[Microwave Transfer Deliverable C]
Conceptual Design, Project Plan, and Feasibility Study

Submitted by

[Lab A4 – Group 20]

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Introduction:

This deliverable is centered around exploring many ideas to develop a group project concept. This concept fulfills all core client needs and should be detailed enough to include sketches/drawings, a tentative bill of materials and an estimate on specifications. After establishing a global project concept, the team can create a project plan that contains timelines and dependencies. All components and tasks need to be completed before the concept can be realized.

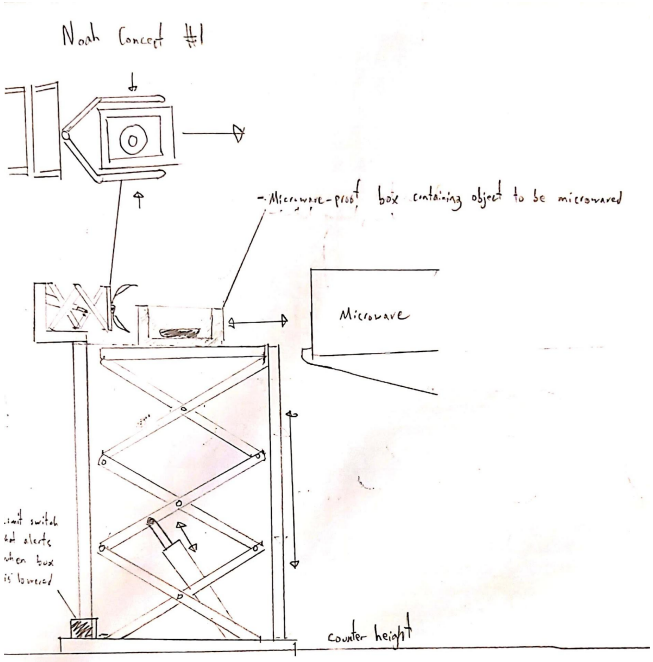
Functional Decomposition:

Before individually brainstorming, it is important for the group to be on the same page regarding what the project needs to accomplish in regards to functionality. Below are the core functions of our microwave transfer project that are required based on client needs:

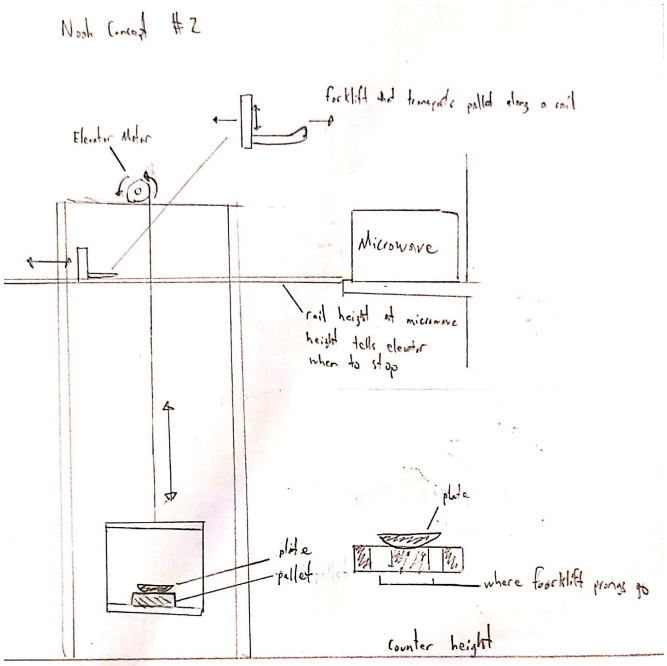
- Secure object on counter.
- Lift the object to microwave level.
- Place the object in the microwave.
- Remove the object from the microwave.
- Lower the object to the counter.
- Alert the client when the procedure is finished.

With these necessary functions in mind, each group member developed concepts that fulfilled at least one of the functions from the list.

