ENGINEERING

McMaster University

Project Three – There's A Recyclable Among Us:

Design a System for Sorting and Recycling Containers

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial 5

Team 26

Sana Khan (khans288)

Yash Patel (pately28)

Amine Hassine (hassinem)

Ahmed Mohamed (mohaa97)

Submitted: March 7, 2021

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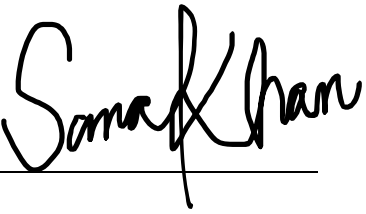
Academic Integrity Statement

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

Sana Khan 400315946

x 

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

Yash Patel 400307333

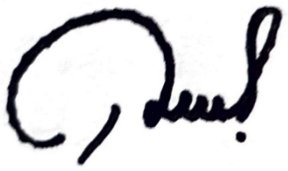
x 

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

Amine Hassine 400232808

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

Ahmed Mohamed 400343870



Executive Summary

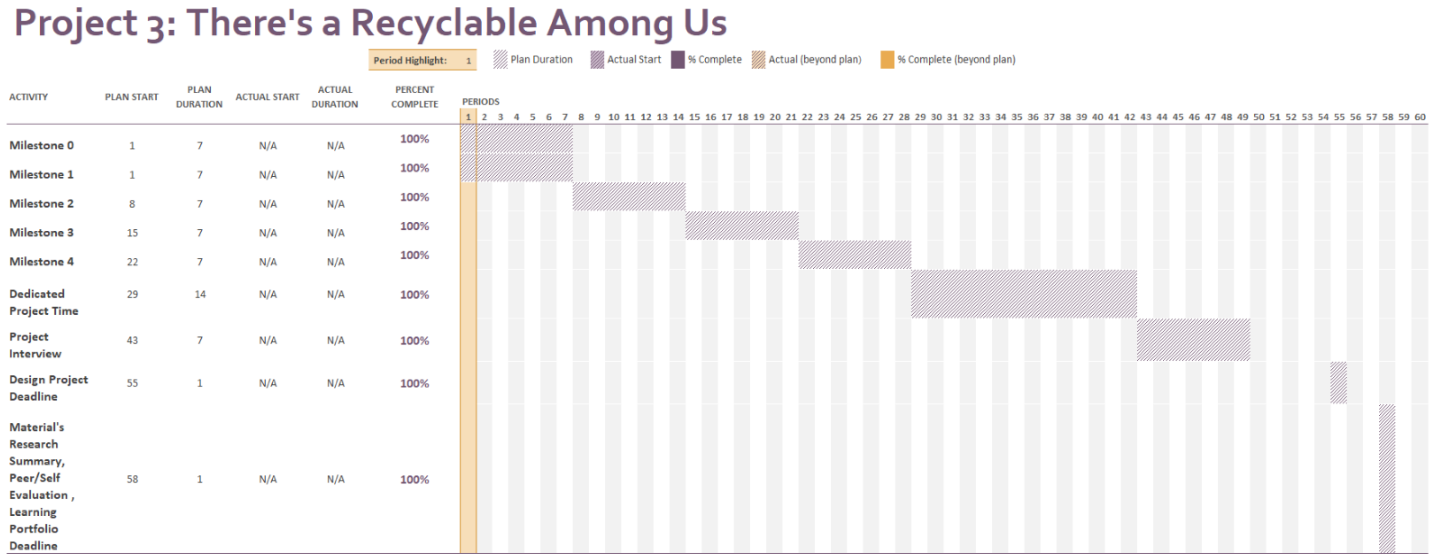
For Design project 3 we were tasked to implement a container sorting and recycling mechanism that places containers in the appropriate disposal bin based on their material. The computing sub team was responsible to manipulate the sorting station, Q-arm, Q-bot, and a sensor of choice to create a functioning code that can detect container properties, assign a bin, dispose the container, and repeatedly do that. The modelling sub team was responsible for designing a device mounted on the Q-bot with an actuator that can facilitate the transfer and dumping of those containers. The implementation of these tasks would create a more efficient sorting facility to fight the ongoing issue of climate change.

The computer program must use the Q-bot and Q-arm to transfer dispensed containers to their appropriate bins on a continuous loop until ended by the user. Our objective for the code was to be efficient, accurate, and consistent. The design required use to split up the code into five different functions, which included Dispense Container, Load Container, Transfer Container, Deposit Container, and Return Home. The first function was responsible for dispensing a random container onto the servo table, where the predetermined properties would be outputted. For the second function, the Q-arm would move its joints and gripper to move the container from the servo table to the hopper. The third function would control the Q-bot, making it follow the line and use our selected sensor, which is the ultrasonic sensor, to stop at the correct bin with the corresponding container. The fourth function would use the actuator designed by the modelling sub team to dump the container into the bin. Finally, the fifth function would allow the Q-bot to follow the line until it returns to its home position. The code achieved its objectives by being straight forward, simple and with the manipulation of several nested if statements and Boolean operator logic.

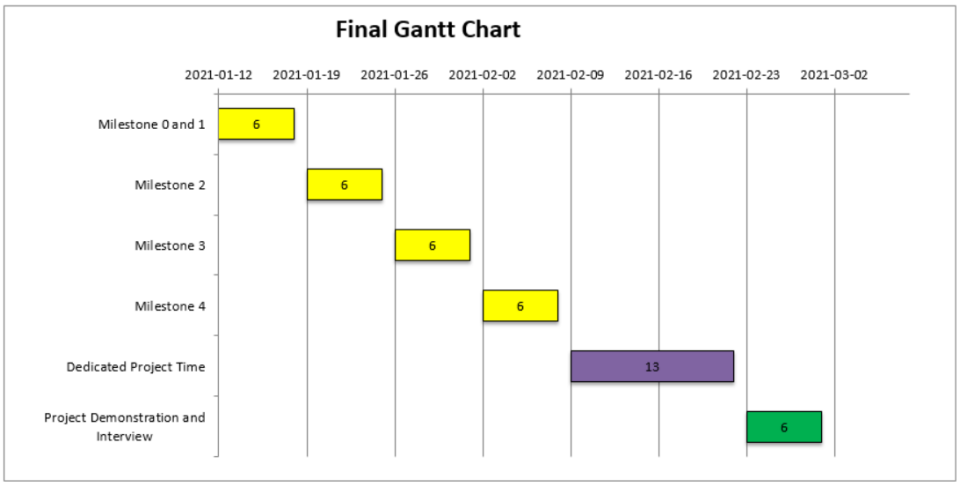
For the design of the mechanism that facilitates the transfer of the recyclable material into the recycling bin, we decided to keep it simple and only used three main components, two rods and one rotary actuator. One rod is fixed to the bottom of the hopper and to the mounting plate with the help of a base support. The second rod is fixed to the bottom of the first rod on one end and to the rotary actuator on the other end. When the rotatory actuator rotates, it causes rod 2 to slide up rod 1 which causes rotational motion of rod 1. This causes rod 1 to slide at the bottom of the hopper which allows it to rotate up and transfer the containers within it. Rotating the actuator in the counter clockwise direction, will cause the hopper to move down, as the rods slide back to their home position.

Project Schedule

Preliminary Gantt Chart:



Final Gantt Chart:



Logbook of Additional Meetings and Discussions:

LOG BOOK

DATE	TIME	Meeting
Jan-23	17:00	Modelling sub-team working on milestone 3
Jan-30	17:00	Modelling sub-team working on milestone 4
Jan-31	17:00	Modelling sub-team working on milestone 4
Feb-1	14:30	Modelling sub-team working on milestone 4
Feb-2	12:00	Modelling sub-team checking over milestone 4 before the start of the design studio
Feb-15	15:00	Modelling sub-team working on final model and simulation
Feb-19	16:00	Modelling sub-team working on final model and simulation
Feb-20	17:00	Working on project report
Feb-25	15:00	Modelling sub-team working on final model and simulation

Weekly Design Studio Agendas

ENGINEER 1P13
MEETING WITH TEAM 26 - TUESDAY, JAN. 19, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Yash Patel	Pately28	Yes
Administrator	Ahmed Mohamed	mohaa97	Yes
Coordinator	Amine Hassine	hassinem	Yes
Subject Matter Expert	Sana Khan	khans288	Yes
Guest	Richard Liu		

AGENDA ITEMS

1. Attendance and anything important to bring up immediately?
2. Did anyone have any issues or concerns about last week's design studio and project time?
3. Did we have any new objectives or constraints come up or any ideas for the direction of this project?
4. What are our plans for today and what should each team have done?
5. Any final notes or comments, or any outstanding concerns? Advice or Questions?

MEETING MINUTES

1. . No issues for milestone 0 and 1
2. . Modelling – Sub team
   a. Focus only on deposit mechanism, no need to worry about which recycling materials are in the hopper (that is computing sub team concern)
3. . Work done before this design studio
   a. Computing sub team: research summary on the sensors (color sensor is the probably the most optimal one)
   b. Modeling sub team : 2 sketches for each member with different actuator for each

POST-MEETING ACTION ITEMS

1. *Design Matrix Worksheet Completion [Modelling Sub team, Sana and Amine]*
2. *Sensor Characterization Worksheet Completion [Computing Sub team, Yash and Ahmed]*

ENGINEER 1P13
MEETING WITH TEAM 26 - TUESDAY, JAN. 26, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Yash Patel	Pately28	Yes
Administrator	Ahmed Mohamed	mohaa97	Yes
Coordinator	Amine Hassine	hassinem	Yes
Subject Matter Expert	Sana Khan	khans288	Yes
Guest	Richard Liu		YES

AGENDA ITEMS

1. Attendance and anything important to bring up immediately?
2. Did anyone have any issues or concerns about last week's design studio and project time?
3. Did we have any new objectives or constraints come up or any ideas for the direction of this project?
4. What are our plans for today and what should each team have done?
5. Any final notes or comments, or any outstanding concerns? Advice or Questions?

MEETING MINUTES

1. . For the modelling sub team is the mechanism due next week? No
2. . No issues with last design projects
3. . Work prior to this design is done for both teams
4. .Today:
   a. Modelling sub team: design each part of the mechanism on inventor
   b. Coding sub team: work on the pseudo code and start the code at least 3 out of 5 functions
5. . Submit Preliminary Modelling Worksheet and Program Tasks Planning Worksheet

POST-MEETING ACTION ITEMS

1. *Preliminary Modelling Worksheet Completion [Modelling Sub team, Sana and Amine]*
2. *Program Tasks Planning Worksheet Completion [Computing Sub team, Yash and Ahmed]*

***There was no Agenda required for Tuesday February 2nd, 2021

ENGINEER 1P13
MEETING WITH TEAM 26 - TUESDAY, FEB. 9, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Yash Patel	Pately28	YES
Administrator	Ahmed Mohamed	mohaa97	YES
Coordinator	Amine Hassine	hassinem	YES
Subject Matter Expert	Sana Khan	khans288	YES
Guest	Richard Liu		YES

AGENDA ITEMS

1. Attendance and anything important to bring up immediately?
2. Did anyone have any issues or concerns about last week's design studio and project time, did we feel that the feedback from the TA was helpful?
3. What are some of the developments and how is the model and code coming along?
4. What are our plans for today and what should each team have done?
5. Any final notes or comments, or any outstanding concerns? Advice or Questions?

