

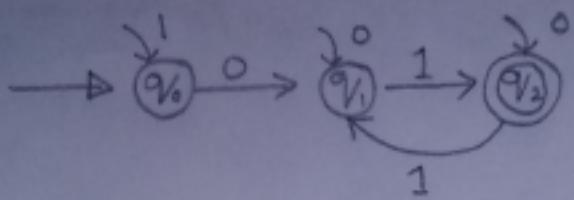
SUBJECT- THEORY OF COMPUTATION

MID TERM HAND NOTES

SOLVED BY- MUSTAFIZUR RAHMAN

Deterministic Finite Automata (DFA)

Formal Definition



An automaton in a five tuple $(Q, \Sigma, \delta, q_0, F)$ where

1. Q is a finite set called the states
2. Σ is a finite set called the alphabates
3. $\delta : Q \times \Sigma \rightarrow Q$ is the transition function
4. $q_0 \in Q$ is the start state
5. $F \subseteq Q$ is the set of accept states.

here

$$1. Q = \{q_0, q_1, q_2\}$$

$$2. \Sigma = \{0, 1\}$$

3.

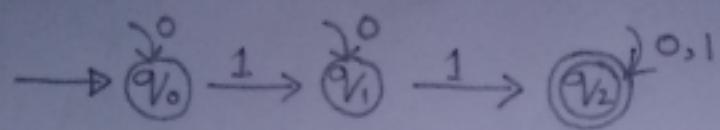
S-state	0	1
q_0	q_1	q_0
q_1	q_1	q_2
q_2	q_2	q_1

4. $q_0 = \{q_0\}$ is the start state

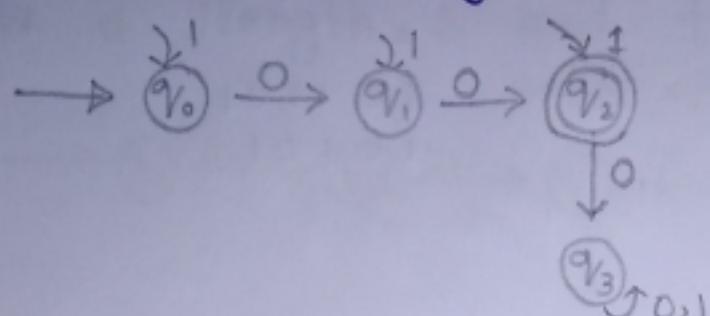
5. $F = \{q_2\}$

Designing of DFA

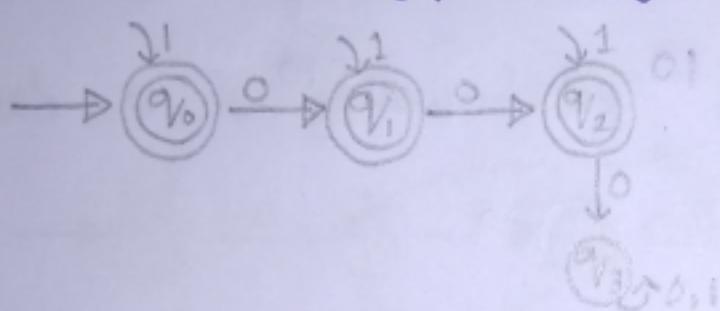
1. $L = \{w / w \text{ contains at least two } 1's\}$



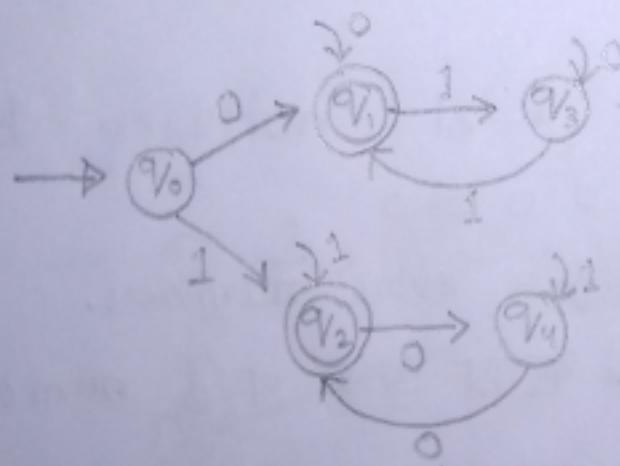
2. contains exactly two 0's



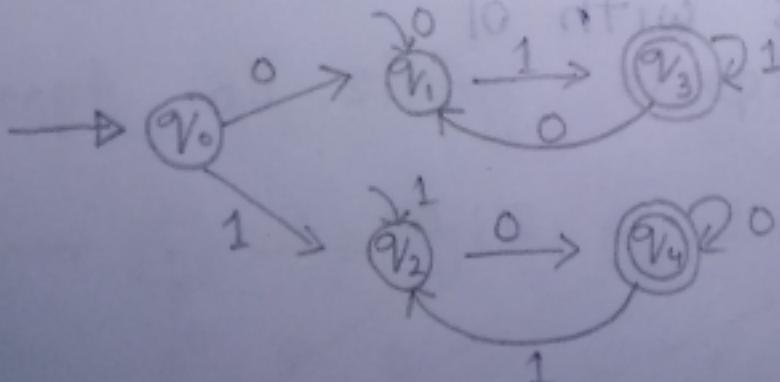
3. contains at most two 0's



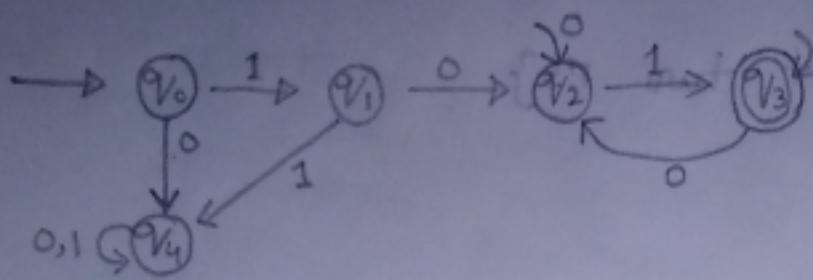
4. starts and ends with same symbol



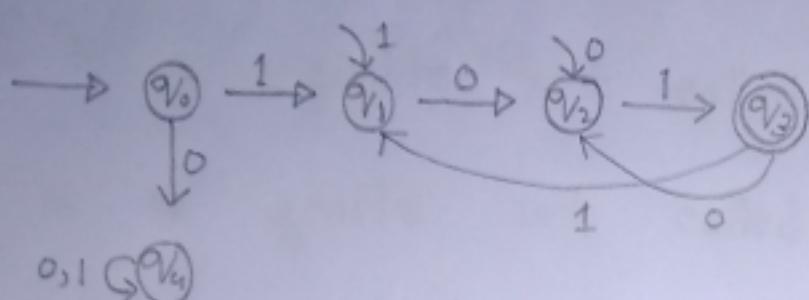
5. starts and ends with different symbol



6. Starts with 10 and ends with 1

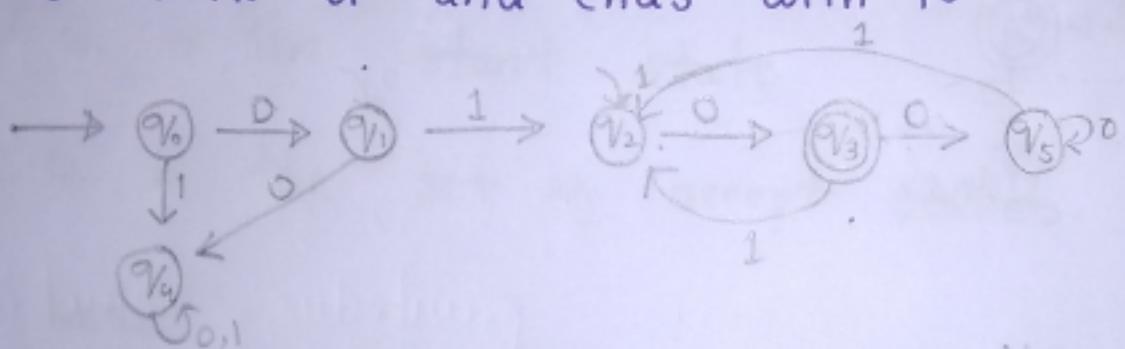


7. starts with 1 ends with 01



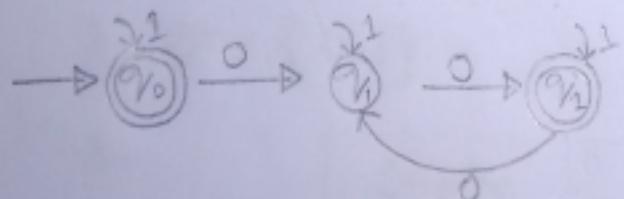
101101
10101

8. starts with 01 and ends with 10



010

9. contains even num of 0

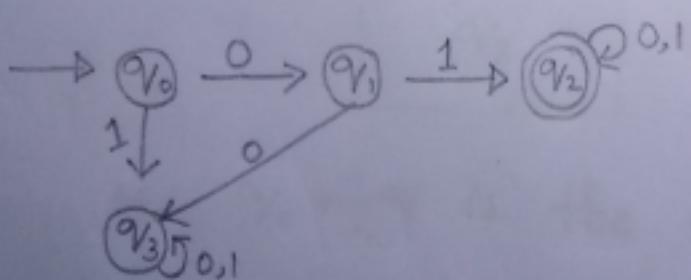


0 0 0 0

0 itself a even number.

