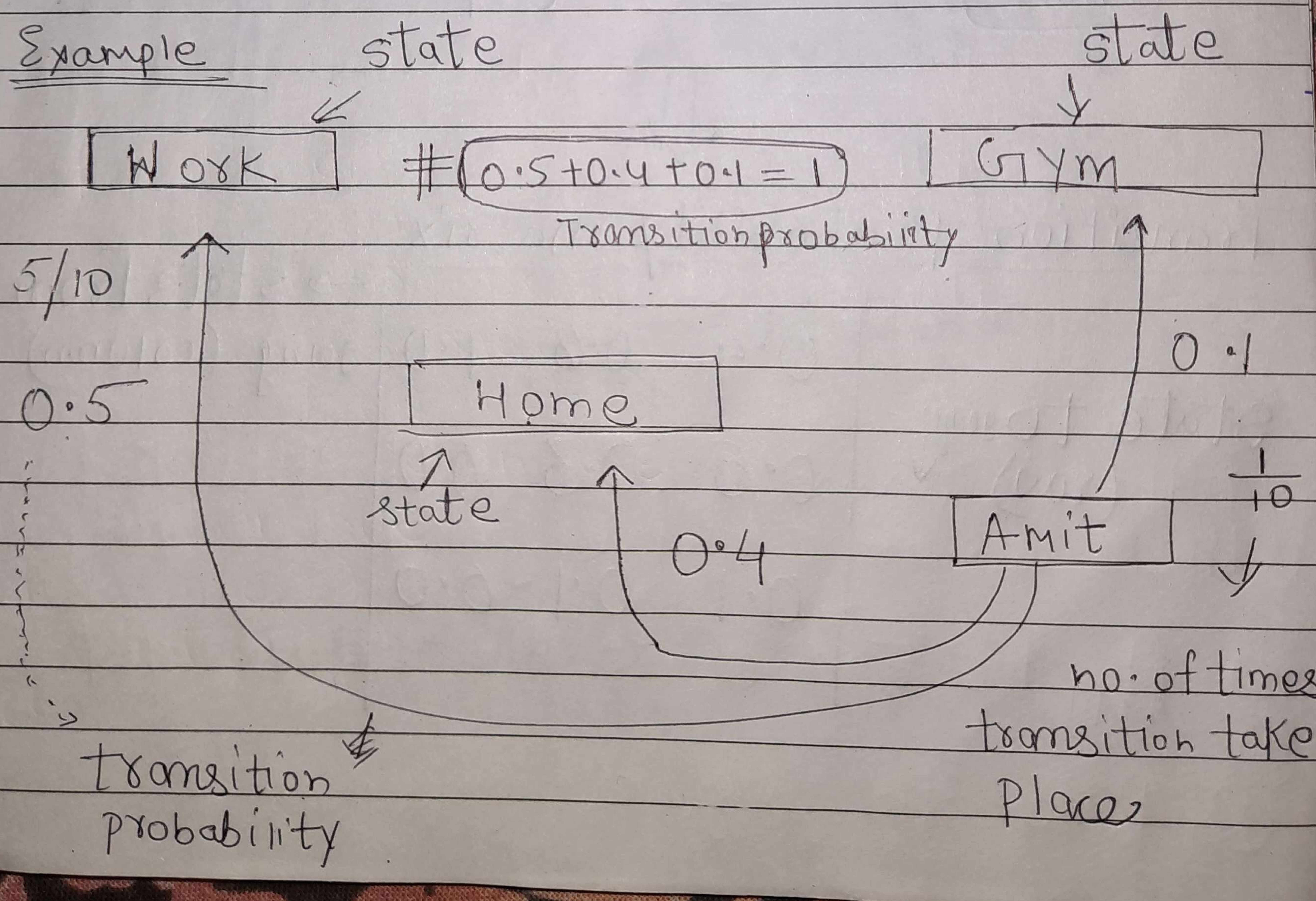
Markov Model (Andrey Markov (1856-1922)

DATE : __ - __ - ____

- Markov process is change of events that are (memoryless).
- This is the asumption that next event will going to happen depend completely on what is happening now (current event)

