



# FROM CONCEPT TO CREATION: THE ITERATIVE DESIGN PROCESS

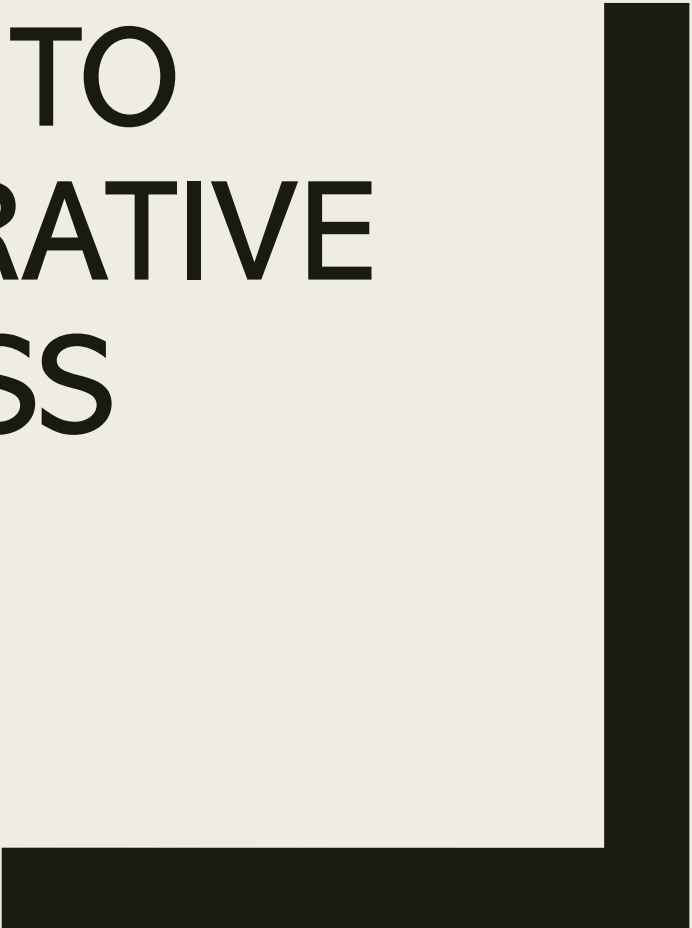
ME 2110 Spring 2024 Final Presentation

“Terrible Three”

Alec Grosswald

Nicholas Trujillo

Stephen Jones



# Introduction

## Goal:

- Design, fabricate and test and automated system that must:
  - *Compete against others to achieve tasks*
  - *Maximize points*
  - *Operate within restrictions to avoid disqualification*

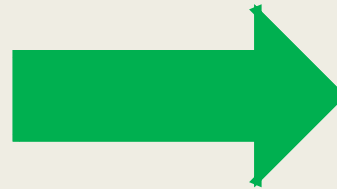
## Our Approach:

- Maximized customer needs under design constraints
- Iterative design process
  - *Testing*
  - *Trial and error*
  - *Learning from our results*

# Problem Understanding

## Customer Requirements

|    |                        |
|----|------------------------|
| 10 | Maximize Score         |
| 10 | Comp. Rules Compliance |
| 7  | Accessible Components  |
| 8  | Affordable Cost        |
| 9  | Performance Efficiency |
| 10 | Safe Operation         |
| 5  | Durable                |
| 7  | Reliable               |
| 8  | Feasible Design        |



## Engineering Specifications

## Target Values

|                           |                             |
|---------------------------|-----------------------------|
| Operation Time            | < 40 seconds                |
| Setup Time                | < 3:30                      |
| Approved Power Source Use | < Power from Controller Box |
| Angular Displacement      | < 10° of tilting            |
| Average Score Deviation   | > 20 Points                 |
| Tolerances                | > 1 inch                    |
| Machine Size              | 12-inch x 24-inch x 18-inch |
| Avg. Points Scored        | 50 Points                   |
| Drawer Slider Deploy Time | < 1 second                  |
| Po Lift Time              | < 35 seconds                |

