Executive Summary

This report entails all aspects of the Vandalay Industries Catapult. The Vandalay catapult integrates cost efficiency, reliability, safety and practicality into one product. Many hours were spent designing, testing and refining the final product. For any catapult design, Vandalay Industries is capable of designing catapults for of means or methods. During the prototype competition, the results spoke for themselves. This catapult is the best overall catapult.

Table of Contents

Introduction

The purpose of creating this project was to work as a team to create a catapult that would consistently hit a target standing three meters away and has it perform superior in every aspect over other companies' catapults. Since Vandalay Industries prides itself on designing the absolute best products, this was not a problem.

A catapult design was to be created and built. This catapult, however, had to meet certain specifications. The criteria are as follows:

- The catapult cannot have an area exceeding 1.5 cubic feet
- The catapult must hit the target
- The catapult must fire a golf ball
- The catapult must have a triggering mechanism

After being built, the prototype would then be tested with competing companies' prototypes. After the testing, improvements were to be made to the prototype and a final product was to be created. The final product would then test, examined, and graded.

This report discusses in detail the methods and logic used to design this catapult, the VIC.

Methodology

Brainstorming

To come up with an idea for the catapult each member of the team drew a design. The drawings were then discussed openly. The pros and cons of each design were examined. The best aspects were taken from each design and the prototype design was created. The preliminary AutoCAD sketch of the prototype drawing is shown below.

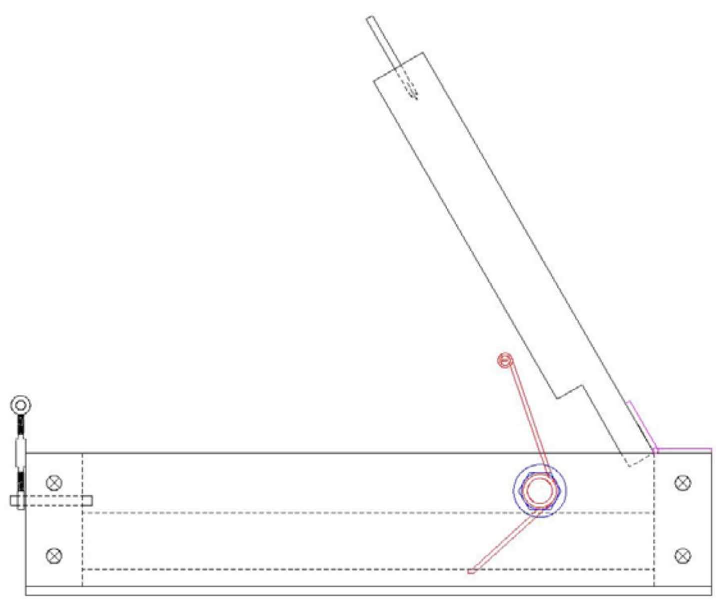


Figure 1

This design is the product of the fusion of all of the best ideas Vandalay Industries has to offer. The simplicity of this design is by far the catapult's best feature.

Catapult Construction

The most logical choice for the material to be used was wood. Wood is cheap and is easily manipulated. A combination of 2x4's and screws were used to hold the wood together. Plywood was used for the bottom surface to support the bricks used to hold the catapult in position. A jet-ski handpole spring (for further information on the spring see **Force**) was used to give maximum force to launch the golf ball. A bolt was inserted through the coil of the spring to hold the spring in place. A heavy-duty door hinge was implemented to allow our throwing to move. A gate latch was used to secure the catapult. Everything that was used in the making of this catapult was found from scraps. Since the materials weren't directly purchased, the overall cost had to be estimated. The overall estimated cost of the project was found to be about twenty dollars.

The prototype was finished and tested. We tested the prototype thoroughly and often. For each minor adjustment that was made, a test was done. These results are shown on the next page in figure 2.

