Handheld Sewing Machine

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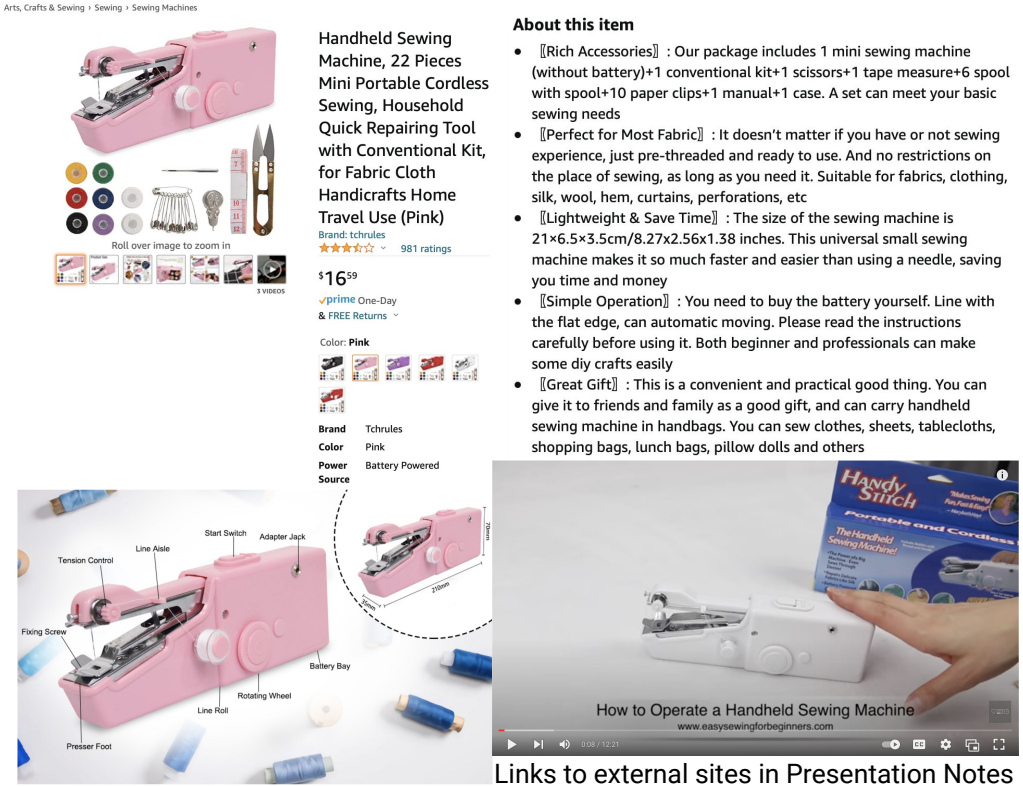
Part I: Product Teardown

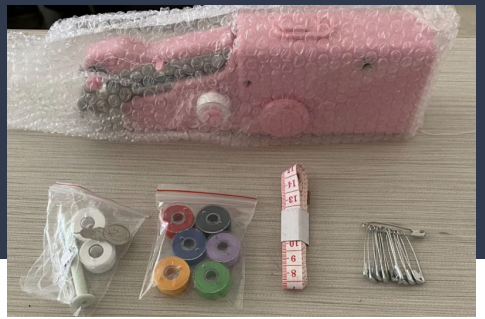
A) User-Centered Design



Links to external sites in Presentation Notes

- Intended Audience
  - Novice/beginner sewers (maybe even a gift)
  - For people looking to make the transition from hand to machine sewing cheaply
  - Compact size for easy storage
    - People with limited space or people who want to travel with a sewing device
  - People who frequently sew but want a compact and easy device for quick repairs
- Intended Use Environment
  - Wherever anyone needs to and is comfortable sewing - this is the main selling point (portable, handheld, cordless)
  - Anywhere with good lighting, preferably indoors

B) Packaging



Packaging (looks and feel):

- Low-quality cardboard
- Low resolution images
- Made-in-china sticker covering the front
- Several typos on the box
- Cheap tape on the edges (primary to keep the box together)
- Bubble wrap around the sewing machine
- Small plastic wraps to hold the smaller components

What was included:

- Handheld sewing machine
- 9 bobbins (spools with thread)
- 10 Safety pins
- Spindle
- Needle threader
- Instruction manual
- Measuring tape

Did not include: (false advertising from Amazon page

- Scissors

Documentation notes: (See next slide)

- Difficult to read and interpret
- Very small font size
- Difficult to read diagrams
- Wordy and confusing
- Spacing errors

Unboxing process:

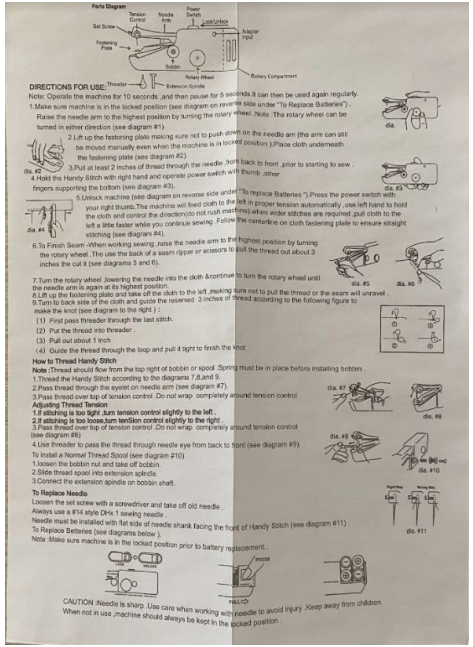
1. Opened the box from the top
2. Remove the contents from the box
3. Observation and experimentation process - tried to figure out the functioning of different parts
4. Read the instruction manual (it was not intuitive on how to operate it)

C) First Use

Assembly/Setup:

- We know that the handheld machine is battery powered - opened the bottom to insert the batteries (we know how to insert batteries based mental models/prior experience)
- The moment the batteries were inserted, the needle arm moved up
- Pressed the on button - caused the machine to turn on and move the piece of fabric out;
- Only intuitive thing is a trigger button on the top; box has a photo of a hand holding the sewing machine and pressing the button
- Confusing design choices; button on the side that isn't actually a button
- Wanted to use it without the instructions, as the instructions were tiny, unclear, and wordy. The trigger button was also tempting as it was shown on the box

Box image showing potential usage



Unhelpful instructions

C) First Use

First Canonical Use:

Environment:
- Indoors, on a hard surface (table), medium natural light, in a somewhat loud room, room temperature, noon

Usage:
- Setup for usage does take some figuring out for first-time users; reading and following instructions, inserting batteries
- Time to complete is variable, depending on the size of the user's project
- Cleanup is easy; break off excess thread, turn on safety, put away

Notes:
- Large and awkward to hold
- Lifting the fastening plate is awkward
- Once turned on, actually fairly easy to use - just pull the machine from left to right
- Getting consistent stitches is difficult for beginners
- Stitches fall out, need to use threader to make a knot (more difficult)

