Update Mecanum Drivepods

Problem Description:

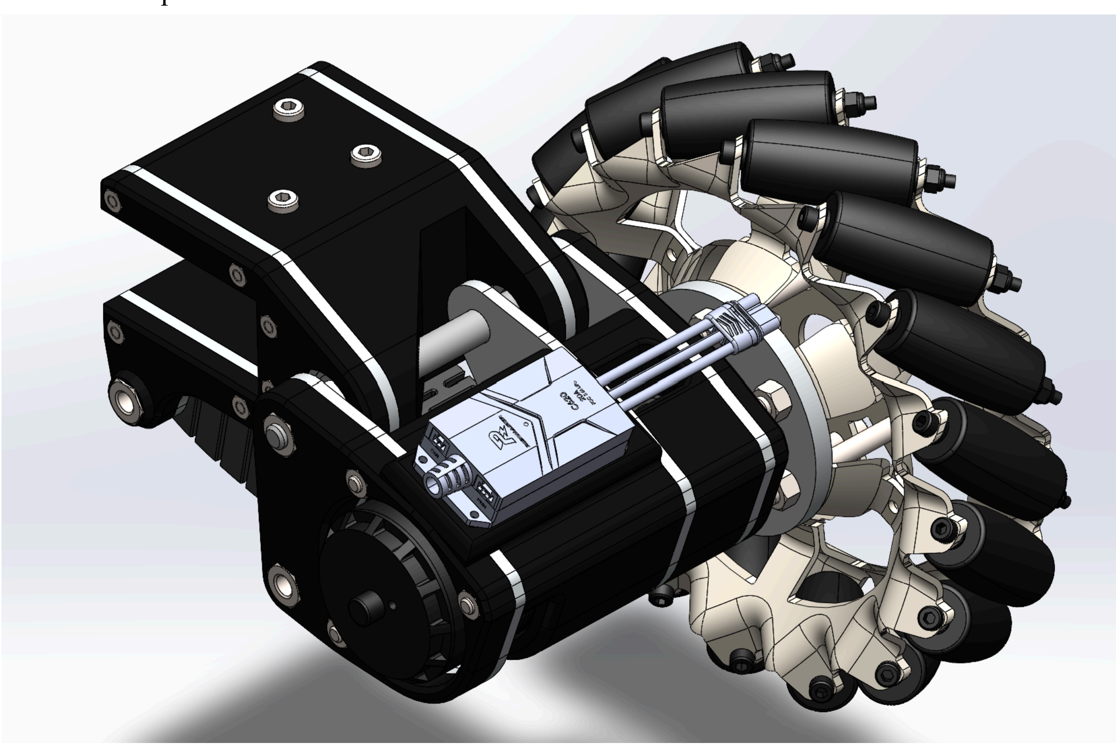
The current drivepods are designed to be robust and feature TPU dampers that effectively absorb vibrational energy. However, they are too heavy and overengineered for their intended use. While the RMNA competition does not involve significant bumps and drops, the RMUC competition does. To improve robot agility and prepare for potential participation in the RMUC competition in the future, we should consider redesigning the drivepods to be configurable with shock absorbers. Shocks provide greater versatility and configurability, allowing our robot to traverse a variety of terrains. By adjusting the spring strength and the weight of the shock oil, we can treat the system as a spring-damper system, optimizing performance for different competition environments.

Constraints:

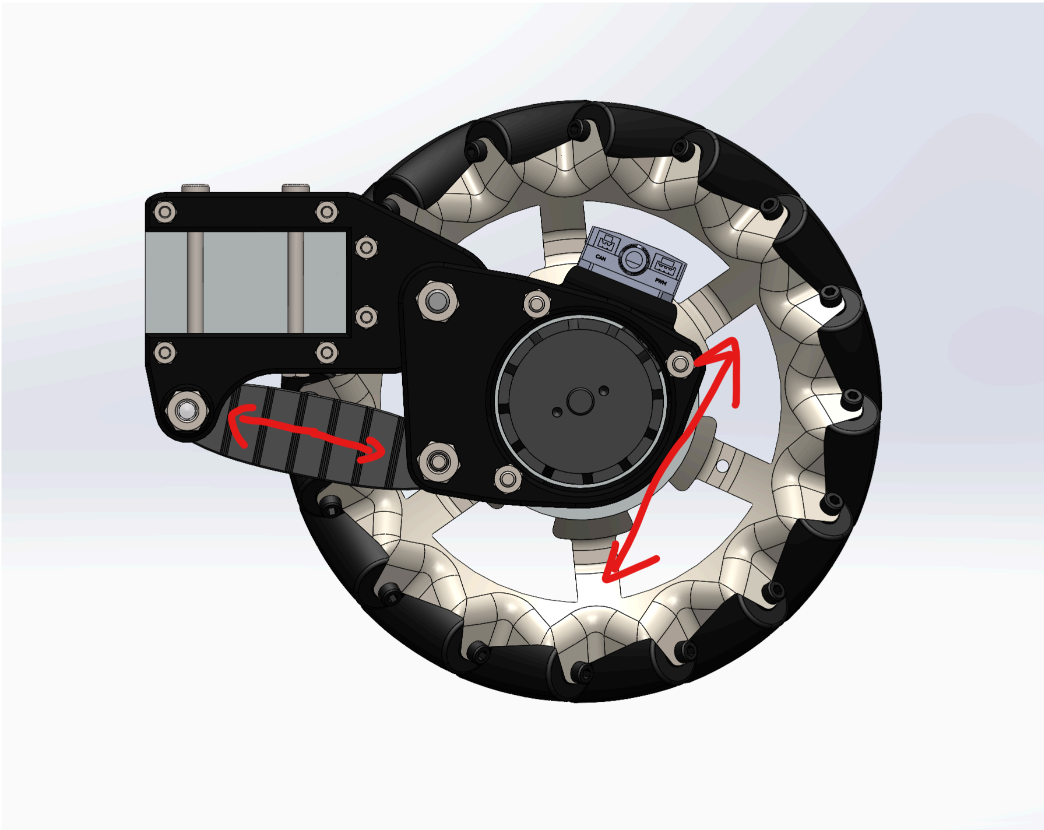
- Lightweight
- Compact form factor
- Features versatile shock absorbers
- Attaches to 1” boxtube chassis frame

Images:

Current Drivepods:



Drivepod Damper Motion:



Project Timeline:

- **Background research (Friday 9/27 - Tuesday 10/1)**
    - Understand anatomy of shock absorber and how to spec
    - Thoroughly dissect the current drivepod. To open drive pod assembly, find on Standard CAD assembly). Hint: use hide and transparent options to see into drivepod
    - Research how to characterize forces on shocks
    - Add findings to progress documentation *by Tuesday 10/1*
- **Brainstorm (Wednesday 10/2 - Friday 10/4)**
    - Theorize high level structure of new solution
    - Account for details (bearings/interfaces)
    - Sketch design and add to progress documentation by Thursday (10/3) evening
    - Present initial solution on Friday, 10/4
- **Redesign (Saturday 10/5 - Sunday 10/6)**
    - Finalize sketch
    - Add to progress documentation by Sunday evening (10/6) for approval
- **CAD Stage 1 (Monday 10/7 - Friday, 10/11)**
    - Monday 10/7: Review feedback
    - Tuesday 10/8 - Thursday (10/10): CAD rough design and document

    - Friday 10/11: Present solution and coordinate next week's CAD tasks
- **CAD Stage 2 (Saturday 10/12 - Friday 10/18)**
    - Continue CAD through Thursday, 10/17 and document
    - Present final CAD Friday, 10/18
- **Prototype (Saturday, 10/19 - Friday, 10/24)**
    - Saturday 10/19 - Sunday 10/20: Convert all components into 3D print (.stl, .3mf) and laser cut (.pdf) formats
    - Monday 10/21 - Tuesday 10/22: 3D Print and laser cut components (including printed dummy bearings)
    - Wednesday 10/23 - Thursday 10/24: Build drivepod prototype
    - Friday 10/24: Present solution, get feedback/approval
- **Redesign/Procurement (10/25 - 11/8)**
    - TBD
- **Final Build (11/9 - 11/15)**
    - TBD

Proposed Solution:

-

Priority Level:

[High/Medium/Low]

Team Members Involved: (2-3)

- Matthew Burkhart
- Prad
-

Estimated Timeframe:

- 20 hours

Dependencies:

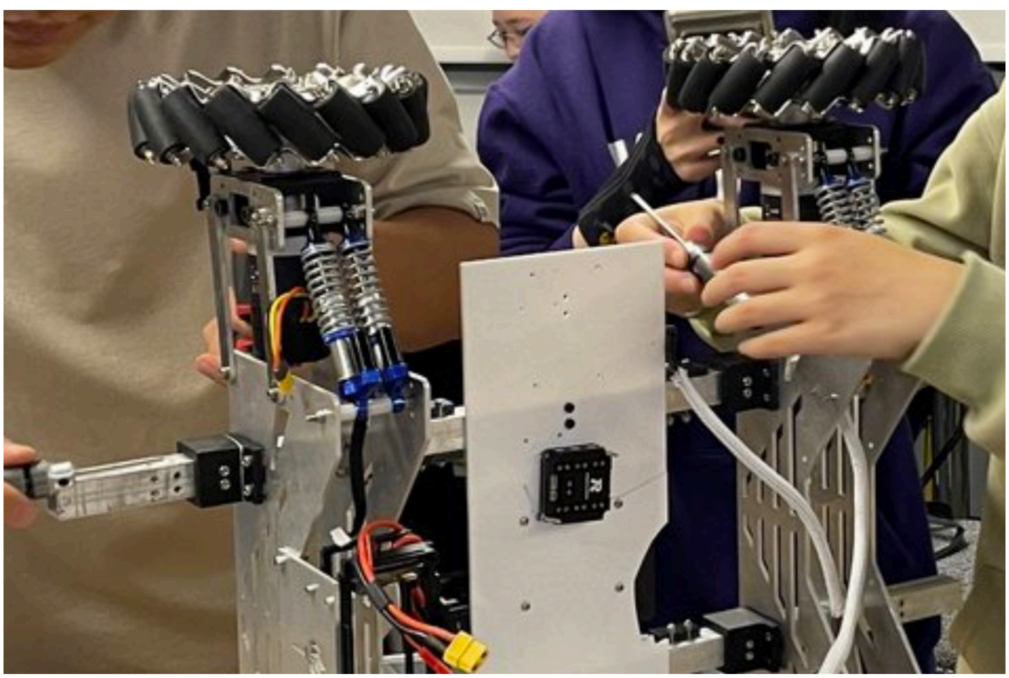
Prerequisites: N/A
Dependent Tasks: "Develop Omni-Wheel Drive Pods", "Hero Chassis Redesign", "Standard Chassis Redesign"