MEETING MINUTES

1. . no issues, everything is going well
2. . Modelling sub-team work: dynamic simulation, small adjustments on design
3. . Computing sub-team work: finish code

POST-MEETING ACTION ITEMS

1. *Continue working on Final Model [Modelling Sub team, Sana and Amine]*
2. *Continue working on Final Code [Computing Sub team, Yash and Ahmed]*

Design Studio Worksheets

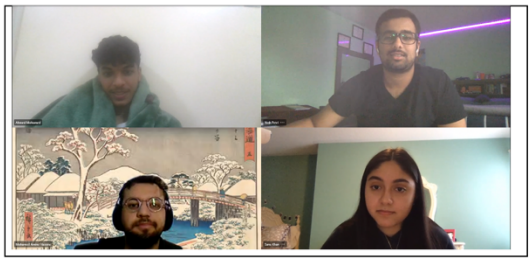
PROJECT THREE: MILESTONE 0 – COVER PAGE

Team Number: Tues-26

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

Full Name:	MacID:
Yash Patel	pately28
Ahmed Mohamed	mohaa97
Amine Hassine	hassinem
Sana Khan	khans288

Insert your Team Portrait in the dialog box below



MILESTONE 0 – TEAM CHARTER

Team Number: Tues-26

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Yash Patel	☐M ☐A ☒C ☒S
2.	Ahmed Mohamed	☒M ☐A ☐C ☐S
3.	Sana Khan	☐M ☒A ☒C ☐S
4.	Amine Hassine	☐M ☒A ☐C ☒S

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

Project Leads:

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

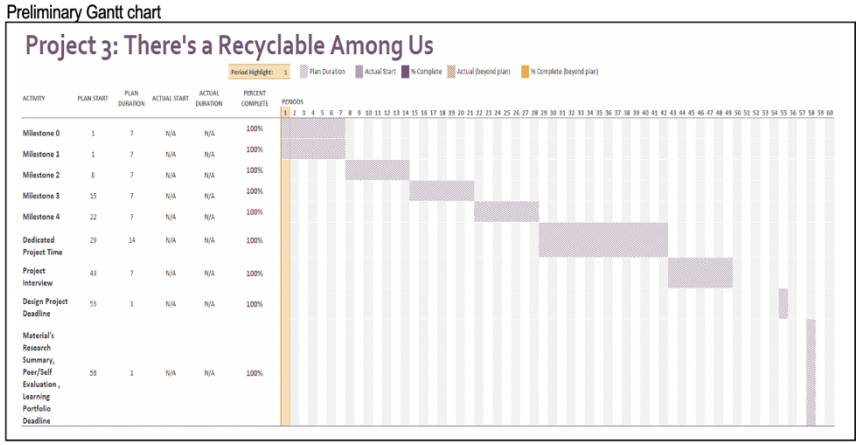
Role:	Team Member Name:	MacID
Manager	Yash Patel	pately28
Administrator	Ahmed Mohamed	mohaa97
Coordinator	Amine Hassine	hassinem
Subject Matter Expert	Sana Khan	khans288

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team Number: Tues-26

Full Name of Team Manager:	MacID:
Yash Patel	pately28

Preliminary Gantt chart



PROJECT THREE: MILESTONE 1 – COVER PAGE

Team Number: Tues-26

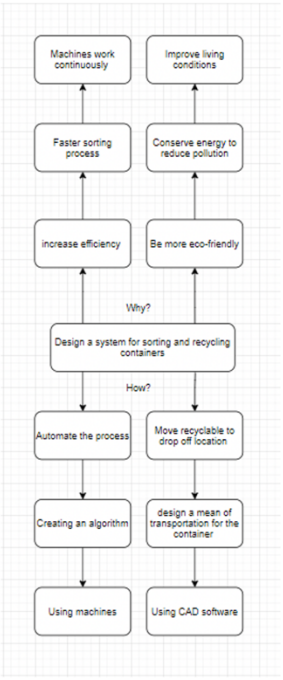
Please list full names and MacID's of all *present* Team Members

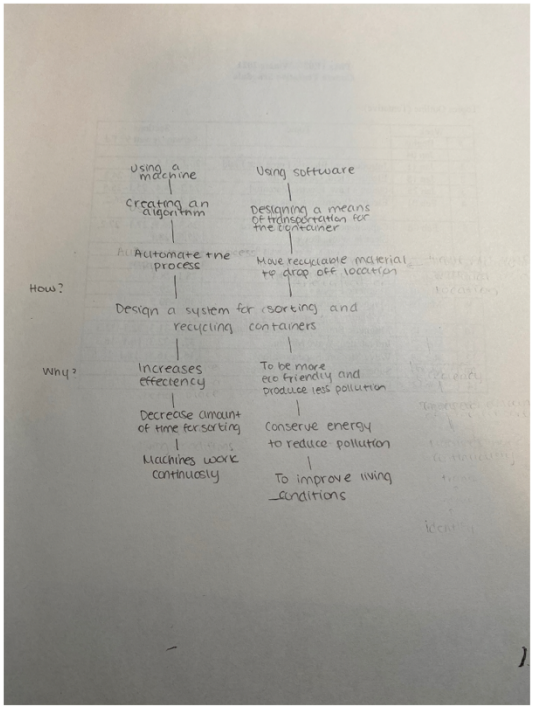
Full Name:	MacID:
Sana Khan	khans288
Amine Hassine	hassinem
Ahmed Mohamed	mohaa97
Yash Patel	pately28

MILESTONE 1 (STAGE 1) – WHY/HOW LADDERING

Team Number: Tues-26

1. Document both your conversation and a refined visual on a separate sheet of paper
2. Take a photo of both your rough work and refined visual
3. Insert each photo as a Picture (Insert > Picture > This Device)
4. **Do not include more than one Picture per page**





MILESTONE 1 (STAGE 2) – LIST OF OBJECTIVES AND CONSTRAINTS

Team Number: Tues-26

As a team, create a list of objectives and constraints in the table below. The exact number you should have depends on what information you have gathered from the Project Pack as well your previously completed needs hierarchy.

Objectives	Can determine the material of the container and allocate it to the correct bin
	Automate the process of recycling containers
	Hopper can hold containers securely for transport
	Robot arm can securely pick-up container for placement
	Device can deposit containers into bin
	Code allows for transfer of container from the sorting station to the correct bin in the recycling station
Constraints	Can't hold more than three containers
	Container must fit into base plate in two locations
	Required to connect the actuator on the base plate
	The Q-bot must return to home position after tasks are performed

MILESTONE 1 (STAGE 3) – REFINED PROBLEM STATEMENT

Team Number: Tues-26

Initial Problem Statement

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

Design a system for sorting and recycling containers.

Refined Problem Statement

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

Design a system for identifying, sorting, and recycling containers so that they can be placed into the appropriate bins in accordance with their material in an efficient manner. Doing so will reduce landfill pollution and move the world in an eco-friendlier direction.

PROJECT THREE: MILESTONE 2 – COVER PAGE

Team Number: Tues -26

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

Full Name:	MacID:
Sana Khan	khans288
Yash Patel	pately28
Ahmed Mohamed	mohaa97
Amine Hassine	hassinem

MILESTONE 2 (STAGE 1) – SENSOR RESEARCH (COMPUTATION SUB-TEAM)

Team Number: Tues-26

You should have already completed this task individually *prior* to Design Studio 14.

1. Each team member is expected to research 3 types of sensors for characterizing bins
   → Refer to Table 3 of the Computation Sub-Team Objectives document
2. For each sensor:
   → Briefly describe how the sensor works
   → Indicate the attribute you would measure to characterize each bin (refer to Table 4 of the Computation Sub-Team Objectives document)

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

- Each team member needs to submit their sensor research with the **Milestone Two Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Two Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing ***Stage 3*** of the milestone

Team Number: Tues-26

Name: Yash Patel	MacID: pately28

Sensor Type	Description	Attribute(s)
Ultrasonic Sensor	An ultrasonic sensor uses ultrasonic sound waves that cannot be heard by the human ear to detect the distance of objects from it [1]. It uses the speed of the waves and the time taken for the waves to bounce back to the sensor to calculate its distance from an object. For the purpose of this project, the different bin types can be offset from the yellow line in the QLab environment. Using this, a distance can be set for the offset of each bin type, for example, the metal bin is 20cm from the yellow line whereas the plastic bin is 40cm, so on and so forth. The ultrasonic sensor will then face towards the side of the bins and according to the data transmitted from the Q-arm of the corresponding bin distance from the yellow line, the ultrasonic sensor will detect the correct bin. The Q-bot can then drop the container into the bin. [1] R. R. Dam, H. Biswas, S. Barman and A. Ahmed, "Determining 2D shape of object using ultrasonic sensor," 2016 3rd International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), Dhaka, 2016 [Online] Available: https://ieeexplore.ieee.org/document/7873143/citations#citations [Accessed: January 18, 2021]	Distance from Yellow Line
Hall Sensor	Hall sensors essentially use the laws of electromagnetism to detect proximity to an object and electric fields [2]. A constant voltage on the hall sensor cycles through a metal plate, when a magnet or metal creates an external magnet field, the electrons are attracted or repelled indicating the presence of an object. In terms of project 3, it is difficult to incorporate this sensor purely because it only detects metals/magnets so there is only a yes, it is a metal or no it is not option but there are 4 bins that need to be characterized individually. What could be done is using a ultrasonic sensor along with a hall sensor, two metal bins can be placed at different distances and two non-metal bins can be placed at different distances.	Material of Bin
	This help us individualize each container, so the Qbot can detect how far and if it is a metal bin or not, helping it find the correct bin. [2] A. Gofuku, N. Yokomitsu, T. Yano and N. Kasashima, "A Rotor Posture Measurement System by Analyzing Sensed Magnetic Field from Arrayed Hall Sensors," 2019 12th International Symposium on Linear Drives for Industry Applications (LDIA), Neuchatel, Switzerland, [Online] Available: https://ieeexplore.ieee.org/document/8770988 [Accessed: January 18, 2021]	
Active Infrared (IR) Sensor	Hall sensors essentially use the laws of electromagnetism to detect proximity to an object and electric fields [3]. A constant voltage on the hall sensor cycles through a metal plate, when a magnet or metal creates an external magnet field, the electrons are attracted or repelled indicating the presence of an object. In terms of project 3, it is difficult to incorporate this sensor purely because it only detects metals/magnets so there is only a yes, it is a metal or no it is not option but there are 4 bins that need to be characterized individually. What could be done is the bins can be staggered individually so the strength of the electromagnetic fields being radiated from each bin changes, hence helping individualize the bins. (Built in proximity sensor) [3] Y. I. Gudkov, V. N. Azarov and A. L. Tuv, "Active infrared sensor for monitoring protected areas," 2017 International Conference "Quality Management,Transport and Information Security, Information Technologies" (IT&QM&IS), St. Petersburg, 2017, [Online] Available: https://ieeexplore.ieee.org/document/8085927 [Accessed: January 18, 2021]	Distance from Yellow Line

