Design Project 2 – Get A Grip

ENGINEER 1P13 – Integrated Cornerstone Design Projects in Engineering

Tutorial 11

Team Fri-30

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Submitted: December 6th, 2023

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

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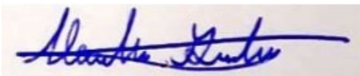
Alexander Gascho 400495599

 (Student Signature)

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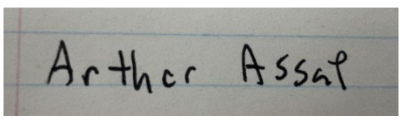
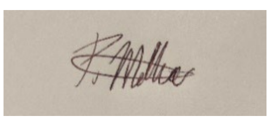
Arther Assaf 400522187



(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.

Patrick Molka 400537630

 (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.

Adrian Winter 400495595

 (Student Signature)

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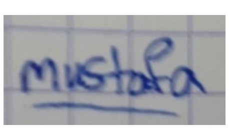
Mohammad Mustafa 400505810



(Student Signature)

Executive Summary

During this design project, our team aimed to develop a solution that combines the usage of python programming and Autodesk Inventor modelling to automate the transfer of a container holding a surgical tool into an autoclave for sterilization. Divided into two sub-teams (computing and modelling); we worked together to ensure the safety and reliability of surgical instruments in the healthcare industry. Our primary objectives were to create a durable container, minimize the complexity of our code, ensure proper sterilization of surgical equipment, and have a container that's easy to pick up with the Q-Arm. Our motivation behind this project is our understanding that it's essential that instruments handled in a medical setting are not only sterilized, but also handled with extreme precision.

The coding sub-team developed a program that randomly selects containers from a list, determines the size and color of the container, and uses potentiometer readings to drop the container off at the correct autoclave position (*Figure 11, Figure 12, Figure 13*). The program continues to loop until all containers are processed and concludes by returning the arm back to the home position (*Figure 12*).

Moving onto the modelling sub-team, their aim was to make sure the container could securely hold our assigned surgical tool, a retractor, fit within the autoclave drawers, and be compatible with the program the computing team came up with (*Figure 4*). We made sure to prioritize ventilation and security in our container design. For example, our design includes a bar that the tool can hook onto, so it doesn't slip out during transfer (*Figure 4, Figure 7)*. In terms of sterilization, the design has an open top and holes on every side of the container, including the bottom, to ensure optimal pressure of and exposure to steam and even sterilization (*Figure 4, Figure 7*). One improvement we could have made to our design is how easy it is to pick up. As of now, the Q-arm is meant to pick up the container by gripping on the removeable top bar in the middle our design (*Figure 5, Figure 9*). However, it's possible the container may slip out of the grip, which can be rectified by increasing the size of this bar or by adding grooves or ridges to it to increase friction and prevent slippage.

Our solution addresses a critical aspect of the healthcare industry, which is the need for reliably clean and safe surgical tools. By utilizing creative design and computing solutions, our team was able to come up with a way to enhance and automate the sterilization process of surgical tools, a fundamental step in maintaining proper patient care.

Main Body

Summary of Design Objectives:

Objectives	Constraints	Functions
High durability (container)	Container must fit into the footprint	The container securely holds tool
Code makes arm easy to control	All coding tasks must be in functions	Facilitate Sterilization by letting steam through
High code modularity/maintainability	All features must be greater than 2mm	Code recognizes container types
Minimize complexity of code	Container must be able to be picked up by the Q-arm	Container must securely hold tool
Container should be easy to pick up		The arm safely transfers the container
Container lets high amounts of steam through		

Background and Research Summary:

The project's main objective for the modelling sub-team was to design a model and fabricate a sterilization container that securely hold a surgical tool during transfer, and during steam sterilization in an autoclave. After use, surgical tools must undergo sterilization to inhibit infectious agents and to promote general health safety, this project focuses on the use of autoclaves as the method for sterilization. Autoclaves are steam pressurized chambers that use high temperature and internal pressure to sufficiently eliminate bacteria, viruses, and other microbes [1]. During the design process for the sterilization container, we had several considerations regarding the internal conditions the container will endure, medical standards involving sterilization, as well as the transfer process to the autoclaves. The standard minimum sterilization time for the tools is 30 minutes inside of the autoclave, with temperatures of at least 121°C [2], [3]. When designing the container, we had to consider the affects long-term exposure to extreme temperature and pressure had on the container and make choices to ensure the conditions will not cause deformation and hinder sterilization. The industry standard sterilization container is a rectangular, mesh, lidded container, typically made from stainless steel or medical grade plastic [3]. For this project the container design is required to depart from the standard design to meet the additional requirements of the project, such as securely holding the instrument during the tele-controlled transfer process, as well as the size constraints set by the given footprint. The physical prototype for this project is 3D printed using PLA (polylactic acid) filament. Due to the nature of 3D printed models, all features of the sterilization container model must be at least 2mm to ensure that the design can be fabricated without error [4].

The computing sub-team's objective was to design computer code that enables a remote crew to tele-control a robotic arm to transport the sterilization container into the autoclave. During the design and prototyping of the computer program, the team used the virtualized environment (Q-Labs). Currently, low latency, tele-controlled robotics are used in the medical field to allow surgeons to remotely operate on patients around the world. When this technology was first emerging, it had high latency (760 ± 606 milliseconds) which severely impacted the effectiveness of the system [5]. When designing the computer program the sub-team had to optimize their code such that the performance of the program does not impede the user's ability to operate the Q-Arm [6]. Further, this project involved multiple team members collaborating on the computer program throughout various stages of the project. Considering this dynamic, the sub-team had to ensure that their workflow had high modularity (breaking code into smaller modules/functions) which makes the program easier to understand, and update during the different stages of development [7].

Description of Proposed Solution:

The functionality of the design solution involves the pickup and transferring process, which is executed by the code. Within the code, the pickup function (*Figure 11*) accesses a list of which containers have yet to be handled, and spawns one in on random. The Q-arm then picks up the container from the pre-determined coordinates. The function then returns information on the chosen container's ID, color, and the updated version of the list used to keep track of unhandled containers. The rotate_base function (*Figure 12*) handles the transfer process. It takes an input of the color of the container being handled and then reads the left potentiometer's values. Each potentiometer value is compared to an old one and the difference is multiplied by an empirically found constant. This allows the Q-arm's base to rotate using an absolute reference point. This adjustment of the rotation is done continuously using a while loop. The program exits the while loop only when it has deemed that it is in front of the correct autoclave using the color information that was passed into the function. Once the container has been dropped, the program evaluates the list of containers left to handle (*Figure 13*). If it is empty, the program will terminate, but, if there is at least one container left to handle, then the program will execute the spawning, picking up, rotating, and dropping off functions again.

Our finalized design for the sterilization container has an open top, as well as holes on all sides of the container (*Figure 7*). This design choice allows for adequate ventilation, facilitating sterilization, as well as reducing the number of materials required to print the solid model. To further maximize sterilization, our design has two support bars on the bottom of the container to elevate the surgical tool, increasing the surface area of the tool which is exposed to the steam. To ensure that the tool is securely held during transfer we designed an upper (*Figure 9*) and lower (*Figure 8*) support rod. The surgical tool hooks around the end of the lower bar, securing the tool horizontally, while the upper bar vertically secures the tool. Although both bars are friction fitted in the container, the larger bar has an extrusion at the end to allow the bar to be pulled out to place the tool in and slide back in to lock it in place. Finally, we decreased the overall dimension of the container from the footprint to match the dimensions of the surgical tool more closely while still leaving space between the tool and the walls of the container to facilitate sterilization. We chose a rectangular shape to ensure that the robotic arm will be capable of securely grabbing the container from all sides, as well as from above by using the upper rod.

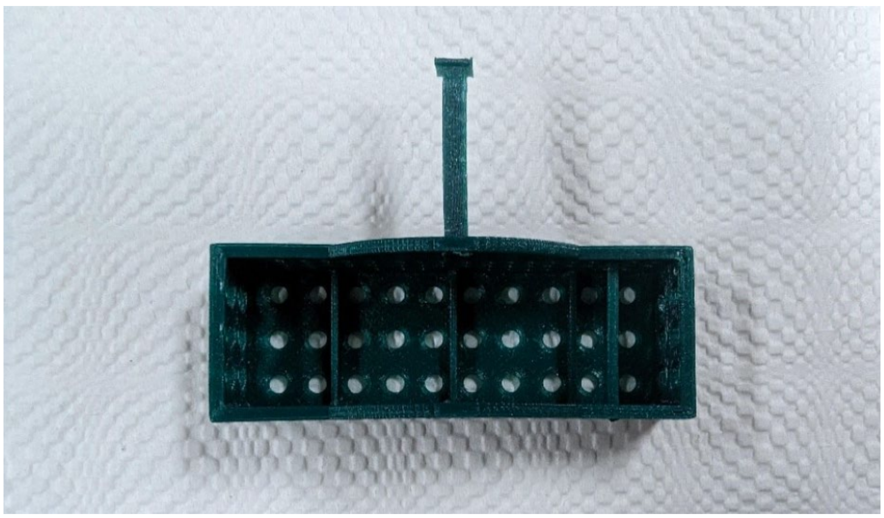


Figure 1: Physical model with upper bar removed

Strengths and Limitations of Design:

Our design has many strengths relating to the sterilization process. Starting with the form of our container, the excellent ventilation helps facilitate sterilization. This ventilation comes from numerous holes on all sides of the container, which can be seen in (*Figure 1*, *Figure 6*). Additionally, there are ridges on the bottom to increase exposed surface area. Another strength of our design is the security of the tool. The container has a bar that the tool is hooked onto and secured in place, with a top bar that provides an extra layer of security. This can be observed in (*Figure 4)*. The final strength of the design is its simplicity. Our design gives the user the ability to remove the top bar, which lessens 3D printing time and simplifies the process of inserting and removing the tool. With only two separate pieces, our design also has an extremely simple assembly process.

One particular strength of our code is the precision of the pickup and transfer process, as we can consistently complete the pickup and drop off all six containers due to several code implementations. Firstly, in the rotate_base function, we reposition the Q-arm to predetermined coordinates after verifying that it is in range of the correct autoclave, guaranteeing accurate arm positioning. Another instance is the reset process after completing a transfer. The new container will not spawn until both potentiometers are reset to 50%. This ensures that the potentiometers will always have maximum range and be able to rotate to all autoclaves. The final strength of our code is that it is easy to understand, allowing for easier future edits and updates. This can be attributed to the detailed comments and the use and organization of functions.

Although our design has a lot of strengths, there are also some limitations in both the form and functionality of the design. The main limitation of the form involves the top bar that is meant to be grabbed by the Q-arm, which is visible in (*Figure 2*). The bar is a simple rectangular prism without any hooks or attachments which could make it difficult to pick up. There is a rare possibility of the container slipping out of the gripper, which would cause the entire sterilization process to fail.

The functionality of our design also had a couple of limitations. First of all, the pickup and transfer process was slow due to the repeated use of time.sleep. While the sleep functions were necessary for functionality, it is possible that we could have lessened the time of some of these functions, or even cut some of the functions out entirely. Our last limitation pertains to our drop_container function. In some cases, the way that the container was dropped in the drawer would make the drawer not close, even though the drop-off was accurate. Although it was clarified by TAs that this was simply a bug in Quanser, it may have been possible to refine the drop-off coordinates to prevent this occurrence.

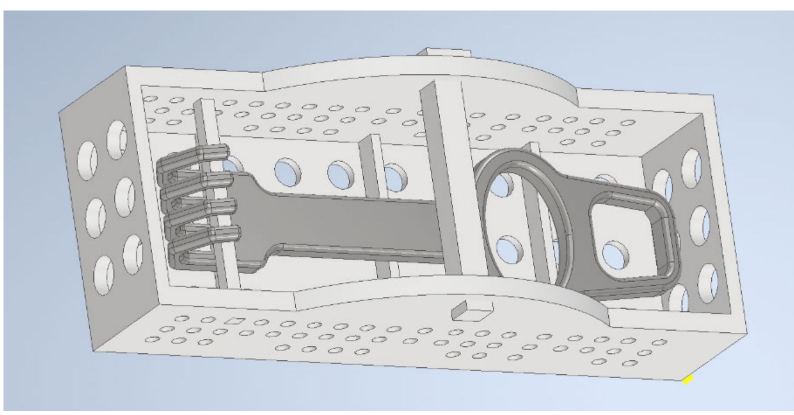


Figure 2: CAD model of finalized container design

Summary of Contributions:

Team Member	Contribution to Project Report
Alexander Gascho	Modelling half of description of proposed solution. Background and Research Summary.
Mohammad Mustafa	Computing half of description of proposed solution. Computing half of meeting minutes. Logbook of Additional Meetings.
Adrian Winter	Strengths and limitations of design. Preliminary Gantt Chart. Agenda.
Patrick Molka	Background and research summary. Modelling half of meeting minutes.
Arther Assaf	Executive summary. Final Gantt Chart.
All	Proofreading executive summary.

Reference List

[1] L. Czuba, '2 - Application of Plastics in Medical Devices and Equipment', in *Handbook of Polymer Applications in Medicine and Medical Devices*, K. Modjarrad and S. Ebnesajjad, Eds., in Plastics Design Library. Oxford: William Andrew Publishing, 2014, pp. 9–19. doi:10.1016/B978-0-323-22805-3.00002. Available: https://www.sciencedirect.com/science/article/pii/B9780323228053000025

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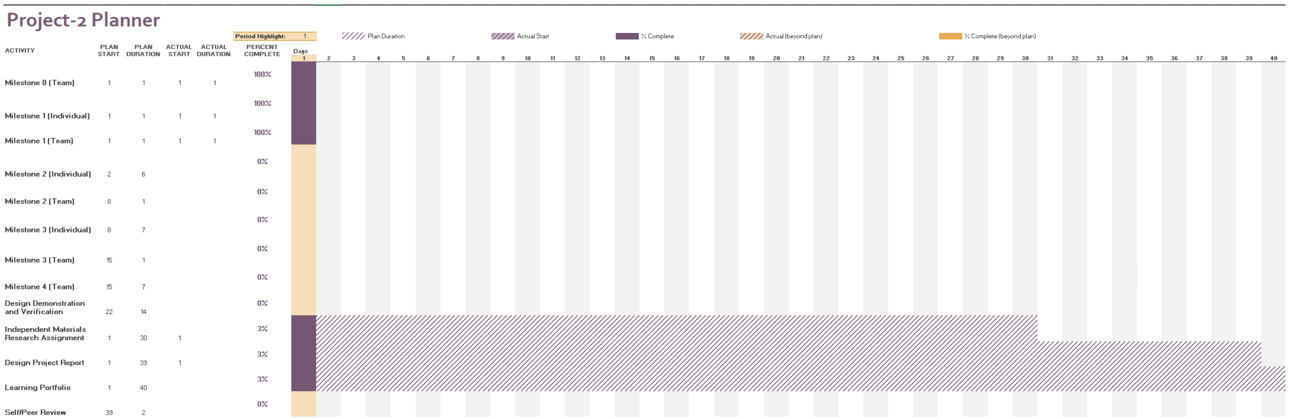
[6] O. Dekel, 'Optimizing Python: Why Python Is Slow & 4 Optimization Methods', *Granulate*, Nov. 08, 2022. Available: https://granulate.io/blog/optimizing-python-why-python-is-slow-optimization-methods/

[7] 'Modularity: What is It and How Does it Enhance Business Productivity? | Lenovo CA'. Available: https://www.lenovo.com/ca/en/glossary/modularity/

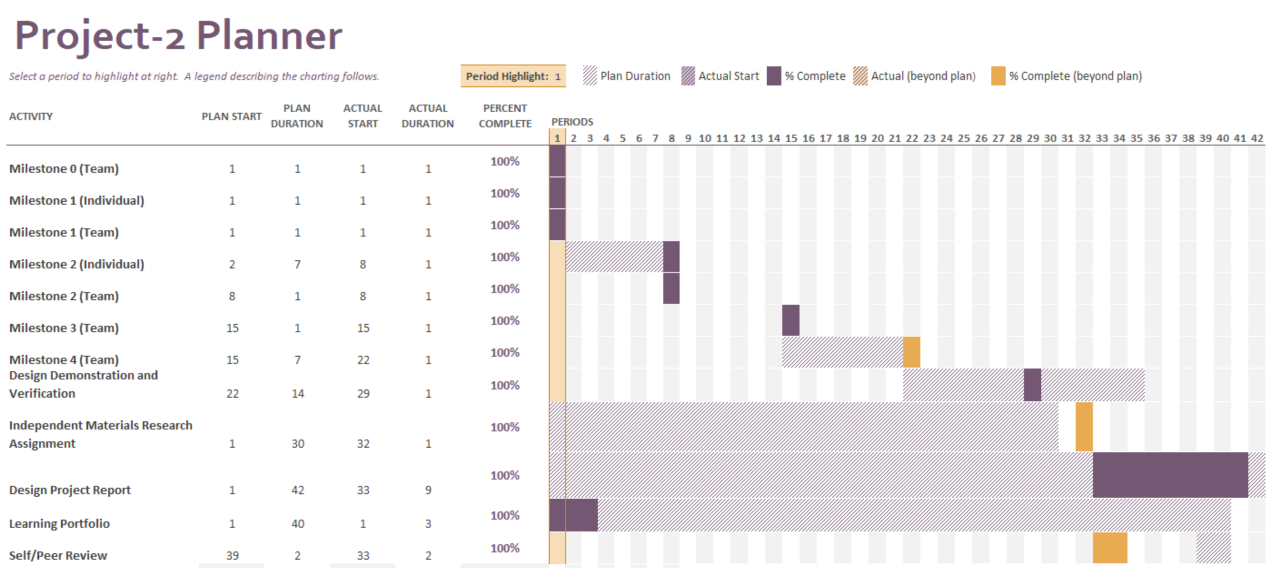
Appendices

Appendix A: Project Schedule

Preliminary Gantt Chart



Final Gantt Chart



Logbook of Additional Meetings and Discussions:

Date	Time	Agenda	Discussion	Attendees
12/4/23	2:30pm-4:15pm	P2 Final Report	• Compiled individual parts of the report that were assigned asynchronously. • Proofread each other's work. • Made plans for next steps on finishing the report.	Mustafa Alex Patrick Adrian Arther

Appendix B: Scheduled Weekly Meetings

Milestone	**Agenda/Meeting Minutes**

1

ENGINEER 1P13
MEETING WITH TEAM 30 – Friday Nov. 3, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Adrian Winter	wintea10	Yes
Administrator 1 (C)	Arther Assaf	assafa2	Yes
Administrator 2 (M)	Alexander Gascho	gachoa	Yes
Coordinator 1 (C)	Mohammad Mustafa	mustam26	Yes
Coordinator 2 (M)	Patrick Molka	molkap	Yes
Guest			

AGENDA ITEMS

1. Attendance and updates
2. Issues from past week
3. Pre design studio activities
4. Action items for next meeting
5. Final Notes

MEETING MINUTES

1. Attendance and updates
    a. Everyone is here.
    b. How is everybody doing?
    c. Any weekend plans?
2. Review from past week
    a. No major issues
    b. Did anyone need anyone encounter any issues last week?
    c. Does anyone need help in any area of the project?
3. Pre design studio activities
    a. Modelling sub-team
       Similar design. Both designs have a handle should make it easy for the arm to pick up, but the code needs to adjust for the handle.
    b. Computing sub-team

       Get the container information using a command, not the sensors.
4. Action items for next meeting
    a. Finish Milestone 2 team worksheets
    b. Finish Milestone 2 individual worksheets (CAD model/function code)
    c. Complete initial design of finalized sterilization container
    d. Complete program task pseudocode worksheet

1

ENGINEER 1P13

MEETING WITH TEAM 30 – Friday Nov. 3, 2023

5. Final notes
   a. Check action items
   b. Communicate/reach out if you need help
   c. Enjoy your weekend!

POST-MEETING ACTION ITEMS

1. Finish Milestone 2 team worksheets [Everyone]
   a. Submit modelling sub-team worksheets [Alexander Gascho]
   b. Submit computing sub-team worksheets [Arther Assaf]
2. Finish and submit Milestone 2 individual worksheets [Everyone]
3. Complete initial design of finalized sterilization container [Modelling Sub-Team]
4. Complete program task pseudocode worksheet [Computing Sub-Team]
   a. Each member needs to complete the workflow chart before the next meeting

2

ENGINEER 1P13
MEETING WITH TEAM 30 – Friday Nov. 10, 2023

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Adrian Winter	wintea10	Yes
Administrator 1 (C)	Arther Assaf	assafa2	Yes
Administrator 2 (M)	Alexander Gascho	gachoa	Yes
Coordinator 1 (C)	Mohammad Mustafa	mustam26	Yes
Coordinator 2 (M)	Patrick Molka	molkap	Yes
Guest			

Agenda Items

1. Attendance and updates
2. Issues from past week
3. Pre design studio activities
4. Action items for next meeting
5. Final Notes

Meeting Minutes

1. Attendance and updates
    a. How is everybody doing?
    b. Everybody is present
    c. Any weekend plans?
2. Review from past week
    a. Did anyone need anyone encounter any issues last week?
    b. Does anyone need help in any area of the project?
3. Pre design studio activities
    a. Modelling sub-team – initial design
    b. Computing sub-team – pseudocode worksheet
    c. Successes, failures, next steps, similarities, differences, etc
4. Action items for next meeting
    a. Finish Milestone 3 team worksheets
        i. Modelling sub-team: Pugh Matrix worksheet
        ii. Computing sub-team: Code Peer-Review worksheet
        iii. Both teams: Preliminary Design Reviews worksheet
    b. Complete finalized design of finalized sterilization container
    c. Complete framework of Python program
5. Final notes
    a. Check action items

1

ENGINEER 1P13

MEETING WITH TEAM 30 – Friday Nov. 10, 2023

   b. Be ready for a meeting sometime next week (pre-design studio)
   c. Enjoy your weekend!

