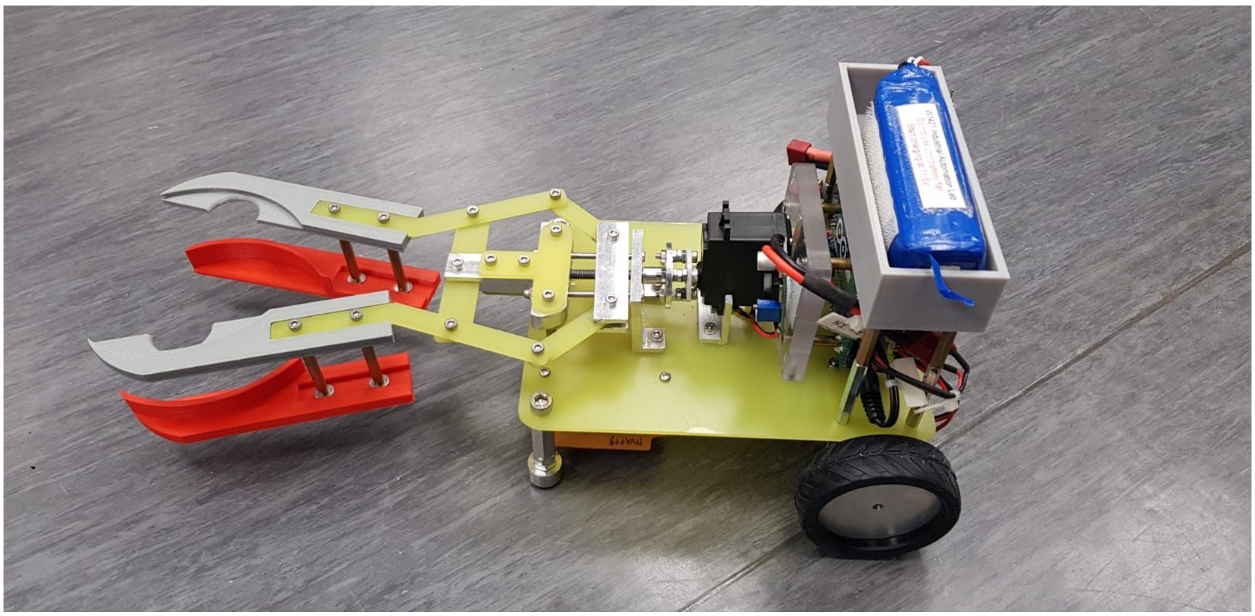
SINGAPORE POLYTECHNIC

SCHOOL OF MECHANICAL AND AERONAUTICAL

DIPLOMA IN MECHATRONICS AND ROBOTICS



Design and Fabrication
ME2023

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Low Zhong Sheng 1850839
Samuel Wong 1850800
Matthew James 1850925
Tan Jun Yin 1850855

Year of Study: 2019

Project Supervisor: Mr Foo

ABSTRACT

The goal of our project is to create automated guided vehicle that uses a line tracking program. Using four sets infrared sensors located at the bottom of the vehicle, to determine its location on the line.

If the vehicle senses it's off the line, it will make necessary changes to realign itself to the center (opAll == b1001).

Once the sensor detects the end of the line(opAll == b000), it will activate a continuous servo motor, to open its claw and pick the ball up by closing its mechanism. It will then continue its line tracking program to the desired location.

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1.1 ACKNOWLEDGEMENT

This project has been the most difficult assignment by far to complete but at the same time the most fruitful one as we have learnt a lot of things that were not taught during the lesson.

We would like to Thank Mr Foo for his recommendations and his resources. Mr. Foo thank you for kindly providing us with materials to make this project a reality, and for guiding us in theory and helping us find design problems and how to solve them. Mr.Foo has always been supportive of trying new ideas. We would like to thank Mr. Foo for his unrelentless support.

We would like to thank all the teachers for guiding us and giving us advice especially Mr. Tan. Although he was busy with his classes, he still made some time for us to discuss our progress as well as the problems we faced. Mr.Tan has always been very patient with us. During the designing phase,

This project will only be an idea without the help of our teachers. We are blessed to have such caring and awesome teachers.

1.2 INTRODUCTION

In many fractory lines, Auto guided vehicles are used to transport items from location from place to place,they are most often used in industrial applications to transport heavy materials around a large industrial building, such as a factory or warehouse. There are many types of AGV, that uses a different kind of tracking system.

Application of the automatic guided vehicle has broadened during the late 20th century. From location tracking to line tracking. Companies invest in such machinery as it is able to deal with heavy loads at a better consistency compared to human labour.AGVs are also employed in nearly every industry, including pulp, paper, metals, newspaper, and general manufacturing. Transporting materials such as food, linen or medicine in hospitals is also done.

This project allows us to understand how AGV manufacturer have to plan and design their product to fit the consumer needs. They have to plan the material, manufacturing process and maintenance in order to keep their product competitive and easy to maintain.

Therefore our goal is to create an automated guided vehicle project to pick and place plastic balls and integrate it with the line tracking program to follow a pre planned route.

1.3 OBJECTIVE

This project aims to equip us with the knowledge and skills to design and construct a simple Automated Guided Vehicle (AGV) that integrates the mechanical, electrical, electronics and programming into a working product.

In the process of designing, building and fabricating the product, we will be able to integrate knowledge of mechanical system design, computer aided design (CAD), basic electrical and electronics learnt in other modules.

Various aspects of personal and interpersonal skills such as teamwork, communications, as well as managing learning are systematically infused in carrying out the design-fabricate project.

1.4 SCOPE OF PROJECT

The automated guided vehicle project consists of two aspects, a mechanical aspect and an electrical cum programming aspect.

Mechanical Aspect
To design and fabricate a mechanism that is able to fulfill a pick and place function

Electrical cum Programming Aspect
To integrate the vehicle and gripper to perform line tracking with pick and place task.

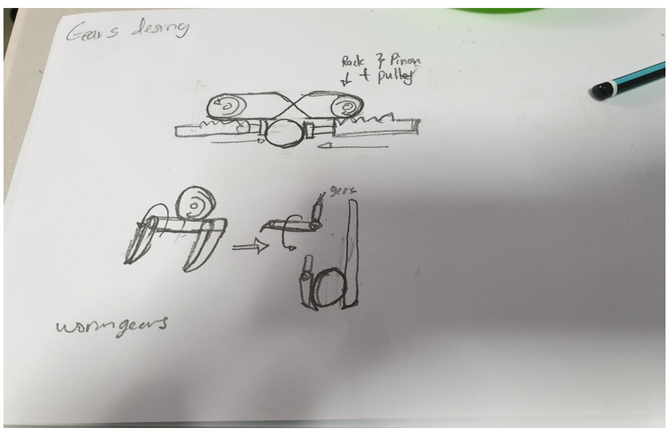
1.5 Project Details

Week 1-3(Mechanism design)

We did intensive research on different mechanical mechanism. Mechanical mechanism is a kinematic chain arrangement which may be used to transmit motion, force or power. We used inventor to test if our ideas could work or not.

- **Gear based design**

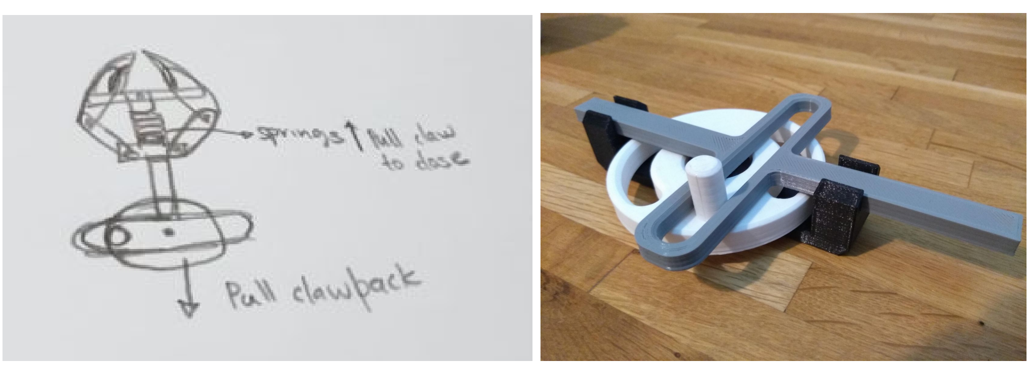
  A toothed wheel that works with others to alter the relation between the speed of a driving mechanism.
  - Rack and pinion is a denoting mechanism (e.g. for a car steering system) using a fixed cogged or toothed bar or rail engaging with a smaller cog.
  - Worm gears are a mechanical arrangement consisting of a toothed wheel worked by a short revolving cylinder (worm) bearing a screw thread.
  - Spur gear is a gear wheel with teeth projecting parallel to the wheel's axis.



[Fig.5 Two different gear setup] [Fig.6 Spur gears]

- **Scotch yoke design**

  The Scotch Yoke (also known as slotted link mechanism) is a reciprocating motion mechanism, converting the linear motion of a slider into rotational motion, or vice versa.

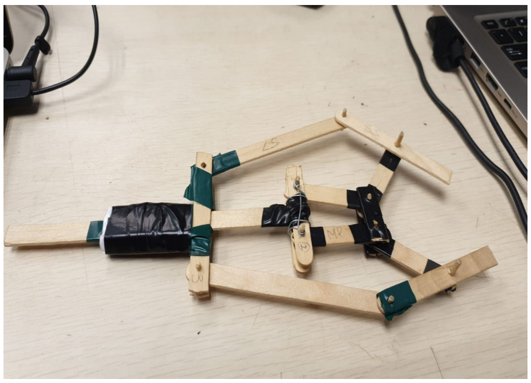


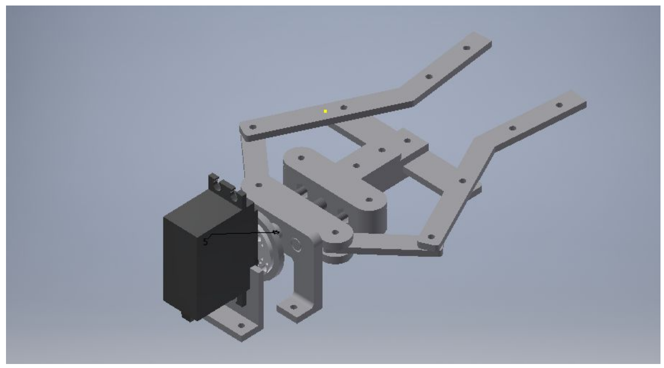
[Fig.7 Scotch yoke]

Lead screw design

A leadscrew (or lead screw), also known as a power screwor translation screw is a screw used as a linkage in a machine, to translate turning motion into linear motion.

