FINAL PROJECT

Line-following robot and Manual robot

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BACKGROUND RESEARCH
Straight Bevel Gear

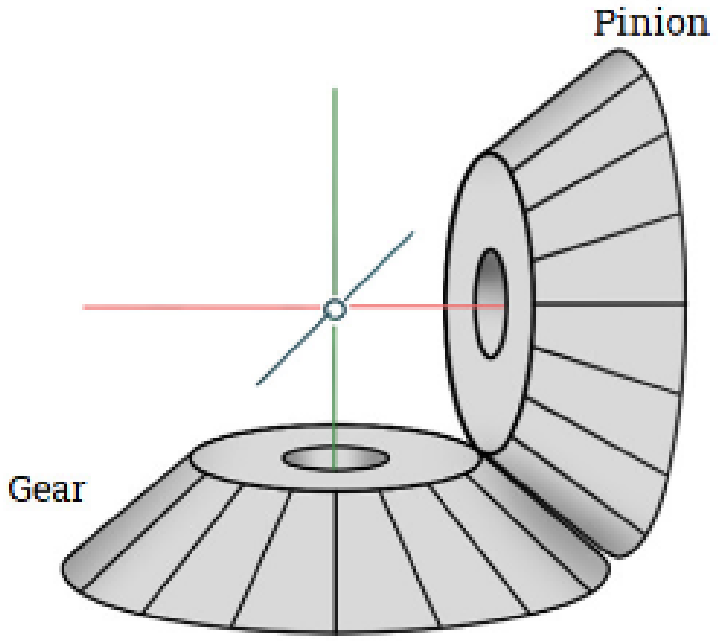


Figure 1.1 - Meshing of Pinion and Gear

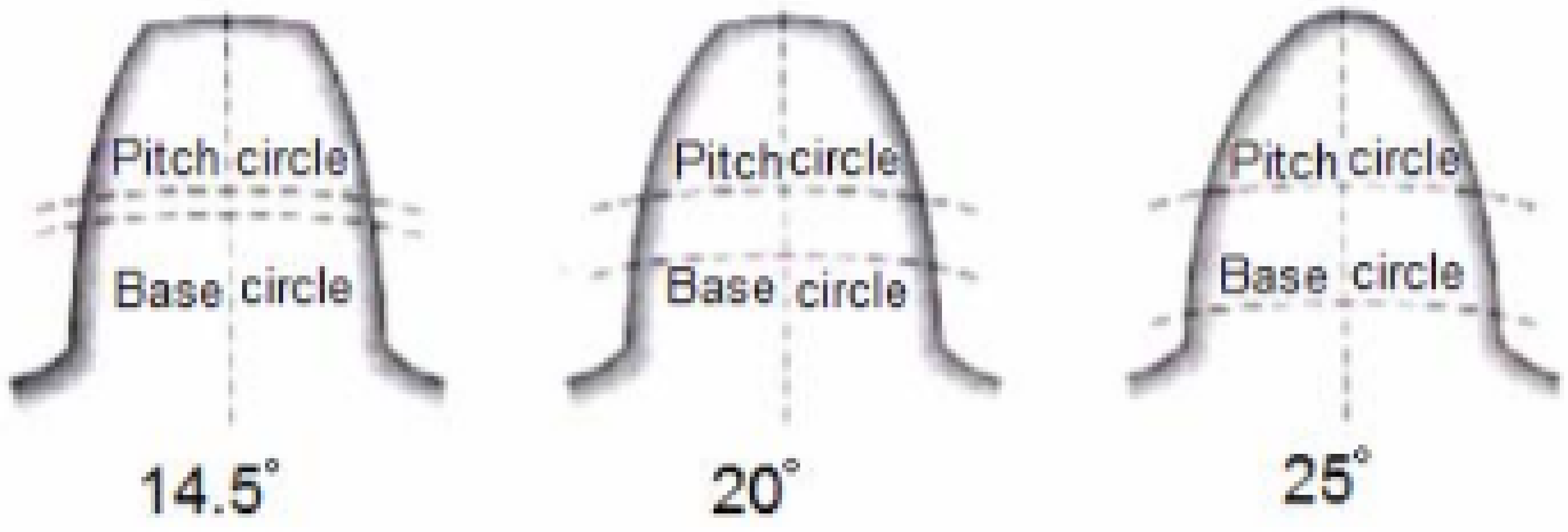


Figure 1.3 - Gear Tooth Profile for different Pressure Angles

Figure 1.2 - Straight Bevel Gear

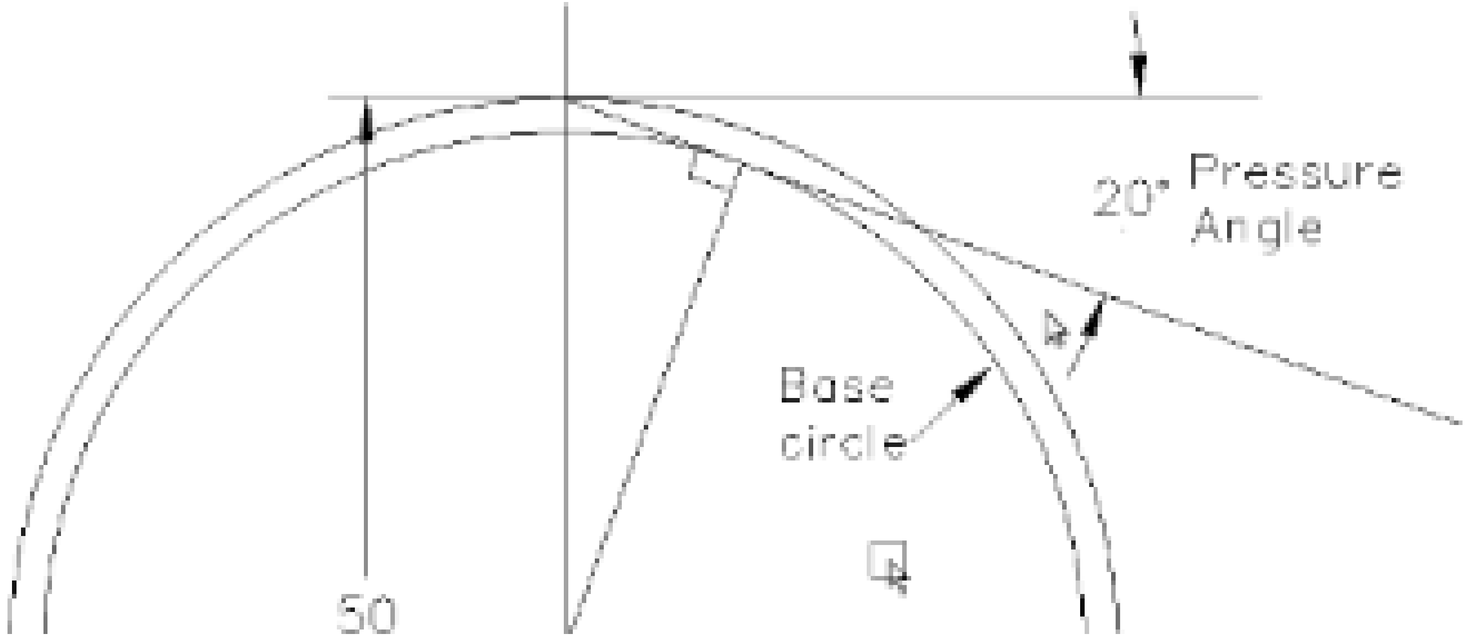


