Design Project 2 – Get a Grip

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial 07

Team Thurs-14

Lucas Gilpin (gilpil2)

Evan Chadwick (chadwe1)

Evan Hong (honge14)

Yahya Zaher (zahery)

Submitted: December 6, 2023

Course Instructors: Dr. McDonald, Dr. Doyle, Dr. Ebrahimi, Dr. Fleisig, Dr. Hassan, Dr. Zurob

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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.

Lucas Gilpin 400540094

Lucas Gilpin

(Student Signature) *

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.

Evan Chadwick 400519884

Evan Chadwick

(Student Signature) *

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.

Evan Hong 400511264

Evan Hong

(Student Signature) *

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.

Yahya Zaher

Yahya Zaher

(Student Signature) *

Executive Summary

Artemis II will be the first crewed mission to the moon since the Apollo mission in 1972. In November 2024, Artemis II will perform a lunar flyby, featuring Canadian astronaut Jeremy Hansen from the Canadian Space Agency. The broader Artemis Program will aim to return humans to the moon's surface and establish a lunar base. Additionally, the Lunar Gateway Program will plan to set up the first human outpost in lunar orbit, laying the groundwork for future missions to Mars.

In Project Two, our aim was to enhance surgical accessibility for people in distant locations, inspired by the challenges of traveling long distances for surgery. Our primary task was to create a system for securely holding and moving surgical tools, improving healthcare in remote areas.The project involved two main components: designing a container for tools and developing code to control a robot arm for easy container movement. Success in the design phase meant meeting specific criteria, such as a container under 350 grams, dimensions exceeding 4 mm, and seamless fit within a designated space. The design, with a round shape, slots, a reliable grip system, and stable ends, offered versatility for moving sterile tools. In the computer aspect, we devised a plan for tasks like guiding the robot's movements. The plan performed well in tests, demonstrating the potential of robots to assist with healthcare in various locations.

Completing both the container and code validated the effectiveness of our project's approach. Our cohesive team, supported by productive discussions and clear instructions, overcame challenges through effective communication. While the system required further research, Project Two addressed real-world healthcare issues by integrating design, computer programming, and system integration, with a focus on practical viability in diverse locations.

List of Objectives, Constraints, and Functions

Objectives	Constraints	Functions
Ensure smooth and precise arm movement	Container must fit snugly within the designated space	Securely grasp the container
Minimize any tool movement within the box	Mass of the container should not exceed 350g	Move the container with precision and stability
Facilitate easy and secure gripping by the arm	All measurements must be greater than 2 mm	Place the container accurately in the autoclave
Identify the container by color and size	Container is lightweight	Efficiently sterilize the surgical tool
	Must fit securely within the robot gripper	Ensure minimal tool disturbance within the box
		Facilitate easy identification by color and size

Main Body

Summary of Contributions

Evan Chadwick	- Simulated and developed the program code, fleshing out all the main program functions. (drop off, pick up, transfer etc.) - Came prepared and lead the team in the q arm challenge - Collaborated with the modelling team to suggest ideas for the solid model
Yahya Zaher	- Created a rough outline for the how the drop off function would execute - Added clear and concise comments to the program code where required - Collaborated with the modelling team to suggest ideas for the solid model
Lucas Gilpin	- Gave constructive feedback to group members when discussing possible features to add to the design.

	- Increased sterilization efficiency as well as minimized weight of the container with rectangular holes covering each side of the container. - Modelled the prototype container design with Autodesk inventor to have a solid foundation for the modelling sub team to build off.
Evan Hong	- Helped designing and modeling the initial model prototypes. - Modeled the final design of the container. - Created many features found in the final design (lip edges, extrusions inside container, bars going through the top). - Computed g-code and oversaw 3d printing.

Background and Research Summary

The problem being addressed in this project is creating methods of remote operation of electronic robotic devices for spaceships that do not have a working crew. A spaceships crew's health is of utmost importance and the support of a remote crew that controls robotic tools could be quite useful in performing effective surgeries.

There is existing technology that proves the effectiveness of this premise on earth already. For example, in 2001, laparoscopic cholecystectomy was remotely performed 14000 kilometers away with a latency of 155 milliseconds [1]. Since 2001, technology has only gotten better and more responsive which proves the viability of telesurgery for small distances.

However, it's also important to consider current cutting-edge technology which can be learned from. For example, Virtual Incision, a medical technology company, plans to send a small robotic surgery platform that can perform a variety of key functions in surgeries [2]. The key innovative aspect of the technology is its weight, a miniscule two pounds. Due to the exorbitant costs associated with transporting a lot of mass into space it is essential that the container is designed to be as light weight as possible. Another interesting aspect of this technology is the fact that its fully automated. The distance between even the ISS and the people on earth is so long that designing fully automated systems may prove to be simpler than operating with excessive latency.

This proposes a few essential design considerations for the entire project, the modularity of the code and reliability and weight of the solid model. Firstly, the code for the project should be built in such a way that it is easy to reuse for a possible fully automated project. Similarly, the solid model should be lightweight as to not cost extra and durable as to ensure consistent transfer of the container.

Description of Proposed Solution

The proposed solution of the overall pick-up and transfer process included a container with multiple specifically selected features, and an efficient code to run the arm [3]. For the design of the container, a lip around the edge of the container was added [4]. This was done to ensure that the container had a safety mechanism in the event that it began to slip from the Q-Arm's grasp. Furthermore, the design of the container was intended to match the shape of the claw to maximize the Q-Arms grip [4]. Square holes were added throughout the bottom of the container as well as rectangular openings along the sides to allow for steam to penetrate the container and sterilize the tool. Four smaller holes facing each other were added on the sides of the box, where two separately printed sticks would be inserted after the tool to ensure it would not fall out in the case that the container was turned upside down. Three pegs were added in the bottom of the box to keep the tool from sliding around after it is placed in. They were arranged to fit the shape of the handle of the tool to lock it in place.

The simulation code is modularly broken into 7 functions: pick up, drop off, transfer, create containers, check if containers is large, print instructions, and main. The main runs immediately after the code is ran and calls the print instructions function to inform the user of how the program is interacted with. Then it calls the create container's function which creates a randomized list of every number between 1 and 6, each number corresponding to one container. Then for every container, using a for loop, the main spawns a container that hasn't been spawned yet and proceeds with the movement of the block. The pick up function is called, and the arm grasps the container and moves back to the home position. Then the transfer function is called and provides constant rotation with the right potentiometer when the user has the left potentiometer set to 0. Once the user is in front of the autoclave and the potentiometer is set to 1 then the drop off function is called. Using the list created from the create container's function, the check if container is large function is called and determines if the container is large or small and using that information the arm drop off movements are made accordingly, in or on top of the autoclave. Finally, the user is prompted to change the left potentiometer value off 1, so the program does not think that the arm is still dropping off and then promptly returns to home to redo the entire process again for the next block.

Strengths and Limitations of Design

The team's proposed container was carefully designed to meet the projects expectations in terms of constraints and objectives [5]. Much consideration of the design went into how the tool would be sterilized and secured effectively. For example, the container is comprised of multiple rectangular (sides) and squares (floor) holes to allow the steam to access each side of the tool [4]. This also ensured that the containers weight was well under the maximum allowed. Furthermore, the final design of the container didn't have a lid, but rather two extrusions were used to secure the tool in case the container was to be inverted [4]. This also further reduced the weight of the design substantially. In order to prevent horizontal movement of the tool in the container itself, small square based extrusions were added near the base of the handle [4]. In addition, the container was designed to fit the claw of the Q-Arm effectively by having one end of the container be the same shape as the Q-Arm as if it were to be closed [4]. Small lips were added to the sides of the container to prevent it from slipping in the grip of the Q-Arm [4]. In the future, the design should have a lip around the entirety of the container rather than just one side to make it more accessible to the Q-Arm. The extrusions securing the tool should also be modified in a way that would make it easier to remove and insert for the user. As of right now, the extrusions remain flush with the container making it a difficult process. Additionally, the container should be shortened since the extra height is simply not needed, this would allow even more weight to be eliminated. In conclusion, the proposed design easily meets the objectives and constraints outlined in the project module and is an ideal container for the given scenario based on the reasoning above.

Reference List

[1] N. Taylor, “Virtual Incision Opens New Frontier for Robotic Surgery with Space Station Mission,” MedTech Dive, Aug. 03, 2022. https://www.medtechdive.com/news/virtual-incision-robotic-surgery-space/628737/#:~:text=Virtual%20Incision%20is%20set%20to (accessed Dec. 05, 2023).

[2] J. Marescaux et al., “Transcontinental Robot-Assisted Remote Telesurgery: Feasibility and Potential Applications,” Annals of Surgery, vol. 235, no. 4, pp. 487–492, Apr. 2002, doi: https://doi.org/10.1097/00000658-200204000-00005.

[3] “P2 Project Module,” class notes for ENG 1P13, Department of engineering, McMaster University, Fall, 2023

[4] Autodesk® Inventor LT™ software, Autodesk, Inc, 2023 (www.autodesk.com)

[5] Ansys Granta EduPack software, Granta Design Limited, Cambridge, UK, 2023 (www.grantadesign.com)

Appendicies

Appendix A: Project Schedule

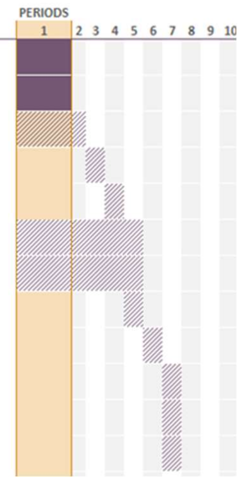
Preliminary Gantt Chart

Project Planner

Select a period to highlight at right. A legend describing the charting follows.

Period Highlight: 1 | Plan Duration | Ac

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	1	1	100%
Milestone 1	1	1	1	1	100%
Milestone 2	2	1	1	1	0%
Milestone 3	3	1	0	0	0%
Milestone 4	4	1	0	0	0%
Sterilization Container Design	1	5	0	0	0%
Computer Program	1	5	0	0	0%
P2 Q-Arm Challenge	5	1	0	0	0%
Research Summary	6	1	0	0	0%
Design Project Report	7	1	0	0	0%
Learning Portfolio	7	1	0	0	0%
Self- and Peer-Evaluation	7	1	0	0	0%



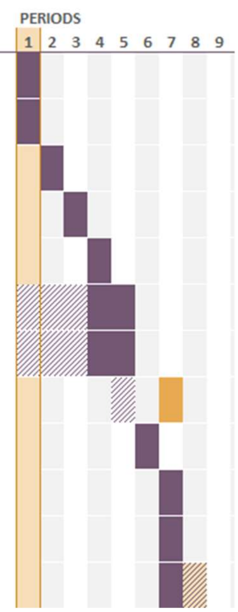
Final Gantt Chart

Project 2

Select a period to highlight at right. A legend describing the charting follows.

Period Highlight: 1 | Plan Duration

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	1	1	100%
Milestone 1	1	1	1	1	100%
Milestone 2	2	1	2	1	100%
Milestone 3	3	1	3	1	100%
Milestone 4	4	1	4	1	100%
Sterilization Container Design	1	5	4	2	100%
Computer Program	1	5	4	2	100%
P2 Q-Arm Challenge	5	1	7	1	100%
Independent Research Assignment	6	1	6	1	100%
Design Project Report	7	1	7	1	100%
Learning Portfolio	7	1	7	1	100%
Self and Peer Evaluation	7	1	7	2	50%



Appendix B: Scheduled Weekly Meetings

ENGINEER 1P13

MEETING WITH TEAM Thurs14 - Thursday, Nov 2, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Yahya Zaher**	**zahery**	**Yes**
Administrator	**Evan Chadwick**	**chadwe1**	**Yes**
Coordinator	**Evan Hong**	**honge14**	**Yes**
Subject Matter Expert	**Lucas Gilpin**	**gilpil2**	**Yes**
Guest			

AGENDA ITEMS

1. Catching up with the computing sub team (workflow diagrams)
2. Catching up with the modelling sub team (preliminary refined sketches

MEETING MINUTES

Everyone is present

1. .
    a. Ta asked about milestone 1, how the workload was distributed and how the work is going.
2. .
    a. Modeling team presented the new model and talked about the features.
    b. Team suggested up some changes that we should make (holes for sterilization, extrusions inside, thicker walls)
3. Coding team showed and explained their pseudocode to the ta.

