ENGINEERING

McMaster University

Project Two – Get a Grip:

Design a system for Sterilizing Surgical Tools using Remote Sensing and Actuation

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial T05

Team Tues-23

Adiyan Ahmed (ahmea45)

Josh Suh (suhj13)

Borna Sadeghi (sadegb1)

Aldraech Liac (liaca)

Submitted: December 9, 2020

Table of Contents

Academic Integrity Statement

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

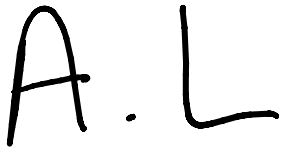
Adiyan Ahmed 400295190

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.

Josh Suh 400307433

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.

Aldraech Liac. 400311751



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.

Borna Sadeghi 400315188

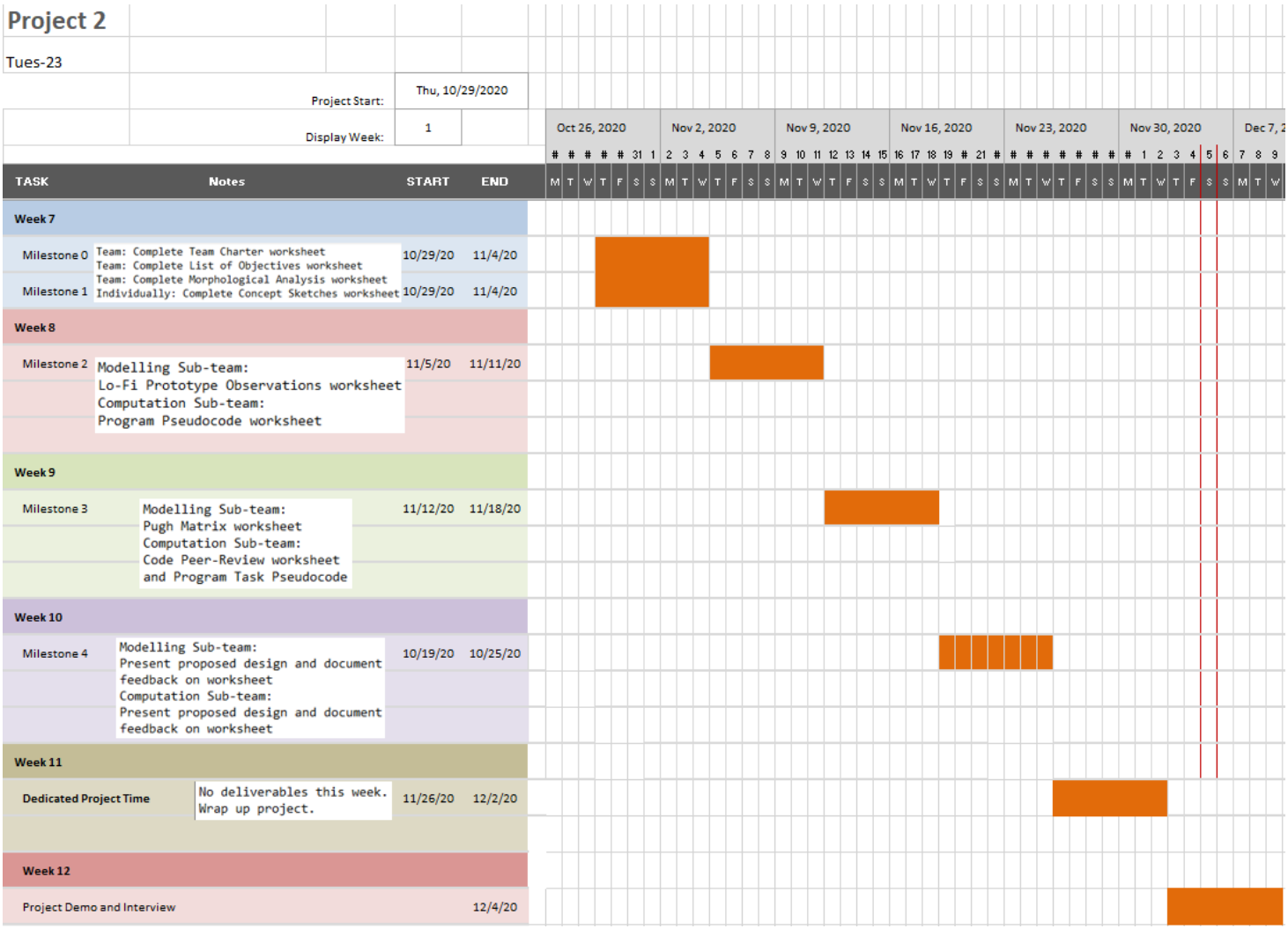

X
Borna Sadeghi

Executive Summary

The motivation for this project stems from poor accessibility to medical care in rural and remote areas [1]. These areas do not contain many healthcare services which means there would be an even smaller number of specialized services [1]. Due to the poor accessibility, there is a trend that civilians living in these areas generally have poorer health and a shorter life expectancy compared to people living in urban cities [1]. How can we attempt to increase accessibility to the public that is not only affordable but is also convenient for public use? Remote surgery along with remote mentoring of physicians is a possible solution to this problem. Remote surgery is a type of technology that is relatively simple. This technology comprises of robots capable of performing surgery, computer-driven devices that support surgical techniques, as well as surgical robotic assistants [2]. These are machines that are digitally controlled by the surgeon [2]. This implies that the surgeon is fully engaged in the surgery throughout the procedure [2]. Remote surgeries provide better and quicker access to care, higher efficiency, precision in surgery, and is also safer [2]. With the services remote surgery provides, a potential solution to the problem is found. The P2 team will attempt to create a system that will be able to securely transfer surgical instrument to an autoclave for sterilization using a robotic arm.

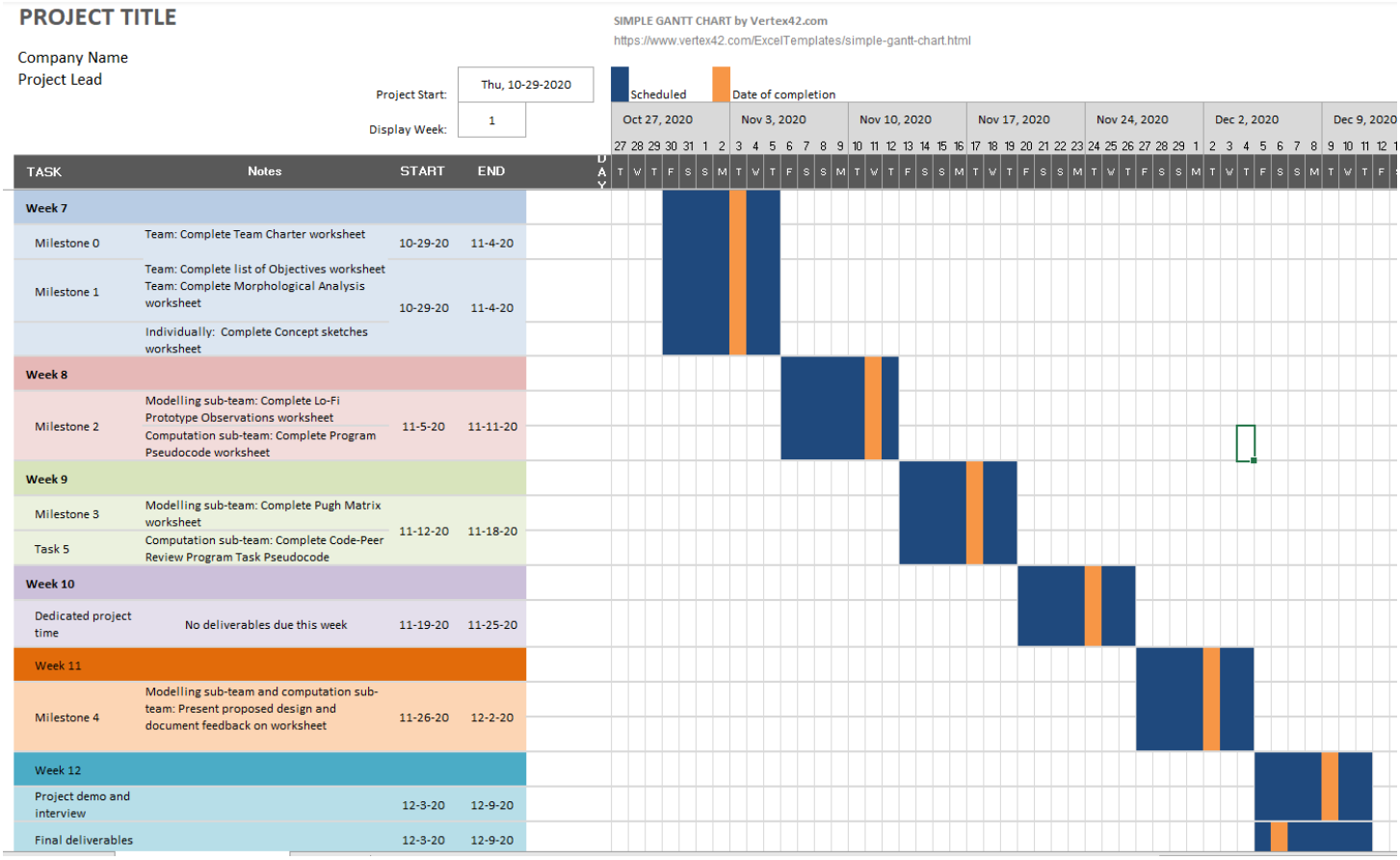
Main Body

Project Schedule:



Preliminary Gantt Chart:

Final Gantt Chart:



PROJECT TITLE

Company Name
Project Lead

SIMPLE GANTT CHART by Vertex42.com
https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

Project Start: Thu, 10-29-2020
Display Week: 1

Scheduled
Date of completion

Oct 27, 2020 | Nov 3, 2020 | Nov 10, 2020 | Nov 17, 2020 | Nov 24, 2020 | Dec 2, 2020 | Dec 9, 2020

DAY: 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 1 2 3 4 5 6 7 8 9 10 11 12 1
T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F

TASK	Notes	START	END
Week 7			
Milestone 0	Team: Complete Team Charter worksheet	10-29-20	11-4-20
Milestone 1	Team: Complete list of Objectives worksheet Team: Complete Morphological Analysis worksheet Individually: Complete Concept sketches worksheet	10-29-20	11-4-20
Week 8			
Milestone 2	Modelling sub-team: Complete Lo-Fi Prototype Observations worksheet Computation sub-team: Complete Program Pseudocode worksheet	11-5-20	11-11-20
Week 9			
Milestone 3	Modelling sub-team: Complete Pugh Matrix worksheet	11-12-20	11-18-20
Task 5	Computation sub-team: Complete Code-Peer Review Program Task Pseudocode		
Week 10			
Dedicated project time	No deliverables due this week	11-19-20	11-25-20
Week 11			
Milestone 4	Modelling sub-team and computation sub-team: Present proposed design and document feedback on worksheet	11-26-20	12-2-20
Week 12			
Project demo and interview		12-3-20	12-9-20
Final deliverables		12-3-20	12-9-20

Logbook of additional meetings:

Thursday November 10th 2020

Milestone 2: Milestone 2 required each sub-team to complete their respective tasks. The modelling sub-team is tasked with refining their prototype sketches while the computation sub-team with the creation of a storyboard and/or creating a computation tree.

- **The modelling sub team required extra time to complete their peer evaluation of each other's sketch. Following which, took some time to complete their low fidelity prototype.**
- **The milestone was completed the same day after the peer evaluation was conducted with no other issues.**

Tues December 1st , 2020

Milestone 4: The objective of milestone 4 required the modelling sub-team to come up with the final solid model and assembly along with the G code for 3D printing. The computation sub team on the other hand, was tasked with the finalization of their code, their program should make the Quanser robotic arm to complete one full cycle. One picking a small container and placing it in its respective autoclave, and the other cycle to pick up and place a larger container into the drawer of its respective autoclave. After which, an interview with a TA would determine whether each sub team is ready to move on or not giving either a GO or a NO-GO.

- **The modelling sub team received a NO GO on their model because their finalized model requires more than 2 hours to print, 40 min over the 2-hour print time constraint. The modelling sub team met up the same day to mitigate this issue. The new design being slimmer and more efficient 3D printing wise, was completed that evening and got a GO from the TA.**

Saturday December 5th 2020

The Final Deliverable: For the most part, the group split the sections of the deliverable into their respective administrative roles. We discussed other important parts of the deliverable such as the citations, what occurred at each milestone, and the final executive summary. For the most part, the deliverable was essentially completed without much of an issue the same day. We plan to review and look over the deliverable the next day.

Sunday December 6th 2020

Finishing up the Final deliverable: A majority of the meeting was just completing tasks that were not completed in the last meeting. Just uploading milestones to the document alongside completing the engineering drawing of the final container and uploading a picture of the final gantt chart.

