UNRAVELLING PHYSICS THROUGH SIMPLE EXPERIMENTS

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A great deal of science can be explained through simple experiments, performed at home, using locally available and low-cost material. Similarly, science can also be discovered by questioning a phenomenon or incident. This article presents a few simple but exciting experiments that can be used to understand some foundational principles in physics.

Science is fun

We often come across phenomena that leave us with a feeling of astonishment or wonder. Questioning the science behind them can make our observation of these phenomena far more enjoyable and also result in learning. Similarly, concepts in science textbooks can be brought to life in classrooms through simple experiments using a variety of locally available low-cost materials. Such teaching learning experiences create excitement in students, enhancing their interest and understanding of concepts.

We present a few such experiments here, which you could perform in the classroom or encourage students to perform at home. Each of these experiments will help students reflect on the underlying science and, in the process, learn a great deal of science themselves.

Experiment 1: Lazy stick

Take two identical wooden sticks (or aluminium/pvc pipes), each of about 1m length and 2cm width. Hold both sticks together, pointing vertically upwards but slightly inclined (refer **Fig. 1a**) and let go of them at the same time. You will observe that both sticks drop to the floor at about the same time.

Now tie a small weight of about 250g or a stone to the upper end of one of the sticks. Then, hold them together like before, with the weight or stone on top, and, again, let go of them simultaneously (refer **Fig.1b**).

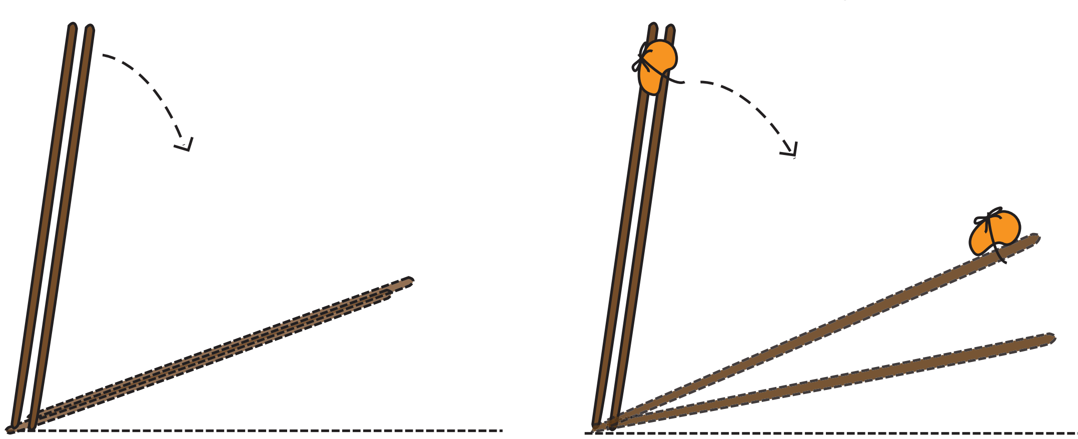

Fig. 1. Why is the stick with a weight a lazy stick?

a) The sticks reach the ground at the same time.

b) The stick with the weight attached to it reaches the ground later.

You may think that the stick with the weight attached to it will reach the floor first. But exactly the opposite happens. Why?

What's going on?

This unusual observation can be explained by a property of matter called 'Inertia'. Inertia is the tendency of an object to resist any change in its position or state of motion.

In the experiment, each stick is undergoing rotary motion, pivoting on a point resting on the floor. The kinetic energy and momentum with which each stick falls to the ground depends upon its moment of inertia. And the moment of inertia, in turn, depends upon the distribution of mass within the stick and the position of the axis along which the stick pivots.

How do we calculate the moment of inertia of each stick? By using the standard formulae: $I = \sum mr^2$, where I = moment of inertia, m = mass of each particle within the stick, r = the distance between that particle and the point at which the stick pivots along its axis, and $\sum$ indicates the sum of each of the values of mr^2 that we obtain for the entire stick.

Based on this relationship, it becomes evident that the stick with a weight tied to it will have a greater moment of inertia than the one without. The moment of inertia can be thought of as representing the stick's resistance to its angular velocity in rotational motion. Therefore, a higher value for the moment of inertia will mean greater resistance to motion, or, in other words, slower rotational motion — which explains why the stick with the mass tied to it, falls slower than the one without.

Explore this concept!

What would happen if you repeat this experiment but with sticks of two different lengths? Or with a weight tied at the centre or at the bottom of one stick rather than to the top? Can you predict the conditions under which the two sticks — one with a weight attached to it — will fall to the ground at the same time?

