Design Project 3 – Revenge of the Recycling System

Design a System for Sorting and Recycling Containers

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial T12

Team Fri-37

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Submitted: March 4, 2024

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Academic Integrity Statement

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(Student Signature) *

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Executive Summary

In the waste industry, recycling faces challenges due to contamination and limitations in sorting algorithms & technology [1]. Although facilities use sensors to classify materials, many items remain unrecycled, like black plastics undetected by optical systems. However, a controlled recycling station with sensors to sort and identify recyclable materials could enhance this process [3].

The main objective of the "Revenge of the Recycling System" project was to design a system for sorting waste and recyclables into designated containers [4]. To create this system, students were split into modeling and computing sub-teams. The modeling sub-team used Autodesk Inventor to design a solid model of a mechanism that deposits recyclable containers into bins. The mechanism connects to the Q-Bot and a hopper and uses the motion of an actuator to rotate the hopper and deposit the containers. The computing sub-team used Python to develop a program that controlled the robotic arm's movements, safely picking up and transferring items to the container for recycling. Once loaded, the system continued by guiding the waste disposal process via Q-Bot using an intricately designed algorithm [4]. The algorithm included functions like "dispense_container", "load_container", and "deposit_container", utilizing Q-Arm and Q-Bot specific code along with general Python programming.

Together, the teams established a comprehensive workflow for the robotic arm system and Q-Bot to effectively sort and dispose of materials. This project served as an opportunity for students to explore rapid prototyping and physical computing by developing a system that uses remote sensing and actuation to assist in creating a healthy future for the environment, gaining hands-on experience in tackling real-world environmental challenges.

Reference List

[1] "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.

[2] "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/ .

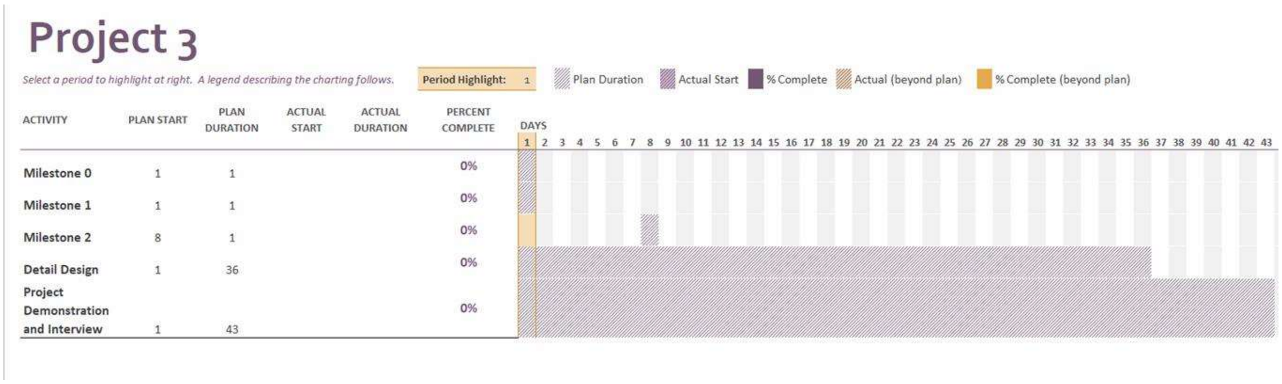
[3] J. Fingas, "Recycling robot can sort paper and plastic by touch," Engadget, 11-Apr-2019.[Online].Available: https://www.engadget.com/2019-04-11-mit-recycling-robot.html

[4] P3 - Project Module, McMaster University, Hamilton, Canada, 2023

Appendices

Appendix A: Project Schedule

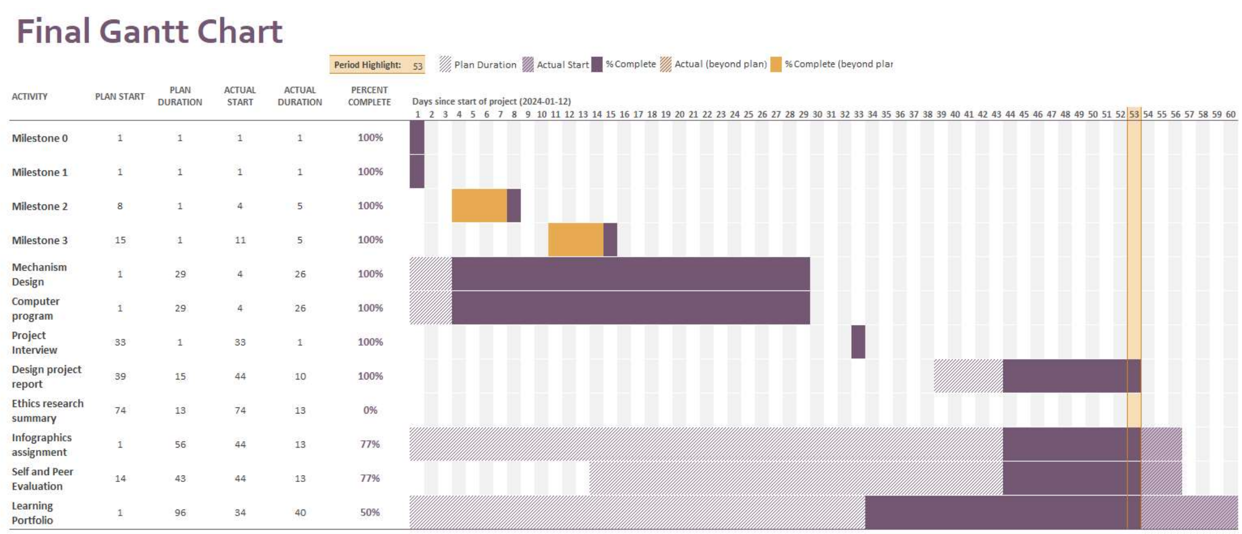
Preliminary Gantt Chart:



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1			0%
Milestone 1	1	1			0%
Milestone 2	8	1			0%
Detail Design	1	36			0%
Project Demonstration and Interview	1	43			0%

Figure 1: Preliminary Gantt Chart

Final Gantt Chart:



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	1	1	100%
Milestone 1	1	1	1	1	100%
Milestone 2	8	1	4	5	100%
Milestone 3	15	1	11	5	100%
Mechanism Design	1	29	4	26	100%
Computer program	1	29	4	26	100%
Project Interview	33	1	33	1	100%
Design project report	39	15	44	10	100%
Ethics research summary	74	13	74	13	0%
Infographics assignment	1	56	44	13	77%
Self and Peer Evaluation	14	43	44	13	77%
Learning Portfolio	1	96	34	40	50%

Figure 2: Final Gantt Chart

Logbook of Additional Modelling Sub-team Meetings:

January 22, 2024

Attendance (modelling sub-team)

Role	Name	Mac ID	Attendance (Yes/No)
Manager			
Administrator	**Maahi Sharma**	**sharm20**	**Yes**
Coordinator	**Milana Kalinic**	**kalinicm**	**Yes**
Subject Matter Expert			
Guest			

Agenda Items

1. .Choosing mechanism
2. .Discussion of actuator choice
3. .Writing out decision-making process
4. .Starting to draw design
5. .Final Notes

Meeting Minutes

1. . Choosing mechanism
   a. Triangular linkage mechanism
   b. We decided it'd be a good idea to stay away from gears as they introduce potential issues with laser cutting
2. . Discussion of actuator choice
   a. Since we are using a triangular linkage mechanism, a linear actuator makes the most sense as it can push the linkage upward
3. .Writing out decision-making process
   a. Explaining our reasoning behind our mechanism and actuator choice
   b. Proofreading (checking grammar, spelling, etc.)
4. . Starting to draw design
   a. Transfer position drawing assigned to Milana and deposit position assigned to Maahi
5. .Final Notes
   a. Agreeing on post-meeting action items

Post-Meeting Action Items

1. *Complete transfer position drawing [Milana]*
2. *Complete deposit position drawing [Maahi]*
3. *Begin Autodesk Inventor design [Milana and Maahi]*

January 30, 2024:

Attendance (modelling sub-team

Role	**Name**	**Mac ID**	**Attendance (Yes/No)**
Manager			
Administrator	**Maahi Sharma**	**sharm20**	**Yes**
Coordinator	**Milana Kalinic**	**kalinicm**	**Yes**
Subject Matter Expert			
Guest			

Agenda Items

1. .Address issue with hopper transfer position
2. .Discuss attachment of slider to linear actuator
3. .Refine design sizing
4. .Prepare for Design Studio

Meeting Minutes

1. .Address issue with hopper transfer position
    a. Hopper does not lay fully horizontal in transfer position
    b. Adjustment of linkage length does not help
    c. Ask mentor in design studio if this will raise issues
2. . Discuss attachment of slider to linear actuator
    a. Currently slider is not attached to linear actuator
    b. This may cause issues when the slider retracts (from drop-off to transfer position)

    c. Consult mentor in design studio if hopper is heavy enough to push slider back on its own or if we should attach it to the linear actuator
3. .Refine design sizing
    a. Slightly resize linkages so that the hopper elevates to a larger degree in drop-off position
4. .Prepare for Design Studio
    a. Brainstorm questions for our mentor
    b. Go over how we will present our design

Post-Meeting Action Items

1. *Finish editing design [Maahi]*
2. *Plan design studio TA meeting [Milana]*

February 9, 2024

Attendance (modelling sub-team

Role	Name	Mac ID	Attendance (Yes/No)
Manager			
Administrator	**Maahi Sharma**	**sharm20**	**Yes**
Coordinator	**Milana Kalinic**	**kalinicm**	**Yes**
Subject Matter Expert			
Guest	**Ben (mentor)**		**Yes**

Agenda Items

1. .Showcase mechanism design
2. .Receive mentor feedback
3. .3D print components

Meeting Minutes

1. .Showcase mechanism design
    a. Explain mechanism to mentor
    b. Explain how we constrained and CADed the parts
    c. Showcase assembly and part files
    d. Explain slight adjustment to design from last design studio
4. . Receive mentor feedback
    e. Mentor approves of design
    f. Design follows marking scheme
2. .3D print components
    a. Set up 3D print in Design Studio using PrusaSlicer

Post-Meeting Action Items

3. *Purchase screws [Milana]*
4. *Assemble mechanism with screws [Maahi and Milana]*

Feb 10-11, 2024:

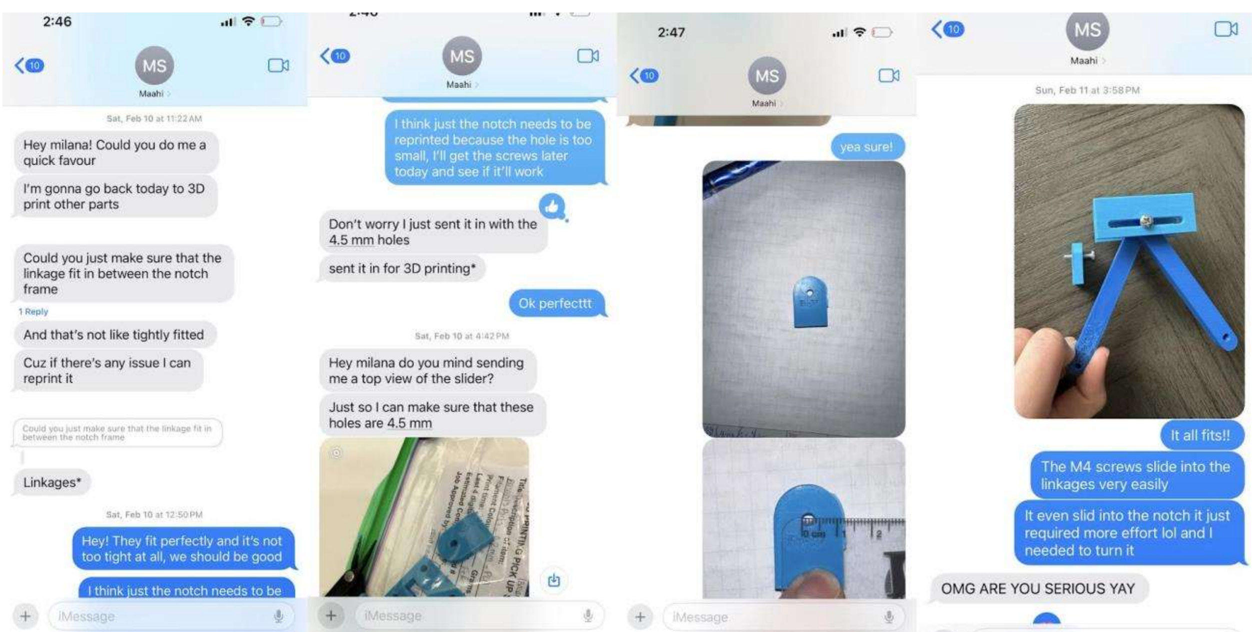


Figure 3: Discussions of the 3D printed parts of the mechanism

Appendix B: Scheduled Weekly Meetings

January 19, 2024

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Dillion Robert**	**robertd50**	**Yes**
Administrator	**Ben Malkovich**	**malkovib**	**Yes**
Coordinator	**Shadi El-Fares**	**elfaress**	**Yes**
Administrator	**Maahi Sharma**	**sharm20**	**Yes**
Coordinator	**Milana Kalinic**	**kalinicm**	**Yes**

ITEMS

1. Computing Check-In
2. Modelling Check-in

MEETING MINUTES

1. Why choose sensors.
    a. Color sensor because it returns good values that are easier to work with as well as traverse the yellow line.
    b. Ultrasonic sensor because it gives us the ability to navigate distance between the Q-Bot and the bins.
2. Don't include python syntax when submitting pseudocode.
3. The table that dispenses the bottles doesn't need to be included in our dispense container function.
4. Using IR Sensors to traverse the line not the color sensor.

