what is happening.

Once you have a few people gathered, try to involve them. Walk amongst your audience and invite them to try some tricks. Straw Oboes and the Potato Straw are good for this. Again, these tricks are highly visual/noisy so will assist in attracting a crowd.

You should now have an audience – who are probably wondering what strange and interesting things are going to happen next. You can now begin to perform demonstrations that require a table top (and their attention), e.g. the Lifting Lemon.

Remember that your audience is likely to consist of very different age groups and backgrounds. So try to arrange the order of the tricks to cater for both adults and children. For example, the Lifting Lemon demonstration is fairly complex – and often debated by adults! Hence the next trick needs to be very visual and simple to operate – such as the Water-Proof Hanky. The entertainment aspect of this trick also keeps the audience's interest and maintains enthusiasm within the show.

Finishing the show with a bang – literally! – will impress your audience and give them something to remember. You also want to use a trick that appeals to all age groups. The Alka-Seltzer rocket is the perfect finale in this respect.

In a public venue you will most likely have a rolling audience, with people dropping in and out throughout the show. So keep the show short, fun and entertaining, and immediately start again from the beginning to keep the enthusiasm and audience interest alive.

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1. Alka-Seltzer Rocket

An oldie but a goodie – guaranteed to impress audiences of all ages. Turn simple familiar household ingredients into an awesome rocket!

Ingredients

- empty film cannister
- Alka-Seltzer tablet
- water

Instructions

1. Place the Alka-Seltzer tablet in the film cannister.
2. Add ~1cm of water.
3. Fit the lid on the cannister, making sure the seal is tight.
4. Turn the cannister upside-down and place it on a flat surface. Stand back!

How does it work?

When water is added to the Alka-Seltzer tablet, bubbles of carbon dioxide gas are given off. When the lid is fitted tightly to the cannister this gas is contained within an enclosed space. As more gas is given off the pressure inside the cannister rises until there is enough force to overcome the seal of the lid. The built up pressure exerts enough force to shoot the cannister into the air, forming the rocket.

Tips for Success

Make sure the film cannister lid is tightly fitting or you will only get a disappointing 'fizz'. You should also clean the cannister lip and lid between demonstrations so that no pieces of Alka-Seltzer get stuck between them, ruining the seal.

Serving Suggestions

This is a good demonstration for attracting people from far away as they can see and hear the rocket in action.

It can be fairly messy so is either most suited to outside environments OR locations that are easily cleaned! It works with audiences of all ages.

Did You Know?

The Chinese began building chemically powered rockets as long ago as the 1150's. One of the great pioneers of modern rocketry, N. I. Kibaltchich was executed in 1881 after manufacturing the bomb that was used to assassinate Tsar Alexander II.

2. Water-Proof Hanky

A great excuse to threaten to pour water over your audience – but with a surprise twist thanks to physics.

Ingredients

- large glass
- ashtray or similar
- water
- handkerchief

Instructions

1. Push the centre of the handkerchief into the glass, so that the edges are hanging over the outside of the rim of the glass.
2. Pour water into the glass, through the loose handkerchief. Make sure that your audience can see the water easily passing through the handkerchief into the glass. Keep pouring the water until the glass is roughly half full.
3. Pull the corners of the handkerchief so that the material is taut over the top of the glass. Hold the glass and handkerchief so that the material stays tightly stretched over the opening. For younger audiences you may like to say some 'magic words' that make the hanky water proof.
4. Place the ashtray on the top of the glass and tip it all upside down, being careful to keep the handkerchief pulled tight.
5. Choose a likely suspect from your audience to threaten with a drenching! Hold the upside-down glass and ashtray above their head, making sure that the glass is vertical and the handkerchief is tight. Remove the ashtray and voila! – nothing happens! The water stays inside the glass.

How does it work?

This demonstration is based on surface tension and air pressure. When the handkerchief is loose, the water can pour through the gaps in the fabric. However, when the handkerchief is pulled tight, the water molecules can form a single surface or membrane across the handkerchief due to a property called surface tension. The air surrounding us is exerting a force in all directions - air pressure. When the membrane is formed on the surface of the handkerchief, it provides a uniform surface for the air pressure to act upon. The force of the surrounding air acting upon this membrane is sufficient to overcome gravity, and so the water stays in the glass.

Tips for Success

Don't try to substitute a paper tissue for the handkerchief as it won't work!

If the glass isn't held vertically, some water may dribble out where the membrane attaches to the edge of the glass.

Serving Suggestions

This trick will work in almost any environment and with any age group.

Did You Know?

Galileo was among the earliest to demonstrate the existence of surface tension on water by showing that an iron needle can be floated lengthways on water, but not on it's point.

3. Straw Oboes

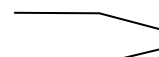
A noisy, amusing demonstration of the physics of music. It can take a bit of practice to get exactly right, but it's well worth the effort.

Ingredients

- straws (need to be straight – cut off the bendy bits if there are any)
- scissors

Instructions

1. Flatten one end of the straw ~2cm from the end to the tip.
2. Make two cuts in the now flattened end of the straw, to form a triangular tip.
3. Insert the triangular tip of the straw into your mouth and blow hard. You should hear a loud 'buzzing' sound.
4. While blowing on the straw oboe, get a volunteer to cut the straw shorter, ~1cm at a time. With each cut you will hear the pitch of the oboe sound go up.