Usage Video:
https://drive.google.com/file/d/1mtSLP5tFuU_TjoC1fSeTPkndEhFA5uZR/view?usp=sharing

D) Knowledge Elicitation/Observation

User Profile:

- User has never sewn before nor are they comfortable using new technology
  - Confused with some of the part names and didn't know basic sewing procedures like tying knots etc.
- Task performed on a crowded table so space was limited, however the user didn't have a problem with space

1. Unboxing

- Reads text on packaging, notices typos
- Opens box
- Removes machine from packaging
- Spool falls from device — unraveling thread from the spool
  - Respools the thread

2. Reads instructions

3. Installs Batteries

- Mistakes the lock switch and on button for the battery compartment
- Struggles to open battery compartment
- Inspects battery orientation as designated on the manual and puts batteries in accordingly

4. Sets device into lock position

- Assumes the switch is already in the locked position
- Keeps the device locked position for the setup

5. Prepares the device to sew

- Turns the rotating wheel to raise the needle arm
- Lifts fastening plate and fits cloth underneath plate
- Reattaches spool to side of device with bobbin

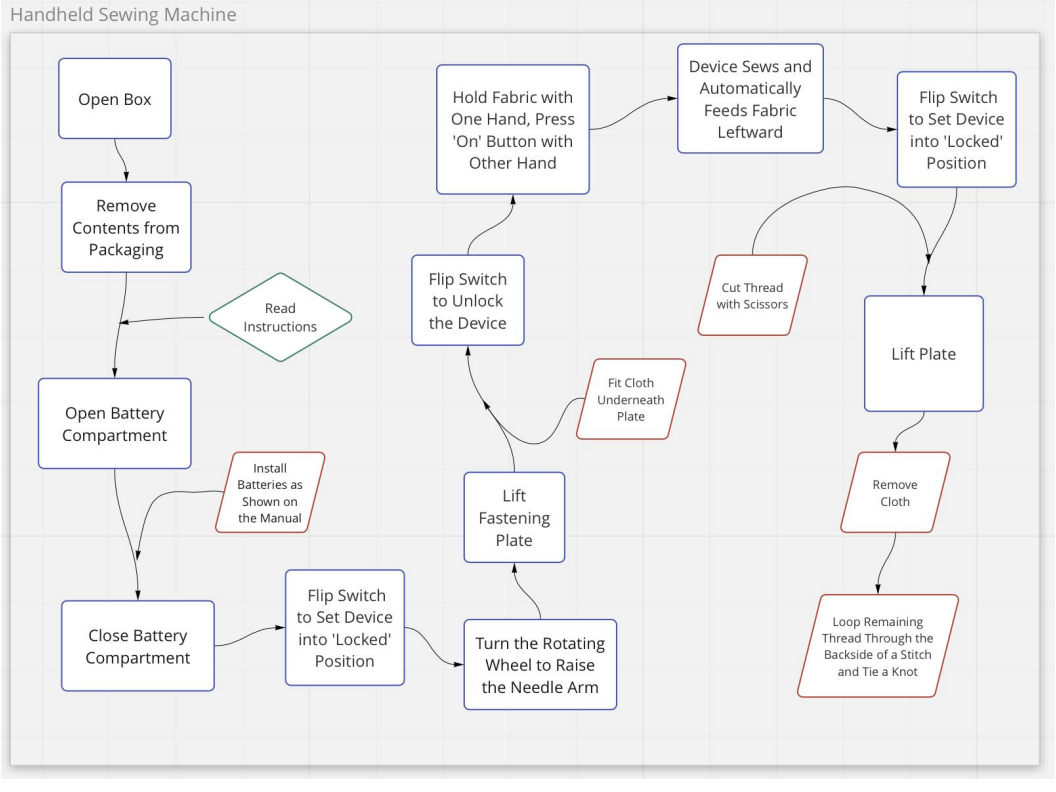
6. Sews

- Holds fabric with left hand, presses on button with right hand
  - Nothing happens
- Unlocks the device by moving the switch from the locked position and then pushes start button
  - Machine starts to sew
  - The machine feeds the fabric in one direction
  - Almost runs out of fabric because she didn't realize it would sew in that specific direction
    - Reads directions and realizes it tells direction of sewing machine

7. Finishing the sewn piece

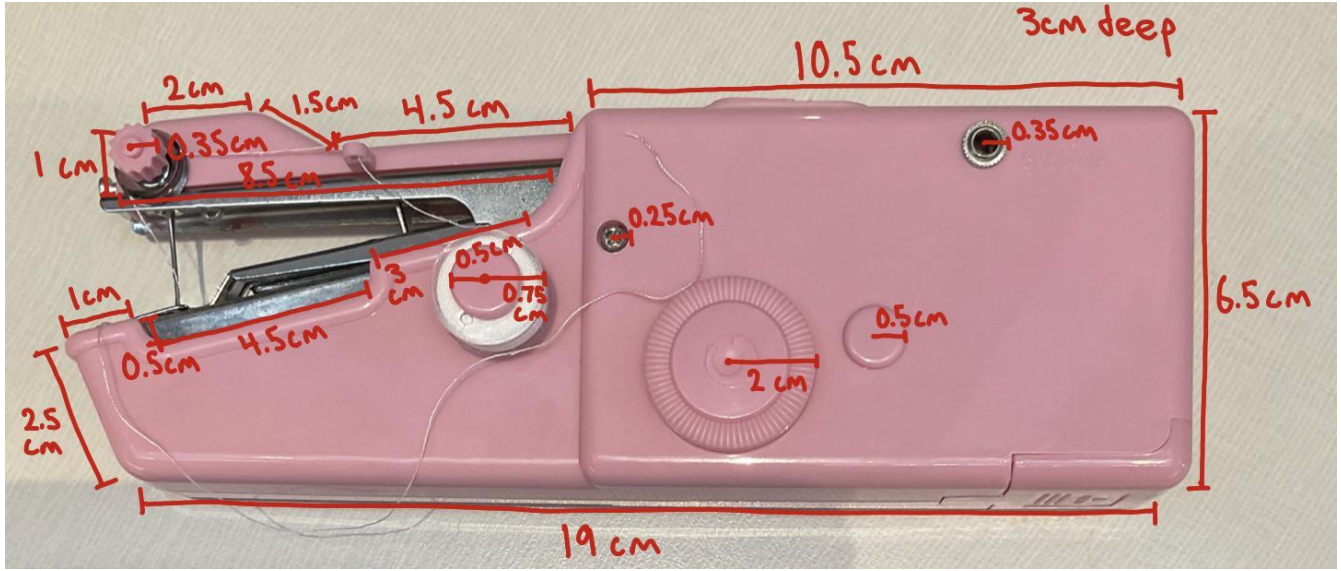
- Sets the device into the locked position
- Runs to get scissors
- Cuts thread from the cloth
- Lifts plate and removes cloth
- On the reverse side, loop remaining threat through a stitch and tie a knot