POST-MEETING ACTION ITEMS

1. *Implement the suggested ideas into the 3d model [modeling subteam]*
2. *Continue working on pseudocode [coding subteam]*

ENGINEER 1P13

MEETING WITH TEAM Thurs14 - Thursday, Nov 9, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Yahya Zaher**	**zahery**	**Yes**
Administrator	**Evan Chadwick**	**chadwe1**	**Yes**
Coordinator	**Evan Hong**	**honge14**	**Yes**
Subject Matter Expert	**Lucas Gilpin**	**gilpil2**	**Yes**
Guest			

AGENDA ITEMS

1. Attendance
2. Discuss Last Design Studio: What did the sub teams accomplish? Any Issues?
3. Discuss What was done between design studios (Initial Code, Preliminary Cad Models)
4. Discuss what we want to achieve for today's design studio

MEETING MINUTES

Everyone is present

1. Modeling team compared the two preliminary designs they had come up with and chose a final one using a design evaluation.
2. Came up with new improvements to be added to the design
3. Computing team continued to build on pseudocode and compared each other's work
4. Gave each other feedback on how it could be improved
5. Met with ta
    a. Both subteams presented their progress for feedback
    b. Ta suggests some changes to the modeling team about sterilization and wall thickness
    c. Modeling team comes up with some improvements (thicker walls, extrusions in the base to hold the tool, holes in walls for sterilization)
    d. Ta suggests to coding subteam to include more comments about what each function does and how they work for overall readability and that the pseudocode should include the potentiometer.

POST-MEETING ACTION ITEMS

1. *Add proposed changes to the 3d model [modeling team]*
2. *Make proposed edits to the pseudocode [coding team]*

ENGINEER 1P13

MEETING WITH TEAM Thurs14 - Thursday, Nov 16, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Yahya Zaher**	**zahery**	**Yes**
Administrator	**Evan Chadwick**	**chadwe1**	**Yes**
Coordinator	**Evan Hong**	**honge14**	**Yes**
Subject Matter Expert	**Lucas Gilpin**	**gilpil2**	**Yes**
Guest			

AGENDA ITEMS

1. Attendance and Updates
2. What has been accomplished since last design Studio (improvements in code/Cad design)
3. What has to be accomplished by the end of this design studio (Finish the code and finalize the Cad Design)
4. Discuss issues

MEETING MINUTES

Everyone is present

Teams presented their progress to a ta for feedback

1. Modeling team was missing g-code, so could not start 3d printing
2. Ta gave feedback about the 3d model:
    a. May be too much material
    b. Not enough holes (especially on side)
    c. Some features were less than 2mm
    d. Suggested filleting edges to make it easier for the 3d printer
    e. Add something that would keep the tool in place if the container was turned upside down
3. Ta gave feedback about the python code
    a. Add more comments and documentation to each function, explaining what it does and what happens

POST-MEETING ACTION ITEMS

1. *Make proposed changes to the 3d model [modeling team]*
2. *Get g-code ready [modeling team]*
3. *Add comments to python code [coding team]*

ENGINEER 1P13

MEETING WITH TEAM Thurs14 - Thursday, Nov 23, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Yahya Zaher**	**zahery**	**Yes**
Administrator	**Evan Chadwick**	**chadwe1**	**Yes**
Coordinator	**Evan Hong**	**honge14**	**Yes**
Subject Matter Expert	**Lucas Gilpin**	**gilpil2**	**Yes**
Guest			

AGENDA ITEMS

1. Attendance and Updates
2. Computing team: Show Finalized Code
3. Modelling Team: Show Finalized Design
4. Explain Issues from last week
5. Prepare for Final Project review

MEETING MINUTES

Everyone is present

1. Modeling team reviewed their changes to the 3d model and g-code with ta
2. Modeling team begins 3d printing
3. Coding subteam tests final code on q arm

POST-MEETING ACTION ITEMS

1. Prepare for interview
2. Get final submissions ready
3. Prepare for design challenge
4. Start the final report

Appendix C: Additional Documentation

lakeairitsupport, “What Stainless Steel is used for Medical Instruments?,” *Lake Air Products*, 2021. [Online]. Available: https://lakeairmetals.com/which-grades-of-stainless-steel-are-used-for-medical-instruments/ [Accessed Nov. 23, 2023].

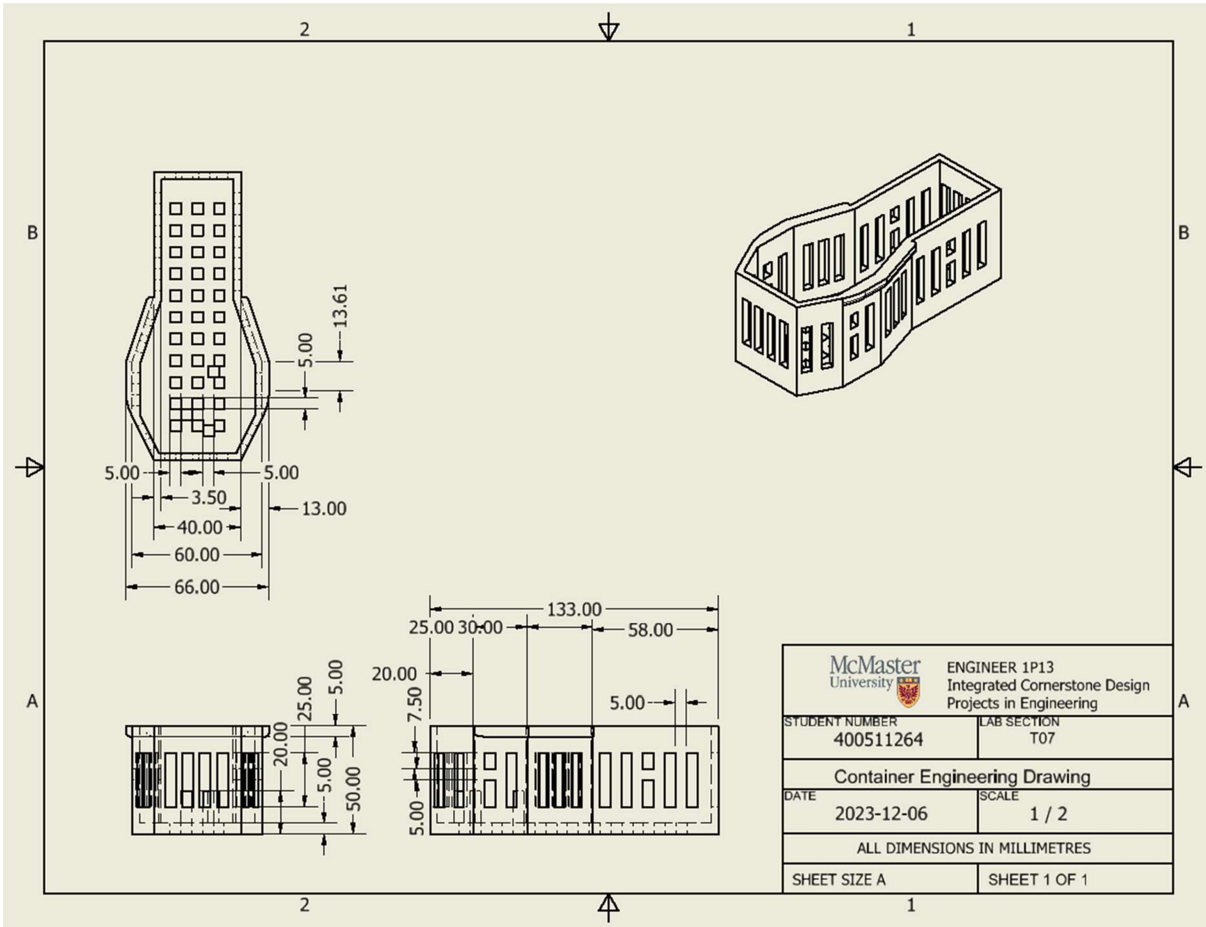
M. Anderson, “Stainless Steel vs. Carbon Steel: What’s the Difference?,” *Mead Metals, Inc.* [Online] Available: https://www.meadmetals.com/blog/stainless-steel-vs-carbon-steel [Accessed Nov. 27, 2023].

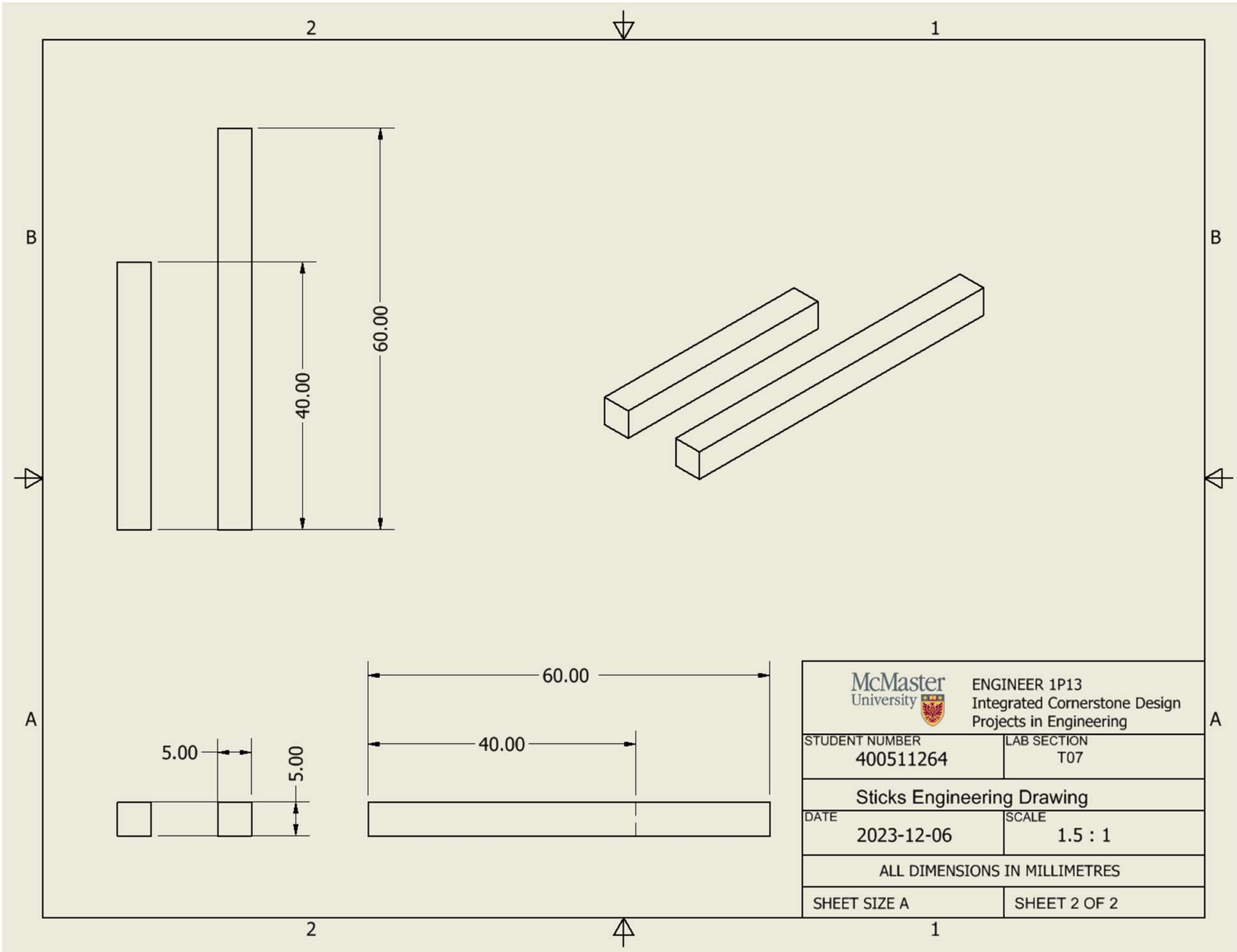
Ansys Granta EduPack software, Granta Design Limited, Cambridge, UK, 2023 (www.grantadesgin.com)

Autodesk® Inventor LT™ software, Autodesk, Inc, 2023 (www.autodesk.com)

R. Ahmed, “The difference between Titanium vs Steel?,” Metal Supermarkets, https://www.metalsupermarkets.com/the-difference-between-titanium-vs-steel/ (accessed Nov. 26, 2023).

K. J. Penick, L. A. Solchaga, J. A. Berilla, and J. F. Welter, “Performance of polyoxymethylene plastic (POM) as a component of a tissue engineering bioreactor,” Journal of Biomedical Materials Research, vol. 75A, no. 1, pp. 168–174, Jul. 2005, doi: https://doi.org/10.1002/jbm.a.30351.


