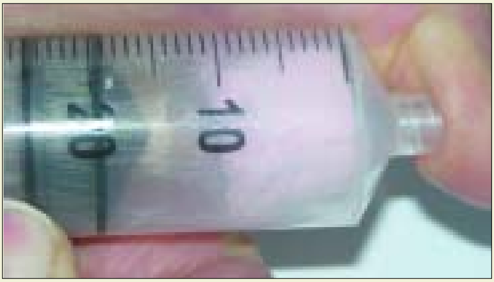
The incredible shrinking marshmallow

Spain/Austria

At constant temperature, volume increases as pressure decreases



Background

Boyle's Law states that when the temperature is held constant, the volume of a gas is inversely proportional to its pressure.

Follow these steps

1 Place a cylindrical marshmallow inside a large plastic syringe.
2 Place your thumb over the end to seal the nozzle.
3 Push the plunger in and then out and note what happens now.

So what happened?

The marshmallow shrinks when you push the plunger in but then regains its original size when you pull the plunger out again.

The structure of a marshmallow is such that there are many bubbles of air trapped by sugar molecules. There is a fixed number of air molecules inside the marshmallow–syringe system.

As the plunger is pushed in, the pressure inside the syringe increases and the bubbles of air decrease in size, therefore the volume of the marshmallow decreases. Exactly the opposite then occurs when the plunger is pulled outwards.

Eventually the marshmallow responds less well because bubbles of gas inside it have been punctured because their internal pressure is much greater than the external pressure.

You will need...

✔ a large plastic syringe
✔ fresh marshmallows

Note: you can also perform this demonstration with a wine-bottle pump (used to expel air from a wine bottle to prolong the life of the unfinished wine)

What next?

Boyle's Law can also be demonstrated by placing a marshmallow or a partially inflated balloon inside a bell-jar and then evacuating the jar – the marshmallow/balloon swells as the pressure is reduced.

Surprisingly, this also works well with ice cream.

Can you feel the force?

The Czech Republic

You can really experience and feel atmospheric pressure

You will need...

- ✔ a large paperclip
- ✔ a CD
- ✔ a piece of string
- ✔ a large sheet of newspaper

Background

We live at the bottom of an ocean of atmosphere. Atmospheric pressure is equivalent to the weight of 10 tonnes over a square metre.

Follow these steps

1 Attach the CD to the string using the paperclip.
2 Feed the string through a small hole in the centre of the sheet of newspaper.
3 Place the newspaper flat on the ground without allowing any wrinkles.
4 Exert a firm upwards tug on the string.

So what happened?

It is surprisingly difficult to lift the newspaper because of the atmospheric pressure acting on it.

The balloon 'sucked' into a bottle

Belgium

Witness the effects of atmospheric pressure

You will need...

- ✔ a bottle
- ✔ a balloon
- ✔ a piece of string
- ✔ boiling water

Background

This experiment is a variation on the egg-in-a-milk-bottle experiment, which is often used to demonstrate the effect of atmospheric pressure. In this version a water-filled balloon is used.

The advantage of the balloon is that its size can be adjusted by changing the amount of water in the balloon, allowing it to be customized to fit whatever bottle you have.

Follow these steps

1 Attach a piece of string to the neck of the balloon.
2 Pour some boiling water into the bottom of the bottle.
3 Place the balloon over the neck of the bottle so that it makes an airtight seal.
4 Allow the water to cool.

So what happened?

As the temperature falls the warm vapour condenses and the internal pressure drops, so the balloon is sucked (or, more correctly, pushed by external pressure) slowly into the bottle. If you stand the bottle in cold water you can speed up the process.

The experiment proceeds slowly compared with the demonstration that uses an egg and burning methylated spirits in a milk bottle. Students therefore have more time to observe what is going on and work out what might be happening.

The string attached to the balloon makes it easy to remove the balloon from the bottle at the end of the experiment.

What next?

This can lead to a discussion about atmospheric (condensing) engines, which were the first type of steam engine that worked on this principle and were first used in coalmines.

Pressure with a difference

Belgium

Pressure is dependent on depth

You will need...

- ✔ a sealed container (e.g. a sweet tin)
- ✔ a piece of wooden dowel
- ✔ a container of water

Background

The pressure exerted on a fluid depends on the depth of the fluid.

Follow these steps

1 Glue a piece of dowel to the centre of the tin (see picture).
2 Make two holes in the lid of the tin, about 1–2 mm in diameter, one each side of the dowel, about halfway between the rim of the tin and the dowel. The holes and dowel should all lie along a straight line.
3 Ask the students what will happen if you lower the tin into the water while keeping the tin level.
4 Do it and see if the water enters the tin via the holes.
5 Repeat the exercise, this time tilting the tin slightly as you lower it so that one hole is higher in the water than the other. Will the water enter the holes this time?

So what happened?

Once the tin has been lowered into the water, the surface tension of the water at the holes and the pressure of the trapped air prevent the water from entering the tin.

If, however, you tilt the tin so that one of the holes is higher in the water than the other, the water enters the lower hole and bubbles of air come from the upper hole.

Why? The holes are at different depths, so the pressure at the upper of the two holes is less than that at the lower hole. This causes the water to enter at the lower hole at the same time as air is forced out of the upper hole.

What next?

See what happens if you make the holes bigger.

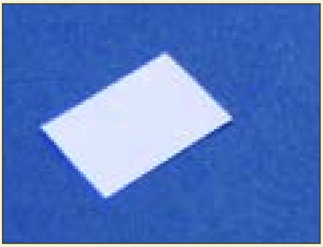
Air race between identical pieces of paper

The Czech Republic

Air resistance has less effect on dense objects

You will need...

- ✔ a coin
- ✔ two small pieces of paper (same weight and dimensions)



Background

A skydiver relies on air resistance to allow him/her to fall through the air for several seconds before deploying a parachute.

Follow these steps

1 Place a small piece of paper on a large coin.
2 Drop the coin and paper as well as an identical piece of paper at the same time.
3 Watch which piece of paper reaches the floor first.

So what happened?

The paper on the coin reaches the floor first because it does not experience the slowing-down effect of air resistance as much as the piece of paper without the coin.

What next?

This leads on neatly to a discussion of slipstream, coefficients of drag aerodynamics, etc.