Leaving Certificate Engineering 2013

Design Project

Exam No. 123456

Design Brief

1. **Introduction**

Electromechanical games of skill and chance, such as the crane vending machine, date back to the early 20th century. One design of this machine, popular in amusement parks and arcades, presents a unique opportunity where the payload of the game is lifted and dropped. The challenges of the crane vending machine are to judge precisely the distances which the crane will move to collect a payload, to then lift the payload and finally deposit it through a selected hatch.

Design a model of a crane vending machine to the general specifications outlined below using a table tennis ball as the payload.

The model should :

a. Have a lifting mechanism capable of picking up a table tennis ball from a designated area, using a lift, grab or suction technique;
b. Incorporate a switching panel to operate the various movements of the crane;
c. Include a novel receiving platform for the released table tennis ball with a number of hatches of various scoring results.

Presentation of the completed model should ensure that :

d. All main operating features are **clearly visible without dismantling**.
e. The longest dimension of the model does not exceed **350 mm**.
f. Electric power does not exceed **9 volts**.

2. **Design Process (40 marks)**

A design folio must be compiled which will detail your :

a. Analysis of the given brief and investigation of possible solutions;
b. Criteria for selection of your own individual solution and production drawings/plans;
c. Testing and evaluation of your design solution;
d. Special instructions, if required, regarding the testing of the solution by the examiner.

Note: Marks are awarded as shown in Marking Scheme (below).
Computer-aided design (CAD) should be used where possible.

3. **Design Realisation (110 marks)**

Using appropriate materials, make the model according to your own individual design plans. Computer numerical control (CNC) technology should be used, where possible, to support manufacture. You are required to manufacture and assemble all the parts, subject to the following guidelines :

a. Standard components may be used to support the assembly and interconnection of various parts;
b. Unnecessary recycling will result in lost marks. Recycling will be acceptable **only** in cases where a complex **part** cannot readily be made in the school;
c. **Bought-in electronic solutions will result in lost marks**;
d. Adhesives, if used, should be applied sparingly.

Contents

Analysis of the Design Brief

The design brief for the leaving cert 2013 requires us to design and make a model Crane Vending Machine.

Crane Vending Machines have been around since the early 1900s and the earliest US patent was taken out in 1927 by Mordicha Margolith. Back then they were less of a game and more of a gimmick to entice potential buyers of a product by playing on their curiosity.

They became popular in the US and Europe in the 1980s with the surge in electronics and technology. They were used to promote sports teams and products. They then found their way into arcades and are now a common game played by people the world over. Their prominence in popular culture and recreational activity has gone from strength to strength and today they can be found on every continent. In East Asia, they are extremely popular and in some cases there are entire arcades dedicated to them. In China and Japan, they have been known to stock live animals as prizes.

The design brief states that the model should have electro-mechanical operation. This means that both electronic and mechanical components will be used in its manufacture. A game of skill and chance means there must be elements of skill involved to win, along with chance, this suggests even a skilled player may be unlucky and find it difficult to win/score. There is a variety of ways skill and chance can be incorporated.

The payload of the game, in this case, a table tennis ball gives us consistent shape and weight. This removes the difficulties some cranes have when dealing with irregular shapes. The table tennis ball will be lifted and dropped into hatches with various scoring results. The operator must be able to accurately judge the distances which the crane will move to collect, lift and deposit the ball. This adds an element of skill and depth perception and also an element of luck.

Investigation of Possible Solutions

I began my investigation by analysing different designs of Crane Claw machines. We made the trip to ‘Star Leisure’, an arcade which features many CVMs. I looked at the range of machines and noted many designs and models.

The overall structure of the machines remained mostly the same: a cuboid shape with a protruding control panel. The user is attracted by a variety of features. Firstly the machines are brightly coloured. They are often accompanied by upbeat music and flashing lights. However the prospect of winning the prize/payload is also a main point of attraction.

Studying these crane claw machines in action allowed me to understand them in practice. Now armed with this information I did some secondary research. I investigated the different mechanisms and the different types of machines since their first patent in 1927. I looked through the separate patents over the years and compared and contrasted them to gain a broader understanding of what I needed to do.

Next, I noted the mechanisms they used to: Transport the carriage along two axes, to lower the claw and to grab and release the payload.

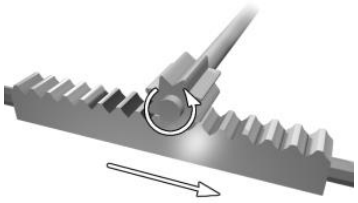
The Carriage

The possible methods of transporting the carriage that I investigated are:

- Rack & pinion.
- 'Rod & roller'.

Rack and Pinion:

This mechanism did not feature in many of the crane claw machines I studied. Although it did seem to work well in the ones it did feature in. Studying the US patents it also did not feature in a great number of CVMs.

