ECE 3704: Course Introduction

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July 8, 2014

Welcome to ECE 3704 for Summer Session II, 2014. After some introductions, this first class meeting will be split into two parts. The first part will cover the course content, the second will cover the course administration.

Course Content

This course is a continuation of the material from ECE 2704 (Signals and Systems). Approximately a quarter of the course relates to continuous-time, linear, time-invariant (CTLTI) systems and thus is an extension of 2704. The remaining three-quarters of the course is a discrete-time parallel to 2704. The counterpart of differential equations in discrete-time are difference equations, the Laplace Transform becomes the z-Transform, the Fourier Series becomes the Discrete Fourier Series, and the Fourier Transform becomes the Discrete Fourier Transform. Along the way we will see connections between the continuous and discrete-time formulations of systems. As in 2704, applications of the discrete-time methods will include filtering and control.

Just as in ECE 2704, this course boils down to studying

\[ y(t) = T[x(t)] \]

where \( x(t) \) is the input to the system \( T \), which transforms it into the output \( y(t) \) (Fig. 1). However, we now consider the case where the signal is sampled at discrete intervals of time as required for computer-based processing, i.e. where \( T \) is a finite state or Turing machine.

The formal learning objectives for the course are (in bold):

a. **Describe complex systems with the use of block diagrams and signal flow graphs.** These graphical methods of system representation help us visualize the flow of information in a system. They also help isolate subsystems at different levels of detail, for example the mechanical model versus the circuit model in an electro-mechanical system (e.g. a servo).

b. **Analyze the performance and stability of interconnected linear systems, including feedback systems.** Stability is a central concept in signal processing because any practical system must be
stable. Stability is also an important goal in most controls systems. Fourier analysis cannot be applied to unstable systems.

c. **Construct Bode plots for systems and interpret these plots to predict system responses.** These are logarithmic plots of the system frequency response with magnitude in decibels and angle in degrees. This specific choice of coordinates simplifies the use of frequency plot for analysis and system identification.

d. **Solve difference equations by using Z-transforms.** Difference equations are the discrete-time equivalent of differential equations in continuous-time. They arise from modeling of inherently discrete events (e.g.) or through discretization of a differential equation. More importantly they are a convenient method for describing the implementation of a system (e.g. filters) as state-machines. This is the basis of digital signal processing.

e. **Analyze discrete-time systems with Z-transforms and transfer functions.** The z-transform is the analog of the Laplace transform for continuous-time systems and plays a similar role in analysis and design of discrete signals and systems.

f. **Sample continuous-time systems to create a discrete-time system model.** This is the link between the discrete and continuous systems. Real systems often have both continuous and discrete components, for example computer processing of signals such as audio or control such as in robotics.

g. **Compute discrete-time Fourier transforms and use fast Fourier transforms.** This is the discrete-time analog of Fourier analysis in continuous-time systems and plays a similar role in analysis, such as steady state response. It is also the primary means to measure the frequency response of continuous-time signals, through sampling and discrete Fourier analysis. As such we will see intimate connections between continuous and discrete frequency domain concepts.

If you and I have done our jobs, then everyone should have mastered each of these abilities by the end of the summer.

**Prerequisites**

As in 2704, we use the tools of calculus and differential equations heavily. You should be comfortable with complex numbers. Since we use many examples from linear circuits you also need a good background in passive networks as well as first and second order circuits. We will be using Matlab in the course for some basic computation, you should be able to analyze a circuit including resistors, inductors, capacitors, and op-amps.
plotting, and in-class examples, so I will assume you can write and run basic Matlab scripts and navigate the user interface.

You should be familiar with the concepts of continuous linear systems from 2704, including convolution, Laplace, and Fourier. Problem Set 0 will help you review this material.

Course Administration and Pedagogy

This course is highly structured. Each class meeting is designed so that you leave knowing how to do something new (and you know what that something is). I assume you have completed the assigned reading for each class meeting and only give a brief overview of the material for that day. The majority of the class time is spent in a "I do, we do, you do" cycle, where the latter occurs in the problem sets. Since this is a summer course, the content moves fast and furious. Each week is equivalent to 2.5 weeks in a regular semester. For this reason, no late assignments will be accepted. It is important that you keep up with readings and problem sets. The schedule of topics and readings is posted on the course website and updated regularly, so you always know what you are responsible for.

The majority of your learning will be driven by the problem sets. Only selected problems are graded, but solutions are provided. You are encouraged to work in groups (3 is optimal) on the problem sets, however each person should write up and submit their own solutions. These are due in class on the day we review that material (see the schedule).

The course is divided roughly into four parts with a corresponding problem set and quiz. The final exam is split into the same four parts, each graded separately. The grade for each part of the course is determined by the completion of the problem sets and the maximum of the quiz and the corresponding part of the final. Thus, you can replace a bad quiz grade with part of the final, and vice-versa.

Finally, see the course website for full policy and administrative details:

https://www.filebox.ece.vt.edu/~ECE3704

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