[Microwave Transfer Project Deliverable F: Prototype 2]

Submitted by

[Lab A4 – Group 20]

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Introduction :

In this deliverable, we will present the second prototype of our product. First, we will summarize the feedback from our third client meeting to clearly illustrate the changes and improvements needed to improve our product. Based on the feedback received, we will create and interpret the list of potential improvements of the prototype and what we need to adjust in our design to connect the client's needs using inexpensive material to produce an introductory model. In addition, we will test our prototype, including analysis and evaluation performance , and compare it with the target specifications we achieved in deliverable B. There are some standard goals to ensure the realization of the test plan. Our goal is to establish feasibility and analyze key subsystems. Finally, we will provide an updated outline of the project plan to align with the work.

Summarize client feedback from third meeting

On October 23, 2021, we had our third client meeting to discuss the model. We show the client some of the slides we have made where we have explained each subsystem and ask for his opinion and feedback. Based on our presentation, we got positive feedback where we received an excellent comment on the work we did since we haven't done our second meeting. The client was satisfied with what we have accomplished so far. In addition, we were given a few things to improve our design.

Developed a second prototype based on the client feedback

Since the first prototype, not much progress has been made with the physical prototype but most details have been finalized with the 2nd prototype. Another very important role that is heavily needed with a project like this is someone who does ‘instrumentation’. The entire device needs to keep its center of gravity (CG) within its frame and keeping the device CG as low as possible is preferred to stop it from tipping over. We also need to consider the center of gravity of the machine while it’s in one of the 3 motions. Therefore, a base that has a big surface area and is heavy can maintain the device center of gravity and keep it low and ultimately stop the device from tipping over when it’s working similar to what's demonstrated in the following figure.

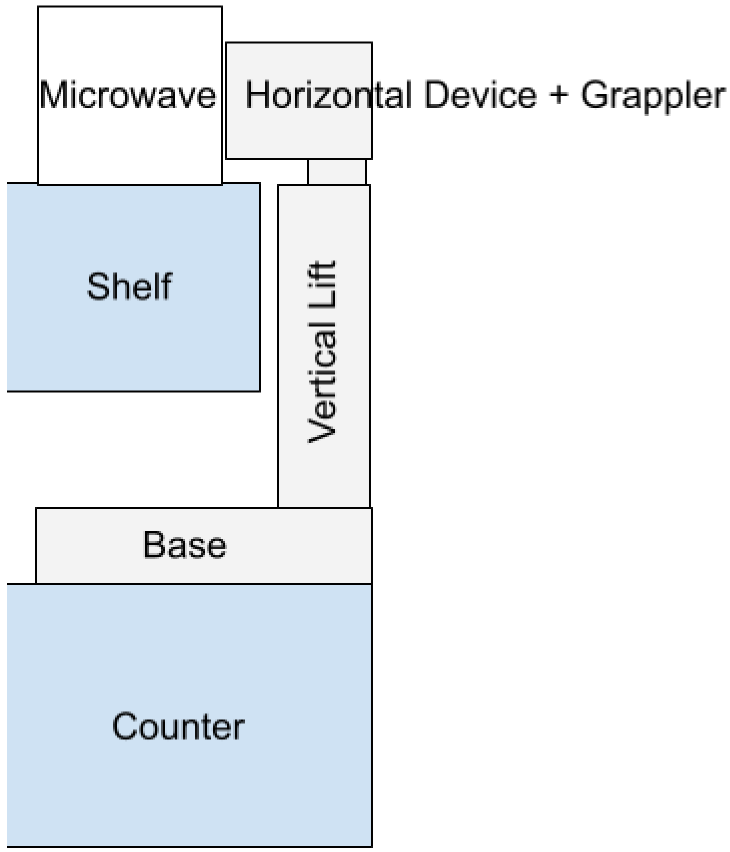


Figure 1: Drawing of the Machine Setup

A base is needed to ensure that stabilization is maintained and that the device doesn’t tip over, especially during movement (transferring the object in and out of the microwave). In the ‘ideate’ step, I proposed having screwed in legs at each edge of the device for support but this idea obstructs the user's need for a device that can be moved and installed anywhere, and a device that is easy and simple to use. A different solution needs to be researched and explored but it’s low on the list of priorities and therefore will only be done if there is enough time in the end after we have completed everything. Overall, the group is expecting the final product to have issues with stabilization and vibration (which can be unsafe for the customer) but this could be a project for a future group.

