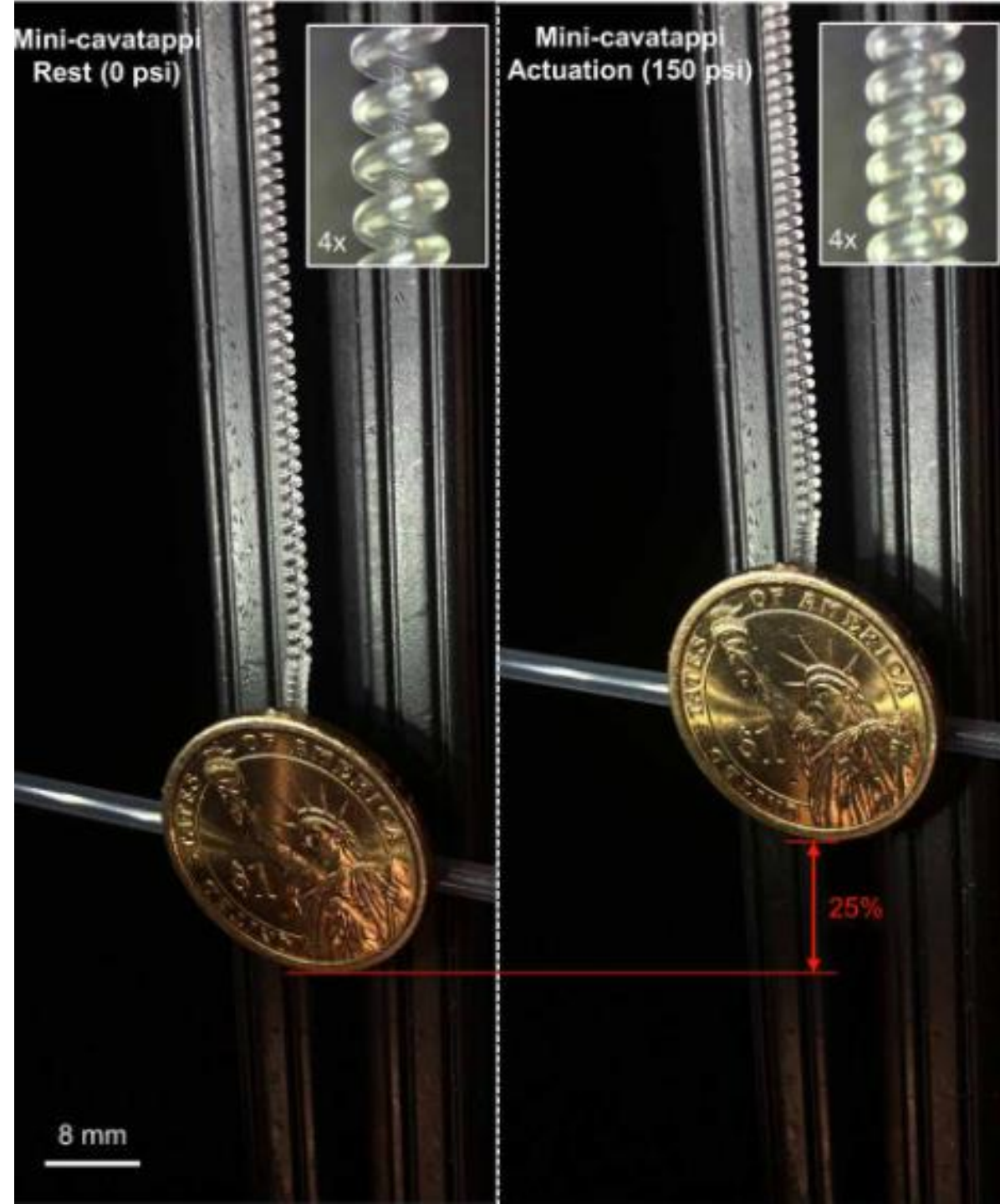


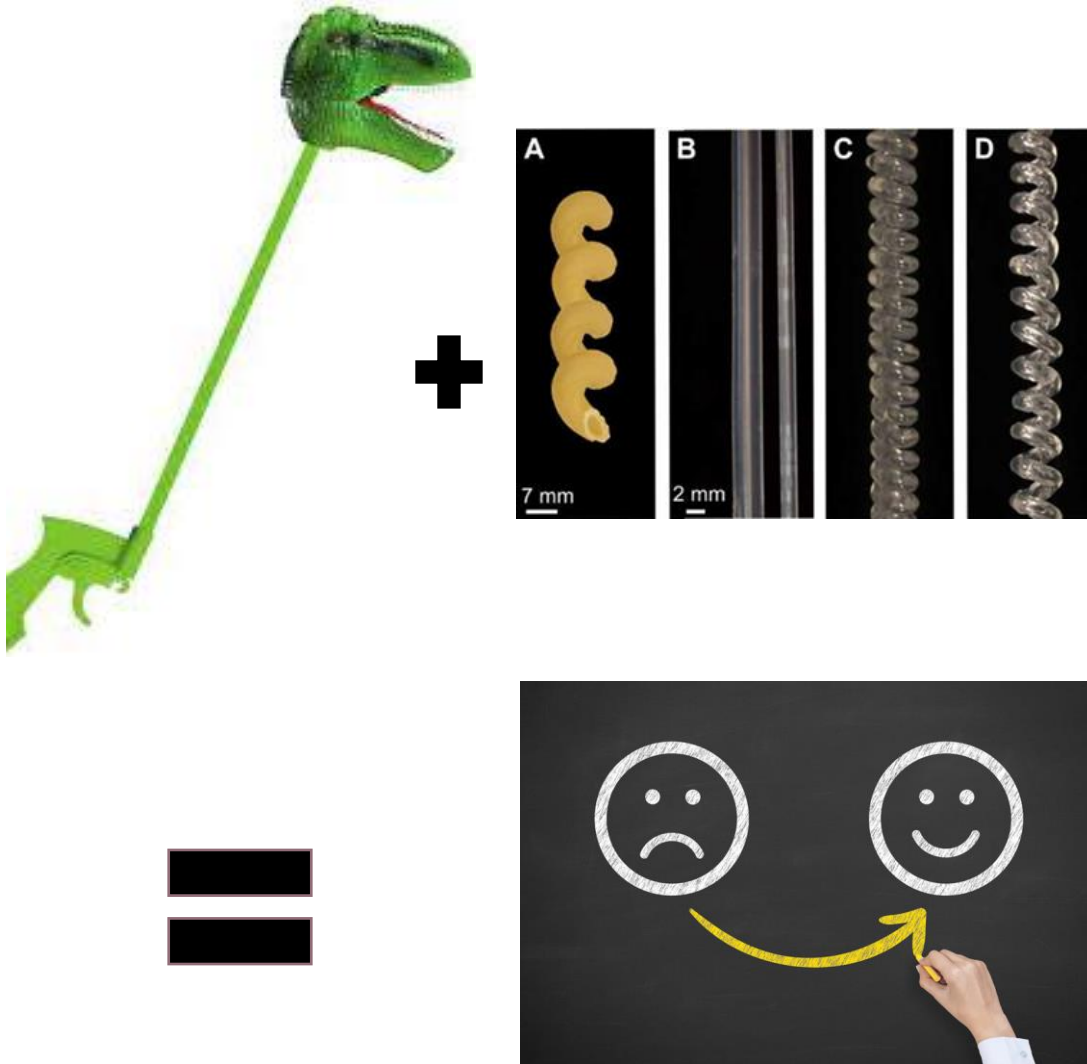
---

# MINI-CAVATAPPI ACTUATED LAPAROSCOPIC TOOL

By: