ENGINEERING

McMaster University

Project Two – Get A Grip:

Designing a System for Sterilizing Surgical Tools using Remote Sensing and Actuation

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial 15

Team MON-42

Mohammad Muntazar Bhurwani (bhurwanm)

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Eniolaoluwa Adebayo (adebaye)

Housam Alamour (Alamourh)

Submitted: December 9, 2020

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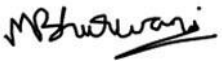
Academic Integrity Statement

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

Mohammad Muntazar Bhurwani 400296770

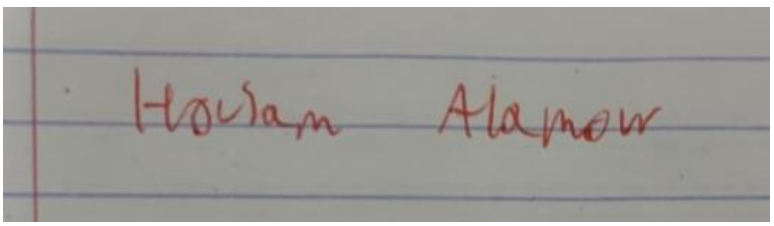


The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Matthew Zhang 400321538

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.

Housam Alamour 400317089



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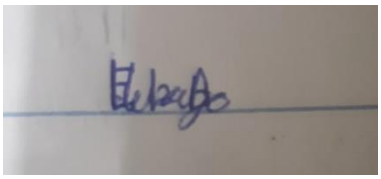
Eniolaoluwa Adebayo 400298504



Executive Summary

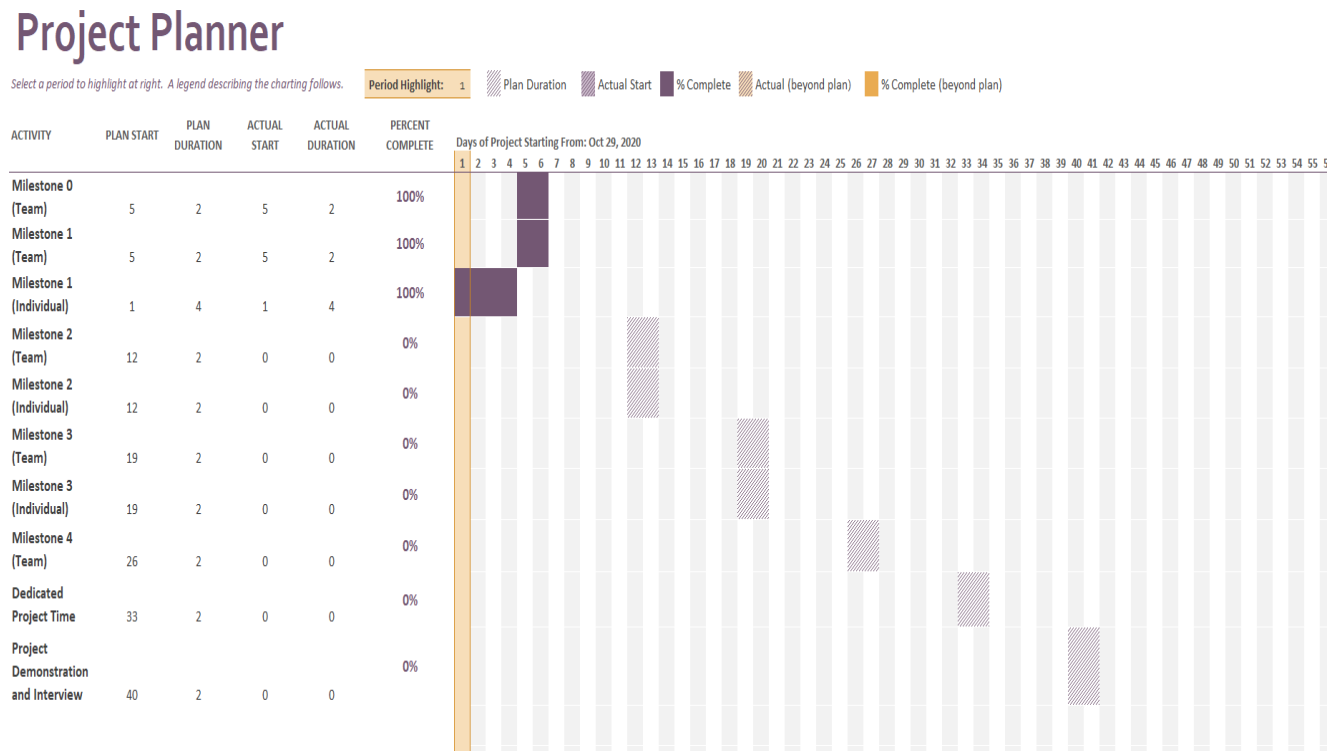
In project 2, our team was assigned to design a system that can securely transport a surgical tool to an autoclave for sterilization using a robotic arm. This project was split up into two sub-teams: modelling and computing. The modelling sub-team was responsible for designing a container that can securely hold a surgical instrument for sterilization. The model has strict constraints as all features are required to have a minimum dimension of 4mm and we had to adhere to a given footprint (amount of occupied space) and surgical tool. Furthermore, we were supposed to prepare a G-Code file for fabrication on a 3D printer. After scaling down the design by 50%, it was required that the print time does not exceed 2 hours. The mass of the object before scaling down also cannot exceed 350 grams. The model we created is an opened-face rectangular container with holes around the sides and bottom of the container. Inside the container, we added parts that matched with the shape of the surgical instrument to constrain it inside the container for security. As for the G-Code fabrication, after scaling down by 50%, our print time is 1h 50min. The mass of the object before scaling down is 57.49 grams.

The team was also required to design a computer program to operate a robotic arm and transfer the surgical tool safely for sterilisation. The arm was to be controlled using two muscle sensor emulators integrated into the Python code, where each function of the code corresponds to a separate action of the EMG muscles. The code was split up into four distinct functions that are integrated into the main function. The first function identified the drop off location (found by trial and error) depending on which container ID is inputted as an argument. The second function takes an XYZ coordinate as an argument and moves the end effector to that location only if the right arm exceeds the predefined global threshold (found using the documentation method [2]). The third function takes claw open or close as input and changes the gripper to that state only if the left arm exceeds the threshold (0.5). The final function was split into an open and close function for opening the large autoclave bins. It takes in the container ID and opens the corresponding large container drawer only if both arms exceed the threshold (0.5).

These functions were combined into the main function that used a for loop to run through a randomized list of each container ID and drop them off into their respective containers. In the for loop, the container i is first spawned and determined to be large or small. The drop off location is set and the end effector moves from to pickup, closing the claw when it reaches the container. The drawer opened if it is large then finally the arm moves to the drop-off, the container is placed and the code repeats for all the container IDs.

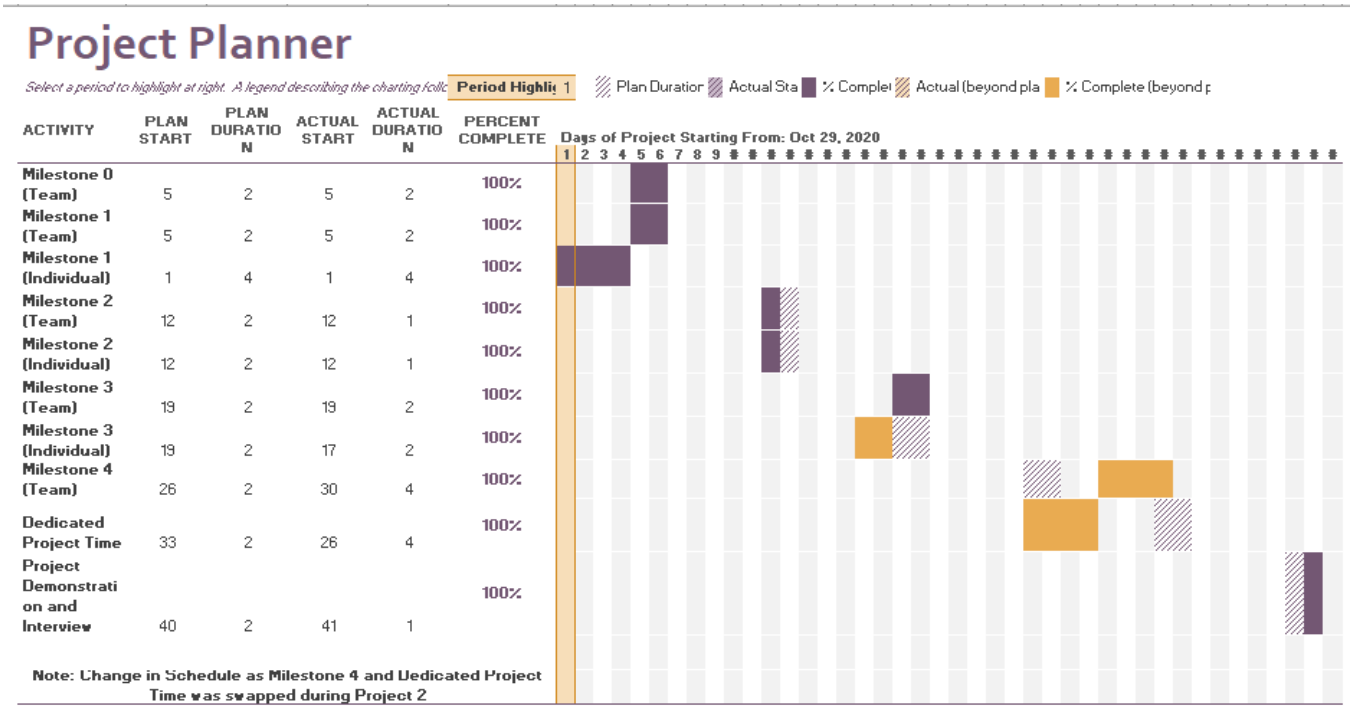
Project Schedule:

Preliminary Gantt Chart:



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Milestone 0 (Team)	5	2	5	2	100%
Milestone 1 (Team)	5	2	5	2	100%
Milestone 1 (Individual)	1	4	1	4	100%
Milestone 2 (Team)	12	2	0	0	0%
Milestone 2 (Individual)	12	2	0	0	0%
Milestone 3 (Team)	19	2	0	0	0%
Milestone 3 (Individual)	19	2	0	0	0%
Milestone 4 (Team)	26	2	0	0	0%
Dedicated Project Time	33	2	0	0	0%
Project Demonstration and Interview	40	2	0	0	0%

Final Gantt Chart:



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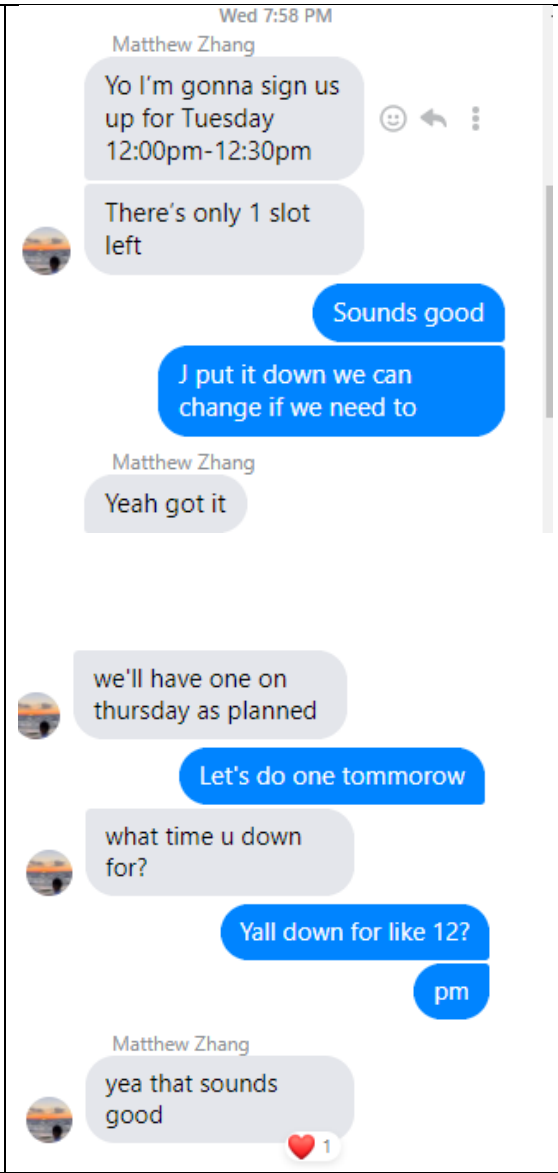
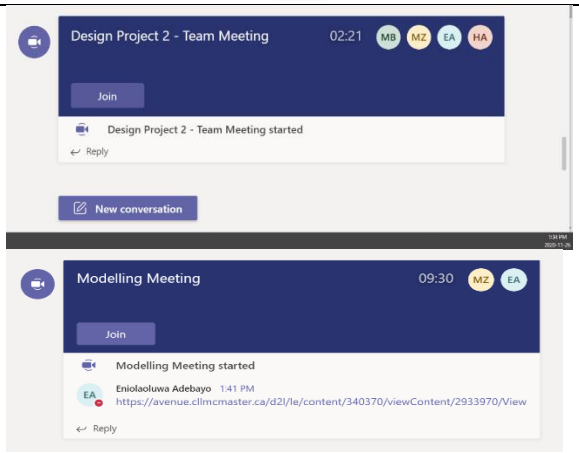
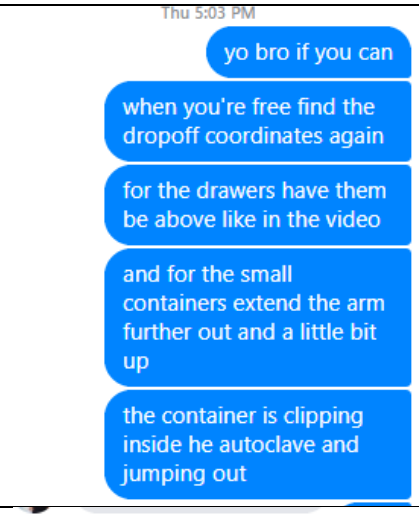
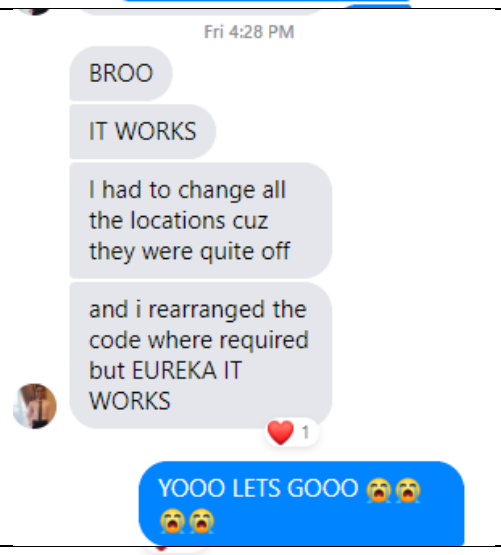
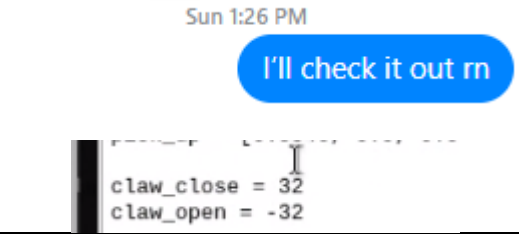
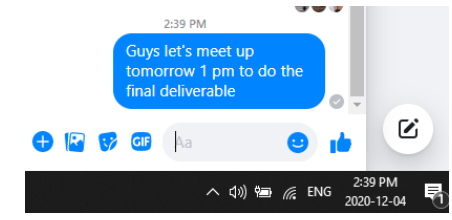
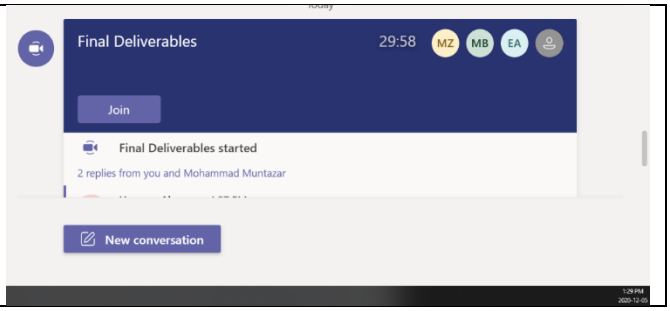
Milestone 0 (Team)	5	2	5	2	100%
Milestone 1 (Team)	5	2	5	2	100%
Milestone 1 (Individual)	1	4	1	4	100%
Milestone 2 (Team)	12	2	12	1	100%
Milestone 2 (Individual)	12	2	12	1	100%
Milestone 3 (Team)	19	2	19	2	100%
Milestone 3 (Individual)	19	2	17	2	100%
Milestone 4 (Team)	26	2	30	4	100%
Dedicated Project Time	33	2	26	4	100%
Project Demonstration and Interview	40	2	41	1	100%

Note: Change in Schedule as Milestone 4 and Dedicated Project Time was swapped during Project 2

Logbook of Additional Meetings and Discussions:

November 25:	Project interview date is decided and an additional meeting outside class time is planned	
November 26:	- Meeting is held to work on the code and solid model. By the end Modelling team planned to have finalized their model and coding team must finish the code, CAD model finished and implemented g-code and coding team created all their functions. - Move end effector function is updated to be more compact and efficient by removing	

	unnecessary updated of emg muscle values Instead of using arm.home, which opens the gripper and drops the object, the home coordinates were found using arm.effector position and move end effector function was used.	
Nov 27:	Code is finished, dropoff positions are finalized and main function runs through all the objects without error	
Nov 29: **Nov 30:**	Code testing and bug detection/fixing phase Claw open/close changed from 45 to 35 to make pickup more consistent	
Dec 04:	Planned a meeting for final deliverable	

Dec 5:	Meeting to work on the final deliverable and discuss interview details.	

Scheduled Weekly Meetings:

Weekly Design Studio Agenda's:

WEEK 8 – NOVEMBER 9, 2020 AGENDA ITEMS

1. . Modelling Sub team split up
2. . Computing Sub team split up
3. . Discussion with TA
4. . Split up and work on sub team projects
5. . Meet up again and discuss work

WEEK 9 – NOVEMBER 16 AGENDA ITEMS

1. Modelling sub team expected to complete preliminary solid model
2. Computing sub team expected to complete preliminary program tasks
3. Modelling sub team work on sterilization container design evaluation
4. Computing sub team work on detailed plan of entire program

WEEK 10 – NOVEMBER 23 AGENDA ITEMS

1. . Update Both teams on progress
2. . Designated work time

WEEK 11 – NOVEMBER 30 AGENDA ITEMS

1. . Sub teams present their finalized product to TA's

Weekly Design Studio Meeting Minute's:

MEETING MINUTES

WEEK 8 – NOVEMBER 9, 2020

1. . Modelling Sub team split up
    a. Share each other's refined concept sketch
    b. Compare each concept sketch
2. . Computing Sub team split up
    a. Share each others storyboard
    b. Compare the story boards
3. . Discussion with TA
    a. Run through what is expected of us
    b. Explained to computing sub team how to design pseudocode without python syntax
    c. Explain to Design team foundations and how to get started modeling
4. . Split up and work on sub team projects
    a. Computing sub team came up with initial pseudocode
    b. Pseudocode is then refined to include more detail and avoid python syntax
    c. Modelling sub team created prototypes
5. . Meet up again and discuss work
    a. **Computing sub team finished and explained code**
    b. **Modeling sub team showed design and finished up after meeting**

POST-MEETING ACTION ITEMS

c. *Computing sub team code [manager]: come up with function for code for next design studio*
d. *Design sub team [manager]: create preliminary model*

WEEK 9 – NOVEMBER 16 AGENDA ITEMS

1. . Modelling sub team expected to complete preliminary solid model
    a. Share each others refined concept sketch
    b. Compare each concept sketch
    c. Eniolaoluwa had questions about the solid model lid
    d. Matthew had difficulty implementing handle from refined concept sketch into cad model
2. Computing sub team expected to complete preliminary program tasks
    a. Housam implemented code from previous EMG lab into the move end effector function
    b. Housam had trouble finding out how to get the drop off and pick up coordinates
    c. Muntazar was unsure of how the drawer would open, found out there is a method from the library from the IA
3. . Discussion with TA
    a. Run through what is expected of us
    b. Coding team had some trouble implanting drop off coordinates into code
    c. Explained to computing sub team what functions to work on next
    d. Modeling sub team shared their preliminary models and discussed errors they had

4. . Split up and work on sub team projects
    a. Computing sub team combines code and fixes each other's errors
    b. Pseudocode is then refines to include more detail and avoid python syntax
    c. Modelling sub team created prototypes
5. . Meet up again and discuss work
    a. **Computing sub team finished and explained code**
    b. **Modeling g sub team shoed design and finished up after meeting**

POST-MEETING ACTION ITEMS

1. *Both teams continue working on the model and the code respectively* [team]

WEEK 10 – NOVEMBER 23

1. . Update Both teams on progress
    a. Modelling team started building final model for container
    b. Take into consideration constraints, how to build model using data from last milestone
    c. Coding team has their first 2 functions and pseudocode for the final 3 functions that they will use and develop the final code
2. . Designated work time
    a. Teams split up and worked on design and code
    b. Design team finalized their design
    c. Coding team worked on defined functions and looping of main function

POST-MEETING ACTION ITEMS

d. *Review code and design [Team]*

WEEK 11 – NOVEMBER 30

MEETING MINUTES

1. . Sub teams present their finalized product to TA's
    a. Computing team showed their code and IA checked it all and found no errors. He suggested to improve comments by removing the double ## and legibility by changing spacing between functions
    b. Design Subteam showed model and it checked out and the g code came in within the footprint and under the threshold mass. The IA recommended to add more holes to the design to improve sterilization

POST-MEETING ACTION ITEMS

1. *Review code and design for interview and follow guidelines from Dr. MacDonald lecture [Team]*

Design Studio Worksheets:

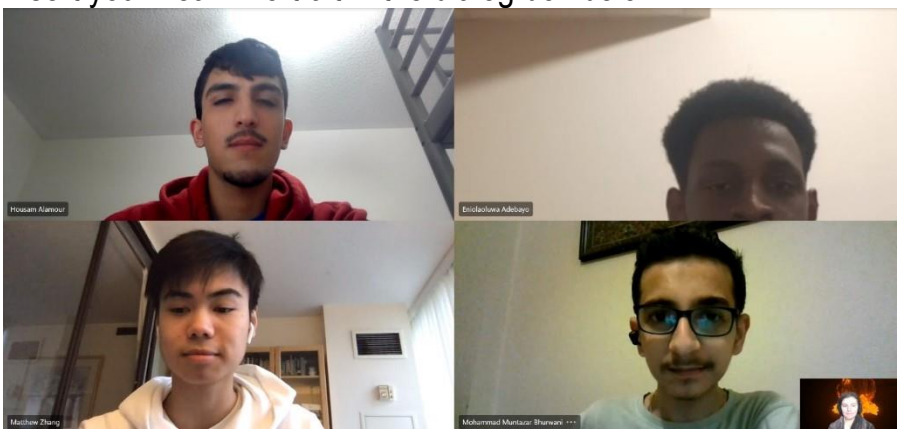
PROJECT TWO: MILESTONE 0 – COVER PAGE

Team Number: Mon-42

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

Full Name:	MacID:
Housam Alamour	alamourh
Matthew Zhang	zhanm75
Eniolaoluwa Adebayo	adebaye
Mohammad Muntazar Bhurwani	bhurwanm

Insert your Team Portrait in the dialog box below



MILESTONE 0 – TEAM CHARTER

Team Number: MON-42

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Housam Alamour	☒M ☐A ☐C ☐S
2.	Mohammad Muntazar Bhurwani	☐M ☐A ☒C ☐S
3.	Eniolaoluwa Adebayo	☐M ☒A ☐C ☐S
4.	Matthew Zhang	☐M ☐A ☐C ☒S

Project Leads:

Identify team member details (Name and MACID) in the space below.

