

[4] Information Extraction, and Pattern Recognition
↳ Machine Learning, Deep Learning

SAS → To extract information from signal.

Why information extraction?

↳ Pattern Recognition

A B C

Patterns.

→ Recognize familiar faces
→ ———— Voices over telephone.

Pattern Recognition → AI

What is AI? → Artificial Intelligence

⇒ When your computer performs on intelligent task like humans, it is AI.

(1)

Pattern Recognition: →

cognition

Pattern → Repetitive structures.

(A) A A A A A A A A A A

Pattern for 'A', Character Recognition

(B) B B B B B B B B

⇒ We perceive the pattern & edges

Hill

Sun

Bridge

Knowledge

edge

Edge detection is a fundamental research problem in computer vision

River

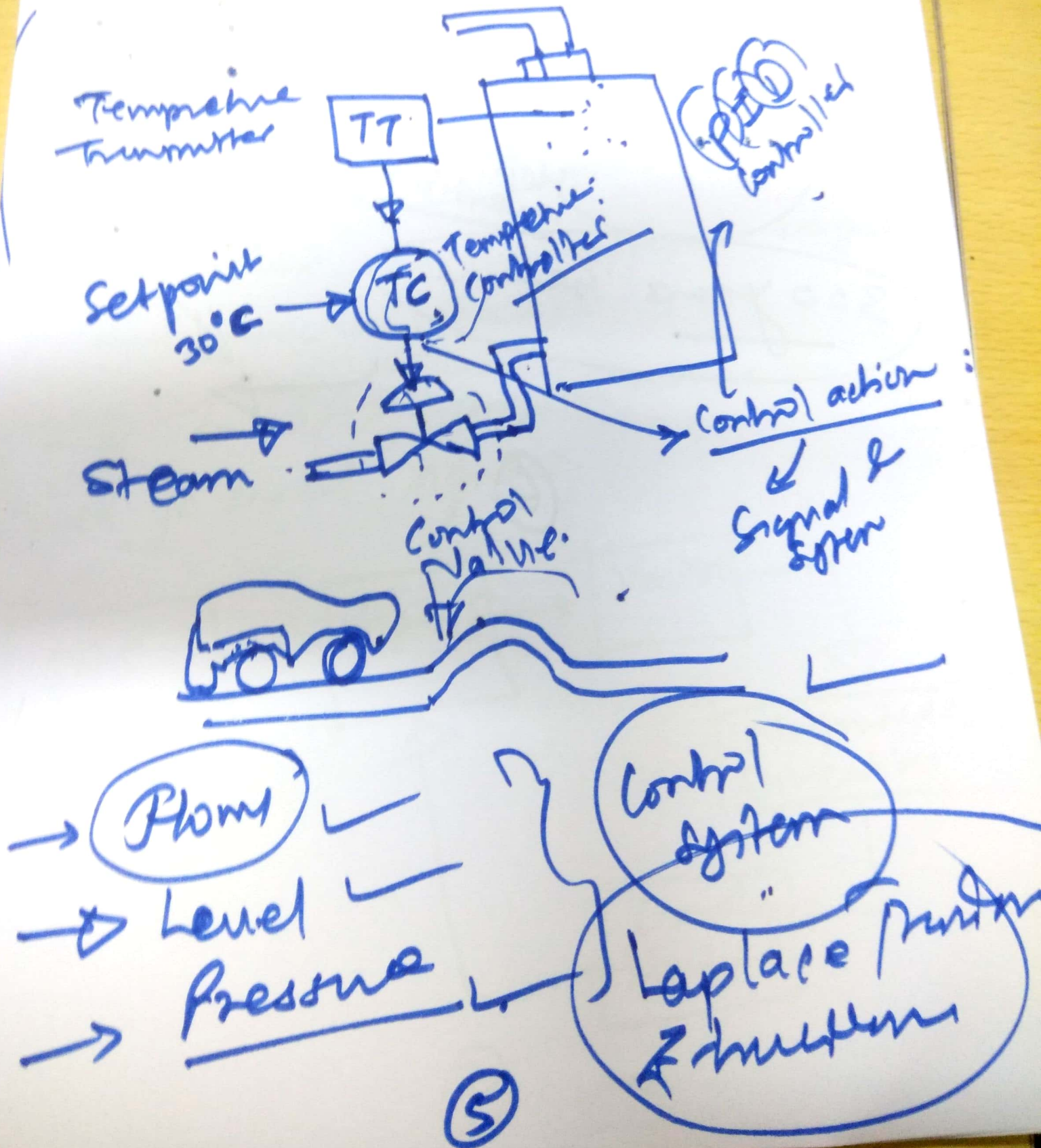
(2)