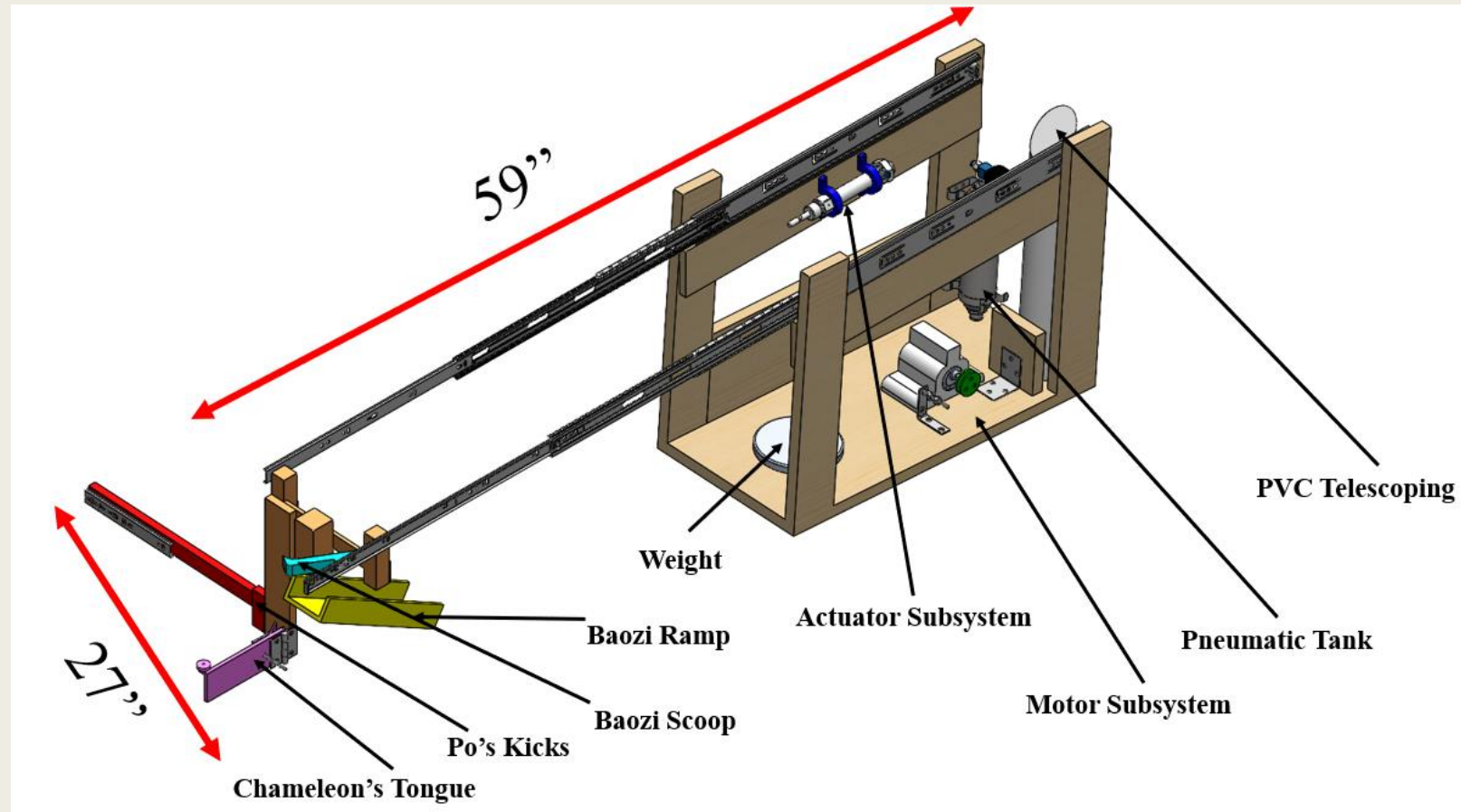
# Final Design

## Maximizes:

- Feasibility
- Performance Efficiency
- Reliability

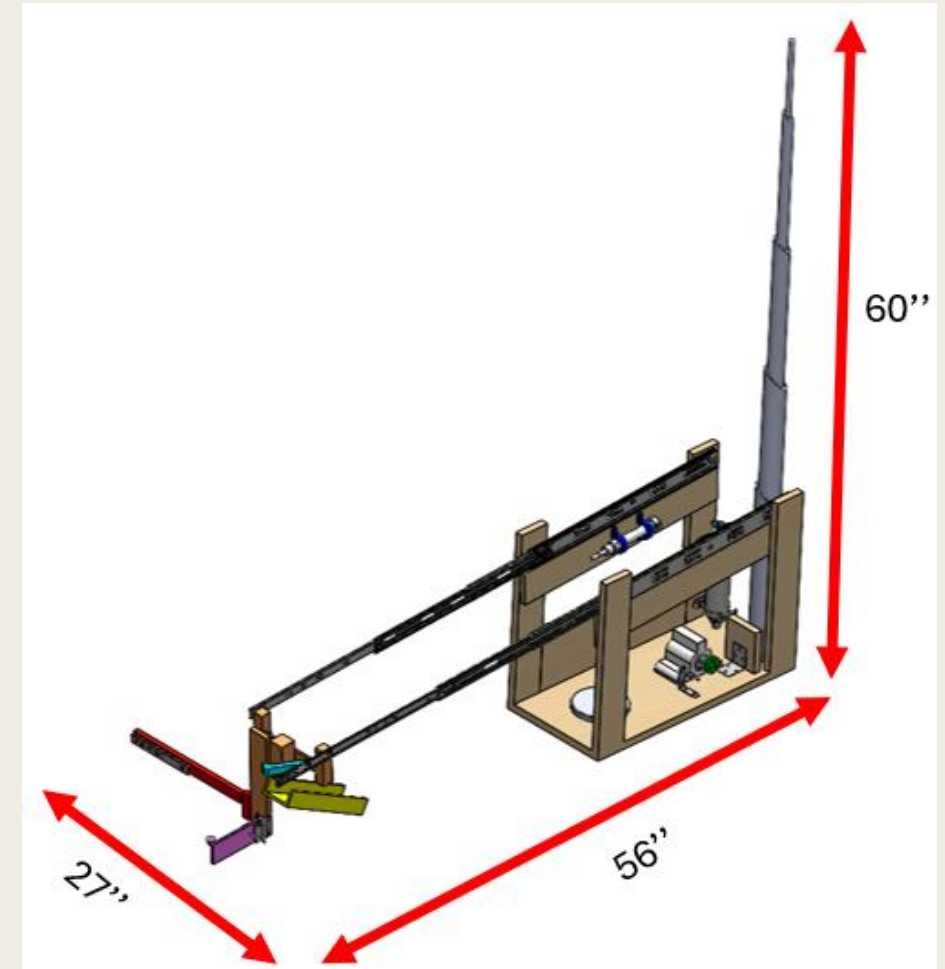
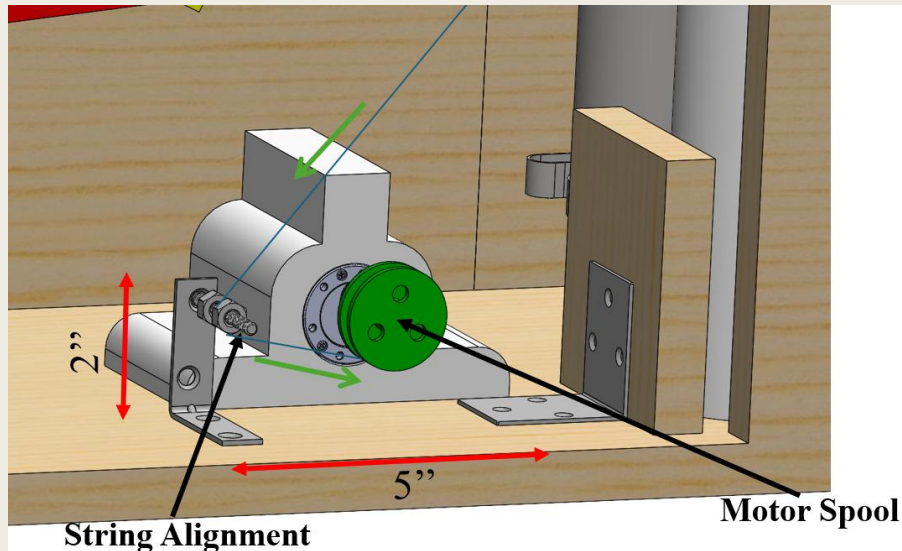
## Under Constraints:

- Size
- Cost
- Limited resources



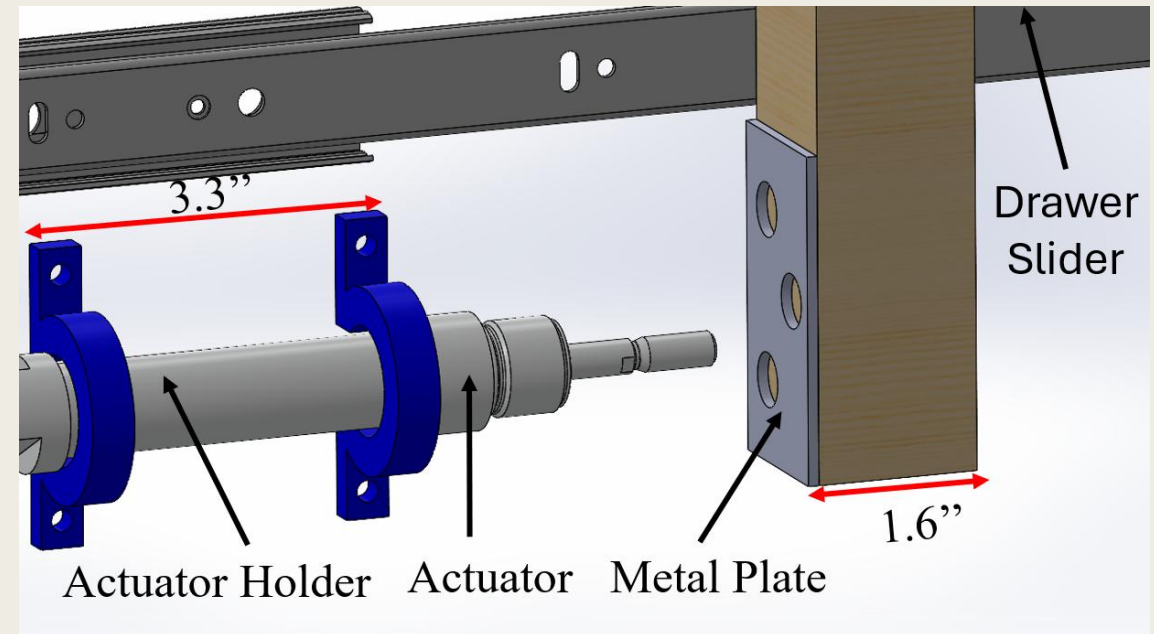
# Design for Reliability: Flying Fireworks Lift

- Saw this Design was consistent with previous competitions
- **Goal:** lift Po 3ft, not reach courtyard (more feasible)



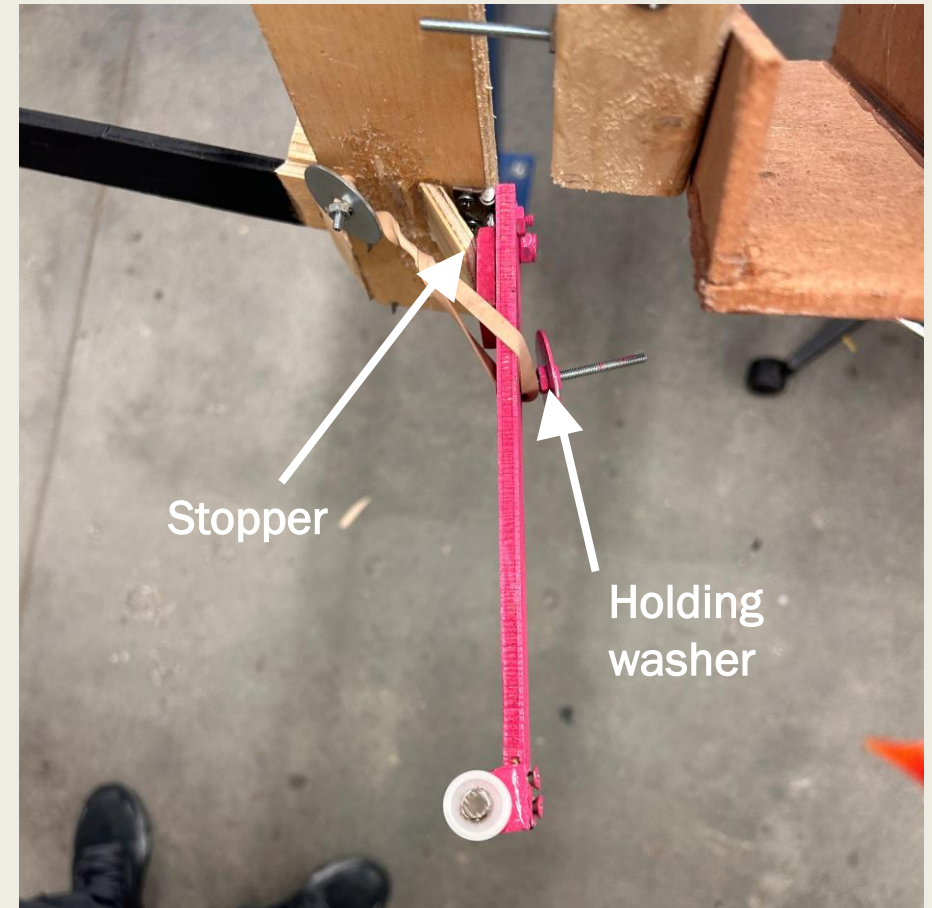
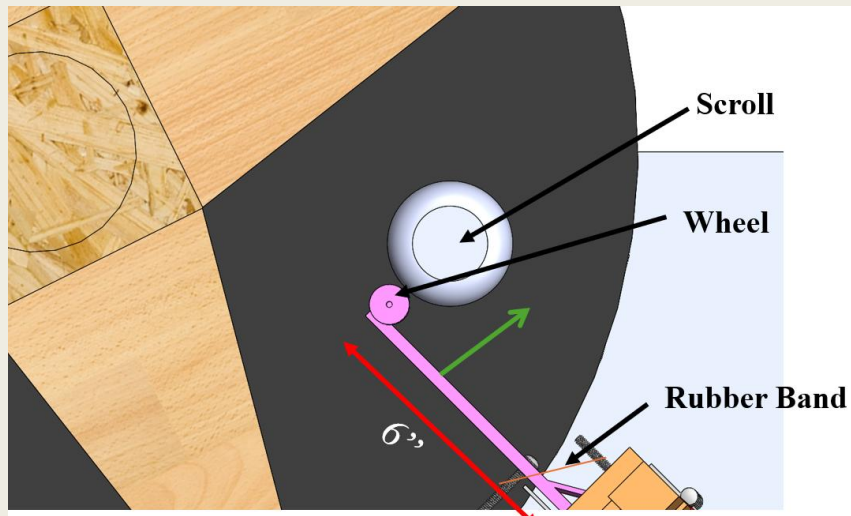
# Actuator Subsystem– Twin Dragons

