SmartBoy

Theory of Computations

①

TUT - 1

Q1) set of strings up to length 4 in lexographic ordering.
over $\Sigma = \{a,b\}$

1) start with a →

$L = \{a, aa, ab, aaa, aab, aba, abb, aaaa \ldots\ldots\}$

$a(a+b)^*$

2) Start with b →

$L = \{b, bb, ba, bbb, \ldots\ldots\}$

$b(a+b)^*$

3) having substring aa →

$L = \{aa, baa, aaa, aab, aaaa, \ldots\ldots\}$

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

4) starting & ending letter diff. →

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

5) atleast one a →

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

6) exactly one a →

$b^* a b^*$

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②

7) at most one a →

$\underset{\text{No } a}{b^*} + \underset{1a}{b^* a b^*}$

TUT-2

a) Regular expression

1) over {0,1} such that no. of 1s are div. by 4.

$(0^* 1 0^* 1 0^* 1 0^* 1 0^*)^*$ 0, 4, 8, 12, 16, ...

2) substring ccc

$(a+b+c)^* ccc (a+b+c)^*$

3) $L = \{ w : |w| \bmod 5 = 0 \}, w \in (a,b)^* \}$

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

4) atleast one 1 a & 1 b.

~~(a+b)(a+b)~~

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

(v) even length.

