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 T09

Team Thurs-49

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Submitted: December 8, 2021

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Academic Integrity Statement

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

Marisa Patel 400393635

X Marisa Patel

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Jingting Su 400317790

X Jingting Su

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Huan. Tran 400390120

X 

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Zein Deeb 400412632

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Executive Summary

The primary problem of this project was to design a container that enables the sterilization process in the autoclave and a computing program that enables the robotic arm to transfer the containers to the correct autoclave location. For such reasons, the team was divided into a computation sub-team and a modeling sub-team.

The modeling sub-team was responsible for designing the container that enables the process of sterilization to take place while abiding the size constraints so that the assigned tool (flat clamp) fits inside the container and the final container fits inside the provided footprint. Using the software called "Autodesk Inventor," we were able to create a design that looks creative as the shape of the container doesn't resemble the shape of the footprint along with incorporating a rod and a cap to serve the purpose of securing the tool inside the container which allowed the 3D print time to be at its minimum. Additionally, we decided to include a triangle looking shape along with reducing the size of the front part of the container to enable stability for the tool held inside the container. Besides the stabilization, we also paid close attention for maximizing the sterilization process by creating multiple windows on each side of the container. Beyond that, the idea of removing the lid and incorporating the lid and rod provided incredible results by increasing the performance of sterilization and disabling the tool to escape the container.

The computing sub-team was in responsibility of developing a computer program using Python in Quanser Interactive Labs (Q-Labs) interfacing with a robotic arm (Q-arm) that picks up, transfers, and drops off a container in the appropriate position. There are three small and three large containers. If the container is large, a drawer will open; however, if the container is small, it will be put on top of the autoclave bin. In Q-Labs, we identified the autoclave bin locations using trial and error. The program then identifies these values and places the containers. We created functions that execute a specific task to allow the Q-arm to operate. These functions include identifying the autoclave bin location, moving the end-effector, controlling the gripper, opening/closing the autoclave drawer, and the main function to call each function. To control each task, we used a sensor emulator value from combination 2 that are evaluated before executing each action, where our threshold is 0.5. The program begins at the home position, then the Q-arm moves to the pick-up position and grabs the container. Following this, the Q-arm returns to the home position. Next, the Q-arm transfers the container to the drop-off location, either on top or inside the drawer. Finally, the Q-arm returns to the home position and repeats the tasks until all six containers are transferred. Overall, we were successfully able to design a container and create a working computing program resulting in transfer, pick up and drop off the container while the tool was held and stable inside the designed container enabling sterilization.

Source Materials Database

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Appendix A – Supporting Documents

Final Computer Program Code

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

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

from Common_Libraries.p2_sim_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
#----------------------------------------------------------------------------------
#Marisa Patel and Zein Deeb
#defining bin_location
def bin_location(container_ID):
    if container_ID == 1: #small red container
        bin_loc = [-0.581,0.241,0.47]
    elif container_ID == 2:#small green container
        bin_loc = [0.0,-0.629,0.47]
    elif container_ID == 3:#small blue container
        bin_loc = [0.0,0.629,0.47]
    elif container_ID == 4:#large red container
        bin_loc = [-0.4, 0.18, 0.35]
    elif container_ID == 5:#large green container
        bin_loc = [0.0, -0.44, 0.354]
    elif container_ID == 6:#large blue container
        bin_loc = [0, 0.44, 0.354]
    return bin_loc
```

Figure 1. Final Computer Program Code Part 1, Defining bin_location function

```
#Jingting Su
#defining the end effector function

def move_end_effector (container_ID,location):
    while True :
        L = arm.emg_left()
        R = arm.emg_right()

        if L > 0.5 and R == 0  : #checking the L and R value
            arm.move_arm(0.406, 0.0, 0.483) #go to home position first
            time.sleep(0.5)
            arm.move_arm (location[0],location[1],location[2])
            break



#Marisa Patel, Zein Deeb and Jingting Su
# defining the function to open/close the drawer

def control_drawer(flag,container_ID):
    while True :
        L = arm.emg_left()
        R = arm.emg_right()
        if L == 0 and R > 0.5 and container_ID >= 4 : #checking the L and R value
            if container_ID == 4 :
                arm.open_red_autoclave(flag)
            elif container_ID == 5 :
                arm.open_green_autoclave(flag)
            elif container_ID == 6 :
                arm.open_blue_autoclave(flag)
            break
        elif  container_ID < 4:#checking if the drawer should open
            break
```

Figure 2. Final Computer Program Code Part 2, Defining move_end_effector and control_drawer functions

```python
#Marisa Patel, Zein Deeb and Jingting Su
#defining the function to control gripper

def control_gripper(flag):
    while True:
        L = arm.emg_left()
        R = arm.emg_right()
        if L > 0.5 and R > 0.5 : #checking the L and R value
            if flag == True:
                arm.control_gripper(-40)
            elif flag == False :
                arm.control_gripper(40)
            break
```

Figure 3. Final Computer Program Code Part 3, Defining control_gripper function

```python
#Marisa Patel, Zein Deeb and Jingting Su
#calling the main function to start the task

def main() :
    import random
    L = arm.emg_left()
    R = arm.emg_right()
    pick_location =  [0.534, 0.0, 0.035]#container's pickup location
    home_location = [0.406, 0.0, 0.483]
    my_list = [1,2,3,4,5,6]
    i = 0
    while i < 6 :
            ID = random.sample(my_list,1) # randomly picking one item in my_list  and put it in to ID
            container_ID = ID[0] # picking the first item in ID
            i = i+1
            my_list.remove(ID[0])#removing the item to avoid repetition
            arm.spawn_cage(container_ID) #spawning the conatiner
            print("The container ID selected is:", container_ID)
            move_end_effector(container_ID,pick_location)
            print("Move to the pick up location:",pick_location)
            control_gripper(False) #close the gripper to pick up container
            bin_loc = bin_location(container_ID)
            move_end_effector(container_ID,bin_loc)
            print("Move to the bin location:", bin_loc)
            control_drawer(True,container_ID) #if the container is large, open the drawer
            control_gripper(True) # open the gripper to drop off container
            control_drawer(False,container_ID)#if the container is large, close the drawer
            move_end_effector(container_ID,home_location)
            print("Move to the home location:", home_location)
            time.sleep(1.5) #avoid interfacing the arm and container
    print("The program will terminate.")