Modeling:

1. Explaining the functionality of the lever arm that will push the container (*linear actuator)*
    a. Feedback: Constraining the parts is a good start in preparation for printing.
    b. We cannot have the actuator raised, it must be flat with the base-plate.
2. Possible problems:
    a. Might not be able to get enough motion / force with the current output of the linear actuator.
    b. Consider the current raised angle of the joint.

POST-MEETING ACTION ITEMS

1. *Get rid of current python code in pseudocode*
2. *Adjust the current angle of the joint, and consider the position of the linear actuator to generate enough force.*

January 26, 2024

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Dillon Robert	roberd50	Yes
Administrator 1	Ben Malkovich	malkovib	Yes
Administrator 2	Maahi Sharma	sharm20	Yes
Coordinator 1	Shadi El-Fares	elfaress	Yes
Coordinator 2	Milana Kalinic	kalinicm	Yes

AGENDA ITEMS

1. TA Check-in with computing subteam.
2. TA Check-in with modelling subteam.
3. Consolidating Feedback.
4. Seeing each other's mechanism and code.

MEETING MINUTES

1. .TA check-in with computing subteam.
    a. Question regarding functions in code
    b. Troubleshooting code
2. .TA Check-in with modelling subteam
    a. Addressing concern of hopper plate not being fully flat in transfer position
    b. Documenting feedback
3. .Consolidating Feedback
    a. Both subteams fill out Milestone 3 mentor comments
    b. Brainstorming action items in Team worksheet
    c. Modelling subteam adjusts design, computing subteam works on code
4. .Seeing each other's mechanism and code
    a. Modelling and coding show each other what we have so far

POST-MEETING ACTION ITEMS

1. Refine transfer function and ensure it contains 3 loading positions [Computing Subteam]

2. Implement feedback from mentor into modelling design [Modelling Subteam]
3. Both subteams will have their own check-in meeting prior to the next DS [Computing and Modelling]

February 2, 2024

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Dillion Robert	robertd50	Yes
Administrator	Ben Malkovich	malkovib	Yes
Coordinator	Shadi El-Fares	elfaress	Yes
Administrator	Maahi Sharma	sharm20	Yes
Coordinator	Milana Kalinic	kalinicm	Yes

ITEMS

1. Computing Check-In
2. Modelling Check-in

MEETING MINUTES

1. Previous issues resolved, current issue is: Linear Actuator is not functioning properly to release the container properly.
    a. Current diagnoses from instructor: No degrees of freedom left in the currently designed model.
    b. Potential Fix: Deleting holes on the top, while keeping mate constraint to resolve overlapping issue. The currently designed model, might be a trust, which is entirely fixed at all points of pivot.
2. Coding has to fix the actuator coming down (fixed in DS)
    a. Also fix two full cycles in one run.

POST-MEETING ACTION ITEMS

1. Fix minor bugs and get two full cycles working – Coding
2. Small adjustments to Modelled design, regarding linear actuator.

Appendix C: Comprehensive List of Sources

[1] "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.

[2] "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/ .

[3] 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

[4] "P3- Project Module", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

[5] "ENG_1P13 Lecture 40-41, Jan10 2024, Mechanisms", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

[6] "Depositing Containers (Modelling Sub-Team) - Demo Video", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

[7] "Shape construction," Unacademy, [Online], Available: A Brief Note on Shape Construction (unacademy.com)

[8] "Moving the Q-bot – Demo Video", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

[9] "Using Q-bot Sensors – Demo Video", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

[10] "ENGINEER 1P13 Lab and Project Python Hardware Library Documentation", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

[11] "How-To Guide-Fabrication", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

[12] "How-To Guide-3D Printing", class notes for 1P13, Engineering, McMaster University, Term 2, 2024.

Appendix D: Supporting Documentation

Computer Program:

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

import random
bot.activate_color_sensor()
bot.activate_line_following_sensor()
bot.activate_ir_sensor()
HQ = bot.position()
print(HQ)
og2 = 0 #used later to store the binID of the regected containers
count = 0 #used later in order to inform if the program has looped once or not

def dispense_container():#this function dispenses 1 container
    global container
    container = table.dispense_container(random.randint(1,6),True)# container variable holds container properties
    print(container)

def load_container():# loads 1 container onto the q-bot
    print(bot.position())
    home_position = bot.position()
    global original_x
    original_x = home_position[0]
    global original_y
    original_y = home_position[1]
    global original_z
    original_z = home_position[2]
    time.sleep(.5)
    arm.rotate_elbow(-30)
    time.sleep(1)
    arm.rotate_shoulder(45)
    time.sleep(1)
    arm.control_gripper(40)
    time.sleep(1)
    arm.rotate_shoulder(-45)
    time.sleep(1)
    arm.rotate_base(-90)
    time.sleep(1)
    arm.rotate_shoulder(15)
    time.sleep(1)
    arm.rotate_elbow(12)
    time.sleep(1)
    arm.control_gripper(-40)
    time.sleep(1)
    arm.home()
```

Figure 4: dispense_container() and load_container() functions

```
def load_containers():#loads multiple containers until one of the coditions are met
    global count
    global og
    global og2
    global weight2
    global container
    if count == 0: # if the program is looping for the first time
        dispense_container()
        load_container()#calls dispense and load container functions
        og = container[2]#og holds the originals containers bin Id
        weight = container[1]
        i=0
        while i < 2:#loop to reapeat process up to 2 more times
            time.sleep(2)
            dispense_container()
            weight += container[1]
            if weight <= 90 and og == container[2]:
                load_container()
            else:
                i=2
                og2 = container[2]
                weight2 = container[1] #stores weight of rejected container
                print("Cannot load another container")
            i=i+1
    elif count == 1: #if this is not the first time the program has looped
        arm.rotate_shoulder(15) #code places the rejected container from the last loop into place
        time.sleep(1)
        arm.rotate_elbow(12)
        time.sleep(1)
        arm.control_gripper(-40)
        time.sleep(1)
        arm.home()
        weight = weight2 #setting the weight of the rejected container as the initial weight
        i=0
        while i < 2:#loop to reapeat process up to 2 more times
            time.sleep(2)
            dispense_container()
            weight += container[1]
            if weight <= 90 and og2 == container[2]:
                load_container()
            else:
                i=2
                og = og2
                og2 = container[2]
                weight2 = container[1] #stores weight of rejected container
                print("Cannot load another container")
            i=i+1
```

Figure 5: load_containers() function

```python
def colour_detection():
    colour=bot.read_color_sensor()[0]
    print(colour)
    return colour#returns the colour

def transfer_container():
    a=1
    global og
    while a==1:#this is the line folloing loop
        l=bot.line_following_sensors()
        if l==[1, 1]:
            bot.set_wheel_speed([0.02, 0.02])
        elif l==[1, 0]:
            bot.set_wheel_speed([0.01, 0.02])
        elif l==[0, 1]:
            bot.set_wheel_speed([0.02, 0.01])
        else:
            print("line not detected")
        bin_colour=colour_detection()
        if bin_colour == [1,0,0] and og == 'Bin01':#stops the q-bot when the colour matches the bin ID
            a=0
            print("bin found")
            bot.stop()
        elif bin_colour == [0,1,0] and og == 'Bin02':
            a=0
            print("bin found")
            bot.stop()
        elif bin_colour == [0,0,1] and og == 'Bin03':
            a=0
            print("bin found")
            bot.stop()
        elif bin_colour == [0,0,1] and og == 'Bin04': #detects bin 3, will move to bin 4
            a=0
            print("bin found")
            bot.stop()
```

Figure 6: colour_detection() and transfer_container() functions

```python
def deposit_container():
    line = bot.line_following_sensors()
    if og == 'Bin01':#directs the q bot to the bin then doposits and goes back to the line
        bot.rotate(90)
        bot.forward_distance(0.15)
        bot.rotate(-90)
        bot.forward_distance(.2)
        bot.activate_linear_actuator()
        bot.rotate_hopper(35)
        time.sleep(0.5)
        bot.rotate_hopper(55)
        time.sleep(2)
        bot.rotate_hopper(0)
        bot.set_wheel_speed([0.01, 0.02])
        time.sleep(.5)
        bot.set_wheel_speed([0.01, 0.02])
        if line == [1, 1] or [0, 1] or [1, 0]:
            bot.stop()
    elif og == 'Bin02':
        bot.rotate(90)
        bot.forward_distance(0.15)
        bot.rotate(-90)
        bot.forward_distance(.2)
        bot.activate_linear_actuator()
        bot.rotate_hopper(45)
        time.sleep(0.5)
        bot.rotate_hopper(60)
        time.sleep(2)
        bot.rotate_hopper(70)
        time.sleep(2)
        bot.rotate_hopper(0)
        bot.set_wheel_speed([0.01, 0.02])
        if line == [1, 1] or [0, 1] or [1, 0]:
            bot.stop()
```

Figure 7: deposit_container() function

```python
elif og == 'Bin03':
    bot.rotate(90)
    bot.forward_distance(0.15)
    bot.rotate(-90)
    bot.forward_distance(.2)
    bot.activate_linear_actuator()
    bot.rotate_hopper(30)
    time.sleep(0.5)
    bot.rotate_hopper(60)
    time.sleep(2)
    bot.rotate_hopper(0)
    bot.set_wheel_speed([0.01, 0.02])
    time.sleep(2)
    bot.set_wheel_speed([0.01, 0.02])
    if line == [1, 1] or [0, 1] or [1, 0]:
        bot.stop()
elif og == 'Bin04':
    bot.rotate(90)
    bot.forward_distance(0.15)
    bot.rotate(-90)
    bot.forward_distance(.65)
    bot.activate_linear_actuator()
    bot.rotate_hopper(35)
    time.sleep(0.5)
    bot.rotate_hopper(55)
    time.sleep(2)
    bot.rotate_hopper(0)
    time.sleep(2)
    bot.rotate(-45) #to ensure the bot will be able to see the line once it begins to return home
    time.sleep(0.5)
    bot.set_wheel_speed([0.01, 0.02])
    time.sleep(2)
    bot.set_wheel_speed([0.01, 0.02])
    if line == [1, 1] or [0, 1] or [1, 0]:
        bot.stop()
```

Figure 8: deposit_container() function continued

```python
def home():
    while True:#line following loop
        l=bot.line_following_sensors()
        if l==[1, 1]:
            bot.set_wheel_speed([0.02, 0.02])
        elif l==[1, 0]:
            bot.set_wheel_speed([0.01, 0.02])
        elif l==[0, 1]:
            bot.set_wheel_speed([0.02, 0.01])
        else:
            print("line not detected")
        pos = bot.position()#stops bot when it is in the home range
        #print(pos)
        if 1.4 < pos[0] < 1.5 and 0.01 < pos[1] < 0.1:
            break
    bot.stop()
    print("I have found Home")
    home_position = bot.position() #picks up the rejected container in preparation for the program loop
    global original_x              #so that when dispense container is called in the loop, the platform is clear
    original_x = home_position[0]
    global original_y
    original_y = home_position[1]
    global original_z
    original_z = home_position[2]
    time.sleep(.5)
    arm.rotate_elbow(-30)
    time.sleep(1)
    arm.rotate_shoulder(45)
    time.sleep(1)
    arm.control_gripper(40)
    time.sleep(1)
    arm.rotate_shoulder(-45)
    time.sleep(1)
    arm.rotate_base(-90)
    time.sleep(1)
    global count
    count = 1 #indicates that the first loop has ended so that load_containers will work properly
```

Figure 9: home() function