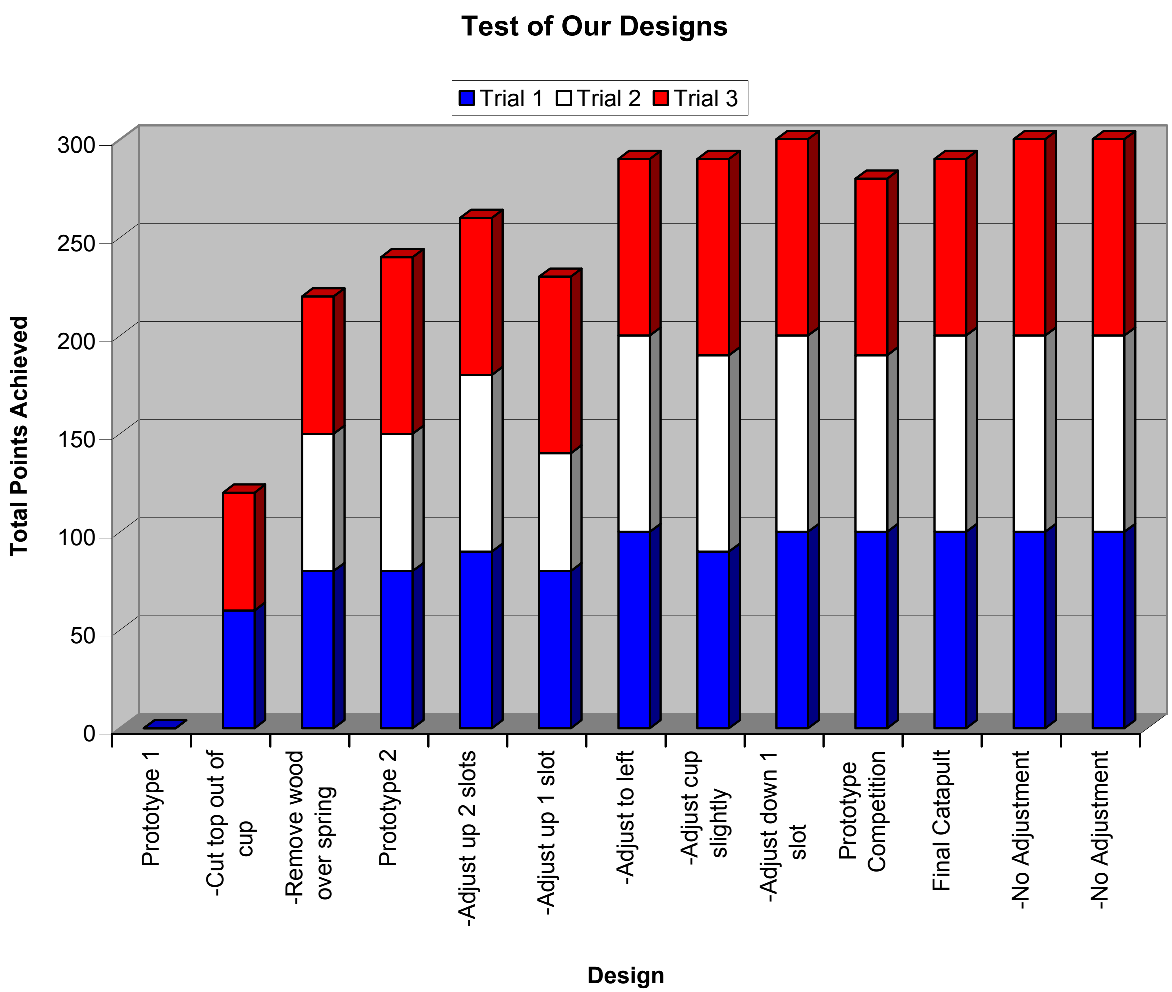


Figure 2

The final product was built over a period of one month. The Gnatt chart, shown below (figure 3), shows in detail progress in relation to time.