POST-MEETING ACTION ITEMS

1. Finish Milestone 3 team worksheets [Everyone]
   a. Submit modelling sub-team worksheets [Alexander Gascho]
   b. Submit computing sub-team worksheets [Arther Assaf]
2. Complete finalized design of sterilization container [Modelling Sub-Team]
3. Write the function for rotateBase() and dropContainer() of the Python program (one per member) [Computing Sub-Team]

2

3

ENGINEER 1P13

MEETING WITH TEAM 30 – Friday Nov. 17, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Adrian Winter	wintea10	Yes
Administrator 1 (C)	Arther Assaf	assafa2	Yes
Administrator 2 (M)	Alexander Gascho	gachoa	No
Coordinator 1 (C)	Mohammad Mustafa	mustam26	Yes
Coordinator 2 (M)	Patrick Molka	molkap	Yes
Guest			

AGENDA ITEMS

1. Attendance and updates
2. Issues from past week
3. Design and code discussion
4. Action items for next meeting
5. Final Notes

MEETING MINUTES

1. Attendance and updates
   a. Alex is away due to COVID
2. Review from past week
   a. Check over CAD design
   b. Ensure G-code is complete
   c. Combined and implemented functions to get a working version of the code.
3. Design and code discussion
   a. CAD design not approved for printing
   b. Design must meet given constraints and be easier for printer to print
   c. Code must meet commenting standards
   d. Code must use check autoclave method.
4. Action items for next meeting
   a. Make changes to meet all objectives in CAD design
   b. Ensure that it all fits in assembly
   c. Create new G-code with improve design
   d. Add comments and make sure to use required method.
5. Final note
   a. Decided to reset potentiometers to 0.5 between each container handling to get rid of "drifting" issue occurring.

1

ENGINEER 1P13

MEETING WITH TEAM 30 – Friday Nov. 17, 2023

b. No need for a lid design, a design using inserts will be used instead for secure holding and easier 3D printing

POST-MEETING ACTION ITEMS

1. CAD team improve final design for next week
2. CAD team make new G-code for final design
3. Make a finalized prototype of the computer program

2

4

ENGINEER 1P13

MEETING WITH TEAM 30 – Friday Nov. 24, 2023

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Adrian Winter	wintea10	Yes
Administrator 1 (C)	Arther Assaf	assafa2	Yes
Administrator 2 (M)	Alexander Gascho	gachoa	Yes
Coordinator 1 (C)	Mohammad Mustafa	mustam26	Yes
Coordinator 2 (M)	Patrick Molka	molkap	Yes
Guest			

AGENDA ITEMS

1. Attendance and updates
2. Review of final code
3. Review of final model design
4. Discuss working on Q-Arm
5. Final notes

MEETING MINUTES

1. Attendance and updates
    a. Everybody is present.
2. Review of final code
    a. Found better versions of the coordinates for more accurate container placement.
    b. Worked out final issues with the code.
3. Review of final model design
    a. No more changes to design required
    b. Print times lowered to 1-hour
    c. Approved for 3D printing
4. Discuss working on Q-Arm
    a. More empirical data is needed as real Q-arm is less accurate than computer version
    b. Real Q-Arm is unable to check colours, use any colour.
    c. Final model is sturdy enough to withstand Q-Arm gripper copression
5. Final notes
    a. All DP2 tasks have been completed

POST-MEETING ACTION ITEMS

1. Add TA comments and feeback to computer program.

1

Appendix C: Additional Documentation

Comprehensive List of Sources:

[1] L. Czuba, '2 - Application of Plastics in Medical Devices and Equipment', in *Handbook of Polymer Applications in Medicine and Medical Devices*, K. Modjarrad and S. Ebnesajjad, Eds., in Plastics Design Library. Oxford: William Andrew Publishing, 2014, pp. 9–19. doi: 10.1016/B978-0-323-22805-3.00002. Available: https://www.sciencedirect.com/science/article/pii/B9780323228053000025

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[12] "1 - P2 Project Module," class notes for 1P13A, Department of Engineering, McMaster University, Fall, 2023

Solid Model:

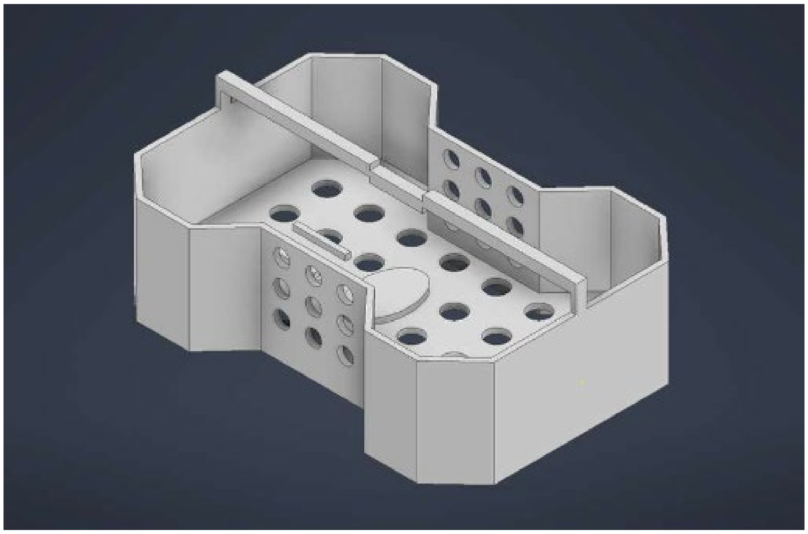


Figure 3: Preliminary solid model

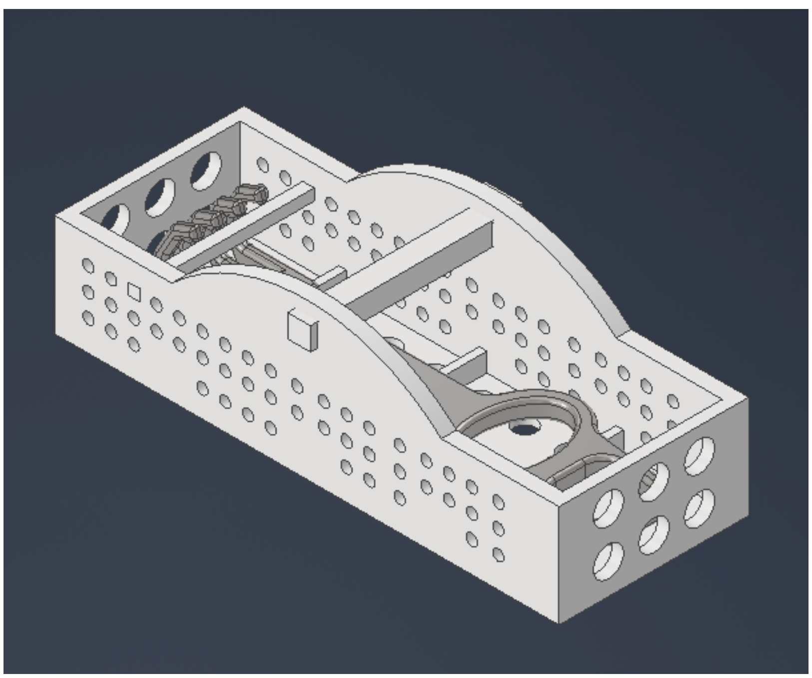


Figure 4: Finalized solid model (with retractor)

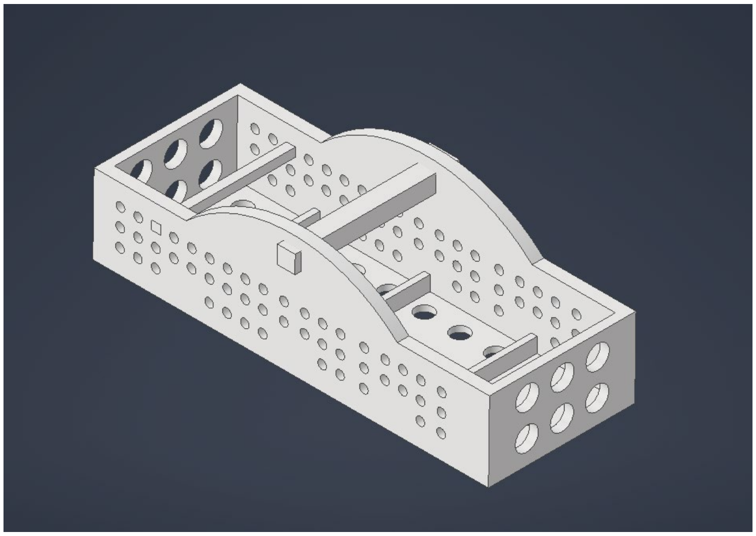


Figure 5: Finalized solid model (without retractor)

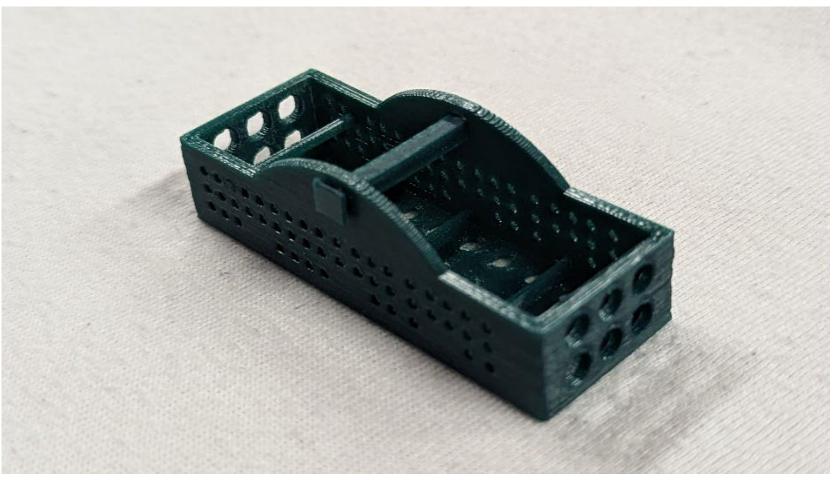


Figure 6: Physical model of finalized design

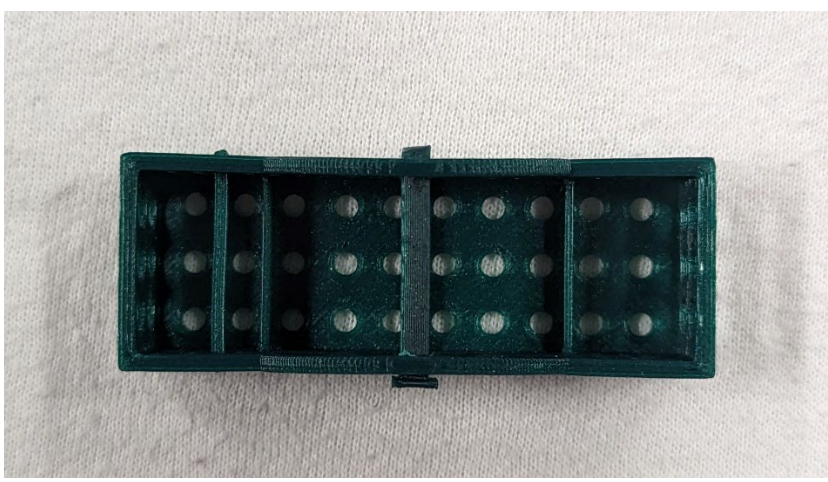


Figure 7: Physical model of finalized design (top-down)

Engineering Drawings:

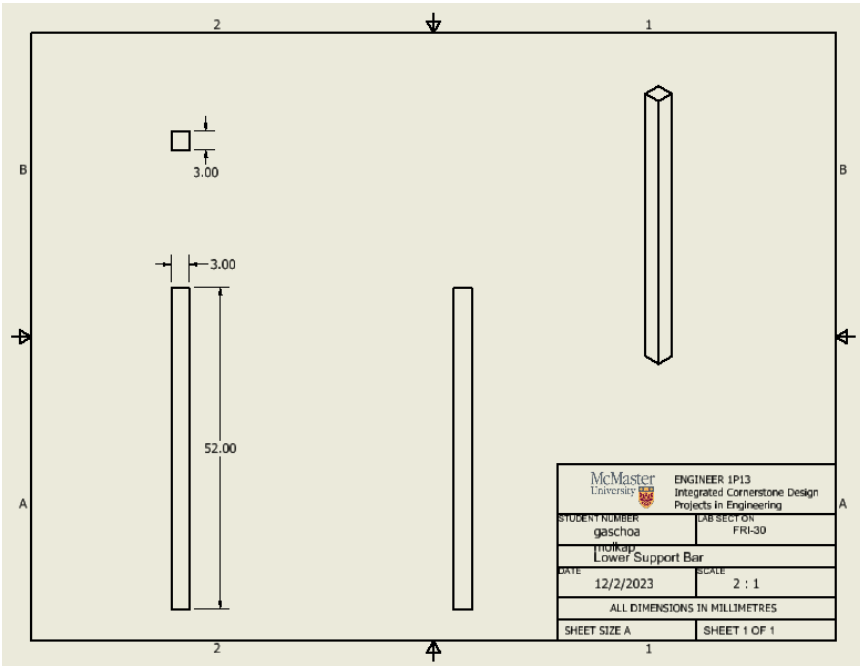


Figure 8: Engineering drawing of the lower support bar

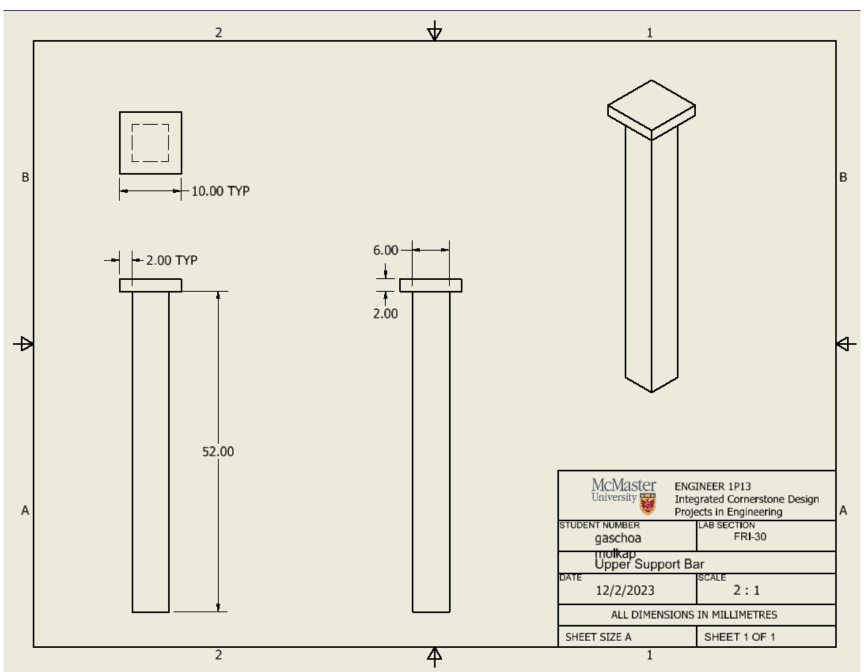


Figure 9: Engineering drawing of upper support bar

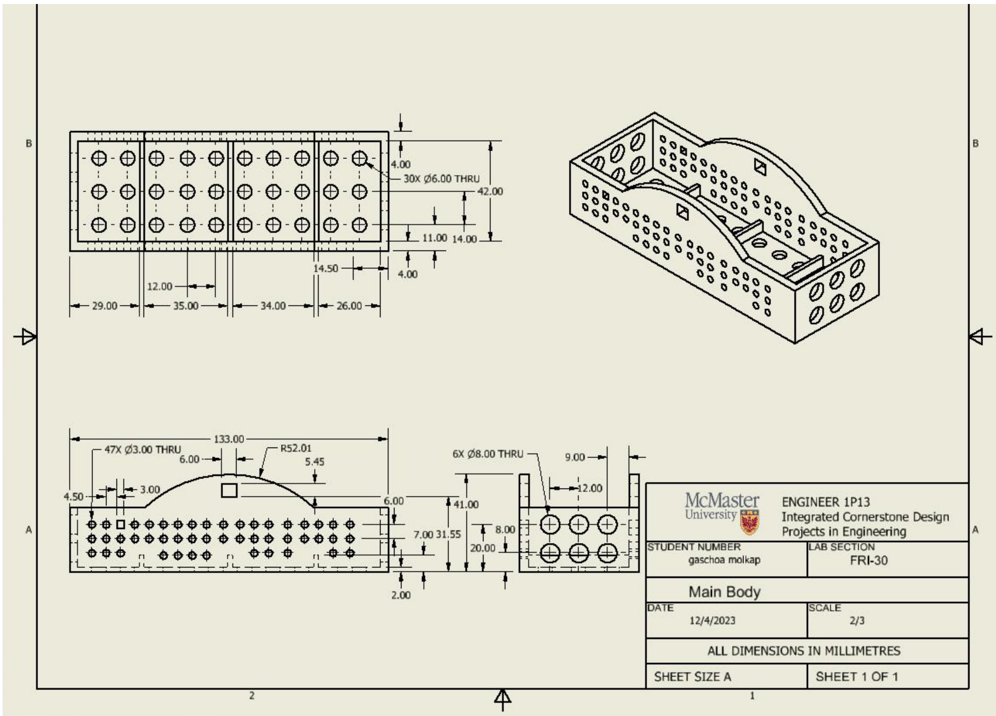


Figure 10: Engineering drawing of main body

Final Program Code:

P2-FinalVersion.py - C:\Users\musta\OneDrive\Desktop\Uni\1P13\Project2\Q-Labs Python Files\Q-Labs Python Files\Student_Files\P2-FinalVersion.py (3.8.10)

