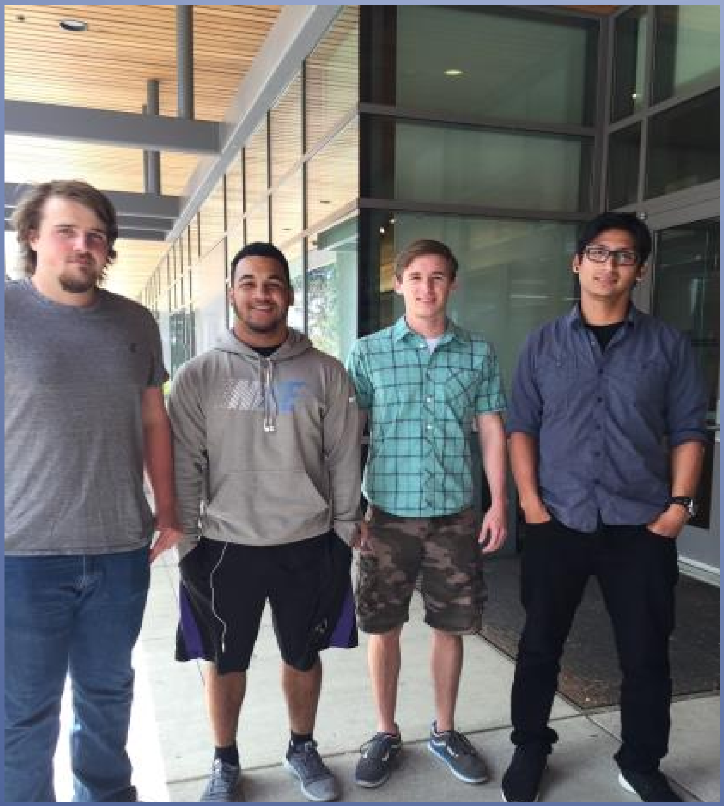

Team BBB – Multiple Rocket Launcher

Engineering 215 – Spring 2015

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1 Problem Formulation

1.1 Introduction

In Section 1 of the design project, the Team BBB began to gather information and formulate the problem. This project is based out of Engineering 215 at Humboldt State University during the spring semester of 2015. The client, Mr. Pinkerton, is a science teacher at Zane Middle School in Eureka, California. His classes are designed to inspire his students to be involved in STEM programs. He frequently uses a simple paper stomp rocket launcher, which will later be described, in his classes in order to display projectile motion in a way that interests his students. He has found that the current system he uses produces inconsistent launches and constantly breaks due to the stomping required. With this information, Team BBB was to come up with an objective and implement a solution.

1.2 Objective

The objective of this project is to create a system that can easily be assembled to propel multiple paper rockets at one time, centered on the desires of the client.

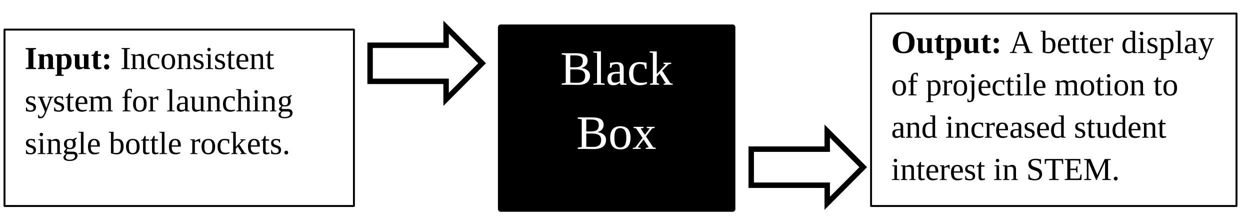


Figure 1-1: Black Box model displaying states of the world.

2 Problem Analysis and Literature Review

2.1 Problem Analysis

2.1.1 Introduction

Section 2.1 describes the problem formulated in section 1 and its requirements, which includes specifications and considerations, criteria and constraints, usage, and product volume.

2.1.2 Specifications and Constraints

These specifications and constraints are guidelines provided by the client that must be followed in order to fulfill the client's desires. Specifications are requirements made by the client that the Multiple Rocket Launcher must meet.

The specifications provided by the client are as follows:

- Propels paper rockets a minimum of 60 feet in horizontal distance.
- Propels a minimum of four paper rockets at once.
- Propels all paper rockets with equal force.
- Propels all rockets consistently.

2.1.3 Criteria

Criteria and constraints are important requirements that must be met in order to fulfill the client's needs and are specified in table 2-1 below.

Table 2-1

Criteria	Constraints
Consistency	Repeats the same results when propelled at the same conditions
Effectiveness	Produces the clients desired specifications
Safety	Projectile is triggered at a distance, pressure chamber is securely constructed
Durability	Lasts for years with inconsistent use
Ease of Use	Easy to trigger the projectile, easy to set up
Reparability	Easy to repair or replace pieces if they malfunction
Compactability	Able to store in a small space (2ftx2ftx2ft)
Adjustibility	Projectile can be fired at multiple different angles, not going under 30 degrees
Aesthetics	Looks clean and professionally built, incorporates Zane School colors
Attractiveness	Product is attractive to middle school students

2.1.4 Usage

The Multiple Rocket Launcher will be used by a teacher at Zane Middle School in Eureka, California. The Multiple Rocket Launcher will be designed so that any middle school student can understand how it works. It should only be triggered by the teacher. The Multiple Rocket Launcher is not expected to be used consistently throughout the school year; only on certain occasions around the school year.

2.1.5 Production Volume

Only one Multiple Rocket Launcher is to be made. The client will only receive one and will not be given supplies to make another. The Multiple Rocket Launcher expected to last a very long time due to the nature of the way it is built and the materials used to build it.

2.2 Literature Review

2.2.1 Introduction

Section two contains information on components that will go into the design of the Multiple Rocket Launcher. There are many different variable components that can be factored in to the design of any type of rocket launcher. The following information is directly relevant to the project, based on criteria specified by the client.

2.2.2 Client Information

Mr. Pinkerton is a science teacher at Zane Middle School. He has experience in the field of engineering and encourages his students to be involved in science, technology, engineering, and mathematics (STEM) fields. He provided in-depth information about this project on February 13th, 2015. He gave several suggestions about building materials and firing mechanisms. He also gave several requirements for the final product (Pinkerton, February 13, 2015).

2.2.3 Client Suggestions

Mr. Pinkerton recommended that we look into using a bladder compressed by a falling weight as our firing mechanism. The particular bladder he suggested was an ULTRA Stomp Rocket bladder for its durability. He also suggested that we use PVC to construct a light weight and sturdy frame (Pinkerton, February 13, 2015).

Figure 2-1: An ULTRA Stomp Rocket launching bladder suggested as a firing mechanism by Mr. Pinkerton.

2.2.4 Client Requirements

Mr. Pinkerton requires a product that is:

- Light weight and portable

- Able to fire at least four paper rockets at equal force
- Safe for use around middle school students
- Durable enough to work for many years with inconsistent use
- Easily storable
- Compact
- Consistent
- Compatible with paper rockets that have the same diameter as a piece of three quarters of an inch PVC tubing

(Pinkerton, February 13, 2015)

2.2.5 Curriculum

The state of California has set certain requirements for what skills science classes need to develop in students. Students are required to have certain core skills and abilities as well as having certain understandings of the world around us. Mr. Pinker teaches these requirements to his students in his classes (NGSS, 2014)

2.2.6 Core Skills

Students should be able to:

- Identify criteria, limitations, and objectives of design tasks.
- Design items that will satisfy the given requirements of the task.
- Identify preferable characteristics from different designs in order to optimize the final design.
- Use models to gather data on an event.
- Generate their own models based off of data they gathered.
- Compare different sets of data.
- Analyze data and come to conclusions from said analysis.
- Defend their conclusions with arguments.
- Create explanations for given phenomena.
- Design an experiment to answer a given question.
- Carryout an experiment in accordance with the scientific method.
- Identify cause and effect relationships.

2.2.7 Core Knowledge

Students should have a simple understanding of Newton's laws and projectile motion. Students should know the relationship between forces and energy, and how pressure relates to it. Students should also know about and be conscious of the impacts human activity has on the planet.

2.2.8 Building Materials (Piping)

PVC pipe and vinyl tubing are two main possibilities for building materials. The materials used to build this kit need to be easily assembled and durable. The kit will be used multiple times over a long period of time so the building materials used must also be reliable.

2.2.8.1 PVC Pipe

PVC pipe is made out of polyvinyl chloride, a plastic compound. PVC is typically used for plumbing and other piping as well. It is also light and pretty flexible which makes it easier to use (MarkT). As a result of this it is one of the more commonly used forms of piping (*Uni-bell PVC Pipe Association).*

Figure 2-2: Schedule 40 PVC Pipe http://iscaper.com/blog/2011/07/pvc-pipe/

2.2.8.2 Advantages of Using PVC

PVC is one of the more common pipes used with fluid mechanics. PVC is easy to connect because there are a wide range of connectors for it. Elbows, couplings and 45 degree connectors are used to put PVC pipes together (MarkT). Since PVC does not corrode and it is a non-conductor, it lasts long and is ideal for use in the project (*Uni-bell PVC Pipe Association*). Since it does not corrode, it does not need protective coats or liners. This makes PVC pipe very cost effective (*Uni-bell PVC Pipe Association).*

Figure 2-3: PVC Pipe Fittings http://www.allrightmachinery.com/pvc-pipe-fittings.html

2.2.8.3 Disadvantages of Using PVC

PVC is not the best type of pipe to keep outdoors for long periods of time because UV rays can damage it. If PVC is left out it cold climates, the PVC can freeze and possibly crack (MarkT). Couplings or connector pieces must be made tight to keep air from leaking through the connectors. PVC is light weight and easy to handle but because of this it can be broken easily if it is mishandled (Wanamaker, 2013). It also has a maximum service temperature of 140 degrees Fahrenheit (Wanamaker, 2013). This will not be a concern because it will not get that hot in Eureka.

Figure 2-4: Broken PVC Pipe http://www.home-dzine.co.za/garden/garden-cracked-pool-pipe.htm

2.2.8.4 Vinyl Tubing (Flexible PVC)

Vinyl tubes are made from polyvinyl chloride just like PVC pipes but they are made more flexible with the addition of materials that increase plasticity (Diversitech). Flexible PVC, also known as vinyl tubes, are mostly used for coating cables and wires for electrical use (Diversitech). These clear vinyl tubes are also used for condensation pump discharge lines (Diversitech). The more flexible tubing rarely leaks and it does not contain odors (Diversitech).

