FINITE AUTOMATA

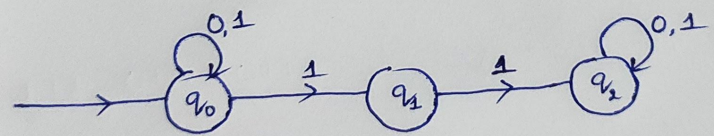
PART-A

1. Describe NFA for accepting any binary string that contains 11 as a substring and Convert to DFA.

1) Given,

NFA which accepts any binary string that contains 11 as a substring.

$\Sigma = \{0, 1\}$; $\{11, 011, 111, \ldots\ldots\}$



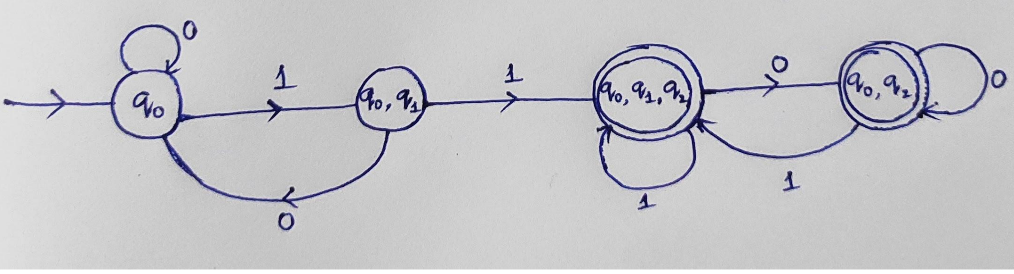
NFA:

δ	0	1
$\rightarrow q_0$	$\{q_0\}$	$\{q_0, q_1\}$
q_1	$\emptyset$	$\{q_2\}$
$* q_2$	$\{q_2\}$	$\{q_2\}$

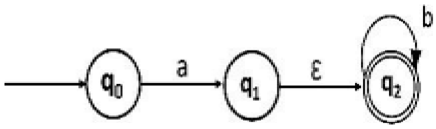
$\longrightarrow$

DFA

δ	0	1
$\rightarrow q_0$	$\{q_0\}$	$\{q_0, q_1\}$
$\{q_0, q_1\}$	$\{q_0\}$	$\{q_0, q_1, q_2\}$
$* \{q_0, q_1, q_2\}$	$\{q_0, q_2\}$	$\{q_0, q_1, q_2\}$
$* \{q_0, q_2\}$	$\{q_0, q_2\}$	$\{q_0, q_1, q_2\}$.

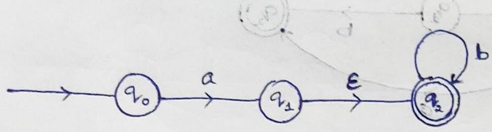


2. Convert NFA with ϵ to equivalent DFA



2) Given,

ε - NFA:



Transition table:

δ	a	b	ε
$\rightarrow q_0$	q_1	$\emptyset$	$\emptyset$
q_1	$\emptyset$	$\emptyset$	ε
$*q_2$	$\emptyset$	q_2	$\emptyset$

Transition function:-

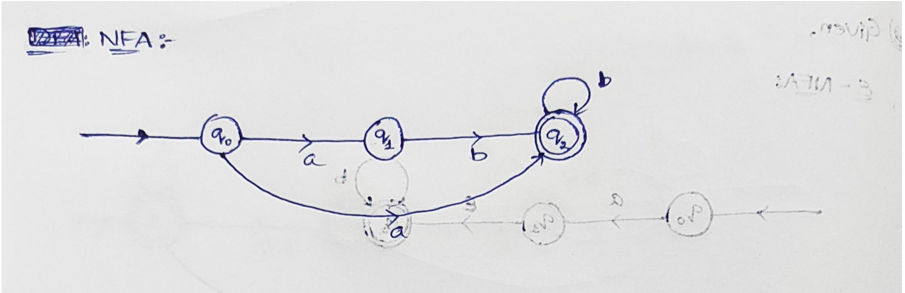
$$\hat{\delta}(q_0, \varepsilon) = \{q_0\} = \varepsilon\text{-closure}(q_0)$$

$$\hat{\delta}(q_1, \varepsilon) = \{q_1, q_2\} = \varepsilon\text{-closure}(q_1)$$

$$\hat{\delta}(q_2, \varepsilon) = \{q_2\} = \varepsilon\text{-closure}(q_2)$$

$$\hat{\delta}(q_0, a) = \varepsilon\text{-closure}(\delta(\hat{\delta}(q_0, \varepsilon), a))$$
$$= \varepsilon\text{-closure}(\delta((q_0), a))$$
$$= \varepsilon\text{-closure}(\delta(q_0, a)) = \varepsilon\text{-closure}(q_1)$$
$$= \{q_1, q_2\}.$$

$\hat{\delta}(q_0, b) = \emptyset$	$\hat{\delta}(q_1, a) = \emptyset$	$\hat{\delta}(q_2, a) = \emptyset$
	$\hat{\delta}(q_1, b) = \{q_2\}$	$\hat{\delta}(q_2, b) = q_2.$



3. Describe a DFA that any given decimal number is divisible by 5

3) Given, a DFA that any given decimal number is divisible by 5.

$\Sigma = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$.

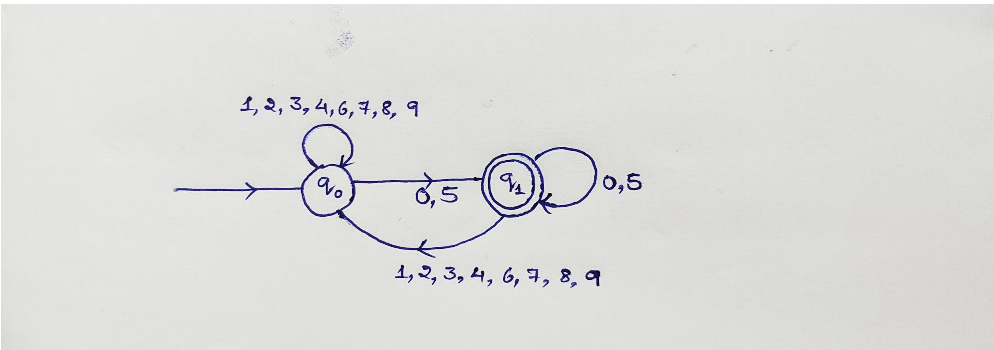
$q_0 \longrightarrow n \bmod 5 = 0$

$q_1 \longrightarrow n \bmod 5 = 1$

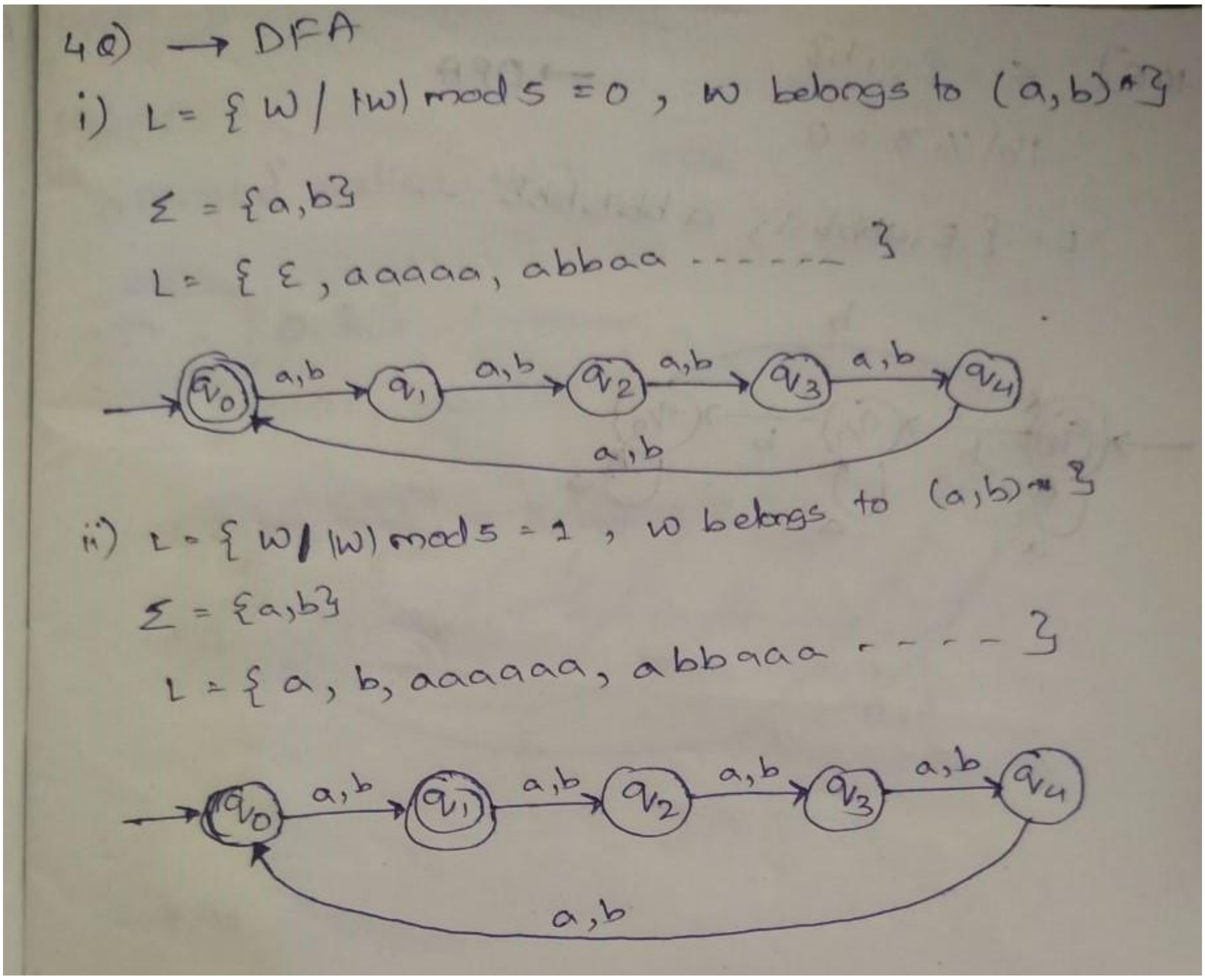
$q_2 \longrightarrow n \bmod 5 = 2$

$q_3 \longrightarrow n \bmod 5 = 3$

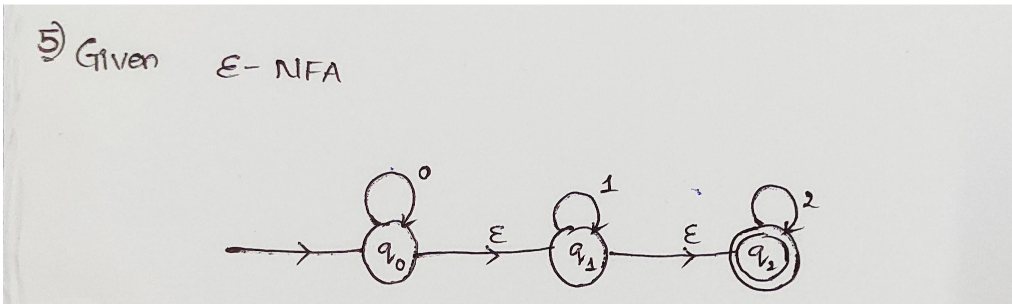
$q_4 \longrightarrow n \bmod 5 = 4$.



