Development of a Tree Climbing Snake Robot

Team 10

Jorge Campa

Michelle Maggiore

Justin Morales

Esteban Szalay

Advisor

Dr. Jonathan Clark

Instructors

Dr. Nikhil Gupta

Dr. Chiang Shih

Sponsor

Jeff Phipps

Project Overview

Every year, 200 people are killed in tree related incidents.

The average cost for removing a fallen tree is between $500-1000.

- This does not include repair cost.

The cost of cutting the tree itself is $150-1500.

Goal Statement:

- Build a remotely operated snake-like robot that will safely climb trees.

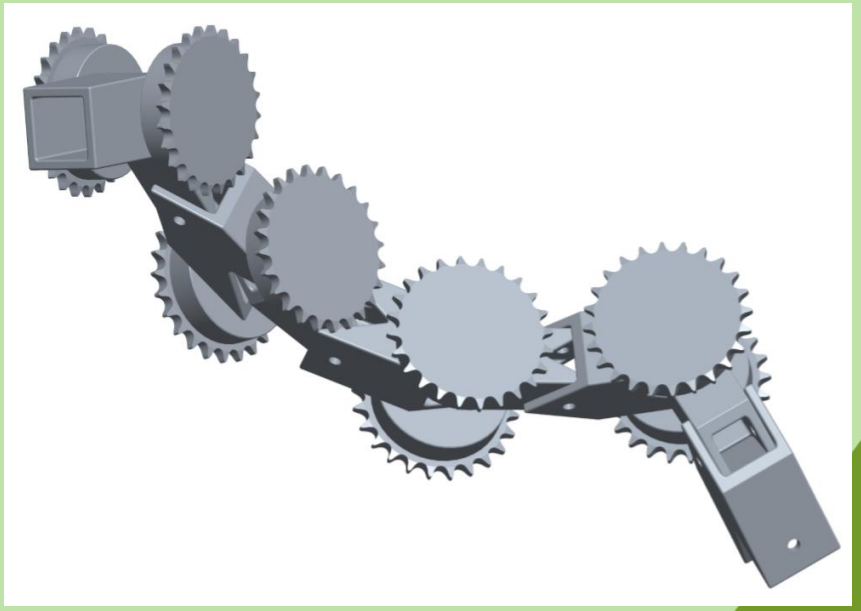
Introduction

Objectives

- 1.5 times the length of circumference
- Must climb at a minimum of 60ft/hr
- Carry a 20lb payload

Tentative Design

- Motorized Modular Aluminum Robotic Snake



Design Considerations – Steps

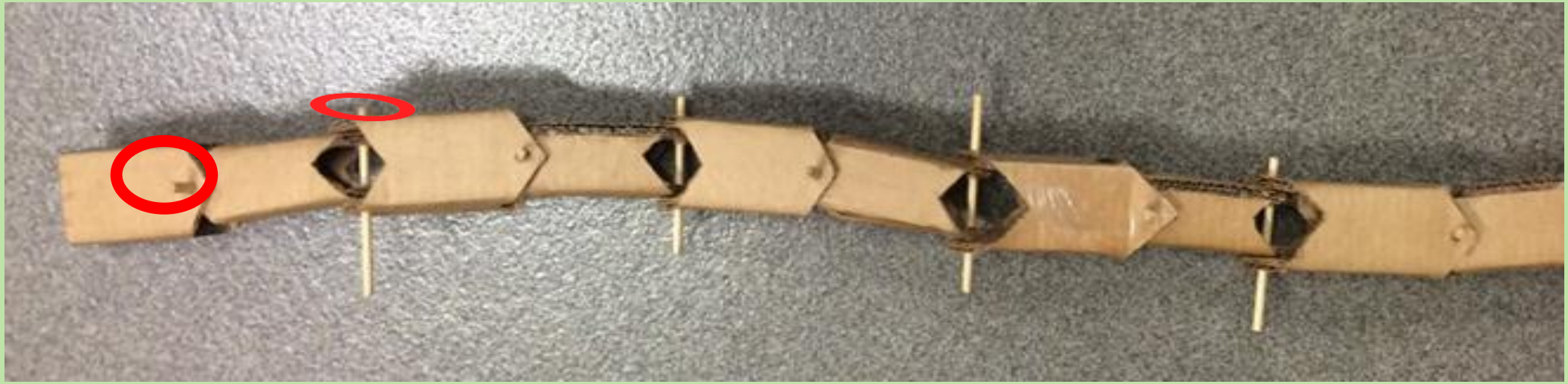
Objectives

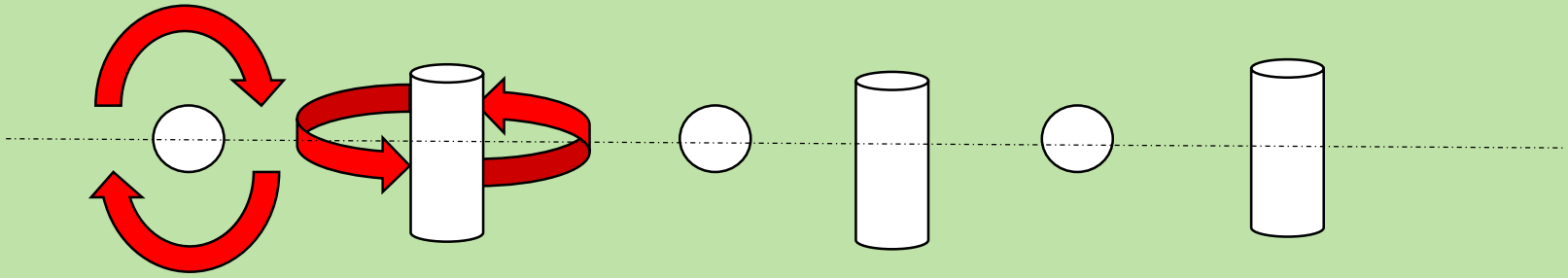
- 1.5 times the length of circumference
- Must climb at a minimum of 60ft/hr
- Carry a 20lb payload

1. Helical shape generation
2. Clamping mechanism
3. Climbing Speed
4. Branch Avoidance

Helical Shape Generation

- Test joint design as alternating degrees of freedom (DOF)



