

# FINAL PROJECT

Line-following robot and Manual robot



Napak Suthapintu  
Varit Roongrotekarnkha  
Kunlanith Busabong

65011374  
65011620  
65110141

# BACKGROUND RESEARCH

## Straight Bevel Gear

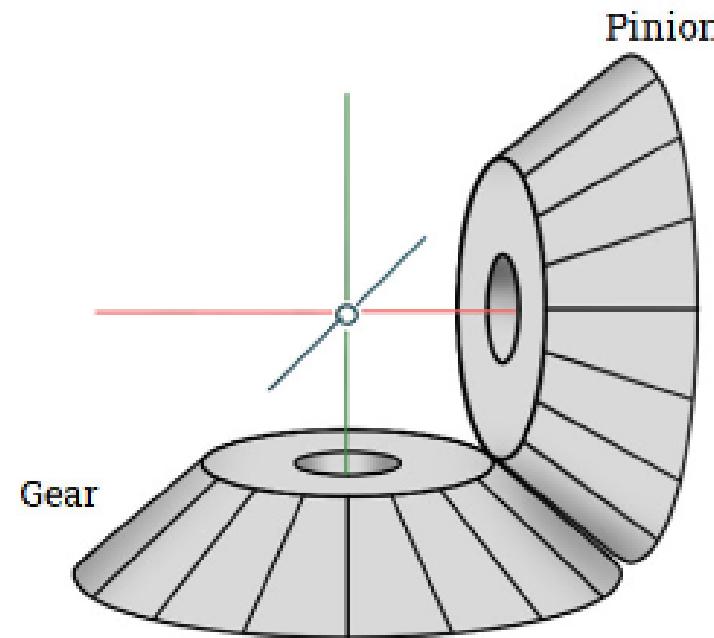


Figure 1.1 - Meshing of Pinion and Gear



Figure 1.2 - Straight Bevel Gear

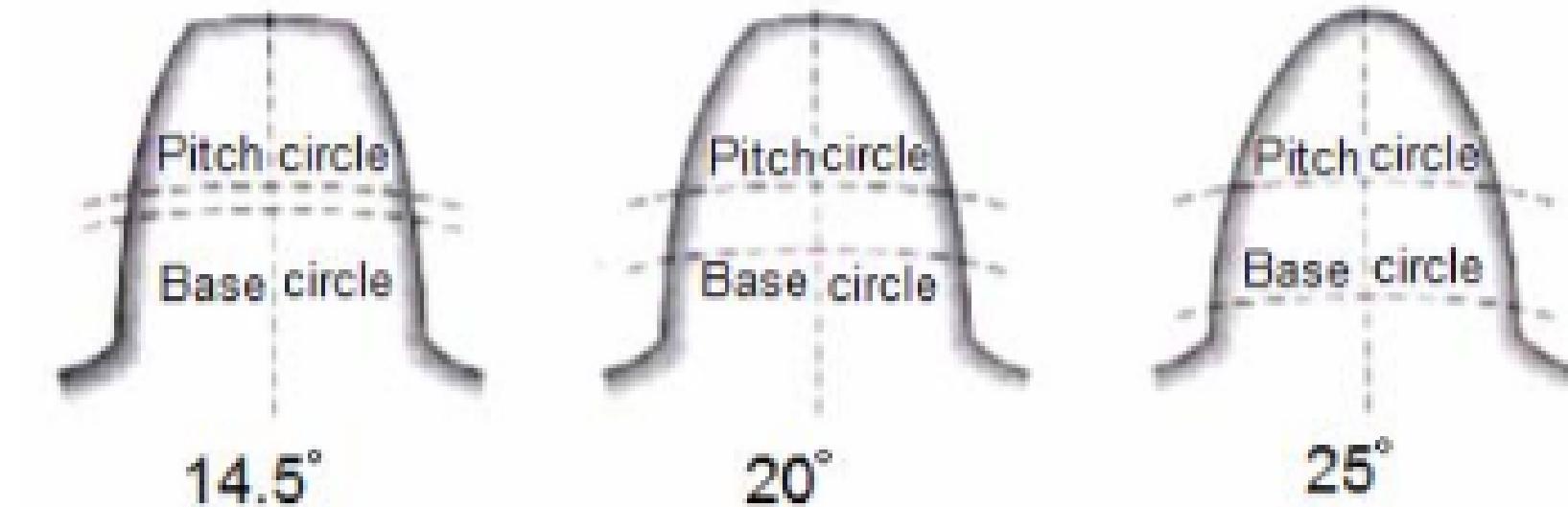


Figure 1.3 - Gear Tooth Profile for different Pressure Angles

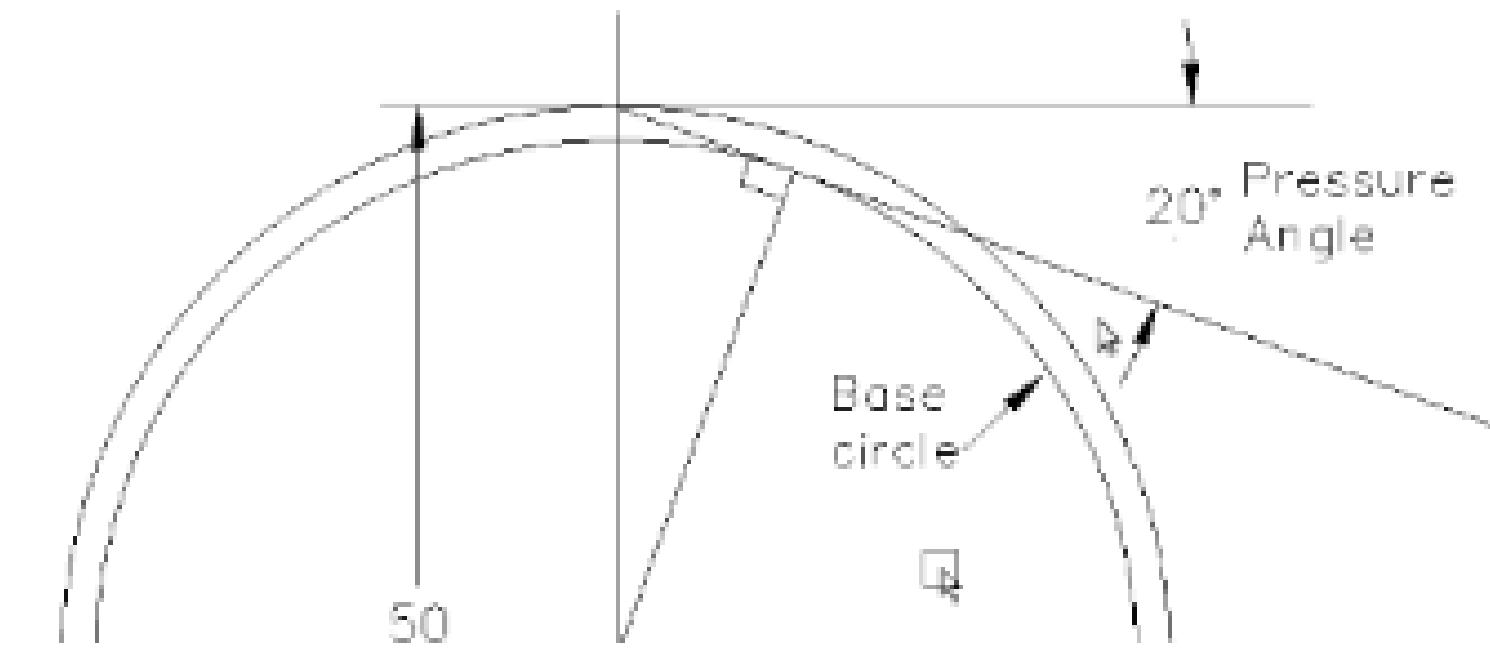


