Introduction to Signals and Systems

Lecture #1

Chapter 1

What Is this Course All About ?

- To Gain an Appreciation of the Various Types of Signals and Systems
- To Analyze The Various Types of Systems
- To Learn the Skills and Tools needed to Perform These Analyses.
- To Understand How Computers Process Signals and Systems

What are Signals?

- A Signal is a term used to denote the information carrying property being transmitted to or from an entity such as a device, instrument, or physiological source
- Examples:
  - Radio and Television Signals
  - Telecommunications and Computer Signals
  - Biomedical Engineering Signals

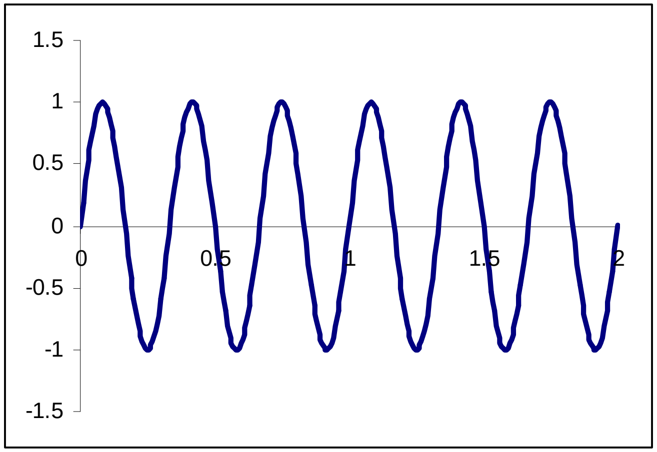
What is a System?

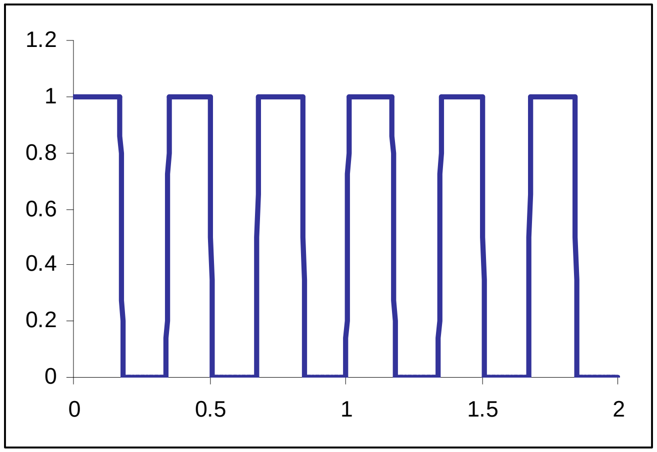
- A System is a term used to denote an entity that processes or operates on Signal(s) to transform one signal to another
  - Manipulate
  - Change
  - Record
  - Transmit
- A System has inputs and outputs
- Examples
  - Amplifiers, Radios, Televisions
  - Telephone, Modem, Computer
  - Oscilloscopes, ECG, EEG, EMG

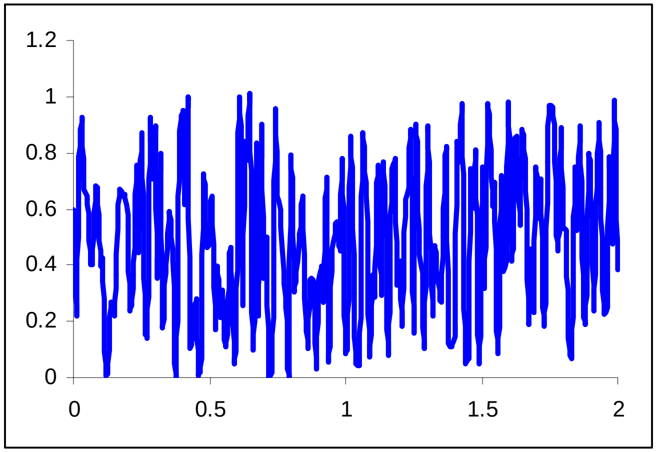
How do we describe Signals?