```python
def main():#calls all functions
    run_main = True
    while run_main == True:
        load_containers()
        transfer_container()
        deposit_container()
        home()

main()

#-----------------------------------------------------------------------------
# STUDENT CODE ENDS
#-----------------------------------------------------------------------------
```

Figure 10: main() function

Mechanism Low-Fidelity Prototype:

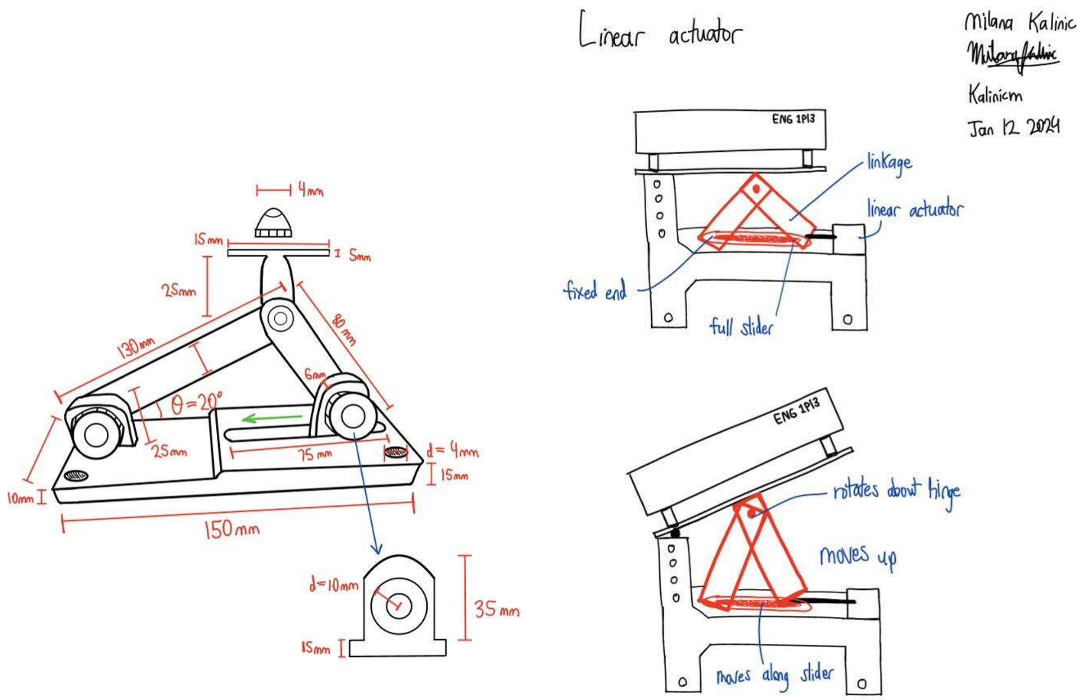


Figure 11: Low-Fidelity Prototype of mechanism

Mechanism Solid Model:

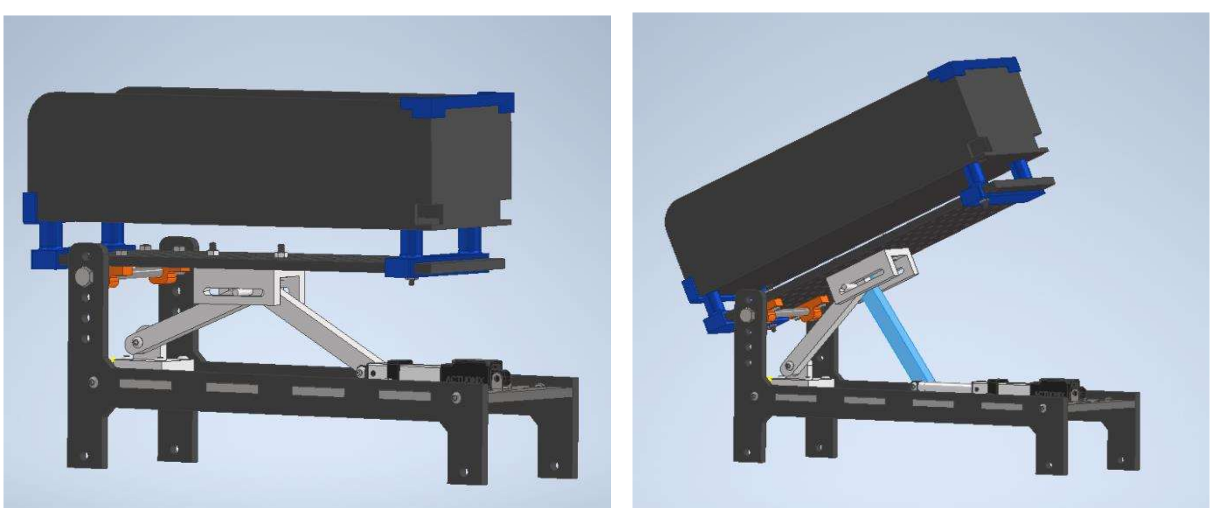


Figure 12: AutoCAD of Solid Model Mechanism in Transfer and Drop-Off Position

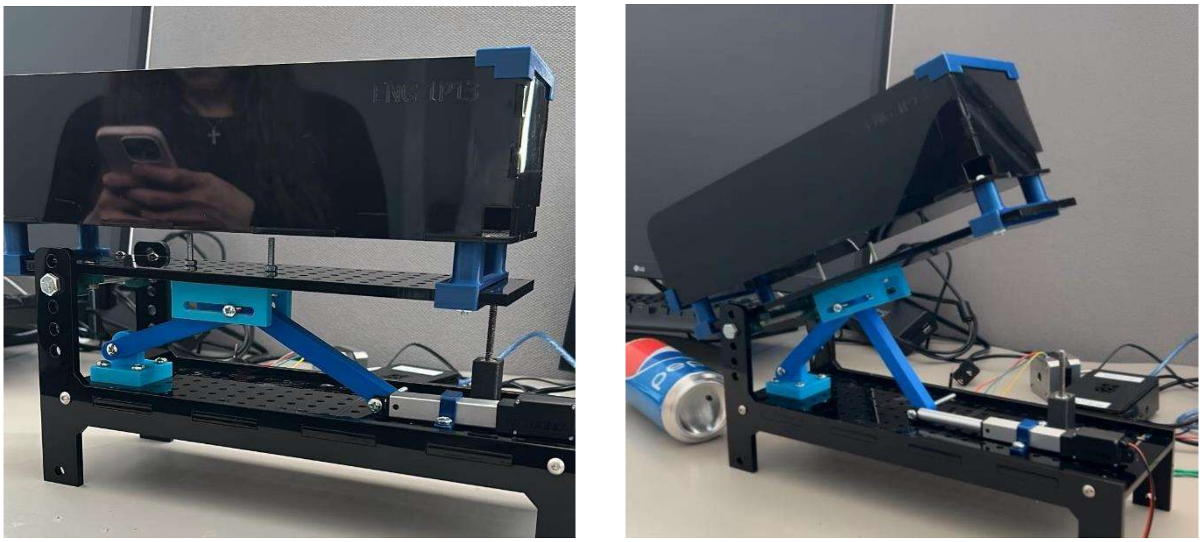


Figure 13 - 3D-Printed Solid Model Mechanism in Transfer and Drop-Off Position

Engineering drawings:

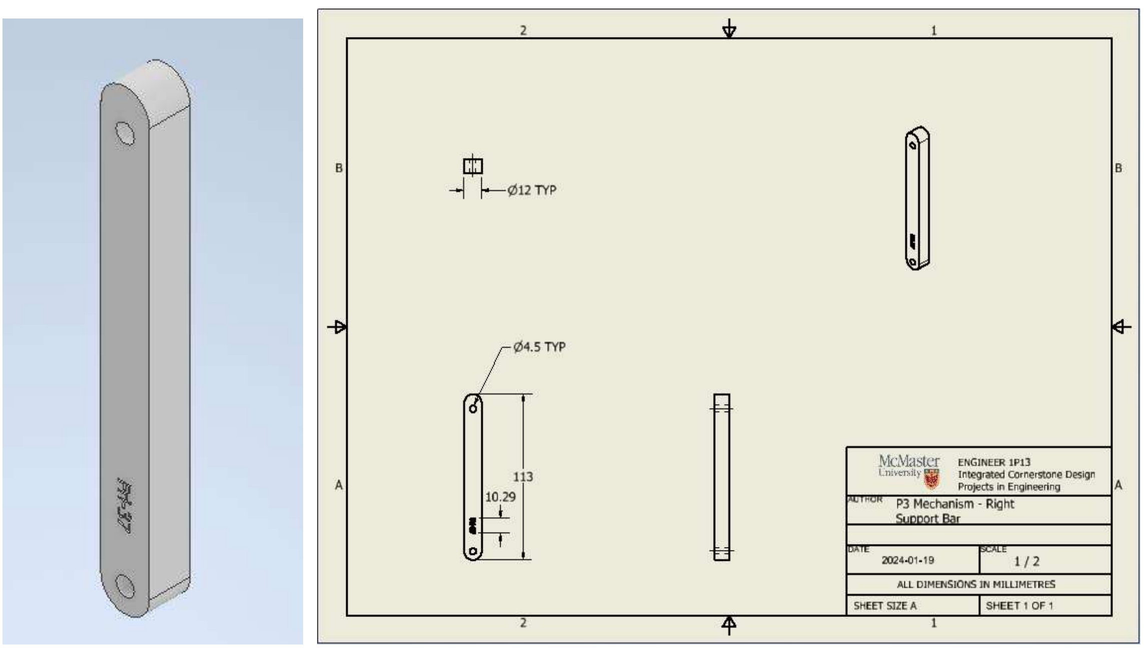


Figure 14: Right Support Bar

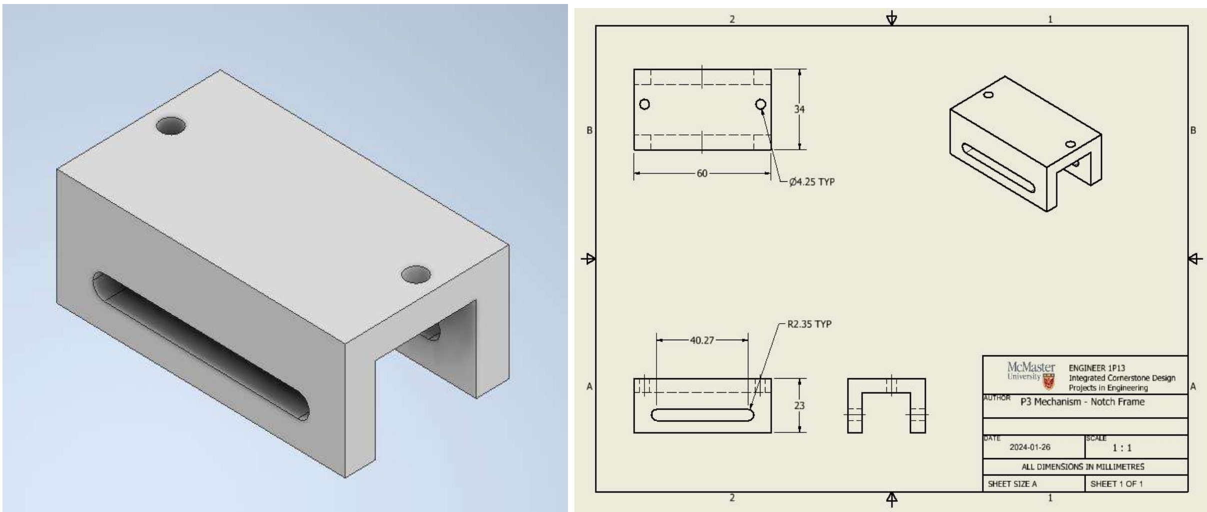


Figure 15: Notch Frame

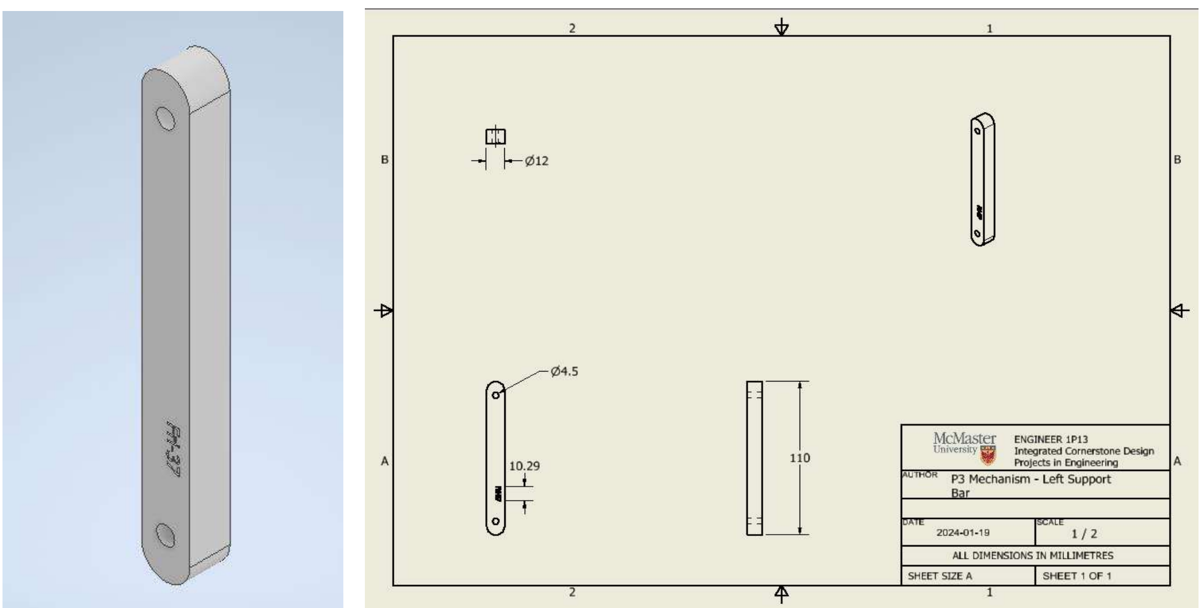


Figure 16: Left Support Bar

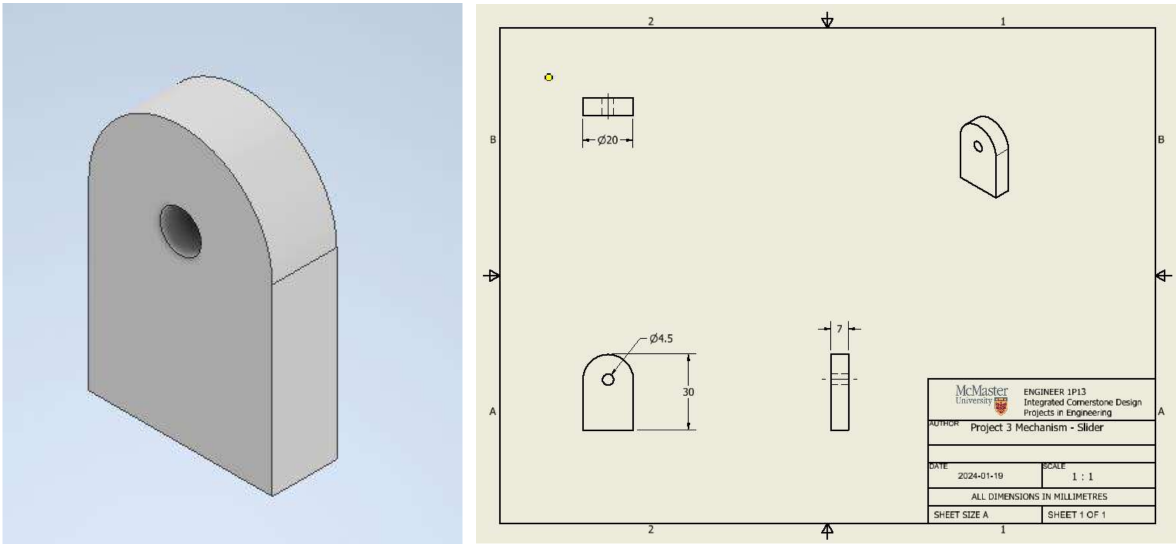


Figure 17: Slider

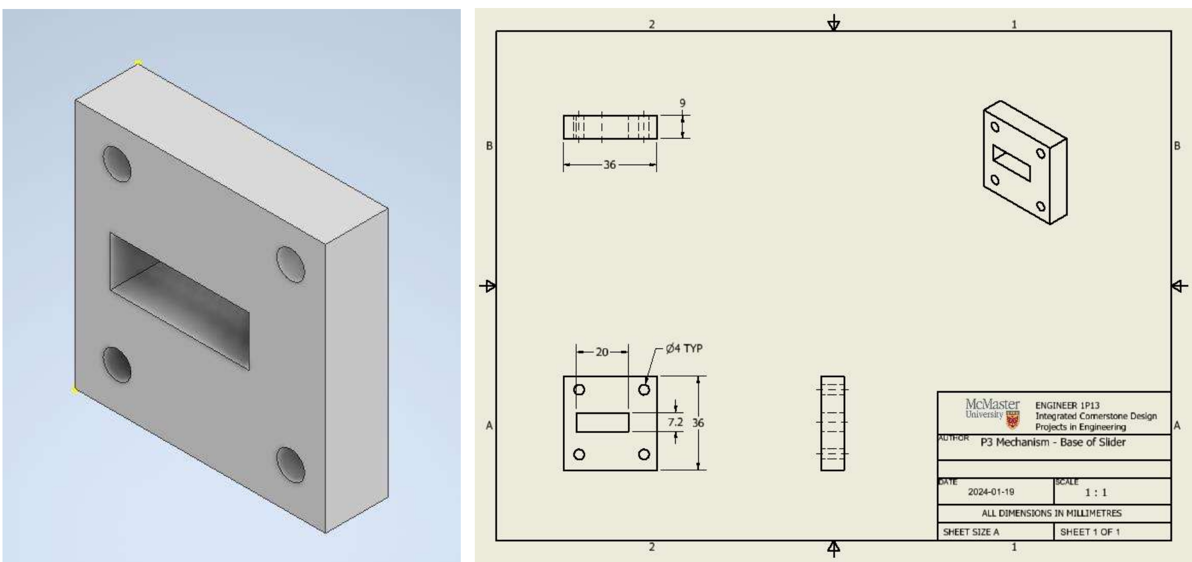


Figure 18: Base of Slider

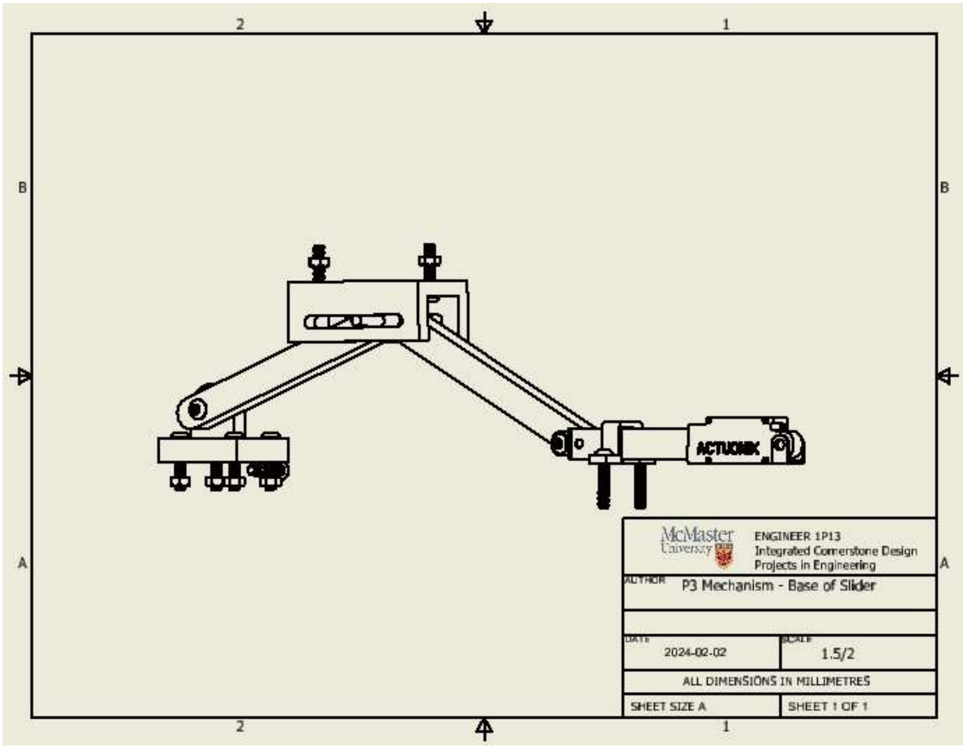


Figure 19: Assembled Mechanism Engineering Drawing

Appendix E: Design Studio Worksheets

ENGINEER 1P13:
PROJECT THREE WORKSHEETS (TEAM)

Table of Contents

PROJECT THREE: MILESTONE ZERO (TEAM): TEAM DEVELOPMENT AND PROJECT PLANNING

Milestone 0 – Cover Page

Team ID: Fri-37

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

Full Name:	MacID:
Milana Kalinic	kalinicm
Maahi Sharma	sharm20
Ben Malkovich	malkovib
Shadi El-Fares	elfaress
Dillon Robert	roberd50

Insert your Team Portrait in the dialog box below

Milestone 0 – Team Charter

Team ID: Fri-37

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Maahi Sharma	☒M ☒A ☐C ☐S
2.	Ben Malkovich	☐M ☐A ☒C ☒S
3.	Milana Kalinic	☐M ☒A ☐C ☒S
4.	Dillon Robert	☐M ☒A ☒C ☐S
5.	Shadi El-Fares	☒M ☐A ☒C ☐S

To 'check' each box in the Project Leads column, you must have this document open in the Microsoft Word Desktop App (not the browser and not MS Teams)

Project Leads:

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

Role:	Team Member Name:	MacID
Manager	Dillon Robert	roberd50
Administrator 1 (Computing)	Ben Malkovich	malkovib
Administrator 2 (Modelling)	Maahi Sharma	sharm20
Coordinator (Computing)	Shadi El-Fares	elfaress

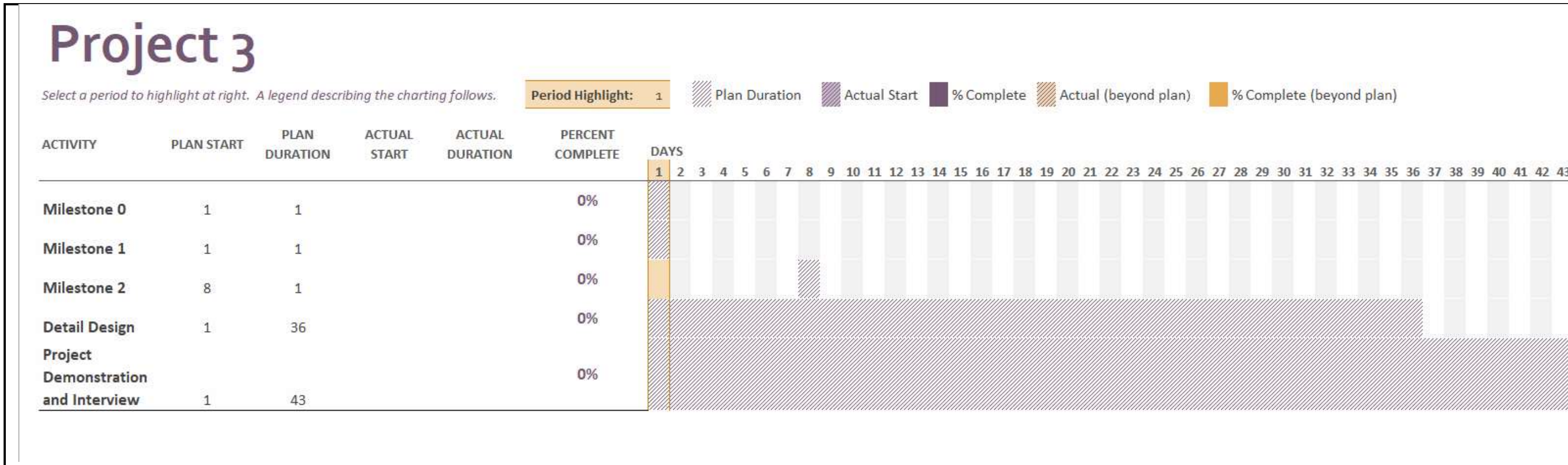
Coordinator (Modelling)	Milana Kalinic	kalinicm

Milestone 0 – Preliminary Gantt Chart (Team Manager Only)

Team ID: Fri-37

Full Name of Team Manager:	MacID:
Dillon Robert	roberd50

Preliminary Gantt chart



PROJECT THREE: MILESTONE ONE (TEAM):
PROBLEM FRAMING AND CONCEPTUAL DESIGN

Milestone 1 – Cover Page

Team ID: Fri-37

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

Full Name:	MacID:
Milana Kalinic	kalinicm
Maahi Sharma	sharm20
Ben Malkovich	malkovib
Dillon Robert	roberd50
Shadi El-Fares	elfaress

Milestone 1 (Stage 1) – Initial Problem Statement, Objectives and Constraints

Team ID: Fri-37

You should have already completed these tasks individually *prior* to Design Studio 13.

Initial Problem Statements

Copy and paste the initial problem statement(s) below.

Design a system for sorting and recycling containers.

Objectives and Constraints

Copy and paste each team member's Objectives and Constraints tables here or combine the objectives and constraints into the single table below.

Objectives	Identify different materials via sensors. Assess recyclability of items. Transfer items to a transport system. Facilitate the transport of items to their designated bin. Dispense items into their designated bin. Deposit mechanism should mount easily to frame. Return transport system to the original position to receive more items. Code is easy and intuitive to use by user Code accurately identifies container and sorts it Containers are securely transferred

	Mechanism angle chosen such that container is precisely deposited into correct bin Program efficiently and quickly identifies container type and deposit bin Determing Container Variables o Mass dependant delivery later. Sensor Activation and Deactiviation – Trajectory Following – Home Position Return – Repeated Task Execution (i.e the above in a loop of some kind) Virtually mounted sensors Maintenance and Reliability (if we consider a long-term solution) Cost Consideration (More of Modelling as I believe they have to pay)