Figure 1.4 - Pressure Angle of gear

## BACKGROUND RESEARCH

Lift

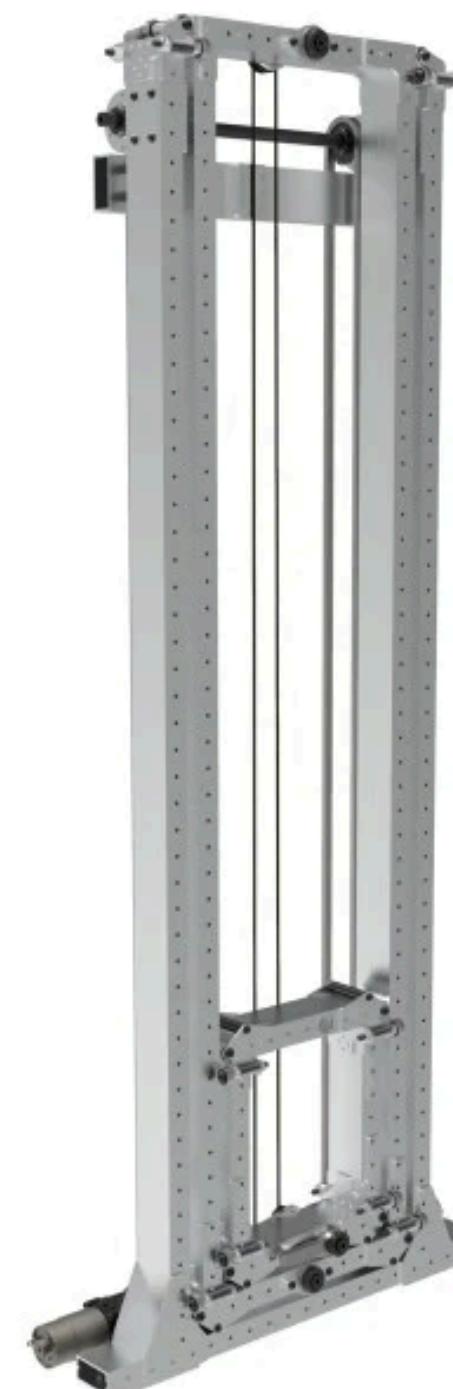


Figure 2.1 -Elevator

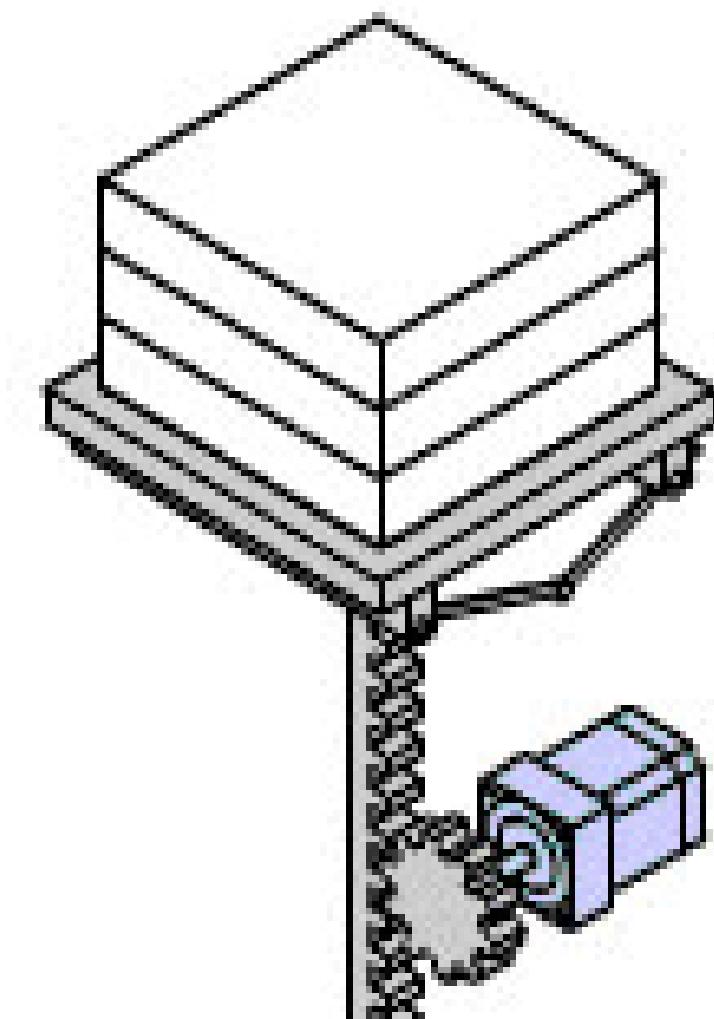


Figure 2.2 - Load Elevator

## Gripper

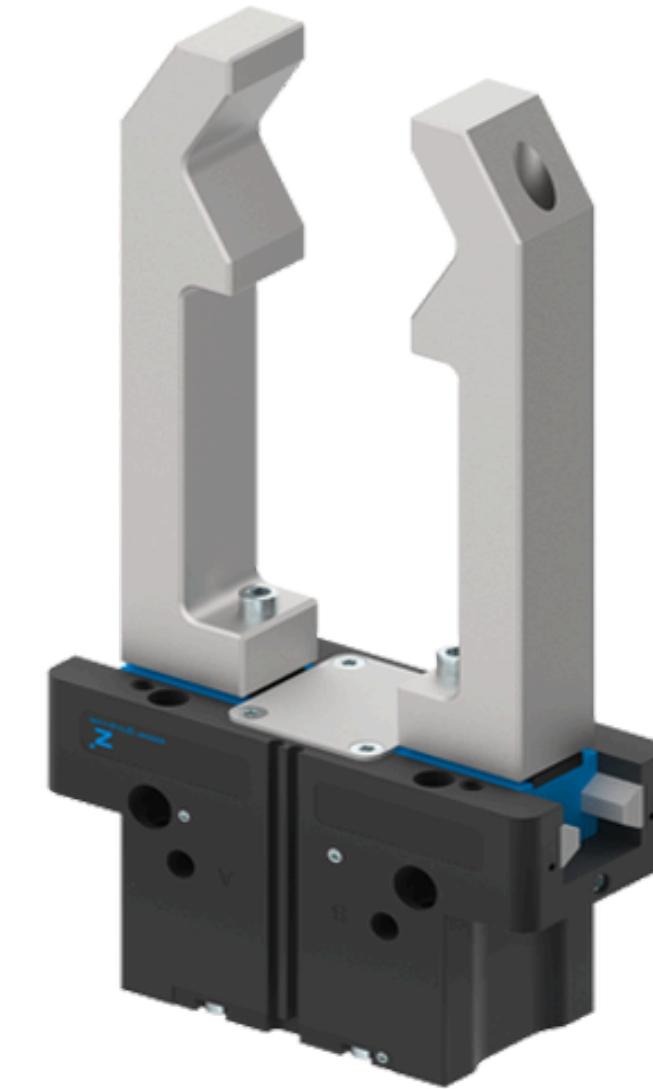


Figure 3.1 - Jaw Gripper



Figure 3.2 - Angular Gripper

# BACKGROUND RESEARCH

## 3D Printing

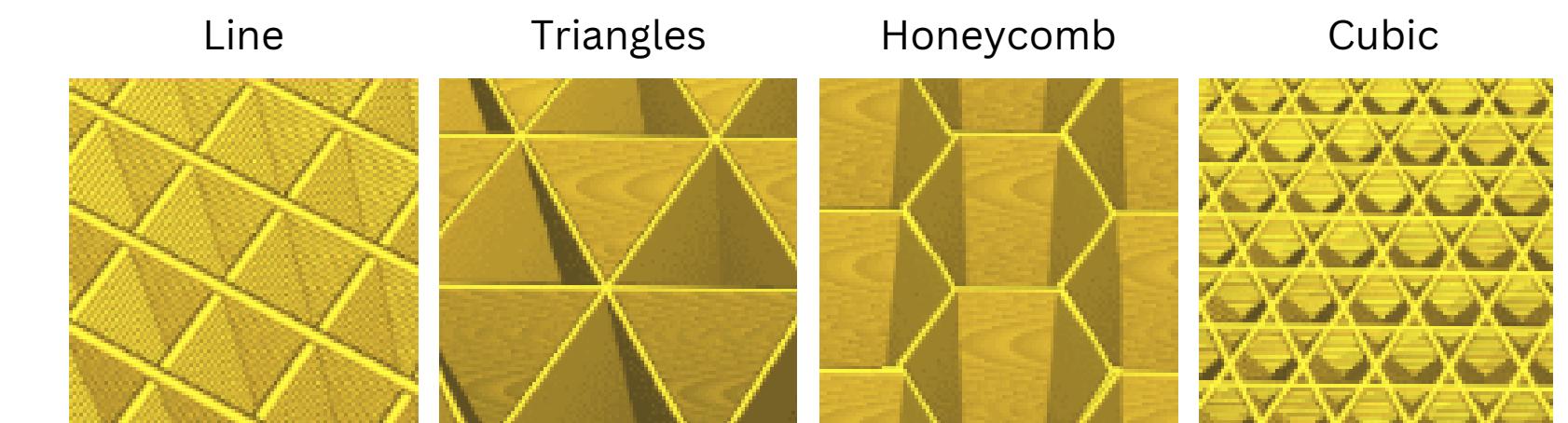
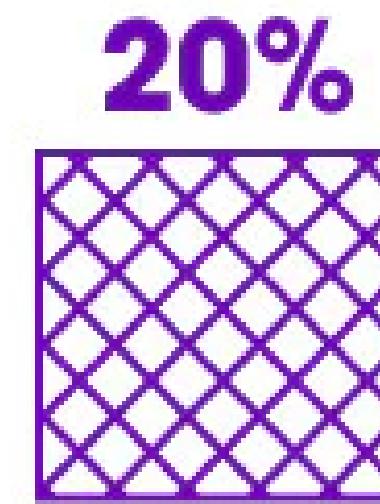
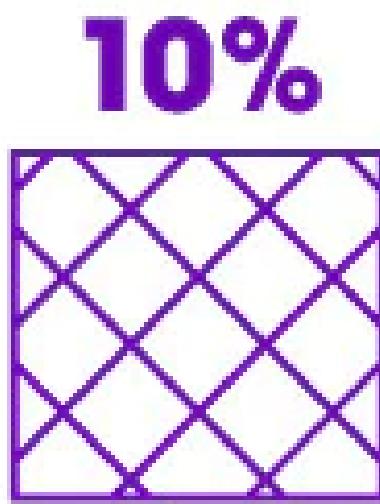