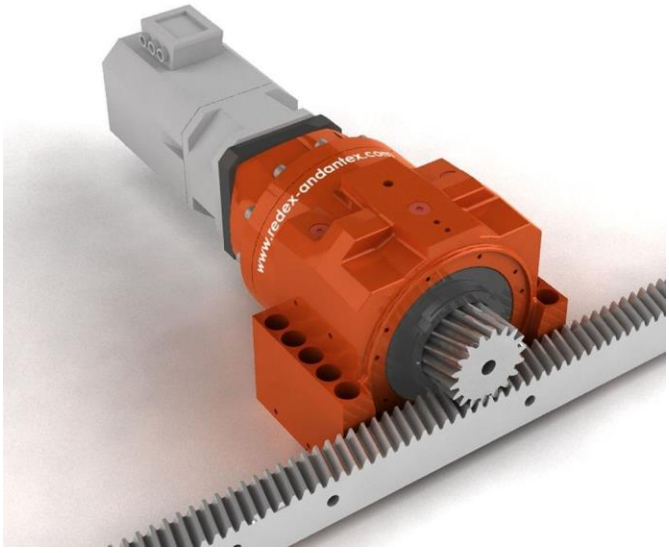


Advantages

- Precise movement.
- Positive tooth for tooth travel.
- Can be compact allowing space to be maximised.
- Ready made component.

Disadvantages

- Can be difficult to arrange for precise operation.
- Relatively expensive by comparison to rollers or pulleys.
- Requires limit switches and the ends of its travel, due to the fact that it cannot 'slip'.



Rod and Roller:

This mechanism was common to many of the machines. It seems to be a robust and relatively simple design. One bar drives the entire mechanism along the Z axis by rod and roller. The carriage runs on two rods along the X axis. The claw is lowered on the Y axis by a winch to collect the payload.

Advantages

- Simple and robust.
- Easy to manufacture.
- Operates effectively.
- Can ‘slip’ at end of its travel.

Disadvantages:

- Takes up a relatively large amount of space.

The Claw

Possible methods of lifting the payload are; suction, grabbing (like the conventional CVM) and lifting.

These methods could allow for **a traditional claw or a variation.**

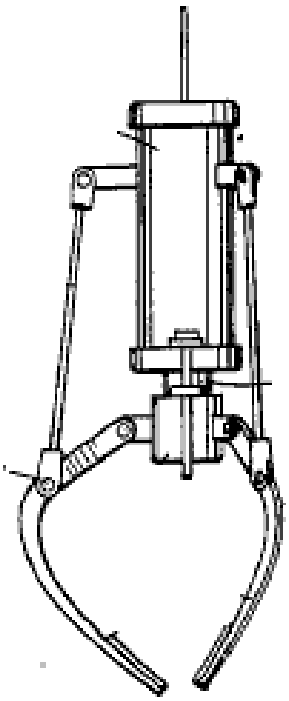
A traditional claw is operated by a solenoid plunger and grabs the payload with 2 – 4 limbs. It is usually lowered by a winch type mechanism and activated by the solenoid.

Advantages:

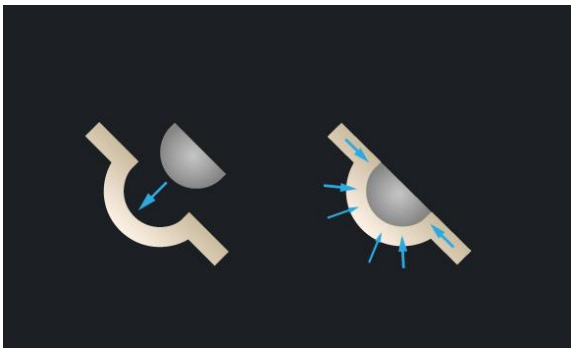
- Positive lifting and dropping action.
- Designed for its specific function.

Disadvantages:

- Complicated design.
- Difficult to manufacture.
- Complex opening and closing operation.



I also investigated **an interference cup or claw**. An interference cup/claw is another possible solution for "the claw", with a relatively simple design. An interference fit with the table tennis ball would cause it to be held by the cup/claw due to friction.



Interference Cup

Advantages:

- Simple design.
- Easy to manufacture.
- Readily available as a recyclable item.

Disadvantages:

- Poses problem of how to release payload.

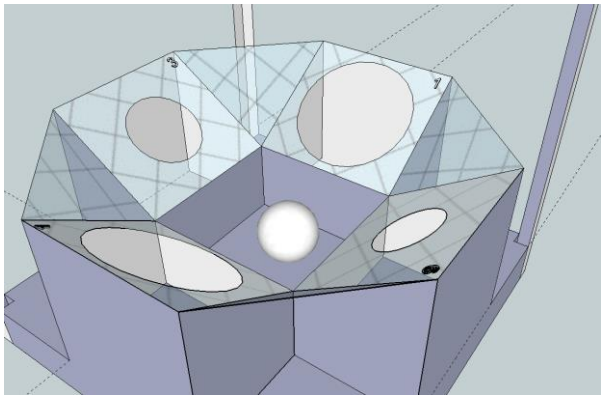
Interference Claw Prototype

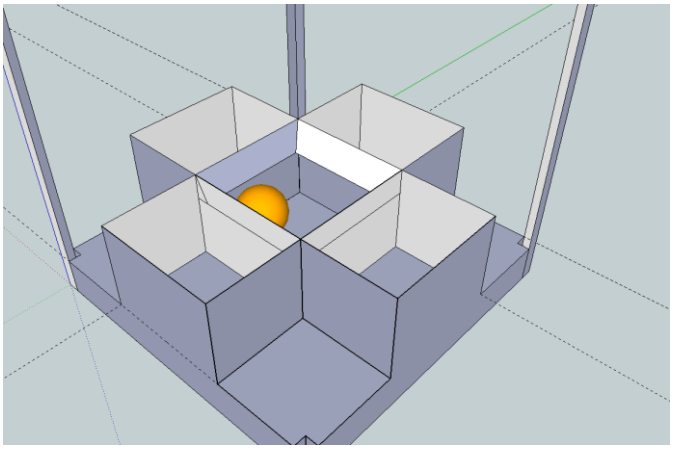
Possible Scoring Solutions

I investigated the different scoring solutions on arcade crane claw machines and found they were mostly the same, to facilitate collecting of the payload. Since the payload will be a table tennis ball I came up with a number of possible scoring solutions.