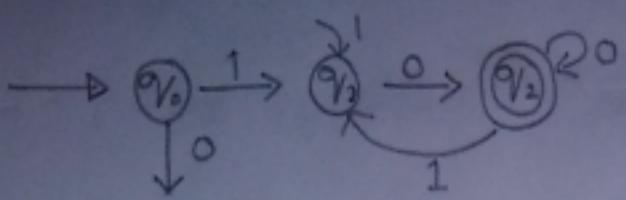
0 read কুরার আসল পর্যট নুম অফ ০ ই ০

10. starts with 01 and ends with 01



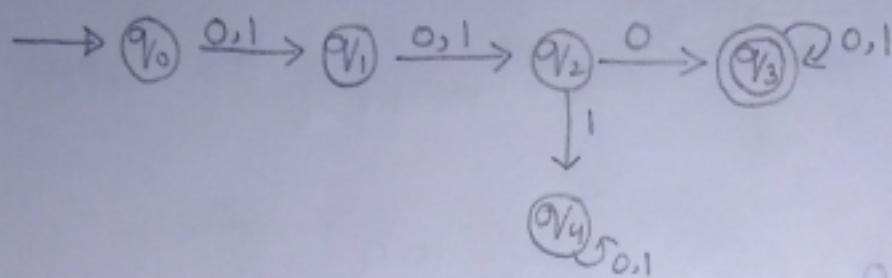
0101

11. starts with 1 ends with 0

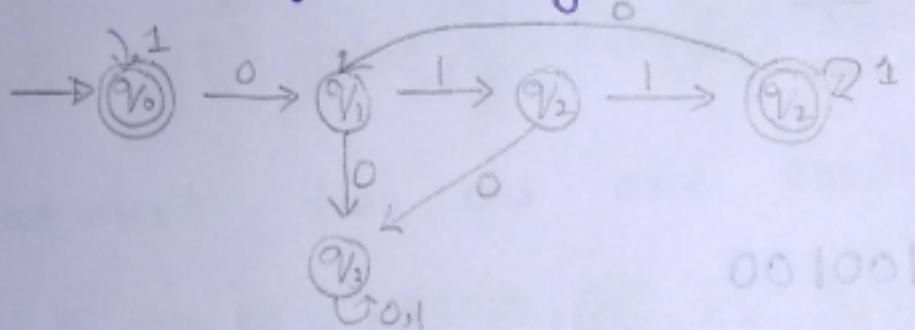


$q_3 \xrightarrow{0,1} q_4$

12. Has a length ≥ 3 and third symbol is 0



13. each 0 is followed by at least two 1's

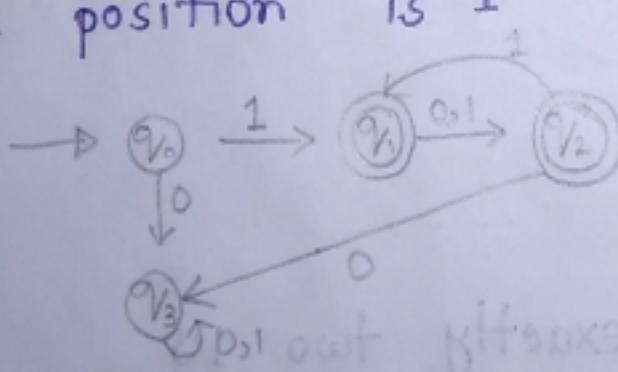


0 input फैलेंगे ॥

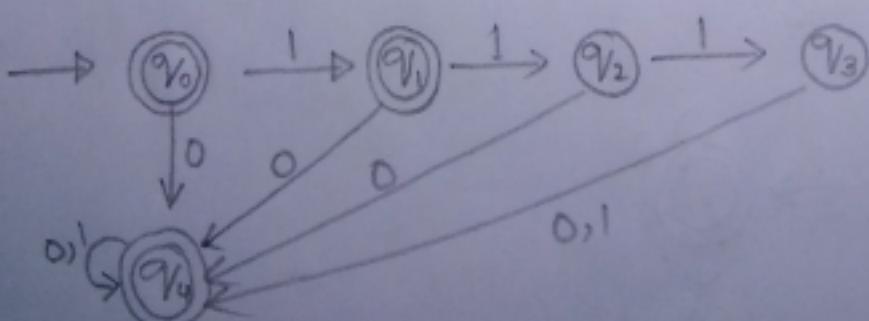
नाखल या टेक्स तरीके accept

प्रिंटर्डम् उत्तरान् ॥

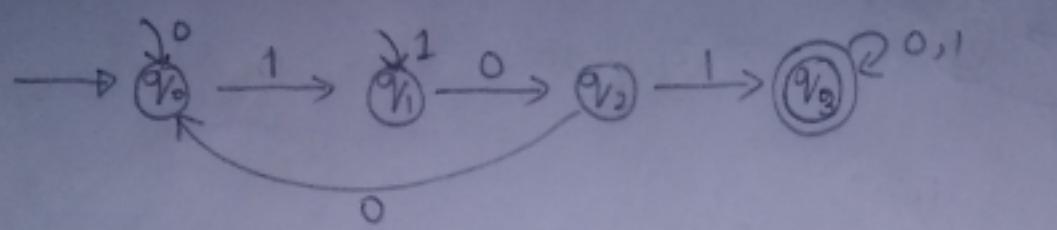
14. odd position is 1



