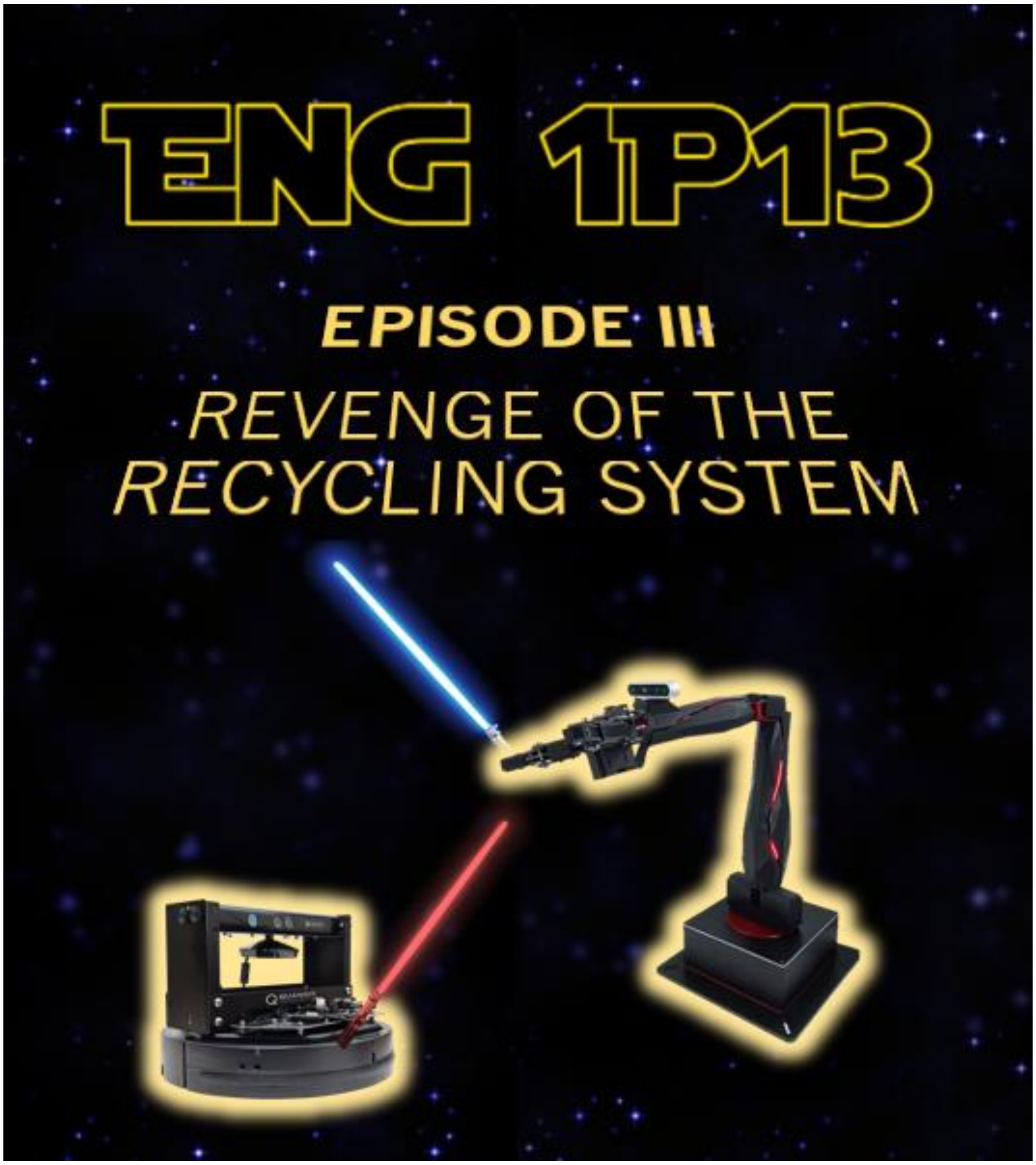


Project Three: *Revenge of the Recycling System*

Design a System for Sorting and Recycling Containers

TABLE OF CONTENTS

Project Summary

In Project Three, students will work in teams to design a system for sorting and recycling containers of varying materials. This project will introduce you to principles of smart devices and assembly modelling as you design a computer program for controlling robotic devices and fabricate a mechanism for depositing the containers into a recycling bin. It is expected that your design will successfully classify containers using data from the physical environment, analyze the container for contamination, and transfer the container to the correct bin for recycling. At completion of the project, you will integrate the digital and physical elements of your design to showcase your results and demonstrate functionality of the entire system during a Design Expo.

TIMELINE

WEEK	DATE	DESIGN STUDIO AGENDA
1	Jan 10 – Jan 14	Milestone 0 and Milestone 1
2	Jan 17 – Jan 21	Milestone 2
3	Jan 24 – Jan 28	Milestone 3
4	Jan 31 – Feb 4	Dedicated Project Time (No Milestone)
5	Feb 7 – Feb 11	Dedicated Project Time (No Milestone)
6	Feb 14 – Feb 18	Dedicated Project Time (No Milestone)
7	Feb 28 – March 4	Project Demonstrations

TEAM FORMATION

Assigned teams of 4-5 students. Sub-teams are assigned based on previous project experience, where students will join a sub-team they were not a part of for project 2.

SUMMARY OF PROJECT OBJECTIVES

Working in a team of 4 students, you will be required to:

1. *Identify*, *classify* and *verify* containers for recyclability

Working in 2 groups of 2 students, each group will complete *one* of the following:

2. *Design and fabricate* a mechanism for depositing containers into a recycling bin (Modelling Sub-Team)
3. *Design* a computer program for transferring containers from the sorting station to the correct bin in the recycling station (Computing sub-team)

Once again in a team of 4 students, you will be required to:

4. *Evaluate* both computational and physical design elements for functionality and correctness

As a ***bonus***, you may opt to *integrate* modelling and computing designs in a physical environment upon completion of the above requirements.

This module is accurate as of January 10th, 2022 assuming in-person delivery of weekly design studios and access to McMaster facilities beginning January 31st, 2022. The project agenda and expectations are subject to change with a change in university protocols to minimize the disruption to the student experience **

SUMMARY OF PROJECT DELIVERABLES

At the end of the project, you will be required to submit:

1. An *assembly model* and physical prototype of your proposed mechanism for depositing containers into a recycling bin (i.e., a ***mechanism to actuate a recycling hopper***) modelled in Autodesk Inventor (Modelling Sub-Team)
2. A *computer program* written in Python (Computation Sub-Team)
3. A *design project report* that documents your work throughout the project
4. **As a <u>bonus</u> upon completion of the above <u>required</u> deliverables:** Your physical prototype of a working mechanism (Modelling Sub-Team) integrated with a modified computer program (Computational Sub-Team) to validate your design in the physical environment

This project will also require you to: 1) complete a set of assigned administrative tasks inherent to the project, 2) complete and submit a series of milestones throughout the project, 3) write an *independent research summary*, 4) update your learning portfolio to reflect your progress and development, and 5) complete a self / peer-evaluation at the end of the project.

SUMMARY OF PROJECT GRADING BREAKDOWN

Project 3 is worth **10% of your overall ENGINEER 1P13 grade (i.e., 10 marks out of 100**). Each team of students will be divided into sub-teams, each having their own set of deliverables throughout the project. Each deliverable is associated with 1 of 3 course modules (C – Computation, M – Materials, D – Design and Professionalism). Table 1 outlines the breakdown of Project 3 marks by course module. Table 2 lists each deliverable, the number of marks available for that deliverable, and the module associated with that deliverable.

Table 1. Breakdown of Project 2 marks by course module

COURSE MODULE	MODELLING SUB-TEAM	COMPUTATION SUB-TEAM
Computation (C)	-	6
Design and Professionalism (D)	8	2
Materials (M)	2	2

Table 2. List of deliverables

Deliverable	Deadline	Modelling Sub-Team		Computation Sub-Team	
		Marks	**Module**	**Marks**	**Module**
Admin Responsibilities	–	P/F	D	P/F	D
Milestone 0	End of DS-13 (Wk-1)	P/F	D	P/F	D
Milestone 1	End of DS-13 (Wk-1)	0.5	D	0.5	D
Milestone 2	End of DS-14 (Wk-2)	1	D	1	C
Milestone 3	End of DS-15 (Wk-3)	P/F	D	P/F	C
Mechanism Design	Prior to DS-18 (Wk-7)	5	D	-	-
Computer Program	Prior to DS-18 (Wk-7)	-	-	5	C
Design Project Report	Sun March 6th	1.5	D	1.5	D
Materials Research Summary	Wed March 9th	2	M	2	M
Learning Portfolio	Wed March 9th	P/F	D	P/F	D
Self- and Peer-Evaluation	Wed March 9th	P/F	D	P/F	D

Introduction

Jack Armstrong is an NBA analyst for TSN, and he has been part of the broadcast team for the Toronto Raptors since 2000 [1]. Armstrong is well-known for his catchphrases, including “HELLO!” and “Get that garbage outta here!” Did you know that Armstrong also used his catchphrases in a recycling campaign with the City of Toronto in 2018? The purpose of this campaign was to remind the public that trash does not belong in recycling bins [2].

Approximately 30 percent of items placed in recycling bins are not actually recyclable [2]. Because of this large amount of garbage being sent to the recycling facilities, an overwhelmingly large number of recyclable materials are lost every year. Canada recycles just 9 percent of its recyclable plastics, leaving the rest to be incinerated or placed in a landfill with other garbage [3]. Although recycling stations have sorting facilities that attempt to remove trash, they cannot always recycle everything that should be recycled. Food or beverage residue is often left in plastic containers, preventing it from being recycled properly [2].

Sorting facilities are equipped with technology to detect different kinds of materials, as well as the presence of contaminants. Sensors such as strain sensors, conductivity sensors and infrared sensors can be used to classify containers, covering a wide variety of characteristics. While most sorting systems detect recyclable materials on a conveyor belt, researchers at MIT CSAIL have developed a recycling robot that classifies a container once it has picked it up [4].

Even with all of the sensors used for detection, some nonrecyclable (and even recyclable) materials still cause issues for sorting facilities. For example, black plastics, often used in take-out and reusable containers, do not belong in the blue bin. This is because the optical sorting technology currently in place cannot recognize the black container [2].

In a controlled environment, we can create our own recycling station with sorting capabilities. In Project Three, your team will be provided with a wide array of sensors, allowing you to determine what kind of container you have been given and if the container is recyclable or not. Using new concepts with some technology that you have already been exposed to, you will sort these containers into their correct recycling categories.

Futuristic robot designed to sort garbage and organic material. Fitted with optical sensors used in sorting process.

LIST OF SOURCES

[1] T. O'Shei, "Jack Armstrong is going strong as broadcast analyst for the Toronto Raptors," The Buffalo News, 18-Jul-2015. [Online]. Available: https://buffalonews.com/sports/college/jack-armstrong-is-going-strong-as-broadcast-analyst-for-the-toronto-raptors/article_010eaa9d-816e-5b76-b0c7-75a9950c413a.html. [Accessed: 04-Jan-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: 04-Jan-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: 04-Jan-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: 04-Jan-2021].

Project Three Objectives

Your team has been tasked with designing a system for sorting and recycling containers based on their material (metal, paper, or clear plastic). Working within a virtual environment comprised of a **Sorting Station** (Figure 1) and a **Recycling Station** (Figure 2), you team is required to:

1. Identify, classify, and verify containers for recyclability
2. Design and physically fabricate a mechanism for depositing containers into a recycling bin
3. Design a computer program for transferring containers from the Sorting Station to the correct bin in the Recycling Station
4. Evaluate your design for functionality and correctness

To meet these objectives, your team has been **provided** with the following:

1. A virtualized environment of both the Sorting Station (Figure 1) and Recycling Station (Figure 2) that includes a servo-controlled turntable, robotic arm, and terrestrial drone equipped with sensors
2. Solid models (*.IPT files) of the Q-bot, including a base-plate for mounting components and a recycling hopper (refer to Objective 2 for hopper description)
    a. Prefabricated components such as the base-plate and recycling hopper will be available to you for prototyping. See the **Provided Parts Documentation** file for more info as to what components are available for you.
3. Solid and physical models of various containers for recycling (bottles/cans)
4. Solid models of various fasteners that can be used in designing your mechanism
    a. Note, while you will be provided with some core fasteners, **the majority of those used in your mechanism will likely require you to purchase your own.** See the **Provided Fasteners Documentation** file for various fasteners that have been provided to you/can be used for your mechanism.
5. An actuator (linear or rotary) for controlling motion of your mechanism for depositing containers

Bonus – The Physical Environment Objectives

Upon completion and verification of the above **required** objectives within the **virtual environment**, you may opt to work to work with a **physical environment** to validate and finalize your design for a <u>bonus mark</u>. To accomplish this, your team will be provided a physical recycling station consisting of only the Recycling Station and terrestrial drone (Figure 3). Your team will be required to:

1. Integrate your assembled physical mechanism onto a Q-Bot to deposit containers into provided recycling bins
2. Modify your computer program to work with a terrestrial drone and sensors to function in the physical environment

a. You will have the opportunity to test the terrestrial drone and mounted sensors in the physical environment to accomplish this task

Figure 1. The virtualized environment's *Sorting Station* includes a servo-controlled turntable for receiving various containers from a chute.

Figure 2. The virtualized environment's *Recycling Station* includes a series of bins for receiving different containers (metal, paper, clear plastic, and anything deemed contaminated). A robotic arm transfers containers from the *Sorting Station* into a recycling hopper (small red container) mounted to a terrestrial drone. You will interface with the terrestrial drone in order to transfer the containers to the correct bin.

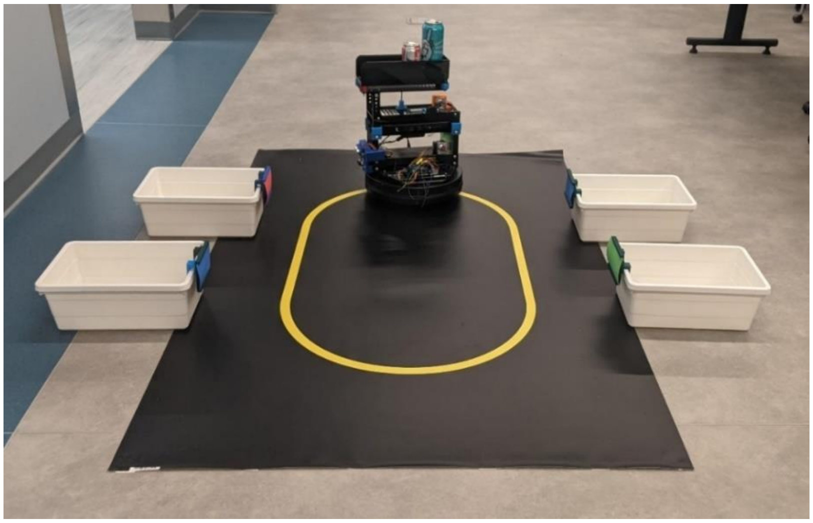


Figure 3. The physical environment's *Recycling Station* also includes a series of bins for receiving containers with the same properties as the virtual station. Each bin has a special mount for interfacing with various sensors. There is no sorting station or robotic arm in this environment, and you only need to interface with the terrestrial drone in order to transfer the containers to the correct bin.

This project requires that your team complete and submit several assigned deliverables by the appropriate deadline(s) and present your proposed design at the conclusion of the project during a scheduled Project Demonstration.

COVID-19 Disclaimer and Contingency Plans

In compliance with the university and its recent announcement regarding access to university space, the physical environment **will be accessible beginning the week of January 31st**. Our current plan is to begin a fully in-person design studio environment, allowing physical testing and fabrication of prototypes (**Scenario 1**). However, due to the sensitive nature of provincial and university protocols, we are prepared for a scenario where Project 3 is fully virtual (**Scenario 2**). **This is a transparent contingency plan** we wish to share with you to relieve any stress or uncertainty in the event of a change.