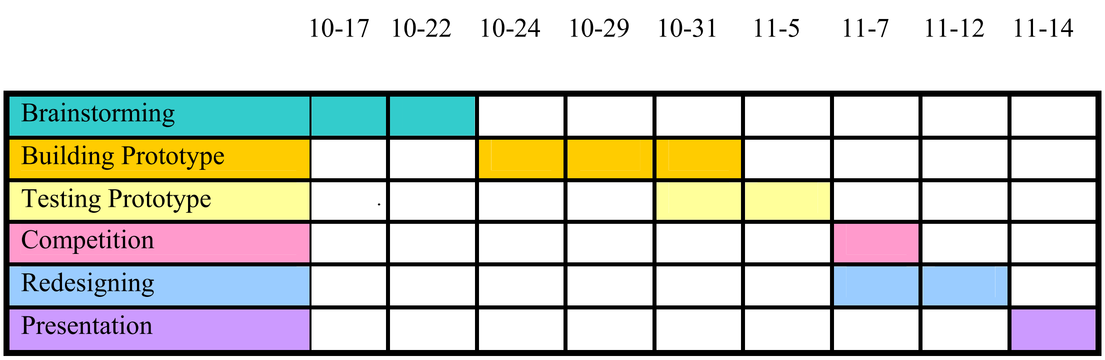
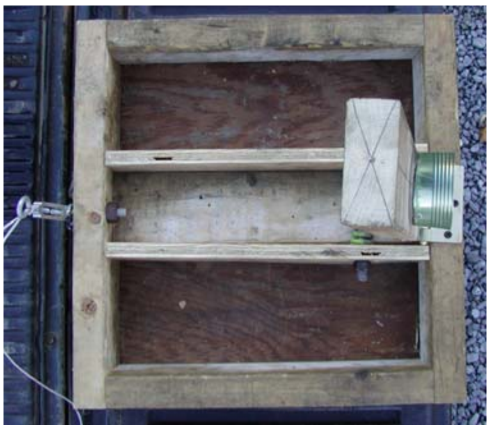


Figure 3

As one can see from figure 2 and 3, the VIC needed very little redesigning. For more information on the redesigning process see the problems addressed section.

