The Knights Who Say NI

EGR 150-4264
Wake Tech Community College

Final Trebuchet Report

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Chapter 1

Final Design

1.1 Specifications of the Design

1.1.1 History of Design

Our design started as a rough SolidWorks sketch and has been modified extensively from it's inception. It was originally a three foot by ten inch platform with two three foot poles situated six inches apart in the center. This was quickly improved upon by making the base much larger, spreading the arms farther apart, and adding struts to help stabilize the trebuchet. We also added a guide area down the middle of the base for the sling to rest that will be greased before firing to reduce friction. Furthermore, we added a safety pin into the release pin to keep it from prematurely firing.

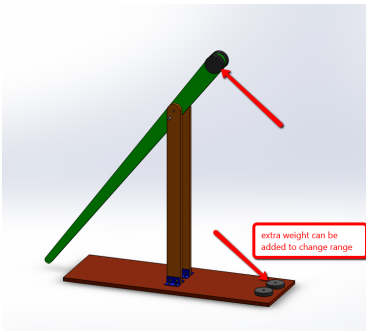

Figure 1.1: Original Isometric View

Moving on from the first design review we decreased the width of the main frame by 1 foot to decrease the stress on the bar serving as the fulcrum. We thought we needed additional stabilization to make up for this though so we added a small leg to each side to keep it from rocking side to side. We also added a floating arm with a counterweight bucket.

Figure 1.2: Design Review 2

Figure 1.3: Design Review 1

When it came time to build the trebuchet we reinforced a few key joints with small 2x4 struts and got rid of the side stabilizers when we realized that the trebuchet was extremely solid as it was. We also added a 2x4 across both short sides of the bottom to elevate the trebuchet off the ground for better positioning on uneven surfaces and to aid transportation.

1.1.2 Purpose of Design

We are using a floating counterweight without wheels design because of its ease of construction and lower cost compared to the more complicated spring and vertical designs. The floating counterweight trebuchet is slightly more complicated than its fixed counterweight brother but offers increased power and stability. The floating counterweight more efficiently imparts its energy into the projectile and less into the frame of the trebuchet.

1.1.3 Acceptance Criteria

Our trebuchet will be considered acceptable if it is able to consistently hit targets at 25, 50, and 75 feet out. It also needs to be able to be built for under $125.

1.2 Design Views

1.2.1 Size

Figure 1.4: Basic dimensions of the trebuchet

1.2.2 Remote Trigger and Safety of Use

The firing release pin has a cord attached to it, allowing the trebuchet to be fired from a distance. We also have a safety pin through the firing release pin to keep it from being inadvertently pulled and firing the trebuchet on accident.

Figure 1.5: Close up of Safety Pin on Firing Release Pin

1.2.3 Sling Design

The left side of the sling is attached to the stationary eye bolt on the bottom of the sling arm and the right side is attached to the ring around the sling release hook. The sling itself is a roughly 10 inch piece of material attached to the release cords on it's four corners.