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

(vi) odd length

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

(vii) $L = \{ a^n b^m \mid n, m \geq 1 \}$

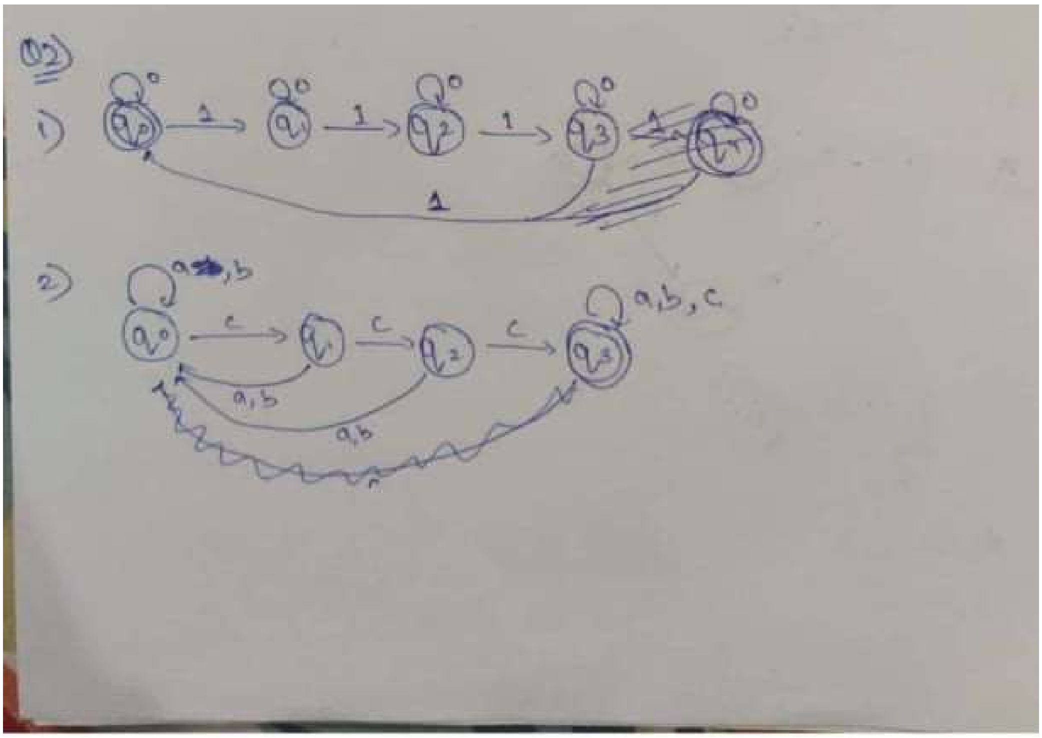
$a a^* b b^*$

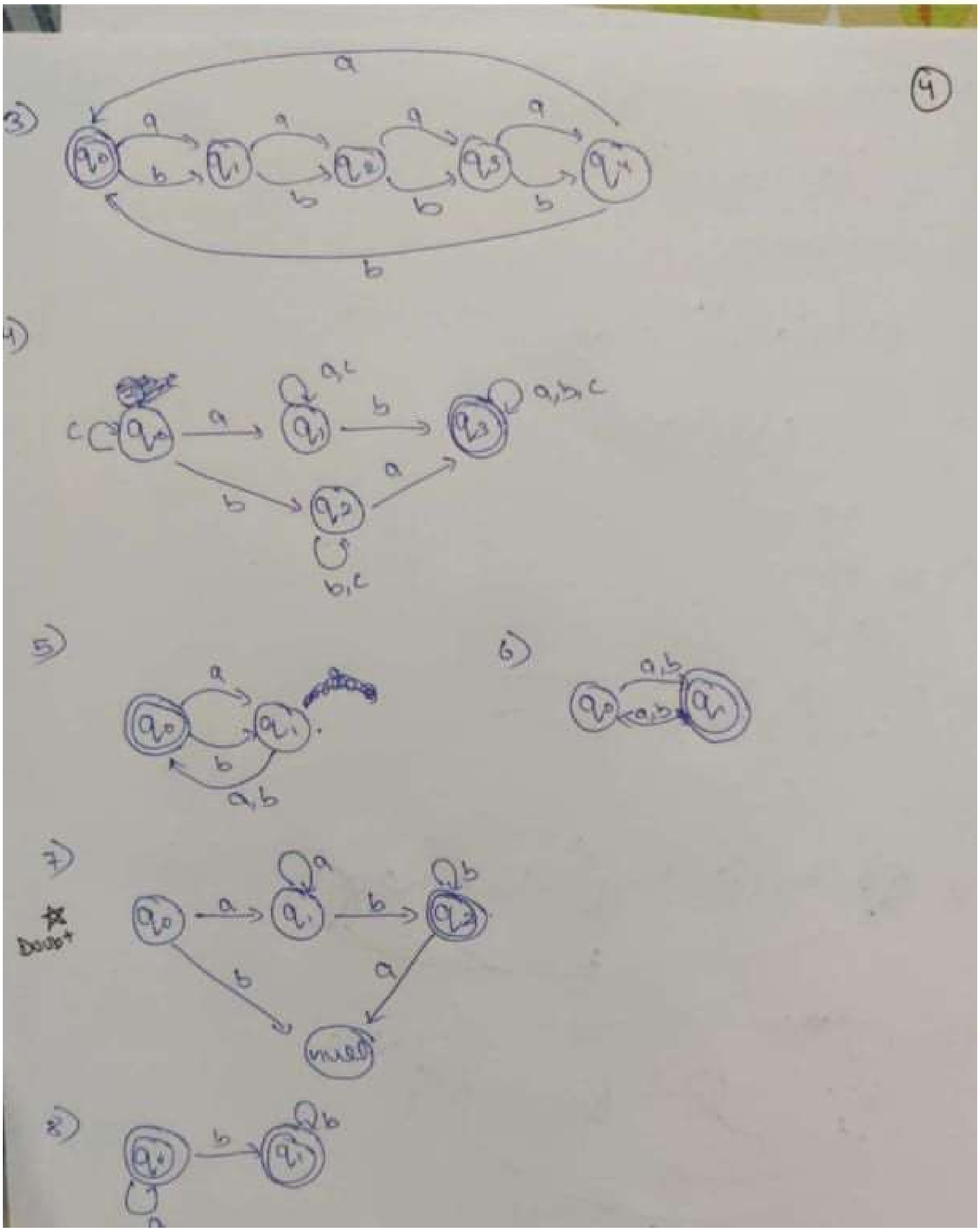
(viii) n, m ≥ 0

$a^* b^*$

(ix) 5th symb. 1 from right end.

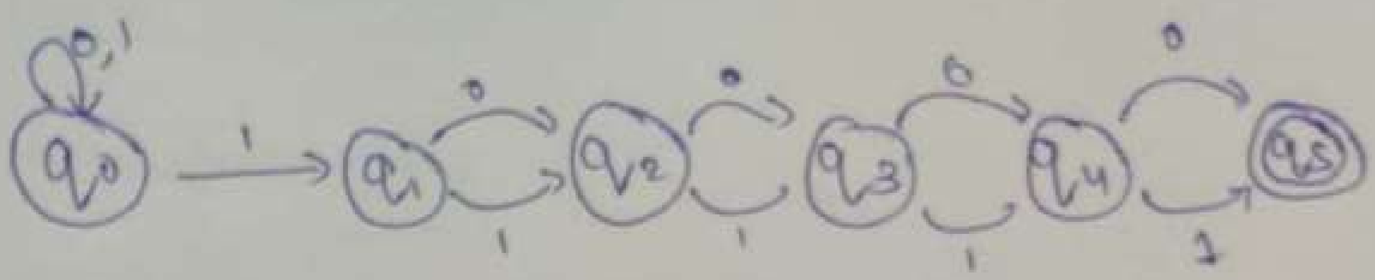
$(0+1)^* 1 (0+1)(0+1)(0+1)(0+1)$


Q2)
1)
2)
a,b,c
a,b


4
3)
4)
a,b,c
b,c
5)
6)
a,b
7)
Doubt
8)

5

9)



NFA

States	0	1
q_0	q_0	$\{q_0, q_1\}$
q_1	q_2	q_2
q_2	q_3	q_3
q_3	q_4	q_4
q_4	q_5	q_5
q_5	-	-

DFA

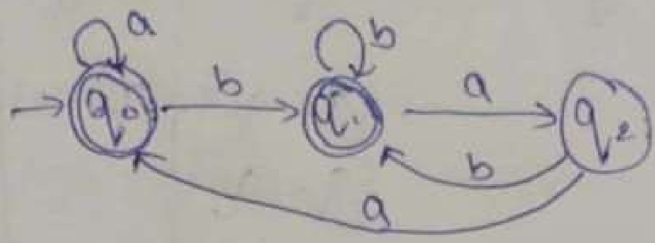
	0	1
q_0	q_0	$\{q_0, q_1\}$
$\{q_0, q_1\}$	$\{q_0, q_2\}$	$\{q_0, q_1, q_2\}$
$\{q_0, q_2\}$		
⋮		

and so on

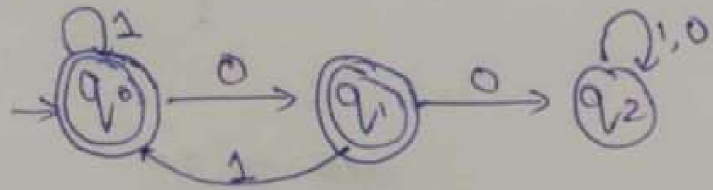
TUT-3

DFA

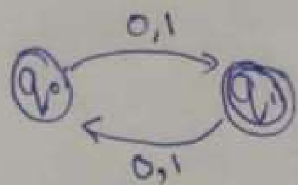
1) $\{a,b\}$ not ending with ba.