ENGINEER 1P13
Integrated Cornerstone Design Projects in Engineering
STUDENT NUMBER
400511264
LAB SECTION
T07
Container Engineering Drawing
DATE
2023-12-06
SCALE
1 / 2
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1



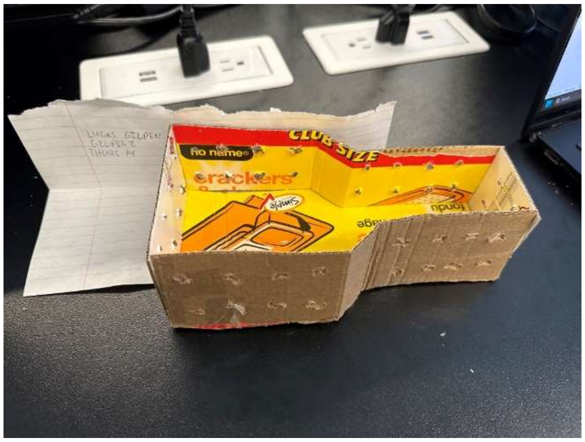


Figure 1. Model Prototype (Physical Model)

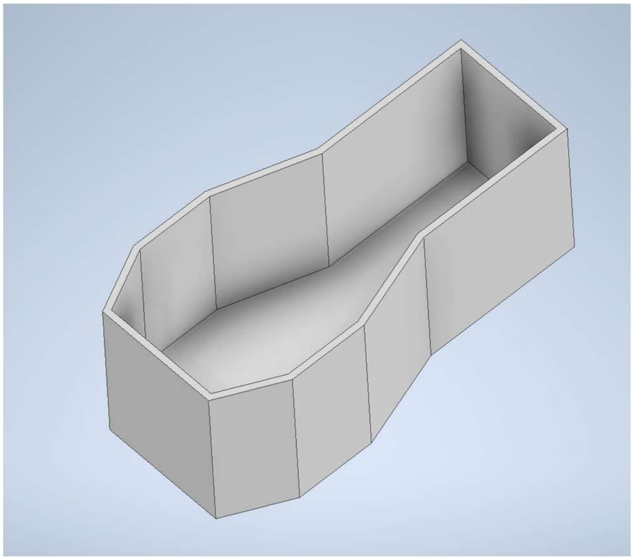


Figure 2. Preliminary Solid Model (Autodesk Inventor)

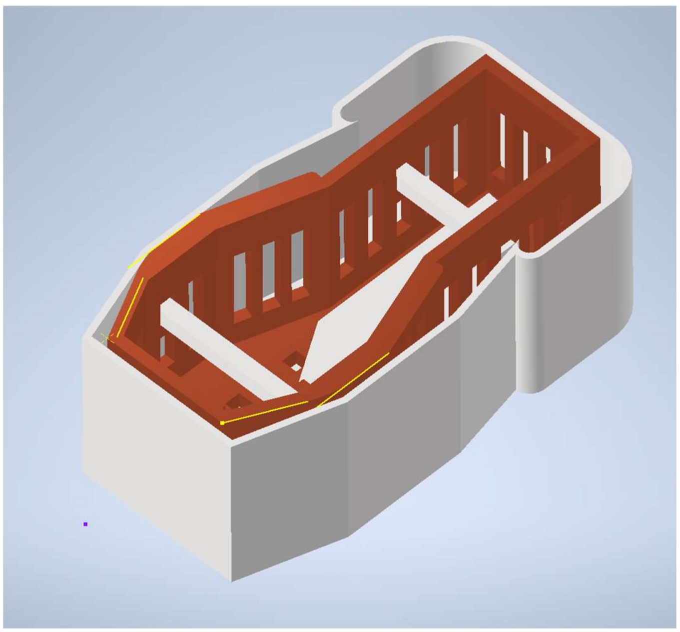


Figure 3. Final Solid Model + Assembly (Autodesk Inventor)

Figure 4. Final Solid Model + Assembly (Autodesk Inventor)

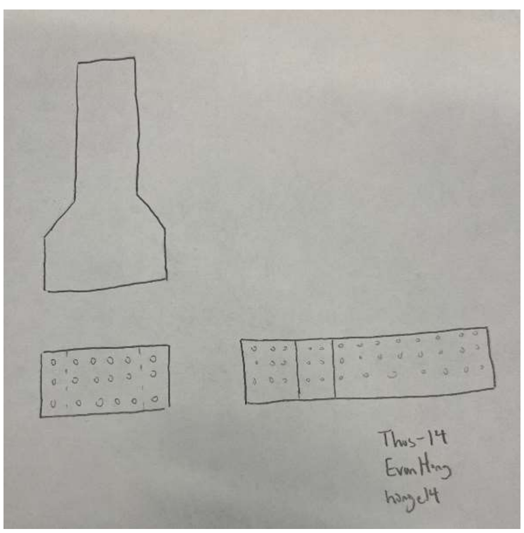


Figure 5: Preliminary Sketch

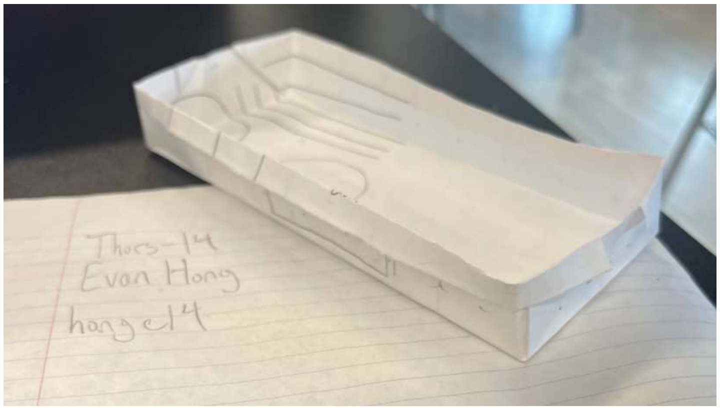


Figure 6: Low-Fidelity prototype

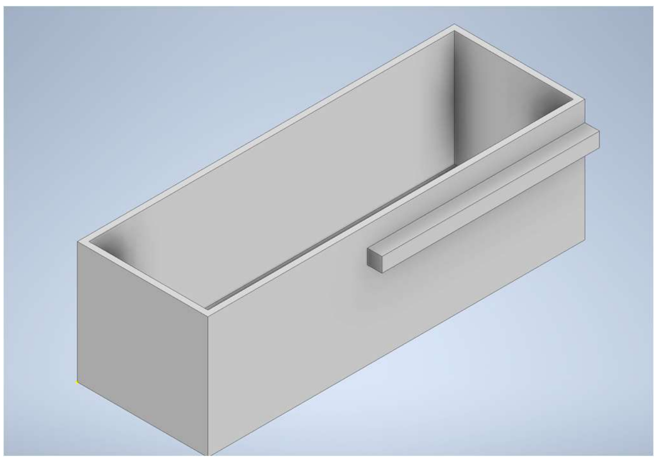


Figure 7: Preliminary Solid Model

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: Thurs-14

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

Full Name:	MacID:
Yahya Zaher	zahery
Evan Hong	honge14
Evan Chadwick	chadwe1
Lucas Gilpin	gilpil2

Insert your Team Portrait in the dialog box below

MILESTONE 0 – SUB-TEAM CHARTER

Team ID: Thurs-14

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	Lucas Gilpin
	Evan Hong
Computing	Evan Chadwick
	Yahya Zaher

MILESTONE 0 – TEAM CHARTER

Team ID: Thurs-14

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Yahya Zaher	☐M ☒A ☐C ☐S
2.	Evan Hong	☐M ☒A ☐C ☐S
3.	Evan Chadwick	☒M ☐A ☐C ☐S
4.	Lucas Gilpin	☐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	Yahya Zaher	zahery
Administrator 1	Evan Chadwick	chadwe1
Administrator 2	Lucas Gilpin	gilpil2
Coordinator	Evan Hong	honge14

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team ID: Thurs-14

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

Full Name of Team Manager:	MacID:
Yahya Zaher	zahery

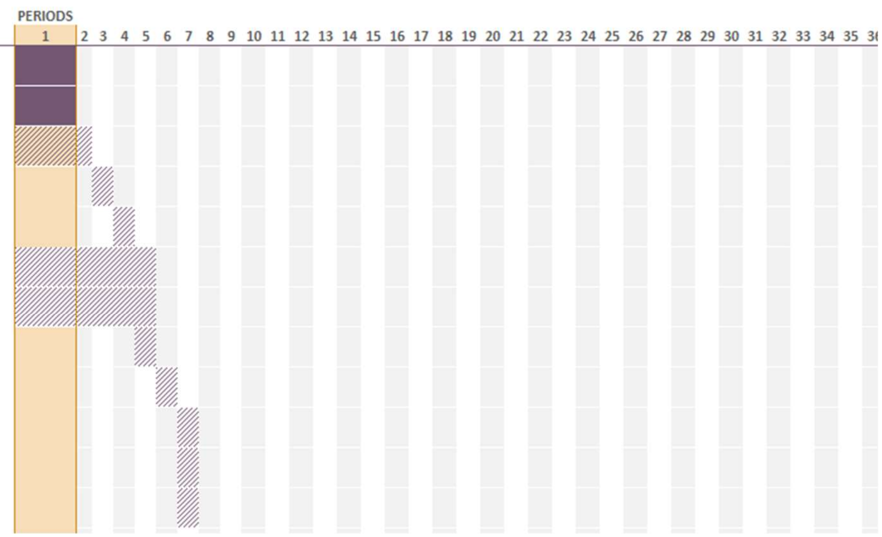
Preliminary Gantt chart:

Project Planner

Select a period to highlight at right. A legend describing the charting follows.

Period Highlight: 1 | Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete (beyond plan)

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	1	1	100%
Milestone 1	1	1	1	1	100%
Milestone 2	2	1	1	1	0%
Milestone 3	3	1	0	0	0%
Milestone 4	4	1	0	0	0%
Sterilization Container Design	1	5	0	0	0%
Computer Program	1	5	0	0	0%
P2 Q-Arm Challenge	5	1	0	0	0%
Research Summary	6	1	0	0	0%
Design Project Report	7	1	0	0	0%
Learning Portfolio	7	1	0	0	0%
Self- and Peer-Evaluation	7	1	0	0	0%



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

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team ID: Thurs-14

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

Full Name:	MacID:
Lucas Gilpin	gilpil2
Evan Hong	honge14
Evan Chadwick	chadwe1
Yahya Zaher	zahery

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

Team ID: Thurs-14

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
Smooth movement of arm	Container must fit in footprint	Grasp the container
Minimal movement of the tool within the box	Mass must not exceed 350g	Move the container
Easy for the arm to hold	All measurements must be greater than 2 mm	Place container in correct autoclave
Container is lightweight	Must fit securely in between the robot Gripper	Sterilizes the surgical tool
		Identifiable by Colour and Size

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

Must allow sterilization of tools by steam

a

3. What are the secondary functions?

Be able to identify the colour and size of containers
Place container in correct autoclave
Pick up and manipulate objects

MILESTONE 1 (STAGE 2) – MORPHOLOGICAL ANALYSIS

Team ID: Thurs-14

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	Magnetic	Handle on container	Claw	Rough Surface of container	Forklift Style	Grab from top
Container	Inside Padding	Snap in component for tool	Inside Tape	Magnetic Inside		
Place	Throw it	Set down	Drop from height			

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

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team ID: Thurs-14

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

Full Name:	MacID:
Evan Hong	honge14
Yahya Zaher	zahery
Lucas Gilpin	gilpil2
Evan Chadwick	chadwe1

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

Team ID: Thurs-14

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.*

Evan Design Observations	Lucas Design Observations
- Shape is more form fitting to the tool - Easier to hold tool in place - Easier for the arm to grab - Lightweight - More durable - Relatively complex - Has holes for sterilization - Measurements are greater than 2mm	- Rectangular shape - Simple design - Easy to model - Claw will have more difficulty picking up the box due to the shape. - Ensures the tool will not be dropped - Allows for 360degree sterilization of the tool - Lightweight - Tool may move around in the box

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

Team ID: Thurs-14

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.

Document your observations for each visual storyboard / flowchart in the space below.

