EE 302 - Spring 2019

Exam Study Guide (Midterm 1 and Midterm 2)

MIDTERM 1:

1. **Basic Concepts**
   You should be able to
   a. Understand the feedback concept and its purpose,
   b. Give real-life examples of feedback systems,
   c. Be able to draw the block diagram of a system in feedback configuration

2. **Mathematical modeling of Physical Systems.**
   You should be able to
   a. Understand the relationship and difference between a physical system itself and its mathematical model,
   b. Understand the assumptions in deriving a given mathematical model,
   c. write the differential equations model describing the behavior of simple mechanical and electrical systems from first principles,
   d. Use the Laplace-Transform to write the s-domain models of components and constructively draw the block diagram representation,
   e. Manipulate block diagrams to find mathematically equivalent representations,
   f. Derive the transfer function representation of simple mechanical and electrical systems.
   g. Understand the concept of closed-loop poles (and zeros) and be able to determine them,
   h. Define appropriate states and derive the state-space representation of simple mechanical and electrical systems.
   i. Understand the relationships between different system representations for a single system.

3. **Time-Domain behavior of System Models.**
   You should be able to
   a. understand the relationship between the response of a system and its mathematical model,
   b. Understand the basic stability criteria (convergent behavior) based on the location of the closed-loop poles in the s-plane.
   c. know the typical input types and resulting responses used to characterize control systems,
   d. analyze the behavior of first, second systems given or assumed in standard form,
   e. understand the dominant pole(s) concept and its use in analyzing higher order systems,

f. know important performance measures (design criteria) used to characterize control systems,
g. know the relationship between the performance measures and the location of the closed-loop poles of the system in s-plane,
h. compare different systems in terms of performance measures from the location of the closed-loop poles,
i. Understand the relationship between the parameters of a system and its transient response,
j. Understand the relationship between the parameters of a system and its steady-state behavior.
k. Understand when and how Final-Value Theorem can be applied to determine the limiting (steady-state) behavior from Laplace Transform,
l. Know how to determine the Type of an open-loop system and its relationship with the closed-loop steady-state error behavior.
m. Draw the block diagram of a system with proportional (P), Integral (I) and Derivative (D) control actions and their combinations,
n. For simple cases, predict the effect of these control actions on system transient and steady-state behavior.

MIDTERM 2:

4. Stability - Analysis and Design : Routh-Hurwitz Criterion

You should be able to

a. find the characteristic equation of a system given in any mathematical model representation,
b. understand the necessary and sufficient conditions for stability defined by the Routh-Hurwitz criterion,
c. Construct the Routh array,
d. Determine stability and the number of right-half-plane (unstable) closed-loop poles of a system using the array,
e. handle zero first column difficulty with the method of your choice,
f. understand the pole configuration (*jw* axis crossing) causing this difficulty,
g. handle all-zero row difficulty, determining the auxiliary polynomial,
h. understand the pole configurations (symmetry with respect to *jw* axis inclusing *jw* axis poles) causing the all-zero row difficulty,
i. use the Routh-Hurwitz procedure with characteristic polynomials with variables,
j. use the Routh-Hurwitz criterion to determine stability as a function of one variable,
k. use the Routh-Hurwitz criterion to determine stability regions in a plane of two variables,
l. use axis-shift to use the criteria to determine number of closed-loop poles with real-part in the specified regions,
m. apply Routh-Hurwitz criteria to simple design problems where one or two design parameters are to be selected.

5. Stability - Analysis and Design : Root-Locus Plots

You should be able to

a. construct the Root-locus sketch for a given open-loop system with one variable parameter using root-locus rules,
b. handle the case where the variable parameter is not the gain,
c. determine all critical points on the root-locus, e.g., break-in/break-away points, *jw*-axis crossings,
d. *optional*: determine the departure and arrival angles from/to poles and zeros,
e. Use the constructed root-locus sketch to make design decisions based on stability and/or time-domain performace criteria (overshoot, settling time, damping),

6. Stability - Analysis and Design : Nyquist Plots

You should be able to

a. select an appropriate contour in the s-plane for sketching the Nyquist plot,
b. handle origin poles/zeros when selecting an appropriate contour,
c. *optional*: handle complex conjugate imaginary poles/zeros when selecting the appropriate contour,
d. construct the Nyquist plot for a given open-loop system,
e. determine stability using the "principle of argument" based on the Nyquist plot,
f. determine stability as a function of one variable using the Nyquist plot (e.g., by anayzing the encirclement of the $-1/K$ point by the Nyquist plot),
g. handle the case where the variable parameter is not the gain (again by putting the characteristic equation into its standard form $q(s) = 1+KG(s)H(s)$),
h. know the definitions of Gain and Phase Margins as measures of relative stability of systems as well as determine these parameters approximately from the Nyquist Plots.