Digital Signal Processing

Lecture-1

Presented By: Dr Kiran Khurshid

Course Outline

Course Information	
Course Number and Title:	EC-313 Digital Signal Processing
Credits:	4 (3+1)
Instructor(s)-in-charge:	Dr Kiran Khurshid / LE Sundas Ashraf
Course type:	Lecture + Lab
Required or Elective:	Required
Course pre-requisites	EE-231 Signal and Systems
Degree and Semester	DCE-44
Month and Year	Spring 2025

Course Assessment

Exam:	1 Mid Term and 1 Final	
Lab reports:	12 reports (minimum)	
Design reports:	1 Design report based on Semester Project	
Quizzes:	6 Quizzes	
Assignments:	3-4 Assignments	
Grading Tentative:	**Lecture 75%**	Quizzes: 10%
		Assignments: 10%
		Mid Term: 30%
		Final Exam: 50%
		Semester Project: 10%
	Lab 25%	Lab Work: 40%
		Lab Mid: 25%
		Lab Final: 25%
Plagiarism Policy	Any work (Assignment, Projects, labs etc.) if found copied, will have strict penalties	

Course Outline

Topics	Week
Introduction to DSP • Representation of Discrete Signals • Standard Signals • Complex Exponential Signals • Even and Odd Signals	Week 1
○ Periodic and Aperiodic Signals ○ Bounded Signals ○ Delta and Unit Step Function	Week 2

• Linearity
  ○ Scale property
  ○ Shift in time
• Additive Property
	Week 3

• Stability • Causality	Week 4
• Convolution • Linear and Circular Convolution • Recursive and non-recursive • Static and Dynamic Systems	Week 5
• Fourier Transform • Properties of Fourier Transform	Week 6

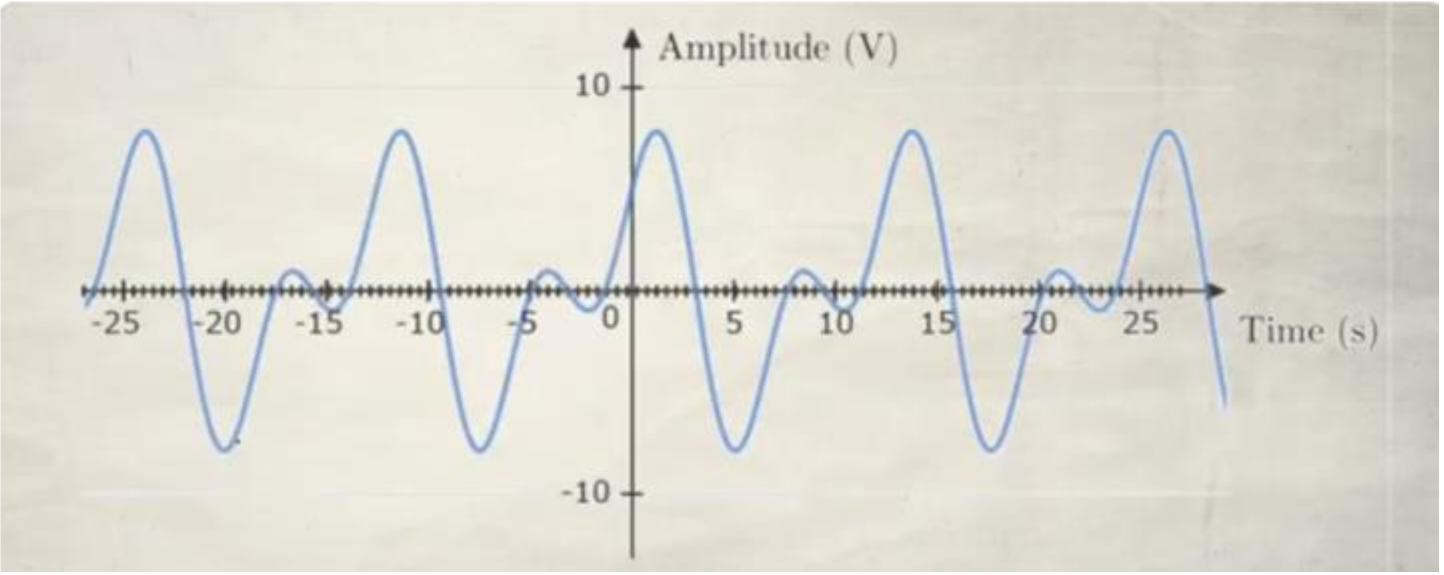
Course Outline

• DFT	Week 7
• FFT • DITFFT • Z-Transform	Week 8
• RHSeq and LHSeq • ROC • Pole Zero plot • All pole and All zeros signals	Week 9
• Sampling • Down sampling	Week 10
• Up-sampling • Multi-rate Signal Processing	Week 11
• Mag Response • Filter implementation DF-I, DF-II, TDF-I, TDF-II	Week 12
• Filter Design • Impulse invariance • Bilinear Transform	Week 13
• Filter Design Butter worth	Week 14

Course book and Related Course Material	
Textbooks:	1. A. V. Oppenheim and R. W. Schafer: Discrete-time Signal Processing, 3rd Edition Pearson Education Limited, 2013 2. J. G. Proakis, C. M. Rader, F. Ling, & L. Nikias Advanced Digital Signal Processing 3. A. Nagoor kani , Digital Signal Processing, 2nd Edition., McGraw-Hill, 2012
Reference Books:	1. James H. McClellan, Ronald W. Schafer, Mark A. Yoder DSP First: A multimedia approach Prentice Hall 2. S. K. Mitra, Digital Signal Processing: A Computer-Based Approach, McGraw-Hill, 1998.

The data or information about an underlying physical phenomenon expressed as a function of an independent variable (eg. time) is called "Signal".

A signal is a mathematical function between an independent variable and a dependent variable



Amplitude (V)
10
-10
-25
-20
-15
-10
-5
0
5
10
15
20
25
Time (s)