File Edit Format Run Options Window Help

```python
#pickUpContainer
#Author - Mustafa
#Inputs - the current list of containers that have not been processed
#Outputs - returns a list that holds the updated container list, the color of the chosen container, and the chosen container's ID
#What it does - picks a random container from current container list and removes it from the list. Finds that container's color and ID.
#Also spawns the container and then makes the arm pick it up and return with the container to the home position.
def pickUpContainer(containerList):
    container = random.choice(containerList)
    containerList.remove(container) #choose a random container and remove it from the list of containers left to handle
    arm.spawn_cage(container) #spawn the container
    time.sleep(2)
    arm.move_arm(containerSpawnLocation[0],containerSpawnLocation[1],containerSpawnLocation[2]) #this is where the container will spawn, it is pre determined
    time.sleep(2)
    arm.control_gripper(45)
    time.sleep(2)
    arm.move_arm(0.406, 0.0, 0.483) #coordinates of home (using the home function will open the gripper arm)

    if container == 1 or container == 4: #find the color of the container to return
        color = "red"

    elif container == 2 or container == 5:
        color = "green"

    elif container == 3 or container == 6:
        color = "blue"

    return [color, containerList, container] #return the updated container list and other container information
```

Figure 11: Final program's pickUpContainer function

P2-FinalVersion.py - C:\Users\musta\OneDrive\Desktop\Uni\1P13\Project2\Q-Labs Python Files\Q-Labs Python Files\Student_Files\P2-FinalVersion.py (3.8.10)

File Edit Format Run Options Window Help

```python
#FRI-30
import random

#Rotate_base
#Author - Adrian
#Inputs - The color of the autoclave being rotated to
#Outputs - None
#What it does - Rotates toward the potentiometer ussing the right potentiometer.
#Checks to see that the arm is in the range of the correct potentiometer, and then snaps to that autoclaves center point.
def rotate_base(colour):
    autoclave_found = False #this boolean checks if we found the correct autoclave
    old_reading = potentiometer.right() #the very first potentiometer reading
    while not autoclave_found:
        if arm.check_autoclave(colour) == True: #arm is in autoclave range
            if colour == "red":
                arm.move_arm(0.0, 0.406, 0.483) #coordinates for each autoclave
            elif colour == "blue":
                arm.move_arm(0.0, -0.406, 0.483)
            else: #green
                arm.move_arm(-0.379, 0.146, 0.483)
            autoclave_found = True
        else:
            new_reading = potentiometer.right() #if the autoclave hasnt been found yet
            delta = new_reading - old_reading
            increment = 348*delta
            arm.rotate_base(increment) #keep moving using absolute angles
            time.sleep(0.2)
            old_reading = new_reading
    time.sleep(2)


#continue_or_terminate
#Author - Adrian
#Inputs - the current list of containers that have not been processed
#Outputs - a boolean saying if more containers need to be processed or not
#What it does - checks to see if the input list is greater than 0. Also doubles as our goHome() function and brings the arm home.
def continue_or_terminate(container_list): #decide when to end the program
    potReset = False #before looping the program wait for the potentiometer values to be reset
    while not potReset:
        if potentiometer.left() == 0.5 and potentiometer .right() == 0.5:
            potReset = True

    if len(container_list) > 0: #there is atleast one container left to handle
        arm.home() #bring the arm home
        return True
    else:
        return False
```

Figure 12: The final program's rotate base and continue_or_terminate functions

P2-FinalVersion.py - C:\Users\musta\OneDrive\Desktop\Uni\1P13\Project2\Q-Labs Python Files\Q-Labs Python Files\Student_Files\P2-FinalVersion.py (3.8.10)

File Edit Format Run Options Window Help

```python
#dropContainer
#Author - Mustafa/Arther
#Inputs - color of the container being handled along with its ID.
#Output - No output
#What it does - Decides if the container is small or large. Double checks the container color is the same as the autoclave color.
#Drops the container into the correct position depending on size.
def dropContainer(color, container):
    dropped = False
    arm.activate_autoclaves() #activate the autoclaves
    while not dropped:
        time.sleep(1)
        potRead = potentiometer.left() #read the left potentiometer to determine where to drop the container
        if potRead > 0.5 and potRead < 1 and container <= 3: #position is 1 AND container is small
            time.sleep(2)
            if color == "red":
                #arm.move_arm(0.0, 0.652, 0.308)  #predetermined coordinates
                arm.move_arm(0.0, 0.696, 0.296)

            elif color == "blue":
                #arm.move_arm(0.0, -0.652, 0.308)
                arm.move_arm(0.0, -0.696, 0.295)

            elif color == "green":
                #arm.move_arm(-0.608, 0.234, 0.308)
                arm.move_arm(-0.679, 0.261, 0.313)
            time.sleep(2)

            arm.control_gripper(-45) #actually drop the container
            time.sleep(2)
            dropped = True

        elif potRead == 1 and container >= 4: #position is 2 AND container is large
            arm.open_autoclave(color, True) #open the drawer
            time.sleep(2)
            if color == "red":
                arm.move_arm(0.0, 0.484, 0.177) #predetermined coordinates

            elif color == "blue":
                arm.move_arm(0.0, -0.465, 0.148)

            elif color == "green":
                #arm.move_arm(-0.476, 0.182, 0.161)
                arm.move_arm(-0.496, 0.19, 0.189)

            time.sleep(2)
            arm.control_gripper(-45) #do the drop
            time.sleep(2)
```

Figure 13: Final program's dropContainer function

```
#Implmentation of functions

containerSpawnLocation = [0.653, 0.057, 0.044]
oldContainerList = [1,2,3,4,5,6] #all the containers


con_or_term = True
while con_or_term:


    containerInfo = pickUpContainer(oldContainerList) #recall this function returns container info after picking it up
    newContainerList = containerInfo[1]
    oldContainerList = newContainerList

    color = containerInfo[0]
    container = containerInfo[2] #unpacking the container information

    rotate_base(color)

    dropContainer(color, container)

    con_or_term = continue_or_terminate(oldContainerList)  #check to see if we should continue or not and then update the flag accordingly

print("End of Program!!")
```

Figure 14: : Implementation of all the program's functions

Appendix D: Design Studio Worksheets

Individual Submissions:

INDEPENDENT MATERIALS RESEARCH ASSIGNMENT

MATERIAL SELECTION (STAGE 1) - PROBLEM DEFINITION

Use the following information to help you in your assignment:

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

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

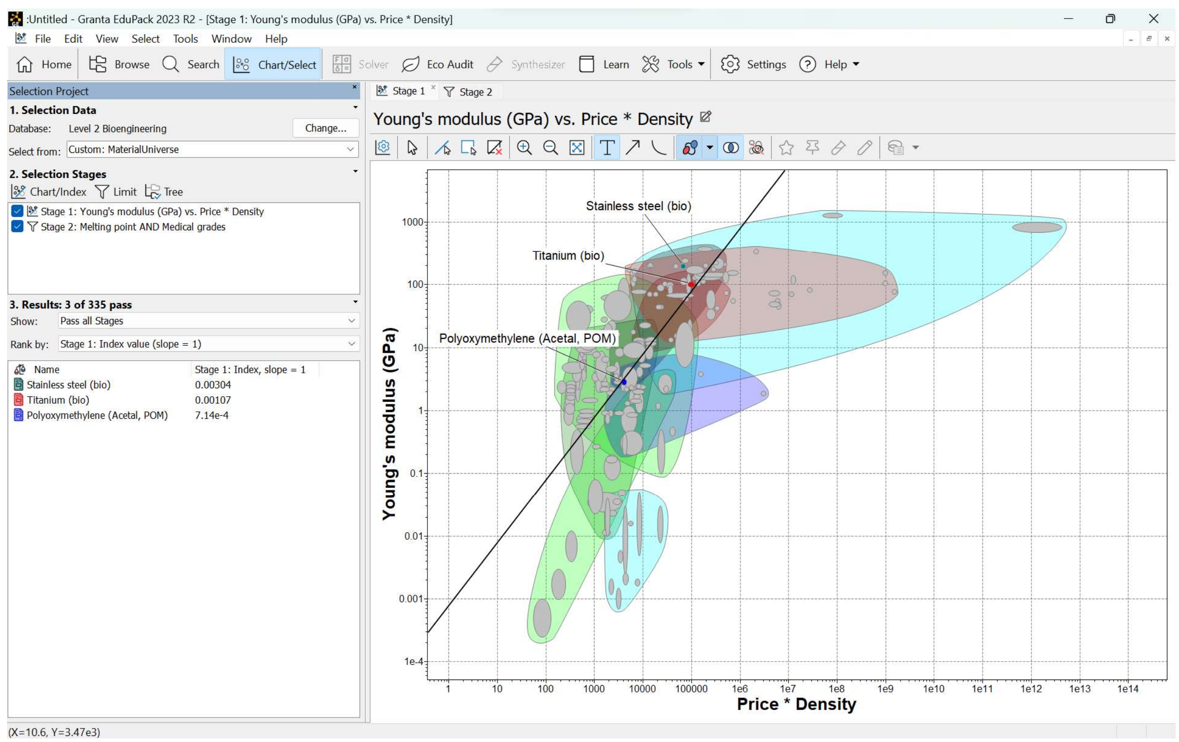
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Stiffness Design	$\frac{E}{\rho C_m}$	Minimizing cost
Please provide a short justification for your chosen design and MPI. A stiffness design is optimal for this scenario because the sterilization container must be capable of enduring high temperatures and pressure inside of the autoclave, optimizing the material selection such that the container the autoclave's conditions will not cause 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 (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).

Stainless steel is the optimal choice of material for the sterilization container. My selection is based on the material's MPI ranking as well as a few other considerations. When considering the long-term utility of the sterilization container metals such as stainless steel have an advantage over polymer materials, such as polyoxymethylene, since polymer materials have a higher risk of deformation over time as well as the risk of absorbing steam during the sterilization process, thus impacting the effectiveness [1]. When comparing the two metals, although titanium has a greater tensile strength per mass, when minimizing for mass stainless steel is the superior choice, as evident in the MPI rankings [2].

References (If any):

[1] E. P. Sosnowski and J. Morrison, "Sterilization of Medical 3d Printed Plastics: Is H2O2 Vapour Suitable?", *CMBES Proc.*, vol. 40, no. 1, May 2017.
[2] Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023 (www.ansys.com/materials)

INDEPENDENT MATERIALS RESEARCH ASSIGNMENT

MATERIAL SELECTION (STAGE 1) - PROBLEM DEFINITION

Use the following information to help you in your assignment:

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

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

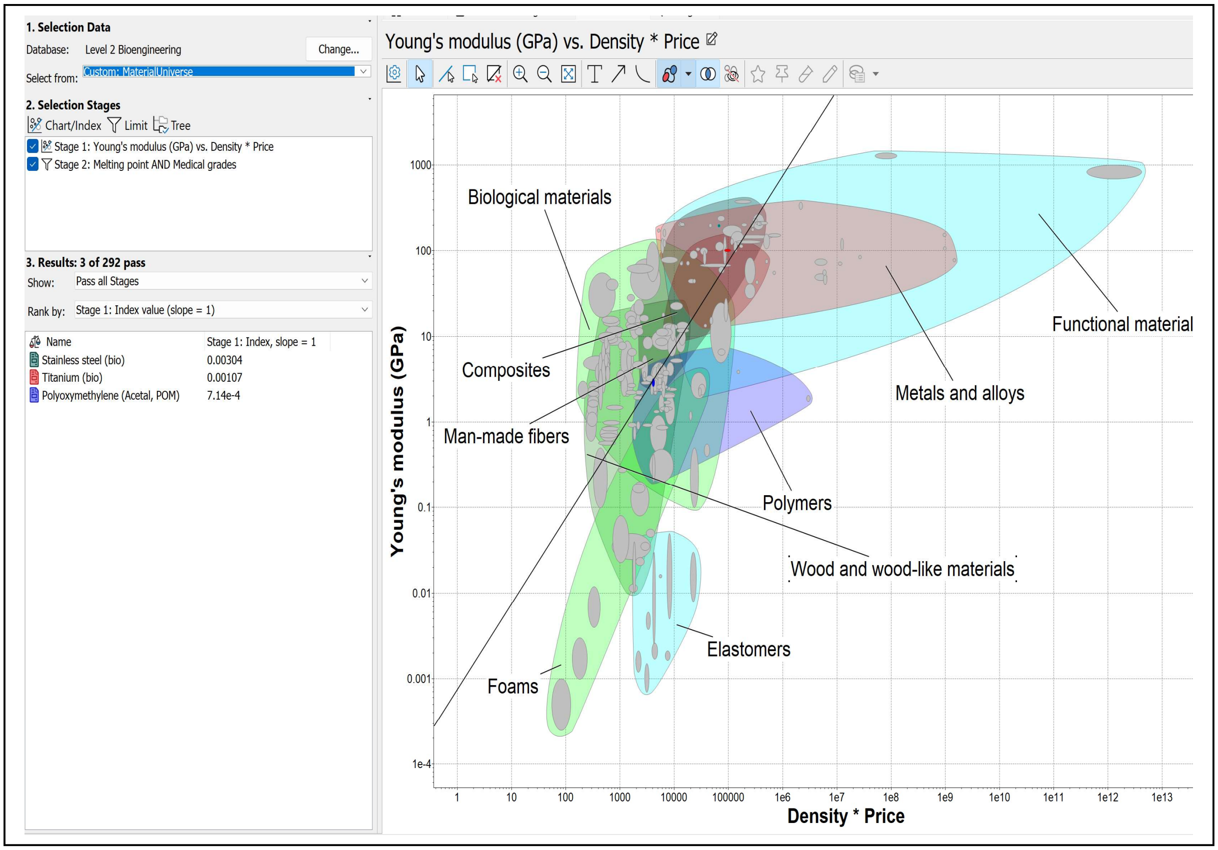
- Stiffness Design: $\frac{E}{\rho C_m}$
- Strength Design: $\frac{\sigma}{\rho C_m}$

Chosen Design	Chosen MPI	Objective
Stiffness Design	$\frac{E}{\rho C_m}$	Must minimize cost and mass
Please provide a short justification for your chosen design and MPI. For this material selection, I chose the MPI of the stiffness design. This seemed like an appropriate choice because the cylinder will be used to securely contain an object, so it should not be distorting out of shape and risking potential damage to the surgical tool. The elastic deformation caused by a low stiffness would almost always occur at a much lower stress than the fracture or tensile point. For this reason, it may be beneficial to maximize the Young's modulus and assume that the stiff material will be able to handle the internalized pressure in the autoclave. It is important to note that this will not always be the case, and in other scenarios it may have been more beneficial to focus on strength.		

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

Chosen Material:	Titanium (bio)
Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations). For the container, I chose the material titanium. Titanium had the second highest index value for the stiffness MPI out of any other medical grade material with a melting point above 140 degrees Celsius. Titanium had a high enough melting point to sustain temperatures from any autoclave. Finally, since the previous material selection only considered stiffness, I compared the yield strength of the top two materials, since they had relatively similar MPI index values. Titanium had a significantly higher yield strength than stainless steel, indicating that it is a stronger material which is less likely to break in the autoclave. Based on its high Young's modulus relative to its density times cost, as well as its high melting point, and finally its high yield strength relative to its top contender, stainless steel, I chose titanium as the sterilization container material [1].	
References (If any): [1] Granta EduPack software, Granta Design Limited. [Online]. Available: www.grantadesign.com. [Accessed Nov. 26, 2023].	

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	$\frac{\sigma}{\rho C_m}$	Minimize cost and mass (material density and CAD)

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

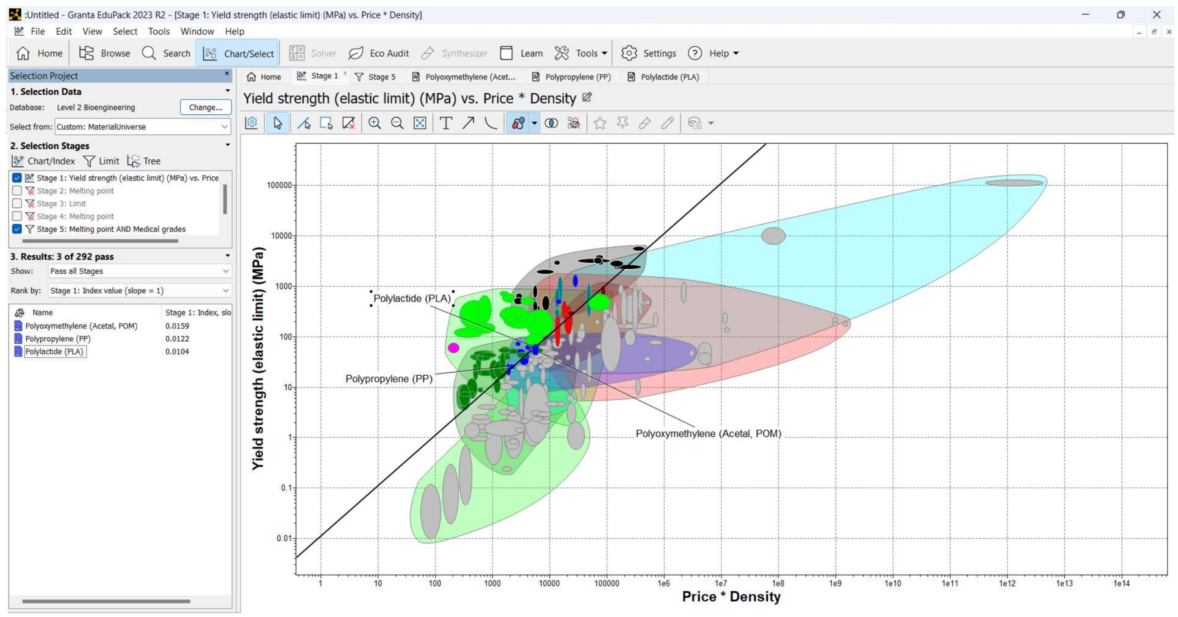
I've decided to choose the strength design for the material of the sterilization container. I've chosen a strength design because I want to prioritize the materials ability to resist deformation and stay durable throughout the autoclave process. The material is going to have to undergo very high temperatures and pressure so by ensuring the main focus of the design is geared towards its strength, the material will be more reliable in the face of mechanical stresses.

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: $\dfrac{\sigma}{\rho C_m}$	Polyoxymethylene (Acetal, POM)	Polypropylene (PP)	Polylactide (PLA)

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

Chosen Material:	Polypropylene (PP)

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

Based on the MPI results, the best material to use in this case would be polypropylene (PP). Out of the three materials, polypropylene has the lowest yield strength (elastic limit), however it makes up for it given its low cost (ranging from 2.22-2.54 CAD/kg) and density (ranging from 895-909kg/m^3) [1]. So, considering that our main objective was to minimize density and cost, it makes polypropylene the best choice of the top three materials. Furthermore, polypropylene has good durability under high temperatures, which will ensure the material can withstand the stress and pressure of the autoclave process without being damaged or deformed. Overall, polypropylene's small cost, low density and durability makes it the most optimal choice for the autoclave process.

References (If any):

[1] Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023, www.ansys.com/materials [Accessed Nov. 27, 2023].

