University of East London

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

Mechatronics and Automation Engineering Programs (CHEP) Midterm - Academic Year 2020/2021

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ASU Course Code **MCT 131**	*ASU Course Name* **Introduction to Mechatronics**	
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Abstract:

In this report we will discuss final project for MCT 131- introduction to mechatronics. Project details, design, manufacturing of ball sorting mechanism and applying of principles of design such as user experience, mind maps and mood board.

Introduction:

Our project is a marble track for kids, it is a closed loop game which ball starts at the reservoir or anyplace then it goes through stages which is:

1- Elevator
2- Shooting
3- Sorting
4- Pathways

Ball sorting mechanism is designed to sort balls of 3 different colors into 3 different tracks by way of automatic system containing sensors and actuators.
The balls are then collected through pathways and fed into elevator system which lifts and guides the balls into a shooting mechanism. Then the balls after being shot are caught and delivered to sorting mechanism which sorts them, and the loop continue.

This was a brief overview of the game.

Research

We got most of our ideas from asking older students and from these links:
https://www.youtube.com/watch?v=Qeyvpp_-dkk&t=2s
https://www.youtube.com/watch?v=6FFw3J79-GM
http://doityourselfgadgets.com/2011/07/ball-throwing-machine.html
https://learn.adafruit.com/adafruit-color-sensors/arduino-code
https://howtomechatronics.com/tutorials/arduino/arduino-dc-motor-control-tutorial-l298n-pwm-h-bridge/

Work Planning

We divided the project into 3 stages…

Stage 1: Brainstorming

We decided to brainstorm a general design that includes size, general positioning, and an abstract flow of mechanisms.

Stage 2: Main Work Process

Then we started detailing and designing each mechanism separately but considering the general design.

Stage 4: Integrating

After individually finishing each part we started working on integrating all parts with each other

Stage 3: Calibrating and Finishing

Upon completion of each mechanism, we started putting it together and calibrating each mechanism to fit into the project. Then we started decorating the project to fit into our theme

Design and Theme

Theme:

Our chosen theme is “Amusement park” as this theme would provide us with several design ideas that would fit our project requirements.

Mood board:

Fig. 1: mood board design

Mind Map:

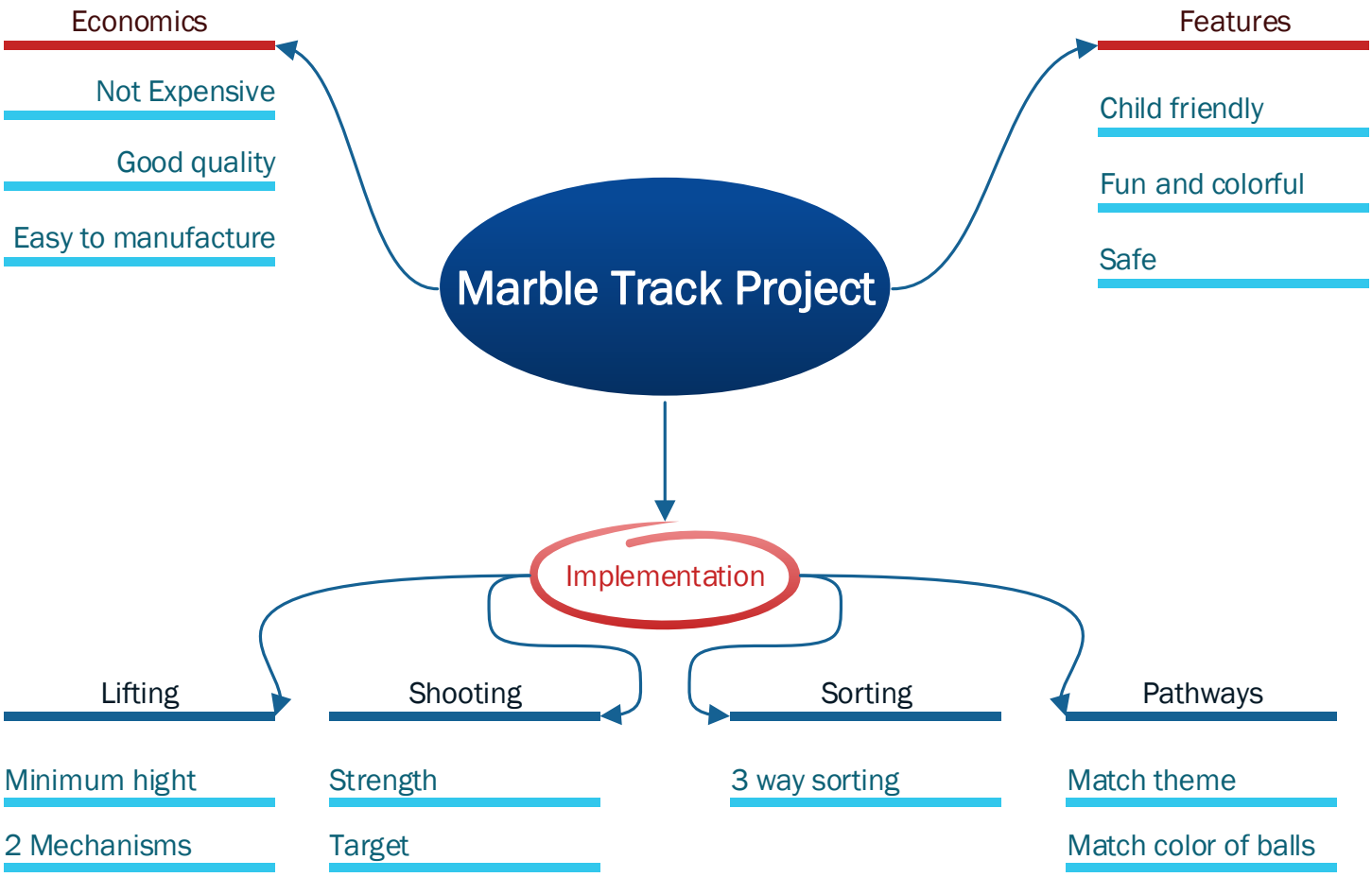


Fig. 2: Mind map design

First Draft of the general design:

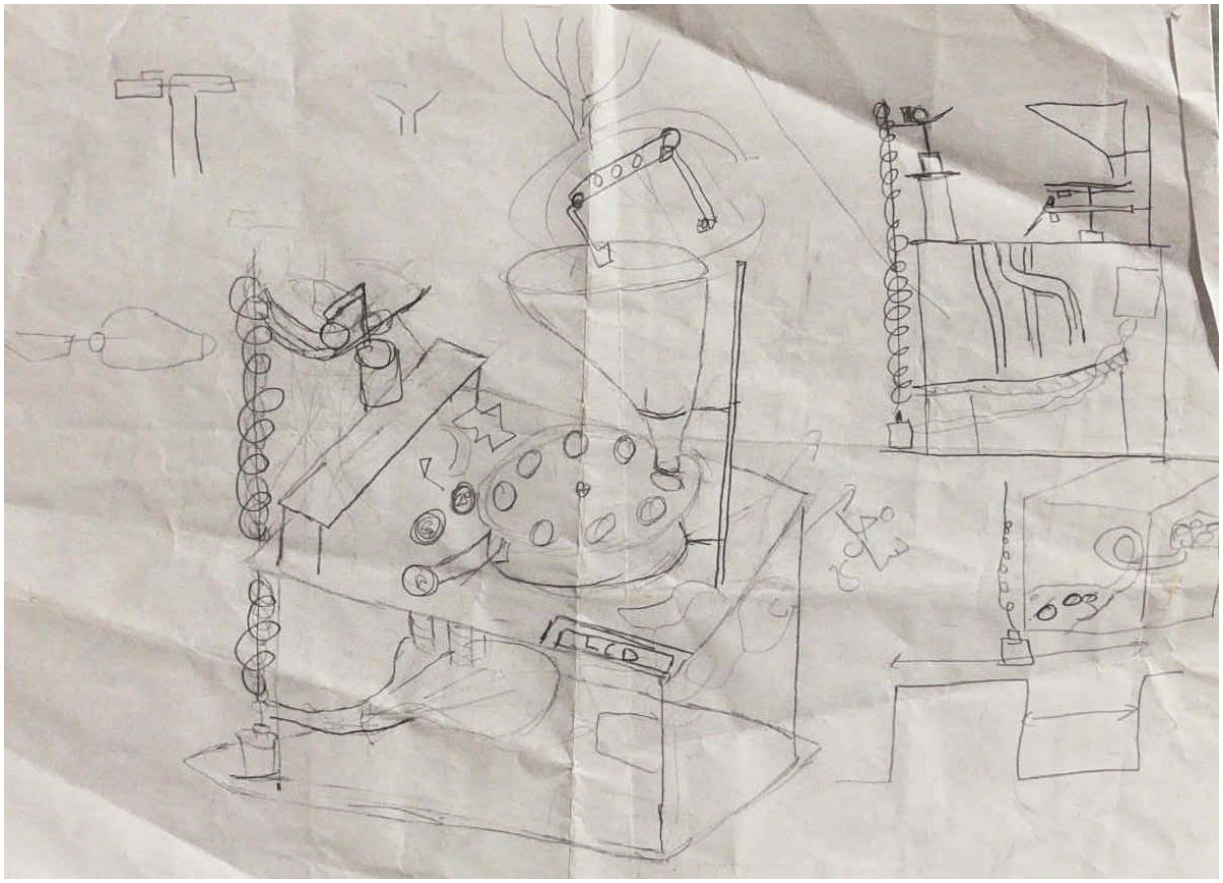


Fig. 3: image of draft drawing

We used this draft as a starting point to picture the positioning, size, theme and mechanisms.

Sketches:

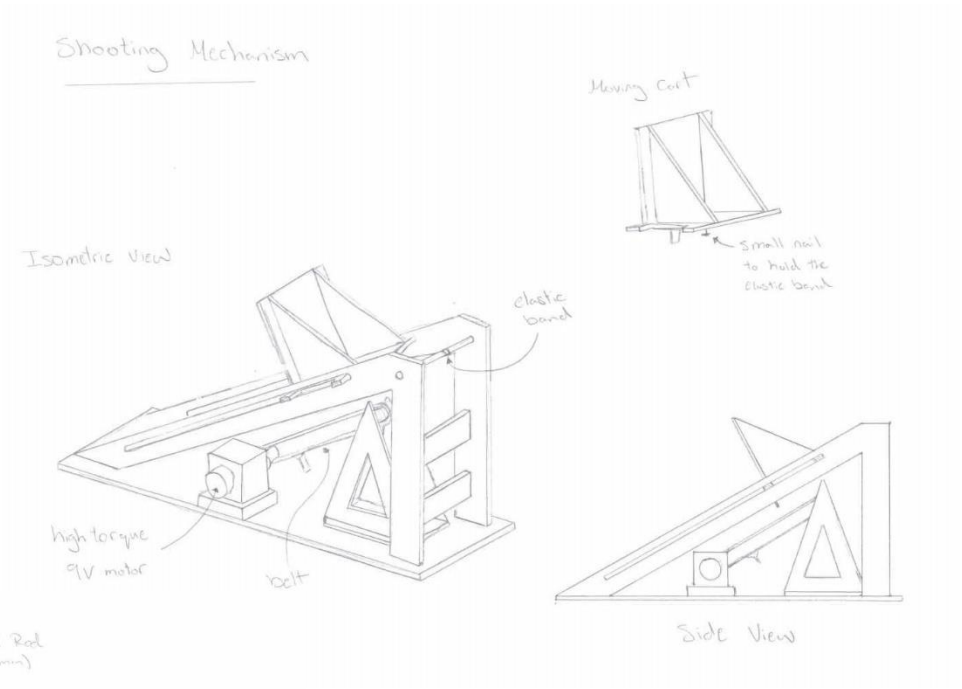


Fig. 4-1: sketch of shooting mechanism

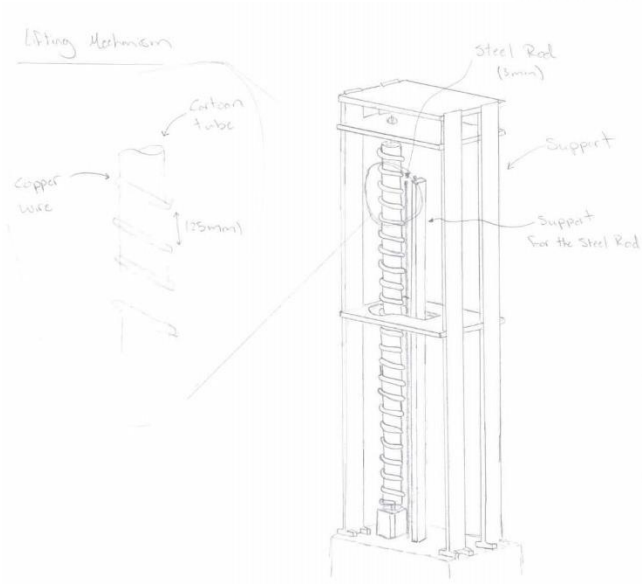


Fig. 4-2: sketch of lifting mechanism

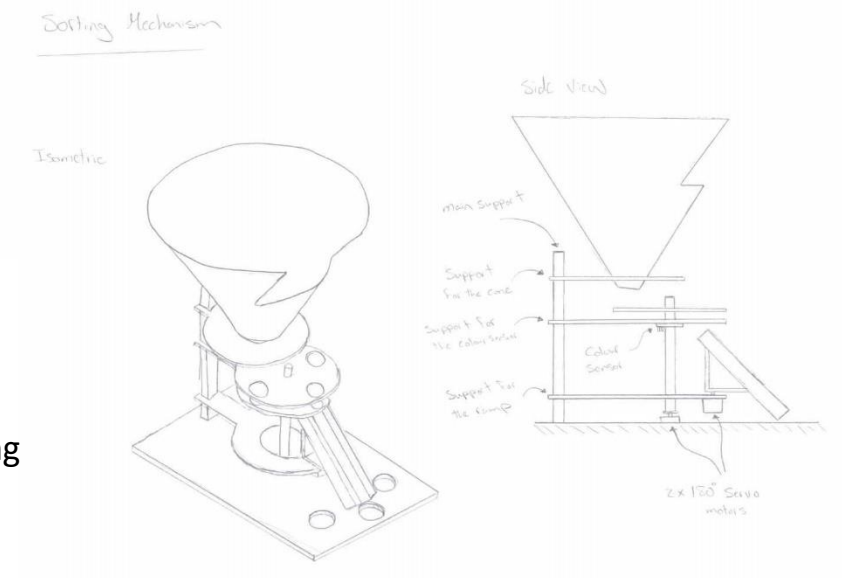


Fig. 4-3: sketch of sorting mechanism

Inventor Model:

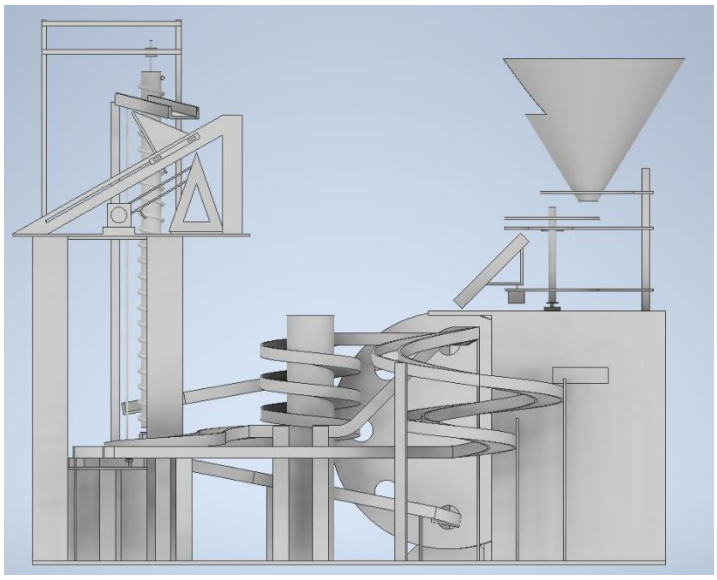


Fig. 5-1: Inventor Model Elevation view

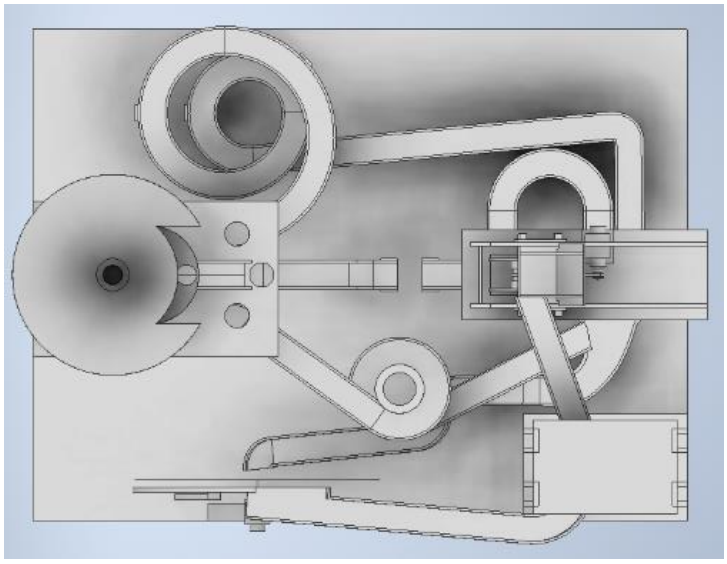
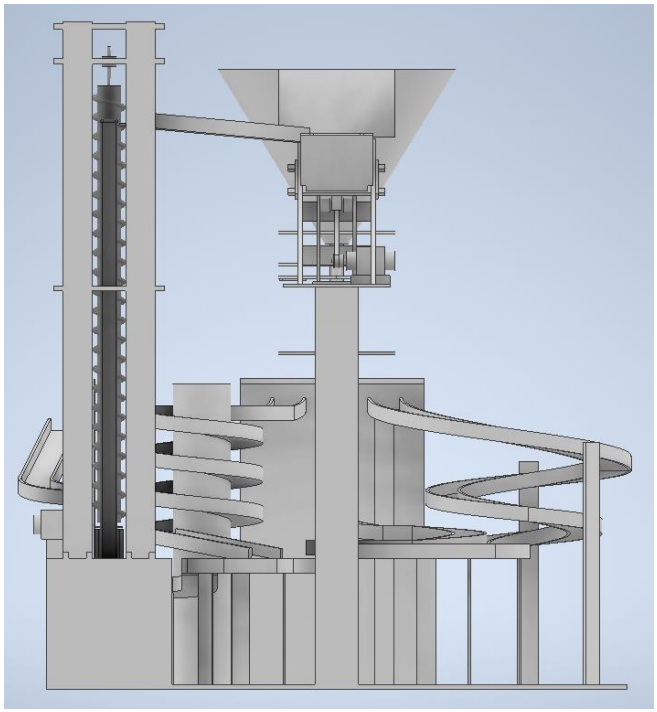
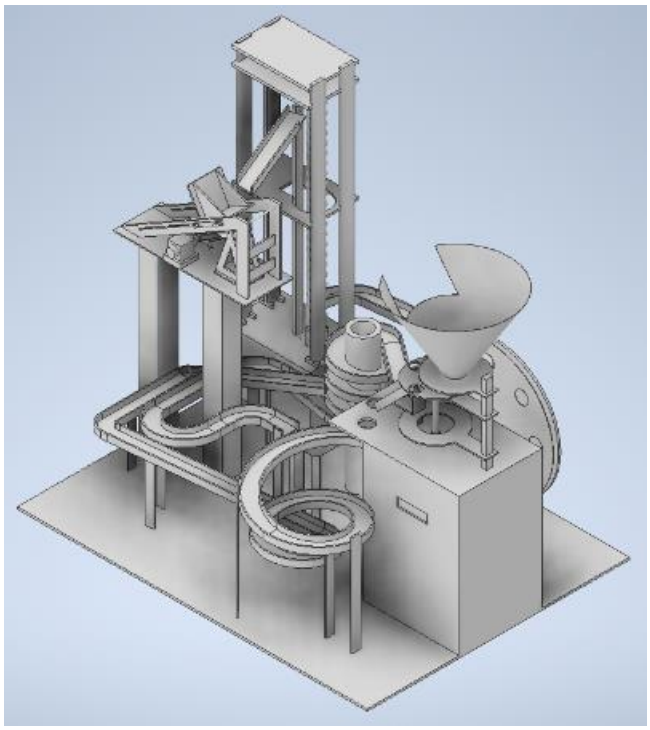