The tip of the straw oboe

How does it work?

The flattened triangular tip acts like the reed found in most wind instruments. Blowing on the reed causes the straw to vibrate. A standing wave pattern is created along the length of the straw, which we hear as sound. As you shorten the straw you shorten the wavelength of the standing wave pattern and therefore increase the pitch of the note.

Tips for Success

It can take some practice to get the right sound – if it doesn't work straight away then slowly move the straw in and out of your mouth whilst still blowing until you hear the sound. Definitely a good demonstration to practice before performing it in front of an audience!

Serving Suggestions

This is a good demonstration to attract a crowd due to the amount of noise involved. Younger kids in particular will love hearing the effect of the pitch going up as the straw is cut shorter and shorter. They will also enjoy making their own straw oboe as part of the demonstration, which they can keep afterwards.

Did You Know?

As long ago as the fifth century BC Pythagoras and his followers were experimenting with standing waves and calculating the values of their harmonics. Another way to set up a standing wave is to blow across the top of a beer bottle. In this case the note gets deeper as you drink the beer (sorry, tune the instrument). Pythagoras refused to let his followers eat beans for fear of flatulence; fortunately, no such effects are associated with beer drinking.

4. Cloud In A Bottle

Now-you-see-it, now-you-don't! This is a good trick for people to try themselves, watching a cloud appear and disappear before their own eyes.

Ingredients

- plastic bottle with cap (fairly flexible e.g. from most soft drinks)
- water
- match

Instructions

1. Place a splash (~1 teaspoon) of water into the plastic bottle.
2. Light the match and make sure it is burning well, then drop it into the bottle.
3. Quickly screw the cap on, and squeeze the bottle with your hand five or six times (for larger bottles you may have to do it slightly more). You should see a cloud form in the bottle, then magically disappear when you squeeze it.
4. Pass the bottle around the audience to give everyone a chance to experience it for themselves.

How does it work?

Clouds are formed when water droplets in the air cool and then collect on dust particles. In this demonstration, the dust particles were provided by the smoke from the match. The air inside the bottle was cooled by releasing the pressure after the bottle was squeezed. The temperature is changed by squeezing the bottle: the amount of air within the bottle is constant, but squeezing the plastic bottle changes the volume of the gas. Expanding the bottle causes a lowering of the air temperature – in this case, enough to cause the water gas to form a liquid – the cloud.

Tips for Success

Try adding a small amount of food colouring to the water – it can help to increase the visibility of the effect.

Serving Suggestions

This works well for small groups of people of all ages. It is particularly applicable in outside environments where you can actually see clouds and potentially discuss the science behind them.

Did You Know?

This demonstration involves building a small cloud chamber exactly like those used to first record the tracks of subatomic particles (alpha and beta radiation) by Charles Wilson in 1911. Wilson (who was born on St Valentine's Day) was awarded the Nobel Prize in 1927 for this discovery.

5. Lifting Lemon

Levitate a slice of lemon using a few simple ingredients found in any pub.

Ingredients

- slice of lemon
- four matches
- pint glass
- ashtray
- water

Instructions

1. Pour water into the ashtray until the water is ~1cm deep.
2. Push three matchsticks into the slice of lemon, in the shape of a triangular pyramid, with the match heads together at the top point of the pyramid.
3. Place the lemon and matchsticks in the centre of the ashtray, so that they float on the water.
4. Light the fourth match and use it to light the other three together.
5. Invert the pint glass over the lemon and matches, letting it sit inside the ashtray.
6. Watch as the lemon slice magically levitates within the pint glass!

How does it work?

The simplicity of this trick belies the complexity of the physical processes that contribute to the effect...

Firstly, there is a simple air pressure effect caused by the expansion and contraction of the gas within the pint glass as it heats up and cools down. The heat from the three matches causes the air inside the pint glass to get hot. When all the oxygen within the glass is exhausted, the matches go out and the air inside the glass cools down. The cooler air takes up much less space, so water gets sucked up into the glass to take up that extra volume.

Secondly, the combustion reaction changes the species present, thereby changing the volume of gas within the glass. When the matches burn they consume the oxygen from the air within the pint glass. The products of this reaction are carbon dioxide and water. The water will be a liquid, thus there will be less gas in the glass, causing the water to be sucked up into the glass to fill the volume.

Tips for Success

The lemon slice needs to be thick enough to support the matches, yet still able to float on the water.

Serving Suggestions

This trick was first developed for use in pubs, and draws on ingredients commonly found in most pubs. However, there's no reason not to use it in other environments also. It is most suitable for demonstrating to small groups of onlookers – it won't attract a crowd by itself, but will maintain the interest of audiences that you are already engaged with.

Did You Know?

This demo is based on the methodology used by Joseph Priestley to demonstrate that Oxygen is a component of atmospheric air, and to estimate the proportion of Oxygen in the air.

6. The Power Of Words

This demonstration challenges common preconceptions about forces, and demonstrates the strength of atmospheric pressure.