- Signals are associated with an independent variable(s): e.g., time, single or multivariate spatial coordinate
  - Most instrumentation signals have time as their independent variable
  - A digital photograph or image has spatial coordinates as its independent variables
- We can also represent a Signal by a waveform
- Signal Independent Variables can be either Continuous (also called Analog) or Discrete

Continuous-Time Signals

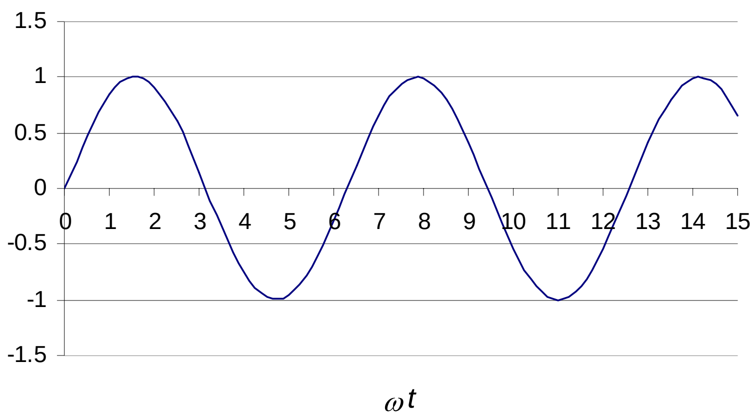


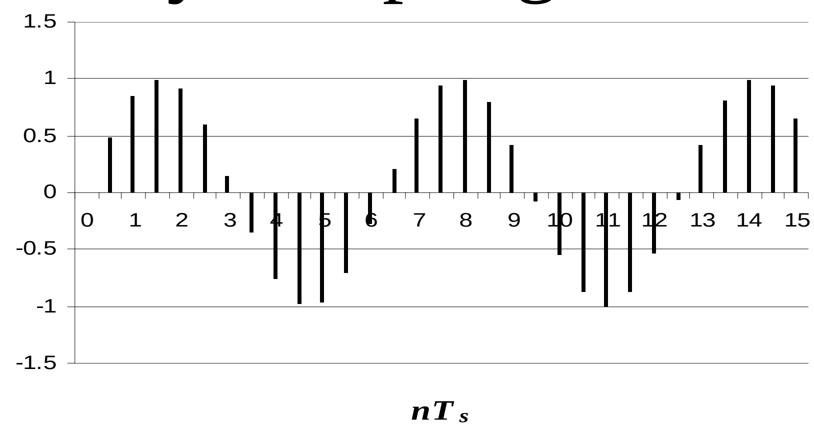




Discrete-Time Signals

A Discrete-Time Signal can be obtained from a Continuous-Time signal by Sampling.





Continuous-Time Signal

$$x(t) = \sin(\omega t)$$

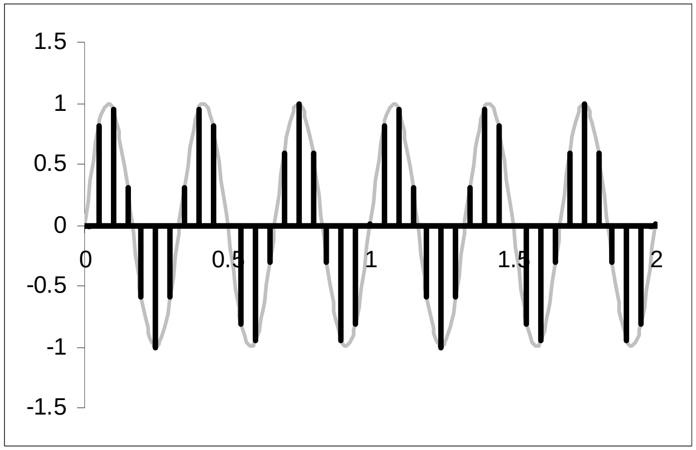
Discrete-Time Signal

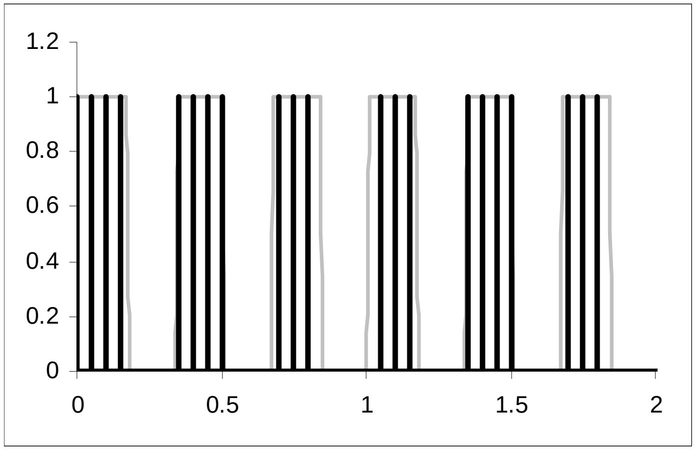
$$x(t \Rightarrow nT_s) \Rightarrow x(nT_s) = x[n] = \sin\ (\omega nT_s)$$

