Career Episode 1

33rd Warman Design & Build Competition [redacted]

Introduction

CE 1.1.1

I have done my Bachelor of Mechanical Engineering (Technology) from [redacted] University and during that time, I participated in an exciting competition that involved creating a prototype for proof of concept of a system according to the given requirements. This was 33rd Warman Design & Build Competition [redacted] in which I took part along with 4 other team members. I submitted this project in [redacted] began working on it in [redacted].

Background

CE 1.2.1

As per the requirements of the competition, Ten boats' payloads were to be delivered by the system in order to replicate wellheads using four vertical tubes of varying heights.

.

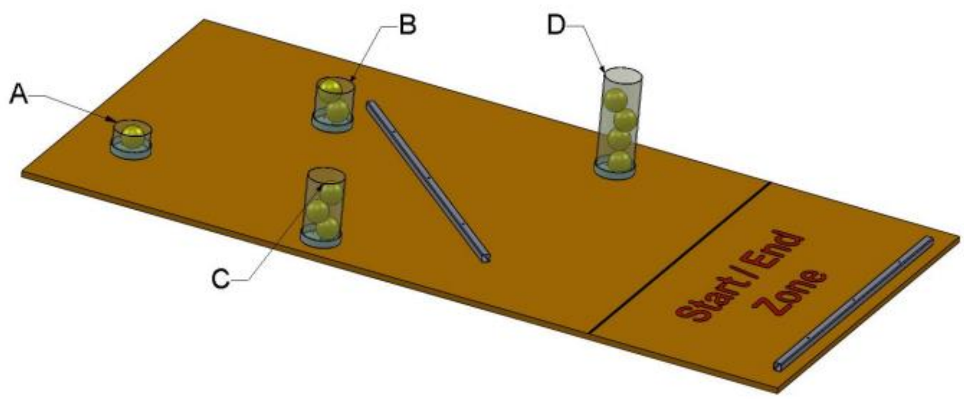


Figure 1: Schematic view of the Competition Track (Given)

More vessels had to be deposited since taller tubes were indicative of greater output heads. The Start/End zone has to be a safe location for the autonomous system to begin, such an access road. The crew would load up to 10 vessels into the system, which would then return to the Start/End zone after delivering the proper amount of vessels into each tube. The system had to operate in the active fire zone for a short period of time since the actual application temperature at the delivery point was quite high. The system would be destroyed if it didn't return within the 120 seconds that the timed ignition would take place following system activation. There were size and weight constraints since the device would often be delivered to the fields by truck or helicopter.

CE 1.2.2

I worked on this project to create a system that would meet the requirements of the Flameout 2020 Warman Design and Build Competition. The mechanism replicated the wellhead by accurately delivering 10 vessels (the payload) into four vertical tubes of varying heights. The crew put a maximum of 10 vessels into the system, which, when triggered, returned to the Start/End zone after delivering the proper amount of vessels into each tube. After 120 seconds of system activation, the system completed the task and went back to its Start/End zone. The system's maximum weight was 6 kg since it was often delivered to the fields by truck or helicopter. We ensured that no PLCs (Programmable Logic Controllers) were used on the device. In this career episode, I have described different concepts developed and the evaluation conducted to select the best working model to satisfy the entire given problem, constraints, and design safety criteria.

CE 1.2.3

As per the requirement of the competition, I and my team designed a system weighing less than 6 kilograms that accuralty produces the vessels into 4 tubes with different length in 120 seconds. I provided Product Design Specification (PDS), Solid-Works models and calculations, structural calculations, Load/Design analysis, Manufacturing details and cost analysis for the purpose of the competition.

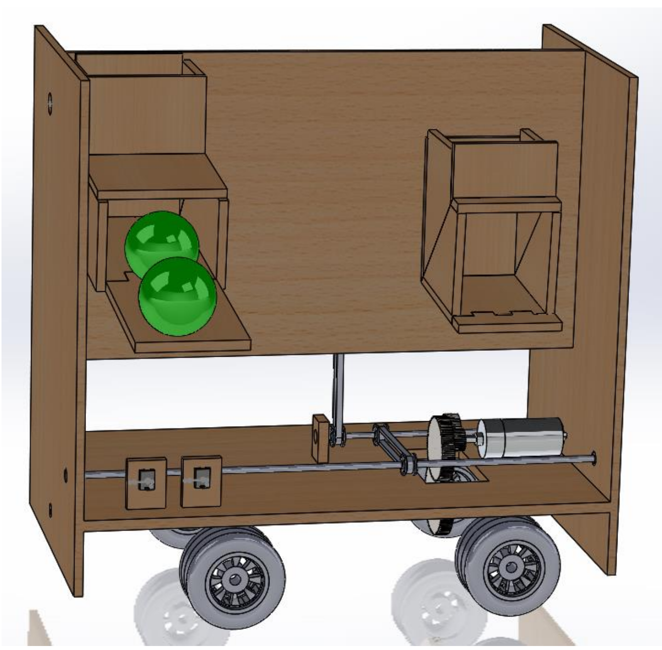


Figure 2: Finalized Conceptual model

CE 1.2.4

It was a team of 5 students including me, and I was leading the team.

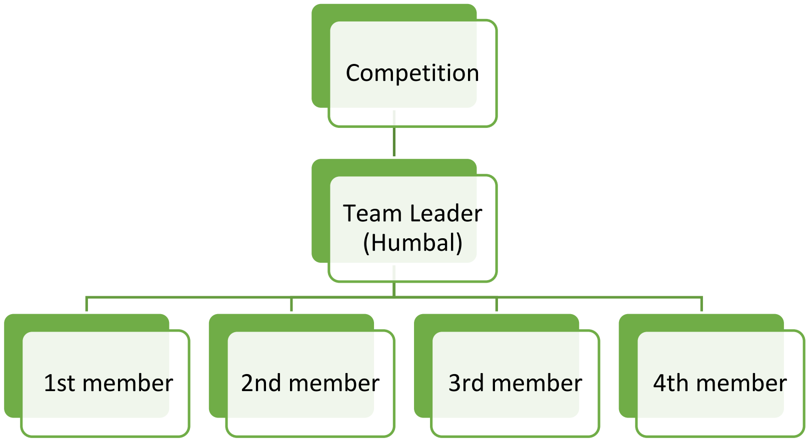


Figure 3: Project Reporting

Engineering Activity

CE 1.3.1

In the very initial step, I discussed with team members about the importance of getting things done effectively. I told them that in this project, we had to stay self-motivated as this was not part of a mandatory assessment like our academic projects. For timely completion, I knew that we had to get things right in the minimum amounts of tries possible. Moving on, I stressed upon studying the requirements of the competition in detail in order to develop the best understanding of what we had to do. I chose gathering as much information regarding the project as we could so that we knew exactly what is required. I preferred that we spent more time on understanding the project first, instead of just beginning it without understanding and then wasting more time redoing things in order to get them right.

