1 Course Overview

"...we feel that a course in signals and systems not only is an essential element in an engineering program but also can be one of the most rewarding, exciting, and useful courses that engineering students take during their undergraduate education." from *Signals & Systems, 2/E* by A. V. Oppenheim and A. S. Willsky.

"Learn as much as you can. It's hard. It takes work." – Anonymous.

1.1 Course Syllabus

Please see syllabus handout. The syllabus for EE312 Signals and Systems I is also available at:

http://wordpress.nmsu.edu/pdeleon/teaching/ee312/syllabus

1.2 Course Outline

Please see syllabus handout. The outline for EE312 Signals and Systems I is also available at:

http://wordpress.nmsu.edu/pdeleon/teaching/ee312/outline

2 Lecture Outline

Reading: Chapter 1

- Introduction
- Continuous-time and discrete-time signals

3 Introduction

Definition: A *signal* is a wave that conveys information. The information is contained in a pattern of variations of some form.

Demos

4 Continuous-Time and Discrete-Time Signals

Here are a few preliminary things you should start thinking about.

- In this course, we will develop powerful mathematical tools to analyze signals in terms of *frequencies*. Formally, this is known as Fourier analysis or frequency-domain analysis or more generally, harmonic analysis.
- Signals can be continuous in time or *continuous-time* (CT) a.k.a. *analog*. This is to say that the signal is a function of a *continuous* variable where at all points in time t, there is a value $x(t)$. The independent variable, t is always a real number. Examples include acoustic waves coming from a piano or radio waves radiating from an antenna.

- Signals can be discrete in time or *discrete-time* (DT) a.k.a. *digital*. This is to say that the signal is a function of a *discrete* variable where at all time instants n, there is a value $x[n]$. The independent variable, n is always an integer and denotes specific points in time, i.e. first time instant, second time instant, third time instant, ..., nth time instant. Examples include hourly temperature data i.e. temperature at hour one, hour two, hour three, ... or stock market data i.e. DJIA at the close on day 1, day 2, day 3, ... The use of brackets indicates that $x[n]$ is a list or array or sequence of signal data indexed by an integer. A DT signal is defined *only* for integer values of the independent variable.

Figure 1: Text Figure 1.7

- Signals may originate as continuous-time but processed in a discrete-time fashion through a process known as *sampling* or *digitizing*. In sampling, we make periodic voltage measurements of the electrical signal. Sampling makes possible digital audio, digital cameras, digital video, cellular telephone, HDTV, satellite imagery, etc. Rather than processing continuous-time signals with analog electronics, discrete-time (digital) signals are processed by computer chips.

Definition: A *system* transforms an input signal into an output signal.

Demos

There are a variety of important problems and questions that arise in signals and system analysis. These include:

- Characterization of a specific system in order to understand how it will respond to various inputs. Examples include analysis of a circuit in response to different voltage and current sources and the determination of an aircraft's response characteristics to pilot commands and to wind gusts.
- Design of a system in order to process signals in a particular way. Examples include frequency-selective filtering and signal enhancement, i.e. removing noise from an audio signal.
- Design of a system in order to extract specific pieces of information from signals. Examples include estimation of heart rate from an electrocardiogram or trend estimation in economic data.
- Design of a signal with certain desirable characteristics. Examples include radar and communications signals which must operate at certain frequencies and be robust against noise and multipath.
- Modification or control of a system through choice of specific signals. Examples include the use of sensors to regulate chemical processing plants. The control system adjusts flow rate depending on temperature data. Also, autopilot systems that control flying surfaces in response to sensor readings such as aircraft speed, altitude, and bearing. Here feedback plays an important role in the control process.

Any study of signals and systems is a large undertaking. To reduce the scope, we focus on a class of systems known as *linear, time-invariant* (LTI) *systems*. LTI systems have a remarkable set of properties and can be analyzed with a powerful set of tools. LTI systems are of major practical importance.