Audio is a 1-Dimensional Signal

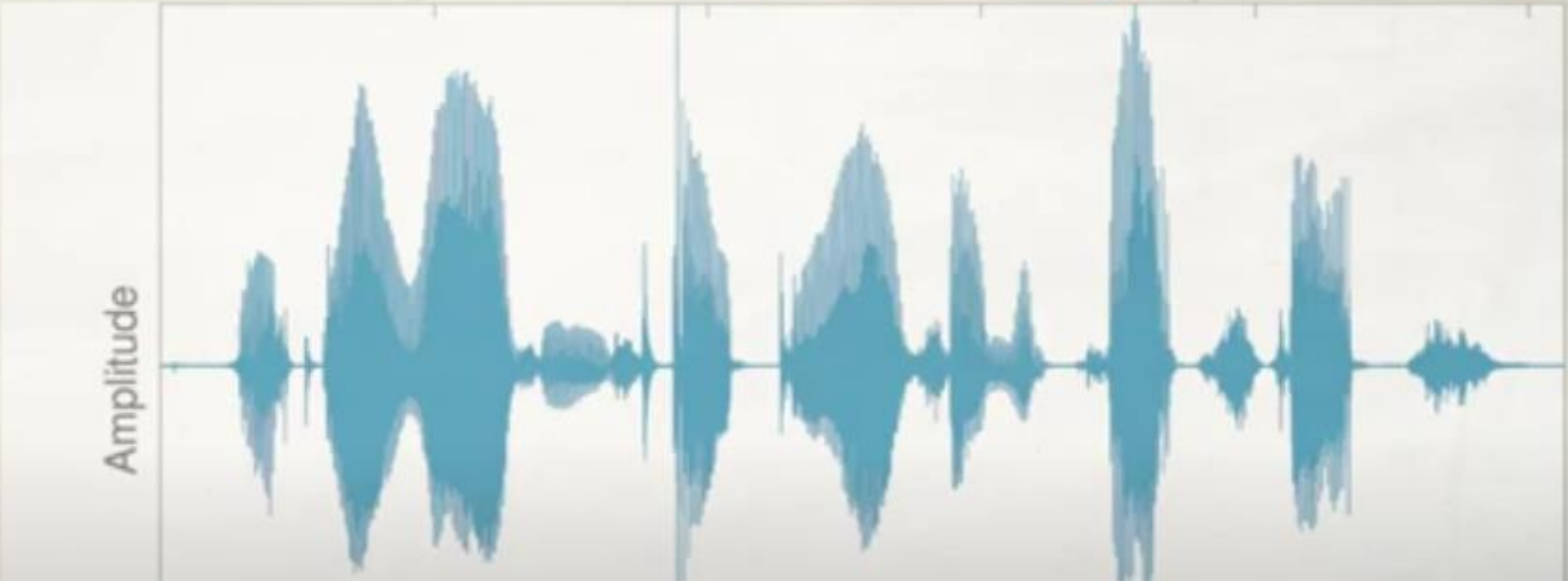
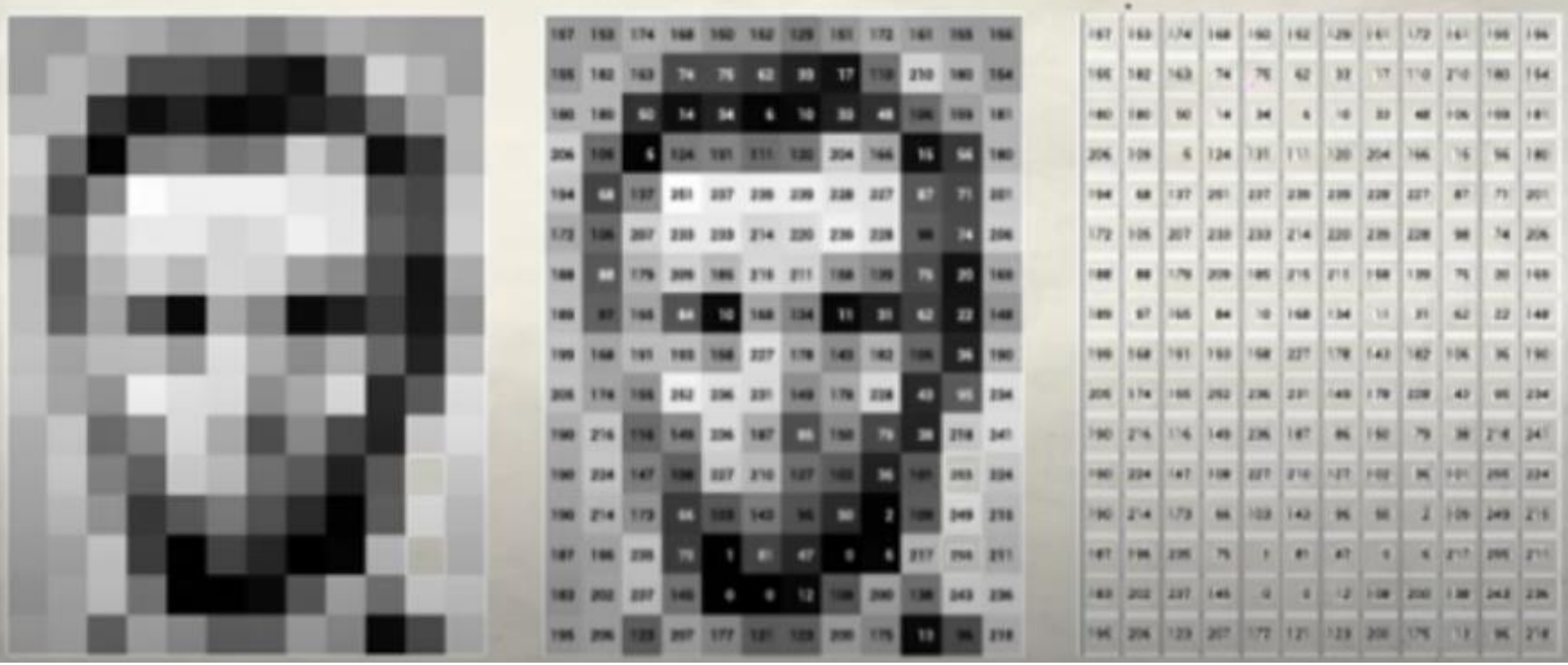
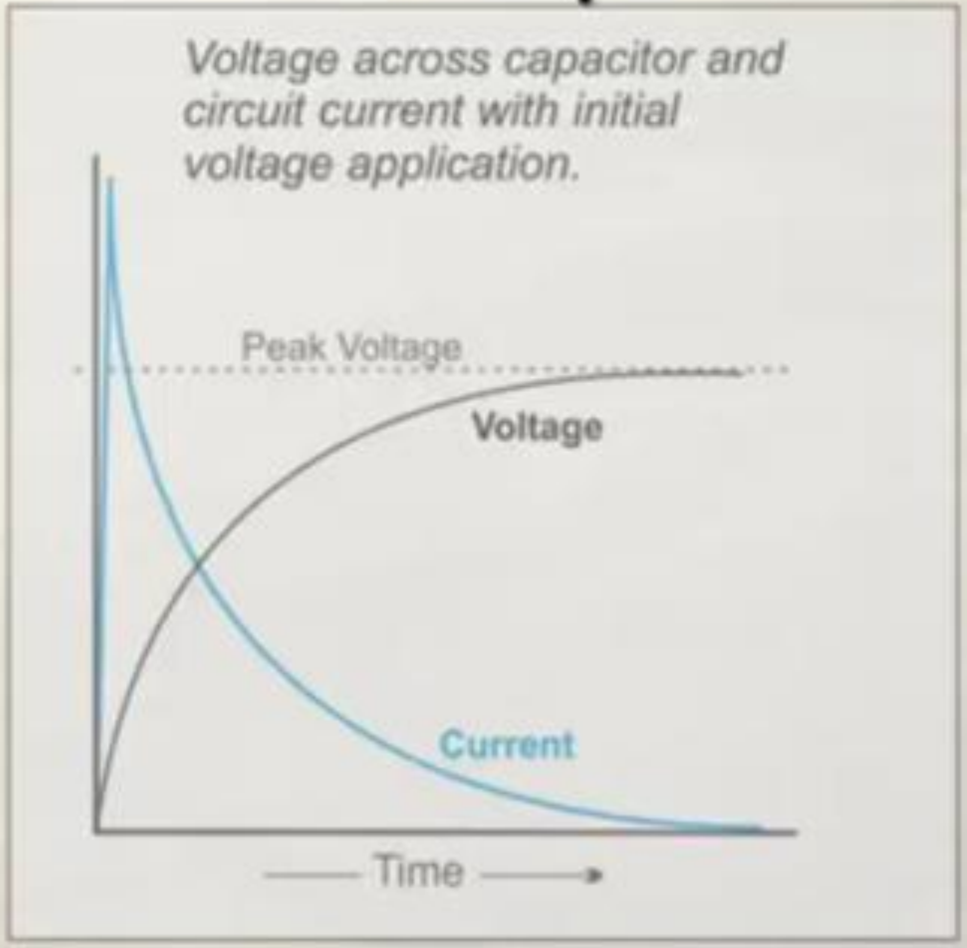