Ann Lester, James Bennett, Ryn  
Shuster

---





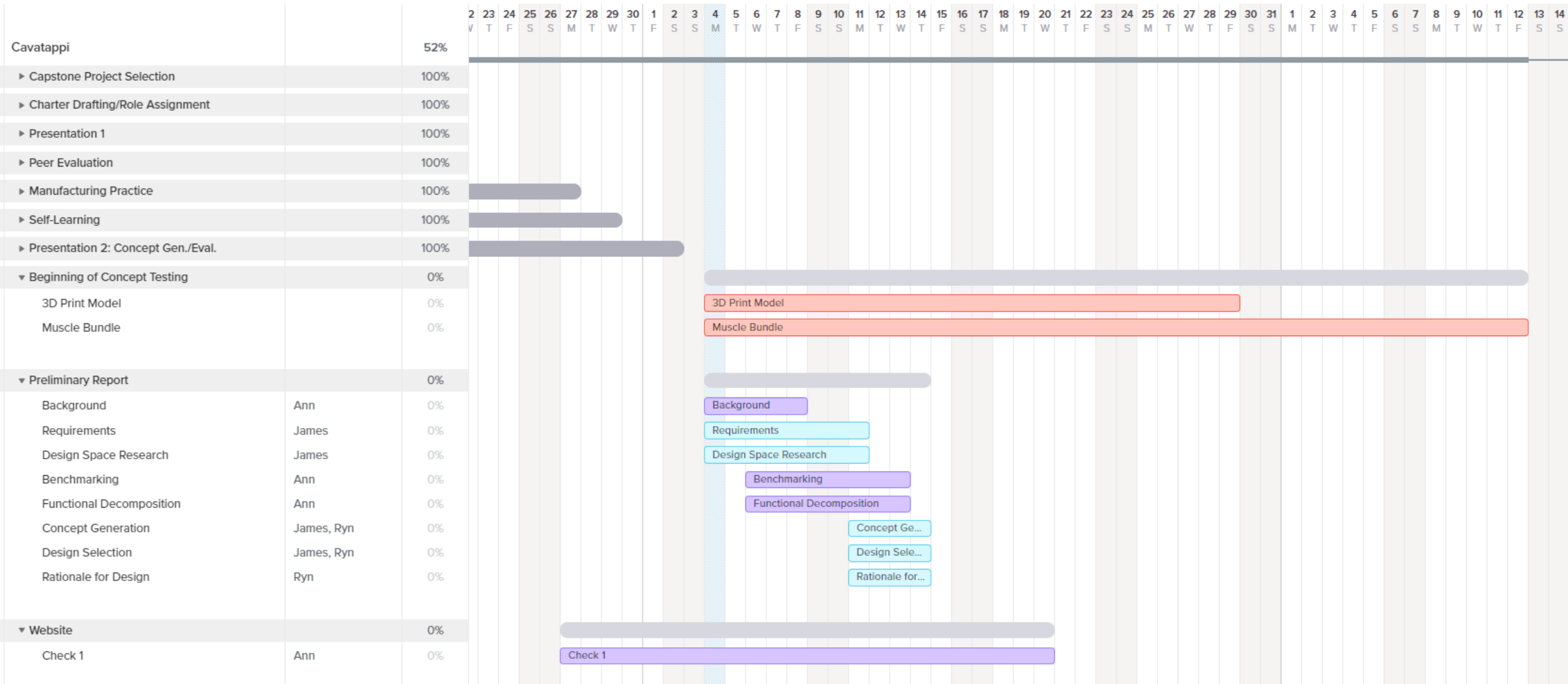
**Figure 1::** Project Description graphic