Scheduled Weekly Meetings:

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Adiyan Ahmed**	**ahmea45**	**Yes**
Administrator	**Joshua Suh**	**suhj13**	**Yes**
Coordinator	**Aldraech Liac**	**liaca**	**Yes**
Subject Matter Expert	**Borna Sadeghi**	**sadeg1**	**Yes**
Guest			

Agenda Items

1. Attendance and Updates
2. Completion of Milestone 2 Individual Assignments
3. Issues/difficulties with completion of tasks
4. Action items for next meeting
5. Final Notes

Meeting Minutes (Notes)

1. Attendance and updates
    a. Borna? (late)
    b. We discuss about the Chem test and studying
    c. Discussion about the physics lab
    d. No one likes econ lol
2. Completion of Milestone 2 Individual Assignments
    a. Everyone finished their pre milestone assignments but Borna?? (just a bit late)
    b. We are on track with finishing this project so far
    c. We work on milestone 2 assignment problems and
3. Issues/difficulties with completion of tasks
    a. No difficulties with completing the tasks given
    b. The workflow should include the arm and program (there are 6 containers, and three different autoclaves, the program should determine which autoclave the container will be placed in),
        i. **NOTE THAT**: the container will be placed by the arm at given locations. The program should determine the color and the size of the container, if the container is large then the drawer must open for the large container. Whereas if the container is small then the container can just be placed into the autoclave.
    c. Relative ease, we were quick and efficient with completing the tasks
4. Action items for next meeting
    a. We should complete our next week predesign studio tasks and complete this week's milestone before then
    b. For The modelling sub team, we must have a preliminary design on inventor.
    c. For the computation sub team, they must complete a part of the code, each task such as (identify the coordinates etc.) functions, plan out the rest of the program. MUST identify inputs, processes and outputs for each task.
5. Final Notes
    a. Finish the preliminary tasks for each sub team next time, and study for econ

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Adiyan Ahmed**	**ahmea45**	**yes**
Administrator	**Joshua Suh**	**suhj13**	**yes**
Coordinator	**Aldraech Liac**	**liaca**	**yes**
Subject Matter Expert	**Borna Sadeghi**	**sadeg1**	**yes**
Guest	**Mark Danial**	**TA**	**Yes**

Agenda Items

1. Attendance and Updates
- We all made it!
- We talked about our day and what was going on in our lives currently
- Most of us did bad in chem
- We were planning out the rest of the design and program, we are on track to finish next week
2. Progress update on Milestone 4 Deliverables
- We are on track with finishing everything, modelling and computing can probably finish by next week
- Modelling are deciding on the final model, basically done, just a little bit of time we are basically on the verge of deciding on one last design
3. Nothing to hand in this week. Issues/difficulties with completion of tasks?
- Hard to design a lid, and a little misunderstanding on the modelling sub team portion
4. Action items for next meeting
- Finish all of our parts and individual tasks
5. Final Notes
- Stay on task and keep a consistent work schedule to finish every task. Stay healthy and study for exams

Meeting Minutes (Notes)

1. Attendance and updates
- We talk more about how econ sucks
- Talking about reviewing for the exams
- Aldraech has some difficulty making some of his parts and is unable to finish his lid
- We sing a bit (especially joshua)
2. Progress on Milestone 4 Individual Assignments
- Modelling sub team had a little misunderstanding but finalized their design at the beginning of the design studio
- Computing sub team finished their portion and are ready for the rest of their tasks (to finalize)
3. Issues/difficulties with completion of task
- Modelling sub team had a misunderstanding on deciding on the finalized design
4. Action items for next meeting
- Just for modelling sub team to finalize their G code
5. Final Notes
- Stay safe, stay warm, and stay cute :)

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Adiyan Ahmed**	**ahmea45**	**Yes**
Administrator	**Joshua Suh**	**suhj13**	**Yes**
Coordinator	**Aldraech Liac**	**liaca**	**yes**
Subject Matter Expert	**Borna Sadeghi**	**sadeg1**	**Yes**
Guest	**Mark Daniel**	**TA**	**Yes**

Agenda Items

1. Attendance and Updates
2. Completion of Milestone 3 Individual Assignments
3. Issues/difficulties with completion of tasks
4. Action items for next meeting
5. Final Notes

Meeting Minutes (Notes)

1. Attendance and updates
   - We are all worried about math test
   - We have completed the tasks for the week
2. Completion of Milestone 3 Individual Assignments
   - We have completed the individual pre-design studio assignments
   - Borna finished the design just before the meeting.
3. Issues/difficulties with completion of tasks
   - Aldraech and Borna still had to discuss the final design of the container, but both had preliminary designs.
     - Borna finishes his task a few minutes into the session but the design was more than ready to be discussed between each other.
   - Adiyan has a bit of trouble with the look of the 'main function' (looking forward).
   - Joshua had a bit of trouble coding the function in general but got through. He finished most of the code once the meeting began. All his issues were resolved after this session
4. Action items for next meeting
   - We know that the milestone 4 is pushed up a week, so we do not need to worry about any deliverables.
5. Final Notes
   - Moving forward, we just must do the preliminary designs and tasks just before the actual lab
   - Study for math and physics!!

Attendance

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Adiyan Ahmed**	**ahmea45**	**yes**
Administrator	**Joshua Suh**	**suhj13**	**yes**
Coordinator	**Aldraech Liac**	**liaca**	**yes**
Subject Matter Expert	**Borna Sadeghi**	**sadeg1**	**yes**
Guest			

Agenda Items

1. Attendance and Updates
- Everyone attended
- We talk about the issues we had completing the given tasks
- We all finish our parts for the assignment
- We just discuss what we are being graded on for this week

2. Progress update on Milestone 4 Deliverables
- We are all done, finished refining the code and cad model before this design studio

3. Issues/difficulties with completion of tasks?
- A little bit of a problem setting up the accuracy for the code, but nothing to major
- Container was finished the day before

4. Action items for next meeting
- Practice presenting and have all pre-design assignments done

5. Final Notes
- Get ready for exams and study hard!
- Don't forget we have an interview on Dec 8 for the project

Meeting Minutes (Notes)

1. Attendance and updates
- All members attended the feedback session
2. Progress on Milestone 4 Individual Assignments
- Both sub teams are finished but the modelling sub team did not meet constraints (must cut down on material)
3. Issues/difficulties with completion of task
- Modelling sub team must remake the design to cut down on the material usage
4. Action items for next meeting
- Modelling sub team must finish the design before the next design studio
5. Final Notes
- Computation sub team got the go, modelling did not get the go sign, modelling must finish by next week (due date).

Design Studio Worksheets:

PROJECT TWO: MILESTONE 0 – COVER PAGE

Team Number: Tues-23

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

Full Name:	MacID:
Adiyan Ahmed	ahmea45
Borna Sadeghi	sadegb1
Josh Suh	suhj13
Aldraech Liac	liaca

Insert your Team Portrait in the dialog box below

MILESTONE 0 – TEAM CHARTER

Team Number: Tues-23

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Adiyan Ahmed	☐M ☒A ☐C ☐S
2.	Josh Suh	☐M ☐A ☒C ☐S
3.	Aldaraech Liac	☐M ☐A ☐C ☒S
4.	Borna Sadeghi	☒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	Adiyan Ahmed	ahmea45
Administrator	Josh Suh	suhj13
Coordinator	Aldraech Liac	laica
Subject Matter Expert	Borna Sadeghi	sadegb1

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team Number: Tues-23

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

Full Name:	MacID:
Josh Suh	suhj13
Adiyan Ahmed	ahmea45
Borna Sadeghi	sadegb1
Aldraech Liac	liaca

MILESTONE 1 (STAGE 1) – PRE-PROJECT ASSIGNMENT

Team Number: Tues-23

Team Number: Tues-23

Name: Adiyan Ahmed	MacID: ahmea45

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

Objectives

- Container should be secure (to hold tool)
- Container should be penetrable (to allow sterilization)
- Program should be able to correctly match container and autoclave
- Program should be able to be controlled accurately
- Arm should be securely holding onto container

Constraints

- Size of base of each container must be less than size of corresponding autoclave
- Each container must be less than 80mm in width, to allow tight grip
- Every feature in the container must be greater than 4mm in size
- Container must be able to be picked up by two fingered robot arms

Functions

- System should securely transfer containers to autoclave for sterilization* (Primary function)
- Container should restrict movement of tool inside
- Container should allow access for steam (to facilitate sterilization)
- Container should fit in autoclave
- Program should identify size and colour
- Program should pick up and release container
- Program should open and close drawers
- Program should track which containers have been placed

Team Number: Tues-23

Name: Josh Suh	MacID: suhj13

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

Objectives

- Containers should be lightweight
- Robotic arm should easily grip onto the container
- Container can be eco friendly
- Containers can be reusable
- Robotic arm should be lightweight
- Robotic arm should be able to transfer equipment without much delay

Constraints

- Size of base of each container must be less than size of corresponding autoclave
- The width of the container should be at most 80mm
- The space in container should be wide enough to hold tools
- Container should allow enough gas to enter for tools to be sterilized
- The program should be able to distinguish which container corresponds to an autoclave

Functions

- Program must be able to recognize which container goes into which autoclave
- Program must be able to recognize which tool goes into corresponding container
- Container must be able to be picked up
- Container must be able to hold tools with no problem
- Autoclave should be able to seal itself to pressurize the gas which sterilizes the tool
- The tools should be sterilized at the end of the process

Team Number: Tues-23

Name: Aldraech Liac	MacID: liaca

Objectives

- Design can be light weight
- Be small and compact
- Be durable
- Be relatively cheap to manufacture
- Be easy to access
- Be able to clean and maintain sterilization of tools within
- Box can be reusable
- Box can be versatile
- Arm can be able to drop the tools in certain positions

Constraints

- Box Must keep instruments inside clean and sterile
- Box Must open and close
- Container must be large enough to house tools
- The box must have a width of 80mm or less to have a strong grip
- Container must have holes so that steam can enter and sterilize the tools within the box
- Container must be able to fit inside of the autoclave
- Despite abuse on the outside, the box must keep the tools inside safe
- Arm must be able to carry the container and the tools
- Arm must be able to move within a certain degree (to reach the tools and box)

Functions

- Is easily opened/closed when desired
- Tools can be taken out of the box relatively easy
- Box cannot be opened unless desired
- Container is easily carried around
- Arm can pick up the tools and the box
- Program can distinguish the containers and keep track of the which containers are placed
- Can place containers in their proper containers

Team Number: Tues-23

Name: Borna Sadeghi	MacID: sadegb1

Objectives

- Should be able to grasp all given surgical tools
- Container should securely transfer tools
- Should be able to identify tool sizes
- Should be able to put tools in the correct container
- Container should be lightweight for easy storage
- Container should be made of durable materials
- Computer program should always work
- Container should be easy to grab

Constraints

- Items should not slip from the grip of the arm
- Should be large enough to fit all given tools
- Should be small enough to minimize space taken in autoclave
- Container should not be sealed to allow the autoclave to sterilize the tools inside
- Container must not be damaged by arm or autoclave

Functions

- Carry tools
- Identify tools by size
- Place tools in their respective container

MILESTONE 1 (STAGE 2) – LIST OF OBJECTIVES, CONSTRAINTS, AND FUNCTIONS

Team Number: Tues-23

1. As a team, create a final a list of objectives, constraints, and functions in the table below.
   → Use your individual *Pre-Project Assignment* to build your team's final list
   → The exact number you should have depends on what information you have gathered from the Project Pack.

Objectives	Constraints	Functions
Container should be able to keep the contained tool secure	Container holding the tool must be able to fit within the autoclave.	System can securely transfer containers to autoclaves and should be holding tools securely
Container should be relatively light weight and easy to transport	The width of the container (where arm grabs) should be at most 80mm	The tools should be sterilized at the end of the process
Robotic arm should be able to transfer equipment accurately without much delay	Container should allow enough gas to enter for tools to be sterilized	Program must be able to recognize which container goes into which autoclave
Container should be durable and minimize damage from arm and autoclave environment	Tool must be able to enter and exit the container (if desired)	Program must be able to recognize which tool goes into corresponding container
The container should be reusable	Every feature in the container must be greater than 4mm in size (for 3D printing)	Program should be able to open and close drawers of autoclave

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

The system should be easy to use and be able to fully sterilize surgical equipment.

3. What are the secondary functions?

Pick up
Securely transfer
Hold tools

MILESTONE 1 (STAGE 3) – MORPHOLOGICAL ANALYSIS

Team Number: Tues-23

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.

