

# **INITIAL DESIGN OF AN AUTOMATIC CROCHET MACHINE**

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# OUTLINE

- 1. Problem Statement and Background**
- 2. Kinematic Studies and Research**
- 3. Design Process and Implementation**
- 4. Future Work**

# PROBLEM STATEMENT



- Big brand name companies outsource their products from other countries
- Sewing and knitting is automated, but crochet is not – all crochet items are handmade

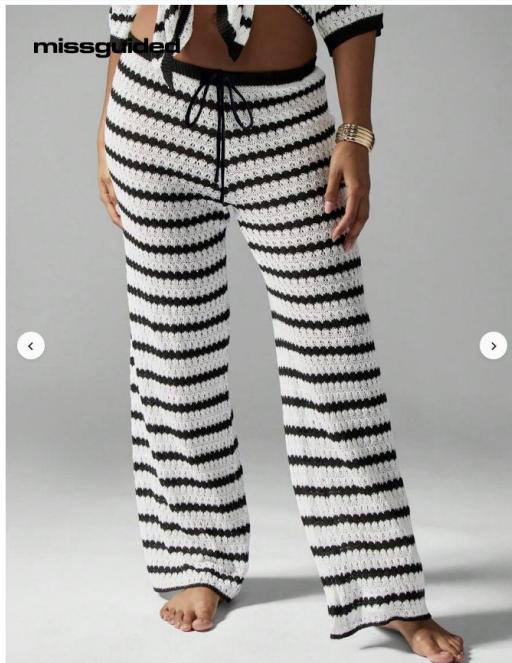


# Fast Fashion Industry



- 85% of textiles end up in landfills each year
- Fast fashion generates 10% of global carbon emissions
- Dyeing textiles accounts for 20% of global industrial water pollution

**SHEIN**



**10-14 hours  
\$13.99**

**ZARA**



**14-20 hours  
\$80**

**H&M**



**3-5 hours  
\$16.99**

# Child Labor

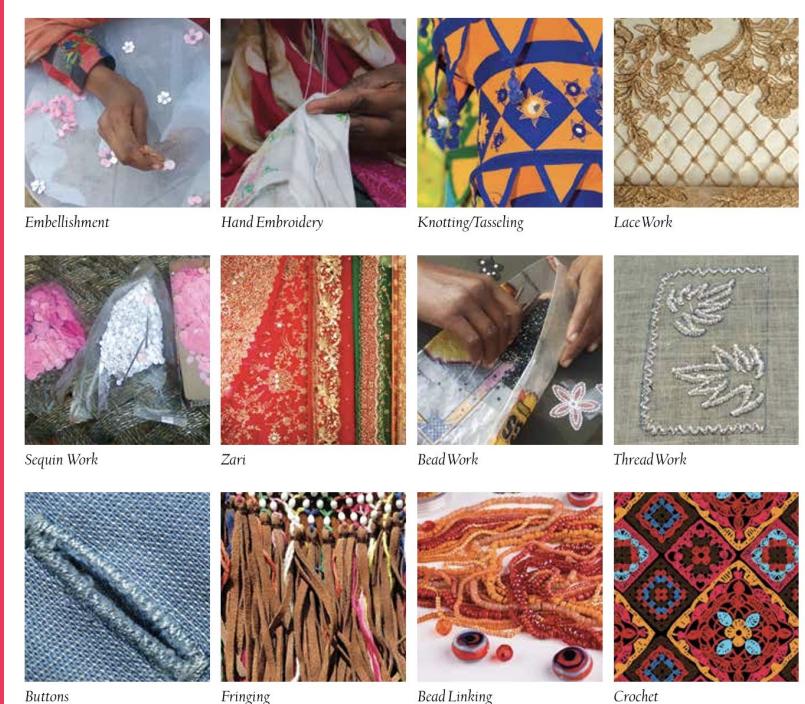
## Child Labour in the World

**160 million** in child labour

**79 million** in hazardous work



Source and copyright: Child Labour: Global estimates 2020; Trends, Results and The Road Forward International Labour Office (ILO), Geneva, 2021



# MY GOALS

Design a low cost crochet machine that:

- Uses off the shelf parts
- Open-loop control
- Can crochet at least one chain stitch (minimum)

Code a pattern generator:

- Displays 3d plots of rectangular and circular patterns
- Estimates dimensions of projects based on hook size and yarn weight

# HOW ARE DIFFERENT FABRICS MADE?

**weaving**



**sewing**

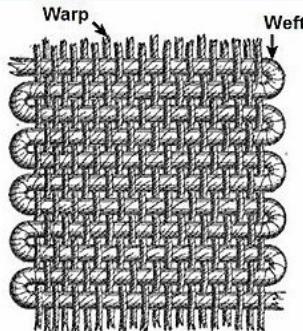


**knitting**



# HOW ARE DIFFERENT FABRICS MADE?

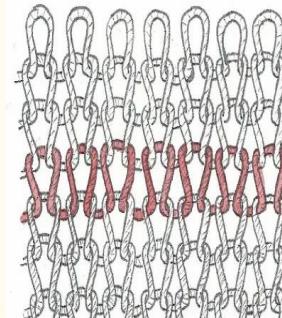
**weaving**



**sewing**

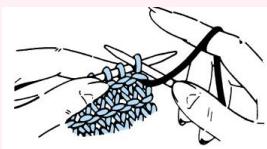


**knitting**



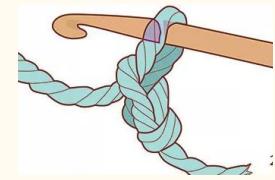
# WHAT'S THE DIFFERENCE?