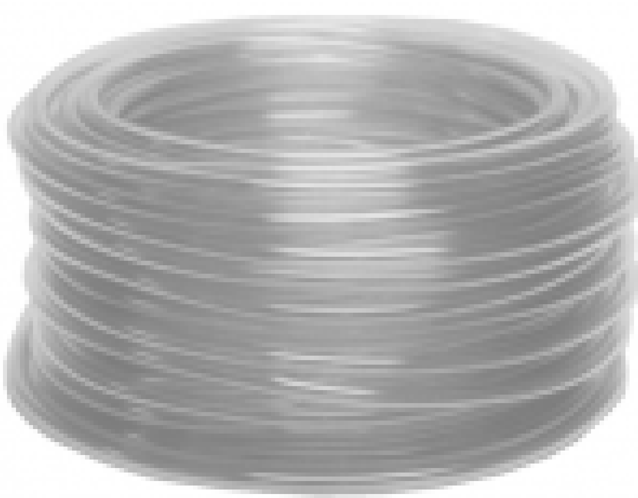


Figure 2-5: Vinyl Tubing http://www.rubberonline.com.au/hose-and-tubing-c51/clear-vinyl-tubing-c52/

2.2.8.5 Other Types of Pipes

2.2.8.5.1 Cast Iron Pipes

Cast iron pipe is strong but it is likely too heavy for use with middle school students. It also rusts easily, which could compromise the system (Wanamaker, 2013).

Figure 2-6: Cast Iron Pipe http://hubpages.com/hub/The-Advantages-and-Disadvantages-of-Different-Residential-Plumbing-Materials

2.2.8.5.2 Copper Pipes

Copper is one of the most commonly used plumbing material in the U.S. today (Wanamaker, 2013). Copper is soft enough to avoid shattering with hard impact. It is very durable which means it has good long term effects. It also has a high melting point and is naturally able to resist the growth of bacteria (Wanamaker, 2013).

Figure 2-7: Copper Pipe http://hubpages.com/hub/The-Advantages-and-Disadvantages-of-Different-Residential-Plumbing-Materials

2.2.8.5.3 ABS Pipe

ABS is short for acrylonitrile butadiene styrene. ABS pipes can properly function from -40 to 180 degrees Fahrenheit. Compared to PVC, ABS piping works more efficiently in colder climates (Dr. Pipe). ABS is lightweight and easily transported. It can be used in either above-ground or underground applications (Dr. Pipe). ABS pipes can also be destroyed by UV rays so when used outside they should be painted with protective coating.

Figure 2-8: ABS Pipe http://www.muellerindustries.com/products/plumbing/tube-and-pipe/abs-dwv-pipe

2.2.9 Fluid Mechanics

Fluid mechanics is a sub-category to physics which comprises of the study of fluids and the forces attributed on to them. These consist of liquids, gases, and plasmas. There are complex mathematical problem solving methods associated with fluid mechanics. Fluid mechanics is broken into two separate categories that comprise of fluid statics and fluid dynamics (Encyclopedia Britannica, 2015).

Fluid statics, also known as hydrostatics, is the study of liquid at rest with high pressure (Encyclopedia Britannica, 2015). Pressure can vary with temperature and elevation (Encyclopedia Britannica, 2015).

Fluid Dynamics, in comparison to Fluid statics, is study of liquids in motion. This elaborates in fluid flow, like in small tubing, of volume and has wide scale of different forces acting on it (Batchelor, 2000).

2.2.9.1 Aerodynamics

The study of aerodynamics is a branch of physics that handles motions of air and many other gaseous fluids. Aerodynamics also deals with forces that pass as fluids on solid objects and include the shape and size of the body. Aerodynamics in particular elaborates in the central idea of flight of aircraft, rockets, and missiles (Encyclopedia Britannica, 2015).

2.2.9.2 Managing leakage of Pressures

It is crucial to minimize the excess pressure on any system under pressure. This is crucial as it will reduce leakage and lower the chances of bursting of pipes bladders. The considerations of frequent external factors that must be taken are rising of temperature, height elevation, and addition of external pressure to the system. There best way to act on the risks is to constantly monitor them. Taking precautions by doing extensive research the system will be exposed and planning out different scenarios will minimize risk (Civil Engineering, 2000).

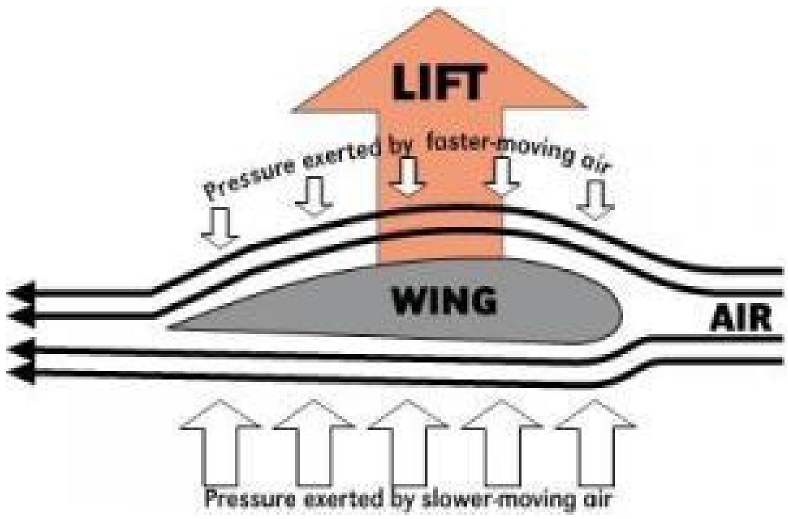


Figure 2-9:Pressure Diagram http://subversiveinfluence.com/2008/04/thinking-differently-to-accomplish-flight/

2.2.9.3 Physical Properties of Gases

Gases are made up of atoms that combine to form molecules. The physical properties that gases have are its elasticity and comprehensibility. Gases are more willing to change shape than liquids and that leads to change in different pressure depending volume. The properties of gases are related to its molecular structure and can also vary due to temperature (Batchelor, 2000). Viscosity also plays a role as gas particles stick to surfaces and create layers of air called boundary layers. This affects the flow of the gas (Benson, 2014).

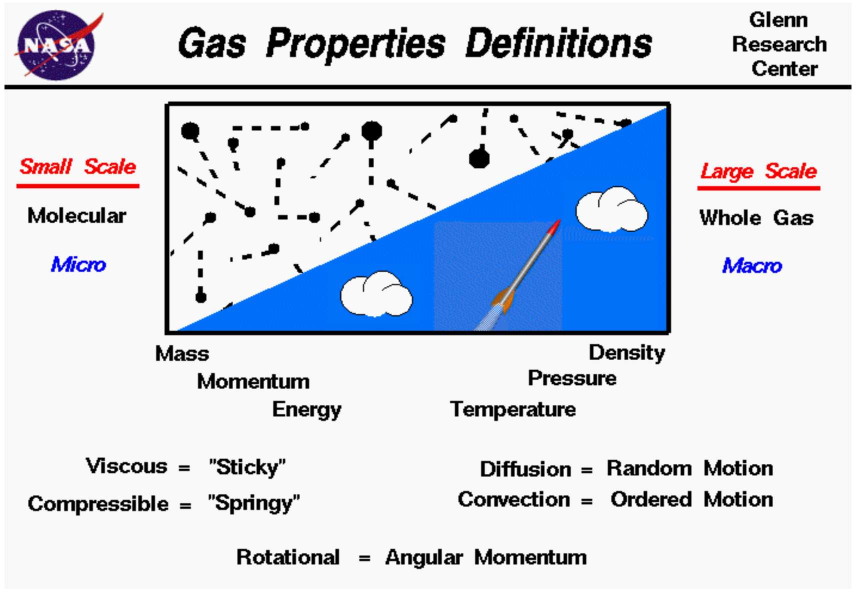


Figure 2-10: Gas Property Definitions http://www.grc.nasa.gov/WWW/k-12/airplane/gasprop.html

2.2.9.4 Fluid Pressure

The ratio of force per unit of area is pressure. The pressure is perpendicular to the surface of a body. Common units used for pressure is pounds per square inch, or psi. Fluids and gases function similarly under pressure and are broken into two separate scenarios; an open or closed state. In an open state, the pressure is in an open channel flow the moves freely in the atmosphere while a close condition travels thru a channel and restricts its flow similarly to a water or gas line. This creates either hydrostatic pressure or dynamic pressure (Benson, 2014).

2.2.9.4.1 Bladders

Bladder are containers that hold air with an elasticity property for the adjustment of the pressure of the gas contained. The stretch components are incorporated inside the tank to sustain the elongation within satisfactory restrictions and adapt to the situation the bladder is used. As the gas is released out of the bladder, it will compress to its original size (Elastomeric, 1975). These are essential components for bladder for its expulsion of gas and intake.

Figure 2-11: Tank Bladder http://royalliner.com/bladder.htm

2.2.9.4.2 Air Compressors

Compressors are unit devices that convert energy, either by gas or electricity, by receiving air into a small container and decreases the volume that results in increase pressure. Thus, the pressure can then be utilized by many different physical application using the increase of kinetic energy (Encyclopedia Britannica, 2015).

Figure 2-12: Demonstrative large compressor http://www.centrair.ca/piston_compressors.html

2.2.10 Wiring

Circuits wired in parallel have the same voltage across them. The current is divided over all the pathways according to resistance. If the resistance is equal on all pathways, then the amps are equally distributed over all of the pathways. When in series the total volts in a system are added together. The current is constant throughout the entire circuit (Current vs. Voltage, 2013).

2.2.11 Types of launching devices

There are hundreds of different ways to propel a paper/ bottle rocket. The following are designs that are most practical, efficient, reliable, and relevant to the desires of the client.

Figure 2-13: Stomp Bladder Method http://howtosmile.org/record/3815

The "Stomp Launch" method is one of the simplest designs for launching bottle rockets. The bottle rocket is propelled into the air by the user applying force to a bladder attached at the end of the device. This forces a burst of air pressure into the rocket, launching it into the air. The "Stomp Launch" is constructed entirely out of cylinder piping; usually PVC pipe. The bladder is usually a two liter plastic bottle. The bladder is easily susceptible to failure during multiple uses. The client currently uses the "Stomp Launch" method and has pointed out that it is inconsistent due to the difficulty of consistently stomping on the bladder. We will not be using this method, but we will likely use its basic principles in our final design (Shearer, 2013).