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	$\frac{E}{\rho C_m}$	Minimizing cost and mass

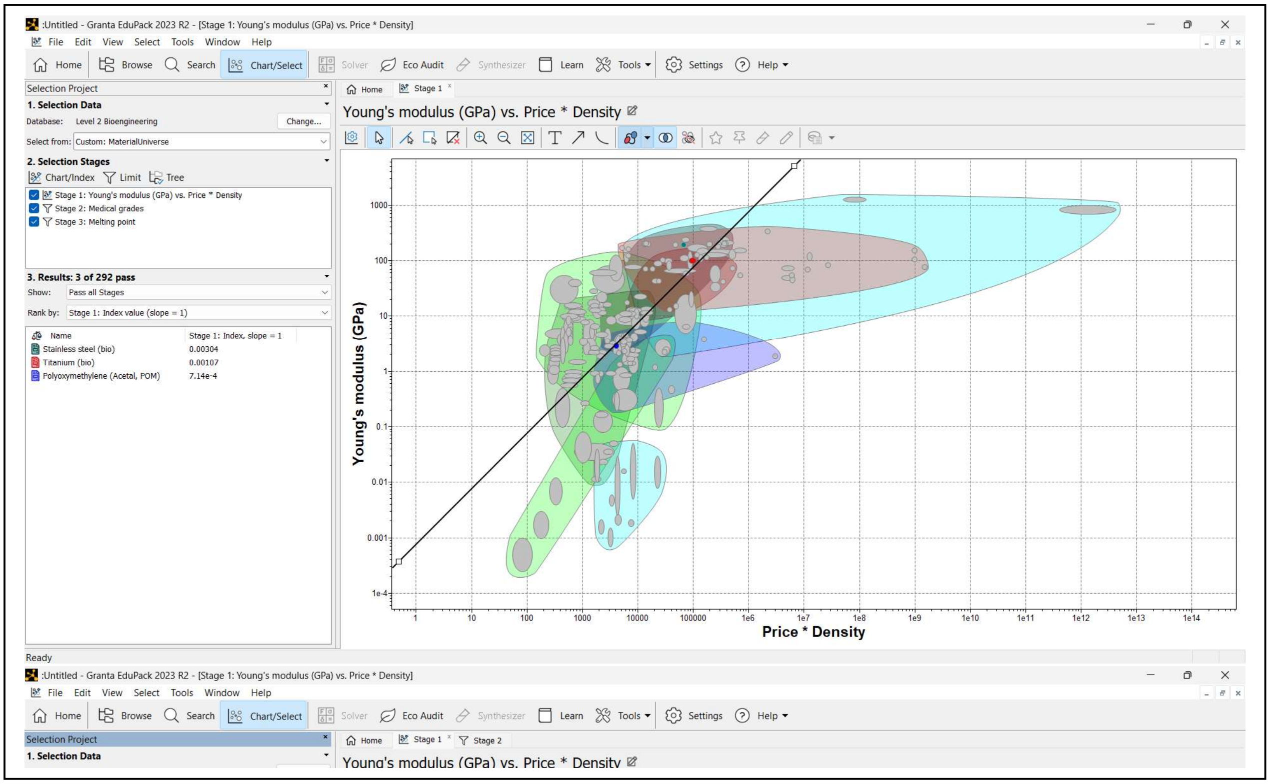
Please provide a short justification for your chosen design and MPI.

The reason I chose a design that maximizes stiffness is that the sterilization container will be put under constant stress as tools are taken out of or put into the container, and also when the container itself is inserted and removed from the autoclave. Therefore, it is important the container's material has a high elastic modulus to minimize the strain of the container as it goes through normal use. The strength is not as important because the container should never face any major sources of stress that will cause it to plastically deform.

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

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).

The main reason stainless steel was chosen was for its high performance on the MPI applied to it. Stainless steel has the best index value when the stiffness MPI is applied to it, with titanium being a close contender and polyoxymethylene being four orders of magnitude worse [1]. Additionally, it is significantly cheaper than titanium and is only a few dollars per unit mass more expensive than polyoxymethylene. [1]. It is, however, the option with the most density. The low cost of stainless steel means it meets the design objectives reasonably well. Additionally, stainless steel meets all the constraints of the design task, that being that it has a melting point that is above an autoclave’s operating temperatures [1], is medical grade [1], and is a not a ceramic or glass.</td></tr>
<tr><td colspan="2">References (If any):

[1] Ansys Granta EduPack software, ANSYS, Inc., Cambridge, UK, 2023 Available: www.ansys.com/materials</td></tr>
</table>

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: $\frac{\sigma}{\rho C_m}$

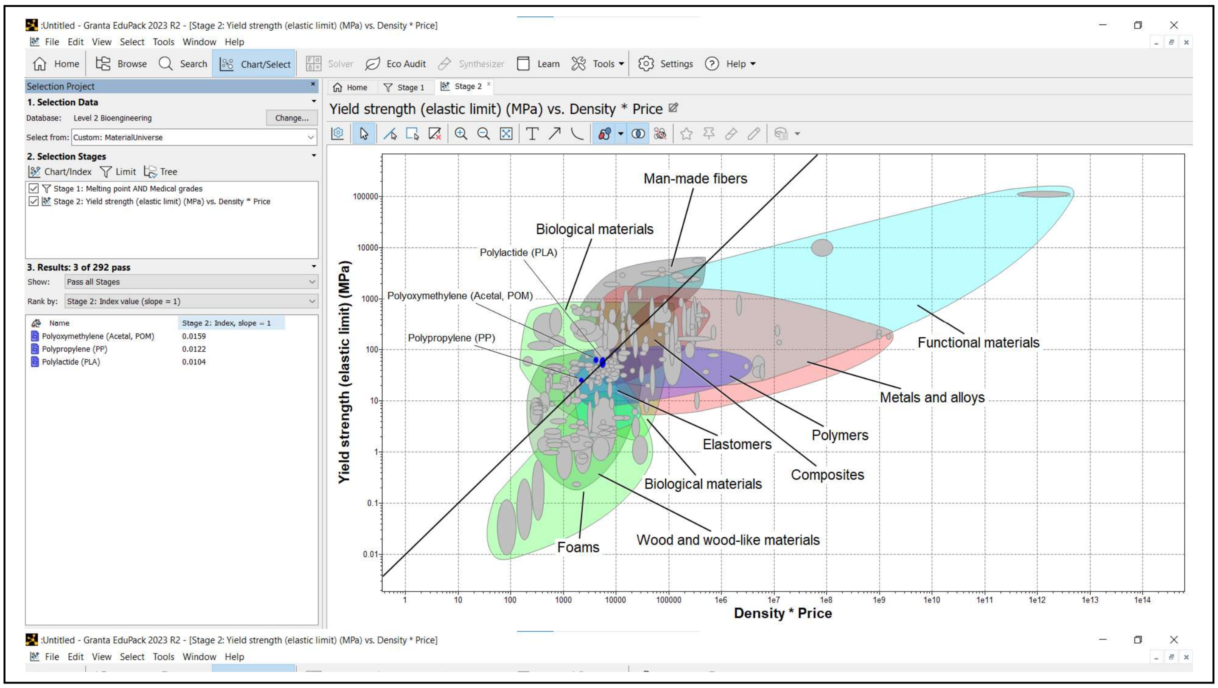
<table>
<tr><th>Chosen Design</th><th>Chosen MPI</th><th>Objective</th></tr>
<tr><td>Strength Design</td><td>$\frac{\sigma}{\rho C_m}$</td><td>Minimize Cost and Mass</td></tr>
<tr><td colspan="3">Please provide a short justification for your chosen design and MPI.

The function that helped played the biggest part in choosing strength design was the ability to withstand the internal pressures in the autoclave. Young's modulus defines a materials resistance to deformation while yield strength is the maximum stress a material can resist before permanent deformation is caused. The autoclave exerts a high amount of pressure on the material from all directions causing stress and strain. Maximizing yield strength makes it harder to rupture the container. Additionally, minimizing density lowers the weight of the container, allowing for the Q-arm to pick up the container more easily, and minimizing cost makes the container design more economical and affordable.</td></tr>
</table>

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: Strength Design $\frac{\sigma}{\rho C_m}$	Polyoxymethylene (Acetal, POM)	Polypropylene (PP)	Polylactide (PLA)

MATERIAL SELECTION (STAGE 3) - FINAL SELECTION

State your chosen material and justify your final selection

Chosen Material:	Polypropylene (PP)
Discuss and justify your final selection in the space below (based on the MPI results and any other relevant considerations). Polypropylene (PP) is the best material of the three because it has both a lower density and cost per kg compared when compared to the other two materials. Despite having a lower yield strength than the other two options, polypropylene is still able to maintain its form while under the pressure caused by the autoclave. This can be proven with the following information: PP has a yield strength of 24.1 MPa--or--3495.4 at its minimum, [1]. The autoclave only produces about 15psi of pressure operating at 121 degrees Celsius, meaning that PP can handle the pressure load [2]. Since polypropylene can maintain its form despite the pressures caused by the autoclave, the yield strength of the other two materials is not important. Polypropylene is the best option because it is more cost-efficient than the other two options, while still maintaining the required strength for the autoclave.	
References (If any): [1] Ansys Granta Edupack software, ANSYS, Inc., Cambridge, UK, 2023 (ansys.com/materials) [2] "Autoclave Overview," Blink, UC San Diego [Online]. Available: (https://blink.ucsd.edu/safety/research-lab/biosafety/autoclave) [Accessed: November 27, 2023].	

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

Team ID: Fri-30

Name: Mohammad Mustafa	MacID: mustam26

Write your pseudocode in the space below:

1. Arm begins at the home position, defined as the base, should, and elbow joints being at a rotation of 0 degrees and the gripper being open.
2. Wait for a container to spawn in
3. ID the container (note its size and colour) and note where it's pickup position is.
4. Find the location of the container's corresponding autoclave and note it's position. (XYZ coordinates)
5. Reading the user's inputs of the right potentiometer to navigate the arm in front of the container so the end-effectors are at the pick-up position.
6. Read user's inputs to close the gripper and grab the container.
7. Move the arm to the home position with the container.
8. Move the arm (with the container) to the correct autoclave's position using user inputs.
9. .Raed user's input of the left potentiometer to decide to put the arm into position 1 or position 2. Use the activate autoclave command.
    - If it's position 1, move arm to the top of autoclave
    - If it's position 2
        - Open the autoclave drawer
        - Move the container into the drawer
10. Verify that the container is at the correct autoclave and in the correct position.
11. Open the arm gripper and release the container
12. Close the autoclave drawer if the container was large and it was opened
13. Use the deactivate autoclave command
14. If less than 6 containers have been sorted, go to step 1. If 6 have been sorted, move on.
15. Move arm to home position.
16. End program.

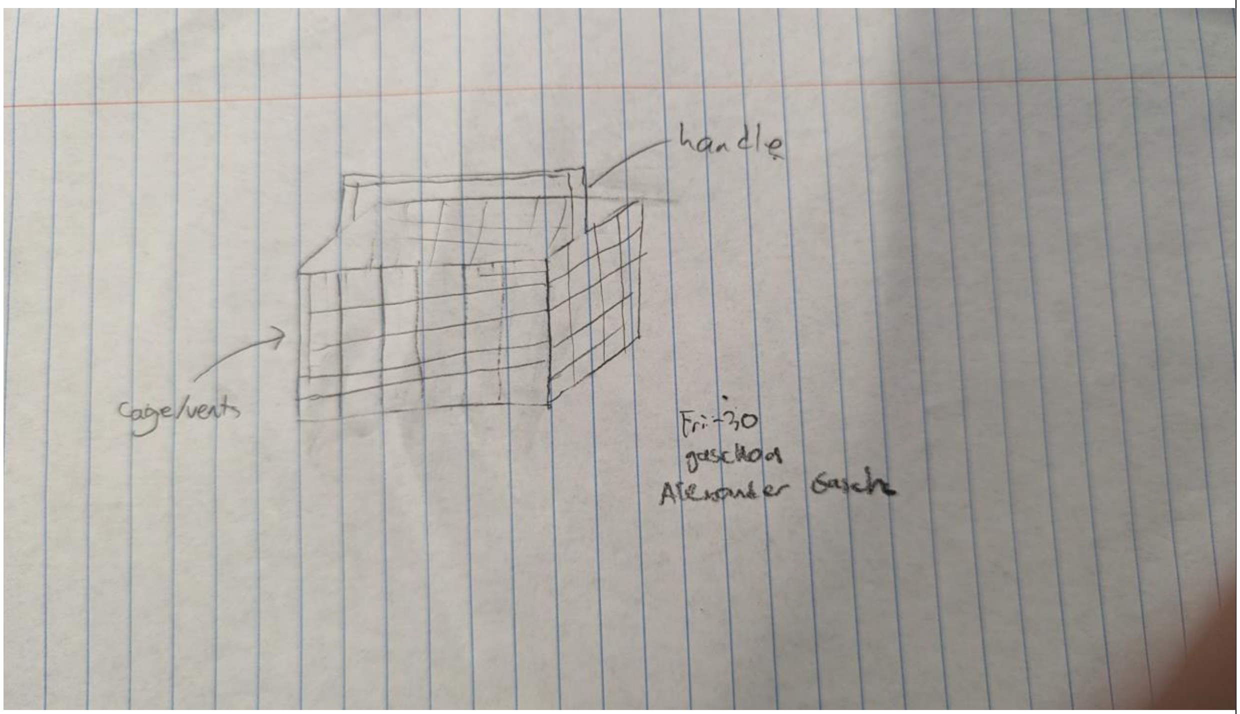
MILESTONE 1 (STAGE 3) – PRELIMINARY CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID: Fri-30

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: Fri-30

Name: Alexander Gascho	MacID: gaschoa
Insert screenshot(s) of your preliminary sketch below	



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

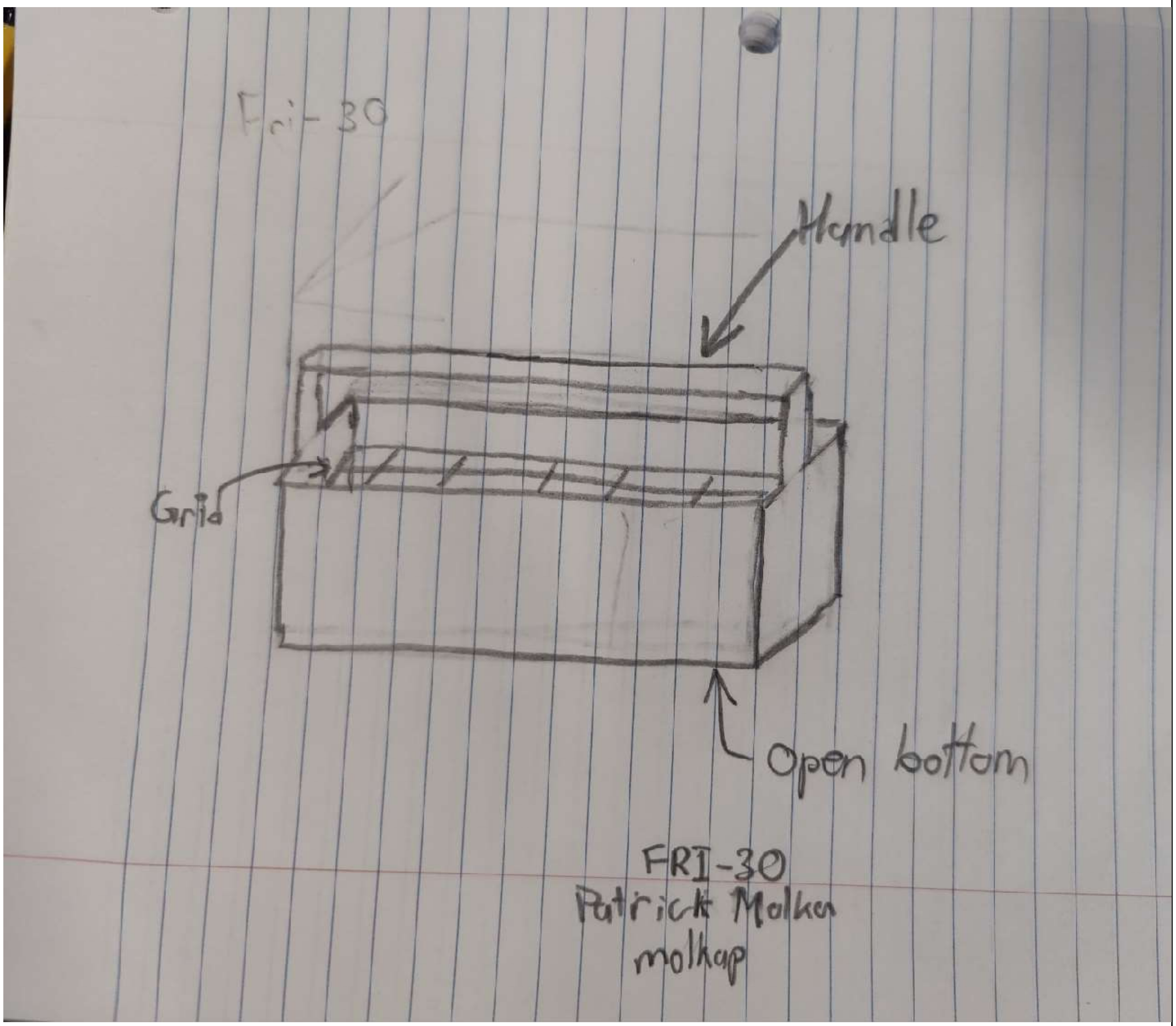
MILESTONE 1 (STAGE 3) – PRELIMINARY CONCEPT SKETCHES (MODELLING SUB-TEAM)

Team ID: Fri-30

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: Fri-30

Name: Patrick Molka	MacID: molkap
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: Fri-30

Name: Adrian Winter	MacID: wintea10

Write your pseudocode in the space below

```
START OF CODE
While count variable is less than 6
    Set Q-arm base, shoulder, and elbow joints to 0 degree rotation
    Open Q-arm gripper
    Create a container ID from a list of 6 containers (with unique size and colours), and set it to the "pick-up location" (a predetermined XYZ location)
    Remove the container from the list so it cannot be spawned again
    Move the Q-arm to the "pick-up location" (XYZ)
    Close the Q-arm gripper
    Move the Q-arm base, shoulder, and elbow joints to 0 degree rotation
        If the left potentiometer threshold is >50% but <100%
            Move the Q-arm base incrementally based on the right potentiometer
            If the autoclave colour matches the container colour in the XY range
                Move the Q-arm to the drop-off position (on top of the autoclave)
                Activate autoclaves
                Open Q-arm gripper
        Else if left potentiometer threshold is 100%
            Drop container at home position
            Move the Q-arm base incrementally based on the right potentiometer
            If the autoclave colour matches the container colour in the XY range
                Move the Q-arm to the drop-off position (on top of the autoclave)
                Open the autoclave drawer
                Return to home position
                Close Q-arm gripper
                Return to autoclave position
                Activate autoclaves
                Open Q-arm gripper
                Close the autoclave drawer
    Deactivate autoclaves
    Increase count variable by 1
END OF CODE
```

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

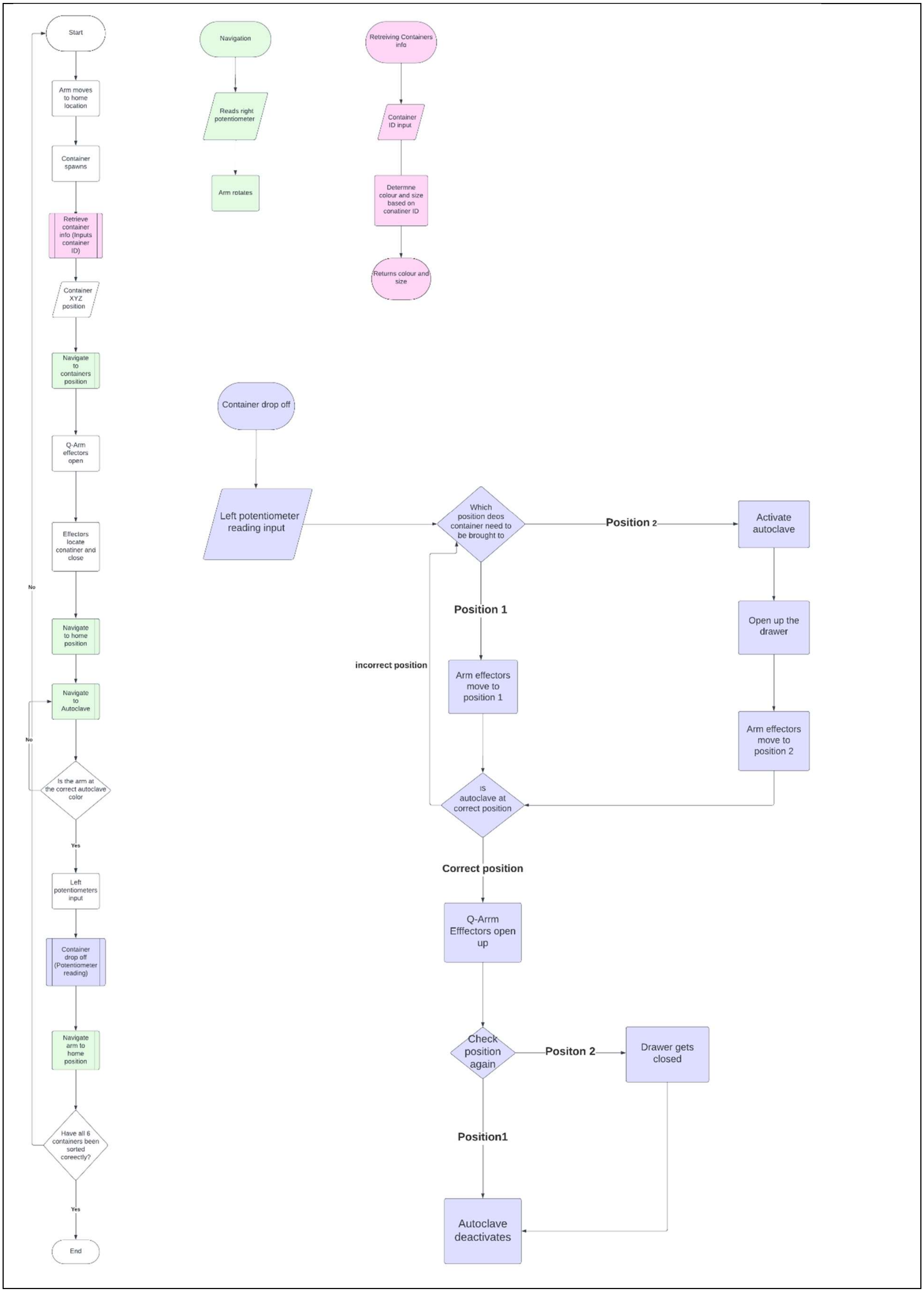
Team ID: Fri-30

Complete this worksheet individually <u>before</u> 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 <u>*each*</u> workflow
2. Take a photo of your sketch
3. Insert your photo as a Picture (Insert > Picture > This Device)

