[Microwave Transfer Deliverable D]
Detailed Design, Prototype 1, BOM, Peer Feedback and Team Dynamics

Submitted by

[Lab A4 – Group 20]

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Introduction

In this deliverable, we will review the customer feedback received during the second customer meeting. Based on his recommendation, we will be able to implement our conceptual design to have a better solution. We will update a new detailed design concept based on the modification we have received from the client. Certain mechanisms will be created toward our first prototype using the CAD model to help visualize the concept's purpose. Then, prototype testing and evaluation will be carried out taking into account the functional requirements and target specifications. Finally, a detailed bill of materials will be created for our final prototype.

Client Feedback and Updated Design Concept

Unfortunately, client meeting 2 did not occur this week. Originally scheduled for the Tuesday October 5th morning lab session, the meeting was first delayed until 6:15 pm the same day. Unfortunately, the client was not able to attend and the client meeting was further delayed until Friday October 8th at 3:15 pm. The client was not able to attend this meeting until 3:55 at which point all 4 of our group members needed to leave to attend classes/labs for other courses. After this, the client meeting was rescheduled again for Saturday at 2:15 pm. The client once again was not able to attend this meeting.

As this deliverable was due on Thursday October 7th, we have decided as a group to submit despite not completing the client meeting in order to not continue to fall behind.

While the client meeting did not happen, the group was able to email the client to clarify a few measurements that were not clear after the first client meeting. The client did respond with the measurements in a response email. They also said they attached a photo of their kitchen setup as we requested, but the group was unable to find this photo in the client's response email.

Table 1: New Target Specifications

#	Metric	Units	Ideal Value	Marginal Values
1	Vertical Lift Distance	in	>36	>34
2	Maximum Dish Dimensions	in	>12	>10.5
3	Width of Gripping Device	in	12>, >11	12.5>, >10.5
4	Height of Gripping Device	in	6.5>	7.5>

The vertical lift distance corresponds to the distance from the client's counter to their microwave. The width and height of the gripping device are constrained by the client's microwave dimensions being 12.75 by 7.5 inches. Another measurement requested was the maximum counter area we could use to house the base of our transfer device, but due to our poor communication, the client misunderstood the question "What is the maximum counter area (length, width) you are willing to sacrifice to house the base of the device?" and responded with "We currently have the microwave sitting on a shelf not on the counter". The group hopes to clarify this detail whenever we can meet the client.

Table 2: Other Measurements

#	Measurements	Units	Value
1	Client Height	ft	6.0
2	Client's Counter Height	in	78 - 34 = 44

These measurements were also received in the client's email and may be useful in the future. One thing these numbers do clarify is why the client needs a microwave transfer device; lifting an object over your head to put into a microwave is undoubtedly difficult with limited mobility.

As we were unable to get design feedback from the client in the second client meeting, the group was forced to proceed with the concept developed in deliverable C. This time however, the group aims to include as many details as possible in the design in order to come up with a somewhat accurate bill of materials.

Detailed Design and Prototype 1

The main goal the group wanted to achieve with prototype 1 was determine what parts will be required to complete our design, and whether or not it is within our budget. The second objective was to determine whether or not the mechanical components could support the weights that are required.

To determine this information, the group decided to create CAD models of the 3 primary mechanical subsystems–the vertical lifting, horizontal lifting and gripping functions–and quickly research the cost and strength of different materials that could be used to make the parts in the CAD models. The group made use of the Solidworks experience from the group's two mechanical engineering students to make the models and do virtual material testing. These CAD models would also serve as detailed design drawings with measurements to help the group communicate our ideas.

Vertical Lift Prototype

Critical Assumptions

Placing the lifting device on the counter rather than the floor will reduce the vertical distance to the microwave by 44 inches. However, due to not having client meeting 2, we do not know how the client's microwave shelf is positioned or how much counter area we are able to use for the base of the lifting device. As such, the first critical assumption we are making for this subsystem is that we will be able to place the lifting device on the counter.