Figure 4.1 - Infill Percentage of 3D Printing

Figure 4.2 - Example of Grid Infill patterns

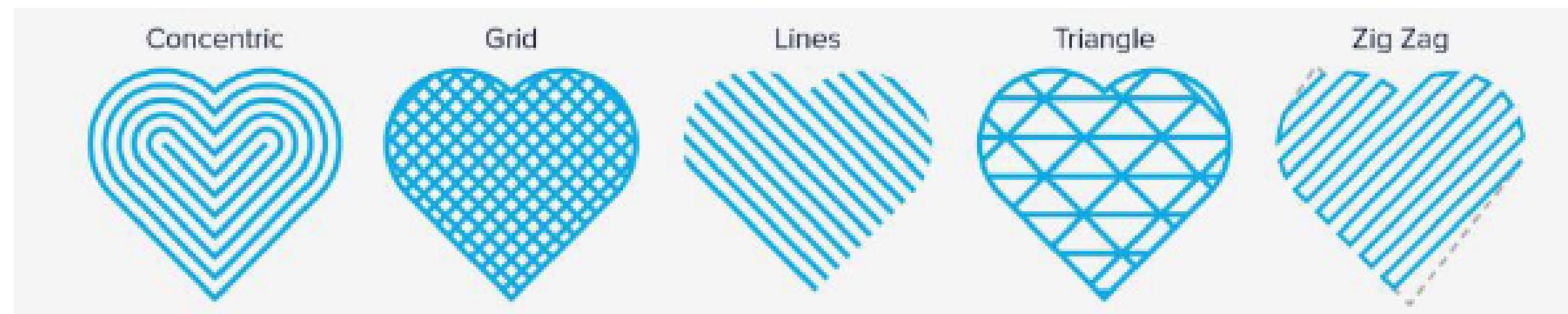


Figure 4.3 - Example of Support Pattern

# METHODOLOGY 1

## Line follower

### List of component

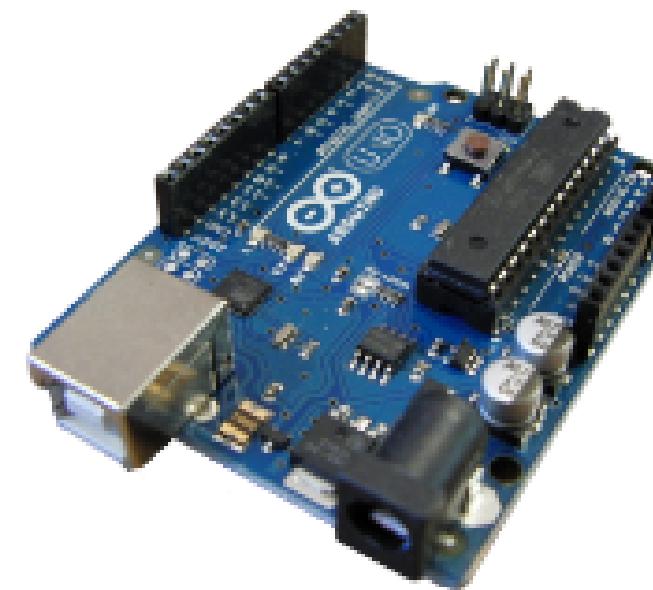


Figure 5.1 - Arduino UNO

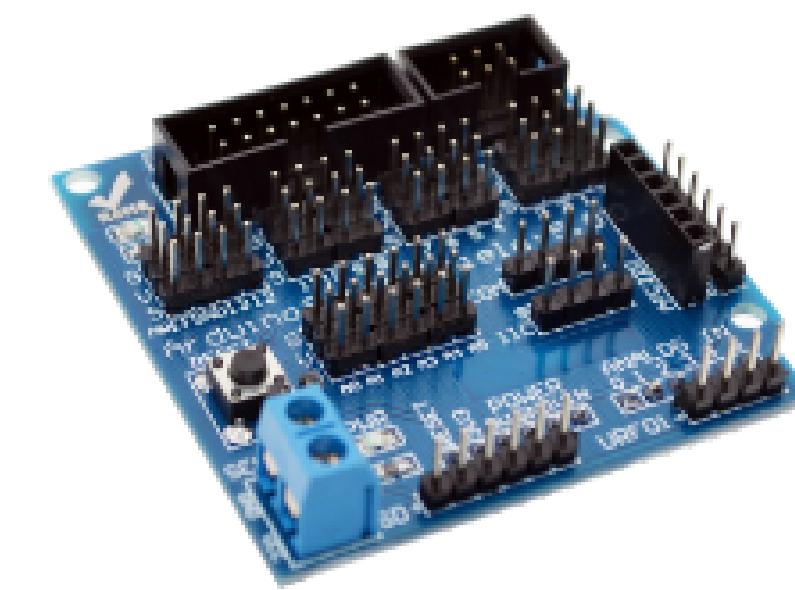


Figure 5.2 - Sensor Shield V5.0

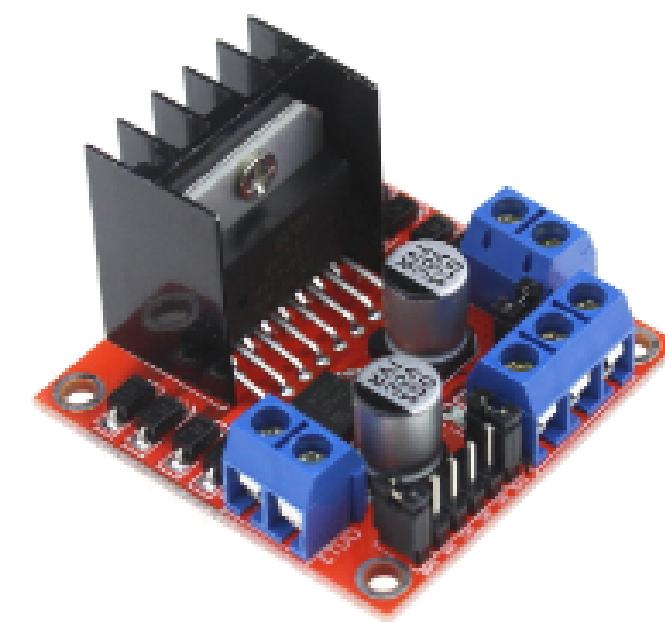


Figure 5.3 - Motor driver

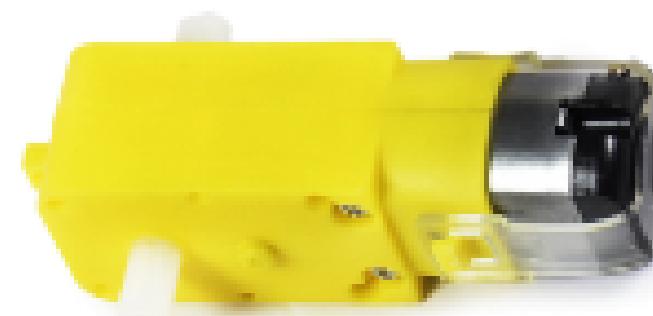


