Backyard Ballistics Teachers Guide

Lesson Plan: Spin Stabilization

Objective:

How do engineers get rockets to fly straight? A stable rocket flies in a straight line, while an unstable rocket constantly turns its nose away from the intended flight path. This lesson plan investigates one important method that aeronautical engineers and scientists use to keep rockets on target. This method is called spin stabilization.

Concepts:

A rocket designer must determine two important locations on a rocket body before actually building and launching the rocket. The first location is called the “center of gravity”. The center of gravity is the simply the point where if you placed it on a fulcrum, the rocket would be balanced; that is, it would not tip one way or the other.

The second important location is called the center of pressure. The CP is the point where all aerodynamic forces acting on a rocket are in balance. This is a much harder point to find. Usually, wind tunnel testing and computer simulation are required to pinpoint the CP.

For a rocket to be in balance and fly in stable flight, the Center of Pressure must always be behind (to the rear of) the Center of Gravity. But because the weight of a rocket is constantly changing as fuel is burned, it is very difficult to make any accurate calculations.

In chapter three of Backyard Ballistics (Chicago Review Press, 2001) there are directions for building a water rocket, which is a soda bottle filled with water and pressurized. When the stopper is released, water shoots out of the back. In this experiment, you will find that the longer that you can make the rocket fly without tumbling and swerving, the higher it will go. How can that be done without wind tunnels and changing the shape of the soda bottle? With a technique called “spin stabilization”.

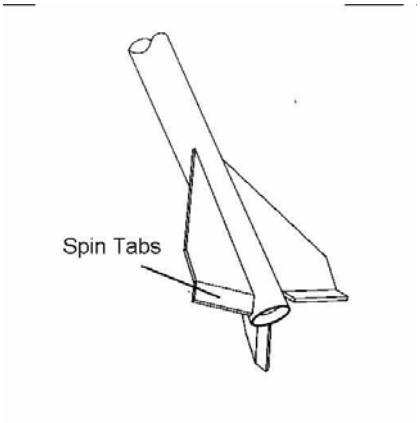
Instead of the modifying the rocket body to keep the CP behind CG, spin stabilization corrects instability by creating angular momentum. Angular momentum makes spinning objects inherently stable – think of a bicycle or a spinning top or a gyroscope. The spinning action cancels out any unbalanced forces acting on the rocket.

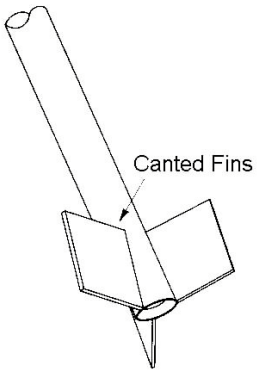
Field Work

In this project, we will use spin stabilization to increase the altitude performance of the water rocket. Build the water rocket as explained in chapter 3 of the book **Backyard Ballistics** by William Gurstelle (Chicago Review Press, 2001).
Other materials required, besides those listed in chapter three of Backyard Ballistics:

- Additional cardboard or thin wood for fin material
- Tape, glue, or cord for attaching the fins to the bottle.
- Field protractor for measuring angles (described in chapter 3 of Backyard Ballistics).

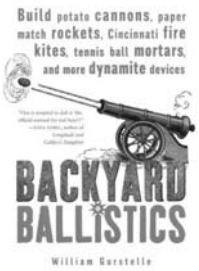
To spin stabilize a water rocket:
Method 1: Make fins out of cardboard or wood and attach them to the rocket body using whatever combination of tape, glue, and cord that seems to work best. To make the rocket spin, cant the fins, that is, attach them at an angle (the same angle for each fin). Then the rocket rises, it canted fins will induce a spin.
Method 2: Make straight fins out of cardboard or wood, but attach angled tabs to the bottom of each fin. These are called "spin tabs"





Ideas for Further Field Work
Fins can be designed in a variety of ways. Students can add or reduce the number of fins. It may be instructive to try various angles of cant to see which gives the best performance. The location of fin attachment can be varied and optimized as well.

Backyard Ballistics (ISBN: 1556523750) is available from most bookstores, online, and from the publisher
Sales: orders@ipgbook.com


Build potato cannons, paper match rockets, Cincinnati fire kites, tennis ball mortars, and more dynamite devices
BACKYARD BALLISTICS
William Gurstelle