ENGINEERING

McMaster University

Project Three –There's A Recyclable Among Us:

Design a System for Sorting and Recycling Containers

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial T02

Team Mon-32

Juliana Konstantinou (konstanj)

Benjamin Richler (richlerb)

Thivagar Yogaratnam(yogaratt)

Gurleen Dhillon (dhillg25)

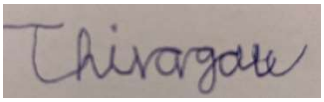
Submitted: March 7, 2021

Table of Contents

Academic Integrity Statement

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Thivagar Yogaratnam 400213615



The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Benji Richler 400296988

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Juliana Konstantinou 400334350

The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Gurleen Dhillon 400301955

Executive Summary

For this project we had to design a system that will sort and recycle various bottles of different materials [1]. In Canada, roughly 30% of containers placed in recycling bins are not recyclable [2], and because of this, only 9% of recyclable plastics get recycled [3]. It is important that the containers are separated and sorted properly so that we can maximize the number of items being recycled instead of it all going to landfills.

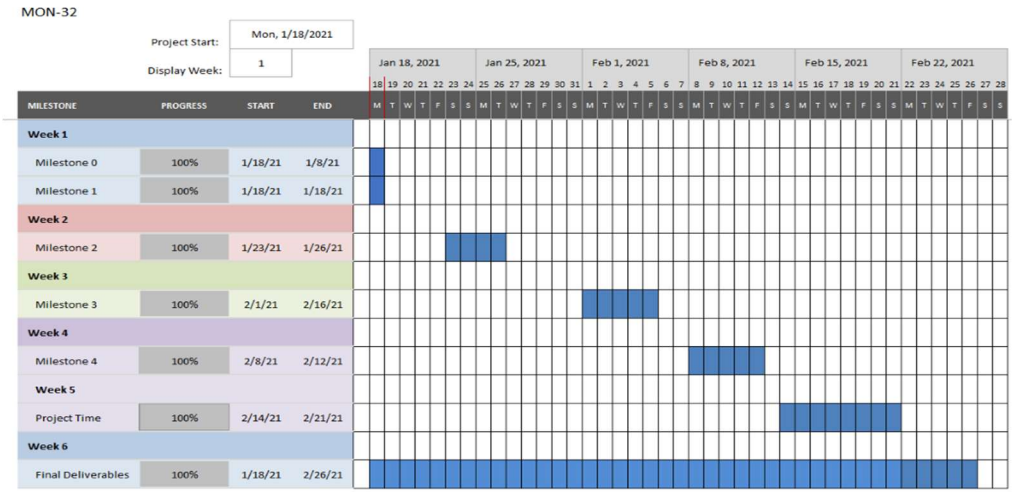
Some facilities have added robots to this recycling process, and they are able to determine what material each container is made of and if it has been contaminated [4]. For this project, we were tasked to simplify and replicate the robot's actions.

The computing team designed a computer program to manipulate a system of devices so that the containers will be sorted into bins based on material and contamination. The container was first dropped onto the sorting station. Here the bottles are tested for what material it is made of and the mass of the container. Then, a robot arm will grab the container and place it onto the Q-bot for transportation. Another bottle will be dropped and if the containers meet the following conditions: the containers have the same bin destination, total mass of containers is less than 90 grams and there less than three bottles already on the Q-bot, then the bottle will be added to the Q-bot, otherwise it will wait until the next round to be dropped off to its bin. The Q-bot will use colour sensors to move toward the proper bin assigned to the bottles and will drop the bottles into the bin. The colour sensor can determine the colour of an object by emitting light onto it and detecting how much of the reflected light is red, green, and blue [5]. The Q-bot will then return to its home position and will continuously repeat this process.

The modelling team designed a device for depositing the containers into the recycling bins. This device consists of a rotary actuator, three gears, and a simple two-linkage system is also used for stability. The actuator is placed on top of the Q-bot. This device holds up to three bottles. Using a system of gears attached to a rung, a hopper pivots about the axis of the rung and dispenses the containers into the bins. An extra linkage was added to the side opposite of the gears to add support to the hopper when it drops the bottles.

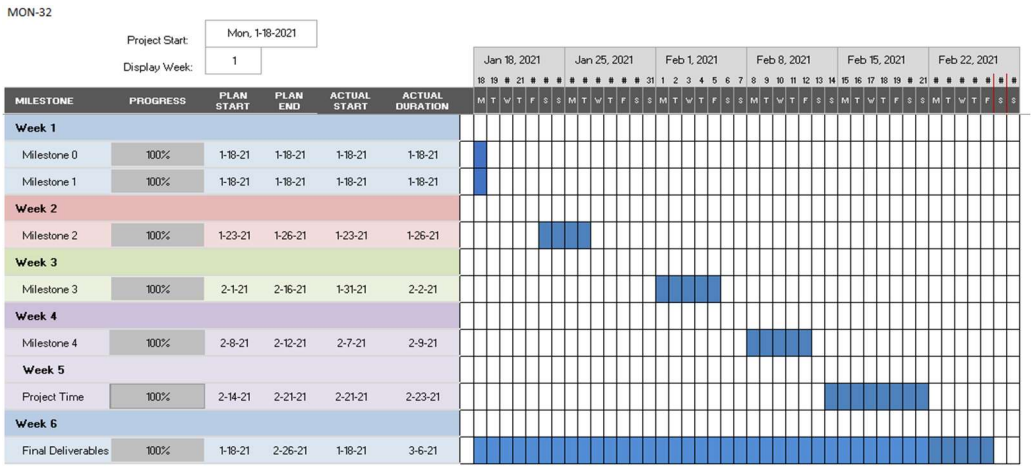
Project Schedule

Preliminary Gantt Chart



MILESTONE	PROGRESS	START	END
Week 1			
Milestone 0	100%	1/18/21	1/8/21
Milestone 1	100%	1/18/21	1/18/21
Week 2			
Milestone 2	100%	1/23/21	1/26/21
Week 3			
Milestone 3	100%	2/1/21	2/16/21
Week 4			
Milestone 4	100%	2/8/21	2/12/21
Week 5			
Project Time	100%	2/14/21	2/21/21
Week 6			
Final Deliverables	100%	1/18/21	2/26/21

Final Gantt Chart



MILESTONE	PROGRESS	PLAN START	PLAN END	ACTUAL START	ACTUAL DURATION
Week 1					
Milestone 0	100%	1-18-21	1-18-21	1-18-21	1-18-21
Milestone 1	100%	1-18-21	1-18-21	1-18-21	1-18-21
Week 2					
Milestone 2	100%	1-23-21	1-26-21	1-23-21	1-26-21
Week 3					
Milestone 3	100%	2-1-21	2-16-21	1-31-21	2-2-21
Week 4					
Milestone 4	100%	2-8-21	2-12-21	2-7-21	2-9-21
Week 5					
Project Time	100%	2-14-21	2-21-21	2-21-21	2-23-21
Week 6					
Final Deliverables	100%	1-18-21	2-26-21	1-18-21	3-6-21

Logbook of Additional Meetings and Discussions

Date	Additional Meetings
January 18th	- Stayed late to finish Milestone 1 deliverables
February 4th	- Modeling team - Figuring out how gears work
February 11th	- Discussion of Project 3 Interview through Instagram group chat
February 24th	- Discussion of Project 3 files through group chat - Computation team - from 4:30-5:45pm to make code loop - Modeling team - finishing up inventor model
February 25th	- Computation team - from 1:00-1:30pm to explain code
February 27th	- Worked on project report from 3:30-5:30pm
March 6th	- Worked on project report from 2:30-3:30pm

Scheduled Weekly Meetings

Weekly Design Studio Agenda and Meeting Minutes

ENGINEER 1P13
MEETING WITH MON - 32 - MONDAY, JAN. 25, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Thivagar Yogaratnam	yogaratt	Yes
Administrator	Juliana Konstantinou	konstanj	Yes
Coordinator	Benji Richler	richlerb	Yes
Subject Matter Expert	Gurleen Dhillon	dhillg25	Yes

AGENDA ITEMS

1. Attendance
2. What we got done before design studio
3. Issues from last week
4. Action items for next week's meeting
5. Final Notes

MEETING MINUTES

1. Attendance
   a. All here
2. What we got done before design studio
   a. Modelling subteam and computing subteam did pre ms2 research + sketches
3. Issues from last week
   a. Had confusion with details of project module requirements (cleared up during design studio hours)
4. Action items for next week's meeting
   a. Modelling subteam makes detailed sketch of design of device assembly
   b. Computing subteam makes a storyboard/flowchart of their program
5. Final Notes
   a. Refer to post-meeting action items

POST-MEETING ACTION ITEMS

1. *Complete Stage 3 [Juliana and Gurleen]*
2. *Complete Stage 4 [Thivagar and Benji]*
3. *Complete Pre Design Studio For Milestone 3 [Juliana, Gurleen, Thivagar, Benji]*

ENGINEER 1P13
MEETING WITH MON - 32 - MONDAY, FEB. 1, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Thivagar Yogaratnam	yogaratt	Yes
Administrator	Juliana Konstantinou	konstanj	Yes
Coordinator	Benji Richler	richlerb	Yes
Subject Matter Expert	Gurleen Dhillon	dhillg25	Yes
Guest			

AGENDA ITEMS

1. Attendance
2. How are we doing.
3. Computing progress.
4. Modelling progress.
5. Final Notes.

MEETING MINUTES

1. Attendance.
   a. All here
2. How are we doing.
   a. good
3. Computing progress.
   a. Pseudocode and flow charts, haven't gotten to combine together at this moment
4. Modelling progress.
   a. Working on backup plan of new hopper and modifying it, have a gearset plan
5. .

   A)Refer to Post Meeting Action Items

POST-MEETING ACTION ITEMS

1. *Begin Modelling on the Gear system (Thivagar and Benji)*
2. *Begin Writing Code (Juliana and Gurleen)*

ENGINEER 1P13
MEETING WITH MON - 32 - MONDAY, FEB. 8, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Thivagar Yogaratnam	yogaratt	YES
Administrator	Juliana Konstantinou	konstanj	YES
Coordinator	Benji Richler	richlerb	YES
Subject Matter Expert	Gurleen Dhillon	dhillg25	YES
Guest			

AGENDA ITEMS

1. Attendance and Updates.
2. Issues from last week
3. Discuss changes from last week's prototype
4. Action items for next week's meetings
5. Final Notes

MEETING MINUTES

1. .
   a. Everyone is present
2. .
   a. Modeling sub team had issues with positioning of the hopper (Thivagar, Benji). Computation sub team had issues with their different functions working together in one document. (Juliana, Gurleen)
3. .
   a. Adjusted gear train design to be angled (modeling sub team). Last week, the functions the team members worked on individually weren't together in one code file and they worked fine on their own, but now are one document (computation).
4. .
   a. Use fewer gears and make a device to help support the hopper (Thivagar, Benji). Get rid of any errors/bugs and have the code run smoothly (Juliana, Gurleen).
5. .
   a. Refer to Post Meeting Action Items

POST-MEETING ACTION ITEMS

1. *Fix errors in code*
2. *Edit design of the hopper*

ENGINEER 1P13
MEETING WITH Mon-32 - Monday, Feb. 22, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Thivagar Yogaratnam	yogaratt	Yes
Administrator	Juliana Konstantinou	konstanj	Yes
Coordinator	Benji Richler	richlerb	Yes
Subject Matter Expert	Gurleen Dhillon	dhillg25	Yes
Guest			

AGENDA ITEMS

1. Attendance and how was reading week.
2. Modelling progress and what working on.
3. Computing progress and what working on.
4. Bonus?!?.
5. Final Notes.