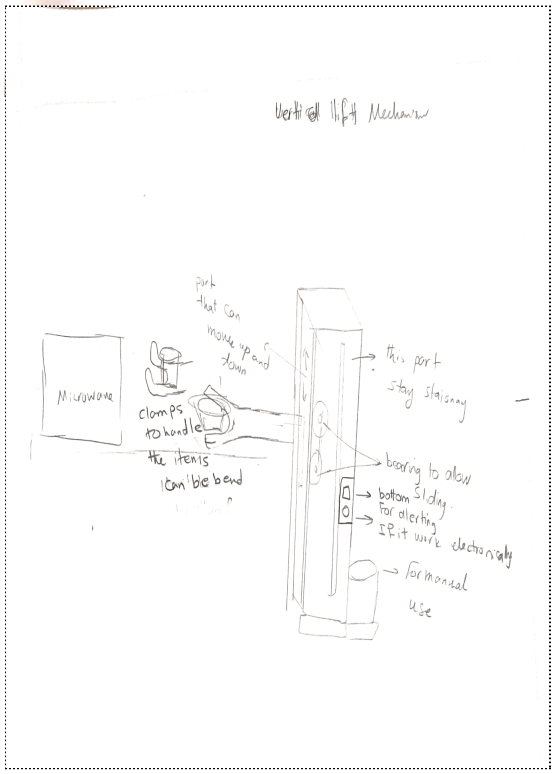
Concepts:



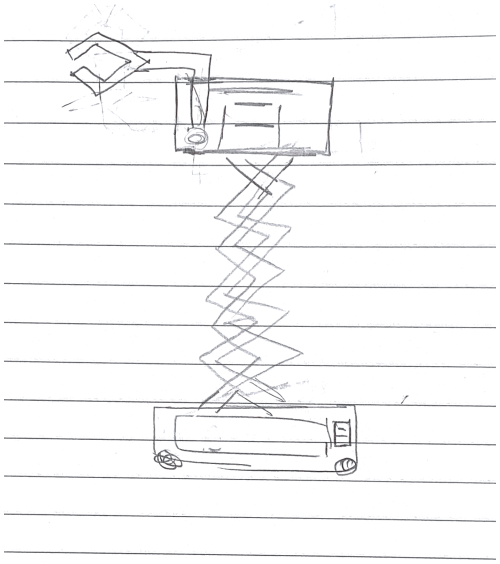
Noah Concept 1: This concept uses scissor lifts and linear actuators to transport a dish both vertically and horizontally. The object to be microwaved is placed inside a box before being transported. This box is designed to be easily grippale by a claw mechanism that will secure the box for horizontal movement in and out of the microwave. The downward motion of the vertical lift will trigger a switch that will alert the client of the process being completed.



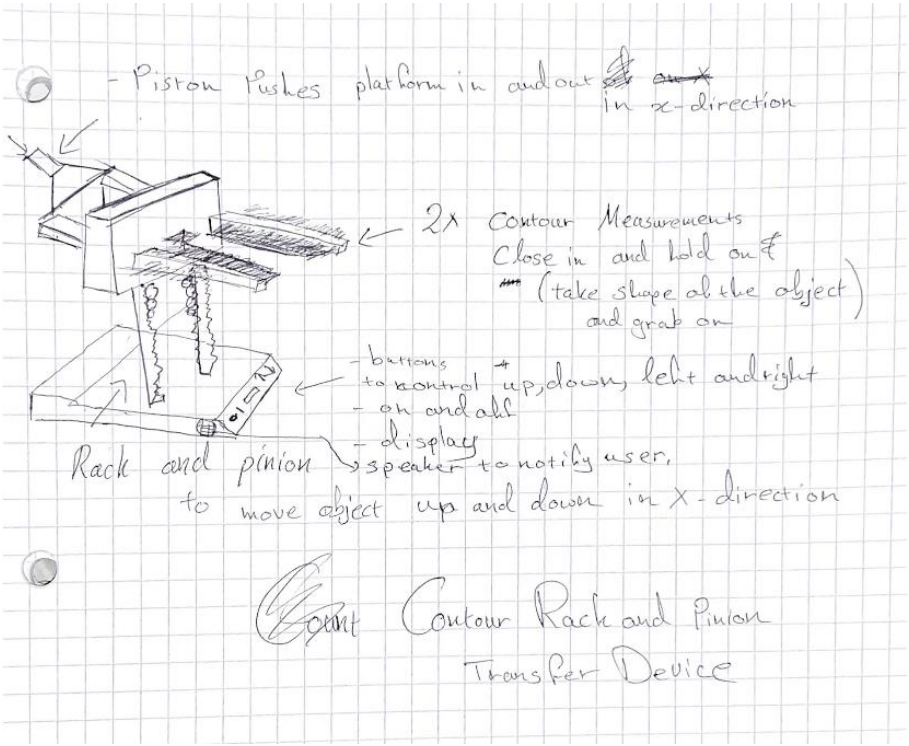
Noah Concept 2: Concept 2 replaces the box with a pallet upon which a microwavable object is placed. The object is placed on top of the pallet and then inside an elevator car. This elevator car is lifted until it reaches a set of rails. Here, a forklift-esque mechanism lifts the pallet off the elevator car and transports it horizontally into the microwave.