- Subsystem was **consistent** in Sprint 1 and 2
- Inspired by previous ME2110 competitions



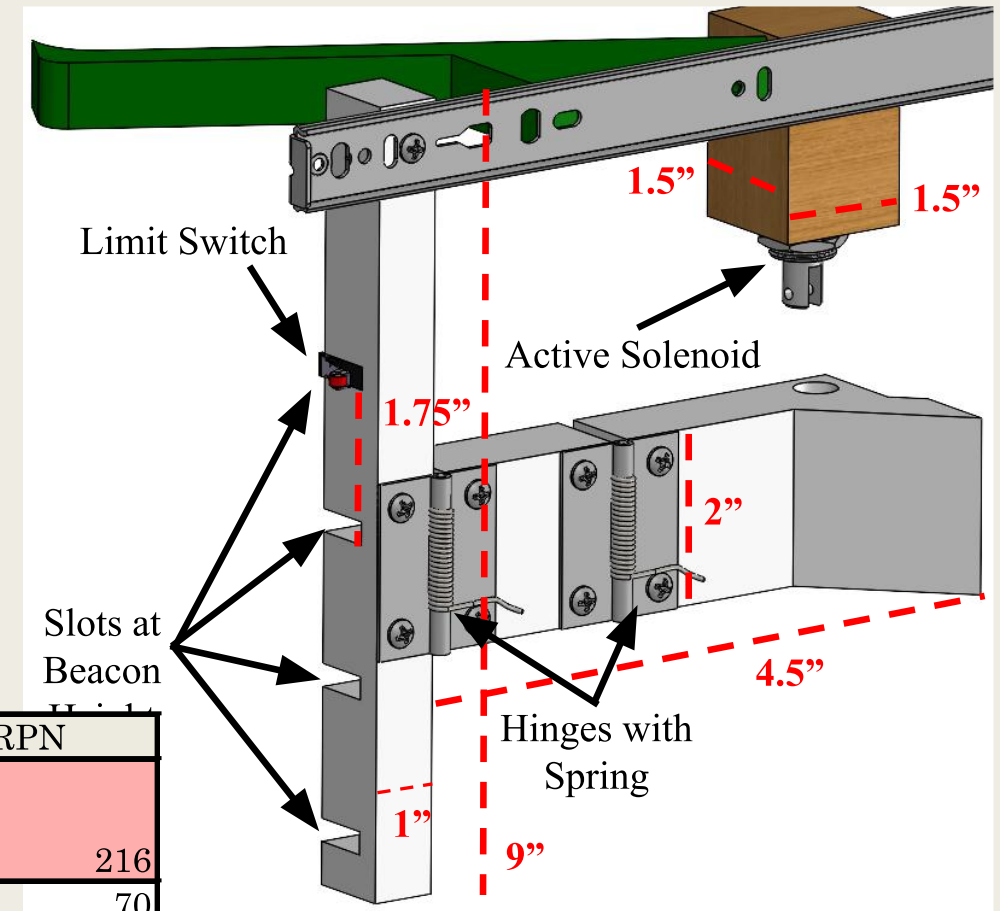
# Scroll Subsystem– Chameleon's Tongue

- Inspired by Sprint 2
- Highly inconsistent (on purpose)
  - Average points scored: **+ 1 point**
  - Average net loss for other teams: **- 35 points**
- Time and resource efficient fabrication

