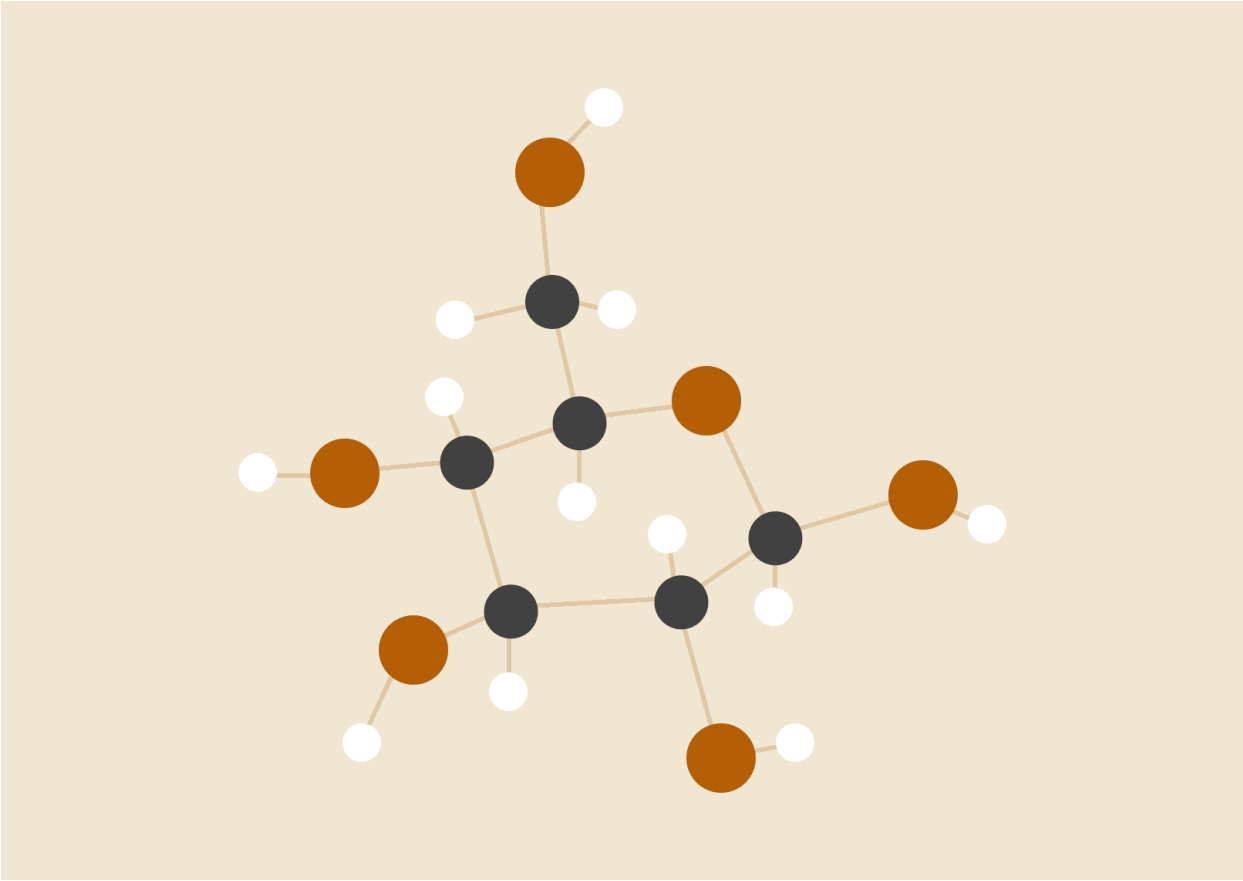
CATAPULT PROJECT



Daniyal Hashmi

31 October, 2023
SPH3U

Research

DESIGN #1

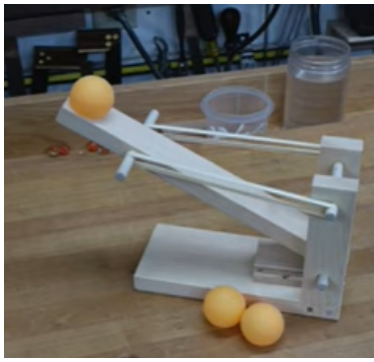
Because John Cann. (2020, April 5). Making catapults, a great project for kids and adults [Video]. YouTube. https://www.youtube.com/watch?v=rA6TOfwxjL4