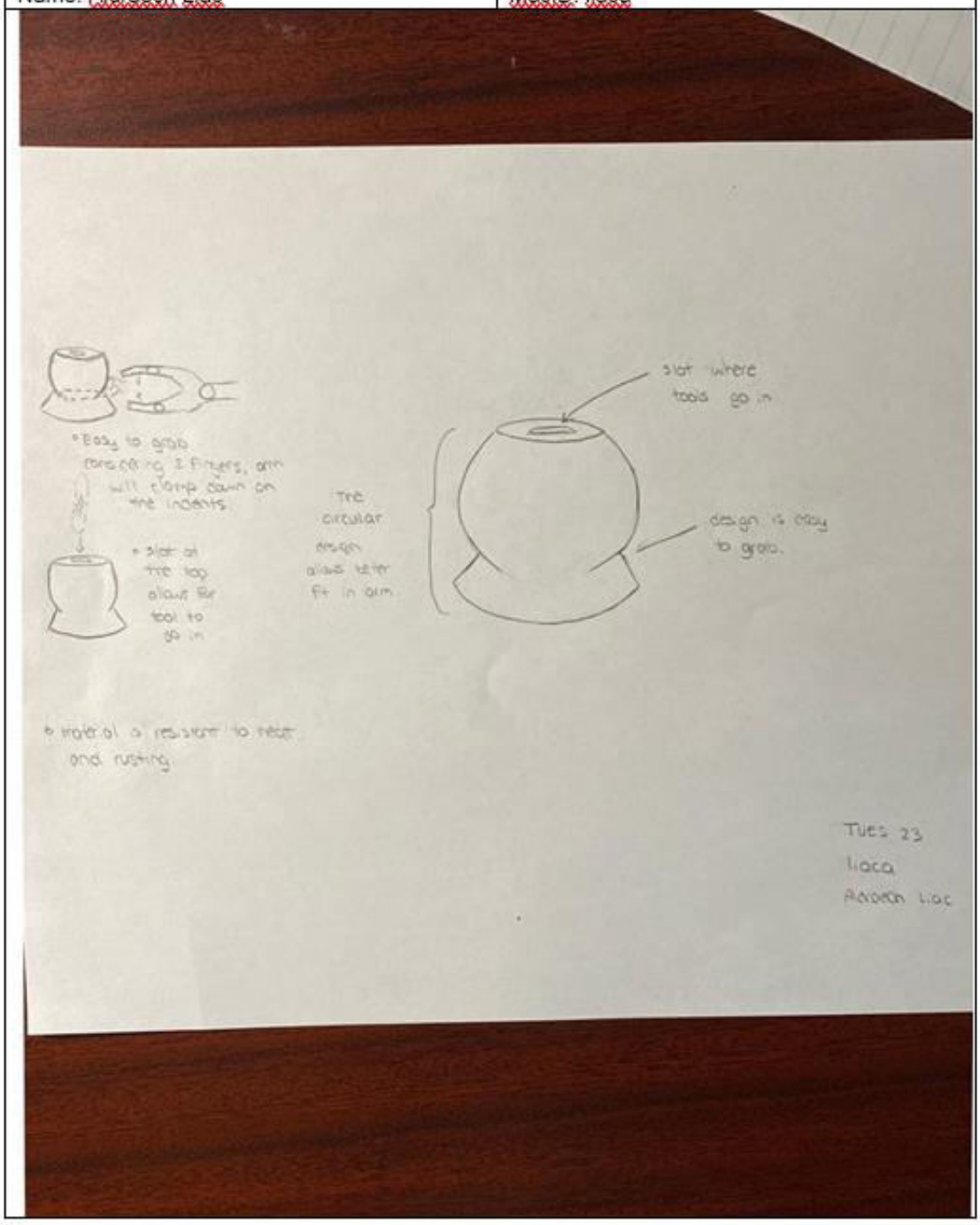
Function	**Means**					
Pick up	Grab from the side	Lift container from bottom	Bring toward autoclave	Indents that allow easy grip	Curved container for gripping	Grippy sides on container
Carry tools in container	Secure lid	The inside of the container has the shape of the tool	Small/ tight container that does not allow movement	Grippy interior	Single slot that restricts movement	Lay down tool horizontally inside container
Sterilization	Vents on container	Mesh around container	Open top	Sealed autoclave	Intake/outtake fans	Large surface area to contact disinfectant

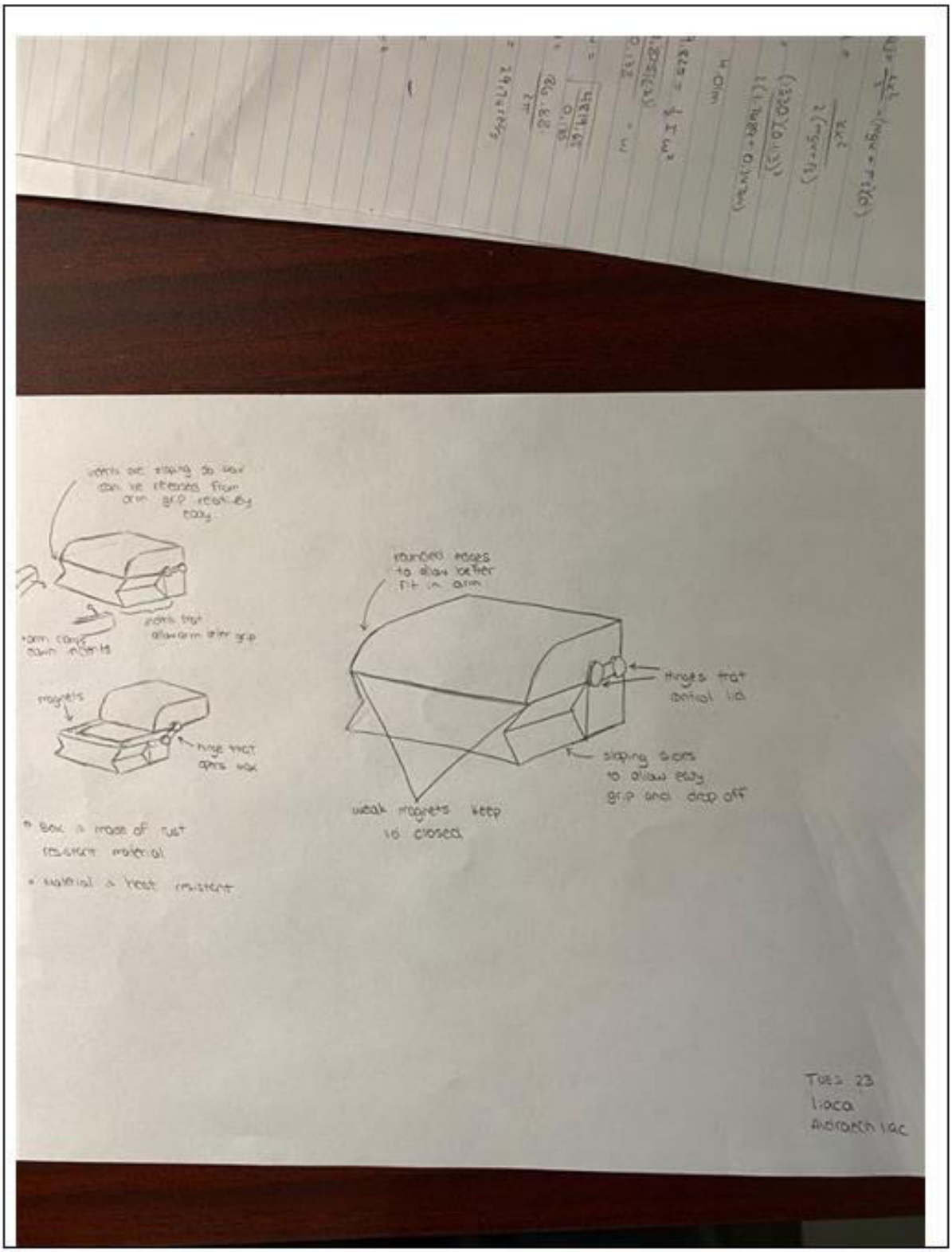
MILESTONE 1 (STAGE 4) – CONCEPT SKETCHES