Similarities:

-Both had the basic functions required to complete the task

Both described the action of picking up the container similarly

Both had a loop to pick up the 6 containers and place them in the right place

Similar cyclical breakdown of workflow diagram

Chose to do a flowchart instead of storyboard

Had similar processes to place the container inside the drawer

Differences:

- Evan considered functions to begin sterilization in the pseudo code
- Yahya had a more specific breakdown of each of the individual functions in the pseudo code
- One had a more linear structure of the workflow chart while the other broke down the individual colours into separate blocks

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

Team ID: Thurs-14

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

```
Start at Home Position
Loop for each container (1 to 6):

    Move Q-arm to Pick-up coordinates of specific box
    Sleep for a few seconds
    Grab the container
    Sleep for a few seconds
    Move Q-arm from Pick-up Position to the correct autoclave XY range
    Sleep for a few seconds
    Move Q-arm to the correct drop-off location
    Sleep for a few seconds

        If the container is large:
            Open Drawer
Sleep for a few seconds
            Open the gripper, releasing the container into the drop-off bin
Sleep for a few seconds
            Close the Drawer
```

Else If the container is small:

Place the container on top

Return to Home Position

Sleep for a few seconds

Repeat for each container

End of the program

MILESTONE THREE (TEAM): PRELIMINARY MODEL & CODE

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team ID: Thurs-14

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

Full Name:	MacID:
Evan Hong	honge14
Lucas Gilpin	gilpil2
Evan Chadwick	chadwe1
Yahya Zaher	zahery

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

Team ID: Thurs-14

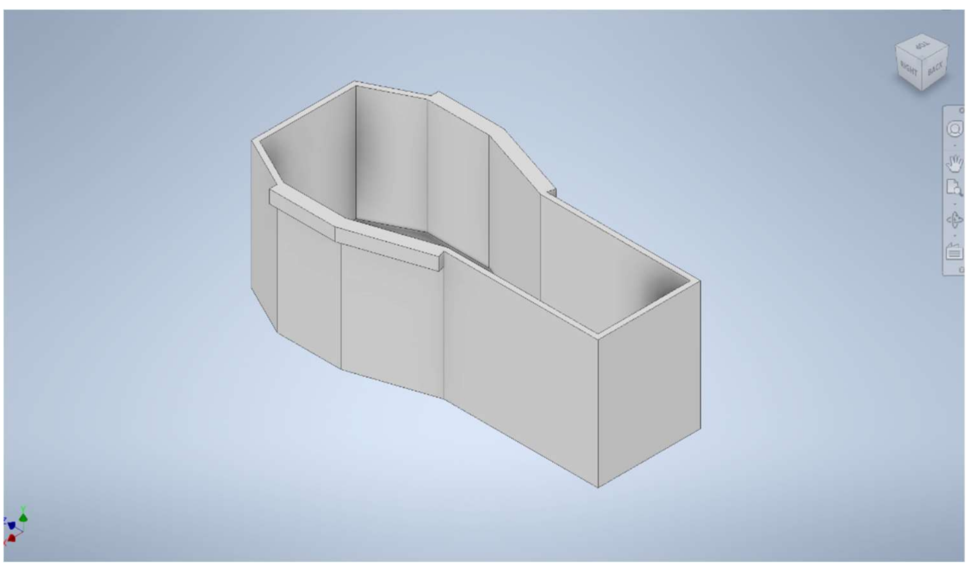
As a team, review each other's preliminary solid models and discuss which features from each other's models align best with the project objectives, constraints and functions. Summarize this in the table below.

Container	Feature	How it aligns with project objectives, constraints and functions.
Evan	Flaps	Ensures box won't slip from Q-Arm
	Measurements aren't too small	Measurements need to be larger or equal to 2 mm
Lucas	Wider base	Easier to grip for Q arm
	tapered corners	Needed to fit within the footprint
	Measurements aren't too small	Measurements need to be larger or equal to 2 mm

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): Evan	Name (Team Member #2): Lucas

Insert an image of your solid model here.



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

Team ID: Thurs-14

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

Pick-up Container

Function PickUpContainer(containerNumber)

MoveQArmToPickUpPosition(containerNumber)

GrabContainer()

Continue or Terminate Program

If all containers are in their desired locations

    Terminate

Else

    Which container must be moved?

        move that container to desired x,y,z

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

Team ID: Thurs-14

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	Rectangle	Wider end, narrow end	Finalized Design
Easy to grip	s	s	+	+
Secures tool	s	-	-	-
Allows Sterilization	s	-	-	-
Failsafe if arm slips	s	+	s	+
Quantity of tools held	s	-	-	-
Lightweight	s	-	-	-
Total +		1	1	2
Total –		4	4	4
Total Score		-3	-3	-2

*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.

- Include holes or slots to allow for easier sterilization - Small extrusions inside the box to hold the tool in place - Thicker walls

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

Team ID: Thurs-14

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**: Yahya Zaher
- The Code runs without error - Degrees is wrong it is supposed to be 175 instead of 345 since its maximum degrees is +- 175 degrees - Consider how the potentiometer interacts with the q arm and how it moves	
Drop-off Container & Return Home	**Team Member Name**: Evan Chadwick
Enter code errors and/or observations here - Doesn't run, it depends on other functions - Doesn't contain the defined arm variable in the code - Functions are kind of mixed in with if statements making it a little confusing (kind of pseudo code like)	

*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.

Rotate
Since the degrees don't go all the way to 345 and only go to +- 175,
Rotate Q-arm Base (Yahya Zaher):
→ Refine the degrees value to be 175 instead of 345.
  - Create if statements to determine when needed to rotate negatively or positively

→ Consider that the arm rotates relatively rather than to a specific position
Drop-off Container & Return Home (Evan Chadwick):

- → Organize code into separate functions to improve readability.
- → Introduce the missing arm variable and define its scope.
- → Clearly separate functions and if statements to enhance code structure and understanding.

MILESTONE 3 (STAGE 3) – PRELIMINARY DESIGN REVIEWS

Team ID: Thurs 14

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.

1. Ask questions, are we on track to complete our milestones?
2. Planned to show our finalized model to demonstrate how it meets the project's objectives and constraints and to receive feedback
    a. Demonstrated the most recent design to computing sub team
    b. Meets objectives by holding the tool, and allows for the q arm to hold the box easily, fits in the footprint
    c. 3D print the final design
3. Planned to show our pseudo code to demonstrate the high-level objectives of our code.
    a. Demonstrate program
    b. Show the pickup and rotate functions
    c. Explain how the code was integrated

Modelling Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.

Walls should be thicker, there should be holes for sterilization, there should be extrusions to hold the tool in place
Make a model of the footprint to use assembly to make sure the container fits in the footprint

Use the space below to propose further design refinements based on the feedback.
Continue to make additions and edits to the 3d model:
Walls should be a few mm thicker in order to ensure printing works properly
Add holes to the sides or bottom of the box for sterilization
Create extrusions along the bottom of the box around the shape of the tool so that it doesn't move

Computing Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.
The code should consider the potentiometer for the rotate function
Integrate the functions so they seamlessly work together
Take a deeper look at the detailed description for project objective 3

The pseudocode should consider the potentiometer
Use the space below to propose further design refinements based on the feedback.

MILESTONE FOUR: DETAIL DESIGN (DESIGN REVIEW AND FEEDBACK)

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team ID: Thurs-14

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

Full Name:	MacID:
Evan Chadwick	chadwe1
Evan Hong	honge14
Lucas Gilpin	gilpil2
Yahya Zaher	zahery

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: Thurs-14

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 reviewing progress next design studio.

TA asks why the container is shaped larger at one end, said it is using more material than necessary, and there might not be enough holes for sterilization (no holes on the side). Some of the features are less than 2mm like the spaces between certain extrusions and holes. Suggested filleting edges for 3d printing purposes and making the structure stronger. Also said if the container was dropped or something went wrong, the tool is not being kept from falling out if it were turned upside down.

Next design studio: add holes, show gcode, change extrusions on the inside of box

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

- Add holes to side of box
- Add method to hold tool in from going out of box from the top
- Export g code
- Change extrusions from cylinders to squares
-

COMPUTATION SUB-TEAM

Team ID: Thurs-14

☐ 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.

Ta says there should be more comments/documentation in the functions.

Next design studio meeting: Include more comments, otherwise it's already repeating for each block

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

- Add more comments about the inputs, outputs and what the function does
- Provide print outputs such that a completely new user could effectively operate the program
  - What each potentiometer does etc

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:	Thurs - 14

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: Thurs-14

Name: Evan Chadwick	MacID: chadwe1
Insert screenshot(s) of your preliminary sketch below	

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

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

Team ID: Thurs - 14

Name: Evan Chadwick	MacID: chadwe1
Write your pseudocode in the space below Move to the location of the first box. Pick up the first box. Move to box associated with that color If it's a small box, then place on top If it's a big box than place inside the draw Repeat for each consecutive box (6 times) Start sterilization (if there's a button needed to be pressed)	

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

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

Team ID: Thurs-14

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:

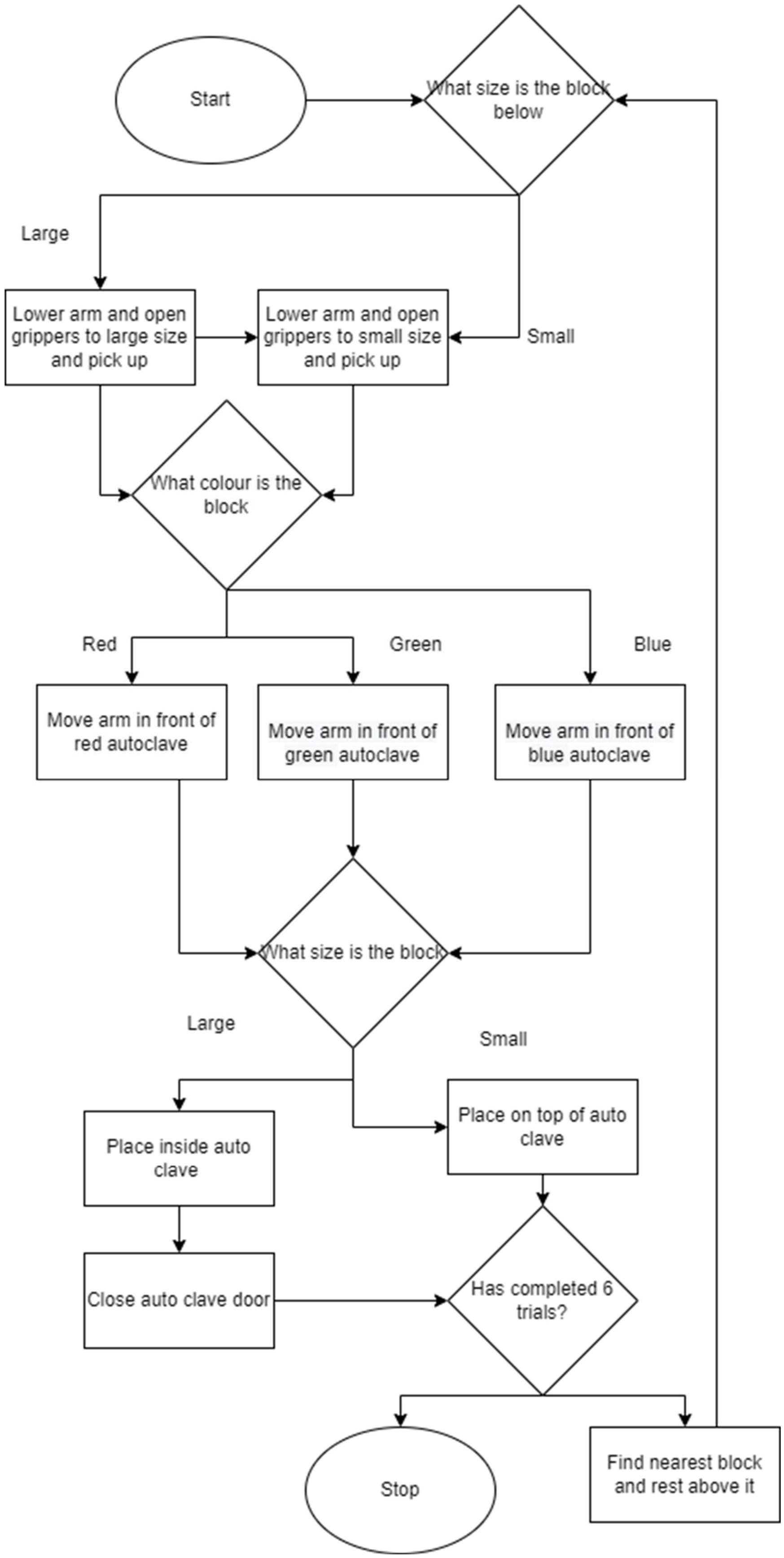
Name:	MacID:
Insert screenshot(s) of the low-fidelity prototype below	

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

Team ID: Thurs-18

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)