Image is a 2-Dimensional Signal

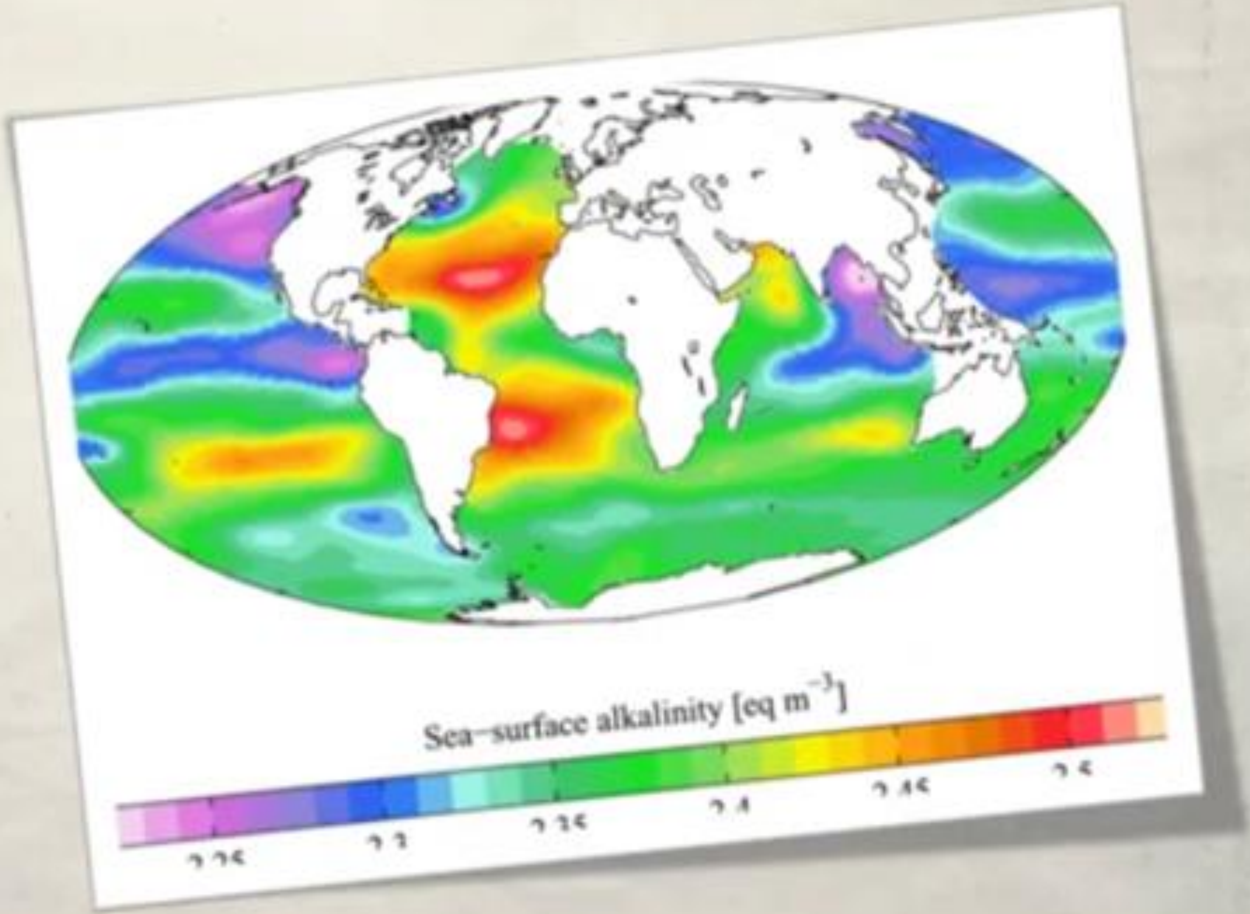


Video is a 3-Dimensional Signal

Voltage Across the Capacitor



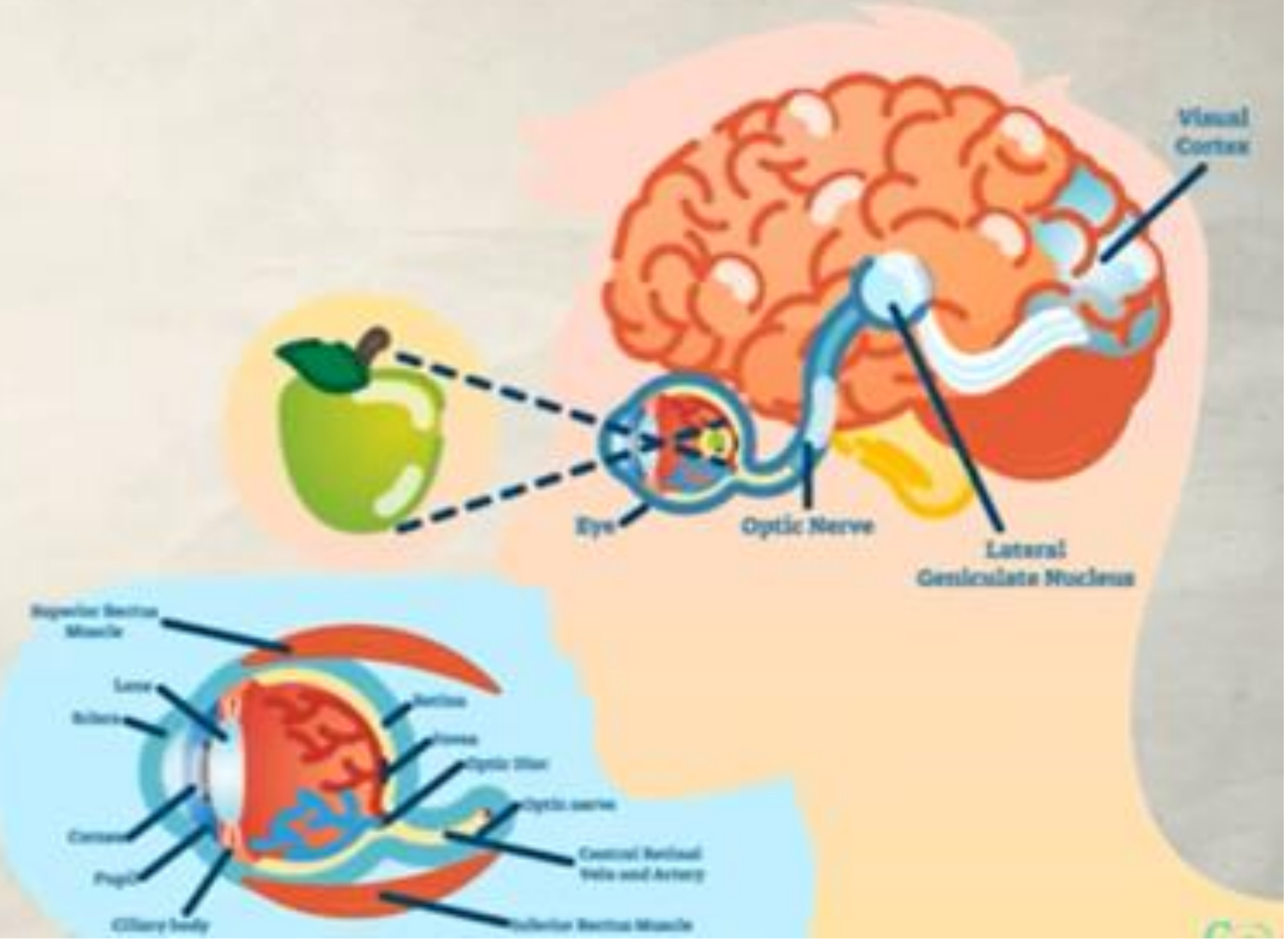
Chemical Concentration - Earth Surface



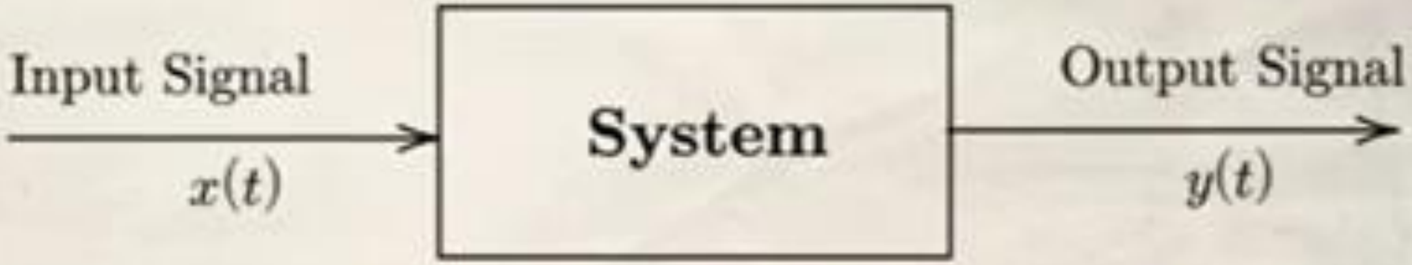
Biomedical Engineering : All about Signals!

EC Engineering : All about Signals!

Systems are Essential to Process the Signals!



