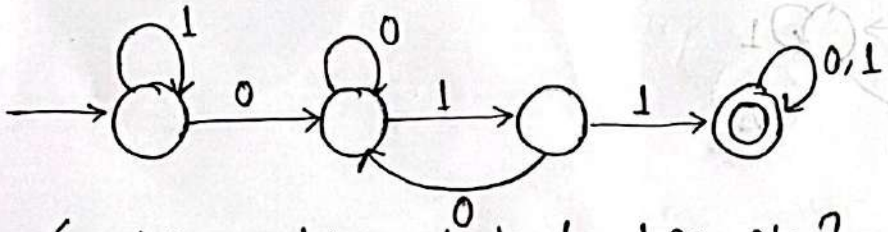
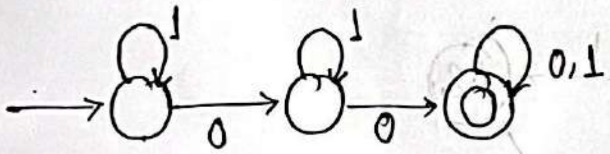
Subject:

Date:

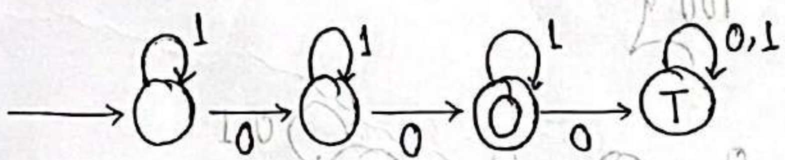
Type 1 $L = \{ w \in \{0,1\}^* : w \text{ contains } 011 \}$



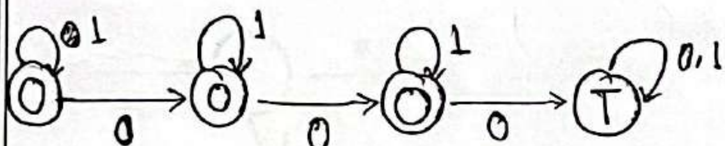
Type 2 $L = \{ w \mid w \text{ contains at least two } 0\text{'s} \}$ [two or more zeros]



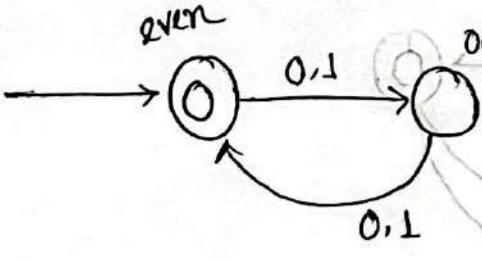
Type 3 $L = \{ w \mid w \text{ contains exactly two } 0\text{'s} \}$ [neither 1 or 3]



Type 4 $L = \{ w \mid w \text{ contains at most two } 0\text{'s} \}$ [Not up to 2]

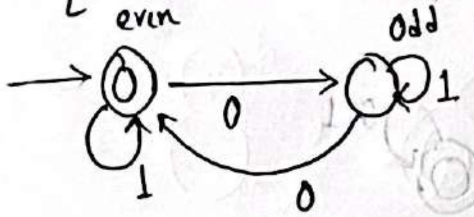


Type 5 $L = \{ w \mid \text{length of } w \text{ is even} \}$

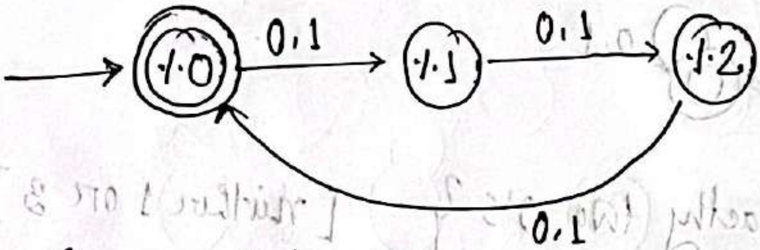


Subject: | Date:

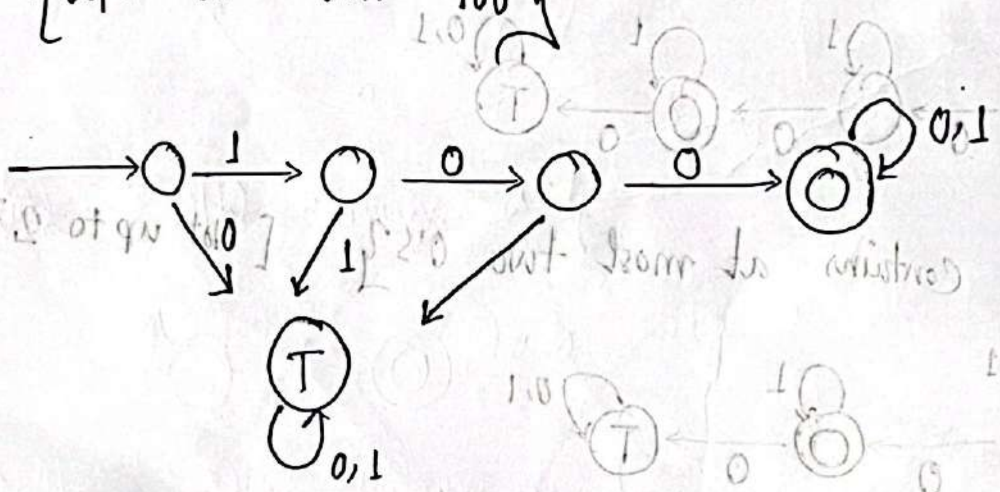
Type 6 $L = \{ w \mid w$ count of 0's is even $\}$



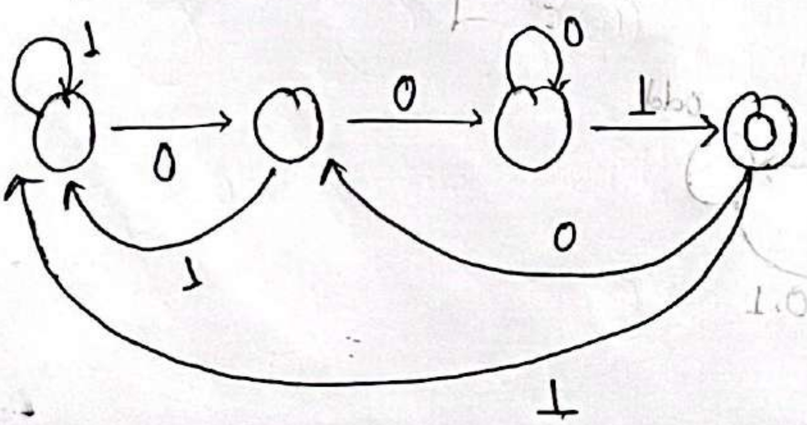
Type 7 $L = \{ w \mid w$ multiple of 3 $\}$



Type 8. $L = \{ w \mid w$ start with 100 $\}$



Type 9 $L = \{ w \mid w$ ends with 001 $\}$



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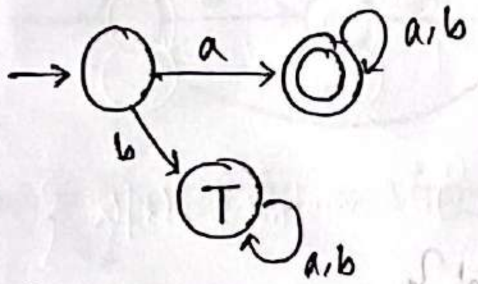
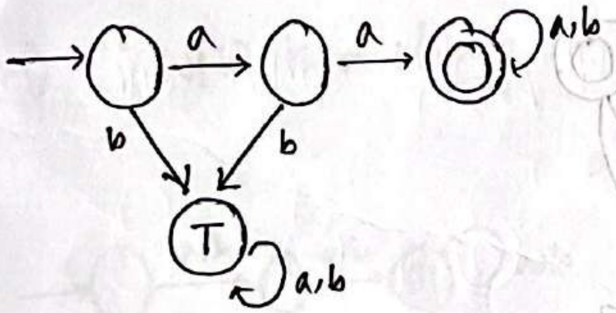
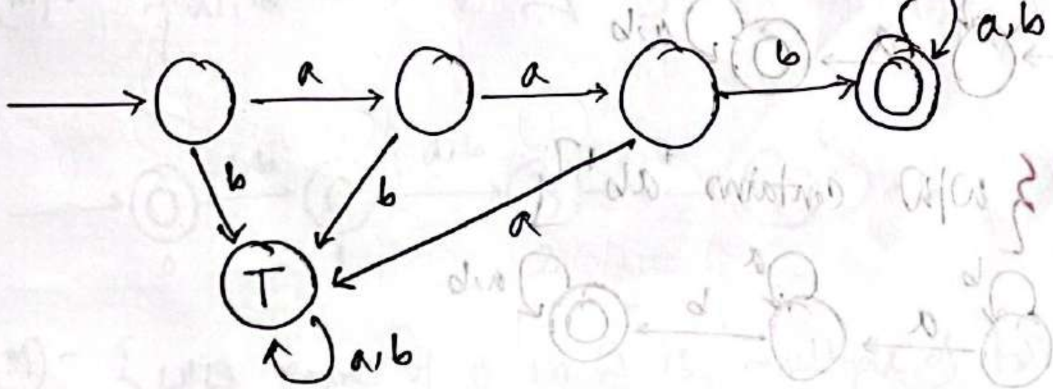
* $L(m) = \{ w \mid w$ starts with an 'a' $\}$