Start
What size is the block below
Large
Small
Lower arm and open grippers to large size and pick up
Lower arm and open grippers to small size and pick up
What colour is the block
Red
Green
Blue
Move arm in front of red autoclave
Move arm in front of green autoclave
Move arm in front of blue autoclave
What size is the block
Large
Small
Place inside auto clave
Place on top of auto clave
Close auto clave door
Has completed 6 trials?
Stop
Find nearest block and rest above it

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:

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:

Name:	MacID
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: Thurs-14

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>**

```
def Rotate(position):
    degrees = 345 * position
    arm.rotate_base(degrees)
```

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	$\frac{E}{\rho C_m}$	Minimize cost and Mass

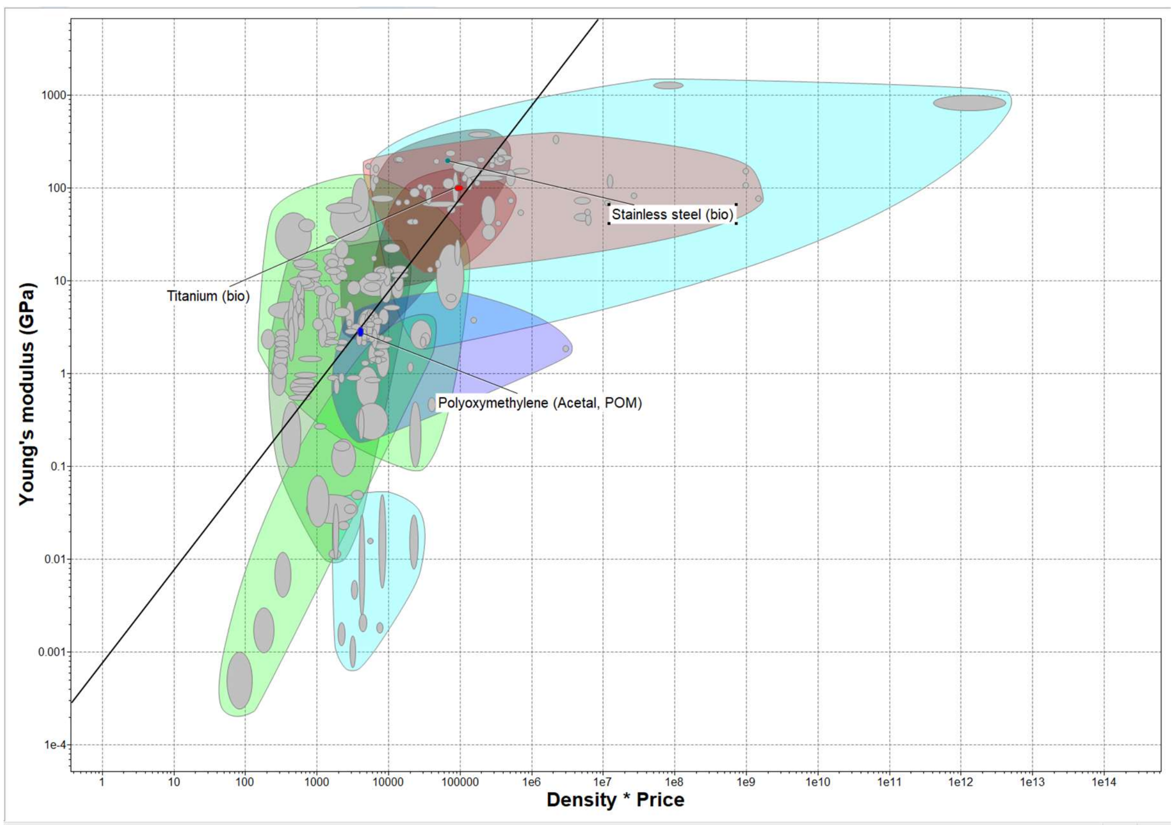
Please provide a short justification for your chosen design and MPI.

Stiffness is the measure to which an object resists deformation to a force. It is of great importance in this case because of the high pressures that the container must withstand. It is especially important that the container does not deform at all because of the very small excess room between the container and the tools stored inside, if the container starts to deform then it jeopardizes the shape of the tool inside. Strength, on the other hand, is arguably less important because although we don't want the container to plastically deform, it ignores the fact that the tool inside may still be misshapen even if the container only experiences elastic 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:	Stainless Steel	Titanium	Polyoxymethylene

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

Chosen Material:	Stainless Steel

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

Stainless Steel ranks the highest given my chosen mpi. Although titanium tends to be a lighter material and slightly easier to handle it does not justify itself enough to overtake stainless steel given its price. Polyoxymethylene has not been thoroughly tested enough to justify choosing the material when a medical grade material is required. Specifically, Repeated exposure to high temperatures may cause unexpected breakdown of the material, which could jeopardize the medical viability of the tools inside the container [1]. Through this, stainless steel proves itself to be the most desirable material.

References (If any):

Bibliography

[1]K. J. Penick, L. A. Solchaga, J. A. Berilla, and J. F. Welter, "Performance of polyoxymethylene plastic (POM) as a component of a tissue engineering bioreactor," *Journal of Biomedical Materials Research*, vol. 75A, no. 1, pp. 168–174, Jul. 2005, doi: https://doi.org/10.1002/jbm.a.30351.

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

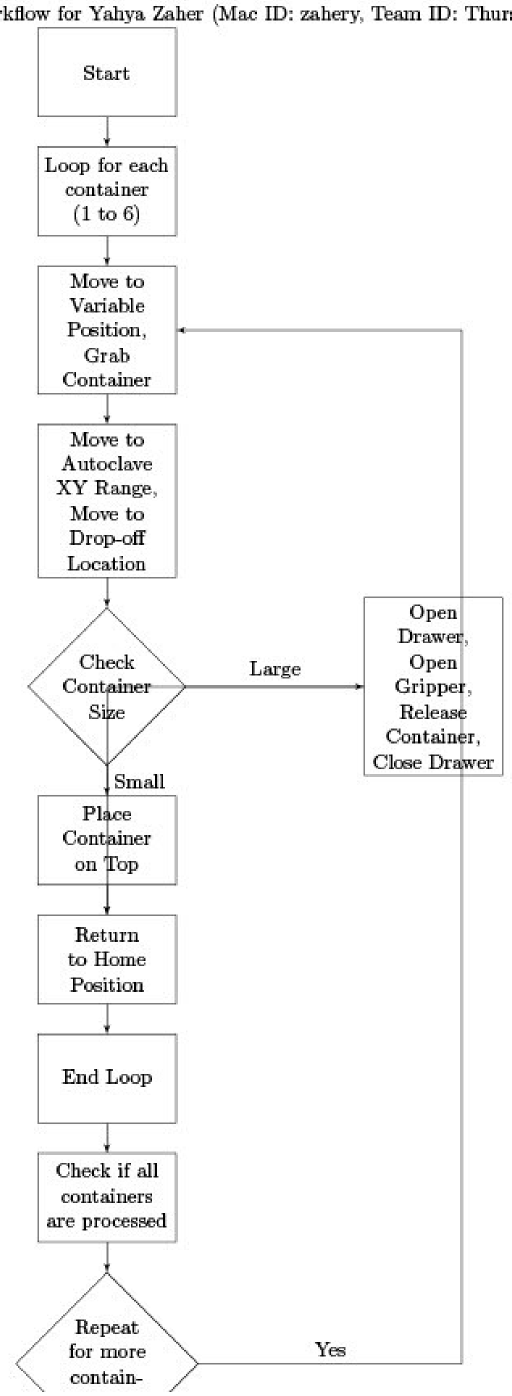
Team ID: Thurs-14

Name: Yahya Zaher	MacID: zahery

Write your pseudocode in the space below
Start at Home Position
Loop for each container (1 to 6):
 	
    Move Q-arm to Pick-up Position 1
    Grab the container
 	
    Move Q-arm from Pick-up Position to the correct autoclave XY range
 	
    Move Q-arm to the correct drop-off location
 	
      If the container is large:
        Open Drawer
        Open the gripper, releasing the container into the drop-off bin
        Close the Drawer
      Else If the container is small:
        Place the container on top
 	
Return to Home Position
 	
Repeat for each container
 	
End of the program	

Figure 1:

Figure 2: *
Automated Container Handling System
Workflow for Yahya Zaher (Mac ID: zahery, Team ID: Thurs-14)



Team ID:

Thurs	14

Name: Yahya Zaher	MacID: zahery

Insert screenshot(s) of your code below

```python
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_container(size, color):
    # Assuming you have defined functions like home(), check_autoclave(color), open_autoclave(color, is_large),
    # open_drawer(), close_drawer(), place_container_on_top(), control_gripper(angle), deactivate_autoclaves(), and print_error_message(message).

    home()

    if check_autoclave(color):
        open_autoclave(color, is_large(size))
        if is_large(size):
            open_drawer()
            control_gripper(-45)
            control_gripper(0)
            close_drawer()
        else:
            place_container_on_top()

        deactivate_autoclaves()
        home()
    else:
        print_error_message("Incorrect autoclave. Aborting.")
```

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

Project Two Worksheets (INDIVIDUAL)

TABLE OF CONTENTS

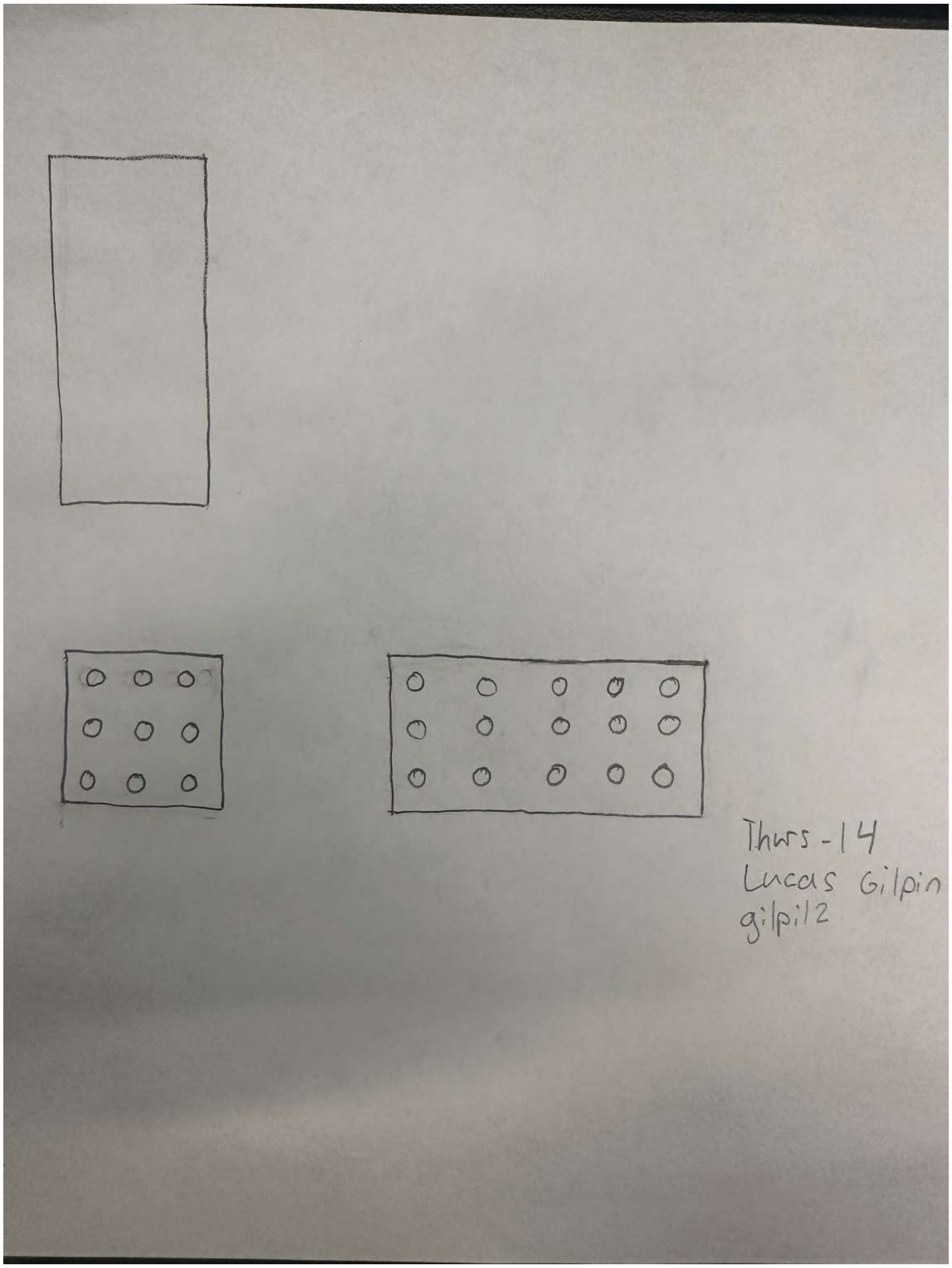
MILESTONE 1 (STAGE 3) – PRELIMINARY CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID: Thurs-14