Figure 1.6: Sling Rlease Mechanism

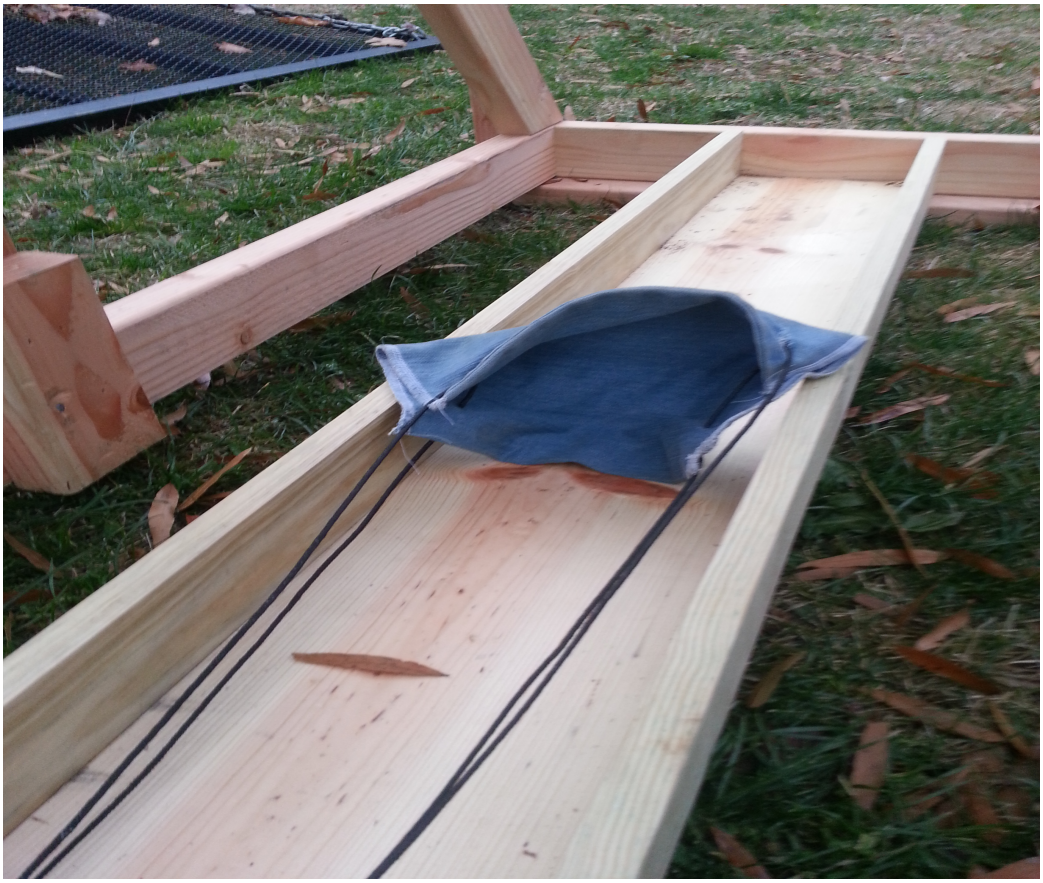

Figure 1.7: Close up of the Sling

1.2.4 Forces Operating Trebuchet

The counterweight is a floating bucket designed to swing freely. This motion helps transfer energy from the arm into the sling instead of wasting it in the frame. This also helps stabilize the design since less energy is imparted into the frame. The bucket allows easy loading and unloading of rocks, sand, or any desired counterweight. In our current configuration we will be using 10 pounds for 25 feet, 35 pounds for 50 feet, and 49.4 pounds for the 75 foot target.

Figure 1.8: Close up of the Counterweight Bucket

1.2.5 Launch Requirements

To prime the trebuchet we will pull the long arm down and attach the chain on the base to the arm using the firing release pin. We'll then place the safety pin into the firing release pin. After that, all that's left is to ensure that the payload is placed into the sling and that the sling is attached to the sling release hook.

Figure 1.9: Trebuchet in the Armed Position

1.2.6 Design Limitations

A couple of things are currently limiting our designs viability.

- Our trebuchet is pretty heavy which seems to be limiting it's efficiency a good bit. With a higher budget we would have constructed the long arm out of a lightweight metal tube to help shift the balance more towards the counterweight.
- In moving from a fixed to floating counterweight we didn't take in to account the added length of the floating arm. This could have thrown the throwing arm weight ratio off as well, limiting our efficiency unless we shorten the counterweight arm.

1.2.7 Label Placement

We had the firing and safety pin labels positioned on their respective ropes but they were destroyed by the forces involved in firing. We removed the safety pin label as it was obliterated; but the firing pin label survived so we taped it to the trebuchet on the side where the person pulling them would stand.

Figure 1.10: WTCC label

Figure 1.11: Firing Pin label

1.3 Documention of Build and Changes

We don't have a huge amount of pictures from construction as we got rather tunnel visioned on finishing before it got to late and forgot to take more pictures.