Figure 1.4 - Pressure Angle of gear

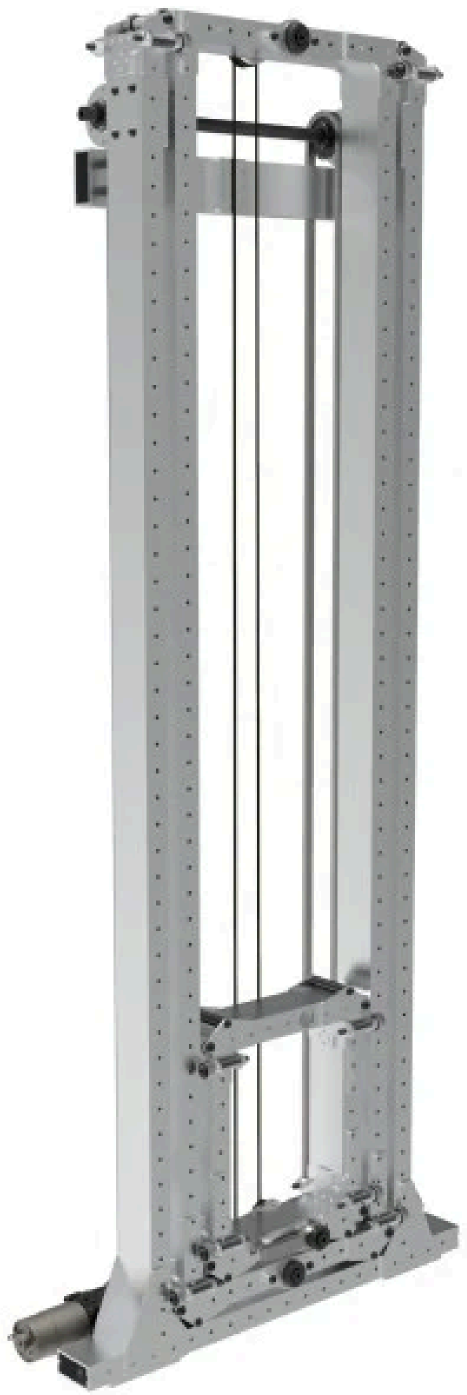


Figure 2.1 -Elevator

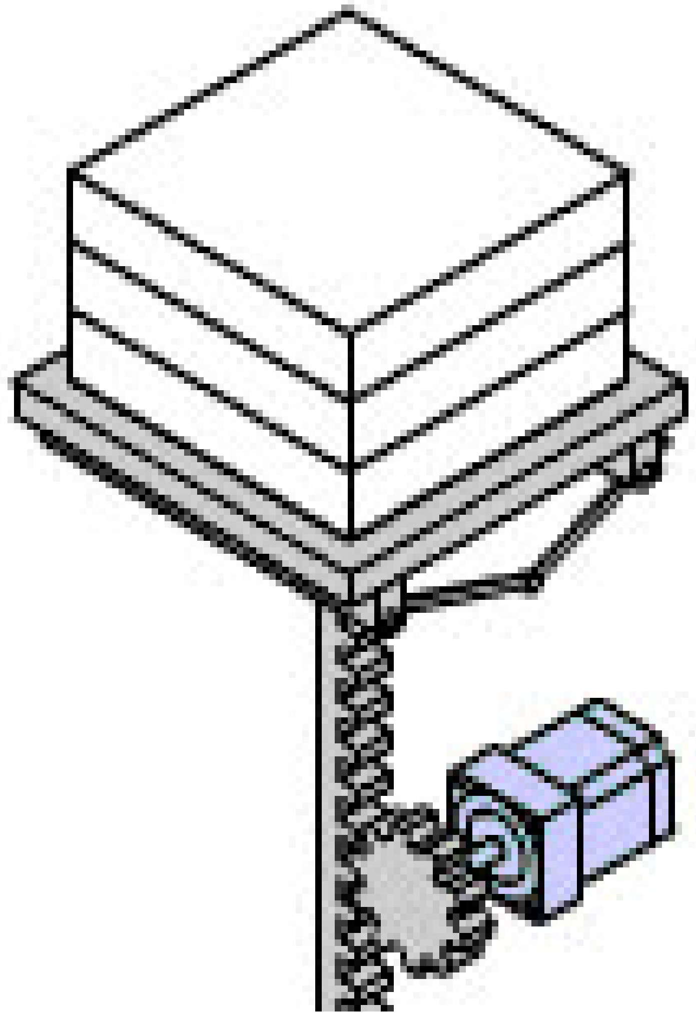


Figure 2.2 - Load Elevator

Gripper

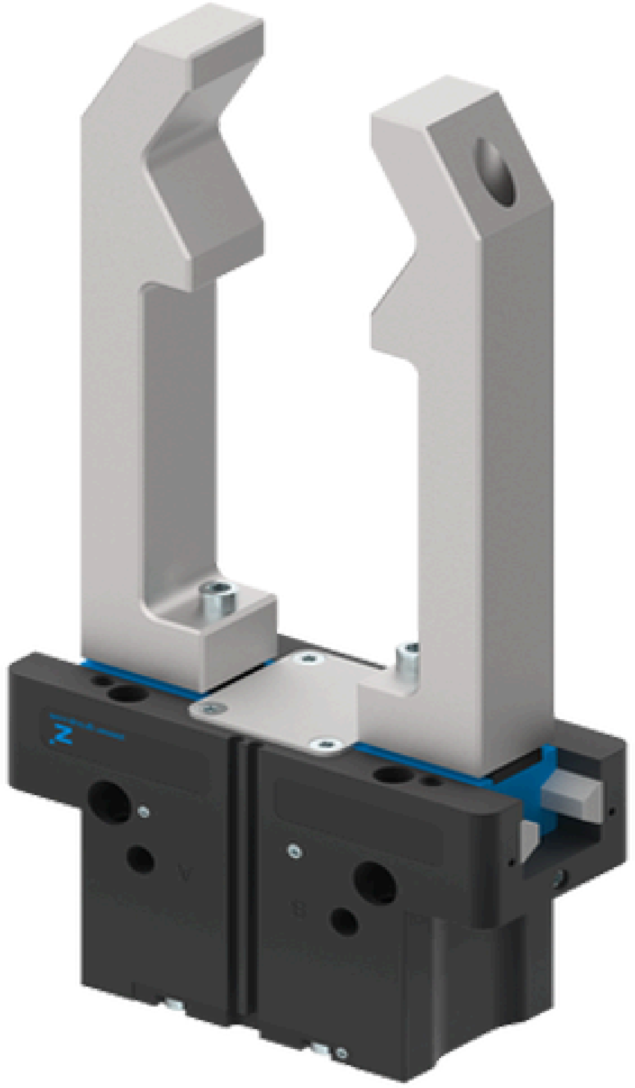


Figure 3.1 - Jaw Gripper

Figure 3.2 - Angular Gripper

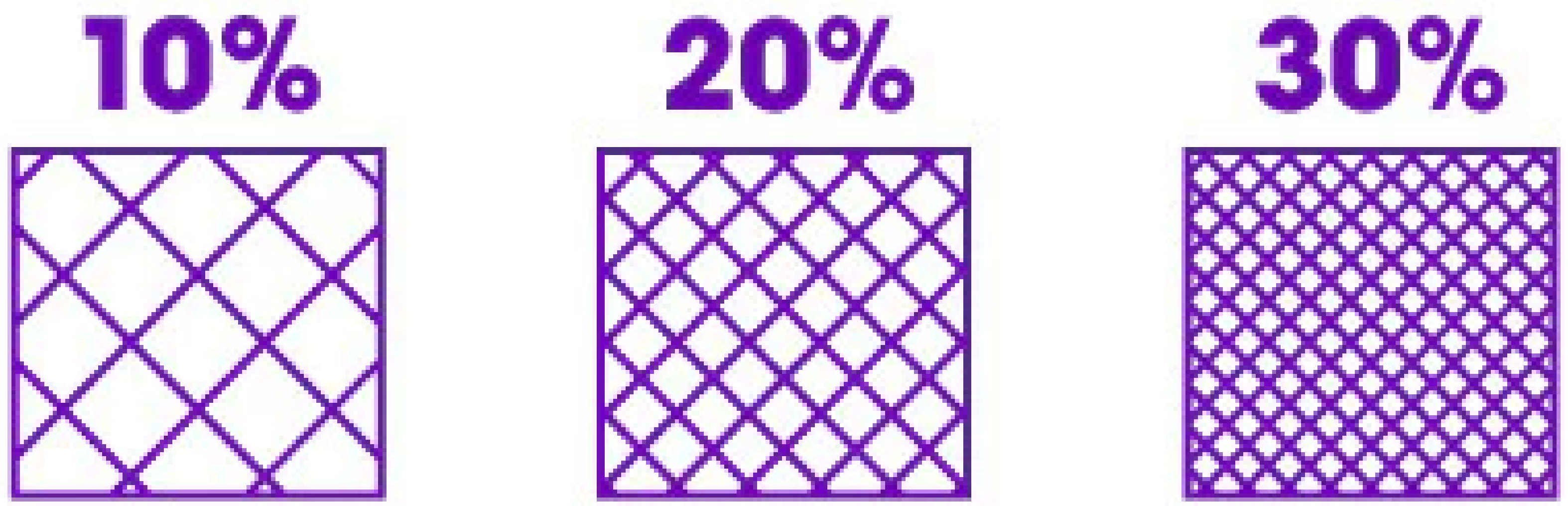


Figure 4.1 - Infill Percentage of 3D Printing

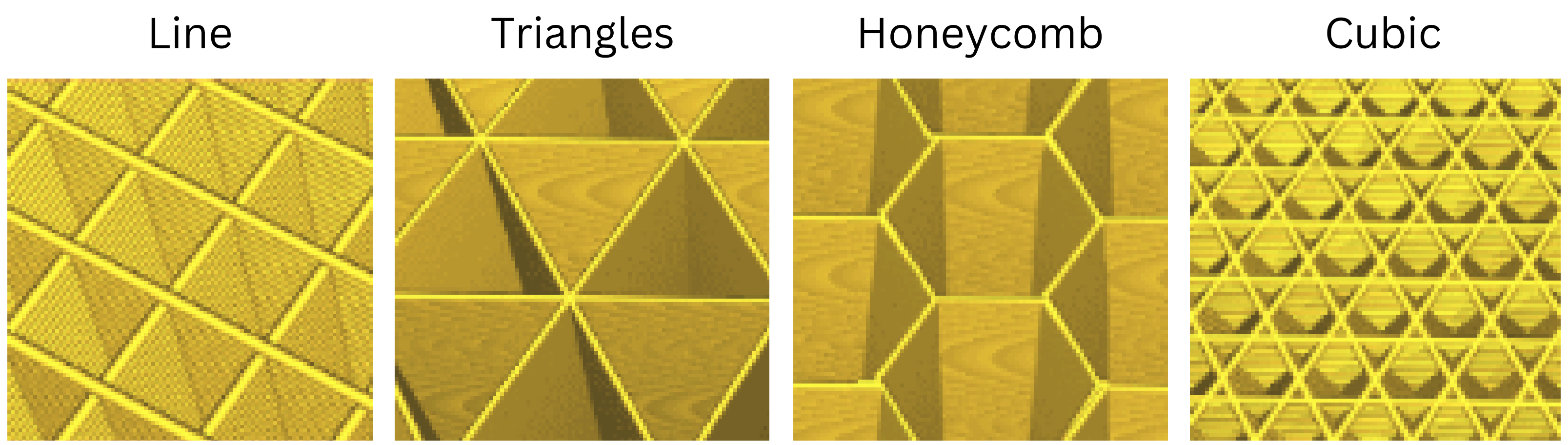