Figure 5.4 - 3-6V Yellow DC Gear Motor

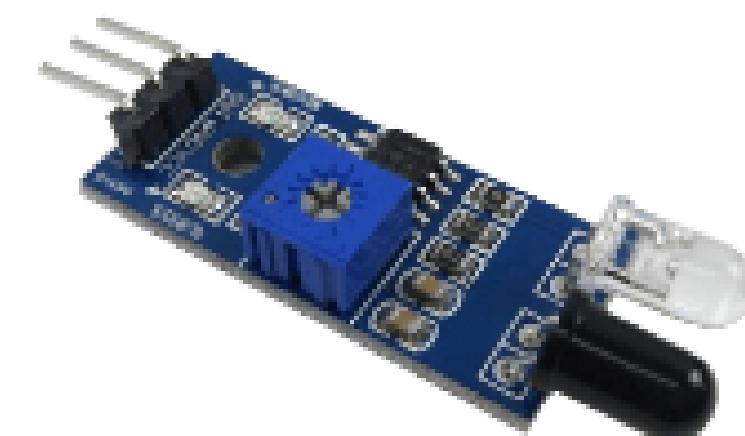


Figure 5.5 - IR Sensor



Figure 5.6 - Battery AA

# METHODOLOGY 1

## Line follower Design

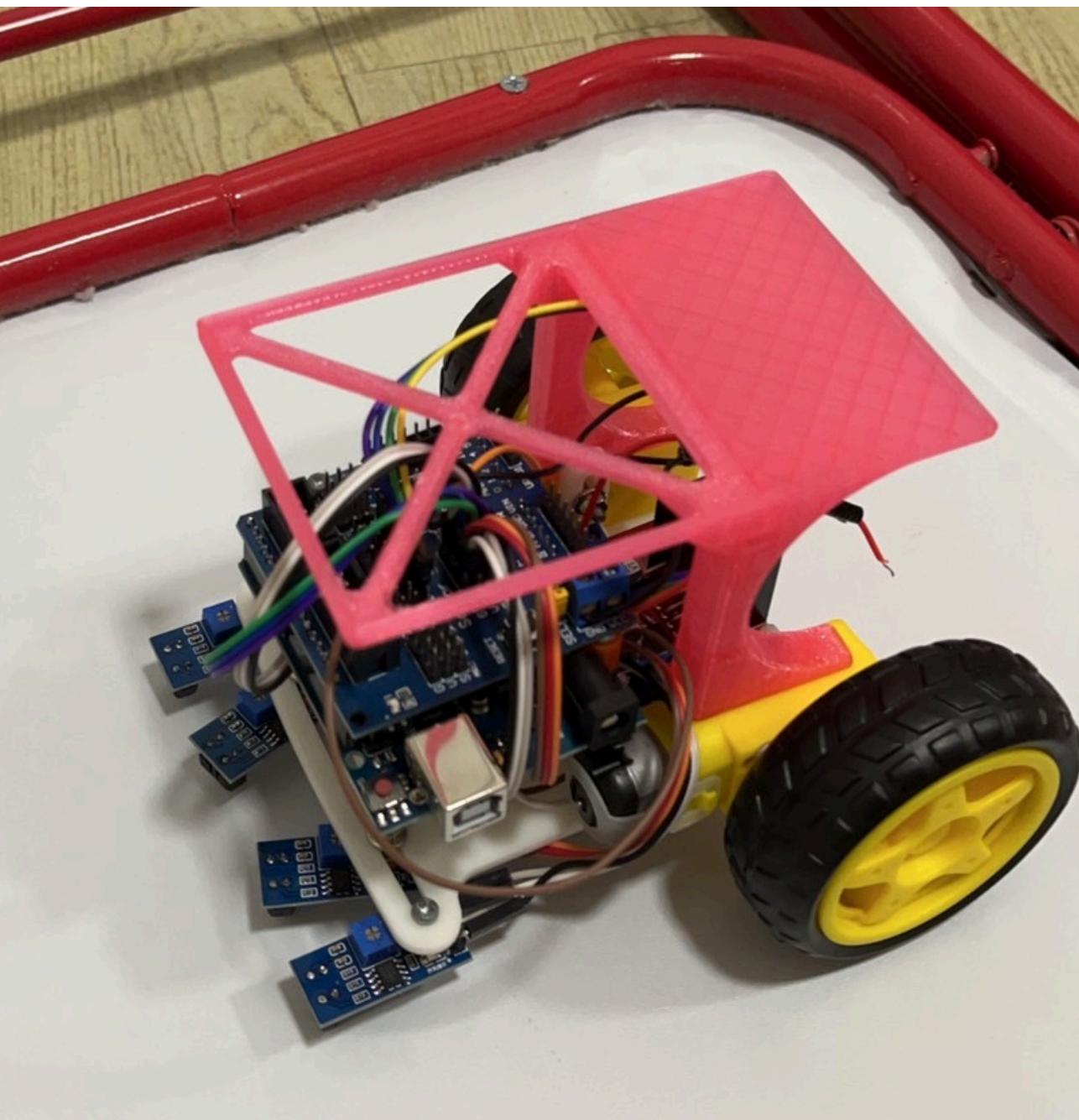


Figure 6.1 - Line Following Robot

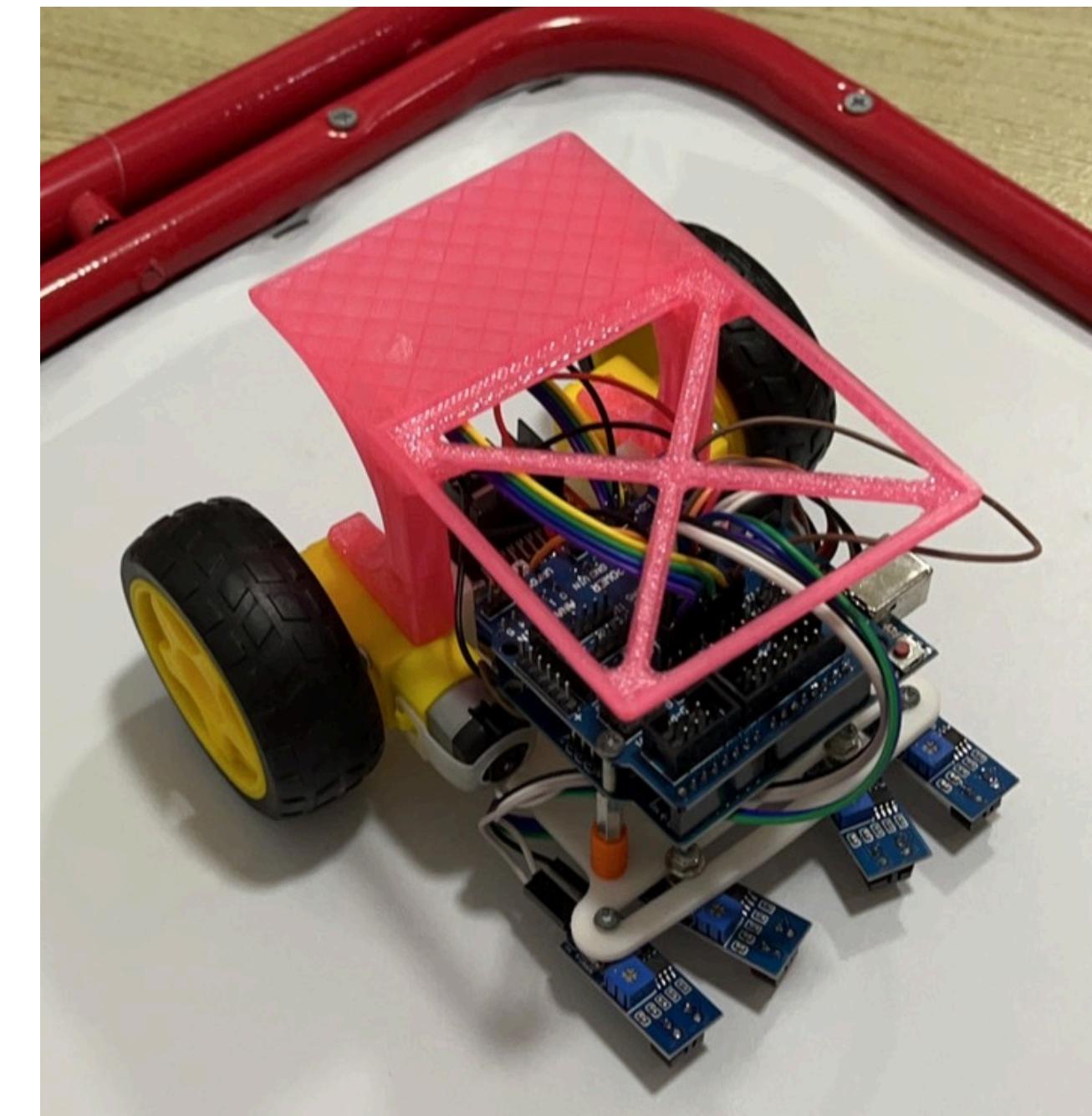


Figure 6.2 - Line Following Robot

# METHODOLOGY 1

## Line follower Flowchart

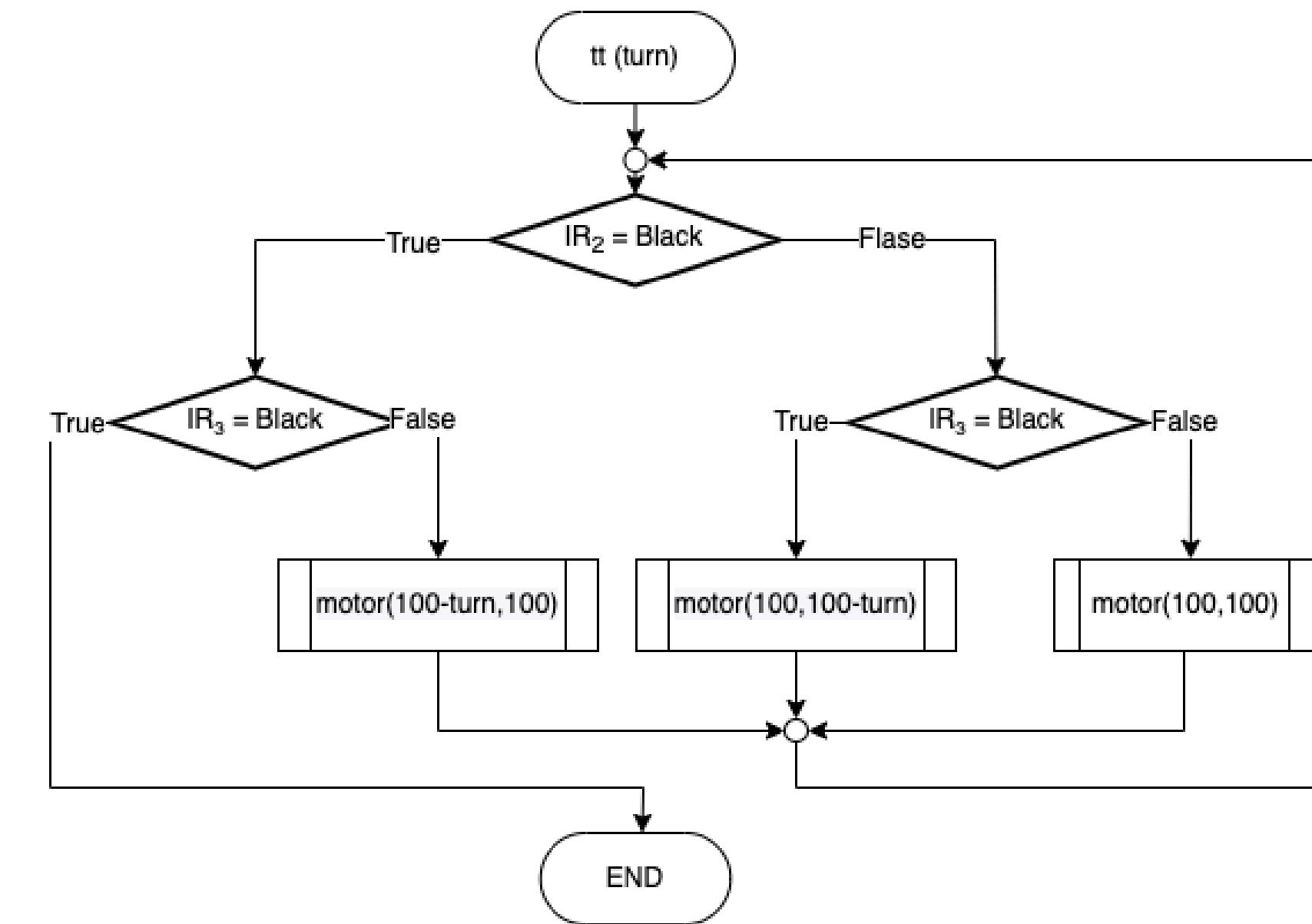
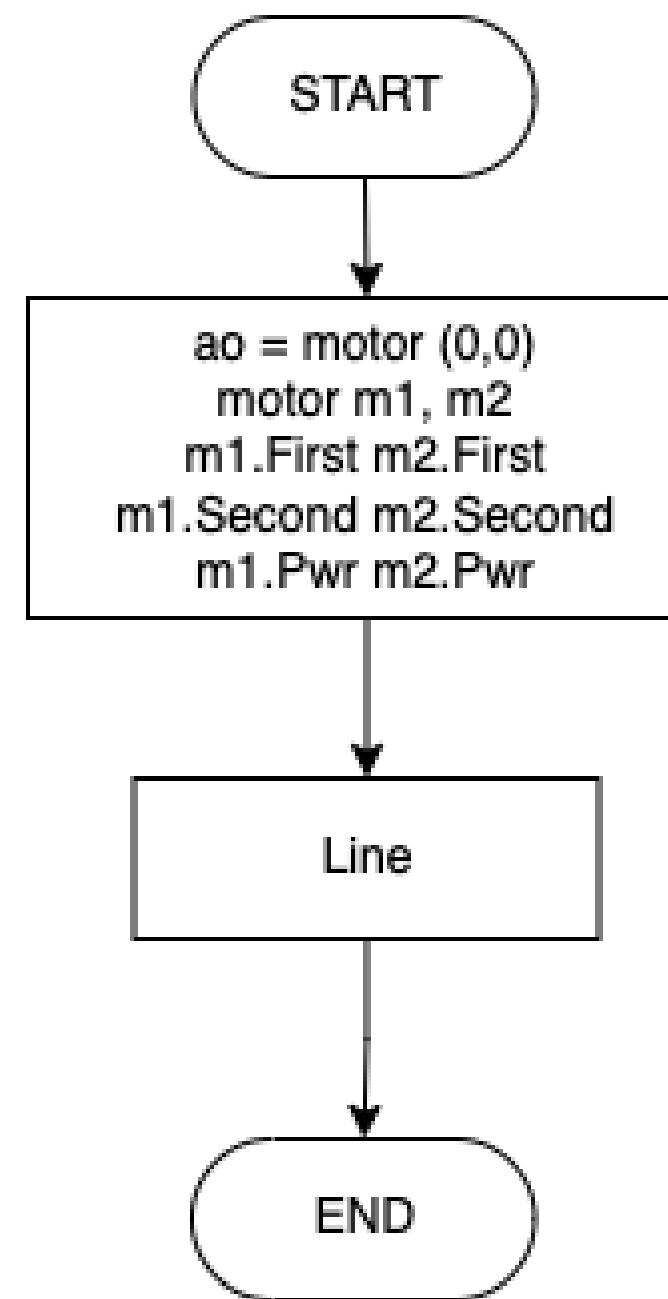