MEETING MINUTES

1) Attendance and how was reading week.
   a) All here and good
2) Modelling progress and what working on.
   a) Working on assembly and simulation
3) Computing progress and what working on.
   a) Wrote all the code, making it compatible and fixing bugs
4) Bonus?!?.
   a) Something we'd have had to have done since beginning, so not gonna do
5) Final Notes

   A) Refer to Post-Meeting Action Items

POST-MEETING ACTION ITEMS

1. *Prepare for interview (Thivagar, Juliana, Benji, Gurleen)*
2. *Finish Code (Juliana, Gurleen)*
3. *Finish Dynamic Simulation and Linkage Mechanism (Thivagar, Benji)*

Design Studio Worksheets

Milestone 0

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Gurleen Dhillon	dhillg25
Juliana Konstantinou	konstanj
Benji Richler	richlerb
Thivagar Yogaratnam	vogaratt

Insert your Team Portrait in the dialog box below

Project Leads:

Identify team member details (Name and MACID) in the space below.

Role:	Team Member Name:	MacID
Manager	Thivagar Yogaratnam	vogaratt
Administrator	Juliana Konstantinou	konstanj
Coordinator	Benji Richler	richlerb
Subject Matter Expert	Gurleen Dhillon	dhillg25

Incoming Personnel Administrative Portfolio:

Prior to identifying Leads, identify each team members incoming experience with various **Project Leads**

	Team Member Name:	Project Leads
1.	Gurleen Dhillon	☒M ☐A ☒C ☐S
2.	Juliana Konstantinou	☒M ☐A ☐C ☒S
3.	Benji Richler	☒M ☐A ☐C ☒S
4.	Thivagar Yogaratnam	☐M ☐A ☒C ☒S

Milestone 1

Rough Work

Why should we design a system for sorting and recycling containers?

- Makes recycling process less time consuming (can recycle more in a certain time)
- Reuse old material so there won't be a need to use new materials
- This will reduce the amount many types of pollution

How should we design this system for recycling the containers?

- Put the different types of containers into separate bins
- By transporting containers from one spot to a dedicated location
- By using a mechanism to transfer the containers to the transport

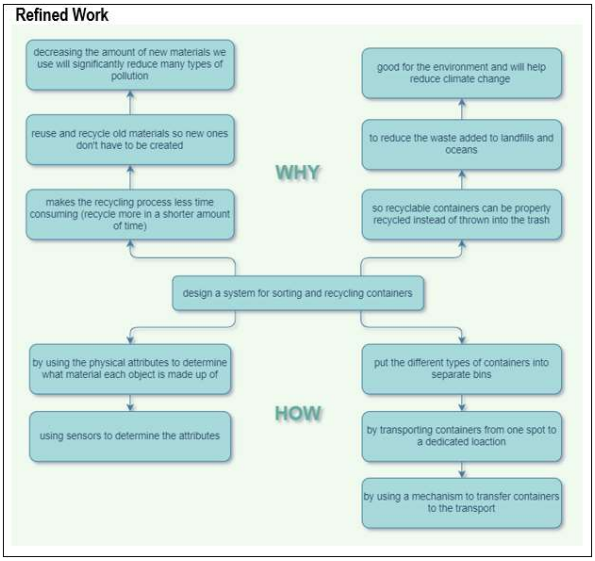
Why should we be designing a system for sorting and recycling containers?

- So containers can be properly recycled instead of being thrown into the trash
- Reduces the waste going into the oceans and landfills
- It's good for the environment and will help reduce climate change

How should we design this system for sorting the containers?

- By using the physical attributes to determine what material each object is made up of
- Using sensors to determine the attributes

Refined Work



Initial Problem Statement

1. Write the initial problem statement in the space below. This will have been defined in a previous lecture, prior to your scheduled Design Studio.

Design a system for sorting and recycling containers.

Refined Problem Statement

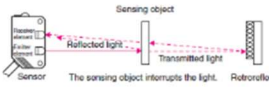
2. Write the refined problem statement below. Kindly refer to the Refined Problem Statement rubric provided on Avenue (see P3 Rubrics). This will guide your group in creating a valid statement.

Design a system to sort multiple recyclable containers of different materials and transport the containers into the proper recycling bins so they can be properly recycled and reduce the waste entering the environment.

Objectives	- Quick, efficient and durable - Can distinguish between different materials - Safely transfers containers to disposal bins - Environmentally friendly
Constraints	- Must hold up to 3 containers - Must hold up to 90 grams - Must utilise 2 sensors

Milestone 2

Name: Juliana | MacID: konstanj

Sensor Type	Description	Attribute(s)
Colour Sensor	A colour sensor is a photoelectric sensor. It emits light on to an object from a light transmitter. Then it detects the red, blue, and green light that is reflected from the object. Using the light intensities detected, the sensor can determine the colour of the object. There are two types of colour sensors. One emits broad wavelength light and then differentiates the colours in the receiver and the other emits the three light colours independently. [1]	This sensor can help detect the different colours of the bins or its surroundings.
Active Infrared (IR) Sensor	An active IR sensor is a type of infrared sensor that has both an emitter and a receiver. The emitter (IR Light Emitting Diode or LED) shoots an IR ray toward a receiver. If the receiver gets a signal, then nothing is in the way. If the receiver does not see the ray, then an object is in the between the emitter and receiver. These sensors can help figure out the shape and location of the object. [2]	This sensor can help detect the bins.
Retro-reflective Photoelectric Sensor	Photoelectric sensors detect objects, changes in the surface and other conditions using optical properties. A retro-reflective photoelectric sensor is a type of photoelectric sensor. When there is no object, light is reflected by the reflector normally. When there is an object, light is interrupted, and the amount of light received reduces. [3]  *Figure 1 Retro-reflection sensor [3]* This sensor had light passing through the object twice, so it is good for detecting transparent objects. Not the best for objects with a mirrored finish because it just reflects the light. [3]	This can help detect the location of the bins and detect difference the between transparent and opaque bins.

[1] "What is a Colour sensor?", Keyence [Online]. Available: https://www.keyence.ca/ss/products/sensor/sensorbasics/color/info/ [Accessed: January 23, 2021].

[2] J. S. Cook, "The Right Tool for the Job: Active and Passive Infrared Sensors", Arrow [Online]. Available: https://www.arrow.com/en/research-and-events/articles/understanding-active-and-passive-infrared-sensors [Accessed: January 23, 2021].

[3] "Photoelectric Sensors", Omron Industrial Automation [Online]. Available: https://www.ia.omron.com/support/guide/43/introduction.html [Accessed January 24, 2021].

Name: Gurleen Dhillon | MacID: dhillg25

Sensor Type	Description	Attribute(s)
Ultrasonic Sensor	The ultrasonic sensor works by sending a sound wave at a frequency that humans cannot hear. The sensor can determine how far an object is by measuring the time lapse of when the sound wave was first sent off and when it was received back. [1]	It could detect how far a bin might be and how much further the q-bot needs to travel to reach that bin. Each bin could be placed at a different distance from the yellow line.
Light-Dependant Resistor	The light-dependant resistor is very sensitive to light. Its' resistance greatly changes when the light levels change because as it gets darker, the lass electricity it would conduct. [2]	It could detect how translucent a certain object is. Each bin could allow a different amount of light to pass through.
Hall Sensor	The hall sensor measures the magnitude of a magnetic field of an object by measuring the hall voltage when the sensors are placed in said magnetic field. The hall voltage is directly proportional to the magnetic field. [3]	It could detect how metallic a certain object is (based on the magnetic field). Each bin could have different strengths in magnetic fields.

Works Cited

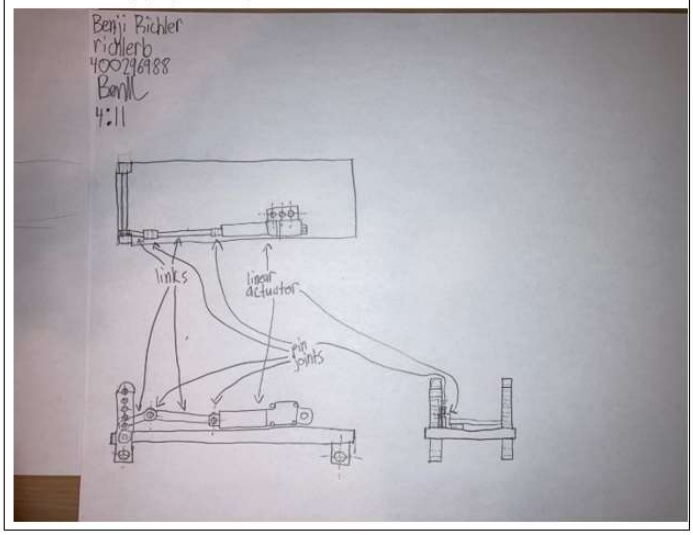
[1] R. Burnett, "Understanding How Ultrasonic Sensors Work" *MaxBotix Inc.*, Mar. 24, 2020. https://www.maxbotix.com/articles/how-ultrasonic-sensors-work.htm (Accessed Jan. 25, 2021).

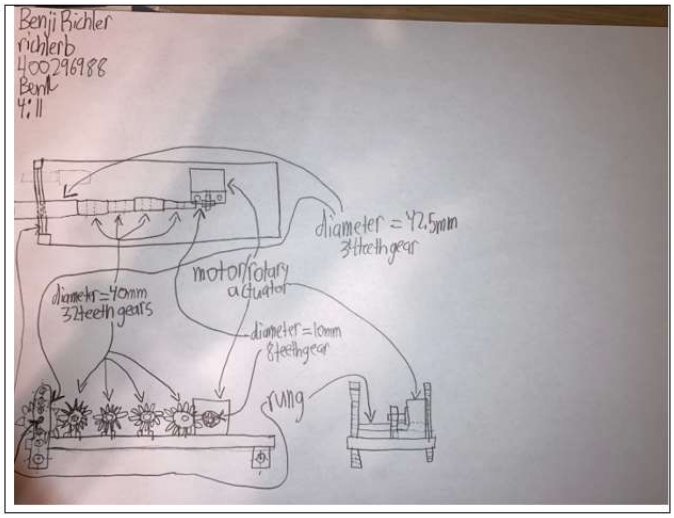
[2] K. Spurr, "How an LDR (Light Dependent Resistor) Works," *Kitronik Ltd*, Jan. 14, 2014. https://kitronik.co.uk/blogs/resources/how-an-ldr-light-dependent-resistor-works (accessed Jan. 25, 2021).

[3] C. Woodford, "How Hall effect sensors and probes work," *Explain that Stuff*, Aug. 13, 2020. https://www.explainthatstuff.com/hall-effect-sensors.html (accessed Jan. 25, 2021).