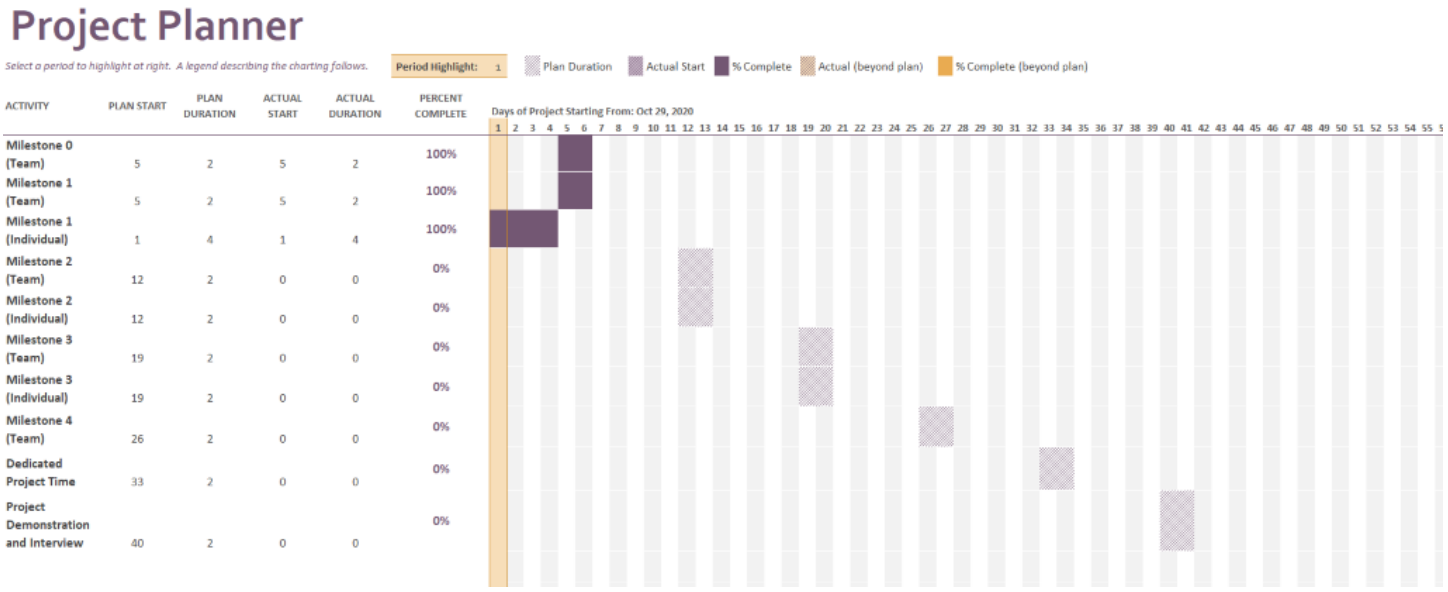
Role:	Team Member Name:	MacID
Manager	Matthew Zhang	zhanm75
Administrator	Mohammad Muntazar Bhurwani	bhurwanm
Coordinator	Housam Alamour	alamourh
Subject Matter Expert	Eniolaoluwa Adebayo	adebaye

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team Number:	MON-42

Full Name of Team Manager:	MacID:
Matthew Zhang	zhanm75

Preliminary Gantt chart



PROJECT TWO: MILESTONE 1 – COVER PAGE

Team Number: Mon-42

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

Full Name:	MacID:
Housam Alamour	alamourh
Eniolaoluwa Adebayo	adebaye
Matthew Zhang	zhanm75
Mohammad Muntazar Bhurwani	bhurwanm

MILESTONE 1 (STAGE 1) – PRE-PROJECT ASSIGNMENT

Team Number: Mon-42

You should have already completed this task individually prior to Design Studio 7.

1. Copy-and-paste each team member's list of surgical instrumentives, constraints and functions on the following pages (1 team member per page)
    a. Be sure to indicate each team member's Name and MacID

We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their list of surgical instrumentives, constraints and functions with the **Milestone One Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone One Team Worksheets** document allows you to readily access your team member's work
    - This will be especially helpful when completing ***Stage 2*** of the milestone

Name: Housam Alamour	MacID: alamourh

Objectives

- Should be accurate in how it picks up surgical instruments
- Should be precise (able to precisely pick up small and weirdly shaped surgical instruments)
- Should have a secure grip
- Be easy to clean/sterilize
- Arm should be water resistant (eg. Place scalpel in alcohol for sterilization)

Constraints

- Should not break or yield under the load of the surgical instrument
- Should be durable enough to complete the task
- The arm should not drop the surgical instruments when picking them up or moving
- Must have the power to move the surgical instruments to another position

Functions

- Be able to move the arm in 3-d space to the surgical instrument
- Be able to control the arm movement using muscle sensors (method: where are muscle sensors placed?)
- Be able to read the muscle sensor input and translate it to the arm
- The arm must be able to securely pick up surgical instruments
- The arm must be able to move the surgical instruments
- The arm must be able to release the surgical instruments
- Container must hold surgical instrument

Team Number: Mon-42

Name: Eniolaoluwa Adebayo	MacID: adebaye

Objectives

- Should be easy to use
- Should not be time-consuming
- Should hold surgical equipment
- Should transfer container

Constraints

- Lighter than 10kg
- Sanitary
- Smaller than $1m^3$

Functions

- Able to hold surgical tools
- Able to lift weights up to 8kg
- Able to fit in autoclave

Page Break

Team Number: Mon-42

Name: Matthew Zhang	MacID: zhanm75

Objectives

- Arm should have a good grip
- Arm should be accurate in its ability to pick up container
- Arm should be accurate in its ability to put down container
- Container should be lightweight

Constraints

- *Arm must be durable so it does not break*
- *Arm must have the power to lift container*
- *Arm should not drop the container during lift*
- *Container must fit in autoclave*

Functions

- Arm is able to lift container
- Be able to move arm
- able to control arm movement
- Sterilization of surgical instrument in container

Page Break

Team Number: Mon-42

Name: Mohammad Muntazar Bhurwani	MacID: bhurwanm

Objectives

- Should be precise to be able to pick small instruments
- Should have a secure grip to ensure safe transfer of instrument
- Easy to use

Constraints

- Must be able to withstand weight of the instrument
- Must have appropriate dimensions to hold the instrument

Functions

- Arm should pick up and move the container
- Container should be able to hold the instrument safely

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

Team Number: Mon-42

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

Objectives	Constraints	Functions
Arm should be accurate in how it picks up the container	Arm and container is durable so it doesn't break	Arm can hold the container
Arm should have a secure grip	Arm must have power to lift the container	Container able to contain surgical instruments
Container should be easily transported with the arm	Container shouldn't be too big	Arm is able to securely pick-up container
Arm should be easy to use, control	The arm should not drop the surgical instrument when picking them up or moving	Arm is able to move the container
Container should be lightweight	Container must be able to fit in autoclave	Arm is able to release the container

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

Arm is able to move and transfer container

3. What are the secondary functions?

Arm is able to pick up container
Arm is able to release container
Container is able to contain tools (surgical)
Arm is able to securely grip container
Sterilization of surgical instrument in container

MILESTONE 1 (STAGE 3) – MORPHOLOGICAL ANALYSIS

Team Number: Mon-42

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	Cup Handle (side of container)	Bucket handle (top of container)	Magnet	Hook	Clasping extension	
Sterilize tools in container	Holes	Drawer	Net	Cap		
Contains surgical instruments	Bag	Can	Bucket	Bowl	Cup	Box

Page Break

MILESTONE 1 (STAGE 4) – CONCEPT SKETCHES

Team Number: Mon-42

Complete this worksheet *after* having completed stage 3 as a team ***and*** after having ***individually*** created your concept sketches.

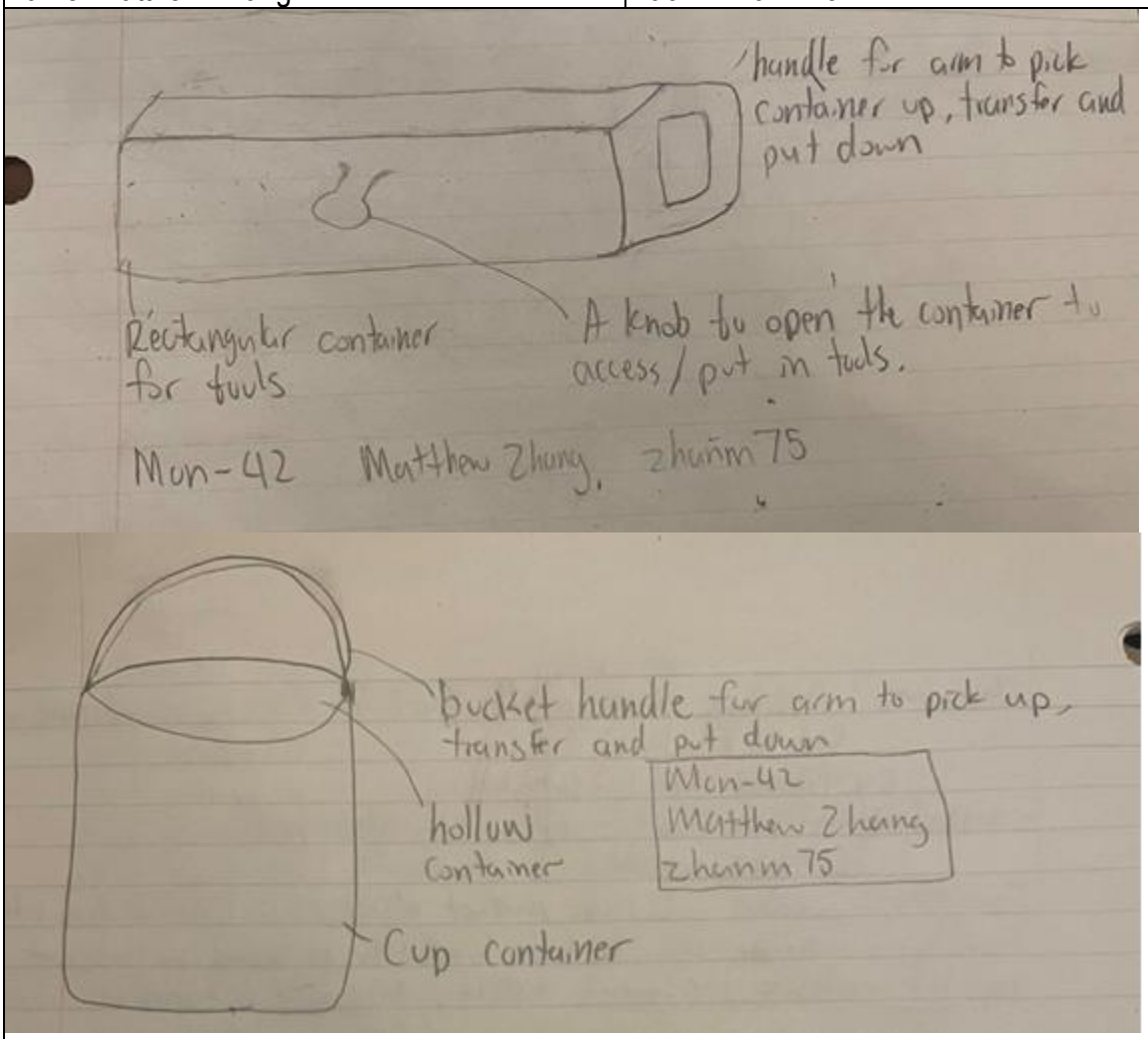
1. Each team member should copy-and-paste the photo of their individual concept sketches in the space indicated on the following pages
    - The photo's should be the same one your included in the **Milestone One Individual Worksheets** document
    - Be sure to include your **Team Number** on each page
    - Be sure each team member's **Name** and **MacID** are included with each sketch

We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their sketch with the **Milestone One Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone One Team Worksheets** document allows you to readily access your team member's work

Team Number: Mon-42

Name: Matthew Zhang	MacID: zhanm75



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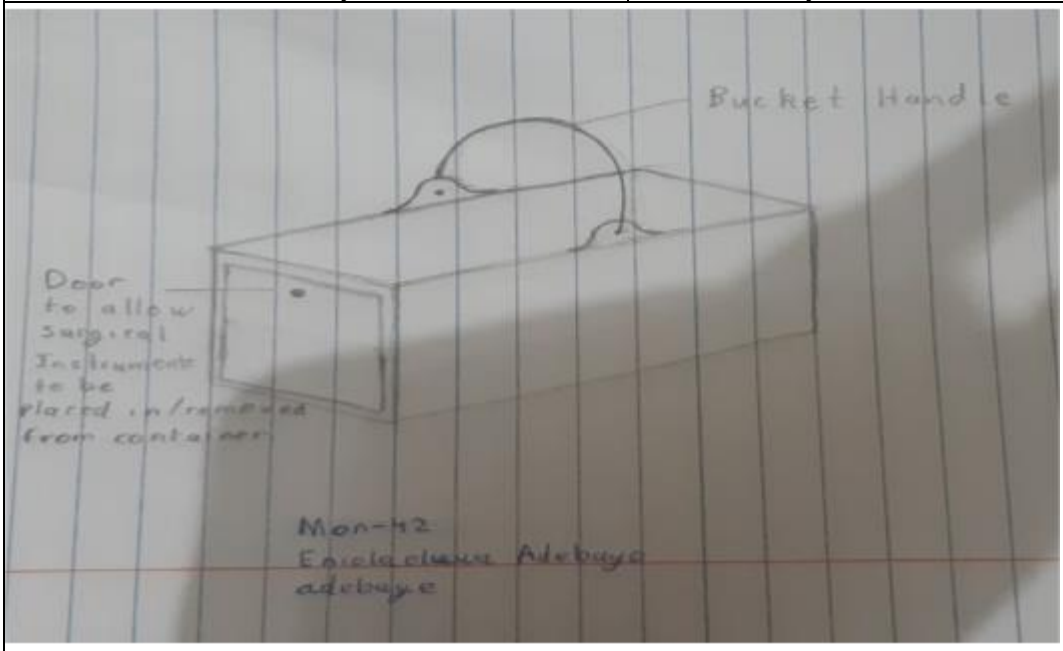
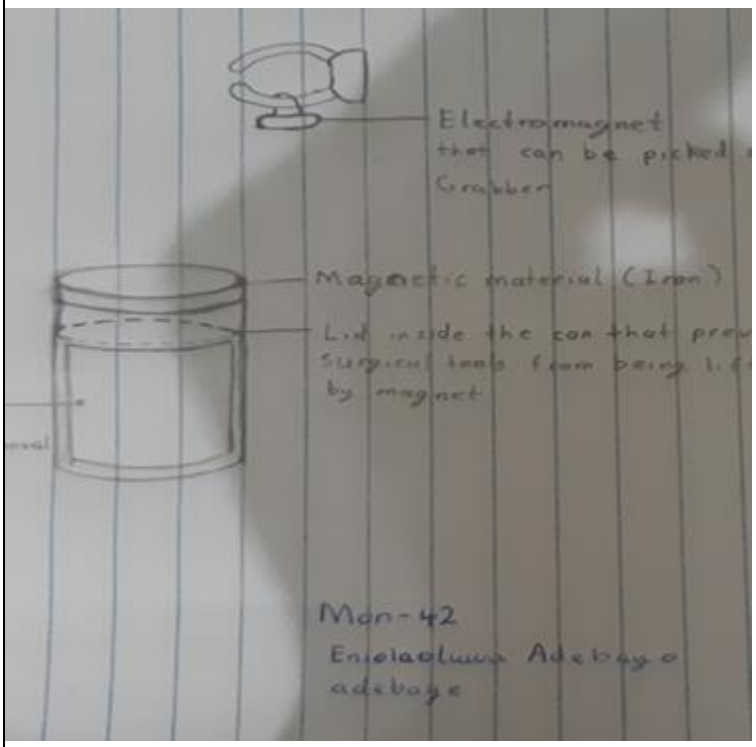
Team Number: Mon-42