## KNITTING



- Two needles
- Each row is based off the previous row

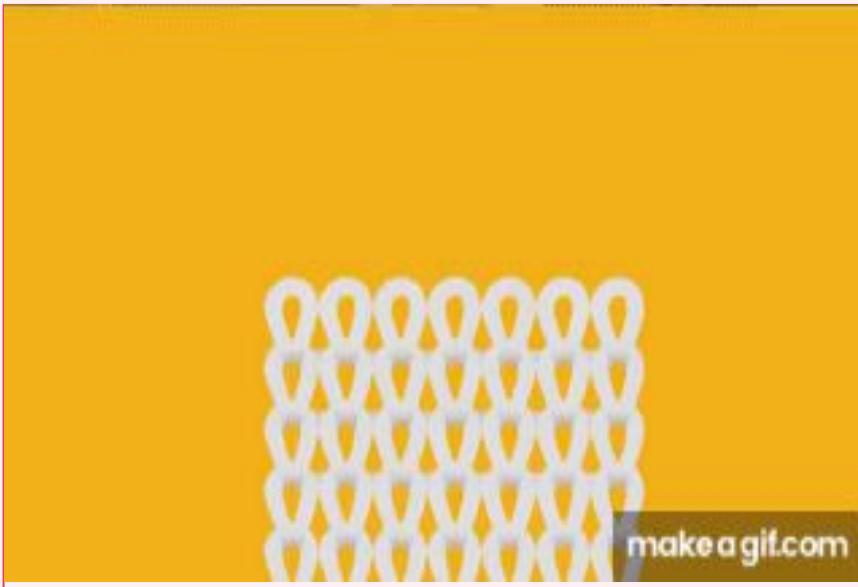
## CROCHET



- One hook
- Each stitch is directly based off of the previous stitch

# WHAT'S THE DIFFERENCE?

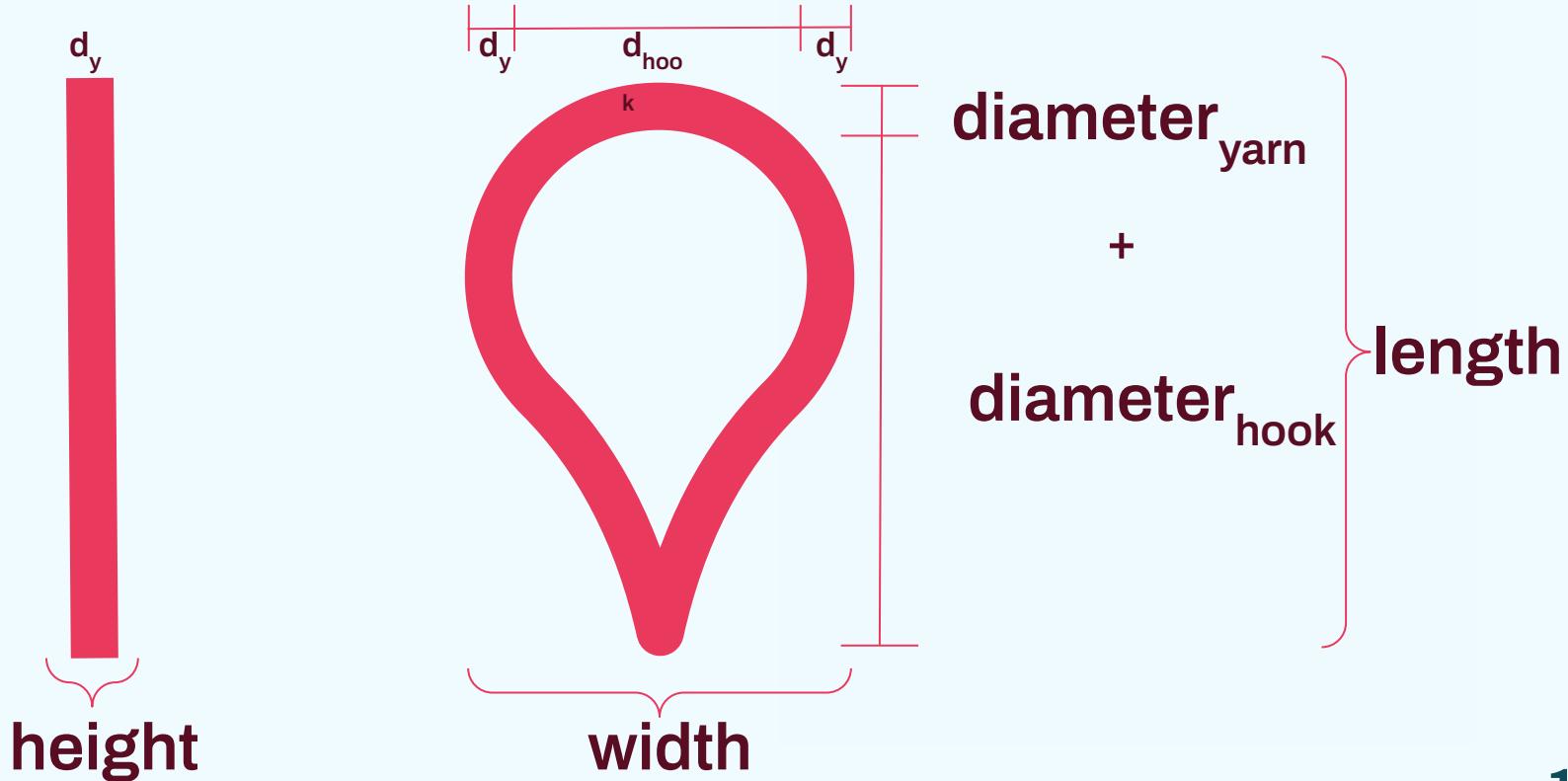
KNITTING



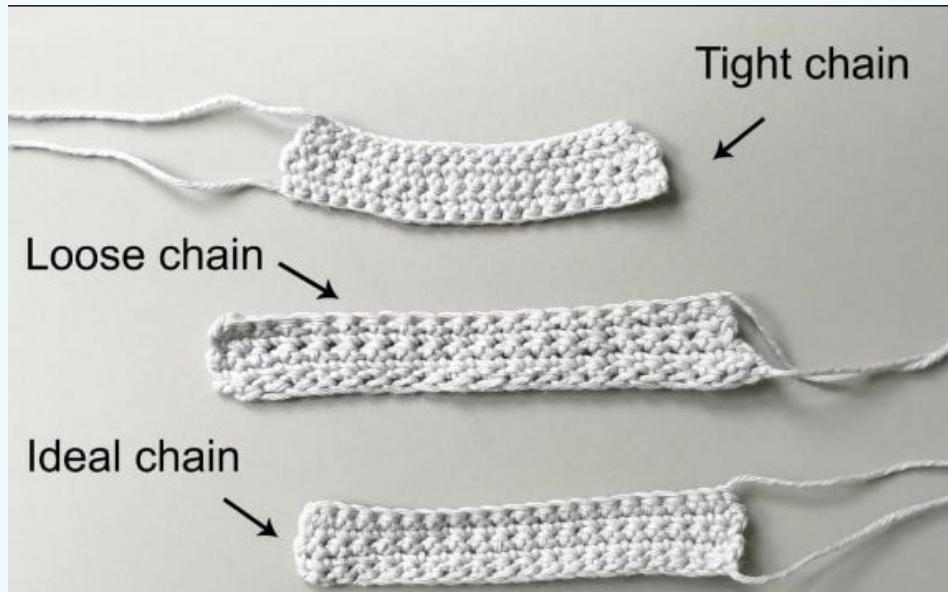
CROCHET



# Crochet Basics - Chain

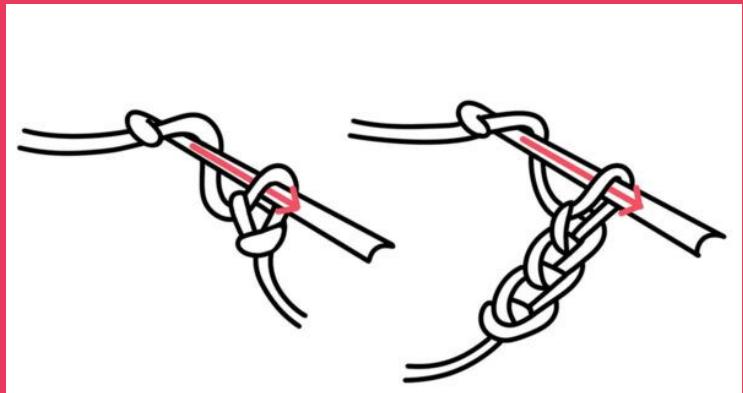


# The Importance of Tension



# HOW DO YOU CROCHET A CHAIN STITCH?

1. Yarn over
2. Pull through



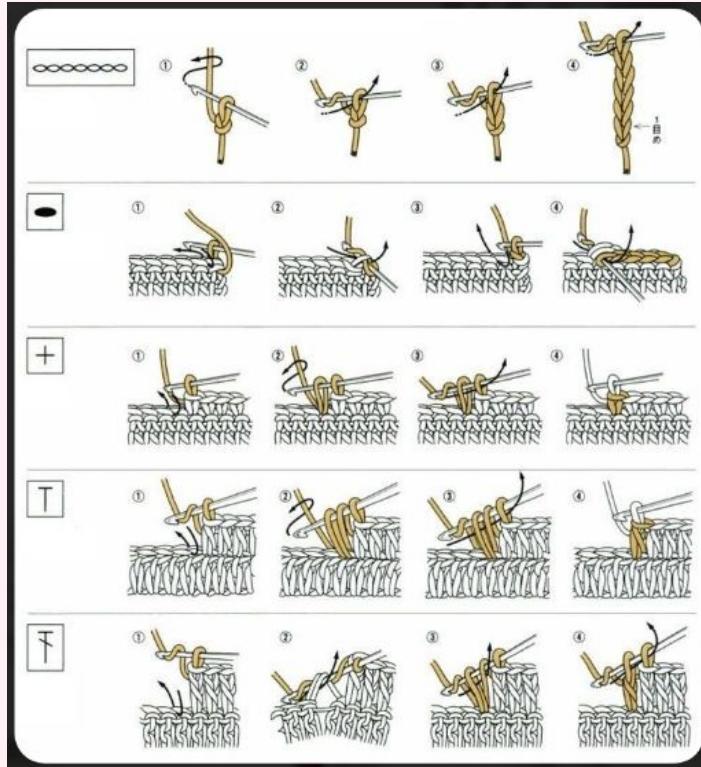
chain

slip

single

half-double

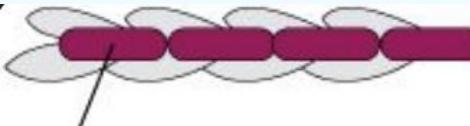
double



# EVERYTHING IS MADE FROM CHAINS!

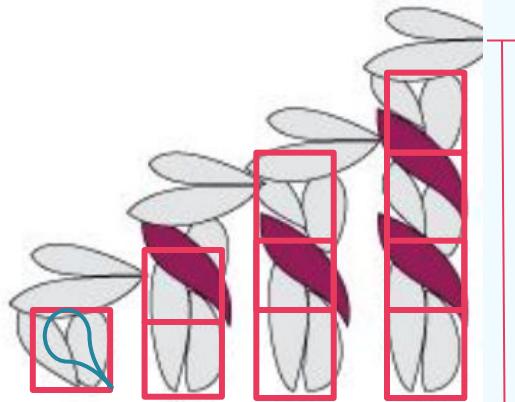
CROCHET STITCH	STITCH SWATCH (depicting turning chain)	TURNING CHAIN LENGTH
Single crochet (sc)	 1	<b>1 chain</b>
Half double crochet (hdc)	 1 2	<b>2 chains</b>
Double crochet (dc)	 1 2 3	<b>3 chains</b>
Treble crochet (tr)	 1 2 3 4	<b>4 chains</b>
Double treble crochet (dtr)	 1 2 3 4 5	<b>5 chains</b>

# HEIGHT OF STITCHES



back of ch

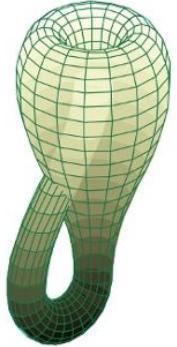
length = length of chain stitch  
width = width of chain stitch



height = (# of chain stitches stitch is composed of)\*(length of chain stitch)

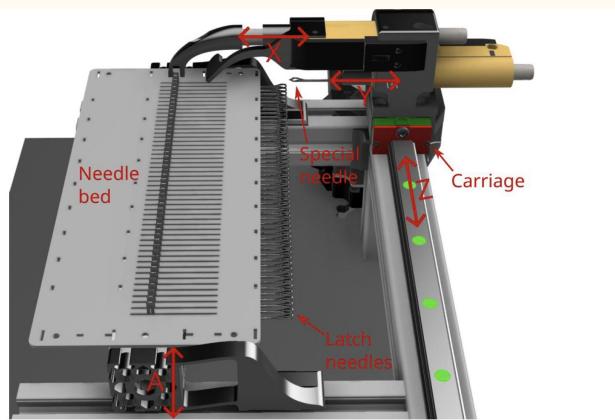
sc    hdc    dc    tr

# You can make ANYTHING!



chain stitch (ch)	○	back loop only	^
slip stitch (sl st)	●	front loop only	∨
single crochet (sc)	X or +	decrease dc	V
half double (hdc)	T	2 st decrease dc	V\
double (dc)	F	chain 3	o
treble (tr)		ch3 picot	o○
double treble (dtr)		chain 5	o
sc2tog	Δ	2 crossed dc	X
sc3tog	ΔΔ	2 crossed dc w/ch	XΔ
dc2tog	Δ	magic loop	○○
dc3tog	ΔΔΔ	front post dc (fpdc)	F
3 dc cluster	◎	back post dc (bpdc)	F
3 hdc cluster	◎	5 dc shell	○○○○○
5 dc popcorn	◎	fan	◇
V-stitch	▽	beginning of work	△
dir of work	→	end / bind off	▲