Previous Event → Current Events → Next Events

Example



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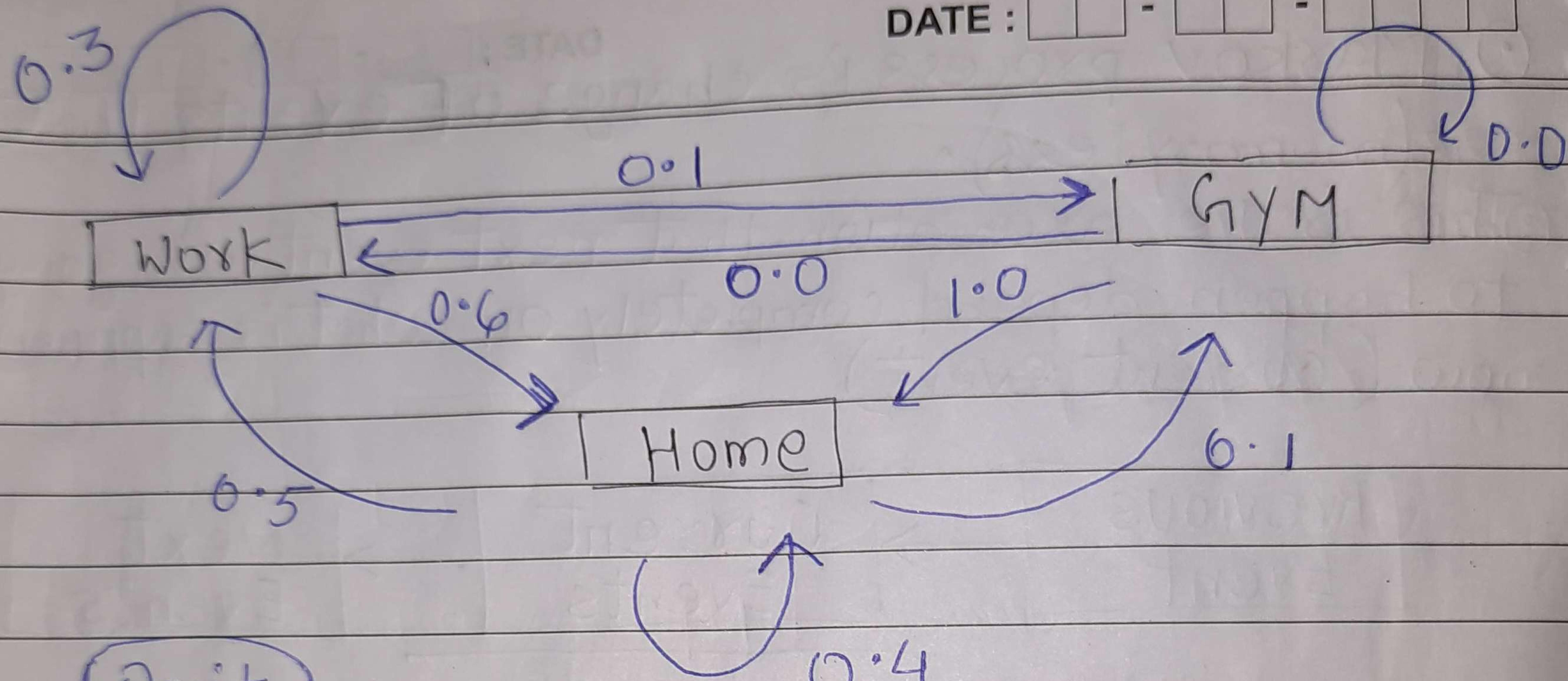


Amit

$\Downarrow$

Transition Probability matrix

$$
\begin{array}{c|c|l}
 & & \rightarrow \text{state from going (column)} \\
\text{state to going} \downarrow \\ \text{(row)} & \begin{matrix} 0.4 & 0.6 & 1.0 \\ 0.5 & 0.3 & 0.0 \\ 0.1 & 0.1 & 0.0 \end{matrix} &
\end{array}
$$

$n = 2, 3 \ldots r$ times

$\therefore$ n = used to find the position of "Amit" after two event, n event, n cycle, in future