Ingredients

- table with flat edge
- ruler
- newspaper

Instructions

1. Lay the ruler over the edge of the table so that $\sim 1/3$ of it's length is over the edge.
2. Ask your audience what will happen if you hit the ruler from above.
3. Hit the ruler – as expected it flips off the table.
4. Ask your audience how you might possibly keep the ruler on the table while you hit it, using only newspaper. Hopefully someone will guess that you need to exert an opposing force on the far end of the ruler – you may need to prompt them.
5. Tell your audience that you can only use a sheet of newspaper. Try first by folding up a sheet of newspaper as small as possible and placing it at the back end of the ruler so that it acts as a counterweight. Get an audience member to hit the ruler again – still it flips off the table, this time along with the folded up newspaper!
6. Ask your audience how else you might be able to use a sheet of newspaper to hold the ruler down. If your audience guess the trick, ask them to explain the physics behind the idea. Lay a single sheet of newspaper flat on the table so that the ruler is roughly in the center. When you hit the ruler it will stay on the table!

How does it work?

It all comes down to air pressure. Atmospheric pressure is exerting a downward force on the single sheet of newspaper. The area of a single sheet of newspaper is fairly large, therefore the downward force of the atmospheric pressure exerted on the newspaper is strong enough to counter the upward force of hitting the ruler. It didn't work with the folded-up newspaper because the surface area over which the atmospheric pressure could act was far too small.

Tips for Success

For optimal effect, make sure as little air as possible is under the newspaper by smoothing it out flat prior to hitting the ruler.

Serving Suggestions

This works well with audiences of all ages, but does require a sturdy table or bench, so is best suited for performing when an audience has already been gathered.

Did You Know?

During the scientific revolution it was common to think of air pressure in terms of the total weight of a column of air pressing down on a unit area. In 1643 Evangelista Torricelli, a pupil of Galileo, inverted a mercury filled glass tube, sealed at one end, into a basin also containing mercury. He found that the weight of air over the basin was sufficient to support a column of mercury to a height of 76 cm. This invention is the basis of using 'millimetres of mercury' as a unit of air pressure.

7. Potato Straw

A good visual demonstration to question our intuition regarding forces.

Ingredients

- straws (need to be straight – cut off the bendy bits if there are any)
- large baking potatoes

Instructions

1. Challenge members of your audience to see who can insert a straw the furthest into a potato. To increase the excitement you may want to line up a row of volunteers, each with a straw and potato, and run the demo as a race.
2. Give them a while to try the challenge – they will almost certainly twist the straws slowly into the flesh of the potato. When their straws are bent and not going in any further, show them how to do it:
 - i. Hold the potato between thumb and fingers (note: do NOT have your hand behind the potato!).
 - ii. Grasp the straw firmly about 2/3 of the way up (so you have plenty of straw to go into the potato).
 - iii. Use a sharp thrusting movement to force the straw through. Be confident – it really will go!

How does it work?

There are two principles contributing to this trick:

- 1) The sharp thrusting movement delivers a much larger instantaneous force than the slow gradual twisting motion, thereby allowing the straw to get further.
- 2) The end of the straw has a very small surface area, so the force you impart is concentrated very strongly. If you tried to do the trick with a pencil roughly the same size as the straw you would find it much more difficult – you would need to displace a much greater area of potato, which would require a much greater force.

Tips for Success

The straws need to be straight, with no defects. Don't try to re-use the same straw. Have confidence that the straw will go through – you don't have to be particularly strong to make this trick work, but you do have to be aggressive. Practice this one in advance so that you gain confidence and believe it will work!

If you still have difficulty getting the straw very far into the potato, try changing your grip – some people find that holding the straw with their thumb over the other end works best, while others like to pinch the straw part way down.

Serving Suggestions

This demonstration works best when run as a competition between different members of your audience, especially for teenagers. Regardless of their age, many members of your audience won't believe this trick, even after they've witnessed it with their own eyes! It would be worthwhile having a good supply of straws and potatoes available so that everyone can have a try for themselves.

Did You Know?

This effect (the concentration of force into a small area) can be seen quite frequently in everyday life, from vinyl floors damaged by stiletto heels to its inverse, extra wide tyres on tractors and wheel barrows.

8. Erupting Fizz

A great visual demonstration of density effects.

Ingredients

- pint glass
- lager or other fizzy drink
- vegetable oil
- food colouring
- Alka-Seltzer tablet
- salt
- stirrer

Instructions

1. Drink some of the lager (or other fizzy drink) so that the pint glass is roughly half full.
2. Pour vegetable oil into the pint glass so that the glass is roughly 2/3 full in total. Point out to your audience that the oil and water (lager) don't mix.
3. Add a few drops of food colouring and stir the mixture – again highlighting that the food colouring only affects the water-based liquid (although you should see some interesting effects of tiny food colouring drops as they move through the oil mixture). Wait until the two layers have clearly separated.
4. Add approximately 2 tablespoons of salt to the liquid in one go – a great foam eruption occurs! Observe the liquids after the eruption has settled down – you should be able to see a lava-lamp style bubble effect.
5. Add an Alka-Seltzer tablet to the liquid – you should see some interesting bubbling effects from the gas given off by the Alka-Seltzer, and the change in the speed of those bubbles as they travel through water versus oil. You can prolong the effect by breaking the Alka-Seltzer tablet into smaller pieces and getting members of the audience to add the pieces individually.

How does it work?

Water and oil do not mix; they are called immiscible liquids. Lager or other fizzy drinks are mainly made of water, so they will not mix with oil either. Water is more dense than oil therefore all the water will sink to the bottom of the glass, leaving a separate layer of oil on top. Food colouring is a water-based substance therefore it will only mix with the water layer, leaving the oil layer in the original colour. Sometimes small droplets of pure food colouring will get stuck in the oil layer, creating highly visible blobs, but they will not colour the oil layer.

