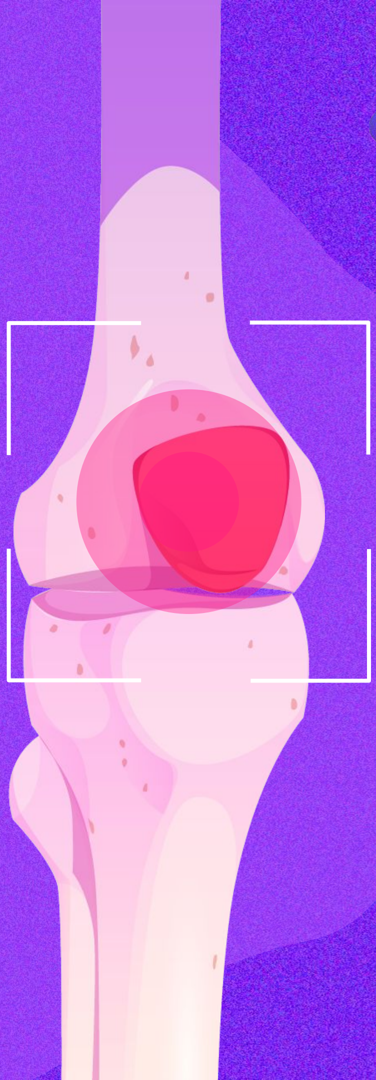
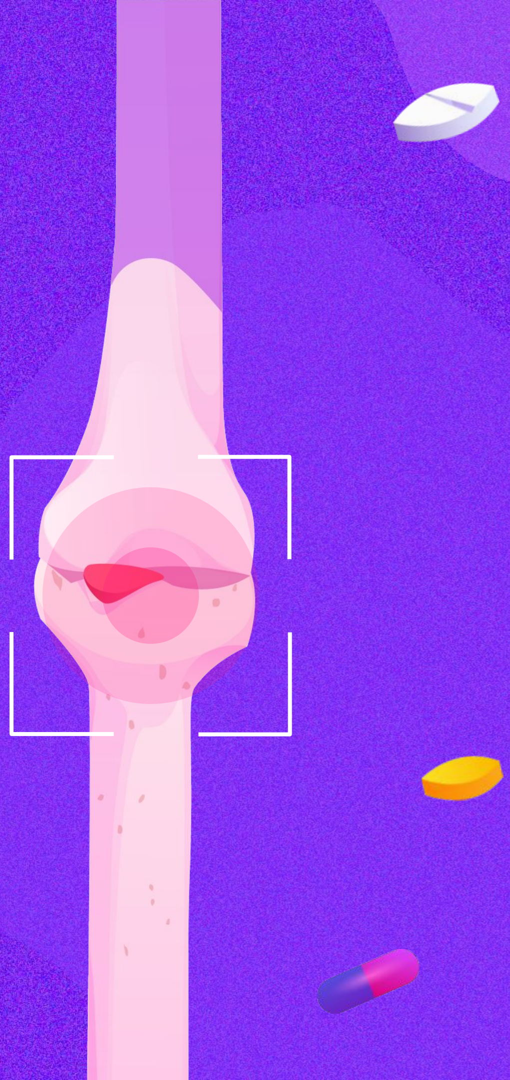


Streamlining Cordage Weaving for Osteoarthritis Relief

Beta Release Presentation

Opportunity Statement

"This opportunity focuses on assisting individuals with osteoarthritis within the Toronto Guild of Spinners and Weavers to make cordage-making less strenuous"



CONTEXTUALIZING THE OPPORTUNITY

WHAT IS OSTEOARTHRITIS?

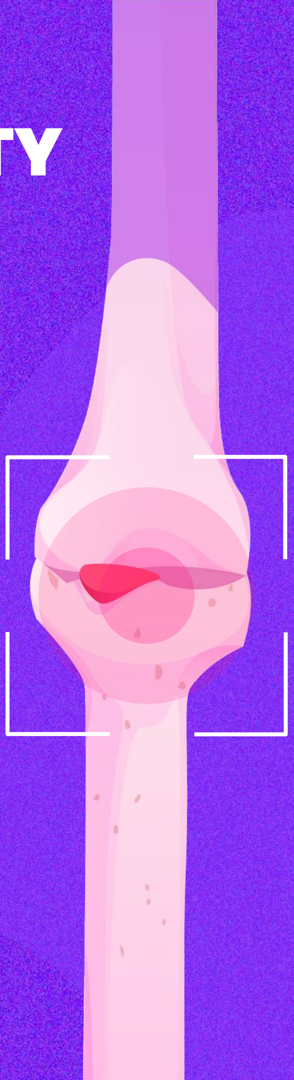
Degenerative joint disease in which tissues in the joints break down over time

HOW DOES IT IMPACT CORDAGE MAKING?

