Design Project 2 – Get a Grip

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial T02

Team Mon-27

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Submitted: December 6, 2023

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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.

Joshua Harding 400535799

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(Student Signature) *

Executive Summary

For missions in 2024, the Canadian Space Agency and its partners require the use of robotically performed tasks to conduct experiments and to maintain the comfort of the crew [1]. One of these tasks is robot-facilitated sterilization of surgical tools [2]. The group Mon-27 has been consulted to design a process for the transportation of used tools to an autoclave for sterilization. The team is split up into two sub-teams, the modelling sub-team and the computing-sub team. The modelling sub-team must create a container to secure a specific surgical tool in such a way that the tool can still be sterilized while in the container. The coding sub-team must design a program that can accurately command a robotic arm to pick up the container and transport it to the correct autoclave location. Over the course of nearly six weeks, both teams developed and improved their designs.

The modelling sub-team's primary objective is to assure overall sterility of surgical tools as sterility is necessary in the field of healthcare. In order to best achieve the objective, the group implemented various innovative features to the design to maximize functionality. The team designed a container body that is shaped to fit the team's assigned tool, the retractor. Holes were added to allow for the moisture and pressure from the autoclave to reach the tool while inside the container. A closing lid was designed to prevent the tool from falling out during transportation. Finally, extrusions were made in the container interior to prevent the tool from sliding across the base of the container during transportation. Many iterations were made to the design, in order for to meet the weight constraint of 350g and the maximum scaled-down print time of two hours. Ultimately, the final container design satisfied all the team's functions, objectives, and constraints.

The coding sub-team is tasked with creating an algorithm to move the autoclave from a specific position into or on top of the autoclaves depending on the size of the container. This process will be completed using a robotic Q arm. The algorithm used to complete the cycle of sterilization would make sure to efficiently complete each cycle, performing all necessary additions and improvements. The team's proposed solution allows for breakthrough procedures and exciting new ideas for few to isolated missions as the assistance from technology provides great ease and comfort. The benefits span a wide range of possibilities in different fields simply due to the algorithm we created. The tasks such as pick up, rotation and drop-off can be manipulated to suit desired needs as well as understanding the value of how little actions that may be deemed tedious can be automated. To solve this issue the team worked on the best possible solution given our environment, using the coordinates to pinpoint exact locations for pickup and drop-off as well as the sensors to check for the position of the autoclave themselves. Using top-down processing a uniform and organized algorithm was created to complete the task.

Main Body

Summary of Design Objectives:

Objectives:

1. Ensure mass of container is minimized
2. Container can be transferred by the Q-arm multiple times without breaking
3. Can be easily and quickly created using a 3-D printer
4. Container spawns in same location each cycle
5. Program allows for smooth movements of the Q-arm without interruptions or delays

Constraints:

1. Weight of container model cannot exceed 350g
2. Dimensions expected to be greater than 2 mm, with most 4mm or more.
3. Model must be printable at ½ scale by a 3D printer in less than 2 hours
4. Any movement command in python code must be contained inside a function.

Primary Functions:

1. Use a Q-arm to pick up and transfer surgical tools secured by a container from a pre-determined random spawn location to the designated autoclave for sterilization.

Secondary Functions:

1. Container securely holds tools inside
2. Program uses both potentiometers for movement and drop off commands

3. Activate, open and close autoclave
4. Drop off container in designated autoclave based on colour and size of the container
5. Code is functional with a real Q-arm in a real environment
6. Grippers open and close during pick up and drop off.
7. Arm rotates without pauses and stops rotating when prompted

Background and Research Summary (CAD)

When designing a sterilization container for surgical devices, the group should be aware of numerous key elements to ensure the effectiveness, protection, and practicality of the container. That includes understanding the compatibility of field materials with numerous surgical gadgets and sterilization techniques is critical. Different materials might also react in another way to sterilization retailers and strategies, impacting the durability and efficacy of the box. Thorough information on different sterilization strategies (e.g. steam sterilization, ethylene oxide gas, hydrogen peroxide plasma) is important [3]. The box design must accommodate the unique necessities and constraints of the selected sterilization method. Surgical tools undergo more than one sterilization cycle throughout their lifespan. The box ought to be durable, proof against put and tear, and capable of withstanding repeated sterilization processes without compromising its structural integrity. Consideration of user ergonomics is crucial. The container layout must facilitate easy loading and unloading of devices, ensuring that healthcare specialists can cope with it effectively and accurately. Designing the box simply for cleansing and maintenance in thoughts enables stopping the accumulation of contaminants and preserving the greatest functionality over the years.

Background and Research Summary (coding):

Regarding the coding aspect of this project, the underlying theme was the use of a robotic arm to transfer containers to their designated autoclaves for sterilization. For one to familiarize themselves with the implications and impacts of robotic arms, extensive background information and research is crucial. In the modern world, as humans are becoming more reliant on robots and machines, the use of robotic arms in a wide variety of friends are being implemented to ease human labour and exceed human limitations. One extensive use of robotic arms in the modern age is in manufacturing, assembly, and packaging. Robotic arms are used in a variety of ways such as drilling, material handling, cutting, cleaning, etc. [4]. The application of robotic arms in this field greatly allows for the manufacturing, assembly, and packing process of various goods to be more efficient, while greatly easing human labour. On a much larger scale, the Canadarm, a massive robotic arm attached to the International Space Station, is used in space for reasons such as repositioning astronauts or capturing broken satellites or space debris [5]. This project focuses on the use of robotic arms in the medical field, more specifically in the process of sterilization of medical tools, by loading autoclaves. A similar use of robotic arms is used in the food industry, where robotic arms are used to place food containers inside for sterilization and preservation of food products [6]. To conclude, robotic arms are used to serve a multitude of purposes in the modern world, some very similar to the purpose of this project.

Description of Proposed Solution

To securely transport a used tool to an autoclave for sterilization, the team was required to design a transportation container and program to achieve this task. When considering the container, the modelling sub-team identified low mass, strength and reuse, low print time, and tool security as primary objectives, functions, and constraints. The container design takes on a form that accurately surrounds the retractor tool, the specific tool given to the modelling sub-team to design a container for. To achieve additional security, vertical extrusions were added to the interior of the container for the tool handle to fit into in order to further satisfy the security objective, as seen in figure 3.1. To meet the low mass and low print time objectives, the modelling team added many holes in the lid and base of the container using the hole tool and square pattern tool in inventor [7]. This reduces the mass and print time of both these components tremendously. Typically, autoclaves use moisture, pressure, and heat to kill harmful bacteria present on the surface of the tools. They apply hot steam at high pressures to the tool to achieve sterility [8]. To maximize the effectiveness of this process, holes were added to the side of the container. However, not too many were added, as the supports required to produce them add additional print time. After completing material research, the team determined that stainless steel would be the ideal material, as it is strong, relatively low cost, and highly corrosion resistant, satisfying all the team's objectives and constraints [9].

Regarding the code, the tool in the container is to be transferred securely from its drop-off location into or on top of an autoclave depending on its size. Using a robotic Quanser arm controlled by two potentiometers, the container can be moved around its environment for sterilization. To fully compute a functional arm the computing team considered 4 subgroups of actions. To start, there was the pick-up action which would pick up the container from its original position. Then there would be the rotation of the arm which would allow the arm to move freely around its environment. Lastly, reaching the desired location based on the autoclave color and containers size, the container would be a drop-off action. To create a smooth and efficient program, each major action is embedded in a function that carries out the procedure in the main program. Additionally, there were constraints that had to be considered during a cycle. For example, in the virtual Quanser environment, a container should not be spawned twice. A list is created in order to remove a container's value when it has been spawned. Next, container drop off locations are dependent on colour and size, and a container could either be dropped off on top of an autoclave or inside a drawer. Finally, the mock cycle for the program ran in a linear manner starting from pickup to rotation, then dropping off the container and finally, returning to home position until all 6 containers were put away.

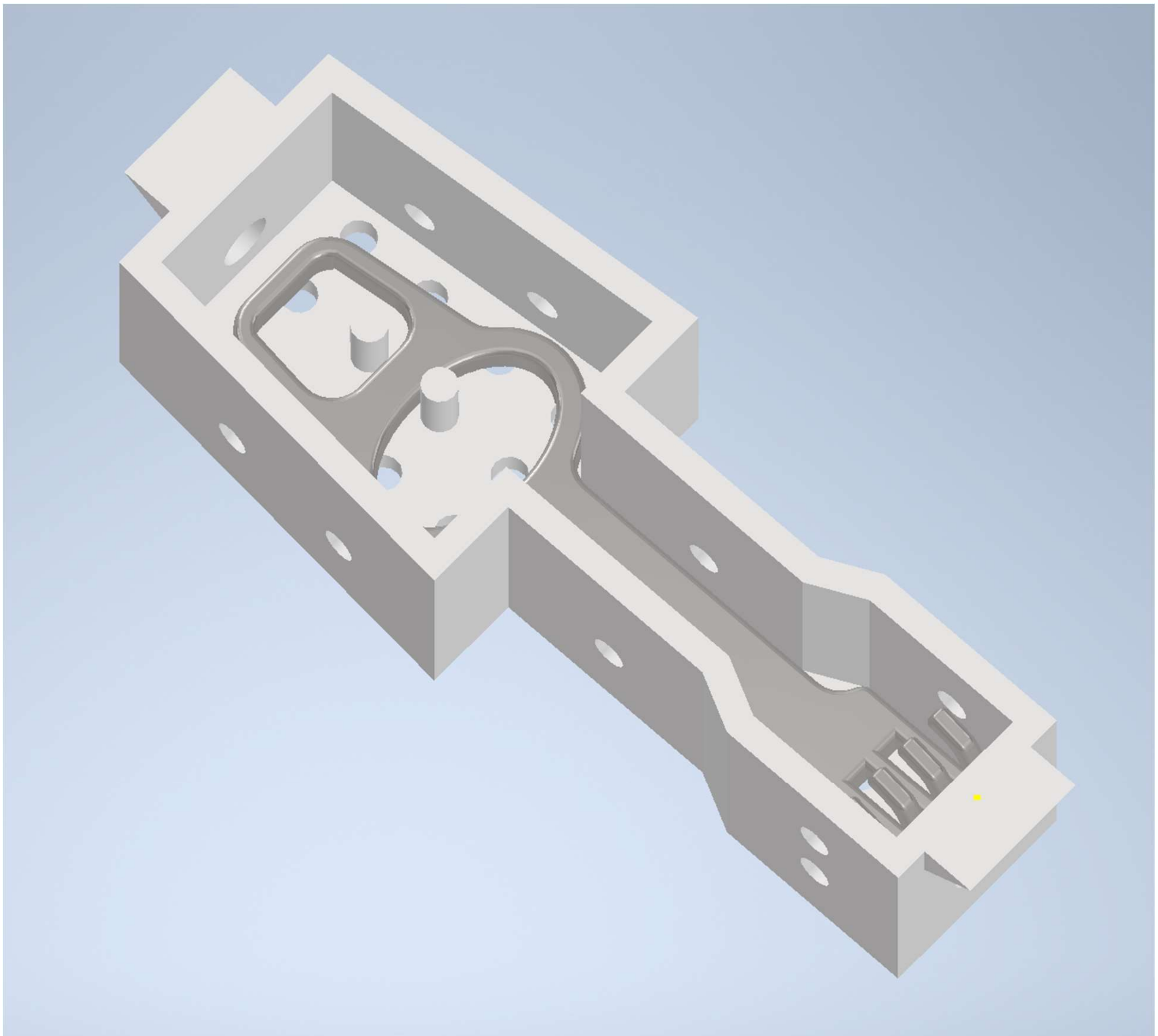

Figure 3.1. Container Body with Retractor Tool Inside

Strengths and Limitations of Design

Having completed the final design of the container, the strengths and limitations of the design can be reflected upon. The container design features many defining characteristics, such as the secure lid, holes throughout the design, internal supports, and the unique shape of the container body, all outlined in figure 4.1. These features combine to create an effective design. However, there still remain features that serve as limitations that could be further improved upon. One of the design's most significant strengths is its shape. The modelling sub-team was given the task to design a container for the retractor tool specifically, shown in figure 4.2. The container was designed to fit that tool specifically in order to satisfy the security objective, with only a few millimeters of additional length and width. This way, the tool is easy to insert but also secure once inside. To provide additional security, cylindrical extrusions were added to the interior container to further hold the tool in place. While these supports do a good job of preventing movement along the container base, they do not provide any vertical security in the event of the container being flipped in the transportation process. The supports only reach a height of 10mm, allowing the tool to become loose if the container were upside down. Possible solutions to this limitation include the extrusion being extended up to the lid or having the extrusion instead come down from the lid itself with an additional component to prevent vertical movement. However, the ladder would require the lid design to be adjusted, as the current connection method would be useless. The container has a length of 148mm [7], which allows to it satisfy the constraint of fitting in the autoclave as well as fitting the tool itself, demonstrated in figure 4.4. With the autoclave footprint being 152.67mm long, there is little room for error in the computer program for drop off the container. This featured could be improved upon by adding the lid handles to the longer sides of the container, so that the additional length required for this feature is added to the pair of sides with more room in the autoclave footprint. The team identified an objective for the design to be low mass, with constraints including the mass being less than 350g and the print time being less than two hours after being scaled down by 50%. The additions of holes, reducing the height of the container, and minimizing thickness of the container body all helped to reduce print time to 1h43m and reduce mass to 245.02g at full scale [10], as shown in figure 4.4. However, to reduce mass and print time, the group had to remove holes on the sides and make almost all the dimensions smaller, making sterilization more difficult and the container slightly weaker. The modelling sub-team made many important design decisions, ultimately satisfying every function, constraint, and objective. Although, there are still some improvements that could be made.

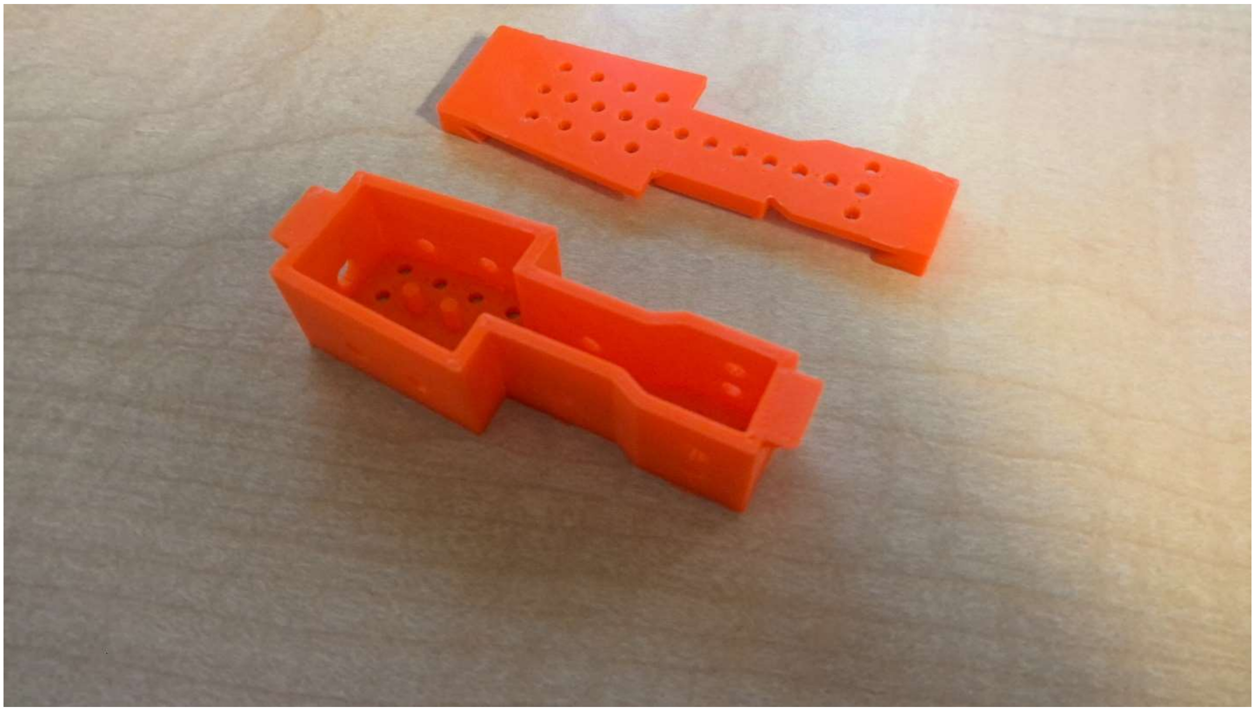

Figure 4.1. 3D Printed Prototype of Container Design

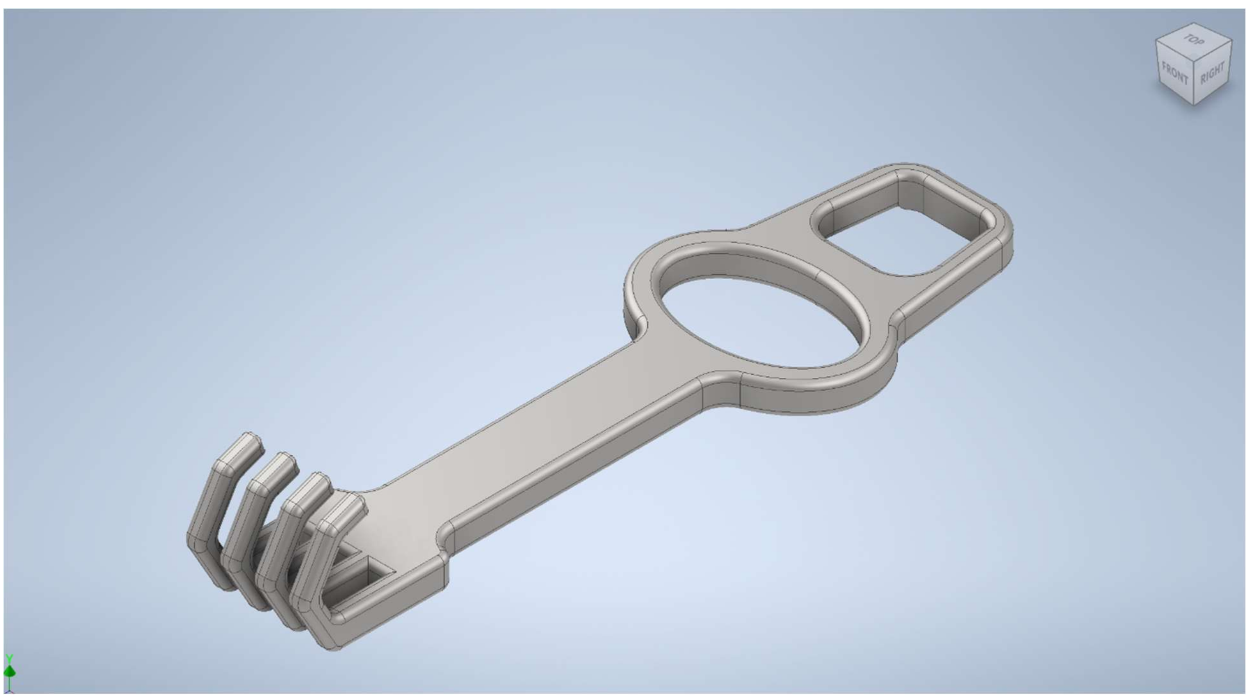

Figure 4.2. Retractor Tool Shape

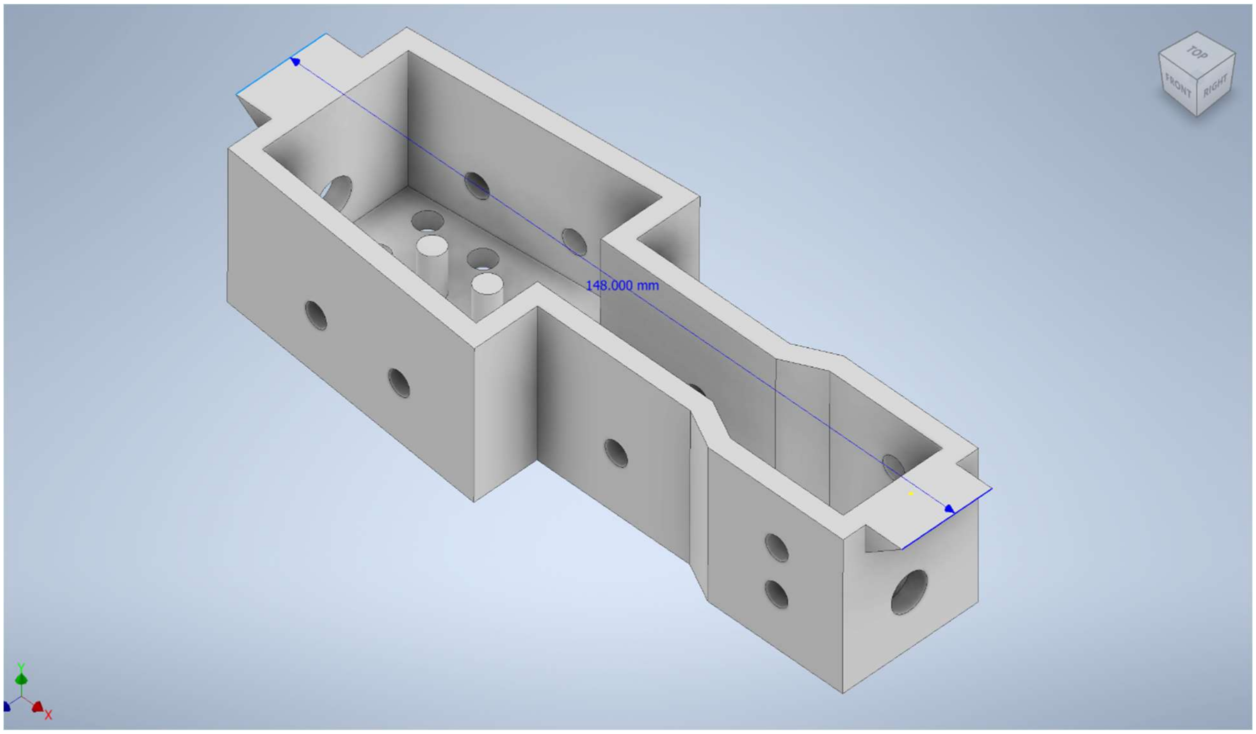

Figure 4.3. Container Length of 148mm

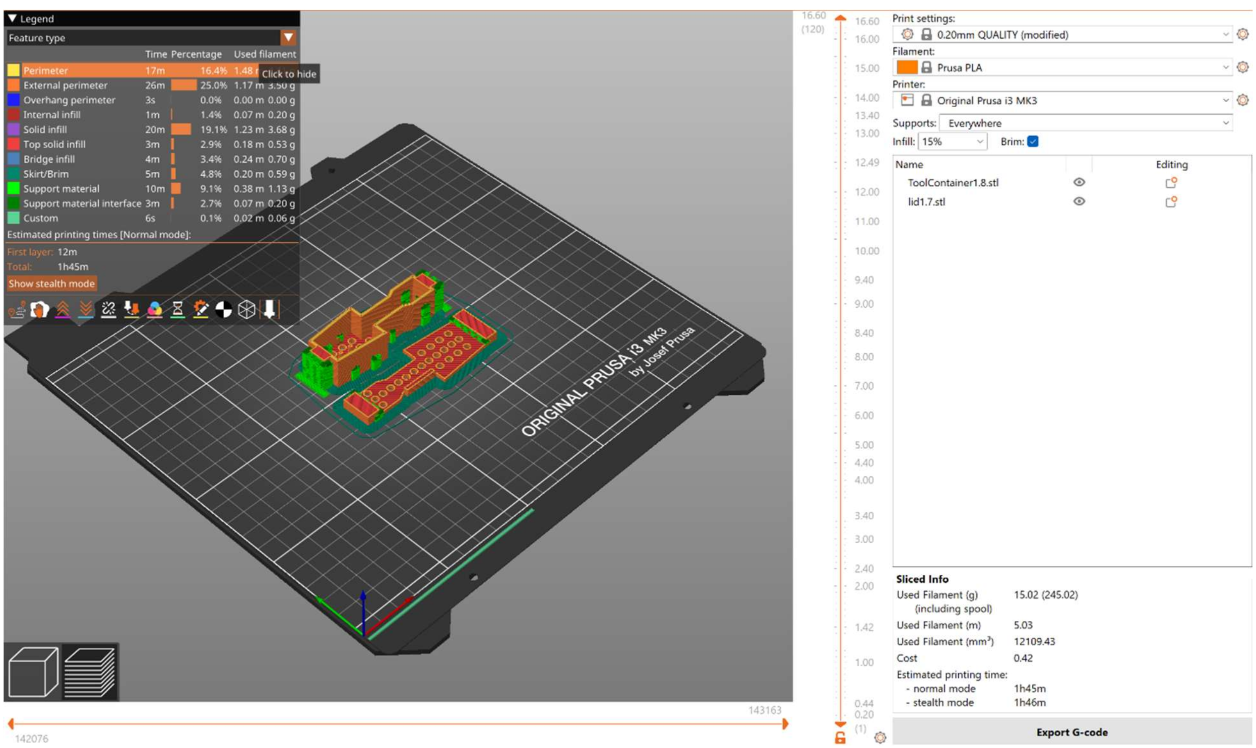

Figure 4.4. PrusaSlicer Print Information

Summary of Contributions

	Josh	**Mark**	**Farhan**	**Matthew**
Executive Summary		✓		✓
Summary of Design Objectives			✓	✓
Background and Research Summary		✓	✓	
Description of Proposed Solution	✓			
Strengths and Limitations of Design	✓			✓
Appendix A		✓		
Appendix B		✓		
Appendix C	✓			
Appendix D	✓			

Reference List

[1] Canadian Space Agency, "Health care with space exploration," Canadian Space Agency, Accessed: Dec. 5, 2023 https://www.asc-csa.gc.ca/eng/about/everyday-benefits-of-space-exploration/improving-health-care.asp

[2] "Project Two: Get a Grip," McMaster University, Module, 2023.