Adding salt to a fizzy drink causes a release of large quantities of the carbon dioxide trapped within the drink, creating the highly visible eruption. After the initial reaction has slowed down you should be able to see salt crystals at the bottom of the glass – salt is more dense than water so sinks to the bottom. Pouring the salt into the liquid in one go also causes some oil (stuck around the salt crystals) to be dragged down into the water layer. As the salt dissolves in the water the oil is released, which rises back through the water layer, creating the lava lamp effect. Some air may also be trapped with the salt, which will also travel up through both layers of liquid.

When Alka-Seltzer is placed into water it starts fizzing, giving off bubbles of carbon dioxide. This effect is greatly magnified if you place the whole Alka-Seltzer tablet in a drink that is already fizzy, since the drink will also give off bubbles of carbon dioxide.

If you use smaller pieces of Alka-Seltzer, it should be possible to see individual bubbles of carbon dioxide being given off by the Alka-Seltzer tablet. These bubbles are much less dense than either the water or the oil, so they travel upwards through the liquid layers. Since oil is much more viscous than water, the bubbles will travel through the layers at different rates. You may also be able to see small coloured bubbles passing through the oil layer – those occur when some of the coloured water has got trapped inside an air bubble. When those coloured bubbles get to the top and the air is released, the coloured water will sink back down again through the oil layer.

Tips for Success

This trick can keep working for quite a while – just add more Alka-Seltzer. You won't see the big fizzy eruption once the drink loses its fizz, but the bubble effect is still very clear. The salt will tend to supersaturate the drink solution after a while, making it go cloudy and reducing the effect of the trick.

Make sure your fizzy drink isn't too dark in colour or you won't be able to see the bubbles passing through the liquid.

Serving Suggestions

This is another great trick for pub environments, where most of the ingredients lay readily to hand. However, it is easily transferable to other environments and age groups. For younger audiences, substitute the beer for any other fizzy drink – a light coloured one will absorb the food colouring best.

Did You Know?

The similarity between this trick and that classic of retro chic the lava lamp is obvious to anyone who sees it. However, while this trick relies on the movement of liquids of different density for its effect the lava lamp achieves this by heating wax which is less dense than water when warm and molten, but denser than water when cold.

9. Magical Match

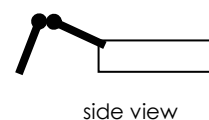
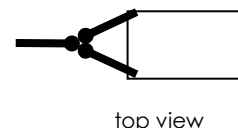
A very visual physics-related magic trick to wow your audience.

Ingredients

- matchboxes (one empty)
- matches

Instructions

1. Lie the empty matchbox flat on the table, slightly open, with the empty section facing upwards.
2. Insert two matches into the empty matchbox so that the heads point out from the matchbox. Close the matchbox as much as possible so that the two matches are securely held.
3. Angle the two matches so that the heads are touching.
4. Rest a third match so that the head meets the other two, and the tail is resting on the table, pointing away from the empty matchbox. The three matches should now form a triangular pyramid shape with the three heads at the top point of the pyramid.
5. Use a fourth match to light the others from underneath.
6. Watch as the third match 'magically' rises off the table!



How does it work?

When the three match heads ignite they fuse together. In the case of the third match, the top and bottom surfaces of the match burn at different rates, causing a gradient in the surface temperature and tension across the match. The differing tensions across the third match cause an upward force to be exerted upon it. The two original matches are fixed in place, therefore the three match heads form a pivot point, from which the third match 'magically' rises.

Tips for Success

For the greatest amount of lift make sure that the matches are placed as symmetrically and as securely as possible.

Serving Suggestions

This is a good demonstration to perform for small groups, i.e. once you have attracted a small crowd.

Did You Know?

The same effect can be seen in many domestic thermostats. It can be amplified by attaching two strips of material together with different rates of expansion (a bi-metallic strip). As the temperature rises, the greater expansion on one side of the strips causes it to curve further and further. This can be incorporated into a switch that will connect and cut off a heating apparatus when a particular temperature has been reached.

10. Amazing Marshmallows

The effects of air pressure are investigated in this highly visual demonstration.

Ingredients

- marshmallows (+ cornflour, depending on the type of marshmallows you use)
- wine bottle (must be clean and dry, and preferably light coloured)
- vacuum wine saver pump and stopper (available from most supermarkets)

Instructions

1. Roll the marshmallows gently between your hands until they are small enough to pass through the opening of the wine bottle. Note: if the marshmallows become at all sticky then roll them in cornflour, otherwise they will just stick to the sides of the bottle and make a big mess.
2. Insert the vacuum stopper into the neck of the wine bottle. Explain to the audience that the vacuum pump removes air from the bottle. Instruct them to carefully watch the marshmallows.
3. Pump the vacuum pump a few times – the marshmallows inside the bottle begin to expand. Shake the bottle gently up and down to distribute the marshmallows throughout the bottle, then pump again. Repeat until the marshmallows are no longer expanding. Discuss with your audience.
4. Tell your audience that you are going to let the air back into the bottle. Remind them to watch the marshmallows closely as you do so.
5. Release the valve on the vacuum stopper – the marshmallows will rapidly shrink back to their normal size.

How does it work?