4. Describe a DFA for the following language L={w/|w | mod 5=0, w belongs to (a, b)} L={w/|w mod 5=1, w belongs to (a, b)}



5. Convert NFA with ϵ to equivalent NFA M=({q0,q1,q2},{0,1,2}, δ, q0, {q2}) where δ is given by [δ (q0,0)={q0}, δ (q0,1)=ϕ, δ (q0,2)=ϕ, δ(q0, ϵ)=q1] ; [δ (q1,0)=ϕ, δ (q1,1)=q1 , δ (q1,2)=ϕ ,δ (q1,ϵ)=q2] ; [δ (q2,0)=ϕ, δ (q2,1)= ϕ , δ(q2,2)= {q2},δ (q2, ϵ)= ϕ] .



1) Transition table:-

δ	0	1	2	ϵ
q_0	q_0	$\emptyset$	$\emptyset$	q_1
q_1	$\emptyset$	q_1	$\emptyset$	q_2
q_2	$\emptyset$	$\emptyset$	q_2	$\emptyset$

2) Transition function for NFA with ϵ

$\hat{\delta}(q_0, \epsilon) = \{q_0, q_1, q_2\} = \epsilon\text{-closure}(q_0)$

$\hat{\delta}(q_1, \epsilon) = \{q_1, q_2\} = \epsilon\text{-closure}(q_1)$

$\hat{\delta}(q_2, \epsilon) = \{q_2\} = \epsilon\text{-closure}(q_2)$

$\hat{\delta}(q_0, 0) = \epsilon\text{-closure}(\delta(\hat{\delta}(q_0, \epsilon), 0))$

$= \epsilon\text{-closure}(\delta(\hat{\delta}(q_0, q_1, q_2\}, 0)$

$= \epsilon\text{-closure}(\delta(q_0, 0) \cup \delta(q_1, 0) \cup \delta(q_2, 0))$

$= \epsilon\text{-closure}(q_0 \cup \emptyset \cup \emptyset\}$.

$= \epsilon\text{-closure}\ \{q_0\}$.

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

$$\hat{\delta}(q_0, 1) = \varepsilon\text{-closure}(\delta(\hat{\delta}(q_0, \varepsilon), 1))$$

$$= \varepsilon\text{-closure}(\delta(q_0, 1) \cup \delta(q_1, 1) \cup \delta(q_2; 1))$$

$$= \varepsilon\text{-closure}(q_1)$$

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

$$\hat{\delta}(q_0, 2) = \varepsilon\text{-closure}(\delta(\hat{\delta}(q_0, \varepsilon), 2))$$

$$= \varepsilon\text{-closure}(\delta(q_0, 2) \cup \delta(q_1, 2) \cup \delta(q_2, 2))$$

$$= \varepsilon\text{-closure}(q_2)$$

$$= \{q_2\}$$

$$\hat{\delta}(q_1, 0) = \epsilon\text{-closure}(\delta(\hat{\delta}(q_1, \epsilon), 0))$$

$$= \epsilon\text{-closure}(\delta\{q_1, q_2\}, 0))$$

$$= \epsilon\text{-closure}(\delta(q_1, 0) \cup \delta(q_2, 0))$$

$$= \epsilon\text{-closure}(\phi \cup \phi)$$

$$= \phi$$

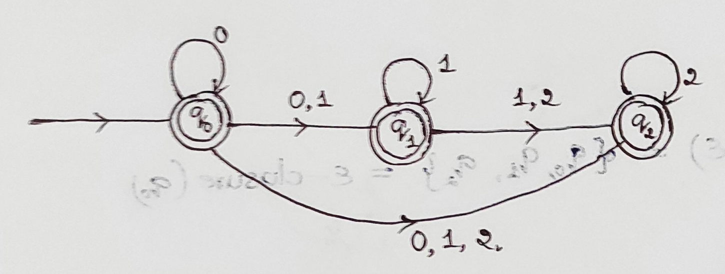
$$\hat{\delta}(q_1, 1) = \epsilon\text{-closure}(\delta(\hat{\delta}(q_1, \epsilon), 1))$$

$$= \epsilon\text{-closure}(\delta\{q_1, q_2\}, 1))$$

$$= \epsilon\text{-closure}(\delta(q_1, 1) \cup \delta(q_2, 1))$$

$$= \epsilon\text{-closure}(q_1 \cup \phi)$$

$$= \{q_1, q_2\}.$$



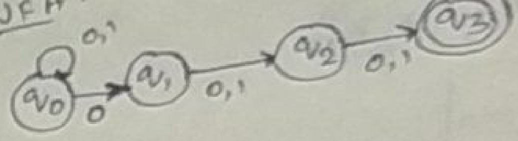
6. Demonstrate NFA that strings such that the third symbol from the right end is a 0 over an alphabet P={0,1}. And Convert it into equivalent DFA.

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

$L = \{w \mid$ 3rd symbol from right end is 0$\}$

$= \{000, 001, 010, 011, 1011 \ldots\ldots\}$

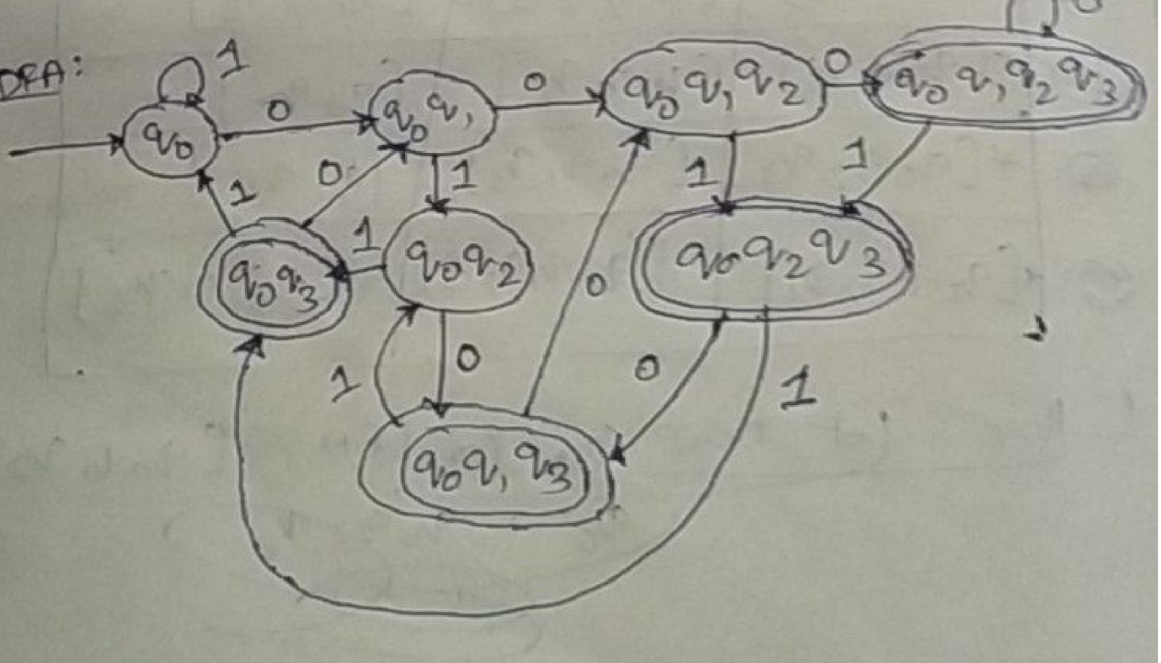
NFA:



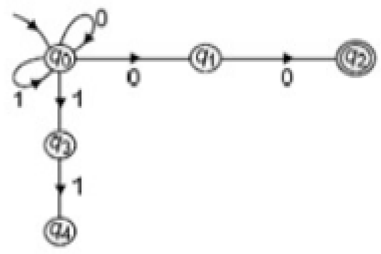
	0	1
q_0	$\{q_0 q_1\}$	q_0
q_1	q_2	q_2
q_2	q_3	q_3
q_3	–	–

DFA:	0	1
q_0	$[q_0 q_1]$	q_0
$[q_0 q_1]$	$[q_0 q_1 q_2]$	$[q_0 q_2]$
$[q_0 q_2]$	$[q_0 q_1 q_3]$	$[q_0 q_3]$
$[q_0 q_3]$	$[q_0 q_1]$	q_0
* $[q_0 q_1 q_2]$	$[q_0 q_1 q_2 q_3]$	$[q_0 q_2 q_3]$
$[q_0 q_1 q_3]$	$[q_0 q_1 q_2]$	$[q_0 q_2]$
* $[q_0 q_2 q_3]$	$[q_0 q_1 q_3]$	$[q_0 q_3]$
* $[q_0 q_1 q_2 q_3]$	$[q_0 q_1 q_2 q_3]$	$[q_0 q_2 q_3]$

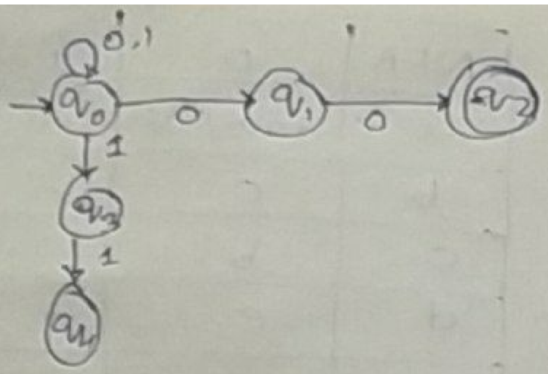
DFA:



7. Convert the NFA to equivalent DFA, as shown in fig. below.



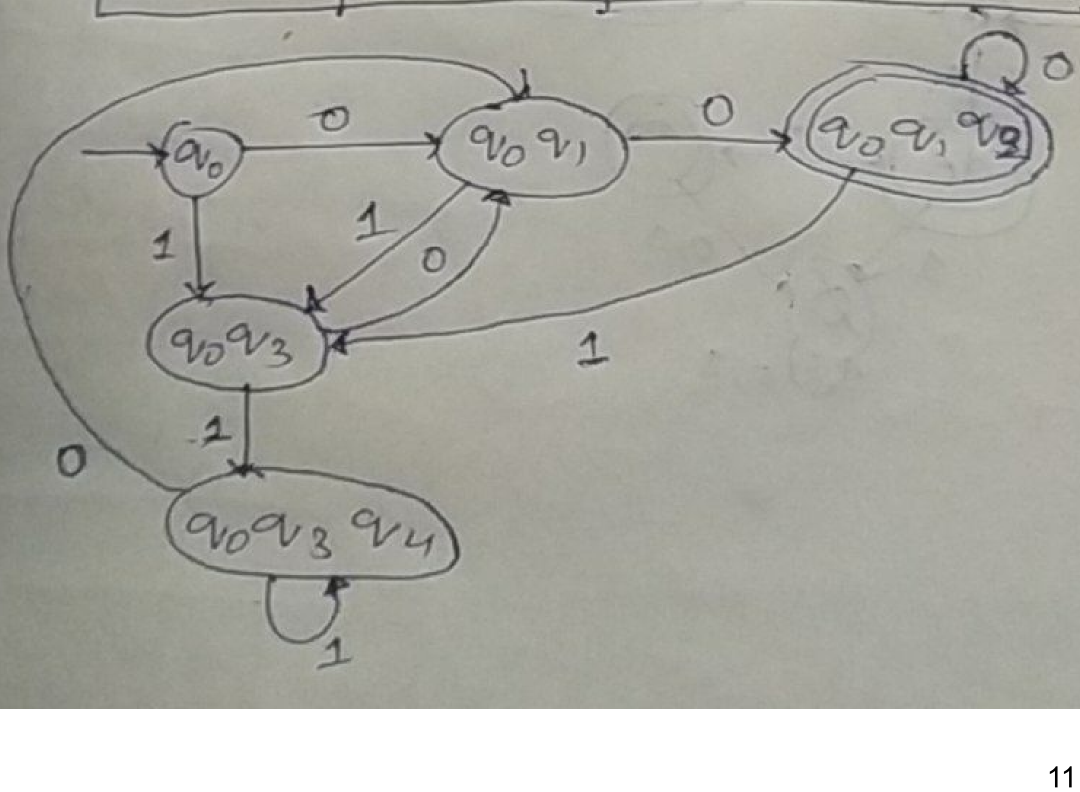
0
q0
0
q1
0
q2
1
1
q3
1
q4

7. 

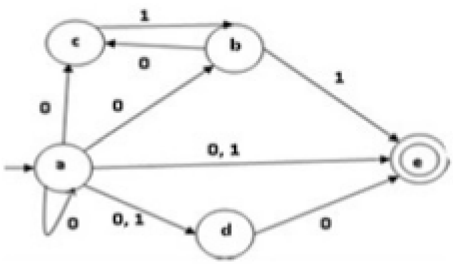
NFA	0	1
q_0	$\{q_0 q_1\}$	$\{q_0 q_3\}$
q_1	q_2	–
q_2	–	–
q_3	–	q_4
q_4	–	–

DFA:

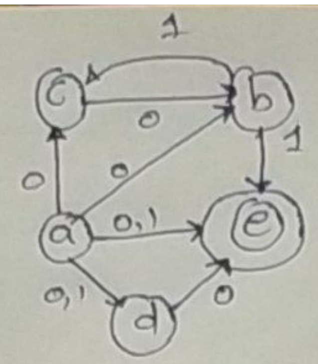
	0	1
q_0	$[q_0 q_1]$	$[q_0 q_3]$
$[q_0 q_1]$	$[q_0 q_1 q_2]$	$[q_0 q_3]$
$[q_0 q_3]$	$[q_0 q_1]$	$[q_0 q_3 q_4]$
* $[q_0 q_1 q_2]$	$[q_0 q_1 q_2]$	$[q_0 q_3]$
$[q_0 q_3 q_4]$	$[q_0 q_1]$	$[q_0 q_3 q_4]$



8. Describe the transition Table for the below NFA and then convert its equivalent transition diagram for DFA.



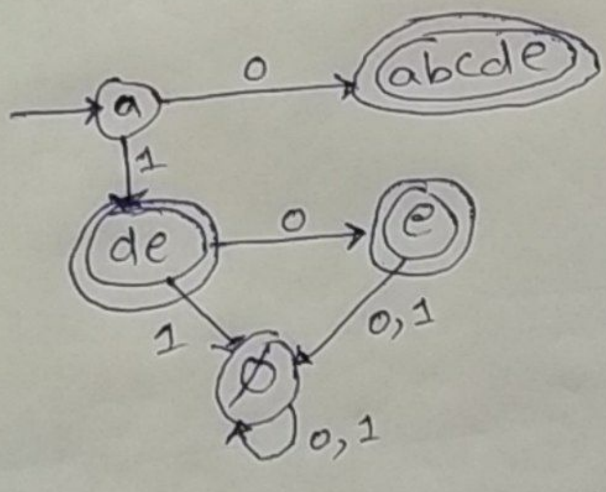
8.



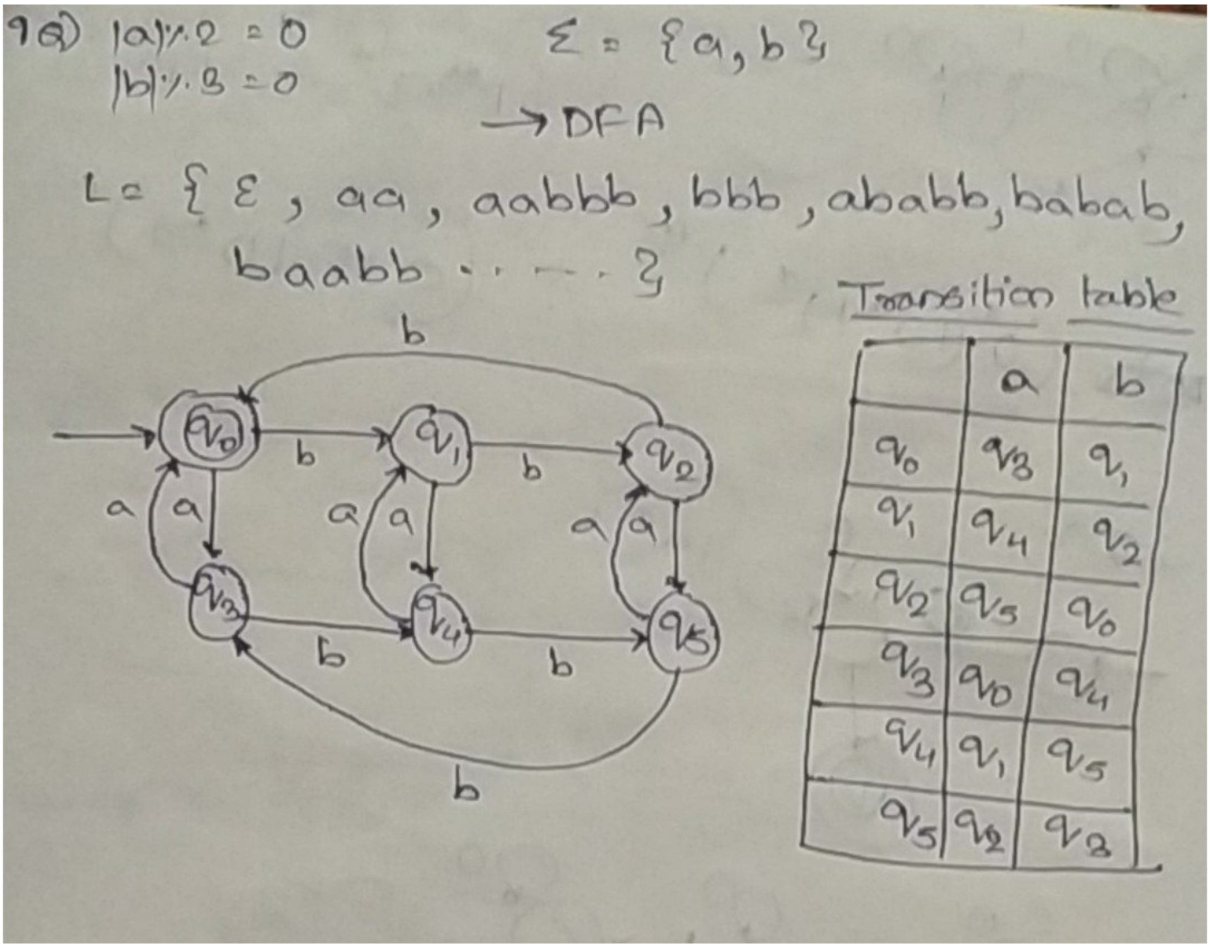
NFA	0	1
a	{a,b,c,d,e}	{d,e}
b	c	r
c	b	-
d	e	-
e	-	-

DFA:

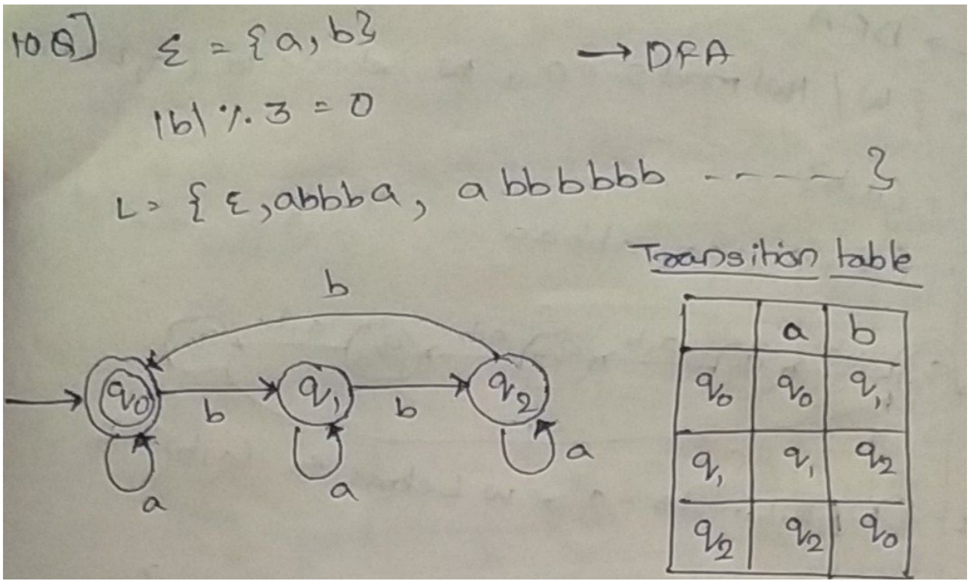
	0	1
a	[a bcde]	[de]
[de]	e	ϕ
e	ϕ	ϕ
ϕ	ϕ	ϕ
[abcde]	[abcde]	[de]



9. Describe a DFA that will accept those words from P= {a, b} where the number of a’s is divisible by two and the number of b’s is divisible by three. Sketch the transition table of the finite automata.

