Class-01

Symbol, Alphabet, String

- **Symbol** – Basic building block of TOC. [Ex – a, b, 1, 2]
- **Alphabet** – Finite set of symbol.

$$\Sigma = \{a, b, c\}; \quad \Sigma = \{1, 2, 3\}$$

String – Finite sequence of symbols.

$$\omega = 0110; \quad \omega = abcd$$

Length of String – $\omega = ababa$

$\hookrightarrow |\omega| = 5$

Class-02

Language

→ Collection of strings which can be finite / Infinite.

Power of Σ (sigma):

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

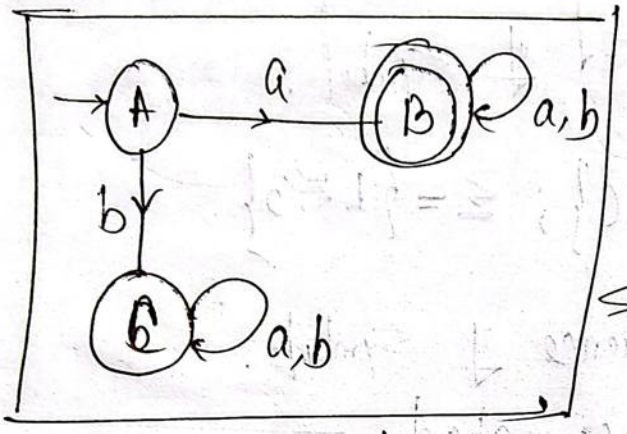
Σ^1 = Set of all string over this "Σ" of length "1"

Σ^2 = " " " " " "2"

Σ^0 = of length '0' [$= \{\varepsilon\}$]

Class-03

★ Finite Automaton



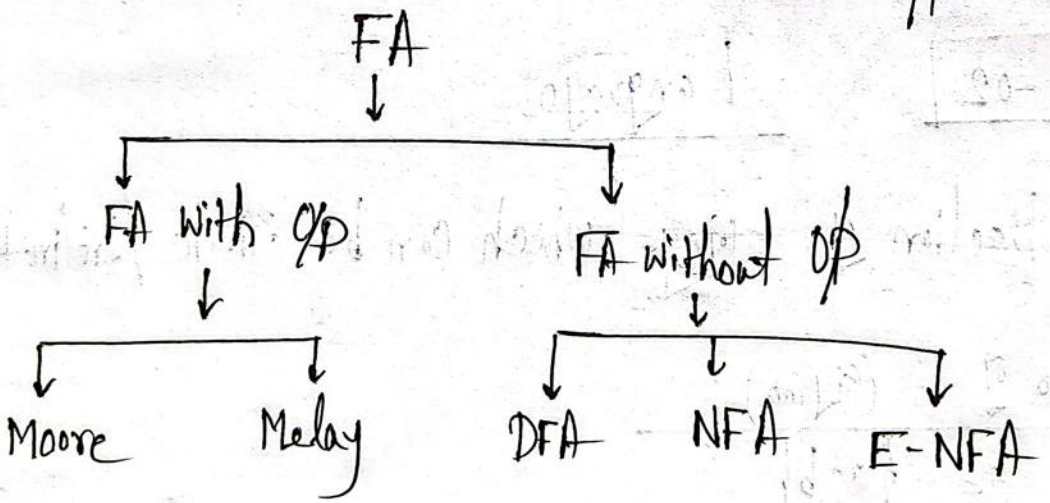
State transition Diagram

Finite Automaton

Class-04

DFA

o/p → output



✱ DFA (Deterministic Finite Automaton)

✱ DFA is a finite Automaton that Contain 5 tuples
→ $(Q, \Sigma, \delta, q_0, F)$

✱ In DFA for each input there will be one state.

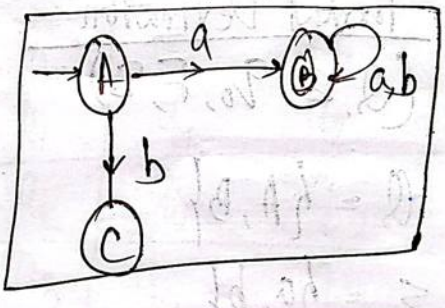
Q = Set of all state
= {A, B, C}

Σ = Input Alphabet
= {a, b}

q_0 = Start state = A

F = Set of final state(s) → one/more
= {B}

δ = transition function
= $Q \times \Sigma \rightarrow Q$



DFA

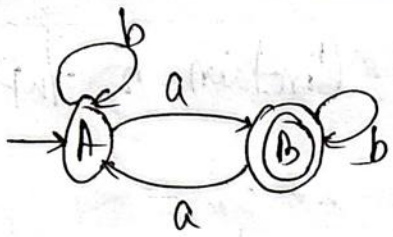
Σ = {a, b}

L(M) = Set of all string start with "a".

State	Input a	Input b
→ A	B	C
* B	B	B
C	C	C

Class - 05

Formal definition of DFA



M_1

Formal Definition

$(Q, \Sigma, q_0, F, \delta)$

$Q = \{A, B\}$

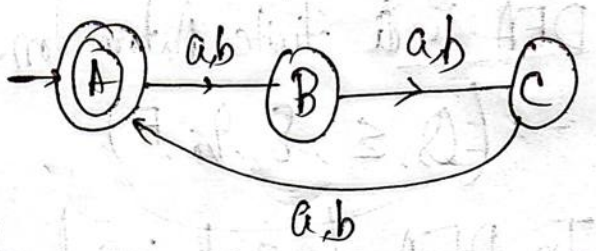
$\Sigma = \{a, b\}$

$q_0 = A$

$F = \{B\}$

$\delta : Q \times \Sigma \to Q$

State	a	b
→ A	B	A
* B	A	B



M_2

$Q = \{A, B, C\}$

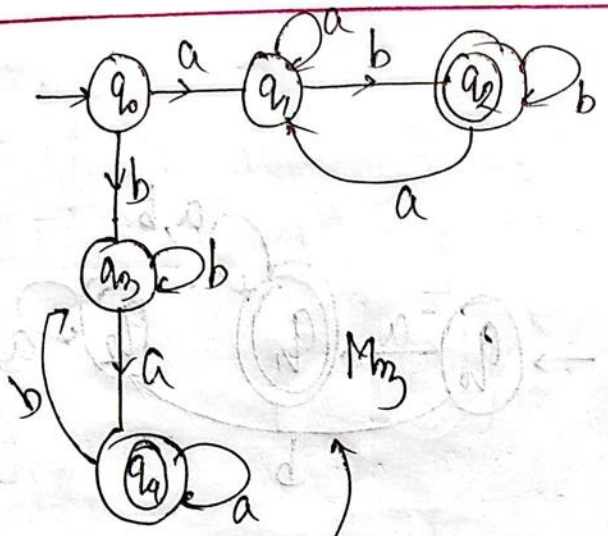
$\Sigma = \{a, b\}$

$q_0 = A$

$F = \{A\}$

δ:

State	a	b
→ * A	B	B
B	C	C
C	A	A



State Diagram

$Q = \{q_0, q_1, q_2, q_3, q_4\}$

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

$q_0 = q_0$

$F = \{q_2, q_4\}$

State	a	b
q_0	q_1	q_3
q_1	q_1	q_2
q_2	q_1	q_2
q_3	q_4	q_3
q_4	q_4	q_3

State Table

The formal description of a DFA M is $(\{q_0, q_1, q_2\}, \{a, b\}, \delta, q_0, \{q_1\})$. where δ is a given by the following table. Give the state diagram of the machine.

	a	b
q_0	q_1	q_2
q_1	q_1	q_1
q_2	q_2	q_2

Answer:

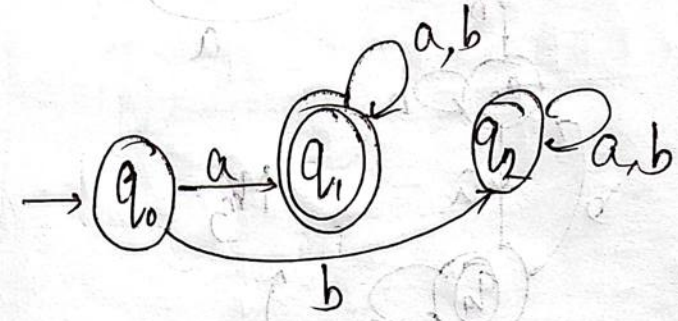
Given,

$Q = \{q_0, q_1, q_2\}$

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

$q_0 = q_0$

$F = q_1$

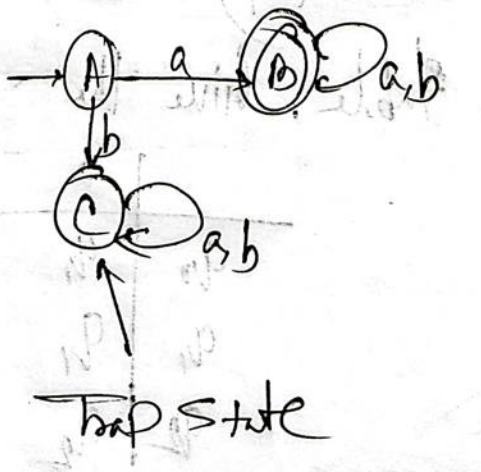


Lecture - 6 Construct DFA

Problem: Construct a DFA which accepts set of all strings over the $\Sigma = \{a, b\}$, where each string start with 'a'.

OR, $L(M) = \{w / w \text{ starts with an 'a'}\}$

Answer:



Lecture-7

Problem: Construct DFA for,

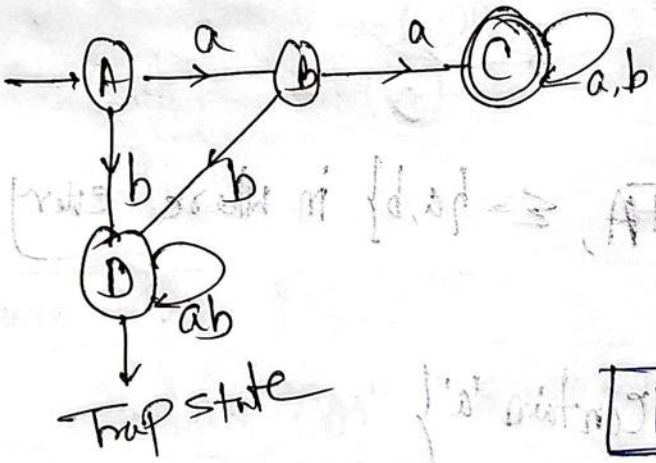
$L(M) = \{w/w \text{ start with 'aa'}\}$

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

Sol^n:

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

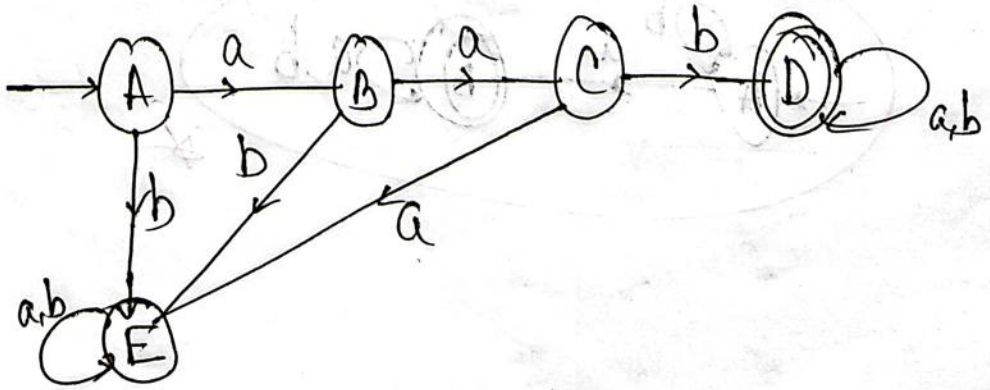
$L = \{aa, aaa, aab, aaab, aabba \cdots\}$



Lecture-8

Problem: Construct DFA, $\Sigma = \{a, b\}$, $L(M) = \{w/w \text{ start with 'aab'}\}$

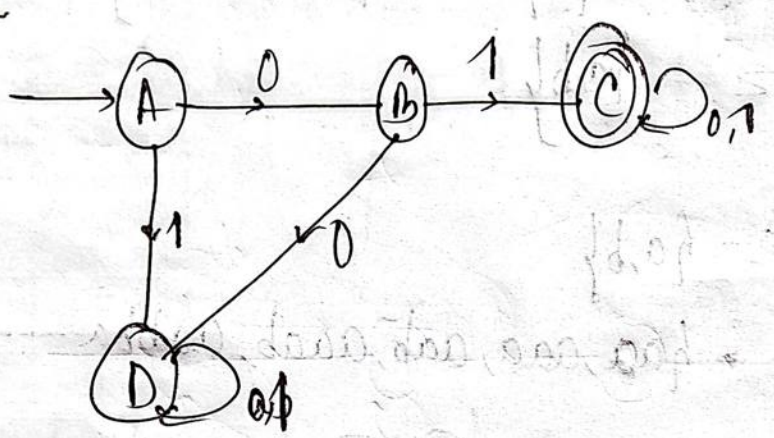
Sol^n: $\Sigma = \{a, b\}$, $L = \{aab, aaba, aabab, aabbba \cdots\}$



Lecture-9

Prob : $\Sigma = \{0,1\}$, $L(M) = \{w / w$ start with '01'$\}$

Soln:



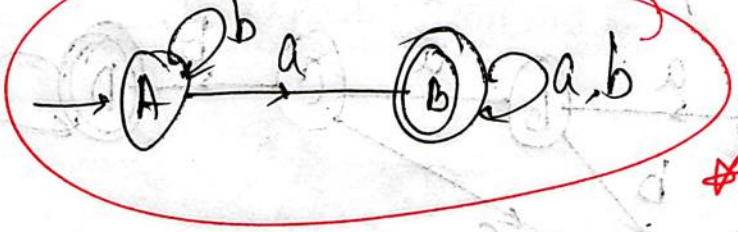
Lecture-10

Prob: Construct DFA, $\Sigma = \{a,b\}$ in where every string contains 'a'.