Team ID: Fri-30

Name: Arther Assaf	MacID: assafa2
Insert screenshot(s) of your workflow below	


Start
Arm moves to home location
Container spawns
Retrieve container info (Inputs container ID)
Container XYZ position
Navigate to containers position
Q-Arm effectors open
Effectors locate conatiner and close
Navigate to home position
Navigate to Autoclave
Is the arm at the correct autoclave color
No
Yes
Left potentiometers input
Container drop off (Potentiometer reading)
Navigate arm to home position
Have all 6 containers been sorted coreectly?
No
Yes
End
Navigation
Reads right potentiometer
Arm rotates
Retreiving Containers info
Container ID input
Determne colour and size based on conatiner ID
Returns colour and size
Container drop off
Left potentiometer reading input
Which position deos container need to be brought to
Position 2
Activate autoclave
Open up the drawer
Arm effectors move to position 2
Position 1
Arm effectors move to position 1
incorrect position
is autoclave at correct position
Correct position
Q-Arrm Efffectors open up
Check position again
Positon 2
Drawer gets closed
Position1
Autoclave deactivates

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

Team ID: Fri-30

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: Fri-30

Name: Arther Assaf	MacID: assafa2

Insert screenshot(s) of your code below

P2_Simulation_Template.py - C:\Users\exp-029\Downloads\Q-Labs Python Files\Q-Labs Python Files\Student_Files\P2_Simulation_Template.py (3.8.8)

File Edit Format Run Options Window Help

```
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
#---------------------------------------------------------------------------------
# Mac ID: assafa2 NAME: Arther Assaf

def dropContainer (position, color):
    # valid = arm.check_autoclaves(color)
    #if not valid:
    #    return "Q-arm is in front of the wrong autoclave"
    if position == 1: #small container
        y = 1
    else: #large container

        arm.activate_autoclaves()
        arm.open_autoclave(color, True) #open drawer
        arm.rotate_shoulder(35)
        arm.rotate_elbow(20)
        arm.control_gripper(-45)
        time.sleep(2)
        arm.rotate_shoulder(-35)
        arm.rotate_elbow(-20)
        arm.open_autoclave(color, False) #close drawer

    arm.deactivate_autoclaves()
    return None
arm.rotate_base(-90)#bring the arm in front of an autoclave to the test
arm.control_gripper(45)
dropContainer(2, "blue")
```

*Limit screenshots to no more than 1 per page. For additional screenshots, 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)

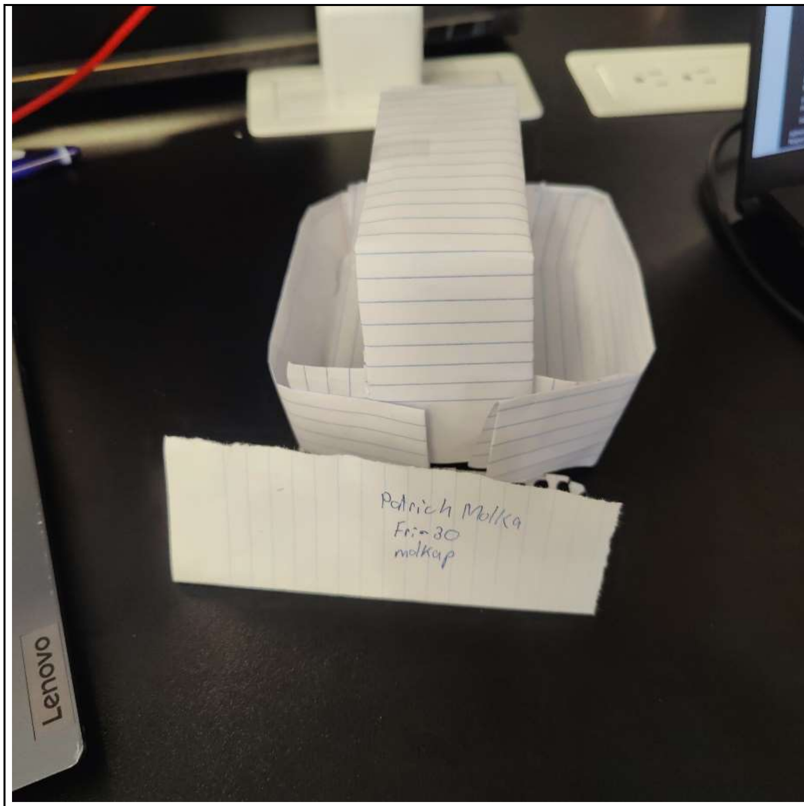
Team ID: Fri-30

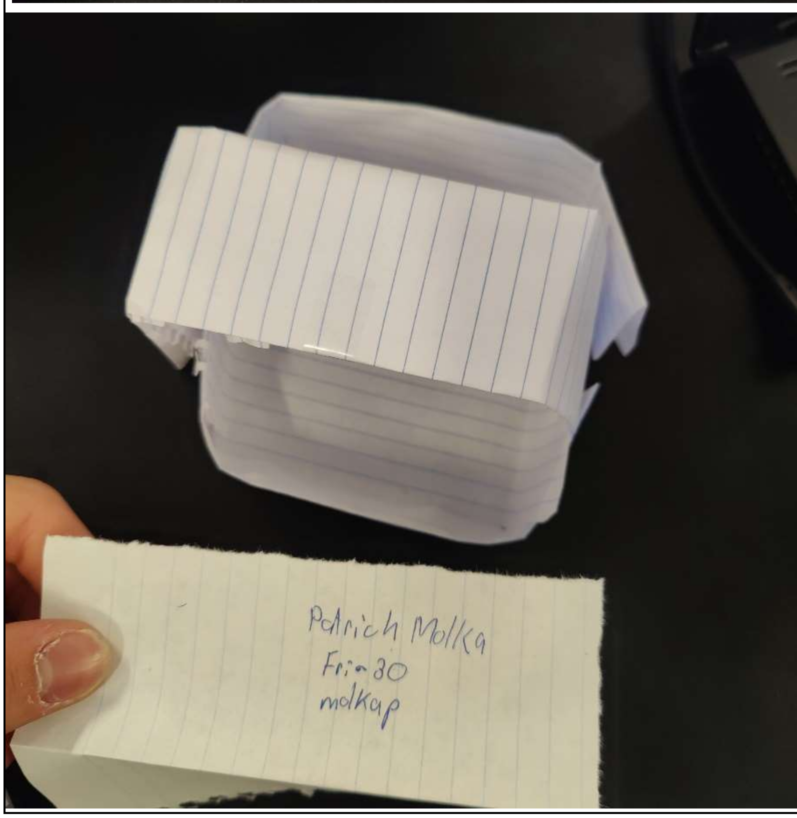
Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

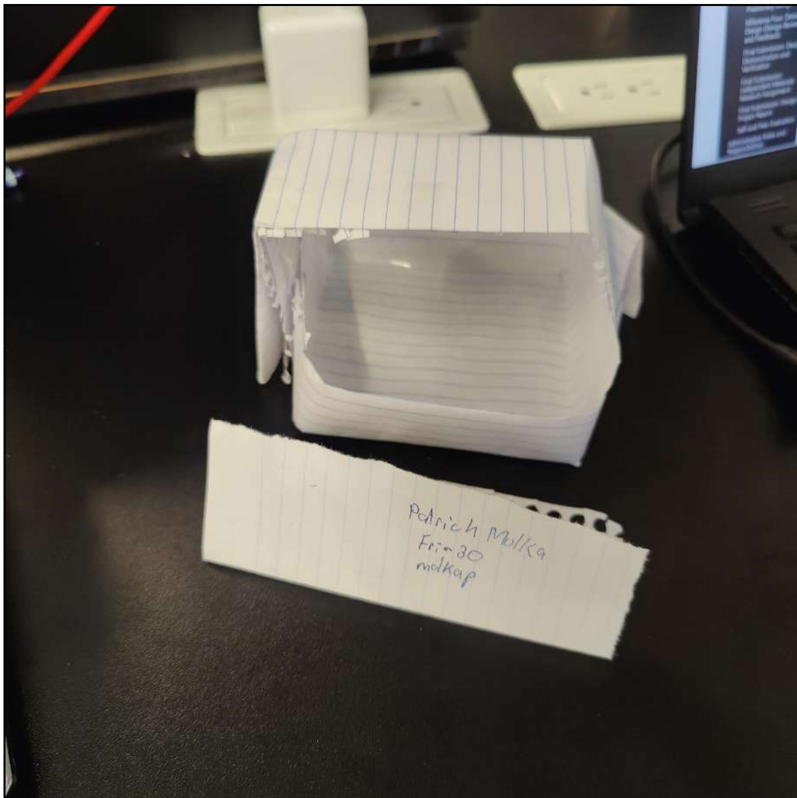
1. Take multiple photos of the low-fidelity prototype
   - Include an index card (or similar) next to the prototype, clearly indicating your Team Number, Name and MacID on *each* picture
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* prototype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

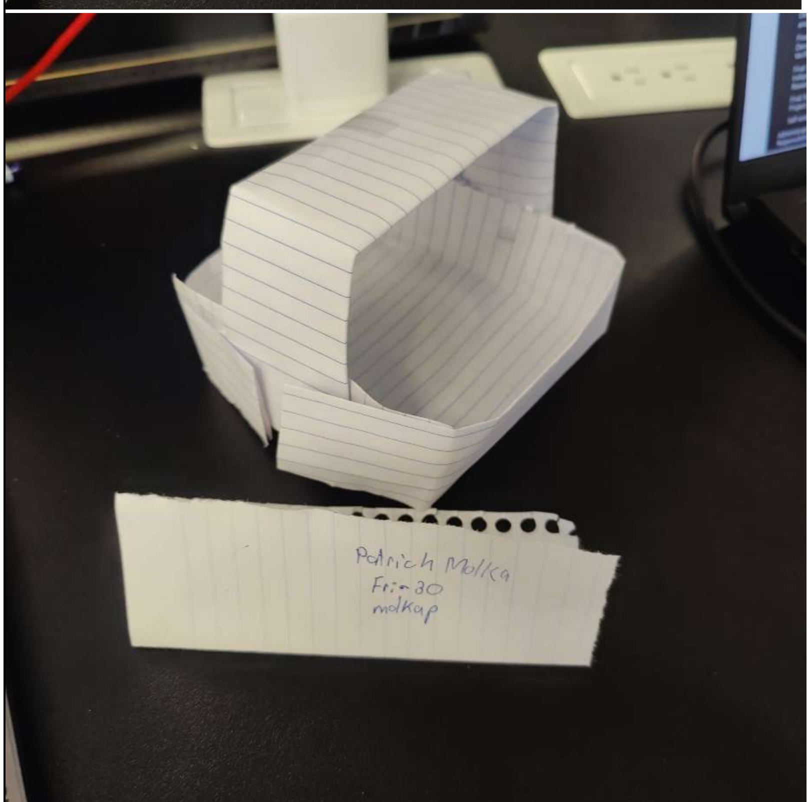
Team ID: Fri-32

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


Patrick Molka
Fri-30
molkap
Lenovo


Patrick Molka
Fri-30
molkap


Patrick Molka
Fri-30
molkap


Patrick Molka
Fri-30
molkap

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

Team ID: Fri-30

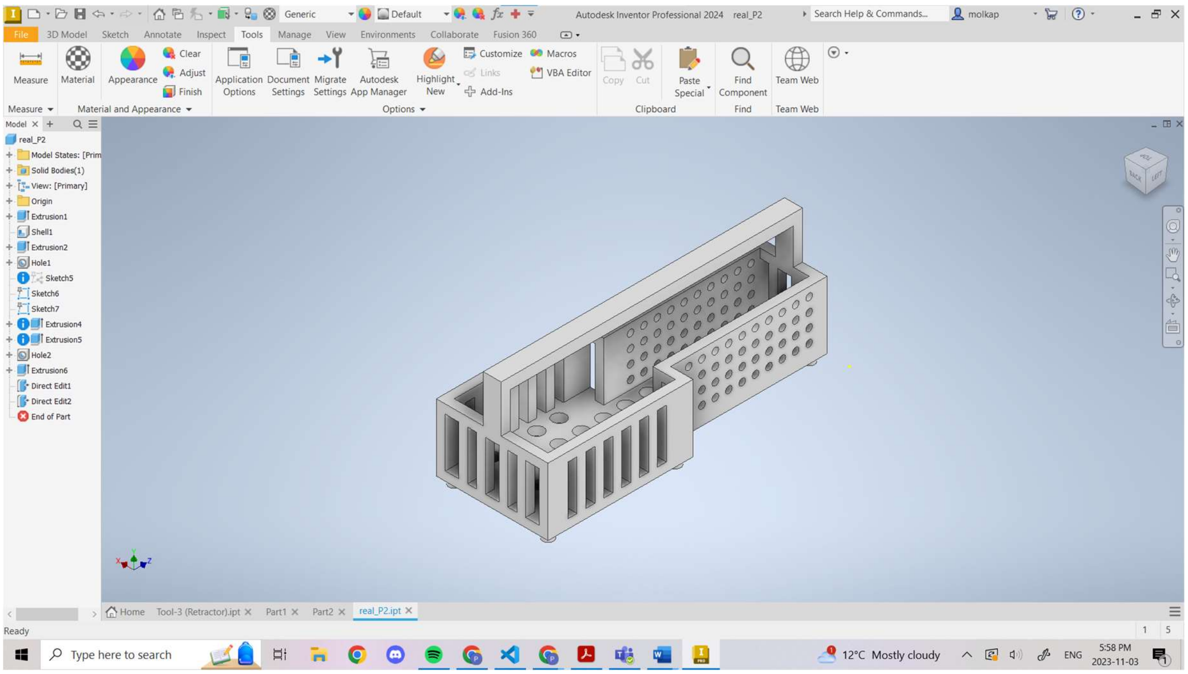
Complete this worksheet individually <u>during</u> Design Studio 8.

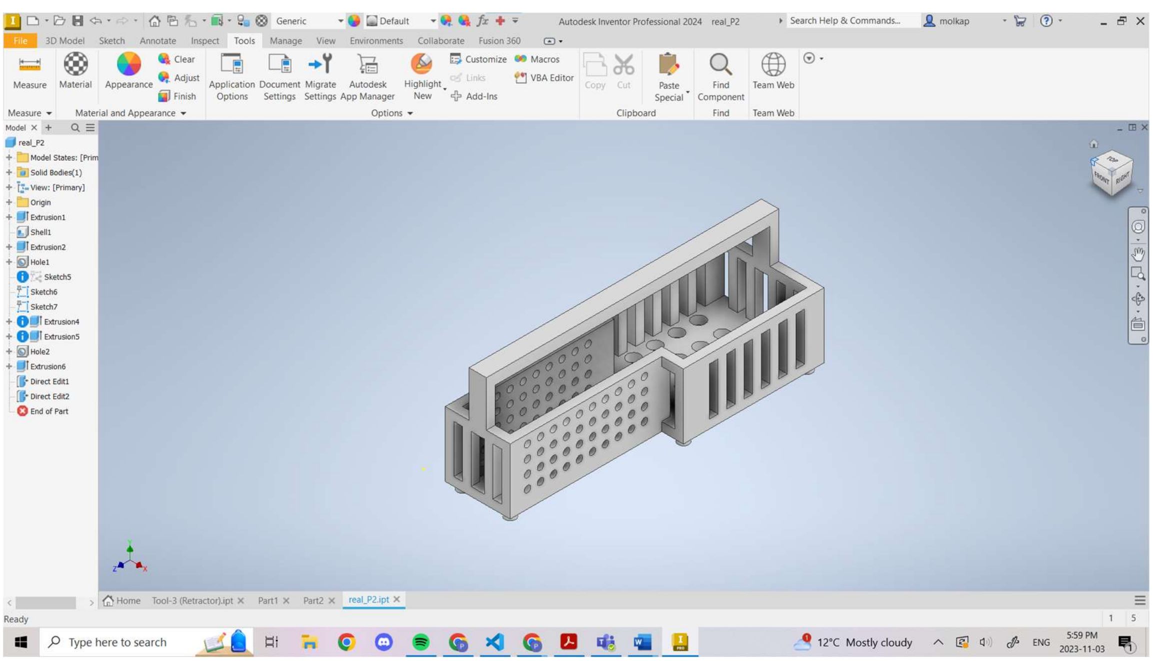
1. Take multiple screenshots of your preliminary solid model
   → You are also required to submit an IPT file of each solid model (see Submission Details section above)
   → Be sure to label model with your Name and MacID
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **<u>Do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

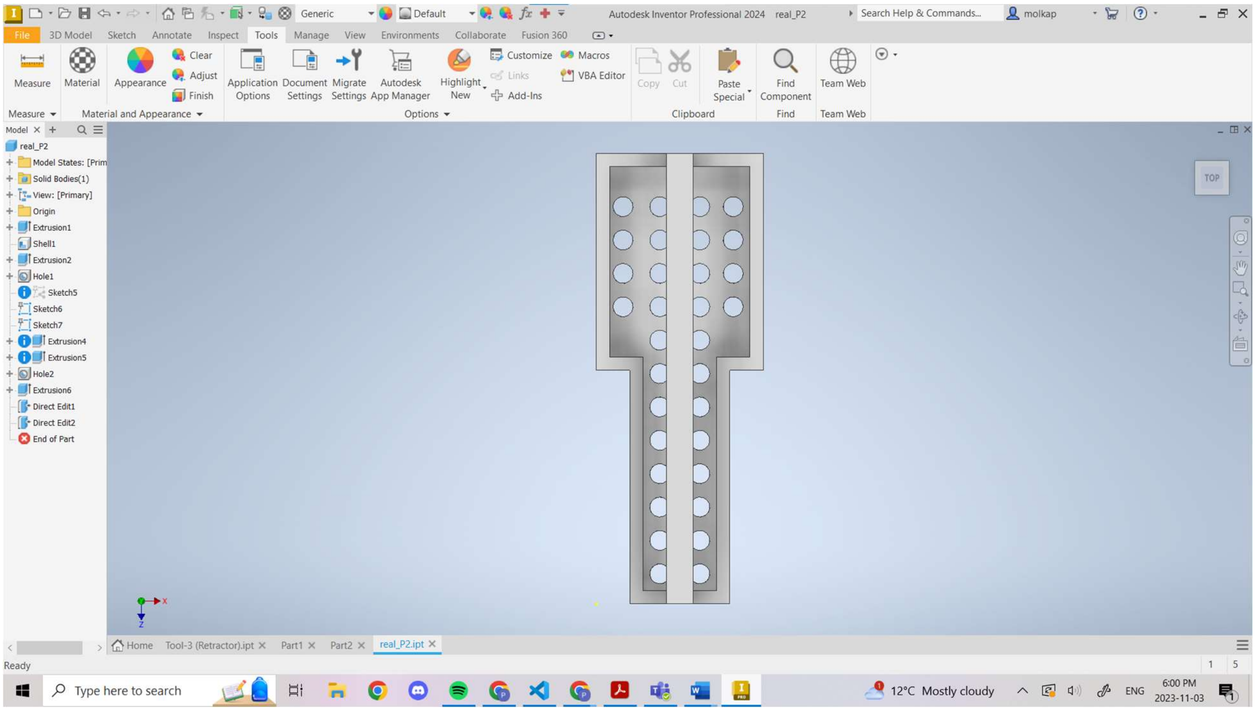
Team ID: Fri-30

Name: Patrick Molka	MacID molkap
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






