Design and Make Activity - Automatic Clone Deployment - Group 20

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Table of Contents

Introduction

Maintenance of roads is an essential requirement to keep the economic and social flow of a country stable. To preserve the roads in a safe manner, traffic cones are used to block off areas that are damaged, being restored or being built to warn drivers of danger. Currently, cones are dropped manually off a moving vehicle which is time consuming and risky for the workers involved. An autonomous way of completing this job would reduce the amount of time taken and allow us to focus on reopening the area of the road whilst also lowering the cost spent by businesses to run maintenance operations. However, there are many problems that must be overcome to achieve an effective model that can consistently outperform previous techniques whilst also being cost viable to the businesses using this equipment. By doing this, the maintenance industry can be modernised.

For this project, the group were tasked with the design and development of a reliable and accurate 'cone placer' capable of aligning three identical cones in a set diagonal formation. The design must also be able to work under numerous constraints given in the assignment. Using our mechanical knowledge, technical ability and teamwork, the group worked together to complete this assignment by the end of the semester by holding meetings multiple times a week to gather ideas and delegate roles for each member to complete. The finished product could then, hypothetically, be scaled up and modified to be used in real world situations.

Design Specification

Function

- Must be able to dispense 3 cones
- Must dispense the cones at the specified distance apart (see assignment document)
- Must place cones within 60 seconds
- Must use a continuous power source
- Must only travel in a straight line
- Must use only mechanical ways of transferring energy
- Have the facilities to place more than three cones
- Complete the cycle quickly but effectively

Materials

- Must not exceed a maximum of 9V of battery power
- Must only use products from accepted sources only (see spreadsheet with acceptable suppliers)
- Must not exceed a maximum of 2 motors
- Must use materials with correctly appreciated material properties for specific parts
- Use cheaper but responsibly sourced materials

Form

- Must not exceed a storage volume of 380mm x 180mm x 300mm
- Must use U-channel as main chassis
- Must use a minimum of four wheels
- Must not use electrical components (Excluding the two motors)
- Look clean and well-constructed

Safety

- Must not fail or have a large potential to fail, catastrophically.
- Must not cause harm to the user(s)
- Must not build large potential energy sources which could cause terminal failures
- Must have all wirings enclosed properly
- Contain safety back up features in case of damages

Sustainability

- Be able to disassemble easily so pieces can be reused in other projects.
- Utilise materials that can easily be recycled
- Use rechargeable batteries
- Pieces used in the product are reliable and long lasting

Quality and Costs

- Must not exceed the £80 budget
- Must be aware of setup fees for machines
- Must be aware of additional machining costs for bespoke pieces
- Must reliably be able to complete the necessary procedure
- Materials need to be fit for the purpose of the specific piece without damage or large wear.
- Keep the number of pieces in the product to a minimum
- Use cost effective methods to construct the product

Scale of Manufacture

- Must be able to be completed by hand assembly and manufacture
- Must be able to be completed with workshop safe tools and machines
- Use easy and basic techniques to complete construction
- Design can be assembled quickly

Isometric Concept Drawings

Each member of the group project was tasked with generating an isometric drawing of their own concept design, these can be seen below in Figures 1, 2, 3, 4, 5 and 6.

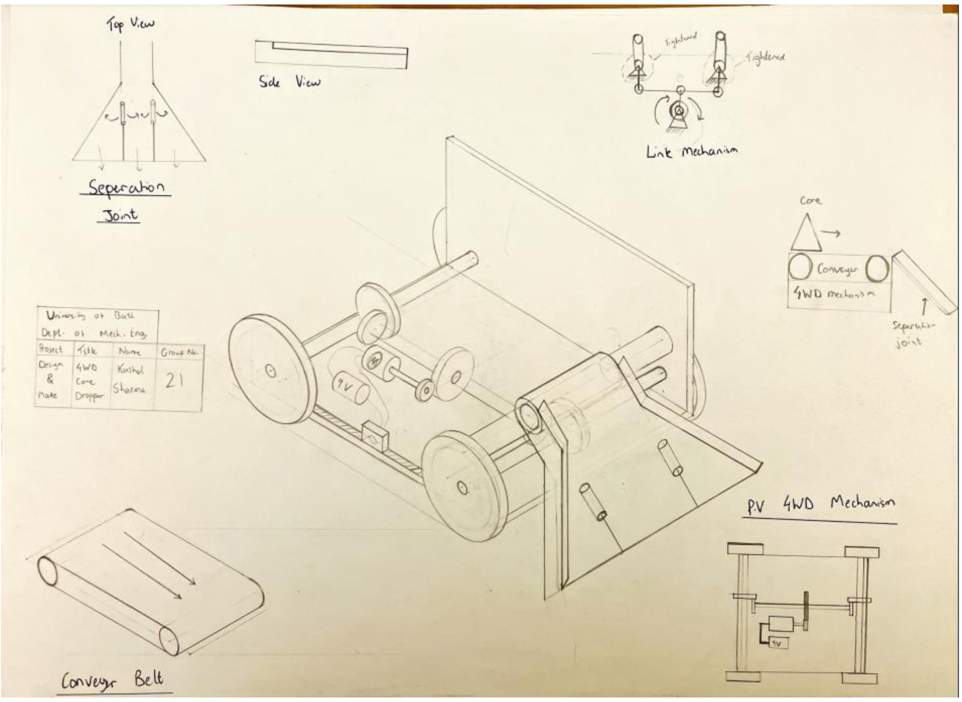


Figure 1: Design concept developed by Kushal Sharma (1.0K)

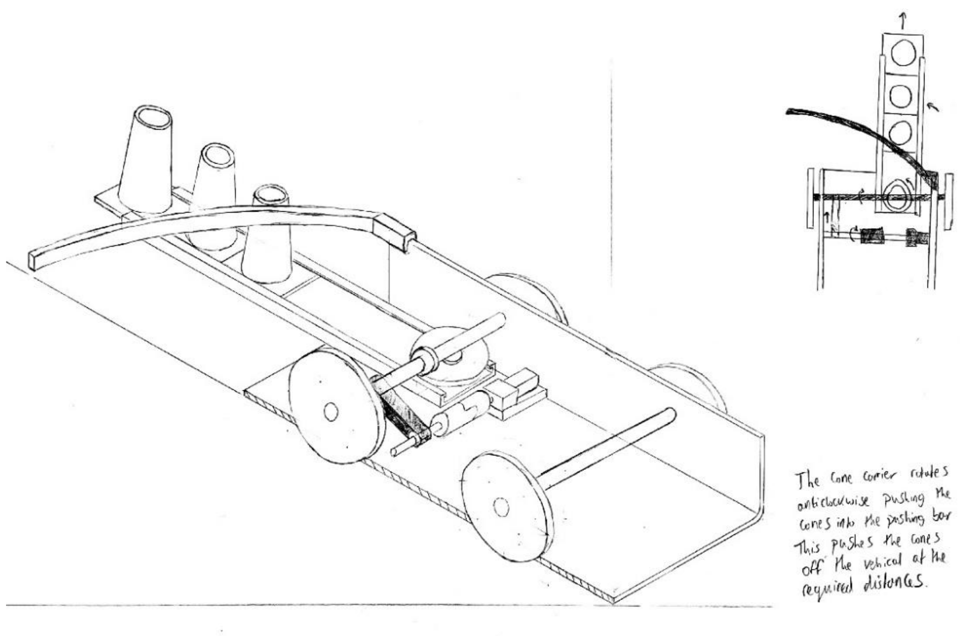


Figure 2: Design concept developed by Josh Keenan (1.0JK)

