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Theory of Computation

1. Automata Theory } Mid Term
2. Push Down Automata
3. Pursing Machine

Book : Ullman

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Class - 01, 02 — 16/09/25

Symbol:

- সব কিছু Symbol এর অন্তর্ভুক্ত।

$A \to Z$, $a \to z$, $0 \to 9$

Alphabet:

Finite Number of Symbol. Σ চিহ্ন দিয়ে Represent করা হয়।

$\Sigma = \{a, b\}$, $\Sigma = \{0, 1, 2\}$

String:

Alphabet নিয়ে গঠিত যে কোনো Possible Combination. কোনো string এর Length বা value = $|abc| = 3$, $|aab| = 3$.

Empty element কে ε (EF Silon) দিয়ে Represent করা হয়।

$|a\varepsilon b| = 2$, $|aa\varepsilon a| = 3$

Power:

Σ^1 = Power: 1, → Alphabet নিয়ে গঠিত 1 Length এর Combinati

Σ^3 = Power: 3 → Alphabet নিয়ে গঠিত 3 Length এর Combinatio

Closser:

1. Positive Closser (Σ^+):

$$\Sigma^+ = \Sigma^1 \cup \Sigma^2 \cup \Sigma^3 \cup \Sigma^4 \ldots\ldots$$

2. Kleen Closser (Σ^*):

$$\Sigma^* = \Sigma^0 \cup \Sigma^1 \cup \Sigma^2 \cup \Sigma^3 \cup \Sigma^4 \ldots\ldots$$

Note:

$\Sigma^0 = \varepsilon$

GOOD LUCK

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Automata Theory :-

L(1) = set of all string of length 1. L দ্বারা Language বুঝানো হয়।

Automata = Automatic কাজ করতে পারে এমন Device.

Automata → Finite [Syllebus]
Automata → Infinite X

Finite Automata তে Memory তে set store থাকে।

Q → set of all states. Σ = set of Alphbets.

δ → Transition function. q_0 = start point / starting state.

F → ~~Finish Point~~ // set of Finishing states

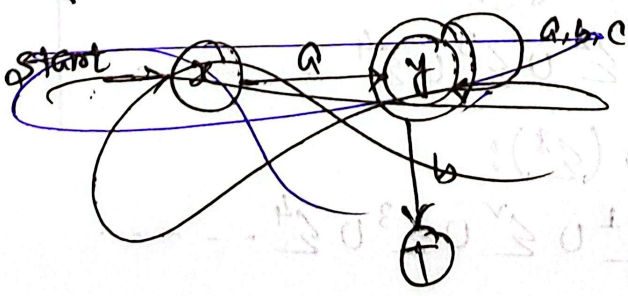
কোনো একটি System এর starting Point থাকে একটা এবং Finishing Point একাধিক থাকতে পারে।

Finite Automata = {Q, Σ, δ, q_0, F}

Finite Automata ২ প্রকার।
1. F.A with output.
2. F.A without output.
DFA NFA ε-NFA

DFA = Deterministic F.A.
NFA = Non-Deterministic F.A

* Transition Function এর দুটি Concept: → 1. Diagram, 2. Table.



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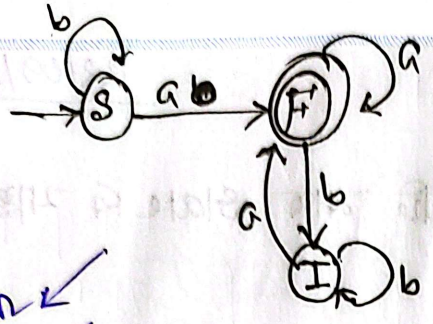


Diagram of → A machine which ends at "a".

Transition Diagram

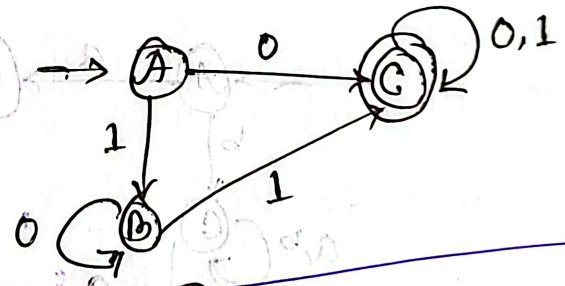
Alphaset →

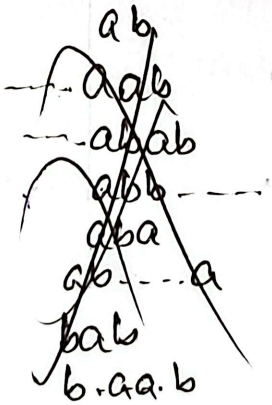
States	a	b
→S	F	S
*F	F	I
I	F	I

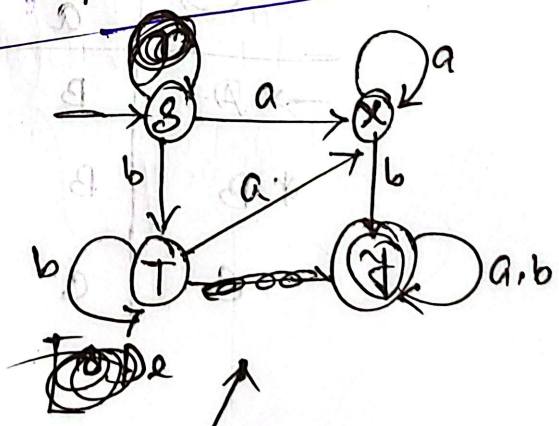
[Diagram to Table]