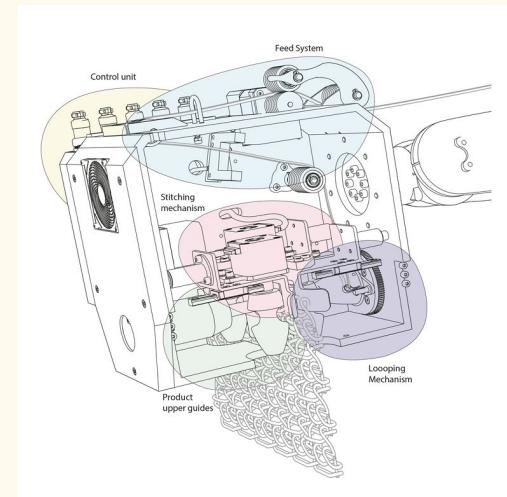
# Existing Machines



CroMat

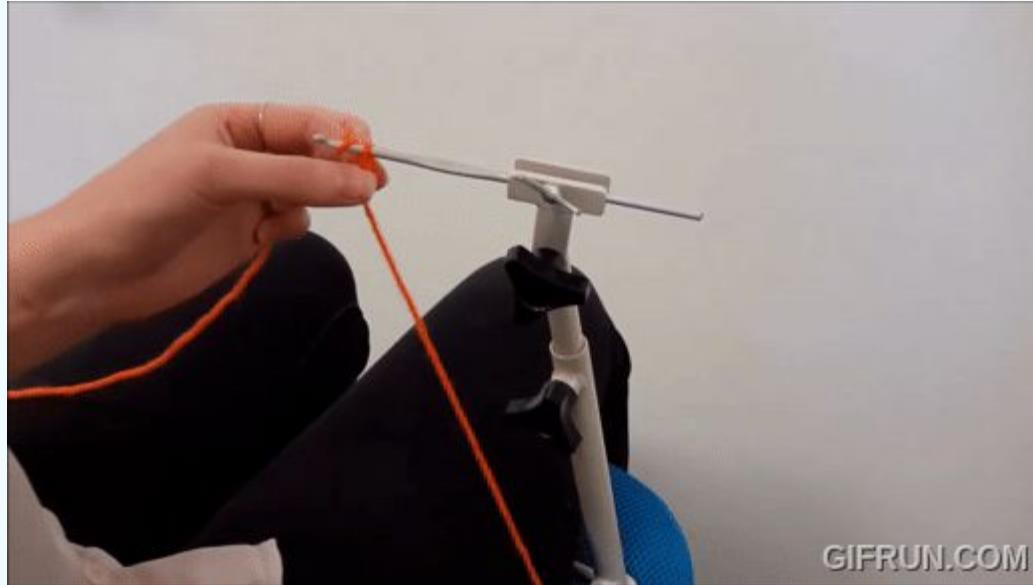


Crochet-Matic

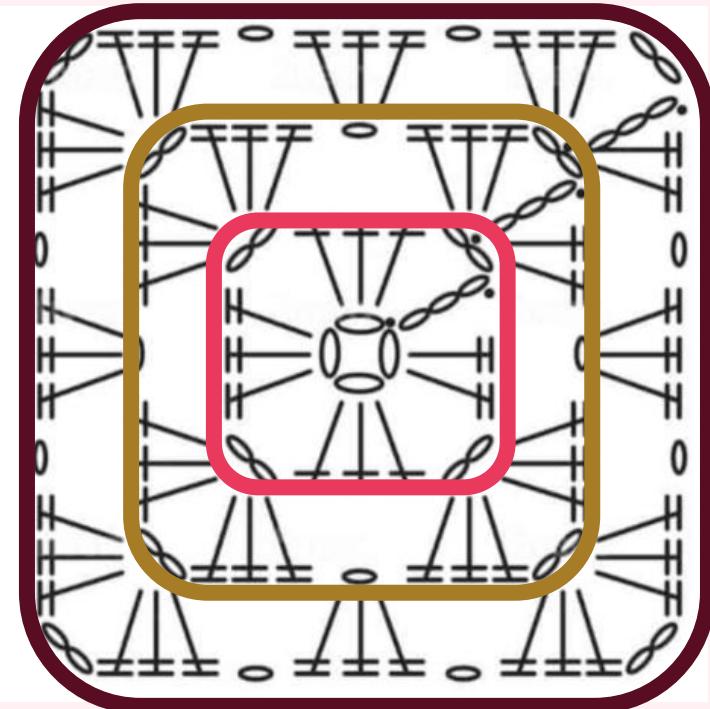


KUKA Arm

# One-Handed Crochet



# GRANNY SQUARE EXAMPLE



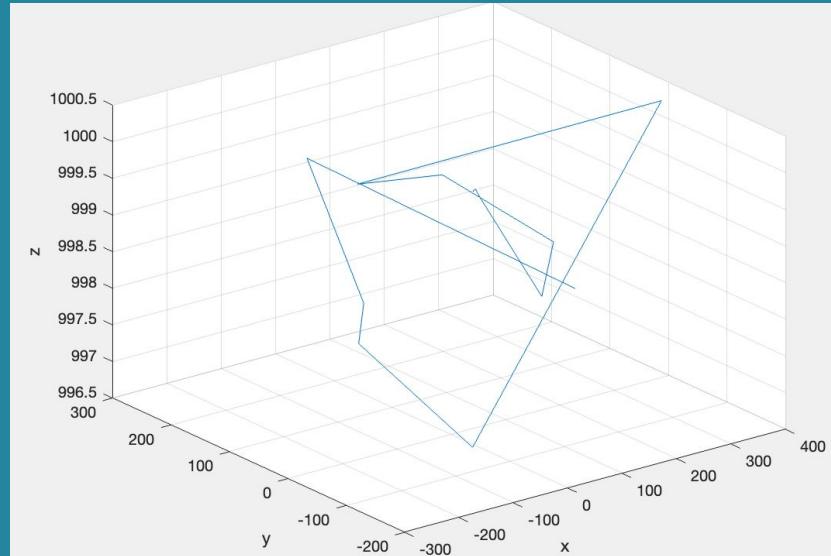
# IMU EXPERIMENT

## Materials:

- Arduino Qwiic Board
- 6 DoF IMU
- Yarn
- Hook

## Methods:

- Calibrate
- Gather crochet data



# Motion Capture Test 1 - AG Lab

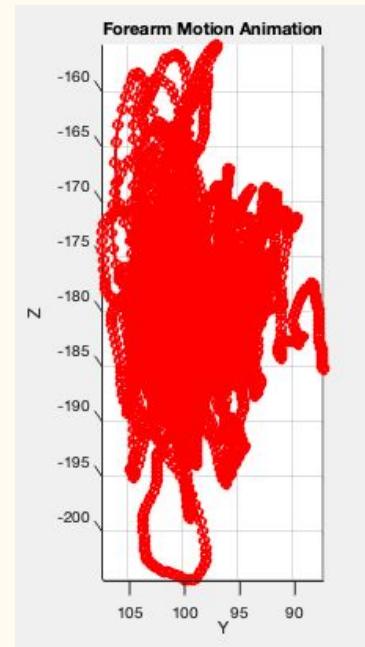
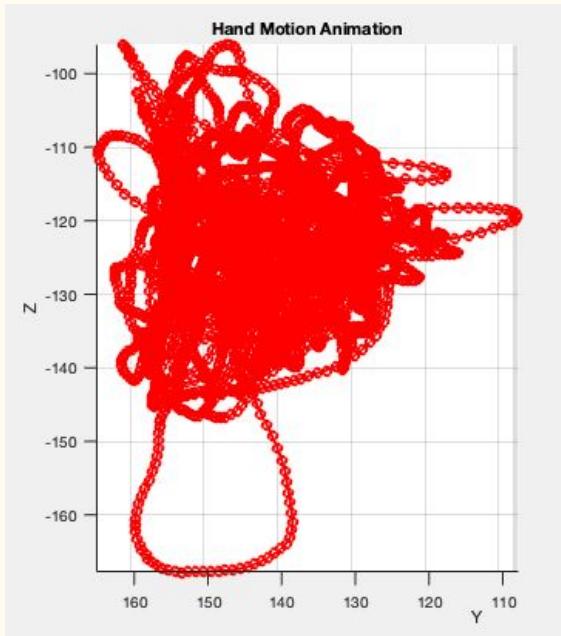


# Motion Capture

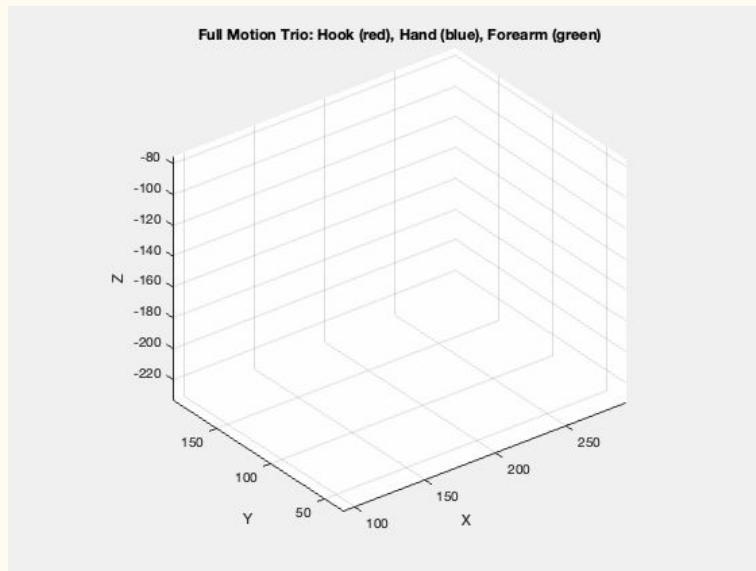
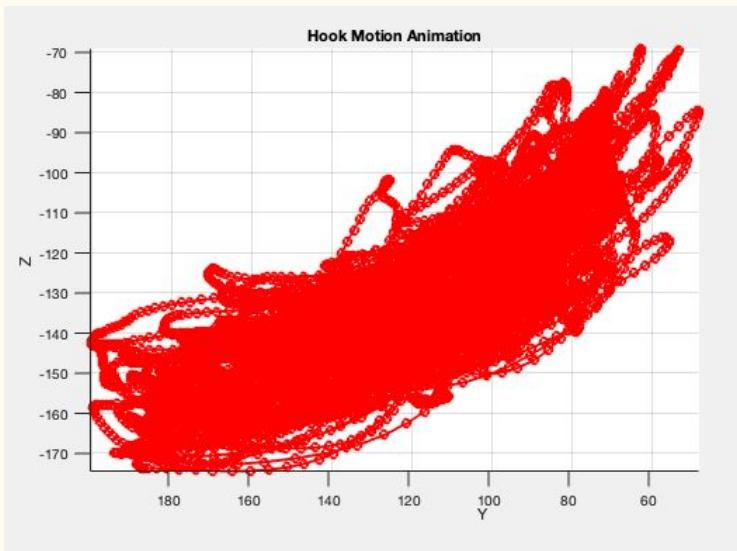
Professor CJ Hasson  
Bouve College of Health Sciences