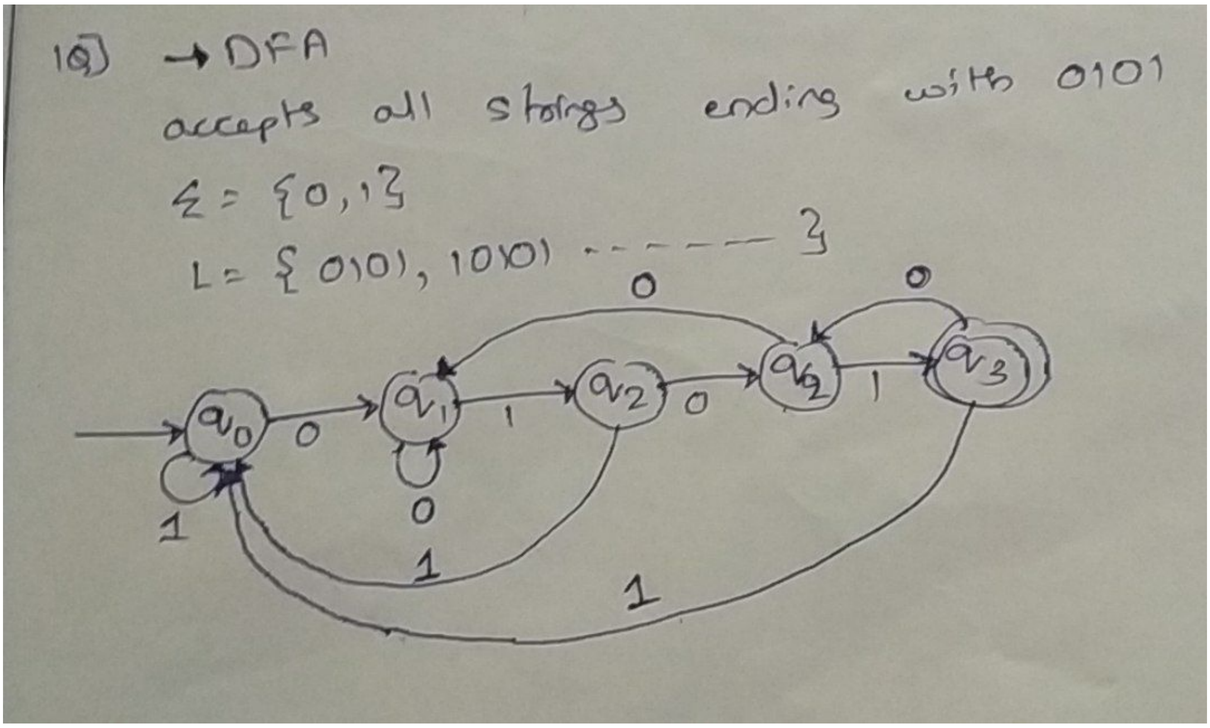


10. Describe a DFA that will accept those words from alphabets P= {a, b} where the number of bs is divisible by three. Sketch the transition table and diagram of the finite Automata.

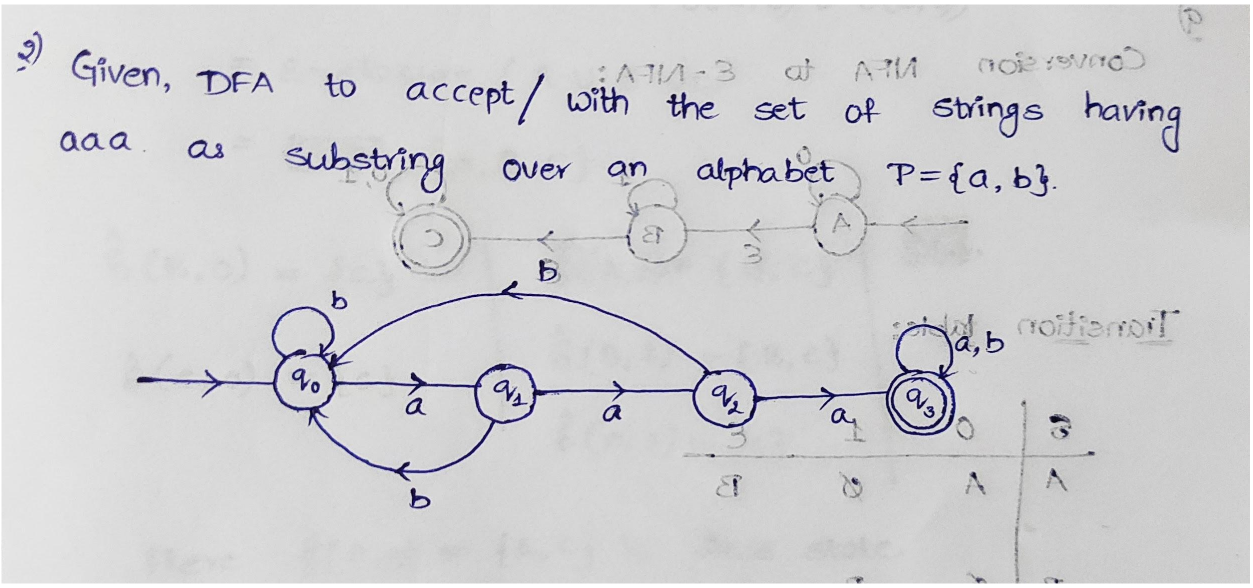


PART-B

1. Demonstrate DFA to accept a set of all strings ending with 0101.



2. Describe the DFA with the set of strings having “aaa as a substring over an alphabet P ={a,b}.



3. List out the various differences between DFA and NFA.

DFA :

DFA refers to Deterministic Finite Automaton. A Finite Automata(FA) is said to be deterministic, if corresponding to an input symbol, there is a single resultant state i.e. there is only one transition.

NFA :

NFA refers to Nondeterministic Finite Automaton. A Finite Automata(FA) is said to be non deterministic, if there is more than one possible transition from one state on the same input symbol.

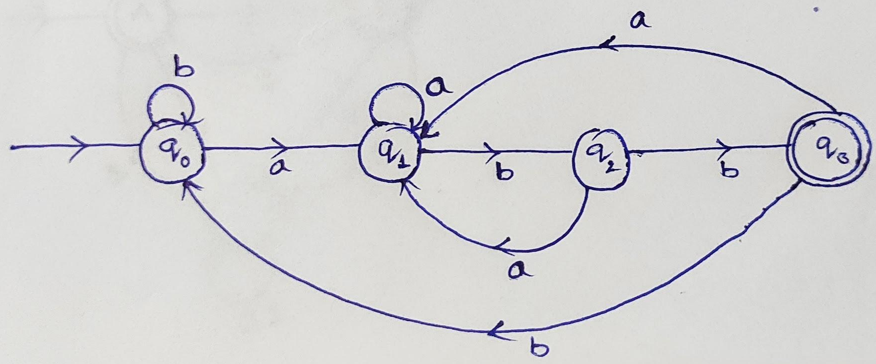
S.NO	DFA	NFA
1	DFA stands for Deterministic Finite Automata.	NFA stands for Nondeterministic Finite Automata.
2	For each symbolic representation of the alphabet, there is only one state transition in DFA.	No need to specify how the NFA reacts according to some symbol.
3	DFA cannot use the Empty String transition.	NFA can use the Empty String transition.
4	DFA can be understood as one machine.	NFA can be understood as multiple little machines computing at the same time.
5	DFA is more difficult to construct.	NFA is easier to construct.
6	DFA requires more space	NFA requires less space than DFA.
7	Dead state may be required.	Dead state is not required.
8	All DFA are NFA.	Not all NFA are DFA.

4. Describe how various phases could be combined as a pass in the compiler? Describe NFA with ϵ to NFA conversion with an example.

5. Describe a DFA to accept the string as and bs ending with abb over an alphabet

P ={a,b}

5) Given, DFA to accept the string 'a's' and 'b's' ending with abb over an alphabet, P = {a, b}.



6. List the properties and operations of strings and languages.

String: A string is a finite set sequence of symbols chosen from some alphabets.

For example,

a. 00011001 is a string from binary alphabet Σ={0,1}
b. aabbcabcd is a string from alphabet Σ={a,b,c,d}

The different operations performed on strings are:

- Concatenation.
- Substring.
- Kleen star operation.
- Reversal.

Language: A language is a set of strings, chosen from some Σ* or we can say- 'A language is a subset of Σ* '. A language that can be formed over 'Σ' can be Finite or Infinite.

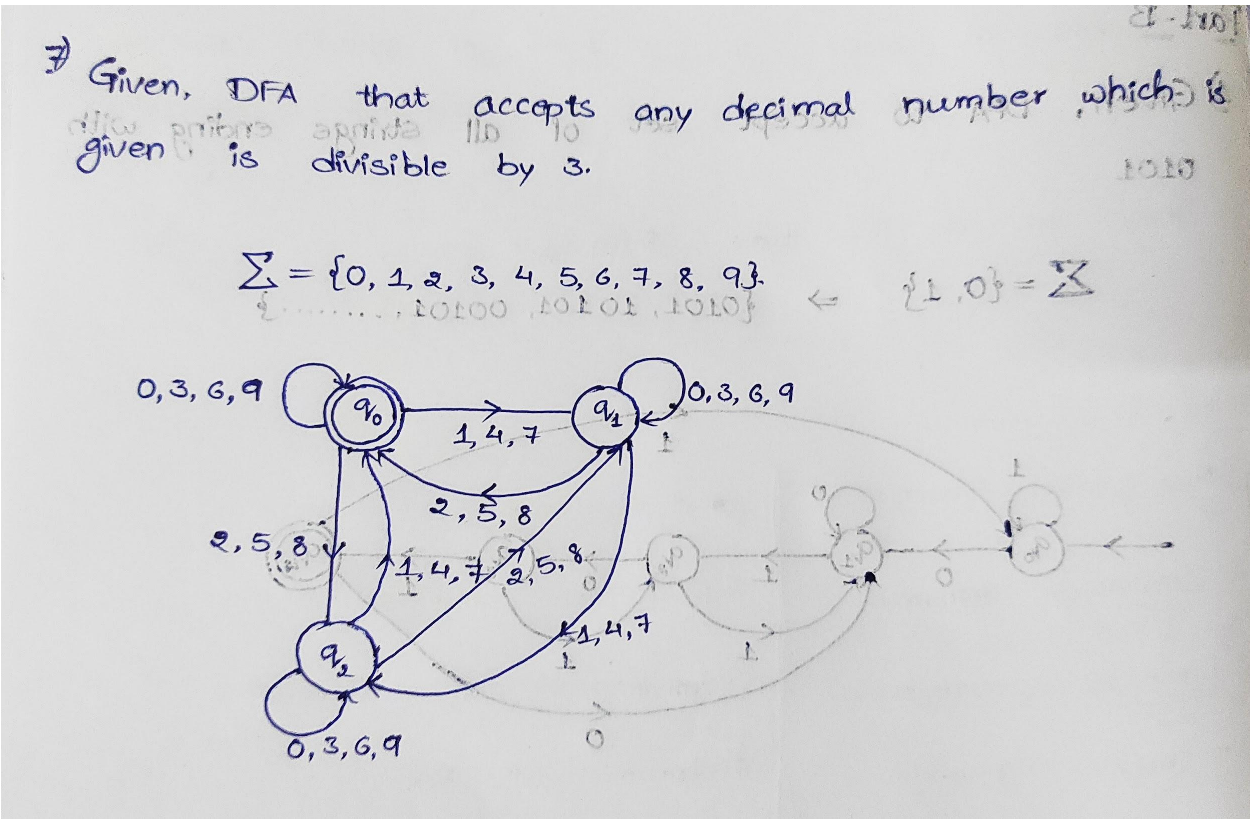
Some of the operations on regular languages are as follows −