Applications

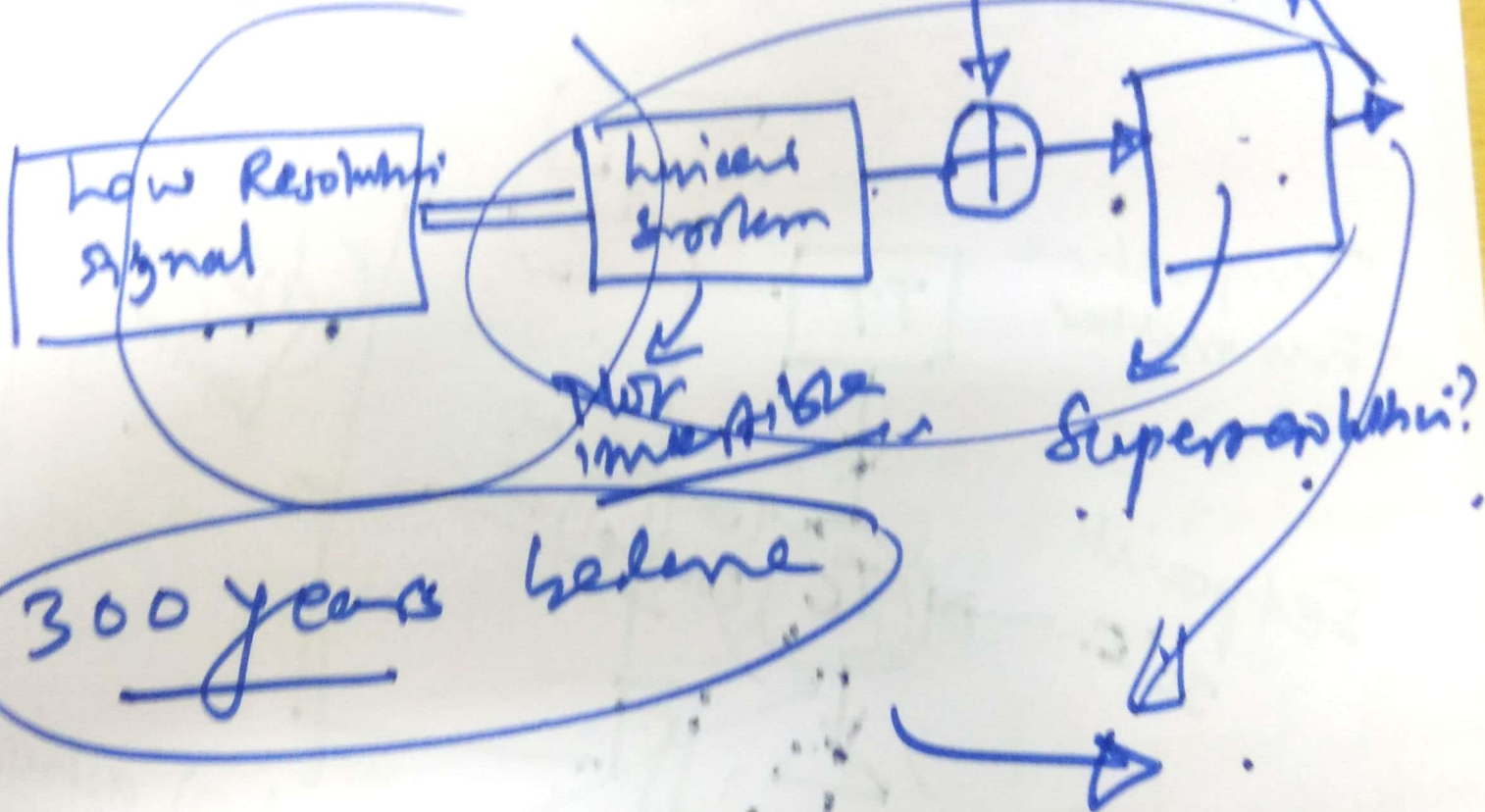
- ① Automatic Speech Recognition (ASR)
- 2) Speaker Recognition / Voice Biometrics
- 3) Face Recognition
- 4) Fingerprint / Palmpoint / Iris.
- 5) Gait (Walking Patterns) Recognition.
- 6) Optical Character Recognition (OCR).
- 7) Language Recognition.
- 8) Texture Segmentation.