Constraints	Program needs to be able spawn exactly six containers (iterate through a list of six container ID's) Q-bot must follow a line on the floor to move to different locations (cannot make shortcuts i.e. cut through the middle) Each container ID must be assigned specific attributes and specific target bins (cannot randomly assign attributes) Can only transport one item type at a time. Total item load cannot exceed 90 grams. Only can transport 3 containers maximum. Only 4 possible bin designations. Deposit mechanism can only use linear or rotary actuator. Mechanism must function with given hopper and base plate. Code is written in Python

	Workflow/steps outlined in Project Module are followed (Qbot transfers container, deposits it, returns to home, etc.) Different types of containers are deposited to their respective bins (determined by material, contamination, etc.) Actuator must mount within a specific region of designated mechanism that connects to baseplate and connecting plate Mechanism must connect to base plate and connecting plate User Input Validation (code is not completely autonomous) Bin Recognition Accuracy Safety Measures Power Consumption Environment Adaptability (having the Q-bot understand the environment it will work in) Sensor accuracy

We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their work with the **Milestone 1 Individual Worksheet** document so that it can be ***graded***
- Compiling your individual work into this **Milestone 1 Team Worksheet** document allows you to readily access your team member's work
  - This will be especially helpful when completing ***Stage 2*** of the milestone

Milestone 1 (Stage 2) – Refined Problem Statement

Team ID: Fri-37

Refined Problem Statement

1. As a team, write the refined problem statement below. Kindly refer to the Refined Problem Statement rubric in the P3 Project Module. This will guide your group in creating a valid statement.

Design a sorting system that can accurately sort recyclable items from those that aren't, since the current system is unable to accommodate for a complete sorting solution, and is therefore highly inefficient.

PROJECT THREE: MILESTONE TWO (TEAM): PRELIMINARY DESIGN

Milestone 2 – Cover Page

Team ID: Fri-37

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

Full Name:	MacID:
Shadi El-Fares	elfaress
Milana Kalinic	kalinicm
Maahi Sharma	sharm20
Ben Malkovich	malkovib
Dillon Robert	roberd50

Milestone 2 (Stage 1) – Sensor Selection and Computer Program Workflow (Computation Sub-Team)

Team ID: Fri-37

1. As a sub-team, discuss the results of your individual sensor demo activity and select the sensor(s) that you will use in your project. Identify the sensor(s) in the box below and include any decision-making tools or justification in the space provided. *Teams are allowed to use a maximum of 2 sensors*

Chosen Sensors: Color Sensor, Ultrasonic Sensor

Decision-making tools and/or justification: The color sensor will facilitate easy differentiation of containers based on color, eliminating the need to distinguish between metal, paper, or plastic. This choice is supported by the observation that the demo bot effectively follows the yellow color. The ultrasonic sensor is chosen for its larger range and convenient return values, making it easier to work with compared to IR and Hall sensors. Additionally, the IR and Hall Sensors have limitations in range which would require additional functionalities for the same served purpose. The decision is grounded in the practical advantages of these sensors for the project's objectives.

2. As a sub-team, write out the pseudocode or create a flowchart for the indicated tasks in the space below
    → If creating a flowchart, complete your flowchart on a separate sheet of paper, take a photo of your sketch and insert photo as a Picture under the appropriate task

Dispense Container

- Rotate platform until container detected
- Use above to determine bin location for container

Load Container