Name: Benji Richler	MacID: richlerb

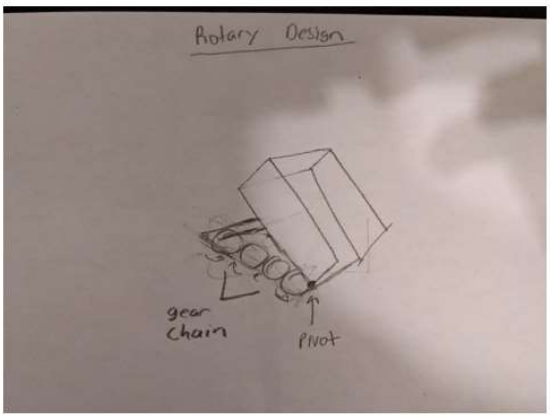
Insert screenshot(s) of your concept sketches below

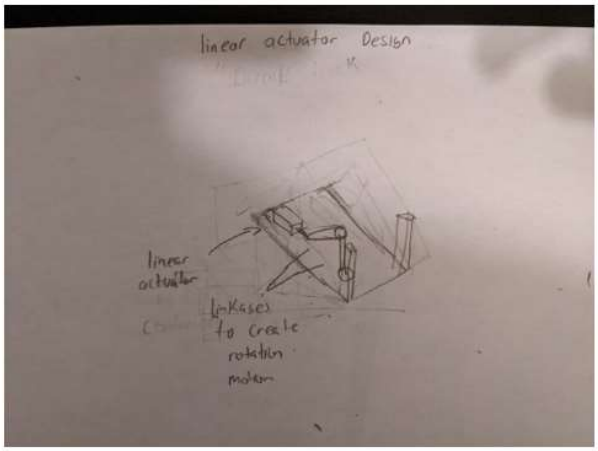




Name: Thivagar Yogartnam	MacID:yogaratt

Insert screenshot(s) of your concept sketches below





Sensor Type	Findings and Appropriateness for Application
Ultrasonic Sensor	• Uses a sound wave to find location/distance of an object • Could be practical to use because we can see the location and how far the bins are • We decided against this sensor because it will be harder to between differentiate the different bins with a sensor that just sees how far all the bins are from it.
Light-Dependant Resistor	• Can see how much light will go through the object • Mostly looks at the transparentness of an object. • This sensor won't be much help for getting to the bins
Hall Sensor	• Can detect how metallic an object is • In the environment, the bins can either be metallic or not • Since this sensor just sees how metallic an object is, it won't be much help for differentiating between the four bins
Colour Sensor	• Good for sensing colour • If we coloured the bins and other parts of the environment, this sensor could be very practical. • This is the most practical sensor choice for us. Since we can just assign each bin a colour and the bot can easily differentiate between the 4 different bins.
Active Infrared (IR) Sensor	• Can determine shape and location of object • Since the bins are all similar in shape, this sensor won't be very useful for discerning between the bins. • Also, would not be the best to use since there will need to be a receiver on the other side of the bins.
Retro-Reflective Photoelectric Sensor	• Can see if there is something in the way based on how much light passes through • Since the bins are all similar, this sensor won't be very useful for discerning between the bins. • Also, reflectors would need to be behind the bins for this to work, so it's not the most practical choice

2. Identify one sensor to incorporate into your computer program

Colour Sensor

3. Identify an attribute value for each bin

Bin ID	Attribute Value
Bin01: Metal Bin	The bin and leading line would be coloured black. red = 0, blue = 0, green = 0
Bin02: Paper Bin	The bin and leading line would be coloured red. red = 1, blue = 0, green = 0
Bin03: Plastic Bin	The bin and leading line would be coloured blue. red = 0, blue = 1, green = 0
Bin04: Garbage Bin	The bin and leading line would be coloured green. red = 0, blue = 0, green = 0.5

1. As a team, establish a weighting factor for each criterion
   → Move row-by-row
   - If *Criteria 1* is preferred over *Criteria 2*, assign a 1. Otherwise, assign 0
   - If *Criteria 1* is preferred over *Criteria 3*, assign a 1. Otherwise, assign 0

   → Add additional rows/columns as needed

	Few parts used	Simple	Runtime of mechanism	Lightweight	Reliability	Smooth output	Score
Few parts used	N/A	1	1	0	0	0	2
Simple	0	N/A	1	0	0	0	1
Runtime of mechanism	0	0	N/A	0	0	0	0
Lightweight	1	1	1	N/A	0	0	3
Reliability	1	1	1	1	N/A	1	5
Smooth output	1	1	1	1	0	N/A	4

2. As a team, evaluate your concepts against each criterion using your weighting
   → Add additional rows as needed

	Weight	Benji linear		Benji rotary		Thivagar linear		Thivagar rotary	
		Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Few parts used	2	4	8	3	6	4	8	3	6
Simple	1	4	4	4	4	5	5	4	4
Runtime of mechanism	0	4	0	3	0	4	0	3	0
Lightweight	3	3	9	3	9	2	6	2	6
Reliability	5	3	15	3	15	3	15	2	10
Smooth output	4	3	12	5	20	3	12	4	16
TOTAL		48		54		46		42	

Milestone 3

Name: Juliana Konstantinou	MacID: konstanj

*Write out a pseudocode outlining the **high-level workflow** of your computer program in the space below.*

Q-arm and Q-bot start at home position

Define function for determining attributes of the container:

- If metal, go to bin-01 (black bin)
- Elif clean paper, go to bin-02 (red bin)
- Elif clean plastic, go to bin-03 (blue bin)
- Else go to bin-04 (green bin)
- Return the mass and bin destination of the container

Move container to pick-up spot for Q-arm to pick up container

Use Q-arm to pick up and transfer the container onto the Q-bot

Q-arm returns to home position

Repeat the above steps two more times:

- If the containers have same bin id and total mass of containers is less than 90 grams
- Else do not repeat steps and continue onto the next step

Q-bot will use colour sensor differentiate between the bins and follow lines on floor to get Q-bot to correct bin

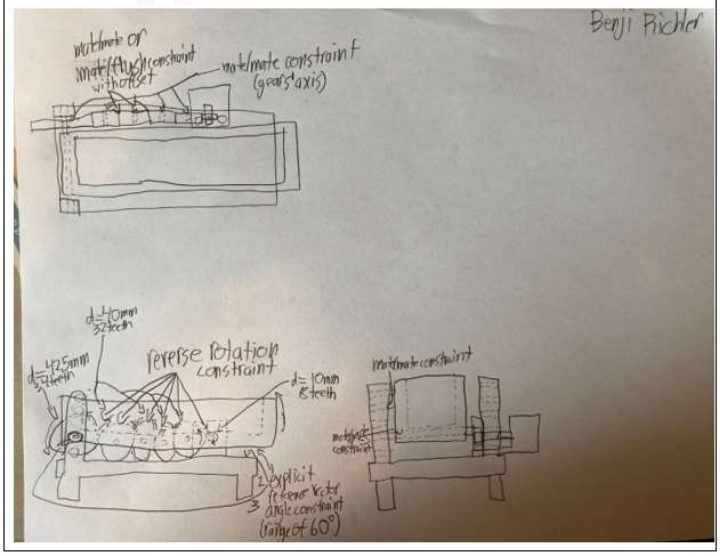
Q-bot puts container into bin

Q-bot returns to home position

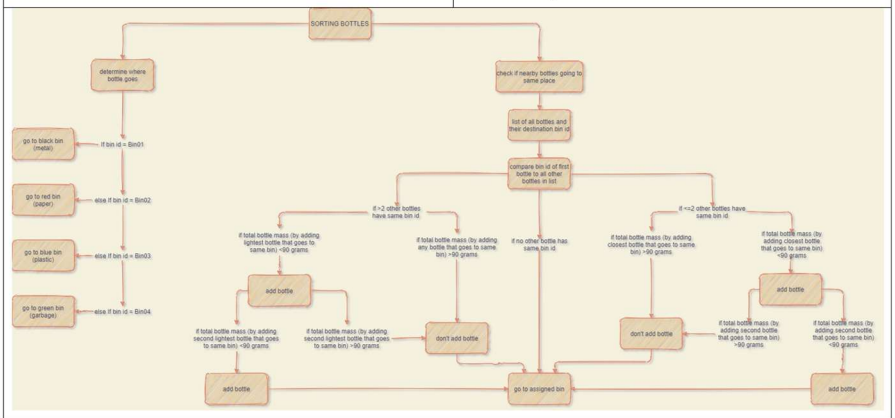
Repeat entire program until it is terminated

Name: Benji Richler	MacID: richlerb

Insert screenshot(s) of your detailed sketch below.

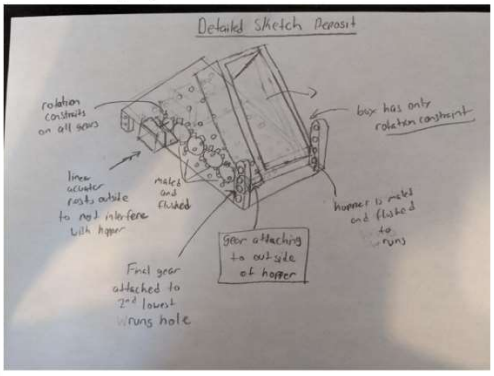


Name: Gurleen Dhillon	MacID: dhillg25



Name: Thivagar Yogaratnam	MacID yogaratt

Insert screenshot(s) of your detailed sketch below.



Dispense Container

```
#drop a bottle at random (from the 6 options)
#turn the turntable so bottle is under the sensors
#define container attribute function:
    If high inductive sensor value(>4):
        Material = metal
    Elif high photoelectric sensor value (>4):
        Material =paper
    Elif low photoelectric sensor value (<4):
        Material = plastic
#compare mass before and after bottle was added to find mass of bottle
    #if Material = metal
        # Bin destination = bin-01 (black bin)
    #elif material = paper
        #if mass<=10 grams
            #Bin destination = bin-02 (red bin)
        #else
            #Bin destination = bin-04 (green bin)
    #elif material = plastic
        #if mass<=9.25 grams
            #Bin destination = bin-03 (blue bin)
        #else
            #Bin destination = bin-04 (green bin)
    Return the mass and bin destination of the container
```

Transfer Container

```
Define transfer container function (input = bin ID):
    #use colour sensor and move forward along the yellow line
    # if bin Id = "Bin01"
        #turn 90deg when black is detected
        #follow black path
        #stop in front of the bin
    # if bin Id = "Bin02"
        #turn 90deg when red is detected
        #follow red path
        #stop in front of the bin
    # if bin Id = "Bin03"
        #turn 90deg when blue is detected
        #follow blue path
        #stop in front of the bin
    # if bin Id = "Bin04"
        #turn 90deg when green is detected
        #follow green path
        #stop in front of the bin
```

Deposit Container

```
#turn 90degrees (when stopped infront of bin)
#lift one side of container so that all bottles can fall into bin
```

Load Container

```
#pick up closest bottle
#Rotate arm so bottle is above Q-bot
#Place bottle onto the Q-bot
#check next bottle's bin Id
#if this bottles ID equals the 1st bottles ID AND total mass of bottles is less than 90g
    #Pick up closest bottle
    #Rotate arm so bottle is above Q-bot
    #Place bottle onto the Q-bot
    #check next bottle's bin Id and repeat this step again for the 3rd bottle
# else:
    #don't add the bottle and move onto transferring the bottle(s)
```

Deposit Container

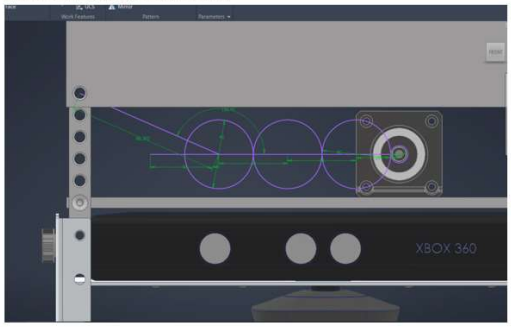
```
#turn 90degrees (when stopped infront of bin)
#lift one side of container so that all bottles can fall into bin
```

Return Home

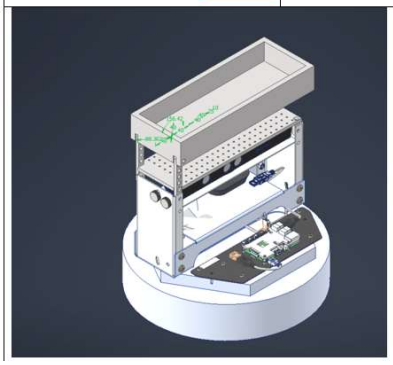
```
#lower container
#turn -90 degrees to travel on coloured path
#when yellow path intersects, turn -90 degrees and follow yellow path
#qbot stops when it is close to hitting the white wall
```

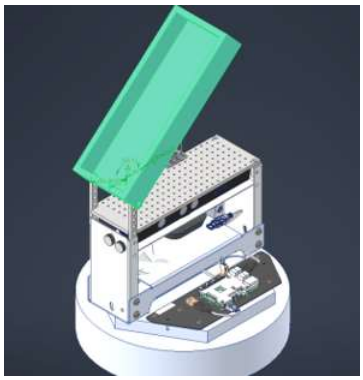
Name: Benji Richler and Thivagar Yogaratnam	MacID: richlerb and yogaratt

Insert screenshot(s) of your model below.