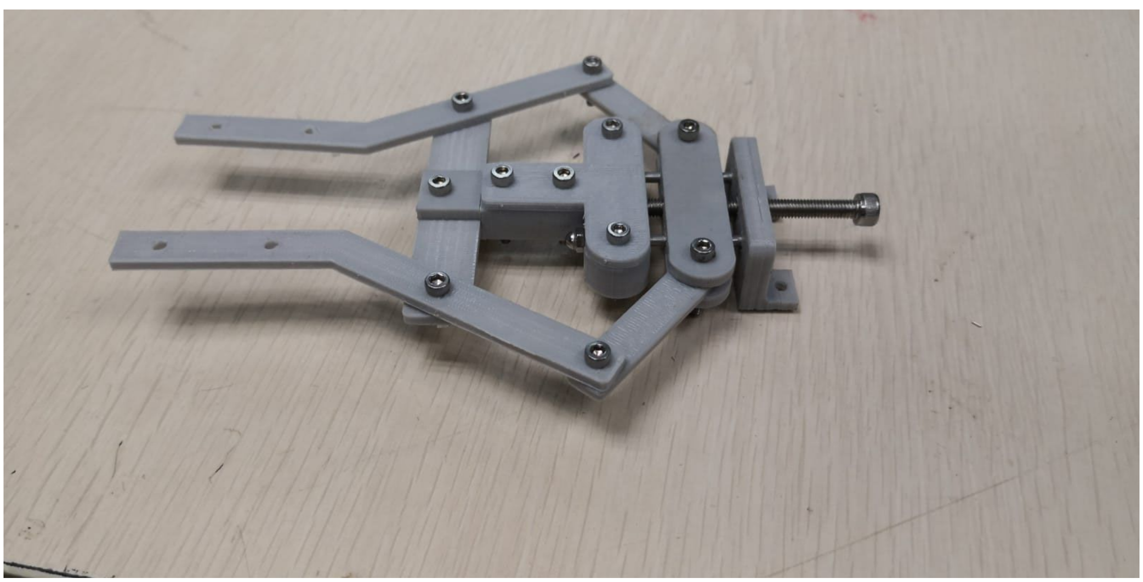
We decided to go with the lead screw design as the design allows our claw to move forward before clamping the ball. We used inventor to assemble the claw with dimension. After which using ice-cream sticks we made our first prototype.





[Fig.8 First Prototype]

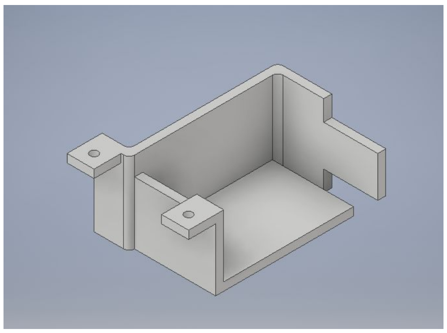
We redesign some parts of the mechanism to reduce the play in the mechanism. Some of our previous design can be seen in the appendix.



[Fig 9 Mechanism Prototype 2]

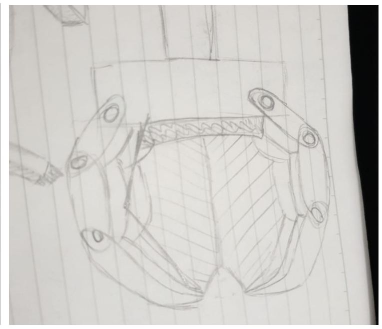
Week 4-5(designing the claw phase)

During the first week, our project supervisor gave us a recap on the skills we have learned from our first semester. He gave us tips and insights on how we can design our claw. We all went home and designed our very own claw, and pitched our ideas on the following lessons.



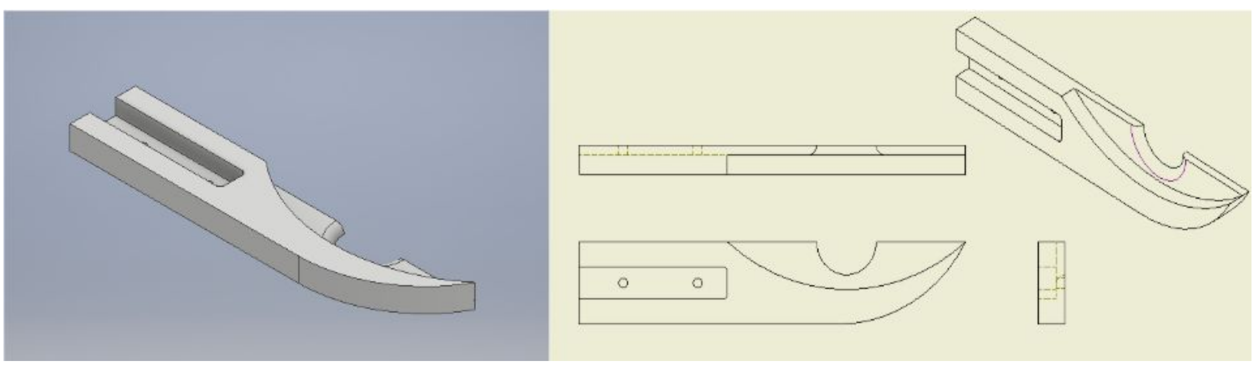
[Fig.1 Sheet metal]

[Fig.2 Routing]



[Fig.3 3D printed]

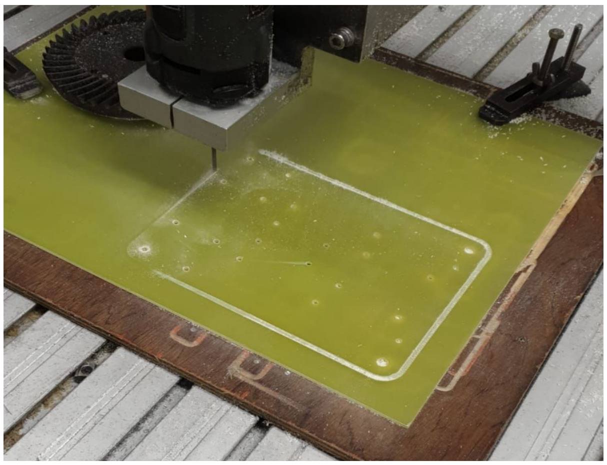
We had many types of design, each have different ways to fabricate. Some required bending, others 3D printing. We finally decided to go with a design inspired by a Leafcutter ant, this insect have a claw like pincers that allow them to lift up objects. We created a 3D rendering of the claw.



[Fig.4 Claw version 1]

Week 8-10 (3D printing, Routing, Circuit making)
Using inventor we draw out the parts we needed. We converted the parts from .IPT to .STL parts. Using a MakerBot Replicator 18, we printed parts that might need changing. Parts that we knew that didn't need changing, we route them out.

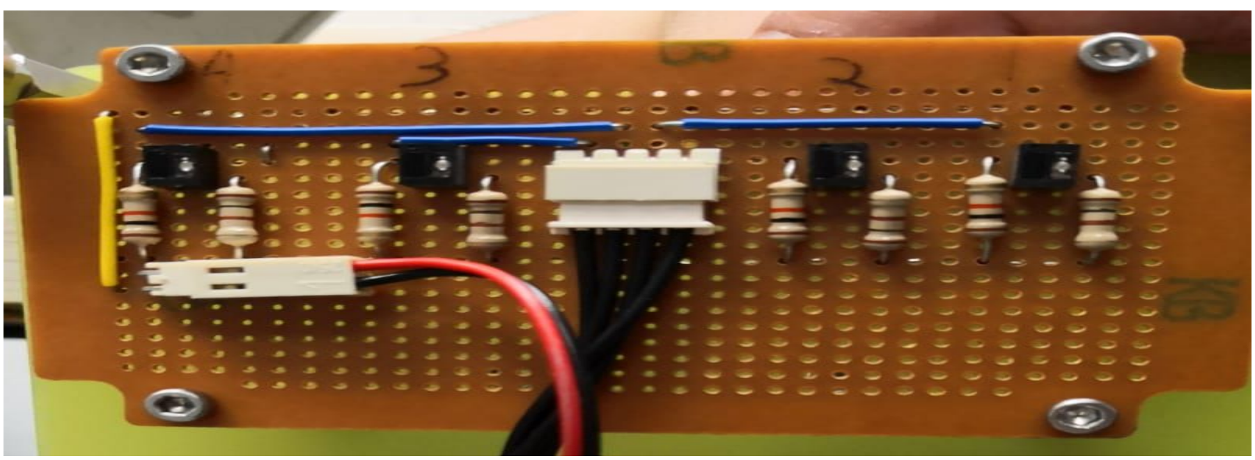
Routing requires more time, however it provides us with stronger and more durable parts. We used Inventor HS to program our NC codes.



[Fig.10 Routing Base plate]

[Fig.11 Routing Motor plates]

We followed the tutorial provided and design our sensors. Matthew soldered on the parts. While soldering, we encountered some problems, one of the IR sensors was placed incorrectly. With the help of Mr Tan, we learnt how to desolder and resolder the broken joint.



[Fig.12 Circuit for sensors]

Week 11-15 (Lathing and Milling)

Turning

Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix toolpath by moving more or less linearly while the workpiece rotates. Mr Foo gave us certain recommendations to ease the fabrication process.

Challenges faced (turning):

- Overheating of the cutter or workpiece.

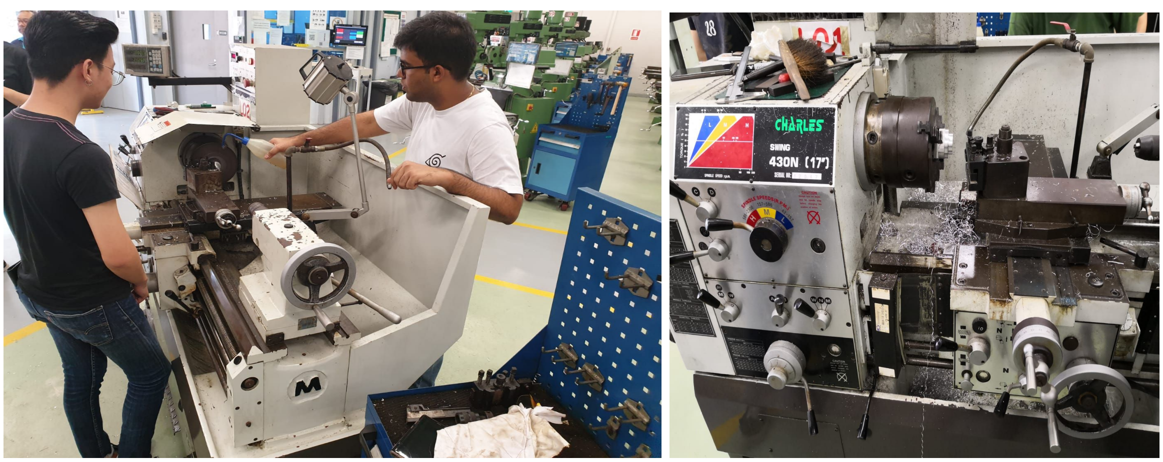
We would make an effort to use the coolant every now and then to make sure we did not overheat the workpiece or tool.