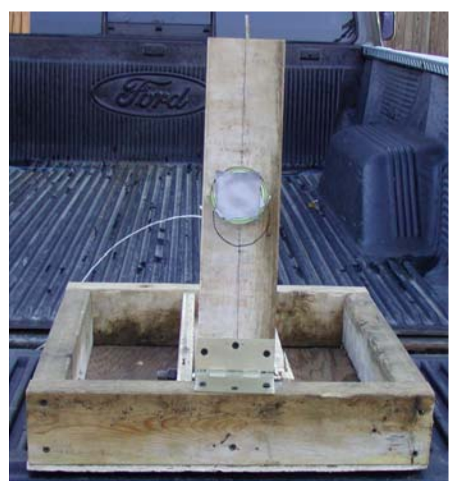
Prototype Pictures



Top View

Isometric View

Front View



Right Side View

Results and Discussion

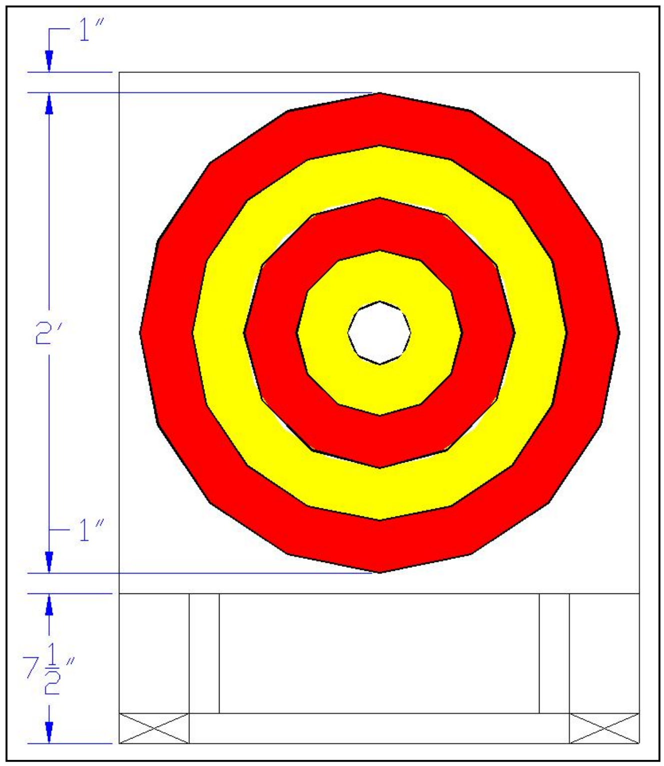


Figure 4

Target

The target is the means in which our performance for this project is determined. The target itself has its own specified dimensions which were given. The dimensions stated that the target would be located three meters from the catapult's launch site. The bull's eye would have a diameter of three inches. The center of the bull's eye would be located twenty and one-half inches from the ground. The catapult's performance would be judged based on how close the ball hit in relation to the bull's eye. The point values decreased the further we hit from the bull's eye. The values were one hundred points for the bull's eye, ninety for the next ring, eighty for the next, and on down to zero points for not hitting anything. Each group also had one fault or misfire they could commit and that score would be omitted. The best three scores are added to determine each group's catapult performance.

Force

The force used in the Vandalay Industries catapult comes from a Kawasaki Jet Ski handpole spring. The purpose of the handpole spring is to lessen the amount of weight of the handpole so that the rider will not get fatigued. The handpole spring is a torsion spring rather than an extension or compression spring.

There are three types of springs, torsion, extension and compression. An extension springs characteristics is that when extended or stretched out; its force causes it to return to its original length. This type of spring is commonly used to close screen doors. Sometimes they are placed at the end of a porch swing chain to lessen the amount of stress on the swings mounting hooks. Extensions look very similar to compression springs.

Compression springs are also a common spring used everyday. Compression springs are compressed or squeezed than return to its original length. The springs are the same typed used on a car's suspension. These types of springs can support very heavy or light loads. Compression springs are also used ballpoint pens. The forces capable of either an extension or compression spring depend all on the spring constant. This constant is measured in lbs per in or kg per mm. Also this constant varies with its size of coils, number of coils, and spacing between the coils. Although extension and compression are similar, torsion springs are different.

A torsion spring is twisted or wound up to produce the force. A torsion spring is used on the cover of a floppy diskette to keep it closed when not opened by the computer drive. This type of spring was ideal for a catapult since the firing arm of the catapult rotates about a hinged point. All three types of springs work because of the elasticity properties of the metal, which is used. All metals and materials have elastic and plastic properties; this is how springs are able to work.

Because of the small size and great force of a torsion spring, this was the best choice for this project. Pictured to the right in figure 5 the VIC's torsion spring is shown.

Figure 5

Trajectory

When any object is shot or fired into the air, it is subjected to the forces that fired it and other forces such as air friction and gravity. The gravitational constant is 9.806 meters per second squared or 32.174 feet per second squared. The force of gravity causes the object or projectile, to follow a parabolic path. This is path that is in the shape of an arc, as shown in figure 6. Using the laws and formulas from physics, many things can be determined about the path of the projectile.

The projectile is a vector force at a certain angle. When this vector is broken down into its horizontal and vertical components, the distance and height of the projectile can be determined. When finding the distance, the x version of the projectile motion formula is used. The horizontal force component and the time are needed to find out how far the projectile went. Likewise if the any two of the three variables are know, the other can be found. This is also true for the vertical time, force and distances. When finding the maximum height of the projectile from the ground, the vertical force will be zero since the projectile is not moving upwards anymore.

With physics, any specific point or target can be calculated out to find the setting of the catapult. So if the distance in both the horizontal and vertical directions is given, the catapult can be set up to hit this target. However, the force of the catapult and the angle at which the projectile is launched must be known.

