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

Tues-19

Kyle McMaster (mcmask2)

Sana Khan (khans288)

Abeka Selliah (selliaha)

Zhuohua Hu (huz80)

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.

Sana Khan 400315946

X 

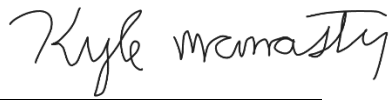
The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Abeka Selliah 400309497

X 

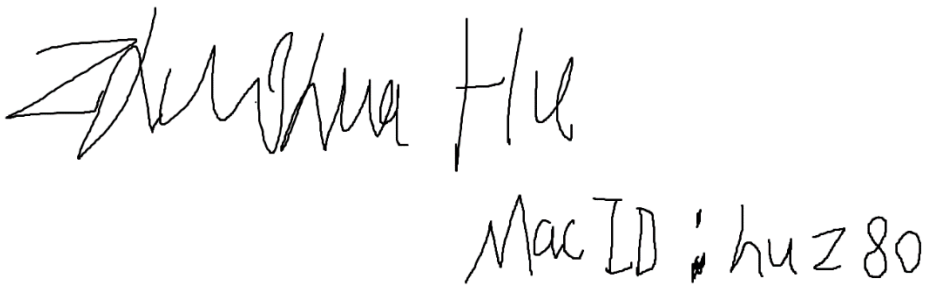
The student is responsible for performing the required work in an honest manner, without plagiarism and cheating. Submitting this work with my name and student number is a statement and understanding that this work is my own and adheres to the Academic Integrity Policy of McMaster University.

Kyle McMaster 400328819

X 

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.

Zhuohua Hu 400299785



Executive Summary

The use of robotic surgery has become increasingly popular as it allows for surgeries to be performed remotely for a variety of purposes. Ensuring all tools and environments are sterile is crucial for all surgeries, regardless of whether humans or robots are performing the surgery. In this project, the computing team has designed a computer program to control a robotic arm which will pick up and deliver a surgical sterilization container into the appropriate autoclave bin for sterilization in a virtual environment. The modelling team has designed a surgical sterilization container to hold specific tools using CAD software.

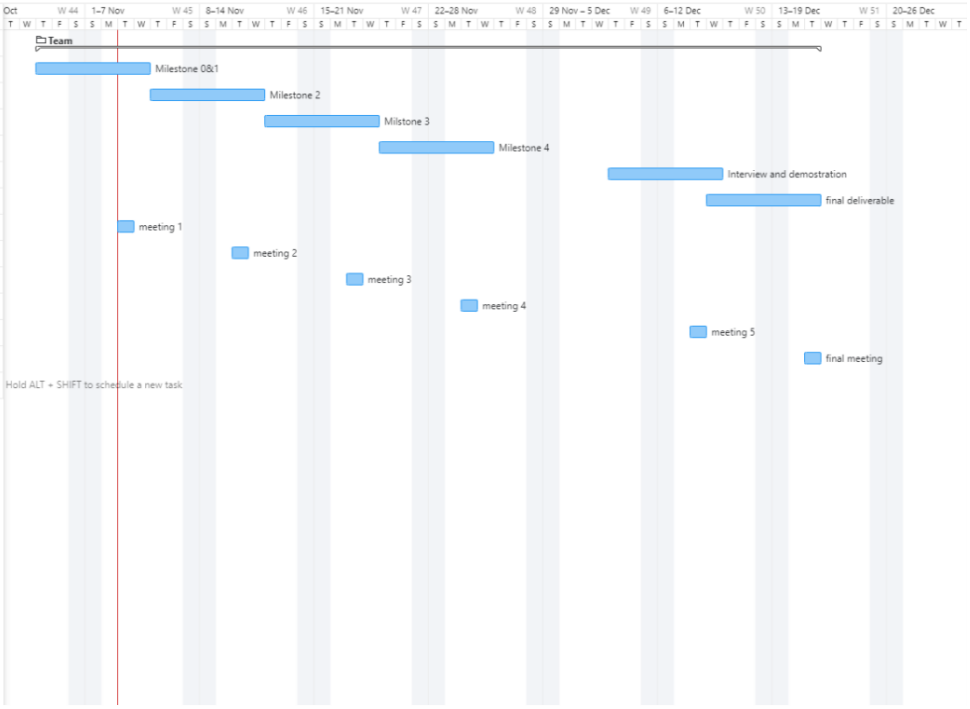
This report examines the process and steps taken to produce the computer program and surgical sterilization container over several meetings in and out of class for both the computing and modelling sub team. Each week, our group met with a TA to discuss our progress and worked to complete a weekly milestone. Through careful design, frequent testing, and thoughtful design adjustments, both sub teams were able to meet the constraints, functionalities, and objectives required. The computer program incorporated all required functions and met the main objectives of being able to recognize, pick up, and drop off each container to its specific location. The program recognizes containers by size and colour, allowing them to be spawned randomly. This is more realistic and important for a hospital environment. The sterilization container met the constraint of each feature being over 4mm, total printing time being under two hours, and the whole design fitting in the given footprint. The design also effectively facilitates sterilization by having several holes to allow vapour to flow into the device. The container has space for two tools instead of the required one tool. This increases the efficiency of the materials used and the workflow of hospital workers performing sterilization. The final products are shown towards the end of this report where screenshots of the sterilization container, engineering drawings, and code can be found.

Project Schedule

Preliminary Gantt Chart

Preliminary Gantt chart

Title	Start date	Due date	Predecessors
Team			
Milestone 0&1	29/10/2020	04/11/2020	
Milestone 2	05/11/2020	11/11/2020	
Milstone 3	12/11/2020	18/11/2020	
Milestone 4	19/11/2020	25/11/2020	
Interview and demos...	03/12/2020	09/12/2020	
final deliverable	09/12/2020	15/12/2020	
meeting 1	03/11/2020	03/11/2020	
meeting 2	10/11/2020	10/11/2020	
meeting 3	17/11/2020	17/11/2020	
meeting 4	24/11/2020	24/11/2020	
meeting 5	08/12/2020	08/12/2020	
final meeting	15/12/2020	15/12/2020	
Add task			



Final Gantt Chart

Final Gantt Chart

PROJECT TITLE	Design Project 2 - Get a Grip	PROJECT MANAGER	Zhuohua Hu huz80
DATE	2020/12/12	PROJECT ADMINISTRATOR	Abeka Sellah sellahs
		PROJECT COORDINATOR	Sana Khan khans288
		SUBJECT MATTER EXPERT	Kyle Mcmaster mcmask2

Legend
- Team meeting
- Low priority
- Intermediate priority
- High priority

TASK NUMBER	TASK TITLE	TASK OWNER	ACUTAL START	DUE DATE	% Complete	DURATION (DAYS)
0	**Team Meetings**					
0.1	Design Studios	Team	11/3/20	12/8/20	100%	35
1	**Project Conception/ Milestones**					
1.1	Submit Milestone 0 Team	Abeka	11/3/20	11/4/20	100%	1
1.2	Submit Milestone 1 Team	Abeka	11/3/20	11/4/20	100%	1
1.2.1	Submit Milestone 2 Individual	Individually	11/10/20	11/11/20	100%	1
1.2.2	Submit Milestone 2 Team	Abeka	11/10/20	11/11/20	100%	1
1.3.1	Submit Milestone 3 Individual	Individually	11/17/20	11/18/20	100%	1
1.3.2	Submit Milestone 3 Team	Abeka	11/17/20	11/25/20	100%	8
1.4	Submit Milestone 4 Individual	Individually	12/1/20	12/2/20	100%	1
1.4.1	Submit Milestone 4 Team	Abeka	11/25/20	11/26/20	100%	1
2	**Project Creation - Due December 2nd**					
2.1	Create preliminary design	Modeling Subteam	11/3/20	11/11/20	100%	8
2.2	Finalize pseudo code	Computation Subteam	11/3/20	11/11/20	100%	8
2.3	Create sketch	Modeling Subteam	11/10/20	11/18/20	100%	8
2.4	Create solid model	Modeling Subteam	11/10/20	11/18/20	100%	8
2.4.1	Create assembly file	Modeling Subteam	11/17/20	11/25/20	100%	7
2.4.2	Create Engineering Drawing	Modeling Subteam	11/25/20	12/2/20	100%	7
2.5	Create Code	Computation Subteam	11/10/20	11/25/20	100%	8
2.5.1	Finalize Code	Computation Subteam	11/24/20	12/2/20	100%	8
3	**Project Interview - On December 9th**					
3.1	Book a meeting time	Zhuohua	12/1/20	12/4/20	100%	3
3.2	Prepare for interview	Individually	11/24/20	12/9/20	100%	15
4	**Project Report - Due December 8th**					
4.1	Title page and academic integrity	Team	12/3/20	12/9/20	100%	6
4.1.1	Executive Summary	Team	12/3/20	12/9/20	100%	4
4.2	Project schedule	Sana	12/3/20	12/9/20	100%	6
4.2.1	Preliminary Gantt chart	Zhouhua	12/3/20	12/9/20	100%	6
4.2.2	Final Gantt chart	Abeka	12/3/20	12/9/20	100%	6
4.3.1	Weekly Design Studio Agendas/ Meeting minutes	Sana	11/11/20	12/9/20	100%	28
4.5	List of sources	Kyle	11/11/20	12/9/20	100%	28
4.6	Appendices	Kyle	12/3/20	12/9/20	100%	6
4.7	Submit project report	Abeka	12/3/20	12/9/20	100%	6
5	**Individual Projects**					
5.1	Independant Research Summary	Individually	12/4/20	12/9/20	100%	5
5.2	Learning portfolio entries	Individually	11/3/20	12/10/20	100%	37
5.3	Self and Peer Evaluation	Individually	12/4/20	12/10/20	100%	6

