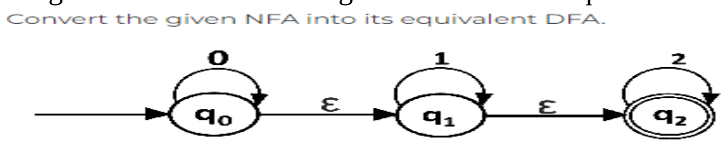
USN | | | | | | | | | | |

Internal Assessment Test 1 – November 2024

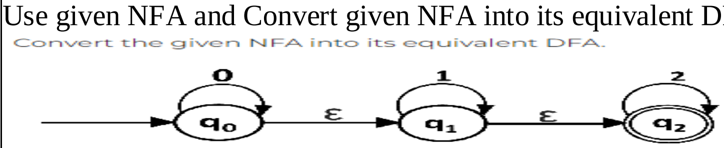
Sub:	Theory of Computation					Sub Code:	BCS503	Branch:	ISE
Date:	11/11/2024	Duration:	90 min’s	Max Marks:	50	Sem/Sec:	V / A, B, C		OBE

		MARKS	CO	RBT
	<u>Answer any FIVE FULL Questions</u>			
1 a)	Use below language to design a DFA to accept all the following languages: i. L= b*ab*a(a+b)* ii. L={w ;where |w| mod 3 =0 where ∑ ={a}, i.e. {a^{3n} | n >= 0}} iii. L= { input alphabets ∑ = {0, 1} , L is the set of all strings starting with 00}	10M	CO1	L3
2 a)	Use given NFA and Convert given NFA into its equivalent DFA. 	10M	CO1	L3
3 a)	Define the following with an example: (i) Alphabet (ii) String (iii) Symbol (iv) Language	6M	CO1	L1
3 b)	Explain Pumping lemma of regular languages (Prove language not to be regular) and explain using example.	4M	CO1	L2

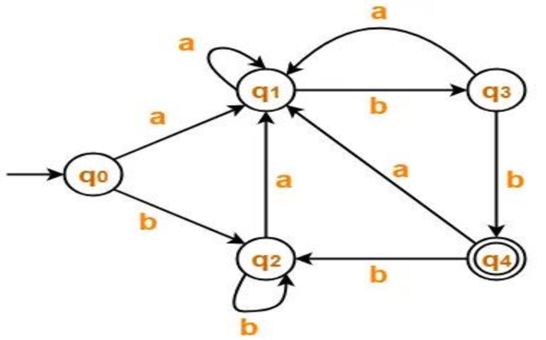
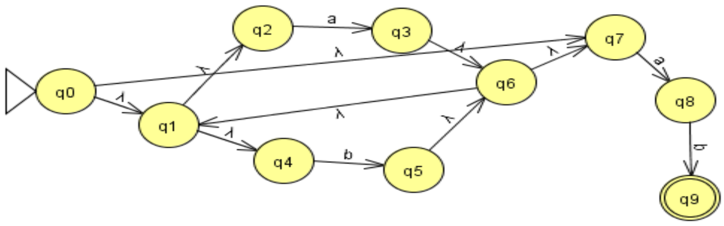
USN | | | | | | | | | | |

Internal Assessment Test 1 – November 2024

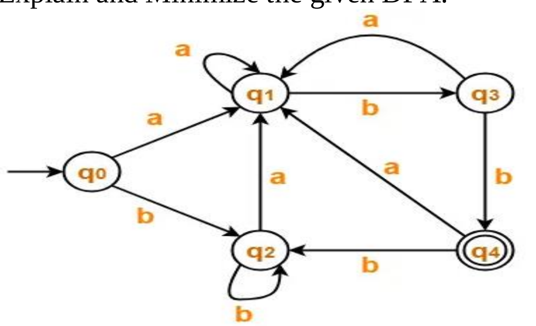
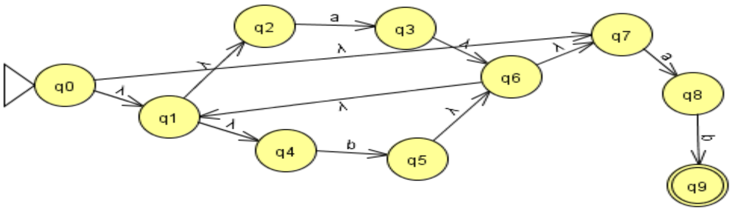
Sub:	Theory of Computation					Sub Code:	BCS503	Branch:	ISE
Date:	11/11/2024	Duration:	90 min’s	Max Marks:	50	Sem/Sec:	V / A, B, C		OBE