Team Number: Tues-26

Name: Ahmed Mohamed	MacID:mohaa97

Sensor Type	Description	Attribute(s)
LDR(Light dependent Resistor)	Light dependent resistors, LDRs or photoresistors are used in circuits where it is necessary to detect the presence of light. LDRs or photo-resistors are particularly convenient to use in many electronic circuit designs since they provide large change in resistance for changes in light level. LDR will help the transporter to detect the color of the bin by calculating the resistance each color will show	Color Intensity
Color Sensor	A color sensor identifies the color of the material. This sensor usually detects color in Red, Blue and Green scale. These sensors are also equipped with filters to reject the unwanted IR light and UV light. The Color sensor will easily detect the color of the bin by emitting light from a transmitter, and then detects the light reflected back from the detection object with a receiver. Lastly, the sensor will initiate a signal to the robotic arm that this specific bin is either Red, Green or blue and the arm will identify which bin stores which material.	Color of the bins
Retro-reflective Photoelectric Sensor	A photoelectric sensor emits a light beam (visible or infrared) from its light-emitting element. A reflective-type photoelectric sensor is used to detect the light beam reflected from the target. A thrubeam type sensor is used to measure the change in light quantity caused by the target crossing the optical axis. Retro-reflective Photoelectric Sensor have the emitter and receiver co-located. Once the light is emitted it will travel across the detection zone and bounce of a prismatic retroreflective, the receiver will then detect that the light has returned, once the light beam is broken the sensor will indicate that an object is present Lastly, the Retro-reflective Photoelectric Sensor will detect the colored bins and depending on the color of the bin the sensor will read a specific voltage and will initiate a signal to the robotic arm that contains the color of the bin.	Distance of the bins

MILESTONE 2 (STAGE 2) – CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team Number: Tues-26

You should have already completed this task individually *prior* to Design Studio 14.

1. Copy-and-paste each sub-team member's refined sketch on the following pages (1 sketch per page)
   → Be sure to indicate each team member's Name and MacID

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

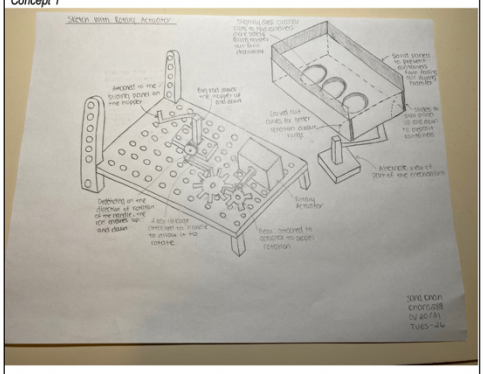
- Each team member needs to submit their concept sketches with the **Milestone Two Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Two Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing ***Stage 4*** of the milestone

Team Number: Tues-26

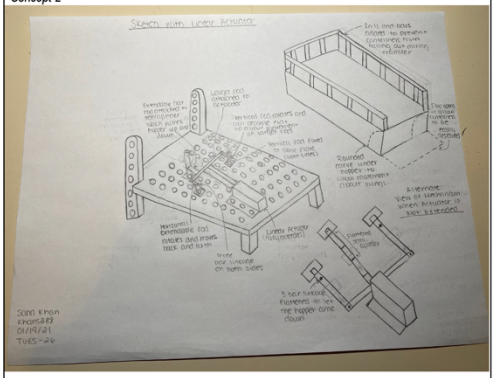
Name: Sana Khan	MacID: khans288

Insert screenshot(s) of your concept sketches below

Concept 1



Concept 2

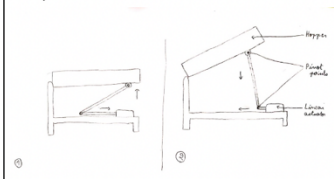


Team Number: Tues-26

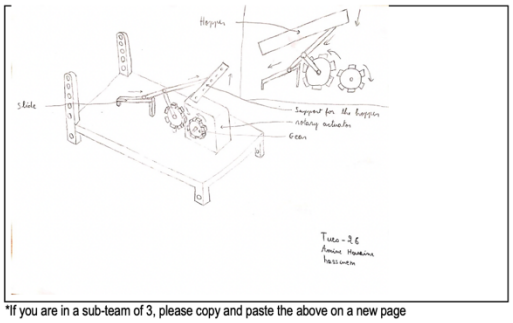
Name: Hassine Amine	MacID: hassinem

Insert screenshot(s) of your concept sketches below

Concept 3:



Concept 4:



*If you are in a sub-team of 3, please copy and paste the above on a new page

	• Can distinguish the bins individually by color, decreasing the chance of error
Retro-reflective Photoelectric Sensor	• Detects an object coming into proximity • Light emit onto object is reflected and caught on the receiver were depending on the color's absorptance, a different voltage would be read a lot like light dependent resistor • Slower than color sensor and can struggle with the ambience of the room

2. Identify one sensor to incorporate into your computer program

Color Sensor

3. Identify an attribute value for each bin

Bin ID	Attribute Value (What we are changing about the bin)
Bin01: Metal Bin	Red Bin Color
Bin02: Paper Bin	Green Bin Color
Bin03: Plastic Bin	Blue Bin Color
Bin04: Garbage Bin	White Bin Color

MILESTONE 2 (STAGE 4) – DECISION MATRIX (MODELLING SUB-TEAM)

Team Number: Tues-26

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

   → Add additional rows/columns as needed

	Simplicity	Cost Effective	*Efficient*	Size	Durability	Accuracy of Depositing	**Score**
Simplicity	0	0	0	1	0	1	3
Cost Effective	1	0	0	1	0	1	4
Efficient	1	1	0	1	1	1	6
Size	0	0	0	0	0	1	2
Durability	1	1	0	1	0	1	5
Accuracy of Depositing	0	0	0	0	0	0	1

MILESTONE 2 (STAGE 3) – SENSOR CHARACTERIZATION (COMPUTATION SUB-TEAM)

Team Number: Tues-26

1. As a team, consolidate the results of your individual sensor research
   → Discuss your findings and appropriateness of each sensor for your application
   → Keep discussion brief, using point form

Sensor Type	Findings and Appropriateness for Application (3 Discussion points per sensor)
Ultrasonic Sensor	• Proximity Sensor that detects the distance of an object from it • Could offset different bins to different lengths to distinguish between bins • Could run into configuration errors if the ultrasonic sensor locks onto another surface besides the bin
Hall Sensor	• Uses electromagnetic laws to detect the proximity of a metal object and strength of electromagnetic field • Determines if object in proximity is metal or not • Could set the distance to staggered and the strength of the electromagnetic field of the metal bins would change, helping individualize the bins
Active Infrared Sensor	• Uses infrared radiation waves that aren't visible to detect proximity of an object • Active infrared sensor uses led light to bounce off bin surface and detect proximity • Using staggering bin position alike the ultrasonic sensor, bins can be detected based on the change in proximity
Light Dependent Resistor	• Detects presence of the level of light depending on proximity • Depending on the color of the bin and its absorption of light, the LDR will calculate a resistance value unique to the color • Results can be impacted by the ambience of the room and slower than the color sensor
Color Sensor	• Detects the color of the material in the RGB scale • Bin can be assigned a specific color to be detected by the color sensor either, Red, Yellow, or Blue

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

	Weight	*Concept 1*		*Concept 2*		*Concept 3*		*Concept 4*	
		Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Simplicity	3	2	6	1	3	4	12	3	9
Cost Effective	4	3	12	2	8	4	16	3	12
Efficient	6	4	24	2	12	3	18	4	24
Size	2	2	4	4	8	1	2	2	4
Durability	5	4	20	3	15	2	10	4	20
Accuracy of Depositing	1	4	4	4	4	2	2	2	2
TOTAL	21	19	70	16	50	16	60	18	71

3. Discuss conclusions based on evaluation, including what concept you've chosen

Based off the weighted matrix, we have decided that concept 4 is the optimal choice of design for our mechanism. However, we will still add some components of concept 1 such as the sliding panel and a railing on the hopper, as it was the second optimal choice. Concept 2 was too complicated and had not met our requirements. It was also confusing and did not seem realistic. In terms of size, concept 3 was not optimal since the linear actuator would have to move far out. It would take more space and more time which makes it inefficient. Using only 1 component with the actuator would be too much stress on the mechanism meaning it is not durable and could fail.

PROJECT THREE: MILESTONE 3 – COVER PAGE

Team Number: Tues-26

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

Full Name:	MacID:
Sana Khan	khans288
Yash Patel	pately28
Amine Hassine	hassinem
Ahmed Mohamed	mohaa97

MILESTONE 3 (STAGE 1A) – WORKFLOW PSEUDOCODE (COMPUTATION SUB-TEAM)

Team Number: Tues-26

You should have already completed this task individually *prior* to Design Studio 15.

1. Write out a pseudocode outlining the *high-level workflow* of your computer program on the following page
   → Only one team member is responsible for this task (not *both*)
   → Be sure to clearly indicate who each code belongs to

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

- Each team member needs to submit their pseudocode with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing ***Stage 3*** of the milestone

Team Number: Tues-26

Name: Yash Patel	MacID: pately28

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

This program will allow for containers to be transferred from the sorting station to the recycling station.

```
Determine bin_id function:
    Determine container attributes
    Material = -----
    Mass = -----

    If material = ----- and Mass = ------:
        recycling_bin = bin_id
        rotate sorting station for Q-arm to pickup

    return recycling_bin

Main function:
    While True:
      Bin_id = Determine_bin_id()
      Rotate sorting station
      Bin_id2 = Determine_bin_id()
      Rotate sorting station

      While num_container < 3 or mass_Qbot < 90 or bin_id = bin_id2:
        Q arm moves adjacent to container
        Q arm closes gripper
        Q arm moves container to hopper
        Q arm opens gripper
        Return Q arm to home position
```

```
If bin_id = ###:
  color = ####

Qbot starts moving
Sensor on Q-bot is activated
If sensor_color = ###
  Stop_Q-bot
  Move Q-bot to bin
  Rotate hopper to drop containers into bin
  Return q-bot to home
```

MILESTONE 3 (STAGE 1B) – WORKFLOW FLOWCHART / STORYBOARD (COMPUTATION SUB-TEAM)

Team Number: Tues-26

You should have already completed this task individually *prior* to Design Studio 15.