This YouTube video shows a simple design for a small catapult. The materials used were rope, wood, a bottle cap, gears to tighten the rope pulling the arm down, glue, nails, and screws. This design looks easy to make, and affordable. In this design a rope is wrapped around a dowel twisted and locked in place using a gear, then another rope pulls the throwing arm down and locks in place, and then when the gear is released the rope releases the launching arm and the other rope pulls it back up and stopping which results in it launching the object. This video is a great starting point and can be used in designing a catapult that I can make with the tools and materials I have while making it on a larger to make the golf ball go a greater distance. The distance that the catapult can launch to is short as the rope doesn't swing the launching arm fast enough to launch the object as far as I want it to, the launching mechanism looks complicated and I do not have all the tools used in the video to make it. This gives me an idea of how I could make the catapult but maybe use a different launching mechanism to launch the ball further.

DESIGN #2

Acutabove Woodworking. (2020, May 15). *Making a toy catapult* [Video]. YouTube. https://www.youtube.com/watch?v=ha-tfgvFGW0

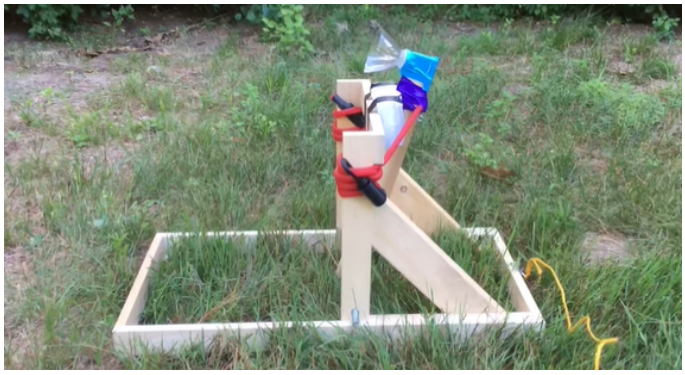
This video shows a design for a small catapult. The materials used in making this catapult are a few small pieces of wood, a dowel, glue to join all the pieces together, and two rubber bands to launch the catapult. This design for a catapult uses rubberbands to pull on the dowel going through the throwing arm and a dowel going through the



two pieces of wood standing vertically to hold the rubberbands and stop the launching arm which launches the ball. This design does not use any tools I do not have and is not complicated. It is a simple and affordable catapult which would be very easy to build, but it is small and would not launch the golf ball we will be launching very far. I could make this design on a bigger scale to make it launch further by giving the launching arm more velocity by using a bigger or stretchier band/rope or using it as an idea when designing my own catapult and add a locking mechanism for safety.

DESIGN #3

TheRcMaker. (2018, July 25). *100 ft + Catapult Project* [Video]. YouTube. https://www.youtube.com/watch?v=n3VjVjaECVI



This is a video of a catapult that is able to launch an object over 100ft. This video shows a simple design for a catapult that could possibly the under 50cm requirement that I am aiming for. This design uses a stretchy band that is tied/wrapped around the two vertical pieces of wood that pulls the launching arm up once the safety pin that is holding the arm back is pulled. The object is held in the top part of a bottle attached to the launching arm.The launching arm is stopped by a piece of wood connecting the two vertical pieces of wood. This design is good as the tension of the stretchy rope give the throwing arm a lot of velocity which is transferred over to the ball once stopped. This design is very efficient and doesn't use any complicated tools or mechanisms and looks easy to make. I could use this an inspiration for my final design and make some modifications such as making the base more stable so I can put more tension on the rope to try to make it launch our ball further.