Autodesk Inventor Professional 2024 real_P2
File 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Fusion 360
Measure Material Appearance Clear Adjust Finish Application Options Document Settings Migrate Settings Autodesk App Manager Highlight New Customize Links Add-Ins Macros VBA Editor Copy Cut Paste Special Find Component Team Web
real_P2
Model States: [Prim
Solid Bodies(1)
View: [Primary]
Origin
Extrusion1
Shell1
Extrusion2
Hole1
Sketch5
Sketch6
Sketch7
Extrusion4
Extrusion5
Hole2
Extrusion6
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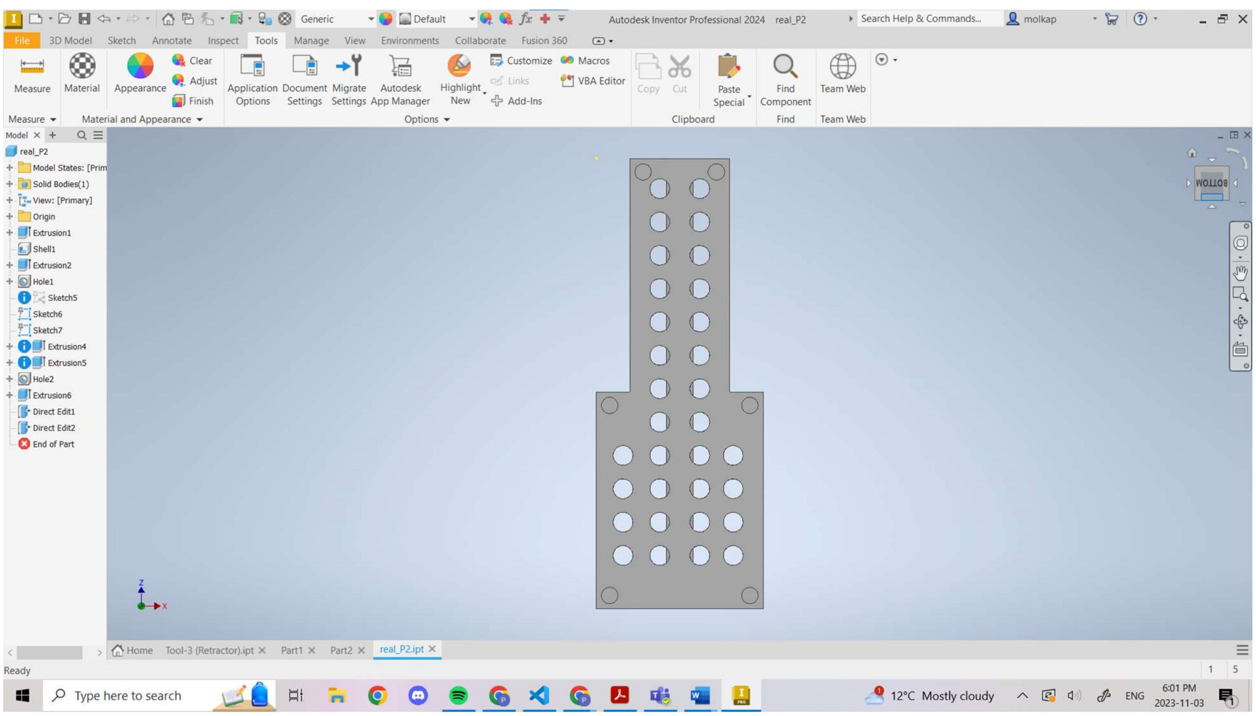
2023-11-03


Autodesk Inventor Professional 2024 real_P2
File 3D Model Sketch Annotate Inspect Tools Manage View Environments Collaborate Fusion 360
real_P2
Model States: [Prim
Solid Bodies(1)
View: [Primary]
Origin
Extrusion1
Shell1
Extrusion2
Hole1
Sketch5
Sketch6
Sketch7
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Extrusion5
Hole2
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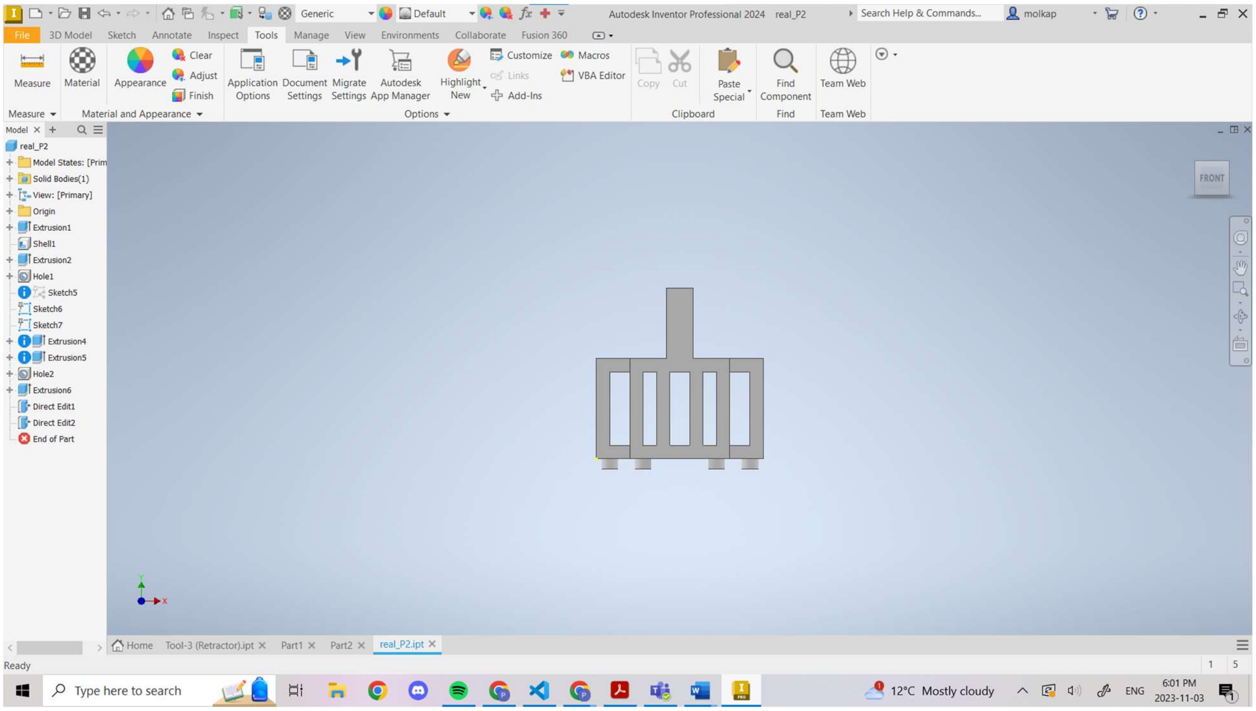
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real_P2
Model States: [Prim
Solid Bodies(1)
View: [Primary]
Origin
Extrusion1
Shell1
Extrusion2
Hole1
Sketch5
Sketch6
Sketch7
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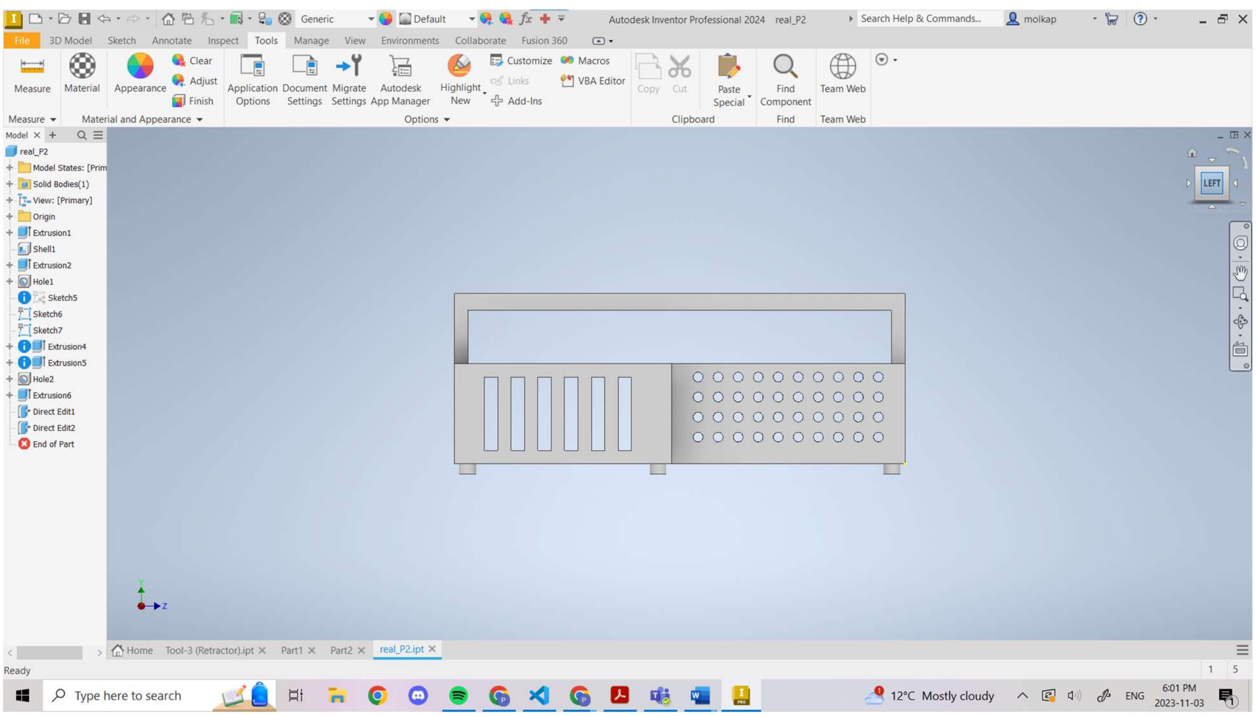
2023-11-03


Autodesk Inventor Professional 2024 real_P2
Search Help & Commands...
molkap
File
3D Model
Sketch
Annotate
Inspect
Tools
Manage
View
Environments
Collaborate
Fusion 360
Measure
Material
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Sketch7
Extrusion4
Extrusion5
Hole2
Extrusion6
Direct Edit1
Direct Edit2
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Home
Tool-3 (Retractor).ipt
Part1
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real_P2.ipt
Ready
Type here to search
12°C Mostly cloudy
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6:01 PM
2023-11-03

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

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

Team ID: Fri-30

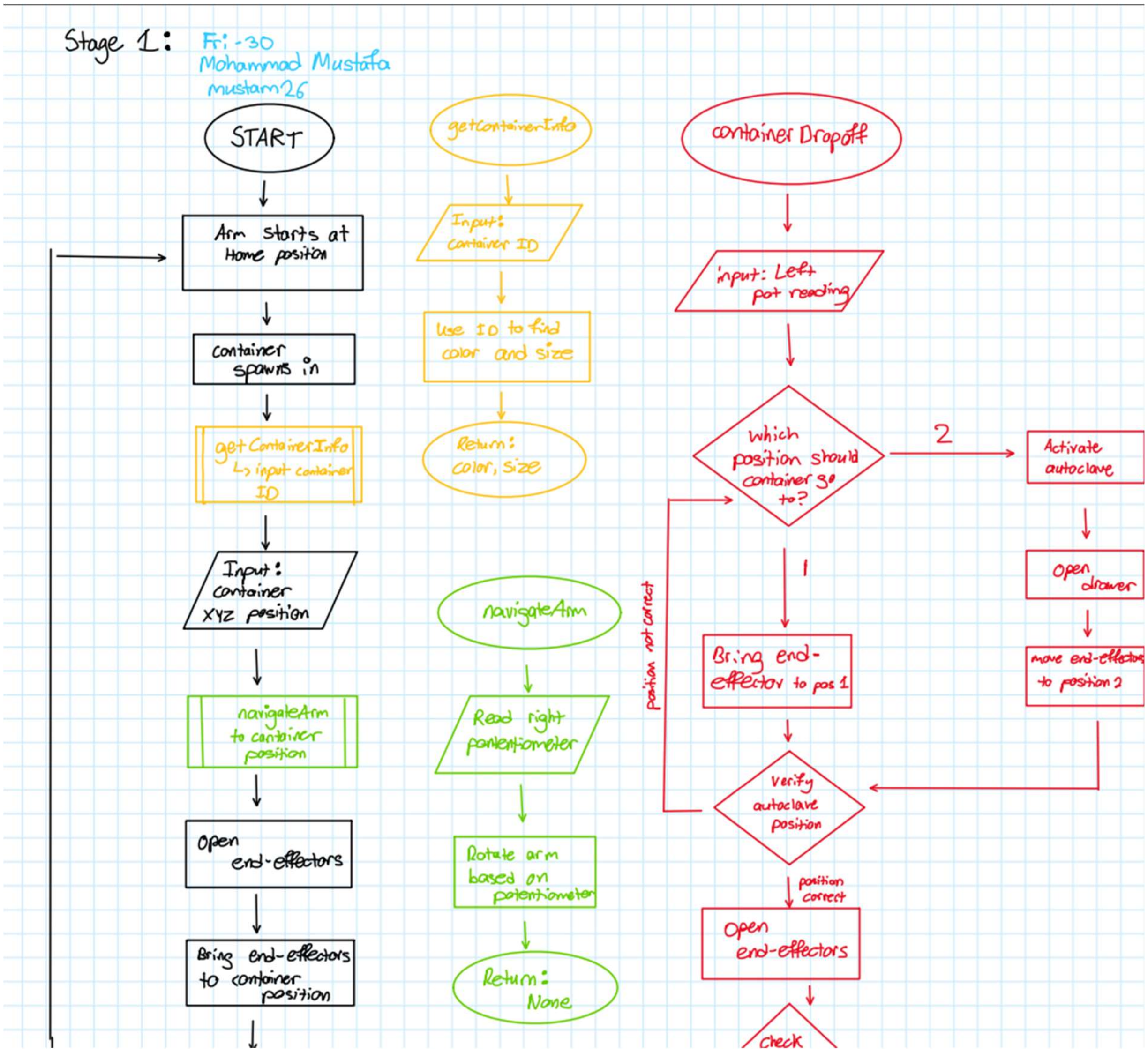
Complete this worksheet individually <u>before</u> coming to Design Studio 8.

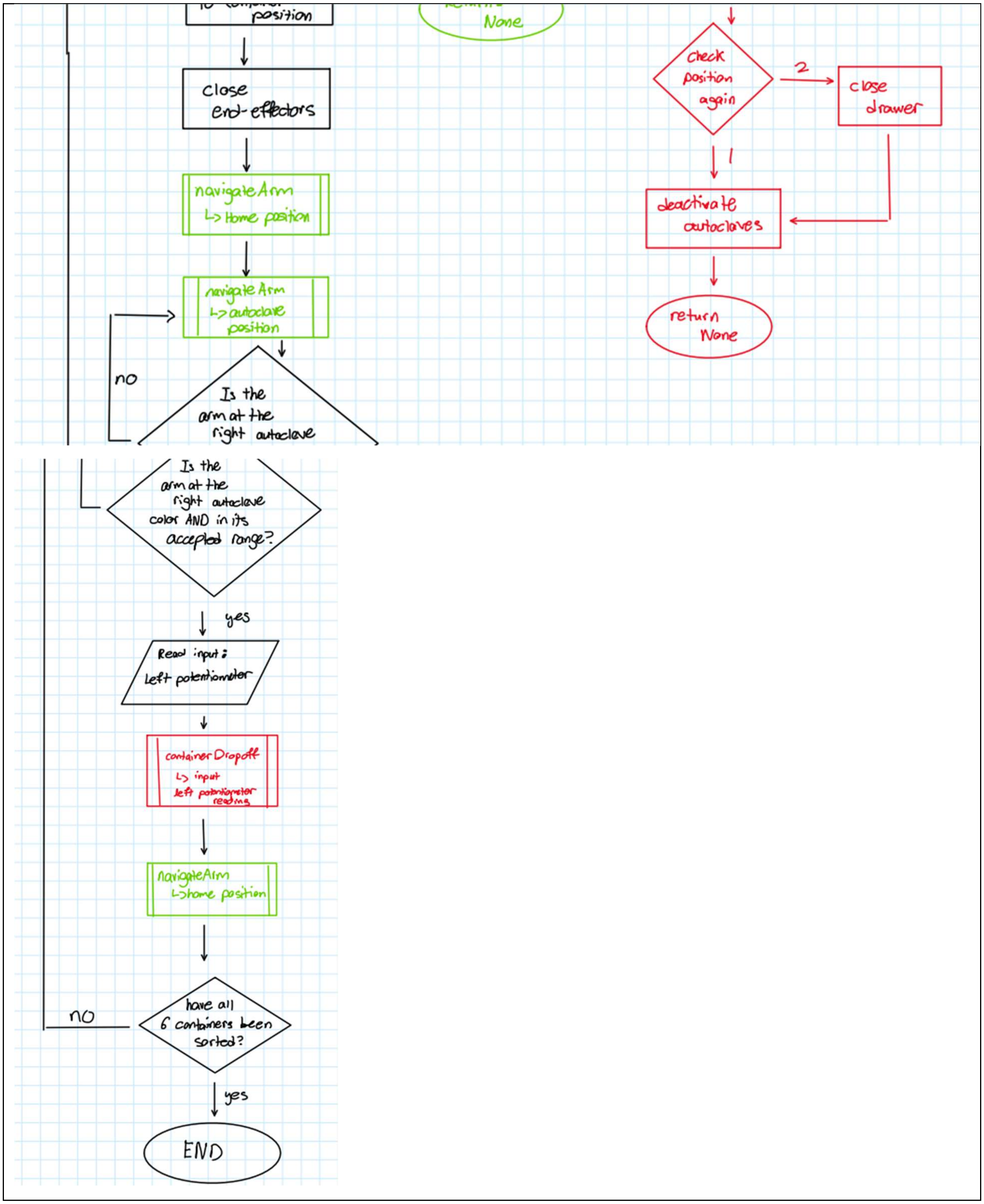
1. Complete your storyboard or flowchart sketches on a separate sheet of paper
   → Be sure to clearly write your Team ID, Name and MacID on <u>*each*</u> workflow
2. Take a photo of your sketch
3. Insert your photo as a Picture (Insert > Picture > This Device)

Team ID: Fri-30

Name: Mohammad Mustafa	MacID: mustam26

Insert screenshot(s) of your workflow below




position
None
check position again
2
close drawer
1
deactivate autoclaves
return None
close end-effectors
navigateArm ↳ Home position
navigateArm ↳ autoclave position
no
Is the arm at the right autoclave color AND in its accepted range?
yes
Read input: Left potentiometer
containerDropoff ↳ input left potentiometer reading
navigateArm ↳ home position
no
have all 6 containers been sorted?
yes
END