		MARKS	CO	RBT
	<u>Answer any FIVE FULL Questions</u>			
1 a)	Use below language to design a DFA to accept all the following languages: i. L= b*ab*a(a+b)* ii. L={w ;where |w| mod 3 =0 where ∑ ={a}, i.e. {a^{3n} | n >= 0}} iii. L= { input alphabets ∑ = {0, 1} , L is the set of all strings starting with 00}	10M	CO1	L3
2 a)	Use given NFA and Convert given NFA into its equivalent DFA. 	10M	CO1	L3
3 a)	Define the following with an example: (i) Alphabet (ii) String (iii) Symbol (iv) Language	6M	CO1	L1
3 b)	Explain Pumping lemma of regular languages (Prove language not to be regular) and explain using example.	4M	CO1	L2

4 a)	Explain and Minimize the given DFA:	10M	CO2	L2

<table>
<tr><td></td><td>
</td><td></td><td></td><td></td></tr>
<tr><td>5 a)</td><td>Use the following NFA with ε-transitions. Construct an equivalent DFA.
HERE epsilon is shown with(lambda symbol)

</td><td>10M</td><td>CO2</td><td>L3</td></tr>
<tr><td>6 a)</td><td>Explain and construct a DFA over input={a,b} where no. of a’s are divisible by 3 and no. of b’s are divisible by 3.</td><td>5M</td><td>CO1</td><td>L2</td></tr>
<tr><td>6 b)</td><td>Explain the properties of Regular languages alongwith examples.</td><td>5M</td><td>CO2</td><td>L2</td></tr>
</table>

Faculty Signature CCI Signature HOD Signature

<table>
<tr><td>4 a)</td><td>Explain and Minimize the given DFA:

</td><td>10M</td><td>CO2</td><td>L2</td></tr>
<tr><td>5 a)</td><td>Use the following NFA with ε-transitions. Construct an equivalent DFA.
HERE epsilon is shown with(lambda symbol)

</td><td>10M</td><td>CO2</td><td>L3</td></tr>
<tr><td>6 a)</td><td>Explain and construct a DFA over input={a,b} where no. of a’s are divisible by 3 and no. of b’s are divisible by 3.</td><td>5M</td><td>CO1</td><td>L2</td></tr>
<tr><td>6 b)</td><td>Explain the properties of Regular languages alongwith examples.</td><td>5M</td><td>CO2</td><td>L2</td></tr>
</table>

Faculty Signature CCI Signature HOD Signature

① Define the following with the examples.

(i) Alphabet

An Alphabet is a finite, non-empty set of symbols. conventionally, we use symbol Σ for an alphabet.

ex:- binary alphabet $\Sigma = \{0,1\}$

$\Sigma = \{a, b \ldots z\}$ set of all lower case letters.

(ii) String

A string is a finite sequence of symbols choosen from some alphabet

ex:- 01101 is a string from binary alphabet $\Sigma = \{0,1\}$. the string 111 is another string choosen from this alphabet.

(iii) Symbol

A symbol is any single element (or) character that belongs to an alphabet. It is basic building block for forming strings.

ex:- $\Sigma = \{a, b, c\}$, "a" is a symbol.

(iv) Language.

A language is a set of strings formed from an alphabet. It can be finite or infinite and is usually defined by specific rules.

