Design Project 2 – Get a Grip

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial 03

Team Mon-39

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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.

Julianne Berniquer

JULIANNE BERNIQUER 400500325

(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.

Benjamin Semmler 400504135

Benjamin Semmler

(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.

Bacem Karray 400509045

BaceM Karray

(Student Signature) *

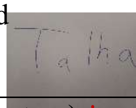
The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Camryn Lavigne 400505340

[illegible]

(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.

Talha Ahmad 

400517273

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(Student Signature) *

Executive Summary

The Artemis II mission intends to be the first crewed mission to return to the moon's surface by November 2024, the last crewed mission being the 1972 Apollo mission [1]. This expedition will perform a lunar flyby, meaning the spacecraft will pass closely around the moon's surface, gaining information about it. While also returning humans to the moon’s surface. In addition, the Lunar Gateway Program will also be established and carried through to establish a human outpost in lunar orbit, it being the first [1]. These missions are essential to the eventual mission to Mars.

The Canadian Space Agency and their partners NASA and ESA, foresee the use of robotic devices to perform experiments and tasks, along with operating the lunar outpost when a space crew isn’t present [1]. These robot devices are essential in the continuity of these missions and the development of future missions to other planets, such as Mars. More specifically, the use of robotic arms can help support the crew's health, by means of transporting and sterilizing surgical tools.

The approach to this project is designing a container that can securely hold a surgical tool and that is fit for effective sterilization. That container is then to be transferred, using a robot arm, into an autoclave for sterilization. For starters, autoclaves use steam under pressure to kill bacteria, meaning that the container for this tool cannot fully enclose the surgical tool, the steam needs to be able to access the tool [2]. Thus, adding slate-like cutouts to the sides, bottom, and lid of the container allows for a more effective and thorough sterilization.

Furthermore, the main advantage of the use of the robot arm is the improved security and efficiency they offer. Therefore, writing a computer program is imperative in addressing this problem, since it allows for even more autonomy, precision, and consistency. That computer

program would need to perform the tasks of picking up the container, transferring it to the correct autoclave bin, and repeating those same steps for the remainder of the surgical tools. The crew members should be able to assist in the movements of this robotic arm using two potentiometers controlled by them. The right allows the arm to rotate on its base, and the left assists in the drop-off motion. To conclude, having a container with an "open concept" design further promotes circulation within the container and a computer program for the robot arm allows for effective and efficient surgical tool sterilization. The crew for the Artemis II should greatly profit from this solution and be able to sterilize all the surgical tools they could possibly need with the utmost efficiency.

Main Body

Summary of Design Objectives

Objectives	Constraints	Functions
Simple operation: concise and efficient code, repeatability.	Weight and size of the Q arm and container: minimize weight and size to improve operation efficiency.	Pick up object.
Affordable: cheap material.	Grip strength: too strong will crush the container and not strong enough will make for inconsistent pick-up.	Move arm to displace object.
Durable: no material degradation due to the heat of the autoclave, no rusting of the Q arm,	Length of the arm: affects efficient of functionality.	Release object into designated autoclave.
Highly accurate functionality: no unpredictability in the code.	Speed of execution: too fast will make for inconsistent pick-up and drop-off, too slow will be inefficient.	Safely sterilize surgical tool.

Background and Research Summary

This project centered around transporting a surgical tool to and from an autoclave without a human physically intervening and touching the tools. To fulfill this goal, we used a robotic arm that held a sterilization cage with a preassigned tool in it. Our role as the engineers for this project was designing the sterilization cage as well as developing a program for the robotic arm to run on.

For the sterilization cage, the design had to easily fit inside the assigned footprint, which led to the development of a much smaller design. Moreover, despite the smaller design requirement, it was more important, given that functionality was our ultimate goal before all else for this project, to create a cage that perfectly fits and holds our assigned tool. A cage that does not perfectly hold the tool would be prone to having the tool fall out and as such would lead to a situation where, considering the use case, surgeons themselves may need to intervene and clean the tools themself. Considering that our project would be used in an operation theater while surgery is being performed, time might, in some cases, be a precious commodity. For this reason, our number one priority on the physical design side was to ensure that the tool was fully functional.

Regarding the program development side of this project, the main goals for the robotic arm were to pick up the tool, move it around, and drop it off. The robotic arm itself will be controlled through two potentiometers, both of which pass input and are responsible for selecting both a command as well as a position for that respective command. By using this potentiometer system, we can ensure that individuals present within the operating theater can control the robotic arm and fully sterilize the tools they wish to use without physically intervening.

For P2, we were responsible for designing a system with which a robotic arm could transport surgical tools to and from an autoclave. We designed both a sterilization cage which will hold the tool and be placed inside an autoclave, as well as a program that the robotic arm is run on. For both sides, we had to ensure that the system was fully functional with the provided resources. That is, the sterilization cage had to fit inside our assigned footprint and the program had to allow control by receiving input from potentiometers. These considerations forced us to create a design that while still fully functional, considers both aspects and builds upon them.

Description of Proposed Solution

The proposed solution to transfer unsterilized tools to their appropriate autoclave utilizes a robotic arm that takes inputs from two potentiometers to control the movement and drop-off of the tools. The computer program that runs this process takes input from the right potentiometer and calculates the difference between the current reading of the potentiometer versus the previous reading. This is done to determine how much to rotate the base of the robotic arm. Once the arm is in front of the correct autoclave the program will lock the arm in place and will terminate inputs from the right potentiometer until the tool is dropped off. Then the drop-off placement of the tool is determined by the left potentiometer readings, once the correct thresholds are met the arm will place the tool in the correct drop-off location and reset back to the home position ready to pick up the next tool.

The model was designed to maximize the surface area of the tool that is in direct contact with the steam while keeping it held securely. That was achieved by featuring diagonal steam vents along the sides of the model, as well as holes all along the bottom. The assigned tool rests on two ledges on the front and back and is prevented from moving forward and backward by a ring near the back. That, as opposed to having the tool rest on the bottom of the model, ensures that only a small surface area of the tool is not being directly sterilized. The two ledges are smoothed out so that over time, any inaccuracies in the Q-Arm that might make the tool hit the sides of the ledges when inserting the tool into the model will not cause the corners to be chipped away. The front and back sides do not have steam vents for increased structural stability.

Strengths and Limitations of Design

The program code has a variety of strengths and weaknesses. The strengths of the program code are that it is modular, consistent, and has a small margin for user error. Due to its modularity, it is easy to edit and reprogram for future uses. It is consistent and reproducible, i.e. it will drop off and pick up in the same locations every time thus allowing for reliable drop-off of tools. Finally, there is a small margin for user error, as the code has multiple fail-safes to stop the user from causing errors. The limitations of the program code are that it has fixed drop-off locations, however these can be easily edited, but cannot be changed while the program is running. Another limitation is that the program has fixed pick-up locations, thus if the tool is not placed properly the arm will not pick up the tool. Future considerations would be to devise a system for randomized drop-off locations and pick-up locations, although this would require some way of detecting the location of the tool.

The model itself has many strengths and few limitations. For starters, it contains many holes in the base and diagonal slits along the sides, as well as no cover for maximum steam flow to ensure that the tool will be sufficiently sterilized. The two ends of the model have gaps so that the tool can fit inside it (Figure 1). Not only does this minimize the materials used (because this design enables the model to be shorter than the length of the tool), but it also allows for the two ends of the tool to receive unrestricted access to the steam from the autoclave. That is especially important for the front of the tool, since in the context of surgeries, that portion will have the most contact with any living specimen. Because the two gaps enable the tool to only rest near the top of the model, there is plenty of space underneath the tool. Not only that, but the model is wide enough so that if the model is scaled up, the Q-Arm would have enough clearance to pick up the part easily. That is very crucial since it means that the Q-Arm will not need very precise positioning to pick up the part successfully. On top of that, the tool can be inverted and still fit in the model, which also serves to simplify the movements the Q-Arm needs to make to handle the tool. Another strength is that it is very well supported (primarily due to the oval protrusion), so the model can rapidly be moved and rotated and there would be no cause for concern of the tool falling out of the model. One limitation of the model is that the sides with the diagonal slits are weak due to the amount of empty space (Figure 2). However, this could be circumvented easily simply by making these sides thicker.

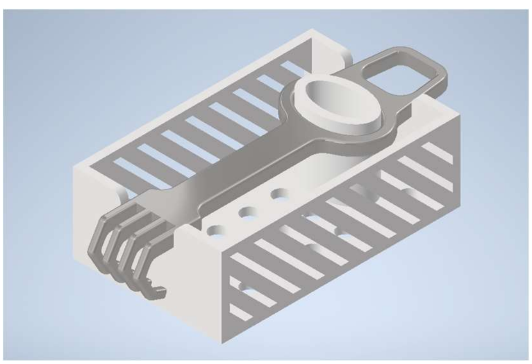


Figure 1

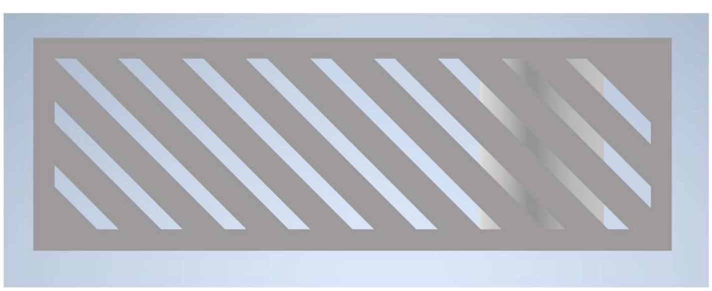


Figure 2

Summary of Contributions

Member	Contributions
Camryn Lavigne	Coordinator of the computing sub-team. Wrote the executive summary for the Design Report. Took notes and kept a logbook of additional meetings for computing sub-team.
Bacem Karray	All expected tasks assigned to Administrator 2. Wrote the strengths and limitations of the model design, as well as the modelling and fabrication portion of the proposed solution. Member of the modelling team.
Talha Ahmad	Coordinator of the modelling sub-team. Responsible for writing the Background and Research Summary.
Benjamin Semmler	Major contributor to program code. Wrote part of Description of Proposed solution and Strengths and Limitations. Administrator 1.
Julianne Berniquer	Project manager and member of the coding team. Wrote the summary of design objectives.

Reference List

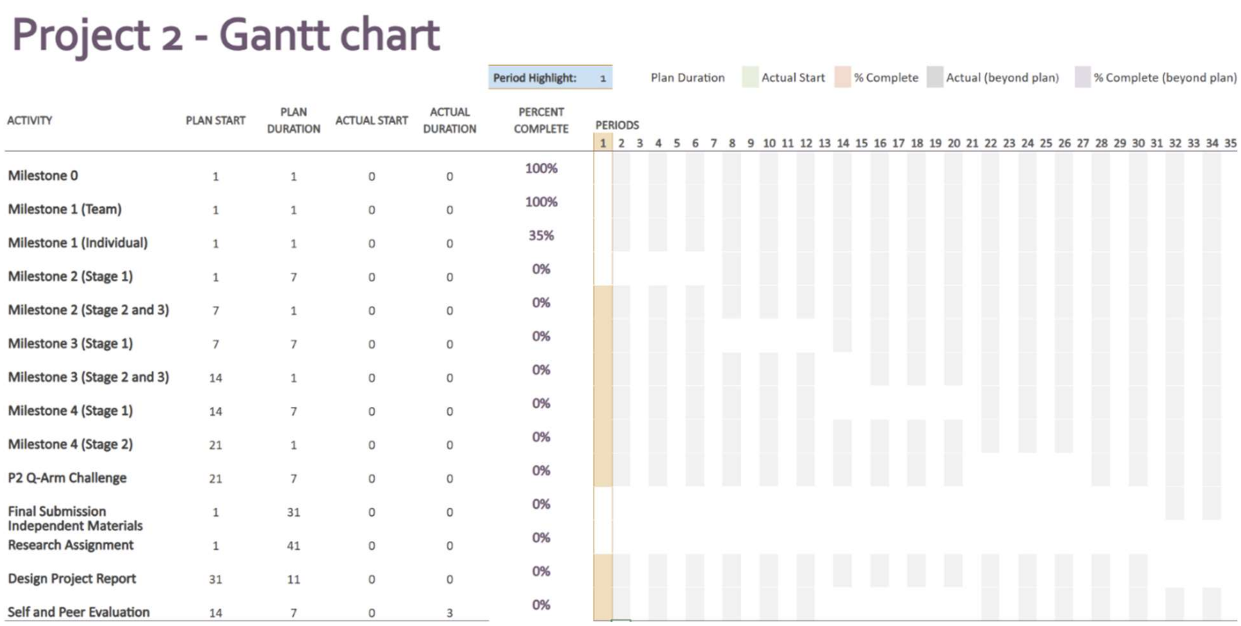
[1] “Engineer 1P13 – P2 Project Module.” Avenue to Learn. (accessed Dec. 6, 2023)

[2] “Steam sterilization,” Centers for Disease Control and Prevention, https://www.cdc.gov/infectioncontrol/guidelines/disinfection/sterilization/steam.html (accessed Dec. 6, 2023).

