ENGINEERING

McMaster University

Project Two – Get a Grip:

Design a System for Sterilizing Surgical Tools using Remote Sensing and Actuation

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial 09

Team Thurs-62

Dennis Fong (fongd1)

Bradley Charko (charkb1)

Omar Muhammad (muhammao)

Qasim Siddiq (siddiq2)

Muhammad Sibtain Raza (razam26)

Submitted: December 10th, 2020

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Executive Summary

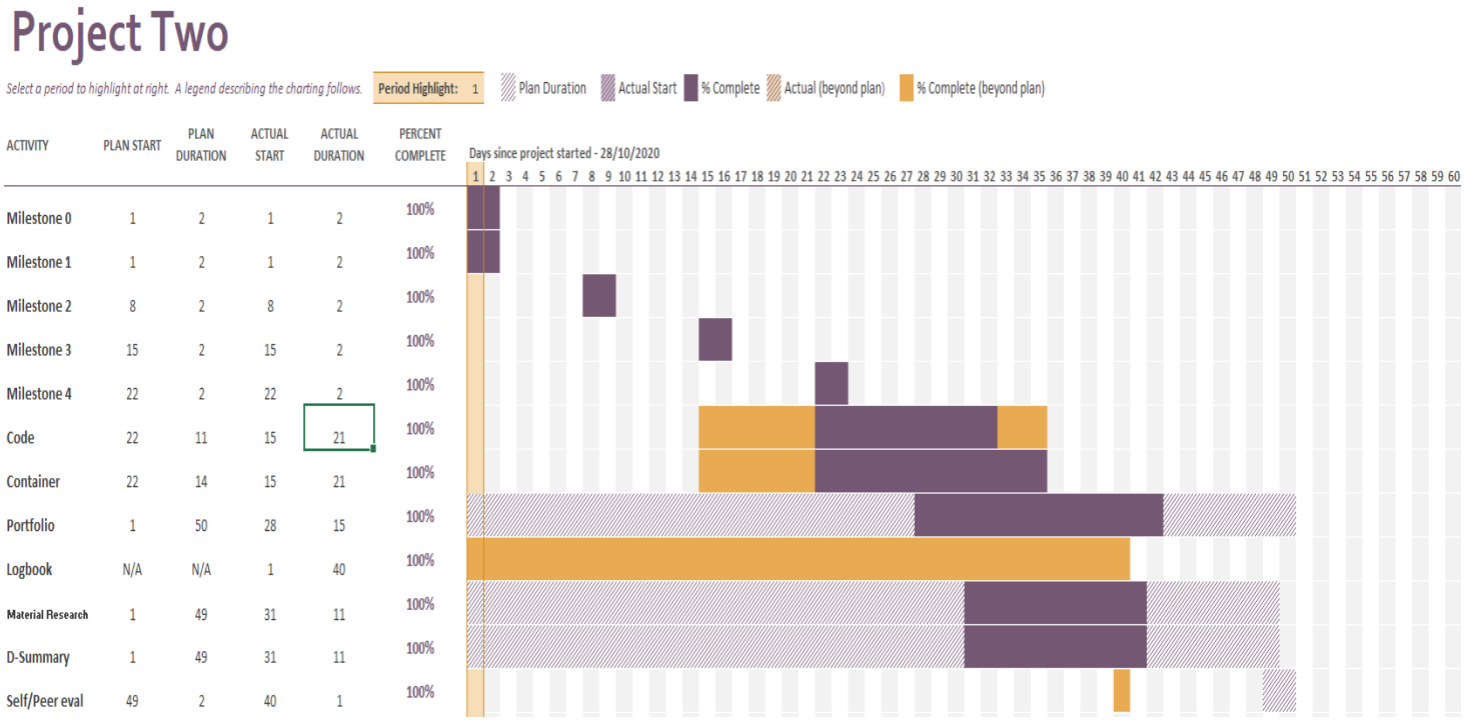
Infections and diseases are often spread by human contact. As a result, tasks which require a sterile and sanitary environment are best performed by a robot. Robots can perform repetitive tasks effectively and are not held back from potential exposure to an infection or disease. An example of one of these tasks are surgeries, and the tasks associated with surgeries such as the sterilization of surgical tools [1]. It is effective to use a robot for a repeated process of commands since they can complete the commands without fail and whilst doing so, the risk of infection is minimized. Furthermore, robots can be used if a job may be too tiring for a person to do; researchers from the University of South Carolina have developed a robot that is able to do tedious and tiresome tasks. Such as shining a UV ray on a specific region for an extended period of time [2]. For the sterilization of surgical tools, designing a robot that can transport tools will lower the risk of infections. The robot would transport a sterilization container that carries the tools to an appropriate autoclave bin, where the sterilization occurs. The design of the container must consider the method in which the tools will get sterilized; the most common form of sterilization for such a container is to be heated using pressurized, saturated steam [3]. In this project, the modelling sub-team designed a container with a minimized weight to make it easier for the robot to carry. There were also indents on the side of the container that were coated with rubber to increase the frictional force of the sides to ensure that the robot could carry the container without slipping. The dimensions were chosen so that the tweezers would not slide from side to side and for weight to be minimized. There was also an additional section added for the handle of the tweezers to ensure that there was no unwanted movement of the tool inside the container. Additionally, a lid was added which was made with mesh-like material to represent a semi-permeable membrane which would allow for less troublesome sterilization. This made it so that the design requirements were fulfilled. On the computation sub-team, a set of functions written in python were executed to place six containers randomly in the appropriate autoclave location. After the six containers were placed, the program would terminate. These concepts fulfill the original goal of using a robot, which is to safely perform tasks and reduce the spread of infection and viruses. The container’s design and the program work in tandem to ensure the tweezers will be sterilized whilst maintaining minimal human contact, preventing unwanted adverse effects. In summary, we aimed to emulate a safe, and functioning environment for the sterilization of the tweezers using the robotic arm to move the container.

Project Schedule

Preliminary Gantt Chart

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	2	1	2	100%
Milestone 1 (Team)	1	2	1	2	100%
Milestone 2 (Team) (C)	8	2			0%
Milestone 2 (Team) (G)	8	2			0%
Milestone 3 (Team) (C)	15	2			0%
Milestone 3 (Team) (G)	15	2			0%
Milestone 4 (Team) (C)	22	2			0%
Milestone 4 (Team) (G)	22	2			0%
Technical Deliverable (Individual) (C)	22	11			0%
Technical Deliverable (Team) (C)	22	11			0%
Technical Deliverable (Individual) (G)	22	14			0%
Technical Deliverable (Team) (G)	22	14			0%
Materials Research Summary	1	49			0%
Design Project Report	1	49			0%
Learning Portfolio	1	50	1		15%
Self/Peer Evaluation	49	2			0%

Final Gantt Chart



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	2	1	2	100%
Milestone 1	1	2	1	2	100%
Milestone 2	8	2	8	2	100%
Milestone 3	15	2	15	2	100%
Milestone 4	22	2	22	2	100%
Code	22	11	15	21	100%
Container	22	14	15	21	100%
Portfolio	1	50	28	15	100%
Logbook	N/A	N/A	1	40	100%
Material Research	1	49	31	11	100%
D-Summary	1	49	31	11	100%
Self/Peer eval	49	2	40	1	100%

Logbook of Additional Meetings and Discussions

Modelling sub-team 11/22 (32 minutes)

- Completing design
- Discussion for what to do moving forward

Modelling sub-team 11/24 (20 minutes)

- Finalization of design

Computing sub-team meeting 11/26 (34 minutes)

- Working on code together

Computation sub-team meeting 11/27 (45 minutes)

- Code finalization, taking feedback into account

Computing sub-team meeting 12/02 (18 minutes)

- Interview prep
- Code review

Full team meeting (1 hour)

- Pre-interview discussion
- Final review of all contents

Scheduled Weekly Meetings

Weekly Design Studio Agendas

November 5, 2020 (1h 30min)

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Qasim Siddiq	siddiq2	Yes
Administrator	Omar Muhammad	muhammao	Yes
Coordinator	Dennis Fong	Fongd1	Yes
Subject Matter Expert	Muhammad Sibtain Raza	razam26	Yes
Subject Matter Expert	Bradley Charko	charkb1	Yes

Agenda Items

1. Attendance and updates
2. Issues from past week
3. Discuss workflow / model
4. Action items for next meeting
5. Final items

Post-Meeting Action Items

1. Finish pseudocode *[Computing sub-team]*
2. Finish low-fidelity prototype *[Modelling sub-team]*
3. Submit worksheets *[Administrator]*

November 12, 2020 (1h 30min)

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Qasim Siddiq	siddiq2	Yes
Administrator	Omar Muhammad	muhammao	Yes
Coordinator	Dennis Fong	Fongd1	Yes
Subject Matter Expert	Muhammad Sibtain Raza	razam26	Yes
Subject Matter Expert	Bradley Charko	charkb1	Yes

Agenda Items

1. Attendance & Updates
2. Issues from past week
3. Discuss our prototype / our functions
4. Action Items for next meeting
5. Final Notes

Post-Meeting Action Items

1. Submit Worksheets *[Administrator]*

November 19, 2020 (1h 30min)

Attendance

Role	**Name**	**Mac ID**	**Attendance (Yes/No)**
Manager	Qasim Siddiq	siddiq2	Yes
Administrator	Omar Muhammad	muhammao	Yes
Coordinator	Dennis Fong	Fongd1	Yes
Subject Matter Expert	Muhammad Sibtain Raza	razam26	Yes
Subject Matter Expert	Bradley Charko	charkb1	Yes

Agenda Items

1. Attendance & Updates
2. Issues from past week
3. Discuss our prototype / our functions
4. Action Items for next meeting
5. Final Notes

Post-Meeting Action Items

1. Finish the code *[Computing sub-team]*
2. Get g-code ready *[Modelling sub-team]*
3. Prepare for design review

November 26, 2020 (1h 30min)

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Qasim Siddiq	siddiq2	Yes
Administrator	Omar Muhammad	muhammao	Yes
Coordinator	Dennis Fong	Fongd1	Yes
Subject Matter Expert	Muhammad Sibtain Raza	razam26	Yes
Subject Matter Expert	Bradley Charko	charkb1	Yes

Agenda Items

1. Attendance & Updates
2. Issues from past week
3. Discuss our prototype / our code
4. Action Items for next meeting

Post-Meeting Action Items

1. Finish code *[Computing sub-team]*
2. Get g-code ready *[Modelling sub-team]*
3. Prepare for design interview

Weekly Design Studio Minutes

November 5, 2020 (1h 30min)

1. Attendance and updates
    a. How is everybody doing?
    b. Anything in other classes?
    c. Everyone is okay with sub team roles?
2. Issues from past week
    a. Objectives versus functions (unfair for us)
3. Discuss workflow/model
    a. Quick summaries of your pre-DS work
    b. Questions about current DS work
4. Action items for next meeting
    a. Finish pseudocode
    b. Finish low-fidelity prototype
    c. Any outstanding worksheets that must be submitted
5. Final items
    a. **Check action items**

November 12, 2020 (1h 30min)

1. Attendance & Updates
    a. How is everyone?
    b. Anything we can help each other out with?
    c. How are other classes going?
2. Issues from past week
    a. Explain functions
3. Discuss our prototype/ our functions
    a. How can we integrate each other's functions?
4. Action Items for next meeting
    a. Finish Individual Worksheets
    b. Finish Team Worksheets
5. Final Notes
    a. **Check your action items**

November 19, 2020 (1h 30min)

1. Attendance & Updates
    a. How is everyone?
    b. Anything we can help each other out with?
    c. How are other classes going?
2. Issues from past week
    a. How to integrate muscle sensors into code
3. Discuss our prototype/ our functions
    a. How can we integrate all the functions together?
4. Action Items for next meeting
    a. Finish the code
    b. Get g-code ready
    c. Prepare for design review
5. Final Notes
    a. **Check your action items**

November 26, 2020 (1h 30min)

1. Attendance & Updates
    a. How is everyone?
    b. Anything we can help each other out with?
    c. How are other classes going?
2. Issues from past week
    a. Drawers not closing
    b. Large container drop-off locations need to be altered
3. Discussion and Preparation for Meeting
    a. Any errors with code
    b. Any problems with model of design
4. Action Items for next meeting
    a. Prepare for interview

Design studio Worksheets

Milestone 0

PROJECT TWO: MILESTONE 0 – COVER PAGE

Team Number: Thurs-62

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

Full Name:	MacID:
Dennis Fong	fongd1
Qasim Siddiq	siddiq2
Omar Muhammad	muhammao
Bradley Charko	charkb1
Muhammad Sibtain Raza	razam26

Insert your Team Portrait in the dialog box below

Figure 1: Milestone 0 Page1

MILESTONE 0 – TEAM CHARTER

Team Number: Thurs-62

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Dennis Fong	☐M ☐A ☐C ☒S
2.	Qasim Siddiq	☐M ☒A ☐C ☐S
3.	Omar Muhammad	☐M ☐A ☒C ☐S
4.	Bradley Charko	☒M ☐A ☐C ☐S
5.	Muhammad Sibtain Raza	☐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	Qasim Siddiq	siddiq2
Administrator	Omar Muhammad	muhammao
Coordinator	Dennis Fong	Fongd1
Subject Matter Expert	Muhammad Sibtain Raza	razam26
Subject Matter Expert	Bradley Charko	charkb1

Figure 2: Milestone 0 Page 2

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team Number: Thurs-62

Full Name of Team Manager:	MacID:
Qasim Ahmad Siddiq	siddiq2

Preliminary Gantt chart

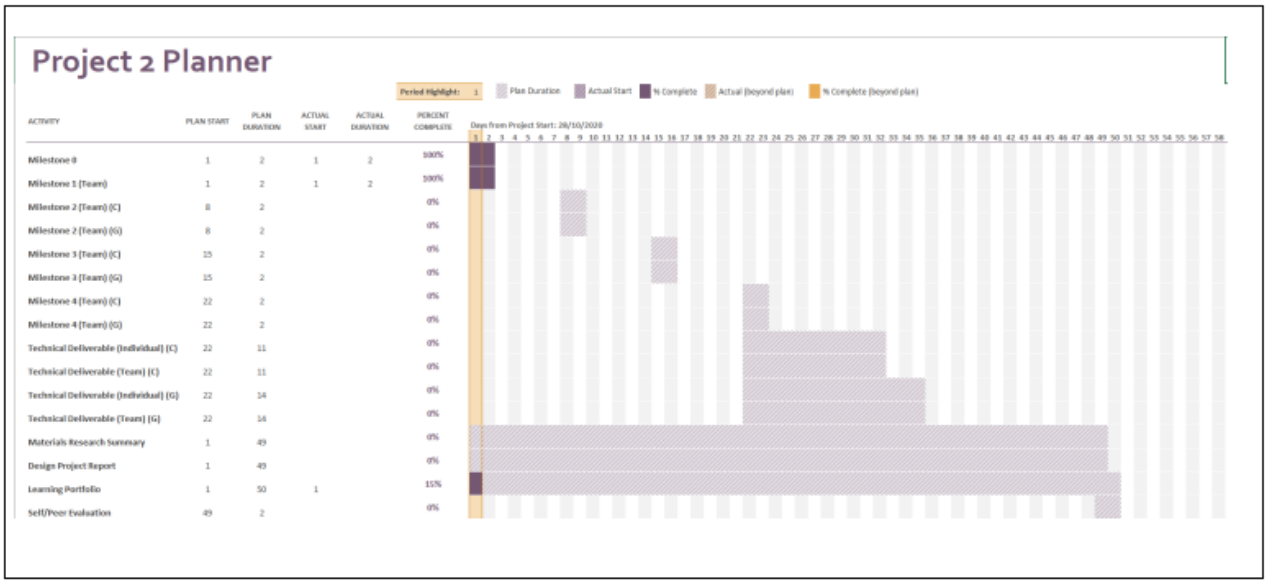


Figure 3: Milestone 0 Page 3

Milestone 1

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team Number: Thurs-62

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

Full Name:	MacID:
Omar Muhammad	muhammao
Qasim Siddiq	siddiq2
Dennis Fong	fongd1
Muhammad Sibtain Raza	razam26
Bradley Charko	charkb1

Figure 4: Milestone 1 Page 1

MILESTONE 1 (STAGE 1) – PRE-PROJECT ASSIGNMENT

Team Number: Thurs-62

You should have already completed this task individually prior to Design Studio 7.