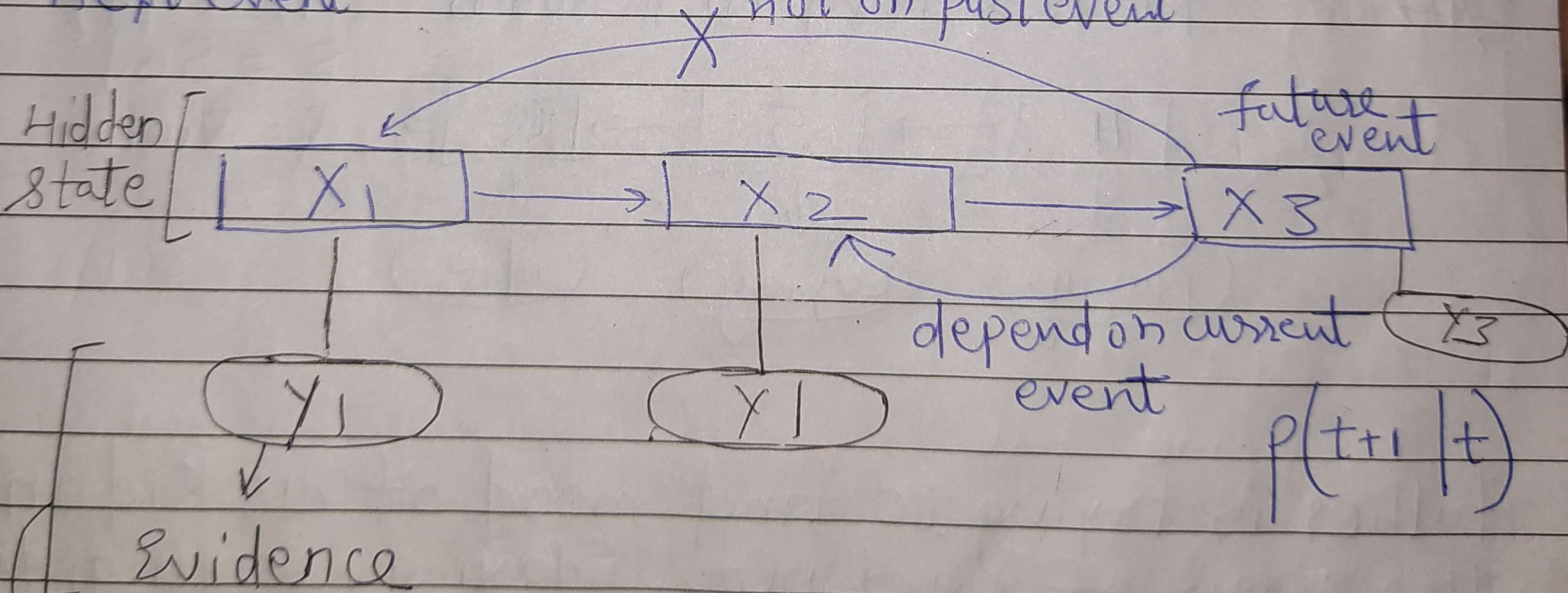
DATE :

3

$$\begin{bmatrix} 0.4 \\ 0.5 \\ 0.1 \end{bmatrix} = \begin{bmatrix} 0.4 & 0.6 & 1.0 \\ 0.5 & 0.3 & 0.0 \\ 0.1 & 0.1 & 0.0 \end{bmatrix}^{n} * \begin{bmatrix} 1.0 \\ 0.0 \\ 0.0 \end{bmatrix}$$

↑ Starting Probability vector

Prediction next event



$p(t+1 \mid t)$

Observable state → Emit signals

DATE : __ - __ - ____

Weather →

Sunny — Umbrella
Rainy — Coat
Cloudy — Short

Transition Probability $P(t+1 \mid t)$

Hidden state: $X_1 \to X_2 \to X_3$

Observable state: Coat, Short, Umbrella

Emission Probability

→ Evidence, emit signals

Ex → Kid is sitting in 1 Room

H = Happy
S = Sad
Q = Quite

$H \to S \to Q \to$

Playing, Crying, idle

father is trying to find mood of his Kid on the basis of evidence {playing, crying, idle}