- Fine motor skills obstructed → difficult for making Cordage

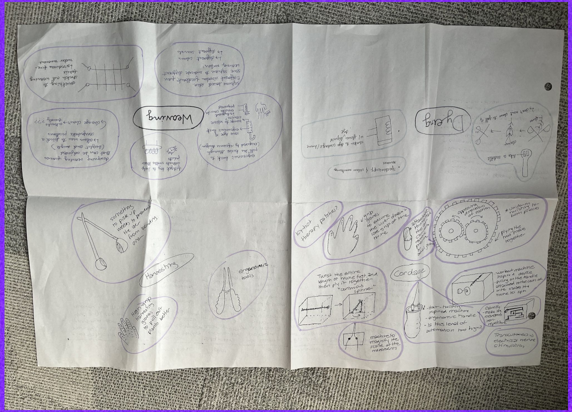
HOW CAN IT BE TREATED

Heat/Cold Therapy, ergonomic tools, massages

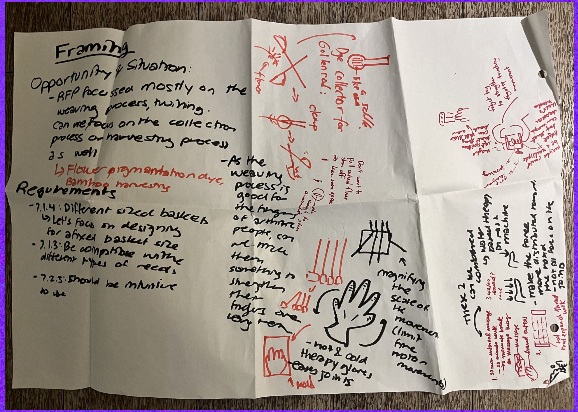


Cordage Making

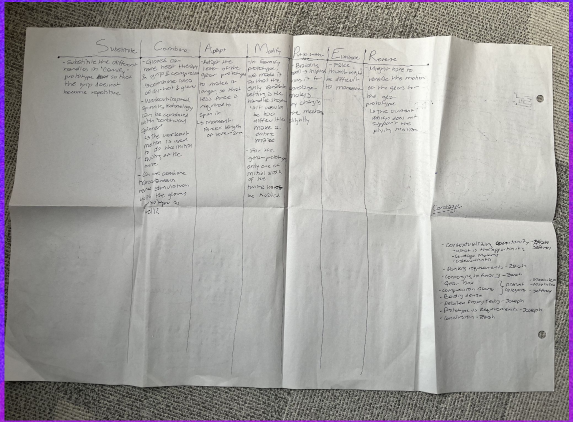
Diverging Tools



Lotus Blossom



Brainwrite 365



Scamper

Ranking the Requirements

Objectives	Justification on change	Metric	Criteria/Constraint
1. Should minimize force on thumb joints during cordage-making	Kept this (modified it to focus on the thumb joints in particular as it is the most affected)	Gripping Pressure (kPa)	**Constraint:** The pressure should not exceed 0.4 kPa. Criteria: The lower the effort required, the better
2. Should minimize repetitive movements in comparison to the original tool	Repetitive motion can worsen symptoms of osteoarthritis	Maximum time spent doing a task without breaks compared to without the tool (s)	**Criteria:** The less, the better
3. Should reduce fine-motor movements for user	Based on research on osteoarthritis– fine motor skills are obstructed, making it difficult to perform everyday tasks such as tying shoelaces.	Scale/Magnitude of movement	**Criteria:** The less, the better
4. To increase the speed of cordage making	Based on stakeholder needs (Interview with Miriam)	Time it takes to make cordage (s)	**Criteria:** The more faster it is, the better
5. Should not be fully automated	Based on Stakeholders needs [Miriam]	Levels of Automation (Levels 1-5) Pass/Fail	**Constraint:** Must not exceed Level 2
6. Should be intuitive to use	As the majority of the primary stakeholders are older people with arthritis, products should be intuitive to use.	The time it takes to learn (minutes)	**Criteria:** The less time, the better **Constraint:** Must not take more than 30 minutes.
7. Should accommodate varying lengths of cordage	Based on Stakeholder needs [Miriam] (that is how long cordage is usually woven)	Length (m)	**Constraint:** Should be able to accommodate 1m and below

Our final three prototypes

Criteria	Gamify design	Compression/Temperature Gloves	Gear Idea	Continuous Spinner	Thermal Camera based App	Braiding Spinner
Not Automated	Better	Better	Better	Better	Worse	Better
Non repetitive movement	Worse	Same	Better	Better	Same	Better
Accomodate the length of cordage	Same	Same	Same	Same	Same	Better
Intutitve to use	Worse	Better	Same	Same	Same	Same
Not much force on the thumb joint	Better [different exercises to relieve arthritis]	Better	Better [pressure distributed throughout the hand]	Better	Worse	Better
Speed up the process	Better [but something that needs to be proxy tested]	Same [but something that needs to be proxy tested]	Better [but something that needs to be proxy tested]	Better [but something that needs to be proxy tested]	Worse	Better [but something that needs to be proxy tested]
Less fine motor movements	Better	Same	Better	Better	Same	Better