OR, $L(M) = \{w / w$ contain 'a'$\}$

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

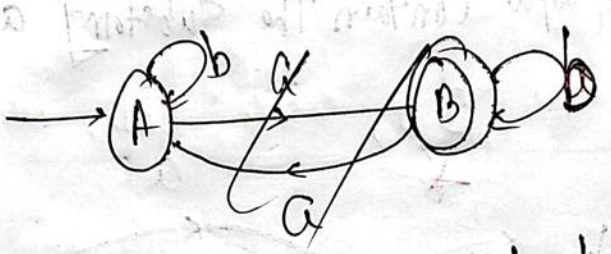
$L = \{a, aa, ab, aba, ba, aaa, abab \ldots\}$



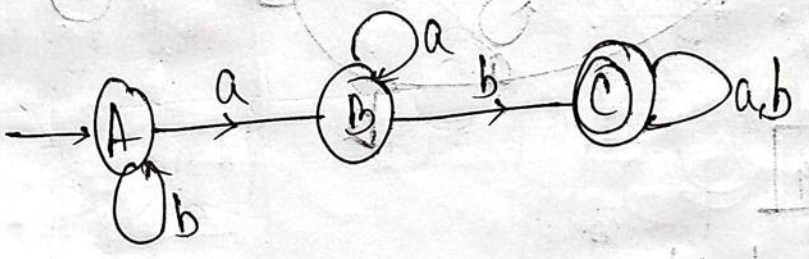
Lecture – 11

Prob.: $\Sigma = \{a, b\}$, $L(M) = \{$ Contain 'ab' $\}$

Soln:



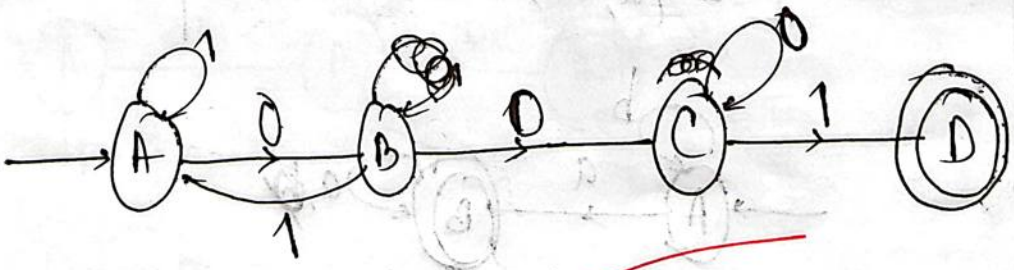
$L = \{ab, aab, bab, abab, aaab \cdots\}$



Lecture – 12

Prob: Contain "001", $\Sigma = \{0, 1\}$

Soln:



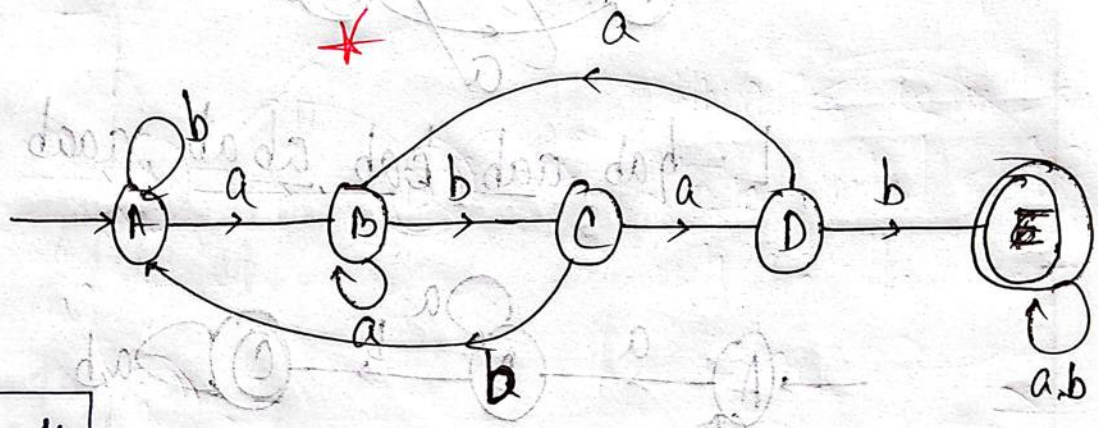
VII

Lecture - 13

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

$L(M) = \{ w/w \text{ Contain the substring 'abab'} \}$

Soln:

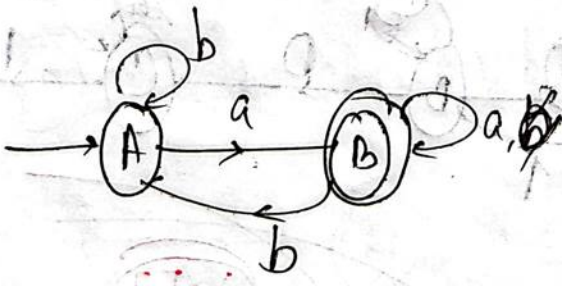


Lecture - 14

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

$L(M) = \{ w/w \text{ ends with an 'a'} \}$

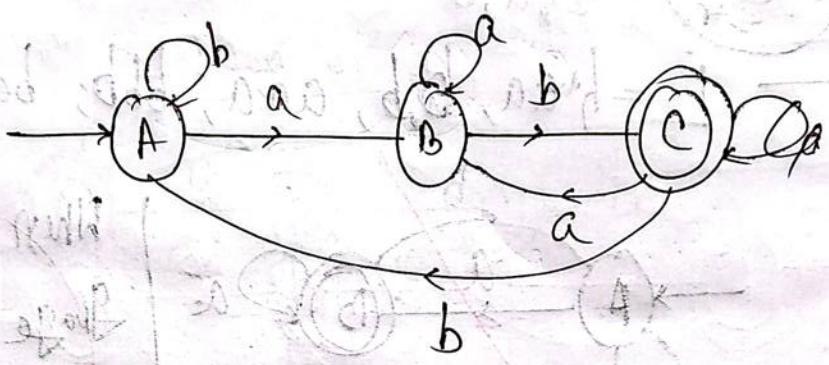
Soln: $L = \{a, ba, aaa, bba \ldots\}$



Lecture-15

Prob: $\Sigma = \{a, b\}$, $L(M) = \{ w/w \text{ strings ends with 'ab'} \}$

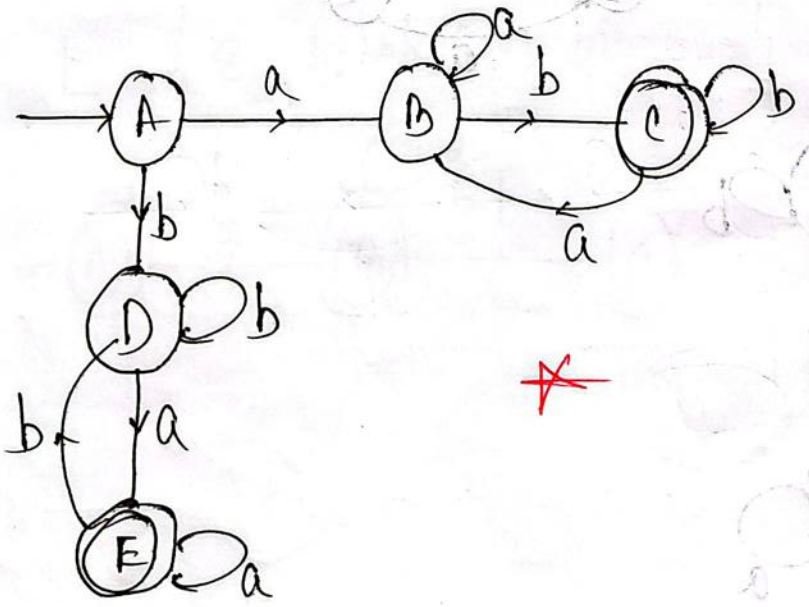
Soln:



Lecture-16

Prob: $\Sigma = \{a, b\}$, $L(M) = \{ w/w,$ starts and ends with different symbol $\}$

Soln: $L = \{ ab, ba, aaab, bbba, \dots \}$

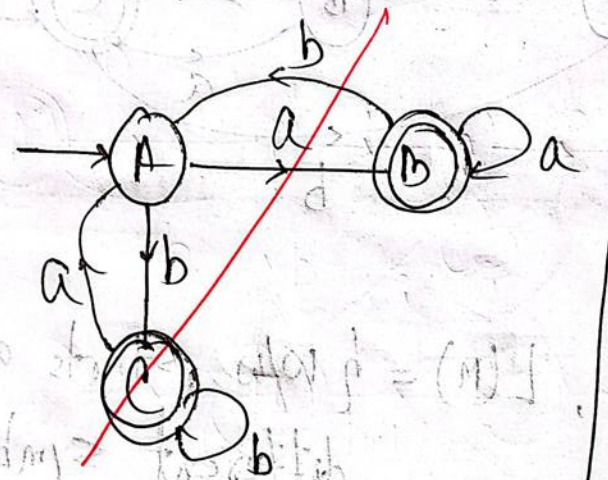


Lecture-17

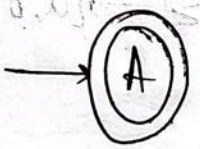
Prob: $\Sigma = \{a, b\}$ and, $L(M) = \{w/w$, start and end with same symbol$\}$

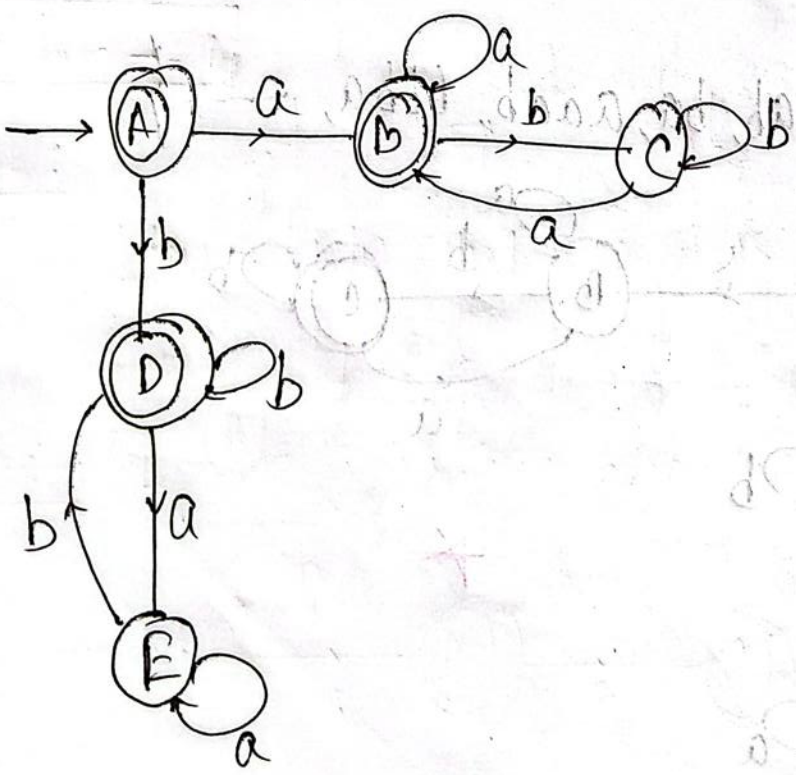
Soln: (Length of str.) $\rightarrow \Sigma, a, b$

$L = \{aa, bb, aaa, bbb, baab \cdots\}$



When Σ in Language initial state will be the final state.

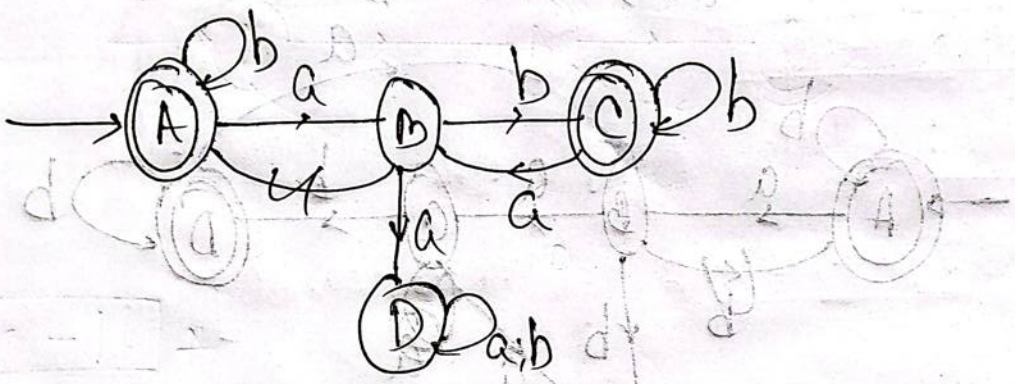




Lecture – 18

Prob : $\Sigma = \{a, b\}$, $L(M) = \{w / w$ every a in w is followed by one 'b'$\}$

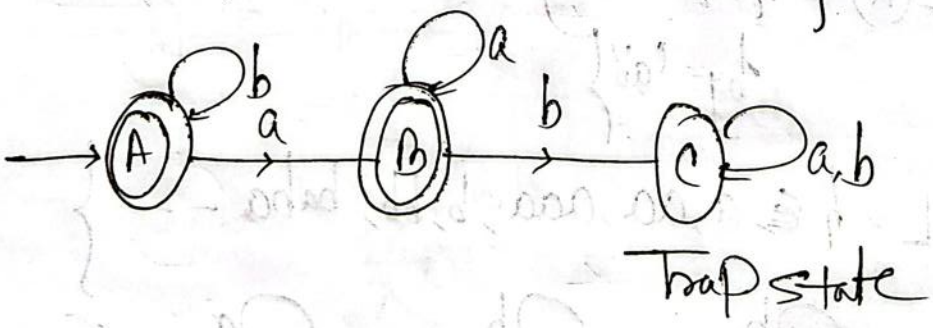
Soln : $L = \{ab, abab, \varepsilon, b, bb, bbb, bab \ldots\}$



Lecture – 19

Prob : $\Sigma = \{a, b\}$, $L(M) = \{w / w$, every 'a' in w is never followed by one 'b'$\}$

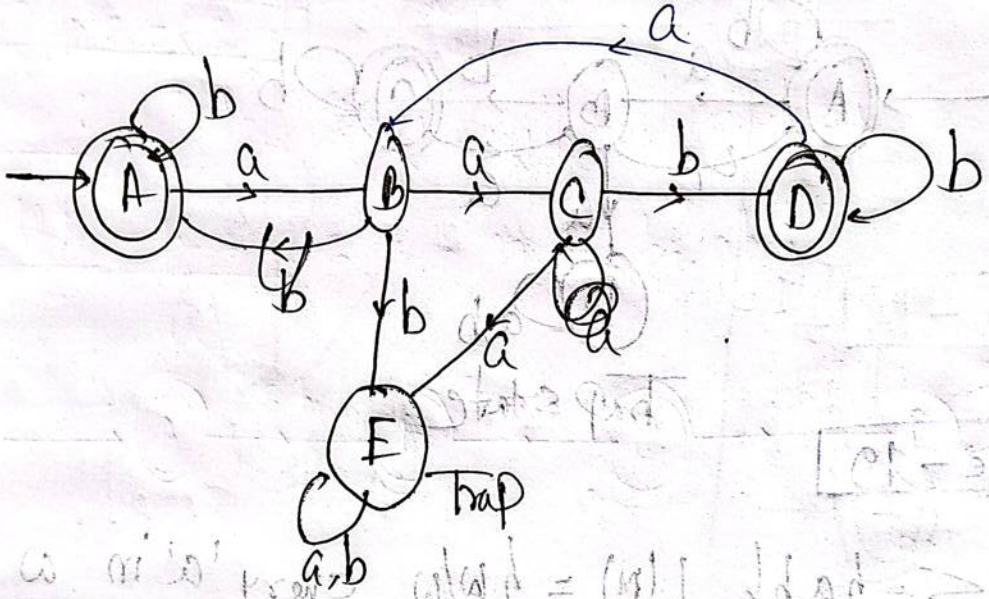
Soln : $L = \{\varepsilon, b, bbb, aa, ba \ldots\}$



Lecture – 20

Prob : $\{w / w$, 'a' is followed by 'ab'$\}$

Soln: $L = \{\varepsilon, b, bb, bbb, aab, aaab, baab \cdots\}$

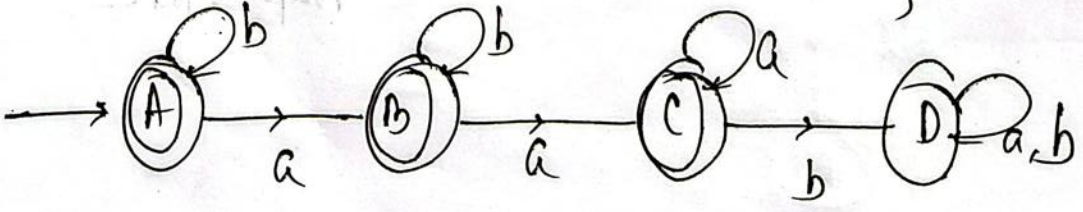


Lecture – 21

Prob : Construct a DFA, $\Sigma = \{a, b\}$

$L(M) = \{w / w$ every 'a' in w is never be followed by 'ab'$\}$

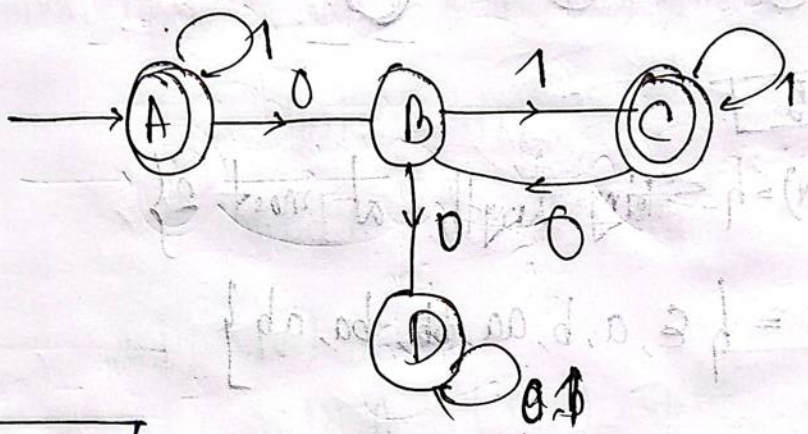
Soln: $L = \{\varepsilon, a, aa, aaa, b, bb, baba \cdots\}$