Figure 1.12: Building the Frame

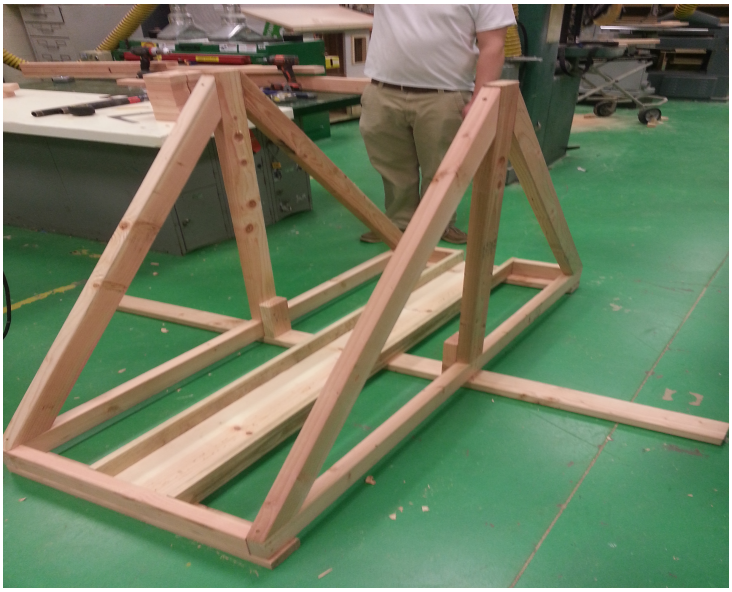

Figure 1.13: Added the bottom beam that we later removed

Figure 1.14: Added some more supports to critical joints

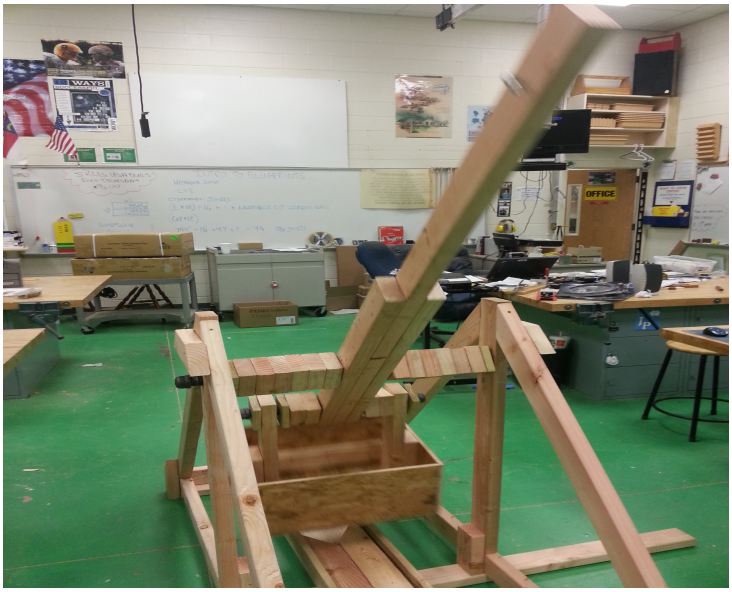

Figure 1.15: All put together and swinging freely

- Initial proposal dimensions are 3ft long x 1ft wide x 3 ft tall with a wheel-less fixed counterweight design
- This is quickly discarded and changed to 6ft long x 3 feet wide x 3'6" tall for stability
- Concerns about the strength of the fulcrum prompt the design being brought down to 2ft wide
- Side legs are added to gain stability that was lost in the transition from 3ft to 2ft in width
- The design is changed from a fixed counterweight to a floating counterweight to better facilitate energy transfer into the projectile while keeping it from making the frame unstable
- The weight plates originally planned as counterweights are replaced by rocks in a move to save a large amount of money
- This change necessitates the addition of a bucket to hold the new counterweights

- Donated items no longer factor into our budge, therefore we can use weight plates as counterweights again.
- At the time of construction, several small reinforcements were made to key joints.
- Also during construction, the decision was made to not use the side stabilizer feet previously designed, as the build was determined to be extremely solid.
- An adjustable sling release hook was designed and installed during the tuning process.

Chapter 2

Materials List and Estimated Cost

Table 2.1: Materials and Vendor Information

Building Materials List	**Amount**	**Total**	**Vendor**	**Prices**
1X4X8	5	40ft	Lowes	$14.00
2X4X8	10	80ft	Lowes	$40.00
Screw Hooks	1	1	Lowes	$1.00
Grip-Rite 1-lbs (Screws)	1	1-lbs	Lowes	$10.00
Screw Eye Hooks	4	4	Lowes	$5.00
Weights	60lbs	60lbs	Adam	$0.00
Metal Ring/ Circle	1	1	Lowes	$1.00
Grip-Rite 5-lbs (Nails)	1	1-lbs	Lowes	$2.40
Metal Rod	1	2ft long / 2in thick	Lowes	$10.00
Metal Rod	1	1ft long / 1in thick	Lowes	$11.00
Metal Bolt	1	1	Lowes	$2.00
ACA Beanbag	7	7	Adam	$0.00
Metal Pin	1	1	Lowes	$1.00
Large Strip of Cloth	1	1	Adam	$0.00
Rope	1	20 ft	Adam	$0.00
			Total:	$97.40

Chapter 3

Testing Plan

3.1 Design Validation and Meeting Acceptance Criteria

The design was initially validated by inputting the basic dimensions into a virtual trebuchet simulator on the Internet. In the simulation we were able to hit our target distances by varying the counterweight from 33, 45, and 60 pounds. In reality though it wasn't quite that simple. We used 10 pounds for 25 feet, 35 pounds for 50 feet and 49.4 pounds for 75 feet. Though there was fairly significant drift in distance thrown, these weights got us as close as we could to our target in the time we had available for testing.

