

MAE106 Midterm #1

Scope

University of California, Irvine
Department of Mechanical and Aerospace Engineering

The goal of Midterm #1 is to test your individual knowledge about the theoretical and practical knowledge of weeks 1 to 3. The topics that will be testing include:

LABS

1. Lab 1
 - a. What is the role of the oscilloscope and function generator in creating and debugging circuits?
 - b. Understand the equation and properties of a simple wave (i.e $v(t) = v_{offset} + A\sin(\omega t)$)
 - c. Understand the built-in functions that we used to program the microcontroller.
 - d. What is the Serial Monitor? How can we use it to debug an Arduino program?
2. Lab 2
 - a. How does a data acquisition system work?
 - b. Understand why we need analog-to-digital and digital-to-analog conversion.
 - c. How do Arduino-type microcontrollers generate analog outputs?
 - d. Understand the behavior of first-order systems in the time and frequency domains (i.e. RC circuit).
 - e. How can an RC circuit act as a low-pass filter?
 - f. What is the behavior of a low-pass filter on the time domain? Make sure that you understand the differential equation that relates the output of an RC low-pass filter to its input.
 - g. How does the time constant of an RC filter (or other first-order systems) help us characterize the behavior of such system?
 - h. How do the terms pulse duration, period duration, and duty cycle help us characterize a PWM signal?
 - i. Understand the relation between the input and output of the digital filter used in Part II of the lab. When are digital filters preferred over analog ones?
3. Lab 3
 - a. Understand the practical issues of using a DC motor (i.e. what happens if you run the motor at a high current for an extended period of time?)
 - b. What is the relation between input voltage and the stall current of the motor?
 - c. What is the purpose of a MOSFET? Why did we use one in lab?

- d. What is the relation between R_{DS} and V_{GS} for the MOSFET used in lab?
- e. How did the MOSFET help us control the motor?
- f. Why did the motor spin constantly even though we were sending PWM signal as input?

LECTURES

Review of circuits

1. Understand the concepts of current, voltage, resistance, conductance, power, and energy.
2. Know how to add resistors in series and in parallel.
3. Know how to use Ohm's law to compute the voltage, resistance, or current of a circuit or an electrical component.
4. Know how to use Kirchhoff's circuit laws:
 - a. KCL: The sum of currents coming into a node equal the sum of currents coming out of a node.

$$\sum_{k=1}^n I_k = 0$$
 - b. KVL: The sum of voltages around a closed network is zero.

$$\sum_{k=1}^n V_k = 0$$
5. Know how to use the voltage divider equation. How does this apply to a potentiometer?

DC motors

1. What is the relation between input current and torque?
2. What is the relation between input voltage and velocity?
3. Understand the mathematical model of a DC motor as it pertains to:
 - a. The time-response of the stall torque
 - b. The time-response of the no-load velocity
 - c. What does the time constant tell us about the time-evolution of these responses?
4. Understand the relation between torque and speed of a DC motor

Responses in the time and frequency domains

1. What do an impulse, step, and ramp inputs look like in the time domain?
2. What is a transfer function?
 - a. What is the relation between an ODE and a transfer function?
 - b. How does a transfer function relate the output(s) to the input(s) of a dynamic system?
3. Be comfortable using the Laplace transform the Laplace to transform from the time domain to the frequency domain and back to the time domain.

Filters

1. Understand the plots in the frequency domain of the four filters we have discussed: low-pass filter, high-pass filter, band-pass filter, notch filter.
2. Understand the gain vs. frequency plot for a low-pass filter.

Basic control concepts

1. Given the block diagram of a system, be able to identify the input(s), plant, and output.
2. Given a block diagram, understand what how the output of a gain or summer block relates to its input(s).

Make sure you have a good understanding of the units used throughout the lab and that you are comfortable converting from one set of units to another.

You may also be asked to interpret specific plots and be able to extract data/parameters/values from the plots.