

Furuta Pendulum Lab Report

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1 1. Hands-on Parameter Tuning

1.1 Task 1.1: Upload and Set Dampening Constants

The pendulum angle was changed to start in 0.01. We have tried many different parameters for the pendulum damper and the rotor damper. Starting from 1 for both rotor and pendulum and end up with 0.000006 for pendulum damper and 0.05 for the rotor damper. These parameters give a similar graph to the real pendulum.

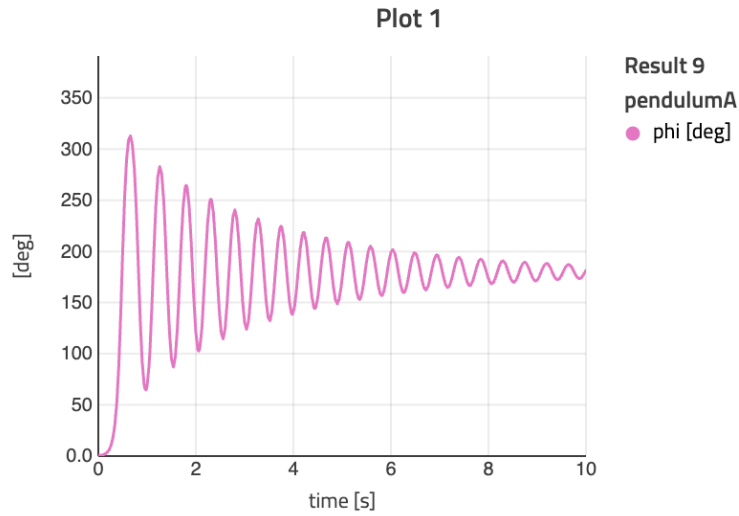


Figure 1: PendulumA with pendulumA ,start at phi =0.01

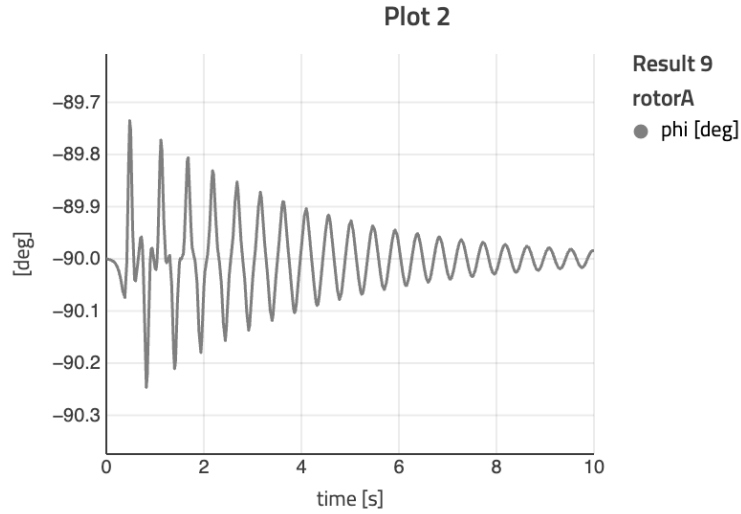


Figure 2: The rotor A phi

1.2 Task 1.2: Apply Disturbances

The initial pendulum angle was set to its original -Phi position and we applied a disturbance with amplitude $\{0.025, 0, 0\}$, $\{0.06, 0, 0\}$ and $\{0.08, 0, 0\}$. As we can see, the pendulum can handle disturbances and it stabilize itself after some time, However its response needs to be improved. We see also that greater disturbances leads to violent reactions.

