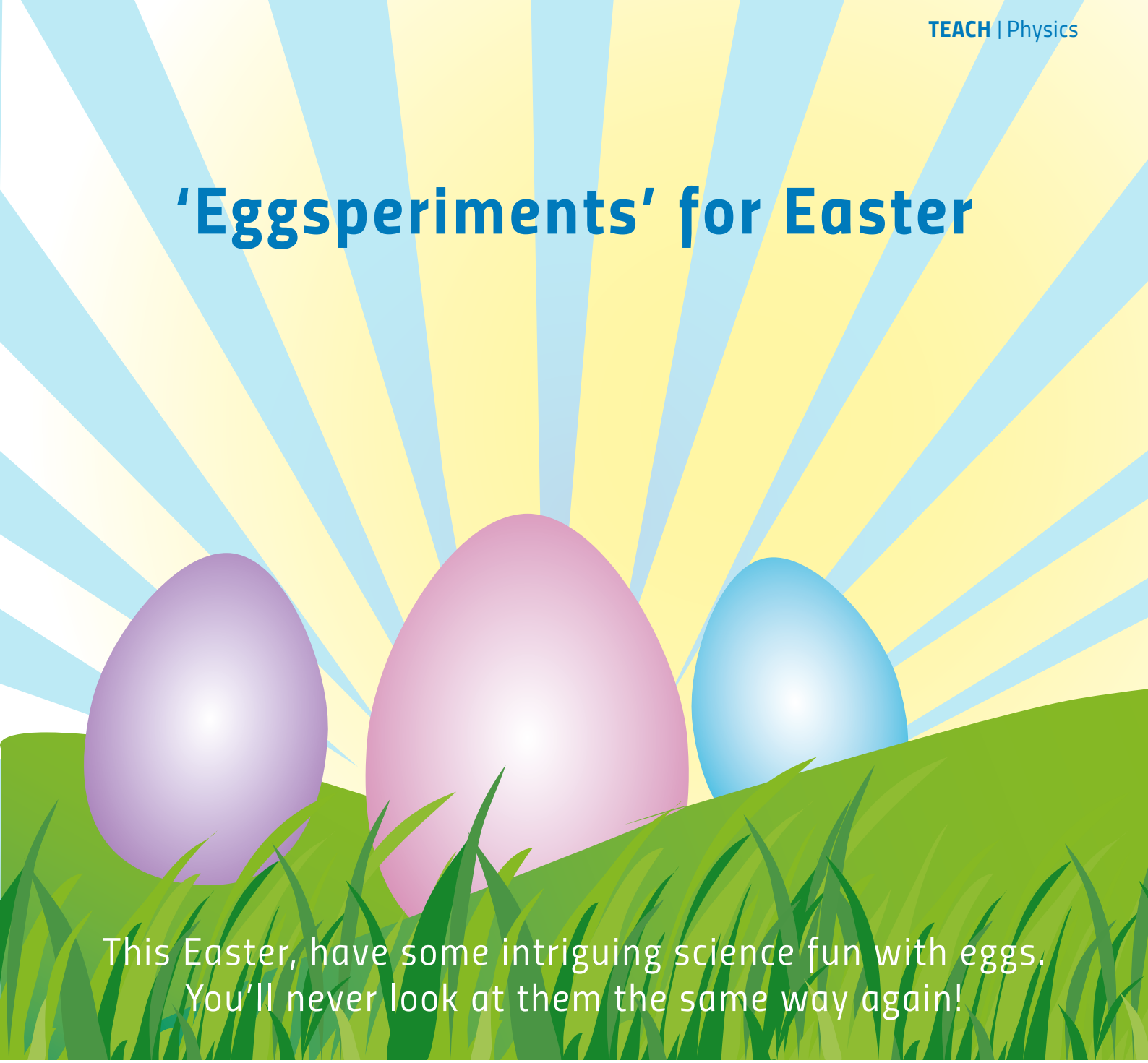
'Eggsperiments' for Easter



This Easter, have some intriguing science fun with eggs. You'll never look at them the same way again!

Image courtesy of Nicola Graf

By David Featonby and Susan Watt

Traditionally, Easter is the season of eggs – whether chocolate, painted or special in some other way. Along with the fun of egg hunts and creating (or buying) decorative eggs, we can use eggs to learn some science – as these five light-hearted activities show.

Most of the experiments described here are suitable for almost all ages and can usually be done in a few minutes with simple, easy-to-find materials – including quite a few eggs.

A normal hen's egg consists of three main parts: shell, white (or albumen) and yolk. However, if you can get some really fresh eggs, you may see when you crack them open that the white itself has two distinct parts: a firm inner layer and a runnier outer layer. Between the white and the shell there is another structure: a thin but quite strong membrane. In the activities below, we'll be looking at how this anatomy of eggs affects their properties.