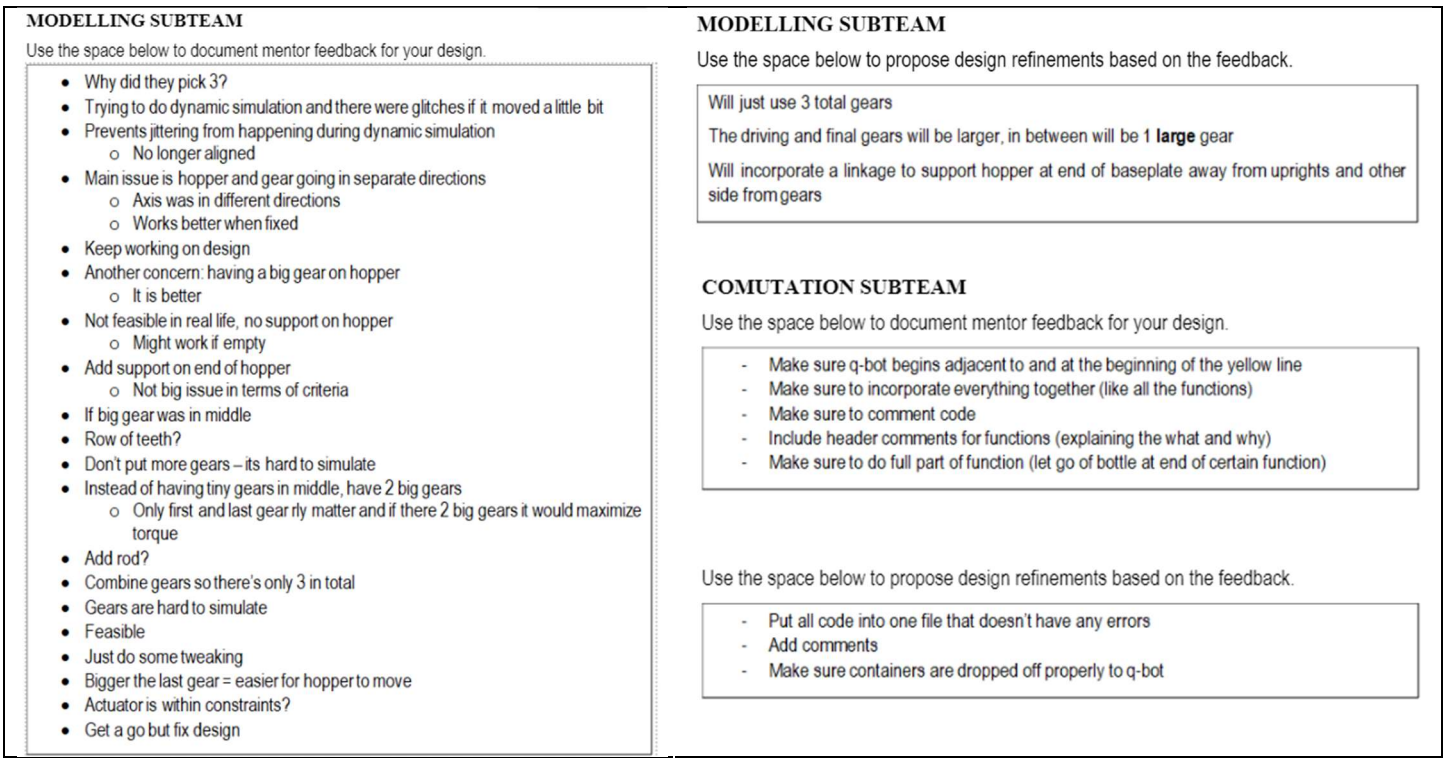


Name: Benji Richler and Thivagar Yogaratnam	MacID: richlerb and yogaratt





Milestone 4



MODELLING SUBTEAM

Use the space below to document mentor feedback for your design.

- Why did they pick 3?
- Trying to do dynamic simulation and there were glitches if it moved a little bit
- Prevents jittering from happening during dynamic simulation
  - No longer aligned
- Main issue is hopper and gear going in separate directions
  - Axis was in different directions
  - Works better when fixed
- Keep working on design
- Another concern: having a big gear on hopper
  - It is better
- Not feasible in real life, no support on hopper
  - Might work if empty
- Add support on end of hopper
  - Not big issue in terms of criteria
- If big gear was in middle
- Row of teeth?
- Don't put more gears – its hard to simulate
- Instead of having tiny gears in middle, have 2 big gears
  - Only first and last gear rly matter and if there 2 big gears it would maximize torque
- Add rod?
- Combine gears so there's only 3 in total
- Gears are hard to simulate
- Feasible
- Just do some tweaking
- Bigger the last gear = easier for hopper to move
- Actuator is within constraints?
- Get a go but fix design

MODELLING SUBTEAM

Use the space below to propose design refinements based on the feedback.

Will just use 3 total gears

The driving and final gears will be larger, in between will be 1 **large** gear

Will incorporate a linkage to support hopper at end of baseplate away from uprights and other side from gears

COMUTATION SUBTEAM

Use the space below to document mentor feedback for your design.

- Make sure q-bot begins adjacent to and at the beginning of the yellow line
- Make sure to incorporate everything together (like all the functions)
- Make sure to comment code
- Include header comments for functions (explaining the what and why)
- Make sure to do full part of function (let go of bottle at end of certain function)

Use the space below to propose design refinements based on the feedback.

- Put all code into one file that doesn't have any errors
- Add comments
- Make sure containers are dropped off properly to q-bot

List of Sources

[1] Department of Engineering, "Project 3: There's A Recyclable Among Us," [Online]. *Avenue to Learn*, 2021. https://avenue.cllmcmaster.ca/d2l/le/content/340370/viewContent/3021767/View. [Accessed March 4, 2021].

[2] "What Goes in the Blue Bin (Recycling)?," *City of Toronto*, 23-Dec-2020. [Online]. Available: https://www.toronto.ca/services-payments/recycling-organics-garbage/houses/what-goes-in-my-blue-bin/. [Accessed: March 4, 2021].

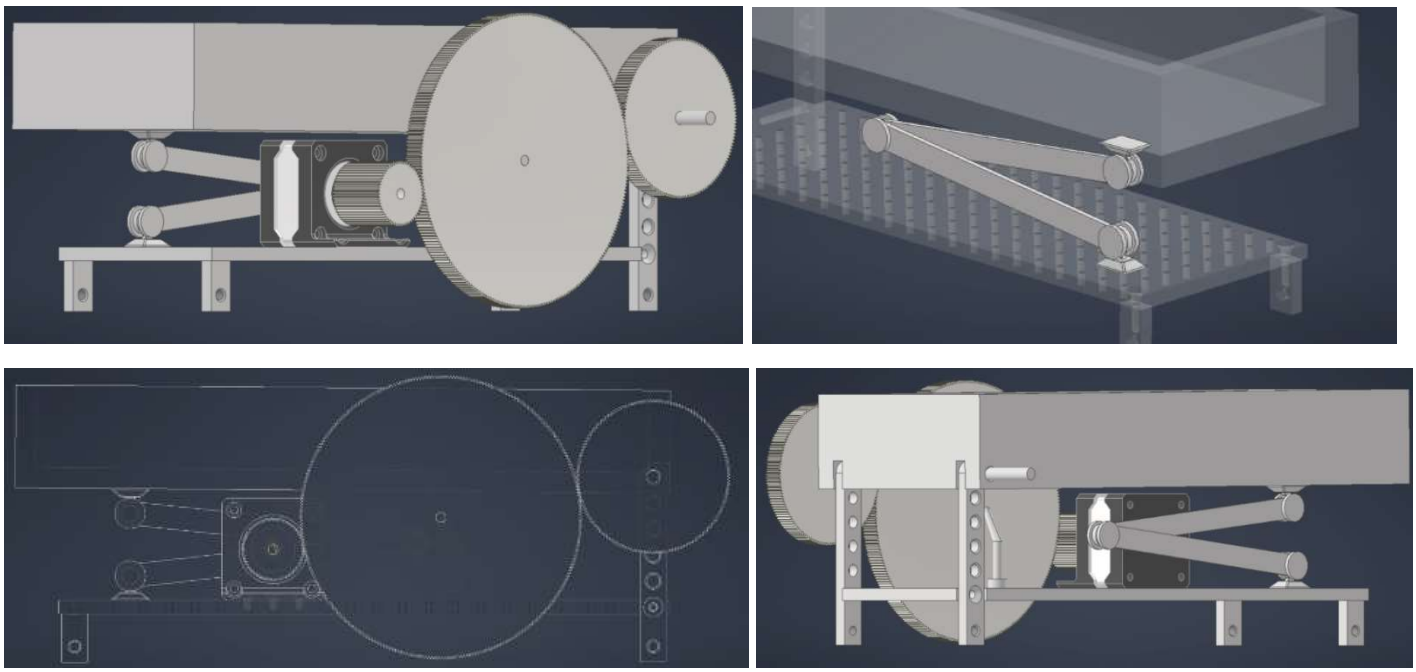
[3] "Canada recycles just 9 per cent of its plastics," *Recycling Council of Ontario*, 06-Dec-2019. [Online]. Available: https://rco.on.ca/canada-recycles-just-9-per-cent-of-its-plastics/. Accessed: March 4, 2021].

