
Terrific Two-sdays
PROJECT IT
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Contents

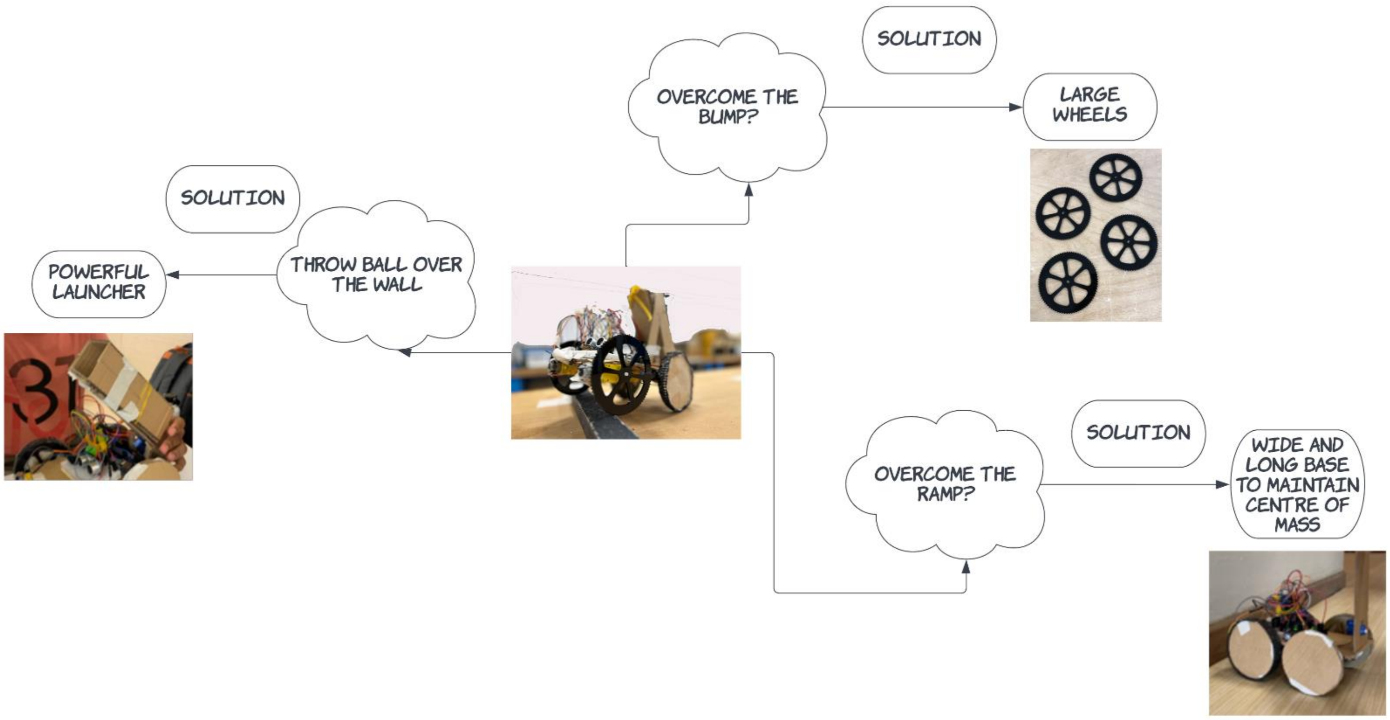
Introduction

Aim of project:

The aim of the project was to design a robot that could successfully traverse an obstacle course consisting of a bump and a ramp, whilst also being capable of releasing a ball over a 30cm wall from minimally 5cm away. The report details the various ideas, structures and procedures that were observed to achieve the required standards.

Prototype requirements:

- The robot must fit within a 30 ×30 ×30 cm cubic at start.
- The robot must be made using only the materials provided.
- The team may not interact with the robot after it leaves the starting area.
- The team may not attach anything to the ping pong ball.
- The robot has up to 30 seconds to complete the course.



DESIGN	CHALLENGES FACED AND LESSONS LEARNT
Design 1 Our first design was a slight augmentation to the template project. Our main objective was to ensure that the robot could pass both the bump and the ramp. To do so, we wanted to ascertain whether an increased wheel size was suitable for overcoming the first two physical obstacles before making further modifications. 1. ***Two additional motors were added to construct a 4-wheeled robot***. 2. The ***diameter of the cardboard wheels was increased*** from 8cm to 10cm.	**Challenges faced:** 1. The robot was ***unable to overcome both the bump and the ramp.*** The uneven design of the wheels caused ***instability*** as shown by the robot's inconsistent path of motion. 2. The wheels also ***could not provide sufficient friction*** to overcome both obstacles. **<u>Lessons learnt</u>** After the first test run, we opted to rebuild the body structure in our next design.
Design 2 Our second design involved a few changes. 1. The ***distance between the wheels was increased.*** *T*o compensate for this increase, the body also required an upgrade in its size. Hence, the base of the robot ***was made larger.*** 2. Upon deciding to create a 4-wheeled robot, we decided to alter the ***shape of the base to a fully rectangular base*** to create more stability for the robot as well as to allow the Arduino board, the breadboard, and the battery to be properly placed within the body of the robot. 3. The ***vertical walls at the sides of the body were also lengthened*** to ensure that the components will not fall out as the robot moves along the obstacle course.	**Challenges faced:** 1. The robot was ***unable to move straight*** due to the hand-crafted wheels which were misaligned and unidentical. 2. The wheels of the robot were ***unable to provide sufficient stability*** due to the weak connections between the robot and the wheels. 3. ***Only the front half of the robot was able to get pass the bump most of the time,*** suggesting that the wheels did not have sufficient grip strength on the bump. 4. The robot was ***unable to move up the ramp,*** due to a lack of friction. **<u>Lessons learnt</u>** In this run, we discovered the need for wheels with greater grip strength on the bump and to cross the ramp. The wheels also needed to have stronger connections to the body to improve the overall stability of the robot.