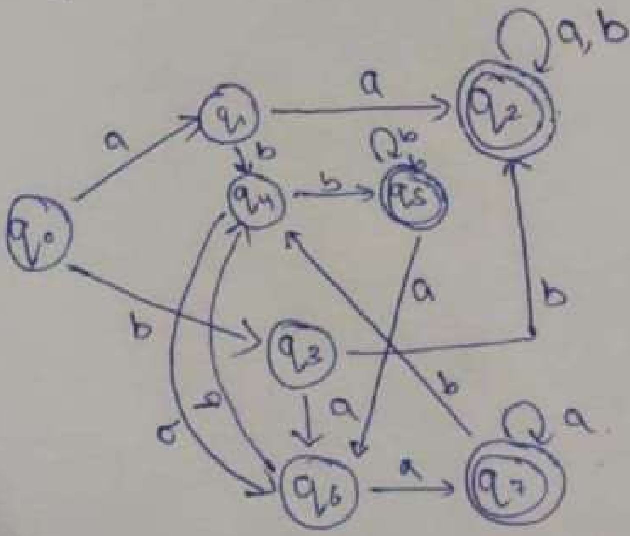
2) not containg substring 00



3) not even no. of letters.



4) begins or end with aa / bb.



Q5 Not in R.E. (min string)

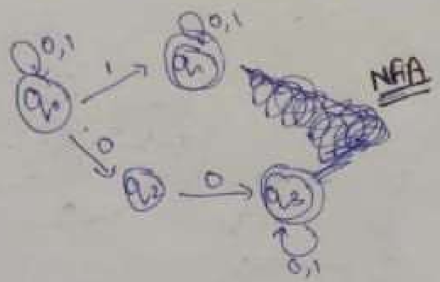
i) $1^*(01)^*0^*$ → 011 or 001

ii) $1^*(0+10)^*1^*$ → 0110

iii) $(0^*+1^*)(0^*+1^*)(0^*+1^*)$ → 0101 or 1010

Q7 Draw DFA

a) $(0+1)^*(1+00)(0+1)^*$

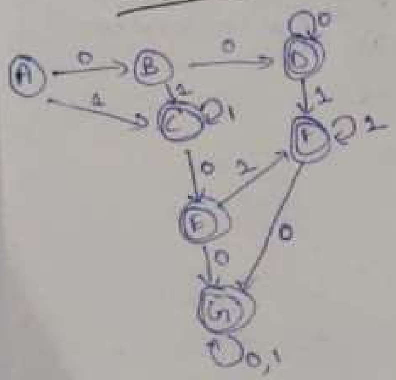


	0	1
q_0	$\{q_0, q_2\}$	$\{q_0, q_1\}$
q_1	q_1	q_1
q_2	q_3	–
q_3	q_3	q_3

DFA

	0	1
A q_0	B $\{q_0, q_2\}$	C $\{q_0, q_1\}$
B $\{q_0, q_2\}$	D $\{q_0, q_2, q_3\}$	C $\{q_0, q_1\}$
C $\{q_0, q_1\}$	E $\{q_0, q_1, q_2\}$	C $\{q_0, q_1\}$
D $\{q_0, q_2, q_3\}$	D $\{q_0, q_2, q_3\}$	F $\{q_0, q_1, q_3\}$
E $\{q_0, q_1, q_2\}$	G $\{q_0, q_1, q_2, q_3\}$	F $\{q_0, q_1, q_3\}$
F $\{q_0, q_1, q_3\}$	G $\{q_0, q_1, q_2, q_3\}$	F $\{q_0, q_1, q_3\}$
G $\{q_0, q_1, q_2, q_3\}$	G $\{q_0, q_1, q_2, q_3\}$	G $\{q_0, q_1, q_3\}$

Final DFA



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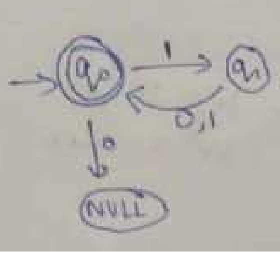
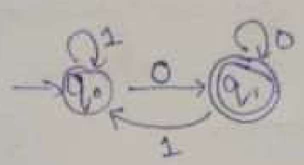
b) $(11+10)^*$