The shell of an egg laid by a healthy, outdoor hen is surprisingly strong; battery-raised hens often lay eggs with thinner shells. Although a sharp tap can break the shell, the shell's hard material and its rounded, regular shape mean it is remarkably good at withstanding a heavy weight or force (such as the mother hen). There are several experiments you can do to demonstrate this strength – including, if you dare, actually walking on eggs.

Squeezing eggs

Students can try this simple experiment themselves to feel the surprising amount of force that eggs can withstand.

Materials

- Good-quality eggs, one per group of students. (Free-range eggs are best.)
- Cling film

Procedure

1. Wrap each egg in cling film, as a precaution in case it cracks.
2. Ask the students to remove any rings from their fingers.
3. Ask the students to take an egg in one hand and squeeze it as tightly as possible (figure 1). They should keep fingernails away from the egg.
4. It should be almost impossible, or at least very difficult, for anyone to break an egg, even squeezing very tightly.

Image courtesy of David Featonby

Figure 1: Holding an egg and increasing the pressure to try and crack the shell

What is happening? An 'eggsplanation'

The shell is made of a thin, brittle material – so why doesn't it break? The answer is the egg's domed shape, which – like a dome or arch in architecture – distributes the applied force to the over the whole structure, decreasing the pressure on any one part and so reducing the chance of breakage. This shape also ensures that the force acts only to compress the shell, rather than to stretch it or push it sideways. Because the eggshell is a hard material, it is very strong when compressed and so doesn't break.

In fact, the shape of an egg at the pointed end may be ideal for load-bearing. Engineers know that the arch shape that distributes weight best is the catenary. This mathematical curve has a shape similar to an egg at the pointed end, which is why eggshells will support even more weight when force is applied to the ends of the egg (as in the next activity), rather than around the middle.

Walking on eggs

It's even more impressive to walk on eggs – although it's riskier too!

Materials

- At least two boxes of a dozen good-quality eggs

Procedure

1. Check that the eggs are not cracked.
2. Put the boxes of eggs on the floor, placing two boxes next to each other so that you can stand with a foot on each box.
3. If you have more than two boxes, pair up the extra boxes and form a line for walking along. Consider placing the boxes near a wall to help the walker keep their balance.
4. Remove your shoes.
5. Gently step onto the boxes of eggs, one foot per box, spreading the pressure evenly as you stand (figure 2).

REVIEW

- ✓ Physics
- ✓ Pressure
- ✓ Motion
- ✓ Ages 4-19

It might seem unbelievable that you cannot break eggs by squeezing them or even walking on them. However, these and other strange facts can be demonstrated with the fun activities described in this article, which will make your students want to start 'eggsperimenting' and testing the laws of physics. The instructions are easy to follow and with some minor precautions (such as plastic sheets and paper towels), the activities shouldn't be too messy. An ideal way to learn traditional concepts of physics in a novel, fun and interesting way.

Catherine Cutajar, St Martin's College Sixth Form, Malta

Image courtesy of David Featonby

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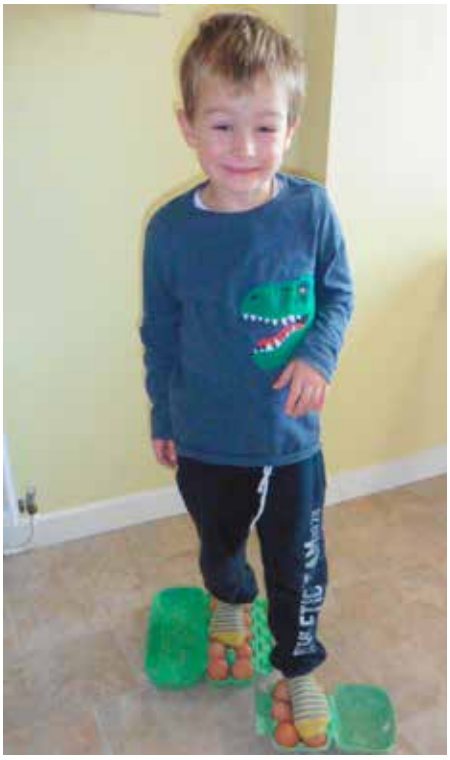

Image courtesy of David Featonby

Figure 2: Walking on eggs

6. If you have extra boxes, gently walk along the eggs in the same way.

What is happening? An 'eggsplanation'

Because the eggs are in their boxes, they are kept upright. The walker's weight presses on the domed ends of the eggs instead of their sides, enabling them to withstand the maximum force. The weight is also shared between all the eggs you are standing on, thus minimising the pressure on each egg.