---

# PROJECT DESCRIPTION

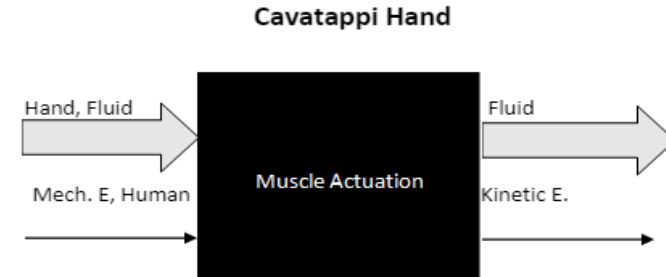
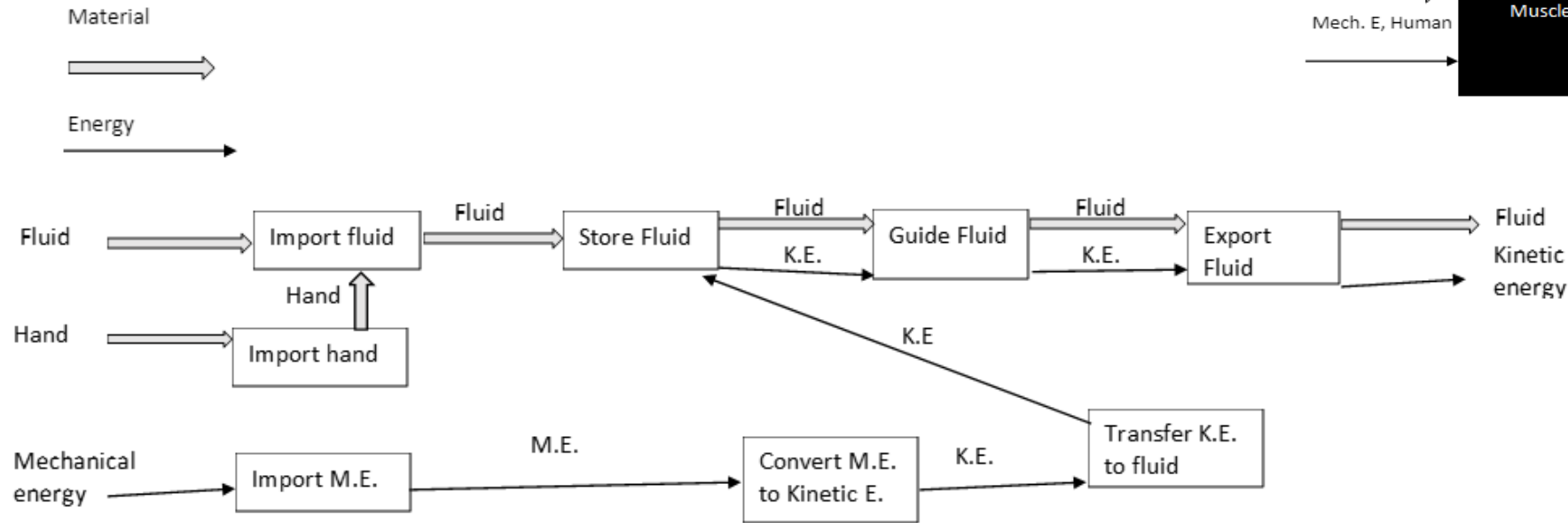
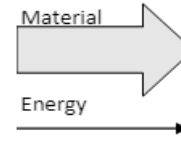
- Our Project:
  - To design a scaled down mechanical hand powered by Cavatappi muscle actuation
    - Must be able to pick up a coin from a flat surface
    - Has multiple independent degrees of actuation

# UPDATED GANTT



---

# PROJECT DESCRIPTION (CONT.)



---

# DATUM



**Figure 2:** Current Coiling setup



**Figure 3:** Current Heating setup



**Figure 3:** Current Clamps

# CONCEPT GENERATION-MECHANICAL HAND

| Criteria               | Datum (Forceps) | Finger nails | Finger Tip grips | Trumpet  | Capsule | Spring Loaded Fingers | Rubber Finger Tips | Fleshy Hand | Pincer  | Flexible Joints | Thumb muscle pattern |
|------------------------|-----------------|--------------|------------------|----------|---------|-----------------------|--------------------|-------------|---------|-----------------|----------------------|
| A-Aesthetic            | Same            | Inferior     | Exceeds          | Exceeds  | Exceeds | Inferior              | Same               | Exceeds     | Same    | Same            | Inferior             |
| B-Reliability          | Same            | Exceeds      | Exceeds          | Inferior | Same    | Inferior              | Exceeds            | Exceeds     | Exceeds | Inferior        | Exceeds              |
| C-Degrees of freedom   | Same            | Same         | Same             | Exceeds  | Same    | Same                  | Same               | Same        | Same    | Exceeds         | Exceeds              |
| D-Ease of Construction | Same            | Exceeds      | Inferior         | Inferior | Same    | Inferior              | Exceeds            | Inferior    | Same    | Inferior        | Inferior             |
| SUM Exceeds            | 0               | 2            | 2                | 2        | 1       | 0                     | 2                  | 2           | 1       | 1               | 2                    |
| SUM Inferior           | 0               | 1            | 1                | 2        | 0       | 3                     | 0                  | 1           | 0       | 2               | 2                    |
| SUM Same               | 4               | 1            | 1                | 0        | 3       | 1                     | 2                  | 1           | 3       | 1               | 0                    |