(1) Application of Hidden Markov model

(a) POS tagging

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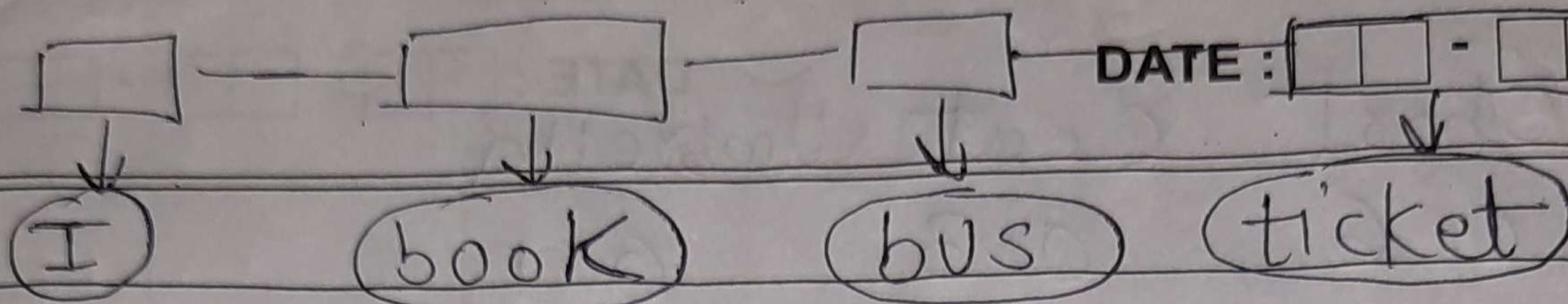
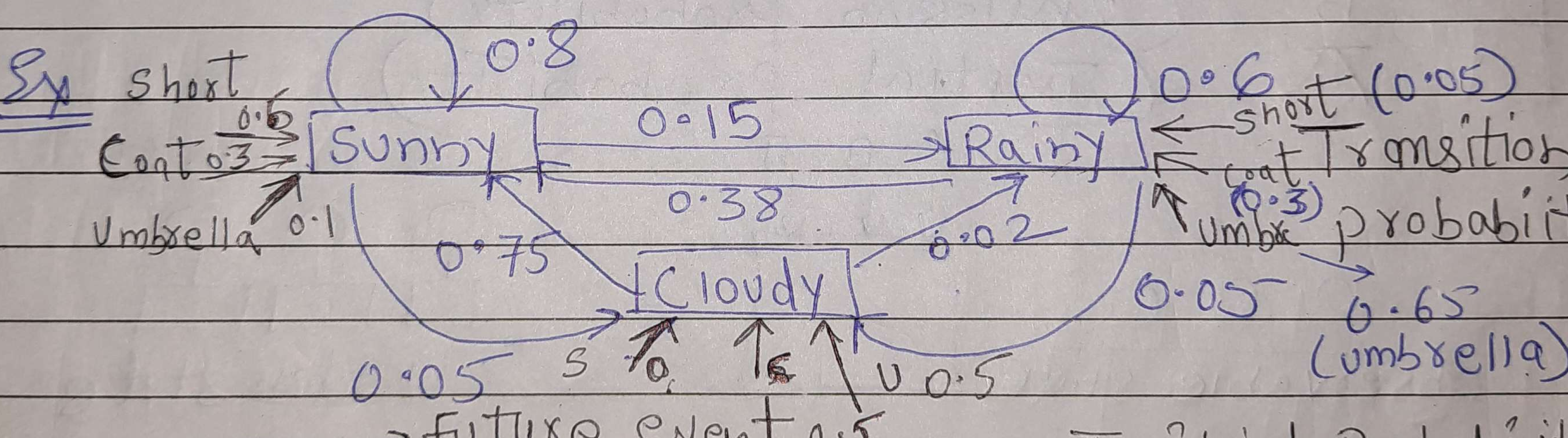


HMM

- States
  - Hidden state
  - Observable state
- Probability
  - Transition Probability
  - Emission Probability
  - Initial Probability

Ex



→ future event 0.5

current event ↓

	SU	RA	CL	
SU	0.8	0.15	0.05	=1
RA	0.38	0.6	0.02	=1
CL	0.75	0.05	0.2	=1

Initial Probability

$$\pi = \begin{array}{ccc} S & R & C \\ \end{array}$$
$$\pi = [0.75 \quad 0.2 \quad 0.05$$