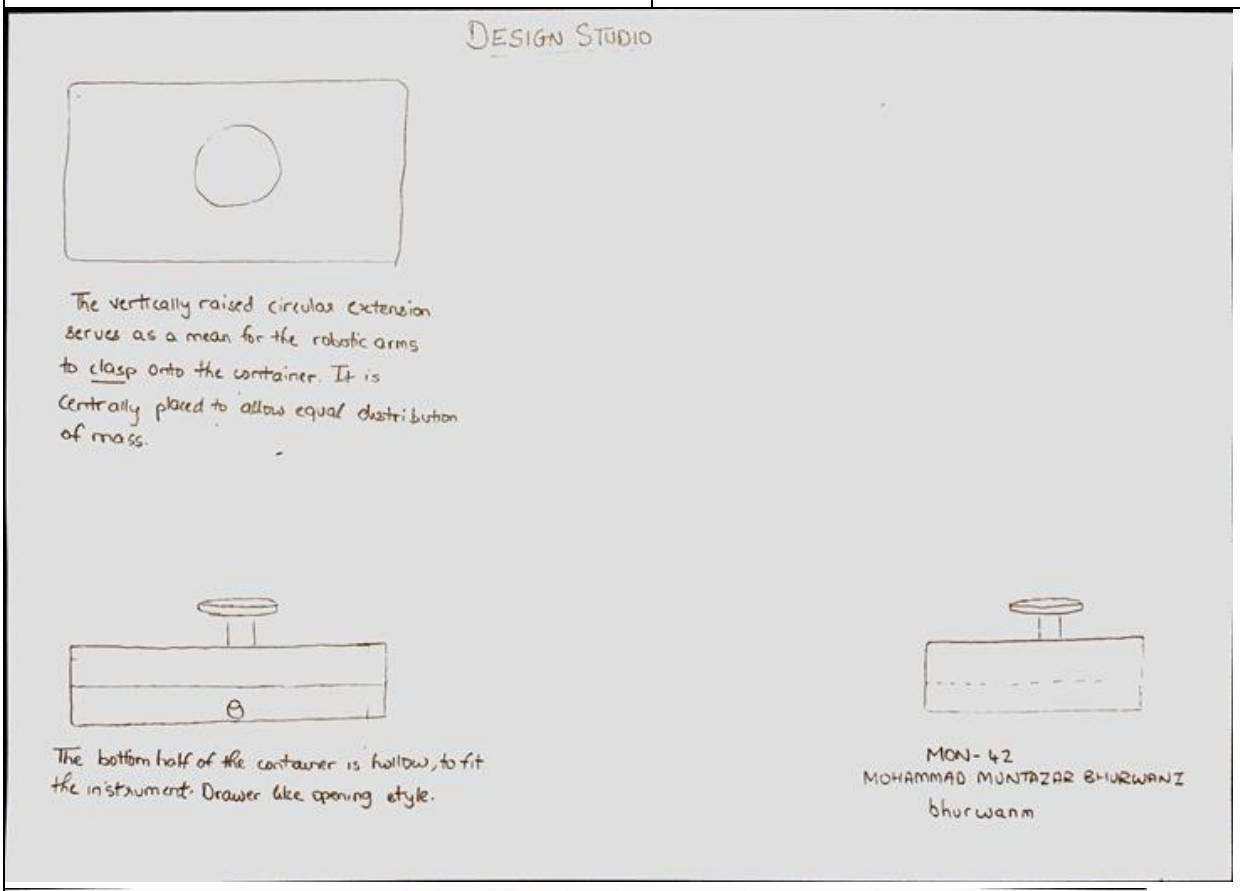
Name: Eniolaoluwa Adebayo	MacID: adebaye

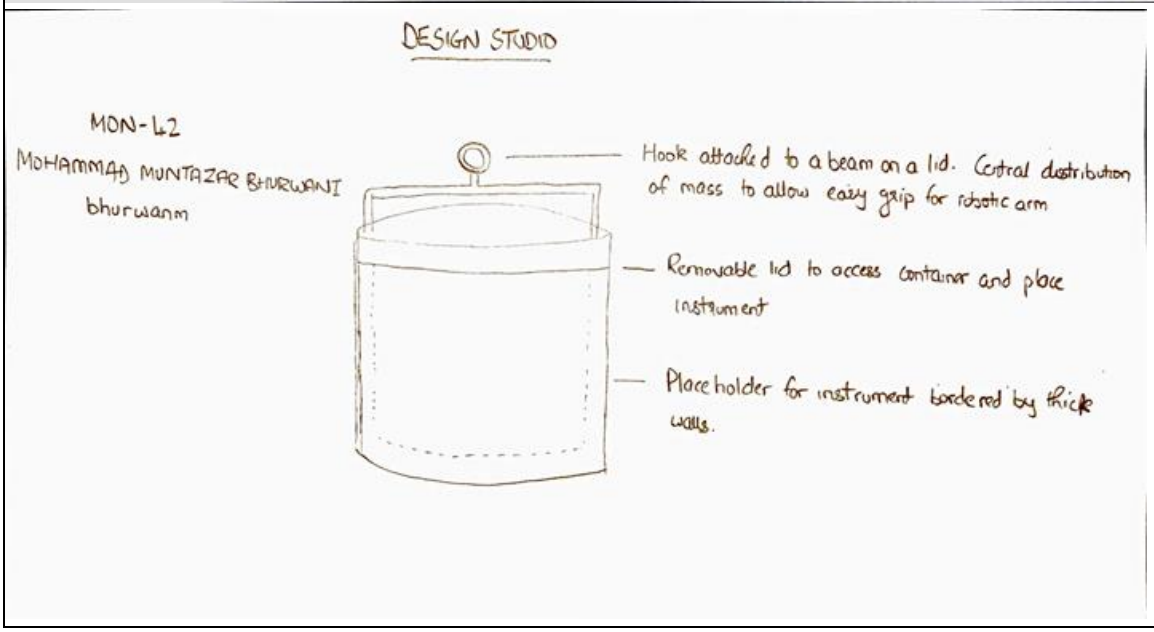




Team Number: Mon-42

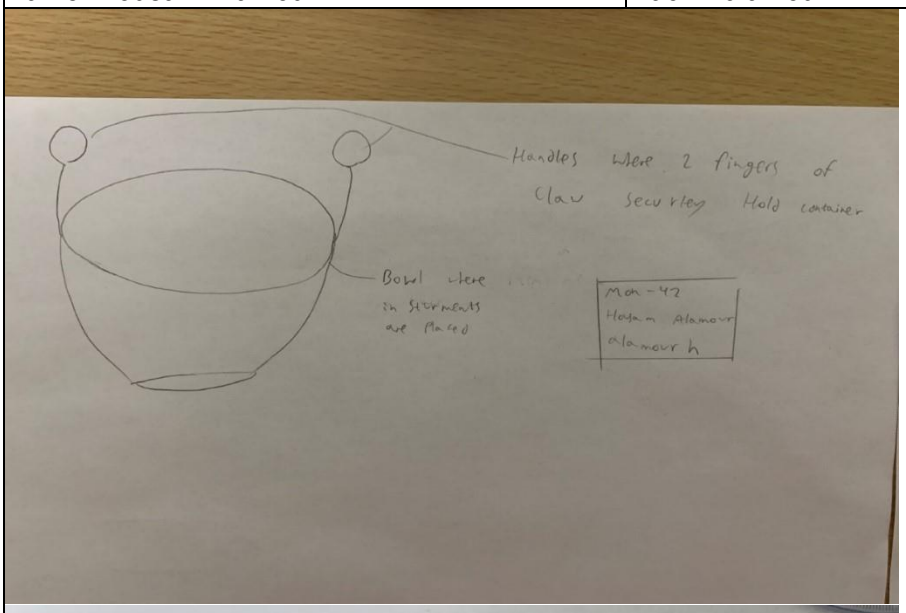
Name: Mohammad Muntazar Bhurwani	MacID: bhurwanm

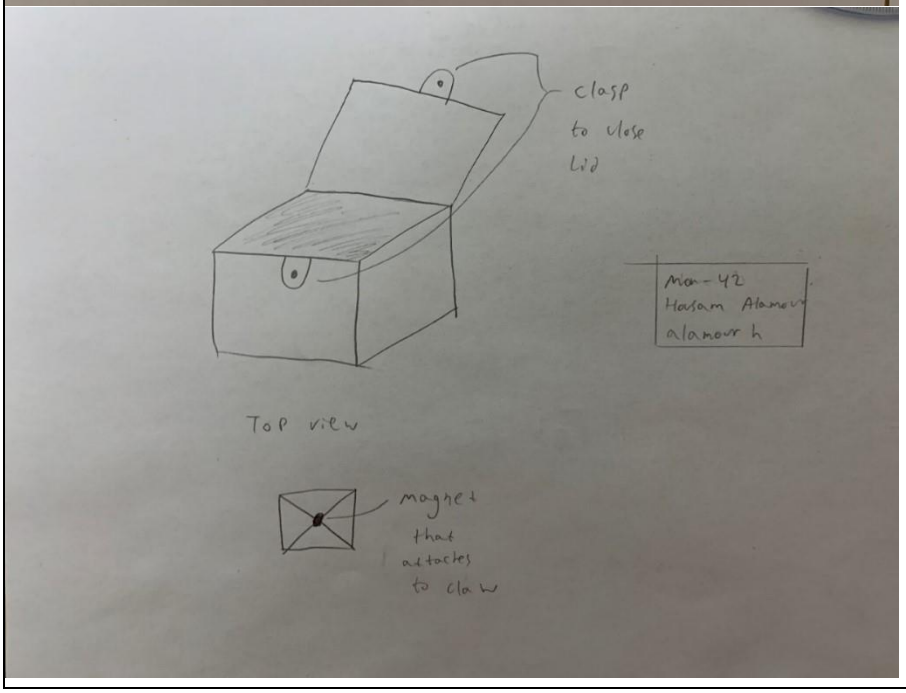




Team Number: Mon-42

Name: Housam Alamour	MacID: alamourh





PROJECT TWO: MILESTONE 2 – COVER PAGE

Team Number: Mon-42

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

Full Name:	MacID:
Matthew Zhang	zhanm75
Eniolaoluwa Adebayo	adebaye
Mohammad Muntazar Bhurwani	bhurwanm
Housam Alamour	alamourh

Page Break

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

Team Number: Mon-42

You should have already completed this task individually prior to Design Studio 8.