[5] Instrumentation and Process Control

a) Temperature Control Loop (System).

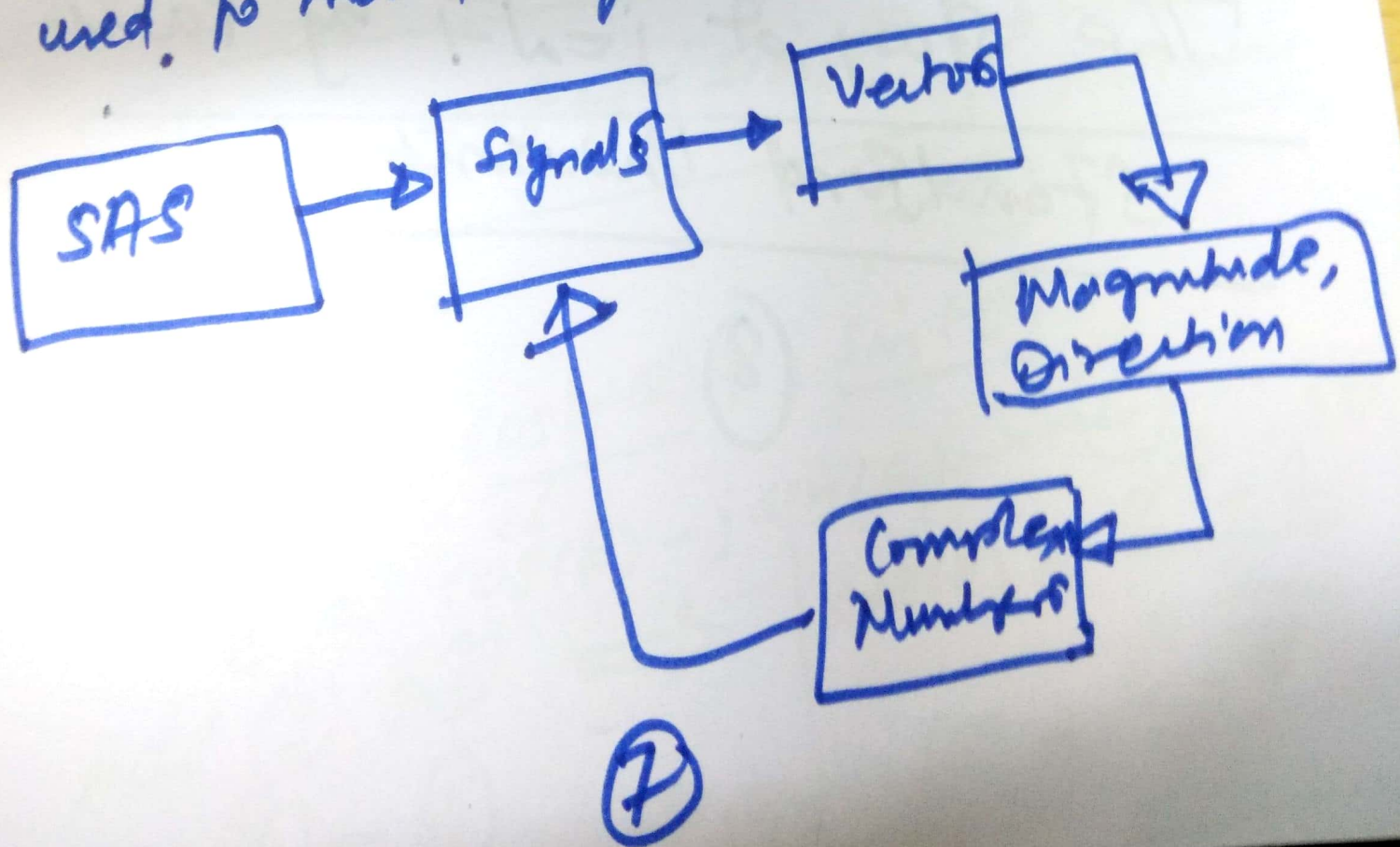


[6] Inverse Problems in Signal & Measurement Systems.



Mathematical Background.

- In Signals and Systems, we model signals as vectors.
- Vector is modeled/represented via magnitude and phase (direction).
- Complex numbers represent magnitude and direction (phase).
- ⇒ In S&S, complex numbers are used to model signals.



Complex Numbers

$$x \in \mathbb{R}, y \in \mathbb{R}$$

$$z \in \mathbb{C}, \quad z = x + j \cdot y$$

$$x = \operatorname{Re}\{z\}, \quad y = \operatorname{Im}\{z\}, \quad j = \text{Imaginary unit}$$

$$j = \sqrt{-1}$$

$$\sqrt{1} \Rightarrow 1$$
$$\textcircled{\sqrt{-1}} \rightarrow \text{imaginary } j$$

Civil Engineering

→ surveying

~~what~~ Wessel → \textcircled{j}

The story of $j = \sqrt{-1}$ by Paul

Stanford University

$\textcircled{8}$

$$Z = x + jy \rightarrow \text{Cartesian}$$

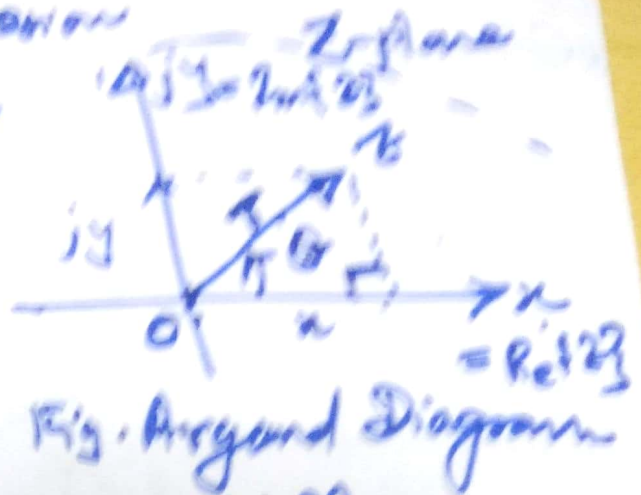
$$Z = r e^{j\theta} \rightarrow \text{Polar}$$