3 state = 3 × 3 matrix

~~Short~~

DATE : __ - __ - ____

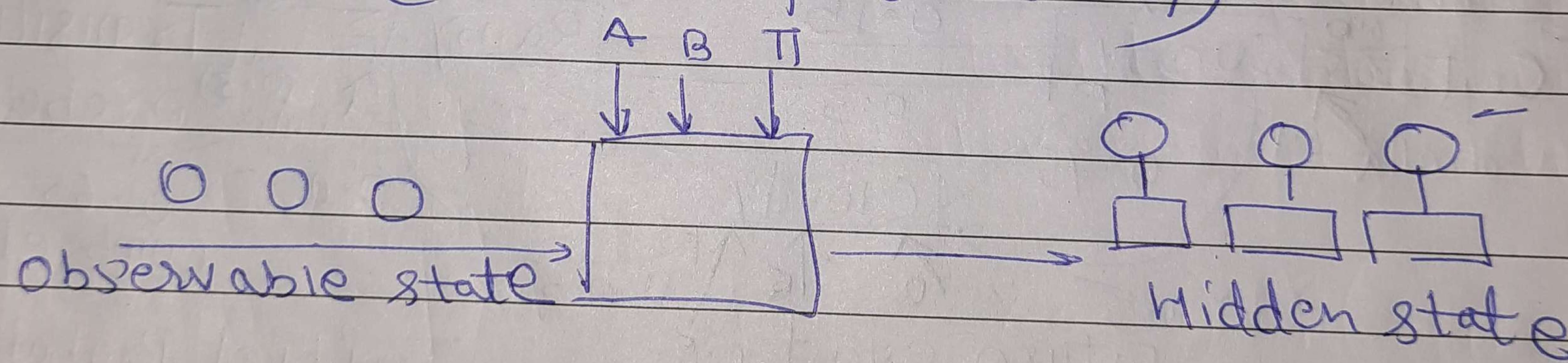
	Short	Coat	Umbrella
Sunny	0.6	0.3	0.1
Rainy	0.05	0.30	0.65
Cloudy	0	0.5	0.5

Data ~~avita~~ available

$X \xrightarrow{} \boxed{} \xrightarrow{} Y$

feature o/p

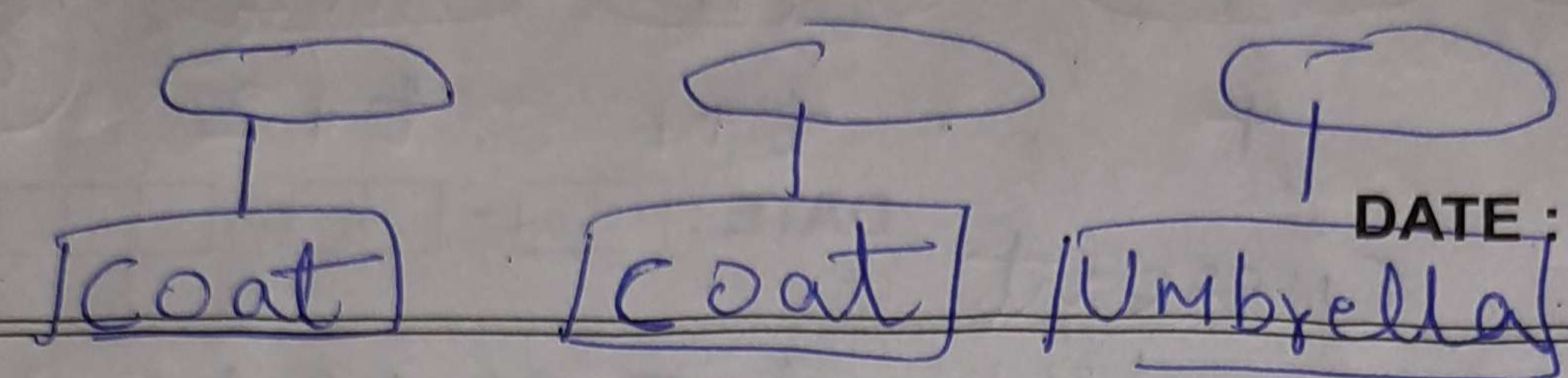
Machine learning
- Dataset (Train + Test)
- A (Transition Probability)
- B (Emission Probability)
- π (Initial Probability)



① Observable state (given) $\xrightarrow{\text{find out}}$ Hidden state

② Hidden state $\xrightarrow{\text{find out}}$ Observable state

③ or both



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A markov model is stochastic model used to model randomly changing system. It is assumed that future states depend on the current state, Not on the event that occured before it (Wickipedia)

event state system

Markov process

x_1 — past $(t-1)$

x_2 — current (t)

x_3 — future $(t+1)$

$(t+1)$ depend on (t) event Not on $(t-1)$.

