

Signals and Systems

Fall 2003

Lecture #1

Prof. Alan S. Willsky

4 September 2003

- 1) Administrative details
- 2) Signals
- 3) Systems
- 4) For examples ...

“Figures and images used in these lecture notes by permission, copyright 1997 by Alan V. Oppenheim and Alan S. Willsky”

SIGNALS

Signals are functions of independent variables that carry information. For example:

- Electrical signals --- voltages and currents in a circuit
 - Acoustic signals --- audio or speech signals (analog or digital)
 - Video signals --- intensity variations in an image (e.g. a CAT scan)
 - Biological signals --- sequence of bases in a gene
- ⋮

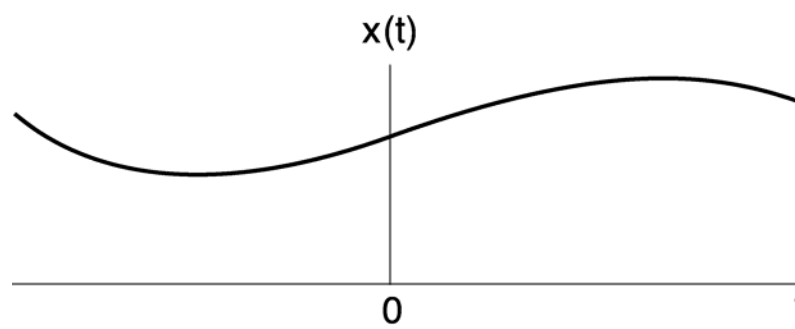
THE INDEPENDENT VARIABLES

- Can be continuous
 - Trajectory of a space shuttle
 - Mass density in a cross-section of a brain
- Can be discrete
 - DNA base sequence
 - Digital image pixels
- Can be 1-D, 2-D, ••• N-D
- For this course: Focus on a single (1-D) independent variable which we call “time”.

Continuous-Time (CT) signals: $x(t)$, t — continuous values

Discrete-Time (DT) signals: $x[n]$, n — integer values only

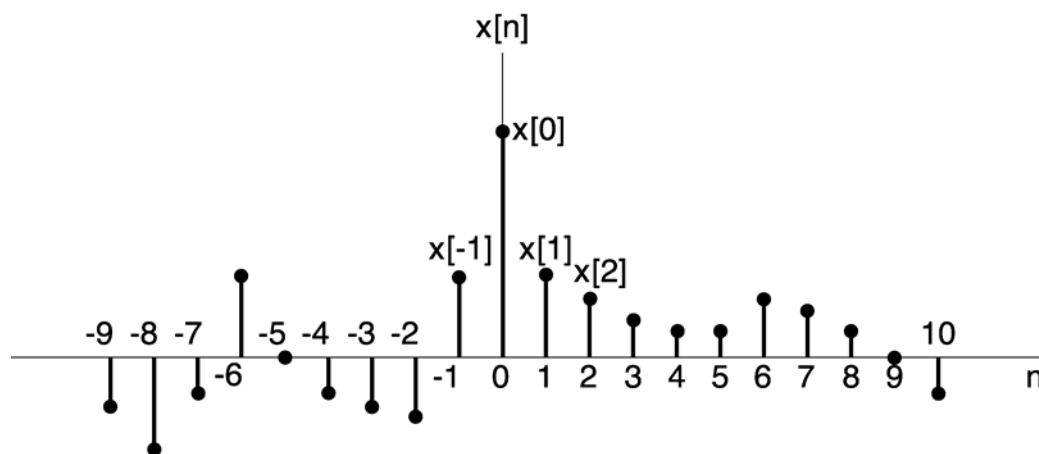
CT Signals



- Most of the signals in the physical world are CT signals—E.g. voltage & current, pressure, temperature, velocity, etc.

DT Signals

- $x[n]$, n — integer, time varies discretely



- Examples of DT signals in nature:
 - DNA base sequence
 - Population of the n th generation of certain species
 - ⋮

Many human-made DT Signals

Ex.#1 Weekly Dow-Jones industrial average



Ex.#2 digital image



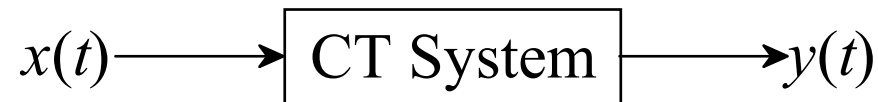
Courtesy of Jason Oppenheim.
Used with permission.

Why DT? — Can be processed by modern digital computers and digital signal processors (DSPs).

SYSTEMS

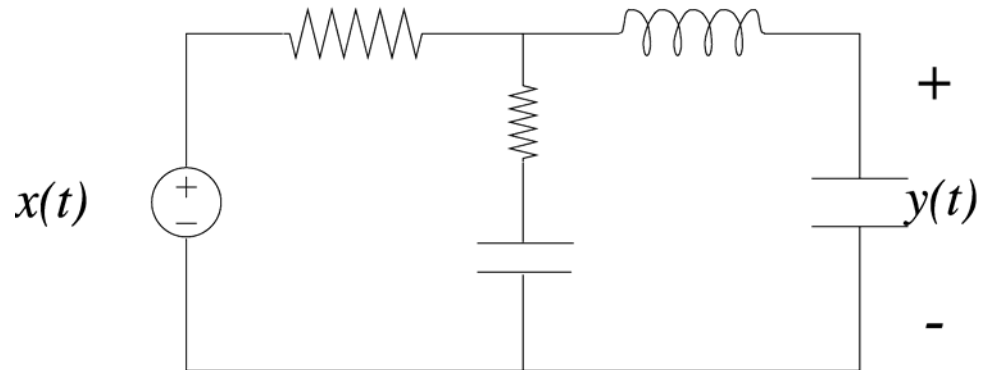
For the most part, our view of systems will be from an input-output perspective:

A system responds to applied input signals, and its response is described in terms of one or more output signals



EXAMPLES OF SYSTEMS

- An RLC circuit



- Dynamics of an aircraft or space vehicle
- An algorithm for analyzing financial and economic factors to predict bond prices
- An algorithm for post-flight analysis of a space launch
- An edge detection algorithm for medical images

⋮

SYSTEM INTERCONNECTIONS

- An important concept is that of interconnecting systems
 - To build more complex systems by interconnecting simpler subsystems
 - To modify response of a system
- Signal flow (Block) diagram