```
Initialize a list giving the coordinates of the pickup position
Initialize a list of lists containing the positions for each drop off
Initialize the count of containers as 0
Initialize a variable describing matching IDs as true
Store the bin ID of the current container
Store the mass of the current container
Set while loop that runs when there are less than 3 containers, the mass is less than 90 grams,
and the ID match variable is true
        Move arm to the coordinates given, close claw
        Move arm to Qbot hopper using coordinates in the drop off list, release claw
        Move to home position
        Iterate the count by 1
        Get the bin ID of the next container
        If the new container has the same bin ID
                Add the new mass to the mass of the first container
        If the ids do not match (else)
                Set the ID match variable as False
```

Transfer Container

Initialize a target bin ID as the bin id the qbot must move to

Initialize a list of lists containing RBG values of each bin, 1 – 4

Set the target list of values as the corresponding list in the list of lists

Set arrived variable as False

Activate the colour sensor

Activate the qbot so it begins moving along the path

Set up a while loop so while arrived is False these actions are taken

    Obtain the RGB values output by the colour sensor (first list)

    If what the sensor reads matches the targeted bin

        Stop the qbot

        Set arrived as True

Deposit Container

1. Q-bot identifies and positions the containers into the appropriate destination bins.
2. Q-bot needs to be shifted until the hopper is next to the bin.
3. The hopper undergoes rotation to deposit containers into the bin.
4. Q-bot is realigned with the trajectory line after positioning.

Return Home

- Return hopper to initial position
- Activate colour sensor
- Move Q-bot along path using colour sensor
- Set up a loop to stop the Q-bot once its returned home
- Rotate Q-bot back into original orientation

Milestone 2 (Stage 2) – Detailed Sketches of Mechanism Assembly (Modelling Sub-Team)

Team ID: Fri-37

1. As a sub-team, review your concept mechanism concept sketches, and use a decision-making tool of your choice to decide which mechanism design to pursue. Examples of decision-making tools include simple or weighted decision matrices (Slide 22 of the P1 Milestone 3A Slides). Show evidence of your decision-making below, and clearly identify which mechanism design your sub-team has chosen.

Name: Milana Kalinic	MacID: kalinicm
Name: Maahi Sharma	MacID: sharm20

Show your decision-making process below, and clearly identify which mechanism concept your team will pursue.

Chosen Design: *Triangular Linkage Mechanism*

Design Process:

Below are pictures of how we went through our design process for the mechanism.

Design Process:

? Things to consider!!

- strength of mechanism
- is laser cutting ideal?
- linear or rotary?
- which actuator offers more accuracy?
- Do we need to consider shapes and forces?

Some Background Knowledge!

Fact!

↳ triangular shapes are known to be the strongest shapes in construction; any load at the top of a triangle splits itself into two loads, offering more stability

* consider this when developing the structure and shape of the mechanism.

Fact!

↳ to output most movement with minimal force required, torque should be applied a farther distance away from pivot point!

* consider this when determining where to hook mechanism onto hopper.

Pros and Cons: Linear vs Rotary Actuator

Linear Actuator

Pros

- ✓ offers more control over movement
- ✓ linear movement is more guaranteed
- ✓ gears may be excluded from mechanism if desired!

Cons

- ✗ could offer difficulty when lifting hopper at an angle
- ✗ limited movement options, only linear movement

Better Choice?

Rotary Actuator

Pros

- ✓ offers more choices of movement
- ✓ high force output
- ✓ gears may be included in mechanism if desired!

Cons

- ✗ movement may not be so accurate, interruptions
- ✗ laser cutting gears for actuator may result in errors (need a lot of precision)

Justification of Design:

Our chosen design incorporates the use of a linear actuator to drive the mechanism. For the mechanism, two support bars are strategically arranged onto the base plate in the shape of a triangle, with a small height when in transfer position (refer to detailed sketch of transfer position below). One of the support bars will be attached to the linear actuator with the use of a sliding plate (grounded to the base plate). The linear actuator will then move the support bar, causing it to push the support bar on the opposite side. The linkage between both bars will then **lift** the hopper. Additionally, to ensure that the support bars are effectively able to lift the hopper, a degree of freedom must be incorporated between the linkage of the support bars and the hopper. This can be done by including a notch between the linkage and hopper, which can rotate depending on the angle that the hopper is lifted at (refer to detailed sketch of deposit position below). After dropping off the containers, the linear actuator will move the mechanism back to its transfer position until the next round of dropping off containers.

The triangular configuration of the mechanism is a key element to our design, as it implements its inherent structural robustness, and minimizes the chances of error/failure. Our design also considers the point of contact between the linkage and hopper, and what position would offer the most force. This is an important aspect of the design, since pushing the hopper a further distance away from its hinge would be more optimal than pushing it closer to its hinge (reflect on torque). To achieve this design component, our support bars would vary in length, meaning that one would have to be longer than the other to provide the optimal point of contact.

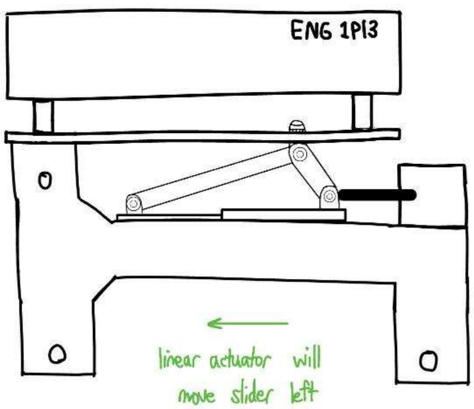
Team ID: Fri-37

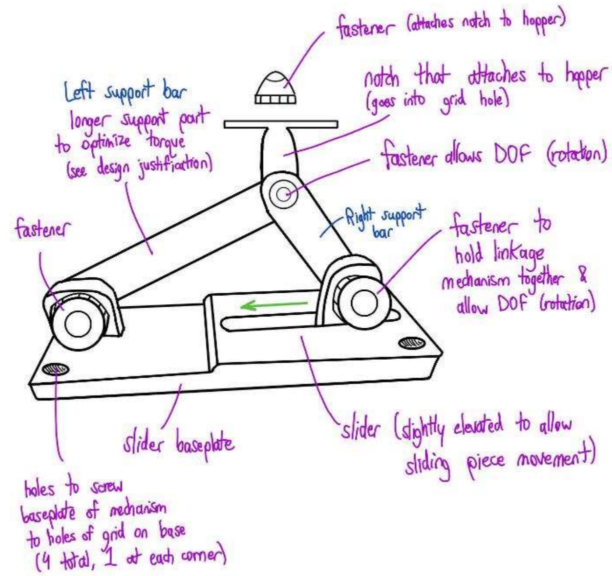
2. As a sub-team, select a design for your mechanism, then use that one (1) design for the detailed sketches.
   - → Each sub-team member is responsible for one (1) detailed sketch of the same design, either in the transfer position or the deposit position
   - → For sub-teams with 3 members, the work of 2 sketches should be split evenly between members. For example, 2 members could complete the sketches while the other member adds labels, descriptors, and constraints to both sketches.
   - → Complete your sketches on a separate sheet of paper
     i. Be sure to indicate each team member's Name and MacID
   - → Take a photo of your sketch
   - → Insert your photo as a Picture in the space below

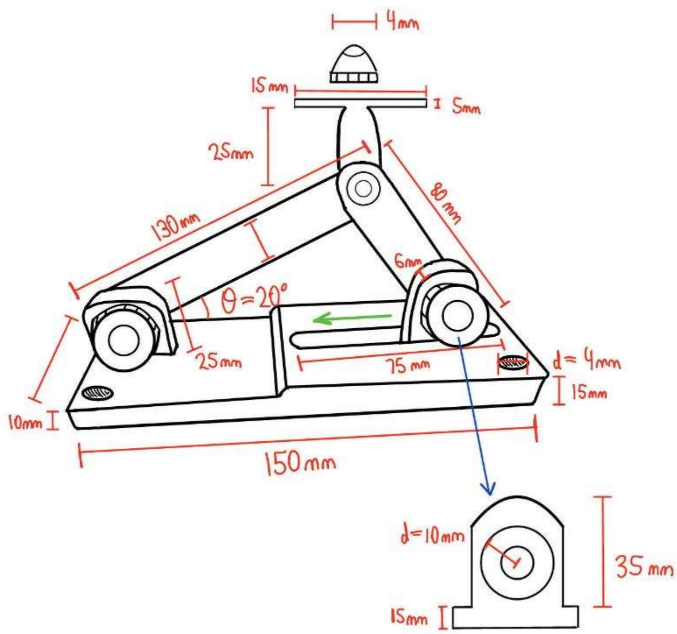
Team ID: Fri-37

Name: Milana Kalinic	MacID: kalinicm

Transfer position







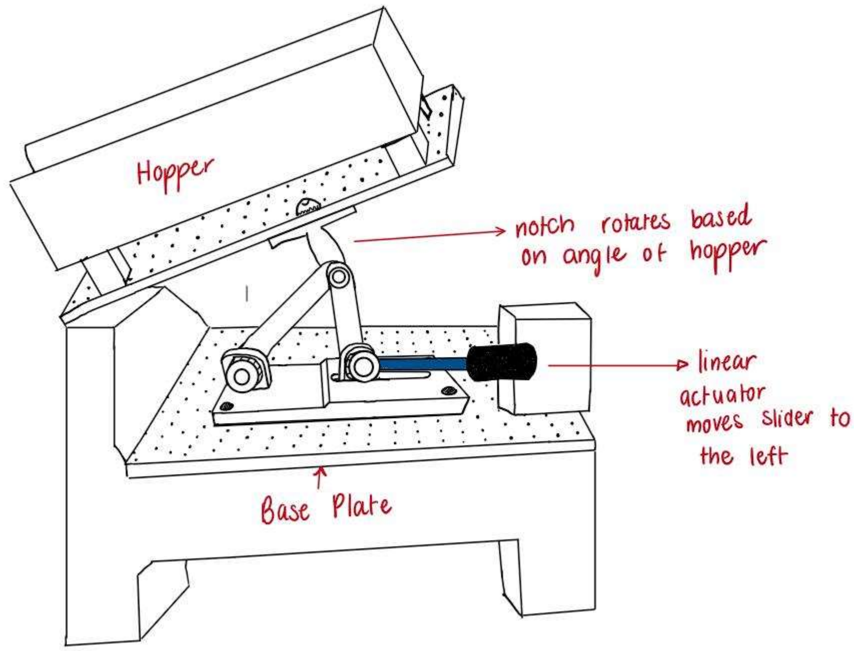
Constraints in transfer position:

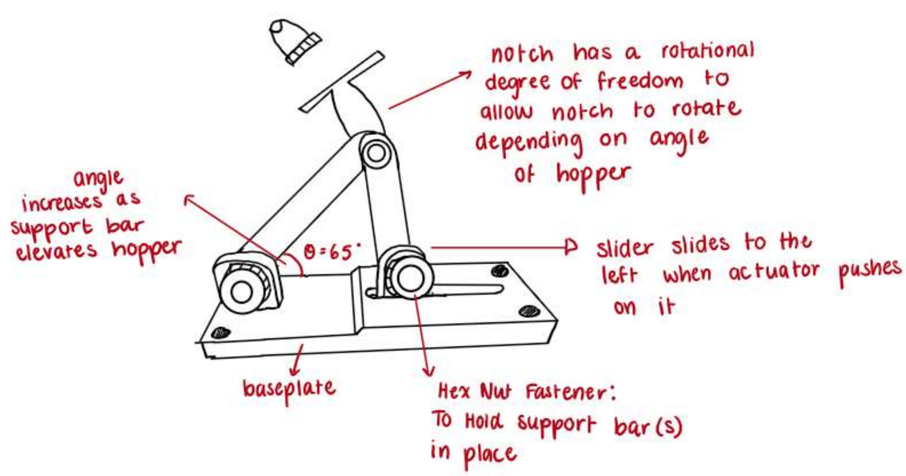
- Notch
  - Notch must have ONE rotational degree of freedom to allow for notch to rotate along with the hopper when the cans are being deposited
- Slider Baseplate:
  - Slider baseplate of mechanism must be grounded to the baseplate of the hopper assembly
- Support Bars:
  - Each support bar must have ONE rotational degree of freedom to allow for rotation
- Slider
  - Must have ONE horizontal translational degree of freedom, to allow the linear actuator to move it

Team ID: Fri-37

Name: Maahi Sharma	MacID: sharm20

*Insert picture of the **deposit** detailed sketch below*





Constraints in Deposit Position:

- Angle of Rotation:
  - Angle of left support bar must be larger than when in transfer position, to allow for hopper to lift at an angle
- All holes on slider baseplate MUST have a diameter of 4 mm to match the holes on the baseplate

Milestone 2 (Stage 5) – Informal TA check-in (Modelling Sub-Team)

Team ID: Fri-37

☐ Sketches include ONE actuator (linear or rotary) that is the input of the mechanism

☐ Sketches in both deposit and transfer position are drawn.

- Components are identified and labelled
- Any relationships and constraints (such as assembly constraints and motion constraints) are highlighted.
- Component that will serve as the grounded part of the assembly once conducted is identified.

Output of the mechanism allows for rotation of the connecting plate/hopper. Rotation angle is sufficient to allow for container deposit.

☐ The mechanism attaches to both the baseplate and the connecting plate (below the hopper)