2.2.11.1 NASA Method

Figure 2-14: NASA Method http://archive.wired.com/geekdad/2012/06/soda-bottle-water-rockets/

This method stores air inside of a bottle, or other storing device. Air is pumped into the storing device or the rocket itself by the user. Increasing the amount of air inside the storing device or the rocket proportionately increases the air pressure inside. The more air pressure inside the storing device or rocket, the greater the acceleration of the rocket once it is released. To even further increase the acceleration, the user can put a small amount of water inside the bottle. Once filled with air, the bottle is ready to be launched and is only being held down by two small bars, shown in Figure. The bars are released by the user pulling the string attached to the bars, shown in Figure. This method is reliable and consistent. Too much air pumped into the storage device or rocket will result in failure and likely cause damage to the surrounding components (Kelly, 2012).

2.2.11.2 100 Yard Paper Rocket Launcher Method

Figure 2-15: 100 Yard Paper Rocket Launcher http://www.instructables.com/id/100-Yard-Paper-Rocket-Launcher/

The "100 Yard Paper Rocket Launcher" works by storing air inside a chamber of PVC pipe, as shown in Figure. A pump is used to store air inside the chamber. The valve (grey piece shown in Figure) is what keeps the air from being released. In the original design of the "100 Yard Paper Rocket Launcher", an electronic trigger is used to open the valve and release the pressurized air, as shown in Figure. However, another triggering method can be used in the place of the electronic one. At the opposite end of the valve there is a PVC pipe attached that is long enough to hold a bottle rocket or paper rocket. The released air launches the rocket off of the PVC pipe and into the air. Under previous testing, it was found that the rocket can only withstand 60 psi of air pressure, but the chamber can hold much more. The chamber from this design is simple but extremely effective. The overall design is reliable (Lance, 2012).

2.2.11.3 Little Joe Method

Figure 2-16: Little Joe Method Rocket Launcher http://www.brownz.com/launchers.htm

Figure 2-17: Release Portion of Little Joe Methodhttp://www.brownz.com/launchers.htm

Air is pumped into the entire mechanism, allowing for greater air pressure. The rocket is held down in place by cable ties, displayed in Figure. A pump is used to pump air into the device. Once it is full of air, the air is released by pulling the string at a distance, which releases the rocket from the cable ties. The whole design is made from PVC pipe. The pipes can be replaced with larger ones in order to hold more air, increasing the air pressure. However, it is not recommended to use too much air pressure as it may damage the rocket. This method is very reliable and produces consistent results. The user must stand back away from the rocket when releasing the air because the velocity at which it leaves the launch base is dangerous (Clark, 2010).

2.2.12 Variable Launching Components

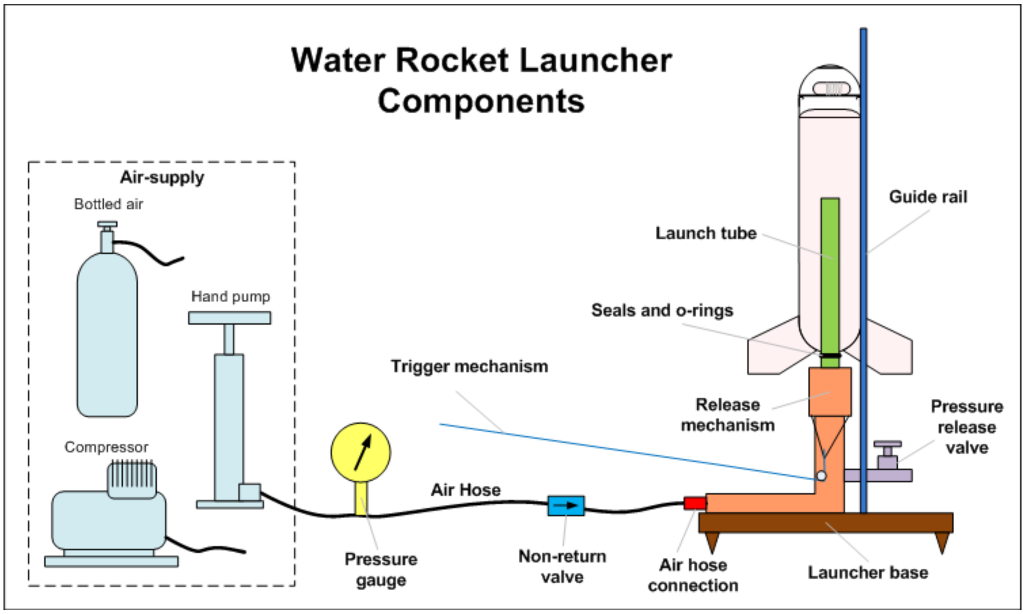


Figure 2-18: Water Rocket Launcher Components http://www.aircommandrockets.com/rocket_launcher.htm#_portability

This section is meant to display different modular designs that can be applied to different parts of the bottle rocket launching system.

2.2.12.1 Air Supply

This section talks specifically about the types of way to deliver air into the bottle rocket system.

2.2.12.1.1 Bicycle/hand pump

Figure 2-19: Bicycle hand and foot pump http://www.aircommandrockets.com/rocket_launcher.htm

This is the easiest and most practical form of device to pump air into the machine. The air hose connecter on the pump will need a tyre valve adapter in order to connect the pump to the PVC pipe. An average pump can easily supply up to 100 psi, which is more than enough needed to propel the rocket (Katz, 2014).

2.2.12.1.2 Air Compressor

Figure 2-20: Air compressor http://www.aircommandrockets.com/rocket_launcher.htm

Air compressors are easy to use and have a pressure gage installed in them. Air compressors require a source of energy. Small compressors that would be used for this project are susceptible to overheating when used consistently over a short period of time. The average small air compressor can pump air into the launcher at up to 150 psi, which is more than enough needed to propel the rocket (Katz, 2014).

2.2.12.2 Pressure Gage

Figure 2-21: Pressure Gauge (Pounds per square inch) http://www.aircommandrockets.com/rocket_launcher.htm

A pressure gage is attached to the air supply line in order to measure internal pressure of the rocket. In order for the pressure gage to work correctly, it is best to pump air into the launching device slowly as to allow the air pressure throughout to equalize. A pressure gage greatly increases consistency among launches (Katz, 2014).

2.2.12.3 Non-Return Valves

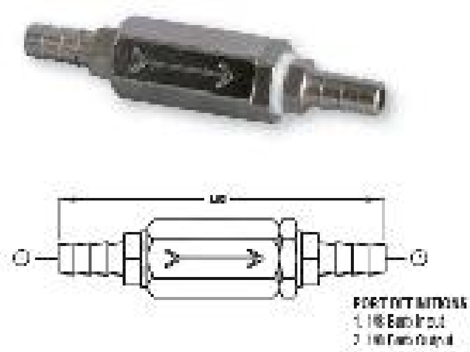


Figure 2-22: Non-Return Pressure valve http://www.aircommandrockets.com/rocket_launcher.htm

A non-return valve is not necessary if the rocket propulsion does not involve water. A non-return valve keeps water from making its way into the air supply. It is most effective for the non-return valve to be as close to the rocket as possible, as to keep the water inside it (Katz, 2014).

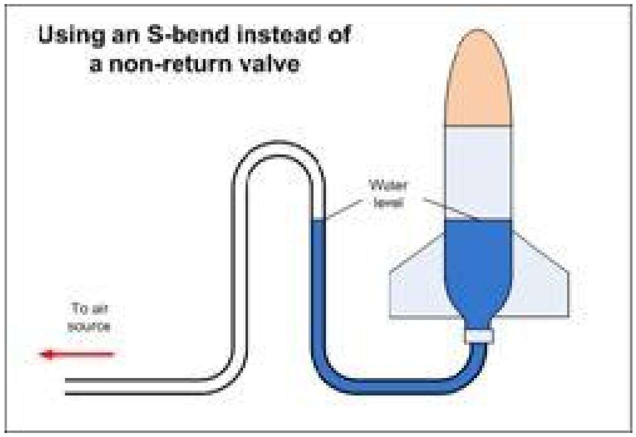


Figure 2-23: S-Bend Method http://www.aircommandrockets.com/rocket_launcher.htm

The "S-bend" as displayed in Figure can be used in place of a non-return valve. However, the water must be measured perfectly so that it does not pour down into the side where the air source is (Katz, 2014).

2.2.12.4 Release Mechanism

The following list includes mechanisms that could be useful in launching the rocket. There are hundreds of ways to do this, but this list is composed of the ways most practical, durable, and reliable that apply to this project.

2.2.12.4.1 Clark Cable Tie Launcher

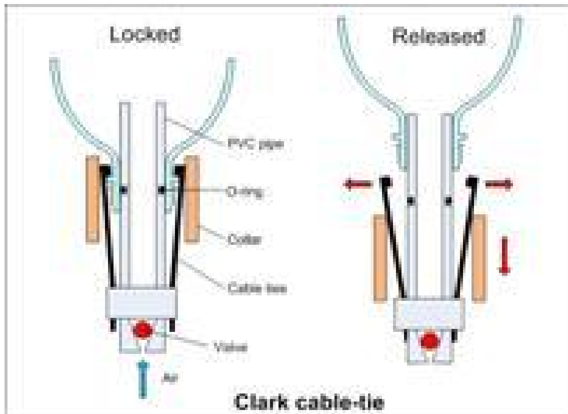


Figure 2-24: Cable Tie Launcher Method http://www.aircommandrockets.com/rocket_launcher.htm

This method uses cables to hold the rocket down while it is being pressurized. The cables are held by a collar that keeps them tight and in place. To launch, the collar is pulled downward and the cables let go of the bottle. This allows the air to be forced downward out of the bottle, projecting it into the air. This method is very reliable, but the collar must be lowered from a distance to avoid injury (Katz, 2014).