Figure 4.2 - Example of Grid Infill patterns

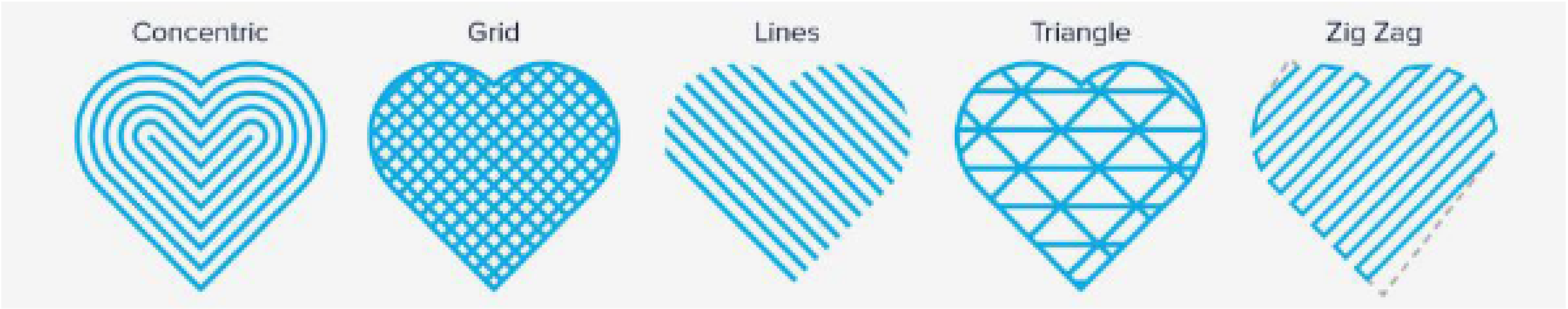


Figure 4.3 - Example of Support Pattern

METHODOLOGY 1

Line follower

List of component

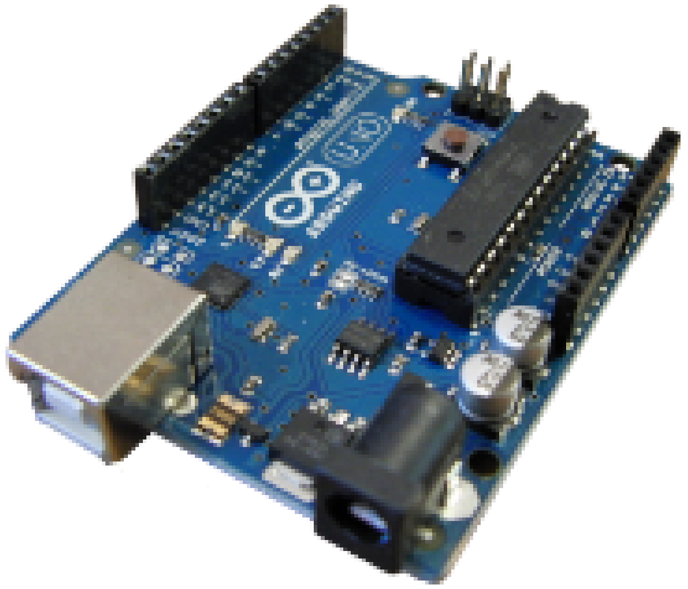


Figure 5.1 - Arduino UNO

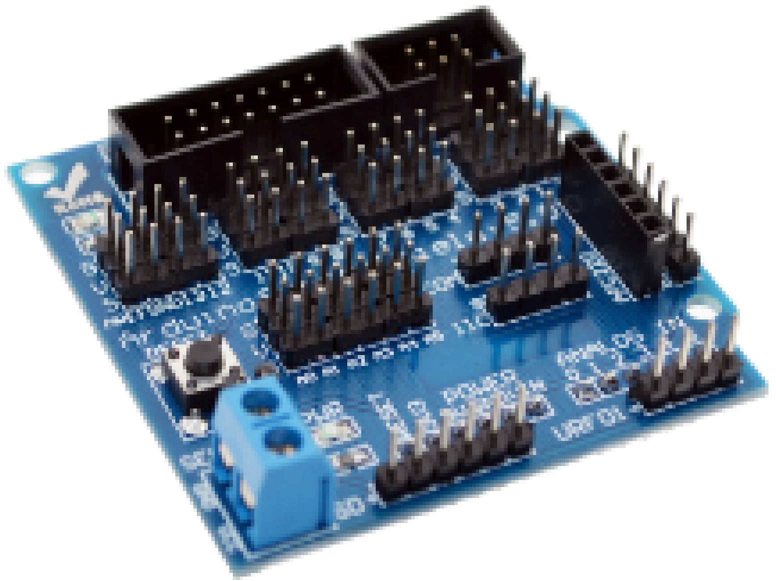


Figure 5.2 - Sensor Shield V5.0

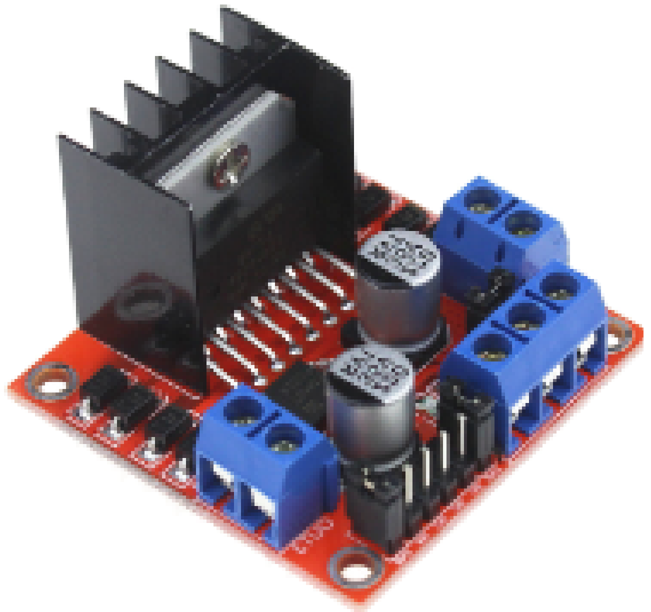


Figure 5.3 - Motor driver

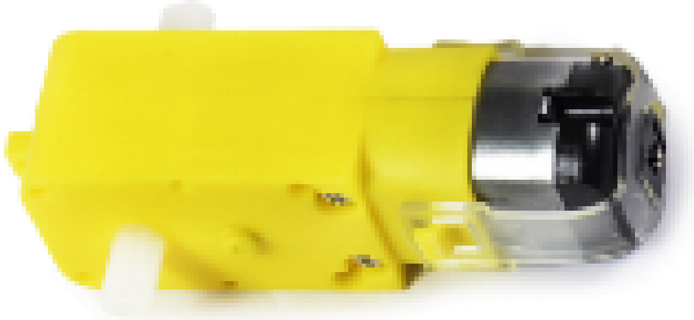


