The resourceful physics teacher

Physics teacher **Keith Gibbs** shares some of his many demonstrations and experiments for the physics classroom.

During more than 30 years of teaching physics, I have come across many interesting demonstrations and teaching ideas – often suggested by relatives, friends, colleagues and past students. In 2000, I began to gather these ideas together – this was the basis of the Schoolphysics website and CD-ROM collection. Over time, I added more explanation and background for teachers whose specialism was not physics.

Below are four ideas from the collection. I hope that you will find at least one of them new, challenging, informative and fun, and that the ideas go some way towards popularising the subject and making people realise that physics can be interesting and fun.

Boiling water under reduced pressure

Age range: 13-15

This simple experiment demonstrates that the saturated vapour pressure of water depends on the temperature. It is best performed as a teacher demonstration, with a safety screen between the apparatus and the students.

Materials

- A round-bottomed flask
- A bung with two holes
- A glass tube, with an external diameter to fit the hole in the bung
- A rubber tube with a diameter to connect to the glass tube
- A thermometer to fit the hole in the bung
- A Bunsen burner
- A retort stand and clamp
- A safety screen
- A tray
- Water

Procedure

1. Fit the rubber tube onto the end of the glass tube.
2. Fit the thermometer and glass tube into the holes in the bung, pour cold water into the flask until it is just less than half full. Then seal the flask with the bung.
3. Fit the clamp onto the rubber tube but do not close the clamp.

Image courtesy of aristotoo / iStockphoto

REVIEW

- Physics
- Chemistry
- Thermodynamics
- Circular motion
- Electromagnetism
- Gravitational fields
- Inertia
- Boiling points
- Ages 13-19

The four experiments described in this article are innovative and use items that are easily available in school laboratories. The aim, materials, procedure and diagram for each experiment make it very straightforward for teachers and students to understand the processes and theories involved. It is also interesting to read about the author's experiences and the results that he obtained from these experiments.

Teachers could use the experiments for a wide array of physics topics and adapt them to different age groups, depending on how much theory the teacher chooses to explain. They can be performed as a pre-topic experiment to introduce the students to the theory or else while the theory is being explained, to consolidate concepts with facts. A discussion can be held with students during the experimental investigations to prompt them to make predictions and explain the outcomes.

The activities can be used with students of different ages, depending on the emphasis. The boiling water activity could be used with students aged 13-15 to discuss the boiling point of water; for students aged 16-19, it could be used in a lesson about gas laws. The coat-hanger experiments could be used with 16- to 18-year-olds to introduce circular motion, centripetal force and centripetal acceleration. For 10- to 13-year-olds, the electromagnetic separator activity could be used in general science lessons or to discuss magnetic materials; for students aged 14+, it could be used in magnetism lessons. Finally, the experiment with the falling jar could be used for students aged 16+ to teach simple harmonic motion, gravitation and inertia.

These types of demonstration are ideal for students who are visual learners and who will understand and remember theory better when they see it applied in practice.

Catherine Cutajar, Malta

4. Use the Bunsen burner to heat the water to boiling.
5. Close the clamp and turn off the Bunsen burner.
6. Invert the flask and pour cold water over it.

Steam will condense inside the flask, reducing the pressure and allowing the water to start boiling again. When the water stops boiling, pour more water over the flask. How low can you get the temperature and still observe the water boiling? You should be able to get the water to boil at 40 °C – I once observed the water boiling at body temperature (37 °C)!

Safety note: wear safely goggles. Although unlikely, it is possible that the glass flask could shatter, so keep a safety screen between the experiments and the students. If possible, stand behind the screen yourself.

See also the general safety note on the *Science in School* website (www.scienceinschool.org/safety) and on page 65.

Theory

The explanation is that the saturated vapour pressure of water depends on the temperature: the lower the temperature, the less water vapour the air can hold (see Table 1). When the water condenses, it lowers the pressure in the flask – and this, of course, allows water to boil at less than 100 °C.

An alternative method

A simpler method is to partly fill (about 20%) a syringe with 50-60 °C warm water. Then pull on the plunger of the syringe. This lowers the pressure in the syringe, causing the water to boil at well below 100 °C.