Please review the Project 3 scenarios below. **Proceed with Project 3 assuming Scenario 1** and consider Scenario 2 **ONLY** if announced (we will alert you **well ahead of time!**).

Scenario 1 – In-Person beginning the week of January 31st, 2022

- Beginning Wk-4, you will have access to the Design Studio for physical testing and fabrication of a prototype mechanism, along with the physical Recycling Station. As you will have access to the design space, the **Modelling Sub-Team** will be **required to create a physical prototype mechanism as part of the final deliverables for this project**. Integration of this physical mechanism with the **Computation Sub-Team's** modifying their program to work in the physical environment (Figure 3) will be a **bonus grade**. To summarize:
    - The Modelling Sub-Team is **required** to physically fabricate and test their designed mechanism as part of a required final-deliverable. No dynamic simulation is required
    - The Computing Sub-Team is **required** to have a working program in the virtual Q-Labs environment only
    - Both Sub-Teams can integrate their design for the physical environment as a **bonus**

Scenario 2 – Fully Virtual for the Entirety of Project 3

- There will be no access to university spaces, and as a result, no opportunity to work with the physical environment or components throughout the entirety of Project 3. In lieu of the **Modelling Sub-Team** not requiring any physical prototype, an **Autodesk Inventor Simulation** will be required instead. See "Detailed Description of Project Objective 2" for more details. An alternative bonus will also be communicated to you in a timely fashion. To summarize:
    - The Modelling Sub-Team is **required** to create a dynamic simulation of their designed mechanism as part of their final deliverable. No physical fabrication is required
    - The Computing Sub-Team is **required** to have a working program in the virtual Q-Labs environment only
    - An alternative bonus will be communicated to you in advance

PROJECT OBJECTIVE #1

IDENTIFY, *CLASSIFY*, AND *VERIFY* CONTAINERS FOR RECYCLABILITY

Working as a team, students are required to write a **computer program that interfaces with the QuanserSim environment**, specifically as it relates to the **Sorting Station**. The computer program is required to include the following tasks: 1) **identify the presence of a container** based on simulated data from a sensor, 2) **classify the container as either metal, paper, or plastic**, based on simulated data from two (2) sensors, and 3) **verify the container as either being recyclable or non-recyclable** based on the type of material and simulated data from a load cell (measures container mass, which is related to its contamination status). Once the container has been verified, it is ready to be picked up and transferred to the **Recycling Station**.

This objective is completed during a series of scheduled 3-hr experiential learning lab in Weeks 2 and 3 (Winter Term). *Identification* of the container occurs during Week 2. *Classification* and *Verification* occur during Week 3.

PROJECT OBJECTIVE #2

DESIGN A MECHANISM FOR DEPOSITING CONTAINERS INTO A RECYCLING BIN (MODELLING SUB-TEAM ONLY)

The Modelling Sub-Team is required to **design**, **model,** and **fabricate** a mechanism for depositing containers into a recycling bin. Your team will be provided with solid models (*.IPT files of components) along with physical components that can be used in your design. This includes a base-plate that mounts on top of the Q-Bot, a recycling hopper that can be used for storing and transferring containers to recycling bins, and various other components (e.g., containers, actuators, etc.). Refer to the "Detailed Description of Project Objective 2" document for additional details, along with the **Provided Parts Documentation** file for examples of what has been provided for you.

PROJECT OBJECTIVE #3

DESIGN A COMPUTER PROGRAM FOR TRANSFERRING CONTAINERS FROM THE SORTING STATION TO THE CORRECT BIN IN THE RECYCLING STATION (COMPUTATION SUB-TEAM ONLY)

The Computation Sub-Team is required to **design a computer program** that interfaces with the Quanser Interactive Labs (Q-Labs) environment, controlling movement of both the Q-arm and Q-bot to transfer containers from the **Sorting Station** to the correct bin in the **Recycling Station** (i.e., Metal/Paper/Plastic/Garbage). Your team will be provided with a general workflow that the computer program is recommended to follow, as well as a list of tasks that the computer program must be able to accomplish. Refer to the “Detailed Description of Project Objective 3” section for additional details.

PROJECT OBJECTIVE #4

EVALUATE BOTH COMPUTATIONAL AND PHYSICAL DESIGN ELEMENTS FOR FUNCTIONALITY AND CORRECTNESS

The final stage of this project is to verify correctness and functionality for both the Computation Sub-Team’s program and Modelling Sub-Team’s design. This requires **integration of the computation and modelling project components, and collaboration between both Sub-Teams** to ensure the mechanism for transferring and removing containers works as intended in a scheduled Project Demonstration. During this demonstration, it is required that you **explain your design** and **justify design decisions** by answering questions asked individually and as a team. It is required that your team **verify that your design meets the required objectives**. For the Modelling Sub-Team, this includes verifying that the correctness of your assembly and prototype. For the Computation Sub-Team, this includes verifying all containers can be successfully transferred to the Q-bot and deposited in the correct bin in the Recycling Station. For teams opting to do the bonus, you will also be asked to **physically demonstrate** your full design in a real-life recycling station.

You will have access to the Design Studio to build, test, and verify the Modelling Sub-Team’s mechanism, and for teams opting to complete the bonus, a modified computer program. This includes having access to individual mechanism testing stations, and individual program testing stations. Ideally, both teams should communicate with each other regarding their computational and physical design elements during this testing phase. Refer to the “Detailed Description of Project Objective 4” section for additional details on booking times for testing, and deadlines for a functioning prototype.

Detailed Description of Sub-Team Objectives

Detailed Description of Project Objective 2

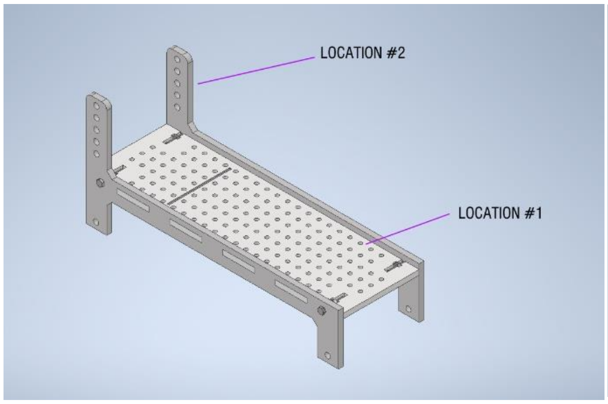
DESIGN A MECHANISM FOR DEPOSITING CONTAINERS INTO A RECYCLING BIN (MODELLING SUB-TEAM ONLY)

The Modelling Sub-Team is required to **design, model, and fabricate a mechanism for depositing containers into a recycling bin**. Your team will be provided with solid models (*.IPT files), along with physical models of components that can be used in your design if you choose to work in the physical environment. This includes a baseplate that mounts on top of the Q-Bot, a recycling hopper that can be used for storing and transferring containers to recycling bins, and various other components (e.g., containers, actuators, etc.).

Design

The Modelling Sub-Team is required to **design and fabricate a mechanism to rotate a recycling hopper which will deposit containers into a recycling bin.** Your mechanism will mount between a **baseplate** on top of the Q-bot and a **connecting plate attached to a hopper** for holding containers during transfer.

A base plate that mounts on top of the Q-bot has been provided to you. The mechanism must be **designed such that it connects to this base plate at 2 locations** as illustrated in Figure 4. At one end of the base plate, **the mechanism is required to connect to an *actuator* mounted on the base plate**. The type of actuator (linear vs. rotary) is determined by you, and a solid model of each has been provided (Figure 5). The actuator can mount to the base plate at any location within the region shown in Figure 4. The orientation of the actuator with respect to the base plate depends on whether it is rotary or linear. At the other end of the base plate, **the mechanism is required to connect to a rung mounted on the pivot legs**, which serves as the *output* of the mechanism (Figure 6). Depositing of containers occurs by rotation of the mechanism about this rung. The height of the rung can be adjusted as needed based on your design.



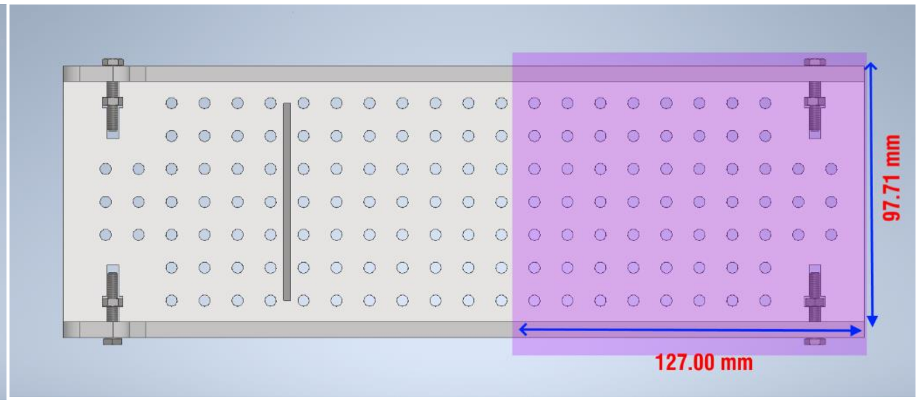
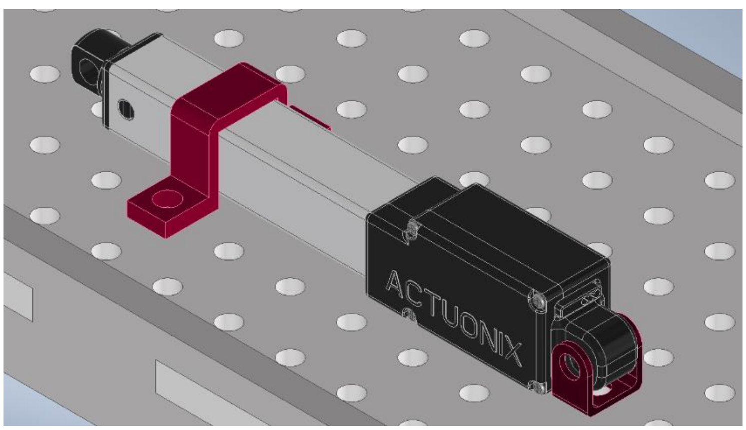


Figure 4. The baseplate mounting to the Q-bot connects to *your* mechanism at 2 locations. The input (an actuator) of your mechanism can mount anywhere within Location #1. Your chosen actuator, which mounts to the baseplate via mounting devices, can be aligned anywhere in the highlighted region shown on the right (a partial grid of 10x7 holes). All mounting holes on the actuator housing must be inside this region. The output connects to one of the rungs at Location #2.



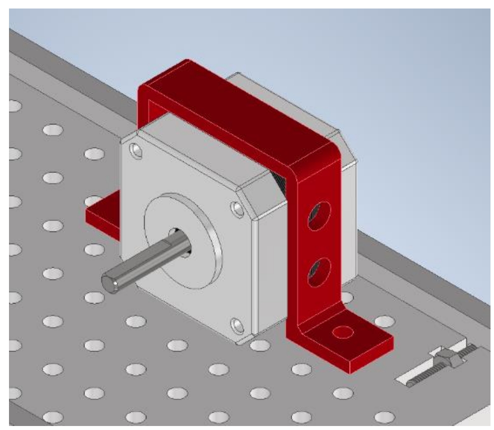


Figure 5. In the design of your mechanism, you may choose whether your input is driven by a linear actuator (left) or rotary actuator (right). Highlighted in red are parts given to you to mount each actuator to the baseplate. For a detailed description of these parts, see the Provided Parts Documentation file.

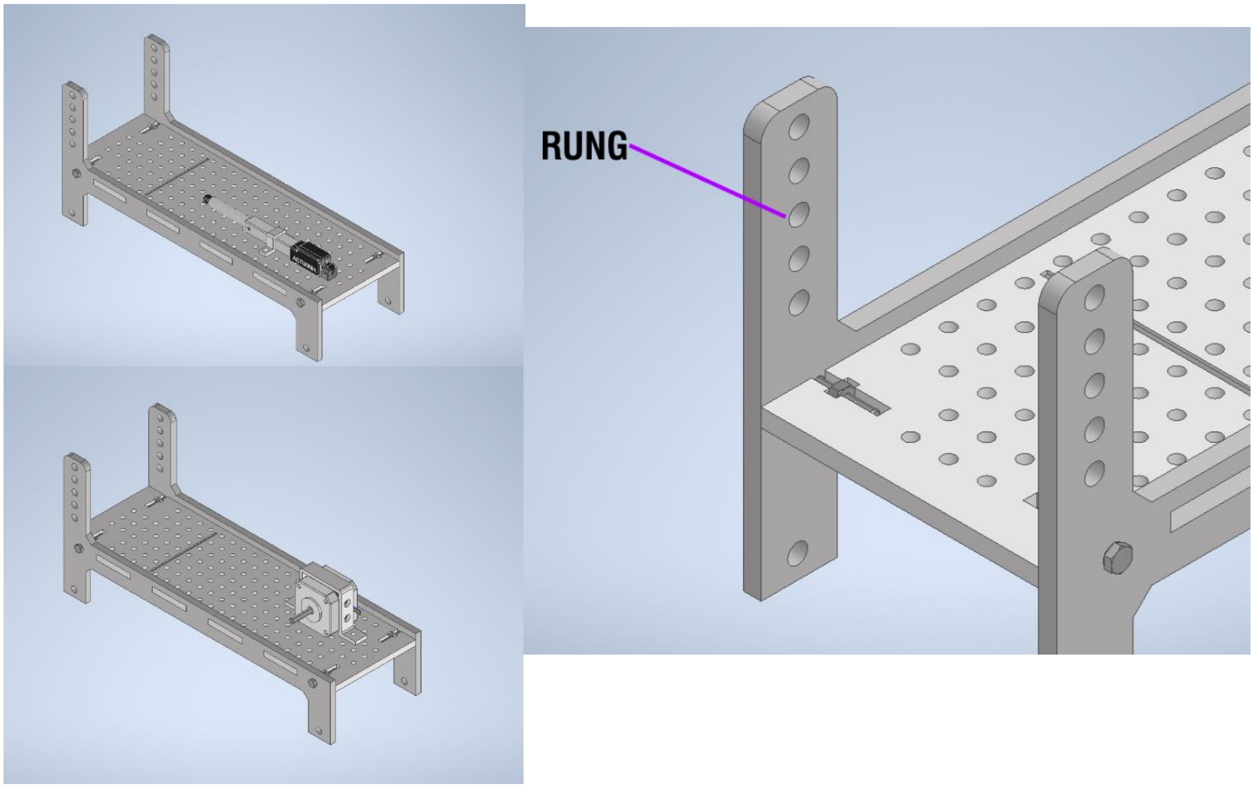


Figure 6. At the input, the mechanism connects to an actuator. The required orientation for the linear (top left) and rotary actuator (bottom left) is shown. At the output, the mechanism connects to a rung mounted on the pivot legs of the baseplate (right).

Once teams have verified a **working assembly**, you will be provided physical components of each to fabricate, test, and prototype your design (Figure 7). To attach the entire baseplate assembly to the Q-Bot for testing, the legs of the baseplate simply slide into 4 pockets pre-fastened on the top of the Q-Bot to allow for easy mounting/dismounting (Figure 8).