Lecture – 22

Prob : $L(M) = \{$ every '0' is followed by at least one '1' $\}$

Soln : $L = \{\epsilon, 1, 11, 111, 01, 0111 \ldots\}$

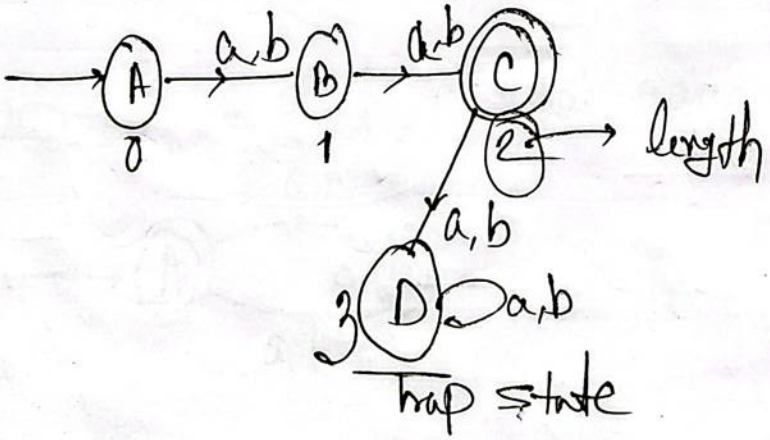


Lecture – 23

Length of string (DFA)

Prob : $\Sigma = \{a, b\}$, $L(M) = \{w / w$ is a string of length $2\}$

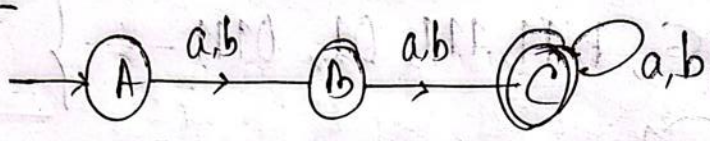
Soln : $L = \{aa, ab, bb, ba\}$ ← finite



Lecture-24

Prob: $\Sigma = \{a, b\}$, $L(M) = \{$ string length at least 2 $\}$

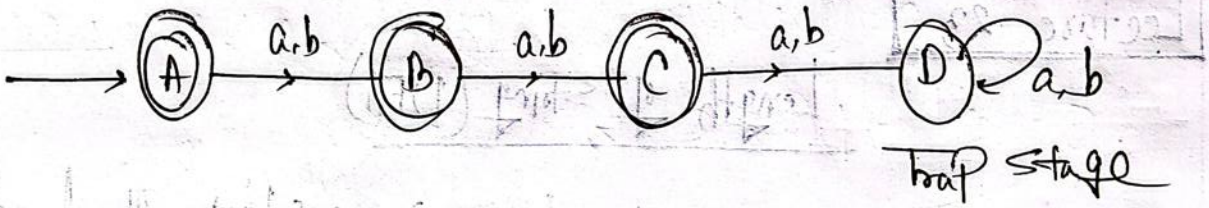
Soln:



Lecture-25

Prob: $L(M) = \{$ string length at most 2 $\}$

Soln: $L = \{\varepsilon, a, b, aa, bb, ba, ab\}$



Lecture – 26

Minimal DFA

→ Length of string $|w| = n$

Minimum num. of DFA = $(n+2)$ state

$|w| \geq n$

mDFA = $(n+1)$ state

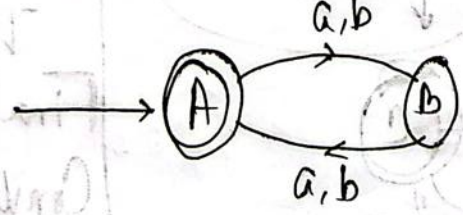
and, $|w| \leq n$

mDFA = $(n+2)$ state

Lecture – 27

★ **Prob :** Construct a minimal DFA which accept set of all string over $\{a,b\}$ which is divisible by 2 / multiple of 2 / $|w| \bmod 2 = 0$ / even length.

Soln : $L = \{\epsilon, aa, bb, ab, abab, aaaa \dots\}$



For divisible by 'n' number of state = n

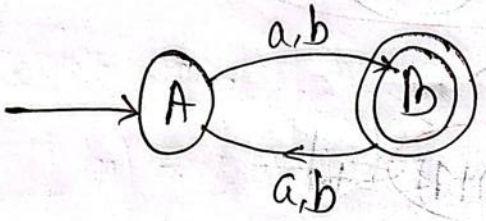
★★★

Lecture-28

Prob : Not divisible by 2 / not multiply of 2.

$L(M) = \{w / w$ has odd length of string$\}$

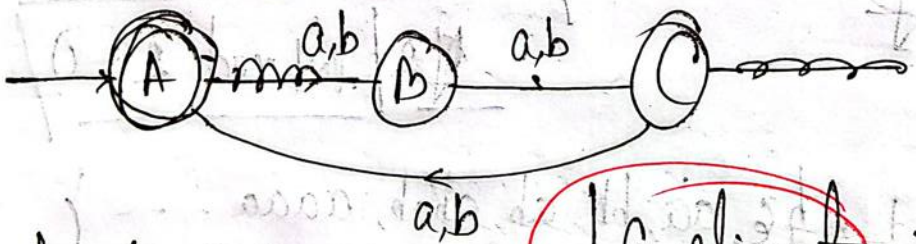
Soln: $L = \{ a, b, aba, aaa, bbb \cdots \}$



Lecture-29

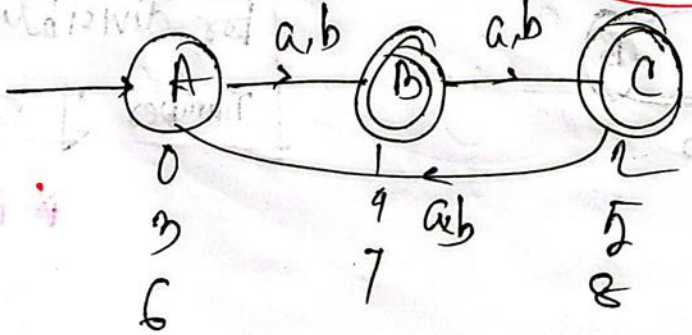
Prob : length of string is divisible by 3 / multiple of 3 / $|w| \bmod 3 = 0$.

Soln: $L = \{ \epsilon, aaa, aba, abaaab \cdots \}$



Complement | Initial state To Final state Convert

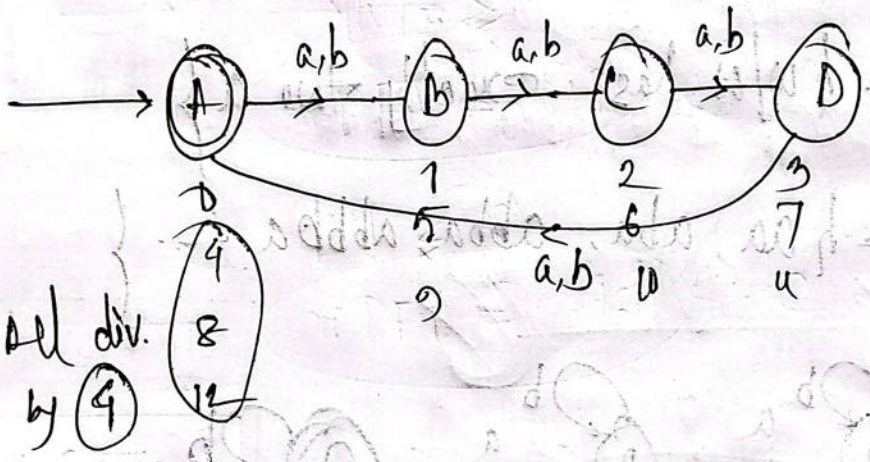
not div by 3:



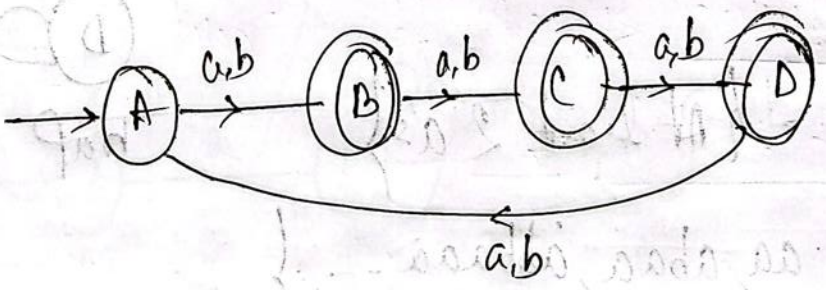
Lecture - 30

Prob: $L(M) = \{$ string length is divisible by 4 / multiple of 4 / $|w| \bmod 4 = 0\}$

Soln: $L = \{\varepsilon, aaaa, bbbb, \dots\}$



Not div. by 4:



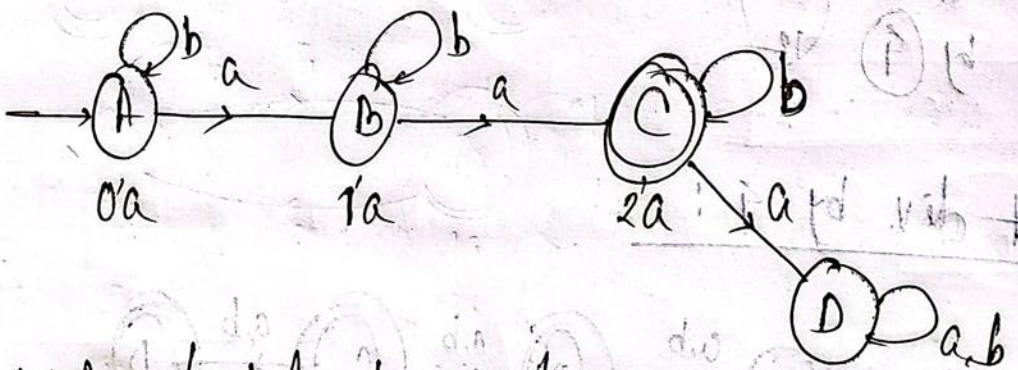
Lecture – 31

Counting a Symbol

Prob: Construct a mDFA which Accepts set of all strings over {a,b} where each string has exactly two a.

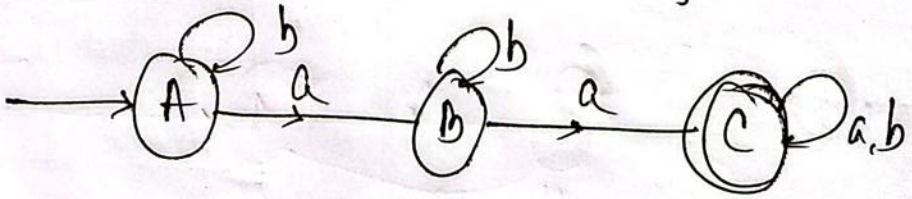
OR, $L(M) = \{w / w$ has exactly two a$\}$

Soln: $L = \{aa, aba, abba, abbba \ldots\}$



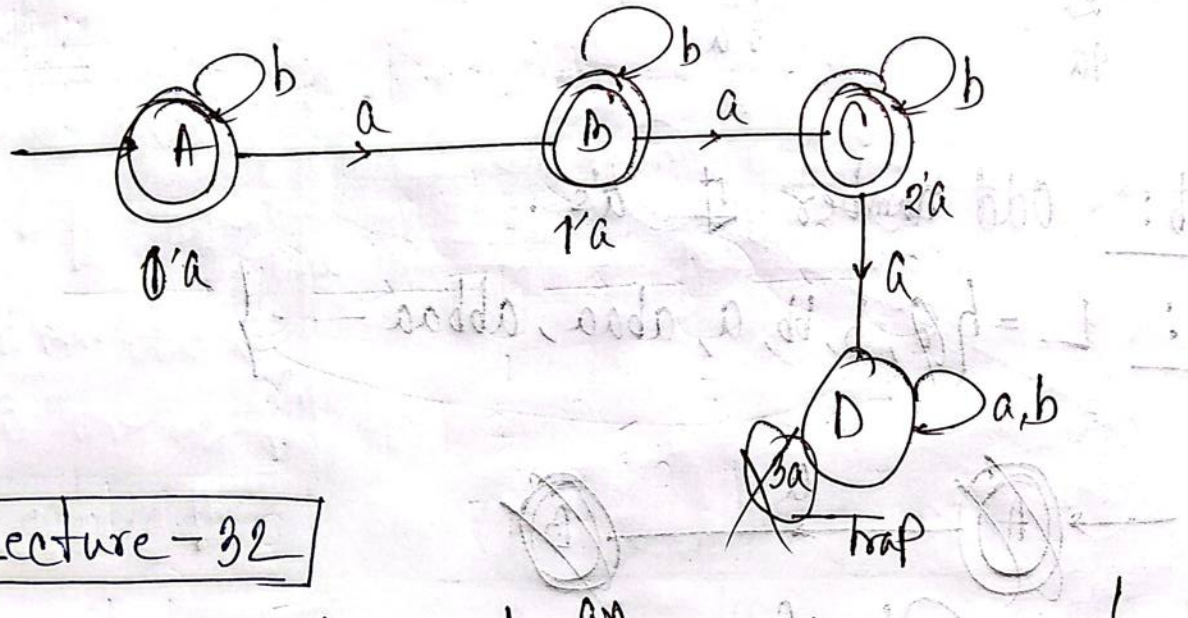
Prob: $L(M) = \{$At least 2 a's$\}$

Soln: $L = \{aa, abaa, abbaaa \ldots\}$



Prob: $L(M) = \{$ at most 2 a's $\}$

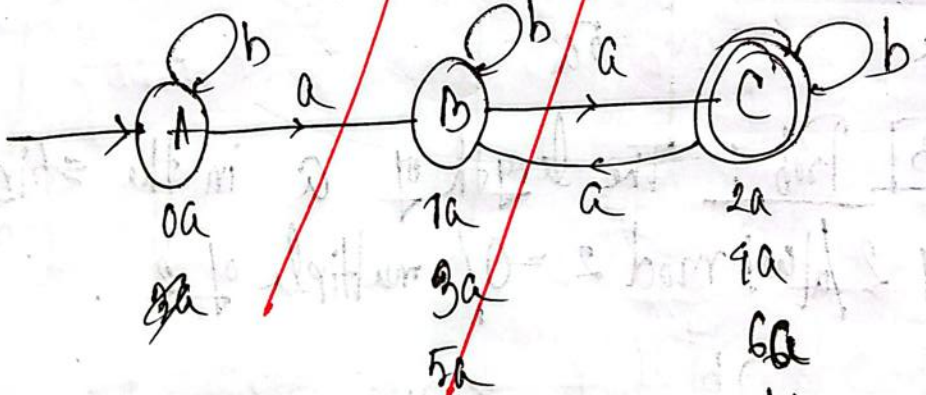
Soln: $L = \{\varepsilon, a, aa, aba, abb, abbba \text{---}\}$



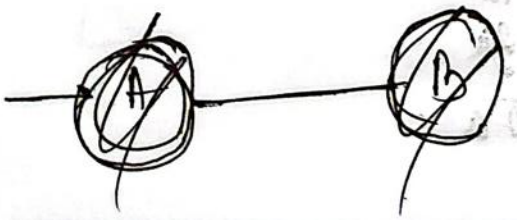
Lecture-32

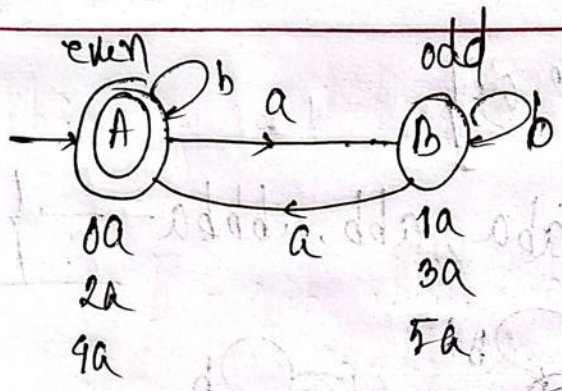
Prob: $L(M) = \{w/w$ has a even number of a's $\}$

Soln: $L = \{aa, aba, abbbaaa \text{---}\}$



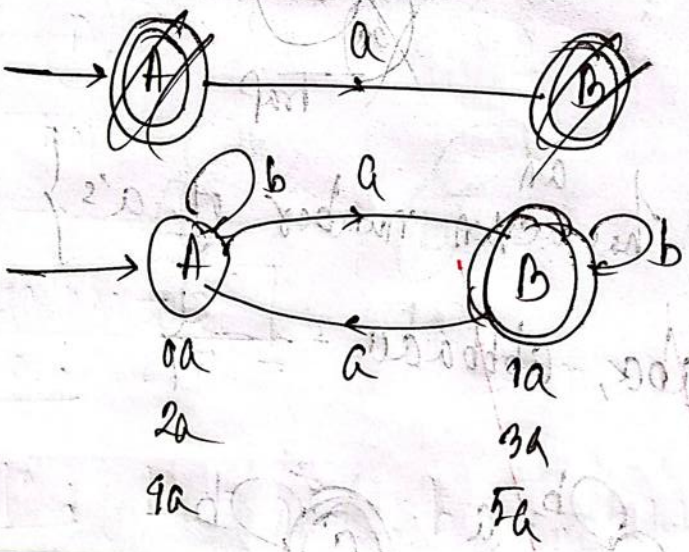
$L = \{\varepsilon, b, bb, bbb, aa, abaaa, abba \text{---}\}$





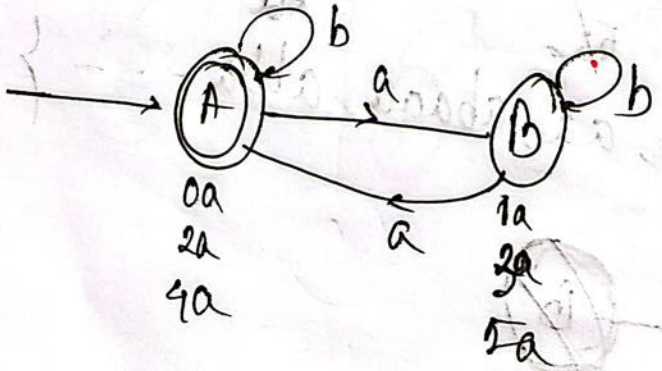
Prob: Odd number of a's.