- Tool wear & tear

There were a few occasions where turning of the workpiece did not go as planned due to the insert that were worn off.

- Continuous chip

Continuous chips are dangerous and can be hazardous.As it tends to tangle around the tool holder and the workpiece obstructing the turning process. This can be countered by changing parameters such as cutting speed, feed and depth of cut.



[Fig.13 Wheel turning]

Milling
Milling is a machine tool that uses a rotating cutter (milling cutter) to produce a plane or form surfaces on a workpiece, usually by moving the workpiece past the cutter.

Challenges faced (milling):

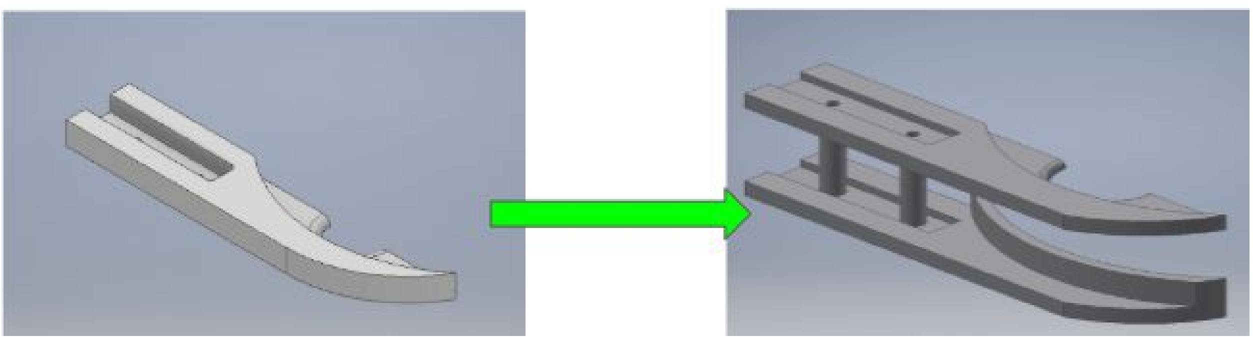
- Clamping of workpiece
  Clamping the workpiece is a challenge as the workpiece we were milling are small
- Orientation of clamping
  The orientation to clamp the Workpiece is also a challenge as we needed to have enough material left to clamp
- Milling a slot
  Milling a slot is difficult as the slot needed is very small and we were doing both upcut and downcut together this causes the cutter to break easily so we needed to be slow and careful to prevent breaking the cutter.
- Accurate dimensions
  Getting the accurate dimensions is tough as the tools and the machine may not be very accurate.

[Fig.14 MIlling]

Week 12-16 (Prototyping, Assembling, refabrication and programming)
We 3D printed parts before going to the workshop to mill or turn out the workpiece to test our ideas. When we assemble the 3D printed parts together we realised we needed guides so the parts move forward properly and we needed support for the claw to hold the weight of the claw and secure it to the base plate.

During assembling, we used the new parts that we fabricated to reassemble the claw but some of the parts are not in accurate dimensions like the holes in the parts due to human error so we refabricate parts that are out of dimensions as the alignment of the holes goes through 3 different workpieces and it is important that the holes in the pieces are aligned with each other. If the alignment of the holes is not straight it can cause the whole claw to jam or not be smooth.

During the refabrication, certain parts needed refabrication to increase efficiency and durability. For example the claw design was changed to grip the ball better. Others required minimal changes to fix the problem.

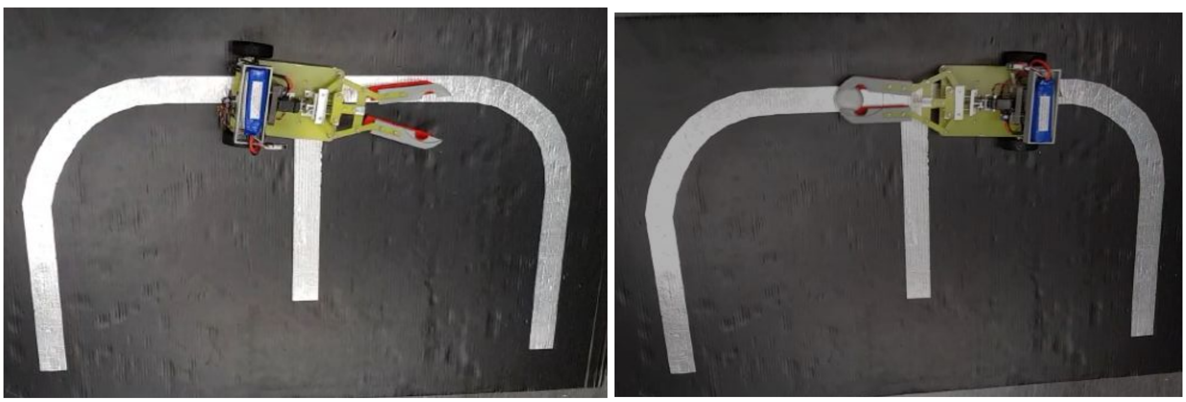


[Fig.15 New claw design]

We used the tutorials provided on blackboard to learn how to start programming the code. Mr Tan guided us step by step to learn the proper way to test our program. This is proven useful as we are able to learn how and what to change the code to fit our needs.

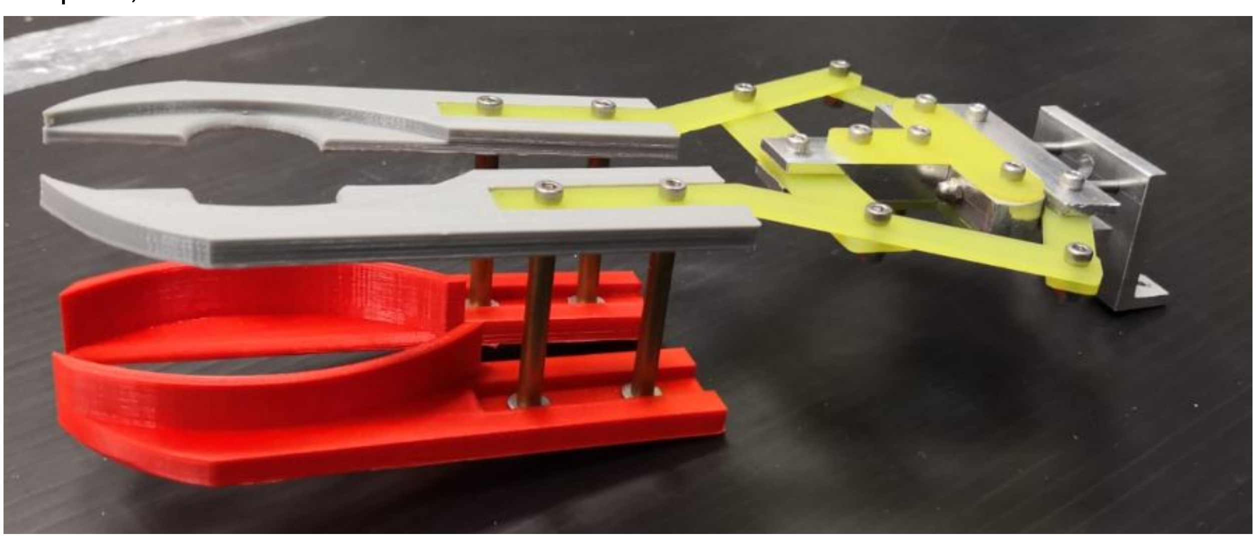
Week 16-17(Program testing and Final assembly)
The final program had two major problems. Firstly the robot kept skipping the middle strip. In order to overcome that problem, we implement a counter, when (opAll==b0000), the counter adds itself. When the sensor detects (opAll==b0000) again, the car will turn a certain angle towards the middle stip. This enables the robot to complete its route.

The second problem was that the during the counter checking, if (opAll==b1001), the robot will just go straight and bypass the middle stip. We changed the turning speed to make the robot swing from side to side more often. This reduces the chance of encountering this bug.



[Fig. 16 Car going through desired route]

After weeks of fabrication and hard work we finally got all the pieces of the puzzle. We did a final assembly with all the newly fabrications and alteration. The robot was complete, and was able to run the desired route.



[Fig.17 Updated claw design]

1.6 Conclusion

The project is a good platform to hone our skills, both in mechanical design and programming. During our idea generation we had many big ideas, however during the drawing process and fabrication we discover that, not all ideas can work. We had to tweak our design to enable the design to be fabricated. This helps reinforce what we had learnt in our year one. Mr Foo gave us many recommendations on how to improve our design in terms of feasibility and machinability.

Our programming journey, help us to build on our problem solving skills. We had to understand the code in order to change it accordingly to what we need. We struggled in the beginning as we didn't have the sensor board. We had to precode the robot without being able to test on our robot. We took this time to understand the code better and ask our classmates how they program their robot. This gave us a good foundation and we are able to program our robot in a short amount of time.

This project also enable us to learn how to work as a group. When having to execute the fabrication process, we often struggle to delicate jobs, as some of us are not familiar with the processes and machines. We had to take time to explain how to use the machines, however it is worthwhile as it enables us to have a smoother fabrication process in the future.