2.2.12.4.2 Twisting Bolt

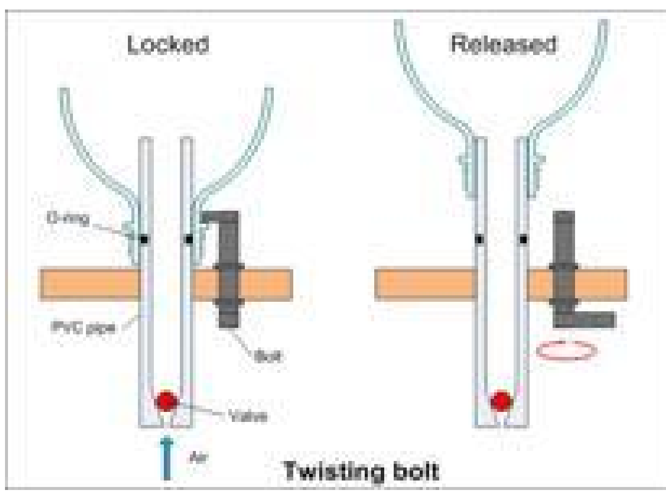


Figure 2-25: Twisted Bolt Method http://www.aircommandrockets.com/rocket_launcher.htm

This method uses a bolt lock to release the air and launch the rocket. When it is in the locked position, the bolt head is holding the rocket down. When twisted and rotated down, it lets go of the rocket and allows it to propel into the air. This method is somewhat reliable and is durable (Katz, 2014).

2.2.12.4.3 Pull Wire

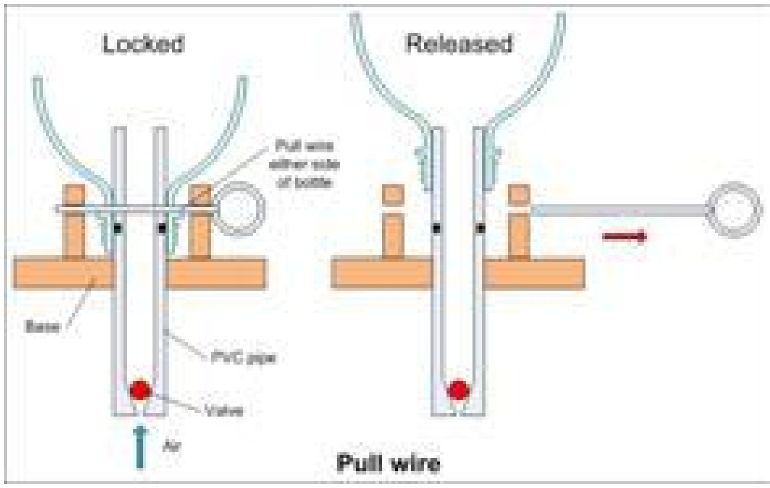


Figure 2-26: Pull Wire System http://www.aircommandrockets.com/rocket_launcher.htm

The pull wire holds the rocket in place while it is being pressurized. It can also be used to hold air pressure back from a chamber. Once the wire is pulled back, the air is released and propels the rocket into the air (Katz, 2014).

2.2.12.4.4 Pressure Release Valve

Figure 2-27: Pressure Release Valve http://www.aircommandrockets.com/rocket_launcher.htm

The pressure release valve attaches directly to the pressure chamber. When opened, it releases the air into the rocket, which propels it into the air. This is the most reliable method of release mechanisms (Katz, 2014).

3 Alternative Solutions

3.1 Introduction

Section 3 displays the different solutions that Team BBB has come up with. There are two main types of solutions; those that use a bladder as the source of air force and those that use a pressure chamber as the source of air force.

3.2 Brainstorming

Our brainstorming process was very simple and effective. We began by breaking the Multiple Rocket Launcher up into different sections that could be interchangeable. We would then throw out as many ideas down about each section as possible and record them. There was approximately two hours that went into this. We then made a list of different combinations of the sections that we believed would work. This produced many possible solutions so we voted on which ones we believed were the best and saved them as our alternate solutions.

3.3 Bladder Systems

3.3.1 Weighted Flexible Bladder

The Flexible Compression Bladder mainly consists of PVC piping. The rocket component, in Figure 3.1.1, launches a maximum of sixteen rockets simultaneously with the pressure given by the weight falling on to the bladder. The number of rocket launching arms in use will be able to change from four to sixteen rocket launching arms. The PVC piping has to be placed strategically in the center of the frame because the pressure will disperse evenly among the rockets. The rockets will all launch with the same force. The pressure chamber is connected with PVC piping or vinyl tubing to the bladder component. The weight guide allows the use of a bowling ball as the weight or any other object that will fit down the guide. The guide also works as a safety measure to reduce the likelihood of any appendages being hit by a falling weight.

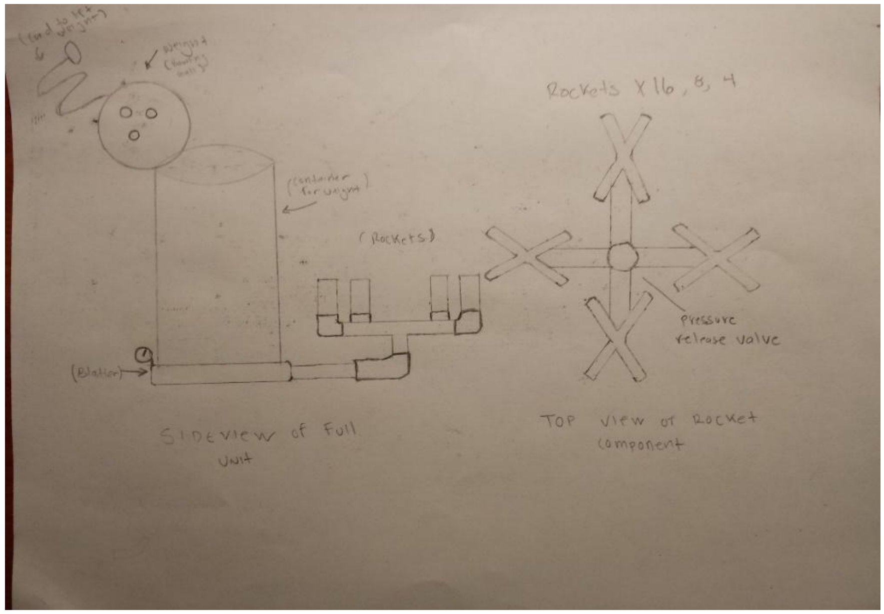


Figure 3-1: On the left is the side view of guide, bladder, and weight. On the right is the top view of the rocket launch area where there is a rocket placed on the end of every X. (Photo by Jason Mora)

3.3.2 Weighted Rigid Bladder

The Rigid weighted bladder shown in Figure 3.1.2 has a main chamber made of sixteen inch PVC that has an end cap sealed around the bottom. The end cap has a hole cut in the middle in order to fit a three quarter inch PVC pipe into the bottom. The pipe, called an outlet pipe, is sealed in place and leads straight into a ball valve that will prevent any air from escaping. Finally, the plunger is a piece of plastic formed to about one half inch smaller diameter than the inner diameter of the pressure chamber. The last half inch will be an O-ring. The entirety of the inner pressure chamber will be coated in heavy duty lubricant to maximize pressure output. Then in order to pressurize the chamber all that would be needed is weight to place on top of the plunger. Additionally, this system can also be used with a falling weight, if the ball valve is left open and the weight falls on the center of the plunger. One aspect that is not shown in the drawing is the pulley that pulls the plunger back into launching position.

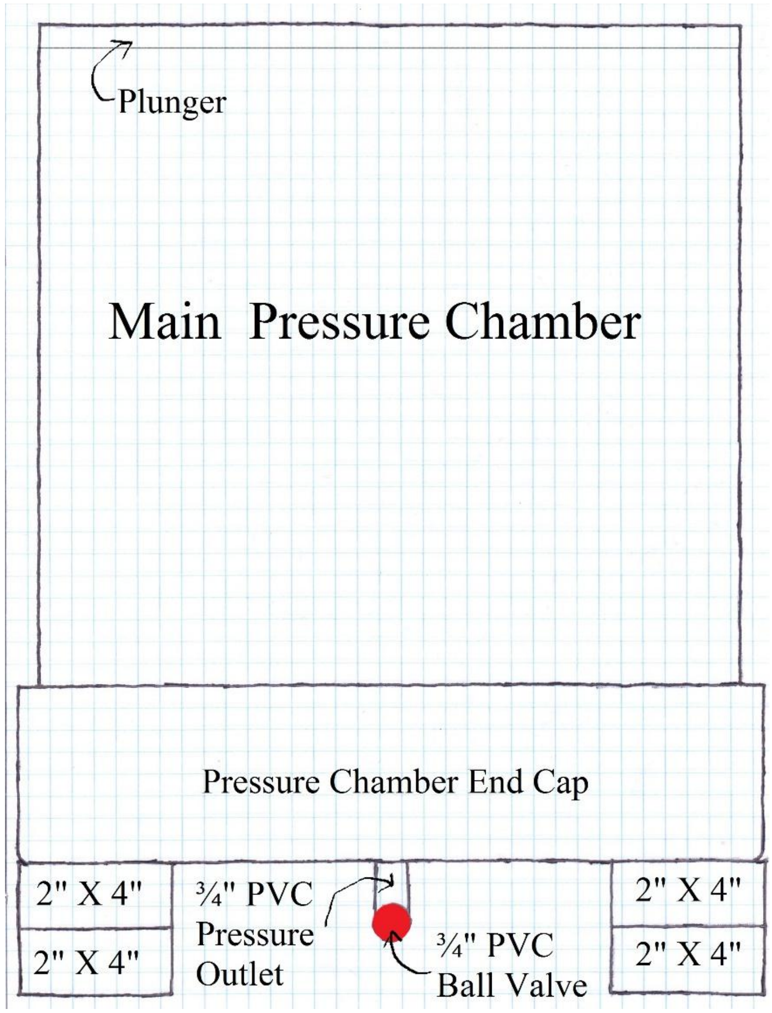


Figure 3-2: The rigid weighted bladder's front view drawn on a 1 unit to ½ inch scale. The red circle indicates that a part is coming out of the drawing. (Photo by Casey Tucker)

3.4 Pressure Systems

3.4.1 Pressure Release Valve

This pressure chamber is made from PVC pipe. One end of it is fitted with a tire valve that allows air to be pumped in. The pieces of the chamber are connected by a "Y" PVC piece, which connects to the release valve. Following and preceding the release valve are reducers; pieces that decrease the diameter of the area in which the air is pushed out of the chamber, increasing the force and velocity of the air.