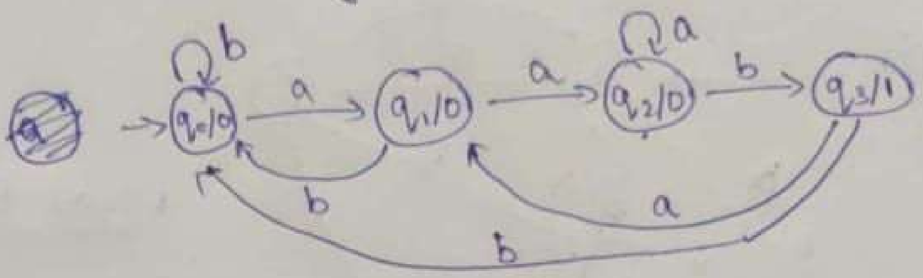


c) $(0+1)^*0$



TUT-~~5~~ 4

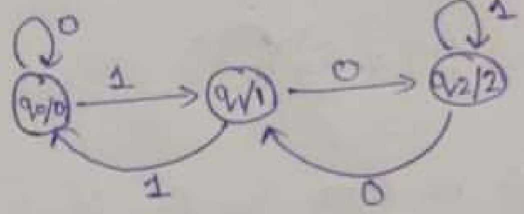
Q1) Moore → count occ. of aab over $\Sigma = \{a,b\}$



Q2) residue mod-3 for binary str. treated as bin. int.

$\Sigma = \{0,1\}$. MOORE

1	1%3	= 1
10	2%3	= 2
11	3%3	= 0
100	4%3	= 1
101	5%3	= 2
110	6%3	= 0
111	7%3	= 1



States	0	1	Output
q_0	q_0	q_1	0
q_1	q_2	q_0	1
q_2	q_1	q_2	2

Q3) MEALY residue mod-4

1	1%4	= 1
10	2%4	= 2
11	3%4	= 3
100	4%4	= 0
101	5%4	= 1
110	6%4	= 2
111	7%4	= 3

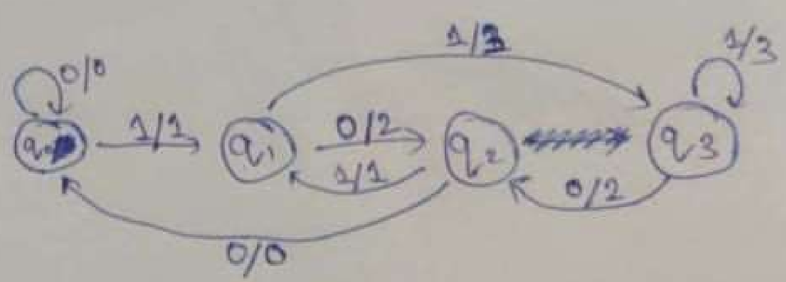
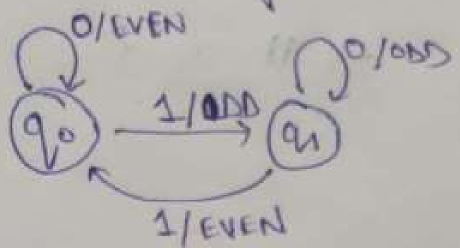


Table.

State	0		1	
	state	o/p	state	o/p
q_0	q_0	0	q_1	1
q_1	q_2	2	q_3	3
q_2	q_0	0	q_1	1
q_3	q_2	2	q_3	3

Q4) Mealy

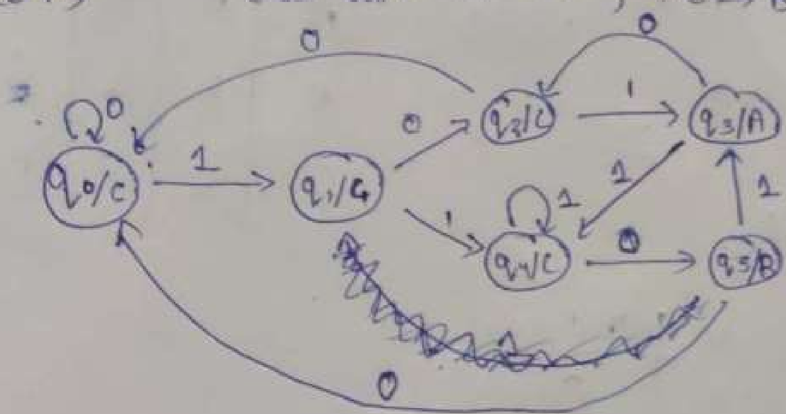
Total no. of 1's encountered is even/odd. $\Sigma = \{0,1\}$



