Signal & Systems

Lecture # 1

Introduction

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Course Assessment

- Total assessment 100%
  - Midterm: 30%
  - Final Exam: 50%
  - Internal Evaluation: 20%
- Internal Evaluation 20%
  - Quizzes: 10%
  - Assignments: 10%

Internal Evaluation Details

- Total Quizzes 6
  Best of 5 Quizzes

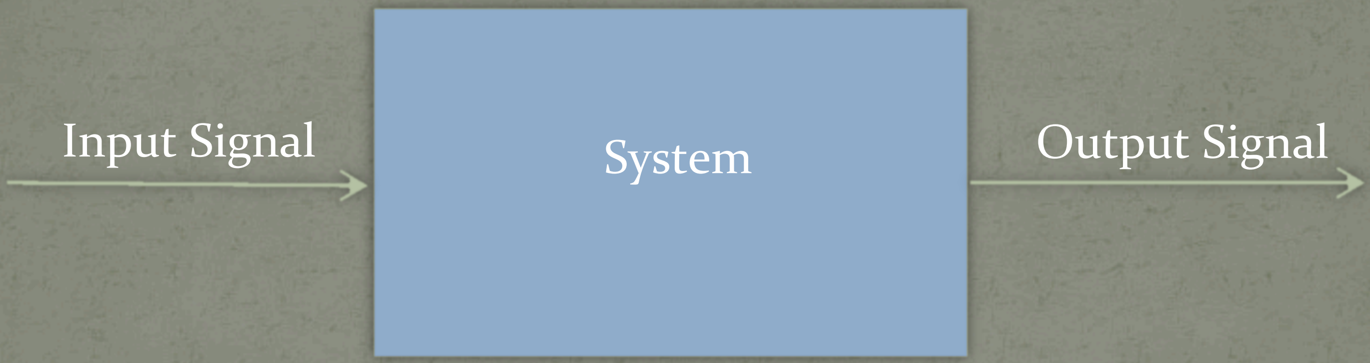
Total Assignments 6
Best of 5 Assignments

Course Book

- Signal & Systems, By Alan V. Oppenheim, Alan S. Willsky with S.Hamid Nawab

Introduction

Signal & System



What is a Signal?

- If a function represents a physical quantity or variable containing information about the behavior and nature of the phenomenon.
- Signals are functions of one or more variables.

Examples of Signals

- Examples of signals include:
  - **A Voltage signal**: voltage across two points varying as a function of time.
  - **A photograph**: color and intensity as a function of 2-dimensional space.
  - **A Video Signal**: color an intensity as a function of 2-dimensional space and time.

What is a System?

- Systems are operator that accept a given signal (the input) and produces a new signal (the output).
- Systems respond to an input signal by producing an output signal.

Examples of Systems

- Examples of system includes:
  - **An Oscilloscope:** takes in a voltage signal, outputs a 2-dimensional image characteristic of the voltage signal.
  - **A computer monitor:** inputs voltage pulses from the CPU and outputs a time varying display.
  - **A capacitance:** terminal voltage signal may be looked at as the input, current signal as the output.

Classifications of Signals

Classification

- Two main broad classification of signals are:
  - Continuous time signal
  - Discrete time signal

Continuous Time Signals

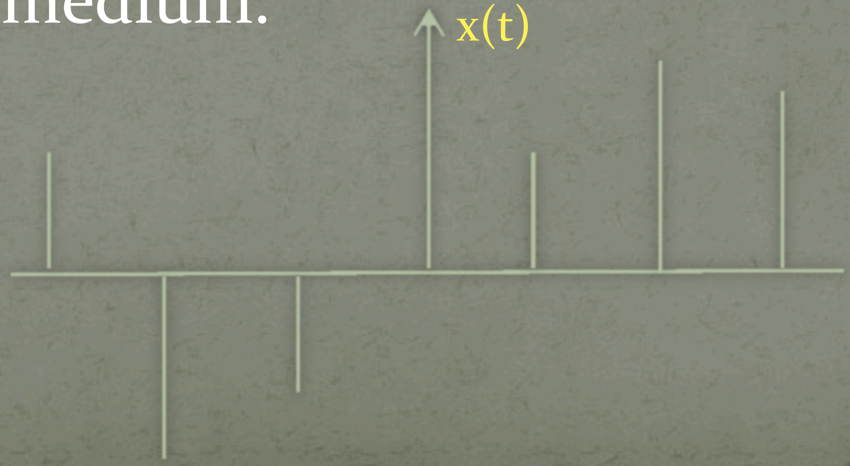
- A signal which is defined for all values of t is known as Continuous time signal.
- A continuous time signal is an infinite and uncountable set of numbers.
- There are infinite possible values from the time t and instantaneous amplitude x(t) between start and end point.