Appendices

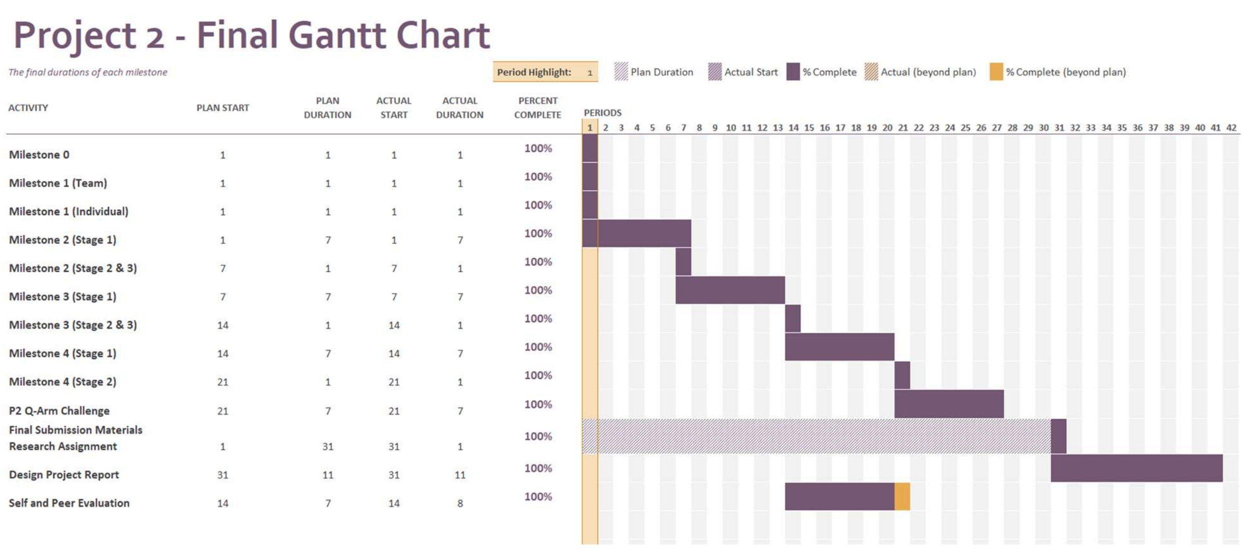
Appendix A: Project Schedule

Preliminary Gantt Chart



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	0	0	100%
Milestone 1 (Team)	1	1	0	0	100%
Milestone 1 (Individual)	1	1	0	0	35%
Milestone 2 (Stage 1)	1	7	0	0	0%
Milestone 2 (Stage 2 and 3)	7	1	0	0	0%
Milestone 3 (Stage 1)	7	7	0	0	0%
Milestone 3 (Stage 2 and 3)	14	1	0	0	0%
Milestone 4 (Stage 1)	14	7	0	0	0%
Milestone 4 (Stage 2)	21	1	0	0	0%
P2 Q-Arm Challenge	21	7	0	0	0%
Final Submission Independent Materials	1	31	0	0	0%
Research Assignment	1	41	0	0	0%
Design Project Report	31	11	0	0	0%
Self and Peer Evaluation	14	7	0	3	0%

Final Gantt Chart



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0	1	1	1	1	100%
Milestone 1 (Team)	1	1	1	1	100%
Milestone 1 (Individual)	1	1	1	1	100%
Milestone 2 (Stage 1)	1	7	1	7	100%
Milestone 2 (Stage 2 & 3)	7	1	7	1	100%
Milestone 3 (Stage 1)	7	7	7	7	100%
Milestone 3 (Stage 2 & 3)	14	1	14	1	100%
Milestone 4 (Stage 1)	14	7	14	7	100%
Milestone 4 (Stage 2)	21	1	21	1	100%
P2 Q-Arm Challenge	21	7	21	7	100%
Final Submission Materials Research Assignment	1	31	31	1	100%
Design Project Report	31	11	31	11	100%
Self and Peer Evaluation	14	7	14	8	100%

Logbook of additional meetings and discussions

ENGINEER 1P13

MEETING WITH TEAM 39 - MONDAY, NOV. 13, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Julianne Berniquer**	**berniquj**	**Yes**
Administrator 2	**Bacem Karray**	**karrayb**	**No**
Administrator 1	**Benjamin Semmler**	**semmlerb**	**Yes**
Coordinator 1	**Camryn Lavigne**	**lavignec**	**Yes**
Coordinator 2	**Talha Ahmad**	**ahmadt20**	**No**

AGENDA ITEMS

1. Completing pre-assignment for Milestone 3.
2. Looking at what going to happen in next design studio.

MEETING MINUTES

1. Looking over both the “Pick-up” and “Continue or Terminate” Pseudocodes that need to be written.
    a. Camryn opens the Detailed Project objectives #3 as a reference to know specifically what needs to be included in each pseudocode.
2. Julianne begins to write the Pick-up container pseudocode.
3. Benjamin begins to write the Continue or terminate pseudocode.

POST-MEETING ACTION ITEMS

1. *Review the worksheets for the next design studio, design studio 9 [All team computing sub—team members]*

ENGINEER 1P13
MEETING WITH TEAM 39 - MONDAY, NOV. 20, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	No
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	No
Coordinator 1	Camryn Lavigne	lavignec	No
Coordinator 2	Talha Ahmad	ahmadt20	Yes

AGENDA ITEMS

1. Making sure container design is ready for Design Review.
2. Refining container design making sure it complies with checklist and rubric.

MEETING MINUTES

1. Looking at the rubric before beginning.
2. Making sketches of possible container designs.
3. Exchanged ideas with each other.
    a. Talha suggested the tool slightly hang out of the box.
    b. Talha suggested adding diagonal slits for aesthetic purposes.
4. Bacem implemented the ideas and sketches into Inventor.
5. Final container design is forged in Inventor.

POST-MEETING ACTION ITEMS

1. *Additional Preparation for design review if needed. [Modelling sub—team]*

ENGINEER 1P13

MEETING WITH TEAM 39 - MONDAY, NOV. 20, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	Yes
Administrator 2	Bacem Karray	karrayb	No
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	No

AGENDA ITEMS

1. Complete the rest of the computer programs needed for Design Reviews in Milestone 4.
2. Get more refined drop-off locations.

MEETING MINUTES

1. Benjamin begins writing the terminate function.
2. Camryn finds better drop-off locations for each of the autoclaves.
    a. For both the small and large containers.
3. Julianne updates the drop-off function.
4. Updates are also made to the function containing location information for each of the containers.
5. Benjamin compiles all functions once they've been written and the drop of locations.
    a. Main() code is ran in Quanser, drop-off locations need to be a bit more precise.
6. Camryn finds new locations.
7. Julianne and Benjamin look at checklist for Design Review.
8. The code is run with the new locations.

POST-MEETING ACTION ITEMS

1. *Prepare for Design Reviews. [All team computing sub—team members]*

ENGINEER 1P13
MEETING WITH TEAM 39 - MONDAY, DEC. 4, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	No
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	No

AGENDA ITEMS

1. Going over Design Report.
2. Assigning tasks to team members.

MEETING MINUTES

1. Camryn ensured the document was shared with everyone in the team.
2. Benjamin listed the elements that needed to be discussed in the main body for the design report.
3. Decided which sub-teams would be best for certain parts of the main body.
    a. i.e. Benjamin and Bacem splitting up the description of the proposed solution, since they are on the computing sub-team and modelling sub-team respectively.
4. Communicated with the other members of the team who weren't able to attend the meeting.
    a. Talha and Julianne decided which part would be best for them based on their sub teams.
5. Discussed roles for the appendices.
    a. Benjamin and Bacem being aware of what their tasks are as administrators.
    b. Julianne knowing her tasks as manager.
    c. Camryn and Talha being aware of their tasks as coordinators.

POST-MEETING ACTION ITEMS

1. *Working on respective tasks before design report deadline. [All team members]*

ENGINEER 1P13

MEETING WITH TEAM 39 - MONDAY, DEC. 6, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	Yes
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	Yes

AGENDA ITEMS

1. Going over Design Report.
2. Finalizing all parts of main body.
3. Finalizing appendices.

MEETING MINUTES

1. Peer-reviewing each of the parts of the main body.
    a. Making modifications when necessary.
2. Ensuring all individual worksheets are sent to administrators.
    a. Bacem compiling them into a single pdf.
3. Compiling team worksheets into a single pdf and adding them to the Design Report
4. Ensuring all the meetings have been documented.
    a. Coordinators, Camryn and Talha, and manager, Julianne, collaborating on that.

POST-MEETING ACTION ITEMS

1. *Submitting finalized Design Report before deadline. [Administrator 2, Bacem]*

Appendix B: Scheduled Weekly Meeting

ENGINEER 1P13

MEETING WITH TEAM 39 - MONDAY, OCT. 30, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	Yes
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	Yes

AGENDA ITEMS

1. Determining and documenting administrative responsibilities for each team member.
2. Complete Milestone 1.

MEETING MINUTES

1. Took our team picture.
    a. Asked a TA to take the picture.
2. Split up into our sub teams.
    a. We looked over the P2P3 overview on Avenue to determine which sub-team we would want to be in for Project 2.
3. Determined which administrative roles we would be doing based on our previous roles.
    a. Made sure it aligned with our chosen sub-teams.
4. Began first stage of Milestone 1
    a. Completed list of objectives, constraints, and functions.
5. Began Stage 2
    a. As a team, we completed the morphological analysis.
6. Began Stage 3
    a. Split up into our individual sub-teams and completed the corresponding task in the individual worksheets.

POST-MEETING ACTION ITEMS

1. Completing and submitting our individual worksheets [All team members]
2. *Submitting the Milestone 0 Team Worksheets [Administrator 2]*
3. *Submitting the Milestone 1 Team Worksheets [Administrator 2]*
4. *Completing the Milestone 2 Individual worksheets prior to next design studio. [Both modelling and computation sub teams.]*

ENGINEER 1P13

MEETING WITH TEAM 39 - MONDAY, NOV.6, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	Yes
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	Yes

AGENDA ITEMS

1. Conceptualize the sterilization container and creating the preliminary model in inventor.
2. Conceptualize the operation of the robotic arm and creating a preliminary model in python.
3. Update TA on team progress.

MEETING MINUTES

1. Split-up into our sub-teams and going over our individual pre-design studio work.
    a. Modeling Sub-team made observations on their low-fidelity prototypes.
    b. Computation Sub-Team exchanged pseudocodes and discussed the similarities and differences between them.
2. Computation Sub-team combining individual pseudocodes into one revised pseudocode.
    a. Some pseudocodes did not include potentiometers or repeating loop, so those were added into the revised pseudocodes.
3. For stage 3, modelling sub-team creating their preliminary solid model in Autodesk Inventor
4. For stage 3, each member of computation sub-team working on two separate functions.
    a. Camryn doing the drop-off function.
    b. Benjamin and Julianne completing the Rotate Q-Arm base function.

POST-MEETING ACTION ITEMS

1. *Completing and submitted our individual worksheets for Milestone 2. [Each member of both Sub-Teams]*
2. *Submitting Milestone 2 Computation Sub-Team Team worksheet. [Administrator 1, Benjamin]*
3. *Submitting Milestone 2 Modelling Sub-Team Team worksheet. [Administrator 2, Bacem]*
4. *Begin the preliminary tasks for Milestone 3, before design studio 9 [All team members]*

ENGINEER 1P13

MEETING WITH TEAM 39 - MONDAY, NOV. 13, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	Yes
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	Yes

AGENDA ITEMS

1. Sterilization container design evaluation for modelling sub-team
2. Code Peer-Review for computation sub-team
3. Complete preliminary design reviews.

MEETING MINUTES

1. Bacem and Talha, members of modelling sub-team, share their preliminary solid model designs.
    a. Together they compile their list of criteria for a sterilization container and complete the evaluation by using the Pugh matrix worksheet.
2. Members of computation sub team, Julianne, Camryn and Benjamin, exchange their python codes based on their assigned tasks.
    a. Documenting observations and errors found in the code. We noticed that there were differences in the autoclave functions such as the existence of an "s".
3. TA comes around for the meeting.
    a. Each sub-team presents their design/code to TA.
4. Modelling team received TA feedback on their design.
    a. The design was too large to fit inside assigned footprint, therefore it needs to be modified.
    b. The design needs to be more "open concept" to allow for better steam flow during sterilization.

POST-MEETING ACTION ITEMS

1. *Completing and submitting Milestone 3 Computation Sub-Team Team worksheet. [Administrator 1, Benjamin]*
2. *Completing and submitting Milestone 3 Modelling Sub-Team Team worksheet. [Administrator 2, Bacem]*
3. Creating an outline for the Preliminary design review. [Manager]
4. *Creating a finalized design for the sterilization container [Modelling Sub-team, Bacem and Talha]*
5. *Writing part of the program, making sure they align with outlined tasks in Project Objective #3 [Computation Sub-Team, Benjamin, Camryn, and Julianne.]*

ENGINEER 1P13

MEETING WITH TEAM 39 - MONDAY, NOV. 20, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	Yes
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	Yes

AGENDA ITEMS

1. Making sure the checklist is completed for both individual sub-teams prior to meeting.
2. Design review and feedback with TA.

MEETING MINUTES

1. Modelling sub-team presenting finalized sterilization model with TA.
   a. Their design did not need any refinement and passed the design review.
2. Computation sub-team present their final program code and demonstrate its functionality in Quanser.
   a. Received and documented minor feedback, such as adding a bit more comments in the code.
   b. Otherwise passed the design review.
3. Talha documents the feedback during the reviews.
4. Incorporating feedback
   a. Computation sub-team adding more comments to code and refining the drop-off locations even more.
5. Modelling sub-team acquires printing approval for design.

POST-MEETING ACTION ITEMS

1. *Completing and submitted our individual worksheets for milestone 2. [Each member of both Sub-Teams]*
2. *Submitting Milestone 4 Computation Sub-Team Team worksheet. [Administrator 1, Benjamin]*
3. *Submitting Milestone 4 Modelling Sub-Team Team worksheet. [Administrator 2, Bacem]*
4. *Completing and Submitting Independent Materials Research Assignment [Each Project Group member]*

ENGINEER 1P13
MEETING WITH TEAM 39 - MONDAY, NOV. 27, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Julianne Berniquer	berniquj	Yes
Administrator 2	Bacem Karray	karrayb	Yes
Administrator 1	Benjamin Semmler	semmlerb	Yes
Coordinator 1	Camryn Lavigne	lavignec	Yes
Coordinator 2	Talha Ahmad	ahmadt20	Yes

AGENDA ITEMS

1. Making sure the container is printed correctly.
2. More testing for the computer program and making sure its ready for the project demonstration and interview.

MEETING MINUTES

1. Modelling sub-team, Bacem and Talha, file down the supports, making sure the edges of the container are smooth after it has been printed.
2. Computing sub-team tests computer program.
    a. Checking for consistency of drop-off locations in Quanser.
    b. Making any adjustments to the code, if necessary, like further organization and comments.
3. Began creating the document for the Design Report.
    a. Modifying the template and adding the elements needed for this specific project.