# CONCEPTION GENERATION-MECHANICAL HAND

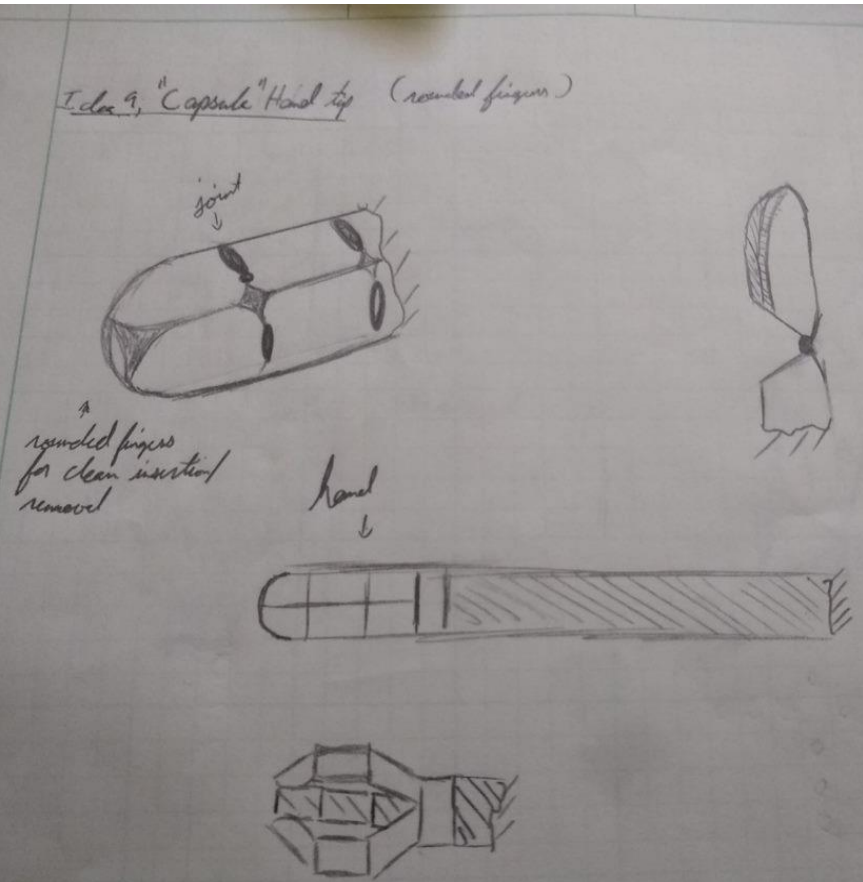


Figure 5: Sample Hand Concept 1

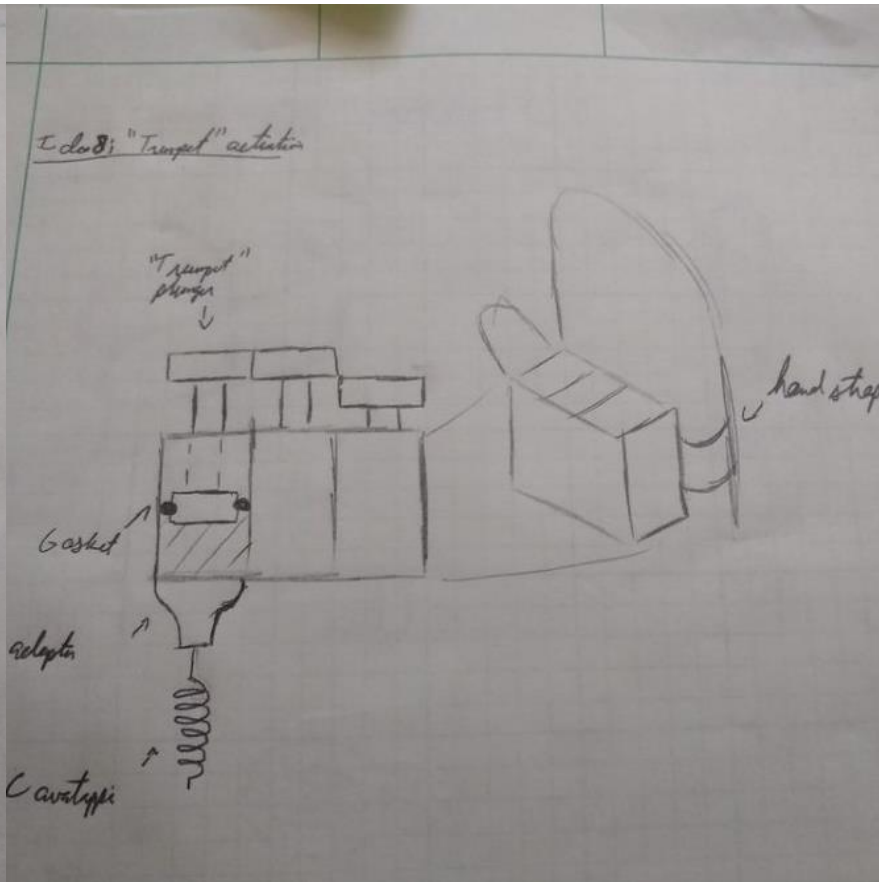


Figure 6: Sample Actuation Concept

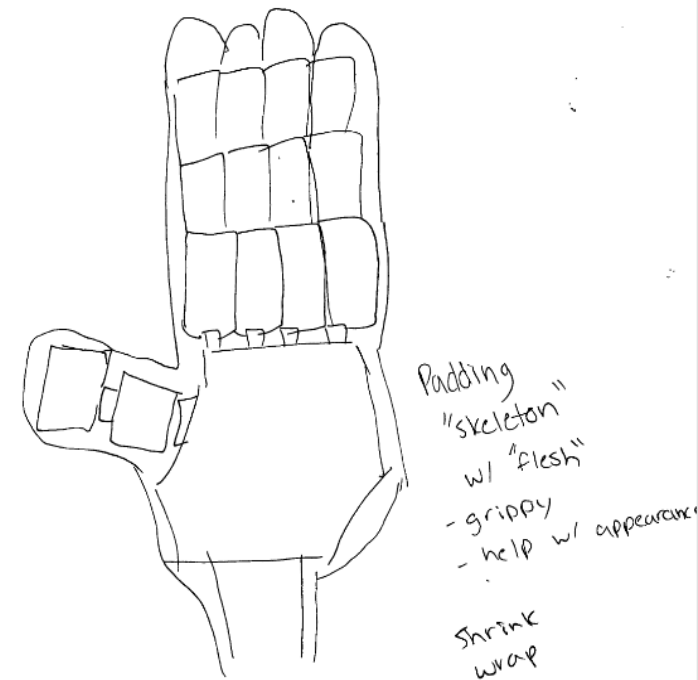


Figure 7: Sample Hand Concept 2  
Ann, Team Cavatappi

# CAVATAPPI MANUFACTURE: PUGH CHART

| Criteria                   | Datum Values           | Annealing                 |                                         |                   |                         | Coiling                  |                         |                               |                     |                               |                           |                      | Clamping            |               |                 |
|----------------------------|------------------------|---------------------------|-----------------------------------------|-------------------|-------------------------|--------------------------|-------------------------|-------------------------------|---------------------|-------------------------------|---------------------------|----------------------|---------------------|---------------|-----------------|
|                            |                        | Resistive Heating Element | Current Heating Method with Larger Rack | Sous-Vide Heating | Annealing Mandrel Stand | Respool Precoiled Tubing | Reusable Mandrel Design | Perpendicular Spooling Method | Double-Motor Method | Auto- Adjusting Mandrel Mount | Navajo String-Coil Method | Carrier Held Mandrel | Updated Clamp Ideas | Workout Clamp | Alligator Clamp |
| A-Scalability of Muscle    | 10 - 90 mm             | Exceeds                   | Exceeds                                 | Same              | Same                    | Same                     | Exceeds                 | Exceeds                       | Same                | Inferior                      | Exceeds                   | Exceeds              | Exceeds             | Same          | Exceeds         |
| B-Reliability of System    | 40%                    | Exceeds                   | Same                                    | Exceeds           | Same                    | Exceeds                  | Exceeds                 | Exceeds                       | Inferior            | Exceeds                       | Same                      | Same                 | Exceeds             | Same          | Exceeds         |
| C-Flexibility of System    | #coils /cm, coil diam. | Exceeds                   | Exceeds                                 | Exceeds           | Exceeds                 | Inferior                 | Same                    | Exceeds                       | Inferior            | Inferior                      | Same                      | Exceeds              | Same                | Same          | Same            |
| D-Quality of Muscle        | 50%                    | Exceeds                   | Same                                    | Exceeds           | Same                    | Exceeds                  | Exceeds                 | Exceeds                       | Same                | Exceeds                       | Same                      | Exceeds              | Same                | Same          | Exceeds         |