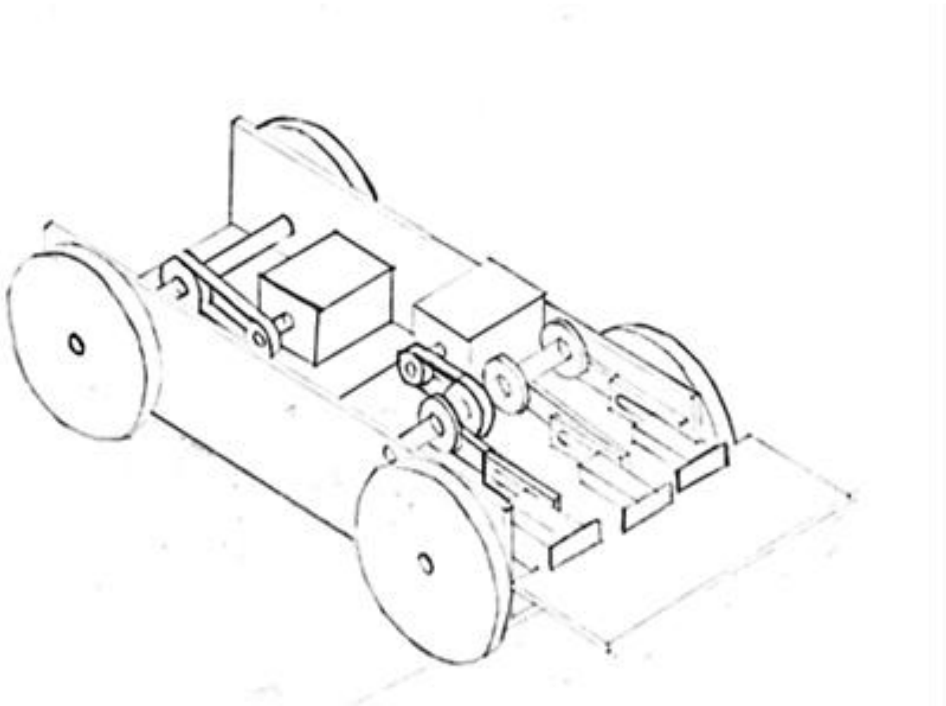


Figure 3: Design concept developed by Anthony Siow (1.0AS)

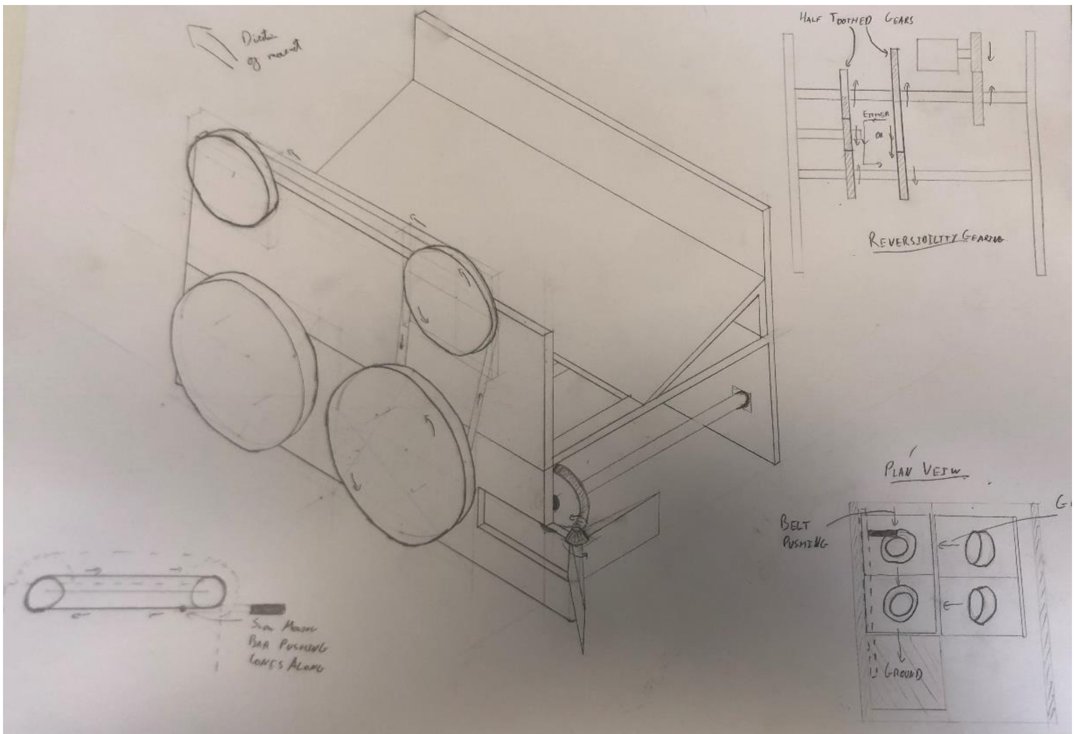


Figure 4: Design concept developed by Ben Parkin (1.0BP)