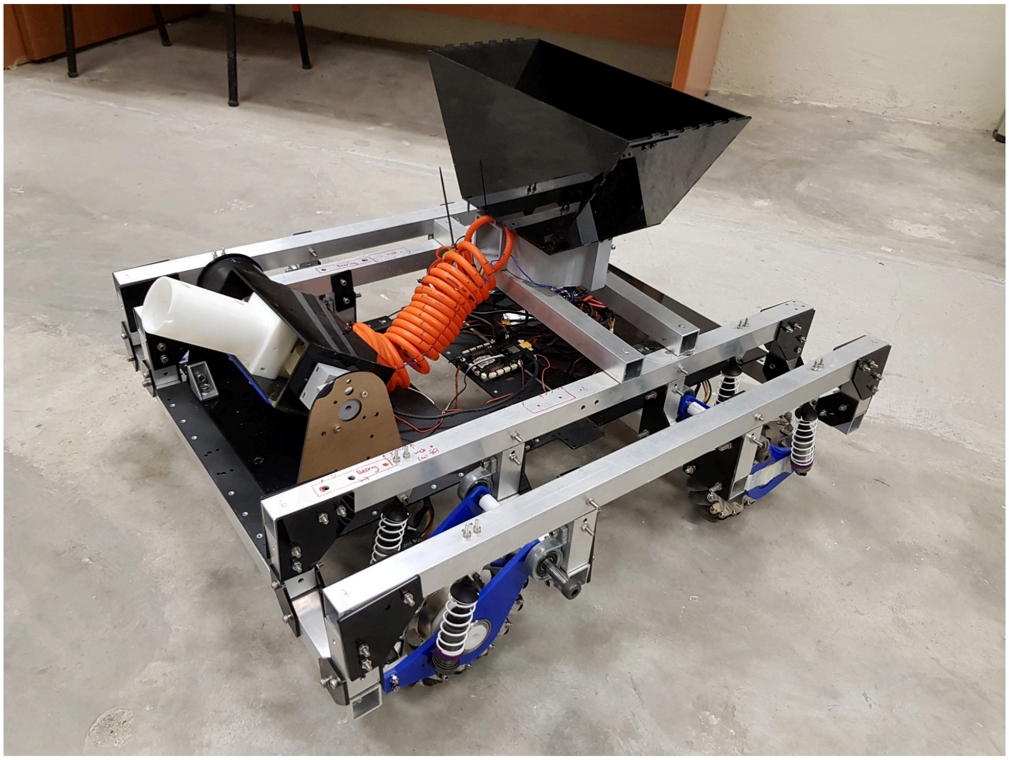
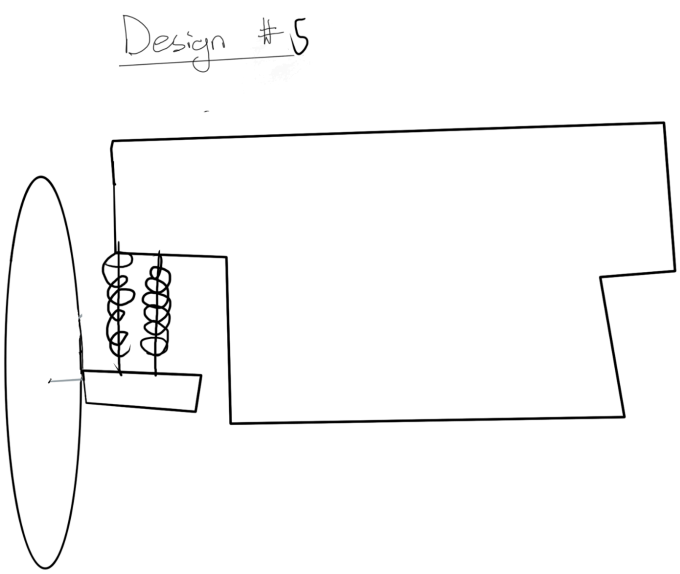
Resources / Materials / Tools Needed:

- Current drivepod CAD
- 3D printing, laser cutting
- Basic build tools

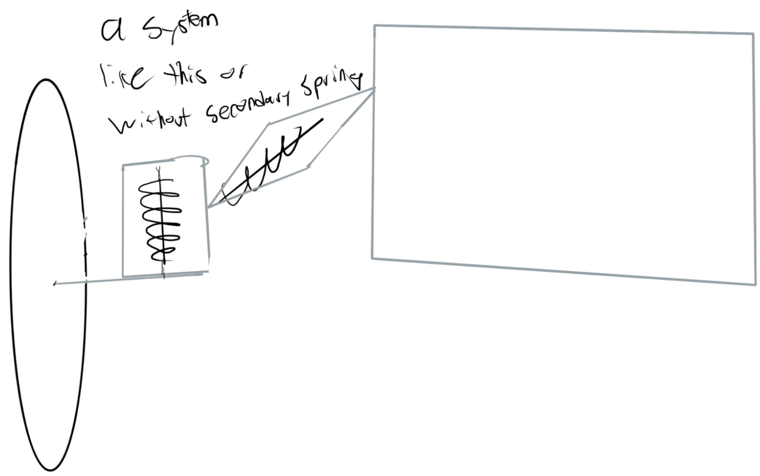
Progress Documentation:

Use this section to record updates, progress, and any changes to the task.

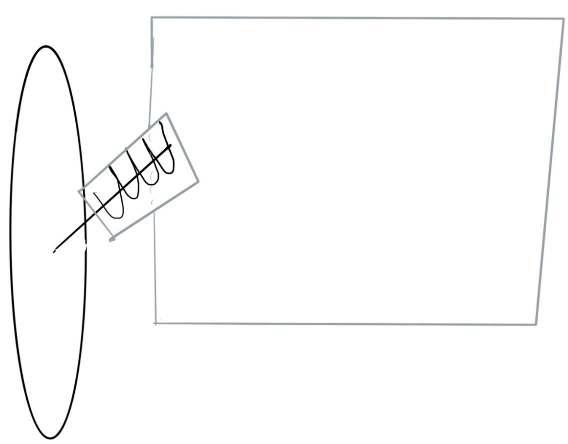
Date	**Update** [Describe progress made, challenges faced, and any solutions implemented.]
9/27/2024	● Shock Absorbers ○ SKU 585032; Servocity Shock absorbers (potential) ○ 2900 Series Shock (120-1) - 2 Pack SKU:2900-0120-0001 ■ https://optii.com.au/products/2900-series-shock-120-1-2-pack ○ 4x Alloy Front/Rear Shock Absorber 80mm for 1-12 1-16 BEZGAR LAEGENDARY Upgrades (Cheap Option??) ■ https://www.ebay.com/itm/335276522279?chn=ps&var=544598562457 ○ Shock Absorbers Alibaba - Try and find cheaper, with same specifications
9/27/24 Sentry 4 Bar Suspension Idea	

	
10/4/24	Low Level Sketches, General ideas possibly 

Design #4



Design #3



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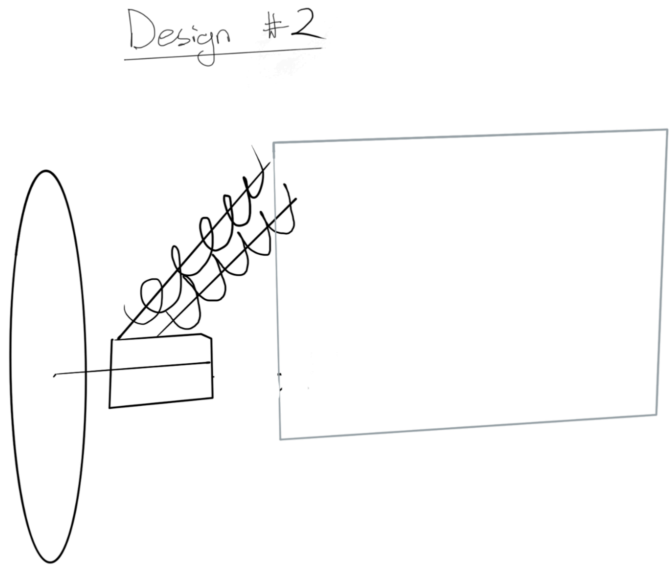