$S = \{x_1, x_2, x_3\}$
state space of state

N = distinct state

depend on previous event

Weather → Sunny Rainy cloudy
Mobile → Samsung, Apple, Mortorola
Infant → playing, crying, sleeping

~~Short~~

⑥

DATE : __ - __ - ____

	Short	Coat	Umbrella
Sunny	0.6	0.3	0.1
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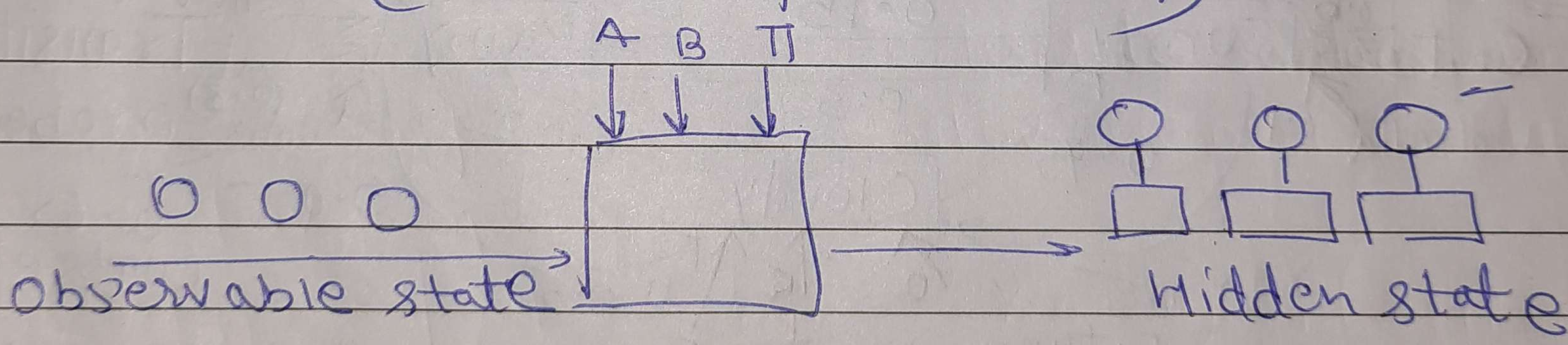
Data ~~avita~~ available

$\underset{\text{feature}}{X} \rightarrow \square \rightarrow \underset{\text{o/p}}{Y}$

Machine learning

- Dataset (Train + Test)
- A (Transition Probability)
- B (Emission Probability)
- π (Initial probability)



1. Observable state (given) $\xrightarrow{\text{findout}}$ Hidden state
2. Hidden state $\xrightarrow{\text{findout}}$ Observable state
3. or both

$X_{t-2} \to X_{t-1} \to X_t \to X_{t+1} \to X_{t+2}$

$t-2 \quad t-1 \quad t \quad t+1 \quad t+2$

DATE : __ - __ - ____

Markov chain. current

$P(X_t \mid X_{t-1})$ = Conditional Probability

$\therefore$ first order markov model

$$P_{ij} = P(X_t = j \mid X_{t-1} = i)$$

from state (i) move to state (j)