1. Copy-and-paste each team member's list of objectives, constraints and functions on the following pages (1 team member per page)
    a. 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 list of objectives, constraints and functions with the **Milestone One Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone One Team Worksheets** document allows you to readily access your team member's work
    - This will be especially helpful when completing ***Stage 2*** of the milestone

Figure 5: Milestone 1 Page 2

Team Number: Thurs-62

Name: Omar Muhammad	MacID: muhammao

Copy-and-paste the pre-project assignment for one team member in the space below
(Container)
Objectives

- Easy to hold for the robot
- Able to effectively store the assigned materials

Constraints

- Container must fit within autoclave
- Material must fit within container
- Can withstand any pressure that may occur (from being held, sterilization, dropped into position)

Functions

- Easy to pick up/carry
- Easy to access surgical tools

Figure 6: Milestone 1 Page 3

Team Number: Thurs-62

Name: Dennis Fong	MacID: fongd1

Objectives

- Autoclave will be easy to open
- Robotic arm can move fluently
- Allows steam to enter (container)

Constraints

- *Robotic Arm Length (and thereby the container's dimensions)*
- *CAD Model complexity (Model must be printed within 2 hours)*

Functions

- Pick up/drop containers into their respective autoclaves
- *Containers store surgical tools*

Figure 7: Milestone 1 Page 4

Team Number: Thurs-62

Name: Qasim Siddiq	MacID: siddiq2

Objectives

- Holds tools securely
- Easy for a robot gripper to grab
- Easy for a robot gripper to hold and transport
- Can hold a variety of tools
- Easily portable

Constraints

- Container width must not exceed width of robotic claw
- The container must fit within the autoclaves
- Container should be light enough to be portable
- Container must be large enough to contain the surgical instrument

Functions

- Holds surgical tools
- Secures surgical tools during transportation of the system
- Acts as a sterilization cage

Figure 8: Milestone 1 Page 5

Team Number: Thurs-62

Name: Muhammad Sibtain Raza	MacID: razam26

Objectives

- Securely hold assigned surgical tools in place
- Container design ensures that steam is able to get inside the container for sterilization of surgical tools

Constraints

- Dimensions and size of container must be in accordance with the dimensions of the autoclave
- Dimensions and size of container must be in accordance with the design of the robotic arm

Functions

- Container properly secures assigned surgical tools for transportation to the autoclave for sterilization

*If you are in a team of 5, please copy and paste the above on a new page

Figure 9: Milestone 1 Page 6

Team Number: Thurs-62

Name: Bradley Charko	MacID: charkb1

Objectives

- Design and container that effectively holds a surgical instrument for sterilization inside an autoclave
- Container is portable by a robotic arm and held securely

Constraints

- Size of container with respect to the size of autoclave
- Size of the container with respect to the size of the surgical instrument
- Size of the container with respect to the size of the robotic claw

Functions

- Container uses hooks, magnetism and/or friction material to effectively be secured in the grasp of the robotic claw

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

Team Number: Thurs-62

1. As a team, create a final a list of objectives, constraints, and functions in the table below.
   → Use your individual *Pre-Project Assignment* to build your team's final list
   → The exact number you should have depends on what information you have gathered from the Project Pack.

Figure 10: Milestone 1 Page 7

Objectives	Constraints	Functions
Easy to grip for the robot	Container must fit withing the claw	Hold the surgical tools so that it is easy to transport to its destination (to sterilize)
Allows steam to enter	Simple (Must be printed within 2 hours)	Safely dropped into the autoclave
Can contain the materials	Container can fit inside the autoclave	Easy to pick up
Securely holds tool(s)	Container can fit the surgical tools without any problems (tool end should not touch anything)	Allow access to surgical tools
Sterilize Tools in the autoclaves	Can withstand pressure from: arm, being dropped, sterilization	Easy to carry and place into autoclave

2. What is the primary function of the entire system?

Hold tools so that they can be transported to a destination

3. What are the secondary functions?

Easy to pick up
Allow access to surgical tools
Easy to carry and place into the autoclave

Figure 11: Milestone 1 Page 8

MILESTONE 1 (STAGE 3) – MORPHOLOGICAL ANALYSIS

Team Number: Thurs-62

1. Identify multiple means to perform the secondary functions that your team came up with during Stage 1 of this milestone. One sub-function (pick up) is already listed for you. The other two sub-functions are for your team to choose.
   → Make sure that every mean for the "pick up" sub-function assumes that the end effector of the robot arm is a gripper. The means for your other sub-functions do not need to follow this assumption.

Function					
Pick up	Has a handle	Force of friction on the sides will be larger so it will have a better grip	Hooks on the side	Will have indents on the sides where the grips can be placed	Can be 'clicked' in when the grips get attached to box
Transfer of box (carry/drop)	Rubber Cushioning	Foam coating on bottom of box (to prevent damage from potential drop)	Container must be reinforced to with stand possible force (of drop)	Force of friction on the sides will be larger (prevent slipping)	
Allow access to contents	Separatable lid (to remove)	Lid with a hinge at the back to open/close	Filter on top (with holes) (helps with sterilize and to view materials)	Slidable, see through lid (easy to open and can see through to determine what is in it and if it is ready to be used)	

Figure 12: Milestone 1 Page 9

MILESTONE 1 (STAGE 4) – CONCEPT SKETCHES

Team Number: Thurs-62

Complete this worksheet *after* having completed stage 3 as a team ***and*** after having ***individually*** created your concept sketches.

1. Each team member should copy-and-paste the photo of their individual concept sketches in the space indicated on the following pages
   → The photo's should be the same one your included in the **Milestone One Individual Worksheets** document
   → Be sure to include your **Team Number** on each page
   → Be sure each team member's **Name** and **MacID** are included with each sketch

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

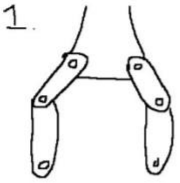
- Each team member needs to submit their sketch with the **Milestone One Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone One Team Worksheets** document allows you to readily access your team member's work

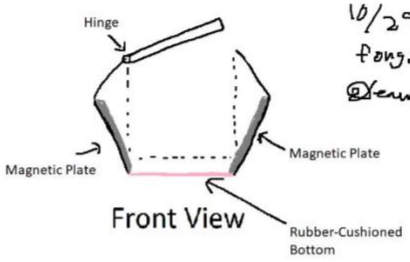
Figure 13: Milestone 1 Page 10

Team Number: Thurs-62

Name: Dennis Fong	MacID: fongd1

1.

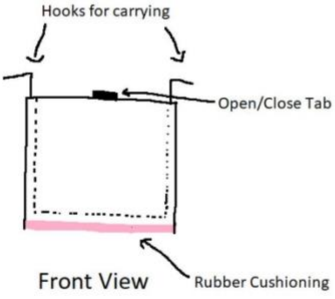


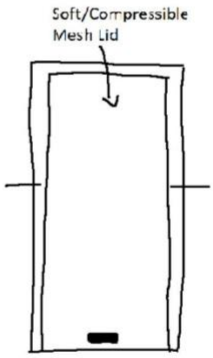


Dennis Fong
10/29/20
fongd1

- Robotic Arm would be gripping the container by the verticies
- Soft padding under the container to be dropped
- Bottom half of container reinforced with magnets to be carried easier
- Hinge with openable lid

2.





Dennis Fong
10/29/20
fongd1

- Hooks for arm to carry container
-Rubber cushioning to protect contents
- Mesh lid can be slide open/closed