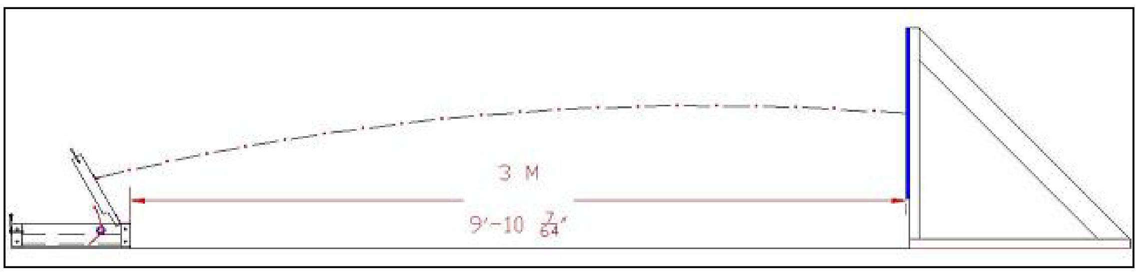


Figure 6

Vandalay Industries' catapult was constructed with a knowledge of Physics and projectile motion. No specific calculations were made concerning force, time, and distance. Instead a trial and error method was implied to get the correct trajectory of the golf ball. Although a flat arc, the flight path of is ideal for the target at which it is firing at. The flatter arc provides shorter flights and reduced air friction. If a taller target must be hit, the ball holder is simply moved farther up the lever. With the consistent launching position from the trigger, the catapult's trajectory is constant.

Trigger

The initial firing system was changed after the prototype competition. It consisted of a turnbuckle bolted to the catapult, a string, and a cut off nail. The nail was inserted into the lever and the head was cut off. This was a safety concern because someone may have been injured by the sharp nail. The string was attached to the turnbuckle. The lever was compressed and the eye bolt hooked the nail. Then the turnbuckle was next pulled away from and off of the nail. The nail which is part of the lever went through the motion of the lever. This is where the safety concern came into effect.

Figure 7

Pictured in the upper left in figure 7 is the turnbuckle and nail design, the original trigger.

Pictured in the bottom right in figure 8 is the new and improved trigger for safety, the gate latch.

Concerned with safety the nail and turnbuckle trigger was changed to a Stanley products gate latch. This type of latch provided a safe and secure way holding and releasing the catapult lever. Another added feature is the opportunity to place a lock through a hole in the catapult. This absolutely locks the catapult in loaded position. Another option it to lock up the trigger so that it can not latched at all. Also the

Figure 8

trigger had to be slightly modified for use. There was a metal edge that had to be filed off to allow smother and easy release. With these changes, the Vandalay Industries is now safer and more accurate. A consistent launching point is now possible. Additionally no misfires or sharp objects are present to injure anyone.

Problems Addressed

Original Design Changes

During the building process of the prototype, there were only two major changes to the design of the prototype. One was the removal of the top portion of the projectile holder to make it hit the target higher. The other was a cut in the lever board to allow the spring to reach a fuller potential.

The removal of the top portion of the holder, a cup, allowed the projectile to have a higher trajectory. With the original cup, the projectile would stay against the top portion all the way through the acceleration process and end up hitting the ground before it reached the target. After the removal, the projectile wouldn't be held down anymore and therefore, hit the target higher. However, this height was still too low to hit the bull's eye. This led to needing more power from the spring.

The power of the spring was not fully harnessed. There was a piece of the lever jamming against the base of the catapult stopping it from being pushed farther down. Removing this piece allowed the spring to be compressed further and hence, more power was acquired. After a small amount of fine tuning with the adjustments between the lever and the cup, the catapult was accurate and precise.

Final Product Design Changes

After the prototype competition, a few more changes were made to improve upon the prototype. These changes made the final product safer, lighter, and very consumer friendly. First of all the hinge was changed to a longer, sturdier one. The lever board was made full again as recessing the spring made this cut unnecessary. Holes were made for the pivot point of the spring making adjustments readily available. The final change was to make the trigger a safer.

In the middle of the prototype competition, we observed a small crack forming around the screws in the hinge. This was an unacceptable risk as the lever could possibly crack off. The problem was rectified by adding a longer hinge with longer screws that would distribute the force evener. This also led to the changing of the old lever.