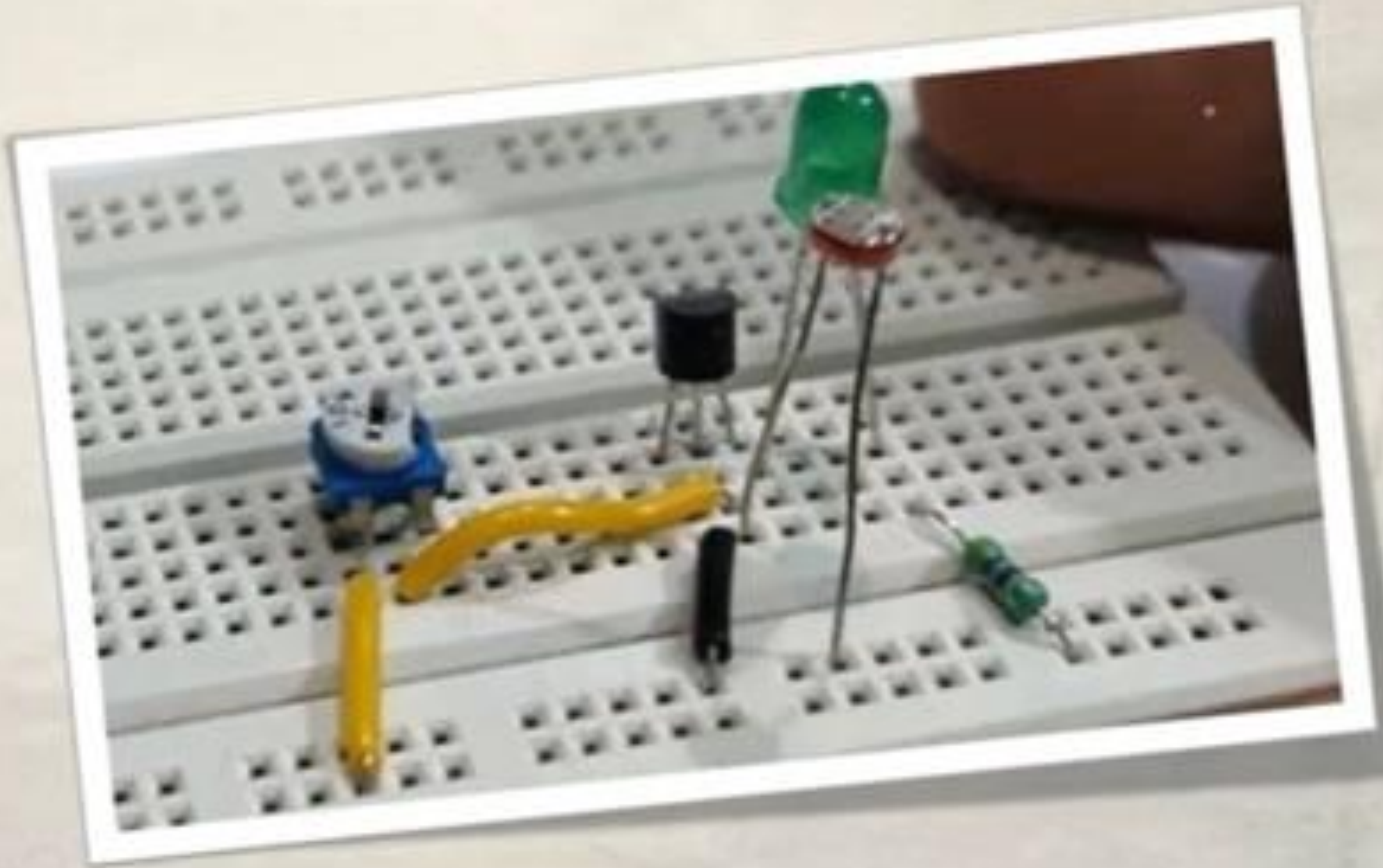
Role of the Systems is to
Transform the input Signal
to Output Signal Based
on the System Function

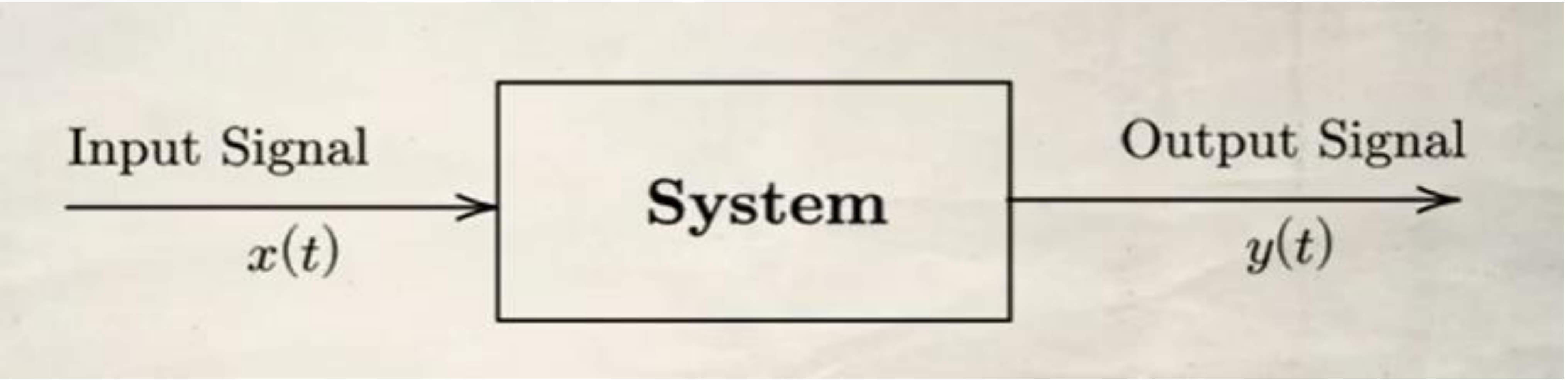


The system is described by the way it transforms the input signal into the output signal.

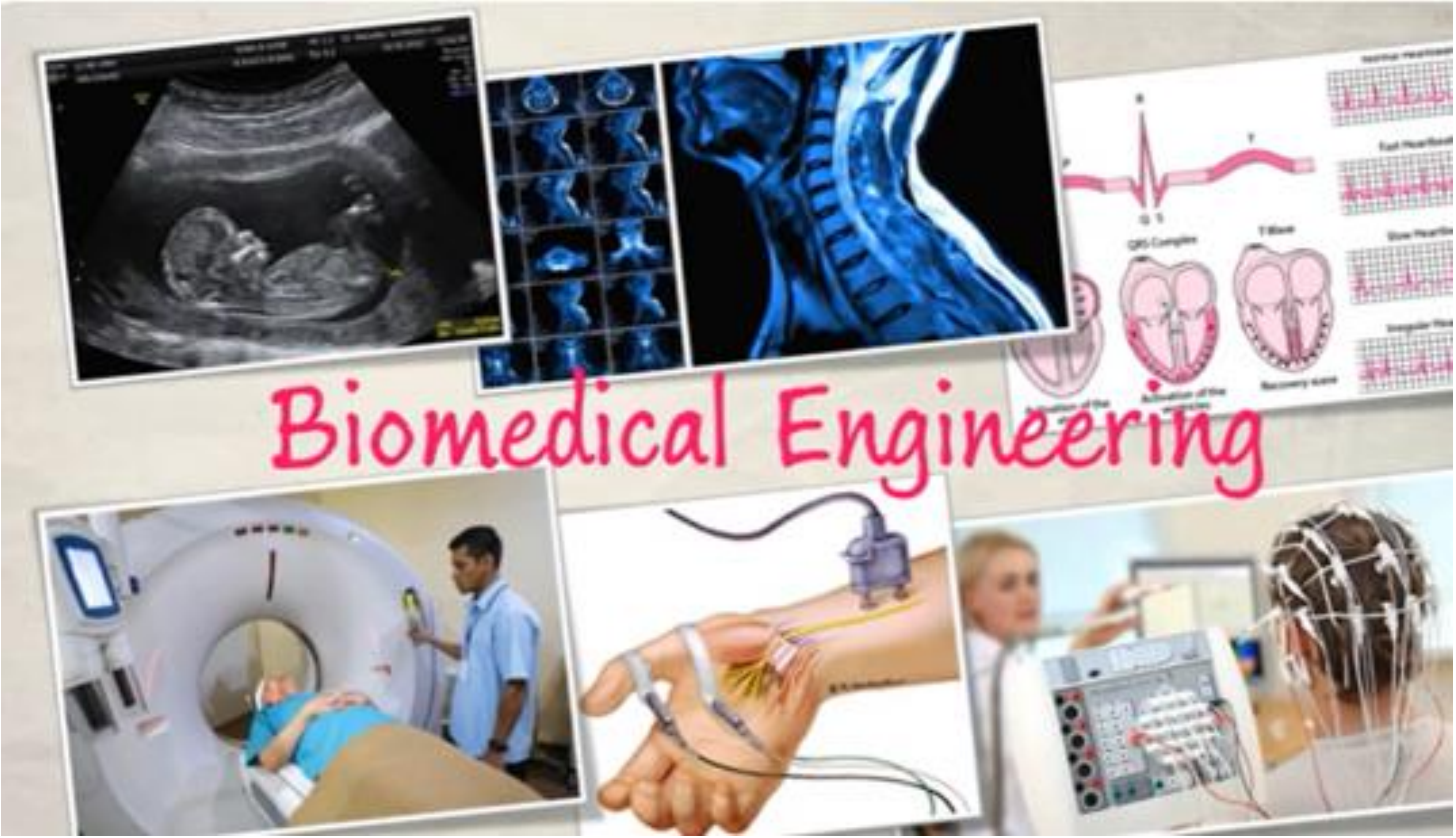

Personal Assistants : Software Systems
“Hey Siri”
“Hey Cortana”
“Alexa”
“OK Google”
2011
2014
2014