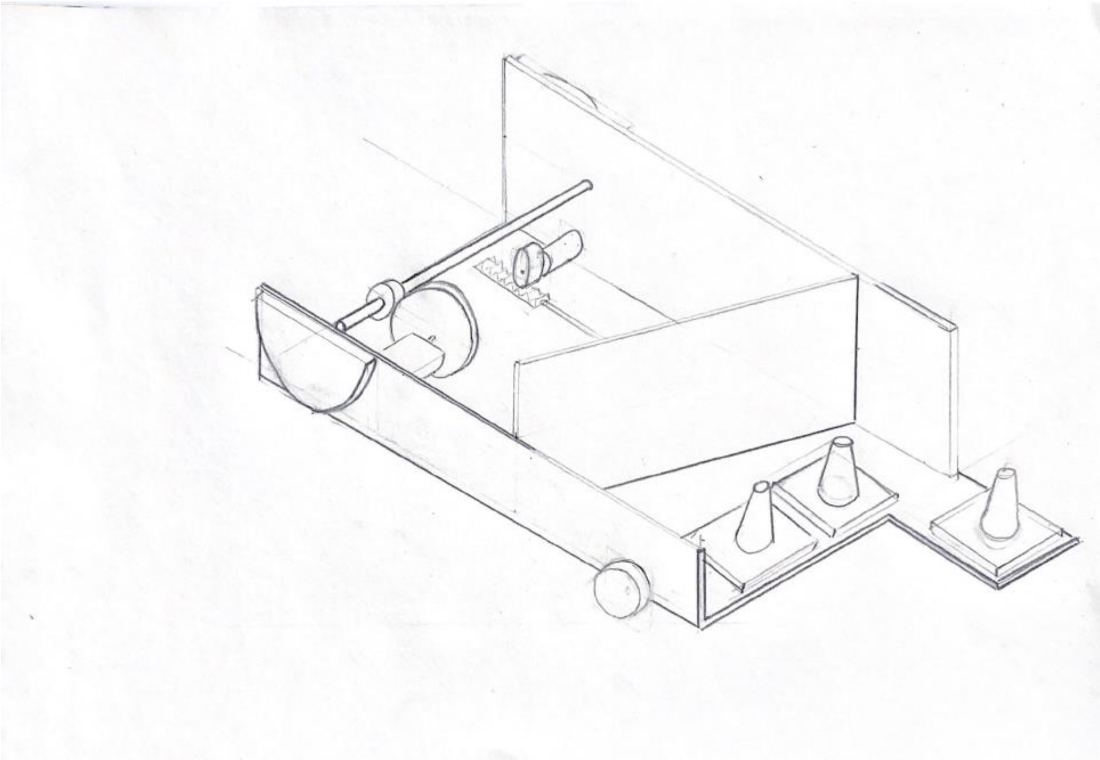


Figure 5: Design concept developed by Jamie Cotter (1.0JC)

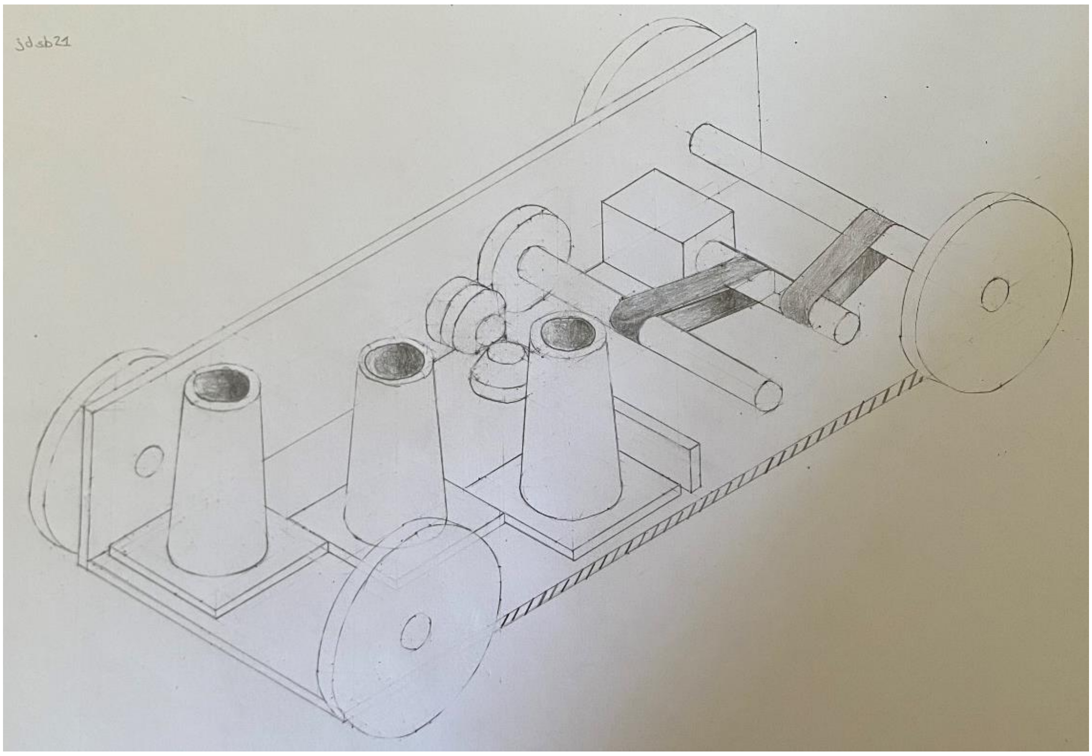


Figure 6: Design concept developed by Joseph Blackler (1.0JB)

Evaluation of Concept Designs

1.0KS – Kushal Sharma

This concept delivers a continuous method to load the cones while being efficient and meeting the minimum functional requirements. The design utilises two motors for two separate functions, this makes the timings easy to calculate. However, there are many bespoken parts required which need to be either 3-D printed such as for the crank mechanism and housing for the motor or be machined such as for the main bulk of the ramp. This can make the design more expensive than necessary and reduces the suitability of the design as a solution to the assignment

1.0JK – Josh Keenan

This concept would fulfil most of the design requirements and place all three of the cones within the time limit and the specified spacing. The design is simplistic with only a belt and a bevel gear to control the wheels and the cone dispensing mechanism. However, the model does fall short on some aspects of the design. The concept relies on two large, bespoke 3-D printed parts; this would dramatically increase the total cost. When placing the cones, the spacing will be inconsistent in both the x and y axis as the cones are dispensed at a large drop. Furthermore, this design is not continuous.

1.0AS – Anthony Siow

This concept performs essential functions needed such as dispensing the 3 cones correctly and can complete the cone placement within the 60 second allowance. However, the concept relies on two motors to function and suffers greatly from the size of the pushers - the large slider and crank mechanism prevent more than 3 cones from being placed. Although the crank and slider mechanism can be continuous, the size inefficiency prevents extra cones to be carried and loaded in the range of the pushers.

The concept also relies heavily on bespoken parts to construct the slider and crank mechanism; this can be costly in terms of raw material and machining/printing and may exceed the budget allowed for the project. However, there are minimal gears involved in the concept vehicle and they can be purchased easily using the given suppliers.

1.0BP – Ben Parkin

The concept can place more than three cones as it has the space to hold and reload multiple cones. The design fits into the given volume and the gears could be run off a single motor reducing the overall cost and simplifying gearing systems. It would be feasible to make the design be able to reverse the motor from a continuous output in a single cycle. The gears were placed underneath the cones, this allows for more cones to be loaded into the system.

However, multiple belts need to be used to transfer energy, these can easily get caught and break. A spinning part is used to place the cones at the wanted y distance, but the shape of the spinner would need to be developed to work at a higher standard. The spinner also must pass through the U-channel, forcing the wheels to be closer to the centre of the design making it less stable. There are a few large bespoke parts that would have to be specifically machined and 3-D printed. This is expensive, non-reusable and time-consuming.