* Table to Diagram :-

	0	1
→A	C	B
B	B	C
*C	C	C







Question : Design a F.A of L(m) = set of all string having "a" followed by "b"

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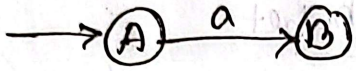
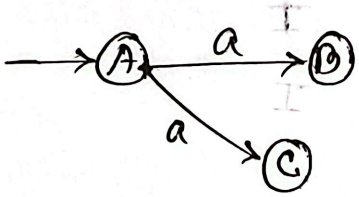
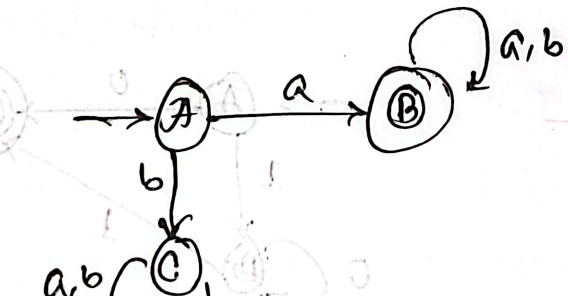
একটি Alphabet নিয়ে যদি একটি মাত্র State এ যাওয়া যায় তাকে Deterministic F.A বলে।



- যদি একাধিক State এ যাওয়া যায়, তাকে Non-Deterministic F.A বলে।





	a	b
→ A	B	C
* B	B	B
C	C	C

* Defination of DFA:-

A DFA is a finite state machine, where each input leads to exactly one next state.

$DFA = \{Q, \Sigma, \delta, q_0, F\}$

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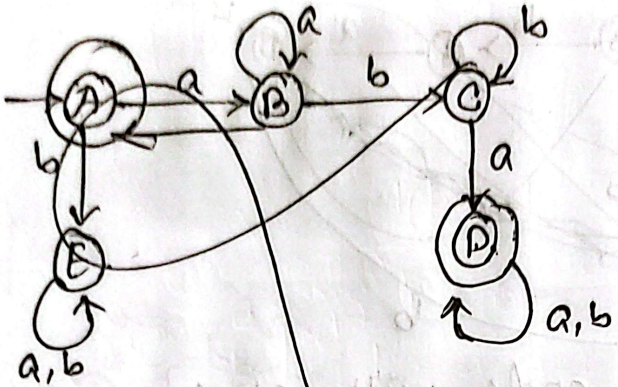
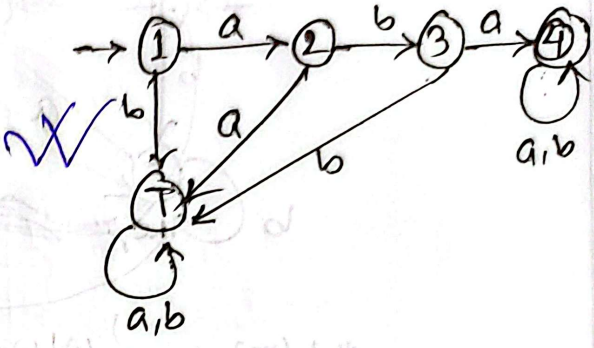
* L(m) = {w|w: start with 'aba'}