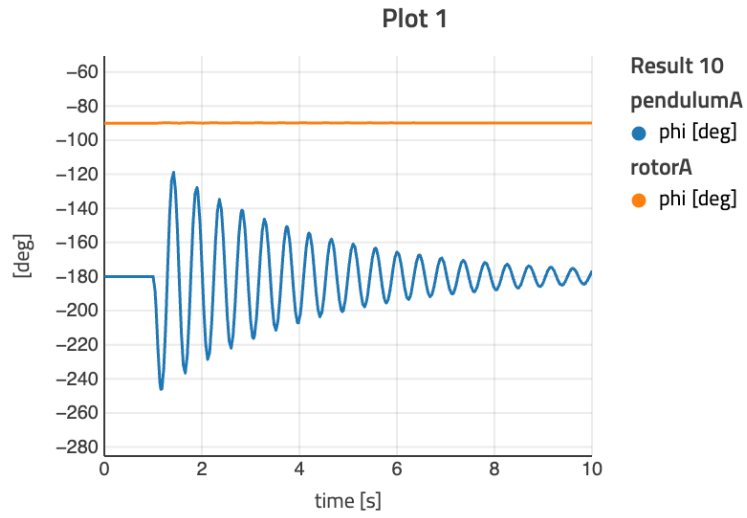


Figure 3: a disturbance with amplitude 0.025, 0, 0

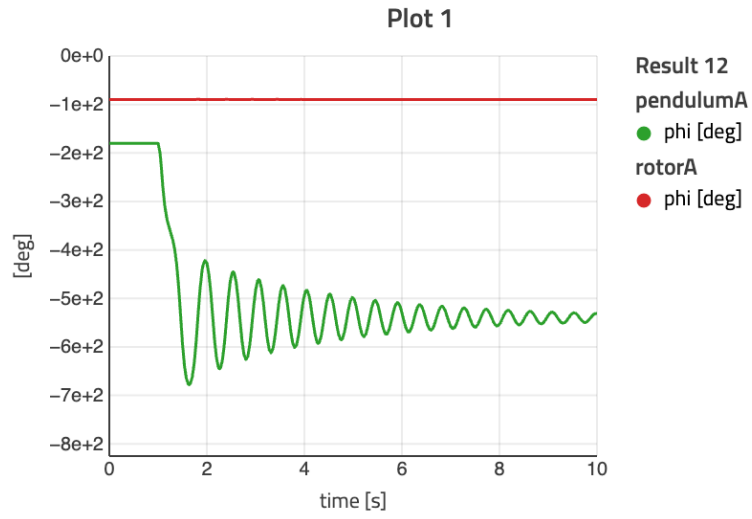


Figure 4: a disturbance with amplitude 0.06, 0, 0

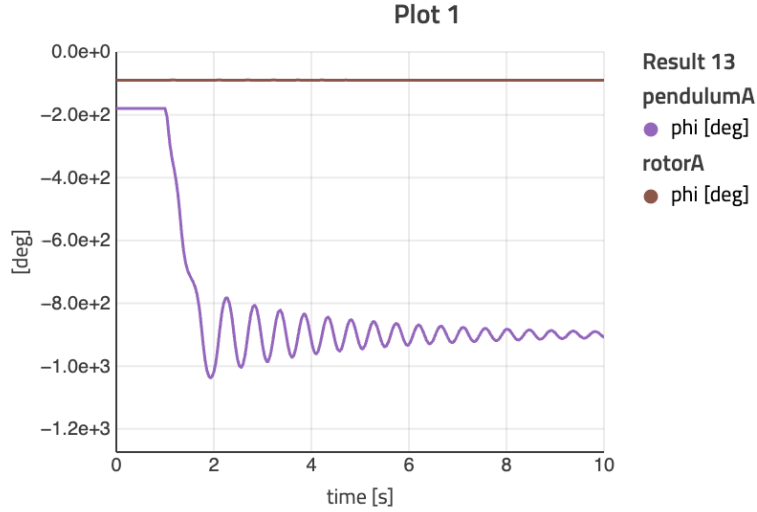


Figure 5: a disturbance with amplitude 0.08, 0, 0

2. Adding an Additional Pendulum Arm

2.1 Task 2.1: Extend the Model

We extended the model by adding a second pendulum. It can be done by just drag and drop component as mentioned in the lab manual. However it can also be done by just copy and paste the original pendulum and change its parameters to make it smaller. As we can see in the plots, we simulated the model to analyze changes in angles due to applied disturbances. Figure 6 the small pendulum (pendulumA2) reaches its stable state in shorter time compared to the larger pendulum (pendulumA). We think, because the small pendulum has a smaller mass and shorter length.