Other sources/links used in research:

Science Oxford. (2016, March). Catapult Engineering - Science Oxford. https://scienceoxford.com/wp-content/uploads/2016/03/3.-Catapult-Engineering.pdf

- Showed me the different types of catapults and their advantages and disadvantages. Trebuchets are the most efficient catapults
- Gave me an idea of the launching angles and the measurements for the launching arm. 45-degree release angle is the most efficient
- Showed many different designs for catapults and how they can be built and gave the measurements as well.
- Showed different locking/safety mechanisms which could easily be made

Catapult project. prezi.com. (n.d.). https://prezi.com/grxl-pz6wegj/catapult-project/

- Gave a idea of the materials I would need
- I liked the design. It looked simple and easy to make
- I could change the launching mechanism to make it lauch further by using a stretchy exercise rope instead of a rope wrapped around the base of the launching arm

Catapult project. YouTube. (2012, December 18). https://youtu.be/cjK_7ymqEXg?si=k5GFBPbuah-j_5_P

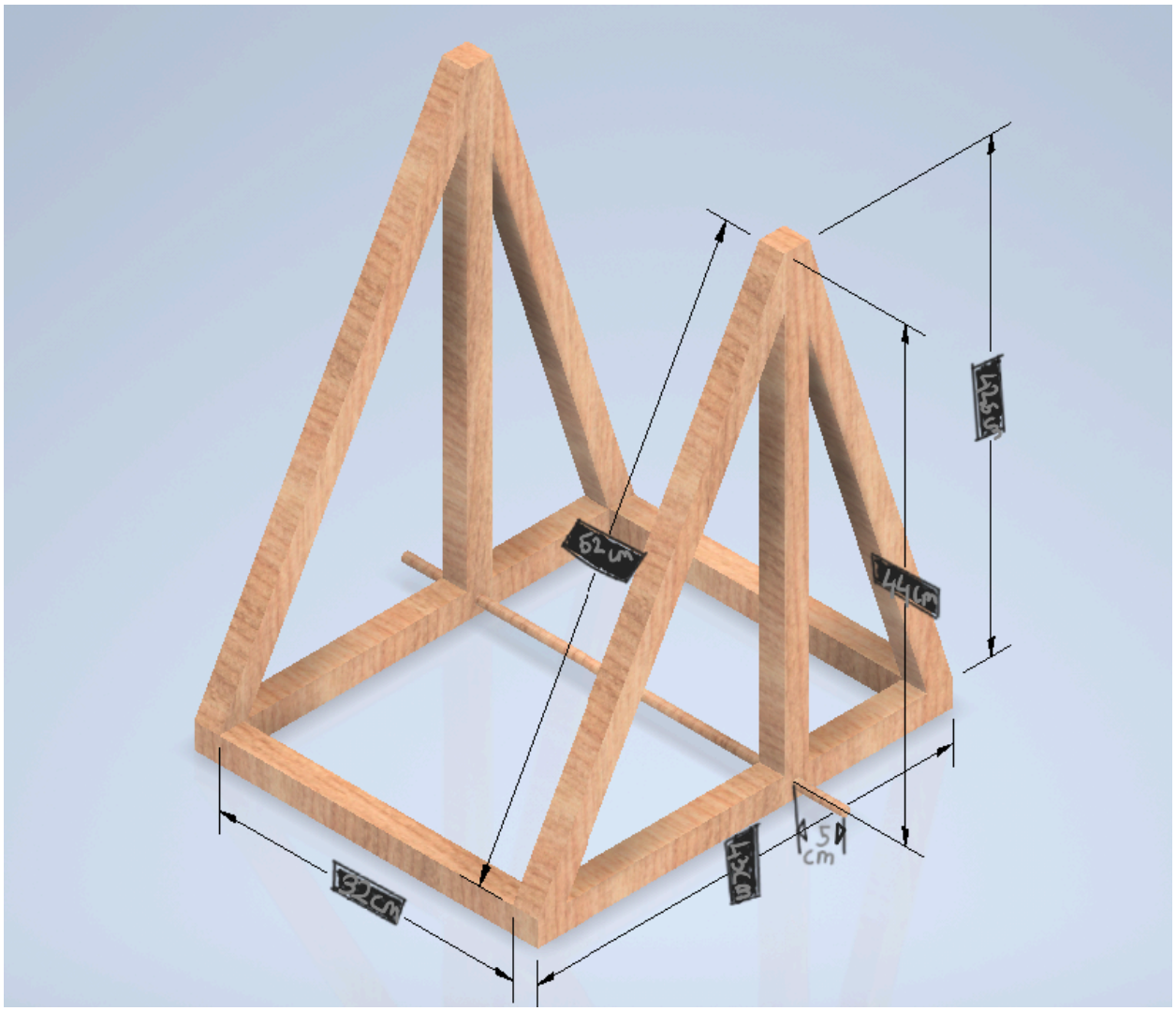
- I really liked the design
- It looked very professional and clean.
- The launching mechanism is very close to what I want it to be. The tension comes from the band/spring that comes from the opposite end of the catapult and isn't connected to the base of the throwing arm
- I like the use of weights to keep the base stable
- I used the base of this catapult when designing mine