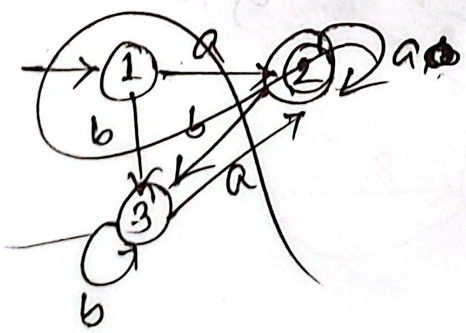


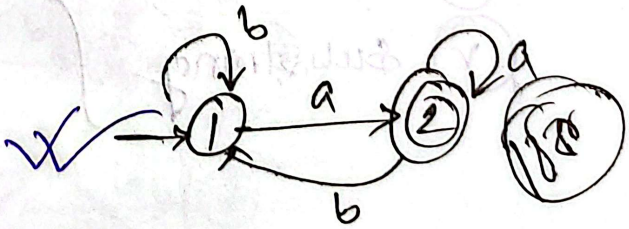


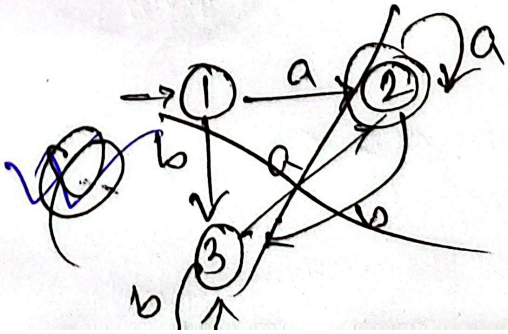
	a	b
→ A	B	E
B	B	C
C	D	C
* D	D	D
E	E	E

bba
aaaa
bbba
bbbaaa
abaaaa
bbaa
b

* L(m) = {w|w: ends with 'a'}







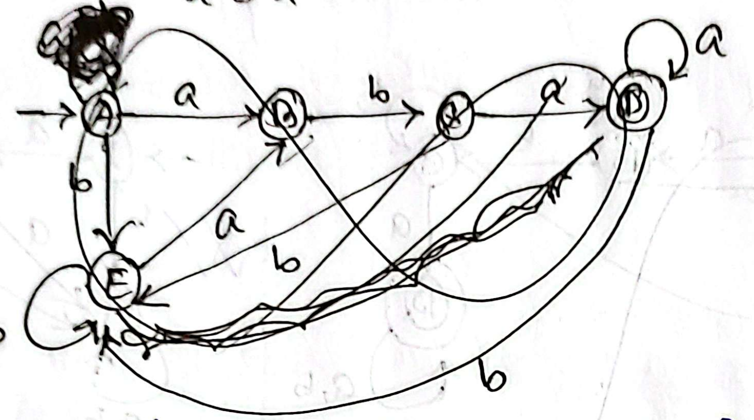
GOOD LUCK

aba
~~bab~~ abb
aabaa
bbaba
bba

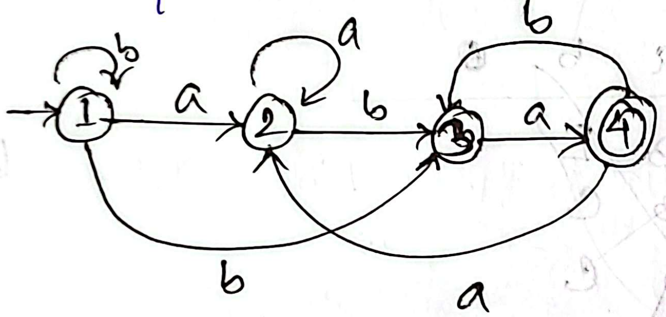
TOPIC NAME : DAY : TIME : DATE / /

baabaa
bab
bba

aba



* L(m) = {w|w: ends with 'aba'}



(i) Start with
(ii) Ends with
(iii) Followed by
(iv) Contains
(v) Substring

} একই অর্থ বুঝায়

'a' followed by 'b' = ab

maam

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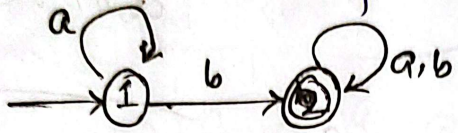
#Class-06 05/10/2025

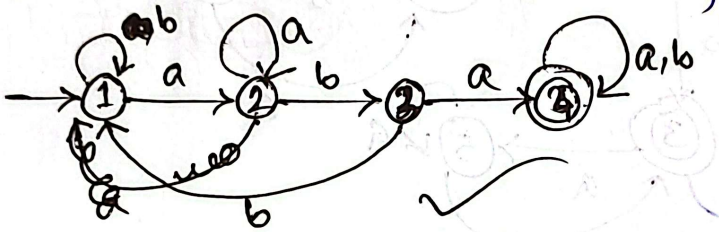
$L(1) = \{w | w : \text{contains 'b'}\}$



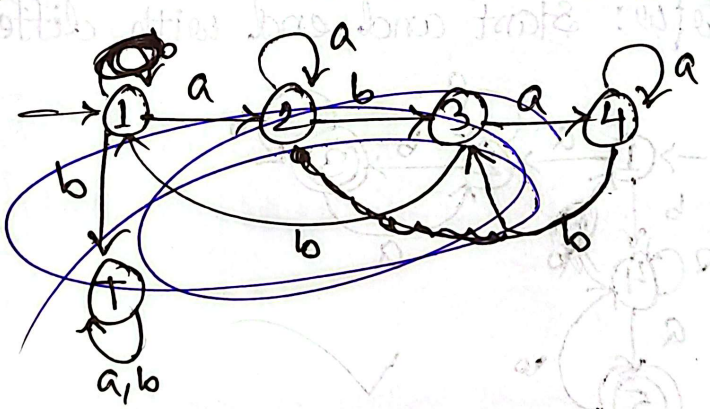
abba

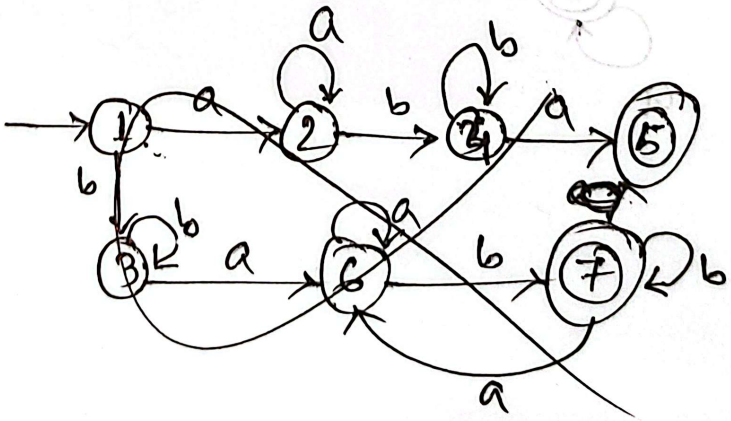
$L(1) = \{w | w : \text{contains substring 'aba'}\}$