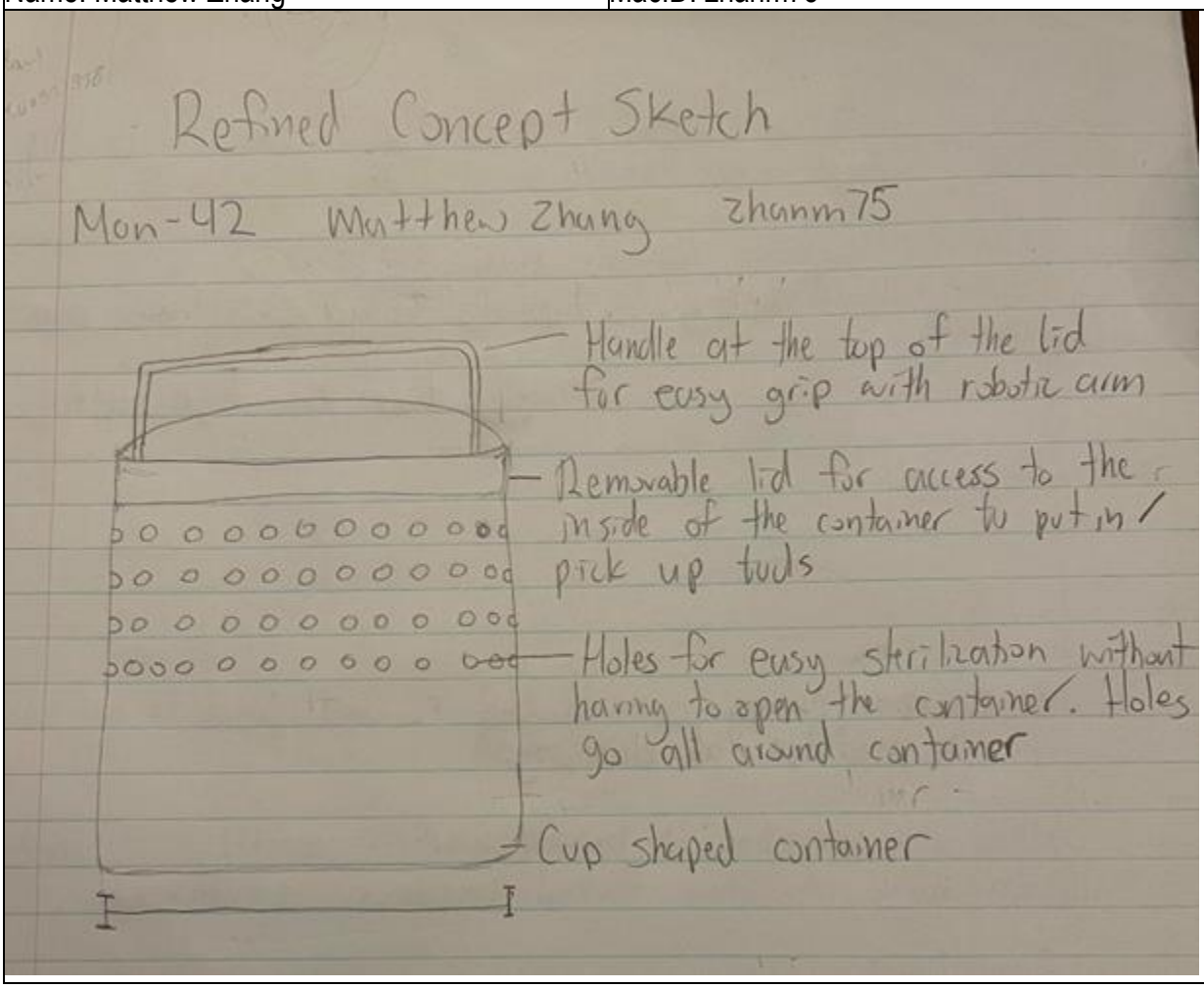
1. Copy-and-paste each sub-team member's refined sketch on the following pages (1 sketch per page)
    - Be sure to indicate each team member's Name and MacID

We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their refined concept sketches with the **Milestone Two Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Two Team Worksheets** document allows you to readily access your team member's work
    - This will be especially helpful when completing ***Stage 3*** of the milestone

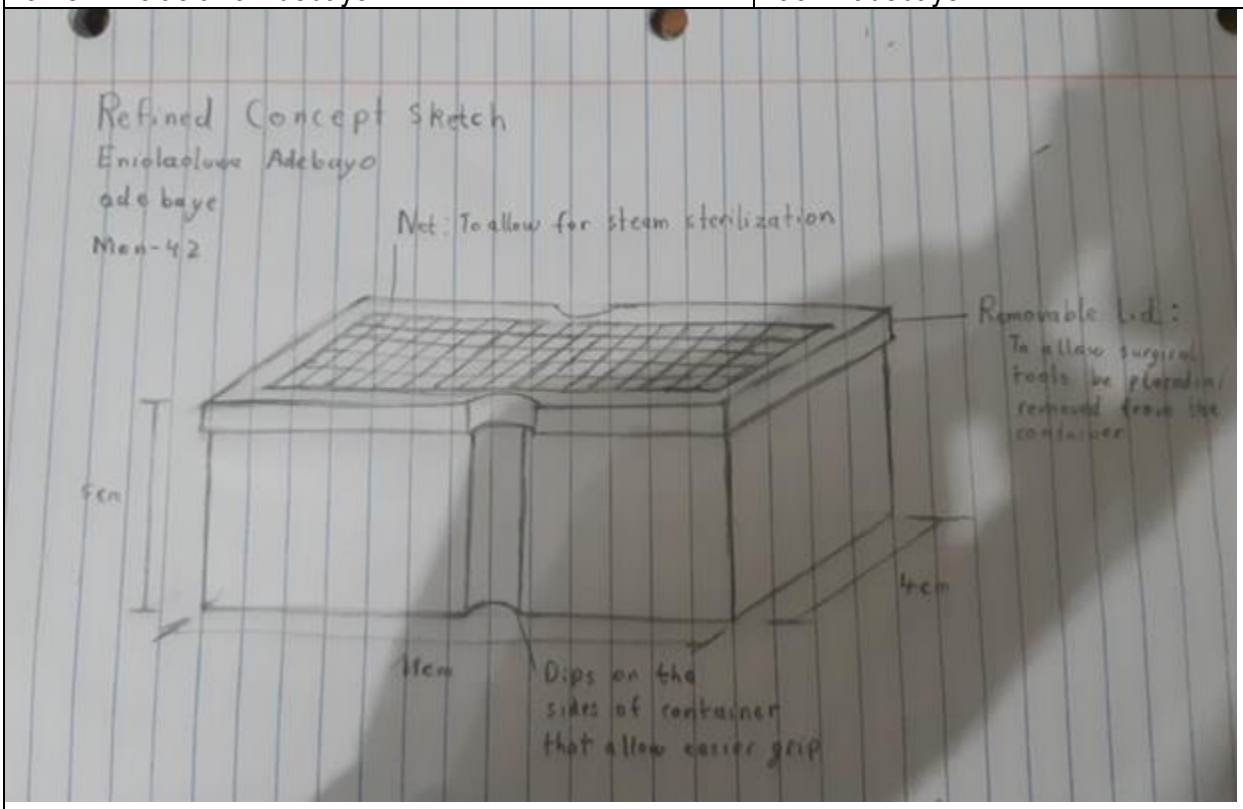
Team Number: Mon-42

Name: Matthew Zhang	MacID: zhanm75



Team Number: Mon-42

Name: Eniolaoluwa Adebayo	MacID: adebaye



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

Team Number: MON-42

You should have already completed this task individually prior to Design Studio 8.

1. Copy-and-paste each team member's storyboard or flowchart sketches on the following pages (1 team member per page)
    - Be sure to indicate each team member's Name and MacID

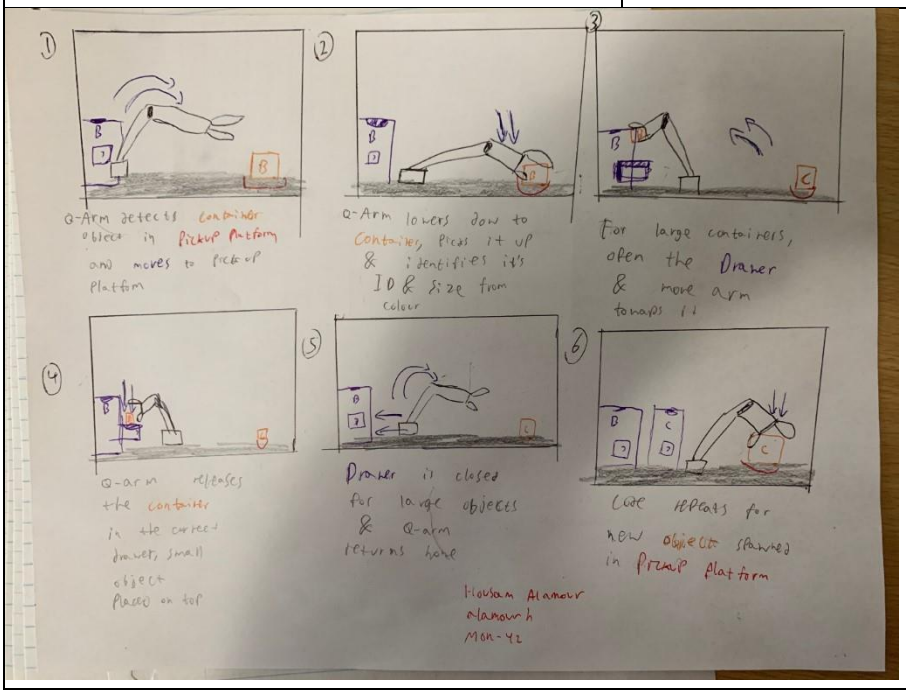
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their storyboard/flowchart with the **Milestone Two Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Two Team Worksheets** document allows you to readily access your team member's work
    - This will be especially helpful when completing ***Stage 4*** of the milestone

Page Break

Team Number: Mon-42

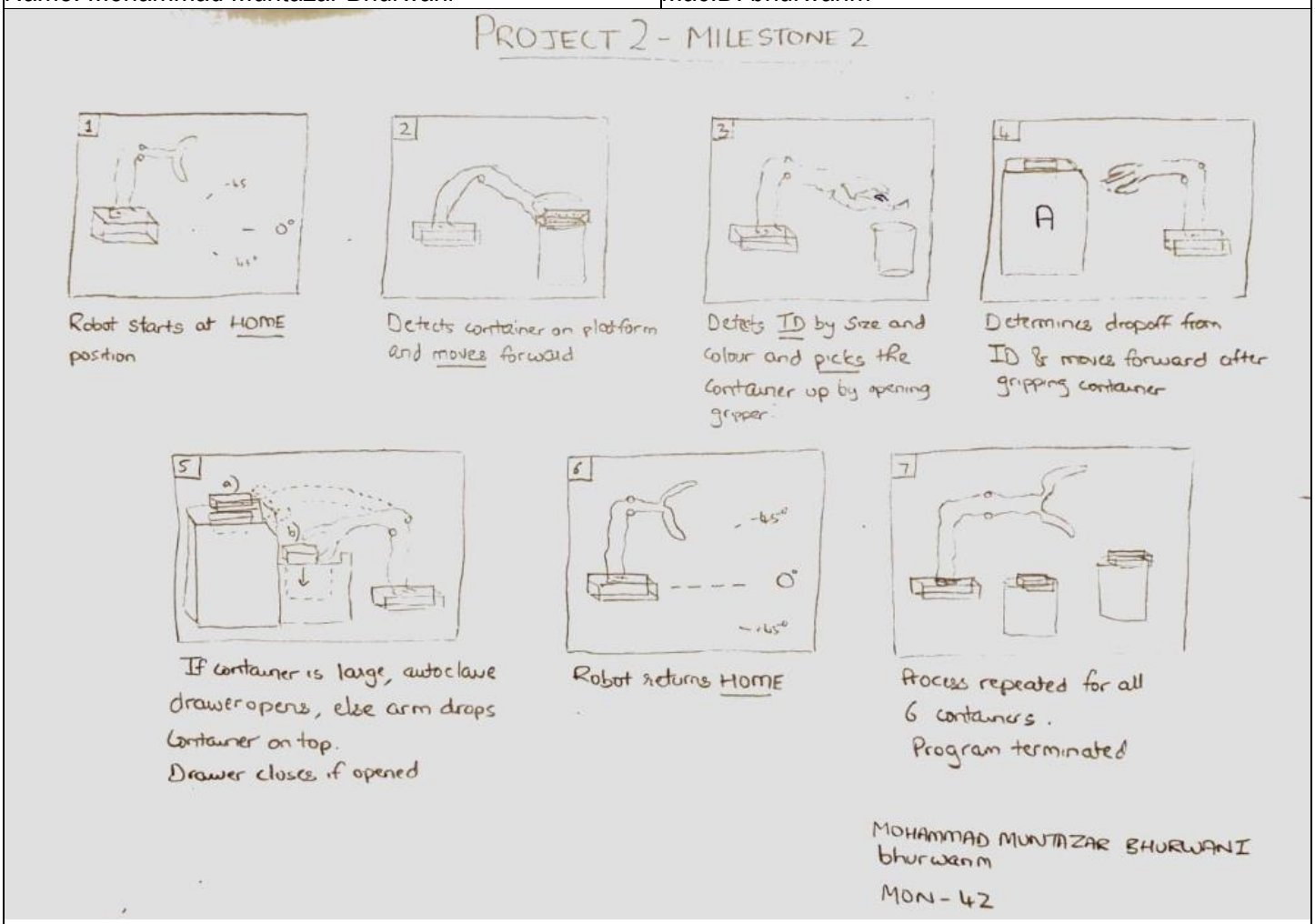
Name: Housam Alamour	MacID: alamourh



Page Break

Team Number: MON-42

Name: Mohammad Muntazar Bhurwani	MacID: bhurwanm



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

Team Number: Mon-42

Complete this worksheet during design studio 8 after creating the low-fidelity prototypes.