LDR Circuit: Hardware Systems



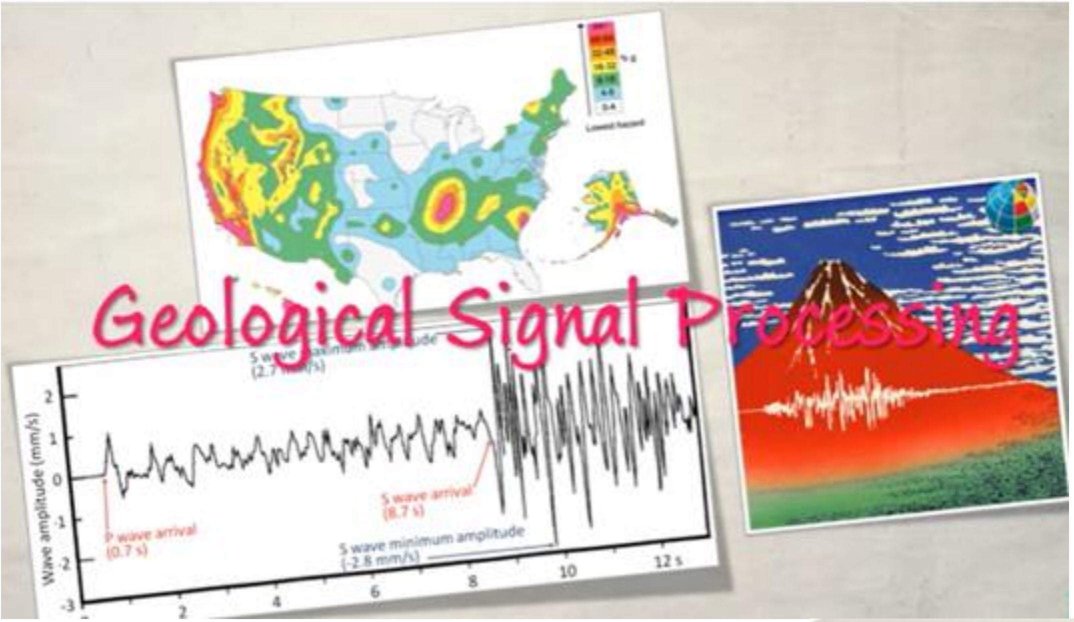


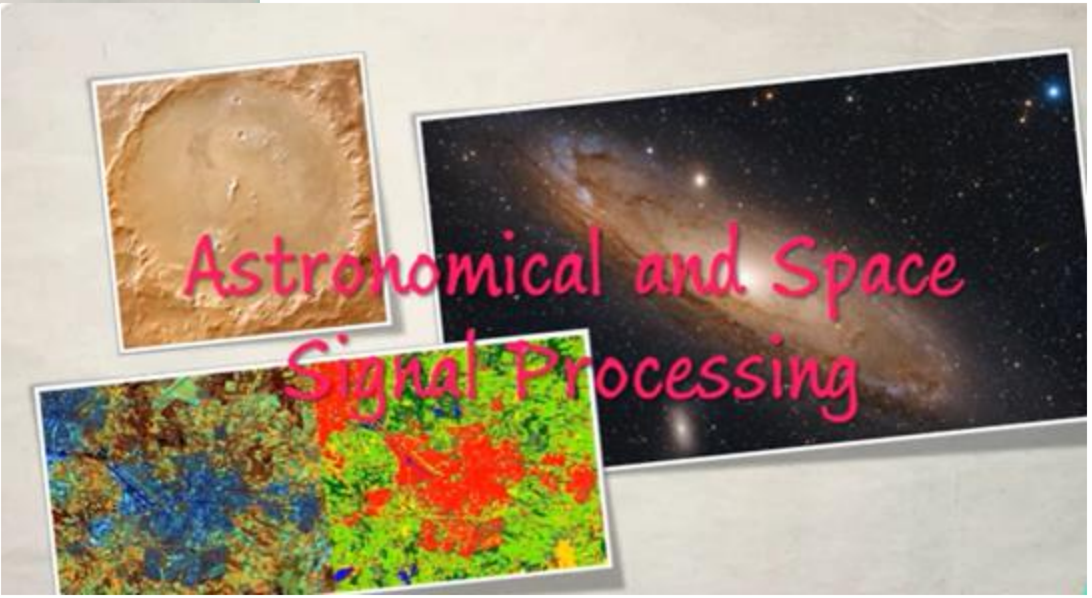
The system is described by the way it transforms the input signal into the output signal.


Biomedical Engineering


Audio File Sizes
AIFF
FLAC
Apple Lossless
MP3 320k
MP3 192
Speech Signal Processing
TTS
Text To Speech


Communication Engineering
Noise Removal
Tracking
Noise
Interference


Geological Signal Processing
Wave amplitude (mm/s)
P wave arrival
(0.7 s)
S wave arrival
(8.7 s)
S wave minimum amplitude
(-2.8 mm/s)