1.7 Reference

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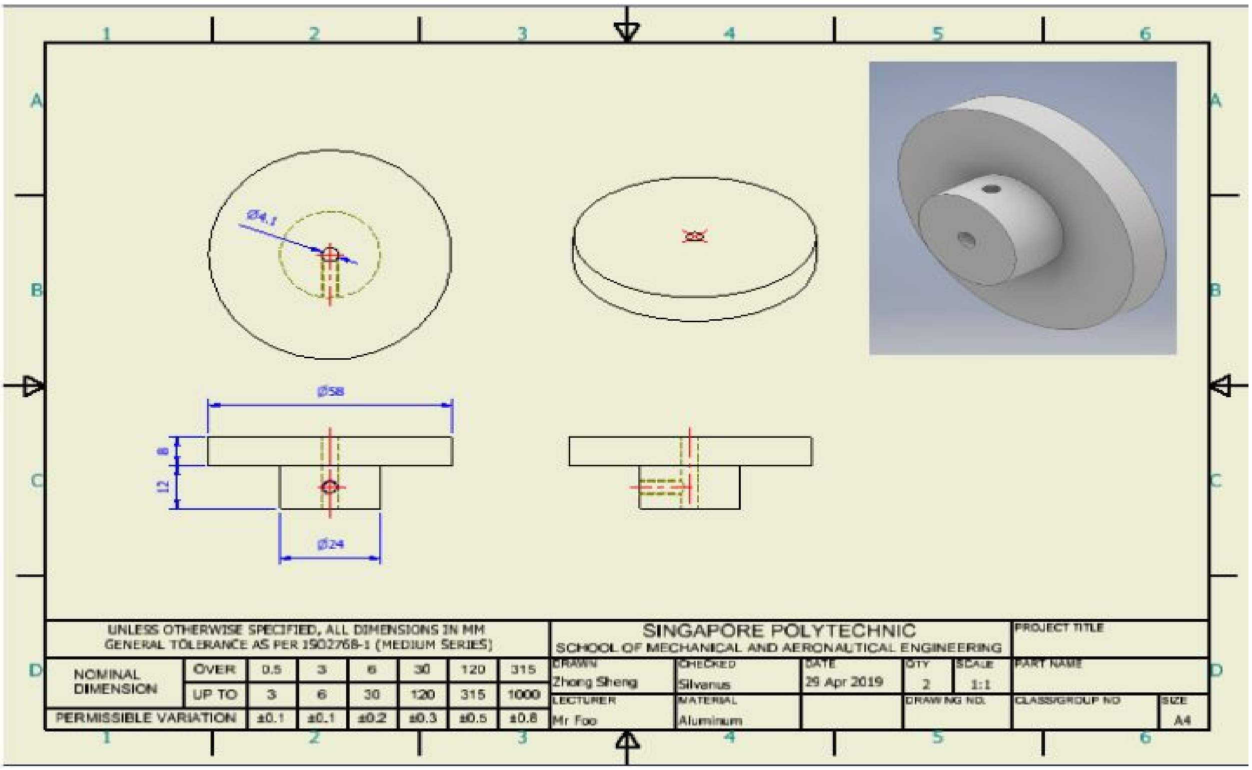
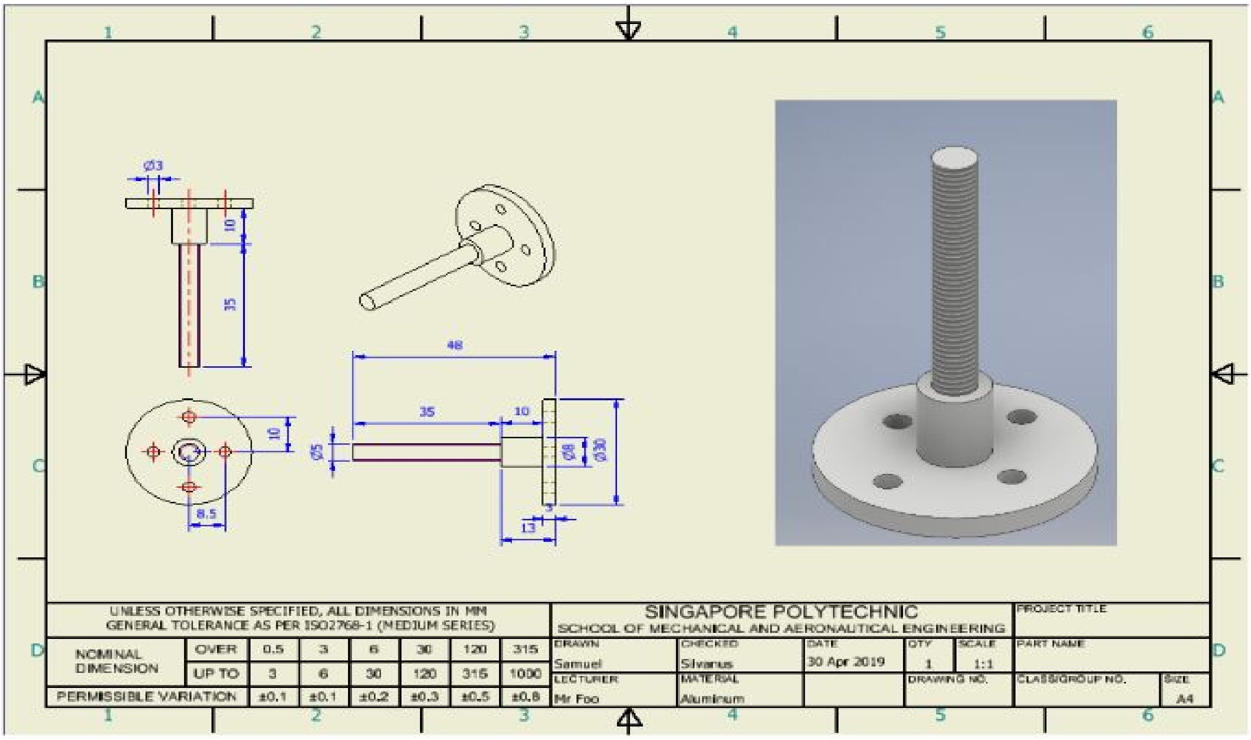
1.8 Appendix

This section includes the drawing used in this project and other designs.