☐ Mass of all components is considered

- The design should intentionally minimize materials

Mentor Comments: Use the space below to document mentor feedback for your design, including requirement for reviewing progress next design studio.

- Overall good design process and justification of design
- Consider how much the linear actuator can extend (about 5 cm)
- Are parts dimensioned with the consideration that the linear actuator can let the mechanism lift the hopper enough?
- REMEMBER: linear actuator is not raised! It is placed flat onto the baseplate
- Can we get enough force outputted onto the mechanism to lift the hopper with our current design?
- Adjust desired angle of hopper when in deposit position (might be too large)

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

- Redesign baseplate so that the slider slides along the base of the hopper
- Adjust dimensions of parts with greater consideration of the placement of the linear actuator
- Adjust hole placements to fit the grid of the base
- Reconsider lengths of linkages (ensure that linkages can lift the hopper to an adequate angle)

Milestone 2 (Stage 5) – Informal TA check-in (Computing Sub-Team)

Team ID: Fri-37

☒ A sensor(s) has been selected. Discuss reasons as to why the group chose said sensor(s).

☒ The following tasks have been planned either in pseudocode or flowchart format:

- → Dispense container
- → Load container
- → Transfer container
- → Deposit container
- → Return home

☒ The following tasks are planned in pseudocode or flowchart format as their own functions:

- → Load container
- → Transfer container
- → Deposit container

☒ Do the tasks cover the following:

- Container attributes are determined
- Containers are positioned in the sorting station
- Q-arm loads the containers until one of the following conditions are met:
    - A container with a different ID is placed in the sorting station
    - The total mass of the bottle placed in the sorting station and the bottles loaded on the Q-bot is greater than 90 grams
    - 3 bottles have been placed on the Q-Bot
- Q-bot transfers the containers to the correct recycling bin
- Q-bot deposits the containers into the bin
    - If needed, Q-bot turns 90 degrees to face the required bin, and then locomotes to bin
- Q-bot returns home
- Cycle repeats

Mentor Comments: Use the space below to document mentor feedback for your design, including requirement for reviewing progress next design studio.

Don't include python syntax when submitting pseudocode. The table that dispenses the bottles doesn't need to be included in our dispense container function. Using IR Sensors to traverse the line not the color sensor

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

Get rid of current python code in pseudocode Adjust the current angle of the joint, and consider the position of the linear actuator to generate enough force.

PROJECT THREE: MILESTONE THREE (TEAM): WORK PERIOD / INFORMAL TA CHECK-IN

Milestone 3 – Cover Page

Team ID: Fri-37

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

Full Name:	MacID:
Maahi Sharma	sharm20
Milana Kalinic	kalinicm
Ben Malkovich	malkovib
Dillon Robert	roberd50
Shadi El-Fares	elfaress

Milestone 3 (Stage 3) – Informal TA check-in (Modelling Sub-Team)

Team ID: Fri-37

☐ Assembly includes one actuator (linear or rotary) that is the input of the mechanism

☐ Output of the mechanism allows for rotation of the connecting plate/hopper. Rotation angle is sufficient to allow for container deposit.

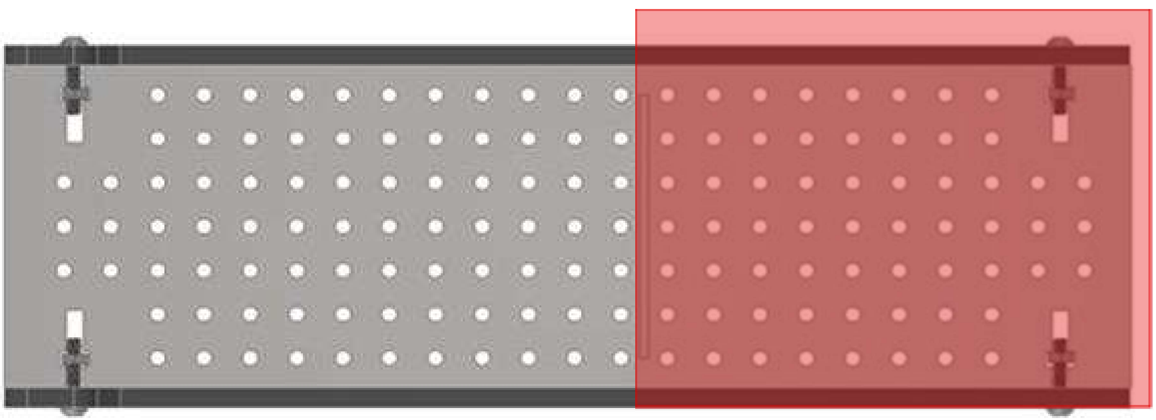
☐ Assembly is complete and constrained properly

→ No interference between parts, clean assembly model, no errors, one part grounded

→ Proper assembly constraints (define position of components in assembly)

→ Proper motion constraints (define motion ratios between assembly components)

☐ The mechanism attaches to both the baseplate and the connecting plate (below the hopper)



☐ All *holes* on the chosen actuator housing are *attached* WITHIN the highlighted region (see figure above)

☐ Mass of all components is considered

- The design should intentionally minimize materials

☐ Total print time of ALL 3D printed components does not exceed 2 hours

- Discuss a prototyping plan. Is it within the time constraint to re-print or redesign if needed?
- Discuss if components need any support for 3D printing (i.e., for any overhanging features). If so, TAs will assist the sub-team in adding supports
- Discuss/suggest potential for laser-cutting (flat components in particular)

☐ ALL features of 3D printed parts are feasible for printing

- Features and spaces are suggested to be 2mm or greater (Features between 2mm and 4mm are appropriately sized and will not compromise the printed design)

☐ Consideration of additional materials

- Students have considered and sourced any additional materials as necessary (i.e. fasteners)

<u>Mentor Comments:</u> Use the space below to document mentor feedback for your design, including requirement for reviewing progress next design studio.

- Enable contact set in assembly file
- Redo offset constraint (could be Inventor error)
- The angle the mechanism elevates the hopper to is large enough, but the hopper not being completely horizontal in the transfer position is an issue
- Laser cut support bars to save time
- The friction of the slider might be too high for it to slide back in the baseplate when the linear actuator retreats; attach link to the linear actuator with a bolt/rod so that the slider moves with it
- Add a matching hole in the slider to put the bolt/rod through it to fix it to linear actuator
- Make a cut in the baseplate for the bolt to slide through along with the slider
- ALTERNATIVE MECHANISM METHOD: Attach the link directly to the linear actuator; get rid of the slider and baseplate altogether
- Review design next design studio

<u>Action Items:</u> Use the space below to propose design refinements based on feedback.

- Implement TA's suggested mechanism method
- Shorten baseplate such that it just holds the joint to allow linkage to rotate
- Get rid of slider and attach linkage directly to linear actuator using a bolt
- Change dimensions of linkages to accommodate altered design (elongate right linkage)

Milestone 3 (Stage 3) – Informal TA check-in (Computing Sub-Team)

Team ID: Fri - 37

☐ All 5 program tasks are accounted for (dispense container, load container, transfer container, deposit container, return home)

☐ One cycle (for ONE container of the sub-team's choice) sufficiently executes based on requirements outlined in project module

- The general flow: home → dispense → load → transfer → deposit → home

☐ The following tasks are written as their own functions:

- Load container
- Transfer container
- Deposit container

☐ The return home task executes properly by following the yellow line *around the loop* and back to the sorting station

☐ No errors in program

☐ Commenting their code (i.e., headers explaining purpose of functions & any other appropriate comments where needed)

Mentor Comments: Use the space below to document mentor feedback for your design, including requirement for reviewing progress next design studio.

Fix the transfer container function, having an issue down to bot wheel speed or potentially the distance to the bins Add sleeps into load container so it can run properly Bot is wobbly on the line, fix bot wheel speeds Main function should repeat instead of running once Containers should be loaded in different positions instead of just one

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

Edit the main function to run multiple times Fix wheel speeds and transfer container function so it properly dispenses containers every time Fix the load container function so it places containers properly

PROJECT THREE: MILESTONE FOUR (TEAM): WORK PERIOD / INFORMAL TA CHECK-IN

Milestone 4 – Cover Page

Team ID: Fri-37

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

Full Name:	MacID:
Maahi Sharma	sharm20
Milana Kalinic	kalinicm
Shadi El-Fares	elfaress
Ben Malkovich	malkovib
Dillon Robert	roberd50

Milestone 4 – Informal TA check-in (Modelling Sub-Team)

Team ID: Fri-37

☐ Design Meets Design Objectives

→ Facilitates container depositing (visual inspection that the hopper rotates enough for container depositing)

☐ Physical model is complete and works as intended

→ All components are ready for assembly or assembled

☐ Mass of all components is considered