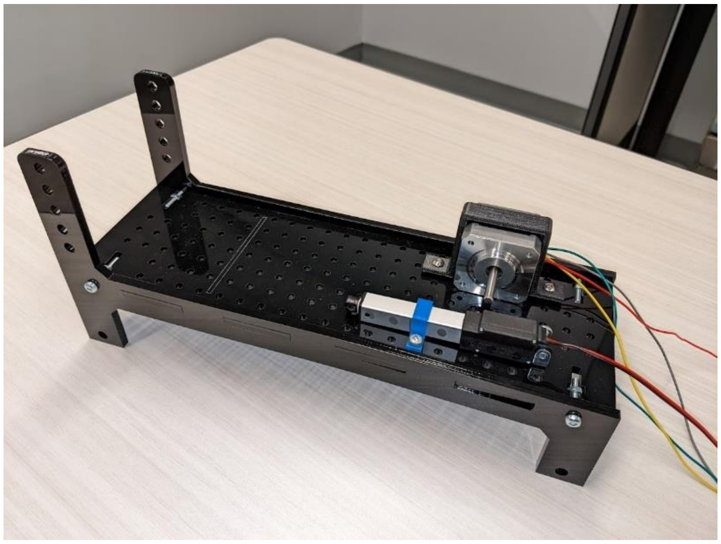
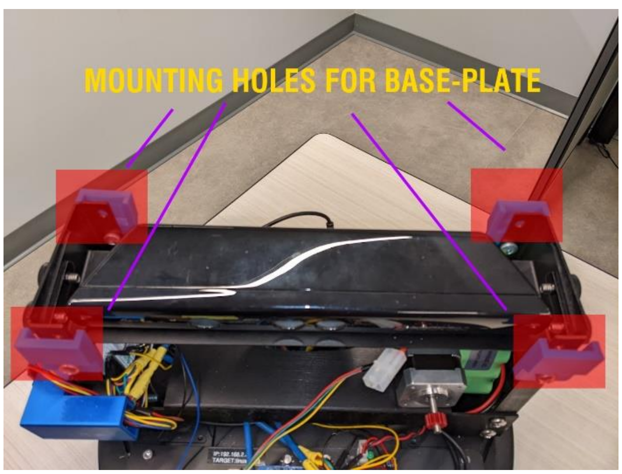


Figure 7. The physical laser-cut base-plate that will be provided to you for your mechanism. As an example, both the rotary and linear actuators have been mounted here using provided mounting devices, whereas your mechanism will only use one or the other.



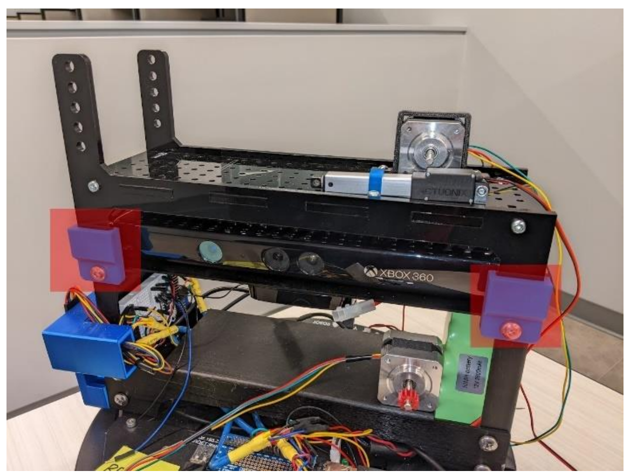


Figure 8. There are four 3D printed pockets fastened on the top of the Q-Bot (left). To attach the baseplate to the Q-Bot, each leg of the base-plate slides in and out of each pocket for easy mounting/dismounting (right).

A **solid and physical model of a recycling hopper has been provided to you for holding containers during transfer** (Figure 9). To attach your mechanism to the recycling hopper, a **connecting plate that consists of a grid of 21x6 holes** has also been provided which attaches to the recycling hopper via a magnetic link. At the end of the connecting plate are two 3D printed axle connectors to fit a **shoulder bolt to a chosen rung on the baseplate** (Figure 10).

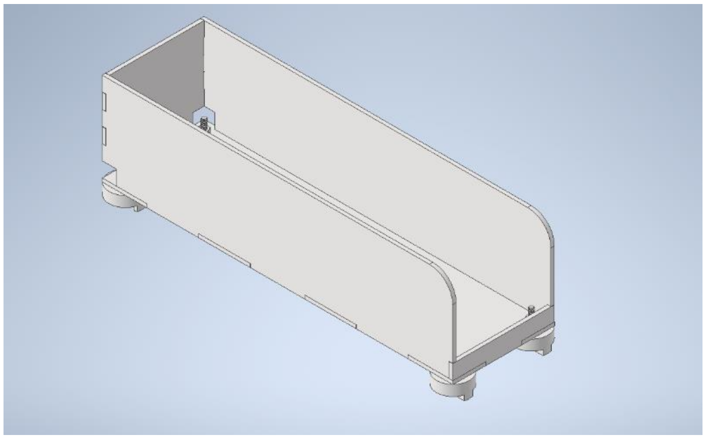
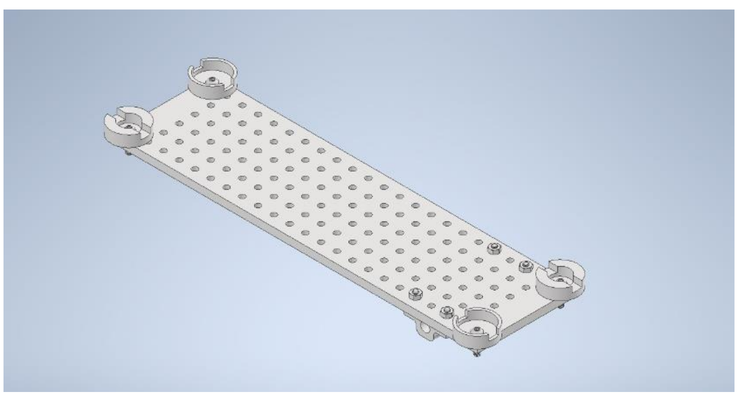


Figure 9. The simple hopper that has been given to you as a solid model to be used during the design phase (left), and laser-cut to be used in your physical prototype (right). There are 2 magnets fastened on two corners underneath the hopper to allow linkage to the connecting plate.



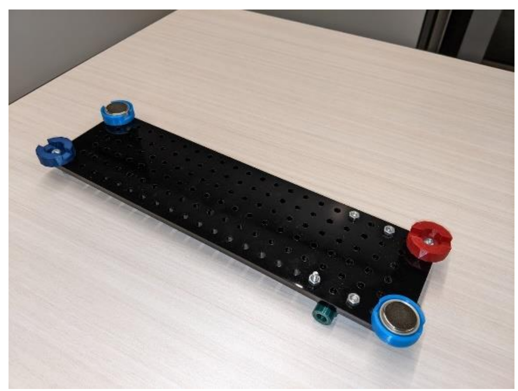


Figure 10. The connecting plate that can be used to attach your mechanism to the hopper for rotation around a rung. Notice the magnets fastened to 2 corners on the physical model to allow simple linkage to the hopper.

The **mechanism must be designed to deposit containers into the bin**. The mechanism should connect directly to the actuator (i.e., the *input*), support the hopper (i.e., attach to it) and be mounted securely to the base plate. The mechanism should also axially connect to a rung mounted on the pivot legs of the base plate (i.e., the *output*), directly via two 3D printed axle pieces on the connecting plate and a shoulder bolt (Figure 11). **Motion of the actuator causes the mechanism to rotate about this rung between two end positions**, one position to facilitate transfer of the containers and one position to facilitate depositing of the containers into the recycling bin (Figure 12 and Figure 13). When working with physical parts, it is recommended you remove the recycling hopper when attaching your mechanism to the connecting plate and magnetically reattach it when you are ready to test depositing of containers.

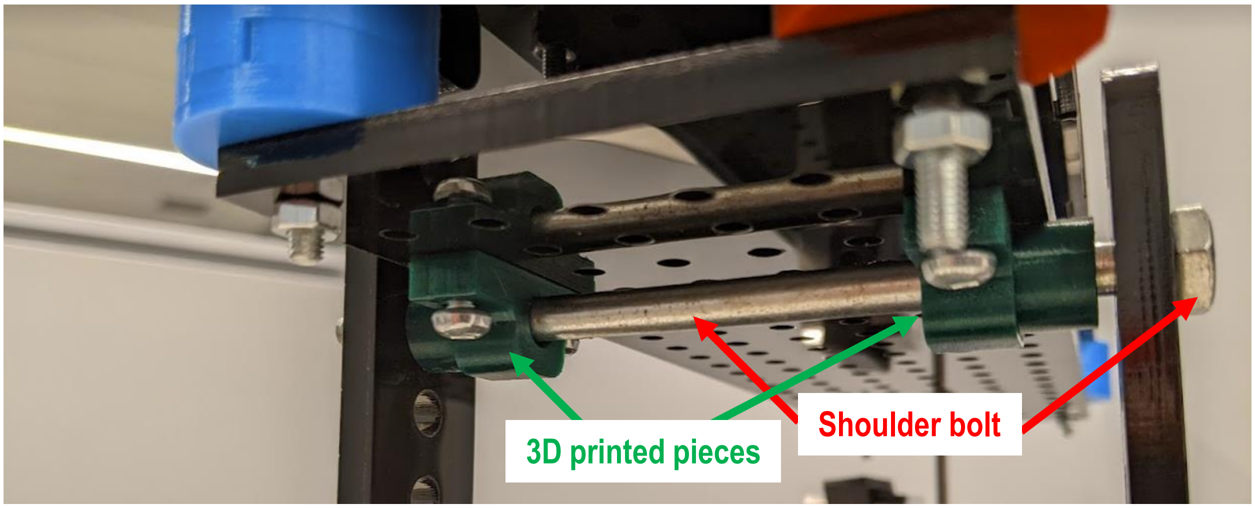


Figure 11. A shoulder bolt should be inserted through a chosen rung and two 3D printed axle pieces on the connecting plate to facilitate rotation of the recycling hopper during actuation.

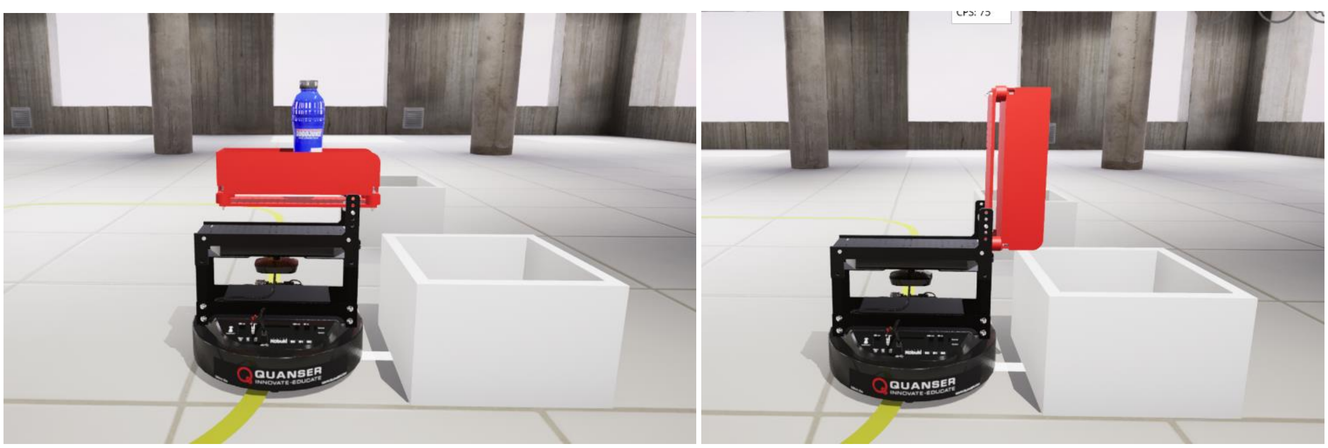


Figure 12. Two end positions of the mechanism in the Q-Labs environment. One before depositing of the containers (left), and one after depositing containers (right).

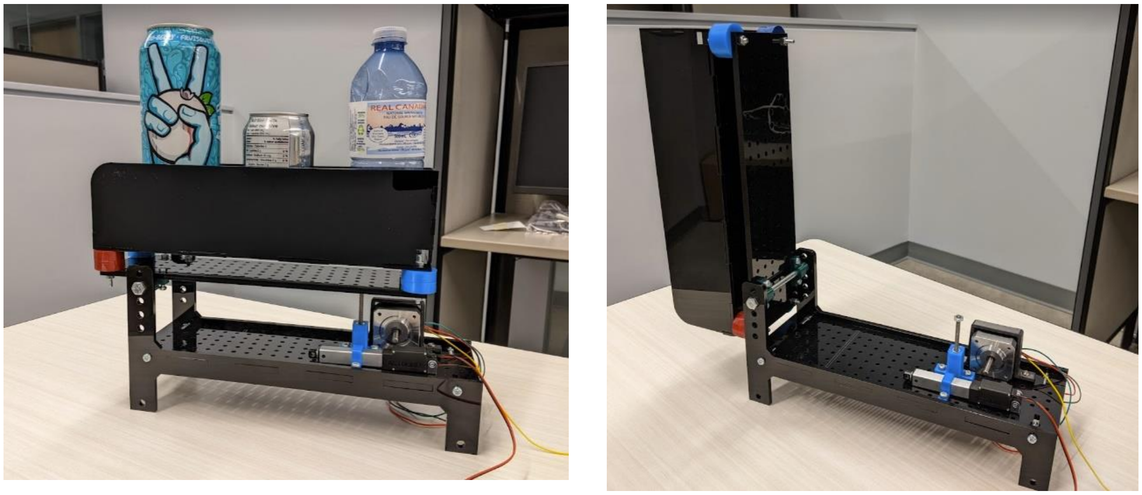


Figure 13. Two end positions of the mechanism in the physical environment. Note the resting piece on one end of the hopper. See the Provided Parts Documentation file.

Model

The Modelling Sub-Team is **required to create a solid model of each component of your mechanism** in Autodesk Inventor, which includes all components of the mechanism. Each solid model is expected to be based off the design you came up with as a team.

The Modelling Sub-Team is also **required to create an assembly model of your mechanism** in Autodesk Inventor. Your assembly model is expected to be based off the design you came up with as a team, although some refinements and deviations are both acceptable and to be expected. It is **required that your assembly be properly constrained**. Structural components should be fully constrained with respect to each other while mechanical components should be constrained with the appropriate degrees of freedom.

The **assembly model of your mechanism should be properly constrained to the base plate, the actuator that has been provided to you, and the connecting plate**. The actuator should be fully constrained to the base plate. At one end, the mechanism should be constrained to the actuator such that the component constrained to the actuator moves *with* the actuator. At the other end, the mechanism should be constrained to a rung mounted on the pivot legs of the base plate such that the mechanism can rotate about this rung, via a shoulder bolt inserted in the connecting plate axle pieces.

It is expected that all solid models and your assembly model be created using correct and efficient modelling practices, and without any errors or warnings. Finally, **it is required that you create fully-dimensioned engineering drawings of all components designed by you** for the purpose of documenting your design, being sure to adhere to ANSI standards. It is **not** required that you create engineering drawings of any *provided* parts (e.g., hopper, actuator, etc.).

COVID-19 CONTINGENCY PLAN (IN THE CASE OF SCENARIO 2)

The fabrication of a physical prototype for the container depositing mechanism will only be required assuming in-person activities resume **January 31, 2022**. Should 1P13 remain entirely virtual by this date, the modelling sub-team will instead be **required to demonstrate mechanism functionality through a motion simulation**, which will replace the physical prototyping portion of Project Objective #2.