<u>1.0JC – Jamie Cotter</u>

This concept design does complete the main functions of the design specification such as moving forward and placing a diagonal pattern of cones. Also, this design would be under the cost cap of £80 and be relatively simple to manufacture.

However, the main drawbacks of the design are that it's not continuous, and it would be very difficult to develop it to be continuous. This means it does not satisfy our design specification. Furthermore, it uses two motors which would put the design at a slightly higher price point than needed and again goes against our ideal design specification. This could be resolved by placing a gear on the axle attached to the first motor, then a reverse gear to account for the pushing function. Additionally, the U-channel is not wide enough for all three cones to sit side by side so a front lip needs to be added. This may make the dropping of the cones less stable and potentially mean they are misplaced. A solution could be to add a ramp to the end. In summary, this design does not fully meet our design criteria and within the group there are better alternatives, this means that the concept was not taken any further.

<u>1.0JB – Joseph Blackler</u>

This concept design delivers many of the key functions that were required for this group project such as the ability to place each cone the correct distance away from each other, both in x and y directions, whilst only moving in a single direction. The idea would also easily fit under £80 budget set for this task as it is relatively simple with few expensive parts and little machining to be completed.

A major issue with the design is that the rotating arm would not be able to reach and push the final cone off the unloader, this is a critical failure for the concept as this is a key specification that is needed to complete the set assignment. To resolve this, a slit may be machined into one of the sides of the U-channel, this would allow the rotating arm to be extended so that it is large enough to push off the third cone. Another issue would be that when the cone is pushed off the vehicle, it does not land on its base. This could be resolved using a small ramp to reduce the impact that the cone undertakes. The concept can only dispense three cones at a time and is unable to be a continuous cycle, although this is only a wishful function for our design, it further reduces the appropriateness of the design for the use in the group design and make project.

Design Scores and Final Concept Chosen

Each of the designs were ranked against four different categories based on their overall performance. Table 1 below shows the outcome of this assessment.

Table 1: Evaluation of each concept design

Design Number	Group Member	Function /5	Materials /5	Form /5	Safety /5	Total /20
1.0KS	Kushal Sharma	3	2	4	5	14
1.0JK	Josh Keenan	3	4	4	4	15
1.0AS	Anthony Siow	3	2	4	4	13
1.0BP	Ben Parkin	4	3	4	3	14
1.0JC	Jamie Cotter	3	2	3	5	13
1.0JB	Joseph Blackler	2	4	4	4	14

As a group, we unanimously agreed to go with design 1.0JK as it met the required specifications to the greatest ability. This design also gave us the chance to develop the concept further and achieve our extra goal of creating a continuous method of deployment. A decision was made to accomplish this by combining aspects of multiple group members' concepts into our final design.

Development of Final Design

With the final concept chosen, development of the design was needed for it to accomplish our goal. As a group, we brainstormed ideas to evolve and improve the model to better accomplish the aim of our assignment. Further proposals for adjustments by each member of the group can be seen in Appendix A. During this development stage, we encountered several obstacles that had to be overcome for the design to be a viable solution to the main problem given. After multiple modifications to the final design, the vehicle was drawn up in Autodesk Inventor to confirm that the alterations made would be feasible when modelled in three-dimensional space. The final model assembly and all bespoke part drawings can be found in Appendix B.

Transmission and Timing

The gearing system became a real challenge as the complexity needed for our design was much greater than first anticipated. This is vital to our design as the timing of our system needs to be highly accurate to ensure that the project is consistent and reliable in placing the cones to the tolerance given in the assignment. It was discovered that not all the gears required to achieve a valid transmission were available as we could not source them from university-approved external suppliers. To resolve this, a mixture of premanufactured gears and 3-D printed gears have been used as well as multiple belt pulleys. The motors used were also not given the maximum power. This gives us the correct step-down ratio from the motor and the correct overall torque to move each component to the time calculated.

Continuous Operation

A major aim for our machine was for it to be able to deploy cones in a continuous process, making the operation faster and more efficient. This is useful because, if done correctly, the process can be cheaper and overall, be a better alternative to preceding methods used in the industry. A decision was made to make the moving arm return to its original position so that the entire process can be repeated. To do this, the gearing was further altered so that the arm would in the opposite direction after deploying the first set of cones. A way of reloading the cones back into the system was also required to make a continuous design. A unique solution to this issue was to implement a conveyor belt that pushes stored cones towards the arm. To allow the storage of multiple cones, two standard part U-channels were used stacked on top of each other which would separate the mechanical gear system from the cone deployment sector. However, this idea stores the cones in a very ineffective manner; in a real-world situation, this solution would not be viable because the amount of storage space required to hold enough cones would be too great and would not be cost-effective for businesses to utilise.

Volume Constraint Issues

Another issue we faced with the design was that it was too large with the addition of the rotating arm compared to the maximum volume for the vehicle. By moving around different elements of the design, the main chassis was reduced in size; allowing for the design to have valid dimensions for the project. This included the movement of multiple gears and the adjustment to the position of the battery pack to enable everything could be included in the design. This led to another issue, as the cone was dropped from the rotating arm, we needed to ensure that the cone stayed upright and did not slide to a great extent. However, due to a lack of available space, the slide could only be a limited size. A compromise was made to develop a curved ramp that, although the ramp gave the cones a relatively large velocity at the drop zone, it guaranteed that the cones remained upright. We made this decision because the cones orientation is a more important factor towards the final project than extent of movement after leaving the slide.

Summary of Group Meetings

Date	Duration	Attendance	Summary	Action Points
21/03	2hrs	All	Group discussed the task given to develop a better understanding of problems that need to be solved to complete the assignment. When doing this, we began to make a rough plan of how we will move forward. Furthermore, we began research into the cost of components and manufacturing. Finally, we then planned to meet every Thursday moving forward.	• Start research into ideas • Start rough sketches and brainstorm ideas
24/03	1.5hrs	All	The meeting began by presenting any rough sketches or concepts thought of since Monday. Following this, discussion and expansion of the ideas were completed to see what could be taken further and help everyone prepare themselves to create their concept drawings. We discovered everyone had a unique vision for the project and planned to complete our concept drawings by the next meeting.	• Complete concept sketches
28/03	2hrs	All	The meeting starts with everyone showing each of our concept drawings and explaining how they would work. The group then questioned everyone's designs and made suggestions on how each could be improved. Once all designs had been analysed, we decided that we would write up evaluations of our concepts based on what we discussed in the meeting and rate different aspects of the concepts.	• Write evaluation of each concept • Rate each concept
31/03	2hrs	All	We started the meeting by going over the evaluations and ratings of all the final concepts. This made our decision on picking a design to move forward with a lot easier. We ended up choosing parts from Josh's design along with multiple key elements	• Start development drawings of chosen design