Figure 1: Missing Counter Measurements

We decided in deliverable C to use a scissor lift for vertical transportation as it is both stable and able to hold the horizontal lift and gripper on top of it. Learning that the device needs to lift an object 34” creates an issue however. Assuming the client’s counter setup is similar to the one in the picture above (still awaiting this information from client meeting 2), there is only about 1 foot between the shelf and the edge of the counter (difference between 2 and 3 in the image). While prototyping for this deliverable, we determined that a scissor lift of base length of 1 foot would require 5 scissor linkages to lift an object 34”. This number can be reduced by rotating the scissor lift 90° such that the Xs are perpendicular to lines 2 and 3 in the image above. Rotating the lift allows us to lengthen the base to increase the scissor arm length. The 20” base length that is used in the CAD model below reduces the scissor linkages from 5 to 3 on each side. The width of the lifting device by consequence is limited to 1 foot which is still able to contain the maximum plate width of 11”. In the event that placing the lift on the counter is impossible (for example if the client’s shelf overhangs the counter too much), we will either have to resort to lifting an object 78” from the floor, or construct some sort of platform that can hold a lifting device at counter level.

In addition to height and dimension constraints, the lifting device must be able to support not only the weight of a dish of up to 10 lbs, but also the weight of the horizontal transport and gripping devices which we estimate to be at most 10 lbs. Furthemore, although this subsystem is the largest of the project, it is still only 1 of the 4 total subsystems. This means that the material costs should be as low as possible.

Detailed Design and Prototype

The group decided in deliverable C that the scissor lift seemed like the best option for a vertical lift mechanism. As such, for prototype 1, a CAD model of the lift was created that tried to address the new specifications obtained from the client.