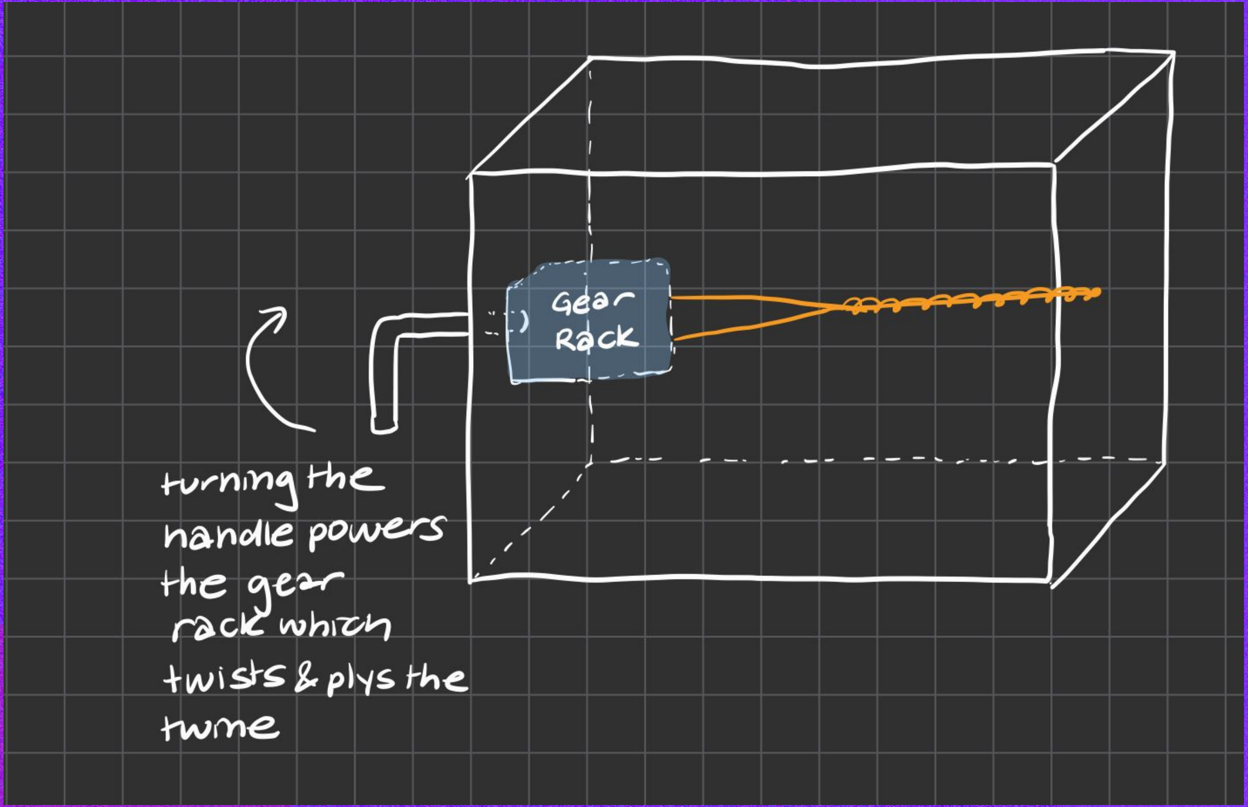
01 GearBox

02 Compression Gloves

03 Braiding Spinner

Gear Prototype

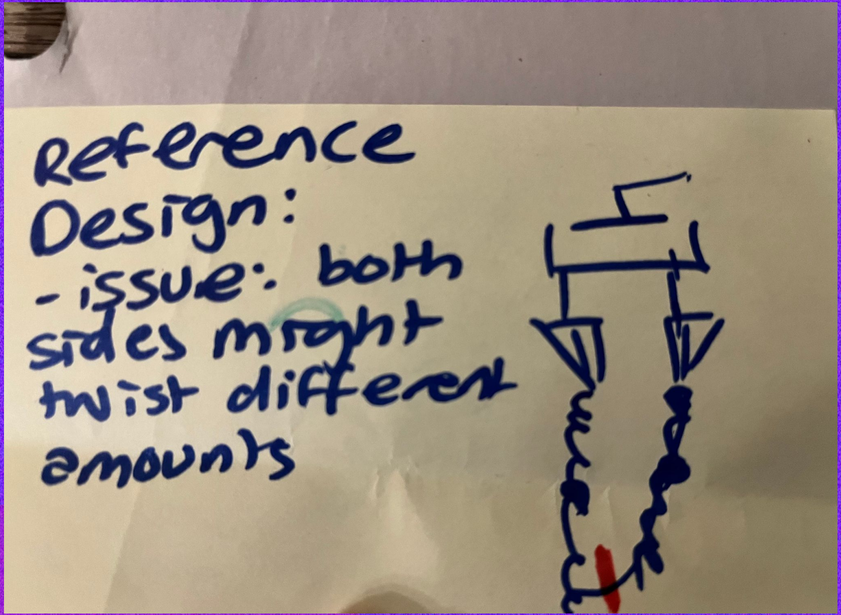
Idea


Gear
Rack
turning the
handle powers
the gear
rack which
twists & plys the
twine

Justification Through Research

Current Cordage Making Process	Cordage Making Using the Gear Box
Extensive Fine Motor Motion 1. People Osteoarthritis have functional ability in their hands and their fine motor ability is limited 2. Fine motor movements put extensive pressure on a single joint, which can worsen the condition of that joint	**Handle-Turning Motion** 1. Mirrors the exercises which are beneficial for people with arthritis  

Reference Design

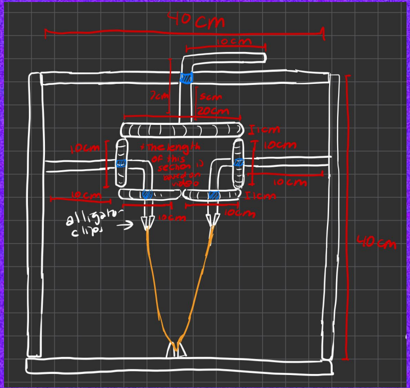


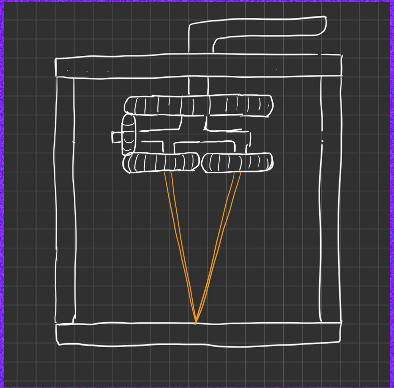
What is it?
Design obtained through communication with the community -> a current alternative to traditional cordage making

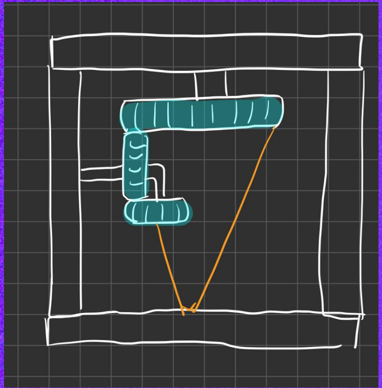
What does it do?
Contains two binder clips attached to handles that the user can turn

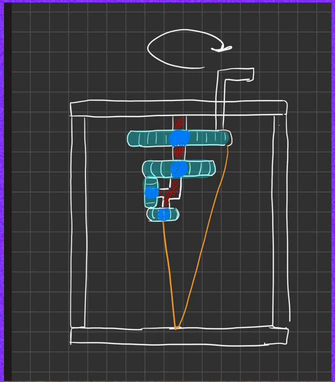
Pros	Cons
Magnifies the size of the movement -> not fine motor	1. Does not guarantee that the two clips spin the same amount 2. Only does twisting motion