Soln: $L = \{\epsilon, b, bb, a, abaa, abbaa \text{---}\}$



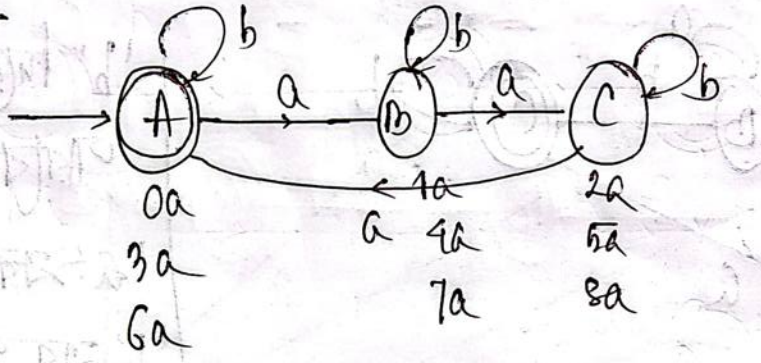
Lecture-33 Prob: The length of a in the string is div by 2 /$|a|_w \bmod 2 = 0$/ multiple of 2.

Soln:



Prob: {Length of 'a' in string div. by 3 / multiple of 3 / no. of 'a' mod 3 = 0}

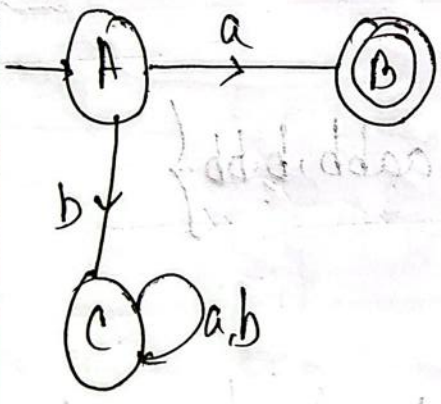
Soln:



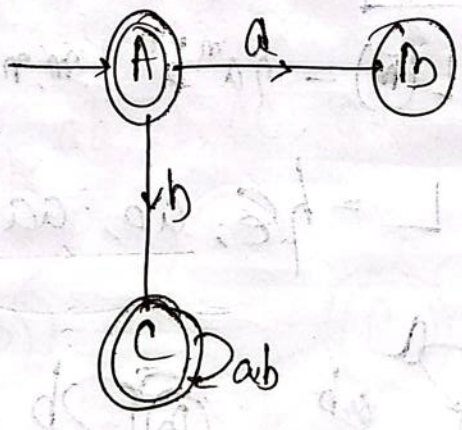
Lecture - 34

Complementation of DFA

L(M) = {start with 'a'}



L(M) = {Doesn't start with 'a'}

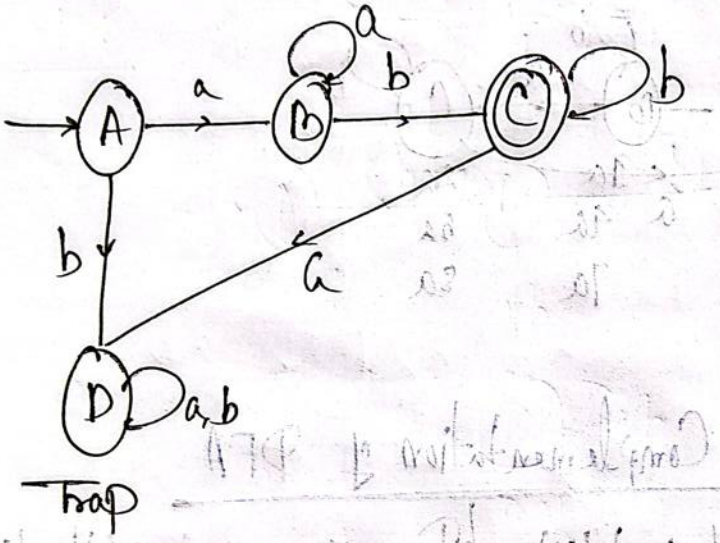


[Final state → Initial state
Initial " → Final "] Conversion

Lecture – 35

Prob: $L(M) = \{a^m b^n / m, n \geq 1\}$

Soln: $L = \{ab, abbb, aab, aaabb \text{---}\}$

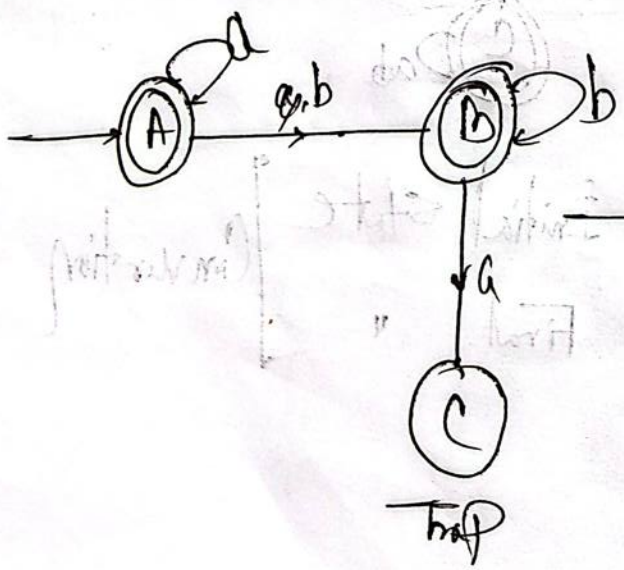


'b' দিয়ে শুরু হতে পারবে না।
'a' এর পর b থাকবে না।
'b' এর পর 'a' থাকবে না

Lecture – 36

Prob: $L(M) = \{a^m b^n, m, n \geq 0\}$

Soln: $L = \{\epsilon, ab, aa, abb, aabb, b, bb\}$

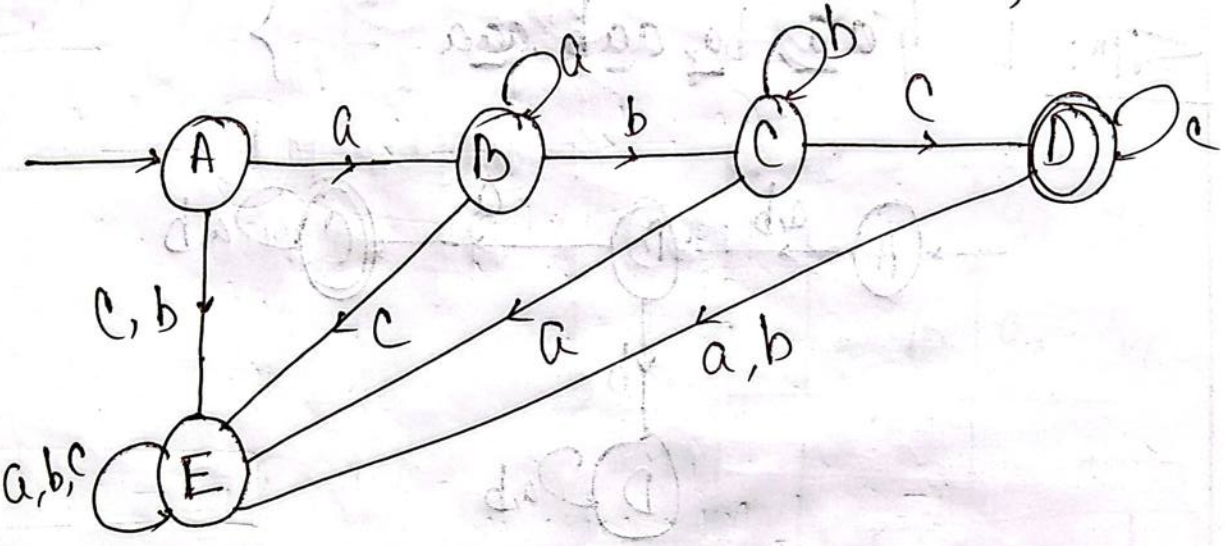


→ Compliment for Containing $(ba)^m n$

Lecture-37

Prob: $L(M) = \{ a^m b^n c^l, m,n,l \geq 1 \}$; $\Sigma = \{a,b,c\}$

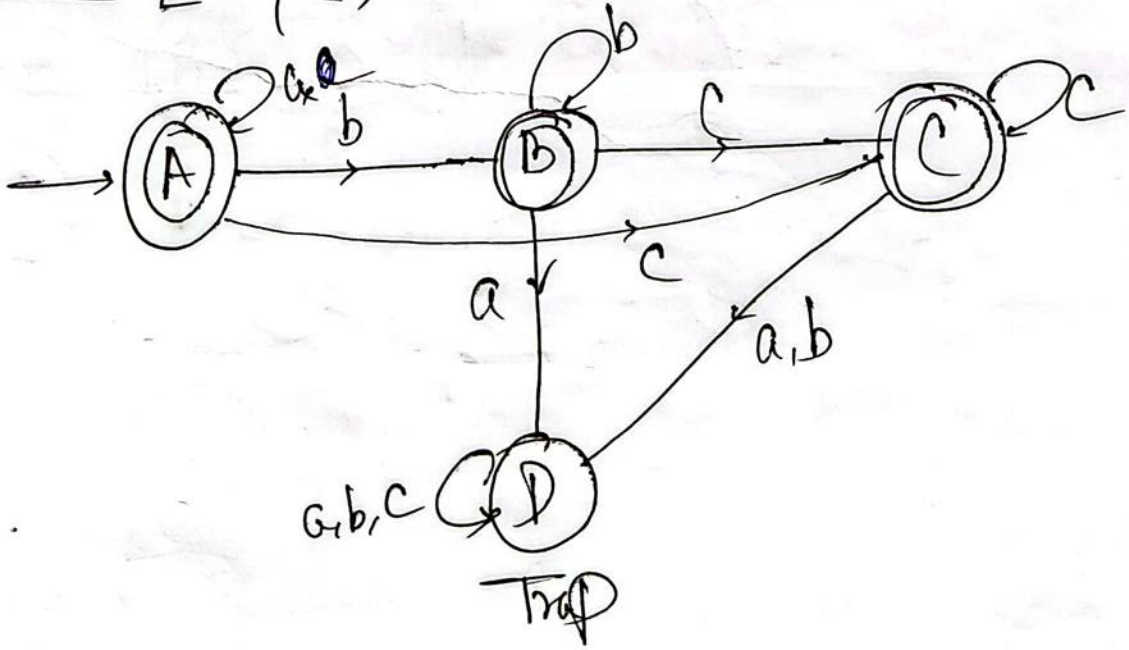
Soln: $L = \{abc, aabc, aaabbccc \ldots\}$



Lecture-38

Prob: $L = \{ a^m b^m c^l / m,n,l \geq 0 \}$; $\Sigma = \{a,b,c\}$

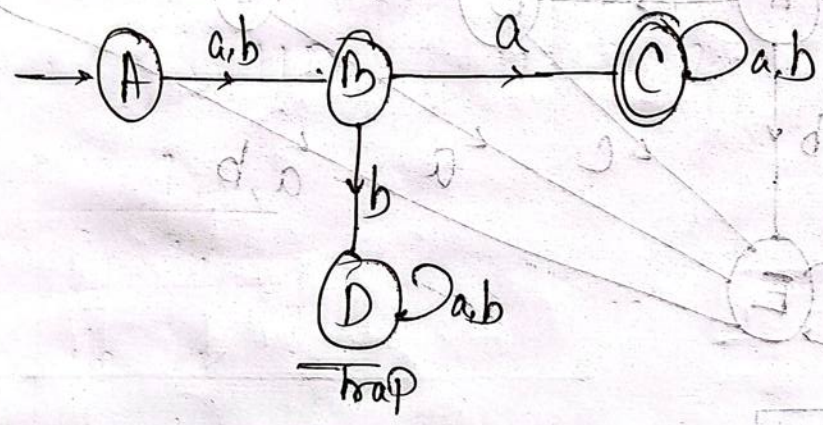
Soln: $L = \{\varepsilon, a, b, c, aa, bb, cc, abc, aabb, cc \ldots\}$



Lecture – 39

Prob: $L(M) = \{w/w$, accept 2nd symbol from left hand site is 'a'$\}$

Soln: $L = \{aa, ba, aab, aaa \ldots\}$



→ 'n'th symbol from left hand site should be

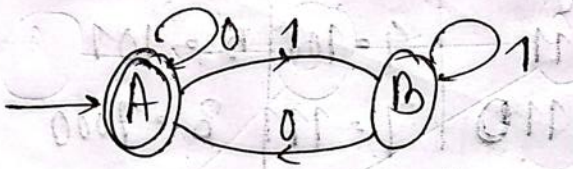
number of states $= (n+2)$

Lecture-40

Binary related DFA

Prob: $L = \{w | w$ binary number is divisible by $2\}$ $\Sigma = \{0,1\}$

Soln:



$0 = 0$ $\quad 1 = 1$

$2 = 10$ $\quad 3 = 11$

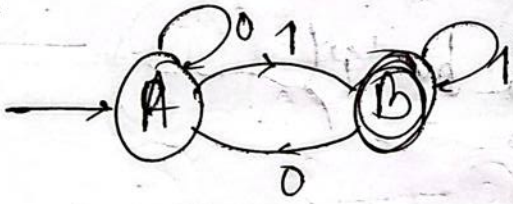
$4 = 100$ $\quad 5 = 101$

Transition Diagram

	0	1
A	q_0	q_1
B	q_0	q_1

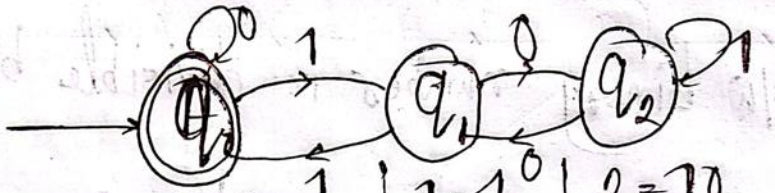
Tran. Table

$\Rightarrow \{$Not divisible by $2\}$



Prob: {Divisible by '3'} $\Sigma = \{0, 1\}$

Ans:



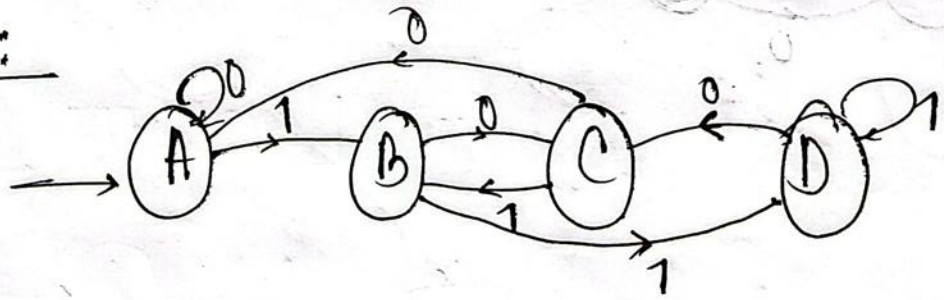
$0 = 0$	$1 = 1$	$2 = 10$
$3 = 11$	$4 = 100$	$5 = 101$
$6 = 110$	$7 = 111$	$8 = 1000$

	0	1
$\rightarrow *q_0$	q_0	q_1
q_1	q_2	q_0
q_2	q_1	q_2

Compliment: {Not divisible by '3'}

Lecture-42 Prob: {Divisible by '4'}

Soln:

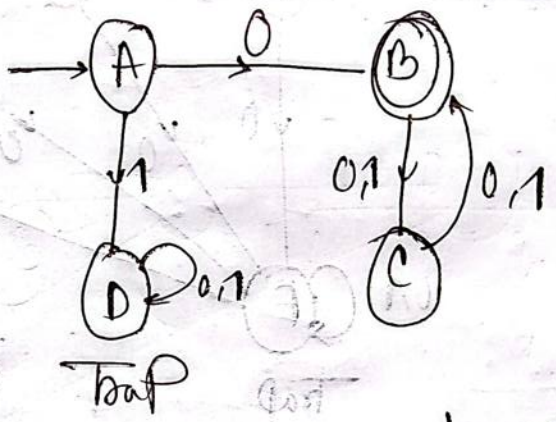


	0	1
A	A	B
B	C	D
C	A	B
D	C	D

Lecture-43

Prob: Start with '0' and odd length.