Exponential Function

- This signal is continuous in time as well as in amplitude.

Discrete Time Signals

- A signal which is defined only at distinct intervals of time is known as Discrete time signal.
- In a Discrete time signal the number of elements in the set as well as the possible values of each element is finite and countable.
- It can be represented with computer bits and stored on a digital storage medium.



Basic Operations on Signals

Elementary Operations on Signals

- There are several basic operation by which new signals are formed from given signals:
  - Amplitude Scale: $y(t) = ax(t)$, where a is a real (or possibly complex) constant.
  - Amplitude Shift: $y(t) = x(t) + b$, where b is a real = (or possibly complex) constant
  - Addition: $y(t) = x(t) + z(t)$
  - Multiplication: $y(t) = x(t)z(t)$

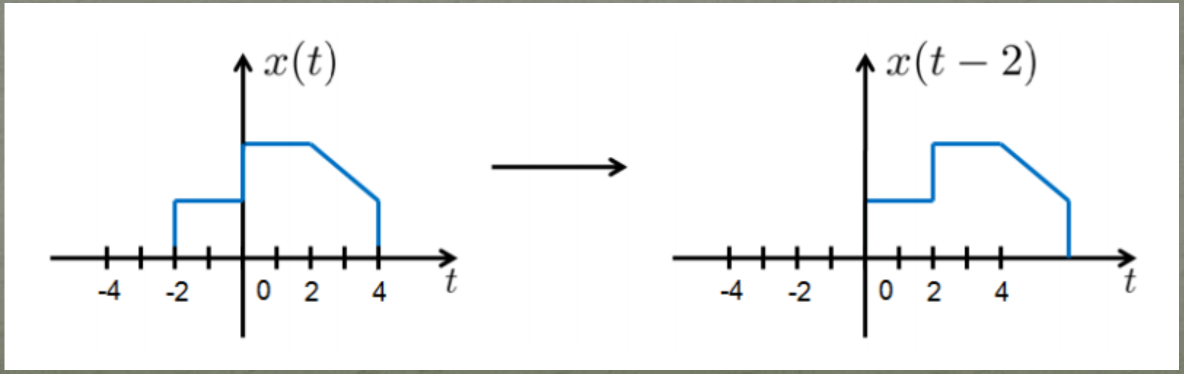
Time Shift

- For any $t_0 \in R$ and $n_0 \in Z$ time shift is an operation defined as:

$$x(t) \rightarrow x(t - t_0)$$

$$x[n] \rightarrow x[n - n_0]$$

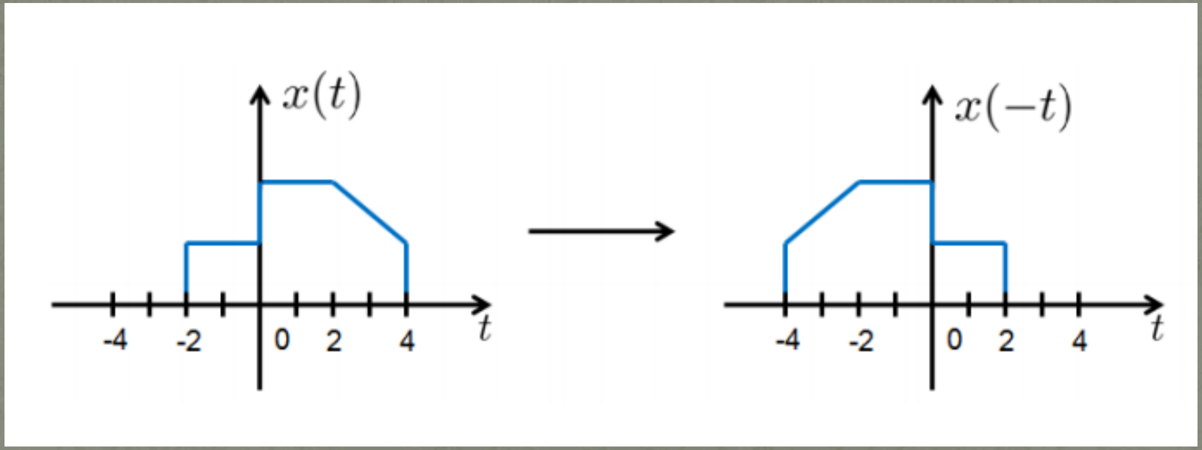
- If $t_0 > 0$, the time shift is known as "delay".
- If $t_0 < 0$, the time shift is known as "advance".
- For example:



Time Reversal

- Time reversal if defined as: $x(t) \rightarrow x(-t)$

  $x[n] \rightarrow x[-n]$
- Which can be interpreted as the “flip over the y-axis”.
- For example:

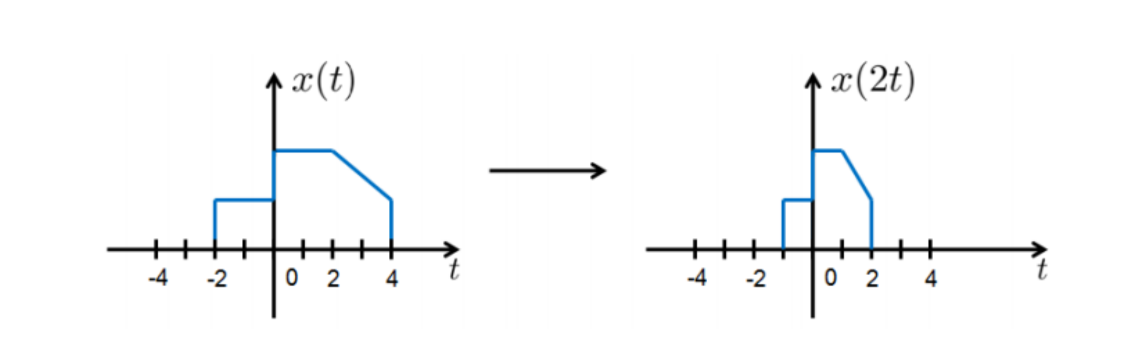


Time Scaling

- Time scaling is the operation where the time variable t is multiplied by a constant a:

$$x(t) \rightarrow x(at), \quad a > 0$$

- If a > 1, the time scale of the resultant signal is "decimated" (speed up).
- If 0 < a < 1, the time scale of the resultant signal is "expanded" (slowed down).
- For example:

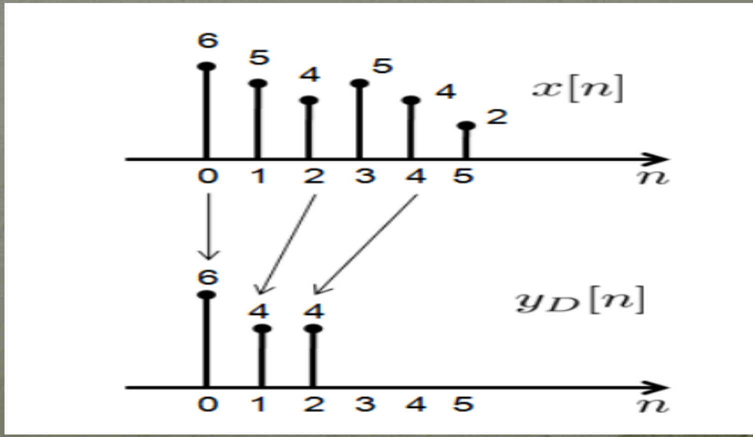


Time Compression

- Time compression is also known as decimation or down sampling.
- When |a|>1, we will have time scaling of discrete signal as time compression.
- For Example: when a=2, then above condition is satisfied.

$$x[n] \to x[2n], \quad |a| > 1$$

  - Signal will compress.

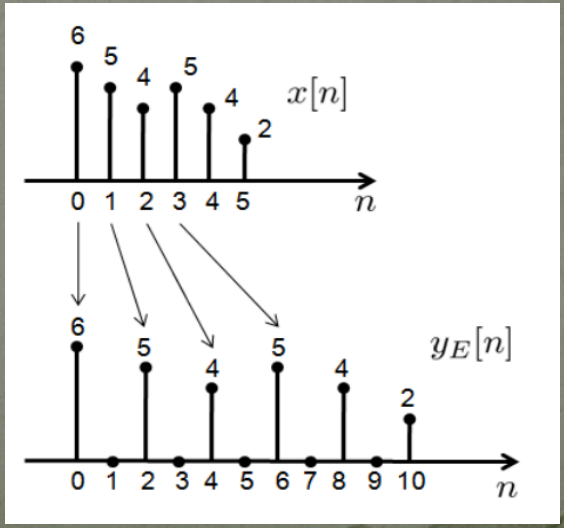


Time Expansion

- Time expansion is also known as interpolation or up sampling.
- Expansion is defined as:

$$y_E[n] = \begin{cases} x\left[\dfrac{n}{L}\right], & n = \text{integer} \quad \text{multiple} \quad \text{of} \quad L \\ 0, & \text{otherwise} \end{cases}$$

- L is called the expansion factor.
- When L=2.