15. accept all string except 11 and 111



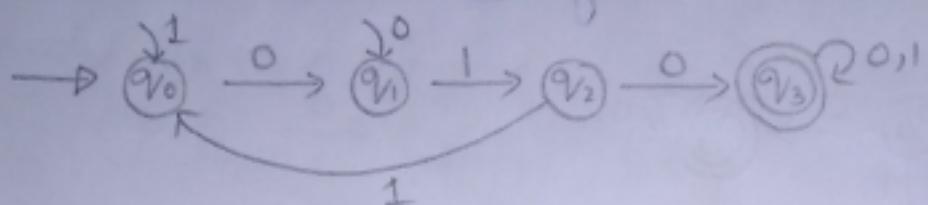
16. Contains substring 101



01101

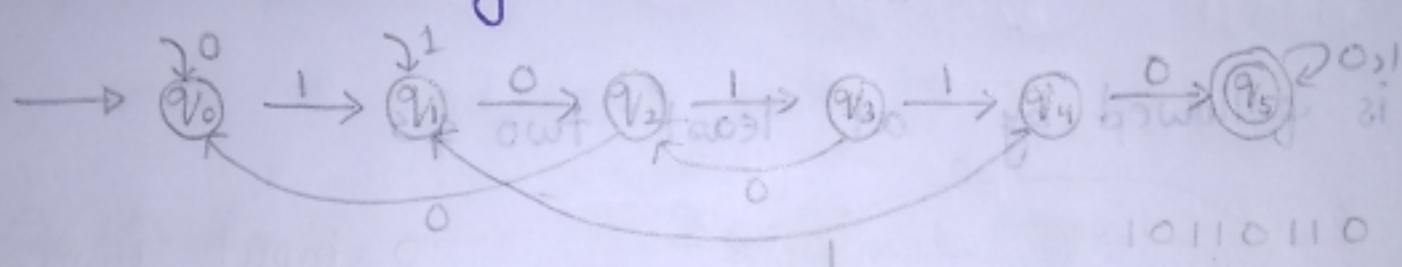
0110

17. contains substring 010



01101
0110

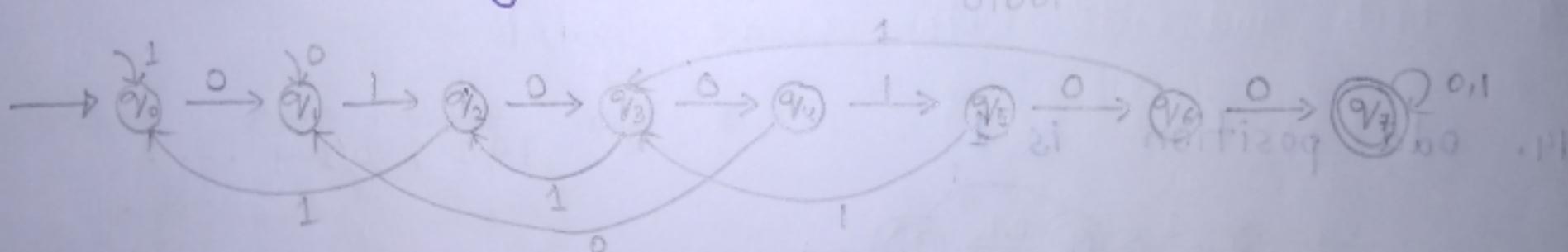
18. contains substring 10110



1011

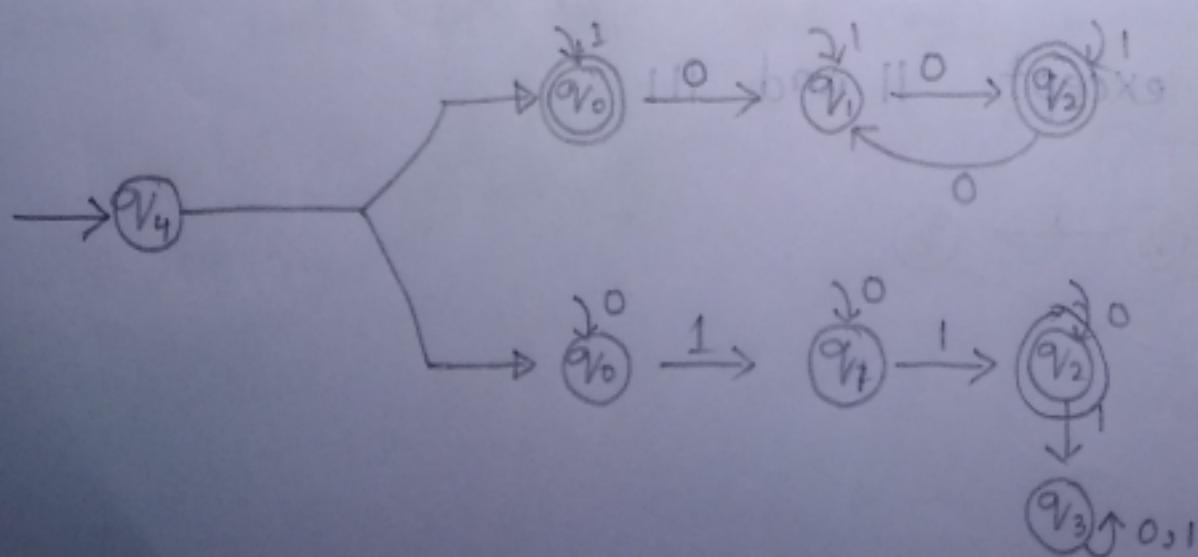
10110110

19. contains substring 0100100

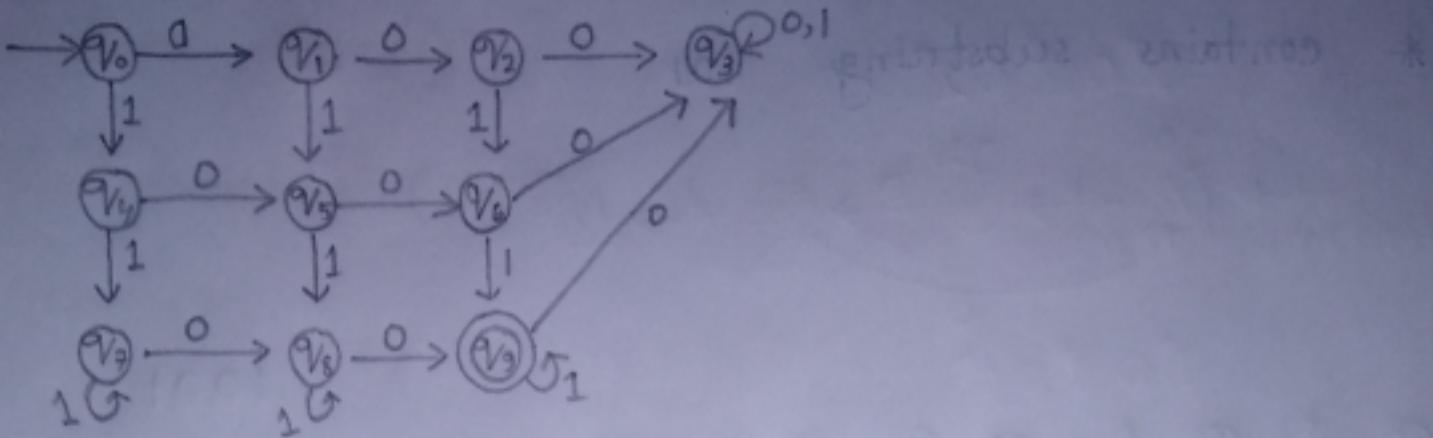


01001

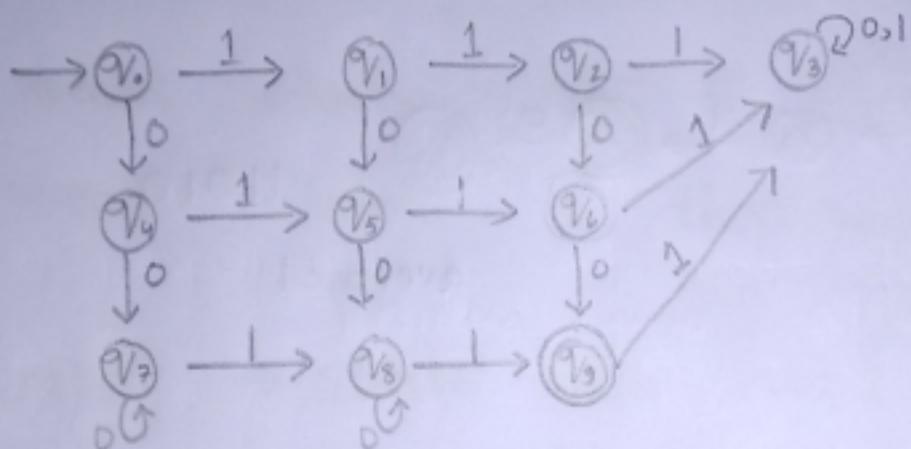
20. contains even num of 0 or exactly two 1's



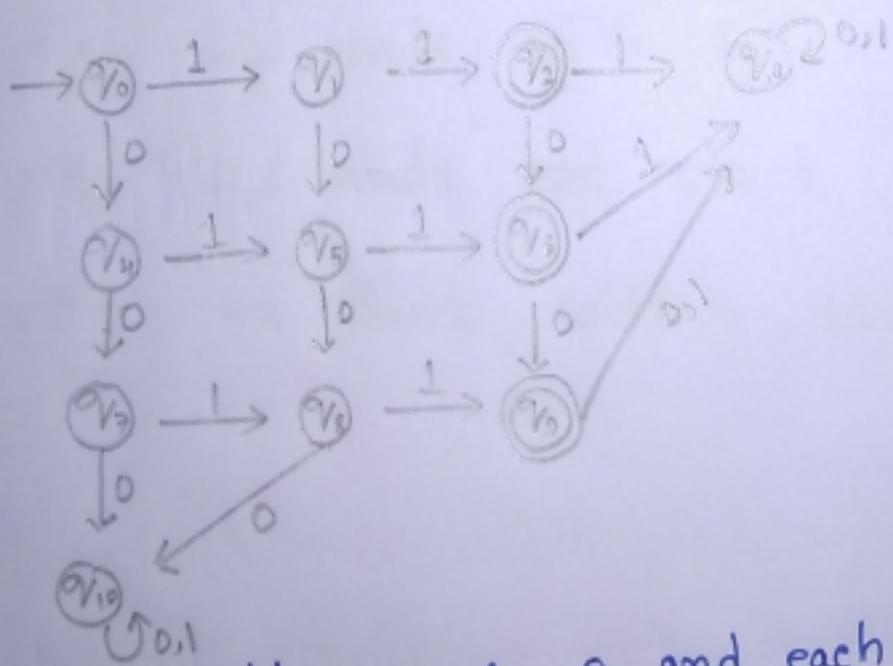
21. contains at least two 1's and exactly two 0's