A motion simulation can be created within Autodesk Inventor's *Dynamic Simulation* environment. The motion simulation is meant to characterize movement (i.e., translation and/or rotation) of the various *joints* within your assembly model. These joints include both mechanical components (e.g., a gear) and the interface of mechanical components (e.g., a gear meshing with another gear). It is **required that you specifically characterize movement of both the *input joint* and the *output joint***. The **input joint** refers to your chosen actuator, with motion being characterized as either pure translation or pure rotation. The **output joint** refers to a joint axis that your mechanism *rotates about* as containers are deposited into the recycling bin. This output joint is the connection between your mechanism and the rung mounted to the base plate.

The complexity of your simulation will directly correspond to the complexity of your design (i.e., the more moving components you have, the more joints you will be required to insert). In any case, your motion simulation is expected to include the following phases:

1. The mechanism is held in its *home position* (i.e., base of hopper parallel with respect to ground) for 1 second
2. The actuator (i.e., input) is activated, either translating or rotating until the containers are deposited into the bin
   - → Translation/rotation of the actuator (input) should impose rotational motion on the output joint axis
3. The mechanism is held in its terminal position (i.e., the terminal position/rotation of the actuator) for 1 second
4. The actuator (i.e., input) is activated, returning the mechanism to its *home position*
5. The mechanism is held in its *home position* for 1 second

Detailed Description of Project Objective 3

DESIGN A COMPUTER PROGRAM FOR TRANSFERRING CONTAINERS FROM THE SORTING STATION TO THE CORRECT BIN IN THE RECYCLING STATION (COMPUTATION SUB-TEAM ONLY)

The Computation Sub-Team is required to design a computer program that controls movement of robotic devices for transferring containers to the correct bin in the **Recycling Station**. Your team's program will interface with a virtual environment (Quanser Interactive Labs, or Q-Labs) allowing you to simulate movement of both a robotic arm and a terrestrial drone.

The **robotic arm** (Q-arm) consists of 4 joints (base, shoulder, wrist, and elbow) and a 2-fingered gripper that serves as the end-effector (Figure 8, left). Within the virtual environment, you will control movement of the Q-arm end effector by specifying xyz coordinates and pick up / drop off containers by closing or opening the gripper. All Python commands associated with controlling movement of the Q-arm can be found in the P3 Python Library Documentation PDF posted to Avenue.

The **terrestrial drone** (Q-bot) is a souped-up Roomba equipped with a number of sensors, some built-in and some chosen by your team (Figure 8, right). Within your program, you will control forward movement of the Q-bot *only*. To control the path of motion (i.e., forward, left turn, right turn, etc.), you will use two built-in IR sensors to create an algorithm for following a line on the floor. Finally, your program will input data from an additional sensor mounted to the Q-bot to distinguish between the different bins in the Recycling Station. The type of sensor is chosen by your Sub-Team. Available sensors are listed in Table 3. All Python commands associated with controlling movement of the Q-bot and the various sensors can be found in the P3 Python Library Documentation PDF posted to Avenue.

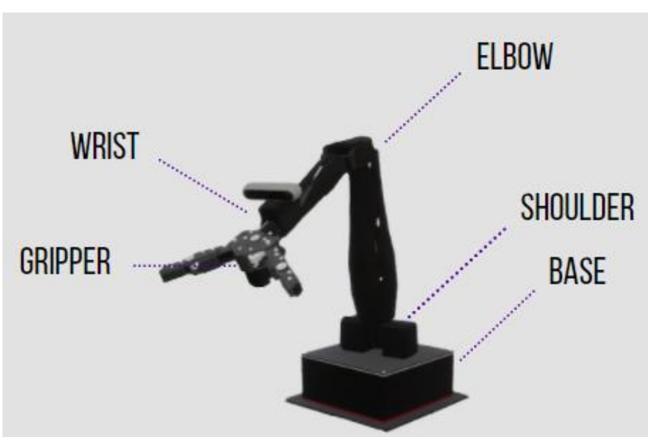


Figure 14. Completion of Project Objective 3 will require use of a robotic arm (the Q-arm, left image) and a terrestrial drone (the Q-bot, right image).

Table 3. List of sensors available to virtually mount to the Q-bot

Ultrasonic Sensor	LDR (Light Dependent Resistor)
Active Infrared (IR) Sensor	Color Sensor

The **Recycling Station** consists of 4 bins, with each bin meant to receive a different container (Metal, Paper, Plastic, Garbage) based on its material and recyclability (Figure 15). To ensure your chosen sensor (mounted to the Q-bot) can distinguish between each bin, the bins have a set of attributes (e.g., distance from line on the floor, color, etc.) you can control within the template program provided for you (Figure 16). A full description of bin attributes and how to modify them can be found in the P3 Configure Q-Labs Environment PDF posted to Avenue.

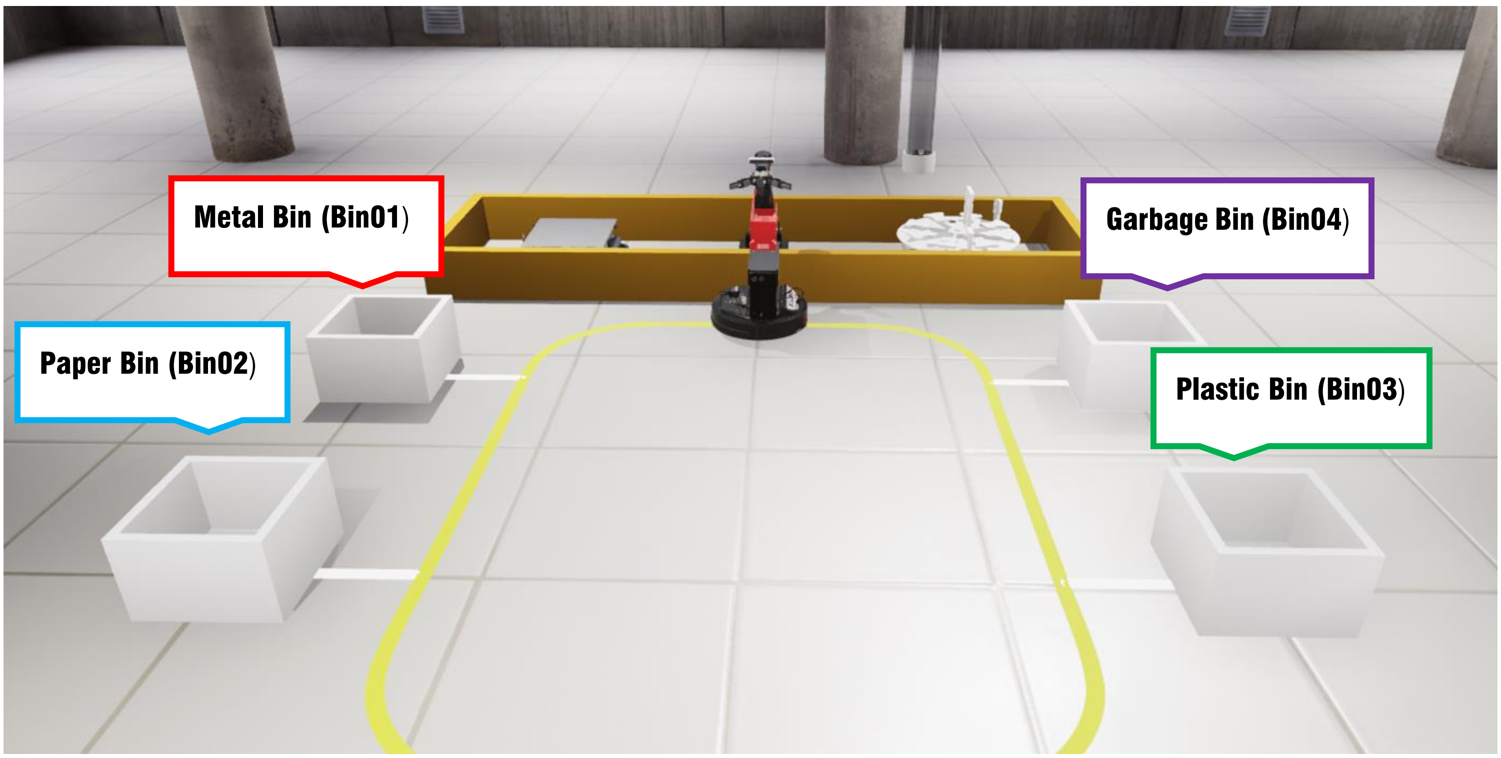


Figure 15. The 4 bins of the Recycling Station are shown. Containers are sent to one of the bins based on their material and recyclability.

```
# 1. Interface Configuration
project_identifier = 'P3B' # enter a string corresponding to P0, P2A, P2A, P3A, or P3B
ip_address = '169.254.135.12' # enter your computer's IP address
hardware = False # True when working with hardware. False when working in the simulation

# 2. Servo Table configuration
short_tower_angle = 315 # enter the value in degrees for the identification tower
tall_tower_angle = 90 # enter the value in degrees for the classification tower
drop_tube_angle = 180#270# enter the value in degrees for the drop tube. clockwise rotation from zero degrees

# 3. Qbot Configuration
bot_camera_angle = -21.5 # angle in degrees between -21.5 and 0

# 4. Bin Configuration
# Configuration for the colors for the bins and the lines leading to those bins.
# Note: The line leading up to the bin will be the same color as the bin

bin1_offset = 0.1 # offset in meters
bin1_color = [1,0,0] # e.g. [1,0,0] for red
bin2_offset = 0.2
bin2_color = [0,1,0]
bin3_offset = 0.3
bin3_color = [0,0,1]
bin4_offset = 0.4
bin4_color = [0,0,0]
```

BIN COLORS AND DISTANCE FROM LINE

Figure 16. Each bin within the Q-Labs environment can have its offset from the line and color modified within the given program template file. Note the comments within the code explaining each Q-Labs environment property.

As mentioned previously, you will be required to write a computer program in the **virtual Q-Labs to simulate your program**. Once you have a successful simulation, you will be approved to work in the physical environment if you choose to do so for a **bonus grade**, involving **uploading your program** to a physical Q-Bot. Both environments have been created to be as close as possible to each other, including sharing the same sensors, hopper, and the ability to change bin offsets and bin color (through a mount). The physical environment however **does not** include the sorting station meaning your general program workflow will be slightly different from the virtual environment. You may also have to modify your program through repeated testing of the physical sensors and actuators to ensure a successful cycle of depositing containers into the correct bin can run.

The following is a general workflow for your program in the **virtual Q-Labs environment**:

→ The Q-arm and the Q-bot begin at their respective *Home* positions
- For the Q-arm, this corresponds to the base, shoulder and elbow joints at 0° rotation and the gripper being fully open
- For the Q-bot, this corresponds to the middle of a yellow-line circular loop on the floor, adjacent to the Q-arm and hopper facing the **Recycling Station** area

→ The **container attributes are determined** (i.e., mass and bin destination) and the **container is positioned in the *Sorting Station*** for pick-up
- The attributes for a container, specifically its material, mass (in grams) and the destination bin in the **Recycling Station**, are determined and assigned to variables
  - The destination bin (i.e., Bin01, Bin02, Bin03, Bin04) is based on the material of the container (Metal/Paper/Plastic) and its recyclability
- The container is positioned in the **Sorting Station** for pick-up by the Q-arm

→ The **Q-arm loads the container** onto the Q-bot
- The Q-arm moves, positioning the gripper end-effector adjacent to the container
- The Q-arm picks up the container by closing the gripper
- The Q-arm moves, transferring the container to the hopper mounted on the Q-bot
- The Q-arm releases the container by opening the gripper
- The Q-arm moves, returning to its *Home* position

→ The above 2 steps repeat until one of the following conditions is met:
- A container with a different *ID* than what is currently on the Q-bot is positioned in the **Sorting Station**, *or*
- Three containers have been placed on the Q-bot, *or*
- The total mass of the new container positioned in the **Sorting Station** as well as all the containers currently on the Q-bot exceeds 90-grams

→ The **Q-bot transfers the container(s)** to the correct bin in the **Recycling Station**
- A sensor mounted to Q-bot for differentiating between the 4 types of bins is activated
- The Q-bot moves forward, following the trajectory of a line on the floor
- The Q-bot stops at the correct bin based on data measured from the sensor
- The sensor is deactivated

→ The **Q-bot deposits the container** into the correct bin in the **Recycling Station**
- The Q-bot is moved to a position immediately adjacent to the side of the bin
- The hopper mounted to Q-bot rotates about a single axis until containers fall into bin
  - The rate of rotation and the length of time the hopper rotates are defined by the Modelling Sub-Team's motion simulation

→ The **Q-bot returns to its *Home* position**
- The Q-bot moves forward, following the trajectory of a line on the floor
- The Q-bot stops once it reaches the *Home* position

→ The above steps repeat indefinitely until the program is terminated by the user

You will need to write a set of functions to accomplish the following tasks:

1. Dispense a container at the **Sorting Station**
2. Load containers onto a hopper mounted on top of the Q-bot
3. Transfer the container(s) to the correct bin in the **Recycling Station**
4. Rotate the hopper to deposit the containers into the correct bin
5. Return the Q-bot to its *Home* position, repeating the above tasks until the program is terminated by the user

To see a detailed breakdown of what the general workflow for your program in the physical environment is, see Objective 4: **Integration of the computation and modelling project components.** Remember, this is **not** a required final deliverable, and only for teams that have verified a working computer program in the Q-Labs environment and choose to work in the physical environment for a bonus mark.

There are built-in libraries you have been provided that includes pre-defined functions for controlling various aspects of the virtual and physical environment (the library has already been imported in the template file you have been provided). These built-in functions are described in the "**P3 Python Library Documentation**" PDF posted to the Avenue course page. Note that the simulation and hardware libraries have been kept as consistent as possible, but outputs such as sensor readings will differ.

Some basic requirements of your computer program are as follows:

1. Your program is required to be written in Python
2. Unless otherwise specified, each of the tasks described below must be written as a function

Dispense Container

Each container that is meant to be picked up by the Q-arm has a set of known attributes – specifically its material, mass, and target bin destination in the **Recycling Station** (Bin01 – Metal, Bin02 – Paper, Bin03 – Plastic, Bin04 – Garbage). The target bin destination is *known* and is based on the material and the mass of the container (Table 4). Within the Computation Sub-Team's computer program, **code should be written for determining specific container attributes and assigning to a variable**. These attributes are output from a built-in function in the P3 Library and include the container material, the mass (in grams) and the target bin in the **Recycling Station** (i.e., Bin01, Bin02, Bin03 or Bin04). Once these attributes have been determined, **the container should be dispensed and positioned in the Sorting Station for pick-up**. Unlike most of the tasks outlined below, it is not explicitly required that this task be written as a function. Your sub-team may choose whatever approach you think is appropriate.

Table 4. List of container attributes

ID	Q-Lab Render	Material	Mass (*g*)	Contamination	Target Bin
01	White bottle	Plastic	~9.25	Clean	Bin03
02	Red can	Metal	~15.0	Clean	Bin01
03	Blue bottle	Paper	~10.0	Clean	Bin02
04	White bottle	Plastic	> 9.25	Dirty	Bin04
05	Red can	Metal	> 15.0	Dirty	Bin01
06	Blue bottle	Paper	> 10.0	Dirty	Bin04

In the above table, a clean (i.e., empty) plastic container weighs 9.25-grams whereas a dirty (i.e., not empty) plastic container weighs more than 9.25-grams (the exact value varies by container). Similarly, a clean metal container weights 15-grams whereas a dirty metal container weighs more than 15-grams. However, a dirty plastic container cannot be recycled and thus must be placed in the garbage (i.e., Bin04), whereas a dirty metal container *can* be recycled.