POST-MEETING ACTION ITEMS

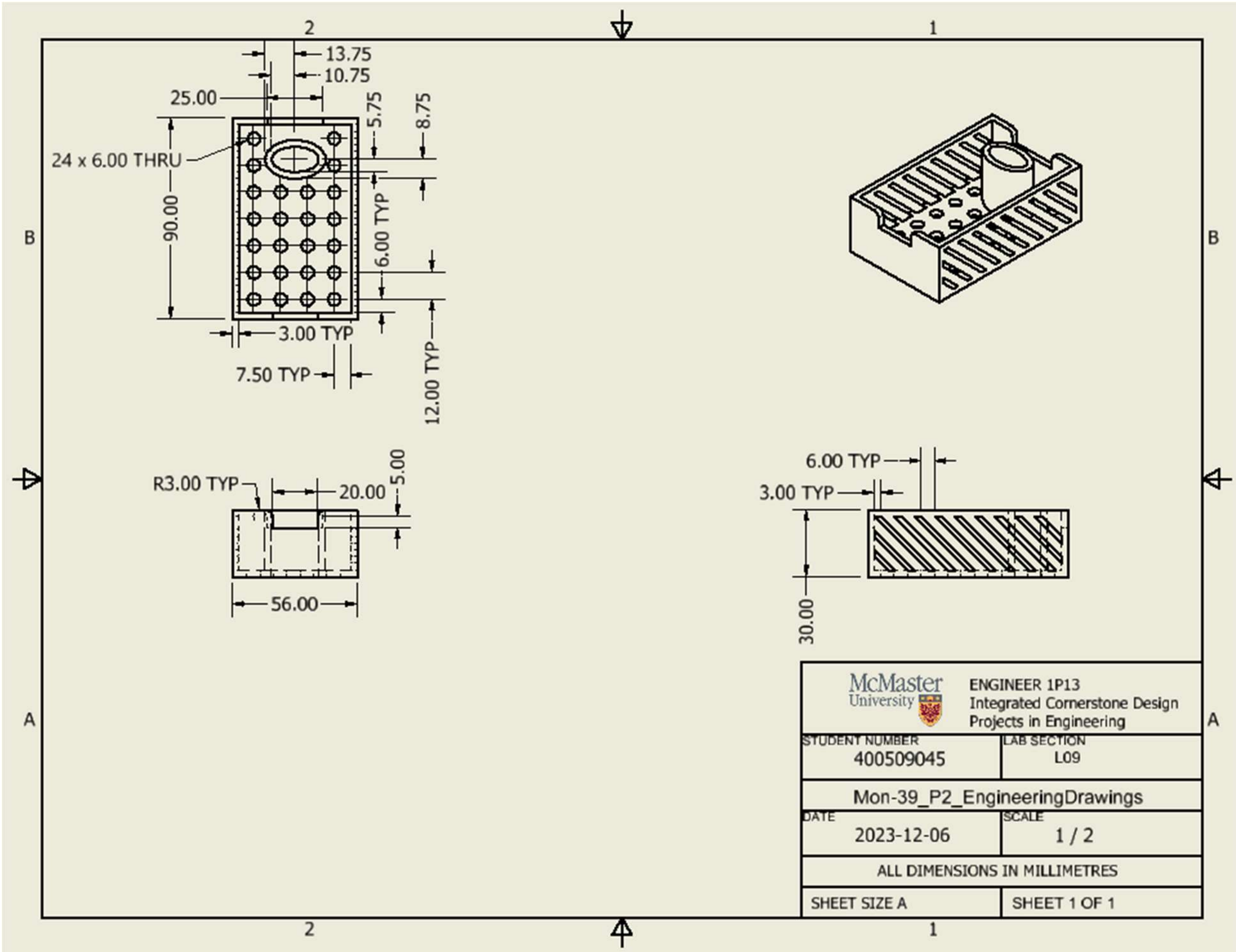
1. *Submitting the Final Sterilization Container Design prior to Project Interview [Administrator 2, Bacem]*
2. *Submitting the Final Computer Program prior to Project Interview [Administrator 1, Benjamin]*
3. *Beginning the Design Report [All team members]*
4. *Preparing for Interviews. [All team members]*

Appendix C: Additional Documentation

Source Materials Database:

Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023

(https://www.ansys.com/materials) (accessed Nov. 27, 2023)


13.75
10.75
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24 x 6.00 THRU
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12.00 TYP
R3.00 TYP
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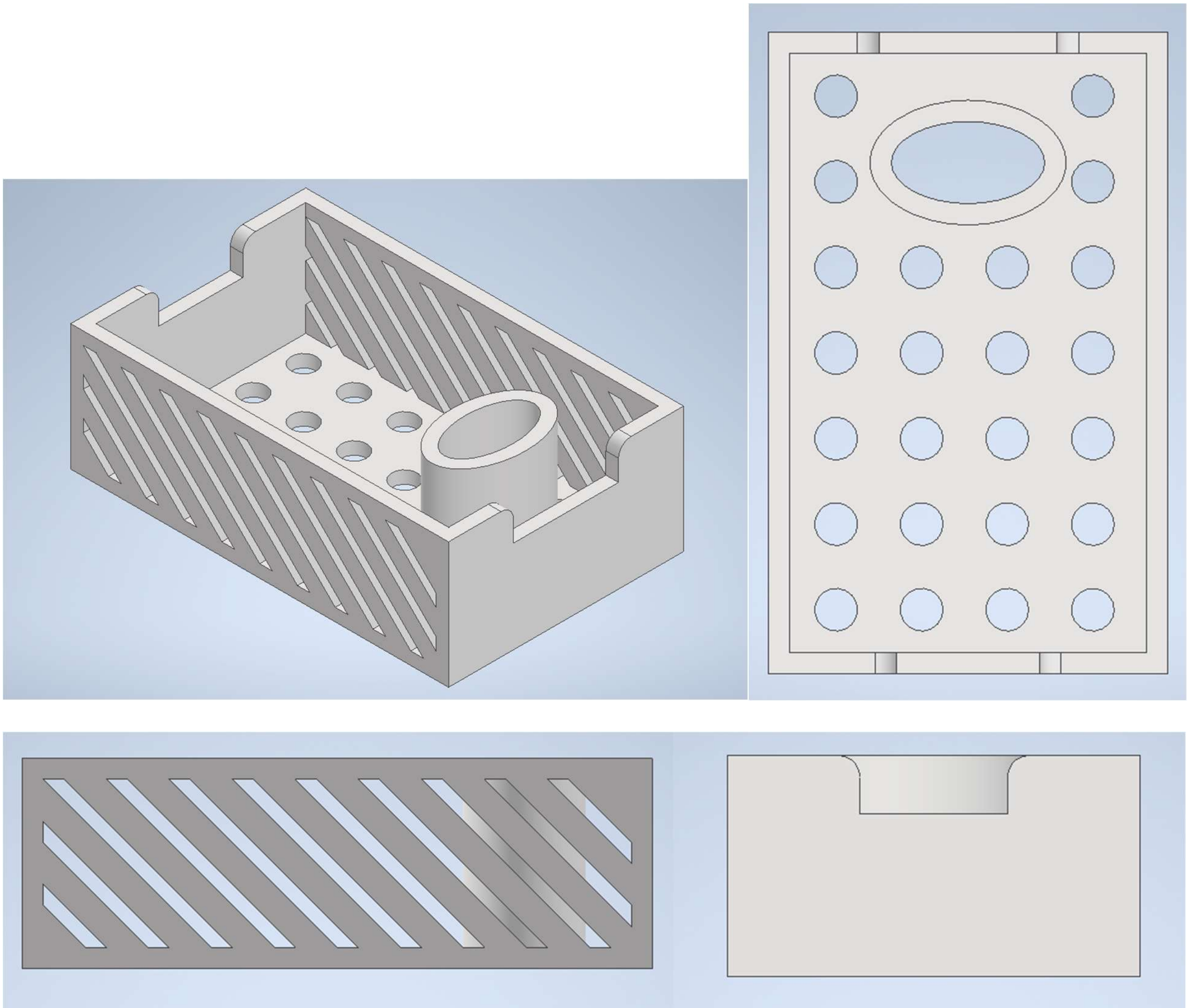
56.00
6.00 TYP
3.00 TYP
30.00
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
400509045
LAB SECTION
L09
Mon-39_P2_EngineeringDrawings
DATE
2023-12-06
SCALE
1 / 2
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1



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

# Code created by Mon-39
# This code will run a full cycle of picking up and dropping off all six types of boxes
# Benjamin Semmler - semmlerb
# Julianne Berniquer - berniquj
# Camryn Lavigne - lavignec


#written by Camryn Lavigne
def terminate(unclean,pickedup):#gets 2 lists, unclean being not picked up items and picked up items already put away
    if(len(unclean) == 0 or len(pickedup) == 6):
        return (True)
    else:
        return (False)
```

```python
#written by Benjamin Semmler, Cameryn Lavigne and Julianne Berniquer
def rotation_of_arm(loc, colour): #Rotates the arm based off of potentiometer readings
    end = False
    old_reading = potentiometer.right()
    while not end: #Loops until arm is in the proper location
        if(arm.check_autoclave(colour)==False):
            new_reading = potentiometer.right()
            delta = new_reading - old_reading
            increment = 348*delta
            arm.rotate_base(increment)
            time.sleep(0.2)
            old_reading = new_reading
        elif (arm.check_autoclave(colour)==True):
            end = True

#written by Benjamin Semmler
def drop_off(colour,size,loc): #drops off the box at the determined locations either in or ontop of container & colour.
    boolean = True
    while boolean:
        reading = potentiometer.left()
        if (reading > 0.5 and reading < 1 and size == 'small'): #This if else statement decides where the arm drops off the box
            arm.move_arm(loc[0],loc[1],loc[2])
            time.sleep(2)
            arm.control_gripper(-45)
            boolean = False
        elif(reading==1 and size == 'large'):
            arm.open_autoclave(colour,True)
            time.sleep(2)
            arm.move_arm(loc[0],loc[1],loc[2])
            time.sleep(2)
            arm.control_gripper(-45)
            boolean = False
    time.sleep(1)
    goHome()
    arm.open_autoclave(colour,False)
```

```python
#written by Julianne Berniquer
def pick_up(loc):#Picks up box and returns home, input box pickup location
    arm.move_arm(loc[0],loc[1],loc[2])
    time.sleep(1)
    arm.control_gripper(45)
    time.sleep(1)
    goHome()

#Written by Benjamin Semmler
def selectlistrand (array): #selects a random entry number for a list
    length = len(array)-1
    listnum = random.randint(0,length)
    return (listnum)

#Written by Cameryn Lavigne
def getinfo(box): #Provides info on the boxes

    info = []

    if(box==1): #these boxes are small
        info = ['red','small',0.0,-0.658,0.320]
    elif(box==2):
        info = ['green','small',0.0,0.635,0.320]
    elif(box==3):
        info = ['blue','small',-0.620,0.230,0.310]
    elif(box==4): #boxes after this are large
        info = ['red','large',0.0,-0.440,0.190]
    elif(box==5):
        info = ['green','large',0.0,0.435,0.190]
    elif(box==6):
        info = ['blue','large',-0.450,0.157,0.190]

    return(info)
```

```
#written by Julianne Berniquer
def goHome(): #Go home
    arm.move_arm(0.406,0.0,0.483)
```

```
#written by Benjamin Semmler
def main ():
    arm.activate_autoclaves()
    arm.home()

    unclean = [1,2,3,4,5,6] #get box ids
    clean = []

    pickuploc = [0.612,0.043,0.011]

    end = terminate(unclean,clean)

    while not (end): #Loops until all boxes are dropped off
        reset = False
        num = unclean.pop(selectlistrand(unclean)) #removes entry from unclean saves as num

        clean.append(num)

        arm.spawn_cage(num)#spawns the cage from the randomly selected element in unclean

        box = getinfo(num) #gets a random element from the unclean list and gets the id information
        location = [box[2],box[3],box[4]]