Team Number: Tues-23

Team Number: Tues-23

Name: Aldraech Liac	MacID: liaca

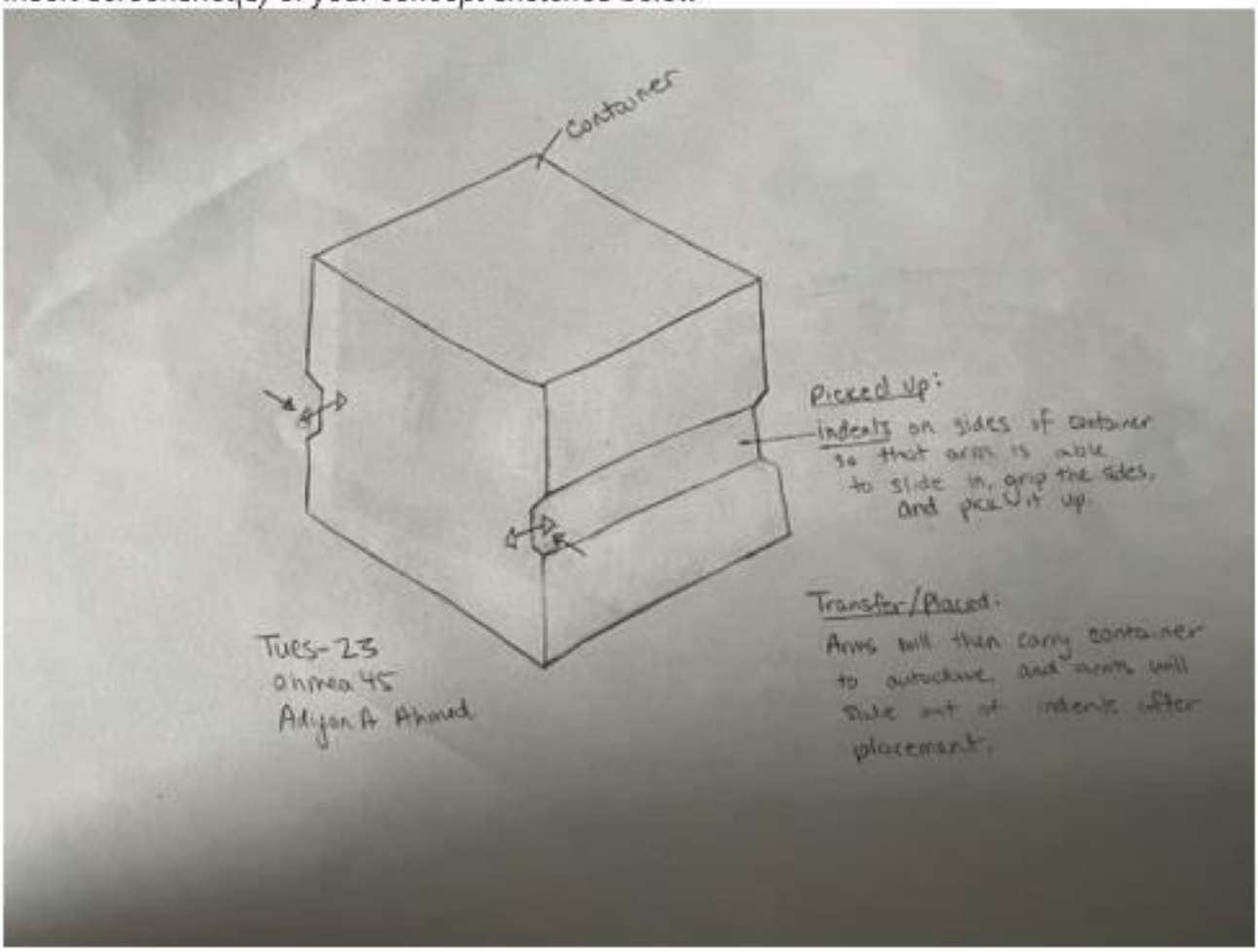


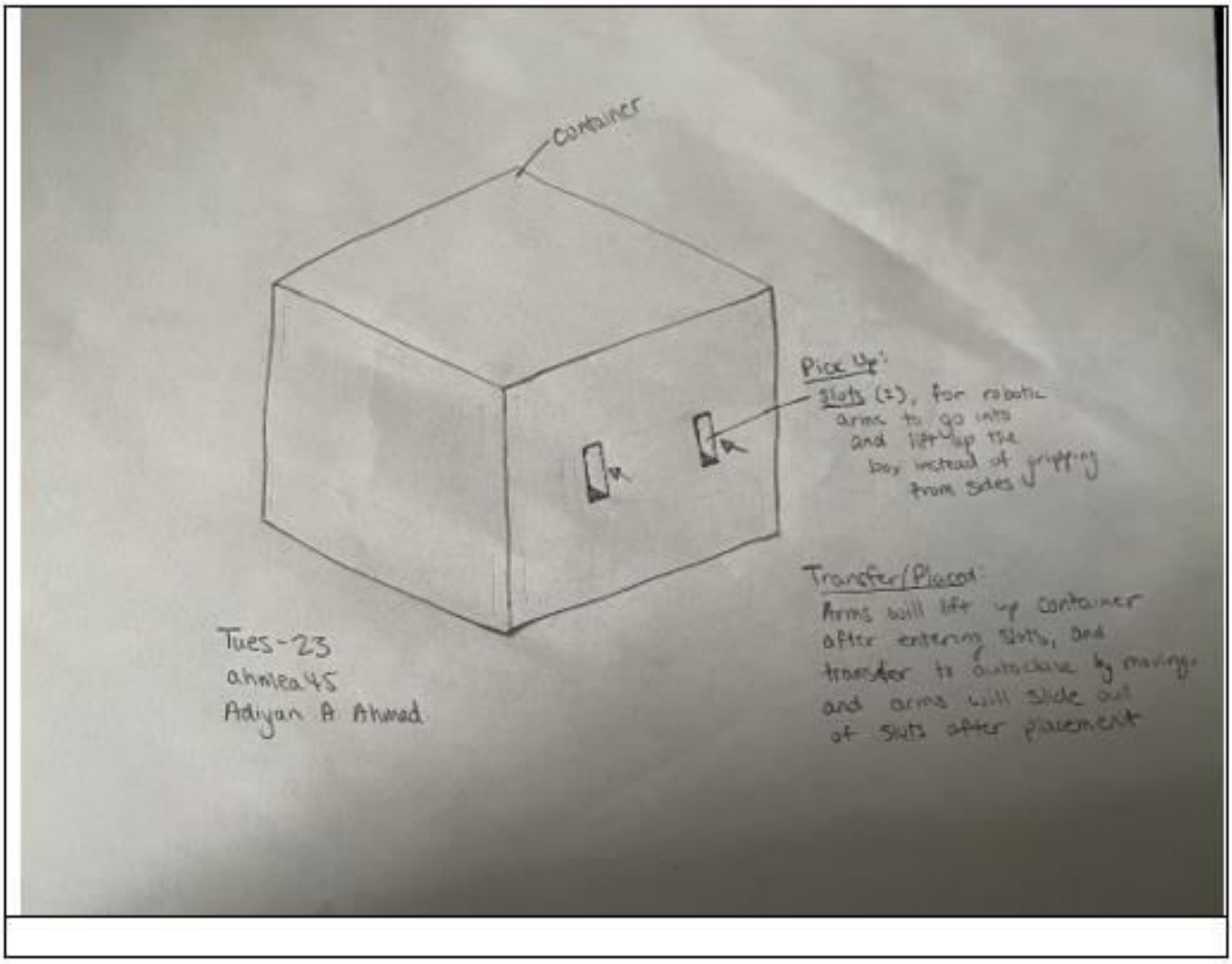

rounded edges to allow better fit in arm
hinges that attach lid
sloping arms to allow easy grip and drop off
weak magnets keep lid closed
magnets
hinge that opens box
* Box is made of rigid resistant material
* material is heat resistant
Tues 23
Ioca
Andreea Iac

Team Number: Tues-23

Name: Adiyan Ahmed	MacID: ahmea45

Insert screenshot(s) of your concept sketches below

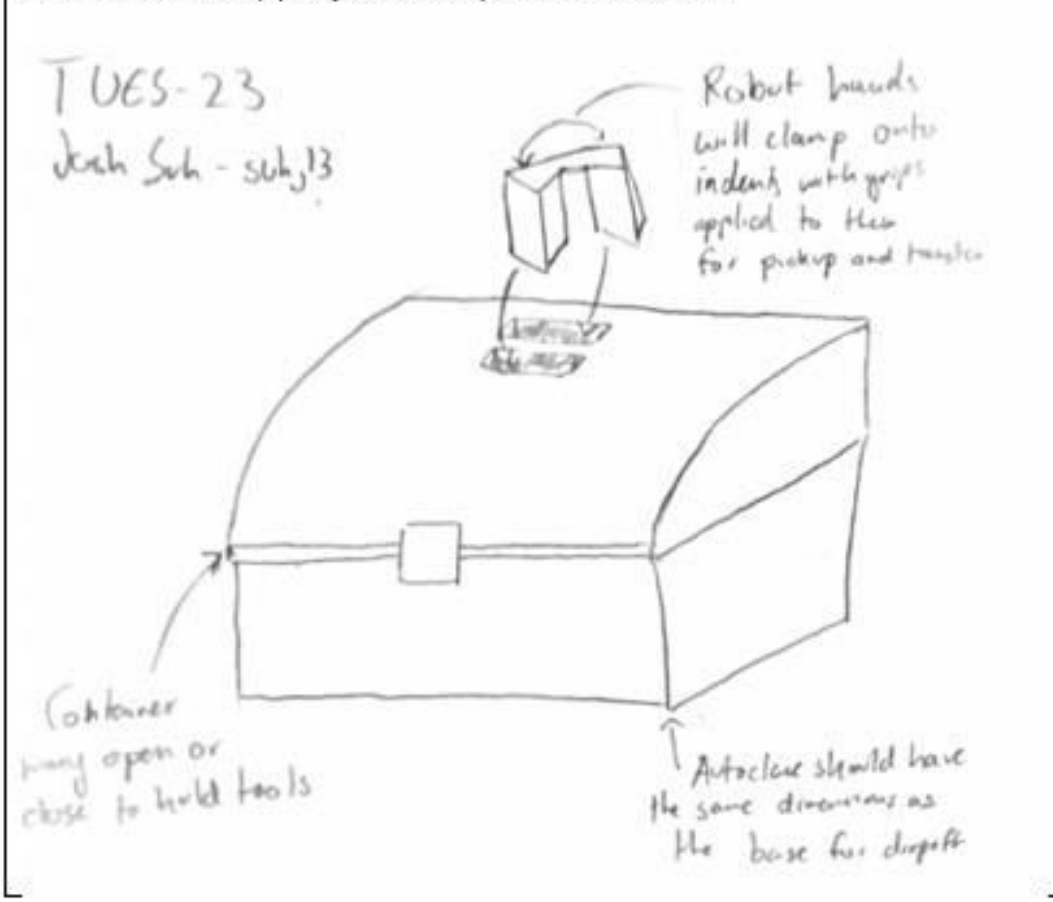


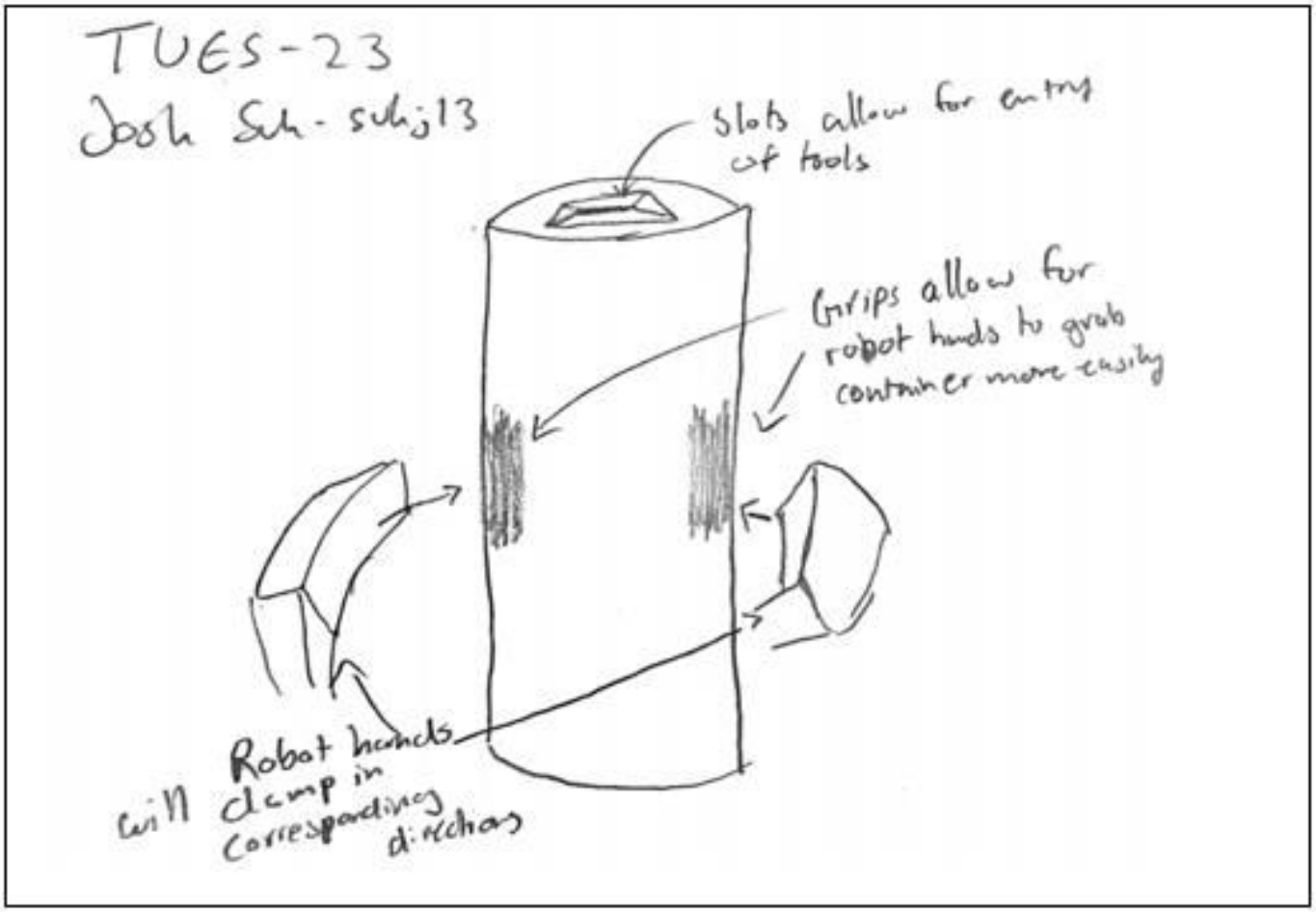

Container
Pick Up:
Slots (=), for robotic arms to go into and lift up the box instead of gripping from sides
Transfer/Placed:
Arms will lift up container after entering slots, and transfer to autoclave by moving. and arms will slide out of slots after placement
Tues-23
ahmea45
Adiyan A Ahmed

Team Number: Tues-23

Name: Josh Suh	MacID: suhj13

Insert screenshot(s) of your concept sketches below




TUES-23
Josh Suh - suhj13
Slots allow for entry of tools
Grips allow for robot hands to grab container more easily
Robot hands will clamp in corresponding directions

Team Number: Tues-23

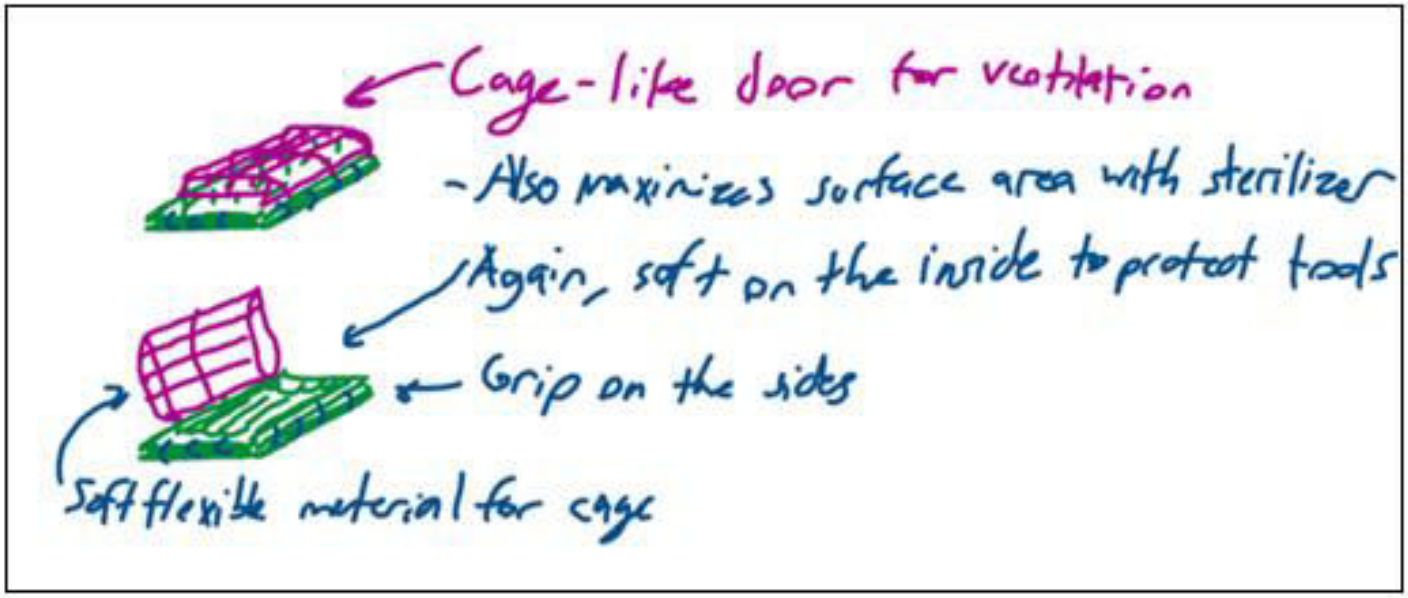
Name: Borna Sadeghi	MacID: sadegb1

Grippy sides

Hinged, ventilated door with lock

- Made of durable material
- Resistant to oxidizing/rusting
- Large enough to fit tools