Figure 14: Milestone 1 Page 11

Team Number: Thurs-62

Name: Qasim Siddiq	MacID: siddiq2

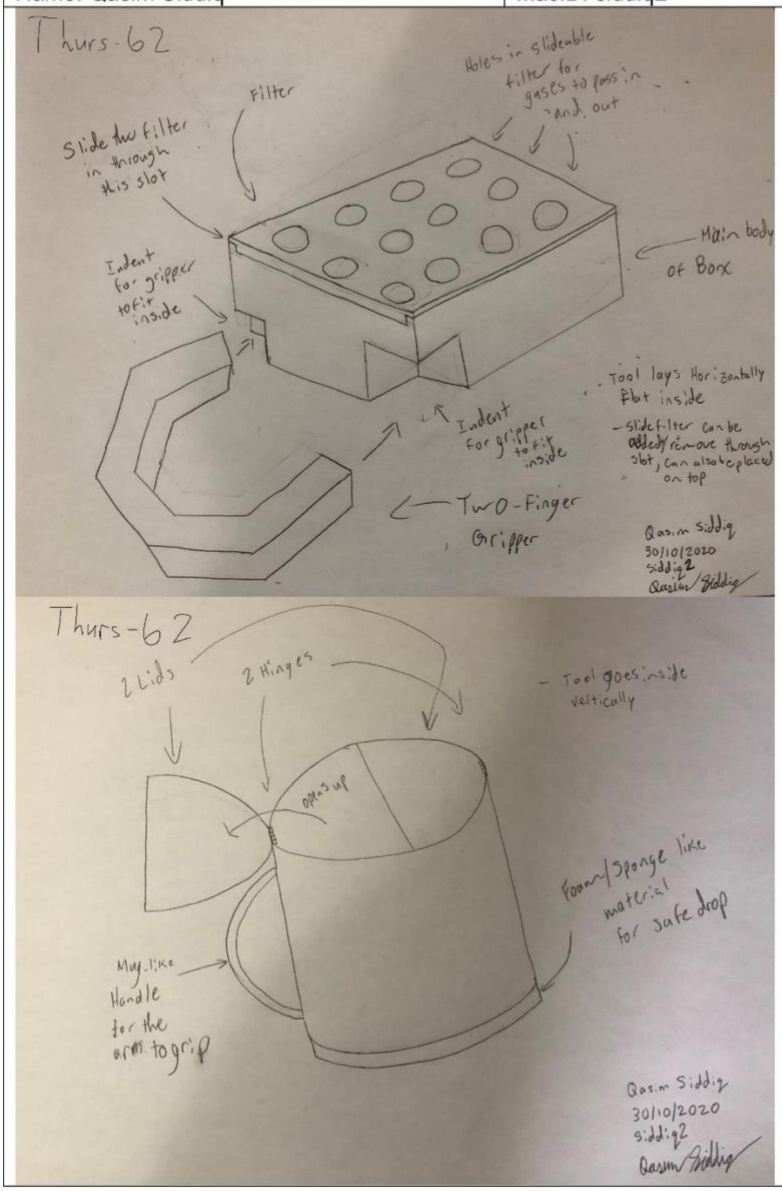


Figure 15: Milestone 1 Page 12

Team Number: Thurs-62

Name: Bradley Charko	MacID: charkb1

Insert screenshot(s) of your concept sketches below

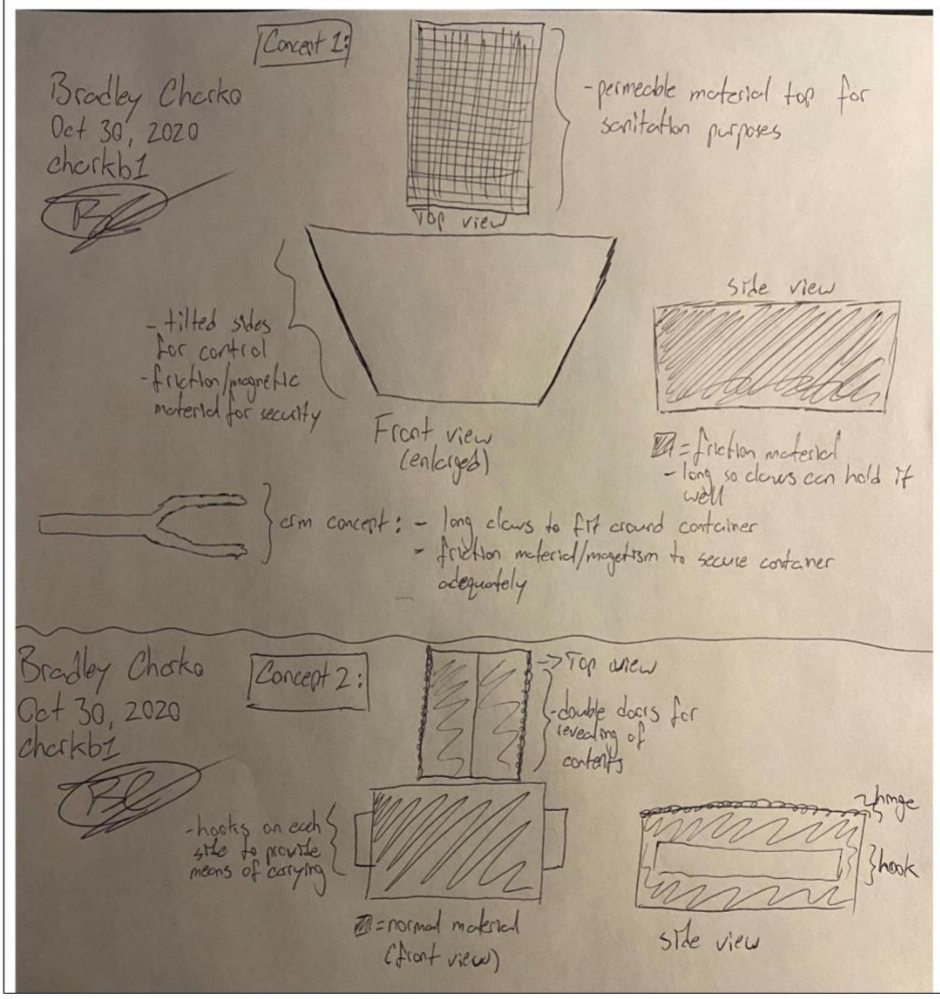


Figure 16: Milestone 1 Page 13

Team Number: Thurs-62

Name: Muhammad Sibtain Raza	MacID: razam26

Insert screenshot(s) of your concept sketches below

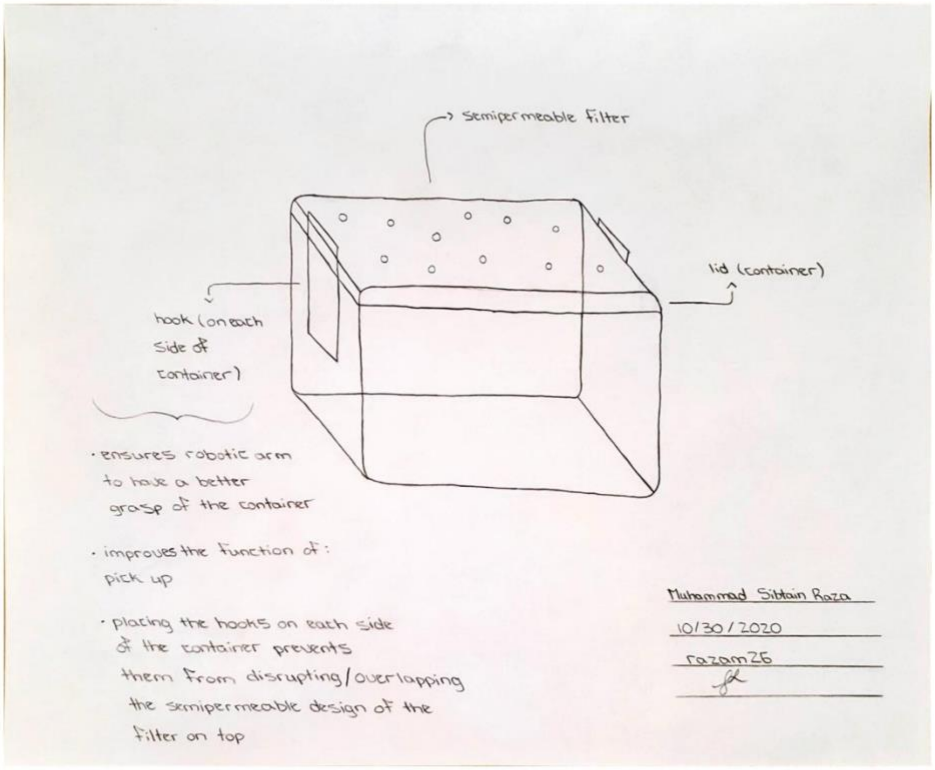


Figure 17: Milestone 1 Page 14

Team Number: Thurs-62

Name: Muhammad Sibtain Raza	MacID: razam26

Insert screenshot(s) of your concept sketches below

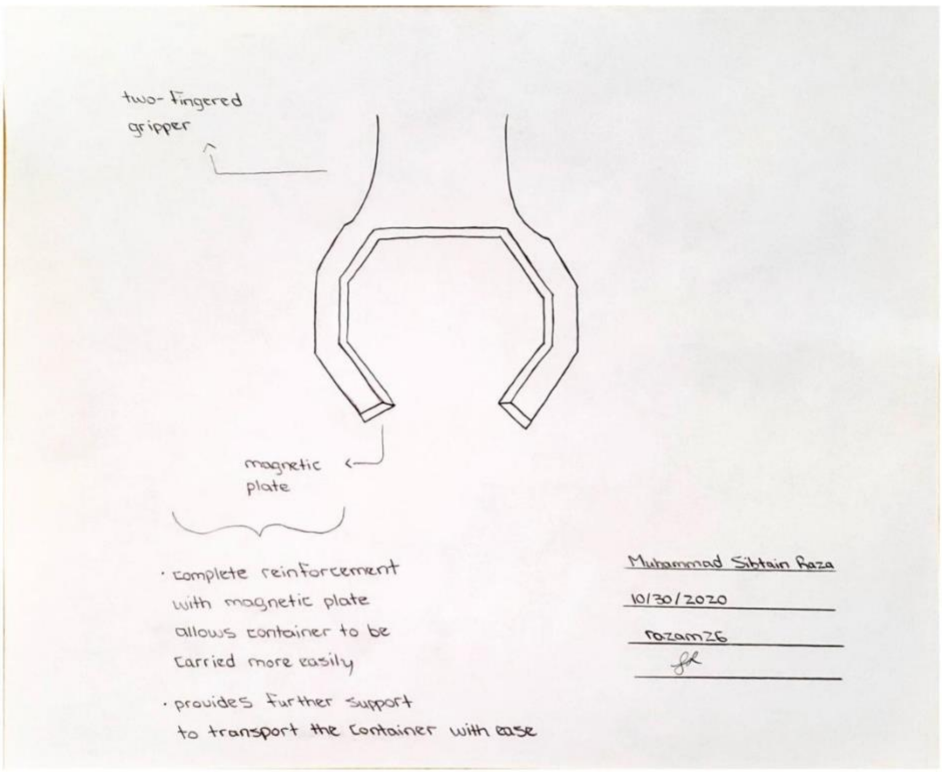


Figure 18: Milestone 1 Page 15

Team Number: Thurs-62

Name: Omar Muhammad	MacID: muhammao

Insert screenshot(s) of your concept sketches below

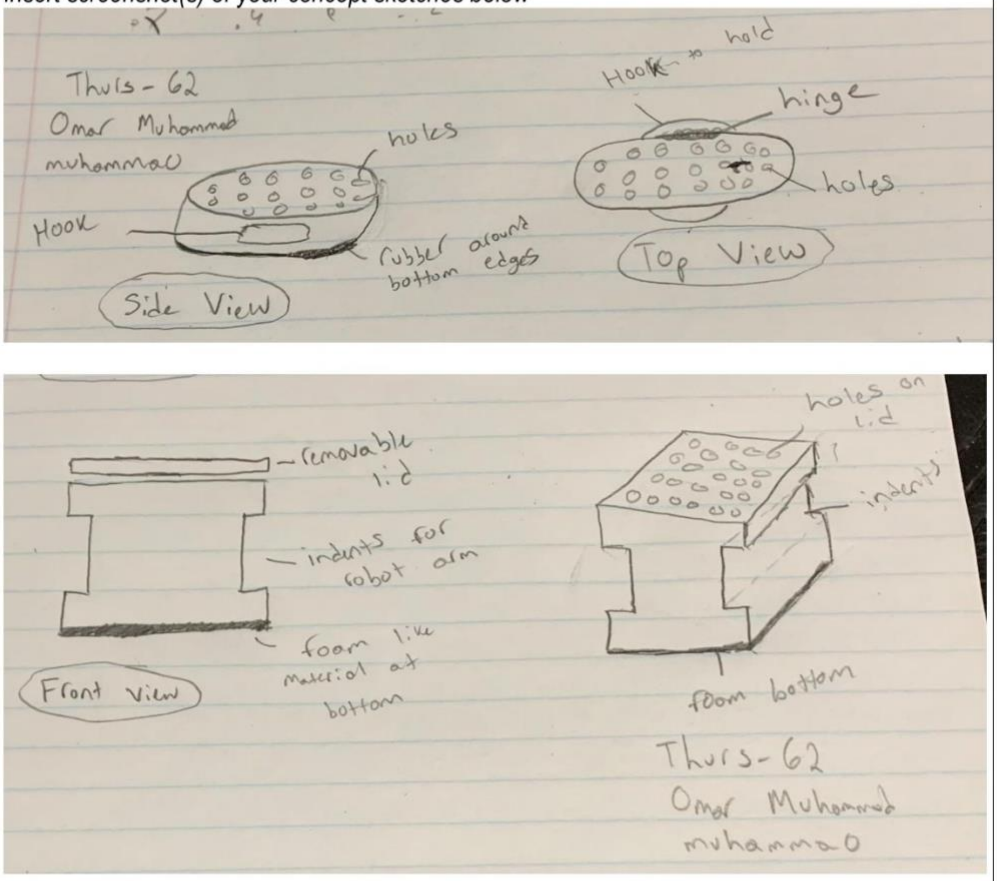


Figure 19: Milestone 1 Page 16

Milestone 2

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team Number: Thurs-62

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

Full Name:	MacID:
Omar Muhammad	muhammao
Qasim Siddiq	siddiq2
Dennis Fong	fongd1
Bradley Charko	charkb1
Muhammad Sibtain Raza	razam26

Figure 20: Milestone 2 Page 1

MILESTONE 2 (STAGE 1) – REFINED CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team Number: Thurs-62

You should have already completed this task individually prior to Design Studio 8.

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 refined 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 3*** of the milestone

Figure 21: Milestone 2 Page 2

Team Number: Thurs-62

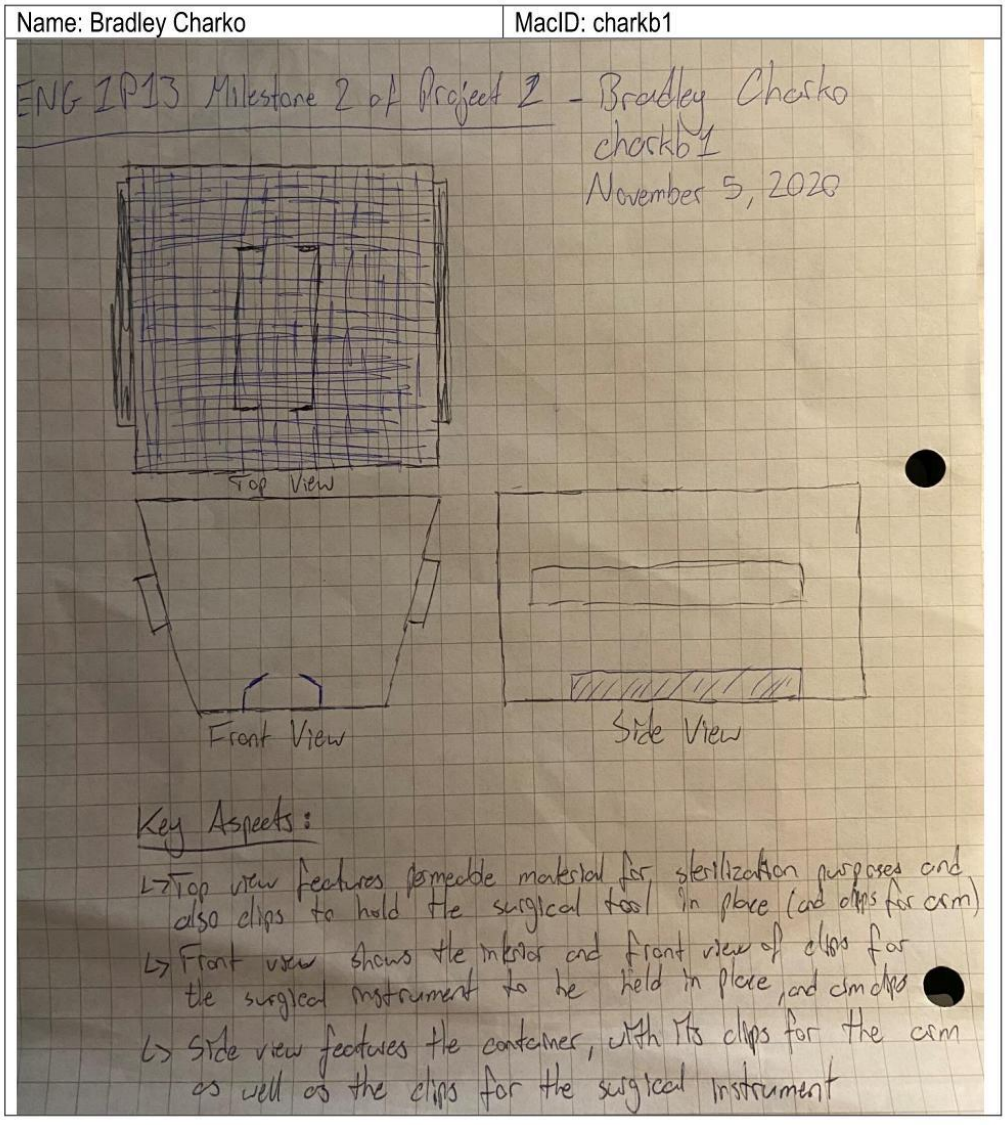
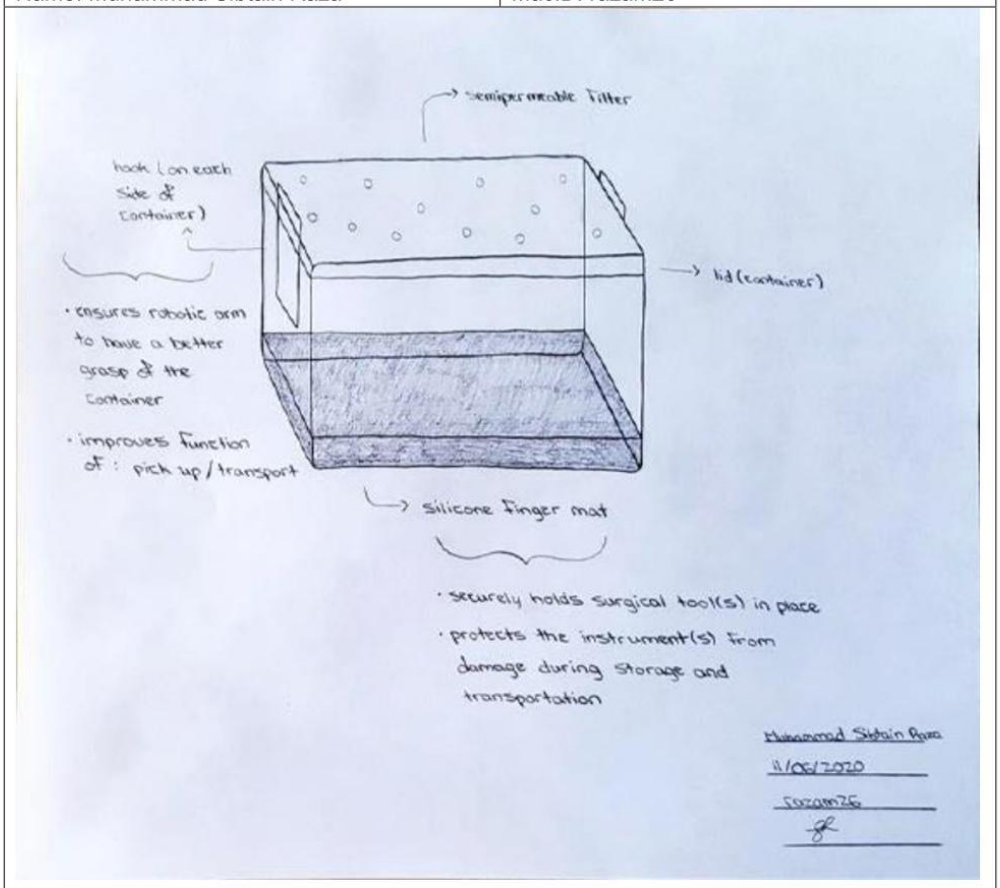


Figure 22: Milestone 2 Page 3

Team Number: Thurs-62

Name: Muhammad Sibtain Raza	MacID: razam26



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

Figure 23: Milestone 2 Page 4

MILESTONE 2 (STAGE 2) – COMPUTER PROGRAM WORKFLOW (COMPUTATION SUB-TEAM)

Team Number: Thurs-62

You should have already completed this task individually prior to Design Studio 8.