- Union
- Intersection
- Difference
- Concatenation

- kleen * closure

Strings and Language doesn't have any special properties

7. Demonstrate a DFA that any given decimal number is divisible by 3.

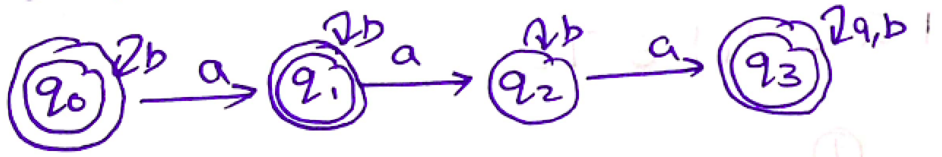


8. Describe DFA for the following languages shown below P = { a,b}.
a) L={w/ w is any string that doesn't contain exactly two a's}

b) L={w/ w is any string that contain at most 3 a's}

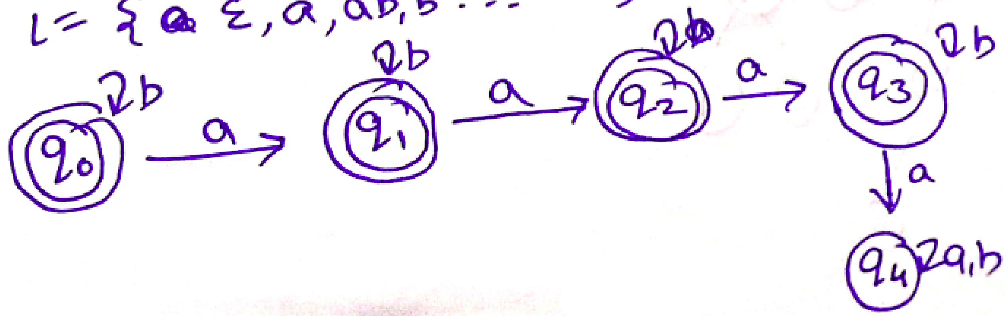
8) a) doesn't contain exactly two a's.

L= {a, b, ab, abb, aaab... }



b) atmost 3 a's

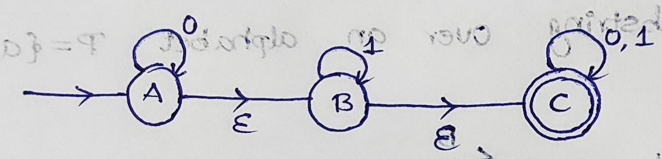
L= {ε, a, ab, b ... }



9. Convert the following NFA with ϵ to NFA.

9)

Conversion NFA to ε-NFA:



Transition table:

δ	0	1	ε
A	A	∅	B
B	∅	B	C
C	C	C	∅

Transition function:

$\hat{\delta}(A, \varepsilon) = \{A, B, C\}. = \varepsilon\text{-closure}(A)$

$\hat{\delta}(B, \varepsilon) = \{B, C\} = \varepsilon\text{-closure}(B)$

$\hat{\delta}(C, \varepsilon) = \{C\}. = \varepsilon\text{-closure}(C).$

$$
\begin{aligned}
\hat{\delta}(A, 0) &= \varepsilon\text{-closure}(\delta(\hat{\delta}(A, \varepsilon), 0)) \\
&= \varepsilon\text{-closure}(\delta(\hat{\delta}\{A, B, C\}, 0)) \\
&= \varepsilon\text{-closure}(\delta(A, 0) \cup \delta(B, 0) \cup \delta(C, 0)) \\
&= \varepsilon\text{-closure}(A \cup \emptyset \cup C) \\
&= \cancel{\{A, C\}}\ \{A, B, C\}
\end{aligned}
$$

$\hat{\delta}(B, 0) = \{C\}$

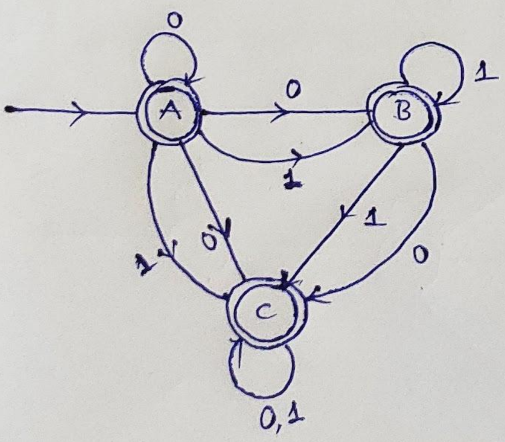
$\hat{\delta}(C, 0) = \{C\}.$

$\hat{\delta}(A, 1) = \{B, C\}$

$\hat{\delta}(B, 1) = \{B, C\}$

$\hat{\delta}(C, 1) = \{C\}$

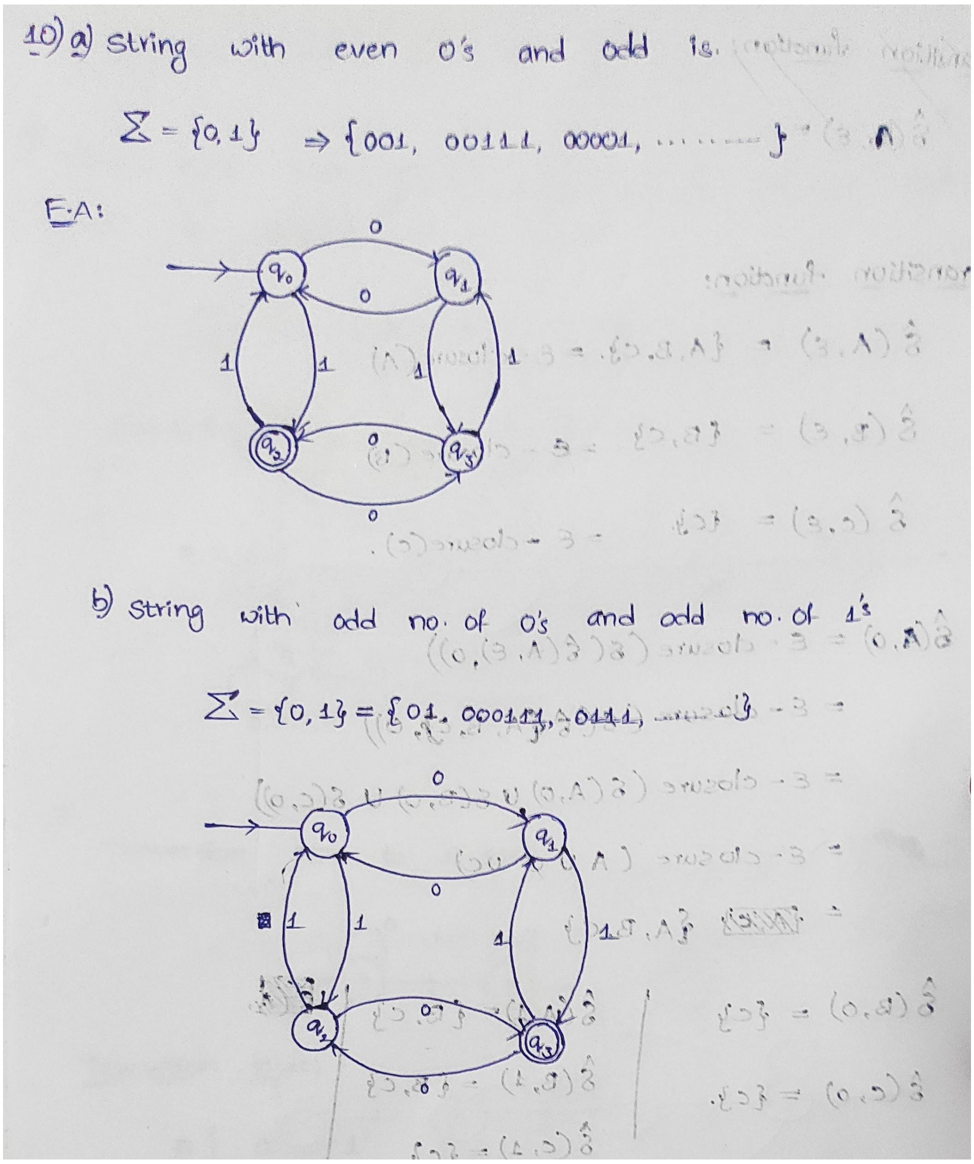
Here $\hat{\delta}(A, 0) = \{A, C\}$ is final state.



10. Describe Finite Automata and draw FA for the strings over an alphabet P = {0,1}

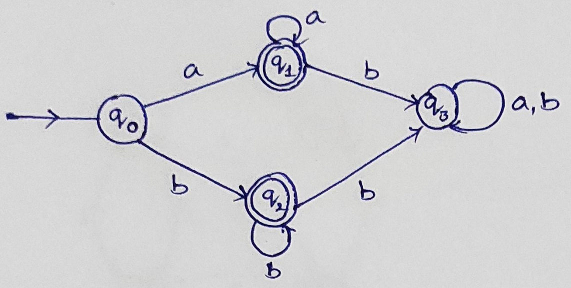
a. The string with even no of 0s and odd no of1s

b. The string with odd no of 0s and odd no of 1s



11. Describe a DFA, the language recognized by the Automaton being L={w/ w contains neither the substring ab nor ba}.Draw the transition table.

11) Given, L = {w/w contains neither the substring ab nor ba}.