* $L(m) = \{ w \mid w$ starts with 'aa' $\}$



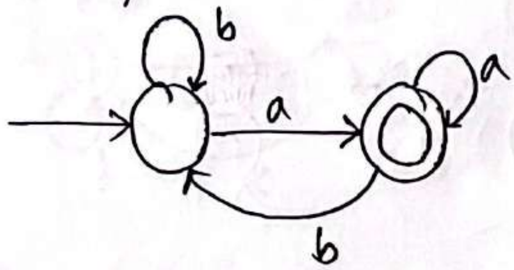
* $L(m) = \{ w \mid w$ starts with "aab" $\}$



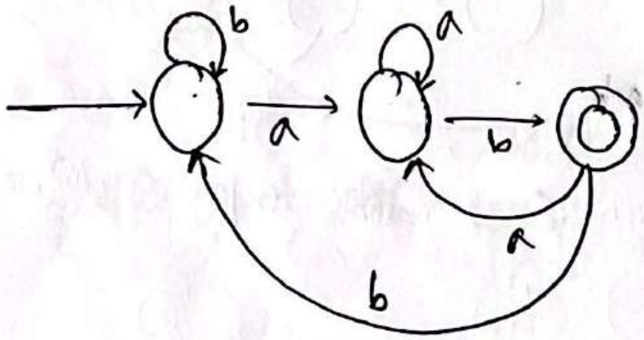
Subject: Date:

Hamid Book Bainding

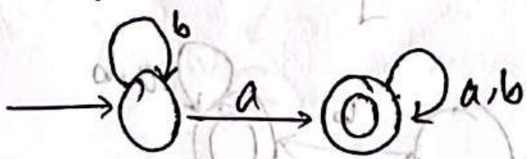
* $L(m) = \{ w \mid w$ ends with an 'a' $\}$



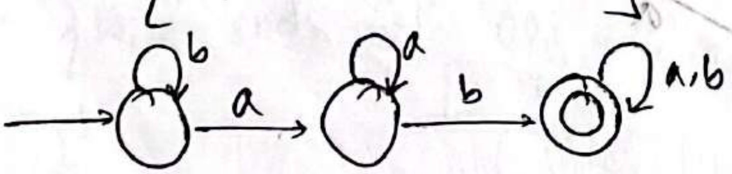
* $L(m) = \{ w \mid w$ ends with an 'ab' $\}$



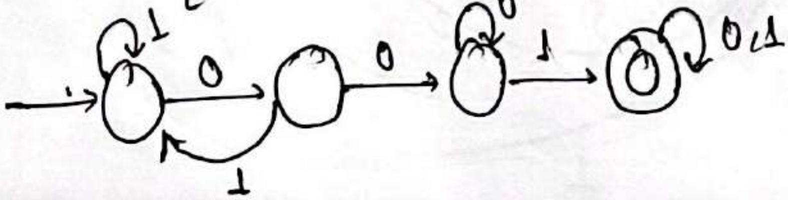
* $L(m) = \{ w \mid w$ contains 'a' $\}$



* $L(m) = \{ w \mid w$ contains 'ab' $\}$

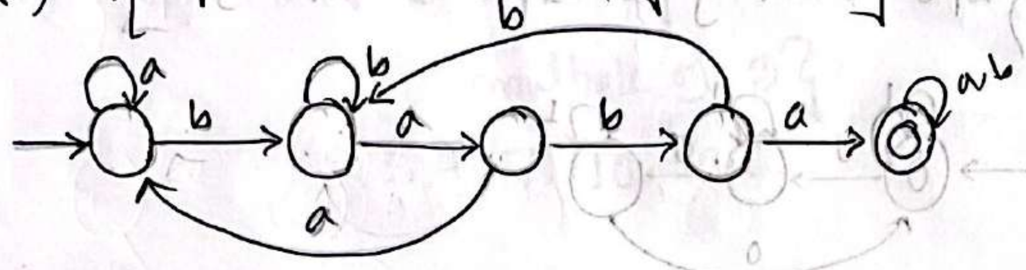


* $L(m) = \{ w \mid w$ contains '001' $\}$

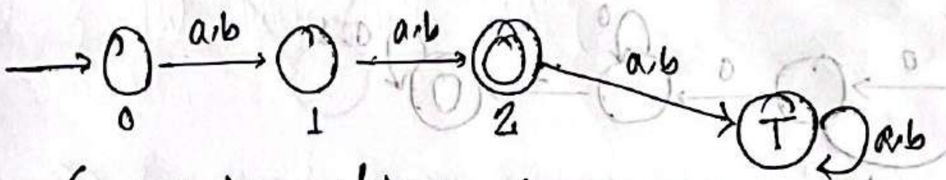


Subject: Date:

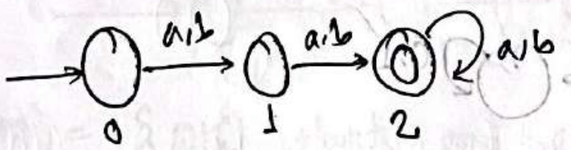
* $L(M) = \{ w \mid w$ contains substring 'baba' $\}$



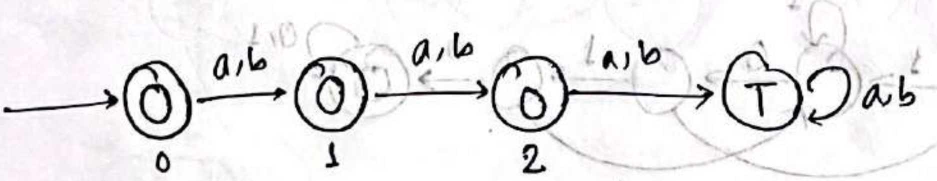
* $L(M) = \{ w \mid w$ is a string of length 2 $\}$



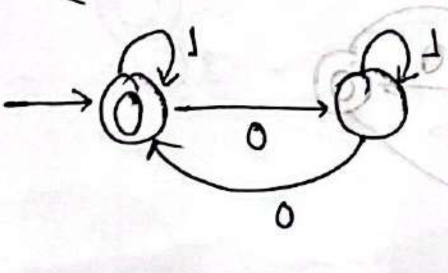
* $L(M) = \{ w \mid w$ is a string of length at least 2 $\}$



* $L(M) = \{ w \mid w$ is a string of length at most 2 $\}$

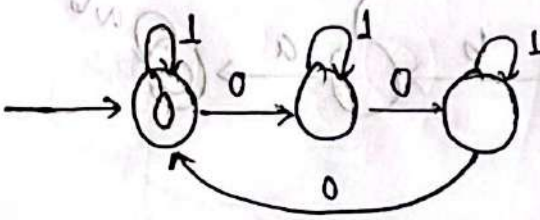


* $L(M) = \{ w \mid w$ count of 0 in w is multiple of two $\}$

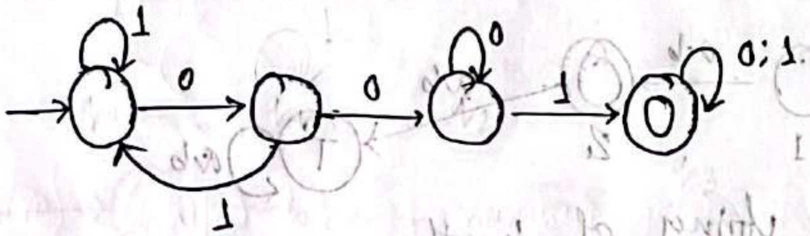


Subject : Date :