1. Copy-and-paste each team member's storyboard or flowchart sketches on the following pages (1 team member 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 storyboard/flowchart 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

Figure 24: Milestone 2 Page 5

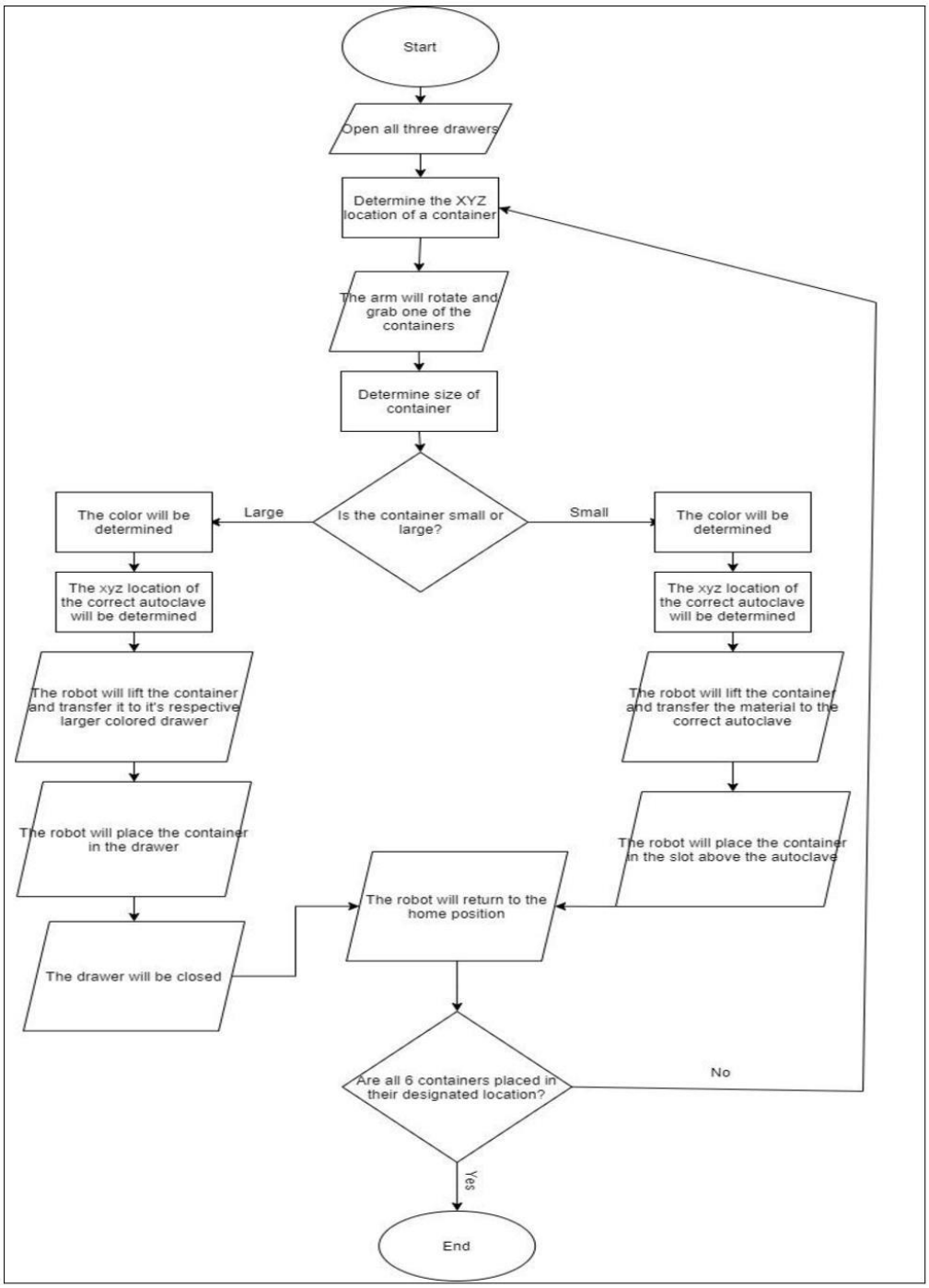


Figure 25: Milestone 2 Page 6

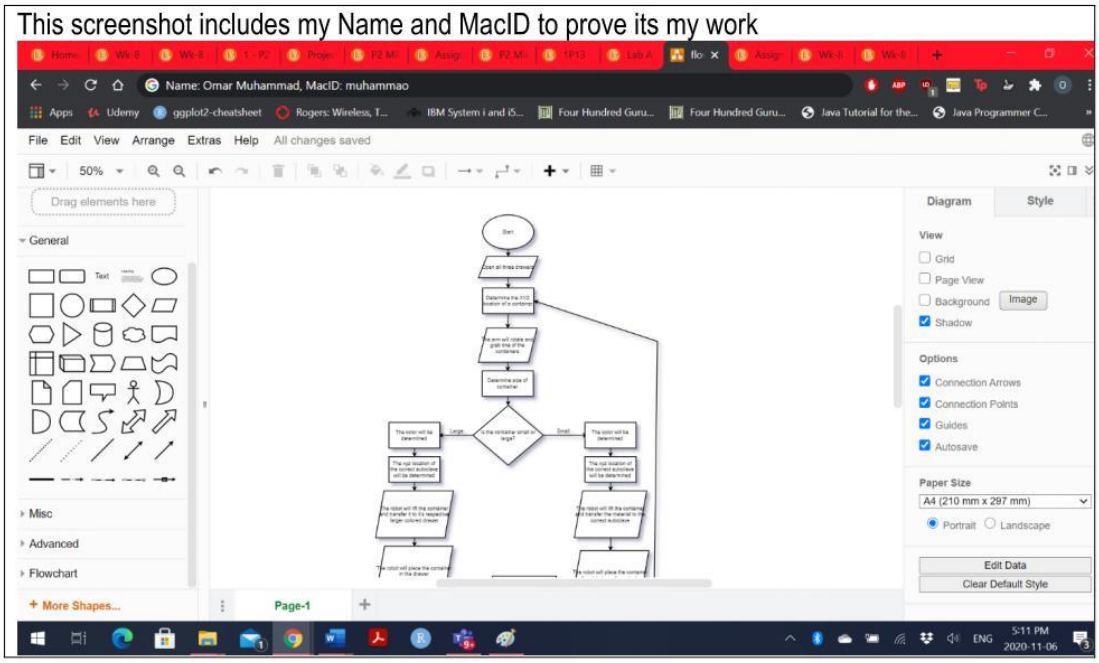


Figure 26: Milestone 2 Page 7

Team Number: Thurs-62

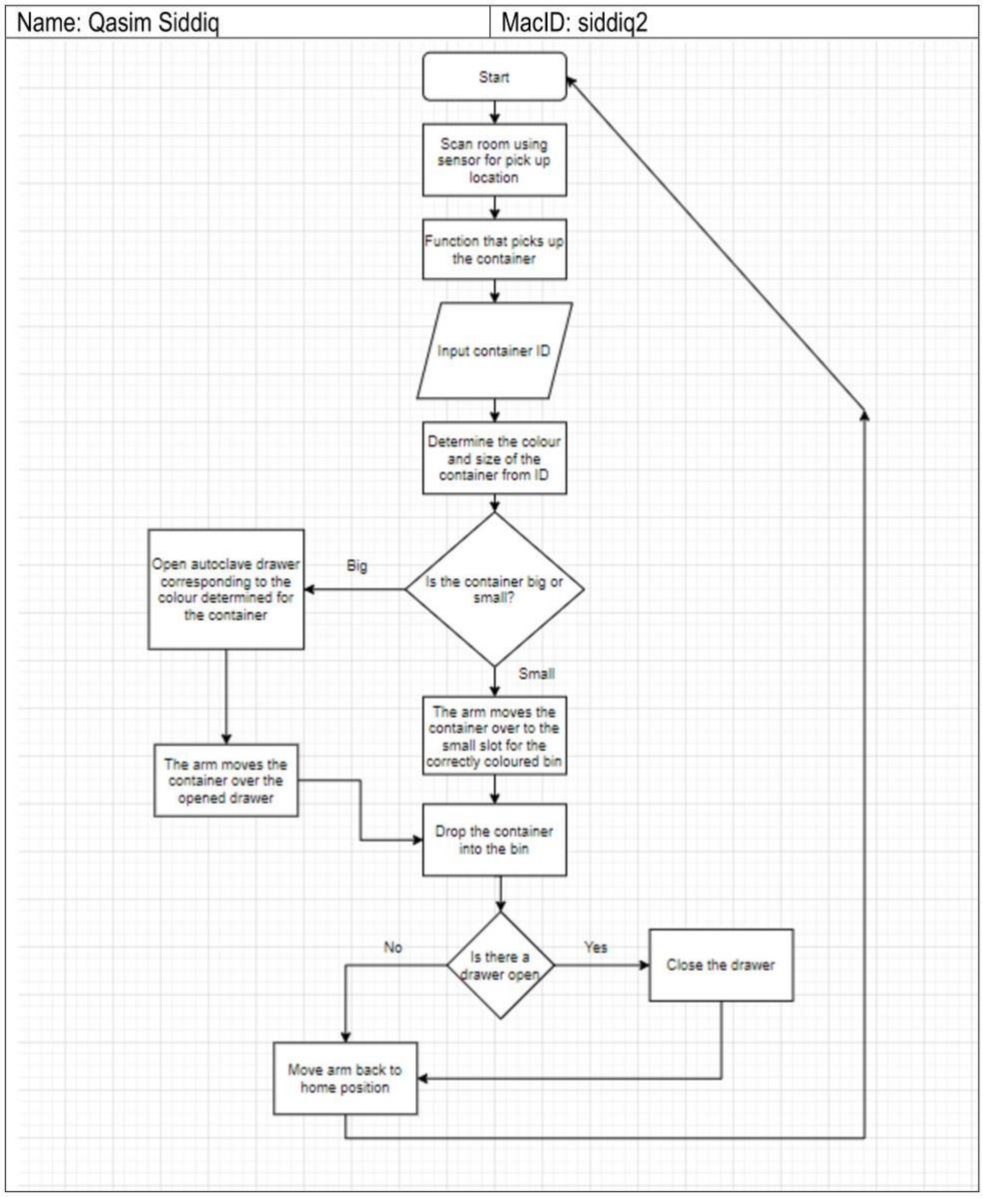


Figure 27: Milestone 2 Page 8

Team Number: Thurs-62

Name: Dennis Fong | MacID: fongd1

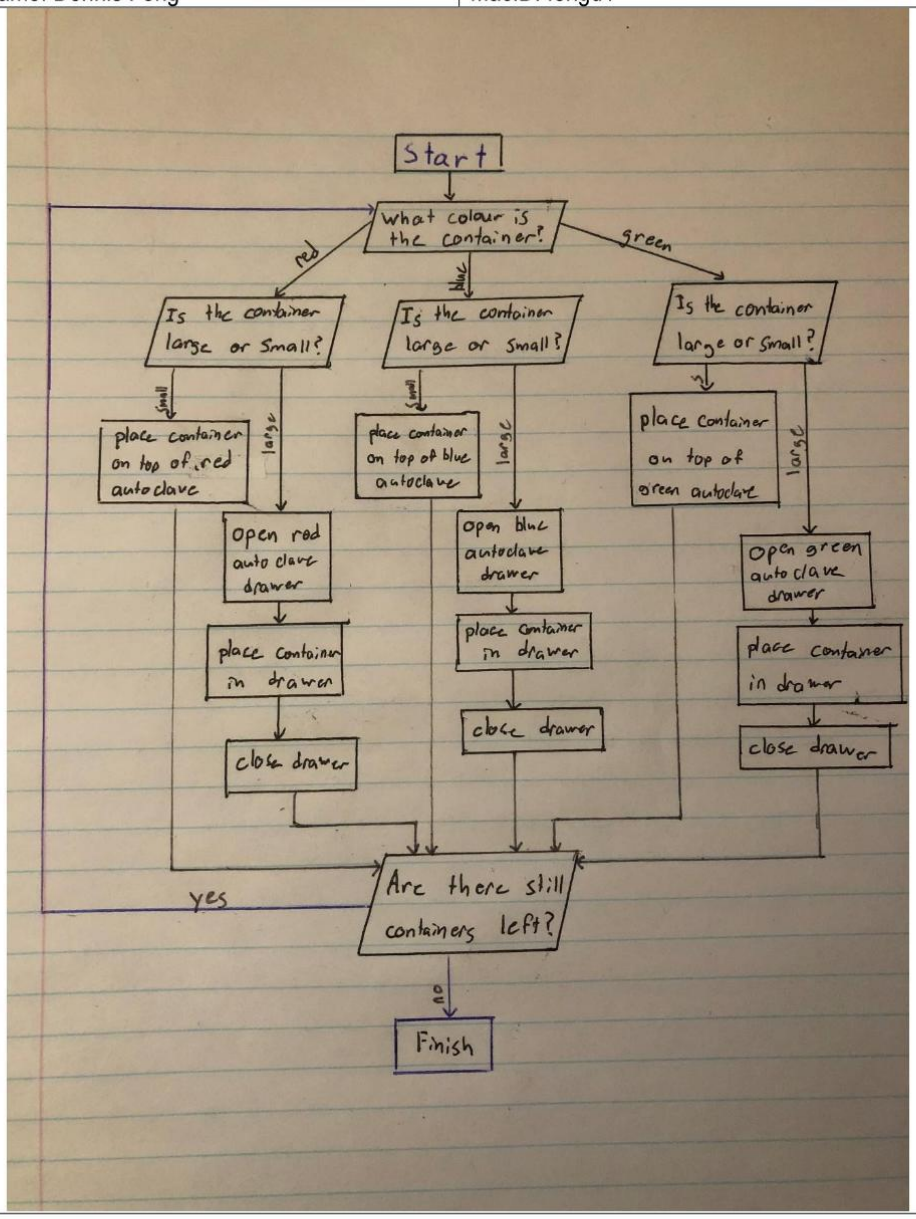


Figure 28: Milestone 2 Page 9

MILESTONE 2 (STAGE 3A) – LOW-FIDELITY PROTOTYPE (MODELLING SUB-TEAM)

Team Number: Thurs-62

Complete this worksheet during design studio 8 after creating the low-fidelity prototypes.