Logbook of Additional Meetings and Discussions

PROJECT 2 LOGBOOK

Date	Time	Meeting For	What Was Completed
Nov 3	12:30-2:20	Design Studio	Milestone 0 and Milestone 1
Nov 10	12:20-2:20	Design Studio	Milestone 2
Nov 17	12:20-2:20	Design Studio	Milestone 3
Nov 18	1:00-3:00	Modelling sub team	-Sketch possible design ideas -Made primary design on Autodesk
Nov 21	4:00-6:00	Computing sub team	Starting to put all the functions together
Nov 22	4:00-6:00	Modelling sub team	Chose one design and started to implement other features to it
Nov 24	12:30-2:20	Design Studio (free period)	Implement emg sensor values correctly -Work through debugging code
Nov 25	3:30-4:30	Computing sub team	Revised Autodesk design to fit objective/constraint -Fit given tool to design
Nov 27	1:30-2:30	Computing sub team	Fixing emg sensor values
Nov 29	6:12-8:00	Computing sub team	Working through errors and fixing code
Nov 30	12:00-3:00	Computing sub team	Refining code -Completing commenting
Nov 30	5:30-7:00	Modelling sub team	Finished model on Autodesk -Constrained/ made assembly
Nov 30	9:30-12:15	Modelling sub team	Edited container to fit 2h 3d print time
Dec 1	12:20-2:20	Design Studio	Milestone 4
Dec 6	1-3	Final Deliverable	-Uploaded screenshots of code, engineering drawings, and CAD design -Uploaded milestone worksheets and meeting minute charts
Dec 8	12:20-2:20	Final Deliverable	-Finished up log book

PROJECT 2 LOGBOOK

			-Add in all of our sources
Dec 9	1-1:30	Interview	---

Scheduled Weekly Meetings

ENGINEER 1P13
MEETING WITH TEAM 19 - TUESDAY, Nov. 3, 2020

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Zhuohua Hu	Huz80	Yes
Administrator	Abeka Selliah	Selliaha	Yes
Coordinator	Sana Khan	Khans288	Yes
Subject Matter Expert	Kyle McMaster	Mcmask2	Yes
Guest	Husain Tapia	tapish	yes

AGENDA ITEMS

1. Meeting with team/ introductions
2. Work on Milestone 0/ taking pictures
3. Review the P2 Project Module
4. Complete pre-project 2 assignment
5. Assign Sub-team/ roles for each member

MEETING MINUTES

1. Introductions
    a. Say Hello to the team members.
    b. "How was your project 1"
    c. "How are classes going for you guys"
2. . Role assignation
    a. " I was the subject Expert for last project, so I will be Manager for this one" – Zhuohua Hu
    b. "I will be Administrator" – Abeka Selliah
    c. "Subject Expert" – Kyle McMaster
    d. "I want to be the Coordinator" – Sana Khan
3. Milestone 0/ review P2 Project module
    a. The IAI takes a team picture for the team
4. Assign Sub-team
    a. Zhuohua and Sana are on the coding team
    b. Kyle and Abeka are on the modelling team

POST-MEETING ACTION ITEMS

1. *Administrator submits the Group deliverable*
2. *Each individual should submit their own individual deliverable(s)*
3. *Enroll in correcponding groups on A2L*

ENGINEER 1P13
MEETING WITH TEAM 19 - TUESDAY, Nov. 3, 2020

MEETING TIME

12:40 ---- 1:20 ------→ one hour

ENGINEER 1P13
MEETING WITH TUES 19- TUESDAY, Nov 10, 2020

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Zhuohua Hu	huz80	Yes
Administrator	Abeka Selliah	selliaha	Yes
Coordinator	Sana Khan	khans288	Yes
Subject Matter Expert	Kyle Mcmaster	mcmask2	Yes
Guest	Husain Tapia	tapiah	Yes

AGENDA ITEMS

1. Updates on everybody
2. Discuss refined sketch
3. Questions regarding work flow of program
4. How will the prototype work
5. Thought process on planning code

MEETING MINUTES

1. . Updates on everybody
    a. How is everybody doing?
    b. Any midterms coming up?
2. Discuss refined sketch
    a. Talk about Kyle and Abeka's different ideas for the sketch
    b. How will components of both models be combined together
    c. Picking and choosing what designs seem significant but realistic (many design options but harder to build really difficult designs on Autodesk)
3. Questions regarding work flow of program
    a. Going over project module and what is required for certain components of program
    b. Sana showed her program flow to confirm the detail of the drawings and explanations
    c. Asking about naming conventions and submission details
        i. Make sure to submit with name, macid, and date for each drawing not just per page
4. How will the prototype work
    a. Using whatever materials found at home
    b. Helps you get a good idea of what designs are realistic and how it would feel in real life
    c. Helps realize what designs would be too difficult to model and the general strength and structure of the container needs to be considered
    d. See if the design meets constraints and objectives

1

ENGINEER 1P13
MEETING WITH TUES 19- TUESDAY, Nov 10, 2020

5. Thought process on planning code
    a. Suggested to plan out ahead of time instead of trying to code right away
    b. Organize thoughts and each requirement to ensure everything is being met and considered
    c. Plan out pseudocode for function in more than one way to see what works and doesn't

POST-MEETING ACTION ITEMS

1. Compare concept sketch and work on pseudocode workflow for program *[Sana and Steve]*
2. *Compare concept sketch and work on refining the sketch [Kyle and Abeka]*
3. *Build each other's prototypes [Kyle and Abeka]*

MEETING TIME

8:01-15:00 → 8 minutes 59 seconds

2

ENGINEER 1P13
MEETING WITH TUES 19 - TUESDAY, Nov 17, 2020

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Zhuohua Hu	huz80	yes
Administrator	Abeka Selliah	selliaha	yes
Coordinator	Sana Khan	khans288	yes
Subject Matter Expert	Kyle Mcmaster	mcmask2	yes
Guest	Husain Tapia	tapiah	yes

AGENDA ITEMS

1. . How to work on solid model
2. . How to use the main function in the code
3. . Modelling team finished their solid model and are comparing them
4. .Computation team finished their preliminary code

MEETING MINUTES

1. . How to work on solid model
    a. Choosing one design and adjusting it to meet objectives, constraints, and requirements
    b. Add in components of the other persons design that would benefit the container and meet the requirements
    c. Ensure to use both Abeka and Kyle's ideas into one container instead of only sticking with one persons and disregarding the others' work
2. .How to use main function in code
    a. Implementing it by defining a main function
    b. That function will include a call back of the small functions for each task that needs to executed in the program
        i. Main functions include: move_end_effector, control the gripper, drop off locations, autoclave drawer
    c. Ensure to incorporate the emg sensor values – see project module for more detail
    d. Do not use big repetitive chunks of code- try to put code like that into a function so it is easier for us too
3. .Modelling team finished solid models
    a. Showed their solid model to the team and TA
4. .Computation team finished preliminary code
    a. Sana finished finding drop off locations for the large and small containers and made a basic function to start off
    b. Steve wrote the function for the controlling of the gripper and incorporating the use of emg sensor values

1

ENGINEER 1P13
MEETING WITH TUES 19 - TUESDAY, Nov 17, 2020

POST-MEETING ACTION ITEMS

1. Finish comparing solid models and deciding on who's to use in addition to when the modelling part of the milestone will be completed *[Abeka and Kyle]*
2. Finish the pseudocode for the rest of the functions and plan a day to work on and finish up code so we can move to testing stage*[Sana and Steve]*

MEETING TIME

3:06-13:02 → 9 minutes 56 seconds

2

ENGINEER 1P13
MEETING WITH TUES 19 - TUESDAY, NOV 24, 2020

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	Zhuohua Hu	huz80	Yes
Administrator	Abeka Selliah	selliaha	Yes
Coordinator	Sana Khan	khans288	Yes
Subject Matter Expert	Kyle Mcmaster	mcmask2	Yes
Guest	Husain Tapia	tapiah	Yes

AGENDA ITEMS

1. Updates on everyone
2. Progress on coding
3. Progress on modelling
4. Where to go for help

MEETING MINUTES

1. Updates on everyone
    a. How is everyone doing
    b. How were our midterms
2. Progress on coding
    a. All functions have been completed, now Sana and Steve are on testing stage
    b. Running into errors with drop off coordinates being returned
    c. Confused as to whether emg sensor code has been implemented correctly
        i. Right arm controls one function while left arm = 0 given a threshold
        ii. Left arm control one function while right arm = 0 given a threshold
        iii. Right and left arm control one function given a threshold
    d. Getting parameters of functions checked to ensure right values are being passed
        i. Not all functions require a parameter if a value isn't being returned
3. Progress on modelling
    a. Abeka and Kyle working on combining both ideas from previous milestone together and finalizing their final container
    b. Talked about different aspects of their container that they have included
        i. Sliding lid
        ii. Ability to hold two surgical tools in place
        iii. Many holes for sterilization

1

ENGINEER 1P13
MEETING WITH TUES 19 - TUESDAY, NOV 24, 2020

4. Where to go for help
    a. Any issues with coding, modelling, or if we have questions in general we should go to the 1p13 virtual office hours for project 2

POST-MEETING ACTION ITEMS

1. *Working on debugging code and implementing the emg sensor into the functions correctly [Sana and Steve]*
2. *Finalize and complete their container design [Abeka and Kyle]*

MEETING TIME

2:31-12:45 → 10 minutes 14 seconds

2

ENGINEER 1P13
MEETING WITH TEAM 19 - TUESDAY, Dec 1, 2020

ATTENDANCE

Role	Name	Mac ID	Attendance (Yes/No)
Manager	**Zhuohua Hu**	**Huz80**	**Yes**
Administrator	**Abeka Selliah**	**Selliaha**	**Yes**
Coordinator	**Sana Khan**	**Khans288**	**Yes**
Subject Matter Expert	**Kyle McMaster**	**Mcmask2**	**Yes**
Guest	**Ruben Zhou Yang**	**zhouyanr**	**Yes**