Fig. 5-2: Inventor Model top view

Fig. 5-3: Inventor Model side view

Fig. 5-4: Inventor Model isometric view





Real Model:

Fig. 6-1: physical Model Elevation view

Fig. 6-2: physical Model top view

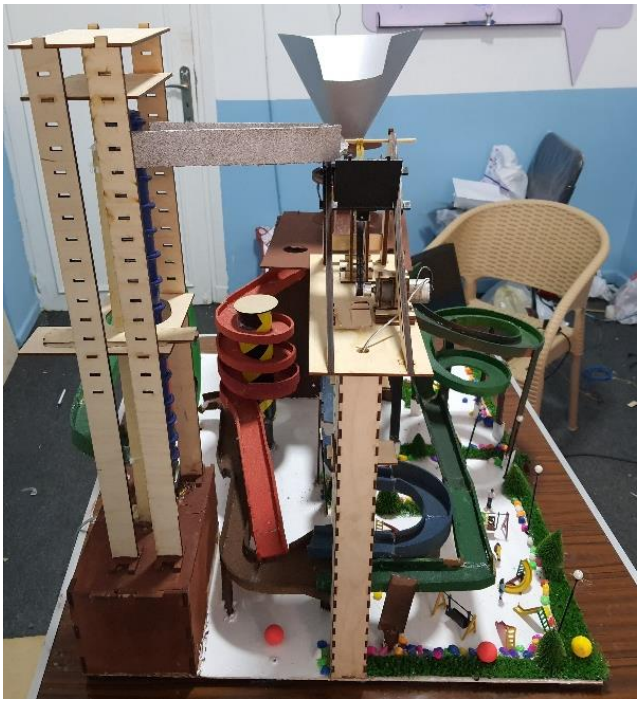


Fig. 6-3: physical Model side view

Fig. 6-4: physical Model isometric view

Mechanisms

For the mechanisms of the project, it all starts at a reservoir which is located at the lowest point (brown pathway).

Then it moves on to…

Fig. 7-1: reservoir

1- Lifting Mechanism:

We got 2 different lifting mechanisms integrated in this project...

1) Circular elevator

The elevator receives the ball in one of its groves then moves it up in a circular motion. The ball stays in grove because of a back support and upon arriving to the top there is no support. Therefore, the ball falls on the dedicated pathway to the 2nd lifting mechanism.

Fig. 7-2: circular elevator

2) Spiral elevator

The elevator receives the ball at the bottom and pushes it up by the spiral between it and metal rail until the top where it falls out onto a track to take it to shooting mechanism. The ball is kept on the spiral as it continues motion and only falls out at the top where the rails end.

Fig. 8-1: spiral elevator

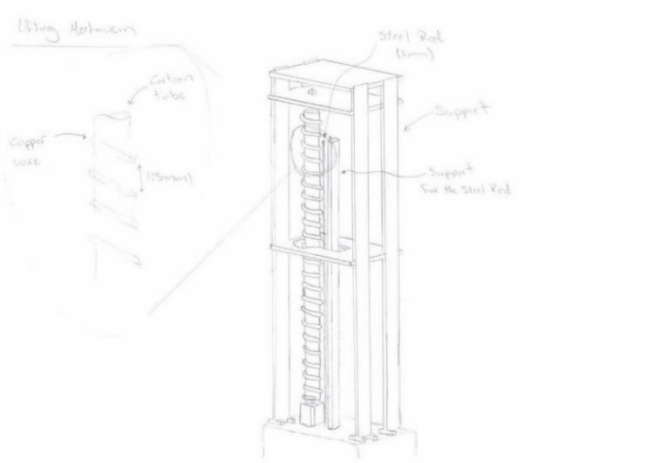


Fig. 8-2: drawing of spiral elevator

2- Shooting:

Our shooting mechanism is inspired by crossbow mechanism where a motor moves a belt that pulls a small cart backwards and on release the cart is sling shot due to elastic bands. The shooting is aimed at the funnel at the start of the sorting mechanism.

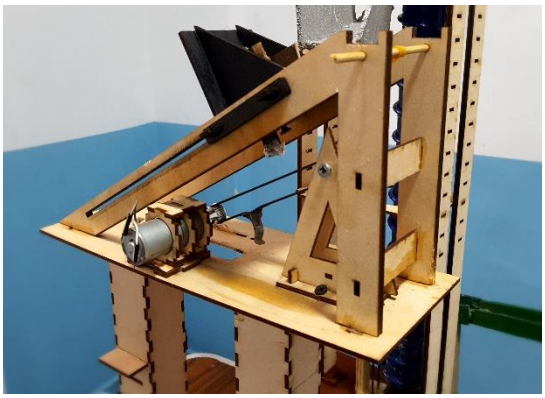


Fig. 8-3: shooting mechanism

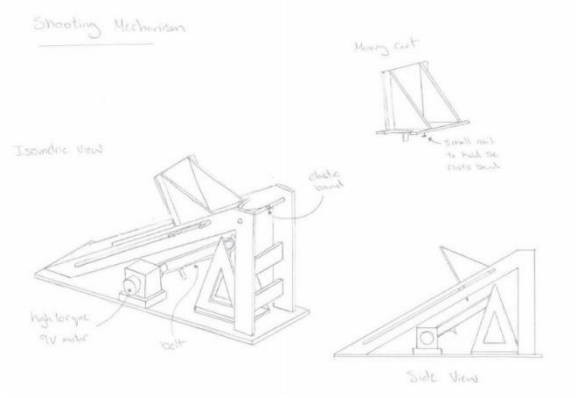


Fig. 8-4: drawing of shooting mechanism

3- Sorting:

Our sorting mechanism works by first catching a ball with funnel connected to the upper plate. The cone funnels the ball into a hole in a plate connected in the middle with a metal shaft which is connected to a **180-degree servo motor** (sg 90 micro servo) connected to the base of sorting mechanism. The ball rolls on the middle plate on which the color sensor is fixed under an acrylic window, after the ball falls into the hole in the moving plate the plate first moves 90 degrees to put the ball in front of the color sensor which detects color of the ball.