| E-Simplicity of Design     | # of Parts             | Inferior                  | Exceeds                                 | Exceeds           | Exceeds                 | Exceeds                  | Exceeds                 | Exceeds                       | Inferior            | Inferior                      | Inferior                  | Inferior             | Exceeds             | Inferior      | Exceeds         |
| F-Heating Consistency      | 170 °F                 | Exceeds                   | Same                                    | Exceeds           | Exceeds                 | Same                     | Same                    | Same                          | Same                | Same                          | Same                      | Same                 | Same                | Same          | Same            |
| G-Expected Additional Cost | ~\$130.00              | Exceeds                   | Inferior                                | Exceeds           | Exceeds                 | Inferior                 | Exceeds                 | Exceeds                       | Inferior            | Inferior                      | Inferior                  | Inferior             | Exceeds             | Inferior      | Exceeds         |
| SUM Exceeds                | 0                      | 6                         | 3                                       | 6                 | 4                       | 3                        | 5                       | 6                             | 0                   | 2                             | 1                         | 3                    | 4                   | 0             | 5               |
| SUM Inferior               | 0                      | 1                         | 1                                       | 0                 | 0                       | 2                        | 0                       | 0                             | 5                   | 4                             | 2                         | 2                    | 0                   | 2             | 0               |
| SUM Same                   | 7                      | 0                         | 3                                       | 1                 | 3                       | 2                        | 2                       | 1                             | 2                   | 1                             | 4                         | 2                    | 3                   | 5             | 2               |



# CAVATAPPI MANUFACTURE: COILING

- Best Concepts

- Carrier Method

- Tygon in middle, mandrel rotates on carrier
    - Less moving parts
    - May be more difficult to make

- Spooling Method

- Mandrel in middle, Tygon spooled separately
    - Spool runs perpendicular to mandrel
    - Easy to make
    - A few more moving parts, more clamps necessary

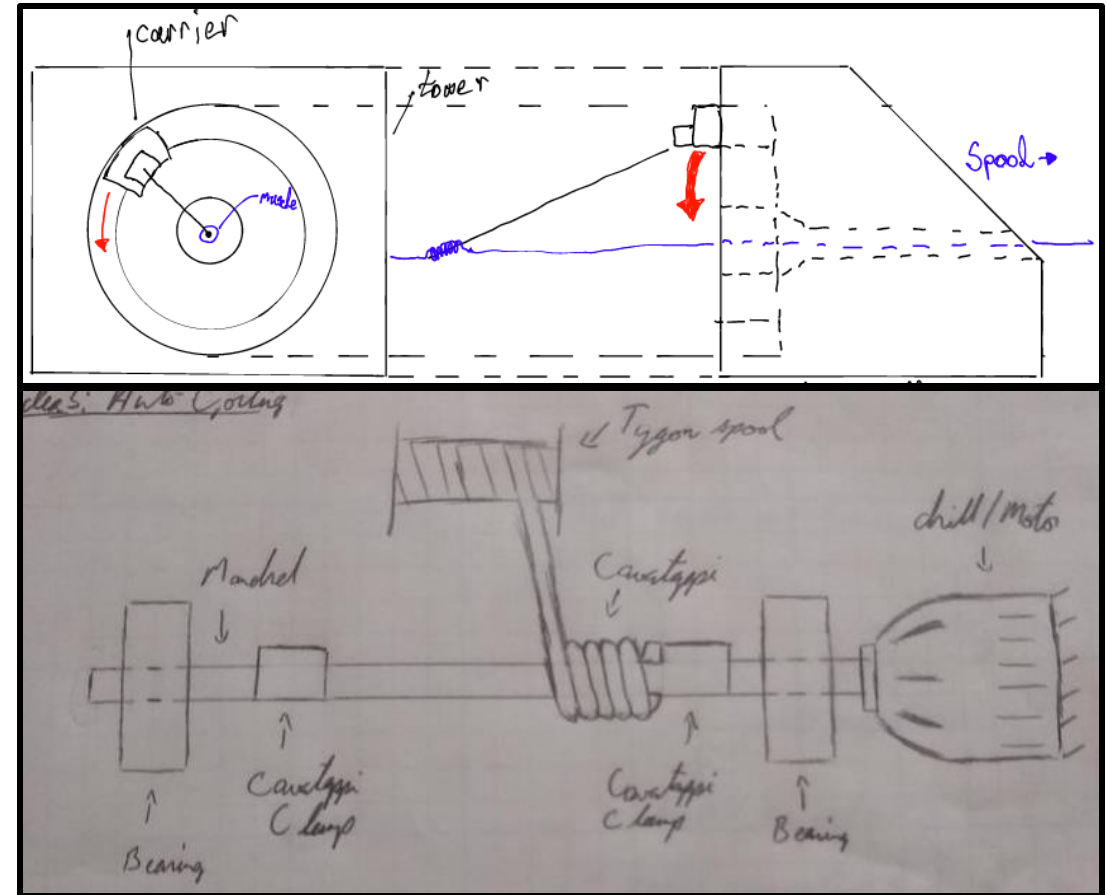


Figure 7: Carrier Method (top) vs. Spooling Method (bottom)

---

# CAVATAPPI MANUFACTURE: ANNEALING

- Best Concepts:
  - Sous-Vide
    - Even heating
    - Easily controlled
    - Long warmup time
  - Resistive Heating Element (RHE)
    - Quick warmup time
    - Easy to use
    - Concerns about even heating
    - Potentially complex setup
    - Needs assembly/ fan system/ enclosure