Figure 8.1 - Variable Declaration Flowchart

Figure 8.2 - Tracking Line Flowchart

# METHODOLOGY 1

## Line follower Flowchart

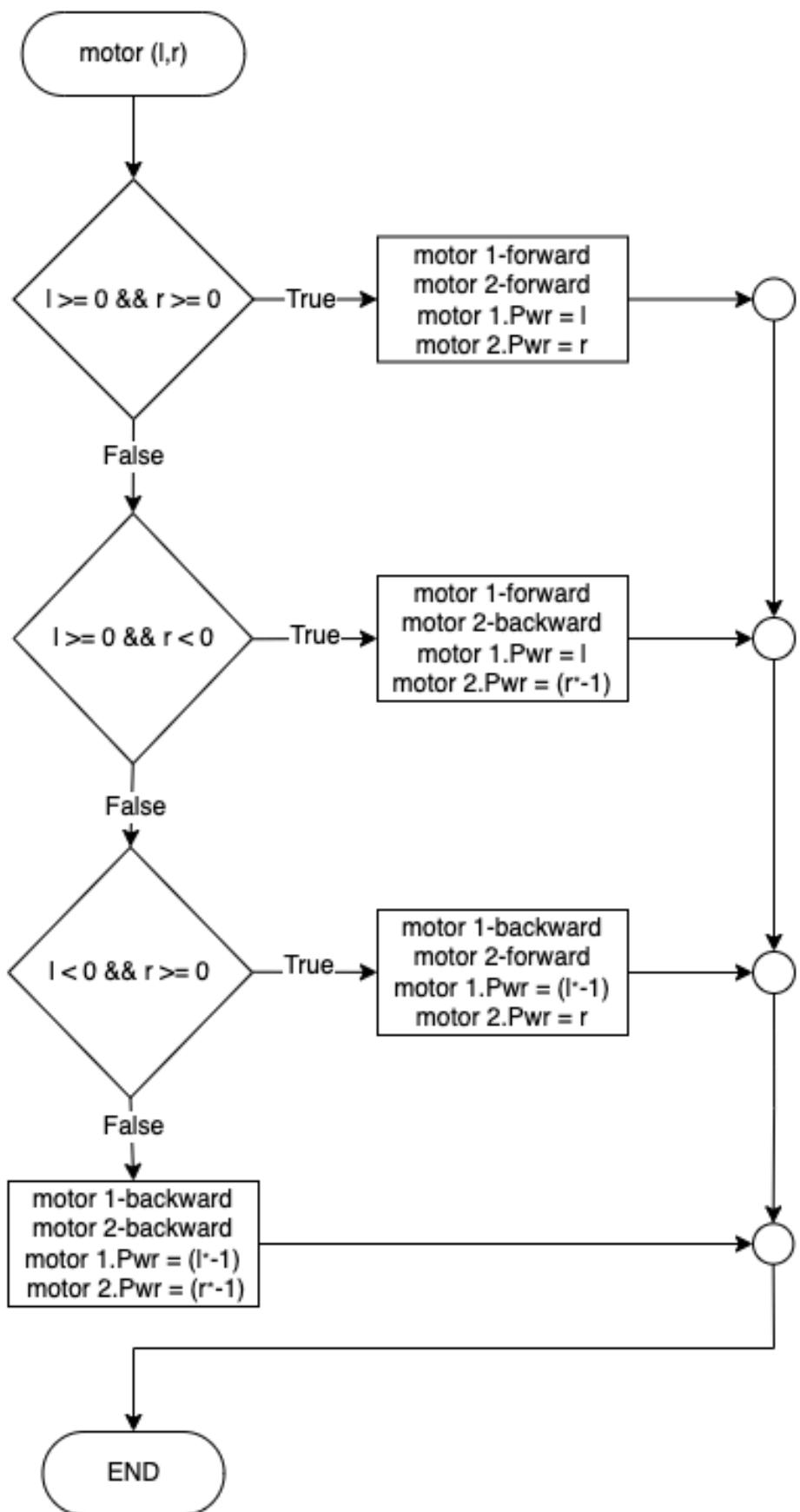


Figure 8.3 - Movement Control Flowchart

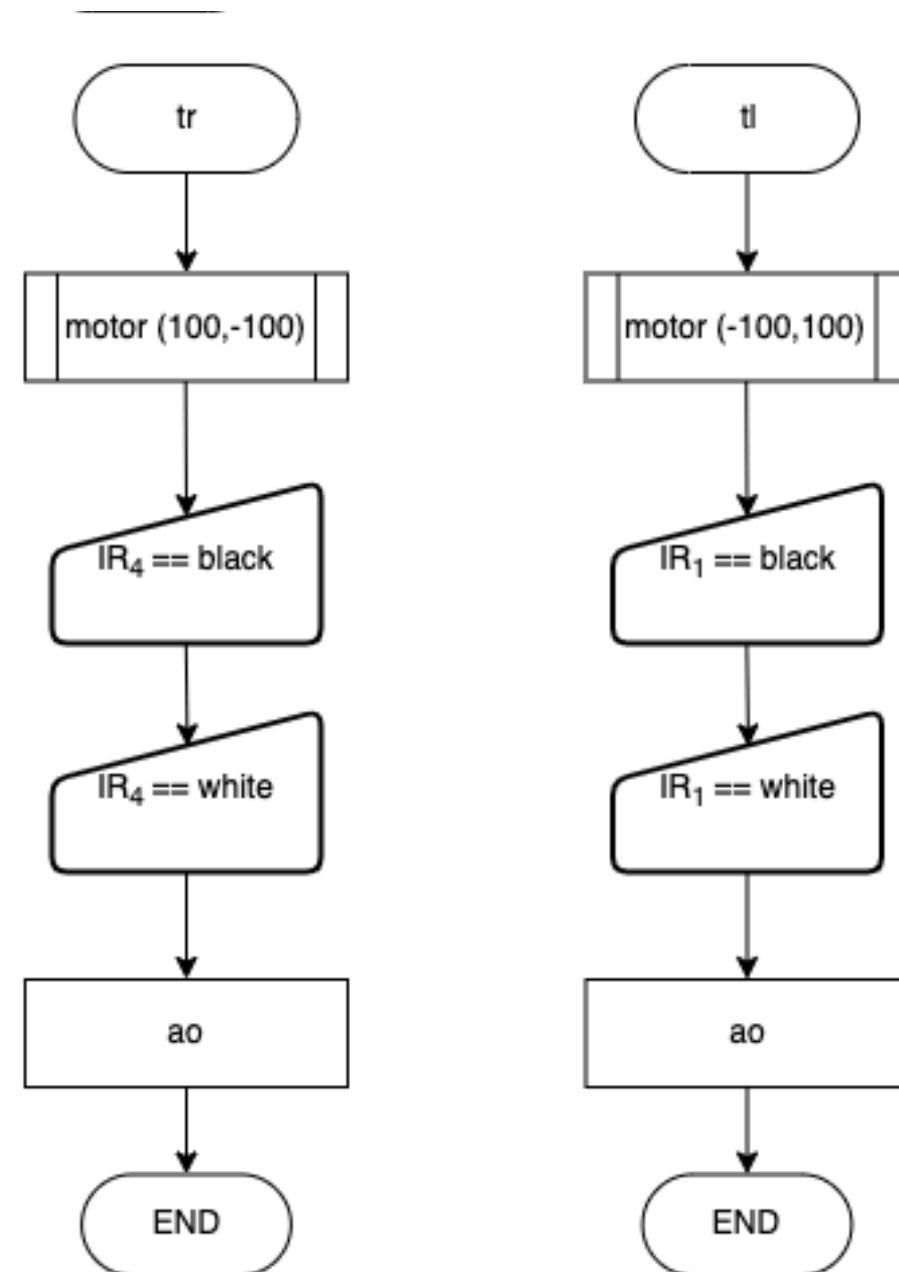


Figure 8.3 - Robot Movement Control Flowchart

## METHODOLOGY 2

### Manual Robot

### List of component



Figure 9.1 - Cyber Pi



Figure 9.2 - Makeblock Controller

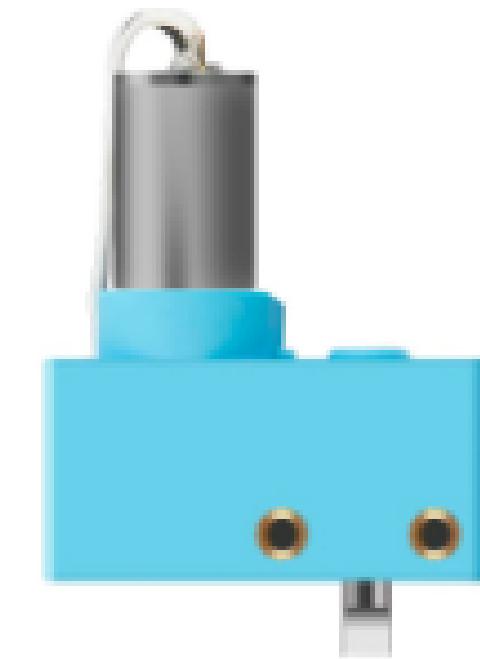