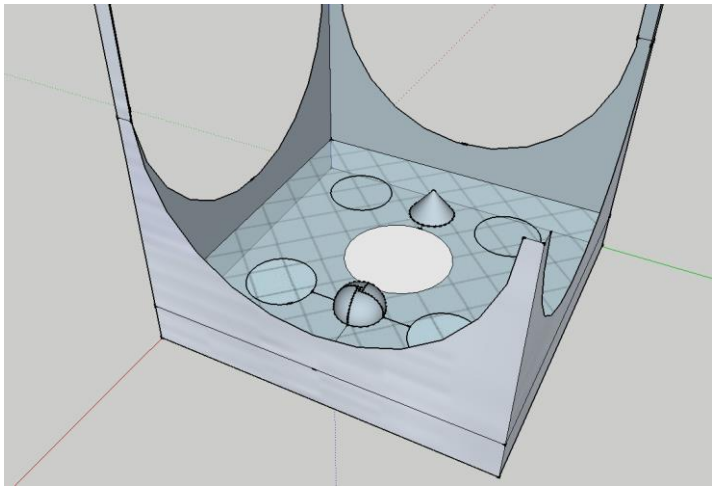
1.

This is the first solution I designed.
It has multiple scoring hatches with different sized holes corresponding to different scores.





2. This is another possible solution.



3. Another scoring solution I came up with was this. Four holes surrounding a starting platform.
It also has two obstacles; a cone and a dome.

Criteria for selection of Solutions

Having completed my investigation I considered all the resources at my disposal, including: materials, processes, time, and my own knowledge and ability.

I laid out a timeframe for completion of the project which is shown below.

Proposed Timeframe for Engineering Project Work

15th October 2012 – 1st March 2013

	Wk1	Wk2	Wk3	Wk4	Wk5	Wk6	Wk7	Wk8	Wk9	Wk10	Wk11	Wk12	Wk13	Wk14
	15-19 Oct	22-26 Oct	5-9 Nov	12-16 Nov	19-23 Nov	26-30 Nov	3-7 Dec	10-14 Dec	17-21 Dec	7-11 Jan	14-18 Jan	21-25 Jan	18-22 Feb	25 Feb - 1 Mar
Design Brief Issued														
Analysis of Design Brief														
Investigation of possible Solutions														
Selection of Solution (Criteria)														
Production Drawings & Plans														
Realisation Of Project (Making)														
Testing & Evaluation of Project														
Presentation of Folio & Instructions														

Note: Autumn Mid-term break = 1 week, Xmas Holidays = 2 weeks, Mock Exams. = 2 weeks & Spring Mid-term break = 1 week

It appears to be a difficult project to realise. Therefore I want to keep it as simple as possible so that I can complete it. However, I do not want to compromise on its operation.

Chosen Traverse Mechanism

I decided to use the 'Rod and Roller' Mechanism for both my X and Z movements after considering it's pros and cons. I chose to use this method as it best reflects the mechanisms of most real Crane Claw Vending machines. I feel that it will provide accurate, precise movement as well as the ability to 'slip' at the end of its travel, unlike the rack and pinion. The 'Rod and Roller' also allows for variation including using wheels as rollers on a flat bar.

Following my time plan I found that I would have enough time to make this mechanism and it could be made with the materials available at my school.

I also decided on the mechanism as it was with my own technological abilities and it followed the K.I.S.S. principle: Keep It Simple, Smart.

Chosen Claw

I decided to use and interference claw to grab the ball and a threaded bar to raise and lower it as well as to release the ball. After considering the pros and cons, I originally thought about manufacturing a traditional claw, however due to the time constraints I decide to opt for the interference claw, following the K.I.S.S. principal once again.