aba



$L(1) = \{w | w : \text{Starts and Ends with same symbol}\}$





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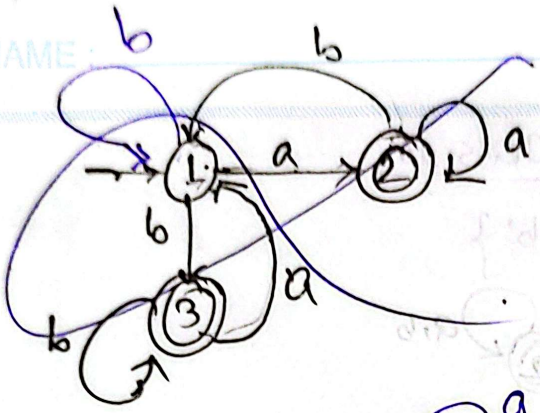
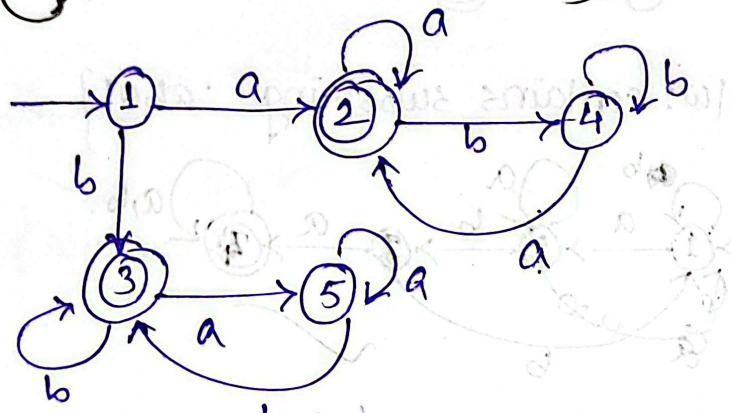


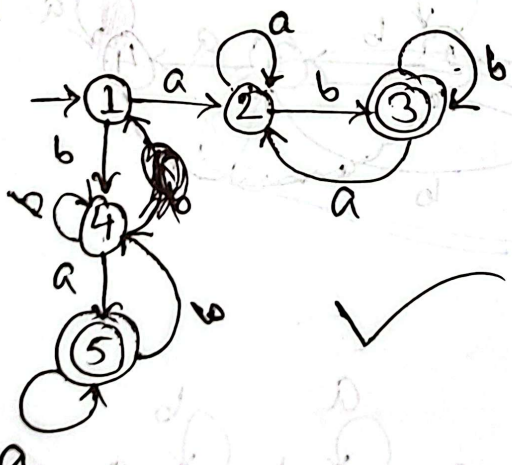
ab

abba

ba



$L(1) = \{ w \mid w$: start and end with different symbol $\}$



✓

aabb
abab
baba
bbaa

abba
baab

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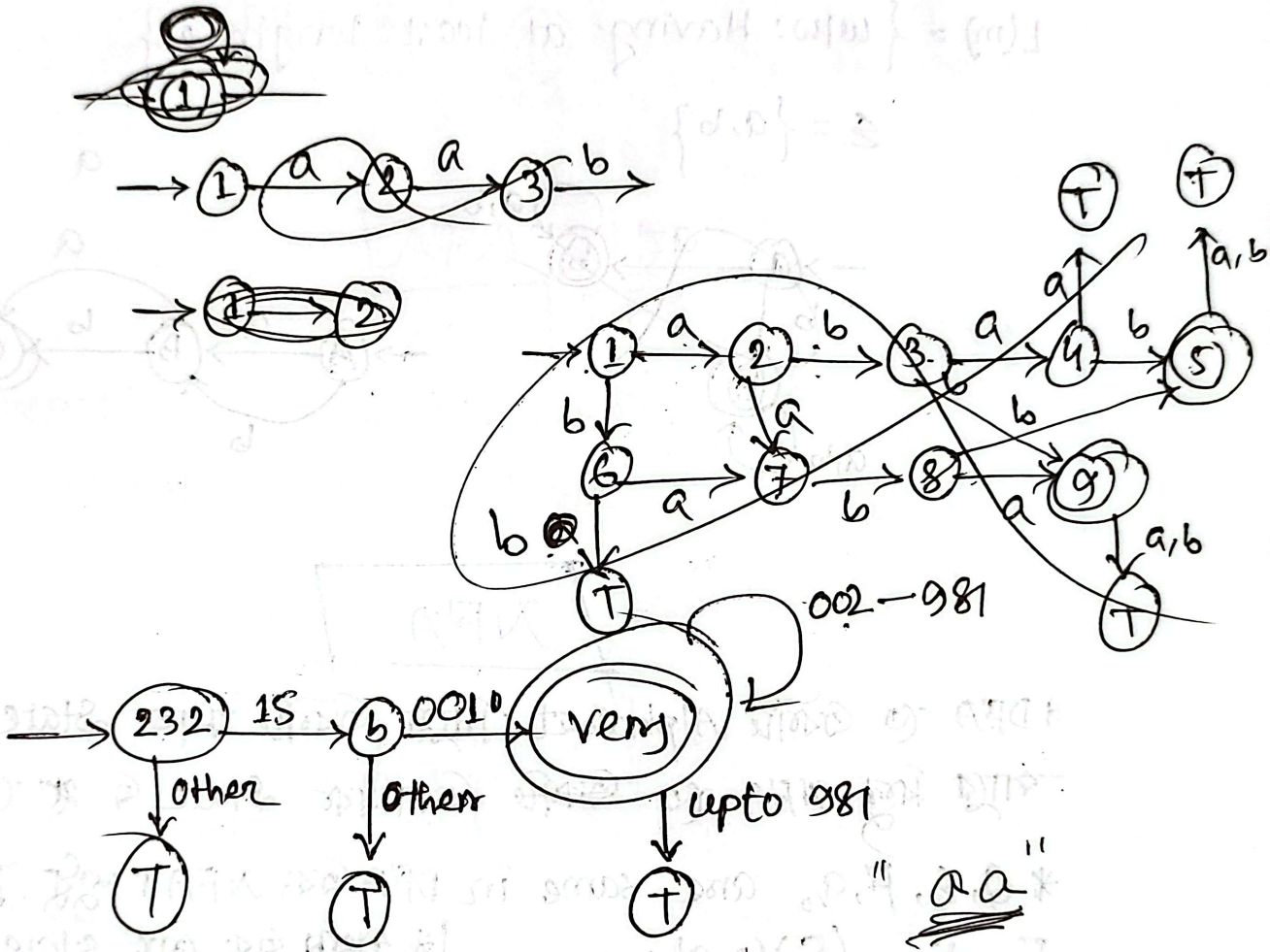
$L(1) = \{w | w$: even number of 'a' and even nuber of 'b'$\}$