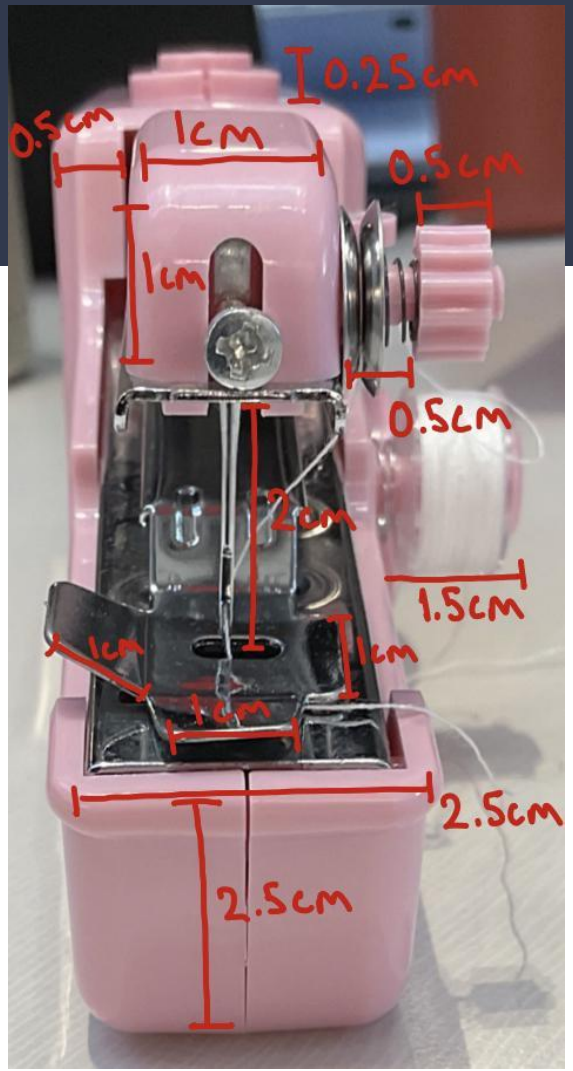
D) Task Analysis



E) External Product Overview

Measurements





E) External Product Overview

<u>Affordances & Visual Cues</u>

Usage:

- The sewing machine is very unwieldy, being a large brick with no human-centered design elements (textured grippy surfaces, physical handles, etc)
- The power button is relatively inconspicuous as well, being on the top of the machine and relatively subtle (same color and material as the rest of the product, with no labeling)
- However, the product packaging does demonstrate how to hold it

Power:

- There is a tab on the bottom with a textured groove and arrow that says OPEN
- From previous use of battery-powered electronics, we can assume this is where batteries are inserted
- However, there is also a charging port, although no documentation makes any mention of this (perhaps for in-factory testing?)

F) Off-nominal Use

1) Sewing non-fabric materials
   - The product is advertised as being able to sew fabric as thick as denim, so it would be off-nominal use to sew thicker materials like rubber or plastics
   - This could result in the small needle not being able to pierce the fabric, or the motor encountering difficulties pushing the needle through
2) High-quality projects
   - The sewing machine is not a high-end product; it is very cheap and clearly not well made, and its advertising promotes it as “Fun, Fast, & Easy”, not incredibly precise or high-performing
   - This may mean it will not create the ideal stitches for very high-quality projects, although it would not create problems within the sewing machine itself
3) Medical usage
   - The sewing machine is quite cheap and would not do well for high-risk situations like stitching a wound up
4) As a brick
   - The machine is very rectangular, so it might invite usage as an improvised prop in various situations, but it is very flimsy and light and likely cannot support high forces
5) As a toy
   - The machine is marketed as a fun, easy, and cheap product, so one might use it as a toy for kids
   - This is not ideal, as it presents several electrical, mechanical, and choking hazards

G) CONOPS

Purpose:

- The purpose of the handheld sewing machine is to provide a cheap and portable alternative to traditional sewing machines. It allows users to repair and sew together delicate fabrics.

Target Audience:

- Largely intended for novice or beginner sewers looking for a quick and portable option for sewing.
- Cheap alternative that allows people to transition from hand sewing to machine sewing
- For any sewer with limited space or travel frequently
- Any hobbyist or DIY oriented individuals who might need a sewing alternative to repair or modify clothing

Conditions of use:

- Virtually anywhere - the main selling point of this product is that it is portable, handheld and cordless.
- Ideally, the product should be used indoors with good lighting and ventilation.

Limitations:

- The product is designed to be used with your right hand on the machine and the other directing the fabric through the machine. It requires fine and accurate motor skills (difficult to use for those with fine motor skill problems or left-handed users who do not have as much control with their non-dominant hand)
- Sewing machine makes weak and loose stitches which could fall apart easily if the stitches are not made correctly; additionally unable to stitch thicker pieces of fabric
- The product cannot be used underwater; users should also avoid areas that would cause large particles to get within the sewing machine (this could interfere with the gear system and motor functioning)

G) CONOPS cont.

Workflow:

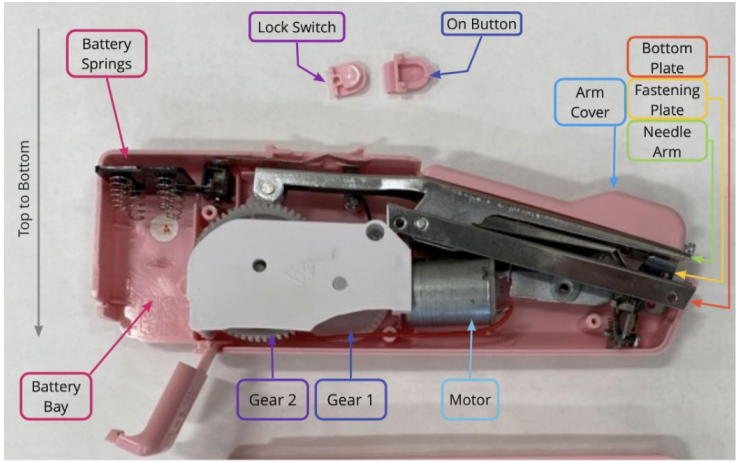
Initial setup:

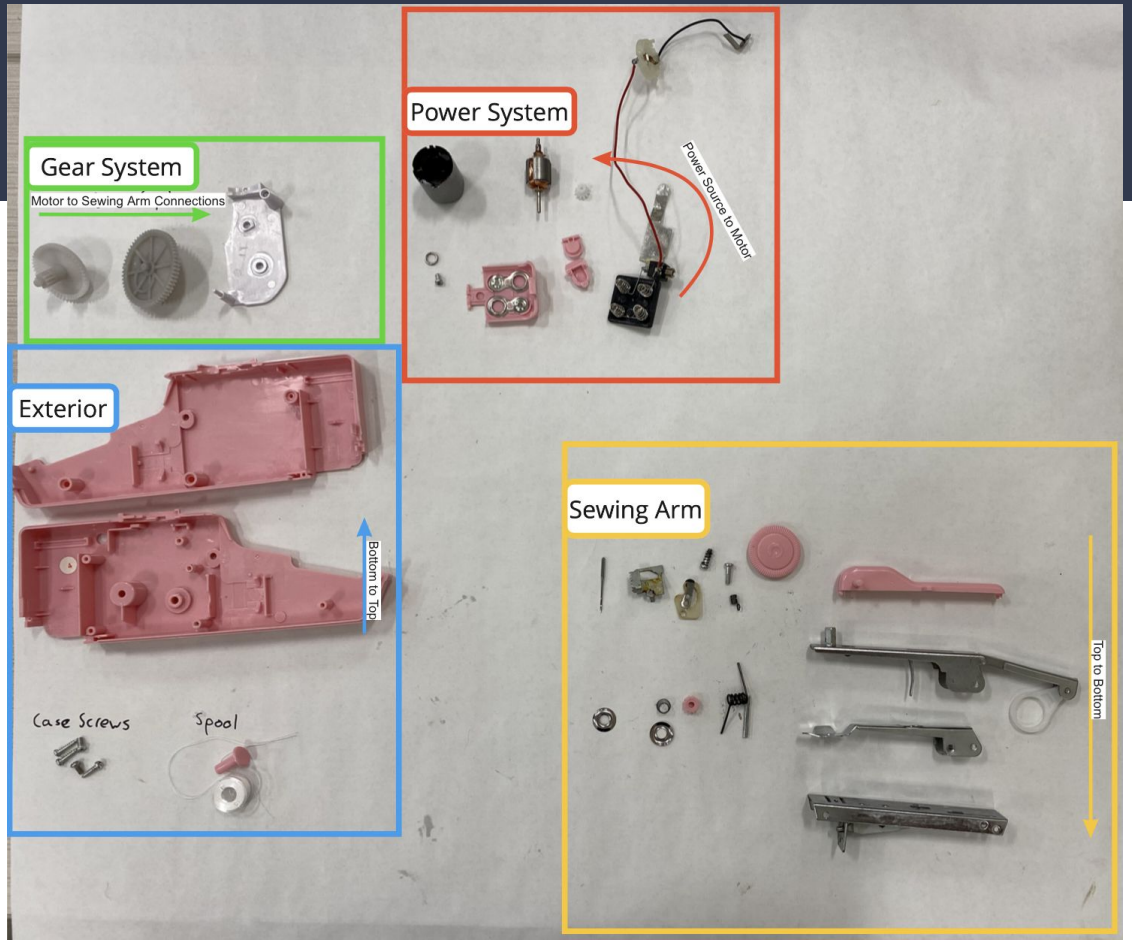
1. Remove contents from the box
2. Insert batteries into the sewing machine
3. Make sure the machine is in the locked position
4. Remove the pre-stitched cloth and/or change the thread to the desired color
5. Using the rotary wheel, raise the needle arm to the highest position

Machine use:

1. Lift the fastening plate and plate cloth underneath the plate
2. Pull at least 2 inches of thread through the needle
3. Unlock the sewing machine
4. Gently pull the cloth using your left hand to create tension between the cloth and machine
5. Using your right hand, press the power button and feed the cloth through the machine from left to right (lifting your finger from the button will cause the machine to stop
6. Once the seam is complete, raise the needle to the highest position using the rotary wheel.
7. Use scissors to then cut at least three inches of thread from the seam.

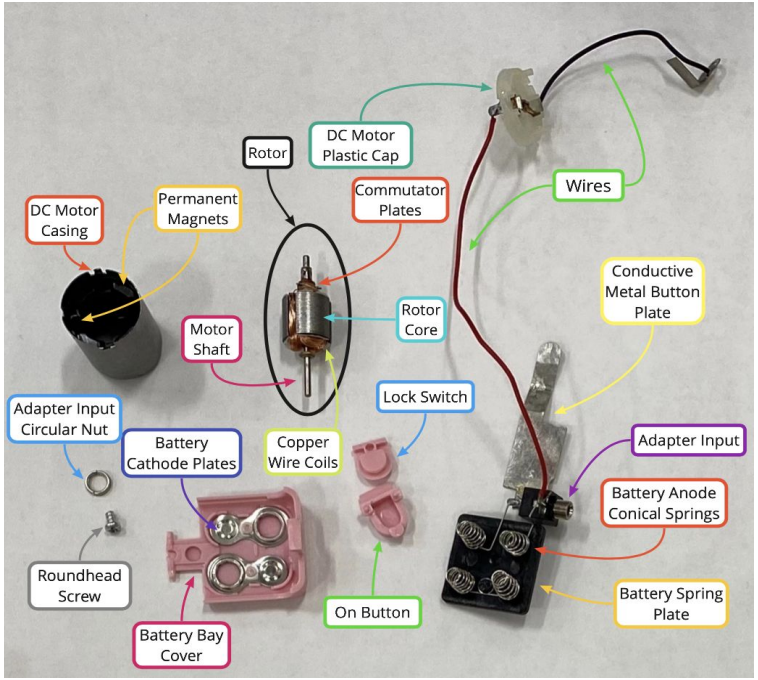
H) Exploded View



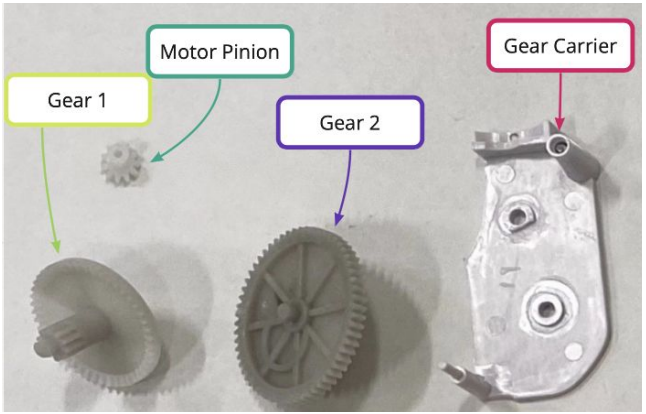


H) Exploded View (Subsystems)