Figure 9.3 - Makeblock 180 Encoder Motor

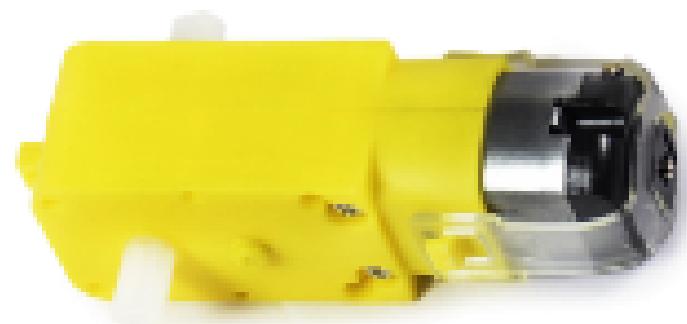


Figure 9.4 - 3-6V Yellow DC Gear Motor

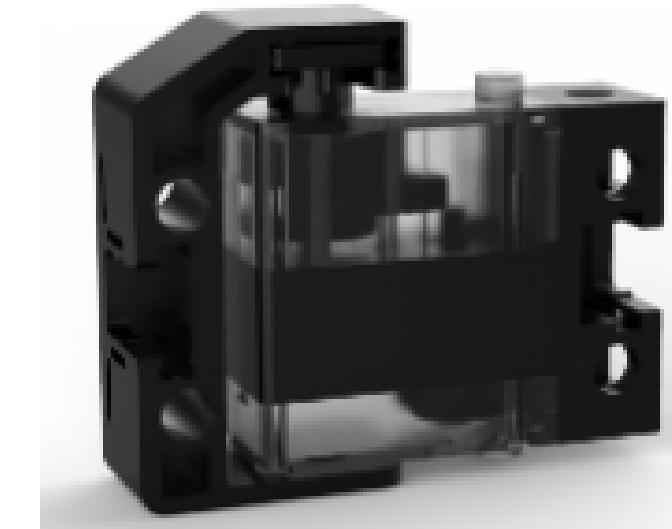


Figure 9.5 - Makeblock MS-1.5 Servo



Figure 9.6 - Makeblock Digital Servo

# METHODOLOGY 2

## Manual Robot Design

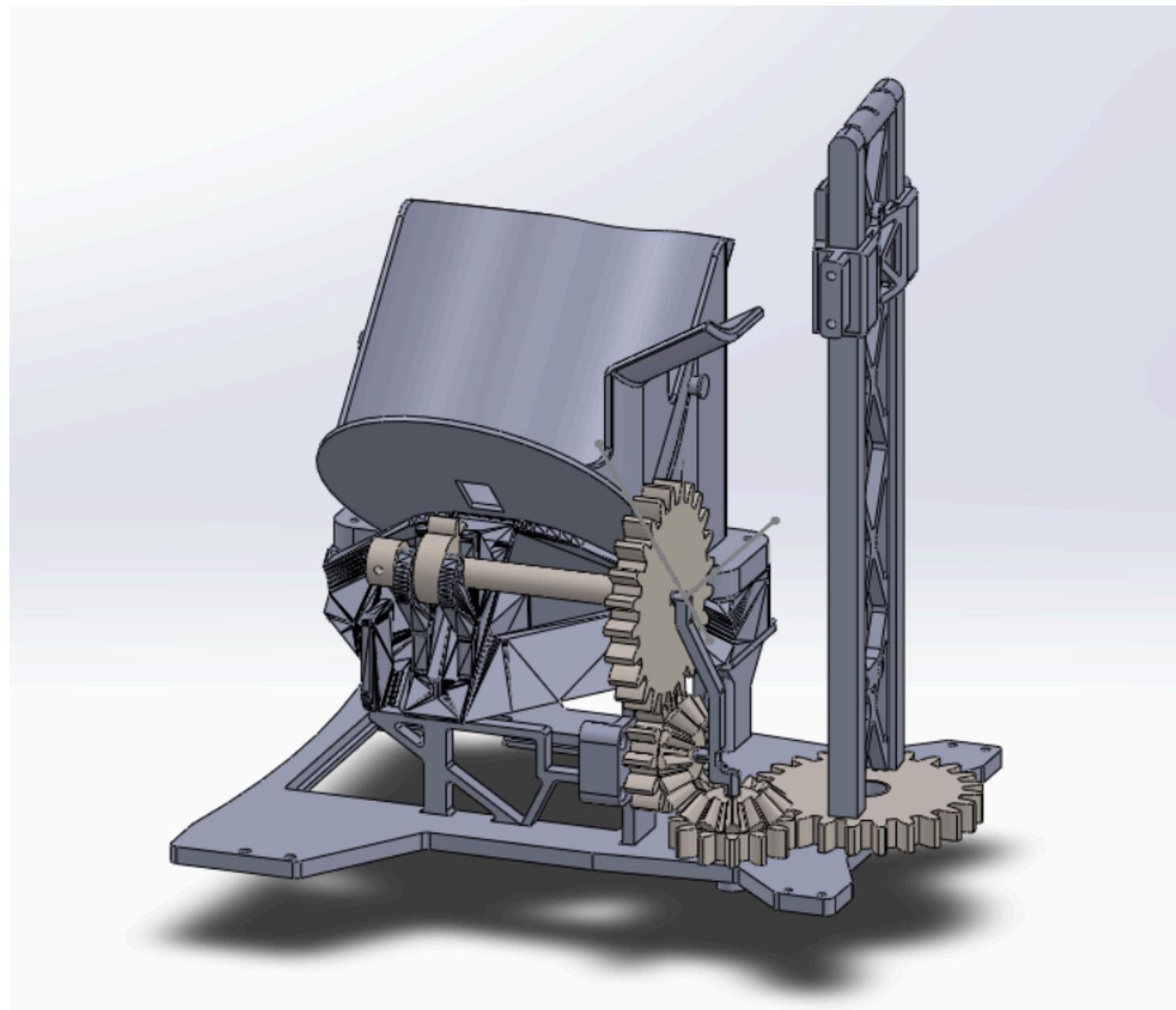


Figure 10.1 - Isometric view of manual CAD.

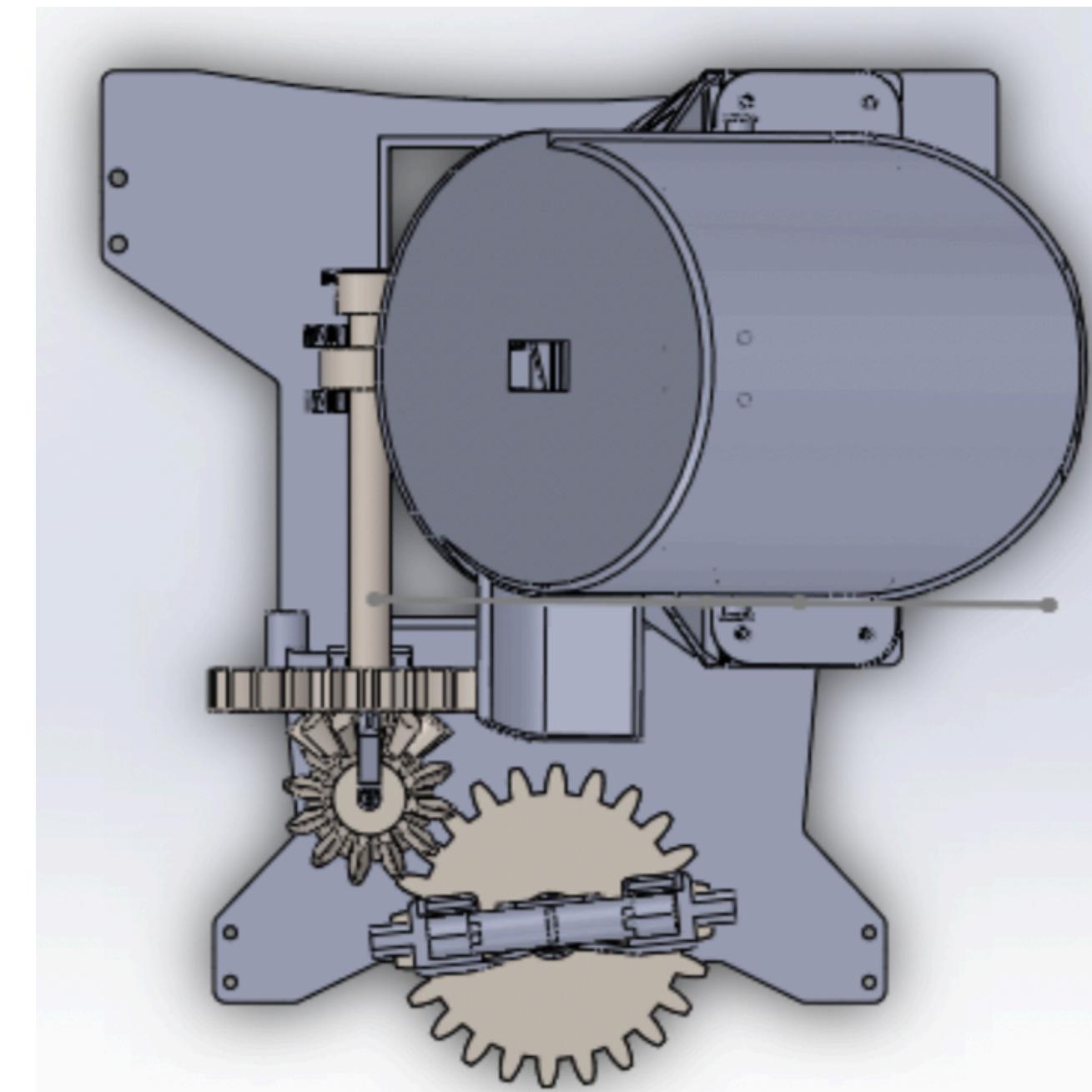


Figure 10.1 - Top view of manual CAD.

