ABE 460 Final Exam Review

December 5, 2018

# Final Exam Overview

* Closed book and closed notes
* 1 single-sided 8.5”x11” crib sheet
  + Can be typed or handwritten
  + Can photocopy a friend’s
  + Will be turned in with exam
* Will provide equations/tables that were provided on the Midterm
* Thursday December 13, 8am - 10am, WALC B093
* 10-11 questions (not doubled from Midterm)
* Can bring a calculator
* Look on blackboard for new examples in all folders
* Bring extra batteries, pencils, erasers, pens, etc.
* cumulative

# Chapter 1: Introduction

## Basic Control System Blocks

* Review the general layout of a feedback control system and the common blocks
* Be able to know how to label a block diagram
  + Error
  + Controller command
  + Set point
  + Output

# Chapter 2: Modeling Dynamic Systems

## Write the equations of motion for common physical systems (differential equations)

* Mechanical (Translational and Rotational)
* Electrical
* Hydraulic
* Liquid Level

## Block Diagram Reduction

## Linearization

* Only looking at linear systems in this class
* Non-linear in real life
* Remember valid range identification for variables

# Chapter 3: Analysis Methods for Dynamic Systems

## Differential Equations

* 1st and 2nd order step input responses
  + Know what a unit step input is and how to draw it
* Generalized characteristics
* Time domain

## Laplace Transforms

* Transfer functions
  + Input and output on opposite sides
  + TF = out/in
* Characteristic equation and response types
  + CE = denominator of transfer function
* S-domain
* Know how to go between diff. Eq. and Laplace
* Type number

## Frequency response plots (Bode Plots)

* Construction and deconstruction
  + Straight line approximations
  + Getting function from plot
* General characteristics
  + Bandwidth
  + Gain margin
  + Phase margin
  + Margins are factors of safety: how close is system to becoming unstable?
* Frequency domain
* Describe how a Bode Plot is formed
  + Input is a sine wave, gives frequency
  + Measure sine wave on output
  + Produces one data point, repeat a lot of times and Bode plot is produced

State Space is a fourth domain, but we will not be tested on it.

# Chapter 4: Analog Control System Performance

## Open loop versus Closed loop

* Command and disturbance inputs
  + Steady state errors from both
    - How much contributed from both?
  + Transient response (stability)

## Root Locus Method

* Constructing root locus plots
  + Ten step process
  + What value of K will place pole on the line
* Understanding response characteristics
  + Where would poles move if something is added to the system?
  + Each pair of Xs responds to a new value of K
  + The root locus draws the paths of how the poles move as they go to find a zero

## Frequency Response methods

* Stability margins
  + Phase margin
  + Gain margin
  + Calculations and how to increase margins to something more desireable

# Chapter 5: Analog Control System Design

## PID Controllers and characteristics

* Role and characteristics of each gain
  + How do you deal with error?
  + How is the error currently changing?
  + How does controller change the error?
  + Steady-state change: Integral
  + Rise-time change
  + Smoothing out system
* Phase-lag/lead similarities
* Ziegler-Nichols tuning
  + Tuning a controller on-site
  + If you have no idea where to start with gains, gives a good starting point

## Root Locus design of controllers

* How do we adjust the Root Locus based on adding a controller to the system?

## Frequency response design of controllers

* Lag/Lead
* Design with frequency domain: Bode plot

On Blackboard: “For this exam you should be able to:” slides!!!

# Example Problem:

Given the following open loop transfer function of a marginally stable system, use frequency domain design techniques to design a controller which results in a system with a phase margin of approximately 60 degrees and a crossover frequency of approximately 1 rad/sec.

G(s) = 1/s2

Starting point: what does my system look like now?

Make uncompensated Bode plot.

|  |  |  |  |
| --- | --- | --- | --- |
| omega | 1/s | 1/s | total |
| 0.1 | 20 | 20 | 40 |
| 1 | 0 | 0 | 0 |
| 10 | -20 | -20 | -40 |
| 100 | -40 | -40 | -80 |
| 0.1 | -90 | -90 | -180 |
| 1 | -90 | -90 | -180 |
| 10 | -90 | -90 | -180 |
| 100 | -90 | -90 | -180 |

PM\* = phiomega gc + 180o = 600

phigc\* = -120o

phigc = -180

* Need to contribute a positive angle to shift the gain up
* This value is the angle at the frequency where magnitude crosses 0 db

Omegagc = 1 = omegagc\*

* Already at desired value
* Need negiligible magnitude shift while shifting frequency

Where do I go to achieve goals?

Can choose any type of controller

* Choosing PD controller
  + Phi = tan-1(omega/(Kp / Kd))
  + 60 = tan-1(1/(Kp/Kd)
  + Kp/Kd = 0.577
* Gc = Kp [Kd/Kp s + 1]
  + Gc = Kp [1.732s+1]