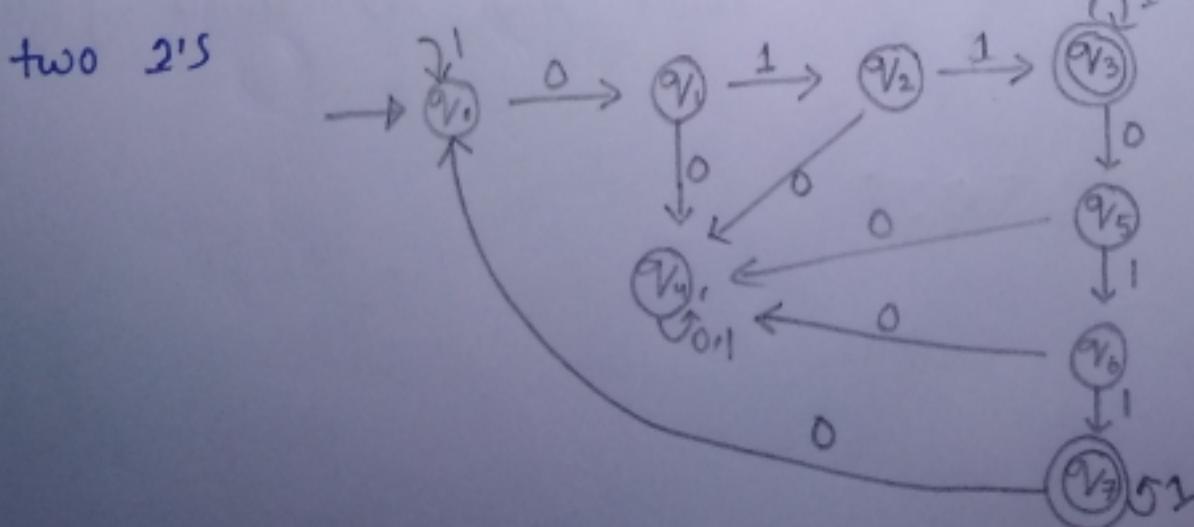
22. contains at least two 0's and exactly two 1's



23. at most two 0's and exactly two 1's

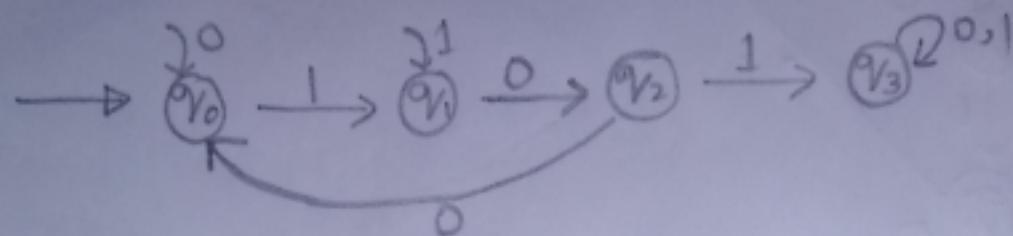


24. contains odd num of 0 and each 0 is followed by at least two 1's



DFA Simulation

* contains substring 101



1001

$\square \rightarrow V_0 \xrightarrow{1} V_1 \xrightarrow{0} V_2 \xrightarrow{0} V_3 \xrightarrow{1} V_1$

not accepted

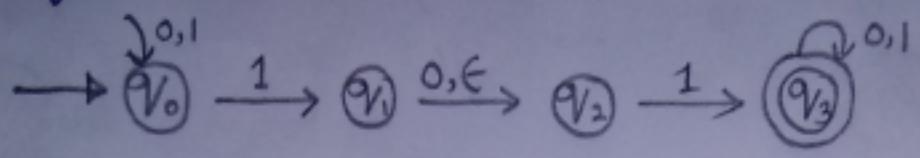
$\square \rightarrow V_0 \xrightarrow{1} V_1 \xrightarrow{1} V_2 \xrightarrow{0} V_3 \xrightarrow{1} V_1$

11010

accepted

Nondeterministic Finite Automata (NFA)

Formal Definition



$\epsilon \rightarrow$ empty string
 * before reading ϵ
 one input must be read

A NFA is a five tuple $(Q, \Sigma, \delta, q_0, F)$ where

1. Q is a finite set of all states.
2. Σ is a finite set called the alphabates.
3. $\delta: Q \times \Sigma \rightarrow P(Q)$ is a transition function.
4. $q_0 \in Q$ is the start state.
5. $F \subseteq Q$ is the set of accept state.

here,

1. $Q = \{q_0, q_1, q_2, q_3\}$

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

3.

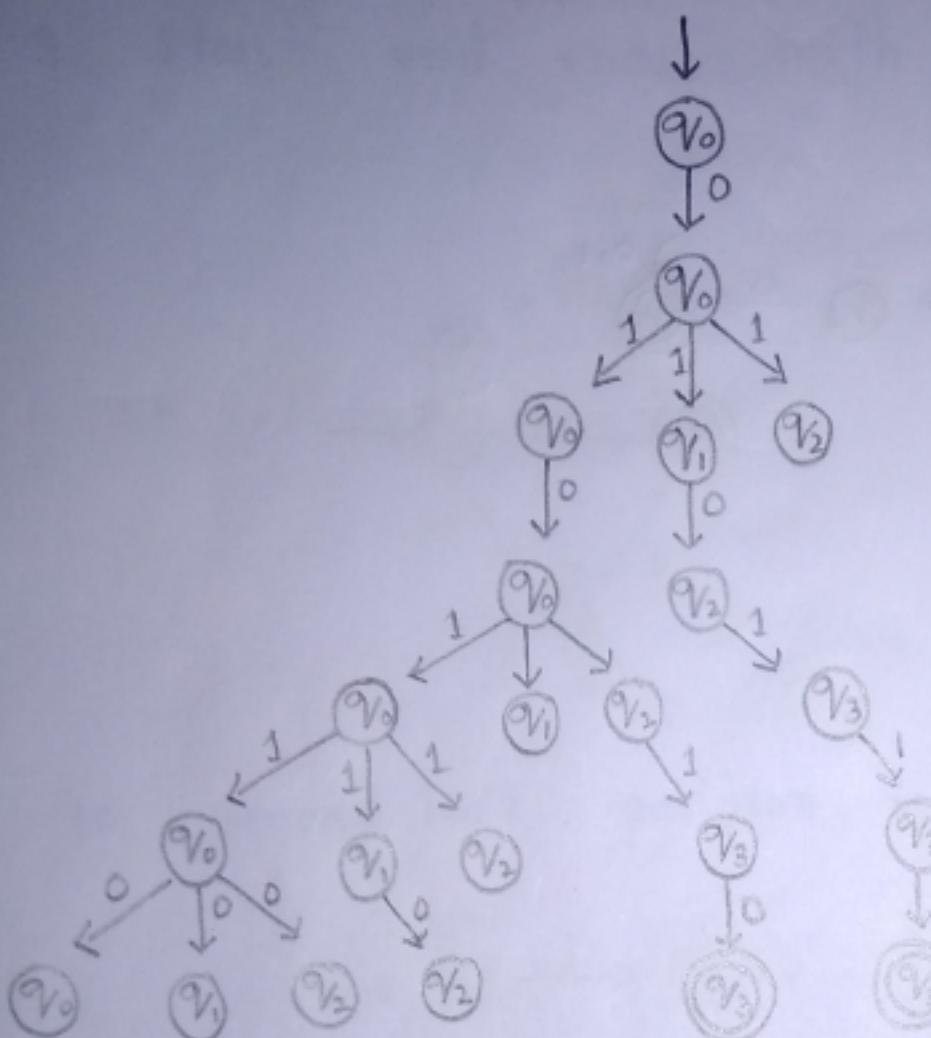
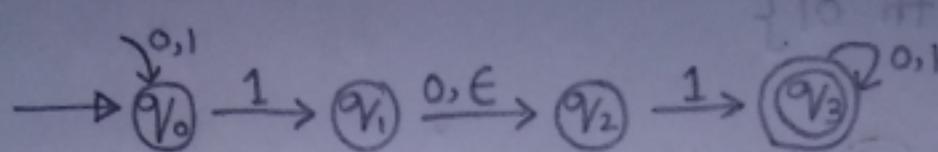
State	0	1	ϵ
q_0	$\{q_0\}$	$\{q_0, q_1\}$	\emptyset
q_1	$\{q_2\}$	\emptyset	$\{q_2\}$
q_2	\emptyset	$\{q_3\}$	\emptyset
q_3	$\{q_3\}$	$\{q_3\}$	\emptyset