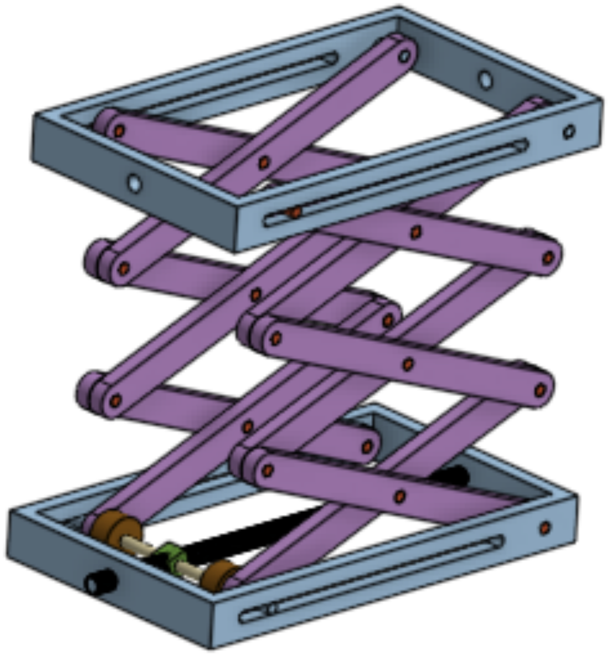


Figure 2: Scissor Lift Model

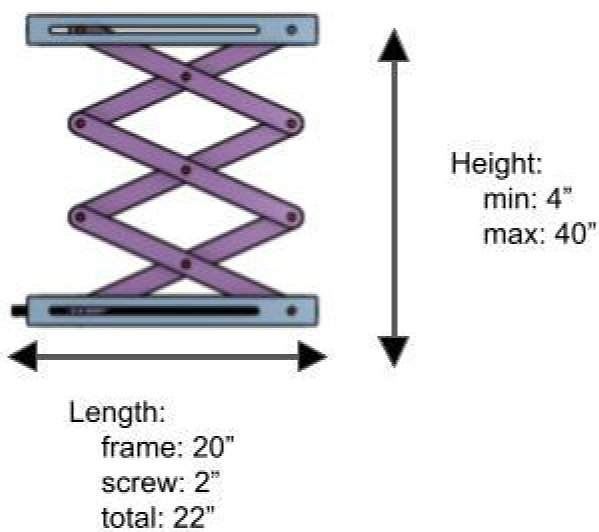


Figure 3: Scissor Lift Side View

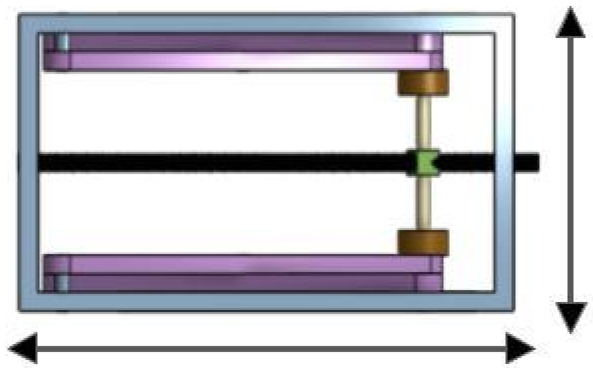


Figure 4: Scissor Lift Top View

Bill of Materials

With the completed CAD design, we are able to assess the parts and quantity of parts we will need to construct a physical prototype. Listed in the table below are the required parts for the scissor lift and their function in the design.

Table 3: Vertical Lift Part List

#	Part Name	Quantity	Purpose
1	Thread Rod (24" long, 0.5" diameter)	1	Convert rotational motion from a motor into linear motion to raise/lower the lift.
2	Nut (0.5" diameter)	1	Moves linearly when the threaded rod is rotated by a motor.
3	End Nut (0.5" diameter)	1	Holds threaded rod in place on the side opposite to the motor.
4	Bushing (0.5" diameter)	2	Allows threaded rod to rotate while keeping it positioned in the lift frame.
5	DC Motor	1	Automatically operates the lift.
6	Bolts (3" length, 0.5" diameter)	18	Hold the lift arms together.

7	Nuts (0.5” diameter)	18	Hold the bolts in place.
8	Wheels (2” diameter, 0.5” axel)	2	Attached to rods 9. Roll on ground when nut (2) is moved along the threaded rod.
9	Rod (7” length, 0.5” diameter)	4	To connect the nut on the rod to lift arms and frame.
10	Frame and Arm Material	272.8 in^3	The material of which the majority of the device will be constructed.

With a list of materials, we are then able to determine the total cost of this design,

Table 4: Vertical Lift Part Prices

#	Part	Cost
1	Threaded Rod	$5
2	Nut	$1
3	End Nut	$1
4	Bushing x2	$3
5	DC Motor	$15
6	Bolts x18	$10
7	Nuts x18	
8	Wheels x2	$4
9	Metal Rod x4	$5
10	Frame and Arm Material	$15
11	Arduino Board	$17
12	Wires	$2
Sum	-	$78

Vertical Lift Prototype Evaluation

Table 5: Vertical Lift Prototype Specifications

Specification	Target Value	Prototype Value	Acceptable (Y/N)
Cost	<$50	$78	N

Base Dimensions	12” x 14” *	12” x 22”	Y *
Lift Distance	34”	40”	Y
Load Capacity	25 lbs	not tested	-

*These are Critical Assumptions

A sum of $78 is clearly over budget for a component that is only ⅓ of the total design. Ideally, this subsystem should cost at most $50. Furthermore, it became apparent when making the CAD model that this design would require a large amount of machining and assembly time to construct physically. With these two factors in mind, it is clear that this prototype is outside of our budget and not feasible to construct within our timeframe. As this design already failed the primary goal of prototype 1, the group felt it was useless to analyze the load capacity and stability of an already rejected design.