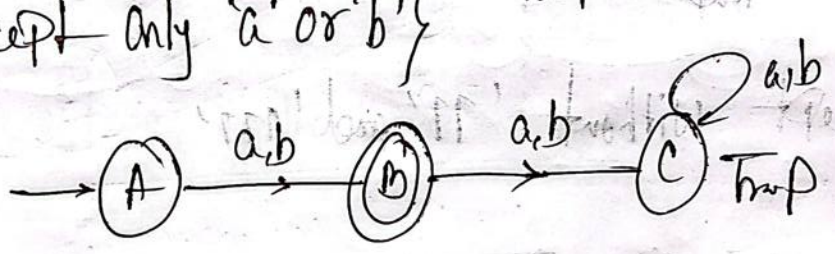
Soln:



L-44

Prob: Does {Accept only 'a' or 'b'}

Soln:



$L = \{a, b\}$

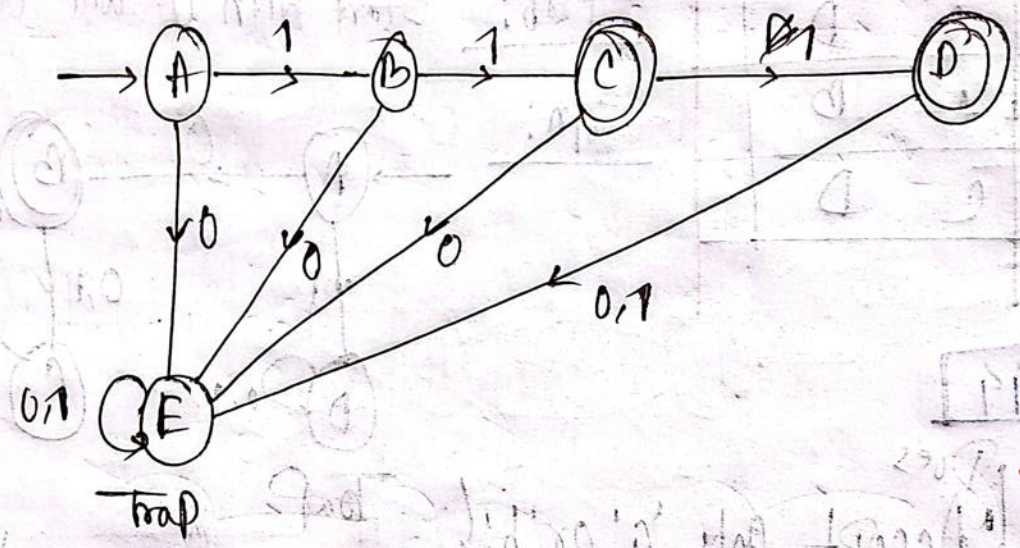
Prob: {~~Accept 'a' and 'b'~~} {Doesn't Acc. only 'a' and 'b'}

$L = \{ab, abb, aaba \text{ ---}\}$

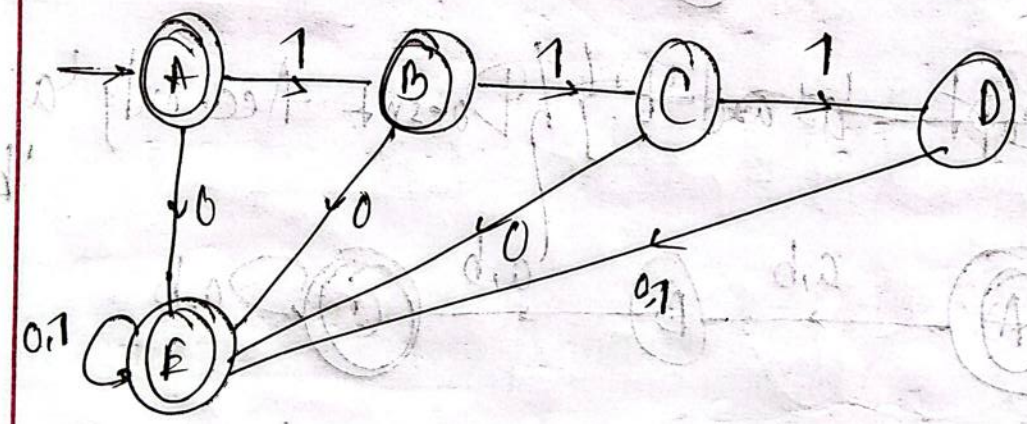
Lecture-45

Prob: Accept only '11' and '111'

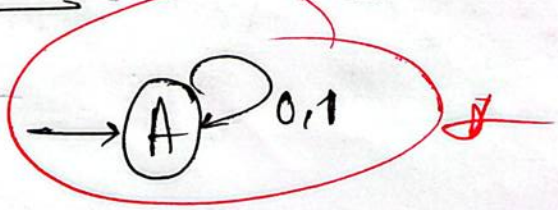
Soln:



→ Accept without '11' and '111'



Prob: The empty set, $\Sigma = \{0,1\}$

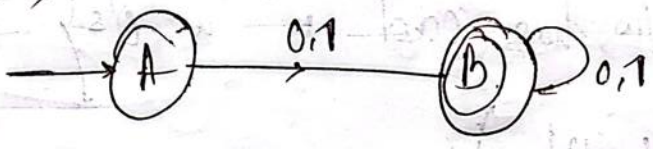


Doesn't Acc. Anything

Prob: Accept with out empty string. $\Sigma = \{0, 1\}$

Soln:

or, length of ω doesn't 0.



Lecture—46

Regular Operation

$\cup, \cap, 0, *$ → Regular Operation

↓ ↓

or and

→ The union of 2 regular language is also a RL.

→ যেই ধরনের Language এর জন্য finite Automata তৈরি করা সম্ভব তাকে Regular Language.

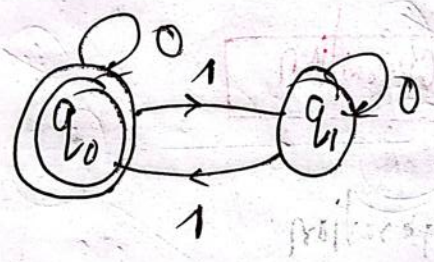
Example:

$L_1 = \{w/w$ has even number of 1's$\} \longrightarrow M_1$

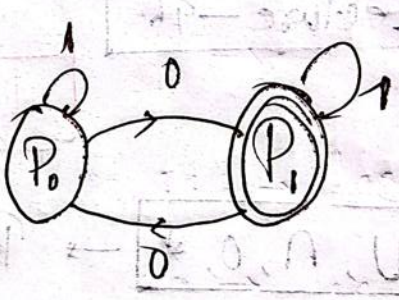
$L_2 = \{w/w$ has odd " " 0's$\} \longrightarrow M_2$

Find, $(L_1 \cup L_2)$

Soln:



M_1



M_2

$M_1 = \{Q_1, \Sigma_1, \delta_1, q_{0_1}, F_1\}$

$Q_1 = \{q_0, q_1\}$

$\Sigma_1 = \{0, 1\}$

$q_{0_1} = q_0$

$F_1 = q_0$

$M_2 = \{Q_2, \Sigma_2, \delta_2, q_{0_2}, F_2\}$

$Q_2 = \{P_0, P_1\}$

$\Sigma_2 = \{0, 1\}$

$q_{0_2} \& \Sigma_2 = P_0$

$F_2 = P_1$

$Q = Q_1 \times Q_2$

$= \{(q_0, q_1) \times (P_0, P_1)\}$

$= \{q_0P_0, q_0P_1, q_1P_0, q_1P_1\}$

$\Sigma = \Sigma_1 \cup \Sigma_2$

$= \{0, 1\}$

$q_0 = (q_{01}, q_{02})$

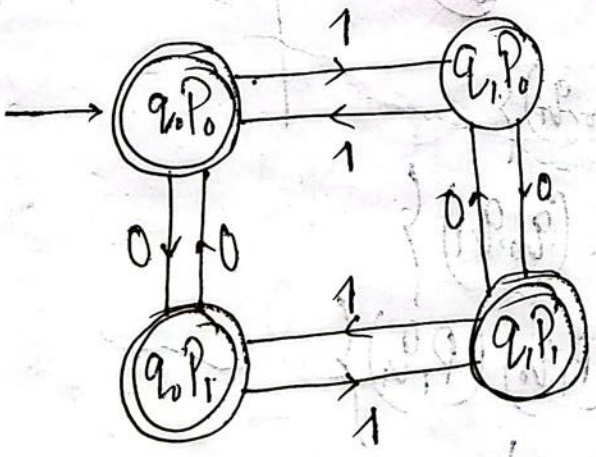
$= q_0P_0$

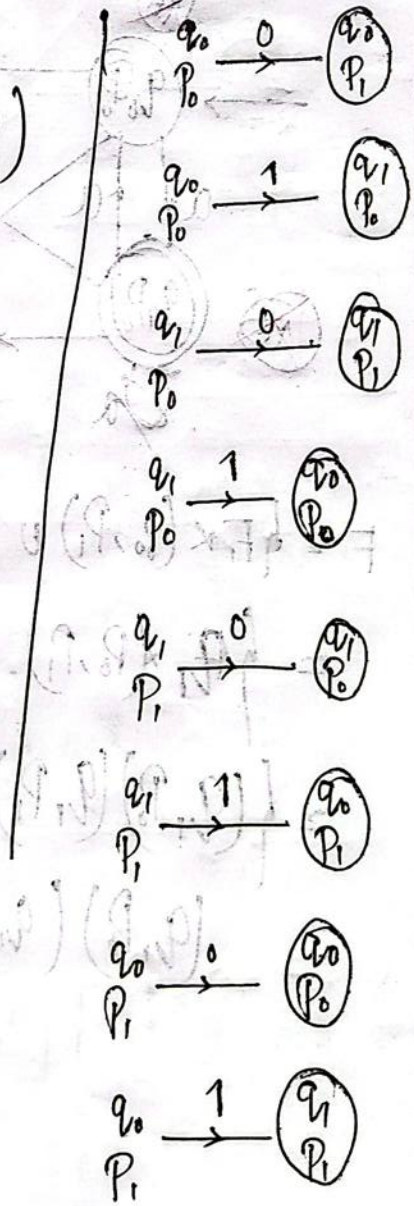
$F = (F_1 \times Q_2) \cup (F_2 \times Q_1)$

$= \{q_0\} \times (P_0, P_1) \cup \{P_1\} \times (q_0, q_1)$

$= (q_0P_0, q_0P_1) \cup (q_0P_1, q_1P_1)$

$= (q_0P_0, q_0P_1, q_1P_1)$



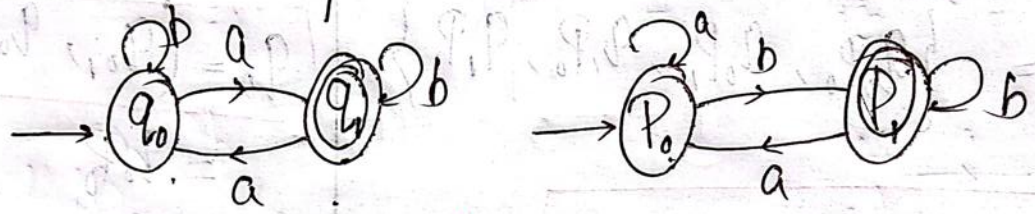


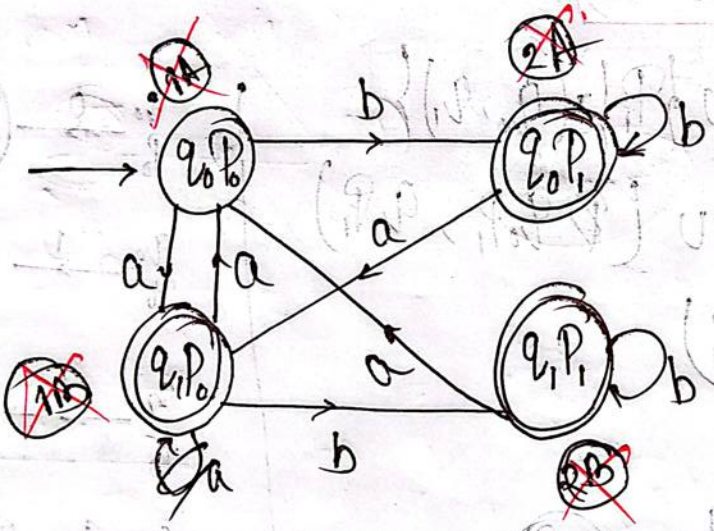
110 — Acc

0001 — Acc

100 — No Acc

Ques: L = {w/w has an odd number of a's or end with a 'b'}





aaa → Acc

ab → Acc

aa → Not Acc

$F = \{F_1 \times (P_0, P_1) \cup F_2 \times (q_0, q_1)\}$

$= \{F_1 \times (P_0, P_1) \cup P_1 \times (q_0, q_1)\}$

$= \{(q_1P_0)(q_1P_1) \cup (P_1q_0)(P_1q_1)\}$

$= (q_1P_0)(q_0P_1)(q_1P_1)$

Lecture – 50

Minimization of DFA

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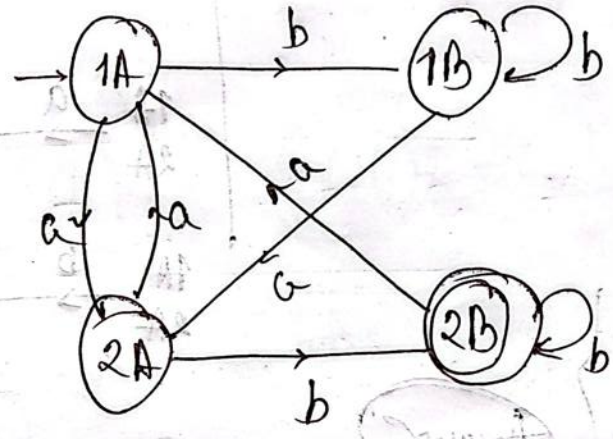


	a	b
→ 1A	2A	1B
1B	2A	1B
2A	1A	2B *
* 2B	1A	2B *

step (1) → Remove all the states those are not reachable from initial state.

step (2) → Draw state transition table.

step (3) → Mark the initial and final state.

step (4) → 0 equivalent
1
2
} find out

0 equivalent = [set of final state] [set of non final state]

= [2B] [1A, 1B 2A]

Fahim Reza | C211046

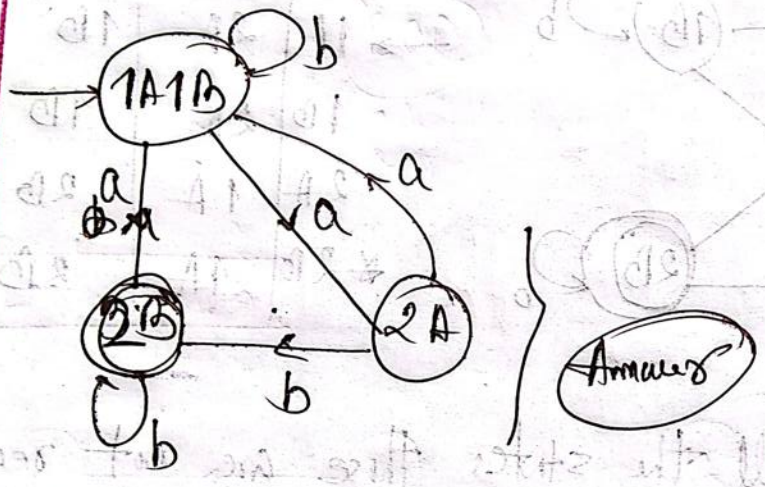
Same

1 equivalent = [2B] [1A 1B] [2A]