Design	Challenges and lessons
Design 3 For the entire robot to pass the bump: 1. ***Acrylic wheels with jagged edges*** were made**.** This modification improved the overall performance of the robot in 2 main aspects: Firstly, the jagged edges hooked onto the edges of the bump, allowing the robot to cross the obstacle with ease; Secondly, all 4 acrylic wheels used were dimensioned to the same size - eliminating the possibility of the robot drifting off-course because of inconsistent wheel dimensions. 2. ***Replaced motor couplers*** which functioned as the contact point between the gear motors and cardboard wheels with ***identically shaped holes within the acrylic wheels*** themselves – reducing the number of contact points between the wheel and the motor and hence increasing stability.	**Challenges faced:** 1. The robot started moving straighter than it did before and successfully cleared the bump for all runs but was ***not able to travel up the ramp.*** As acrylic is a smooth surface and the edges of the wheels were jagged (reducing the surface area of contact), there was insufficient friction between the wheels and the ramp. **<u>Lessons learnt</u>** We rooted out that either of these 2 modifications had to be made: increasing friction between the wheels and the ground (by thickening the wheels or changing to a rougher material) or increasing the size of the wheels (so that the robot travels less distance before reaching the top of the ramp).
Design 4 Learning from prior prototypes we changed: 1. The ***base of the robot,*** making it a basic rectangle with no raised edges (10cm by 15cm) such that it could fit our launcher and the Arduino board. 2. ***Adding ice cream sticks in between the adjacent motors*** such that it stabilised the entire robot further and kept the wheels parallel so that the car could travel in a straight line. 3. Utilising the concept of a slingshot, we ***included a round cannon launcher*** with a slit attached to a rubber band such that the tension in the rubber band was sufficient to launch the ping-pong ball over the wall. We decided on a ***launcher instead of a catapult*** to shoot the ping pong ball over the 30cm wall since there was better aiming and force applied to project it over the wall.	**Challenges faced:** 1. While testing the rubber band and launcher manually, there was sufficient tension to propel the ball over the 30cm wall. However, the ***tension in the rubber band was too great for the servo arm to support*** causing the rubber band and hence the ball to be launched prematurely. 2. The ***high tension in the rubber band caused the shape of the round cannon launcher to be deformed*** when the rubber band is stretched, affecting the performance of the launcher to release the ball. 3. There was still ***insufficient friction on the four wheels***, hence although the car could travel past the block, it could not go over the ramp. **<u>Lessons learnt</u>** From this run, we understood that we had to build a base with a stronger support for the servo. We inferred that we had to increase the friction on the wheels and the distance between the front and back wheels so that the robot could make it across the ramp easily.

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Design 5
Our fifth design involved a few changes:

We increased the distance between the front and back wheels by lengthening the base. We used a base of dimensions 11cm by 20cm.
Since there was little friction on the back wheels, the wheels were made thicker by overlapping 2 layers of cardboard on the existing acrylic wheels. The anti-slip mat was added along the circumference of the wheels to increase friction further.
To reduce the deformity of the launcher when the rubber band is stretched over it, we changed it to a cuboid-shaped launcher.

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Challenges faced:

After running the prototype on the course, we realised that the left back motor was defective. This caused a power imbalance on both sides of the robot, making it unable to travel straight.
The newly improved launcher system still did not successfully launch the ball due to structural instability. The launcher still became deformed by the large amount of strain on the cardboard shell from a single whole rubber band.

<u>Lessons learnt</u>
After this run, we changed the defective motor. We have found the need to further strengthen the launcher structure such that it would not deform when a large tension is applied to it. We also aim to reduce the tension in the rubber band, such that it would not cause the launcher to be deformed, yet still have enough tension to propel the ball over the wall.
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Design 6
In our final design:

Switching the faulty motor for a new one.
Upgraded the launcher for our ping-pong ball. In the new design of the launcher, we changed its shape from a 4-sided box that encapsulates the ball to a 3-sided case with reinforced sides that hugs the ball. This is to improve structural stability.
Changed the launching mechanism from one full rubber band system to a sling system which comprises two rubber bands attached to each other. This helped to reduce the strain on the cardboard box while ensuring that the power and efficiency of the launcher were not hindered. These changes removed the deformity in the launcher when the rubber band is stretched.