Then the servo moves another 90 degrees dropping the ball through a hole in the middle plate onto a ramp connected to another micro servo which moves to drop the ball onto one of the three tracks through one of three holes in the base of the sorting mechanism. The holes are at 18, 90 and 150 degrees for red, blue and green tracks respectively. The ramp is connected directly to another servo which is fixed on a lower plate. All plates are connected to a wooden shaft through a slot at the back and fixed with metal L shape and screws. The wooden shaft is connected to the base with metal L shape and screws.

Fig. 9-1: sorting mechanism

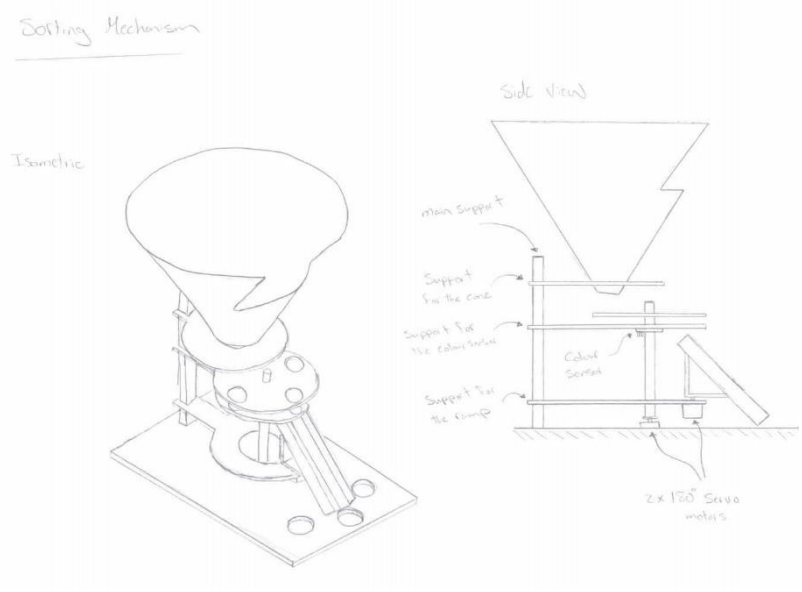


Fig. 9-2: drawing of sorting mechanism

4- Pathways:

The tracks were designed to maintain the fun part of the park to the child, the three tracks are similar to the playground slides but in many shapes, to provide happiness, joy and pleasure to the kid who is playing.

To make the tracks in the way we desired -to be like the amusement park- there were specified requirements in the material we need:

1- Soft because there are many curves in the tracks.
2- Safe material for the children

So, we decided to use cork as it is a safe material for the children and to be able to do the track with its curves.

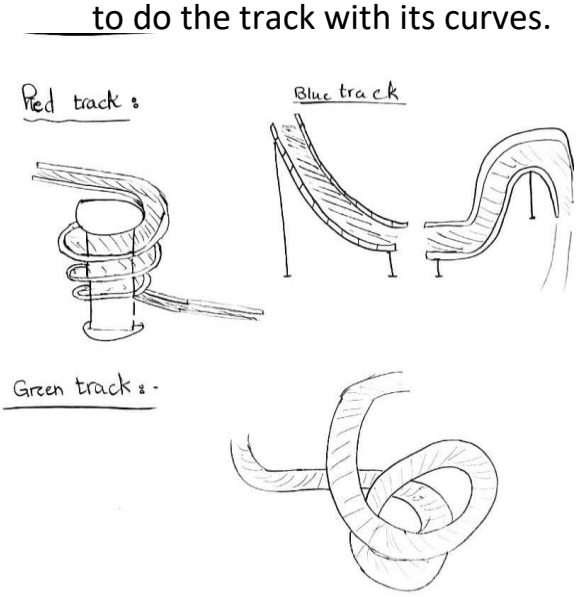


Fig. 10-2: drawing of tracks.

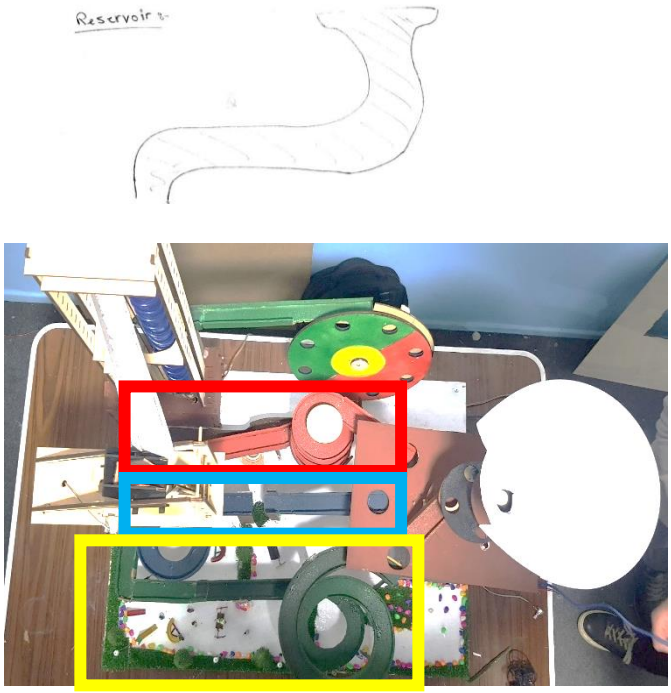


Fig 10-1: tracks

5- LCD:

Depending on the ball color the LCD counts each color that paths from sorting mechanism to pathways.

The LCD gives a purpose for the whole cycle.

Fig. 10-3: LCD screen

Manufacturing

During manufacturing we used several tools and processes to save time, money and have a high-quality product.
These considerations also affected our material selection.
Our project was mainly manufactured using 3 mm thick plywood that was laser cut and cork sheet cut by hand and put together using hot glue.

1) We used laser cutting plywood due to its low price, very high accuracy, and speed of manufacturing. It allowed us to prototype more easily and helped us keep costs down while using good parts.

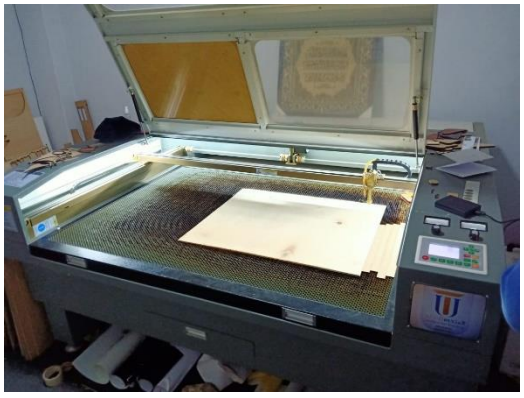


Fig. 11-2: laser cutting machine


Fig. 11-1: laser cutting


Fig. 11-3: cork

2) We used cork for our pathways for its flexibility and ability to bend without breaking, we also used it due to its ability to be cut with simple workshop knife and glued together with hot glue easily

3) We also used multiple hand tools and power tools in making our product.