Figure 5.4 - 3-6V Yellow DC Gear Motor

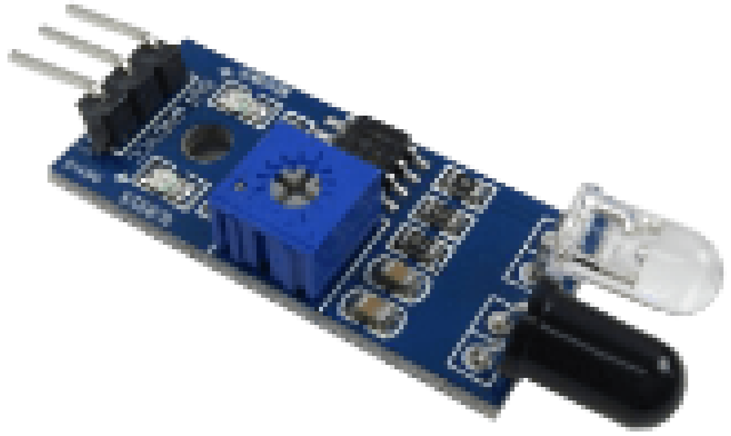


Figure 5.5 - IR Sensor

Figure 5.6 - Battery AA

METHODOLOGY 1
Line follower
Design

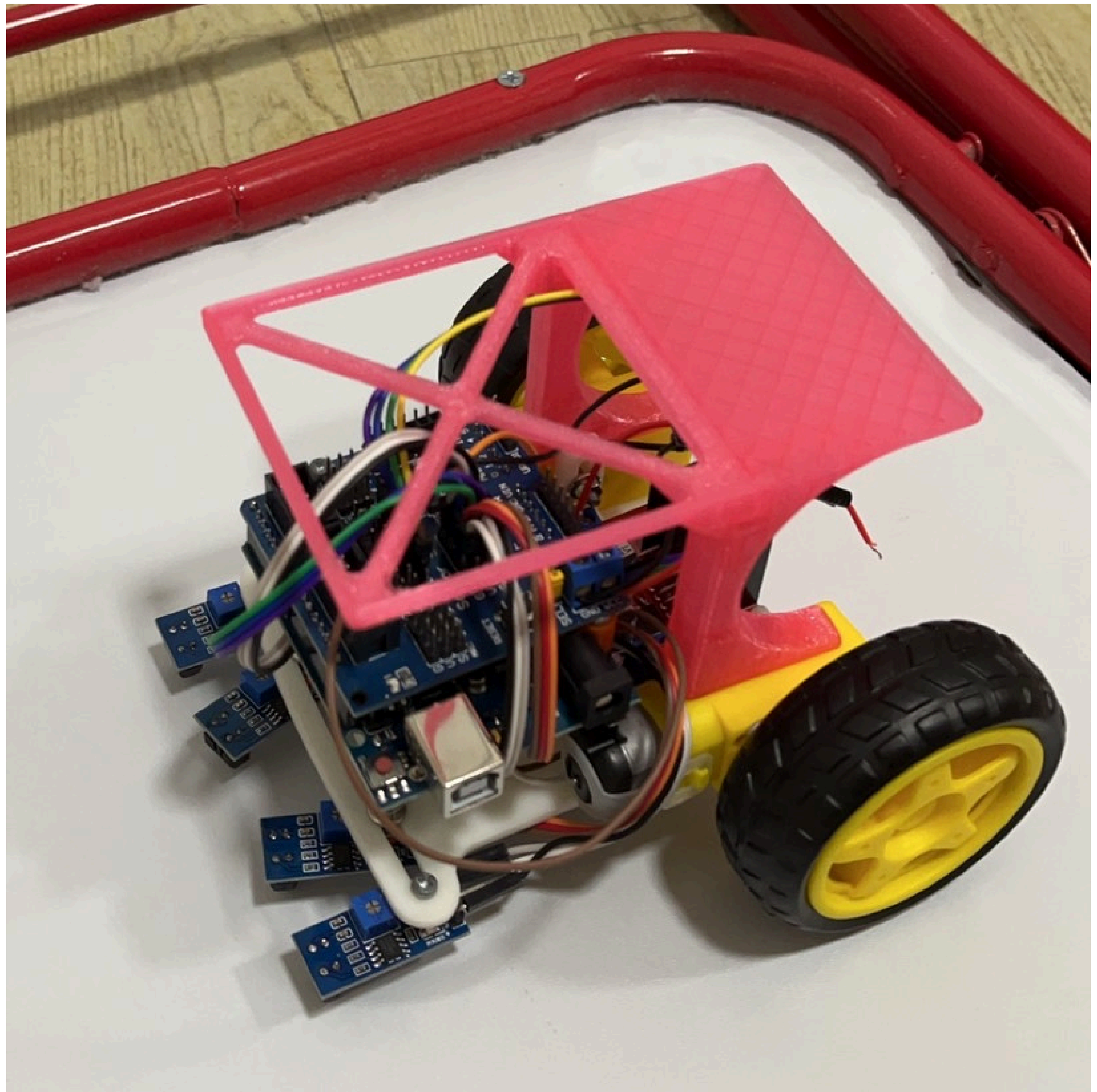


Figure 6.1 - Line Following Robot

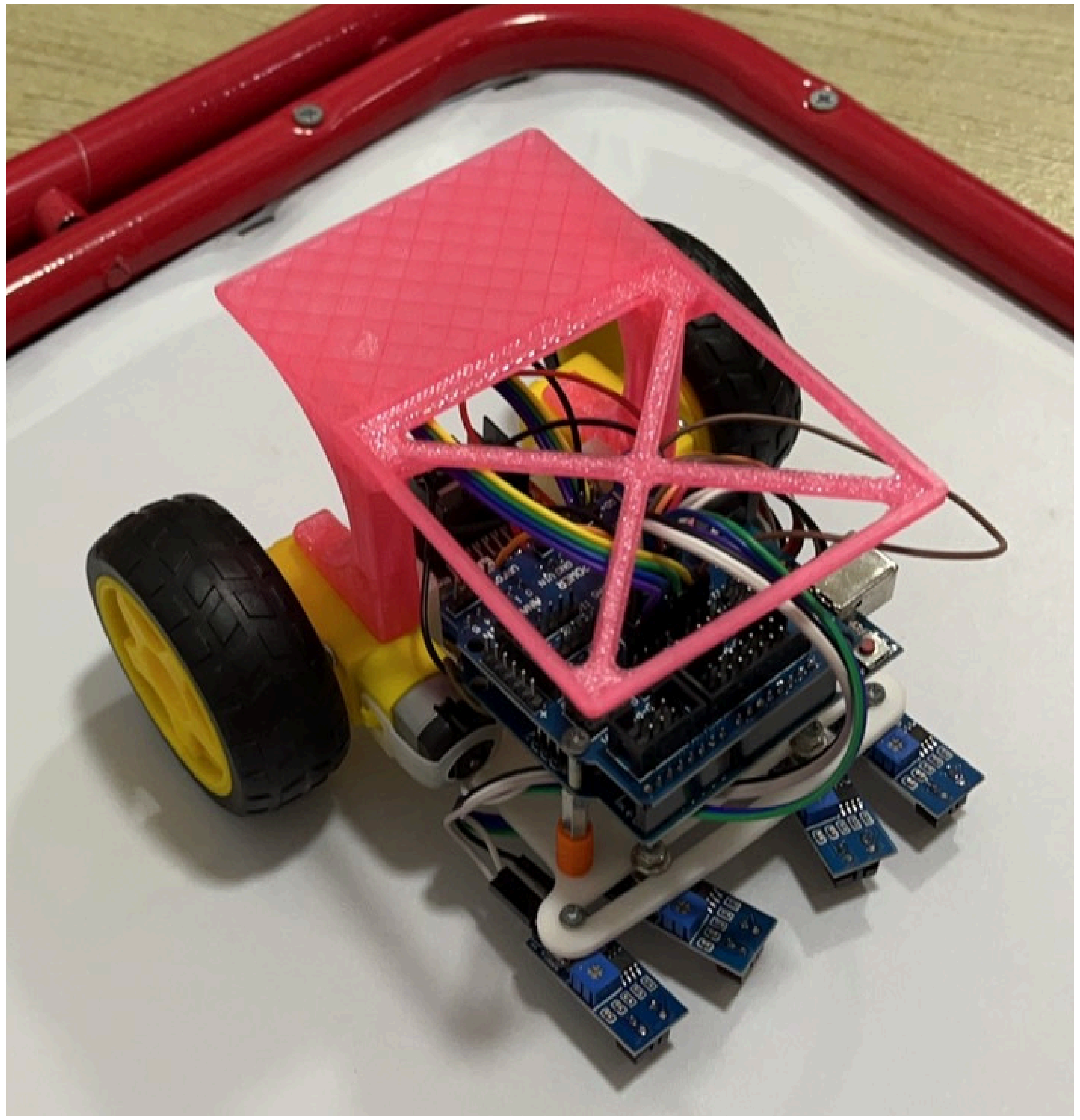


Figure 6.2 - Line Following Robot

METHODOLOGY 1
Line follower
Flowchart

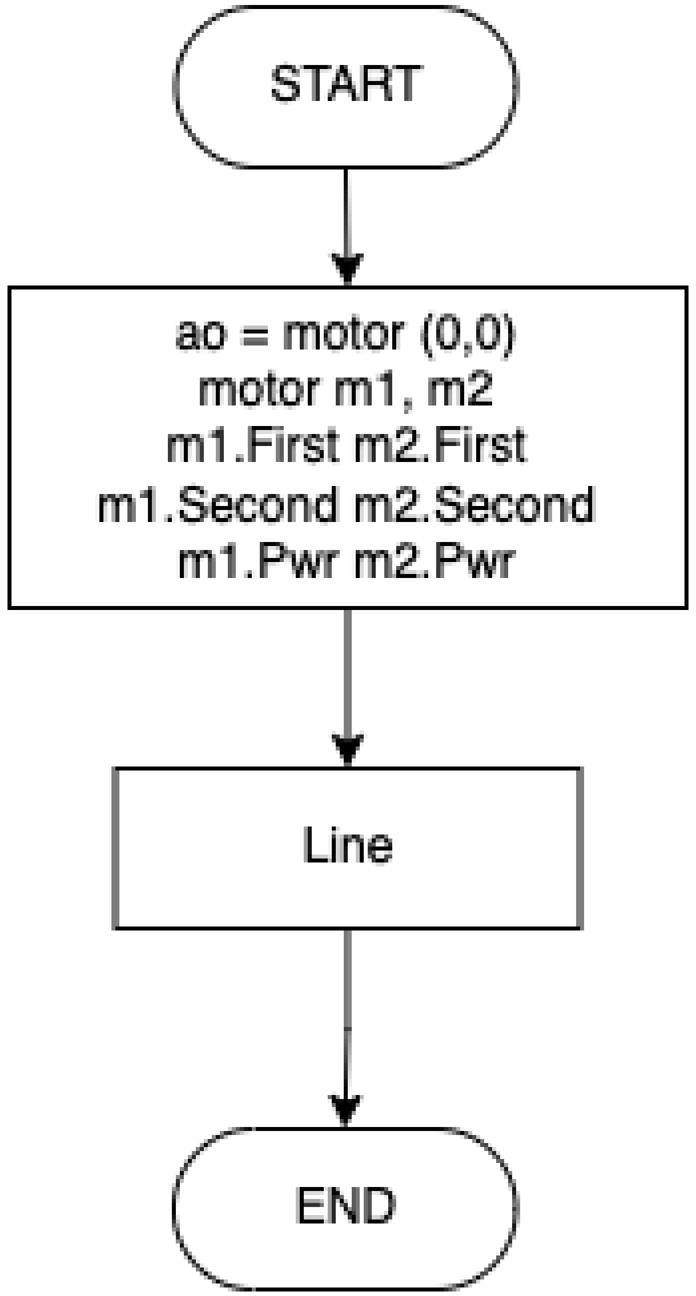