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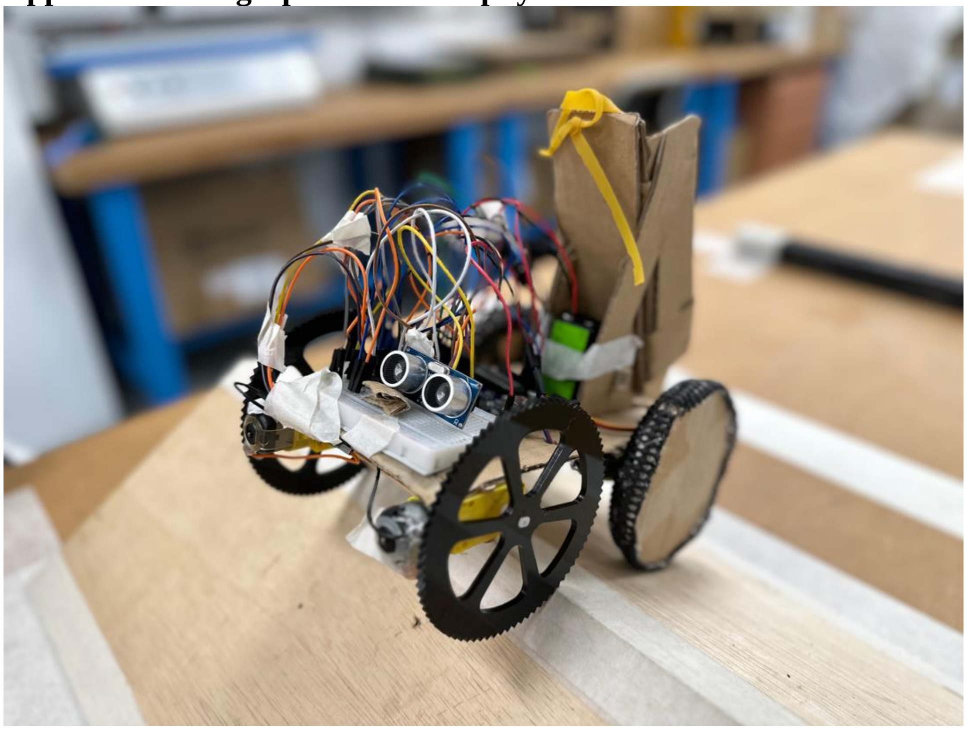
<u>Conclusion:</u>

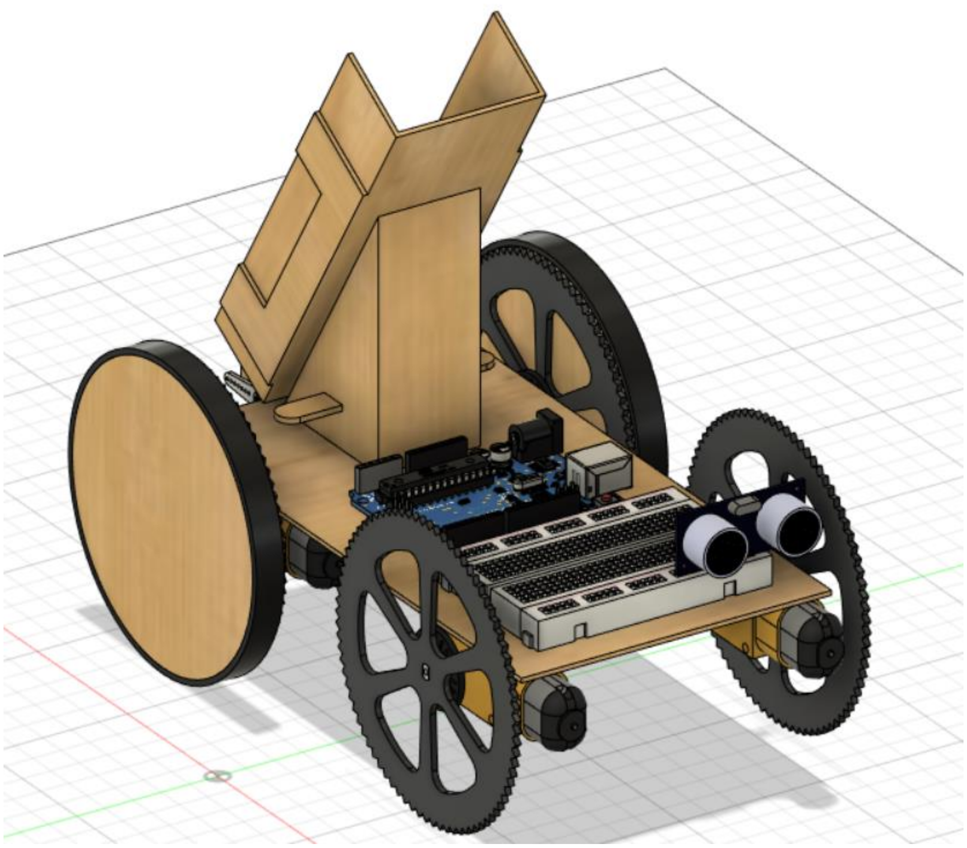
As seen from the report above, our team has gone through the steps of prototyping systematically. Upon realising the failure of a model, we sketched out our new idea, modified the current model and kept repeating this process until the robot successfully completed the task at hand. The final prototype handles the challenges faced by every prototype before it accurately, allowing it to complete the course while attaining all ten requirements needed for a successful run.