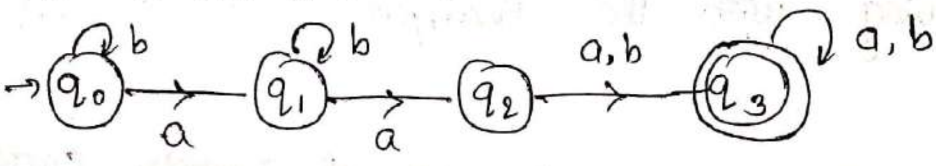
ex:- set of all strings of length 2 formed from the alphabet

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

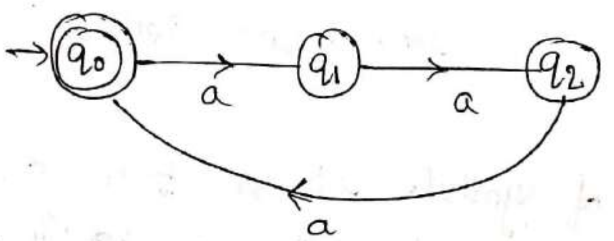
$L = \{aa, ab, ba, bb\}$

(2) Design a DFA to accept all the following language

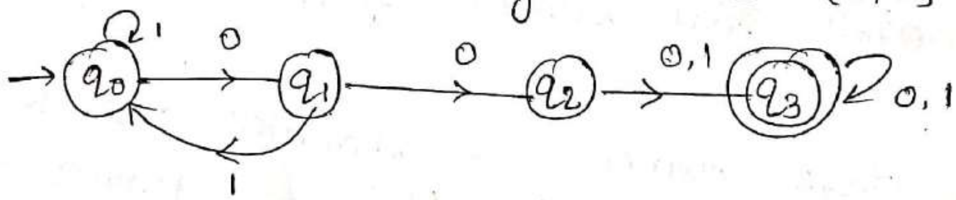
(i) $L = b^*ab^*a(a+b)^*$



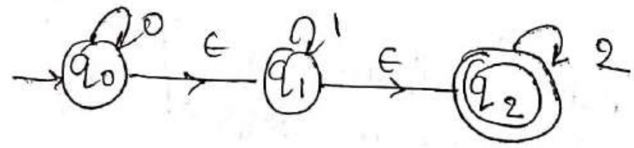
(ii) DFA for $L = \{ w \mid |w| \bmod 3 = 0$ and $w \in \{a\}^* \}$
i.e $\{ a^{3n} \mid n >= 0 \}$.



(iii) DFA for L = {all strings over $\Sigma = \{0,1\}$ that start with 00}

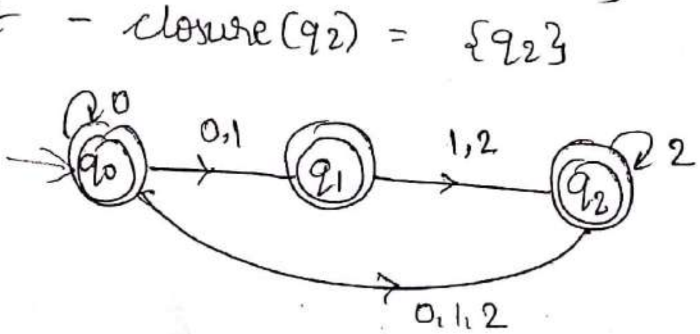


(3) Convert the given NFA into its equivalent DFA ϵ NFA to NFA



	0	1	2
$\rightarrow q_0$	$(q_0 q_1 q_2)$	$(q_1 q_2)$	q_2
q_1	ϕ	$(q_1 q_2)$	q_2
$* q_2$	ϕ	ϕ	q_2

ϵ - closure $(q_0) = \{q_0, q_1, q_2\}$
ϵ - closure $(q_1) = \{q_1, q_2\}$
ϵ - closure $(q_2) = \{q_2\}$