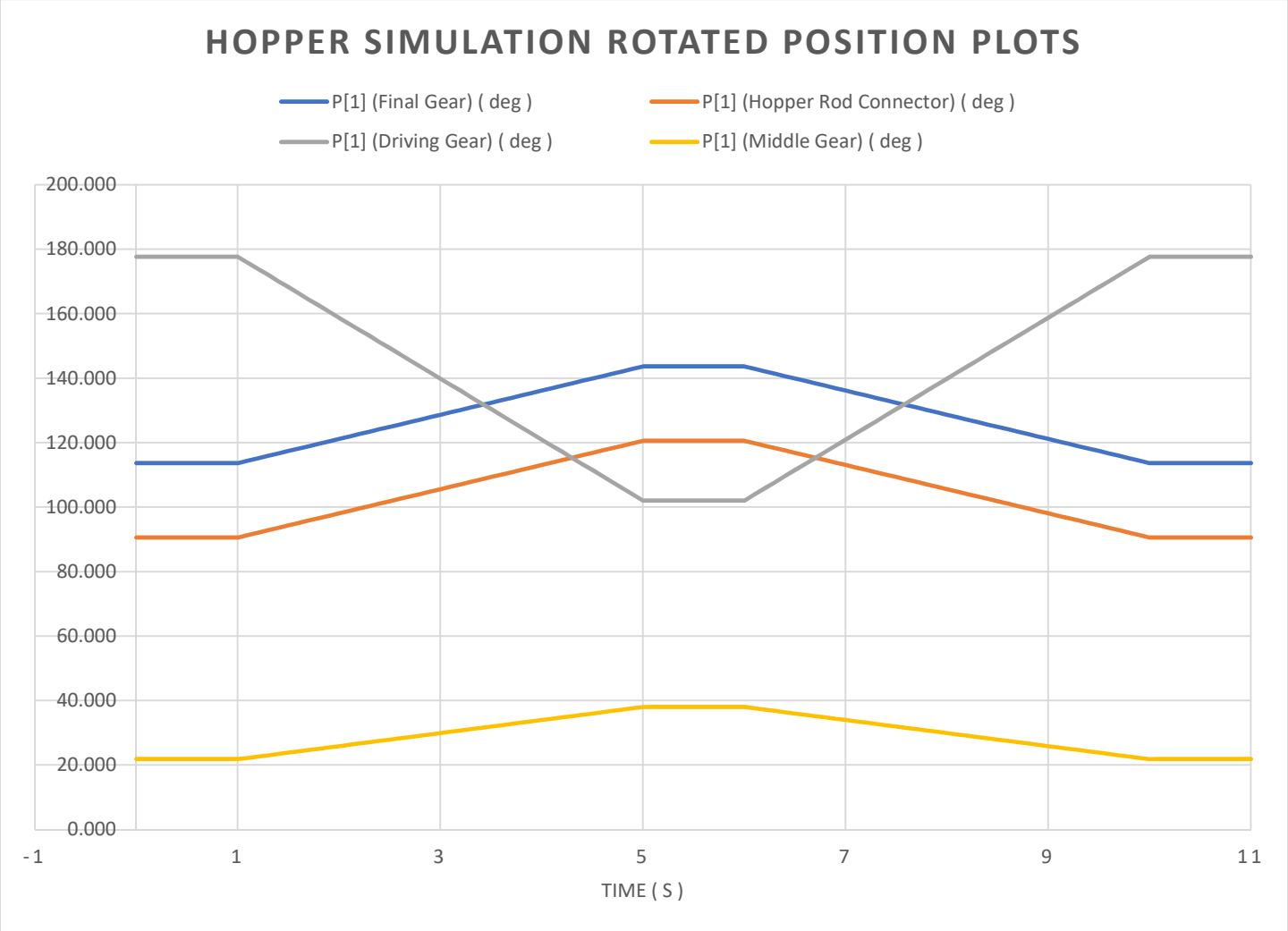
[4] J. Fingas, "Recycling robot can sort paper and plastic by touch," *Engadget*, 11-Apr-2019. [Online]. Available: https://www.engadget.com/2019-04-11-mit-recycling-robot.html. [Accessed: March 4, 2021].

[5] Keyence, "What is a Colour sensor?," [Online]. *Keyence.ca,* 2021. Available: https://www.keyence.ca/ss/products/sensor/sensorbasics/color/info/ [Accessed March 4, 2021].