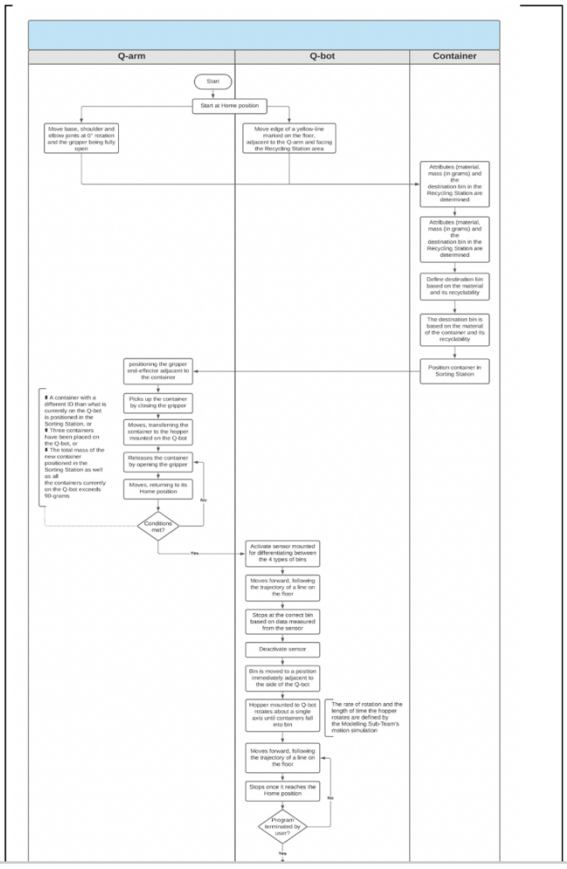
1. Only one team member is responsible for this task (not *both*)
2. Copy-and-paste your flowchart or storyboard on the following page
   → Be sure to include your Team Number, Name and MacID
3. Take a photo of your flowchart / storyboard
4. Insert your photo as a Picture (Insert > Picture > This Device)

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

- Each team member needs to submit their flowchart/storyboard screenshots with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing ***Stage 3*** of the milestone

Team Number: Tues-26

Name: Ahmed Mohamed	MacID mohaa97



MILESTONE 3 (STAGE 2) – DETAILED SKETCHES (MODELLING SUB-TEAM)

Team Number: Tues-26

You should have already completed this task individually *prior* to Design Studio 15.

1. Copy-and-paste each sub-team member's detailed sketch on the following pages (1 sketch per page)
   → Be sure to indicate each team member's Name and MacID

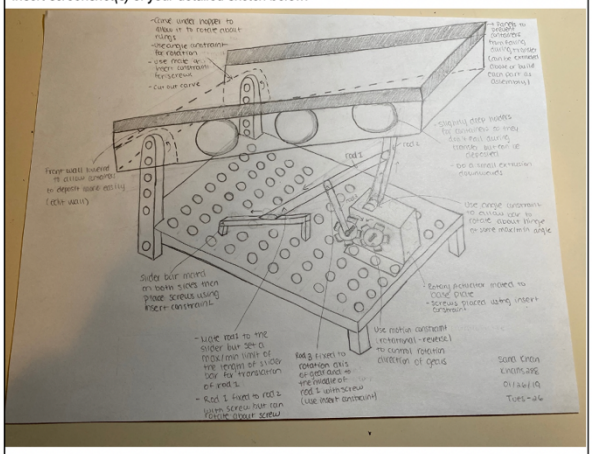
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their detailed sketches with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing ***Stage 4*** of the milestone

Team Number: Tues-26

Name: Sana Khan	MacID khans288

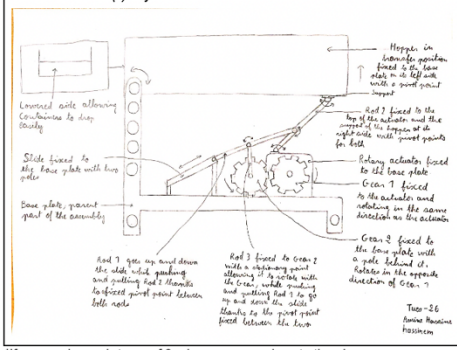
Insert screenshot(s) of your detailed sketch below.



Team Number: Tues-26

Name: Amine Hassine	MacID hassinem

Insert screenshot(s) of your detailed sketch below.



*If you are in a sub-team of 3, please copy and paste the above on a new page.

MILESTONE 3 (STAGE 3) – PROGRAM TASK PLANNING (COMPUTATION SUB-TEAM)

Team Number: Tues-26

1. As a team, write out the pseudocode or create a flowchart for the indicated tasks in the space below.
   → If creating a flowchart, complete your flowchart on a separate sheet of paper, take a photo of your sketch and insert photo as a Picture (Insert > Picture > This Device)

Dispense Container

```
Dispense_container function:
    bottles = [1,2,3,4,5,6]
    Container_Properties = [ ]
    My_table.dispense_container(random.choice(bottles))
    Container_properties = My_table.container_properties()
    Rotate turntable for Qarm pickup

    Return Container_properties
```

Load Container

```
load_container function:
    num_container = 0
    con_properties = Dispense_container()
    If con_properties = #######:
        Color = ####
    Elif.....

    While num_container < 3 or mass_qbot < 90 or con_properties == new_conprop:
        rest
        arm.home()
        arm.move_arm(x,y,z of the container at sorting station)
        arm.control_gripper(45)
        arm.home()
        arm.move_arm(x,y,z of the hopper on Q_bot)
        arm.control_gripper(-45)
        arm.home()
        mass_Qbot()
        num_container += 1
        new_conprop = Dispense_container()

    return Color
```

Transfer Container

```
transfer_container function:
    bin_color = load_container()
    bot.activate_color_sensor(bin_color)
    bot.follow_line(0.1)

    if bot.activate_color == color:
        bot.stop()
        bot.rotate(90)
```

Deposit Container

```
Deposit_container function:
    Bot.follow_line(0.1)
    Bot.dump()
```

Return Home

```
Return home function:
    Bot.rotate(180)
    Bot.follow_line(0.1)
    Bot.rotate(180)
    Bot.follow_line(0.1)
```

MILESTONE 3 (STAGE 4) – PRELIMINARY MODELLING (MODELLING SUB-TEAM)

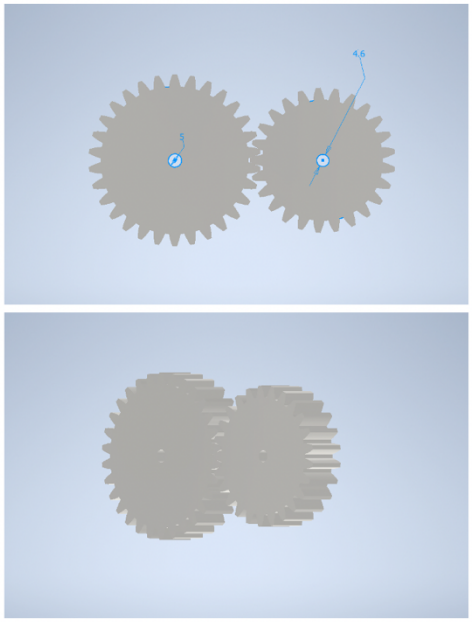
Team Number: Tues-26

1. As a team, create solid models of the various components of your device in Autodesk Inventor, based on the detailed sketches.
   → Take multiple screenshots of each solid model you create
   → Insert your photo(s) as a Picture (Insert > Picture > This Device)
   → **Do not include more than *two* solid modelling screenshots per page**

Team Number: Tues-26

Name: Amine Hassine	MacID hassinem

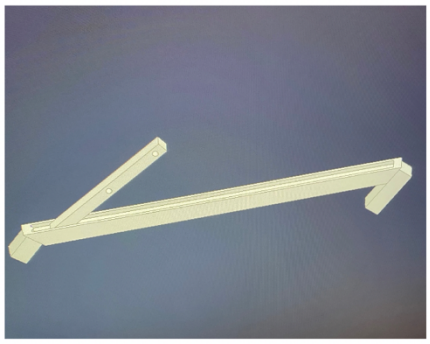
Gear 1 and 2

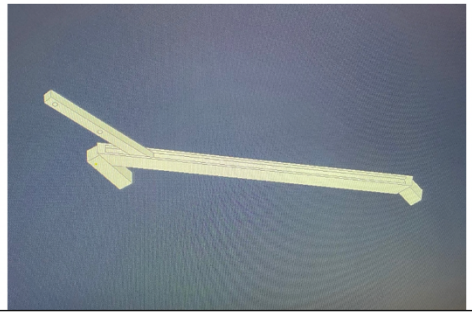


*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page

Name: Sana Khan	MacID khans288

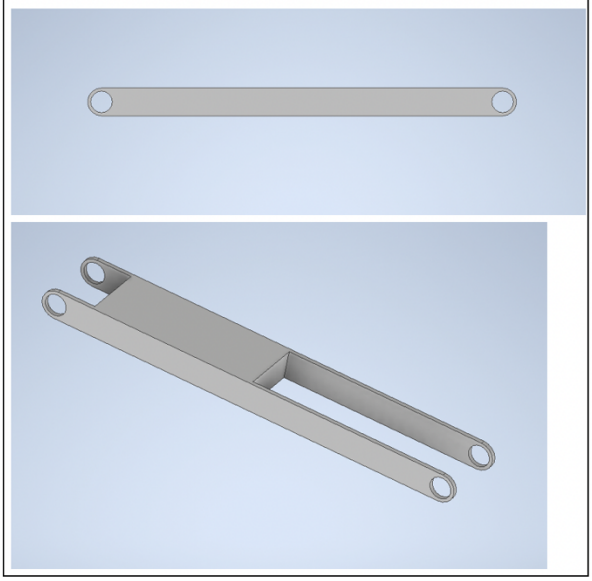
Slider and Rod 1





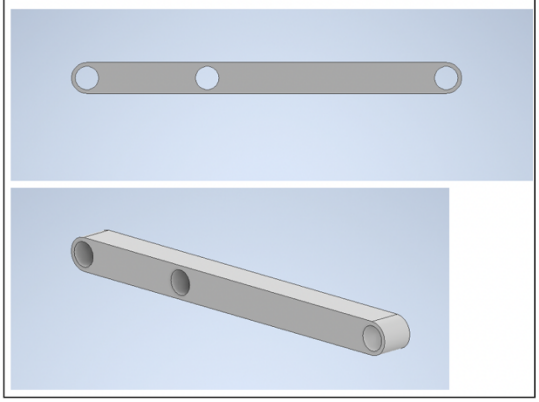
Name: Amine Hassine	MacID hassinem

Rod 3



Name: Amine Hassine	MacID hassinem

Rod 2



PROJECT THREE: MILESTONE 4 – COVER PAGE

Team Number: Tues-26

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

Full Name:	MacID:
Sana Khan	khans288
Amine Hassine	hassinem
Yash Patel	pately28
Ahmed Mohamed	mohaa97

MILESTONE 4 (STAGE 3) – DESIGN REVIEW FEEDBACK (MODELLING SUB-TEAM)

Team Number: Tues-26

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

1) Get rid of the gear attached to the linear actuator
2) Make the creases deeper so it doesn't detach or add more hinges

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

1) We will remove the gear
2) We may consider adding hinges between the two rods to make the design more realistic as the two rods may slip and disconnect if there is too much momentum or weight

MILESTONE 4 (STAGE 3) – DESIGN REVIEW FEEDBACK (COMPUTATION SUB-TEAM)

Team Number: Tues-26

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

1) Move bot function should be renamed to transfer container.
2) Repositioning the containers on the hopper
3) Return home function should be added
4) Deposit container function
5) For final submission we should comment our codes

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

We will rename some functions to make our code easy to understand
We will work on making the containers fit the hopper for more stability
Finally, we will comment our codes for final submission

List of Sources

Sources Material Data Base:

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[2] Y.-X. Guo, C. Lai, Z.-B. Shao, K.-L. Xu, and T. Li, "Differential Structure of Inductive Proximity Sensor," *mdpi.com*, 2019, doi: 10.3390/s19092210.