1.8.1 Drawings

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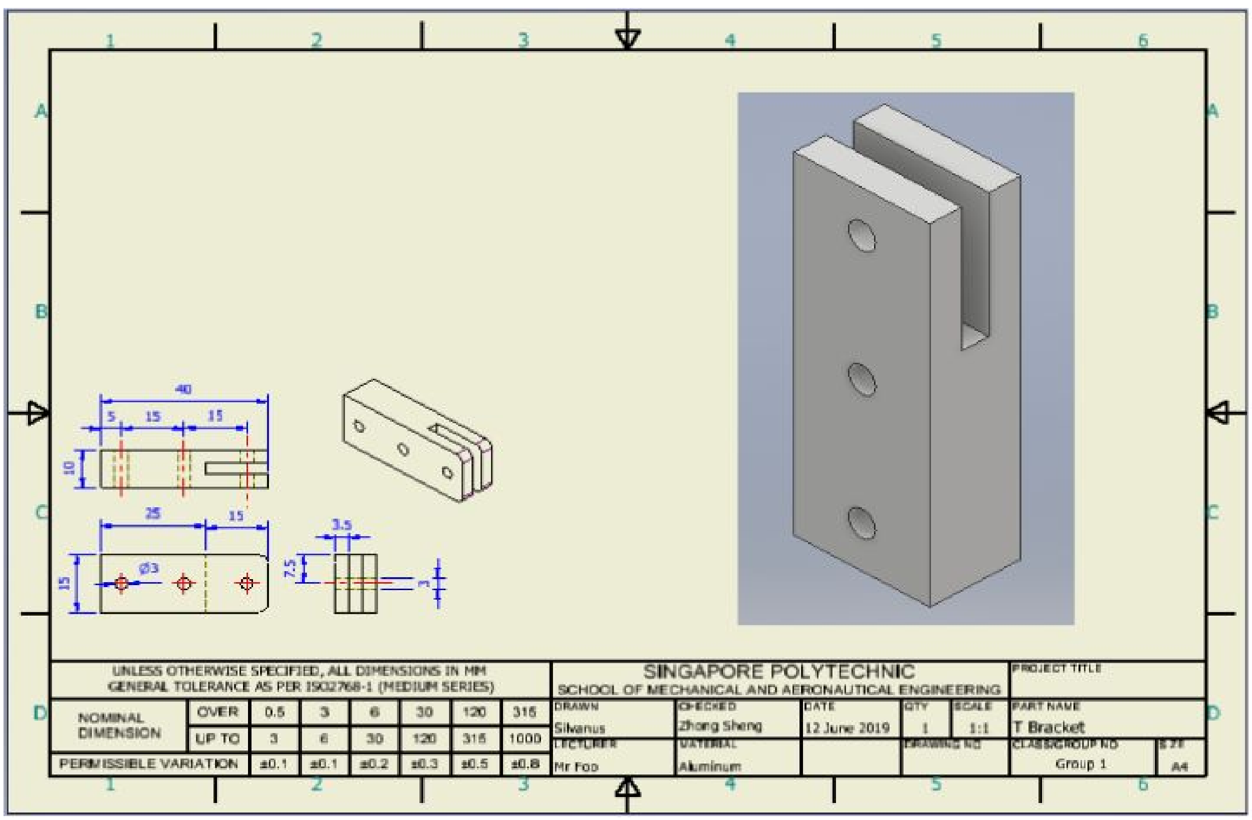
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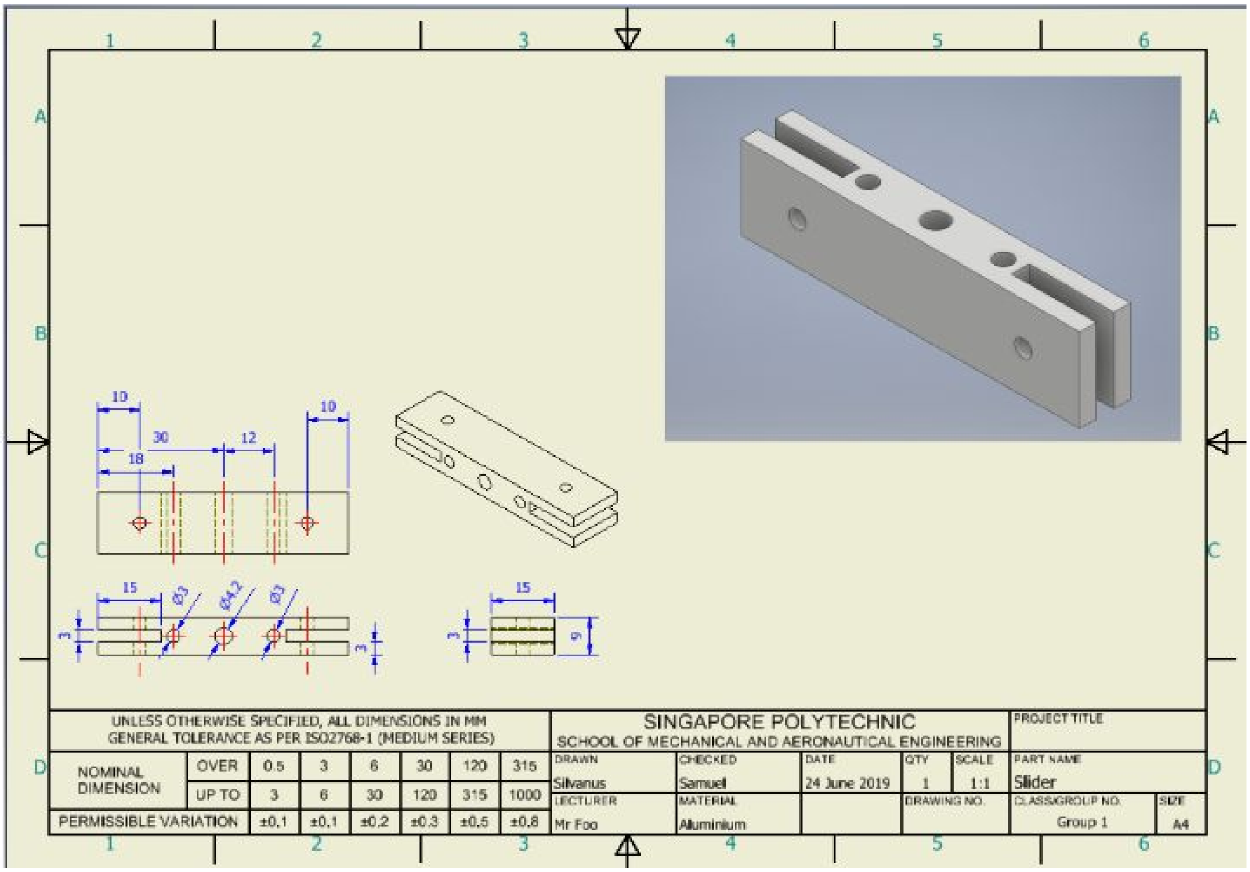
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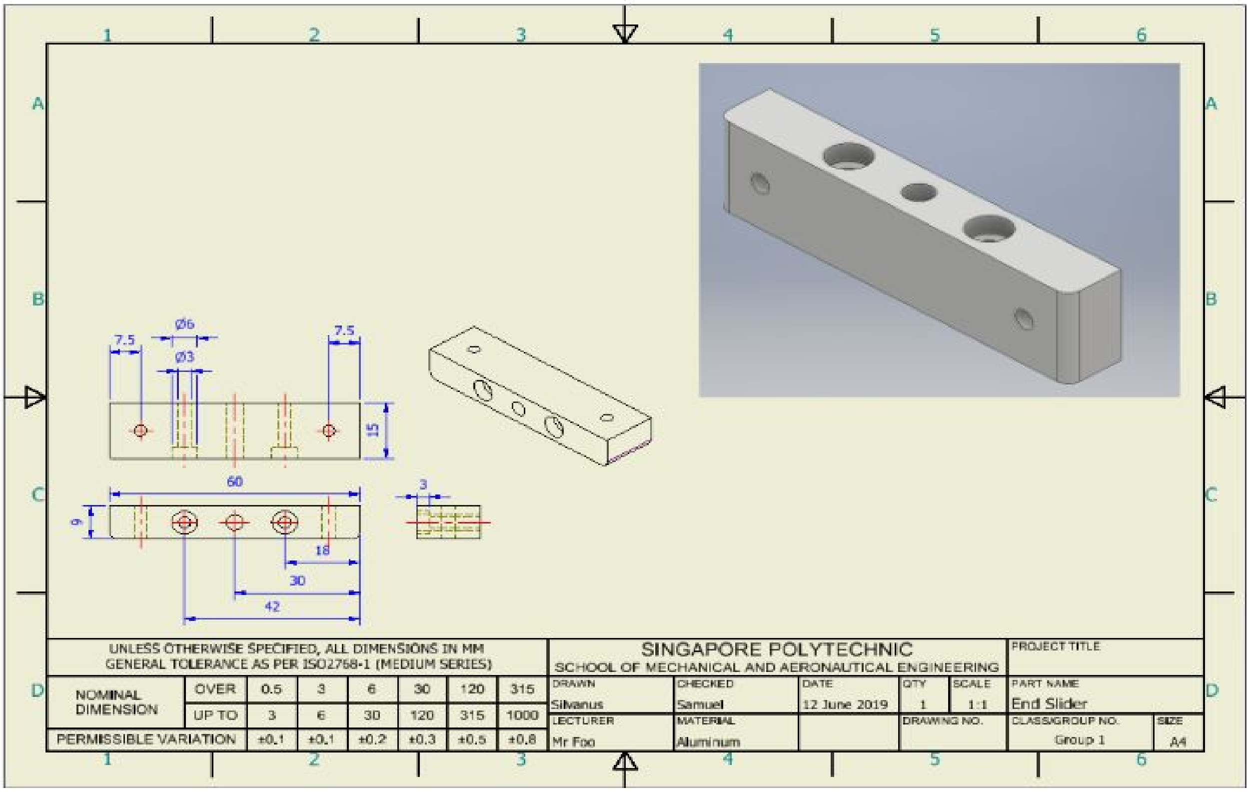
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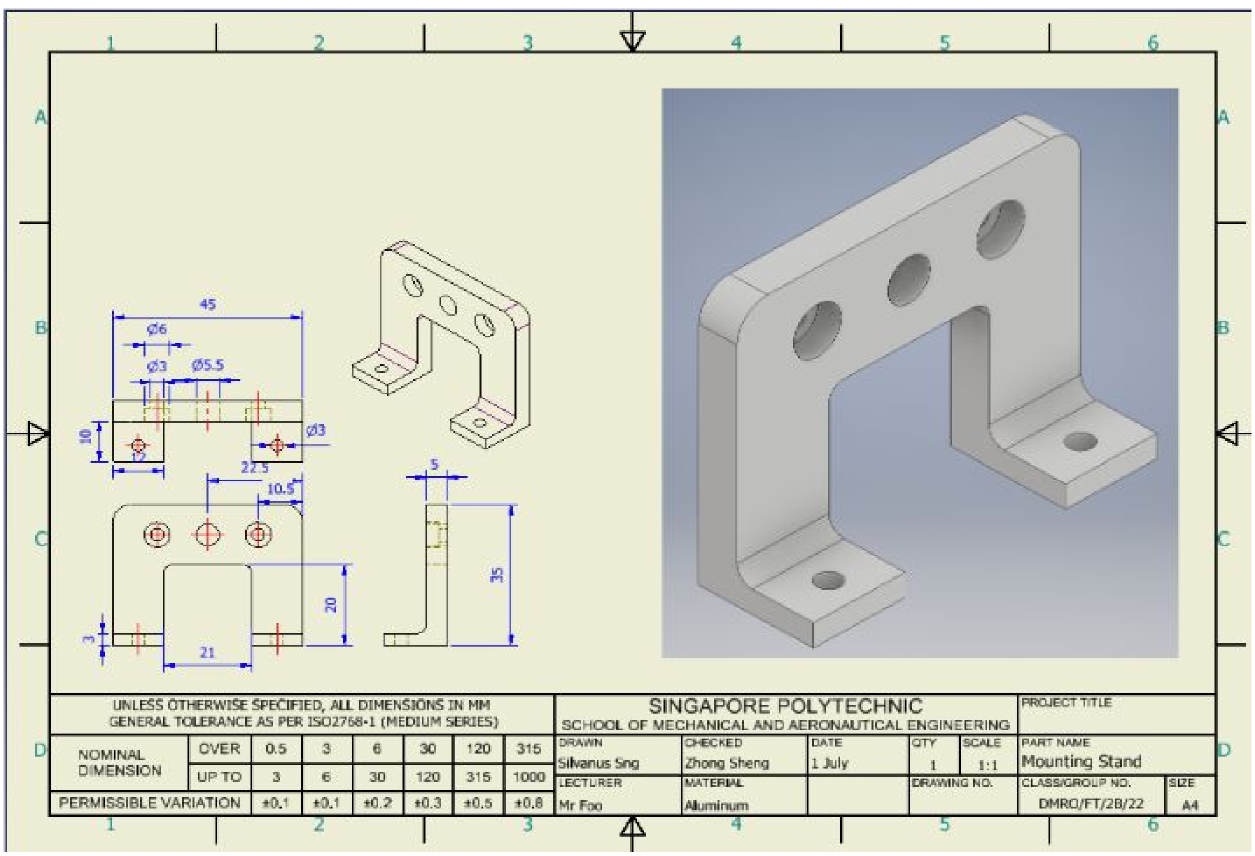
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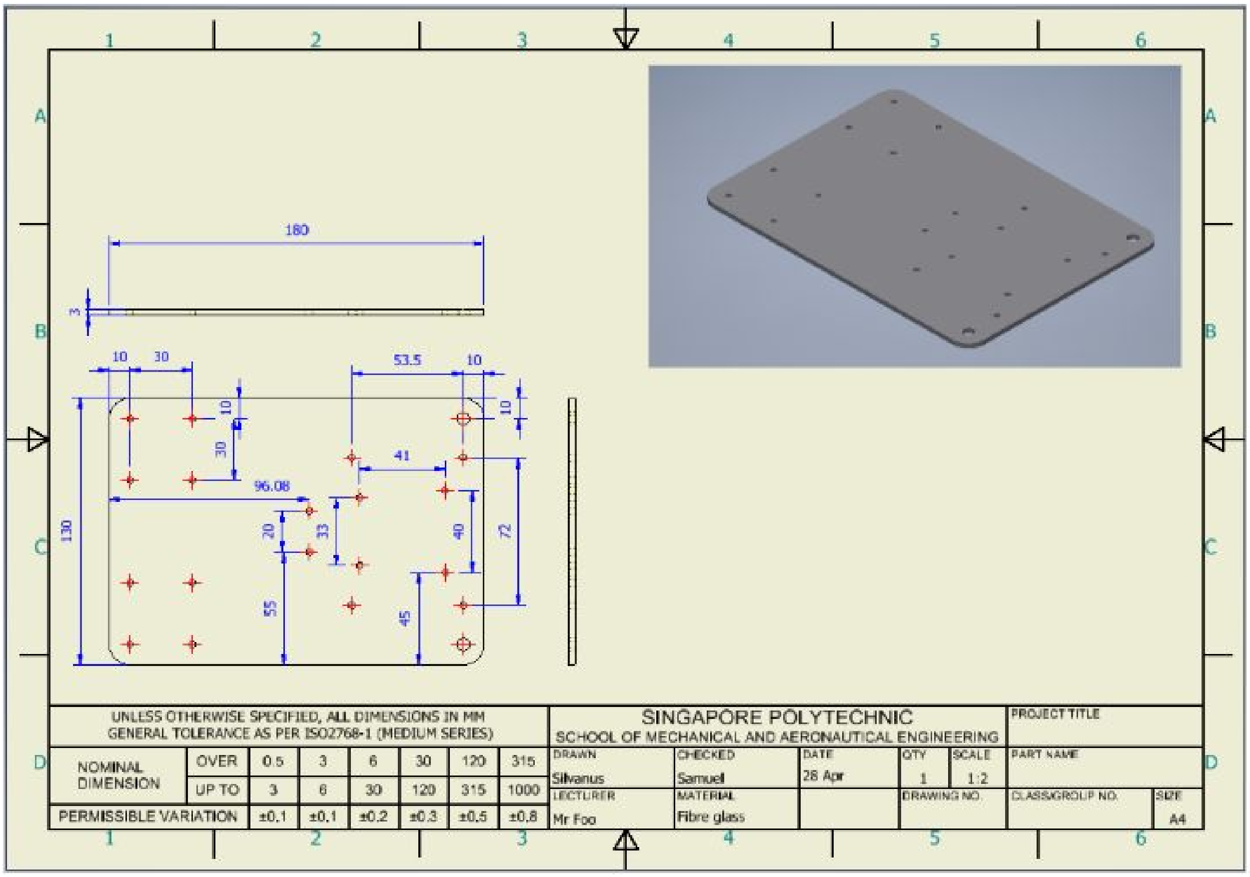