Figure 8.1 - Variable Declaration Flowchart

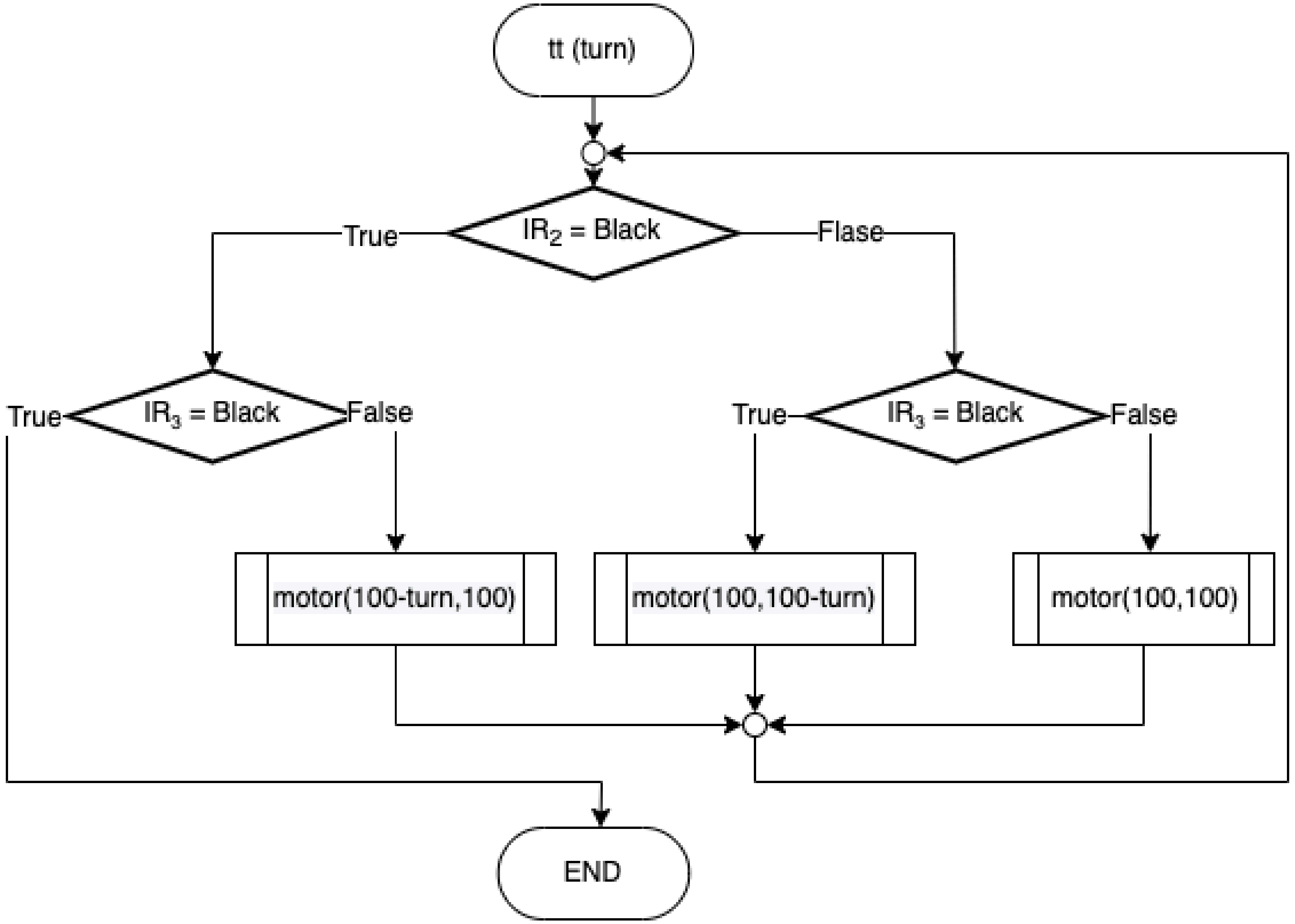


Figure 8.2 - Tracking Line Flowchart

METHODOLOGY 1
Line follower
Flowchart

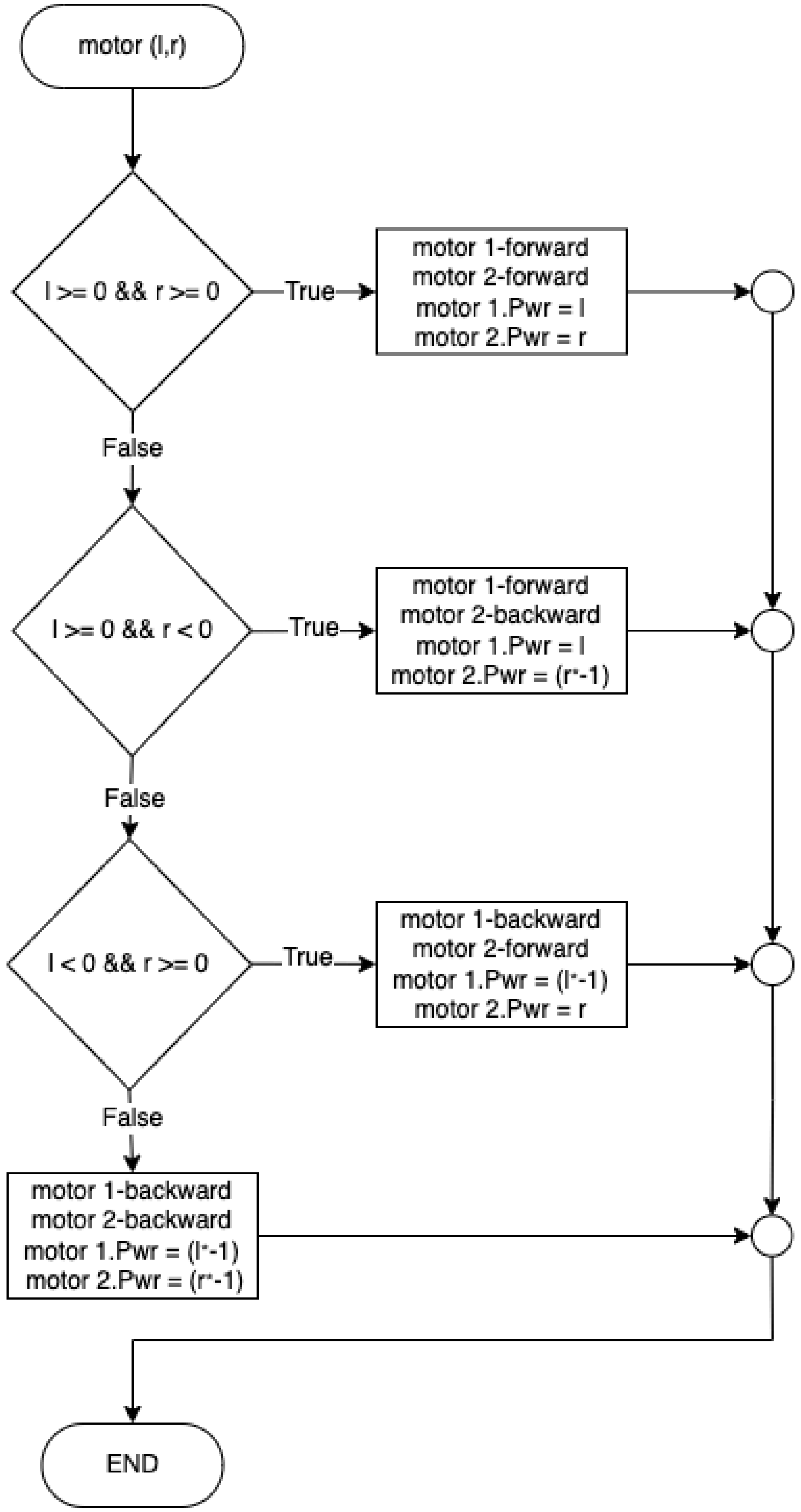


Figure 8.3 - Movement Control Flowchart

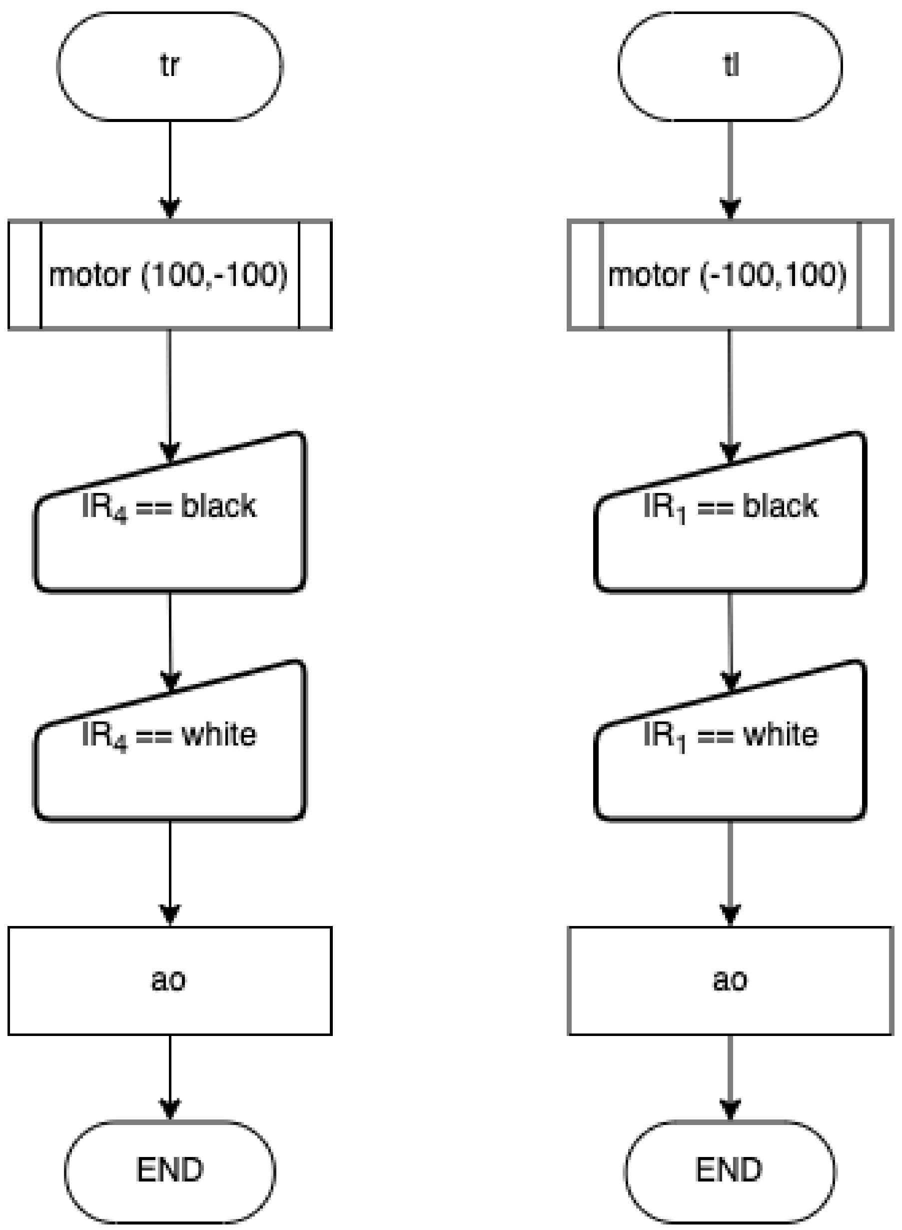


Figure 8.3 - Robot Movement Control Flowchart

METHODOLOGY 2
Manual Robot
List of component

Figure 9.1 - Cyber Pi