Load Container

The Q-arm is required to pick up the container from where it's positioned on the **Sorting Station** turntable and load it onto the Q-bot (Figure 17). Within the Computation Sub-Team's computer program, **a function should be written for controlling the Q-arm joints to pick-up and load containers onto the Q-bot**. The pick-up location of the containers in the **Sorting Station** is *unknown* and needs to be determined. **This container pick-up location should be defined as a *3-item list***. The Q-arm can load **up to 3 containers** onto the Q-bot for a single run, provided **all containers are destined for the same bin** and the **total mass of containers on the Q-bot is less than 90-grams**. The Q-arm should only pick up and load a container onto the Q-bot under the following conditions:

→ There are fewer than 3 containers already on the Q-bot

→ The new container placed at the **Sorting Station** is to be transferred to the same bin (Bin01, Bin02, Bin03, Bin04) as any existing containers already on the Q-bot

→ The total mass of all containers on the Q-bot as well as the new container placed at the **Sorting Station** is less than 90-grams

Figure 17. Placement of a container onto the Q-bot is shown.

If more than one of these conditions are not satisfied, then no action should be taken (i.e., the container should not be loaded). For example, consider a scenario where there are *fewer than 3* containers already on the Q-bot, but the new container is ***not*** to be transferred to the *same* bin (e.g., one is metal, and one is plastic). In this scenario, the new container should ***not*** be loaded.

Each container placed on the Q-bot (i.e., first, second, and third) has a different drop-off location on the Q-bot that is *unknown* and needs to be determined (Figure 18). **Each unique container drop-off location should be defined as a 3-item list** within your function.

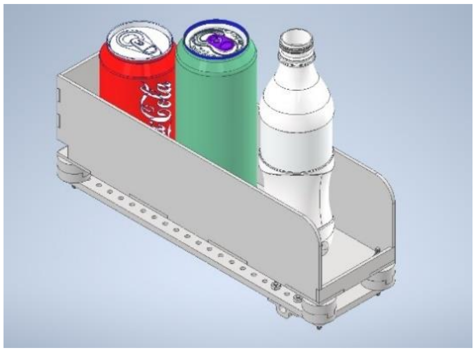


Figure 18. The hopper mounted atop the Q-bot can hold up to 3 containers. Each of the 3 drop-off locations are unknown and need to be determined.

Transfer Container

The Q-bot is required to transfer the container(s) to the correct bin (Metal/Paper/Plastic/Garbage) in the **Recycling Station**, moving along a pathway by following a line on the floor, and stopping once it is correctly positioned (Figure 19). Within the Computation Sub-Team's program, **a function should be written for moving the Q-bot to the Recycling Station and stopping once it has reached the location of the correct bin**. The 4 bins in the **Recycling Station** are differentiated between each other using a sensor virtually mounted to the side of the Q-bot.

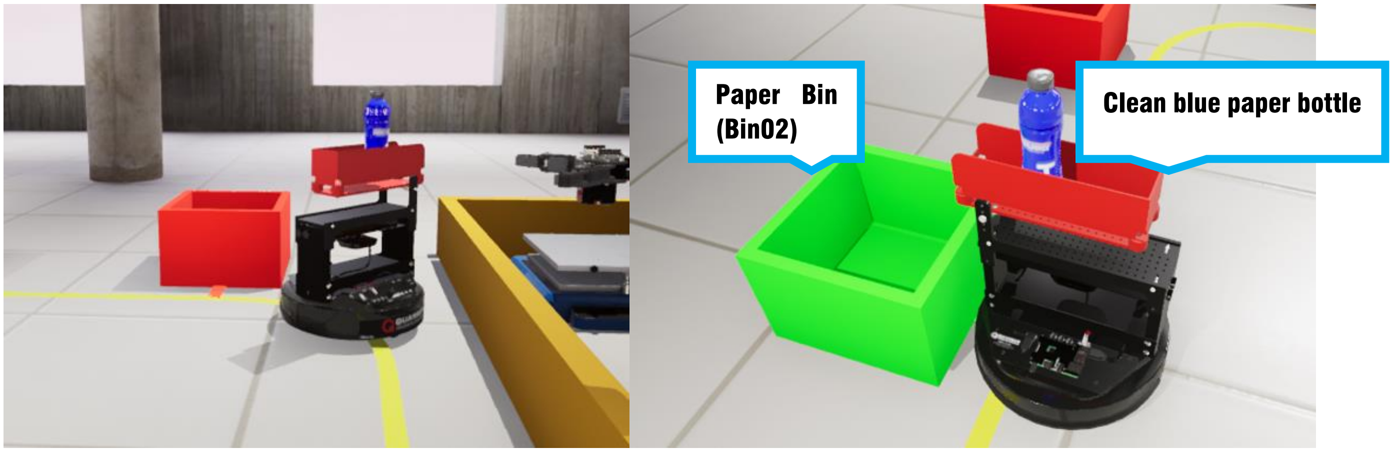


Figure 19. Images of the Q-bot moving along the pathway by following a line on the floor (left) and stopping at the correct bin (right) are shown.

To transfer containers to the **Recycling Station**, the **sensor mounted to the Q-bot is activated using a built-in function within the P3 Library**. The *type* of sensor for differentiating between bins is chosen from the list of sensors outlined in Table 3. Once this sensor is activated, the **Q-bot should move forward, following the trajectory of a line on the floor, towards the bins in the Recycling Station**. Each of the 4 bins (Bin01 – Metal, Bin02 – Paper, Bin03 – Plastic, Bin04 – Garbage) has a set of attributes (e.g., distance from line on the floor, color, etc.) that can be modified by *you* within the Q-Labs environment (Figure 16). Depending on your chosen sensor, **the value of one or more of these attributes should be defined such that your chosen sensor can differentiate between bins**. The choice of sensor and the value of each bin's attributes is entirely up to you, but you will be expected to defend your choices during your Project Interview.

As the Q-bot moves forward, the value of these attributes can be measured using your chosen sensor. Based on your sensor and the measured value of each bin's attributes, the **Q-bot should stop moving once it is positioned next to the correct bin**. Once the Q-bot has stopped, **the mounted sensor should be deactivated using a built-in function within the P3 Library**.

Deposit Container

Once the Q-bot is positioned next to the correct bin in the **Recycling Station**, it is required to *deposit* (i.e., *dump*) the container(s) into the bin. Within the Computation Sub-Team's program, **a function should be written for positioning the Q-bot hopper immediately adjacent to the bin and rotating the hopper to deposit the containers into the bin**. Note, this is ***not mandatory***, and only should be done in the case where the bins are too far from the yellow loop. To ensure the containers on the Q-bot will fall *into* the bin, **the Q-bot should be moved so that the hopper is positioned immediately adjacent to the bin**. To accomplish this, the Q-bot should be rotated approximately 90-degrees *clockwise* so that it is facing the bin (Figure 20). The Q-bot should then travel forward, measuring distance from the nearest object using distance-based movement. The Q-bot should stop once it is positioned close enough to the bin that the container(s) fall inside the bin upon rotation of the hopper from the bin (Figure 21, left). The Q-bot should then rotate approximately 90 degrees *counterclockwise* so that it is facing the same direction it was previously (Figure 21, centre). Rotation of the Q-bot, forward movement and depth measurement are all achieved by calling the appropriate functions in the built-in library.

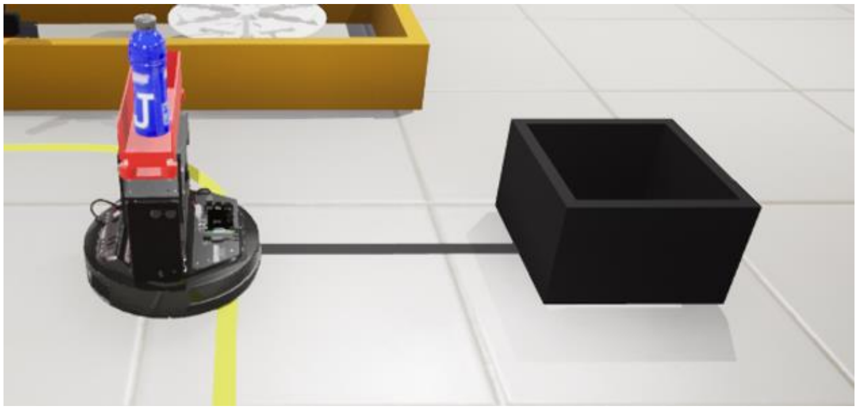


Figure 20. To move the Q-bot such that the hopper is immediately adjacent to the bin, the Q-bot should first rotate 90-degrees clockwise as shown.

Once the Q-bot is immediately adjacent to the bin, **the hopper mounted to the Q-bot should rotate until all containers fall into the bin** (Figure 15, right). Rotation of the hopper to *dump the containers* is achieved by calling the appropriate function in the built-in library.

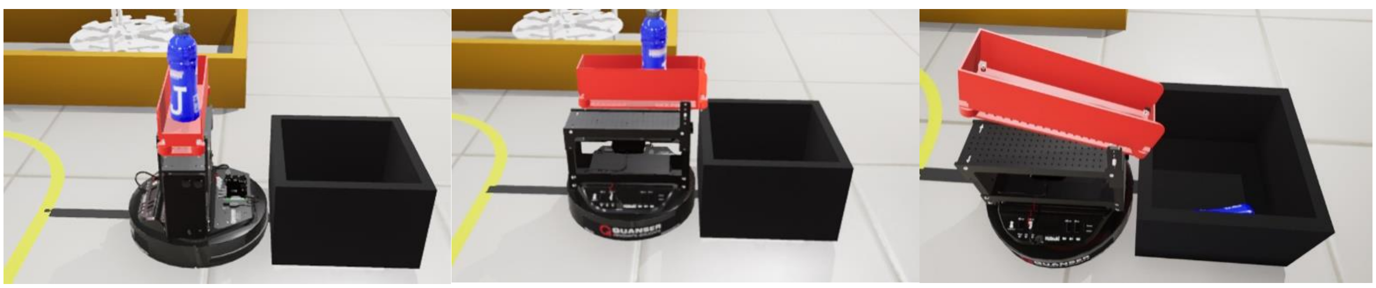


Figure 21. Once the Q-bot is rotated to face the correct bin, the Q-bot should travel forward until it is positioned close enough to the bin (left image). Once positioned close enough, the Q-bot should rotate 90 degrees counterclockwise (centre image). The hopper mounted to the Q-bot should then rotate until all containers fall into the bin (right image).

To complete this task, **the Q-bot should be moved back to its position on the yellow line**. To accomplish this, the Q-bot should be rotated 90-degress *counterclockwise* so that it is facing *away* from the bin. The Q-bot should then travel forward, following the offset line on the floor (which is perpendicular to the yellow line, Figure 22, left). Once the line cannot be found, indicating it has reached the end of the line, the Q-bot should rotate 90-degress *clockwise* so that it is facing the same direction it was at the beginning of the task (Figure 22, right).

Figure 22. Once containers are deposited, the Q-bot should travel forward along the offset line until it again reaches the yellow line on the floor (left image). Once at the yellow line (i.e., when the offset line can no longer be found), the Q-bot should rotate 90-degrees counter-clockwise so that it is facing the same direction it was at the beginning.

Return Home

The Q-bot is required to return to the **Sorting Station** so that the next container(s) can be loaded up. Within the Computation Sub-Team's computer program, **code should be written for controlling movement of the Q-bot until it has returned to the Sorting Station**. To return home, the **Q-bot should move forward, following the trajectory of a line on the floor**. The yellow line on the floor forms a closed loop meant to return the Q-bot to the **Sorting Station**. The **Q-bot should stop moving once it has reached the original position it spawned at**, which corresponds to its *Home* position. Unlike most of the previous tasks, it is not explicitly required that this task be written as a function. Your sub-team may choose whatever approach you think is appropriate.

Detailed Description of Project Objective 4

EVALUATE BOTH COMPUTATIONAL AND PHYSICAL DESIGN ELEMENTS FOR FUNCTIONALITY AND CORRECTNESS

The final stage of this project is to verify correctness and functionality for both the Computation Sub-Team's program and Modelling Sub-Team's design.

Project Demonstration

During Wk-7, you will have a project demonstration. During this demonstration, it is required that you **explain your design** and **justify design decisions** by answering questions asked individually and as a team. It is required that your team **verify that your design meets the required objectives**. For the Modelling Sub-Team, this includes verifying the correctness and functionality of your assembly and prototype. For the Computation Sub-Team, this includes verifying all containers can be successfully transferred to the Q-bot and deposited in the correct bin in the Recycling Station. To teams that have opted to the bonus and work in the physical environment, you will be asked to demonstrate your physical assembly and program in a real-life recycling station.

Bonus Integration Requirements: The Physical Environment

The bonus grade requires **integration of the computation and modelling project components, and collaboration between both Sub-Teams** to ensure the mechanism for transferring and removing containers works as intended in a scheduled Project Demonstration.

Project integration should successfully demonstrate a working program and physical prototype. This demonstration includes manually loading containers onto the hopper, inputting into the program which type of container was loaded, Q-Bot determines the correct drop-off bin using a mounted sensor, the Q-bot deposits the bins by controlling the actuator and engaging student-designed mechanism, the Q-bot returns home to repeat this loop multiple times.

The following is a general workflow for your program in the **physical hardware environment ONLY**:

→ A human, (you!), **loads a container or multiple containers** onto the Q-bot
- Ensure that you have fully assembled your mechanism for depositing containers and attach the baseplate and hopper to the Q-Bot before doing this step
- Load up to three containers of the **same type** into the hopper

→ The **computer program asks for a user input on what bin to go to**
- A user should then input an option on their Python console corresponding to the containers they loaded (Paper containers to Bin 2 for example)

→ The **Q-bot transfers the container(s)** to the correct bin in the **Recycling Station**
- A sensor mounted to Q-bot for differentiating between the 4 types of bins is activated
- The Q-bot moves forward, following the trajectory of a line on the floor

- The Q-bot stops at the correct bin based on data measured from the sensor
- The sensor is deactivated

→ The **Q-bot deposits the container** into the correct bin in the **Recycling Station**

- The Q-bot is moved to a position immediately adjacent to the side of the bin
- The hopper mounted to Q-bot rotates about a single axis until containers fall into bin
  - If your mechanism uses a linear actuator, extend/retract the actuator to facilitate your mechanisms rotation for depositing containers
  - If your mechanism uses a rotary actuator, rotate the actuator clockwise/counter-clockwise to facilitate your mechanisms rotation for depositing containers
  - The actuation time is defined by the Modelling Sub-Team's design, which should be clearly communicated to the Computing Sub-Team

→ The **Q-bot returns to its *Home* position**

- The Q-bot moves forward, following the trajectory of a line on the floor
- The Q-bot is **manually** stopped from the shell when it reaches its home position

→ The above steps repeat indefinitely until the program is terminated by the user

As this general workflow is slightly different, your program for the physical environment requires slight modifications and fewer functions.

You will need to write a set of functions to accomplish the following tasks:

1. Take a user input on what containers are being deposited into the hopper
2. Transfer the container(s) to the correct bin in the **Recycling Station**
3. Rotate the hopper to deposit the containers into the correct bin
4. Return the Q-bot to its *Home* position, repeating the above tasks until the program is terminated by the user

Bonus Integration Requirements

If the Modelling Sub-Team has a functioning physical prototype, and the Computational Sub-Team has a functional program for the Q-Labs environment, you will be approved to work with the physical environment for a bonus grade. If your team *successfully accomplishes the above workflow* in the physical environment, members of both the modelling sub-team and the computation sub-team will receive a **bonus 7 marks (out of 100) towards their overall Project-3 grade.**

As this is an *optional approach* with bonus marks, please ensure you are confident with your program and prototype before moving on to attempting this bonus. It is expected that both Sub-Teams can work however they please to accomplish the above bonus task.