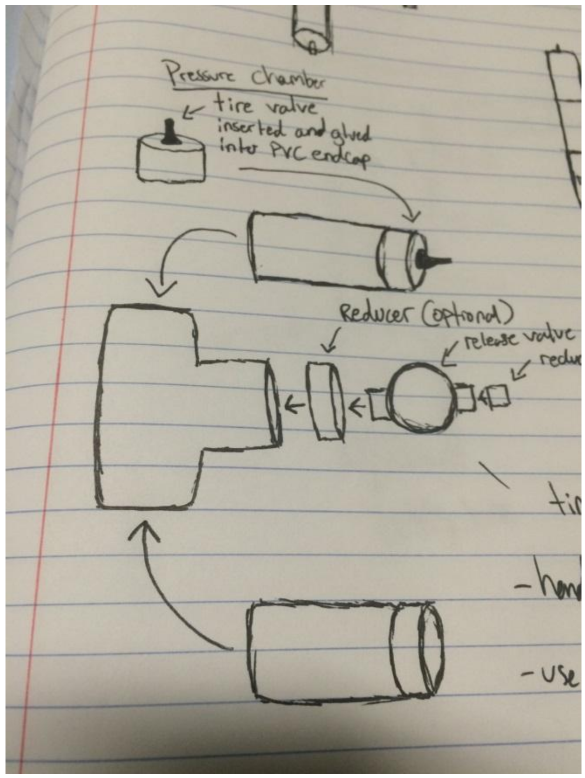


Figure 3-3: The pressure chamber is made to have two sealed dead ends in both of the parallel inlets with another endcap with a one way valve sealed in the center in the perpendicular outlet. (Photo by Tyler Caseltine)

3.4.2 Stacked Pressure Chamber

The Pressurized Launch Rocket pressurizes a PVC chamber to a high pressure thru an adjusted valve for a bike pump with a pressure gauge. The launcher component launches four rockets, but can be customizable to launch a maximum of eight rockets. The pressurized chamber is the essential piece and must be completely sealed to allow build of high pressure and is released thru wiring of the four rocket releases with a sprinkler valve to each and linked to a release button. The rocket unit is placed on top of an adjustable stand that allows it to adjust to different angles that include 30° and 45°. There are two rotating handles that are linked to the stand on two sides with a support bearing that support the rise of the stand.

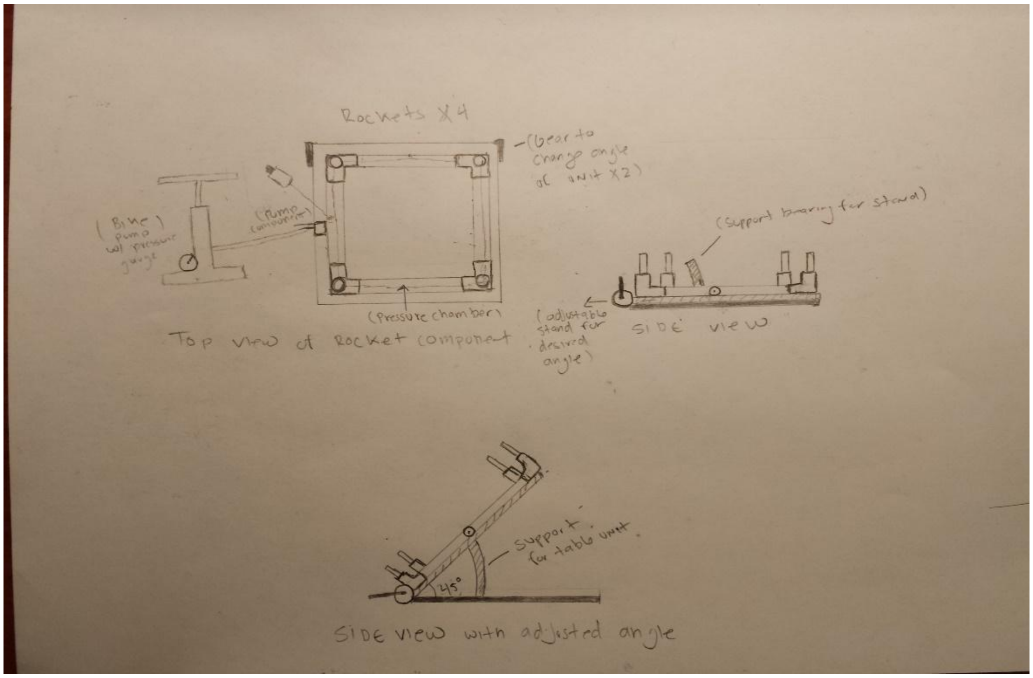


Figure 3-4: Pressurized paper rocket launcher that can be angled for different launch positions and is pumped up with a bicycle pump. (Photo by Jason Mora)

3.4.3 Main Pressure Chamber

The center pressure chamber has one chamber that is pressurized. Every rocket launch arm comes out from the main chamber. Every rocket has its own valve, which gives control of which rocket arms discharge to the operator. In addition, the center axial design of the rotary base allows for any angle of the operator’s choosing to be a possible launch angle.

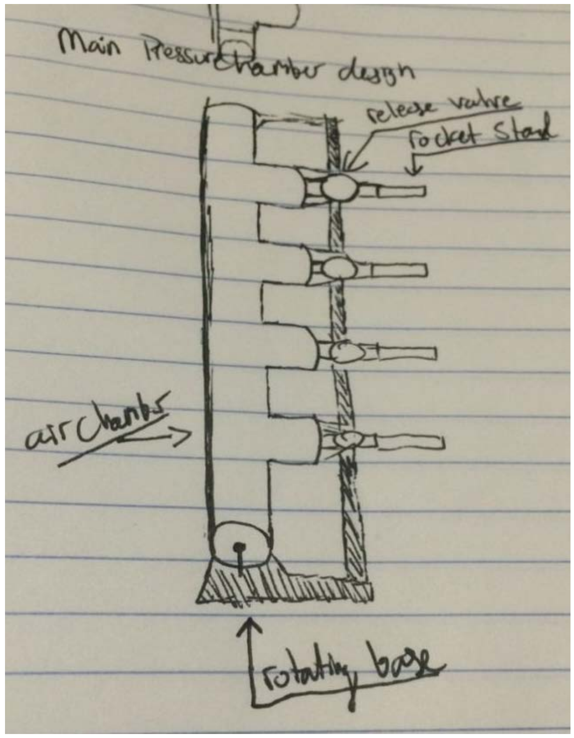


Figure 3-5: The center pressure chamber is shown here from a top view. Every rocket has an individual valve to fire. The rotary base allows for changing of the launch angle. (Photo by Tyler Caseltine)

3.4.4 Central Pressure Chamber

The stacked pressure chamber, seen in Figure 3.2.4, features a similar concept to the main pressure chamber design, but the stacked design separates out the rockets into pairs that share one pressure chamber. Each pressure chamber would be completely self-contained and would be strapped to the base so that they could rotate freely allowing for any possible launch angle. The stacked pressure chamber design is completely modular allowing for as many chambers as wanted to be used. The stacked pressure chambers would be paired with inexpensive hand pumps, so that the students could pressurize the chambers.

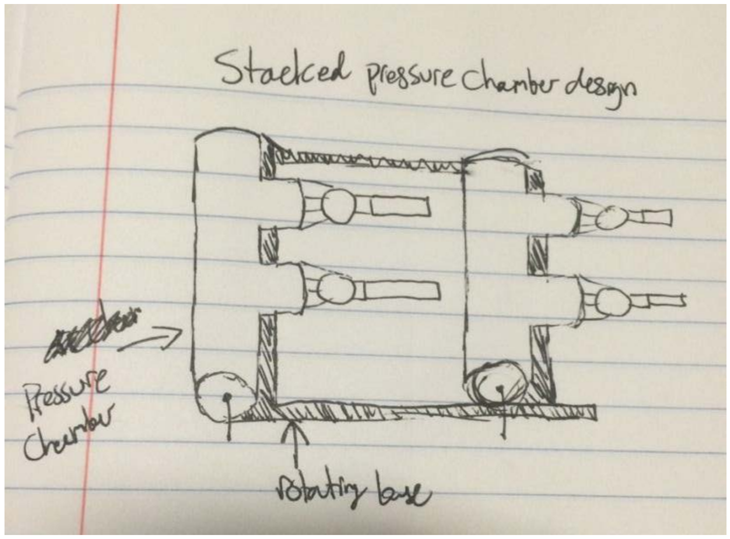


Figure 3-6: The stacked pressure chamber has been flattened on to the paper in this drawing. Each set of launchers has a separate pressure chamber and can rotate in the base to adjust the launch angle. (Photo by Tyler Caseltine)

4 Decision Making Process

4.1 Introduction

Section 4 describes how the team rated the alternative solutions to ultimately pick a design that would be constructed and implemented. The team used a Delphi Matrix to come up with numerical values of the alternate solutions in order to display which solution was the best. The Delphi Matrix helped to provide a final decision on which solution would be constructed.

4.2 Criteria Definition

The following are definitions of the criteria listed in Section 2.

Consistency: Repeats the same results when propelled at the same condition.

Effectiveness: Minimal amount of work put in produces the desired amount of work put out.

Safety: Does not cause any bodily harm to users or observers of the system.

Durability: Components maintain structural integrity throughout the products lifespan.

Ease of Use: Middle school students are able to comprehend and use the product.

Reparability: Price of individual components and ease of replacing those components.

Compactability: Ability to be taken apart and stored.

Adjustability: Ability to manipulate launch angles.

Aesthetics: Physical appearance of the product.

Attractiveness: Appeal to middle school students.

4.3 Solutions

The following are possible solutions that are described in Section 3.

- Weighted Flexible Bladder
- Weighted Rigid Bladder
- Main Pressure Chamber
- Central Pressure Chamber
- Stacked Pressure Chamber
- Pressure Release Valve

4.4 Decision Process

A decision method called Delphi Matrix was used to help choose the best alternative solution. First, criteria must be placed as shown in Table 4.1 and a value from 0-10 is assigned, 10 being the highest. Second, the group individually voted for alternatives and gave them a value from 0-100, the highest 100, and was then averaged to the nearest whole number. In figure 4.2 in the Delphi Matrix, it displays our alternative solutions and assigns a total number based off the criteria and alternatives. Upon looking at the data, the chart states the best solution having the highest number total. Lastly, the team has a consensus based upon the data and speaks about the assigned numbers and verifies on the alternative solutions verbally on why they are given certain scores to finalize our decision.