Soft inside to protect tools



PROJECT TWO: MILESTONE 2 – COVER PAGE

Team Number: Tues-23

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

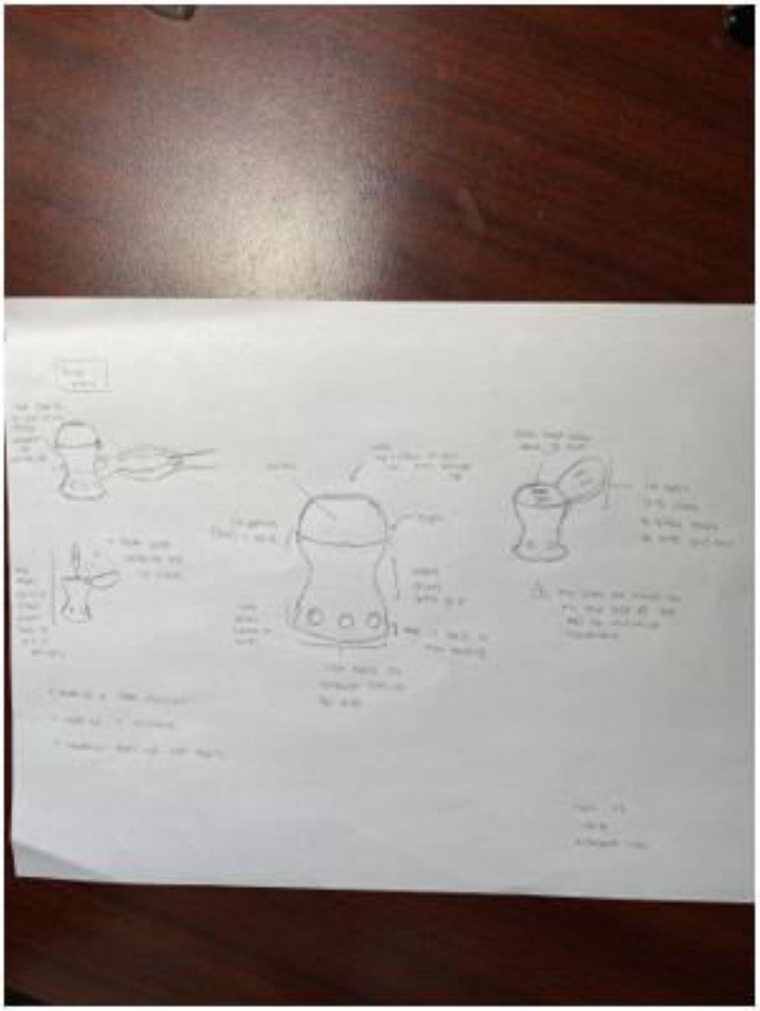
Full Name:	MacID:
Adiyan Ahmed	ahmea45
Josh Suh	suhj13
Aldraech Liac	liaca
Borna Sadeghi	sadegb1

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

Team Number: Tues-23

Team Number: Tues-23

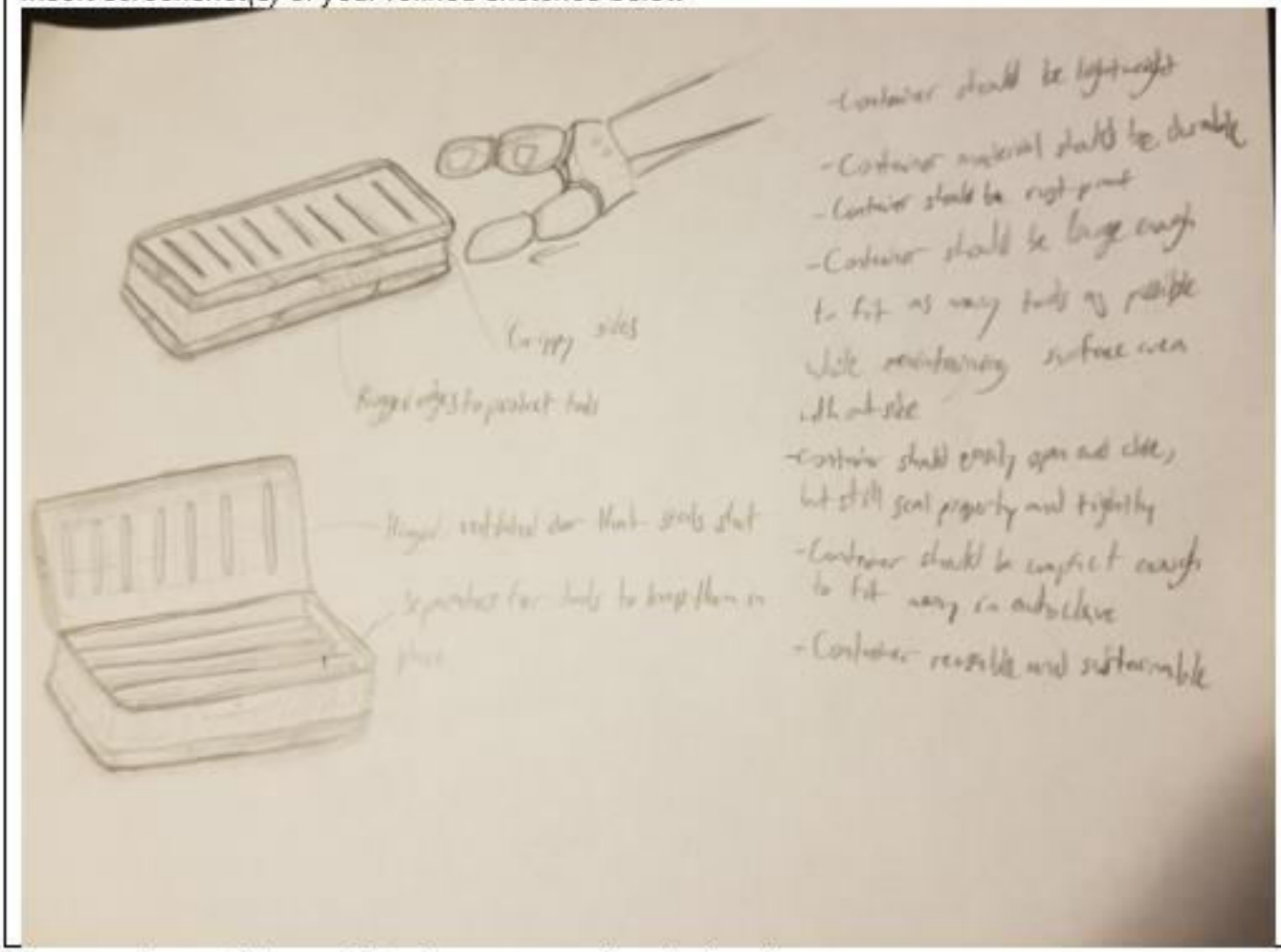
Name: Aldraech Liac	MacID: liaca



Team Number: Tues-23

Name: Borna Sadeghi	MacID: sadegb1

Insert screenshot(s) of your refined sketches below



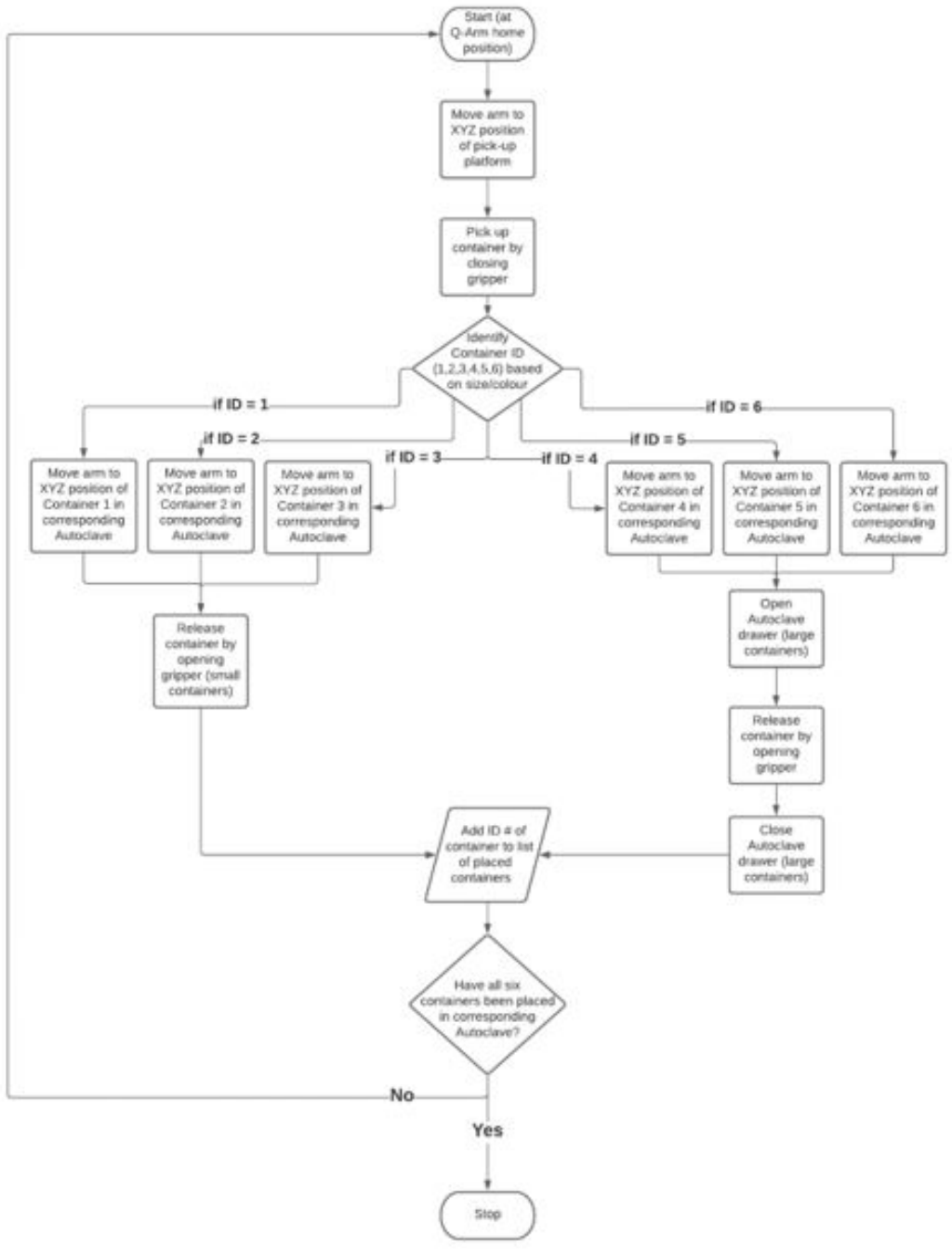
MILESTONE 2 (STAGE 2) – COMPUTER PROGRAM WORKFLOW (COMPUTATION SUB-TEAM)

