First Last

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Catapults and their Arms

Abstract

This experiment was conducted to learn about the affect of the radius of the rotating arm of a catapult on the distance the projectile travels. A catapult was built to launch a projectile from various places on the catapult arm to test this. The bean bag (projectile) was launched from each point on the arm. Because distance is easily measured and directly related to velocity, the distance the projectile travels each time was recorded, graphed and analyzed to test the hypothesis. The data showed that the farther the bean bag was place from the axis, the farther it traveled.

Introduction

In the ancient Roman times they used catapults for warfare. There were specific engineers to alter the catapult to shoot however far they wanted the projectile to go. The changes may have been to the spring, the base, or the arm. These changes were made to perfect the distance the projectile traveled. This can be replicated today to answer the question: How does the radius of a rotating arm of a catapult affect the distance its projectile travels?

In order to understand how the length of a catapult arm affects the distance of its projectile, one must first understand some key words and history related to this problem. First, one must understand that the projectile of a catapult has tangential velocity when launched. "The concept of tangential velocity is based on the fact that if were to suddenly release the rotating object from its orbit it would fly off at a tangent." (Angular Quantities). Tangential velocity is related to the radius. The smaller the radius the smaller the tangential velocity (Angular Quantities). Catapults were first created specifically for warfare, and perfected to be very efficient weapons. "During the middle ages, many weapons were created to help...in the winning of battles. As the castle walls became higher and stronger, a new way had to be invented to destroy them. One such weapon was the siege engine called a catapult." (Tevnane). Catapults were very efficient. They could be used to defend one's castle or destroy another's. They were also very mobile, and a useful weapon of war (Tevnane). When the catapult launches its projectile, the projectile has tangential velocity. The catapult is a very useful weapon of war.

In order to further understand how the length of a catapult arm affects the distance its projectile travels, one must first understand the background of scientists and other research done on this topic. There is some confusion of who invented the catapult. Catapults were first invented under the reign of Dionysus (Lahanas). Some people think Archimedes invented the catapult, but they were actually invented by Greek engineers (Lahanas). Some high school students did an experiment very similar to this one. Their hypothesis was: If the arm is shorter, then the velocity will be higher (Cooley). But, they found that the longer the arm of the catapult, the more velocity, therefore the projectile traveled farther (Cooley). This would prove to be very helpful information for the Greek engineers long ago.

Methods

This research will attempt to find if the length of the catapult arm affects the distance the projectile travels. If a projectile is placed at various distances from the axis of a rotating arm of a catapult, then the projectile will travel father(when launched) when place farther from the axis because the tangential velocity increases as the radius increases (tangential velocity is the velocity of an object rotating around a fixed point; released at any given time. Using various pieces of plywood, screws, nuts, bolts, and springs, a catapult was constructed with three different launching blocks. Then a bean bag was used as the launching projectile from the launching blocks. Using the catapult that was constructed, the bean bag was launched five times from each of the three launching blocks. The distance the bean bag traveled each time was recorded, and then compared in a graph. The plywood is very reliable and strong and a bean bag doesn't bounce, creating a good catapult and projectile. Five trials were conducted to provide a sufficient amount of data to compare.

Results

As shown in the graph, as the radius of the arm of the catapult increased, the distance the beanbag traveled also increased. This proves the hypothesis was correctly stated as: "If a projectile is placed at various distances from the axis of a rotating arm of a catapult, then the projectile will travel father (when launched) when place farther from the axis because the tangential velocity increases as the radius increases (tangential velocity is the velocity of an object rotating around a fixed point; released at any given time."

In Trial 1, with the first launching block (14 inches from the axis) the bean bag traveled 80.5 inches. Using the second launching block (22 inches from the axis) the bean bag flew 128 inches. The launch with the third launching block (29 inches from the axis) caused the bean bag to travel farthest, landing at 187 inches. This data proves the hypothesis to be correct. (See Appendix 1)

When Trial 2 was performed, with the 14 inch block the bean bag traveled 77 inches. With the 22 inch block the bean bag traveled 103 inches, and with the 29 inch block the bean bag traveled 187 inches. Again, the bean bag traveled farthest when the 29 inch block was used. This shows the hypothesis to be accurate.

During Trial 3, the results were very similar to previous data. Using the first block the bean bag traveled 75.5 inches, 124.5 inches with the second block, and 187 inches with the third block. The data again proves the hypothesis true.

While performing Trial 4, the bean bag traveled 82 inches when launched from the 14 inch block. When launched from the 22 inch block, the bean bag traveled 129.5 inches. With the 29 inch block the bean bag traveled 180 inches. Again, this data supports the hypothesis.

In Trial 5 the launch with the 14 inch block caused the beanbag to travel 68.5 inches. But when using the 22 inch block the beanbag traveled 129.5 inches. The beanbag traveled even farther from the 29 inch block, measuring 180 inches. This data helps prove the hypothesis valid.

Though all of the data proves the hypothesis to be correct, there is a slight possibility that error may have occurred. When the beanbag was launched the beanbag may have bounced slightly causing a minimal skew in the data. Another plausible source of error is the fact that the

catapult moves slightly when the beanbag is launched. If the catapult is not placed back in the exact starting position, the data might not be accurate.

It was found that the distance from the axis does affect the distance the projectile travels. As it was placed farther from the axis, the projectile had more tangential velocity. This cause the bean bag to travel farther (as shown in Graph 1).

Conclusion

During this experiment it was tested how the radius of a catapult arm affects the distance its projectile travels. While observing, the farther the bean bag was placed from the axis, the farther it traveled. This was because as the radius of a rotating arm is increased, its tangential velocity increases. To change these results you could instead test if the shooting angle of a catapult affects the distance the projectile travels. This might be some thing a mechanical engineer would like to research. Because they help manufacture and test all sorts of products, this might be helpful to them.

Works Cited

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Appendix 1

Data Table #1: Distance the Bean Bag Traveled

	Trial 1			Trial 2			Trial 3			Trial 4			Trial 5		
Inches from hinge to launching point	14	22	29	14	22	29	14	22	29	14	22	29	14	22	29
Distance bean bag traveled (inches)	80 ½	128	187	77	103	187	75 ½	124 ½	187	82	103	182 ½	68 ½	129 ½	180

Graph #1: The Distance the Bean Bag Traveled