The smaller pendulum (pendulumA2) tends to have higher natural frequencies, the number of swings per second is higher compared to the larger pendulum. see figure 8 and 7

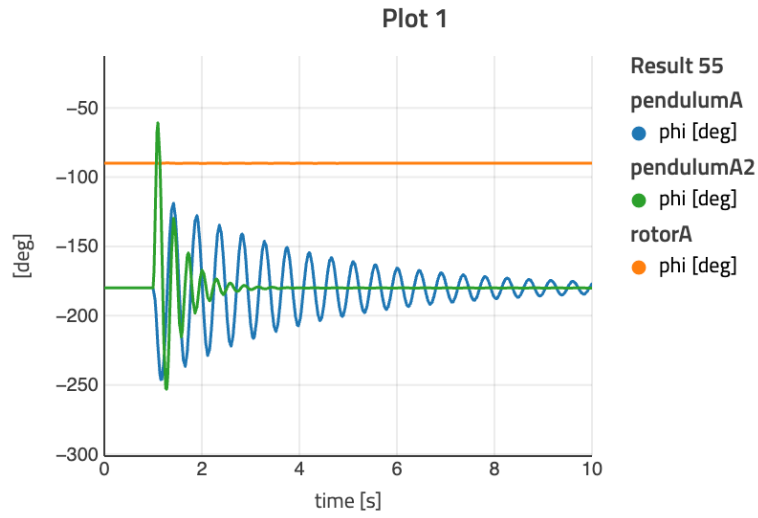


Figure 6: a disturbance with amplitude 0.025, 0, 0

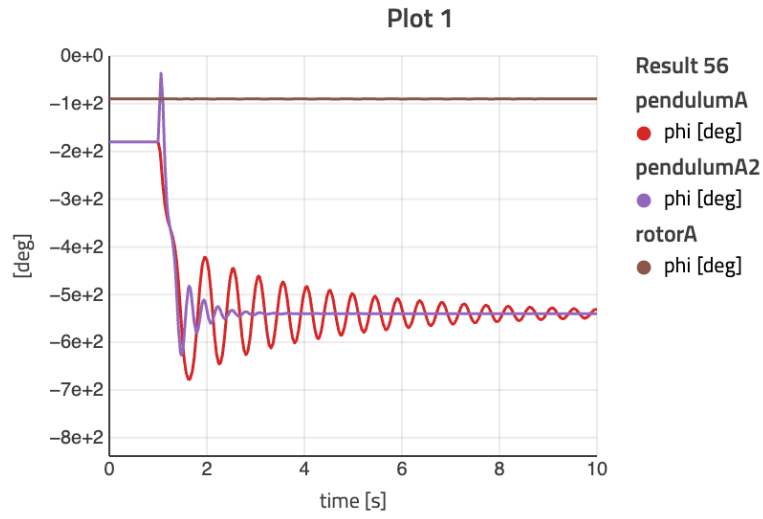


Figure 7: a disturbance with amplitude 0.06, 0, 0

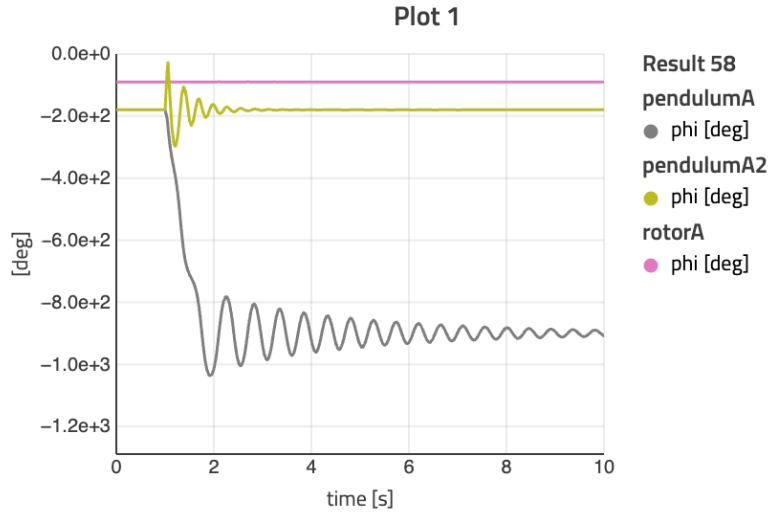


Figure 8: a disturbance with amplitude 0.08, 0, 0

3. Adding a Damping Controller

3.1 Task 3.1: Implement the LQR Controller

The model stabilize itself after some time as it mentioned above and it needs more than 10 sec to stabilize. That is why we need to implement an LQR controller to dampen oscillations. The LQR vector that was given in the lab manual could not give us a good response. However, by changing the Q matrix we got a better response, see figures 9 , 10 and 11