CE 1.3.2

According to the given problem definition, I gathered data for the most part through the internet and library resources. I reviewed and collected data with respect to the various crane mechanisms being used all over the world to develop the device which fulfills the given constraints and criteria. With the assistance of the collected data, I then selected multiple concepts for the project. I visited online websites, articles, and videos to construct the working model for the assignment. The table below outlines the detail requirement of the device.

Table 1: Product Design Specification of the device

Sr. No.	Subject	Detail Description
1.	Product Performance	• Should Start initially from Start/End Zone • Device to start on ground • No PLC • Only single action to start the device • The device would complete the operation in 120 seconds
2.	Product Service Environment	• Very high temperature environment • No materials to be used that has adverse effect to environment
3.	Product Safety Requirement	• Parts should not have sharp projection • High quality material to be used for avoiding failure • Safe to be operated without using gloves
4.	Ergonomics	• Must be easy to handle and Shift • Easy installation and setup
5.	Product size and weight	• The device must fit within (500 x 500 x 500) mm envelope • The device must weigh less than 6kilograms
6.	Maintenance	• Easy to repair and maintain
7.	Product life /shelf life	• 3-4 months
8.	Material requirement	• Light weight material to be used • Material withstanding high temperature • Product to be light weight
9.	Packaging and Shipping	• Relevant standards such as ISO • Can be shipped by air
10.	Manufacturing cost	• Low manufacturing cost (cheap to buy)
11.	Documentation	• User manual must be provided • Picture provided with details of parts and functions
12.	Aesthetics	• Appealing design
13.	Standards and Specification	• Comply with relevant standards
14.	Quantity	• 1

CE 1.3.3

I developed 4 design concepts taking into consideration the constraints and the criteria given in the assignment sheet. I analysed the constraints and criteria and translated them into PDS of the device. From the PDS the critical and most important design aspects which I considered to select the best concept were performance, manufacturing cost, material required and timescale to complete the project. I finally designed the first concept of the system. I used SolidWorks for dinging the concept.

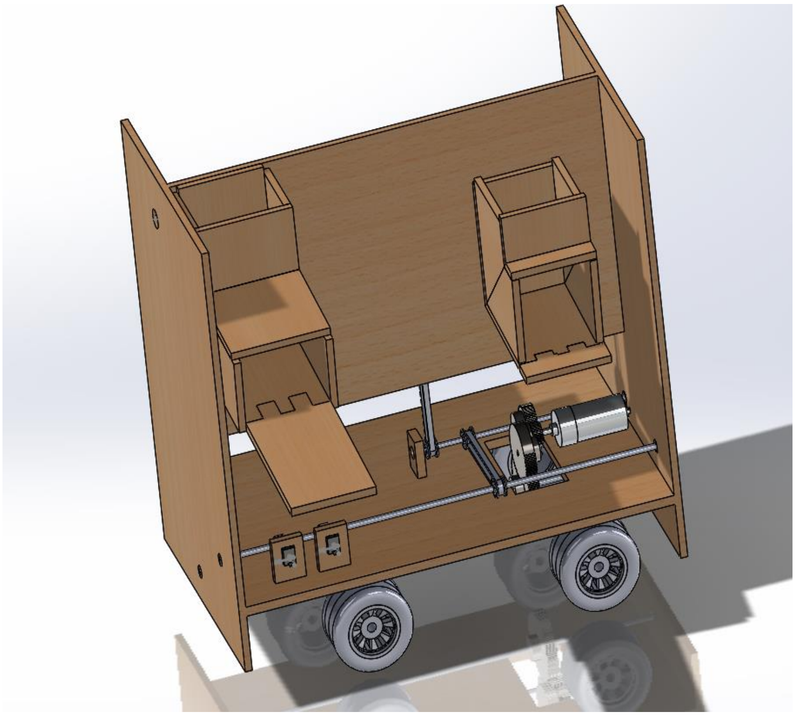


Figure 4: Solid Works design of Concept 1

CE 1.3.4

I used the concept of lever in my second concept, in which I understood that when the trigger would be activated, it would press down the slab from one end and lift it from the other end which would make a sufficient way for a ball to fall into the vessel. I understood that as per Newton's Law of Inertia, the system would stay at the same place and there was a need for the system to get back to its original position. Therefore, I used a spring for the seesaw mechanism to return to its original position, when the trigger was deactivated. In the system designed, the trigger needed to be activated every time to put each ball in the tubes. I drew a hand sketch of the concept 2 first, which I have shown below.