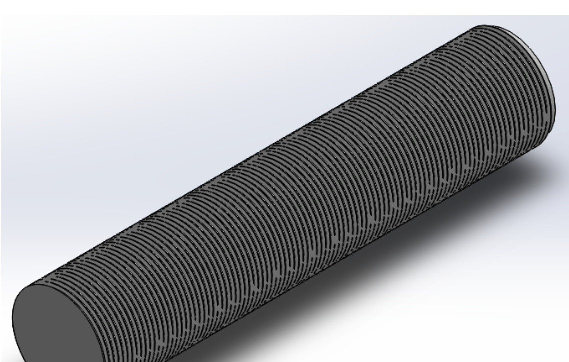
One thing that should be considered is ways to operate all the mechanisms with a single arduino board. This will drastically reduce the overall project cost if it can be achieved.

Moving forward, another concept will have to be selected. The main advantages of the scissor lift were the it’s ability to not obstruct the opening of the microwave door and its ability to hold the other necessary devices on top of it. The next concept will need to find a way to address these two issues. The group aims to have a new lift prototype similar to this one completed before deliverable E.

Horizontal Lift Prototype

For the horizontal portion of the device, we first decided to use a rack and pinion but after doing more research, I changed the mechanism to something else completely different. What I found with the rack and pinion is that it’s complex, expensive, and not realistic to build within the budget and time constraints of the project. Additionally, there was the problem of opening and closing the microwave door after placing the object inside the microwave. To tackle all these issues, I decided to use a simple mechanism instead. For the first issue, a threaded bar and nut will be used instead of a rack and pinion. A DC motor will be planted on the support and will rotate a threaded bar clockwise and anti-clockwise. The threaded bar will be attached to two stationary nuts found on the support, and the sliding part. When the threaded bar rotates, the sliding part will move horizontally along the threaded bar. The direction of movement will depend on the rotation of the engine (clockwise or anti-clockwise). Finally, to tackle the issue of closing and opening the microwave door without the device getting in the way, I decided to implement a telescopic guide. The guide will extend and retract depending on the movement of the sliding part. The guide will be attached to the side of the support (U-shaped support) and sliding part. The guide is going to be attached by a total of 8 screws (4 for the support and 4 for the sliding part).

Images:



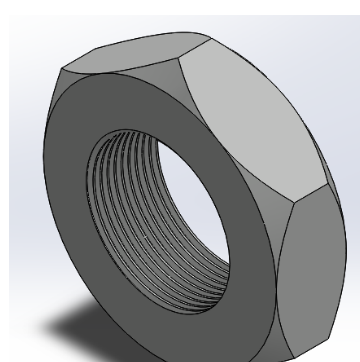


Figure 5: Threaded Bar

Figure 6: Nut

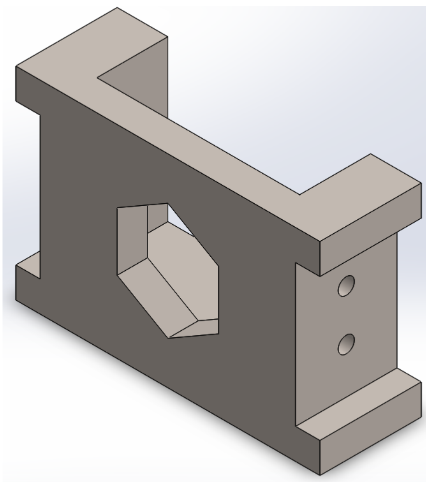


Figure 7: Support

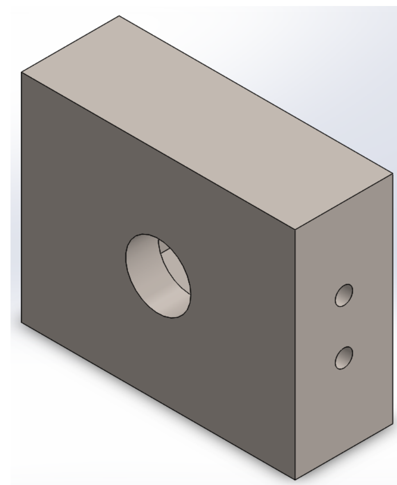
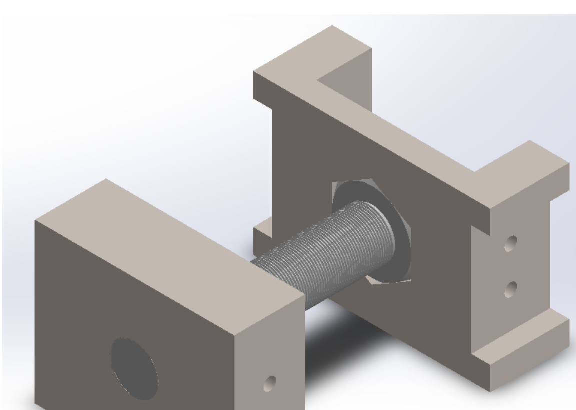