# METHODOLOGY 2

## Manual Robot Flowchart

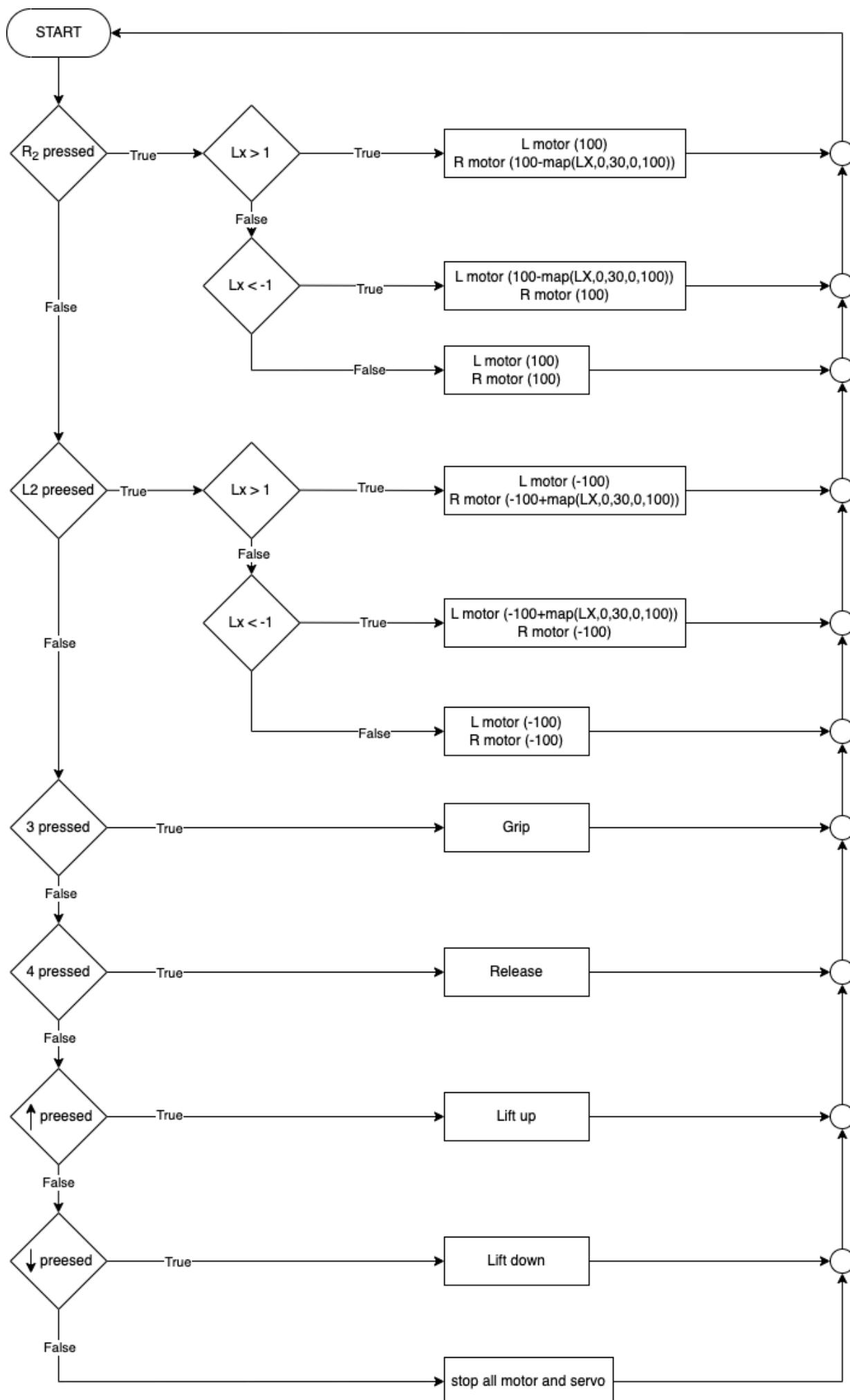
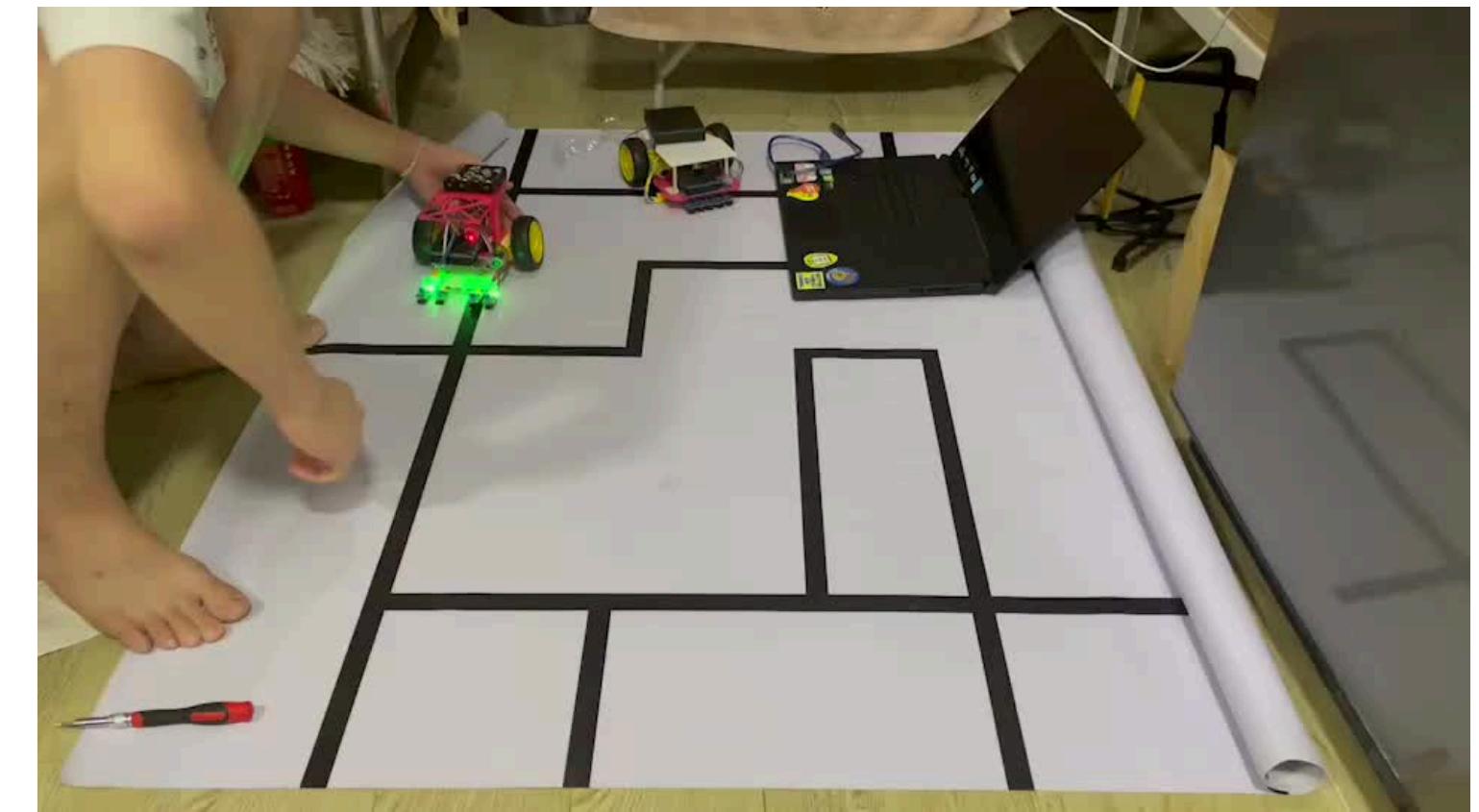


Figure 12.1 - Flowchart of Manual robot

# TEST PROCESS



Video 13.1 - Video testing manual robot



Video 13.2 - Video testing auto robot

# Calculation

## Calculation 1 - Find velocity of the ball in 2 gantries.

- Displacement = velocity<sub>x</sub> x time

$$S = v_x t$$

$$v_x = s/t$$

$$v_x = (0.45m) / (0.49s)$$

$$v_x = \underline{0.92\text{m/s} \pm 0.02\text{m/s}}$$

- Final  $v_y^2 = u_y^2 - 2 \times \text{acceleration} \times \text{displacement}$

$$v_y^2 = u_y^2 - 2as$$

$$0 = u_y^2 - 2(9.8\text{m/s}^2)(0.112)$$

$$u_y = \underline{1.5\text{m/s} \pm 0.1\text{m/s}}$$

- Final initial velocity by pythagoras theorem is

$$= \sqrt{0.92^2 + 1.5^2}$$

$$= \underline{1.75\text{m/s} \pm 0\text{m/s}}$$

## Calculation 2 - Find k of the rubber band

- k in this case is a rubber band elastic constant and can be find with  $0.5kx^2$

$$0.5(k)(\text{displacement})^2 = 0.5(\text{mass})(\text{velocity})^2$$

$$+ (\text{mass})(\text{gravitational acceleration})(\text{height})$$

In this equation you can see that the spring potential energy transforms to mechanical energy.

$$0.5kx^2 = 0.5mv^2 + mgh$$

$$0.5k(0.06\text{m})^2 = 0.5(0.044\text{kg})(1.75\text{m/s})^2 + (0.044\text{kg})(9.8\text{m/s}^2)(0.10\text{m})$$

$$0.5k(0.06\text{m})^2 = 0.074 + 0.043$$

$$0.5k(0.06\text{m})^2 = 0.117 \quad 0.004$$

$$k = (0.117)(2) / (0.06)^2$$

$$k = \underline{61.31\text{N/m} \pm 3\text{N/m}}$$

$$\tau = \underline{0.06\text{Nm} \pm 0.03\text{Nm}}$$

- Yellow DC motor could give out 0.08Nm of torque. This means that we only used 75% of its power. If we don't have the gear reduction the motor would be able to handle twice as much torque.