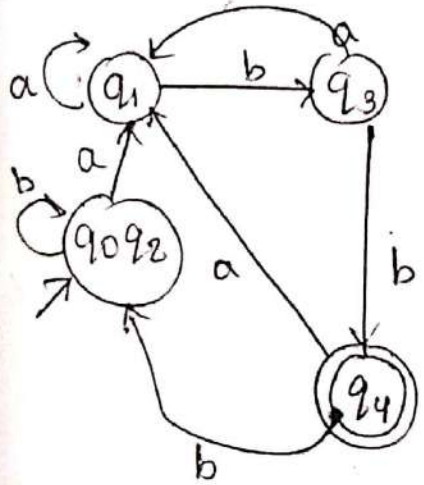
Step5 :- set 2 has no similar rows so set 2 will be the same, only replacing q_2 by q_0.

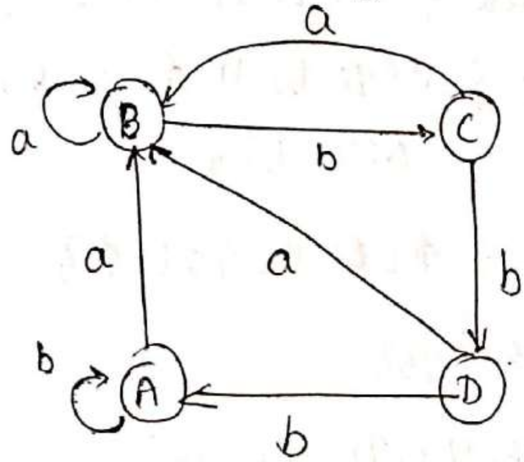
	a	b
$*q_4$	q_1	q_0

Step6 : Now combine set 1 and set 2 as:

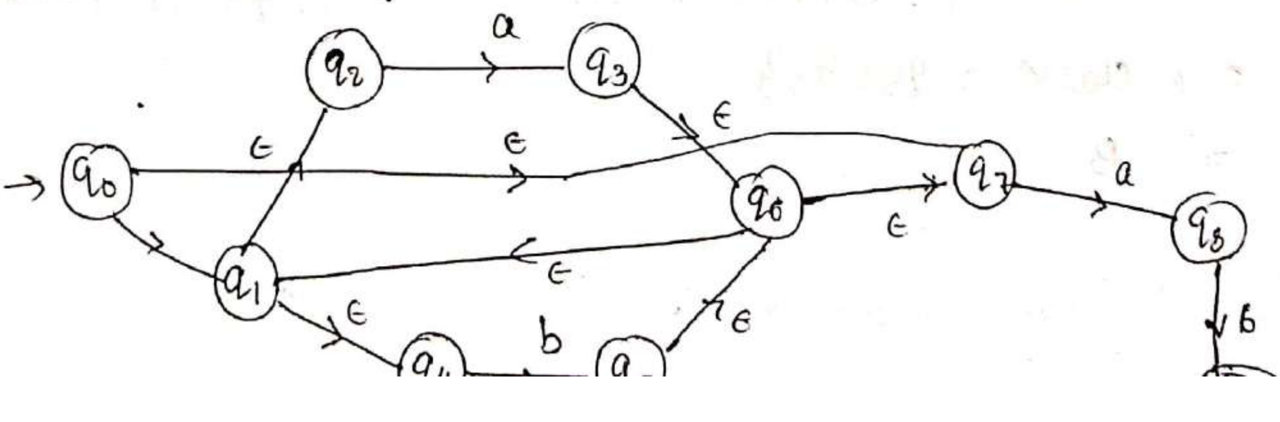
	a	b
$\rightarrow q_0$	q_1	q_0
q_1	q_1	q_3
q_2	q_1	$*q_4$
q_3	q_1	q_0