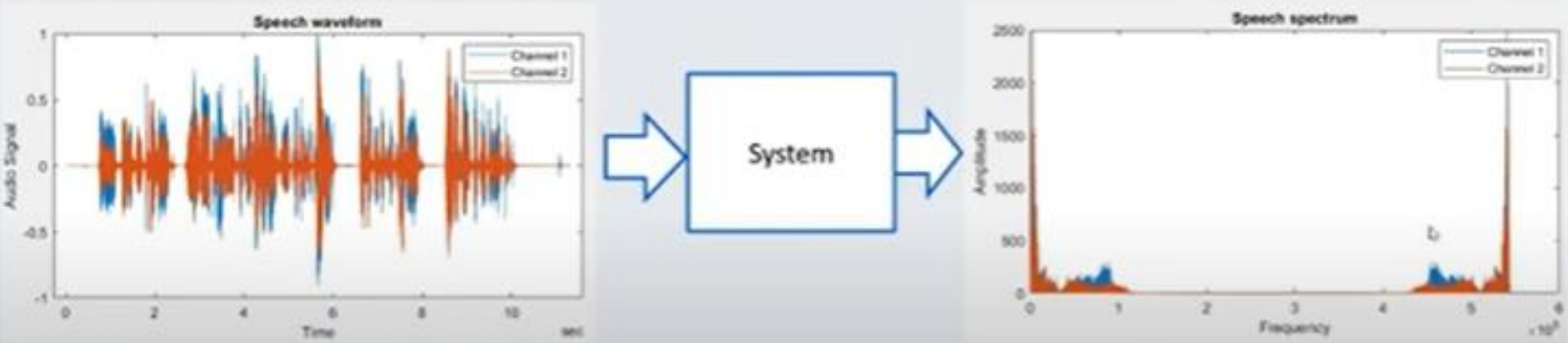

Astronomical and Space Signal Processing

Examples of systems: analysis

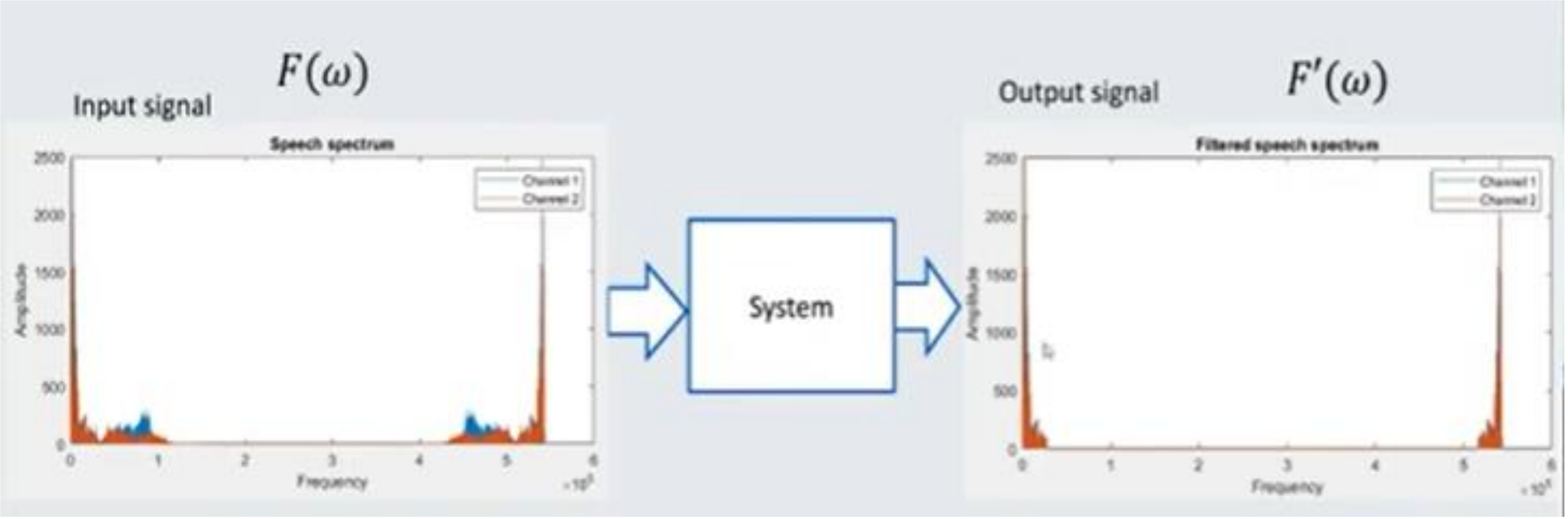
- Spectral analysis of speech

Input signal $f(t)$

Output signal $F(\omega)$



$$F(\omega) = \mathcal{F}\{f(t)\}$$

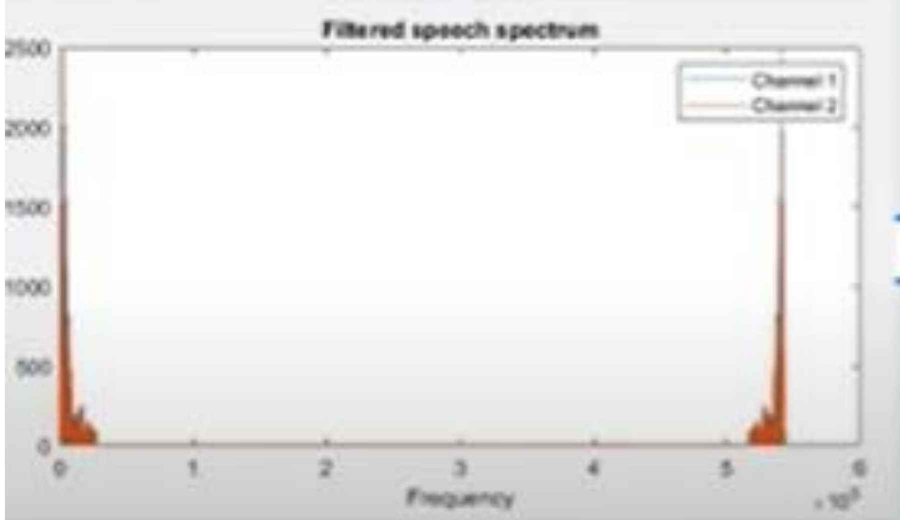


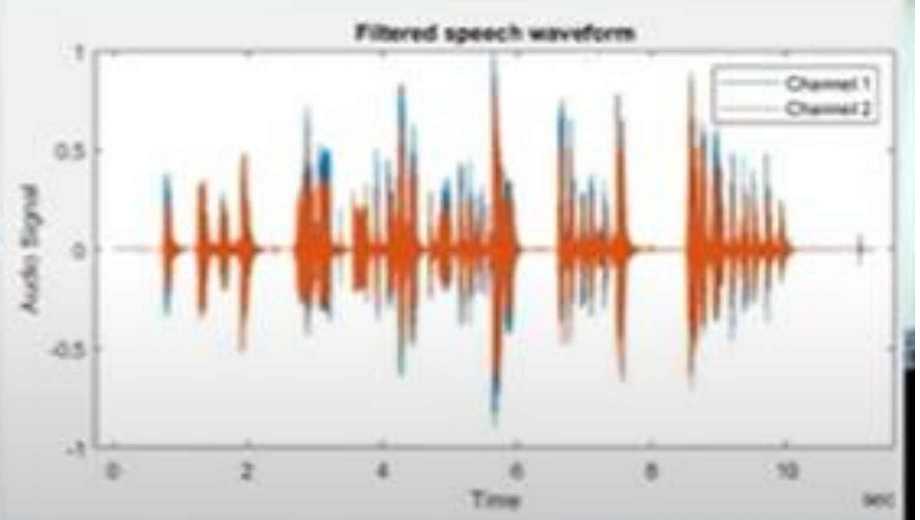
F(ω)
Input signal
Speech spectrum
Channel 1
Channel 2
Amplitude
Frequency
System
F′(ω)
Output signal
Filtered speech spectrum
Channel 1
Channel 2
Amplitude
Frequency

- Filtering a spectrum

Input signal $F'(\omega)$

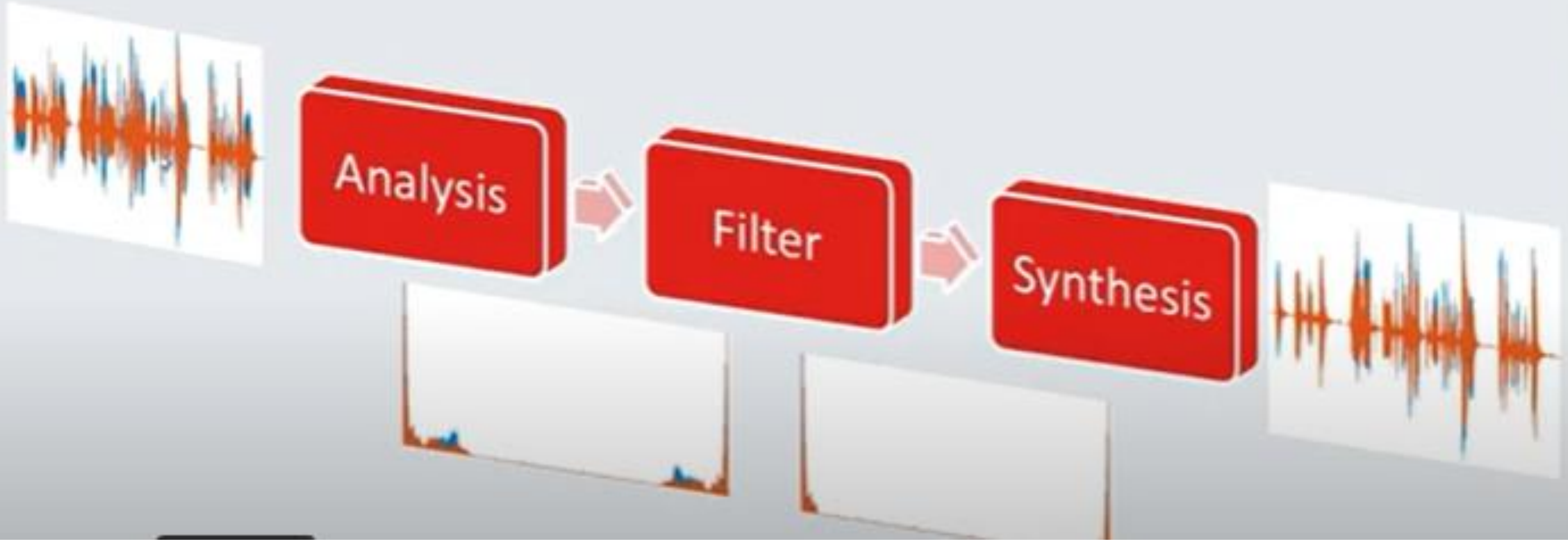
Output signal $f'(t)$





Cascading systems

We use different representations of the information (the signal) according to whatever is easiest for our task



Communication in Olden Days

Efficient Storage is Essential

Introduction to Digital Signal Processing

Signal:

Function that is dependant on some variable.

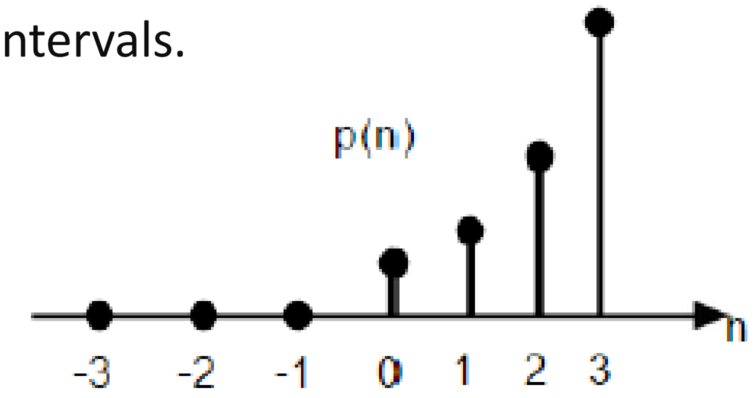
Signal Types: (Synthetic, Natural)

Analog Signal

Digital Signal

Discrete Signal:

A discrete signal is one that is defined or measured at distinct points or intervals.



