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

Time and place. The second midterm exam will be held on *Thursday, Nov 9, in class*. It is designed to be a 1-hour exam, so it will start at 12:30pm and you should be able to finish around 1:30pm. There is no conflict exam offered at any other time. Students requiring special accommodations should contact me at this time to discuss specific arrangements.

Topics covered. The exam will cover everything up to but not including the Nyquist criterion. Knowledge of topics covered on the first midterm will be assumed. Here is a list of specific topics:

- All rules for plotting the positive root locus; positive vs. negative root loci; choosing the gain for pole placement using root locus
- Design using root locus method: PD and lead control, PI and lag control, lead+lag control
- Bode magnitude and phase plots
- Bode plots and stability, gain and phase margins, Bode's gain-phase relationship
- Relations between properties of the open-loop Bode plot (phase margin, crossover frequency) and properties of the closed-loop system (damping ratio, overshoot, bandwidth)
- Frequency response design method: PD and lead control, PI and lag control, lead+lag control

What to bring. The exam is closed-book, closed-notes. You may bring one (double-sided) sheet of notes with any necessary formulas. (In addition, you can bring the sheet you prepared earlier for the first midterm.) A calculator will not be necessary or helpful.

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. You may also find useful the slides by Prof. Max Raginsky posted on the class website. On the next page is an exam from a past semester, solutions to which will be posted later (disclaimer: the exam this semester may be completely different in style and content from that older one). For additional practice, you can look at the problems for Chapters 5 and 6 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 extra office hours before the exam, details to be announced. Please also take advantage of homework TAs' office hours to clear up any homework-related questions.

SAMPLE MIDTERM EXAM 2

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1. Consider the plant with transfer function $G(s) = \dfrac{1}{s}$ connected in standard feedback configuration with the controller $D(s) = k_1 + \dfrac{k_2}{s+1}$ where k_1 and k_2 are some parameters.

a) Rewrite the closed-loop characteristic equation in the form $1 + KL(s) = 0$, suitable for the root locus method. You can assume for simplicity that $k_1 = k_2$.

b) Sketch the (positive) root locus for $L(s)$. Explain what rules you used to plot it. Describe the behavior of the root locus branches as K varies from 0 to $+\infty$.

c) Based on the root locus, discuss what values of the rise time, overshoot, and settling time are achievable by picking appropriate gain K. If exactly calculating the best values is difficult for some of these specs, it is enough if you explain graphically whether arbitrarily good values of the specs are achievable or not, and why.

2. Consider the plant with transfer function $G(s) = \dfrac{1}{(s+1)(s+2)}$.

a) Sketch the Bode plot of $G(s)$ (for $K = 1$). Explain what rules you used to plot it.

b) Find a value of K such that for the Bode plot of $KG(s)$ the crossover frequency becomess $\omega_c = 3$. (If the exact numerical value is not "nice" it is enough to approximate it by an integer.)

c) With K fixed at the value you found in part b), suppose you want to use a lead or lag controller to increase the phase margin by at least 30°. Explain which controller type (lead or lag) you would choose and how you would design it. (If finding exact parameters of the controller by hand is difficult, describe the procedure you would follow if Matlab were available to you.)

d) With K from part b) and the lead or lag controller from part c) fixed, suppose you want to add another lead or lag controller to ensure steady-state tracking of constant references within 10%. Explain which controller type (lead or lag) you would choose and how you would design it.