Power System

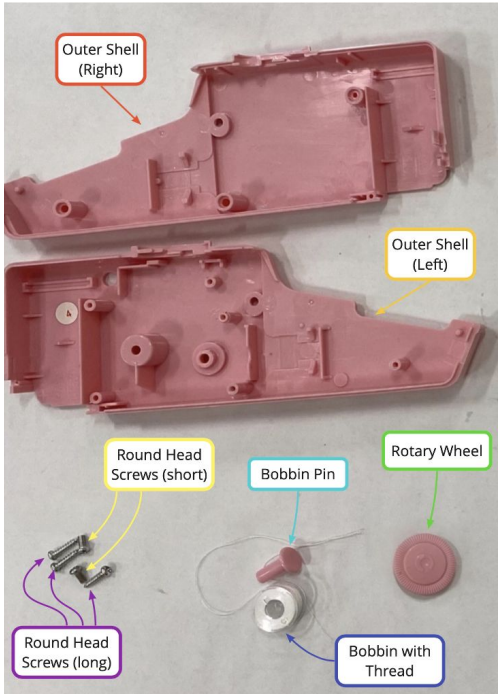


Gear System

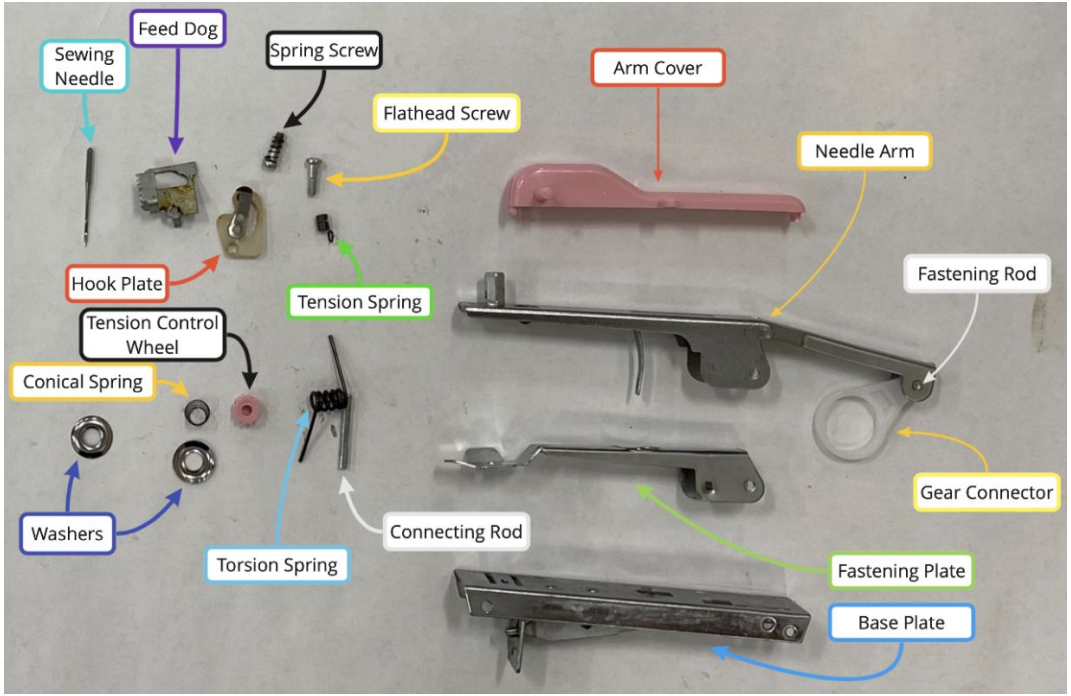


H) Exploded View (Subsystems)

Exterior



Sewing Arm



I) Product Decomposition

See attached PDF for full Product Decomposition

Product Decomposition

Design Organization: ME40 Lab 5: Group #37	Date: 3/11/21
Product Decomposed: Handheld Sewing Machine	

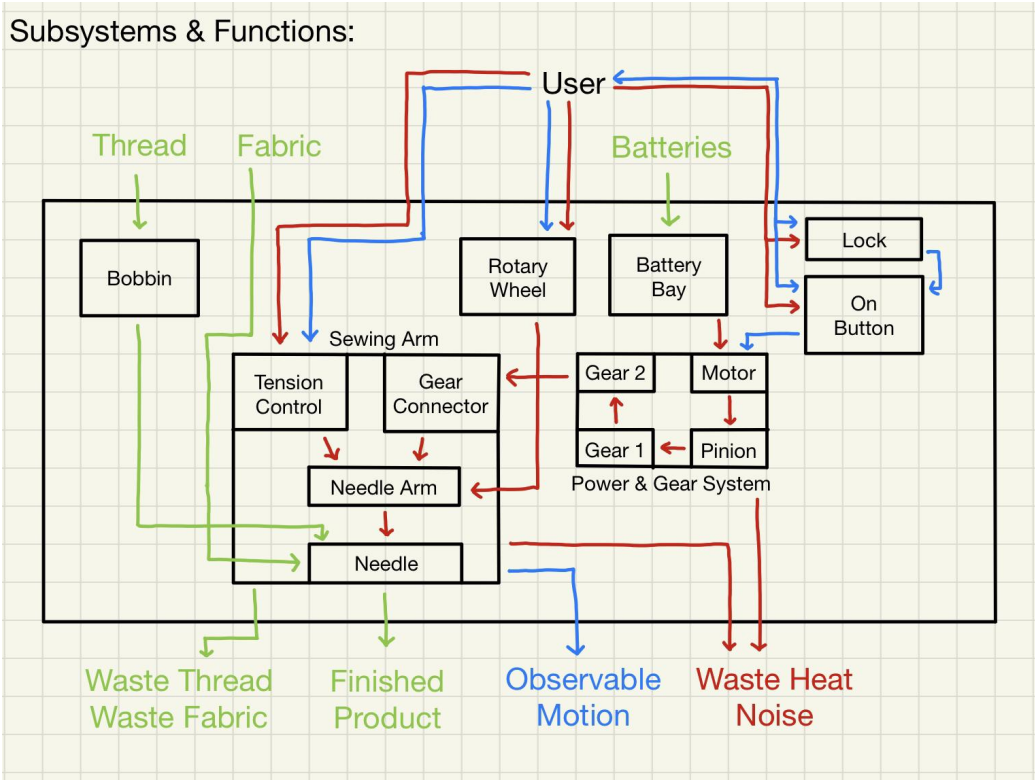
Description: This is a portable, battery-powered, handheld sewing machine.

J) Function Structure (Black Box)