AGENDA ITEMS

1. Coding team perfects the codes
2. Modelling team perfects drawing/G-codes
3. Presenting to the IAI and ask for feed backs
4. Coordinator records suggestions

MEETING MINUTES

1. Coding team tries to fix errors before presentation
    a. Zhuohua and Sana fixes the error
2. Modelling team discuss on what to say during presentation
    a. Abeka and Kyle discusses on who says what and what to say for the presentation.
3. Present to the IAI
    a. Coding team demonstrate how their codes functions
    b. Modelling team shows the functions of their model method on writing G-codes

POST-MEETING ACTION ITEMS

1. *Coordinator records feedback and formulates it on the milestone deliverable*
2. *Everyone starts their research*
3. Discussion on when to work on the P2 final deliverable

MEETING TIME

12: 40 – 1:20 ---→40 minutes (including meeting and presentation)

Design Studio Worksheets

Milestone 0

PROJECT TWO: MILESTONE 0 – COVER PAGE

Team Number: Tues19

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

Full Name:	Mac ID:
Kyle McMaster	mcmask2
Sana Khan	khans288
Abeka Selliah	selliaha
Zhuohua Hu	Huz80

Insert your Team Portrait in the dialog box below

MILESTONE 0 – TEAM CHARTER

Team Number: Tues19

Incoming Personnel Administrative Portfolio:

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

	Team Member Name:	Project Leads
1.	Kyle McMaster	☐M ☒A ☐C ☐S
2.	Sana Khan	☐M ☒A ☐C ☐S
3.	Abeka Selliah	☐M ☐A ☐C ☒S
4.	Zhuohua Hu	☐M ☐A ☐C ☒S
		☐M ☐A ☐C ☐S

To 'check' each box in the Project Leads column, you must have this document open in the Microsoft Word Desktop App (not the browser and not MS Teams)

Project Leads:

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

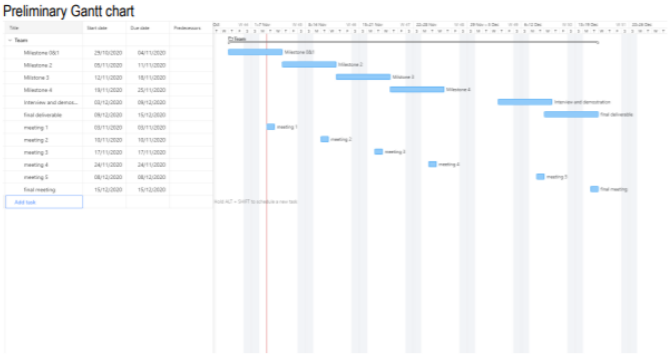
Role:	Team Member Name:	MacID
Manager	Zhuohua Hu	Huz80
Administrator	Abeka Selliah	selliaha
Coordinator	Sana Khan	khans288
Subject Matter Expert	Kyle McMaster	Mcmask2

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team Number: Tues19

Full Name of Team Manager:	MacID:
Zhuohua Hu	Huz80

Preliminary Gantt chart



Milestone 1

PROJECT TWO: MILESTONE 1 – COVER PAGE

Team Number: Tues19

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

Full Name:	MacID:
Kyle McMaster	mcmask2
Sana Khan	khans288
Zhuohua Hu	Huz80
Abeka Selliah	selliaha

MILESTONE 1 (STAGE 1) – PRE-PROJECT ASSIGNMENT

Team Number: Tues19

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

1. Copy-and-paste each team member's list of objectives, 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 objectives, 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

Team Number: Tues19

Name: Kyle McMaster | MacID: mcmask2

Objectives

- Should be easy to pick up by mechanical arm
- Should minimize cost of manufacturing
- Be an appropriate size

Constraints

- *Must withstand heat from sterilization*
- *Must be light enough to be carried*
- *Features must be > 4mm*

Functions

- Able to hold tool
- Able to be picked up
- Able to be released in controlled manner
- Will Not insulate tool from heat for sterilization

Team Number: Tues19

Name: Sana Khan | MacID: khans288

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

Objectives

- Container design should properly sterilize
- A container that securely holds a tool
- Container easy to pick up
- Program is efficient

Constraints

- Must have a firm grip
- Container must be 4mm
- Sliding drawer must open before container is transferred
- Container dimensions should fit end-effector
- Container must be designed to allow for sterilization

Functions

- Transfer the surgical tool into correct bin and colour of autoclave
- Be able to identify correct colour and size
- Should be able to move to the correct location
- Container holds tool without it moving
- Be able to move without colliding with obstacles

Team Number: Tues19

Name: Abeka Selliah	MacID: selliaha

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

Objectives
- Should be easy to pickup
- Should use minimal energy

Constraints
- The container must be light enough to be transferred
- Container dimensions must be greater 4mm
- Must fit in the robot arm's end
- Be durable enough to cleaned repeatedly

Functions
- Able to hold surgical tool in place
- Able to be transferred
- Able to be released in controlled manner (By arm)

Team Number: Tues19

Name:Zhuohua Hu	Huz80

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

Objectives
- Should pick up the tool
- should follow the command given
- Material should withstand some force
- Container should store tools
- Container should remain sterilized after uses

Constraints
- *Container must accommodate the size of the arm*
- *Robotic arm must move and rotate*
- *Container must have walls*

Functions
- Able to hold tool while moving
- Able to be cleaned

*If you are in a team of 5, please copy and paste the above on a new page

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

Team Number: Tues19

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 is easy to pick up	Must have walls	Identify correct location
Holds container securely	Individual features of container must be > 4mm	Container holds a tool
Program is energy efficient	Must be light enough to carry	transport container to correct location
Program is fast	Must withstand the heat of sterilization	Pick up container
System is long lasting	Width < 150 mm	Releases container in controlled manner
	Must be durable to be sterilized repeatedly	Doesn't collide with obstacles

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

Transport container to correct location

3. What are the secondary functions?

Identify correct location
Pick up container
Container holds a tool
Releases container in controlled manner

MILESTONE 1 (STAGE 3) – MORPHOLOGICAL ANALYSIS

Team Number: Tues19

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	Container has indents (ergonomic)	Container has a tab to grab onto	Magnetic container	Dustpan/ forklift	crane	Rubber grip on container
Identify correct location	Colour detector	Feel container for size	Person watching	Bar code on container	Sensor to determine colour	
Container holds a tool	Strap/ seatbelt	Closed lid	Tool pokes out through top	Tape	Magnet	rope

MILESTONE 1 (STAGE 4) – CONCEPT SKETCHES

Team Number: Tues19

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

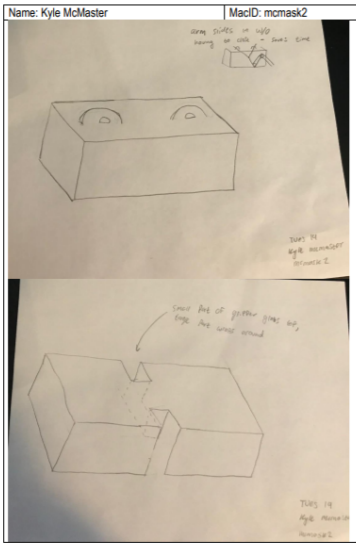
1. Each team member should copy-and-paste the photo of their individual concept sketches in the space indicated on the following pages
   - → The photo's should be the same one your included in the **Milestone One Individual Worksheets** document
   - → Be sure to include your **Team Number** on each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

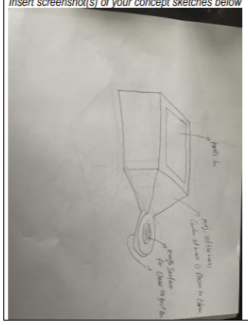
Team Number: Tues19

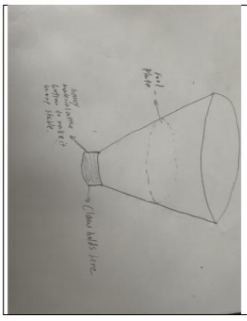
Name: Kyle McMaster	MacID: mcmask2

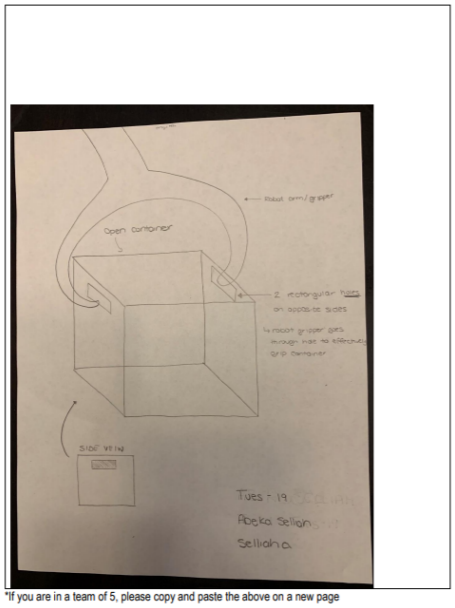


Name:Zhuohua Hu	MacID: huz80

Insert screenshot(s) of your concept sketches below





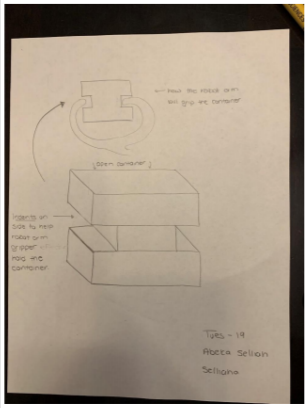


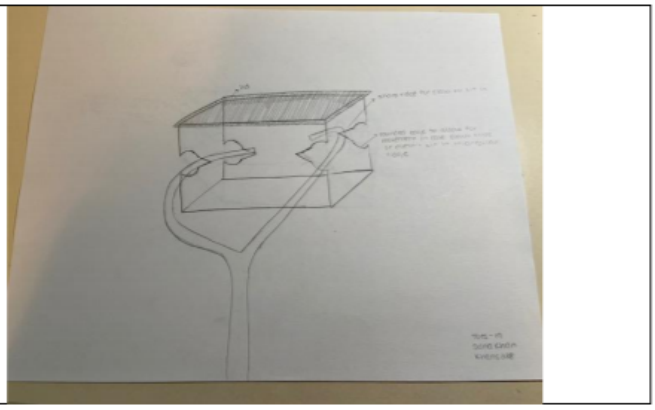
*If you are in a team of 5, please copy and paste the above on a new page