[3] S. Tumanski, "Induction coil sensors-a review," *Meas. Sci. Technol*, vol. 18, pp. 31–46, 2007, doi: 10.1088/0957-0233/18/3/R01.

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[9] R. R. Dam, H. Biswas, S. Barman and A. Ahmed, "Determining 2D shape of object using ultrasonic sensor," 2016 3rd International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), Dhaka, 2016 [Online]
Available: https://ieeexplore.ieee.org/document/7873143/citations#citations [Accessed: January 18, 2021]

[10] Gofuku, N. Yokomitsu, T. Yano and N. Kasashima, "A Rotor Posture Measurement System by Analyzing Sensed Magnetic Field from Arrayed Hall Sensors," 2019 12th International Symposium on Linear Drives for Industry Applications (LDIA), Neuchatel, Switzerland, [Online]
Available: https://ieeexplore.ieee.org/document/8770988 [Accessed: January 18, 2021]

[11] Y. I. Gudkov, V. N. Azarov and A. L. Tuv, "Active infrared sensor for monitoring protected areas," 2017 International Conference "Quality Management,Transport and Information Security, Information Technologies" (IT&QM&IS), St. Petersburg, 2017, [Online]
Available: https://ieeexplore.ieee.org/document/8085927 [Accessed: January 18, 2021]

[12] "Colour Sensor-Working and Applications," ELPROCUS,
[Online] Available: https://owl.purdue.edu/owl/research_and_citation/ieee_style/reference_list.html
[Accessed: March 7, 2021]

[13] Electronics-notes, "Light Dependent Resistor LDR: Photoresistor," *electronics-notes*, 2019.
[14] OMRON, "Photoelectric Sensors", [Online] Available: https://www.ia.omron.com/support/guide/43/introduction.html [Accessed: March 7, 2021]
[15] T. Wang *et al.*, "Fabrication and sensitivity optimization of garnet crystal-fiber ultrasonic temperature sensor," *Journal of Materials Chemistry C*, vol. 8, no. 11, pp. 3830–3837, Mar. 2020, doi: 10.1039/c9tc07071k.

[16] S. Liu, Z. Zhang, J. Xu, J. Xiao, X. Wang, and H. Luo, "Optimizing dual-piezoelectric-layer ultrasonic transducer via systematic analysis," *Sensors and Actuators, A: Physical*, vol. 315, Nov. 2020, doi: 10.1016/j.sna.2020.112336.

[17] R. R. Dam, H. Biswas, S. Barman, and A. Q. Ahmed, "Determining 2D shape of object using ultrasonic sensor," Mar. 2017, doi: 10.1109/CEEICT.2016.7873143.

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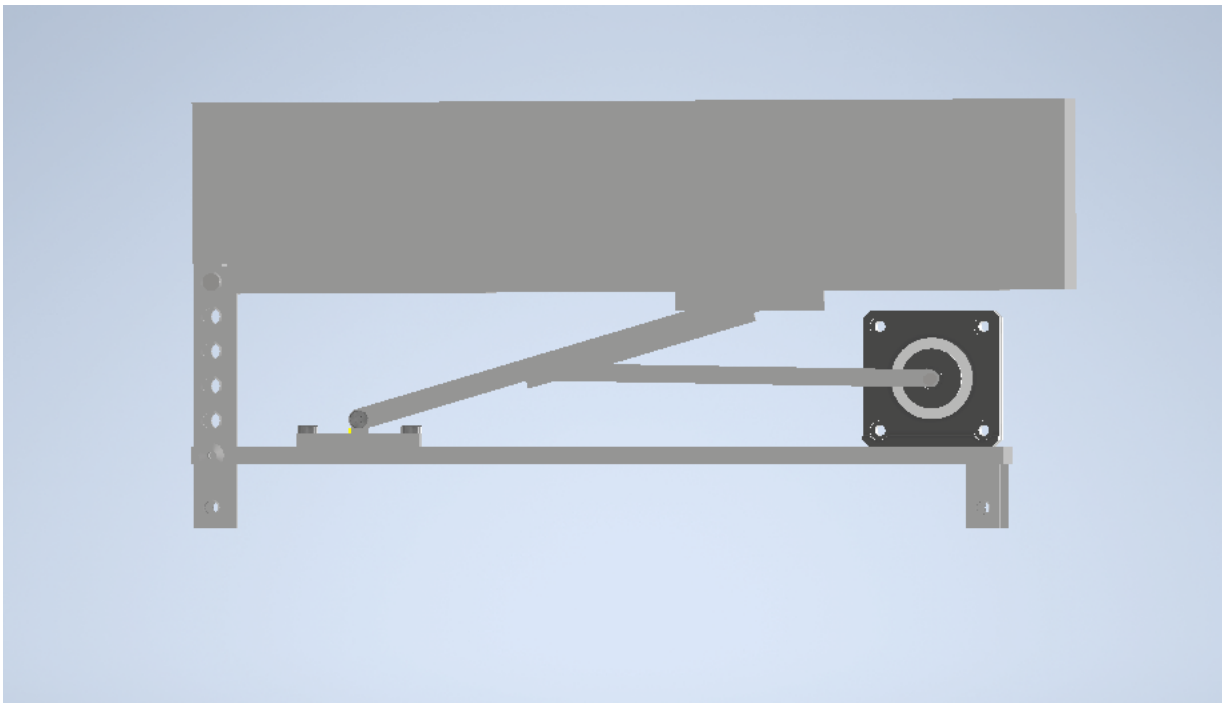
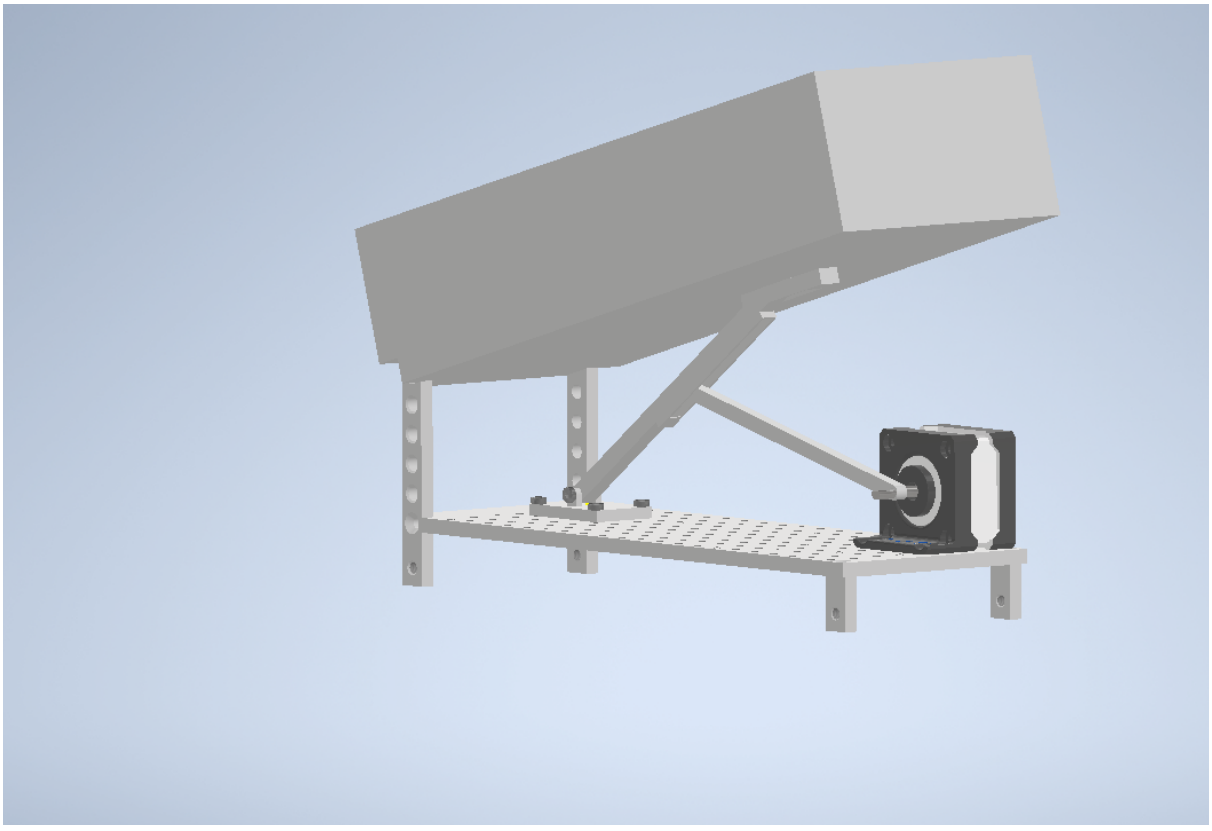
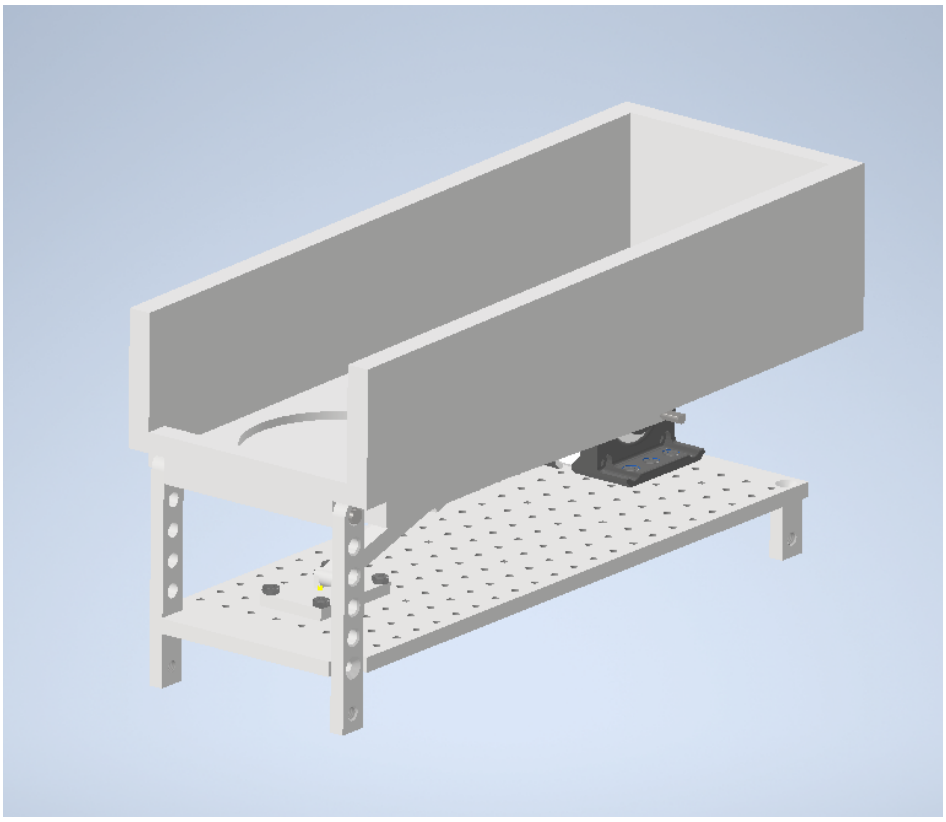
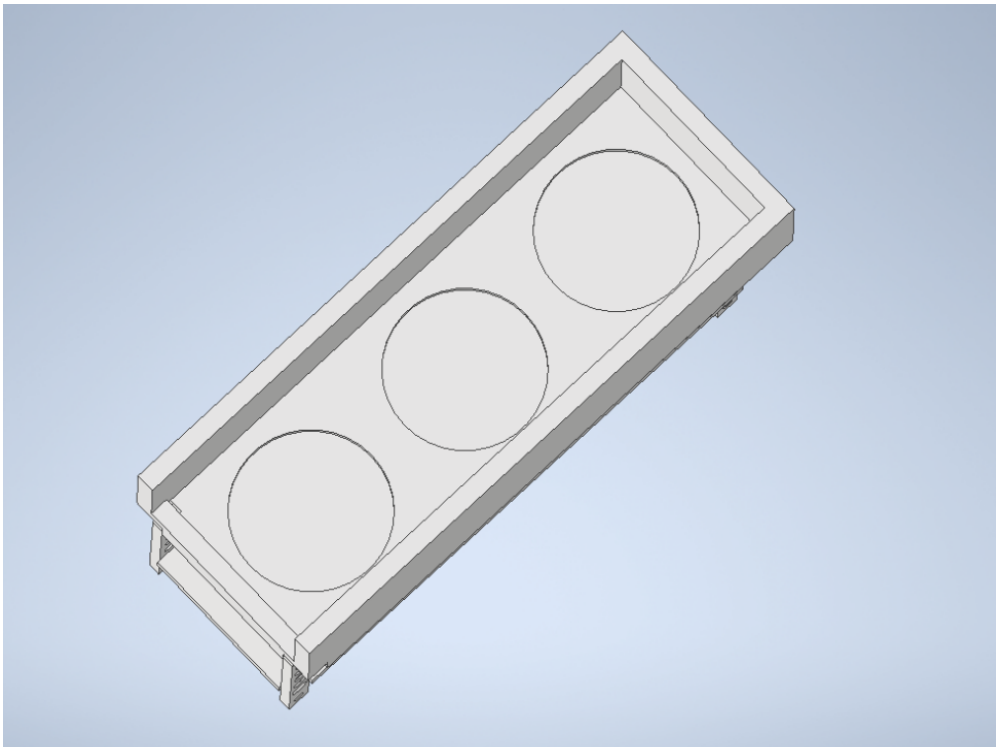
Appendices