			from Ben's designs. From here, we discussed the downsides of both concepts and how to fix them. We decided everyone would make a development drawing on these designs within a week.	
04/04	1hr	All	A slightly shorter meeting because we were still working on our development sketches, meaning that we had less to discuss. However, we were able to start making a rough parts list to estimate the overall cost.	• Complete development drawings
07/04	2hrs	All	The meeting begins with everyone presenting their development drawings and sketches. We then discussed them further to see how each worked and how they solved the problems that were mentioned in earlier meetings. We concluded that using a belt drive to push the cones towards an angled arm to remove them was the best idea to resolve our issues. Once this was finalised and everyone understood how our design would work, we planned to have a final design done after easter.	• Complete final design drawings
25/04	2hrs	All	After returning from Easter, we had a final design ready that all members were happy to use. A CAD version of this design was then to be developed by the next meeting, while other members would create a parts list and a cost analysis of the project. The math for the gearing was yet to be completed. This was needed to ensure that the timing of the belt and spinning channel worked together.	• Complete a CAD version of final design
28/04	2hrs	All	By this meeting, the CAD model was complete. We now had a better understanding of the final design and how it would operate. This then allowed us to begin to discuss a manufacturing plan for the project, this will help us when we eventually	• Fill in individual parts of report

			need to build the project and it helps us get a more accurate project cost.	
02/05	3hrs	All	The meeting began by reading through the Lab report to view what we could improve. Following this, we then began to discuss the gearing system of the design to ensure the correct timing. Furthermore, we worked on reducing the overall length, which was longer than the maximum stated in the assignment.	• Complete report improvements • Update CAD to new measurements
03/05	3hrs	All	The meeting was broken into different sections with each member working on separate tasks. These included completing the gearing maths, updating the CAD to new the measurements and gearing layout, and updating the report to reflect new adjustments.	• Update parts list to reflect new improvements • Prepare part files for manufacture
06/05	2hrs	All	The final meeting objective was to complete the project and be ready to submit the report. This included finalising part files and ensuring they can all be manufactured without delay. The parts list was also completed so necessary components can be ordered. Finished the report by drawing all work together.	• Collect all finalised work ready to submit

Order Forms and Cost Calculation

External Supplier Cost

The overall budget allowed was £80, this was only for parts bought by external supplies and excludes further machining and processing. The total cost for these parts was [], this can be seen from the [order form table/figure] below.

3-D Printing and Laser Cutting Cost

~155g of plastic filament

Overall Cost of Design

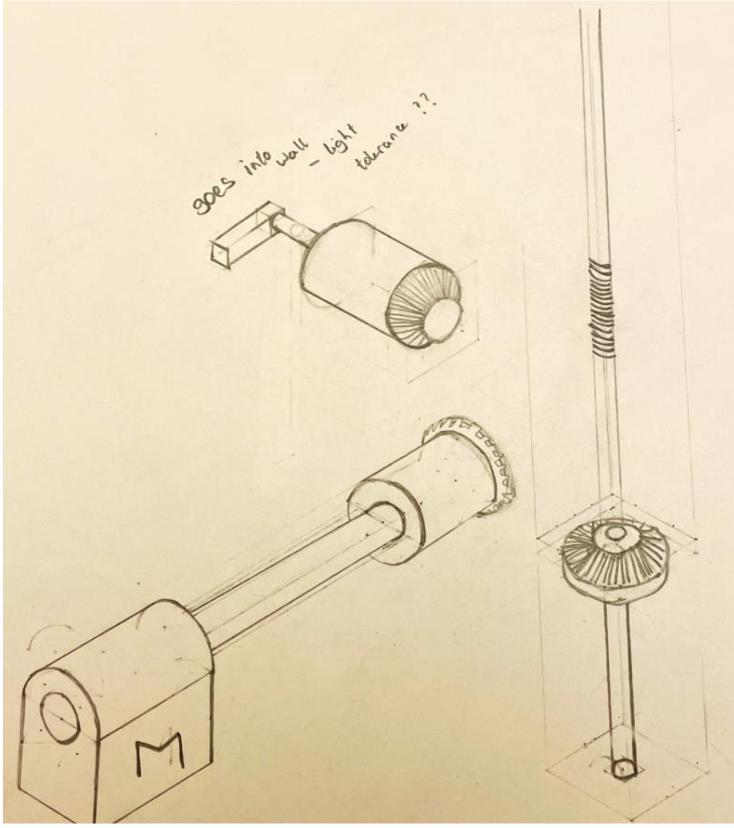
Conclusion

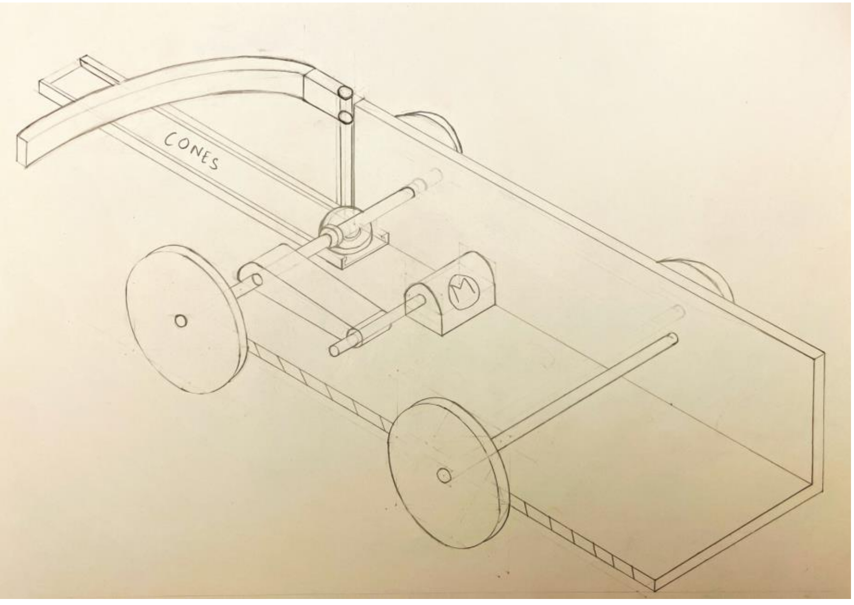
Ultimately, after multiple group meetings and evaluation each of our concept designs, the final concept was then chosen by the group. The design was then further developed individually with each member bringing a unique and conceptually interesting evolution to make the design feasible for the assignment and to further allow for a continuous operation of cone deployment. The final design and each bespoke part were then drawn up on Autodesk Inventor. The overall cost of the project was [] using [] of the £80 from external suppliers. Overall, the group believes the alterations made and the mathematics used to make the 'cone placer' are valid and the prototype should work when it is built next year. The project does have some known issues that have been addressed by the team and we are hopeful that we have minimised their effects. More improvements could have been made to maximise the efficiency of the cone storage and to the reliability of the operation.

