A2 ACTIVITY 2: THE OBEDIENT BOTTLE

Background

The **Obedient Bottle** or **Come Back Can** is a visual, explorative introduction to **elastic potential energy** and its conversion to **kinetic energy**.

When the cylinder is rolled, it acquires **kinetic energy**. As it slows down, this energy is transferred to the twisted elastic band inside in the form of **potential energy**. The twisted band's **potential energy** is then transferred back to the container in **kinetic energy** as it unwinds.

The energy transfer is due to a weight attached to the elastic band. This weight is pulled down by gravity, but it is also subjected to the twisting force from the elastic band. As long as the weight is greater than the twisting force on the band the elastic band will continue to twist. When the **kinetic energy** is mostly transferred to **potential energy** (to the elastic band) the bottle or can will stop rolling allowing the elastic band to untwist. However, because the weight is in the middle of the band only the end loops will unwind, causing the can to roll backwards.

This activity is useful for addressing some misconceptions such as: *Something not moving cannot have energy* (**potential energy** is energy **stored** in an object **due to position**); *An object has potential energy only when it is not moving* (**potential energy** depends on an object's **position**, whether it is moving or not); *The only type of potential energy is gravitational* (there are **other forms** of **potential energy**, such as **elastic potential energy** and **chemical potential energy**).

Suggested approaches:

- The **Obedient Bottle** may be carried out in two parts: before the session prepare the bottle or can. Have the bottle totally covered so that the students just see a cylindrical container. Gently roll it on the table for the students to see what happens – do not let them handle it. Continue rolling it as the students hypothesise as to what is happening. Depending on the class you may now decide to let them make their own Obedient Bottle so that they can test their hypotheses.
- Alternatively you may decide to let the students experiment with the prepared bottle, encouraging them to be observant and explain to you what they see and why the bottle behaves in this way.

Equipment required:

- Plastic bottle (any soft-drink size is suitable) with top, or a cylindrical, Pringles© tube-type container with a lid (again any size is suitable)
- Length of string – slightly longer than the length of whichever container is being used
- Metal nuts or washers (size depends on width of bottle/container)
- Two paper clips/two matchsticks
- Elastic bands
- Hook, such as a crochet needle (one can be fashioned using a large paperclip)
- Scissors or knitting needle, for boring holes in the container lids

What to do:

USING A CYLINDRICAL CONTAINER, E.G. A PRINGLES© TUBE

1. Carefully punch a hole in the centre of both the lid and the base of the container as shown in **A** below.
2. Slip the elastic band into the nut and tie a knot as shown in **B** below.
3. Using a paper clip or matchstick to keep it in place, insert the elastic band through the hole in the base as shown in **C** below.
4. Using the hook, pull the elastic band up to the top of the container and through the lid of the container as shown in **D** below.
5. Put the lid on the container and secure the elastic with the other matchstick or paperclip.
6. Cover the can completely with paper, ensuring that all signs of elastics and matchsticks are concealed. This will be the demonstration can prepared before class.

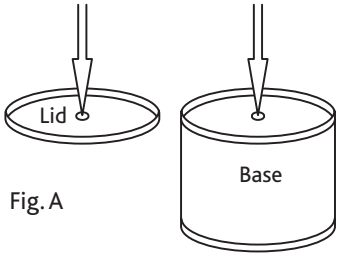

Fig. A

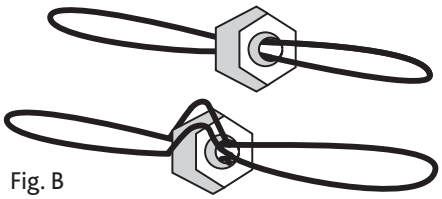
Fig. B

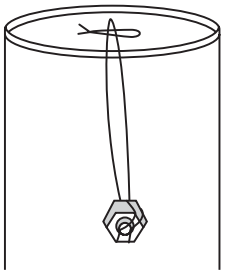
Fig. C

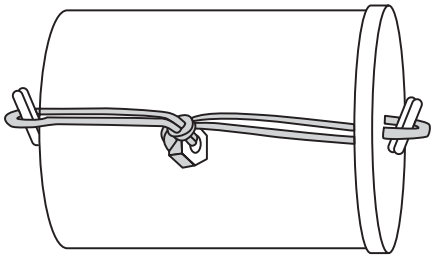
Fig. D

USING A CLEAR PLASTIC BOTTLE

1. Remove all labels from the bottle.
2. Carefully punch a hole in the centre of both the lid and the base of the bottle as shown in **A** above.
3. Slip the elastic band into the nut and tie a knot as shown in **B** above.
4. Make a neat cut in the side of the bottle to insert the elastic band with the nut.
5. Carefully attach one end of the elastic band with a paperclip or matchstick to the lid as in Figure **E**.
6. Pull the other end with the hook through the hole in the base. Secure it using the other paperclip or matchstick and seal with tape as shown in **E** above.
7. Check if the nut/washer is touching the side of the container. If it is then you will need to use a shorter elastic band.
8. If making two bottles, instead of a bottle and a can, conceal what is happening in the demonstration bottle by covering it with paper or painting the outside and covering the lid and base carefully with opaque tape.

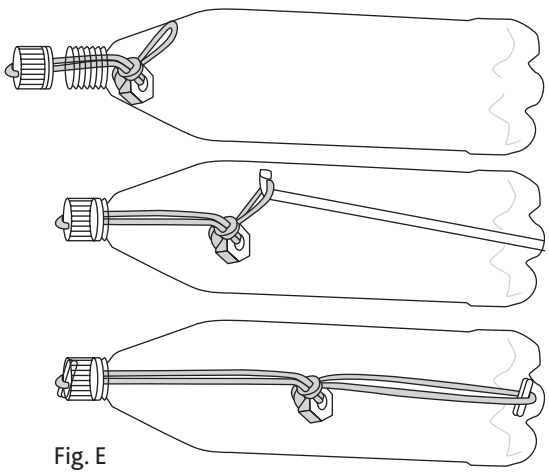
Fig. E

A useful video on the construction of the bottle is available at http://www.stevespanglerscience.com/lab/experiments/magic-rollback-can-sick-science.

Questions to promote discussion:

1. What do you expect to happen within the bottle/can if you roll it on a flat surface?
2. How could you observe and record it in action?
3. What happens when you roll the bottle/can?
4. Can you explain why?
5. How does this compare with your predictions?
6. What energies are involved?
7. What do you think might happen if there was no nut?
8. Does the position of the nut make a difference to the behaviour of the bottle/can?
9. How do you think the bottle would roll if the nut was positioned as shown in Figure 2?

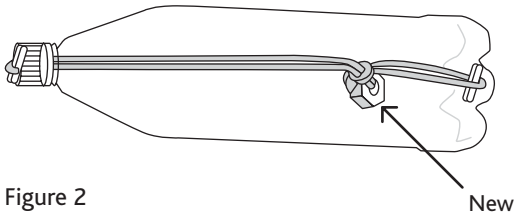

Figure 2

Click here to explore an interesting interactive site for the students in preparation for the remaining questions.

10. What do you expect will happen if you roll the bottle on an inclined surface?
11. Are there any other forces in action if you use an inclined surface?
12. Does the rise of this inclined surface make a difference to the outcome?