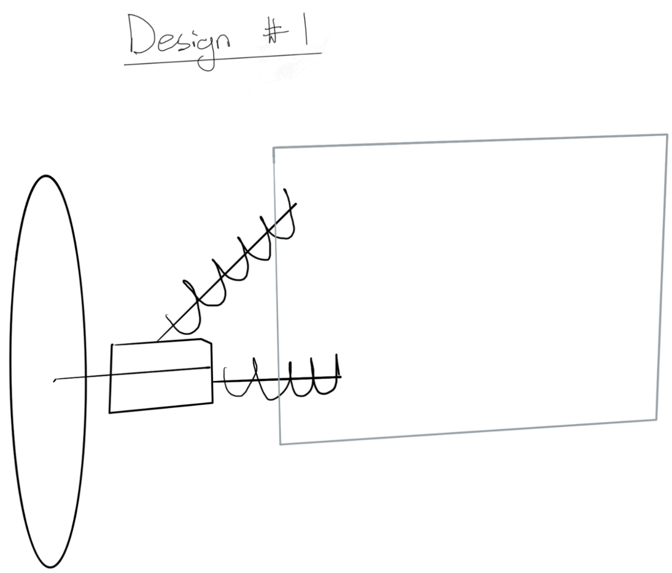

We decided on going with something like design 2. Will get final design sketch finalized sunday or monday and cad rough design by next week
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<tr>
<td>10/11/24</td>
<td>- Looked a bunch of shocks to test: In Discord Drivepod Channel; Need to buy some to test
- Pivot idea slightly; current design is good for sentry.</td>
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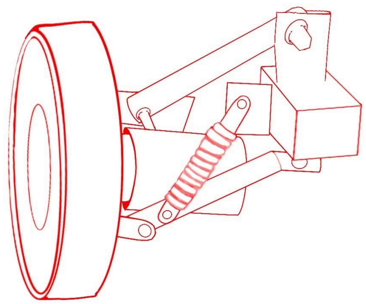
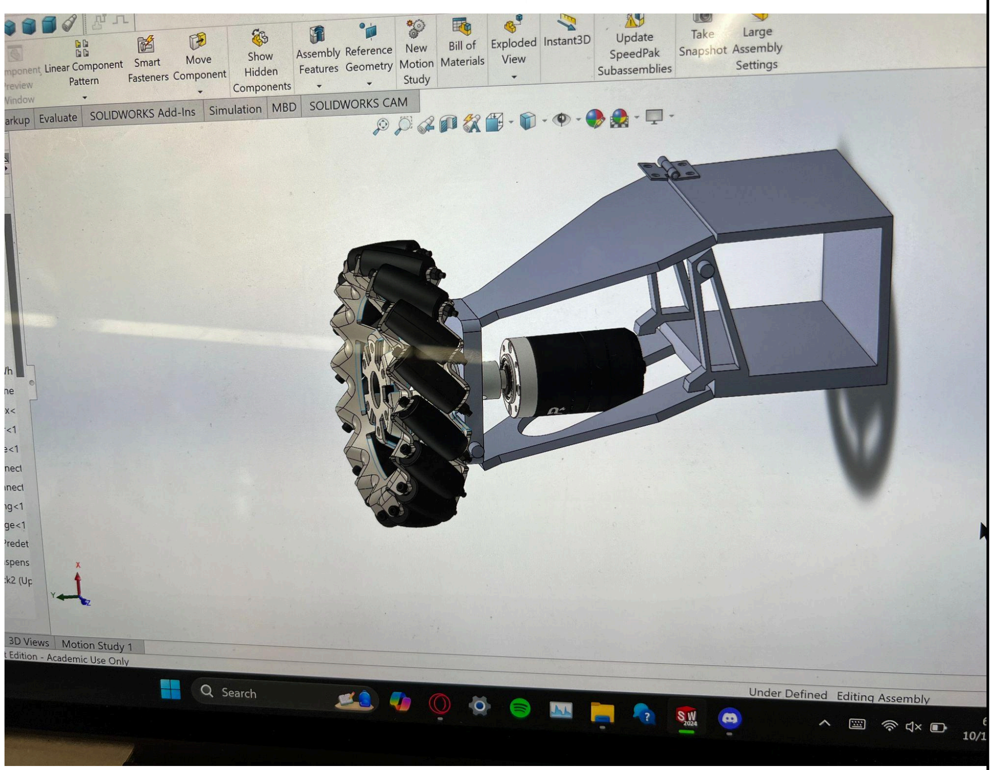
- We are going to change the motor axis to be perpendicular to shocks rather than parallel, making it more compact (Standard & Hero)