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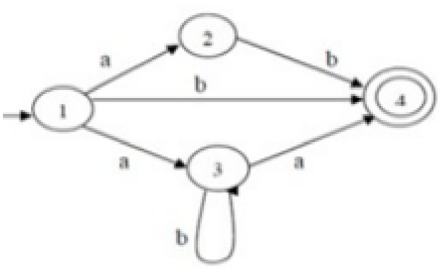
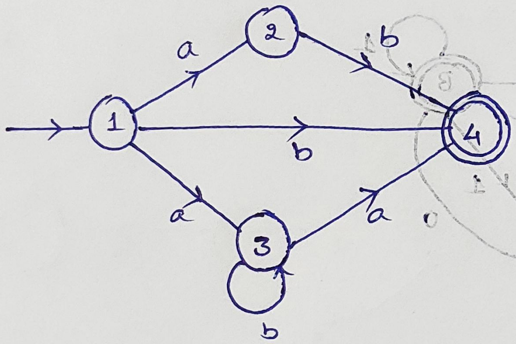
Transition table:-

δ	a	b
→ q_0	q_1	q_2
* q_1	q_1	q_3
* q_2	q_3	q_2
q_3	q_3	q_3

12. Convert the following NFA into DFA



12) Given, NFA is



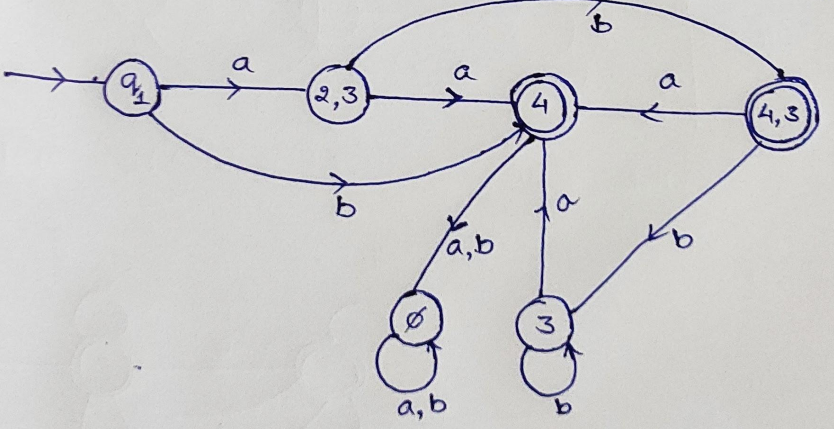
NFA:-

δ	a	b
→1	2,3	4
2	∅	4
3	4	3
*4	∅	∅

→

DFA:

δ	a	b
→1	2,3	4
2,3	4	4,3
*4	∅	∅
*4,3	4	3
3	4	3
∅	∅	∅



13. Describe a DFA for the following language L={w/| w| mod 3=0, w belongs to (a,b)* }

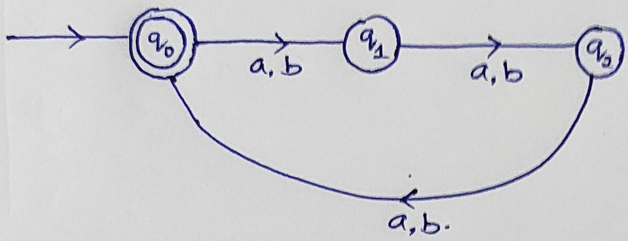
L={w/| w | mod 3=1, w belongs to (a,b)*}

13)

Given, L = {w/|w| mod3 = 0 , w belongs to (a, b)* }

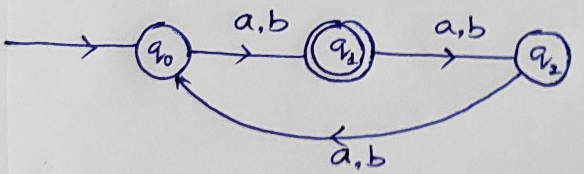
L = {ε, abb, bababb, ...}

DFA:



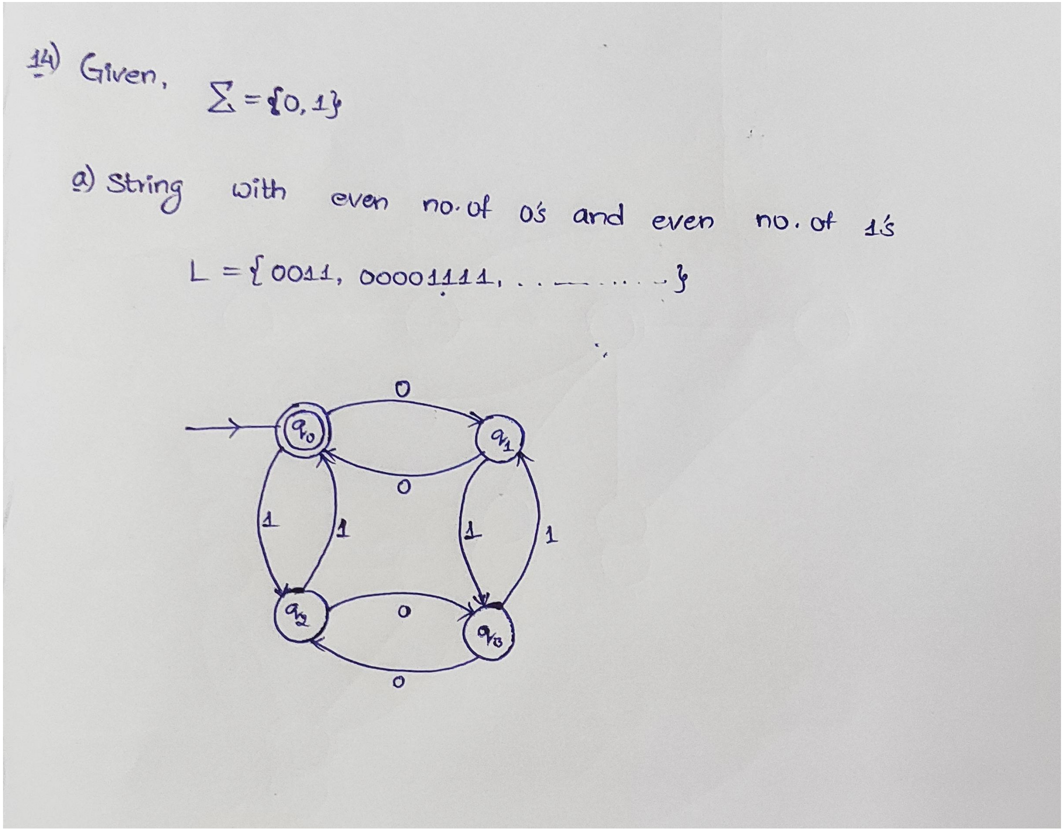
L = {w/|w| mod3 = 1, w belongs to (a, b)*}.

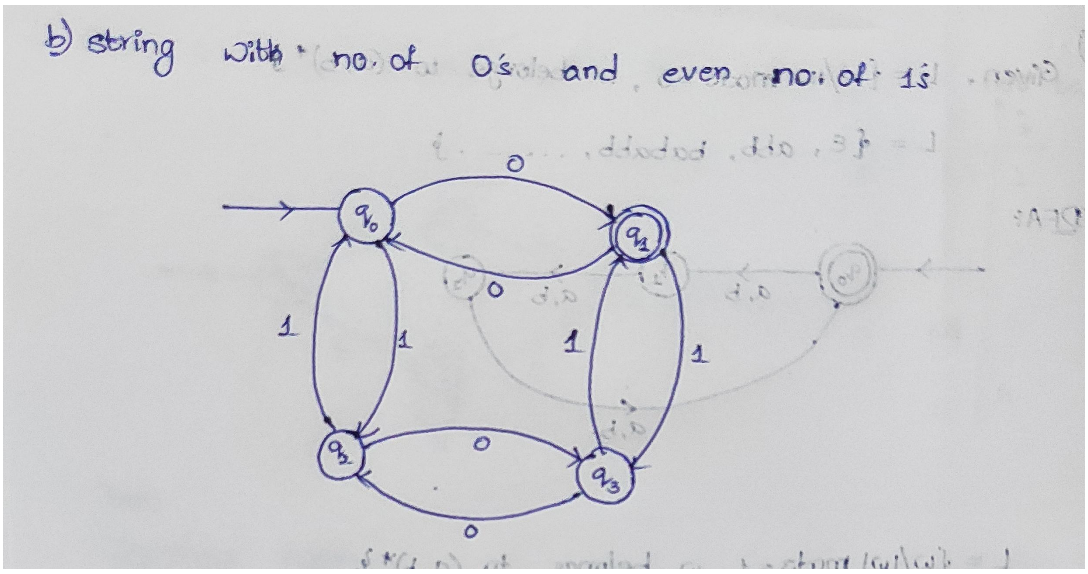
DFA:-



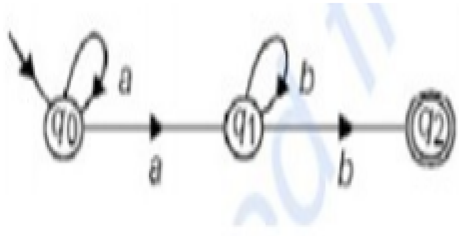
14. Describe a DFA for the following language over an alphabet P = { 0,1}

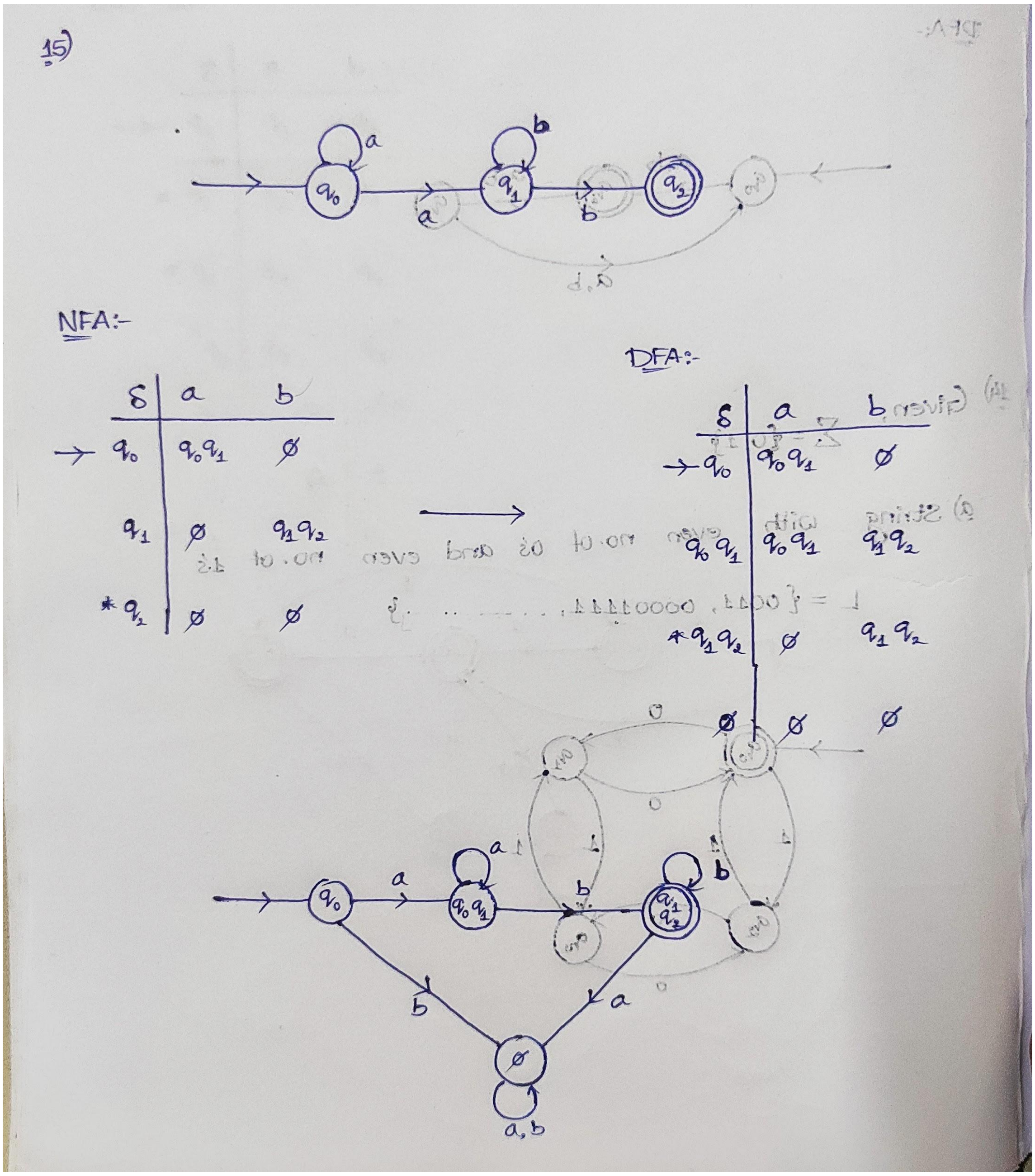
a)The string with even no of 0s and even no of1s b)The string with odd no of 0s and even no of1s