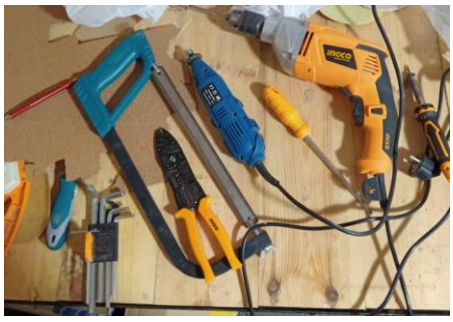


Fig. 11-4: hand tools

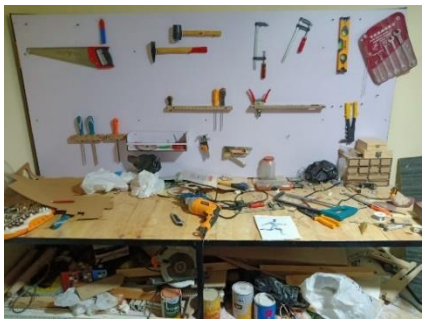


Fig. 11-5: work bench

4) For painting our project, we used both acrylic paint and spray cans.

Fig. 12-1: paint

5) In assembling our project, we used a wide range of fixation methods.

   - We used two-part epoxy, super glue and screws with steel L shape in parts that needed high strength, such as shooting mechanism.


Fig. 12-2: steel L shape and screws

   - We used hot glue in parts that required a lot of adjustment such as the tracks.


Fig. 12-3: super glue and hot glue

6) Finally, we used several measuring devices in construction of our project to ensure accuracy of dimensions and fits (aristo, Vernier caliber). We also used multi-meter to test and trouble shoot our electronic.

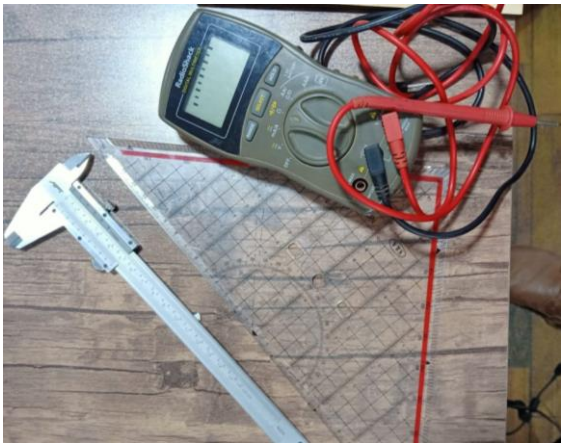


Fig. 12-4: measuring devices

Electrical Design

Our goal in this project was to implement all what we have studied in this course in one project with minimum complications.

Our system consists of:

- 2 servo motors (1.5k/180°).
- 1 stepper motor (nema17).
- 2 dc motors (high torque 3-9v).
- 1 color sensor.
- 2 H-bridges.
- Micro controller ARDUINO MEGA.
- Lcd screen
- Power supply 8.5A 12V

We have managed to combine all different types of motors in one project to gain experience in wiring all different systems.

Wiring: we put in our considerations that this is a children friendly game, all wires are sealed and run under the base of the game to be safe away from any users, we designed an electric box which contain all of the components and sealed from all corners, designed a power supply box which is hidden under the elevator**.**

Controlling different motors:

As we mentioned our system consists of different majority of motors.

Controlling dc motors:

We used H-bridge L298N to control the two motors direction and speed.

Note: our dc motors are 3-9v where our supply is a 12v so from the driver we can regulate the voltage via PWM.

Controlling stepper motor:

We have managed to control a stepper motor with a L298N to cut expenses and it's much more reliable**.**

Controlling servo motors:

Actually, servo motors are very simple to control where it has 3 wires one +5V one GND and the last is the input for the Arduino.

LCD screen:

We managed to make our game user friendly by adding a screen which displays the amount and the color of balls thrown to the cone.

Combining electric systems:

Our wiring system is simple and functional, we decided to use one Arduino mega which benefits of 53 pins to control the system which is much better and cheaper than using 2 or 3 UNOs.

Wiring color code:

All BROWN wires are GND.

All BLACK wires are GND.

All RED wires are +5V.

All BLUE wires are +12V.

ALL YELLOW wires are consisted for sensors output/input.

Simulation and wiring box:

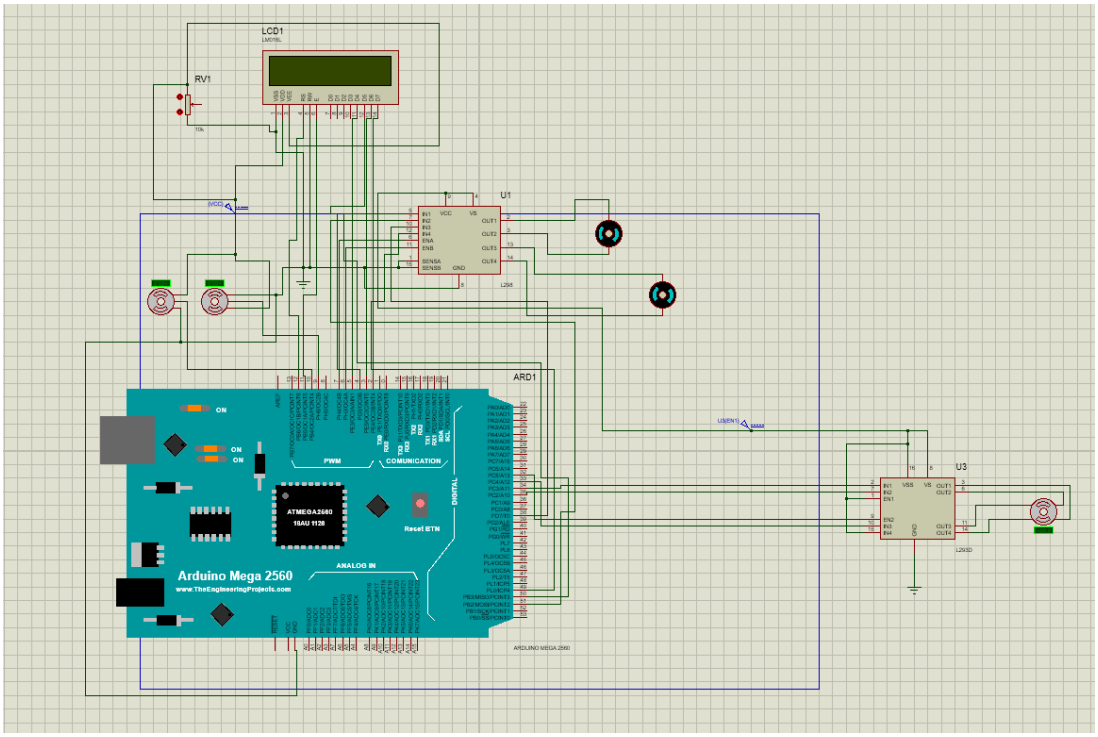


Fig. 13-1: simulation on Proteus

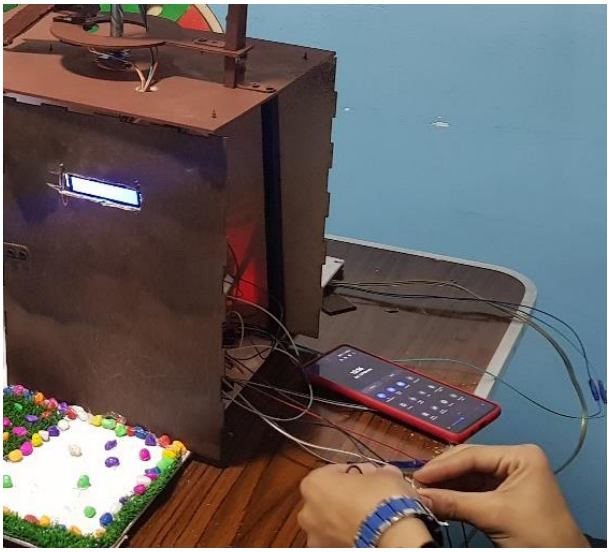


Fig. 13-2: wiring box

Programming

-Software flowchart

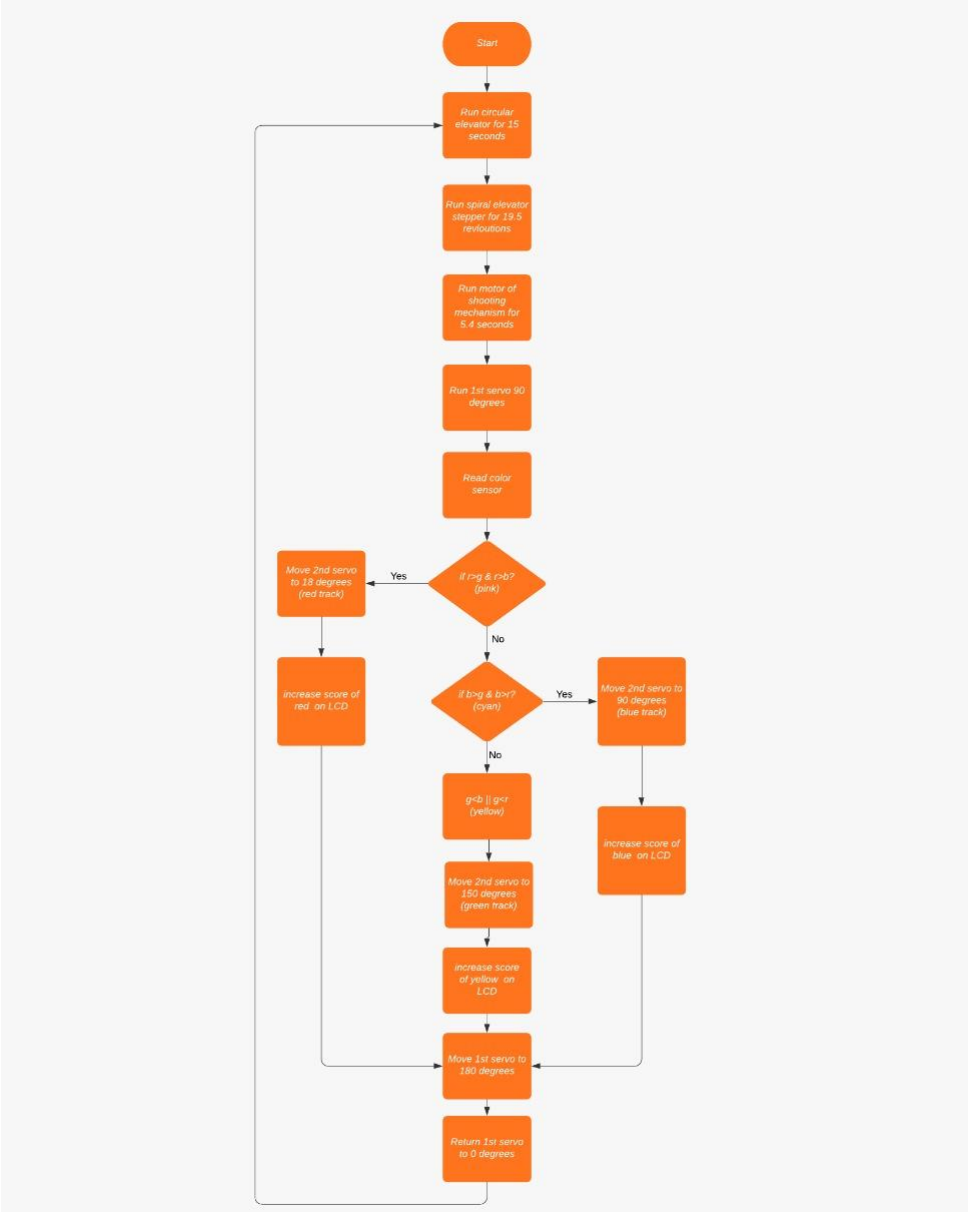


Fig. 14-1: software flow chart

Controlling stepper motors:

To control the stepper motors I included a library STEPPER.h

```
#include <Stepper.h>
```

Stepper motors are controlled via pulses to its coils so to control its speed and rpm we declare a library which is called mystepper:

```
Stepper myStepper = Stepper(stepsPerRevolution, 34, 35, 32,33);
```

To control stepper motor speed:

```
myStepper.setSpeed(42)
```

To control number of rpms the stepper will rotate:

Note: nema17 is stepper motor which 200 pulses makes a fully revolution so if we took 3900/200 its 19.5 rpm in every cycle.

```
myStepper.step(-3900);
```

Controlling DC motors:

First we have to understand that controlling a dc motor with a driver consists of three main wires to the microcontroller which are IN1 IN2 ENABLE.

If IN1 and IN2 are HIGH the motor is stopped.

If IN1 is low and IN2 is HIGH the motor rotates in a clockwise direction and vice versa.

ENABLE controls the speed of the motor via PWM pin.