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: Thurs-14

Name: Lucas Gilpin	MacID: gilpil2
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: Thurs-14

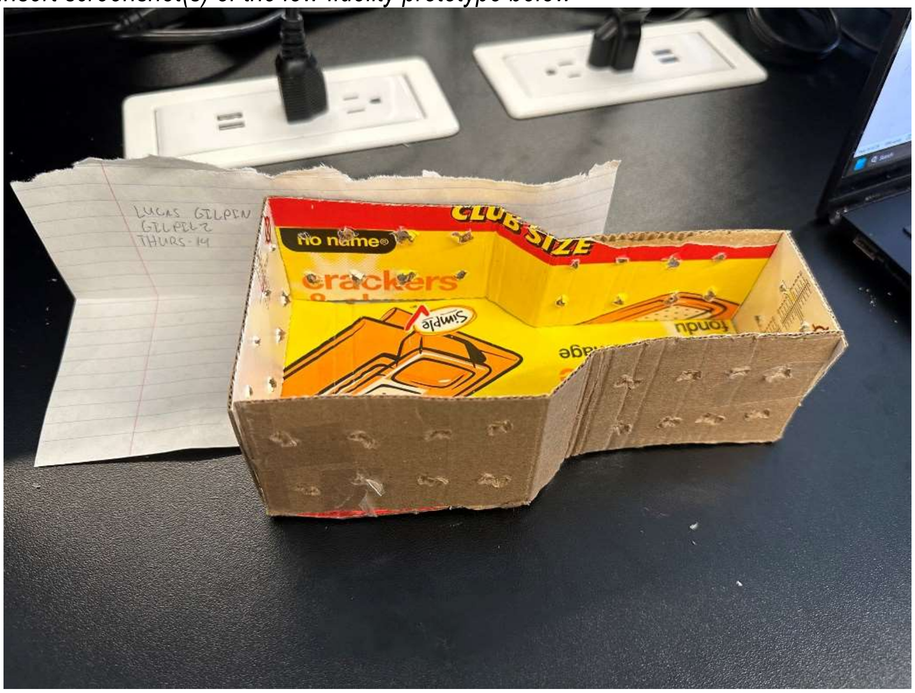
Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

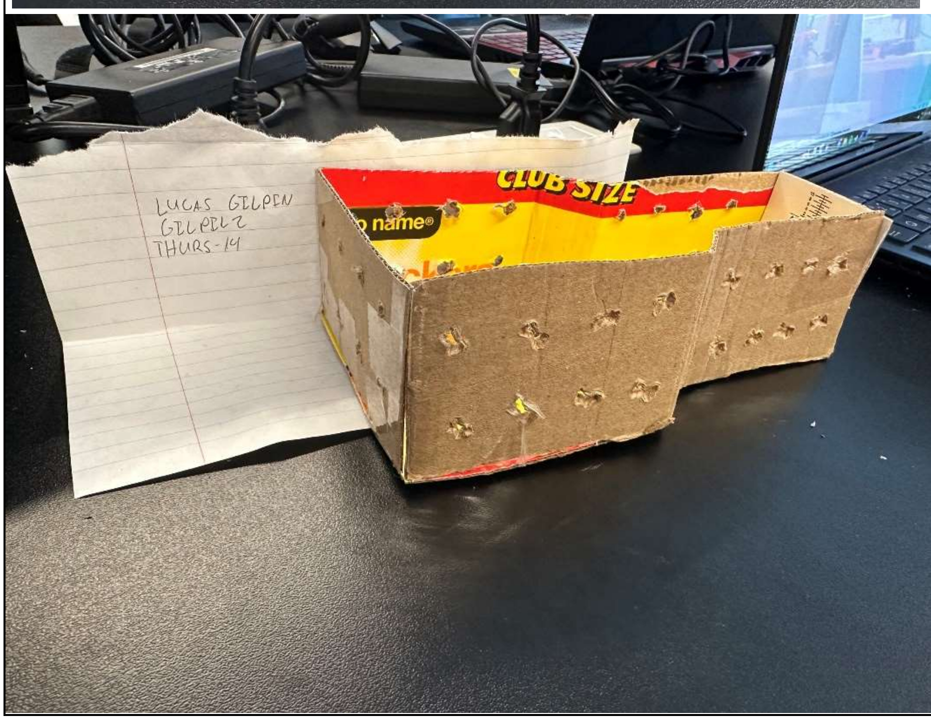
1. Take multiple photos of the low-fidelity prototype
    - Include an index card (or similar) next to the prototype, clearly indicating your Team Number, Name and MacID on *each* picture
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* prototype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

Team ID: Thurs-14

Name: Lucas Gilpin	MacID: gilpil2

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





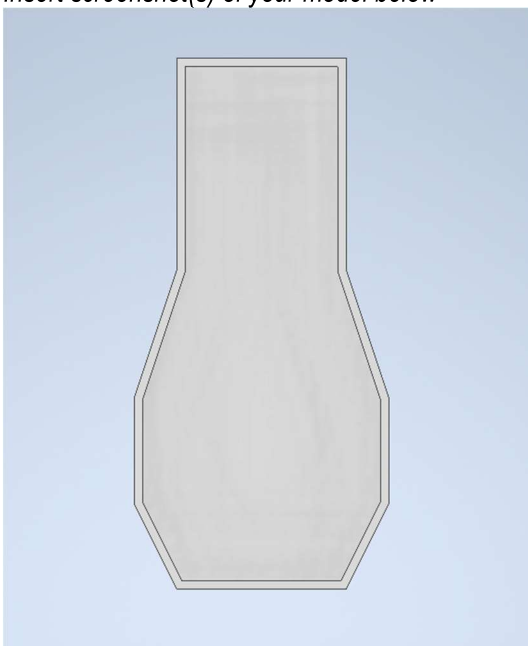
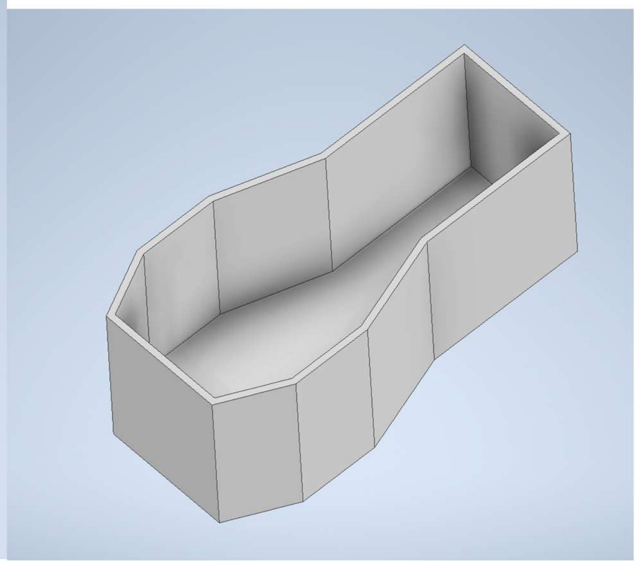
MILESTONE 2 (STAGE 3) – PRELIMINARY SOLID MODEL (MODELLING SUB-TEAM)

Team ID: Thurs-14

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: Thurs-14

Name: Lucas Gilpin	gilpil2
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

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

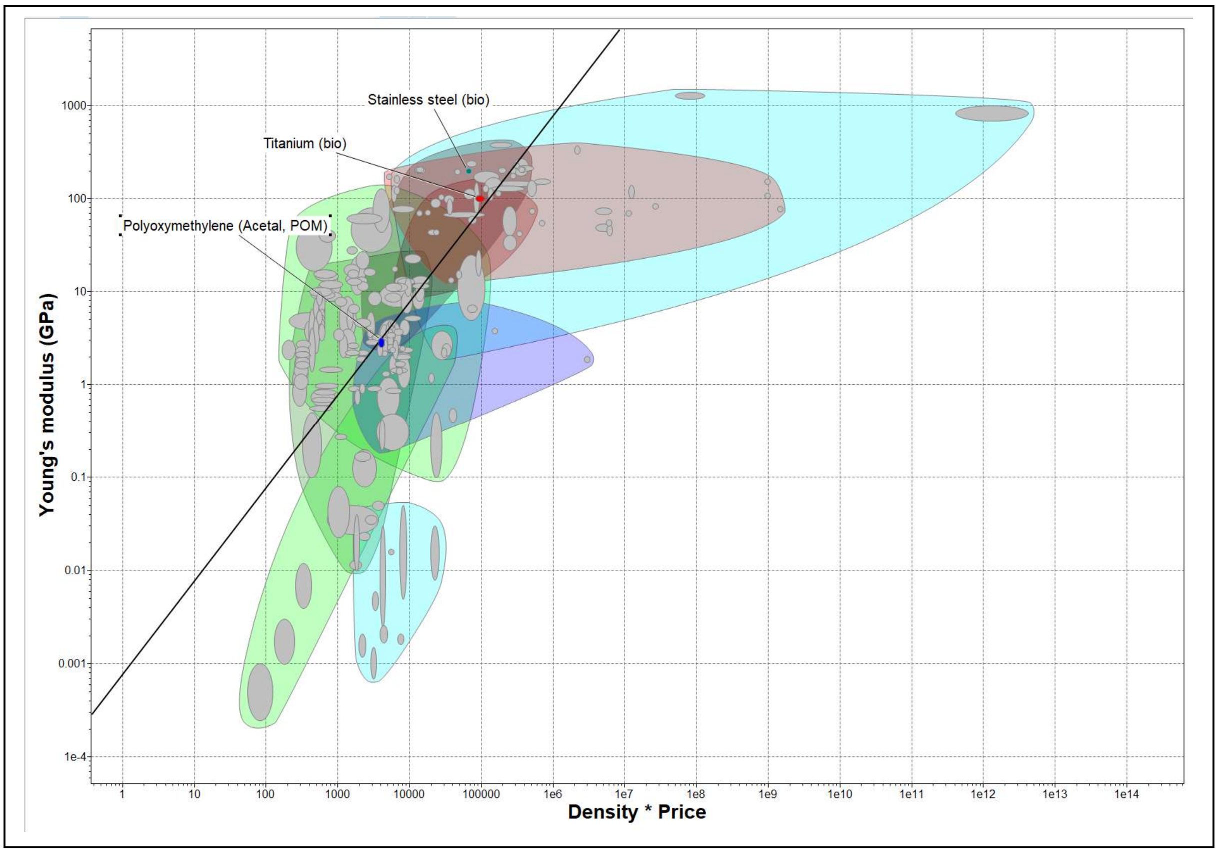
Please provide a short justification for your chosen design and MPI.

I chose to use the Stiffness MPI to select the final material. The reason for this selection is due to the container needing to withstand internalized pressure. With a stiffer material, more pressure is needed to compromise the containers' structure. Since it is a stiffer material, thinner walls can be used to minimize mass without sacrificing the structural integrity of the container. Furthermore, this MPI considers the cost of the material compared to its density, ensuring the objective of minimizing cost is taken into consideration when creating a chart in GRANTA. In conclusion, this chosen design, MPI, and objectives are the most appropriate options to create an effective container.

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: $\dfrac{E}{\rho C_m}$	Stainless Steel (bio)	Titanium (bio)	Polyoxymethylene (Acetal, POM)

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

<table>
<tr><td>Chosen Material:</td><td>Stainless Steel</td></tr>
<tr><td colspan="2">Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations).
As my final selection, Stainless Steel, a frequently used material in the medical industry, was selected [1]. From the top 3 materials Stainless Steel had the highest young's modulus [2]. This ensures that the container is extremely stiff and can easily withstand the internalized pressure created by the autoclave. Furthermore, this material can withstand temperatures of at least 140 degrees Celsius, making it more than capable of being heated to high temperatures by the autoclave [2]. Furthermore, being ranked 2nd overall, it ensures cost-effectiveness [2]. Stainless steel is also incredibly durable, ensuring that the container can be used frequently [1]. Finally, stainless steel is a lightweight material allowing it to meet the objective of minimizing mass [3]. In conclusion, this material meets the needs of the scenario making it an ideal selection.</td></tr>
<tr><td colspan="2">References (If any):

[1] lakeairitsupport, "What Stainless Steel is used for Medical Instruments?," Lake Air Products, 2021. [Online]. Available: https://lakeairmetals.com/which-grades-of-stainless-steel-are- used-for-medical-instruments/ [Accessed Nov. 23, 2023].
[2] Ansys Grants: Materials information management, https://www.ansys.com/products/materials [Accessed Nov. 27, 2023].
[3] M. Anderson, "Stainless Steel vs. Carbon Steel: What's the Difference?," Mead Metals, Inc. [Online] Available: https://www.meadmetals.com/blog/stainless-steel-vs-carbon-steel [Accessed Nov. 27, 2023].</td></tr>
</table>

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.