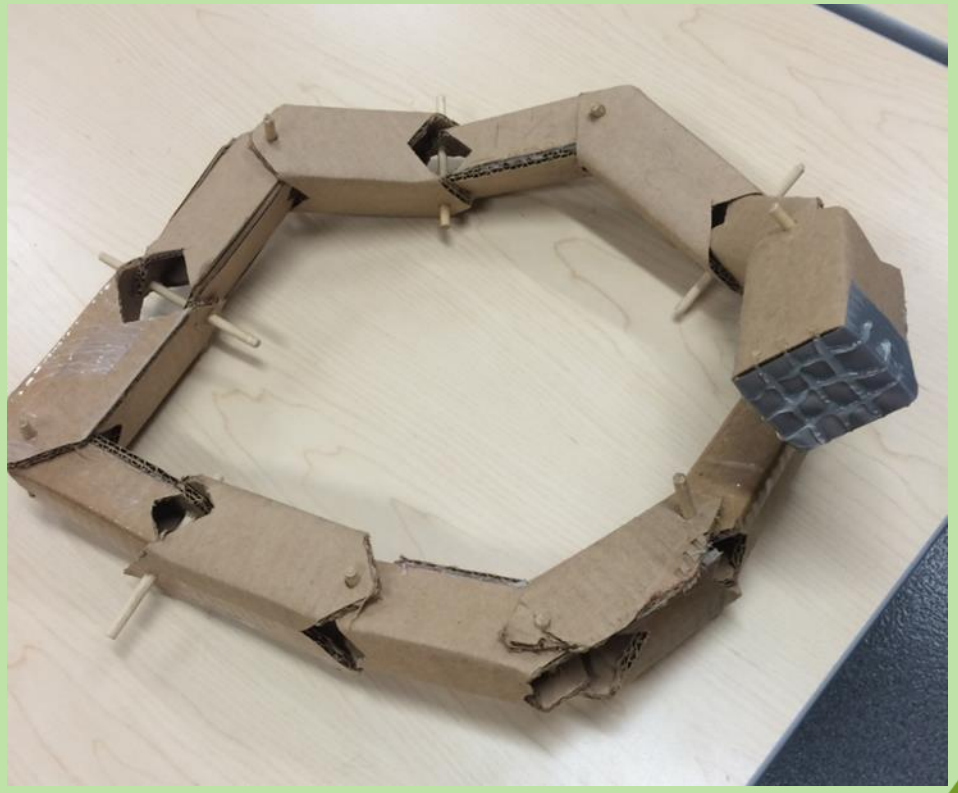


Motivating Questions and Assumptions

How to coil into a helix?

How do modules act individually and as a whole?

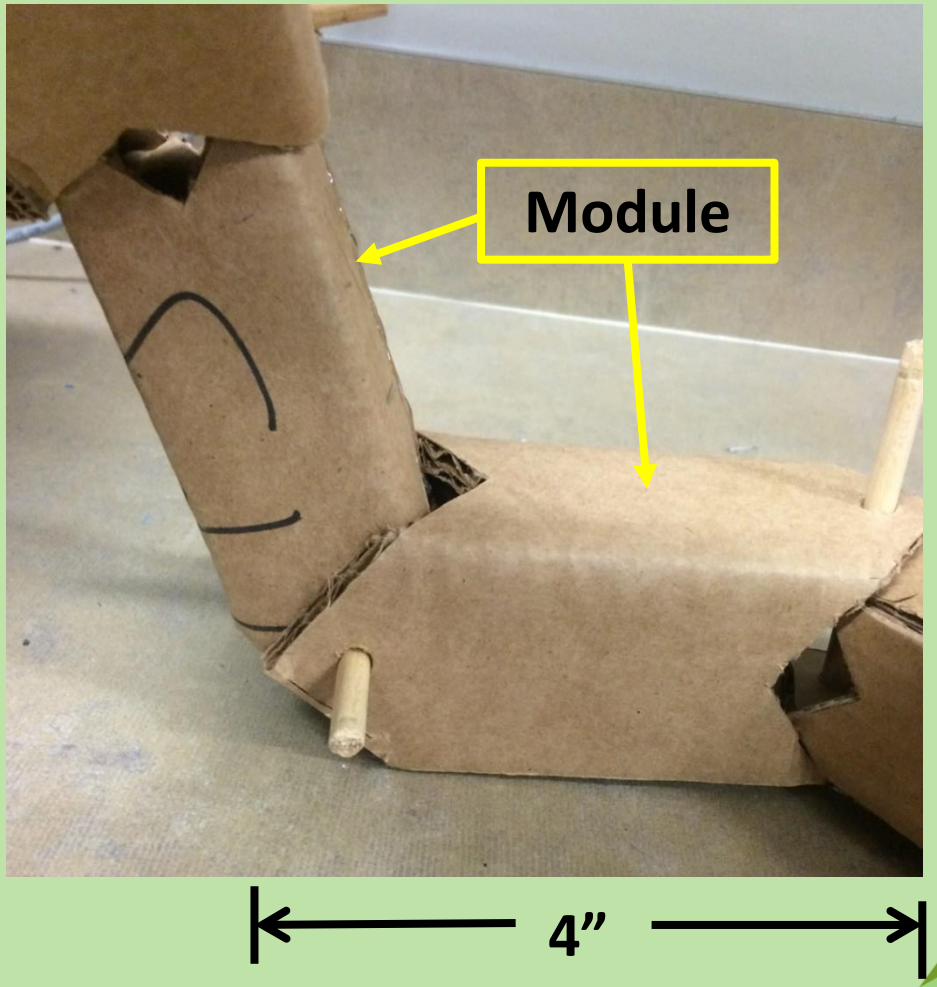
Assumed: Wheels and clamping do not affect the helical structure



Test and Results

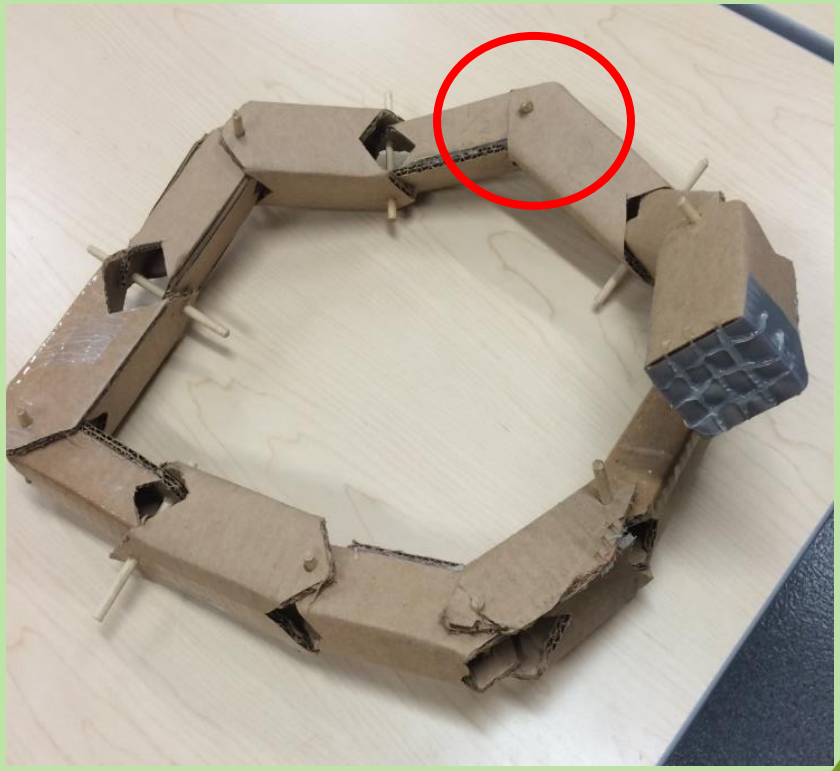
Tested range of motion of each of the joints by flexing them to their limit

Found that triangular cut out limited range of motion of each of the joints individually



Test and Results

Tested the shape and structure of the snake robot when coiled



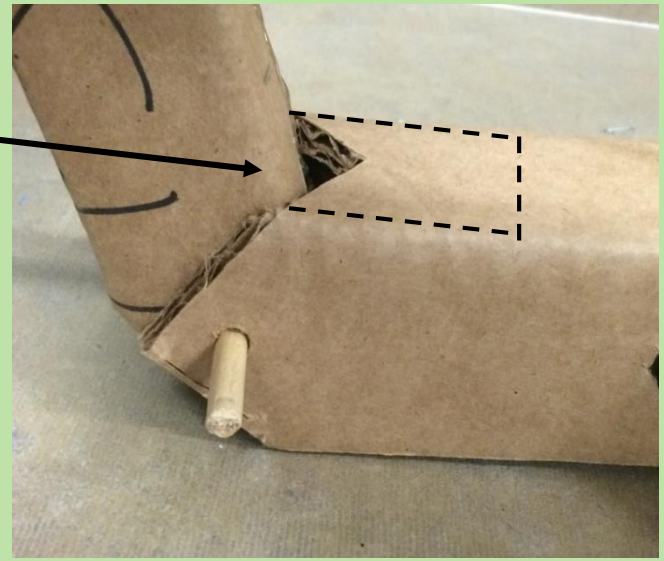
Realized that the snake did not coil into a perfect circle.