- 

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<td>10/18/24</td>
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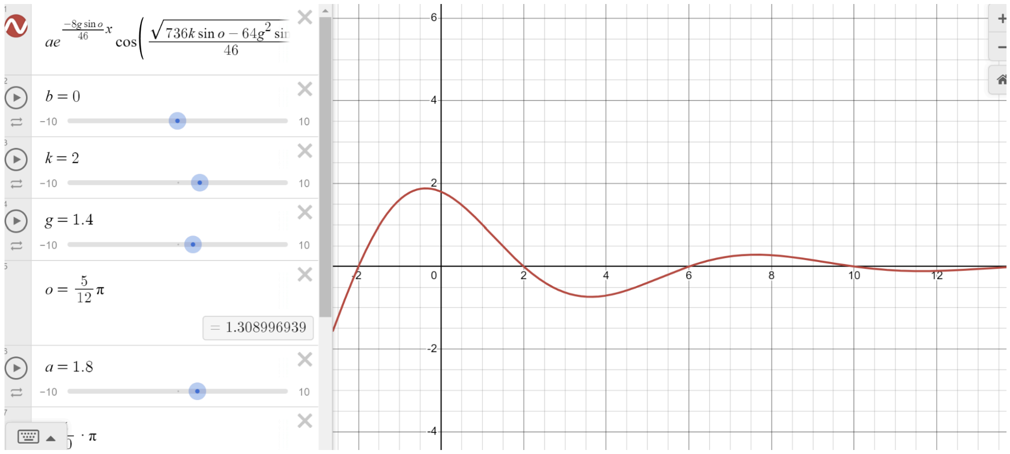
10/25/24

```python
import math

# Constants for the robot
mass_robot = 23  # kg
gravity = 9.81  # m/s^2, acceleration due to gravity
displacement_min = 0.01  # m (1 cm)
displacement_max = 0.02  # m (2 cm)
num_springs = 8  # total springs on robot
damping_coefficient = 0.5  # Damping coefficient (Ns/m)
theta = 75  # degrees, angle of the springs

# Force on each spring (weight of robot distributed over springs)
force_per_spring = (mass_robot * gravity) / num_springs

# Hooke's law: F = k * x -> k = F / x (spring rate for static loading)
# Calculate the spring rate for min and max displacement without angle correction
spring_rate_min = force_per_spring / displacement_max
spring_rate_max = force_per_spring / displacement_min

# Angle correction factor (ACF) based on theta (cosine of the angle)
acf = math.cos(math.radians(theta))

# Adjusted spring rate considering the angle
adjusted_spring_rate_min = spring_rate_min / acf
adjusted_spring_rate_max = spring_rate_max / acf

# Function to calculate total force (spring + damping)
def total_damped_force(displacement, velocity):
    # Select appropriate spring rate based on displacement range
    spring_rate = adjusted_spring_rate_min if displacement <= displacement_max else adjusted_spring_rate_max
    spring_force = spring_rate * displacement  # F = k * x
    damping_force = damping_coefficient * velocity  # F = c * v
    return spring_force + damping_force

# Example of force calculations for specific displacement and velocity
velocity_example = 0.1  # m/s, example relative velocity
displacement_example = 0.015  # m, example displacement within range

# Calculating force with the example displacement and velocity
force_example = total_damped_force(displacement_example, velocity_example)

# Final outputs
output_data = {
    "force_per_spring_N": force_per_spring,
    "spring_rate_min_N_per_m": spring_rate_min,
    "spring_rate_max_N_per_m": spring_rate_max,
    "adjusted_spring_rate_min_N_per_m": adjusted_spring_rate_min,
    "adjusted_spring_rate_max_N_per_m": adjusted_spring_rate_max,
    "example_total_damped_force_N": force_example
}

print(output_data)
```

Output: (i don’t know too much about damped spring motion, this one is based on hookes law) I used a guide on car suspension?
{'force_per_spring_N': 28.203750000000003, 'spring_rate_min_N_per_m': 1410.1875000000002, 'spring_rate_max_N_per_m': 2820.3750000000005, 'adjusted_spring_rate_min_N_per_m': 5448.546104640063, 'adjusted_spring_rate_max_N_per_m': 10897.092209280127, 'example_total_damped_force_N': 81.77819156960095}

Andrew Kwa’s work



$mu'' + \gamma u' + ku = 0$

$r_{1,2} = \frac{-\gamma \pm \sqrt{\gamma^2 - 4mk}}{2m}$

m - mass
γ - damping ratio
k - spring constant
θ - angle of spring to ground

kg m/s² kg m/s kg/s² m $\frac{F}{m}$

$23u'' + 8\sin\theta\,\gamma u' + 8\sin\theta\, ku = 0$

$r_{1,2} = \frac{-8\sin\theta\,\gamma}{46} \pm \frac{\sqrt{-64\gamma^2\sin^2\theta + 736k\sin\theta}}{46} i$

$$u(t) = C_1 e^{\frac{-8\gamma\sin\theta}{46}t}\cos\left(\frac{\sqrt{736k\sin\theta - 64\gamma^2\sin^2\theta}}{46}t\right) + C_2 e^{\frac{-8\gamma\sin\theta}{46}t}\sin\left(\frac{\sqrt{736k\sin\theta - 64\gamma^2\sin^2\theta}}{46}t\right)$$

$736k\sin\theta = 64\gamma^2\sin^2\theta$

$736k = 64\gamma^2\sin\theta$

assume $\theta = 75°$

$\gamma^2 < 11.91\,k$ ← relationship to follow...

$u(0) = 0.02$ $C_1 = 0.02$

$u'(0) = 0$ $C_2 = 0$

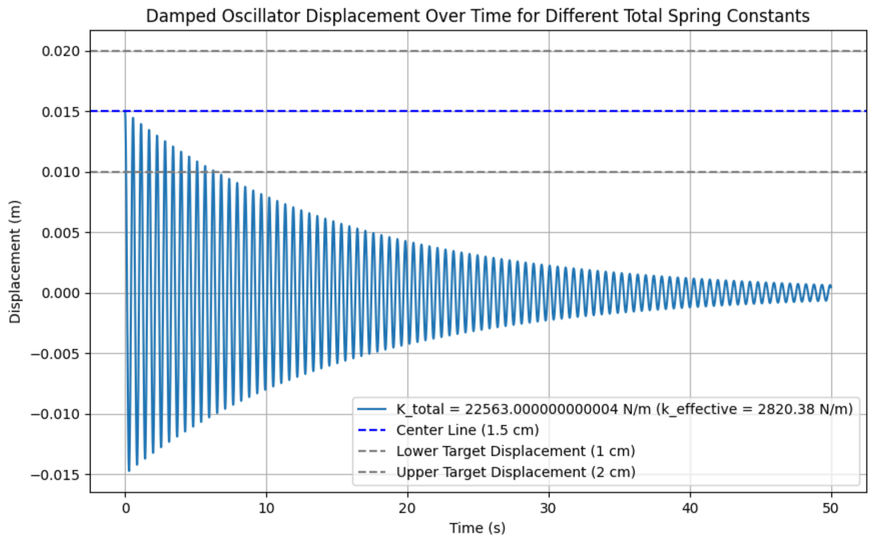
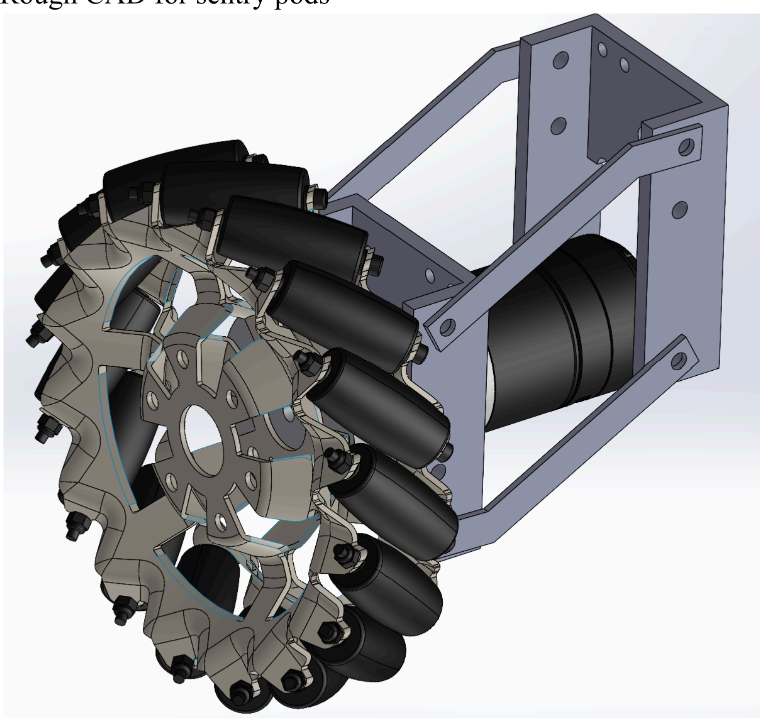
$$u(t) = 0.02\, e^{\frac{-8\gamma\sin\theta}{46}t}\cos\left(\frac{\sqrt{736k\sin\theta - 64\gamma^2\sin^2\theta}}{46}t\right)$$