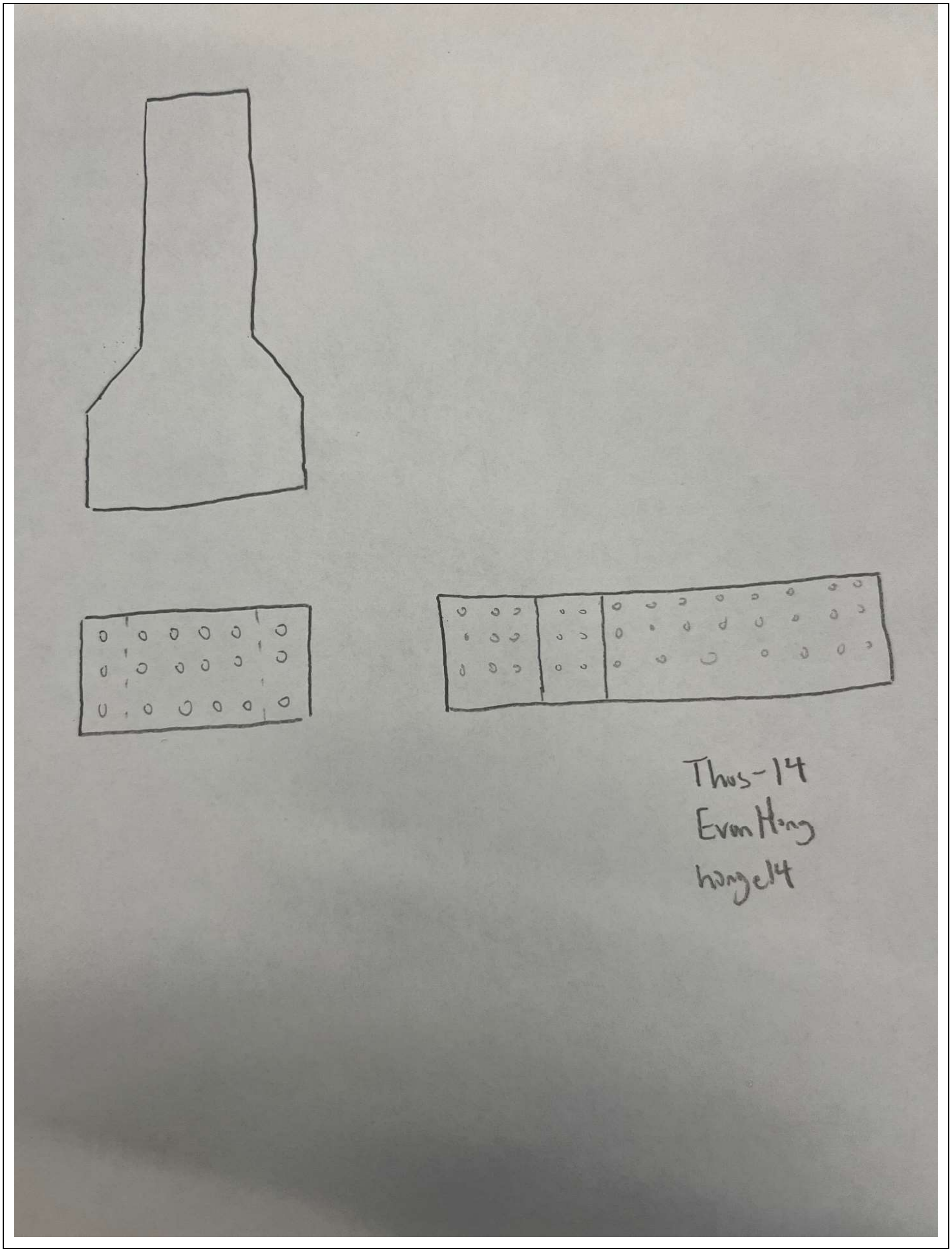
MILESTONE 1 (STAGE 3) – PRELIMINARY CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID: Thurs-14

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: Thurs-14

Name:Evan Hong	MacID: honge14
Insert screenshot(s) of your preliminary sketch below	



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

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)

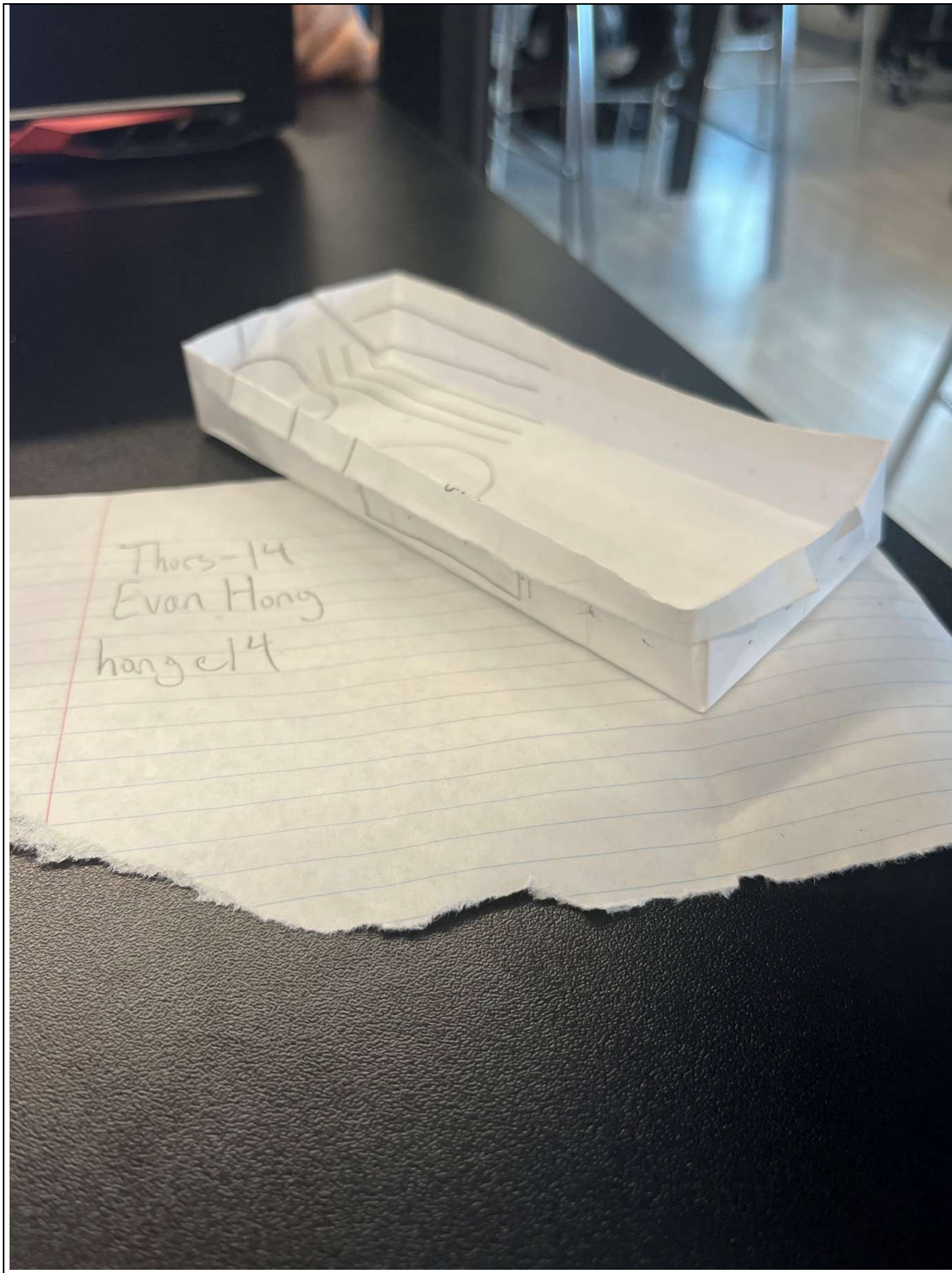
Team ID: Thurs-14

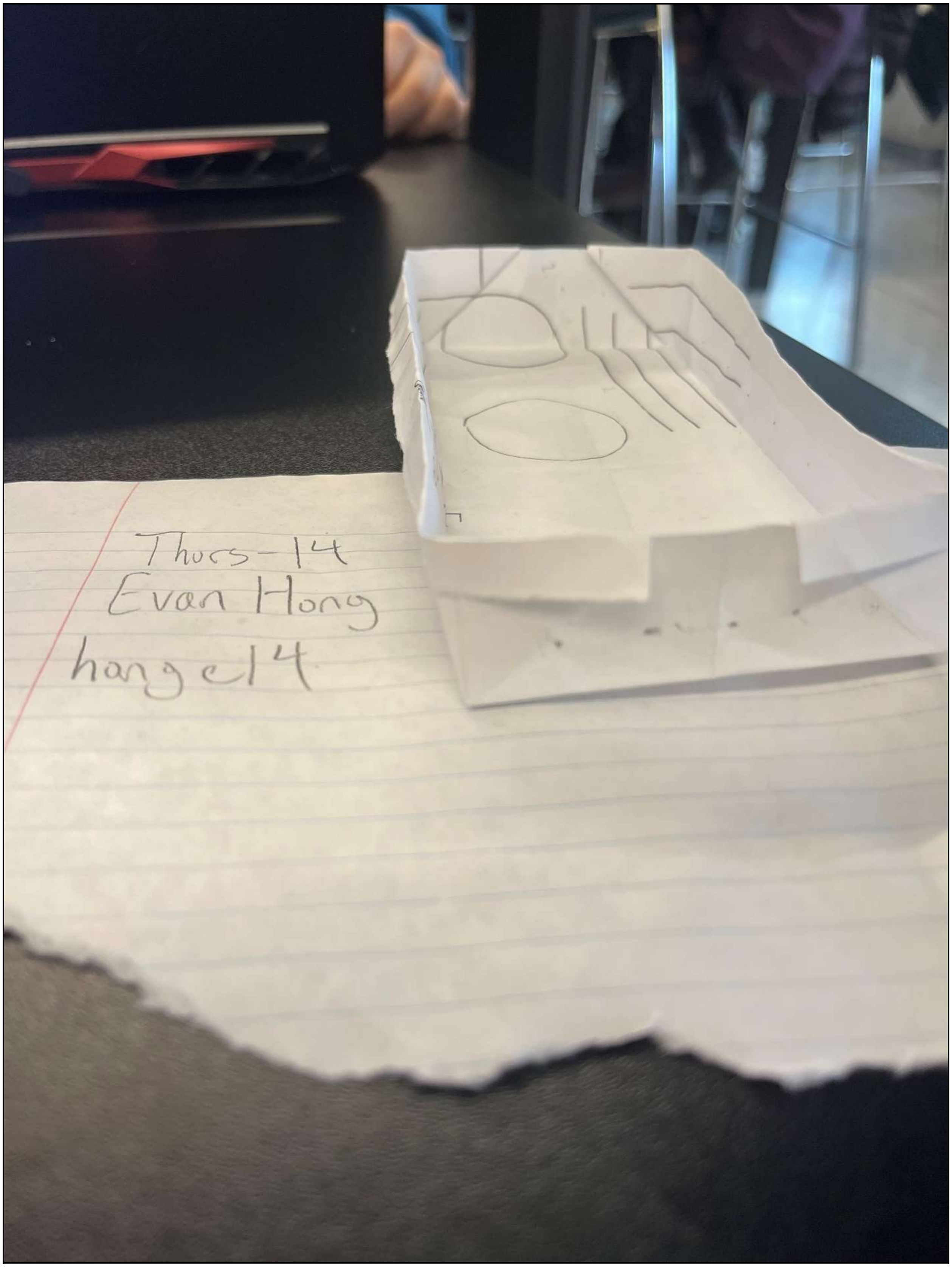
Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

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: Thurs-14

Name: Evan Hong	MacID: honge14
Insert screenshot(s) of the low-fidelity prototype below	