Initial Design and Modifications:

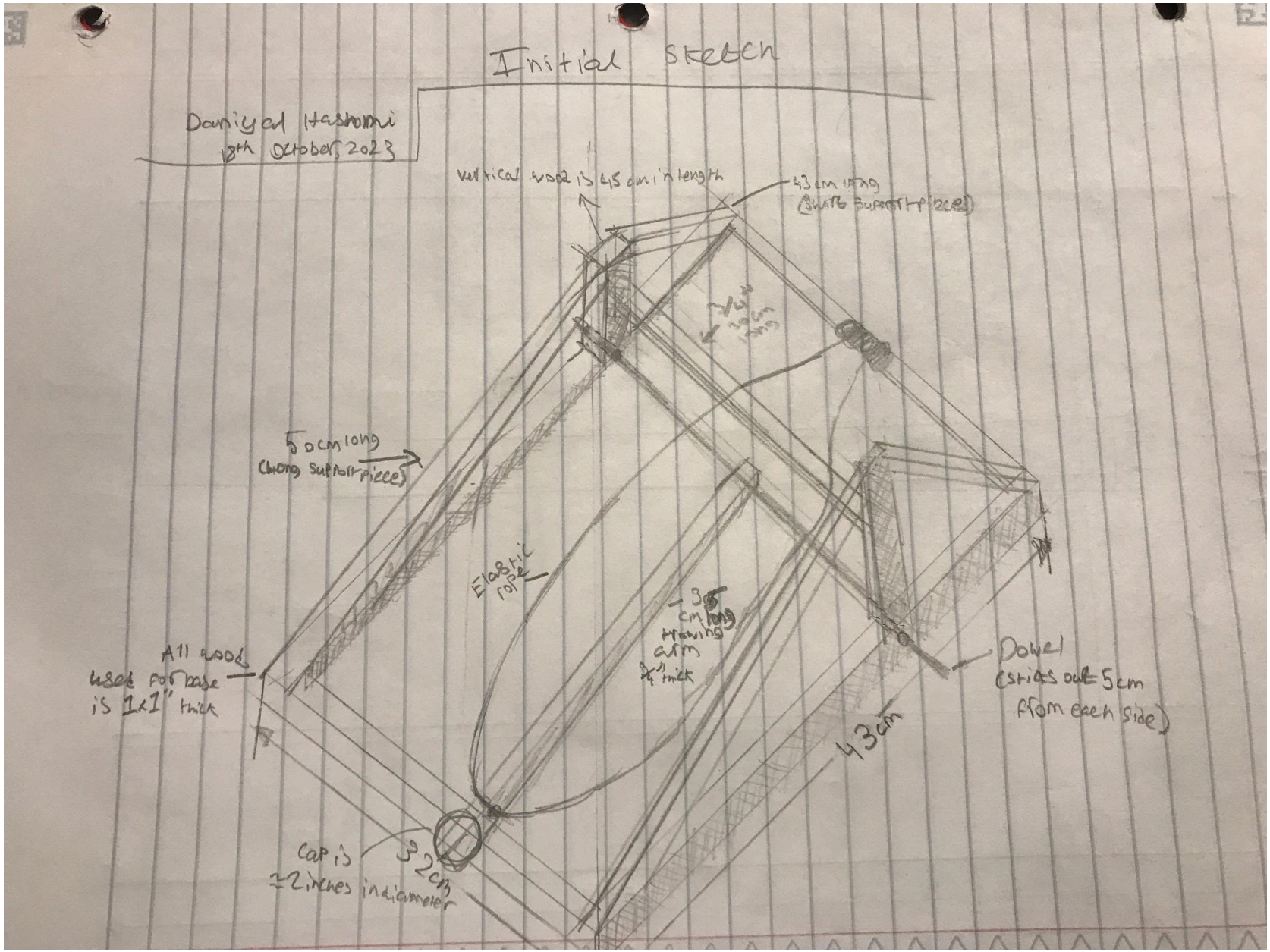
For my initial design, I decided to go with design #3 as it was the design that seemed to do the best and be the most efficient. I also took inspiration from the other 2 designs as well as the other videos and websites I used in my research to try to make the best catapult I could. My initial plan is to make the base of design #2 more stable by adding support on both sides of the vertical pieces of wood. I would use a cap to hold the golf ball. I will make the Elastic cord stretch out more (give it more tension) so it pulls the Throwing arm faster giving the ball a greater Initial Velocity. My goal is to make the ball have a high initial velocity and more airtime as the horizontal velocity does not change much as the ball can go very fast despite the air resistance and gravity is pulling it down which means I have to try to give the ball as much airtime as possible to make it go far. We will make use of a 30cm long ¾" piece of wood to be used as a stopper to stop the launching arm.