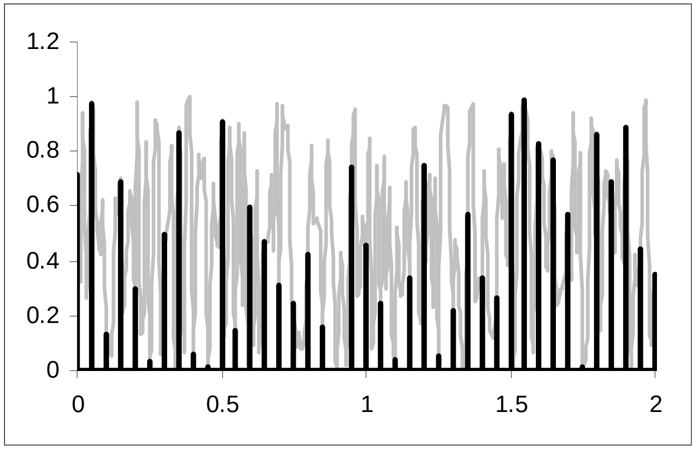
where n is an integer: $N_1 < n < N_2$

and T_s is the sampling period

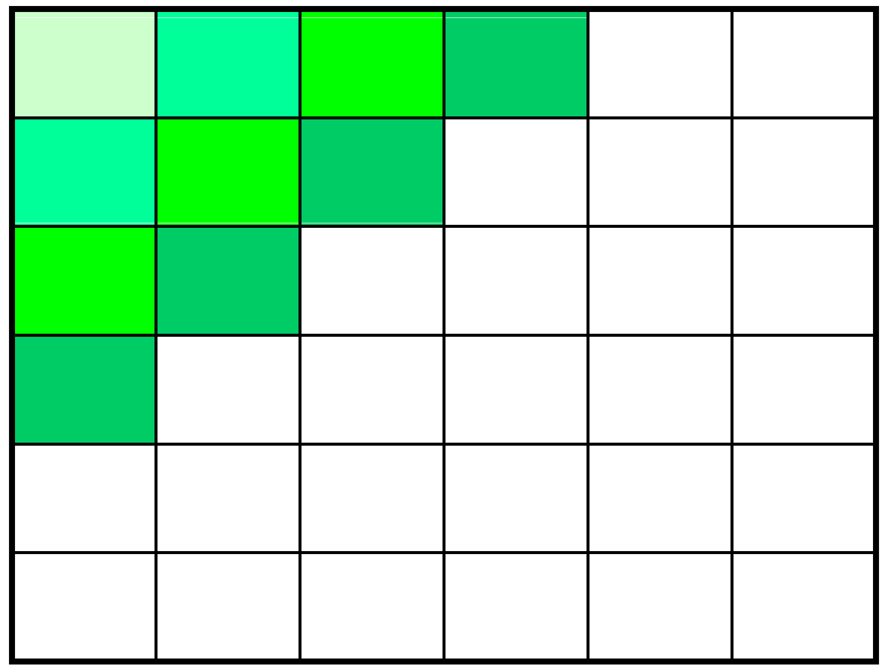
Discrete Time Signals







Discrete-Spatial Signal



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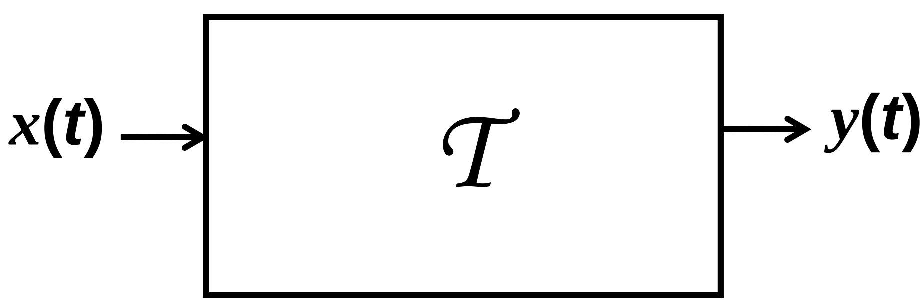
Representation of a System