Thurs-14
Evan Hong
hongel4


Thurs-14
Evan Hong
hange14

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

Team ID: Thurs-14

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: Thurs-14

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: Thurs-14

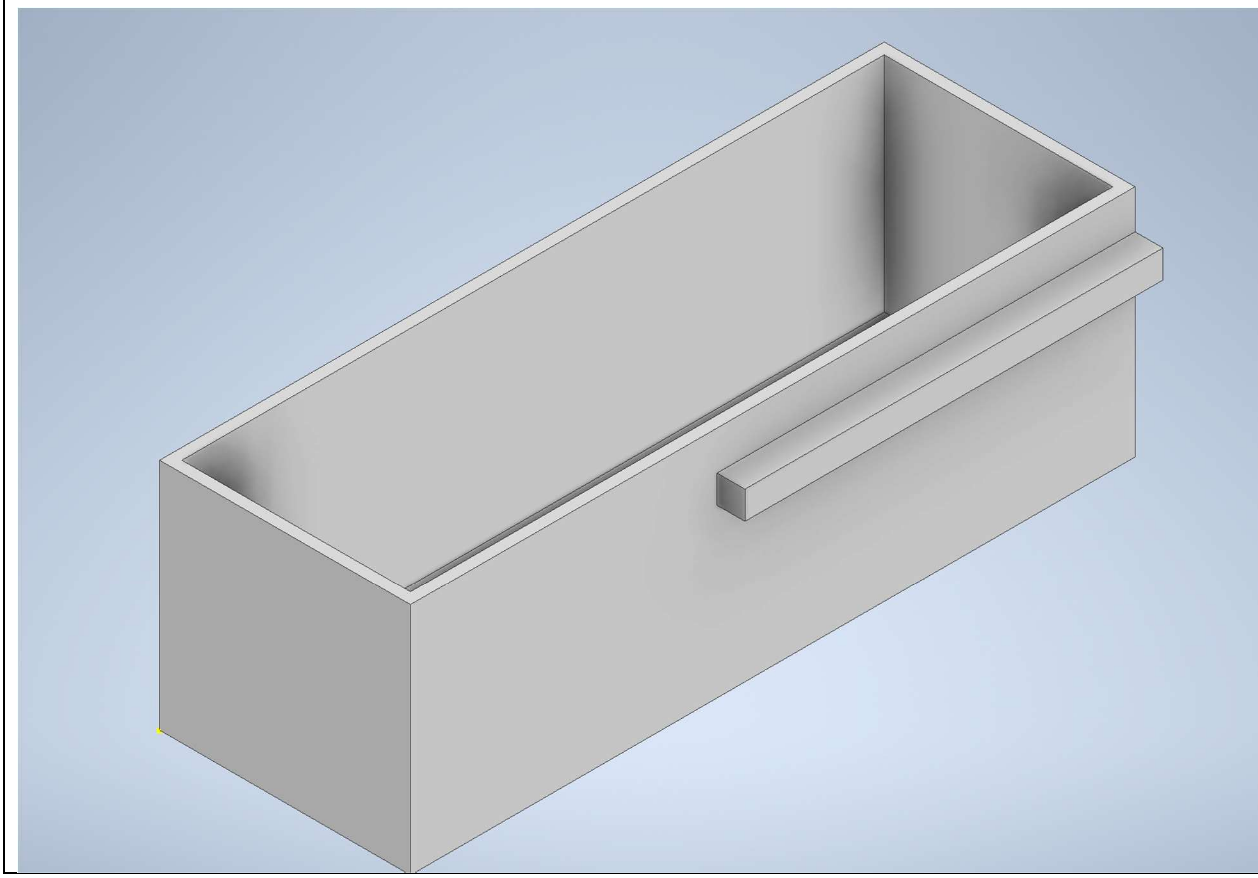
Complete this worksheet individually <u>during</u> Design Studio 8.

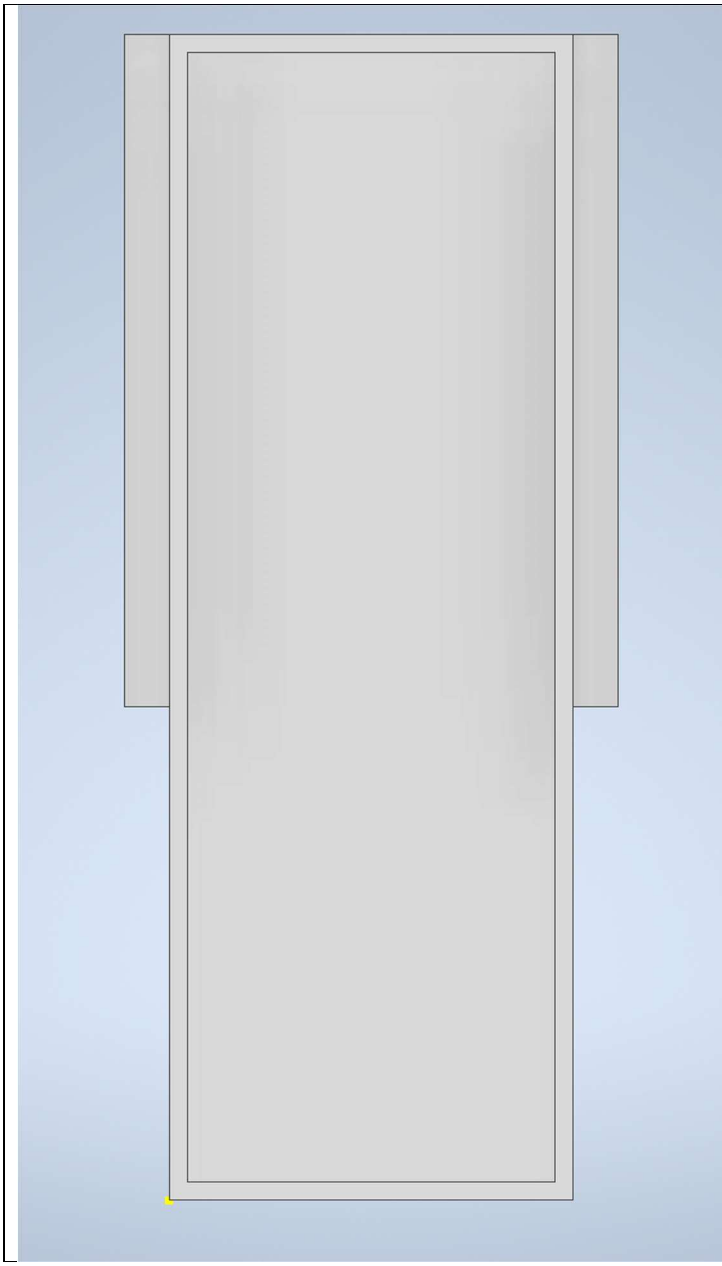
1. Take multiple screenshots of your preliminary solid model
   → You are also required to submit an IPT file of each solid model (see Submission Details section above)
   → Be sure to label model with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **<u>Do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

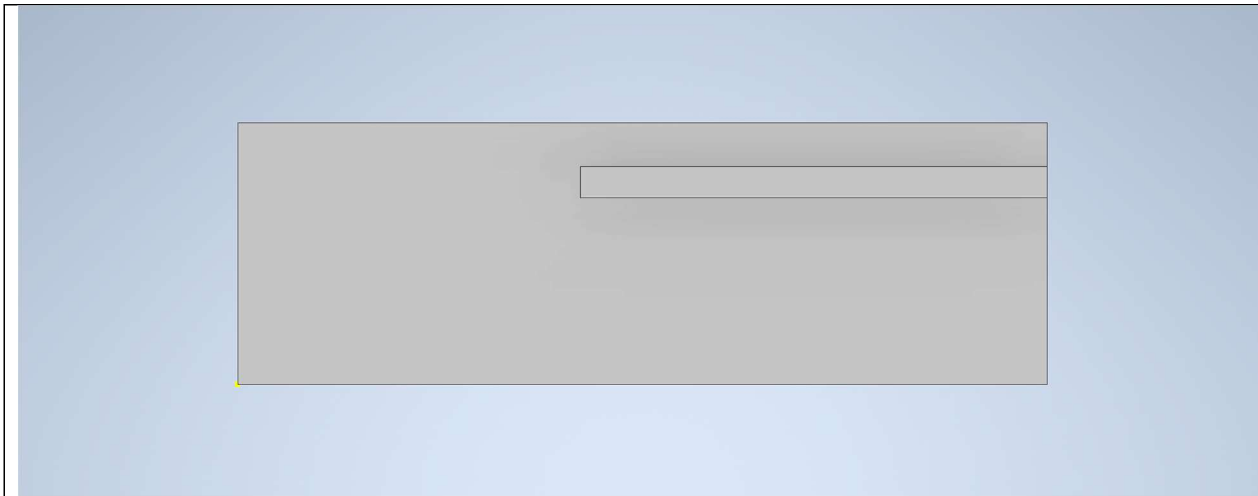
Team ID: Thurs-14

Name:Evan Hong	MacID honge14

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: Thurs-14

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:

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:

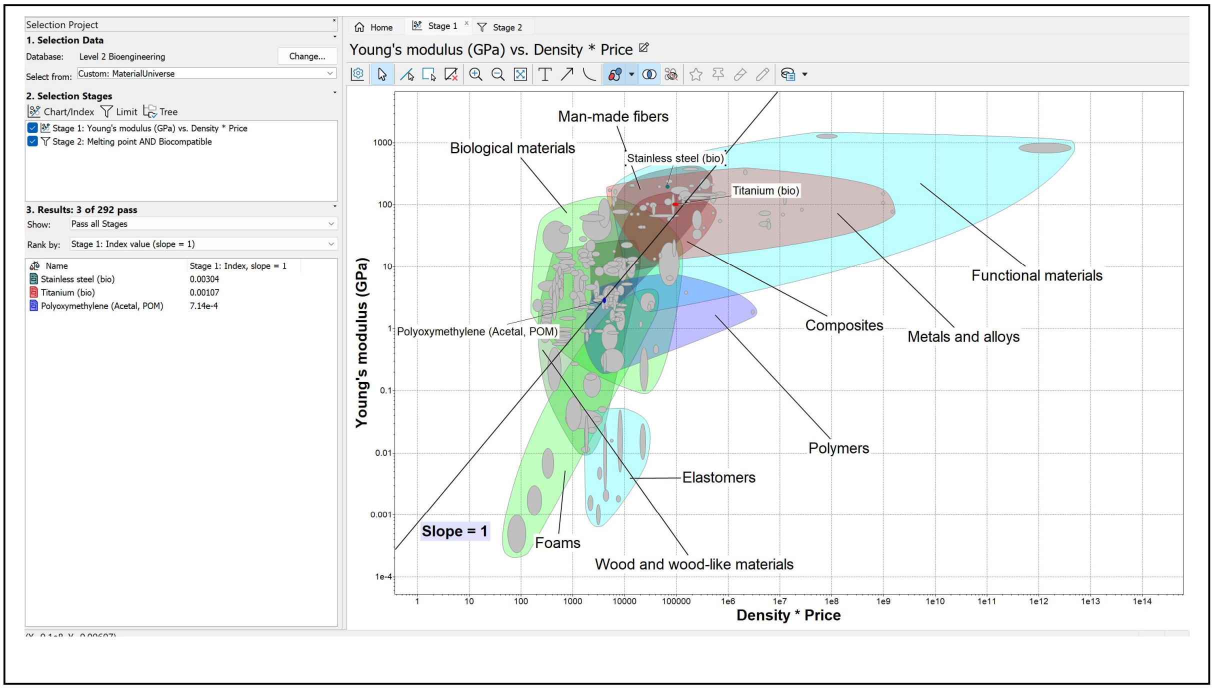
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Stiffness	$\frac{E}{\rho C_m}$	Minimize cost and mass
Please provide a short justification for your chosen design and MPI. The stiffness design with $\frac{E}{\rho C_m}$ as its mpi was chosen because the surgical tool's container is not being subjected to very large forces, but it will be undergoing high heat and It will hopefully be reused many times. If the stiffness is high, it should be able to withstand the high temperatures of the sterilization process without undergoing deformation and allow it to be reused for a long time.		

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

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 material Stainless steel (bio) was chosen because it ranked very highly in terms of Young's modulus while also meeting the other requirements of being biocompatible and have a high enough melting point of over 120 degrees C. Stainless steel is a strong, easily accessible and cheap metal, making it a good material that is suitable for mass production and sustained reusage. While titanium is a stronger, lighter and more corrosion resistant material, it is also very expensive and difficult to work with, and one of the main objectives is to minimize cost.	
References (If any): [1] R. Ahmed, "The difference between Titanium vs Steel?," Metal Supermarkets, https://www.metalsupermarkets.com/the-difference-between-titanium-vs-steel/ (accessed Nov. 26, 2023).	