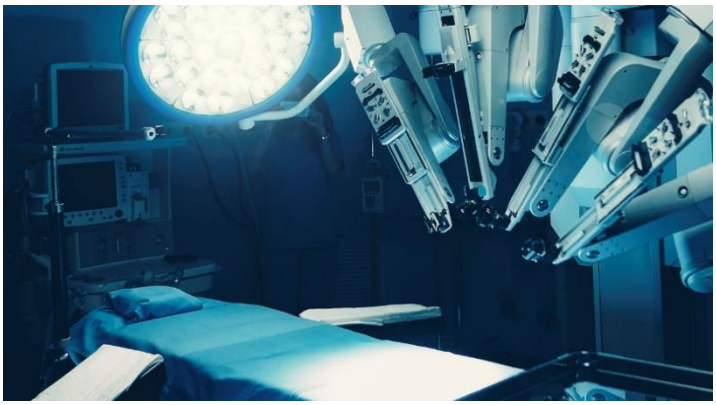
ENGINEERING

McMaster University



Project Two – Get a Grip:

Design a System for Sterilizing Surgical Tools Using Remote Sensing Actuation

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial 16

Thurs-03

Kartik Chaudhari (chaudk4)

Adam Podolak (podola2)

Kareem Shabaka (shabakak)

Wenxiao Pan (panw10)

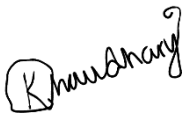
Submitted: December 9, 2020

Table of Contents

Academic Integrity Statement

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

Kartik Chaudhari 400300382

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.

Adam Podolak 400306153

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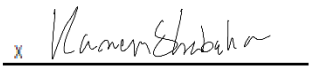
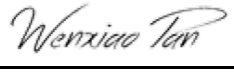
Kareem Shabaka 400294637



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.

Wenxiao Pan 400292192

X 

Executive Summary

Motivations

The unequal health care access distributed in the country is increasing the difference of lifespan between the developed regions with those underdeveloped ones. Remoted medical services seem to be the optimal solution in this era. In Project 2, we have designed a robotic arm controlled through the EMG (*Electromyography*) sensor along with a sterilization container that securely holds a surgical tool. By emulating a doctor's actions in a real surgery room, the arm can help the surgeons complete the medical tasks disconnectedly with patients. The robotic arm along with the sterilization container serve together to effectively assist in the sterilization of surgical tools.

Modelling Consideration

When designing the container, it needed to facilitate sterilizing when placed in an autoclave. Therefore, the container has many slits on all 6 faces, allowing for steam to sterilize the tweezer in an efficient manner. The container will be picked up by robotic arm that is remotely controlled, so the container needs to be able to be picked up from all directions, as it may be placed in different orientations. The handle was designed symmetrically so that the gripper can pick the container up from all sides. To hold the tweezer securely in place, 2 different parts were designed. The larger part conforms to the shape of the head of the tweezer, holding it in place, preventing it from moving left, right, up, down or backwards, ultimately restricting most degrees of freedom. The second part holds the 2 tips or arms of the tweezer, providing extra support and security. Both these parts were designed to the exact size of the tweezer, so friction can be used to securely hold the tweezer in place. Efforts were made to minimize material in several places in order to meet the mass constraint of 350 grams, particularly in the handle, lid, and the container itself. The container itself was designed to be sleek, effective, unique, and cost minimizing. However, the objectives, functions and constraints were the first priority. Many designs were tested and compared (see Design Studio Milestones), but in the end, the final concept was chosen because of its ability to satisfy the constraints, perform effectively to carry out the main functions, and meet every objective.

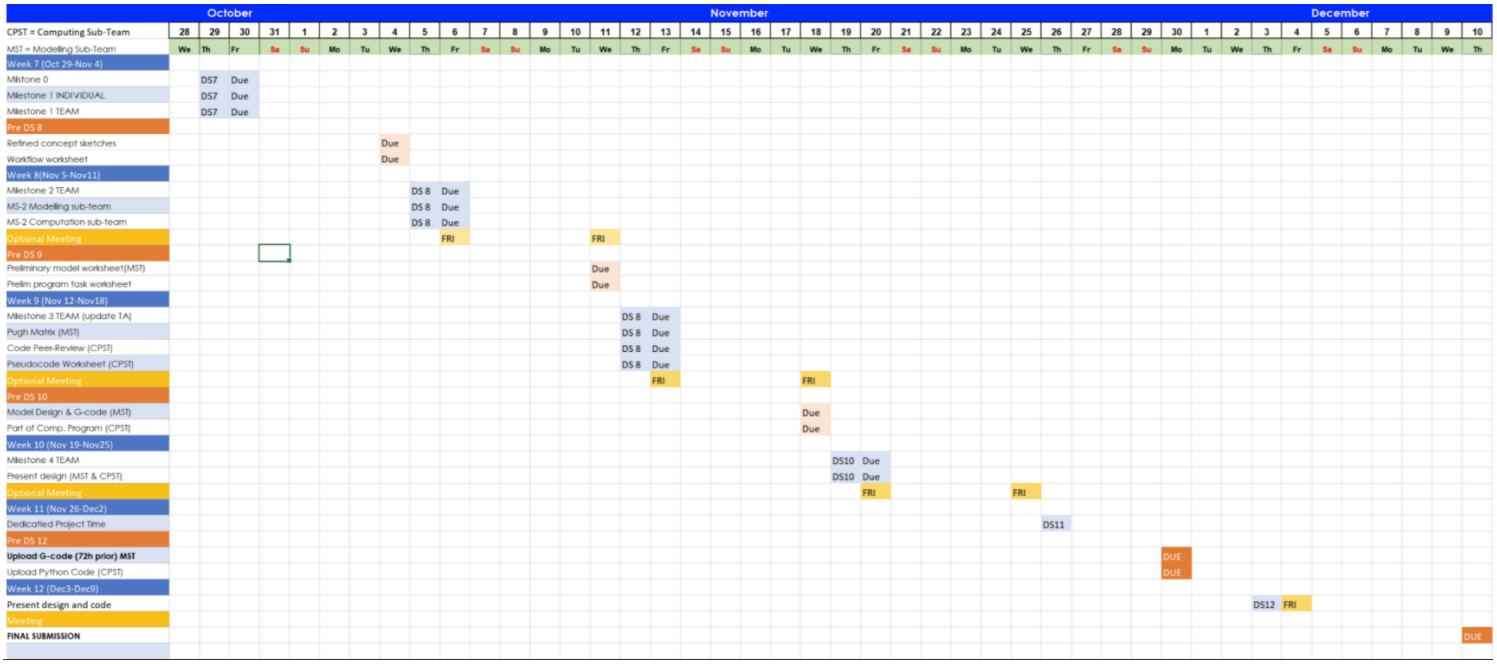
Computing Consideration

When designing a program, in addition to making it usable, we try to simulate human behavior as much as possible to make it usable. For example, people will associate muscle contraction with closing and stretching with opening. This universally accepted logic makes the program a quick starter for anyone. From a software

engineering standpoint, using a version control system maximizes the efficiency of communication when committing multiple programmers. In this project, we used Github for versioning. By reviewing the revision logs between team members, we can quickly understand the logical intent of both parties and thus achieve a more efficient and high-quality development of the project.

Project Schedule

Preliminary Gantt Chart



Final Gantt Chart

Logbook

Date: Dec 5, 2020

Task: Discuss about the project report

Attendance:

Role	Name	Macid	Attendance
Manager	Adam Podolak	podola2	Yes
Administrator	Kartik Chaudhari	chaudk4	Yes
Coordinator	Wenxiao Pan	panw10	Yes
Subject Matter Expert	Kareem Shabaka	shabakak	Yes

In-meeting:

We scheduled this extra meeting to finish our Project 2 Final Report. We reorganized each milestone, and summarize the experiences in Project 2, then documented them as an executive summary.

Weekly Design Studio Agendas

Date: Nov, 5

Attendance

Role	Name	Macid	Attendance
Manager	Adam Podolak	podola2	Yes
Administrator	Kartik Chaudhari	chaudk4	Yes
Coordinator	Wenxiao Pan	panw10	Yes
Subject Matter Expert	Kareem Shabaka	shabakak	Yes

Agenda

1. – Attendance
2. – Update TA on progress
3. – Discuss refined concept sketches and workflow worksheet
4. – Action items for next week and submissions
5. – Final notes

Date: Nov, 12

Attendance

Role	Name	Macid	Attendance
Manager	Adam Podolak	podola2	Yes
Administrator	Kartik Chaudhari	chaudk4	Yes
Coordinator	Wenxiao Pan	panw10	Yes
Subject Matter Expert	Kareem Shabaka	shabakak	Yes

Agenda

1. – Attendance
2. – Update TA on progress
3. – Discuss changes from last weeks prototype/program
4. – Action items for next week and submissions
5. – Final notes

Date: Nov, 19

Attendance

Role	Name	Macid	Attendance
Manager	Adam Podolak	podola2	Yes
Administrator	Kartik Chaudhari	chaudk4	Yes
Coordinator	Wenxiao Pan	panw10	Yes
Subject Matter Expert	Kareem Shabaka	shabakak	Yes

Agenda

1. – Attendance
2. – Update TA on progress
3. – Discuss changes from last weeks prototype/program
4. – Action items for next week and submissions
5. – Final notes

Date: Nov, 26

Attendance

Role	Name	Macid	Attendance
Manager	Adam Podolak	podola2	Yes
Administrator	Kartik Chaudhari	chaudk4	Yes
Coordinator	Wenxiao Pan	panw10	Yes
Subject Matter Expert	Kareem Shabaka	shabakak	Yes

Agenda

1. – Attendance
2. – Update TA on progress
3. – Discuss changes from last weeks prototype/program
4. – Action items for next week and submissions
5. – Final notes

Weekly Design Studio Meeting Minutes

Date: Nov, 5

Meeting Minutes

1. Model Sub team
    a. Finish the prototype of the container model
    b. Analyse the observations for each prototype
2. Computing sub team
    a. Finish flowchart/storybook of functions satisfy the objectives
    b. Write down the pseudo code of functions
    c. Swap suggestion on the code

Post-Meeting Action Items

1. Thurs-03 Milestone 2 Team Worksheet [prototype, pseudo code, flowchart]

Date: Nov, 12

Meeting Minutes

1. Model Sub Team
    a. Preliminarily model the container
    b. Evaluate the model's features
2. Computing Sub Team
    a. Preliminarily code the basic functions involving the identification of autoclaves and arm's movement
    b. Write the pseudo code for remaining tasks.

Post-Meeting Action Items

1. Thurs03_P2_Milestone3(Computation) [Preliminary codes and pseudo code of remaining tasks]
2. Thurs03_P2_Milestone3(modelling) [Preliminary models and evaluation on the features of model]

Date: Nov, 19

Meeting Minutes

1. Modelling Sub Team
    a. Working on the final steps of modelling
2. Computing Sub Team
    a. Run unit tests of codes
    b. Debug

Post-Meeting Action Items

No items submitted this week!

