

6.3. Inertia Demonstrations²

Pen and Embroidery Hoop

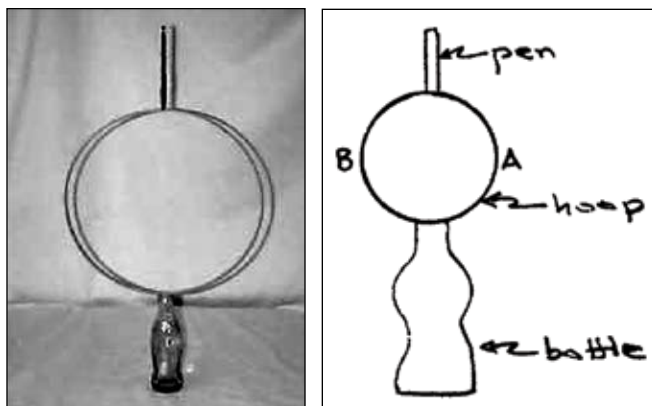


Fig. 6.3. Bottle, Hoop, and Pen Setup for Demonstration of Inertia³

Description

Balance the inner ring of an embroidery hoop on top of a bottle, such as a glass soft drink bottle. Remove the cap from a plastic pen that has a larger barrel with a FLAT end. Balance the flat end of the pen barrel on top of the hoop. When the hoop is snatched from under the pen, the pen falls down into the bottle.

Discussion

Inertia causes the pen to tend to remain at rest as the embroidery hoop is removed. If the hoop is snapped out quickly enough, the pen will remain in place and drop straight down into the bottle.

To keep the pen *almost* stationary, remember that

$$\Delta p = m\Delta v = F\Delta t$$

$$\text{Make } \Delta t \cong 0 \text{ to get } \Delta v \cong 0$$

To keep the base of the pen from being pulled sideways, the hoop is hit (or grabbed) on the *inside* of the loop. This will elongate the hoop horizontally enough to reduce the friction. If the hoop is hit on the outside, the hoop will elongate vertically, which exerts a slight upward force on the pen causing it to tumble upward and miss the bottle on the way down.

Hints for This Demo

- The outstretched finger(s) must hit (or grab) the *INSIDE* edge of the embroidery hoop quickly and fairly hard. The demonstrator should try to hit the hoop just below B (about 8 o'clock) if right handed and just below A (about 4 o'clock) if left handed.
- The most difficult part of this demo is balancing the pen. A pen that has a large, flat end will make the balancing easier. Once a good pen has been found, store it with the bottle for future use. A flat-headed nail can also be used and is easier to balance.

- When storing the ring for next year, put it back into the outside ring and tighten the screw. This will keep the inner ring from warping while stored. Several extra embroidery hoops should be on hand because students will want to try the experiment. The natural tendency is to hit the hoop very hard on the outside (if they have not been told the “trick.”) Hitting the hoop this hard often breaks it.

How To Present This Demo

Before doing the demonstration, challenge a student to remove the embroidery hoop with one hand and have the pen drop into the bottle. If the student has not seen the demonstration before, she will invariably hit the outside of the hoop causing the pen to miss the bottle.

Equipment Needed for This Demo

- Glass bottle such as a soft drink bottle
- Inner ring from an embroidery hoop (have extras—they sometimes break)
- Pen with a wide flat end or flat headed nail

Other Inertia Demonstrations

Below are two alternate demonstrations taken from G.D. Freier and F.J. Anderson, *A Demonstration Handbook for Physics*, ©AAPT 1996.

(A) A slender steel cylinder is placed on end onto a sheet of paper. The paper is jerked out without upsetting the cylinder.

(B) Instead of the cylinder, one may use a dinner setting on a tablecloth. The tablecloth must have no seam on the back end that slides under the dishes.

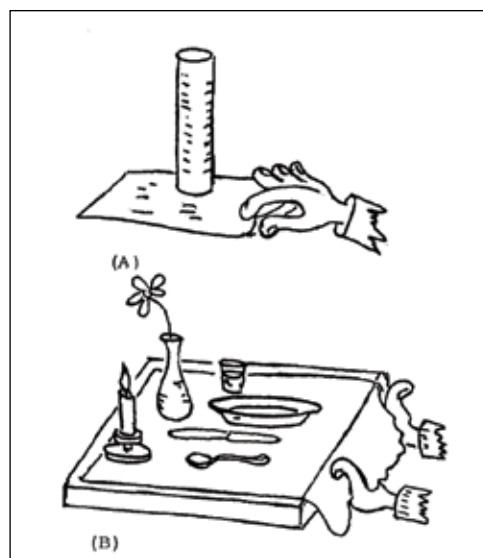


Fig. 6.4. Two More Inertia Demonstrations

Teacher's Notes

Demonstration (B) works much more easily if satin cloth or flannel-backed vinyl is used because both are very smooth.

Also, instead of just pulling with the hands as shown, wrap the edge of the cloth around a meterstick, put both hands on the meterstick, and jerk very quickly downward. A fast jerk with only the hands may wrinkle the fabric which will cause a fold to topple some of the items. (It may work better to have the back edge of the fabric just barely past the dishes while doing initial trials.) Use items as massive as possible for they have more inertia to cause them to stay at rest while the cloth is jerked from underneath, but remember that friction is also proportional to weight. If a glass or vase is used, fill it about halfway with water for increased inertia. If the dishes seem to “stick” to the tablecloth, spread some baby powder on their bottoms, then brush off lightly.

The demonstration can be repeated using paper cups and paper plates to show the effect of mass in this demonstration.