[Total costs]

Appendices

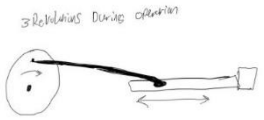
Appendix A – Ideas and Developments for Concept Designs



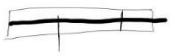


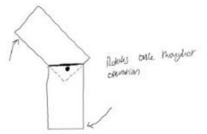
Cone pusher/placer

Top lever

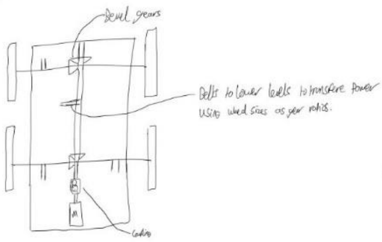


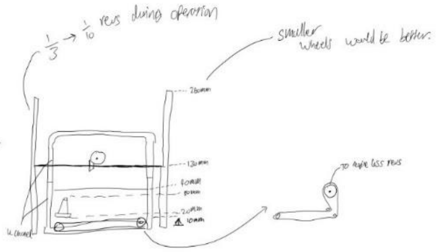
Location selector

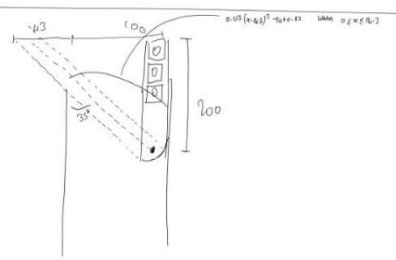


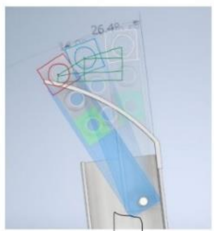


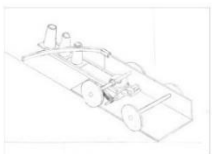