[3] "Other sterilization methods," Centers for Disease Control and Prevention, https://www.cdc.gov/infectioncontrol/guidelines/disinfection/sterilization/other-methods.html (accessed Dec. 6, 2023).

[4] "Best Applications Of Robotic Arms," Universal Robots. Nov 15, 2022. [Online]. Available: https://www.universal-robots.com/in/blog/applications-of-robotic-arms/

[5] K. H. Doestsch and G. Lindberg, "Canadarm," The Canadian Encyclopedia. November 10, 2021. [Online]. Available: https://www.thecanadianencyclopedia.ca/en/article/canadarm

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[8] "Everything About Autoclaves," Steris Healthcare. March 24, 2022. [Online]. Available: https://www.steris.com/healthcare/knowledge-center/sterile-processing/everything-about-autoclaves#:~:text=An%20autoclave%20is%20a%20machine,a%20given%20amount%20of%20time.

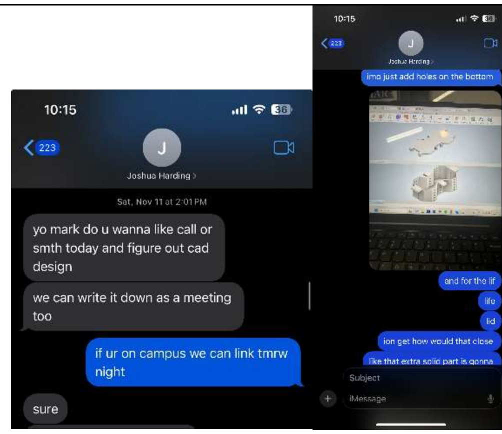
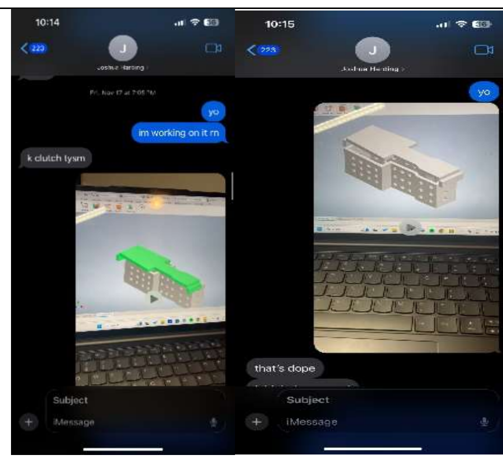
[9] "High-Temperature Characteristics of Stainless Steel." Nickel Development Institute. Accessed: Nov. 26, 2023. [Online]. Available: https://nickelinstitute.org/media/1699/high_temperaturecharacteristicsofstainlesssteel_9004_.pdf

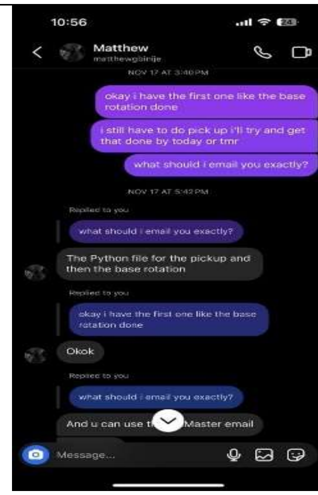
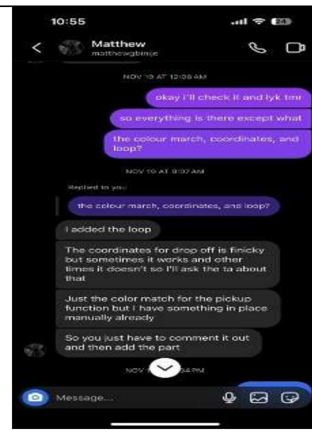
[10] J. Prusa and A. Ranellucci, "PrusaSlicer." 2016.

Appendices

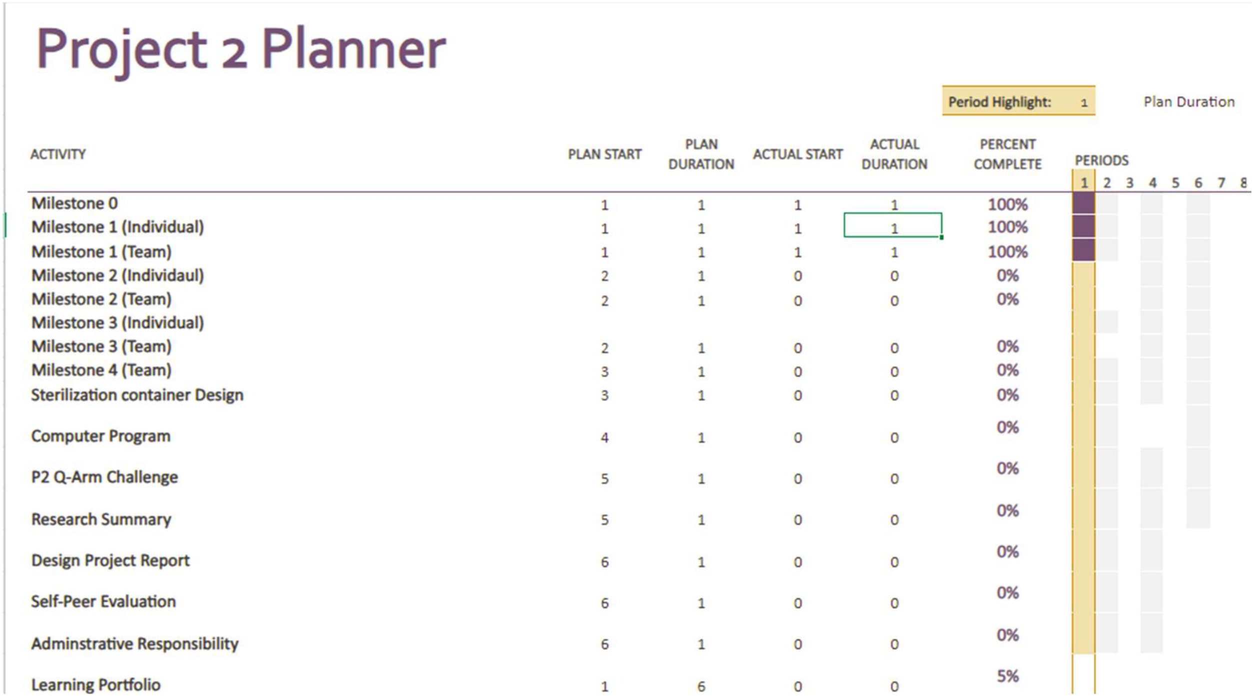
Appendix A: Project Schedule

Logbook of Additional Meetings:

Date:	Discussion	Proof
Sunday November 12. 7 pm to 8pm	Discussing our CAD design and how we can implement it. Trying to figure out a unique way to make sure the container is holding the tool safely and securely. Discussing potentially changing the lid design a bit to fit better.	
Friday - November 17. 7 pm to 8:30 pm	- Meeting on a Facetime to discuss the lid design. - In the image on the right you could see the texts that show the final lid design for Milestone 3.	

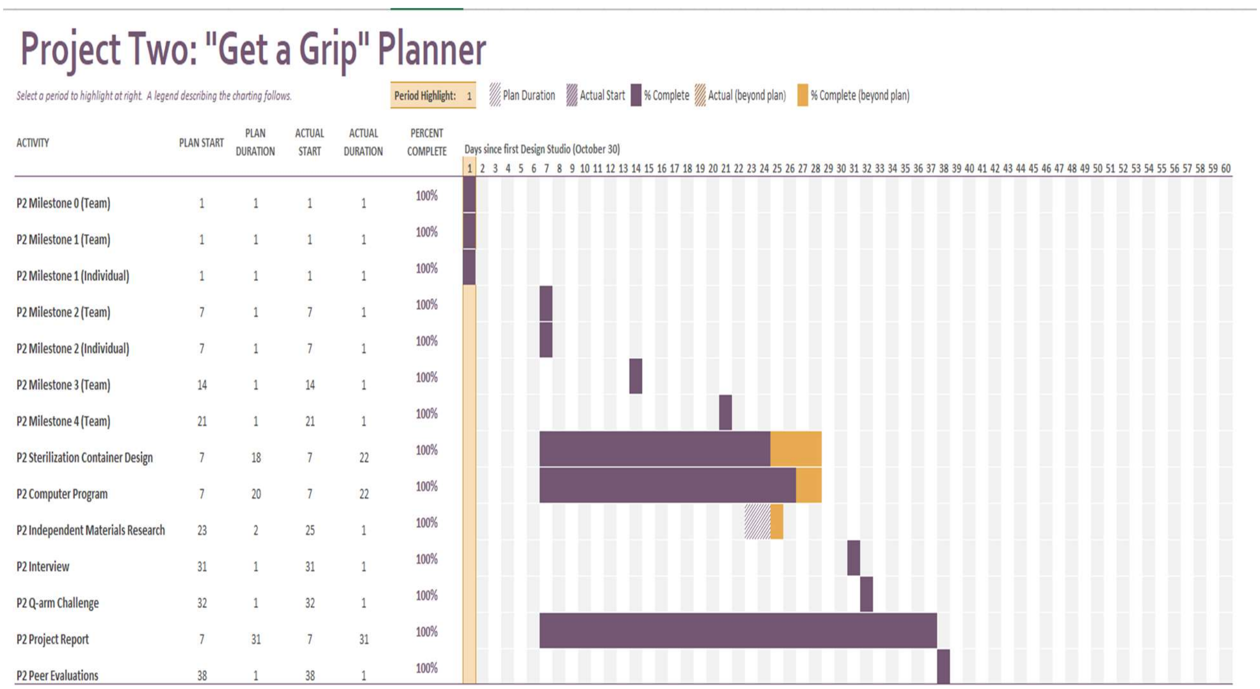
Friday - November 17. 3:40 pm to 6 pm	- An online meeting discussing what the coding team should be doing next. - Spoke about what has been done so far and sent files to Matthew to check over code	
Sunday - November 19. 8 am to 9 am	- Once again, discussed the progress with the code, such as current errors and what more needs to be implemented.	

Preliminary Gantt Chart:



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	1	1	100%
Milestone 1 (Individual)	1	1	1	1	100%
Milestone 1 (Team)	1	1	1	1	100%
Milestone 2 (Individaul)	2	1	0	0	0%
Milestone 2 (Team)	2	1	0	0	0%
Milestone 3 (Individual)					
Milestone 3 (Team)	2	1	0	0	0%
Milestone 4 (Team)	3	1	0	0	0%
Sterilization container Design	3	1	0	0	0%
Computer Program	4	1	0	0	0%
P2 Q-Arm Challenge	5	1	0	0	0%
Research Summary	5	1	0	0	0%
Design Project Report	6	1	0	0	0%
Self-Peer Evaluation	6	1	0	0	0%
Adminstrative Responsibility	6	1	0	0	0%
Learning Portfolio	1	6	0	0	5%

Final Gantt Chart:



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
P2 Milestone 0 (Team)	1	1	1	1	100%
P2 Milestone 1 (Team)	1	1	1	1	100%
P2 Milestone 1 (Individual)	1	1	1	1	100%
P2 Milestone 2 (Team)	7	1	7	1	100%
P2 Milestone 2 (Individual)	7	1	7	1	100%
P2 Milestone 3 (Team)	14	1	14	1	100%
P2 Milestone 4 (Team)	21	1	21	1	100%
P2 Sterilization Container Design	7	18	7	22	100%
P2 Computer Program	7	20	7	22	100%
P2 Independent Materials Research	23	2	25	1	100%
P2 Interview	31	1	31	1	100%
P2 Q-arm Challenge	32	1	32	1	100%
P2 Project Report	7	31	7	31	100%
P2 Peer Evaluations	38	1	38	1	100%

Appendix B: Scheduled Weekly Meetings

Milestone 0&1 - Date: October 30th

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Gbinije Matthew**	**Gbinijo**	**Yes**
Administrator 1	**Farhan Sifar**	**sifarf**	**Yes**
Coordinator	**Mark Atalla**	**Atallm7**	**Yes**
Administrator 2	**Joshua Harding**	**Hardiji8**	**Yes**

Agenda Items

1. Attendance and check-in
2. Assigning roles
3. Completing the milestone worksheet

Meeting Minutes

1. Attendance and check-in
    a. Making sure everyone went over the Project Module
2. Assigning Roles
    a. Making sure every group member has a unique role that differs from their last project.
3. Completing the milestone worksheet
    a. Making sure that the administrator is aware of the team submission that is due.
    b. Making sure that the manager creates a detailed Grantt Chart.
    c. Problem framing

Post Meeting

1. Update on past weeks work items (for this week: N/A)
2. Ask questions about roadblock, concerns or general inquiries
3. Update sub team on what the opposing sub team has been working on and vice versa
4. Plan out the strategies for moving forward efficiently and productively.

Milestone 2 - Date: November 6th

Attendance

Role	Name	Mac ID	Attendance (Yes/No)

Manager	**Gbinije Matthew**	**Gbinijo**	**Yes**
Administrator 1	**Farhan Sifar**	**sifarf**	**Yes**
Coordinator	**Mark Atalla**	**Atallm7**	**Yes**
Administrator 2	**Joshua Harding**	**Hardiji8**	**Yes**

Agenda Items

1. Checking Attendance
2. Project Planning
3. Identifying the common problems that could occur.
4. Each team doing their assigned task.

Meeting Minutes

1. Checking Attendance:
    a. Make sure every group member is present.
2. Project Planning
    a. Start bringing in some ideas to see how we should design & code.
3. Identifying the common problems that could occur.
    a. Identifying what are some of the problems that could occur along the way:
        i. We could face some issues as not knowing who's design we should use therefore a solution to that is scheduling a TA meeting and asking them about the strongest aspects of each of the design
4. Each team doing their assigned task.
    a. Modeling to design a low fidelity prototype
    b. Coding to create a Pseudocode

Post Meeting

1. Update on past weeks work items
    a. CAD Team on Lo Fi model, explaining the thought process behind it and computing team talking about their pseudo code and how it works.
2. Ask questions about roadblock, concerns or general inquiries

3. Update sub team on what the opposing sub team has been working on and vice versa
4. Plan out the strategies for moving forward efficiently and productively.

Milestone 3 - Date: November 13th

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Gbinije Matthew**	**Gbinijo**	**Yes**
Administrator 1	**Farhan Sifar**	**sifarf**	**Yes**
Coordinator	**Mark Atalla**	**Atallm7**	**Yes**
Administrator 2	**Joshua Harding**	**Hardiji8**	**Yes**

Agenda Items

1. Checking Attendance
2. Creating a rough design/code
3. TA Interview

Meeting Minutes

1. Checking Attendance:
    a. Make sure every group member is present.
2. Creating a rough design/code
    a. Implementing an actual CAD design
    b. Implementing a rough code using Python
3. TA Interview
    a. We talked about what we could implement in our CAD design and how we could create a lid in a unique way.

Post Meeting

1. Update on past weeks work items

- CAD and modelling team explaining their refinements to both the container design and pseudo code after considering suggested changes.

2. Ask questions about roadblock, concerns or general inquiries
3. Update sub team on what the opposing sub team has been working on and vice versa
4. Plan out the strategies for moving forward efficiently and productively.

Milestone 4 - Date: November 20th

Attendance

Role	**Name**	**Mac ID**	**Attendance (Yes/No)**
Manager	**Gbinije Matthew**	**Gbinijo**	**Yes**
Administrator 1	**Farhan Sifar**	**sifarf**	**Yes**
Coordinator	**Mark Atalla**	**Atallm7**	**Yes**
Administrator 2	**Joshua Harding**	**Hardiji8**	**Yes**

Agenda Items

1. Checking Attendance
2. Final Design
3. G-Code Ready
4. TA Feedback

Meeting Minutes

1. Checking Attendance:
    a. Make sure every group member is present.
2. Final Design:
    a. Through an additional meeting the CAD team was able to agree on a final design and implement it on CAD so that it get the feedback to make sure it meets the standards.
    b. Through an additional meeting the coding team was able to discuss some code lines that will result into the project's expectations
3. G-Code Ready

a. The CAD team should have finished the G-Code and ready to be able to 3D print the design after getting the approval through the TA feedback.

4. TA feedback
    a. In our TA interview we have discussed adding a ramp to the design to promote a secure lid and preventing the id from falling off. We concluded to add that ramp to the lid and to the container and allowing them to slide together. We also discussed adding holes to the lid resulting in a reduced printing time as we were a bit higher than 2 hours.

Post Meeting

1. Update on past weeks work items

- Walk through on all finalizations, explain the thought process behind your working models and code to allow for any final suggestions before interview.

2. Ask questions about roadblock, concerns or general inquiries
3. Update sub team on what the opposing sub team has been working on and vice versa
4. Plan out the strategies for moving forward efficiently and productively.

Appendix C: Additional Documentation

Source Materials Database:

[1] "AutoDesk Inventor 2024." AutoDesk, 2023.

[2] J. Prusa and A. Ranellucci, "PrusaSlicer." 2016.

[3] "ANSYS-Grantaa EduPack Database." Ansys, 2023.

[4] "High-Temperature Characteristics of Stainless Steel." Nickel Development Institute. Accessed: Nov. 26, 2023. [Online]. Available: https://nickelinstitute.org/media/1699/high_temperaturecharacteristicsofstainlesssteel_9004_.pdf

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[6] Canadian Space Agency, “Health care with space exploration,” Canadian Space Agency, Accessed: Dec. 5, 2023 https://www.asc-csa.gc.ca/eng/about/everyday-benefits-of-space-exploration/improving-health-care.asp

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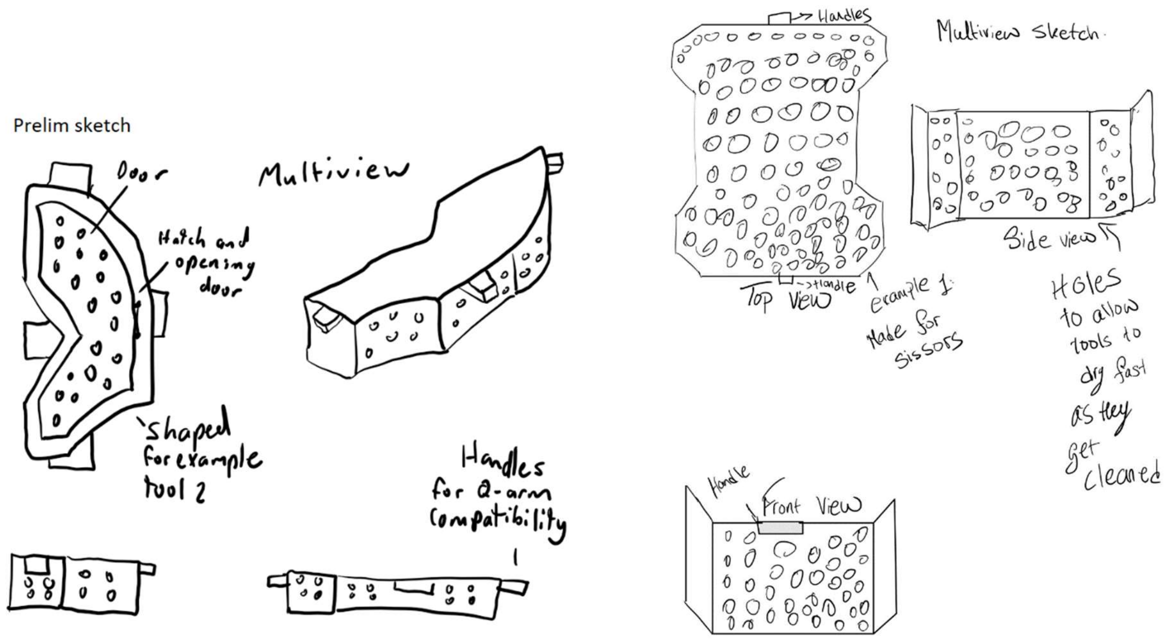
[12] Cretex Medical, "Stainless Steel or Aluminum: Material Considerations for Sterilization Cases & Trays," Cretex Medical Blog. [Online]. Available: https://www.cretexmedical.com/blog/2022/06/08/stainless-steel-or-aluminum-material-considerations-for-sterilization-cases-trays/. [Accessed: November 27 2023]

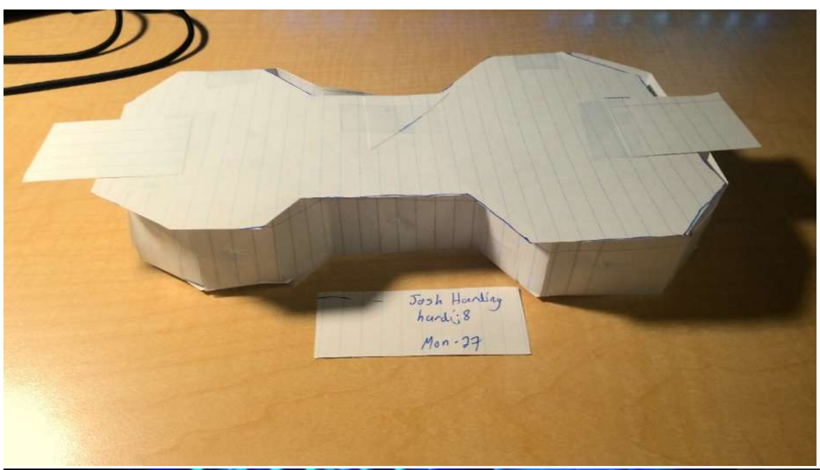
[13] EuroPlas, “What is pom plastic? key properties, benefits & applications,” EuroPlas, https://europlas.com.vn/en-US/blog-1/what-is-pom-plastic-key-properties-benefitsapplications (accessed Nov. 27, 2023).