**Figure 8:** Sous Vide (left) and RHE system controls (right)

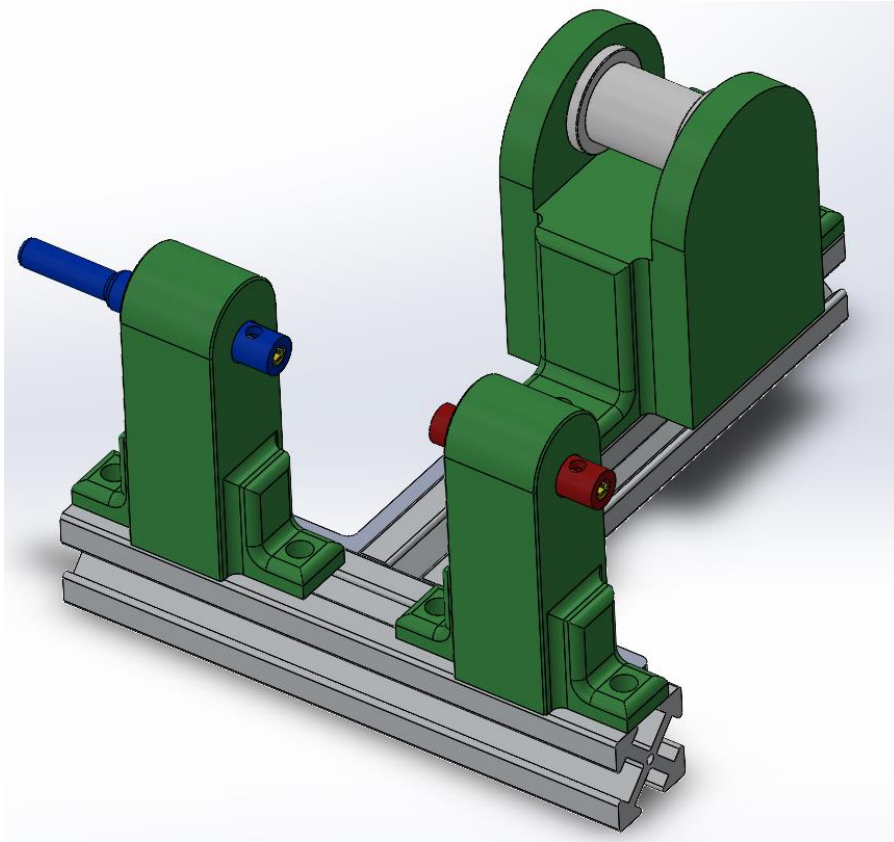
# MANUFACTURING DECISION MATRIX

- Carrier vs. Spooling
  - Criteria based on Pugh Chart
  - Heavy weighting
    - System Reliability (30 %)
    - Muscle Quality (25 %)
  - Percentages vs. Weights
    - How well do we think it'll perform?
    - Weights are out of 100 points

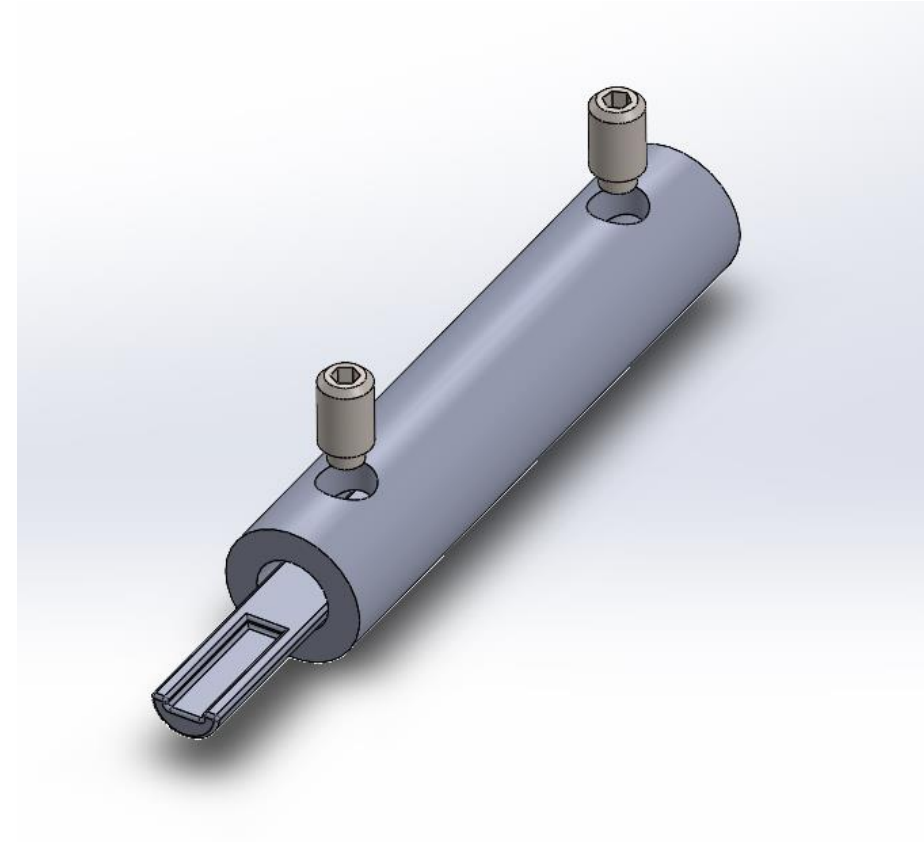
| Decision Matrix: Muscle Production |            |                |                |                 |                |
|------------------------------------|------------|----------------|----------------|-----------------|----------------|
| Criteria                           |            | Carrier Method |                | Spooling Method |                |
|                                    |            | Percentage Met | Weighted Score | Percentage Met  | Weighted Score |
| Criteria                           | Weight     |                |                |                 |                |
| A-Scalability of Muscle Length     | 10.00      | 80%            | 8.00           | 80%             | 8.00           |
| B-Reliability of system            | 30.00      | 70%            | 21.00          | 85%             | 25.50          |
| C-Flexibility of system            | 5.00       | 80%            | 4.00           | 85%             | 4.25           |
| D-Quality of Muscle                | 25.00      | 90%            | 22.50          | 90%             | 22.50          |
| E-Simplicity of Design             | 15.00      | 60%            | 9.00           | 85%             | 12.75          |
| F-Ease of Construction             | 15.00      | 55%            | 8.25           | 85%             | 12.75          |
| <b>Total Points</b>                | <b>100</b> |                | <b>72.75</b>   |                 | <b>85.75</b>   |
| Relative Ranking                   | 1st/2nd    |                | 2nd            |                 | 1st            |