Digital Signal:

A digital signal is a specific type of discrete signal that is represented using discrete symbols or levels

Introduction to Digital Signal Processing

Why Signals?

Because signals carry information.

Why Processing?

To obtain them in a more desirable form.

Example: MUX, DeMUX, Noise Filtering (ECG, EMG Signals)

Ways to Process?

Analog, Digital, Mixed

Convenient and accurate?

Vacuum tubes..transistors, Ics…..

Advantages

- Less sensitivity to components tolerance
- Fully integrated. More accurate.
- Same processor can do Time Multiplexing (by utilizing space).
- Different parts can work at different rates. Multirate Sampling.
- Data can be stored easily.
- Easy adjustment of processor characteristics.

Disadvantages

- ???
- Increased Complexity
- A to D conversion- Speed is limited.
- Power dissipations

Evolution of Communication

Fire

Wall of China

Lighthouse

What is Comminucation in Today's World?

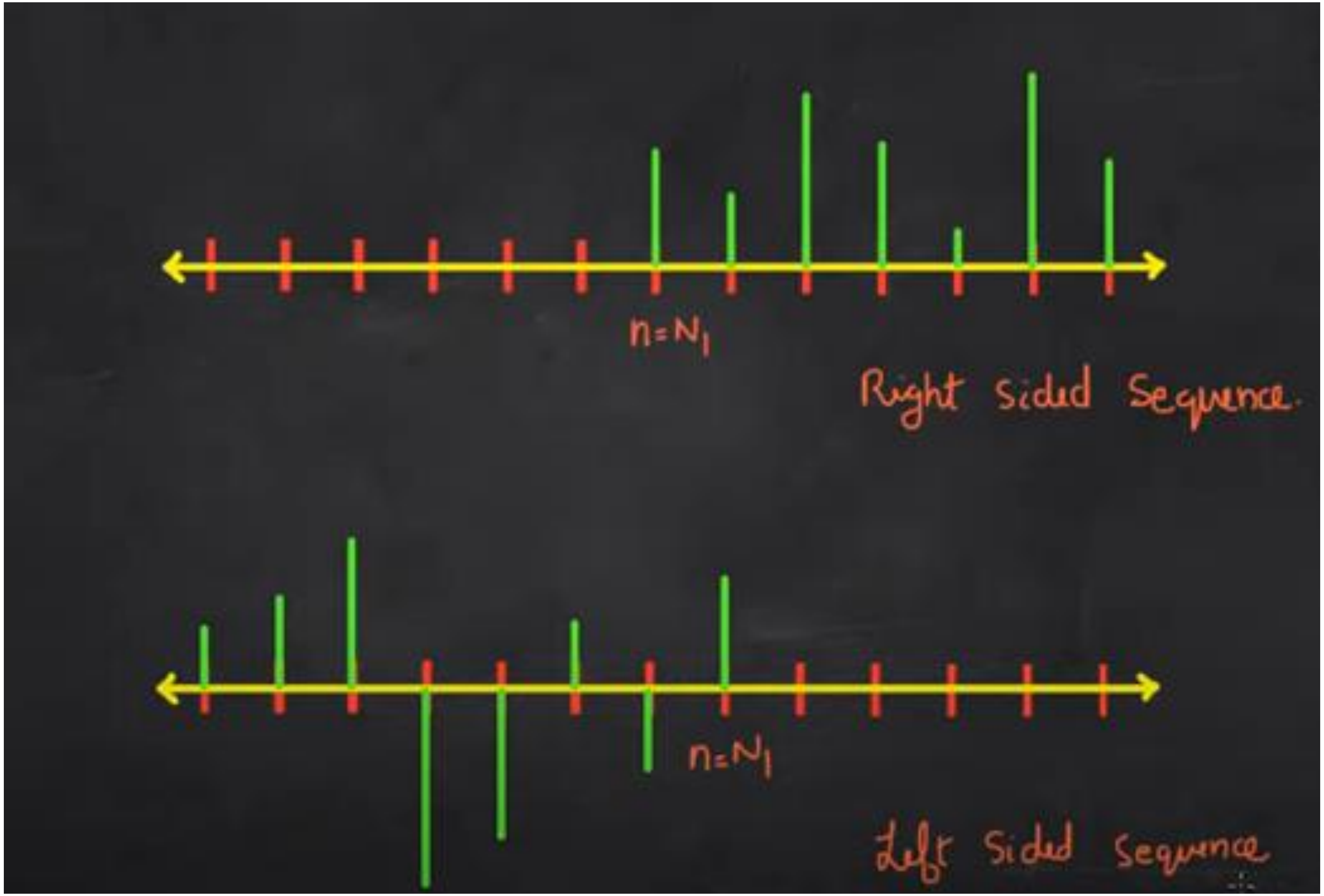
Digital Signal

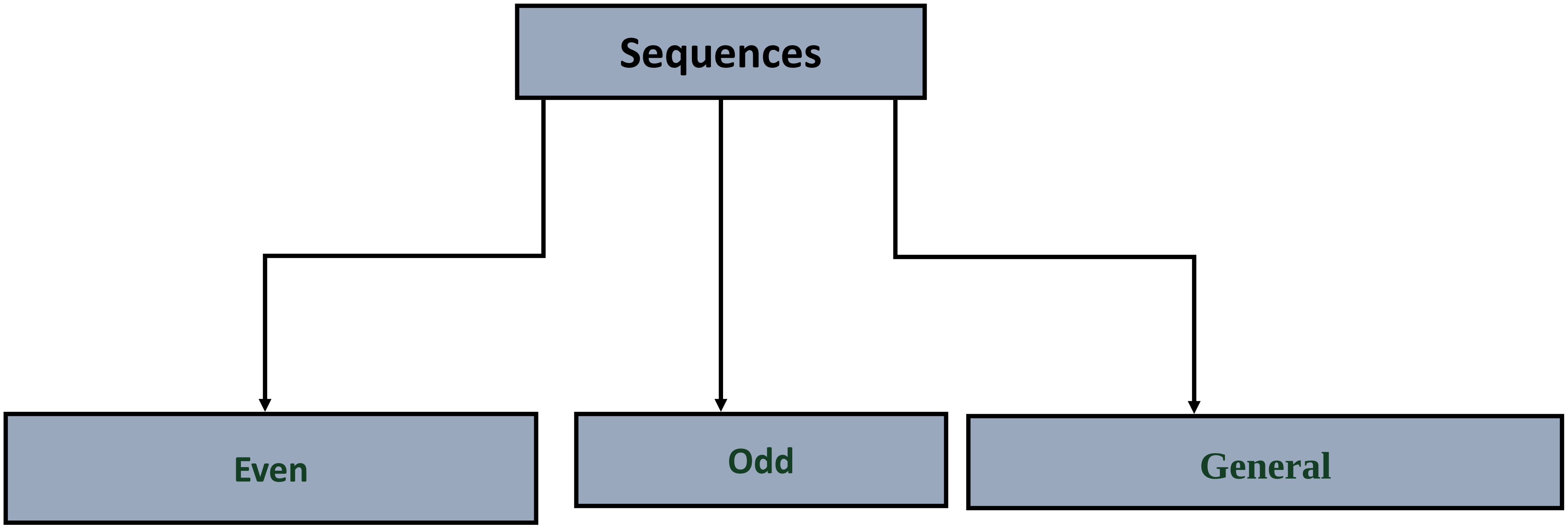
$x(n) = \{ 1, 2, -2, 1, 5\}$

$N = 5$

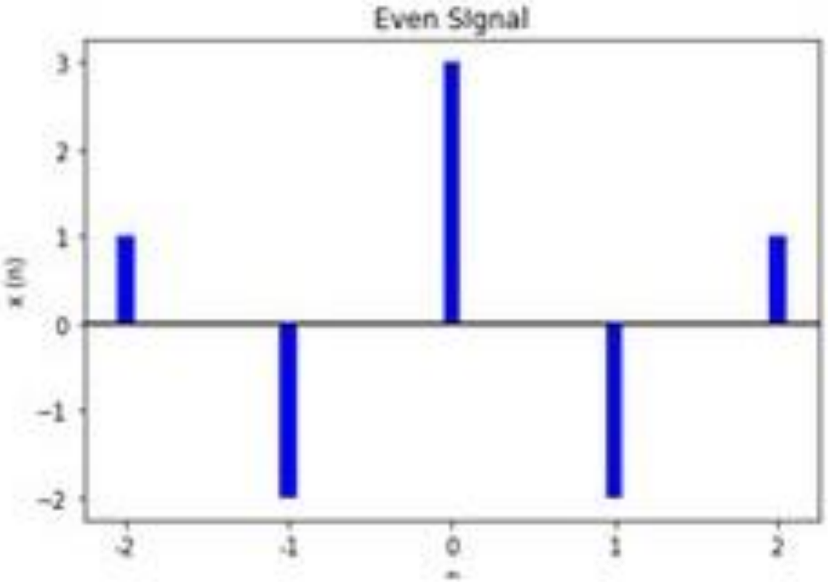
$n = 0 : N-1$

Right Sided Sequence? Left Sided Sequence?