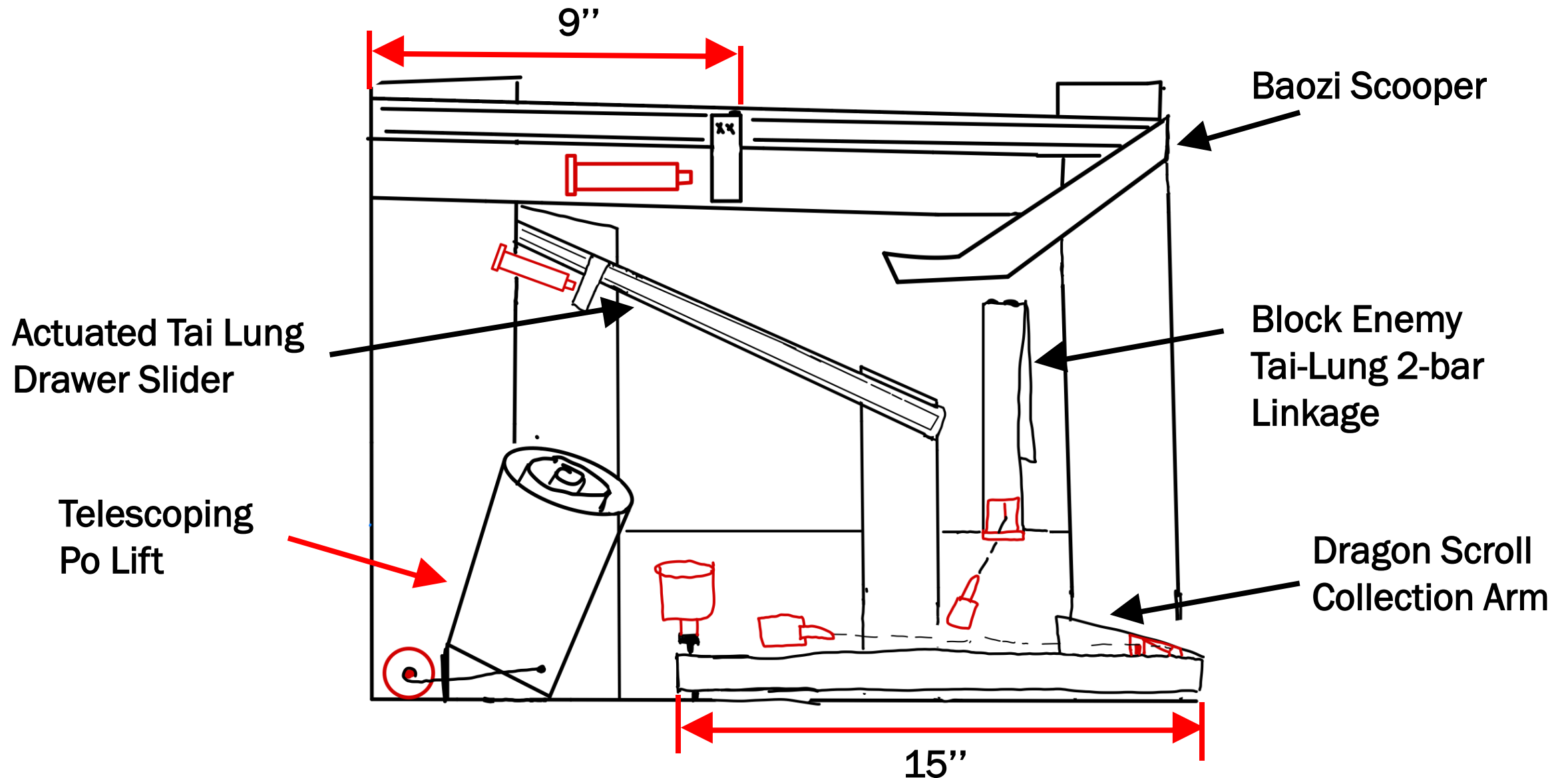


# Sprint 2 Subsystem Failure Analysis

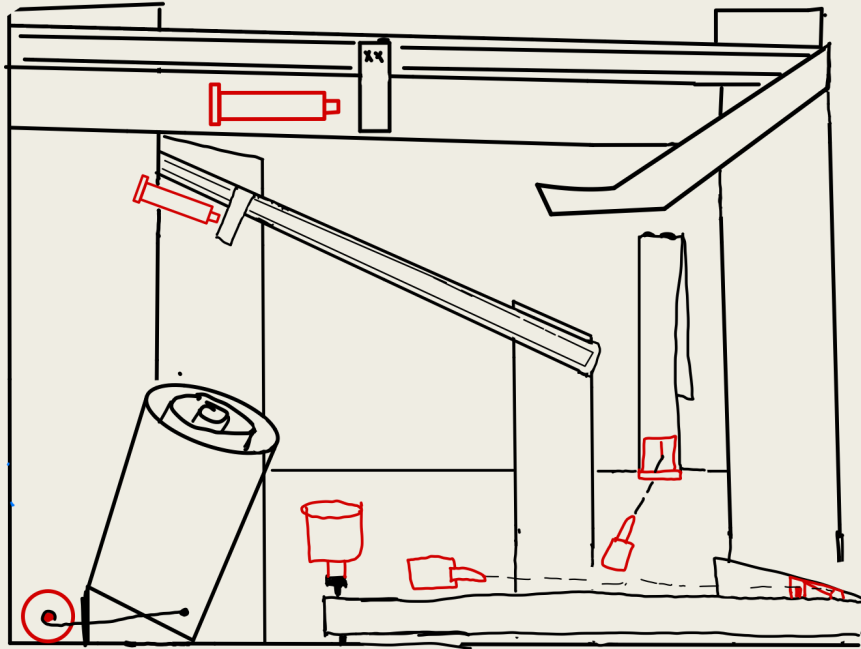
| Possible Effect                           | Root Cause                                              | S | O | D  | RPN |
|-------------------------------------------|---------------------------------------------------------|---|---|----|-----|
| Scroll Subsystem does not retrieve scroll | Switch becomes dislodged from nesting                   | 9 | 4 | 6  | 216 |
|                                           | Bad wire connection                                     | 7 | 1 | 10 | 70  |
|                                           | Switch does not recognize collision                     | 5 | 8 | 7  | 280 |
|                                           | Motor deploys too slowly                                | 5 | 2 | 3  | 30  |
|                                           | Shaking from beacon collision pushes scroll out of zone | 7 | 6 | 4  | 168 |