Marshmallows have small bubbles of air trapped inside them. These bubbles are at atmospheric pressure. When the air inside the glass container is sucked out, the volume of the container remains the same although there is much less air inside – so the pressure is reduced. The air bubbles inside the marshmallows are therefore at a much higher pressure than the air surrounding the marshmallows, so those bubbles push outwards, causing the marshmallows to expand. When air is let back into the glass container, the surrounding pressure increases again, and the marshmallows deflate back to their normal size.

Tips for Success

Don't try to re-use the same marshmallows too much or they'll stretch and stop working properly. Long thin marshmallows work best because they are less sticky than the traditional sort, so easier to insert into the wine bottle.

If you have access to a vacuum pump and bell jar, this trick works beautifully. Try using matchsticks to make marshmallow shapes – e.g. animals or a person – which the audience can see grow and shrink as you decrease and increase the pressure.

Serving Suggestions

This demonstration will impress audiences of all ages. It is most suitable when you have already gathered a small audience.

Did You Know?

Although aircraft cabins are pressurised, they are not kept at sea level pressure. A similar effect to the marshmallow experiment can be observed by drinking half a bottle of water during a flight. When the aircraft lands you will see that the sealed plastic bottle is slightly crushed by the higher atmospheric pressure at about the same time as your ears pop on the approach to landing.

11. Cartesian Diver

Density and pressure effects are explored using a simple visual demonstration.

Ingredients

- large plastic bottle (~2L) with lid, filled with water
- glass filled with water (for testing the 'diver')
- straw
- BluTack
- scissors

Instructions

1. Cut the straw to ~4cm in length.
2. Use small blobs of BluTack to seal each end of the straw.
3. Check that the sealed straw just floats in the glass of water. It should slowly rise to the top of the water after you drop it in. If it sinks, remove some of the BluTack. If it floats too easily add some more BluTack.
4. Drop the straw 'diver' into the bottle.
5. Fill the bottle with water from the glass if necessary.
6. Screw the cap on the bottle.
7. Squeeze the sides of the bottle (fairly firmly). The straw diver will sink through the water. Let go of the bottle and the diver will float back up to the top.

How does it work?

The straw diver contains an air bubble sealed inside. The combined density of the straw, air and BluTack is slightly lower than that of the water, so it floats. When you squeeze the sides of the bottle you increase the pressure pushing on the air bubble, making it compress into a smaller space. This decrease in volume causes the air bubble to increase in density. Therefore the overall density of the straw diver will now be greater than that of the surrounding water, making it sink. Releasing the pressure (by stopping squeezing the bottle) allows the air bubble to expand back to its normal size, and so the straw diver will float again.

Tips for Success

Don't be scared about pushing hard on the sides of the bottle – they can take a lot of force. It may be easier to rest the bottle on a flat surface and then use both hands to push the sides.

If your diver keeps floating then take it out and add more BluTack, making sure to test it in the glass of water to be sure that it doesn't immediately sink – you'll find it easier to get it out of the glass than out of the bottle if it does sink!

Serving Suggestions

This is a good visual demonstration when you have a small crowd. However it works best if everyone can have a try for themselves, so it's not recommended for large crowds.

Did You Know?

Sperm whales regularly dive to depths of at least 1000m where the water pressure is on the order of 100 atmospheres. In the process, the rib cage will fold and collapse and the lungs will compress down to one per cent of their size at the surface. The associated change in buoyancy is essential to keep the animal at such a great depth.

12. Balloon Kebabs

This is a good visual challenge that requires a bit of lateral thinking.

Ingredients

- balloons
- wooden kebab skewers

Instructions

1. Blow up the balloons (not full) and tie them off.
2. Challenge your audience to make a 'balloon kebab' – to insert the wooden skewer all the way through the balloon without popping it. Let a few people have a try – they will invariably try to insert the skewer fairly slowly through the side, and the balloon will pop.
3. Show them how physics can make the trick work:
 - i. Start by lining up the skewer point with the darker patch on the balloon, opposite the tie end. Gently push the skewer through. You may find that a twisting motion works best.
 - ii. Once the skewer is through one side, push it gently through the balloon until the point of the skewer is at the opposite end – the darker area around the tie.
 - iii. Insert the skewer tip gently through the soft part of the balloon where the tie is – again use the twisting motion if it helps. Voila! – you have made a balloon kebab!

How does it work?

This trick works through an understanding of surface properties. A balloon is formed by inserting air into a flexible thin rubber sheet. Most of the balloon is stretched evenly, but there are two points where the rubber is least stretched – and thus there is the lowest surface tension. These correspond to the tied section and the darker patch at the opposite side of the balloon – in fact the darker colour indicates that the balloon is less stretched over that region. Most of the balloon is under high tension, so attempting to push the skewer through just makes the balloon pop. But at the low tension sections it is possible to make a small hole without breaking the overall surface of the balloon.

Tips for Success

This trick works best with round balloons (rather than long skinny ones) – mainly so that the kebab skewers can fit! Don't blow up the balloon too much or it will pop even if you do it correctly.

Make sure the skewer ends are fairly sharp – blunt skewers are more likely to pop the balloon.

You may find that your balloons sometimes burst even if you follow the instructions. The audience will enjoy the entertainment so just laugh it off and try again!

Serving Suggestions

Balloons are very visual, so this is a good trick to take around your chosen venue and challenge bystanders to get involved. The noise from popping balloons will also attract attention. You can get a few people to attempt the challenge, then gather them all together to show them the successful method – and point them in the direction of other tricks and demonstrations that are occurring.