main()
#-------------------------------------------------------------------------------
# STUDENT CODE ENDS
#-------------------------------------------------------------------------------
```

Figure 4. Final Computer Program Code Part 4, Defining main function

Final Solid Model

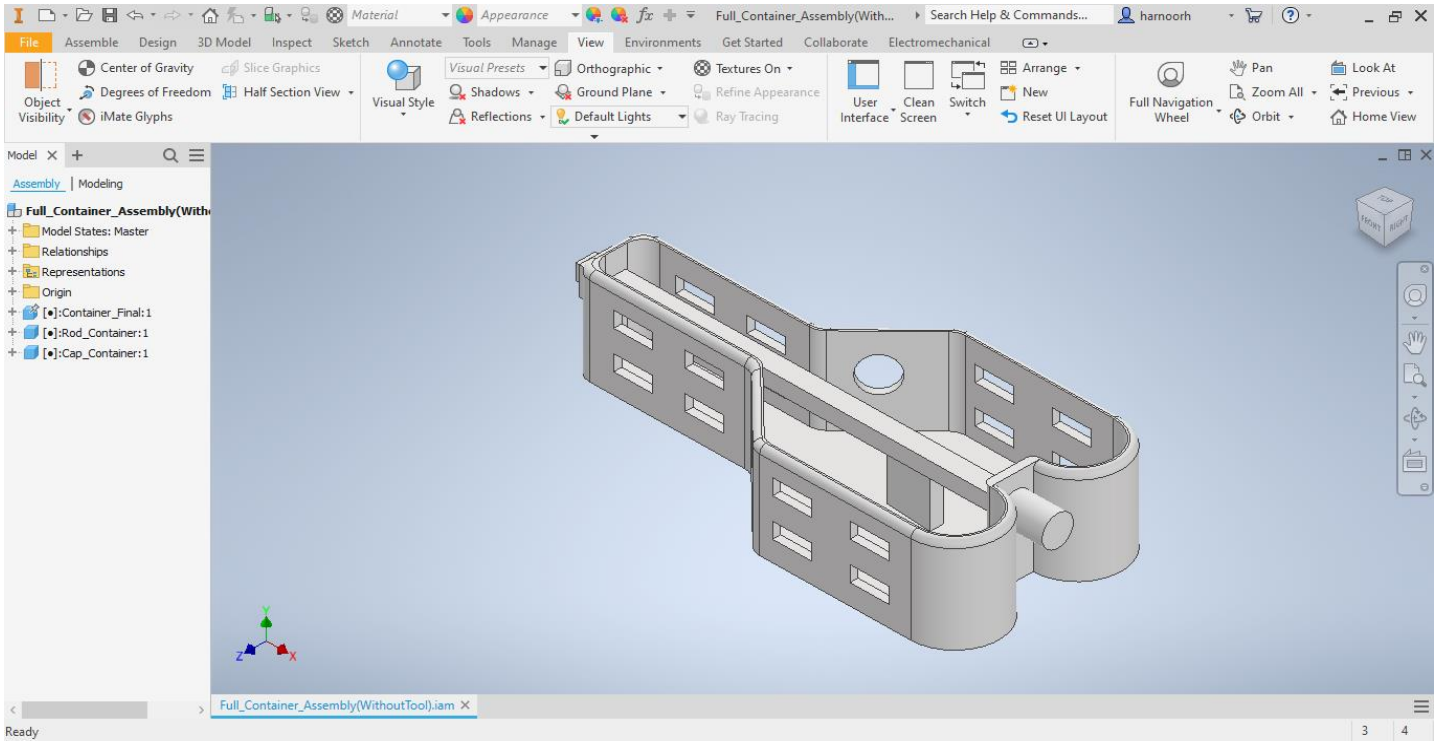


Figure 5. Final Container Assembly Without Tool

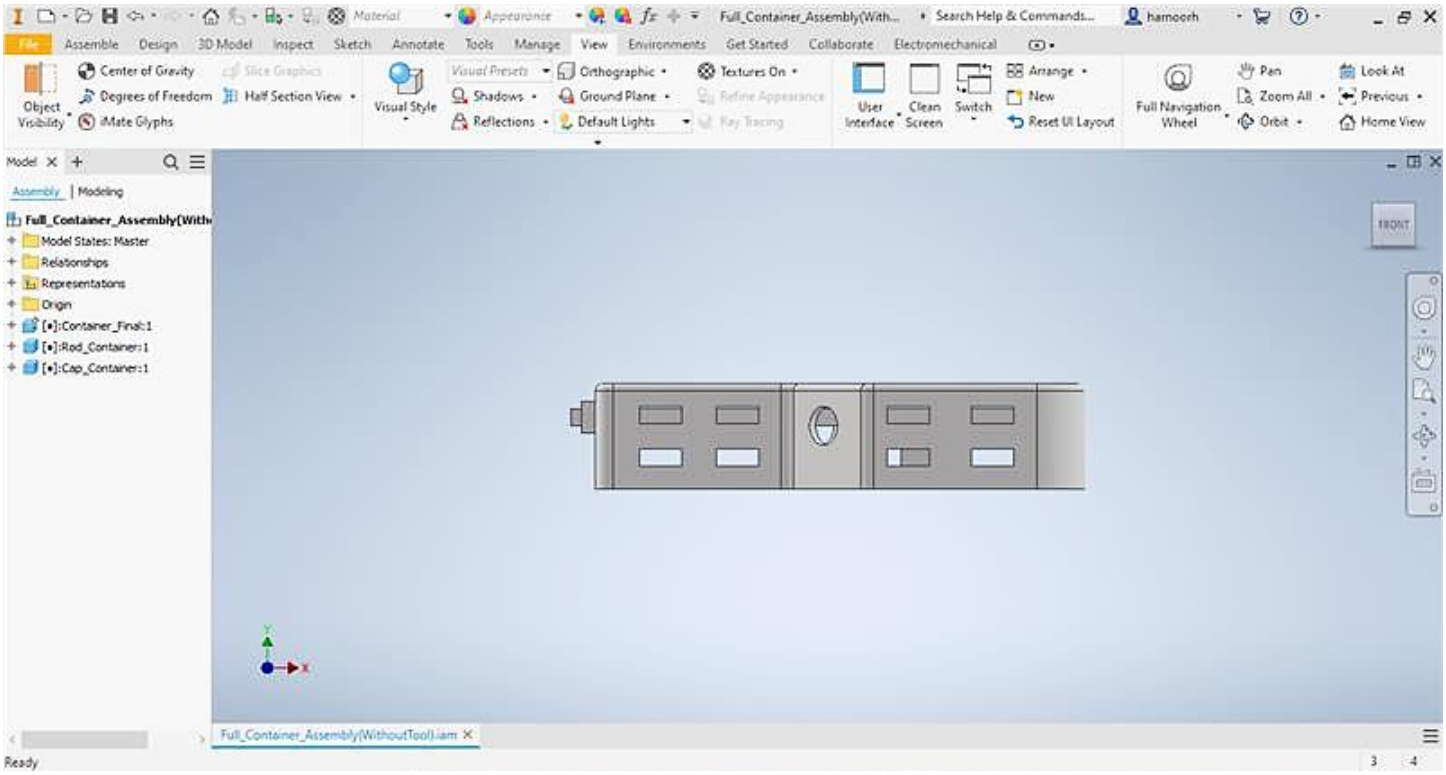


Figure 6. Final Container Assembly Without Tool, Front View

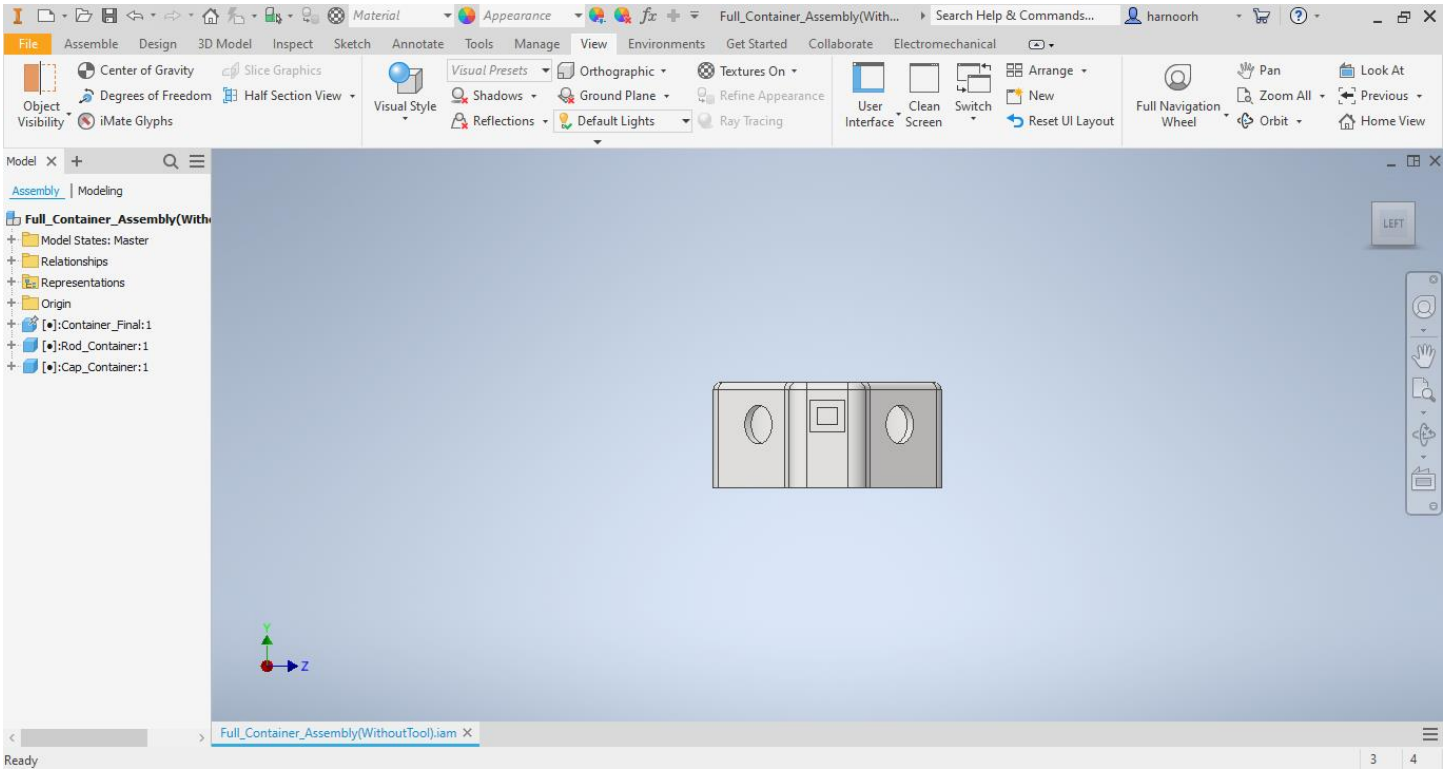


Figure 7. Final Container Assembly Without Tool, Left View

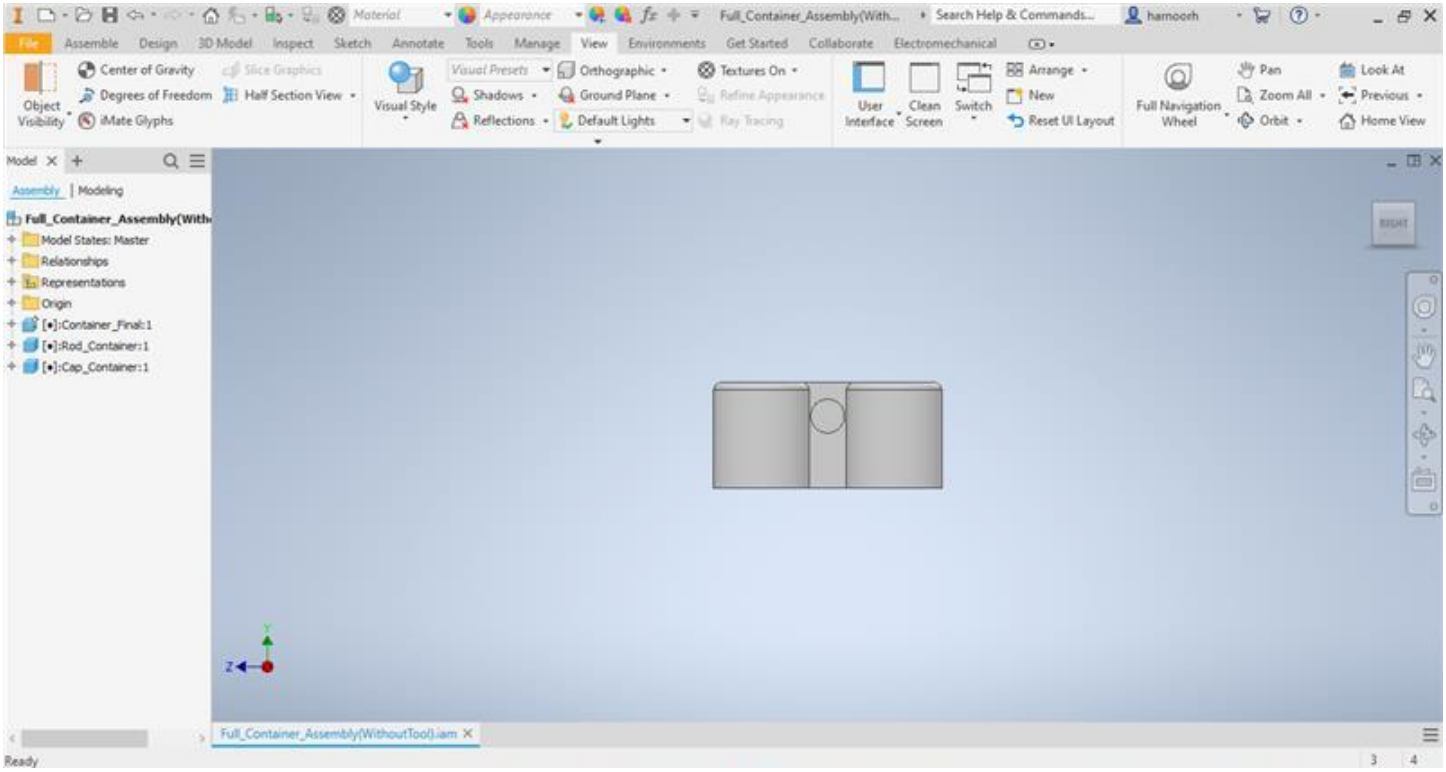


Figure 8. Final Container Assembly Without Tool, Right View

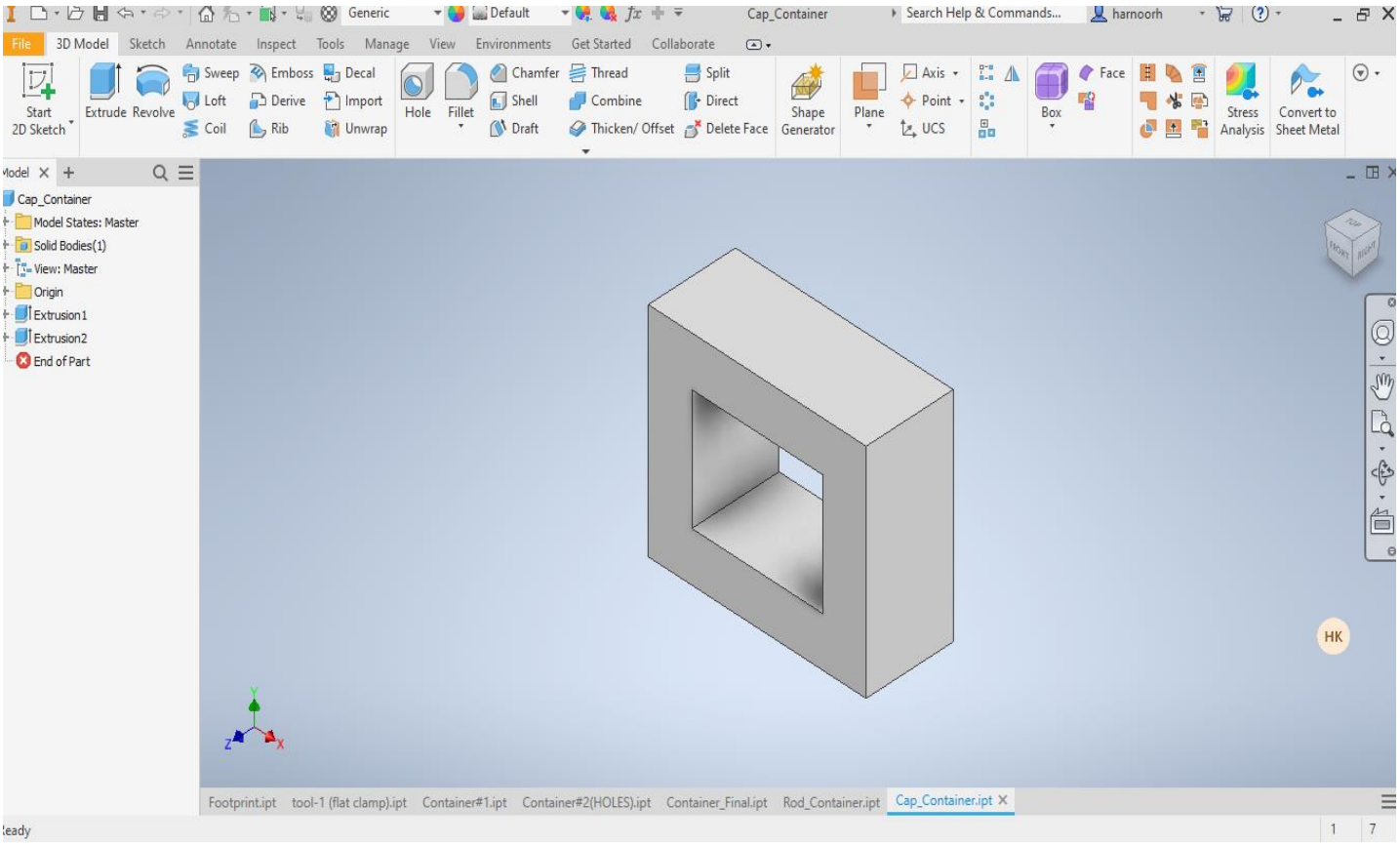


Figure 9. Final Container Cap

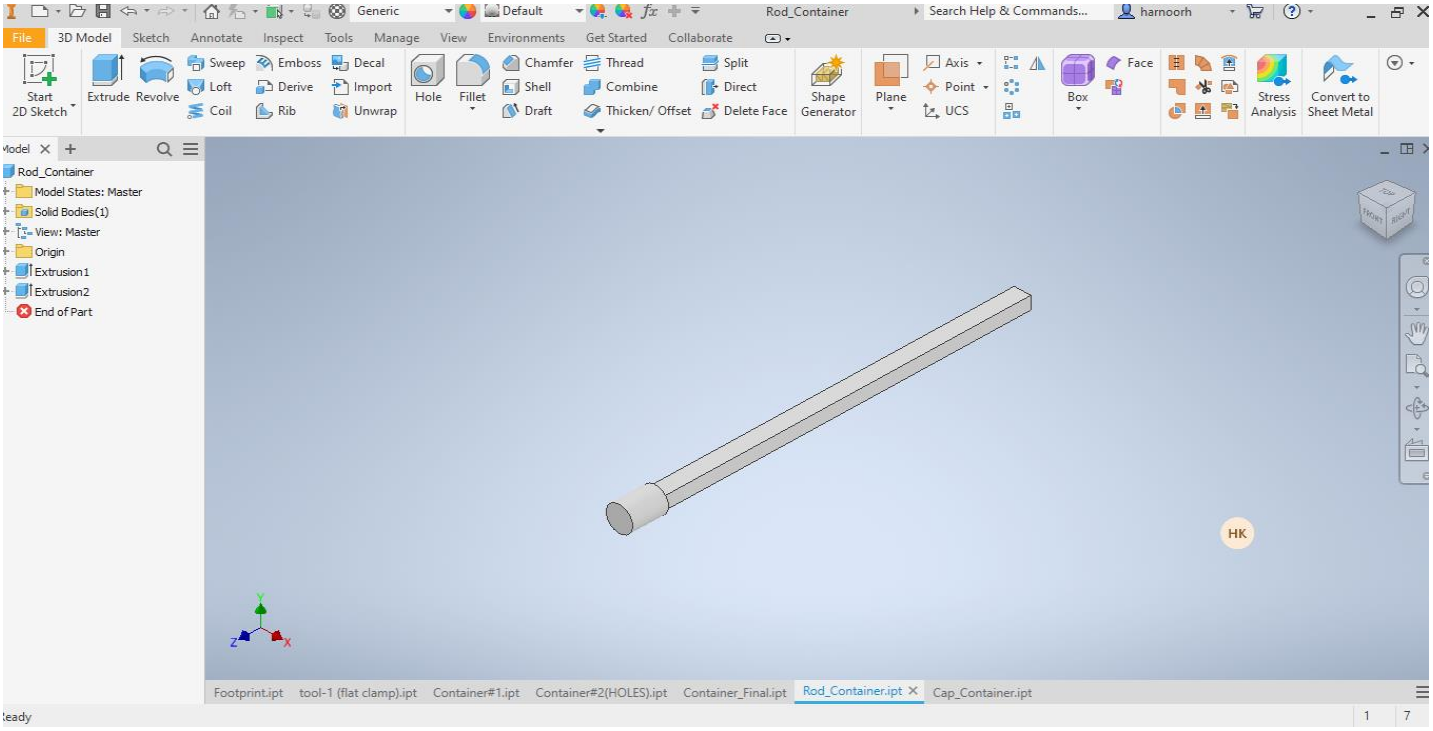


Figure 10. Final Container Rod

Engineering Drawings

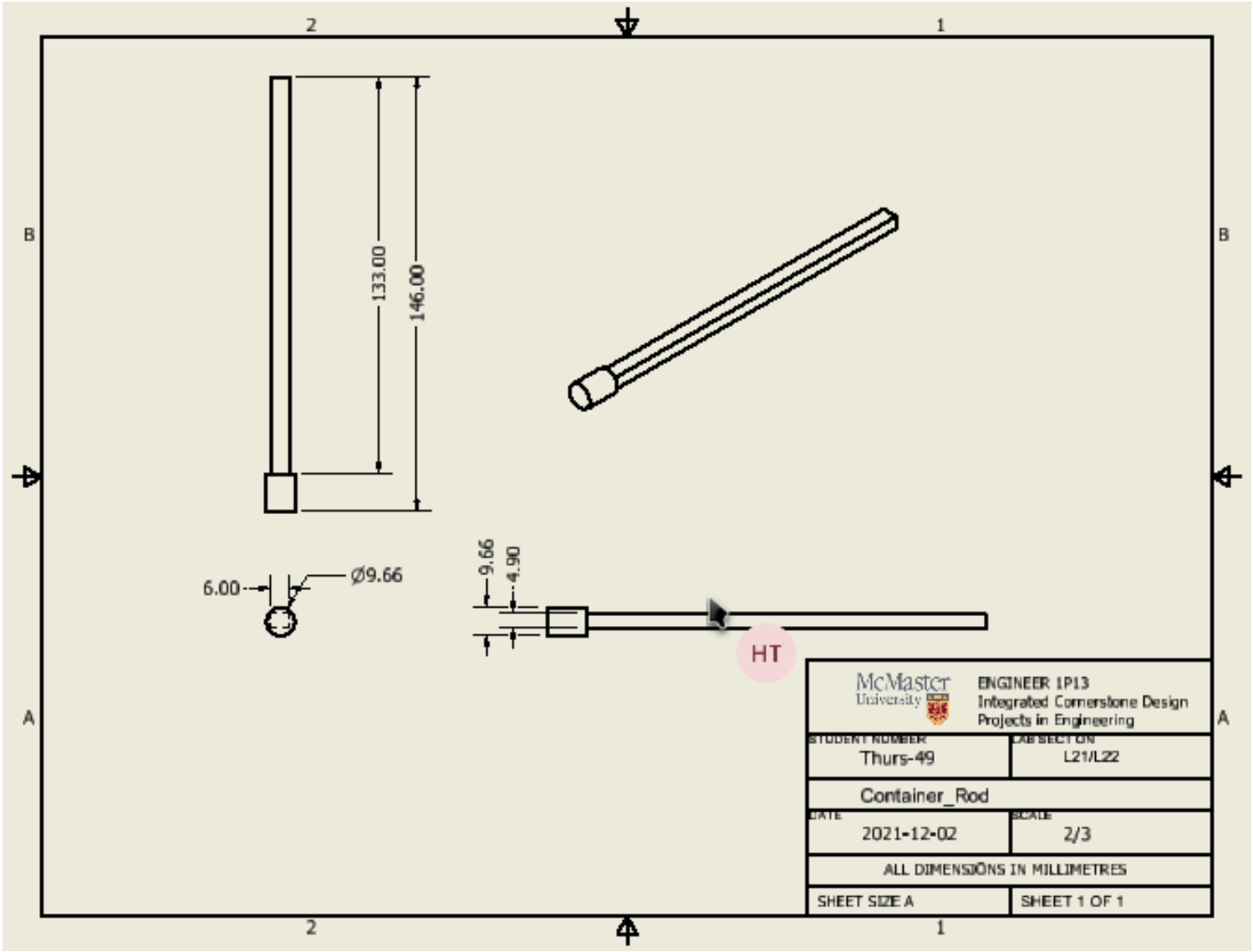


Figure 11. Engineering Drawing of Container Rod

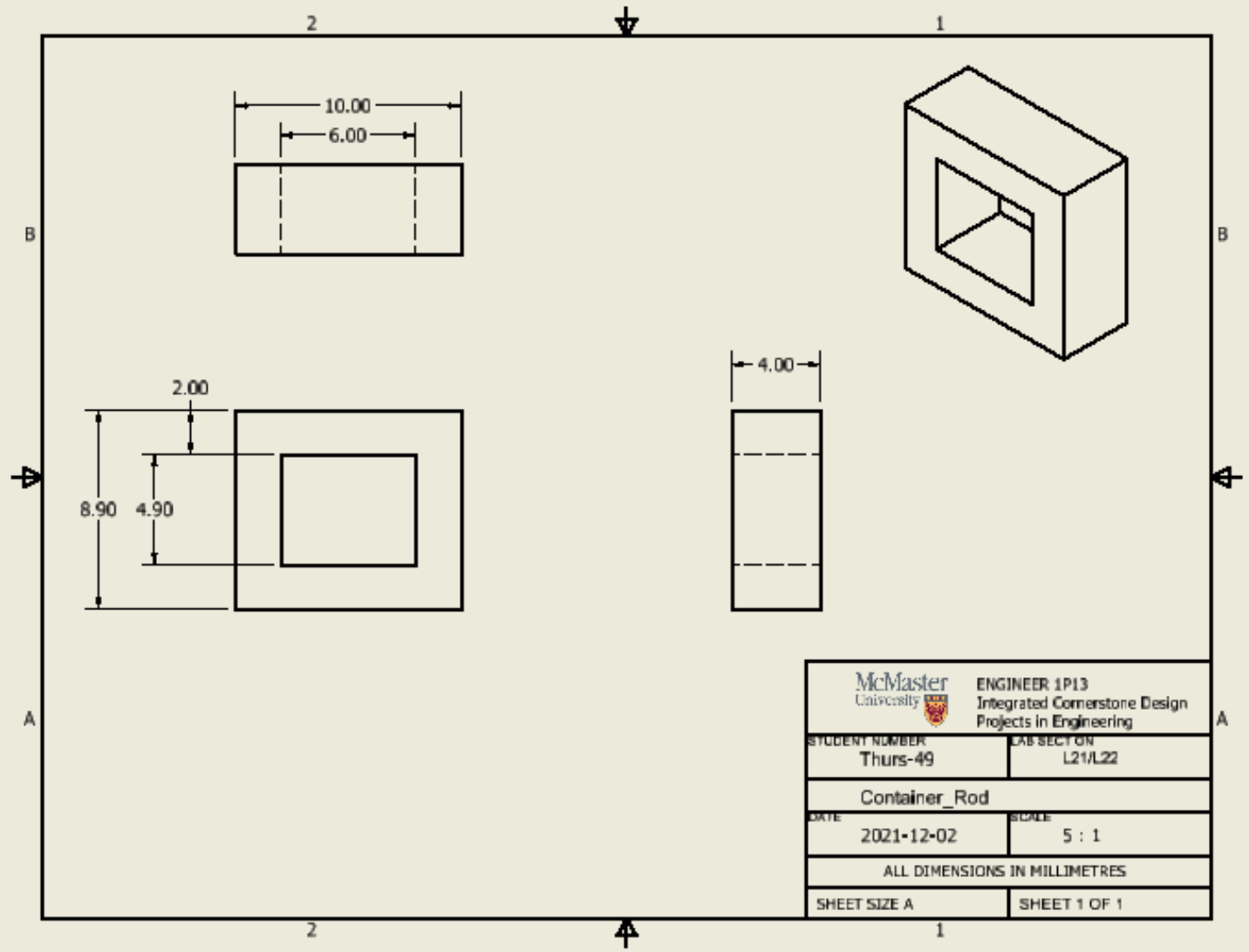


Figure 12. Engineering Drawing of Container Cap

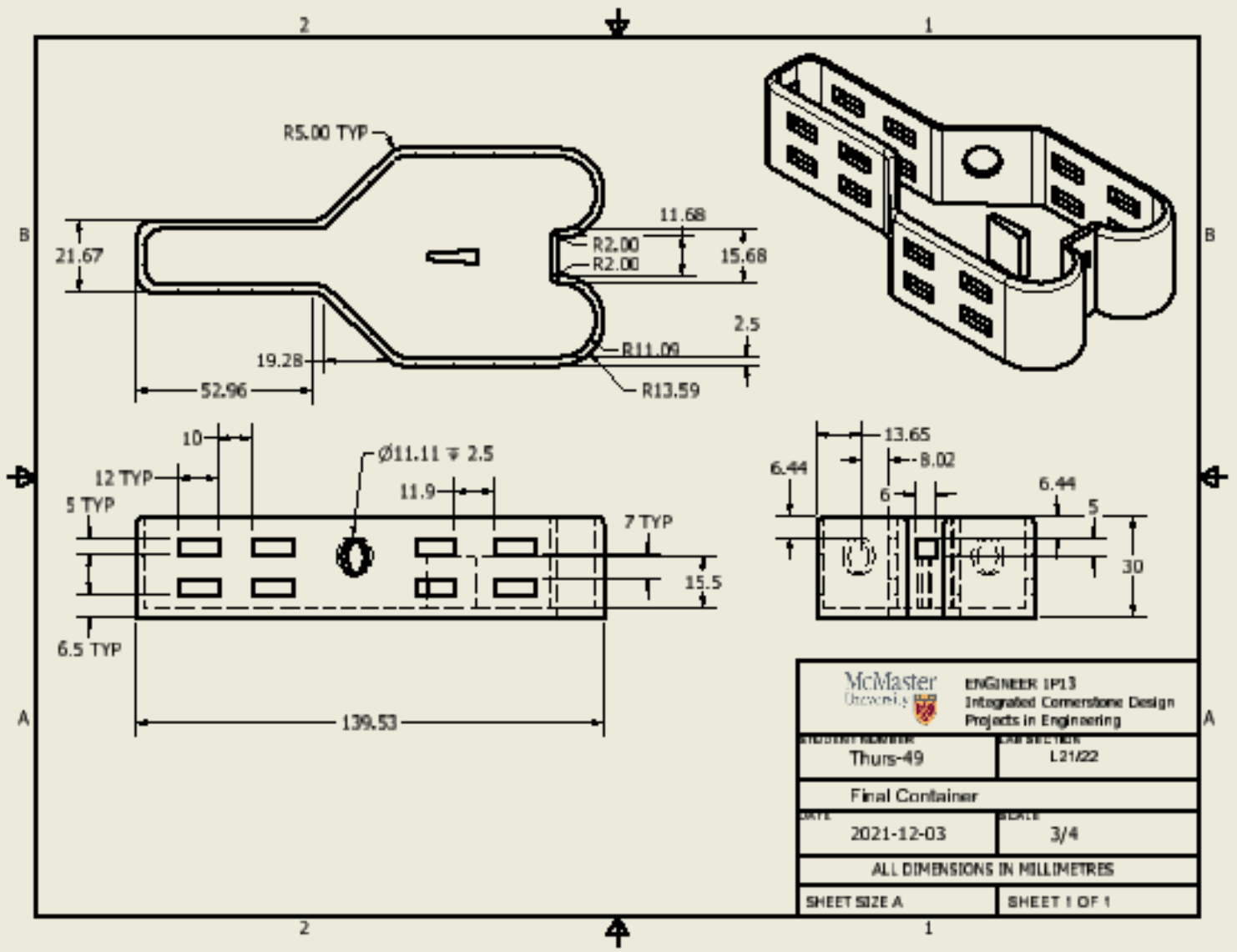


Figure 13. Engineering Drawing of Final Container

Appendix B – Project Schedule

Preliminary Gantt Chart

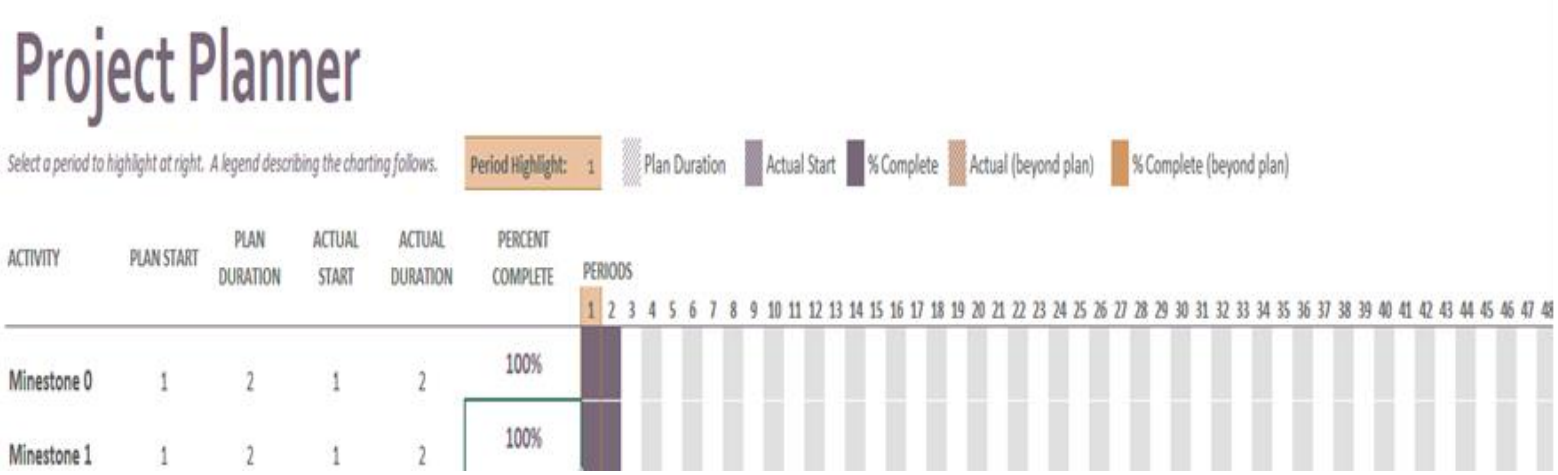


Figure 14. Preliminary Gantt Chart

Final Gantt Chart

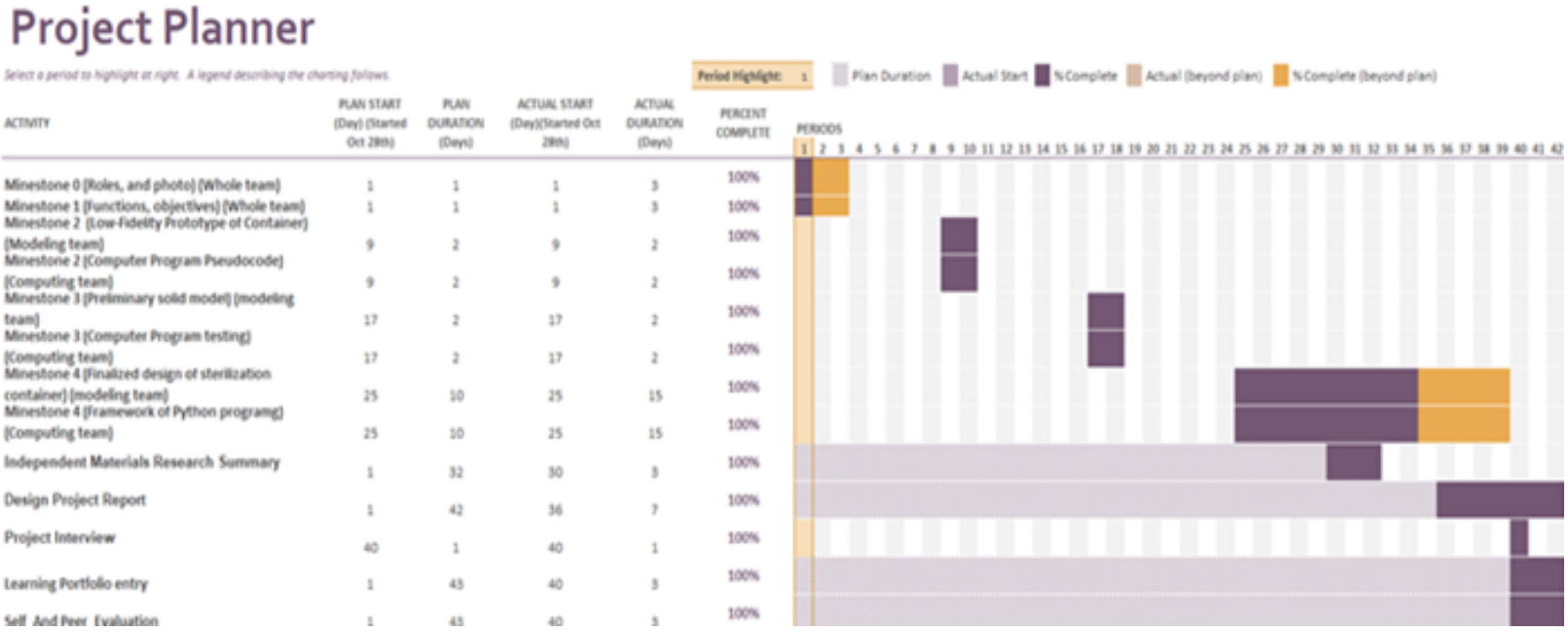


Figure 15. Final Gantt Chart

Logbook of Additional Meetings and Discussions

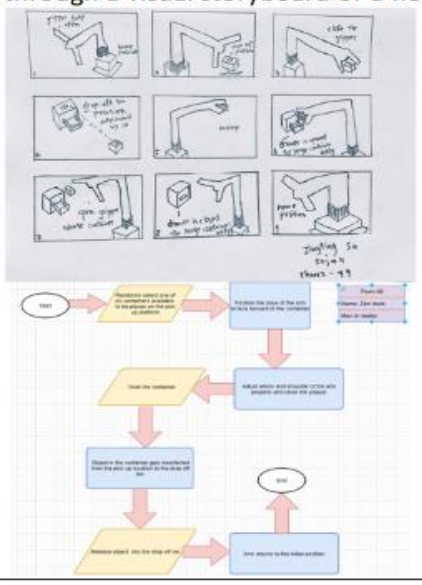
Logbook of Additional Meetings and Discussions			
Date	Time duration	Work done	Members
28-Oct	52 min	This was a whole group meeting to work on the functions, objectives, and means before submitting. (Confusion about the "Means" has been solved)	Everyone is here
6-Nov	1h 30mins	P2 (Milestone 2): We worked on the workflow of the entire system through a visual storyboard or a flowchart. 	Computation sub-team (Jingting, Marisa and Zein)

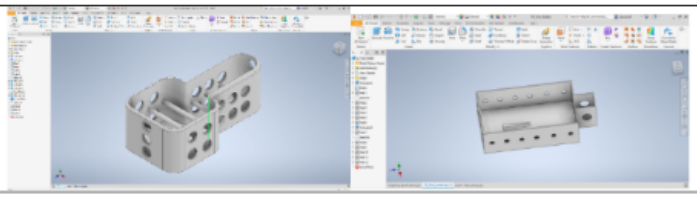
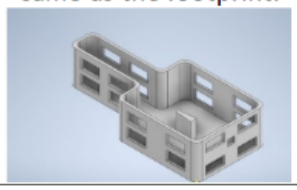
Figure 16. Logbook Part 1

13-Nov	2 hours	P2 (Milestone 3):
		We worked on the identify bin location function and move end-effector function in the Python code
		`def bin_location(container_ID):`
		`  if container_ID == 1: #small red container`
		`  bin_loc = [-0.581,0.241,0.47]`
		`  elif container_ID == 2:#small green container`
		`  bin_loc = [0.0,-0.629,0.47]`
		`  elif container_ID == 3:#small blue container`
		`  bin_loc = [0.0,0.629,0.47]`
		`  elif container_ID == 4:#large red container`
		`  bin_loc = [-0.4, 0.18, 0.35]`
		`  elif container_ID == 5:#large green container`
		`  bin_loc = [0.0, -0.44, 0.354]`
		`  elif container_ID == 6:#large blue container`
		`  bin_loc = [0, 0.44, 0.354]`
		`  return bin_loc`
		`def move_end_effector (container_ID,location):`
		`  while True :`
		`  L = arm.emg_left()`
		`  R = arm.emg_right()`
		`  if L > 0.5 and R == 0  : #checking the L and R value`
		`  arm.move_arm(0.406, 0.0, 0.483) #go to home position first`
		`  time.sleep(0.5)`
		`  arm.move_arm (location[0],location[1],location[2])`
		`  break`
			Computation sub-team (Jingting,Marisa and Zein)

13-Nov	1h 34 min	Milestone Three: We were coming up with Preliminary Solid Model for the purpose of sterilization. Then creating each individual model in Autodesk Inventor. 	Modeling sub team (Huan and Harnoor)
19-Nov	2 hours	P2 (Milestone 4): We finished the designs that hadn't finished from last week then working on the final container (Expected), creating G-code.	Modeling subteam (Huan and Harnoor)

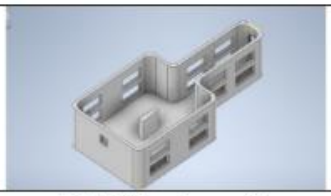
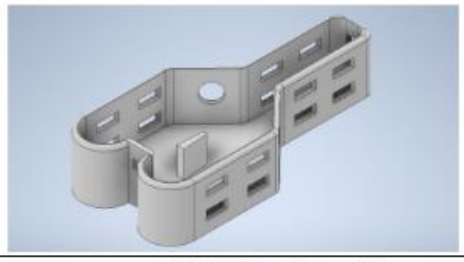
Figure 17. Logbook Part 2

<table>
<tr><td></td><td></td><td>  </td><td></td></tr>
<tr><td>20-Nov</td><td>1h 47 min</td><td>P2 (Milestone 4):
We came up with a new idea for the container to fix last day issue. We increased the wide of the windows to be greater than 2 mm (printable). Next we filleted all conners and made half of the container longer than the other so it won't be the same as the footprint.
  </td><td>Modeling subteam (Huan and Harnoor)</td></tr>
<tr><td>20-Nov</td><td>2h 30 min</td><td>P2 (Milestone 4):
Worked on the control gripper function and control drawer function in the Python code