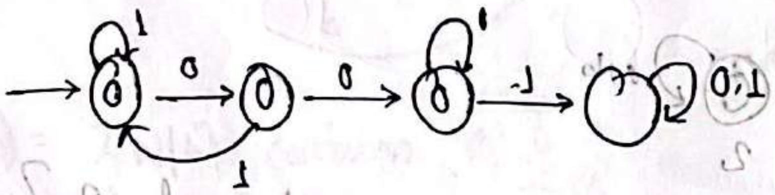
$L(M) = \{ \omega \mid \omega$ count of zeros is multiple of $3 \}$



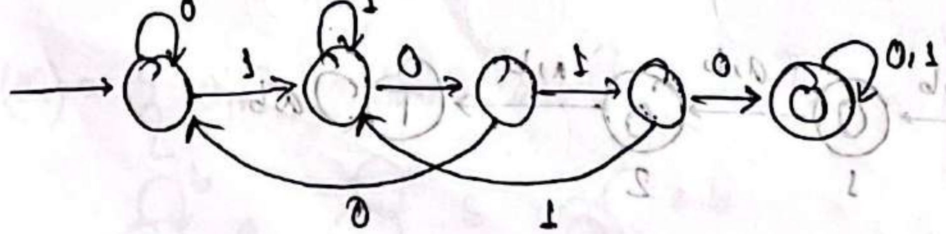
$L(M) = \{ \omega \mid \omega$ contains $001 \}$



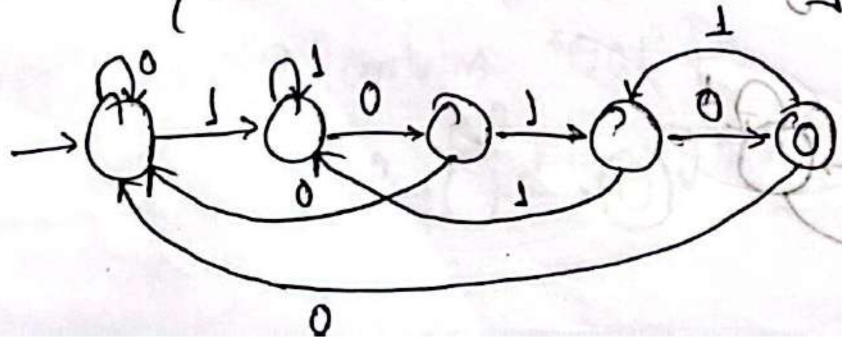
$L(M) = \{ \omega \mid \omega$ doesnot contains $001 \}$



$L(M) = \{ \omega \mid \omega$ w contains 1010 as substring $\}$



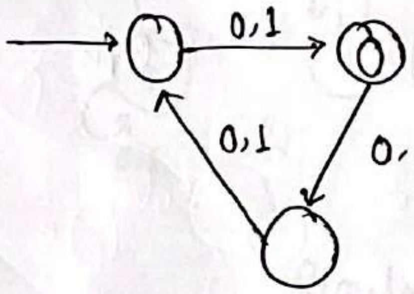
$L(M) = \{ \omega \mid \omega$ w ends with $1010 \}$



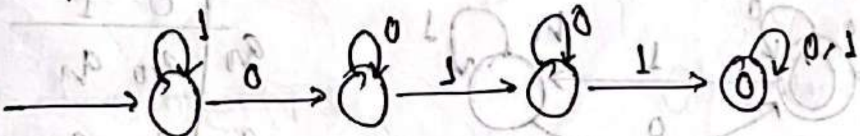
Subject : Date :

L(m) = { w | w length of the string is one more than multiple of 3 }

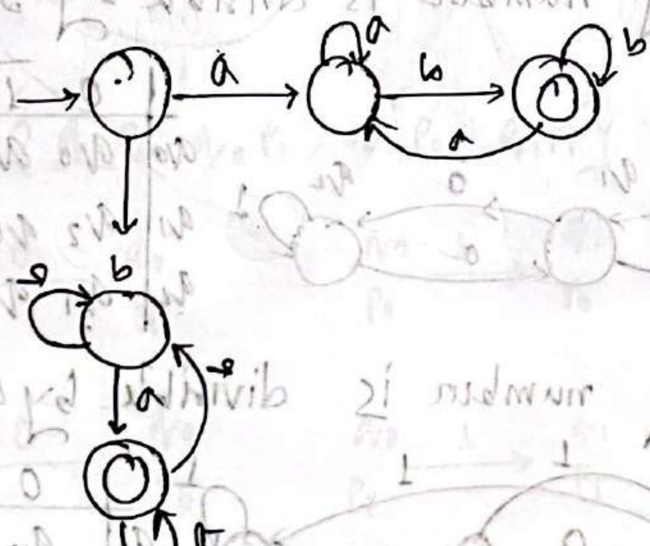
1, 4, 7, 10, 13 . . . .



L(m) = { w | w have 011 as subsequence }

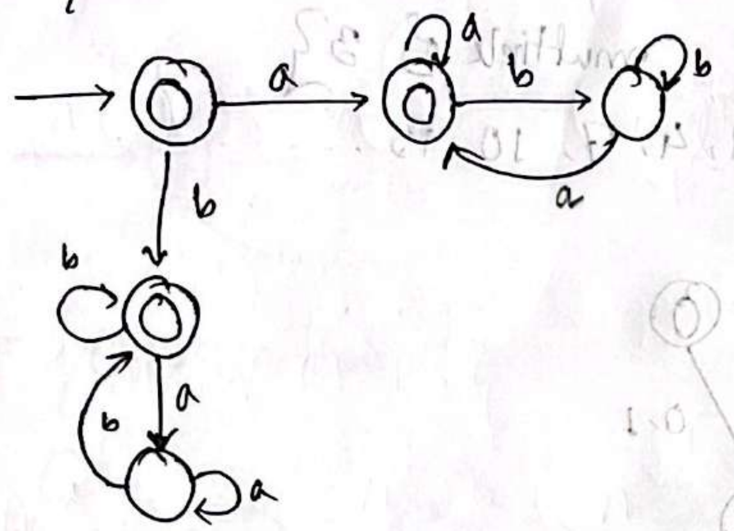


L(m) = { w | w starts and ends with the different symbol }

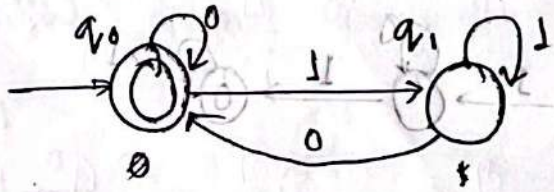


Subject :   Date :

* $L(m) = \{w \mid w$ starts and ends with same symbol$\}$

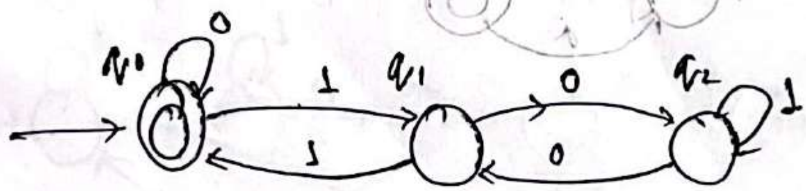


* $L(m) = \{w \mid w$ binary number is divisible by $2\}$



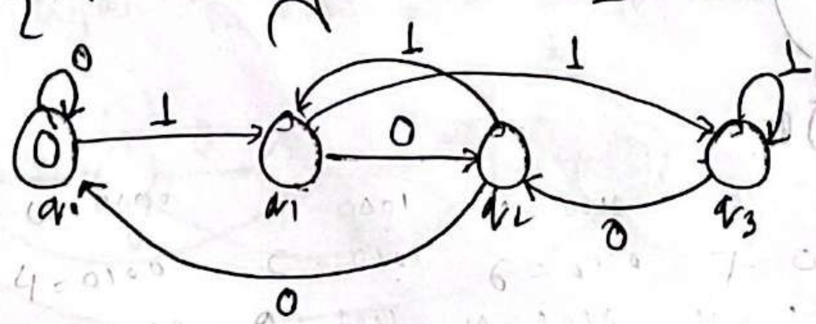
	0	1
q_0	q_0	q_1
q_1	q_0	q_1

* $L(m) = \{w \mid w$ binary number is divisible by $3\}$



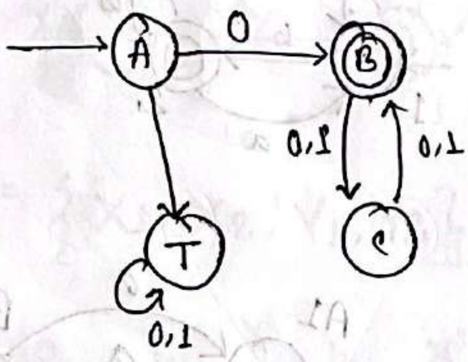
	0	1
q_0	q_0	q_1
q_1	q_2	q_0
q_2	q_1	q_2