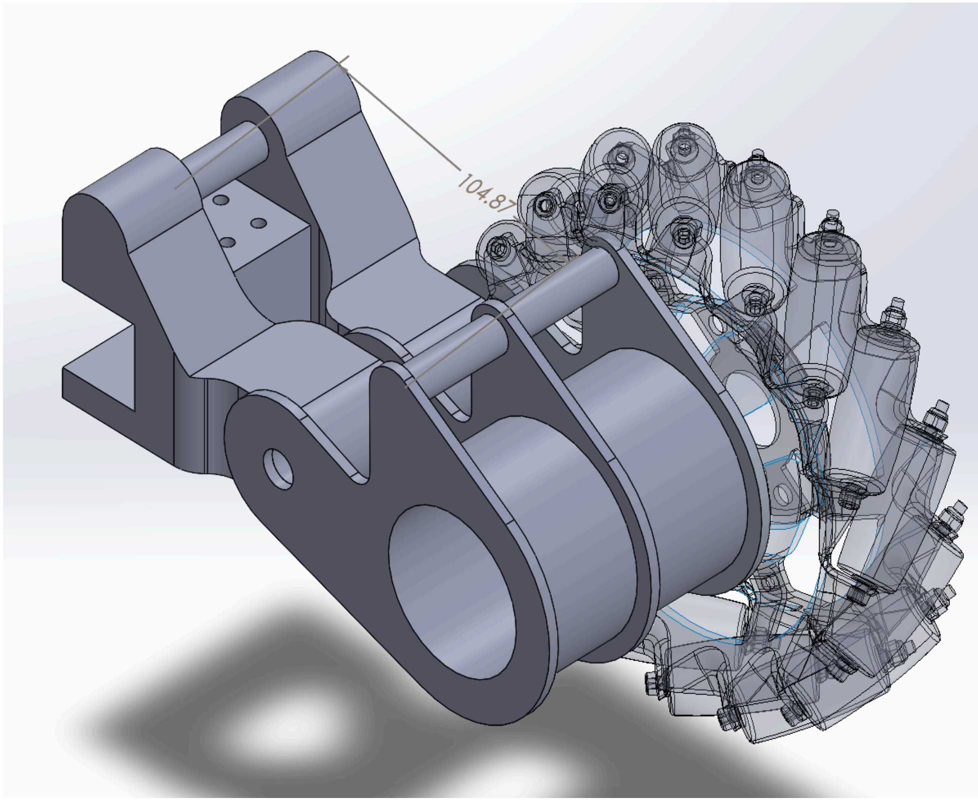
$\gamma^2 < 11.91\,k$

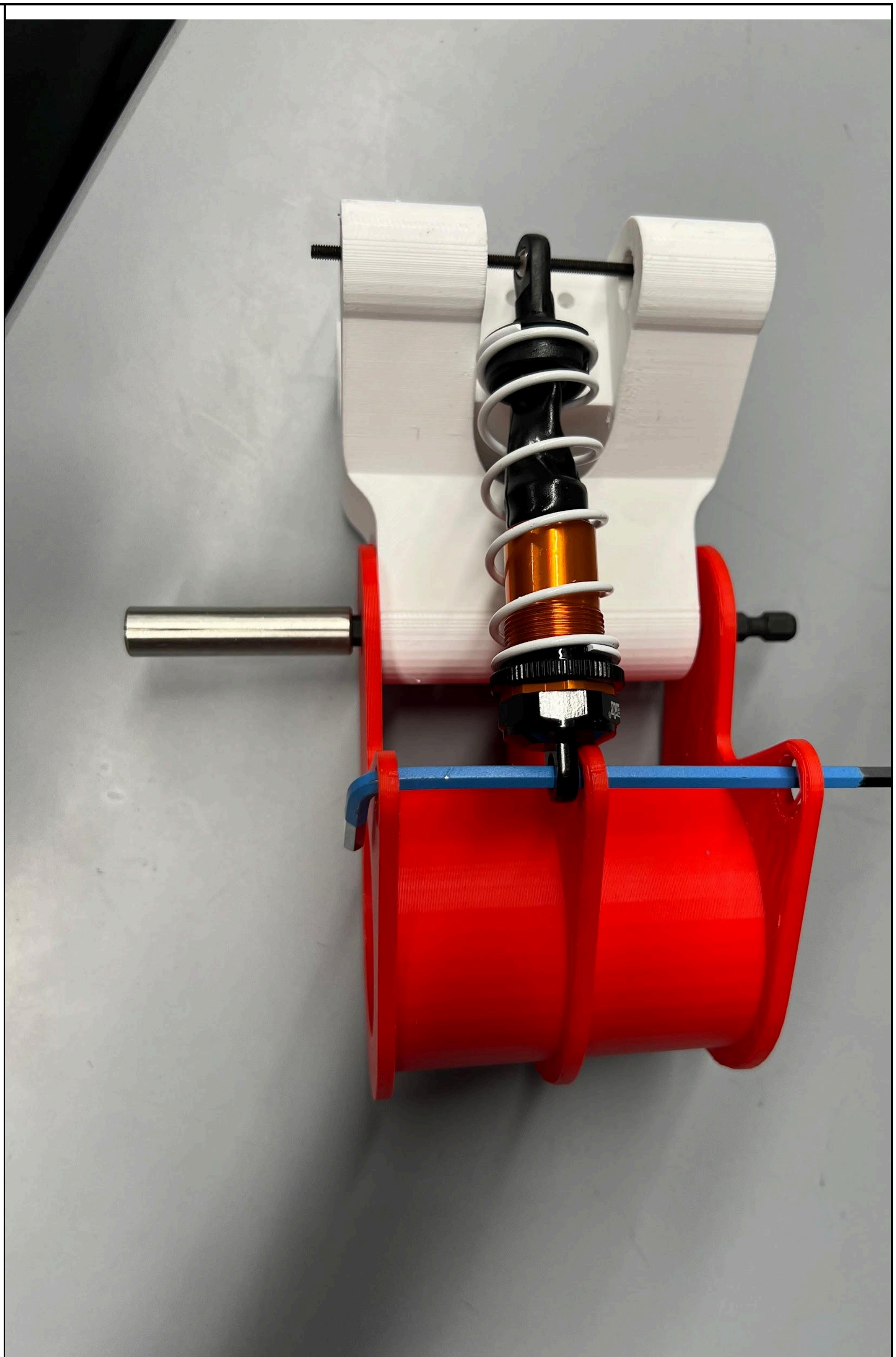
u(t) = position equation
γ = damping ratio
k = spring constant
θ = angle of absorber to the ground