→ The design should intentionally minimize materials

☐ ALL features are reasonably sized

→ No components contain small features that are likely to break

☐ Consideration of additional materials

→ Students have considered and/or sourced additional materials as necessary (ie. fasteners)

☐ APPROVED FOR PHYSICAL ENVIRONMENT

Mentor Comments: Use the space below to document mentor feedback for your design, including requirement for reviewing progress next design studio.

- Lower stand-piece to make hopper rest horizontally (if it doesn't)
- No rotational degrees of freedom in mechanism assembly on Inventor
- May have made too many links; removed too many DOF
- Fix: delete constraint on the holes that fit the plate of the mechanism to the top of the hopper, but leave mate constraint

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

- Remove constraint on the holes that fit the plate of the mechanism to the top of the hopper so that the plate can slide and introduce a degree of freedom to lift the hopper
- Lower stand-piece to make hopper rest horizontally

Milestone 4 – Informal TA check-in (Computing Sub-Team)

Team ID: Fri-37

☐ More than one cycle of pick-up/transfer/drop-off sufficiently executes

→ At least two different containers are correctly deposited

→ The general flow should be Home → Dispense Container → Q-Arm Loads Container onto Q-Bot → Transfer Container to Proper Bin → Deposit Container → Home

→ Q-Bot should determine bin using line-following and using measured sensor values.

→ If the bins are setup so that they are far away from the yellow loop, the Q-Bot should move as specified on page 16 and 17 of the project module.

☐ All required program tasks are written as their own section of code (Dispense Container, Return Home) or function (Load Containers, Transfer Containers, Deposit Containers)

☐ No errors in program

☐ Code well commented

☐ APPROVED FOR PHYSICAL ENVIRONMENT

Mentor Comments: Use the space below to document mentor feedback for your design, including requirement for reviewing progress next design studio.

Ensure that the hopper lid rotates down (didn't for some reason).

Update main function so it has a while loop, runs indefinitely.

Show the start of a successful run.

Almost ready for physical environment aside from comments above

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

Add in appropriate deactivate/activate functions to lower hopper.

Add while loop in main() function.

Further refine code.

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

Milestone 1 (Stage 1) – Initial Problem Statement, Objectives and Constraints

Team ID: Fri-37

Complete this worksheet individually *before* coming to Design Studio.

Initial Problem Statement

1. Write the initial problem statement in the space below. This was discussed in your first lecture and is provided in the Avenue announcement.

Design a system for sorting and recycling containers.

Objectives and Constraints

Create a list of objectives and constraints in the table below. The exact number you should have depends on what information you have gathered from the Project Module and previous lectures.

Objectives	- Code is easy and intuitive to use by user - Code accurately identifies container and sorts it - Containers are securely transported to correct bins without being dropped - Mechanism angle chosen such that container is precisely deposited into correct bin - Program efficiently and quickly identifies container type and deposit bin
Constraints	- Code is written in Python - Code uses human input (is not completely autonomous) - Workflow/steps outlined in Project Module are followed (Qbot transfers container, deposits it, returns to home, etc.) - Different types of containers are deposited to their respective bins (determined by material, contamination, etc.)

	- Actuator must mount within a specific region of designated mechanism that connects to baseplate and connecting plate - Mechanism must connect to base plate and connecting plate

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

MILESTONE 1 (STAGE 4) – MECHANISM CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID:	Fri-37

1. Each team member is required to complete **two (2)** preliminary concept sketches for the mechanism design. You should incorporate a different actuator for each sketch.
   → Each sketch should be on a separate piece of paper
   → Be sure to clearly write your Team ID, Name and MacID for each sketch
2. Take photos of your sketches
3. Insert your photos as a Picture on the following pages

Team ID:	Fri-37

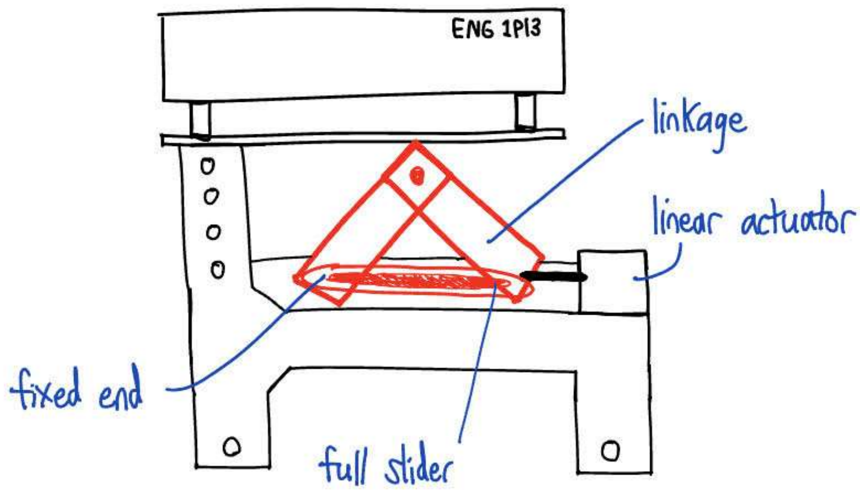
Name: Milana Kalinic	MacID: kalinicm

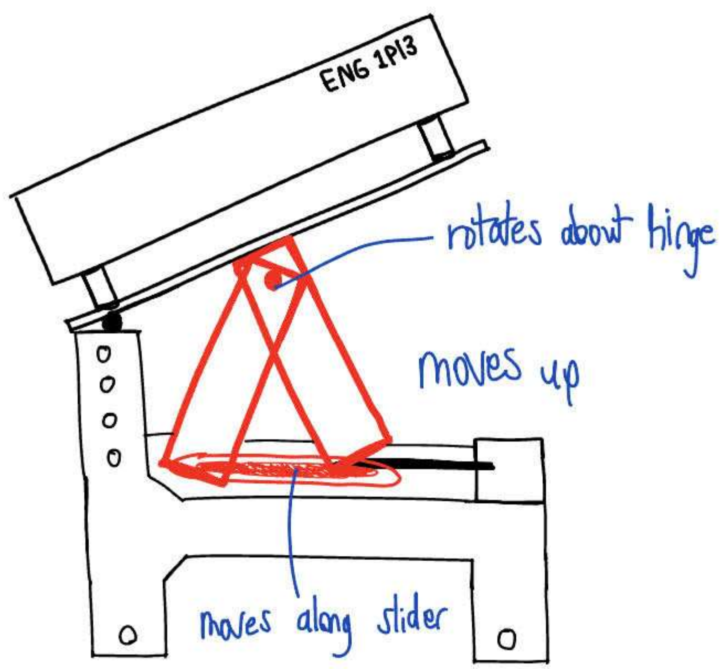
Linear actuator

Milana Kalinic

Kalinicm

Jan 12 2024





Team ID: Fri-37

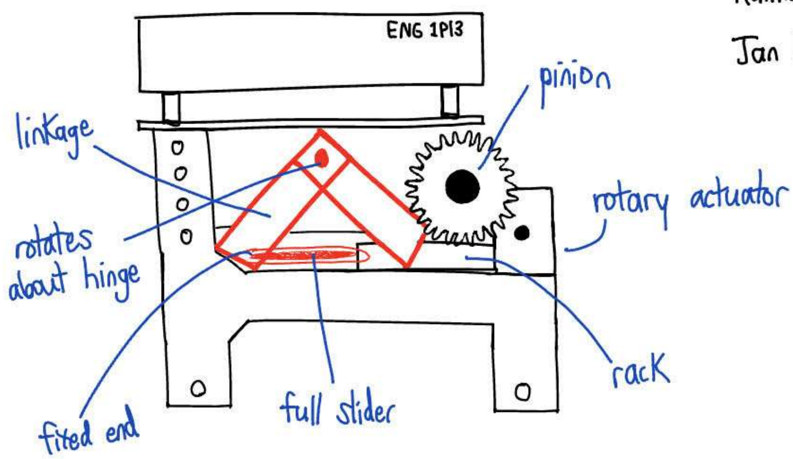
Name: Milana Kalinic	MacID: kalinicm

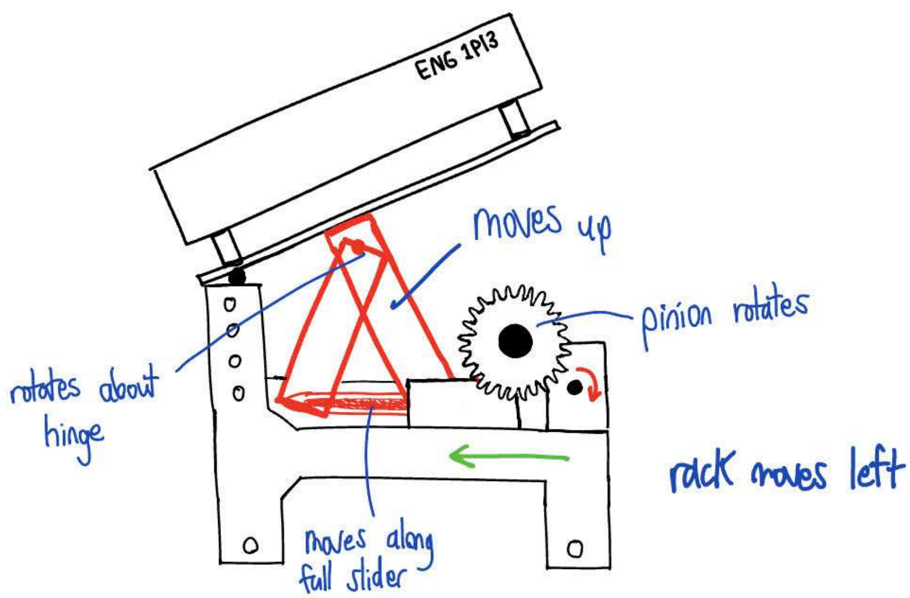
Rotary Actuator

Milana Kalinic

Kalinicm

Jan 12 2024





ENGINEER 1P13:
PROJECT THREE WORKSHEETS (INDIVIDUAL)

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

Milestone 1 (Stage 1) – Initial Problem Statement, Objectives and Constraints

Team ID: Fri-37

Complete this worksheet individually *before* coming to Design Studio.

Initial Problem Statement

1. Write the initial problem statement in the space below. This was discussed in your first lecture and is provided in the Avenue announcement.

First, define the statement of fact:

- About 30% of items placed in recycling bins aren't recyclable. Most items contain contaminants such as food or beverage residue, and other items go through misdetection in current sorting technology, which all prevent items from being recycled appropriately.

Now, define initial problem statement:

- Our team's goal is to design a sorting system that can accurately sort and detect recyclable containers, since current sorting technology for recycling does not offer a high level of accuracy.

- Design a system for sorting and recycling containers

Objectives and Constraints

Create a list of objectives and constraints in the table below. The exact number you should have depends on what information you have gathered from the Project Module and previous lectures.

Objectives	- Perform tasks with precision and accuracy. - Should take minimal time to detect material and prove whether it is recyclable or not (to allow for a quick and efficient process) - Should transfer recycle securely (no loose grip on items, to avoid failure of the item reaching the desired bin) - Assembly on Q-bot should be able to hold 3 containers at most - All assemblies should be secured onto the baseplate to avoid pieces falling apart - Should use sensors when and where needed (such as detection purposes) - Should define bin attributes in order for sensor to differentiate between different bins -

Constraints	- Program needs to be able to spawn exactly six containers (iterate through a list of six container ID's)
	- Q-arm can only load a container onto the Q-bot if and only if:
	    o Less than 3 containers loaded on Q-bot previously (no more than 3 containers of the same destination must be loaded on the hopper)
	    o Total mass of all existing containers on Q-bot + new container must weigh less than 90 grams (does not exceed 90 grams)
	    o New container must go to the same bin as all previous containers loaded on the Q-bot
	- Q-bot must follow a line on the floor to move to different locations (cannot make shortcuts i.e cut through the middle)
	- Each container ID must be assigned specific attributes and specific target bins (cannot randomly assign attributes)

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

MILESTONE 1 (STAGE 4) – MECHANISM CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID: Fri - 37

1. Each team member is required to complete **two (2)** preliminary concept sketches for the mechanism design. You should incorporate a different actuator for each sketch.
   → Each sketch should be on a separate piece of paper
   → Be sure to clearly write your Team ID, Name and MacID for each sketch
2. Take photos of your sketches
3. Insert your photos as a Picture on the following pages

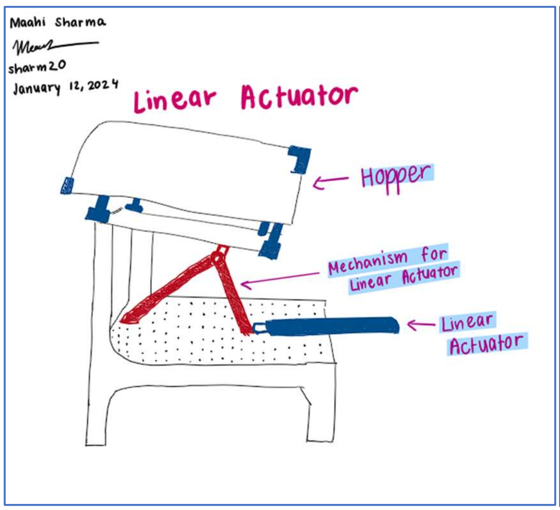
Team ID: Fri-37

Name: Maahi Sharma	MacID: sharm20

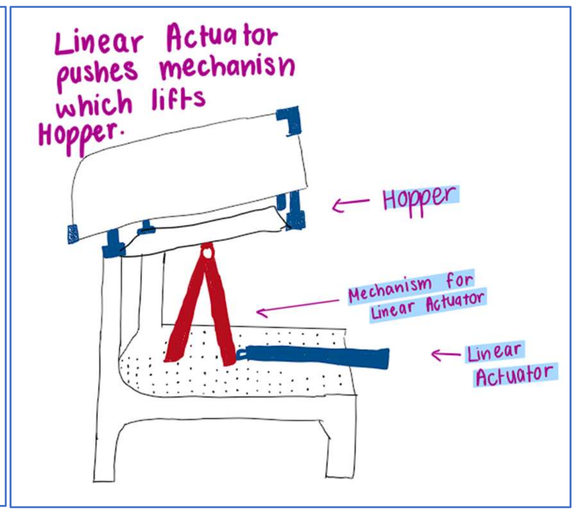
Insert picture of preliminary concept sketch below