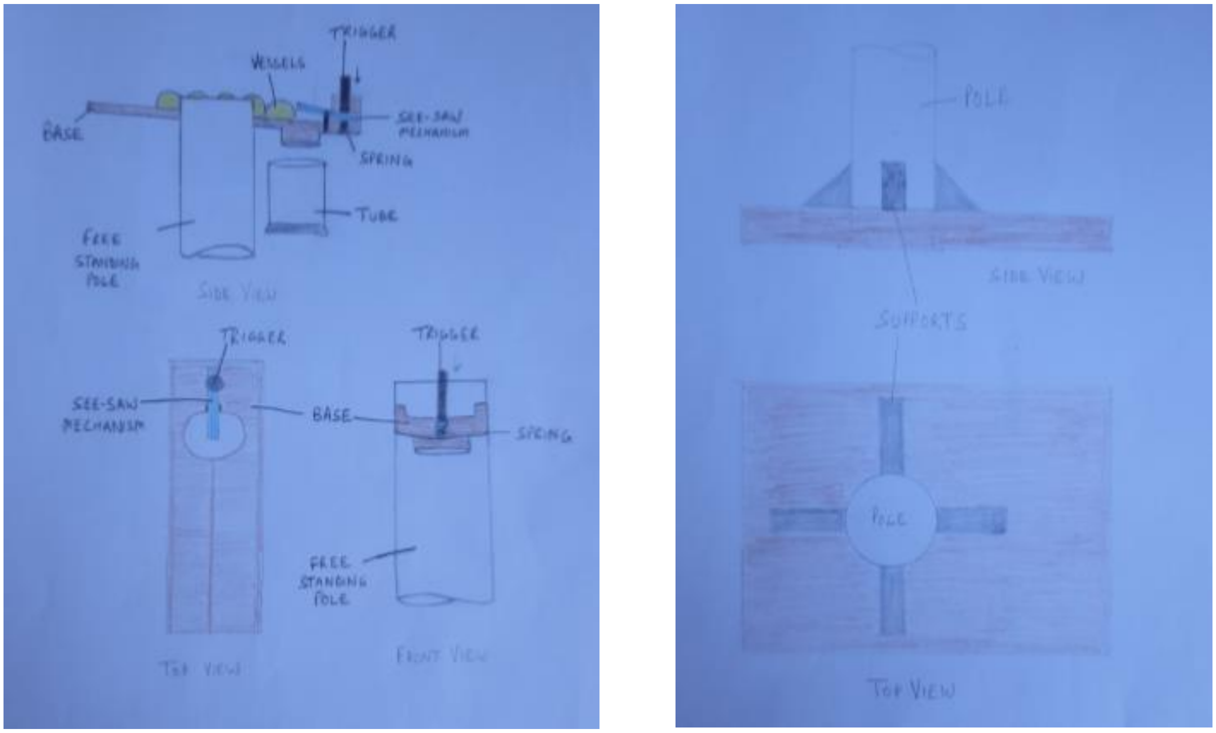
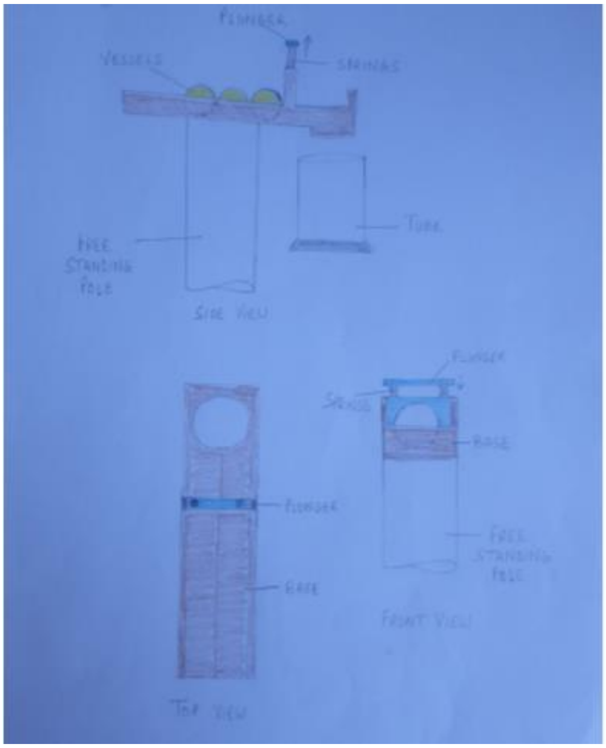


Figure 5: Hand Sketch of Concept 2

However, the team members rightly pointed out the limitations of the concept, including that for each ball to fall into the tube we needed to trigger it each time and the length was not long enough for holding all the ten balls so, recognizing their fair criticism, I did not finalize it as such.

CE 1.3.5

For the concept 3, I developed a mechanism such that when the plunger was pressed it moved the die downwards and die matched the shape of the ball and let the ball move through it. Once the plunger was back to its original position by springs, die made irregular shape which stopped the next ball to enter through it.



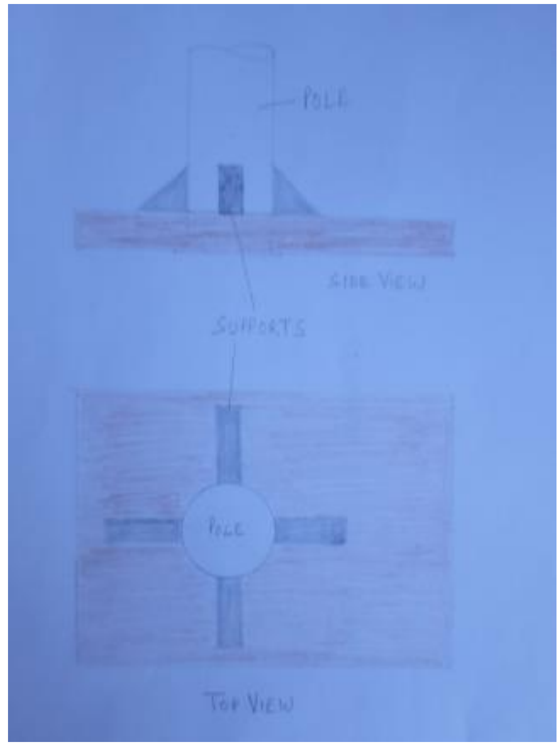


Figure 6: Hand Sketch of Concept 3

This conceptual design, however, was quite impossible for us to construct due to high restrictions. This design was unable to rotate in 360° to drop balls in each tube. Moreover, the manufacturing method was complicated.

CE 1.3.6

The Concept 4 that I developed was based on the mechanism of canon, which threw balls to the tubes. In this concept I made the balls to be arranged in a tubular design, which were then pushed out by the spring beneath every ball to the dispenser area where piston threw the ball upwards and then with a suitable track tube, it was thrown towards the designated tube. I used various springs and electrical components in the concept 4. I used my understanding of the electrical energy and electronics to make the system in Concept 4 work.

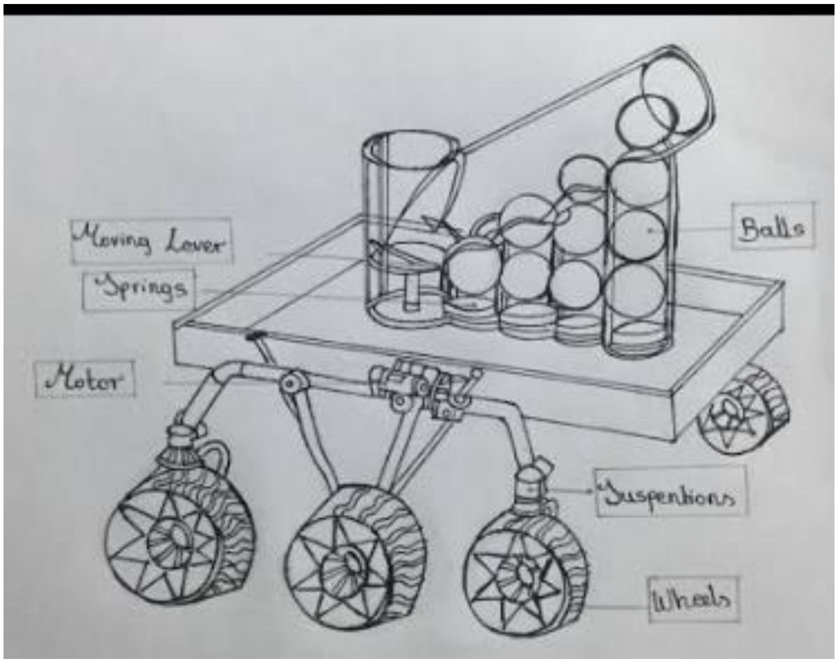


Figure 7: Hand Sketch of Concept 4

The limitation of this system, as discussed with the team, was that its manufacturing method was too complicated. Moreover, it was an expensive design and required a fully automated process.

