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Counterweight for Long Reach Robotic Arm

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The Robot's Intention

Vital accelerator components can often be difficult to inspect in the event of a failure. The use of a robotic arm simplifies the identification of broken components due to its ability to maneuver through limited spaces. This robot is the second iteration and was redesigned with a greater focus on safety and structural integrity. Refer to Brenda Sanchez's poster for more information about the arm linkages.

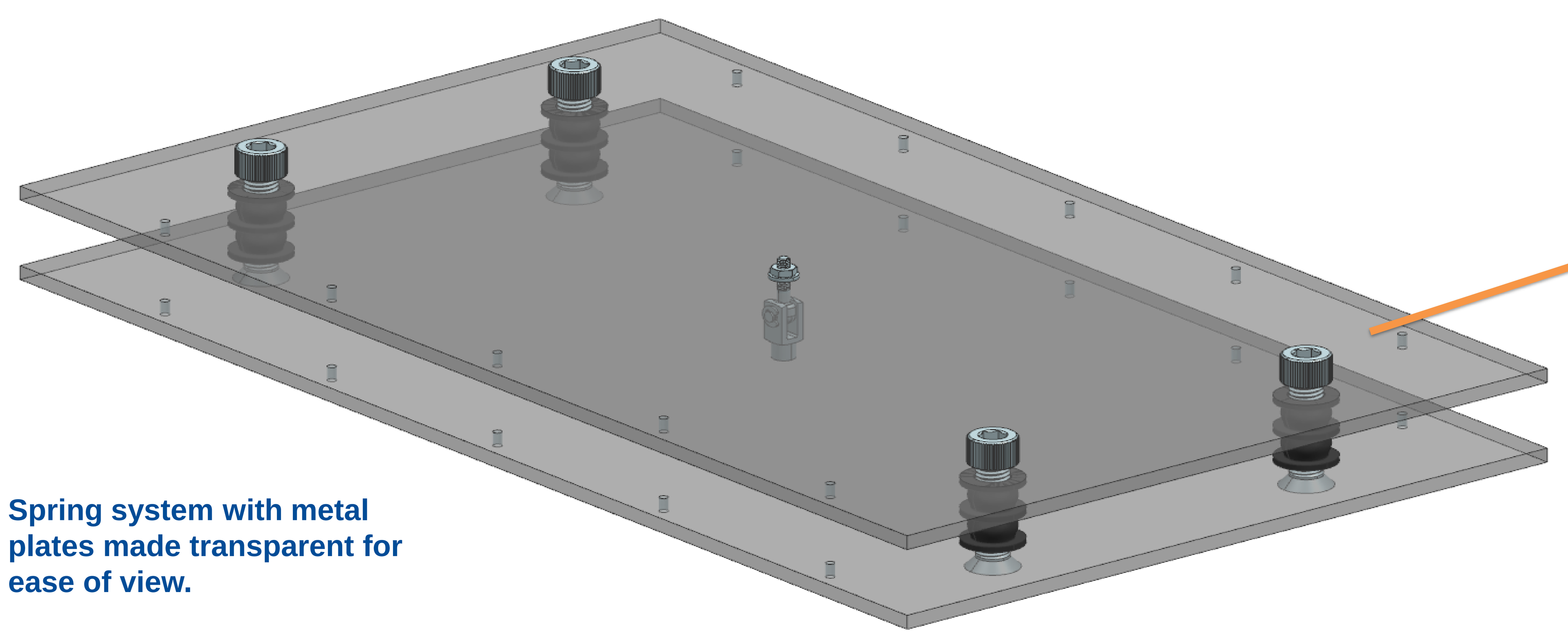
Spring System Design and Calculations

The arm links and counterweight will attach to a spring-based platform. This system consists of four flanged rubber compression springs and a clevis rod and rod end mounted in the center. The springs analyze the system's tilt while the clevis rod provides greater stability by limiting the tilting motion to two directions, preventing the platform from entering three directional rotation.

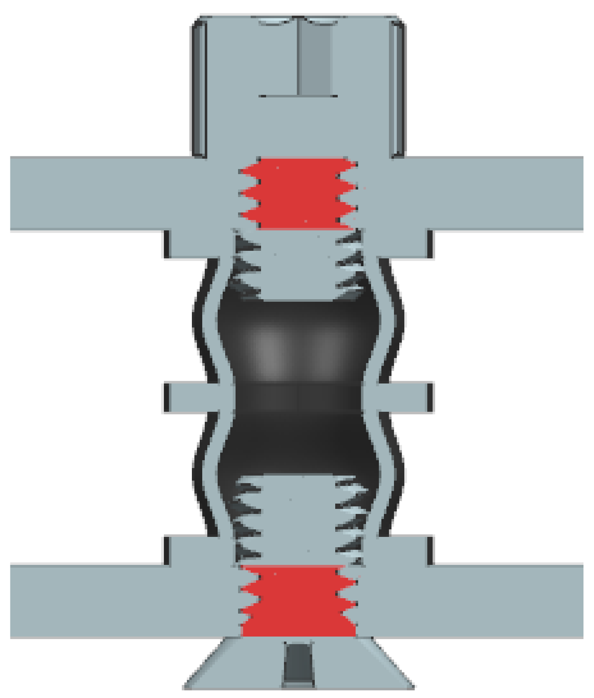
$$\theta = 90^\circ - tan^{-1}(\frac{x_{cm}}{y_{cm}}) \qquad rateofdeflection = \frac{arm_{load}}{sin(\theta - \frac{1}{4}\theta)}$$