Figure 9.2 - Makeblock Controller

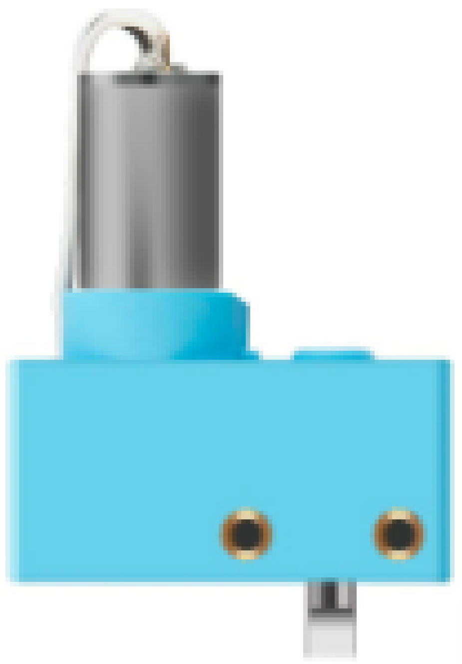


Figure 9.3 - Makeblock 180 Encoder Motor

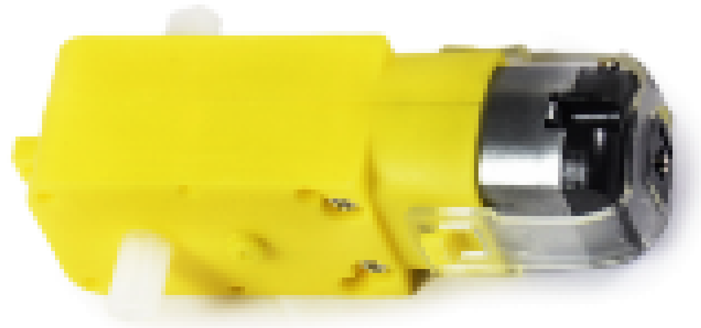


Figure 9.4 - 3-6V Yellow DC Gear Motor

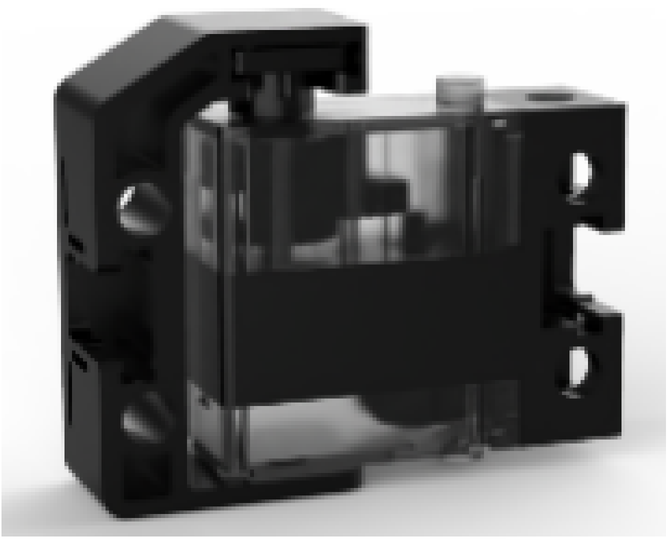


Figure 9.5 - Makeblock MS-1.5 Servo

Figure 9.6 - Makeblock Digital Servo

Manual Robot Design

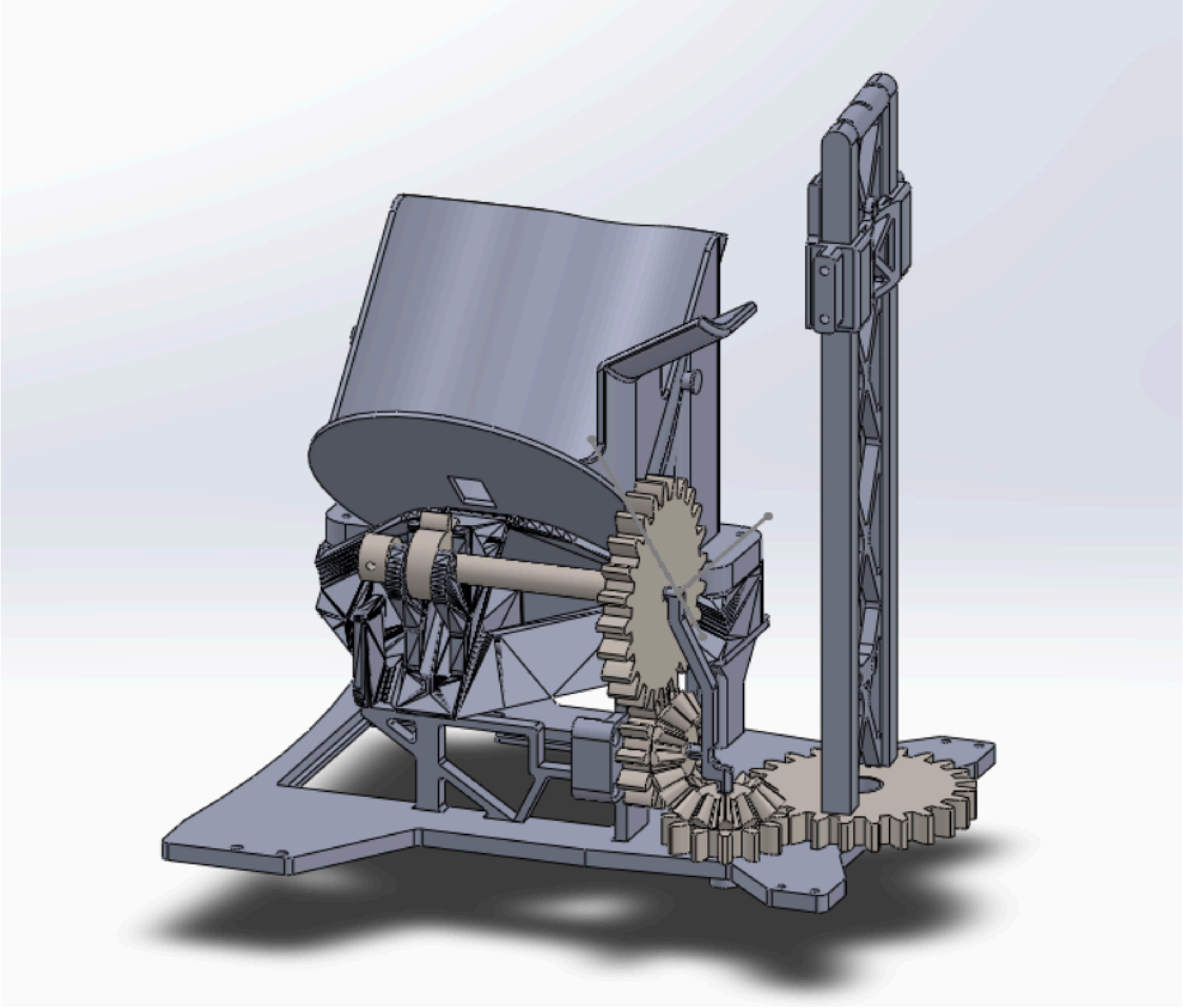


Figure 10.1 - Isometric view of manual CAD.