CE 1.3.7

Eventually after discussion, the team selected the first concept as final because of good mechanisms and since it offered stability while operation. To ensure getting high rubric points, I performed a detailed analysis of the design in SolidWorks.

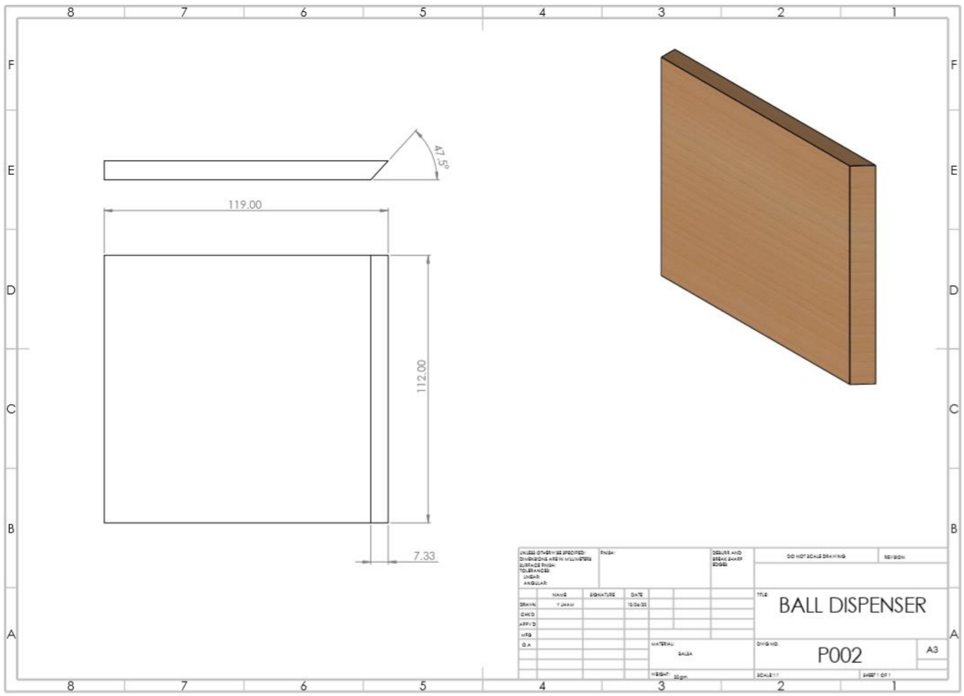


Figure 8: SolidWorks Design Analysis (1)

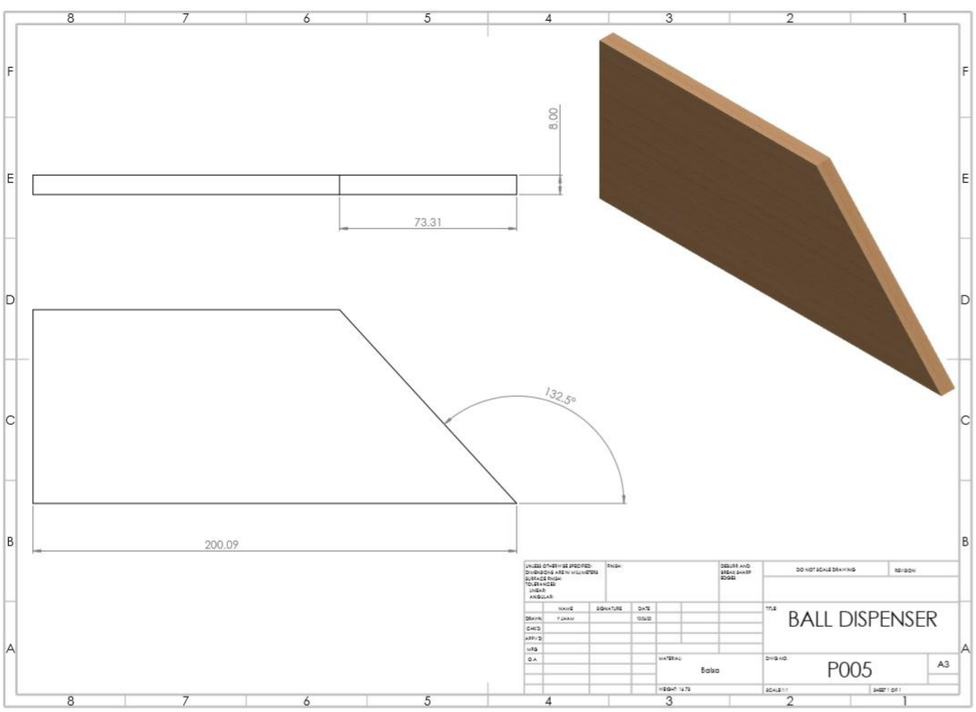


Figure 9: Analysis of SolidWroks (2)

