

Texas A & M University
Department of Mechanical Engineering
MEEN 651 Control System Design

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Lecture 1A: Introduction to Signals and Systems

The objective of this lecture is to introduce you to the various concept regarding signals and systems. Furthermore, the widely used representation of signals and systems are introduced and the mathematical tools needed for their treatment are mentioned.

Definitions of Signals and Systems

Signals and systems arise in many different areas of science and engineering, such as aeronautics and astronautics, electrical circuit design, automobiles, energy systems, process control, speech processing, etc. Though the physical nature of the underlying signals and systems might be different, they have two very basic features in common. The signals we are referring to are functions of one or more independent variable, such as time and space¹, and they typically contain or carry information about the underlying natural phenomena they represent. For example, an acoustic sound signal consists of pressure variations propagating through air that carry information about the music being played. The systems, on the other hand, we are interested respond to particular signals (the input signals) by producing other signals (output signals). Voltages and currents as a function of time in an electrical circuit are examples of signals, whereas the circuit itself is an example of a system.

Representations of Signals and Systems

In general, there are two frameworks for signal and system analysis, one for phenomena that are described in *continuous time* and one for those described in *discrete time*. Occasionally, phenomena in the continuous time are dealt with either in continuous or discrete time. All physical phenomena can be described using continuous time (or analog) signals.

¹In this course, we will primarily deal with signals that are only functions of time.

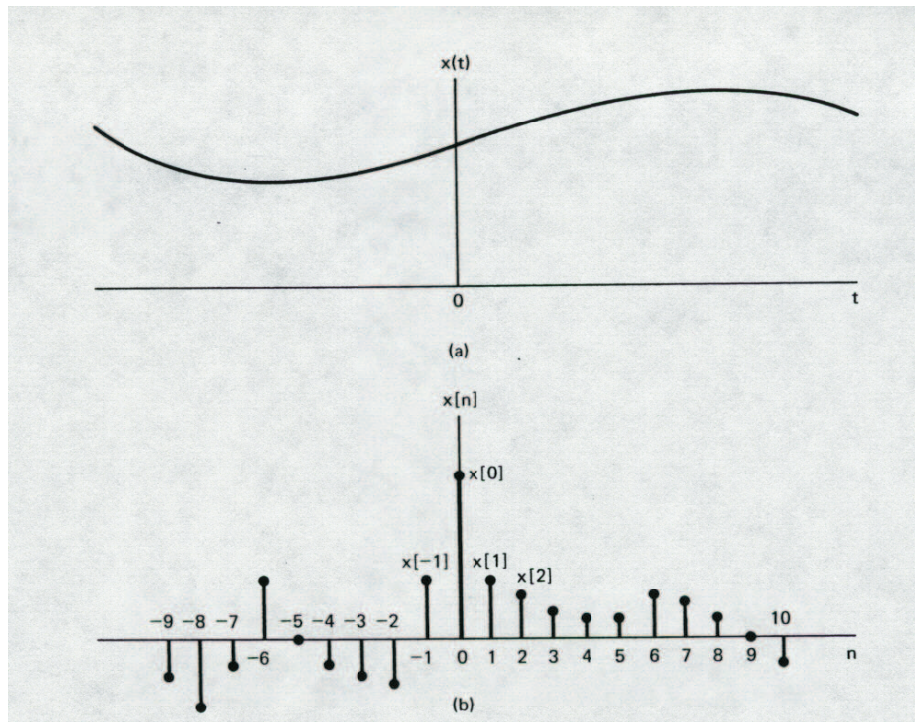


Figure 1: Graphical representation of (a) continuous time and (b) discrete time signals.

In the case of continuous time signals the independent variable is continuous, and thus these signals are defined for a continuum of values of the independent variable. On the other hand, discrete time signals are only defined at discrete times, and consequently for these signals the independent variable takes on only a discrete set of values. An example of a continuous and a discrete time signal is shown in Figure 1.

Similarly to signals, systems can also be classified as continuous time or discrete time. A continuous time system transforms a continuous time input signal into a continuous time output signal. Similarly, a discrete time signal transforms a discrete time input signal into a discrete time output signal. A schematic representation of continuous time and discrete time systems is shown in Figure 2.

Use of Mathematical Transforms in Dealing with Signals and Systems

In dealing with the analysis of signals and systems we use various mathematical tools. In particular, we use differential equations and their discrete counterparts, difference equations, extensively. We will do so in this course, especially when we model various dynamic systems.

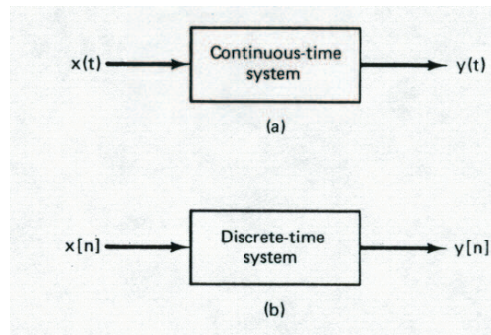


Figure 2: (a) continuous time systems and (b) discrete time system.

Table 1: Use of Transforms in Signals and Systems

	Continuous time	Discrete time
Steady-state Behavior	Continuous Fourier Transform	Discrete Fourier Transform
Transient Behavior	Laplace Transform	z -Transform

One particular class of mathematical tools that is very useful in the analysis of dynamic signals and systems is the various mathematical transforms. Two particular transforms deserve our attention and we will spend the next a couple of lectures briefly talking about them; these are the *Fourier transform* (FT) and the *Laplace transform* (LT). The former is primarily used for signals and systems when we are interested to analyze their steady-state behavior. The latter is a generalization of the former and it is used to analyze the transient behavior of signals and systems. Both transforms have continuous time and discrete time equivalents. For the FT, we have a continuous and discrete time formulation, i.e. continuous time FT and discrete time FT (DFT). The LT is used exclusively for continuous time, whereas its discrete time equivalent is called the *z -Transform*. Table 1 summarizes the use of these transforms in the analysis of signals and systems.

Reading Assignment

Read Chapter 1 of the course text by Franklin, Powell and Emami-Naeini, and Handout E.1 with examples on signals and systems posted on the course web page. Furthermore, make sure you download and read handouts M.1 through M.4 on the required math background.