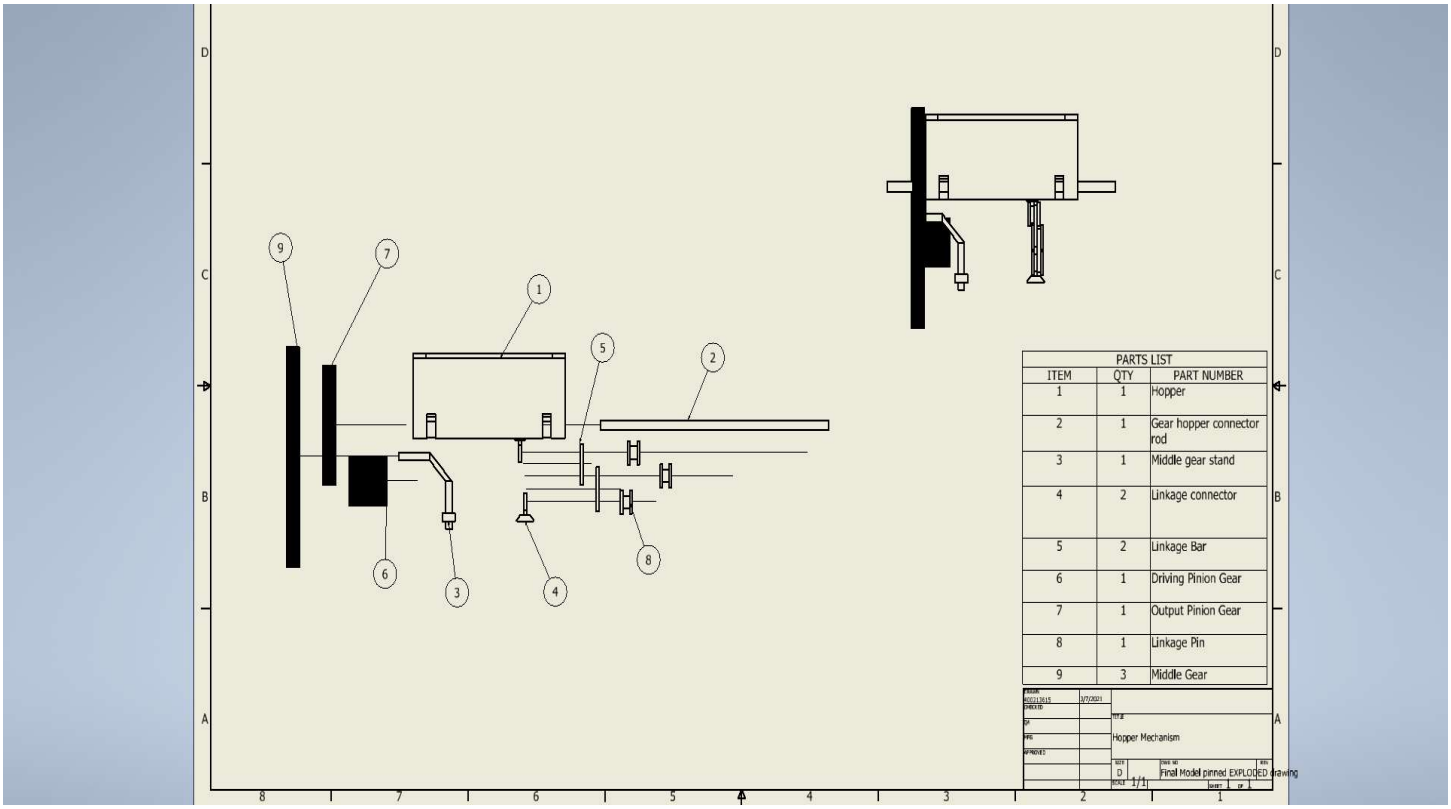
Appendices

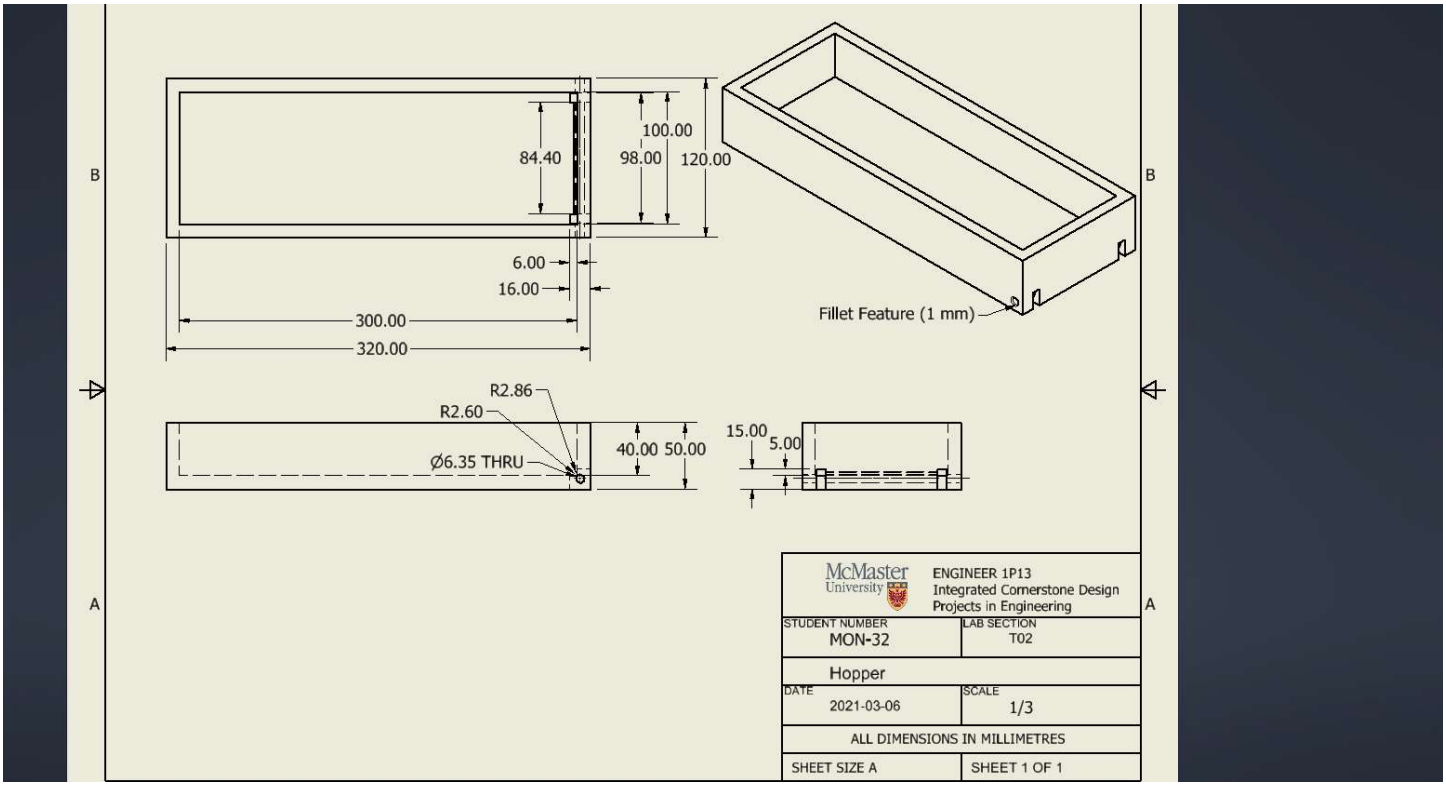
Screenshots of Model

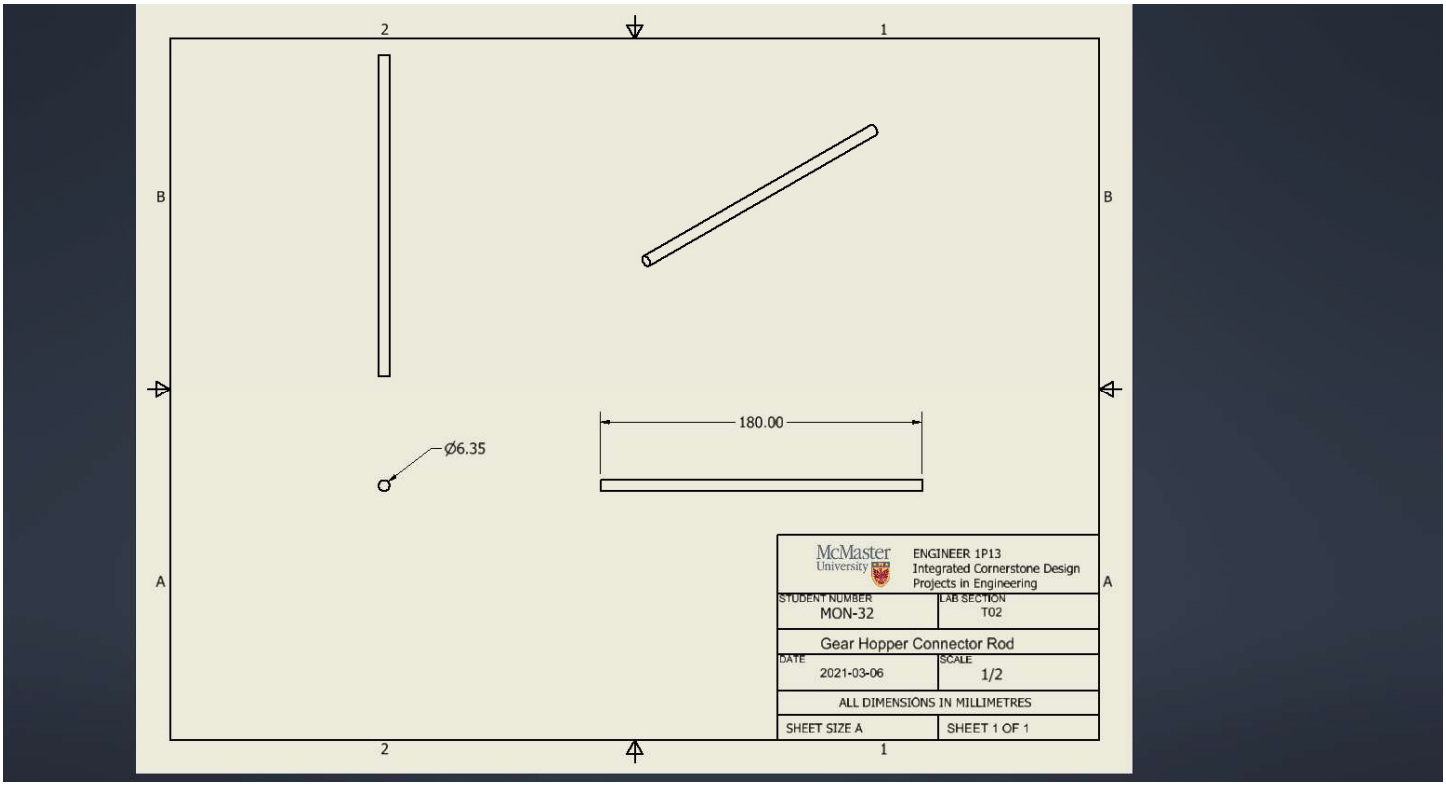


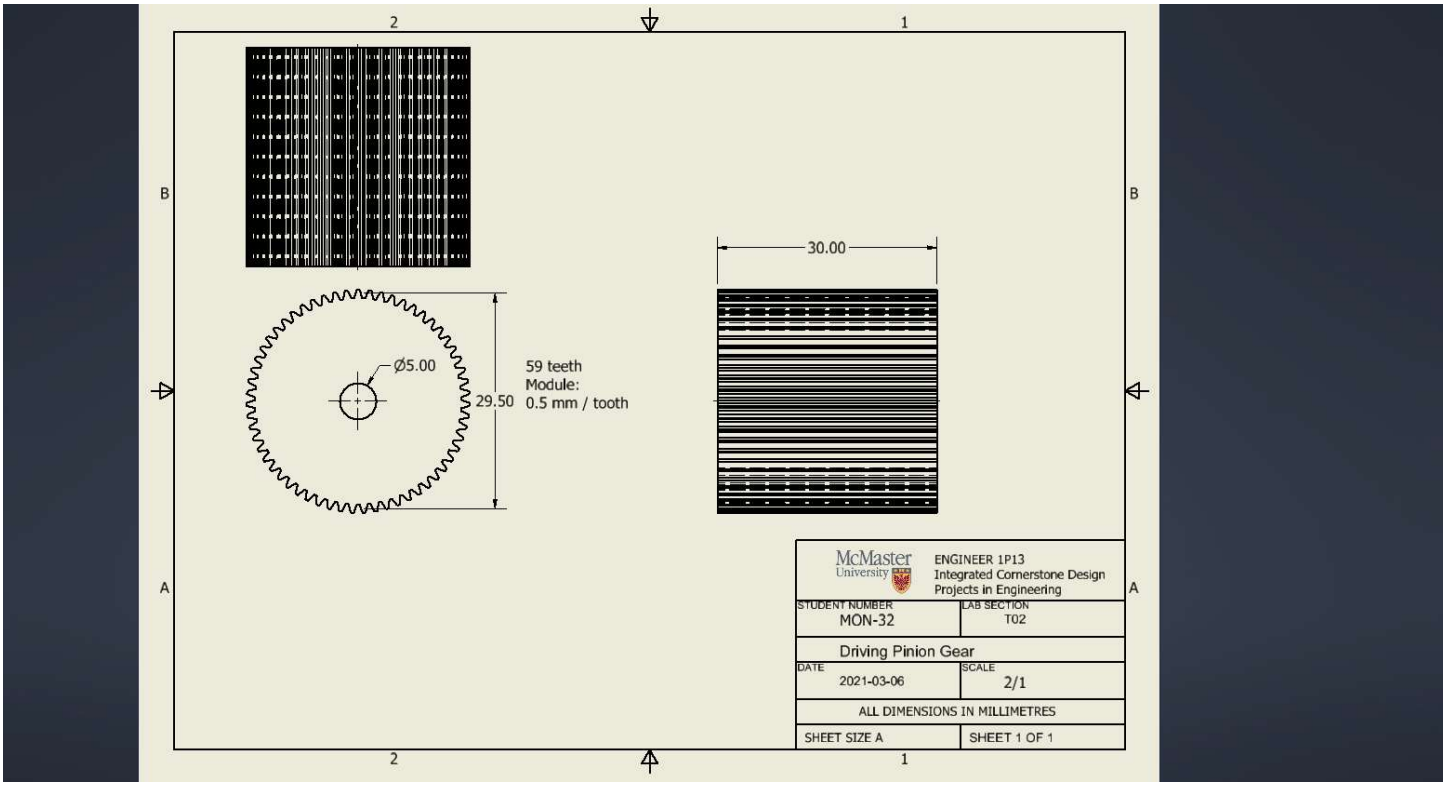

HOPPER SIMULATION ROTATED POSITION PLOTS
P[1] (Final Gear) (deg)
P[1] (Hopper Rod Connector) (deg)
P[1] (Driving Gear) (deg)
P[1] (Middle Gear) (deg)
200.000
180.000
160.000
140.000
120.000
100.000
80.000
60.000
40.000
20.000
0.000
-1
1
3
5
7
9
11
TIME (S)