Now it is the transition table of minimized DFA





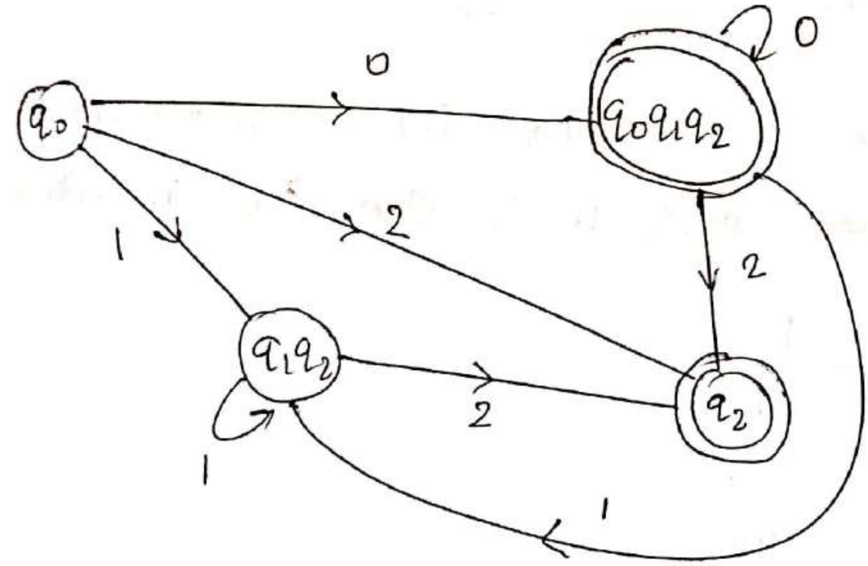
(5) Consider the following NFA with ε transition construct an equivalent DFA



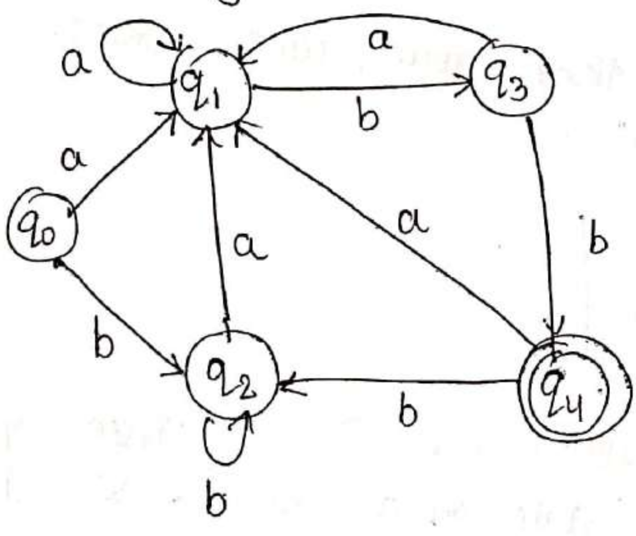
* NFA to DFA

	0	1	2
q_0	$(q_0q_1q_2)$	(q_1q_2)	q_2
q_1	ϕ	(q_1q_2)	q_2
q_2	ϕ	ϕ	q_2

	0	1	2
q_0	$q_0q_1q_2$	q_1q_2	q_2
* $q_0q_1q_2$	$q_0q_1q_2$	q_1q_2	q_2
* q_1q_2	ϕ	q_1q_2	q_2



4) Minimize the given DFA.



solution :

step 1 : In the given DFA, all states are reachable so no states need to be removed

step 2 : Draw the transition table for the states.

	a	b
→ q_0	q_1	q_2
q_1	q_1	q_3
q_2	q_1	q_2
q_3	q_1	$*q_4$
$*q_4$	q_1	q_2.

Step3 : Now divide rows of transition table into two sets as:

1. One set contains those rows, which start from non-final states

	a	b
→ q_0	q_1	q_2
q_1	q_1	q_3
q_2	q_1	q_2
q_3	q_1	$*q_4$

2. Another set contains those rows, which starts from final states

	a	b
$*q_4$	q_1	q_2

Step4 : In set1, row 1 and row 3 are similar since q_0 & q_2 transit to the same state on a and b. So, skip q_2 and replace q_2 by q_0 in rest.

