EEE328
Digital Signal Processing

Ankara University

Faculty of Engineering

Electrical and Electronics Engineering Department

Discrete-Time Signals: Sequences

EEE328 Digital Signal Processing

Lecture 3

Agenda

- Basic Sequences
- Sequence Operations
- Discrete-Time Systems
- Ideal Delay System
- Moving Average Filter
- System Properties

- Basic Sequences

$x=\{x[n]\}, -\infty \leq n \leq \infty$

$x[n]= x_a(nT)$

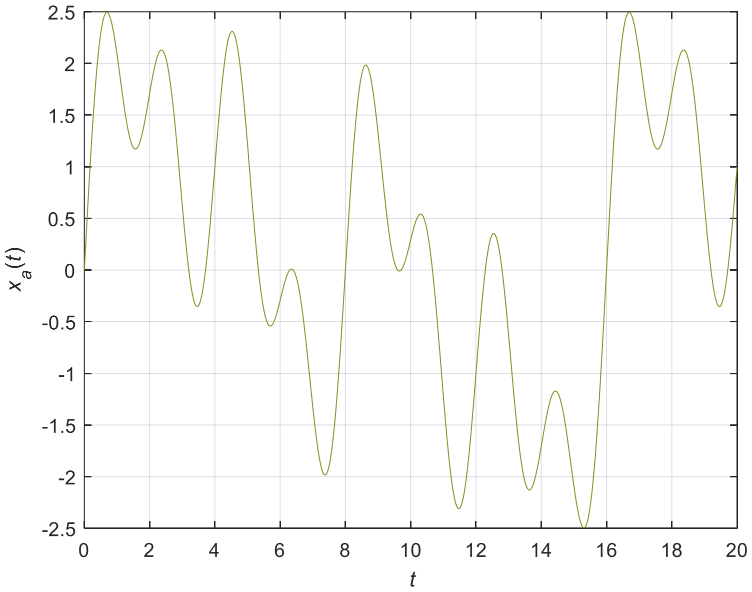
$x[n]$: Discrete-time signal

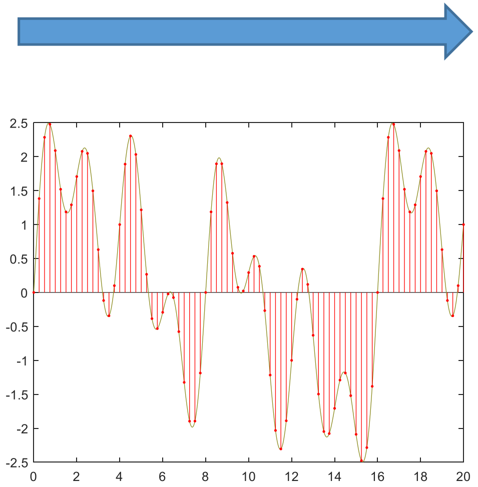
n: Discrete-time independent variable

T: Sampling period

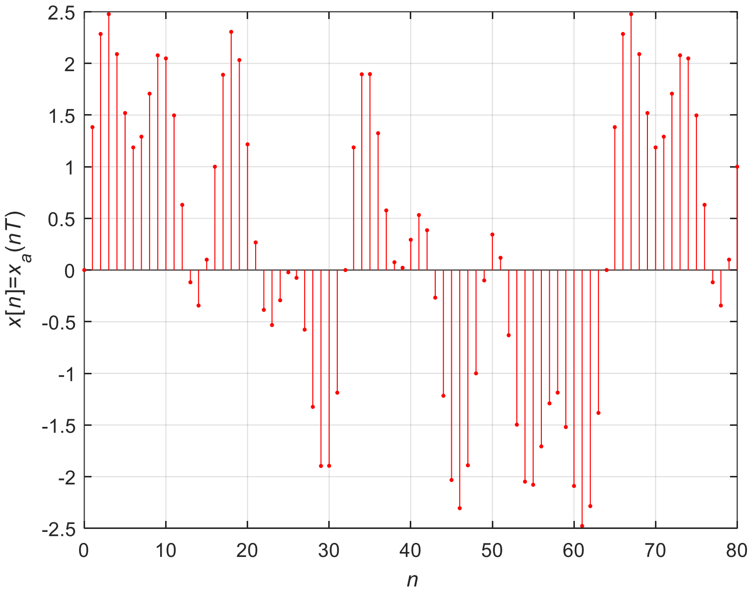
$x_a(nT)$: Analog signal