Equations for finding the tipping angle of the system and the spring's rate of deflection to obtain three quarters of the tipping angle.

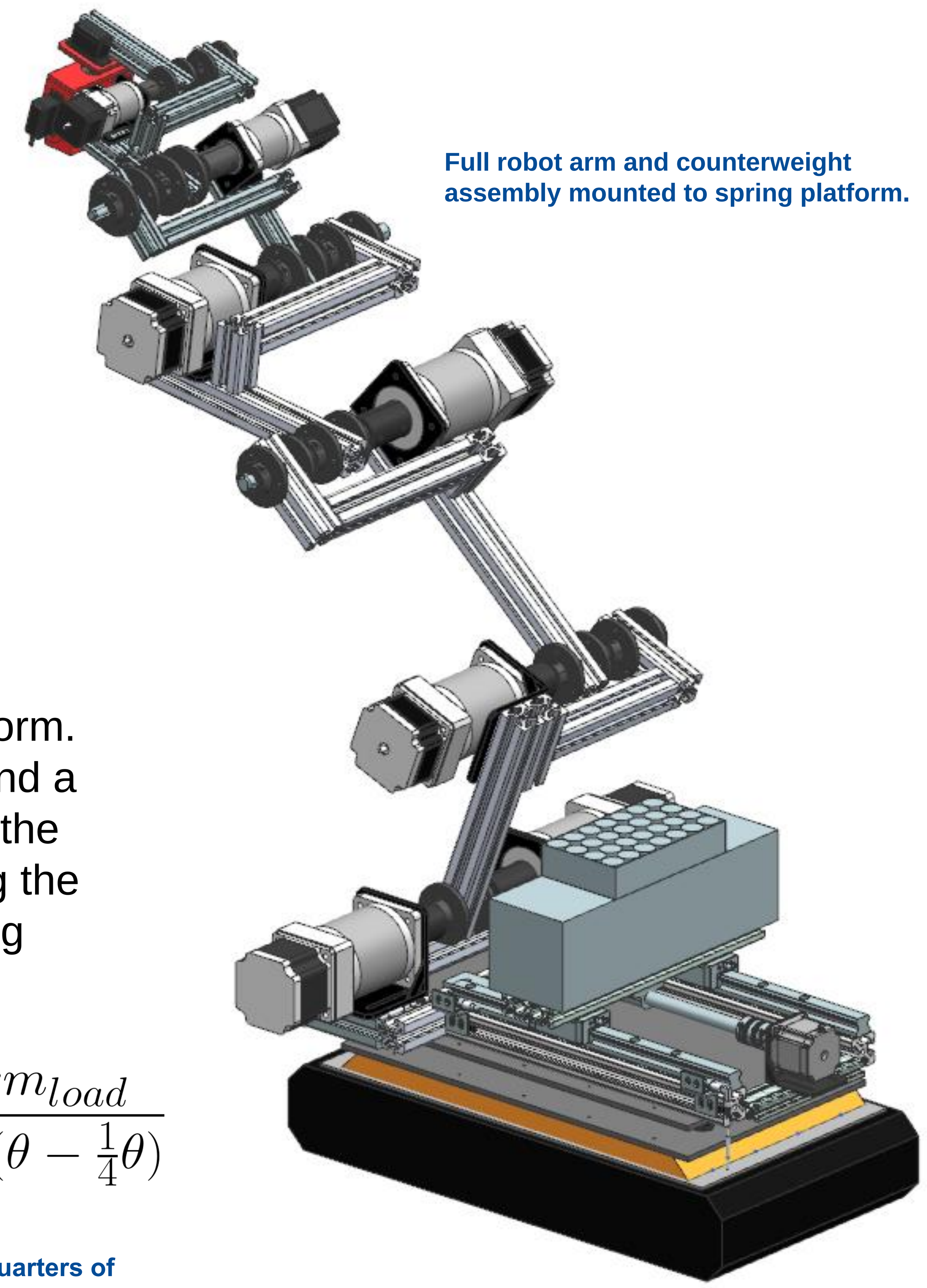
To specify the needed rate of deflection of the springs, the x and y location of the entire arm and counterweight system's center of mass needed to be pinpointed. Using these x and y values, the precise tipping angle of the system was found. The tipping angle then allowed the rate of deflection to be specified. To the left are the equations used.