Temperature	Saturated vapour pressure
37 °C	0.06 x 10^5 Pa
60 °C	0.19 x 10^5 Pa
75 °C	0.38 x 10^5 Pa
85 °C	0.57 x 10^5 Pa
100 °C	10^5 Pa

Table 1: Dependence of saturated vapour pressure of water on temperature

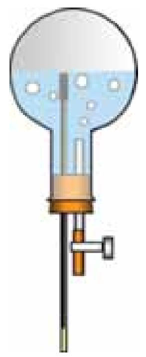

Image courtesy of Keith Gibbs

Image courtesy of Floortje / iStockphoto

The wire coat hanger and circular motion

Age range: 14-18

This is a simple demonstration of centripetal force.

Materials

- A wire coat hanger with the end filed to a point
- A metal file
- A small coin

Procedure

1. Bend the wire coat hanger until it forms a square.
2. File the tip of the hook flat and then bend the hook until it points towards the opposite corner of the square (see diagram).

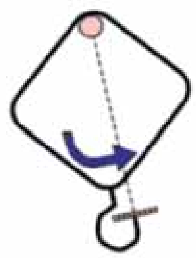

Image courtesy of Keith Gibbs

3. Balance a small coin (try a UK one-penny piece or a 5 or 10 Euro-cent coin) on the hook.
4. Place one finger in the corner of the square opposite the hook and spin the coat hanger in a vertical circle. The coin should remain in place.

Theory

The force of the hook on the coin provides the centripetal force, and this always acts towards the centre of rotation.

How many coins can you balance on the swinging coat hanger? My record is five one-penny pieces. With only one penny and with great care, I have once even been able to bring the coat hanger to rest without the coin falling off.

Electromagnetic separator

Age range: 16-18

This is a small-scale simulation of the type of electromagnetic separator that is used industrially to separate non-ferrous metals from other non-metallic scrap, and is suitable as a teacher demonstration.

Materials

- A U-shaped electromagnet with an iron core to give a high field intensity
- An AC (alternating current) power supply
- Aluminium scraps (e.g. kitchen foil)
- A piece of thin card
- Some scraps of paper

Procedure

1. Place the card on top of one arm of the electromagnet and put a few scraps of aluminium and paper onto the card.
2. Connect the electromagnet to an AC supply and turn on the current. The aluminium scraps will be ejected from the magnetic field.

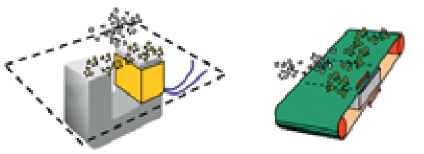

Image courtesy of Keith Gibbs

Theory

The AC electromagnet induces eddy currents within the aluminium scraps. These turn the scraps into tiny electromagnets that are then repelled by the large electromagnet and so fly off the card. With non-metallic scraps there are no induced currents and so these scraps remain on the card.

In a moving-belt version of this experiment, mixed metal and non-metal scraps are passed along a belt over an AC electromagnet. This induces eddy currents in the metal scraps, which are then repelled by the field and fly off sideways while the remaining non-metal scraps continue along the belt. Schools might be able to construct such a version for demonstration use, using a mixture of paper and aluminium.

A floating block in a falling jar

Age range: 11-18, depending on the treatment of the theory.

This is a very useful demonstration of one of the ideas of general relativity, using a wooden block floating in a jar of water that is suspended from a spring.

Fairground ride-goers should be grateful to centripetal force

Image courtesy of inabeanpod; image source: Flickr

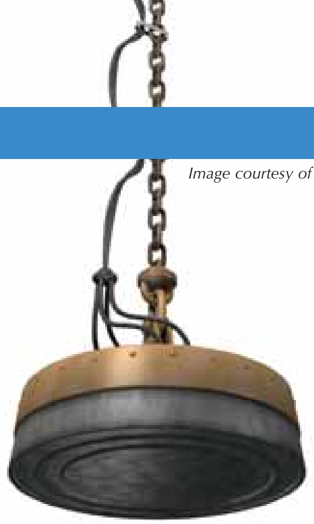

Image courtesy of ZargonDesign / iStockphoto

Artist's impression of a large electromagnet, of the type used for separation in an industrial setting

Materials

- A helical spring tied with string to a plastic jar
- A wooden block or straw loaded with modelling clay (e.g. Plasticine®)
- Water

Procedure

1. Half fill the jar with water, add the wooden block or straw, and suspend the apparatus from the spring.
2. Support the jar, then let it fall, suspended from the spring. The jar and contents will then oscillate in a vertical plane (up and down) but the water level will stay at the same position in the jar and the block or straw will float at the same level in the water as it falls and rises.