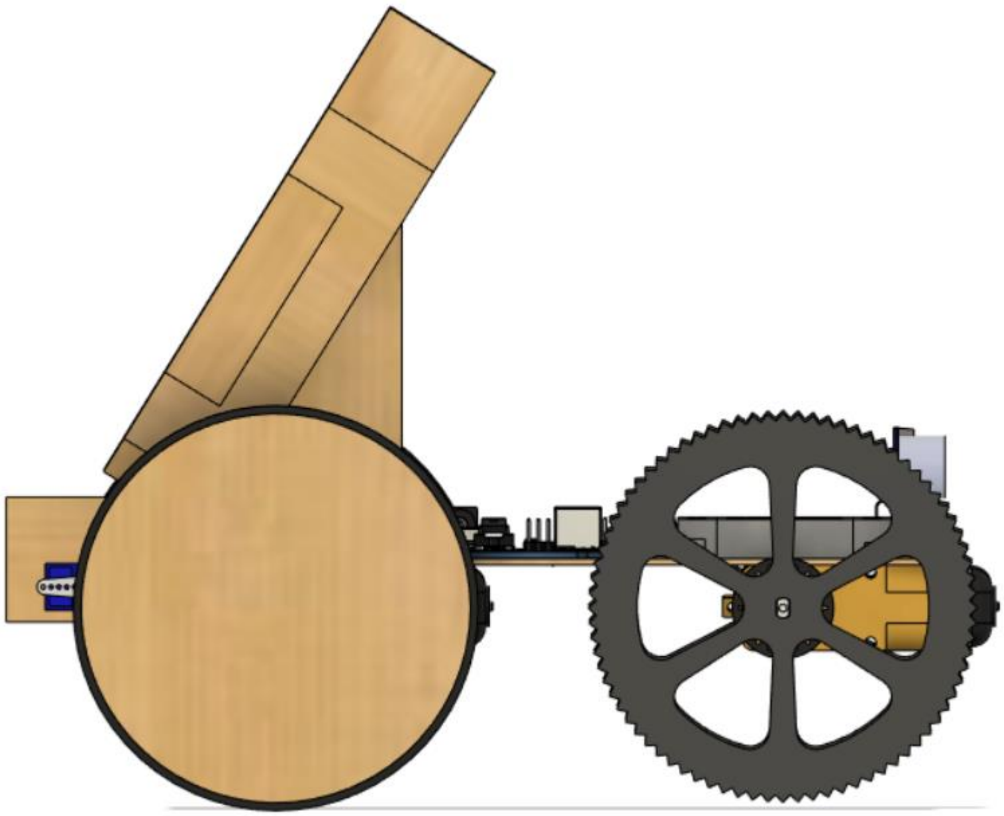
Appendix

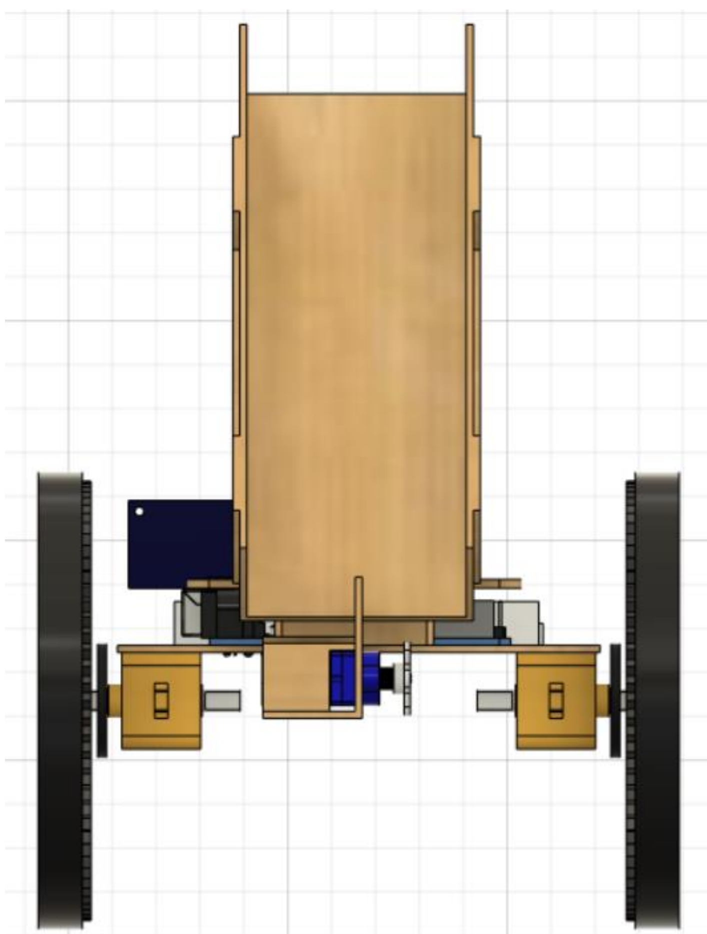
Appendix: Photograph of the final physical robot