# Sprint 1 and 2 Design



# Sprint 1 and 2 Design



## Pros:

- Drawer slider use maximizes efficiency
- Short ramp is space efficient

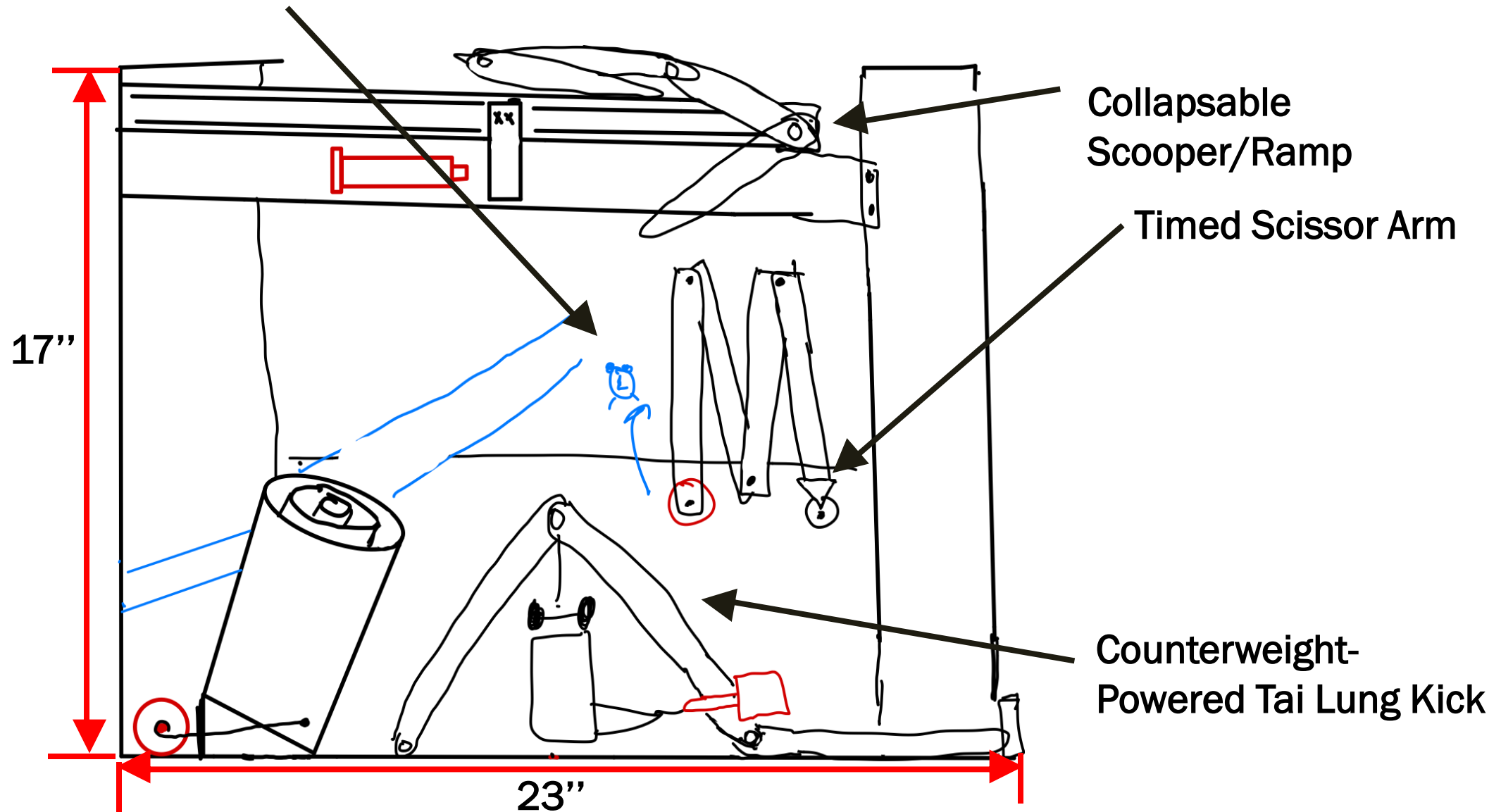
## Cons:

- Tai Lung drawer slider had high error margin
- Motor operated dragon scroll arm could be easily displaced

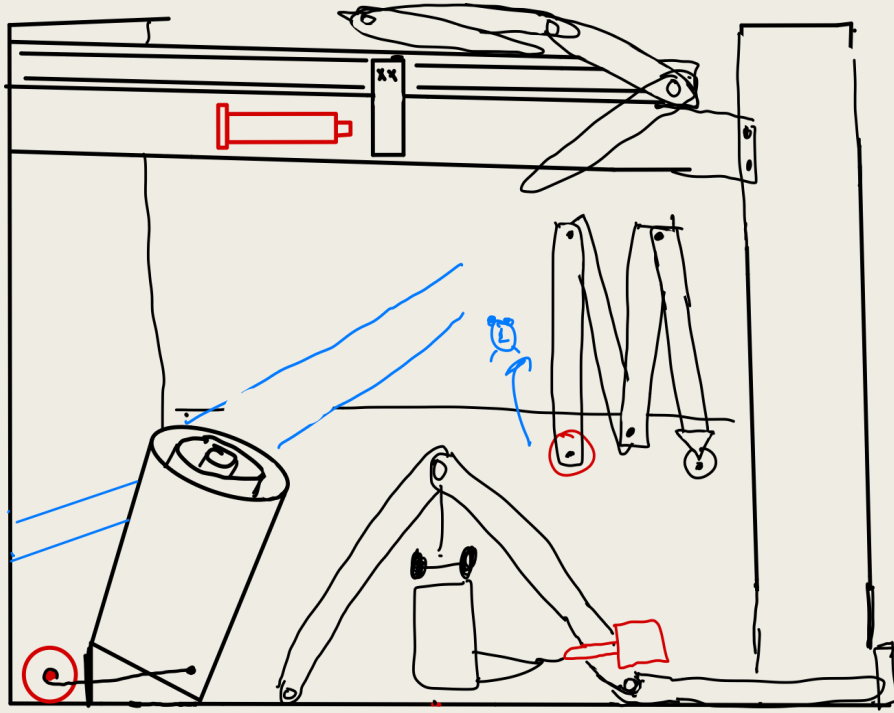
|                           | Importance | Sprint 1 and 2 Design |                |
|---------------------------|------------|-----------------------|----------------|
|                           |            | Rating                | Weighted Total |
| Maximize Score            | 10         | 3                     | 30             |
| Meets ME 2110 Comp. Rules | 10         | 4                     | 40             |
| Accessible Components     | 7          | 3                     | 21             |
| Affordable Cost           | 8          | 2                     | 16             |
| Performance Efficiency    | 9          | 3                     | 27             |
| Safe Operation            | 10         | 4                     | 40             |
| Durability                | 5          | 3                     | 15             |
| Reliability               | 7          | 2                     | 14             |
| Consistency               | 7          | 3                     | 21             |
| Feasible Design           | 6          | 3                     | 18             |
| Weighted Total            | 316        | 242                   |                |
| Relative Total            | N/A        | 0.77                  |                |
| Rank                      | N/A        | 3                     |                |