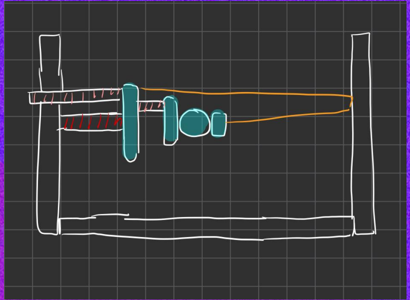
Iterations

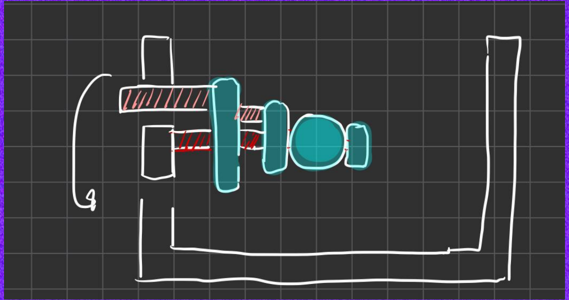

40cm
10cm
7cm
5cm
20cm
1cm
10cm
*The length of this section is based on video
10cm
10cm
1cm
10cm
10cm
10cm
alligator clips
40cm

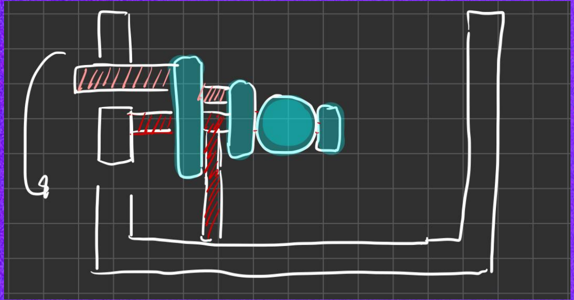




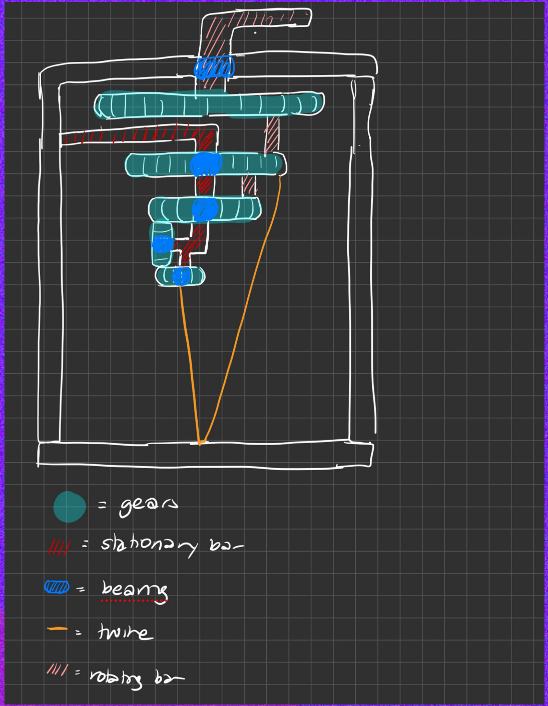




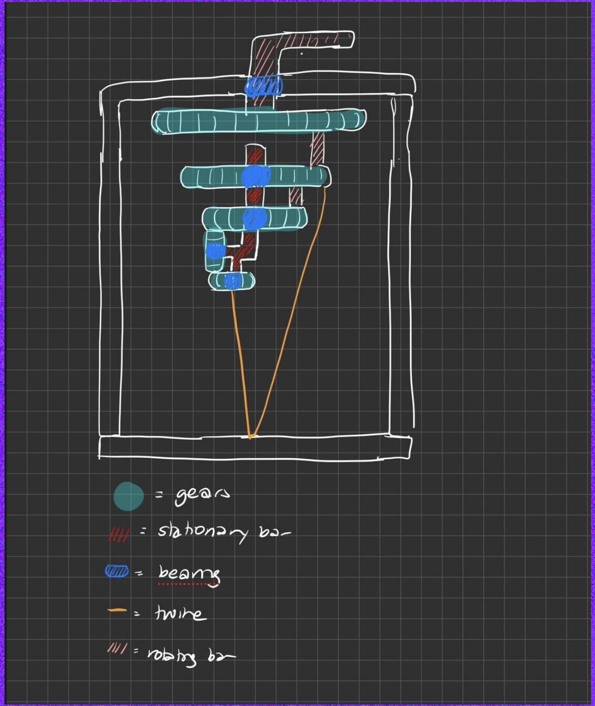




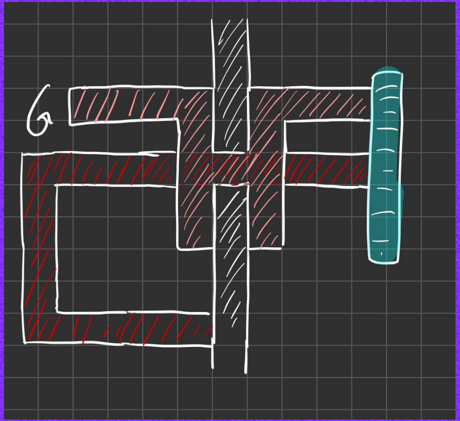
Iterations

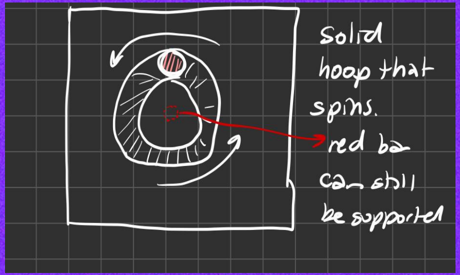


= gears
= stationary bar
= bearing
= twine
= rotating bar