4. q_0 is the start state

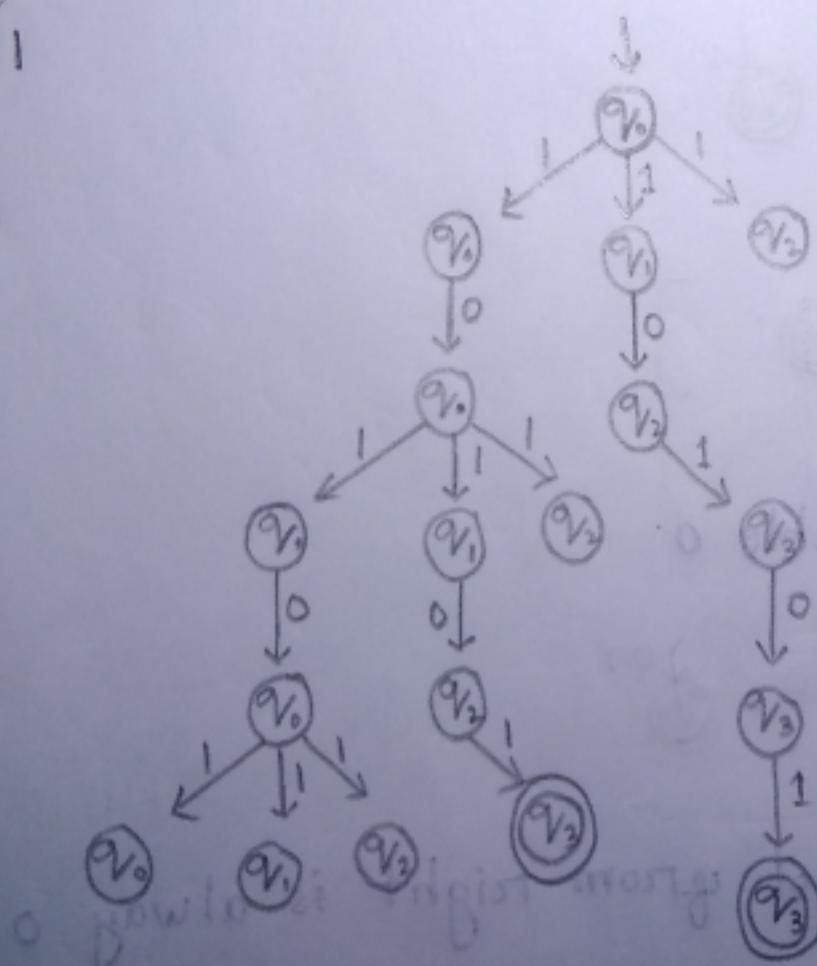
5. $F = \{q_3\}$

Simulation

011010

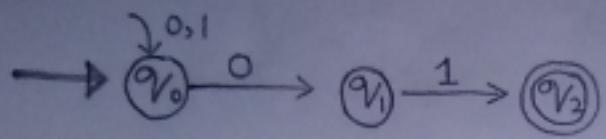


10101

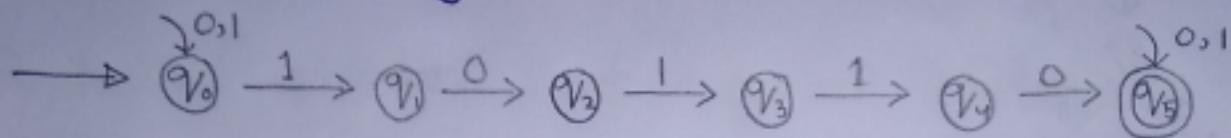


Designing of NFA

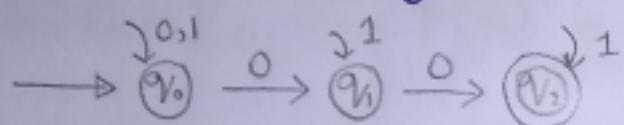
1. $L = \{w/w \text{ ends with } 01\}$



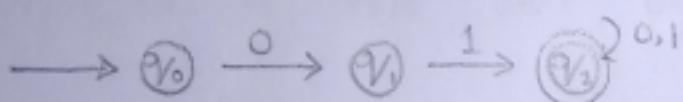
2. contains substring 10110



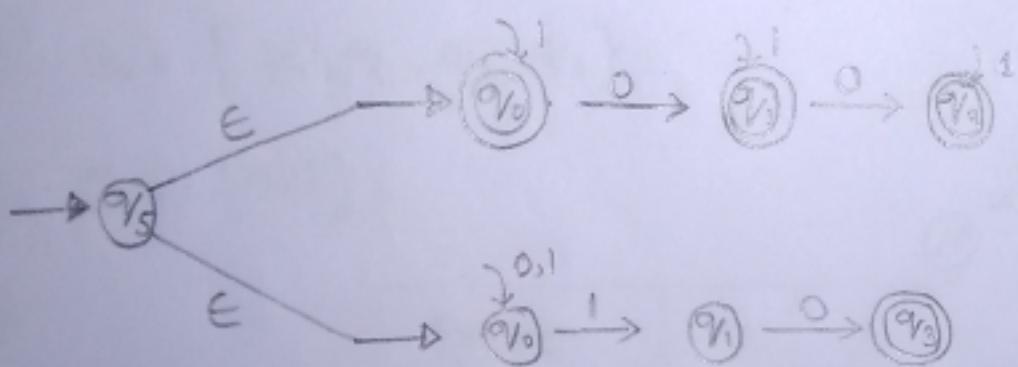
3. contains exactly two 0's



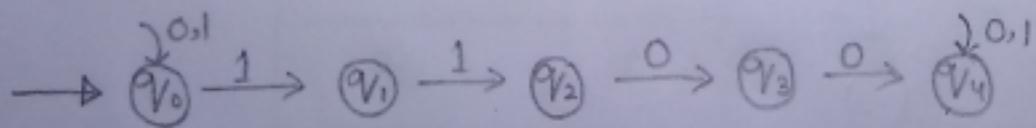
4. start with 01.



