# CALIFORNIA SCIENCE & ENGINEERING FAIR
# 2018 PROJECT SUMMARY

**Name(s)**

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**Project Number**

38127

**Project Title**

## Optimal Ballista Launch Angle

**Abstract**

**Objectives/Goals**

Ballistas were weapons of war used to launch projectiles at enemy fortresses. Attackers would want to fire the ballista from as far away as possible, so the army would want to know which launch angle results in the projectile traveling the farthest distance. The hypothesis is: A 45° launch angle will maximize the distance traveled by the projectile.

**Methods/Materials**

A model ballista was constructed and a standard projectile was launched from angles ranging from 15° to 75°. A minimum of 10 trials were made at each launch angle and the distance that the projectile traveled was recorded. The data were tabulated and graphed and the mean and standard deviation were calculated. To test if the optimal launch angle remained the same under different conditions, the experiment was repeated using different string tensions with the standard projectile and then with projectiles of different weights keeping the string tension constant.

**Results**

In the first experiment, the 45° launch angle resulted in the farthest travel distance. Travel distances for launch angles of 30° and 60° were somewhat shorter, and travel distances for launch angles of 15° and 75° were much shorter. Changing the string tension with a constant launch angle of 30° changed how far the projectile traveled. In a later experiment, the distance traveled was once again farthest with a launch angle of 45°, but the travel distance was shorter for launch angles greater than 45° than for launch angles less than 45°. With a lighter projectile there was a lot of variability; there was no significant difference between the travel distance for launch angles of 30°, 45°, and 60°. A heavier projectile traveled a shorter distance but had less variability in the distance traveled.

**Conclusions/Discussion**

For a variety of string tensions and projectile weights, a launch angle of 45° produced the maximum average travel distance. However, for most conditions there was no statistically significant difference for launch angles between 30° and 45°. A launch angle of 60° resulted in travel distances that were shorter than those for 30°. This is not consistent with the idealized trajectory for projectile motion which predicts that the distance traveled for launch angles 30° and 60° will be the same. Therefore, if the objective is to maximize the distance traveled by the projectile, it is better to use a launch angle that is a little less than 45° rather than a little greater.

**Summary Statement**

This project evaluated ballista launch angles for a variety of conditions and determined that launch angles of 45° or a little less resulted in the longest projectile travel distance.

**Help Received**

This project would not have happened without the help of the McWilliams family who ordered the ballista kit, helped me assemble it, and supported me during the experiments.