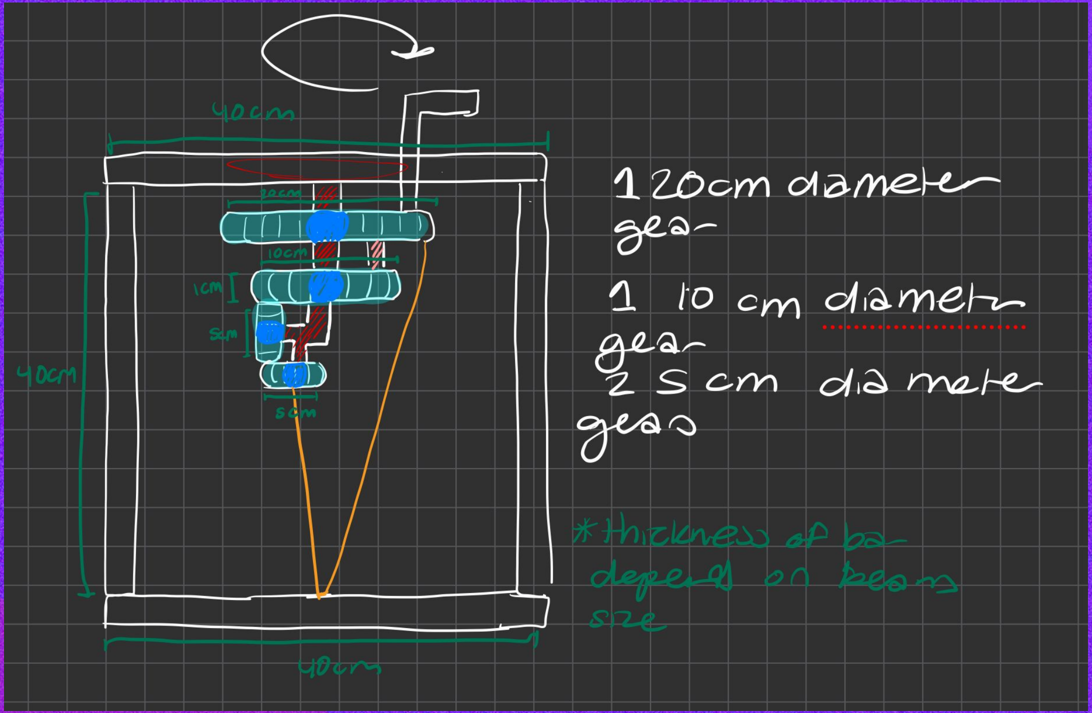
= gears
= stationary bar
= bearing
= twine
= rotating bar

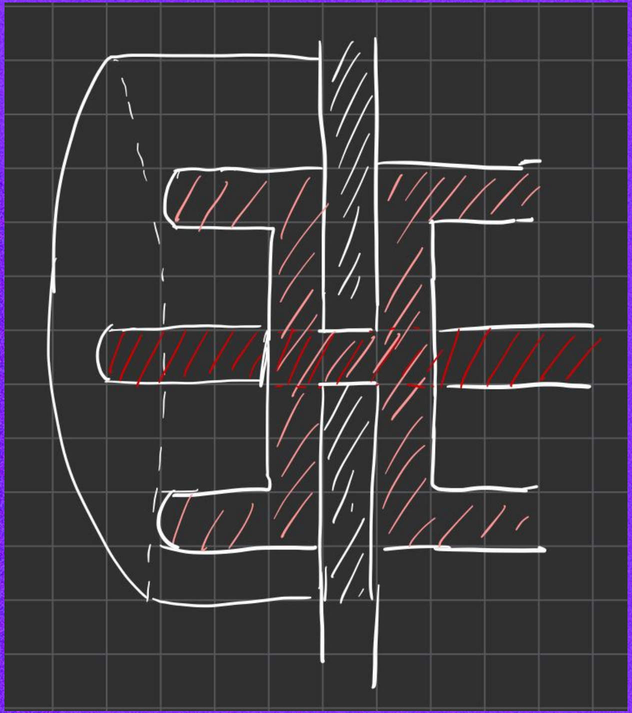




Solid hoop that spins.
red bar can still be supported

Final Design

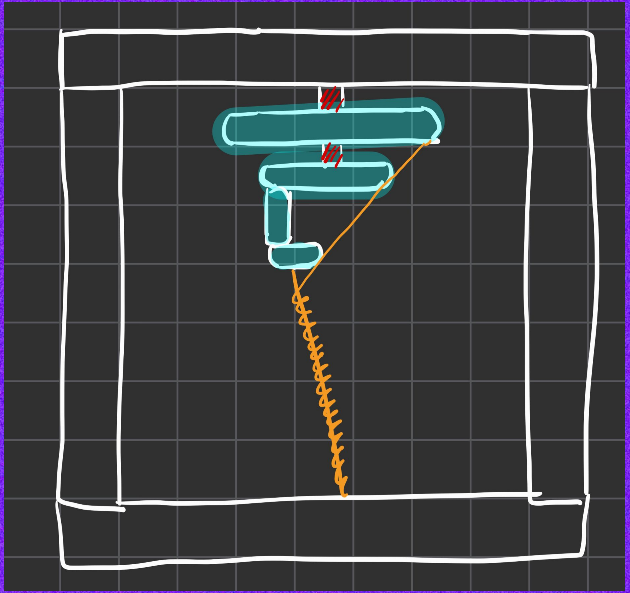




Future Considerations

Sustainability:

- Current design suggests that there would be wastage in the longer piece of twine
- The twine would be unable the twist the full amount as it would start getting impeded by the other gears, increasing wastage