Building and Testing: Design Studio Resources

You will have access to the Design Studio to build, test, and verify both the Modelling Sub-Team's mechanism and the bonus integration. This includes having access to individual mechanism testing stations, and individual program testing stations.

Design Studios 4, 5 and 6 are designated work periods which are to be used for building and experimenting with physical resources. Students are also permitted to use resources external to design studio, within the limits given below.

Table 5. Permitted and Banned Resources

Allowed	Not Allowed
• Approved 3D Printer. This includes: o Design Studio printers o Personal printers o Non-personal printing services (online, print stores, libraries, etc.) • Design Studio Laser Cutter o To be operated by trained staff **ONLY!** • Industrial fasteners and parts o Nuts, screws, bolts, etc. sourced from a hardware store • Crafting/building supplies o Glue, string, dowelling, etc.	• External robotics or manufactured parts o Manufactured gears, pre-built mechanism, etc. • Tools and equipment not available in the Design Studio o Band Saws, milling equipment, welding, etc. • Expensive sourced materials • Anything deemed unsafe by a TA, faculty mentor or staff member (e.g elements with stored energy, compressed gases)

Note that the limitations placed here are to encourage design of your mechanism components and ensure equal opportunities for all students.

Testing Stations

Beginning Wk-4, testing stations will be available for use in the Design Studio to test both the Modelling Sub-Teams mechanism, and the bonus integration challenge. Details for both are provided below:

Table 6. Testing Stations per subgroup

Modelling Sub-Team	Bonus Integration

Mechanism Testing Stations
• A standalone hopper and baseplate setup will be available. You are encouraged to test your mechanism by attaching your mechanism to a setup.
    o Each setup will have a linear and rotary actuator already setup for you to test
	Sensor Testing
	• Sensors will be available for testing and determining any additional considerations that should be made in the physical environment.
	Q-Bot Stations
	• Once you have physical sensor threshold values for your program, Q-Bots equipped with sensors, a mat with the recycling track, and bins will be available for program testing.
	    o This will be supervised

PROJECT THREE SCHEDULE OF ACTIVITIES

Week #	Date	Activity	Complete **BEFORE** Design Studio	Complete **DURING** Design Studio
Wk-1	Mon Jan 10 – Fri Jan 14	**Milestone 0** • Determine and document administrative responsibilities	• Review the Administrative Responsibilities section of the P3 Project Module (Individually)	***Team***: Complete Team Charter worksheet (Milestone Zero Team Worksheet)
		Milestone 1 • Complete a series of design exercises to frame the given problem	***Team***: N/A • Complete Initial Problem Statement, Objectives and Constraints worksheet (individually)	***Team***: Complete Refined Problem Statement worksheet ***Modelling Sub-Team***: Concept Sketches worksheet (Individually) ***Computation Sub-Team***: Workflow Pseudocode worksheet or Workflow Flowchart/Storyboard worksheet (Individually)
Wk-2	Mon Jan 17 – Fri Jan 21	**Milestone 2** • Conceptualize both how the containers will be transferred and how the containers will be dropped off • Evaluate and propose refinements/corrections	***Team***: N/A	***Team***: Update your TA on team progress (Manager chairs meeting and Coordinator takes minutes)
			Modelling Sub-Team: Refine concept sketches (Individually)	***Modelling Sub-Team***: Mechanism Design Evaluation and Detailed sketch of Finalized Mechanism Assembly
			Computation Sub-Team: Sensor Research worksheet (Individually)	***Computation Sub-Team***: Sensor characterization evaluation and develop program framework to complete preliminary program tasks
Wk-3	Mon Jan 24 – Fri Jan 28	**Milestone 3** • Create preliminary models of design in Autodesk Inventor based on detailed sketches • Create preliminary program tasks	***Team***: N/A	***Team***: update your TA on team progress (Manager chairs meeting and Coordinator takes minutes)
			Modelling Sub-Team: Model your design in Autodesk Inventor	***Modelling Sub-Team***: Present proposed design and document feedback on worksheet
			Computation Sub-Team: Write your Computer Program in Python to run one pick up and drop-off cycle.	***Computation Sub-Team***: Present proposed design and document feedback on worksheet

Week #	Date	Activity	Complete **BEFORE** Design Studio	Complete **DURING** Design Studio
Wk-4	Mon Jan 31– Fri Feb 4	**Dedicated Project Time** Student teams work towards finalizing their designs, prototypes, and sub-team integration	N/A	***Team***: update your TA on team progress (Manager chairs meeting and Coordinator takes minutes)
			N/A	**There are no deliverables for this week**
Wk-5	Mon Feb 7 – Fri Feb 11	**Dedicated Project Time** • Student teams work towards finalizing their designs, prototypes, and sub-team integration	N/A	***Team***: update your TA on team progress (Manager chairs meeting and Coordinator takes minutes)
				There are no deliverables for this week
Wk-6	Mon Feb 14 – Fri Feb 18	**Dedicated Project Time** • Student teams work towards finalizing their designs, prototypes, and sub-team integration	N/A	***Team***: update your TA on team progress (Manager chairs meeting and Coordinator takes minutes)
				There are no deliverables for this week
Wk-7	Mon Feb 28 – Fri Mar 4	**Project Demonstration and Interview** • Student teams demonstrate their design and prototype to an IAI. Students are expected to individually answer questions of their design in an individual interview	***Modelling Sub-Team***: Upload Autodesk Inventor files (in a ZIPPED folder) to Avenue	***Modelling Sub-Team***: Explain design and prototype to IAI. Individually, students answer questions related to both the design and modelling practices
			Computation Sub-Team: Upload Python code (in a ZIPPED folder) to Avenue	***Computation Sub-Team***: Explain and demonstrate design to IAI. Individually, students answer questions related to both the design and computing practices
			If attempting bonus - Team: *Be prepared to demonstrate the integration of the computational program and the physical mechanism in the physical environment*	***If attempting bonus - Team:*** *Demonstrate the integration of the computational program and the physical mechanism by completing one "Transfer Container"* cycle.

Project Three Deliverables

MILESTONE ZERO: TEAM DEVELOPMENT AND PROJECT PLANNING

Assessment Type: Team
Time Allotted: Week 1 (Winter) Design Studio (DS-13)
Submission Deadline: 11:59 PM EST the day after DS-13

Objectives and Requirements

For Milestone Zero, your team is required to formally document your team's personnel and the administrative roles and responsibilities each member will take on for the duration of the project. This formal documentation process is in the form of a **Team Charter**. Complete your charter on the *Team Charter* worksheet. Your worksheet must include the following:

1. **Team Personnel**: Record each team member's name (preferred name) and MacID in the Team Personnel table on the **Milestone 0 Cover Page worksheet**.
2. **Team Portrait**: Take a selfie of your team. Be creative! Include your photo on the **Cover Page worksheet**.
3. **Incoming Personnel Administrative Portfolio**: Record each team's administrative contributions on all projects up to this point, identifying their Project Lead roles
4. **Project Leads**: *As a team*, come to an agreement on who will take the **Lead** for each administrative task (**M**anager, **A**dministrator1, **A**dministrator2, **C**oordinator). The administrators must be on different sub-teams, due to their required administrative duties.
   → Record each team members name next to their assigned role in the *Project Leads* table on the **Team Charter worksheet**
   - For a team of 5 students, there will be **two (2) Coordinators**
   - Otherwise, there can only be one team member for each role

   → Give consideration to each team member's administrative portfolio to ensure team members have the opportunity to take on different roles across projects
   → Each team member must sign next to their name, indicating their acceptance of the expectations and responsibilities specific to their assigned role
   - Refer to the ***P3 Administrative Responsibilities***
5. **Team Manager ONLY:** Complete a preliminary Gantt Chart of your team's proposed project schedule, outlining team meetings, and planned progression of tasks.
   → You can refer to the *Getting Started – Gantt Chart* file on Avenue for reference on creating a Gantt Chart using Excel

Submission Details

1. **Project Administrator 2 ONLY**: save your Milestone 0 *Cover Page* and *Team Charter* worksheets (both pages) as a single PDF, and submit it to the *Avenue Dropbox* titled **P3 Milestone 0 (Team) – *Day***
   → Use the following naming convention: **Day-##_P3_Milestone0.pdf**
   → This is a *team* submission that is the responsibility of the *Project Administrator 2*
   → Files missing from your submission will not be graded. **No exceptions**!

Grading of Milestone Zero

Milestone Zero is graded on a **Pass/Fail** basis. Failure to submit all worksheets will result in a **10% deduction to your Project 3 grade**.

MILESTONE ONE: PROBLEM FRAMING AND CONCEPTUAL DESIGN

Assessment Type: Team
Time Allotted: Week 1 (Winter) Design Studio (DS-13)
Submission Deadline: 11:59 PM the day after DS-13

Objectives and Requirements

For Milestone One, your team will work to define the needs, objectives, and constraints for your assigned design challenge, with an outcome of this Milestone being a refined problem statement. Your team will also **plan the tasks of your computer program** (Computation Sub-Team), and **conceptualize how containers will be deposited** into the recycling bin (Modelling Sub-Team). This Milestone, and all subsequent Milestones completed during Design Studio, will focus on the **Recycling Station**.

1. **Initial Problem Statement, Objectives and Constraints (Prior to DS-13)**: Individually, identify a *list of objectives and constraints* and an *initial problem statement* (from lecture). Objectives and constraints must be clearly distinguished from each other. Complete your work on the **Problem Statement, Objectives and Constraints worksheet**, located in the *Wk-1 (Winter) – P3 Milestone 1 Worksheets INDIVIDUAL.docx* document.

2. **Refined Problem Statement (During DS-13)**: As a team, develop a *refined problem statement*, using the initial problem statement(s) to guide you. Refer to the Refined Problem Statement rubric provided on Avenue (see P3 Milestone Rubrics) to understand the expectations of the statement. Complete your refined problem statement on the **Refined Problem Statement, Objectives and Constraints worksheet**, located in the *Wk-1 (Winter) – P3 Milestone 1 Worksheets TEAM.docx* document.

3. **Computer Program Workflow (During DS-13, Computation Sub-Team ONLY)**: *Each team member of the Computation Sub-Team* is required to describe the workflow of the sub-system outlined in Project Objective #3 (i.e., transferring containers from sorting station to bins in the recycling station). ***One*** team member should outline the high-level workflow using ***pseudocode*** whereas the ***other*** team member should create either a ***flowchart or a visual storyboard***. Complete your pseudo code and flowchart/storyboard on the **Workflow Pseudocode worksheet** or the **Workflow Flowchart/Storyboard worksheet**, respectively. Each worksheet is located in the *Wk-1 (Winter) - P3 Milestone 1 Worksheets TEAM.docx* document.
    a. The focus should be on how the program achieves the high-level objective rather than how each of the various tasks are executed
        i. i.e., your pseudocode and flowchart/storyboard should simply list the functions and not describe the processes involved in executing the function

4. **Mechanism Concept Sketches (During DS-13, Modelling Sub-Team ONLY)**: *Each team member* of the *Modelling Sub-Team* is required to create ***two (2)*** concept sketches for the

mechanism that will deposit containers into a recycling station bin. Each concept sketch should incorporate a different actuator, one linear and one rotary. Recall that the actuator serves as the input to the mechanism. Complete your sketches on a separate sheet of paper, take a photo, and insert the sketch as a picture on the **Concept Sketches worksheet**, located in the *Wk-2 (Winter) - P3 Milestone 1 Worksheets TEAM.docx* document.

Submission Details

1. **Each Team Member (Computation Sub-Team ONLY)**:
    - Upload a ***.PDF** copy of the *Wk-1 (Winter) - P3 Milestone 1 Worksheets INDIVIDUAL* document to *Avenue Dropbox* titled **P3 Milestone 1 (Individual - Computation)**
        - → Use the following naming convention: **macID_P3_Milestone1.pdf**
        - → The Project Administrator must submit a copy as well, if applicable
2. **Each Team Member (Modelling Sub-Team ONLY)**:
    - Upload a ***.PDF** copy of the *Wk-1 (Winter) - P3 Milestone 1 Worksheets INDIVIDUAL* document to *Avenue Dropbox* titled **P3 Milestone 1 (Individual - Modelling)**
        - → Use the following naming convention: **macID_P3_Milestone1.pdf**
        - → The Project Administrator must submit a copy as well, if applicable
3. **Project Administrator 1 and Project Administrator 2 ONLY**:
    - Upload a ***.PDF** file of the *Wk-1 (Winter) - P3 Milestone 1 Worksheets TEAM* document to *Avenue Dropbox* titled **P3 Milestone 1 (Computation Sub-Team) – *Day***
        - → Use the naming convention: **Day-#_P3_Milestone1 (Computation).pdf**
        - → This is a sub-*team* submission that is the responsibility of the Project *Administrator 1*
    - Upload a ***.PDF** file of the *Wk-1 (Winter) - P3 Milestone 1 Worksheets TEAM* document to *Avenue Dropbox* titled **P3 Milestone 1 (Modelling Sub-Team) – *Day***
        - → Use the naming convention: **Day-#_P3_Milestone1 (Modelling).pdf**
        - → This is a sub-*team* submission that is the responsibility of the Project *Administrator 2*

Grading of Milestone One

Milestone One is worth **0.5/10 marks of your total Project-3 grade (5%)**. All team members will receive the same grade for this Milestone. A Milestone One Rubric is available on Avenue (Content > 4-Design Projects > Project 3 > 9 - P3 Milestone Rubrics).

MILESTONE TWO: PRELIMINARY DESIGN

Assessment Type: Individual + Team
Time Allotted: ***Prior to*** and ***During*** Week 2 (Winter) Design Studio (DS-14)
Submission Deadline: 11:59 PM EST the day after DS-14

Objectives and Requirements

For Milestone Two, you are required to: 1) **conceptualize how containers will be transferred** from the sorting station to correct bin in the recycling station (Computation Sub-Team), 2) **conceptualize how containers will be deposited** into the recycling bin (Modelling Sub-Team), and 3) **evaluate the concept solutions**, selecting one to pursue further.

1. **Research of Sensors for Characterizing Bins (Prior to DS-14, Computation Sub-Team ONLY)**: *Each team member* of the *Computation Sub-Team* is required to research **two (2)** ***types*** of sensors for characterizing each recycling bin. For computing sub-teams with 3 members, it is acceptable to have duplicate sensors researched between sub-team members. Refer to Table 3 of the Computation Sub-Team Objectives document for a list of available sensors. For each sensor, you should briefly *describe* how the sensor works and indicate what *attribute* you would measure to characterize each bin. Each team member should research *different* sensors. Your description should be concise and in point form (i.e., you only need to describe *basic* sensor functionality). For attributes, refer to Table 4 of the Computation Sub-Team Objectives document. Complete your research on the **Sensor Research worksheet**, located in the *Wk-2 (Winter) – P3 Milestone 2 Worksheets INDIVIDUAL.docx* document.
2. **Refined Concept Sketches (Prior to DS-14, Modelling Sub-Team ONLY)**: *Each team member of the Modelling Sub-Team* is required to create ***two (2)*** refined concept sketches for the mechanism that will deposit containers into a recycling station bin, building off one or more of your concept sketches from Milestone One. Each refined concept sketch should incorporate a different actuator, one linear and one rotary. Recall that the actuator serves as the input to the mechanism. Complete your sketches on a separate sheet of paper *prior to your scheduled Design Studio*, take a photo, and insert the sketch as a picture on the Concept Sketches worksheet, located in the *Wk-2 (Winter) – P3 Milestone 2 Worksheets INDIVIDUAL.docx* document.
3. **Preliminary Program Tasks (During DS-14, Computation Sub-Team ONLY)**: The *Computation Sub-Team* is required to plan each of the tasks identified in Project Objective #3 (Dispense Container, Load Container, Transfer Container, Deposit Container, Return Home). Your plan for each task can *either* be in the form of pseudocode or a flowchart. Write out the pseudocode or flowchart for each of task on the **Program Task Planning worksheet**, located in the *Wk-3 (Winter) - P3 Milestone 2 Worksheets TEAM.docx* document.