MATERIALS NEEDED (estimate):

QUANTITY	ITEM	USE
≈175"	2x4" wood	Base
≈15"	Metal Rod	Base
≈20	Screws	Connecting wood
1	Wood Glue/Hot Glue	Connecting wood
4	Strong-Tie Wood Connectors	Connecting wood
1	Elastic cord/Workout Band	Torsion Device (Pulling the throwing arm)
1	Spoon/Cap	Holding object to launch



*Picture of initial design I made on AutoDesk Inventor. Dimensions came out wrong so I drew over the original.


Initial sketch
Danial Hashmi
13th October 2023
Vertical wood is 45 cm in length
43 cm long
(Shape support piece)
50cm long
(long support piece)
Elastic rope
All wood used for base is 1x1" thick
Cap is ~2 inches in diameter
32cm
Dowel
(sticks out 5cm from each side)
43cm

Final Design:

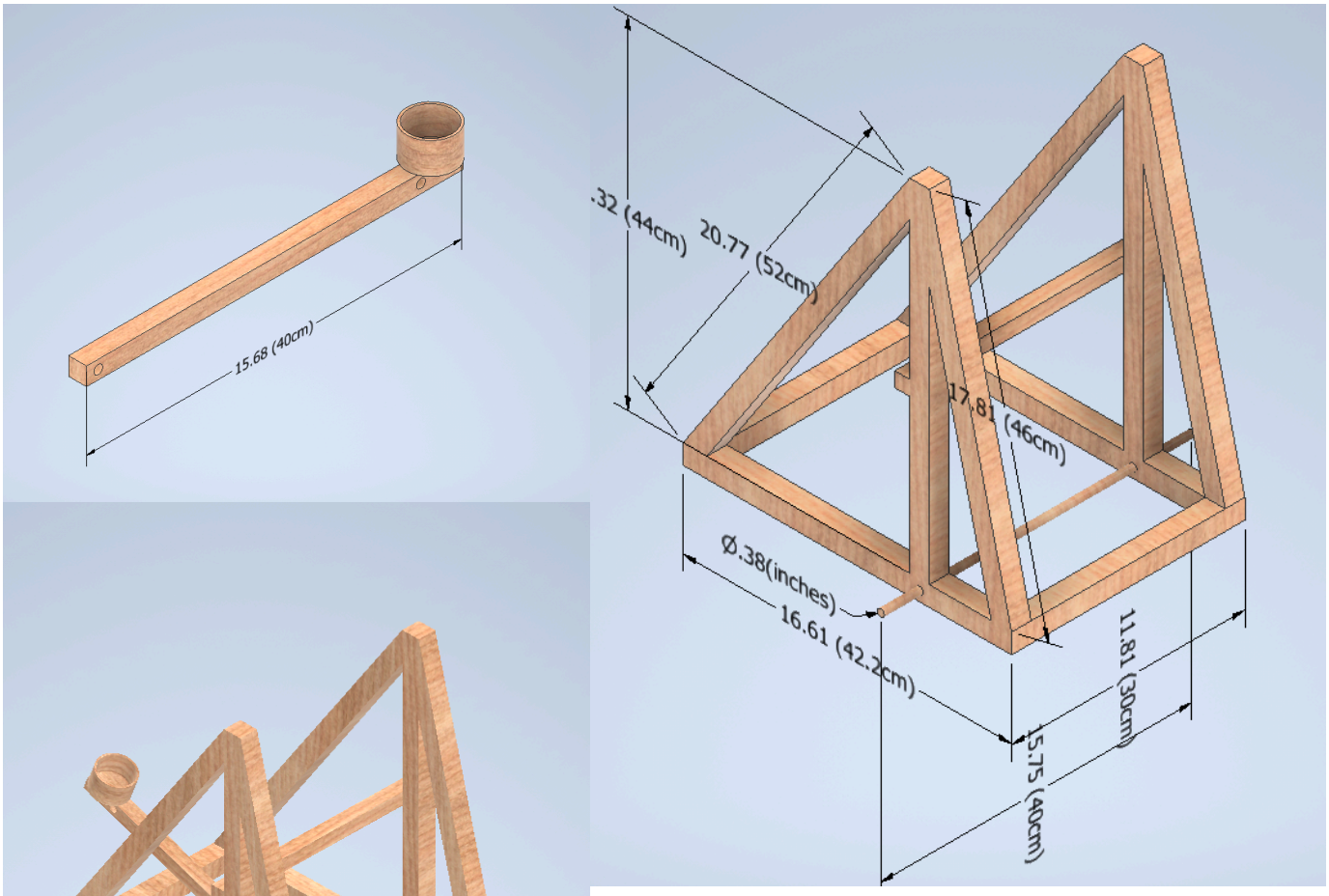
I started off by designing the catapult I had in mind on AutoDesk Inventor so I would have a complete plan with measurements and the angles for the sidepieces so I could easily cut all the needed parts and start assembling the catapult. For this part I took inspiration from the different designs and videos I watched during the research phase. My design looked a lot like design #3 but included aspects from the other videos and designs I saw like the *Catapult Project* I saw. The first problem I ran into was that I could not find many options for 2x4" pieces of wood near me and I did not have any tools that could easily and quickly cut through wood that thick. I ended up using 1x1" thick wood pieces as it was easy to cut through and I could easily get them. Another problem I ran into was finding a metal rod to hold the bottom of the throwing arm in place as I had nothing to cut a metal rod with. I replaced the metal rod with a ¼"(Diameter) wooden dowel as it was cheap and I could easily cut it down to size. The only problem that came with this was that I now had to use less tension/force on the elastic cord as too much would result in the dowel snapping. I figured that out during testing when my dowel kept snapping because of the force on it. I was able to stretch it enough