5. contains at most two 0's or ends with 10

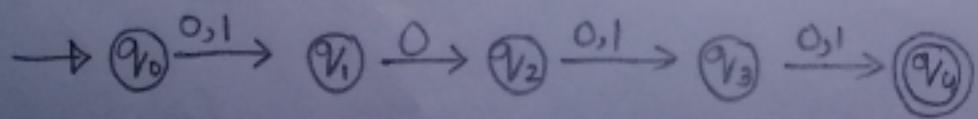


6. double one(1) is followed by double 0

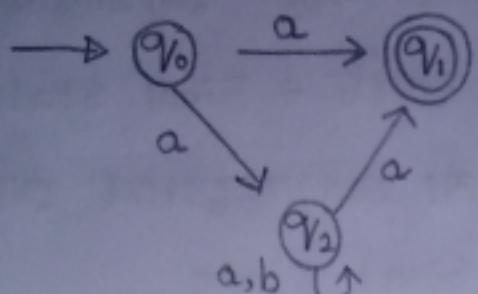


□ ○ □ □

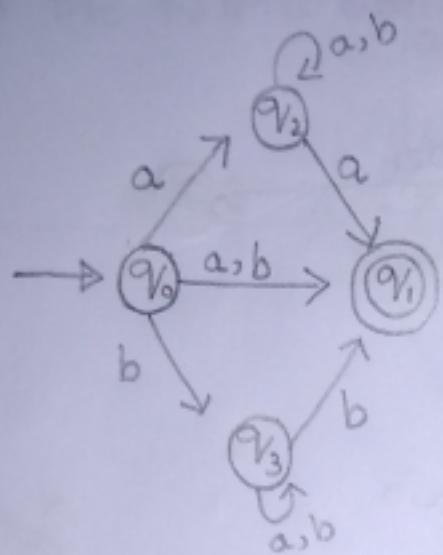
7. all string in which third symbol from right is always 0



8. start and end with a



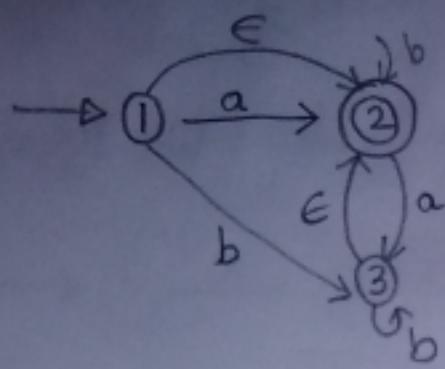
9. start and ends with same symbol



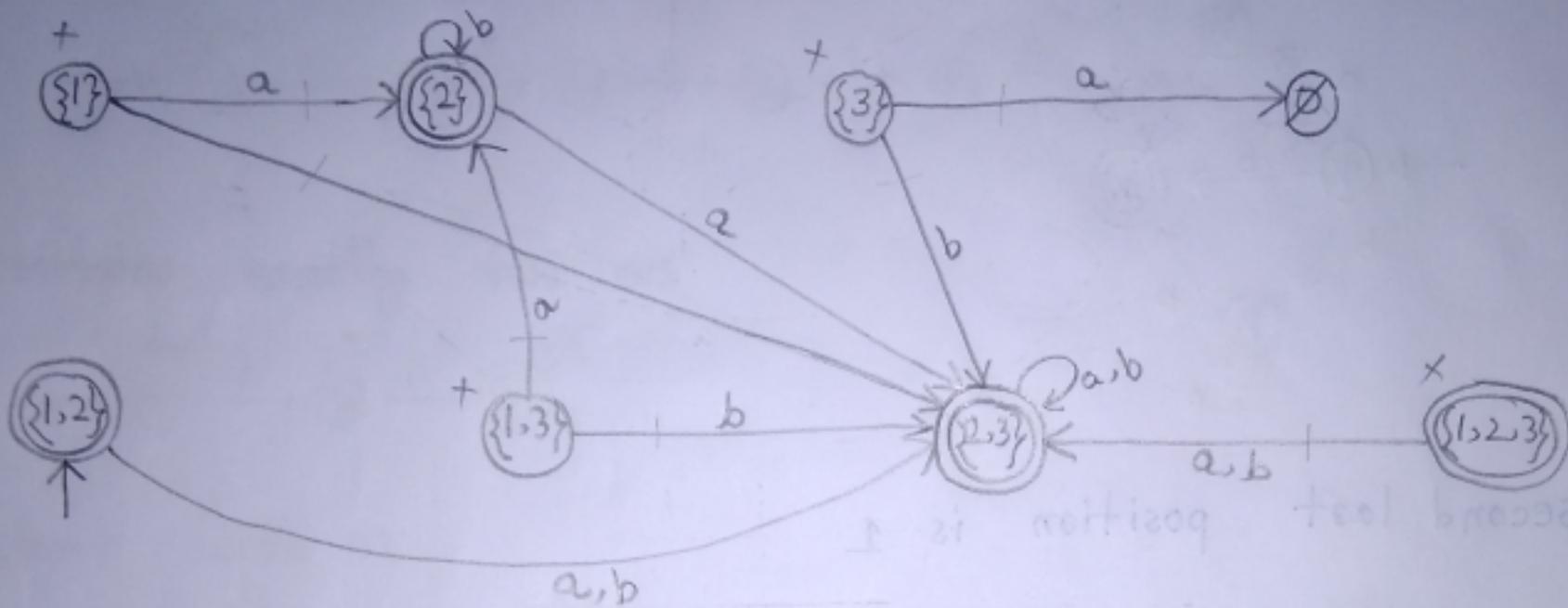
10. second last position is 1



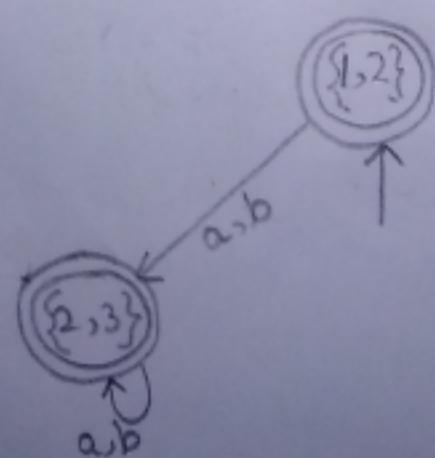
NFA to DFA conversion

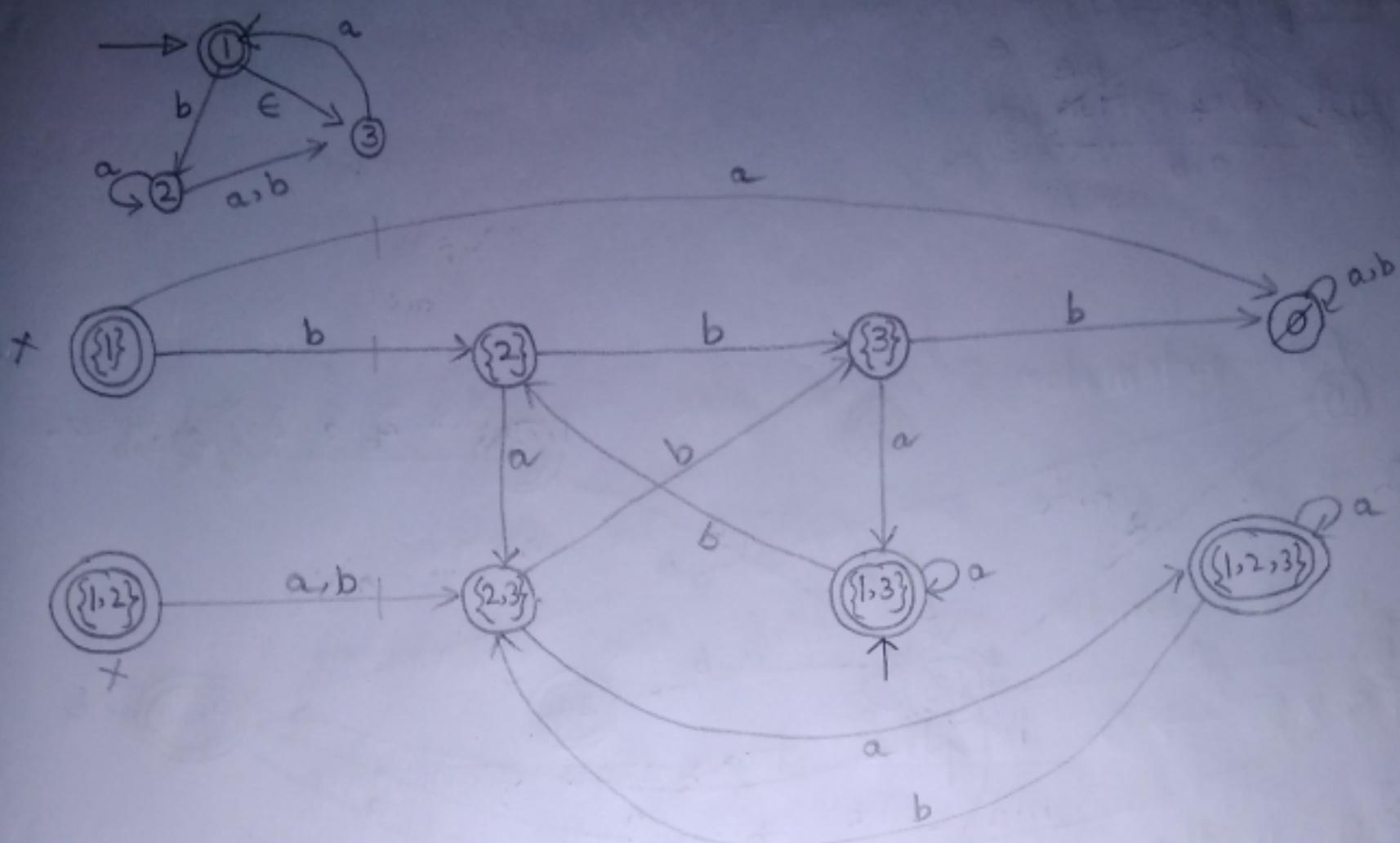


- * NFA ඇත් start state ලෙස ϵ සිදු කළ යාවහා තොන් තෝරී + Final state = start state.
- * නා යාවහා තොන් තෝරී හිළ තැන් Start state
- * තෝරී Final state තෝරී වන් ගුලාංගාකාරී Final state