$$\cos(\theta) = \frac{x}{r}$$

$$\sin(\theta) = \frac{y}{r}$$

$$x = r \cos(\theta)$$

$$y = r \sin(\theta)$$



$$Z = r \cos \theta + j r \sin \theta$$

$$r e^{j\theta} = r (\cos \theta + j \sin \theta)$$

$$e^{j\theta} = \cos \theta + j \sin \theta \rightarrow \text{Euler's formula}$$

$$\theta \rightarrow -\theta$$

$$e^{-j\theta} = \cos(-\theta) + j \sin(-\theta)$$

$$\therefore e^{-j\theta} = \cos(\theta) - j \sin(\theta)$$

$$\text{Add (3) + (4)}$$

$$(2) - (4)$$

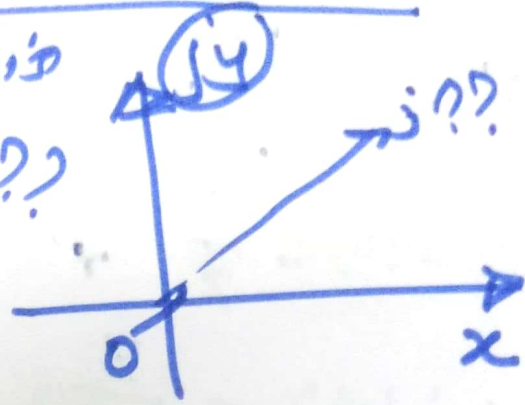
$$\Rightarrow (5)$$

$$\cos(\theta) = \frac{e^{j\theta} + e^{-j\theta}}{2}$$

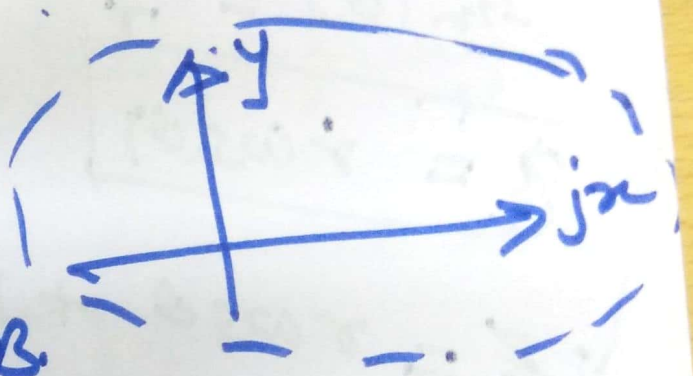
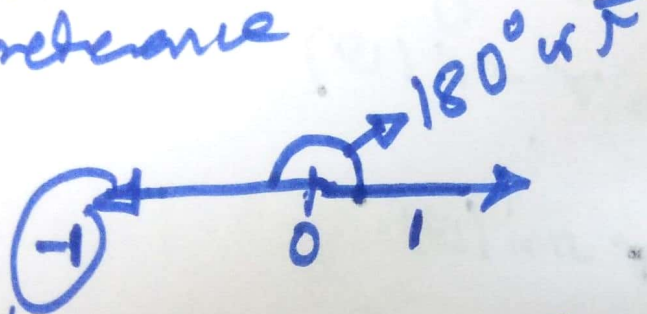
$$\sin(\theta) = \frac{e^{j\theta} - e^{-j\theta}}{2j}$$