Date: Nov, 26

Meeting Minutes

1. Modelling Sub Team
    a. Get feedback from TA
    b. Refine the model and G-code
2. Computing Sub Team
    a. Get feedback from TA
    b. Refine the code and add comments
    c. Improve the code structure

Post-Meeting Action Items

1. Thurs-03 Milestone 4 TEAM Worksheets (Modelling/Computing)[Feedback, problems solving]

Design Studio Worksheets

Milestone 0

PROJECT TWO: MILESTONE 0 – COVER PAGE

Team Number: Thurs-03

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

Full Name:	MacID:
Adam Podolak	podola2
Wenxiao Pan	panw10
Kareem Shabaka	shabakak
Kartik Chaudhari	chaudk4

Insert your Team Portrait in the dialog box below

MILESTONE 0 – TEAM CHARTER

Team Number: Thurs-03

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Adam Podolak	☐M ☒A ☐C ☐S
2.	Kareem Shabaka	☒M ☐A ☐C ☐S
3.	Wenxiao Pan	☐M ☒A ☐C ☐S
4.	Kartik Chaudhari	☐M ☐A ☐C ☒S
		☐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.

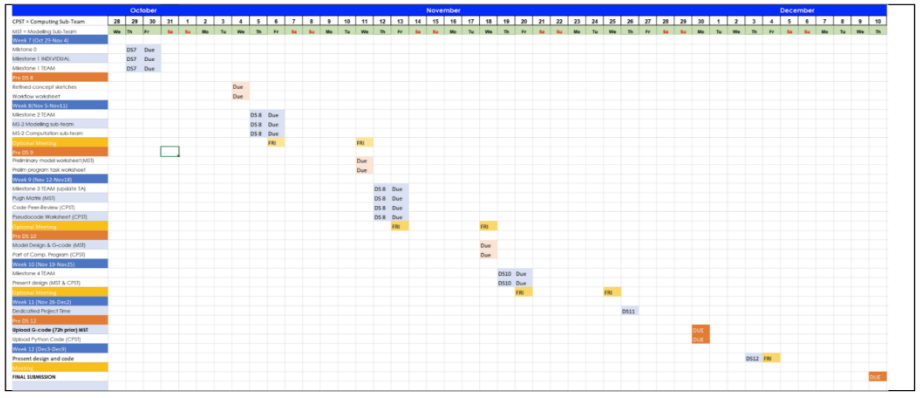
Role:	Team Member Name:	MacID
Manager	Adam Podolak	podola2
Administrator	Kartik Chaudhari	chaudk4
Coordinator	Wenxiao Pan	panw10
Subject Matter Expert	Kareem Shabaka	shabakak

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team Number: Thurs-03

Full Name of Team Manager:	MacID:
Adam Podolak	podola2

Preliminary Gantt chart



Milestone 1

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team Number: Thurs-03

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

Full Name:	MacID:
Kartik Chadhari	chaudk4
Kareem Shabaka	shabakak
Adam Podolak	podola2
Wenxiao Pan	Panw10

MILESTONE 1 (STAGE 1) – PRE-PROJECT ASSIGNMENT

Team Number: Thurs-03

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

Team Number: Thurs-03

Name: Kareem Shabaka	MacID: shabakak

Objectives

- *Be used by robotic arm to move the container to the autoclave*
- *Allow ease of sterilization of the surgical equipment*
- *Fast and efficient transfer of equipment*
- *Be able to be grabbed in different orientations*

Constraints

- *Does not drop the equipment during the motion*
- *Places the equipment in the correct place and orientation*
- *Strong enough to withstand arm pressure*

Functions

- *Allow movement in all dimensions*
- *Allows carrying of equipment*
- *Be detected by arm*
- *Protects equipment*

Team Number: Thurs-03

Name: Wenxiao Pan	MacID: panw10

Objectives

- Should Well-place the surgical tools
- Should be easy to pick up the surgical tools by the robot
- The types of surgical tools can be identified by robot
- Should be efficient to transfer the objects
- The instruments should be safely transferred
- The port should be comfort to the shapes of instruments

Constraints

- *The container should be identified by the arm*
- *The size is fit for arm to operate*
- *Mass is less than 350 g*

Functions

- Classify the surgical tools by colors
- Heat up the contained tools if possible
- Sterilize the surgical tools

Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2

Objectives

- Should securely hold instruments in place during transport
- Should conform to the shape of the instrument in some way
- Should be easy enough to grip and be lifted by the arm
- Open cage to allow for sterilization (not airtight)
- Easy to insert the surgical instruments
- Rigid enough as to not harm the instruments during transport
- Minimizes contact with sensitive components of instrument (blade of a scalpel)
- Low production cost? (minimal material)

Constraints

- *Light enough to be picked up by arm*
- *Small enough for it to be picked up by arm*
- *Width is less than 85 mm*
- *Less than 350g*

Functions

- Holds surgical instrument
- Facilitates sterilization
- Allows carrying
- Prevents damage to instruments

Team Number: Thurs-03

Name: Kartik Chaudhari	MacID: chaudk4

Copy-and-paste the pre-project assignment for one team member in the space below

Objectives

- Quick and successful equipment transfer
- Enable the surgical equipment to be easily sterilised.
- To pass the container to the autoclave using a robotic arm
- Instruments should be kept in place safely during transport.
- Simple insertion of surgical tools
- Rigid enough not to hurt the tools during transport
- Reduces interaction with sensitive instrument (scalpel blade) materials

Constraints

- Good enough to endure pressure from the arm
- The dimension is ideal for operating.
- Does not lose the machinery during movement
- Places the equipment in the right position and orientation

Functions

- Sterilize the surgical equipment
- Allowing accurate motions
- Classify the surgical instruments according to colors
- Enable motion in all dimensions
- Enables the carriage of equipment

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

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

Team Number: Thurs-03

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.

Objectives	Constraints	Functions
Should be rigid enough to not damage tools during transport (withstand the grip of the arm)	Must be identifiable by arm (specific colour)	Holds tools
Conform to the shape of the tool	Width must be less than 80 mm	Pick up
Securely holds the tool in place during transport	Mass must be less than 350g	Prevents damage to instruments
Easily transferable	Minimum thickness of 4mm	Opens shelf
Minimal material		

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

Pick up and transport into autoclaves

3. What are the secondary functions?

Securely holds tools
Prevents damage to tools
Opens shelf

MILESTONE 1 (STAGE 3) – MORPHOLOGICAL ANALYSIS

Team Number: Thurs-03

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	**Means**					
Pick up	Clamps directly onto container	Handle	Magnet (one on container and one grabbed by the gripper)	String	Hook (on container)	Scoop
Holds tools	Slot	Clamp	Hook	Suction	Tape	
Opens shelf	Magnet	Button connected to motor	Handle	Suction cup	Motion sensor	

MILESTONE 1 (STAGE 4) – CONCEPT SKETCHES

Team Number: Thurs-03

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

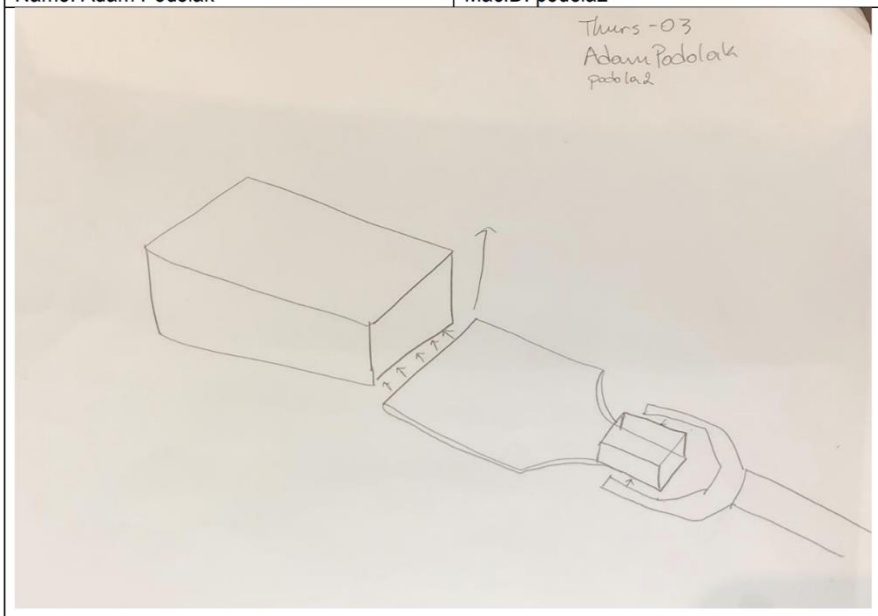
1. Each team member should copy-and-paste the photo of their individual concept sketches in the space indicated on the following pages
   → The photo's should be the same one your included in the **Milestone One Individual Worksheets** document
   → Be sure to include your **Team Number** on each page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

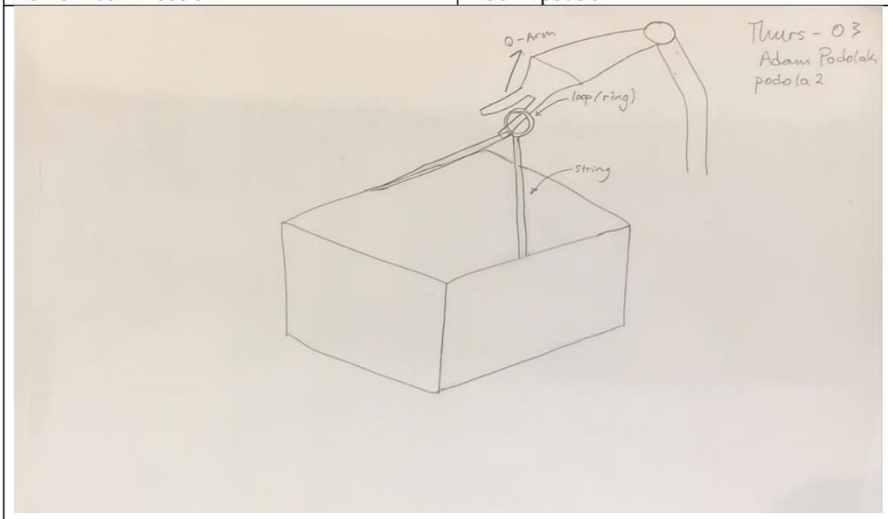
Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2



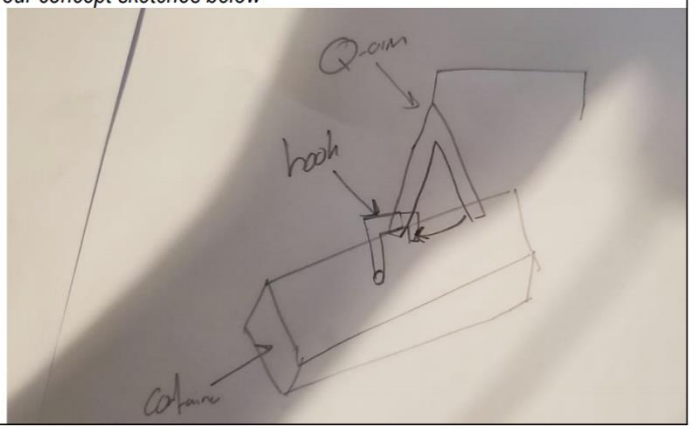
Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2



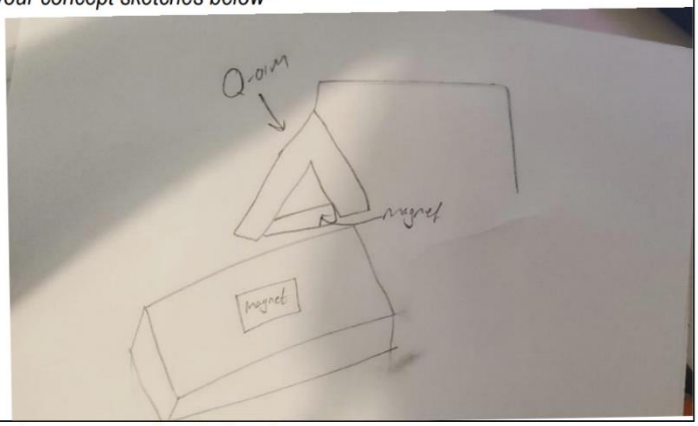
Team Number: Thurs-03

Name: Kareem Shabaka	MacID: shabakak
Insert screenshot(s) of your concept sketches below	