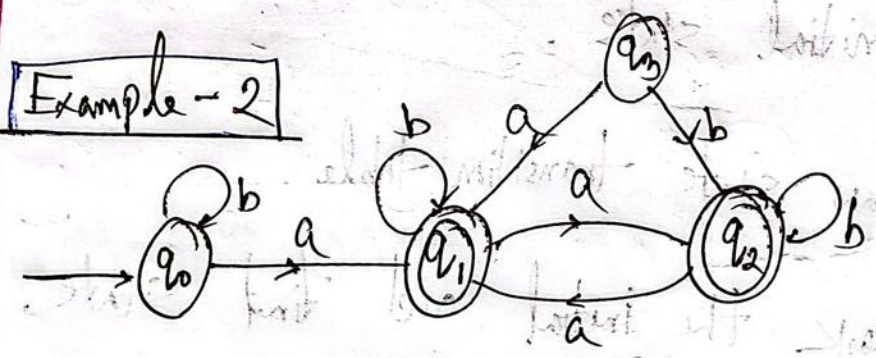
2 " = [2B] [1A 1B] [2A]

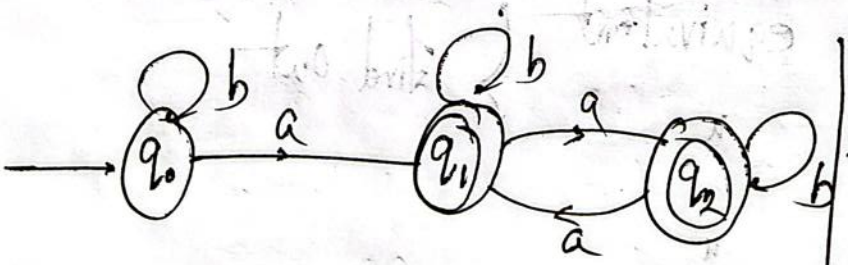
1A 1B	a	2A	Same
1A 1B	b	2B	

1A	a	2A	*
2A		1A	
1A	b	1B	
2A		2b	



Example - 2





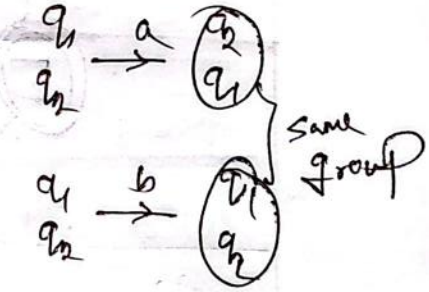
Step (1)

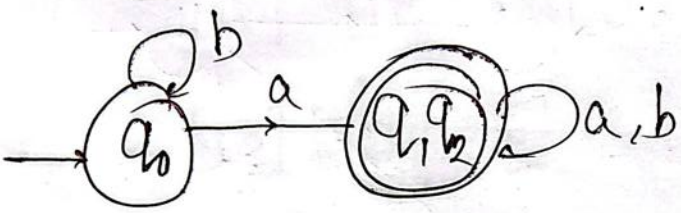
Step (2)

	a	b
→ q0	q1 *	q0
* q1	q2 *	q1 *
* q2	q1 *	q2 *

0 eq. = [q_1, q_2] [q_0]

1 eq. = [q_1 q_2] [q_0] } same

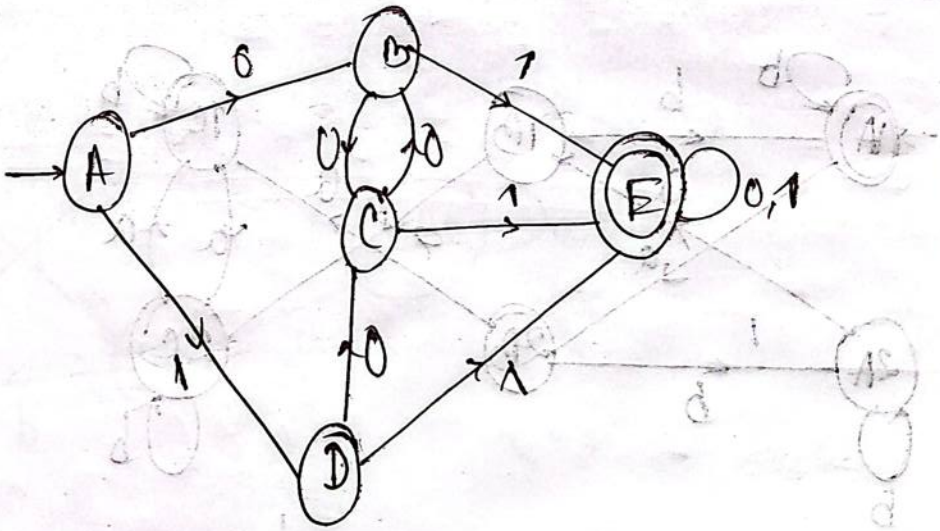




Ans.

L-52

Example (3)



	0	1
→ A	B	D
B	C	E
C	D	E
D	C	E
E	E	E

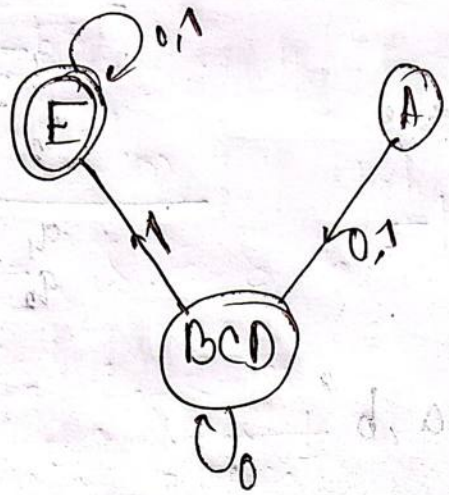
0 eq. = [E] [A B C D]

1 eq. ~~= [E] [A] [B] [C] [D]~~

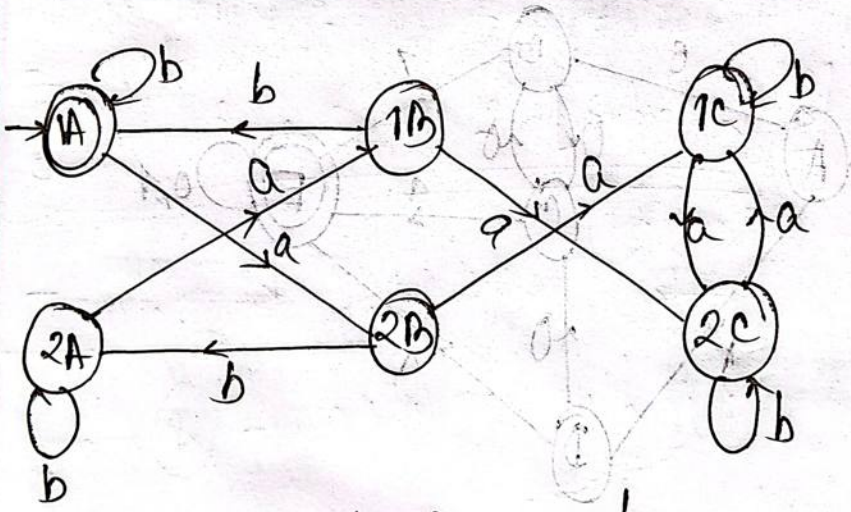
1 eq = [E] [A] [B C D]

2 eq = [E] [A] [B C D]

} same



Lecture - 53



	a	b
→ *1A	2B	1A*
1B	2C	1A*
2A	1B	2A
2B	1C	2A
1C	2C	1C
2C	1C	2C

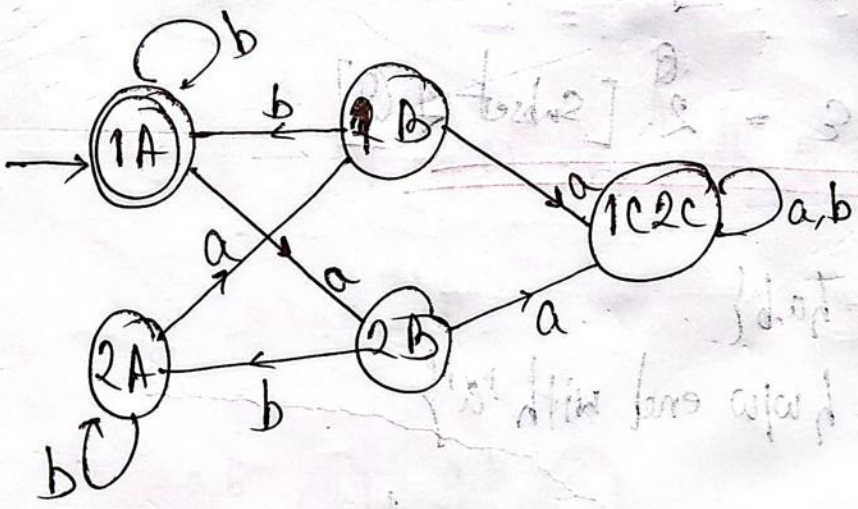
0 eq. = [1B 1C 2A 2B 2C] [1A]

1 eq. = [1B] [1C 2A 2B 2C] [1A]

2 eq = [1B] [1C 2B 2C] [2A] [1A]

3 eq. = [1B] [1C2C] [2B] [2A] [1A] } same

4 eq = [1B] [1C 2C] [2B] [2A] [1A]



NFA

Lecture-55

Formal Definition

NFA = $(Q, \Sigma, \delta, q_0, F)$

Q = Set of states

Σ = input Alphabet

q_0 = Initial state

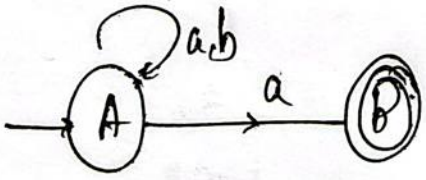
F = [Final state set]

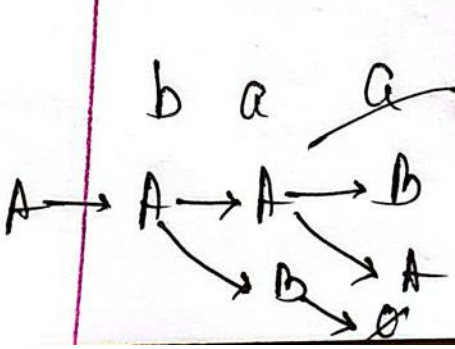
$\delta = Q \times \Sigma = 2^Q$ [subset of Q]

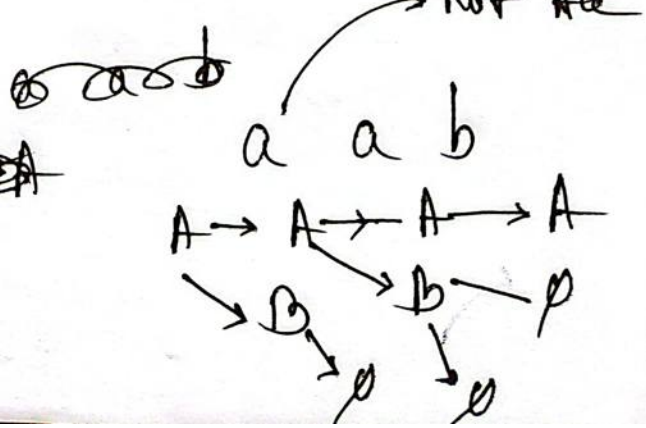
Example: $\Sigma = \{a, b\}$

$L = \{w / w$ end with 'a'$\}$

Soln: $L = \{a, aa, bbaa \cdots\}$

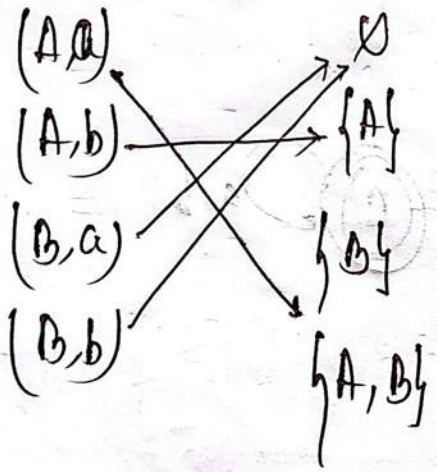






$\delta = Q \times \Sigma \longrightarrow 2^Q$

$\Rightarrow \{A,B\} \times \{a,b\} \longrightarrow 2^Q$



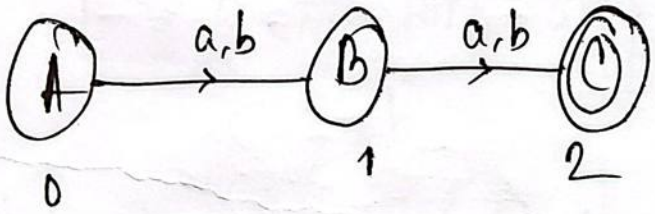
DFA : $Q \times \Sigma \to Q$

NFA : $Q \times \epsilon = 2^Q$

L-5

Example: $\Sigma = \{a,b\}$, $L = \{$ w the length of str exactly 2 $\}$

Soln: $L = \{aa, ab, bb\}$



bb → Acc

A → B → C

a b b

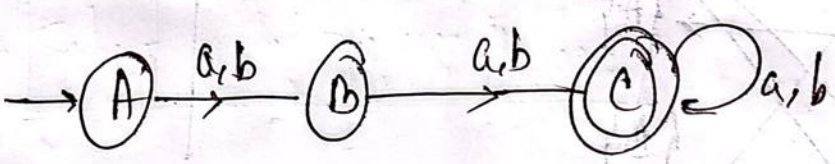
A → B → C → ∅

Deth Configuration

Ques: $L = \{w \mid$ the length of str atleast 2$\}$

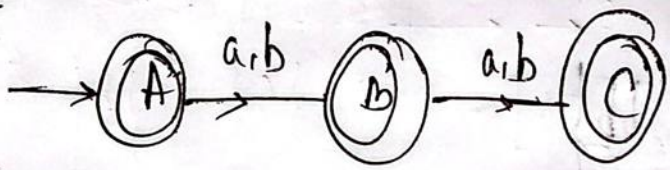
$|w| \geq 2$

Soln:



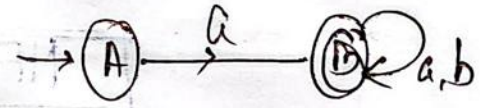
$|w|$ atmost 2 / $|w| \leq 2$

Soln:

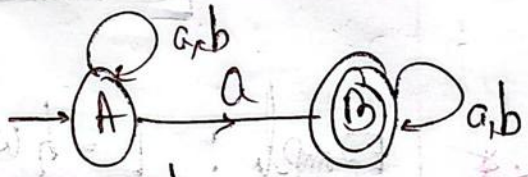


Lecture – 57

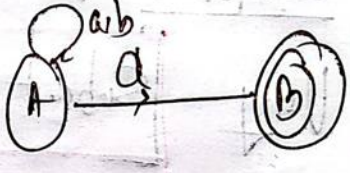
Ques: L = { start with 'a' } **Soln:**



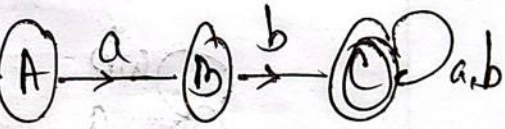
Ques: L = { Containing 'a' } **Soln:**



Ques: L = { Ends with 'a' } **Soln:**

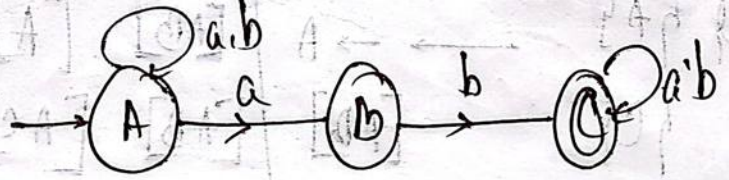


Ques: L = { start with 'ab' } **Soln:**



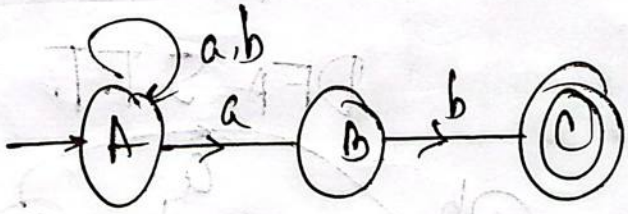
Ques: L = { Contain 'ab' }

Soln:



Ques: L = { ends with 'ab' }

Soln:

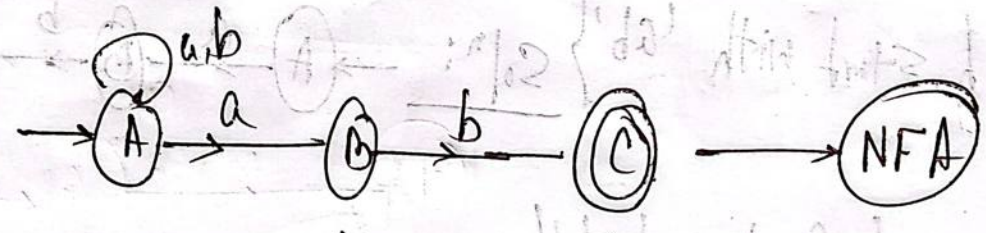


Lecture - 59

NFA To DFA

Example : $L = \{w \mid w$ end with 'ab'$\}$

Using – Subset Construction Method

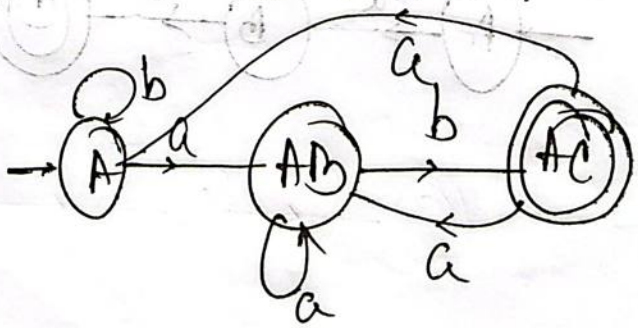


	a	b
→ A	{A, B}	{A}
B	{ }	{C}
* C	{ }	{ }

NFA S.T.T

	a	b
→ A	[AB]	[A]
[AB]	[AB]	[AC]
* [AC]	[AB]	[A]

DFA S.T.T.



Lecture-66

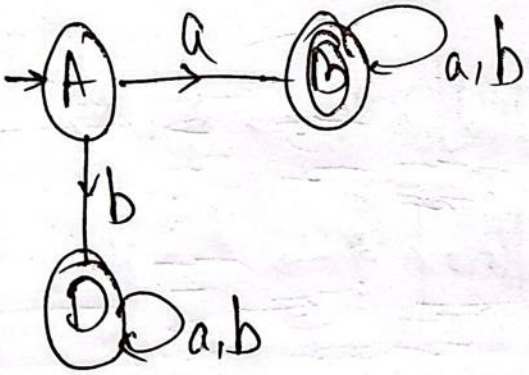
Ques: $L = \{w | w$ starting with 'a'$\}$

NFA

	a	b	← Deth Config.
→ A	{B}	ϕ	
*B	{B}	{B}	

↓

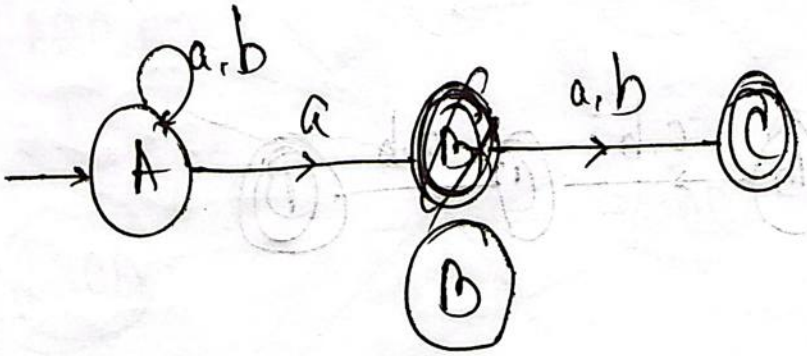
	a	b	← Trap
→ [A]	[B]	[D]	
*[B]	[B]	[B]	
[D]	[D]	[D]	



DFA S.T.T

Lecture-63

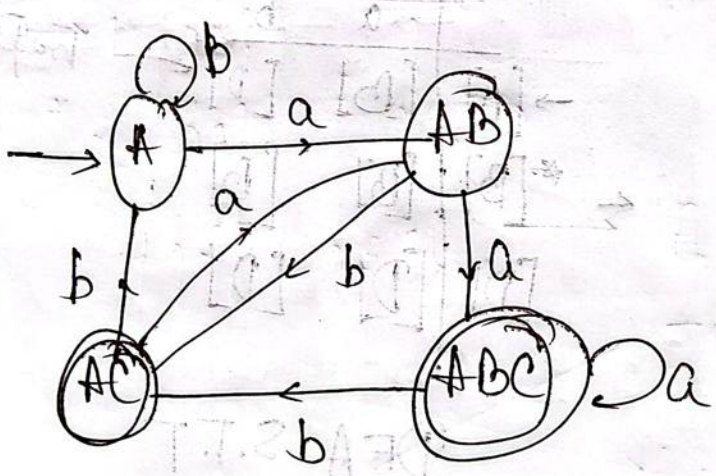
Ques: $L = \{$ second Symbol from RHS is 'a' $\}$



abbaabab

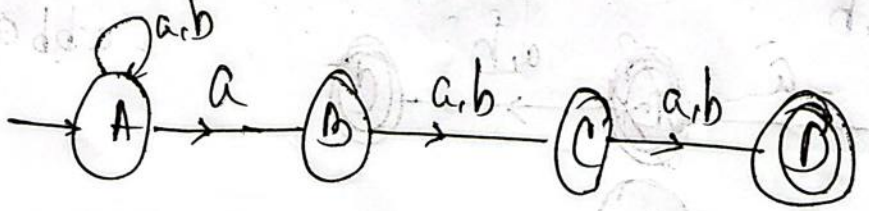
	a	b
→ A	{A,B}	{A}
B	{C}	{C}
*C	{}	{}

	a	b
→ A	[AB]	[A]
→ [AB]	[ABC]	[AC]
* [ABC]	[ABC]	[AC]
* [AC]	[AB]	[A]



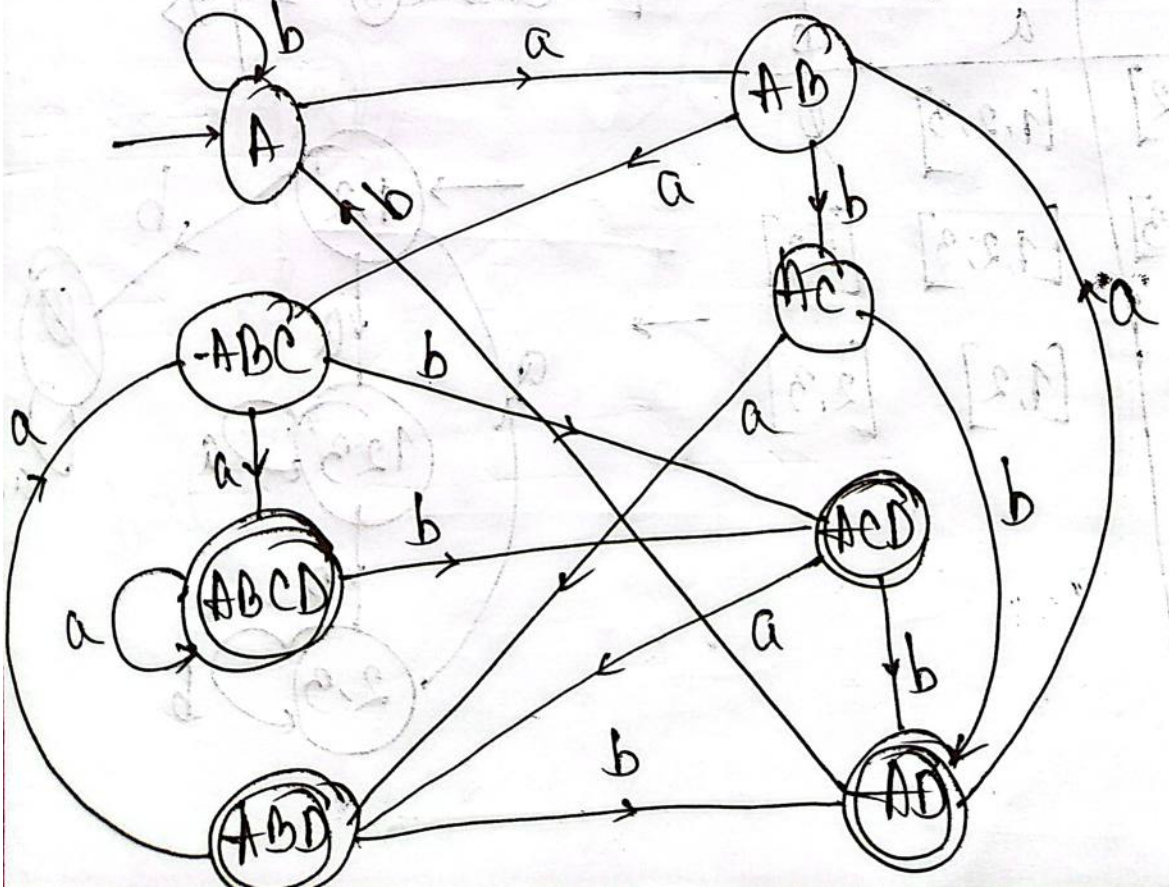
Lecture: 69

Ques: L = {2nd symbol from RHS is 'a'}



	a	b
→ A	{AB}	{A}
B	{C}	{C}
C	{D}	{D}
* D	{}	{}

	a	b
→ [A]	[AB]	[A]
→ [AB]	[ABC]	[AC]
[ABC]	[ABCD]	[ACD]
[AC]	[ABD]	[AD]
* [ABCD]	[ABCD]	[ACD]
* [ACD]	[ABD]	[AD]
* [ABD]	[ABC]	[AD]
* [AD]	[AB]	[A]



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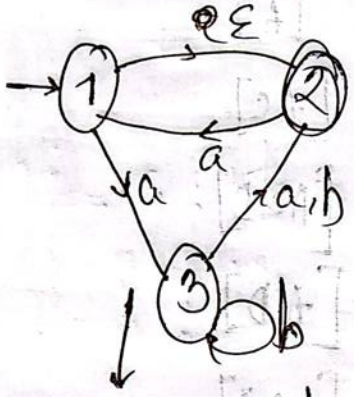
ε-NFA To DFA

Lecture – 67



Rules:

1. S.T.T for ∈-NFA
2. Find ∈-closure for all states
3. Mak STT for DFA
4. $q_0' = E(\{q_0\})$

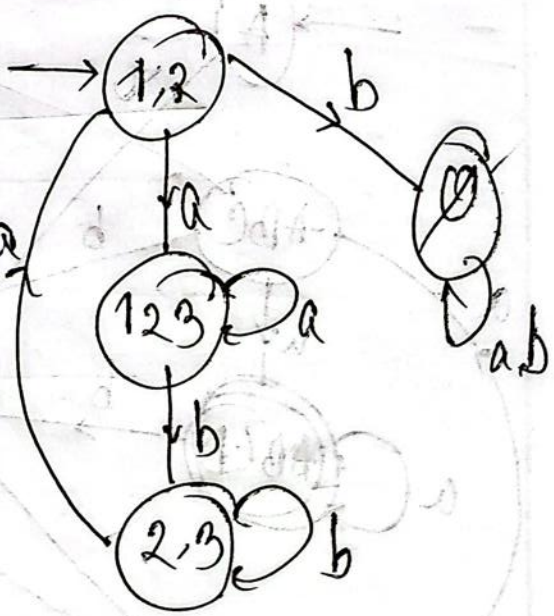
	a	b
→ 1	{3}	∅
* 2	{1}	∅
3	{2}	{2,3}

E-Closure (1) → {1,2}

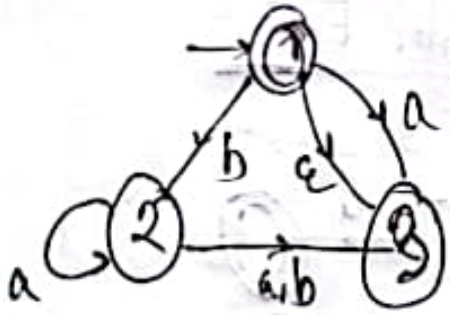
E-Closure (2) → {2}

E-Closure (3) → {3}

	a	b
→ [1,2]	[1,2,3]	∅
* [1,2,3]	[1,2,3]	[2,3]
* [2,3]	[1,2]	[2,3]



Lecture – 18



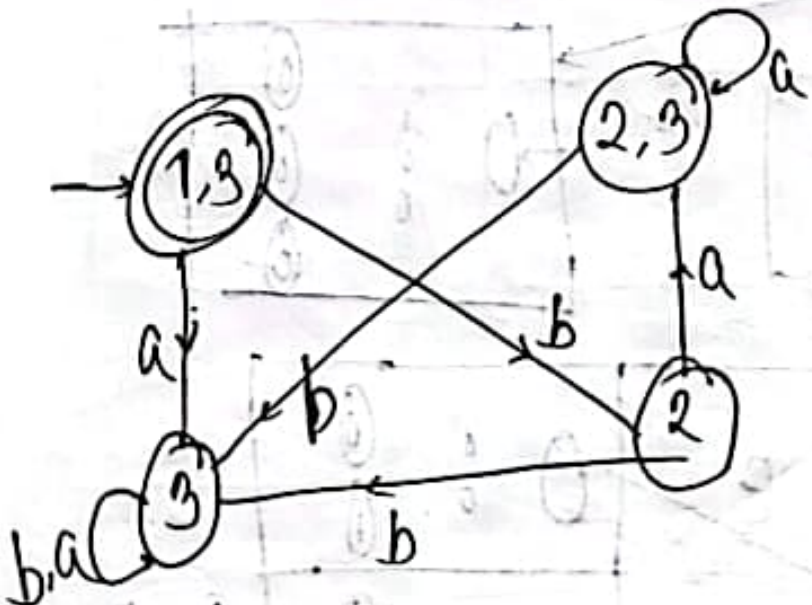
	a	b
→ 1	3	2
2	{2,3}	3
3	∅	∅

ε-closure (1) → {1,3}

E-Closure (2) → {2}

E-Closure (3) → {3}

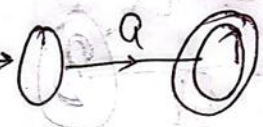
	a	b
*→ {1,3}	[3]	[2]
[3]	[3]	[3]
[2]	[2,3]	[3]
[2,3]	[2,3]	[3]