* $L(m) = \{w \mid w$ binary number is divisible by $4\}$



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

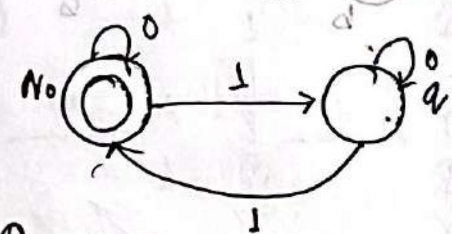
$L = \{ w \mid w$ starts with 0 and has odd length $\}$



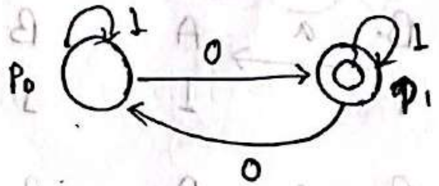
Regular Operation

$L = \{ w \mid w$ has even number of 1's or odd number of 0's $\}$

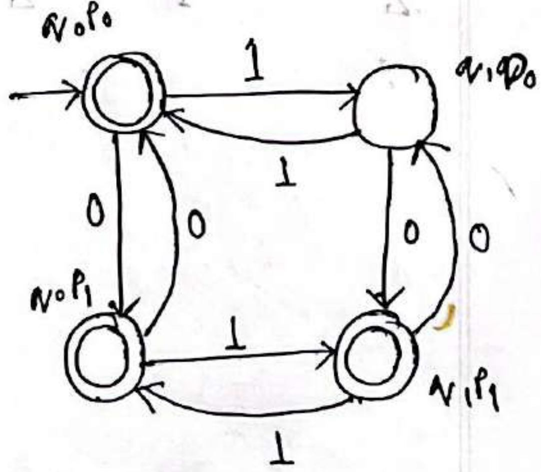
Even number of 1's



Odd number of 0's



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



$q_0P_0 \xrightarrow{0} q_0P_1$ $\qquad$ $q_0P_0 \xrightarrow{1} q_1P_0$

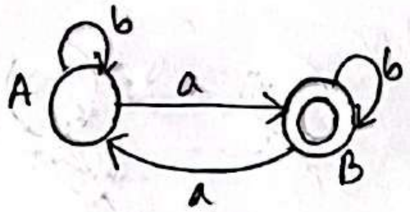
$q_0P_1 \xrightarrow{0} q_0P_0$ $\qquad$ $q_0P_1 \xrightarrow{1} q_1P_1$

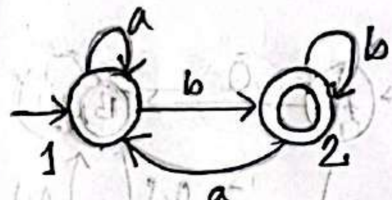
$q_1P_0 \xrightarrow{0} q_1P_1$ $\qquad$ $q_1P_0 \xrightarrow{1} q_0P_0$

$q_1P_1 \xrightarrow{0} q_1P_0$ $\qquad$ $q_1P_1 \xrightarrow{1} q_0P_1$

Subject: | Date:

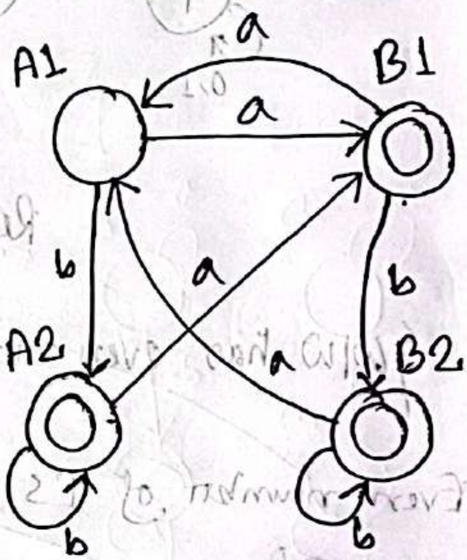
L = {w | w has an odd number of a's or ends with b}





~~ab → Initial stage~~

Q = {A1, A2, B1, B2}



$A_1 \xrightarrow{a} B_1$ $\quad A_1 \xrightarrow{b} A_2$

$A_2 \xrightarrow{a} B_1$ $\quad A_2 \xrightarrow{b} A_2$

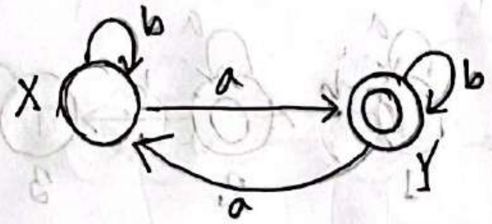
$B_1 \xrightarrow{a} A_1$ $\quad B_1 \xrightarrow{b} B_2$

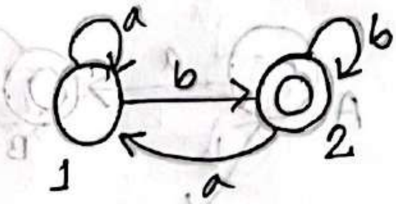
$B_2 \xrightarrow{a} A_1$ $\quad B_2 \xrightarrow{b} B_2$

Subject :

Date :

$L = \{ w \mid w$ has an odd number of a's and ends with b $\}$





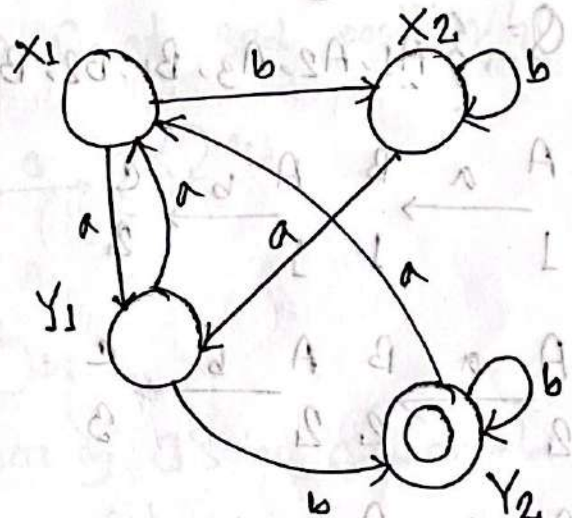
$Q = \{ X_1, X_2, Y_1, Y_2 \}$

$X_1 \xrightarrow{a} Y_1 \quad X_1 \xrightarrow{b} X_2$

$X_2 \xrightarrow{a} Y_1 \quad X_2 \xrightarrow{b} X_2$

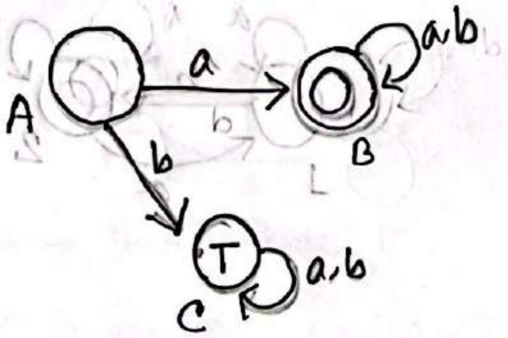
$\cancel{X}_1 \xrightarrow{a} X_1 \quad Y_1 \xrightarrow{b} Y_2$

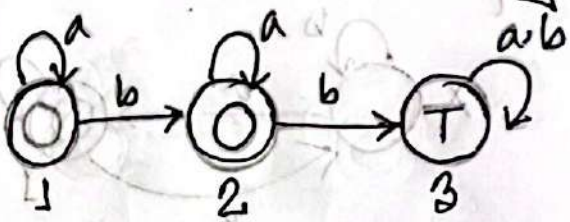
$Y_2 \xrightarrow{a} X_1 \quad Y_2 \xrightarrow{b} Y_2$



Subject: | Date:

$L = \{ w \mid w$ starts with an a and has at most one $b \}$





$Q = \{ A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3 \}$

$A_1 \xrightarrow{a} B_1 \quad A_1 \xrightarrow{b} C_2$

$A_2 \xrightarrow{a} B_2 \quad A_2 \xrightarrow{b} C_3$

$A_3 \xrightarrow{a} A_3 \quad A_3 \xrightarrow{b} C_3$

$B_1 \xrightarrow{a} B_1 \quad B_1 \xrightarrow{b} B_2$

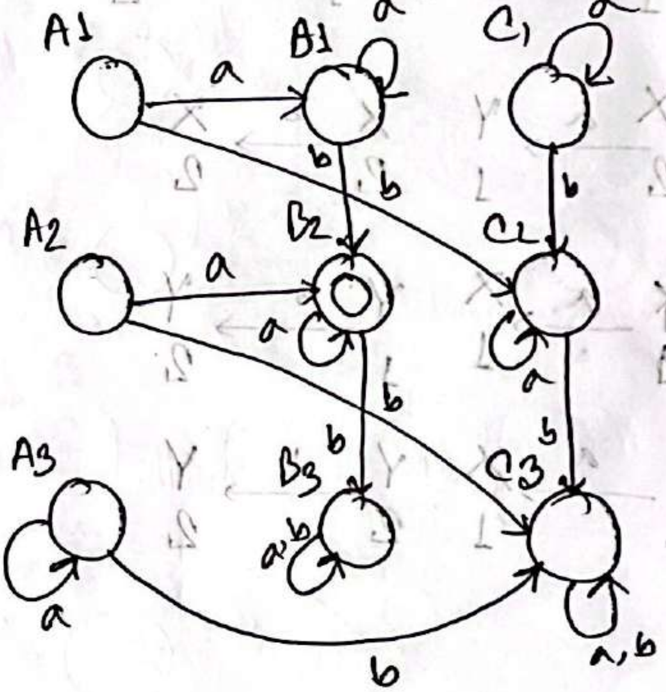
$B_2 \xrightarrow{a} B_2 \quad B_2 \xrightarrow{b} B_3$

$B_3 \xrightarrow{a} B_3 \quad B_3 \xrightarrow{b} B_3$

$C_1 \xrightarrow{a} C_1 \quad C_1 \xrightarrow{b} C_2$

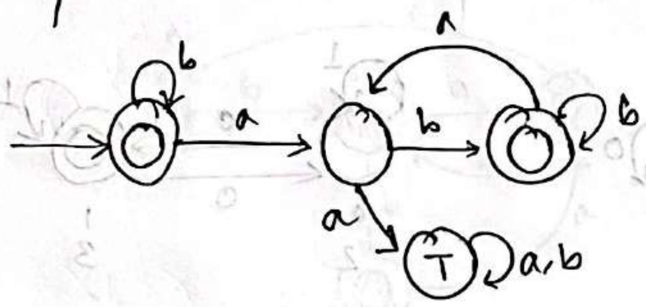
$C_2 \xrightarrow{a} C_2 \quad C_2 \xrightarrow{b} C_3$

$C_3 \xrightarrow{a} C_3 \quad C_3 \xrightarrow{b} C_3$

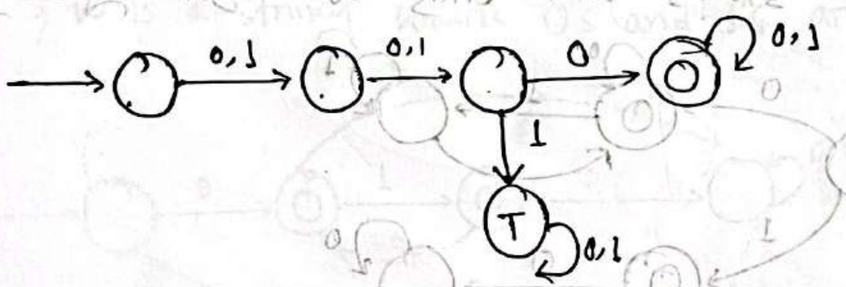


Subject : Date :

* $L(M) = \{ w \mid w$ every a in w is following by one $b \}$



* $L(m) = \{ w \mid w$ string that has 0 at 3rd position $\}$



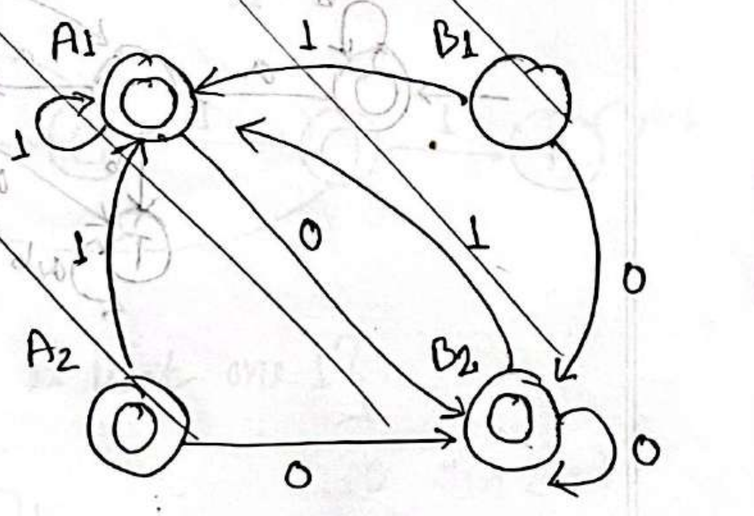
$L(m) = \{ w \mid w$ have even number of 1's or odd number of 0's $\}$

$A_1 \xrightarrow{0} B_2$ $A_1 \xrightarrow{1} A_1$

$A_2 \xrightarrow{0} B_2$ $A_2 \xrightarrow{1} A_1$

$B_1 \xrightarrow{0} B_2$ $B_1 \xrightarrow{1} A_1$

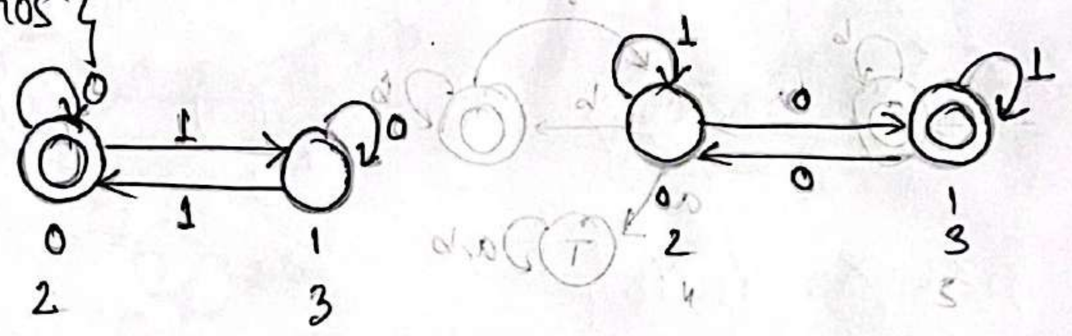
$B_2 \xrightarrow{0} B_2$ $B_2 \xrightarrow{1} A_1$



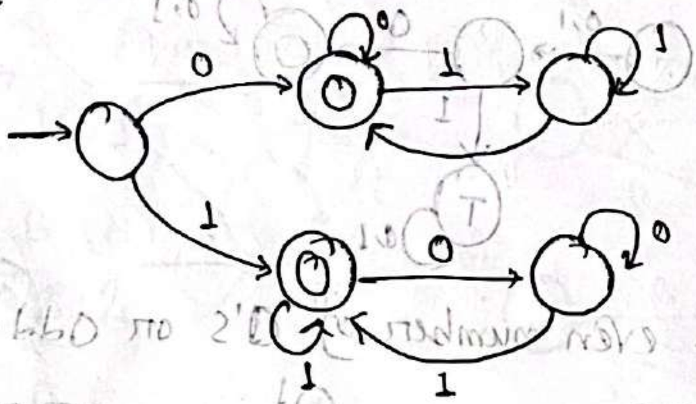
Test case: 11000, 100

Subject : Date :

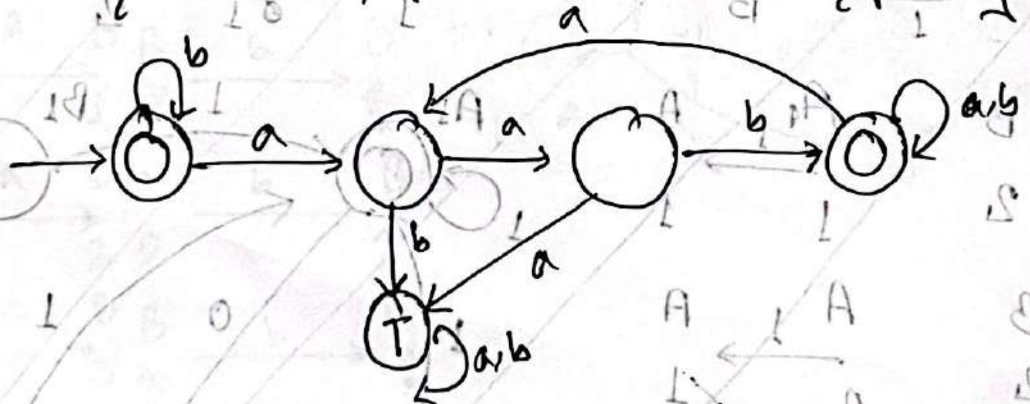
{W | W have an even number of 1's or odd number of zeros}



