

ME 418/518 – Data-Based Control

Problem Set 3

Deadline – November 10th, 2025

Employment of LLMs is strictly prohibited

Problem 1. Consider a single-input single-output discrete time plant dynamics whose state space matrices are given as in the following, with a sampling interval of $T=0.1$ seconds:

$$A = \begin{bmatrix} 1 & T \\ -\frac{k}{m}T & 1 - \frac{c}{m}T \end{bmatrix}, B = \begin{bmatrix} 0 \\ \frac{T}{m} \end{bmatrix}, C = [1 \ 0],$$

where $m=1$, $c=0.4$, and $k=1$.

- a) Use $N_p=5$, and $N_c=5$. Derive F and H matrices discussed in class by hand.
- b) Use $N_p=5$, and $N_c=3$. Explain how the matrix H is modified in for this case.
- c) Write (by hand) the matrix S that is used to map the stacked incremental control input vector ΔU to the stacked input vector U . (Use $N_p=5$, $N_c=3$)
- d) For $N_p=5$, $N_c=3$, find the matrix Φ , and the vector u_b discussed in class. Then, express the stacked output predictions $Y = b_k + \Phi \Delta U$ by hand.
- e) Simulate your system in MATLAB using the prediction vector Y you constructed in the previous step, and some ΔU pattern of your choice (for example, you can assume a step or ramp input that persists for 5 samples). You can use longer N_p and N_c values. (For example, you can test for $N_p=200$)