Fall 2020 – 16-642 Manipulation, Estimation, and Control
Problem Set 2

Due: 16 October 2020

GUIDELINES:

- You must *neatly* write up your solutions and submit all required material electronically via canvas by the start of the lecture on the due date. Include any MATLAB scripts that were used in finding the solutions.
- You are encouraged to work with other students in the class, however you must turn in your own *unique* solution.
- Late Policy: If you do not turn your problem set in on time, you can turn it in up to 48 hours later but you will lose half of the points. After 48 hours, you will receive a zero.

1. Given an open-loop transfer function $G(\mathrm{s}) = \frac{200}{\mathrm{s}^3+22\mathrm{s}^2+141\mathrm{s}+2}$, answer the following questions (5 points each):
   (a) (5 points) Determine the closed-loop transfer function $T(\mathrm{s}) = \frac{Y(\mathrm{s})}{R(\mathrm{s})}$ with unity negative feedback.
   (b) (5 points) Determine poles and zeros of $T(\mathrm{s})$.
   (c) (5 points) Plot $y(t)$ using MATLAB's $step$ function and discuss which poles of $T(\mathrm{s})$ dominate the response and why?
   (d) (5 points) Find the steady state value using Final Value Theorem.
2. (40 points) Implement a PID controller in MATLAB and use it to control the plant with transfer function
$$G(s) = \frac{s+10}{s^4+71s^3+1070s^2+1000s}.$$
   Your design objectives are to have a rise time of 0.5 seconds, a maximum percent overshoot of less than 5%, and a steady state error of zero. Tune the gains manually to achieve these objectives. List the final gains you choose and provide a plot of the resulting closed loop step response.
3. (40 points) Picking up from Problem 2(h) in Problem Set 1, build an observer for the cart-pendulum system and repeat your most successful tracking controller simulation replacing the state feedback you used in PS1 with the state estimate from your observer.