Table 3.1: Testing Distance Averages

Distance	Average
25	22.3
50	50.2
75	74.7

Those averages are very close to the target distance; however, each test had significant outliers which could easily throw the actual value off one way or another.

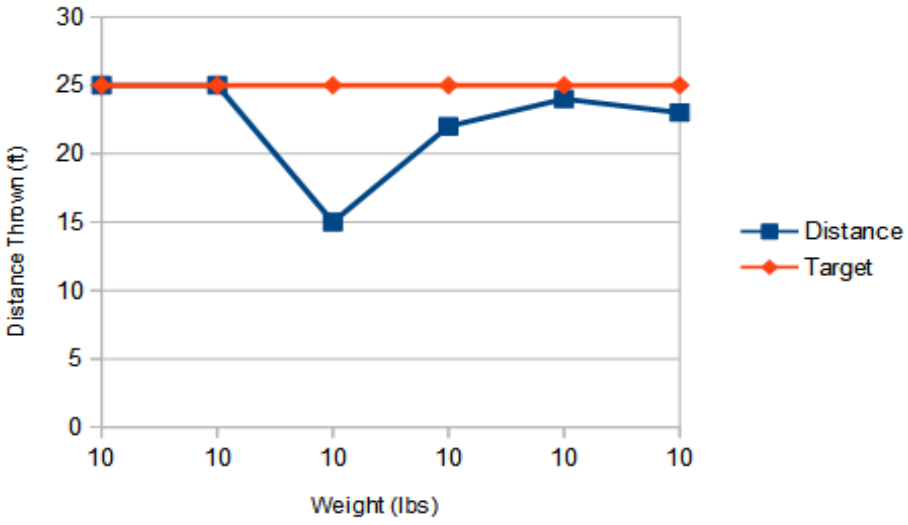

Figure 3.1: 25 feet test throws

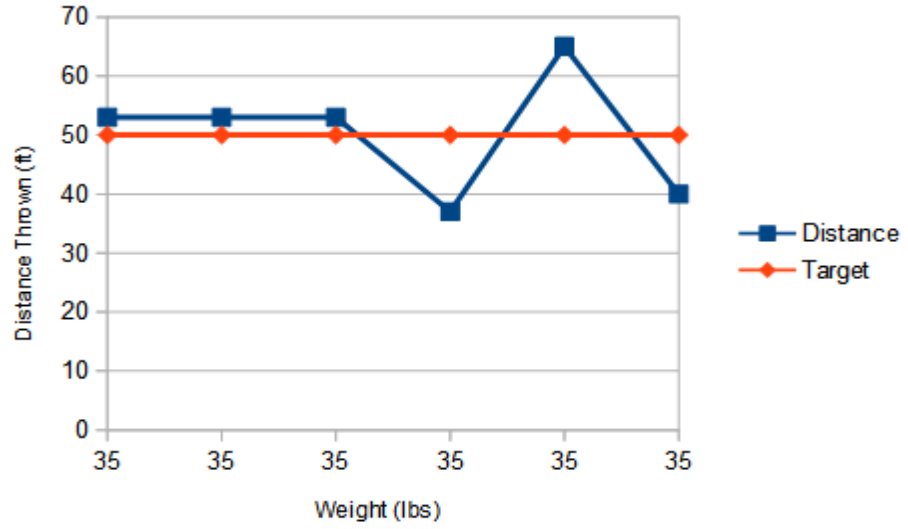

Figure 3.2: 50 feet test throws

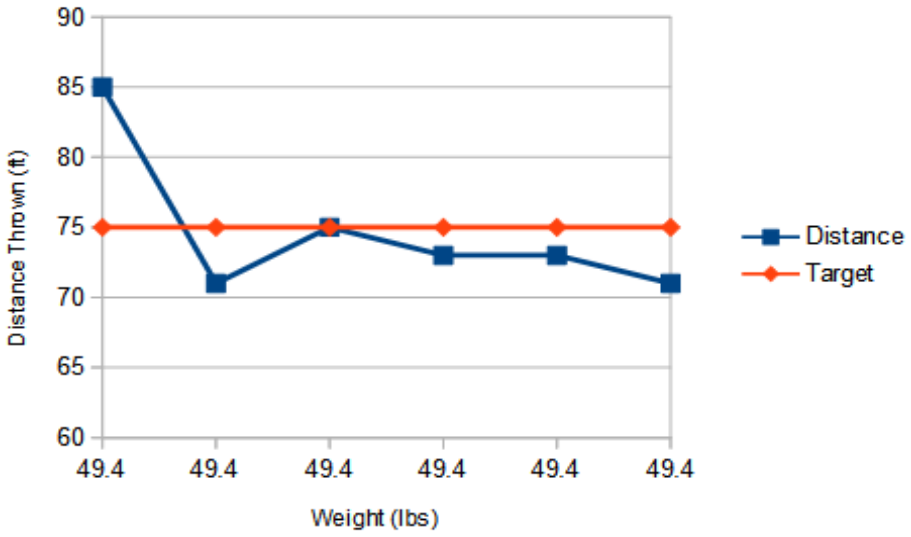

Figure 3.3: 75 feet test throws

3.2 Critical Dimensions and their Testing Requirements

The ratio and lengths of the long and short arm is very important to ensure adequate force is transferred into your projectile. We came up with a 4:1 long to short arm ratio by using the virtual trebuchet simulator to test a number of different configurations. It would be prohibitively cost and time intensive to test different arm ratios so we will just have to compare our actual results to the expected results from the simulator.

The angle of the sling release hook is another critical dimension as it is entirely responsible for your release angle. A 45 degree release angle is the optimum release angle; and this is attained by positioning the sling release hook at a 45 degree angle to the arm it is attached to. We can test this easily by adjusting the hook to different angles and firing the trebuchet to see how they compare.

Chapter 4

Competition Results

Our competition scores were as follows:

Table 4.1: Competition Results

Check-In Score	10 out of 10
Safety Judge Score	29 out of 40
Design Judge Score	24 out of 40
Build and Test Judge Score	32 out of 40
Total Judge Score	85 out of 120
Firing Score	10 out of 120
Total Score	105 out of 250
Percent out of 250	42.00%