The goal for the vertical lift subsystem in prototype 2 was to update the design taking into client feedback and begin constructing the physical prototype to verify assumptions made in previous deliverables.

A few challenges appeared this week. The client’s feedback resulted in a few modifications being needed for the subsystem design. Furthermore, the Brunsfield center, where we had intended to construct the second prototype, was closed during reading week. This limited access to necessary machines limited the progress that could be made.

An updated CAD model was created taking into consideration available materials and client feedback. A glaring issue we need to resolve is how to position the device on the client's counter. The client stated that there was only 6" between their microwave overhang and the edge of the counter below. As the device needs to lift dishes of diameters up to 11", the device will need to overhang the counter somewhat. The group has determined a few potential solutions including a counterweight, support post and string attached to the wall, but still needs to finalize some system that will enable the device to have a width of 11" and not hit the microwave on ascent.

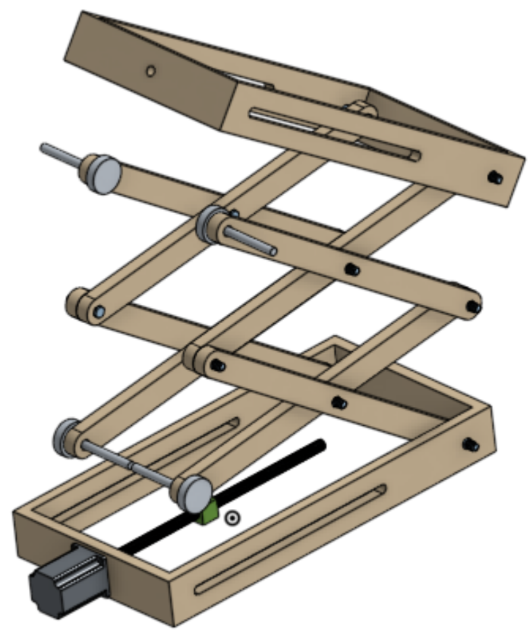


Figure 2: Updated Vertical Lift CAD Design

While the Brunsfield center was closed for the entirety (Monday-Friday) of reading week ~~(why on earth this is the case, I have no idea. The STEM complex seems to be doing everything in their power to prevent me from actually using the facilities)~~ , the staff were nice enough to allow a group member in for a limited period of time. Due to time constraints, the group member was only able to construct a small prototype. The

Figure 3: Incomplete Scissor Arms

A single bolt was purchased to determine how well it would hold scissor arms together while still allowing them to rotate. Fortunately, the nut and bolt fastener solution seems to allow the arms to rotate with minimum friction. Considering that this is a relatively cheap option that requires no additional machining, the group intends to purchase the required amount once our bill of materials is approved.

Figure 4: Nut and Bolt used to Fasten Arms

Machining the arms themselves to the required dimensions shown in Figure _ proved more difficult than anticipated. Using a drill press resulted in slightly misaligned holes which would ultimately result in a crooked and/or unstable vertical lift. Our group intends to try using a mill for more accurate cutting when we can find time in the makerspace.

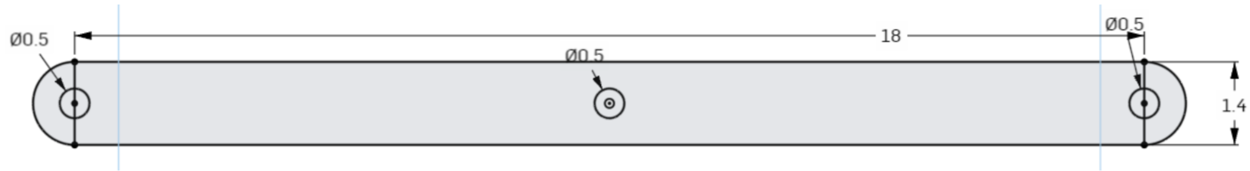


Figure 5: Scissor Arm Dimensions

The largest uncertainty still remaining for this subsystem is how to attach the wheel shafts to the lead screw. Figure _ depicts a potential concept that might achieve this function. Due to our limited knowledge of machining, the group will try to seek advice on if this method would work and if so, how to implement it.