Figure 8: Sliding Part



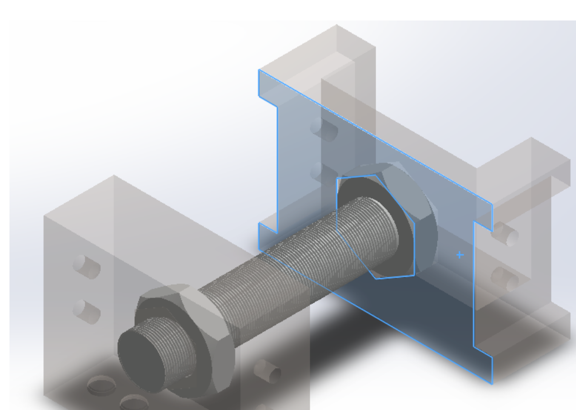


Figure 9: Main Body of the Horizontal Device

Figure 10: Main Body of the Horizontal Device (Transparent)

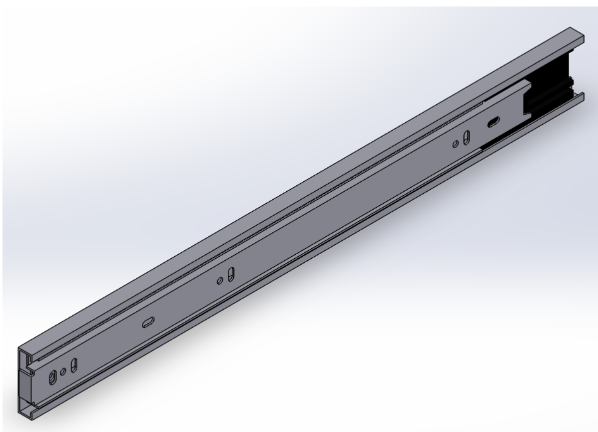


Figure 11: Secondary Body of the Horizontal Device (Telescopic Guide - Retracted)

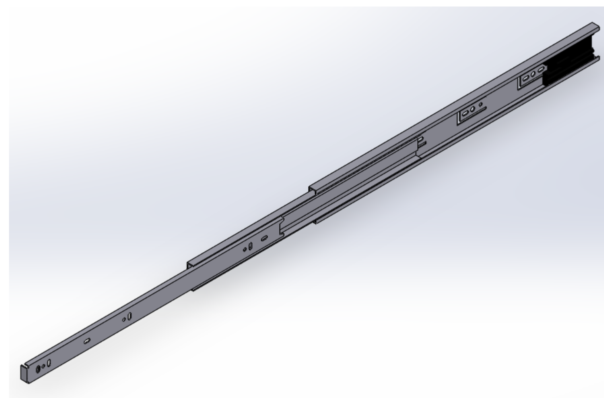


Figure 12: Secondary Body of the Horizontal Device (Telescopic Guide - Extended)