State	0		1	
	state	o/p	state	o/p
q_0	q_0	EVEN	q_1	ODD
q_1	q_1	ODD	q_0	EVEN

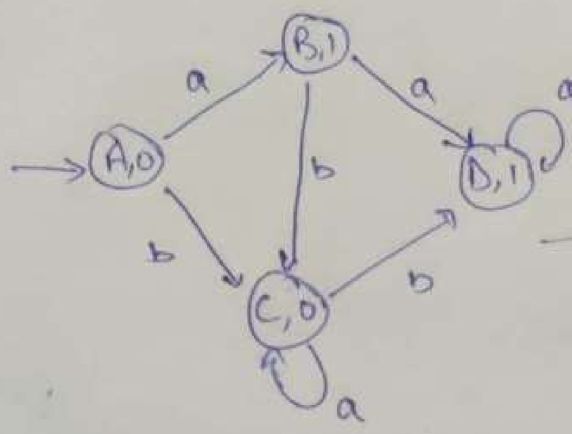
Q5) Moore

$(0+1)^*$ ends with 101 → A, 110 → B else → C



IIly draw for mealy

Q6) a) convert into mealy



→ Moorey

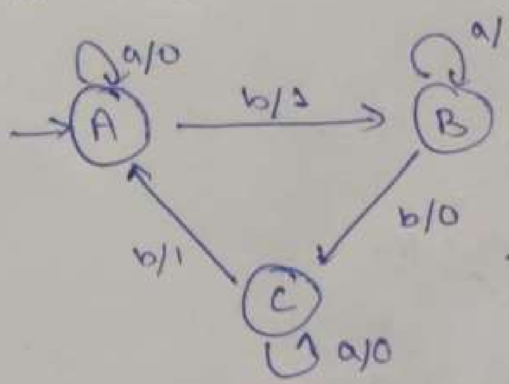
States	a	b	Output
A	B	C	0
B	D	C	1
C	C	D	0
D	D	D	1

Mealy

States	a		b	
	state	O/P	state	O/P
A	B	1	C	0
B	D	1	C	0
C	C	0	D	1
D	D	1	D	1

b) Hly as a)

Q7) a) convert into moore



Mealy →

States	a		b	
	state	o/p	state	o/p
A	A	0	B	1
B	B	1	C	0
C	C	0	A	1

$A_0 \to 0$

$A_1 \to 1$

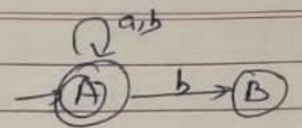
States	a	b	Output
A_0	A_0	B	0
A_1	A_0	B	1
B	B	C	1
C	C	A_1	0

Moore

b) Hly as a)

Tut - 3
Question - 5

Q5
a)

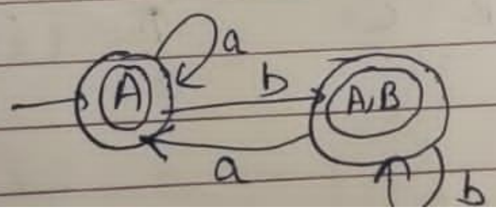


State \ Input	a	b
→A	A	A,B
B	–	–

NFA (Transition table)

State \ Input	a	b
→A	A	[A,B]
[A,B]	A	[A,B]

DFA (transition Table)



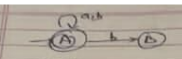
DFA

3

not

+bb) + (λ + a + b)

Q5
a)



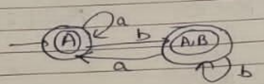
NFA (Transition table)

State \ Input	a	b
→A	A	A, B
B	—	—

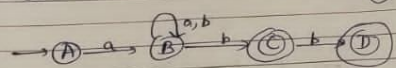
DFA (Transition Table)

State \ Input	a	b
→A	A	[A, B]
[A, B]	A	[A, B]

DFA



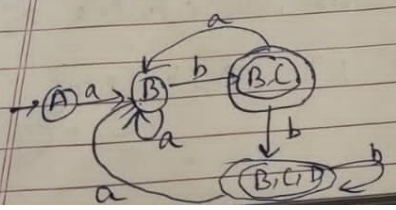
b)



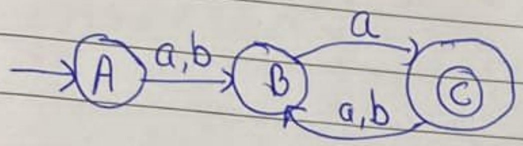
State \ Input	a	b
→A	B	—
B	B	B, C
C	—	D
D	—	—

NFA table

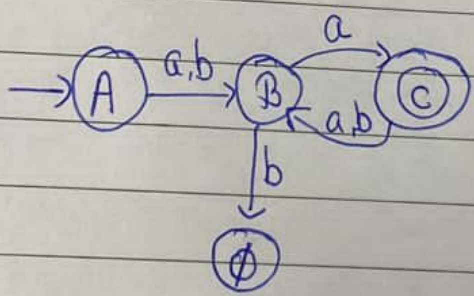
State \ Input	a	b
→A	B	—
B	B	[B, C]
[B, C]	B	[B, C, D]
[B, C, D]	B	[B, C, D]



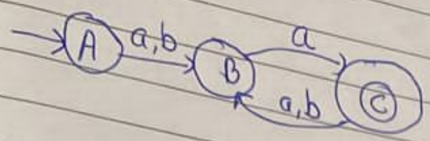
d)



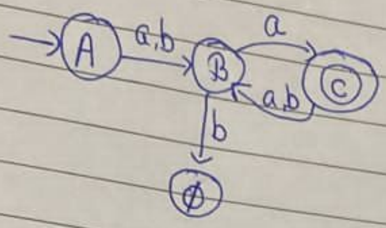
	a	b	~~ε~~
→A	B	B	~~∅~~
B	C	∅	~~∅~~
C	B	B	~~∅~~



