

# Trebuchet

**Category:** Physics: Force & Motion

**Type:** Make & Take

## Rough Parts List:

3'	1/4" dowel
1	Nut, 5/16 or 3/8, or cork to thow
1	Baseboard, 2" x 4" x 8"
	Wood pieces, side verticals
	Wood piece for dowel intersection and bottle connection
1	Water bottle
	Kite string
	Wire, steel or thick copper
	Drill, 19/64" bit



**Video:** [http://youtu.be/r8\\_fvGG8jBg](http://youtu.be/r8_fvGG8jBg)

## A Closer Look:



Hook



Projectile



### Fine Points:

- The hook release may need to be fiddled with to get it just right. The loop should be small and curved just right so that the string does not catch as the trebuchet swings.
- The horizontal dowel needs to turn loosely in the center piece OR the vertical wood pieces. It should not let the long dowel move through loosely.
- Fancy slings can be constructed, but the easiest way to launch something is to connect the string to it, as is shown above, and launch the string together with the projectile.

### Concepts Involved:

- The trebuchet is powered by gravity; the heavier the bottle, the more force it will be able to give.
- The trebuchet is a lever with one side giving a force and the other side receiving a force. The lengths of the arms on each side will determine whether the force increases, decreases, or stays the same.
- An important factor is the position at which the string pops off the end of the throwing arm. For best distance, it should launch the projectile at 45 degrees from the ground.
- The length of the string is also important, to determine how far the weight is behind the throwing arm.

### Focus Questions:

1. How could you make the trebuchet throw farther?
2. What would happen if you made the arm twice as long?
3. Do you think it makes more sense to have a heavy arm or a light arm on your trebuchet?
4. What do you think would happen if you tried to throw something much heavier with the trebuchet?

### Elaboration:

A trebuchet throws things using the force of gravity. There is in theory no limit to how strong a trebuchet could be or how far it could throw, if it is built big enough. This makes it more formidable than a catapult. Trebuchets were used several hundred years ago to fight wars, especially wars in which one side was in siege inside a castle or fort.

A trebuchet has a throwing arm that is a lever. A lever has two sides and a pivot point called a fulcrum. The trebuchet's main weight is one end of the arm, and the throwing string is on the other end. How far the trebuchet throws depends on the length of these arms. In general, the larger the trebuchet, the longer arm it can have, and the farther it can throw.

The distance also depends on several other factors, such as the length of the string, the weight, the angle of the hook at the end of the arm, and the shape of the projectile, that is, the object being thrown. The throwing arm has to be strong, but if it is too heavy, it will take up some of the throwing force just to get it moving.

The release of a trebuchet's projectile is complicated. According to theory, for farthest flight, the arm should release at 45 degrees. But the trebuchet's arm is not going fast enough when it is at 45 degrees. A string is used to pull on the projectile, so that when the arm reaches 90 degrees and its fastest motion, it is still giving force to the projectile, and the projectile behind it flies off at 45 degrees.

### **Links to k-12 California Content Standards:**

#### Grades k-8 Standard Set Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other strands, students should develop their own questions and perform investigations.

#### Grades k-12 Mathematical Reasoning:

1.0 Students make decisions about how to approach problems:

- 1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
- 1.2 Determine when and how to break a problem into simpler parts.

2.0 Students use strategies, skills, and concepts in finding solutions:

- 2.1 Use estimation to verify the reasonableness of calculated results.
- 2.2 Apply strategies and results from simpler problems to more complex problems.
- 2.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
- 2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.

3.0 Students move beyond a particular problem by generalizing to other situations:

- 3.1 Evaluate the reasonableness of the solution in the context of the original situation.
- 3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
- 3.3 Develop generalizations of the results obtained and apply them in other circumstances.

#### Grade 2 Standard Set 1. Physical Sciences:

The motion of objects can be observed and measured.

- 1.b Students know an object's motion can be described by recording the change in position of the object over time.
- 1.c Students know the way to change how something is moving is by giving it a push or a pull. The size of the change is related to the strength, or the amount of force, of the push or pull.
- 1.d Students know tools and machines are used to apply pushes and pulls (forces) to make things move.

#### Grade 3 Standard Set 1. Physical Sciences (Energy & Matter)

- 1.c Students know machines and living things convert stored energy to motion and heat.
- 1.d Students know energy can be carried from one place to another by waves, such as water waves and

sound waves, by electric current, and by moving objects.

Grade 9-12 Physics Standard Set 1. Motion & Forces

Newton's laws predict the motion of most objects.

1.b Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's First Law).