        time.sleep(1)
        pick_up(pickuploc)
        time.sleep(1)
        rotation_of_arm(location,box[0])
        time.sleep(1)
        drop_off(box[0],box[1],location)
        print("Please reset the potentiometers to 0.5 or 50%")
        while not (reset): #This is here to make sure the potentiometers are put back to starting values otherwise the arm wont
            if(potentiometer.right()==0.5 and potentiometer.left()<=0.5):
                reset = True
        end = terminate(unclean,clean)
```

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-39

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

Full Name:	MacID:
Bacem Karray	karrayb
Camryn Lavigne	lavignec
Julianne Berniquer	berniquj
Talha Ahmad	ahmadt20
Benjamin Semmler	semmlerb

Insert your Team Portrait in the dialog box below

MILESTONE 0 – SUB-TEAM CHARTER

Team ID: Mon-39

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	Talha Ahmad
	Bacem Karray
Computing	Julianne Berniquer
	Camryn Lavigne
	Benjamin Semmler

MILESTONE 0 – TEAM CHARTER

Team ID: Mon-39

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Bacem Karray	☐M ☒A ☐C ☐S
2.	Julianne Berniquer	☒M ☐A ☐C ☐S
3.	Camryn Lavigne	☐M ☐A ☒C ☐S
4.	Benjamin Semmler	☐M ☒A ☐C ☐S
	Talha Ahmad	☐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	Julianne Berniquer	berniquj
Administrator 1	Benjamin Semmler	semmlerb
Administrator 2	Bacem Karray	karrayb
Coordinator 1	Camryn Lavigne	lavignec
Coordinator 2	Talha Ahmad	ahmadt20

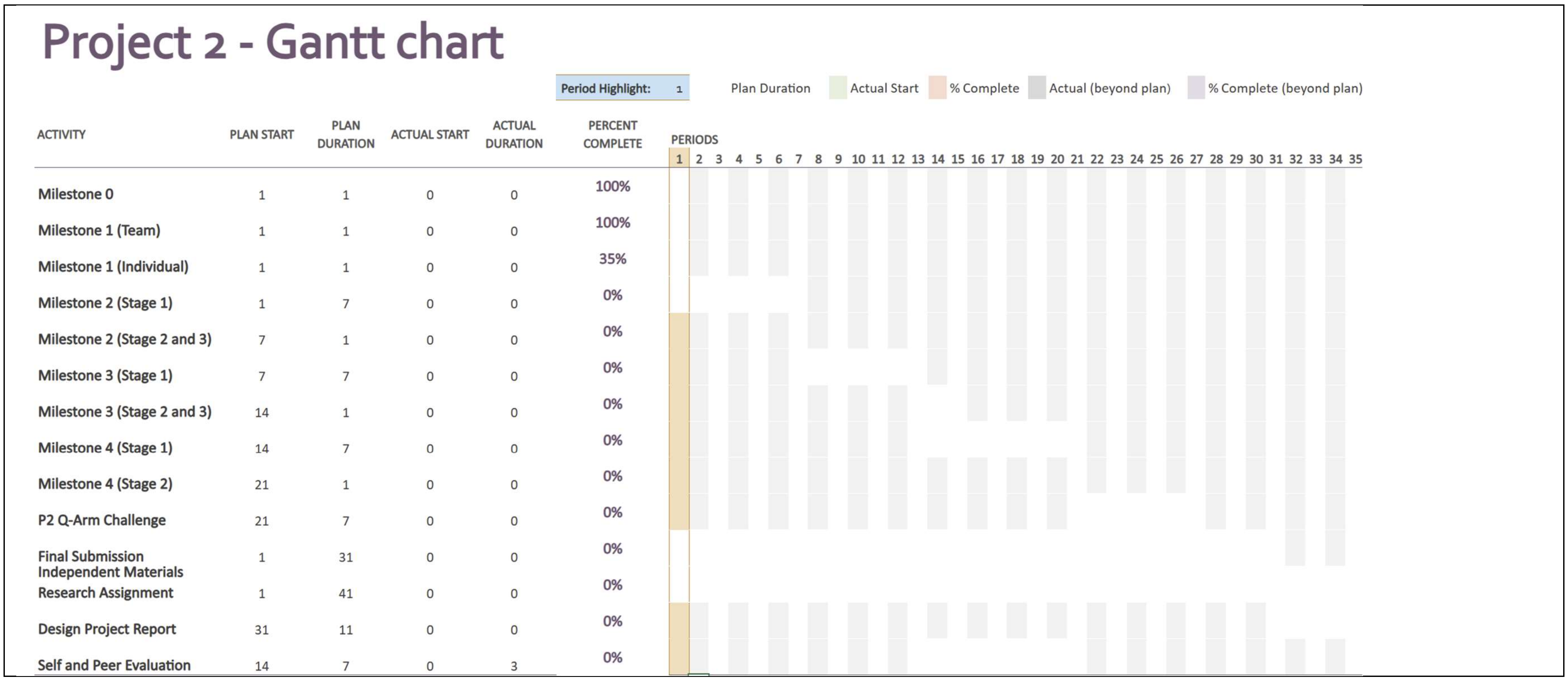
MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team ID: Mon-39

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

Full Name of Team Manager:	MacID:
Julianne Berniquer	berniquj

Preliminary Gantt chart:



Project 2 - Gantt chart

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	0	0	100%
Milestone 1 (Team)	1	1	0	0	100%
Milestone 1 (Individual)	1	1	0	0	35%
Milestone 2 (Stage 1)	1	7	0	0	0%
Milestone 2 (Stage 2 and 3)	7	1	0	0	0%
Milestone 3 (Stage 1)	7	7	0	0	0%
Milestone 3 (Stage 2 and 3)	14	1	0	0	0%
Milestone 4 (Stage 1)	14	7	0	0	0%
Milestone 4 (Stage 2)	21	1	0	0	0%
P2 Q-Arm Challenge	21	7	0	0	0%
Final Submission	1	31	0	0	0%
Independent Materials Research Assignment	1	41	0	0	0%
Design Project Report	31	11	0	0	0%
Self and Peer Evaluation	14	7	0	3	0%

PERIODS: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35

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

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team ID: Mon-39

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

Full Name:	MacID:
Bacem Karray	karrayb
Talha Ahmad	ahmadt20
Benjamin Semmler	semmlerb
Camryn Lavigne	lavignec
Julianne Berniquer	berniquj

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

Team ID: Mon-39

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
Easy to operate	Weight of the object	Pick up object
Affordable	Grip strength	Move arm to displace object
Durable	Length of the arm	Release object into matching container
High accuracy		Container holds the object
Repeatability		

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

Able to accurately transfer a surgical instrument in a container to a sterilization autoclave.

3. What are the secondary functions?

Safely pick up a surgical instrument container.
Displace the object.
Release object into matching sterilization autoclave gently.
Container holds object

MILESTONE 1 (STAGE 2) – MORPHOLOGICAL ANALYSIS

Team ID: Mon-39

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	Velcro on end of gripper	Hydraulics	Hooks	Magnets	Pneumatics	Bubble gum
Move arm	Strings attached to the arm to pull	Hydraulics	Nuclear power	Rail system	Chains hooked up to the arms to move it	Thrusters
Drop tools	Open gripper to pull away velcro	Hydraulics	Unhook	Open gripper to pull away magnets	Pneumatics	Unstick

MILESTONE TWO (TEAM): SUB-TEAMS, SKETCHES, & WORKFLOW

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team ID: Mon-39

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

Full Name:	MacID:
Julianne Berniquer	berniquj
Bacem Karray	karrayb
Benjamin Semmler	semmlerb
Talha Ahmad	ahmadt20
Camryn Lavigne	lavignec

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

Team ID: Mon-39

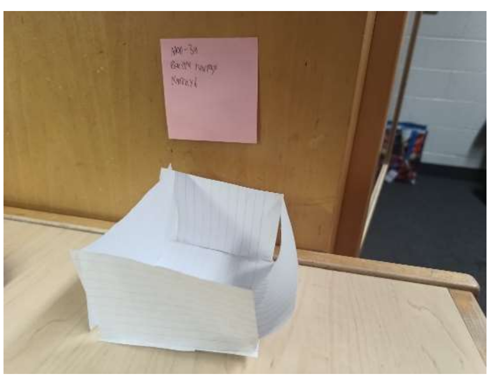
As a sub-team, document your observations for each low-fidelity prototype. Make sure to label your observations to indicate which prototype it belongs to. As a starting, consider the following: (note, this does not fully encompass all discussion points)

→ 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*** *(it should be clear which prototype you are referring to for each observation).*

Bacem's prototype:

- Solid and stable design.
- Minimalistic so low cost to mass produce and maintain.
- Design efficiency might be lacking because of there not being a closed top.
- Dangers of air and outside substances leaking in.
- Light so low pressure and stress on the Q-Arm, which would minimalize damage done on the outside.
- Aligns with the objective's constraints and functions list to a good extent since it is small and the Q-Arm will not struggle to carry it but it might be too small to hold some of the tools.



Talha's prototype:

- Solid structure, no to low risk of Q-arm damaging the model.

- Has a complex lid, which can be difficult to mass produce but ensures reliable security of the surgical tools.
- Since it can be fully sealed, it can allow for tool sterilization to a good extent.
- Large, so will require more precision from the Q-Arm to be able to grip the model.
- Aligns with the list of objectives, constraints, and functions to a good extent. While the Q-arm may struggle to consistently hold this container due to its size, it is both durable and light.

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

Team ID: Mon-39

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 flowchart in the space below. • *Some flowcharts did not have a repeat loop.* • *Some programs returned to home position before going to drop off and some didn't.* • *Some flowcharts included a potentiometer, and some didn't.* • *In general, most of our flowcharts were similar*

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

Team ID: Mon-39

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.

1. Arm at original position
2. Get location of pick up and drop off locations
3. Identify what object to pick up/drop off
4. Bring arm to pick-up position in front of object
5. Arm lowers to object
6. Grippers close on object
7. Arm raises with object
8. Arm moves to the correct container
9. Arm is at drop-off position
10. Object is lowered to container
11. Grippers open, objects is dropped in container
12. Arm raises upwards
13. Arm returns to position of origin
14. Repeat steps until all 6 container objects have been placed.
15. Program terminates

MILESTONE THREE (TEAM): PRELIMINARY MODEL & CODE

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team ID: Mon-39

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

Full Name:	MacID:
Julianne Berniquer	berniquj
Benjamin Semmler	semmlerb
Bacem Karray	karrayb
Talha Ahmad	ahmadt20
Camryn Lavigne	lavignec

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

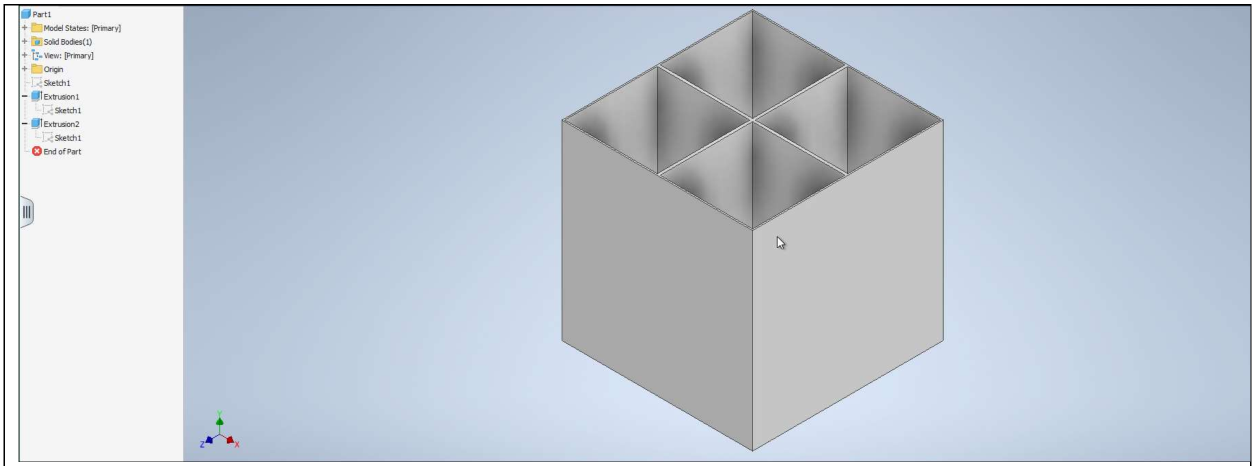
Team ID: Mon-39

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.
Talha's Container	Stable while still light	Prevents objects from dropping out while not exerting stress on the robotic arm.
	Airtight	Prevents exposure to outside elements which keeps the objects being sterilized clean.
	Large	The box should be able to fit a variety of tools in a single process, so the design should be big enough for this to happen.
Bacem's Container	Simple and minimalistic design	This product is to be used in medical offices, which means that it needs to be mass producible while relatively inexpensive. For this to happen, a simple design is necessary.
	Separations	To maximize the arm's accuracy, we have decided for the container to have separations with each instrument occupying a single area during each wash cycle.

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): Talha Ahmad	Name (Team Member #2): Bacem Karray
Insert an image of your solid model here.	


Part1
Model States: [Primary]
Solid Bodies(1)
View: [Primary]
Origin
Sketch1
Extrusion1
Sketch1
Extrusion2
Sketch1
End of Part

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

Team ID: Mon-39

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

Pick-up Container

1. Get position data
2. Move arm to box position.
3. Close gripper
4. Move arm to home position

Continue or Terminate Program

1. Have two lists containing information on non-picked up items, and put away items
2. If the non-picked item list still has stuff in it continue program
3. If the non- picked up list has nothing in it terminate program.

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

Team ID: Mon-39

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	Bacem Karray Design	Talha Ahmad Design	**Finalized Design**
Design allows steam to enter and sterilize tools adequately	S	-	-	-
Can be easily picked up by the robot arm	S	S	S	-
Securely holds the tool	S	-	-	+
Large enough for tools to fit inside	S	S	S	+
Fits inside of the footprint	S	-	-	-
Total +	0	0	0	2
Total –	0	3	3	3
Total Score	0	-3	-3	-1

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

2. Propose one or more design refinements moving forward.

- Have a more stable hold for robotic arm to hold on to. Can be accomplished by implementing indents on the sides to ensure a steady grip.
- Reduce the size so that it fits inside the footprint and add holes that allow steam to pass through and efficiently sterilize the tools. Alternatively, adjust the design to be larger laterally than vertically to allow for adequate steam passage.
- Remove the separators as they are not necessary. Securing the tool can instead be done by having the tools being put in slots.

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

Team ID: Mon-39

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**: Julianne
Enter code errors and/or observations here - Forgot to add "arm." - Incorrect indentation.	
Rotate Q-arm Base	**Team Member Name**: Benjamin
Enter code errors and/or observations here - Minor spelling errors. - Logic is there for the code.	
Drop-off Container & Return Home	**Team Member Name**: Camryn
Enter code errors and/or observations here - Used "&&" instead of the word "and" for if statement. - Forgot to put "arm." In front of "activate_autoclaves". - Added an unnecessary "s" to open in.	

*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.

- Added arm.check_autoclaves to ensure Q bot arm is within range of the autoclave.
- Pay more attention to spelling in order to avoid spelling errors.
- Change time.sleep to 5 in order to have more rest time.

MILESTONE 3 (STAGE 3) – PRELIMINARY DESIGN REVIEWS

Team ID: Mon-39

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.

Both sub-teams:

- Planning to pass the design review the first time to print as soon as possible.

Modelling sub-team:

- Sterilized container does not currently meet project objectives

Computing sub-team

- Show rotate base and drop-off functions.
- Changed arm.control_gripper in the drop-off function and the time.sleep function.

Modelling Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.

Our design was too large to fit inside our assigned footprint. Moreover, we aimed to make it way too complex which prevented our design from following the objectives.

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

Reduce the size and allow for steam flow.
Need to make the design more of an "open concept" for sterilization to be adequately performed.

Computing Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.

- Logic was there, minor errors in code.

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

- Fix minor errors in code.
- Need to adjust code so that the arm does not move automatically and moves with the potentiometer instead.

MILESTONE FOUR: DETAIL DESIGN (DESIGN REVIEW AND FEEDBACK)

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team ID: Mon-39

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

Full Name:	MacID:
Bacem Karray	karrayb
Julianne Berniquer	berniquj
Benjamin Semmler	semmlerb
Talha Ahmad	ahmadt20
Camryn Lavigne	lavignec

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-39

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.

No mentor comments.

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

No design refinements needed, design passed and was printed.

COMPUTATION SUB-TEAM

Team ID: Mon-39

☒ 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.

Define a home function. Add more comments.

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

Defining that home function. Added more comments to the code.

Project Two Worksheets (INDIVIDUAL)

TABLE OF CONTENTS

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

Team ID: Mon-39

Name: Camryn Lavigne	MacID: lavignec
Write your pseudocode in the space below 1. Arm at original position 2. Bring arm to pick-up position in front of object 3. Arm lowers to object 4. Grippers close on object 5. Arm raises with object 6. Arm moves to the correct container 7. Arm is at drop-off position 8. Object is lowered to container 9. Grippers open, objects is dropped in container 10. Arm raises upwards 11. Arm returns to position of origin 12. Repeat steps until all 6 container objects have been placed. 13. Program terminates	

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

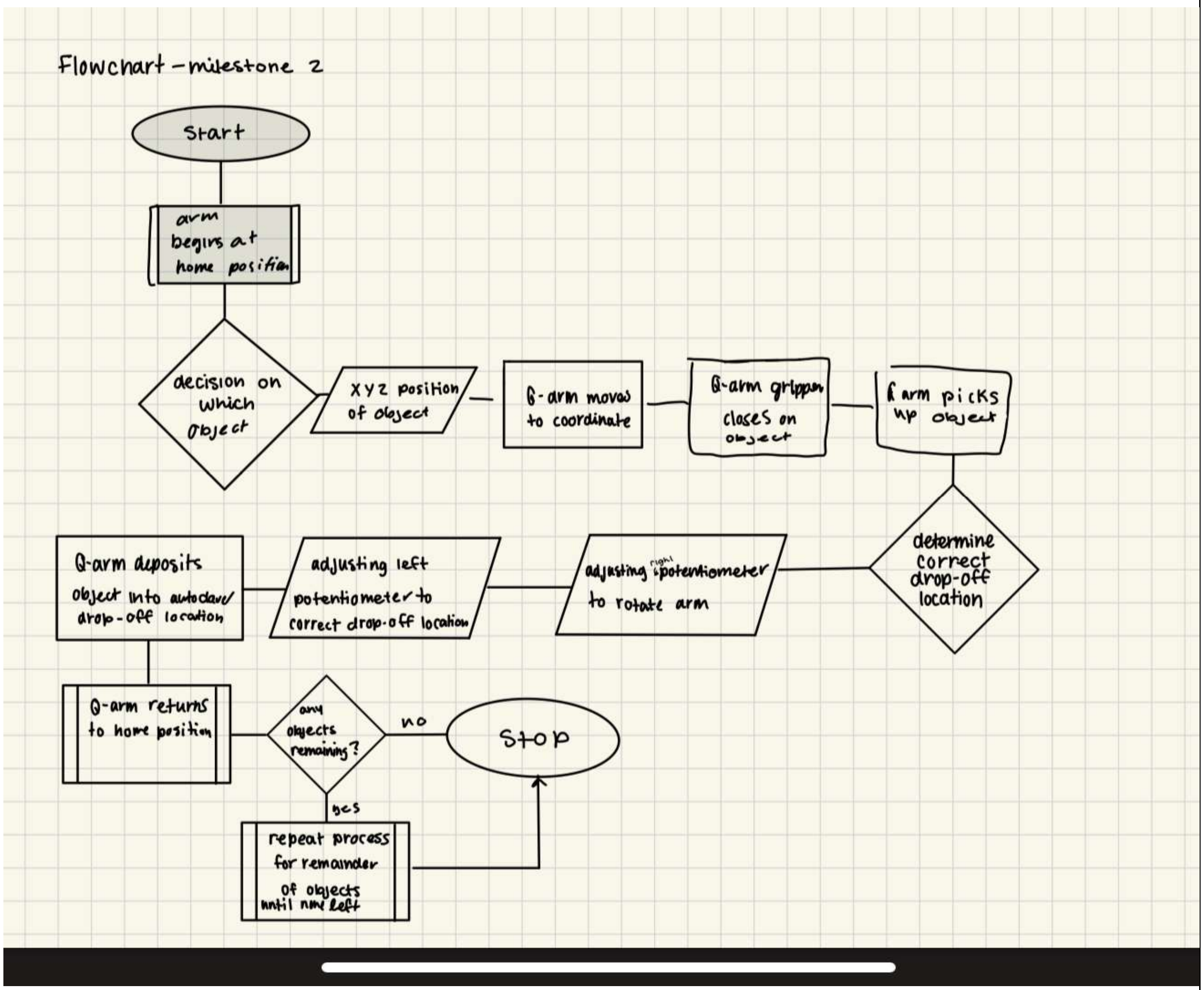
Team ID: Mon-39

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-39

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



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

Team ID: Mon-39

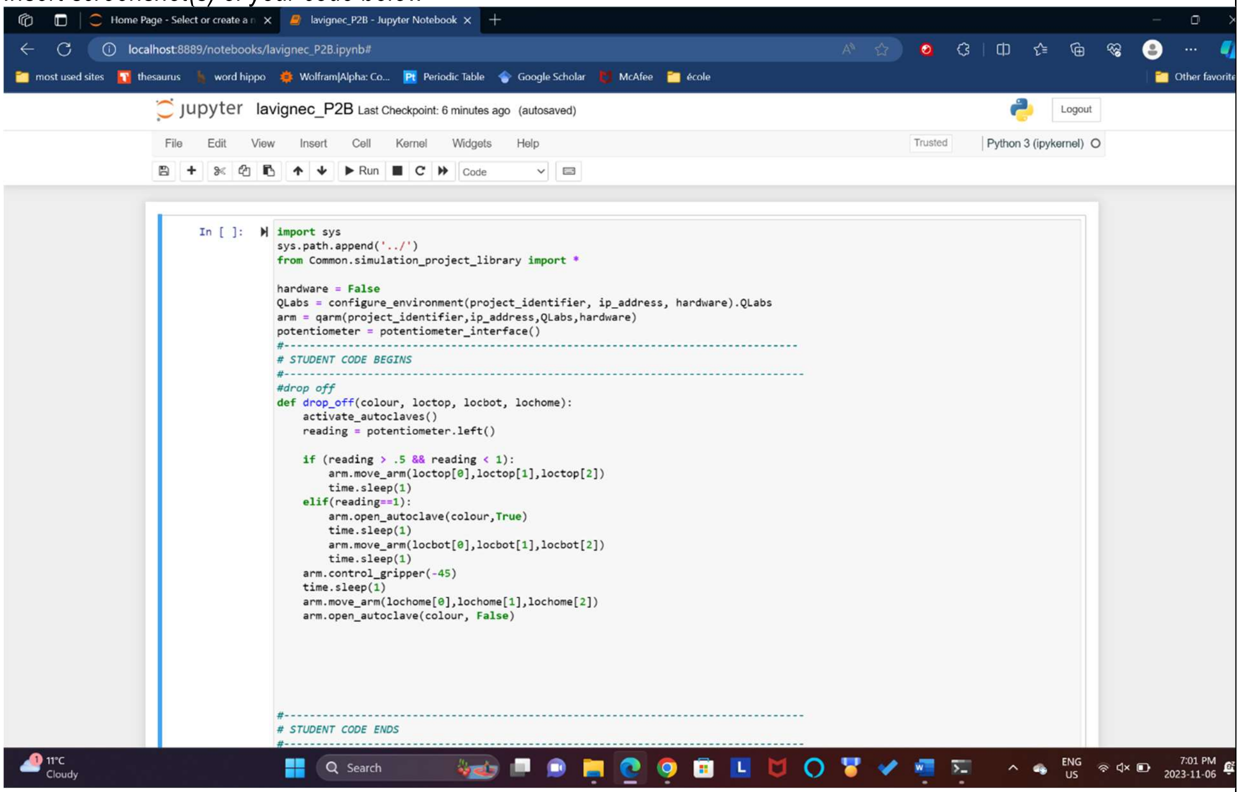
Complete this worksheet individually during Design Studio 8.

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-39

Name: Camryn Lavigne	MacID: lavignec

Insert screenshot(s) of your code below



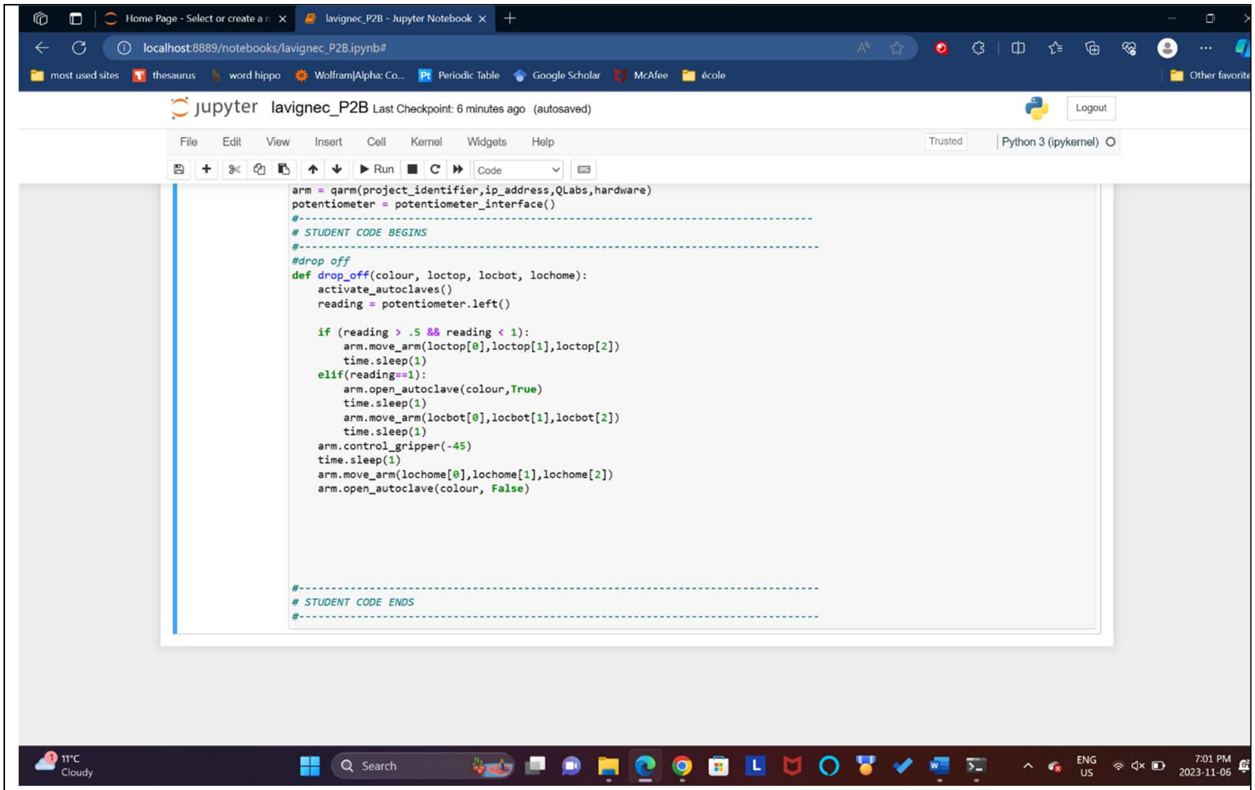