- Sharp turns could affect clamping

Design Modifications

From these results, we want to:

- Make joint cutouts square
- Make modules smaller and to scale:



$$Diameter\ of\ tree = d$$

$$Circumference\ of\ tree = C = pi * d$$

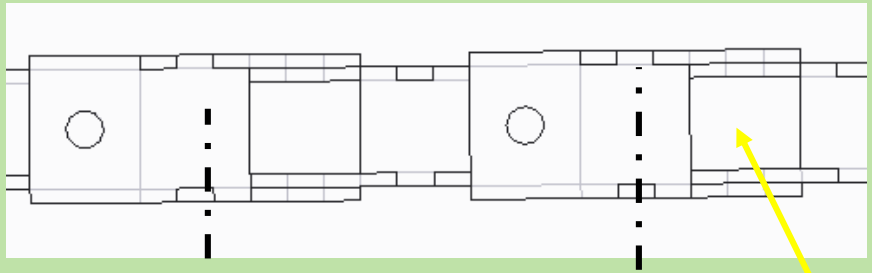
$$Length\ of\ snake = 1.5 * C = 1.5 * pi * d$$

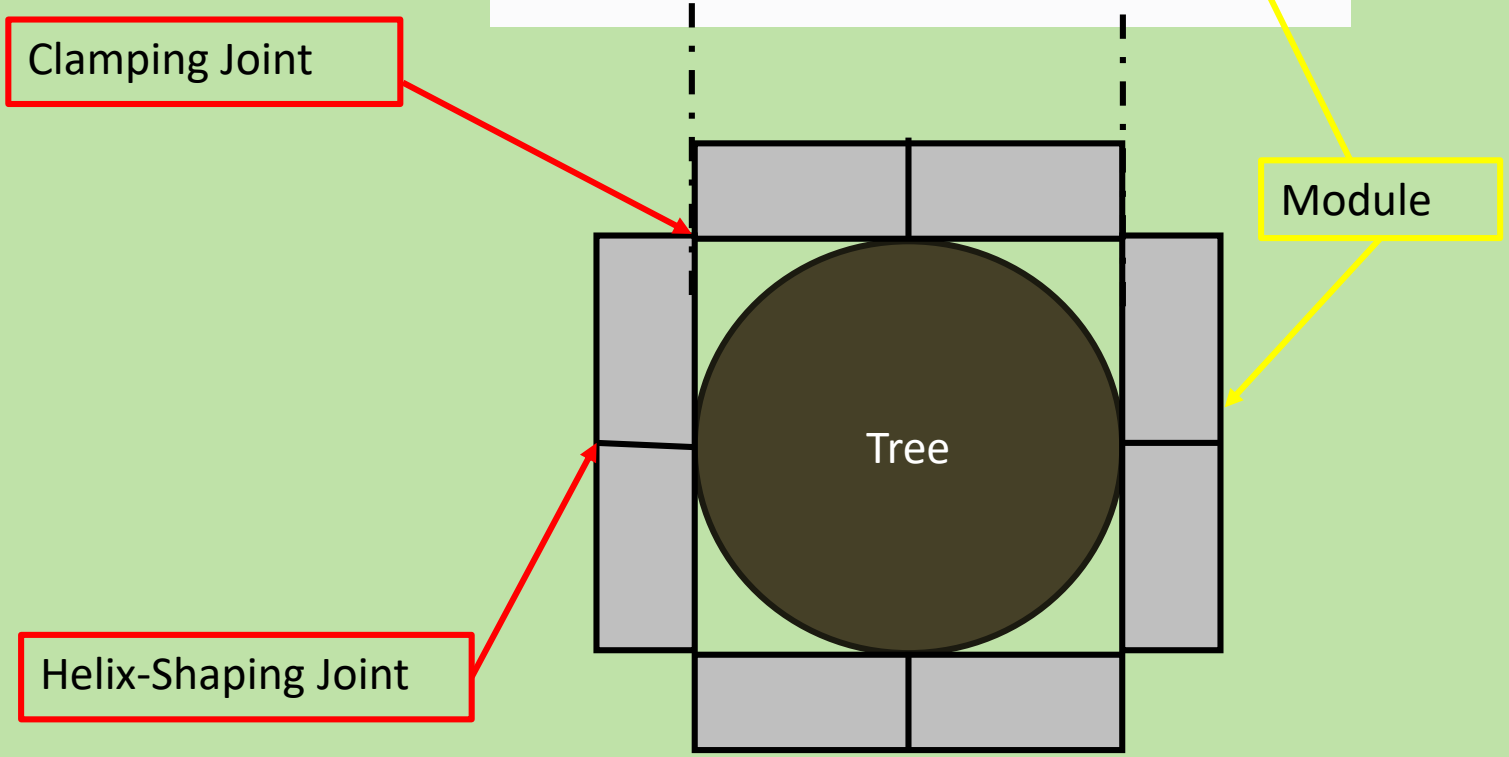
$$Length\ of\ module = \frac{Length\ of\ snake}{\#\ of\ modules\ desired}$$

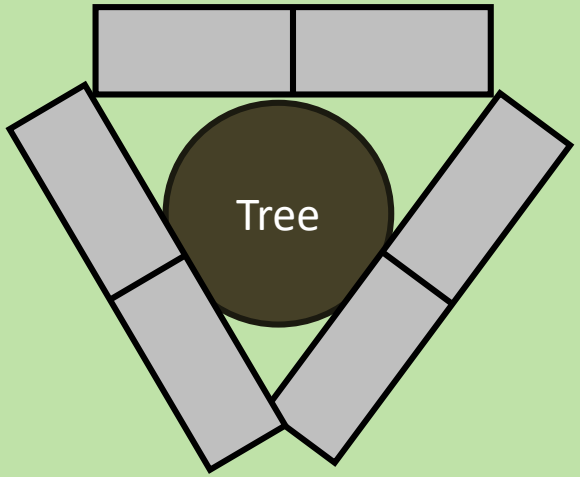
$$Diameter = 5in; Modules\ Desired = 8\ cnt$$

