MAE 106 Midterm # 2
Review Sheet

Midterm 2 will build on the entire course to date, including material included for Midterm 1. So, study using the Midterm 1 review sheet as well! Midterm 2 will also include new material from the lectures since Midterm 1 and Labs 4-6.

LABS

1. Lab 4
   a. Why use feedback control?
   b. What is P-type feedback control?
   c. How does a rotary encoder work, including optical and Hall effect versions?
   d. What is quadrature encoding?
   e. What is an interrupt service routine and why do you use it?
   f. What steps do you need in your computer control to implement a feedback controller?
   g. What is the P-type feedback control law for velocity control?
   h. What does the step response of motor velocity look like for p-type feedback control?
   i. What does the frequency response of motor velocity look like for p-type feedback control?
   j. How does changing the proportional gain affect the step and frequency responses?
   k. How does changing the proportional gain affect the steady state error?
   l. How does changing the proportional gain affect the time constant?
   m. What type of filter does the P-controlled motor act like?

2. Lab 5
   a. What is a PD position controller?
   b. What is a PID position controller?
   c. What is the control law and block diagram for a PD position controller?
   d. What are the closed loop dynamics for PID controlled motor, with a current amplifier?
   e. How are the closed loop dynamics analogous to a mass-spring-damper system?
   f. What are four types or levels of damping and how do the closed loop dynamics vary with each of these damping types?
   g. What is "tuning" of a PD controller and how do you do it?
   h. What is the frequency response of a PD position-controlled motor?
   i. What is a Bode plot and why do engineers use them?

3. Lab 6
   a. Why study vibrations?
   b. What is a second order system?
   c. What is the transfer function of a mass-spring-damper system?
   d. Why is developing intuition about a second order system important?

e. What are differences between second and first order systems?
f. What is a transient response or impulse response?
g. How do you calibrate an accelerometer?
h. Why does the accelerometer approximately measure position for a vibrating beam?
i. What are natural frequency, damped natural frequency, and damping ratio?
j. What is the logarithmic decrement method for estimating damping ratio?
k. What can the frequency response of a second order system look like?
l. What is resonance?
m. How does an off-balance load create a sinusoidal forcing function?
n. When you coupled two beams, what are the three distinct movement patters of the beams?
o. How do these patterns correspond to the mathematics of the transfer function?
p. How can you estimate resonant frequency from the step response?
q. For what values of damping ratio can resonance occur?
r.

LECTURES

4. Lecture – Integral control
   a. What is integral control, how does it work, and what benefits and possible drawbacks does it provide?
   b. What are typical behaviors of first and second systems in the time and frequency domain?

5. Lecture – Second order systems, including the vibrating beam
   a. How can you model a vibrating beam as second order system?
   b. What is the transfer function of a second order system, in terms of M, K, and C, or in terms of natural frequency and damping ratio.
   c. What are the equations for natural frequency, damping ratio, and damped natural frequency?
   d. How do we mathematically model an impulse input?
   e. Why is the inverse Laplace transform of the transfer function the impulse response?
   f. How do you find the impulse response of a second order system?
   g. What is partial fraction expansion?
   h. What expression in the Laplace domain maps to an exponential in the time domain?
   i. How does the damping ratio affect the impulse response?
   j. What is the frequency response of an underdamped beam?
   k. What are some positive uses of resonance, and why can resonance be a negative thing?

6. Lecture – Stability and PD control
   a. Why does the transfer function, and more specifically the poles of the transfer function, determine stability?

   b. What can you say about the way a system responds from where its poles lie in the complex plane?
   c. Why do you need damping in a position controller for a mass?
   d. What is a PD controller?
   e. What are the closed loop dynamics of a PD position controlled mass?
   f. What is the step response of a PD position controlled mass and how does it vary with damping ratio?
   g. Among systems responding without overshoot, what level of damping results in the fastest response?
   h. Why do underdamped systems get close to the final value more rapidly than critically damped systems?
   i. What is a 5% settling criterion?
   j. How can you design PD controller gains given constraints on the settling time and overshoot of the step response?

7. Lecture – Proof of sine wave in -> sine wave out
   a. What is a linear system?
   b. How can you prove that a linear system has the property: sine wave in -> sine wave out at same frequency, scaled by magnitude of transfer function evaluated at s = jw, and phase shifted.

8. Lecture – Systems with two modes of vibration/vibration isolation
   a. What are the equations of motion and transfer function for two coupled beams
   b. How do you use matrix algebra to solve these equations?
   c. How does the math predict a vibration isolation phenomenon?
   d. How does the math predict two modes of vibration?