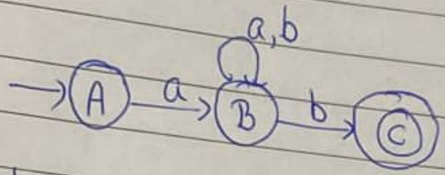
d)



	a	b	~~c~~
→A	B	B	~~∅~~
B	C	∅	~~∅~~
C	B	B	~~∅~~

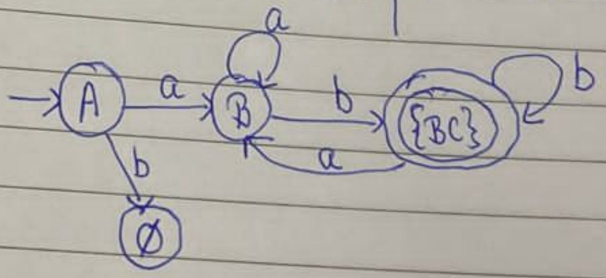


c)

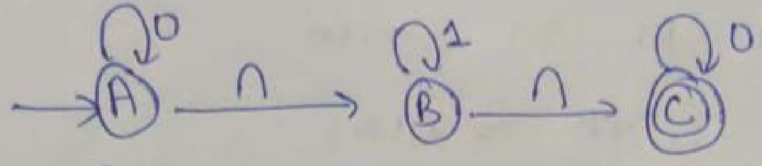


	~~a~~	~~b~~
~~A~~	~~B~~	~~∅~~
~~B~~	~~B~~	
~~C~~		

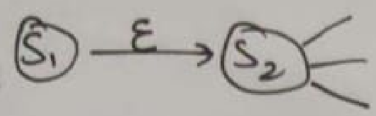
	a	b
→A	B	∅
B	B	{BC}
{BC}	B	{BC}



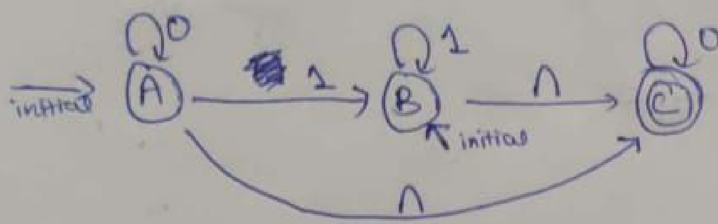
Q1



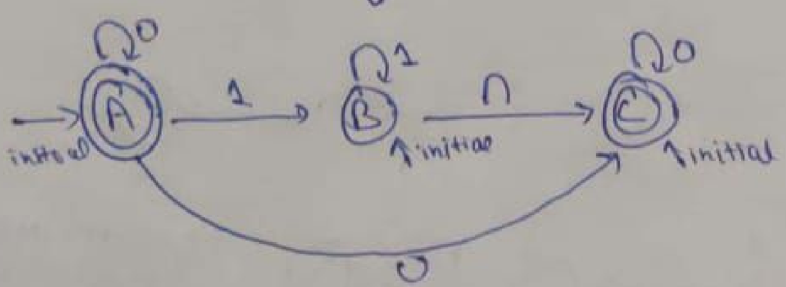
Find eq. NFA without ∩ transitions.



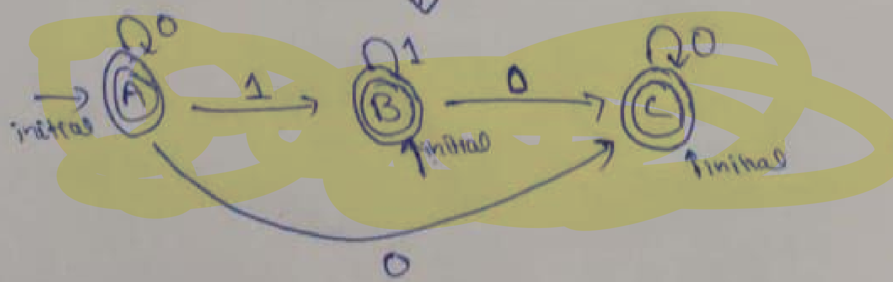
1) Find all edges starting from S_2
2) Duplicate all edges to S_1 without changing edge labels
3) If S_1 is initial state, make S_2 initial
4) If S_2 is final state, make S_1 final.