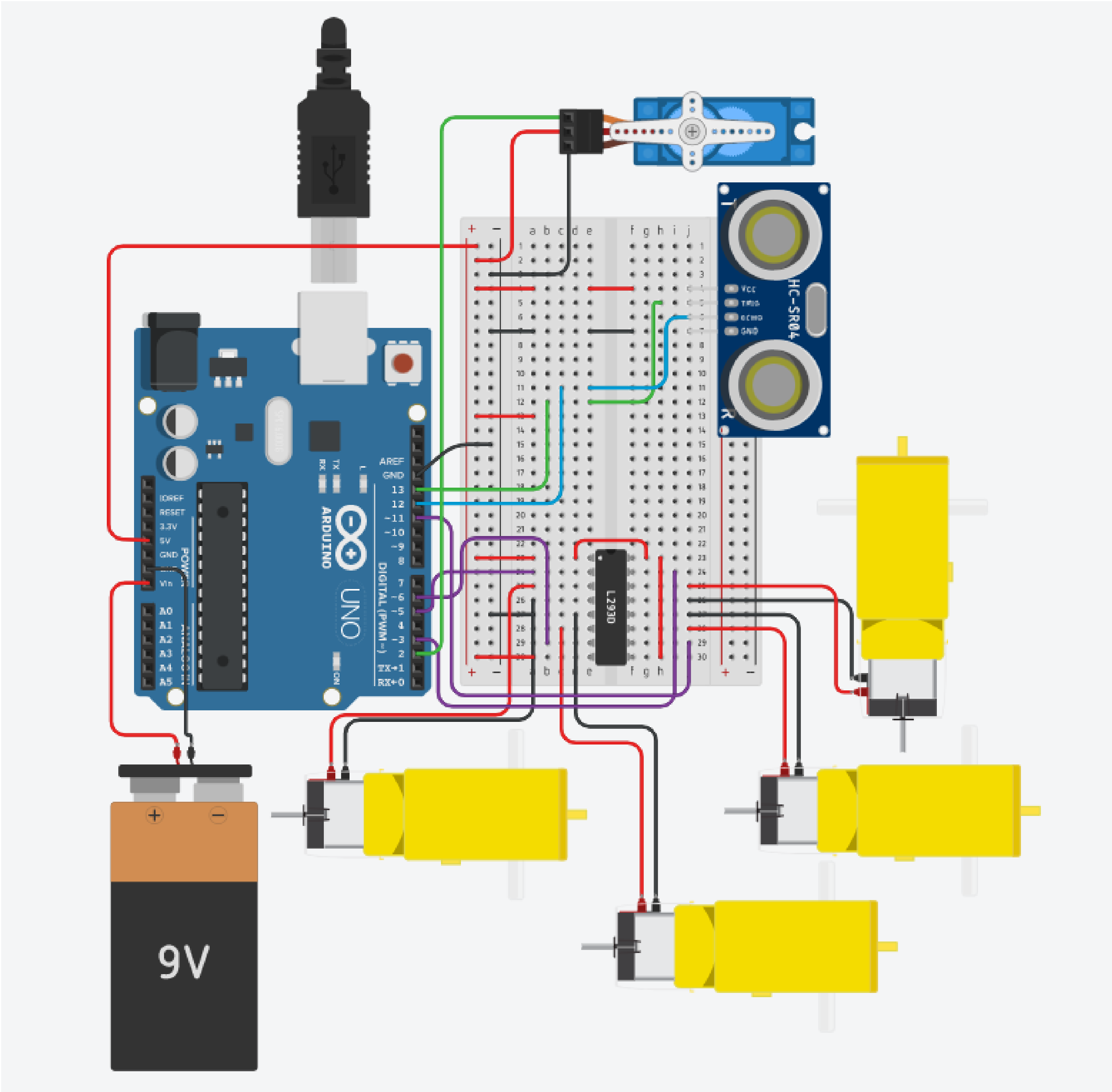
Appendix: CAD rendering of a model for the final design







