

## Thoughts about the ENGR-325 midterm

Topics covered in our reading, homework, or lab work from which exam questions may come include:

Chapter 1; 1.4 where terms such as the following are discussed. Knowing these will help if they are encountered on the exam:

calibration, static sensitivity (often just referred to as sensitivity), range and span (likely to be seen), resolution (likely to be seen), accuracy, error, random (bias) error, systematic (precision) error, uncertainty (for sure).

Note the common elements (types) of instrument error in Figure 1.12

Chapter 5; 5.3 discusses design stage uncertainty, i.e. considers what they call zero-order uncertainty which, at a minimum, is related to the instrument resolution (i.e. interpolation error or what can be reading resolution) plus the instrument uncertainty (typically stated by the manufacture's specifications for the measurement instrument). As shown in equation 5.3 the RMS method of combining this is typically used since the uncertainties are likely not correlated. A worst case combining would be to simply add the uncertainties. In problems 3 and 5 of HW#2 instrument uncertainty and uncertainty of reading the instrument were combined in an RMS way (several of you forgot about the zero-order uncertainty of reading the instrument). Examples 5.1 and 5.2 are useful.

We spent time in class looking at hw#2 problem 4 which illustrates dealing with finding uncertainty introduced by random error when multiple measurements are made. Knowing uncertainty of individual measurements we found the combined uncertainty of a quantity derived from those measurements. Section 5.6 covered this and also the "handout" I posted on the class web page. Highly likely to appear on the exam.

While on the topic of errors and uncertainty, chapter 7 section 7.5 on voltage measurements defines A/D converter resolution, quantization error, saturation error, and conversion error. Problems 1, 3, and 4 of HW#3 touched on some of this (I will not ask you to work through a sequence of guesses like that in problem 2 for a successive approximation A/D). However, you should recognize that it takes time for a conversion and that how long it takes to do one conversion limits the sample rate of a converter. Given the range or span of a converter and the number of bits be able to determine its voltage resolution. Or conversely, if a certain voltage resolution is needed determine how many bits the converter needs. Pretty certain a question along these lines will hatch.

Related to the A/D is determining how fast and long to sample to obtain data that can be transformed to find constituent frequencies using the fourier transform. Chapter 7 section 7.2 is the relevant reference with theoretical background coming from chapter 2 sections 2.3 & 2.4. On this exam I will focus on the applied aspect, i.e. how fast to sample as related to frequencies in the signal (Nyquist frequency and Nyquist sampling rate are terms you should know) and how to obtain desired frequency resolution. What determines the frequency scale on a spectral plot (i.e. the stem plots we created in lab) Also the problem of "leakage".

Turning to electrical details and concepts, ohms law will go a long way here. Know it. In the first lecture or two, and lab 1, the concept of loading was covered. Chapter 6, section 6.5 covers that. Also, HW#1 problems 2 and 5 covered loading. Expect a question on loading.

Regarding amplifiers, there is the concept of the ideal OpAmp (no input current and thus infinite input impedance, very large gain and thus zero voltage difference between the - and + input terminals, and the ability to supply as much output current as needed). There are modern opamps which approximate the ideal and thus making the ideal assumptions is ok for this class. Know how to use a few resistors and an OpAmp to create a useful non-inverting or an inverting amplifier. In addition to section 6.6 in the textbook I posted notes on op-amp circuits.

While I don't expect you to know the internal circuit topology for an instrumentation amplifier (an instrumentation amplifier is a difference amplifier that can be used to amplify or measure the difference in voltage between two points), we showed in lab how it could be used with proper wiring to avoid noise caused by ground currents. Reference material includes section 6.9 in the text and a set of notes I handed out (and posted for those who didn't get them) on amplifiers and how to hook up sensors to avoid noise due to "ground loops".

Regarding temperature measurement, in lab we used a thermistor and several thermocouples as well as working a couple problems in homework, thereby "scratching the surface" of understanding them. There could be a problem based on the work you have done. Chapter 8 contains details. Homework and class have not delved deeply into the theory so any question would be application oriented.