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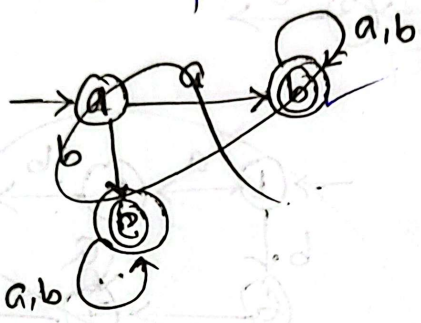
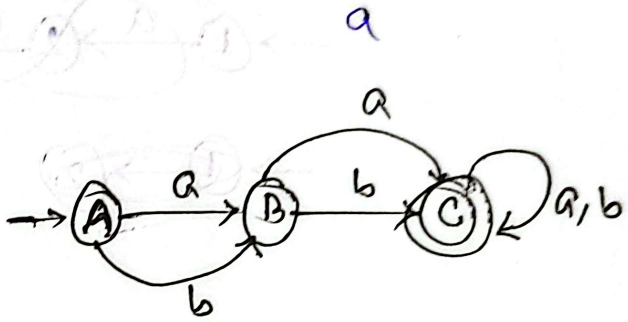
$L(m) = \{w | w$: Having at least length 2$\}$

$\Sigma = \{a, b\}$





NFA

* DFA তে একটি Alphabet নিয়ে একটি মাত্র State এ যেতে পারে কিন্তু NFA তে একটি একাধিক State এ যেতে পারে।

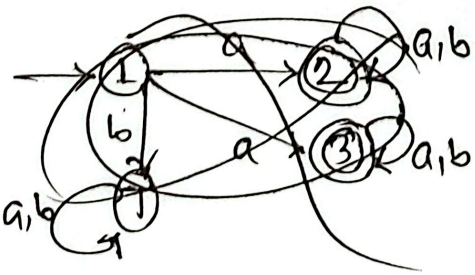
* Q, Σ, F, q_0 are same in DFA এবং NFA। শুধু Transition Function (δ) এ change.

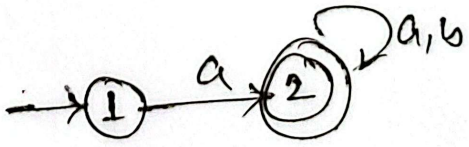
$\delta = \Sigma \times Q = Q$ (DFA)

$\delta = \Sigma \times Q = 2^Q$ (NFA), T এর পরিবর্তে ϕ ব্যবহৃত হয়।

* প্রথম এবং শেষ state ছাড়া একাধিক way / Loop থাকবে না।

$L(1) = \{w | w$: start with 'a'$\}$





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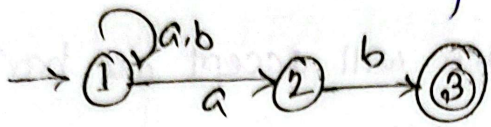
$L(1) = \{w/w : \text{ends with 'ab'}\}$



NFA To ~~DAF~~ DFA

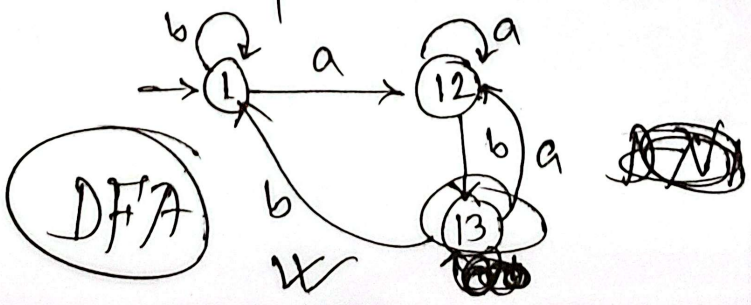
~~Ed~~ Steps :

1. Construct Transition Table.

	a	b
→ 1	{1,2}	{1}
2	{ }	{3}
* 3	{ }	{ }

2. Construct NFA Table to ~~DAF~~ DFA Table :

	a	b
→[1]	[12]	[1]
[12]	[12]	[13]
* [13]	[12]	[1]



GOOD LUCK

abbab

ab

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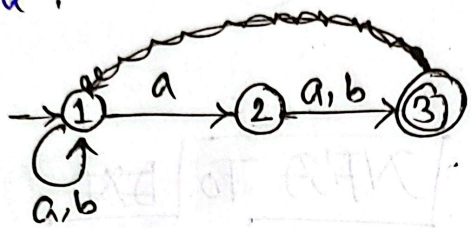
* Constract a NFA which will accept all having second last element as "a".



Note:

NFA design এর সময় Start with something বললে Final state এ self-loop হবে।

End with something বললে start state এ self-loop হবে।

Contain something বললে start এবং Final উভয়ে self-loop হবে।

* Convert this NFA to DNFA.