Team Number: Thurs-03

Name: Kareem Shabakak	MacID: shabakak
Insert screenshot(s) of your concept sketches below	

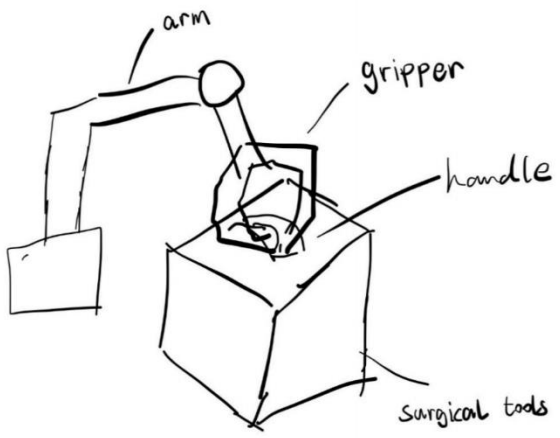


*If you are in a team of 5, please copy and paste the above on a new page

Team Number: Thurs-03

Name: Wenxiao Pan	MacID: panw10

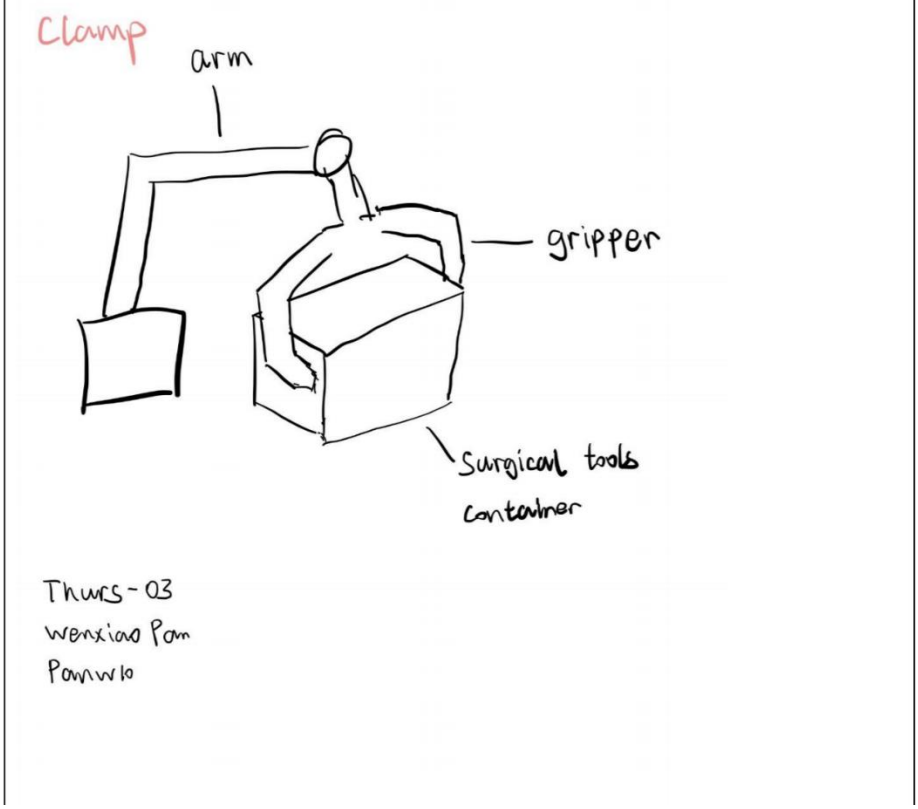
Handle



Thurs-03
Wenxiao Pan
Panw10

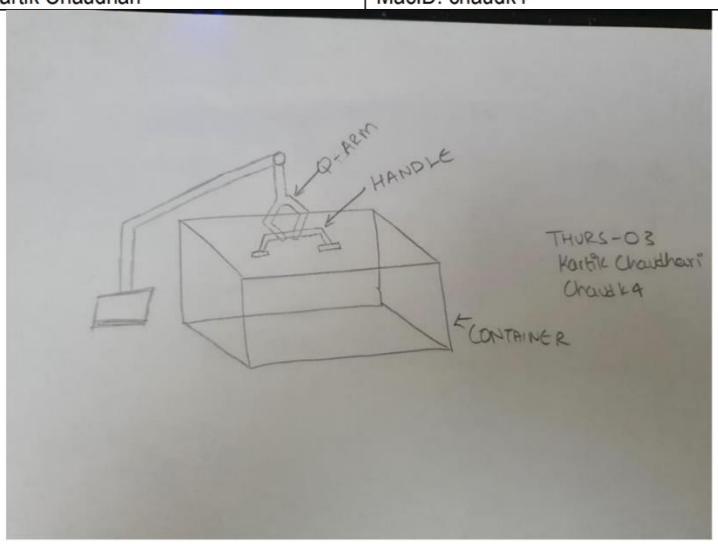
Team Number: Thurs-03

Name: Wenxiao Pan	MacID: panw10



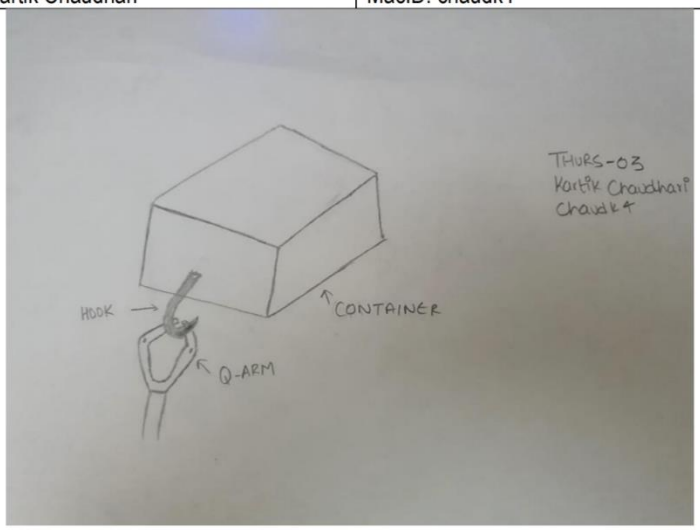
Team Number: Thurs-03

Name: Kartik Chaudhari	MacID: chaudk4



Team Number: Thurs-03

Name: Kartik Chaudhari	MacID: chaudk4



Milestone 2

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team Number: Thurs-03

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

Full Name:	MacID:
Adam Podolak	podola2
Kartik Chaudhari	chaudk4
Wenxiao Pan	Panw10
Kareem Shabaka	shabakak

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

Team Number: Thurs-03

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

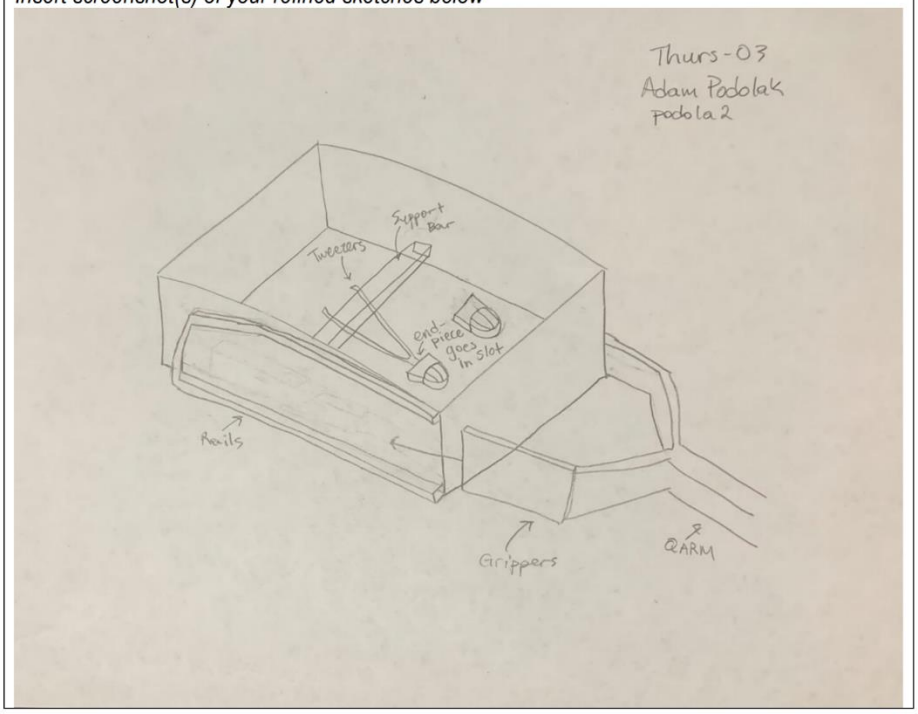
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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

Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2

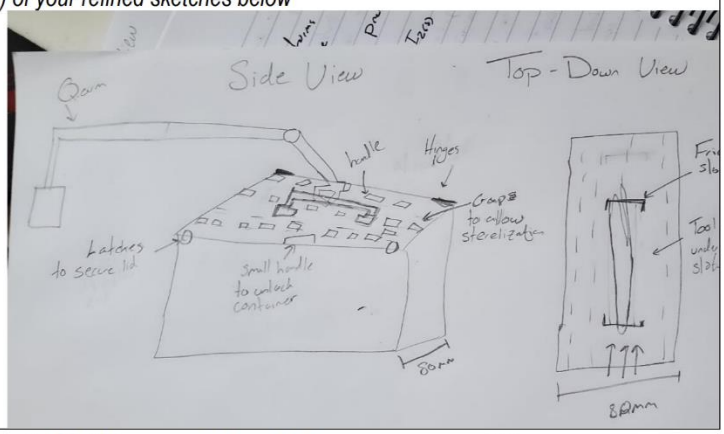
Insert screenshot(s) of your refined sketches below



Team Number: Thurs-03

Name: Kareem Shabaka	MacID: shabakak

Insert screenshot(s) of your refined sketches below



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

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

Team Number: Thurs-03

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

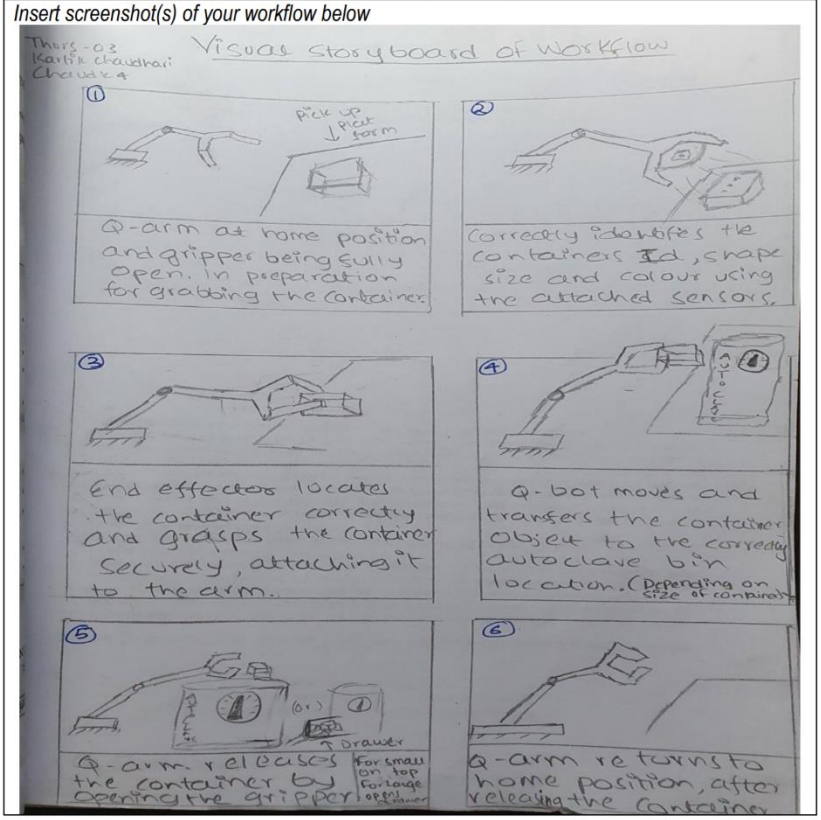
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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