Without access to the judge sheets we can't really speculate on what they marked us down on for the Safety, Design, and Build/Test categories. The firing score was rather low for all the teams involved, with no teams getting higher than a 60 out of 120. Common problems were the incline of the parking lot we were using as a firing range, and the intermittent wind. Our trebuchet also had a problem with the sling getting soaked during transportation which caused it to not open or throw off our distances by huge degrees. In the 50 foot test we were hitting anywhere from 4 feet to 65 feet which makes it pretty much impossible to consistently hit a small target at 50 feet. We could probably improve our accuracy by re-designing the sling with a more waterproof material than denim.

Appendix A

Timeline and Milestones

September 9:	Project Introduction
October 2:	Project Proposal Due
October 20:	Meet to put together and discuss Design Review 1
October 23:	Adam sends material cost data to Andrew for inclusion into the report
October 23:	RJ sends any assigned sections of the report to Andrew
October 23:	Be done with Design Review 1 to give time for complications
October 30:	Design Review 1 Due
November 11:	Meet to put together and discuss Design Review 2
November 13:	Adam sends material cost data to Andrew for inclusion into the report
November 13:	RJ sends any assigned sections of the report to Andrew
November 13:	Be done with Design Review 2 to give time for complications
November 20:	Design Review 2 Due
November 21:	Build and fine tune trebuchet
December 7:	Competition
December 17:	Final Exam

Appendix B

References

http://www.virtualtrebuchet.com/ - Online Virtual Trebuchet Simulator
http://thehurl.wikidot.com/tuning - Trebuchet Wiki

Appendix C

Personnel and Time Sheet

Table C.1: Man-hours

	Man-hours
Andrew	45
Adam	30
RJ	20
Total	95

Andrew Poe, Group Leader, Design: ampoe1@my.waketech.edu
Adam Cook, Materials and Building: atcook@my.waketeck.edu
Ralph Church, Documentation, Editing: rachurch1@my.waketech.edu