L(m) {W | W starts and ends with same symbol}

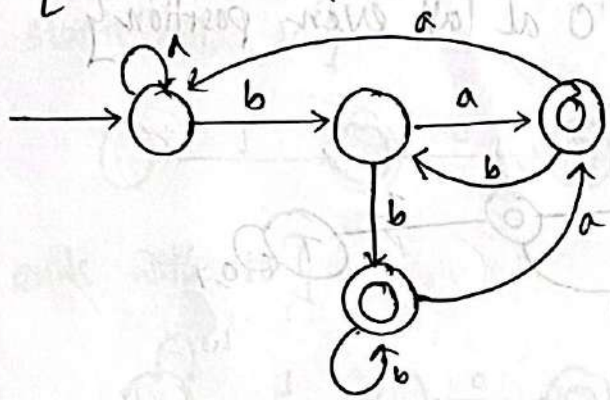


L(m) = {W | W every a is followed by ab}

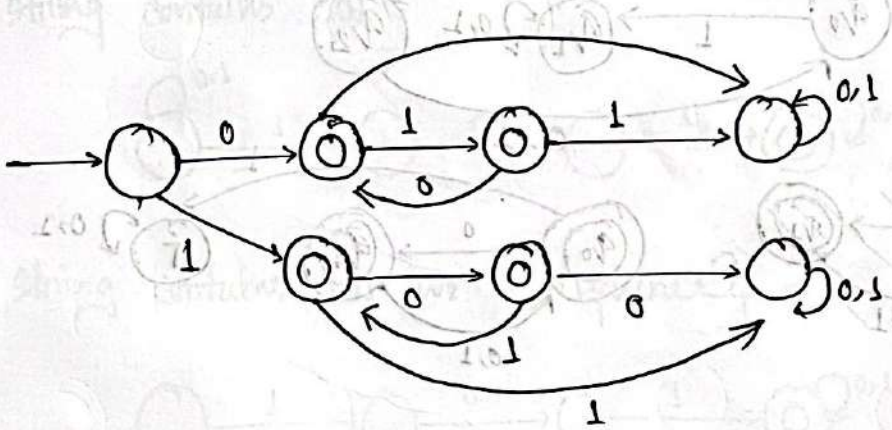


Subject: Date:

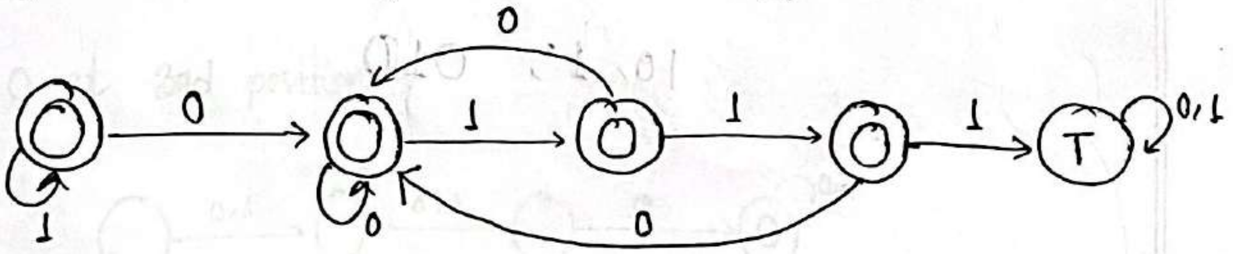
★ $L(M) = \{$ second last symbol is b $\}$



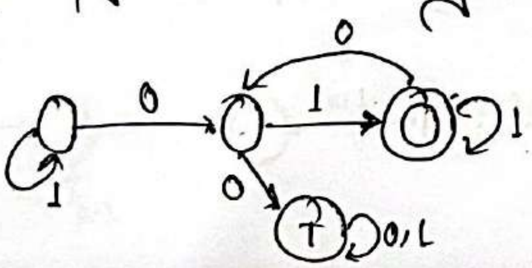
★ $L(M) = \{$ W is a string where 0's and 1's are alternate $\}$



★ $L(M) = \{$ Each 0 followed by at most two 1 $\}$

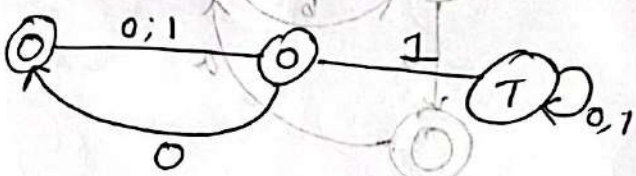


★ $L(M) = \{$ Every 0 is followed by at least one 1 $\}$

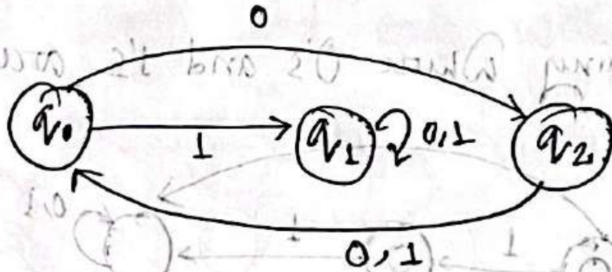


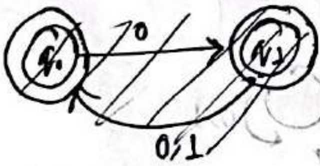
Subject: Date:

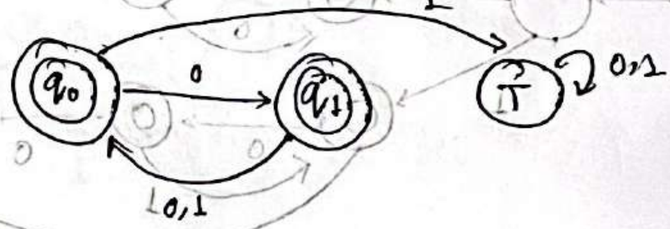
L(M) = { binary number 0 at all even position }



L(M) = { .







0101

001

01

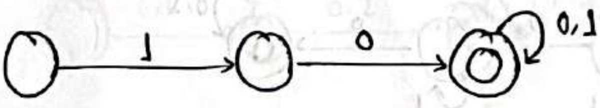
~~08~~

10, 1', 010

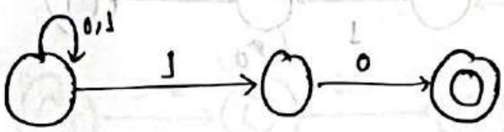
Subject : Date :

NFA

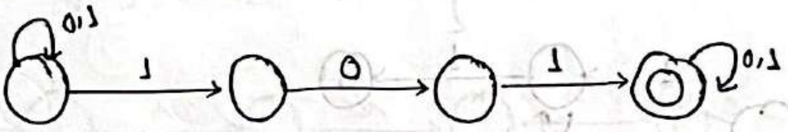
(1) L = { starts with 10 }



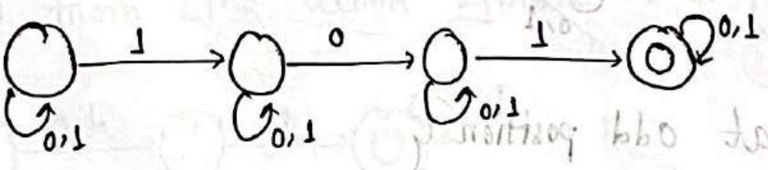
(2) L = { ends with 10 }



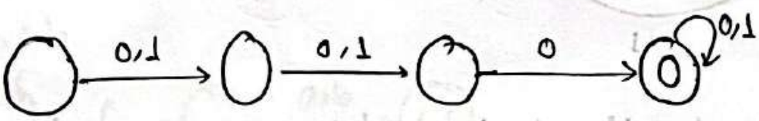
(3) L = { string contains 101 }



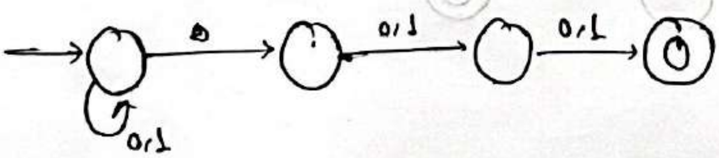
(4) L = { string contains 101 as subsequence }