	a	b
→ q_0	q_1	q_0
q_1	q_1	q_3
q_3	q_1	$*q_4$

→ Initial state → q_0

ϵ - closure (q_0) = $\{q_0, q_1, q_2, q_4, q_7\}$. ⇒ lets say it as st

$\delta(A,a) = \epsilon\text{-closure}(\delta(A), a)\}$

$= \epsilon\text{-closure}(\delta(q_0, q_1, q_2, q_4, q_7), a)\}$

$= \epsilon\text{-closure}\{\delta(q_0, a) \cup \delta(q_1, a) \cup \delta(q_2, a) \cup (q_4, a) \cup (q$

$= \epsilon\text{-closure}\{\phi \cup \phi \cup q_3 \cup \phi \cup q_8\}$

$= \epsilon\text{-closure}\{q_3 \cup q_8\}$

$= \epsilon\text{-closure}\{q_3\} \cup \epsilon\text{-closure}\{q_8\}$

$= \{q_3, q_6, q_1, q_2, q_4, q_7\} \cup \{q_8\}$

$= \{q_1, q_2, q_3, q_4, q_6, q_7, q_8\}$ ⇒ let say it as B

$\delta(A, b) = \epsilon\text{-closure}\{\delta(q_0, q_1, q_2, q_4, q_7), b\}$

$= \epsilon\text{-closure}\{\delta(q_0, b) \cup \delta(q_1, b) \cup \delta(q_2, b) \cup \delta(q_4, b) \cup \delta(q_7, b)\}$

$= \epsilon\text{-closure}\{\phi \cup \phi \cup \phi \cup q_5 \cup \phi\}$

$= \epsilon\text{-closure}\{q_5\}$

$= \{q_5, q_6, q_7, q_1, q_2, q_4\}$

$= \{q_1, q_2, q_4, q_5, q_6, q_7\}$ → let's say C

$\delta(B, a) = \epsilon\text{-closure}\{\delta(q_1, q_2, q_3, q_4, q_6, q_7, q_8, a\}$

$= \epsilon\text{-closure}\{q_3 \cup q_8\}$

$= B$

$\delta(B,b) = \epsilon\text{-Closure } \{\delta(q_1, q_2, q_3, q_4, q_6, q_7, q_8, b\}$

$= \epsilon\text{-Closure } \{q_5 \cup q_9\}$

$= \epsilon\text{-Closure } \{q_5\} \cup \epsilon\text{-Closure } \{q_9\}$

$= \{q_1, q_2, q_4, q_5, q_6, q_7\} \cup \{q_9\}$

$= \{q_1, q_2, q_4, q_5, q_6, q_7, q_9\}$ → Let's say D

$\delta(C,a) = \epsilon\text{-closure } \{\delta(q_1, q_2, q_4, q_5, q_6, q_7, q_?, a\}$

$= \epsilon\text{-Closure } \{q_3 \cup q_8\}$

$= B$

$\delta(C,b) = \epsilon\text{-Closure } \{\delta(q_1, q_3, q_4, q_5, q_6, q_7, q_8\}$

$= \epsilon\text{-Closure } \{q_5\}$

$= C.$

$\delta(D,a) = \epsilon\text{-Closure } \{\delta(q_1, q_2, q_4, q_5, q_6, q_7, q_9), a.\}$