Any chain/ process of event that follow markov property is called markov chain

Let $\{X_0, X_1, X_2 \ldots\}$ be a sequence of discrete random variable

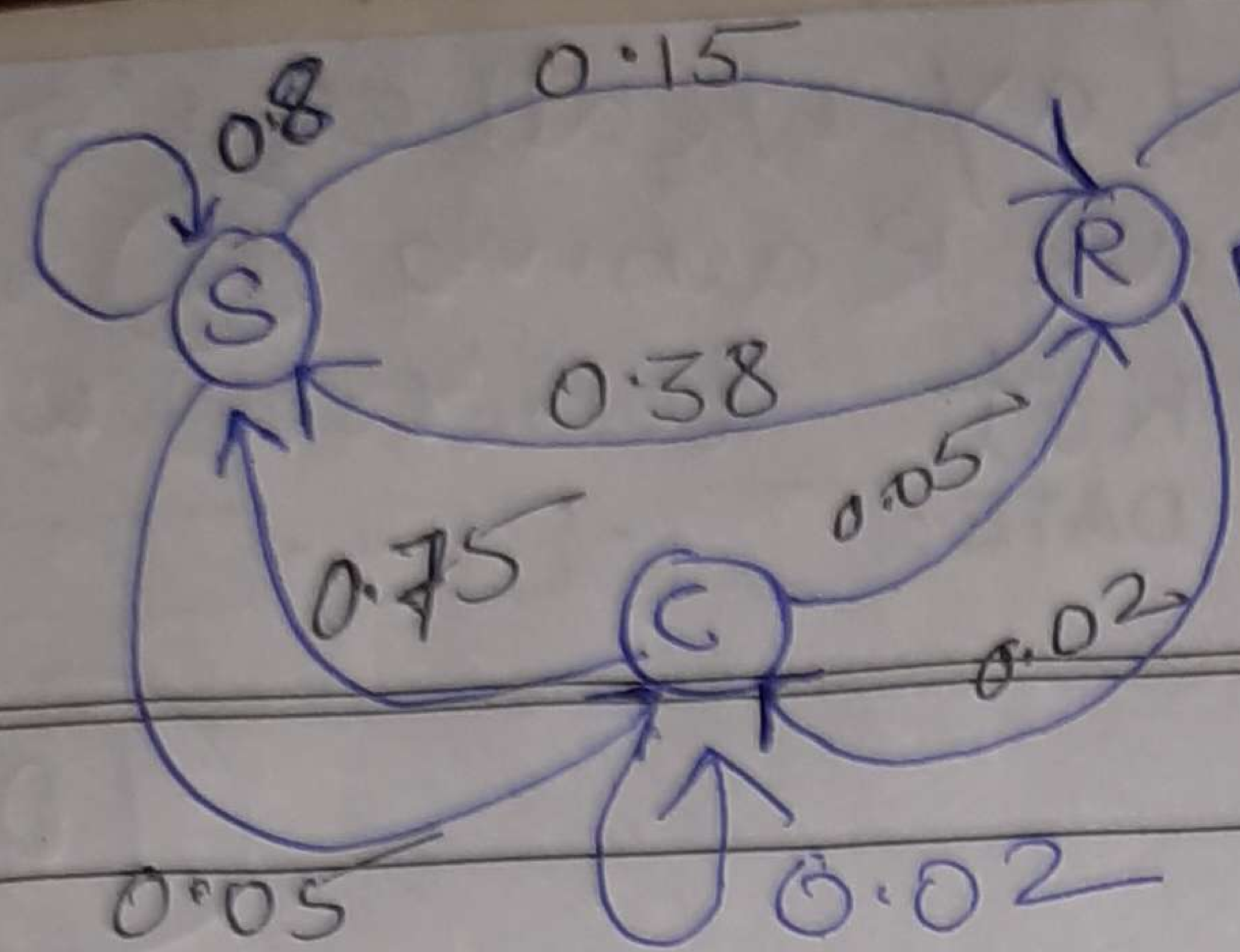
$\{X_1, X_2 \ldots X_n\}$ is called Markov chain if it satisfy the markov property.

$$P(X_{t+1} = S \mid X_t = S_t, \ldots \ldots X_0 = S_0) = P(X_{t+1} = S \mid X_t = S_t)$$

$X_{t+1} \quad X_t \quad X_{t-1}$

Second order Markov model ⇒

$$P(X_t \mid X_{t-1}, X_{t-2})$$



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2 State space

$S = \{S, R, C\}$

9

DATE : __-__-____

3 Initial state distribution

4 $\pi = \{0.7, 0.25, 0.05\}$

$\downarrow S \quad \downarrow R \quad \downarrow C$

Ques

Given that today the weather is Sunny (S), what is probability that if tomorrow is Sunny (S) & day after tomorrow Raining (R)

Solution t_1 = Sunny (S), t_2 = Sunny (S)