Spring system with metal plates made transparent for ease of view.



Cut view to show mounting of springs.



Full robot arm and counterweight assembly mounted to spring platform.

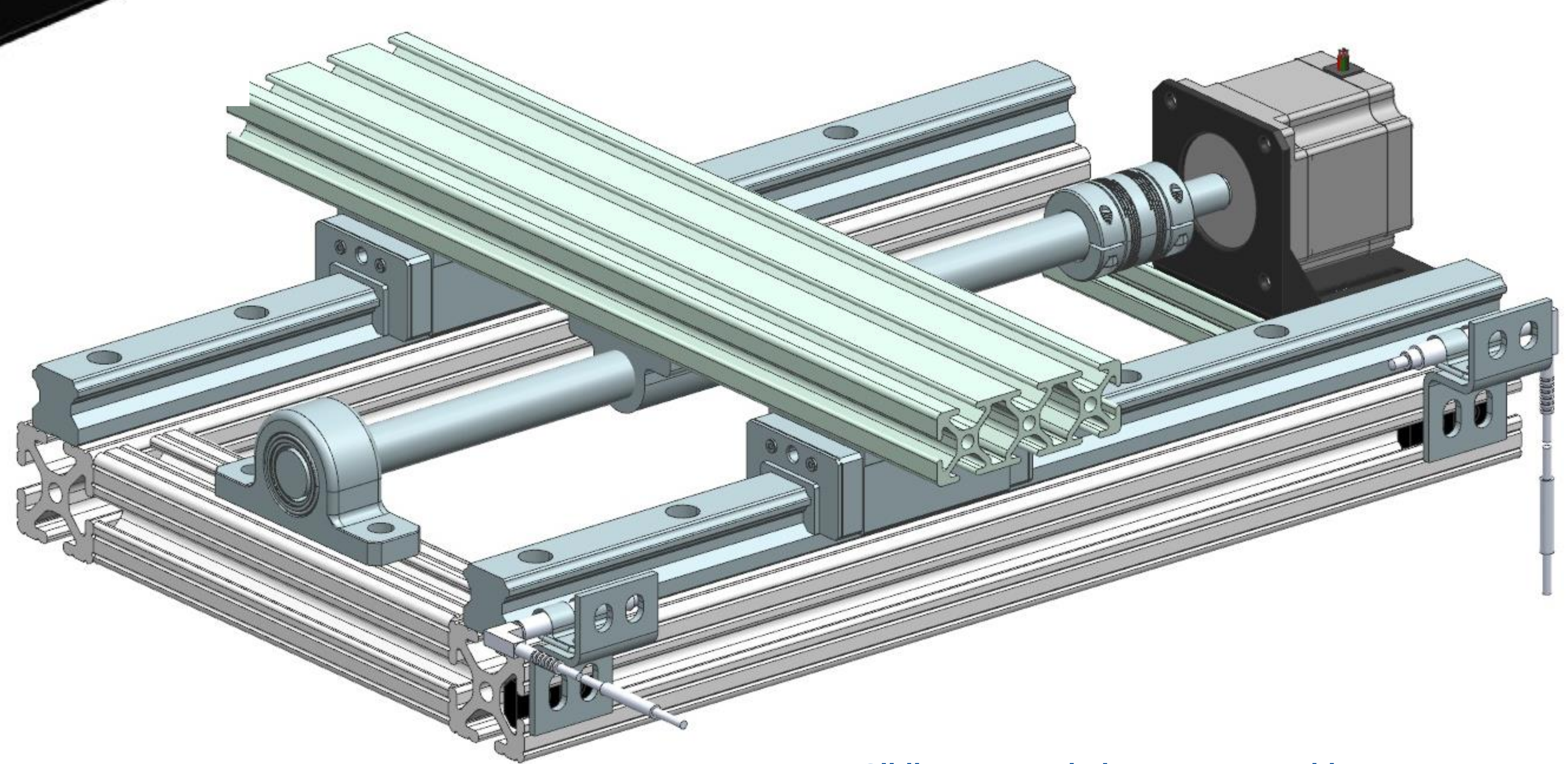
Counterweight Design and Calculations

The counterweight system required one-directional mobility to counterbalance the outward movement of the arm linkages. The base structure of the counterweight system consists of t-slotted profiles and the mass is supported by linear rails and carriages. The linear motion of the counterweight is driven by a Nema 23 stepper motor coupled to an acme lead screw.

$$CW_{mass} = \frac{X_{CM}}{CW_{Xmax}}$$

Equation to find the needed mass of the counterbalance.

To identify the weight of the counterbalance and its maximum linear translation, the process is as follows: locate the center of mass of the arm and use this value to determine the weight of the counterweight after setting its max displacement from the arm base.



Sliding counterbalance system with an absence of the weight for ease of view.

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