Table 6: Horizontal Part List

#	Part Name	Quantity	Purpose
1	Threaded Bar	x1	The threaded bar is connected to a nut, support, and motor on one side and to a nut and slide on the other. When the motor is on, the bar rotates and forces the slide to slide across the bar.
2	Nut	x2	There is a nut inside the slide and support and are both connected to the threaded bar. They are stationary and do not rotate which forces the slide to move horizontally across the threaded bar.
3	Support	x1	The support acts as the base for the device and holds all the parts including: the telescopic gate, motor, nut, and threaded bar.
4	Slide	x1	The slide is connected to a nut and slides on the threaded

			bar, moving it horizontally in and out of the microwave. The slide is also connected at the bottom to the gripper that's used to pick and drop the object off.
5	Telescopic Gate	x2	The telescopic gate extends and shortens, allowing enough space for the microwave door to open and close when the device isn't in use.
6	Screw	x8	The screws are used to lock both the support and slide to both the telescopic gates.
7	DC/Stepper Motor	x1	The motor powers the thread bar and rotates it, forcing the slide to move linearly across the horizontal axes

Table 7: Horizontal Lift Part Prices

#	Material/Existing Part	Cost	Pros	Cons
1	Sheet Metal Screws	$1.3	Cheap and durable enough to sustain everyday stress and pressure	Not as strong as machine screws
2	DC Motor	$15	The motor is small and cheap enough to fit the support compartment	Might not have enough power to power the device (need to test it out)
3	Threaded Steel Rod(Zinc Plated)	$5.5	The length and size are perfect for the required use, and it can resist corrosion	Material needs to be further tested to ensure that it's strong enough to not break or bend
4	Hex Nut (Zinc Plated)	$0.072	Size is small enough for the overall size of the entire device, and it can also resist corrosion	N/A
5	Metallic Telescopic Gate (Zinc Plated)	$13.5	Perfectly functional and just needs to be installed to the main device, it can also resist corrosion	Quite expensive for the amount that is being bought
6	Stainless Steel Bar (20 Inches)	$10.06	Cheap, easily manufacturable,	Is vulnerable to corrosion and isn't

			and durable	strong enough as other more expensive alloys and metals

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Gripper Prototype

Yazan, place your prototype details here.

Conclusion and Recommendations for Future Work

To summarize, Due to being unable to have our meeting with the client and not receive direct feedback on the concept. We were not capable of deciding the best design mechanisms so we just used our ideas from deliverable C and developed them and came up with a global design. However, we have been able to get information by email about some of the specific points that assist us to complete the mechanisms required, and with defining some of the critical assumptions we were able to develop our prototype. We examine our design by comparing it to the target specifications. Our bill of materials will be entirely based on the quantity of each part required and keeping in mind the budget we have.

The next prototype will center on developing mechanisms, and we will focus on expanding the automation plan of the project using Arduino. We are working on establishing an outline of the presentation for the following step. In addition, we prepare well for our next client meeting to get the most feedback that will aid us to improve our design. We need to prioritize ordering materials as fast as possible to ensure that they arrive on time.