[14] M. Steel, “Improving Autoclave Medical Sterilization Methods with Stainless Steel.” Accessed: Nov. 27, 2023. [Online]. Available: https://www.marlinwire.com/blog/improvingautoclave-medical-sterilization-methods-with-stainless-steel

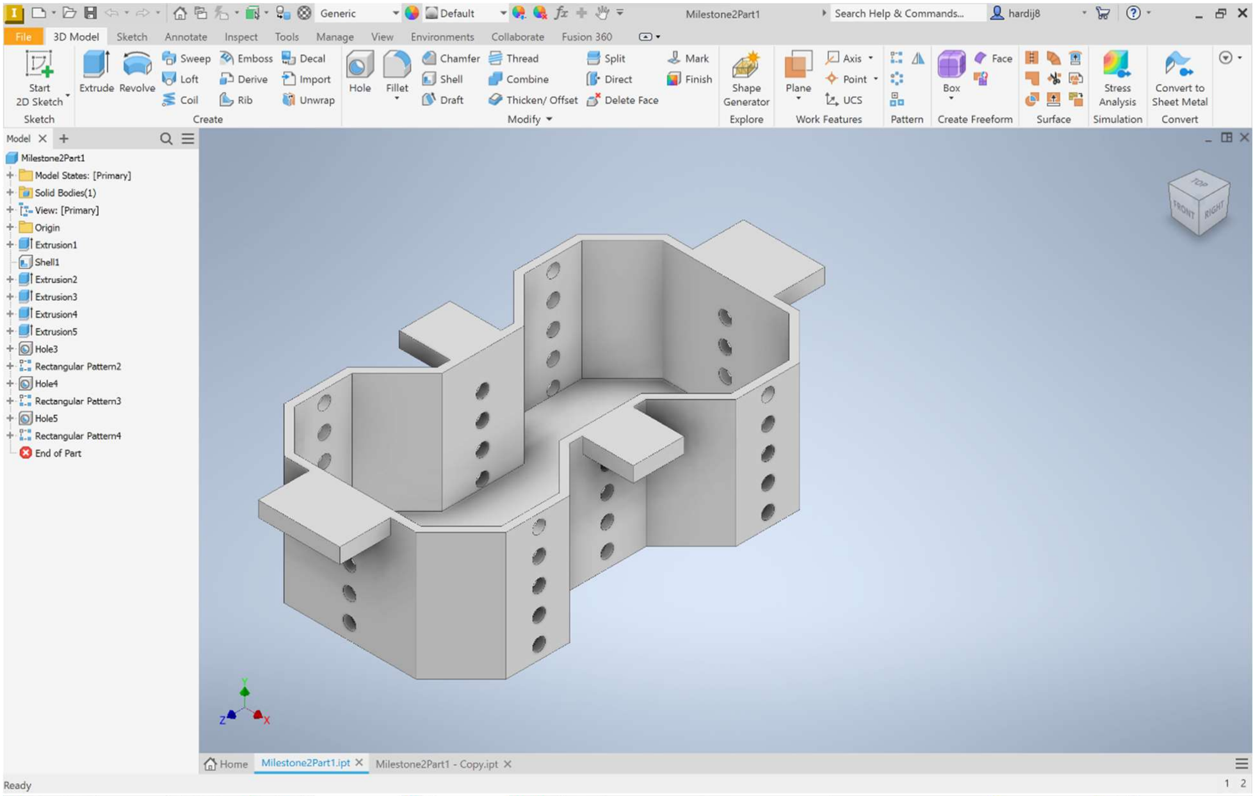
Additional Documentation

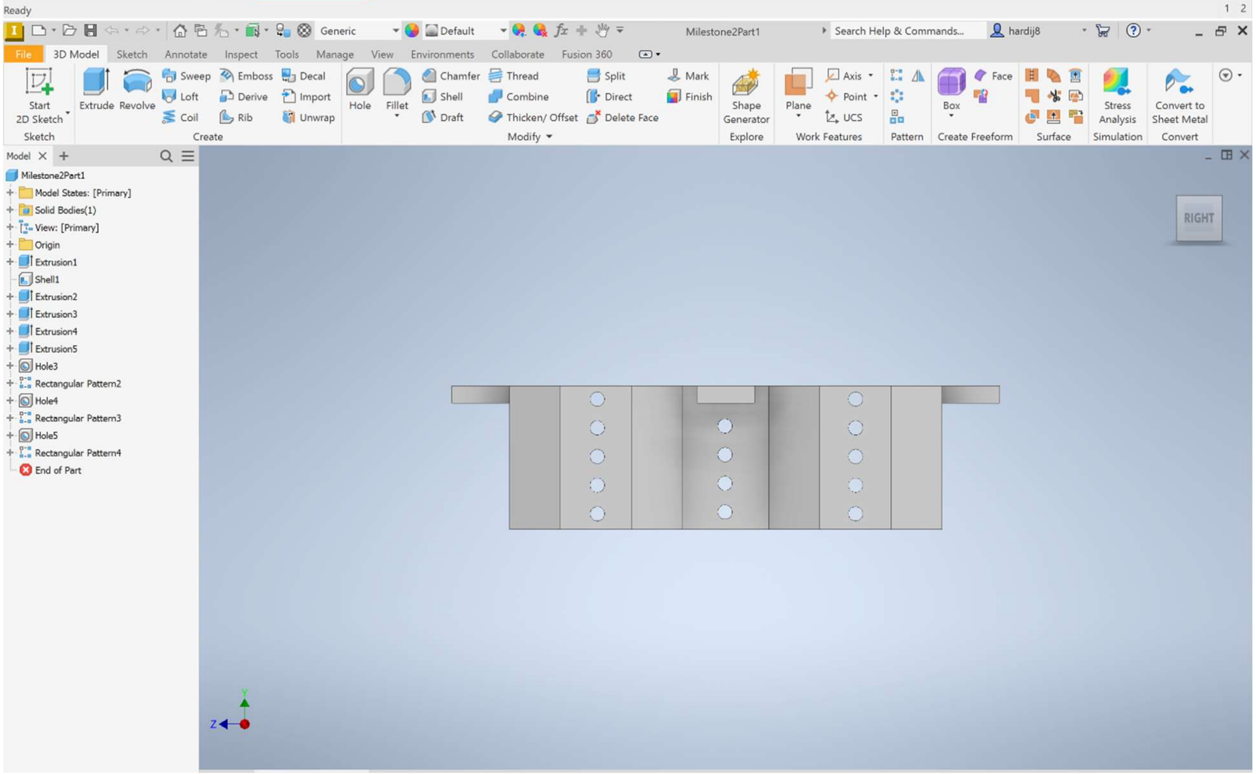


Preliminary Design Sketches

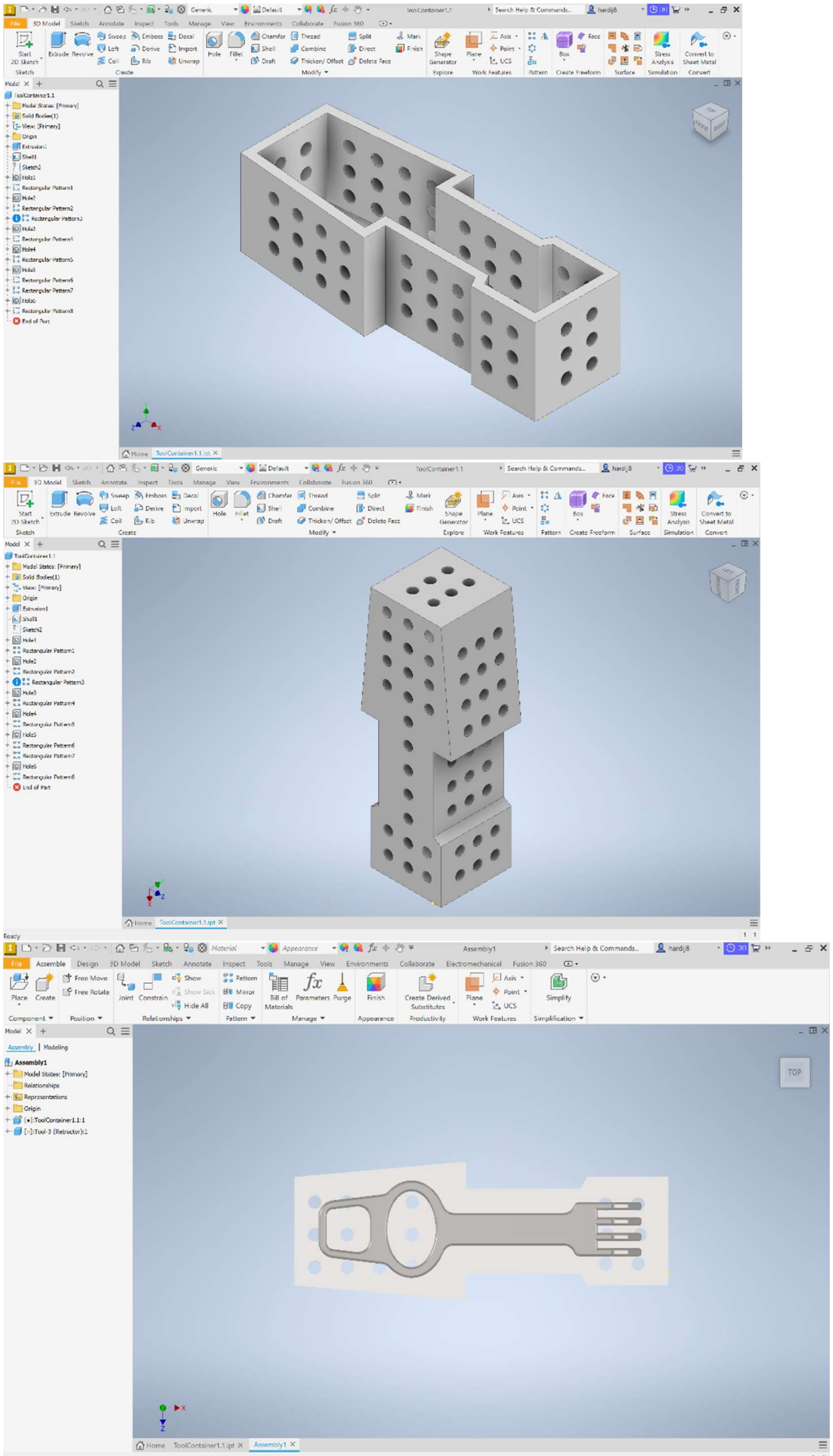


Initial Low-Fidelity Prototype

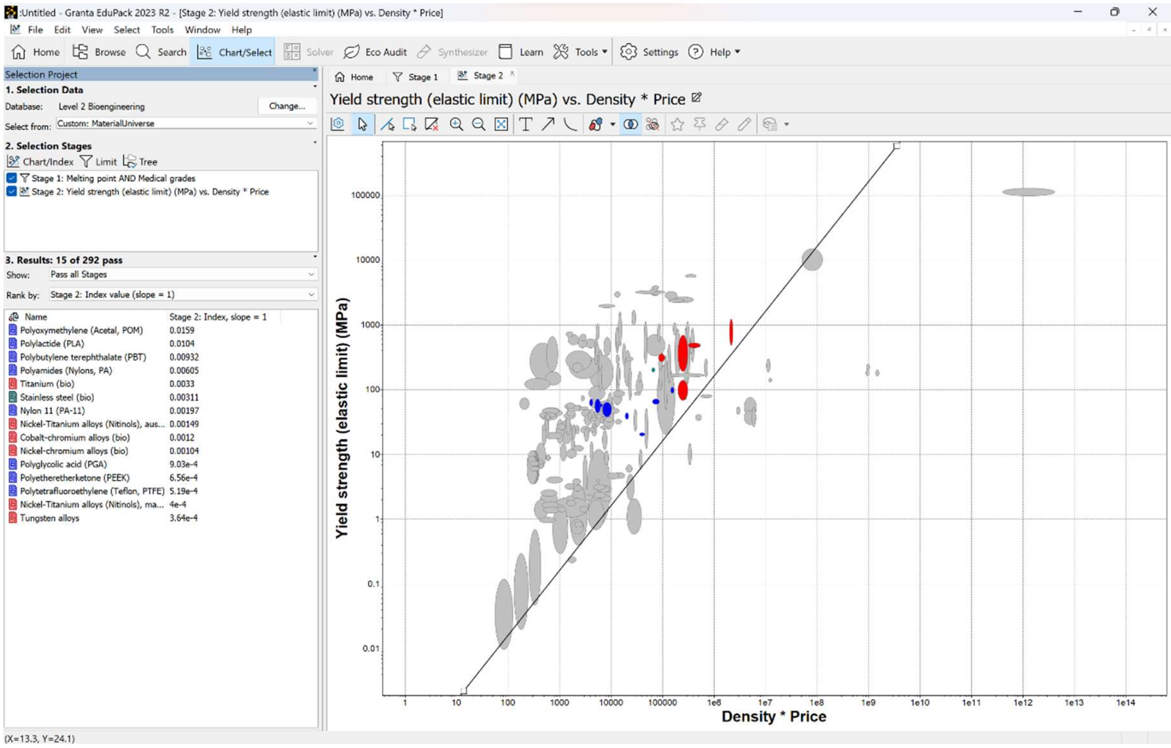




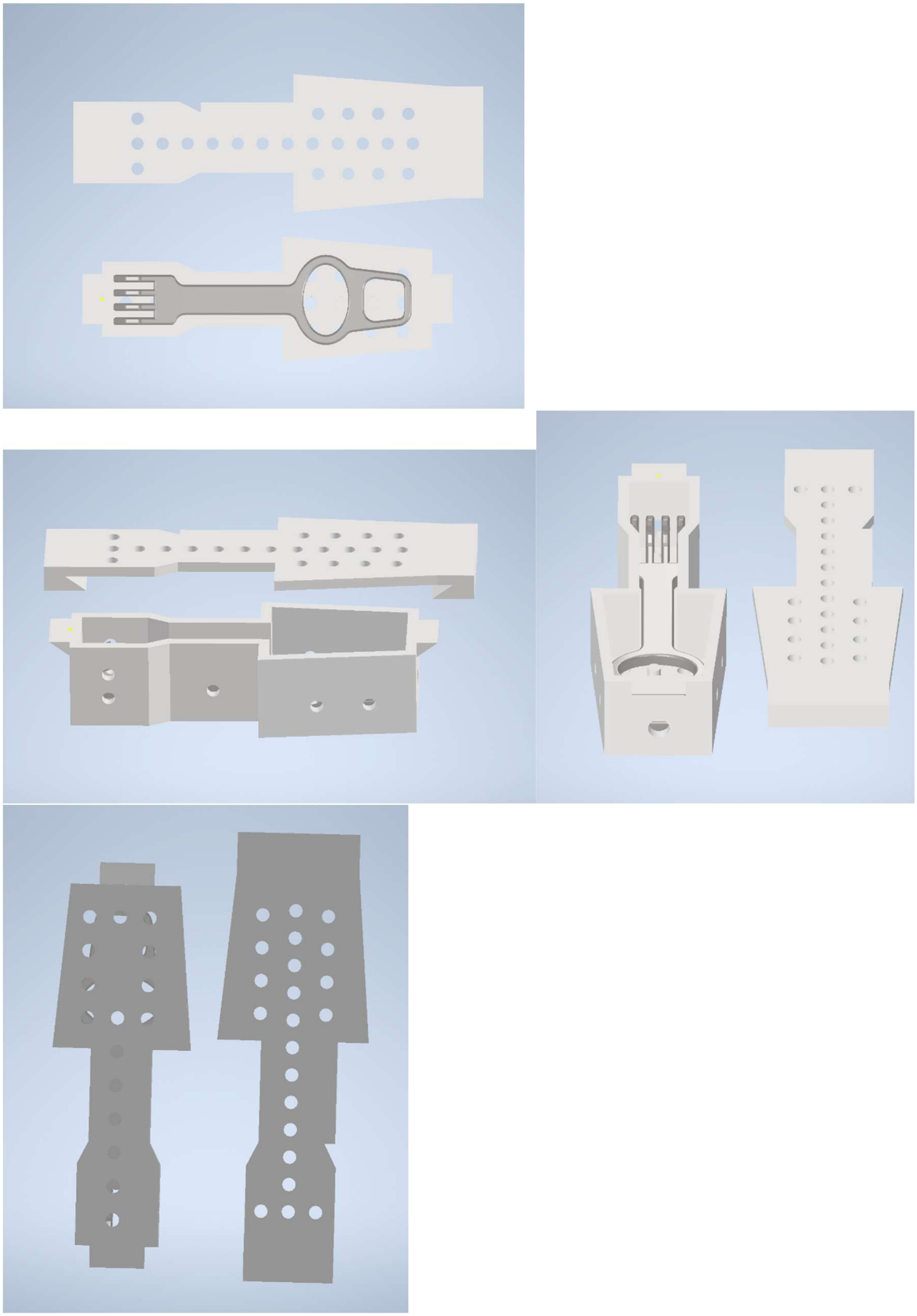
General Tool Container Design



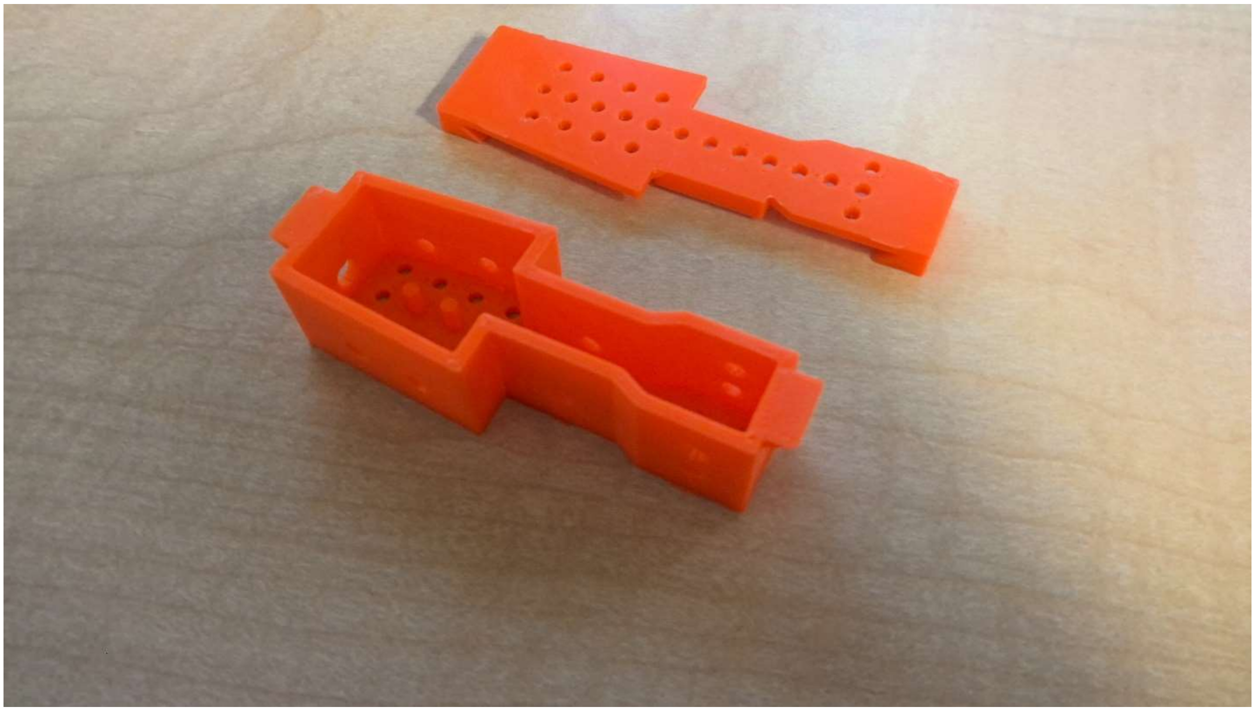
Initial Tool-Specific Design



Granta MPI – Strength vs Price Density



Final Container Design in AutoDesk



3D Printed Prototype of Final Container Design

```python
#-------------------------------------------------------------------------------
# STUDENT CODE BEGINS
#-------------------------------------------------------------------------------
import random

color = ''
generated_container_list = [1,2,3,4,5,6]

'''The method container_list generates a random number from the list of the six containers
then it removes the specific container from the list.
There is an if statement for if the list is empty, it will output the message to the user.
'''
def container_list():
    if potentiometer.right() == 0.5:
        global generated_container_list

        '''If statement to remove the container generated from the list of containers
        if the array for the list has values, else it will output a message for user'''
        if generated_container_list:
            container_number = random.choice(generated_container_list)
            generated_container_list.remove(container_number)
            return container_number
    else:
        print("All containers have been filled")

'''The method container_color defines the global variable by tracking the colors and changing
the variable depending on the container spawned, this is done by having a value passed as an argument in
the function.'''

def container_color(value):
    global color
```

```
    #If statements to change to color depending on the arguement passed in the method.
    if value == 1:
        print("Small Red container spawned!")
        color = 'red'
    elif value == 2:
        print("Small Green container spawned!")
        color = 'green'
    elif value == 3:
        print("Small Blue container spawned!")
        color = 'blue'
    elif value == 4:
        print("Large Red container spawned!")
        color = 'red'
    elif value == 5:
        print("Large Green container spawned!")
        color = 'green'
    elif value == 6:
        print("Large Blue container spawned!")
        color = 'blue'

'''The pick_up() function moves the q arm to the specific position of
the spawned container postion and then grips the container and returns back
to the original postion. All actions have a time delay in order for smooth
processes'''
def pick_up():
    spawned_container_position = [0.617, 0.054, 0.044]
    home_position = [0.406, 0.0, 0.483]

    arm.move_arm(0.617,0.040,0.044)
    time.sleep(1)
    arm.control_gripper(45)
```

```
    time.sleep(1)
    arm.move_arm(0.406, 0.0, 0.483)
    time.sleep(1)

'''The drop_off_container() function will take the generated value from the list
refernceing the spawned container and drop off the container in the corresponding
autoclave. It will begin by activating the autoclaves and then assigning the position
in order for the container to be dropped in the correct place depending on the size
of the container, when all actions are complete it will deactivate the autoclaves'''
def drop_off_container(value):
    position = ''
    arm.activate_autoclaves()

    #if statement to determine the size of the container and asign it a postion
    if value <= 3 and value >= 1 :
        position = 1
        print('Small Container being stored...')
    elif value <=6 and value >= 4:
        position = 2
        print('Big Container being stored...')

    #Loop to keep the code checking for the potentiometer values
    while True:

        #if statement block to determine the actions for the corresponding position
        if position == 1:

            '''if statement for the potentiometer values to determine whether the container
            is being placed on top of the autoclave or inside the drawer'''
            if 0.0 < potentiometer.left() < 0.5:

```

```
            #If statement to drop off the container based on the size and output the completed action
            if value == 1:
                arm.move_arm(-0.625, 0.241, 0.273)
                time.sleep(1)
                print('Red container has been stored!')
            elif value== 2:
                arm.move_arm(0.0, -0.644, 0.273)
                time.sleep(1)
                print('Green container has been stored!')
            elif value == 3:
                arm.move_arm(0.0, 0.644, 0.273)
                time.sleep(1)
                print('Blue container has been stored!')
            #set postion for all large containers and all small containers
            arm.control_gripper(-45)
            time.sleep(1)
            arm.deactivate_autoclaves()
            break
    elif position == 2:
        if potentiometer.left() == 1.00:
            if value == 4:
                arm.open_autoclave('red')
                time.sleep(1)
                arm.move_arm(-0.477, 0.174, 0.140)
                time.sleep(1)
                print('Red container has been stored!')
            elif value== 5:
                arm.open_autoclave('green')
                time.sleep(1)
                arm.move_arm(0.0, -0.491, 0.140)
```

```
                time.sleep(1)
                print('Green container has been stored!')
            elif value == 6:
                arm.open_autoclave('blue')
                time.sleep(1)
                arm.move_arm(0.0,0.466,0.140)
                time.sleep(1)
                print('Blue container has been stored!')
            arm.control_gripper(-45)
            time.sleep(2)
            arm.open_autoclave(color,False)
            arm.deactivate_autoclaves()
            break

'''The base_rotate() function will allow the potentiometer input to be recieved
and then checked against the location of an autoclave to correctly \
allow the matching container to be placed'''
def base_rotate(value):
    red_autoclave = [-0.382,0.139,0.483]
    green_autoclave = [0.0,-0.406,0.483]
    blue_autoclave = [0.0, 0.406, 0.483]

    x = False
    previous_reading = potentiometer.right()
    while not x:
        current_reading = potentiometer.right()
        difference = current_reading - previous_reading
        rotation_angle = 360*difference
        arm.rotate_base(rotation_angle)
        previous_reading = current_reading

```

```
        if value == 1 or value == 4:
            if arm.check_autoclave('red') == True:
                time.sleep(1)
                x = True

        if value == 2 or value == 5:
            if arm.check_autoclave('green')== True:
                time.sleep(1)
                x = True

        if value == 3 or value == 6:
            if arm.check_autoclave('blue')== True:
                time.sleep(1)
                x = True

#The return home function will reset the position of the q arm
def return_home():
    arm.home()

'''This main method will run the code fully, it will comprise of all the methods in order for
the container to be spawned, picked up, dropped off for all the containers by using a
while loop, which only breaks when all 6 containers have been stored'''
def main():
    global generated_container_list
    counter = generated_container_list
    #while loop combining all the methods to form a cycle
    while counter:
        container_no = container_list()
        arm.spawn_cage(container_no)
        container_color(container_no)
```

```
def main():
    global generated_container_list
    counter = generated_container_list
    #while loop combining all the methods to form a cycle
    while counter:
        container_no = container_list()
        arm.spawn_cage(container_no)
        container_color(container_no)
        pick_up()
        base_rotate(container_no)
        drop_off_container(container_no)
        return_home()
        print('Please reset both potentiometer values to 50 percent, in order to spawn the next container')
        #while true loop in order to wait for the potentiometers to be reset before it starts a cycle
        while True:
            if potentiometer.right() == 0.5 and potentiometer.left() == 0.5:
                break

    print('All containers have been filled successfully')









#---------------------------------------------------------------------------------
# STUDENT CODE ENDS
#---------------------------------------------------------------------------------
```

Main Code (full solution)

Appendix D: Design Studio Worksheets

Project Two Worksheets (TEAM)

TABLE OF CONTENTS

MILESTONE ZERO (TEAM): TEAM DEVELOPMENT AND PROJECT PLANNING

PROJECT TWO: MILESTONE 0 – COVER PAGE

Team ID: Mon-27

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

Full Name:	MacID:
Joshua Harding	hardij8
Mark Atalla	Atallm7
Gbinijr Obaro Matthew	Gbinijo
Farhan Sifar	sifarf

Insert your Team Portrait in the dialog box below

MILESTONE 0 – SUB-TEAM CHARTER

Team ID: Mon-27

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

Sub-Team	Team Member's Full Name
Modelling	Mark Atalla
	Joshua Harding
Computing	Farhan Sifar
	Gbinije Matthew

MILESTONE 0 – TEAM CHARTER

Team ID: MON-27

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Mark Atalla	☐M ☐A ☒C ☐S
2.	Joshua Harding	☐M ☒A ☐C ☐S
3.	Gbinije Matthew	☒M ☐A ☐C ☐S
4.	Farhan Sifar	☐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	Gbinije Matthew	Gbinijo
Administrator 1	Farhan Sifar	sifarf
Administrator 2	Joshua Harding	hardij8
Coordinator	Mark Atalla	Atallm7

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team ID: MON-27

Only the **Team Manager** is completing this section!