1. Take multiple photos of your low-fidelity prototypes
   → Include an index card (or similar) next to the prototype, clearly indicating your Team Number, Name and MacID on *each* sketch
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* prototype photo's per page**

Make sure to include photos of each team member's prototype

Figure 29: Milestone 2 Page 10

Team Number: Thurs-62

Name: Bradley Charko	MacID: charkb1

Figure 30: Milestone 2 Page 11

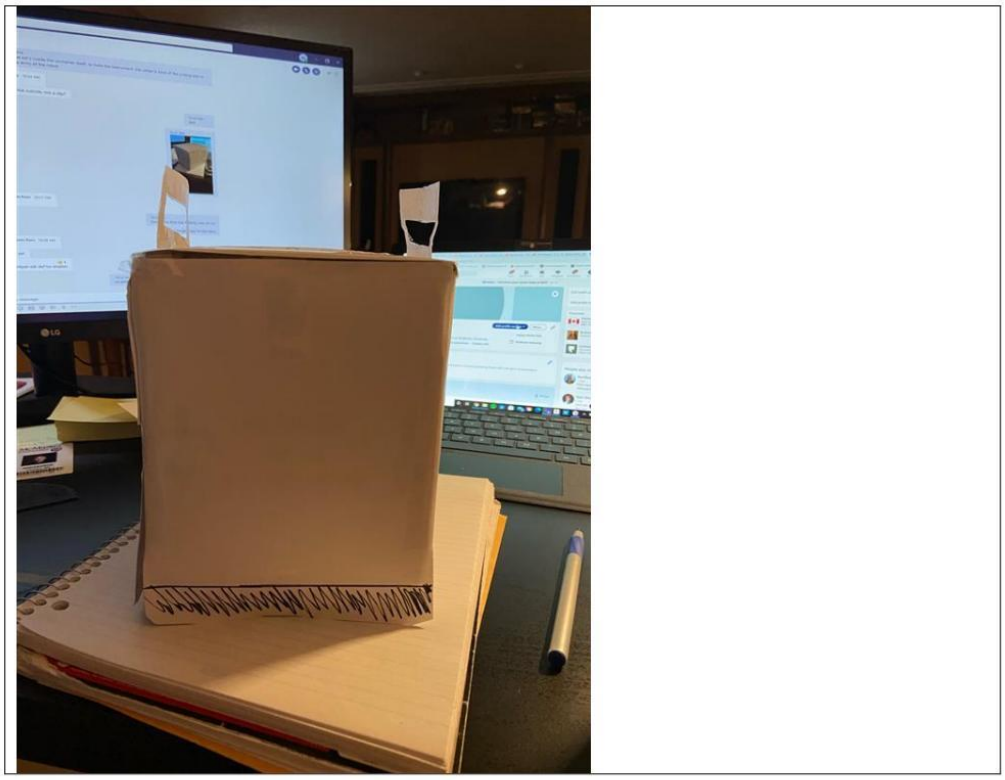


Figure 31: Milestone 2 Page 12

Figure 32: Milestone 2 Page 13

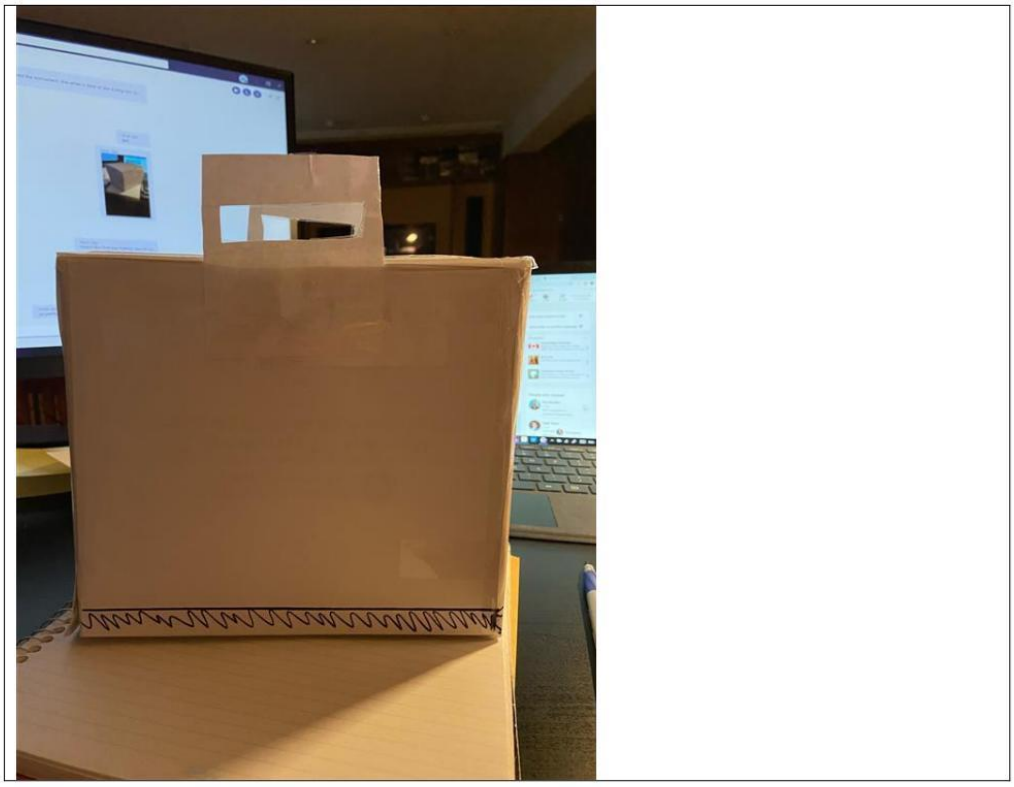


Figure 33: Milestone 2 Page 14

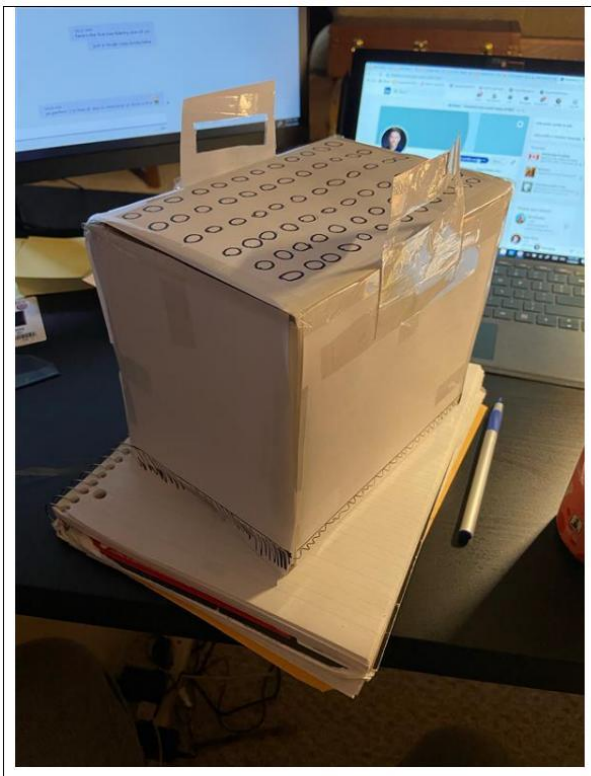
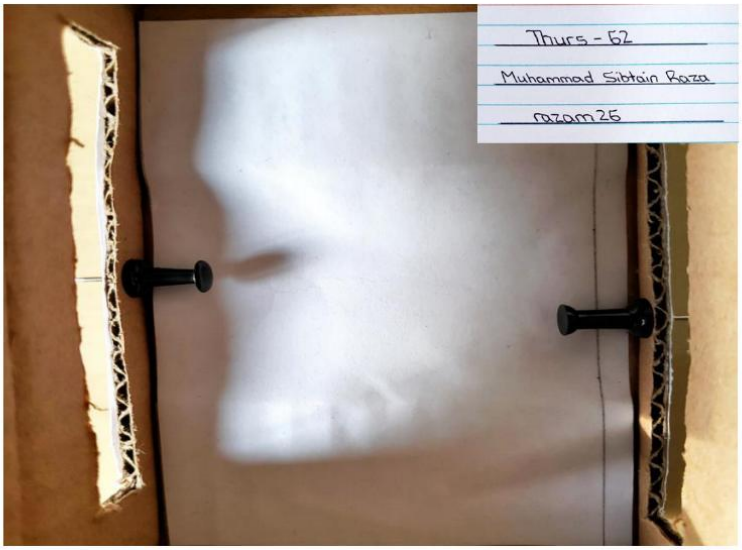


Figure 34: Milestone 2 Page 15

Team Number: Thurs-62

Name: Muhammad Sibtain Raza	MacID: razam26

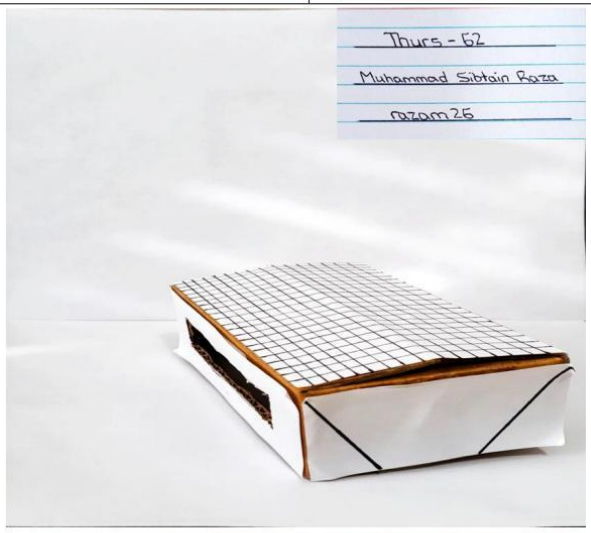


*If you are in a sub-team of 3, please copy and paste the above on a new page

Figure 35: Milestone 2 Page 16

Team Number: Thurs-62

Name: Muhammad Sibtain Raza	MacID: razam26



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

Figure 36: Milestone 2 Page 17

MILESTONE 2 (STAGE 3B) – LOW-FIDELITY PROTOTYPE OBSERVATIONS (MODELLING SUB-TEAM)

Team Number: Thurs-62

As a team, document your observations for each low-fidelity prototype. Make sure to label your observations to indicate which prototype it belongs to. As a starting, consider the following: (note, this does not fully encompass all discussion points)

→ Advantages and disadvantages of each prototype
→ Extent to which each concept aligns (or does not align) with the List of Objectives, Constraints, and Functions you came up with for Milestone 1
→ Reliability of the design in picking up the surgical tool
→ Reliability of the design in securing the surgical tool
→ Extent to which it allows for tool sterilization

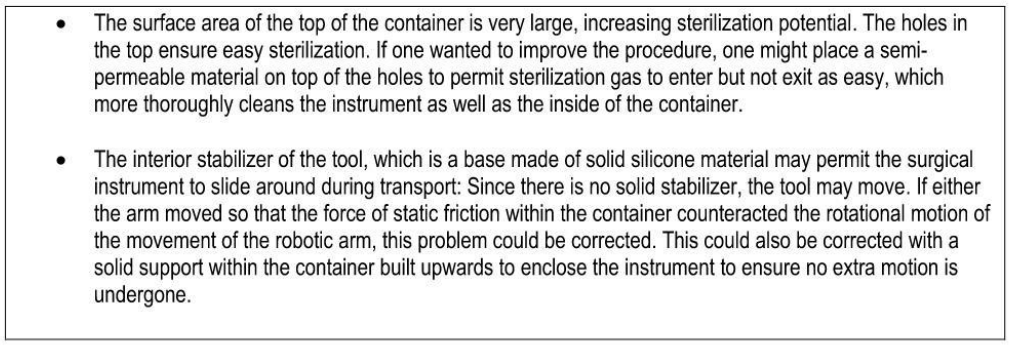
Prototype 1: (Muhammad Sibtain Raza, razam26)

- The long slot design can lead to possible disruption of sterilization process, as the big gaps on each side of the container will be unable to prevent solutes from entering the system (container); unlike a semipermeable filter.
- Placing hooks on the inside of the container ensures that the surgical tools are securely held in place. As well, it acts as additional support, which aids the container in meeting the requirements of the following constraint: being able to withstand pressure from the robotic arm, being dropped, and the process of sterilization.
- The upside-down trapezoid shape of the container (short side) is not ideal, as a trapezoid does not have four congruent vertices. This goes against the following constraint: being simple in design. As well, due to the unbalanced nature of a trapezoid, the container will be top-heavy, thus having a greater chance of being dropped during pick up/transportation.

Prototype 2: (Bradley Charko, charkb1)

- Perfect size to hold a surgical instrument: A surgical instrument is generally long and thin, and the modelled container fits these parameters. To improve even further, the container may be made thinner widthwise to fit the tools even further.

Figure 37: Milestone 2 Page 18



- The surface area of the top of the container is very large, increasing sterilization potential. The holes in the top ensure easy sterilization. If one wanted to improve the procedure, one might place a semi-permeable material on top of the holes to permit sterilization gas to enter but not exit as easy, which more thoroughly cleans the instrument as well as the inside of the container.

- The interior stabilizer of the tool, which is a base made of solid silicone material may permit the surgical instrument to slide around during transport: Since there is no solid stabilizer, the tool may move. If either the arm moved so that the force of static friction within the container counteracted the rotational motion of the movement of the robotic arm, this problem could be corrected. This could also be corrected with a solid support within the container built upwards to enclose the instrument to ensure no extra motion is undergone.

Figure 38: Milestone 2 Page 19

MILESTONE 2 (STAGE 4A) – WORKFLOW PEER-REVIEW (COMPUTATION SUB-TEAM)

Team Number: Thurs-62

As a team, document your observations, specifically any similarities and differences between each team member's visual storyboard or flowchart in the table below.

Similarities

- *Identify size*
- *Identify color*
- *Identify where to place the box*
- *Loop back to beginning if all boxes are not placed*
- *Closing drawer if it is a big container after it is placed (if small then nothing is done)*
- *Transferring box*
- *Placing box*
- *Returning to home position after placement*

Differences

- *Opening the drawers at different times, the difference was either before picking up the object or after; it is better to open the drawer before picking up the object because the robot may have trouble dropping the material on the ground then opening the drawer and then placing it in, it is easier to open it before and then just place the container in the autoclave.*
- *One of the flowcharts breaks the workflow into 3 different branches based on color. From a coding perspective, this is inefficient. Instead, the container color should be determined first, and then run the same set of operations instead of three different functions. This will limit the amount of lines of code.*

Figure 39: Milestone 2 Page 20

MILESTONE 2 (STAGE 4B) – PROGRAM PSEUDOCODE (COMPUTATION SUB-TEAM)

Team Number: Thurs-62

As a team, write out a pseudocode outlining the high-level workflow of your computer program in the space below.

```
Start
Open all 3 autoclave drawers
If an autoclave slot is empty
        Determine XYZ location of a container
        Determine size and colour of the container
        If the size of the container is large
                If the colour of the red, green or blue
                Determine the XYZ location of the corresponding autoclave
                Pick up the container
                Move arm to the corresponding autoclave
                Place the container into the large drawer
        If the size of the container is small
                If the colour of the red, green or blue
                Determine the XYZ location of the corresponding autoclave
                Pick up the container
                Move arm to the corresponding autoclave
                Place the container in the top slot of the autoclave
Close all 3 autoclave drawers
Finish
```

Figure 40: Milestone 2 Page 21

Milestone 3

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team Number: Thurs-62

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

Full Name:	MacID:
Dennis Fong	Fongd1
Omar Muhammad	muhammao
Qasim Siddiq	siddiq2
Muhammad Sibtain Raza	razam26
Bradley Charko	charkb1

Figure 41: Milestone 3 Page 1

MILESTONE 3 (STAGE 1) – PRELIMINARY SOLID MODEL (MODELLING SUB-TEAM)

Team Number: Thurs-62

You should have already completed this task individually prior to Design Studio 9.

