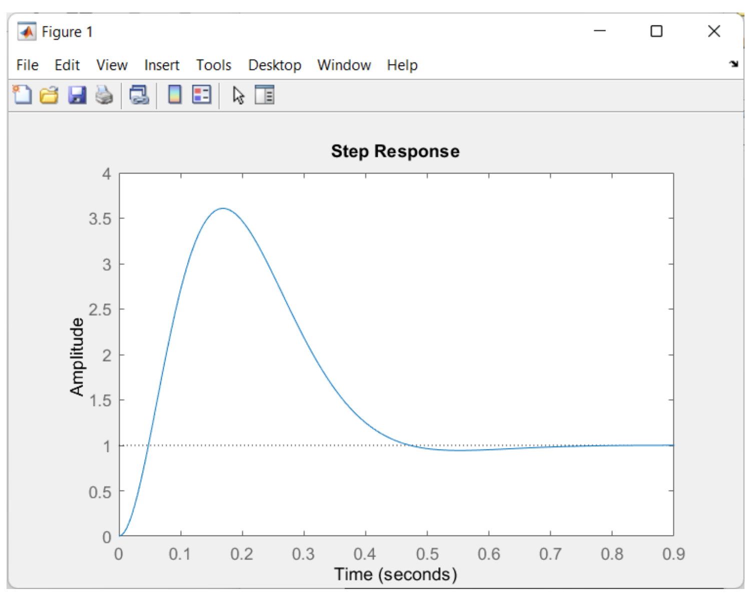
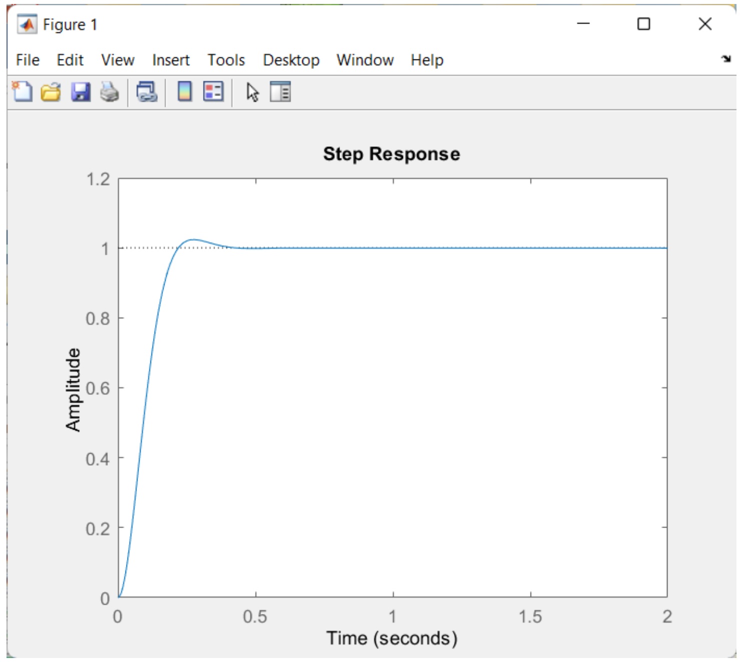
Design Project Part – IV

Persuasive Memo

The hybrid magnetic levitation system, comprised of a permanent magnet and an electromagnet, is designed to make a 1 kg steel ball hover using a control system for the electromagnet. In order to control the unstable system, a feedback controller of some kind was necessary to ensure that the ball would stay within the required safety limits; if the ball fell too low and beyond the critical range, then the electromagnet would lose influence over the ball and it would be beyond the point of no return. On the other hand, if the ball was too close to the permanent magnet, the upper critical point, then the electromagnet would not be strong enough to overcome the effect of the permanent magnet and the ball would essentially become permanently stuck to the surface of the magnet.

From our results in part 2, the best choice for the classical controller was PID control with a prefilter design. With PI or PD control alone, the simulated response was significantly reduced in oscillations but the percent overshoot was unacceptably high, even with all three in a PID controller. Employing the use of the linearized model, the addition of a prefilter ensured that the response was dampened significantly in order to maintain a stable output in ball height while manipulating the step input. Figure 1 shows the step response without the prefilter, and the second figure shows the improved response with the prefilter. While a state-space based control could be used, the response was significant





enough with classical control so the need for designing a second type of controller became obsolete. Our experimental results were less than supportive for successive loop closure or a controlled feedback state-space model such that it made sense to proceed with the PID and prefilter design. The gains for proportional, integral, and derivative controls are -2500, -1800, and -50 respectively. Overshoot is significantly reduced, and the experimental output from our simulink model reflects the improvements made with the improved design.

For future recommendations, I would recommend hardware additions to the setup so that the response of the ball can be tested for maximum speed when introduced to pertubation. For instance, if the ball is used to model a train hovering on a magnetically powered rail, then the ball should be able to simulate someone stepping onto the train as the sudden introduction of an external force. The faster the setup is able to deal with the change in observable load, the smoother the experience will be for the passengers. It would also be interesting to test the limits of the response for the ball, like how fast the ball travels from one critical point to another.

I also wondered when we first began this project if the maglev setup could be modeled with a ball between two vertical springs. Perhaps it would be easier to model a spring with a dynamic spring constant that is controlled to maintain ball height so that the maglev designer has a better idea of what the final output should be visualized to be.