15. Convert the following NFA into equivalent DFA.




15)

NFA:-

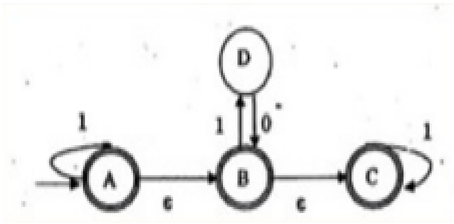
δ	a	b
$\rightarrow q_0$	q_0q_1	$\emptyset$
q_1	$\emptyset$	q_1q_2
$*q_2$	$\emptyset$	$\emptyset$

DFA:-

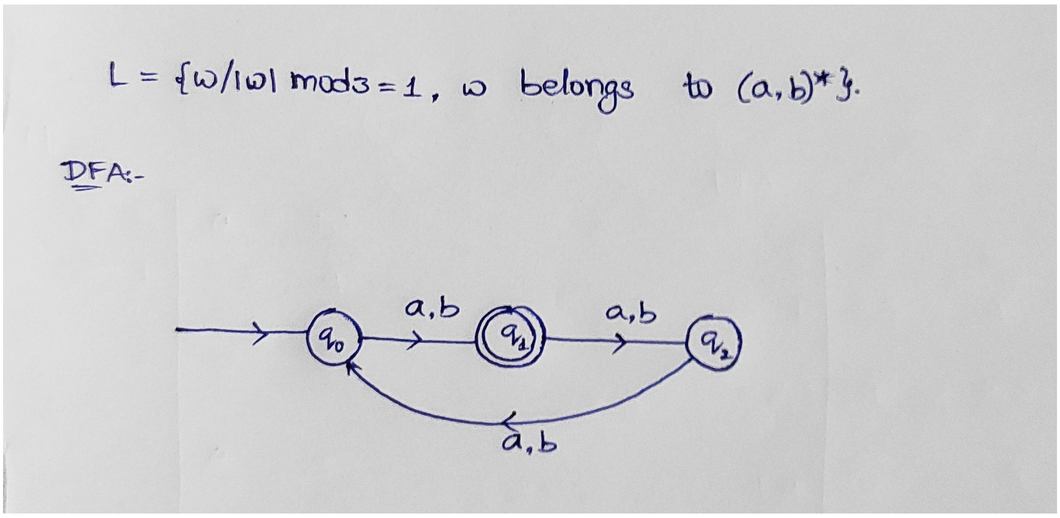
δ	a	b
$\rightarrow q_0$	q_0q_1	$\emptyset$
q_0q_1	q_0q_1	q_1q_2
$*q_1q_2$	$\emptyset$	q_1q_2
$\emptyset$	$\emptyset$	$\emptyset$

16. Convert the followinNFA-ϵ to NFA.

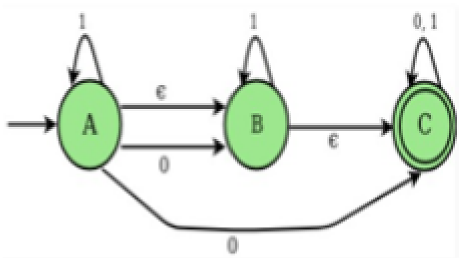
*****(QUESTION DOUBT)**



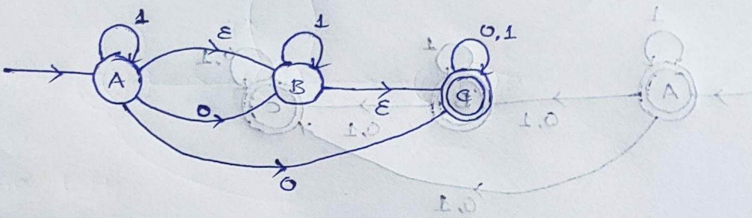
17. Describe a DFA for the following language L={w/na| w | mod 3=1, w belongs to (a,b)*}



18. Convert the following NFA with ϵ to NFA.



18) Given ε-NFA:



Transition table:

δ	0	1	ε
A	B,C	A	B
B	$\emptyset$	B	C
C	C	C	$\emptyset$

Trasition function:

$\hat{\delta}(A,\varepsilon) = \{A, B, C\} = \varepsilon\text{-closure}(A)$

$\hat{\delta}(B,\varepsilon) = \{B, C\} = \varepsilon\text{-closure}(B)$

$\hat{\delta}(C,\varepsilon) = \{C\} = \varepsilon\text{-closure}(C)$

$$\begin{aligned}\hat{\delta}(A,0) &= \varepsilon\text{-closure}(\delta(\hat{\delta}(A,\varepsilon),0)) \\ &= \varepsilon\text{-closure}(\delta(A,B,C),0)) \\ &= \varepsilon\text{-closure}(\delta(A,0) \cup \delta(B,0) \cup \delta(C,0)) \\ &= \varepsilon\text{-closure}((B,C) \cup B \cup C) \\ &= \{B, C\}\end{aligned}$$

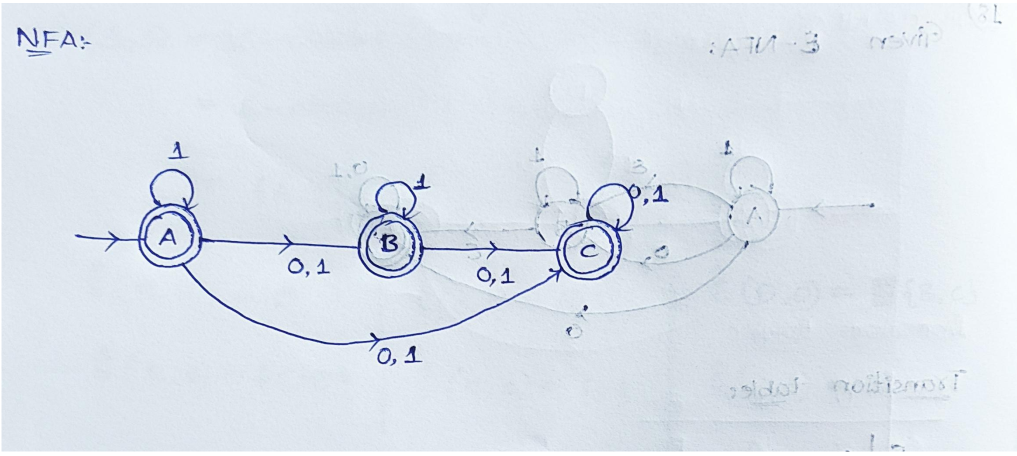
$\hat{\delta}(A,1) = \{A, B, C\}$

$\hat{\delta}(B,0) = \{C\}$

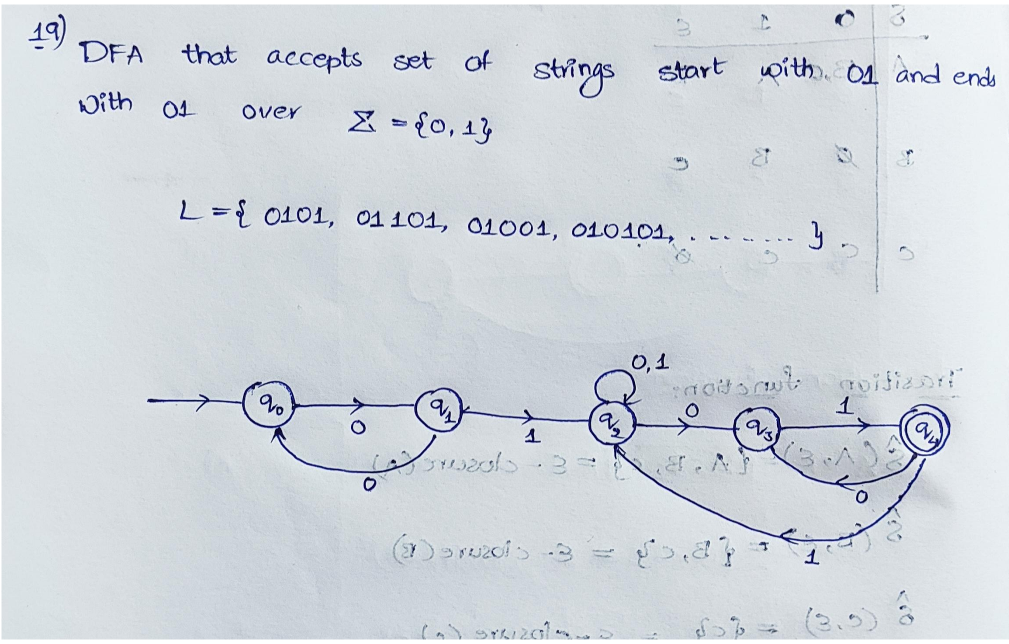
$\hat{\delta}(B,1) = \{B, C\}$

$\hat{\delta}(C,0) = \{C\}$

$\hat{\delta}(C,1) = \{C\}$



19. Describe a DFA that accepts set of strings starts with 01 and ends with 01 over alphabet P = {0,1}



20. Illustrate the model and behavior of finite automata with a neat block diagram.

PART-C

1. Define Automata.
2. Compare DFA and NFA.
3. Define the String.

4. Define transition function of DFA.

5. Define ϵ–transitions.

6. Define power of an alphabet (**Σ***).

7. List the applications of finite automata.

8. Define Null string.

9. Define Kleene Star?

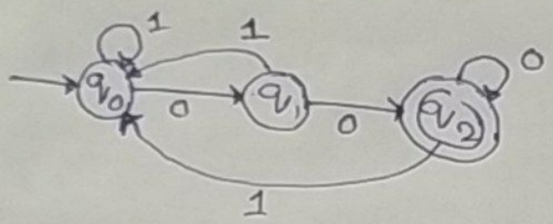
10. Define NFA with an example.

