

Work is equal to force times distance. The work put in on the effort side of the arm is always equal to the work done on the load side of the arm.

$$\frac{\text{Effort (E)}}{\text{work} = \text{force} \times \text{distance}} = \frac{\text{Load (L)}}{\text{work} = \text{force} \times \text{distance}}$$

$$f_E \times d_E = f_L \times d_L$$

Normally, our goal in using a lever is to decrease the amount of force that we need to apply on the effort side (f_E). We do this by increasing the distance that we apply this effort force (d_E) to, so that the product of ($f_E \times d_E$) remains the same.

But in the case of a trebuchet, our goal is to increase the velocity of the object, or load, in other words to increase the distance (d_L) that the load will travel in a certain amount of time. In other words, the load must be placed on the long arm of the lever and the effort (the counterweight) on the short end, making the distance that the effort is applied (d_E) small. Therefore, the effort force (f_E) must be large so that the product ($f_E \times d_E$) remains the same. In other words, an Inverse Type 1 Lever increases the force needed to do the work. But the sore muscles are worth it if the object is thrown faster.

The higher the ratio of the length of the projectile arm to the counterbalance arm, the greater the mechanical advantage and the faster the projectile will be thrown.

Most of the catapults and trebuchets over history were complex machines that became more and more complex over time. For example, wheels and axels were added to trebuchets so that when launched, the trebuchets could travel along a track rather than over-balancing themselves forward. Catapults often contained gears to apply maximum force to the elastic material attached to the arm.

MAKING THE MOST OF YOUR VISIT

Using This Guide

Before you visit, review the Essential Questions to see how the Inventor Center's educational themes connect with your curriculum. Identify what you would like your students to learn from the Inventor Center and how they could continue learning back in the classroom.

This Guide includes Activities for Before Your Visit, During Your Visit, and Back in the Classroom.