to have the catapult work efficiently but not enough to snap the wooden dowel. Next, I figured out that my placement for the stopper was not efficient as it didn't create a 45° which caused the ball to have a low airtime which reduced its launching distance and had a total launching distance of 7 meters. I used the cord to create a stopper by stretching it further around the two support pieces which helped create a launch angle of 45°. This increased my total distance by 6 meters. I noticed that the cord would get loose after each launch and after some time it would begin to untie itself. I fixed this by making them tighter and using zip ties to hold them together. Next, I used a 2-inch cap found on canned sprays. This was almost the exact size of the golf ball we were launching which made it the perfect thing to hold it. Underneath the launching arm, I attached one piece of a safety hasp and the other half of the hasp on the base and I used a nail that I put in between the two holes which worked as my safety/locking mechanism. I also drilled a hole through the launching arm in which the elastic cord would go through as the elastic would keep on slipping

from its position, and this also allowed me to have more consistent results as well as being able to quickly put it back down to launch again. The support pieces on the side of the vertical piece helped make the catapult more stable and also helped with creating an angle for the launch. This design gave the catapult enough velocity in both the x and y axis' to go a far enough distance. The final measurements for the catapult were:

BASE: ≈42.2cm by ≈30cm (All pieces 1x1")
VERTICAL PIECE: ≈44cm (All pieces 1x1")
SHORT SUPPORT PIECE: ≈46cm (All pieces 1x1")
LONG SUPPORT PIECE: ≈52cm (All pieces 1x1")
WOOD STOPPER: ≈30cm (¾x¾")
LAUNCHING ARM: ≈40cm (¾x¾")

The average distance of launch I had during testing was ≈15 meters which was more than the average of 10m.

I decided to call my catapult CAT.



*I was unable to show the elastic cord in the diagrams.