Fatmah's Concept 1: The concept is based on a vertical pinion and rack lifting mechanism. An accessory that slides up and down will allow the arm connected to the clamps to place the object into the microwave. The arm can be adjusted according to the items it transports, and then horizontally converted into a microwave.



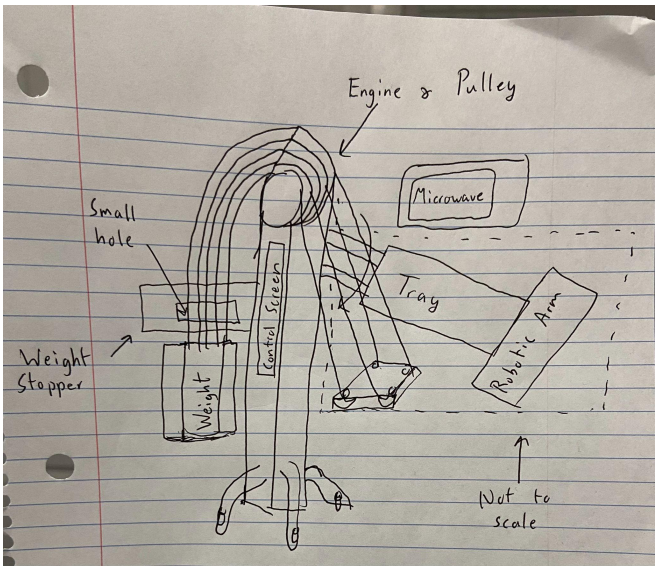
Fatmah's Concept 2: This concept is a mechanical scissor lift, which provides a safe and reliable way of lifting. It consists of a series of linked parallelograms with a hinged intersection, which allows the operator to elongate the mechanism. A pallet is the part of the machine where the object will be placed by holding the item needed using clamps that it is free to move horizontally and vertically to move the object securely from into and out of the microwave to the platform.



Yazan's Concept 1: Contour Rack and Pinion transfer device. The device operated with two 'hands'(contour measuring tools) which would take shape and grab on to the object. The rack and pinion will proceed to lift the object up and down , then a piston or another rack and pinion can be used to move the object in x direction. There are buttons on the device to control the direction and a speaker to notify the user.
The display would present the weight of the device and show progress.

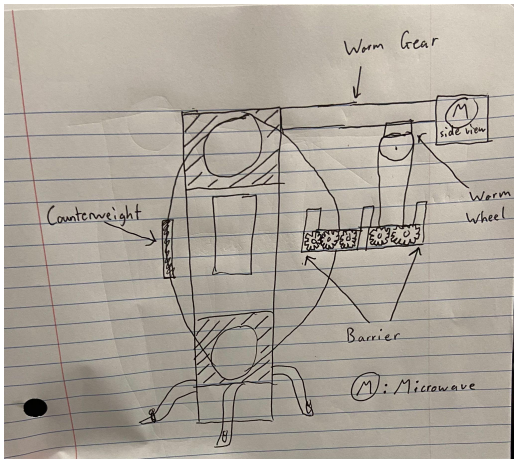
Ps. Base of the device is not to scale.