Team Number: Tues19

Name: Abeka Selliah	MacID: selliaha

Insert screenshot(s) of your concept sketches below





Milestone 2

PROJECT TWO: MILESTONE 2 – COVER PAGE

Team Number: TUES-19

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

Full Name:	MacID:
Abeka Selliah	selliaha
Zhuohua Hu	huz80
Kyle McMaster	mcmask2
Sana Khan	khans288

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

Team Number: TUES-19

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

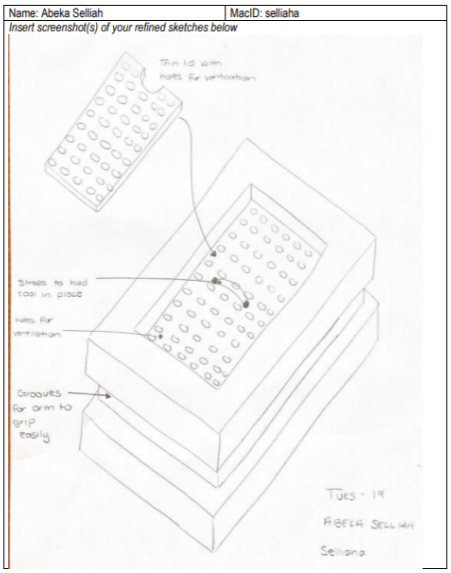
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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: TUES-19

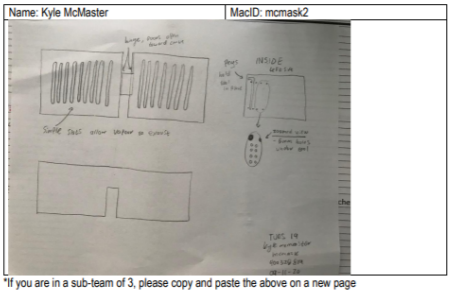
Name: Abeka Selliah	MacID: selliaha

Insert screenshot(s) of your refined sketches below



Team Number: TUES-19

Name: Kyle McMaster	MacID: mcmask2



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

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

Team Number: TUES-19

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

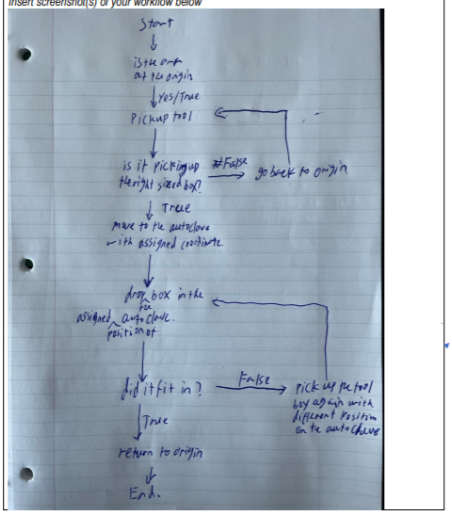
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

- 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

Team Number: TUES-19

Name:Zhuohua Hu	MacID:huz80

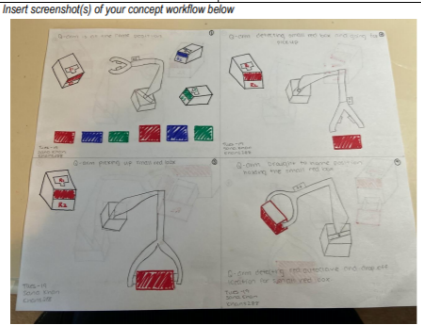
Insert screenshot(s) of your workflow below

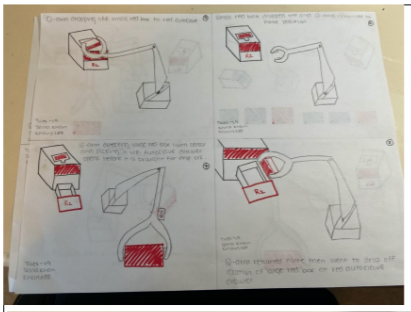


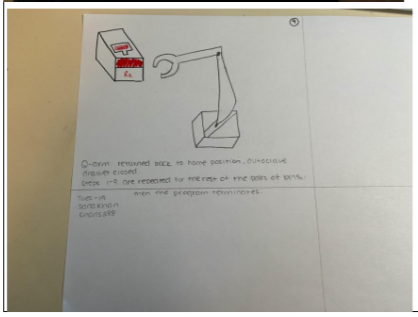
Team Number: TUES-19

Name: Sana Khan	MacID: khans288

Insert screenshot(s) of your concept workflow below







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

Team Number: TUES-19

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**

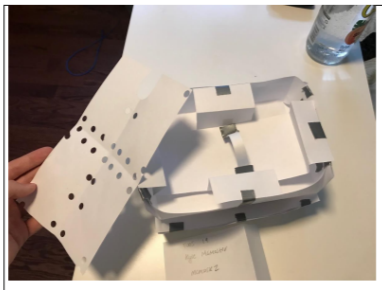
Make sure to include photos of each team member's prototype

Team Number: TUES-19

Name: Kyle McMaster	MacID: mcmask2

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

PROTOTYPE 1

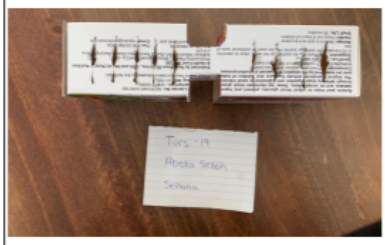


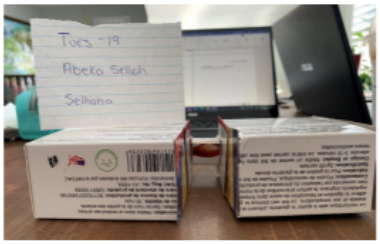
Team Number: TUES-19

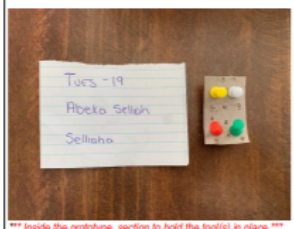
Name: Abeka Selliah	MacID: selliaha

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

PROTOTYPE 2







*** Inside the prototype, section to hold the tool(s) in place ***

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

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

Team Number: TUES-19

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 (Kyle's)	*PROTOTYPE 2 (Abeka's)*
Advantages	*-Can be scaled easily depending on footprint required -shape is easy to manufacture -Strap completely secures tool*	*-Easy for arm to pick up the container -Lots of room for multiple tools -Easy to insert and remove tools from container*
Disadvantages	*-could be hard for arm to grab the horizontal indentation -might be challenging to insert/remove tools from bottom section*	*-Not very durable/steady due to the gap between the left and right side -Not enough ventilation, no way for vapour/water to exit the container at the bottom -Extra material might make it too heavy*
		- Waste of material: Both left and right side are not needed to hold tool(s)
Alignment with Objectives, constraints, Functions	*-Arm might have challenge picking up box from floor with horizontal indentation -meets objective of holding surgical tool in place -meets constraint of having walls, being light, and facilitating sterilization -strap used may wear out after repeated use, potentially failing constraint that device must be sterilized repeatedly*	*-meets objectives of arm being able to pick up container and container holding surgical tool in place - Meets constraints of having walls, being light and facilitating sterilization. However, it might not be durable enough to be sterilized repeatedly due to the center of the prototype being unsteady - Meets functions of holding and transferring tool securely, facilitating sterilization (to some extent) and being able to be carried by robotic arm*
Reliability picking up surgical tool	*-potentially challenging to pick up, perhaps indentation should be adjusted -*	*-Container design makes it easy for arm to pick up the container/tool -Picking up container from center allows for maximum stability*
Reliability securing surgical tool	*-can hold tools very reliably and adaptable to new tools if needed -must ensure strap is durable*	*-reliable if pegs are spaced close together and measured to fit chosen surgical tool -not reliable if a variety of tools or different sizes need to be held*
Extent to which it allows tool sterilization	*-allows for entry and exit of steam, tool will be immersed and sterilized*	*-allows for steam to enter the container, however, more holes will be beneficial to maximize sterilization -does not have holes/gaps on surfaces other than the top, limiting the extent of sterilization*

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

Team Number: TUES-19

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:
-Having drop of location pre-defined so Q-arm knows where to go
-The Q-arm should return to the home position after picking up container
-Detecting the colour and sizes of the container to understand where to drop off the box
-Returning to the origin after dropping off the container

Differences:
-Considering what happens if the box doesn't fit in the container
-Using variables that contain the size and colour of the box for the drop off location instead of specifically stating the colour. So, labelling the autoclave by numbers instead of colour
- Figuring out what to do if the big size container is picked up. So how and when the autoclave drawer will open and close

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

Team Number: TUES-19

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

Assign a variable with coordinates for the Location of the bot's origin and that is where the program begins

If the bot is not at origin it should start at the origin

Find the toolbox coordinates and move the arm to that location

Ask the user to pick from red green or blue toolboxes

Define a function with autoclave red autoclave green and autoclave blue in its parameters

Depending on the angle at which the claw closes, it will determine whether the box is small or large.