```
def control_drawer(flag,container_ID):
    while True :
        L = arm.emg_left()
        R = arm.emg_right()
        if L == 0 and R > 0.5 and container_ID >= 4 : #checking the L and R value
            if container_ID == 4 :
                arm.open_red_autoclave(flag)
            elif container_ID == 5 :
                arm.open_green_autoclave(flag)
            elif container_ID == 6 :
                arm.open_blue_autoclave(flag)
            break
        elif  container_ID < 4:#checking if the drawer should open
            break

'
def control_gripper(flag):
    while True:
        L = arm.emg_left()
        R = arm.emg_right()
        if L > 0.5 and R > 0.5 : #checking the L and R value
            if flag == True:
                arm.control_gripper(-40)
            elif flag == False :
                arm.control_gripper(40)
            break
```

</td><td>Computation sub-team (Jingting,Marisa and Zein)</td></tr>
<tr><td>21-Nov</td><td>1h 45 min</td><td>P2 (Milestone 4):
We remade our final container in order to cut down the printing time. We removed the windows from the back of the container. As a result, printing time was secured under 2h.</td><td>Modeling subteam (Huan and Harnoor)</td></tr>
</table>

Figure 18. Logbook Part 3

			
24-Nov	1h 26 min	P2 (Milestone 4): We changed our design by addng two semi-circle in the back so it looks different from the footprint. 	Modeling subteam (Huan and Harnoor)

25-Nov	2h 46min	P2 (Milestone 4):
		Worked on the main function
		`arm.spawn_cage(container_ID) #spawning the conatiner`
		`print("The container ID selected is:", container_ID)`
		`move_end_effector(container_ID,pick_location)`
		`print("Move to the pick up location:",pick_location)`
		`control_gripper(False) #close the gripper to pick up container`
		`bin_loc = bin_location(container_ID)`
		`move_end_effector(container_ID,bin_loc)`
		`print("Move to the bin location:", bin_loc)`
		`control_drawer(True,container_ID) #if the container is large, open the drawer`
		`control_gripper(True) # open the gripper to drop off container`
		`control_drawer(False,container_ID)#if the container is large, close the drawer`
		`move_end_effector(container_ID,home_location)`
		`print("Move to the home location:", home_location)`
		`time.sleep(1.5) #avoid interfacing the arm and conatiner`
			Computation sub-team (Jingting,Marisa and Zein)

Figure 19. Logbook Part 4

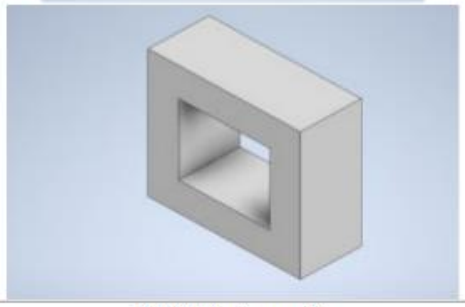
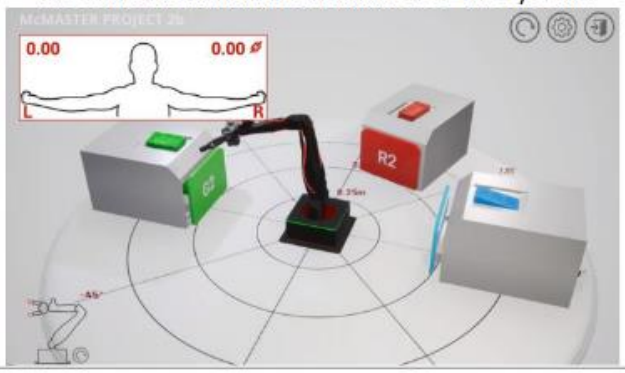
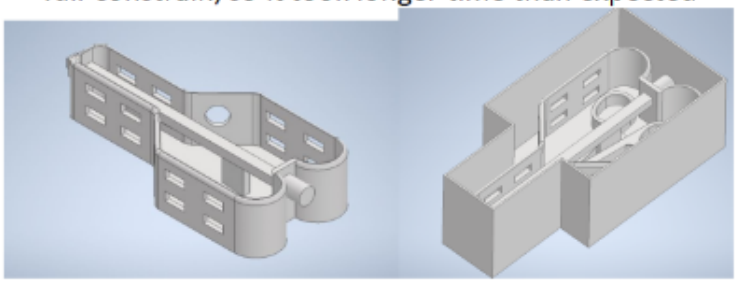
25-Nov 26-Nov 29-Nov	30 min 3h 48 min 33 min	P2 (Milestone 4): In order to maximize the stabilization, we created a rod and a cap. The rod was going through the two holds at the back and the front of the container. The rod will keep the tool stay secure even if there are rotating or dropping during the transporting process.  	Modeling subteam (Huan and Harnoor)
30-Nov	4 hours	P2 (Milestone 4): Solved the problem of the drawer not opening and worked on the continuation and termination of the system. 	Computation sub-team (Jingting,Marisa and Zein)

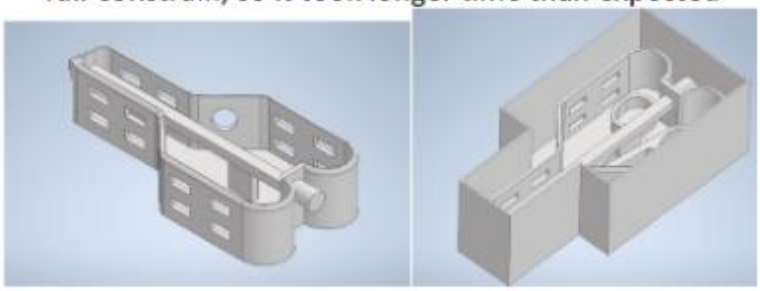
Figure 20. Logbook Part 5

1-Dec 2-Dec 3-Dec	1h 33 min 1h 18 min 2h	We finished the assembly for the container, rod, cap. Then created another one for the container, rod, cap, tool, and footprint. During the assembly, there were some problem with full-constrain, so it took longer time than expected 	Modeling subteam (Huan and Harnoor)

2-Dec	2hours	P2 (Milestone 4):
		Made the code simpler, added comments, and final tested the code
		`def main() :`
		`  import random`
		`  L = arm.eeg_left()`
		`  R = arm.eeg_right()`
		`  pick_location =  [0.534, 0.0, 0.035]#container's pickup location`
		`  home_location = [0.406, 0.0, 0.483]`
		`  my_list = [1,2,3,4,5,6]`
		`  i = 0`
		`  while i < 6 :`
		`  ID = random.sample(my_list,1) # randomly picking one item in my_list  and put it in to ID`
		`  container_ID = ID[0] # picking the first item in ID`
		`  i = i+1`
		`  my_list.remove(ID[0])#removing the item to avoid repetition`
		`  arm.spawn_cage(container_ID) #spawning the conatiner`
		`  print("The container ID selected is:", container_ID)`
		`  move_end_effector(container_ID,pick_location)`
		`  print("Move to the pick up location:",pick_location)`
		`  control_gripper(False) #close the gripper to pick up container`
		`  bin_loc = bin_location(container_ID)`
		`  move_end_effector(container_ID,bin_loc)`
		`  print("Move to the bin location:", bin_loc)`
		`  control_drawer(True,container_ID) #if the container is large, open the drawer`
		`  control_gripper(True) # open the gripper to drop off container`
		`  control_drawer(False,container_ID)#if the container is large, close the drawer`
		`  move_end_effector(container_ID,home_location)`
		`  print("Move to the home location:", home_location)`
		`  time.sleep(1.5) #avoid interfacing the arm and conatiner`
		`  print("The program will terminate.")`
		`main()`
			Computation sub-team (Jingting,Marisa and Zein)

4-Dec 5-Dec	2h 5 min 30 min	We submitted the files but we cannot open it when redownloaded (Because of the renamed and changed location files). Thus, we had to reassembly with the new name and send the files to our friends to open (it's opened). Then we resubmitted our file.	Modeling subteam (Huan and Harnoor)
4-Dec 5-Dec		After finishing with Autodesk inventor, we moved on to our interview. We create an presentation and interviewed each other to prepare for the interview in 6-Dec.	Modeling subteam (Huan and Harnoor)

Figure 21. Logbook Part 6

1-Dec 2-Dec 3-Dec	1h 33 min 1h 18 min 2h	We finished the assembly for the container, rod, cap. Then created another one for the container, rod, cap, tool, and footprint. During the assembly, there were some problem with full-constrain, so it took longer time than expected 	Modeling subteam (Huan and Harnoor)

2-Dec	2hours	P2 (Milestone 4):
		Made the code simpler, added comments, and final tested the code
		`def main() :`
		`  import random`
		`  L = arm.eeg_left()`
		`  R = arm.eeg_right()`
		`  pick_location =  [0.534, 0.0, 0.035]#container's pickup location`
		`  home_location = [0.406, 0.0, 0.483]`
		`  my_list = [1,2,3,4,5,6]`
		`  i = 0`
		`  while i < 6 :`
		`  ID = random.sample(my_list,1) # randomly picking one item in my_list  and put it in to ID`
		`  container_ID = ID[0] # picking the first item in ID`
		`  i = i+1`
		`  my_list.remove(ID[0])#removing the item to avoid repetition`
		`  arm.spawn_cage(container_ID) #spawning the conatiner`
		`  print("The container ID selected is:", container_ID)`
		`  move_end_effector(container_ID,pick_location)`
		`  print("Move to the pick up location:",pick_location)`
		`  control_gripper(False) #close the gripper to pick up container`
		`  bin_loc = bin_location(container_ID)`
		`  move_end_effector(container_ID,bin_loc)`
		`  print("Move to the bin location:", bin_loc)`
		`  control_drawer(True,container_ID) #if the container is large, open the drawer`
		`  control_gripper(True) # open the gripper to drop off container`
		`  control_drawer(False,container_ID)#if the container is large, close the drawer`
		`  move_end_effector(container_ID,home_location)`
		`  print("Move to the home location:", home_location)`
		`  time.sleep(1.5) #avoid interfacing the arm and conatiner`
		`  print("The program will terminate.")`
		`main()`
			Computation sub-team (Jingting,Marisa and Zein)

4-Dec 5-Dec	2h 5 min 30 min	We submitted the files but we cannot open it when redownloaded (Because of the renamed and changed location files). Thus, we had to reassembly with the new name and send the files to our friends to open (it's opened). Then we resubmitted our file.	Modeling subteam (Huan and Harnoor)
4-Dec 5-Dec		After finishing with Autodesk inventor, we moved on to our interview. We create an presentation and interviewed each other to prepare for the interview in 6-Dec.	Modeling subteam (Huan and Harnoor)

Figure 22. Logbook Part 7

			
7-Dec	4hours	We worked on the final report together	Computation sub-team and Modelling sub-team

Figure 23. Logbook Part 8

Appendix C – Weekly Meetings

Weekly Design Studio Agendas and Meeting Minutes

ENGINEER 1P13

MEETING WITH TEAM Thurs-49 - Thursday, Nov.4, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Huan Tran	tranh28	yes
Administrator1	Zein Deeb	deebz	Yes
Administrator2	HarnoorKaur Harnoor Kaur	harnoork	Yes
Coordinator 1	Marisa Patel	patem156	Yes
Coordinator 2	Jingting Su	suj49	Yes
IAI	Anish Rangarajan	rangaraa	Yes

AGENDA ITEMS

1. Attendance & Updates
2. Issue from past week
3. Discuss changes from last week's prototype
4. Action Items for next meeting
5. Final Notes

MEETING MINUTES

1. Attendance & Updates
    a. Everyone is here!
2. Issue from past week
    a. Functions and means were hard to determine
3. Discuss changes from last week's prototype
    a. We changed the functions and means
        i. Facilitate sterilization
        ii. Maximum storage and stability
4. . Action Items for next meeting
    a. Filling the individual worksheet
        i. Coming up the flowchart/storyboard
        ii. Finish the refined sketch
5. . Final Notes