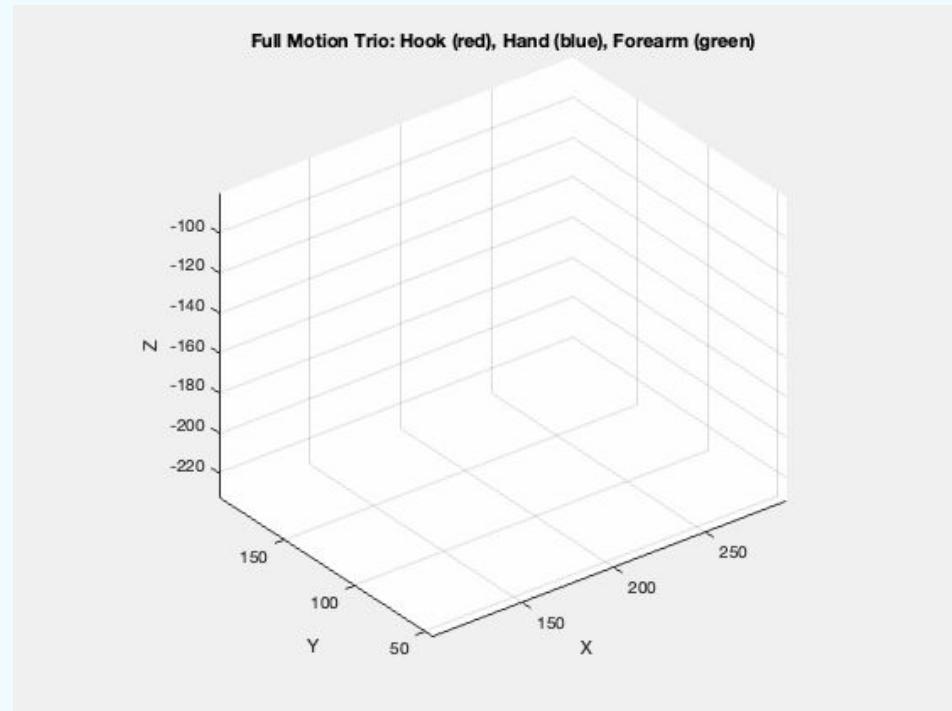
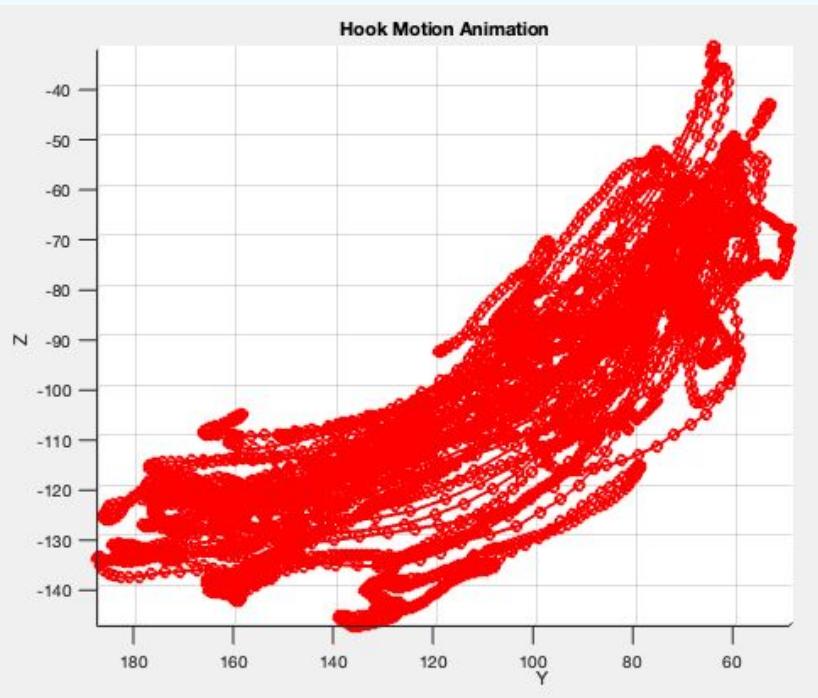
# Granny Square Data - Hand and Forearm



# Granny Square Hook Data



# Double Crochet Data





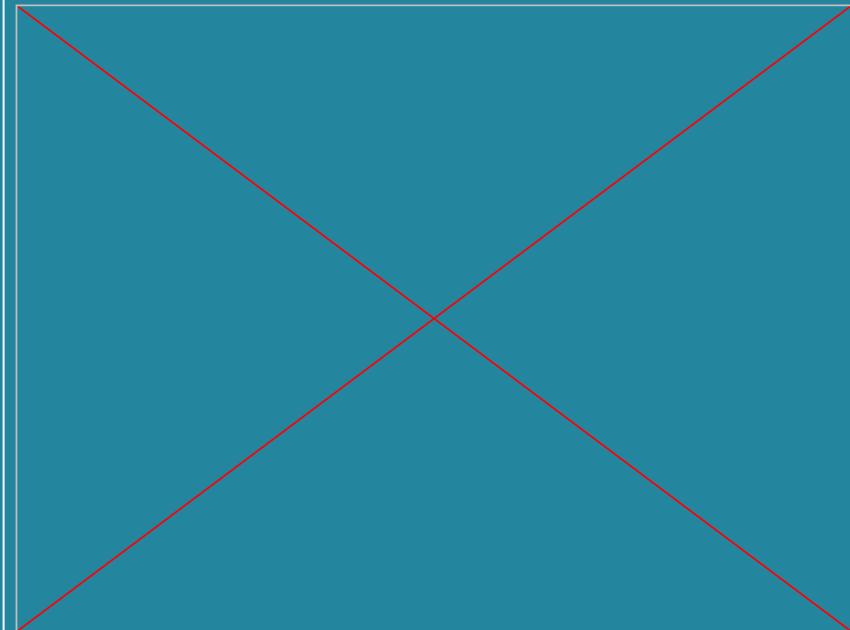
# LINEAR SOLENOID EXPERIMENT

## Materials:

- Linear solenoid
- Yarn
- Hook
- 3D printed housing

## Methods:

- Crochet chain stitches



# 3 SUBSYSTEMS

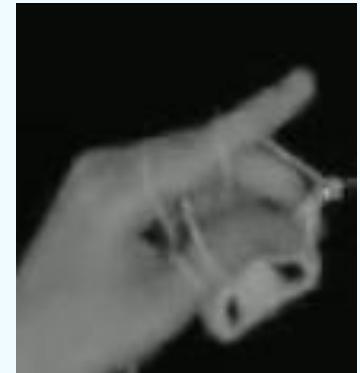
**crocheter**



**tensioner**



**holder**



# Design Process

① Holding the tension before the stitch:

- constant force retractor ↳ static or dynamic
- capstan?
- tension ring
- similar system to a sewing machine?
  - ↳ find video how sewing machines + knitting machines hold tension
- rope tensioners: 

② holding tension during work:

- 2 clamps? to hold the work down? → how to get crochet hook(s) through the work?
- depends on holding the tension before the stitch too

③ holding tension after work/holding work

- pins?
- velcro? → acrylic laundry maybe

④ make a stitch

- ↳ move crochet hook's work
- ↳ move crochet hook only
- ↳ move work only

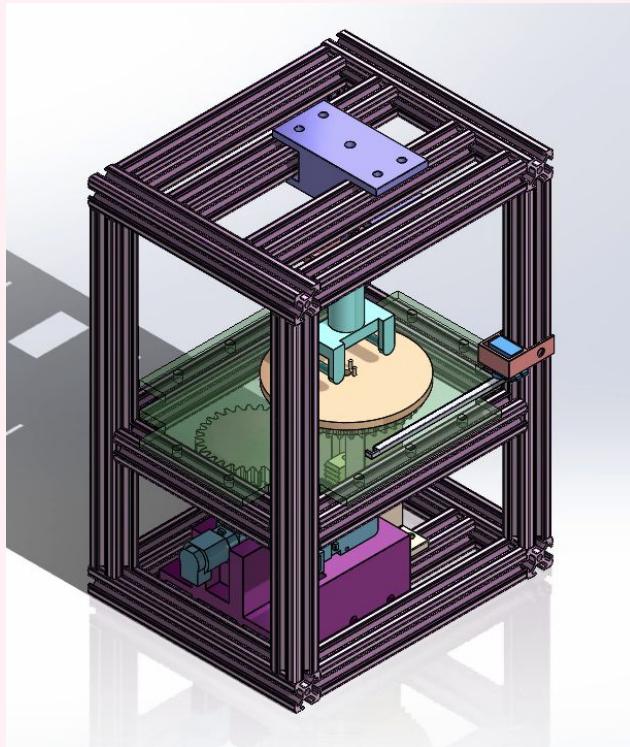
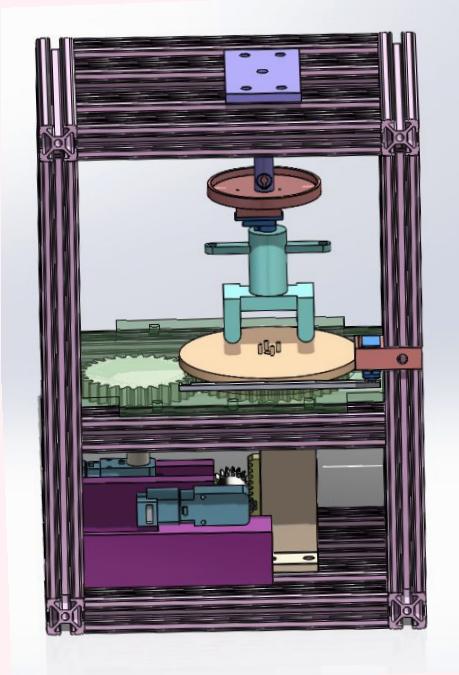
3 subsystems:

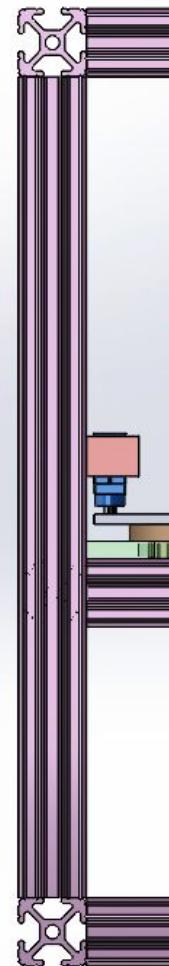
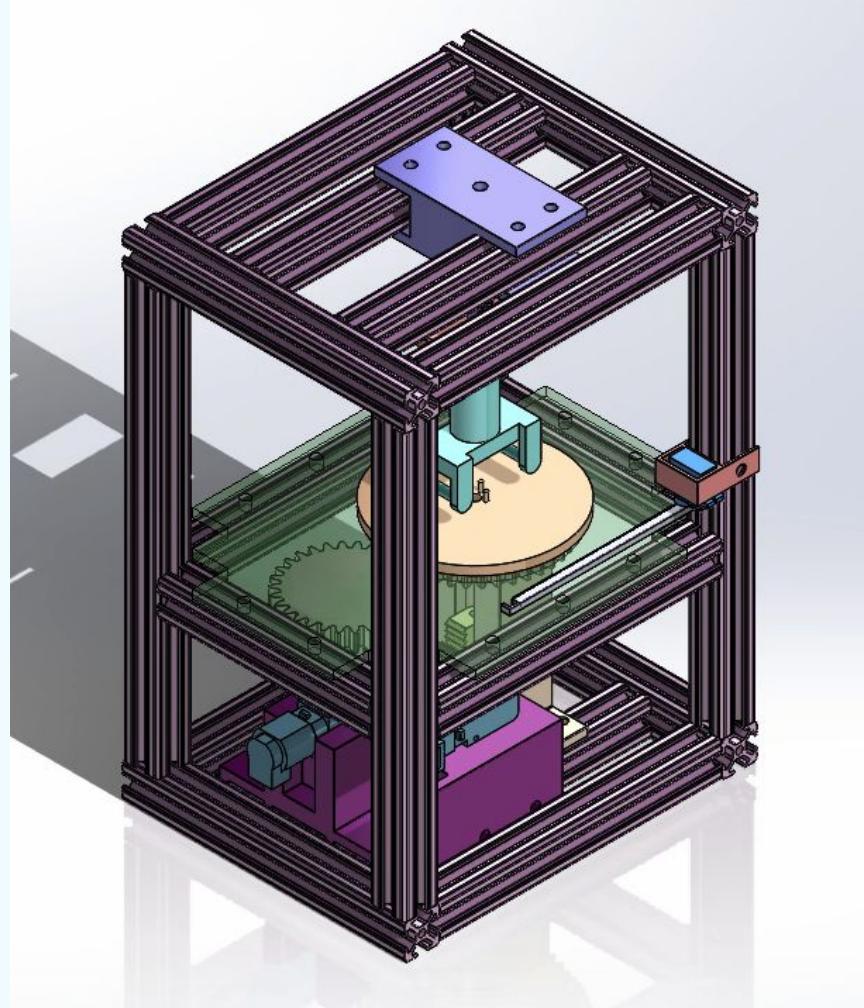
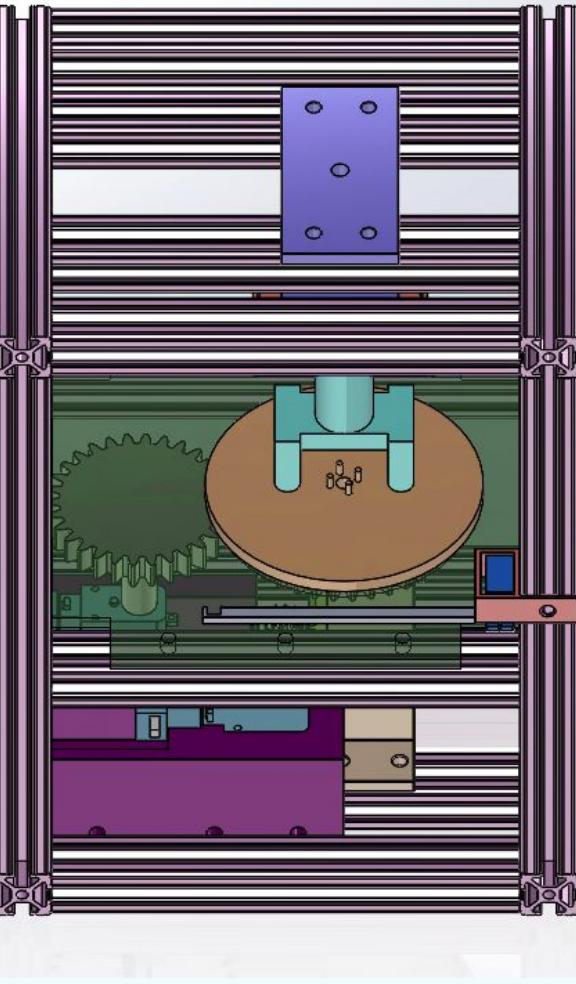
- ↳ pre stitch (tensioner)
- ↳ stitch (crocheter) → must be moving
- ↳ post stitch (holder)

options:

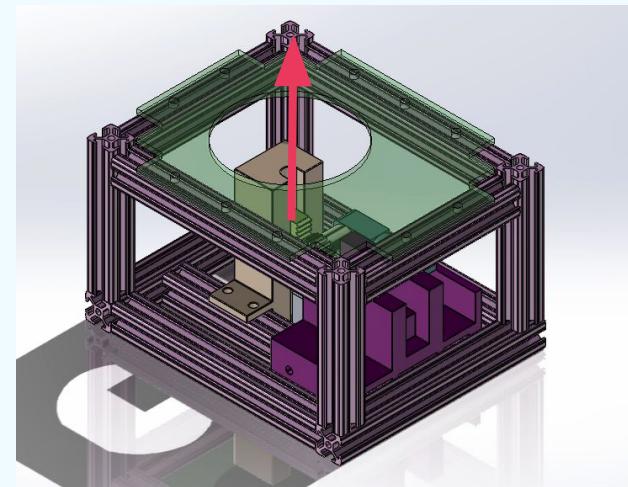
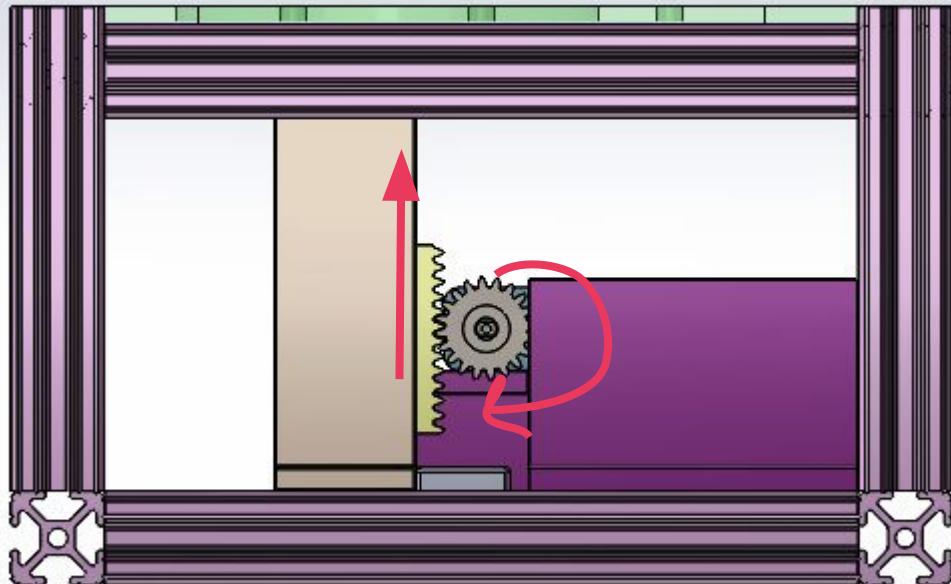
	P.S	S	P.o.S	impossible
1	moving	static	static	
2	moving	moving	static	
3	moving	static	moving	
4	moving	moving	moving	
5	static	static	moving	
6	static	moving	moving	
7	static	moving	static	
8	static	static	static	