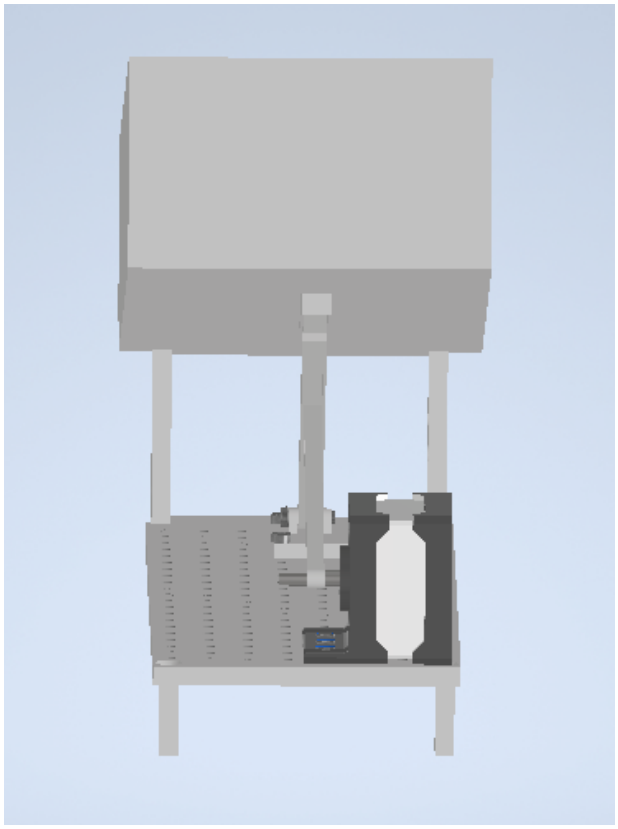
Appendix A: Solid Model:

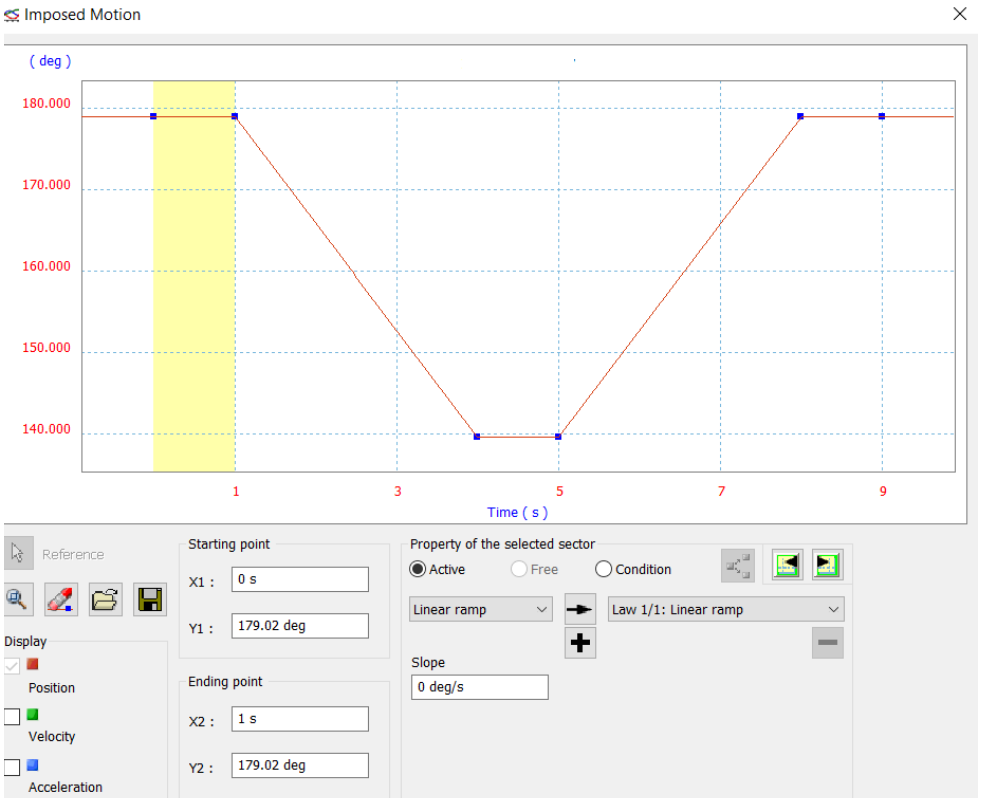











Imposed Motion
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Time (s)
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Starting point
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Active
Free
Condition
Linear ramp
Law 1/1: Linear ramp
Slope
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Display
Position
Velocity
Acceleration
Ending point
X2 :
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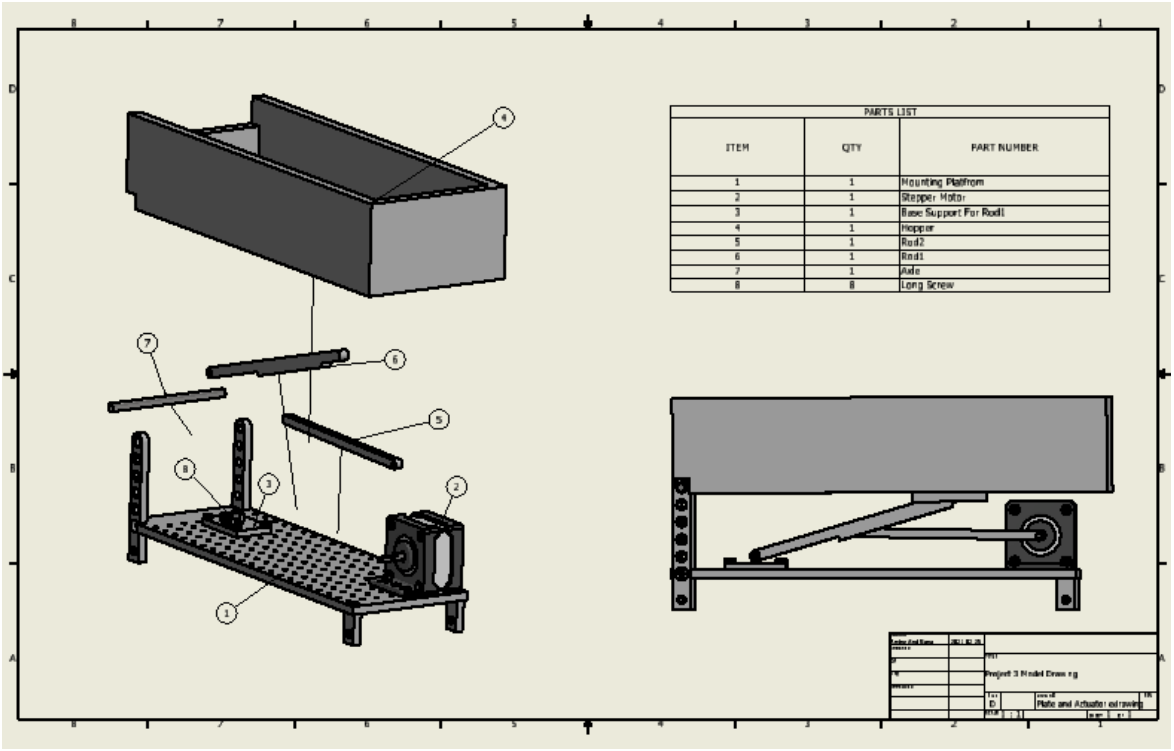
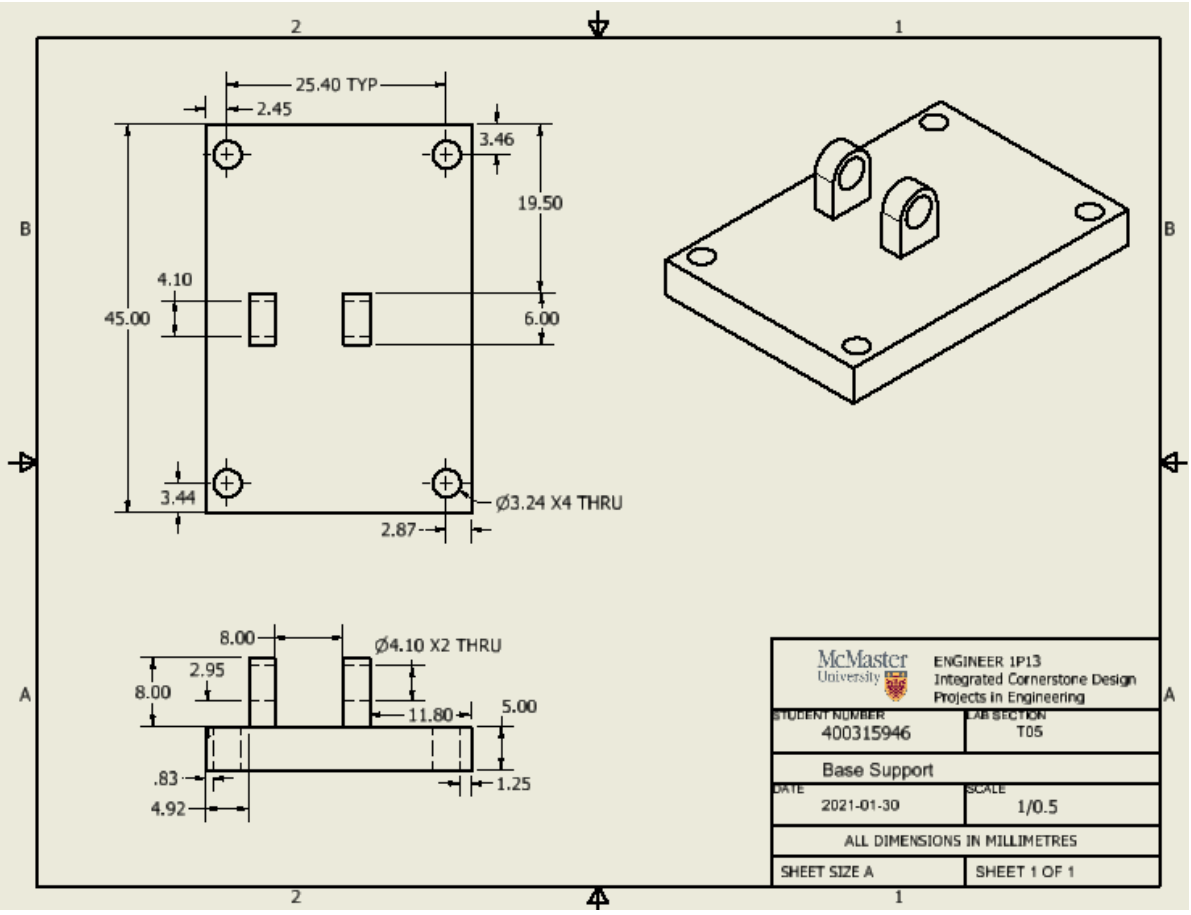
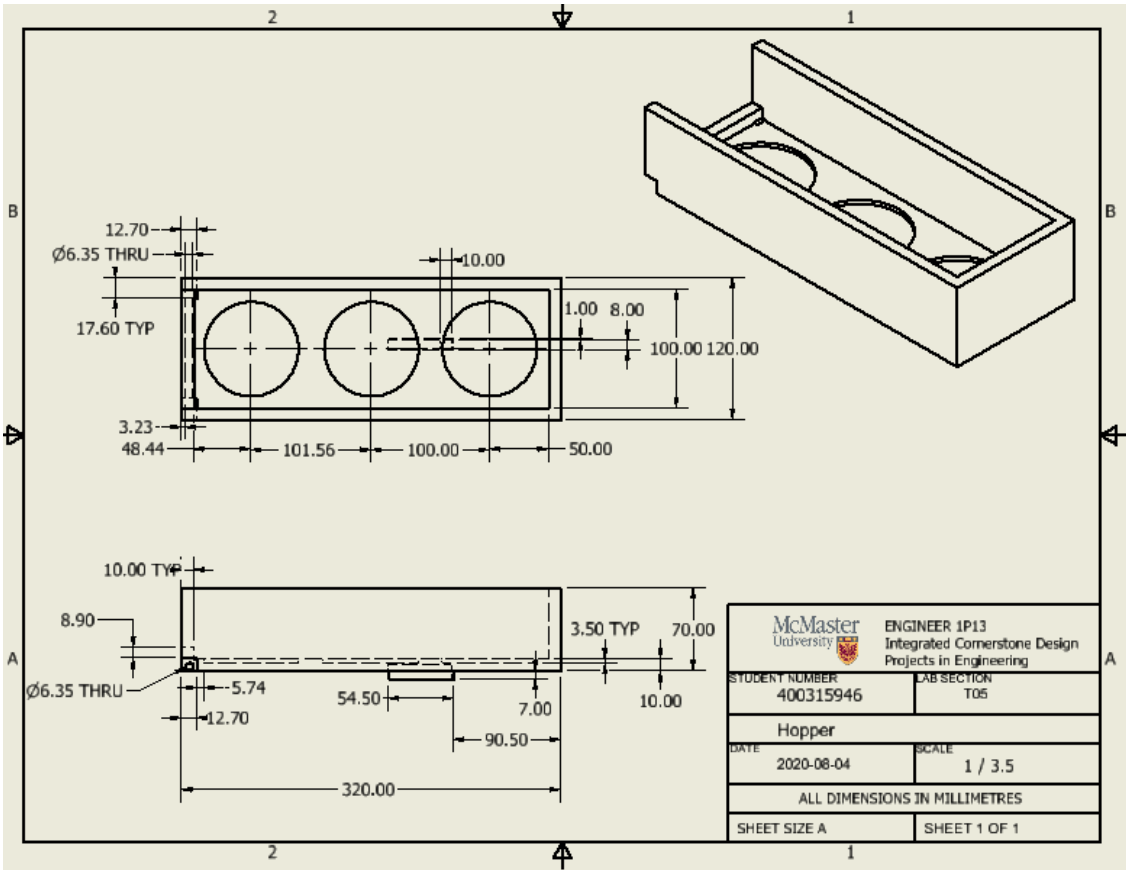
Y2 :
179.02 deg

Appendix B: Engineering Drawings:



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McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
400315946
LAB SECTION
T05
Hopper
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2020-08-04
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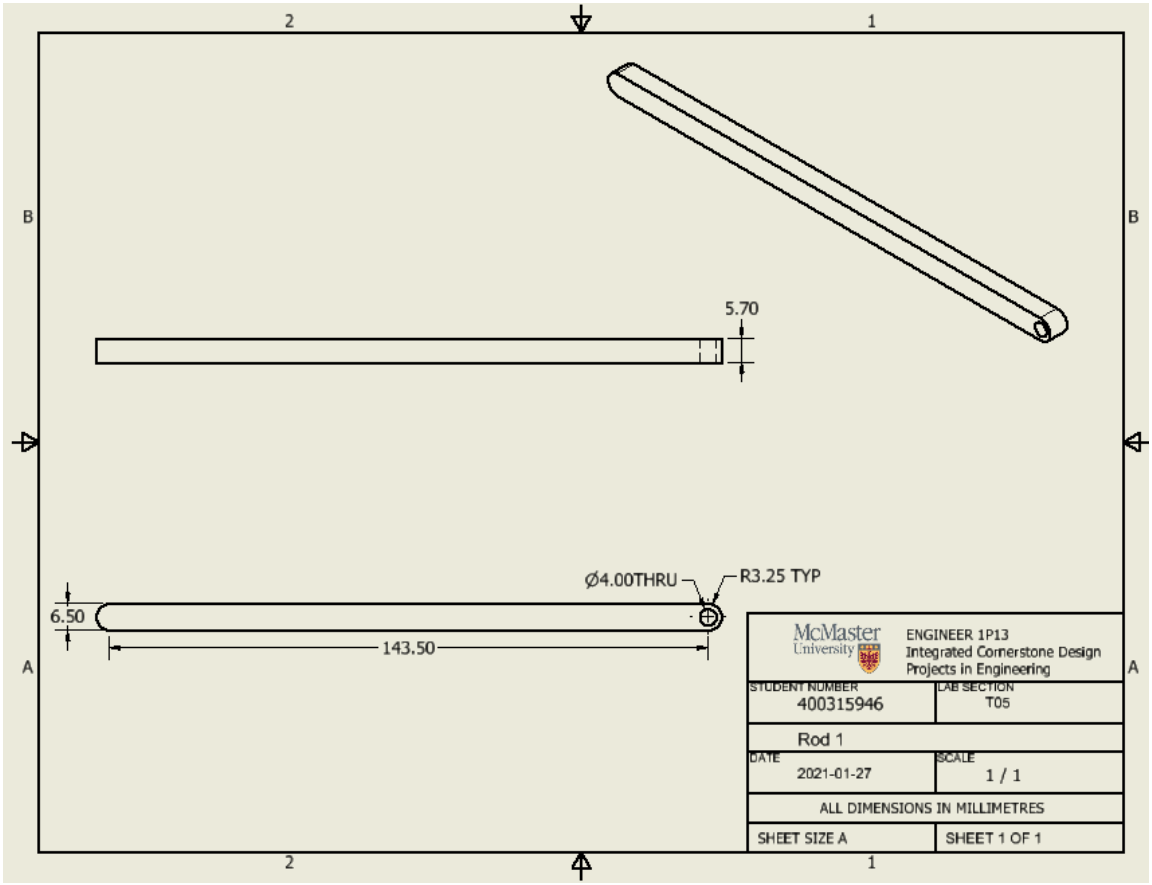
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Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
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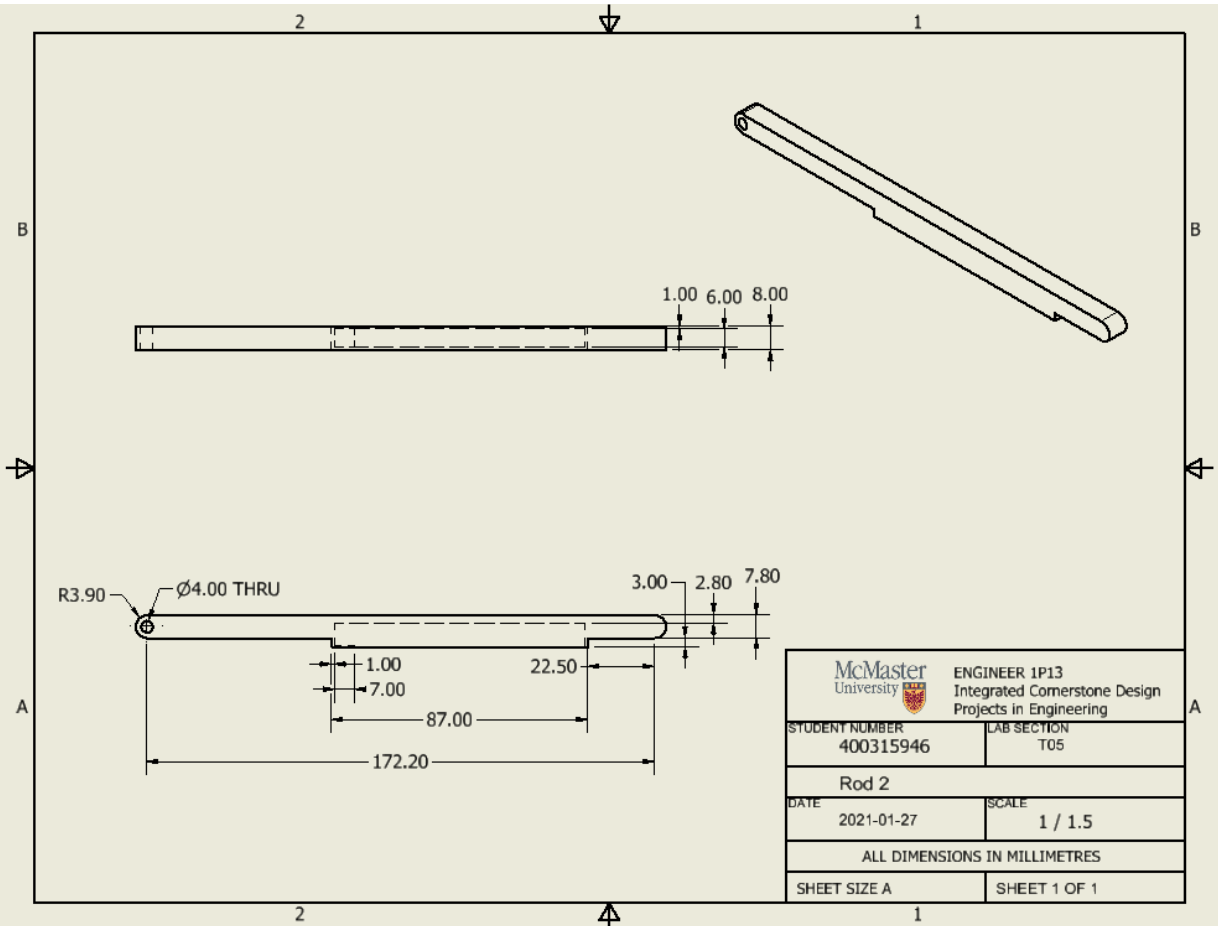
SHEET 1 OF 1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McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
400315946
LAB SECTION
T05
Rod 2
DATE
2021-01-27
SCALE
1 / 1.5
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1

Appendix C: Computer Program:

```
'''
Work done by: Yash Patel
Function: Dispenses a random type of container along with an output of the container properties.
Output: Container Property of the dispensed container
'''

def random_dispense():
    bottles = [1,2,3,4,5,6] #List of the Selection of Container IDs
    bottle_num = random.choice(bottles) #Chooses a random container id value from list
    #Determines properties of dispensed container
    container_properties = my_table.container_properties(bottle_num)
    my_table.dispense_container()
    time.sleep(0.5)
    print("The Container should go to", container_properties[2],"!")
    print(container_properties)
    return container_properties

'''
Work done by: Yash Patel
Function: Moves the Q arm to load the container from the servo table to the hopper
Input: Takes in dropoff location as a list of x,y,z coordinates of the corresponding container on the hopper.
'''

def dropoff_container(dropoff_location):
    home_position = [0.4064, 0.0, 0.4826] #Home Position of arm
    pickup_location = [0.689, 0.0, 0.2571] #Location of Table Container Pickup

    arm.home()
    #Moves arm to pickup location
    arm.move_arm(pickup_location[0], pickup_location[1], pickup_location[2])
    arm.control_gripper(45)
    arm.move_arm(0.2, 0.0, 0.22)
    arm.move_arm(home_position[0], home_position[1], home_position[2])
    #Moves arm to specific container's dropoff location on hopper
    arm.move_arm(dropoff_location[0], dropoff_location[1], dropoff_location[2])
    arm.control_gripper(-25)
    arm.rotate_shoulder(-45)
    time.sleep(0.5)
    arm.home()
```

```
'''
Work done by: Yash Patel
Function: Sets conditional statements that help determine if more containers can be transfered in one trip.

'''

def load_container():
    dispense_indicator = 0 #Helps determine if container should be dispensed or not
    while True:
        if dispense_indicator == 0: #First time iterating through loop, container will be dispensed
            container_one = random_dispense()
        drop_off = [-0.1188, -0.3886, 0.4826] #Coordinates for drop off location of first container
        dropoff_container(drop_off)

        if dispense_indicator > 0: #Container from previous loop is already present on servo table
            container_one = missed_container
        container_two = random_dispense()
        table_mass = int(container_one[1]) + int(container_two[1]) #Determines mass of two containers together

        #Verifies that the bin location of both containers is the same and the mass of the bin is less than 90 before it loa
        if container_one[2] == container_two[2] and table_mass <= 90:
            drop_off = [0.0, -0.4064, 0.4826]
            dropoff_container(drop_off)
            container_three = random_dispense()
            table_mass += int(container_three[1]) #Adds mass of third container to total mass
            '''
            Verifies the bin location of the third container corresponds to location of first container and ensures mass is
            still less tahn 90
            '''
            if container_three[2] == container_one[2] and table_mass <= 90:
                drop_off = [0.1052, -0.3926, 0.4826]
                dropoff_container(drop_off)
            else:
                missed_container = container_three

        else:
            missed_container = container_two
        transfer_container(container_one[2]) #Calls transfer function to deliver containers to bin
        dispense_indicator += 1 #Increments indicator to ensure two containers aren't dispensed atop one another


'''
Work done by: Yash Patel
Function: Uses the Qbot to transfer the container to its corresponding bin.
'''

def transfer_container(bin_ID):
    bot.activate_ultrasonic_sensor()
    lost_line = 0
    read_distance = [] #Creates list that will take in distance values from ultrasonic sensor

    #Ensures the divergence of line following sensor from yellow line is less than 1
    while lost_line < 1:
        #Determines speed of left and right wheel depending on divergence from yellow line
        lost_line, velocity = bot.follow_line(0.3)
        bot.forward_velocity(velocity) #Uses calculated speed to move the Qbot
        #Reads distance of ultrasonic sensor from correct bin and inserts value into list
        read_distance.insert(0, bot.read_ultrasonic_sensor(bin_ID))
        bin_distance = float(read_distance[0])
        if bin_distance <= 0.03: #When distance from bin is less than 0.03 Qbot stops moving
            bot.stop()
            break
    deposit_container()
    return_home()
```

```
'''
Work done by: Yash Patel
Function: Rotates actuator to dump container into bin (BONUS)
'''

def deposit_container():

    bot.deactivate_ultrasonic_sensor()
    bot.activate_actuator()
    actuator_file = bot.process_file("Actuator.txt") #Processes Inventor Simulation TXT File

    #Determines interval of time that actuator should rotate with
    time_diff = float(actuator_file[0][1]) - float(actuator_file[0][0])
    print(time_diff)
    print(len(actuator_file[0]) - 1)
    i = 0 #time increment variable

    #As long as increment value in in the range of time values in text file -1 (Noot considering 0)
    while i in range(len(actuator_file[0]) - 1):
        bot.rotate_actuator(actuator_file[1][i]) #Rotates actuator based on read values in simulation file
        time.sleep(time_diff) #Waits the time interval before making next rotation
        i += 1
    bot.dump()
    bot.deactivate_actuator()
```

```
'''
Work done by: Yash Patel
Function: The Qbot follows the yellow line until it returns to its home position
'''

def return_home():
    lost_line = 0
    #Ensures the divergence of line following sensor from yellow line is less than 1
    while lost_line < 1:
        #Determines speed of left and right wheel depending on divergence from yellow line
        lost_line, velocity = bot.follow_line(0.3)
        bot.forward_velocity(velocity) #Uses calculated speed to move the Qbot

    bot.forward_time(0.3) #Corrects Position of Qbot
    bot.rotate(197) #Rotates container for next round of disposal

load_container()
```

Actuator.txt - Mousepad

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```
        0.00000 0.304
        0.10000 0.304
        0.20000 0.304
        0.30000 0.304
        0.40000 0.304
        0.50000 0.304
        0.60000 0.304
        0.70000 0.304
        0.80000 0.304
        0.90000 0.304
        1.00000 0.304
        1.10000 2.263
        1.20000 4.156
        1.30000 5.971
        1.40000 7.702
        1.50000 9.343
        1.60000 10.889
        1.70000 12.34
        1.80000 13.695
        1.90000 14.955
        2.00000 16.122
        2.10000 17.199
```

Quansar Environment Settings:

Q-Labs Environment Configuration

Table Configuration:

Short Tower Angle: 270 deg

Tall Tower Angle: 0 deg

Drop Tube Angle: 180 deg

Hopper Configuration:

Box Width: 32.0 cm

Box Length: 12.0 cm

Wall Height: 7.0 cm (3 walls) and 0.0 cm for wall facing towards bins.

Origin Location X = -2.0

Bin Configuration:

Box Spacing: 20 cm

Offset: 13cm (All Boxes)

*All other settings are kept the same!