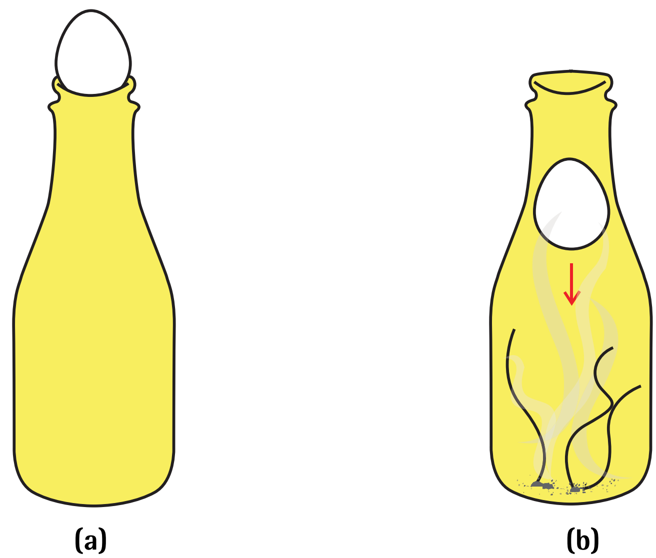

Fig. 2. Why does the egg shrink? a) The peeled boiled egg remains balanced on top of the bottle. b) The egg slips into the bottle immediately after the flame of the paper extinguishes.

Experiment 2: Shrinking Egg

Choose a glass bottle with an opening that is of a diameter (of about 4cm) a little smaller than an egg (about 4.5cm). Peel the shell off a boiled egg. Now, place this egg on top of the bottle. As expected, the egg will remain balanced there, and not drop into the bottle (refer **Fig. 2a**).

Now remove the egg from the top of the bottle, and put a piece of burning paper inside the bottle instead. As soon as the flame dies out, place the egg on the top of the bottle again (refer **Fig. 2b**).

While you may think that the egg will stay balanced on top of the bottle, it gradually slides into the bottle! Why?

What's going on?

When a burning piece of paper is put inside the bottle, it heats up the air inside. The hot air expands and some of it escapes out of the bottle. This reduces the amount of air inside the bottle. When the egg is put back on top of the bottle immediately after the flame extinguishes, it seals the bottle, preventing any more air from escaping or entering the bottle.

What happens next can be explained through a gas law called Gay-Lussac's law, which states that for a constant volume, the temperature of a gas is directly related to its pressure. Why does this matter? With time, the air in the bottle starts cooling. Since the sealed bottle has a constant volume of air within it, a drop in temperature leads to a drop in air pressure.

The reduced air pressure in the bottle acts both on its walls and that part of the surface of the egg that seals the bottle's opening. But the rest of the egg, which remains exposed to the air outside, continues to experience normal atmospheric pressure. As a result of this imbalance, the higher atmospheric pressure exerts a differential force downward that pushes the egg into the bottle. With the egg no longer sealing the bottle, air from outside rushes into the bottle and balances the pressure within and outside.

Explore this concept!

What would happen if you repeat this experiment but instead of dropping a piece of burning paper, pour some hot or cold water into the bottle?

Experiment 3: Hiding Balls

Take a tin can with an open lid. Tie two highly stretchable and small elastic rubber bands at the bottom of the can. To the free end of each of these bands, attach steel balls (with a weight of about 100g). Let the two balls hang outside the can (refer **Fig. 3**).

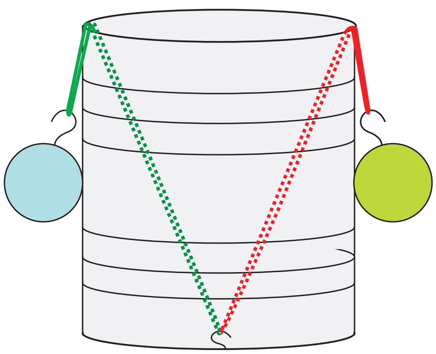

Fig. 3. Why do the balls hide within a free-falling can?

You will notice that the balls continue to dangle outside as long you hold the can. Would things change if you were to suddenly drop the can with the balls into free space?

While you may expect the balls to remain outside the can, you will observe that the elastic rubber bands suddenly retract and the balls go inside the can. Why?

What's going on?

When the can is held in hand, each ball experiences a gravitational force that stretches the elastic bands on both ends. This keeps the balls hanging outside the can. But when you drop the can, the free-falling balls, as well as the can become weightless. The weightless falling balls can no longer exert the force needed to stretch the elastic bands. The elastic bands retract and, as a result, the balls go inside the can.

Conclusion

Our quest to understand natural phenomenon arises from an inherent curiosity that we all possess. Through these simple experiments, we've looked at how day-to-day phenomena can be understood better by an appreciation for the science behind them. This can be extended to the science classroom, with teachers using experiments to create exciting and motivational hands-on learning experiences. Science is, after all, best understood by doing and discovering. Encouraging students to use the scientific method – including observation, questioning, experimentation, and analysis of data to draw conclusions – can only result in a better understanding of concepts. As science educators, therefore, our role is of paramount importance – go ahead and explore the science of other such phenomena!

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