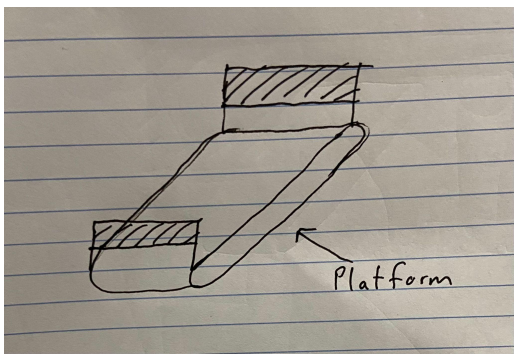
Mahdi Concept 1:



Mahdi Concept 1: This concept uses a pulley and an engine to lift a platform upwards. The platform is connected by a cord and a hook system. Once the platform is level with the microwave, a different platform that contains a tray and a robotic arm rotates from the side of the device and is placed under the platform. The robotic arm then picks up the object and places it in the microwave. At the end of the cord there is a counterweight attached with a stopper attached to the main body to stop the weight from going back all the way up. It does this by having a hole that is big enough for just the cords to pass through but is small enough to block the weight. This is all controlled by a control screen that can be found on the front face of the main body of the device. The main is also screwed to the ground with the support of four legs and screws to ensure that there is no vibration or movement. Additionally, the mechanism of a spring could be added as support for the platform at the bottom of the device for safety reasons (absorbing the shock in case the platform falls and blocking the platform from falling on the customer)

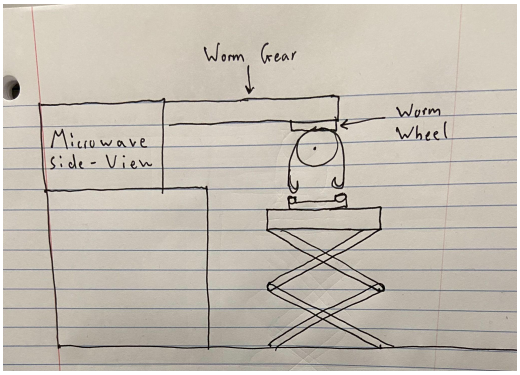
Mahdi Concept 2:





This concept uses the mechanism of an elevator and gears. There are two platforms that can connect and disconnect. The platforms are actually conveyor belts as can be seen from the second picture, and there are barriers at the edges to protect anything from falling. The idea is that once something is put on tray 1 and is lifted upwards, tray 1 connects with tray 2 and the object rolls from tray 1 to tray 2 with the use of springs. Tray 2 is then moved along the x-axis through the combination of a worm gear (connected to the microwave) and a worm wheel that's connected to tray 2. This can all be controlled using the control screen at the center of the main device. The main device also has four legs that are screwed to the ground to ensure stability throughout the process.

Mahdi Concept 3:



This concept uses a scissor lift to lift objects to the top level with the counter and the microwave. The tray that's found on top of the lift platform is a specialized tray that has holes at its corners. The secondary part of the device consists of a warm gear that is attached to the microwave. This worm gear has a device attached to it that consists of a worm wheel and a cord with hooks at the end. These hooks latch on to the holes on the tray to pick it up from the scissor lift's platform and transfer it into the microwave.

Concepts Analysis and Evaluation:

Table 1: Individual Concepts and by Function

Function	Concepts							
	Noah (1)	Noah (2)	Fatmah(1)	Fatmah(2)	Yazan (1)	Mahdi (1)	Mahdi (2)	Mahdi (3)
Secure object on counter	place object in container	place object on high friction pallet	Jack at the center to hold objects	A platform where object will be placed	Contour measurement tool	Barriered tray that stops the object from sliding off	Barriered tray that stops the object from sliding off	Slot and Pin
Lift object to microwave level	scissor lift	elevator motor winch	Pinions driven by linear actuator	Scissor lift	Rack and pinion motor	Pulley and Engine System	Elevator System	Scissor Lift
Place object in microwave	claw grips container and puts it in microwave	horizontal forklift on rail	An arm slides up and down connected to clamps to pick the object	Use clamps to lift the object into and out microwave to the pallet	piston/rack and pinion motor	Robotic hand that picks up and places the object in and out of the microwave	Conveyor Belt	Rack and Pinion
Remove object from microwave	claw grips container and puts it in microwave	horizontal forklift on rail	An arm slides up and down connected to clamps to pick the object	Use clamps to lift the object into and out microwave to the pallet	piston/rack and pinion	Robotic hand that picks up and places the object in and out of the microwave	Conveyor Belt	Rack and Pinion

Lower object to counter	scissor lift	elevator motor winch	Pinions driven by linear actuator	Scissor lift	Rack and pinion motor	Pulley and Engine System	Elevator System	Scissor Lift
Alert the Client	switch triggered by scissor lift descent	timer that starts after client presses button to remove object from microwave	Alarm notification display	Alarm system provide notification	Speaker notification/ display	Automatic alarm that's set to go off once the object is lowered to the counter	Automatic alarm that's set to go off once the object is lowered to the counter	Automatic alarm that's set to go off once the object is lowered to the counter

Looking at the results from individual brainstorming, it is apparent that there is some overlap between functions. Lifting and lowering functions for example are often completed with the same mechanism in many of the concepts. As such, the following tables consolidate functions before evaluating them against specifications.

The following tables rate concepts for individual mechanisms on a scale of 1-5. The scores are rough estimates based on quick research and reasoning. These evaluations are tentative and may be reassessed as the project progresses. Note that a higher cost and complexity rating signifies a lower cost and complexity.

Table 2: Method of Securing Object

Concept	Selection Factors				Score
	Estimated Cost ($)	Complexity	Ease of Use	Feasibility	
Claw and Container	2	2	2	4	10
Forklift Pallet	2	1	2	4	9
Adjustable Arm Connected with Clamps	1	1	3	2	7
Arm with Clamps Connected to the Pallet	1	1	3	2	7
Contour Measurement Tool	4	5	5	3	17

Of all the individual concepts, we determined that the contour measurement tool would be the best method of gripping a microwavable object for our purposes. This function involves controlling two horizontal pads and simultaneously pressing them against an object to hold it in place or release it. The primary advantages of this method are the simple mechanism and lack of additional materials like the container or pallet. It is expected that the contour tool will only require 1 electric motor function and be intuitive to users. The potential issues we foresee are difficulty grabbing flat objects (like plates) and making the jaws strong enough to support heavier items.

Table 3: Up and Down Lift Functions

Concept	Specifications (Estimated)				Score
	Estimated Cost ($)	Complexity	Ease of Use	Feasibility	
Elevator Winch Motor	2	2	3	3	10

Scissor lift	3	4	4	4	15
Pinions driven by linear actuator	3	2	2	3	10
Rack and Pinion Motor	1	2	4	3	10
Pulley and Engine	2	3	2	3	11
Elevator System	1	2	3	3	9

The horizontal lift system needs to be able to lift an object at least 3 feet (need to reconfirm exact height with client at meeting 2). The scissor lift has a few distinct advantages when compared to the other concepts. The flat platform of the lift allows for the horizontal motion device to be constructed directly on it rather than on a separate platform, which would be required for the elevator and the pulley. The rack and pinion also had a few issues such as requiring vertical racks that need to be secured and a locking mechanism to keep the object at microwave level.