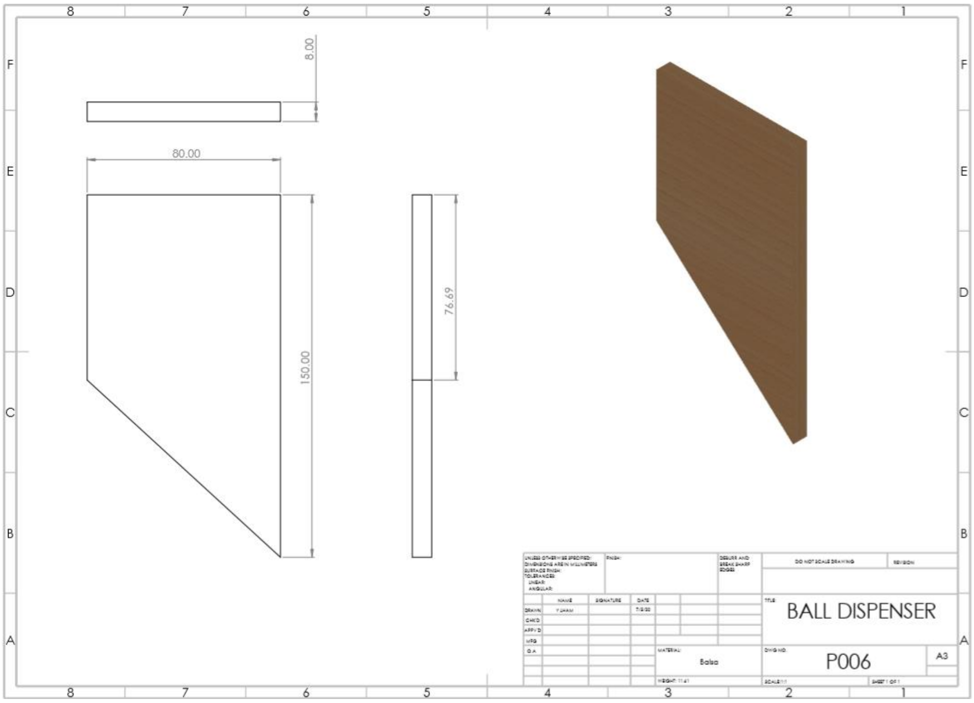
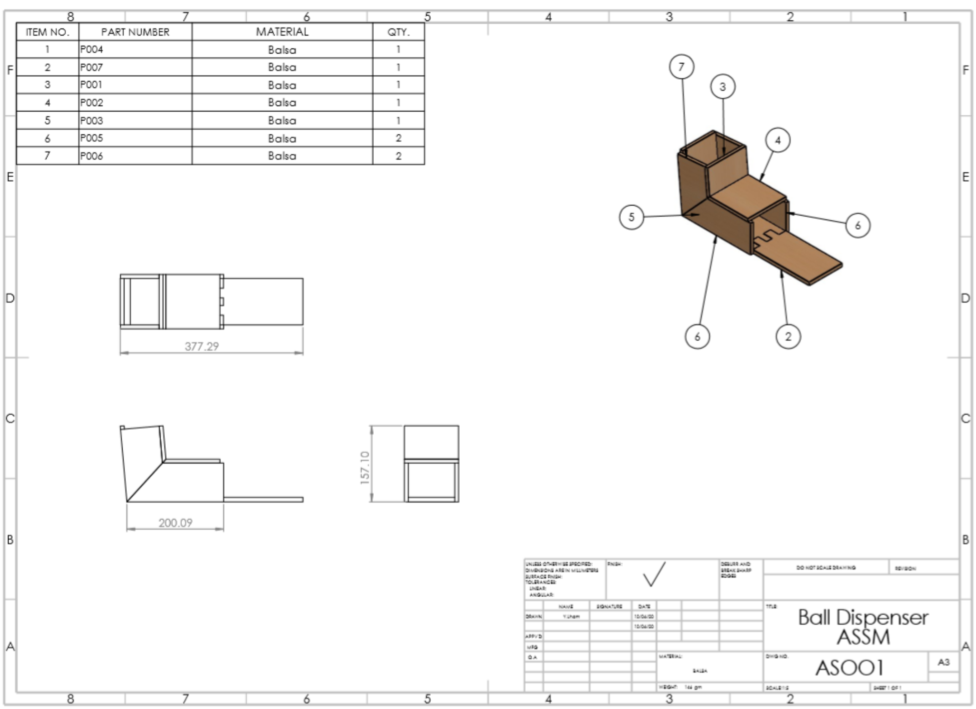


Figure 10: Design Analysis of SolidWorks (3)



ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	P004	Balsa	1
2	P007	Balsa	1
3	P001	Balsa	1
4	P002	Balsa	1
5	P003	Balsa	1
6	P005	Balsa	2
7	P006	Balsa	2

Figure 11: Design Analysis of SolidWorks (4)

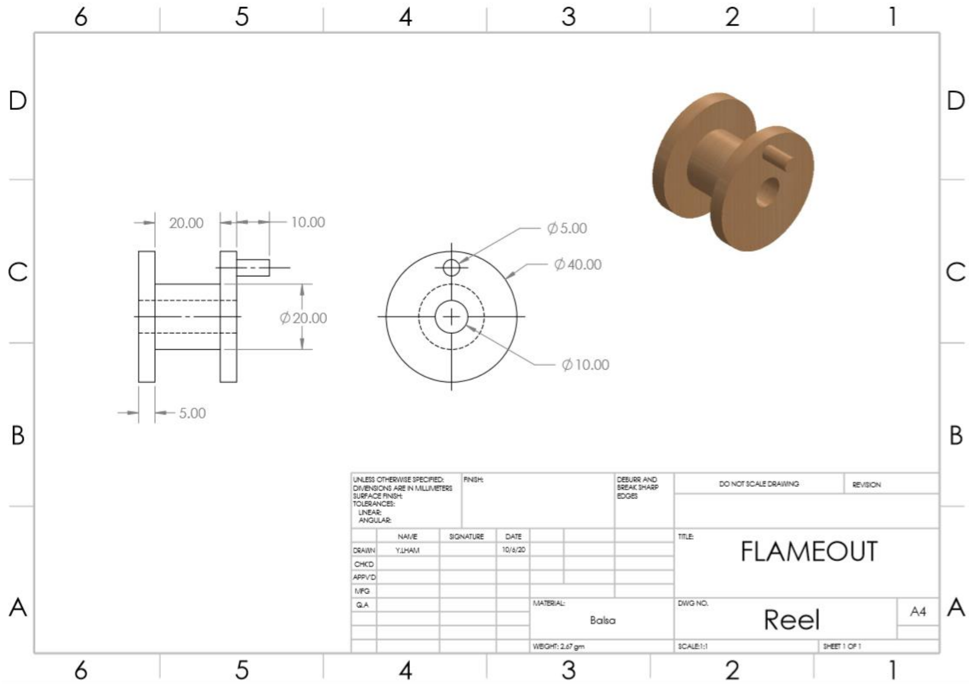


Figure 12: Design Analysis of SolidWorks (5)

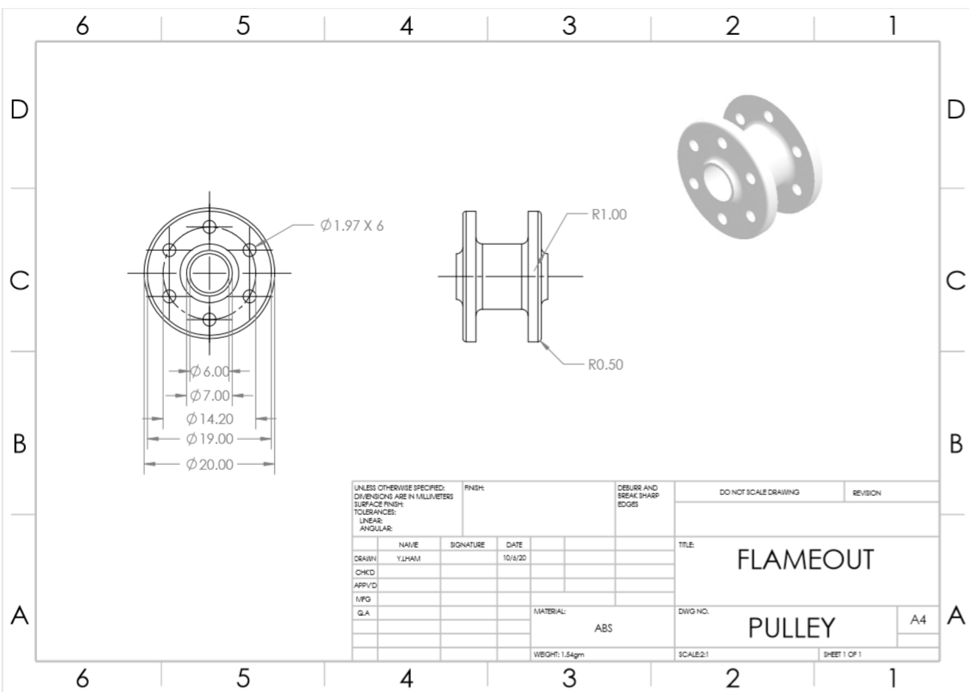


Figure 13: Design Analysis of SolidWorks (6)