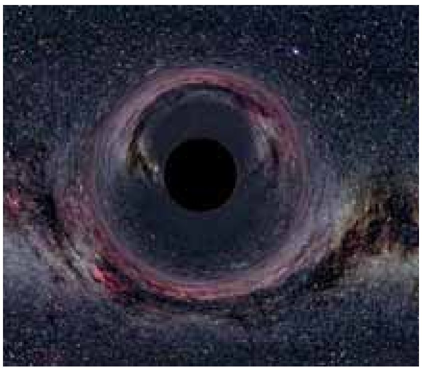

Image courtesy of Ute Kraus; image source: Wikimedia Commons

Computer-simulated image of the night sky, were it to feature a black hole with a mass ten times that of the Sun, and seen from a distance of 600 km. Einstein's theory of general relativity allows details of a black hole's structure to be calculated. Black holes are thought to be distortions in space and time, consisting of zero volume and infinite density.

Theory

The depth at which the wooden block or straw floats depends on both its weight (not its mass) and the upthrust on it. The upthrust depends on the weight of water displaced. Thus, as the acceleration of the jar and the block changes, the weight of the block and the upthrust on it change in direct proportion to each other; as a result, the depth at which the block floats remains unchanged as the apparatus oscillates.

Objects undergoing acceleration behave in the same way as they would in a gravitational field. As the jar and its contents oscillate, they have an acceleration that is due to both the constant gravitational field of Earth and the simple harmonic motion of the oscillation.

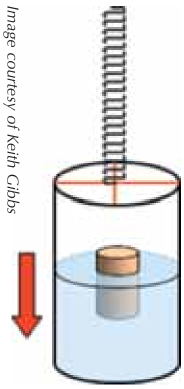

Image courtesy of Keith Gibbs

As the jar moves upwards, its net acceleration is greater than that of Earth's gravitational field and as it falls, its acceleration is less than that of Earth's field. On the downward part of the motion, it is as if the jar were on the Moon, where the gravitational acceleration is less than on Earth.

This is a very useful demonstration of the equivalence of gravitational and inertial fields.

Acknowledgements

The editors of *Science in School* would like to thank Catherine Cutajar and Gerd Vogt for their help in selecting the experiments to include in this article.

Web reference

w1 – To view more (free) teaching material collected by Keith Gibbs or to purchase the CD-ROMs, see: www.schoolphysics.co.uk

Resources

If you enjoyed this article, you might like to browse the rest of the teaching activities on the *Science in School* website. See: www.scienceinschool.org/teaching

If you prefer to concentrate on physics, here is a list of all physics-related articles in *Science in School*: www.scienceinschool.org/physics

---

After graduating from University College London, UK, with a degree in physics, Keith Gibbs took a PGCE teacher training course at Cambridge University, UK. He subsequently taught physics in four different schools across the UK for 36 years, retiring in 2002.

The ideas in this article are just a few of more than 700 ideas and experiments that Keith Gibbs has collected and devised over the years, available on CD-ROM (currently £10). These, as well as explanations suitable for 11- to 19-year-old students, animations, lesson plans, images and much more, are available on a further CD-ROM which, once bought (currently £35), can be copied within the school and made available via the school's intranet. See the Schoolphysics website[w1].

Keith has written and contributed to a number of physics textbooks. Recently, he has worked with Pearson Education on animations for advanced-level physics courses, and practical projects for younger physics students.

Keith also travels extensively, demonstrating his collection of experiments. If you are interested in a visit, contact him via the Schoolphysics website[w1].

To learn how to use this code, see page 1.