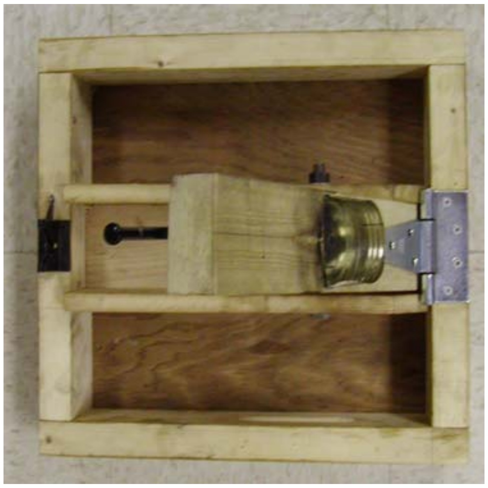
A new lever was added to correct a cut that was made in the prototype. This cut is now unnecessary because the spring is recessed more and adjustable. This lever is now much stronger and therefore safer.

The spring is now adjustable. Five pivot holes were added at a lower level to accept a full lever. This made direct adjustments to the force possible. Each of these adjustments added six inches up if moved towards the front one hole and moved six inches down if moved back one hole. These changes applied for all the adjustable holes.

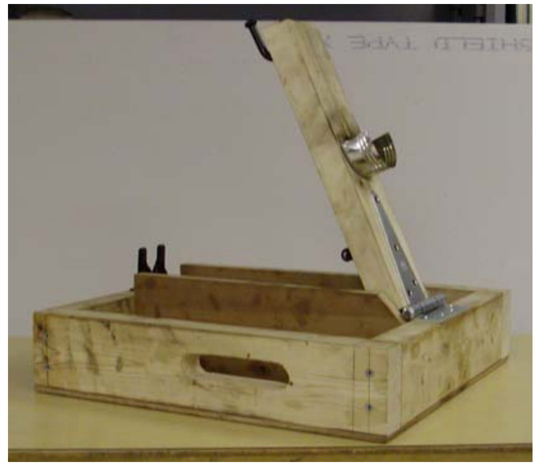
The final change to the prototype to complete the final product was made to the release trigger. The original trigger was sharp and had the small possibility of pinching a finger during a release. This old trigger also had no way to lock the lever down which was thought to be another danger. The new trigger is smoothed over and has no sharp edges. The actual catch has a hole so that if a lock is put through it, the catapult is totally unusable.

After completion of all of these modifications, we have ended up with a safe, secure, and accurate catapult.