Full Name of Team Manager:	MacID:
Gbinije Matthew	Gbinijo

Preliminary Gantt chart:

Project 2 Planner

Period Highlight: 1 Plan Duration

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE	PERIODS 1	2	3	4	5	6	7	8
Milestone 0	1	1	1	1	100%								
Milestone 1 (Individual)	1	1	1	1	100%								
Milestone 1 (Team)	1	1	1	1	100%								
Milestone 2 (Individaul)	2	1	0	0	0%								
Milestone 2 (Team)	2	1	0	0	0%								
Milestone 3 (Individual)													
Milestone 3 (Team)	2	1	0	0	0%								
Milestone 4 (Team)	3	1	0	0	0%								
Sterilization container Design	3	1	0	0	0%								
Computer Program	4	1	0	0	0%								
P2 Q-Arm Challenge	5	1	0	0	0%								
Research Summary	5	1	0	0	0%								
Design Project Report	6	1	0	0	0%								
Self-Peer Evaluation	6	1	0	0	0%								
Adminstrative Responsibility	6	1	0	0	0%								
Learning Portfolio	1	6	0	0	5%								

MILESTONE ONE (TEAM): OBJECTIVES, MORPH CHART, & INITIAL DESIGN

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team ID: Mon-27

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

Full Name:	MacID:
Mark Atalla	Atallm7
Gbinije Matthew	Gbinijo
Joshua Harding	hardij8
Farhan Sifar	sifarf

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

Team ID: MON-27

1. As a team, create a list of objectives, constraints, and functions in the table below.
   → The exact number you should have depends on what information you have gathered from the Project Module.

Objectives	Constraints	Functions
Low mass	Model must weigh less than 350g	Pick up and transfer a container to an autoclave
Container is strong and can be used multiple times.	Model must not have any dimensions that are less than 2mm and most dimensions should be more than 4mm	Design a container that securely holds a surgical tool in place, can be removed by the Q-arm, and can be sterilized.
Easy to be produced by a 3D printer	Model must be printable at ½ scale by a 3D printer in less than 2 hours	Write a computer program that uses two potentiometers to operate the Q-arm
Program is functional no matter the spawn location of the container	Any movement command in the program is a function	Present a functional design in an interview
Container is secure, durable, and can be transferred by a Q arm.		
Program's commands allow for smooth movements of surgical tools without prolonged delays.		

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

Use a robotic arm to pick up and transfer surgical tools secured by a container from a random spawn location to an autoclave for sterilization.

3. What are the secondary functions?

Container securely holds tools in place and tools can be sterilized while in the container.
Computer program uses potentiometers to operate the Q-arm, can pick up surgical tools, and can drop them in a precise location
Program is functional no matter the spawn location of the container.
Program and container can function with a real Q-arm and container and can be functional in an interview setting.

MILESTONE 1 (STAGE 2) – MORPHOLOGICAL ANALYSIS

Team ID: Mon-27

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	Crevice on container	Tighter Grip	Easier shape to mobilize	Strong arm	Various shapes and sizes for the gripper	
Tools can be sterilized in container	Holes in the container	Open face	Built to support the shape of the tool specifically	Compatible with the Q-arm	Strong and reusable	
System function in the lab	Program is compatible with Q labs	Container is 3D printable	Container is compatible with Q-arm	Program can identify all 6 spawn locations	Program has functions for locations	

MILESTONE TWO (TEAM): SUBTEAMS, SKETCHES, & WORKFLOW

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team ID: Mon-27

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

Full Name:	MacID:
Joshua Harding	hardij8
Farhan Sifar	sifarf
Mark Atalla	Atallm7
Gbinije Matthew	Gbinijo

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

Team ID: Mon-27

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 being picked up by the QArm
→ 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.*

Characteristic	**Josh's Prototype**	***Mark's Prototype***
Size	***Observations*** *High Volume* *Big enough to fit any of the given -tool designs.* *-Modern Design* ***Improvements*** - *Could a bit bigger allowing different sizes of the tool in specific scenarios to fit comfortably.* - *Could add a bit more total volume or height so the lid does not interfere with the tool.*	***Observations*** *-High volume* *-Fits all tools in current scale* *-Accurate length* ***Improvements*** *-More accurately fit the dimensions of the example footprints.* *-Design size specifically for a particular tool (smaller)* *-Adjust the size to be better compatible with Qarm gripper*
Shape	***Observations*** *Shaped to fit tools comfortably* *- Wide* *- Fit to size*	***Observations*** *-Box Shape* *-Rectangular Prism* *-Fits all tools*

	- Durable - Shaped to fit tool in scenario 1 - Has a lid. ***Improvements*** *- Could add an inner handle as well. - Lid could have a handle for easy handling. - Add holes for better cleaning - Make lid hang over the sides to block holes after cleaning*	*-Not tool specific -Durable and strong (no obvious weak points in the design)* ***Improvements*** *-Shape could be more specific to a tool for it to securely fit in the dimensions of the container -Holes for ease of cleaning, rinsing, and drying of tools -Shape could be improved to accommodate the Qarm gripper (make container wider at the top or feature an overhang at the top for the gripper to wrap around)*
Functionality	***Observations*** *- Handles to hold it - Holes for cleaning/drying - Thin from the middle for Q-bot handling. - Lid protects from unwanted dust.* ***Improvements*** *- Add more holes to allow the tools to dry faster. - Add more handles to allow better grip. - Allow the holes and the top face to be closed by a lid to maintain sterility after cleaning and during transportation*	***Observations*** *-Strong material -Holes for cleaning -No lid -Difficult shape for Qbot grip* ***Improvements*** *-Add more holes for cleaning, rinsing, and drying as mentioned above -Add lid for more secure transportation -Add customization of state, either open for cleaning or closed and secure for sterility (could be done with a hinged lid)*

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

Team ID: MON-27

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

Flowchart
Let F. be Farhan's flow chart and M. be Matthew's Flow Chart
Similarities:

- *Start with q arm at home position*
- *Decision statement with a reacting loop*
- *Q arm movement of position*
- *Deactivation of autoclave after closing drawer*
- *Check for color match with if statement*
- *Loops until there are no more containers to be moved*

Differences

- *F. uses of a list to remove a container*
- *F.User Adjusts potentiometer without loop*
- *F. Values inputted in the if statement*
- *Generates random number in M. version while in F. value is inputted*
- *F. loops to user adjusting potentiometer if the q arm is not at the correct position*
- *M. Q arm returns to home position after autoclave is deactivated*

Pseudocode:

Similarities:

- *Both follows same general layout or sequence of commands which correspond to actions done by the Q-arm*
- *Both have same movement-based commands*
  - *How Q-arm moves from home position to container position or autoclave position*
- *Both contain same verifications commands*
  - *Check for colour and size*

Differences:

- *Matthew's pseudocode does not use a list while Farhan's pseudocode does.*
- *Farhan's pseudocode uses specific potentiometer values to check for the desired position whereas Matthew uses a more general value*
- *Matthew uses a random number generator while Farhan uses a list with numbers 1-6 in it, which is randomly selected.*
- *Matthew uses an if statement to check if number is used more than once. Farhan Removes the number selected from the list.*

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

Team ID: Mon-27

As a sub-team, write out a pseudocode outlining the high-level workflow of your computer program in the space below. This should be a compilation of the pseudocode completed by each group member in Milestone 1.

Write your pseudocode here

Start

Generate a random number Generator between 1 and 6

Open gripper

Q bot in assigned home position

Remove random number generated from the list.

If statement to check if number is spawned more than once

Move q arm to pick up position.

Q arm closes gripper

Arm moves containers from initial position to home position.

If statement to check if color of autoclave matches with the container

Q arm does transference based on the adjustment of the right potentiometer

Activate autoclave function is utilized.

Verify the size of the container and targeted placement. (if statement)

Open gripper

Autoclave drawer is closed (if size of container is big)

If container is large, correct the autoclaves drawer

Q arm returns to home position

Loop above steps until all matching six containers are correctly placed.

MILESTONE THREE (TEAM): PRELIMINARY MODEL & CODE

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team ID: Mon-27

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

Full Name:	MacID:
Joshua Harding	hardij8
Mark Atalla	Atallm7
Farhan Sifar	sifarf
Matthew Gbinije	gbinijo

MILESTONE 3 (STAGE 1) – INITIAL DESIGN OF FINALIZED STERILIZATION CONTAINER (MODELLING SUB-TEAM)

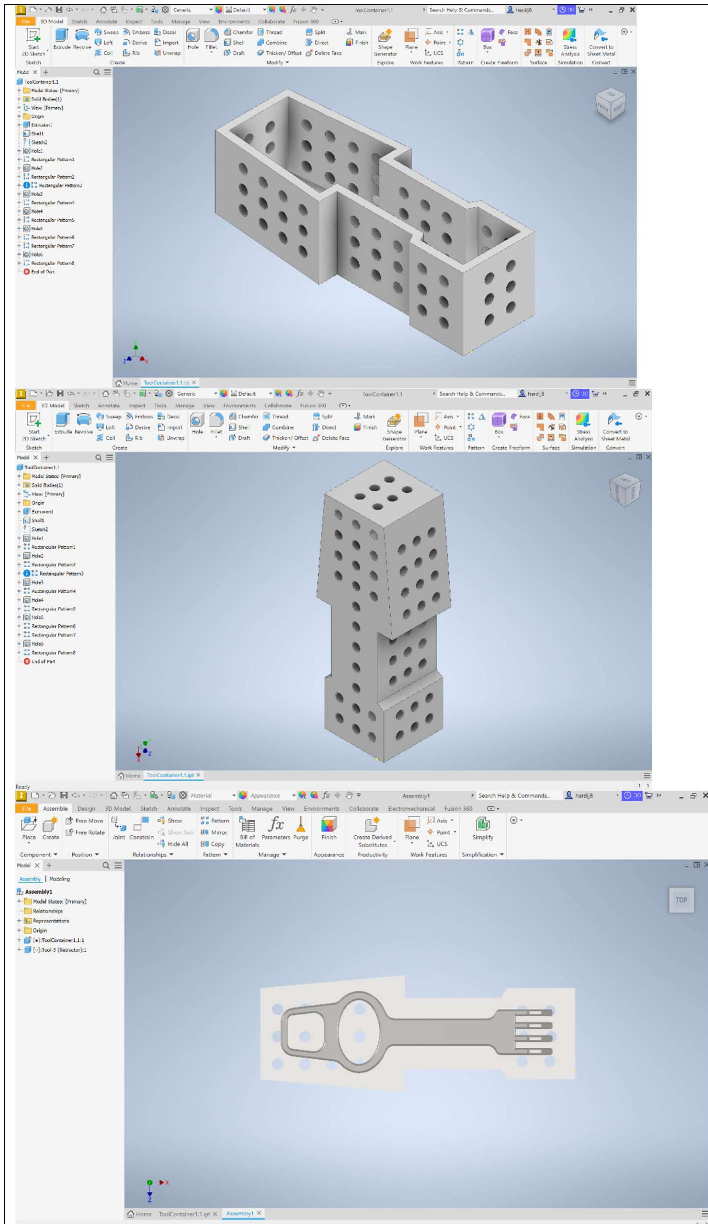
Team ID: Mon-27

As a team, review each other's preliminary solid models and discuss which features from each other's models align best with the project objectives, constraints and functions. Summarize this in the table below.

Container	Feature	How it aligns with project objectives, constraints and functions.
Josh's	Contains holes	Holes allow for openings for cleanings that satisfy the sterilization function
	Fits autoclave	Aligns with the function of securing the tool and fitting the dimensions of the autoclave
	All dimensions above 4mm	Fits constraint where no dimensions are less than 4mm
Mark's	Contains lots of holes	Holes allow creating a clean and quick dry tool.
	Fits autoclave	Dimensions of box aligns with the dimensions of the tool creating fit to shape box.
	All dimensions above 4mm	Fits constraint where no dimensions should be less than 4mm.

Create a preliminary solid model of your finalized sterilization container. This model should consider features from both team-members preliminary solid models.

Name (Team Member #1): Joshua Harding	Name (Team Member #2): Mark Atalla
Insert an image of your solid model here.	



MILESTONE 3 (STAGE 1) – PROGRAM TASK PSEUDOCODE (COMPUTATION SUB-TEAM)

Team ID: Mon-27

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

Pick-up Container

Open gripper to max (45 deg)
Q-arm moves to correct effector position where container is located
Close gripper to pick up container (-45 deg)
Q-arm move back to home position

Continue or Terminate Program

If statement to determine whether all 6 drawers are correctly filled
    If yes, terminate program
If not go run the code again

MILESTONE 3 (STAGE 2) – STERILIZATION CONTAINER DESIGN EVALUATION (MODELLING SUB-TEAM)

Team ID: Mon-27

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	**Design A**	**Design B**	**Finalized Design**
Holes	S	S	-	S
Q-arm compatible	S	+	-	+
Fits dimensions of autoclave	S	S	S	+
Secures tool 3 specifically	S	-	+	+
Designs within 3D printer measurement requirements	S	S	+	+
Low mass	S	-	+	+
Total +	0	1	3	5
Total –	0	1	2	0
Total Score	0	2	1	5

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

2. Propose one or more design refinements moving forward.

- Add a removable lid – secures tool better for transportation - Improve middle of to be easier picked up by q arm - Improve dimensions to better secure retractor tool

MILESTONE 3 (STAGE 2) – CODE PEER-REVIEW (COMPUTATION SUB-TEAM)

Team ID: Mon-27

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

Rotate Q-arm Base	**Team Member Name**: Farhan Sifar
Enter code errors and/or observations here - Code runs without errors but could benefit from more robust methods - Change the coordinates as they are predetermined but also can be manipulated - The function has no exit, no way to know when the function will start and stop correctly - The code runs forever, there is no way to exit the rotate q arm base function - Potentiometer vales are correctly computed to match the full rotation of the q arm base, i.e. the full 360 degrees -	

Drop-off Container & Return Home	**Team Member Name**: Matthew Gbinije
Enter code errors and/or observations here • Potentiometer values are used based off angles, instead of values ranging from 0-1	

- Command if left potentiometer is less than 180, which corresponds to 0.5 on potentiometer reading. This would not do anything since the drop off positions are based on if 50< left pm < 100 (position 1) or if left pm = 100 (position 2)
- Drop off locations use coordinates 0 and 1, instead of pre-determined coordinates from the Quanser environment.
- States if 180 < left pm < 360, code should be set to position 2 and Q-arm should put container inside autoclave drawer. This should correspond to position 1 instead, where Q-arm places container on top of autoclave.

*For a team of 3, copy and paste the table for the function that was done by 2 sub-team members. (Remember each sub-team member should have written their own code before this.)

2. Propose one or more refinements to your code moving forward.

- For the drop off function, the left pm readings should be based on the values 0-1 first, then converted to degrees.
- For drop off function, the values of the left p.m should correspond to the correct drop off positions.
  - < 0.5 left pm < 1, position 1
  - Left pm = 1, position 2
- For drop off function, proper use of coordinates from quanser environment
- There should be a way to stop the rotate base function from running continuously
- There should be a better else statement for if the true on the rotate base function

MILESTONE 3 (STAGE 3) – PRELIMINARY DESIGN REVIEWS

Commented [A1]: Add in something guiding them in creating their design reviews

Team ID: MON-27

Preliminary Design Review Planning:

Create an outline of topics you will cover during your preliminary design review. You should cover the following topics:

1. Both sub-teams:
   a. Integration of both sub-teams for the final deliverables
   b. Timeline for project completion
2. Modelling sub-team:
   a. Demonstrate your most recent prototype
   b. How your current sterilization container meets project objectives.
   c. Plan for fabrication
3. Computing sub-team:
   a. Demonstrate your current program.
   b. Updates on the workflow implementation (i.e. how much of the workflow has been implemented)
   c. Process of integrating both group member's code.

Modelling

- Shape
  - Better fit retractor tool 3
  - Improve the middle or the side so that it can easily be gripped by the Q-arm
  - Consider adding more holes
- Lid
  - Add a removable lid
  - Have it close the entire system including the holes or have it just cover the top
  - Have it open and close so the tool can be inserted
- Securing Pieces
  - Have pieces installed on the inside that hold the tool in place
  - Make sure it fits within the 3D printing capabilities

Computation:

Workflow implementation:

- Code for the base rotation and drop off functions of the Q-arm has been implemented.
  - Some pieces of code do not work, could be changed, or could be better. These need to be looked at and fixed.

- Still need to implement working pick up function and working loops to continue or terminate the code after the desired goal has been accomplished (all containers are dropped off at correct positions).

Process of integrating both member's code:

- First, we much ensure that each code can work on its own. Integrating both member's code should not be too hard, but both codes must be changed so it can join together smoothly.
  - Same variable names, same method of calculating potentiometer readings, Same way of determining the quanser coordinate set, ensuring we use the same coordinates, so Q-arm moves properly.

Modelling Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.

- *How will the lid stay locked*
- *How will you secure the tool*
- *Refine shape to better fit the tool*
- *Adjust the lid to fit a bit big so that when it prints, it still fits on*

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

- Lid will wrap around a handle and slide on
- Refine shape to better surround the tool
- Add securing mechanism inside

Computing Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.

- *When the functions start and stop correctly?*
- *Exit rotation function is missing, there should be a way to stop the rotation function from running without stopping the entire code manually.*
- *Potentiometer values are between 0-1 and should not be turned into angle value for the drop off function. Only for the rotation function.*
- *Effector position should be located.*
- *Python documentation file- function that tells when arm should stop rotating.*
- *Coordinates not specified*
- *Activation of autoclave isn't included*
- *Q arm has not movement to exact drop off position*
- *The rotate arm base works correctly with little to no errors, needs to be refined to be more robust*

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

- *Add effector positions for the positions of each colored box*
- *Have a function or section of code that checks if the colors of the container match the color of the drawer being used. This function would be the final part in the rotation function.*
- *Modify the correct potentiometer values for the user potentiometer input*
- *Make sure the drawer and size match the action being ran i.e.. a large container will specifically trigger a drawer opening, this will make the code more specific and not always open the drawer whether or not an item will be placed in it*
- *Make code more robust and have the main function check the code for correct running output ie. Correct rotation of base and other functions*
- *Find out coordinates of the three containers and make sure they match with the code coordinates*

MILESTONE FOUR: DETAIL DESIGN (DESIGN REVIEW AND FEEDBACK)

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team ID: Mon-27

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

Full Name:	MacID:
Joshua Harding	hardij8`
Farhan Sifar	sifarf
Mark Atalla	Atallm7
Gbinije Matthew	Gbinijo

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.*

Team ID: Mon-27

MODELLING SUB-TEAM

☐ 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 do 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

In our TA interview we have discussed adding a ramp to the design to promote a secure lid and preventing the id from falling off. We concluded to add that ramp to the lid and to the container and allowing them to slide together. We also discussed adding holes to the lid resulting in a reduced printing time as we were a bit higher than 2 hours. However, the overall design was approved by the TA and we will be printing it next week!

reviewing progress next design studio.

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

- We have indeed added the ramp to the lid and to the container to prevent the lid from falling off and making sure it is secure.
- We have also added holes to the lid to reduce our printing time down to an hour and 59 minutes making sure we are under the restricted time.
- We have reduced the number of holes in the main design so that printing time is below the constraint of 2 hours, while also still being functional for sterilization

COMPUTATION SUB-TEAM

Team ID: Mon-27

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

- → The general flow should be home → pick-up → rotate → 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 potentiometers incorrectly to test for malfunctions

☒ All required program tasks are written as their own function (Pick-Up Container, Rotate Q-arm Base , Drop-Off Container & Return Home)

☒ All program tasks are accounted for (Pick-Up Container, Rotate Q-arm Base , Drop-Off Container & Return Home, Continue or Terminate Program)

☒ Each task requiring potentiometer input (Rotate Q-arm Base , Drop-Off Container & Return Home) evaluates the potentiometer values before executing an action

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

☒ Team is running their program in their assigned environment.

☒ 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.

- Ensure that the autoclave colour check is added into program and works.
- Make sure the desk drawers open and close based on size of container
- We must correct our left potentiometer values.
- Add detailed and thorough comments throughout code.

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

- Taking the feedback into account, we have successfully been able to implement the autoclave colour check into the code, ensuring that the Q-arm is locate the position of the correct autoclave and drop off the container.
- Ensure that left potentiometer values are great than 0.5 and less than 1 for position 1 and equal to 1 for position 2.
- We still must implement code to correctly close autoclave drawers, but we are able to successfully open them when the container is large.
- We still have to add comments to our code.

Project Two Worksheets (INDIVIDUAL)

TABLE OF CONTENTS

MILESTONE ONE (INDIVIDUAL): OBJECTIVES, MORPH CHART, & INITIAL DESIGN

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

Please complete this worksheet in your corresponding team document.

MILESTONE 1 (STAGE 2) – MORPHOLOGICAL ANALYSIS

Please complete this worksheet in your corresponding team document.