For adult audiences try substituting the balloon for a condom – although be careful how much you blow it up or the skewer won't be able to reach through both sides!

13. Lager Lamp

Traditional retro lava lamps are familiar to most people, but try this updated version in your local pub.

Ingredients

- pint of lager (or other fizzy drink)
- nuts (a small handful)
- pint glass
- spoon or other stirrer

Instructions

1. Drink some of the beer so that the glass is approximately 3/4 full.
2. Leave the beer for approximately half an hour to reduce the amount of bubbles – it may also be useful to stir the lager a few times.
3. Tip in the nuts.
4. Watch as the nuts gradually float up to the surface of the liquid, then fall back down again, just like a traditional lava lamp.

How does it work?

This effect relies on the gas contained within the fizzy drink. The nuts at the bottom of the drink have imperfect surfaces, where small pockets of air will form. The longer they stay still, the larger the bubbles of air that will accumulate. Eventually the bubbles will be large enough to provide enough buoyancy to counter the weight of the nuts, thereby lifting them off the bottom of the glass. When they get to the top, the bubbles burst, removing the buoyancy from the nuts, causing them to fall back to the bottom of the glass.

Tips for Success

This trick works best if the lager (or other fizzy drink) doesn't have TOO much gas in it. If the nuts all float on the top then there is too much gas. Conversely, if the drink is too flat then they will mostly stay on the bottom – a great excuse to have another beer...

Serving Suggestions

Another pub-oriented trick, but one that will transfer to other venues very easily. If your audience are too young to use beer then substitute any other fizzy drink – light coloured ones are best, so that the audience can see the nuts moving within the liquid. This is a good demonstration to leave on the side for a while, and let your audience notice it while you're performing some of the other demonstrations.

Did You Know?

This demo has been in use for several centuries and was very popular at Versailles where a single raisin would be dropped into a flute of champagne and would then bob up and down all afternoon.

14. Shrinking Coin

This trick requires the audience to think very much "outside the box". Most people simply won't believe it can be done – but with some 3D thinking it's easy!

Ingredients

- 1x 1p coin
- 1x 2p coin
- piece of paper (approx 10cm x 10cm)
- pencil
- scissors

Instructions

1. Lay the 1p coin in the centre of the piece of paper. Trace around it using the pencil.
2. Cut out the centre of the circle so that you are left with a piece of paper with a hole in the centre.
3. Demonstrate that the 1p coin slips easily through the hole.
4. Challenge your audience to get the 2p coin through the 1p-sized hole – WITHOUT ripping the paper or altering it in any way. Give them some time to try (multiple coins & paper to distribute amongst your audience can help at this stage).
5. Show them how it can "really" be done:
 - i. Take the piece of paper and bend it in half. Hold the paper so that the bend is at the bottom. Drop the 2p coin between the sides of the paper into the centre of the hole.
 - ii. Grasp the paper between finger and thumb near the bend, on either side of the coin. Slide your fingers upwards around the coin. Allow the paper to buckle outwards in the dimension perpendicular to the coin.
 - iii. The coin should slip through the hole!

How does it work?

This is all to do with non-Euclidean geometry. The small 2D hole may be stretched in the third dimension to produce a slit that is large enough to allow the larger coin through.

Tips for Success

Don't use the same piece of paper too often or it will develop permanent folds in it, which can cause the coin to get stuck AND help your audience guess the solution to the trick!

Serving Suggestions

This is a good hands-on activity for younger audiences, where they can all have a go at cutting out the hole and trying the trick. However, older audiences also won't believe that it's possible. A good trick to use once you have already formed an audience.

Did You Know?

One of the more intellectually difficult aspects of string theory for the lay person is the concept of folded dimensions. If you are feeling brave, you might want to use this trick as a way to demonstrate how multiple dimensions can be folded into tiny spaces.

15. Extra Bounce

Most people are familiar with physics experiments performed with balls of different sizes. But this demonstration questions our intuitive understanding of the forces at work.

Ingredients

- large ball that bounces (e.g. football or basketball)
- small ball that bounces (approx 10cm in diameter)

Instructions

1. Hold out your hand at shoulder height. Ask your audience to imagine a scale from 0 to 10, with 0 being the ground and 10 being the height of your hand.
2. Pick up the large ball and hold it out at shoulder height. Tell your audience that you are going to drop the ball, and that they should judge (on the imaginary scale) how high it bounces.
3. Drop the ball and ask the audience how high it went (get a rough value).
4. Pick up the small ball and repeat the demonstration.
5. Hold the small ball on top of the large ball at shoulder height and ask the audience what they think will happen to each of the balls if they are dropped.
6. Drop the balls. The small one will shoot off much higher than the sum of the original bounces put together. Repeat the demonstration, asking the audience to closely watch the larger ball. You will see that it hardly bounces at all.

How does it work?

This experiment is all about conservation of energy and momentum. When the balls are dropped together most of the momentum from BOTH balls is transferred to the small ball. Both the kinetic energy and the momentum of any moving object depend on its mass. If the smaller ball receives all the kinetic energy and momentum from the larger ball it will bounce much higher than the original larger ball because it is so much lighter. Add to that the original energy and momentum in the smaller ball and you get a bounce that is much greater than the sum of the two original bounces.

There are also complications due to the materials used to make the balls ('bouncy' balls go wild!). This experiment can also be used as a good demonstration of Chaos effects – small changes in the initial conditions (e.g. exactly how the two balls are held above one another) can cause large differences in the end result.