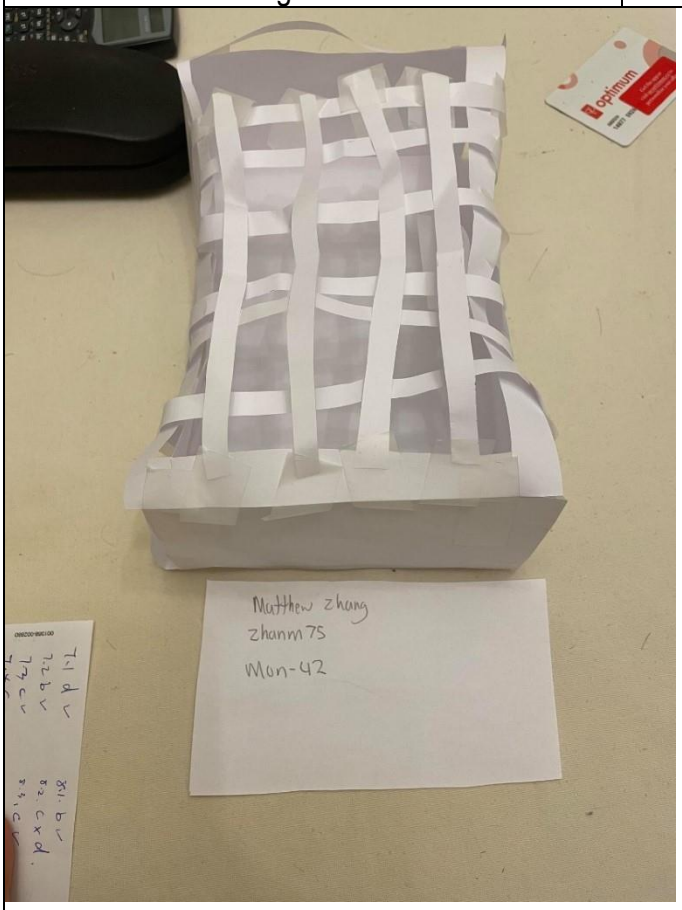
1. Take multiple photos of your low-fidelity prototypes
   - Include an index card (or similar) next to the prototype, clearly indicating your Team Number, Name and MacID on *each* sketch
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* prototype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

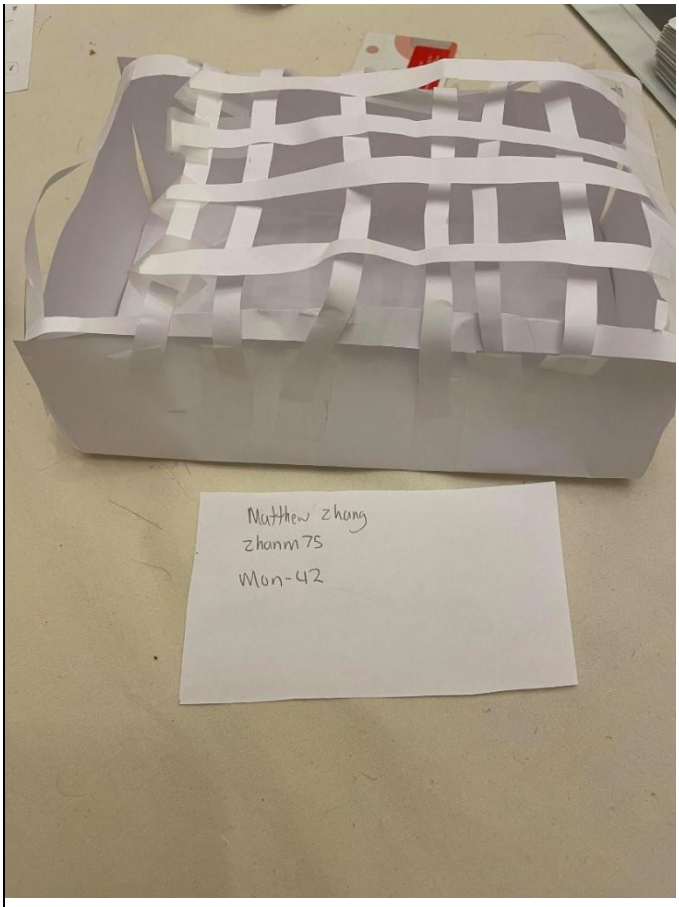
Make sure to include photos of each team member's prototype

Page Break

Team Number: Mon-42

Name: Matthew Zhang	MacID: zhanm75





Please excuse the terrible attempt at making nets

Team Number: Mon-42

Name: Eniolaoluwa Adebayo	MacID: adebaye


MILLIONS
OF PRIZES
YOU'LL LOVE!
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Emidlubluuu Adebaya
Mon-42
adebaye

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

Team Number: Mon-42

As a 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 picking up the surgical tool
- 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.*

	Prototype 1 (Eniolaoluwa)	Prototype 2 (Matthew)
Advantages	Easy to sterilize tools	Easy to pickup
	Very tactile (rectangular shaped box can hold a lot of tools)	Easy to sterilize
Disadvantages	Hard to pick up without a handle	Hard to access tools with a container (takes extra effort)
	Hard to access tools with a container (takes extra effort)	Weaker structure due to many holes
Extent to which concepts aligns	Aligns with our objectives, however the container might not be easily transported with the arm due to its wide shape. Aligns with our constraints (must not be too big). Aligns with our functions (container able to contain surgical instruments).	Aligns with our objectives (easily transported with arm). Aligns with our constraints (must not be too big). Aligns with our functions (container able to contain surgical instruments).
Reliability in picking up container	Requires more specific instructions	Easier to pick up with a handle
Reliability in holding tools	More reliable in holding tools as they lie down flat	Less reliable as tools are left standing in container
Extent to which it allows for sterilization	Allows for weaker sterilization as steam can only access the container from the top face	Allows for better sterilization as steam can enter the container from all angles

Page Break

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

Team Number: Mon-42

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

On comparing the two workflows, we notice most of the steps overlap. With the wanted result and system used being identical, the laid-out process too remains almost identical.

The Q-arm detecting the container, moving forward to reach it, determining it's ID before grabbing it all remain the same. Based on the ID, the Q-arm would then move to reach the specific autoclave bin out of the given 6.

The size of the container also determines whether the drawer must be opened or closed or whether the Q-arm simply drops the container off at the top of the bin as seen in both the workflows.

The process then must be repeated successfully 6 times before stopping.

The multiple similarities in the workflow confirm that the real workflow must remain same or similar to them.

Some of the steps in Housam's storyboard combined elements into 1 picture rather than listing them out in multiple steps like Muntazar's.

A notable difference was the presence of separate steps of starting and returning to home in Muntazar's workflow. It is better to have separate steps for starting at and returning to home as to ensure that the movements of the Q-arm are accurate to allow it to reach the pickup platform efficiently. If the starting or ending position are not defined as home, even a difference of few degrees may cause an error in the entire process.

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

Team Number: Mon-42

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

1. *Detect if there is a container*
1. *Container detected:*
    2. *Move to pre-defined pickup location*
    3. *Determine and store colour and size of container*
    4. *Pick up container and return to home*
    5. *Use colour name to determine respective autoclave coordinates*
    6. *Move to determined coordinates*
    7. *Check size of container*
    A) If container is large, open drawer, drop container, close drawer
    B) Otherwise drop container on top of drop-off coordinates
    8. *Return home*
    9. *Repeat Step 0 (If steps have been repeated 6 times, break)*
10. *Container not detected: Q-arm stays home - Repeat Step 0*

PROJECT TWO: MILESTONE 3 – COVER PAGE

Team Number: Mon-42

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

Full Name:	MacID:
Housam Alamour	alamourh
Mohammad Muntazar Bhurwani	bhurwanm
Matthew Zhang	zhanm75
Eniolaoluwa Adebayo	adebaye

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

Team Number: Mon-42

You should have already completed this task individually prior to Design Studio 9.

1. Copy-and-paste each team member's screenshots of their preliminary solid model on the following pages (1 team member per page)
    - Be sure to clearly indicate who each model belongs to

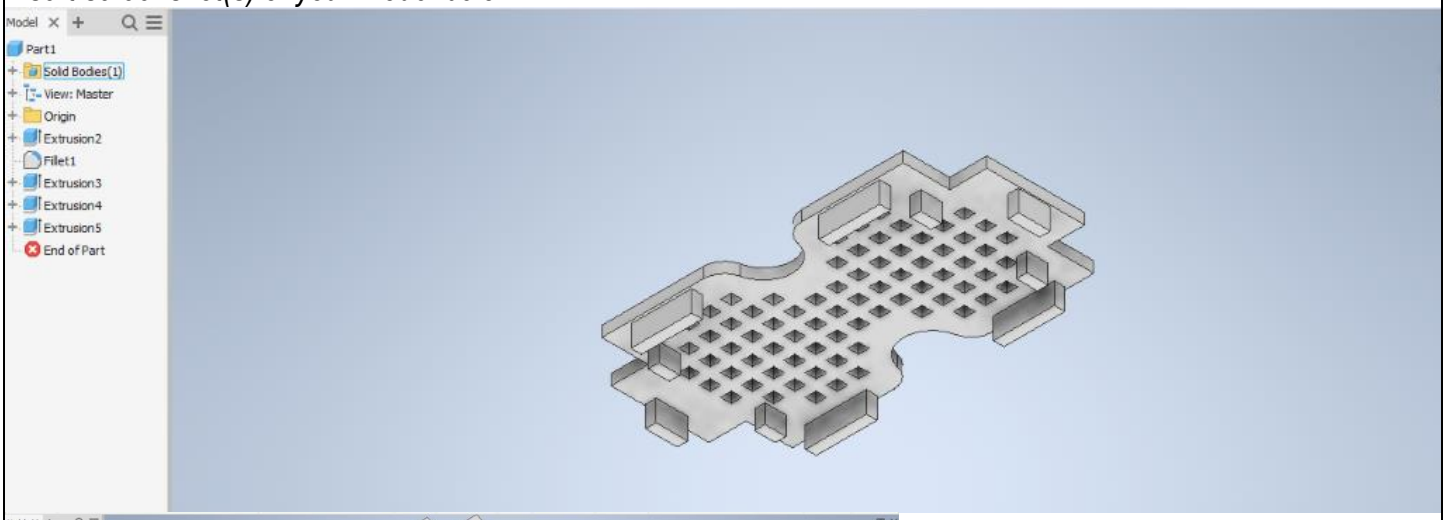
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

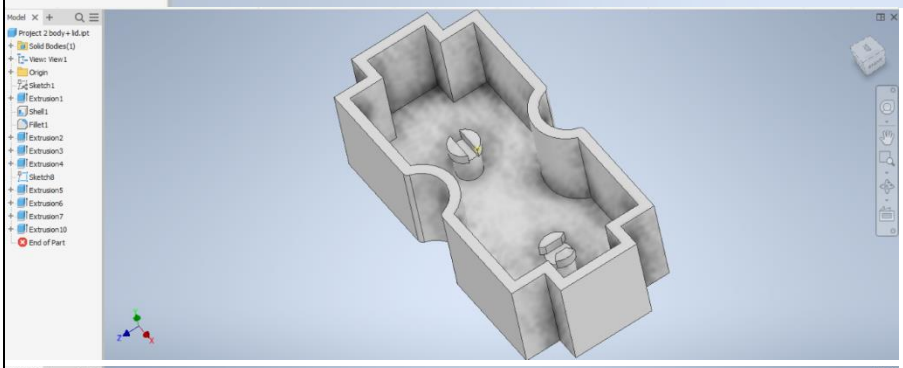
- Each team member needs to submit their solid model screenshots with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
    - This will be especially helpful when completing ***Stage 3*** of the milestone