If container colour is red

Arm moves to the pickup coordinate of red toolbox

Close claw without assigning a specific angle

Move to the coordinates of the home position

If the angle of claw is >= a specific predefined value

Open the drawer

Move to the red autoclave

Move to drawer coordinates

Open claw

Drop toolbox into the drawer

Close drawer and move back to the location of the home position

Or else

Move to the red autoclave

Drop container into the small container drop off location

Return to the coordinates of the home position

If container colour is blue

Arm moves to the pickup coordinate of blue toolbox

Close claw without assigning a specific angle

Move to the coordinates of the home position

If the angle of claw is >= a specific predefined value

Open the drawer

Move to the blue autoclave

Move to drawer coordinates

Open claw

Drop toolbox into the drawer

Close drawer and move back to the location of the home position

Or else

Move to the blue autoclave

Drop container into the small container drop off location

Return to the coordinates of the home position

If container colour is green

Arm moves to the pickup coordinate of green toolbox

Close claw without assigning a specific angle

Move to the coordinates of the home position

If the angle of claw is >= a specific predefined value

Open the drawer

Move to the green autoclave

Move to drawer coordinates

Open claw

Drop toolbox into the drawer

Close drawer and move back to the location of the home position

Or else

Move to the green autoclave

Drop container into the small container drop off location

Return to the coordinates of the home position

If the user inputs something else

Ask user to input a valid color

All 6 boxes will be able to be transferred using these three if statements. After all boxes have been transferred the program will terminate

Milestone 3

Team Number: Tues- 19

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

Full Name:	MacID:
Kyle McMaster	mcmask2
Abeka Selliah	selliaha
Sana Khan	khans288
Zhuohua Hu	huz80

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

Team Number: Tues- 19

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

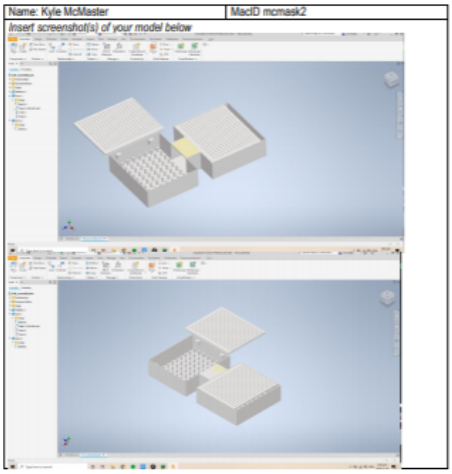
We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

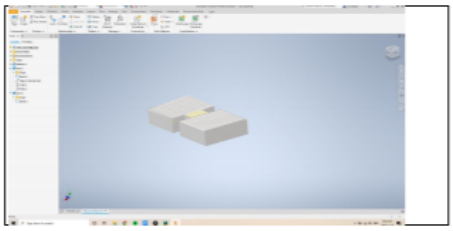
- Each team member needs to submit their solid model screenshots with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
  -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

Team Number: Tues- 19

Name: Kyle McMaster	MacID mcmask2

Insert screenshot(s) of your model below

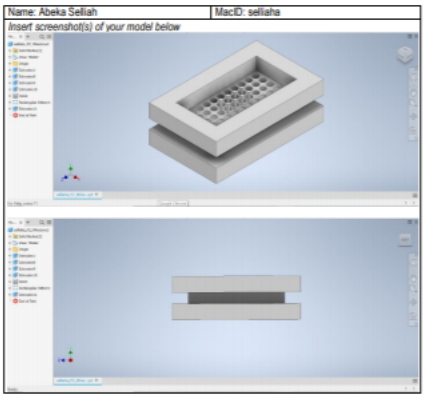


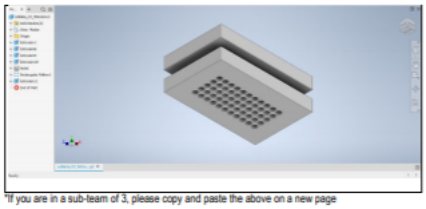


Team Number: Tues- 19

Name: Abeka Selliah | MacID: selliaha

Insert screenshot(s) of your model below





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

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

Team Number: Tues- 19

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: Tues- 19

Name: Sana Khan | MacID khans288

Insert a screenshot of your code below

Team Number: Tues- 19

Name:Zhuohua Hu	MacID: huz80

Insert a screenshot of your code below

```
##
## Username
## Please DO NOT change the naming convention within this template. Some changes may
## lead to your program not functioning as intended.
##
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:
        sim.ping()
    except Exception as error_update_sim:
        print (error_update_sim)

sim = qsim()

update_thread = repeating_timer(2, update_sim)

## STUDENT CODE BEGINS
##
## Example to rotate the base: sim.rotateBase(90)
def sim_movement(left_arm, right_arm):
    tool_pos = ["x", "y", "z", "q1", "q2", "q3"]
    x = [0,0,0,0,0,0]
    left_sim = sim.arm_left(x)
    right_sim = sim.arm_right(x)
    for i in range(len(tool_pos)):
        if x != 0.0:
            left_arm and right_arm
            claw_move = sim.control_gripper(22.5)
        else:
            left_arm and right_arm
            claw_move = sim.control_gripper(45)
    return claw_move
```

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

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

Team Number: Tues- 19

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	Two sections with indent (Kyle)	Brick design (Abeka)
Easy to pick up/ transport	s	+	+
Effectively secures tools	s	–	–
Ability for vapour to flow	s	s	s
Durability	s	-	+
Secure Lid	s	-	-
Lightweight	s	s	-
Ease of manufacturing	s	+	+
Total +		2	3
Total –		3	3
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

- New design must fit in footprint****
- Sticks with pegs
  - Shape them to tool
- Better ventilation
- Hinge for lid
- Remove indentations and add a smaller "hole" for gripper to securely grab container

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

Team Number: Tues- 19

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**: Sana Khan
Enter code errors and/or observations here -There were errors in the return statement -After fixing the return statement there were no errors, but the program did not do anything -Code was a little bit redundant and repetitive so we will make a separate function for the actual movement of the arm and call on that function once the robot recognizes the size and colour of the container	
Move End-Effector Task	**Team Member Name**: Zhuohua Hu
Enter code errors and/or observations here • The return statement had an extra indent • The range of the for loop was inaccurate • the values in the list were not integers and it did not work in the for loop	

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

Team Number: Tues- 19

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

Control Gripper

- If the emg sensor for the right arm is <= 0.5 the anle of the claw is < 45 degrees
- If the emg sensor for the left arm is <=0.5 the angle of the claw is < 45 degrees
- If the emg sensor for the left and right arm is > 0.5
    - the claw closes with 45 degree angle

Open Autoclave Bin Drawer

- Check if the box is the large box
    - If it is check, the colour corresponding to numbers 4,5, and 6
        - Open the drawer of the corresponding colour of the box

Continue or Terminate

- Loop through the main function six times until there are no more boxes left at the pickup platform and all boxes have reached their drop off location
    - End the function and return to home position

Milestone 4

PROJECT TWO: MILESTONE 4 – COVER PAGE

Team Number: Tues-19

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

Full Name:	MacID:
Zhuohua Hu	huz80
Sana Khan	khans288
Kyle McMaster	mcmask2
Abeka Selliah	selliaha

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

Team Number: Tues-19

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

Worried about container falling out

How will container be grabbed

Way the container is secured and upper surgical tool does not fit in right

Hold one surgical tool if there are problems with holding two tools

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

- Container falling out: A peg is added to the design to hold the inner tray and retractor inside the container, to prevent the inner tray and second retractor from moving
- Container being grabbed: dimensions of container is reduced to help facilitate better grip and transfer
- Upper Surgical tool: Dimensions were measured to be perfect for the tool, to ensure it will fit perfectly in the pegs
- Hold one tool: Found a way to make it work with both tools by adding a peg to keep all parts in the container

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

Team Number: Tues-19

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

Add more comments to be more descriptive

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

Be more descriptive with the comments to fully describe what each function, loop, or variable means and what they do.

List of Sources

[1] Ansys Granta EduPack software, Granta Design Limited, Cambridge, UK, 2020

[2] L. C. Rodriguez, J. N. Saba, K. H. Chung, C. Wadhwani, and D. C. Rodrigues, "In vitro effects of dental cements on hard and soft tissues associated with dental implants," *Journal of Prosthetic Dentistry*, vol. 118, no. 1, pp. 31–35, Jul. 2017, doi: 10.1016/j.prosdent.2016.10.002.

[3] O. Addison and G. J. P. Fleming, "Application of analytical stress solutions to bi-axially loaded dental ceramic-dental cement bilayers," *Dental Materials*, vol. 24, no. 10, 2008, doi: 10.1016/j.dental.2008.02.013.