# Back Ramp Design

Home Zone Ramp



# Back Ramp Design



## Pros:

- Ramp to starting zone maximizes points scored
- Collapsible baozi scooper is space efficient

## Cons:

- Counterweight as a power source is not as feasible
- Timed jade scroll retrieval produces higher risk

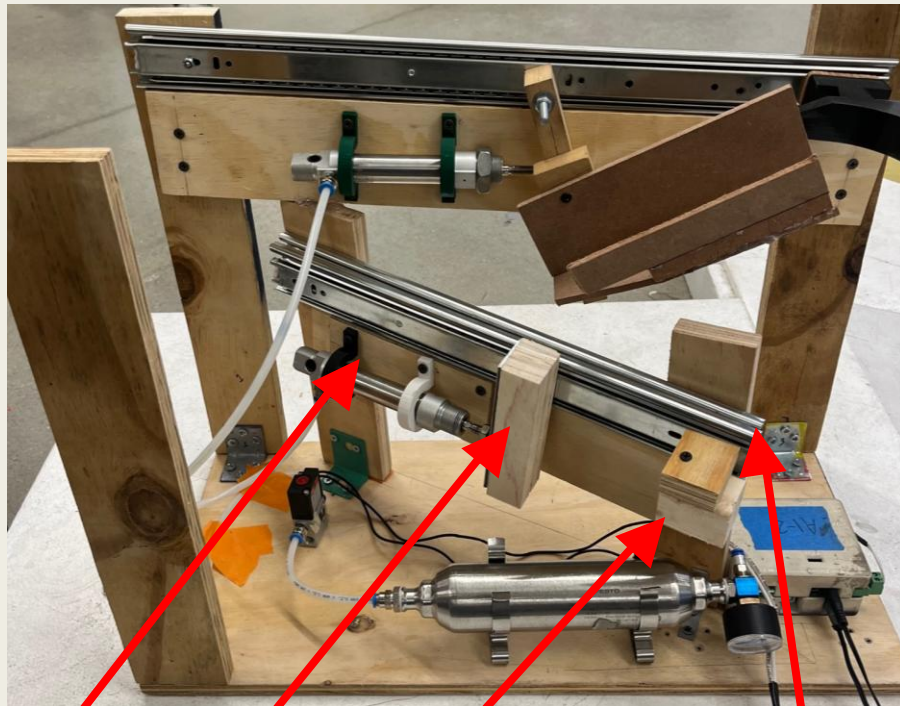
|                           | Importance | Back Ramp Design |                |
|---------------------------|------------|------------------|----------------|
|                           |            | Rating           | Weighted Total |
| Maximize Score            | 10         | 4                | 40             |
| Meets ME 2110 Comp. Rules | 10         | 4                | 40             |
| Accessible Components     | 7          | 2                | 14             |
| Affordable Cost           | 8          | 3                | 24             |
| Performance Efficiency    | 9          | 4                | 36             |
| Safe Operation            | 10         | 2                | 20             |
| Durability                | 5          | 2                | 10             |
| Reliability               | 7          | 2                | 14             |
| Consistency               | 7          | 1                | 7              |
| Feasible Design           | 6          | 3                | 18             |
| Weighted Total            | 316        | 223              |                |
| Relative Total            | N/A        | 0.71             |                |
| Rank                      | N/A        | 3                |                |

# Evaluation Matrix

| Criteria                  | Importance | Sprint 1 and 2 |                | Final  |                | Back Ramp |                |
|---------------------------|------------|----------------|----------------|--------|----------------|-----------|----------------|
|                           |            | Rating         | Weighted Total | Rating | Weighted Total | Rating    | Weighted Total |
| Maximize Score            | 10         | 3              | 30             | 2      | 20             | 4         | 40             |
| Meets ME 2110 Comp. Rules | 10         | 4              | 40             | 4      | 40             | 4         | 40             |
| Accessible Components     | 7          | 3              | 21             | 3      | 21             | 2         | 14             |
| Affordable Cost           | 8          | 2              | 16             | 4      | 32             | 3         | 24             |
| Performance Efficiency    | 9          | 3              | 27             | 4      | 36             | 4         | 36             |
| Safe Operation            | 10         | 4              | 40             | 4      | 40             | 2         | 20             |
| Durability                | 5          | 3              | 15             | 2      | 10             | 2         | 10             |
| Reliability               | 7          | 3              | 21             | 2      | 14             | 2         | 14             |
| Consistency               | 7          | 2              | 14             | 2      | 14             | 1         | 7              |
| Feasible Design           | 6          | 3              | 18             | 4      | 24             | 3         | 18             |
| Weighted Total            | 316        | 242            |                | 251    |                | 223       |                |
| Relative Total            | N/A        | 0.77           |                | 0.79   |                | 0.71      |                |
| Rank                      | N/A        | 2              |                | 1      |                | 3         |                |