*Picture of catapult which shows the elastic cord

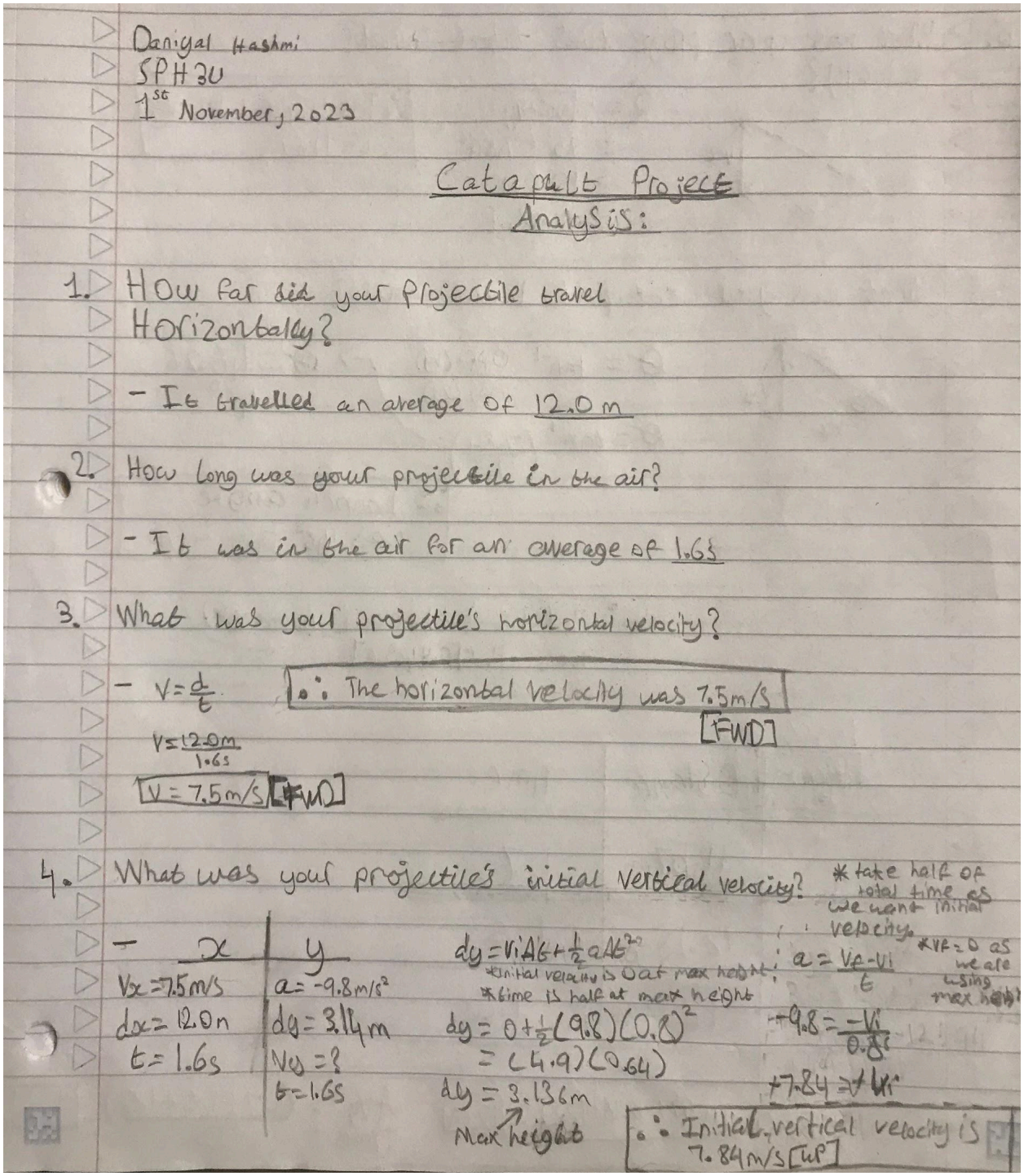
MATERIALS USED:

QUANTITY	MEASUREMENTS	ITEM
2	≈42.2cm	1x1” wood
2	≈30cm	1x1” wood
2	≈44cm	1x1” wood
1	≈40cm	¼” dowel
1	≈30cm	¾” wood
1	≈40cm	¾” wood
2	≈52cm	1x1” wood
2	≈46cm	1x1” wood
10	2”	Screws
4	¾”	Screws
5	½”	Screws
2	1½”	Screws
3		Zip-Ties
2	19.0x12.7mm	Corner Brace
1	38.1mm	Safety Hasp