Table 4-1: Criteria List

Criteria	
List	Weigh t
Consistency	10
Safety	10
Effectiveness	8
Durability	8
Ease of Use	7
Compatibility	7
Repairability	6
Adjustability	5
Attractivenes s	4
Aesthetics	3

Table 4-2: The Delphi Matrix displays alternatives and are categorized on how well they satisfy each weighted criteria. The sum are tallied at the bottom as totals and the highest sum total is the best alternative.

Criteria	Weight (0-10)	Alternatives (0-100 high)					
		Weighted Flexible Bladder	**Weighted Rigid Bladder**	**Pressure Release Valve**	**Main Pressure Chamber**	**Central Pressure Chamber**	**Stacked Pressure Chamber**
Consistency	10	69 / 690	76 / 760	78 / 780	85 / 850	77 / 770	80 / 800
Safety	10	81 / 810	80 / 800	75 / 750	77 / 770	73 / 730	60 / 600
Effectiveness	8	63 / 504	69 / 552	79 / 632	83 / 664	80 / 640	73 / 584
Durability	8	61 / 488	75 / 600	71 / 568	85 / 680	80 / 640	80 / 640
Ease of Use	7	87 / 609	81 / 567	78 / 546	83 / 581	77 / 539	79 / 553
Compactibility	7	76 / 532	72 / 504	70 / 490	82 / 574	77 / 539	72 / 504
Repairability	6	49 / 294	61 / 366	63 / 378	65 / 390	75 / 450	75 / 450
Adjustability	5	58 / 290	59 / 295	71 / 355	57 / 285	73 / 365	65 / 325
Attractiveness	4	63 / 252	78 / 312	73 / 292	66 / 264	72 / 288	75 / 300
Aesthetics	3	76 / 228	71 / 213	64 / 192	61 / 183	64 / 192	70 / 210
Totals		**4697**	**4969**	**4983**	**5241**	**5153**	**4966**

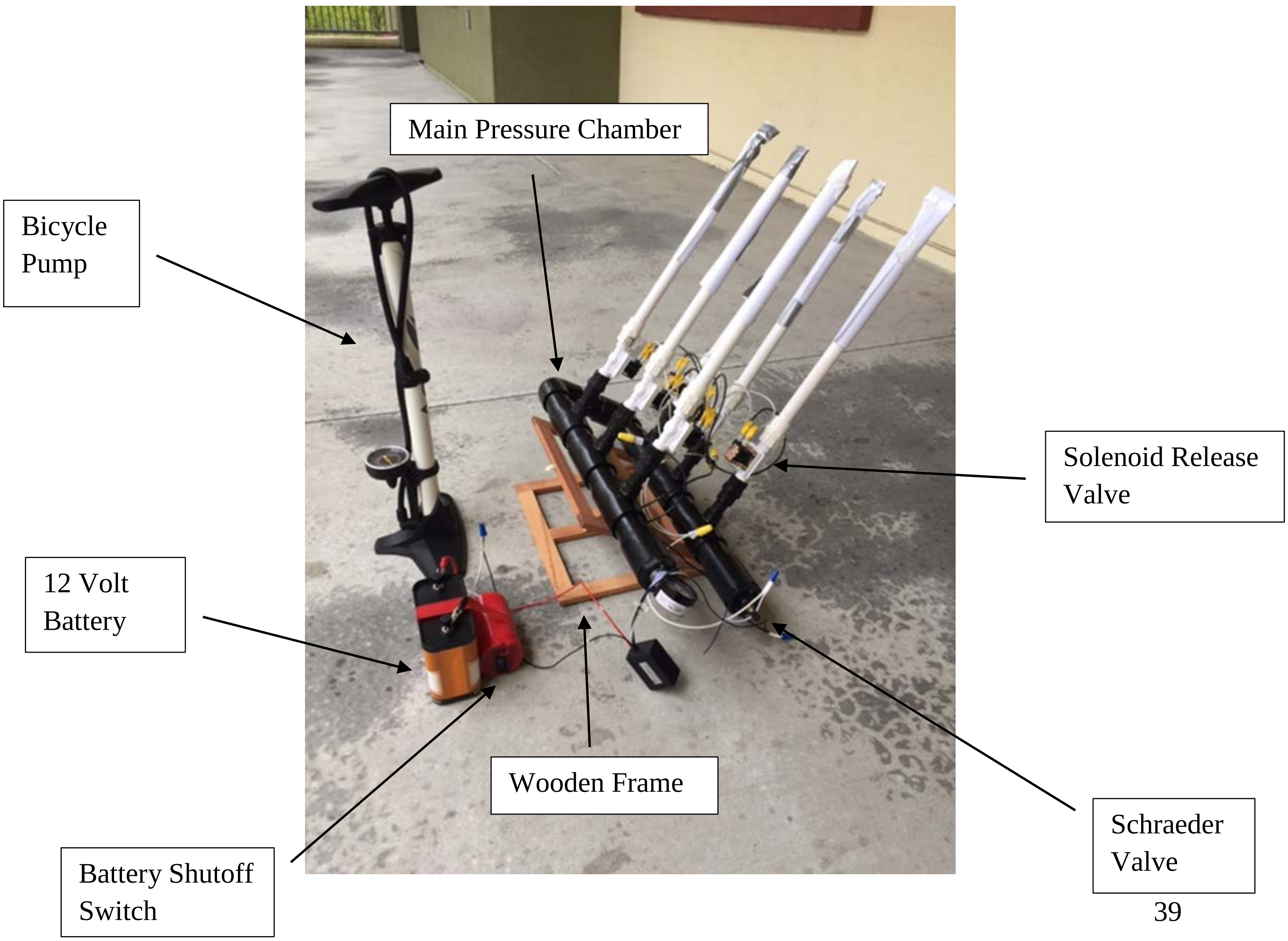
4.5 Final Decision

Delphi Matrix helped decide our final decision on alternatives and gave two possible designs that were the Main Pressure Chamber and the Central Pressure Chamber. This narrowed down our selection of alternatives and we justified choosing one by following the criteria that satisfied the client. Ultimately, the consistency and durability were the deciding factors because these were crucial to the client in keeping the Multiple Rocket Launcher in use for a long time. The decision is a hybrid of the Main Pressure Chamber and Central Pressure Chamber. It is made up of the best components of both.

5 Specifications

5.1 Introduction

Section 5 is an in-depth analysis of the final design. Section 5 covers a breakdown of the different components of the design. The implementation and maintenance of the design is discussed in detail. Additionally the cost of the design is discussed in terms of dollars spent and time spent. Lastly, section 5 covers the qualitative and quantitative results from completion of the Multiple Rocket Launcher.



5.2 Description of Solution

The Multiple Rocket Launcher propels six paper rockets through the air at multiple angles and velocities. It is consistent throughout each launch and is very durable.

The Multiple Rocket Launcher is made out of two different sized PVC tubing, six solenoid valves, a Schrader valve, shelving brackets, hook and loop pads, and a bicycle pump. The pressure chamber consists of nine sections of 1.5 inch diameter PVC tubing cut to 4 inches in length and are combined with six tee reducer joints and two ninety degree. All of the PVC pieces are glued into place. There are three inch long PVC pipes at half inch diameter placed in the top part of the tee joints as a connection to the solenoid valves. The six solenoid valves are then attached to the half inch PVC with an adapter. On the release end of the solenoid valve there is a foot long of half inch PVC that holds the paper rockets. The two ends of the pressure chamber are sealed with one cap that adapts to a Schrader valve and another that adapts to a 100 psi pressure gauge. The pressure chamber is pressurized with the bicycle pump to the desired psi and then a button is pushed to open all of the valves, releasing the pressure and launching the rockets. Finally, this entire system is angled and supported by a rod that is attached to the top of the pressure chamber. This rod adjusts the launch angle by being put into different slots in the shelving brackets.

5.2.1 PVC

The specific PVC tubing used is rated to withstand 480 psi before failing. PVC parts are numerous and diverse and are easy to connect together. PVC glue is comparable to concrete once it hardens and it is nearly impossible to separate two pieces of PVC that are glued together. PVC is generally very inexpensive. Since PVC is designed to transport fluids, it can be made air-tight fairly easily.

5.2.2 Solenoid Valve

The pressure release valve implemented is electromechanically operated at the push of a button. The two-way valve is controlled by an electric current that runs through a coil opening the valve. Once the valve opens the air is released from the chamber and flows through the outlet. This valve was implemented because it has a fast release and a high reliability rate.

5.2.3 Wiring

The positive end of the 12 volt lantern battery is connected to a 10 amp inline fuse. The fuse is wired into a master switch. The master switch then goes to the RF receiver's in. The receiver's out connects to the buss bar. The buss bar then distributes the electricity to each valve individually. The buss bar creates six parallel circuits to power each valve. The receiver will only open if the switch is in the on position and the transmitter sends the on signal. Should the circuit exceed 10 amps, the fuse will blow and the system will cease working.

5.2.4 Frame

The frame is designed to launch rockets at different angles. The frame can be adjusted to 30˚, 45˚, and 60˚ while maintaining stability. It is made out of strips of wood.

5.3 Costs

Costs included in this section are design cost, materials cost, and maintenance cost for our Multiple Rocket Launcher Device.

5.3.1 Design Cost

The design cost illustrated in the pie chart below was derived with respect to the total amount of hours put in by each group member. Cost consists of the total human hours of research, design, and building of the Multiple Rocket Launcher.