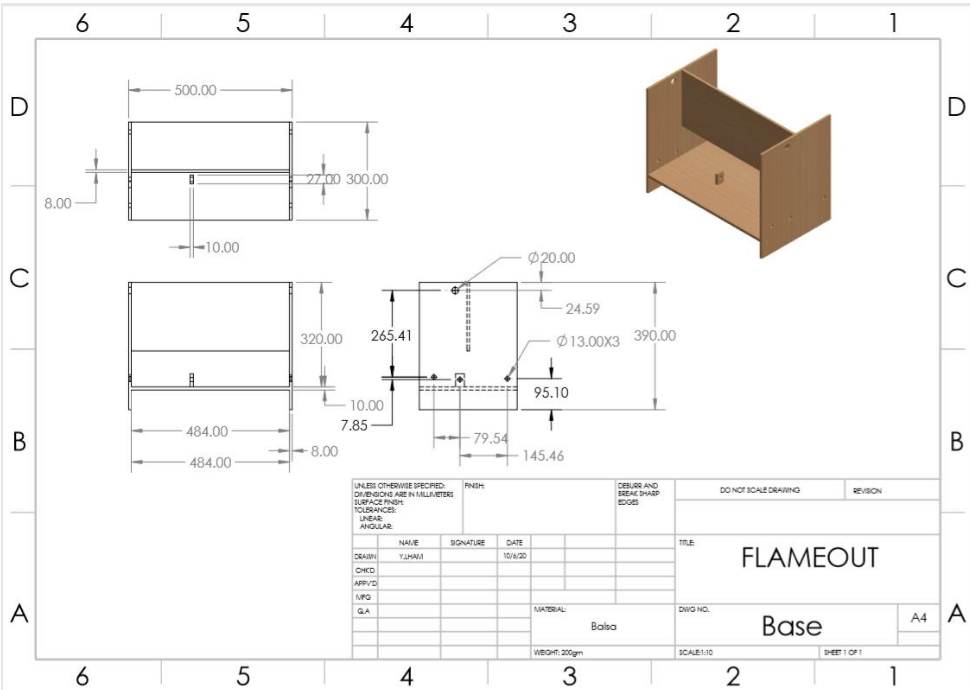


Figure 14: Design Analysis of SolidWorks (7)

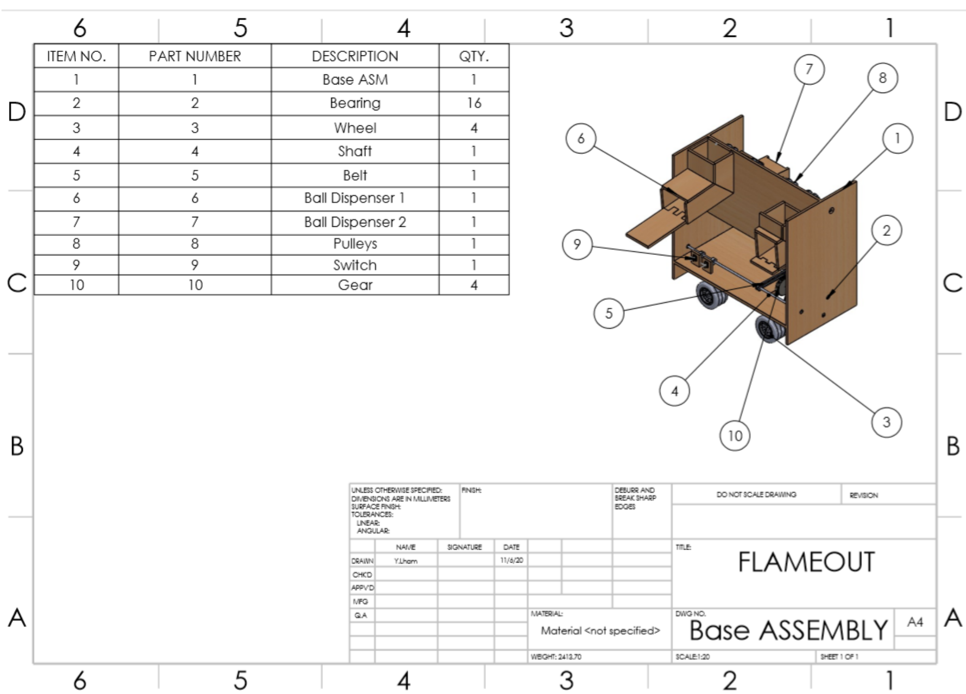


Figure 15: Analysis of SolidWorks Design (8)

CE 1.3.8

Concept 1 was a simple design, which I understood, could be built with the help of materials available at the local hardware store. I knew the components used were cost effective and are easier to assemble. Additionally, it did not require any complex machining process to manufacture. In the below table I have shown the components of the device and the materials selected for each component. In the other section I have included the procedure to assemble the parts.

Table 2: Component and Material Selection for the Manufacturing

Sr. No.	Component	Material Composition	Qty
1.	Ball Dispenser 1	Balsa	1
2.	Ball Dispenser 2	Balsa	1
3.	Ball Dispenser 3	Balsa	1
4.	Ball Bearings	Market	13
5.	Motor	Market	1
6.	Batteries	Market	2
7.	Gear	ABS	2
8.	Shaft	ABS	2
9.	Pulleys	ABS	3
10.	Wheels	ABS	4
11.	Base	Balsa	1
12.	Reel	Balsa	1
13.	Belt	Polyurethane	1
14.	Rope	Cotton	1

I made the whole mechanism up from Balsa and ABS plastic through which I ensured that components were light and strong so that it met the weighting criteria. The device resembled a rover with 3 compartments on top and are closed with a help of hinge. I timed the device such that it would reach a specific location and stop there. The hinges would then open with the help of a pulley mechanism providing a path for the balls to land on the tubes. When the switch button was pressed it would activate the motor which would start moving the centre gear and the centre gear was going to drive the opposite wheels which would lead to the working of the whole system.