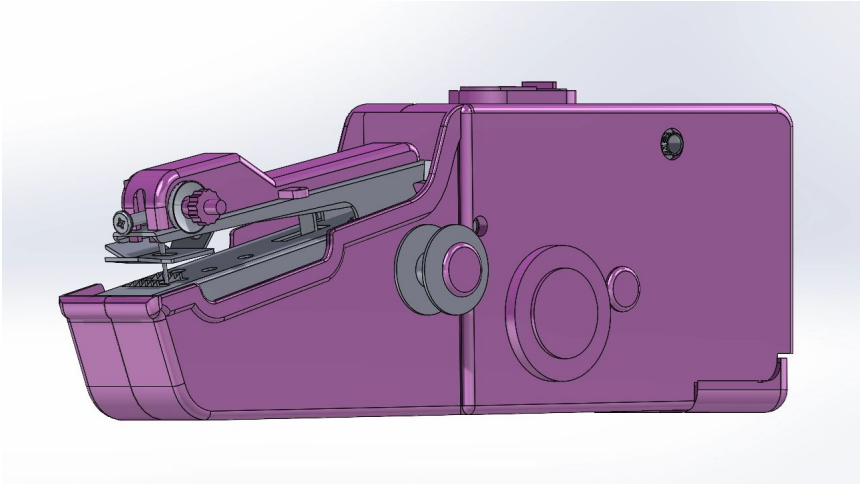
Color Key: Information Energy Materials

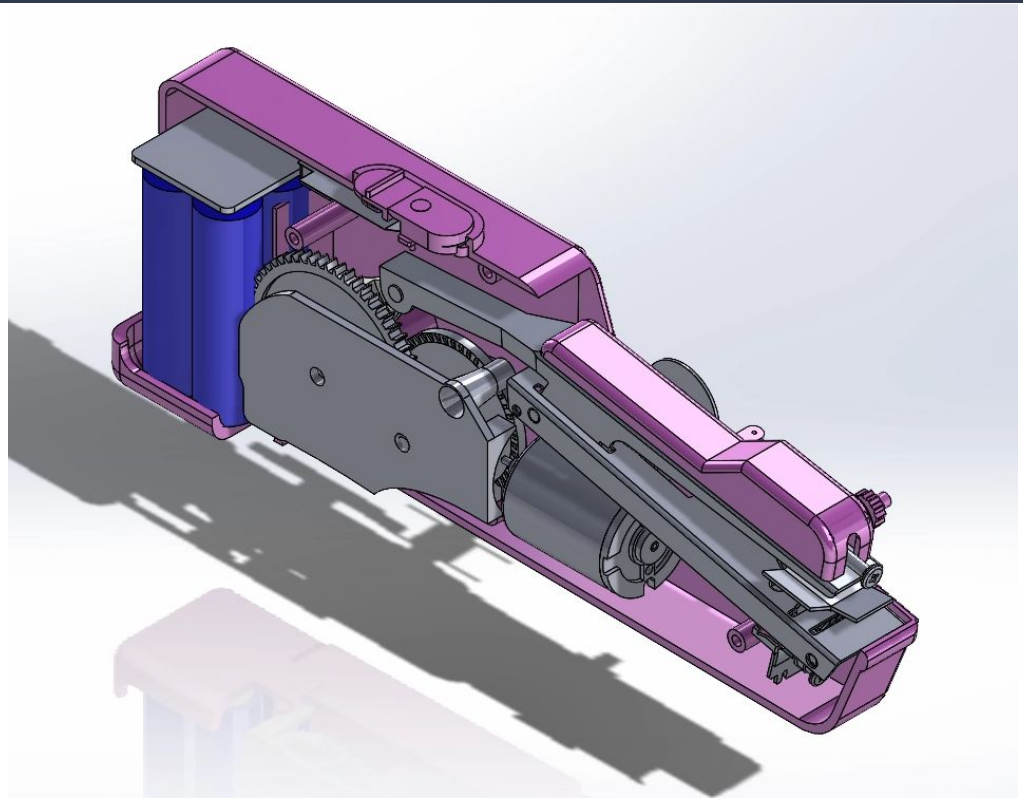
Black Box:

J) Function Structure (Full)

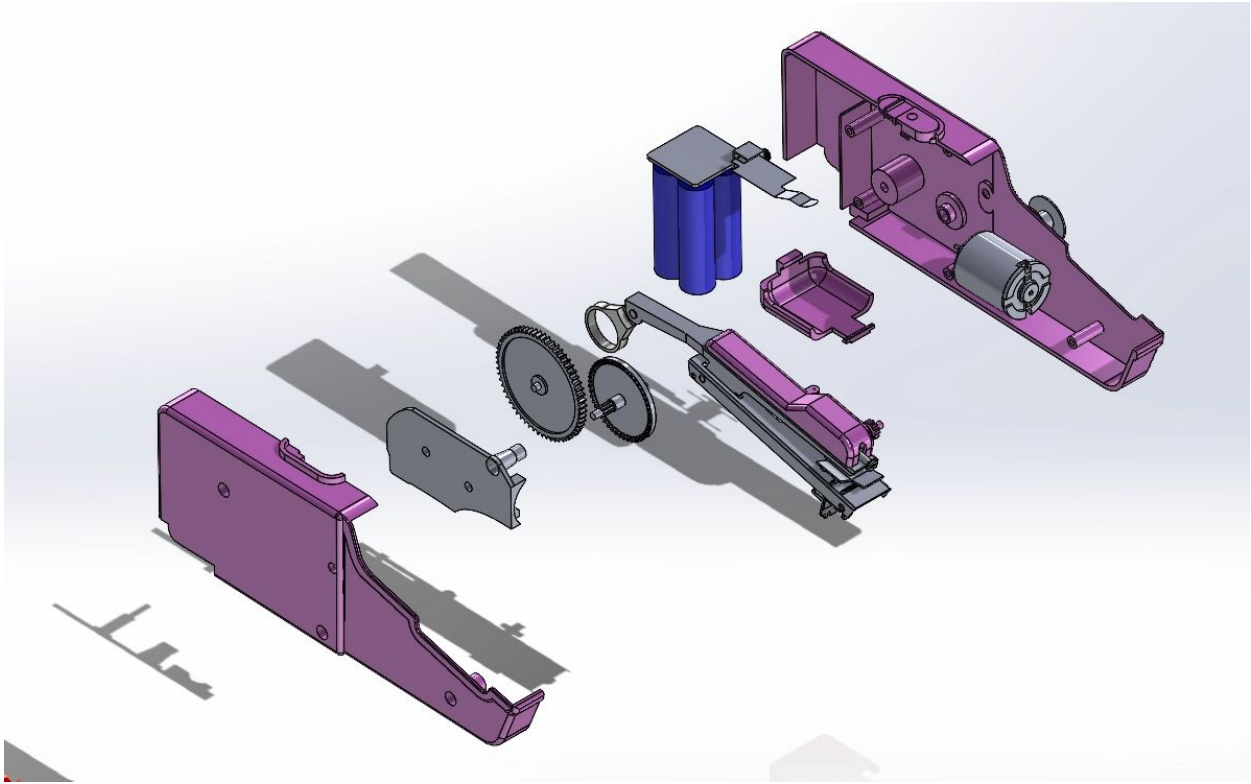


K) CAD Model (Assembled View)





K) CAD Model (Exploded View)



Part II: Redesign for Accessibility

Framing the Design Problem

Target Problem: Emily is a 24 year old college student who has cerebral palsy. We've been tasked with redesigning and modifying a handheld sewing machine so that Emily can easily use it independently.

Persona Overview:

- Frustrations:
  - Coordination problems and shakiness with hands
  - Difficulty with fine motor skills (aligning fabric and sewing)
  - Requires two hands to sew
- Goals:
  - Be able to sew independently and accurately
  - Confidence and ease in using the product

Condition Analysis: Ataxic Cerebral Palsy:

- Developmental disorder, that causes damage to the cerebellum.
- Difficulty in maintaining balance and posture; coordination and voluntary movements; learning fine motor skills; cognitive functions
- Difficulty performing tasks requiring fine motor skills (uncontrollable shaking, erratic movements)

Framing the Design Problem cont.

Risk Matrix:

Severity/Probability	4 (High)	3	2	1 (Low)
>95%			- Inability to stop the machine and sewing where they don't want to sew - Difficulty ending the stitch	- Loss of control of device and sewing in an unintentional pattern - Inability to thread the needle
75%				
50%	- Dropping the needle			
25%	- Slipping and injuring oneself with the needle	- Dropping the device while turned on - Getting hair or other unexpected material caught in the machine		
<5%				

Problem Statement:

Our client, Emily, has the problem that her cerebral palsy prevents her from operating a sewing machine in her house. Our solution should deliver a way for her to sew independently given her ability needs.