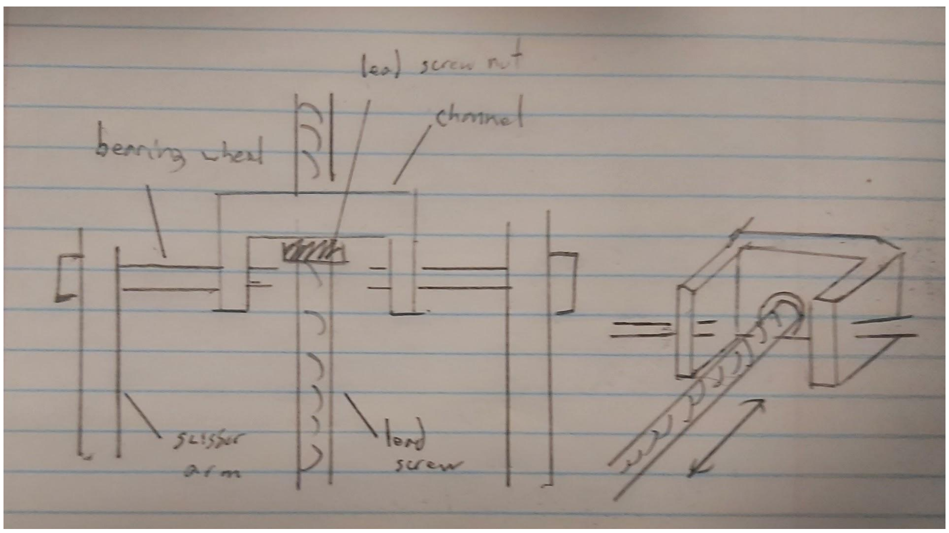


Figure 6: Actuator and Scissor Arm Connection Concept

The client meeting and more detailed designs have allowed us to create a more detailed bill of materials for this subsystem. Listed below are all the necessary parts as the design stands right now.

Table 1: Vertical Lift Bill of Materials

#	Part	Price	Explanation
1	Building material (wood)	-	We were able to salvage unused wood for constructing this prototype.
2	Fasteners (bolts+nuts)	$1 x 10 (bolts) $0.25 x 10 (nuts)	The parts that will hold the scissor arms together. After comparing various online and local prices, what is listed here is the cheapest we are able to find. A single nut+bolt combination was purchased for this prototype for testing.
3	Motor with integrated lead	$40*	After comparing purchasing a motor, coupler and

	screw		lead screw separately to purchasing a motor with an integrated lead screw, the integrated option appears to be cheaper and less prone to failing. The motor referenced here provides sufficient torque to lift the effective load discussed in a previous deliverable and possesses a 400mm lead screw long enough to move the scissor arms.
4	Wheels	-	A group member was able to salvage some unused bearings that would function for the wheels.
5	Channel	$5*	Using this part is the current concept for attaching the wheel shafts to the lead screw. Advice on machining is required before proceeding with this concept.

*These parts/prices and still subject to change

Finally, the group compared what was able to be tested with the limited physical prototype and analytical calculations to design specifications set in previous deliverables.

Table 2: Vertical Lift Prototype vs. Specifications

#	Specification	Units	Target Values	Prototyped Values	Comments
1	Lift Height	in	34	36	This value was taken from the completed CAD model.
2	Maximum Load	lbs	15	7.5	After receiving estimates from other group members regarding their subsystem weight and input from the client on the maximum dish weight, we determined maximum load on top of the lift to be 7.5 lbs. All calculations were done with this number.
3	Base Dimensions	in^2	6 x 11	11 x 21	The client stated they would be able to give 6” x 11” to house the base of the device. However, the width needs to be at least 11” to hold the dishes. Furthermore, a shorter length would require more scissor Xs, drastically increasing the required motor strength.
4	Budget	$	50	55	Using salvaged materials this price was able to be reduced. After the deliverable E presentation, we obtained permission to go over budget for our project. Hopefully, this cost is acceptable.

Unfortunately, not as much physical prototyping was accomplished as was hoped. In the immediate future, cutting the scissor arms to shape is the objective.

Originally, the horizontal device was supposed to have two supports (front and back) to keep it stable when moving horizontally. But, after improving the mechanism and fixing it, only a back support will be possible. Therefore, there are still some tests that need to be done regarding the stability of the device while moving horizontally.