CE 1.3.9

I calculated the cost of the material and presented it in form of a table as given below.

Table 3: Material Cost of the device

Sr. No.	Component	Qty	Total Cost ($)
1	Wood (915x25x100)	4	108
2	Wheel	4	20
3	Base	3	20
4	Rope	1	3

5	Belt	1	10
6	Ball Bearings	13	91
7	Motor 12Volts	1	14
8	Glue	2	6
9	Battery 9Volts	2	6.60
10	Switch	3	9
	TOTAL		**287**

Table 4: Manpower Cost

Sr. No.	Task	No of Person	Wage per hour ($)	Hours spent	Total Cost ($)
1	Conceptual design finalising	5	$20.00	20	400
2	Solid works Design and Drawings	3	$20.00	40	800
3	Calculations	2	$20.00	12	240
4	Material and Costing	2	$20.00	3	600
6	Report Writing Presentation Preparation	2	$20.00	4	80
			Total cost		2120

Table 5: Total cost

Sr. No.	Cost ($)	Total ($)
1	Material	287
2	Total Manpower cost	2129
$ 2,407		

CE 1.3.10

I performed mathematical calculations for Equilibrium.

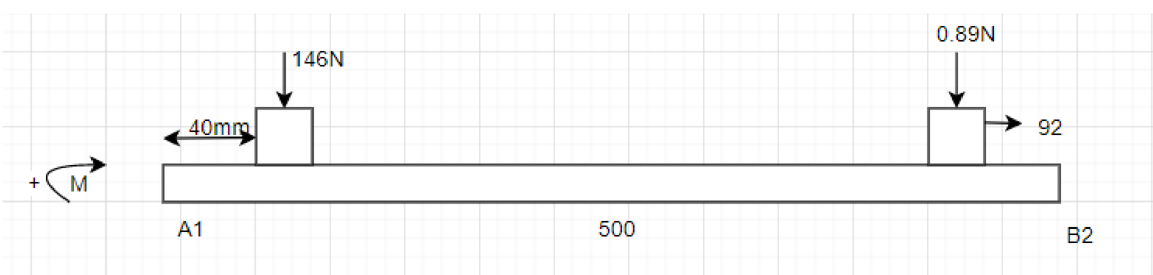


Figure 16: Calculating Equilibrium (1)

∑M=0

0 = -MA = +146 x (40 x 10^{-3}) + 0.89 (408 x 10^{-3})

MA = 0.42 Nm on one side of the car

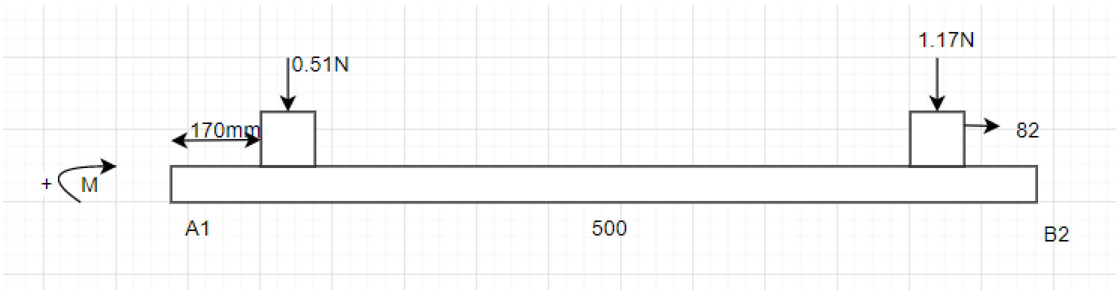


Figure 17: Calculating Equilibrium (2)

∑ MB = 0
0 = -MB + 0.15 (170 x 10^{-3}) + 1.17 (418 x 10^{-3})
MB = 0.57 Nm

The tensile strength of Balsa = 73 MPa
Area = 2m^2 (from SolidWorks)
F = ma
Hence, F = 6.58 x 9.81 = 64.54

$$n = \frac{\text{Sy}}{\text{Max Stress}}$$

Hence, n = 73/32.365 = 2.25
Therefore factor of safety = 2.25
Allowable design stress = S/n = 73/2.25 = 32.44MPa.

I calculated tensile failure of the base

I = bh^3/12 = (280 x 20^3) / 12
=186666.6

σ = 11.6MPa

F = 4 x I σ/Y
= (4 x 11.6 x 186666.6) / (280 x 10)
= 3093.33 N

Tensile failure mode = F = σA = 11.6 x 280 x 20 = 64,960 N

Shear failure mode = F = σA = 11.6 x (0.58) x 280 x 20 = 37676 N

I calculated the time Taken to complete the operation as:
Forward and retrieved motion = 2s
Number of tubes = 4

Machining functioning time + moving time = (10 + 10/3) x 4 x 2

Therefore, time taken to complete the operation = 106s

CE 1.3.11

I understood that in the designed system, the small wheels that needed to activate the hinges were based on a rod that would rotate only one revolution for the whole operation and thus the small wheels must be angled as such that it triggered when the vehicle was in place.

Table 6: Trigger times when the car would be in next to all the tubes

Time(sec)	13.36	26.66	40	53.3
Degree of Wheels (Degree)	45	90.030	13.08	179.00

I calculated as 180 / 53.3 = 3.377°/sec.

I used 180 degrees in the above equation because the other 180° revolution would be when the vehicle was returning.

Revolution required to move 470mm = 470 / (π x 88) = 1.7 revs.

One gear had just half teeth so

½ X =1.7

Hence, X = 3.4 revs required for the ½ teeth gear to move 470mm.

The motor provided 136 revolutions and what I needed was 1.7 revolution so, this gave me a ratio of 80:1.

For individual gear = 1:34
1:4
1:2.4
1:2.4

Therefore, I was able to achieve a revolution of 1.7.

CE 1.3.12

At the culmination of the project, I developed the project report. I included the SolidWorks designs in the project report. My team mate helped me finalize it and make it ready for submission. I have shown some of my SolidWorks designs below.