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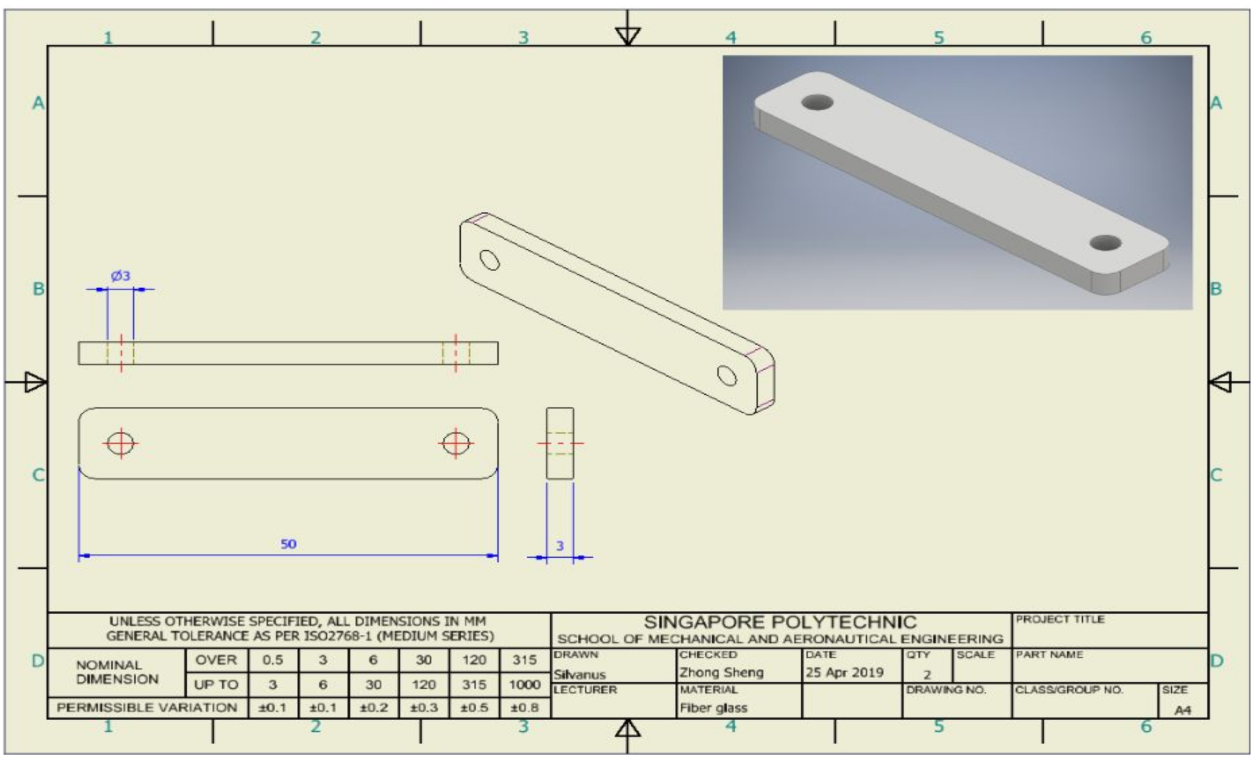
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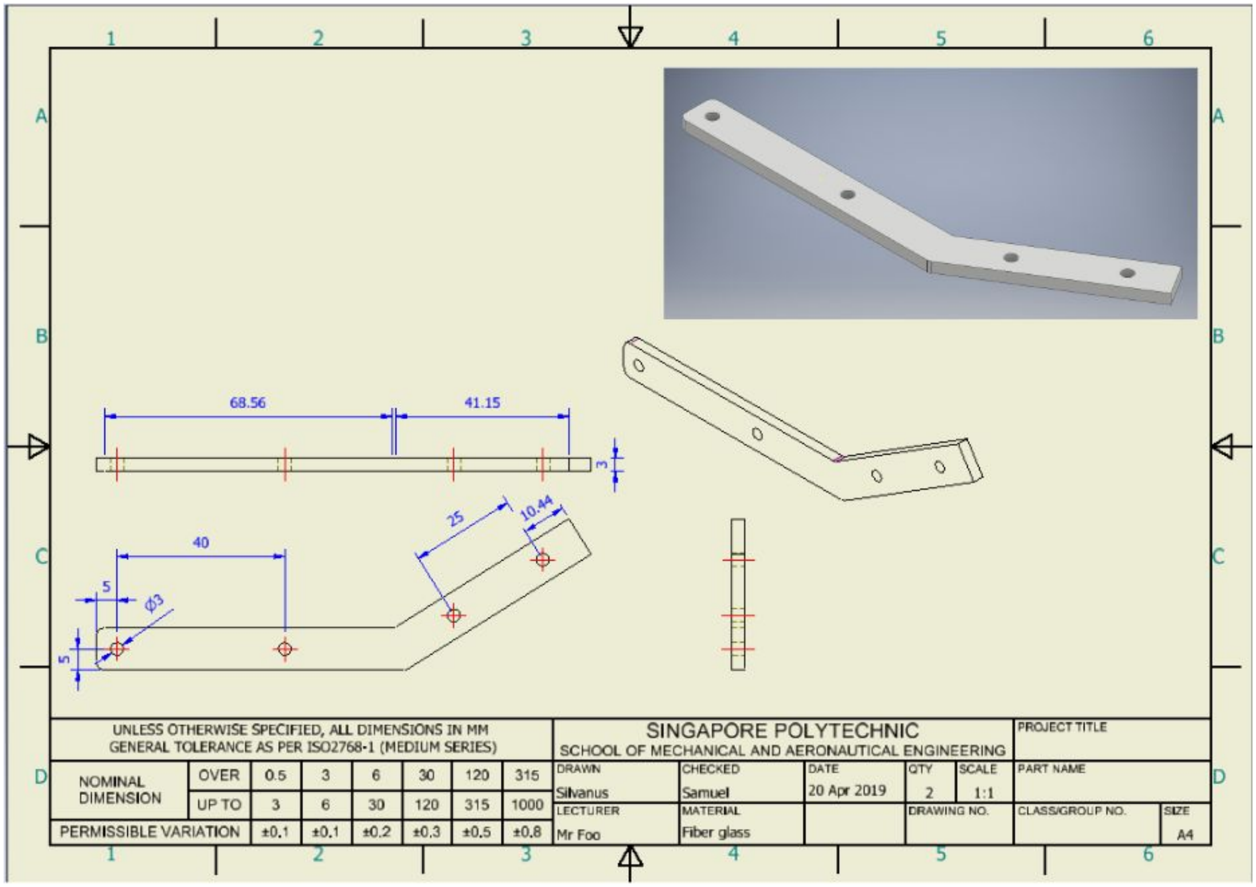
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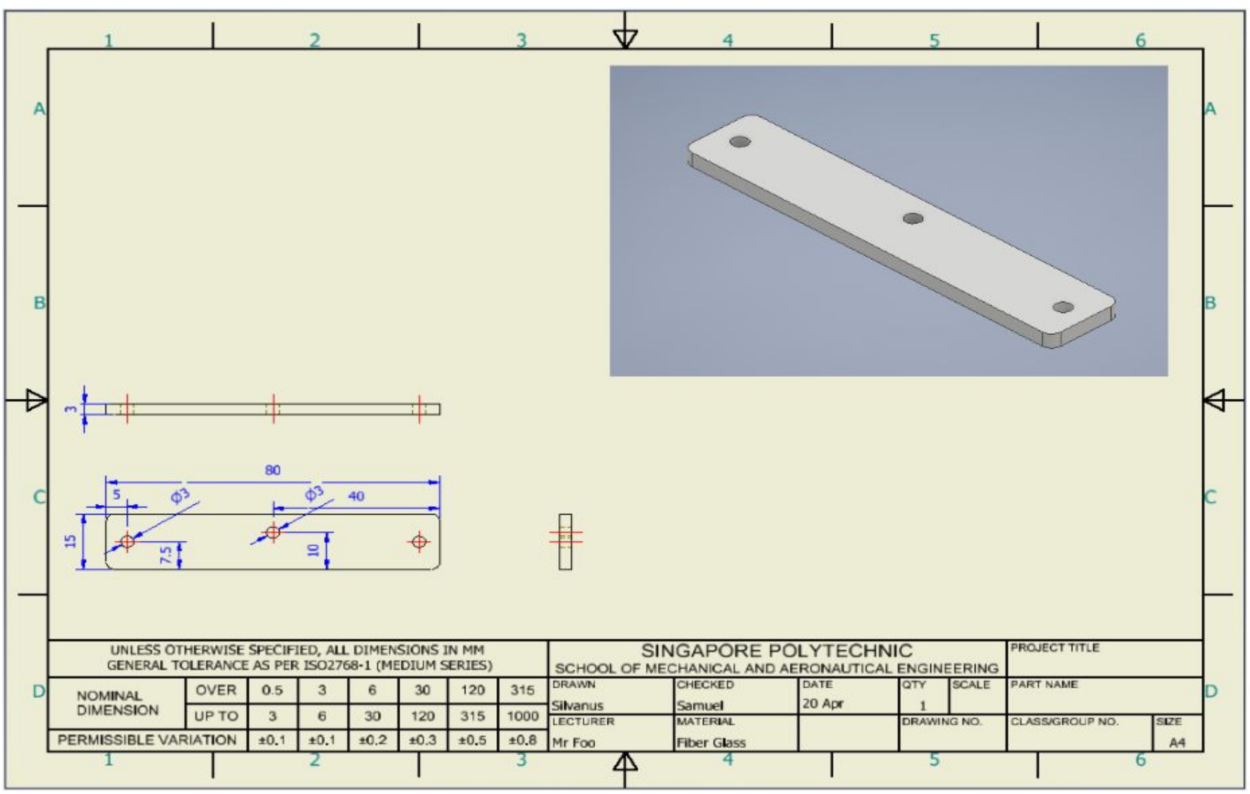
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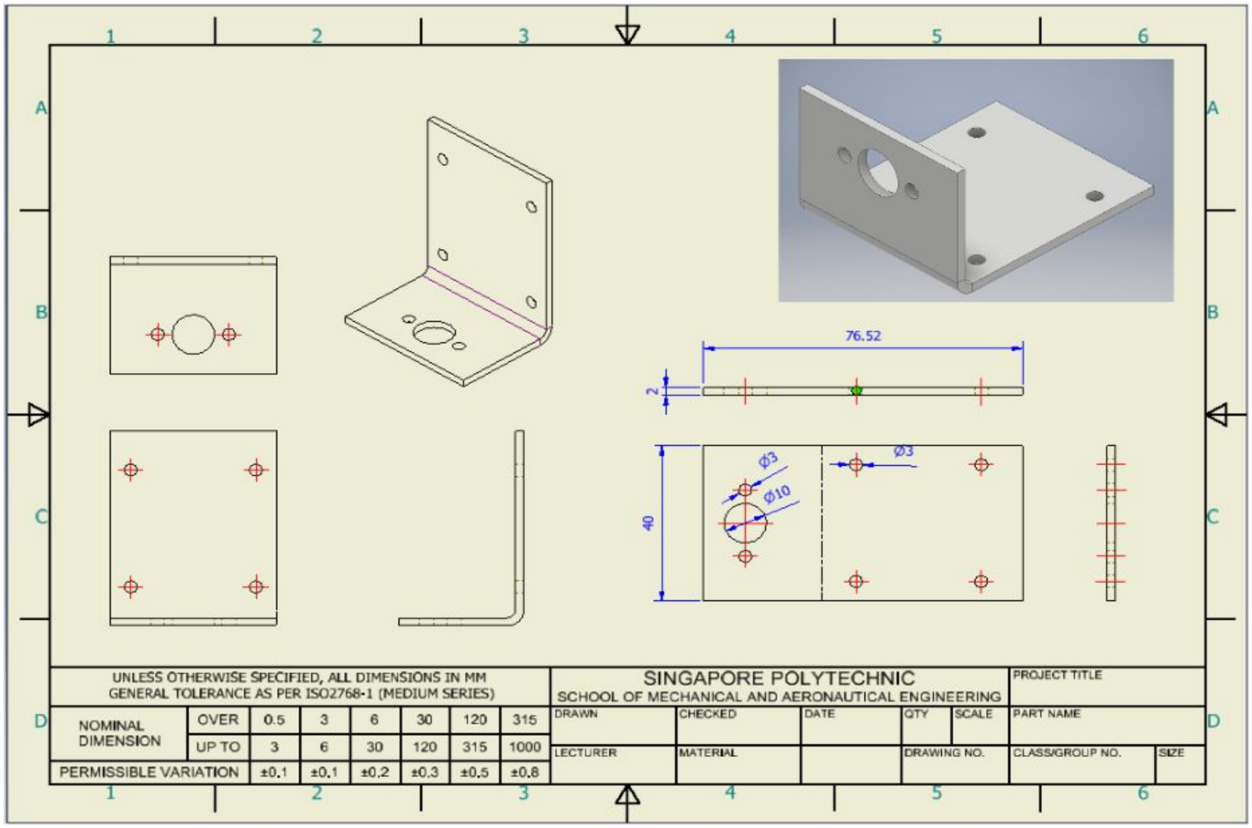
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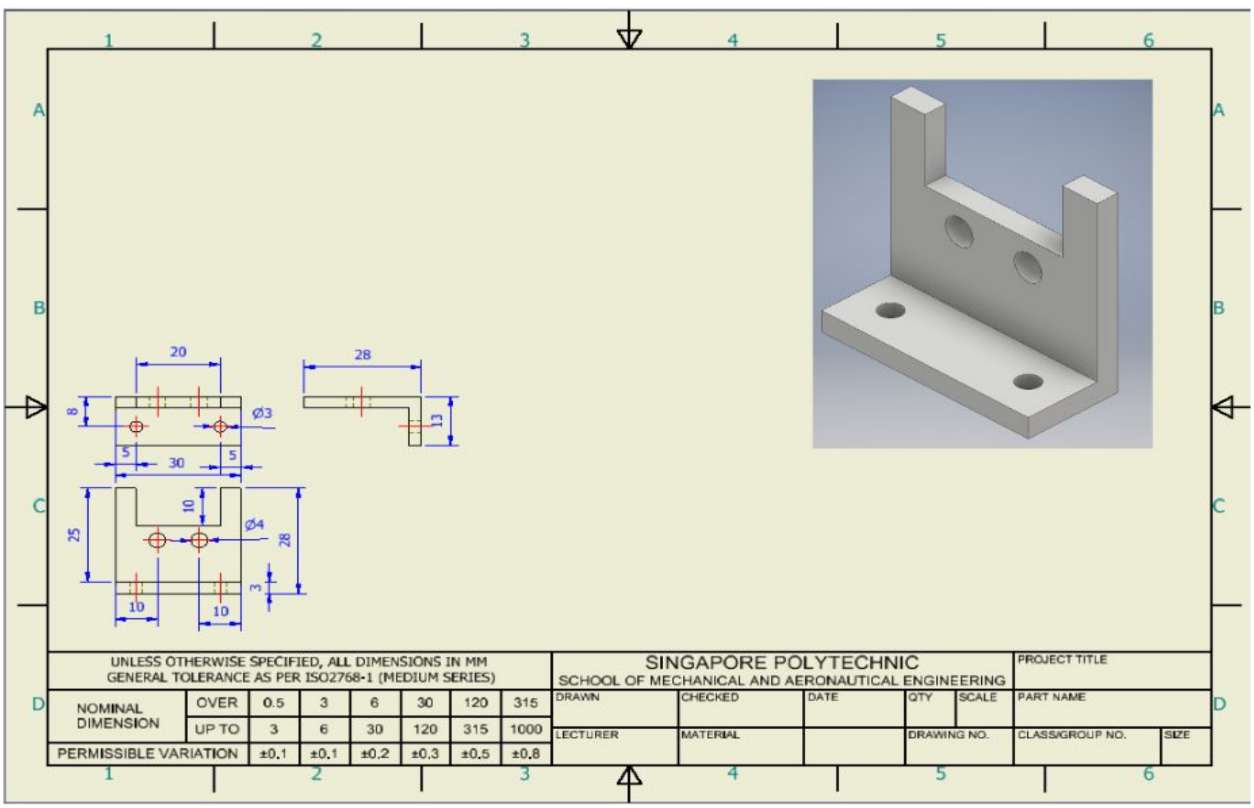
PROJECT TITLE
DRAWN
CHECKED
DATE
QTY
SCALE
PART NAME
LECTURER
MATERIAL
DRAWING NO.
CLASS/GROUP NO.
SIZE