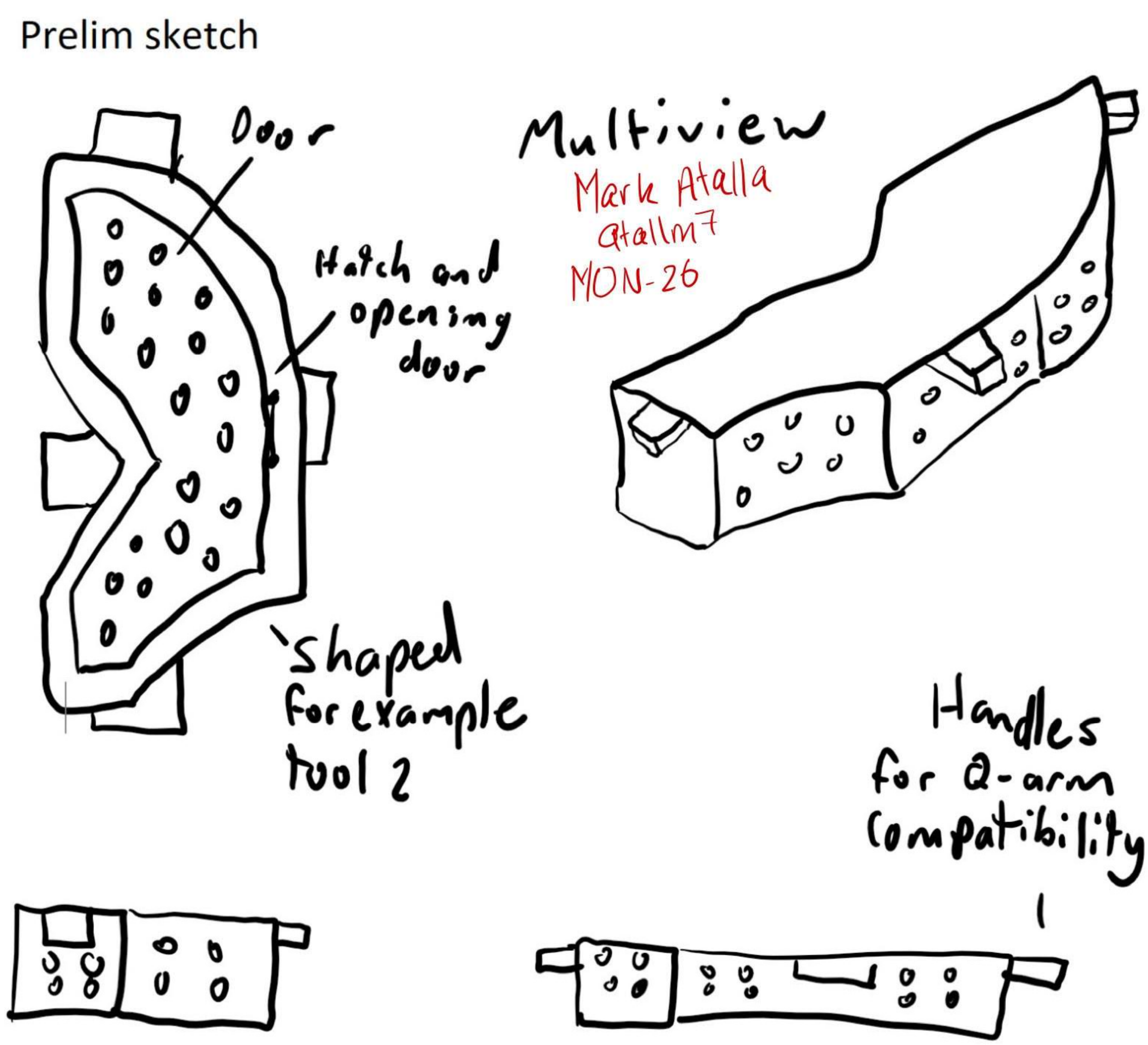
MILESTONE 1 (STAGE 3) – PRELIMINARY CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID: Mon-27

1. Complete your sketch on a separate sheet of paper
   → Be sure to clearly write your Team ID, Name and MacID
2. Take a photo of your sketch
3. Insert your photo as a Picture (Insert > Picture > This Device)

Team ID: MON-27

Name: Mark Atalla	MacID: atallm7
Insert screenshot(s) of your preliminary sketch below	



*For multiple sketches, please copy and paste the above on a new page

MILESTONE TWO (INDIVIDUAL): SUBTEAMS, SKETCHES, & WORKFLOW

MILESTONE 2 (STAGE 1) – LOW-FIDELITY PROTOTYPE (MODELLING SUB-TEAM)

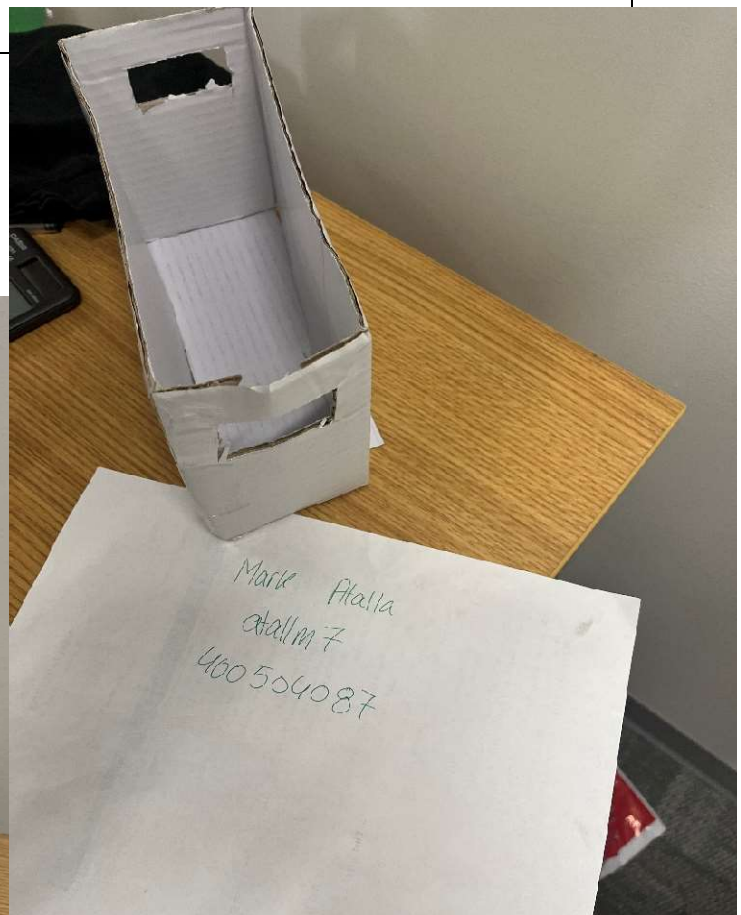
Team ID: MON-27

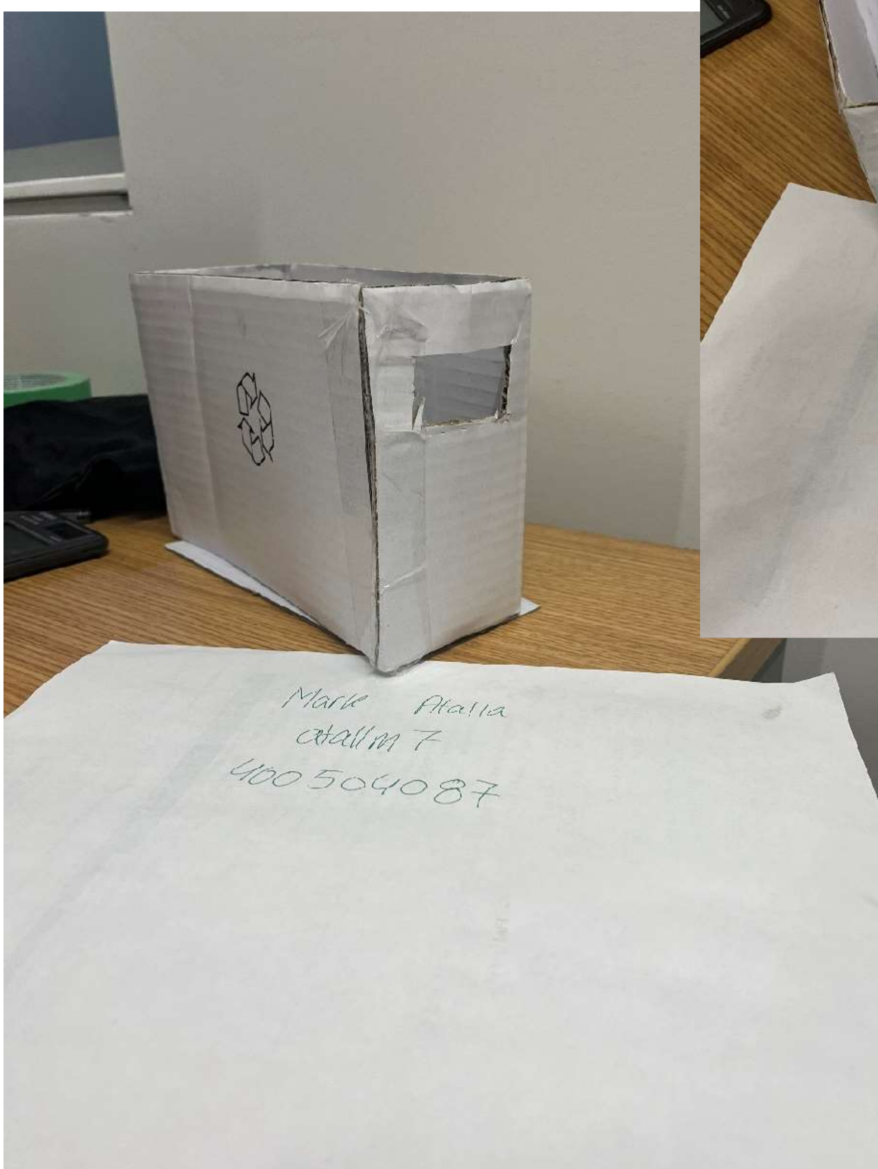
Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

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

Team ID: MON-27

Name: Mark Atalla	MacID: atallm7
Insert screenshot(s) of the low-fidelity prototype below	





MILESTONE 2 (STAGE 1) – COMPUTER PROGRAM WORKFLOW (COMPUTATION SUB-TEAM)

Team ID:

Complete this worksheet individually before coming to Design Studio 8.

1. Complete your storyboard or flowchart sketches on a separate sheet of paper
   → Be sure to clearly write your Team ID, Name and MacID on *each* workflow
2. Take a photo of your sketch
3. Insert your photo as a Picture (Insert > Picture > This Device)

Team ID:

Name:	MacID:
Insert screenshot(s) of your workflow below	

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

Please complete this worksheet in your corresponding team document.

MILESTONE 2 (STAGE 2) – COMPUTER PROGRAM PSEUDOCODE COMPILATION & OBSERVATIONS (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 2 (STAGE 3) – PRELIMINARY SOLID MODEL (MODELLING SUB-TEAM)

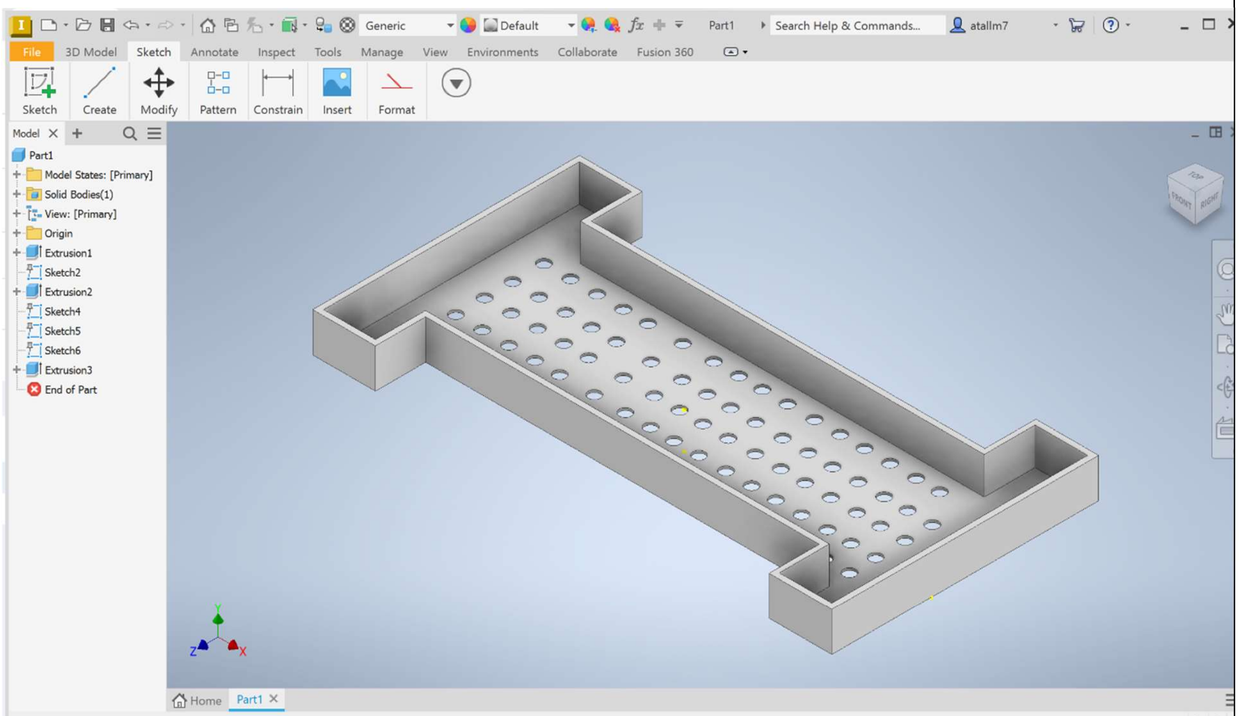
Team ID: MON-27

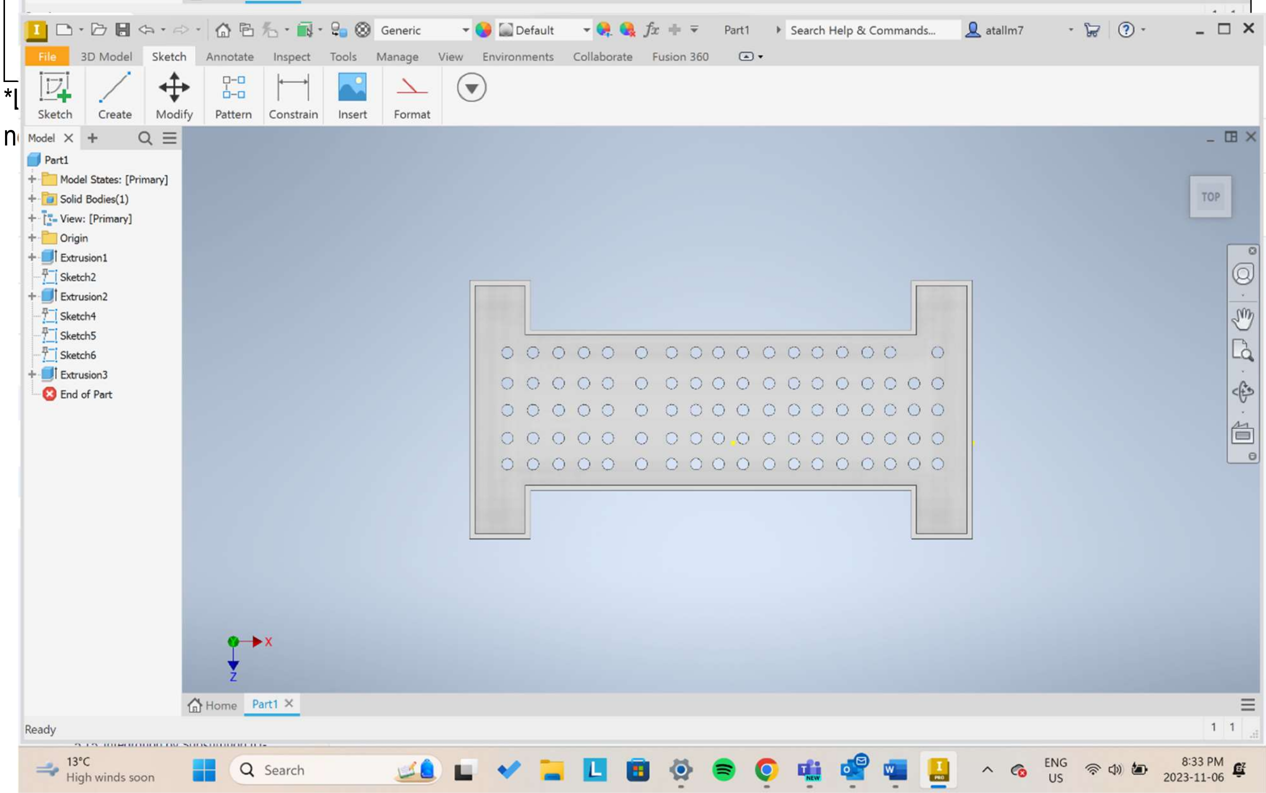
Complete this worksheet individually during Design Studio 8.

1. Take multiple screenshots of your preliminary solid model
   → You are also required to submit an IPT file of each solid model (see Submission Details section above)
   → Be sure to label model with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* solid modelling screenshots per page**

Team ID: MON-27

Name: Mark Atalla	MacID: atallm7
Insert screenshot(s) of your model below	





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

Team ID:

Complete this worksheet individually <u>during</u> Design Studio 8.

1. Take multiple screenshots of your code
   - → You are also required to submit a Python (*.PY) file of your code (see Submission Details section above)
   - → Be sure to label your tasks with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **<u>Do not include more than *one* screenshot per page</u>**

Team ID:

Name:	MacID
Insert screenshot(s) of your code below	

*Limit screenshots to no more than 1 per page. For additional screenshots, please copy and paste the above on a new page

MILESTONE THREE (INDIVIDUAL): PRELIMINARY MODEL & CODE

MILESTONE 3 (STAGE 1) – INITIAL DESIGN OF FINALIZED STERILIZATION CONTAINER (MODELING SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 1) – PROGRAM TASK PSEUDOCODE (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 2) – STERLIZATION CONTAINER DESIGN EVALUATION (MODELING SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 2) – CODE PEER REVIEW (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

INDEPENDENT MATERIALS RESEARCH ASSIGNMENT

MATERIAL SELECTION (STAGE 1) - PROBLEM DEFINITION

Use the following information to help you in your assignment:

- Function: The containers must securely contain a surgical tool during the tool's sterilization period.
- Fixed Variable: Radius, melting temperature (100^{O}C, steam)
- Free Variable: Wall thickness
- Objective: Must minimize cost and mass (material density and CAD)

Use the following MPI's to select your final material:

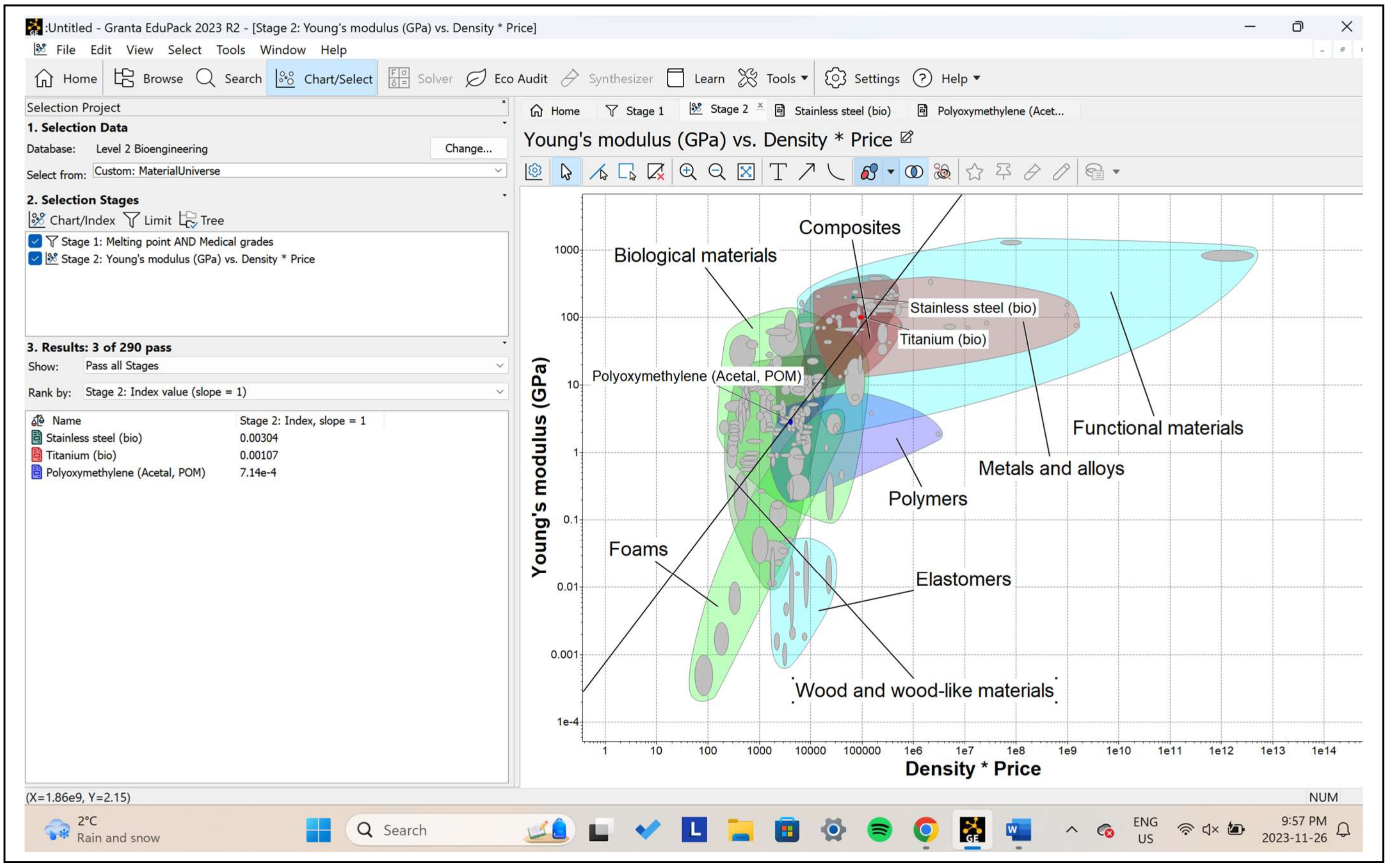
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Stiffness Design	$\frac{E}{\rho C_m}$	Must minimize cost and mass
I have chosen to go with stiffness design for various reasons. Primarily, this type of design ensures a critical feature: it governs the extent of distortion or displacement a structure might undergo. This is extremely crucial when fabricating an item with precise dimensions and form. Considering our project to develop a container for sterilizing specific equipment, upholding accuracy becomes vital since we need to ensure no deformation takes place. By choosing rigid design principles, the pliability of the structure diminishes while its solidity increases; thus, providing stable housing for intended instruments inside the box.		

MATERIAL SELECTION (STAGE 2) - MPI AND MATERIAL RANKING

Include a screenshot of your GRANTA graph in the text box below. The following should be included and clearly visible in your graph:

- X and Y axis
- MPI slope
- Material titles
    - The materials that you may choose from are those that are able to be 3D-printed (i.e., materials such as ceramics and glasses should be excluded from your database)
- Material family bubbles



Material Ranking			
	Rank 1	Rank 2	Rank 3
Assigned MPI:	Stainless Steel	Titanium	Polyoxymethylene

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection.