$$\boxed{Length\ of\ module\ \approx 3in}$$

Design Modifications







Pneumatics

Pneumatics use a combination of oil and air

Rubber seals can break

- Replacing is hard and costly

Small leaks could mean immediate failure of the entire system, not the section

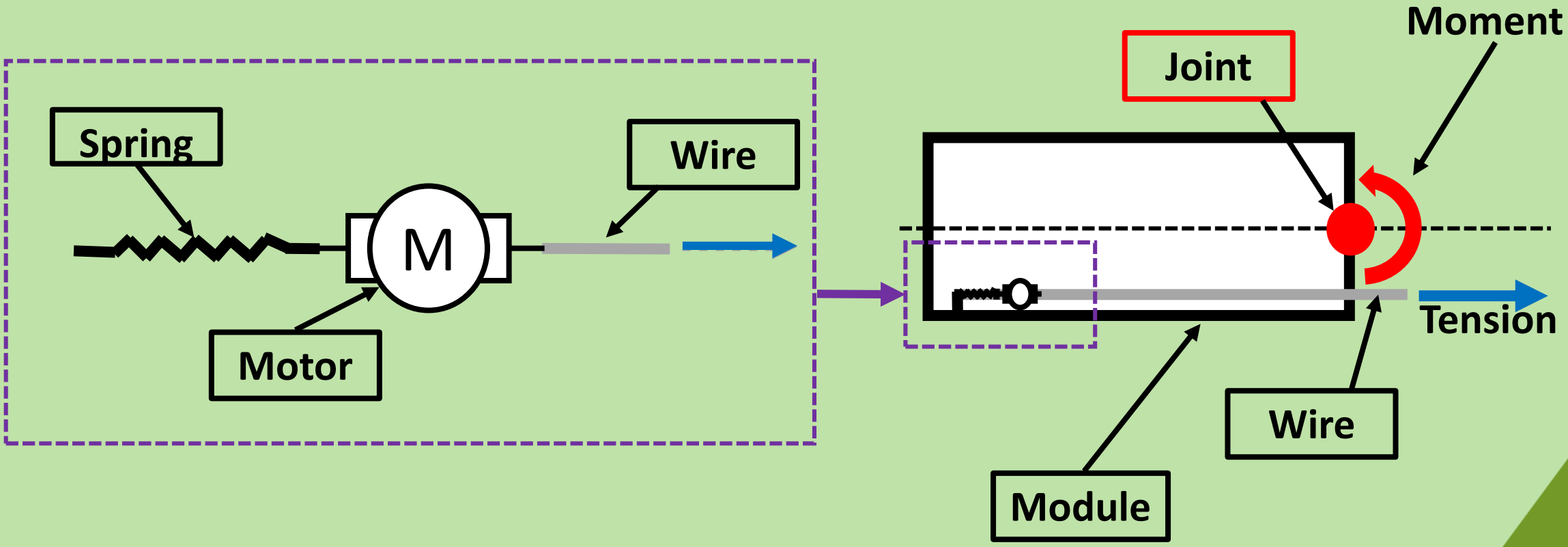
Soft Actuators

A prototype was created to test reliability in strength and flexibility

Flexibility was proven good but limited

When tested at high pressure the soft actuator burst rendering it defective.

Tension Inducing Wire



Motivating Questions and Assumptions

Can the clamping mechanism hold the snake robot's weight?

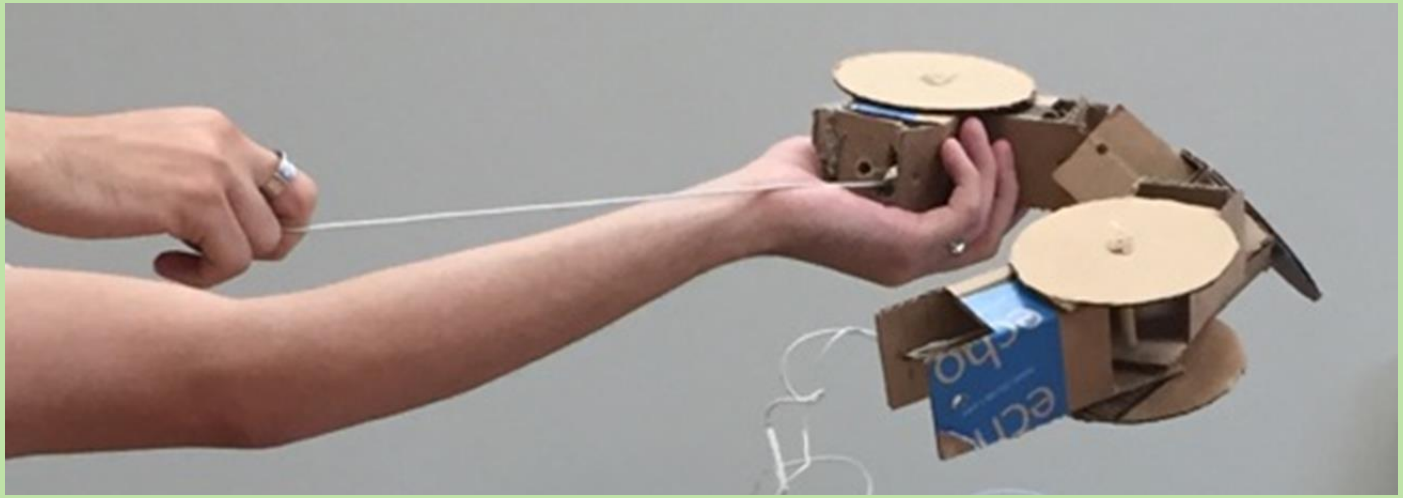
How are wheels oriented when helically clamped?