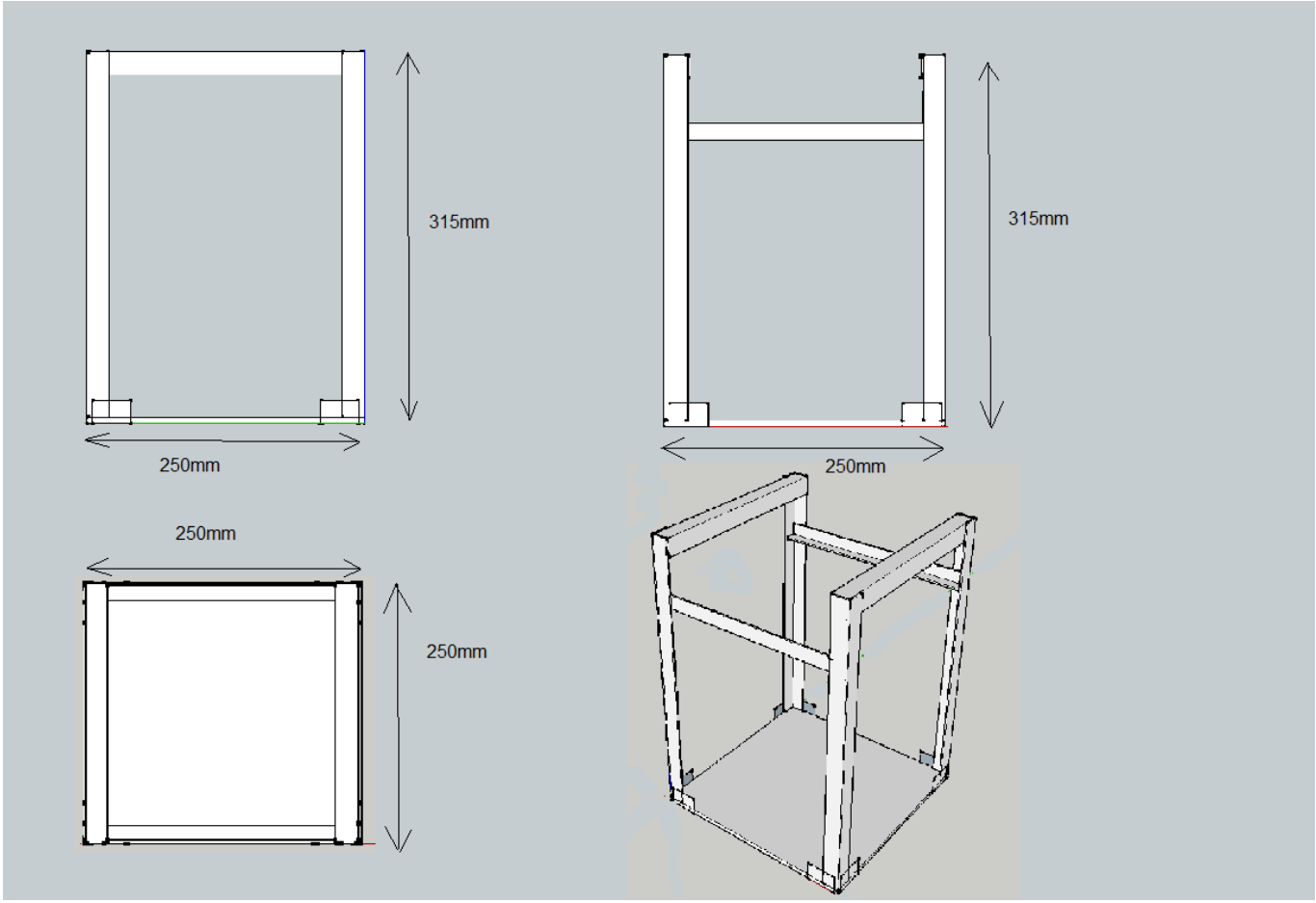
Following the time plan, the interference claw seemed to be very achievable and the materials needed were available at my disposable at my school. My final decision was whether I had the technological skills to make it and I found I had the skills I needed.