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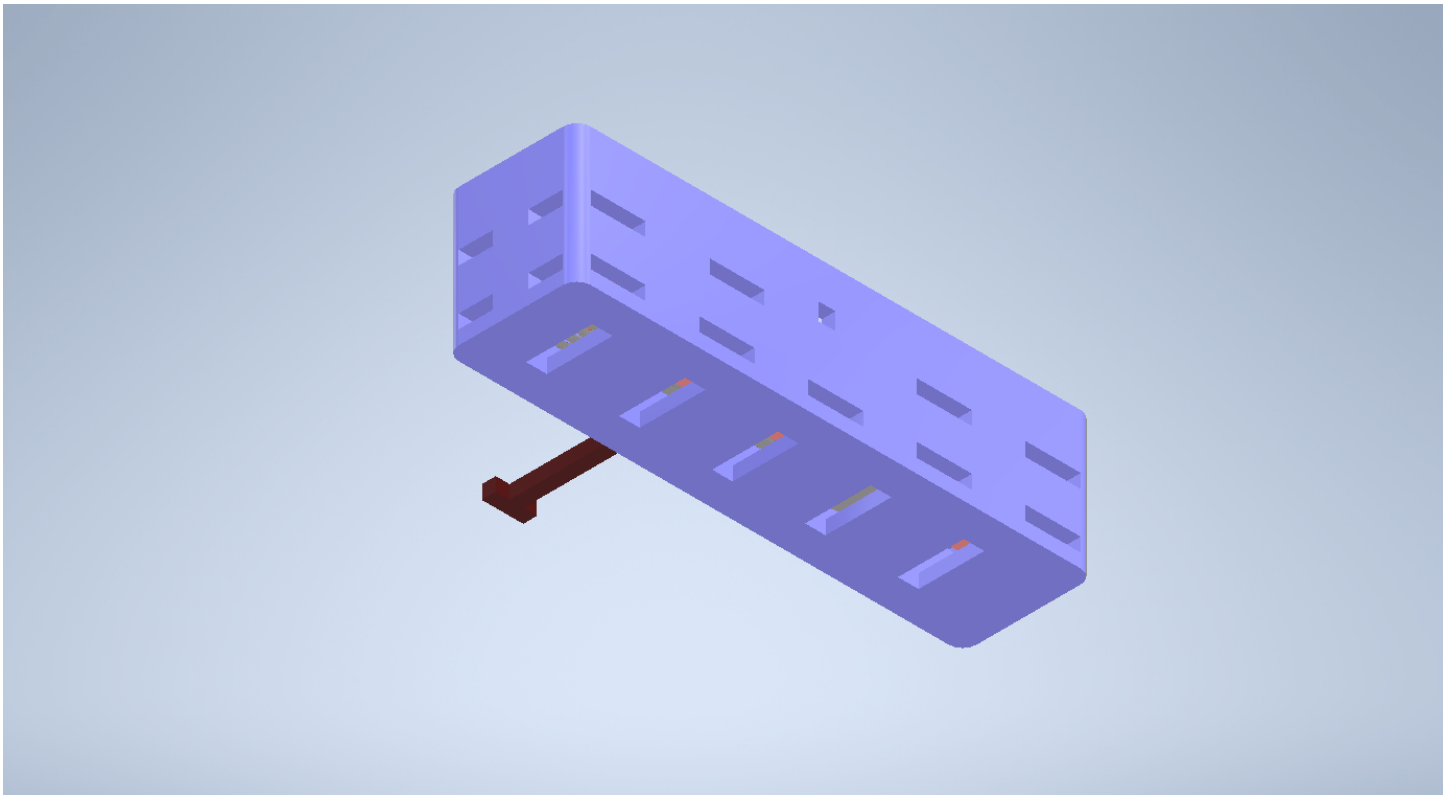
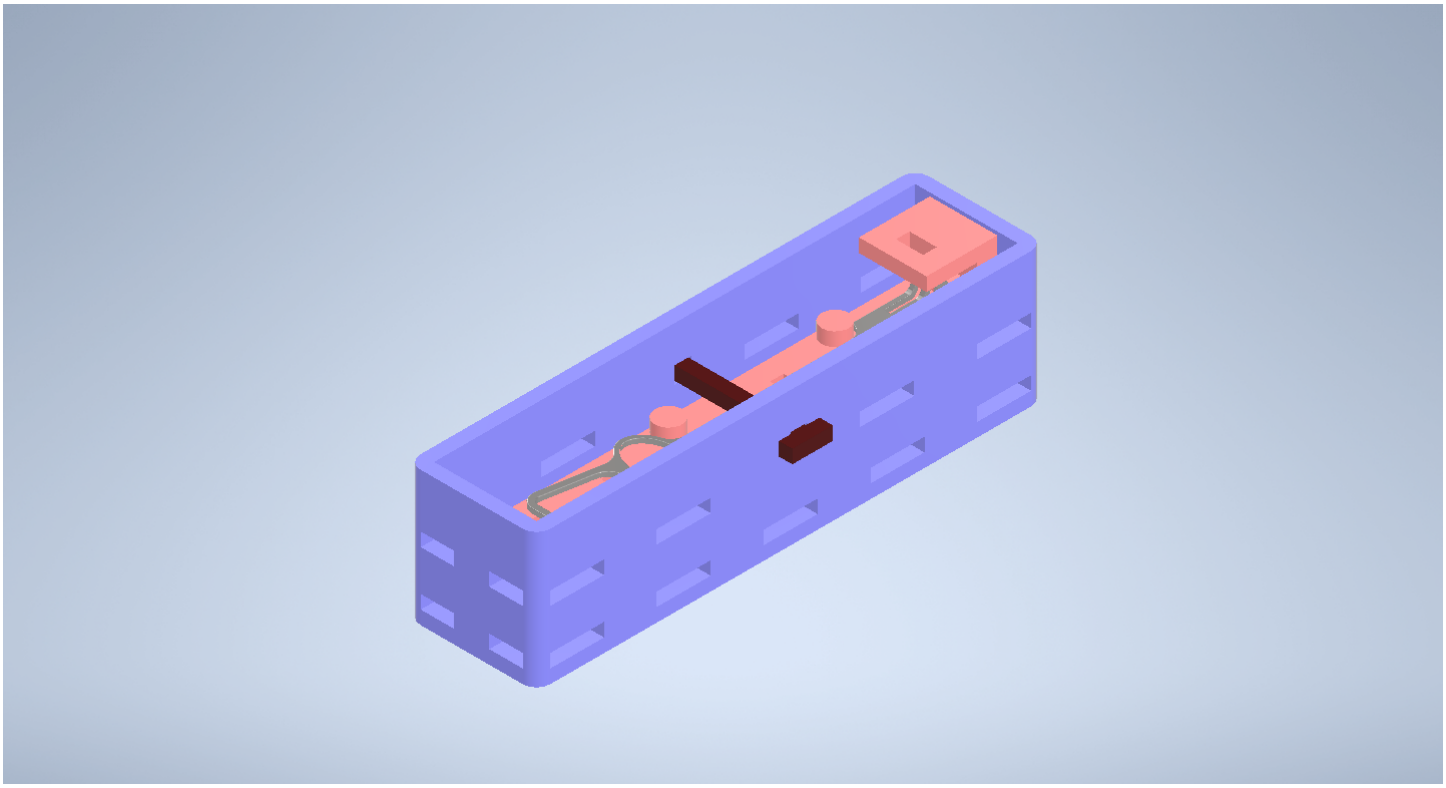
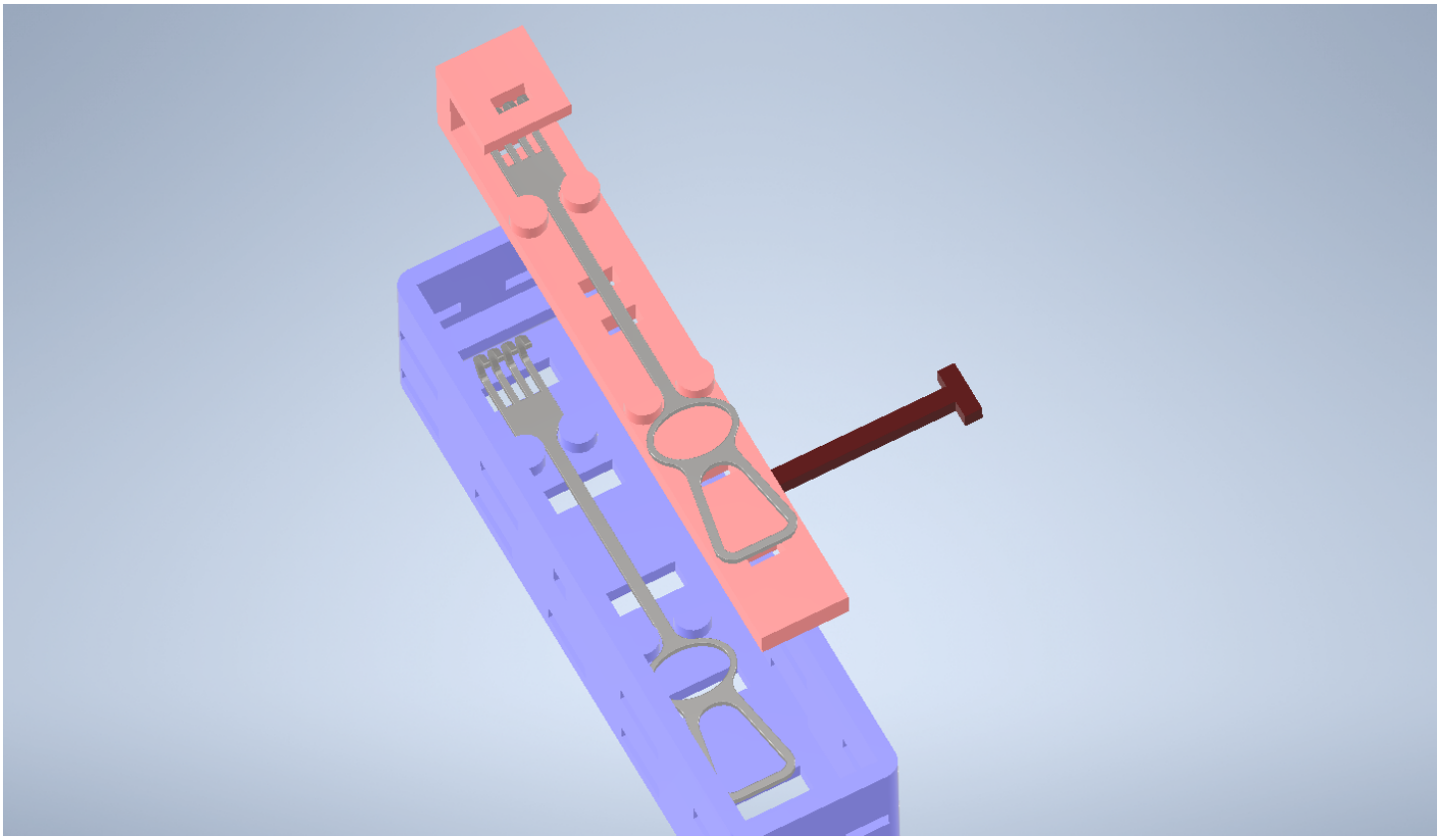
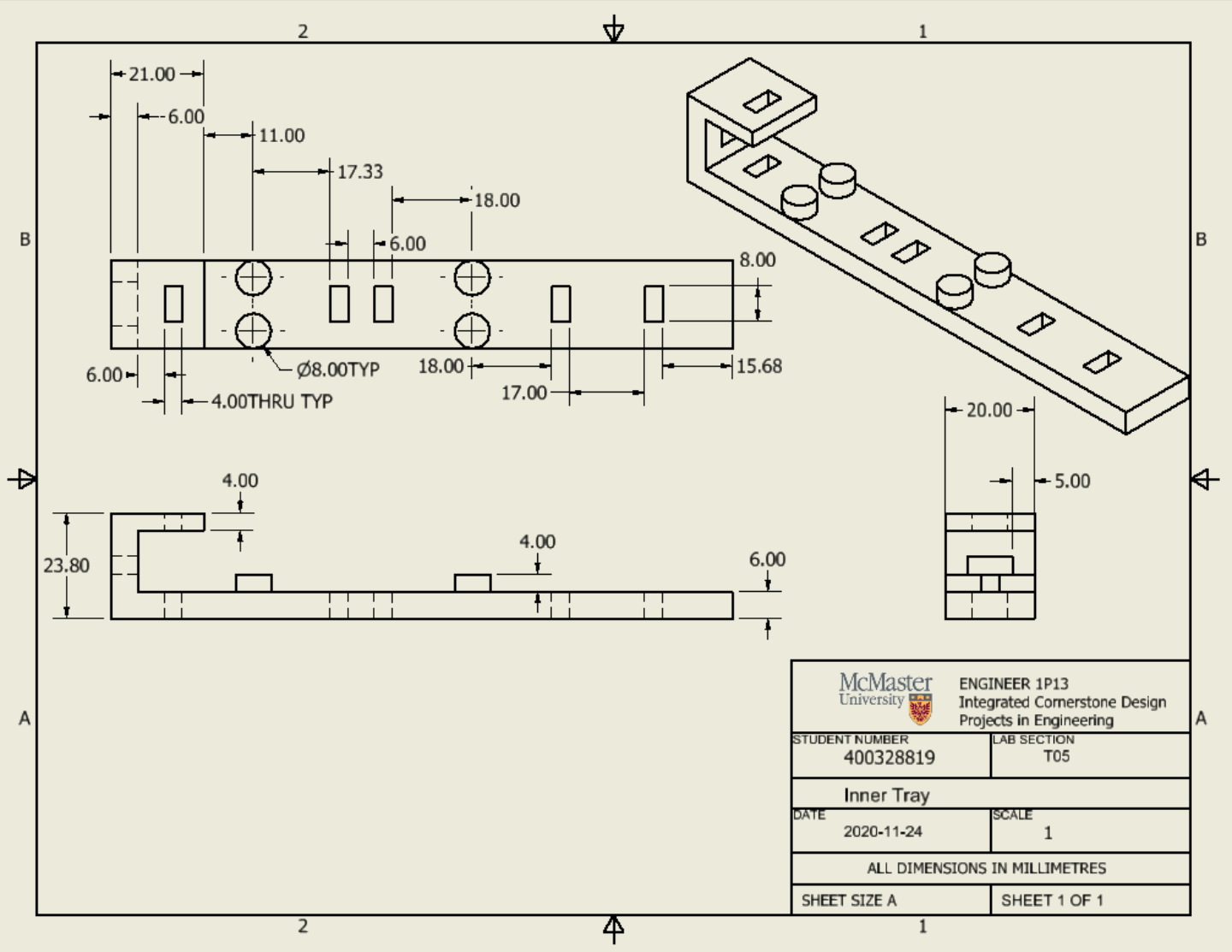
Appendix A – Screenshots of Solid Model:

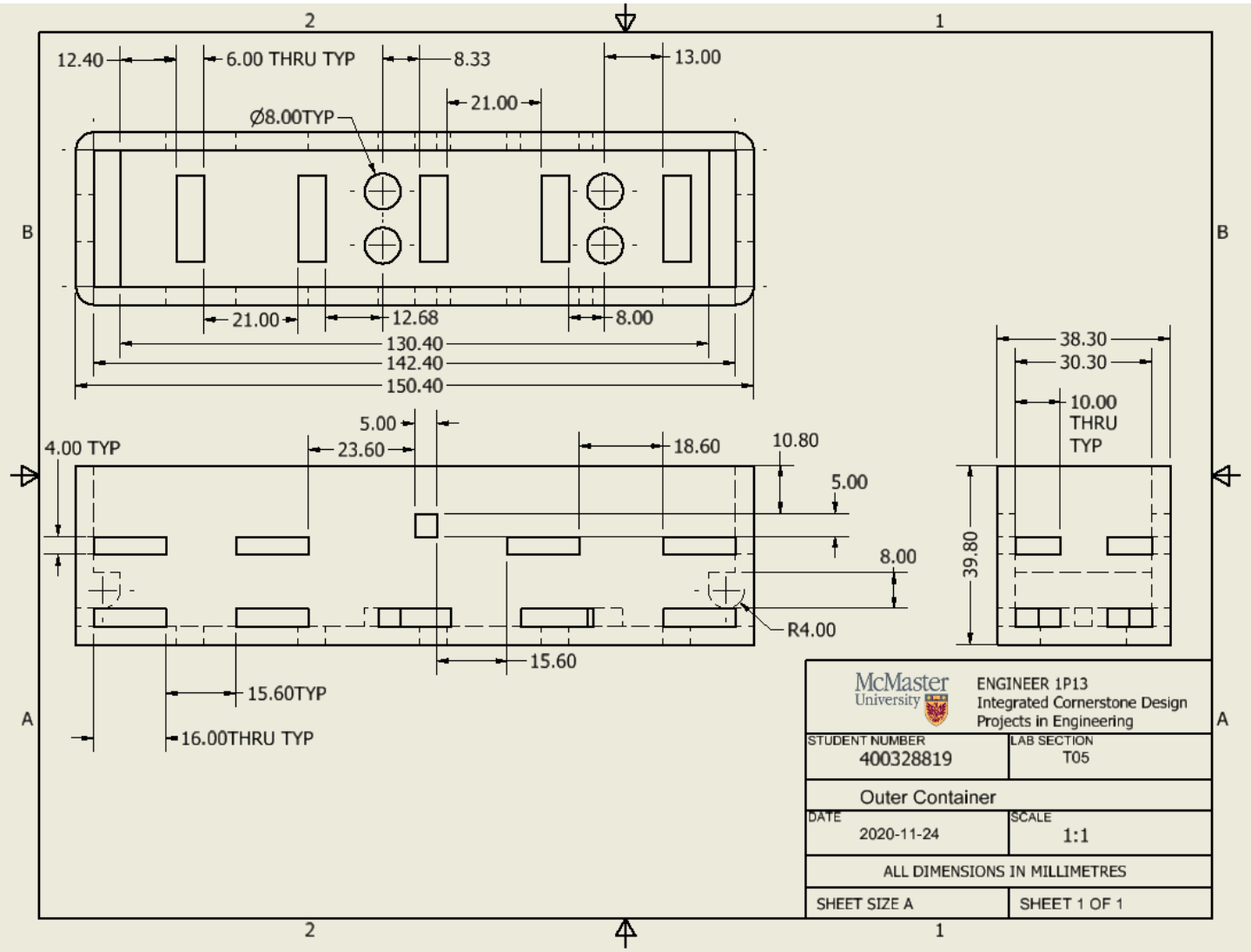






Appendix B – Engineering Drawings of Sterilization Container




12.40
6.00 THRU TYP
8.33
13.00
21.00
Ø8.00TYP
21.00
12.68
8.00
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142.40
150.40
38.30
30.30
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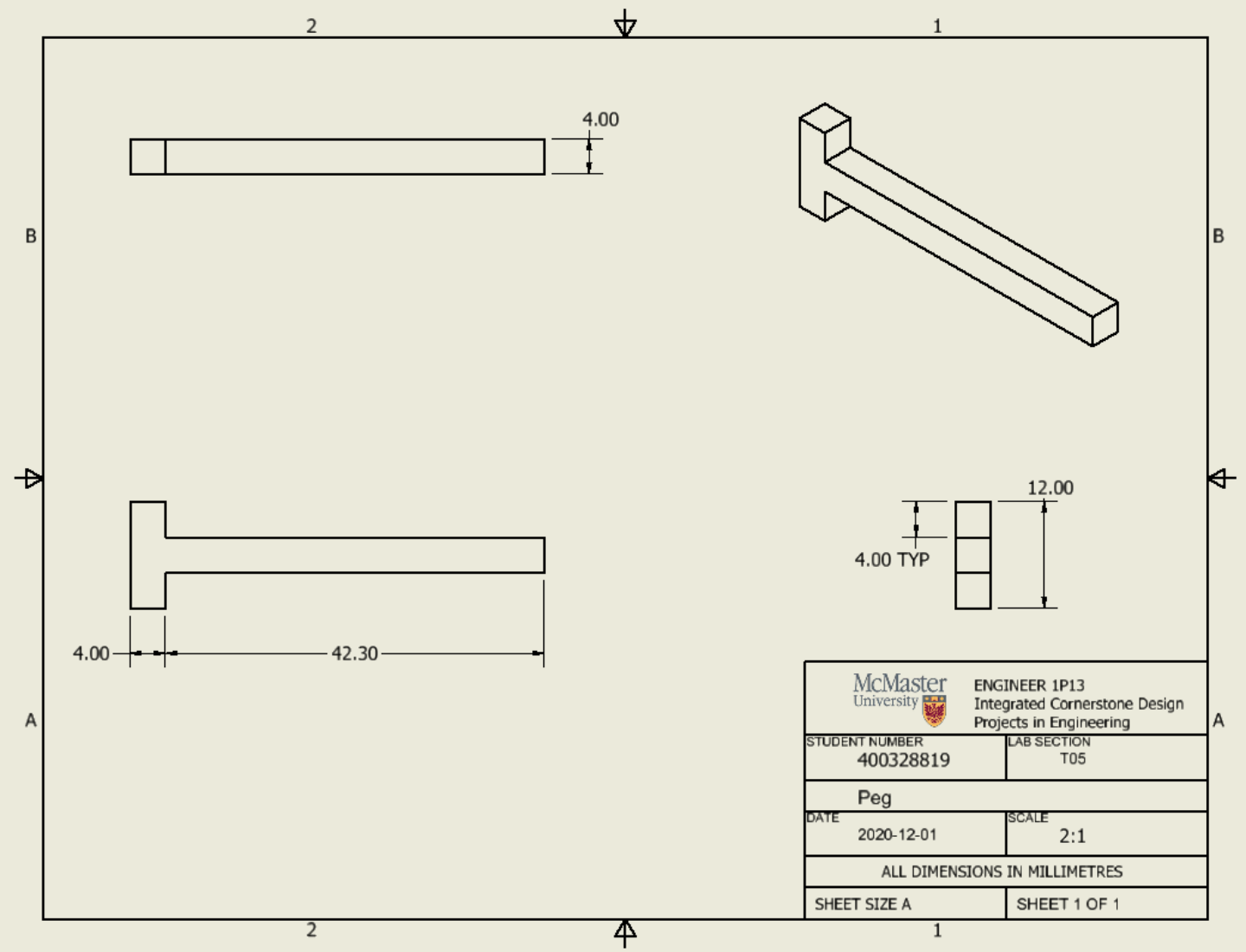
THRU
TYP
5.00
4.00 TYP
23.60
18.60
10.80
5.00
8.00
39.80
R4.00
15.60
15.60TYP
16.00THRU TYP
McMaster University
ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
STUDENT NUMBER
400328819
LAB SECTION
T05
Outer Container
DATE
2020-11-24
SCALE
1:1
ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1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ENGINEER 1P13
Integrated Cornerstone Design
Projects in Engineering
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SCALE
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ALL DIMENSIONS IN MILLIMETRES
SHEET SIZE A
SHEET 1 OF 1

Appendix C – Computer Program

Tues-19_P2_Python_Program .py - /Users/sanakhan/Desktop/ENG 1P13/Project 2/Tues-19_P2_Python_Program/Tues-19_P2_Python_Program .py (3.8.6)

```
#Sana Khan- MacID: khans288
#Zhuohua Hu- MacID: huz80

import time
import sys
import random
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)
#################
#Main Code Below#
#################

#This function provides all the drop off locations for the 6 different containers in order, checks the container spawned and drops it off
#The function returns the appropriate dropoff coordinates for the specific colour of the container
def container_drop(colour):

    R1 = [-0.6103,0.2466,0.4306] #dropoff coordinates small red
    G1 = [0,-0.6539,0.435]       #dropoff coordinates small green
    B1 = [0, 0.6539,0.435]       #dropoff coordinates small blue

    R2 = [-0.4169,0.1517,0.3381] #dropoff coordinates big red
    G2 = [0,-0.4452, 0.3275]     #dropoff coordinates big green
    B2 = [0, 0.4452, 0.3275]     #dropoff coordinates big blue

    drop_loc = [0,0,0]

#If statement checks the corresponding number of the box spawned to figure out the appropriate drop off location
    if colour == 1:
        drop_loc = R1

    elif colour == 2:
        drop_loc = G1

    elif colour == 3:
        drop_loc = B1

    elif colour == 4:
        drop_loc = R2

    elif colour == 5:
        drop_loc = G2

    elif colour == 6:
        drop_loc = B2

    return drop_loc
```

Tues-19_P2_Python_Program .py - /Users/sanakhan/Desktop/ENG 1P13/Project 2/Tues-19_P2_Python_Program/Tues-19_P2_Python_Program .py (3.8.6)

```
#This function opens a specific autoclave bin drawer by controlling the right emg sensor given a threshold value of 0.5
#The colour parameter holds the number of the container spawned and the open_drawer parameter holds a boolean value which determines whether to open or close the drawer
def autoclave_drawer(colour,open_drawer):

    #while loop will execute everything in the loop when True which means that the function will always execute because True is always True
    while True:
        threshold = 0.50
        #checks emg sensor values, if the colour of the box is big red (4), and opens the red autoclave drawer
        if colour == 4 and arm.emg_right() > threshold and arm.emg_left() == 0:
            arm.open_red_autoclave(open_drawer)
            break
        #checks emg sensor values, if the colour of the box is big green (5), and opens the green autoclave drawer
        elif colour == 5 and arm.emg_right() > threshold and arm.emg_left() == 0:
            arm.open_green_autoclave(open_drawer)
            break
        #checks emg sensor values, if the colour of the box is big blue (6), and opens the blue autoclave drawer
        elif colour == 6 and arm.emg_right() > threshold and arm.emg_left() == 0:
            arm.open_blue_autoclave(open_drawer)
            break
        #checks if any of the containers are small and if they are, it breaks of out of the loop
        elif colour == 1 or colour == 2 or colour == 3:
            break


#This function opens and closes the gripper using the right and left emg sensors based on a threshold value of 0.5
#The open_claw parameter holds a boolean value which is used to determine whether to open or close the gripper
#A None value is returned since this function is executing a procedure and not returning a specific value
def control_gripper(open_claw):

    #while loop will execute everything in the loop when True which means that the function will always execute because True is always True