Assumed: wheel placement is independent of clamping mechanism

Test and Results

Clamping mechanism was pulled and showed promise on having snake curl

However, it acted unpredictably when pulled from rest

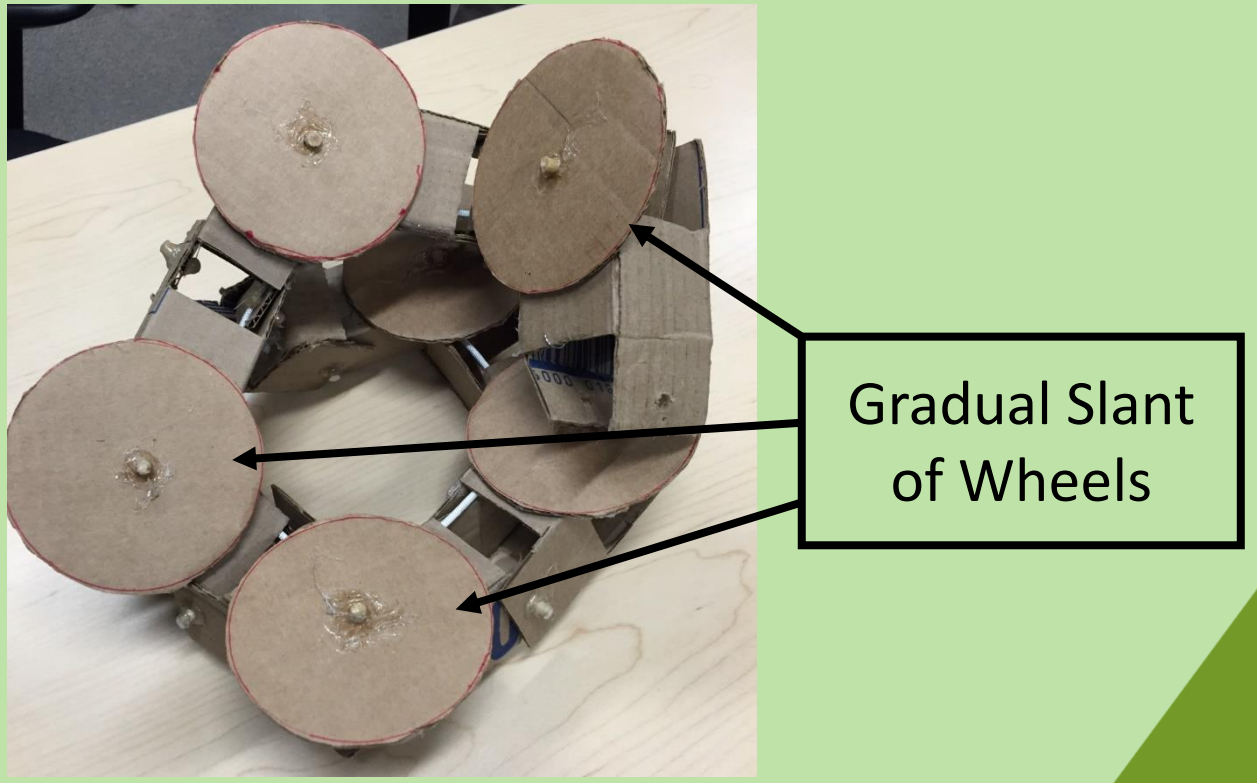


Test and Results

Joints were bent to their maximum angular displacement

Range of motion improved

Wheels were misaligned on tree surface

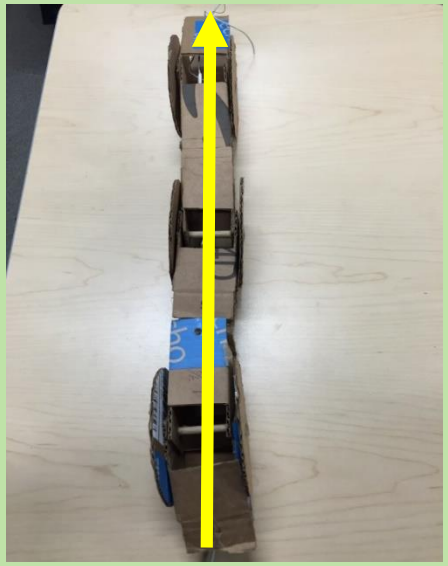


Test and Results

Design Modifications

Clamping mechanism made wheels turn away from tree → Add degree of freedom that will align wheels to surface

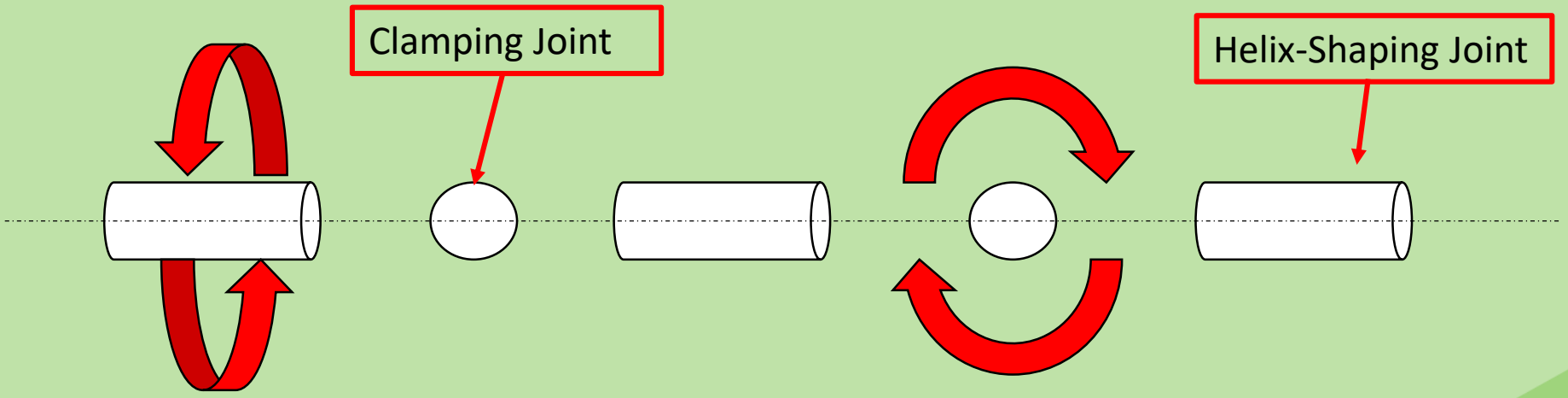
Helical shape was generated but lacked consistency in shape → Have modules align themselves into proper helical shape



Motivating Questions and Assumptions

Can the wheels align with the tree properly with the new degree of freedom?

Assumed: Clamping Mechanism is unaffected

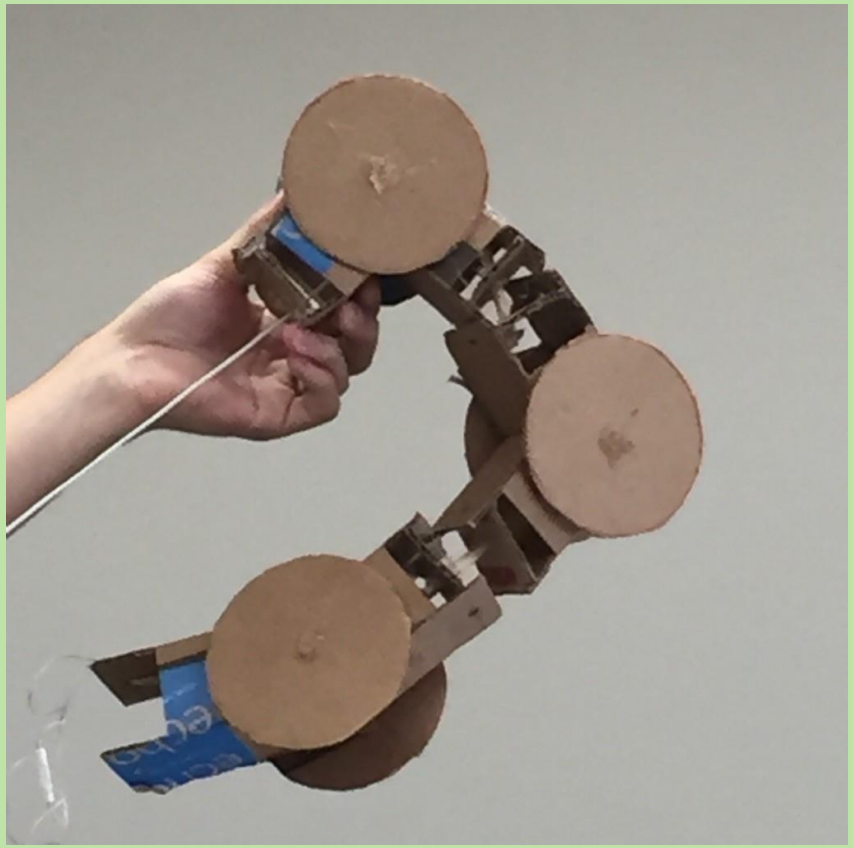


Test and Results

Tested alignment of wheels when curled

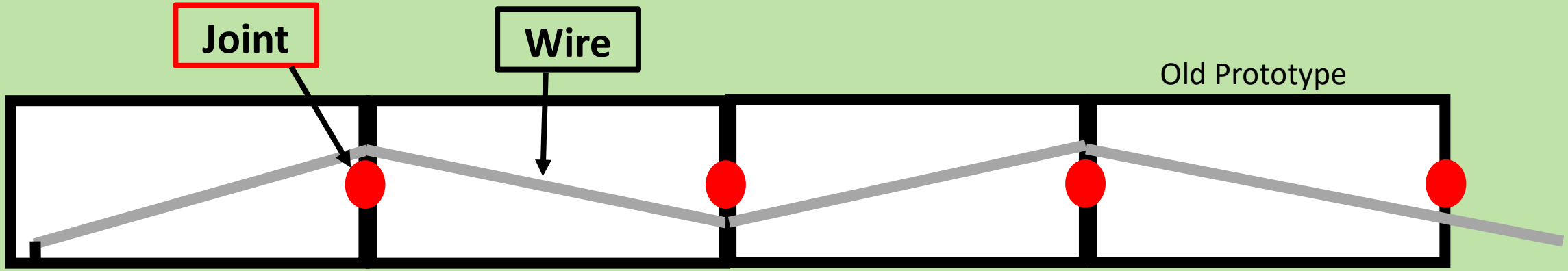
- Wheels aligned properly with cylindrical surface