My work trying the dampening stuffxt

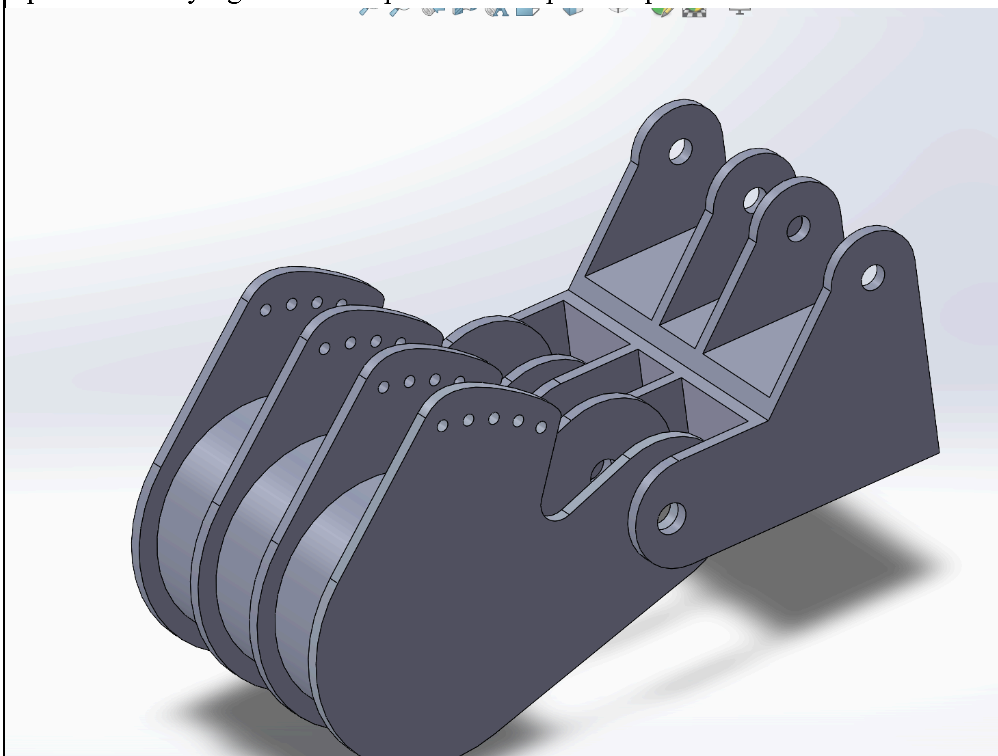
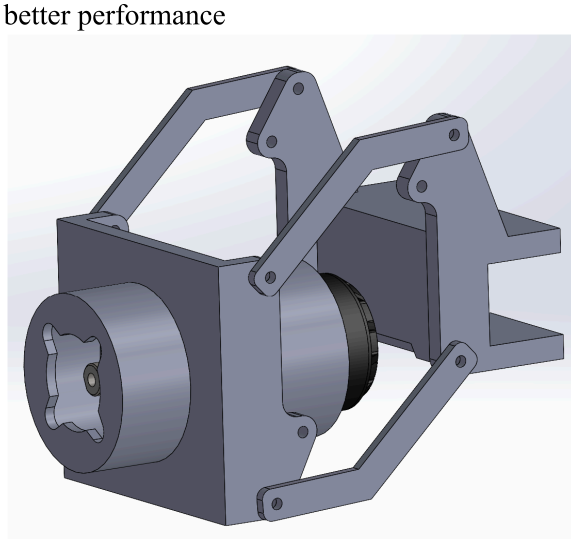
```python
import numpy as np
import matplotlib.pyplot as plt
from scipy.integrate import odeint

# Define system parameters
m = 23  # kg (mass of robot)
delta = 3  # Damping coefficient
theta = np.radians(75)  # Convert angle to radians
sin_theta = np.sin(theta)

# Define the differential equation for the damped oscillator
def damped_oscillator(y, t, k):
    u, v = y  # y = [u, u_dot], where u is displacement and v is velocity
    du_dt = v
    dv_dt = -(delta * sin_theta * v + k * u) / m
    return [du_dt, dv_dt]

# Initial conditions: u(0) = 0.015 m (1.5 cm), u_dot(0) = 0 m/s
initial_conditions = [0.015, 0]

# Time points at which to solve
t = np.linspace(0, 50, 10000)  # Simulate for 50 seconds

# Function to plot the displacement over time for different total spring constants
def plot_displacement_for_K(K_values):
    plt.figure(figsize=(10, 6))

    for K in K_values:
        k_effective = K / 8  # Divide total spring constant by 8 springs
        solution = odeint(damped_oscillator, initial_conditions, t, args=(k_effective,))
        displacement = solution[:, 0]

        plt.plot(t, displacement, label=f'K_total = {K} N/m (k_effective = {k_effective:.2f} N/m)')

    plt.title('Damped Oscillator Displacement Over Time for Different Total Spring Constants')
    plt.xlabel('Time (s)')
    plt.ylabel('Displacement (m)')
    plt.grid(True)
    plt.axhline(0.015, color='blue', linestyle='--', label="Center Line (1.5 cm)")
    plt.axhline(0.01, color='gray', linestyle='--', label="Lower Target Displacement (1 cm)")
    plt.axhline(0.02, color='gray', linestyle='--', label="Upper Target Displacement (2 cm)")
    plt.legend()
    plt.show()

# Try different total spring constant values (for the entire system)
K_values = [2820.3750000000005 * 8]  # Total spring constant for the entire system
plot_displacement_for_K(K_values)
```