Drive train

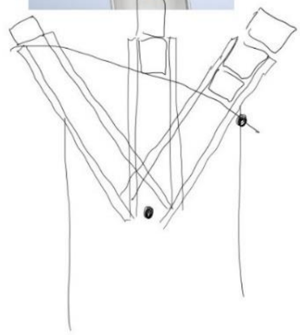


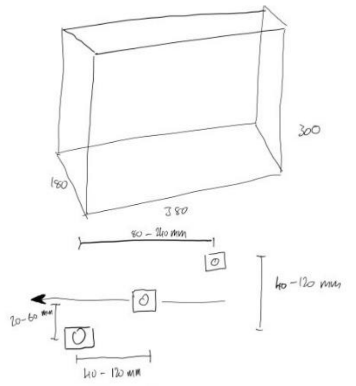


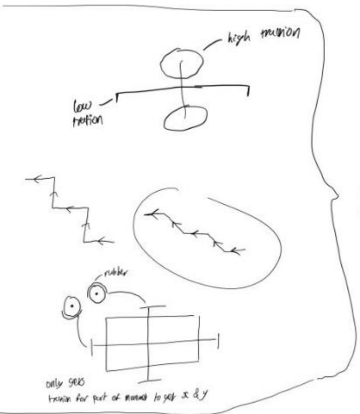




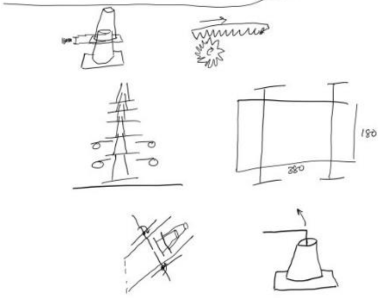


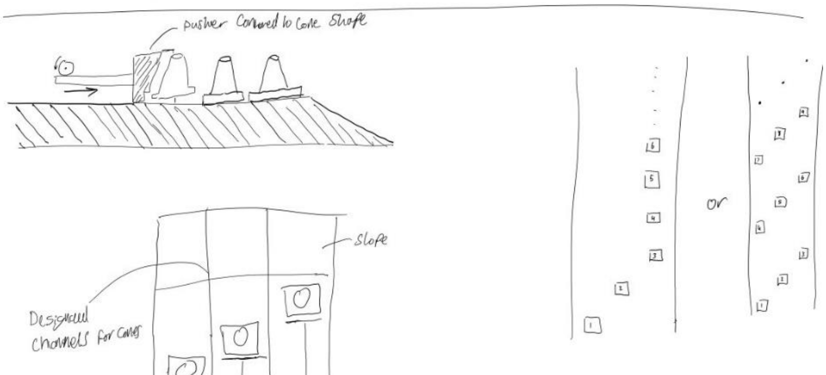


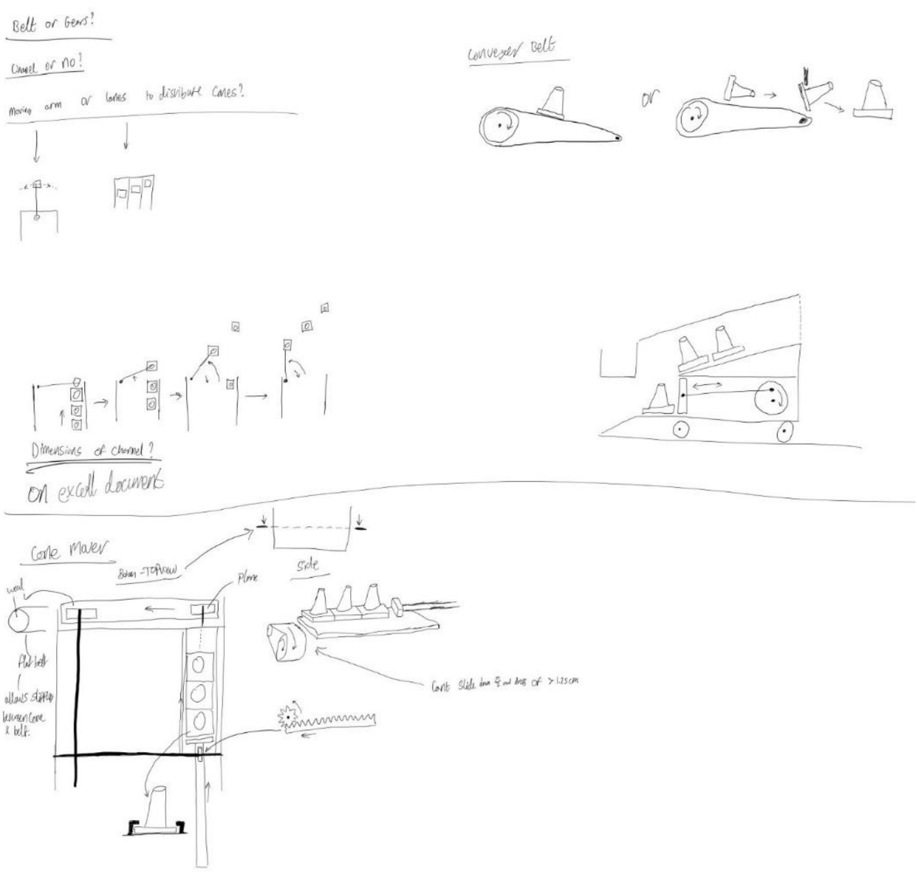


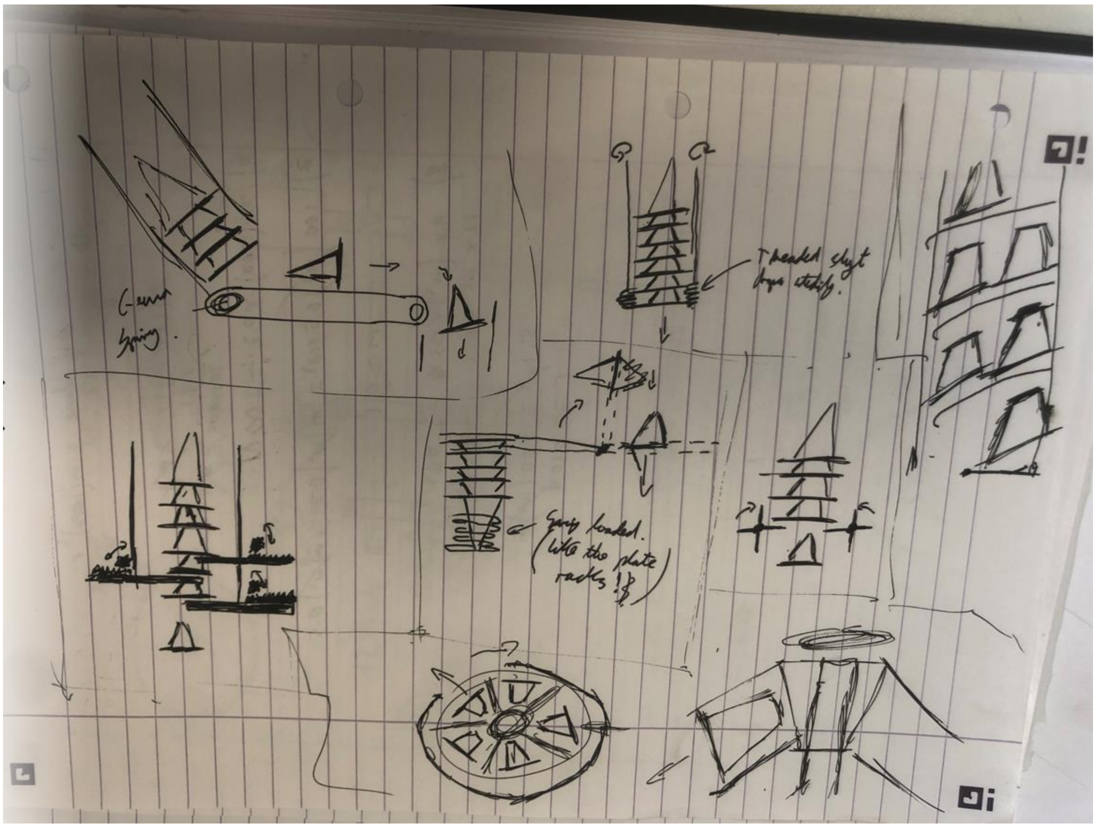


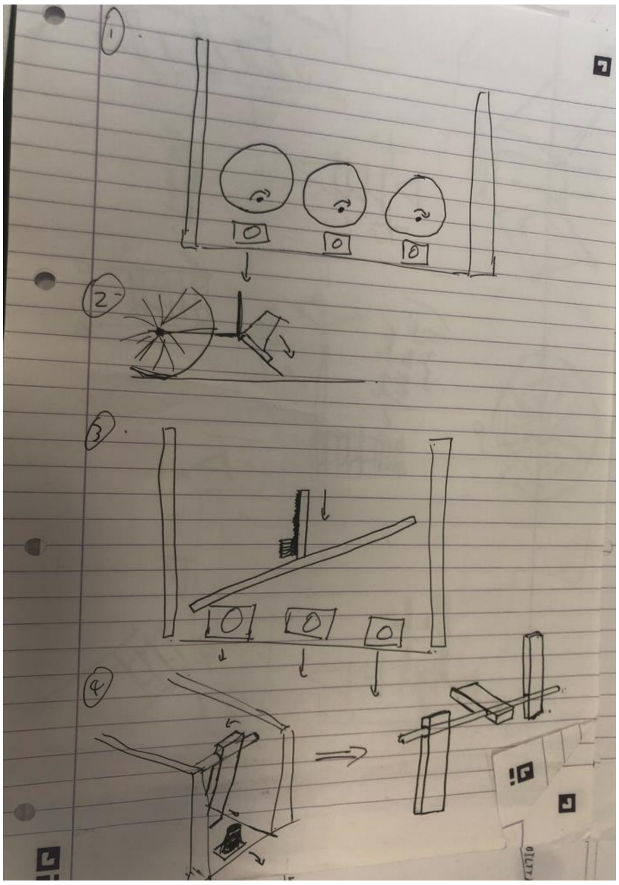
Not allowed to zig zag or move lowards

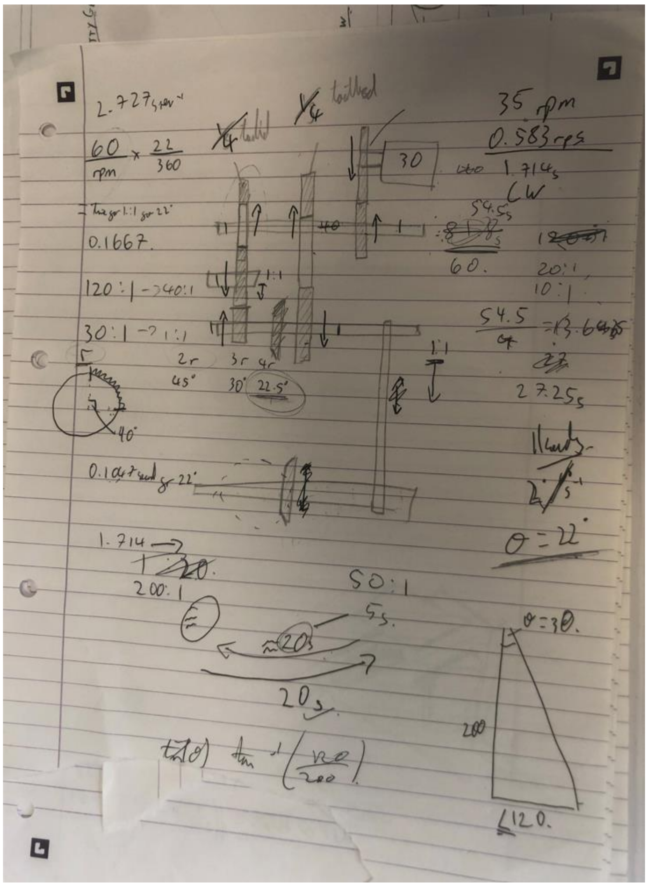


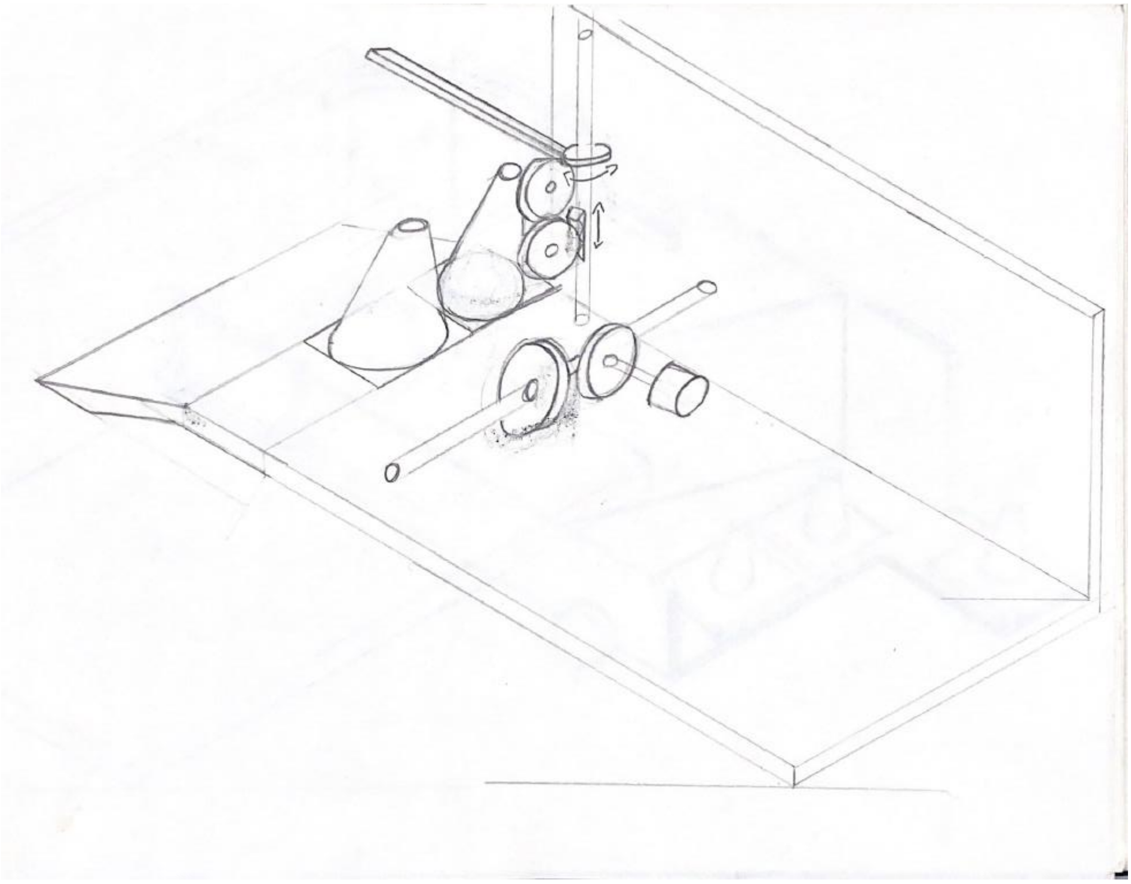