Team Number: Thurs-03

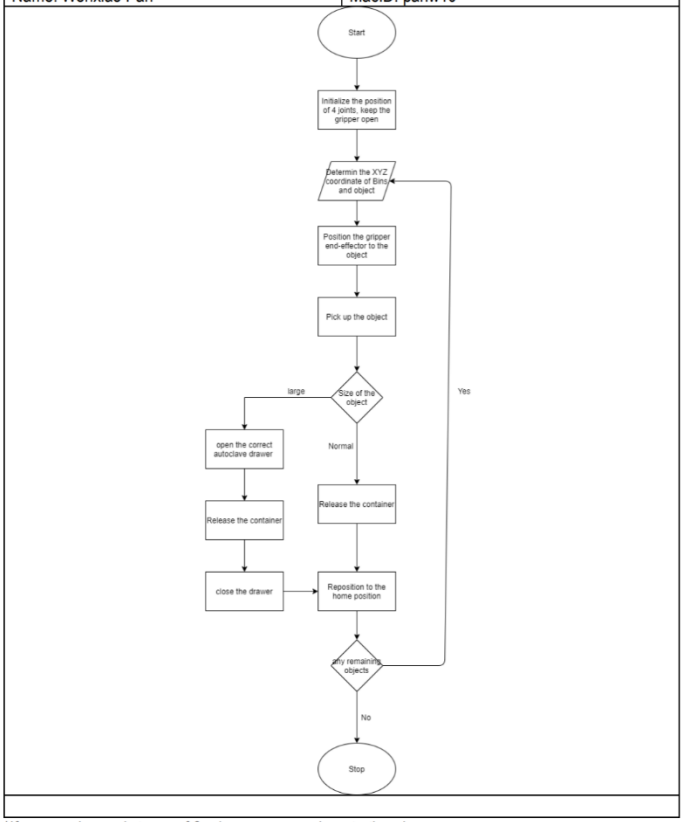
Name: Kartik Chaudhari	MacID: chaudk4

Insert screenshot(s) of your workflow below



Team Number: Thurs-03

Name: Wenxiao Pan | MacID: panw10



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

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

Team Number: Thurs-03

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

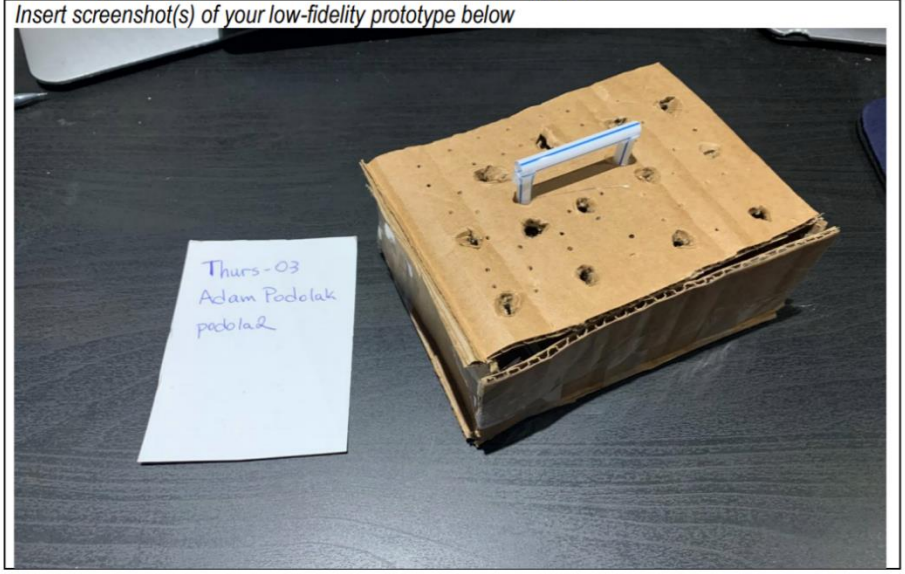
1. Take multiple photos of your low-fidelity prototypes
   → Include an index card (or similar) next to the prototype, clearly indicating your Team Number, Name and MacID on *each* sketch
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* prototype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

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

Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2

Insert screenshot(s) of your low-fidelity prototype below



Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2

Insert screenshot(s) of your low-fidelity prototype below

Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2

Insert screenshot(s) of your low-fidelity prototype below

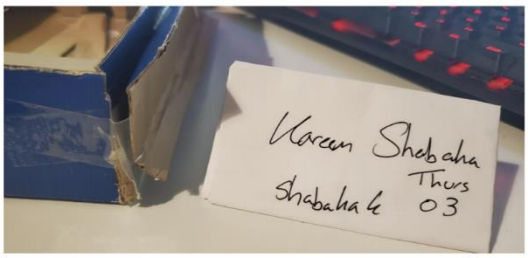
Team Number: Thurs-03

Name: Kareem Shabaka	MacID: shabakak

Insert screenshot(s) of your low-fidelity prototype below

Name: Kareem Shabaka	MacID: shabakak

Insert screenshot(s) of your low-fidelity prototype below

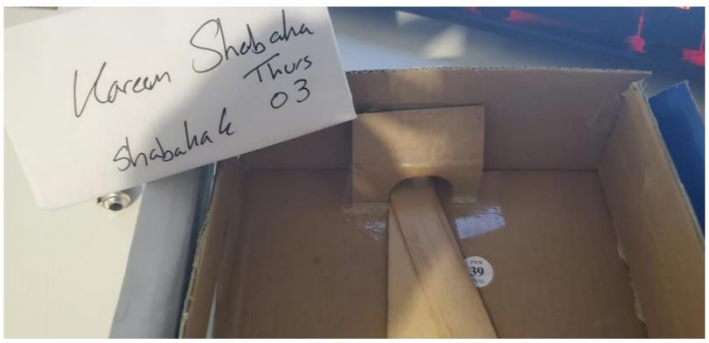


*If you are in a sub-team of 3, please copy and paste the above on a new page

Team Number: Thurs-03

Name: Kareem Shabaka	MacID: shabakak

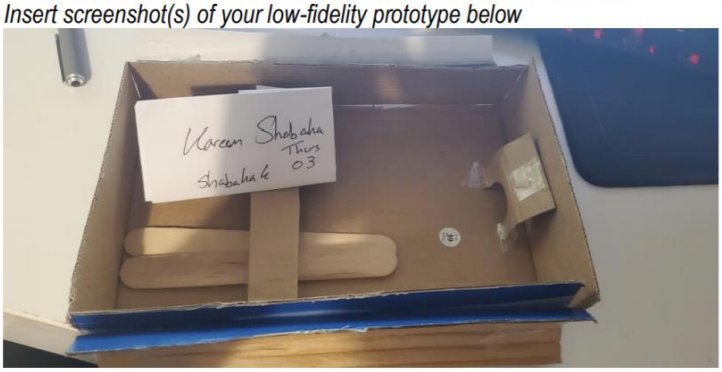
Insert screenshot(s) of your low-fidelity prototype below



Team Number: Thurs-03

Name: Kareem Shabaka	MacID: shabakak

Insert screenshot(s) of your low-fidelity prototype below



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

Team Number: Thurs-03

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

*Document your observations for each prototype in the space below. It is recommended you document observations in a **table** or in bullet form (it should be clear which prototype you are referring to for each observation.*

Prototype	Advantages Disadvantages	Aligns with Objectives, Constraints, and Function?	Reliability in picking up	Reliability in securing tool	Facilitates sterilization	Similarities and differences
Adam Podolak	Advantages -Securely holds tools -Closed lid for more security -Simple design Disadvantages -Qarm could have trouble gripping the handle -Closed lid which makes it harder to insert the tools	Yes -facilitates sterilization with openings in top of lid -might be too heavy because of added mass of lid -allows for picking up -securely holds tools in place -might not be easily picked up with the handle	-Qarm could have difficulty gripping the handle and risks the chance of slipping.	-Very securely holds tools with friction slots. Closed lid adds more security.	-Yes, to an extent, the spaces/holes should be bigger to allow for more steam to enter the container.	-Both use similar method for securing tool (friction slot) but different implementation -Both facilitate sterilization one has a closed lid with holes and the other has an open lid.

	-More material therefore more mass					-One uses rails for picking up the other uses a handle
Kareem Shabaka	Advantages: -Open top, less steps required to place tool -Compact design Disadvantages: -Designed for 1 tool only -Requires more precision by the Q-arm to pick up container (alignment with rails) -Requires specific orientation	-No holes or gaps, so difficult to sterilize -simple design without too many parts, light -Allows for picking up by Q-arm -Securely holds tool by securing on both ends	-If container is not in the correct orientation, difficult to pick up	-Secured at both ends, preventing movement up and down -Prevents side to side movement with slot	-No gaps to facilitate sterilization but has open top, which could allow sterilization	

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

Team Number: Thurs-03

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:

1. Both the flowchart and the storyboard have one thing in common about the Q-arm that is that they both start from their home position and they both have the gripper open.

2. *End effector locates the container and grasps the container securely*
3. *Releasing the container in the right autoclave depending upon the size of the container and then the Q-arm returns to its home position.*

Differences:

1. Our order of determining the coordinates of the objects and bins is different.

2. Flowchart illustrates the entire processes clearly, while the storyboard illustrates well about how the single process works.