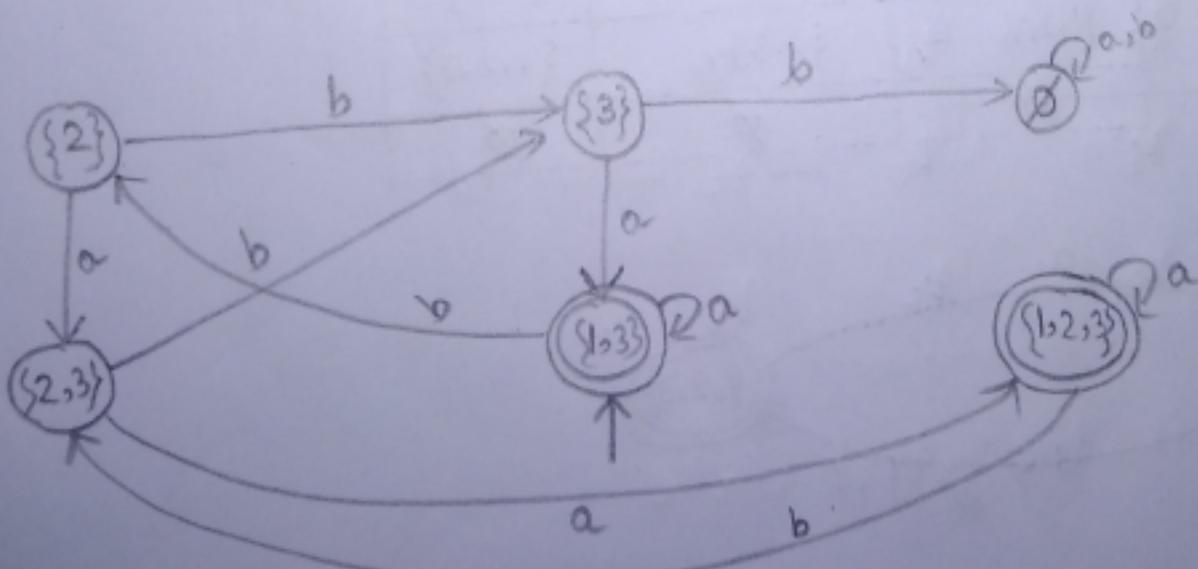


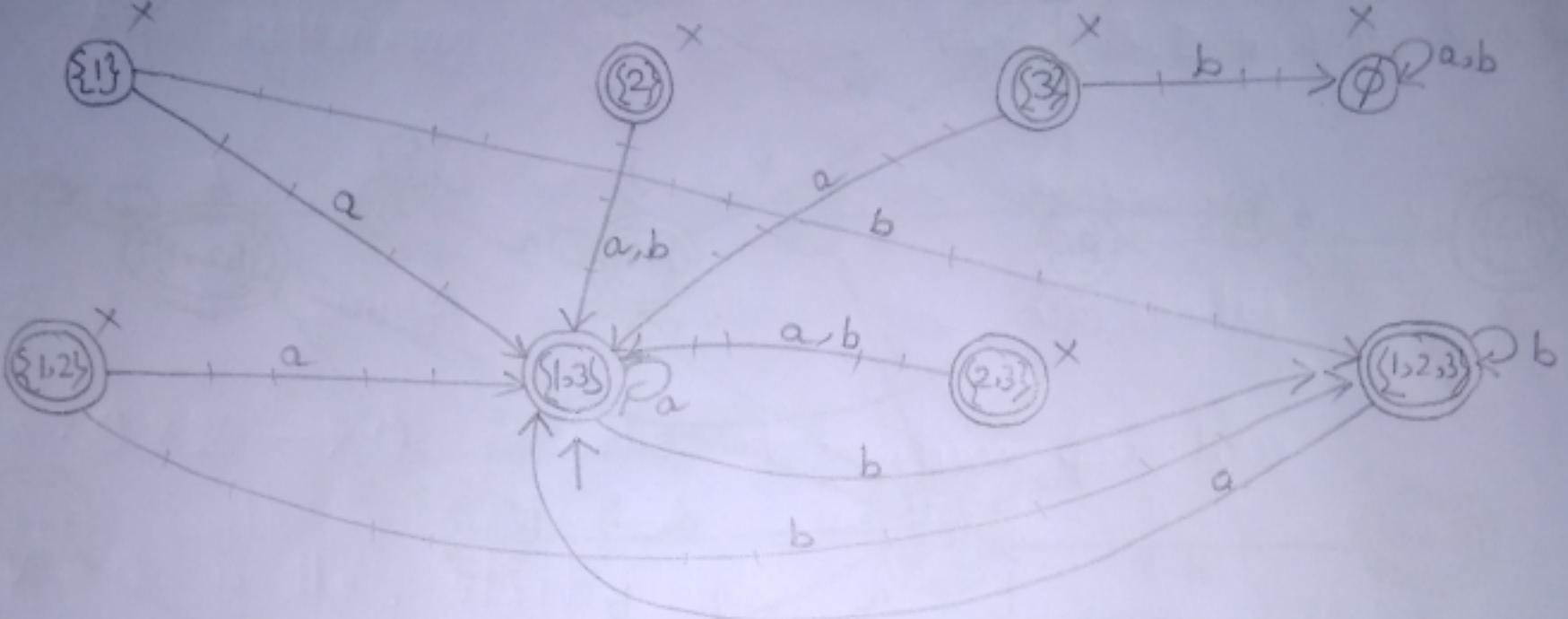
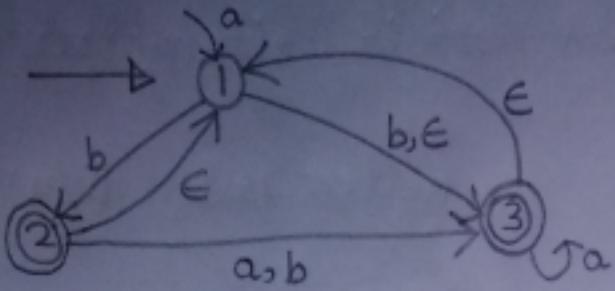
	a	b
{1}	{2}	{3,2}
{2}	{3,2}	{2,3}
{3}	\emptyset	{2,3}
{1,2}	{2,3}	{2,3}
{1,3}	{2}	{2,3}
{2,3}	{2,3}	{2,3}
{1,2,3}	{2,3}	{2,3}
\emptyset	\emptyset	\emptyset



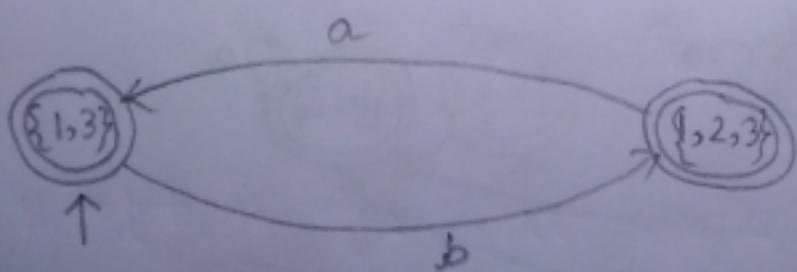


	a	b
{1}	\emptyset	{2}
{2}	{2,3}	{3}
{3}	{1,3}	\emptyset
{1,2}	{2,3}	{2,3}
{1,3}	{1,3}	{2}
{2,3}	{1,2,3}	{3}
{1,2,3}	{1,2,3}	{2,3}
<hr/>		
	\emptyset	\emptyset





State	a	b
{1}	{1,3}	{2,1,3}
{2}	{3,1}	{1,3}
{3}	{3,1}	∅
{1,2}	{1,3}	{1,2,3}
{1,3}	{1,3}	{1,2,3}
{2,3}	{1,3}	{1,3}
{1,2,3}	{1,3}	{1,2,3}
∅	∅	∅



Regular Expression

- ▣ 1. Union ($0 \cup 1$)
- 2. Concatenation (01) Priority $3 > 2 > 1$
- 3. Star (*)

▣ * \rightarrow 0 to many

+ \rightarrow 1 to many

* means starts with \in

+ means minimum 1 then any

▣ $(0 \cup 1)0^*$ \rightarrow starts with 0 or 1 which is followed by any number of 0.