    a. Asked if the agendas need to be submitted now, but we only need to in the final report
    b. The refined sketches need to include more detail

Figure 24. November 4, 2021, Meeting Agenda and Minutes, Part 1

ENGINEER 1P13

MEETING WITH TEAM Thurs-49 - Thursday, Nov.4, 2021

POST-MEETING ACTION ITEMS

1. *Milestone 2 modeling part [HarnoorKaur, Huan Tran]*
2. *Milestone 2 computing part [Zein Deep, Marisa Patel, Jingting Su]*

Figure 25. November 4, 2021, Meeting Agenda and Minutes, Part 2

ENGINEER 1P13
MEETING WITH TEAM Thurs-49 - Thursday, Nov.11, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Huan Tran	tranh28	Yes
Administrator1	Zein Deeb	deebz	Yes
Administrator2	HarnoorKaur Harnoor Kaur	harnoork	Yes
Coordinator 1	Marisa Patel	patem156	Yes
Coordinator 2	Jingting Su	suj49	Yes
TA	Xuan La	lax	Yes

AGENDA ITEMS

1. Attendance & Updates
2. Issues from past week
3. Discuss changes from last week's prototype
4. Action Items for next meeting
5. Final Notes

MEETING MINUTES

1. Attendance & Updates
    a. Everyone is here!
    b. From past week, everyone was time, active, and working as a group
    c. From the modelling sub-team, beside working in class-hours, we were scheduling an off-course meeting to finish up our stretches as well as models
    d. The meeting was around 30-45 mins
    e. From the computing sub-team, we were previously working on the pre-milestone work
2. Issues from past week
    a. Modelling team:
        i. Understanding what our teammate was drawing, hence, it took a bit of time to explain to sketches
        ii. Finding the materials to build up the models
        iii. We utilized papers, drawing, elastic bands and an eyes-glasses box to create the model
        iv. It was hard to imagine and choose the suitable materials.

Figure 26. November 11, 2021, Meeting Agenda and Minutes, Part 1

ENGINEER 1P13
MEETING WITH TEAM Thurs-49 - Thursday, Nov.11, 2021

b. Computing team:
   i. Following the milestone's instructions, the wording was difficult to understand so it took a longer time to understand the steps and start
   ii. Identifying how simple the pseudocode needed to be while outlining the objectives
   iii. In the end, we got an idea and completed it (with the support from the TA)

3. Discuss changes from last week's prototype
   i. We have changed the sketches to fit with the footprint
   ii. At the beginning, we were not pay much attention to the footprint's constrains, so we sketched our containers have the shape exactly like the footprint
   iii. However, after the lecture, we change our containers' sketches to a rectangular and an oval shape

4. . Action Items for next meeting
   a. Fill the individual worksheet
      i. Have finished creating a preliminary solid model by using Autodesk inventor
      ii. Have finished writing a function in Python that achieves either, 1. Identify Autoclave Bin location, 2. Move End-Effector

5. . Final Notes
   a. Chem's mid-term this Saturday and the other two (math and physics) is coming within 2 weeks
   b. Black Friday is coming, as well as the final exam

POST-MEETING ACTION ITEMS

1. *Milestone 3 modeling part [HarnoorKaur HarnoorKaur, Huan Tran], finish it*
2. *Milestone 3 computing part [Zein Deeb, Marisa Patel, Jingting Su], finish it*

Figure 27. November 11, 2021, Meeting Agenda and Minutes, Part 2

ENGINEER 1P13
MEETING WITH TEAM 1 - THURS, NOV. 18, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Huan Tran	tranh28	yes
Administrator1	Zein Deeb	deebz	Yes
Administrator2	HarnoorKaur Harnoor Kaur	harnoork	Yes
Coordinator 1	Marisa Patel	patem156	Yes
Coordinator 2	Jingting Su	suj49	Yes
TA	Muhammad Arsalan Asif	asifm27	Yes

AGENDA ITEMS

1. Attendance & Updates
2. Issues from past week
3. Discuss changes from last week
4. Action Items for next meeting
5. Final Notes

MEETING MINUTES

1. Attendance & Updates
    a. Everyone is doing good!
    b. Everyone is here!
1. Issues from past week
    c. The modeling sub team did not have a finalized design
    d. The computation sub team was having difficulty finishing up components of their code

Figure 28. November 18, 2021, Meeting Agenda and Minutes, Part 1

ENGINEER 1P13

MEETING WITH TEAM 1 - THURS, NOV. 18, 2021

2. Discuss changes from last week
    a. Modelling team:
        i. Modeling team's design is finalized for today's checklist interview and is fully finished on inventor as well as the G-code
    b. Computing team:
        i. Major implementation to the computing sub-team's code
        ii. Got ready for the checklist interview
3. Action Items for next meeting
    a. Complete both checklists
    b. Make sure computer program runs for all six containers without manual input
    c. Discuss final report schedule
    d. Continue to work on the checklist for the designs
    e. Refine the final design for the container
    f. Have a working code
4. Final Notes
    a. Need to continue to complete the entire checklist
    b. Meet with a TA to double check for mistakes and for clarification

Post-Meeting Action Items

1. Continue to work on
2. Try to get feedback from the IAI on specific details

Figure 29. November 18, 2021, Meeting Agenda and Minutes, Part 2

ENGINEER 1P13
MEETING WITH TEAM 1 - THURS, NOV. 25, 2021

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Huan Tran	tranh28	yes
Administrator1	Zein Deeb	deebz	Yes
Administrator2	HarnoorKaur Harnoor Kaur	harnoorh	Yes
Coordinator 1	Marisa Patel	patem156	Yes
Coordinator 2	Jingting Su	suj49	Yes
TA	Xuan La	lax	Yes

AGENDA ITEMS

1. Attendance & Updates
2. Issues from past week
3. Discuss changes from last week
4. Action Items for next meeting
5. Final Notes

MEETING MINUTES

1. Attendance & Updates
    a. Everyone is here!
    b. Everyone is feeling good and ready to go
    c. Modelling team is caught up so far
2. Issues from past week
    a. Modelling team:
        i. Had trouble for the sketch of the container
        ii. Thought the container could be the exact shape of the footprint
        iii. When asked, we found out the shape of the container needed to be changed from the footprint
        iv. To make the G-code, we realized that we could rotate the container

Figure 30. November 25, 2021, Meeting Agenda and Minutes, Part 1

ENGINEER 1P13
MEETING WITH TEAM 1 - THURS, NOV. 25, 2021

i. Everything is well, need to adjust some coordinates in the code

3. Discuss changes from last week
    a. Modelling team:
        i. We redid the entire container and then reduced the time
    b. Computing team:
        i. Modified some coordinates
4. Action Items for next meeting
    a. Complete the checklist and begin to work towards final model and code
5. Final Notes
    a. Adjustments still need to be made to the model and code
    b. We will be contacting TA's for any help as needed

Post-Meeting Action Items

1. Work on final model [HarnoorKaur HarnoorKaur, Huan Tran]
2. Work on final code [Zein Deeb, Marisa Patel, Jingting Su]

Figure 31. November 25, 2021, Meeting Agenda and Minutes, Part 2

Appendix D – Independent Research Summary

Huan Tran

When the world is constantly innovating leading to the improvement of people's lives, needs and spirits. Therefore, people's perception of health becomes more meaningful, leading to the rapid development of the medical industry to protect human health. Nowadays, the aspect that engineers are focusing on is surgical materials because it directly affects human life and also requires a large amount of Manpower. The suture is one of the medical equipment that needs to be upgraded to satisfy biodegradable ability and be safer during wounding. The role of sutures is extremely important for both surgery and curing open injury because it may cause the body to respond and form inflammation at the Stitches after surgery, which leads to a negative consequence on would healing [1]. Hence, it is essential to develop antimicrobial surgical sutures with infection prevention [1]. Over the years, the collaboration between engineers and scientists has resulted in new approaches and technologies which is modifying the structure as well as physical properties of surgical sutures, increasing biocompatibility and reliability [2]. In order words, new sutures need to be unharmful for tissue, stiffness, wick; and improved manipulation properties have been developed [2]. Principles for the production of fibrous polypropylene and polycaproamide suture materials with prolonged antibacterial activity by binding chemotherapeutic drugs using ionic bonds have been found [2]. In order to increase the performance of the new sutures, engineers also perform a radiation coupling method to functionalize the surface of polypropylene (PP) sutures with N-vinyl imidazole (NVI), then loading silver (Ag) particles to the surface [3]. This method aims to create [(PP-g-HEMA)-g-NVI]/Ag and [(PP-) composites in which all the PP monofilaments have been functionalized by FTIR-ATR, SEM, EDS and TGA to improve the antibacterial efficacy and cytocompatibility [3]. Overall, the alternate method of designing sutures could guarantee protection against opportunistic pathogens during the healing [3].

HarnoorKaur HarnoorKaur