## Calculation 3 - Find average k(Young's Modulus) from both ball

- 1st k from the green ball =  $61.31\text{N/m} \pm 3\text{N/m}$
- 2nd k from the yellow ball =  $39.59\text{N/m} \pm 1.93\text{N/m}$
- Average =  $\Sigma X / N$   
 $= (61.31 + 39.59) / 2$   
 $= 50.451$   
 $= \underline{50.45\text{N/m} \pm 2\text{N/m}}$

## Calculation 4 - Find torque require

- We know the energy that goes into the spring mechanism can put its energy equal to rational energy.
- $1/2(k)(\text{displacement})^2 = 1/2(\text{moment of inertia})(\text{angular velocity})^2$   
 $0.5(k)(x)^2 = 0.5(I)(\omega)^2$   
 $(50.45)(0.06)^2 = (mr^2)(\omega)^2$   
 $(50.45)(0.06)^2 = (0.0284)(0.039)^2(\omega)^2$   
 $0.18162 = 0.0000431(\omega)^2$   
 $\omega_{\text{shooter}} = \underline{64.84\text{rad/s} \pm 18.97\text{rad/s}}$

- Then  $\omega_{\text{drive}}$  of the second gear(the drive gear) can be found by

$$\begin{aligned} \text{Angular velocity} \times \text{Teeths} &= \text{Angular velocity} \times \text{Teeths} \\ 64.84 \times 24 &= \omega_{\text{drive}} \times 12 \\ \omega_{\text{drive}} &= \underline{129.68\text{rad/s} \pm 37.94\text{rad/s}} \end{aligned}$$

- By  $\omega_r^2 = \omega_i^2 + 2\alpha\theta$   
 $(129.68)^2 = 0 + 2\alpha(2\pi)$   
 $\alpha = \underline{1338.24\text{rad/s}^2 \pm 783.45\text{rad/s}^2}$

- By knowing the alpha of the drive gear, we can also find torque by applying  $\tau = I\alpha$

$$\begin{aligned} \tau &= I\alpha \\ \tau &= (0.0284)(0.039)^2(1338.24) \\ \tau &= 0.057 \end{aligned}$$

## Calculation 5 - Find max weight carrying capacity of the front gripping part

- Yellow motor could handle 0.08Nm
- Torque = radius x Force  
 $\tau = rF$   
 $0.08 = (0.00475)F$   
 $F = 0.08 / (0.00475)$   
 $F = \underline{16.84\text{N} \pm 3.55\text{N}}$
- Since  $T = F$  and T has to be equal to the weight of all material we can say that  
 $T = mg$  : when m is roller mass, gripper mass x2, servo mass x2  
 $T = (\text{roller} + 2\text{gripper} + 2\text{servo} + M)g$   
 $16.84 / 9.8 = 0.0145 + 2(0.0054) + 2(0.009) + (M)$   
 $M = 1.675\text{kg}$   
 $M = \underline{1.68\text{kg} \pm 0.36\text{kg}}$
- This means that for the maximum power input the motor can lift 1.68kg.

## Calculation 6 - Find the gear revolution for 1 spin of the gripper part

- Angular velocity x Teeths = Angular velocity x Teeths  
 $R \times 12 = 1 \text{ Revolution/s} \times 24$   
 $R = \underline{2 \text{ Revolution/s}}$

∴ When the drive gear turn 2 revolutions the big gear would spin just once.

# Calculation

## Propagation of uncertainty

CASE/FUNCTION	PROPAGATED ERROR
$z = ax \pm b$	$\delta z = a \cdot \delta x$
$z = x \pm y$	$\delta z = [(\delta x)^2 + (\delta y)^2]^{\frac{1}{2}}$
$z = cxy$	$\frac{\delta z}{z} = \left[ \left( \frac{\delta x}{x} \right)^2 + \left( \frac{\delta y}{y} \right)^2 \right]^{\frac{1}{2}}$
$z = c\frac{x}{y}$	$\frac{\delta z}{z} = \left[ \left( \frac{\delta x}{x} \right)^2 + \left( \frac{\delta y}{y} \right)^2 \right]^{\frac{1}{2}}$
$z = cx^a$	$\frac{\delta z}{z} = a \frac{\delta x}{x}$
$z = cx^a y^b$	$\frac{\delta z}{z} = \left[ \left( a \frac{\delta x}{x} \right)^2 + \left( b \frac{\delta y}{y} \right)^2 \right]^{\frac{1}{2}}$
$z = \sin x$	$\frac{\delta z}{z} = \delta x \cot x$
$z = \cos x$	$\frac{\delta z}{z} = \delta x \tan x$
$z = \tan x$	$\frac{\delta z}{z} = \frac{\delta x}{\sin x \cos x}$

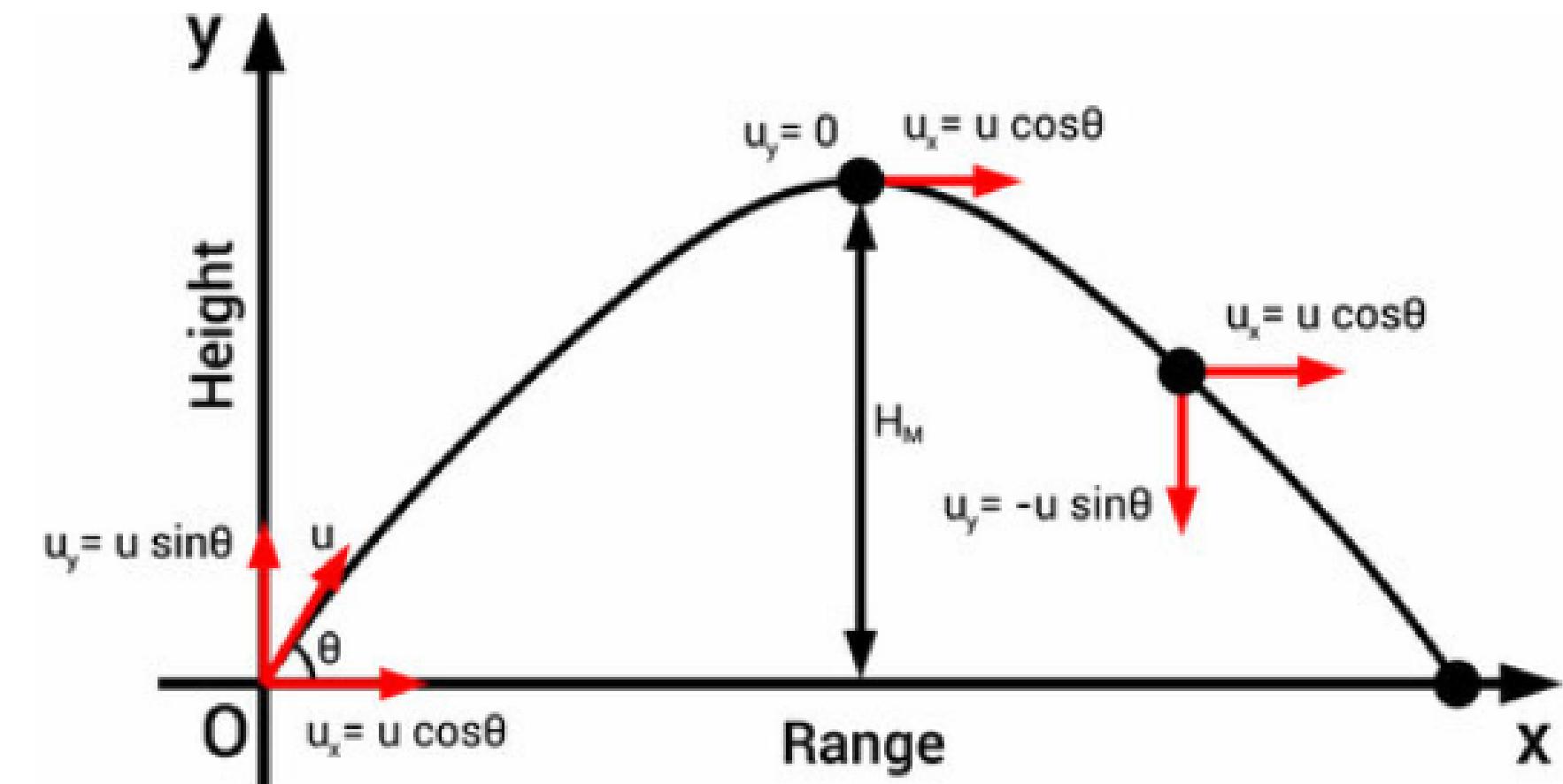


Figure 14.1 - The diagram illustrates Displacement X and Y which paint the picture for the upcoming table.

# RESULT

The diagram illustrates Displacement X and Y which paint the picture for the upcoming table.

The table shows displacement in x, time, and velocity of both balls .

Trials	Green ball			Yellow ball		
	Displacement X	Time	velocity	Displacement X	Time	velocity
1	0.450m±0.001m	0.49s±0.01s	0.92m/s±0.02m/s	0.880m±0.001m	0.42s±0.01s	2.10m/s±0.04m/s
2	0.448m±0.001m	0.47s±0.01s	0.95m/s±0.02m/s	0.871m±0.001m	0.40s±0.01s	2.18m/s±0.04m/s
3	0.451m±0.001m	0.50s±0.01s	0.90m/s±0.02m/s	0.896m±0.001m	0.43s±0.01s	2.08m/s±0.04m/s

The table shows displacement in y, time, and velocity of both balls .

Trials	Green ball		Yellow ball	
	Displacement Y	velocity	Displacement Y	velocity
1	0.112m±0.001m	1.48m/s±0.05m/s	0.188m±0.001m	1.92m/s±0.06m/s
2	0.115m±0.001m	1.50m/s±0.05m/s	0.190m±0.001m	1.93m/s±0.06m/s
3	0.116m±0.001m	1.51m/s±0.05m/s	0.189m±0.001m	1.92m/s±0.06m/s

- Mass of the Green and Yellow balls is  $0.0440\text{kg} \pm 0.001\text{kg}$  and  $0.0143\text{kg} \pm 0.001\text{kg}$ , respectively.
- Average K is  $50.451\text{N/m}$  and the torque required is  $0.06\text{Nm} \pm 0.03\text{Nm}$
- The drive gear has to be turned two times in order to rotate the front part once.
- The maximum load the motor can handle is  $1.68\text{kg} \pm 0.36\text{kg}$ , friction and other resistance force not included.

FUTURE WORK  
FUTURE WORK  
FUTURE WORK  
FUTURE WORK



# REFERENCE

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