Appendix: Tinker CAD diagram of circuitry of the final design



Appendix: Arduino source code deployed on the final design

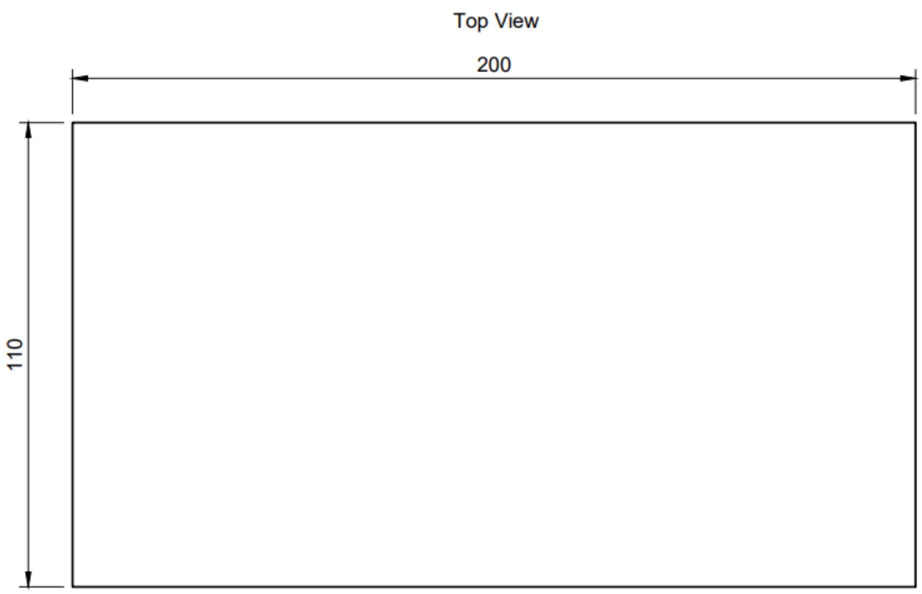
```
#include <Servo.h>
Servo myservo;
int SERVO_PIN = 2;              // Pin for servo on Arduino
int pos;                        // Angle for servo
int TRIG_PIN = 13;              // Pin for TRIG pin of Ultrasonic Distance sensor on Arduino
int ECHO_PIN = 12;              // Pin for ECHO pin of Ultrasonic Distance sensor on Arduino
int MOTOR_PIN1 = 6;             // Pin for motor 1 on Arduino
int MOTOR_PIN2 = 5;             // Pin for motor 2 on Arduino
int MOTOR_PIN3 = 11;            // Pin for motor 3 on Arduino
int MOTOR_PIN4 = 3;             // Pin for motor 4 on Arduino
float SPEED_OF_SOUND = 0.0345;  // Used for calculating distance away from Ultrasonic Distance Sensor
void setup() {
  pinMode(MOTOR_PIN1, OUTPUT);  // Pin mode for motor 1
  pinMode(MOTOR_PIN2, OUTPUT);  // Pin mode for motor 2
  pinMode(MOTOR_PIN3, OUTPUT);  // Pin mode for motor 3
  pinMode(MOTOR_PIN4, OUTPUT);  // Pin mode for motor 4
  pinMode(TRIG_PIN, OUTPUT);    // Pin mode for TRIG on Ultrasonic Distance sensor
  digitalWrite(TRIG_PIN, LOW);  // Switches Ultrasonic Distance sensor's TRIG off
  pinMode(ECHO_PIN, INPUT);     // Pin mode for ECHO on Ultrasonic Distance sensor
  Serial.begin(9600);           // Initialize serial communication
  myservo.attach(SERVO_PIN);    // Attaches servo to corresponding pin on Arduino
}
void loop() {
  digitalWrite(TRIG_PIN, HIGH);               // Activate Ultrasonic Distance sensor
  delayMicroseconds(10);                      // for 10 microseconds
  digitalWrite(TRIG_PIN, LOW);                // Turns off Ultrasonic Distance sensor
  int microsecs = pulseIn(ECHO_PIN, HIGH);    // Measures duration of pulse
  float cms = microsecs*SPEED_OF_SOUND/2;     // Calculates distance of obstacle from Ultrasonic Distance sensor
  Serial.println(cms);                        // Prints distance measured in the serial monitor
  if (cms >= 8)                               // All motors run when distance from Ultrasonic Distance sensor >= 8cm
  {
    digitalWrite(MOTOR_PIN1, HIGH);
    digitalWrite(MOTOR_PIN2, HIGH);
    digitalWrite(MOTOR_PIN3, HIGH);
    digitalWrite(MOTOR_PIN4, HIGH);
  }
  else                                        // All motors stop when distance from Ultrasonic Distance sensor < 8cm
  {
    digitalWrite(MOTOR_PIN1, LOW);
    digitalWrite(MOTOR_PIN2, LOW);
    digitalWrite(MOTOR_PIN3, LOW);
    digitalWrite(MOTOR_PIN4, LOW);
    delay(1000);

    for (pos = 0; pos <= 180; pos += 1) {     // Rotate servo by 180 degrees
      myservo.write(pos);
      delay(10);
    }
    for (pos = 180; pos >= 0; pos -= 1) {     // Rotate servo back to original position
      myservo.write(pos);
      delay(10);
    }
  }
  delay(5);
}
```

Appendix: Fully dimensioned 2D CAD drawing of final design (all parts)

- for each structural component made from sheet material used in the final design, depicting how it was cut. For each part, include the material used (acrylic, cardboard, polypropylene, foam core, or paper).