ECG Electrodes are used to evaluate the heart's activity and its performance for individuals. Electrode is the component that contacts the human body on different areas for which the results combine, and a graphical representation of the heart's activity is outputted on a screen [4]. There are many things to consider while choosing the material for the ECG Electrodes, some of them include: biocompatibility, cost effectiveness of the material, it should be easy to produce and most importantly it should be disposable. Additionally, the material should not provide electricity to the human body in contact but should enable electron conduction to take place from the human body to produce desired results [5]. Since the material should only allow the conduction of electrons from the body, a layer of gel typically made from silver chloride or potassium chloride is present to permit such action. Moreover, considering that a lot of people might have allergies from such material, to suffice the same action, ECG dry electrodes, which are composed of polymer come into use [6]. Polymer is nontoxic, meaning when it encounters your body it does not cause irritation and does not have the ability to systematically impair the biological system, and hence it is considered biocompatible [6]. It is one of the materials that is easily found everywhere, making it cheap and easy to produce. The purpose of the ECG electrodes is to stay intact to the body to get valid results for the progress of the heart, and polymer is a type of material which is lightweight yet very strong, therefore it will be easy to grip on the source and will not break easily [7]. All in all, polymer is an exceptional material selection choice for ECG Electrodes as it resists allergies, easily composed, biocompatible lightweight and suffices the function of electrodes in ECG.

Marisa Patel

Contact lenses are a commonly worn ocular medical device that is placed on the surface of the eyes to help correct eyesight. The three commonly known lenses are soft, hard, and rigid gas permeable (RGP) [8]. It is vital that the material selected is biocompatible and medical grade since it touches the surface of the eyes. A few valuable considerations made when selecting a material include comfort, wettability, thickness, oxygen permeability, Young's Modulus, and transparency [8]-[11]. Comfort is an important factor as contact lenses are worn for a long duration [9]. Comfort can be directly related to wettability [9]. Wettability reduces the friction that occurs between the lens and the eyelids, preventing discomfort [9]. The contact lenses should also have a low thickness (t) to allow for oxygen permeability (Dk) [10]. A lower thickness will allow for oxygen to travel through the lens and to the cornea, which reduces chances of negative effects including corneal swelling [11]. Essentially, high oxygen permeability is favoured over low oxygen permeability [10]. Generally, if the Young's Modulus (E) of the material is lower, the more comfortable and adaptable the lens will be [8]. This indicates that it would have a lower stiffness [8]. The material selected would also be transparent [8]. Considering these factors, typically soft or rigid gas permeable lenses are used [8]. Hard lenses have very low oxygen permeability and wettability, leading to discomfort [8]. Soft and RGP lenses are oxygen permeable and wettable [8]. Some typical materials selected to manufacture contact lenses includes acrylic (polymethyl methacrylate, hard lens) and silicone hydrogel (soft/RGP) [11]. In the past, acrylic was widely used; however, now more are made from silicone hydrogel [11]. This is because silicone hydrogel was more oxygen permeable and had an overall better performance [11].

Zein Deeb

Hip replacement surgery is one of the most common procedures performed across the world, in Canada, for example, a staggering 63,496 hip replacements were done in 2019–2020 [12]. The hips are one of our body's most pivotal joints, connecting the femurs to the pelvis. The hip joint is subjected to everyday stressors in addition to sustaining the weight of the upper half of the body. These stressors, especially as people get older, might put the hip joint's function in jeopardy [13]. A key factor in hip replacements is implants for the hip can be made from multiple combinations of materials like two examples are stainless steel (an alloy of iron, chromium, nickel, and molybdenum) and titanium alloys. In the case of stainless steel it has a very high resistance to corrosion so it does not deteriorate in the body it can also be shaped easily, which is a key consideration for implant manufacturers looking to reduce production costs, on average it would cost 6.06 USD/kg [13][14]. Titanium alloys are known for their exceptional corrosion resistance and mechanical qualities, such as their low density and young's modulus (115 GPA and 9220 Kg/m3, respectively). As a result of its low hardness, titanium and its alloys are characterized by poor fretting fatigue resistance and tribological properties, which limit their use [14][15]. In order to increase the life of metal hip replacements, a strong metal known as cobalt is used. However, as hip replacements fail small metal flakes subtly enter the body which would cause the patients to have cobalt toxicity or in other words high levels of cobalt, the main neurological side effects of systemic cobaltism/cobalt toxicity were determined to be hearing loss, tinnitus and imbalance [16][17].

Jingting Su

In recent years, material selection has been widely used in various aspects, especially in the biomedical field, where material selection is crucial. In this summary, the discussion will focus on materials related to catheters.

A catheter is a medical device tube that can be inserted into the human body. Latex rubber, silicone, PTFE coating, and polyurethane are a few of the materials widely used to make catheters. Latex rubber is cheap, while it is not suitable for people with latex allergies. Silicone has good chemical and thermal stability, but it is somewhat stiff and can cause patient discomfort, as is the PTFE coating. Polyurethane has good tensile strength. However, the disadvantage is that it cannot withstand autoclaving, which is a major drawback in a medical environment [18].

Different types of catheters are similar in that they have to be in contact with the inside of the body. In such cases, it is possible for foreign pathogens to break through the skin barrier and enter human tissue through the catheters [19]. So, it is important to choose the antimicrobial material to prevent bacterial infection. There are many different types of antimicrobial materials with different bactericidal strategies, including broad-spectrum antimicrobial strategies using graphene and its derivatives. And multimodal combinations of antimicrobial agents and antibiotics, such as vancomycin [20]. The application of antibiotics to the catheter coating is also a widely antibacterial method, the process is to dip the catheter into an organic solution containing antibiotics, this method is effective for short-term use of the catheter, but after a long period of use cannot effectively remove all the bacteria [21].

In conclusion, when making medical catheters, the choice of material requires consideration of all aspects. However, no one material is the best, and it is important to choose the most appropriate material for each specific situation.

Appendix E – Worksheets

Milestone 0 Team Worksheet

PROJECT TWO: MILESTONE 0 – COVER PAGE

Team Number: Thurs-49

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

Full Name:	MacID:
Zein Deeb	deebz
Harnoor Kaur Harnoor Kaur	harnoorh
Jingting Su	suj49
Marisa Patel	patem156
Huan. Tran	tranh28

Insert your Team Portrait in the dialog box below

MILESTONE 0 – SUB-TEAM CHARTER

Team Number: Thurs-49

Indicate which team member is on each sub-team in the table below.

- You may refer to the **P2P3 Overview** document on Avenue for information on each sub-team's requirements

	Team Member's Full Name
Modelling	Huan. Tran
	Harnoor Kaur Harnoor Kaur
Computing	Zein Deeb
	Marisa Patel
	Jingting Su

MILESTONE 0 – TEAM CHARTER

Team Number: Thurs-49

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Harnoor Kaur Harnoor Kaur	☐M ☐A ☒C ☐S
2.	Marisa Patel	☐M ☒A ☐C ☐S
3.	Jingting Su	☐M ☒A ☐C ☐S
4.	Zein Deeb	☐M ☐A ☒C ☐S
5.	Huan. Tran	☐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.

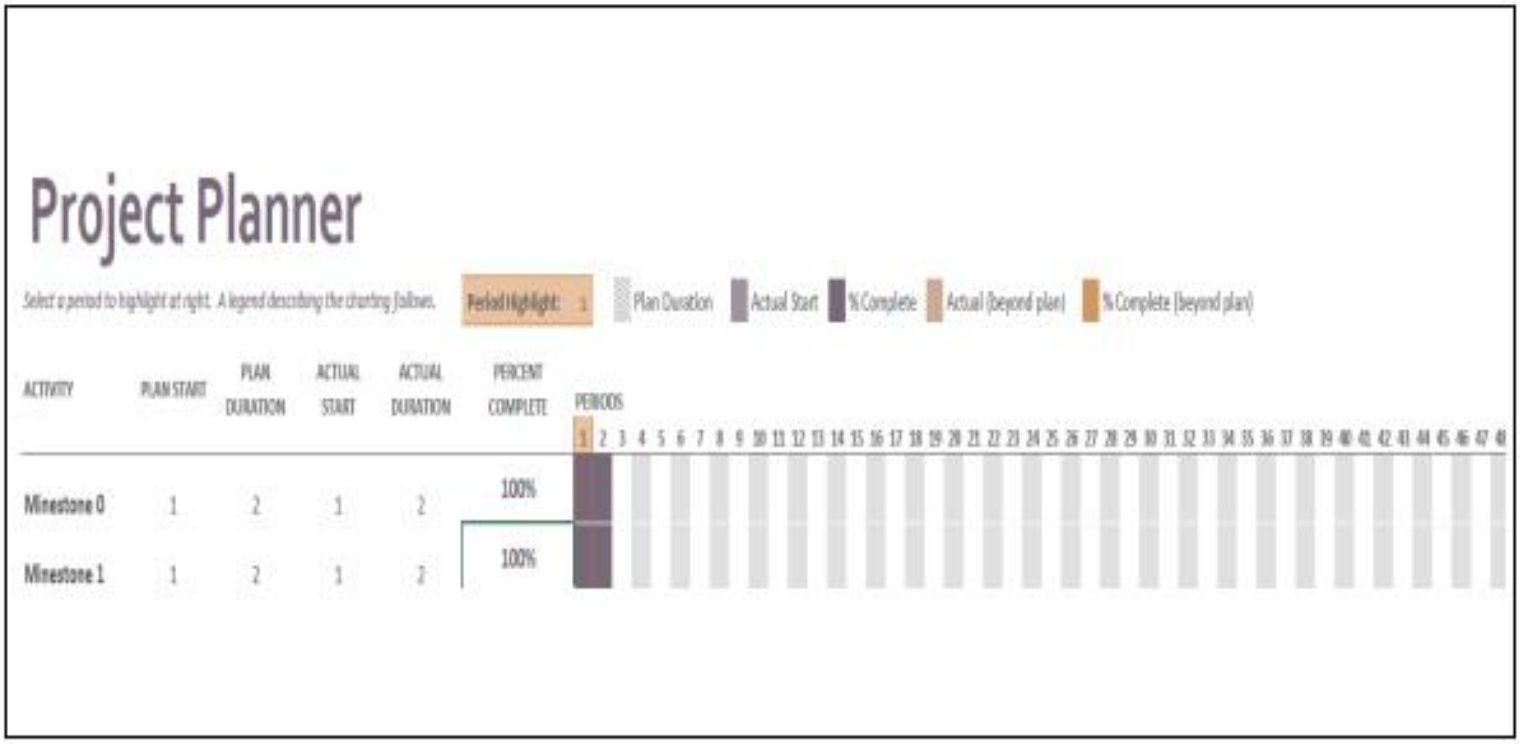
Role:	Team Member Name:	MacID
Manager	Huan. Tran	tranh28
Administrator 1	Zein Deeb	deebz
Administrator 2	Harnoor Kaur Harnoor Kaur	harnoorh
Coordinator	Marisa Patel	patem156
Coordinator	Jingting Su	suj49

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team Number: Thurs-49

Full Name of Team Manager:	MacID:
Huan. Tran	tranh28

Preliminary Gantt chart



Milestone 1 Team Worksheet

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team Number: Thurs-49

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

Full Name:	MacID:
Huan.Tran	tranh28
Zein Deeb	deebz
Harnoor Kaur Harnoor Kaur	harnoorh
Jingting Su	suj49
Marisa Patel	patem156

MILESTONE 1 (STAGE 1) – PRE-PROJECT ASSIGNMENT

Team Number: Thurs-49