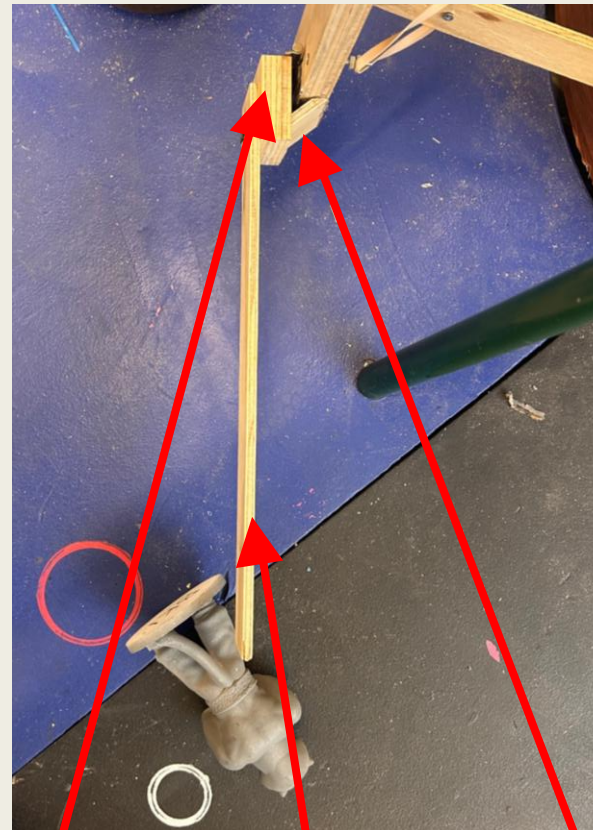
# Iterative design – Po's Kick

Iteration 1: Actuated  
Drawer Slider



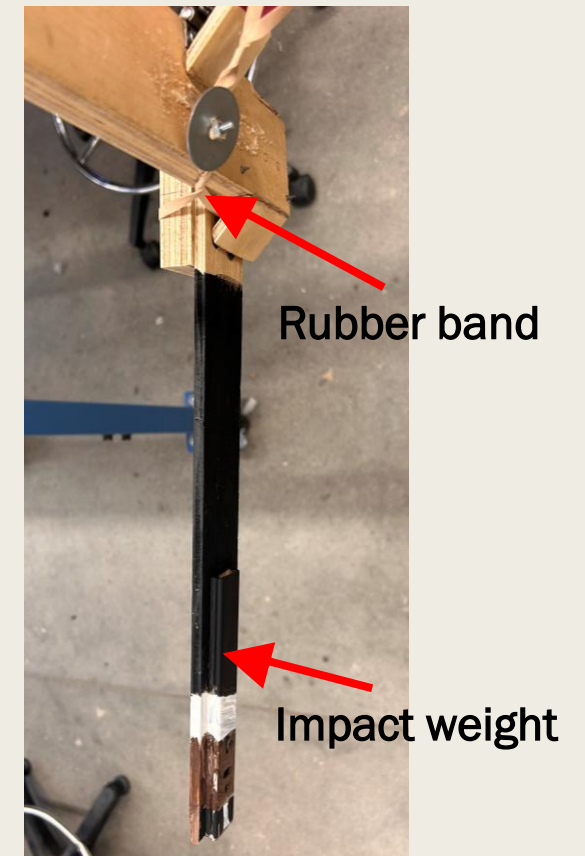
Actuator Stopper Impact Block Drawer Slider

Iteration 2:  
Mouse Trap Arm



Mouse Trap Hinge Lever Stopper

Iteration 3: Reinforced  
Mouse Trap Arm

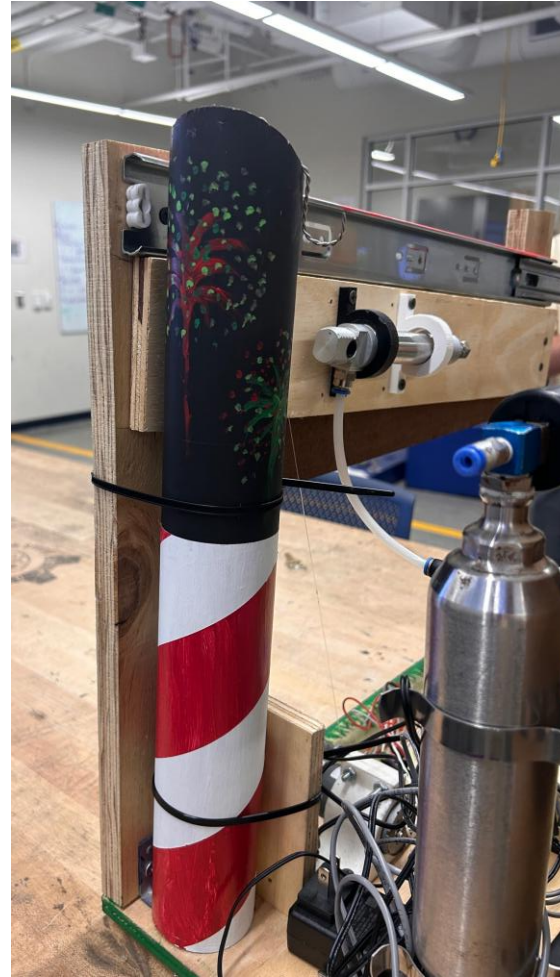


Rubber band Impact weight

# Mid-Competition Changes

- Vertical Po Lift resulted in 0 points
  - *Not compliant with rules*
- Reposition Po Lift
- Change Code

*Before Competition:*



*After Competition:*



# Results and Analysis

| Team             | Cumulative | Average | Comparative Score | Grade | # WINS | TOTAL POINTS |
|------------------|------------|---------|-------------------|-------|--------|--------------|
| Disqualified     | 251        | 83.67   | 0.75              | 1.75  | 3      | 251          |
| Freaky Four      | -132       | -44.00  | -0.39             | 0.61  | 0      | -132         |
| Furious Five     | 127        | 42.33   | 0.38              | 1.38  | 3      | 127          |
| Mr. Ping's Kings | 336        | 112.00  | 1.00              | 2.00  | 4      | 336          |
| Terrible Three   | 5          | 1.67    | 0.01              | 1.01  | 0      | 5            |

- Sprint 1: 3<sup>rd</sup> Place
- Sprint 2: 4<sup>th</sup> Place
- Final Competition:
  - 4<sup>th</sup> Seed in Finals
  - 1<sup>st</sup> Place Overall

# Summary

- **Were we successful?**
  - Yes: Won competition
  - No: Scored 4<sup>th</sup> in Round Robin (Graded)
- **Advice for future engineers taking ME2110?**
  - Build for consistency
  - Be familiar with rules and regulations
  - Think outside the box



| Correlations |   |
|--------------|---|
| Positive     | + |
| Negative     | - |
| Correlation  |   |

| Relationships |   |
|---------------|---|
| Strong        | ● |
| Moderate      | ○ |
| Weak          | ▽ |

| Direction of Improvement |   |
|--------------------------|---|
| Maximize                 | ▲ |
| Target                   | ◇ |
| Minimize                 | ▼ |

|  |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  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