Customer Requirements/Needs

Operational Requirement
Sewing and repairing fabrics independently with minimal effort

Functional Requirements
- Lightweight and portable
- Makes stitches
- Receive power
- Interchangeable spool/thread
- Can fit different fabrics of different thickness
- Able to insert and remove fabric
- Feeds fabric through device to make a row of stitches

System Requirements
- Compliance (CPSC guidelines)
- Usability (ease of use)
  - Minimal number of steps to operate
  - Low reliance on fine motor skills
  - Minimal force to operate
- Accessibility to operate
  - Lightweight and appropriate size to carry
  - Ability to turn on machine and guide fabric using gross motor movements
  - Limited range of motion for operation
- Safety
  - Ability to lock off when not in use
  - Stability to prevent slippage
  - Guards to prevent risk of needle error
- Durability (remain functional without frequent repair; should not break from constant use or minor damage)
- Reliability (works under certain conditions in a specified amount of time)
- Accuracy (needs to create stitches where the user wants)

Market Research

Needle Threader: this product provides a more efficient way of threading a needle. The user can simply insert a needle and thread into a hole, and press a button to thread it.

- The product is rated 4/5 on Amazon, however, there are mixed ratings primarily due to differences in needle eye openings. For oval needles, the product seems to work great but when smaller needle eyes are used, failures occur more frequently
- This feature/product could possibly be incorporated into the modified frame of the sewing machine to facilitate in threading the needle for sewing.
- This product had an interesting feature in which you could simply insert a needle into a hole where it would automatically be aligned to where the thread would be inserted.

Fabric/seam guide: this product can be magnetically attached to the surface of where the sewing occurs. It would facilitate in guiding the fabric through the sewing machine and creating more accurate stitches.

- This product is rated 4.4/5 on Amazon. For the most part, it is effective in creating straight seams and keeping the fabric in place due to the magnetic. There are difficulties, however, with the magnet not working or occasionally falling off.
- This product could be incorporated either on the modified frame or separately as a way of aligning the fabric. Since our modification will likely not include a metal surface, it would make more sense to build a seam guide into the frame rather than relying on a magnet.

Market Research cont.

Wireless charging - to replace hard to insert batteries: wireless charging would allow the sewing machine to charge without having to physically insert a charging cable or reinsert batteries.

- Rated 4.2/5 stars on Amazon, however, a large portion of the reviews are negative. It is noted as being fragile, unreliable, short-ranged and not lasting long.
- This feature could be added to the existing power system of the sewing machine to enable wireless charging. Rechargeable batteries could also be used so that the batteries would not have to be replaced. This would allow our user to simply place the product over a charging station in order to power it.

Engineering Specifications

System	Operational Requirement	Functional Requirements	Performance Requirements
Handheld Sewing Machine	To sew and repair fabrics independently with minimal effort	• Lightweight and portable • Ability to operate with minimal fine motor skills and low two-handed dexterity • Adjustable fastening plate to secure the fabric • Gear system to create motion for stitching • Movable needle arm to be able to insert/remove fabric • Feed dog/hook plate mechanism to feed the fabric through	• Accurate stitches up to 1 cm from the desired stitch path • Makes 4±1 stitch per second **Anthropometric Considerations:** - Hand breadth (grip the case) - Hand length - Thumb breadth (press on/off button) - Thumb-tip reach

Idea Development

Initial Brainstorming:

- Product needs to be stable (should have some sort of support surface rather than just having the person use their hands)
- Needs to be lightweight and easy to use
- Activation (on/off) should be easy and effective - contributes to independence of use
- Should not rely on any additional power sources other than the sewing machine itself (batteries)
    - Requires mechanical energy

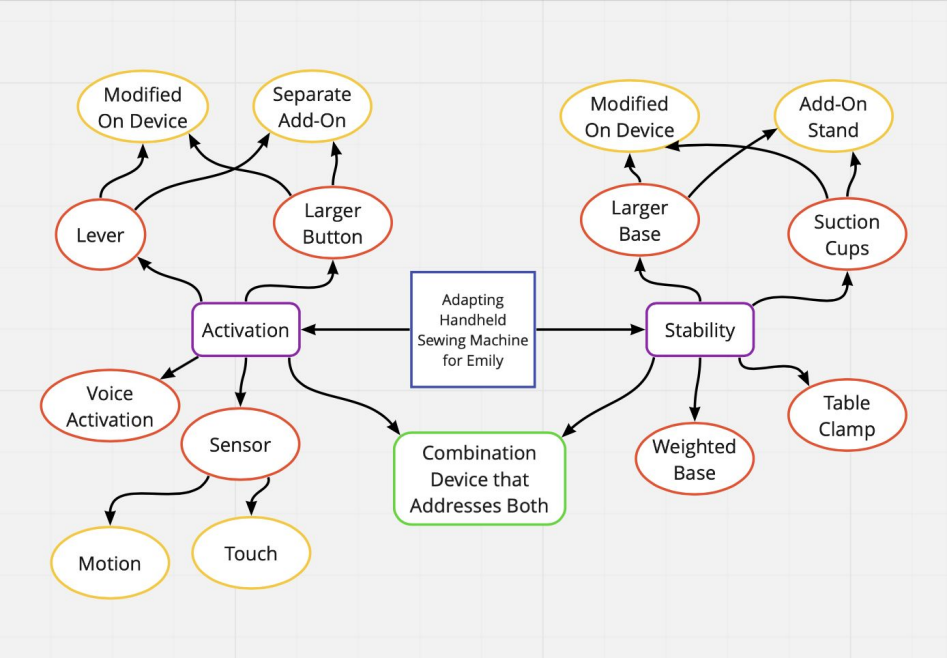
Physical Changes to Product:

- Might be more costly and difficult to change the product itself, therefore add-on modifications might be more effective
- A key element would be to increase the size of the buttons and increase stability to make it more accessible to Emily

Idea Development cont.

Specific Ideas:

- Idea development quickly focused on methods of solving distinct issues, such as stability and ease of activation
- Instead of coming up with many entirely separate solutions, small solutions to individual problems were developed
- This eventually led to two separate down selection processes, as one idea from each down selection could be combined into a superior final product
- Stability revolved around methods to keep the sewing machine attached to a flat surface while in use
- Ease of activation centered on minimizing effort needed to operate the machine given the client's physical disabilities



Down Selection: Stability

1. **Datum:** normal sewing machine
2. **Modified case:** the case itself has a larger weighted bottom to keep the sewing machine stable
3. **Table Clamp:** table clamps on the machine attached to the frame of the sewing machine
4. **Add-on base:** larger base that can be attached to the sewing machine and has four suction cups to keep it in place.