    while True:
        threshold = 0.50

        #checks emg sensor values and then opens the gripper
        if arm.emg_left() > threshold and arm.emg_right() > threshold and open_claw == True:
            arm.control_gripper(45)
            return None
        #checks emg sensor values and then closes the gripper
        elif arm.emg_left() > threshold and arm.emg_right() > threshold and open_claw == False:
            arm.control_gripper(-30) #close the gripper
            return None


#This function moves the end effector to a specific location when given the coordinates using the left emg sensor based on a threshold value of 0.5
#This function works with the container_drop function to obtain the dropoff coordinates to move to the dropoff location in the main function
#A None value is returned since this function is executing a procedure and not returning a specific value
def move_end_effector(x,y,z):

    #while loop will execute everything in the loop when True which means that the function will always execute because True is always True
    while True:
        threshold = 0.50
        #checks emg sensor values then moves to the correct location
        if  arm.emg_left() > threshold and arm.emg_right() == 0:
            arm.move_arm(x,y,z)
            return None
```

Tues-19_P2_Python_Program .py - /Users/sanakhan/Desktop/ENG 1P13/Project 2/Tues-19_P2_Python_Program/Tues-19_P2_Python_Program .py (3.8.6)

```
#This function moves the end effector to a specific location when given the coordinates using the left emg sensor based on a threshold value of 0.5
#This function works with the container_drop function to obtain the dropoff coordinates to move to the dropoff location in the main function
#A None value is returned since this function is executing a procedure and not returning a specific value
def move_end_effector(x,y,z):

    #while loop will execute everything in the loop when True which means that the function will always execute because True is always True
    while True:
        threshold = 0.50
        #checks emg sensor values then moves to the correct location
        if  arm.emg_left() > threshold and arm.emg_right() == 0:
            arm.move_arm(x,y,z)
            return None


#Main function goes through 6 cycles of picking up and dropping off the coressponding bins to their correct location as well as opening the autoclave bin when necessary
#Calls on the different functions to be able to make the program work together
def main():

    cage = list(range(1,7)) #cage holds a list which is created from 1-6
    random.shuffle(cage)    #the numbers within the list in 'cage' are randomly shuffled and then the old list is updated to the new randomized one
    print("The following list shows the order in which the cages will be spawned: ", cage)

    #This allows the whole procedure to loop through 6 times and then terminate
    for i in range(0,6):

        arm.home()    #start at the home position
        time.sleep(2) #wait 2 seconds

        cage_id = arm.spawn_cage(cage[i])#indexes the new shuffled list 'cage' depending on the iteration to obtain each container in the list everytime main function loops
        print("Spawning cage: ", cage_id)

        move_end_effector(0.5559,0,0.038) #goes to pick up location of container
        time.sleep(2) #wait 2 seconds

        control_gripper(True) #passing True back into the function will allow the gripper to close and grasp the container
        time.sleep(2) #wait 2 seconds

        move_end_effector(0.4064,0,0.4826) #move to the home position
        time.sleep(2) #wait 2 seconds

        drop_loc = container_drop(cage[i]) #figure out the container number from the shuffled list 'cage' to be able to get the dropoff location of that specific container
        move_end_effector(drop_loc[0],drop_loc[1],drop_loc[2]) #move to drop off location of specific container
        time.sleep(2) #wait 2 seconds

        autoclave_drawer(cage[i],True) #check the container number and open the drawer or keep it closed based on the number
        time.sleep(2) #wait 2 seconds

        control_gripper(False) #pass False back into the function to allow the gripper to open and drop the container
        time.sleep(2) #wait 2 seconds

        autoclave_drawer(cage[i],False) #if it is one of the larger containers, close the drawer
        time.sleep(2) #wait 2 seconds

    arm.home() #return to the home position


main()
```