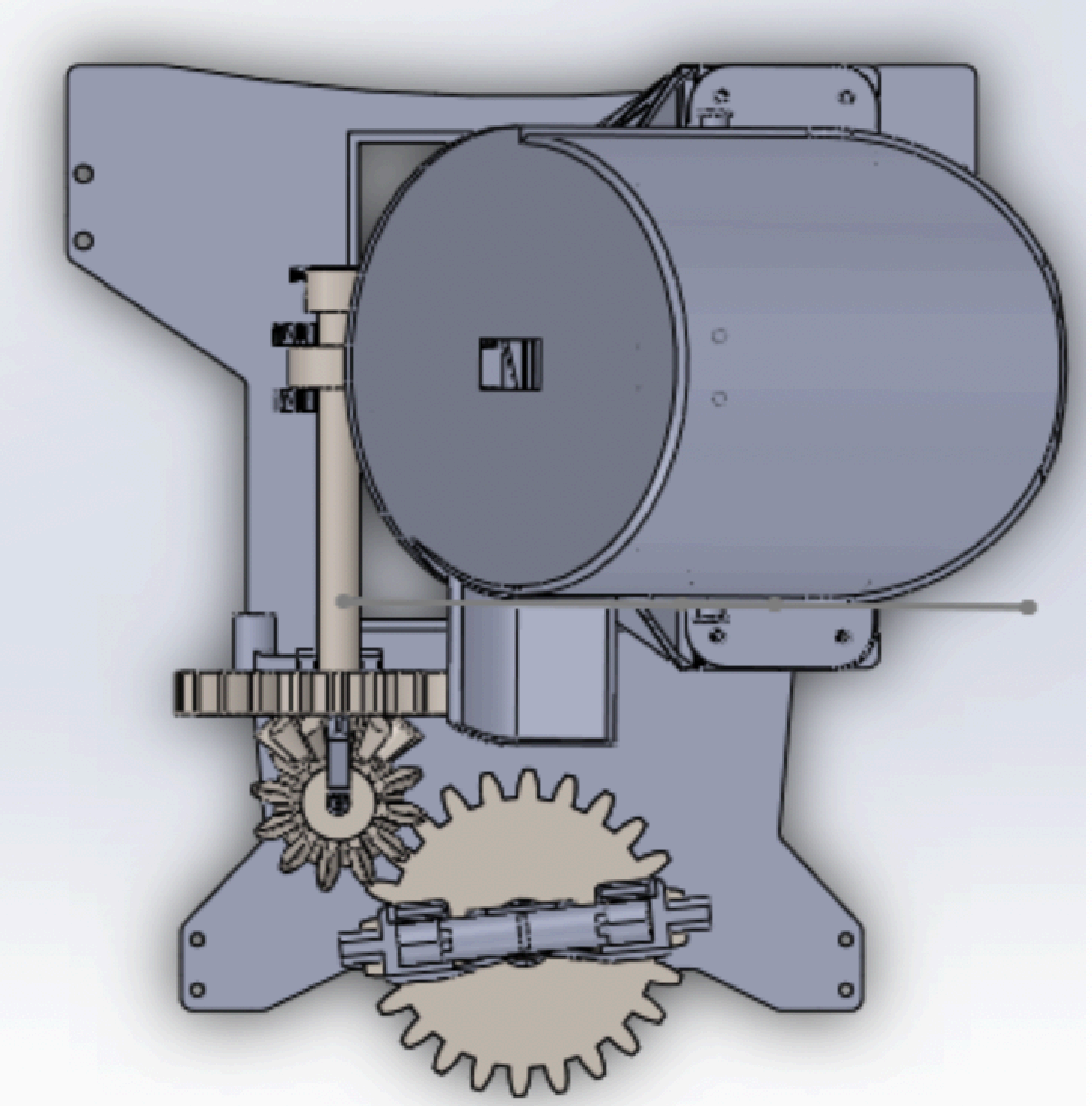


Figure 10.1 - Top view of manual CAD.

METHODOLOGY 2
Manual Robot
Flowchart

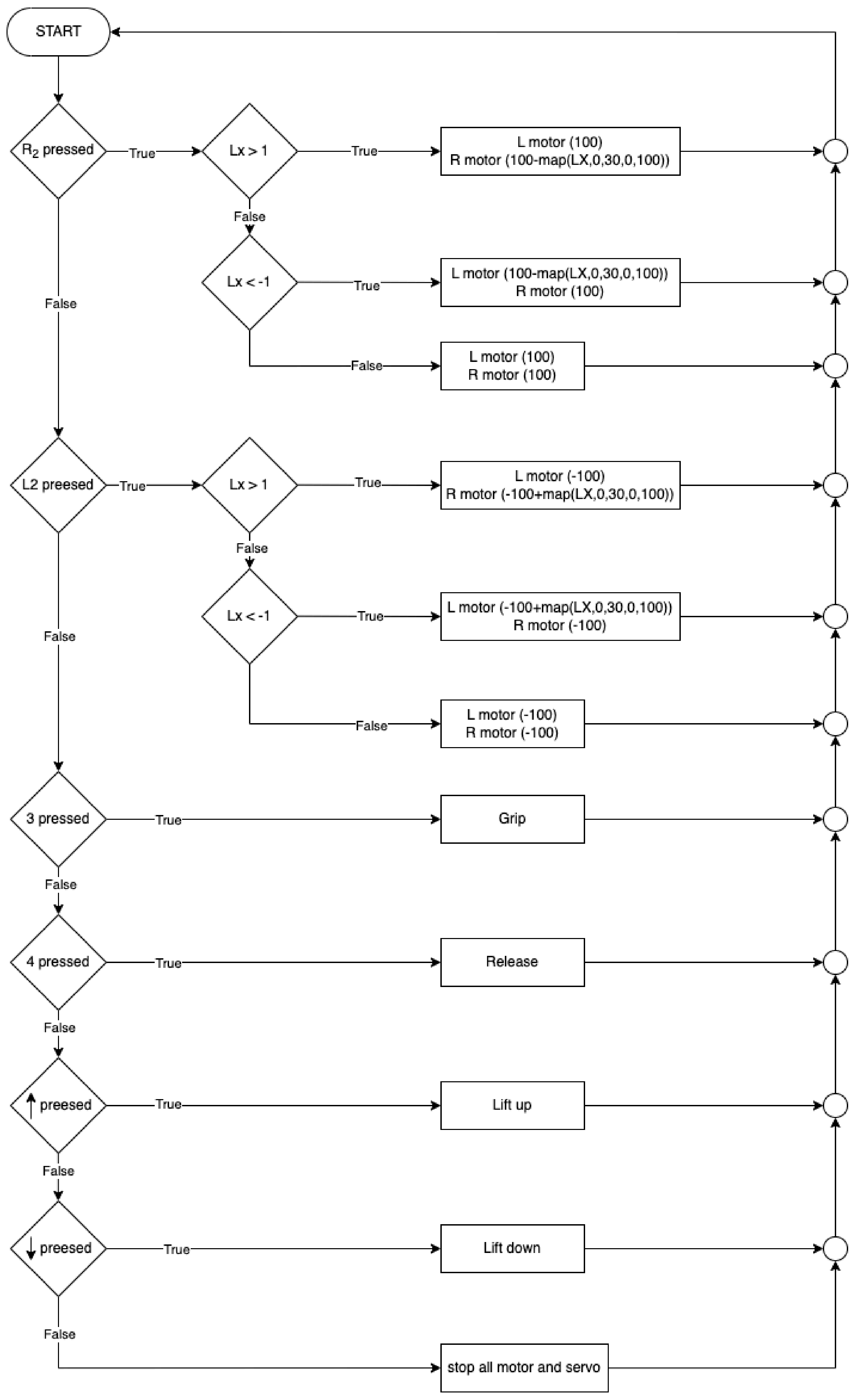
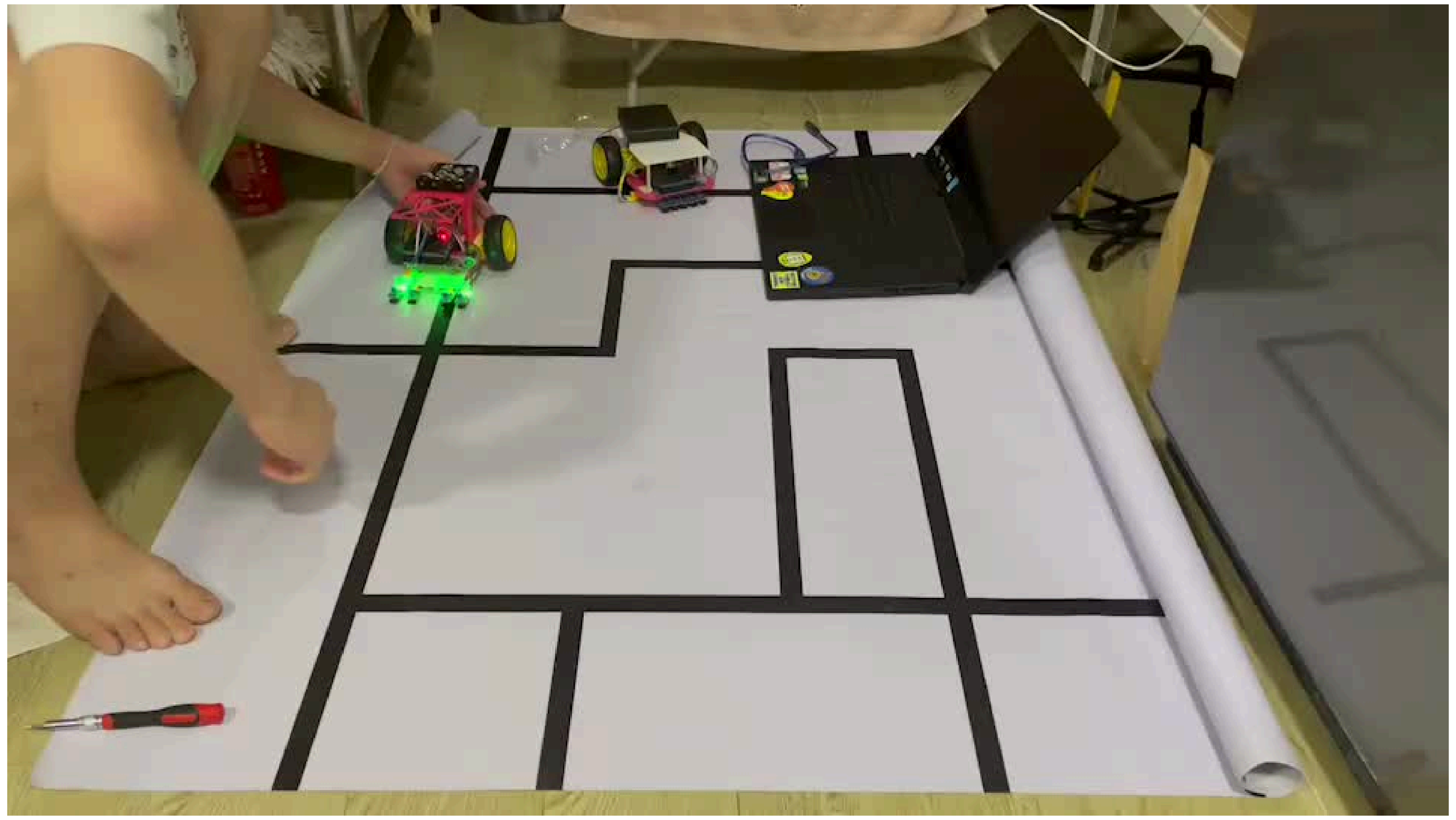