4. **Detailed Sketch of Mechanism Assembly (During DS-14, Modelling Sub-Team ONLY)**: After selecting a design for the mechanism, *each team member of the Modelling Sub-Team* is required to create detailed sketches of their team's mechanism. Your detailed sketches should clearly identify each component and identify any relationships and constraints (e.g., assembly constraints vs. motion constraints). If appropriate, specify the component that will serve as the *parent part* of your assembly. Complete your detailed sketches on a separate sheet of paper, take a photo, and insert the sketch as a picture on the **Detailed Sketches worksheet**, located in the *Wk-3 (Winter) - P3 Milestone 2 Worksheets TEAM.docx* document.
   - → You should complete 2 detailed sketches, one representing the mechanism in the ***transfer*** position (i.e., a position that keeps containers in place during transfer of the Q-bot) and one representing the mechanism in the ***deposit*** position (i.e., a position that facilitates depositing of containers into the appropriate bin
     i. Each detailed sketch should be of the ***same*** design, just in different positions
   - → Each team member is individually responsible for 1 detailed sketch (i.e., one team member is responsible for the ***transfer*** sketch and one team member is responsible for the ***deposit*** sketch)

Submission Details

2. **Each Team Member (Computation Sub-Team ONLY)**:
    - Upload a ***.PDF** copy of the *Wk-2 (Winter) - P3 Milestone 2 Worksheets INDIVIDUAL* document to *Avenue Dropbox* titled **P3 Milestone 2 (Individual - Computation)**
        - → Use the following naming convention: **macID_P3_Milestone2.pdf**
        - → The Project Administrator must submit a copy as well, if applicable
3. **Each Team Member (Modelling Sub-Team ONLY)**:
    - Upload a ***.PDF** copy of the *Wk-2 (Winter) - P3 Milestone 2 Worksheets INDIVIDUAL* document to *Avenue Dropbox* titled **P3 Milestone 2 (Individual - Modelling)**
        - → Use the following naming convention: **macID_P3_Milestone2.pdf**
        - → The Project Administrator must submit a copy as well, if applicable

4. **Project Administrator 1 and Project Administrator 2 ONLY**:
    - Upload a ***.PDF** file of the *Wk-2 (Winter) - P3 Milestone 2 Worksheets TEAM* document to *Avenue Dropbox* titled **P3 Milestone 2 (Computation Sub-Team) – *Day***
        - → Use the naming convention: **Day-#_P3_Milestone2 (Computation).pdf**
        - → This is a sub-*team* submission that is the responsibility of the Project *Administrator 1*
    - Upload a ***.PDF** file of the *Wk-2 (Winter) - P3 Milestone 2 Worksheets TEAM* document to *Avenue Dropbox* titled **P3 Milestone 2 (Modelling Sub-Team) – *Day***
        - → Use the naming convention: **Day-#_P3_Milestone2 (Modelling).pdf**
        - → This is a sub-*team* submission that is the responsibility of the Project *Administrator 2*

Grading of Milestone Two

Milestone Two is worth **1/10 marks of your total Project-3 grade (10%)**. Each sub-team member will receive their own grade for Objectives 1 or 2 of the Milestone (**5%**). All sub-team members will receive the same grade for Objectives 3 or 4 of the Milestone (**5%**). A Milestone Two Rubric is available on Avenue (Content > 4-Design Projects > Project 3 > 9 - P3 Milestone Rubrics).

MILESTONE THREE: DETAIL DESIGN (DESIGN REVIEW AND FEEDBACK)

Assessment Type: Team
Time Allotted: Own Time / Week 3 Design Studio (DS-16)
Submission Deadline: 11:59 PM EST the day after DS-16

Objectives and Requirements

For Milestone Three, your team will submit your design to your mentors for feedback. This milestone serves as an important gateway to either finalizing your design or refining/correcting any design parameters that have been identified by your mentors as potentially problematic, and as a landmark for beginning the development of a physical prototype and recycling program.

1. **Successful Cycle of Python Program (Prior to DS-16, Computation Sub-Team ONLY)**: The *Computation Sub-Team* is required to write the majority of their Computer Program in Python for a **virtual environment** (Q-Labs) demonstration such that one full recycling cycle can be completed. It is not expected to have your final Program written; however it should execute all 5 tasks outlines in Project Objective #3. The hopper angle of the *Deposit Container* task can be arbitrary at this time as this will ultimately be informed by the Modelling Sub-Team's motion simulation.
2. **Preliminary Design of Mechanism (Prior to DS-16, Modelling Sub-Team ONLY)**: The *Modelling Sub-Team* is required to prepare a complete design of their mechanism, modelling and assembling all components in Autodesk Inventor. The Sub-Team is strongly encouraged, although not required, to also begin working on their motion simulation (if applicable).
3. **Design Review (During DS-16)**: Each *Sub-Team* will present their design to their mentors for feedback. You are required to document your reviewers' feedback for submission and to list any proposed "Action Items" for design refinement. Document feedback on the **Design Review Feedback worksheets** located in the *Wk-3 (Winter) - P3 Milestone 3 Worksheets TEAM.docx* document (there is a worksheet for each sub-team).
   - → The *Modelling Sub-Team* will receive feedback based on the completion of their assembly and applied relationships and constraints
   - → The *Computation Sub-Team* will receive feedback based on the execution of their code in the Q-Labs environment.
   - → Design review feedback will gauge project progression and guide students to begin exploring the physical environment and prototypes. Subgroups may be asked to complete a mandatory second design review during the following week's Design Studio (DS-17) if there is any concern regarding their current progress.

Submission Details

1. **Project Administrator 1 ONLY**:
   - Upload a ***.ZIP** file of your team's files to the *Avenue Dropbox* titled **P3 Milestone 3 (Computation Sub-Team) – *Day***
     → Use the following naming convention: **Day-#_P3_Milestone3 (Computation).zip** being sure to include the following:
       - Wk-3 (Winter) - P3 Milestone 3 Worksheets TEAM (*.pdf)
       - The current version of your computer program
         - Save all python (*.py) files to a single folder
2. **Project Administrator 2 ONLY**:
   - Upload a ***.ZIP** file of your team's files to the *Avenue Dropbox* titled **P3 Milestone 3 (Modelling Sub-Team) – *Day***
     → Use the following naming convention: **Day-#_P3_Milestone3 (Modelling).zip** being sure to include the following:
       - Wk-3 (Winter) - P3 Milestone 3 Worksheets TEAM (*.pdf)
       - The current version of your mechanism design
         - Save all files (*.IPT and *.IAM, if applicable) to a single folder

Grading of Milestone Three

Each Sub-Team will be graded only on the feasible list of **Action Items** given by the TA. Each sub-team will receive one of the following:

→ ***Poor Action Items***
→ ***Feasible Action Items***
→ ***No Action Items***

Subgroups who are asked to participate in a second design review are required to show progress in their action items for the following week. Subgroups who do not show productive progress as instructed by their TA's and their action items will be penalized with a **10% deduction to their final project grade.**

A Milestone Three Rubric is available on Avenue (Content > 4-Design Projects > Project 3 > 9 - P3 Milestone Rubrics) for your reference.

FINAL SUBMISSION: DESIGN DEMONSTRATION AND VERIFICATION

Assessment Type: Individual / Team
Time Allotted: Own Time
Submission Deadline: ***Prior to*** Week 7 Design Studio (DS-18)

Objectives and Requirements

As a *team*, you are required to present your design during a scheduled *informal* **Project Demonstration**. This includes presenting both the depositing device design (i.e., **mechanism design and prototype**) and your **computer program**.

1. ***Mechanism Design***: Modelling Sub-Team **only**
   For the *Modelling Sub-Team*, you are required to create an *Assembly Model* (in *Autodesk Inventor*) of a mechanism for depositing containers into a recycling bin, documenting your model through a set of full dimensioned *Engineering Drawings* (which will be submitted as part of your *Design Project Report*).
   - → You will be expected to open up your Autodesk Inventor file(s) in front of your TA and briefly describe to them how you created specific components
   - → A member of the ENGINEER 1P13 Instructional Team will verify your physical mechanism functioning and observe if actuation of the hopper occurs successfully.
     - In the case of **Scenario 2 ONLY**, A member of the ENGINEER 1P13 Instructional Team will verify your motion simulation to determine the extent to which your simulation achieves the phases outlined in the Modelling Sub-Team Objectives document
   - → *Each team member* can expect that the IAI/TA will ask questions related to your solid model and prototype, such as how you modelled certain features, or how your physical prototype functions in contrast to your CAD design.

2. ***Computer Program***: Computation Sub-Team **only**
   For the *Computation Sub-Team*, you are required to design a *Computer Program*, written in Python, that meets the criteria outlined in Project Objective #3. Your program should be written in a single Python file (excluding any libraries you will import). Indicate the team member who was responsible for each task by including their name, in comments, at the top of the respective function.
   - → You will be expected to run your Python file in front of the IAI/TA, interfacing with the Q-Labs environment, and briefly describe how the program works (beyond what is simply displayed on the screen as the program executes)
   - → *Each team member* can expect that the IAI/TA will ask questions related to your program, such as how code is executed or why certain design decisions were made.

3. **Bonus**: Both Sub-Teams
   For teams that opted to do the bonus and work in the physical environment, you will have an in-person interview with additional items to present. *Both* Sub-Teams will present a functional prototype following the criteria outlined in Project Objectives 2, 3, and 4. The *Modelling Sub-Teams* mechanism should be physically assembled onto a provided hopper and base-plate for design verification, and the *Computation Sub-Teams* modified program should be uploaded to a terrestrial drone.
   - → You will be expected to run a Python file interfacing with the Physical Q-Bot and recycling station
   - → A member of the ENGINEER 1P13 Instructional Team will verify your physical mechanism and prototype functioning during one complete cycle of the general workflow for the physical environment outlined in Objective 4, and observe if actuation of the hopper occurs successfully.
   - → You can use this time to explain the differences of working in the virtual environment in contrast to the physical environment, and any design changes that needed to be made.

As a component of the **Project Interview**, each *team member* will also be asked 2-3 questions related to your design. Each member of a specific sub-team (Modelling Sub-Team or Computation Sub-Team) must be able to answer questions about any aspect of their deliverable. All members must be present for the Project Interview.

Submission Details

1. ***Mechanism Design***: Modelling Sub-Team **only**
   - → **Your Sub-Team**: demonstrate both your assembly model and physical prototype during your scheduled Project Interview
   - → **Your Sub-Team**: include the following in your *Design Project Report*
     - Image(s) of your mechanism (both in Autodesk Inventor and physical mechanism)
       - In the case of **Scenario 2 ONLY**, graphical plots of your motion simulation
     - A complete set of dimensioned Engineering Drawings of your *Mechanism* (include in the *Appendices* section)
   - → **Project Administrator ONLY**: upload your Autodesk Inventor file(s) to the *Avenue Dropbox* titled **P3 Mechanism Design – *Day***
     - Save files to a single *.ZIP folder (**Team#_P3_CAD_Files.zip**)
     - Submission is responsibility of *Administrator* (Submit as <u>Group</u> on Avenue)

2. ***Computer Program***: Computation Sub-Team **only**
   → **Your Sub-Team**: demonstrate your Python program during your Project Interview
   → **Your Sub-Team**: include the following in your *Design Project Report*
   - A screenshot of your *Computer Program* as written in Python (include the *Appendices* section)
     - If bonus was completed, include screenshots of modified program

   → **Project Administrator ONLY**: upload your Python file to the *Avenue Dropbox* titled **P3 Computer Program – *Day***
   - Save files to a single *.ZIP folder (**Team#_P3_Python_Program.zip**)
   - Submission is responsibility of *Administrator* (Submit as Group on Avenue)

Grading of Final Submission

1. ***Mechanism and Hopper Design***: Modelling Sub-Team **only**
   The Mechanism and Hopper Design is worth **5.5/10 marks of your total Project-3 grade (55%)**, with marks evenly distributed between evaluation of the CAD files and the Project Interview. Your CAD file grade will be based on the appropriateness of your design, the level of detail and use of appropriate modelling and assembly tools. The Project Demonstration component is based on how well each team member answers questions (team members receive their own grade), and how the physical prototype functions.

2. ***Computer Program***: Computation Sub-Team **only**
   The Computer Program is worth **5.5/10 marks of your total Project-3 grade (55%)**, with marks evenly distributed between evaluation of the Python file(s) and the Project Demonstration. Your grade will be based on the correctness and succinctness of your code, the adequacy of commenting, and the layout and execution of your program(s). The Project Interview component is based on how well each team member answers questions (team members receive their own grade).

FINAL SUBMISSION: DESIGN PROJECT REPORT

Assessment Type: Team
Time Allotted: Own Time
Submission Deadline: Sunday March 6th 11:59PM, 2022

Objectives and Requirements

As a *team*, you are required to consolidate and present your work in a *Design Project Report*. Your report should: 1) concisely summarize your design solution, 2) include all deliverables related to administrative responsibilities, 3) include all design studio worksheets, and 4) document any other work relevant to your design in an appendix.

> You are required to complete your Design Project Report using the template Word document that has been provided to you on Avenue-to-Learn
>
> - **Content > 4-Design Projects > Student Resources >** *1P13_Project_Report_Template.docx*
>
> Follow the template formatting explicitly!

Your report should include the following sections:

→ *Executive Summary* (All Members):
- A concise summary (500 words or less, strictly enforced) that clearly outlines the motivation for the project and presents the design solution

→ *List of Sources* (Administrator 2):
- Source Materials Database

→ *Appendices:*
- *Supporting Documents:*
    - Screenshots of your solid mode, prototype, l and computer program
    - Fully-dimensioned Engineering Drawings of mechanism and design
- *Project Schedule*:
    - Preliminary Gantt Chart (Manager)
    - Final Gantt Charts (Administrator 1)
    - Logbook of Additional Meetings and Discussions (Coordinator)
- *Scheduled Weekly Meetings*:
    - Weekly Design Studio Agendas (Manager)
    - Weekly Design Studio Meeting Minutes (Coordinator)
- *Design Studio Worksheets*:
    - Worksheets for all Design Studio Milestones, both those submitted as a team (Administrator 2) and those submitted individually

For any of the sections above that require you to include previously compiled documents (e.g., Weekly Meeting Agenda's and Minutes, Design Studio Worksheets, etc.), you may provide a URL link in lieu of transferring all the worksheets into the Project Report.

- Clearly outline all documents you are linking to in a table
- Each worksheet should have a unique URL
    - The URL must ***link directly to the document*** and a not a folder
    - ***Do not*** give us a link to Google Drive 'file dump'
        - **The TA's will not grade it and you will receive a zero**
- It is your responsibility to ensure URLs are valid
    - If a URL does not work, it will be treated the same as if the worksheet was not submitted
- We are making your lives easier by providing this option. Please do not make our TA's lives more difficult

Submission Details

1. **Project Administrator 2 ONLY**: upload your Design Project Report as a **PDF** to the *Avenue Dropbox* titled **P3 Design Report – *Day***
    → Use the following naming convention: **Day-#_P3_DesignReport.pdf**
    → Note that Turnitin.com will be used to check for plagiarism
    → This is a *team* submission that is the responsibility of *Project Administrator 2*

Grading of Final Submission

1. ***Design Project Report***:
    The Design Project Report is worth **1.5/10 marks of your total Project-3 grade (15%)**. Your grade will be based on the executive summary and adherence to proper formatting and inclusion of all documents outlined above.