The code for the motor in charge of the shooting mechanism:

```
//For Clockwise motion , in_1 = High , in_2 = Low
 analogWrite(pwm,190);
digitalWrite(in_1,HIGH) ;
digitalWrite(in_2,LOW) ;
delay(3000);
digitalWrite(in_1,HIGH) ;
digitalWrite(in_2,HIGH) ;
```

The code for the motor in charge of the wheel elevator mechanism:

```
analogWrite(pwm,35);
digitalWrite(in_3,HIGH) ;
digitalWrite(in_4,LOW) ;
delay(3000);
digitalWrite(in_3,HIGH) ;
digitalWrite(in_4,HIGH) ;
```

Sorting :

To do sorting we rely on servo motors that can give specific angles we use them to position balls above color sensor accurately and to change which track the ball goes to based on color detected

```
selector.write(18);
```

we also loops to move steeper in pricis speed as well as angle

```
for( int y=180 ; y> 90; y--){

 continus.write(y);
if(y==180){delay(2000);} // start
 delay(15);
  }
```

color sensor gives different values of red green and blue light and we can compare them to determine color of ball

```
 // pink
if (r>g && r>b )  // sorting
{ selector.write(18);
red=red+1;
}
```

```
//blue
else if(b>g && b>r)
{selector.write(90) ;
blue=blue+1;}
// yellow
else if(g>b || g>r  )
{ selector.write(150);
yellow=yellow+1;}
```

LCD screen and sorting:

We use a LCD screen to display number of balls of each color that is detected

Every time a ball is detected value of a variable that holds number of balls is increased

```
 blue=blue+1;
```

and displayed under the color name

```
lcd.begin(16, 2);
 // Print a message to the LCD.
 lcd.print("Red Yellow Blue");
lcd.setCursor(0, 1)
 lcd.print(red);  lcd.print("   ");  lcd.print(yellow);  lcd.print("     ");  lcd.print(blue);
```

Implementation of all systems:

Our system implementation idea is step by step stages where every stage finishes the next starts, we implemented the ideal delay time between systems by calibration.

We found that delaying time is simpler and more reliable than putting 3 more sensors in the system .

Calibration and Safety Consideration

- **Calibration (integration):**

  The method used into bringing all the mechanisms together is “try and error” method. Where we adjusted position, power, and angles needed for all mechanisms for it to operate correctly.

- **Safety Considerations:**

  As this is a children’s toy, we:

  - Used materials which are soft and safe.
  - Avoided any Sharp edges by chamfering.
  - Grinded all pointed nail ends.
  - Limited visible wires as much as possible by making the base 2 layers of wood to allow all wiring to move underneath.
  - Made boxes for both power supply and electronics to avoid noise and keep it away from reach.

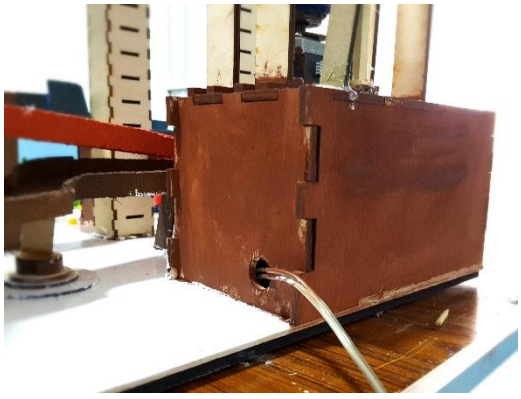


Fig.15-1: Separated power supply box

Fig.15-2: All wires comes from underneath the base and into the electronics box

Costs and Bills

NAME	PRICE	NO, OF	TOTAL COST
SG-90 MICRO SERVO	65	2	130
WOOD	--	--	140
JUMPERS (ALL TYPES)	1	60	60
ARDUINO MEGA 2560 R3	220	1	220
MINI BREADBOARD	12	1	12
3-9 VOLT DC METAL GEARBOX MOTOR	150	2	300
RGB COLOR SENSOR - TCS34725	99	1	99
CORK (4MM)	80	1	80
CORK (3MM)	60	1	60
H BRIDGE L298	55	2	110
SPRAY PAINT	20	5	100
LASER CUTTING	150	--	150
LCD SCREEN 16 CHAR.X2 LINES	35	1	35
SUPER GLUE	2.5	10	25
USED NEMA 17 STERPER MOTOR	15	1	15
PROPS	--	--	100
ACRYLIC PAINT	35	2	70
POWER SUPPLY	110	1	110
		TOTAL	1,816 EGP

Fig.16: bill of materials

Bills available:

Fig.17: bills

Contribution

- **Youssef Khaled Mohamed**

Main Tasks:

- Came up with the general design.
- Mechanisms Manufacturing and Assembly.
- Mechanisms Calibration.
- Wiring passages.
- Team coordination.
- Report.

Side tasks:

- Sketches.
- Decorating for the theme.
- Safety considerations.
- Spiral elevator design and manufacturing.

- **Mohamad Sherif shaaban**

Main Tasks:

- Electrical design and simulation
- Responsible for **coding** stepper motor, dc motors ,sorting function , full system implementation
- Wiring and sorting all systems
- Design of Shooter
- Design of elevator Stand
- Design of sorting
- design of Power supply box
- Code Calibration.

Side tasks:

- Assembly of shooting
- Painting

- **Youssef Ashraf Ahmed Mohamaden**

Main Tasks:

- Pathways Design.
- Manufacturing of pathways
- Implementation of pathways
- Design of circular elevator
- Painting
- Testing final stages
- Decoration of the theme

Side tasks:

- Wiring
- Implementation of circular elevator
- Calibration of mechanical systems
- Documentation

- **Mostafa Ashraf Ebrahim Ali ELFEEL**

Main Tasks:

- Full project 3D Modelling on inventor.
- Pathways Design.
- Manufacturing of pathways.
- Implementing pathways.
- Implementing circular elevator.
- Photographer.
- Testing final stage.

Side tasks:

- Calibration of sorting mechanism.
- Came up with sorting idea (comparing between colors directly rather than using color ranges in if conditions).
- Integrating LCD code with sorting code.
- Software flow chart.

- **Mohamed Sherif Farid**

Main Tasks:

- Color sensor and sorting code
- Calibration of sorting mechanism
- Design of adjustable supports for shooting mechanism
- Design of motor support in shooting mechanism and circular lifter
- Design and manufacturing of cone in sorting

Side tasks:

- Painting
- Documentation
- Finding and acquiring electrical parts

Documentation links

Here is the drive links of all the documents we have made.

- Inventor files
  https://drive.google.com/drive/folders/1FrTpmw0FraUCRafljQq114bz1Z9cbjgx?usp=sharing

- Arduino code
  https://drive.google.com/drive/folders/1scHzKKI9R1HsBMGQeQhna90Tq-H8yCTF?usp=sharing

- Proteus files
  https://drive.google.com/drive/folders/16ooY_BuQNRhmfbX2FgmfHXhDXMu7TFTg?usp=sharing

- Video of project
  https://drive.google.com/drive/folders/1bEXKJVpvYqGoTFXghtoVNARCpgTNY1nO?usp=sharing