Figure 12.1 - Flowchart of Manual robot

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 = $velocity_x$ x time

  $S = v_x t$

  $v_x = s/t$

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

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

- Final $v_y^2 = u_y^2$ - 2 x acceleration x displacement

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

  $0 = u_y^2 - 2(9.8m/s^2)(0.112)$

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

- Final initial velocity by pythagoras theorem is

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

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

Calculation 2 - Find k of the rubber band

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

  $0.5(k)(displacement)^2 = 0.5(mass)(velocity)^2$

  $+ (mass)(gravitational\ acceleration)(height)$

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

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

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

  $0.5k(0.06m)^2 = 0.074 + 0.043$

  $0.5k(0.06m)^2 = 0.117\ 0.004$

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

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

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

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

Calculation 4 - Find torque require

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

- Then ω_{drive} of the second gear(the drive gear) can be found by
  Angular velocity x Teeths = Angular velocity x Teeths
  $64.84 \times 24 = \omega_{drive} \times 12$
  $\omega_{drive} = \underline{129.68rad/s \pm 37.94rad/s}$

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

- By knowing the alpha of the drive gear, we can also find torque by applying $\tau = I\alpha$
  $\tau = I\alpha$
  $\tau = (0.0284)(0.039)^2(1338.24)$
  $\tau = 0.057$
  $\tau = \underline{0.06Nm \pm 0.03Nm}$

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

- Yellow motor could handle 0.08Nm
- Torque = radius x Force
  $\tau = rF$
  $0.08 = (0.00475)F$
  $F = 0.08 / (0.00475)$
  $F = \underline{16.84N \pm 3.55N}$

- 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 = (roller + 2gripper + 2servo + M)g
  16.84/9.8 = 0.0145 + 2(0.0054) + 2(0.009) + (M)
  M = 1.675kg
  M = <u>1.68kg ± 0.36kg</u>

- 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 x 12 = 1 Revolution/s x 24
  R = <u>2 Revolution/s</u>

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

Calculation

Propagation of uncertainty

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

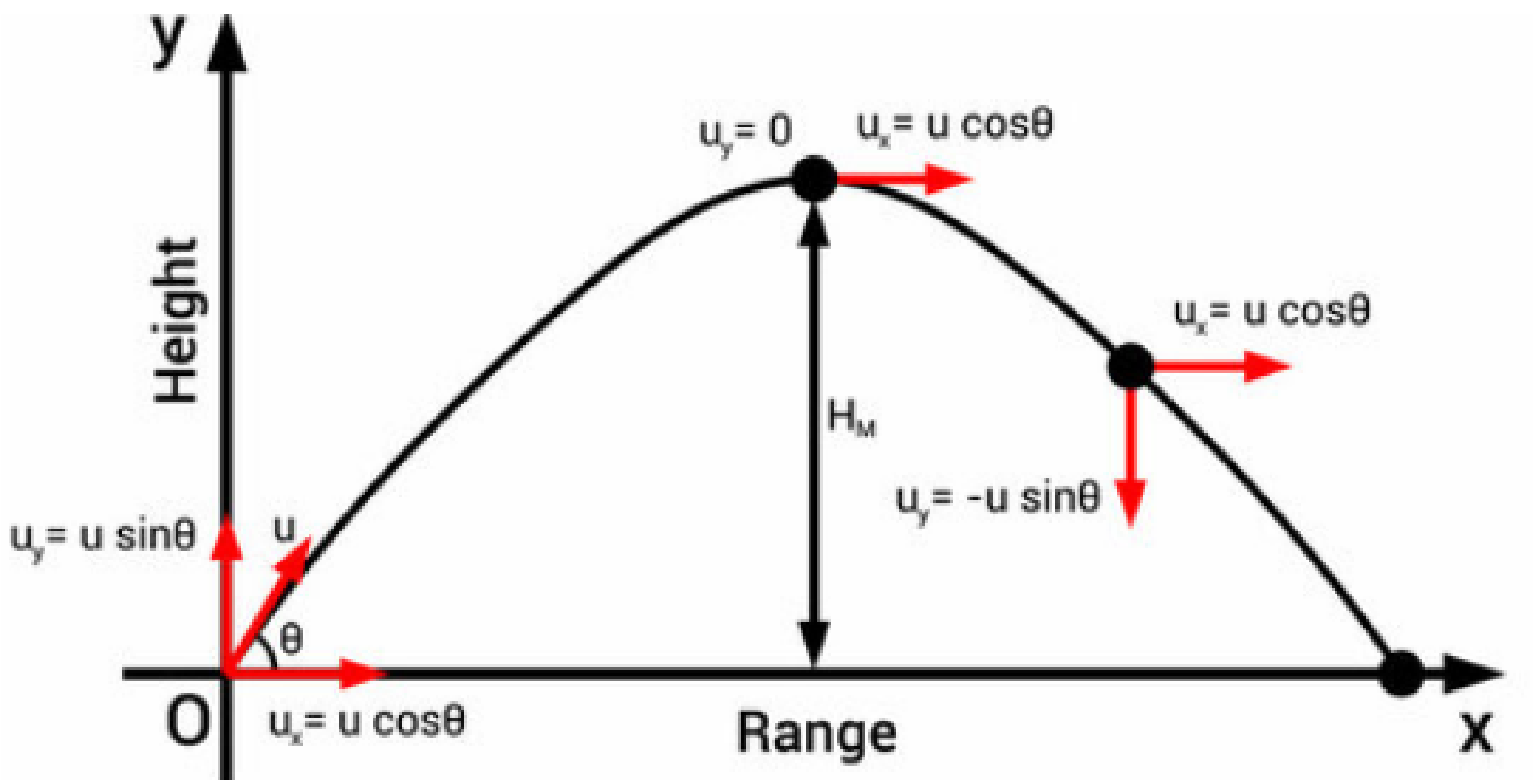


Figure 14.1 - The diagram illustrates Displacement X and Y which paint the picture for the upcoming table.

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 0.0440kg ± 0.001kg and 0.0143kg ± 0.001kg, respectively.
- Average K is 50.451N/m and the torque required is 0.06Nm ± 0.03Nm
- 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 1.68kg ± 0.36kg, friction and other resistance force not included.

FUTURE WORK

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FUTURE WORK

REFERENCE

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