# CAD Model!

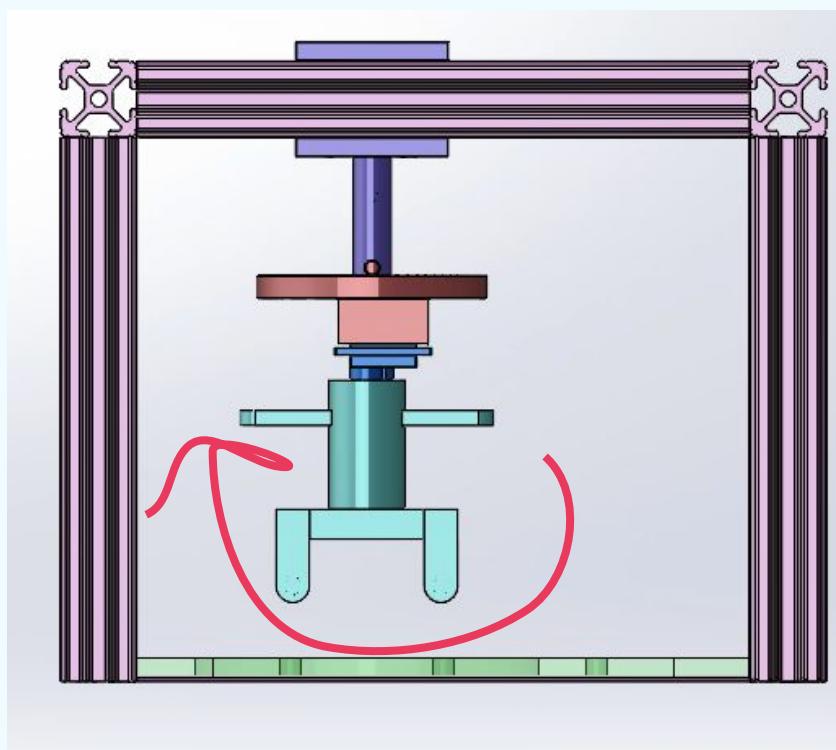
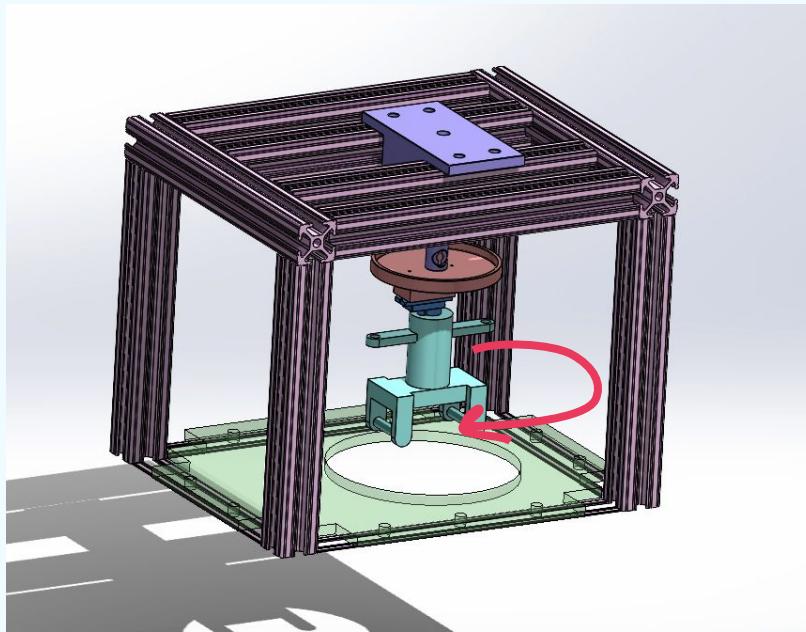




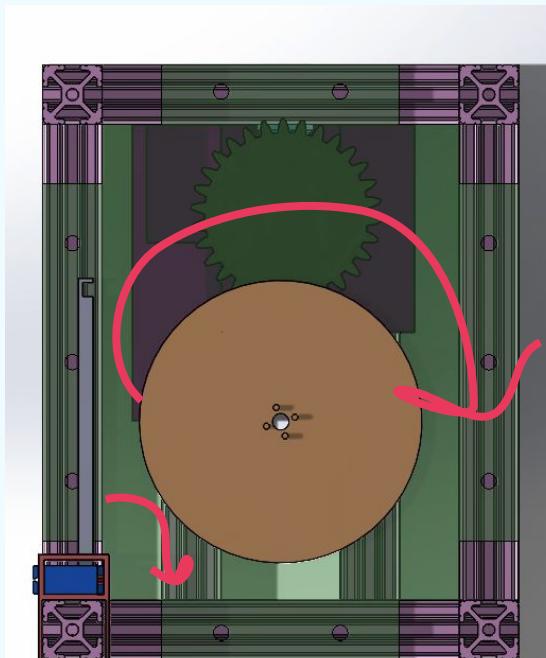
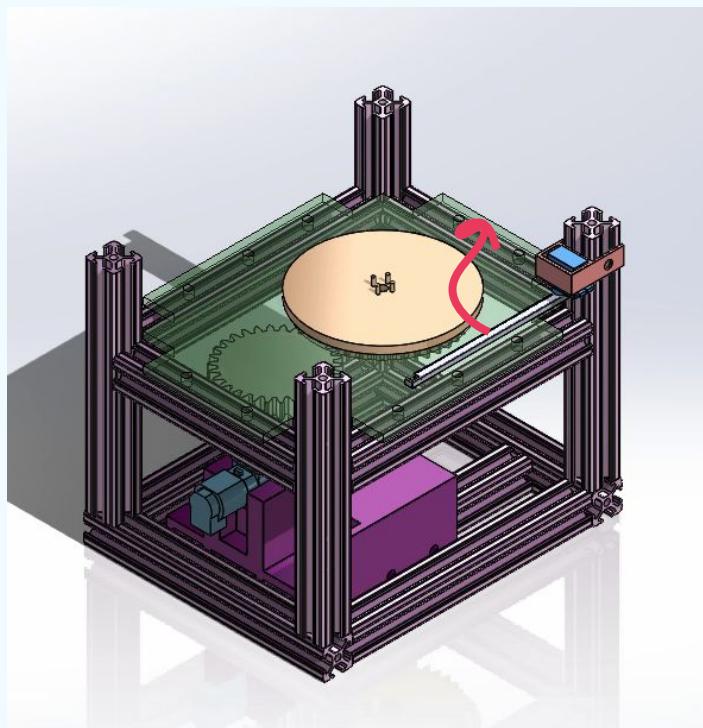
# Crocheter Subsystem