Team Number: Tues-23

Team Number: Tues-23

Name: Adiyan Ahmed | MacID: ahmea45

Insert screenshot(s) of your workflow below



Team Number: Tues-23

Name: Josh Suh	MacID: suhj13

Insert screenshot(s) of your concept workflow below

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

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

Team Number: Tues 23

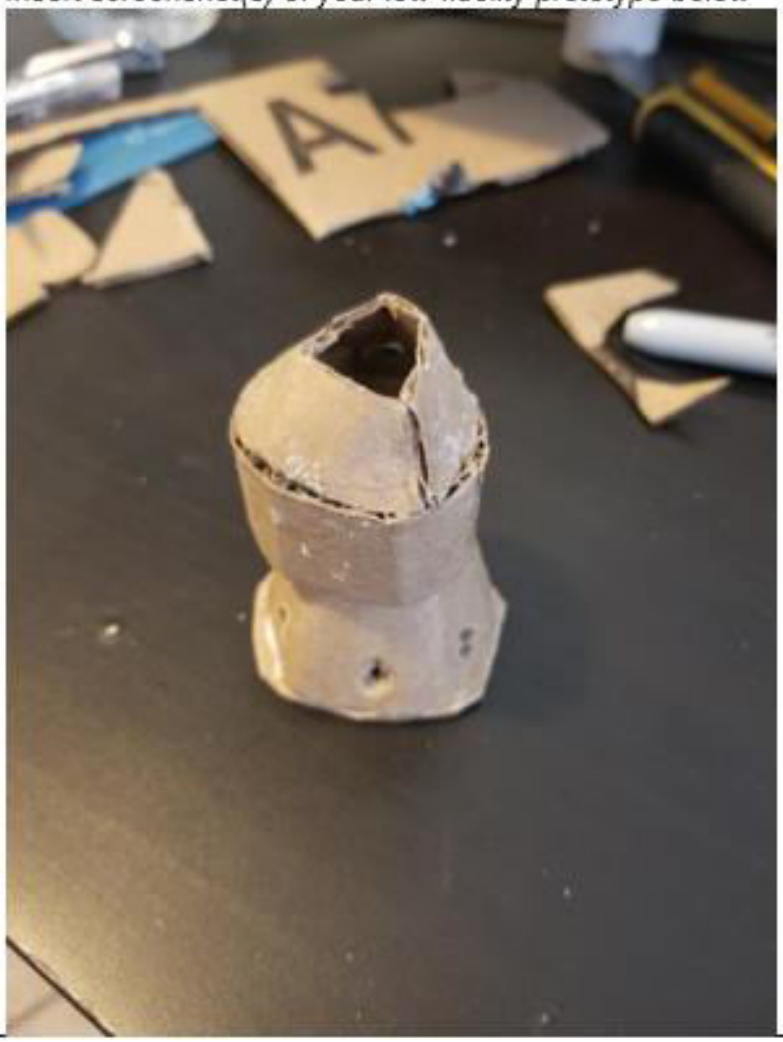
Team Number: Tues 23

Name: Aldraech Liac	MacID: liaca

Team Number: Tues-23

Name:	MacID:

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



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

Team Number: Tues-23

*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.*

Aldraech's design:

Constraints:

- The container varies in size, depending on the size of the tool. Regarding large tools, this may not actually fit within the autoclave due to the container's large vertical component (as it holds the tools vertically to secure them). This is a large issue that must be addressed.
- To ensure a tight grip, the width of the container must not exceed 80mm which is possible for the design of the container. Furthermore, the design allows for a tighter hold due to the indent and sloping sides.
- The holes at the bottom and mesh top allow for steam to enter, rise, and exit. It allows for efficient sterilization.
- The container does allow for easy tool access (enter and exit)
- Every feature is larger than 4mm.

Functions:

- The container allows for easy sterilization via the holes at the bottom and the mesh top; by the end of the process the tool will be sterilized.
- The ideal design allows for a secure hold of the Q arm throughout transport

- The design also allows the Q-arm to grab it from any angle

Objectives:

- The small slots allow for a secure hold on the tool by minimizing movement (of the tool)
- The design is mostly hollow, except for a slightly thicker base, however due to the mostly hollow design the container is relative lightweight
- Due to the many holes at the bottom of the design and its hollow interior, its long-term structural integrity may waver
- The design is reusable.
- The design should be heavier at the bottom in order to lower its center of mass and prevent it from falling over

Borna's design:

Constraints:

- *The container allows for a tool to be placed within, also despite the size of the tool, because it is laying down on its back it should be able to fit within the autoclaves with relative ease.*
- *The container may vary in size depending on the tool within, but for the most part the container can have a default width of less than 80mm. However, its lack of features to aid the arm in grabbing it may be an issue. Albeit, in the project 2 Quanser lab activity, it is seen that the arm can grab a cubic shape with ease and transport it securely.*
- *The slits at the top allows for steam entry and exit, therefore allowing the tool inside to be sterilized.*
- *The lid allows for a tool to be taken out and put back in with fair ease.*
- *The features on the container conform to the 4mm standards as there are no small feature on the design.*

Functions:

- *The container design allows for steam entry and exit via the holes, thus promoting sterilization. By the end of the process tools should be sterilized.*
- *Design properties such as the width can be made a default size to ensure a secure grip on the container. The system according to Quanser, should be able to transport the container to its respective autoclave without an issue.*
- *Can only be grabbed width wise (not length as that would violate the 80mm rule)*

Objectives:

- *The interior of the container has a soft material that prevents any damage to the tools, additionally, the container has seats for individual tools. Although during the event of a drop, the tools may bounce around but the soft interior allows for minimal damage*
- *The mostly hollow design means a lightweight container for transport*
- *The container is both durable and reusable. The container's design is rigid and distributes weight evenly.*

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

Team Number: Tues-23

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

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

Similarities

- *There's a split at the end for the function that will distinguish how the container will enter the autoclave*
- *While loop at the end to keep the program going*
- *Generally, both workflows have similar order of operations*

Differences

- *Different formats*
- *The flowchart identifies the small and large containers while picking it up while the storyboard defines a code that distinguishes the sizes almost at the end of the program with an if statement. The storyboard distinguishes the containers more efficiently in terms of the amount of code since there would only be two if statements instead of the 6 if statements in the flowchart.*
- *At the end of the flowchart, the ID# of the placed containers is added to a list. This approach was better because it would allow the program to keep track of how many containers have been placed and end the program accordingly.*
- *The flowchart opens all the autoclave drawers at the start and closes them as each large container is placed. This is considered a better approach because it makes the arm not have the put the container down and pick it back up again while opening the autoclave drawer.*

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

Team Number: Tues-23

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

```
Run the following code if all 6 containers haven't been placed
    Start the arm at home position
    Take input from muscle sensor emulator
    Open all drawers of the three autoclaves
    Move arm to the x y z coordinates for the pickup position
    Pick up the container by closing the gripper
    Identify the container size
    If the container is small
        Identify the container color
        If the container is red
            The container ID is 01
            Move arm to xyz position where container 01 should be placed in Autoclave
        If the container is green
            The container ID is 02
            Move arm to xyz position where container 02 should be placed in Autoclave
        If the container is blue
            The container ID is 03
            Move arm to xyz position where container 03 should be placed in Autoclave
        Release the container by opening the gripper
        Add the container ID last placed to a list
    If the container is large
        Identify the container color
        If the container is red
            The container ID is 04
```

Move arm to xyz position where container 04 should be placed in Autoclave

If the container is green

The container ID is 05

Move arm to xyz position where container 05 should be placed in Autoclave

If the container is blue

The container ID is 06

Move arm to xyz position where container 06 should be placed in Autoclave

Release the container by opening the gripper

Close the Autoclave drawer

Add the container ID last placed to a list

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team Number: Tues 23

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

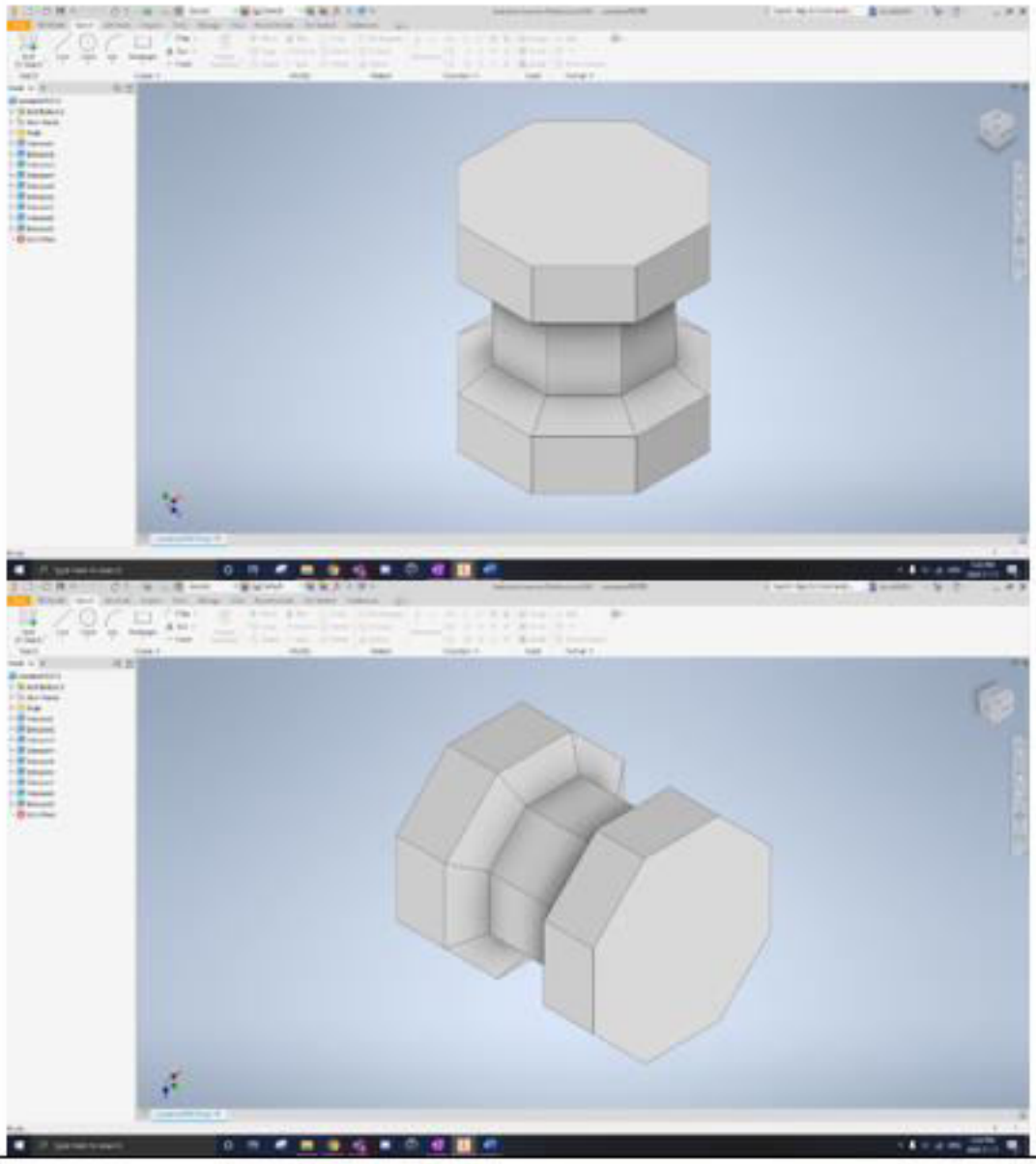
Full Name:	MacID:
Adiyan Ahmed	ahmea45
Borna Sadeghi	sadegb1
Aldraech Liac	liaca
Josh Suh	suhj13