$= \epsilon\text{-Closure } \{q_3 \cup q_8\}$

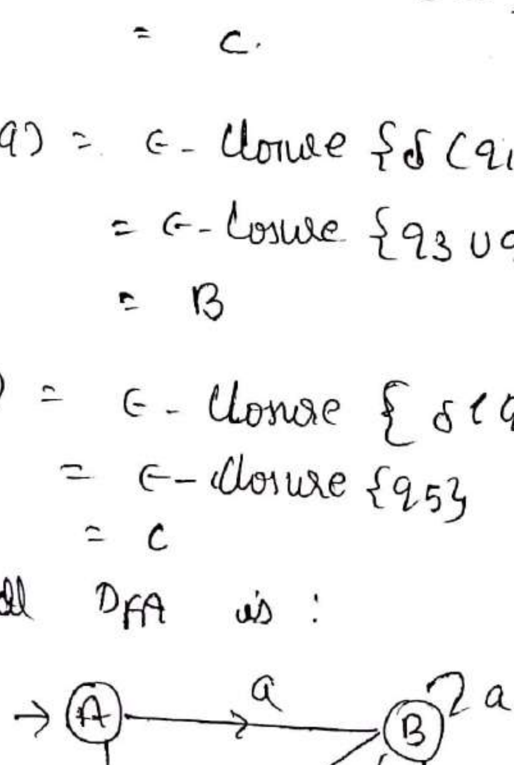
$= B$

$\delta(D,b) = \epsilon\text{-Closure } \{\delta(q_1, q_2, q_4, q_5, q_6, q_7, q_9); b\}$