- How do represent a system mathematically?
  - Since a system transforms a signal into another we write:

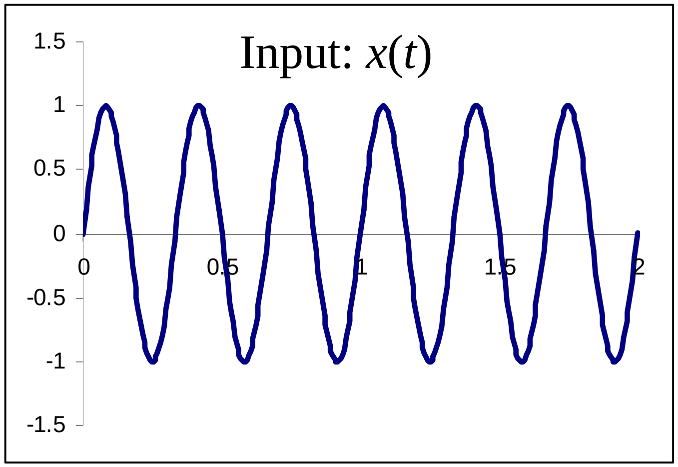
$$y(t)=\mathcal{T}\{x(t)\}$$

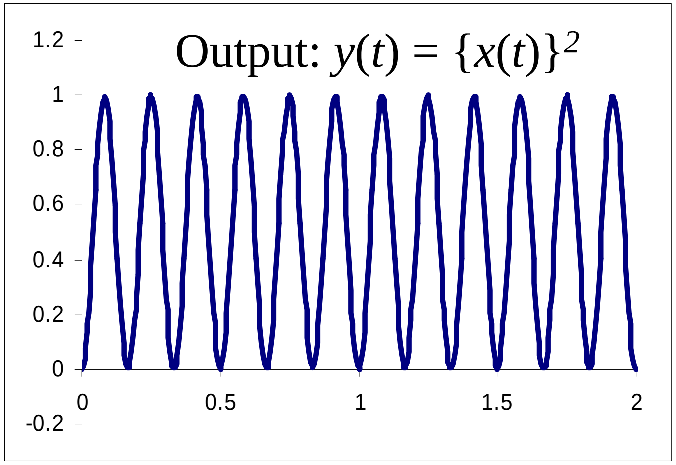
  - where $\mathcal{T}$ is an operator to symbolize a system,
  - $x(t)$ is the signal that goes into the system: input signal
  - And $y(t)$ is transformed signal or output signal
- We can also represent it by a flow diagram



Example of a Continuous-Time System

- A squarer system: $y(t)=\{x(t)\}^2$
  - The output equals the square of the input.
  - This is the result of putting the sine wave into the squarer





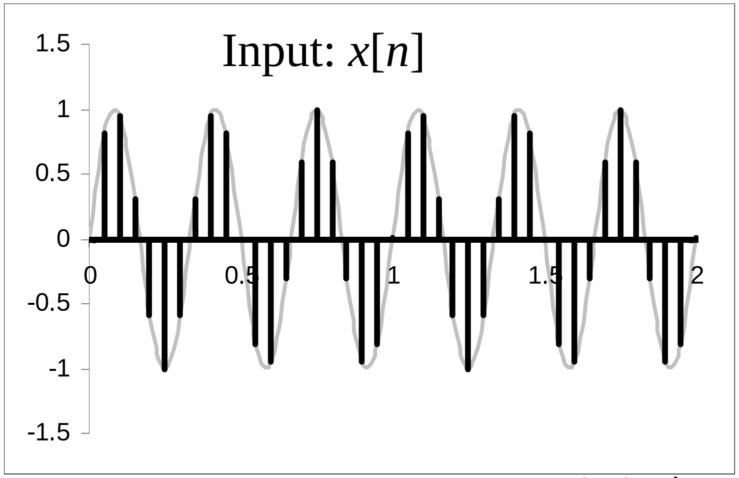
- This is an example of a continuous-time system
- We might be able to build this using an electronic circuit