↓



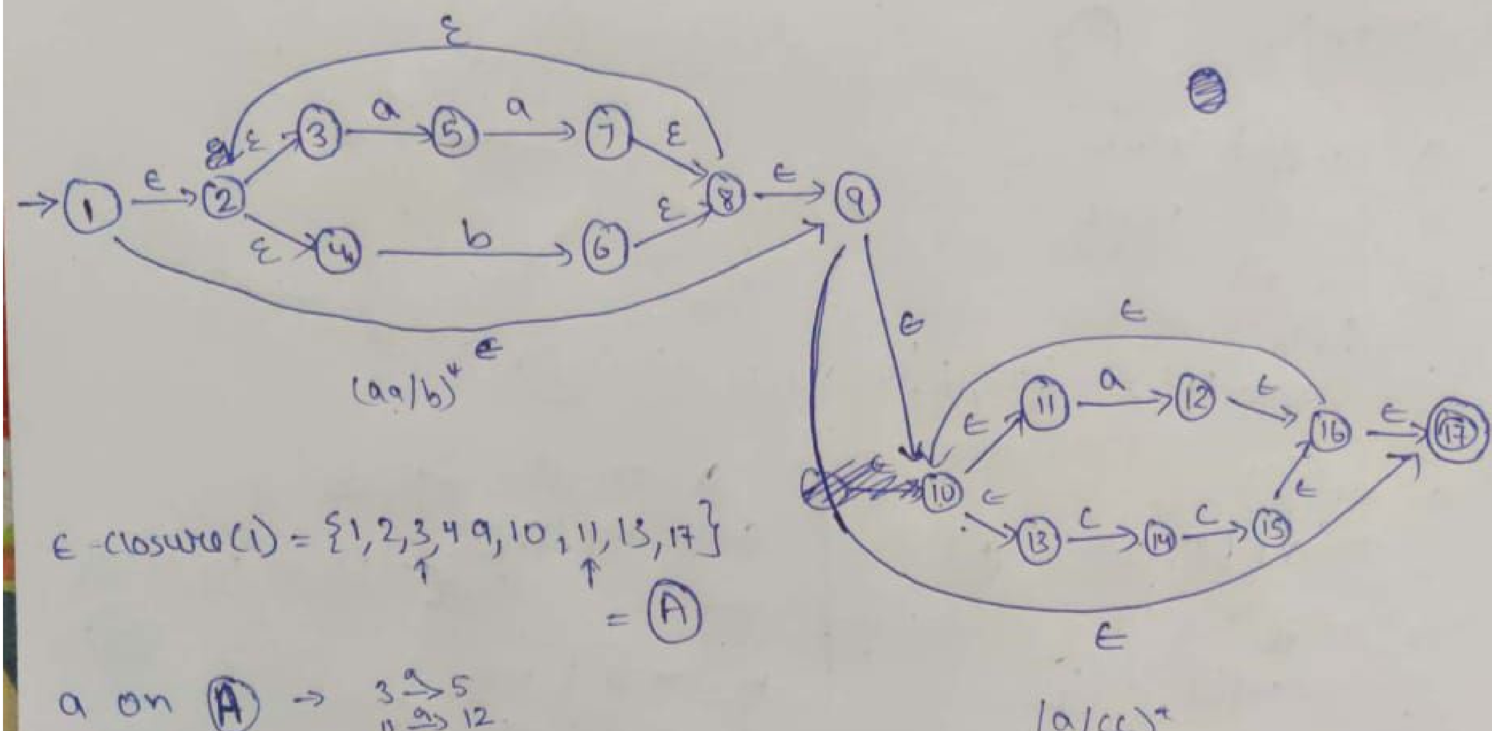
↓



Answer

Q2 Thompson's const.

(aa|b)* (a|cc)*



ε-closure(1) = {1, 2, 3, 4, 9, 10, 11, 13, 17} = A

a on A → 3 →a 5, 11 →a 12

ε-closure(5,12) = {5, 12, 16, 10, 17, 11, 13} = B

b on A → 4 →b 6

ε-closure(6) = {6, 8, 2, 3, 4, 9, 10, 11, 13, 17} = C

c on A → 13 →c 14

ε-closure(14) = {14} = D

a on B → 5 →a 7, 11 →a 12

ε-closure(7,12) = {7, 8, 2, 3, 4, 9, 10, 11, 12, 13, 16, 17} = E

b on B → NULL

c on B → 13 →c 14

ε-closure(14) = D

a on C

$3 \xrightarrow{a} 5$

$11 \xrightarrow{a} 12$

ε-closure (5,12) = B

c on C

$13 \xrightarrow{c} 14$

ε-closure (14) = D

b on C

$4 \xrightarrow{b} 6$

ε-closure (6) = C

a on D NULL

b on D NULL

c on D

$14 \xrightarrow{c} 15$

ε-closure (15) = {15, 16, 17, 10, 11, 13} = F

a on E.

ε-closure (5,12) = B

b on E

ε-closure (6) = C

c on E

ε-closure (14) = D

a on F $11 \xrightarrow{a} 12$

ε-closure (12)

= {12, 16, 17, 10, 11, 13}

G

b on F NULL

c on F $13 \xrightarrow{c} 14$

ε-closure (14) = D

a on G

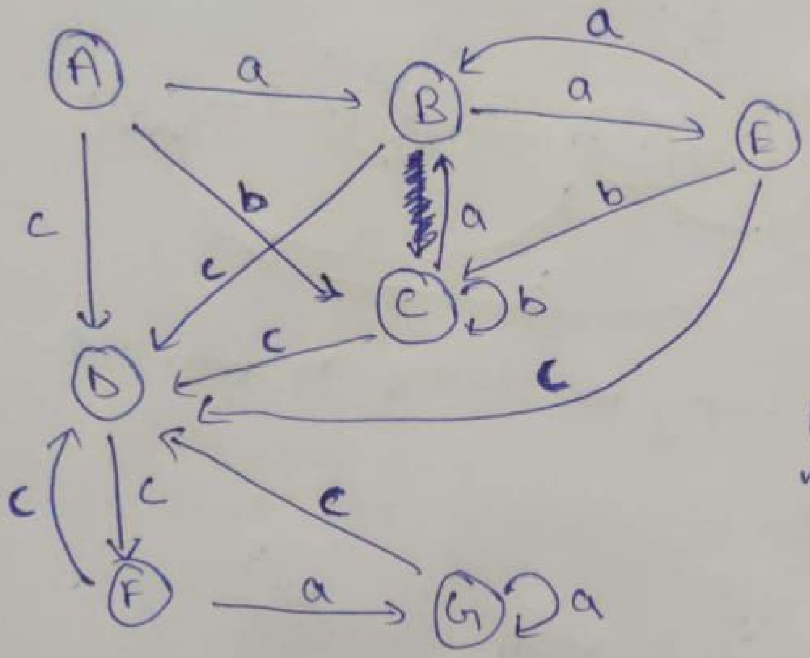
ε-closure (12) = G

b on G NULL

c on G

ε closure (14) = D

Final DFA after subset const.