To ensure minimal vibration and that the device stays stable, we need to keep the center of gravity in all 4 corners of the vertical lift device. To understand this better, a visual representation better explains this in Figure 2.

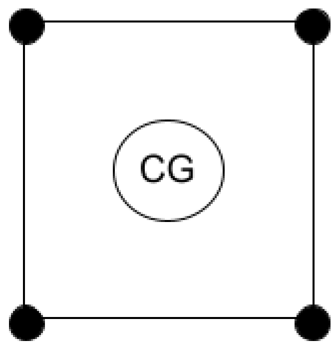


Figure 7: CG Alignment Top View Drawing

The following drawing is the top view of figure 1. The black corners are the corners of the scissor lift machine and the aim is for the center of gravity of the entire machine to be inside all 4 corners.

The support that will be used to connect the vertical lift with the horizontal device is yet to be designed because there are still a lot of unknown factors that we need to find before working on the support. But I have finalized my bill of materials for the device after finding all the exact parts that I need. I'm going to be buying the motor, telescopic guide, threaded bar, and nut. I will also use the 3D printer on campus to print the base part and the sliding part (which will be made of plastic) to complete all the essential necessary parts for the horizontal device. It is important to note that the measurements used were not accurate as the client wasn't able to provide the distance between the edge of the counter and the edge of the microwave (which is essential to know how long the threaded bar has to be - distance of horizontal travel). The client did inform us that the depth of the microwave is 10 inches and according to Google, the average depth of a counter is 24-26 inches.

Horizontal Distance = 26 in - 10 in = 16 in

I used 26 inches in my calculation as an overestimate. I concluded that keeping in mind the actual distance that the device itself takes, the maximum distance that needs to be covered horizontally is ≈ 12 in

The first part that I need is a DC motor and a threaded bar. And over the past few days, I found that I can just purchase a leadscrew which is used to translate rotational motion to linear motion. And on Amazon, you can find a 'lead screw motor' which has a threaded bar, copper nut, and a motor all in one. The lead screw motor in figure 8 has the following specifications:

#	Value	Units
Torque	0.4	N·m
Weight	500	g
Voltage	3.3	V
Current	1.5	A
Bar Length	12	in


Figure 8: 'Redrex' Lead Screw Motor

The material of the threaded bar is zinc-plated steel and the nut between the bar and the motor is made out of copper. The lead screw will be connected to a hex nut on the other side (connected to the sliding part). The hex nut will be brought from Lowe's in Ottawa. The nut is a 'Hillman Zinc Plated Standard (SAE) Hex Nut' with a 5/16-in inner diameter and a thread pitch of 18.00' (threading is right-hand). It's also made of steel but is coated with Zinc for corrosion resistance.'

The next important part is the telescopic guide which will be bought from Amazon. The telescopic guide is colored black and extends from 6 in to 12 in. Both telescopic guides weigh 1 pound together and are made of cold-rolled steel. The telescopic guide uses a 3 section ball bearing and is colored black (see figure 9).

Figure 9: ‘TOOPONE’ Telescopic Guide

The following is the updated and currently the final BOM for the horizontal device:

Table 3: Horizontal Device BOM

#	Material/Existing Part	Cost per x1	Quantity	Total ($)
1	Lead Screw Motor	$30	1	30
2	Hex Nut (Zinc Plated)	$0.21	1	0.21
3	Telescopic Guide (Zinc Plated)	$10	1	10
4	Screw	$1.3	4	5.2
5	Plastic	$0	N/A	0
Total		=	$45.41	

Other than the lead screw motor, hex nut, screw, and telescopic guide, the remaining parts will be 3D printed in the MakerSpace Lab in uOttawa. Specifically, the sliding part and support will be finalized on Solidworks and then 3D printed from plastic.

The gripper mechanism is based on two contour tools being used as a grip. This is because the matrix-like grip that is offered by the two tools allows for the pickup of almost any object. There is not anything like this to base designs or ideas on. Getting positive feedback from the client was a good step in the right direction as the client intuitively compared it to a vice grip.