1. Copy-and-paste each team member's screenshots of their preliminary solid model on the following pages (1 team member per page)
   → Be sure to clearly indicate who each model 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 solid model 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

Figure 42: Milestone 3 Page 2

Team Number: Thurs-62

Name: Muhammad Sibtain Raza	MacID: razam26

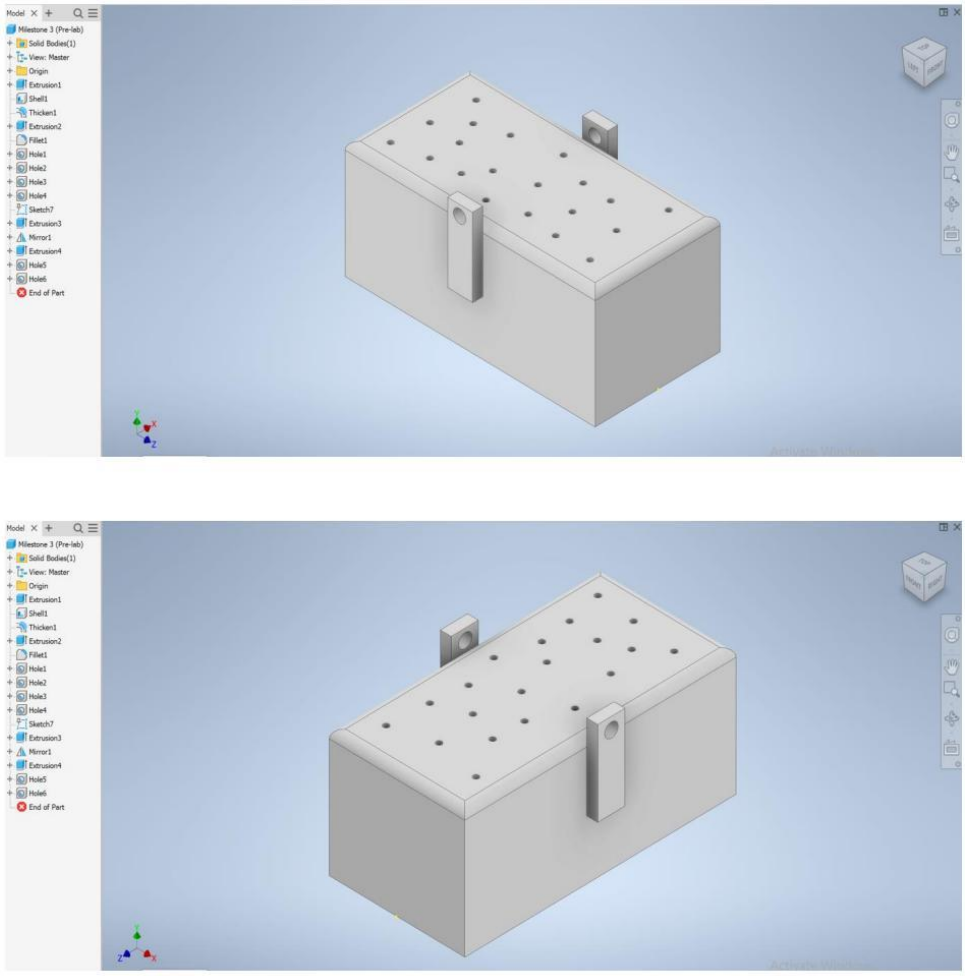


Figure 43: Milestone 3 Page 3

Team Number: Thurs-62

Name: Bradley Charko	MacID: charkb1

Exterior:

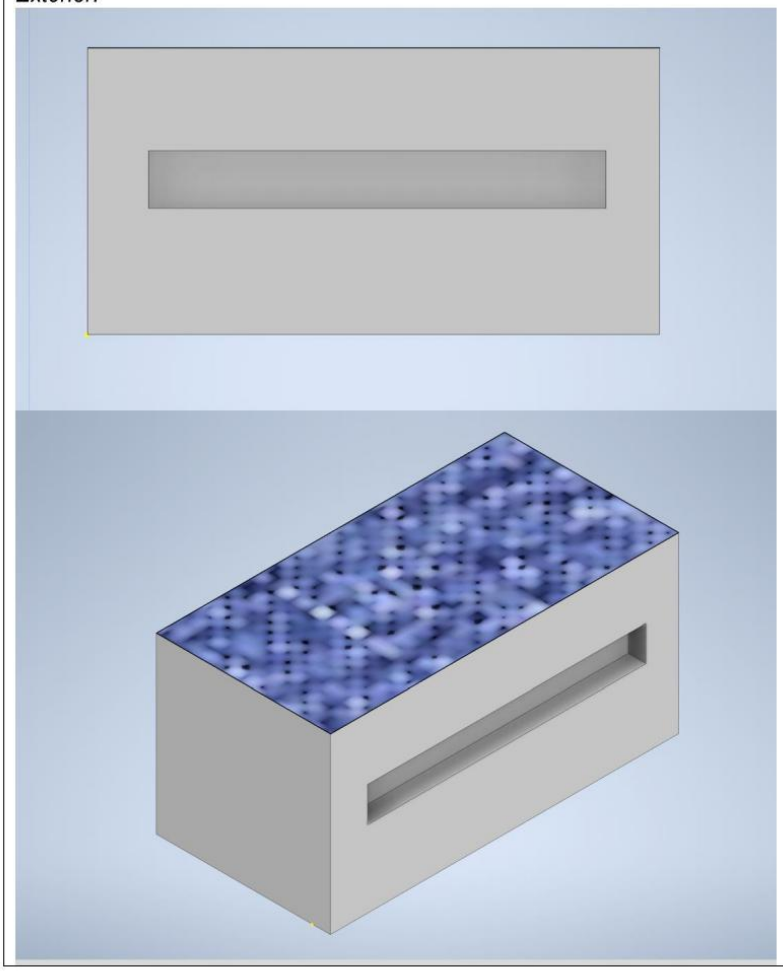


Figure 44: Milestone 3 Page 4

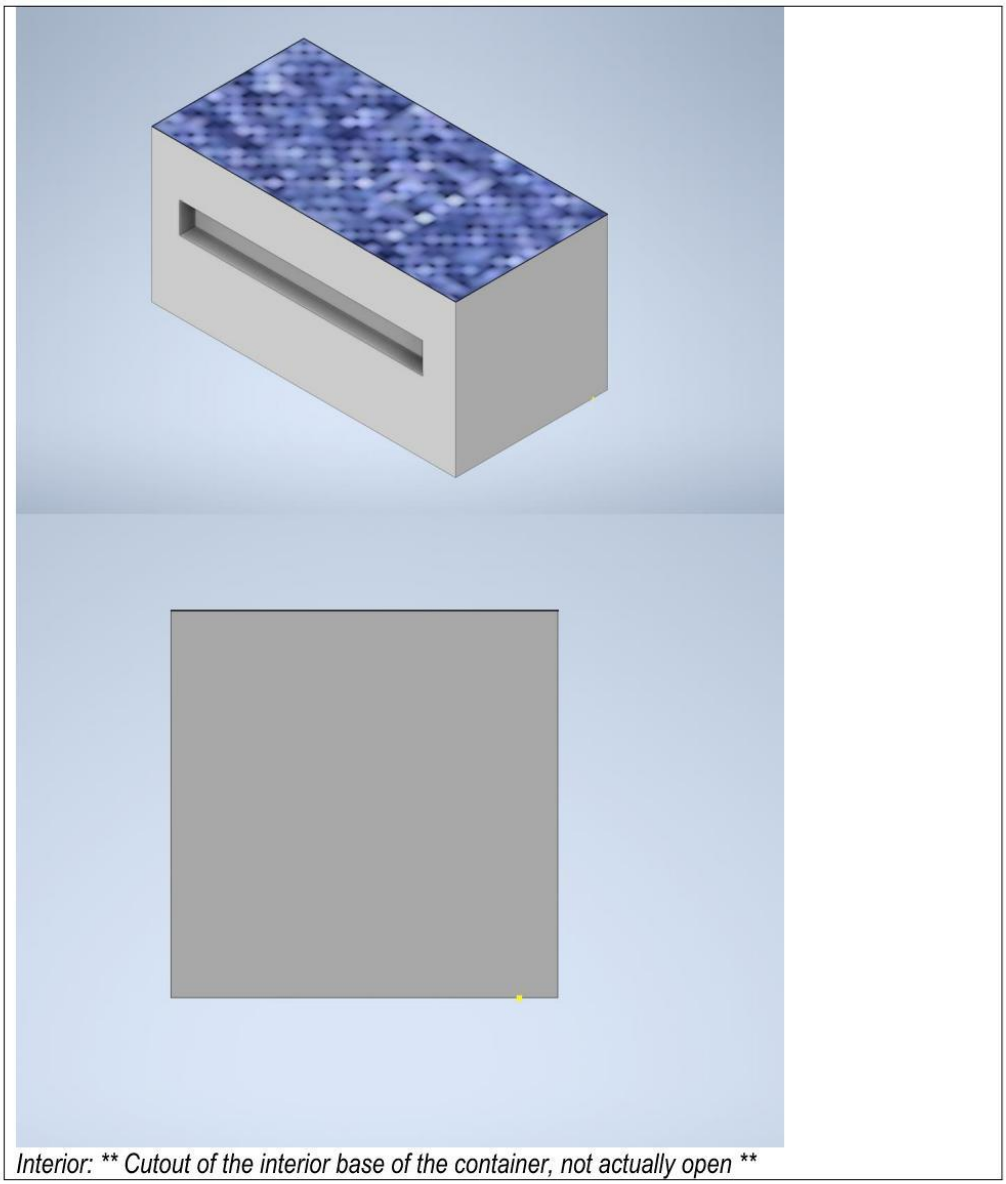
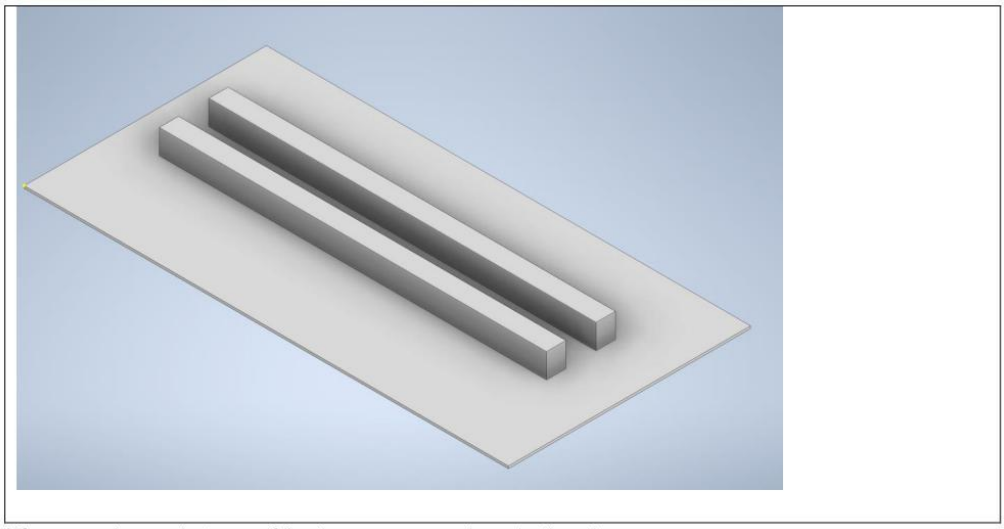


Figure 45: Milestone 3 Page 5



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

Figure 46: Milestone 3 Page 6

MILESTONE 3 (STAGE 2) – PRELIMINARY PROGRAM TASKS (COMPUTATION SUB-TEAM)

Team Number: Thurs-62

You should have already completed this task individually prior to Design Studio 9.

1. Copy-and-paste each team member's code screenshots on the following pages (1 team member per page)
   → 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 code 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 4*** of the milestone

Figure 47: Milestone 3 Page 7

Team Number: Thurs-62

Name: Qasim Siddiq	MacID: siddiq2

```
sys.path.append('../')

from Common_Libraries.p2_lib import *

import os
from Common_Libraries.repeating_timer_lib import repeating_timer

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

arm = qarm()

update_thread = repeating_timer(2, update_sim)
## ************************************************
## DO NOT EDIT ANY OF THE CODE ABOVE THIS LINE
## ************************************************



def identify_bin_location(Container_ID):
    if Container_ID == 1:                #Small Red
        bin_location = [-0.5678, 0.2237, 0.3459]
    elif Container_ID == 2:              #Small Green
        bin_location = [0.0, -0.6252, 0.3397]
    elif Container_ID == 3:              #Small Blue
        bin_location = [0.0, 0.6252, 0.3397]
    elif Container_ID == 4:              #Large Red
        bin_location = [-0.4028, 0.1587, 0.2374]
    elif Container_ID == 5:              #Large Green
        bin_location = [0.0, -0.4249, 0.2374]
    elif Container_ID == 6:              #Large Blue
        bin_location = [0.0, 0.4249, 0.2374]
    else:
        print("Invalid Container ID, input a number in [1,6]")
    return bin_location
```

Figure 48: Milestone 3 Page 8

Team Number: Thurs-62

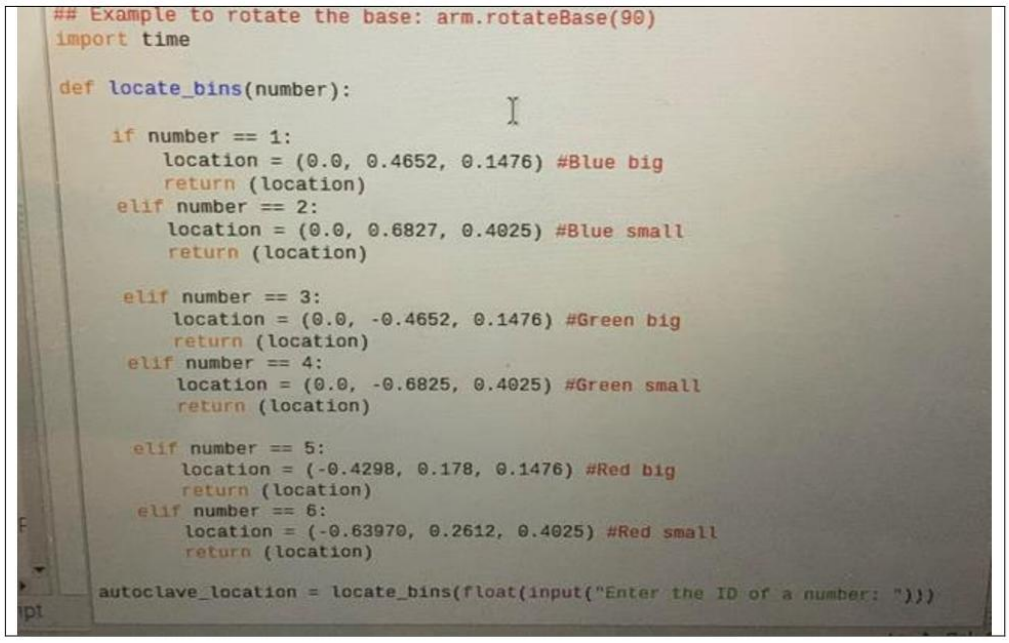
Name: Dennis Fong	MacID: fongd1

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

from Common_Libraries.p2_lib import *

import os
from Common_Libraries.repeating_timer_lib import repeating_timer

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

arm = qarm()

update_thread = repeating_timer(2, update_sim)