(5) L = { 0 at 3rd position }

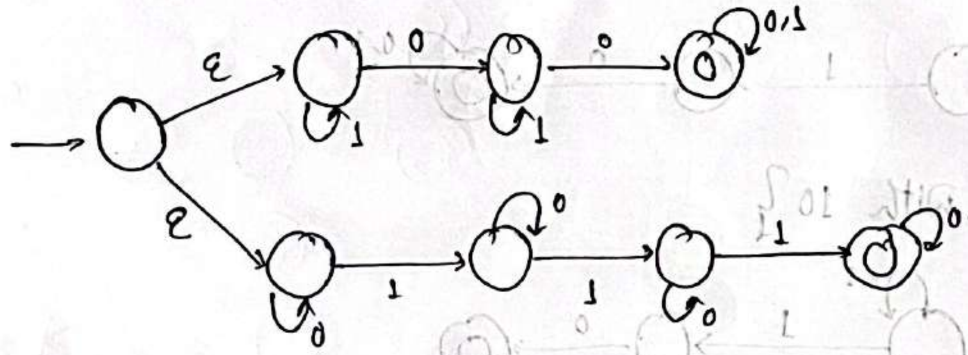


(6) L = { 0 at 3rd last position }

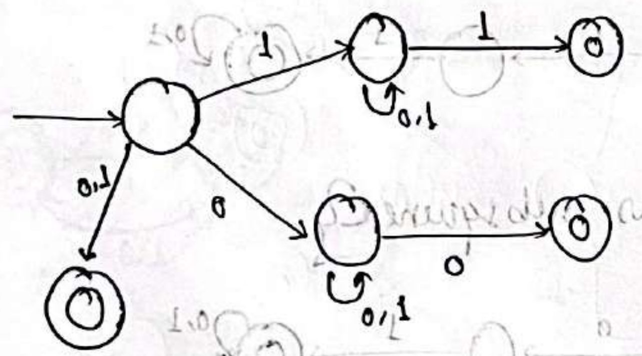


Subject: | Date:

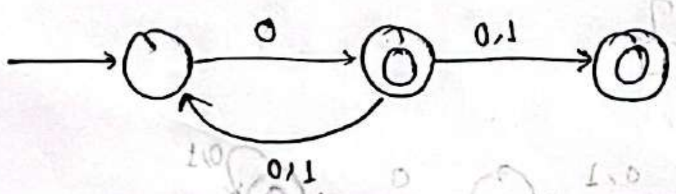
(7) L= { At least two 0's or exactly 3 1's }



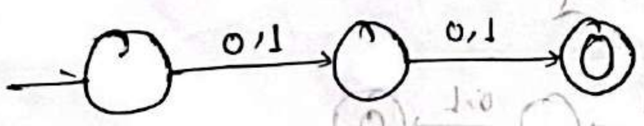
(8) L= { start and ends With same symbol }



(9) L = { zero at odd position }

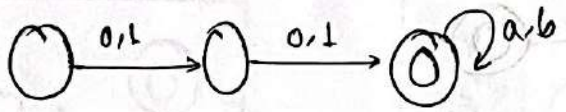


(10) L= { w | the length of the string is exactly 2 }



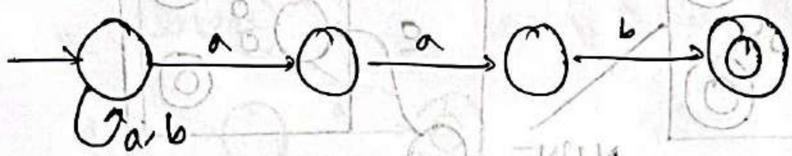
Subject: Date:

(11) $L = \{ w \mid$ the length of the string is atleast 2 $\}$

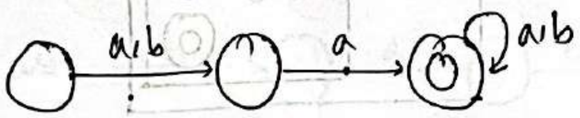


(12) $L = \{ w \mid$ the length of the string is atmost 2 $\}$

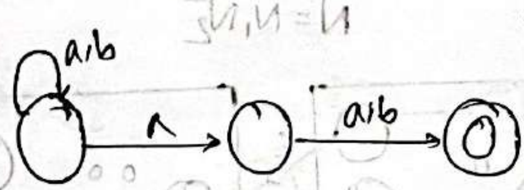
(13) $L = \{ w \mid w$ ends with $aab \}$



(14) $L = \{ w \mid w$ from LHS second symbol is $a \}$

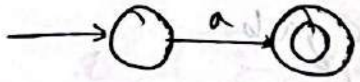


(15) $L = \{ w \mid w$ from RHS second symbol is $a \}$

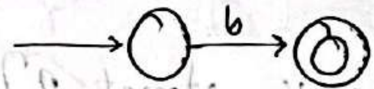


Regular Expression to of NFA

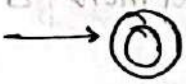
(a) $R = a$



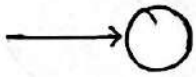
(b) $R = b$



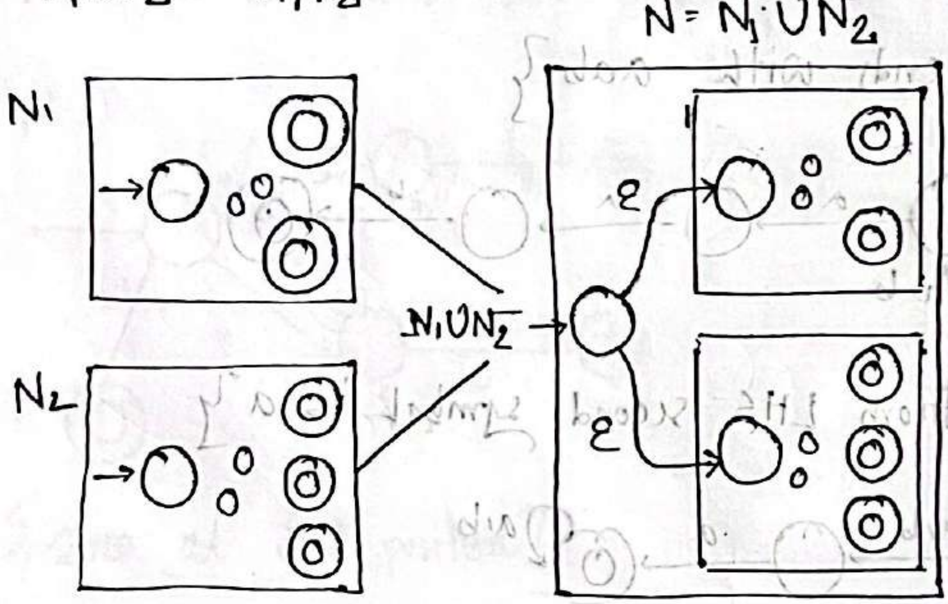
(c) $R = \varepsilon$



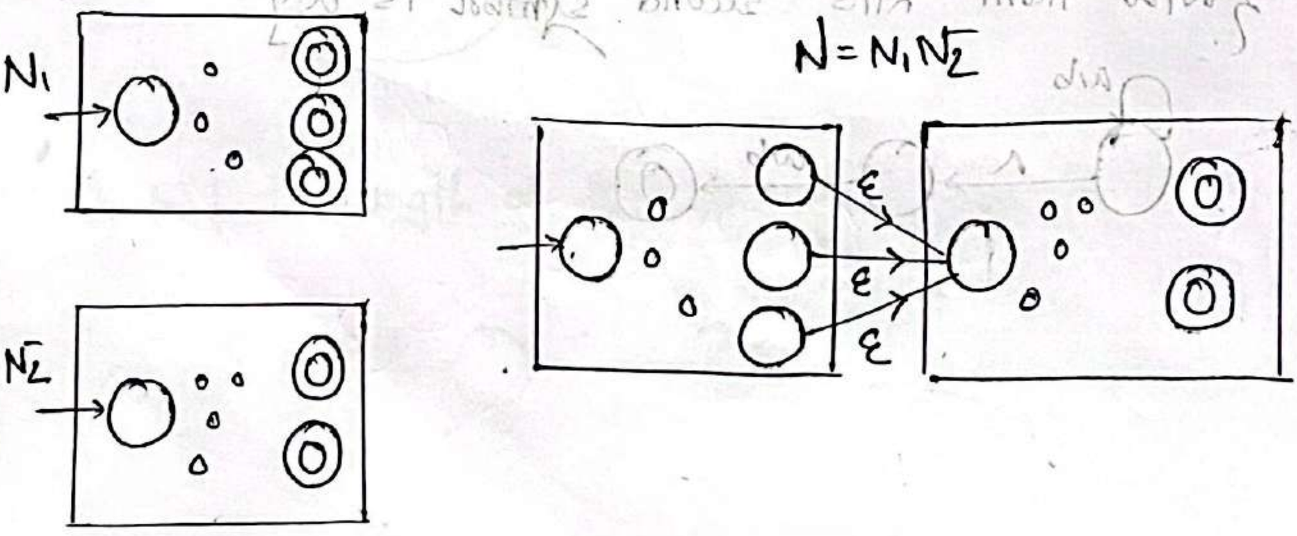
(d) $R = \phi$



(e) $R = R_1 \cup R_2 = R_1 / R_2$



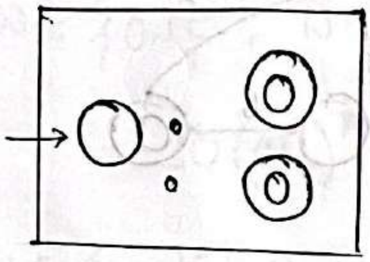
(f) $R = R_1 \circ R_2 = R_1 R_2$



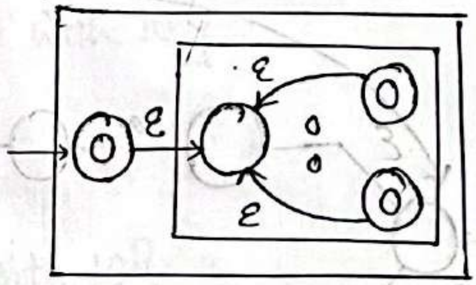
Subject : Date :