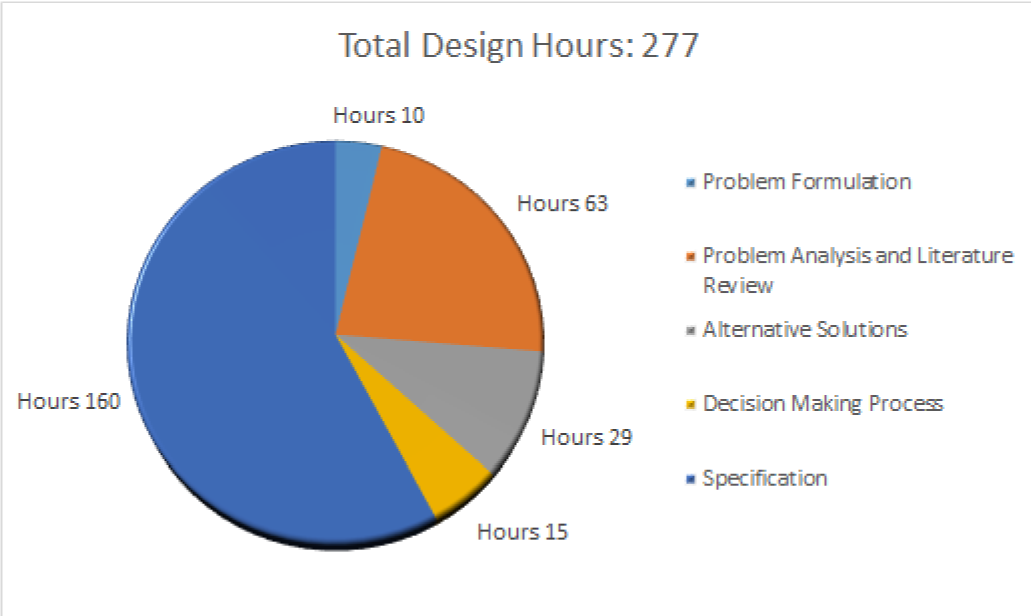


Figure 5-1: Pie Chart of Total Human Hours

5.3.2 Cost and Use of Materials

The table below shows the costs of the items used in the implementation and testing of our product. Not all items purchased were implemented in the final design so their use is solely described as "tested".

Table 5-1: Cost of all Purchased Items

Materials Cost			
Item	Price	Quantity	Subtotal (Each Item)
Schraeder Valve	$6.99	1	$6.99
1 foot Sch 40. 1-1/2" PVC Pipe	$0.99	3	$2.97
T-shaped PVC Adapter 1/2"	$3.49	6	$20.94
PVC Elbow Connectors 1-1/2"	$1.99	2	$3.98
Schraeder Valve Adapter	$0.50	1	$0.50
Pressure Gauge (100 PSI)	$12.99	1	$12.99
Plugs for T-Shaped Adapter	$0.79	6	$4.74
Solenoid 1/2" Pressure Release Valve	$6.99	6	$41.94
1/2" Threaded to Non-threaded adapter	$0.69	12	$8.28
PVC Primer	$7.99	1	$7.99
PVC Glue	$8.99	1	$8.99
Presta Valve (2-Pack)	$19.99	1	$19.99
Teflon Tape	$5.99	1	$5.99
1 foot Sch 40. 2" PVC Pipe	$1.15	3	$3.45
1/2" PVC End Cap	$2.93	1	$2.93
Yellow Wire Connector Pack	$2.29	3	$6.87
In-line Fuse Holder	$3.59	1	$3.59
Painters Abrasive	$1.34	1	$1.34
Long Nose Pliers	$11.69	1	$11.69
Electric Tape	$3.59	2	$7.18
6 Amp Fuse	$4.99	1	$4.99
Alligator Clips	$2.99	1	$2.99
14 Gauge Wire per foot	$0.49	10	$4.90
Screw-on Wire Connectors	$7.19	1	$7.19
Switch Rocker	$7.99	1	$7.99
12 Gauge Wire per foot	$0.59	20	$11.80
Bike Pump	$26.99	1	$26.99
12 Volt Lantern Battery	$13.99	1	$13.99
Holding Frame	$10.96	1	$10.96
Double A Battery Holder	$5.79	1	$5.79
9 Volt Battery Clip	$4.99	1	$4.99
Piece to Holding Frame	$8.68	1	$8.68
Velcro Pads	$3.99	1	$3.99
12 Volt Universal Remote Kit	$17.98	1	$17.98
Gravitech Push Button	$6.00	1	$6.00
Total			$322.57

5.3.3 Maintenance Cost

Little maintenance is needed for this product but there is a possibility of components failing. Most of what could go wrong would be a piece no longer working due to an environmental issue, this results in a quick replacement of the component. These possible fails are listed in the table below.

Table 5-2: Maintenance Cost

Task	Frequency	Task Time	Cost
Replace Solenoid valve	As needed	5 minutes to swap	$ 6.69
Replace pump	As needed	1 minute to swap pump	N/A
Replace Schraeder Valve	As needed	2 Minutes to swap	$ 6.99

5.4 Instructions for Use and Upkeep

5.4.1 Launching the Rocket

Launching the rockets from the device involves a few simple, but crucial steps. These steps must be followed every launch in order to propel the rockets correctly and safely.

5.4.1.1 Filling the Air Chamber

The air chamber can be filled by most common mechanisms for pumping air, such as a small air compressor or a bike pump. A bike pump has been provided with the project. Attach the hose end of the pumping mechanism to the tire valve on the air chamber. Pump air into the pressure chamber until the pressure gage on the chamber reads the desired psi for launch. Do not ever exceed more than 50 psi. Once the desired psi has been reached, stop pumping, detach the pump, and screw the cap on to the tire valve. When the pressure chamber contains air under pressure, it should be handled with extreme care.

5.4.1.2 Angling the Device

There are three possible angles at which the paper rockets can be propelled: 30 degrees, 45 degrees, 60 degrees. Simply move the peg on the frame to different holes that correspond to the desired angle.

5.4.1.3 Rocket Placement and Launching

Once the device is set up to the desired conditions, place the paper rockets on the foot long PVC pipes extending from the release valves. The rockets can be launched once everyone is standing five feet from the launching device. Simply press the release button to open the release valves which will propel the rockets.

5.4.2 Replacing Release Valves

With the delivery of the launch device, an extra release valve is included. While the release valves used in this design are highly durable, with an expected life of 50 million uses, they are the most susceptible to damage. If need be, the release valves can be bought online from Adafruit, a company based out of New York. The valves are inexpensive. To replace, simply unscrew the damaged one and replace it with the new one. Use the directions for wiring the release valves to wire it to the whole system.

5.5 Results

The Multiple Launcher Rocket is able to exert a recorded of 100 psi and launch a maximum of six paper rockets. After multiple testing attempts, it was concluded that the rockets only required up to 60 psi to launch 80 feet successfully. However this is dependent also on the design of the rocket. The Multiple Rocket Launcher produces identical results through each launch. In testing it has had no errors related to consistency.

5.5.1 Discussion

In designing the Multiple Rocket Launcher, many problems arose in the testing process and simplicity became an issue in the design.

- During testing, the pressure chamber had problems sealing the pressure air tight. This led to leaking of pressure and was discovered that some tire valve had issues holding specific pressure. Multiple tire valves were tested until discovering that the ones we were using had a defect in them that prevented them from working under pressure.

- The type of sprinkler valve chosen was key because of the complexity and maintenance cost. Certain sprinkler valve are able to release a specific amount of psi and if it is exceeded, it creates a fluttering motion and disturbing the constant pressure release. The valve needed to release to be able to release the fast and consist. The price of the valve also played a role in deciding different options of valve. The valve chosen has a simple valve and release with a simple power circuit and still being economical in replacing in future issues.

Figure 5-2: Simple Sprinkler Valve (http://www.adafruit.com/products/997)

- The sprinkler valve also served an issue with wiring different valve and still sustaining its simplicity. It was originally wired to close individual valve by closing the circuit per valve manually. This created a problem because of the amount of wiring that was exposed and could be potentially hazardous to the user and possibly damaging the product. The solution most effective was simply closing the valve with a threaded cap to change different amount of rockets launching per attempt. In doing this, the user is safe from any possible injury and the design is able to keep its simplicity.

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Appendices

Table 5-3: Casey Tucker's Timesheet in Hours

All times in Hours						
Date	**Task Description**	**General Course Time**		**Project Time**		**Total Course Time**
		Task	**Total**	**Task**	**Total**	
2/13/2015	Meeting with Point Person		0.00	1.00	1.00	**1.00**
2/15/2015	Group meeting		0.00	0.50	1.50	**1.50**
2/18/2015	Time Sheet	0.25	0.25		1.50	**1.75**
2/18/2015	Research		0.25	1.25	2.75	**3.00**
2/19/2015	Excel #2	0.25	0.50		2.75	**3.25**
2/21/2015	Research		0.50	1.50	4.25	**4.75**
2/22/2015	Research		0.50	2.50	6.75	**7.25**
2/23/2015	Research		0.50	4.00	10.75	**11.25**
2/24/2015	Writing Literature Review		0.50	3.00	13.75	**14.25**
2/26/2015	ACAD #2	2.00	2.50		13.75	**16.25**
2/27/2015	ACAD #2	4.00	6.50		13.75	**20.25**
3/5/2015	ACAD #3	4.00	10.50		13.75	**24.25**
3/7/2015	Formating with Word #3	0.50	11.00		13.75	**24.75**
3/8/2015	ACAD Designing		11.00	3.00	16.75	**27.75**
3/10/2015	Section 3		11.00	5.00	21.75	**32.75**
3/10/2015	ACAD Designing		11.00	2.00	23.75	**34.75**
3/11/2015	Peer Evaluation	1.50	12.50		23.75	**36.25**
3/13/2015	Section 4		12.50	3.00	26.75	**39.25**
3/14/2015	ACAD Designing		12.50	3.00	29.75	**42.25**
3/28/2015	Team Meeting		12.50	4.50	34.25	**46.75**
3/31/2015	Team Meeting		12.50	4.00	38.25	**50.75**
4/5/2015	ACAD #4	0.25	12.75		38.25	**51.00**
4/7/2015	Poster Draft		12.75	7.00	45.25	**58.00**

4/9/2015	Section V		12.75	4.00	49.25	**62.00**
4/12/2015	Appropedia Page		12.75	13.00	62.25	**75.00**
4/18/2015	Team Meeting		12.75	8.00	70.25	**83.00**
4/22/2015	Team Meeting		12.75	12.00	82.25	**95.00**
4/23/2015	Team Meeting		12.75	9.00	91.25	**104.00**
4/25/2015	Team Meeting		12.75	5.00	96.25	**109.00**
5/3/2015	Appropedia Page		12.75	6.00	102.25	**115.00**
5/4/2015	Appropedia Page		12.75	6.00	108.25	**121.00**