# Tensioner Subsystem

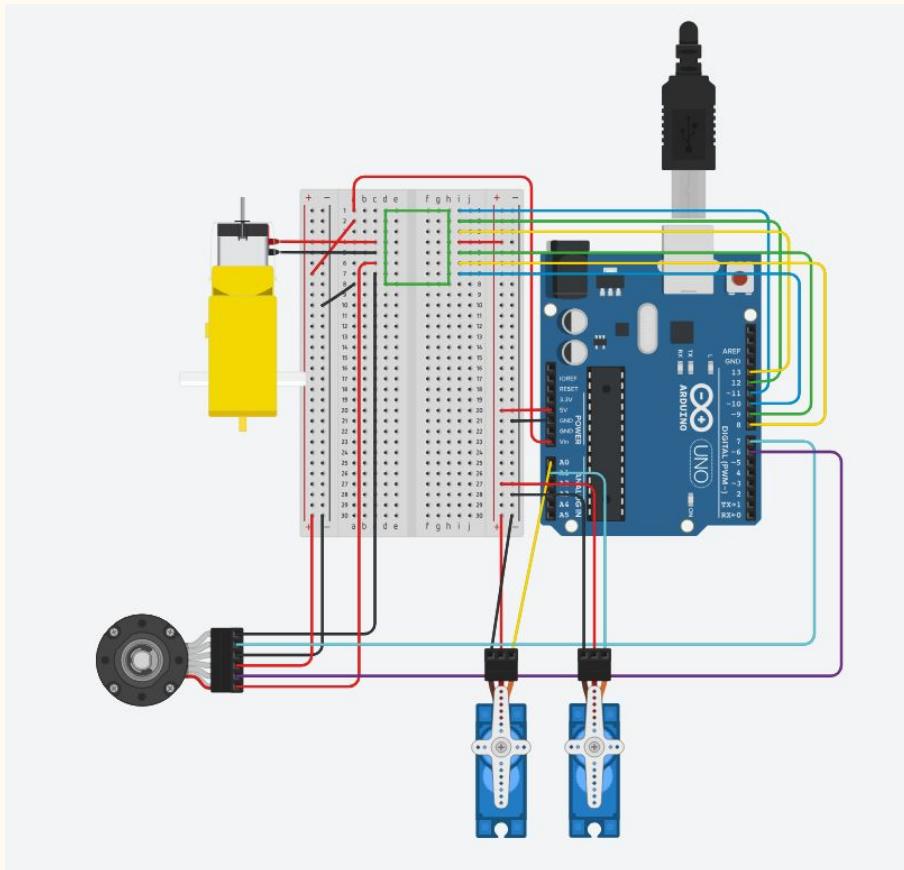


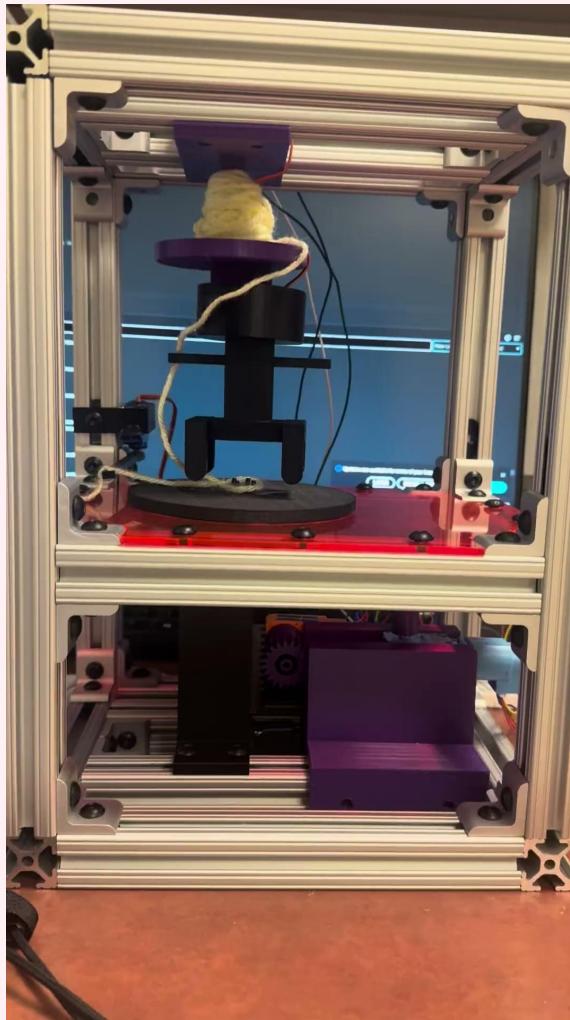
# Holder Subsystem



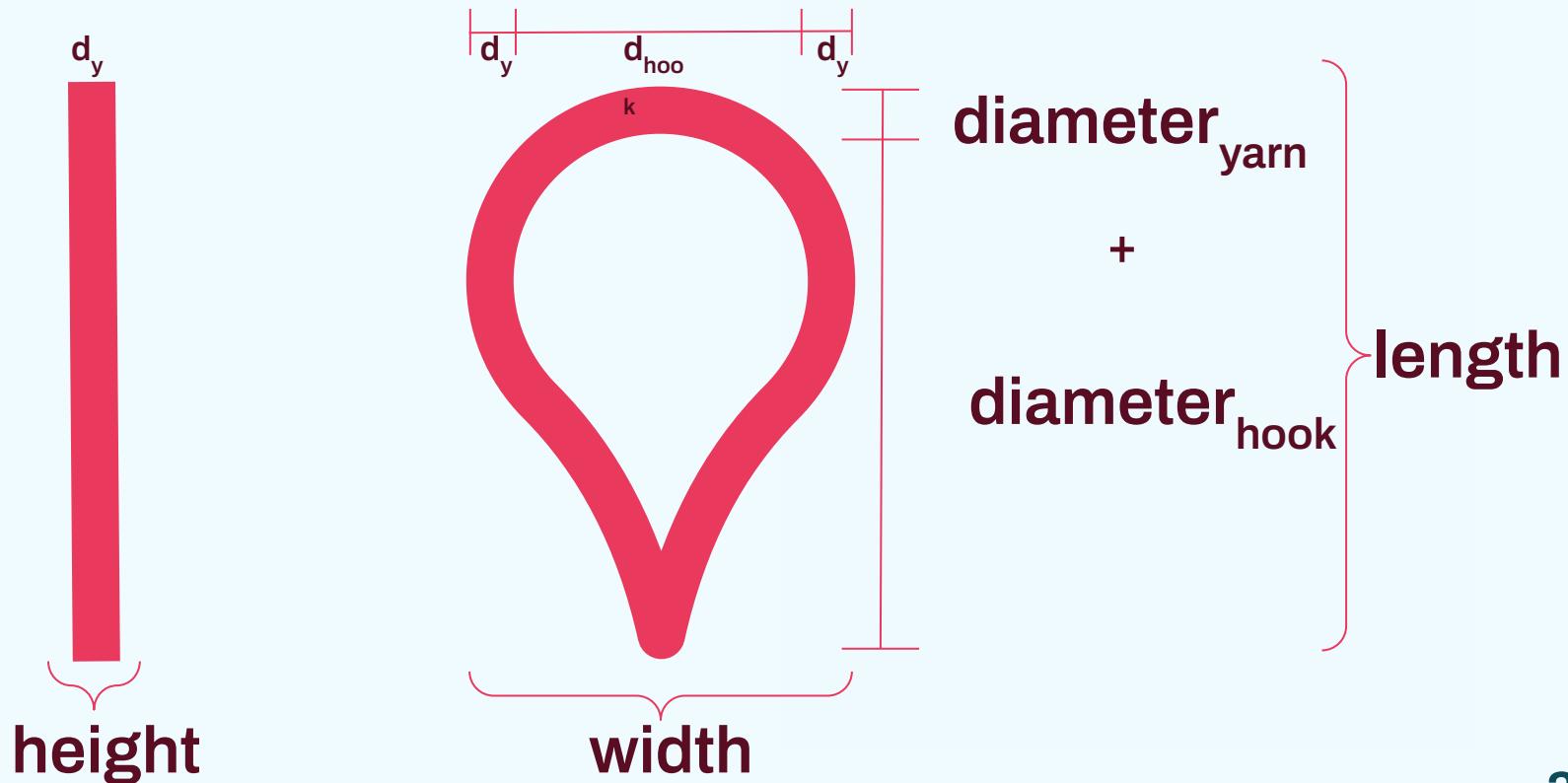
# Electrical Schematic

2 5V DC Motors  
2 Servo motors  
Arduino Uno  
Breadboard





# Revisiting Chain Dimensions



# Crochet Pattern Code! - Loop Input

Select Yarn Weight:

medium (4)

Select Hook Size:

H-8 (5.0 mm)

Input Mode:

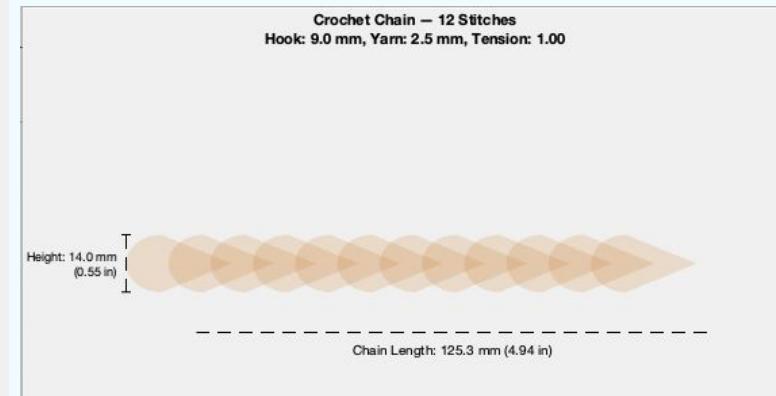
Specify Number of L...

Number of Loops:

12

Tension Scale (0.5–1.5):

1.0



# Crochet Pattern Code! - Length Input

Select Yarn Weight:

bulky (5)

Select Hook Size:

M/N-13 (9.0 mm)

Input Mode:

Specify Length

Chain Length (mm or in):

30

Tension Scale (0.5–1.5):

1.0

Recommended: 74 chain stitches

Crochet Chain – 74 Stitches  
Hook: 9.0 mm, Yarn: 2.5 mm, Tension: 1.00

Height: 14.0 mm  
(0.55 in) —————— Chain Length: 767.0 mm (3020 in) ——————

# Crochet Pattern Code! - Ellipsoid Generator

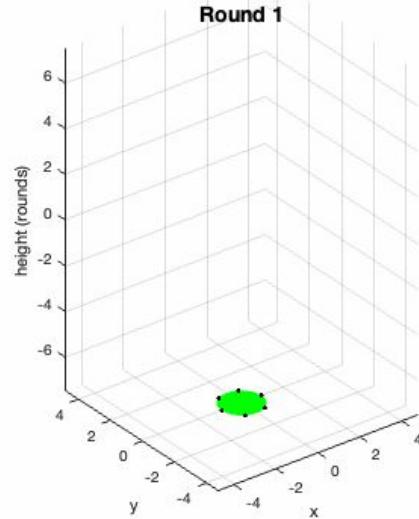
```
% parameters
max_radius = 12;
const_rows = 5;
total_rows = 2 * max_radius + const_rows;
rows = 1:total_rows;

stitches = zeros(1, total_rows);

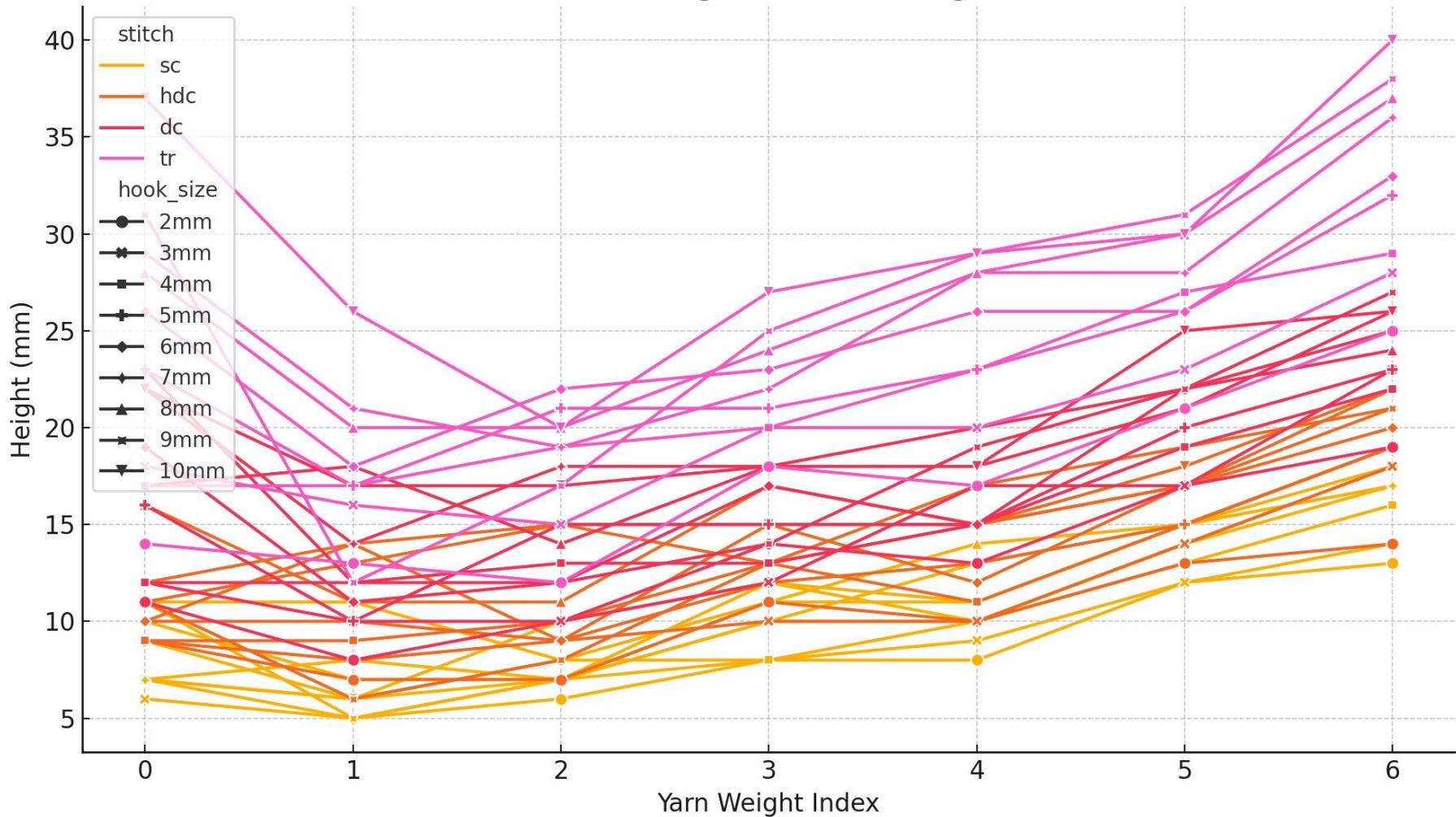
for a = 1:total_rows
    if a <= max_radius
        stitches(a) = 6 * a;
    elseif a <= max_radius + const_rows
        stitches(a) = 6 * max_radius;
    else
        dec_row = a - max_radius - const_rows;
        stitches(a) = 6 * (max_radius - dec_row);
    end
end
```