MODIFICATIONS:

- Replaced metal rod with wooden dowel. This changed the amount of tension I could put on the elastic cord which would reduce my launch distance. I figured out the best angle and way to the catapult efficient by stretching out the cord and wrapping it around the dowel to keep it in place.
- All dimensions were shorter than I planned. This is because of the accuracy of the tools I used. I also had to sand/file down the ends of pieces to make them smooth and flat, because a hacksaw doesn't cut very straight. This did not affect my catapult much just made it slightly smaller than I planned
- The stopper piece I placed was not effective because it lowered the airtime of the projectile, hence reducing the displacement. I used the elastic cord and wrapped it around the support pieces and created a 45° that way. This increased the total displacement by 6m to a total of 15m
- At first, I thought that I could glue all the pieces together and it would hold just fine. I was wrong, the glue was very weak and the pieces were not stable. I simply used screws and corner braces to join the pieces together. I still used the glue to make it more stable.
- I had planned on using 2x4"s for my catapult but I couldn't find any near me so I had to use 1x1"s. This made the size and strength of my catapult less and slightly less stable. It didn't affect it too much, and I use the side support pieces to fix the stability issue.
- I planned on making a small groove on my throwing arm where the band will go. This did not work out and the band kept slipping off. I drilled a hole through the arm instead, this allowed for the band to stay in one place the entire time and made putting down the arm easier as the band was not slipping off and the wood was easier to push than the band alone.

ANALYSIS:



Danyal Hashmi
SPH3U
1st November, 2023

Catapult Project
Analysis:

1. How far did your projectile travel Horizontally?

- It travelled an average of 12.0 m

2. How long was your projectile in the air?

- It was in the air for an average of 1.6 s

3. What was your projectile's horizontal velocity?

- $v = \frac{d}{t}$

$v = \frac{12.0\text{ m}}{1.6\text{ s}}$

$v = 7.5\text{ m/s}$ [FWD]

∴ The horizontal velocity was 7.5 m/s [FWD]

4. What was your projectile's initial vertical velocity?

* take half of total time as we want initial velocity.

x	y
$V_x = 7.5\text{ m/s}$	$a = -9.8\text{ m/s}^2$
$d_x = 12.0\text{ m}$	$d_y = 3.14\text{ m}$
$t = 1.6\text{ s}$	$V_0 = ?$
	$t = 1.6\text{ s}$

$d_y = v_i\Delta t + \frac{1}{2}a\Delta t^2$

*initial velocity is 0 at max height

*time is half at max height

$d_y = 0 + \frac{1}{2}(9.8)(0.8)^2$

$= (4.9)(0.64)$

$d_y = 3.136\text{ m}$

Max height

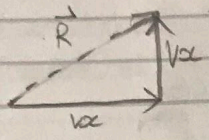
$a = \frac{v_f - v_i}{t}$ *$v_f = 0$ as we are using max height

$-9.8 = \frac{-v_i}{0.8}$

$+7.84 = +v_i$

∴ Initial vertical velocity is 7.84 m/s [UP]

5. What was your projectiles total initial velocity?



$\vec{R} = \sqrt{Vx^2 + Vy^2}$

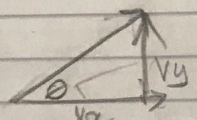
$= 7.5^2 + 7.84^2$

$= 10.84$

$= 11 m/s$

∴ Total Initial Velocity is 11 m/s

6. What was your catapults launch angle?



$\theta = \tan^{-1} \frac{OPP\ (vy)}{Adj\ (vx)}$

$\theta = \tan^{-1} \left(\frac{7.84}{7.5}\right)$

$\theta = 46.26$

$= 46°$

∴ Launch angle was 46° Front - up

∴ Total Initial velocity (with angle) was 11 m/s [Fwd 46° up]

Time

Attempt #	Distance	Time
1	11.57 m	1.7 s
2	12.18 m	1.6 s
3	12.2 m	1.6 s

Average Distance: $\frac{(11.57 + 12.18 + 12.2)}{3} = 12 m$

Avg Time: $\frac{(1.7 + 1.6 + 1.6)}{3} = 1.6$ s