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

Team ID: Fri-30

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: Fri-30

Name: Mohammad Mustafa	MacID mustam26

Insert screenshot(s) of your code below

```
#--------------------------------------------------------------------------------
# STUDENT CODE BEGINS
#--------------------------------------------------------------------------------
#FRI-30
#mustam26

def dropContainer(color):
    #valid = arm.check_autoclaves(color)
    #if not valid:
    #   return "The Q-arm is not in front of the right autoclave"
    potRead = potentiometer.left()
    print(potRead)
    if potRead > 0.5 and potRead < 1:
        position = 1
    elif potRead == 1: position = 2

    if position == 1: #small container
        arm.rotate_shoulder(30)
        arm.rotate_elbow(-20)
        arm.control_gripper(-45)

        time.sleep(2)

    else:
        arm.activate_autoclaves()
        arm.open_autoclave(color, True) #open drawer
        arm.rotate_shoulder(30)
        arm.rotate_elbow(20)
        arm.control_gripper(-35)

        time.sleep(2)

        arm.rotate_shoulder(-30)
        arm.rotate_elbow(-20)
        arm.open_autoclave(color, False) #close drawer

    arm.deactivate_autoclaves()
    arm.home()
    return None

arm.control_gripper(45) #simulate holding a container
arm.rotate_base(90) #bring the arm in front of an autoclave to test

dropContainer("red")
#--------------------------------------------------------------------------------
# STUDENT CODE ENDS
#--------------------------------------------------------------------------------
```

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

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

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

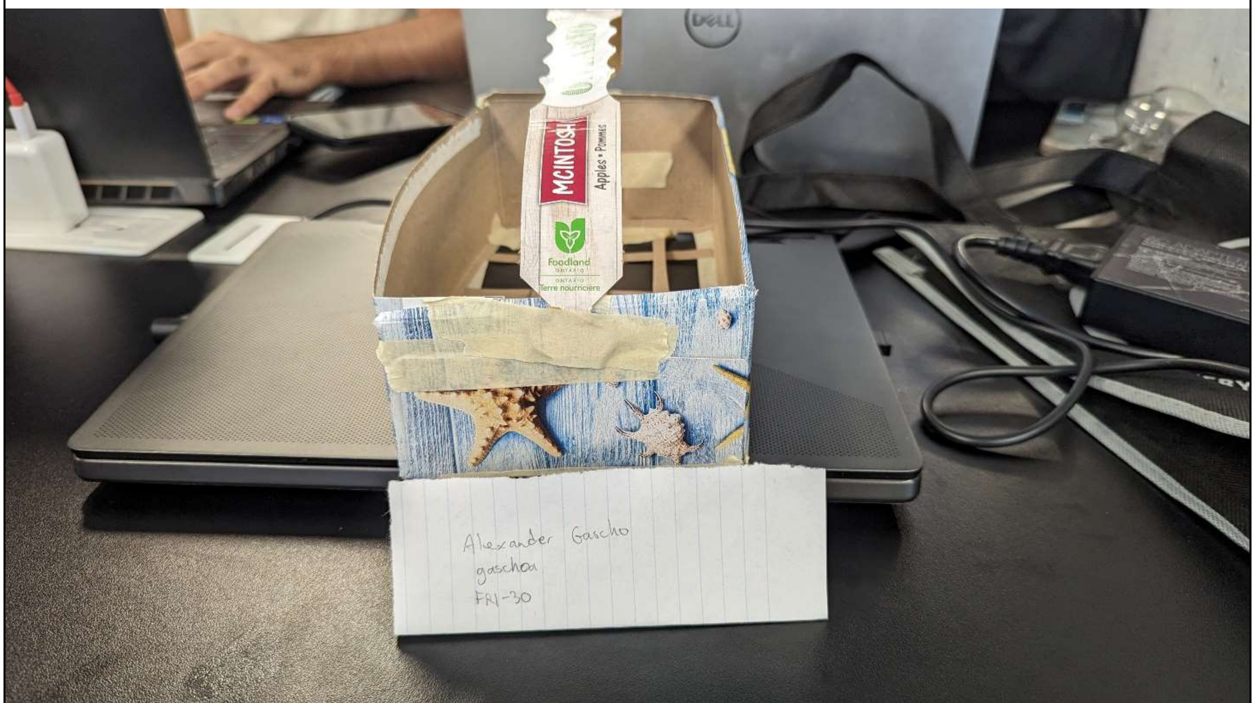
Team ID: FRI-30

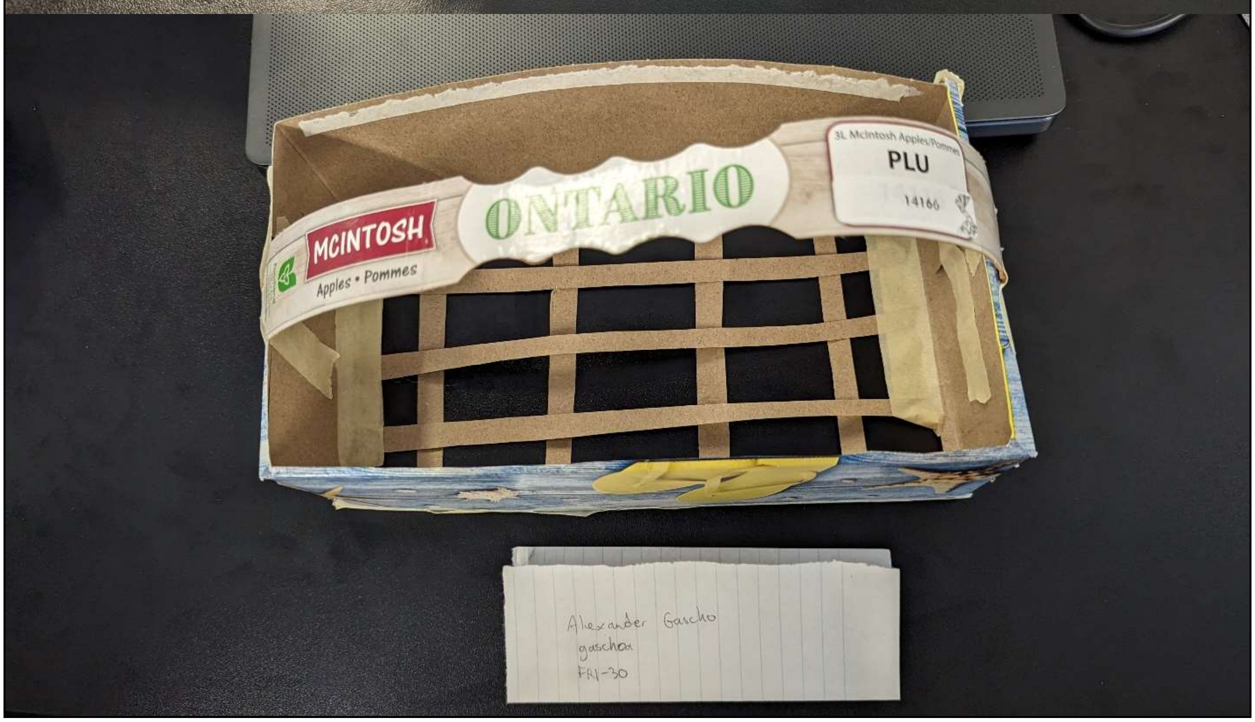
Complete this worksheet before design studio 8 while creating the low-fidelity prototype based on your group members preliminary concept sketch.

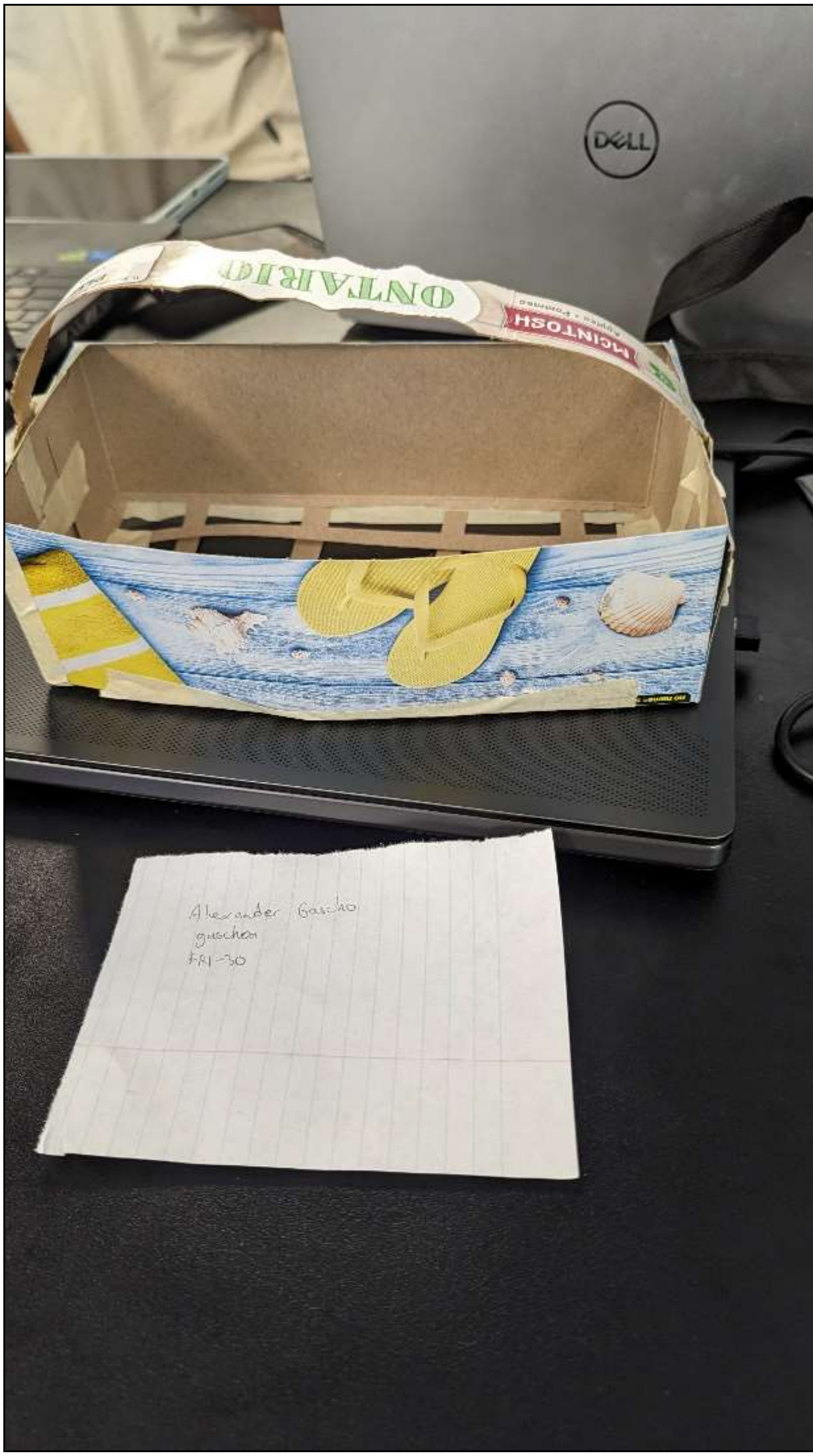
1. Take multiple photos of the low-fidelity prototype
   - Include an index card (or similar) next to the prototype, clearly indicating your Team Number, Name and MacID on *each* picture
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* prototype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

Team ID: FRI-30

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






Alexander Gascho
gaschoa
FRI-30

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

Team ID: FRI-30

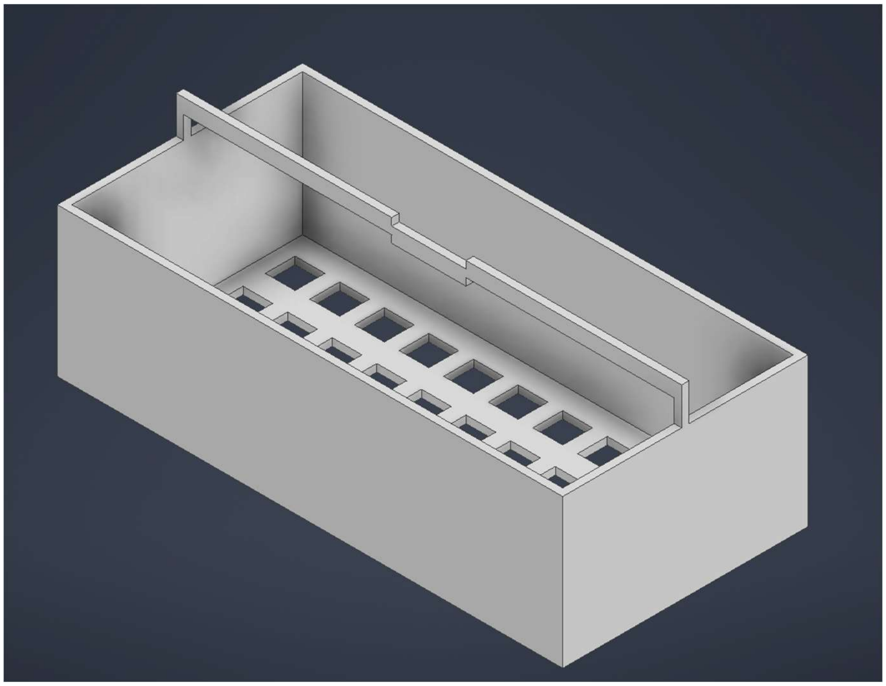
Complete this worksheet individually during Design Studio 8.

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**

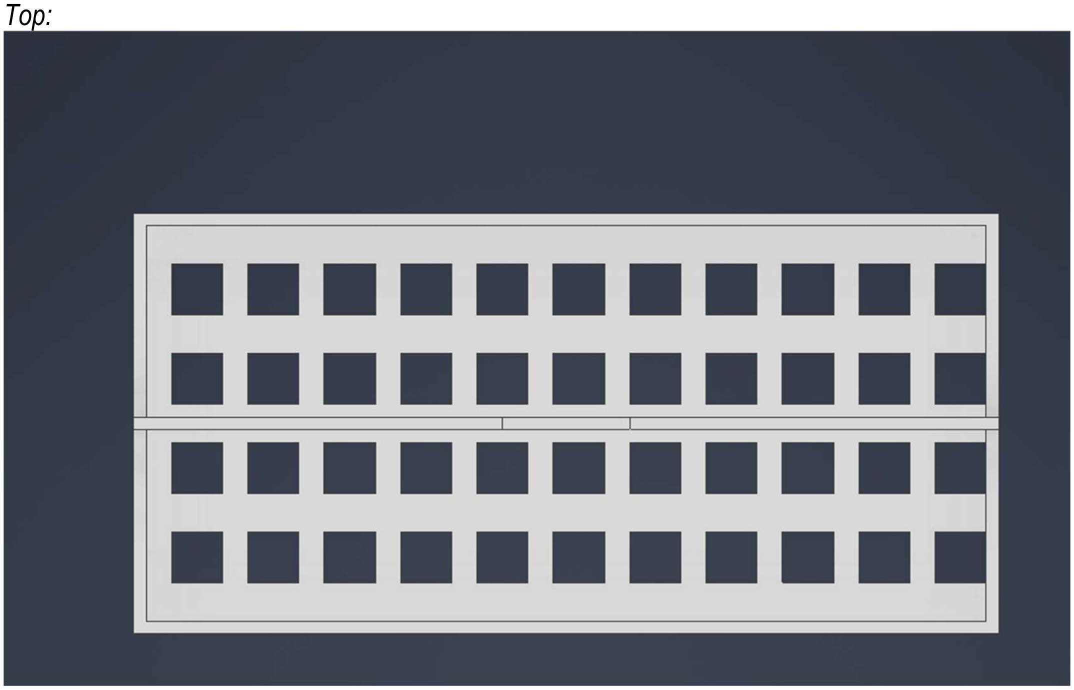
Team ID: FRI-30

Name: Alexander Gascho	MacID gaschoa

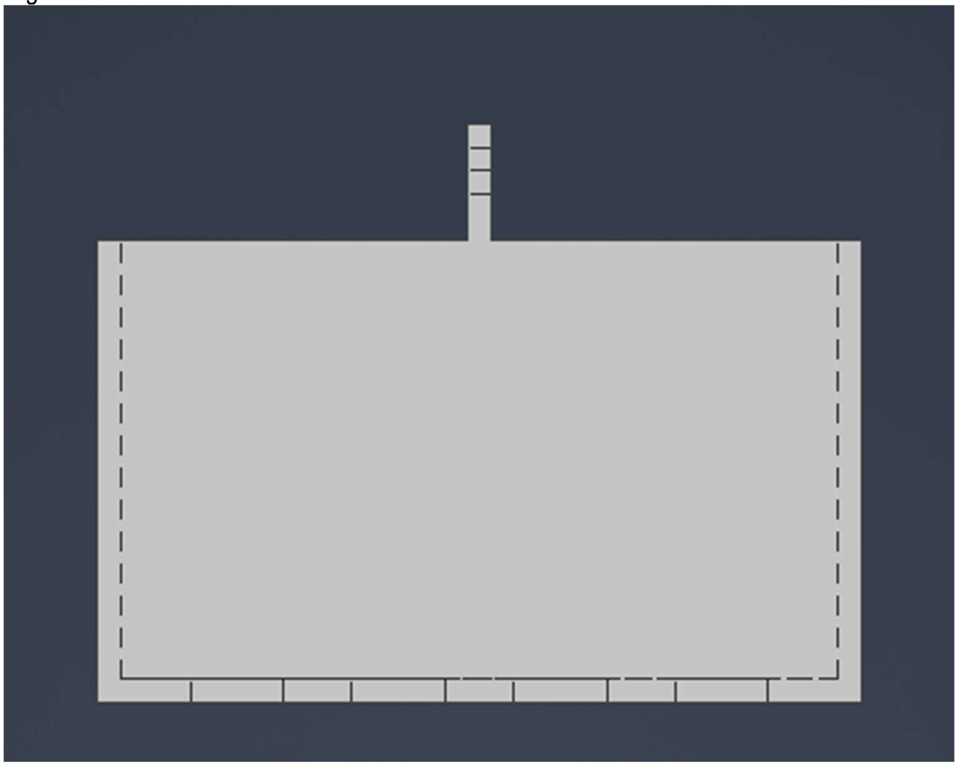
Insert screenshot(s) of your model below



Top:



Right:



Front:

*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: Fri-30

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: Fri-30

Name: Adrian Winter	MacID: wintea10

Insert screenshot(s) of your code below

```
potentiometer = potentiometer_interface()
#-----------------------------------------------------------------------------
# STUDENT CODE BEGINS
#-----------------------------------------------------------------------------

def rotate_base(colour):
    arm.home()
    right_potentiometer_value = 0
    rotation = 0
    total_rotation = 0
    while True:
        if arm.check_autoclave(colour) == True:
            break
        right_potentiometer_value = potentiometer.right()
        rotation = 0
        if right_potentiometer_value <= 0.5:
            rotation = right_potentiometer_value * -10
            if total_rotation + rotation > -175:
                total_rotation += rotation
                arm.rotate_base(rotation)
            else:
                arm.rotate_base(-174-total_rotation)
                total_rotation = -174
        else:
            rotation = right_potentiometer_value * 10 - 50
            if total_rotation + rotation < 175:
                total_rotation += rotation
                arm.rotate_base(rotation)
            else:
                arm.rotate_base(174-total_rotation)
                total_rotation = 174

rotate_base("red")

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

Team Submissions:

TABLE OF CONTENTS

MILESTONE ZERO (TEAM): TEAM DEVELOPMENT AND PROJECT PLANNING

PROJECT TWO: MILESTONE 0 – COVER PAGE

Team ID: Fri-30

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

Full Name:	MacID:
Mohammad Mustafa	mustam26
Patrick Molka	molkap
Adrian Winter	wintea10
Alexander Gascho	gaschoa
Arther Assaf	assafa2

Insert your Team Portrait in the dialog box below

MILESTONE 0 – SUB-TEAM CHARTER

Team ID: Fri-30

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	Patrick Molka
	Alexander Gascho
Computing	Mohammad Mustafa
	Arther Assaf
	Adrian Winter

MILESTONE 0 – TEAM CHARTER

Team ID: Fri-30

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Mohammad Mustafa	☐M ☒A ☐C ☐S
2.	Alexander Gascho	☐M ☐A ☐C ☒S
3.	Patrick Molka	☒M ☐A ☐C ☐S
4.	Arther Assaf	☒M ☐A ☐C ☐S
5.	Adrian Winter	☐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	Adrian Winter	wintea10
Administrator 1	Arther Assaf	assafa2
Administrator 2	Alexander Gascho	gaschoa
Coordinator 1	Mohammad Mustafa	mustam26
Coordinator 2	Patrick Molka	molkap

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team ID: Fri-30

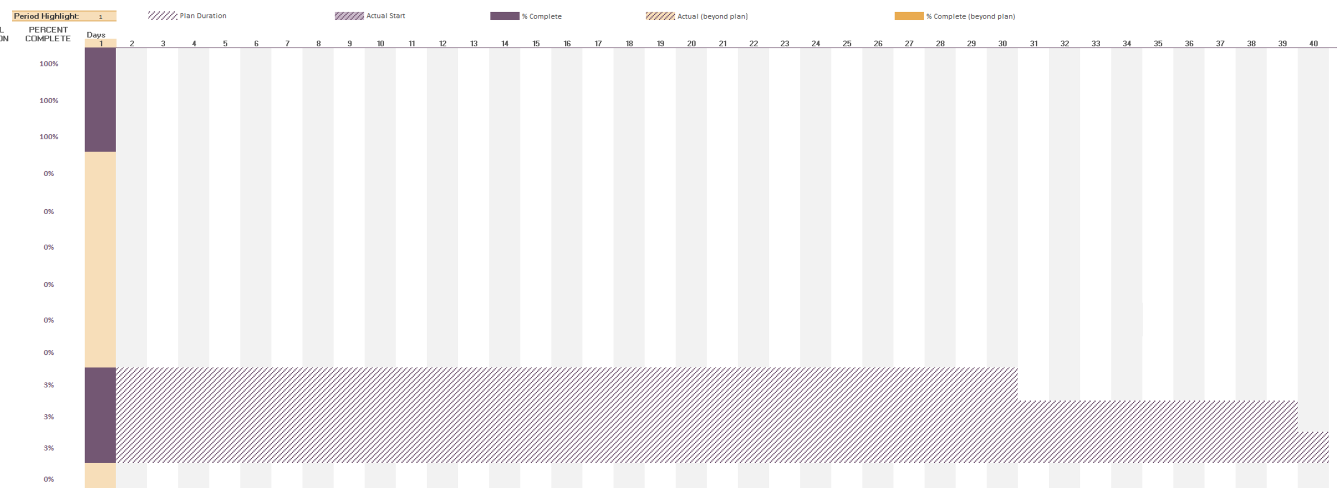
Only the **Team Manager** is completing this section!

Full Name of Team Manager:	MacID:
Adrian Winter	wintea10

Preliminary Gantt chart:

Project-2 Planner

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0 (Team)	1	1	1	1	100%
Milestone 1 (Individual)	1	1	1	1	100%
Milestone 1 (Team)	1	1	1	1	100%
Milestone 2 (Individual)	2	6			0%
Milestone 2 (Team)	8	1			0%
Milestone 3 (Individual)	8	7			0%
Milestone 3 (Team)	15	1			0%
Milestone 4 (Team)	15	7			0%
Design Demonstration and Verification	22	14			0%
Independent Materials Research Assignment	1	30	1		3%
Design Project Report	1	39	1		3%
Learning Portfolio	1	40			3%
Self/Peer Review	39	2			0%



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

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team ID: Fri-30

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

Full Name:	MacID:
Mohammad Mustafa	mustam26
Patrick Molka	molkap
Adrian Winter	wintea10
Alexander Gascho	gaschoa
Arther Assaf	assafa2

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

Team ID: Fri-30

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
High durability of container	Container must fit into the footprint	The container securely holds tool
Code makes arm easy to control	All coding tasks must be in functions	Facilitate Sterilization by letting steam through
High code modularity/maintainability	All features must be greater than 2mm	Code recognizes container types
Minimize complexity of code	Container must be able to be picked up by the Q-arm	Container must securely hold tool
container should be easy to pick up		The arm safely transfers the container
Container lets high amounts of steam through		

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

System must use telecommunication and actuation to sterilize surgical tools by having a robotic arm remotely transfer them into an autoclave.

3. What are the secondary functions?

The robotic arm is actuated using potentiometer inputs and telecommunication.
The container securely holds the surgical tool.
The robotic arm picks up the container and safely transfers it to the autoclave.
The container allows the tool to be sterilized by steam.

MILESTONE 1 (STAGE 2) – MORPHOLOGICAL ANALYSIS

Team ID: Fri-30

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	Hook onto a lip on the top of the container	Grip extends outward and catches handles. Stays up with friction.	A frictional material on the end-effectors improves gripping power			
Secure containment	Container is molded to tool	A lid	Code transfers container slowly.	Strap down the surgical tool		
Sterilization	Vents in container	Container walls are a grid which allows steam through	Open top			

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

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team ID: Fri-30

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

Full Name:	MacID:
Mohammad Mustafa	mustam26
Adrian Winter	wintea10
Alexander Gascho	gaschoa
Patrick Molka	molkap

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

Team ID: Fri-30

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.*

Patrick's preliminary sketch:

Advantages	Disadvantages
• Container allows steam to pass through container • Simple design (easy manufacturing) • Lots of ventilation for steam	• Does not adequately secure the surgical tools (lots of empty space to move around, easily falls out) • Handle design will be very unreliable (unbalanced) • Not shaped for the specific surgical tools • Not very compatible with QArm gripper • Container does not fit in any of the given footprints • Not all features are greater than 2mm (constraint)

Alexander's preliminary sketch:

Advantages	Disadvantages
• Simple design • Allows for a large amount of sterilizing steam to pass through and reach surgical tool • Durable	• One side of the surgical tool may not be sterilized because the container's base does not ventilate well • Q-arm gripper may slide on handle • The container does not keep the medical

	tools adequately secure • Container will not fit in footprint

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

Team ID: Fri-30

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 Main code is in a large loop that iterates 6 times. - Because there are 6 containers. Low-level tasks handled mostly the same. - Based off of the project module. Differences Some flowcharts had functions that were separate flowcharts, and others had everything in the main loop - Will probably stick to functions for modularity and making reading and editing the code easier. Differences in how the right potentiometer directs the Q-arm. - One flowchart used a while loop that breaks when the end-effectors are in the autoclave range - Another was to just wait until the potentiometer values were not changed for a while - We'll go with the while loop breaking once the end-effectors are in the right range so that the code is more accurate and the timer doesn't run out by accident.

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

Team ID: Fri-30

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.

Write your pseudocode here

Consolidated Pseudocode

- Q-arm begins at the home position.
- Wait for container to spawn at pick-up position.
- Q-arm reads container ID. Find correct autoclave and read container size.
- Q-arm gripper moves toward the pickup position using the right potentiometer inputs
- Q-arm picks up container
- Q-arm moves container to home position
- Q-arm now begins to transfer container to autoclave drop-off location
- Depending on size of container it will either place it into position 1 or 2
- Activate autoclave if the size is large
- Open drawer if the size is large
- The Q-arms gripper is opened up
- Container is released into position 1 or 2 depending on size
- Close drawer if it was opened
- Deactivate autoclave.
- Q-arm returns to home position.
- Repeat until all 6 containers are sorted.
- Once complete, the Q-arm returns to home position and the program terminates.

MILESTONE THREE (TEAM): PRELIMINARY MODEL & CODE

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team ID: FRI-30

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

Full Name:	MacID:
Alexander Gascho	gaschoa
Patrick Molka	molkap
Adrian Winter	wintea2
Mohammad Mustafa	mustam26
Arther Assaf	assafa2

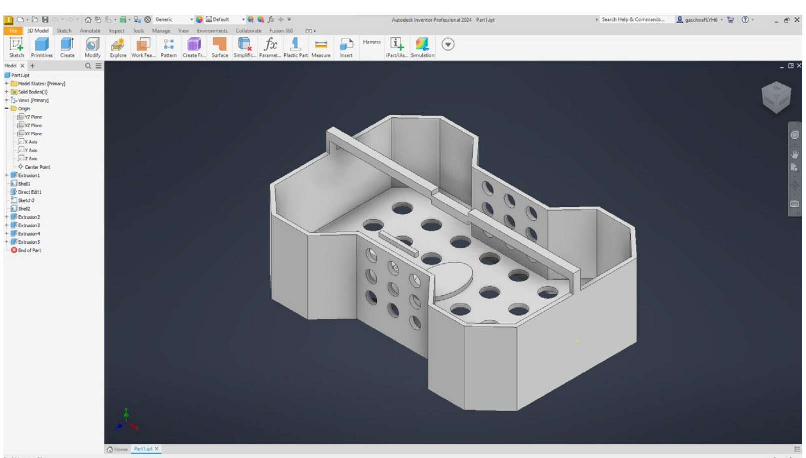
MILESTONE 3 (STAGE 1) – INITIAL DESIGN OF FINALIZED STERILIZATION CONTAINER (MODELLING SUB-TEAM)

Team ID: FRI-30

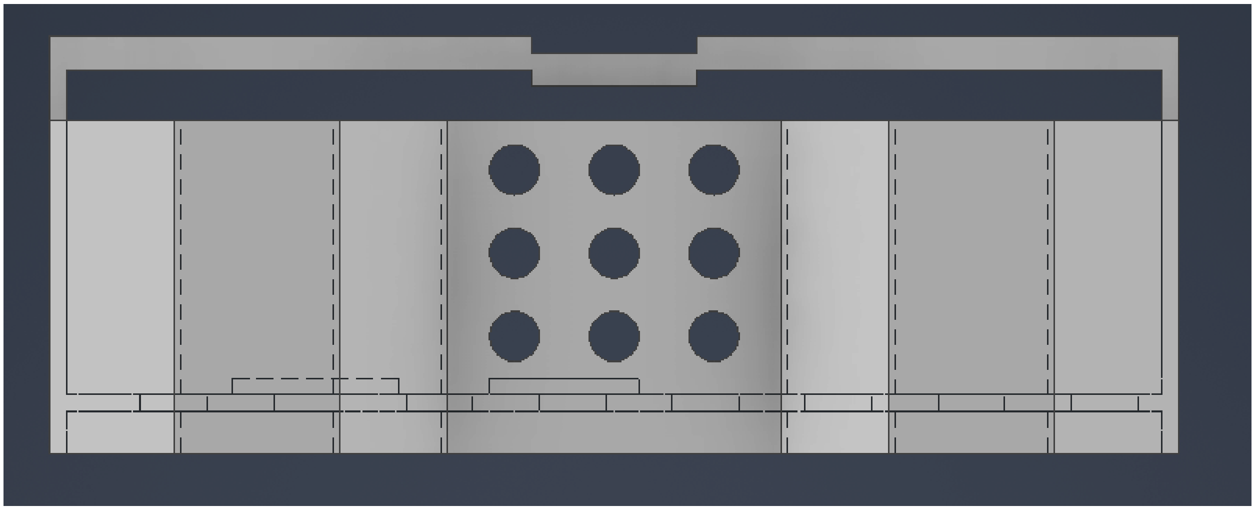
As a team, review each other's preliminary solid models and discuss which features from each other's models align best with the project objectives, constraints and functions. Summarize this in the table below.

Container	Feature	How it aligns with project objectives, constraints and functions.
Alexander	Dip/Intent in middle of bar	Gives the arm something to grip close to center of autoclaves mass to allow more stability when moving autoclave
	Vents on side of container	Facilitates sterilization by allowing steam to pass through sides
Patrick	Bar/Handle	Allows Q-Arm to move the autoclave
	Vent on bottom of container	Facilitates sterilization by allowing steam to pass through the container from below (sterilizing the bottom of tool)
	Feet	Facilitates sterilization by allowing steam to enter through the bottom of the container

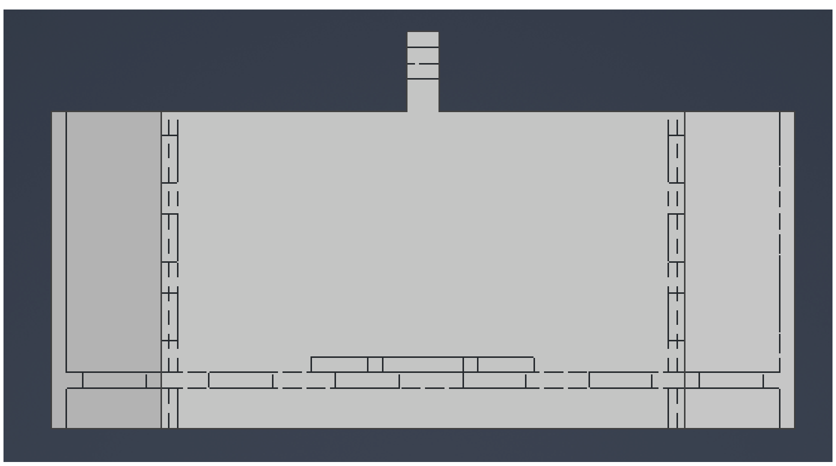
Create a preliminary solid model of your finalized sterilization container. This model should consider features from both team-members preliminary solid models.

Name (Team Member #1): Alexander Gascho	**Name (Team Member #2):** Patrick Molka
Insert an image of your solid model here. 	

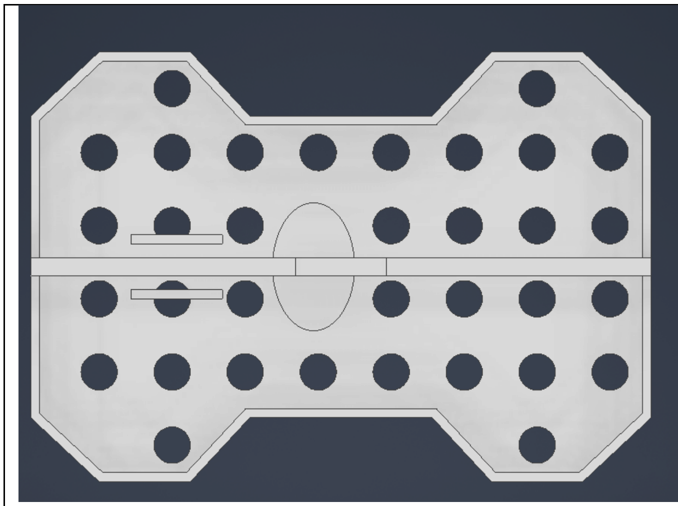
Front:



Right:



Top:



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

Team ID: Fri-30

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

Pick-up Container

- Read container ID for color and size.
- Note somewhere in the code's memory that this container is being processed and will not show up again.
- The pre-determined pickup location is accessed by the code.
- The Q-arm moves to the container's pre-determined pickup location.
- The end-effectors close, holding onto the container.
- The Q-arm moves the container to the home position, still holding it.

Continue or Terminate Program

- Check to see which containers have been processed by accessing where this information was stored in the program's memory.
- If all 6 have been processed, end the program.
- If at least one container remains, loop the program back to the start and run the pick-up container function.

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

Team ID: FRI-30

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	**Alexander**	**Patrick**
Facilitates sterilization (ventilation)	S	+	S
Securely holds surgical tool	S	-	-
Can be picked up by Q-Arm for transfer	S	+	+
Fits inside footprint	S	+	+
Simplicity of design	S	-	-
Total +	0	3	2
Total –	0	2	2
Total Score	0	1	0

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

2. Propose one or more suggested design refinements moving forward

Add lid to ensure that the tool is securely held.

- Design a lid that covers the entire top of out container
- Lid is securely held by sliding into grooves on the side of container

Modify handle design

- Move the handle design onto the lid
- Change the location and orientation of the handle to be along the width of the container (perpendicular to current orientation) and move the handle closer to the edge of the container (current design has handle in center) so that the container is easier to pick up

Simplify shape of container so that it doesn't take up the entire autoclave

- Remove excess space from design
- Dimensions can be decreased to more closely match the dimensions of the surgical tool
- The overall shape of the container can be simplified by making it more rectangular

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

Team ID: Fri-30

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**: Adrian Winter

Enter code errors and/or observations here

- Using relative angles instead of the absolute angles (like we used in Lab-B). This leads to angles out of bounds very quickly.
- The robot base is always rotating when the potentiometer is set to higher than 0, leading to low accuracy.
- When potentiometer value is changed to different range, base isn't changing direction.
    - Caused by a time.sleep command being out of the main while loop instead of within.
- Checks for when the arm is in the range of the correct autoclave to stop the main while loop. Because of this, the arm is not centered with the autoclave when it stops. This might be problematic as the drop-off functions made assume it is.

Drop-off Container & Return Home	**Team Member Name**: Mohammad Mustafa

Enter code errors and/or observations here

- When dropping off the big container, the Q-arm hands hit the edge of the drawer.
- Could use more time.sleep(2), the arm is moving too fast between actions right now
- No else case for if the left potentiometer is less than 0.5, which breaks the code.

Drop-off Container & Return Home	**Team Member Name**: Arther Assaf

Enter code errors and/or observations here

- The Q-arm bangs the drawer when dropping off a big container.
- Does not implement anything for small containers.
- Does not read the left potentiometer

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

Drop Off Container:

- Better handling of edge cases and bad inputs (namely bad potentiometer inputs)
- Do not automatically rotate the arm within this function.
    - This is handled by the Rotate Q-arm base function.

Rotate Q-Arm Base:

- Better handling of edge cases and bad inputs (namely bad potentiometer inputs)
- Better error trapping to prevent reaching an angle out of bounds.
- Use of absolute angles rather than relative angles

MILESTONE 3 (STAGE 3) – PRELIMINARY DESIGN REVIEWS

Team ID: FRI-30

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.

. Plan to have both ends of the project completed by next week before the final design reviews. Integration of both parts will happen in 2 or so weeks.
2. Demonstrated the prototypes. Got feedback to keep the design simple so its easier to 3D print.
Have to choose between the clips and the lid.
3. Demonstrated the drop off and the rotate base function. Of the workflow, the two mentioned functions are mostly implemented. Spawning containers in has not been implemented, nor have the two functions we pseudocoded in the last week.

Modelling Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.

- The presence of a lid might interfere with sterilization.
- The sliding lid will be difficult for the Q-arm to handle.

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

Redesign the holes used for sterilization.

Reconsider if the lid is needed and if its function can be accomplished through another means.

- Either the lid needs to be replaced with just a handle or the lid will need to have enough holes to facilitate sterilization so that it does not need to be removed by the q arm
- If lid is removed we will need to add clips to secure the tool, if we use the lid design we won't need clips

Computing Sub-Team Preliminary Design Review Notes:

Use the space below to document feedback for your design.

The program needs to randomly spawn in a container, it should not be chosen by the user. The pickup function should be completely automated.

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

Automate the rotations of the Q-arm so it is more accurate instead of hard coding rotations.

Implement the containers spawning in themselves instead of taking a user input for those.

MILESTONE FOUR: DETAIL DESIGN (DESIGN REVIEW AND FEEDBACK)

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team ID: FRI-30

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

Full Name:	MacID:
Mohammad Mustafa	mustam26
Arther Assaf	assafa2
Adrian Winter	wintea10
Patrick Molka	molkap

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: FRI-30

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.

- Next week, make sure to have density updated.
- For G code, have it scaled down, make it 50 on all axes.
- Rotate it adding an angle, so it slowly comes up.
- Done great job using a lid.
- Instead of having a feature below have a feature that raises from a flat bottom.
- Give bar an angle.
- Print handle as separate part and glue it on
- Using supports for handle is ineffective.
- slice handle off and glue handle.
- Small holes print well.
- Reconsider bottom – not printable.

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

- arch all hanging components for printing stability →bar →handle →remove the riser on the bottom

COMPUTATION SUB-TEAM

Team ID: FRI-30

☐ 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.

- Not sure if were allowed to have coordinates for autoclave when rotating toward the autoclave using the left potentiometer.
- General comments are good. Need specific comments before each function about inputs, outputs, and what the function does.
- Everything else is great.

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

- Update from the TA: Using coordinates for the autoclave is okay as long as we also use the check autoclave method, so make sure that is included.
- Add comments before each function in the required format.