1. Step: 01

State Transition Table: —

	a	b
→ 1	{1,2}	{1}
2	{3}	{3}
* 3	{ }	{ }

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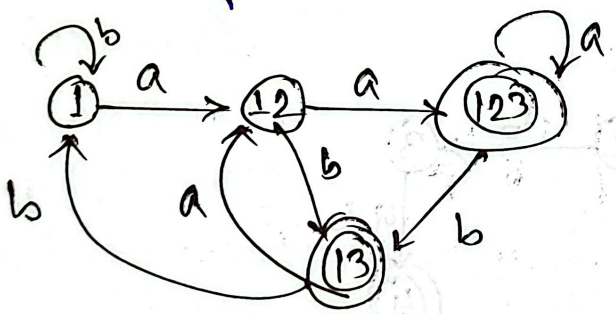
2. Step:02

State Equivalent DFA Table:-

	a	b
[1]	[12]	[1]
[12]	[123]	[13]
[123]	[123]	[13]
[13]	[12]	[1]

3. Step:03

State DFA Diagram:-



Question: Contract NFA to DFA.

Answer:

	a	b
→ 1	{2}	{ }
2	{ }	{3}
3	{4}	{4}
* 4	{ }	{ }

Step:01 S.T.T

	a	b
[1]	[2]	[T]
[2]	[T]	[3]
[3]	[4]	[4]
* [4]	[T]	[T]

Step:02 S.E.D.T

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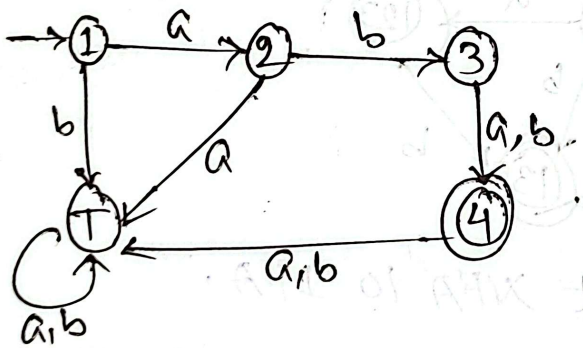
Step:02

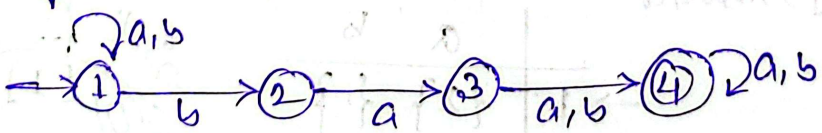
S.E.D.T:

	a	b
→ [1]	[2]	[T]
[2]	[T]	[3]
[T]	[T]	[T]
[3]	[4]	[4]
*[4]	[T]	[T]

Step:03



Question:- Show the extended transmission functions for the string "aababb"



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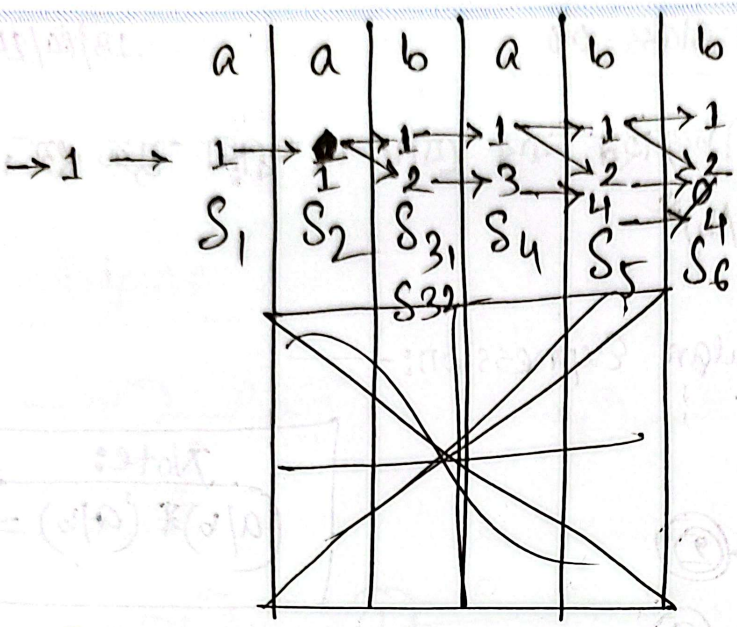

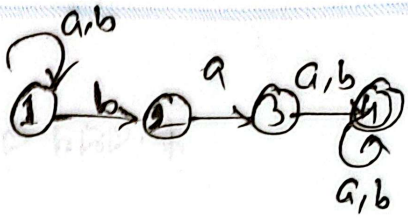

Transition function

$\delta \quad Q \times \Sigma \rightarrow 2^Q$

$\delta_1 (1 \times a \rightarrow 1)$

$\delta_2 (\delta_1 \times a \rightarrow 1)$

$\delta_{31} (\delta_2 \times b \rightarrow 1), (\delta_2 \times b \rightarrow 2)$

~~$\delta_4 (\delta_3 \times a \rightarrow 1), (\delta_3$~~

$\delta_{32} (\delta_2 \times b \rightarrow 2)$

$\delta_4 (\delta_{31} \times a \rightarrow 1)$

$\delta_{51} (\delta_4 \times b \rightarrow 1)$

$\delta_{52} (\delta_4 \times b \rightarrow 2)$

☑ Regular Expression: ——

$(a/b)^* a (a/b)^+$

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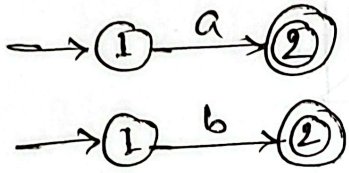
* এমন একটি মেশিন ডিজাইন কর যেটি a দ্বারা শুরু হয়।

