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Celt Spoon

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Introduction

When an oblong, boat-shaped object—known as a celt, rattleback or wobblestone—is rotated about its vertical axis in a particular direction, it will stop rotating, begin oscillating, and then spin in the opposite direction. Here's how to construct your own mysterious celt from an ordinary spoon.

Science Concepts

- Conservation of energy
- Rotational motion
- Moment of inertia

Materials

Spoon, metal (teaspoon or tablespoon)

Smooth tabletop

Pliers

Safety Precautions

Please follow normal laboratory safety guidelines.

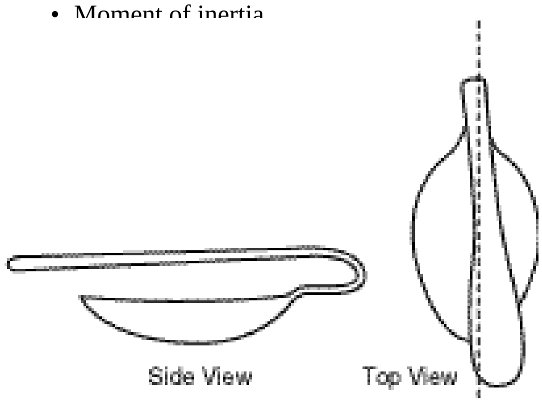

Figure 1. Bent Spoon Handle

Procedure

1. Obtain an old metal teaspoon or tablespoon.
2. Using pliers or your hands, bend the handle of the spoon so that it folds over the bowl of the spoon. Refer to Figure 1. When the handle is properly bent over the bowl, the spoon should remain balanced on the middle of the curved bottom of the spoon.
3. Once the spoon handle has been adjusted so that the spoon remains balanced while resting on its curved bottom, bend the handle of the spoon so that it is slightly skewed from the invisible center line running the length of the spoon's bowl (refer to Figure 1). Bend slightly and make sure the spoon remains balanced on the curved base.
4. Place the bent spoon on a smooth tabletop.
5. Give the spoon a small downward nudge at the bend in the handle so that it will begin to rock back and forth along the length of the spoon. What do you observe? (The celt spoon wobbles for a moment and then begins to spin counterclockwise.)
6. Next, spin the spoon clockwise. What do you observe? (The celt spoon spins clockwise for a short time, stops and wobbles up and down along the length of the spoon, then begins to spin counterclockwise.)
7. Spin the spoon counterclockwise. What do you observe? (The celt spoon continues to spin counterclockwise.)

Tips

- Carefully and evenly spin the spoon so that it remains level and even initially.
- Larger-bowled spoons work better because they have a more stable base.
- For a more stable celt spoon, bend the handle so that it is directly above the bowl of the spoon to create a low center of gravity for the celt spoon. The lower the center of gravity, the more stable the celt spoon will be and the easier it will be to spin it effectively. Pliers may be necessary to get a good bend in the handle.
- If the spoon handle is slightly skewed to the left of the invisible center line of the spoon's bowl (opposite to bend shown in the Top View of Figure 1), the "natural" rotation of the celt spoon will be clockwise.
- For more information on the mathematics of the celt, please refer to the web site: www.autolev.com/WebSite/SampleProblemRattleback/Rattleback.html (accessed March 2002).

Discussion

A celt's mysterious behavior is the result of frictional forces acting on a complex, non-uniform surface. The mathematics of the observed behavior of a celt are complicated and still not fully understood. However, it is known that a celt must have three characteristics for it to perform its unusual act.

First, the curved bottom of the celt cannot be perfectly spherical. That is, the bottom must have two different radii of curvature. Spoons have a long radius of curvature along their length and a shorter radius of curvature along their width. This produces a shape known as an ellipsoid (a three-dimensional ellipse).

The second characteristic of a celt is that the mass distribution along the two horizontal principal axes of inertia must be different. Since the metal used to make the spoon is uniformly distributed, there is more mass in a section running along the length of the spoon than a section across the width of the spoon. Therefore, a spoon's bowl satisfies the second characteristic of a celt.

The final characteristic necessary to produce celt-like rotation is that the principal axes of inertia must be slightly skewed from the axes of symmetry of the celt's curved base (see Figure 2). This characteristic is created when the bent spoon handle is positioned slightly off-axis from the center of the spoon's bowl. This affects the spoon's final moment of inertia, or its effective resistance to a change in its state of rotation.

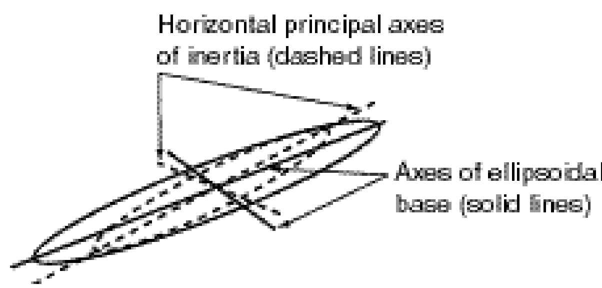

Figure 2

A rotating celt is an excellent example of how different types of energy can be transformed from one type to another. Kinetic energy is the energy of motion. The celt experiences two types of kinetic energy—rotational kinetic energy and vibrational kinetic energy. When the celt is spun it has rotational kinetic energy. Frictional forces act on the ellipsoid bottom of the celt, and act against the direction of the spin (producing what is known as a torque on the spinning celt). On a perfectly spherical bottom, the frictional forces act antiparallel to (directly against) the spin in the horizontal direction. However, because of the ellipsoid shape and asymmetric mass distribution, the frictional forces will not always act in the antiparallel direction to the spin. The forces may be skewed slightly, thus allowing part of the frictional forces to act in other directions perpendicular to the spin, including the vertical direction. Therefore, if a celt is spun in the appropriate direction, the frictional forces transform the initial rotational energy into vibrational energy. The celt stops rotating but continues to vibrate up and down along the length of the spoon's bowl. The frictional forces continue to act on the irregularly shaped bottom and turn the vibrational up and down motion into rotational motion—in the opposite direction to the initial spin. The celt will continue to spin in this "natural" rotation until friction causes it to stop completely.

A *Celt* is available from Flinn Scientific, Inc.

Catalog No.	Description	Price/Each
AP1972	Celt	Consult Your Current *Flinn Catalog/Reference Manual.*