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

Team Number: Thurs-03

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

```
Start
//label of the initialization
initialize:

//initialize the coordinate of the arm.
set Q-arm xyz position to 0
set Q-arm gripper to 270 deg //completely open

fetch the coordinates of bin and object from sensor

Pick Up the object by the xyz coordinates

//Decisions of two situations
if (object is large)
then
    Open the Autoclave Drawer
    release the object from the gripper to the correct bin
    close the Autoclave Drawer
else
    release the object from the gripper to the correct bin

if (there is object remaining)
then
    goto initialize

End
```

Milestone 3

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team Number: Thurs-03

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

Full Name:	MacID:
Wenxiao Pan	panw10
Adam Podolak	podola2
Kareem Shabaka	shabakak
Kartik Chaudhari	chaudk4

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

Team Number: Thurs-03

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

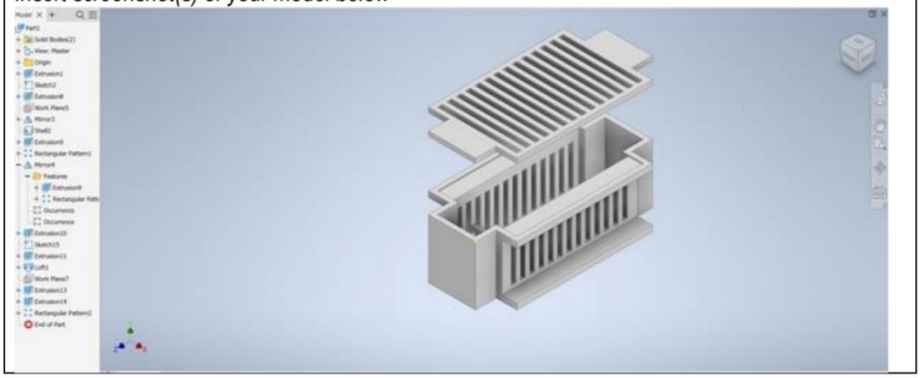
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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

Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2

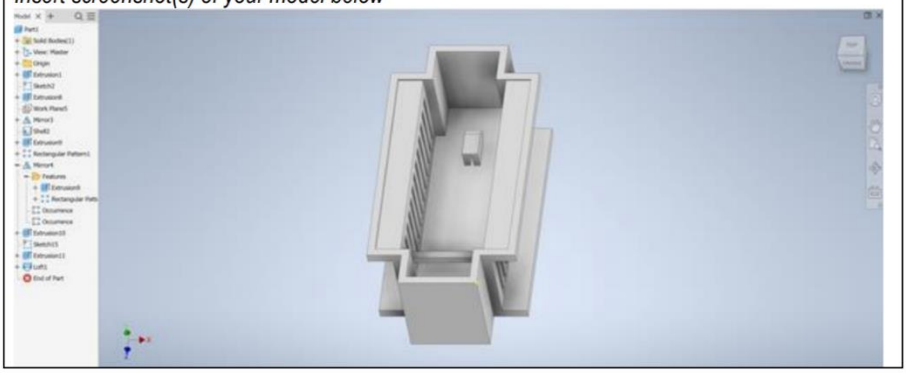
Insert screenshot(s) of your model below



Team Number: Thurs-03

Name: Adam Podolak	MacID: podola2

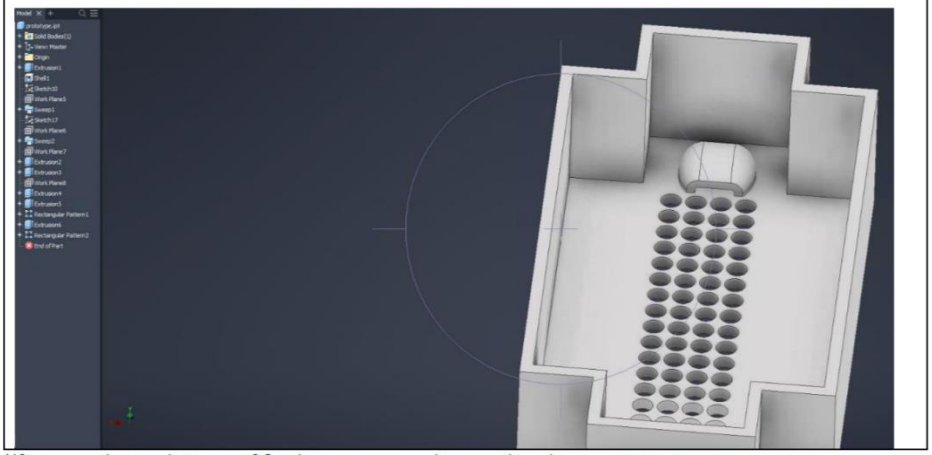
Insert screenshot(s) of your model below



Team Number: Thurs-03

Name: Kareem Shabaka	MacID shabakak

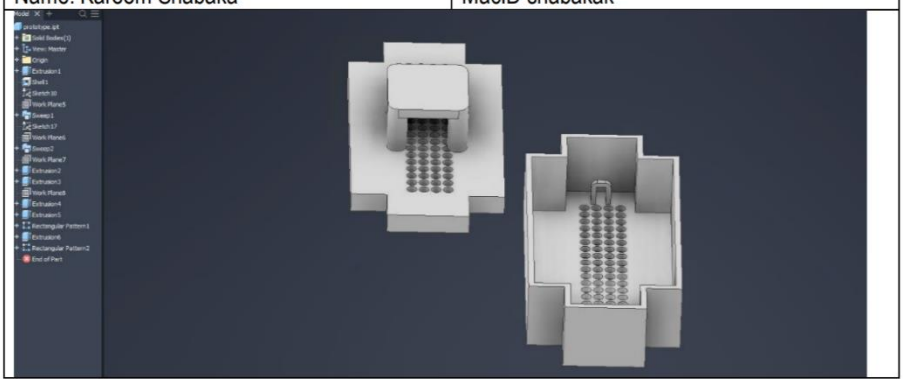
Insert screenshot(s) of your model below



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

Team Number: Thurs-03

Name: Kareem Shabaka	MacID shabakak



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

Team Number: Thurs-03

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

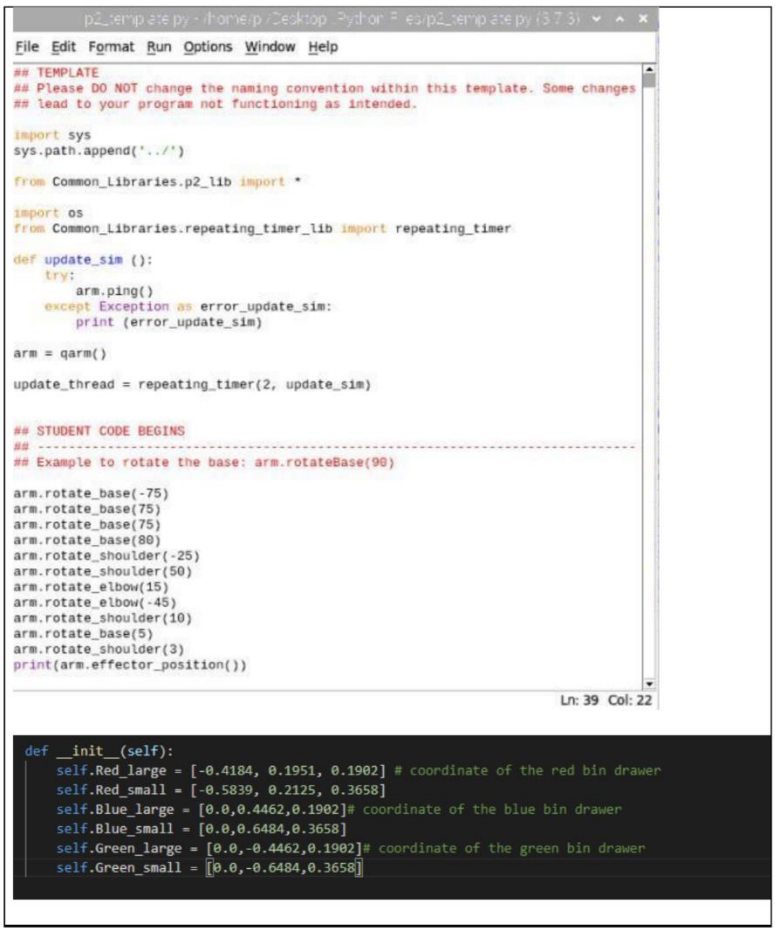
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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

Team Number: Thurs-03

Name: Kartik Chaudhari	MacID chaudk4

Insert a screenshot of your code below



p2_template.py - /home/p/Desktop/Python Files/p2_template.py (3.7.3)

File Edit Format Run Options Window Help

```
## TEMPLATE
## Please DO NOT change the naming convention within this template. Some changes
## lead to your program not functioning as intended.

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)


## STUDENT CODE BEGINS
## ---------------------------------------------------------------------------
## Example to rotate the base: arm.rotateBase(90)

arm.rotate_base(-75)
arm.rotate_base(75)
arm.rotate_base(75)
arm.rotate_base(80)
arm.rotate_shoulder(-25)
arm.rotate_shoulder(50)
arm.rotate_elbow(15)
arm.rotate_elbow(-45)
arm.rotate_shoulder(10)
arm.rotate_base(5)
arm.rotate_shoulder(3)
print(arm.effector_position())
```

Ln: 39 Col: 22

```
def __init__(self):
    self.Red_large = [-0.4184, 0.1951, 0.1902] # coordinate of the red bin drawer
    self.Red_small = [-0.5839, 0.2125, 0.3658]
    self.Blue_large = [0.0,0.4462,0.1902]# coordinate of the blue bin drawer
    self.Blue_small = [0.0,0.6484,0.3658]
    self.Green_large = [0.0,-0.4462,0.1902]# coordinate of the green bin drawer
    self.Green_small = [0.0,-0.6484,0.3658]
```

Team Number: Thurs-03

Name: Wenxiao Pan	MacID: panw10

Insert a screenshot of your code below

p2_template.py

P2_stage-2 > p2_template.py > armAction

```
class armAction:
    #move to smaller blue bin
    def move2BlueS(self):
        arm.move_arm(self.Blue_small[0], self.Blue_small[1], self.Blue_small[2])
        time.sleep(1.2)
        arm.home()
        time.sleep(1.7)

    #move to blue bin drawer
    def move2BlueL(self):
        arm.open_blue_autoclave(True)
        time.sleep(1.7)
        arm.move_arm(self.Blue_large[0], self.Blue_large[1], self.Blue_large[2])
        time.sleep(1.2)
        arm.home()
        time.sleep(1.2)
        arm.open_blue_autoclave(False)
        time.sleep(1.2)

    #move to smaller red bin
    def move2RedS(self):
        arm.move_arm(self.Red_small[0], self.Red_small[1], self.Red_small[2])
        time.sleep(1.2)
        arm.home()
        time.sleep(1.7)

    #move to red bin drawer
    def move2RedL(self):
        arm.open_red_autoclave(True)
        time.sleep(1.7)
        arm.move_arm(self.Red_large[0], self.Red_large[1], self.Red_large[2])
        time.sleep(1.2)
        arm.home()
        time.sleep(1.2)
        arm.open_red_autoclave(False)
        time.sleep(1.2)

    # move to smaller green bin
    def move2GreenS(self):
        arm.move_arm(self.Green_small[0], self.Green_small[1], self.Green_small[2])
        time.sleep(1.2)
        arm.home()
        time.sleep(1.7)

    # move to green bin drawer
    def move2GreenL(self):
        arm.open_green_autoclave(True)
        time.sleep(1.7)
        arm.move_arm(self.Green_large[0], self.Green_large[1], self.Green_large[2])
        time.sleep(1.2)
        arm.home()
        time.sleep(1.2)
        arm.open_green_autoclave(False)
        time.sleep(1.2)

    # reset everything to the initial status
    def reset(self):
        arm.home()
        time.sleep(1)
        arm.open_red_autoclave(False)
        arm.open_green_autoclave(False)
        arm.open_blue_autoclave(False)
```

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

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

Team Number: Thurs-03

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	Adam Podolak (Rail Feature)	Kareem Shabaka (Platform Handle Feature)
Facilitates Sterilization	S	S	S
Securely holds tool	S	S	S
Allows for easy transportation	S	+	+
Rigid/Prevents damage to tools	S	-	-
Minimal material used	S	+	-
Greater than 4 mm thickness for all components	S	+	+
Width less than 80 mm	S	+	+
Total +	0	4	3
Total –	0	1	2
Total Score	0	3	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

Adam Podolak's Design
- Add holes or slots in the bottom of container to allow for steam to pass through
- Add one or more support beams to securely hold tool
- Possibly add another slot or something where the tips/pincers of the tweezers are secured in place.