Clamping mechanism failed to operate due to errors in construction

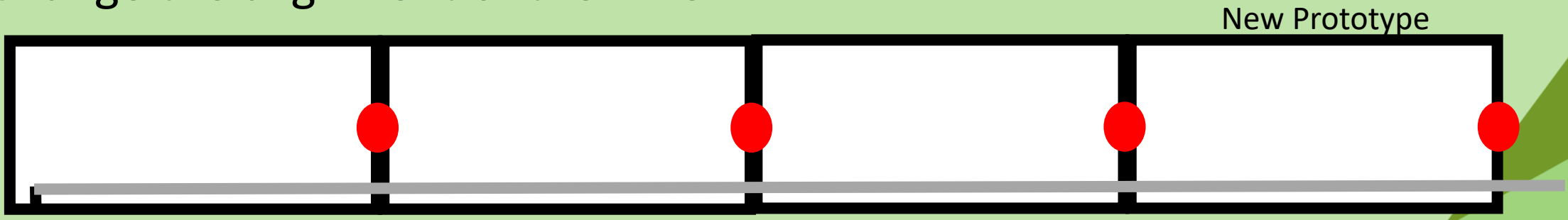


Design Modifications

Clamping mechanism did not provide sufficient tensile force



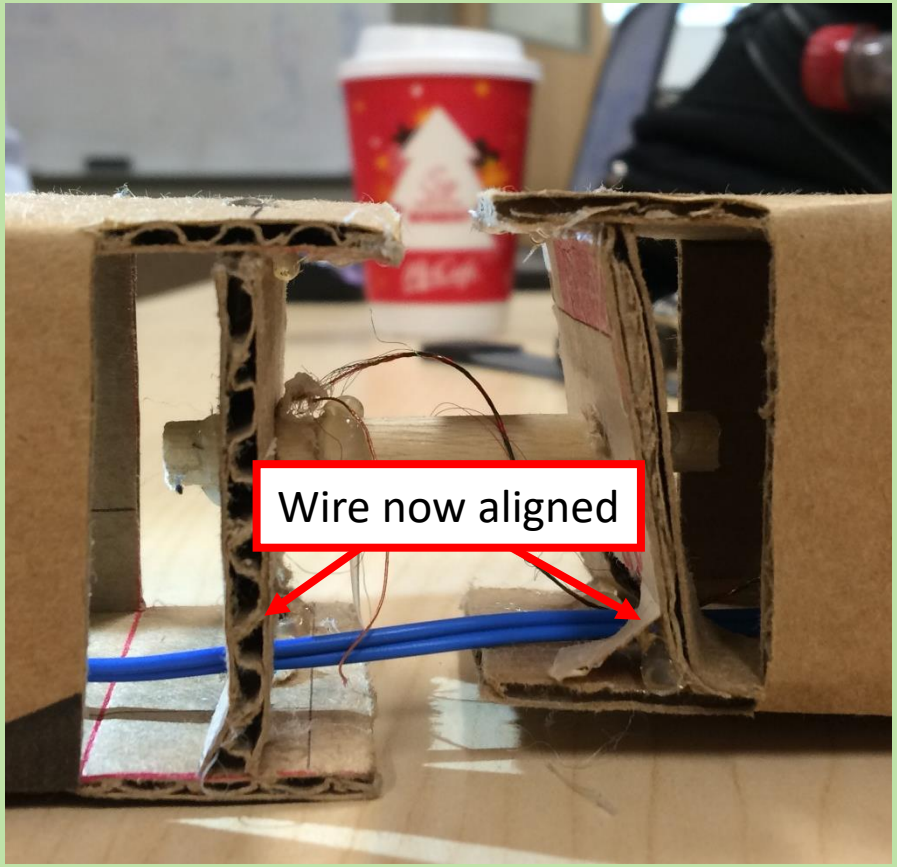
Change the alignment of the wire



Motivating Questions and Assumptions

Did the quick fix solve the clamping issue?

Assumption: Wheel design and placement independent of clamping



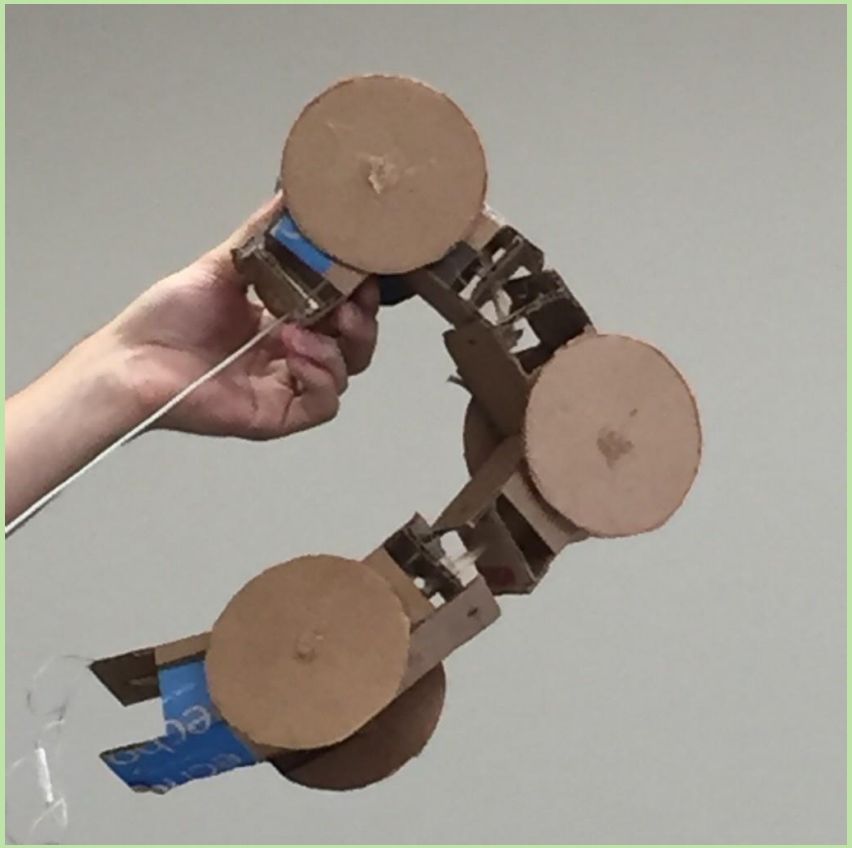
Test and Results

Tested module's alignment when curled into a helix

Modules were now aligned properly

String still may tangle when achieving helical motion

Wheel design still not specified



Test and Results

Tension requirements outweigh structural integrity of cardboard prototype.