*Geometrical Interpretation of $j = \sqrt{-1}$

Q. Why 'j' is on Y-axis and NOT on X-axis??



Positive direction of X-axis is the reference



$$j = \sqrt{-1} \quad \text{--- (2) Fig. B.}$$

$$j = 1 \angle 90^\circ \quad \text{--- (1)}$$

$$\therefore j^2 = j \times j = (1 \angle 90^\circ) \cdot (1 \angle 90^\circ)$$

$$\rightarrow (-1) = 1^2 \angle 180^\circ \quad \text{--- [A]}$$

$$\rightarrow -1 = 1 \angle 180^\circ \quad \text{--- [B]}$$

$$1^2 \angle 180^\circ = 1 \angle 180^\circ$$

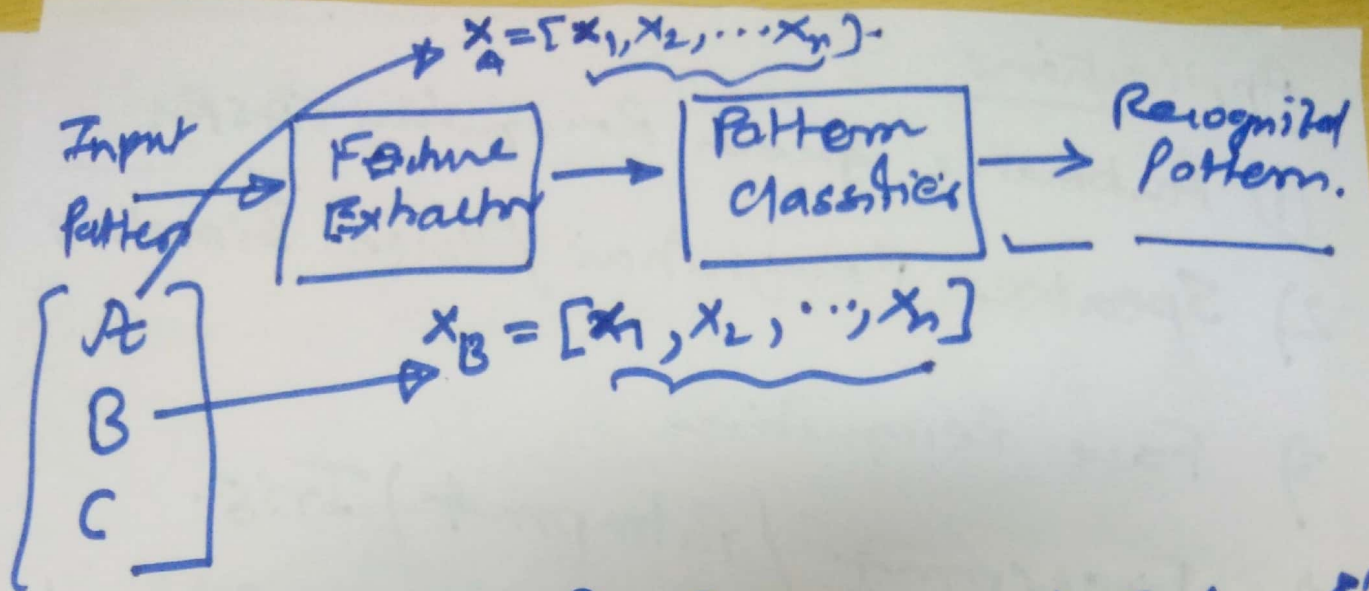
$$1^2 = 1,$$

$$180^\circ = 180^\circ$$

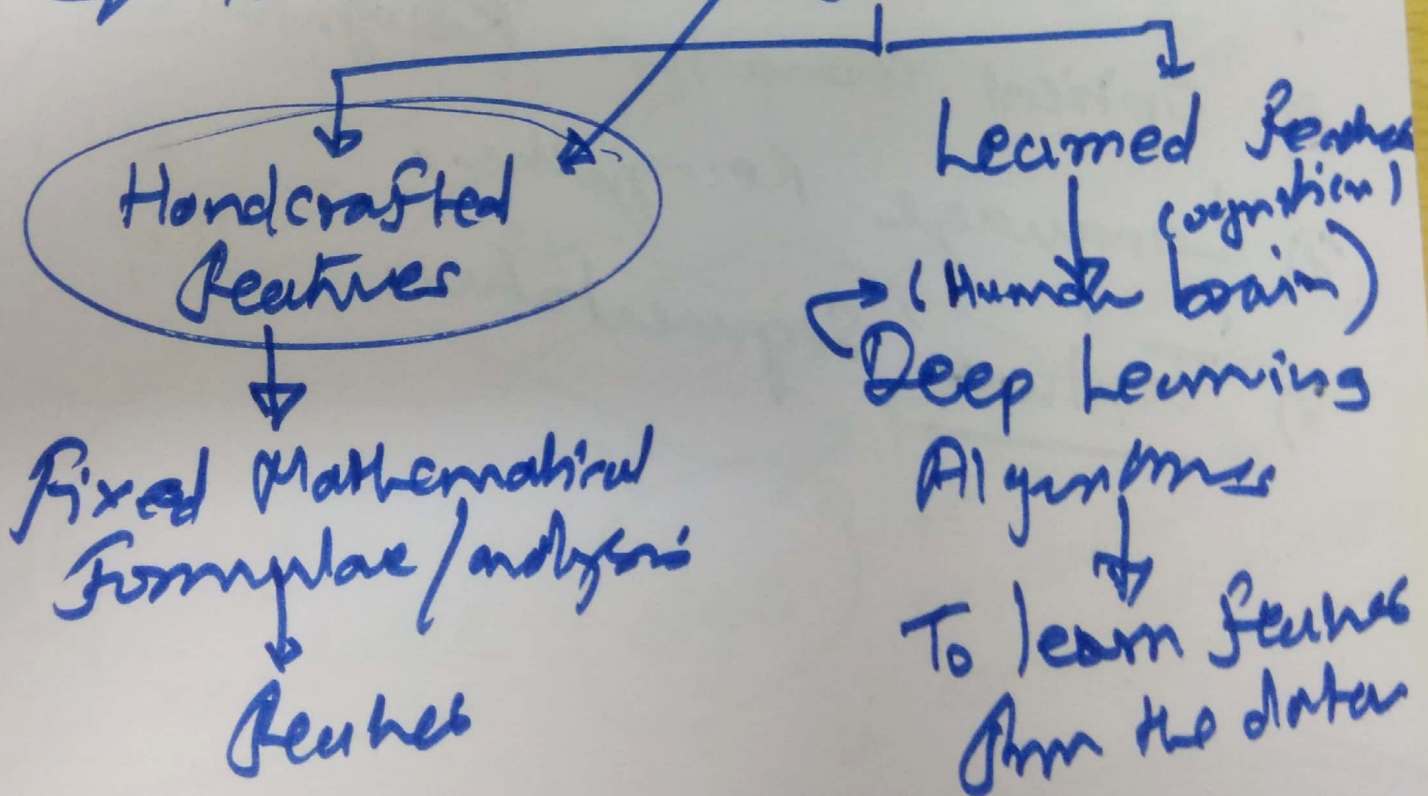
$$180^\circ = 180^\circ$$

$$1 = -1$$

$$\therefore \theta = 90^\circ$$



Where is role of Signals and Systems?
 ↳ To do effective Feature Extraction.



