Proof of Efficacy Document

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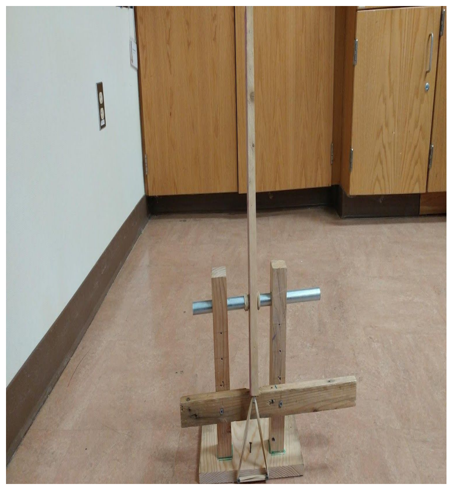
Photos:

Top



Front

Side

Description of the Design:

Our trebuchet features a 28 cm x 19.7 cm x 2.2 cm softwood base with two 28 cm x 3.8 cm x 3.8 cm softwood legs. There are 5 holes drilled into the front of the legs at 8 cm, 9.5 cm, 12 cm, 16 cm, and 20 cm. It's arm is approximately 56 cm long, 2 cm wide, and 4 cm tall with a 2 cm hole for the axle 12 cm from the front of the arm. The trebuchet has an aluminum axle 34 cm in length, 23 cm from the base, and 1.5 cm in diameter going through each leg. The arm has a flat head nail in the back end and a screw on the front end of it. We also have a 47 cm x 4 cm x 2 cm softwood arm stopper drilled in 9.5 cm from the base that stops the arm at 11 cm. Our trebuchet uses rubber bands to propel a projectile forward. We have two screws screwed 1.3 cm into the height of the base, both 10 cm from the edge of the base, that are 8 cm apart from each other. We hook 8 rubber bands onto the two screws and on the screw on the front end of the arm. The projectile, 10g in mass and with an 8 in. string, hooks onto a flat head nail tilted 60° upwards. Our trebuchet generally fires to around

35-40 meters, but our farthest distance is 52 meters. The back end of the arm is pulled down by a person and then released to fire the projectile.

8 Modifications:

1. **Location of Arm Stopper:** We tested the best location for our arm stopper to stop the arm. We found that the projectile should be released at about a 35° angle. For our specific trebuchet, an arm stopper 12 cm from the base released the projectile at this precise angle.

2. **String Length:** We learned that an 8 in. string was best for firing the projectile farther. The long string took longer to fire. This extra time provided more momentum for the projectile. The string wasn't too long though so it didn't drag on the ground and reduce speed. The 8 in. string worked well for our trebuchet.

3. **Arm ratio:** We used a 1:4 ratio for our arm. When we were using a smaller arm, we found that the projectile would not fire horizontally. We learned that we needed a longer arm. We experimented with a 1:3 and a 1:4 and found that the 1:4 fired farther.

4. **Length of Arm:** Our arm length was 56 cm. We found that a longer arm worked best for firing long distances. We wanted to have and arm that could fire quickly, but still needed to be long. We found that the 56cm arm worked best.

5. **Number of Rubber Bands:** We used 8 size 64 rubber bands. We found that the size 64 rubber bands store more potential energy and 8 was just the right number. We learned that 6 rubber bands was best, but we found out that our machine could handle more. Once we started transcending 8, however, the force of the rubber bands became too strong and started moving the base.

6. **Spacers on Axle:** On our trebuchet, we used two rubber bands on our axle on either side of the arm to prevent horizontal movement. This prevents the arm from moving horizontally, which puts all of the force into forwards and vertical motion. This fires the projectile farther.

7. **Mass of Projectile:** Our projectile has a mass of 0.00986 kg. This provides the right amount of momentum to build up, but doesn't make it too heavy to fire. We used some data from another group and found it worked very well.

8. **Size of Rubber Bands:** We used size 64 rubber bands. We tested the efficiency of our trebuchet when we fired using thin and thick rubber bands. We found that the trebuchet consistently fired farther when we used the thick rubber bands. We learned that this happened because the rubber bands can store more potential energy.

CLEAR Paragraph:

Our trebuchet launches a projectile further if the arm stopper stops the arm and releases the projectile at 35°. Our trebuchet purpose was to determine the optimum location for an arm stopper. We tested the trebuchet with a stopper located 4 cm from the base, 8cm from the base, 12 cm from the base, 16cm from the base, and with no stopper. We tried each location four times and found that the trebuchet consistently fired farther when the stopper was at 12cm from the base. We determined that the stopper released the projectile at 35°. This makes sense. The ideal release angle, with no friction, would be 45°. Since we do have friction here in the real world, the projectile would need to launch at a lower angle. When we tested the locations, the stopper 4 cm from the base fired 9-11m. The stopper 8 cm from the base fired between 12 and 13m. The stopper at 16 cm from the based fired between -1 and 6m from the base, and without a stopper, the trebuchet fired 11-13m. However, at 12cm from the base, the projectile launched between 14 and 22m. The projectile was released at just the right angle, 35°, to launch the projectile the farthest.

Technical Specifications:

Mass of Projectile	0.00986 kg	This describes the amount

		of matter in an object.
Time in Air	2.94 s	This is how long the ball was in the air.
Horizontal Velocity	13.95 m/s	This is the speed of the ball in the horizontal direction.
Vertical Velocity	28.812 m/s	This is the speed of the ball in the vertical direction.
Total Velocity	32.01 m/s	This is the total speed of the ball during its path.
Horizontal Distance	41 m	This is how far the ball traveled horizontally.
Vertical Distance	14.835 m	This is how far the ball traveled vertically.
Spring Constant	30.25 N/m	This is the tendency of a spring to go back to its original form.
Initial Spring Potential Energy	43.506 J	This is the energy stored by stretching or compressing an elastic object.
Kinetic Energy of the Ball	5.05 J	This is the ball's energy due to motion.
Percent Energy Converted	11.6%	The percentage of energy converted from potential to kinetic.
Angle of Release	35°	The angle in which the projectile is released.

Main Selling Points:

- The main selling point of our device is the distance. Our trebuchet fires really far. Although it mostly fires around 35-40 m, we have gotten it to fire 52 m. This is a really far distance for a trebuchet so small.

- Another advantage of our trebuchet is that it is small and portable. Granted, this was a requirement, it is still helpful.