Hyperloop Fall 2025 Mechanical Team Report

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During my time on the Cornell Hyperloop Project Team throughout the Fall 2025 semester, I was fortunate enough to contribute towards the following projects:

- Shear Force Analysis for Hyperloop Chassis
- Torque Requirements for Static Start
- Yaw and Pitch of Pod via 4 Adjacent Time-of-Flight Sensors
- Control System Testing and Electromagnet Characterization

Shear Force Analysis for Hyperloop Chassis

To start the semester, I was a member of the Structures subteam (before subsequently joining the Magnetics subteam). As part of my work on the subteam, I tasked myself with designing a script to calculate the shear force and bending moments along the Hyperloop chassis. I modeled the chassis as a cantilevered beam with each component applying a point force at its resulting center-of-mass. The script was successfully developed to quickly test out the resulting stress and strains on the pod in the case we changed material (from steel to aluminum). The result was meant to be a comparison with a loading situation in Ansys. The link to the script is provided here: Shear Analysis Script

Future Work

Future work could more accurately measure the mass of each major component, as well as developing a more accurate method for measuring the distance from the static-load point, rather than measuring from the out-of-date chassis CAD.

Torque Requirements for Static Start

As another project, I tasked myself with designing a parameterized script to determine the necessary torque required by DC-motors to propel the Hyperloop from start, in order to overcome the static-friction barrier and lead to linear-induction-motor performance increases. The script parses over a variety of symmetric wheel setups and determines the necessary torque needed to overcome the static friction barrier given the inherent friction of wheels in the system versus the applied torque provided by the wheels mounted to the DC-motors. The link to the script is provided here: Torque Requirement Script

Future Work

Future work could more accurately look into the static friction coefficient between the surface of contact and the varying wheels. Additionally, although more difficult, the wheels could be modeled as being deformable, and the the resulting deformation could come with changes in surface area in contact with the ground, which could also alter the necessary torque requirements.

Yaw and Pitch of Pod via 4 Adjacent Time-of-Flight Sensors

As an exercise in rigid-body-dynamics, I developed a script that uses the readout from four potential time-of-flight sensors. Then, I calculated the resulting position of the center of mass of the body (ideally outlined by all four time-of-flight sensors) as well as the yaw and pitch of the roll of the system. This could become an important development in trying to stabilize the Hyperloop pod vertically, rather than just our horizontal control system. As a follow-up to the calculation, I created a graph that adds random inputs of position to test whether the yaw and pitch of each corner of the Hyperloop Pod varied accordingly: Yaw and Pitch Script

Future Work

The current script adds sinusoidal inputs into the system. Future work could add random positional movements. Additionally, it was assumed that all of the readings were ideal, thus there was no noise in the readings of any of the time of flight. It could be beneficial to model the time-of-flight sensors as having mm magnitude errors, as is the case of our real-world system, in order to see how the resulting yaws and pitches change.

Control System Testing and Electromagnet Characterization

This semester, I was able to help with the control system of the Hyperloop pod, as well as helping to characterize the electromagnetic force of the system. Although progress was slow throughout the semester on both projects, the team was able to successfully design a control law for horizontal control of the pod. The control law was originally non-linear. I had spoken with a control systems expert (Arslan Al) to see how we could linearize the system. Although he didn't get back to me, I determined that we could Taylor-Series expand around an arbitrary setpoint. This wasn't implemented, but could provide an alternative to the control system developed by Salvatore Ciminello, Riya Guttigoli, and Anubhav Nigam. The main issues with the control system come from trying to turn the resulting force necessary to control the pod (derived from an empirical relationship between Force, distance, and current) into a proportional current driven through an electromagnet to create the force. One of the issues we've come across is that the electromagnet is rated for a holding force and the B-field doesn't permeate through space very well. The goal of our [turn the resulting force needed to control the pod into a current driven through the electromagnet, as well as the fact the electromagnet is rated for holding force and the B-field doesn't permeate through space very well. This was the goal of the testing rig, in order to characterize the force it could produce, and to test whether or not we were correctly varying the current (and force) as a result of distance readings from the time-of-flight sensor. Additionally, there have been major delays with respect to load-cell inaccuracies, buck-converter issues, and circuit redesigns.