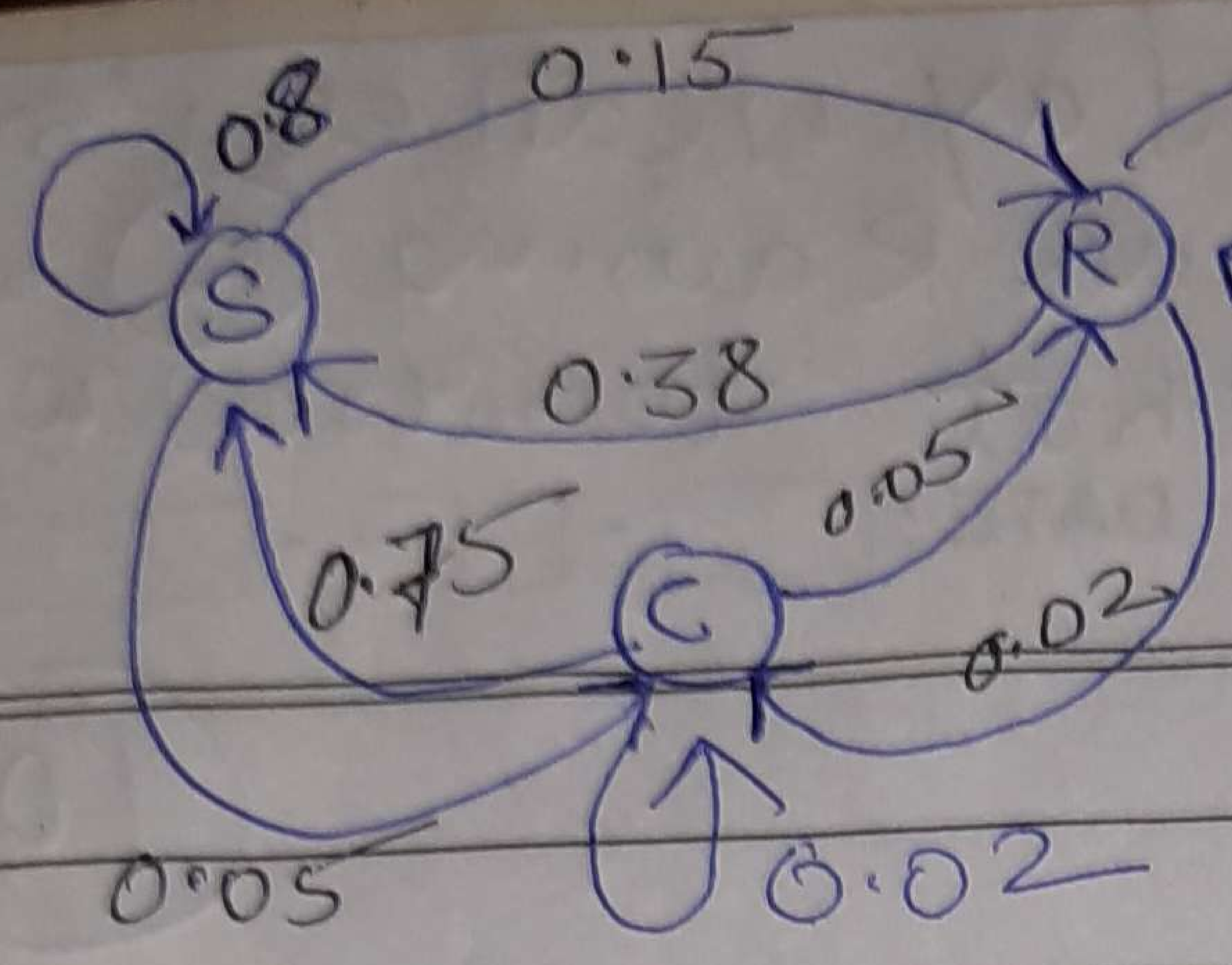
t_3 = Raining (R)

$$P(t_3 = R, t_2 = S \mid t_1 = S) = p(t_3 = R \mid t_2 = S) * p(t_2 = S \mid t_1 = S)$$

$$\Rightarrow 0.15 \times 0.8 = 0.120$$

$\boxed{\text{Answer} = 12\%}$

$$\boxed{p(t_1, t_2 \dots t_n) = \prod_{i=1}^{n} P(t_i \mid t_{i-1})}$$



(1)

(2) State space

$S = \{S, R, C\}$

(3) Initial state distribution

(4) $\pi = \{0.7, 0.25, 0.05\}$

$\downarrow$ S $\quad\downarrow$ R $\quad\downarrow$ C

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Given that today the weather is Sunny (S), what is probability that if tomorrow is Sunny (S) & day after tomorrow Raining (R)

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$$\boxed{p(t_1, t_2 \ldots t_n) = \prod_{i=1}^{n} p(t_i \mid t_{i-1})}$$

Q = Given that the today weather is Cloudy (C) & yesterday has Raining (R). Then what is probability that tomorrow would be Sunny (S)?

DATE : ☐☐ - ☐☐ - ☐☐☐☐

10

Ans

$t_1 = R \qquad t_2 = C \qquad t_3 = S$

$P(t_3 = S \mid (t_2 = C, t_1 = R))$

$\Rightarrow$

$\Rightarrow P(t_3 = S \mid t_2 = C) * P(t_2 = C \mid t_1 = R)$

$= 0.75 * 0.02 = 0.0150 = 1.5\%$ probability

Q What is the probability of series (given)?

$\boxed{S} \quad \boxed{R} \quad \boxed{R} \quad \boxed{R} \quad \boxed{C} \quad \boxed{C}$

$P(S) * P(R \mid S) * P(R \mid R) * P(R \mid R) * P(C \mid R) * P(C \mid C)$

$\Rightarrow 0.7 * 0.15 * 0.6 * 0.6 * 0.02 * 0.2$

$\Rightarrow 0.0001512$