Tips for Success

For indoor spaces use a small ball that isn't too bouncy or it will go crazy and could potentially do damage. You could try using a long ruler to help the audience judge how high the balls bounce (some audiences have difficulty with that part and don't get so involved).

Serving Suggestions

This is a good visual trick that can draw in audiences – especially in outside venues. In outdoor venues it can be a lot of fun to use a bouncy ball as the smaller ball – although you may have to chase after it quite a bit!

16. The Swing Thing

This is a good demonstration of the influence light has on our perception and three-dimensional vision.

Ingredients

- string (approx 1m long)
- 2x 2p coins
- BluTack
- old pair of dark sunglasses

Instructions

1. Use the BluTack to stick together the 2p coins to make a weight. Tie the string to the weight – you now have a pendulum.
2. Ask an audience member to watch the pendulum. Get them to stand ~2m away from you, and swing the pendulum so that it is perpendicular to the line between them and you. Ask them what direction the pendulum is swinging in.
3. Break the sunglasses in half at the nose so that the two lenses are separate. Get your volunteer to hold one lens in front of one eye. Note: they need to keep both eyes open! Swing the pendulum again, exactly as before. Ask them again what direction the pendulum is swinging in (they will see it going in a circle).
4. Get the volunteer to hold the lens in front of the other eye – they will see the pendulum going in a circle in the opposite direction to the previous one.

How does it work?

Sunglasses block some of the light travelling towards them, so that when you wear a pair of sunglasses, less light actually reaches your eye. This makes your eye more sensitive to light. If you think about how a camera works, in darker conditions it is necessary to increase the size of the aperture and the exposure time in order to get a decent photo. In the same way, your eye's aperture (the pupil) automatically increases in size, and the timing of the signals being sent from the eye to the brain is delayed when you wear sunglasses. You don't normally notice this effect when you wear sunglasses because *both* eyes are covered up, and therefore both signals are delayed. But in this experiment only one eye is covered, so you can distinguish the difference between the two.

The eye with the sunglasses lens in front of it sees the pendulum delayed with respect to the normal eye – and therefore in a different position. This has the effect of tricking your brain into thinking that the pendulum is now moving in three dimensions instead of two, i.e. in a circle (or ellipse) instead of a straight line. When you swap the lens to hold it in front of the other eye you swap which signal is being delayed, thereby changing the apparent direction of swing.

Tips for Success

Some people don't see the effect so quickly – they may need to move the lens back and forth in front of one eye in order to see the difference.

If you don't have an old pair of sunglasses lying around, but do have access to an optics lab then neutral density filters will of course work just as well – if you don't mind them being held by the audience members!

Serving Suggestions

This trick works best one at a time as the volunteer needs to be perpendicular to the direction of the pendulum swing. It therefore works well with small audience sizes, where everyone can have a turn to see the effect.

17. Egg-Citing Physics

Ever mixed up your eggs? Some simple physics will enable you to avoid that problem in the future...

Ingredients

- raw egg
- hard boiled egg

Instructions

1. Place the two eggs on a flat surface and set them both spinning.
2. Gently and briefly place your finger on the top centre of each egg.
3. Notice that the hard boiled egg is much easier to spin, but it stays still when you take your finger off. In contrast, the raw egg is difficult to start spinning but will keep spinning when you take your finger off.

How does it work?

Momentum is the key to this demonstration. A raw egg is filled with a liquid, whereas a hard boiled egg is effectively a solid. Firstly consider what happens when you stop the eggs: When you gently place your finger on the top, you stop the outer shell of both eggs from moving. Since the hard boiled egg is solid, all of the egg stops moving, and so the egg remains stationary when you remove your finger. However, the liquid inside the raw egg will keep spinning even though the outside shell is stationary. The drag of that liquid on the shell will start the raw egg spinning again.

Similarly, a hard boiled egg is easier to spin since the entire egg starts spinning at the same time, whereas in the soft boiled egg only the outer shell is spinning at first, and gradually the liquid insides begin to spin as they are dragged around by the shell.

Tips for Success

Don't set your eggs spinning too hard or they may roll off the table. Make sure you start them spinning at approximately the same rates or your audience may think you are trying to fool them!

Serving Suggestions

This trick is of most interest to adult audiences as younger people generally haven't experienced the difficulty of distinguishing between raw and hard boiled eggs.

You may want to demonstrate that the egg really is hard or soft boiled by breaking it in front of the audience.

Did You Know?

There is a classic physics trick that involves placing a lit match or piece of paper into an old milk bottle, and setting a peeled hard boiled egg on top of the bottle. The egg is pushed into the bottle in a very similar way to the water being sucked into the pint glass in the 'Lifting Lemon' trick in this Pack. Unfortunately it is very difficult these days to locate old-style glass milk bottles so this trick seems to be going out of fashion, although it is possible to use a water balloon and a wide-necked bottle instead.

18. One In The Hand

Eggs are traditionally thought of as being very fragile, but in fact the physics behind their shape is astounding.

Ingredients

- raw egg
- plastic bag or glove (for the unconfident!)

Instructions

Challenge audience members to break the egg just by squeezing it. Let them wrap the egg in a plastic bag or wear a glove if they're worried... Believe it or not, it can't be done!

How does it work?