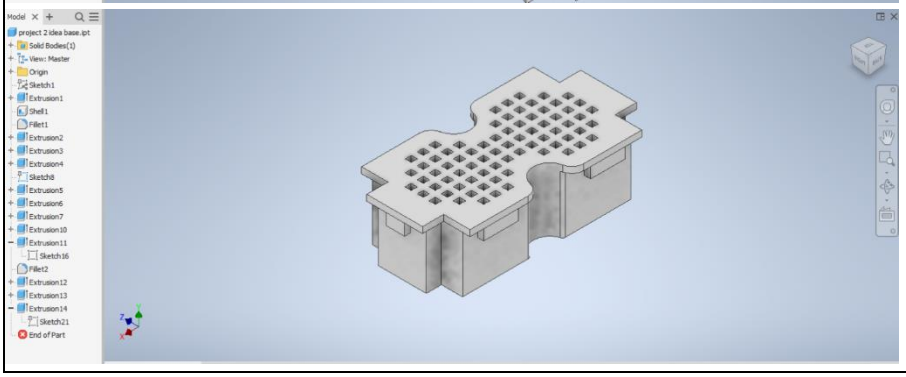
Team Number: Mon-42

Name: Eniolaoluwa Adebayo	MacID: adebaye

Insert screenshot(s) of your model below



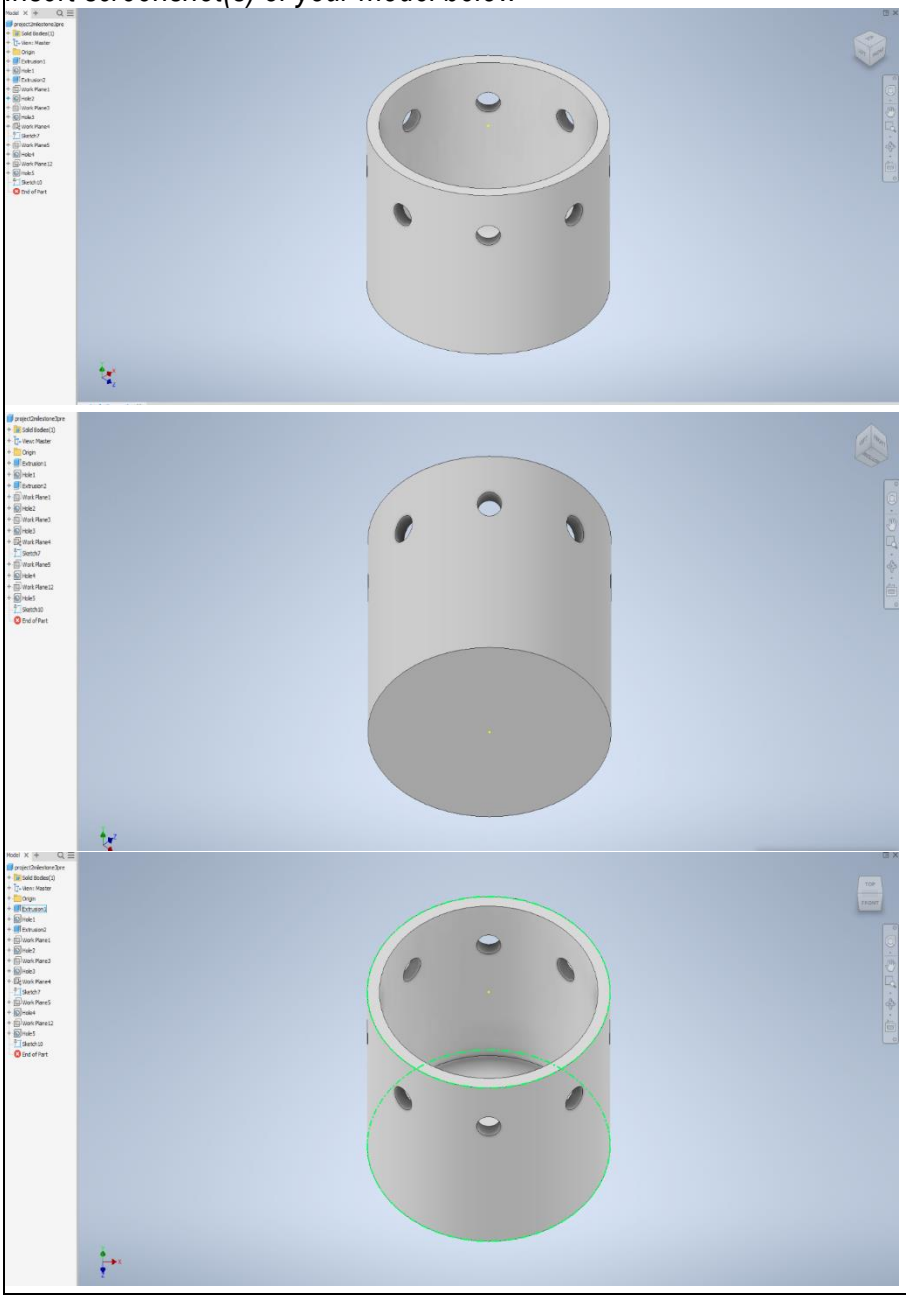




Team Number: Mon-42

Name: Matthew Zhang	MacID: zhanm75

Insert screenshot(s) of your model below



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

Team Number: MON-42

You should have already completed this task individually prior to Design Studio 9.

1. Copy-and-paste each team member's code screenshots on the following pages (1 team member per page)
    - Be sure to clearly indicate who each code belongs to

We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their code screenshots with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
    - This will be especially helpful when completing ***Stage 4*** of the milestone

Team Number: Mon-42

Name: Housam Alamour	MacID: alamourh

```
def move_end_effector(pick_up, drop_off): ####TARGET, PICKUP & DROPOFF TO BE DEFINED


    emg.update() ##Muscle sensor values are updated
    emg_left = emg.myoL
    emg_right = emg.myoR ##Reads and stores left/right muslce sensor data
    print("Left: ", emg.myoL, "\n", "Right: ", emg.myoR) ##Prints the muslce sensor values
    time.sleep(0.2)

    if emg_left == 0 and emg_right == 0: ## Qarm goes to home
        qarm.home()
        time.sleep(2) ## Sleeps program to allow motion to complete
    elif emg_left == 0 and 0 < emg_right < 0.5: ## Qarm moves to pick_up when both muscles half extended
        qarm.move_arm(pick_up[0], pick_up[1], pick_up[2])
        time.sleep(2)
    elif emg_left == 0 and 0.5 < emg_right < 1: ## Qarm moves to drop_off when both muscles full extended
        qarm.move_arm(drop_off[0], drop_off[1], drop_off[2])
        time.sleep(2)

def main():
```

Team Number: MON-42

Name: Mohammad Muntazar Bhurwani	MacID: bhurwanm

```
## STUDENT CODE BEGINS
## ---------------------------------------------------------------------------
## Example to rotate the base: arm.rotateBase(90)
'''
Drop-Off Coordinates determined from Trial & Error
B1 = (0.0, 0.6288, 0.3288)
B2 = (0.0, 0.4377, 0.1619)
G1 = (0.0, -0.6288, 0.3288)
G2 = (0.0, -0.4377, 0.1619)
R1 = (-0.585, 0.2305, 0.3288)
R2 = (-0.4072, 0.1604, 0.1619)
'''

def get_dropoff(dropoff):
    if container == 1: #Returns drop-off coordinates for Small Red Container
        dropoff = [-0.585, 0.2305, 0.3288]
    elif container == 2: #Returns drop-off coordinates for Small Green Container
        dropoff = [0.0, -0.6288, 0.3288]
    elif container == 3: #Returns drop-off coordinates for Small Blue Container
        dropoff = [0.0, 0.6288, 0.3288]
    elif container == 4: #Returns drop-off coordinates for Large Red Container
        dropoff = [-0.4072, 0.1604, 0.1619]
    elif container == 5: #Returns drop-off coordinates for Large Green Container
        dropoff = [0.0, -0.4377, 0.1619]
    elif container == 6: #Returns drop-off coordinates for Large Blue Container
        dropoff = [0.0, 0.4377, 0.1619]
    else:                #Returns arm to Home if invalid container ID is input
        print("Pick a valid shape, returning home")
        dropoff = [0.4064,0,0.4826]
    return dropoff       #Returns drop-off coordinates in the form of a list

while True:             #Takes an input from the user and converts to integer
    container = input("Please enter a container ID: ")
    container = int(container)

    coordinates = get_dropoff(container)
    print (coordinates) #Prints drop-off coordinates for specified container
```

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

Team Number: Mon-42

1. As a team, evaluate your designs for the sterilization container in the table below
   - List your Criteria in the first column
     - You should include a minimum of 5 criteria
   - Fill out the table below, comparing your designs against the given baseline
     - Replace "Design A" and "Design B" with more descriptive labels (e.g., a distinguishing feature or the name of the student author)
     - Assign the datum as the baseline for comparison
     - Indicate a "+" if a concept is better than the baseline, a "–" if a concept is worse, or a "S" if a concept is the same

	Datum	Design A (Eniola)	Design B (Matthew)
Container should be easy to pick up	S	+	-
Container should securely hold tool	S	-	-
Tool should fit in container well	S	+	+
Container should be easy to transport	S	-	-
Container allows for sterilization	S	-	+
Container allows easy access to tool	S	-	+
Total +	0	2	3
Total –	0	4	3
Total Score	0	-2	0

2. Propose one or more suggested design refinements moving forward

Design A (Eniola):

- The container doesn't allow for optimal securing of the tool due to a small number of racks. A refinement would be increasing the number of racks which would allow the tool to be secured better.
- The container isn't as easy to transport due to the number of ledges and its bulky nature. A refinement would be to change the sketch of the design to allow for a more minimalist shape. This would allow the gripper to grip the container more easily due to its smaller size which in turn allows for better transportation. Additionally, adding a handle would also allow for better transportation.
- The container doesn't allow for optimal sterilization because the holes are only located at the top of the container. A refinement would be to increase the number of squares/holes on the sides of the container to allow sterilization from all angles
- The container requires more work to access the tools inside. A refinement would be to change the design of the lid to allow it to slide out or to remove the lid altogether.

Design B (Matthew):

- The container is not easily picked up due to its cylindrical shape. A refinement could be to add a handle at the top of the container for the arm to easily pick it up.
- The container is not as secure as the datum in holding the tool. The datum has specific points for the tool to rest on. Adding a rack or platform for the tool to rest on without moving as much could allow for a better securement of the tool. Lowering the volume of the container so the tool has less room to move in could also better secure the tool.
- The container is also not easily able to be transported, again due to its cylindrical shape. And again, by adding a handle at the top of the container, it'll allow for a better transportation.

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

Team Number: MON-42

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:** Mohammad Muntazar Bhurwani

- *Found out where the location of the drop off was through trial and error documentation and cage spawn method*
- *Find container pickup location through trial and error*
- *Code was not fully functional and did not assign the drop off locations depending on ID*
- *Code was fixed by defining the function and using if statements alongside the coordinate through trial and error*
- *Advantage of the code is that it easily allows for the defining of the dropoff location depending of the item id without having to define and enter the coordinates manually for each time container is spawned*
- *Disadvantage is that the container ID must be figured out and entered manually by the user through a prompt*
- *Another disadvantage is that the drop off coordinates for all 6 Autoclave bins had to be manually found and this was very laborious and time consuming*
- *The code will not be changed as it already completes its desired function within the context of the objective*
- *A great way to improve this code would be to have it automatically choose the correct item ID by identify the size and colour of the container.*

However this is not doable as there are no such methods in the documentation

- *Another way to improve the function would be to have it find the coordinates of the autoclave bins on it's own, maybe through the use of a LIDAR sensor on the qarm*

- *However no distance sensors exist on the Q-arm and no methods for identifying certain locations exist in the document on so at this time it cannot be implemented*

Move End-Effector Task	**Team Member Name**: Housam Alamour

- *Had trouble sharing code through VNC viewer and Microsoft*
- *Fixed issue by sharing missing muscleGUI libraries into program directory*
- *Code did a good job of using the Muscle emg GUI to control the control arm*
- *Function was well documented with comments to show steps*
- *Function was improved through the implantation of a sleep function to allow the arm to go through it's full motion to coordinates*
- *The code will be change to incorporate the identify autoclave function instead of just using the coordinates directly*
- *Advantages of this code are that it automatically moves to the qarm to the correct dropoff location depending on the muscle sensor data, instead of having the user put in the coordinates and giving commands to go to pickup/dropoff themselves*
- *Disadvantages are that the correct pickup and dropoff must be put in as arguments to the function*
- *One way to improve this function would be to have it automatically find out the correct pickup and drop off (maybe through the use of another imbedded function)*
- *Function can also be altered to use either arm instead of both, to match the Project objective specified in Module.*

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

Team Number: MON-42

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

Control Gripper

1. Initialize the muscle sensor
2. Read the muscle sensor data
    a. If the left arm is fully extended,
        i. the gripper is fully opened
    b. If the left arm is fully contracted
        i. the gripper will close

Open Autoclave Bin Drawer

1. Identify the container ID
2. Set the correct autoclave bin drawer depending on ID
3. Read the muscle sensor data
4. If both arms are fully extended (less then threshold),
    a. Correct drawer remains/is closed
5. If both arms are fully contracted (more then threshold)
    a. Correct drawer is opened

Continue or Terminate

1. Initialize a counter/tally that contains all six autoclave bins
2. Increment the tally by one every time a container is placed in/on the respective autoclave bin
3. Read the values for each autoclave
    a. If the values exceed the threshold, terminate the program
    b. If the values are less than the threshold, continues he program

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team Number: Mon-42

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

Full Name:	MacID:
Housam Alamour	alamourh
Matthew Zhang	zhanm75
Eniolaoluwa Adebayo	adebaye
Mohammad Muntazar Bhurwani	bhurwanm

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

Team Number: Mon-42

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

- Because print time is a lot under 2 hours, adding more holes all throughout the container (bottom, sides) for better sterilization is an option.
- Good implementation of parts in the container to secure tool

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

- Add more holes all throughout the container (bottom, sides) for better sterilization.