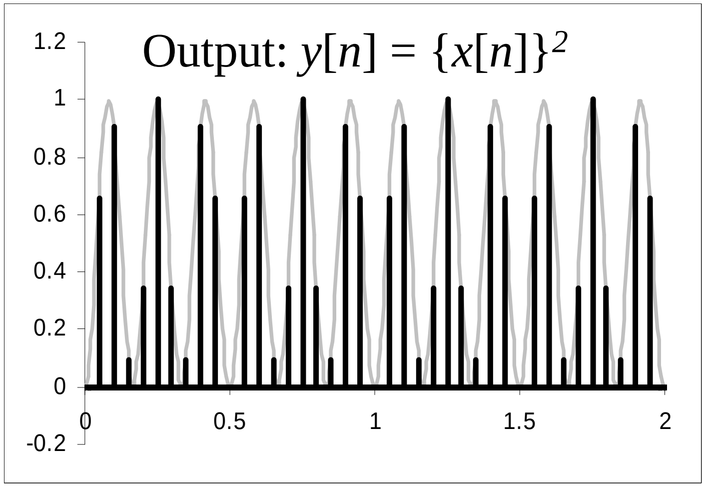
Discrete-Time Systems

- If we put a discrete-time signal into a system the output may be a discrete-time signal
- This is called a Discrete-time system.

$$y[n]=\mathcal{T}\{x[n]\}$$

- Using our squarer example: $y[n]=\{x[n]\}^2$





Mixed Systems

- Continuous-to-Discrete systems

$$y[n] = \mathcal{T}\{x(t)\}$$

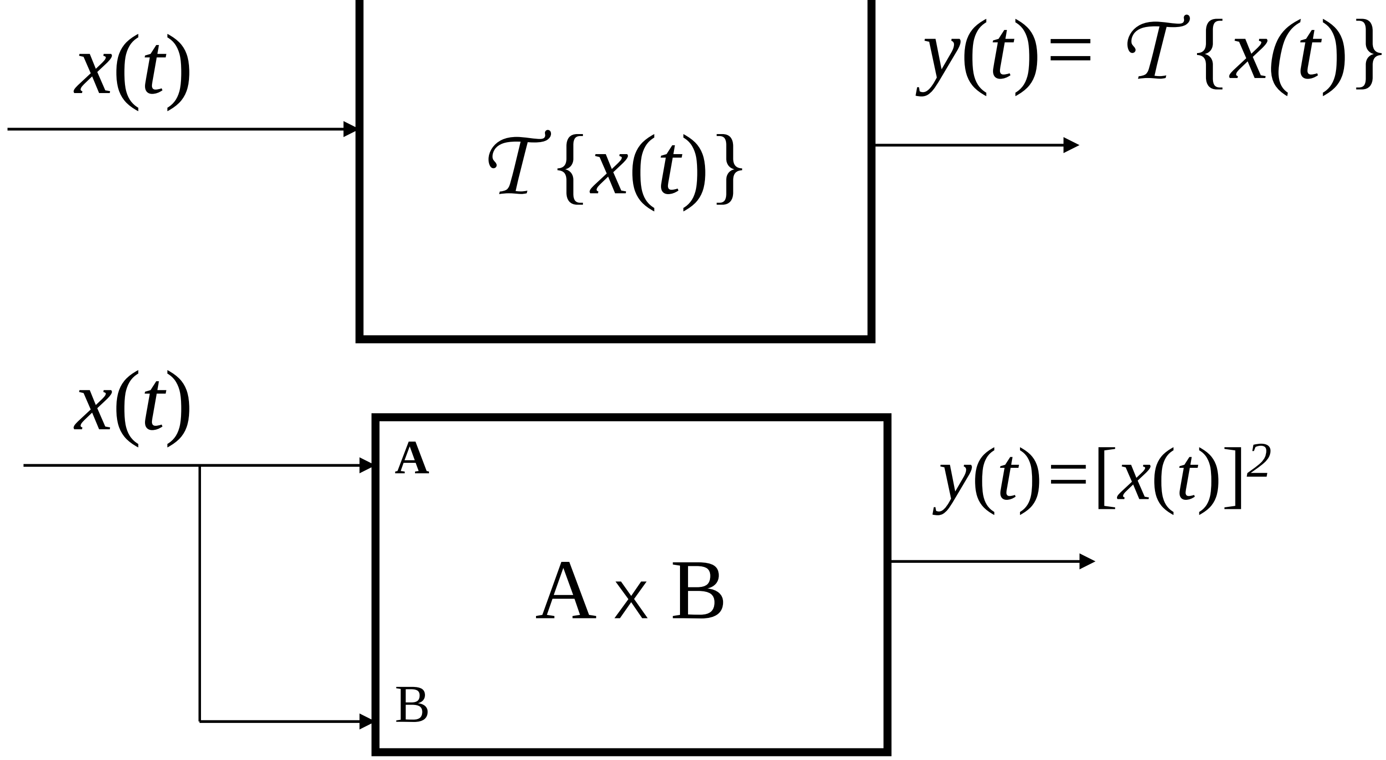
  - Example: a sampler: $y[n]=x(nT_s)$
    - This is also called a A-to-D converter