20
28
8
Ø3
13
5
30
5
10
25
Ø4
28
3
10
10
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS IN MM
GENERAL TOLERANCE AS PER ISO2768-1 (MEDIUM SERIES)
NOMINAL DIMENSION
OVER 0.5 3 6 30 120 315
UP TO 3 6 30 120 315 1000
PERMISSIBLE VARIATION ±0.1 ±0.1 ±0.2 ±0.3 ±0.5 ±0.8
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1.8.2 Program

```
#include <Servo.h>
```

Include Servo.h library

```
Servo servo1;
int servo1GripClose = 1900;
int servo1GripOpen = 1100;
int servo1Stop = 1500;
```

Setting continuous servo:

1. 1500 servo neutral
2. > 1500 servo CCW
3. <1500 servo CW

```
byte pinOP1 = 11;
byte pinOP2 = 10;
byte pinOP3 = 13;
byte pinOP4 = 12;
byte op1;
byte op2;
byte op3;
byte op4;
byte opAll;

byte M1 = 4;
byte E1 = 5;
byte M2 = 7;
byte E2 = 6;
```

Assigning names to Pins

```
byte speedM1A = 100;
byte speedM2A = 90;
byte speedM1B = 83;
byte speedM2B = 75;
byte speedM1C = 70;
byte speedM2C = 65;
int i =0,z=0;
```

Setting parameters for the motor speed

Getting Value from main program

```
void motorPWM(bool motor1dir, byte motor1pwm, bool motor2dir, byte motor2pwm)
{
  digitalWrite(M1, motor1dir);
  analogWrite(E1, motor1pwm);
  digitalWrite(M2, motor2dir);
  analogWrite(E2, motor2pwm);

}
```

Sub motor program

```
void readOpticalSensor()
{
  op1 = digitalRead(pinOP1);
  op2 = digitalRead(pinOP2);
  op3 = digitalRead(pinOP3);
  op4 = digitalRead(pinOP4);
  opAll = op1 * 8 + op2 * 4 + op3 * 2 + op4;

  Serial.print("optical sensor");
  Serial.print(opAll, BIN);
  Serial.print('\n');
```

Sub optical sensor Program

Help detect the position robot

```
void loop()
{
  readOpticalSensor();
  if (opAll == B1001)
  {
    motorPWM(HIGH, speedM1A, HIGH, speedM2A);
    delay(10);
    motorPWM(HIGH, 0, HIGH, 0);
  }
  else if (opAll == B0011 || opAll == B0111)
  {
    motorPWM(HIGH, speedM1B, LOW, speedM2B);
  }
  else if (opAll == B1110 || opAll == B1100)
  {
    motorPWM(LOW, speedM1B, HIGH, speedM2B);
  }
```

Using Sub program to check the position of the robot

Basic positioning of the robot.

```
else if (opAll == B1111)
{
  motorPWM(LOW, 0, LOW, 0);
  delay (1000);
  z++;
  if (z==1)
  {
  servo1.writeMicroseconds(servo1GripClose);
  delay (15000);
  servo1.writeMicroseconds(servo1Stop);

  }
  else if (z==2)
  {
    servo1.writeMicroseconds(servo1GripOpen);
    delay (15000);
    servo1.writeMicroseconds(servo1Stop);
    z =0;
  }

  while (opAll == B1111)
  {
  readOpticalSensor();
  if (opAll == B1111)
  {
    motorPWM(LOW, speedM1A, HIGH, speedM2A);
    delay (10);
    motorPWM(LOW, 0, LOW, 0);
  }
  else
  {
  break;
  }
  }
```

Special condition when robot detect all black.