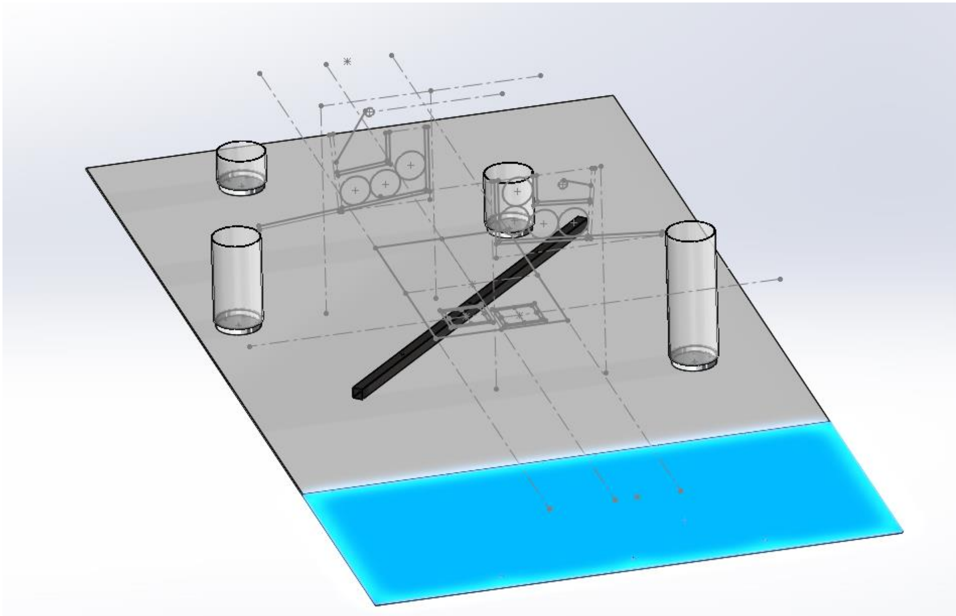


Figure 18: Planning stage sketch

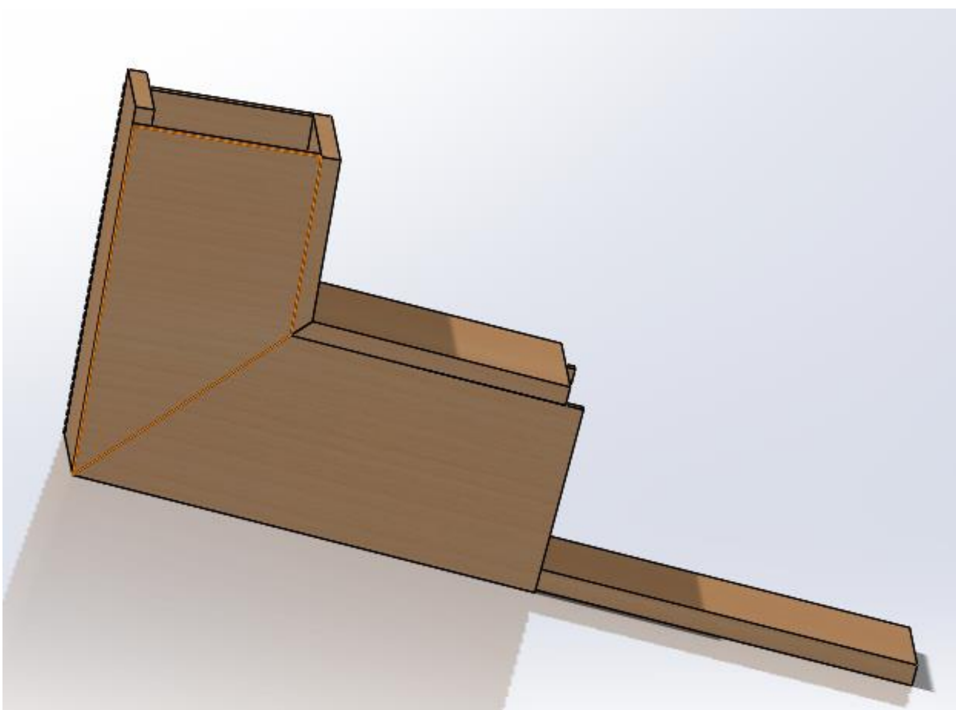


Figure 19: Ball Dispenser

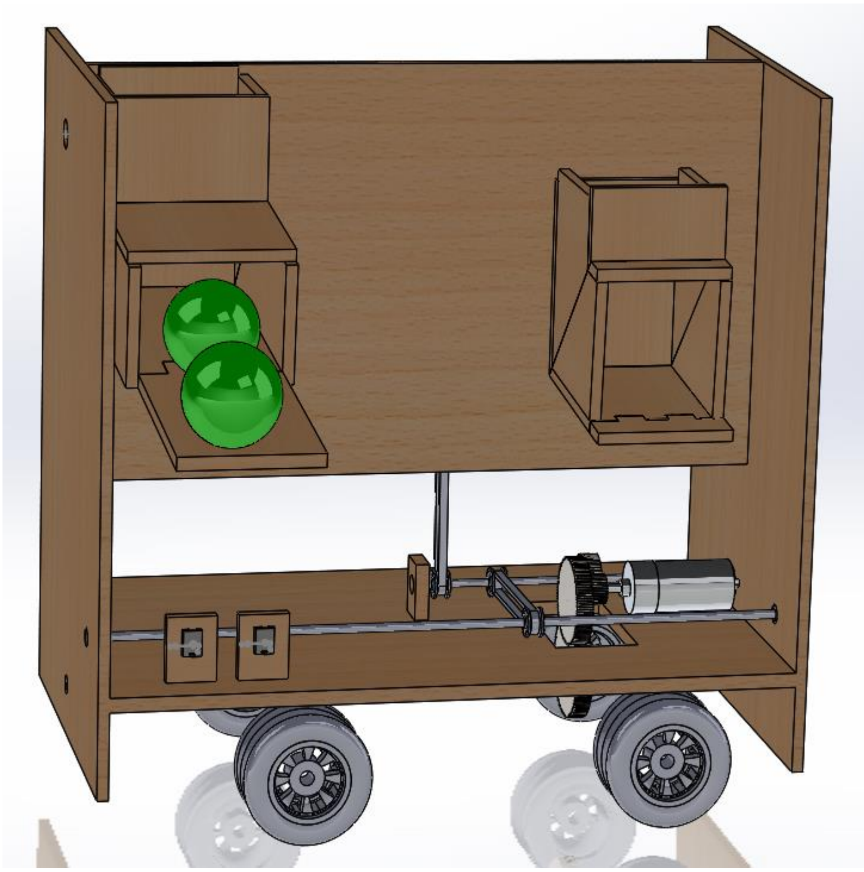


Figure 20: Assembled Model

Summary

CE 1.4.1

Although it was not a mandatory academic assignment, it provided me the opportunity to use my kowledge of fundamentals of product design and development and the key aspects that are related to developing a product. Furthermore, this project enabled me to use the engineering knowledge for the evaluation of design including its optimization using SolidWorks. At the start of the project, I decided that as the team leader, I would be the most punctual, most passionate and most effective team member in order to instil the same qualities among the team. This technique partly worked, but the best outcome of this technique was that I was involved in major project related tasks and I was the one who got the best learning out of it.