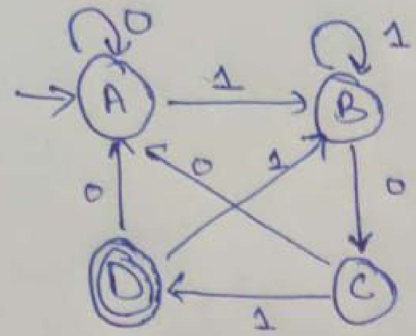


Final DFA

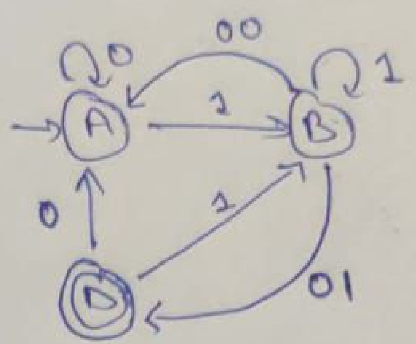
Ab minimazation nhi krunga.

Q3 → Q2 ho gya to Q6 kya cheez hai!

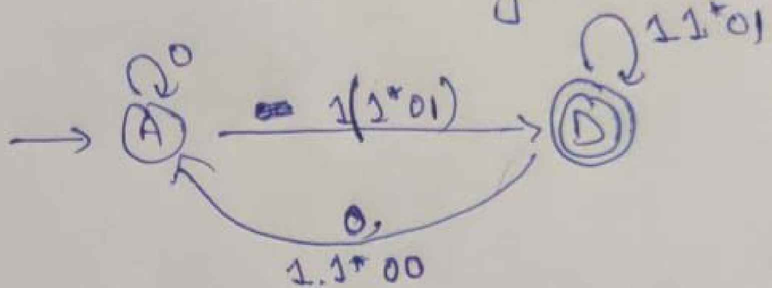
Q14) using State elimination.



eliminating C



eliminating B

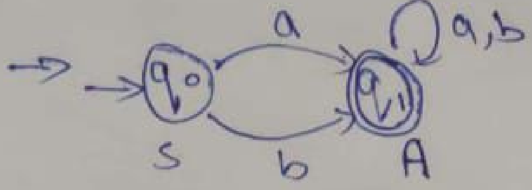


$$R.E \rightarrow \left(0^* 1(1^*01)(11^*01)^*\right)\left[(0+11^*00)0^* 1(1^*01)\right]^*$$

Q5 Atleast one a or one b | Left Linear & Right Linear.

R.E. $\longrightarrow (a+b)^*(a+b)(a+b)^*$

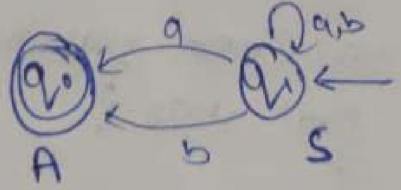
DFA



★ Could be NFA also

$$\boxed{\begin{aligned} S &\rightarrow aA \mid bA \\ A &\rightarrow aA \mid bA \mid \varepsilon \end{aligned}}$$

Right Linear

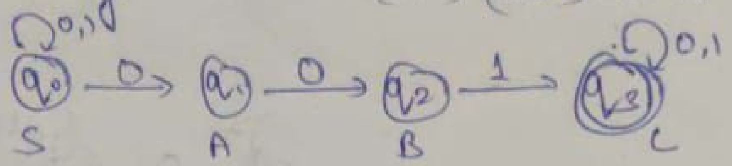


Left Linear

$S \rightarrow Sa \mid Sb \mid Aa \mid Ab$

$A \rightarrow \varepsilon$

6 substring 001 $(0+1)^*(001)(0+1)^*$



Right Linear →

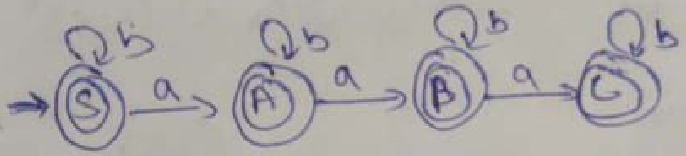
$S \to 0S \mid 1S$
$S \to 0A$
$A \to 0B$
$B \to 1C$
$C \to 0C \mid 1C \mid \varepsilon$

||ly left linear by rev. the NFA.

7 Doubt

at most 3a.

1. $b^* a b^* a b^* a b^*$
2. $b^* a b^* a b^*$
3. $b^* a b^*$
4. b^*



$S \to bS \mid aA \mid \varepsilon$
$A \to bA \mid aB \mid \varepsilon$
$B \to bB \mid aC \mid \varepsilon$
$C \to bC \mid \varepsilon$

Right Linear

→ can linear grammar have no final state ?

$0^n 1^m$ n+m even.

$\underbrace{\cancel{(00)(11)^*} 0(00)^* 1(11)^*}_{\text{odd}} + \underbrace{(00)^*(11)^*}_{\text{even}}$