Chosen scoring solution

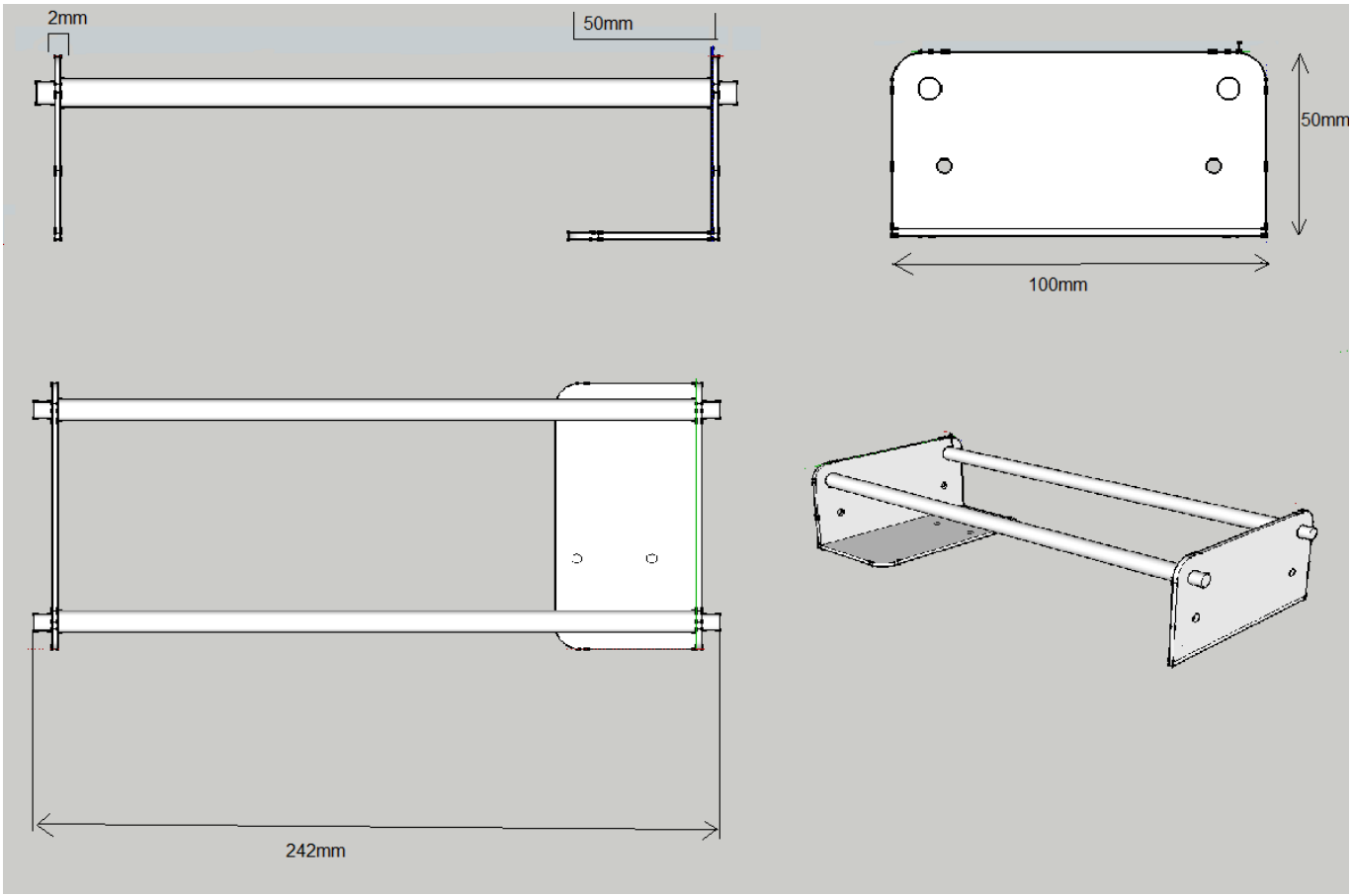
I chose the third scoring solution as it was simple and maximised space. For the various scoring results I decide that two scoring hatches would be easily reachable and the other two would only be reachable by use of the obstacles. This adds an element of skill and chance and covers the brief in terms of various scoring hatches.

Production Drawings and Plans

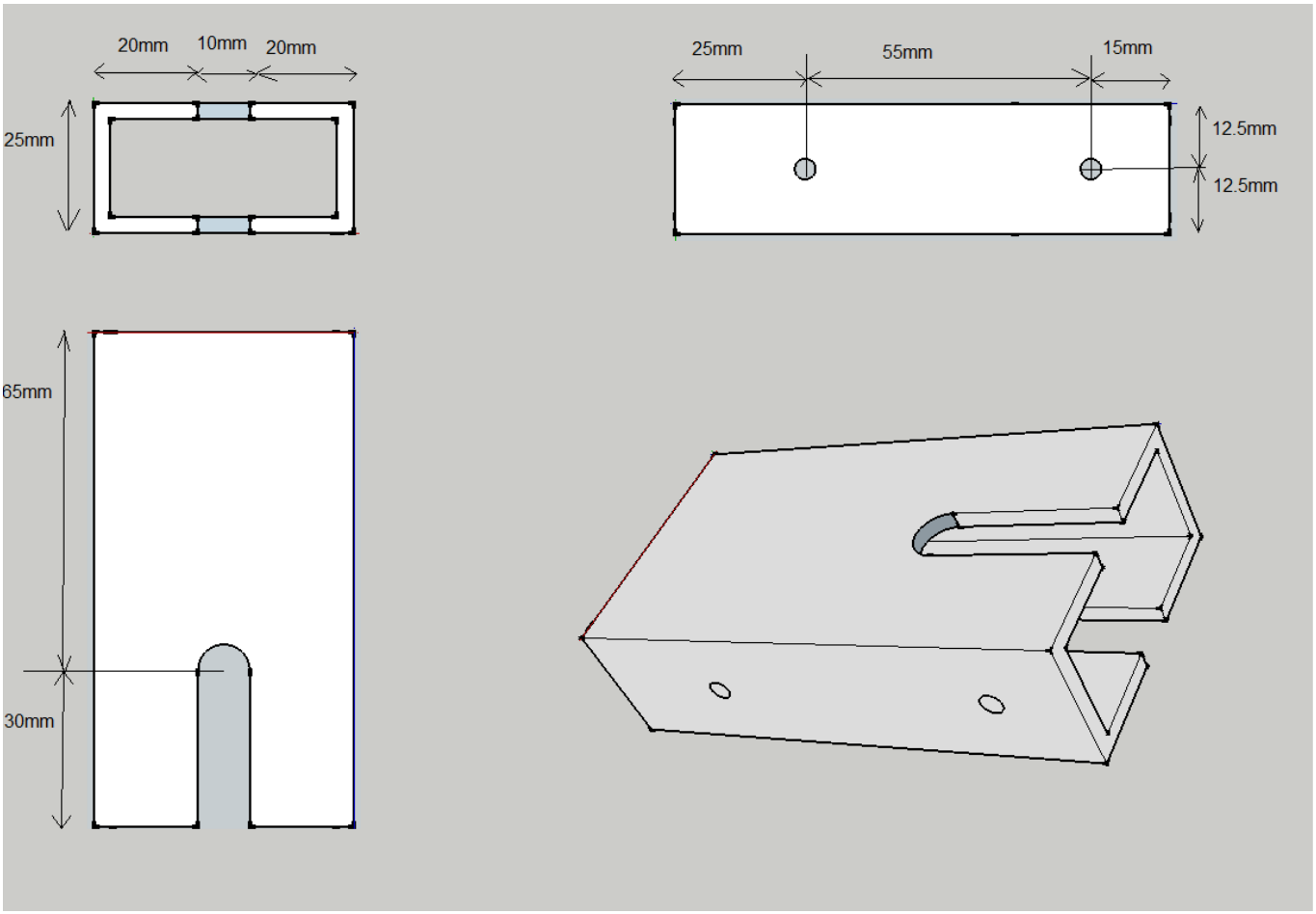
Frame:



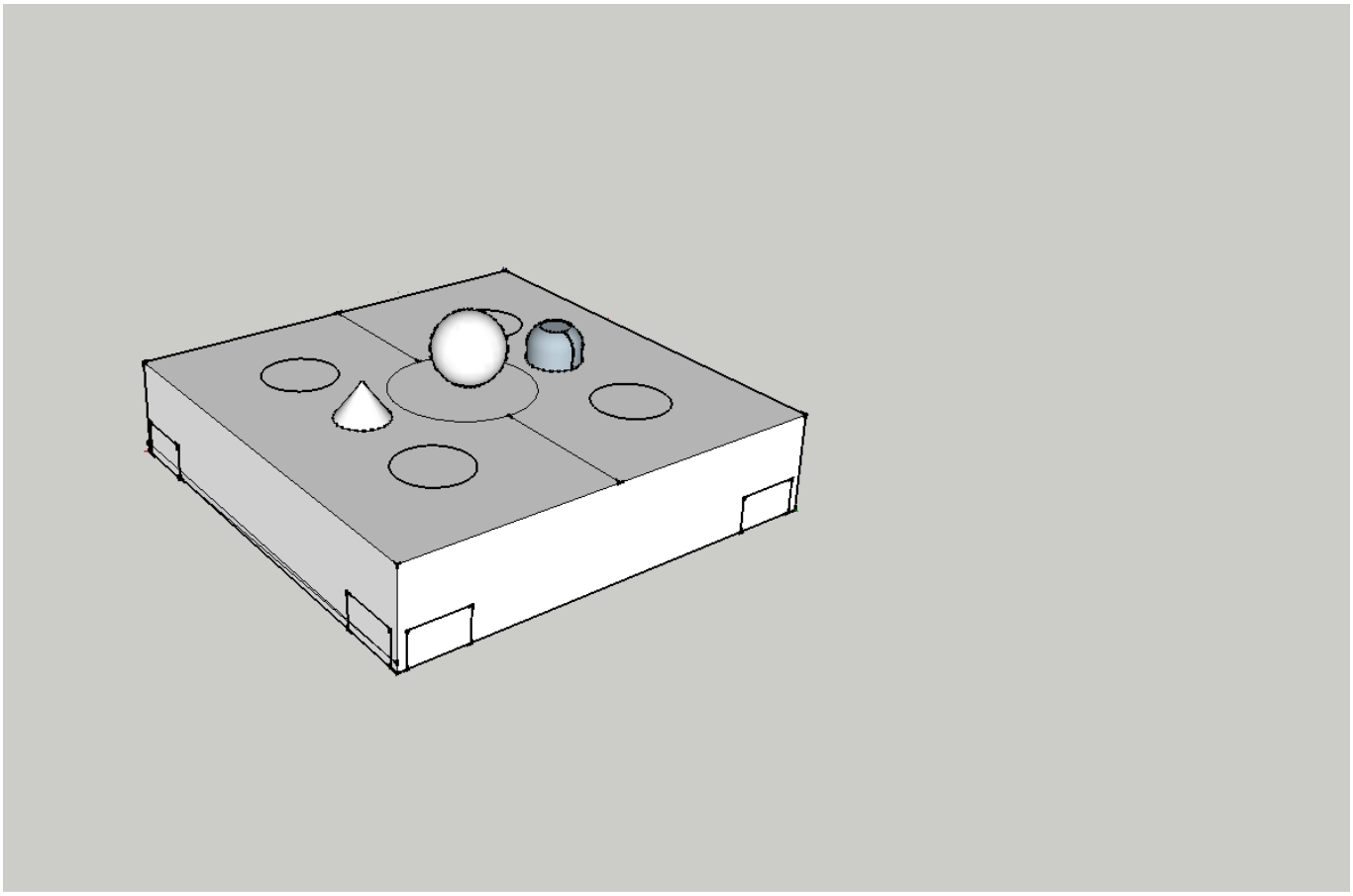
Traverse mechanism:



Carriage:

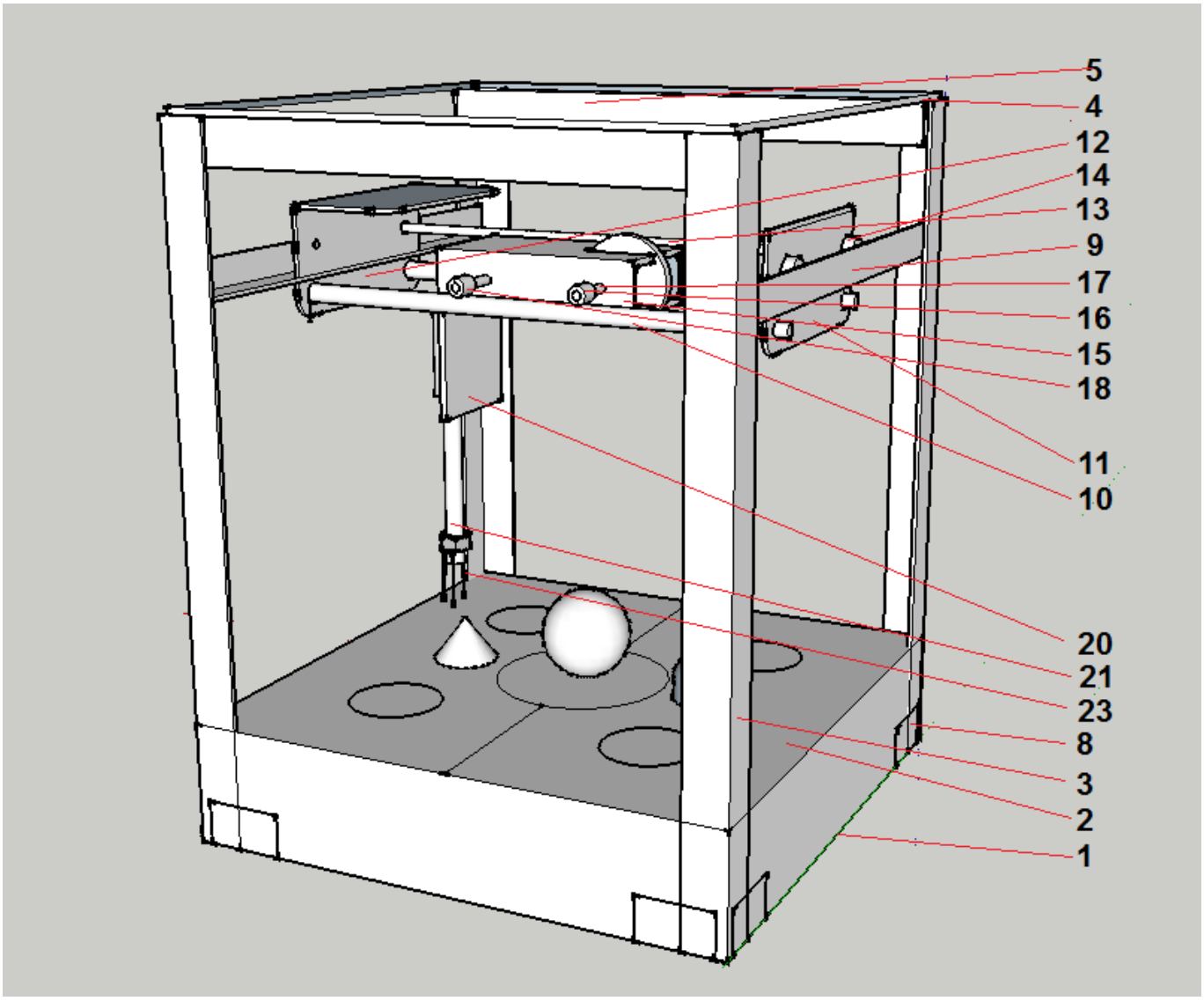


Scoring System:



Scoring hatches: Diam. 42mm x4
Obstacles: Diam. 30mm
Elevation 20mm

Assembly Drawing:

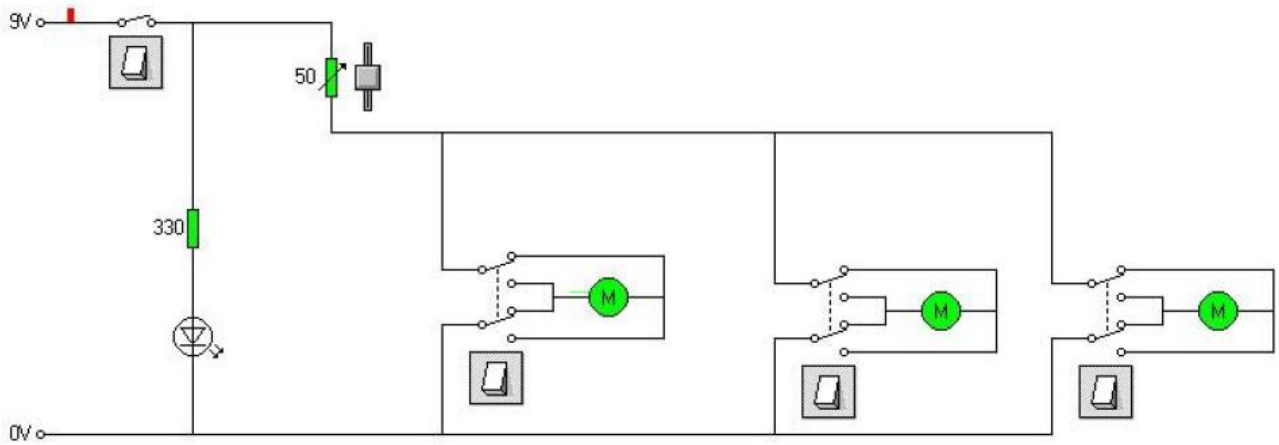


Manufacturing Table

Part No	Name	Material /Size	Manufacturing Process
1	Base	Clear Acrylic 250x250x5mm	Cut on Bench Saw De-burred and sanded
2	Scoring platform	Sheet Aluminium 250x250x1.5mm	Cut, hammered, drilled and bent to shape.
3	Struts x4	Angle Aluminium 25x25x315mm	Cut, filed, drilled and fixed by screws.
4	Roof	Clear Acrylic 250x250x3mm	Cut on bench saw, de-burred, and fixed to box section.
5	Roof supports x2	Box Aluminium 15x15x250mm	Cut, de-burred and riveted to roof.
6	Control panel	Clear Acrylic 175x45x3mm	Cut drilled, thermoformed and fixed to bracket.
7	Control panel brackets x2	Angle Aluminium 50x25x3mm	Cut to length, cut to profile of panel, fixed to panel and scoring platform.
8	Base Brackets x4	Sheet Aluminium 40x20x1.5mm	Cut out, drilled, bent to right angles and fixed to base and struts by screws.
9	Carriage Tracks x2	Angle Aluminium 15x15x246mm	Cut, filed, drilled and fixed to struts by screws.
10	Carriage Rods x2	Brass Bar Diam 8x210mm	Cut, turned ends to diam 6mm, threaded ends and fixed to carriage plates.
11	Carriage plate 1	Flat Aluminium 100x50x3mm	Cut, filed, drilled and fixed to carriage rods.
12	Carriage plate 2	Angle Aluminium 100x50x3mm	Cut, filed, drilled and fixed to carriage rods and motor.
13	Driving rod	Silver Steel Bar diam 4x210mm	Cut, filled and interference fitted to rollers.
14	Cylindrical Rollers x4	Nylon Rod diam20x15mm	Turned, drilled and interference fitted to driving rod.
15	Carriage	Cuboid Aluminium 50x25x95mm	Cut, filed, drilled, slot cut out and motor fitted by screws.

16	Grooved rollers	Nylon Rod diam12x20mm	Turned on CNC lathe, drilled, parted off and interference fitted to axle.
17	Carriage axles x2	Silver Steel diam 4x95mm	Cut, filed and interference fitted to grooved rollers.
18	Sliders	Tube Aluminium Diam8x20mm	Cut, filled and fitted to axle.
19	Carriage washers x4	Sheet Aluminium diam29x1mm	Cut out by hole saw, de-burred and fitted to rollers and sliders.
20	Claw bracket	Angle Aluminium. 50x50x30mm	Cut, filed, drilled and motor fitted.
21	Claw rod	Brass bar diam 8x80mm	Cut, filed, threaded.
22	Claw guide strip	Flat Aluminium 140x10x3mm	Cut, filed, drilled and fitted to claw bracket.
23	Claw limbs x3	Mild Steel Rod diam 2.5x100mm	Cut, filed, MIG welded to M8 nut and bent to shape.
24	Claw guide	Mild Steel Rod diam 2.5mm	Cut, filed, bent to shape and MIG welded to M8 nut.

Electronic Circuit Diagram:



Testing and Evaluation

On completion of the project I was anxious to test its' functionality. The Electronic Circuit controlled all the movements correctly and the potentiometer was a very useful feature in controlling the speeds.

The interference claw grabbed and lifted the ball successfully and the lifting screw fulfilled its' dual function of both lifting and ejecting the ball. However the range of traverse on the X axis is limited by the necessarily large size of the carriage. The Cone and Dome obstacles were my solution to this problem, as they could be used to allow the ball to reach the inaccessible hatches. They also add to the chance feature of the mechanism.

My carriage was unstable on the rods and frequently drifted off course, causing the carriage to stall. I solved this by adding washers to the end of the driving rollers and sliders, so that it cannot deviate from its' axis.

A lack of friction between the Rods and Rollers was also found to be a problem. It made the X axis very slow to move. This proved to be a major challenge to find a way of increasing friction without reducing stability. After trying rubber bands stretched around the rollers I found they were not solving the problem. I searched for another solution and eventually came up with using silicone thinly spread onto the rollers. This proved to be the best solution.

Overall I found this project to be quite challenging compared to examples of previous years projects I have seen. However I enjoyed the challenge and I'm happy that I have satisfied the brief.

I found the time given to manufacture particularly restrictive given the amount of work that had to be done.

If I had to do this project again there are some things that I would do differently, namely; use the maximum dimension of 350mm in all directions to achieve a greater range of travel and source more compact motors in order to save space.

Special Instructions

(For Examiner to operate)

1. Check that SPST is in OFF position.
2. Check that DPDT x 3 are in centre-off position.
3. Ensure fully charged battery is connected (supplied).
4. Throw SPST to ON position.
5. Adjust Potentiometer fully in an anti-clockwise direction.
6. Operate X, Y and Z axis as desired using the potentiometer to adjust their speed.
7. Scores are achieved by dropping the table tennis ball into the hatches.