11. Describe transition diagram for DFA accepting string ending with 00.

11. DFA :

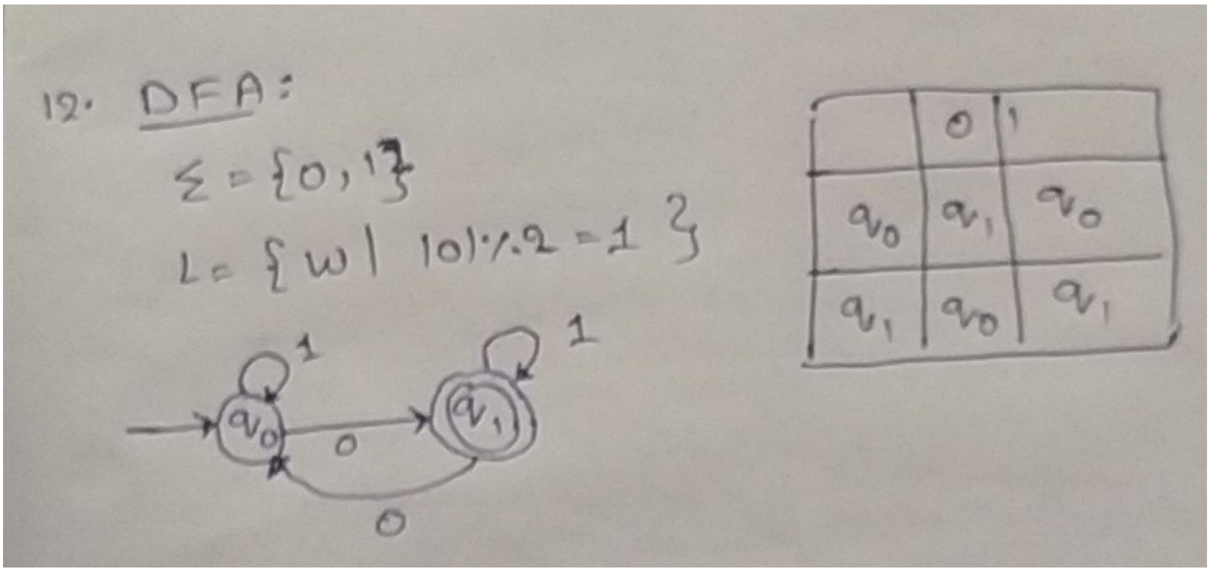
$\Sigma = \{0, 1\}$

$L = \{ w /$ string ending with $00 \}$

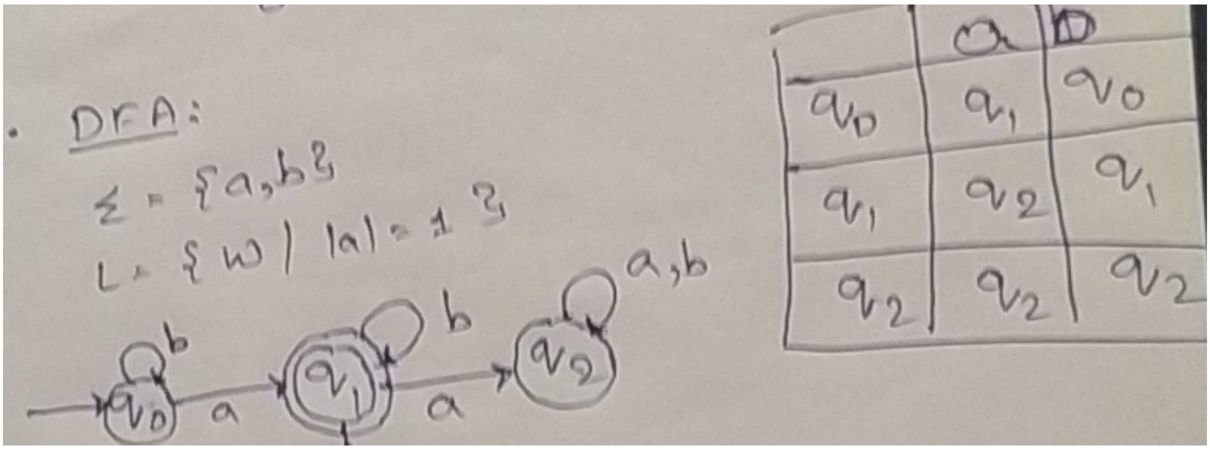


	0	1
q_0	q_1	q_0
q_1	q_2	q_0
q_2	q_2	q_0

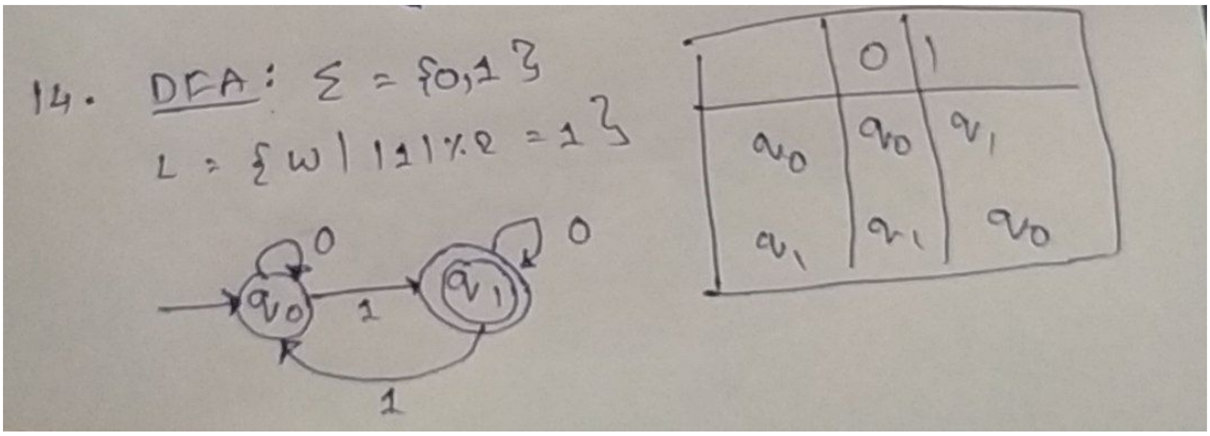
12. Describe DFA for a string accepting odd number of 0’s



13. Describe transition diagram for DFA to accept exactly one ‘a’ defined. over an alphabet P= {a,b}.



14. Demonstrate DFA for odd numbers of 1’s.

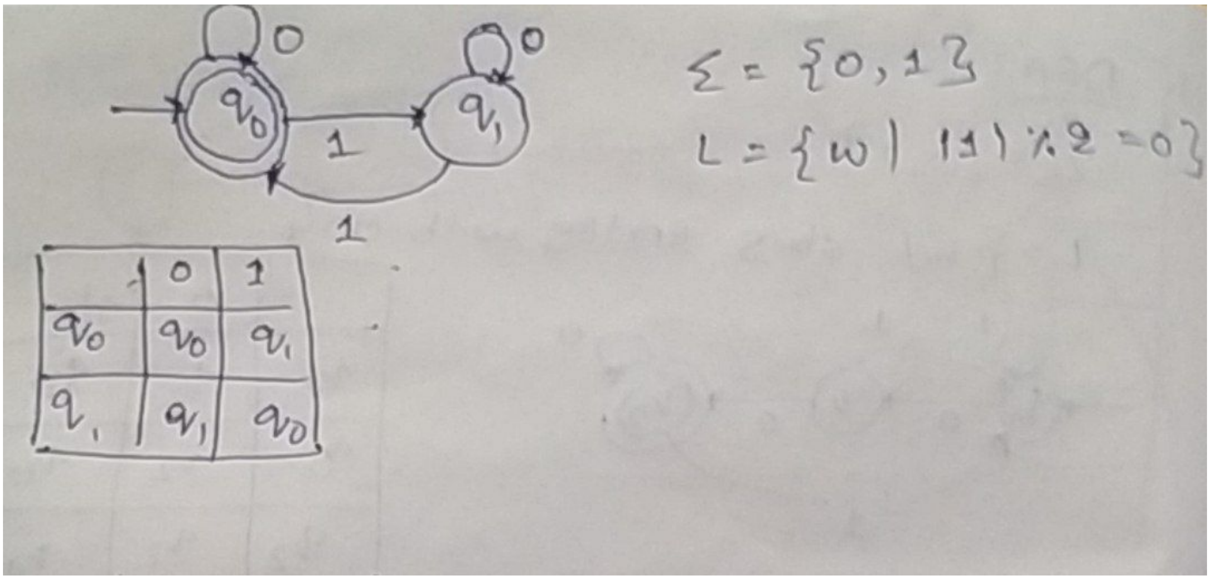


15. Define ϵ - closure.

16. Describe FSM and its structure with an example.

17. State the Mathematical definition of Finite Automata.

18. Demonstrate DFA for even numbers of 1’s.



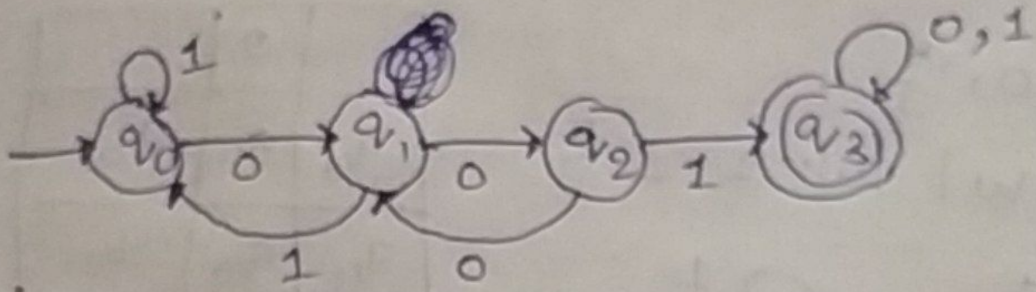
	0	1
q_0	q_0	q_1
q_1	q_1	q_0

19. Define DFA mathematically.

20. Demonstrate DFA for the language accepting strings which contains 001 as substring.

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

$L = \{ w \mid 001 \text{ as substring} \}$



DFA	0	1
q_0	q_1	q_0
q_1	q_2	q_0
q_2	q_1	q_3
q_3	q_3	q_3