Chosen Material:	Stainless Steel
Based on my MPI results, I have decided to go with my rank 1 option which is stainless steel. I choose stainless steel as stainless steel is a highly suitable material for sterilization containers, owing to its corrosion resistance, ability to withstand high temperatures and non-reactive nature. Its seamless, impervious surface enables easy cleanliness and inhibits the growth of microbes, thus maintaining sanitation. The inherent robustness and aesthetic appeal of this substance makes it capable of enduring mechanical impacts while adhering to regulatory stipulations and ensuring longevity. As well as being a relatively low-cost material. [1] Given that stainless steel comes in various grades, it can be customized according to specific demands pertaining to any given sterilization process. [2] Thus far considered holistically, combining resilience with hygiene standards compliance places stainless steel as an optimal choice for applications demanding lasting sterile receptacles such as those prevalent in pharmaceutical settings.	
References (If any): [1] Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023 (www.ansys.com/materials) [2] Cretex Medical, "Stainless Steel or Aluminum: Material Considerations for Sterilization Cases & Trays," Cretex Medical Blog. [Online]. Available: https://www.cretexmedical.com/blog/2022/06/08/stainless-steel-or-aluminum-material-considerations-for-sterilization-cases-trays/. [Accessed: November 27 2023]	

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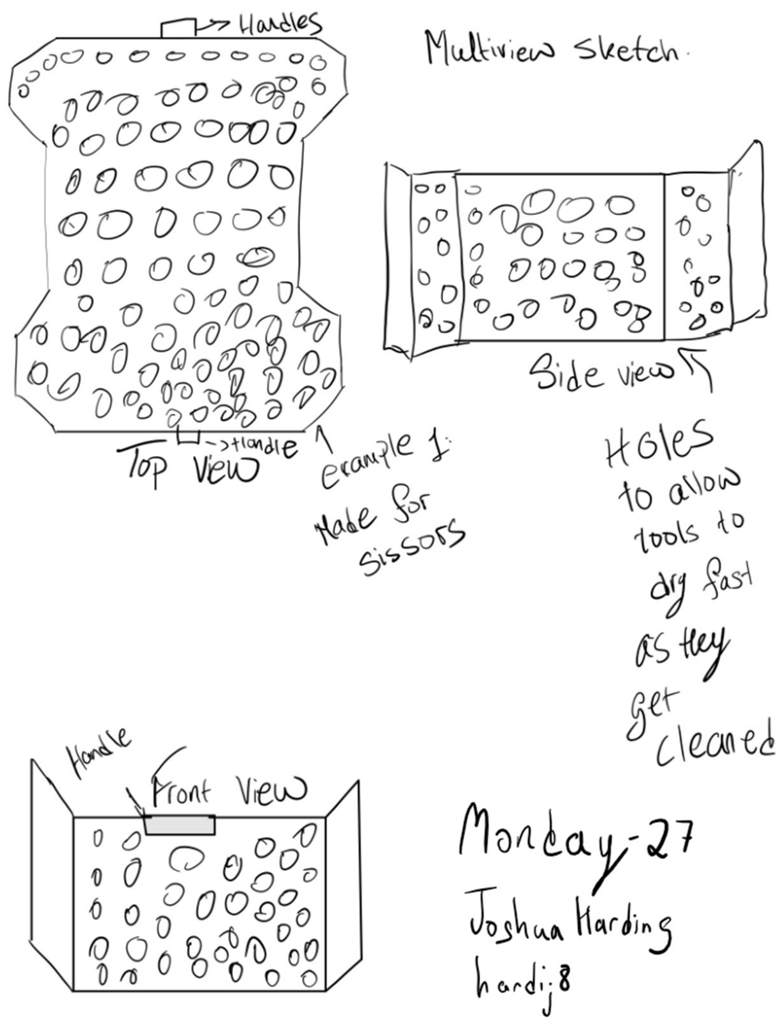
Team ID: Mon-27

Name: Joshua Harding	MacID: hardij8
Insert screenshot(s) of your preliminary sketch below	



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MILESTONE 1 (STAGE 3) – COMPUTER PROGRAM PSEUDOCODE (COMPUTATION SUB-TEAM)

Team ID:

Name:	MacID:
Write your pseudocode in the space below	

MILESTONE TWO (INDIVIDUAL): SUBTEAMS, SKETCHES, & WORKFLOW

MILESTONE 2 (STAGE 1) – LOW-FIDELITY PROTOTYPE (MODELLING SUB-TEAM)

Team ID: Mon-27

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Team ID: Mon-27

Name: Joshua Harding	MacID: hardij8
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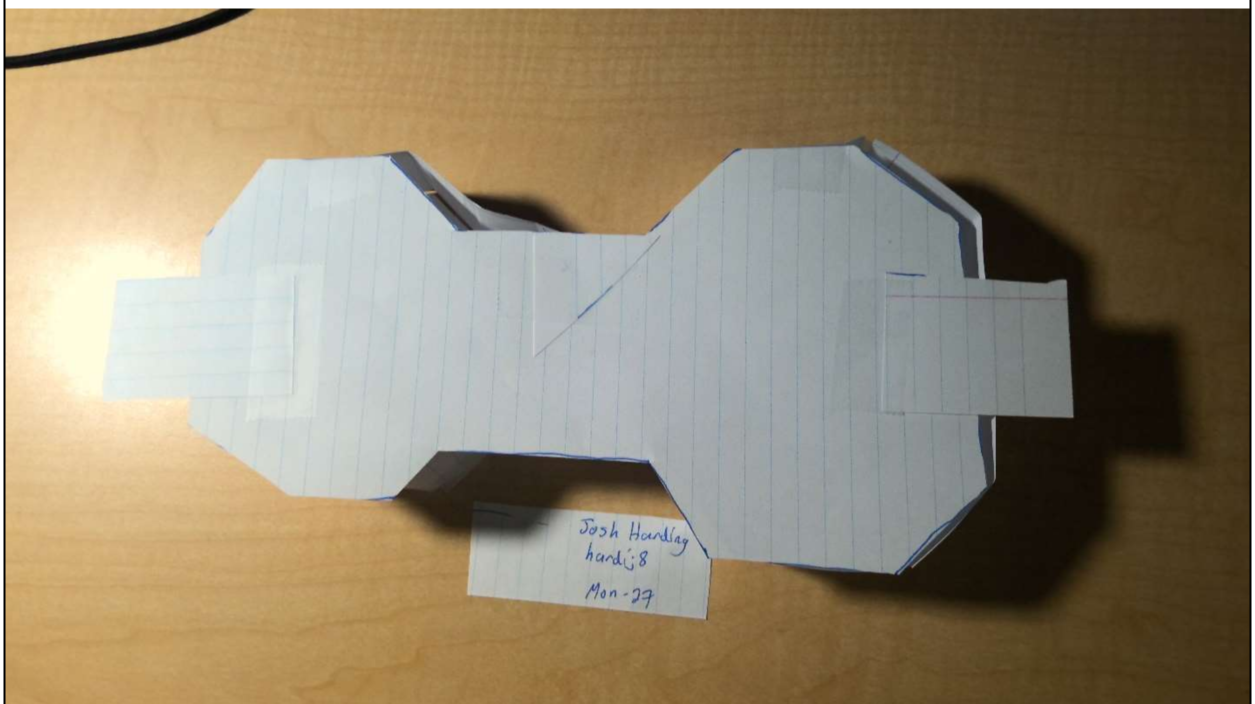
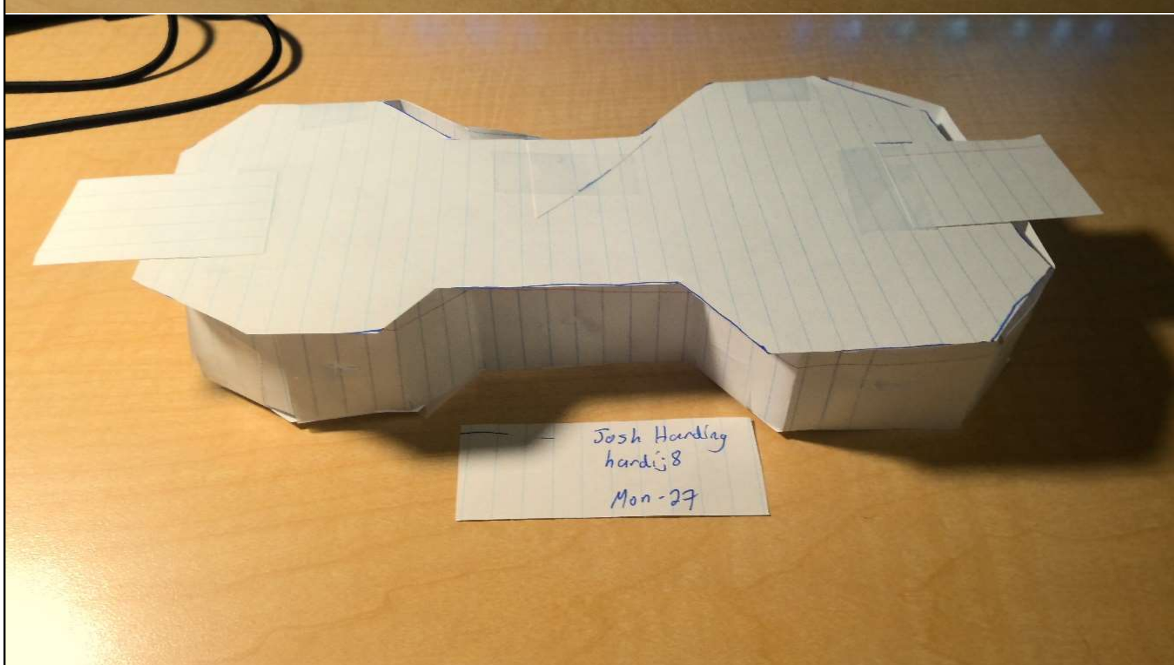
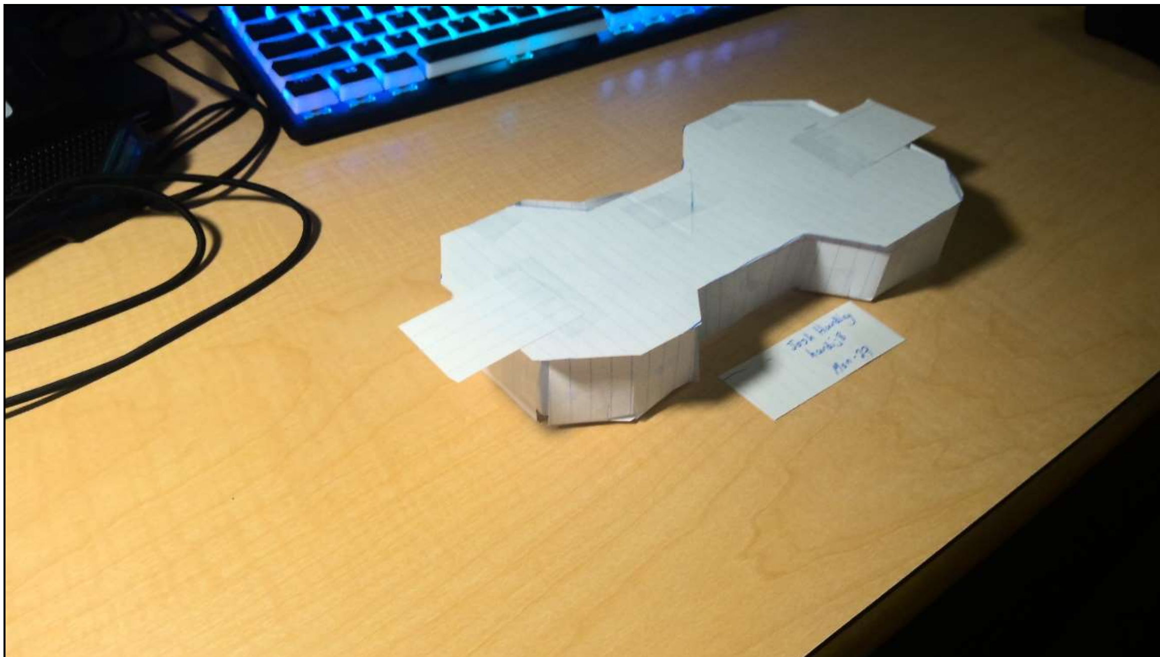
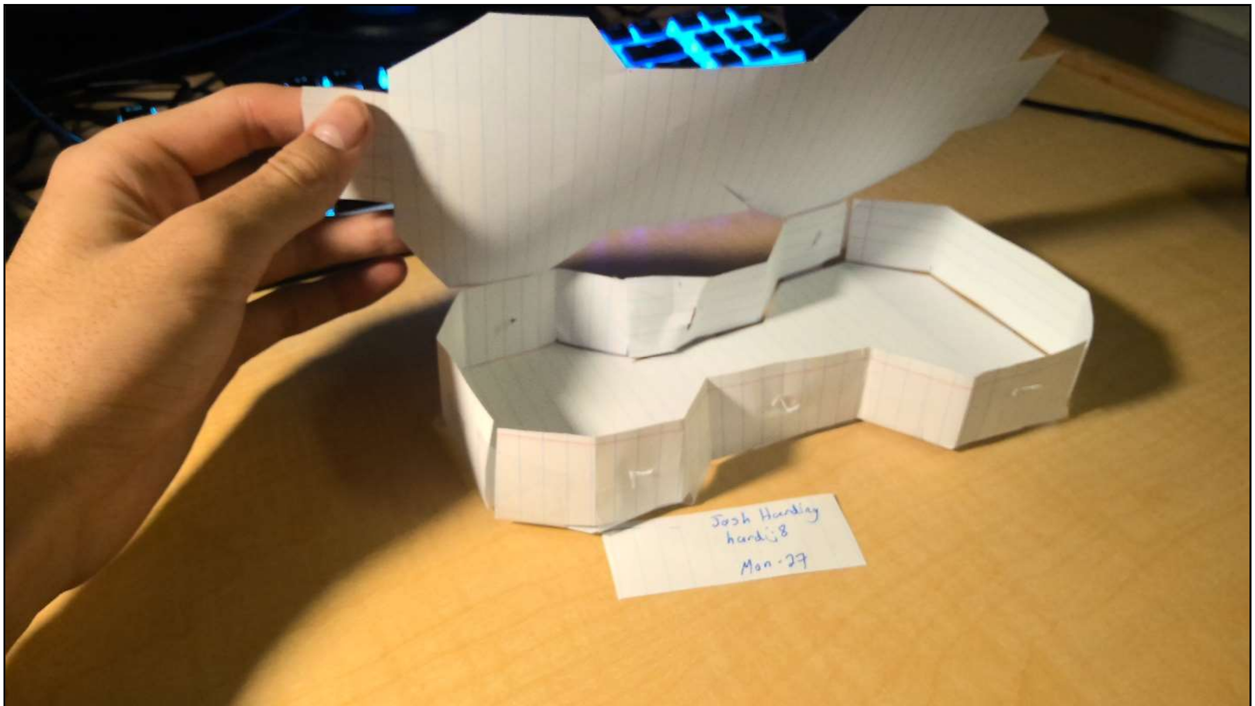






Handles on the sides

Holes on the side faces for autoclave cleaning



Openable top face to expose the tool for cleaning

MILESTONE 2 (STAGE 1) – COMPUTER PROGRAM WORKFLOW (COMPUTATION SUB-TEAM)

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MILESTONE 2 (STAGE 2) – COMPUTER PROGRAM PSEUDOCODE COMPILATION & OBSERVATIONS (COMPUTATION SUB-TEAM)

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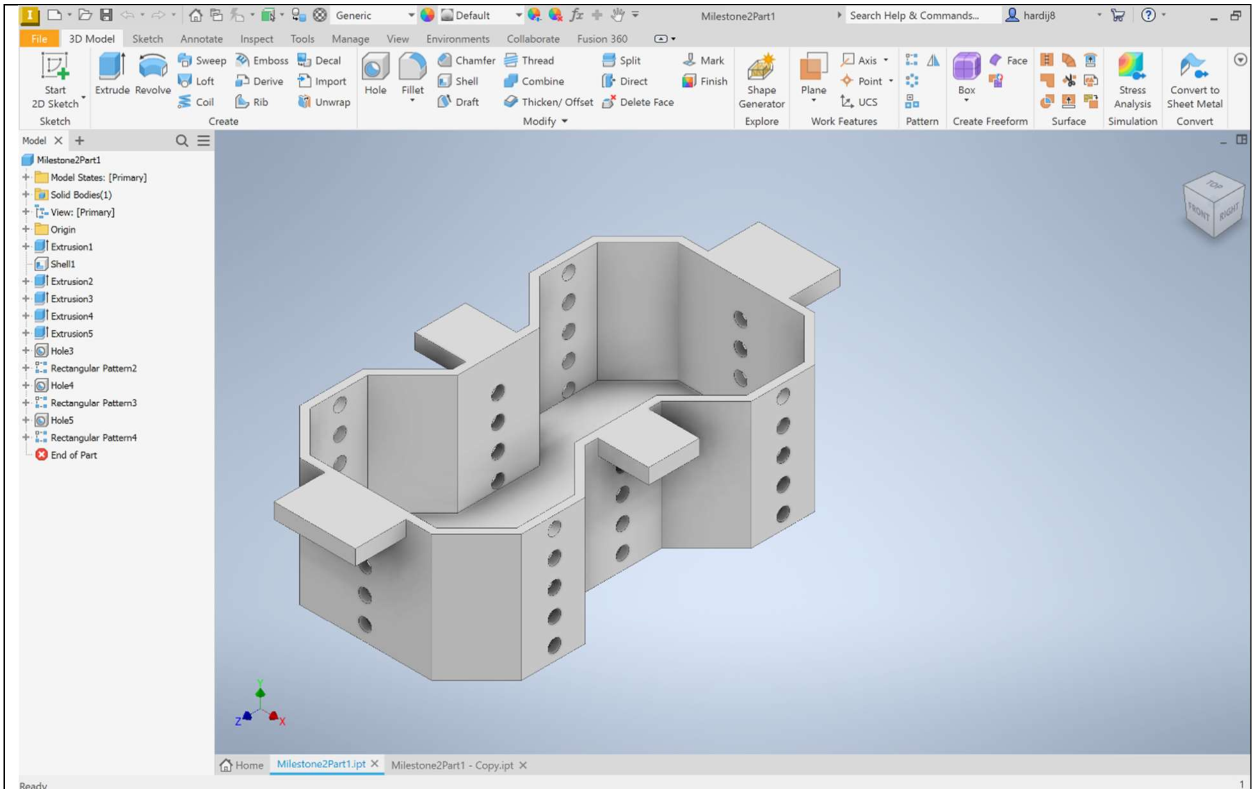
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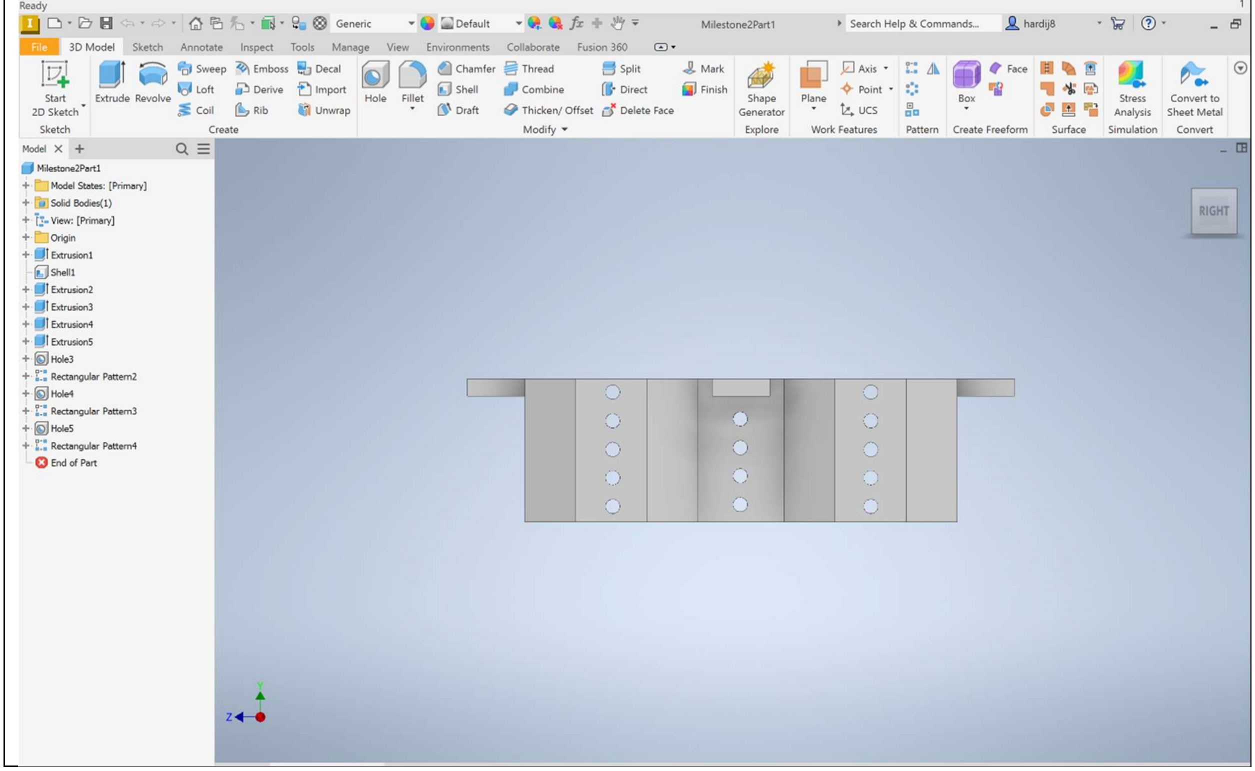
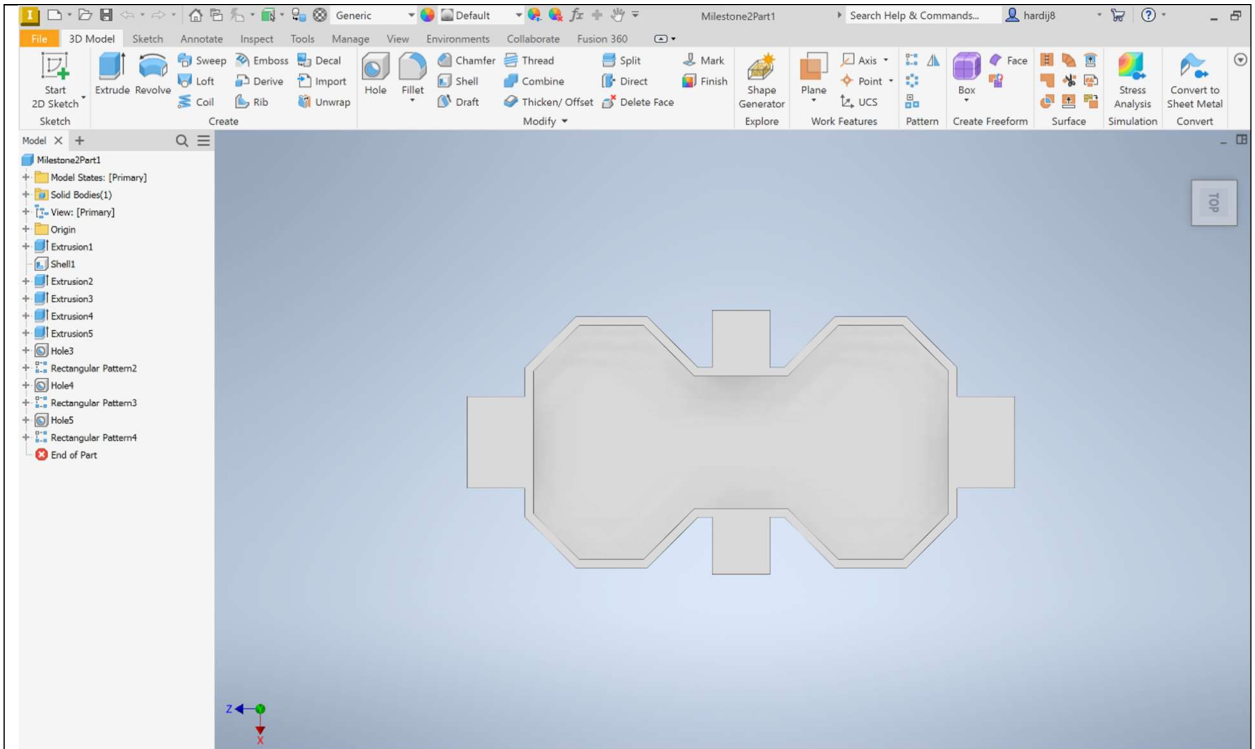
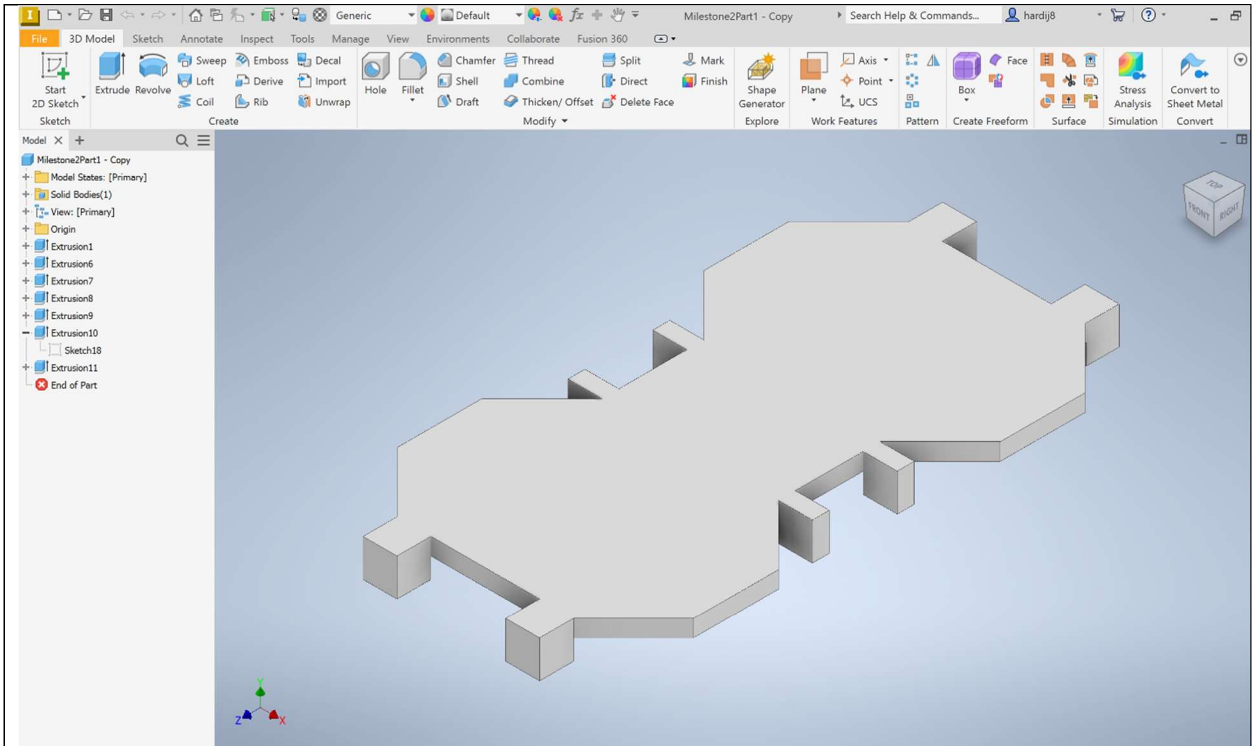
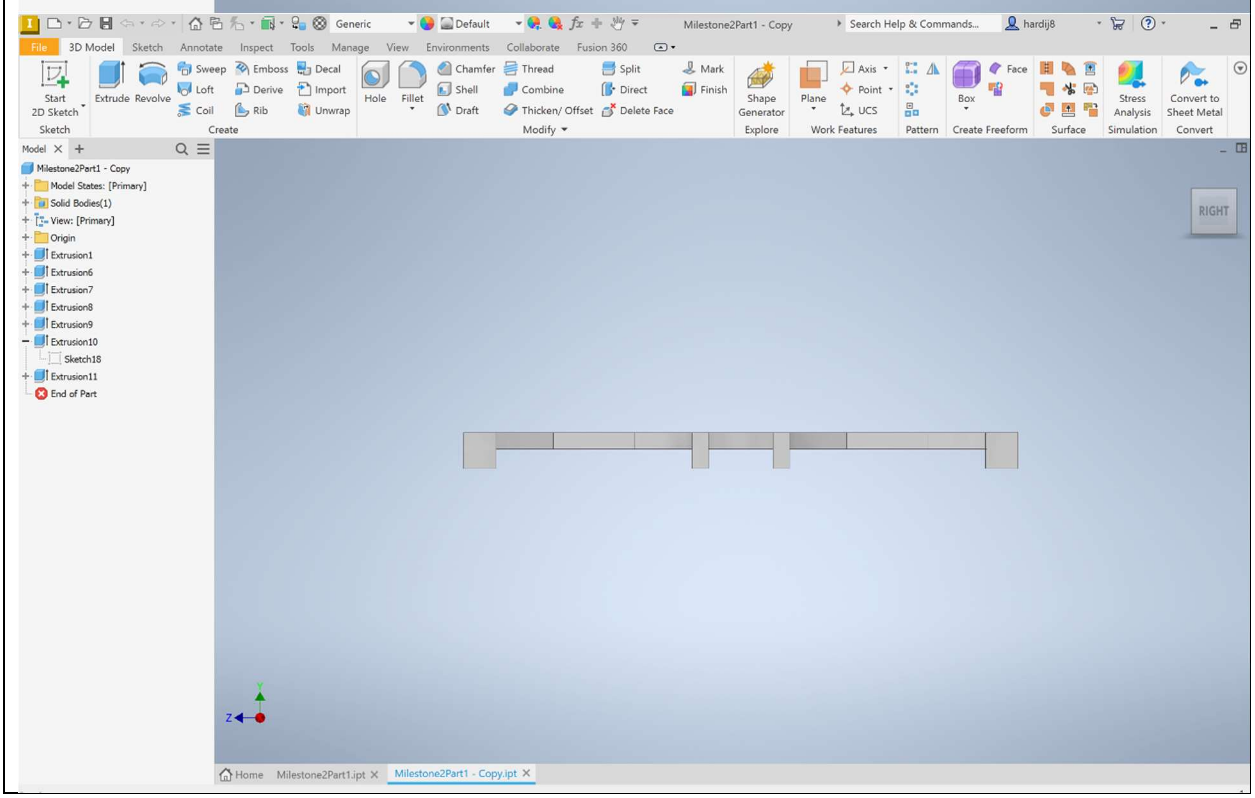
Model States: [Primary]
Solid Bodies(1)
View: [Primary]
Origin
Extrusion1
Shell1
Extrusion2
Extrusion3
Extrusion4
Extrusion5
Hole3
Rectangular Pattern2
Hole4
Rectangular Pattern3
Hole5
Rectangular Pattern4
End of Part
Home
Milestone2Part1.ipt
Milestone2Part1 - Copy.ipt
Ready