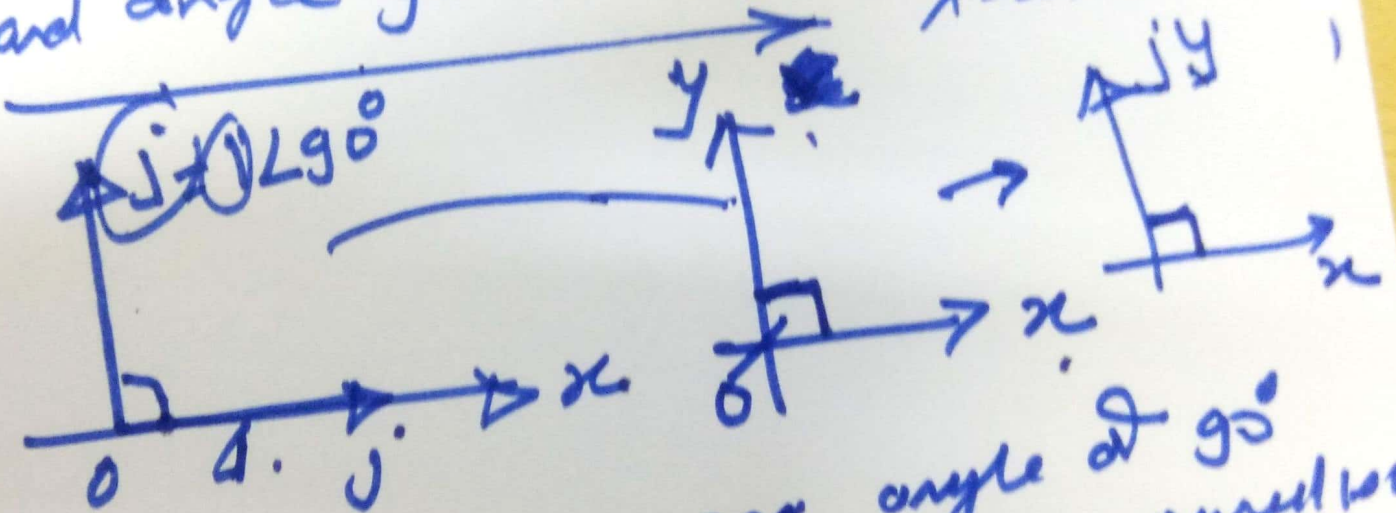
∴ l is a magnitude,

$$l = +1$$

$$\theta = 90^\circ$$

$$\therefore \boxed{j = l L \theta = \boxed{1} L 90^\circ}$$

$|j| = 1$, $\angle j = 90^\circ$
 \Rightarrow 'j' is a vector having magnitude 1 and angle 90° with positive direction of x-axis.



\rightarrow j and y makes an angle of 90° with x-axis \Rightarrow j and y are parallel

(11)