Glove Prototype

Justification Through Research

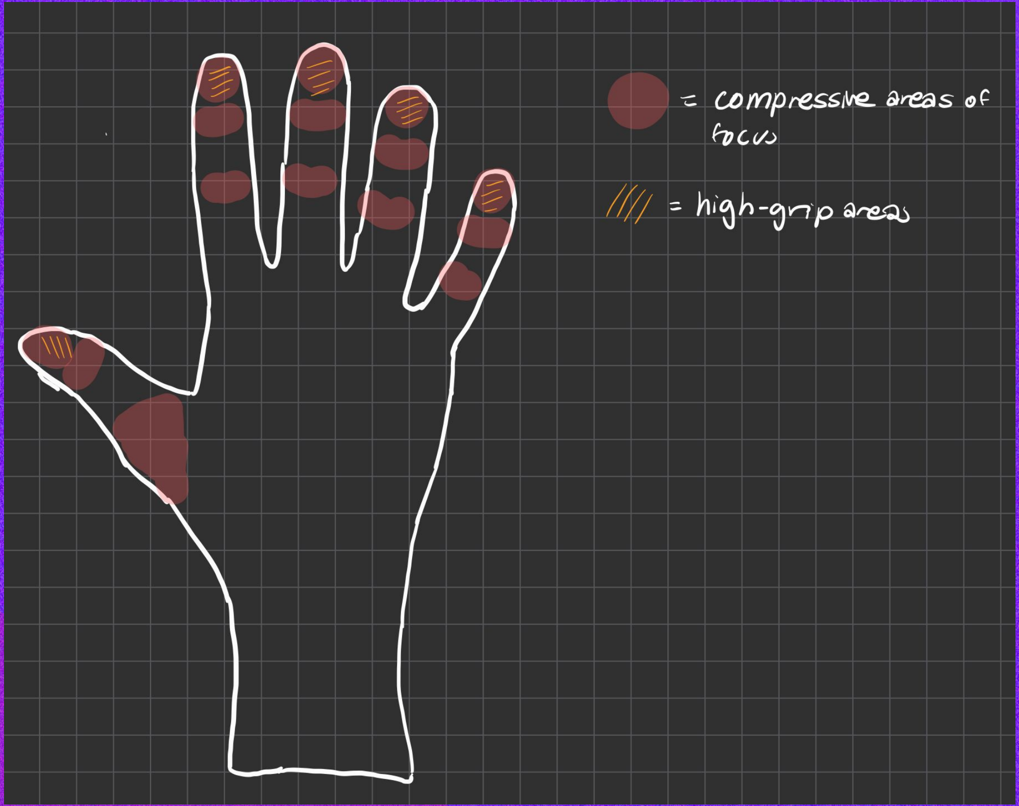
1. **Compression of Joints:**
    a. Provide stability to weak joints
    b. Increase circulation and oxygen delivery in order to reduce inflammation
2. **Hot and Cold Therapy**
    a. Heat Therapy
        i. Improves blood circulation
        ii. Decreases Joint Stiffness
    b. Cold Therapy
        i. Numbs the hand
        ii. Blocks nerve impulses to joints
    c. Chosen feature: Heat Therapy
3. **High Grip Areas**
    a. People with Osteoarthritis have trouble maintaining a strong grip

Reference Design

WHAT DO THEY DO?
Provide Heat
Compression
Enhance Circulation

Pros	Cons
1. Provides compressive support to finger and thumb joints -> areas most affected by Osteoarthritis 2. Provides heat therapy	1. Thick cotton material prevents delicate motion 2. No grip support on the fingertips

Our Prototype



Grip Options

	Oil	Acids	Water	Abrasion	Dry
Max Grid Fabric	5	1	5	4	5
Nitrile	4	4	4	4	4
PU	1	1	4	3	4
Latex	0	1	5	5	5
PVC	3	3	3	3	3
Neoprene	3	4	4	2	4

Best Grip - MaxGrid™ Fabric

Thin Gloves with Grip

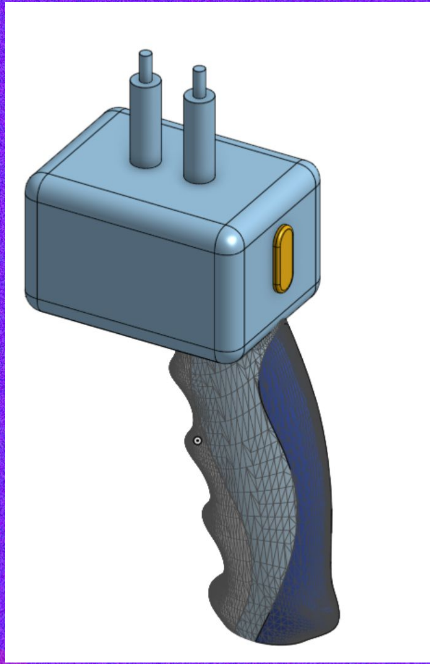
Braiding Spinner

Idea

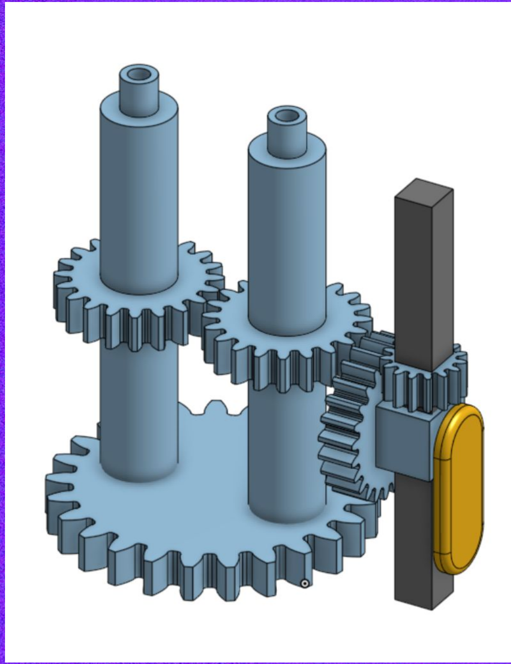
An electric driven cordage maker that allows users to make cordage in the following manner:

1. Requires minimum effort from hands to make cordage
    a. Increased Manual load on hand increases risks of Osteoarthritis.
    (https://pubmed.ncbi.nlm.nih.gov/31959639/)
2. Includes ergonomic design for the handle
    a. Ergonomically designed tools can minimize joint pain.
    (https://www.webmd.com/arthritis/features/ergonomics-at-work)
3. Makes cordage rapidly
    a. Miriam, the main stakeholder, wants the cordage making to be more efficient.
    (Transcript,page 6)

Design



Electric Cordage Maker: Exterior



Electric Cordage Maker: Interior

Reference Design

What is it?
Existing design for braiding hair.