Obtaining Discrete-Time Signal by Sampling Continuous-Time Signal

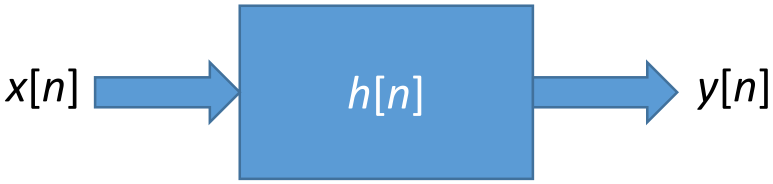




T: Sampling period



- Basic Sequences and Sequence Operations



Discrete-Time System

$y[n]=x[n-n_0]$

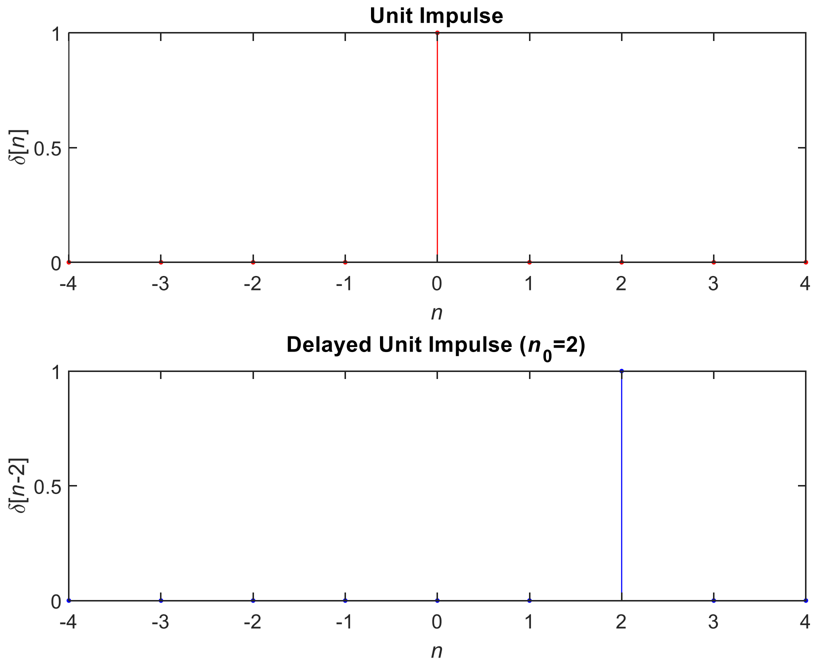
n_0: Delay (shift) in time n

Unit iImpulse at n=0: $\delta[n] = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases}$

Unit Impulse at $n=n_0$: $\delta[n-n_0] = \begin{cases} 1, & n = n_0 \\ 0, & n \neq n_0 \end{cases}$

(Delayed Unit Impulse)

* Ideal Delay *

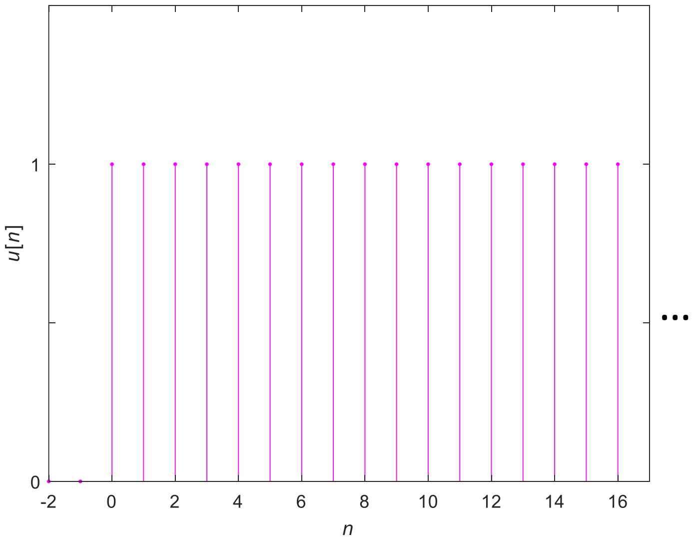


- Discrete-Time Sequence

$$x[n] = \sum_{k=-\infty}^{\infty} x[k]\delta[n-k]$$

- Unit Step Func. (Seq)