```python
import sys
sys.path.append('../')
from Common.simulation_project_library import *

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
#---------------------------------------------------------------------------------
#drop off
def drop_off(colour, loctop, locbot, lochome):
    activate_autoclaves()
    reading = potentiometer.left()

    if (reading > .5 && reading < 1):
        arm.move_arm(loctop[0],loctop[1],loctop[2])
        time.sleep(1)
    elif(reading==1):
        arm.open_autoclave(colour,True)
        time.sleep(1)
        arm.move_arm(locbot[0],locbot[1],locbot[2])
        time.sleep(1)
    arm.control_gripper(-45)
    time.sleep(1)
    arm.move_arm(lochome[0],lochome[1],lochome[2])
    arm.open_autoclave(colour, False)




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



```python
arm = qarm(project_identifier,ip_address,QLabs,hardware)
potentiometer = potentiometer_interface()
#---------------------------------------------------------------------------------
# STUDENT CODE BEGINS
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#drop off
def drop_off(colour, loctop, locbot, lochome):
    activate_autoclaves()
    reading = potentiometer.left()

    if (reading > .5 && reading < 1):
        arm.move_arm(loctop[0],loctop[1],loctop[2])
        time.sleep(1)
    elif(reading==1):
        arm.open_autoclave(colour,True)
        time.sleep(1)
        arm.move_arm(locbot[0],locbot[1],locbot[2])
        time.sleep(1)
    arm.control_gripper(-45)
    time.sleep(1)
    arm.move_arm(lochome[0],lochome[1],lochome[2])
    arm.open_autoclave(colour, False)




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

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:

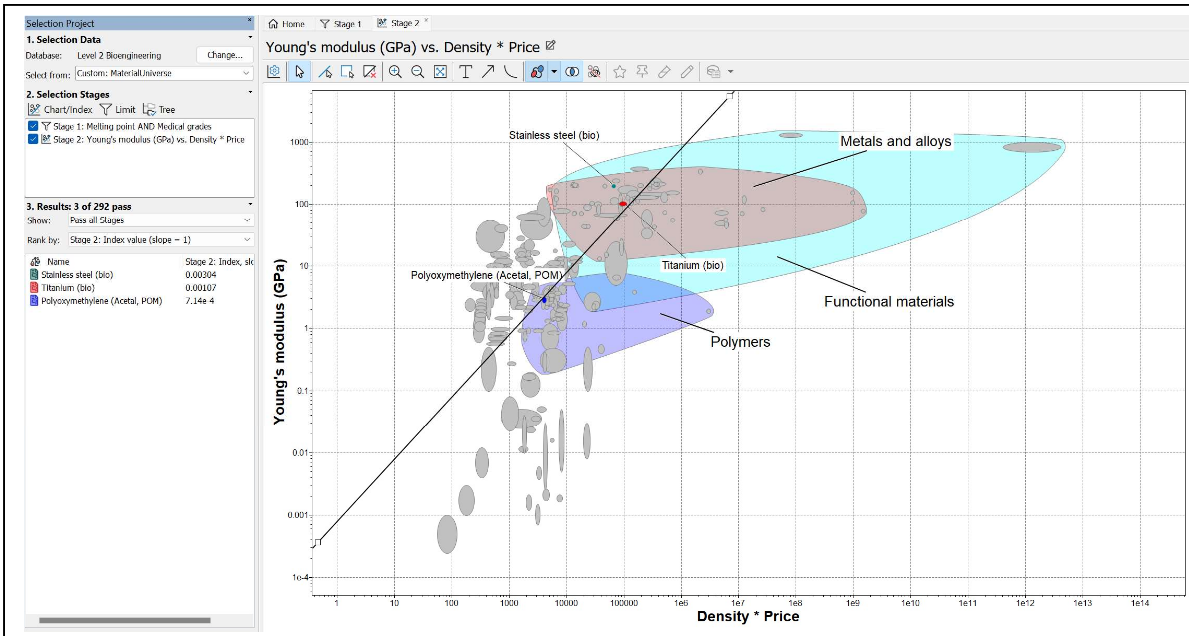
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

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 will be focusing on the stiffness design for this scenario. Seeing as the container will be used for sterilization and needs to withstand high temperatures and stiffness is related to melting point. Therefore, having a design relating to stiffness would be preferable.		

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
Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations). I chose stainless steel as my chosen material. My reasons being its high melting point and durability. For starters, in Granta, based on the MPI slope limited by stiffness, it is the most ideal. In addition, if the materials are ranked by melting points, Stainless steel is the highest with a melting point between 1.37e+3 - 2.4e+3°C [1]. This is preferable seeing as the container must hold objects for sterilization and withstand high melting points while doing so. Additionally, it is highly durable, non-corrosive and has a long lifespan. That explains why it is used so commonly in the medical industry and for items like jewelry and piercings. Furthermore, is relatively low cost. To conclude, I chose stainless steel as the material for my sterilization container based on an MPI limited by stiffness, due to its high melting point and durability.	
References (If any): [1] Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023 (https://www.ansys.com/materials) (accessed Nov. 27, 2023)	

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

Team ID: Mon-39

Name: Julianne Berniquer	MacID: berniquj

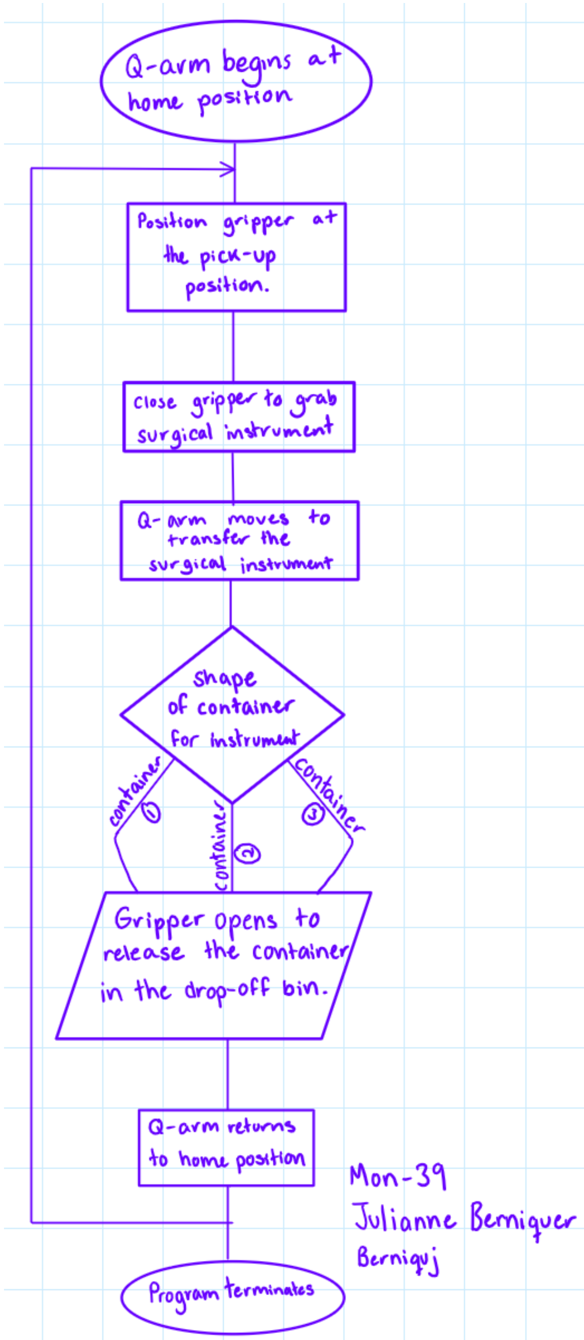
Write your pseudocode in the space below

1. Q-arm begins at the home position.
2. Position gripper at the pick-up position.
3. Close gripper to grab container.
4. Q-arm moves, transferring the container to the autoclave sterilizer.
5. Gripper opens to release the container in drop-off bin.
6. Q-arm returns to the home position.
7. The above steps are repeated until 6 container objects have been successfully transferred to autoclave.
8. Program terminates.

Team ID:	Mon-39

Name: Julianne Berniquer	MacID: berniquj

Insert screenshot(s) of your workflow below



Team ID: Mon-39

Name: Julianne Berniquer	MacID: berniquj

Insert screenshot(s) of your code below