Milestone2Part1
Model States: [Primary]
Solid Bodies(1)
View: [Primary]
Origin
Extrusion1
Shell1
Extrusion2
Extrusion3
Extrusion4
Extrusion5
Hole3
Rectangular Pattern2
Hole4
Rectangular Pattern3
Hole5
Rectangular Pattern4
End of Part
RIGHT



Container Model


Milestone2Part1 - Copy
Search Help & Commands...
File
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Fusion 360
Start 2D Sketch
Extrude
Revolve
Sweep
Emboss
Decal
Loft
Derive
Import
Coil
Rib
Unwrap
Hole
Fillet
Chamfer
Thread
Shell
Combine
Draft
Thicken/ Offset
Split
Direct
Delete Face
Mark
Finish
Shape Generator
Plane
Axis
Point
UCS
Box
Face
Stress Analysis
Convert to Sheet Metal
Sketch
Create
Modify
Explore
Work Features
Pattern
Create Freeform
Surface
Simulation
Convert
Model
Milestone2Part1 - Copy
Model States: [Primary]
Solid Bodies(1)
View: [Primary]
Origin
Extrusion1
Extrusion6
Extrusion7
Extrusion8
Extrusion9
Extrusion10
Sketch18
Extrusion11
End of Part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Extrusion1
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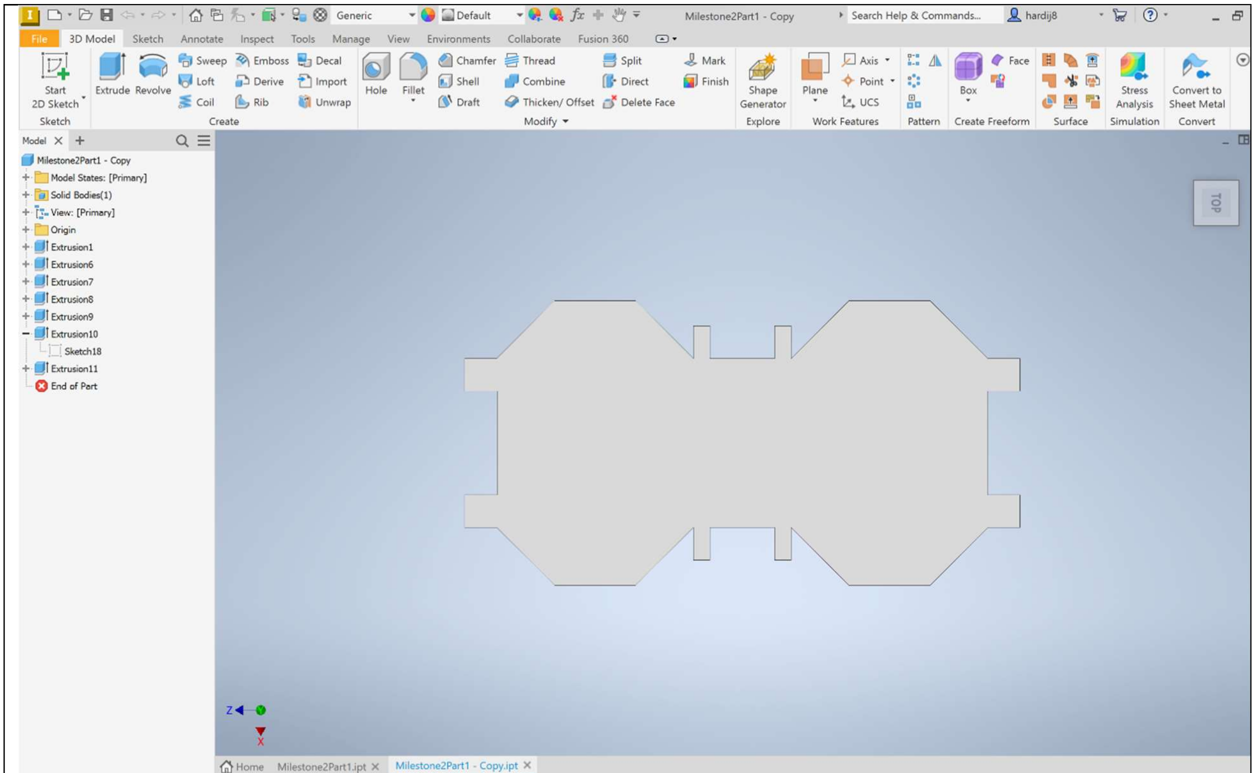


Lid Model

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

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

Team ID:

Complete this worksheet individually <u>during</u> Design Studio 8.

1. Take multiple screenshots of your code
   → You are also required to submit a Python (*.PY) file of your code (see Submission Details section above)
   → Be sure to label your tasks with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **<u>Do not include more than *one* screenshot per page</u>**

Team ID:

Name:	MacID
Insert screenshot(s) of your code below	

*Limit screenshots to no more than 1 per page. For additional screenshots, please copy and paste the above on a new page

MILESTONE THREE (INDIVIDUAL): PRELIMINARY MODEL & CODE

MILESTONE 3 (STAGE 1) – INITIAL DESIGN OF FINALIZED STERILIZATION CONTAINER (MODELING SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 1) – PROGRAM TASK PSEUDOCODE (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 2) – STERLIZATION CONTAINER DESIGN EVALUATION (MODELING SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 2) – CODE PEER REVIEW (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

INDEPENDENT MATERIALS RESEARCH ASSIGNMENT

MATERIAL SELECTION (STAGE 1) - PROBLEM DEFINITION

Use the following information to help you in your assignment:

- Function: The containers must securely contain a surgical tool during the tool's sterilization period.
- Fixed Variable: Radius, melting temperature (100^{O}C, steam)
- Free Variable: Wall thickness
- Objective: Must minimize cost and mass (material density and CAD)

Use the following MPI's to select your final material:

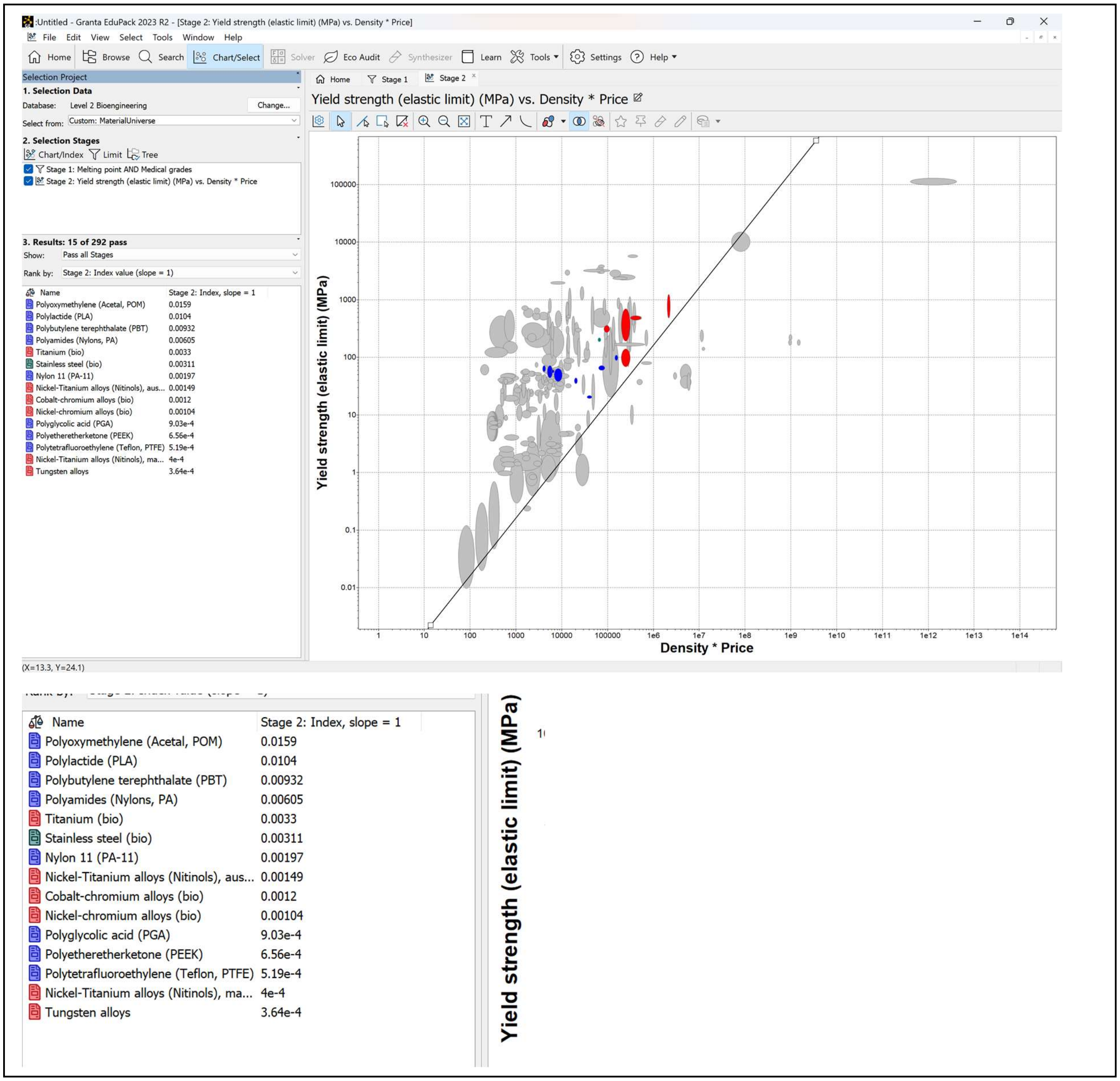
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Strength Design	Yield Strength vs Density Cost	Minimize cost and Mass
I chose the strength design because an increased yield strength in the chosen material would allow for the container to have a higher pressure exerted on it before going into plastic deformation. The autoclave functions by applying high pressure, temperature, and moisture to the tool and container in order to achieve sterility. The container must be able to withstand this pressure without breaking, making yield strength one of the most important material properties to account for in the design.		

MATERIAL SELECTION (STAGE 2) - MPI AND MATERIAL RANKING

Include a screenshot of your GRANTA graph in the text box below. The following should be included and clearly visible in your graph:

- X and Y axis
- MPI slope
- Material titles



    - The materials that you may choose from are those that are able to be 3D-printed (i.e., materials such as ceramics and glasses should be excluded from your database)
- Material family bubbles

Material Ranking			
	Rank 1	Rank 2	Rank 3
Assigned MPI: Yield Strength vs Density*Cost	Polyoxymethylene	Polylactide	Polybutylene Terephthalate

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

Chosen Material:	Stainless Steel
Although not in the top 3 in the MPI, stainless steel is the optimal material as it performs well in various characteristics directly relating to autoclave use. Firstly, stainless steel is highly resistant to corrosion and has a high melting point [1]. As the autoclave used in the design project involves using moist heat to denature bacteria cells, a stainless-steel container can resist corrosion due to moisture and will not melt in the process, as its melting point ranges from 1370-2400C [2]. Additionally, stainless steel is very strong, performing well in the yield strength index, making it compatible with the high-pressure environment in the autoclave and able to better protect tools during transportation [2]. Finally, stainless steel is relatively cheap, costing roughly $8 CAD/kg [2]. As it exceeds design requirements in strength, corrosion-resistance, melting temperature, and cost, stainless steel is the ideal choice of material for the container.	
References (If any): *[1] "High-Temperature Characteristics of Stainless Steel." Nickel Development Institute. Accessed: Nov. 26, 2023. [Online]. Available: https://nickelinstitute.org/media/1699/high_temperaturecharacteristicsofstainlesssteel_9004_.pdf* *[2] "ANSYS-Grantaa EduPack Database." Ansys, 2023.*	

Project Two Worksheets (INDIVIDUAL)

TABLE OF CONTENTS

MILESTONE ONE (INDIVIDUAL): OBJECTIVES, MORPH CHART, & INITIAL DESIGN

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

Please complete this worksheet in your corresponding team document.

MILESTONE 1 (STAGE 2) – MORPHOLOGICAL ANALYSIS

Please complete this worksheet in your corresponding team document.

MILESTONE 1 (STAGE 3) – COMPUTER PROGRAM PSEUDOCODE (COMPUTATION SUB-TEAM)

Team ID: MON-27

Name: Gbinije Matthew	MacID: Gbinijo
Write your pseudocode in the space below	

MILESTONE TWO (INDIVIDUAL): SUBTEAMS, SKETCHES, & WORKFLOW

MILESTONE 2 (STAGE 1) – LOW-FIDELITY PROTOTYPE (MODELLING SUB-TEAM)

Team ID: MON-27

Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

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

Team ID: MON-27

Name: Gbinije Matthew	MacID: Gbinijo
Insert screenshot(s) of the low-fidelity prototype below	

MILESTONE 2 (STAGE 1) – COMPUTER PROGRAM WORKFLOW (COMPUTATION SUB-TEAM)

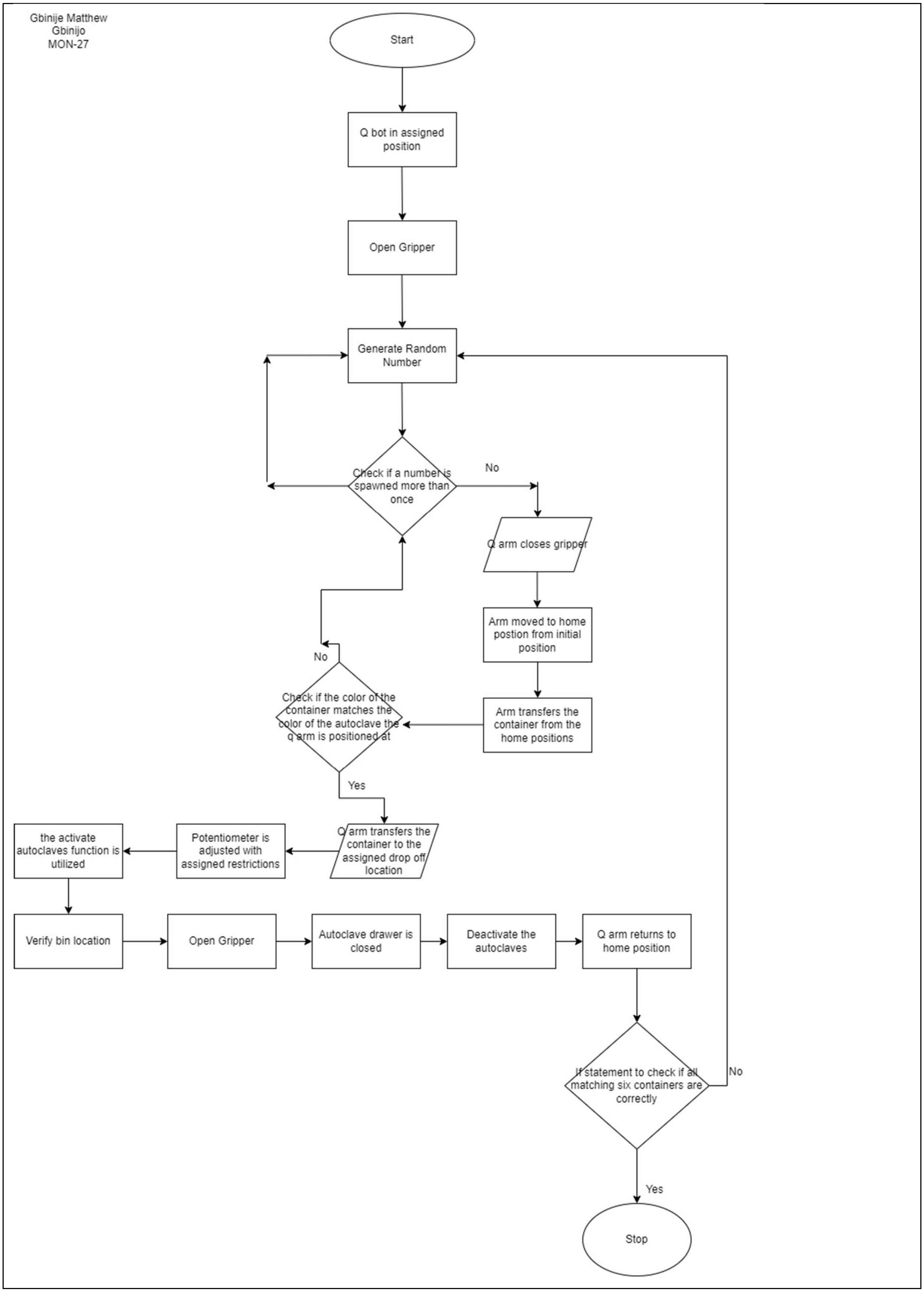
Team ID: MON-27

Complete this worksheet individually before coming to Design Studio 8.

1. Complete your storyboard or flowchart sketches on a separate sheet of paper
   → Be sure to clearly write your Team ID, Name and MacID on *each* workflow
2. Take a photo of your sketch
3. Insert your photo as a Picture (Insert > Picture > This Device)

Team ID: MON-27

Name: Gbinije Matthew	MacID: Gbinijo


Gbinije Matthew
Gbinijo
MON-27
Start
Q bot in assigned position
Open Gripper
Generate Random Number
Check if a number is spawned more than once
No
Q arm closes gripper
Arm moved to home postion from initial position
Arm transfers the container from the home positions
Check if the color of the container matches the color of the autoclave the q arm is positioned at
No
Yes
Q arm transfers the container to the assigned drop off location
Potentiometer is adjusted with assigned restrictions
the activate autoclaves function is utilized
Verify bin location
Open Gripper
Autoclave drawer is closed
Deactivate the autoclaves
Q arm returns to home position
If statement to check if all matching six containers are correctly
No
Yes
Stop

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

Please complete this worksheet in your corresponding team document.

MILESTONE 2 (STAGE 2) – COMPUTER PROGRAM PSEUDOCODE COMPILATION & OBSERVATIONS (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 2 (STAGE 3) – PRELIMINARY SOLID MODEL (MODELLING SUB-TEAM)

Team ID: MON-27

Complete this worksheet individually during Design Studio 8.

1. Take multiple screenshots of your preliminary solid model
   → You are also required to submit an IPT file of each solid model (see Submission Details section above)
   → Be sure to label model with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* solid modelling screenshots per page**

Team ID: MON-27

Name: Gbinije Matthew	MacID: Gbinijo
Insert screenshot(s) of your model below	

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

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

Team ID: MON-27

Complete this worksheet individually during Design Studio 8.

1. Take multiple screenshots of your code
   → You are also required to submit a Python (*.PY) file of your code (see Submission Details section above)
   → Be sure to label your tasks with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *one* screenshot per page**

Team ID: MON-27

Name:	MacID

Insert screenshot(s) of your code below

```
ip_address = 'localhost' # Enter your IP Address here
project_identifier = 'P2B' # Enter the project identifier i.e. P2A or P2B
#--------------------------------------------------------------------------------
import sys
sys.path.append('../')
from Common.simulation_project_library import *

hardware = False
QLabs = configure_environment(project_identifier, ip_address, hardware).QLabs
arm = qarm(project_identifier,ip_address,QLabs,hardware)
potentiometer = potentiometer_interface()
#--------------------------------------------------------------------------------
# STUDENT CODE BEGINS
#---------------------------------------------------------------------------------
def drop_off_containter():
    small_container_position = [0.0,0.0,0.0]
    large_container_position = [1.0,1.0,1.0]
    potentiometer_value = inputted_value * 360
    if potentiometer.left() < 180:
        drop_off_position = small_container_positon
        arm.control_gripper(45)
    elif potentiometer.left () > 180 and potentiometer.left () < 360:
        drop_off_position = large_container_positon
        arm.control_gripper(45)


def main ():
    drop_off_container()
    armm.home

#Gbinijo
#Gbinije Matthew



#---------------------------------------------------------------------------------
# STUDENT CODE ENDS
#---------------------------------------------------------------------------------
```

*Limit screenshots to no more than 1 per page. For additional screenshots, please copy and paste the above on a new page

MILESTONE THREE (INDIVIDUAL): PRELIMINARY MODEL & CODE

MILESTONE 3 (STAGE 1) – INITIAL DESIGN OF FINALIZED STERILIZATION CONTAINER (MODELING SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 1) – PROGRAM TASK PSEUDOCODE (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 2) – STERLIZATION CONTAINER DESIGN EVALUATION (MODELING SUB-TEAM)

Please complete this worksheet in your corresponding team document.

MILESTONE 3 (STAGE 2) – CODE PEER REVIEW (COMPUTATION SUB-TEAM)

Please complete this worksheet in your corresponding team document.

