Backyard Ballistics Teachers Guide

Lesson Plan: Catapult Physics

Objective:

This lesson plan combines history and physical science. The objective is to apply Hooke's Law and to show that science, history, and culture are closely interrelated and impact each other. Understanding history helps the comprehension of science and vice versa.

Concepts:

Catapult Taxonomy

Catapults are machines that were used by ancient civilizations to hurl projectiles in battles. Sometimes catapults are referred to as "ancient artillery". There are four types of catapults, categorized by how they are powered.

- Torsion Catapults use the energy stored in a twisted rope coil to turn a throwing arm.
- Tension Catapults use the energy contained in the fibers of a bent flat spring (like a bow from a bow and arrow) or elastic band (like a spear gun) to throw a rock or bolt.
- Traction Catapults are human powered. They generally used leverage to allow a person or group of people to throw a large rock.
- Gravity powered Catapults also use leverage, but substitute a heavy weight for human muscles.

Hooke's Law

The amount of force stored applied to a suddenly released projectile from a spring is a linear function directly related to how far the spring is twisted or deflected. This is called Hooke's Law and is:

Equation 1: $\text{Force} = K \times \Delta$, where

K is the spring constant unique to the spring's material

Δ is the deflection of the spring.

This equation tells us that distance to which a catapult will shoot its projectile is directly proportional to the number of twists in the rope coil spring for a torsion catapult and is directly proportional to how far the bow is flexed in a tension catapult

Field Work

We will use Hooke's law to determine the spring constant in a torsion powered catapult. Build table top model catapult in accordance with the instructions found in chapter 5 of the book Backyard Ballistics by William Gurstelle (Chicago Review Press, 2001).
Other materials required, besides those listed in chapter five of Backyard Ballistics:

1. Tape measure
2. Graph paper

To determine the spring constant (K)

1. Set up the catapult and count and record the number of twists in the rope spring. Fire the catapult. Walnuts make good projectiles. Fire the walnut five times. Measure and record the distance the projectile is shot.
2. Tighten the rope spring a few turns. Fire the walnut five times and measure and record the distance the projectile is shot.
3. Repeat step 2 two or three more times.
4. Graph the average results on the graph paper, plotting distance in inches or centimeters on X axis and the number of twists in the rope spring on the Y axis.
5. The slope of the line represents the spring constant for the rope spring.

Questions:

1. Is the plotted line straight or curved? A straight line shows a linear relationship and a curved line shows a higher order relationship.
2. If the line is curved how do you account for that, since Hooke's Law is a linear relationship (Hint: the number of twists in a rope is not exactly the same as a simple linear spring deflection)
3. Which type of catapult could be built on the largest scale? (Hint: Gravity powered devices may be built on a very large scale)

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