Combination of Operations

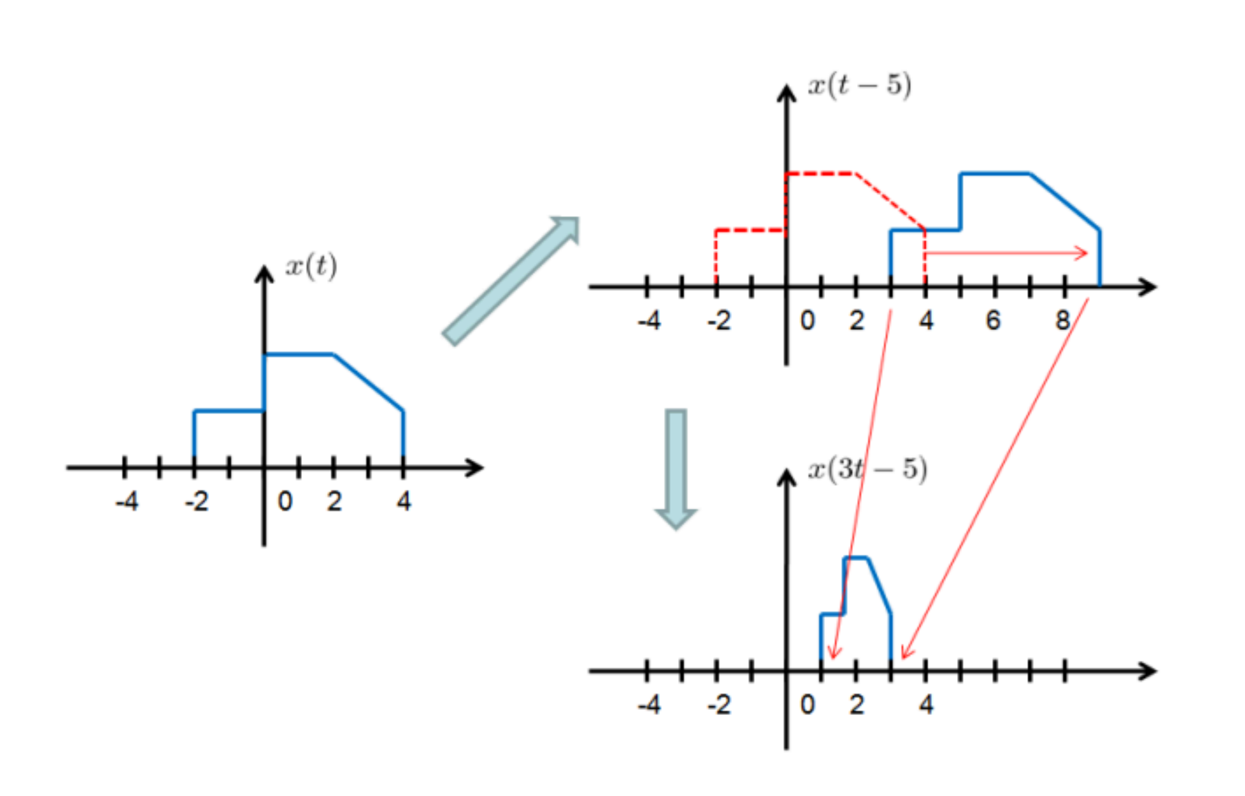
- Linear operation in time on a signal x(t) can be expressed as:

$$y(t)=x(at-b),\quad a,b\in R$$

- There are two methods to describe the output signal:
  - Method A: "shift, then scale"
    - Define v(t)= x(t-b)
    - Define y(t) = v(at) = x(at-b)
  - Method B: "Scale, then shift"
    - Define v(t) = x(at)
    - Define y(t) = x(t-b/a) = x(at-b)

Combination of Operations (cont.)

- Example #1:



Combination of Operations (cont.)

- Example #2:

$$x[n] = \{1, 2, \underset{\uparrow}{3}, 4, 5\}$$

$$\textit{Find} \quad y[n] = x[2n - 1]$$

The End