The same principle of weight distribution means that it is also possible to lie on a 'bed' of eggs (figure 3). To do this, you'll need about ten dozen eggs. Here, the weight is distributed over a large area, in a similar way to a bed of nails.

Egg spinning

From the outside, raw and hard-boiled eggs look just the same, but there is an easy way of telling them apart without breaking them open. This activity shows how to do this, either as a teacher demonstration or a class activity.

Materials

For the teacher or each group of students: one hard-boiled and one raw egg. The eggs in each pair should be closely matched in size and shape (weigh them to check the masses) and be at the same temperature.

Image courtesy of David Featonby

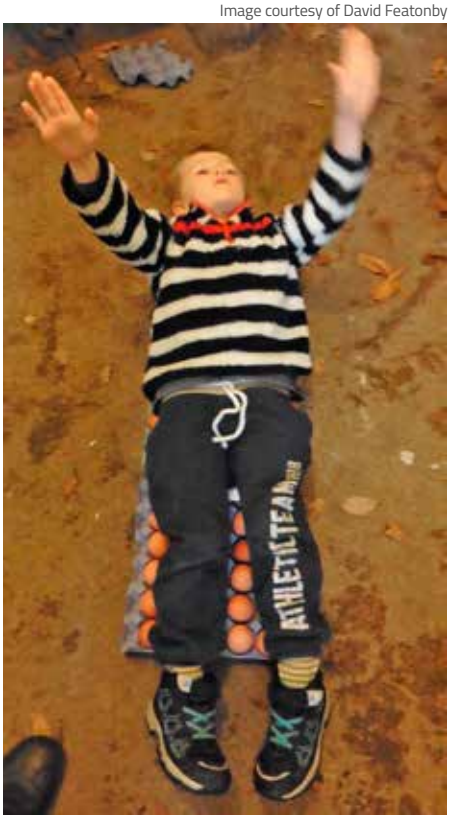

Image courtesy of David Featonby

Figure 3: Enjoying a rest on a bed of eggs

Procedure

1. Ask the students to guess which egg is which (perhaps adding a mark to one egg to avoid confusion).
2. Take one egg and set it spinning quite fast on a hard surface.
3. Quickly stop it with a light touch, then quickly let go again. See whether it starts spinning again at all, or stays stopped. Try this a few times.
4. Do the same with the other egg.
5. You can tell which is the raw egg as this one will restart spinning slightly after being stopped.

What is happening? An 'eggsplanation'

Whereas the inside of the hard-boiled egg is solid, the raw egg is liquid inside. When the raw egg is set spinning and then stopped, the liquid inside it continues to move, which makes the egg start spinning again. But when a hard-boiled egg is spun and stopped, the solid interior cannot continue to move, so the egg will remain stationary.

More scientifically, we can understand this in terms of forces in a viscous (thick) liquid. When the raw egg is stopped by touching the shell momentarily, the liquid inside continues to move, producing forces across the liquid. If the egg is quickly released, these forces can then act on the shell to make the egg move again. With the hard-boiled egg, there is no viscous liquid to store the force, so stopping the spinning (which needs a little more force than with the raw egg) brings it to a complete standstill.

Extension

Ask your students to test which egg is more difficult to get spinning in the first place. Can they explain their answer, based on the principles described above? (They should find that the raw eggs are harder to start spinning for the same reasons that they are harder to stop.)

Bouncing eggs

Did you know that as well as being remarkably strong, eggs can also bounce? First, however, we need to remove the shell.

Materials

- A raw egg
- Vinegar (colourless vinegar is best)

Procedure

1. Place the egg in the vinegar overnight.
2. The following morning, the shell will have softened. Very carefully peel off the softened shell so that just the inner membrane remains. Be careful not to tear the membrane.
3. Rinse the egg so that no bits of shell remain on the membrane.
4. Now try dropping the egg from a few centimetres onto a smooth, hard surface. It should bounce! Take care though – too high a drop and the egg will burst.

What is happening? An 'eggsplanation'

Vinegar contains ethanoic (acetic) acid. This reacts with the eggshell, which is made of calcium carbonate:

$$2CH_3COOH + CaCO_3 \rightarrow H_2O + CO_2 + Ca(CH_3COO)_2$$

Ethanoic acid + calcium carbonate → carbon dioxide and calcium ethanoate

The resulting calcium ethanoate is soluble in water, so the shell begins to dissolve; if you leave it in vinegar for long enough, it will dissolve completely.

Why doesn't the egg burst when it lands? The answer lies with the membrane, which is surprisingly strong and a little bit stretchy. This elasticity allows the egg to spread out as it hits a hard surface, which means it decelerates more slowly than a rigid egg in its shell would. Because the deceleration is reduced, so too is the force that is exerted on the egg (Newton's second law of motion).