- Discrete-to-Continuous systems

$$y(t) = \mathcal{T}\{x[n]\}$$

  - Example: An D-to-A converter
    - The opposite of a sampler
    - Takes the samples a recreates the Continuous Signal

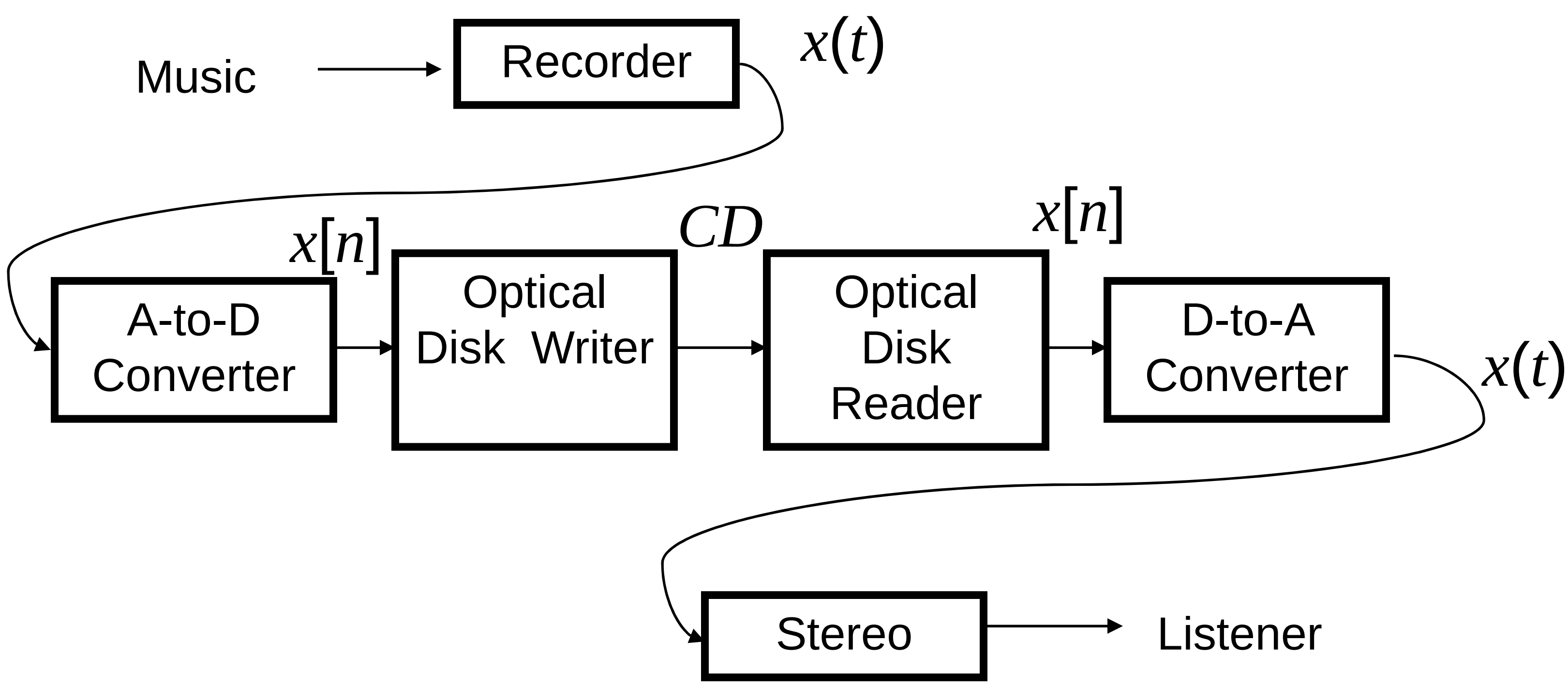
Graphical Representations of a System



Our Squarer Example

An Example

- Example: A music CD



Homework

- Name 5 signals and the systems that process them.
  - Draw the block diagrams to show how the signal gets transformed.
- Choose both Continuous and Discrete signal
- Include some examples from Bio Medical Engineering.