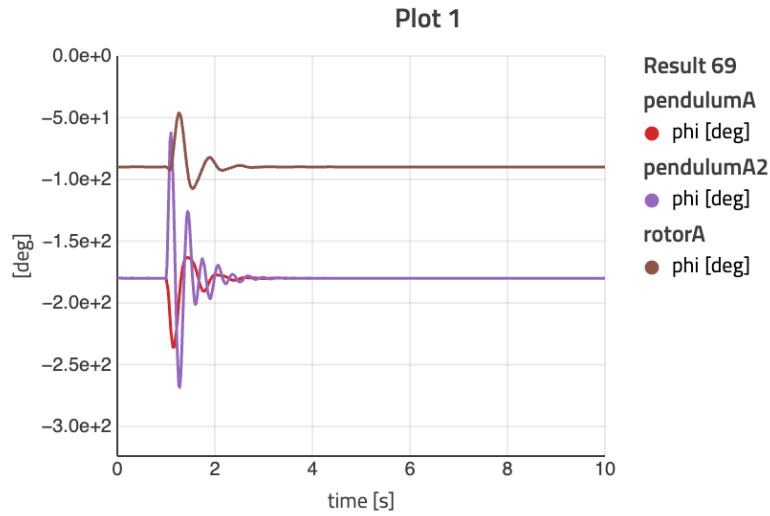


Figure 9: a disturbance with amplitude 0.025, The LQR Vector is manipulated

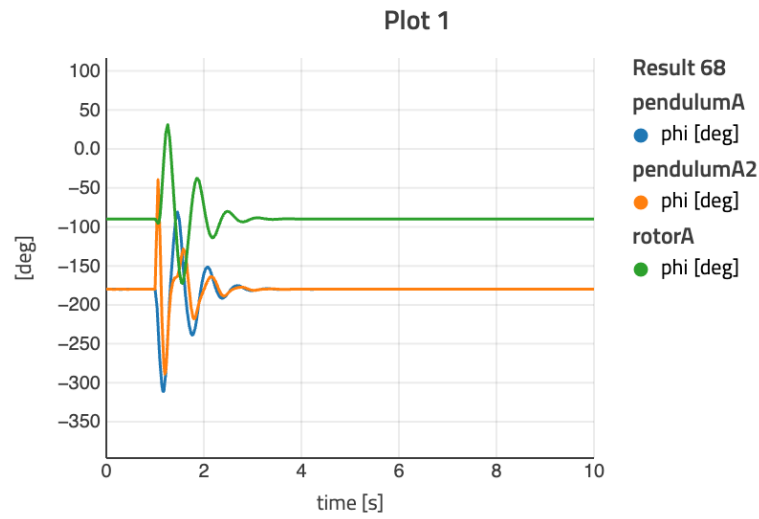


Figure 10: a disturbance with amplitude 0.06, The LQR Vector is manipulated

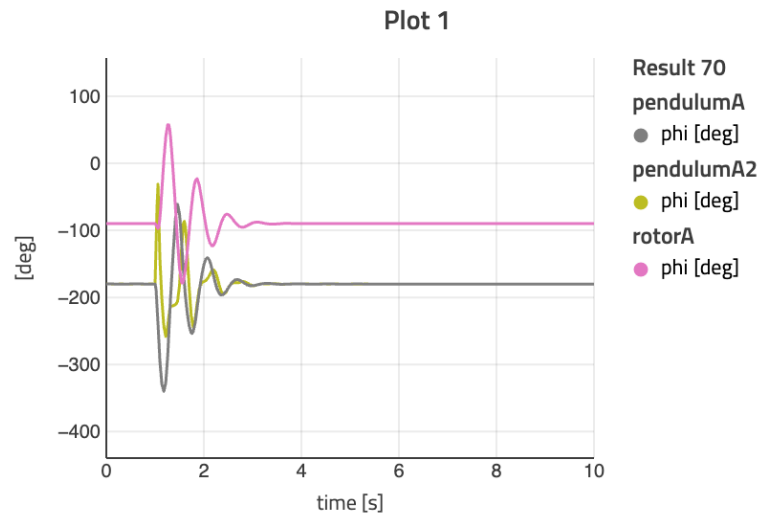


Figure 11: a disturbance with amplitude 0.08, The LQR Vector is manipulated