$a(a/b)^*$

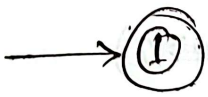
6 Rules of Regular Expression:—

1. $R = a$, $R = b$



Note:
$(a/b)^* (a/b) = (a/b)^+$

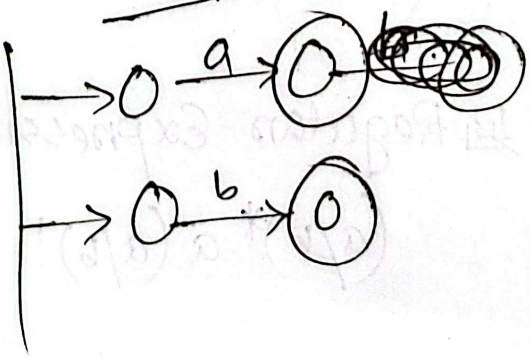
২. $R = \varepsilon$, এর মানে শুরু এবং শেষ state একই।



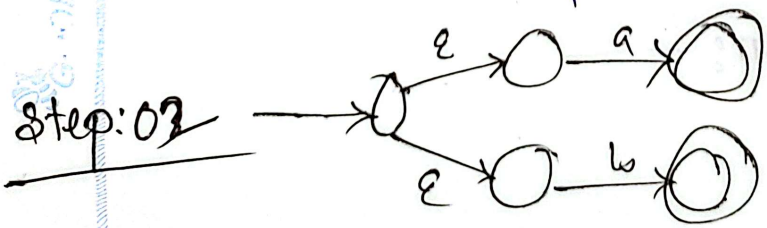
3. $R = \emptyset$, এর মানে final state নেই।

4. $R = a \cup b$
$R = a/b$
$R = a, b$
} Union

Step:01



Step:02



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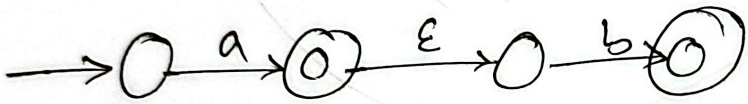
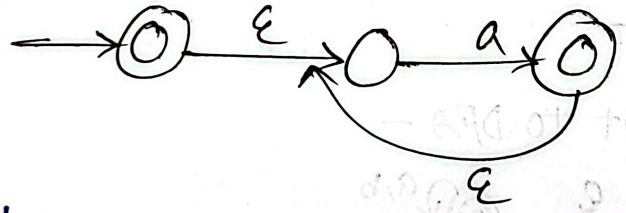
5. $R = a.b$
$= ab$
$= a \times b$
} Intersection