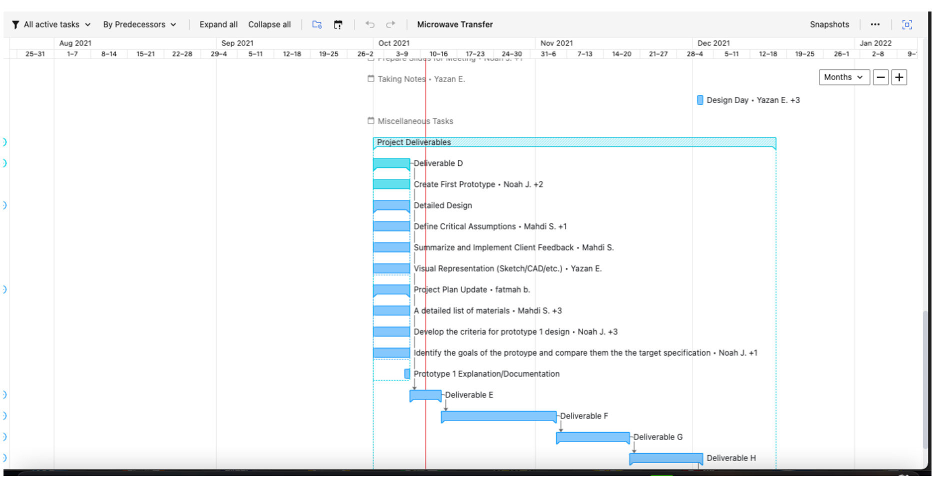
Project Plan Update

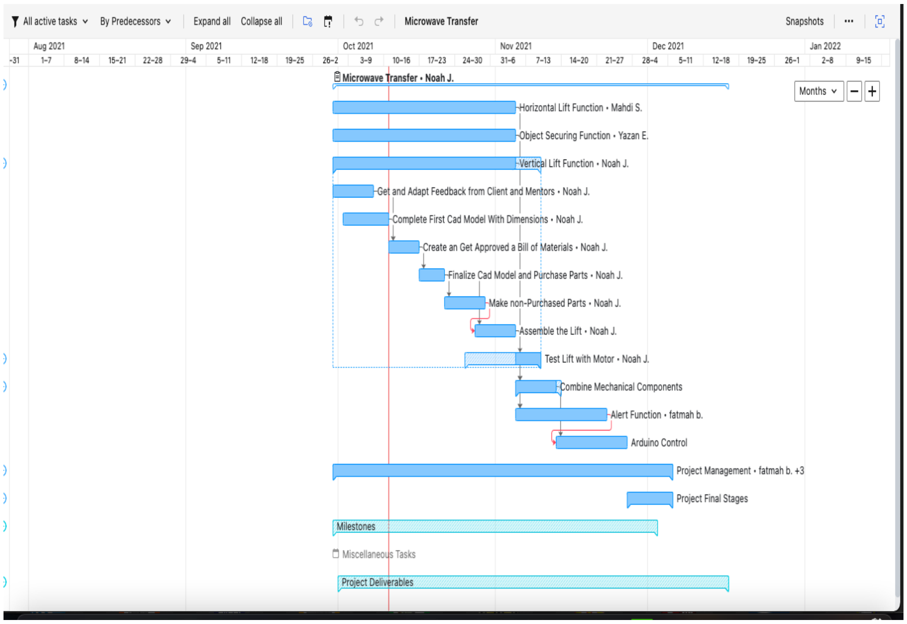
A list of the tasks of deliverable D, E that we are working on completing can be found in the table down . It is important to notice that each letter in “team member “ refers to the first letter of each of the team members.

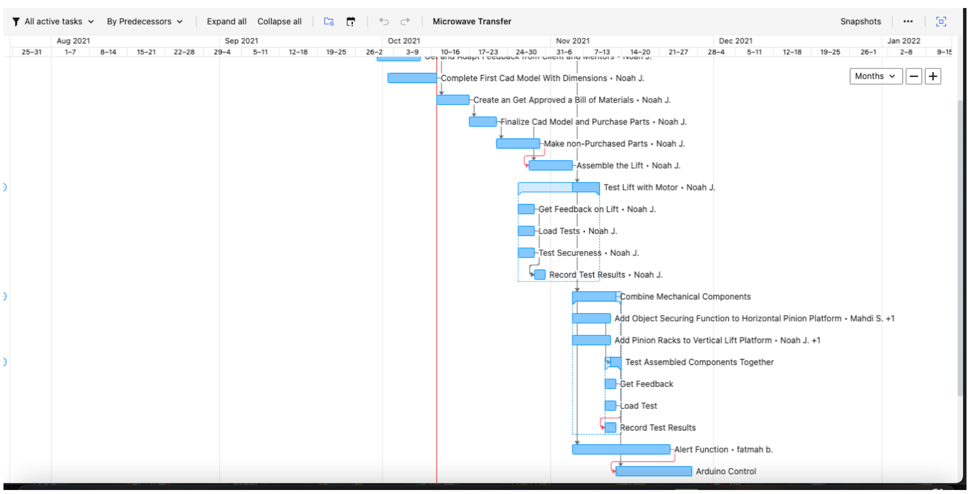
Table X: Group 20 Recent, Current and Future Tasks