---

# CAD: SPOOLING METHOD



**Figure 9:** Spooling Method CAD model



**Figure 10:** Spooling Method Clamp model

# CAD: SPOOLING METHOD

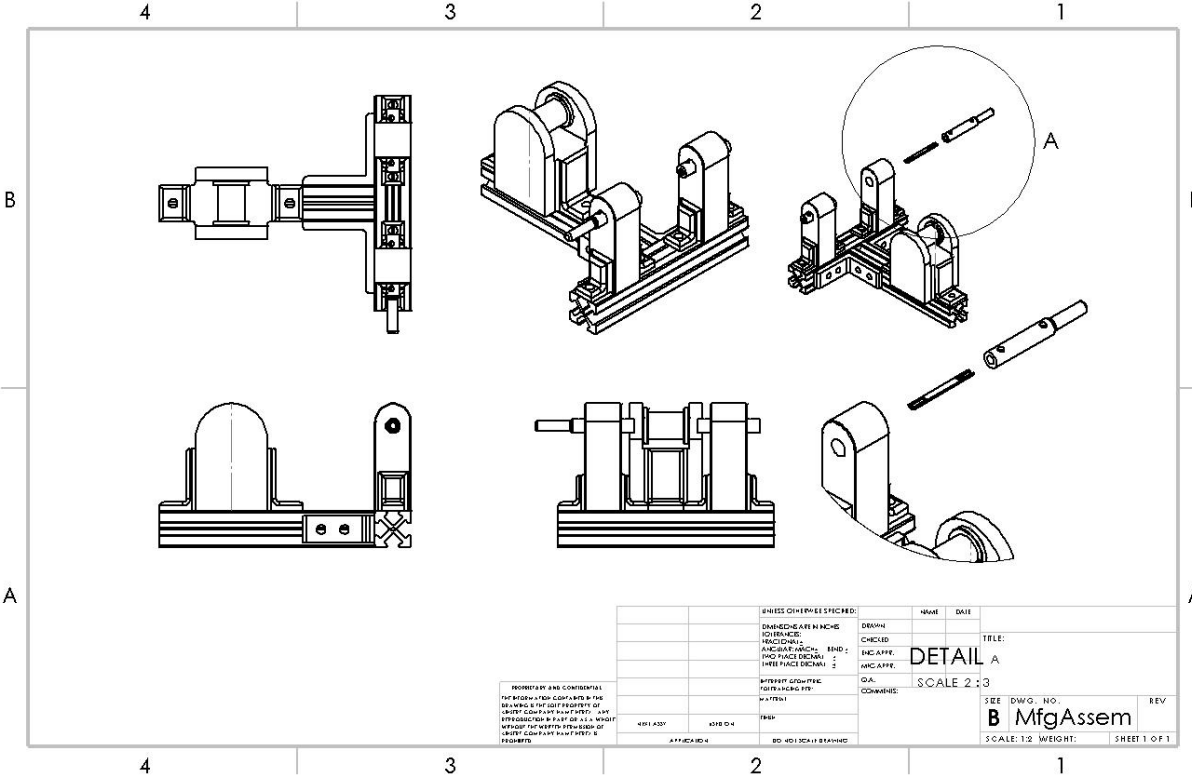


Figure 11: Spooling Method Drawing

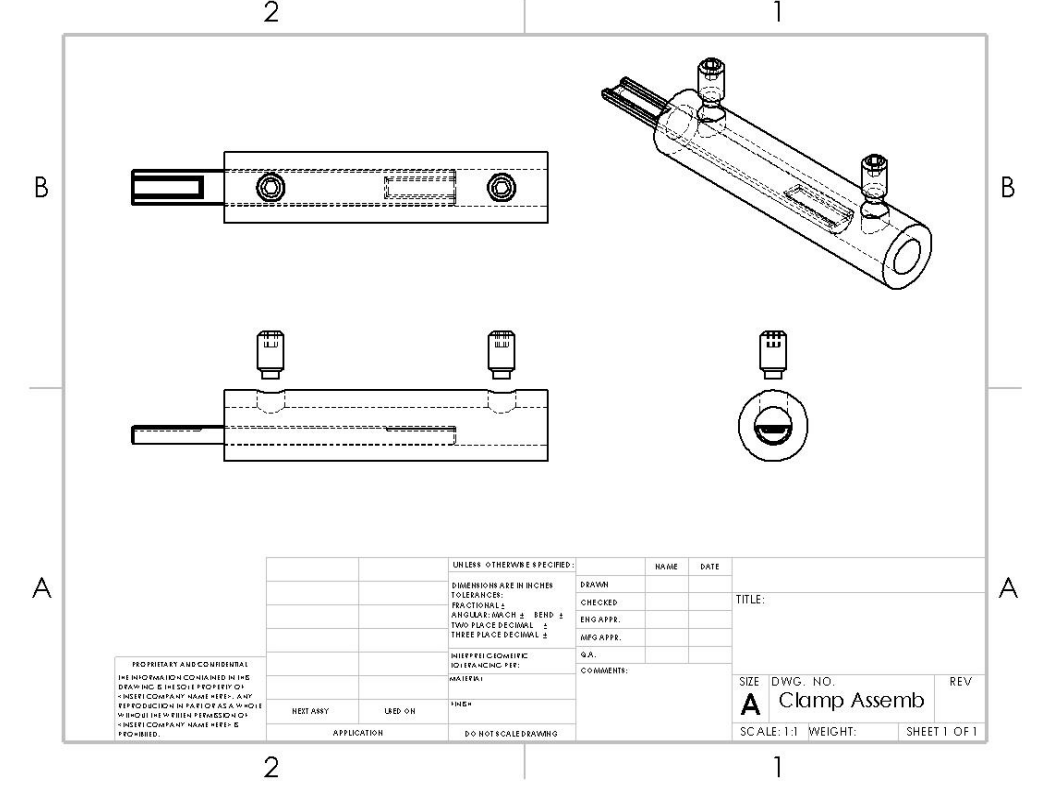
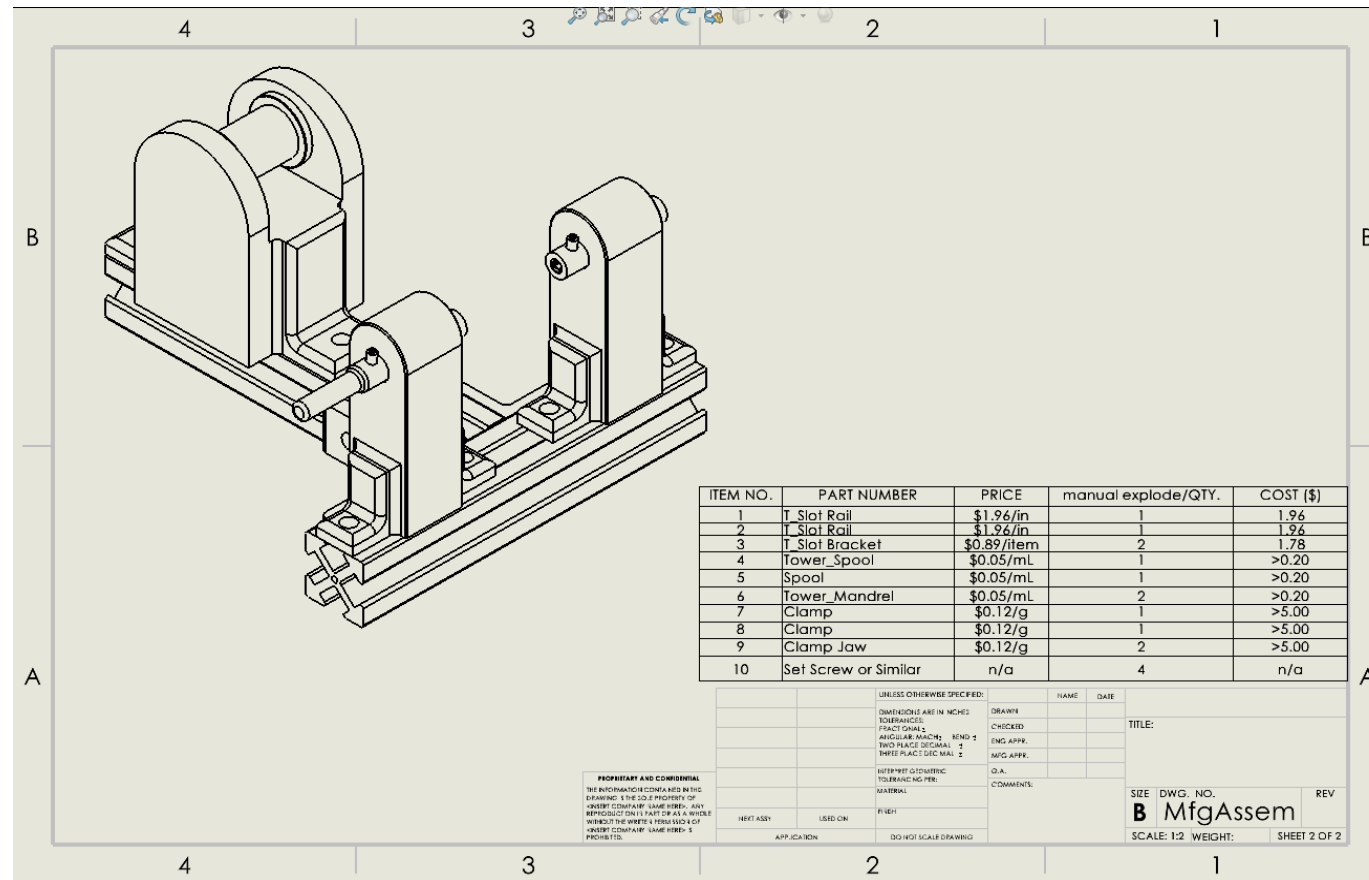


Figure 12: Spooling Method Clamp Drawing

# BUDGET PLANNING: TENTATIVE MFG. BOM



- Listed prices in the current BOM do not reflect available materials.
- Clamps would be printed at Cline.
  - Only item currently requiring purchase.