INDEPENDENT MATERIALS RESEARCH ASSIGNMENT

MATERIAL SELECTION (STAGE 1) - PROBLEM DEFINITION

Use the following information to help you in your assignment:

- Function: The containers must securely contain a surgical tool during the tool's sterilization period.
- Fixed Variable: Radius, melting temperature (100^{O}C, steam)
- Free Variable: Wall thickness
- Objective: Must minimize cost and mass (material density and CAD)

Use the following MPI's to select your final material:

- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Stiffness Design	E/pCm	Minimize cost, mass and stiffness

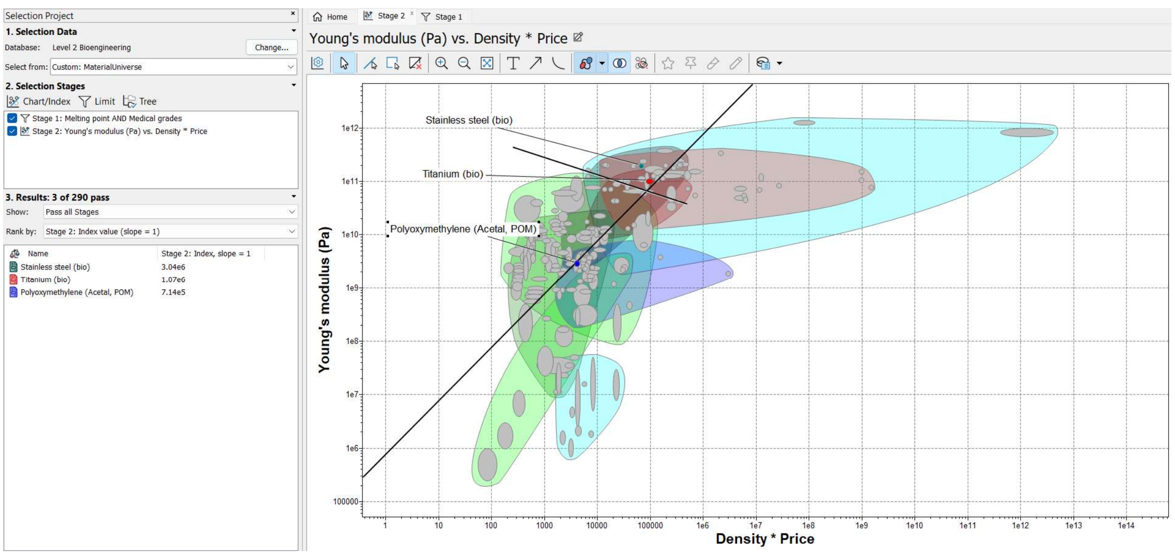
Please provide a short justification for your chosen design and MPI.

I chose stiffness design because the material needs to be as stable as possible and durable for it to be used multiple times. Stiffness is also a good priority for tools that will be used for medical grade as it will have longevity and won't change shape while being highly pressurized causing the materials inside to get damaged or things of that nature. Overall, it will also be able to withstand the changes and not deform the box nor the material. Additionally, stiffness will be young's modulus over density multiplied by price. This will allow us to see the most profitable and efficient material possible.

MATERIAL SELECTION (STAGE 2) - MPI AND MATERIAL RANKING

Include a screenshot of your GRANTA graph in the text box below. The following should be included and clearly visible in your graph:

- X and Y axis
- MPI slope
- Material titles
    - The materials that you may choose from are those that are able to be 3D-printed (i.e., materials such as ceramics and glasses should be excluded from your database)
- Material family bubbles



Material Ranking			
	Rank 1	Rank 2	Rank 3
Assigned MPI:	Stainless steel (bio)	Titanium (bio)	Polyoxymethylene (Acetal, POM)

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

Chosen Material:	Polyoxymethylene
Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations). I chose Polyoxymethylene (POM) because it has good mechanical properties based on its ranking on the MPI scale [1]. It has low friction and is extremely stable. It is incredibly durable and has strength as its density ranges from 1.410-1420 g/cm^3 [2]. It is low friction which will help with the sliding when the steam is inserted or the pressure causing it to move. It also possesses incredible tensile strength which helps with deformation. In addition, it is resistant to many chemicals, alcohols and other organic compounds as well as being a good insulator [2]. Overall, for the reasons listed above I believe Polyoxymethylene is the best material to use.	
References (If any):	

[1] “Ansys Granta EduPack software, ANSYS, Inc, Cambridge, UK, 2023(www.ansys.com/materials)

[2] EuroPlas, “What is pom plastic? key properties, benefits & applications,” EuroPlas, https://europlas.com.vn/en-US/blog-1/what-is-pom-plastic-key-properties-benefits-applications (accessed Nov. 27, 2023).

MILESTONE 1 (STAGE 3) – COMPUTER PROGRAM PSEUDOCODE (COMPUTATION SUB-TEAM)

Team ID: Mon-27

Name: Farhan Sifar	MacID: sifarf

Write your pseudocode in the space below

```
Create list of 6 numbers
Q-arm starts at home position, (0,0,0).
Container spawns at pre-determined pick-up position (x,y,z)
    Select random number from a list of 6 numbers.
        Remove this number from the list once it is picked.
Move Q-arm to pre-determined pick up position (x,y,z)
 Q-arm closes grippers.
    Q-arm picks up containers.
Q-arm moves, transferring container from (x,y,z) to (0,0,0)
Q-arm moves, transferring container from (0,0,0) to autoclave (x,y) range
    rotation of Q-arm based on adjustment of right potentiometer.
    Verify that the Q-arm is positioned at the right autoclave.
        Match colour of autoclave with colour of container
Q-arm moves, transferring container to correct drop off position.
    Movement is based on adjustment of left potentiometer.
        Create threshold value 1 (position 1):
              if  50%<potentiometer reading<100%
                    Place container on top of autoclave
        Create threshold value 2 (position 2):
              if Potentiometer reading = 100%
                   Place container inside autoclave drawer
                       Activate autoclaves.
                       Open correct autoclave drawer
     Verify that size of container matches target placement.
          If size of container is small, place at position 1.
          If size of container is big, place at position 2.
Open Q-arm gripper, releasing container into drop off bin.
If container is large, correct autoclave drawer is closed.
Deactivate autoclaves for all containers
Q-arm moves back to (0,0,0)
```

Repeat until all 6 containers have been placed in correct autoclave bins and list = []

MILESTONE 2 (STAGE 1) – COMPUTER PROGRAM WORKFLOW (COMPUTATION SUB-TEAM)

Team ID:	Mon-27

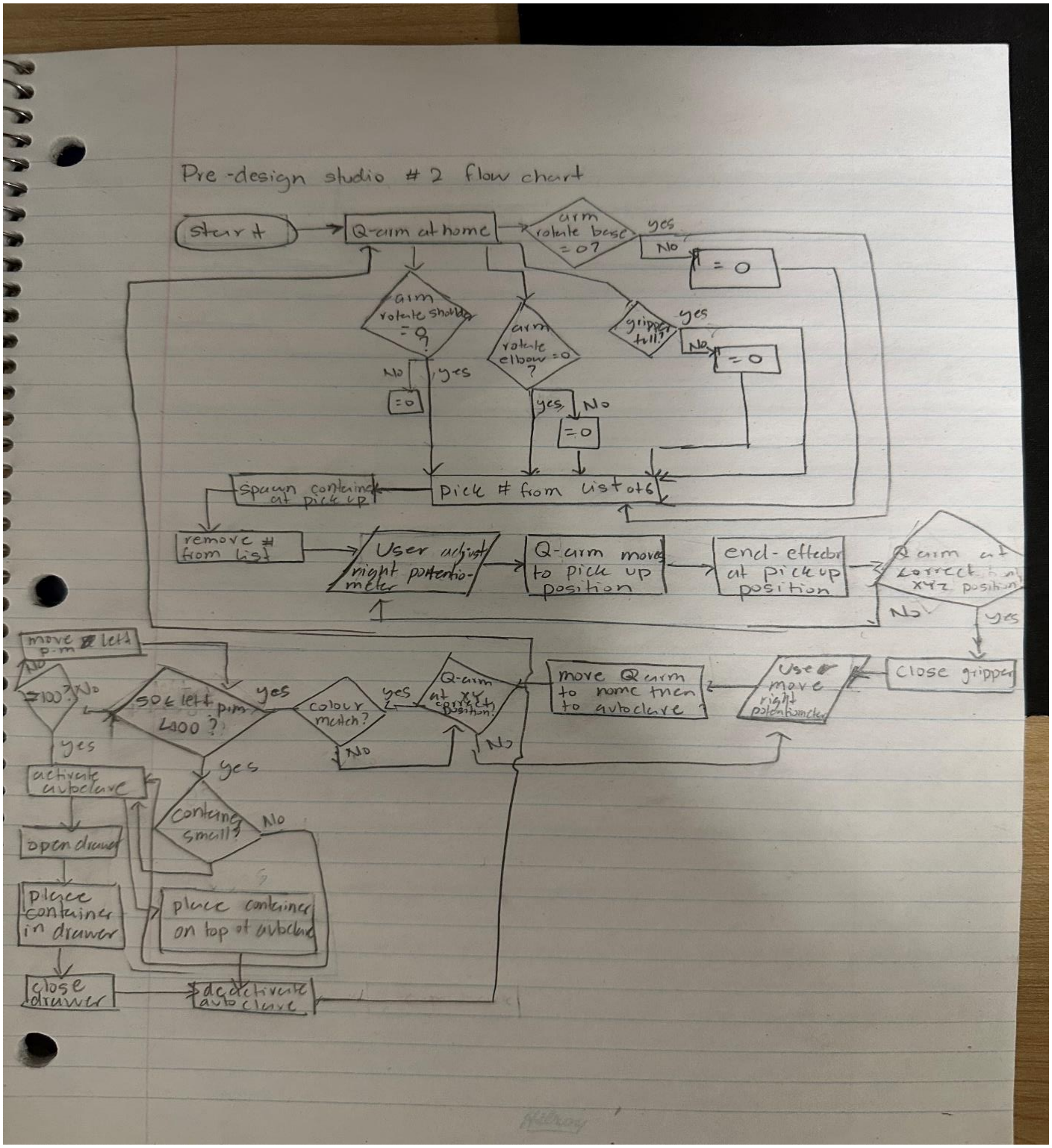
Complete this worksheet individually before coming to Design Studio 8.

1. Complete your storyboard or flowchart sketches on a separate sheet of paper
   → Be sure to clearly write your Team ID, Name and MacID on *each* workflow
2. Take a photo of your sketch
3. Insert your photo as a Picture (Insert > Picture > This Device)

Team ID: Mon-27

Name: Farhan Sifar	MacID: sifarf

Insert screenshot(s) of your workfow below



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

Team ID:	Mon-27

Complete this worksheet individually <u>during</u> Design Studio 8.

1. Take multiple screenshots of your code
   → You are also required to submit a Python (*.PY) file of your code (see Submission Details section above)
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2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **<u>Do not include more than *one* screenshot per page</u>**

Team ID: Mon-27

Name: Farhan Sifar	MacID: sifarf

Insert screenshot(s) of your code below

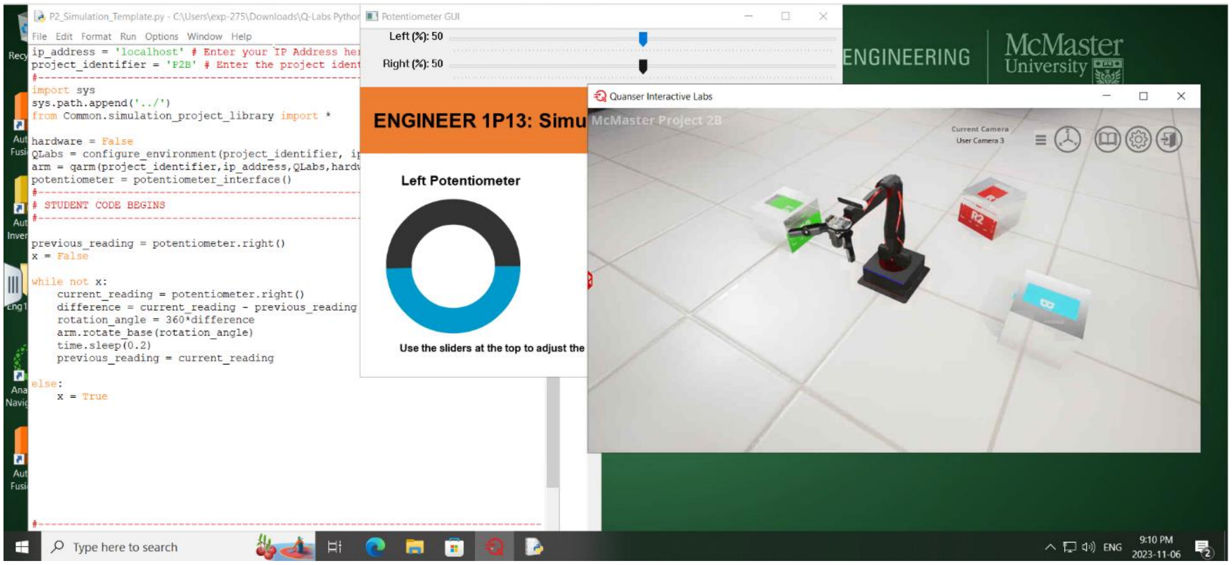
*P2_Simulation_Template.py - C:\Users\exp-275\Downloads\Q-Labs Python Files\Q-Labs Pyt...

File Edit Format Run Options Window Help

```
ip_address = 'localhost' # Enter your IP Address here
project_identifier = 'P2B' # Enter the project identifier i.e. P2A or P2B
#--------------------------------------------------------------------------------
import sys
sys.path.append('../')
from Common.simulation_project_library import *

hardware = False
QLabs = configure_environment(project_identifier, ip_address, hardware).QLabs
arm = qarm(project_identifier,ip_address,QLabs,hardware)
potentiometer = potentiometer_interface()
#--------------------------------------------------------------------------------
# STUDENT CODE BEGINS
#--------------------------------------------------------------------------------

previous_reading = potentiometer.right()
x = False

while not x:
    current_reading = potentiometer.right()
    difference = current_reading - previous_reading
    rotation_angle = 360*difference
    arm.rotate_base(rotation_angle)
    time.sleep(0.2)
    previous_reading = current_reading

else:
    x = True








#--------------------------------------------------------------------------------
```

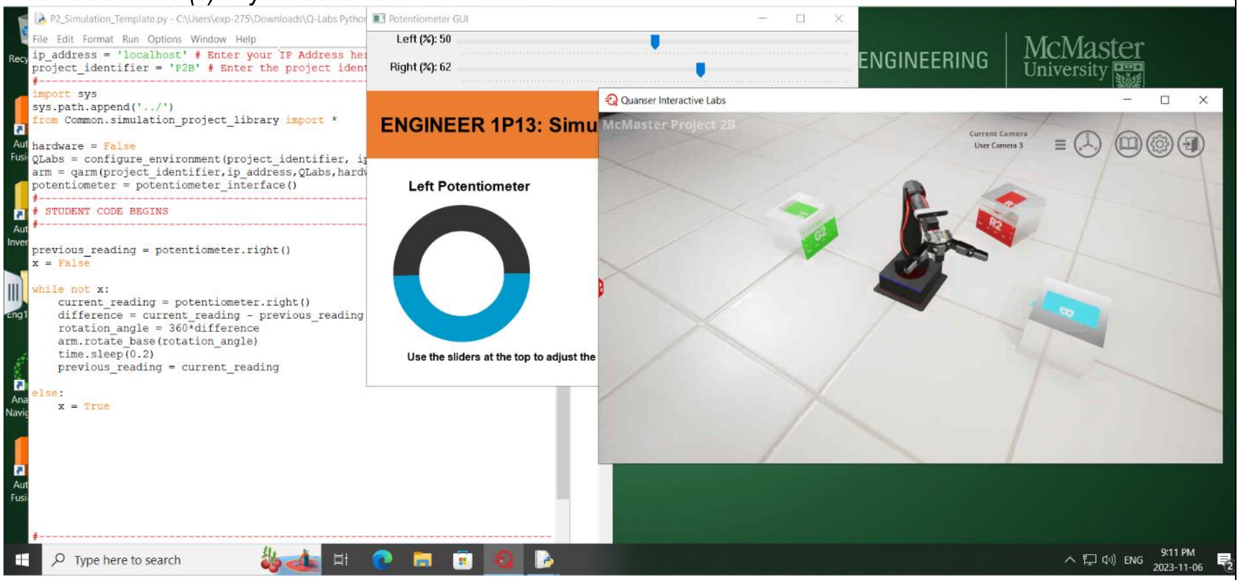
*Limit screenshots to no more than 1 per page. For additional screenshots, please copy and paste the above on a new page

Name: Farhan Sifar	MacID: sifarf
Insert screenshot(s) of your code below	

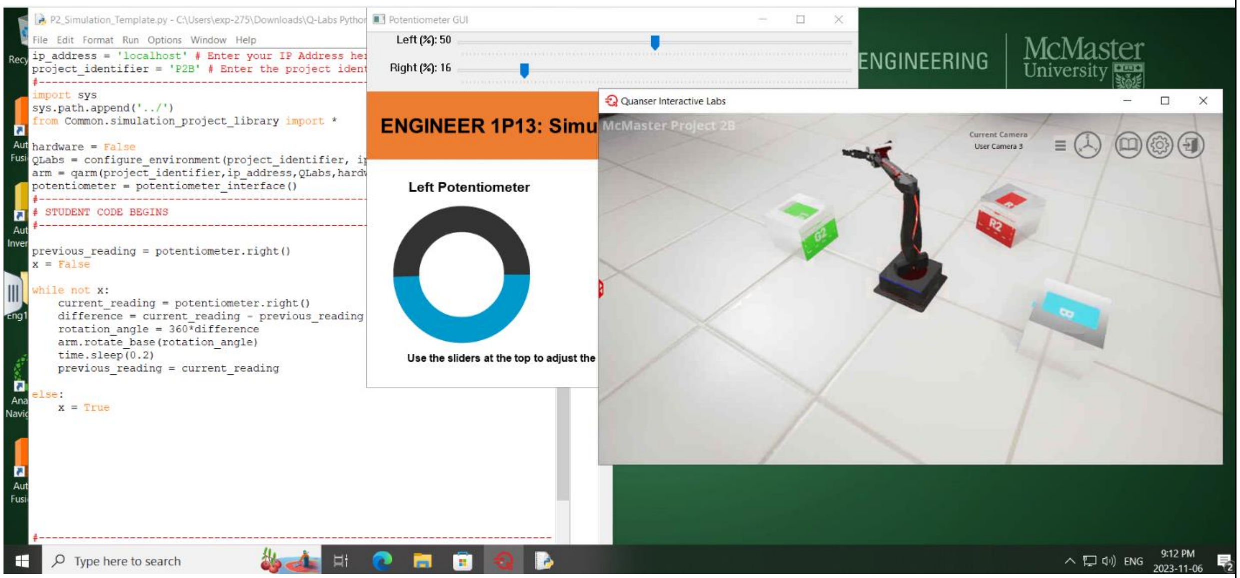


Name: Farhan Sifar	MacID: sifarf

Insert screenshot(s) of your code below



Name: Farhan Sifar	MacID: sifarf
Insert screenshot(s) of your code below	



INDEPENDENT MATERIALS RESEARCH ASSIGNMENT

MATERIAL SELECTION (STAGE 1) - PROBLEM DEFINITION

Use the following information to help you in your assignment:

- Function: The containers must securely contain a surgical tool during the tool's sterilization period.
- Fixed Variable: Radius, melting temperature (100^{O}C, steam)
- Free Variable: Wall thickness
- Objective: Must minimize cost and mass (material density and CAD)

Use the following MPI's to select your final material:

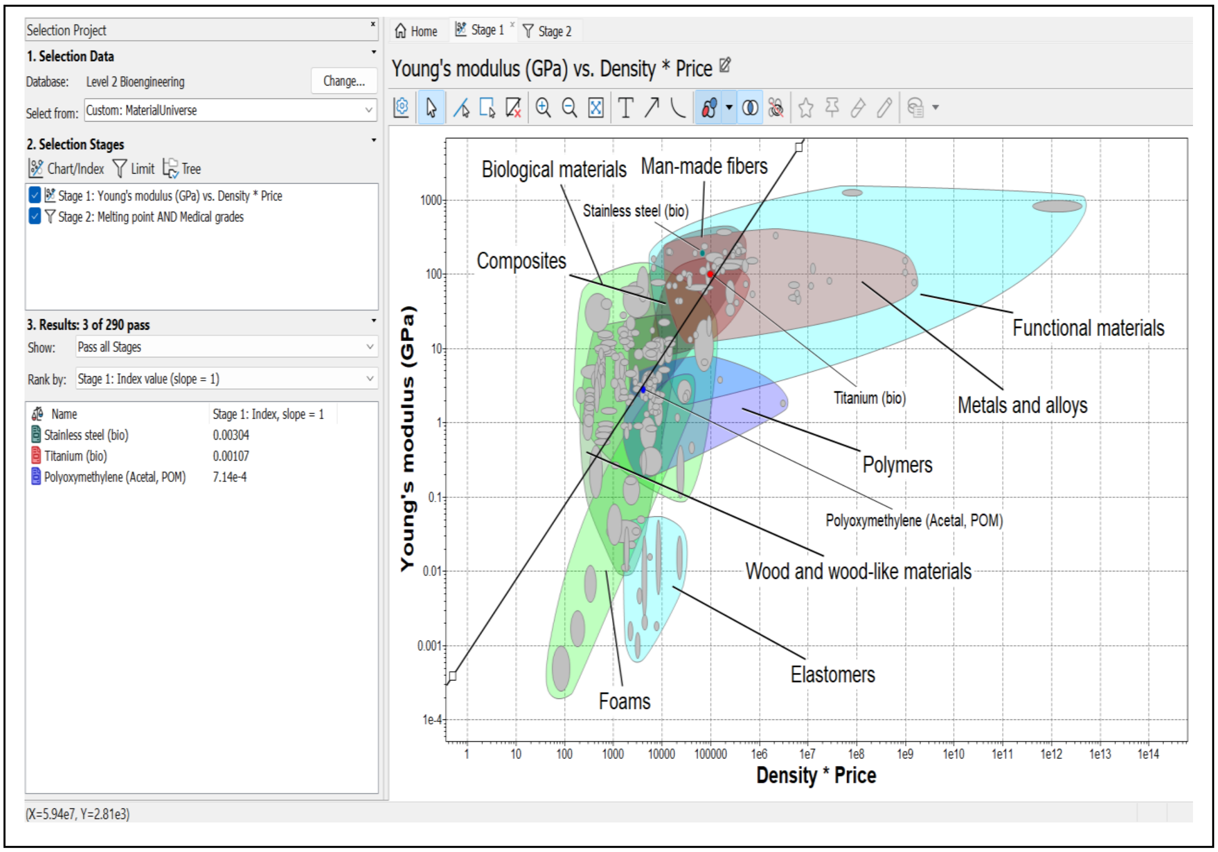
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Stiffness	$\frac{E}{\rho C_m}$	Minimize cost and mass of a container
Please provide a short justification for your chosen design and MPI. The stiffness of a material is often associated with its ability to retain its shape or come back to the original shape while under stress or pressure. It is a measure of a material's Young's modulus (E), which is represented as stress/strain. A high Youngs modulus shows a greater resistance to elastic deformation, meaning the shape will more easily return to its original shape if under pressure. In this specific scenario, the stiffness of the material for the container is crucial due to the high heat and pressure that the container will be subjected to inside the autoclave. As a result, a very stiff and rigid material, that can withstand the intense conditions inside the autoclave is desirable, especially for repeated uses. This would result in the medical tools inside the container staying secure and safe during the sterilization process without the container elastically deforming, changing its shape, which can lead to tools not fitting inside the container or the tools being damaged during sterilization. While strength is also a vital design aspect to consider while selecting a material, I believe stiffness should be prioritized due to the immense heat used inside the autoclave. This heat is likely to expand or contract the container, leading to a change in its shape. Thus, the container should be made from a stiffer material rather than one that is strong and is resistant to plastic deformation.		

MATERIAL SELECTION (STAGE 2) - MPI AND MATERIAL RANKING

Include a screenshot of your GRANTA graph in the text box below. The following should be included and clearly visible in your graph:

- X and Y axis
- MPI slope
- Material titles
  - The materials that you may choose from are those that are able to be 3D-printed (i.e., materials such as ceramics and glasses should be excluded from your database)
- Material family bubbles



Material Ranking			
	Rank 1	Rank 2	Rank 3
Assigned MPI: $\frac{E}{\rho C_m}$	Stainless steel (bio)	Titanium (bio)	Polyoxymethylene (Acetal, POM)

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

Chosen Material:	Stainless steel (bio)

Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations).

The chart indicates that stainless steel is the best material for the container. Stainless steel has an average Youngs modulus of 200 GPa, titanium has 102.5 GPa, and polyoxymethylene has 2.9 GPa. In terms of cost, stainless steel averages 8.3 CAD/kg, while titanium and polyoxymethylene averages 21.4 and 2.9 CAD/kg, respectively. Lastly, in terms of density, stainless steel averages 7.9e^3, titanium averages 4.51e^3, and polyoxymethylene averages 1.4e^3 kg/m^3, respectively [1]. From this data, stainless steel is the best material for the container because it has the best balance of high Young's modulus while having low density and cost relative to the other high-ranking materials. Furthermore, its resistance to corrosion is important because the container will encounter various corrosive materials in medical environments [2]. Finally, the use of stainless steel can save costs for manufacturers as it can be bent into various shapes [1] and has a long useful life [2].

References (If any):

[1] Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023 (www.ansys.com/materials)

[2] M. Steel, "Improving Autoclave Medical Sterilization Methods with Stainless Steel." Accessed: Nov. 27, 2023. [Online]. Available: https://www.marlinwire.com/blog/improving-autoclave-medical-sterilization-methods-with-stainless-steel