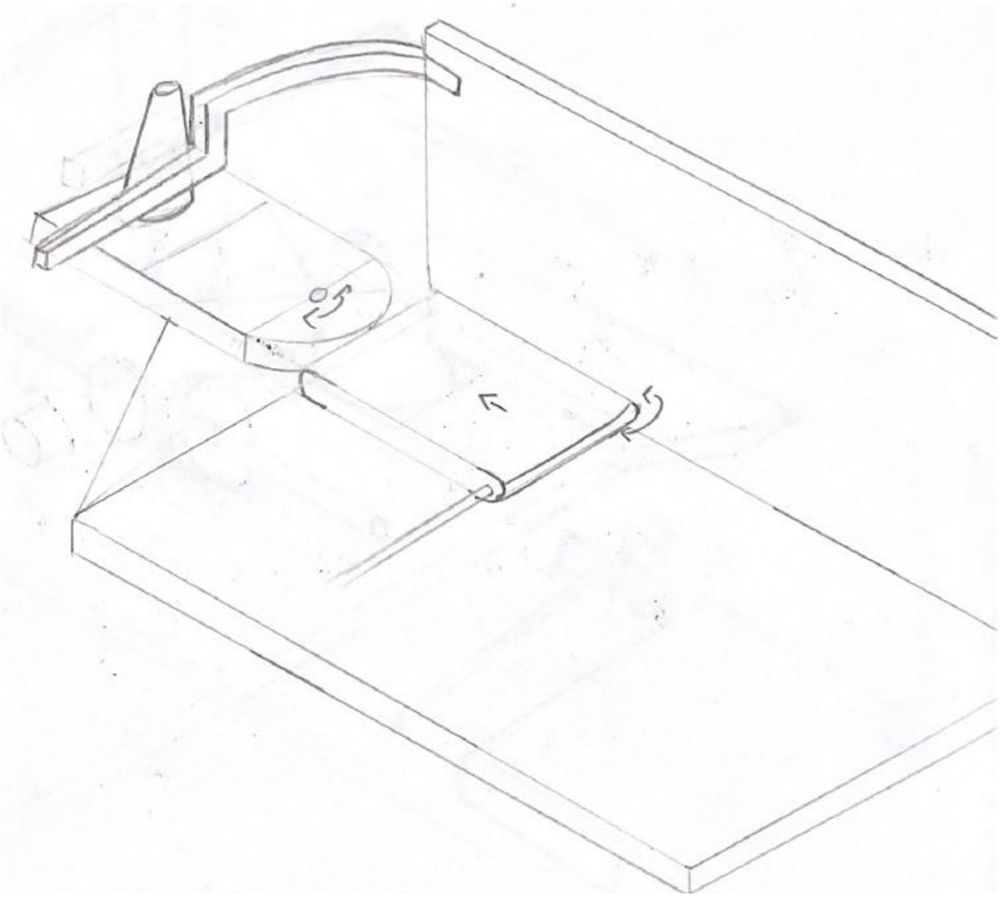

Belt or Gears?
Chanel or no!
Moving arm or lanes to distribute Cones?
Conveyer Belt
or
Dimensions of channel?
On excell document
Cone Mover
side
Plane
flat belt
allows slipping between cone & belt.


Threaded shaft
Spring loaded.
(like the plate racks!?)




35 rpm
0.583 rps
1.714s
CW
60.
20:1
10:1
27.25s
θ = 22°
50:1
5s.
20s
200
120.
120:1
30:1
0.1667
2.727s
1.714
200:1





Appendix B – Engineering Drawings for Final Design