What does it do?
Contains two clips that can braid and ply hair together

Pros	Cons
Very fast in braiding hair -> Increase speed of cordage making.	1. Cannot adjust the level of plying. 2. Only does plying motion

Proxy Tests

Force On Thumb Joint

Requirement: Should minimize force on thumb joints during cordage-making

Utilizing a load cell sensor

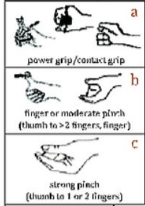
1. Connect pressure sensor to the thumb location
2. Conduct one cycle of twining
3. Identify maximum force involved
4. Force within 40-60N (male) and 30-60N (female)[1]

[1] ISO 20282-1:2006 Ergonomics of human-system interaction - Part 1: Human-centred lifecycle process descriptions for interactive systems (HCI)

Determine the European Assembly Worksheet Index

Table 5 — EAWS Section 4: force-frequency-grip score

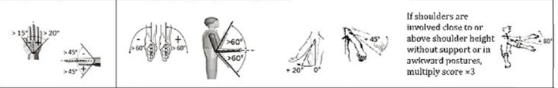
Force & Frequency & Grip (FFG)	Basis: number of real actions per minute or percent static acti ons (analyze only the most loaded limb)



Legend	
%SA = Percentage of Static Actions	%DA = 100% - %SA
FDS = Force-Duration Static	FFD = Force-Frequency Dynamic
GS' = Modified Grip Points Static (Grip x %SA)	GD = Grip Points Dynamic
%FLS = Percentage of Static Actions at force level	%FLD = Percentage of Dynamic Actions at force level
SC = Static Contribution	DC = Dynamic Contribution
FDGS = Sum of Static Contributions	FFGD = Sum of Dynamic Contributions

Force [N]	Calc Stat				Static actions (s/min)						Grip			Dynamic actions (real actions/min)								Calc Dyn			
	FDS	GS'	% FLS	SC	≥15	30	20	10	5	3	0	2	4	2-5	10	15	20	25	30	35	≥40	FFD	GD	%FLD	DC
0 – 5					1	1	0	0	0	0	abc			0	0	0	1	2	3	4	7				
> 5 – 20					4	2	1	1	0	0	ab	bc		0	0	1	2	3	4	6	9				
> 20 – 35					7	5	3	2	1	1	ab	b	c	0	1	2	3	4	6	8	12				
> 35 – 90					11	8	5	3	2	1	a	b	b	1	2	3	5	7	9	12	18				
> 90 – 135					16	11	7	4	3	2	a	ab	b	2	3	5	7	9	12	15	24				
> 135 – 225					21	14	10	6	4	3	a	a	b	4	5	6	8	11	14	20	32				
> 225 – 300					28	18	12	8	5	4	a	a	b	5	6	7	9	12	16	26	40				
20a	FDGS = $\sum SC_i$		100 %		FFG = FDGS + FFGD						FFG			%DA = ΣFLDj					FFGD = $\sum DC_j$			%DA			

Hand / arm / shoulder postures (use duration for worst case of wrist / elbow / shoulder)			
20b	Wrist (deviaton, flex./extens.)	Elbow (pron, sup, flex./extens.)	Shoulder (flexion, extension, abduction)



Posture points	10 %	25 %	33 %	50 %	65 %	85 %	
	0	0,5	1	2	3	4	PP

Additional factors		
20c	Gloves inadequate (which inter fere with the handling ability required) are used for over half the time	2
	Working gestures required imply a countershock. Frequency of 2 time per minute or more (i.e.: hammering over hard surface)	2
	Working gestures imply a countershock (using the hand as a tool) with freq. of 10 time per hour or more	2
	Exposure to cold or refrigeration (less than 0 degree) for over half the time	2
	Vibrating tools are used for 1/3 of the time or more	2
	Tools with a very high level of vibrations	4
	Tools employed cause compressions of the skin (rednesses, callosities, blebs, etc.)	2
	Precision tasks are carried out for over half the time (tasks over areas smaller than 2-3 mm)	2
	More than one additional factor is present at the same time and overall occupy the whole of the time	3
	Additional points (choose the highest value)	= AF

Repetitive tasks duration											
20d	Net Duration [min/shift]		< 60		90	180	300	420	≥ 480		+
	Duration Points		1		1,5	3	5	7	10		
	Work Organization		Breaks are possible at every time (Cycle time longer than 10 minutes)			Breaks are possible at given conditions (Cycle time between 1 and 10 minutes)			Breaks lead to a stop of the process (Cycle time shorter than 1 minute)		+
	Work Organization Points		0			1			2		
	Breaks (≥8 min) [#/shift]		0	1	2	3	4	5	6	≥7	+
	Break points	cycle time ≤30 s	3	2	1	0	-1	-2	-3	-4	
		cycle time >30 s	0		-0,5		-1		-1,5	-2	
	Duration Points										= DP

Figure: Criteria tables in which how EAWS indexes are calculated[2].