```python
#!/usr/bin/env python
# coding: utf-8

# In[ ]:


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
#---------------------------------------------------------------------------------
#Base rotation
def rotation_of_arm(loc):
    end = False
    old_reading = potentiometer.right()
    locratio = loc[0]/loc[1] #gets the ratio of x and y coords

    while not end:
        effcloc = effector_position()
        effecratio = effecloc[0]/effecloc[1] #gets the ratio of sidelength of the triangle with sides x, and y
        if(locratio != effecratio):
            new_reading = potentiometer.right()
            delta = new_reading - old_reading
            increment = 348*delta
            arm.rotate_base(increment)
            time.sleep(0.2)
            old_reading = new_reading
        elif (locratio==effecratio)
            end = True

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

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:

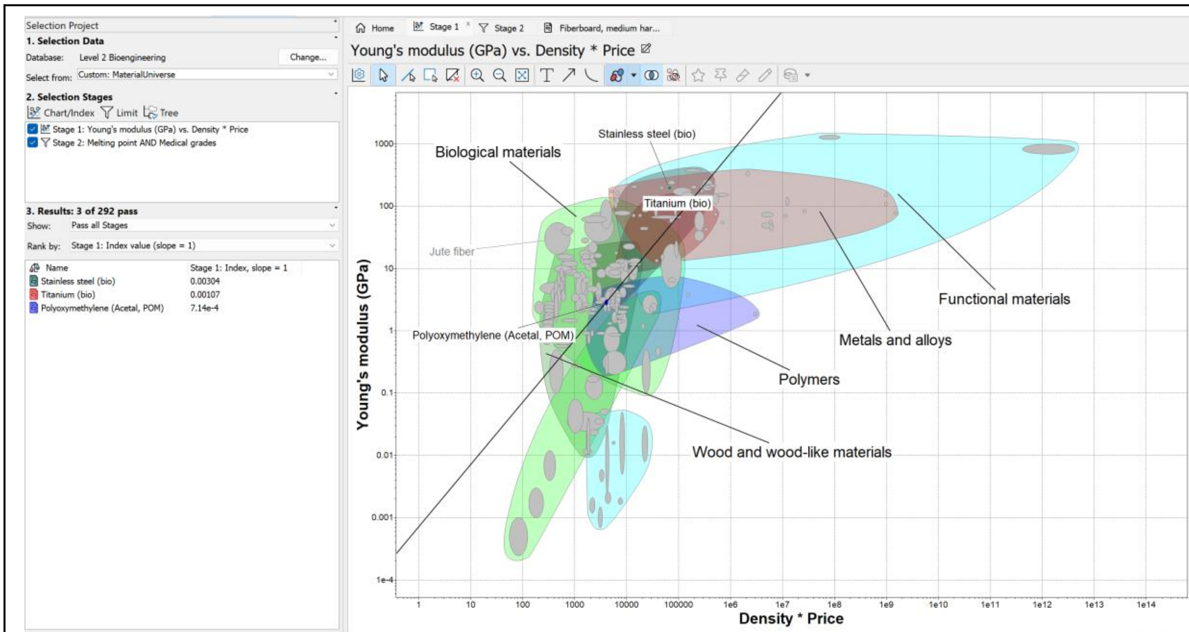
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

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 an important factor to consider while creating the container that will contain the surgical tool during the tool's sterilization period so that the material can maintain its shape while undergoing exposure to extreme heat. Most materials exposed to extreme heat experience reduced stiffness, our goal is to minimize the loss of stiffness by choosing a material who is very stiff to start off with so the application of heat does not change the shape of the 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:	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
Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations). Stainless steel has the best MPI for the assigned objective: maximizing stiffness and minimizing cost and density [1]. The young's modulus, which is the measurement of the elasticity and therefore stiffness of the material, is highest in stainless steel out of our top three options. We want a higher young's modulus because it increases the stiffness of the material. Although all three of our top materials present competitive qualities, stainless steel outputs the best possible combination of qualities as it is reasonably prices, very stiff, and most importantly has a high melting point [1]. The only downfall that stainless steel presents is its relatively high density. However, the container will be printed at such a small scale that the high density should not present any significant problems.	
References (If any): [1] Ansys GRANTA EduPack software, ANSYS, Inc., Cambridge, UK. 2023(www.ansys.com/materials)	

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

Team ID: Mon-39

Name: Benjamin Semmler	MacID: semmlerb

1) Have a starting position clear of boxes
2) Choose colour of small box to pick up
3) Identify location of small box
4) Move arm to small box
   - Rotate shoulder so that wrist is in-line with small box
5) Pick up small box
   - Rotate elbow to small box position
   - Rotate wrist to small box position
   - Close the grippers
   - Rotate elbow and wrist back up to initial position before picking up box
6) Identify location of large box
7) Move arm to large box
   - Rotate shoulder so that wrist is in-line with big box
8) Gently put down small box in big red box
   - Rotate elbow to big box position
   - Rotate wrist to big box position
   - Open grippers
   - Rotate both elbow and wrist to initial position before picking up box
9) Lift arm out of box and reset to starting position
10) Repeat for other box colours until no more small boxes are left

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

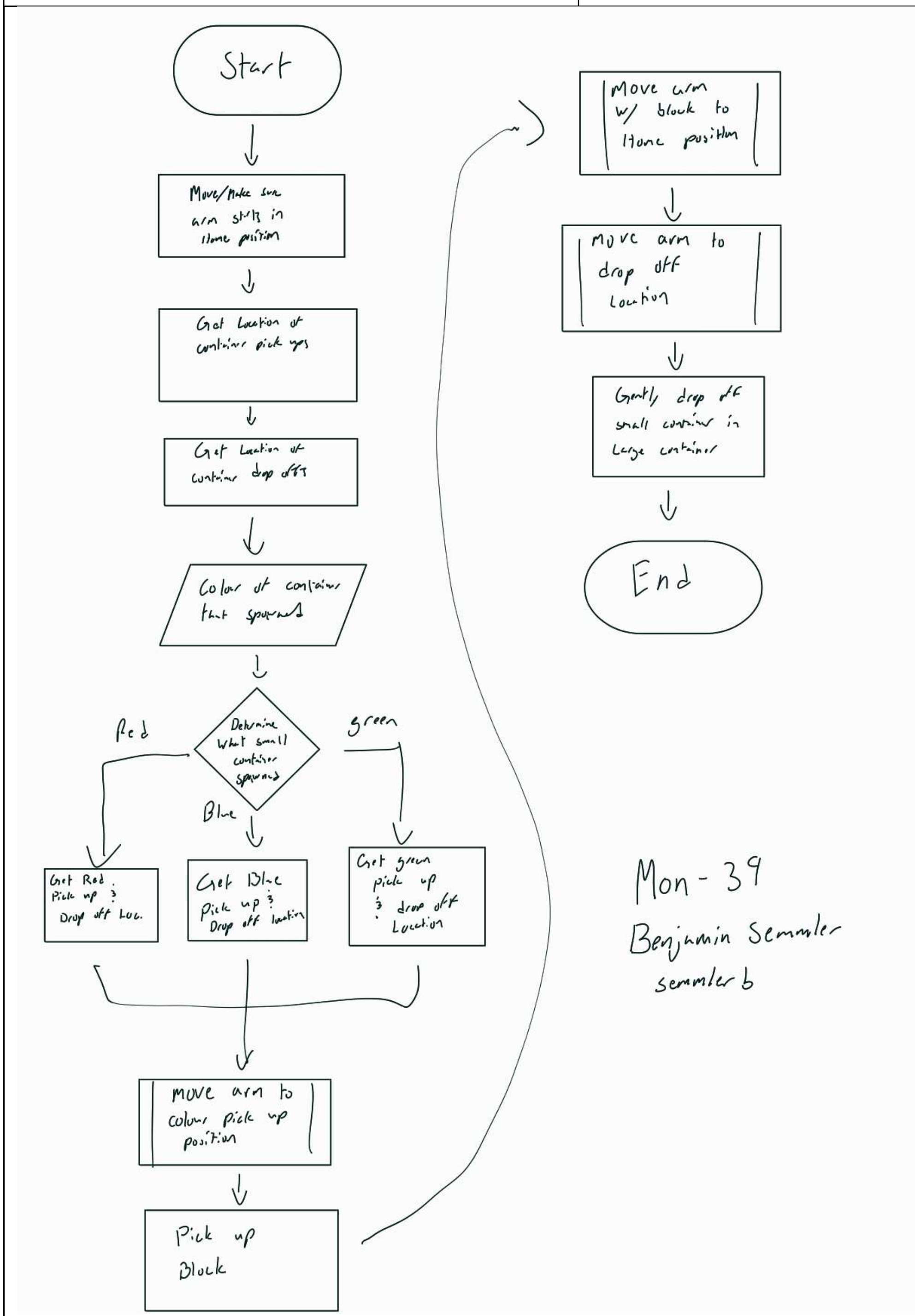
Team ID: Mon-39

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-39

Name: Benjamin Semmler	MacID: semmlerb



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

Team ID: Mon-39

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: Mon-39

Name:Benjamin Semmler	MacID: semmlerb

Insert screenshot(s) of your code below

```
#Base rotation
def rotation_of_arm(loc):
    end = False
    old_reading = potentiometer.right()
    locratio = loc[0]/loc[1] #gets the ratio of x and y coords

    while not end:
        effcloc = effector_position()
        effecratio = effecloc[0]/effecloc[1] #gets the ratio of sidelength of the triangle with sides x, and y
        if(locratio != effecratio):
            new_reading = potentiometer.right()
            delta = new_reading - old_reading
            increment = 348*delta
            arm.rotate_base(increment)
            time.sleep(0.2)
            old_reading = new_reading
        elif (locratio==effecratio)
            end = True
```

*Limit screenshots to no more than 1 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:

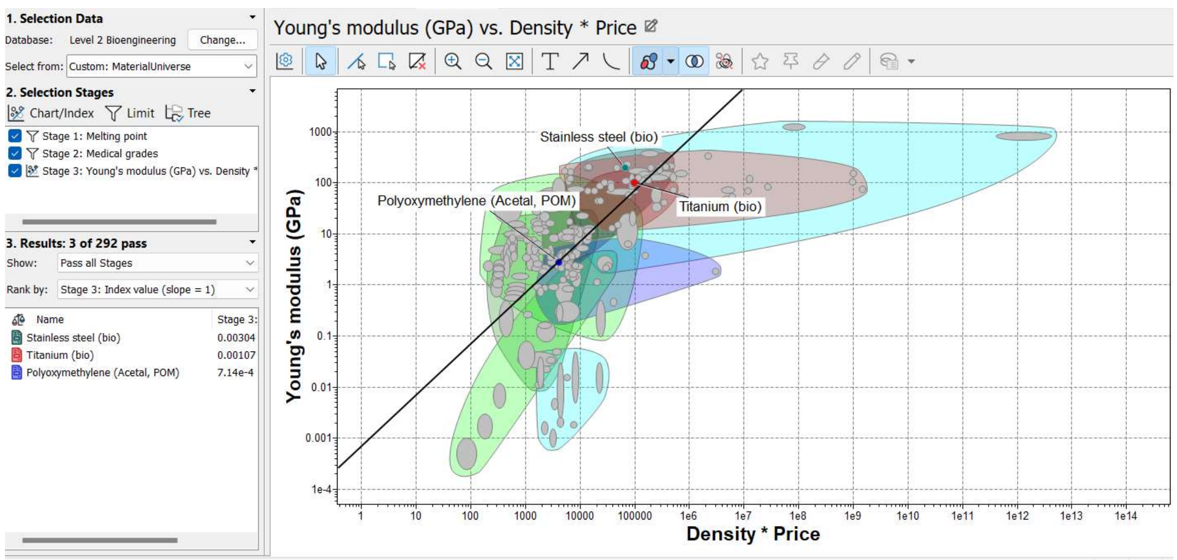
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

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 the stiffness design as we want to minimize the plastic deformation that occurs under high internal pressures, thus allowing us to reuse the 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: $\frac{E}{\rho C_m}$	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). I chose stainless steel as the material of choice for the container. This is due to its high melting point, high stiffness, it is ranking high on the index value, and its resistance to corrosion [1]. It is important that the material has a high melting point so that it does not melt under the high operating temperature. Stainless steels resistance to corrosion and inert-ness to organic material, make it an ideal material, as it means that the container will not react with nor degrade over time [1]. Increasing the lifetime of the container. Stainless steel is already commonly used in medical settings, and along with its stiffness make it an ideal material to use for the container [1].	
References (If any): [1] Ansys GRANTA EduPack software, ANSYS, Inc., Cambridge, UK. 2023(www.ansys.com/materials)	

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

MILESTONE 1 (STAGE 1) – LIST OF OBJECTIVES,

Please complete this worksheet in your corresponding team document.