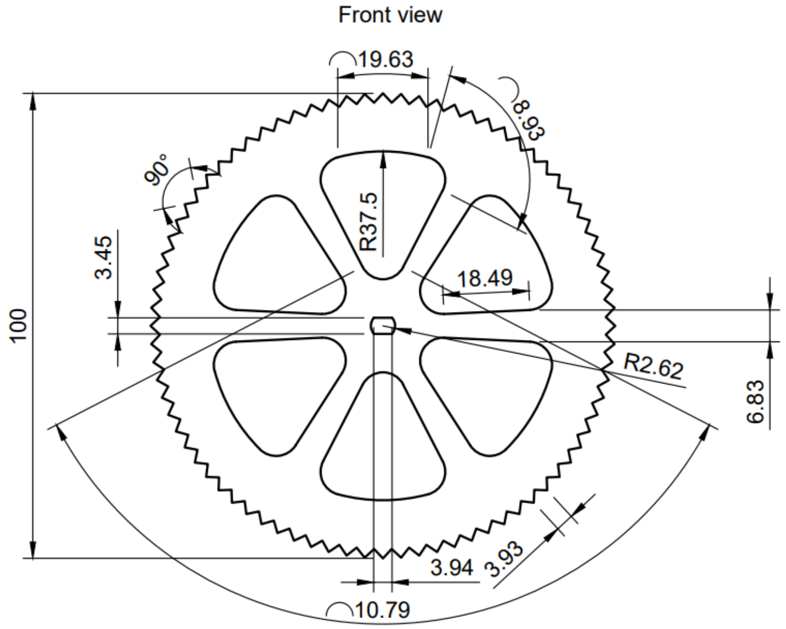
<u>Base:</u>

Materials Used: Cardboard



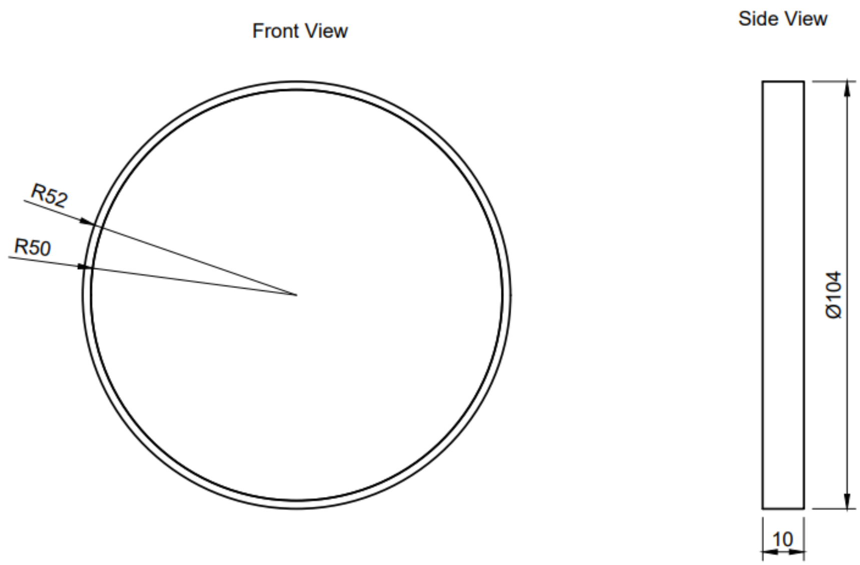
Wheel:

Materials Used: 3mm thick Acrylic



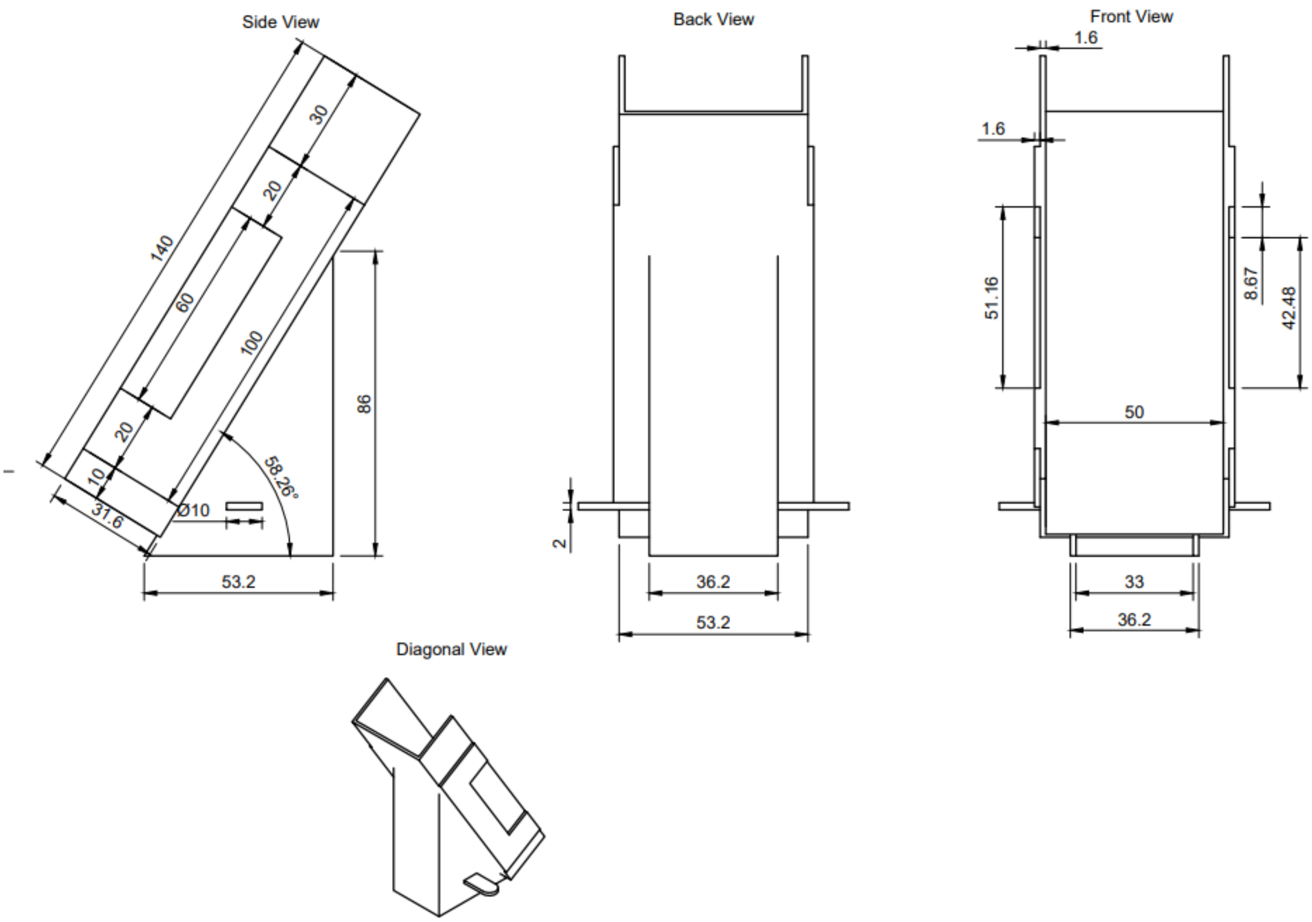
Back Wheel:

Materials Used: Cardboard, Anti-slip mat sheet



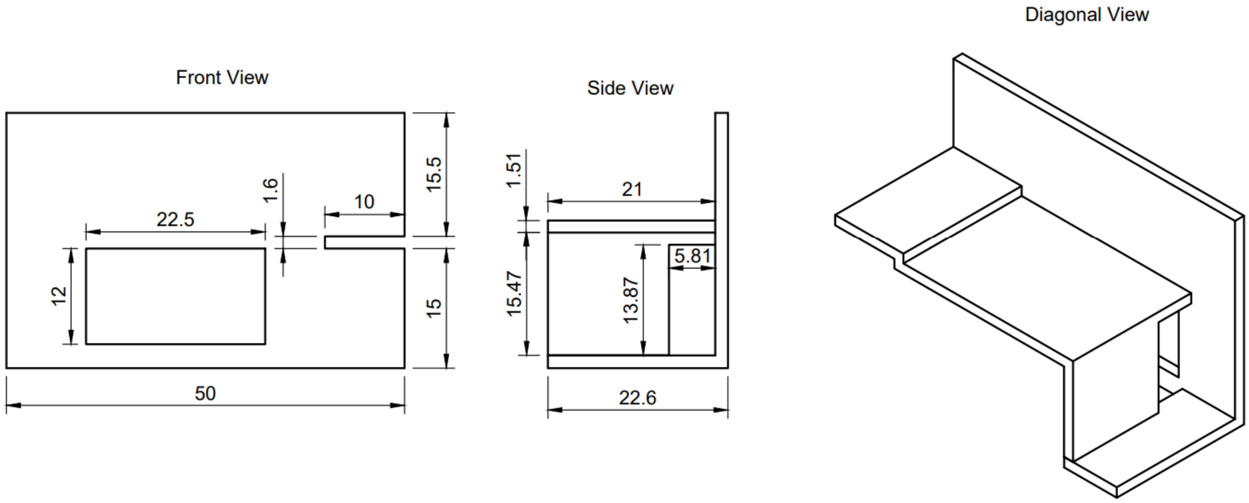
Launcher:

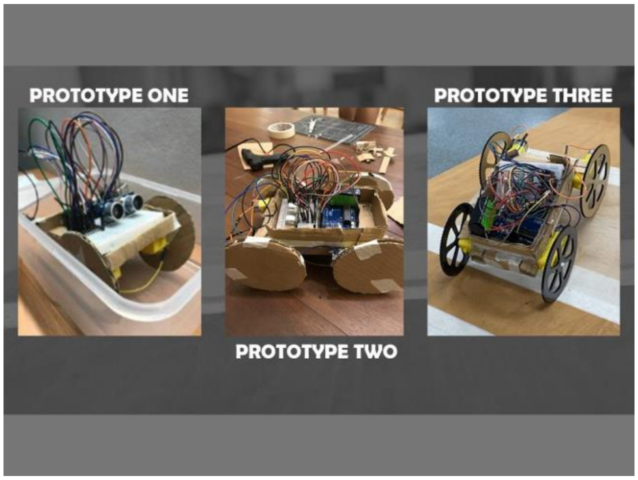
Materials Used: Cardboard, Ice cream stick



<u>Servo Holder:</u>

Materials Used: Cardboard





Prototype Images: 1, 2, 3

Prototype Images: 4, 5, 6