ECE 486 MIDTERM #1 INFO AND PRACTICE EXAM Fall 2017

Please read the following information carefully and start preparing for the exam.

Time and place. The first midterm exam will be held on Thursday, Oct 5, *in class* (9:30–10:45am). There is no conflict exam offered at any other time.

Topics covered. The exam will cover everything up to and including the Thursday Sep 28 class. Here is a list of specific topics:

- Models of simple mechanical and electrical systems; State-space equations; Linearization
- Impulse response and convolution integral; Transfer function, frequency response; Computing transfer functions using Laplace transform, partial fractions method, final-value theorem and DC gain, real poles and transient response
- All-integrator diagrams; Transfer functions for basic block diagrams (series, parallel, and feedback connections) and block diagram reduction
- Prototype 2nd order response, effect of complex poles; Time-domain specifications (rise time, settling time, overshoot) and their interpretation in the s-plane; Effect of zeros; Stability and Routh-Hurwitz criterion
- Open-loop vs. feedback control: reference tracking and disturbance rejection, sensitivity to parameter variations, time response; Basics of PID control, system type
- Root locus (RL): definition of the RL, Evans' rule, Rule A (number of branches), Rule B-D

What to bring. The exam is closed-book, closed-notes. You may bring one (double-sided) letter-sized sheet of notes with any necessary formulas. A calculator will not be necessary or helpful, but you can bring a simple, non-graphic calculator.

Tips for preparing. The primary goal of the exam is to test your understanding of the main concepts, not memorization or computational skills. Make sure to follow up on all lecture material, readings, and homework problems and solutions. On the next page is an exam from a past semester, solutions to which will be posted on the course website (disclaimer: the exam this semester will be completely different in style and content from that older one). For additional practice, you can look at the problems for Chapters 2–5 in the textbook, but beware that some of them refer to material not covered in class and many of them are much more computationally involved than the problems you will be given on the exam.

Office hours. I will hold office hours Tuesday Oct 3 at 11AM.

SAMPLE MIDTERM EXAM 1

1. The pendulum dynamics derived in class are

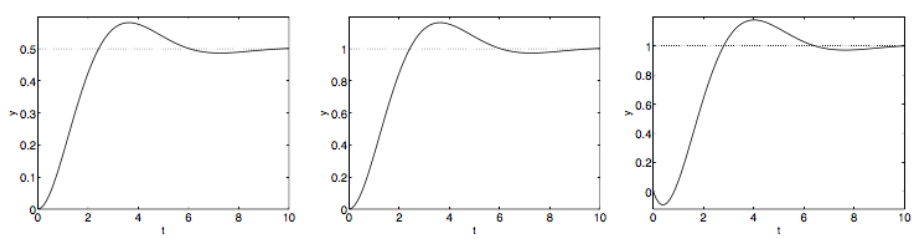
$$\ddot{\theta} = -\frac{g}{\ell}\sin\theta + \frac{1}{m\ell^2}T_e$$

where θ is the angle between the pendulum and the downward vertical direction, g is the gravitational constant, ℓ is the length of the pendulum, m is the tip mass, and T_e is the external torque.

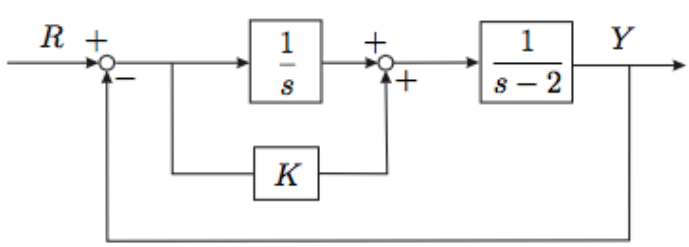
Linearize the above pendulum equation around the upward equilibrium $\theta = \pi$. Write your answer in state space form $\dot{x} = Ax + Bu$ where x is an appropriate vector of state variables and A, B are matrices/vectors of appropriate dimensions.

2. Consider the transfer function $H(s) = \dfrac{1}{s^2 + s + 1}$.

Which of the following is the corresponding step response? Explain your choice and why you rejected the other two possibilities.



3. Consider the system given by the block diagram below:



a) Compute the transfer function from the reference R to the output Y.

b) Determine the range of values of K for which the system is stable.

c) Suppose that the reference is a step: $r(t) = 1(t)$. Does the system achieve perfect steady-state tracking of this reference? If yes, justify. If not, characterize the steady-state tracking error.

d) Suppose that the reference is a ramp: $r(t) = t1(t)$. Answer the same questions as in part c).

4. Draw the positive root locus for the transfer function $L(s) = \dfrac{s}{s^2 + 1}$.

Make your sketch as accurate as you can, relying on the rules learned in class. Explain how you used each rule.