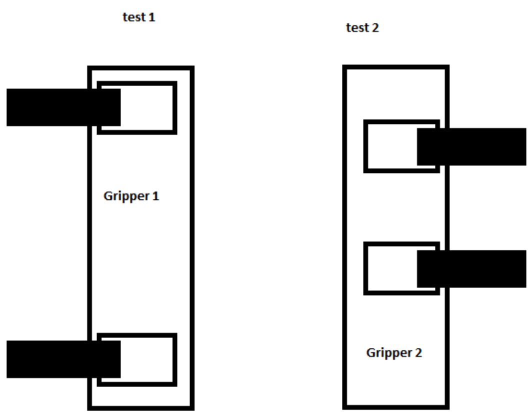
The grippers target specifications are based on the size of the microwave. The gripp should allow objects to be carried in and out of the microwave without any complications.

#	**Value**
Microwave depth	10 inches
Grip length	10.5 inches
Grip width	3..5 inches
Grip weight	700 g
Microwave width	10 inches

Based on client feedback of microwave size the grippers can now be sized to perfectly fit inside the microwave.

Since the two grip tools need to be automated a sort of frame needs to be built to hold the two contour tools together and within the frame it would allow the tools to translate towards each other allowing for gripp.

The use of a rack and pinion is what is going to be tested for translating the grippers. So for the first prototype four clamps were used at different locations on both grippers to try and get an understanding for the best placement of the rack on the gripper.



The image shows different variations of the clamp on the gripper.
The goal of this is to finally replace the clamps with a rack and a motor or a servo motor to control the grip.

Table 4: Horizontal Device BOM

#	Material/Existing Part	Cost per x1	Quantity	Total ($)
1	Contour tool (gripper) *2	N/A	2	N/A
2	Rack and gear	<10$	4	<10$
3	Frame	free	3-5	3d printed
4	Servo motor	8$	2-4	16-35$
5	Rollers	<15$	16	<15$
Total		=	35-40$	

The bill of materials shown is a rough estimate as parts can be salvaged from other devices or 3d printed. Most of the parts for the grip are going to be 3D printed except for the motor and rollers. Even for further prototyping 3D printed parts are going to be used as testing with metal parts would be expensive.

The next step now is to 3d print and test frame stability. The frame has three functions mainly:

- Stabilize the weight and hold the grippers in a steady position
- Allow for motors to translate grippers
- Connect the horizontal mechanism to the gripper

Testing plan:

1) **Test of stability**
    - Successfully connecting the parts that the device is able to stand without any unstability due to its own weight.

The device should be able to stand and perform all three functions, vertical, horizontal, and gripping, without tipping over, falling or motor stalling.

2) **Weight testing**
    - Testing how the device operates with weight loaded.
    - Different object weights are tested

The device should be able to perform its functions with load without tipping over or stalling the motors.

3) **Object variation**
    - Different object shapes and sizes are tested

The device should be able to grip different variations in size, shape, and weight without disturbing the stability or stalling the motors of the device

Conclusion:

To conclude, We summarized the client's feedback during our third meeting. Based on the client's feedback, we worked on implementing the changes to the design and implemented those improvements to improve the second prototype. We have documented all the key subsystems with sketches and diagrams and explained the aim of each of the subsystems. In addition, we have developed a test plan and compared it to the target specifications.

The next prototype will center on developing the testing plan for each mechanism, and we will focus on expanding the automation system of the project using Arduino. We are working on establishing an outline of the project plan for the current step .

Project plan update

Project plan for prototype II:

A list of the tasks of deliverable F 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 Tasks:

Tasks	Description	Due Date	Team members
Create II prototype Deliverable F	Develop the criteria for prototype II	October 23-25	N,M,Y,F
	Review client meeting and develop a list of changes and modification based on the client feedback	October 25-27	N,M,F,Y
Update prototype mechanisms	Update vertical lift CAD design based on the client feedback	Nov 2- 4	N
	Update Horizontal lift function based on the client feedback	Nov 2-4	Y
	Update Object securing Function based on the client feedback	Nov 2-4	M
	Project plan update	Nov 2-4	F
	Complete prototype II	Nov 4	F,N,M,Y
Prototype II explanation and documentations	Analyze the changes with the design model	Nov 1	Y,M,N,F
	Identify the goal of the prototype and compare it to the target specification	Nov 1-3	Y,M,F,M
	Analyze each key subsystems	Nov 1-4	Y,M,N

	List of the material for prototype II	Nov 3	M,N,Y,F
Test prototype with the target specification	Create a project test plan	Nov 4	Y,M,N

A Gantt Chart outlining the the required steps to complete prototype II :