$= \epsilon\text{-Closure } \{q_5\}$

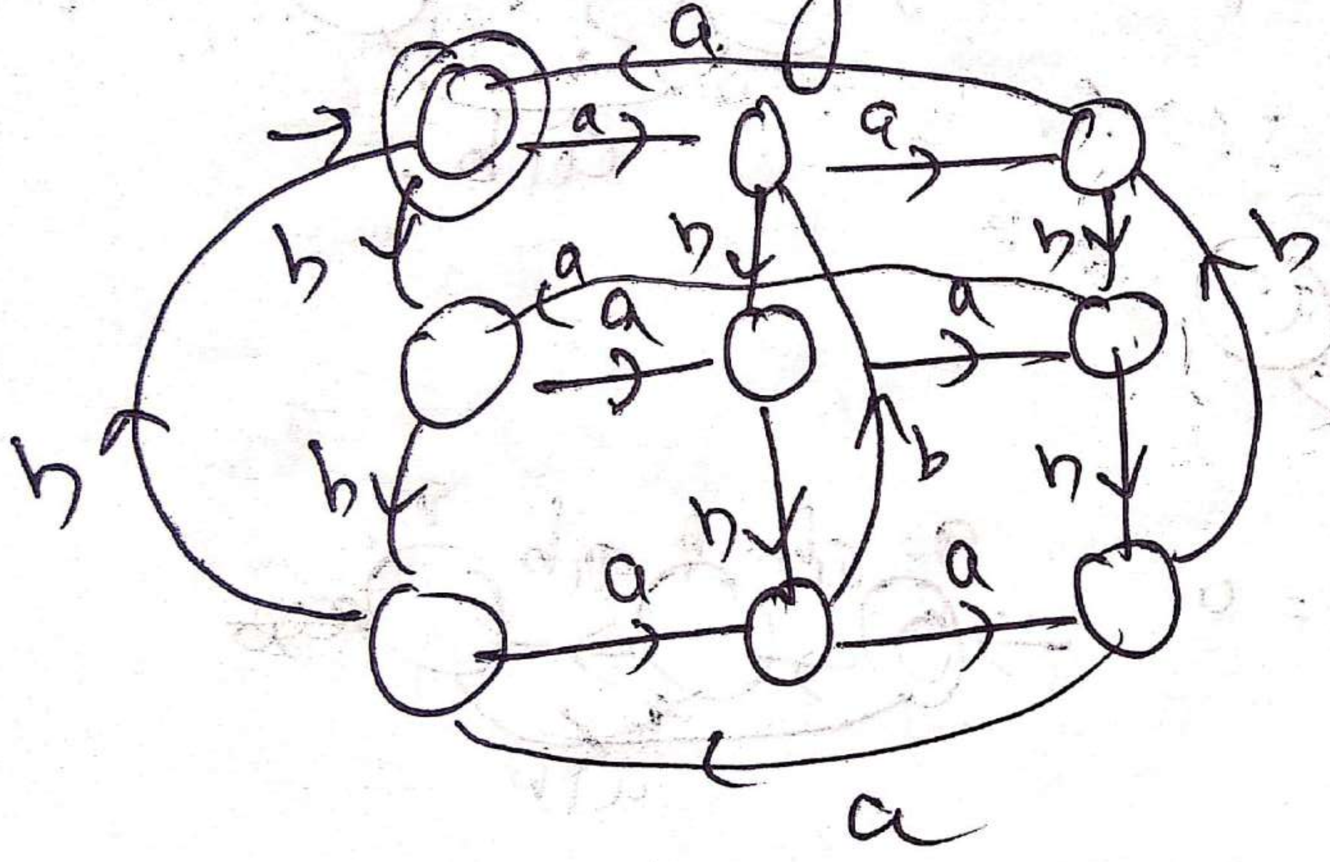
$= C$

So, final DFA is :



As q_9 is final state, D contains q_9. So D because ...

Q a divisible by 3 and a b's divisible by



1*) RL are closed under difference.
2*) RL are closed under reversal

1) $L_1 - L_2 = \boxed{L_1 \cap \overline{L_2}}$ Regular

$\underline{\text{Regular}}\ \underline{\text{Regular}}$

2) ~~Rev~~ $DFA^R \rightarrow (L^R)$

$DFA \rightarrow R$

(L)

L and L^R are regular.

3) The function $h : \Sigma \rightarrow \Gamma^*$ is called homomorphism. RL are closed under homomorphism.

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

$h(a) = 01$

$h(b) = 112$

Q what is homomorphic image of $h(aba)$

$= h(0111201)$.

eg homomorphic image of language

$L_1 = (a)^* b = (01)^* 112$.

4) RL are closed under reversal homomorphism.

Q $\Sigma = \{0, 1, 2\}$ and $\Delta = \{a, b\}$. Define 'h' by

$h(0) = a$, $h(1) = ab$ $h(2) = ba$.

let $L_1 = \{ababa\}$

ababa ababa $\underset{1\ 0\ 2}{ababa} = \{022, 110, \}$

Closure Properties of Regular Languages

Closure means: set — 2 elements. If we do any expression on these 2 elements, the resultant elements also belong to same set.

$RL_1 \cup RL_2 = RL_3$

1) $L_1 \cup L_2 =$ will also RL
L_1 — RL, L_2 — RL

$\underset{\text{Regular exp}}{R_1} + \underset{\text{Regular expression}}{R_2}$

2) $L_1 \cdot L_2 = \underline{R_1 \cdot R_2}$

3) $L^* = R^*$

4) $\overline{L_1} = \Sigma^* - L_1$ $\quad \boxed{\overline{L_1} \quad L_1}$

$L_1 \rightarrow DFA \rightarrow \underline{DFA} \xrightarrow{\text{complement}} \text{accept } L_1^C = \overline{L_1}$

5) $L_1 \cap L_2 = \overline{\overline{L_1} \cup \overline{L_2}} = \overline{RL \cup RL_2}$ $\quad \overline{\overline{a} + \overline{b}} = ab$

$\overline{L_1}$ — RL_1, $\overline{L_2}$ — RL_2

$= \overline{RL}$

$= \overline{RL} = \underline{RL}$

*) Right Quotient

Let L_1 & L_2 be languages on the same alphabet then the right quotient of L_1 with L_2 is

$L_1/L_2 : \{x : xy \in L, \text{ for some } y \in L_2\}$

eg $L_1 = \{01, 001, 101, 0001, 1101\}$

$L_2 = \{01\}$

$L_1/L_2 = \{\epsilon, 0, 1, 00, 11\}$

*) Regular language are closed INIT operation

INIT → Prefix.

eg $L = \{a, ab, aabb\}$

$Init(L) = \{\epsilon, a, \epsilon, a, ab, \epsilon, a, aa, aab, aabb\}$

prefixes → $\{\epsilon, A, AB, ABC, ABCD\}$

RA ABCD =

* Regular sets are closed under substitution.

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

$f(a) = 0^*$

$f(b) = 01^*$

$L = a + b^*$

$f(L) = 0^* + (01^*)^*$

Regular