The shape of an egg is actually one of the strongest designs possible. The curved structure means that applying pressure to any particular area actually spreads the force out over the entire egg. So just squeezing it won't cause it to break. Of course applying a very sharp force to one point WILL cause it to break – which is why we usually tap the egg on the side of a bowl to break it when cooking.

Tips for Success

Ask your volunteers to remove any rings etc. before trying this trick – the sharp uneven force from such metal objects can cause the egg to break.

Check your eggs for hairline fractures before attempting this trick – if there is any existing damage to the egg it won't work.

Did You Know?

The ornate and intricate arched doorways and ceilings in many old buildings aren't just there for their aesthetic qualities. Arches are in fact one of the strongest building structures. In effect, every brick or piece of masonry within the arch is falling on all the others, distributing the weight evenly over the structure.

19. Bernoulli Balls

A simple hair-dryer becomes a magical levitation device through an understanding of the principles of fluid flow.

Ingredients

- hair dryer (make sure you have an appropriate power supply available!)
- small light balls (such as polystyrene balls available at most craft shops, or ping pong balls)

Instructions

1. Orient the hair dryer so that the outlet is pointing directly upwards. Turn it on.
2. Place a ball carefully in the flow from the hairdryer. It will balance in the air, appearing to levitate!
3. Gently move the hairdryer from side to side – the ball will stay in the air stream, i.e. will also move back and forth. Repeat this process moving the hairdryer up and down.
4. Carefully tilt the hairdryer – the ball will still stay in the airstream, hanging in mid-air with nothing directly underneath it.
5. Try using balls of differing sizes, and challenge your audience to see how many they can place in the airstream at once.

How does it work?

The upward pressure from the hairdryer balances the downward force of gravity, keeping the ball 'levitating'. The more impressive part of this trick – being able to move the ball along with the hairdryer and angle it and so on – is based on the Bernoulli principle. This states that fast moving fluids (including gases such as air) are at a lower pressure than slow moving fluids. So the airstream from the hairdryer is at a much lower pressure than the air outside. A ball that is smaller than the diameter of the airstream can therefore be balanced within it – if the ball starts 'falling' out of the airstream to one side then the higher pressure of the air outside the airstream will push the ball back into the centre. This is the process that enables the ball to balance inside the airstream and move around as the hairdryer is moved around.

Tips for Success

Try to find a hairdryer with a 'cool' setting – it will last longer and allow you to perform the trick for much longer in one sitting, without the hairdryer overheating.

Make sure that the balls aren't larger than the output of the hairdryer or it won't work.

Tilting the hairdryer to too great an angle will cause the ball to fall out of the airstream – although most audiences enjoy seeing the effect!

Serving Suggestions

This is a good eye-catching demonstration that can keep audiences amused for a significant period of time – everyone wants to have a go, especially when challenged to make the largest number of balls stay within the airstream. However, it does require a power supply so is generally limited to indoor venues.

Did You Know?

The Bernoulli Effect underlies the principle of the aerofoil. By encouraging air to flow more quickly over the top surface of a wing an upward pressure is produced by the slower moving air beneath. This phenomenon can also be demonstrated by holding up two sheets of paper and blowing between them. Instead of moving apart, they are drawn together. If you thought anyone could have worked this out, remember that Daniel Bernoulli was awarded his masters degree at the ripe old age of 16.

20. Tame Tornado

This is a good visual demonstration of forces, and in particular vortices. This demonstration does require a specialised adapter, but it is readily available throughout the country and the demonstration is striking enough to warrant its inclusion in the list.

Ingredients

- two large (~2 litre) empty soft drink bottles
- tornado adapter (available from most science centres and museums)
- water

Instructions

1. Fill one of the soft drink bottles with water until it is mostly full.
2. Screw the tornado adapter into the empty bottle.
3. Invert the empty bottle and screw the opposite thread of the tornado adapter into the water-filled bottle.
4. Turn the whole contraption upside-down.
5. Grasp the top and middle of the contraption and spin it in a circular motion – either clockwise or counter-clockwise.
6. Once a vortex (whirlpool) forms in the upper bottle, stop spinning – you should see the vortex form throughout the liquid, and continue as long as there is liquid in the upper bottle.

How does it work?

This demonstration produces a 'vortex' such as those observed in cyclones, tornadoes and whirlpools. As the water spins around the bottle there is a downward pull formed due to the water passing through the opening into the empty bottle below. The initial small rotation caused by spinning the bottles gains speed as the water is sucked through the opening. As the rotation speeds up the vortex forms.

Tips for Success

Try adding food colouring to the water for a more colourful visual effect.

Practice making the vortex until you're sure how to do it. If it doesn't work straight away, try reducing the size and increasing the speed of the circles you are making. Make sure that the bottles are held vertically and your circles are centred about the long axis of the contraption.

Replace the plastic bottles if they get too bent out of shape – they need to be round to make a proper vortex.

Serving Suggestions

This is a good visual trick suitable for all ages. It works best with small groups, where each audience member can have a chance to create the vortex. It's also a good demonstration to leave the audience to perform on their own while the demonstrator has a well-earned break!

Did You Know?

It is well known that water always go down the plughole in a clockwise direction in the northern hemisphere and counterclockwise in the southern hemisphere. Unfortunately this is not scientifically valid! What is more interesting is that the whirlpool was first mechanically induced in a bathtub in 1968 by Roy Jacuzzi. Now, what ever became of him?