FINAL SUBMISSION: INDEPENDENT MATERIALS RESEARCH SUMMARY

Assessment Type: Individual
Time Allotted: Own Time
Submission Deadline: Wednesday March 9th 11:59PM, 2022

Objectives and Requirements

In Project-3, you are asked to operate various type of sensing devices in the Q-sim environment to perform specific functions for the recycling challenge. Here we hope that students learn about not only the functionality of these devices but also their scientific working principles. In this deliverable, each team member is required to write an *Independent Research Summary* on one of the device options listed in the table below. Your research summary is expected to focus on two aspects of the sensor you have selected:

1) the physical working principle of the device, and

2) the related material property(s) of one ***crucial material*** that affects the performance of the device.

Each team member must select a *different* topic. Your summary should be written in paragraph form with no use of bullet points and/or lists.

Topics:
Light detector
Piezoelectric force sensor (scale)
Ultrasonic distance sensor
Inductive proximity sensor
Capacitive proximity sensor

Your research summary should include:

1. **Summary of working principle**:
   → State the main ***function(s)*** of the device (mark deduction if this is missing).
   → Write a paragraph to explain what the working physical principle(s) of the component in the device is such that it can achieve its main ***function***.
   → A qualitative explanation would be acceptable.
   → A ***150-word limit*** is strictly enforced.
   → A ***minimum of 2 references*** from a peer-reviewed journal is strictly enforced.

2. **Summary of significant material properties(s)**: Select a ***crucial material*** component within the device and summarize what are the more important material properties in this component that would affect the performance of the device.

→ In this document, a ***crucial material*** is defined to be an essential material component and tied to the main function of the device. (e.g. metal shells or plastic covers of the capacitor are not ***crucial***, but the dielectric components or electrodes in it are ***crucial***)
→ Identify a ***material*** commonly used to make the device and explain how its material property(s) can affect the performance of the device.
→ A ***150-word limit*** is strictly enforced.
→ A ***minimum of 2 references*** from a peer-reviewed journal is strictly enforced.

3. **References**:
   → Adhere to IEEE format
   → A ***minimum of 4 total references*** to a ***maximum of 6 total references.***

> You are required to complete your Research Summary using the template Word document that has been provided to you on Avenue-to-Learn. Follow the template formatting explicitly!
> - **Content > 4-Design Projects > Student Resources >** *1P13_Independent_Research_Summary_Template.docx*

Submission Details

1. **Each Team Member**: upload your Independent Research Summary as a **PDF** to the *Avenue Dropbox* titled **P3 Independent Research Summary**
   → Use the following naming convention: **macID_P3_ResearchSummary.pdf**
   → Use and adhere to the template provided to you
   → Include your MacID and Team Number on the Header
   → Your summary should be written in paragraph form
   → Adhere to IEEE referencing and citation standards (your submission WILL be evaluated and checked for plagiarism)
   → You CANNOT use direct quotations, even if cited correctly
   → The word count limit (excluding the reference list) is strictly enforced

Grading of Final Submission

The Independent Research Summary is worth **1.5/10 marks of your total Project-3 grade (15%)**. Your grade will be based on adherence to formatting and word count, writing quality, citations, and spelling and grammar (refer to the rubric). Each team member will receive their own grade.

> **<u>REMINDER</u>**: While at McMaster, you have free access to a very large database of peer-reviewed articles.

LEARNING PORTFOLIO ENTRY

Assessment Type: Individual
Time Allotted: Own Time
Submission Deadline: Wednesday March 9th 11:59PM, 2022

Objectives and Requirements

Complete your **online learning portfolio** for Project-3. Remember that the goal of the online learning portfolio is to showcase the ways in which your project is unique, as well as the technical and non-technical skills you developed throughout the completion of the project. The online learning portfolio is a summary, highlighting the most crucial aspects of the project. Media should be used to help support your project description.

Submission Details

Each Team Member: ensure your online web Portfolio is complete and up to date:

→ Content should be uploaded to the appropriate subpage under the P3 project page. Follow the same structure you did for your P1 and P2 online learning portfolio entries. Refer to the "Online Learning Portfolio (Notion) Instructions" document if necessary. For example, your P3 project page may look as follows:
- *Summary* subpage
- *Skills* subpage
- *Design Process* subpage

→ Go to share (upper left corner) and ensure that "Anyone with the link can view" is turned on to reflect your changes online
- Remember, you need to do this *every time* you make changes to your website
- In addition, make sure you are sharing from your main page and not one of the subpages

→ *You do not need to resubmit any work already submitted!*

Grading of Learning Portfolio

Your Learning Portfolio is graded on a **Pass/Fail** basis. Any team member who does not complete their learning portfolio will be penalized 5% of their Project-3 grade.

SELF-AND PEER-EVALUATION

Assessment Type: Individual
Time Allotted: Own Time
Submission Deadline: Wednesday March 9th 11:59PM, 2022

Objectives and Requirements

Each team member is expected to contribute equitably and effectively to the team's overall performance, throughout the duration of the project. This contribution is evaluated through both a *self-evaluation* and a *peer-evaluation*. Team members will also be asked to provide peer feedback.

(1) Self- and Peer-Evaluation: Each team member will evaluate themselves and their peers on the following dimensions:

→ Contributing to team's work
→ Interacting with teammates
→ Keeping the team on track
→ Expecting quality
→ Having relevant KSAs (Knowledge, Skills, and Abilities)

(2) Peer-to-Peer Comments: Each team member will be asked to provide comments to their peers based on the project experience. You are expected to adhere to the following:

→ Before you start writing, reflect on the project experience and evaluation you just completed.
→ Comments should include both positive feedback and constructive criticism.
→ Constructive criticism should not be overtly negative, should not include profanity, should be given with a purpose, and should focus on what your peer can do to improve in the future.

While writing Peer-to-Peer comments, consider the following resources:

→ **Belbin Team Roles Inventories**: This inventory recognizes that every team member brings different strengths and weaknesses to the team. Consider using the language and inventories in this document to provide feedback to your team members and yourself.
  - Belbin Inventories Reference Article

→ **Constructive Criticism**: These websites provide tips and tricks on what should be included in constructive criticism.
  - Tips for Giving Constructive Feedback
  - What is Constructive Feedback + Examples

Submission Details

Complete your self- and peer-evaluation using the URL that will be emailed out.

Grading of Self- and Peer-Evaluation

Each team member will have a peer-evaluation score calculated as part of the self- and peer-evaluation. Depending on your own self-evaluation and your team members peer-evaluation, your peer-evaluation score can **add or deduct a maximum of 10% towards your overall Project-3 grade** at the discretion of the instructional team.

Team members are expected to take the self- and peer-evaluation process seriously. This is an important learning opportunity in terms of being able to evaluate one's own work as well as give and receive feedback on the work of others. It is not intended as an exercise in padding each other's marks! Team members may be expected to justify their peer evaluation scores in a meeting with the Course Instructors, individually or as a team. Failure to justify your peer evaluation may result in an adjustment to your peer-evaluation score.

Administrative Roles and Responsibilities

ADMINISTRATIVE RESPONSIBILITIES

Each team member is expected to contribute to the administrative responsibilities inherent in any project. To accomplish this, each project will require members to assume one of four *Project Lead* administrative roles. The purpose of the Leads is to ensure administrative responsibilities are equitably distributed amongst *all* team members. Each Project Lead will have a unique set of expectations and responsibilities.

PROJECT LEADS

Project-3 requires that each team member assume one of four *Project Leads* over the duration of the project (**M**anager, **A**dministrator 1, **A**dministrator 2, **C**oordinator).

Manager

The breakdown of the Project **Manager's** Expectations and Responsibilities is as follows:

→ *Expectations*:
- Facilitate discourse among team members and with 1P13 instructional team
- Promote an equitable work environment
- Assume a leadership role in identifying and managing team conflict

→ *Responsibilities*:
- Assume the role of ***Design Studio Chair*** during scheduled *weekly meetings*
- Complete and submit a ***Preliminary Gantt Chart*** at the beginning of the project

Administrator 1 (Computing Team)

The breakdown of the Project **Administrator 1's** Expectations and Responsibilities is as follows:

→ *Expectations*:
- Monitor progress of deliverables to ensure team remains on track to meet deadlines
- Ensure team members are aware of all project deadlines and expectations
- Assume responsibility for ensuring completion of the Project Report is collaborative

→ *Responsibilities*:
- Share a ***Collaborative Working Document*** of your *Design Project Report* (i.e., Microsoft Office SharePoint document) at the beginning of the Project
- Assume responsibility for ***submitting all computing team deliverables***
- Complete and submit an updated ***Final Gantt Chart*** at the end of the project

Administrator 2 (Modelling Team)

The breakdown of the Project **Administrator 2's** Expectations and Responsibilities is as follows:

→ *Expectations*:
- Monitor progress of deliverables to ensure team remains on track to meet deadlines
- Ensure team members are aware of all project deadlines and expectations

- Assume responsibility for building a database that clearly documents the source (must be broad and reliable) of all information gathered and research conducted

→ *Responsibilities*:

- Assume responsibility for ***submitting all general team deliverables***
- Assume responsibility for ***submitting all modelling team deliverables***
- Complete and submit a ***Source Materials Database*** at the end of the Project

Coordinator

The breakdown of the Project **Coordinator's** Expectations and Responsibilities is as follows:

→ *Expectations*:

- Coordinate team meetings outside of weekly Design Studios
- Keep a record of all meetings and discussions outside of weekly Design Studios, both in-person and online meetings

→ *Responsibilities*:

- Assume the role of Design Studio ***Note-Taker*** during scheduled *weekly meetings*
- Complete and submit a ***Logbook of Additional Meetings and Discussions***

> For a team of 5 students, there are ***2*** Coordinators
> - ***Note-Taking*** and ***Logbook of Additional Meetings and Discussions*** are each to be completed by a different team member

SUBMISSION AND GRADING DETAILS

Each Project Lead has a number of administrative responsibilities that must be completed over the course of the project. A summary of the administrative responsibilities is outlined in the Table below.

Table 1: Project Lead Responsibilities

Lead	Administrative Responsibility	Deadline	Marks	Weight
Manager	Design Studio Chair	Ongoing	P/F	–
	Preliminary Gantt Chart	Prior to Wk-2 DS	P/F	–
Administrator	Submission of Team Deliverables	Ongoing	P/F	–
	Final Gantt Chart	Mar 6th, 2022	P/F	–
Coordinator	Design Studio Note-Taker	Ongoing	P/F	–
	Logbook of Additional Meetings & Discussions	Mar 6th, 2022	P/F	–
Subject Matter Expert	Collaborative Working Document	Prior to Wk-8 DS	P/F	–
	Source Materials Database	Mar 6th, 2022	P/F	–

> Failure to complete your assigned Administrative Responsibilities will result **10% deduction** to the individual students *Project 3 Grade* ***for each occurrence*** (i.e., 1/10 marks).

Preliminary Gantt Chart (Manager)

The Preliminary Gantt Chart is a graphical representation of your team's proposed project schedule, outlining team meetings, planned progression of tasks, and all project deadlines.

→ *Submission and Grading Details*:

- Include *Preliminary Gantt Chart* in *Project Schedule* section of *Design Project Report*
- The *Preliminary Gantt Chart* is graded as **Pass/Fail**

Design Studio Chair (Manager) and Design Studio Note-Taker (Coordinator)

During each Design Studio, beginning the 2nd week (Wk-14 DS), teams will have a scheduled *weekly meeting* with their IAI and/or TA. During these meetings, teams will provide an update on their progress, answer any questions that come up, and discuss plans for the next week.

Chair: The role of the Design Studio **Chair** is to: 1) prepare an agenda for each scheduled weekly meeting, sharing their agenda with their mentor/TA, and 2) lead team discussions during these meetings, ensuring all team members are provided an opportunity to offer their input.

→ *Submission and Grading Details*:

- Include an agenda for each weekly meeting in the *Scheduled Weekly Meetings* section of your *Design Project Report*
    - Each agenda should include date of the meeting and list all discussion items
- The Manager's role as Chair is graded as **Pass/Fail**

Note-Taker: The role of the Design Studio **Note-Taker** is to formally document team discussions during scheduled weekly meetings by recording meeting minutes.

→ *Submission and Grading Details*:

- Include the minutes for each weekly meeting in the *Scheduled Weekly Meetings* section of your *Design Project Report*
    - Meeting Minutes should include the date the meeting was held, a list of those in attendance and those absent, and a written summary of the discussion
- The Coordinator's role as Note-Taker is graded as **Pass/Fail**

Collaborative Working Document (Administrator 1)

The Collaborative Working Document is an editable version of the *Design Project Report*, written in an online document that tracks user history and edits (i.e., Microsoft Office SharePoint document).

→ *Submission and Grading Details*:

- Share your *Collaborative Working Document* with the Course Instructors at prof1p13@mcmaster.ca
    - All team members should use easily identifiable names and not aliases
- The *Collaborative Working Document* is graded as a **Pass/Fail**

Submission of Team Deliverables (**Administrator 1 and Administrator 2**)

Administrator 1 is responsible for the submission of the *computing* team deliverables, whereas Administrator 2 is responsible for the submission of the *modelling* team AND the overall team deliverables. The Administrators must ensure that the correct team deliverables are submitted to the correct location by the required deadline. This includes weekly Milestone worksheets and Final Deliverables. Other team members' individual submissions are ***not*** the Administrator's responsibility. However, the *Administrator* is still responsible for their own individual submissions.

→ *Submission and Grading Details*:

- Milestone Worksheets:
    - Submit to appropriate *Avenue Dropbox* as outlined in *Milestone Instructions*
    - Include worksheets in the *Design Studio Worksheets* section of your *Design Project Report*
- Final Deliverables:
    - Follow submission instructions outlined in the Final Submission section
- The Administrator's role in submitting team deliverables is graded as **Pass/Fail**

Final Gantt Chart (**Administrator 1**)

The *Final Gantt Chart* is a graphical representation of your team's *actual* project schedule and should be overlaid on the *proposed* project schedule.

→ *Submission and Grading Details*:

- Include *Final Gantt Chart* in the *Project Schedule* section of the *Design Project Report*
- The *Final Gantt Chart* is graded as **Pass/Fail**

Source Materials Database (**Administrator 2**)

The *Source Materials Database* is a comprehensive list of *all* source materials and resources that have been used throughout the project. This includes references cited in each *Independent Research Summary*, references cited in your Design Project Report, and any additional sources that directly or indirectly contributed to the overall learning experience but may not have been specifically cited in a written document (e.g., personal communications, websites, etc.). It is **not** the responsibility of Administrator 2 to source all of these resources, but rather they are responsible for consolidating sources collected by all team members in a single location.

→ *Submission and Grading Details*:

- Include your *Source Materials Database* in the *List of Sources* section of your *Design Project Report*
    - The *Source Materials Database* should adhere to IEEE referencing standards
- The *Source Materials Database* is graded as a **Pass/Fail**

Logbook of Additional Meetings and Discussions (**Coordinator**)

The *Logbook of Additional Meetings and Discussions* is a collective of documents, images, and screenshots that reflect team progress outside of scheduled Design Studio's. There is no standard format. In-person meetings can be documented either in a notebook or digitally. For online meetings and discussions on communication platforms (e.g., Slack, Messenger, Group Chat), a screen shot of conversations is sufficient. The only explicit requirements are that: 1) all meetings and discussions are consolidated, 2) meetings and discussions are chronologically presented, and 3) the date of each meeting/discussion is clearly indicated.

→ *Submission and Grading Details*:

- Include your *Logbook of Additional Meetings and Discussions* in the *Project Schedule* section of your *Design Project Report*
- The *Logbook* is graded as a **Pass/Fail**