CONSTRAINTS, AND FUNCTIONS

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)

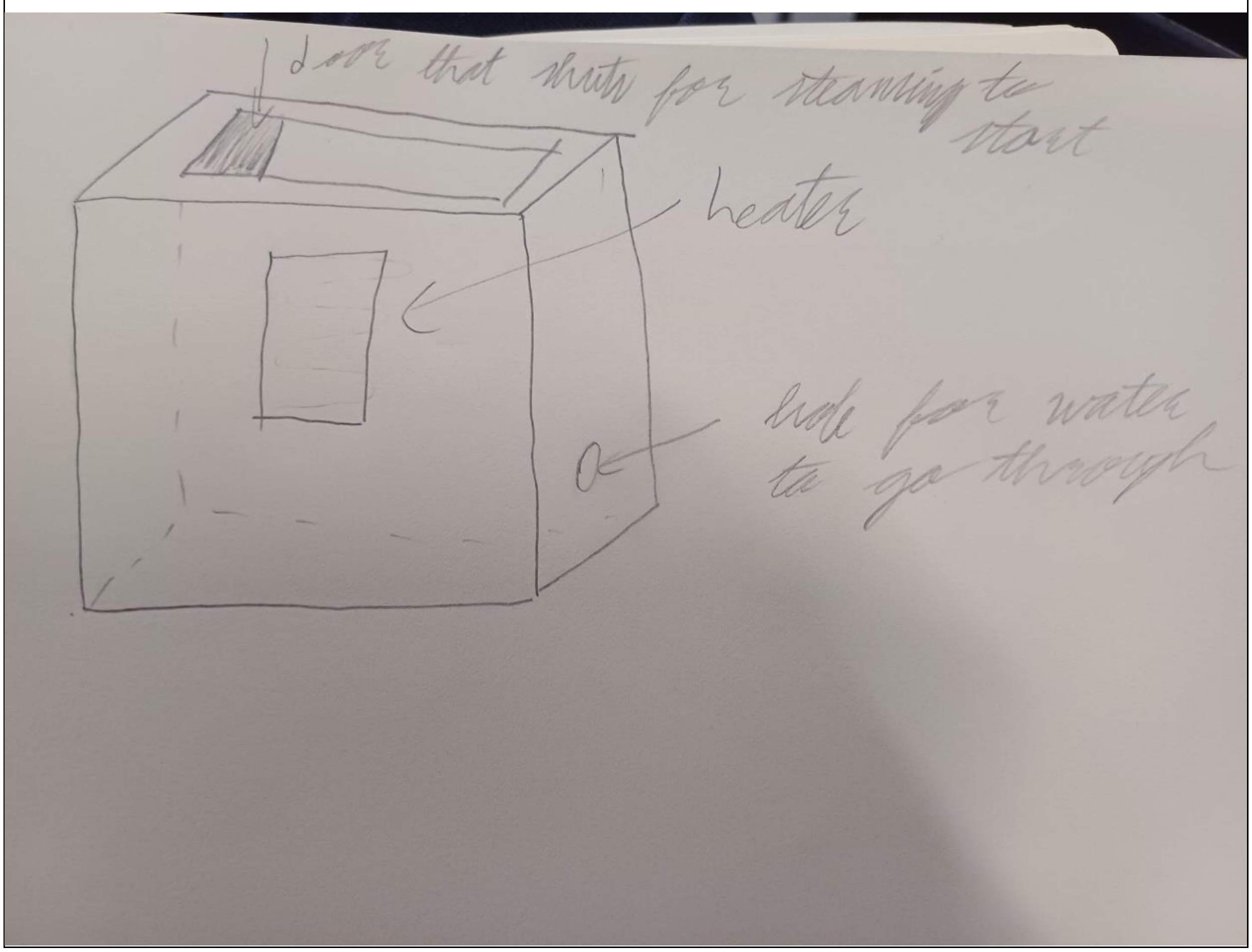
Team ID: Mon-39

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-39

Name: Talha Ahmad	MacID: ahmadt20

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)

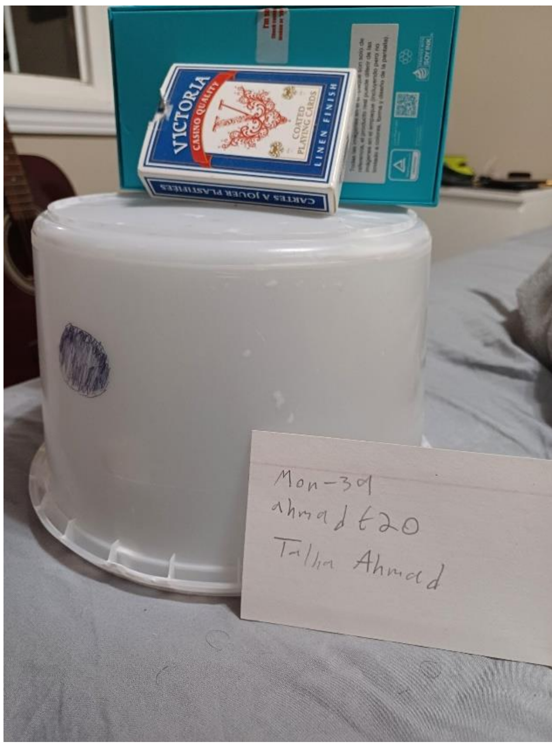
Team ID: Mon-39

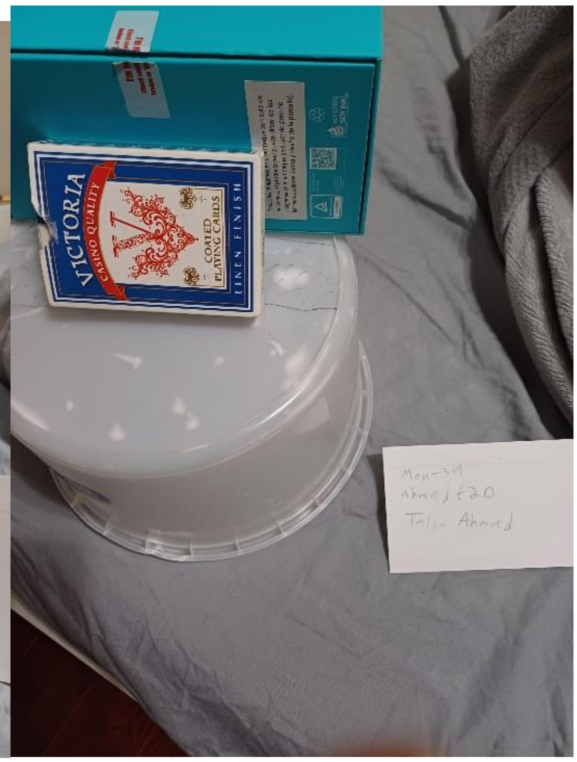
Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

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-39

Name: Talha Ahmad	MacID: ahmadt20
Insert screenshot(s) of the low-fidelity prototype 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-39

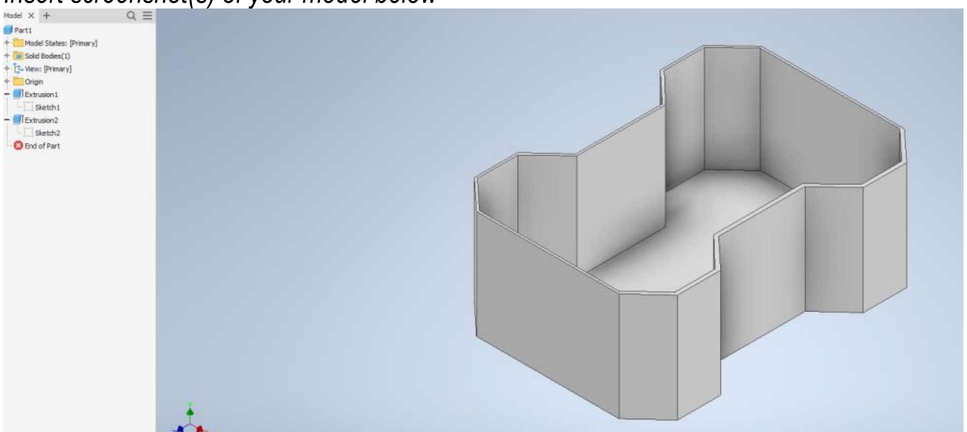
Complete this worksheet individually during Design Studio 8.

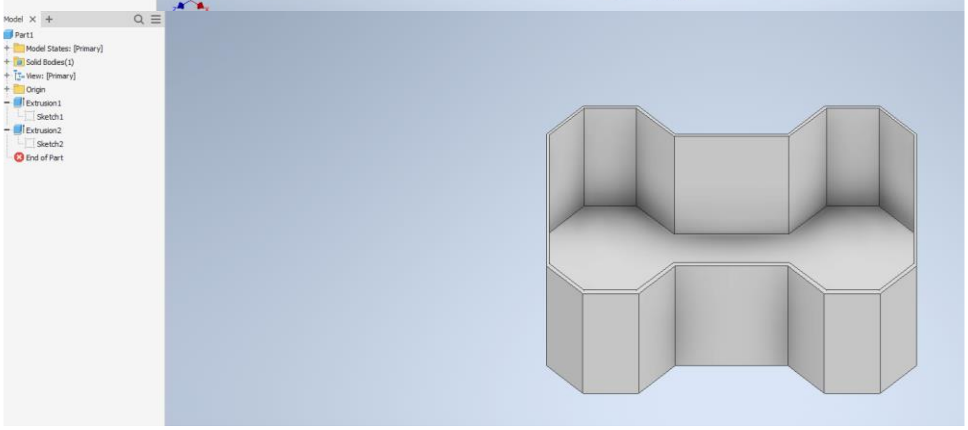
1. Take multiple screenshots of your preliminary solid model
   → You are also required to submit an IPT file of each solid model (see Submission Details section above)
   → Be sure to label model with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not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

Team ID: Mon-39

Name: Talha Ahmad	MacID: ahmadt20

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:

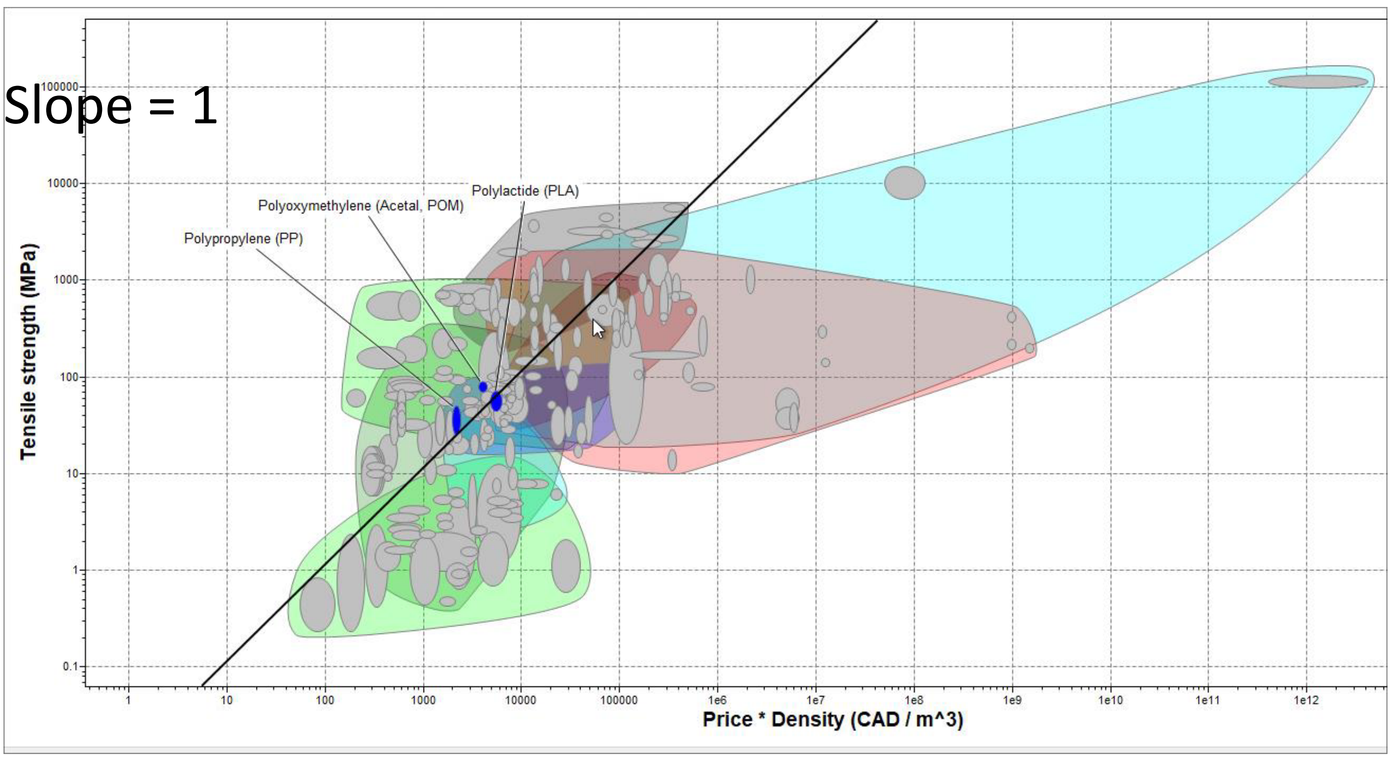
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Strength	MPI = $\frac{\sigma}{p C_m}$	Minimize cost and mass
Please provide a short justification for your chosen design and MPI. My chosen design is strength and my MPI is tensile strength over density times cost of material. The reason I chose tensile strength rather than stiffness as my design factor is because the sterilization container that we are aiming to construct will be subject to extreme pressures within the autoclave. This means that it should be able to resist those forces. If it were to break, there is a chance that the tool inside it will fall out which will prevent the robotic arm from safely and efficiently taking it out of the autoclave. Moreover, if it falls out while being transported out of the autoclave, the tool would be unclean and require sterilization again. If this were to happen during a surgery, infections from an unclean tool could prove fatal, and if the tool were to fall out, it would inhibit the surgeon's ability to perform that surgery. Therefore, tensile strength is of utmost importance when it comes to designing this object.		

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 Polyoxymethylene (POM)	Rank 2 Polypropylene (PP)	Rank 3 Polylactide (PLA)
Assigned MPI:	0.0198	0.0168	0.0104

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). Polyoxymethylene (POM) is the ideal material to choose to construct the sterilization container as seen through our Granta analysis [1]. This material has a melting point greater than our set minimum of 140 degrees celcius and it is also medical grade [1]. Moreover, out of all the materials in the Granta database that fit these two categories, it has the highest MPI, which means that it has the greatest tensile strength in proportion to its density and cost [1]. This means in comparison to the other materials, POM's point of fracture in proportion to its cost and mass is much greater. Therefore, this material is a great choice for constructing the sterilization container.	
References (If any): [1] Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023(www.ansys.com/materials)	