Table 4: Horizontal Motion Mechanisms

Concept	Specifications (Estimated)				Score
	Estimated Cost ($)	Complexity	Ease of Use	Feasibility	
Rack and Pinion	3	3	5	4	15
Conveyor Belt	4	4	3	2	13
Robotic Arm	0	1	2	1	4
Horizontal Forklift	3	2	4	3	12

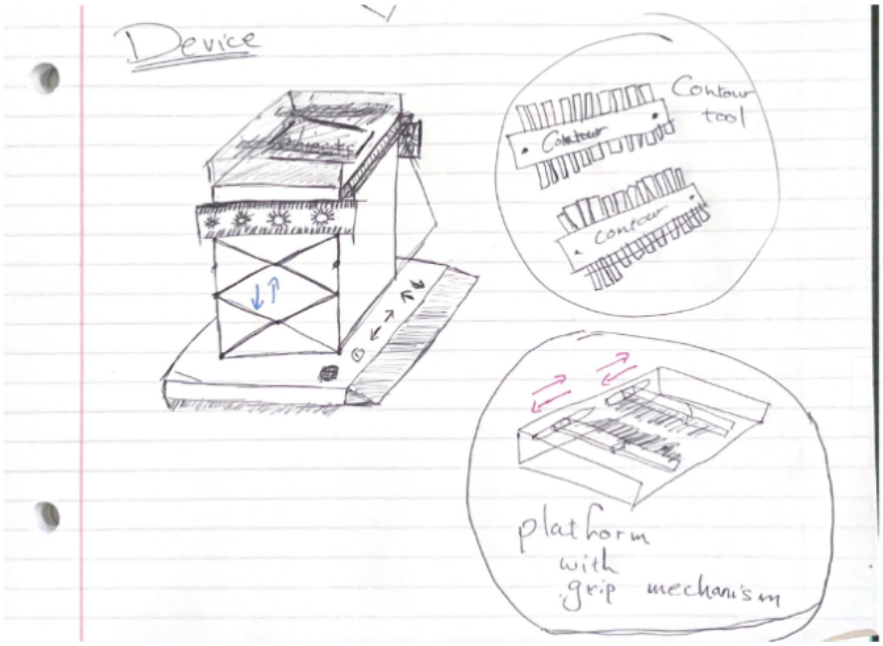
The horizontal motion functions need to be completed after the vertical motion as the client's microwave opens from the side. As such, the mechanism must be suspended level with the microwave and not of the ground/counter below. Additionally, this mechanism will need to support not only the object to be placed in the microwave, but also the gripper that will release the object and pick it up. The robotic arm idea is unrealistic due to them being outside of the project budget and too complex to be made ourselves. The main issue with the forklift is that it

requires two motions, sliding the blades under the object and then lifting the blades up vertically. The remaining two concepts–the conveyor belt and the rack and pinion–are similar. The high price of conveyor belt rubber is what led our group to select the rack and pinion platform.

Group Design Concept:

The final concept combines a variety of mechanisms to transfer an object from the counter to the microwave and back. The object is first placed at the top of a non-extended scissor lift at counter level. A button is pressed causing the contour measurement tool to press against the object to keep it secure and stable for vertical and horizontal transportation. Next, the user will press a button to extend a linear actuator that causes the scissor lift to lift the object until level with the microwave. As soon as the object is finished being lifted, a rack and pinion is used to move the object horizontally into the microwave. The contour measurement tool is loosened and the rack and pinion mechanism is reversed out of the microwave. The user then closes the microwave door and enters a time. After the object is finished being heated, the user will open the microwave door and press a button to retrieve the object. Retrieving the object will involve performing all the mechanical operations listed above is the reverse direction and order. The electrical components will be controlled and operated using an arduino board.

Group Design Drawing:



Conclusions and Recommendations for Future Work:

Now that the group has a global design, we can assign tasks and develop a project plan spanning from now until design day. Each group member was assigned either to one of the functions in tables 2,3 and 4 or as project manager. The next phase of the project is to research parts and materials for constructing each of the components and consult with our TAs, PMs, mentors and anybody we know who is experienced in hardware design.

The group intends to create a CAD for prototype 1 that will communicate to the clients, peers and mentors what we intend to build and accomplish. We hope the model will aid us in understanding exactly what components are necessary for each function and reveal any issues that we have overlooked.

The following prototypes will focus on the mechanical components for the vertical motion, horizontal motion and gripping processes. As most of the group has only done software design in the past, we intend to focus on the functionality of the mechanical components first. The later prototypes will then focus on automating the device with an arduino control scheme. These plans are tentative and are expected to change as we learn more and receive feedback from others.