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-49

Name: Huan.Tran	MacID: tranh28

Objective:

- Should prevent corrosion
- Should be soft inside
- Should be sterilized
- Lightweight

Constraints:

- Eliminate using heavy metals, and fragile materials
- Small size in order to carry

Functions:

- Easy to distribute
- Secure the stuff inside
- Easy to unload

Team Number: Thurs-49

Name: Jingting Su	MacID: suj49

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

Objectives

- Should transfer securely
- Should facilitate sterilization
- Should be stable fixation

Constraints

- Must need a large operating space
- Must hold a fixed shape tool
- Must hold the small size objective

Functions

- Able to pick up container
- Able to transfer to the autoclave

Name: Zein Deeb	MacID: deebz
Objectives • Should be reusable • Should be lightweight *Constraints* • Must be tilted at certain angles • Must be small/light to move around easier • Container should not be designed in a complicated form because it should be 3D printable *Functions* • Able to withstand high temperature when sterilizing • Able to hold liquids and solids • Able to pick up the container	

Team Number: Thurs-49

Name: Marisa Patel	MacID: patem156

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

Objectives

- Should be safe
- Should be sturdy and stable
- Should enable sterilization
- Container should hold surgical instrument for sterilization

Constraints

- Must restrict movement of surgical instrument in container
- Must conform to size standards

Functions

- Able to pick up container
- Able to hold container
- Able to transfer container to autoclave
- Able to put down container
- Able to hold surgical instrument in place during the transfer

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

Team Number: Thurs-49

Name: Harnoor Kaur Harnoor Kaur	MacID: harnoorh

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

Objectives

- Should be light weight
- Should be stable

Constraints

- Must be able to hold the equipment for the sterilization process
- Must meet the maximum and minimum size limit

Functions

- Is able to pick up, drop off the container up and place it in the correct place
- Is able to hold the surgical instruments (strong enough)

IILESTONE 1 (STAGE 2) – LIST OF OBJECTIVES, ONSTRAINTS, AND FUNCTIONS

Team Number: Thurs-49

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 light weight	Must be tilted at certain angles	Design is able to pick up and transfer the container to the autoclave
Should be stable and secure	Must meet the size limits	Able to hold surgical instrument in place during the transfer
Should be reusable	Must restrict movement of surgical instrument in container	Able to hold liquids and solids
Should enable sterilization	Container must be designed in a simple form because it should be 3D printable	Able to withstand high temperature when sterilizing
Should prevent corrosion	Must avoid using heavy metals, and fragile materials	Able to unload with ease

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

Design is able to pick up and transfer the container to the autoclave

3. What are the secondary functions?

Able to hold surgical instrument in place during the transfer
Able to hold liquids and solids
Able to unload with ease
Able to withstand high temperature when sterilizing

MILESTONE 1 (STAGE 3) – MORPHOLOGICAL ANALYSIS

Team Number: Thurs-49

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	Chains	Magnets	Hooks	Grip it with the claw	Add Handles on either side of the container	Making holes on each side of the container so that a finger of the robotic arm perfectly fits in the hole and picks it up.
Transfer	Two wheels	crawler	Add a mini fan at the back of the arm so that it takes the force from the fan to push the arm forward	The arm bends down to pick the container up and then makes a sturdy grip (clamps on to the container) and the container is help up in the air	Continuous track plates (the ones on the military tanks)	Mono wheel
Drop off		Slide	Drop it directly downwards by ungrasping	Let go of one of the handles	Projectile (follow a perfect trajectory to land on the desired position)	

MILESTONE 1 (STAGE 4) – CONCEPT SKETCHES

Team Number: Thurs-49

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 photos 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:

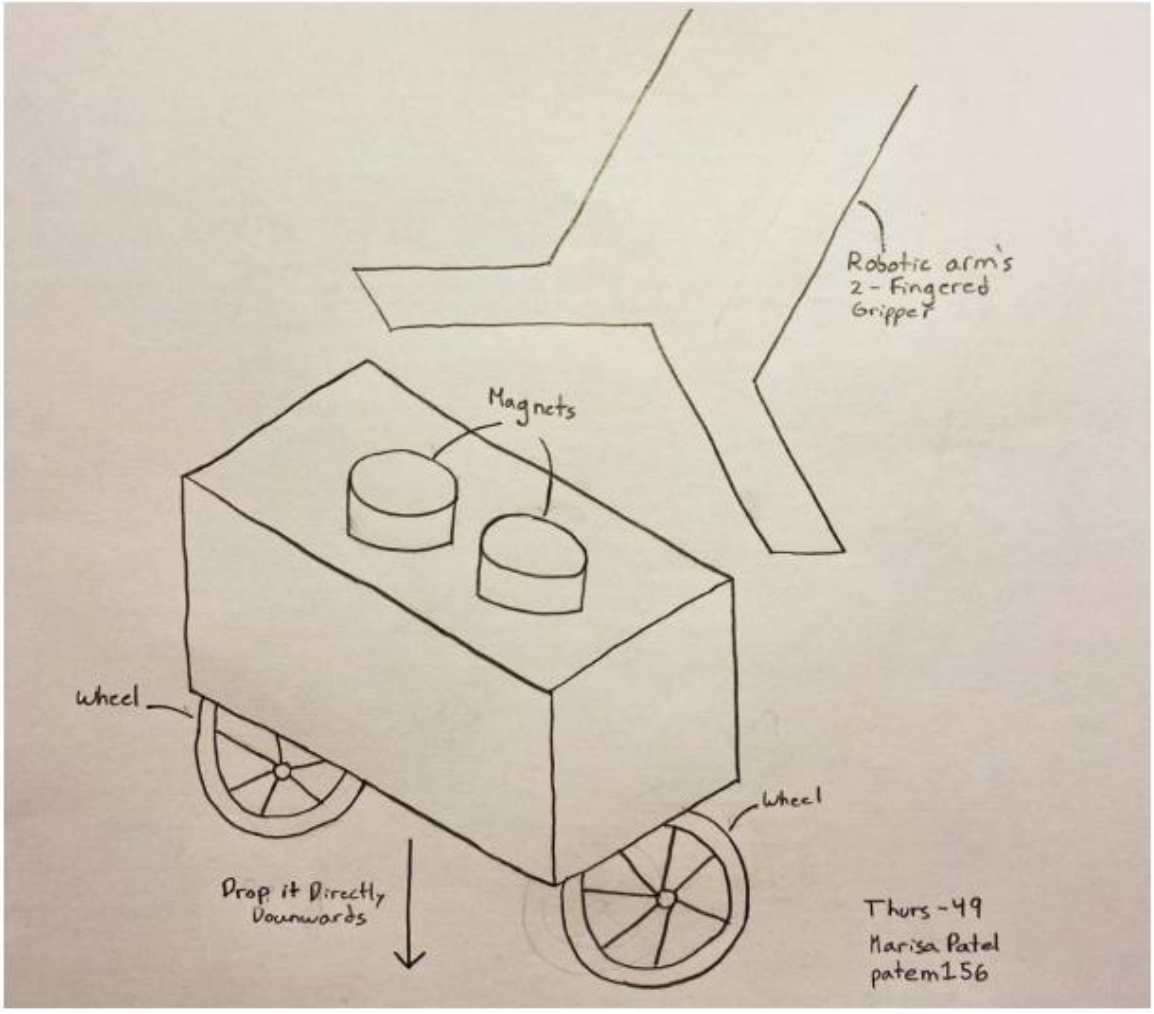
- Each team member needs to submit their sketch with the **Milestone One Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone One Team Worksheets** document allows you to readily access your team member's work

Team Number: Thurs-49

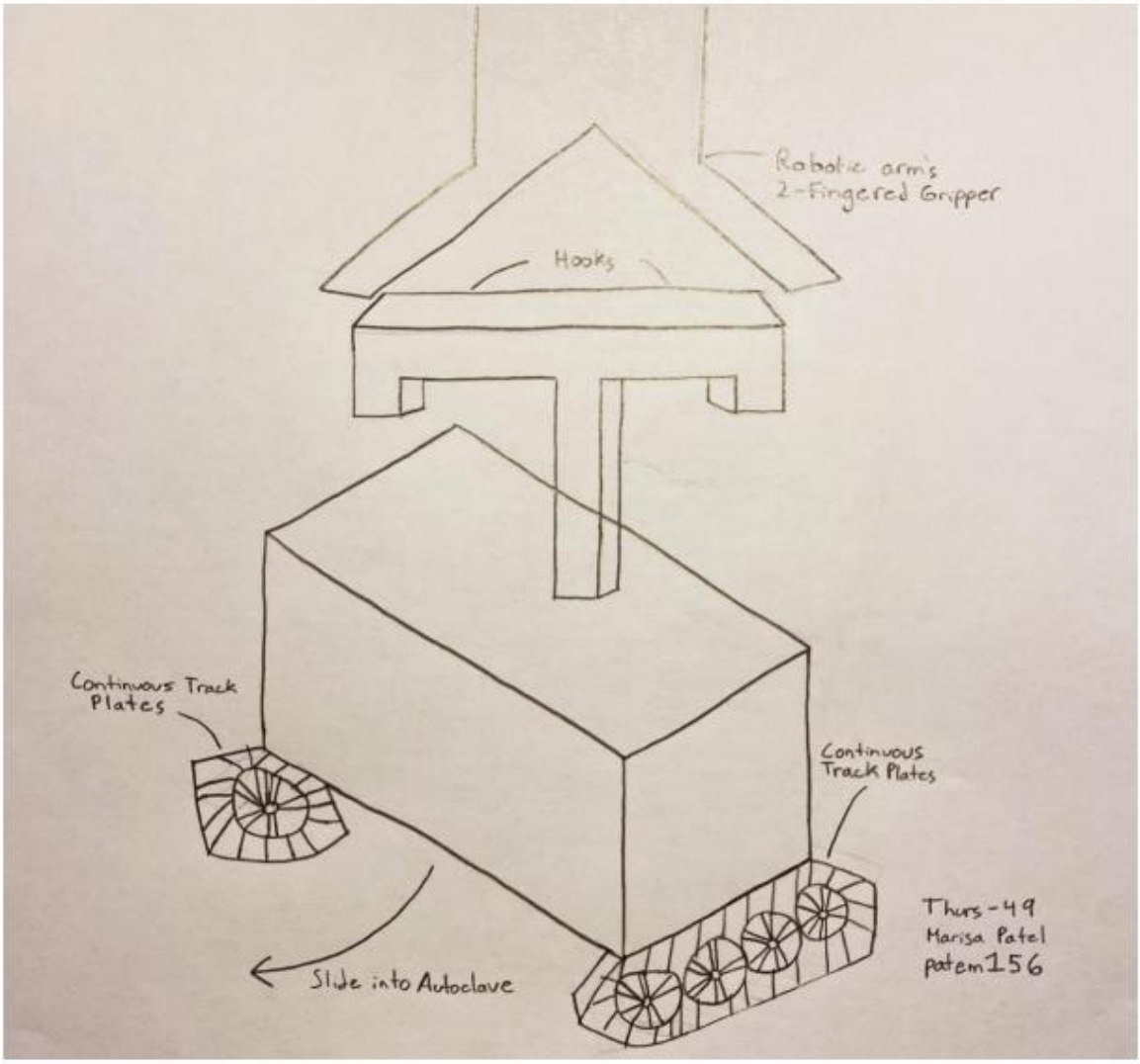
Name: Marisa Patel	MacID: patem156

Insert screenshot(s) of your concept sketches below

Sketch 1: Magnets, two wheels, drop it directly downwards by ungrasping



Sketch 2: Hooks, continuous track plates, slide

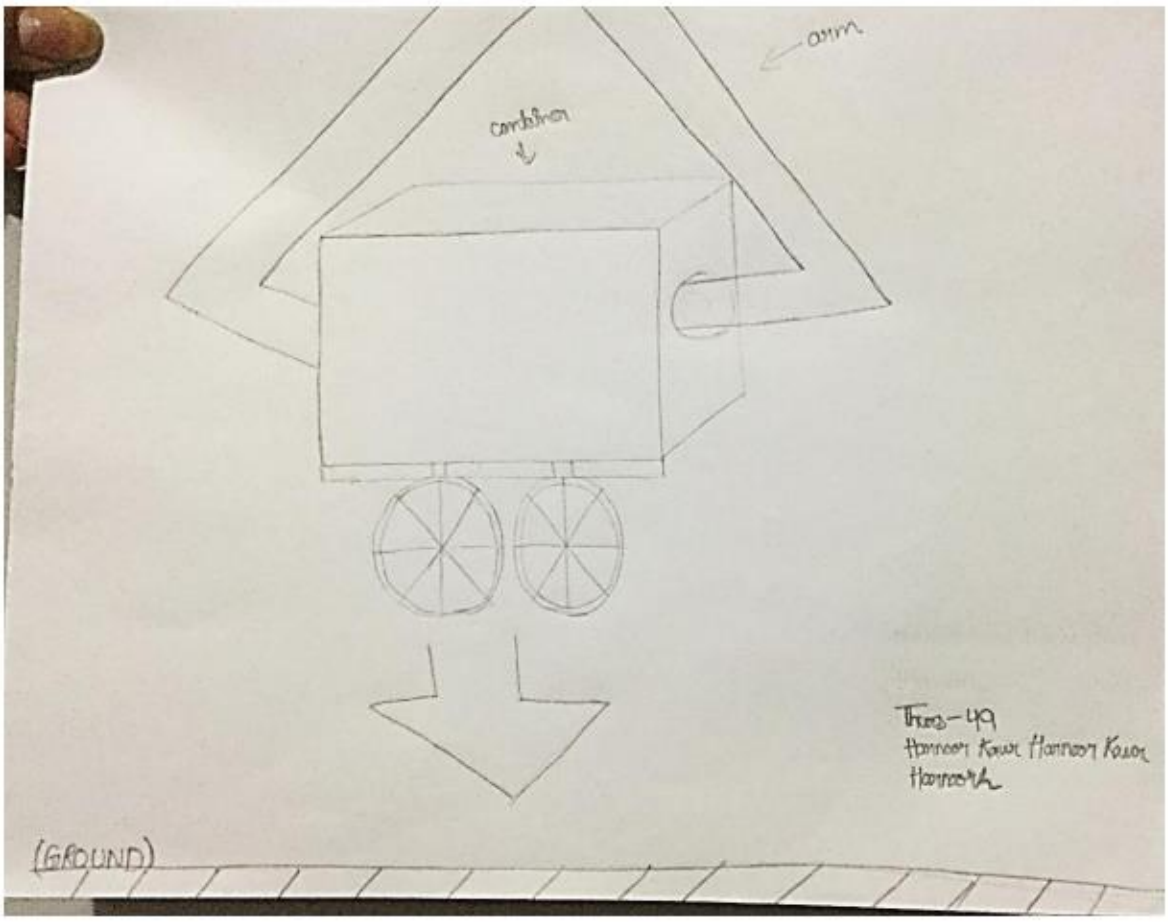


Name: Harnoor Kaur Harnoor Kaur	MacID: harnoorh

Insert screenshot(s) of your concept sketches below

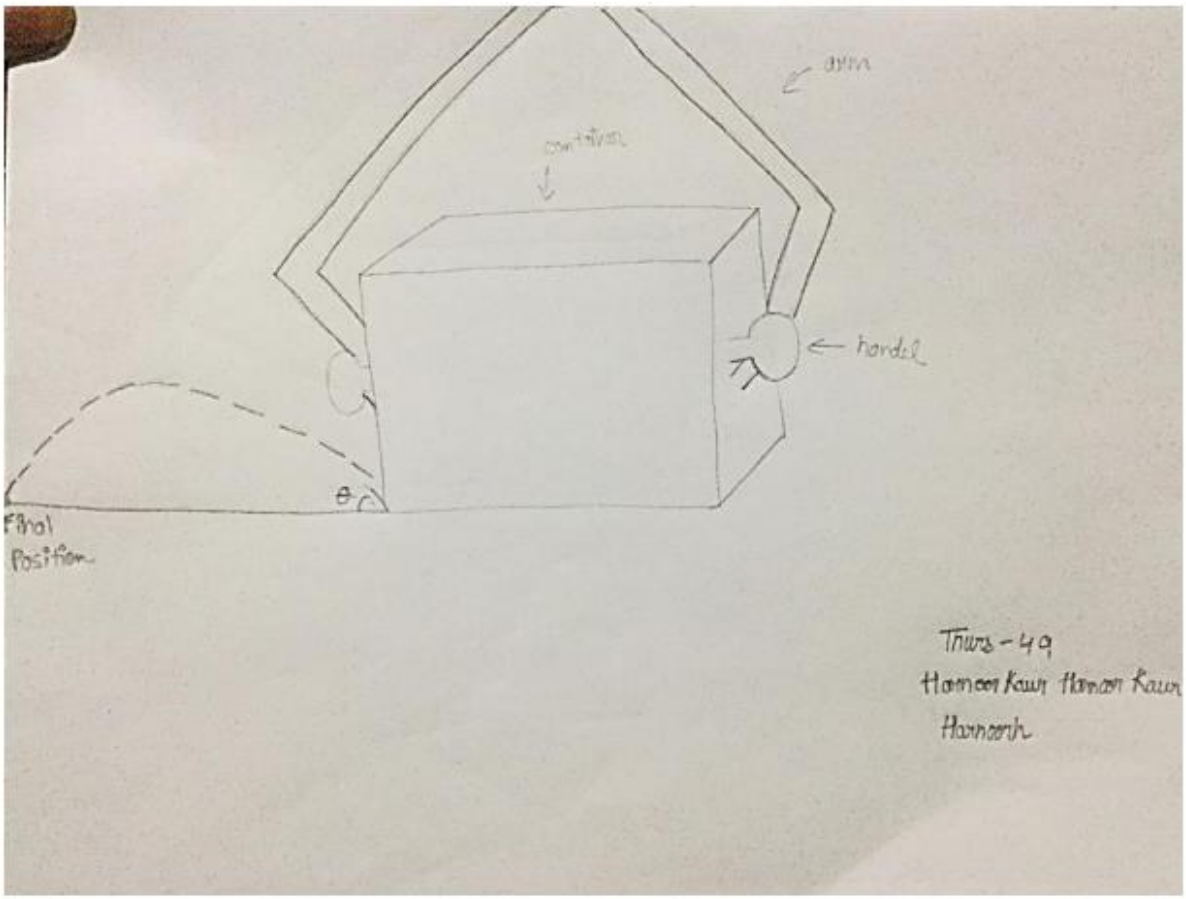
Sketch 1:

- *Making holes on each side of the container so that a finger of the robotic arm perfectly fits in the hole and picks it up.*
- *Two wheels*
- *Drop it directly downwards by ungrasping*



Sketch 2:

- *Add Handles on either side of the container*
- *The arm bends down to pick the container up and then makes a sturdy grip (clamps on to the container) and the container is help up in the air*
- *Projectile (follow a perfect trajectory to land on the desired position)*

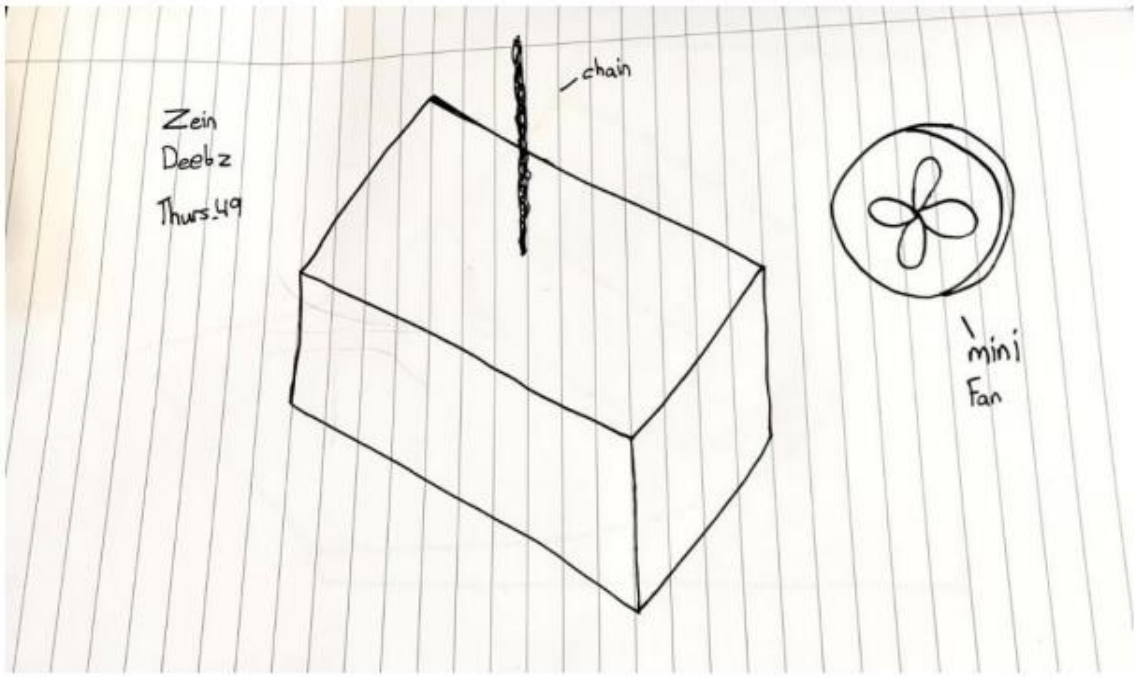


Team Number: Thurs-49

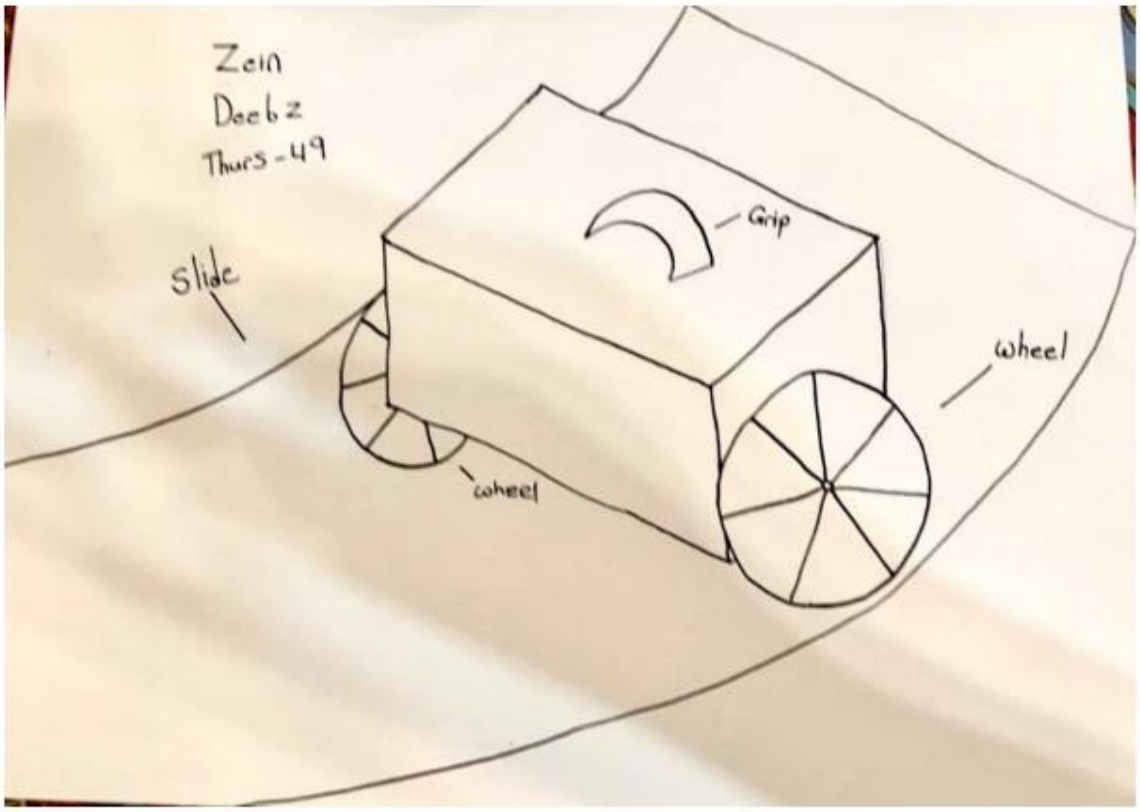
Name: Zein Deeb	MacID: deebz

Insert screenshot(s) of your concept sketches below

Sketch 1: Pulled up by a chain, then transferred by the mini fan, projectile



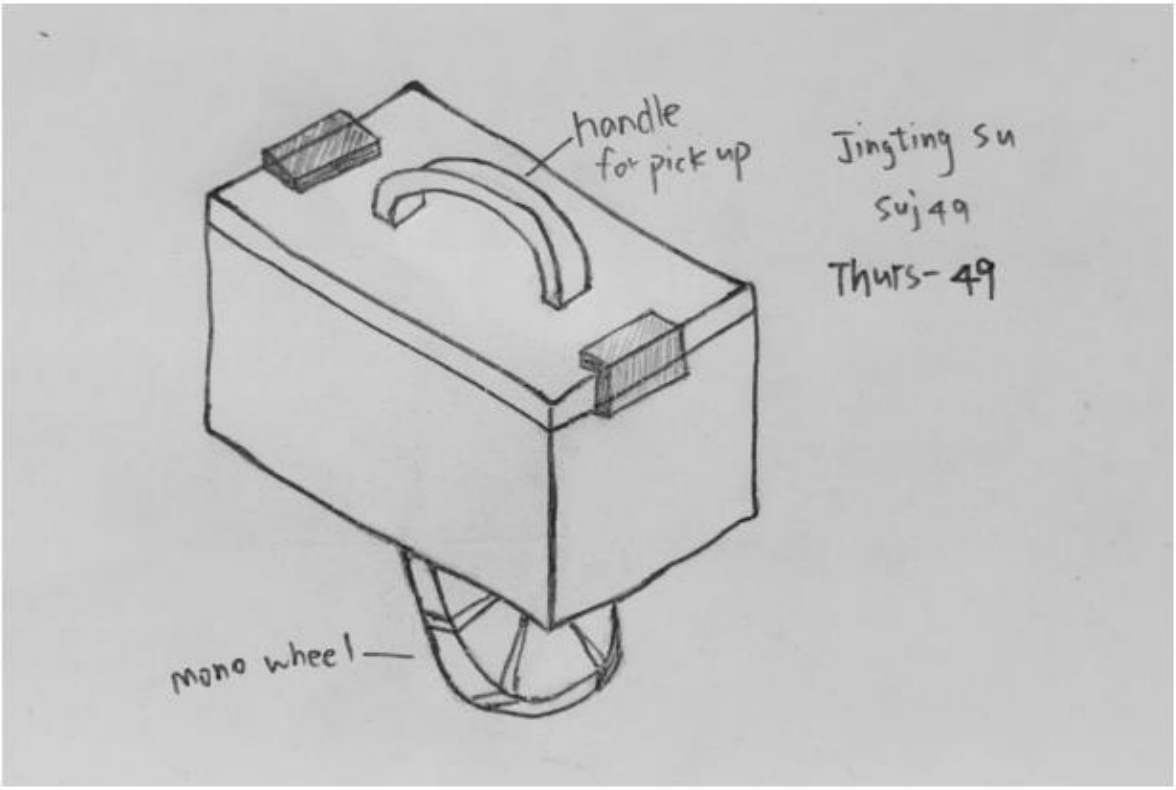
Sketch 2: Container being pulled up by the grip, transferred with the two wheels, and dropped off by sliding



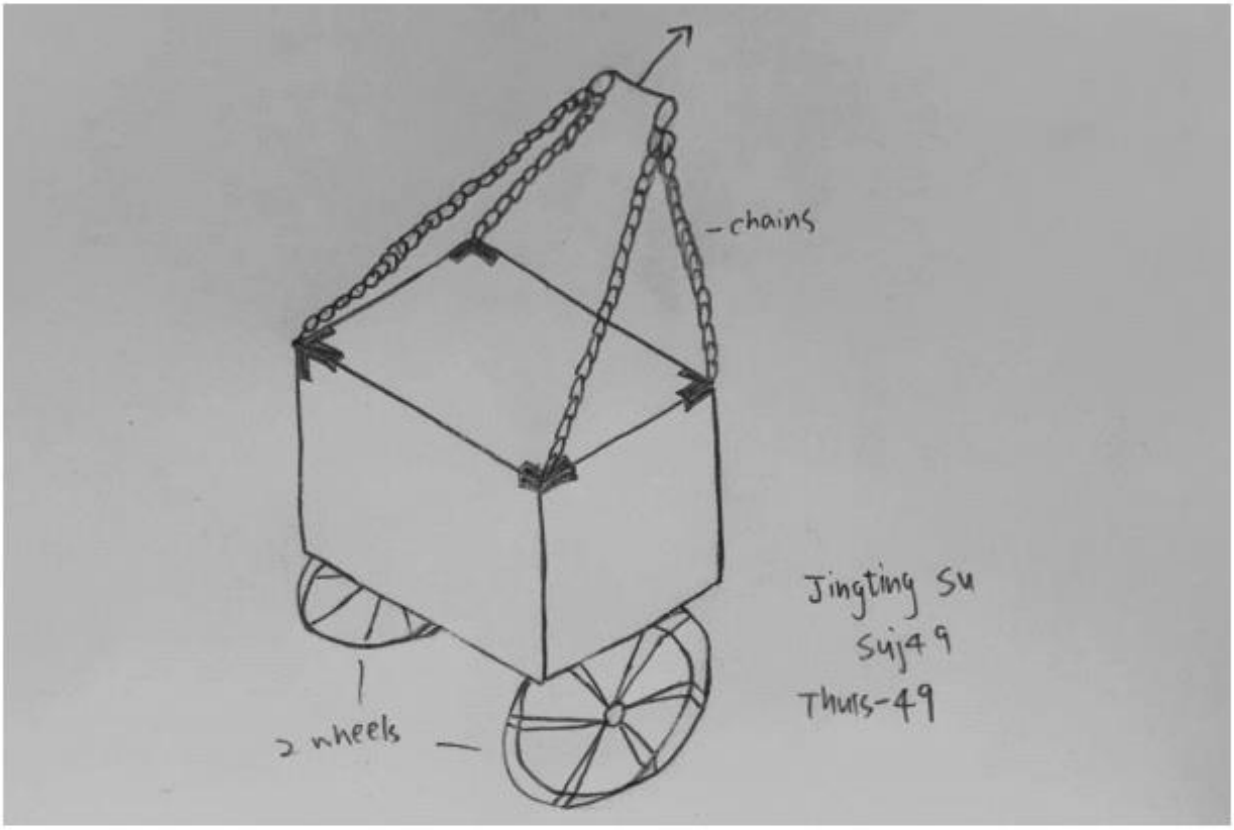
Name: Jingting Su	MacID: suj49

Insert screenshot(s) of your concept sketches below

Sketch 1: Add handles on either side of the container, mono wheel, let go of one of the handles



Sketch 2: Chains, two wheels, drop it directly downwards by ungrasping

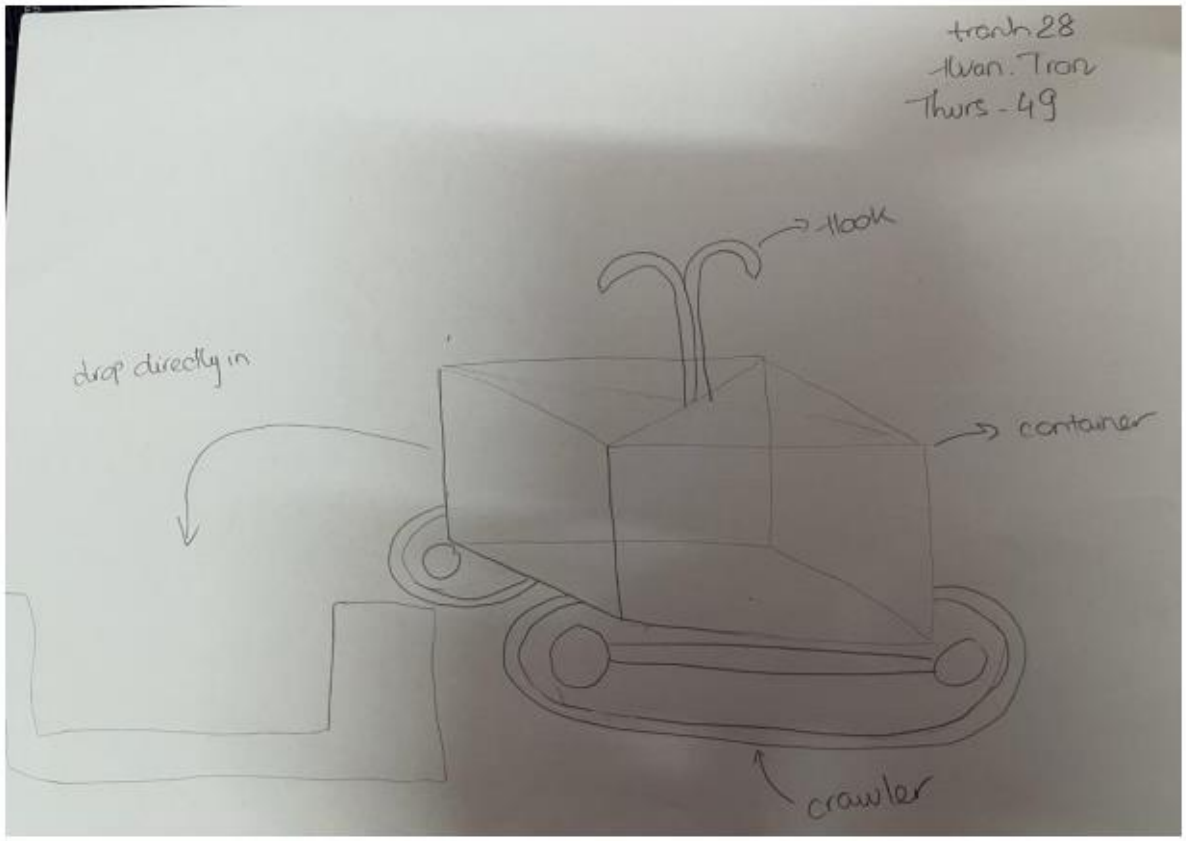


Team Number: Thurs-49

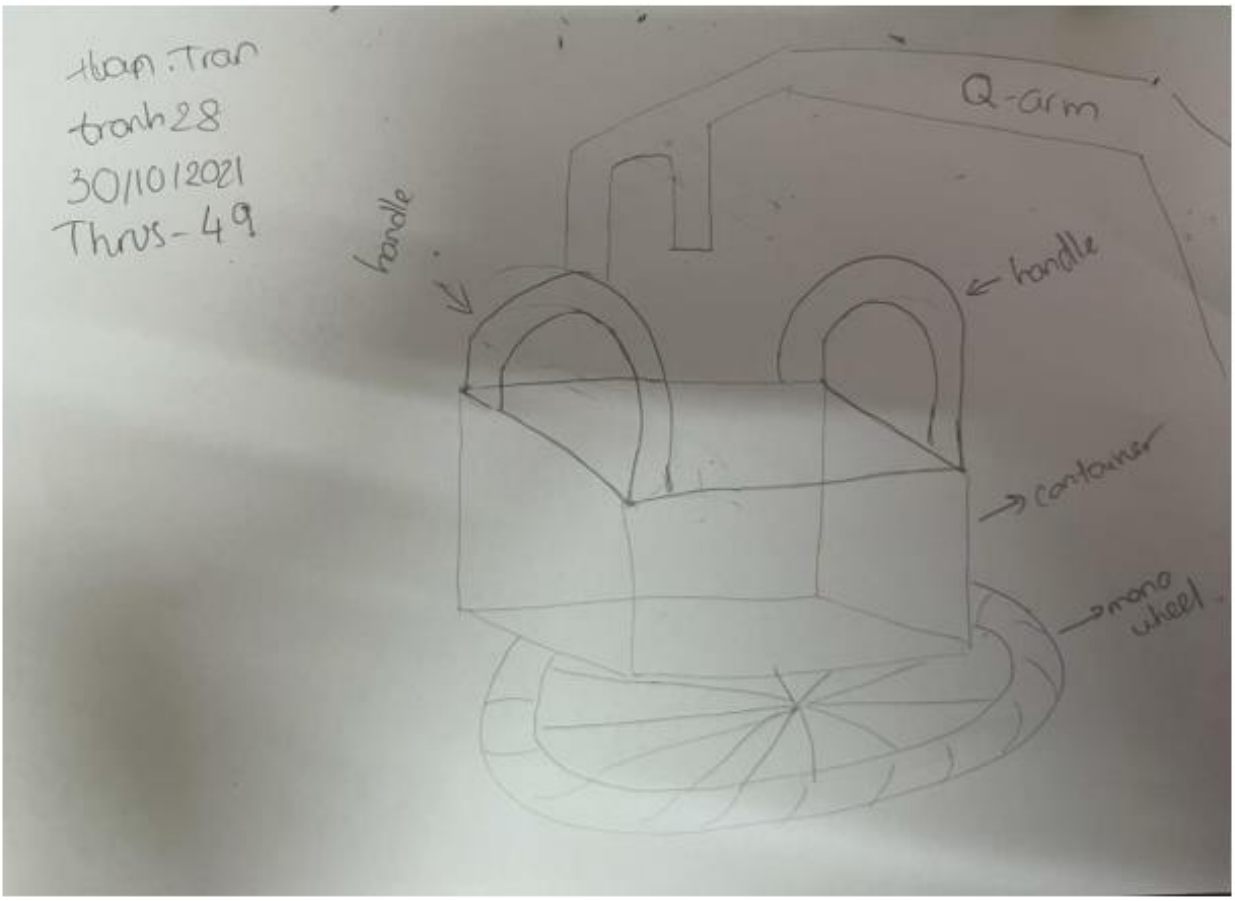
Name: Huan. Tran	MacID: tranh28

Insert screenshot(s) of your concept sketches below

Sketch 1: Hooks, crawler, drop it directly downwards by unwarping



Sketch 2: Add handles on either side of the container, mono wheel, let go of one of the handles



Milestone 2 Team Worksheet

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team Number: Thurs-49

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

Full Name:	MacID:
Zein Deeb	deebz
Jingting Su	suj49
Marisa Patel	patem156
Harnoor Kaur Harnoor Kaur	harnoorh
Huan. Tran	tranh28

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

Team Number: Thurs-49

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

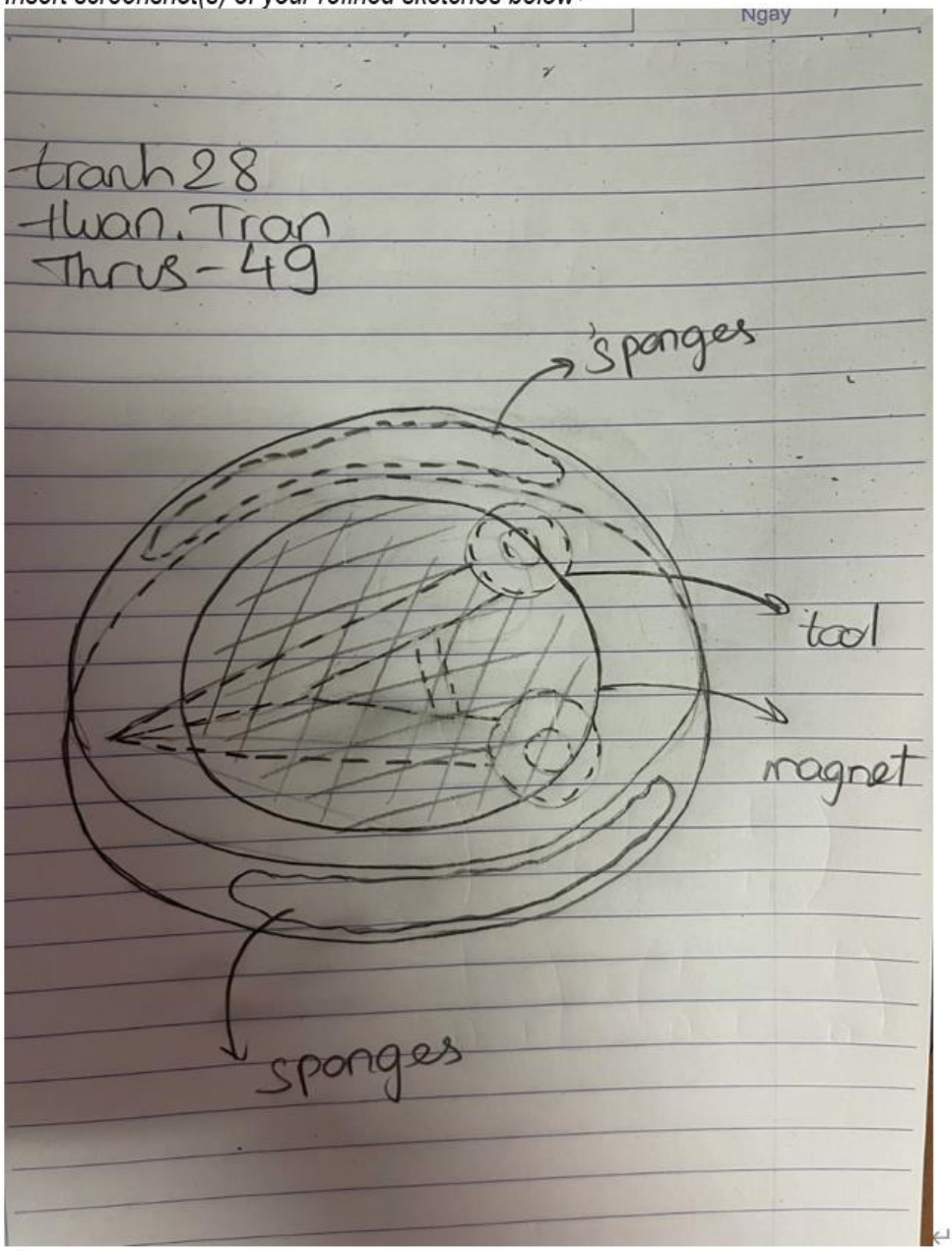
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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-49

Name: Huan. Tran	MacID: tranh28

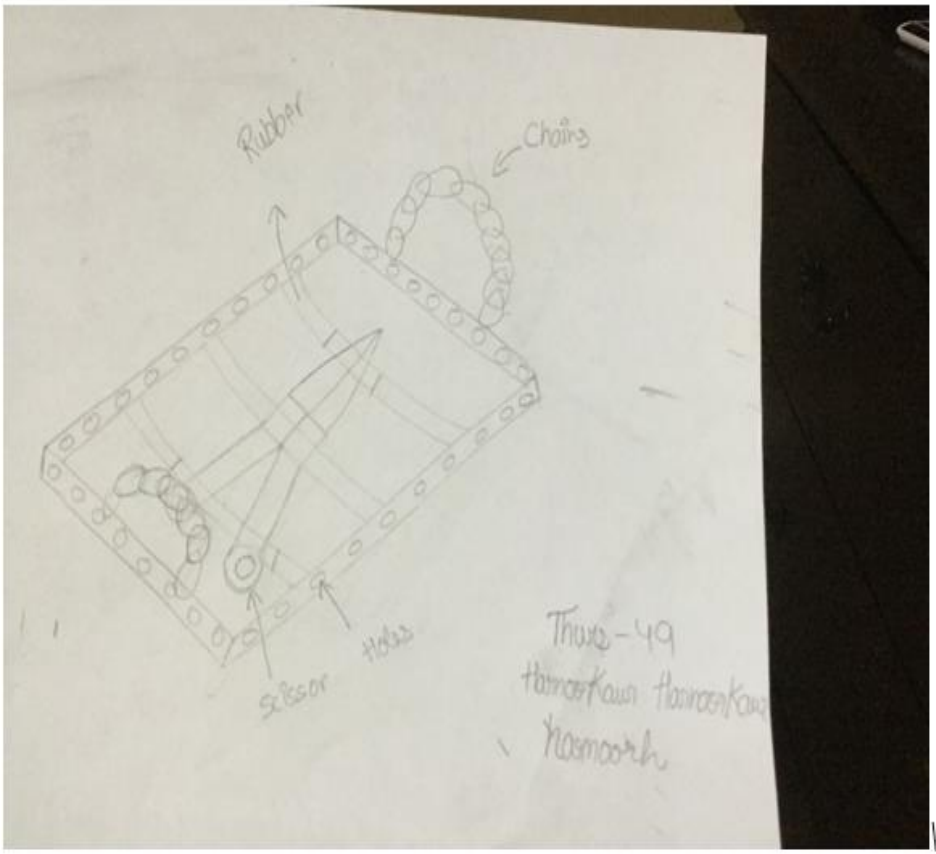
Insert screenshot(s) of your refined sketches below



Team Number: Thurs-49

Name:HarnoorKaur HarnoorKaur	MacID: harnoorh

Insert screenshot(s) of your refined sketches below



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

Team Number: Thurs-49

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

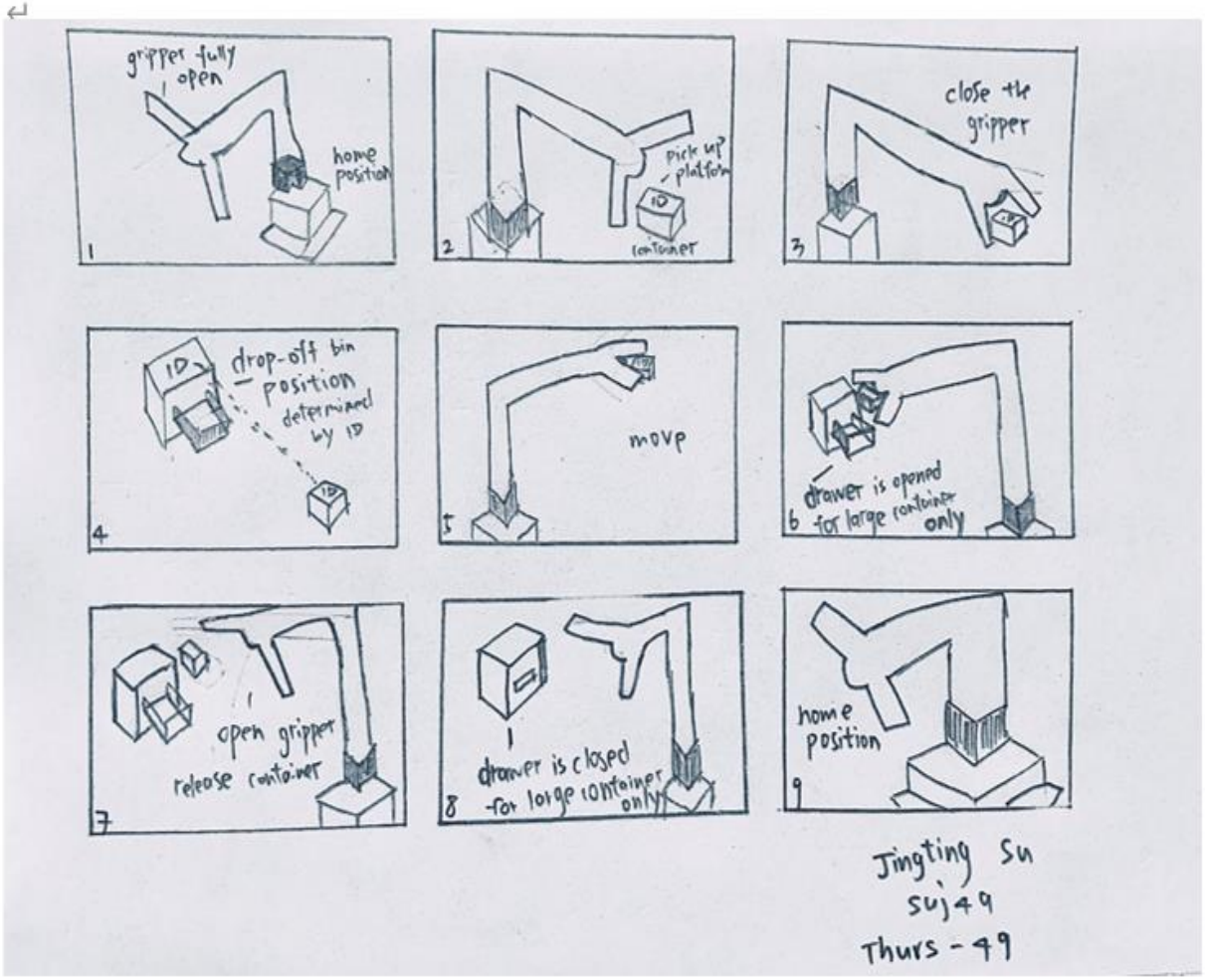
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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-49

Name: Jingting Su	MacID: suj49

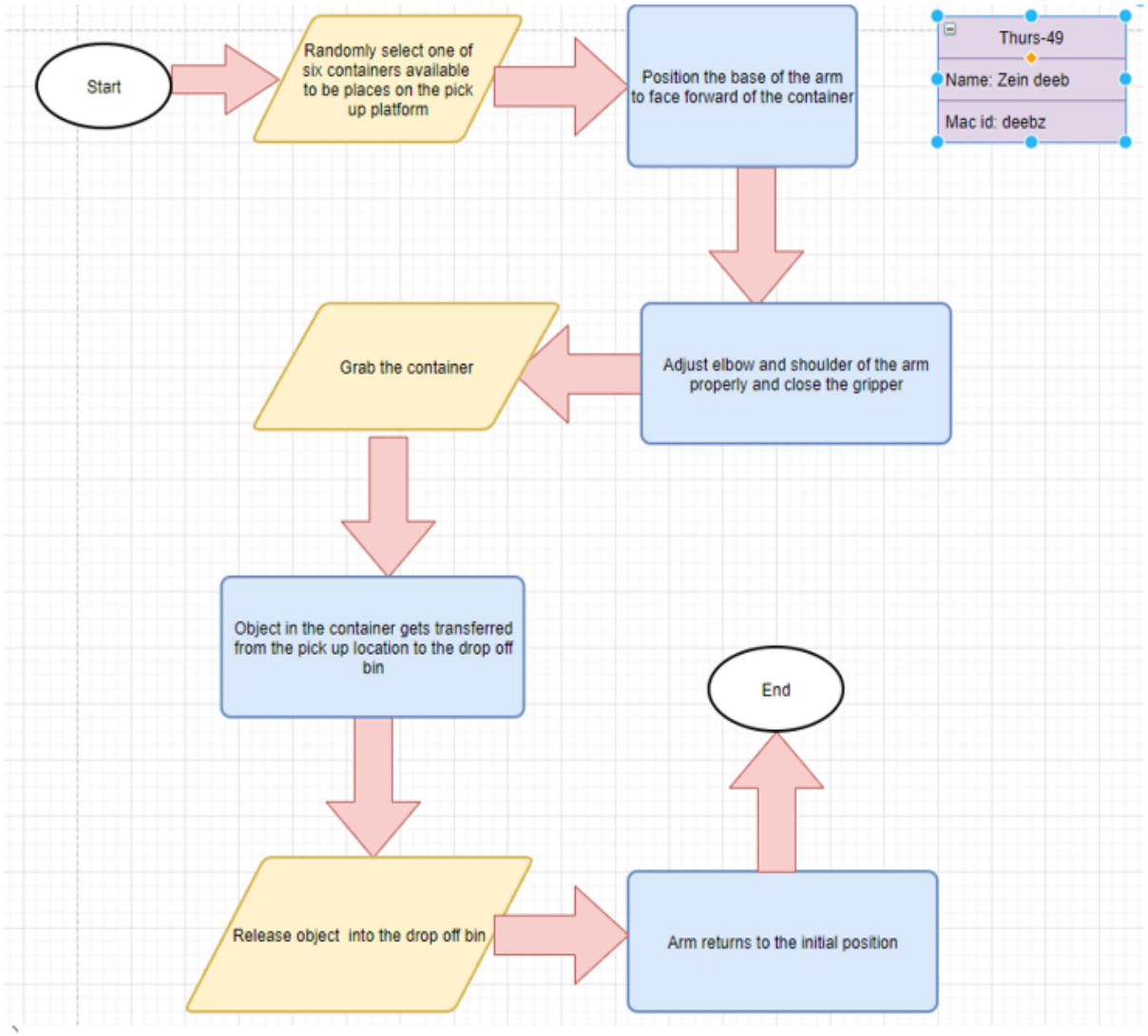
Insert screenshot(s) of your concept workflow below



Team Number: Thurs-49

Name: Zein Deeb	MacID: deebz

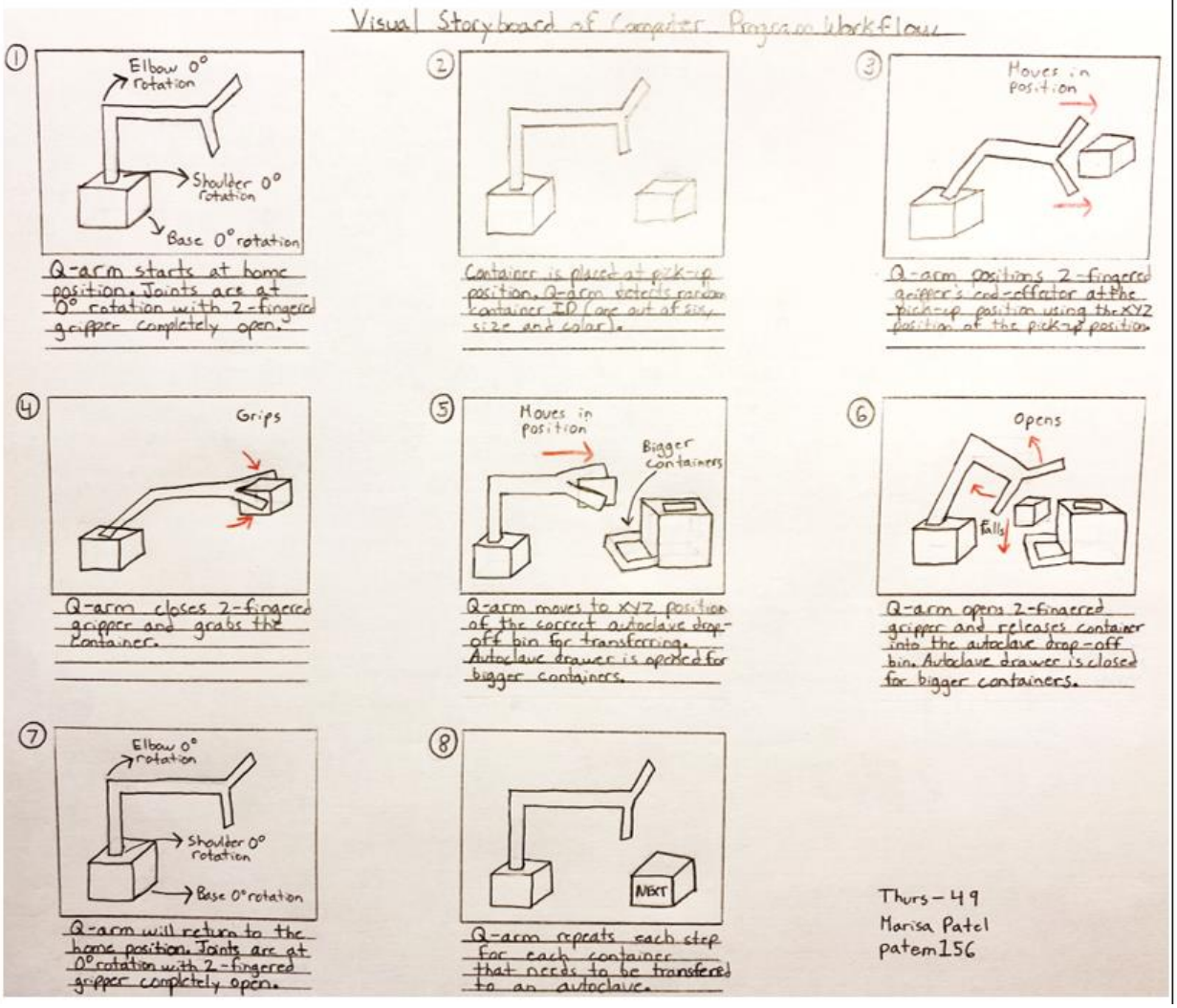
Insert screenshot(s) of your concept workflow below



Team Number: Thurs-49

Name: Marisa Patel	MacID: patem156

Insert screenshot(s) of your concept workflow below



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

Team Number: Thurs-49

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-49

Name:HarnoorKaur HarnoorKaur	MacID: harnoorh
Insert screenshot(s) of your low-fidelity prototype below	


Name: HarnoorKaur
HarnoorKaur
Mac ID: harnoorh
Group name:
Thurs-49
Side view


Name: HarnoorKaur
HarnoorKaur
Mac ID: harnoorh
Group name:
Thurs-49

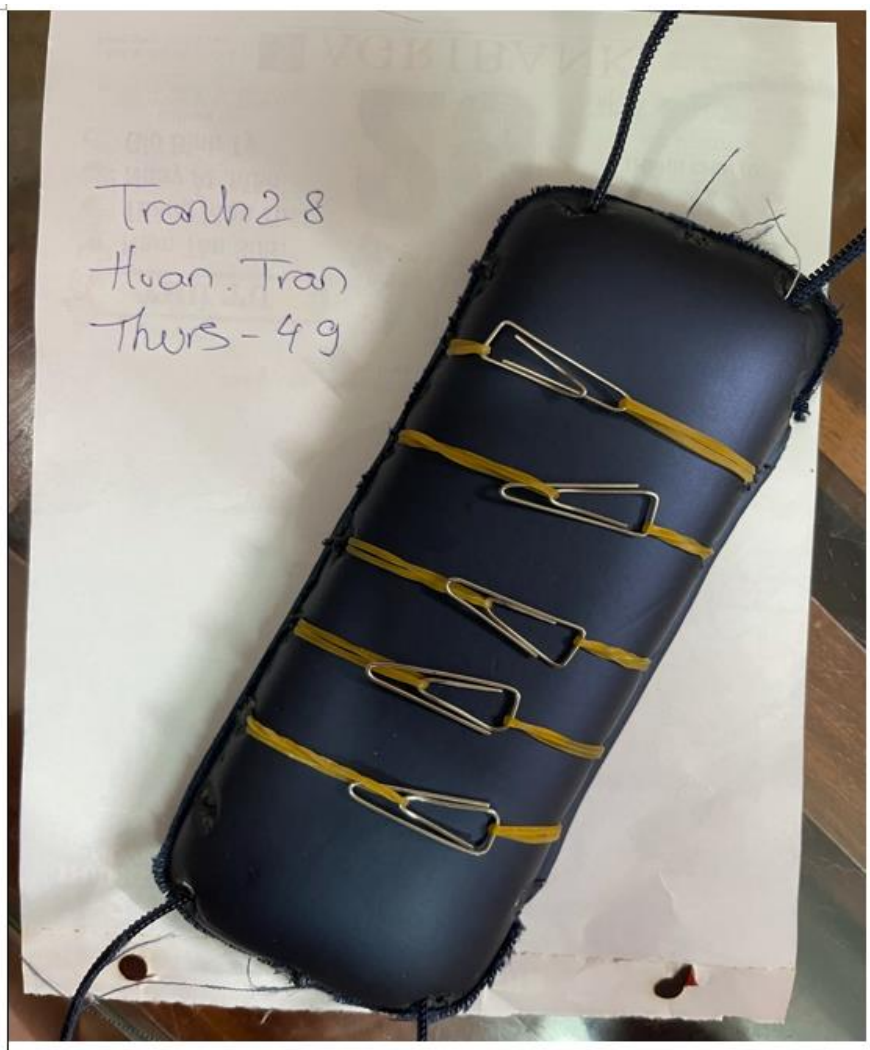

Name: HarnoorKaur
HarnoorKaur
Mac ID: harnoorh
Group name:
Thurs-49

Team Number: Thurs-49

Name: Huan.Tran	MacID: tranh28
Insert screenshot(s) of your low-fidelity prototype below	


Tranh28
Huan. Tran
Thurs-49


Tranh28
Huan. Tran
Thurs-49


Tranh28
Huan. Tran
Thurs-49

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

Team Number: Thurs-49

As a sub-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.*

Do the Functions determined in Milestone 1(Pick up, facilitates sterilization, maximizes storage and stability) align with each prototype?

Huan Tran's prototype:

- Due to the presence of the chains the robotic arm will not be able to sufficiently grab hold of the container as the grip will not be as strong
- The existence of the holes as well as the design without lid enables sterilization to take place
- Due to the presence of the elastics securing the tool in place results in strong stability of the tool inside the container

HarnoorKaur HarnoorKaur's prototype:

- Due to the presence of magnets for the process of picking up the container, it would enable the arm to pick the container up ONLY if the material by which the arm is made up of attracts to magnets
- The process of dropping off seems a bit difficult because the container will be attracted to the arm thought magnets

- The holes on both sides of the container as well as the presence of the sponges, enables sterilization
- Due to the presence of sponges and the oval shape of the container, it resists movement and hence stability is present (not a lot)

What are the Advantages observed for each prototype?

Huan Tran's Prototype:

- Due to the elastic present to hold the tool in place, it won't make the tool fall out of the container
- Shape of the container enables a lot of storage for the tool to fit in

HarnoorKaur HarnoorKaur's Prototype:

- Presence of the magnet at the top of the resists detachment of the container from the arm in the process of transfer
- The presence of the magnets allows the robotic arm to do more moment as it will simply get attracted to it

What are the Disadvantages observed for each prototype?

Huan Tran's Prototype:

- High chances of the tool falling out of the container if there is not a firm grip and if the tool not held upwards inside the container

HarnoorKaur HarnoorKaur's Prototype:

- High chances of the container to slip if the arm grabs it from anywhere other than the centre
- The storage is affected due to the oval shape (less storage inside)
- Tool can be expected to move a lot since it is not tightly secured

Do the Constraints align with the ones determined in Milestone 1?

Huan Tran's Prototype:

- **The elastic ban in Huan's prototype is creating more** stability than using the sponges and oval in Harnoor's prototype. Firstly, the elastic ban is attracted directly on the tool, so I cannot vibrate vertically and horizontally. Whereas, using the oval shape with sponges, will left with some shaking vertically because the oval shape maximizes storage for the container and the sponges cannot hold the tool perfectly without shaking.

HarnoorKaur HarnoorKaur's Prototype:

- The design of the container is simple (meets the constraint)
- The container consists of sponges which can result in the container being heavy (does not correspond with the constraint)

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

Team Number: Thurs-49

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

Similarities

- Jingting and Marisa's representations identified that the Q-arm starts at the home position.
- Zein and Jingting's representations both pictured the Q-arm being picked up in similar fashion, where the Q-arm moves to the container and grabs it (not mentioning the XYZ positions).
- Zein, Jingting, and Marisa's representations identified that the Q-arm gets in position to close the gripper.
- Zein, Jingting, and Marisa's representations identified that the Q- arm will close the 2-fingered gripper to grab the container and open it to release the container.
- Zein, Jingting, and Marisa's representations identified that the Q-arm will be back to the home position after finishing dropping off a container.
- Jingting and Marisa's representations mentioned the opening and closing process of the container's drawer.

Differences

- Marisa's part 2 of the storyboard discusses the Q-arm detecting the size and colour of the container. This was different than Zein and Jingting's representations because this mentions how the Q-arm recognizes through the container ID, what the colour and size of the container is. This approach is important as the colour and size are associated with the container ID, which the Q-arm will need to detect to determine which autoclave the container needs to be taken to.
- Marisa mentioned the XYZ positions of the pick-up and drop-off positions. This was different compared to Zein and Jingting's representations as this deals with the specific coordinates the Q-arm will need to be in to proceed with picking up and dropping off of the containers. This approach can better determine the location of the container and the drop-off bin.
- Marisa's representation mentioned that the Q-arm will repeat the process. This was different than Zein and Jingting's representations because this displays that the Q-arm will continue the process for the other containers as well (six containers in total). This approach is important as it includes how the Q-arm will need to start and complete the process for the alternate containers.

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

Team Number: Thurs-49

As a sub-team, decide which combination of muscle sensor emulator scenarios you will use and fill out the table below accordingly. Please refer to *page 18* in the Project 2 module for this stage.

- Indicate which combo your sub-team chose and justify your reasoning
  - Consider
    - the general workflow of your program
    - the order of operations at certain stages, e.g. For a large red container that has been picked and transferred to the red autoclave -- first, the autoclave bin drawer opens, then the gripper opens to release the container, the autoclave bin drawer closes, then the gripper closes and finally the QArm goes back to the Home Position.
- Indicate your sub-team's threshold value (any value between 0.0 and 1.0)
- Place an 'x' in the appropriate cells, for each muscle sensor emulator scenario and its corresponding action

Combo number: 2 Justification: We selected combo 2 because it seemed the easiest. Combo 2 made the most sense to us in terms of what arm is associated with each operation and the general workflow of our program. It also seemed to be the easiest to actually remember and apply to use the muscle sensor emulator.					
Threshold 0.5					
	Identify Autoclave Bin Location	Control Gripper	Move End-Effector	Open Autoclave Bin Drawer	Continue or Terminate
L > threshold and R = 0			x		
R > threshold and L = 0				x	
L > threshold and R > threshold		x			

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

Step 1: Q-arm starts at home position

Step 2: One container ID is randomly selected out of six

Step 2.1: Selected container is placed at the pick-up position

Step 3: Q-arm will position two-fingered gripper at the pick-up position

Step 4: Q-arm will close the two-fingered gripper

Step 4.1: Grab the container

Step 5: Q-arm will move to the drop-off location

Step 5.1: If the container is large, the associated autoclave drawer will open

Step 6: Q-arm opens the two-fingered gripper

Step 6.1: Q-arm releases the container into the autoclave drop-off bin

Step 6.2: If the container is large, the associated autoclave drawer will close

Step 7: Q-arm will return to home position

Step 8: Q-arm will repeat each step for each container that needs to be dropped off into the correct autoclave drawer

Milestone 3 Team Worksheet

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team Number: Thurs-49

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

Full Name:	MacID:
HarnoorKaur HarnoorKaur	harnoorh
Huan.Tran	tranh28
Zein deeb	deebz
Marisa patel	patem156
Jingting Su	suj49

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

Team Number: Thurs-49

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

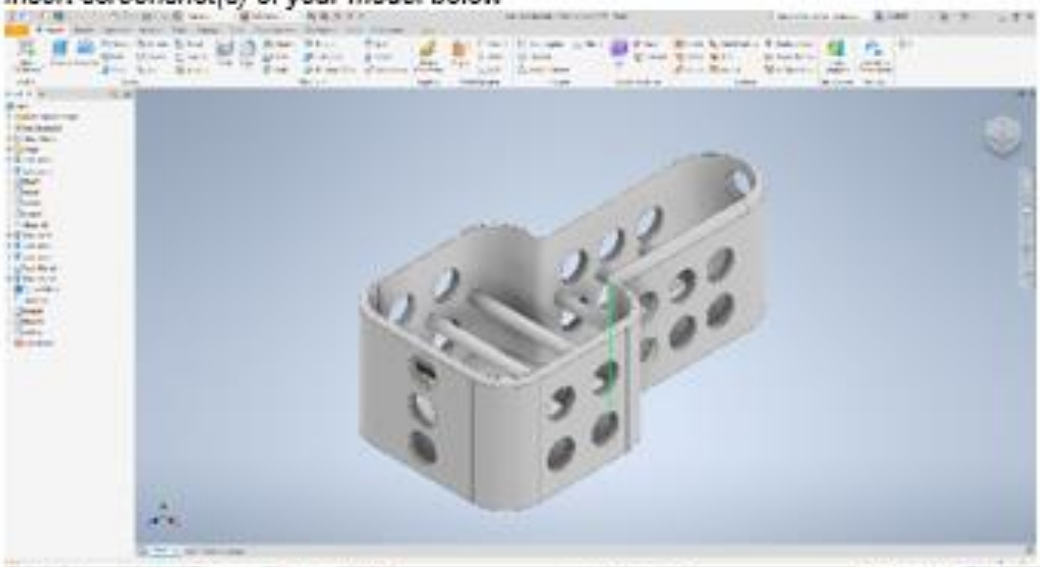
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

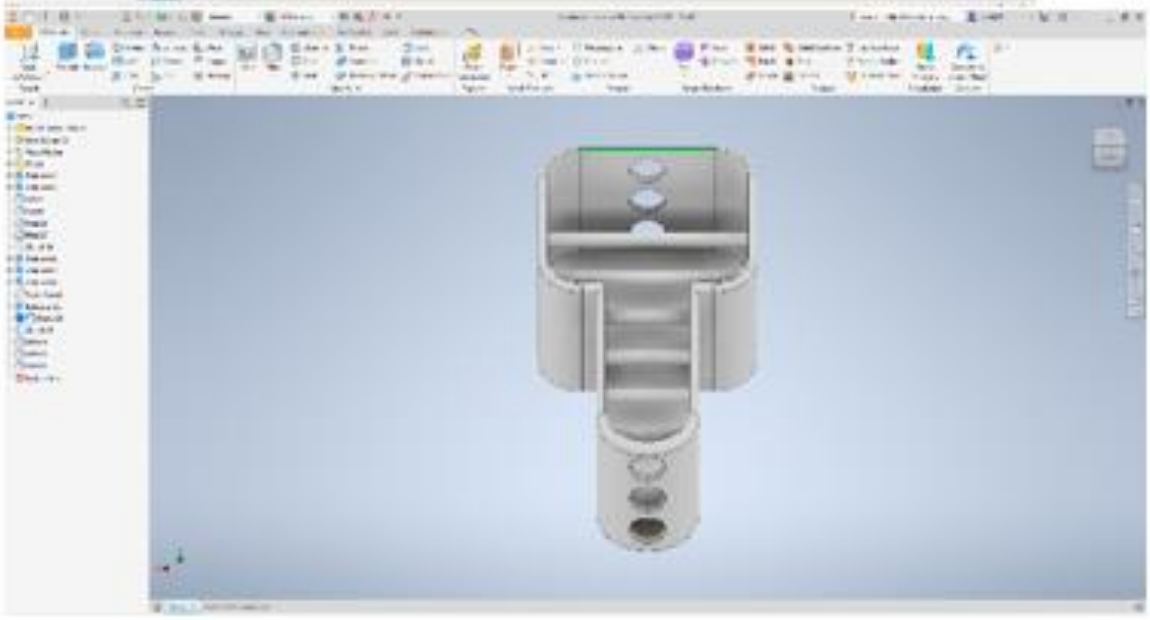
- Each team member needs to submit their solid model screenshots with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
  -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

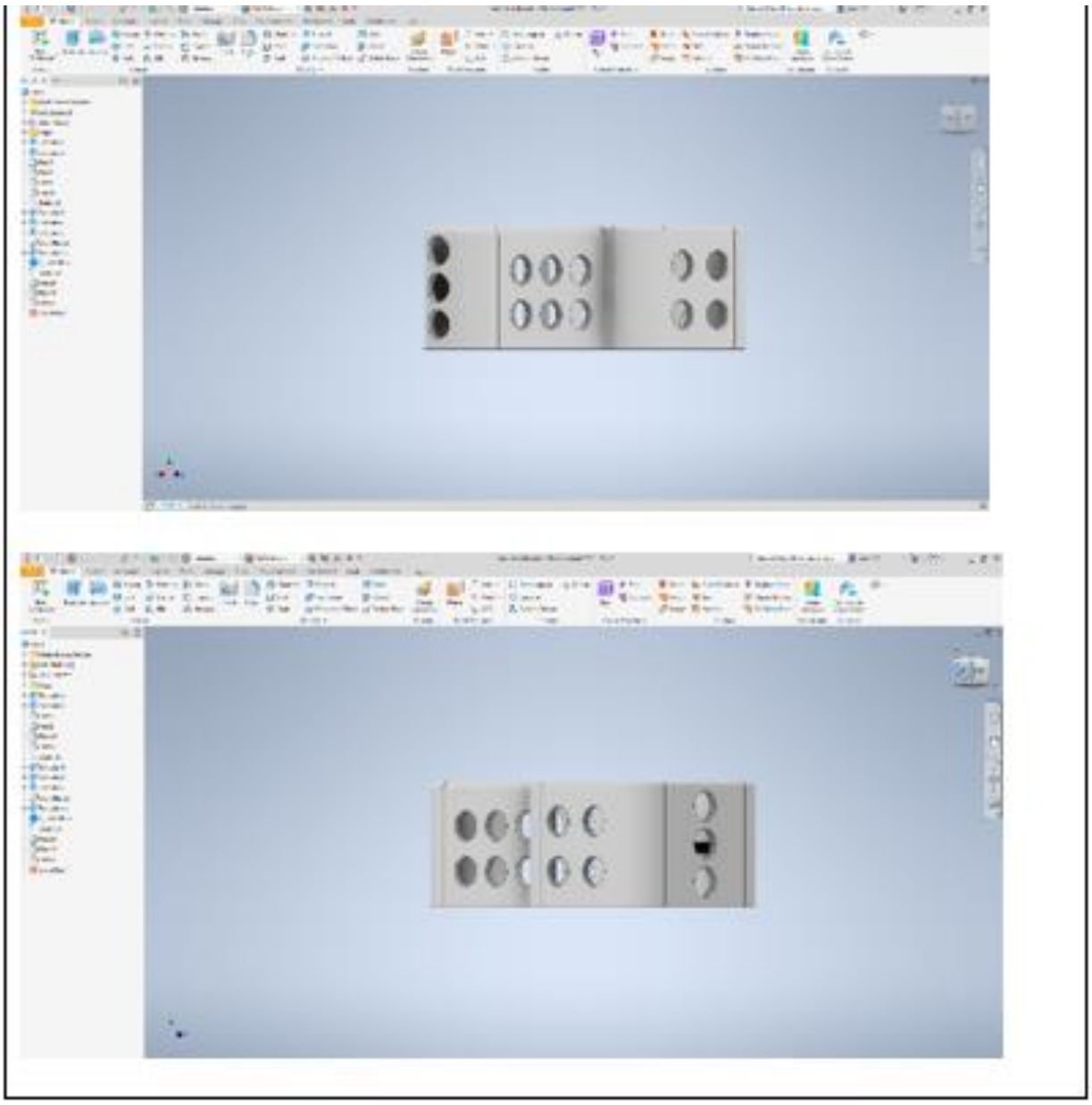
Team Number: Thurs-49

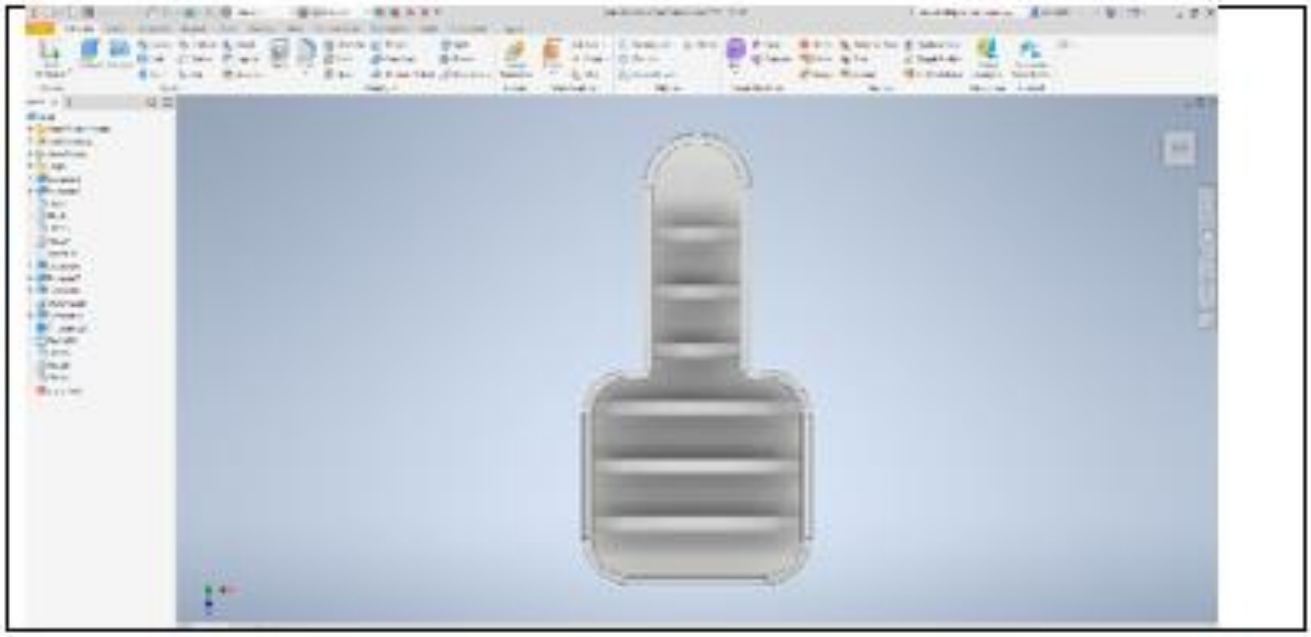
Name: Huan Tran	MacID: tranh28

Insert screenshot(s) of your model below





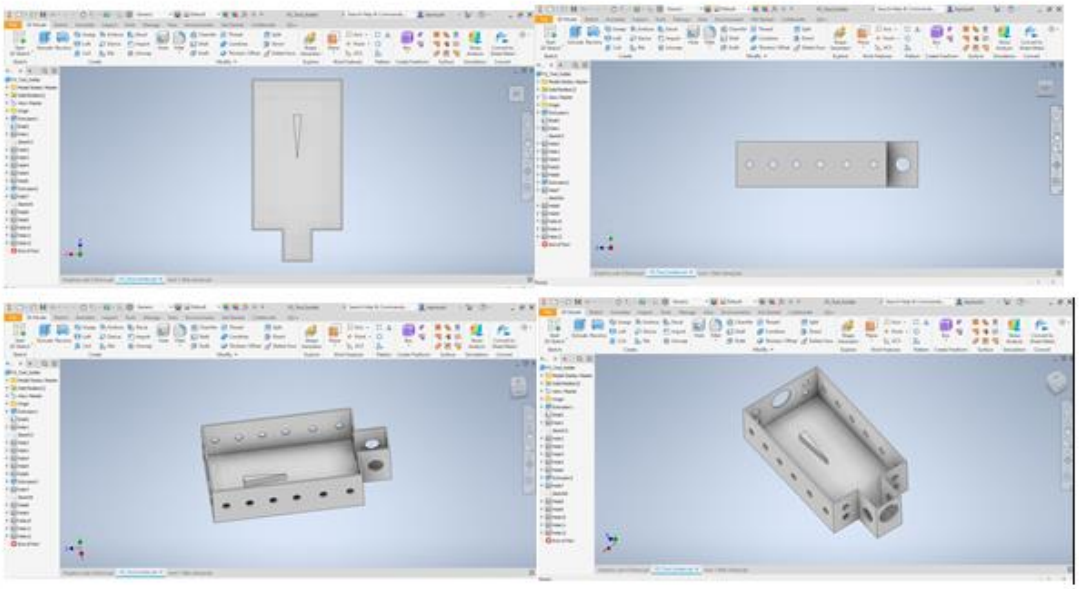




Team Number:	Thurs-49

Name: HarnoorKaur HarnoorKaur	MacID: harnoorh

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

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

Team Number: Thurs-49

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-49

Name: Zein Deeb	MacID: Thurs-49

Python Code for Task#1: Identify Autoclave Bin location

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

def location_bin():
    container = int(input("Enter container ID: "))
    coordinates = None
    if container == 1:
        coordinates = (-0.616, 0.224, 0.344)
    elif container == 2:
        coordinates = (0,-0.677, 0.32)
    elif container == 3:
        coordinates = (0, 0.677, 0.32)
    elif container == 4:
        coordinates = (-0.35, 0.15, 0.34)
    elif container == 5:
        coordinates = (0, -0.44, 0.35)
    elif container == 6:
        coordiantes = (0, 0.44, 0.35)
        location_bin()
    return coordinates
```