#----------------------------

def arm_move(n):
    bin_location = identify_bin_location(Container_ID)
    time.sleep(2)
    arm.move_arm(0.4498, 0.0, 0.0068) #Placeholder variable names for container
    time.sleep(2)
    arm.control_gripper(45)
    time.sleep(2)
    arm.move_arm(0.4064, 0.0, 0.4826)
    time.sleep(2)
    arm.move_arm(bin_location[0], bin_location[1], bin_location[2]
    time.sleep(2)
    arm.control_gripper(-45)
    arm.home()
```

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

Name: Omar Muhammad	MacID: muhammao

Figure 49: Milestone 3 Page 9



```
## Example to rotate the base: arm.rotateBase(90)
import time

def locate_bins(number):

    if number == 1:
        location = (0.0, 0.4652, 0.1476) #Blue big
        return (location)
    elif number == 2:
        location = (0.0, 0.6827, 0.4025) #Blue small
        return (location)

    elif number == 3:
        location = (0.0, -0.4652, 0.1476) #Green big
        return (location)
    elif number == 4:
        location = (0.0, -0.6825, 0.4025) #Green small
        return (location)

    elif number == 5:
        location = (-0.4298, 0.178, 0.1476) #Red big
        return (location)
    elif number == 6:
        location = (-0.63970, 0.2612, 0.4025) #Red small
        return (location)

autoclave_location = locate_bins(float(input("Enter the ID of a number: ")))
```

Figure 50: Milestone 3 Page 10

MILESTONE 3 (STAGE 3) – PUGH MATRIX (MODELLING SUB-TEAM)

Team Number: Thurs-62

1. As a team, evaluate your designs for the sterilization container in the table below
   - → List your Criteria in the first column
     - You should include a minimum of 5 criteria
   - → Fill out the table below, comparing your designs against the given baseline
     - Replace "Design A" and "Design B" with more descriptive labels (e.g., a distinguishing feature or the name of the student author)
     - Assign the datum as the baseline for comparison
     - Indicate a "+" if a concept is better than the baseline, a "–" if a concept is worse, or a "S" if a concept is the same

	Datum	M. Sibtain Raza	Bradley Charko
Accessibility	S	S	-
Containment	S	S	S
Sterilization	S	-	S
Simplicity of design	S	+	+
Ability to be held by the arm	S	+	+
Total +	0	2	2
Total –	0	1	1
Total Score	0	1	1

*For a team of 3, click the top-right corner of the table to "Add a New Column"

2. Propose one or more suggested design refinements moving forward

- Improve the procedure of sterilization, by replacing the holes on top of the container with a semipermeable material; permits gas (sterilization) to enter but not exit as easy, which allows for proper sterilization of the surgical tools.
- Improve balance of container by removing side-oriented chamfer (Bradley's design)

Figure 51: Milestone 3 Page 11

MILESTONE 3 (STAGE 4A) – CODE PEER-REVIEW (COMPUTATION SUB-TEAM)

Team Number: Thurs-62

Document any errors and/or observations for each team member's preliminary Python program in the space below

Identify Autoclave Bin Location Task	**Team Member Name**: Qasim Siddiq, Omar Muhammad
- *The returned location must be stored as a variable when calling the function (i.e. bin_location = identify_bin_location(Container_ID)* - *The location of the gripper is not exact enough* - *Use a while loop instead of a for loop (helps when using counter)* - Add a condition if an ID out of range is inputted	

Move End-Effector Task	**Team Member Name**:
- Time.sleep to be added between line 33 and line 34 - Function variable name changed to match the identify autoclave bin location variable - Remove a time.sleep after receiving the bin location as it is an unnecessary delay - Had to change location values to match with values in the identify autoclave bin location function - Changed time.sleep values to be longer during drop off to ensure the arm is not moving while dropping off the containers	

Figure 52: Milestone 3 Page 12

MILESTONE 3 (STAGE 4B) – PROGRAM TASK PSEUDOCODE (COMPUTATION SUB-TEAM)

Team Number: Thurs-62

As a team, write out the pseudocode for each of the *remaining* tasks in your computer program in the space below.

Control Gripper

```
Both muscle emulator sensors return a value of variable n
multiply n by a co-efficient
control gripper angle will be co-efficient times n
```

Open Autoclave Bin Drawer

```
If muscle emu value (Left) =/= 0 and muscle emu value (Right) = 0
        Q-arm identifies container ID
        Opens autoclave drawer for corresponding container ID
Else:
        Close all drawers
```

Continue or Terminate