Egg 'suction'

A hard-boiled egg that has been very carefully shelled can be used to demonstrate atmospheric pressure.

Materials

- One hard-boiled egg
- Glass bottle with a neck a little smaller than the egg's width
- Matches

Procedure

1. Peel the hard-boiled egg very carefully so that the membrane is completely removed but there are no tears at all in the egg white.
2. Strike a match, wait for the flame to grow, then drop it into the bottle. Quickly do the same with a second match, then immediately seal the bottle with the egg while the matches are still burning.

   Within seconds, you should see the egg appearing to be sucked right into the bottle (figures 4-6).

What is happening? An 'eggsplanation'

As the matches burn, they use up oxygen from the air within the bottle, forming soot. A solid (soot) takes up less space than a gas (oxygen), so the pressure within the sealed bottle

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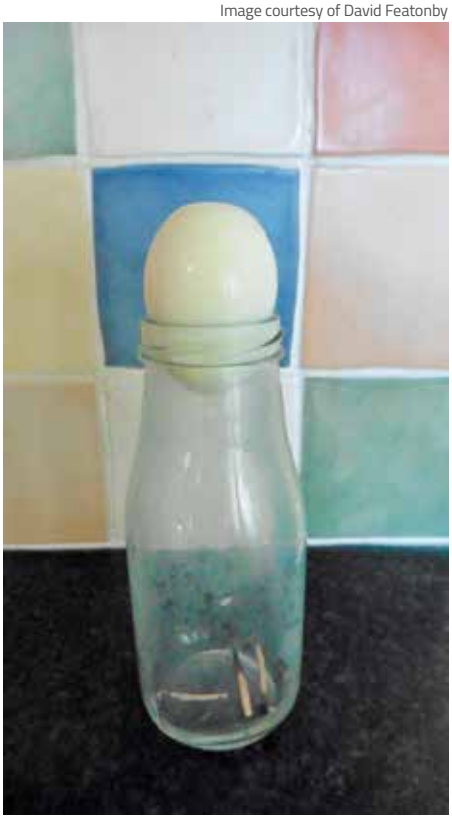

Figure 4: Hard-boiled egg without shell on the bottle

Image courtesy of David Featonby

Figure 5: Hard-boiled egg being 'sucked' into the bottle

Image courtesy of David Featonby

Figure 6: Hard-boiled egg intact inside the bottle

decreases. As a result, the egg appears to be sucked into the bottle; in fact, it is the surrounding air pressure outside that forces the egg into the bottle.

A further consideration is that the burning matches heat the air around them, which you might expect to increase the pressure within the bottle. Clearly the reduction in pressure caused by the removal of oxygen outweighs the increase in pressure caused by the heat.

Extension

Repeat the experiment without the egg, but instead covering the mouth of the bottle with cling film as soon as the matches are dropped in. As the pressure in the bottle decreases, the cling film is drawn into the bottle, forming a concave surface.

Alternatively, this demonstration can be performed by (carefully!) pouring boiling water into the bottle before sealing it with the egg. As the steam condenses and the pressure inside the bottle is reduced, the egg is slowly drawn into the bottle. This can take several minutes.

Your ideas?

Do you do use eggs to do experiments in science lessons? Were these suggestions helpful? Why not leave a comment on the online version of this article, describing how you used these ideas and what other experiments you have tried? Did they work well? What could have been improved?

Resources

A video showing more about the egg squeezing and egg walking experiments. See: www.youtube.com/watch?v=Xckhg7Ns8so

A video showing more about the egg bouncing experiment. See: https://www.youtube.com/watch?v=3Iv9eLO0scA

More details and videos demonstrating the experiments in this article. See: www.science-sparks.com/2013/02/16/10-egg-science-experiments

Some more intriguing egg experiments with science explanations. See: www.livescience.com/44419-egg-science-experiments.htm and www.buzzfeed.com/kasiagalazka/things-you-can-do-with-eggs-besides-coloring-them#.cc8YRYYKq

David Featonby 'retired' from school physics teaching after 35 years in the classroom, and until 2011 was a teacher network co-ordinator for the UK's Institute of Physics. He has represented the UK at Science on Stage and now works voluntarily with the international Science on Stage (Europe) committee as UK representative and member of its European executive board. David is the author of various hands-on articles in *Science in School* and *Physics Education* and has led workshops at many conferences throughout the UK and Europe. He is particularly interested in showing the physics in everyday things to the public, whatever their age.

Susan Watt is a freelance science writer and editor. She studied natural sciences at the University of Cambridge, UK, and has worked for several UK publishers and scientific organisations. Her special interests are philosophy of science and science education.