Step:01

Step:02

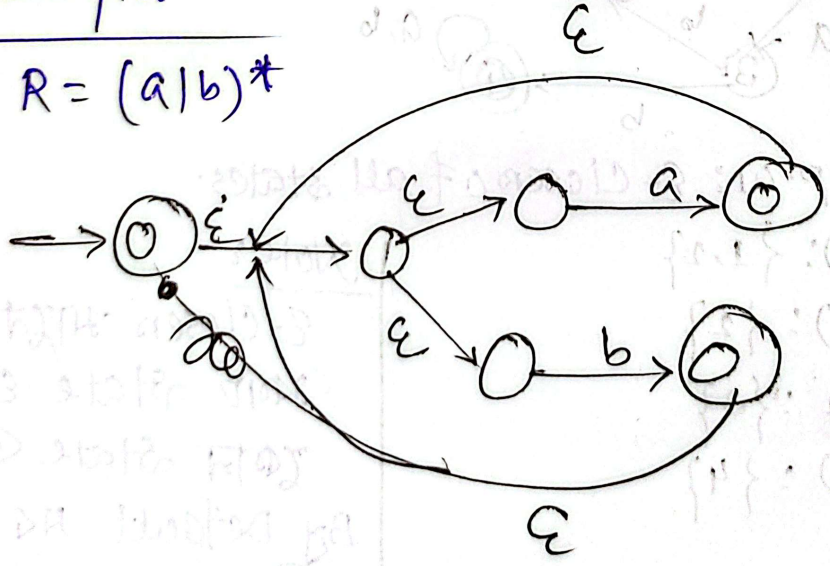


6. $R = a^*$, -যেহেতু Klean closero সেহেতু শুরুতেই Final একটি state থাকতে হবে।



Example:-

$R = (a|b)^*$



GOOD LUCK™

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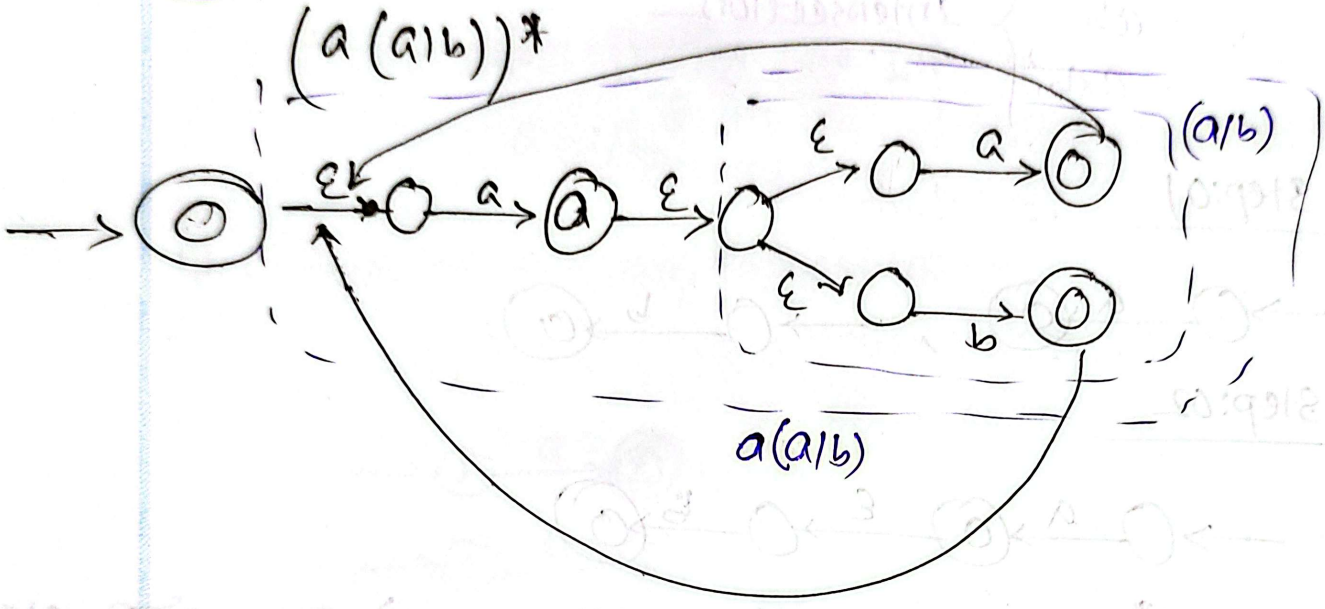
Example:

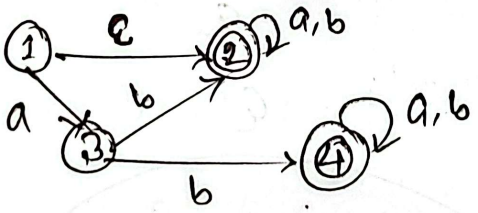


#Class-10

10/10/25

ε-NFA to DFA:

*Question: Convert it to DFA –



* Solution: Step-01: ε-Closer of all states.

ε- closer (1): {1,2}

ε- " (2): {2}

ε- " (3): {3}

ε- " (4): {4}

Note:

ε-Closer মানে কোনো একটি state ε বেলে কোন state এ যায়। By Default সব state ε নিয়ে নিজের state-এ থাকে।

AND LUCK

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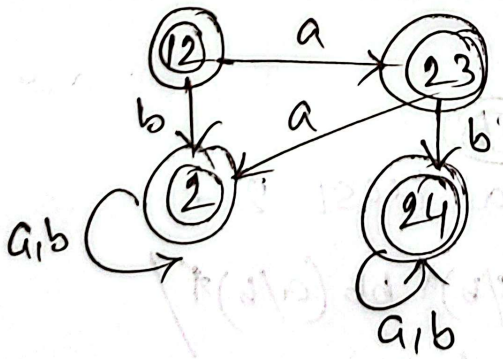
Step-02: State Transition Table: (NFA)

	a	b
→ 1	{3}	∅
*2	{2}	{2}
3	∅	{2,4}
*4	{4}	{4}

Step-03: State equivable Transition Table:

	a	b
→ * [12]	[23]	[2]
* [23]	[2]	[24]
* [2]	[2]	[2]
* [24]	[24]	[24]

Step-04: State Transition Diagram:-



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Regular Expression:

(*) এর মানে zero (ϵ) or more. Example: $a^* = \{\epsilon, a, aa, aaa, \ldots\}$

(+) " " one or more. Example: $a^+ = (a, aa, aaa, \ldots)$

Ques: Express regular expression of start with "a".

Soln: $a.(a/b)^*$ — অথবা, $a.(a^*/b^*)$

Ques: start with "ab".

Soln: $(a/b)^*.a$

Ques: Contains "a"

Soln: $(a/b)^* a (a/b)^*$

Ques: Contains "aba"

Soln: $(a/b)^* aba (a/b)^*$

Ques: String of length 2.

Soln: $(a/b).(a/b)$

Ques: String o length at least 2.

Soln: $(a/b)^* ab.(a/b)^* / (a/b)^* bb (a/b)^* / (a/b)^* aa (a/b)^* / (a/b)^* ba (a/b)^*$

সমাধান

$(a/b)^* (a/b) (a/b) (a/b)^*$

$(a/b)^* \cdot (a/b)^*$

(a/b)

Ques: String of length at most 2.

Soln: $aa/bb/a/b/ab/ba/\varepsilon$ অথবা, $\varepsilon/(a/b)/(a/b)(a/b)$

$= aa/a/bb/b/ab/ba/\varepsilon$

$= a(a+1)/b(b+1)/ab(1+1)/\varepsilon$

$=$

Ques: Even Numbers of "a".

$b \quad a = 0$

$b^* (a \cdot a)^* b^*$

$b \cdot a$

$(aa)^*$ → Soln:

$b^* (a \cdot a)^* b^*$

$b^* \; aa (a \cdot a)^* \; b^*$

↓

Ques: at least length 2 and even number of "a"