Figure 13: Spooling Method BOM



---

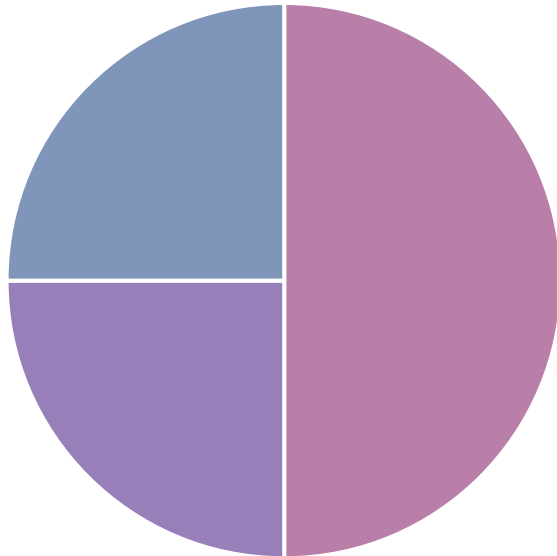
# BUDGET PLANNING: UPDATES

- Actual financial budget is small \$200 to be used for:
  - 3D Prints
  - Extra muscle material
  - Extra hardware not present in the lab
    - Fasteners
    - Pins
    - Motor
- Most will be set aside as an “emergency fund”
- No money has been spent yet

---

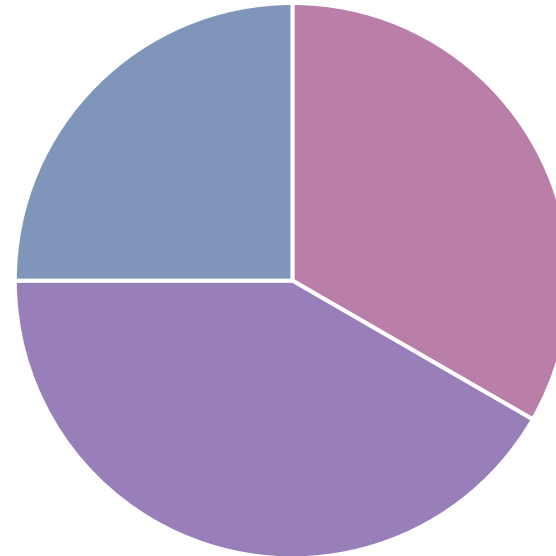
# BUDGET PLANNING: SCENARIOS

Budget Scenario 1



■ Emergency ■ 3D Prints ■ Hardware ■

Budget Scenario 2



■ Emergency ■ 3D Prints ■ Hardware ■