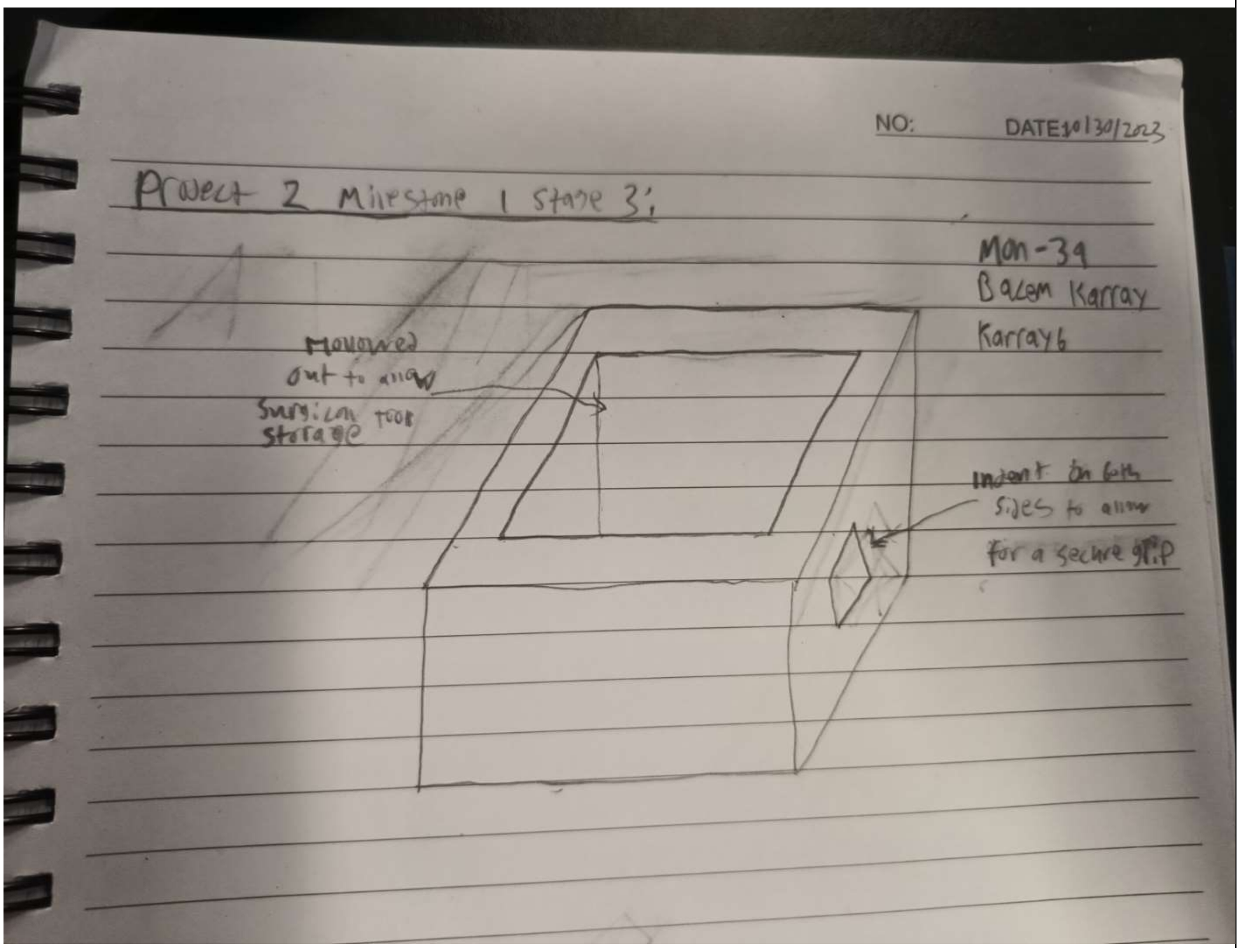
MILESTONE 1 (STAGE 3) – PRELIMINARY CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID: Mon-39

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-39

Name: Bacem Karray	MacID: karrayb
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)

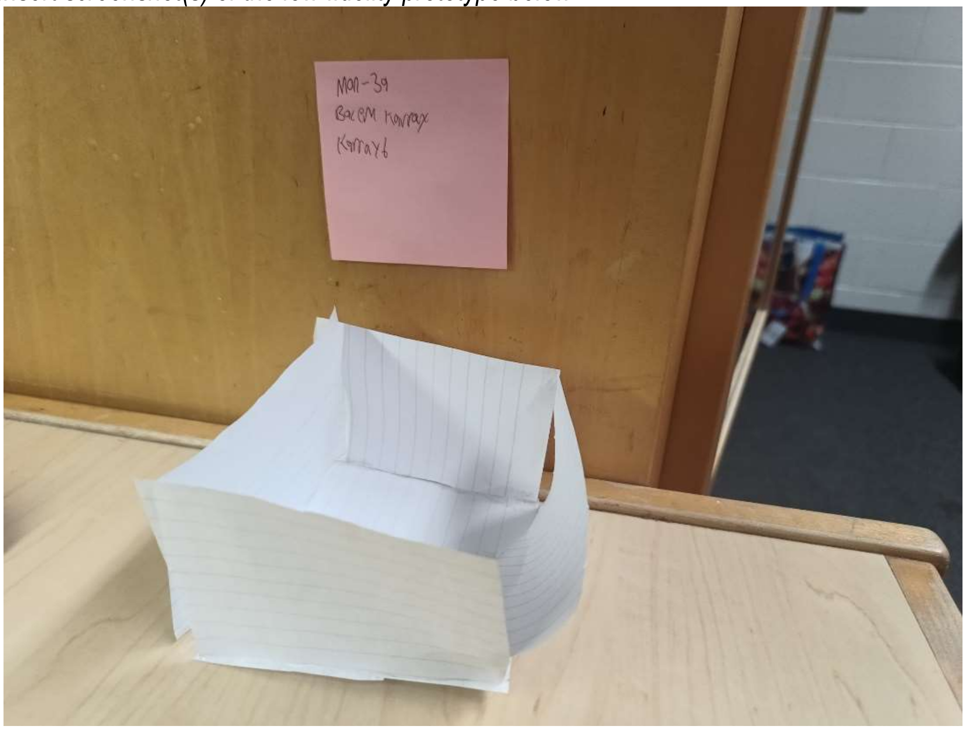
Team ID: Mon-39

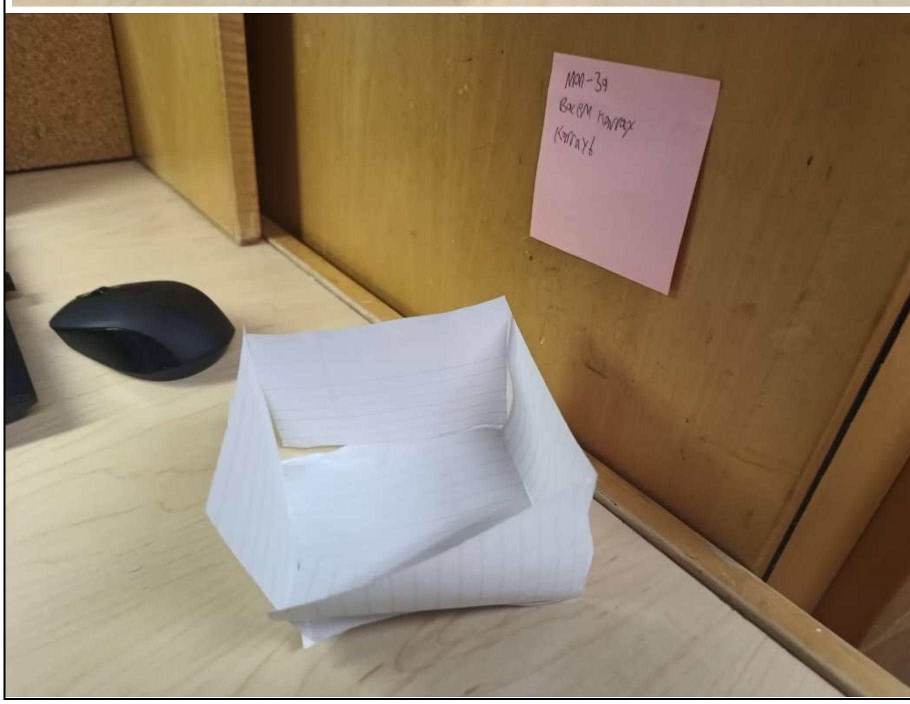
Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

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-39

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





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

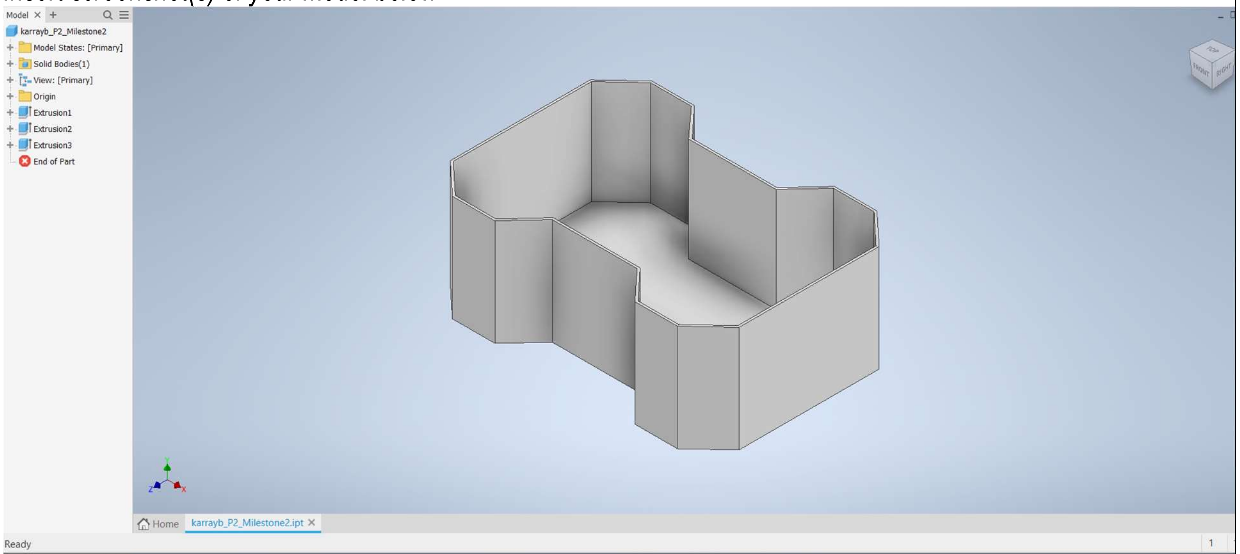
Team ID: Mon-39

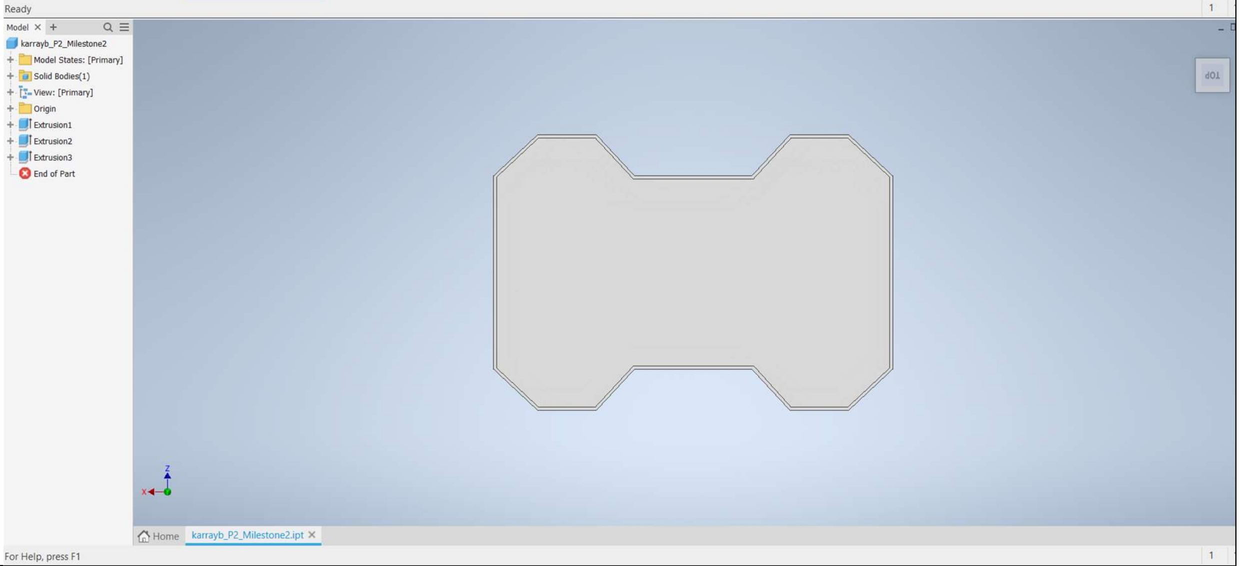
Complete this worksheet individually during Design Studio 8.

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-39

Name: Bacem Karray	MacID: karrayb
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°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	Yield Strength/pC_m	Minimize Cost and Mass

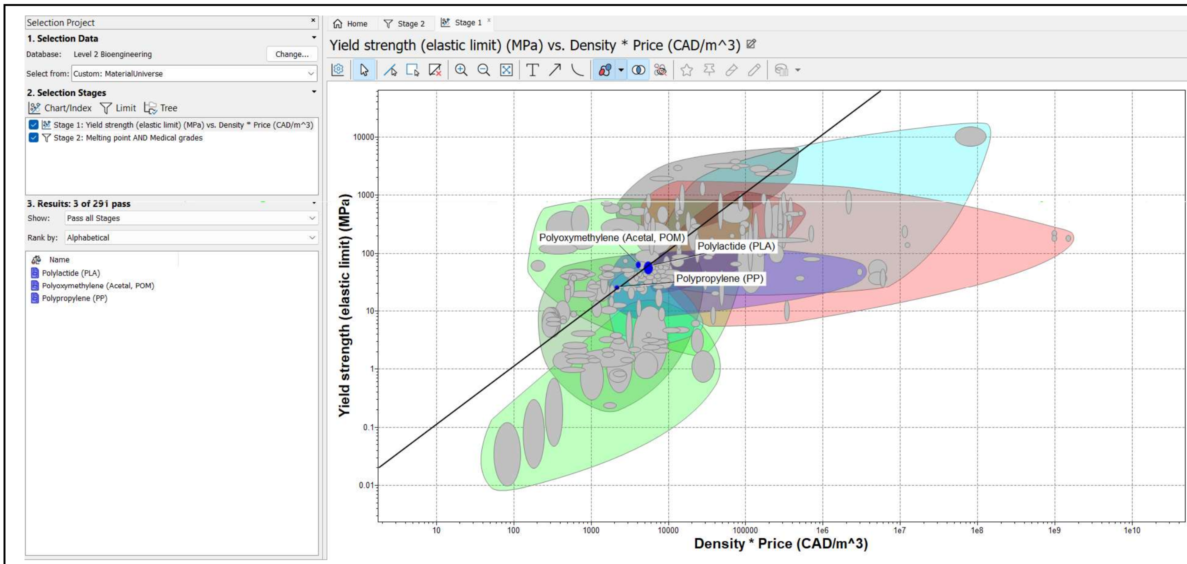
Please provide a short justification for your chosen design and MPI.

I picked strength as my chosen design since I believe it is important that the Q-Arm's load on the sides of the container is not weakened over time. With this logic, it makes sense why I chose Yield Strength/pC_m, since picking a material with a high yield strength means that more loads can be placed on the container (and so there will be no cause for concern in case the robot has a slight malfunction and its set grip strength deviates).

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/pC_m	Polyactide (PLA)	Polyoxymethylene (Acetal, POM)	Polypropylene

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

Chosen Material:	Polyoxymethylene (Acetal, POM)
Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations). Out of the three materials I ranked based on the MPI results, I chose Polyoxymethylene (Acetal, POM). Of all three materials, it had the highest density (1390-1410 kg/m^3), the second lowest price ($2.86-2.91 CAD/kg), and the highest yield strength (57.2-71.7 MPa). Its melting point starts at 160 degrees, which is beyond the max temperature an autoclave typically operates at (140 degrees). Polypropylene melting point starts at 140 degrees, making it risky to operate on an autoclave. Its yield strength sits at 24.1-28.4 MPa, and it has a much lower density (895-909 kg/m^3) and cost ($2.22-2.54 CAD/kg). While our objective is to minimize mass and cost, as mentioned before, polypropylene has too low of a melting temperature, making polyoxymethylene a better selection than it and polylactide.	
References (If any):	