Team Number: Thurs-49

Name: Jingting Su	MacID: suj49

Python Code for Task #2: Move End-Effector:

```
def move_end_effector() :
      L = arm.emg_left()
      R = arm.emg_right()
      if L > 0 and R == 0:
            return arm.move_arm(bin_location)
#bin_location should be defined in the identify bin location function
```

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

Team Number: Thurs-49

Name: Marisa Patel	MacID: patem156

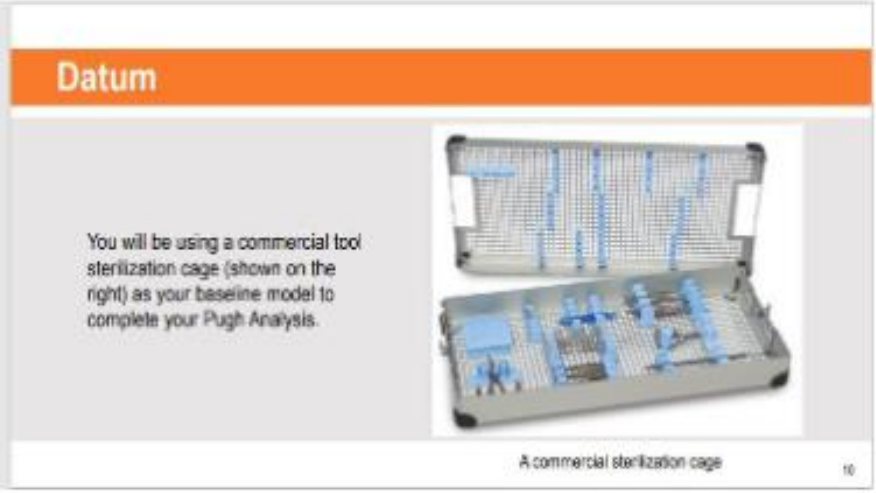
Python Code for Task#1: Identify Autoclave Bin location

```
# Importing Random Module

import random

# Defining container_ID

while True:
    container_ID = random.randint(1,6)
    arm.spawn_cage(container_ID)
    print("The container ID selected is:", container_ID)
    break

# Defining function identifying_bin_location

def identifying_bin_location():
    if container_ID == 1:
        identifying_bin_location = (-0.608, 0.216, 0.334)
    elif container_ID == 2:
        identifying_bin_location = (0.00, -0.656, 0.22)
    elif container_ID == 3:
        identifying_bin_location = (0.00, 0.656, 0.22)
    elif container_ID == 4:
        identifying_bin_location = (-0.250, 0.120, 0.311)
    elif container_ID == 5:
        identifying_bin_location = (0.00, -0.432, 0.342)
    elif container_ID == 6:
        identifying_bin_location = (0.00, 0.432, 0.342)
    return(identifying_bin_location)
    print(identifying_bin_location)
```

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

Team Number: Thurs-49

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	Huan. Tran	HarnoorKaur HarnoorKaur's
Enables Sterilization		+	-
Enables stability		S	S
Easy to use (distribution, take the tools out)		+	+
Reusable		-	S
Maximizes storage		-	-
Lightweight		+	+
Easy to maintain		+	+
Total +		4	3

Total –		2	2
Total Score		2	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

According to the table above, we figured that Huan's overall design is better compared to HarnoorKaur's design. However, there were several criteria's in HarnoorKaur's design that turned out to be better than Huan's design, therefore we decided to incorporate the better criteria from HarrnoorKaur's design to Huan's designs such as adding a lid on top of the container to avoid corrosion and increase the times the container can be reused. Additionally, to keep the container more stable and to make it easy to put the tool inside the container without a lot of assistance needed, the elastic will be removed from Huan's design and the Harnoor's stability procedure will be used where a shape(triangular) will be inserted to that the tool is held in place.

- The length of the container will be greater than or equal to 109 mm and less than or equal to 120mm
- The width of the container will be less than or equal to 75mm and more than or equal to 50 mm

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

Team Number: Thurs-49

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**:Zein Deeb

1. Zein's code allows for a container ID to be selected using the int variable.
2. Using the if and elif statements, Zein's code allows the Q-arm to decipher through the different container ID's, which then leads the Q-arm to the associated autoclave bin drawer.
3. Initially Zein's code included constantly spawning a container using the While True loop which did not let Zein input a number for the container ID so instead of including break at the end of the While True loop, Zein decided to just remove the function as it seemed redundant.

Move End-Effector Task	**Team Member Name**: Jingting Su

1. When running Jingting's code independently, errors occur because the bin-location is not defined. But when replacing it with real coordinates, the code works.
2. After running the code, each time the muscle sensor data is changed, the function needs to be called again, which is not as smooth as shown in the demo video.
3. After running this code, the Q-arm does not return to the home position, but remains in the bin position. So Jingting's code needs another instruction to return to the home position.

Identify Autoclave Bin Location Task	**Team Member Name**: Marisa Patel

1. After running Marisa's code in Q-Labs, it was determined that the code would not have worked if container_ID was not defined before creating the function identifying_bin_location.
2. An observation was made while testing the code that when including the actual coordinates, only one equal sign would be included rather than the double equal signs used in the line of code where the container ID numbers are stated for the code to run correctly.
3. After running Marisa's code and calling the function identifying_bin_location, the message "The container ID selected is: " with the number of the container

ID is displayed, which is then followed by the associated autoclave bin location (the XYZ coordinates).

4. Another observation made was that when you run this code, there is no movement shown in the Q-Labs simulation. Nothing in the code is causing movement in the Q-arm, which is because nothing has yet been included for the movement of the Q-arm. The only output you see is the printing of the randomly selected container ID followed by the XYZ location coordinates of the corresponding autoclave bin.

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

Team Number: Thurs-49

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

Control Gripper

Step 1: Set a threshold value of 0.5

Step 2: Use muscle sensors to adjust both the left and right muscle sensor emulators to a value greater than threshold

Step 3: The gripper picks up the container

Open Autoclave Bin Drawer

Step 1: If the container ID is 4, 5, or 6, the autoclave drawer will need to be opened

Step 1.1: Opening autoclave bin drawer should be done after moving the end-effector, but before controlling the gripper

Step 2: When the right muscle sensor is greater than threshold and the left muscle sensor is equal to zero, then the autoclave bin drawer will be opened

Continue or Terminate

Step 1: Randomly take a value in the range of 1 to 6 from the container ID's

Step 2: Repeat the program until all values have been used

Step 3: Terminate the program once all the containers have been placed in the correct autoclave bin

MILESTONE 3 (STAGE 5) – DESIGN PITCHES

Team Number: Thurs-49

Modelling Sub-Team Preliminary Design

Use the space below to document feedback for your design.

- During the design pitch we were advised to consider the design constraints such as the size of the footprint as the container would have to fit inside the assigned footprint
- Additionally, we were told to be careful with the size of the given tool because it must fit inside the containers that we design and modelling.
- The container was said to be well designed
- During the pitch the plan that we had presented was said to be well however it was strongly advised to not forget the constraints as the container had to fit inside the footprint and the tool had to fit inside the container, so a reasonable size was to be chosen

Computing Sub-Team Preliminary Design

Use the space below to document feedback for your design.

During our design pitch, we were given some reminders and tips for our code. Specifically for task #1, we were reminded that the code for now should only include details about just the target location of the autoclave bin. The code for now, did not need to include moving the Q-arm or picking up the containers (this was something we had questions about). For our task #1 codes, we were told that our code looked good. For task #2, we were advised to again only include code that is just associated with moving the end-effector. We were again told that the code looked good.

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

Since we were told that our codes looked good, we decided to keep our codes as it is. We made sure to not include the parts of code that don't apply to the task we were looking at.

Milestone 4 Team Worksheet

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team Number: Thurs-49

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

Full Name:	MacID:
Marisa Patel	patem156
Zein Deeb	deebz
Huan Tran	tranh28
Jingting Su	suj49
Harnoor Kaur Harnoor Kaur	harnoorh

MILESTONE 4 CHECKLISTS

Mentors and sub-teams will go through each checklist **together** and check off items if the design meets expectations. Mentors will give verbal feedback for each item on the checklists, and students will **summarize the feedback** before creating a list of **Action Items** to be completed before final project submission. *Note that these checklists are not project rubrics. They are a tool to help guide students to successfully meet certain project requirements.*

MILESTONE 4 (STAGE 3) – DESIGN REVIEW FEEDBACK

(MODELLING SUB-TEAM) Team Number: Thurs-49

The following sign is represented as a check mark in the box: ☒

☒ Design Meets Design Objectives

- → Container fits inside the assigned footprint
- → Surgical tools fit securely inside the container
- → Container facilitates sterilization
- → Design is creative with interesting features and/or connections

☐ Assembly model is complete and aesthetic, properly grounded and has no interference or errors

☒ Mass constraint is satisfied (does not exceed 350 g prior to scaling or 43.75 g after scaling to 50%)

- → The design should intentionally minimize materials

☒ Total print time of **ALL** components does not exceed 2 hours

- → All components on the bed when evaluating this
- → Discuss if components need any support for 3D printing (i.e., for any overhanging features). If so, TA's will assist the sub-team in adding support.

☐ ALL features of container are 2mm or more

- → Not only features need to be 2mm or greater, but spaces between them as well
- → Features between 2mm and 4mm are appropriately sized and will not compromise the printed design

☐ **APPROVED FOR PRINTING**

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

- Design looks good but there is one area where there is less than 2 mm of distance between the hole and the top wall
- Improve the triangle as the tip will not be properly 3D printed
- To make sure that the tool does not fall out, add something to secure it

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

- Adding a rod across the container to make sure that the tool does not fall out of the container and if the container is held upside down, with the help of the rod, it stays inside the container
- Fix the holes, increase the size of the holes and decrease the amount of holes
- Add a step to either sides of the container so that the arm can grip the container in a better manner
- Instead of adding a peak to the triangle add a 2mm straight line on that part
- Make sure to have the print time for both components together to be less than 2 hours

MILESTONE 4 (STAGE 3) – DESIGN REVIEW FEEDBACK

(COMPUTATION SUB-TEAM) Team Number: Thurs-49

☐ One cycle of pick-up/transfer/drop-off (one container of any size) sufficiently executes

- → The general flow should be home → pick-up → home → drop-off → home
- → Containers dropped in random order, program identifies the correct drop off location and places the container successfully
- → *If* there is time, demo both a small and a large container, and experiment using the muscle emulators out of order to test for malfunctions

☑ All required program tasks are written as their own function (Identify Autoclave Bin Location, Move End-Effector, Control Gripper, and Opening/Closing the Autoclave Drawer)

☑ All program tasks are accounted for (Identify Autoclave Bin Location, Move End-Effector, Control Gripper, Opening/Closing the Autoclave Drawer, and continue/terminate)

☑ Each task requiring muscle sensor input (Move End-effector, Controlling Gripper and Opening/Closing the Autoclave Drawers) evaluates the muscle sensor emulator values before executing an action

- → Muscle sensor emulator values are evaluated *INSIDE* the functions and not outside and passing their values as arguments.

☑ Each task that requires the muscle sensor emulator is coupled to a different scenario, outlined by the sub-team's combo choice from Milestone 2.

☑ No errors in program

☑ Code well commented

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

The mentor mentioned that the general flow of the code does pick-up, transfer, and drop-off a container, but it will need to return to home in between the pick-up and drop-off, and after dropping off the container. It was also mentioned that the functions were done well, however; the opening and closing of the autoclave bin drawer should be included in one function only. The mentor also mentioned that in the program, we called "L, R," left and right, as parameters in the functions, which is not needed as we are already checking the left and right inside the function anyways. While running the code, the function needs to constantly be called in order for the pick-up, transfer, and drop-off to occur, so this will need to be altered so it is not needed to repeatedly call the function. All of these things will need to be altered and modified for the next reviewing progress session for the next design studio. Each task in the program has been accounted for, including the muscle sensor input according to combo 2 chosen from Milestone 2. The mentor also mentioned that the code did not have any errors and was well commented.

MILESTONE 4 (STAGE 3) – DESIGN REVIEW FEEDBACK

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

One design refinement that will be made is that the Q-arm will be returned to home in between the pick-up and drop-off, and after dropping off the container. After the cycle is running properly, we will be able to fix the continue/terminate task. Another refinement is making the opening and closing of the autoclave bin drawer into one function. The opening and closing of the autoclave bin drawers will also be refined by including "state," which will dictate when the autoclave bin drawer opens and closes. The "L, R" in the defined functions will be removed as they are already being checked within the functions. In addition, a main loop will need to be created to run and execute the cycle by itself (a loop that calls each function). Doing this will allow the code to run and execute without having to repeatedly call the function.