```
Variable = 0
While Variable < 6:
        Move arm to container location
        Pick up container
        Move arm to corresponding autoclave location
        Let go of container
        Variable += 1
```

Figure 53: Milestone 3 Page 13

Milestone 4

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team Number: Thurs-62

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

Full Name:	MacID:
Qasim Siddiq	siddiq2
Omar Muhammad	muhammao
Dennis Fong	fongd1
Bradley Charko	charkb1
Muhammad Sibtain Raza	razam26

Figure 54: Milestone 4 Page 1

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

Team Number: Thurs-62

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

- Will probably need supports around the model in Prusa
- Concern about mesh top layer not showing up in 3D printing, however IAI gave the go ahead for it as a theoretical idea

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

- Change main extrusion height to 27mm to facilitate better hold by the gripper
- Add supports in PRUSA, new print time is 1hr37min, new mass is 16.0g
- Constrain lid to showcase its sliding ability

Figure 55: Milestone 4 Page 2

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

Team Number: Thurs-62

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

- Can only use each combination of muscle sensors once (i.e. the control gripper function only uses the left muscle sensor at 1 and right at zero and no other function can use that setup)
    - Functions that use the muscle sensors
        - Control gripper
        - Move end effector
        - Open/close autoclave bin drawer

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

- Rewrite the three functions to incorporate the muscle sensors in the following manner
    - The control gripper function will use both the left and the right muscle sensors (L=1 & R=1)
    - The move end effector function will use the left muscle sensor (L=1 & R=0)
    - The open/close autoclave bin drawer will use the right muscle sensor (L=0 & R=1)

Figure 56: Milestone 4 Page 3

List of Sources

[1]. Engineer 1P13 - McMaster University, “Project 2, Project Module,” *McMaster University Avenue to Learn*, 08-Sep-2020. [Online]. Available: https://avenue.cllmcmaster.ca/d2l/le/content/340370/viewContent/2899746/View. [Accessed: 07-Dec-2020].

[2]. A. S. | A. 13, “Robotic Arms Extend the Reach of UV Disinfection - USC Viterbi: School of Engineering,” 21-Apr-2020. [Online]. Available: https://viterbischool.usc.edu/news/2020/04/robotic-arms-extend-the-reach-of-uv-disinfection/. [Accessed: 07-Dec-2020].

[3]. “Flash Sterilization,” *Centers for Disease Control and Prevention*, 18-Sep-2016. [Online]. Available: https://www.cdc.gov/infectioncontrol/guidelines/disinfection/sterilization/flash.html. [Accessed: 07-Dec-2020].

Appendices

Appendix A - Screenshots of Solid Model

Figure 58: Home View of Solid Model

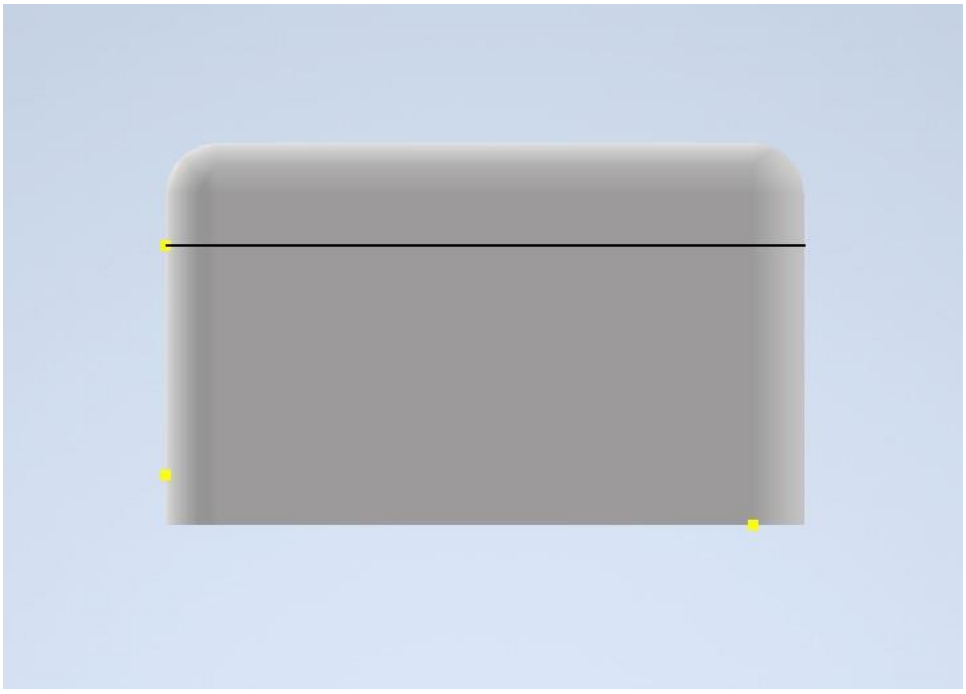


Figure 59: Rear View of Solid Model

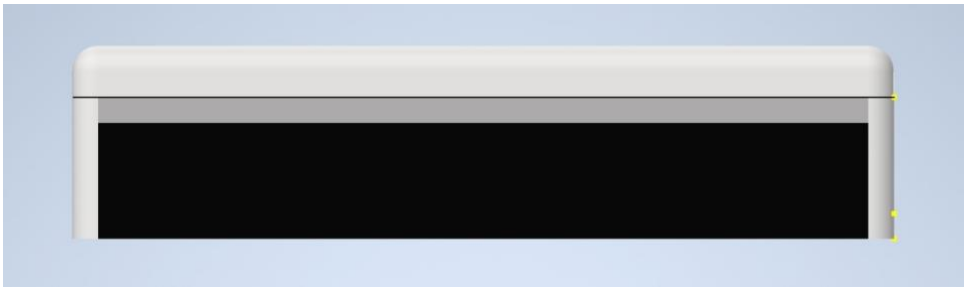


Figure 60: Side View of Solid Model

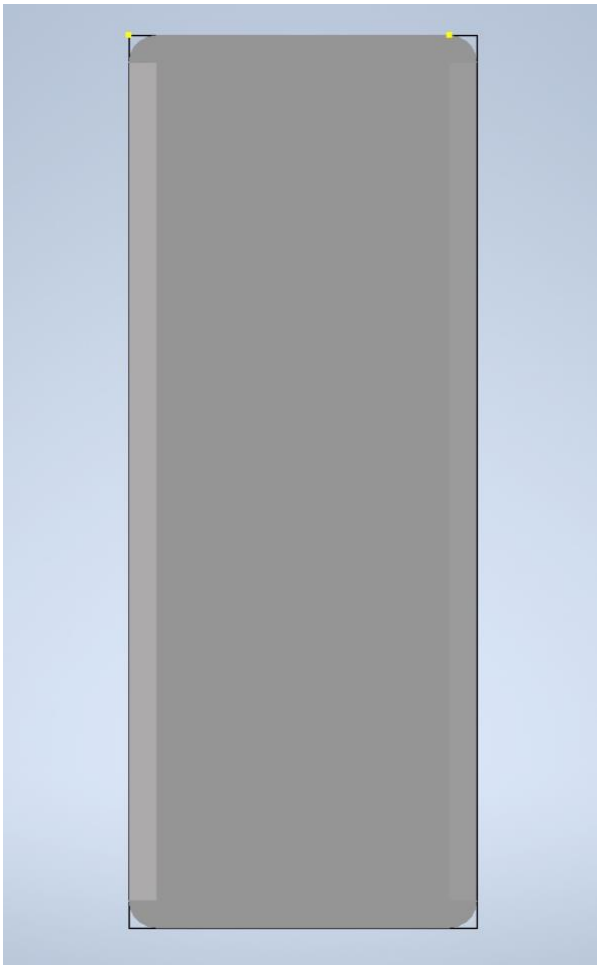


Figure 61: Bottom View of Solid Model

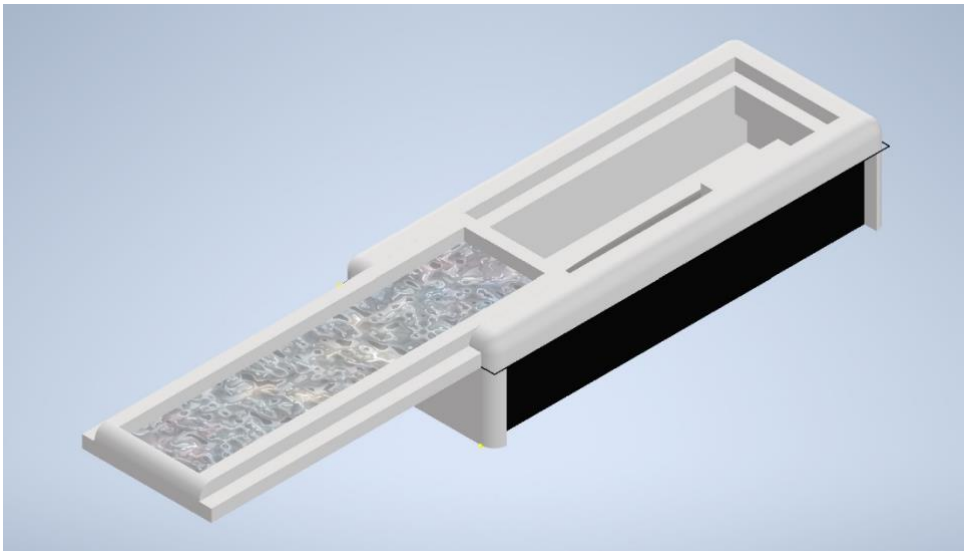


Figure 62: Home View of Solid Model (with open lid)

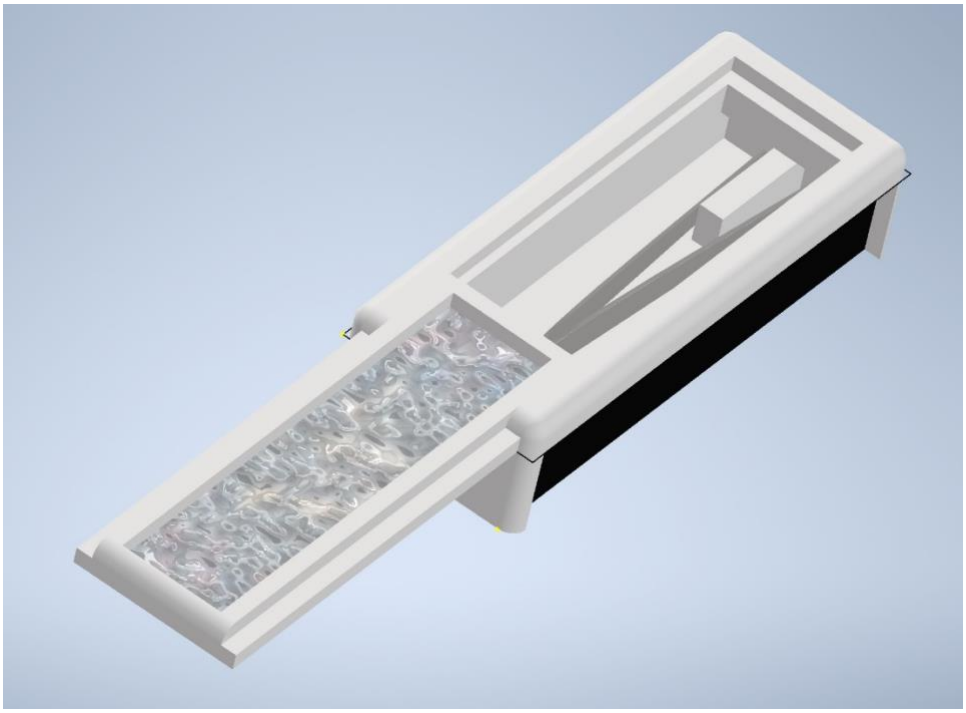


Figure 63: Top View of Solid Model (with open lid and visible tweezers)

Appendix B – Fully-dimensioned Engineering Drawing of your sterilization container design

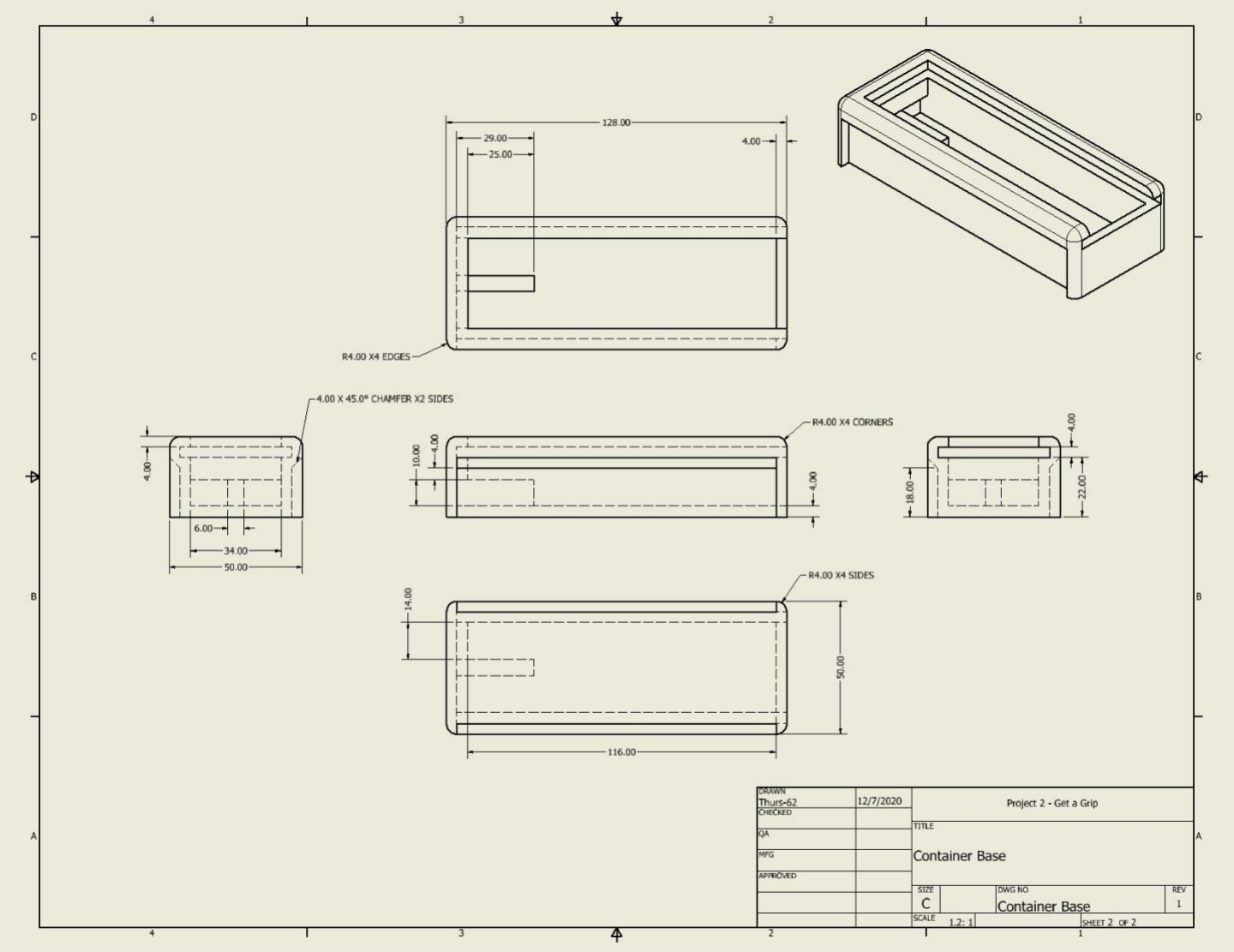


Figure 64: Fully-dimensioned Engineering Drawing of container design

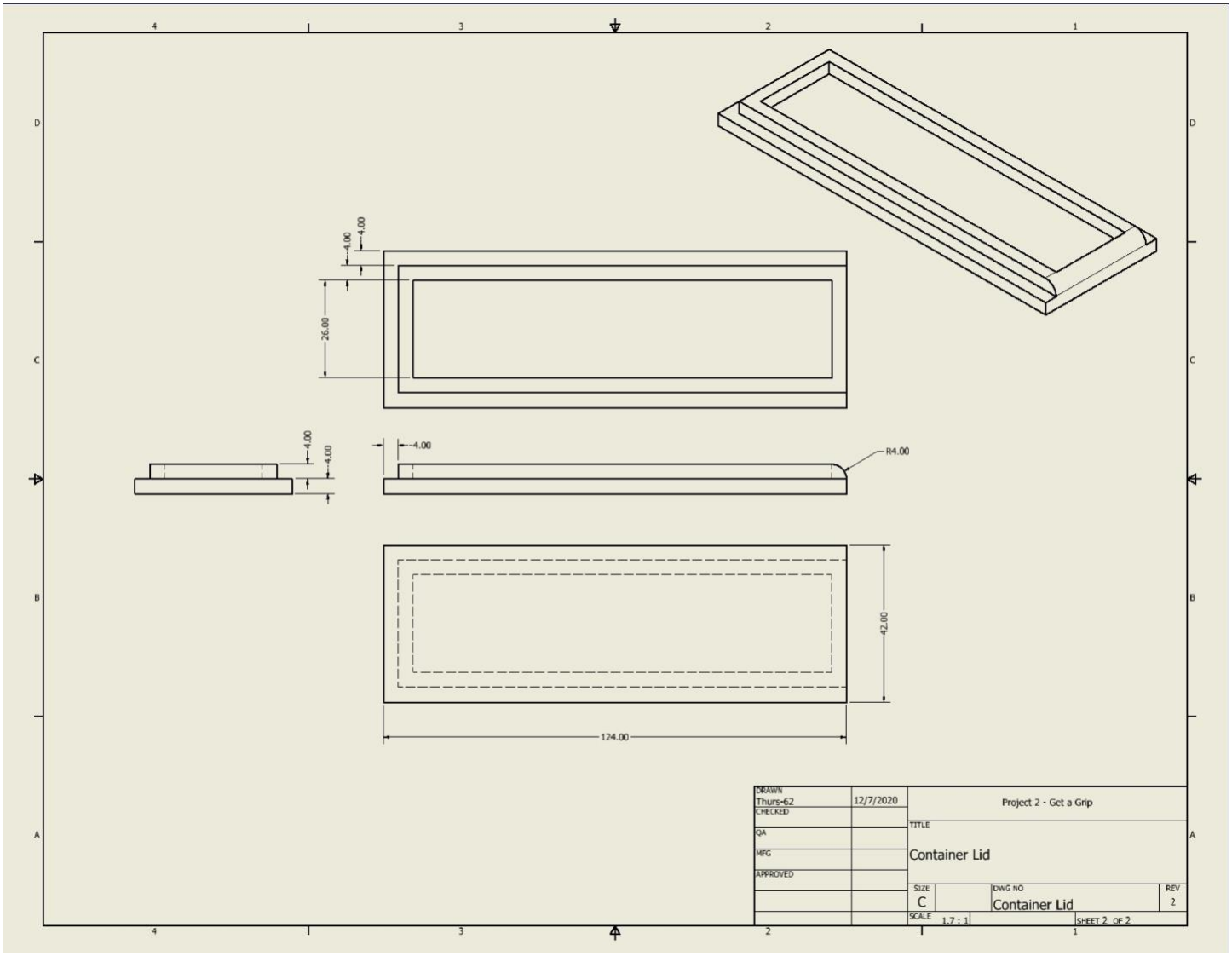


Figure 65: Fully-dimensioned Engineering Drawing of lid design

Appendix C – Screenshots of Computer Program

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

from Common_Libraries.p2_lib import *

import os
from Common_Libraries.repeating_timer_lib import repeating_timer

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

arm = qarm()

update_thread = repeating_timer(2, update_sim)
## ------------------------------------------------------------------------------

#Arm thresholds (L , R):
#go to pickup (1,0)
#grip (1,1)
#go to dropoff (1,0)
#open/close drawer (0,1)
#ungrip (0,0)

#Function takes in container_id number and returns the location of the dropoff
def locate_bins(number):
    if number == 1:
        location = [-0.5796, 0.2313, 0.3151] #Red small
        return location
    elif number == 2:
        location = [0.0, -0.6379, 0.3103] #Green small
        return location
    elif number == 3:
        location = [0.0, 0.6339, 0.3123] #Blue small
        return location
    elif number == 4:
        location = [-0.3191, 0.1263, 0.2961] #Red big
        return location
    elif number == 5:
        location = [0.0, -0.3555, 0.2549] #Green big
        return location
    elif number == 6:
        location = [0.0, 0.3555, 0.2549] #Blue big
        return location

#function takes in a true/false grip statement and depending on if
#It is true or false it will open/close the grippers
def control_gripper(grip):
    while grip == False: #Not gripping anything
        reading_L = arm.emg_left()
        reading_R = arm.emg_right()
        if reading_L == 1 and reading_R == 1:
            arm.control_gripper(45)
            time.sleep(2)
            return True
    while grip == True: #Currently gripping a container
        reading_L = arm.emg_left()
```

Figure 66: Line 1-61 of computer program

```
        reading_L = arm.emg_left()
        reading_R = arm.emg_right()
        if reading_L == 0 and reading_R == 0:
            arm.control_gripper(-45)
            time.sleep(2)
            return False

#Function takes in ID and 'initial' corresponds to the 1st and 2nd positions of
#the arm, the arm will move accordingly and return false if its at its
#second position,it will return true if it completed the cycle
def move_end_effector(ID, initial):
    while initial == True: #If object is at its initial position
        reading_L = arm.emg_left()
        reading_R = arm.emg_right()
        if reading_L == 1.0 and reading_R == 0.0:
            arm.move_arm(0.4498, 0.0, 0.0068) #container spawn coordinates
            grip_status = False #initializes control_gripper() function
            time.sleep(2)
            control_gripper(grip_status) #grip container
            arm.move_arm(0.4064, 0.0, 0.4826)
            time.sleep(2)
            return False
    while initial == False: #If object is not at its initial posiiton
        reading_L = arm.emg_left()
        reading_R = arm.emg_right()
        if reading_L == 1.0 and reading_R == 0.0:
            target = locate_bins(ID)
            arm.move_arm(target[0], target[1], target[2])
            return True

#function takes in container id, and the status of the door (true/false),
#and will open/close door accordingly (large only)
def open_close_autoclave(containerID, door_status):
    while door_status == False: #while door is closed
        reading_L = arm.emg_left()
        reading_R = arm.emg_right()
        if reading_L == 0 and reading_R == 1:
            if containerID == 4: #red
                arm.open_red_autoclave(1)
                return True #return True for next cycle (to close door)
            elif containerID == 5: #Green
                arm.open_green_autoclave(1)
                return True
            elif containerID == 6: #Blue
                arm.open_blue_autoclave(1)
                return True
    while door_status == True: #while door is open
        reading_L = arm.emg_left()
        reading_R = arm.emg_right()
        if reading_L == 0 and reading_R == 1:
            reading_L = arm.emg_left()
            reading_R = arm.emg_right()
            if containerID == 4:
                arm.open_red_autoclave(2)
                return False
            elif containerID == 5:
                arm.open_green_autoclave(2)
                return False
            elif containerID == 6:
                arm.open_blue_autoclave(2)
                return False
```

Figure 67: Line 61-121 of computer program

```
            return False

container_in_bin = [] #List to keep track of whats been put into bin
counter = 0 #How many times loop has been run

while counter != 6: #ends program if process has been run 6 times
    container_ID = random.randint(1,6) #randomly spawn one of the containers
    while True:
        if container_ID in container_in_bin: #Checks if container is already in bin
            container_ID = random.randint(1,6)
        else: #if not in bin continue with original loop
            break
    time.sleep(2)
    arm.spawn_cage(container_ID)
    while True:
        reading_L = arm.emg_left()
        reading_R = arm.emg_right()
        if container_ID >= 4:
            door_status = False #door is closed
            initial = True #at first movement step
            time.sleep(2)
            initial = move_end_effector(container_ID, initial) #move to pickup and grip
            move_end_effector(container_ID, initial) #move to dropoff
            door_status = open_close_autoclave(container_ID, door_status) #open door
            grip_status = True #gripper is holding something, therfore: "True"
            control_gripper(grip_status) #ungrip container
            open_close_autoclave(container_ID, door_status) #close door
            time.sleep(1)
            arm.home()
            container_in_bin.append(container_ID) #Keeps track finished containers
            counter += 1
            break
        else:
            initial = True
            initial = move_end_effector(container_ID, initial) #move to pickup and grip
            move_end_effector(container_ID, initial) #move to dropoff
            grip_status = True
            control_gripper(grip_status) #ungrip container
            arm.home()
            container_in_bin.append(container_ID) #add to list
            counter += 1
            break
```

Figure 68: Line 121-162 of computer program