Table 5-4: Richard Doctor's Timelog in Hours

Date	Task Description	General Course Time		Project Time		Total Course Time
		Task	Total	Task	Total	
2/12/2015	Team Brainstorming	0.00	0.00	0.66	0.66	0.66
2/13/2015	Researched Project	0.00	0.00	0.50	1.16	1.16
2/15/2015	Brainstormed with Team	0.00	0.00	1.00	2.16	2.16
2/15/2015	Researched Project	0.00	0.00	0.50	2.66	2.66
2/16/2015	Class	0.83	0.83	0.00	2.66	3.49
2/18/2015	Class	0.83	1.66	0.00	2.66	4.32
2/18/2015	Time Log	0.33	1.99	0.00	2.66	4.65
2/21/2015	Literature Review	2.00	3.99	2.00	4.66	8.65
2/23/2015	Class	0.83	4.82	0.00	4.66	9.48
2/25/2015	Researched Project	0.83	5.65	0.00	4.66	10.31
2/26/2015	Lab	3.00	8.65	0.00	4.66	13.31
2/26/2015	Time Log	0.50	9.15	0.00	4.66	13.81
2/28/2012	Met with team	0.00	9.15	2.00	6.66	15.81
3/2/2015	Class Work	0.83	9.98	0.00	6.66	16.64
3/4/2015	Researched Project	0.83	10.81	0.00	6.66	17.47
3/5/2015	Lab	3.00	13.81	1.50	8.16	21.97
3/7/2015	Group Meeting	0.00	13.81	2.00	10.16	23.97

3/9/2015	Class	0.83	14.64	0.00	10.16	24.80
3/11/2015	Researched Project	0.83	15.47	0.00	10.16	25.63
3/12/2015	Meeting with Lonny	0.50	15.97	0.50	10.66	26.63
3/23/2015	Class Work	0.83	16.80	0.00	10.66	27.46
3/23/2015	Short meeting with team	0.00	16.80	0.50	11.16	27.96
3/25/2015	Class	0.83	17.63	0.00	11.16	28.79
3/28/2015	Construction	0.00	17.63	3.50	14.66	32.29
3/29/2015	Met with team	0.00	17.63	0.50	15.16	32.79
3/30/2015	Class	0.83	18.46	0.00	15.16	33.62
3/31/2015	Met with team	0.00	18.46	2.00	17.16	35.62
4/1/2015	Class	0.83	19.29	0.00	17.16	36.45
4/2/2015	Lab	2.00	21.29	1.50	18.66	39.95
4/4/2015	Met with team	0.00	21.29	3.00	21.66	42.95
4/6/2015	Met with team	0.83	22.12	0.00	21.66	43.78
4/8/2015	Class Work	0.83	22.95	0.00	21.66	44.61
4/9/2015	Lab	3.00	25.95	0.00	21.66	47.61
4/11/2015	Construction	0.00	25.95	3.00	24.66	50.61
4/13/2015	Class Work	0.83	26.78	0.00	24.66	51.44
4/15/2015	Researched Project	0.83	27.61	0.00	24.66	52.27
4/16/2015	Lab	2.00	29.61	0.00	24.66	54.27
4/18/2015	Met with team	0.00	29.61	2.00	26.66	56.27
4/20/2015	Class	0.83	30.44	0.00	26.66	57.10
4/22/2015	Class	0.83	31.27	0.00	26.66	57.93
4/23/2015	Met with team	0.00	31.27	1.50	28.16	59.43
4/23/2015	Presentations	3.00	34.27	3.00	31.16	65.43
4/25/2015	Met with team	0.00	34.27	3.00	34.16	68.43
4/27/2015	Portfolio	0.83	35.10	0.00	34.16	69.26
4/29/2015	Portfolio	0.83	35.93	0.00	34.16	70.09
4/30/2015	Lab	3.00	38.93	0.00	34.16	73.09

5/3/2015	Met with team	0.00	38.93	1.00	35.16	74.09

Table 5-5 Tyler Caseltine's Time Sheet

Tyler Caseltine						
All time in hours						
Date	Task Description	Course Time		Project Time		Total Course Time
		Task	Total	Task	Total	
2/15/2015	Excel Creation/meeting	1.5	1.5	1	1	2.5
2/16/2015	Short meeting/research	2	3.5	0.5	1.5	5
2/21/2015	Research/meeting	1	4.5	3	4.5	9
2/22/2015	Research/writing	0	4.5	7	11.5	16
2/23/2015	Short meeting with team	0.5	5	0.5	12	17
2/24/2015	section 2	0	5	3	15	20
2/28/2015	meeting/writing	0	5	3	18	23
3/1/2015	AutoCAD/project	3	8	3	21	29
3/7/2015	Team meeting	0	8	3	24	32
3/8/2015	AutoCAD/project	4	12	0.5	24.5	36.5
3/10/2015	Section 3/evaluation	1	13	1	25.5	38.5
3/22/2015	Section 4	0	13	1	26.5	39.5
3/23/2015	Team meeting	0	13	1	27.5	40.5
3/28/2014	Team meeting	0	13	4	31.5	44.5
3/29/2015	Team meeting/word	2	15	1	32.5	47.5
3/31/2015	Team meeting	0	15	2	34.5	49.5
4/2/2015	AutoCAD	2	17	0	34.5	51.5
4/4/2015	Team meeting	0	17	3	37.5	54.5
4/5/2015	Project work/AutoCAD	2	19	0.5	38	57
4/7/2015	Team meeting	0	19	3	41	60
4/11/2015	Team meeting	0	19	3	44	63
4/12/2015	Team meeting/Section 5	0	19	2.5	46.5	65.5
4/17/2015	Team meeting	0	19	1	47.5	66.5
4/18/2015	Team meeting	0	19	3	50.5	69.5
4/19/2015	Team meeting	0	19	1.5	52	71
4/22/2015	Team meeting	0	19	3	55	74
4/23/2015	Team meeting	0	19	3	58	77
4/25/2015	Team meeting/ editing	0	19	4	62	81
4/26/2015	Document editing	0	19	1	63	82
4/27/2015	Document editing	0	19	2	65	84
5/1/2015	Team meeting/ editing	0	19	5	70	89
5/3/2015	Team meeting/ editing	0	19	6	76	95

Table 5-6 Jason Mora's Time Sheet

Jason Mora							
All time in hours							
Date	Task Description	Course Time		Project Time		Total Course Time	
		Task	Total	Task	Total		
2/1/2015	Excel #1	0.5	0.5	0.0	0.0	1.0	
2/5/2015	Team brainstorm	0.5	1.0	1.0	1.0	2.0	
2/1/2014	Rube Goldberg Building	0.0	1.0	4.0	5.0	6.0	
2/5/2015	Rube Goldber Presentation	0.0	1.0	2.9	7.9	8.9	
2/8/2015	Rube Goldberg Assessment	0.5	1.5	3.0	10.9	12.4	
2/8/2015	Team Making tool/Suvey	0.3	1.8	0.0	10.9	12.7	
2/15/2015	Setting up Trello	0.1	1.9	0.0	10.9	12.8	
2/15/2015	Time Sheet #1	0.0	1.9	0.0	10.9	12.8	
2/14/2015	Meeting with Design Team	0.0	1.9	0.5	11.4	17.4	
2/16/2015	Draft Document Outline(Black Box)	0.0	1.9	0.3	11.7	17.7	
2/22/2015	Excel #2	1.4	2.3	0.0	11.7	19.1	
2/22/2015	Formatting Word 1	1.5	3.8	0.0	11.7	20.6	
2/23/2015	Rearching Literature Review	0.0	3.8	5.5	17.2	26.1	
2/23/2015	Writing Literature Review	0.0	3.8	4.0	21.2	30.1	
2/24/2015	Review Literature Review	0.0	3.8	0.5	21.7	30.6	
2/28/2015	2nd Team Meeting	0.0	3.8	2.0	23.7	32.6	
3/1/2015	Time Sheet #2	2.0	5.8	0.0	23.7	34.6	
3/1/2015	AutoCad #2	2.5	8.3	0.0	23.7	37.1	
3/2/2015	Gnatt Project	0.0	8.3	1.5	25.2	38.6	
3/7/2015	Group Meeting	0.0	8.3	2.0	25.2	40.6	
3/8/2015	Formatting Word 2	1.0	9.3	0.0	25.2	41.6	
3/8/2015	AutoCad #3	2.5	11.8	0.0	25.2	44.1	
3/9/2015	Section III	0.0	11.8	3.0	28.2	47.1	
3/10/2015	Midterm Eval Assessment	0.0	11.8	1.5	29.7	48.6	
3/10/2015	Survey and CatME	0.0	11.8	1.5	31.2	50.1	
3/10/2015	Meeting With Lonny	0.0	11.8	0.5	31.7	50.6	
3/11/2015	Building Prototype	0.0	11.8	3.0	34.7	53.6	
3/23/2015	Meeting with group	0.0	11.8	0.5	35.2	541.0	
3/23/2015	Section IV	0.0	11.8	2.0	37.2	56.1	
3/28/2015	Meeting with team	0.0	11.8	3.5	40.7	59.6	
3/29/2015	Meeting with team	0.0	11.8	0.5	41.2	60.1	
3/29/2015	Formatting Word #3	0.5	11.8	0.0	41.2	60.6	
3/30/2015	Testing Pressure Chamber (Product)	0.0	11.8	5.0	46.2	65.1	
3/31/2015	More testing	0.0	11.8	2.0	48.2	67.1	
4/4/2015	Meeting with team	0.0	11.8	4.0	52.2	71.1	
4/5/2015	AutoCad #4	2.0	13.8	0.0	52.2	73.1	
4/5/2015	TimeSheet #4	0.5	14.3	0.0	52.2	73.6	
4/8/2015	Poster Draft	0.0	14.3	1.0	53.2	74.6	
4/11/2015	Meeting with team	0.0	14.3	3.0	56.2	77.6	
4/13/2015	Draft Section Specification	0.0	14.3	2.0	58.2	79.6	
4/16/2015	Practice Presentation	0.0	14.3	2.5	60.7	8.1	
4/18/2015	Meeting with team	0.0	14.3	2.0	62.7	84.1	
4/19/2015	Excel 3	1.0	15.3	0.0	62.7	85.1	
4/25/2015	Meeting with team	0.0	15.3	3.0	65.7	88.1	
4/23/2015	Final Presentation	0.0	15.3	3.0	68.7	91.1	
4/30/2015	Ethics	0.5	15.8	0.0	68.7	91.6	
5/3/2015	Meeting with team	0.0	15.8	1.0	69.7	92.6	
5/3/2015	Worked on paper and update	0.0	15.8	5.0	74.7	97.6	