[2] ISO/TR 23071 Ergonomics - recovery model for cyclic industrial work

Requirement: Should minimize repetitive movements in comparison to the original tool

Metric: EAWS index, a sum of duration points, additional points, dynamic contributions, and static contributions

1. Following the criteria outlined by table 4, identify the maximum force load for the movement.
2. Plot the static and dynamic points associated with the movement cycle.
3. Identify highest additional points value
4. Add on duration points
5. Sum these values up and compare for each tool
6. Confirm that the EAWS index is below 50, which means the workstation generates an excessive load demand

Determine Number of Technical Movements

C.4.1 General formula

Use the following formula to calculate the overall number of RTA within a shift (the OCRA method considers a number of risk factors and corresponding multipliers):

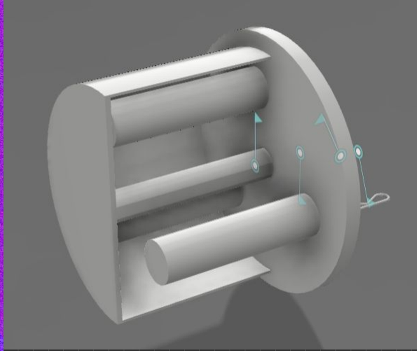
$$n_{\text{RTA}} = \sum_{j=1}^{n} \left[k_{\text{f}} \left(F_{\text{M}j} \times P_{\text{M}j} \times R_{\text{eM}j} \times A_{\text{M}j} \right) \times t_j \right] \times \left(R_{\text{cM}} \times t_{\text{M}} \right) \qquad \text{(C.5)}$$

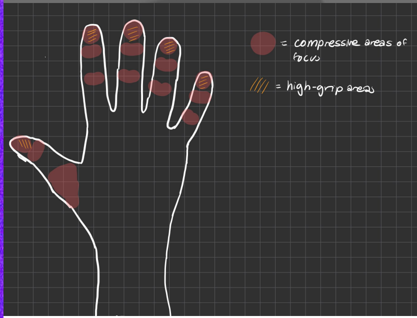
where

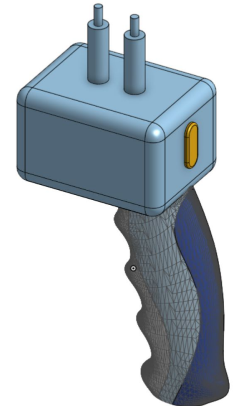
- n is the number of repetitive tasks performed during a shift;
- j is the generic repetitive task;
- k_{f} is the constant of frequency of technical actions per minute (= 30);
- F_{M} frequent or high force exertions (force multiplier) in each repetitive task, j;
- P_{M} awkward or uncomfortable postures or movements (posture multiplier) in each repetitive task, j;
- R_{eM} high repetition of the same movements (repetitiveness multiplier) in each repetitive task, j;
- A_{M} presence of additional factors (additional multiplier) in each repetitive task, j;
- t is the net duration, in minutes, of each repetitive task, j;
- R_{cM} is the multiplier for the risk factor lack of recovery period (recovery multiplier);
- t_{M} is the multiplier according to the overall duration of all repetitive tasks during a shift (duration multiplier).

The determination of these multipliers is given in C.4.2 to C.4.7.

Figure 1: General Formula for Calculating the Number of Reference Technical Actions[3]







[3] ISO 11228-3:2007 Ergonomics - Manual handling - Part 3: Handling of low loads at high frequency

Requirement: Should minimize repetitive movements in comparison to the original tool

1. Following plan outlined by ISO 11228-3:2007, calculate N_{RTA} for each tool
    a. Awkward or uncomfortable movements, net duration, etc.
2. Compare the N_{RTA} for the cycles between tools
3. Tasks should involve smooth force exertion with the avoidance of sudden or jerky movements.
4. Exposure to hand/arm vibration, shocks or impacts can lead to a desensitizing of the hand and increase the force necessary for gripping an object or tool

Prototype Vs Requirements

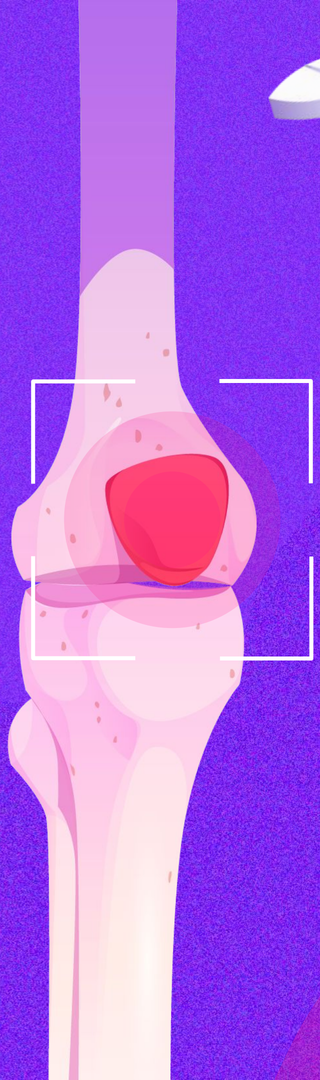
= currently not adequately satisfied

= adequately satisfied

Prototype vs Requirements Chart

Requirements	Gear machine	Glove	Electric Twister
1) Should not be fully automated	Machine is still powered by user turning handle → does not exceed level 2 automation	The user still has to make the cordage themselves	The user has to hold the device but does not perform the action themselves
2) Should minimize repetitive movements in comparison to the original tool	The turning motion is still repetitive, but due to the gears, less twists correspond to more twists	The user creates the cordage themselves, so repetitive movements aren't limited	The user does not have to do any repetitive movements
3) Should accommodate varying lengths of cordage	Future iterations can potentially have adjustable hooks that can change the cordage length	There is no limit on the length of the cordage	There is no limitation on the length of cordage
4) Should be intuitive to use	The machine just requires a turning motion, which is intuitive to use	The glove is intuitive to use	The electric machine might be hard for older audiences
5) Should minimize force on thumb joints during cordage making	The handle distributes force around the hand, ensuring there is less pressure on joints	The compression gloves support weak joints	The user must just hold the handle, so there is limmited force on joints
6) To increase the speed of cordage making	The number of movements the user needs for every twist is less, and thus, it is faster	The user still needs to do all the movements themselves	The machine spins way faster than if the user does it themselves
7) Should reduce fine motor movements for user	The magnitude of the movement is enlarged, and thus, not fine motor	The user still has to do the same fine motor movements	The user does not have to do any fine motor movements

Final Prototype : GearBox



Thank you for listening!