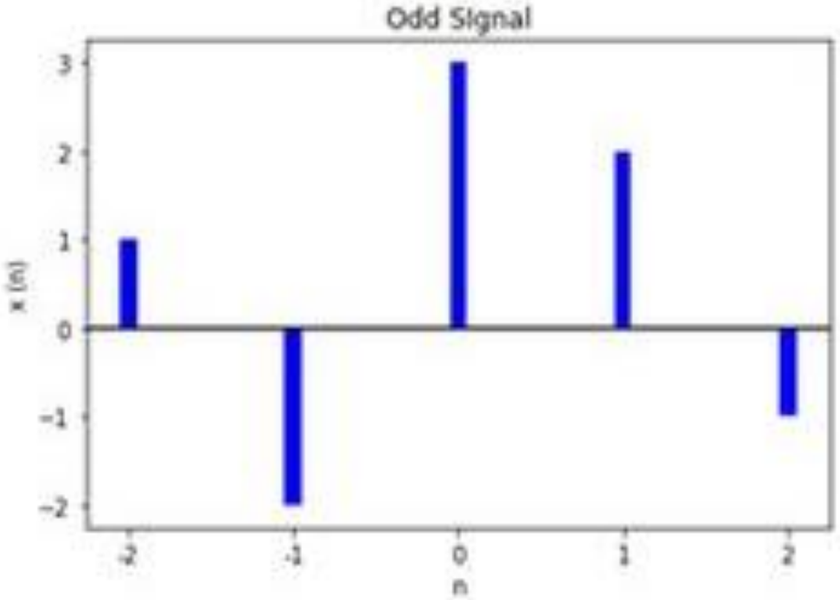

n=N1
Right sided Sequence.
n=N1
Left Sided Sequence


Sequences
Even
Odd
General

$$x(n) = \{1, -2, \underset{\uparrow}{3}, -2, 1\}$$



$$x(n) = \{1, -2, \underset{\uparrow}{3}, 2, -1\}$$



Even (Symmetric) and Odd (Antisymmetric) Signals

The discrete time signal may exhibit symmetry or antisymmetry nature with respect to n=0.

Even Signal (Symmetric): There is symmetry with respect n=0. $x(n) = x(-n)$

Odd Signal (Antisymmetric): There is anisymmetry with respect n=0. $x(n) = -x(-n)$

Signal can be separated into even part and odd part.

$$Even\ Signal = \frac{x(n) + x(-n)}{2} \qquad Odd\ Signal = \frac{x(n) - x(-n)}{2}$$

Find even and odd components of the given discrete time signal

$$x(n) = \{1, 2, 3, \underset{\uparrow}{4}, 1, 2, 2\}$$

$$x(-n) = \{2, 2, 1, \underset{\uparrow}{4}, 3, 2, 1\}$$

n	x(n)
-3	1
-2	2
-1	3
0	4
1	1
2	2
3	2

n	x(n)
-3	1
-2	2
-1	3
0	4
1	1
2	2
3	2

- **Even part?**
- **Odd part?**

n	x(n)	x(-n)
-3	1	2
-2	2	2
-1	3	1
0	4	4
1	1	3
2	2	2
3	2	1

- **Even part?**
- **Odd part?**

Representation of discrete time signals

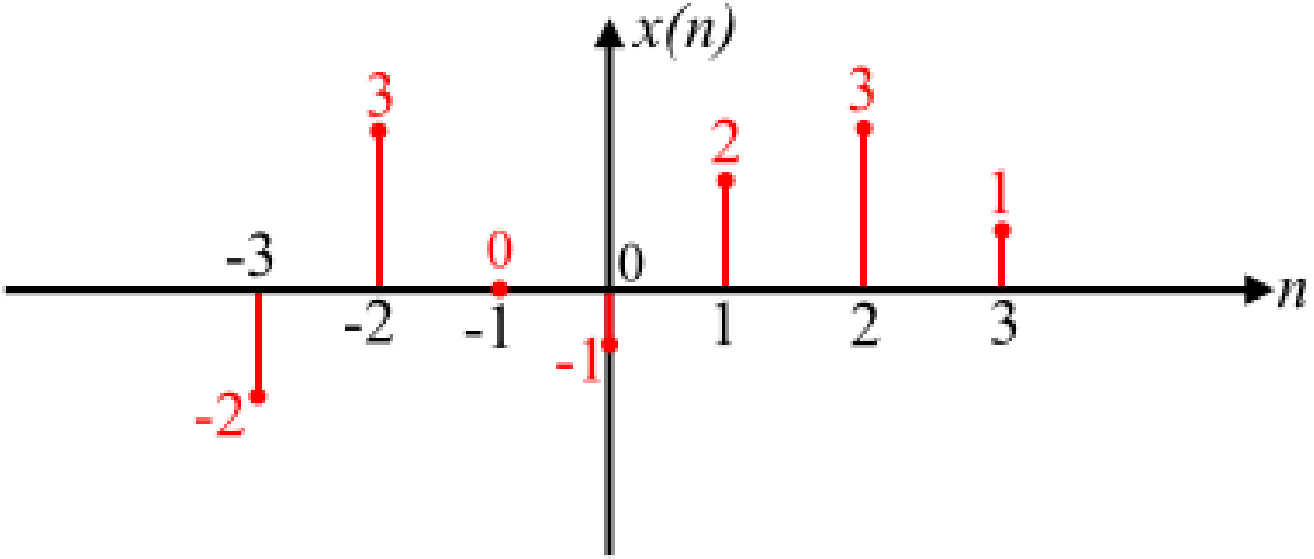
- Graphical Representation
- Functional Representation
- Tabular Representation
- Sequence Representation

Graphical Representation

Consider a discrete time signal $x(n)$ with the values,

$x(-3) = -2$,
$x(-2) = 3$,
$x(-1) = 0$,
$x(0) = -1$,
$x(1) = 2$,
$x(2) = 3$,
$x(3) = 1$

This discrete time signal can be represented graphically as shown in the figure below.



Functional Representation

In the functional representation of discrete time signals, the magnitude of the signal is written against the values of n.

$$x(n) = \begin{cases} 1, & for\ n = 1, 3 \\ 4, & for\ n = 2 \\ 0, & elsewhe \end{cases}$$

Tabular Representation

In the tabular representation of discrete time signals, the sampling instant n and the magnitude of the discrete time signal at the corresponding sampling instant are represented in the form of a table. The discrete time signal x(n) can be represented in the tabular form as given below.

n	-3	-2	-1	0	1	2	3
x(n)	-2	3	0	-1	2	3	1

Sequence Representation

- The discrete time signal x(n) can be represented in the sequence representation as follows:

- $x(n)=\{-2,3,0,-1,2,3,1\}$

The arrow mark (↑) denotes the term corresponding to n = 0. When no arrow is indicated in the sequence representation of a discrete time signal, then the first term of the sequence corresponds to n = 0.

To record the voice signal use following MATLAB function:

recorder = audiorecorder(Fs,nBits,nChannels)

By default, value of Fs=8000Hz, nBits=8 and nChannels=1.

recordblocking(recorder, time in second)

To play the audio file use MATLAB play function:

play(recorder)

Store data in double-precision array to plot.

myRecording = getaudiodata(recorder)

To read the image use following MATLAB function:

A = imread(image_name);

To read the video and frames use following MATLAB function:

V = VideoReader(video_name)
frame = read(V,index)

Section A- Enrollment Code: 612073849

Section B- 749563021