FANTASTIC FEATS

Entertain your audiences with these tricky feats, which showcase Newton's laws of motion in action.

By David Featonby

This article is the first in a series of light-hearted challenges that are fun to do and also demonstrate some intriguing scientific principles – once you know how to solve them. We hope that readers will be tempted to share their own 'fantastic feats', which we will publish in future issues.

Centuries ago, Isaac Newton set out three scientific principles known as the laws of motion. Here we describe some demonstrations involving these principles and set out the challenges. To solve them, think about where the forces are in each situation, and which of Newton's laws apply.

See if you can work out how to succeed. If not, you'll find the solutions on page 60.

Feat 1: money grab

The task is to balance a bottle upside down on top of a banknote, and then remove the note without touching the bottle or knocking it over. You can set this up as a challenge to see who can win the banknote, or just perform it to amaze your audience.

This feat needs steady hands and some nerve, especially if you are using a glass bottle. It's best to practice with a plastic bottle first: once you've mastered the feat with this, you can move on to the harder stuff – or stick with the practice version, which is still guaranteed to impress.

Materials

- A clean, newish banknote
- One plastic soft drink bottle (about 500 ml capacity) – if possible, one with a small, very smooth and perfectly flat cap; or
- One glass bottle (about 500 ml capacity) – a more daring alternative
- A table with a smooth surface

Procedure

1. Half fill the plastic bottle with water and screw the top on well.

Images courtesy of David Featonby

Figure 1: setting up the feat: the banknote beneath the bottle

Figure 2: the bottle challenge – with two bottles

REVIEW

- ✓ Physics
- ✓ Mathematics
- ✓ History
- ✓ Ages 11–19

This article outlines some fun demonstrations using the familiar principles described by the famous scientist Isaac Newton. As well as being suitable for physics lessons, the experiments provide links to mathematics and history.

Possible questions include:

- What are the equations of Newtonian mechanics?
- How can they be applied to dynamic processes?
- What is the relationship between mass and weight?
- What is the relationship between velocity (v), acceleration (a) and time (t)?
- What are some applications of Newton's laws?

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2. Make sure that the bottle cap (or bottle neck, if you are using an empty glass bottle) is perfectly dry. Any dampness will significantly increase the friction with the banknote, making the feat almost impossible to perform. (This is a sure way to win the banknote if you set the task up as a challenge: simply dry the neck when it comes to your turn.)
3. Place the banknote on the table, and place the upturned bottle on top of the note, neck downwards (figure 1).
4. Now try to remove the banknote from under the bottle without knocking it over – or challenge someone else to do this. Hint: think about the forces acting on the bottle, and how to minimise them.
5. Once you can do this with the plastic bottle, perhaps try it with the glass bottle – if you dare. (This is heavy enough, so no need to add any water.)

Trickier tricks

Once you've achieved the banknote and bottle feat, you can try something harder. Can you remove the banknote from between two bottles: an upturned bottle balanced on an upright one (figure 2)? This is a lot more difficult, but it can be done.

Images courtesy of David Featonby

Figure 3: tea for one: the classic tablecloth challenge

Figure 4: holding the rod before dropping, with the catcher's hands above

If you succeed at this, perhaps you'll want to try the ultimate challenge, where keeping tableware upright is needed: the classic tablecloth trick (figure 3).

In this challenge, it's even more spectacular to onlookers if the cup contains coffee and the bottle some liquid – and in fact, this should make the trick slightly easier: can you think why?

Feat 2: drop catch

In this next feat, we show how understanding Newton's equations can again help you to keep things from crashing to the floor. This time, it's a slightly counter-intuitive way to catch a falling rod.

This feat is also a useful follow-up to the classic reaction-time experiment in which students catch a ruler dropped vertically to determine their reaction time (Thibault et al., 2017).

Materials

- One rod, about 50 cm long and 1–2 cm in diameter, not too heavy (wooden dowelling is ideal)
- Two people – one to drop the rod, one to catch it

Procedure

1. One person holds the rod just below shoulder height.
2. The other person (the catcher) must then positon his or her hands about 20 cm above the rod (figure 4).
3. The person holding the rod then drops it without warning, while the catcher tries to grab it. Can they get it before it hits the ground?

Solutions

For solutions and the science behind all these challenges, turn to page 60.

Invitation to readers

Do you have a science trick that you could share with others across Europe? If so, please let us know!

Reference

For an account of the ruler-drop reaction time experiment, see the online materials for:

Thibault E, Biedermann K, Watt S (2017) Cans with a kick: the science of energy drinks. *Science in School* **39**: 48–54. www.scienceinschool.org/2017/issue39/energydrinks