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

Team Number: Tues 23

Team Number: Tues 23

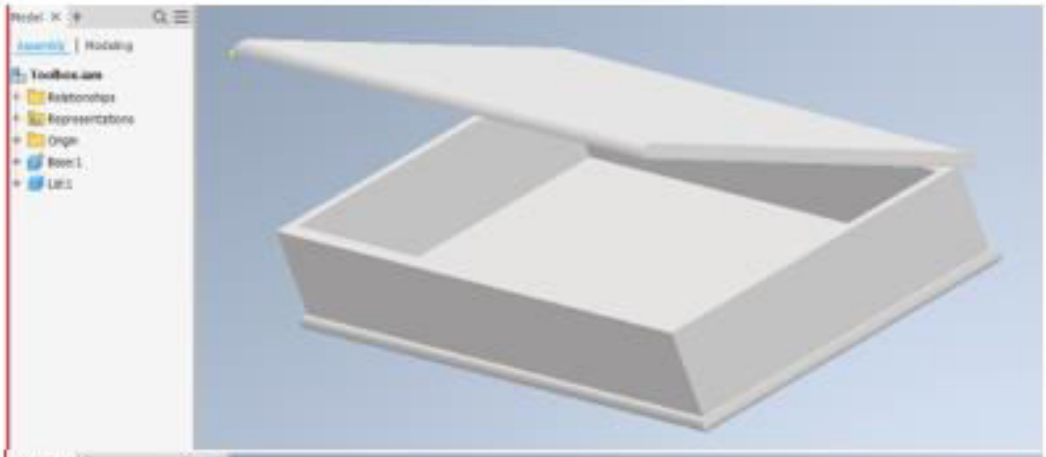
Name:Aldraech Liac	MacID liaca

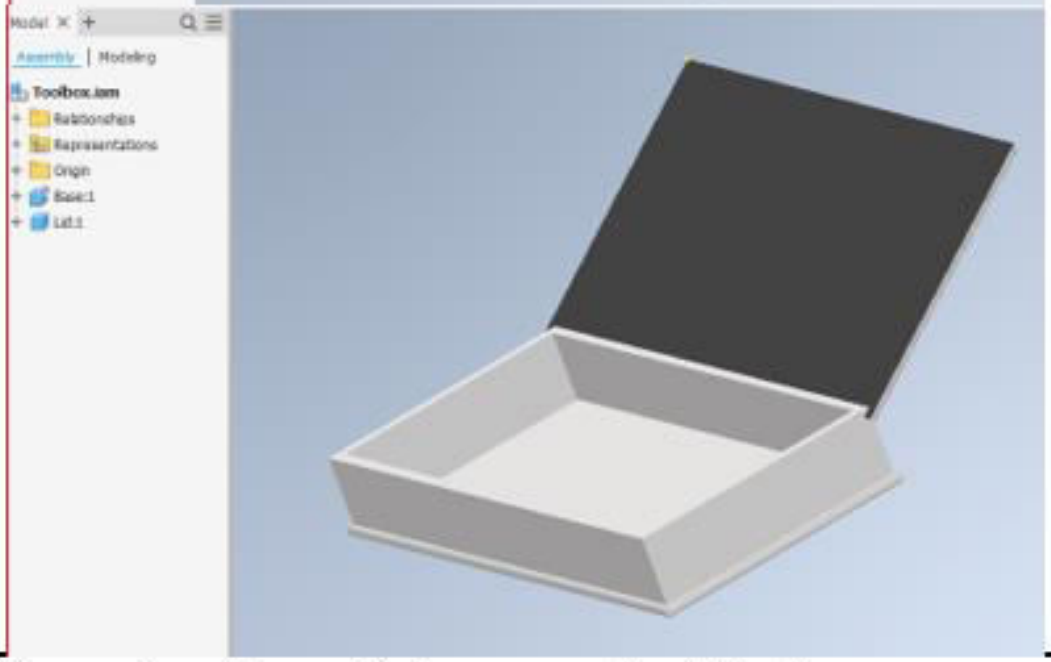


Team Number: Tues 23

Name: Borna Sadeghi	MacID: sadegb1

Insert screenshot(s) of your model below





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

Team Number: Tues 23

Team Number: Tues 23

Name: Josh Suh	MacID: suhj13
Insert a screenshot of your code below	

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

```
## STUDENT CODE BEGINS
## ----------------------------------------------------------------------------
## Example to rotate the base: arm.rotateBase(90)
def identify_autoclave(container_ID):          #This function is based off user input
    if container_ID == 1:
        position = [-0.6078, 0.2517, 0.3784]
    elif container_ID == 2:
        position = [0.0, -0.6578, 0.3784]
    elif container_ID == 3:
        position = [0.0, 0.6563, 0.343]
    elif container_ID == 4:
        position = [-0.464, 0.1922, 0.2461]
    elif container_ID == 5:
        position = [0.0, -0.4911, 0.2279]
    elif container_ID == 6:
        position = [0.0, 0.5022, 0.2461]
    else:
        position = [0.4064, 0.0, 0.4826]       #Arm moves to home position
    return position
```

Team Number: Tues 23

Name: Adiyan Ahmed	MacID: ahmea45

Insert a screenshot of your code below

```
##ahmea45
##Adiyan A. Ahmed
import sys
sys.path.append('../')

from Common_Libraries.p2_lib import *

import os
from Common_Libraries.repeating_timer_lib import repeating_timer

def update_sim ():
    try:
        arm.ping()
    except Exception as error_update_sim:
        print (error_update_sim)

arm = qarm()

update_thread = repeating_timer(2, update_sim)

def move_end_effector(position): #"position" is a list containing xyz coords
    y = True
    x = False
    #updating emg coordinates until threshold reached
    while y == True:
        sensor = arm.emg_right()
        float(sensor)
        if (sensor >= 0.30):
            y = False
        else:
            y = True

    #move end effector to xyz position once threshold has been cleared
    time.sleep(2)
    arm.move_arm(position[0], position[1], position[2])
    time.sleep(2)

position = [0.0399, -0.456, 0.3858] #test coordinates
move_end_effector(position)
```

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

Team Number: Tues 23

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

	Aldraech's Design	Borna's Design
Maximum capacity	-	S
Reliability	S	S
Ease of transport	+	S
Efficiency of sterilization process	-	-
Tool protection	+	+
Durability	+	+
Cost	+	-
Ease of use	-	S
Total +	4	2
Total –	3	2
Total Score	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

- The design must maximize the amount of tools that can be sterilized per sterilization. The shape and thickness of the design can optimize this.
- The design must have the same or improve upon the sterilization effectiveness of the already existing design (the datum). This is mainly affected by the shape of the design.
- The design must have a similar or lower cost than the datum assuming they have the same capacity and reliability.

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

Team Number: Tues 23

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

Identify Autoclave Bin Location Task	**Team Member Name**: Josh Suh
Enter code errors and/or observations here *Observations:* - *The function is dependent on the second task where a user will input the ID number of an autoclave and will cause the arm to move to that position* - *The program will return a list that contains the coordinates in the form of [x, y, z]* *Errors:* - *No errors. The program returns the coordinates just fine.*	

Move End-Effector Task	**Team Member Name**: Adiyan Ahmed
Enter code errors and/or observations here *Observations:* - For the muscle sensor input, there should be parameters for keeping the left arm flex at zero. Currently, the function will still run if the left arm is *also* flexed, but it should not. - Left an unused variable in the code (x = false) that should be removed - Otherwise the program works fine *Errors:* - No errors, program works as intended, moves the end effector to the inputted position	

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

Team Number: Tues 23

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

Control Gripper

While emg value of the left arm and right arm have both not reached threshold

    Update the values of both left arm and right arm

If the emg value of both left and right arms have reached the threshold

    If the control gripper is open

        Close control gripper

    If the control gripper is closed

        Open control gripper

Open Autoclave Bin Drawer

Take input of Container ID (function only called for large containers)

while emg value of left arm has not reached threshold *and* emg value of right arm is zero

    Update the value of the left arm emg sensor value

If the emg value of left arm has exceeded the threshold and emg value of right arm is zero

    If the autoclave bin drawer for the corresponding Container ID is closed

        Open the autoclave bin drawer

    If the autoclave bin drawer for the corresponding Container ID is open

        Close the autoclave bin drawer

Continue or Terminate

**top of program

Set a variable to false

While variable is false

    Code

    If all 6 containers have been placed

        Set variable true

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team Number: Tues-23

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

Full Name:	MacID:
Josh Suh	suhj13
Adiyan Ahmed	ahmea45
Aldraech Liac	liaca

MILESTONE 4 (STAGE 3) – DESIGN REVIEW FEEDBACK (MODELLING SUB-TEAM)

Team Number: Tues-23

Use the space below to document mentor feedback for your design.

- Make sure to check if the container fits into the footprints
- Structural supports may not be required
- Print time is too long and must take less than 2 hours
- Take into consideration the removal of the lid
- Lose some extra mass in order to meet the time requirement

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

- Considering the removal of the lid proved to be a task too difficult as that would require an overhaul of the current design. Due to time constraints impossible
- Dimensions of the container were resized to better fit the exact height of the tool, reducing the overall material used
- Holes were made larger (throughout the entire design)
- Multiple holes were created in the lid to lower the overall material usage.
- The new design leaves just the skeleton of the container.
- Print time, after all modifications, came out to be 1:58 min

MILESTONE 4 (STAGE 3) – DESIGN REVIEW FEEDBACK (COMPUTATION SUB-TEAM)

Team Number: Tues-23

Use the space below to document mentor feedback for your design.

- Everything is working perfectly in the program; we are good to go
- No errors identified; all autoclave bins placed correctly
- Inputs all working properly
- If the code remains constant with the results (placing the container in its respective autoclave and at least getting one corner in) it is perfectly suitable.
- Cycles for pickup/drop-off running in order

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

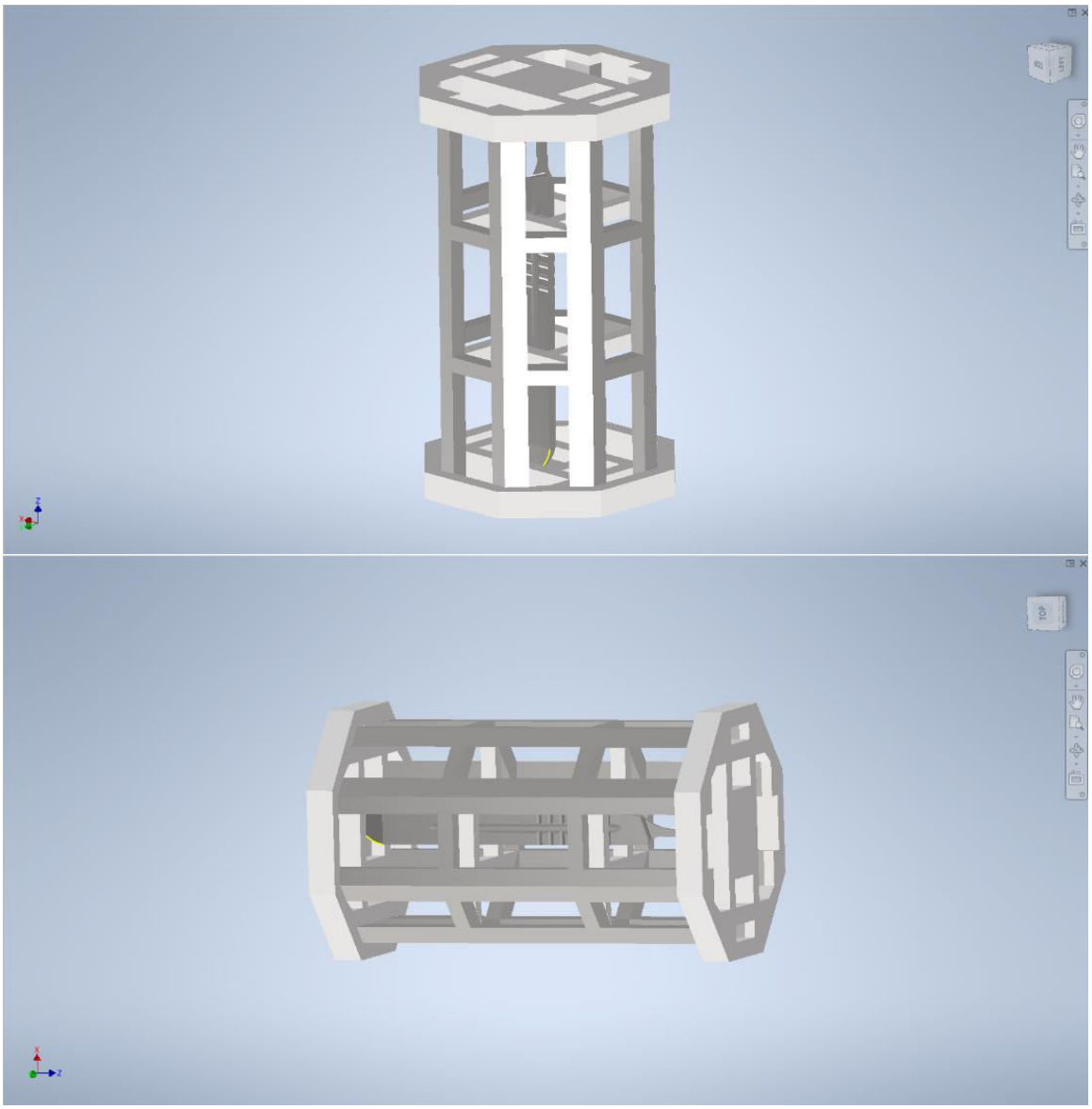
- Refine drop-off coordinates for increased consistency when placing containers in autoclave

List of Sources:

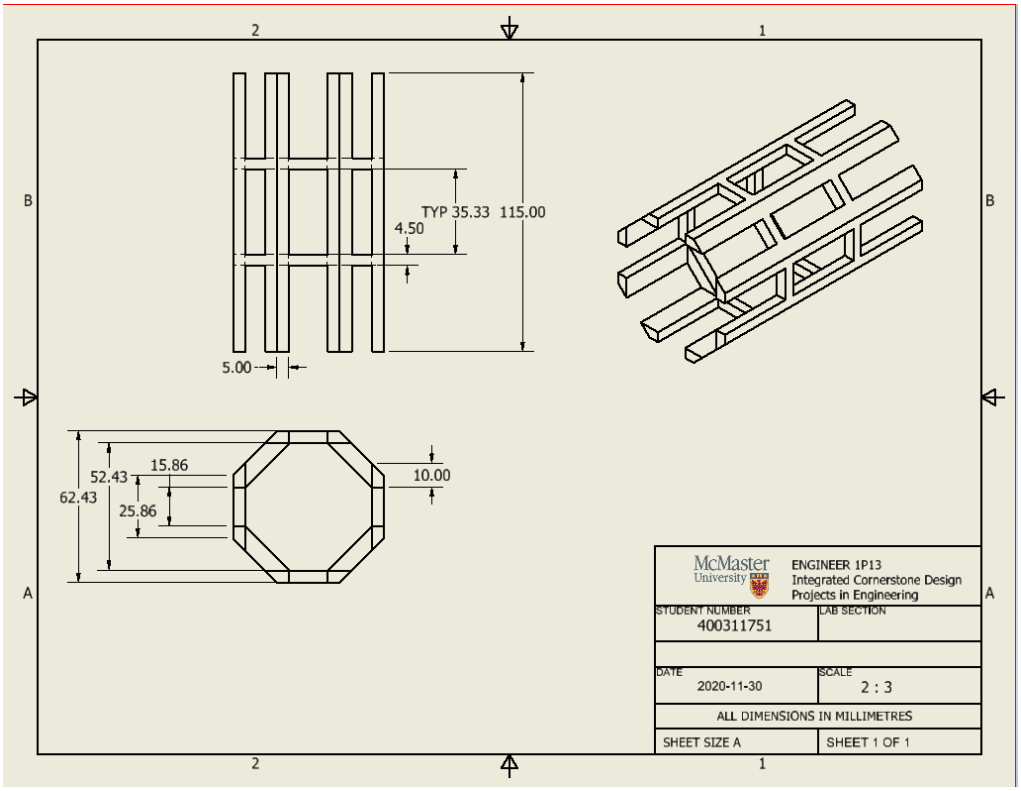
[1] "P2-Project Module," class notes for ENG IP13, Department of Engineering, McMaster University, Fall, 2020

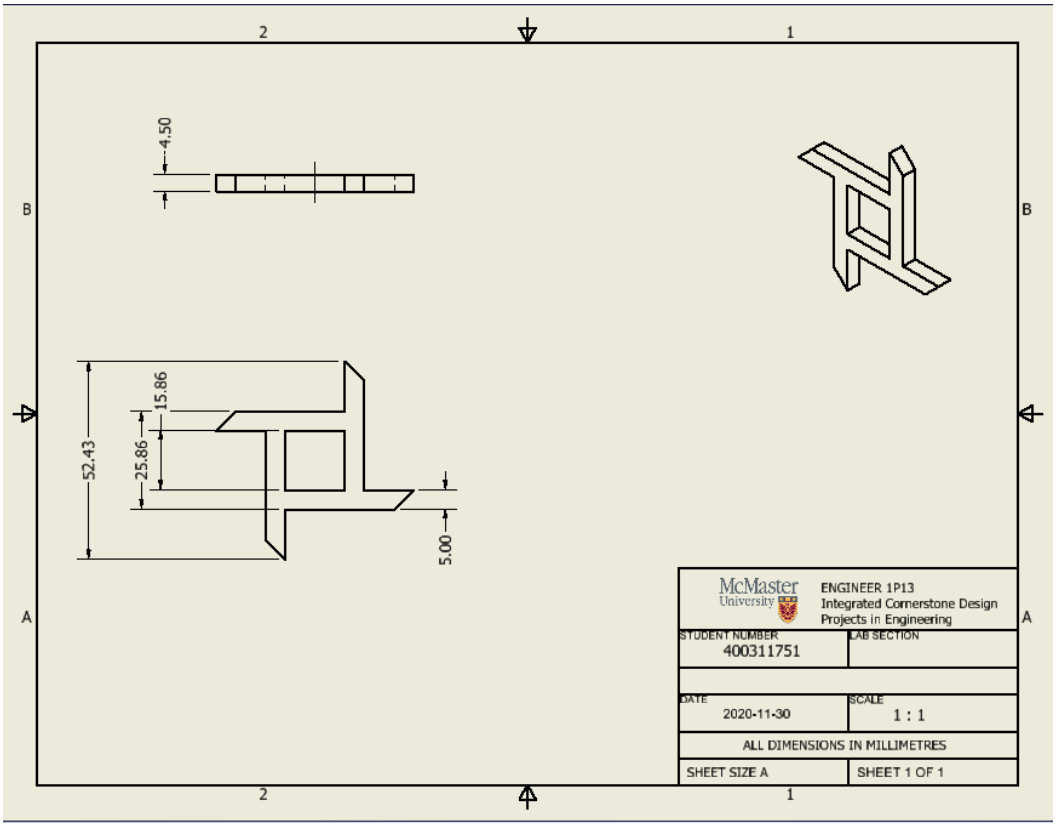
[2] "Will Robotic Surgery Work in the Canadian North?", The Conference Board of Canada [Online]. Available: https://www-conferenceboard-ca.libaccess.lib.mcmaster.ca/temp/0ef292b2-e206-4806-b523-40bee5a20b48/23894_10615_Impact_Paper_Remote_Surgery.pdf [Accessed on: December 5, 2020]

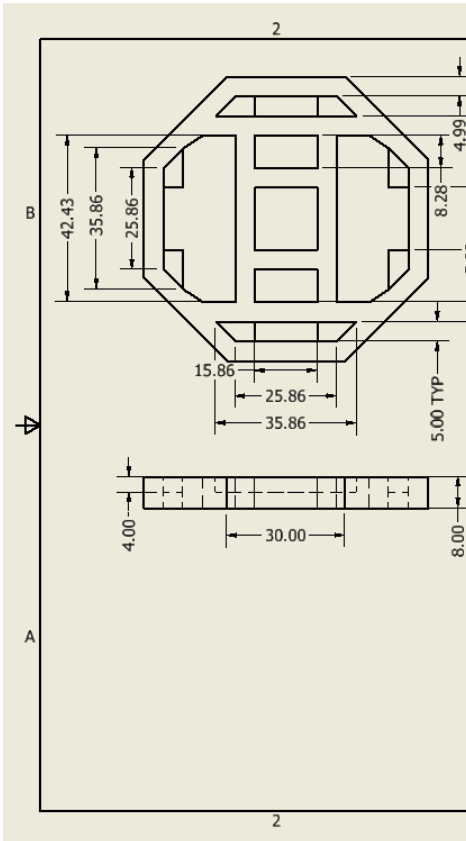
Appendix A – Screenshots of Solid Model:



Appendix B – Fully-dimensioned Engineering Drawing of sterilization container design







Appendix C – Screenshots of Computer Program:

```
##ahmea45, suhj13
##Adiyan A. Ahmed, Joshua Suh
##Tues-23
import sys
sys.path.append('../')

import random

from Common_Libraries.p2_lib import *

import os
from Common_Libraries.repeating_timer_lib import repeating_timer

def update_sim ():
    try:
        arm.ping()
    except Exception as error_update_sim:
        print (error_update_sim)

arm = qarm()

update_thread = repeating_timer(2, update_sim)


#Function takes inputs of xyz coordinates and threshold
#for EMG. Moves the end effector to the given xyz
#position. Runs when only right arm flexed.
#Written by Adiyan Ahmed

def move_end_effector(position, threshold): #"position" is a list containing xyz coords
    y = True
    #updating emg coordinates until threshold reached
    while y == True:
        sensor_right = arm.emg_right()
        sensor_left = arm.emg_left()
        float(sensor_right)
        float(sensor_left)
        #end effector only moves when only right arm is flexed
        if (sensor_right >= threshold and sensor_left == 0):
            y = False
        else:
            y = True

    #move end effector to specified xyz position once threshold has been cleared
    arm.move_arm(position[0], position[1], position[2])
    time.sleep(2)
```

```
#Function takes input of container ID,
#returns xyz coordinates of dropoff
#location for specified ID.
#Written by Joshua Suh

def identify_autoclave(container_ID):
    #identifying dropoff coordinates based on container ID
    if container_ID == 1:
        position = [-0.6108, 0.2443, 0.3784]
    elif container_ID == 2:
        position = [0.0, -0.6578, 0.3784]
    elif container_ID == 3:
        position = [0.0, 0.6578, 0.3784]
    elif container_ID == 4:
        position = [-0.4102, 0.1699, 0.2673]
    elif container_ID == 5:
        position = [0.0, -0.4329, 0.2491]
    elif container_ID == 6:
        position = [0.0, 0.444, 0.2673]
    else:
        position = [0.4064, 0.0, 0.4826] #Arm moves to home position if invalid container ID

    return position


#Function takes input of current gripper status,
#which is either opened or close, and the threshold value
#of the EMG. Opens the gripper if it is closed, and closes
#it if it is open. Runs when only left arm flexed.
#Written by Adiyan Ahmed

def control_gripper(gripper_status, threshold):
    y = True
    #updating emg coordinates until threshold reached
    while y == True:
        sensor_right = arm.emg_right()
        sensor_left = arm.emg_left()
        float(sensor_right)
        float(sensor_left)
        #control gripper only opened and closed when only left arm is flexed
        if (sensor_right == 0 and sensor_left >= threshold):
            y = False
        else:
            y = True

    if (gripper_status == "closed"): #opening gripper if closed
        arm.control_gripper(-45)
        gripper_status = "open"
        time.sleep(2)
    elif (gripper_status == "open"): #closing gripper if opened
        arm.control_gripper(45)
        gripper_status = "closed"
        time.sleep(2)

    return gripper_status
```

```
#Function takes input of autoclave ID, current
#drawer status (open or closed), and the EMG
#threshold. Opens corresponding autoclave drawer
#if closed, closes if open. Runs when both arms flexed.
#Written by Joshua Suh

def autoclave_bin_drawer(autoclave_ID, drawer_status, threshold):
    y = True
    #updating emg coordinates until threshold reached
    while y == True:
        sensor_right = arm.emg_right()
        sensor_left = arm.emg_left()
        float(sensor_right)
        float(sensor_left)
        #autoclave bin drawer opened/closed only if both arms are flexed
        if (sensor_right >= threshold and sensor_left >= threshold):
            y = False
        else:
            y = True

    #opening or closing autoclave drawer based on if it is currently open or closed
    if autoclave_ID == 4 and drawer_status == "closed":
        arm.open_red_autoclave(True)
        drawer_status = "open"
        return drawer_status
    elif autoclave_ID == 4 and drawer_status == "open":
        arm.open_red_autoclave(False)
        drawer_status = "closed"
        return drawer_status
    elif autoclave_ID == 5 and drawer_status == "closed":
        arm.open_green_autoclave(True)
        drawer_status = "open"
        return drawer_status
    elif autoclave_ID == 5 and drawer_status == "open":
        arm.open_green_autoclave(False)
        drawer_status = "closed"
        return drawer_status
    elif autoclave_ID == 6 and drawer_status == "closed":
        arm.open_blue_autoclave(True)
        drawer_status = "open"
        return drawer_status
    elif autoclave_ID == 6 and drawer_status == "open":
        arm.open_blue_autoclave(False)
        drawer_status = "closed"
        return drawer_status
```

```
#main function, goes through cycle of entire
#pickup and dropoff process for all 6 containers
#by using the functions defined above in a specific
#order. Runs until all 6 containers have been placed.
#Written by Adiyan Ahmed

def main():

    #defining variables
    pickup_location = [0.5266, 0.0, 0.0072]
    home_position = [0.4064, 0.0, 0.4826]
    threshold = 0.30

    randomizedIDs = random.sample(range(1,7),6)

    for i in randomizedIDs:

        #returning arm to default position
        arm.home()
        arm.control_gripper(-45)
        gripper_status = "open"
        red_drawer_status = "closed"
        green_drawer_status = "closed"
        blue_drawer_status = "closed"
        time.sleep(3)

        #dropping in random container
        container_ID = i
        arm.spawn_cage(container_ID)

        #determining dropoff location for corresponding autoclave
        dropoff_location = identify_autoclave(container_ID)

        #picking up container
        move_end_effector(pickup_location, threshold) #flex right arm
        gripper_status = control_gripper(gripper_status, threshold) #flex left arm
        move_end_effector(home_position, threshold) #flex right arm

        #opening autoclave drawer if necessary
        #flex both arms to open drawer if large container
        if (container_ID == 4):
            red_drawer_status = autoclave_bin_drawer(container_ID, red_drawer_status, threshold)
        elif (container_ID == 5):
            green_drawer_status = autoclave_bin_drawer(container_ID, green_drawer_status, threshold)
        elif (container_ID == 6):
            blue_drawer_status = autoclave_bin_drawer(container_ID, blue_drawer_status, threshold)

        #dropping off container
        move_end_effector(dropoff_location, threshold) #flex right arm
        gripper_status = control_gripper(gripper_status, threshold) #flex left arm
        arm.home()

        #closing autoclave drawer if necessary
        #flex both arms to close drawer if large container
        if (container_ID == 4):
            red_drawer_status = autoclave_bin_drawer(container_ID, red_drawer_status, threshold)
        elif (container_ID == 5):
            green_drawer_status = autoclave_bin_drawer(container_ID, green_drawer_status, threshold)
        elif (container_ID == 6):
            blue_drawer_status = autoclave_bin_drawer(container_ID, blue_drawer_status, threshold)

main()
```