Crochet Sphere - Animated Build

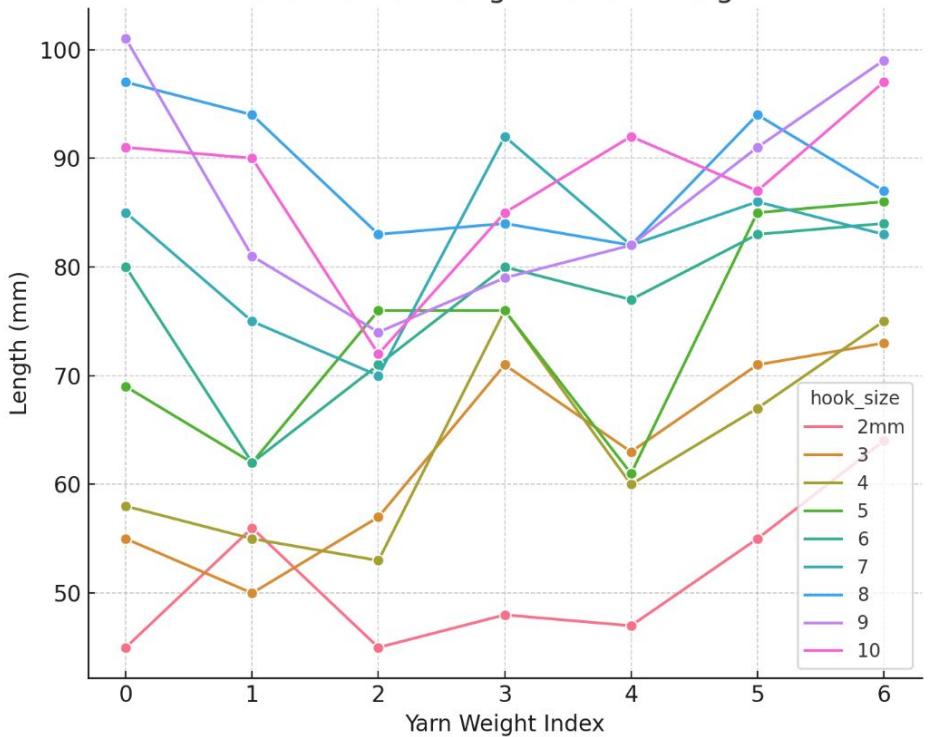
Round 1



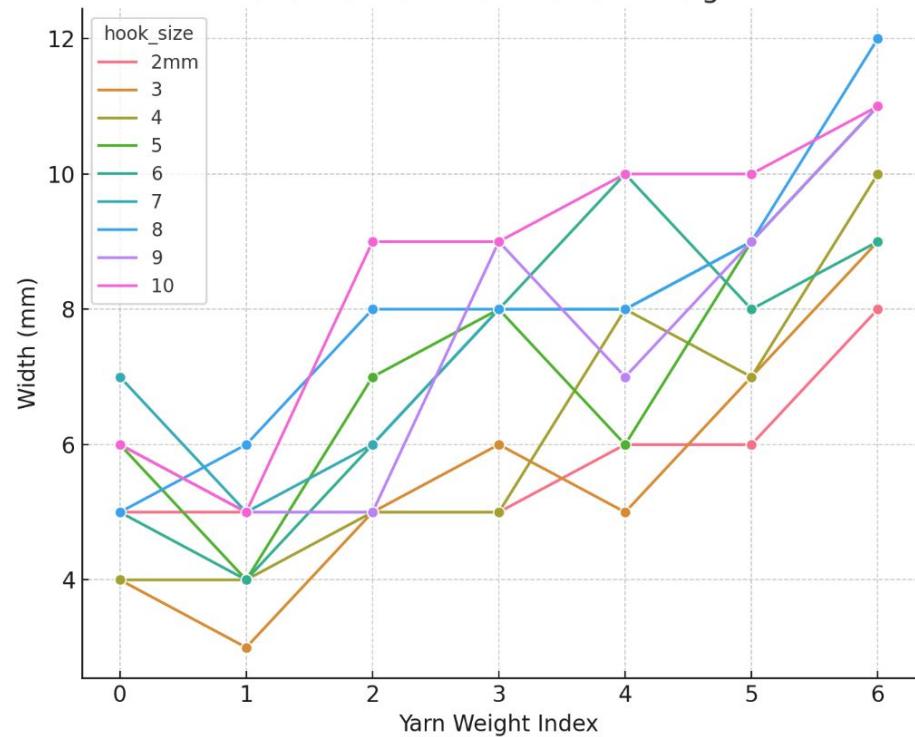
# Stitch Height vs Yarn Weight



### Chain Stitch Length vs Yarn Weight

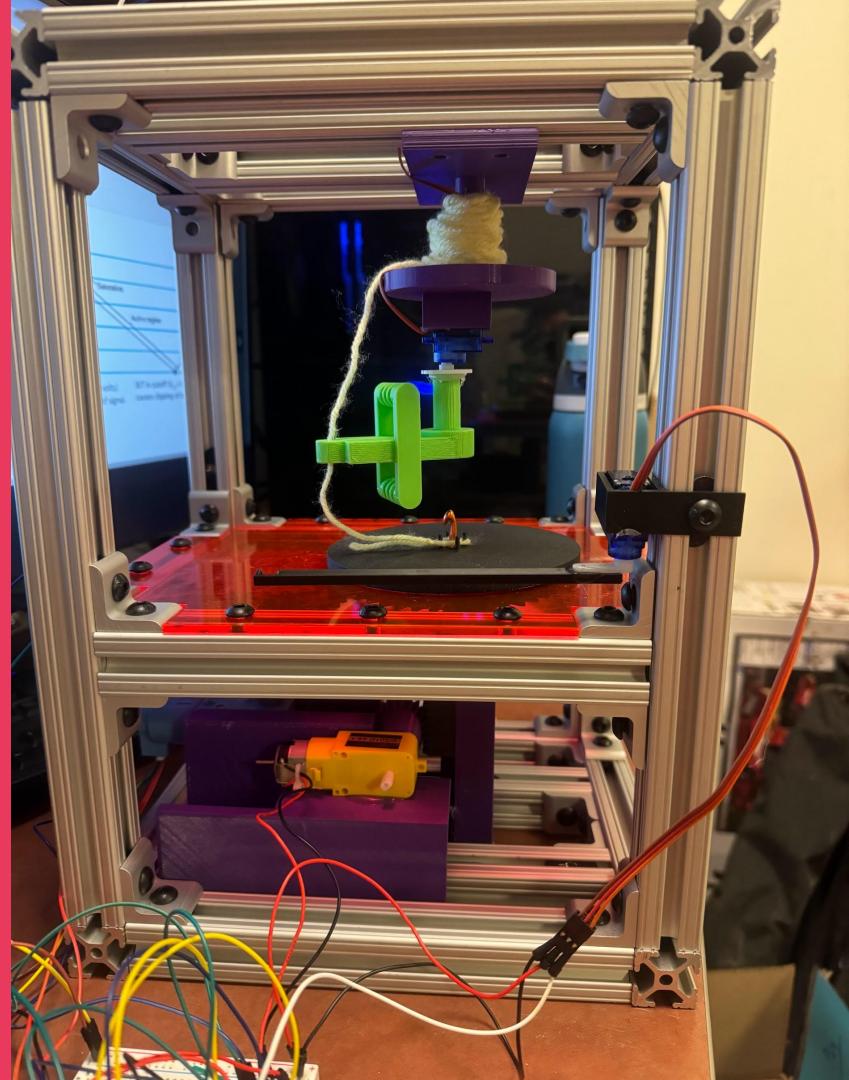


### Chain Stitch Width vs Yarn Weight



# CONCLUSION

- It is possible to replicate crochet hook trajectory using linear and rotational motion
- This initial prototype shows proof of concept and much more can be improved with more precise stepper motors



# CONCLUSION

- It is possible to replicate crochet hook trajectory using linear and rotational motion
- This initial prototype shows proof of concept and much more can be improved with more precise stepper motors



# FUTURE WORK

## Machine

- Makes all stitches
- Works for all hook sizes
- Self-correction
- Stepper motors!!

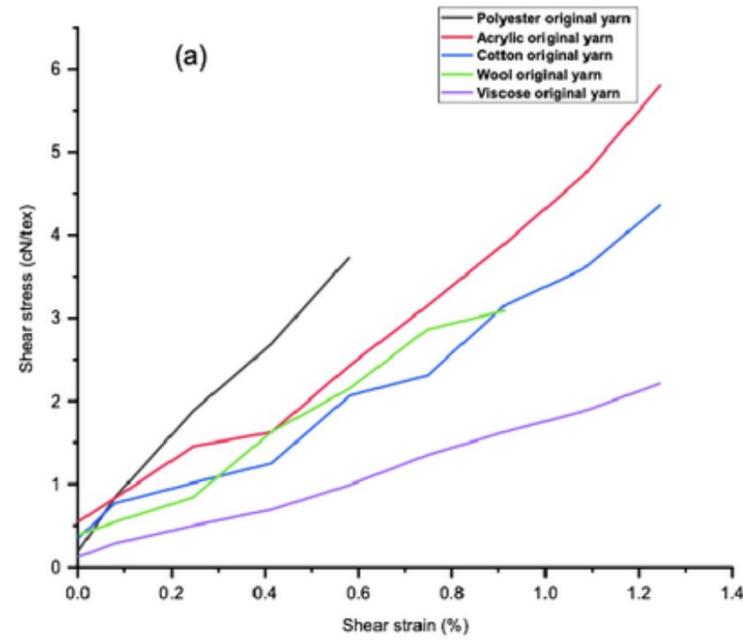
## Code

- Include complex stitches
- Use CV to rewrite a pattern based on an image
- Use CV to export code to crochet based off a diagram

**THANK  
YOU!**

References of pictures i used from the internet

# Backup slides



# Backup slide – break the dress down