Kareem Shabaka's Design
- Use an open platform for the gripper instead of a solid square
- Allow more steam to pass through the container by adding more grills or holes in the bottom and top of the container

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

Team Number: Thurs-03

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**: Kartik Chaudhari
• The coordinates of each component of autoclave bins found by Kartik are correct, no conflicts on the paths. • It successfully returned the possible locations for the autoclave. • Very error-prone during development	

Move End-Effector Task	**Team Member Name**: Wenxiao Pan
• The Q arm moved correctly and didn't have any problems during its motion because the functions were well defined for the Q arm to move to the next point and there was proper usage of the sleep function. • Responds to muscle sensors effectively and smoothly. • The code had no errors and successfully moved the end arm effector to the designated drop off location	

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

Team Number: Thurs-03

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

Control Gripper

If the EMG simulator has a specific value or greater then close the gripper to grab the container using a function

If not then open the gripper to release the container in right position

Open Autoclave Bin Drawer

Open the #color autoclave bin drawer

Sleep 2 sec

Move the arm to the position of the drawer

Sleep 2 sec

Drop the container

Sleep 2 sec

Close the #color autoclave bin drawer

Continue or Terminate

List of bins <- [coordinates of each bins]

If there are bins left:

    continue

    Repeat the process of grabbing container

    Repeat the process of open/close bin drawer

    Repeat the process of dropping container

Else:

    terminate

Milestone 4

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team Number: Thurs-03

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

Full Name:	MacID:
Wenxiao Pan	Panw10
Adam Podolak	podola2
Kareem Shabaka	shabakak
Kartik Chaudhari	chaudk4

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

Team Number: Thurs-03

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

Modelling

No problems with any dimensions. The print time is under 2 hours. No problems with the design itself. Mass of model below limit.

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

Difficult to implement closing mechanism of lid with 3D printing. Friction fit could work, possibly add a mechanism to allow for the lid to be locked in place.

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

Team Number: Thurs-03

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

Add comments. 2-3 comments per function.

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

Add more comments on each function to describe the mechanism better.
Unpack the sensor functions to reduce the number of the number of if-else.

Sources

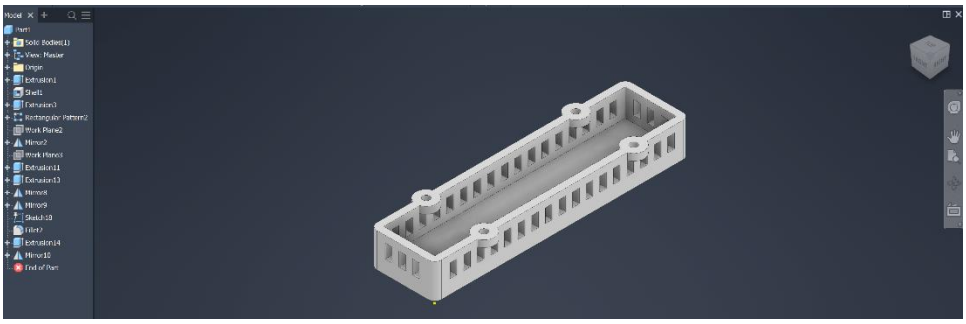
"Autodesk Inventor Professional 2021 software," Autodesk, 2020 (www.autodesk.com).

"Python 3.8 software," Python Software Foundation, 2020 (www.python.org)

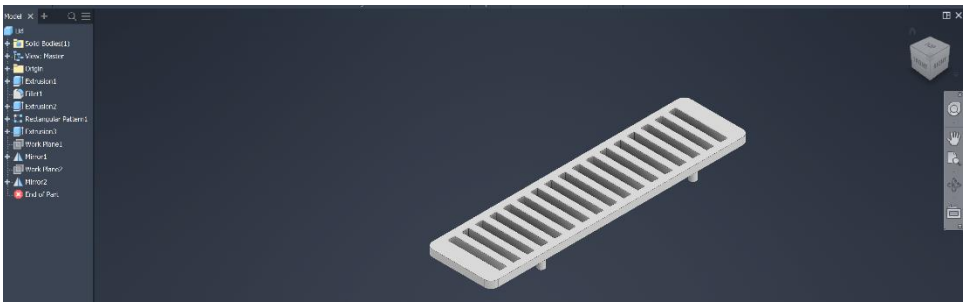
"Quanser Interactive Labs," Quanser, 2020 (www.quanser.com)

Appendix A – Solid Model Screenshots:

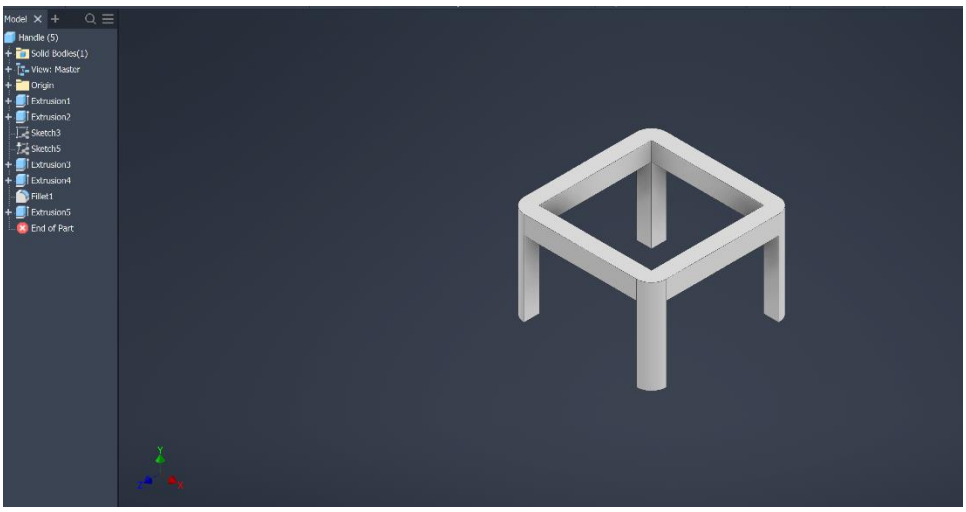
Container



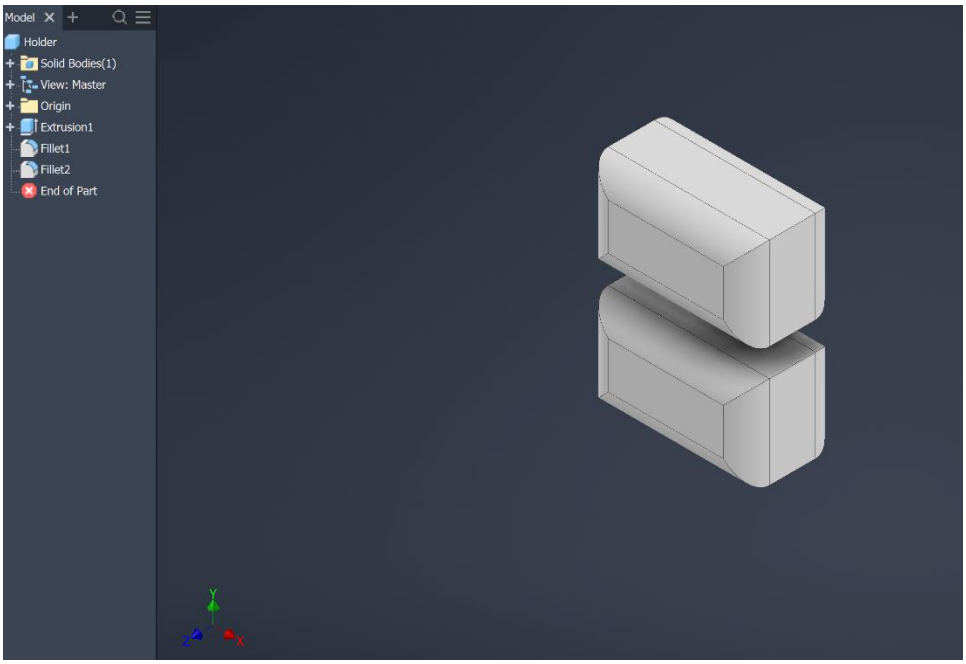
Lid



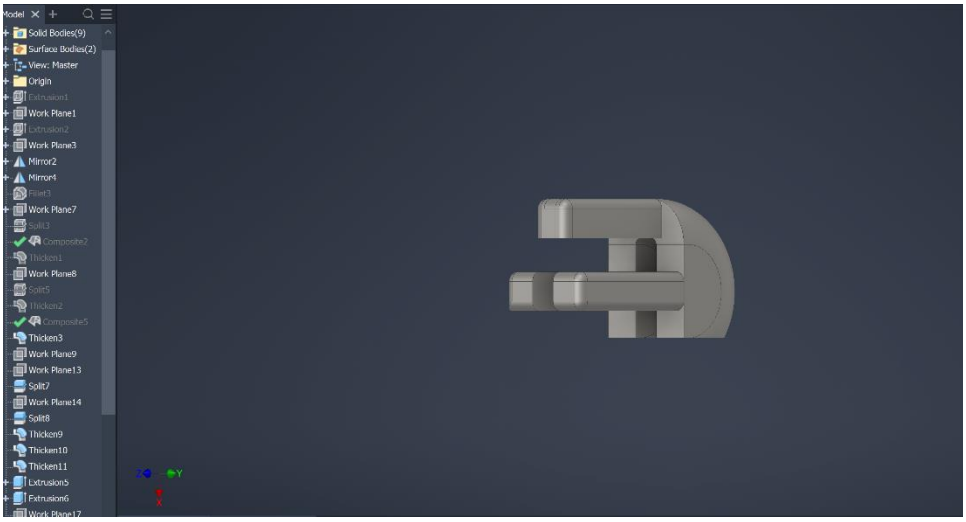
Handle



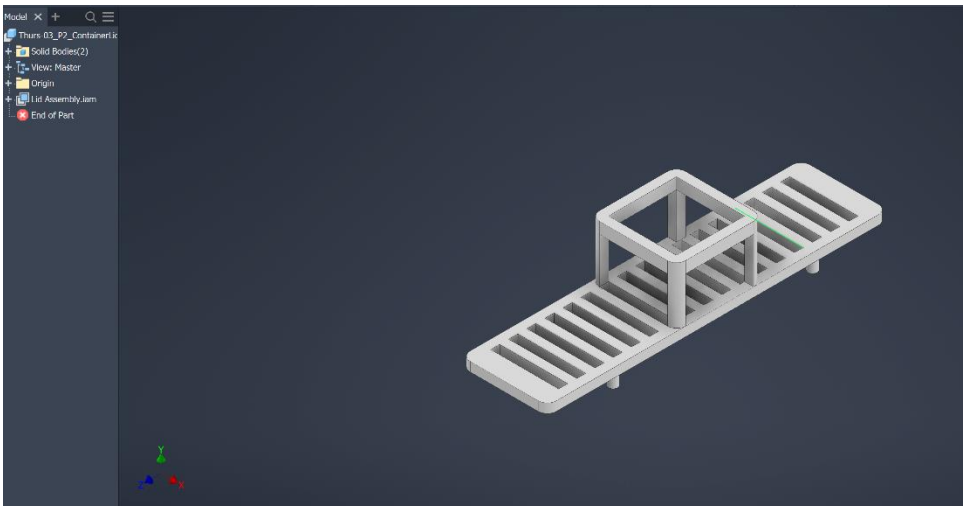
Arm Supports



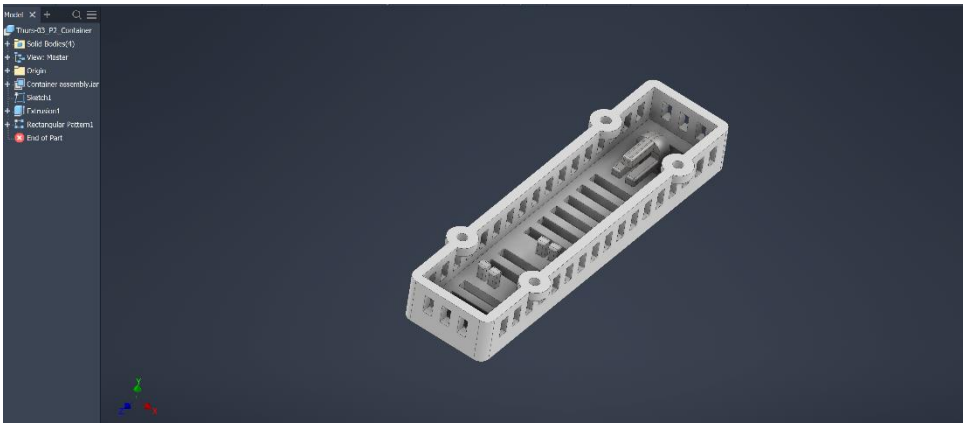
Main Support



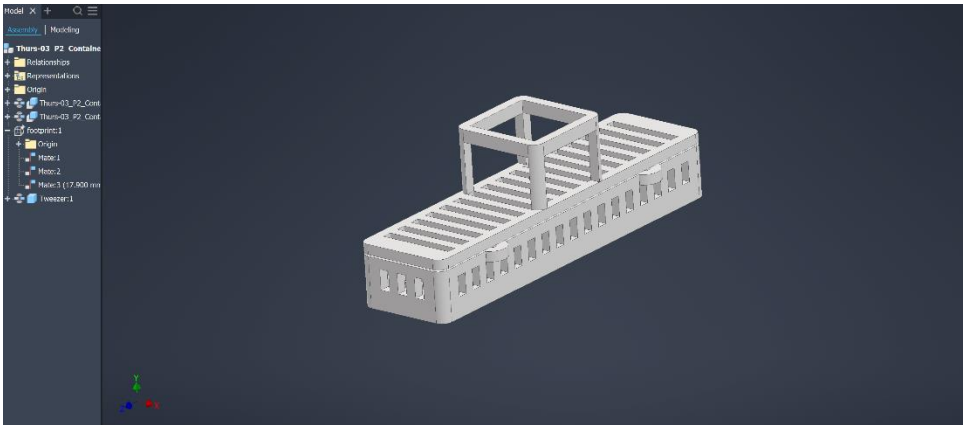
Complete Lid Assembly



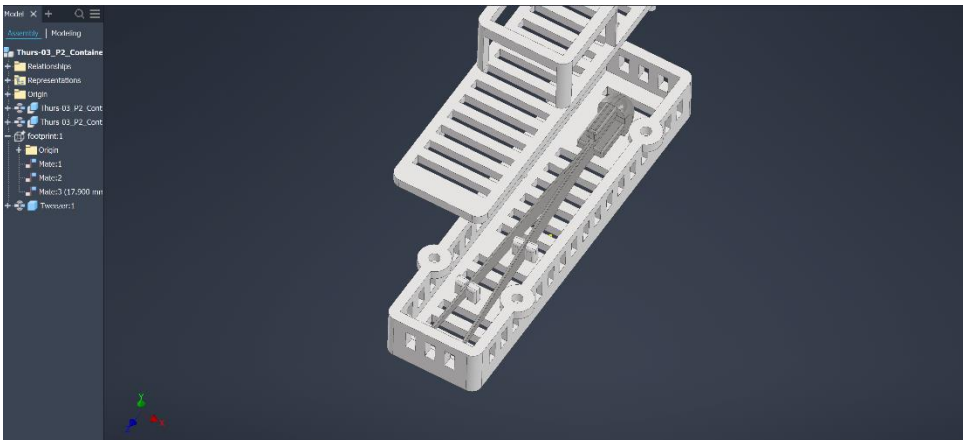
Complete Container Assembly



Complete Model Assembly

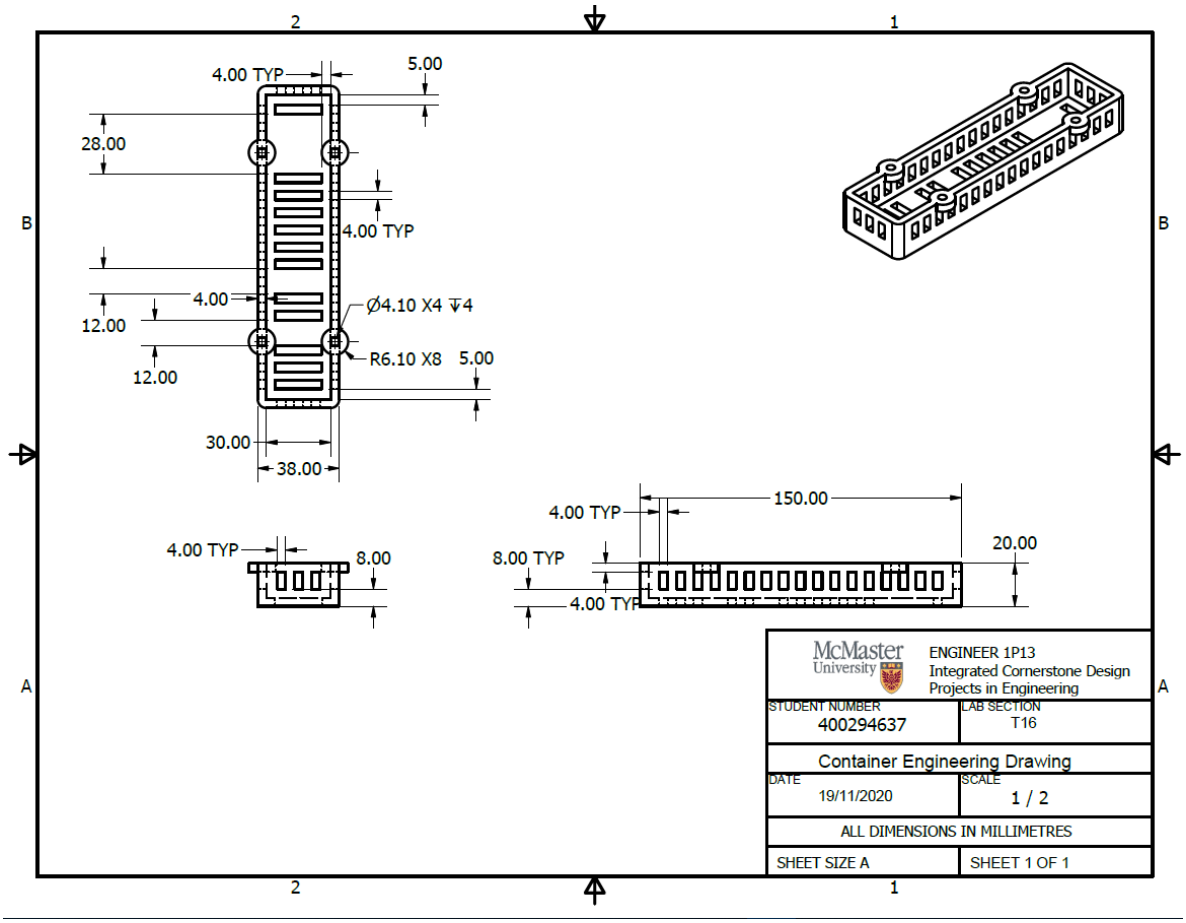


Container with Tweezers

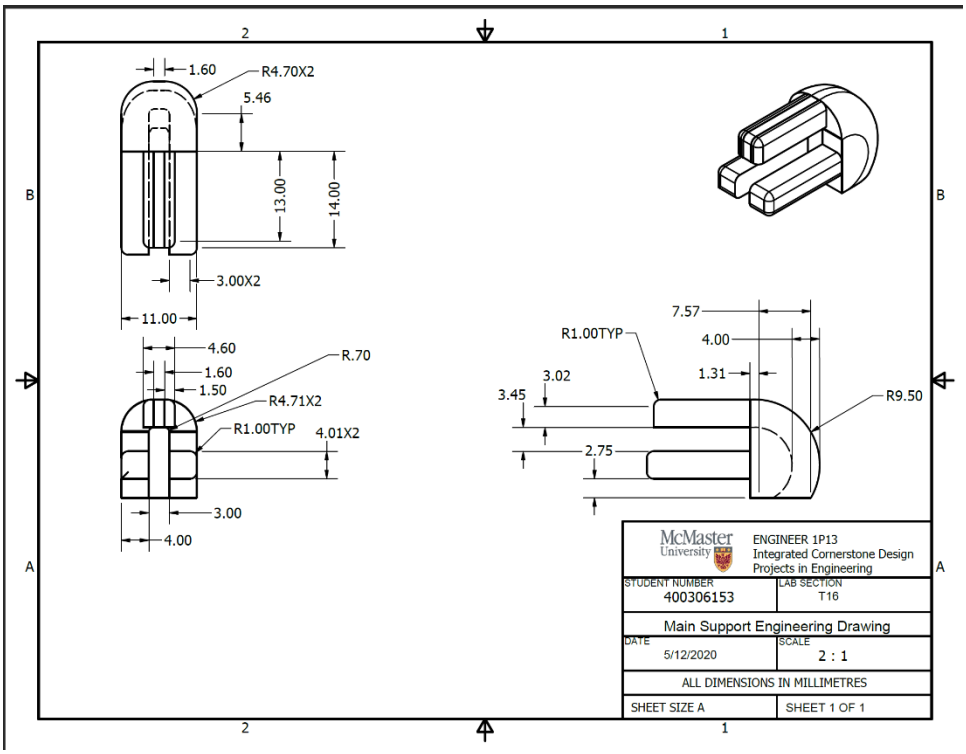


Appendix B – Engineering Drawings:

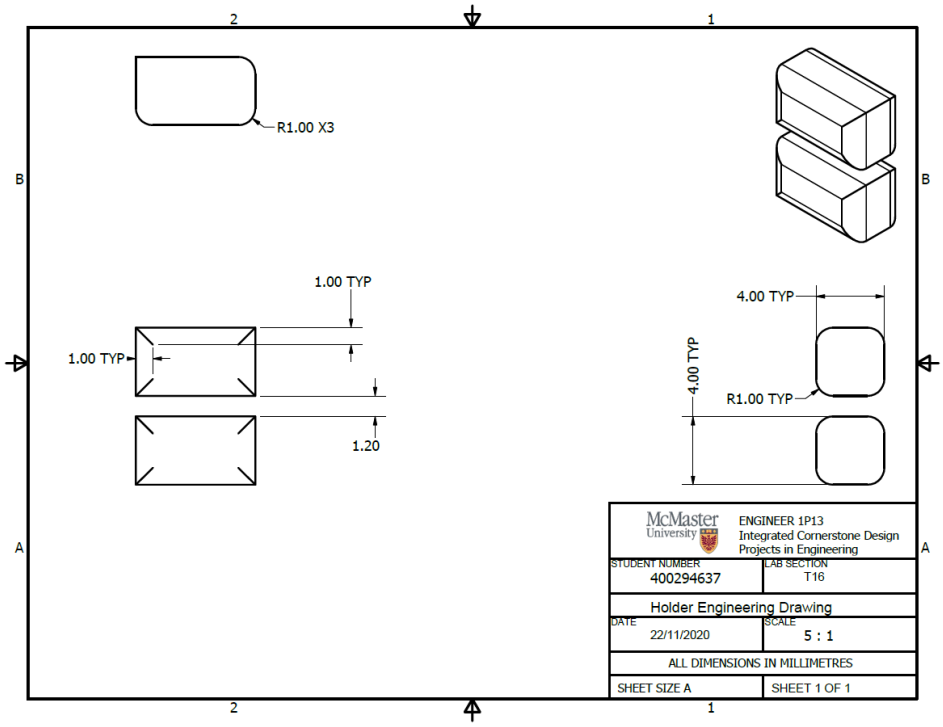
Container Engineering Drawing



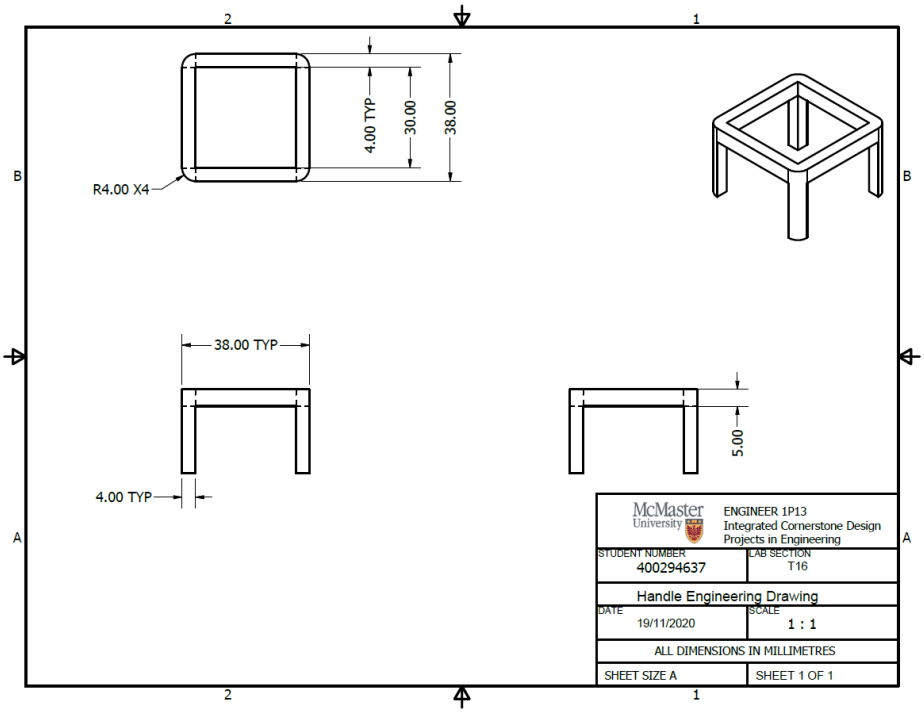
Main Support Engineering Drawing



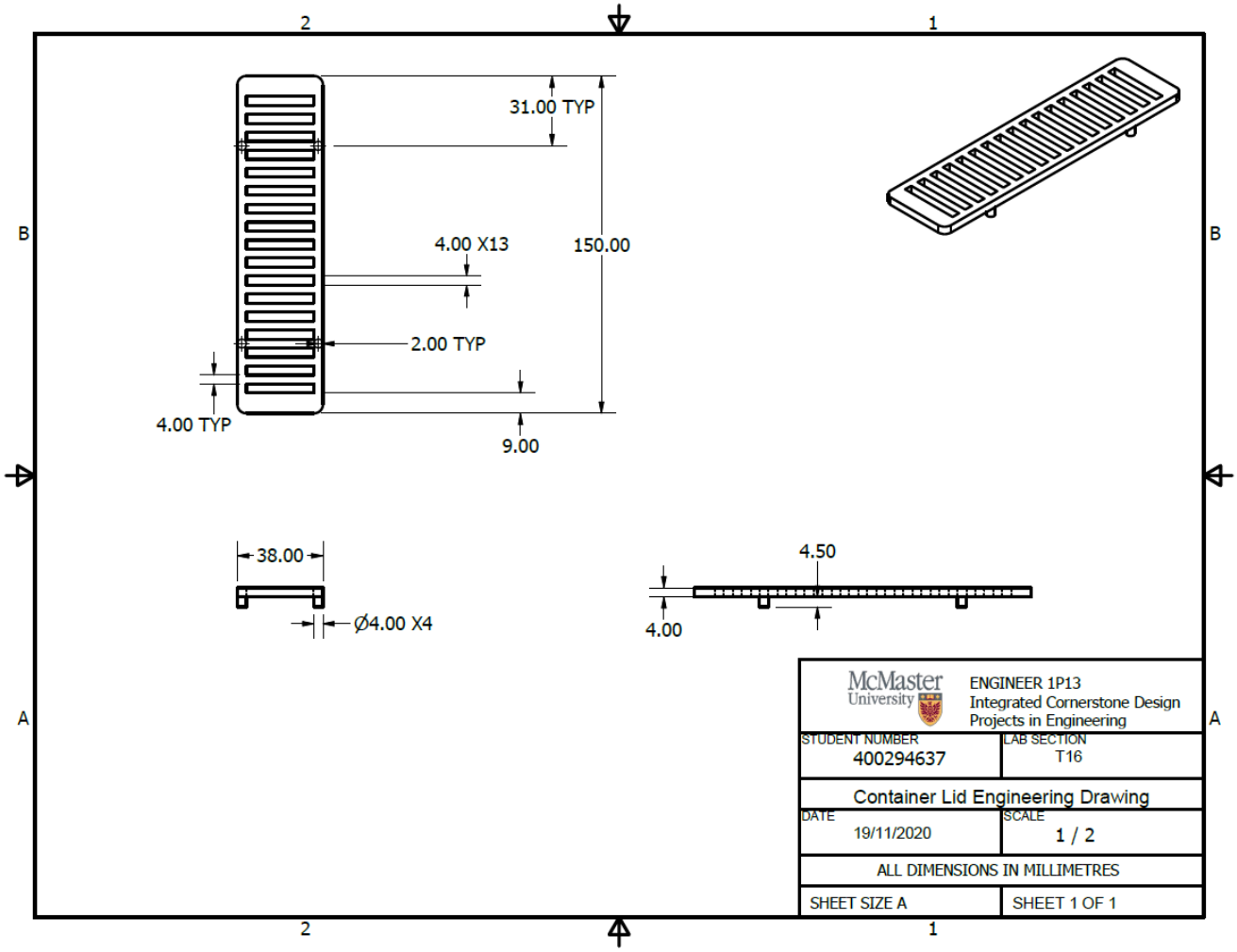
Arm Supports Engineering Drawing



Handle Engineering Drawing



Container Lid Engineering Drawing



Appendix C – Computer Program Screenshots:

main.py

P2.py - C:\Users\kartu\Desktop\p2\P2.py (3.8.6)

File Edit Format Run Options Window Help

```
import sys

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

import random
import os
import status

from Common_Libraries.p2_lib import *
from Common_Libraries.repeating_timer_lib import repeating_timer

# Initializing
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)

#coordinates of the autoclave
Red_large = [-0.3584, 0.1251, 0.2902] # coordinate of the red bin drawer
Red_small = [-0.6105, 0.2258, 0.3958]
Blue_large = [0.0, 0.3952, 0.2902]# coordinate of the blue bin drawer
Blue_small = [0.0, 0.6414, 0.3958]
Green_large = [0.0, -0.3952, 0.2902]# coordinate of the green bin drawer
Green_small = [0.0, -0.6414, 0.3958]
home = [0.4064, 0.0, 0.4826]
coordinateSet = [Red_small, Green_small, Blue_small, Red_large, Green_large, Blue_large]
```

```
#actions
def controlDrawer(id : int):
    if status.drawerFlag == 0: #if the drawer is close now
        status.drawerFlag = 1 #the status of the drawer is set to open
        if status.id == 4:   # open the drawer by the id
            arm.open_red_autoclave(True) # open's the corresponding drawer according to ID
        elif status.id == 5:
            arm.open_green_autoclave(True)
        elif status.id == 6:
            arm.open_blue_autoclave(True)
    elif status.drawerFlag == 1: # if the drawer is open now
        status.drawerFlag = 0 #the status of the drawer is set to close
        if status.id == 4: #close the drawer by id
            arm.open_red_autoclave(False)
        elif status.id == 5:
            arm.open_green_autoclave(False)
        elif status.id == 6:
            arm.open_blue_autoclave(False)

def moveToAutoclave(id:int):
    coordinates = coordinateSet[id-1] #get the autoclave coordinates by id
    arm.move_arm(home[0],home[1],home[2]) # moves the arm to home position
    time.sleep(1.5)
    arm.move_arm(coordinates[0], coordinates[1], coordinates[2]+0.02*status.storage[id-1]) # adjust the z coordinates by the storage of contianer
    time.sleep(2)
```

```
def moveToPickUp(coordinates : list):
    arm.move_arm(coordinates[0], coordinates[1], coordinates[2]) # move to the pick up position ,spawn location , pick up coordinates in(EMR function)
    time.sleep(1.5)

def reset(): # reinitialize the arm to be prepared for the next container
    arm.home()
    time.sleep(1.5)
    arm.open_red_autoclave(False) #closing all drawers of the autoclave
    arm.open_green_autoclave(False)
    arm.open_blue_autoclave(False)
    status.gripperFlag = 1
    status.drawerFlag = 0
    status.id = -1

def randomSpawn(): # random spawn a container
    if status.id != -1: # if there is a container grippered by the arm now
        return # the function will be terminated
    id = random.randint(1,6)
    status.id = id
    status.storage[id-1] += 1 #increments the specific storage value by 1
    arm.spawn_cage(status.id) #random conatiner dropped at pick up location
```

```
def sensorActions(L, R): # deal with the EMG signal
    if L == 1 and R == 0:  #signal vlaues
        randomSpawn()
    elif 0.5 <= L < 1 and 0.5 <= R < 1:
        if status.gripperFlag == 0:  # gripper is closed as the container is grabbed
            moveToAutoclave(status.id)
        else:
            moveToPickUp([0.5, 0, 0.01]) #coordinates of the pickup location, location of the spawn
    elif R == 1:
        controlDrawer(status.id)
    elif 0.5 <= L < 1:
        if status.gripperFlag == 1: #gripper is open
            arm.control_gripper(45)  #changing degree value to close the gripper
            time.sleep(2)
            status.gripperFlag = 0 #changes value of gripperflag to 0 as now its closed
    elif L == 0:
        if status.gripperFlag == 0:  #gripper is closed
            arm.control_gripper(-45)   #changing degree value to open the gripper
            time.sleep(2)
            reset()          #calls the reset function
            status.gripperFlag = 1   #changes value of gripperflag to 1 as now its open

def main():
    while True: # continuing listen to the EMG sensor
        sensorActions(arm.emg_left(), arm.emg_right())
        time.sleep(1.5) # refresh the emg signal every 1.5 sec

main()
```

Status.py

```
# global Variable Module
id = -1 # containner ID
drawerFlag = 0 # status of current drawer
gripperFlag = 1 # status of gripper
storage = [0,0,0,0,0,0] # storage of 6 kinds of container
```