Tasks	Description	Due date	Team members
Prototype I Deliverable D	Worked on developed a detailed concept	October 14	N,F,Y,M
Prototype mechanisms	Vertical lift function	October 13	N
	Horizontal lift function		Y

	Object securing function		M
	Project managing		F
	Complete prototype I	October 14	F,N,Y,N
Project presentation deliverable E	Prepare a powerpoint slide for project presentation	October 18	F,Y,N,M
	Practice presentation		
Client meeting 3	Prepare a powerpoint presentation for the client	October 20-22	F,N,Y,M
	Practice presentation		




All active tasks
By Predecessors
Expand all
Collapse all
Microwave Transfer
Snapshots
Aug 2021
Sep 2021
Oct 2021
Nov 2021
Dec 2021
Jan 2022
Months
Microwave Transfer • Noah J.
Horizontal Lift Function • Mahdi S.
Object Securing Function • Yazan E.
Vertical Lift Function • Noah J.
Get and Adapt Feedback from Client and Mentors • Noah J.
Complete First Cad Model With Dimensions • Noah J.
Create an Get Approved a Bill of Materials • Noah J.
Finalize Cad Model and Purchase Parts • Noah J.
Make non-Purchased Parts • Noah J.
Assemble the Lift • Noah J.
Test Lift with Motor • Noah J.
Combine Mechanical Components
Alert Function • fatmah b.
Arduino Control
Project Management • fatmah b. +3
Project Final Stages
Milestones
Miscellaneous Tasks
Project Deliverables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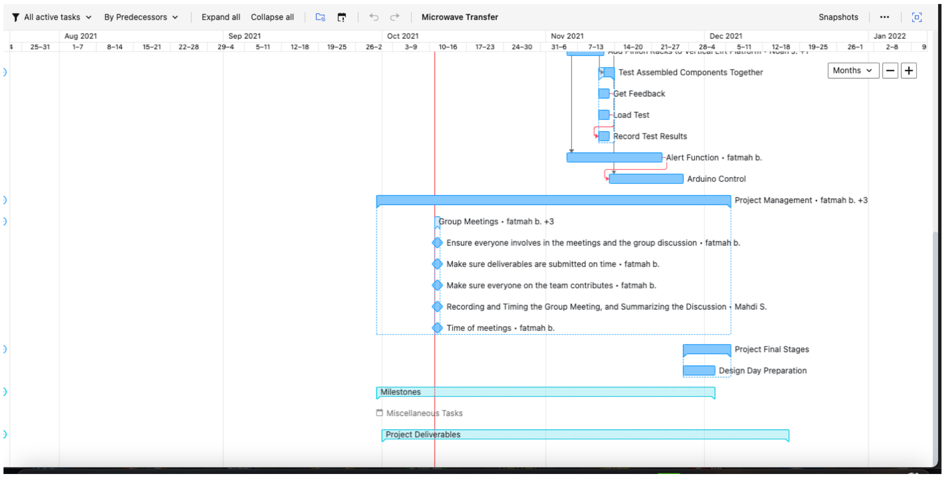
Get Feedback on Lift • Noah J.
Load Tests • Noah J.
Test Secureness • Noah J.
Record Test Results • Noah J.
Combine Mechanical Components
Add Object Securing Function to Horizontal Pinion Platform • Mahdi S. +1
Add Pinion Racks to Vertical Lift Platform • Noah J. +1
Test Assembled Components Together
Get Feedback
Load Test
Record Test Results
Alert Function • fatmah b.
Arduino Control



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Alert Function • fatmah b.
Arduino Control
Project Management • fatmah b. +3
Group Meetings • fatmah b. +3
Ensure everyone involves in the meetings and the group discussion • fatmah b.
Make sure deliverables are submitted on time • fatmah b.
Make sure everyone on the team contributes • fatmah b.
Recording and Timing the Group Meeting, and Summarizing the Discussion • Mahdi S.
Time of meetings • fatmah b.
Project Final Stages
Design Day Preparation
Milestones
Miscellaneous Tasks
Project Deliverables