**** Please note that I have created two sketches for each actuator, a before and after. The "before" sketch displays the set up of the mechanism and actuator BEFORE being lifted, and the "after" sketch is the display of how the actuator moves the mechanism to lift the hopper.**

LINEAR ACTUATOR CONCEPT SKETCHES

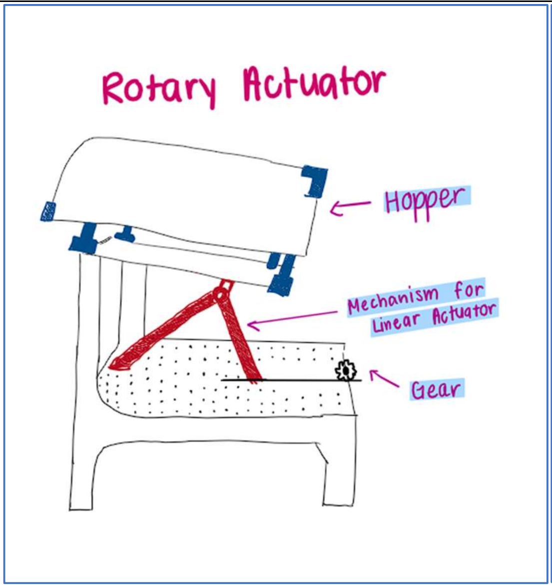


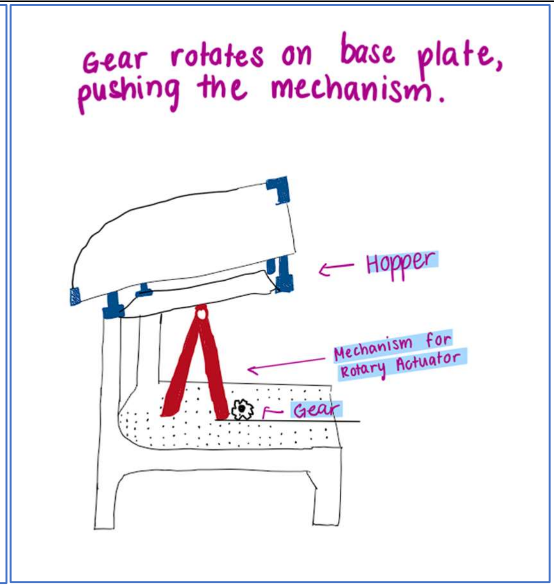
Before



After

ROTARY ACTUATOR CONCEPT SKETCHES (On next page!)





Before	*After*

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

Milestone 1 (Stage 1) – Initial Problem Statement, Objectives and Constraints

Team ID:	Fri-37

Complete this worksheet individually *before* coming to Design Studio.

Initial Problem Statement

1. Write the initial problem statement in the space below. This was discussed in your first lecture and is provided in the Avenue announcement.

Design a system for sorting and recycling containers

Objectives and Constraints

Create a list of objectives and constraints in the table below. The exact number you should have depends on what information you have gathered from the Project Module and previous lectures.

Objectives	Identify different materials via sensors. Assess recyclability of items. Transfer items to a transport system. Facilitate the transport of items to their designated bin. Dispense items into their designated bin. Deposit mechanism should mount easily to frame. Return transport system to the original position to receive more items.
Constraints	Can only transport one item type at a time. Total item load cannot exceed 90 grams.

	Only can transport 3 containers maximum. Only 4 possible bin designations. Deposit mechanism can only use linear or rotary actuator. Mechanism must function with given hopper and base plate.

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

MILESTONE 1 (STAGE 3) – SENSOR EXPLORATION (COMPUTING SUB-TEAM)

Team ID:	Fri-37

Complete this worksheet individually *during* Design Studio.

1. Each team member is expected to complete the demo for at least four (4) of the five (5) sensors available for characterizing bins
   → **Refer to Table 3 in the Project Objective 3 section of the Project Module for a list of available sensors**
2. For each sensor:
   → Briefly describe how the sensor works
   → Indicate the attribute you would measure to characterize each bin
3. Complete your sensor research on the following page
   → Be sure to clearly write your Team ID, Name and MacID

Team ID: Fri-37

Name: Ben Malkovich	MacID: malkovib

Sensor Type	Description	Attribute(s)
Ultrasonic Sensor	• Measures the distance of the QBot bumper to the nearest bin face. • Sensor emits and receives ultrasonic waves to measure the distance to the nearest face. • Has a range of 2.5 meters, if the target face is out of range, returns 0. • On the side of the QBot.	Distance to bin
Active Infrared (IR) Sensor	• IR emits and detects infrared radiation to determine how close an object is. • Has a range of 0.25 meters, if the target face is out of range, returns 0. • Outputs high voltage if an object is close, low if far, and low if out of range. • On side of QBot.	Detects distance to bin
Hall Sensor	• Hall sensor determines if an object is metallic or non-metallic. • Outputs 1 for metallic, 0 for non-metallic. • Works within 0.10m. • On front of QBot.	Detects metallic materials
Colour sensor	• Returns RGB values and raw sensor data of the closest bin. • Will not return values if out of range. • Has a range of 0.25 meters. • On side of Qbot.	Detects RGB values of bin

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

Milestone 1 (Stage 1) – Initial Problem Statement, Objectives and Constraints

Team ID:	FRI-37

Complete this worksheet individually *before* coming to Design Studio.

Initial Problem Statement

1. Write the initial problem statement in the space below. This was discussed in your first lecture and is provided in the Avenue announcement.

A system needs to be designed which can identify and sort recycling materials

Objectives and Constraints

Create a list of objectives and constraints in the table below. The exact number you should have depends on what information you have gathered from the Project Module and previous lectures.

Objectives	Intuitive System Cost Consideration Reliable mechanism and design
Constraints	3 containers per transport Max item load of 90g Only one container type per transport

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

MILESTONE 1 (STAGE 3) – SENSOR EXPLORATION (COMPUTING SUB-TEAM)

Team ID:	Fri-37

Complete this worksheet individually *during* Design Studio.

1. Each team member is expected to complete the demo for at least four (4) of the five (5) sensors available for characterizing bins
   → **Refer to Table 3 in the Project Objective 3 section of the Project Module for a list of available sensors**
2. For each sensor:
   → Briefly describe how the sensor works
   → Indicate the attribute you would measure to characterize each bin
3. Complete your sensor research on the following page
   → Be sure to clearly write your Team ID, Name and MacID

Team ID: Fri-37

Name: Dillon Robert	MacID: roberd50

Sensor Type	**Description**	**Attribute(s)**
Ultrasonic Sensor	Uses sound waves to measure the distance to an object. Location: Front Range: 2.5m	Distance to bins
Hall Sensor	Determines weather or not the object is metal by reading magnetic fields. Location: Side Range: Tested at 0.05m	Detects metal containers
Active IR Sensor	Uses infrared radiation such as heat to determine range to an object Location: Side Range: 0.25m	Measures distance to bins
Colour Sensor	Reads RGB values of object. Location: Side Range: 0.25m	Detects colours

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

Milestone 1 (Stage 1) – Initial Problem Statement, Objectives and Constraints

Team ID: Fri-37

Complete this worksheet individually *before* coming to Design Studio.

Initial Problem Statement

1. Write the initial problem statement in the space below. This was discussed in your first lecture and is provided in the Avenue announcement.

Design a system for sorting and recycling containers.

Objectives and Constraints

Create a list of objectives and constraints in the table below. The exact number you should have depends on what information you have gathered from the Project Module and previous lectures.

Objectives	- User Input Handling (Physical) - Dispense to Sorting Station - Determing Container Variables ○ Mass dependant delivery later. - Container Transfer Q-Arm - Q-Bot Container Delivery - Hopper Rotation - Sensor Activation and Deactiviation - Trajectory Following - Home Position Return - Repeated Task Execution (i.e the above in a loop of some kind) - Virtually mounted sensors
Constraints	- User Input Validation

	- Bin Recognition Accuracy - Safety Measures - Power Consumption - Cost Consideration (More of Modelling as I believe they have to pay) - Maintenance and Reliability (if we consider a long-term solution) - Environment Adaptability (having the Q-bot understand the environment it will work in) - Sensor accuracy

PROJECT THREE: MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

MILESTONE 1 (STAGE 3) – SENSOR EXPLORATION (COMPUTING SUB-TEAM)

Team ID: Fri-37

Complete this worksheet individually *during* Design Studio.

1. Each team member is expected to complete the demo for at least four (4) of the five (5) sensors available for characterizing bins
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2. For each sensor:
   → Briefly describe how the sensor works
   → Indicate the attribute you would measure to characterize each bin
3. Complete your sensor research on the following page
   → Be sure to clearly write your Team ID, Name and MacID

Team ID: Fri-37

Name: Shadi El-Fares	MacID: elfaress

Sensor Type	Description	Attribute(s)
Ultrasonic Sensor	Measures the distance of the target object using ultrasonic sound waves to measure the distance efficiently Location: Front of Q-Bot Range: 2.5m, if not in range returns 0	Distance to Bins
Hall Sensor	Hall Sensor determines if the object is a metal by giving the number 1 if true otherwise 0 for a non-metal. Location: Side of Q-Bot Tested Range: Works at 5cm	Detects Metals
Active Infrared (IR) Sensor	The IR sensor can emit and detect infrared radiation like heat to tell how close the object is to the sensor using voltage readings. Location: Side of Q-Bot Range: 0.25m, if not in range returns 0	Measures distance to bins
Color Sensor	Returns RGB values of the bins that is in front of the sensor. Location: Side of Q-Bot Range: 0.25m	Detects Colors