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

Team Number: Mon-42

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

- The code was good, it placed a large and small container in the appropriate autoclaves and ran through all the shapes once each
- Variable names were good
- One area for improvement was code legibility and commenting, the code was difficult to read in some areas and lacked clear, concise commenting ○ Our comments were placed besides lines of code we were explaining instead of above them

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

- To improve legibility, long, convoluted comments can be condensed and shorted to be easier to understand
- Areas where the code needs commenting such as when moving the q-arm and opening/closing gripper in the main function could be added
- Spacing between the functions and inside the main function could be added to correct formatting

List of Sources

Source Material Database:

[1] Ansys Granta EduPack software, Granta Design Limited, Cambridge, UK, 2020 (www.grantadesign.com)

[2] "P2 Python Library Documentation" [PDF]. Available: https://avenue.cllmcmaster.ca/d2l/le/content/340370/viewContent/2899750/View.

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[5] S. Supriadi, B. Suharno, T. Widjaya, S. T. Ayuningtyas, and E. R. Baek, "Development of Superhydrophobic Material SS 17-4 PH for Bracket Orthodontic Application by Metal Injection Molding," IOP Conf. Ser. Mater. Sci. Eng., vol. 299, no. 1, p. 012096, Jan. 2018, doi: 10.1088/1757-899X/299/1/012096.

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[9] G. Ahmadi Lakalayeh, M. Rahvar, E. Haririan, R. Karimi, and H. Ghanbari, "Comparative study of different polymeric coatings for the next-generation magnesium-based biodegradable stents," Artificial Cells, Nanomedicine and Biotechnology, vol. 46, no. 7, pp. 1380–1389, Oct. 2018, doi: 10.1080/21691401.2017.1369424.

[10] Y. Fan, X. Li, and R. Yang, "The surface modification methods for constructing polymer-coated stents," International Journal of Polymer Science, vol. 2018, 2018, doi: 10.1155/2018/3891686.

[11] O. A. Kashin, K. v. Krukovskii, and A. I. Lotkov, "Potential and Capabilities of Porous Silicon as a Material for Intravascular Drug-Eluting Stents: Brief Summary," Inorganic Materials: Applied Research, vol. 11, no. 2, pp. 287–296, Mar. 2020, doi: 10.1134/S2075113320020161.

[12] H. Lin et al., "In vitro and in vivo evaluation of desogestrel-loaded poly(D,L-lactic acid) nanoparticles," Journal of Nanomaterials, vol. 2019, 2019, doi: 10.1155/2019/8491269.

[13]X. Luo et al., "The self-organized differentiation from MSCs into SMCs with manipulated micro/Nano two-scale arrays on TiO2 surfaces for biomimetic construction of vascular endothelial substratum," Materials Science and Engineering C, vol. 116, p. 111179, Nov. 2020, doi: 10.1016/j.msec.2020.111179.

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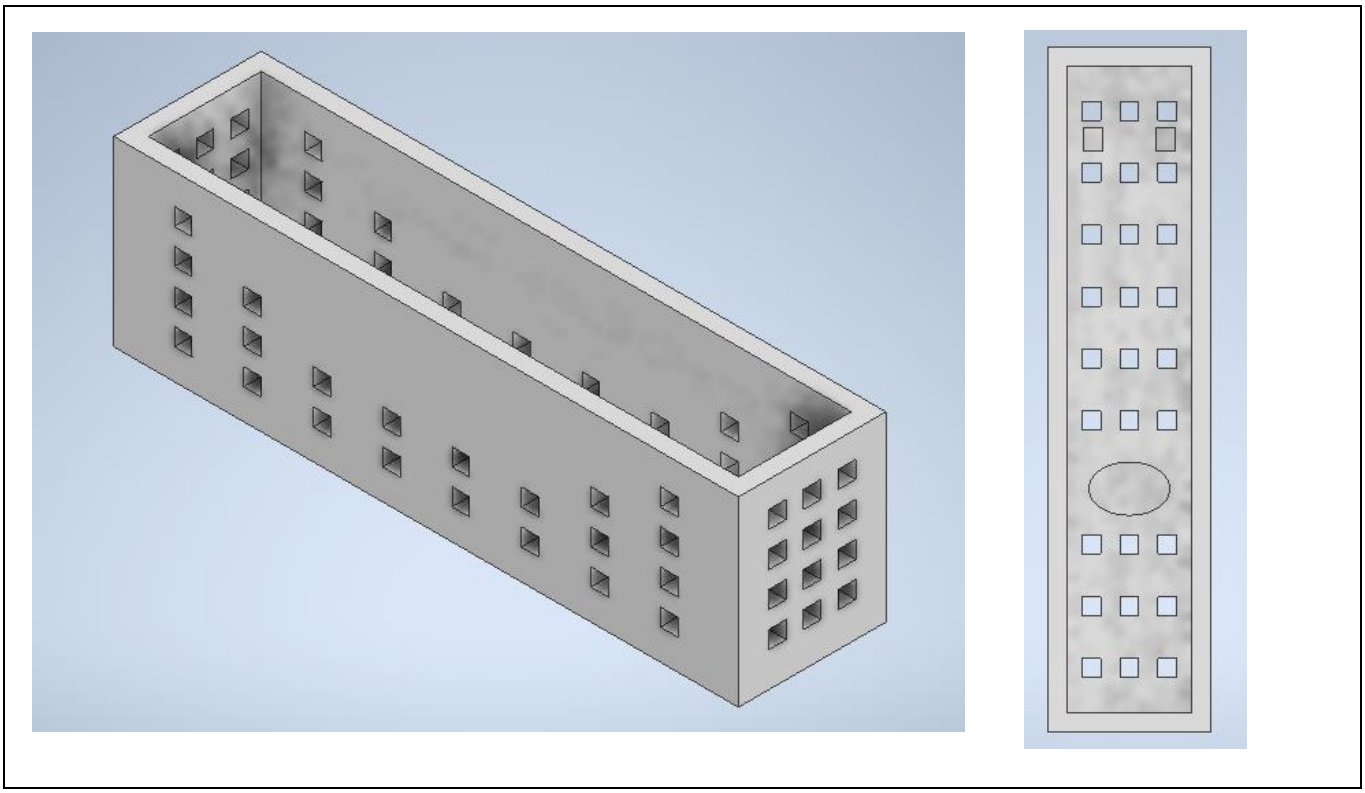
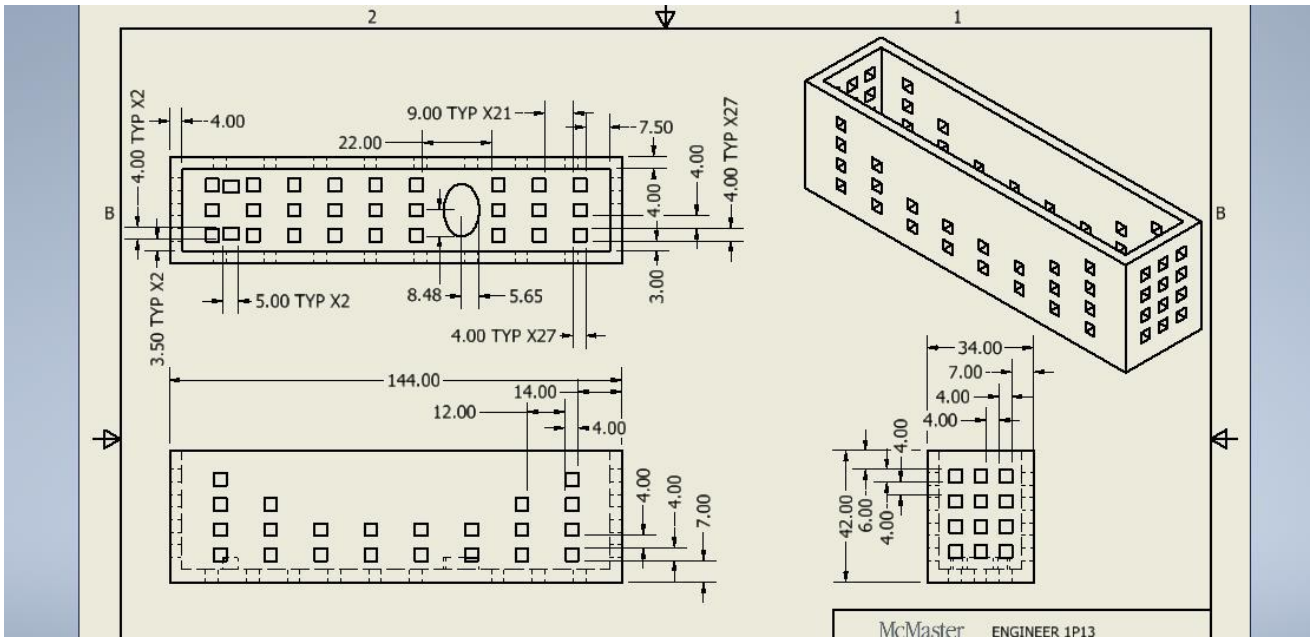
Appendix A – Modelling:

Screenshots of Solid Model:



Fully Dimensioned Engineering Drawings of sterilisation container design:



Appendix B - Computation:

Computer Program:

```
import sys
import random

# Q-Arm Home and container pickup position coordinates
home = [0.4064, 0.0, 0.4826]
pick_up = [0.5046, 0.0, 0.045]

claw_close = 32
claw_open = -32

threshold = 0.5

# Code written by Mohammad Muntazar and Housam Alamour
# Spawns random container and stores and prints it's ID value
def spawn(ID):
    arm.spawn_cage(ID)
    print("Container ID is: ", ID)
    return ID

# Code written by Mohammad Muntazar and Housam Alamour
# Returns the drop-off coordinates of the spawned container
def get_dropoff(container):

    #Small Red
    if container == 1:
        dropoff = [-0.5851, 0.2364, 0.3428]
    #Small Green
    elif container == 2:
        dropoff = [0.0,-0.6347, 0.4136]
    #Small Blue
    elif container == 3:
        dropoff = [0.0, 0.6347, 0.4136]
    #Large Red
    elif container == 4:
        dropoff = [-0.3733, 0.1508, 0.2559]
    #Large Green
    elif container == 5:
        dropoff = [0.0,-0.4026, 0.2559]
    #Large Blue
    elif container == 6:
        dropoff = [0.0, 0.4026, 0.2559]
    else:
        print("Pick a valid shape, returning home")
        dropoff = [0.4064,0,0.4826]
    return dropoff


# Code written by Mohammad Muntazar and Housam Alamour
def move_end_effector(location):
    while True:
        # Moves to input coordinates when only right arm EMG value exceeds threshol
        if arm.emg_left() == 0 and threshold <= arm.emg_right():
            arm.move_arm(location[0], location[1], location[2])
            # Sleeps program to allow motion to complete
            time.sleep(2)
            break
```

```
# Code written by Mohammad Muntazar and Housam Alamour
def control_gripper(claw_degree):
    while True:
        # Gripper opens/closes when only left arms EMG value exceeds threshold
        if arm.emg_left() >= threshold and arm.emg_right() == 0:
            arm.control_gripper(claw_degree)
            time.sleep(2)
            break


# Code written by Mohammad Muntazar and Housam Alamour
def drawer_open(container):
    while True:
        # Autoclave bin drawer opens if both arms EMG value exceeds threshold
        if arm.emg_left() >= threshold and arm.emg_right() >= threshold:
            #Large Red
            if container == 4:
                arm.open_red_autoclave(True)
                break
            #Large Green
            elif container == 5:
                arm.open_green_autoclave(True)
                break
            #Large Blue
            elif container == 6:
                arm.open_blue_autoclave(True)
                break


# Code written by Mohammad Muntazar and Housam Alamour
def drawer_close(container):
    while True:
        # Autoclave bin drawer closes if both arms EMG value exceeds threshold
        if arm.emg_left() >= threshold and arm.emg_right() >= threshold:
            #Large Red
            if container == 4:
                arm.open_red_autoclave(False)
                break
            #Large Green
            elif container == 5:
                arm.open_green_autoclave(False)
                break
            #Large Blue
            elif container == 6:
                arm.open_blue_autoclave(False)
                break
```

```
def main():
    time.sleep(1)

    # List of container IDs that will be spawned after shuffling
    spawn_ID = [1,2,3,4,5,6]
    random.shuffle(spawn_ID)
    for i in spawn_ID:
        large_container = False
        spawn(i)

        # Detects if spawned container is large from ID
        if i == 4 or i ==5 or i == 6:
            large_container = True
            print("This is a large container")
        else:
            print("This is a small container")

        # Drop-off location is determined based on container ID
        drop_off = get_dropoff(i)
        print ("Dropoff coordinates are: ", drop_off)

        # End effector is moved to pickup and claw is closed
        move_end_effector(pick_up)
        control_gripper(claw_close)

        # Autoclave bin drawer opened if container is large
        if large_container == True:
            drawer_open(i)

        # Arm moves home and then to autoclave bin and claw is opened
        move_end_effector(home)
        move_end_effector(drop_off)
        control_gripper(claw_open)

        # Arm moves home, if container was large, drawer is closed
        move_end_effector(home)
        if large_container == True:
            drawer_close(i)
        # Waits for new spawn
        time.sleep(2)

main()
```