$\Sigma^* 1$ \rightarrow ends with 1

$0 \Sigma^* 0$ \rightarrow ends and starts with 0

$0 \Sigma^* 1$ \rightarrow starts with 0 and ends with 1

• $L = \{w \mid w \text{ contains at least two } 0's\}$

$$\Sigma^* 0 \Sigma^* 0 \Sigma^*$$

$1 \leq i \leq n$ ~~if i < n~~

(1U0)

main +

• contains exactly two 0's

$$1^* 0 1^* 0 1^*$$

(*) 2012.6

• starts and ends with same symbol

$$0 \Sigma^* 0 \cup 1 \Sigma^* 1$$

~~also cont~~ ^{special case} 1 minimum

answer *

+

• starts and ends with diff symbol

$$0 \Sigma^* 1 \cup 1 \Sigma^* 0$$

1 diff char $\rightarrow 1^* 3$

• the length of w is even

$$(\Sigma \Sigma)^*$$

• length of w is odd

$$(\Sigma \Sigma)^* \Sigma$$

• the length of w is at least three and its third symbol is zero.

$$\Sigma \Sigma 0 \Sigma^*$$

Contains even num of 0's

$$1^* \cup (1^* 0 1^* 0 1^*)^*$$

each 0 is followed by at least two 1's

$$1^* (0 1 1 1^*)^* \rightarrow \text{any num of } 0$$

contains exactly two 0's and contains at most one 1

$$(00 \cup 001 \cup 100 \cup 010)$$

contains atleast one 0 and at least one 1

$$\Sigma^* 0 \Sigma^* 1 \Sigma^* \cup \Sigma^* 1 \Sigma^* 0 \Sigma^*$$

accept all string except empty string

$$\Sigma^+$$

doesnot contain substring 101

$$0^* (1000^*)^* 1^* 0^*$$

doesnot contain 01

$$1^* 0^*$$

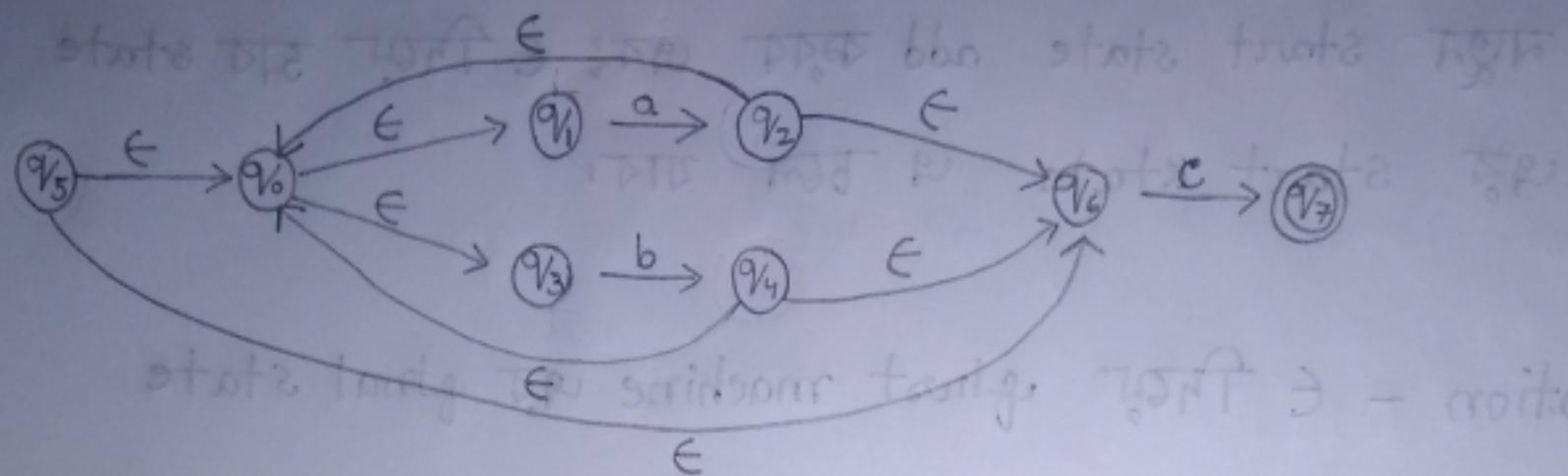
Regular Expression to NFA

১*(পুর)

- ব) Union - নতুন start state add কুবব এবং ϵ দিয়ে অব state
এবং start state এ চলে থাব।
- ব) Concatenation - ϵ দিয়ে first machine এর final state
থেকে second machine এর start state এ চলে থাব,
first machine এর final state normal state
করে দিব।
১*(পুর)
- ব) Star - নতুন start state add কুবব, অব final state
থেকে ϵ দিয়ে old start state এ চলে থাব।
নতুন start state, final state করে দিব।

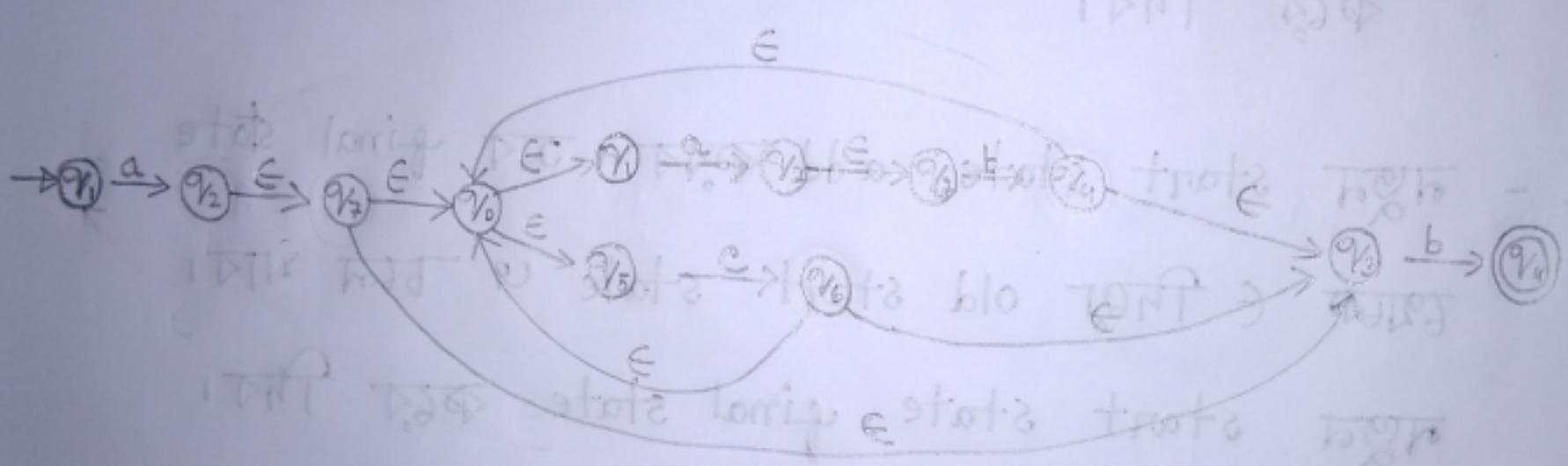
Q $(a \cup b)^* c$

Equivalent Expression



Q $a(ab \cup c)^*b$

Equivalent



I am not sure about ✓ signed questions. .

If you find them wrong please do correct by yourself

Thank you