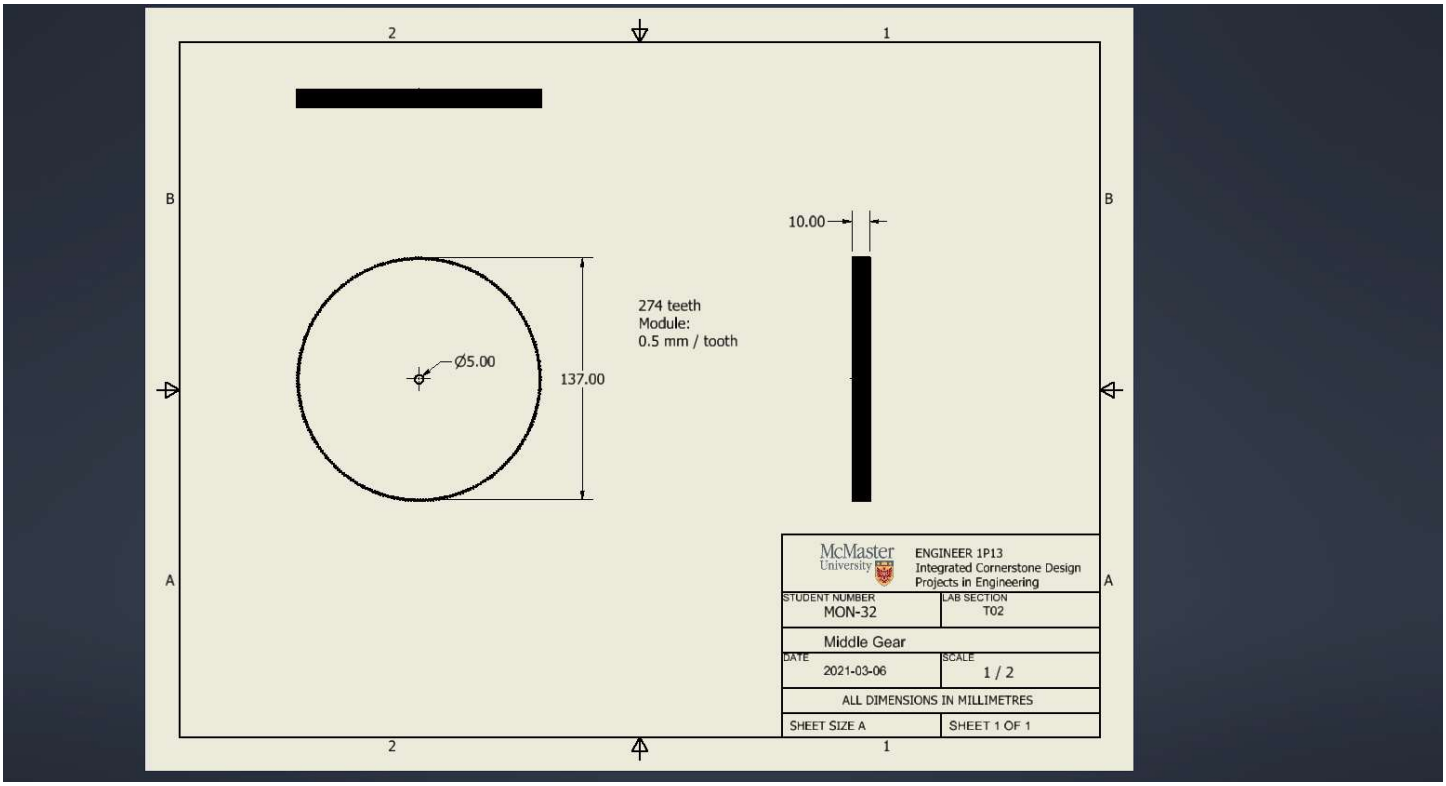
Engineering Drawings

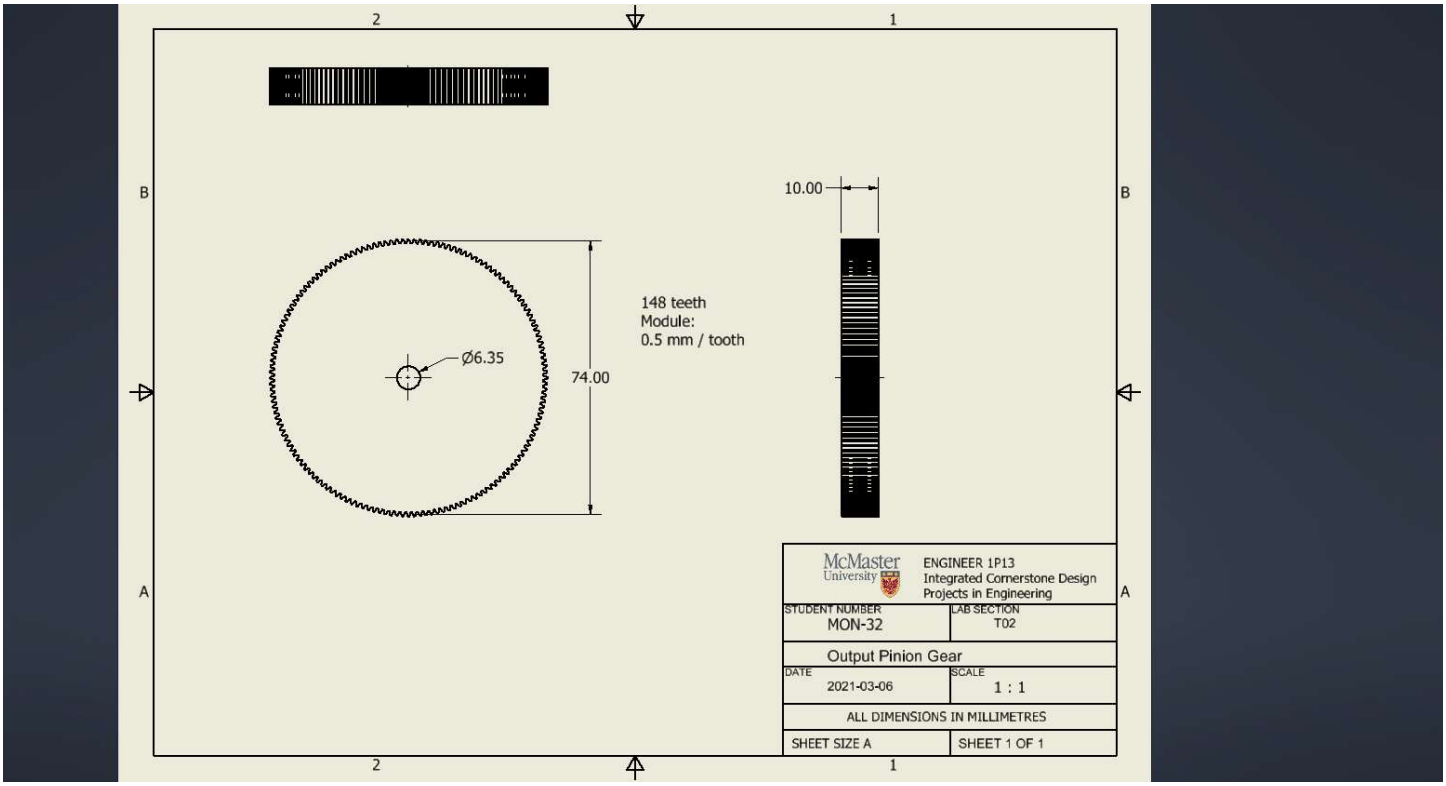


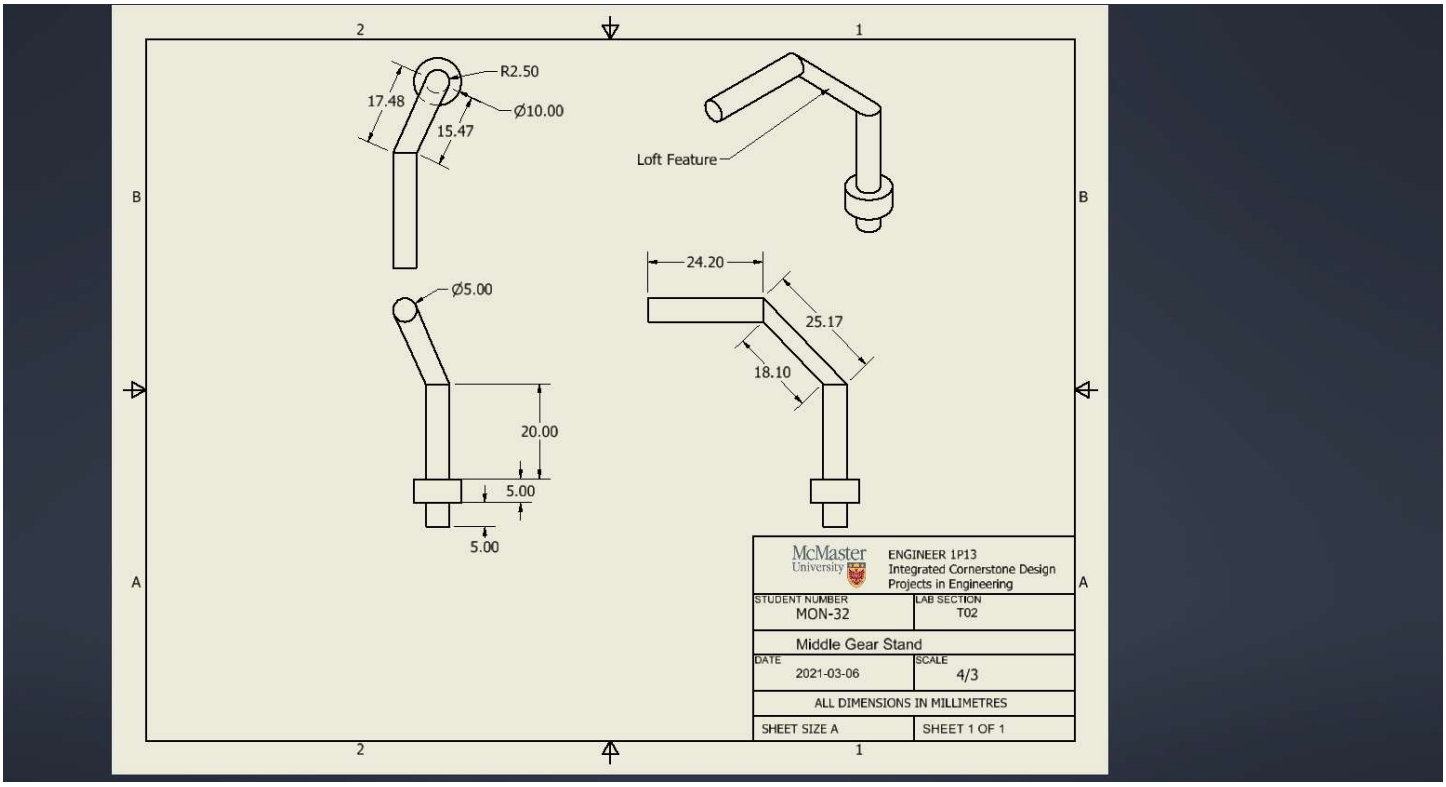


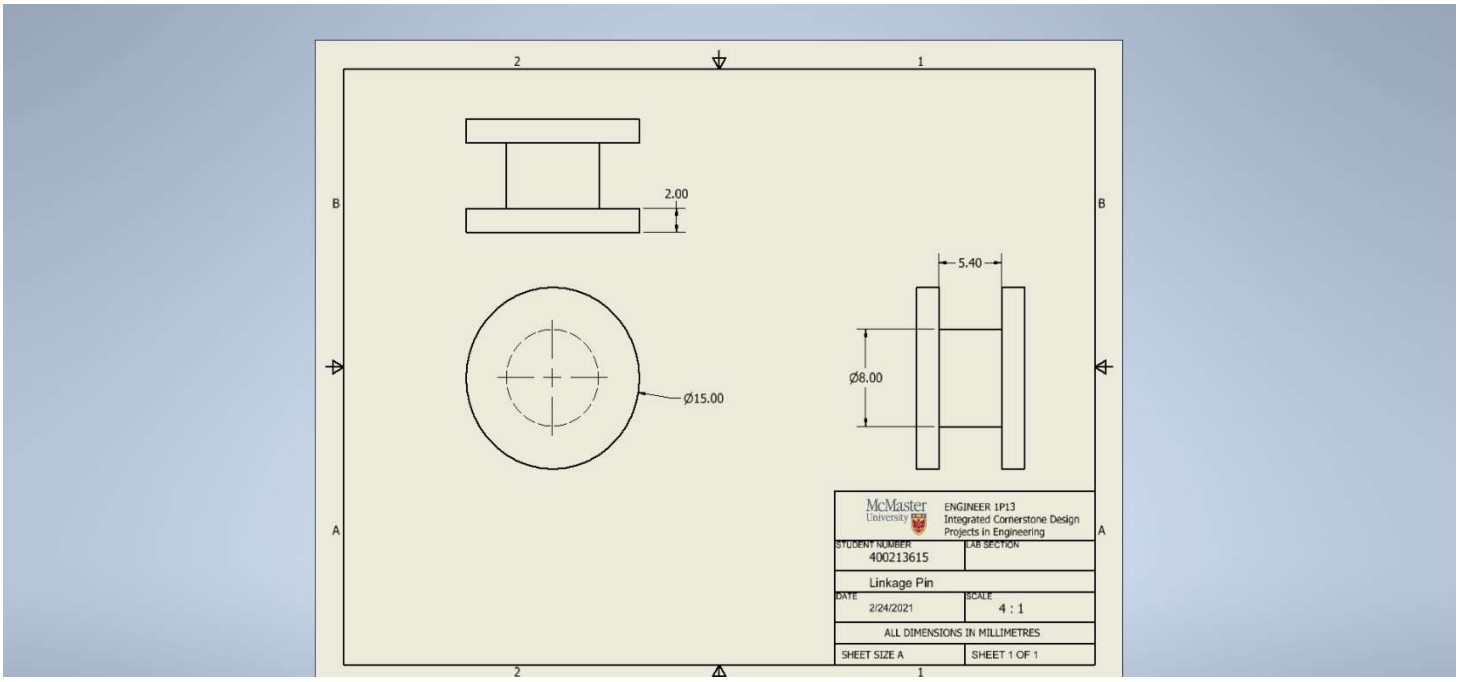

Ø6.35
180.00
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
MON-32
LAB SECTION
T02
Gear Hopper Connector Rod
DATE
2021-03-06
SCALE
1/2
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1

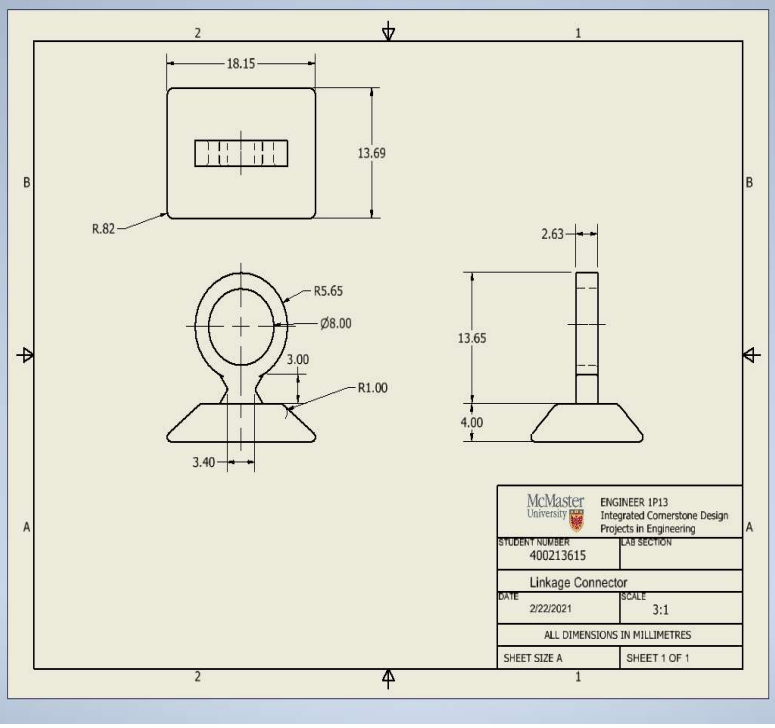

Ø5.00
29.50
59 teeth
Module:
0.5 mm / tooth
30.00
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
MON-32
LAB SECTION
T02
Driving Pinion Gear
DATE
2021-03-06
SCALE
2/1
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1