$$u[n] = \begin{cases} 1, n \geq 0 \\ 0, n < 0 \end{cases} \quad \text{or} \quad u[n] = \sum_{k=-\infty}^{n} \delta[k] \quad \text{or} \quad u[n] = \sum_{k=0}^{\infty} \delta[n-k]$$



- Discrete-Time Systems

Ideal Delay System

$y[n]=x[n-n_0]$

Moving Average System

$$y[n] = \frac{1}{M_1 + M_2 + 1} \sum_{k=-M_1}^{M_2} x[n-k]$$

System Properties

- Memoryless Systems

  A system is memoryless if output $y[n]$ at every value of discrete time n depends only on the input $x[n]$ at the same value of n.

System Properties

- Linear Systems

$$T\{x_1[n] + x_2[n]\} = T\{x_1[n]\} + T\{x_2[n]\} = y_1[n] + y_2[n]$$ Additivity Property ★

$$T\{ax[n]\} = aT\{x[n]\} = ay[n]$$ Scaling (Homogeneity) Property ★

$$T\{ax_1[n] + bx_2[n]\} = aT\{x_1[n]\} + bT\{x_2[n]\} = ay_1[n] + by_2[n]$$

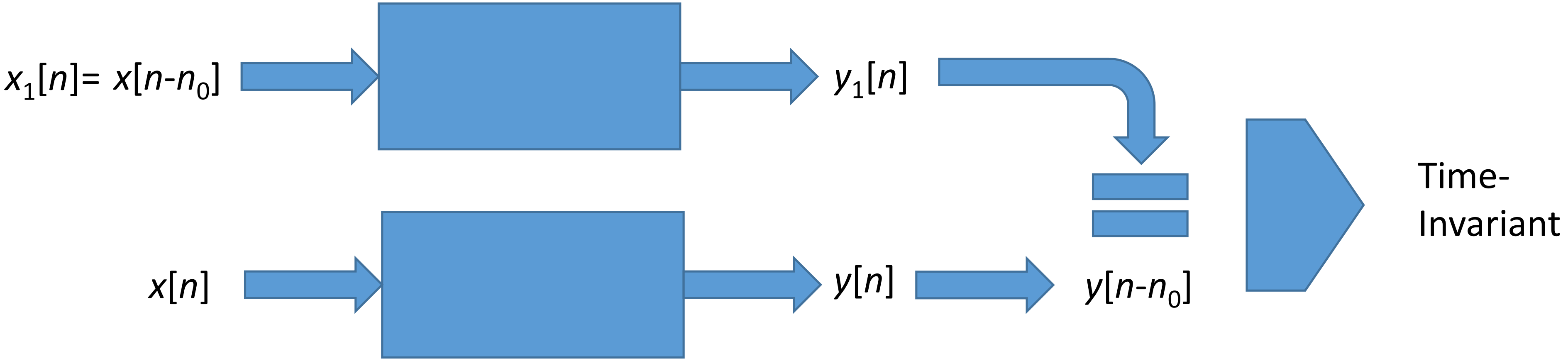
$$x[n] = \sum_k a_k x_k[n]$$

$$y[n] = \sum_k a_k y_k[n]$$

System Properties

- Time-Invariant Systems

$$x[n] \rightarrow y[n]$$



References

- Signals & Systems, Second Edition, A. V. Oppenheim, A. S. Willsky with S. H. Nawab, Prentice Hall, 1997
- Discrete-Time Signal Processing, Second Edition, A. V. Oppenheim, R. W. Schafer with J. R. Buck, Prentice Hall, 1999