CALIFORNIA STATE SCIENCE FAIR
2003 PROJECT SUMMARY

Name(s)
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Project Number
J0210

Project Title
The Medieval Trebuchet: An Experiment in Ancient Applied Mechanics and Ballistics

Abstract

Objectives/Goals
I re-created a small Trebuchet, an ancient siege engine from Medieval Europe. I hoped to be able to duplicate the function of ancient examples, in accurately firing projectiles high enough to clear a hypothetical castle wall (+/- 25 feet) and far enough (+/- 150 feet) to be out of arrow range. I hoped to be able to study the ballistic signature or flight path taken by the projectiles fired, and to be able to make precise mechanical adjustments which would improve both its range and accuracy.

Methods/Materials
I built my trebuchet out of wood, with some metal parts. The counterbalance weight is lead, a ball-bearing pillow block on a steel axle forms the fulcrum of the pivot beam. Water balloons standardized at 1/2 lb. weight gave the most consistent results and best ballistic signature.

Results
I built three different trebuchets, each one an improvement on the one before, with mechanical changes to the basic design made as the result of direct observation of ballistic signatures from approximately 200 individual test-firings. The first (Mark I) Trebuchet barely functioned at all. The second (Mark II)Trebuchet unfortunately fired backwards almost as often as forwards; when it worked, its ballistic signature was high and short (well within arrow range of a hypothetical castle's defenders). The third and final (Mark III) re-designed Trebuchet finally fired a low and long ballistic signature (around 30 feet high and up to 170 feet long), similar to that of ancient examples.

Conclusions/Discussion
I discovered that the most important mechanical principle governing the range and accuracy of my trebuchet was release timing; this is the point at which the trebuchet "lets go" of its projectile. Different release timing results in widely different ballistic signatures. Premature release results in a backwards ballistic signature; early release results in a high and short ballistic signature; a perfect release near TDC (top dead center) results in a low and long or perfect ballistic signature; and a late release results in a low and short ballistic signature. What I learned through all of the test-firings, ballistic observation, mechanical modification and trial and error re-engineering of my Trebuchet was that you should only change one variable at a time in order to fine-tune any machine for increased performance.

Summary Statement
My project involved the recreation of a Trebuchet, an ancient Medieval European siege engine, that throws water balloons up to 170 feet with good accuracy.

Help Received
Father helped build Trebuchet, helps load it each time fired, took photos. Mother helped computerize hand-drawn tables. Science teacher Rickertsen reviewed and critiqued earlier versions of report and display board.