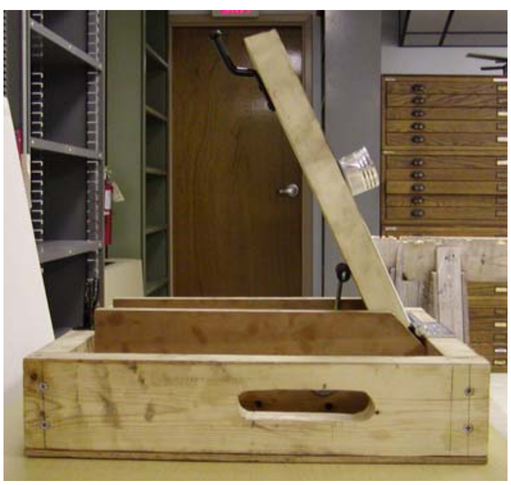
<u>Final Design Pictures</u>



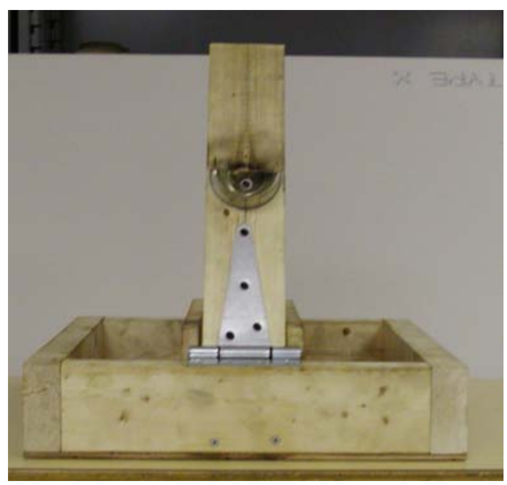
Top View



Isometric View

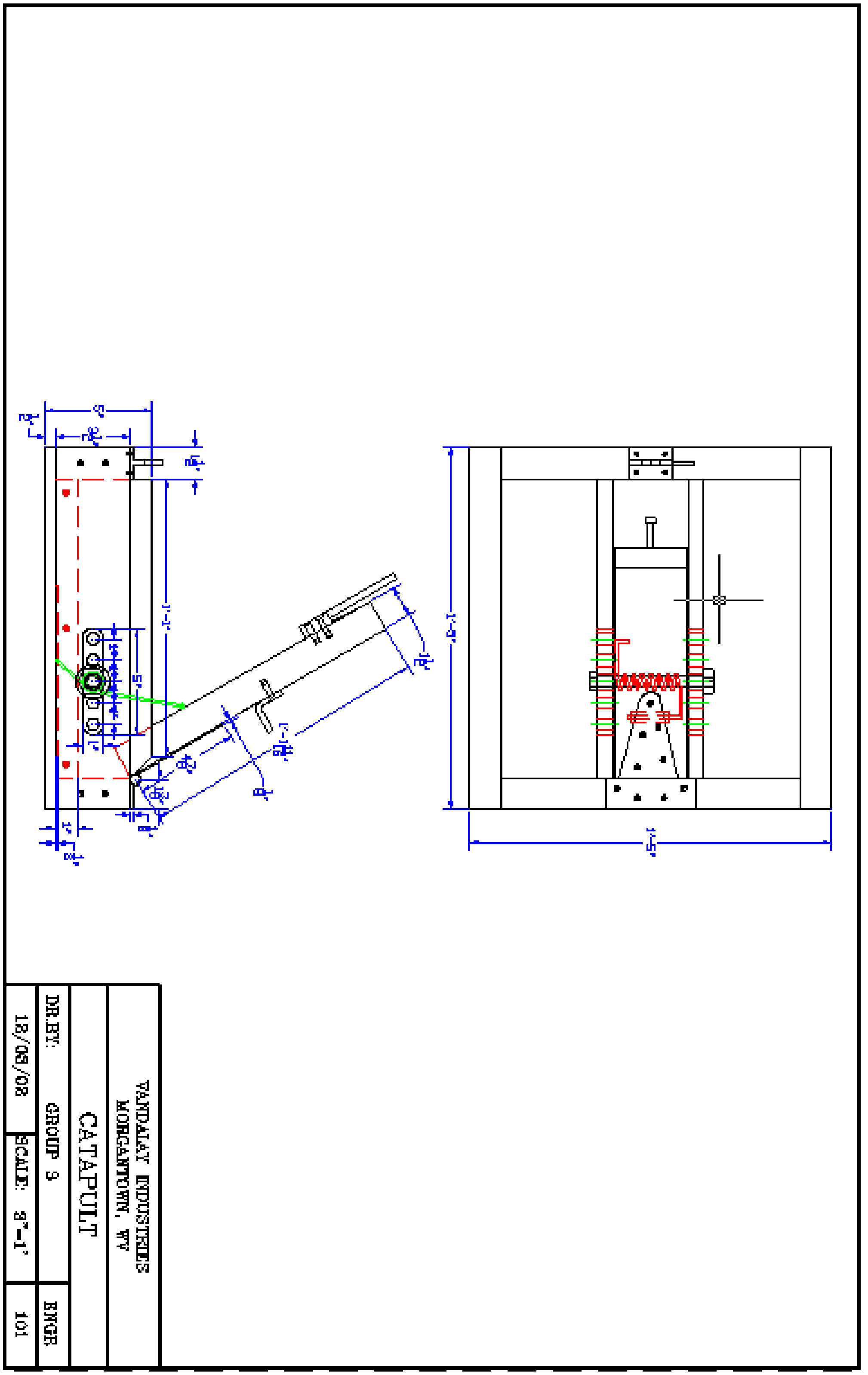


Front View



Right Side View

AutoCAD Final Drawing



Conclusions

The overall design of the Vandalay Industries catapult is relatively simple. It is a very cost efficient and effective design. Also the ease adjustability makes it the very adaptable to different situations. The added benefits of a powerful spring enable the catapult to hit targets much farther than the specified three meters. Other designs are not capable of this task. Add to the fact the catapult's accuracy and precision. The Vandalay Industries catapult is the logical choice for anyone's catapult needs.