First check will close the grip and grab the ball.

First check will open the grip and release the ball.

This program will rotate the robot till a line is detected

```
else if ( opAll == B0000)
{
  i++;
   motorPWM(LOW, 0, LOW, 0);
  delay (1000);
  if (i>1)
  {
  while (opAll == B0000)
  {
  readOpticalSensor();
  if (opAll == B0000)
  {
    motorPWM(HIGH, speedM1B, LOW, speedM2B);
    delay (430);
    motorPWM(LOW, 0, LOW, 0);
  }
  else
  {
  break;
  }
}
}
else
{
  i++;
  motorPWM(HIGH, speedM1A, HIGH, speedM2A);
  delay (400);
}
}
```

Special condition when robot detect all silver.

If counter is more than 1 vehicle will turn left

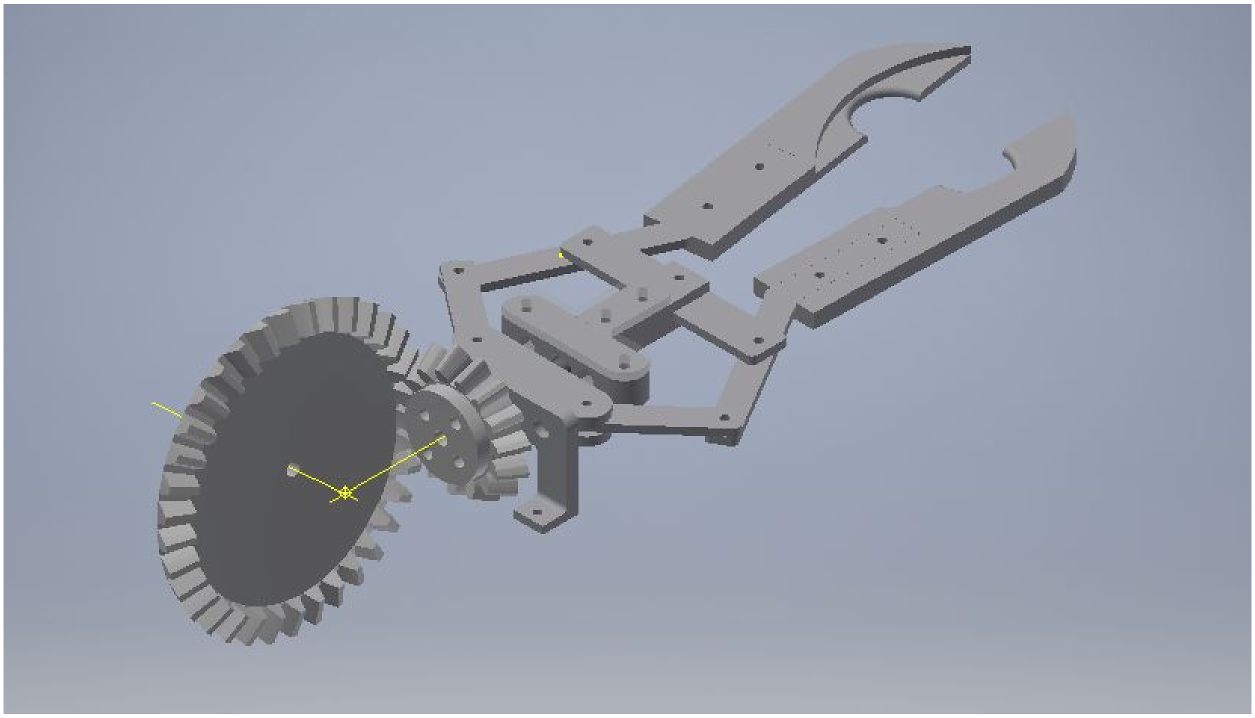
If counter is 0 vehicle will go straight

```
 else
{
  //motorPWM(LOW, 0, LOW, 0);
  motorPWM(HIGH, speedM1B, HIGH, speedM2B);
  delay(50);
  motorPWM(LOW, speedM1B, HIGH, speedM2B);
}
```

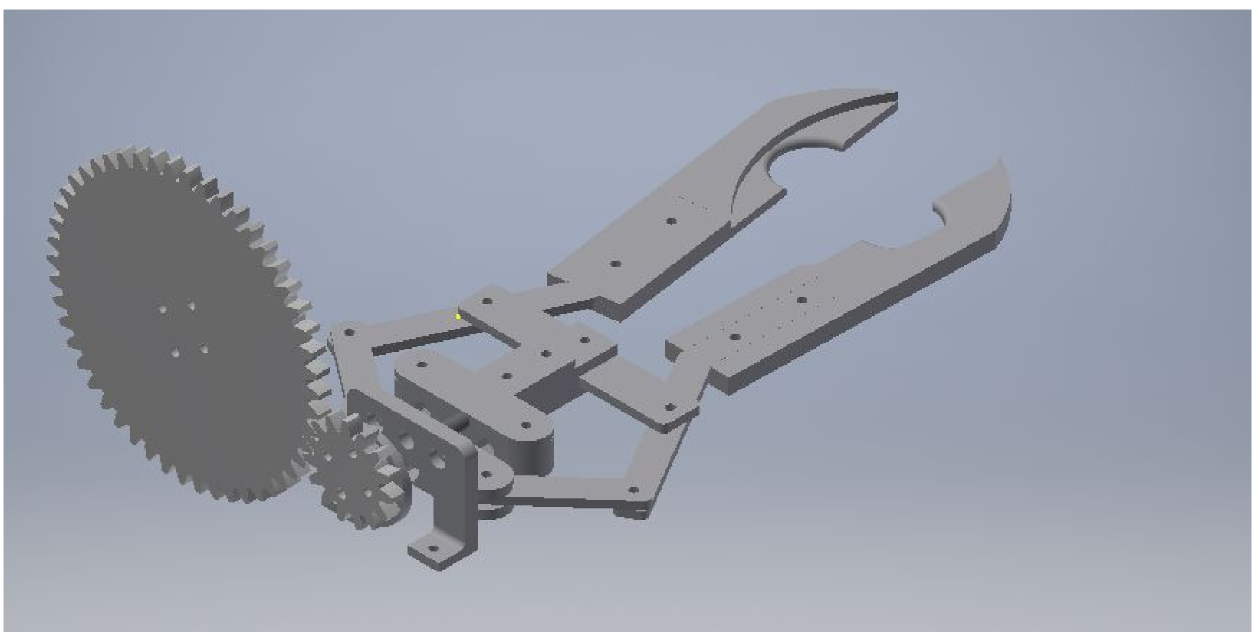
Final condition if anything else was detected, it will go forward and turn slightly.

This will prevent the robot from getting stuck on the same line for too long

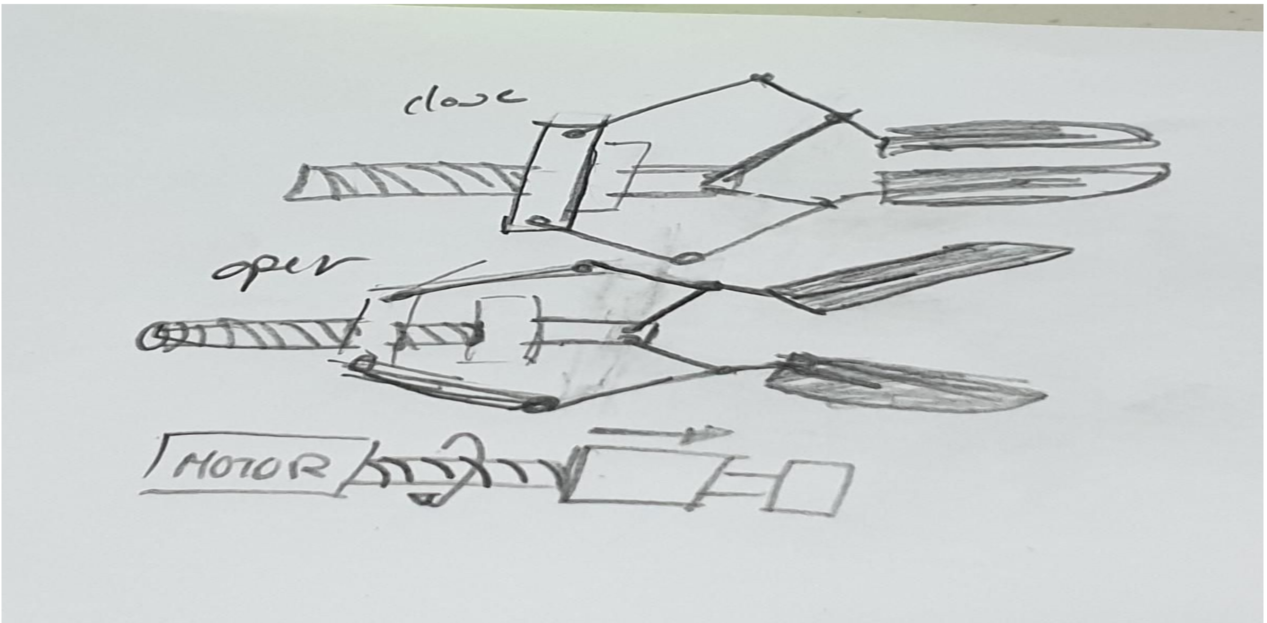
1.8.3 Other design sketches



We wanted to add bevel gears to help lift up the claw. This helps us to introduce a new motion however the design was impractical as we were using a continuous servo which cause the claw to over turn and damage the lead screw.



Spur gear can be added to reduce the amount of turns to help pull the claw up. However the step up gear is to large to fit into the design.


MOTOR