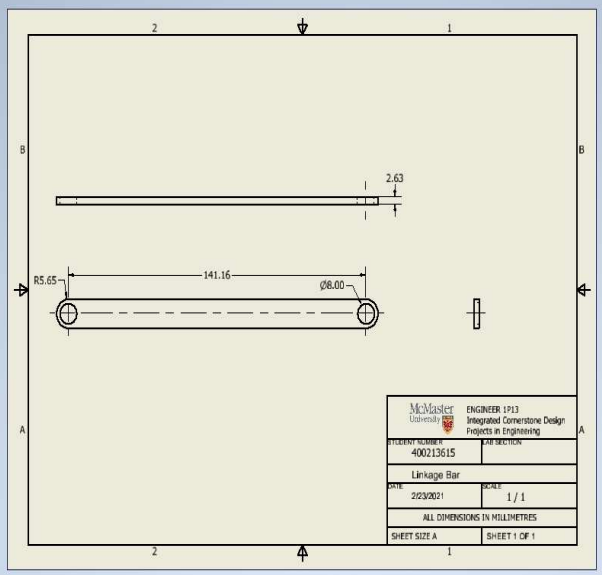

10.00
Ø5.00
137.00
274 teeth
Module:
0.5 mm / tooth
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
MON-32
LAB SECTION
T02
Middle Gear
DATE
2021-03-06
SCALE
1 / 2
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1


10.00
Ø6.35
74.00
148 teeth
Module:
0.5 mm / tooth
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
MON-32
LAB SECTION
T02
Output Pinion Gear
DATE
2021-03-06
SCALE
1 : 1
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1


R2.50
17.48
Ø10.00
15.47
Loft Feature
24.20
Ø5.00
25.17
18.10
20.00
5.00
5.00
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
MON-32
LAB SECTION
T02
Middle Gear Stand
DATE
2021-03-06
SCALE
4/3
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1


2.00
5.40
Ø8.00
Ø15.00
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
400213615
LAB SECTION
Linkage Pin
DATE
2/24/2021
SCALE
4 : 1
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1


18.15
13.69
R.82
R5.65
Ø8.00
3.00
R1.00
3.40
2.63
13.65
4.00
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design Projects in Engineering
STUDENT NUMBER
400213615
LAB SECTION
Linkage Connector
DATE
2/22/2021
SCALE
3:1
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1


2.63
R5.65
141.16
Ø8.00
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design Projects in Engineering
STUDENT NUMBER
400213615
LAB SECTION
Linkage Bar
DATE
2/23/2021
SCALE
1 / 1
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1

Screenshots of Code

```
import time
import random
import sys
sys.path.append('../')

from Common_Libraries.p3b_lib import *

import os
from Common_Libraries.repeating_timer_lib import repeating_timer

def update_sim():
    try:
        my_table.ping()
    except Exception as error_update_sim:
        print (error_update_sim)

### Constants
speed = 0.2 #Qbot's speed

### Initialize the QuanserSim Environment
my_table = servo_table()
arm = qarm()
arm.home()
bot = qbot(speed)

##-------------------------------------------------------------------------------------------
## STUDENT CODE BEGINS
##-------------------------------------------------------------------------------------------


'''
CONFIGURATION SETTINGS
    TABLE
        short tower angle = 270
        tall tower angle = 0
        drop tube angle = 180

    QBOT
        orientation after reset = 180
        location along line after reset = 0
        camera angle = -21.5
        all display options on

    ENVIRONMENT
        all offset = 55
        metallic off
        roughness = 0.5
        all lines = red 1 and green 0.5
        box 1 = all 0
        box 2 = red 1
        box 3 = blue 1
        box 4 = green 1

    BOX
        width = 33.8
        length = 22.7
        wall height (clockwise starting at top) = 10, 1, 7, 10
        x = -2
        y = 0
        z = 27
'''
```

```
def drop_container():
    '''
    Function: drop_container()
    Purpose: dispense a random bottle and finds it's attributes
    Input: N/A
    Output: mass of container and destination bin id of container
    '''
    #gives a random number for the container
    bottle = random.randint(1,6)
    #gather properties od bottle and dispense it
    properties = my_table.container_properties(bottle)
    my_table.dispense_container()
    mass = properties [1]
    bin_id = properties [2]
    time.sleep(0.5)
    return mass, bin_id


def load_container(mass, bin_id):
    '''
    Function: load_container()
    Purpose: puts first container on q-bot and determines if other ...
             ...containers should be placed
    Input: take in the mass and bin_id for the first bottle dropped
    Output: will output the mass of the container and the material...
            ...it is made of
    '''
    #get the properties of the bottle already dropped and move to q-bot
    tot_mass = mass
    og_bin_id = bin_id
    pickup(1)
    #print out total mass on q-bot and where the q-bot will go
    print("bin destination:", og_bin_id)
    print("total mass on q-bot = ", tot_mass)
    new_mass = 0
    new_bin_id = "N/A"
    p = 2

    for i in range (1,3):
        #if the bottle being picked up is the second bottle
        if p == 2:
            mass, bin_id = drop_container()
            if og_bin_id == bin_id:
                if (tot_mass + mass) < 90:
                    #mass of bottle gets added to total mass and ...
                    #... bottle gets transfered to q-bot
                    tot_mass = tot_mass + mass
                    pickup(2)
                    p = 3
                    print("total mass on q-bot = ", tot_mass)
                else:
                    #bottle is now going to be the first bottle...
                    #...in the next dropoff round
                    new_mass = mass
                    new_bin_id = bin_id
                    break
```

```
            else:
                #bottle is now going to be the first bottle...
                #...in the next dropoff round
                new_mass = mass
                new_bin_id = bin_id
                break

        #if the bottle being dropoff is the third bottle
        elif p == 3:
            mass, bin_id = drop_container()
            if og_bin_id == bin_id:
                if (tot_mass + mass) < 90:
                    #mass of bottle gets added to total mass and ...
                    #... bottle gets transfered to q-bot AND a new ...
                    #... bottle will be dropped and will be first...
                    #... bottle in next dropoff round
                    tot_mass = tot_mass + mass
                    pickup(3)
                    print("total mass on q-bot = ", tot_mass)
                    new_mass, new_bin_id = drop_container()
                else:
                    #bottle is now going to be the first bottle...
                    #...in the next dropoff round
                    new_mass = mass
                    new_bin_id = bin_id
                    break
            else:
                #bottle is now going to be the first bottle...
                #...in the next dropoff round
                new_mass = mass
                new_bin_id = bin_id
                break
        else:
            break
    return og_bin_id, new_mass, new_bin_id


def pickup(pickup_num):
    '''
    Function: pickup()
    Purpose: to get q-arm to pick up container and drop it in q-bot
    Input: number of bottles that have been picked up
    Output: N/A
    '''
    #the number of pickups already done determine where the container...
    #...will be placed on q-bot
    if pickup_num == 2:
        bottle = -64
    elif pickup_num == 3:
        bottle = -50
    else:
        bottle = -80
    #q-arm transfers container to q-bot
    arm.home()
    arm.rotate_shoulder(45)
    arm.rotate_elbow(-30)
    arm.control_gripper(32)
    arm.rotate_elbow(-3)
    arm.rotate_base(-25)
    arm.rotate_shoulder(-45)
    arm.rotate_base(bottle)
    arm.rotate_shoulder(-10)
    arm.rotate_elbow(50)
    arm.control_gripper(-5)
    arm.rotate_shoulder(-35)
```

```
def transfer_container(bin_id):
    '''
    Function: transfer_container()
    Purpose: to get q-bot to go to correct bin
    Input: the bin it needs to go to
    Output: no output
    '''
    #bot will move forward so it is in line with first bin, if it is not...
    #...metal then it with test the other bins
    if bin_id == "Bin01":
        #Bin01 is black and is for metal containers
        bot.forward_time(4.4)
    elif bin_id == "Bin02":
        #Bin02 is red and is for paper
        bot.forward_time(4.4)
        bot.activate_color_sensor("Red")
        for i in range(3):
            #will check each bin that it stops beside to detect red
            sensor_readings = bot.read_red_color_sensor("Bin02",0.6)
            sensor_avg = (sensor_readings[0] + sensor_readings[1] + sensor_readings[2])/3
            if sensor_avg >= 4.6:
                bot.stop()
                break
            else:
                #when red is not detected at a bin, the bot will continue...
                #...forward to check the next bin
                bot.forward_time(1.8)
        bot.deactivate_color_sensor()
    elif bin_id == "Bin03":
        #Bin03 is blue and is for plastic
        bot.forward_time(4.4)
        bot.activate_color_sensor("Blue")
        for i in range(3):
            #will check each bin that it stops beside to detect blue
            sensor_readings = bot.read_blue_color_sensor("Bin03",0.6)
            sensor_avg = (sensor_readings[0] + sensor_readings[1] + sensor_readings[2])/3
            if sensor_avg >= 4.6:
                bot.stop()
                break


            else:
                #when blue is not detected at a bin, the bot will continue...
                #...forward to check the next bin
                bot.forward_time(1.8)
        bot.deactivate_color_sensor()
    elif bin_id == "Bin04":
        #Bin04 is green and is for garbage
        bot.forward_time(4.4)
        bot.activate_color_sensor("Green")
        for i in range(3):
            #will check each bin that it stops beside to detect green
            sensor_readings = bot.read_green_color_sensor("Bin04",0.6)
            sensor_avg = (sensor_readings[0] + sensor_readings[1] + sensor_readings[2])/3
            if sensor_avg >= 4.6:
                bot.stop()
                break
            else:
                #when green is not detected at a bin, the bot will continue...
                #...forward to check the next bin
                bot.forward_time(1.8)
        bot.deactivate_color_sensor()
    else:
        bot.stop()
```

```
def deposit_container():
    '''
    Function: depostit_container()
    Purpose: to get q-bot to empty out tray into destination bin
    Input: no inputs
    Output: no outputs
    '''
    #turn qbot so it is heading toward the bin
    bot.rotate(93)
    time.sleep(1)
    bot.forward_time(2.3)
    time.sleep(1)
    #turn qbot so when we lift the box, the container will dump into the bin
    bot.rotate(-91)
    time.sleep(1)
    #dump containers into bin
    bot.activate_actuator()
    bot.dump()
    bot.deactivate_actuator()
    time.sleep(1)
    #go back to the main yellow line
    bot.rotate(-91)
    time.sleep(1)
    bot.forward_time(2.3)
    time.sleep(1)
    bot.rotate(91)


def return_home():
    '''
    Function: return_home()
    Purpose: to get q-bot to return home
    Input: no inputs
    Output: no outputs
    '''
    #follow yellow line back to the home position
    num_line = 0
    while num_line < 2:
        num_line, velocity = bot.follow_line(0.3)
        bot.forward_velocity(velocity)
    bot.stop()
    bot.forward_time(0.5)
    #turn around
    bot.rotate(189.5)


def main():
    #for dispensing first container
    mass, bin_id = drop_container()
    i = 1
    #go through loop infite number of times
    while i == 1:
        #take in last dipensed bottle's bin_id and mass to be used in next loop
        og_bin_id, mass, bin_id = load_container(mass, bin_id)
        #tranfer bottle and go home
        transfer_container(og_bin_id)
        deposit_container()
        return_home()


main()


##-------------------------------------------------------------------------------------
## STUDENT CODE ENDS
##-------------------------------------------------------------------------------------
update_thread = repeating_timer(2,update_sim)
```