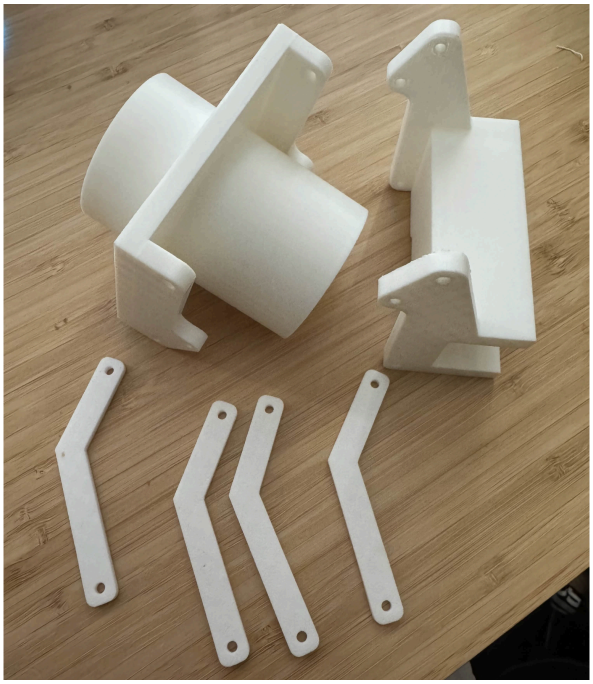
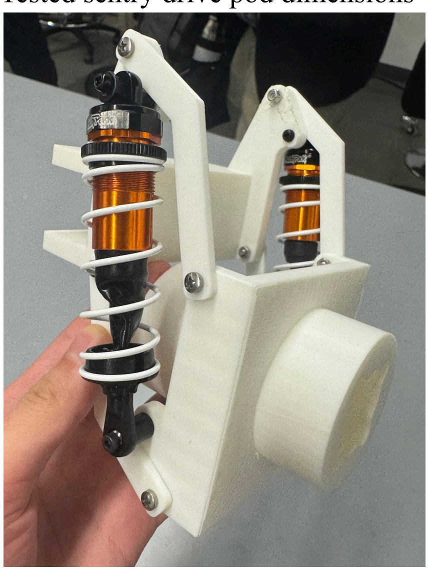
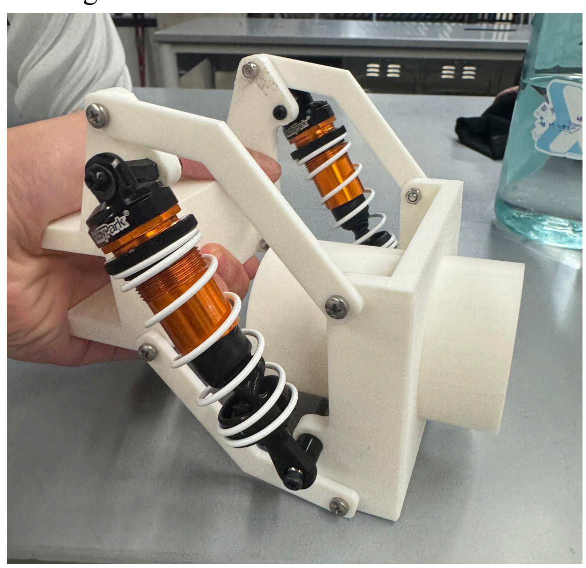
	 Rough CAD for sentry pods 
10/19 - 10/25	Overhaul design to change from 4 small hinges to a central hinge for reliability

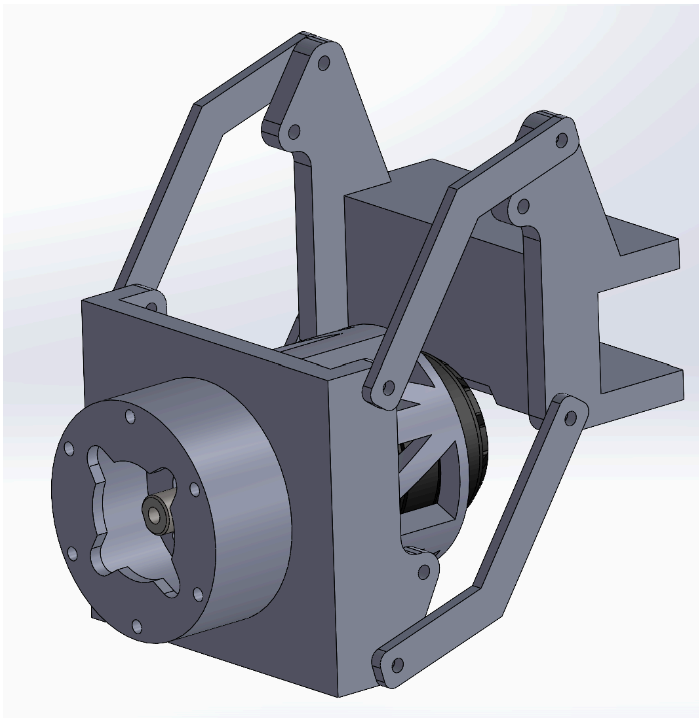
	
10/26 - 11/1	Create a Dummy Suspension Rig for testing shocks and spring constants Add configurations with different angles and locations of springs for optimal movements

11/8	


#WashU28

11/15	Updated dummy rig to include space for 2 suspension pods  Also added multiple holes to adjust spring placement for better testing
11/22/24	41.41.2 lbs for standard, Lower hinge basically done with being manufacturing ready. Upper hinge requires some work, Updated geometry of sentry drivepod for easier bar and shock absorber mounting and better performance 

	 3D printed sentry drivepod parts for testing
12/6/24	Tested sentry drive pod dimensions - looks good  
	Split motor mount into separate pieces

Completion Status:

- ☐ Not Started
- ☑ ~~In Progress~~
- ☐ Completed

(Check the appropriate box to indicate the current status of the task.)