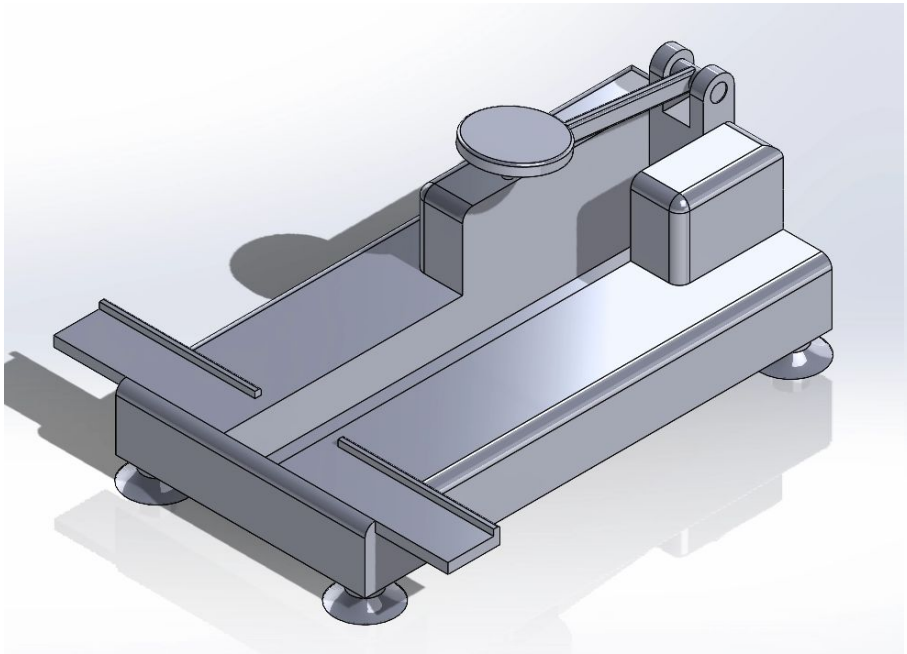
				Modified Case		Table Clamp		Add-On Stand	
	Weight Factor	Scaled Factor	Sewing Machine	Value	Scaled	Value	Scaled	Value	Scaled
Reliability	3	0.13	0	-1	-0.13	-1	-0.13	0	0
Stability	5	0.22	0	-1	-0.22	-1	-0.22	0	0
Size	3	0.13	0	1	0.13	1	0.13	1	0.13
Weight	3	0.13	0	1	0.13	1	0.13	1	0.13
Usability (Ease of Use)	4	0.17	0	0	0	-1	-0.17	0	0
Price	2	0.09	0	1	0.09	1	0.09	1	0.09
Durability	3	0.13	0	-1	-0.13	-1	-0.13	0	0
Total Score					-0.13		-0.3		0.35

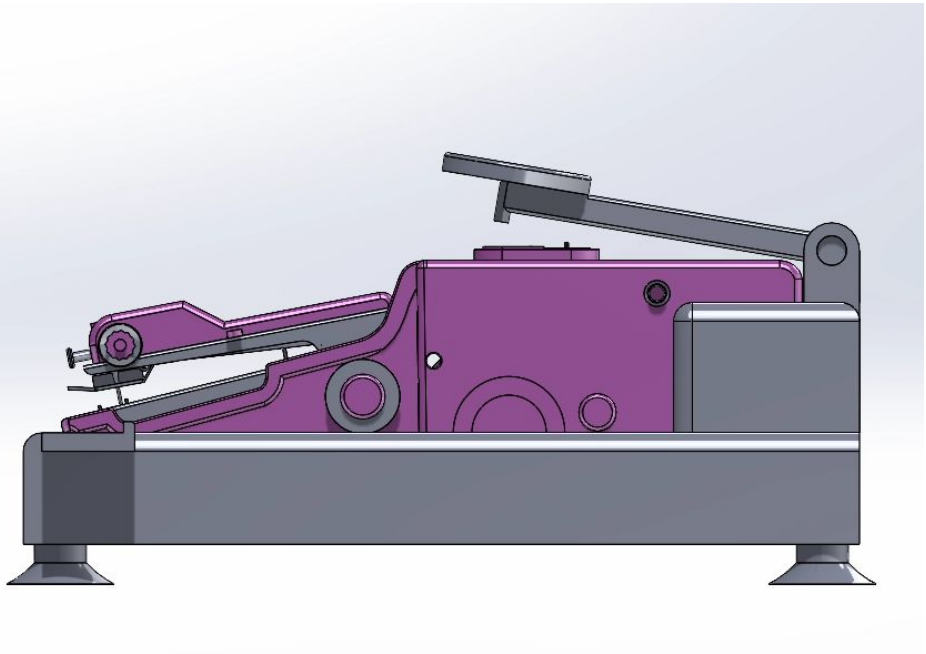
Down Selection: Activation (Facilitate On/Off)

1. **Larger Button (Datum):** larger button attached to the existing sewing machine to allow for easier activation
2. **Voice activation:** user can use voice activation such as Alexa to control the sewing machine
3. **Lever:** lever mechanism attached to the frame of the sewing machine
4. **Touch Sensor:** touch sensor replaces the on/off button and simply requires user to touch the sensor

				Voice Activation		Lever		Sensor	
	Weight Factor	Scaled Factor	Big Button	Value	Scaled	Value	Scaled	Value	Scaled
Reliability	3	0.14	0	-2	-0.28	0	0	-2	-0.28
Usability (Ease of Use)	4	0.18	0	1	0.18	-1	-0.18	0	0
Price	2	0.09	0	-3	-0.27	0	0	-2	-0.18
Physical Effort	4	0.18	0	2	0.36	-1	-0.18	2	0.36
Effectiveness	3	0.14	0	-1	-0.14	0	0	0	0
One-Handed	4	0.18	0	2	0.36	-1	-0.18	0	0
Independence	2	0.09	0	-3	-0.27	0	0	0	0
Total Score					-0.06		-0.54		-0.1

Final Prototype (CAD Model)





CAD Model with sewing machine inserted

Final Prototype

The final prototype combines the add-on stand and enlarged button ideas from the separate down-selection processes. As one can see, the sewing machine is inserted into the open slot, and the base is secured via suction cups onto a flat table. An arm with a large button swings down for easier activation. The structure itself also includes a small guide rail and platform for the fabric to rest on; this draws inspiration from the fabric guide discussed in the market research. By mounting the sewing machine to a base, this also removes the downside of the original machine being unsuitable for most hand geometries.

This does make the handheld sewing machine much more similar to a traditional sewing machine, but given our client's disabilities, handheld operation would likely be difficult anyways. We believe that this prototype maintains the other benefits of the handheld sewing machine as compared to a traditional sewing machine, as it is small, affordable, simple, lightweight, and can be used without a power outlet, without adding excessive cost and complication.

Final Prototype Reflection

While our prototype is a suitable modification to the original sewing machine to accommodate for our client's needs, there are several areas for further improvement. However, one would have to keep in mind that these further modifications would also increase cost and complexity, two major benefits of the original handheld sewing machine.

- Replace difficult-to-install batteries with a rechargeable battery, integrate a wireless charging coil
- Reduce overall base size and instead use folding arms with suction cups at the end that expand for a greater effective base area
- Have fabric guides fold inwards to minimize footprint, aid easy storage