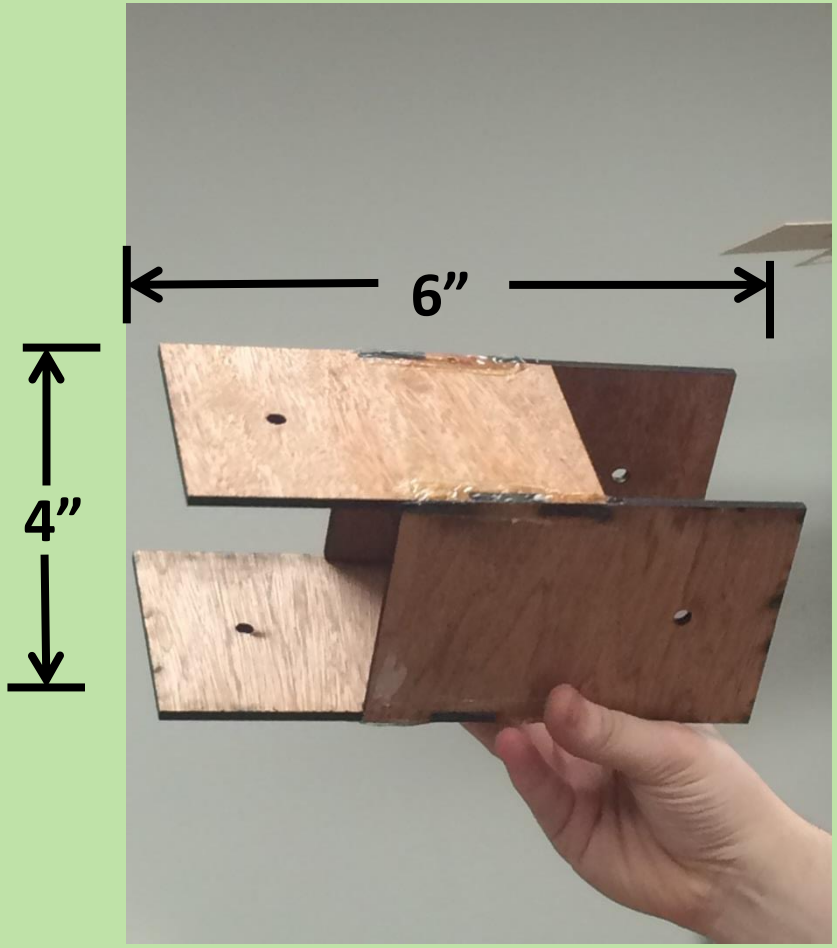
Modules bent beyond repair.

Design Modifications / Upgrade

Add guide for wire (similar to a pulley)