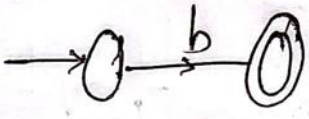
Lecture - 69

Formal Definition of Regular Exp

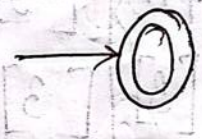
(1) $R = a$; where, $a \in \Sigma$



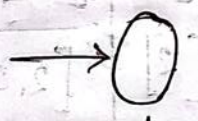
$R = b$; where, $b \in \Sigma$



(2) $R = \varepsilon$

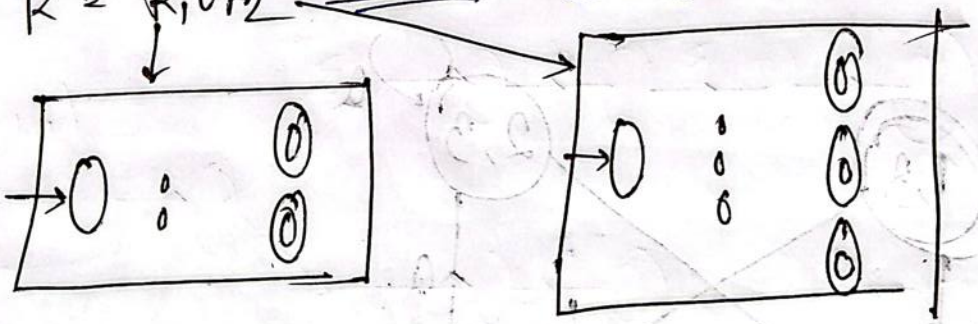


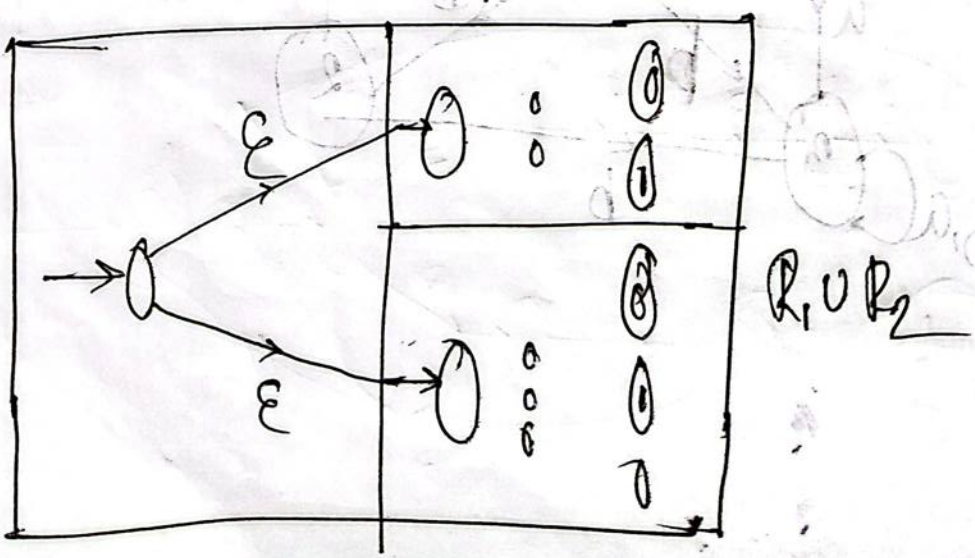
(3) $R = \emptyset$



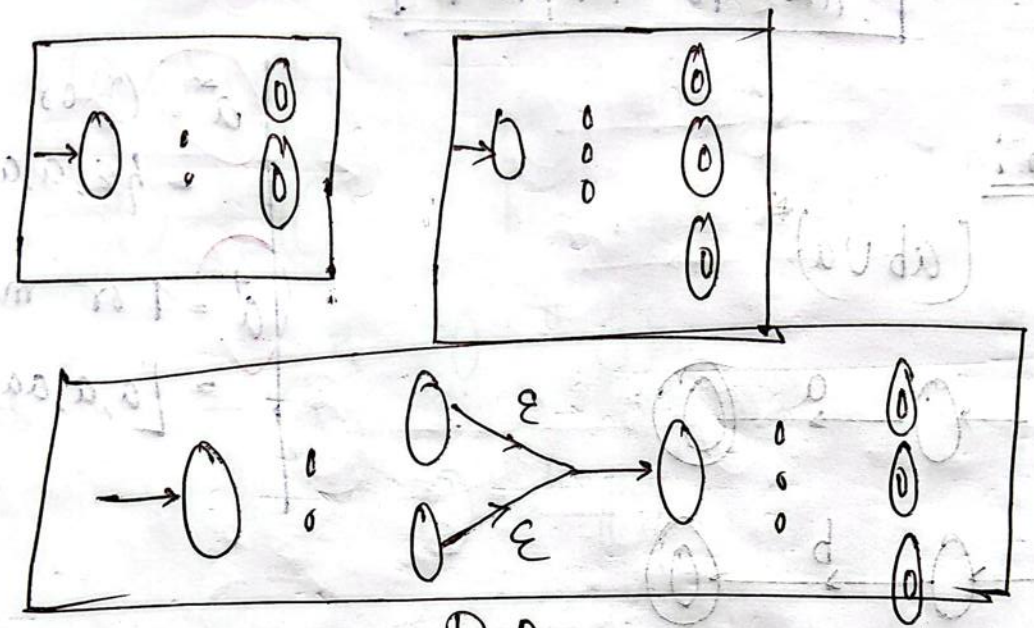
Trap/Death stage

(4) $R = R_1 \cup R_2 = R_1 | R_2 = R_1 + R_2$



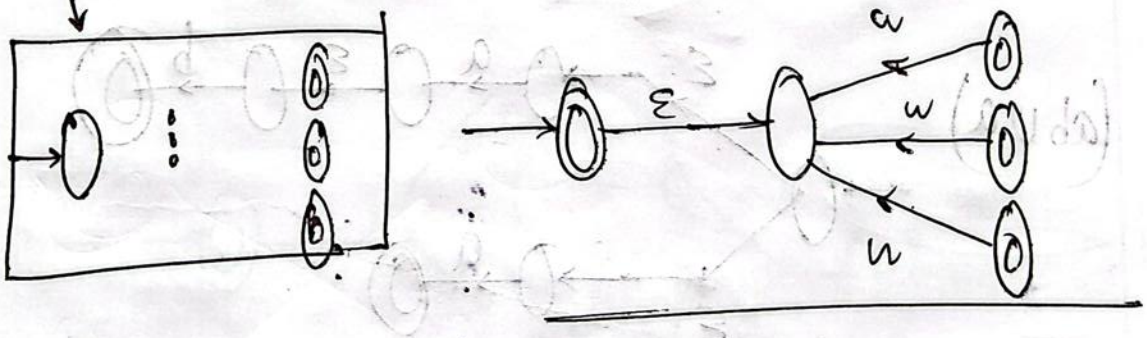


(5) $R = R_1 \cup R_2 = R_1 R_2$

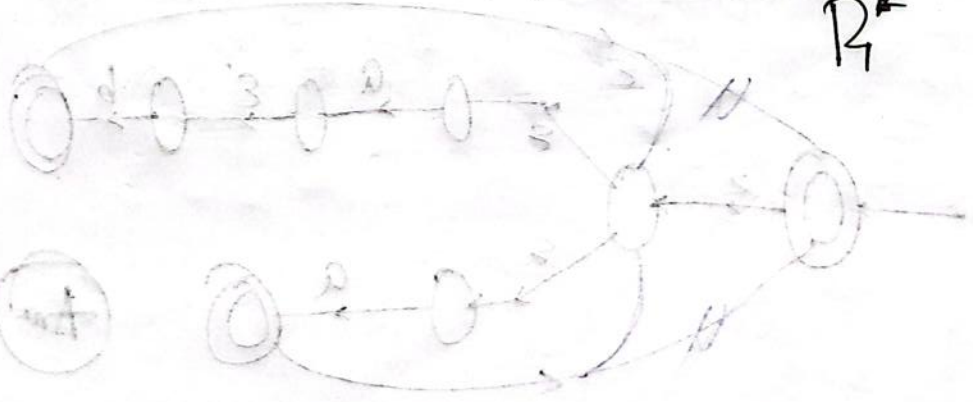


$R_1 \cup R_2$

(6) $R = R_1^*$



R_1^*



Lecture-70

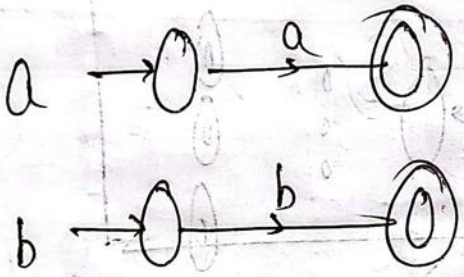
RE To FA/NFA

a^* = 0 or more
= {ε, a, aa, aaa ...}

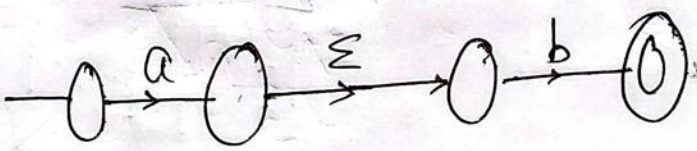
a^+ = 1 or more
= {a, a, aa ...}

Example:

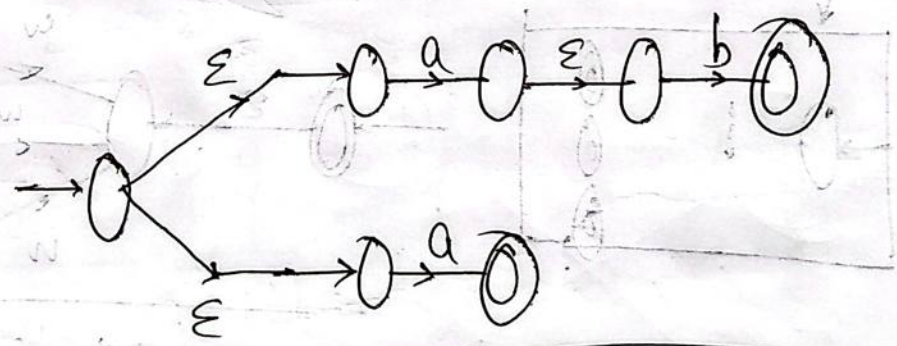
$(ab \cup a)^*$



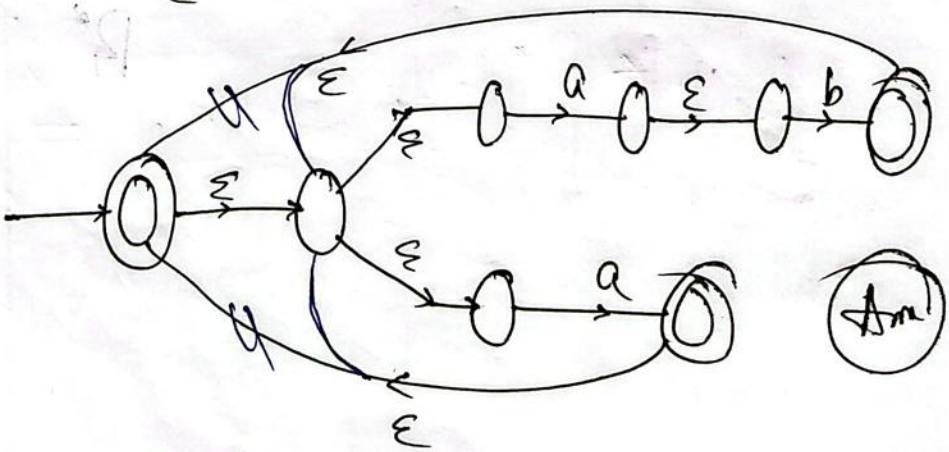
ab/aab =



$(ab \cup a)$



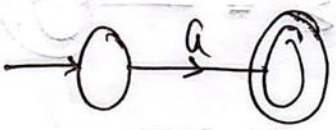
$(ab \cup a)^*$

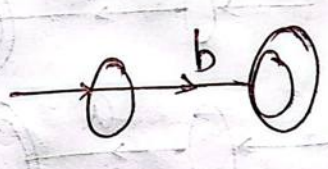


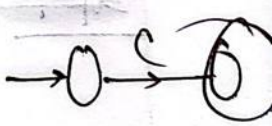
Lecture - 71

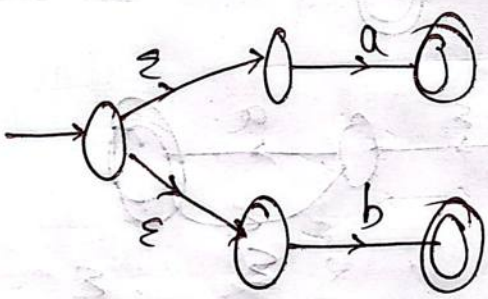
Example ②

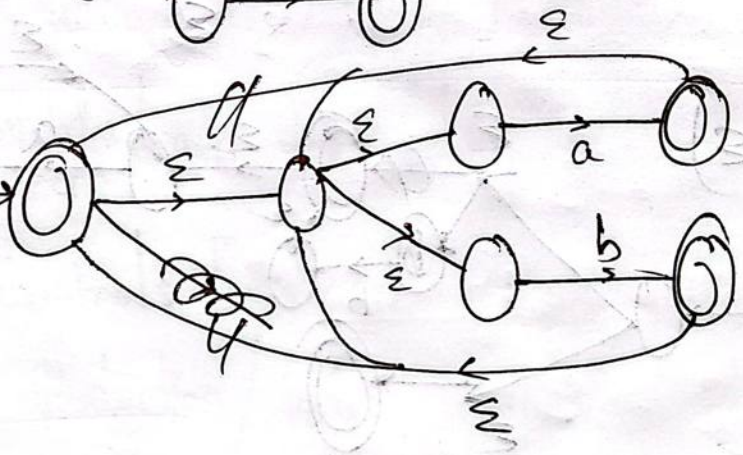
$(a \cup b)^* abc$

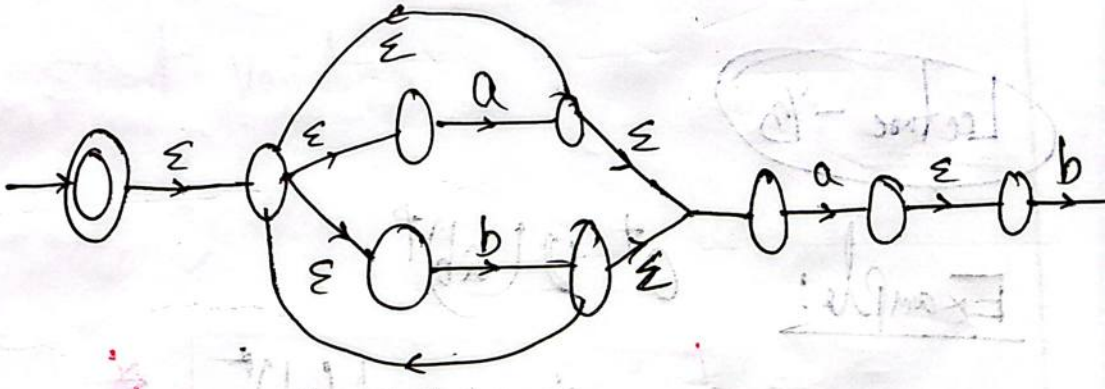
a → 

b → 

c → 

$a \cup b \rightarrow$ 

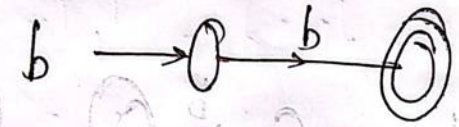
$(a \cup b)^* \rightarrow$ 

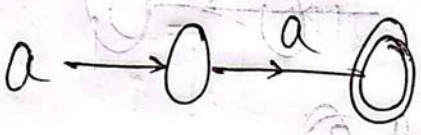
$(a \cup b)^* abc \rightarrow$ 

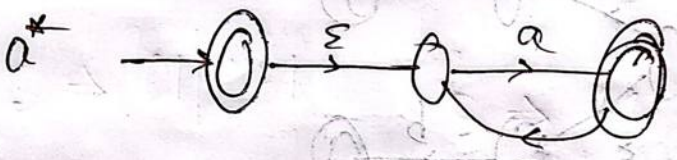
Lecture-12

Ex: $ba^* + \varepsilon$

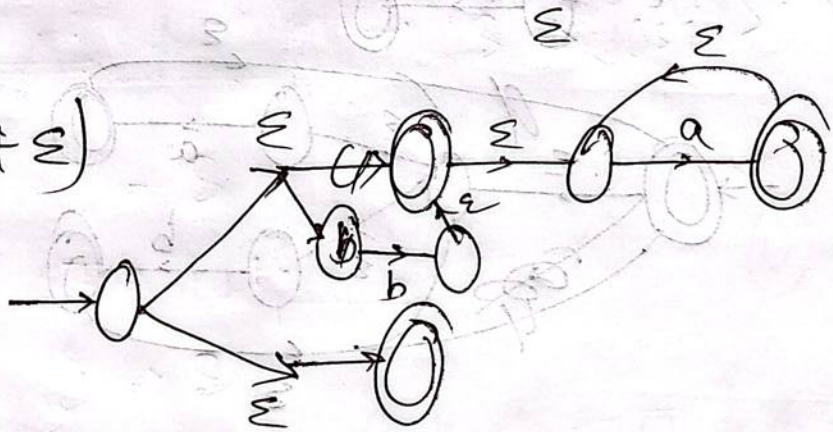
Soln:







$(ba^* + \varepsilon)$



Lecture-13

Example: $a^+ \cup (ab)^+$

$= aa^* \cup ab(ab)^*$ ✱