Test actual clamping capabilities with the new orientation

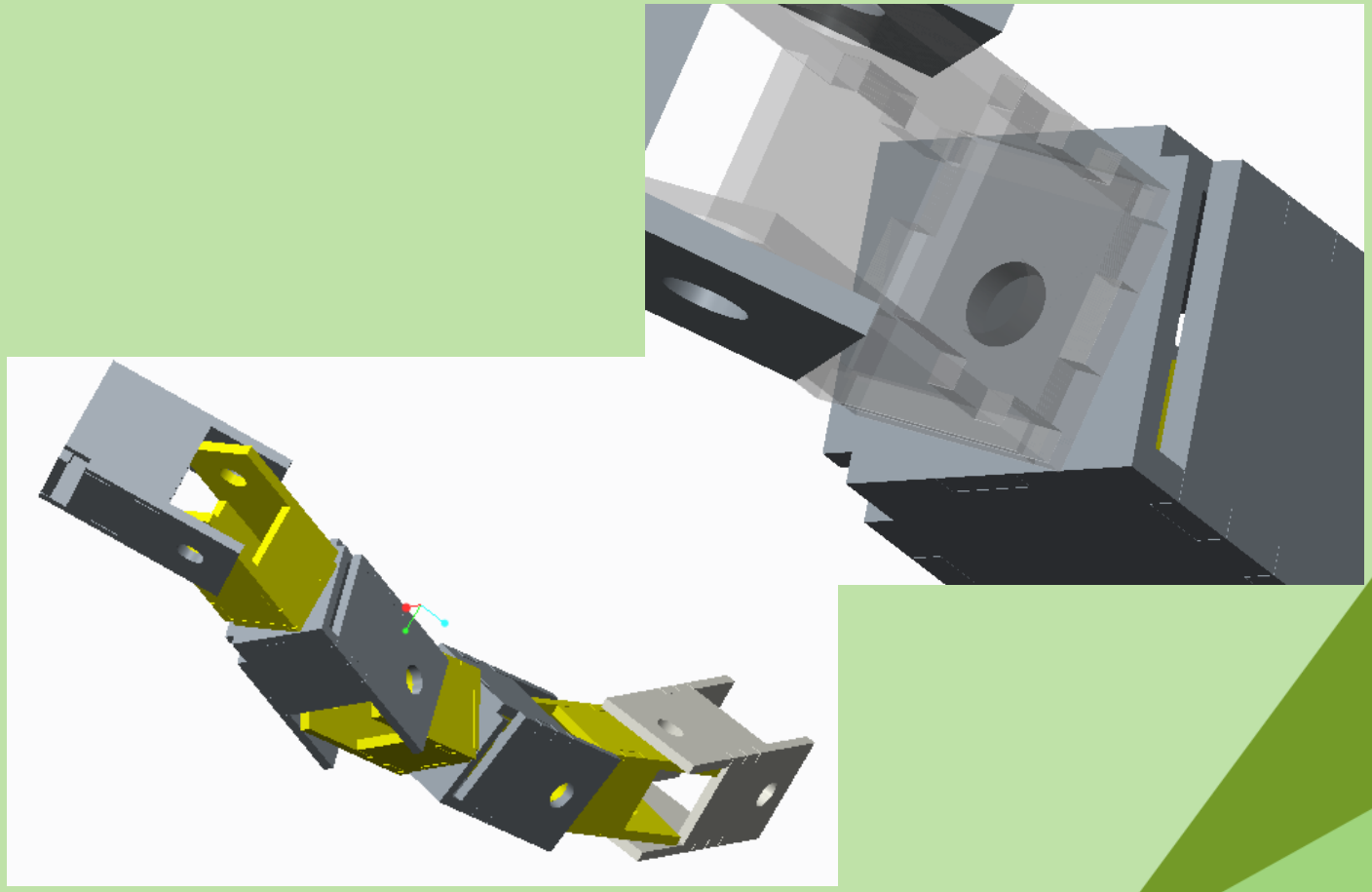
Make it of a sturdier material - wood



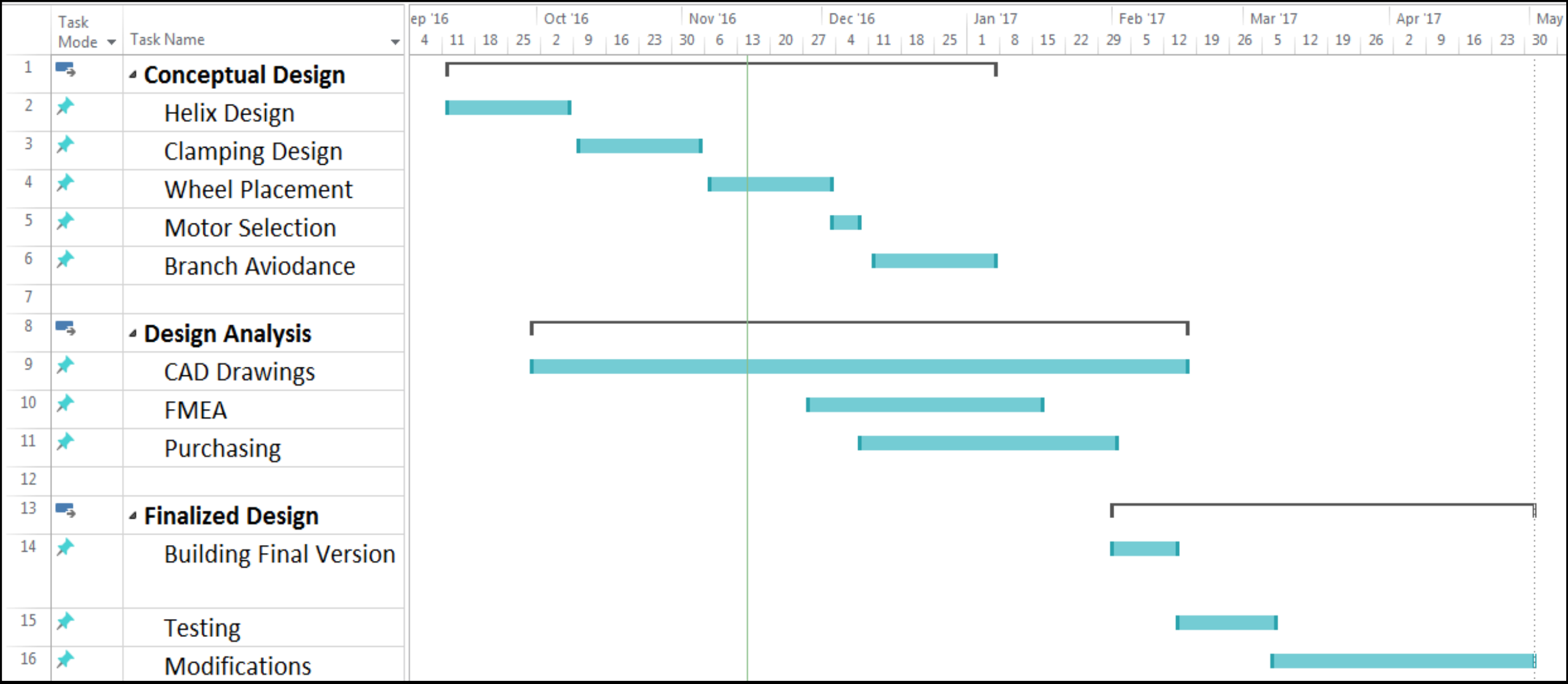
Plan for the future

3rd Prototype to be built out of wood

- Laser cutter to be used
- Jigsaw Design to be used for links and assemble modules

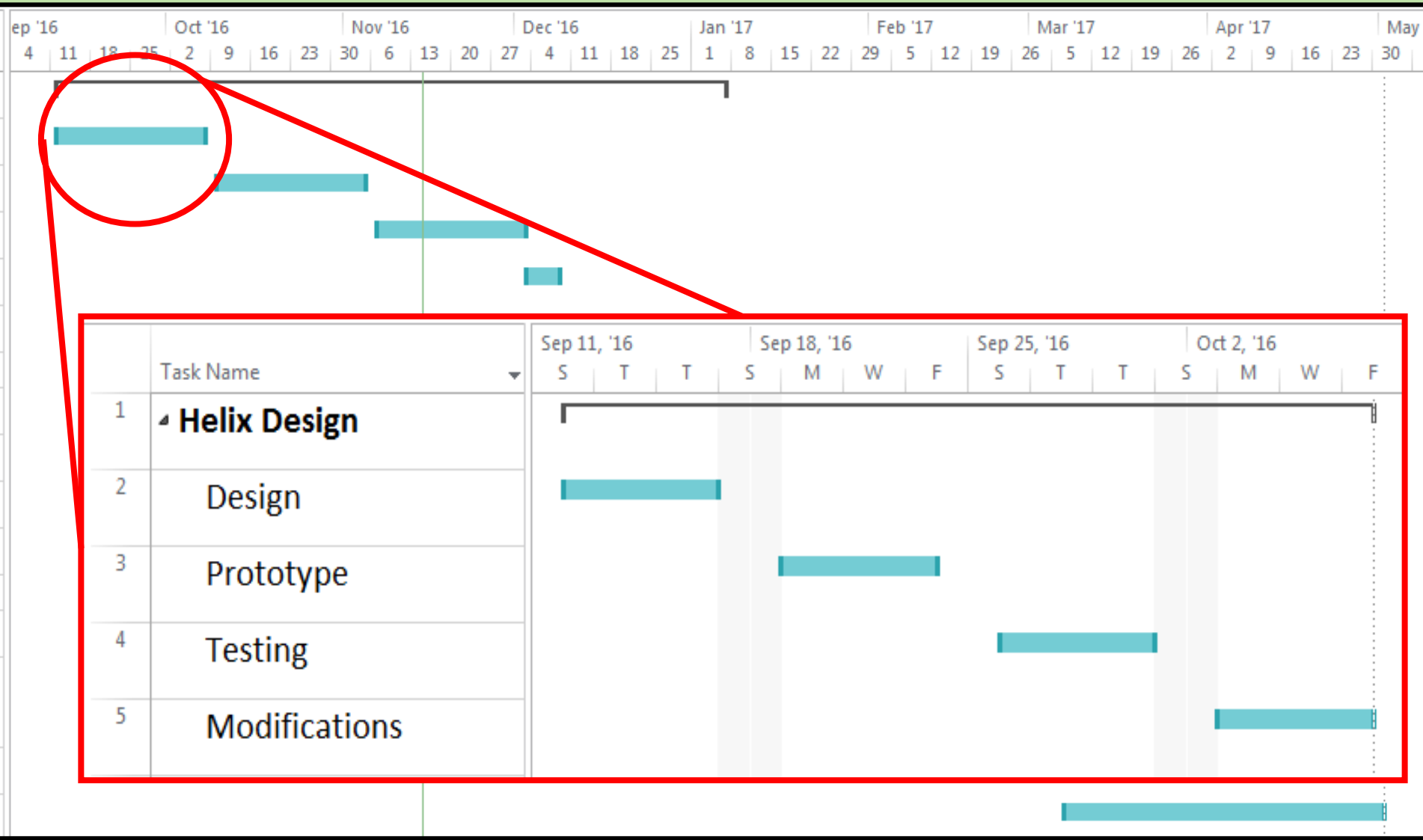


Plan for the future



Plan for the future

	Task Mode	Task Name
1		**Conceptual Design**
2		Helix Design
3		Clamping Design
4		Wheel Placement
5		Motor Selection
6		Branch Aviodance
7		
8		**Design Analysis**
9		CAD Drawings
10		FMEA
11		Purchasing
12		
13		**Finalized Design**
14		Building Final Version
15		Testing
16		Modifications



Summary

We built two prototypes:

1. Module Interaction in Helical Shape formation
2. Clamping Mechanism and Wheel Placement

Next stage is to build a sturdier prototype to do the following:

- Simulate Clamping mechanism
- Helical shape generation
- Motion while in helical configuration

Simulate controlling velocity of dc motor with Arduino™ microcontroller

Questions?