(9) $R = R_1^*$

N₁



R_1^*

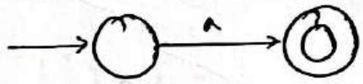


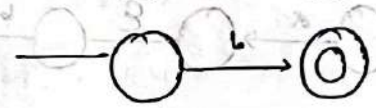
$a^* =$ 0 or more $\{\varepsilon, a, aa, aaa, \ldots\ldots\}$

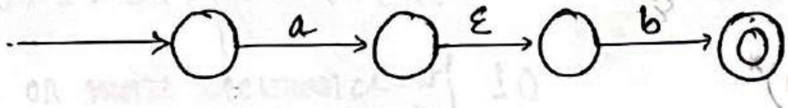
$a^+ =$ 1 or more $\{a, aa, aaa, aaaa, \ldots\ldots\}$

Problem 1

$(ab \cup a)^*$

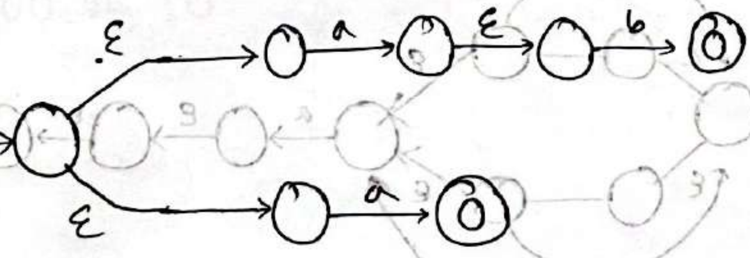
a 

b 

ab 

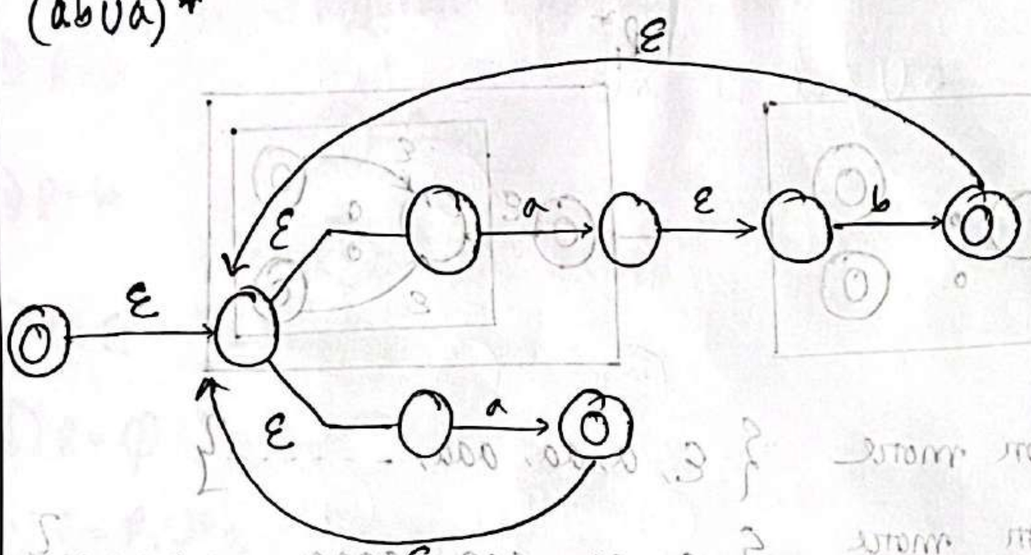
a 

$(ab \cup a)$



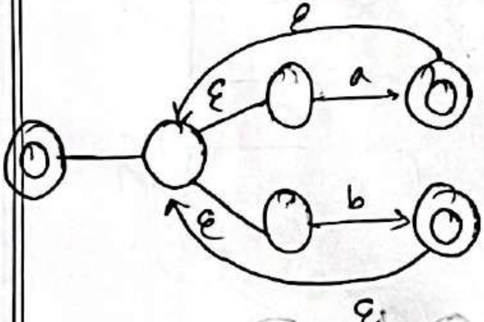
Subject: | Date:

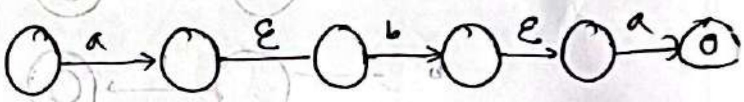
$(ab \cup a)^*$



Problem 2:

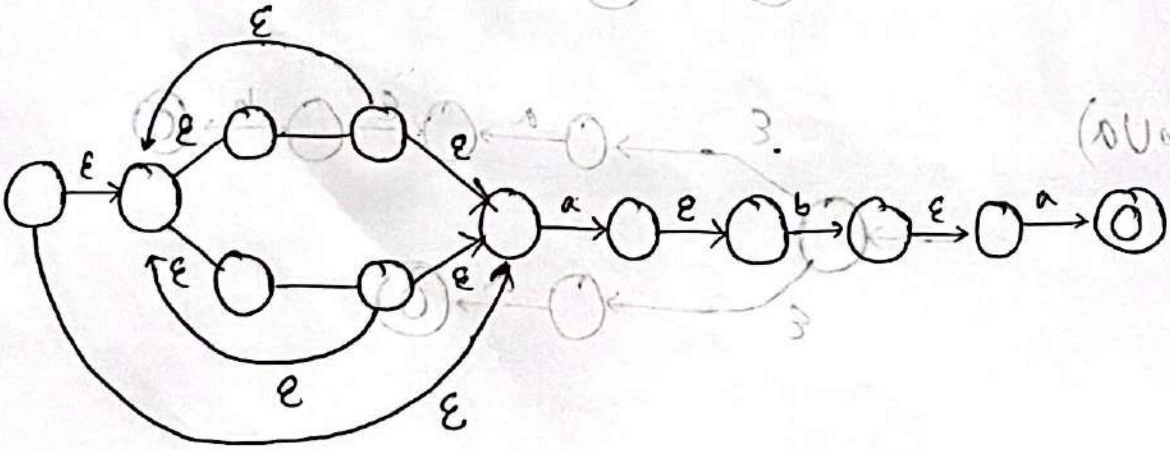
$(a \cup b)^*\ aba$





aba

$(a \cup b)^*$



Subject: Date:

Problem 3:

(a) $L = \{ w \in \{0,1\}^* : w \text{ starts with } 10 \}$

$$10(0|1)^*$$

(b) $L = \{ w \in \{0,1\}^* : w \text{ ends with } 10 \}$

$$(0|1)^* 10$$

(c) $L = \{ w \in \{0,1\}^* : w \text{ doesnot end with } 10 \}$

$$(0|1)^* (11|00|01) | (0|1|\varepsilon)$$

$1^* = $ '', 1, 11, 111, ...

$1^+ = $ 1, 11, 111, ...

$(1|0)^* = \varepsilon, 0, 1, 01, 10,$ (Any combinations of 1's and 0's)

$(10)^+ =$ One or more occurance of 10

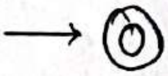
$(00|01|10) =$ Either 00 or 01 or 10

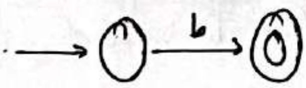
$(00|10) =$ Either 00 or 10

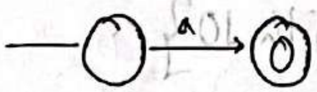
Subject: Date:

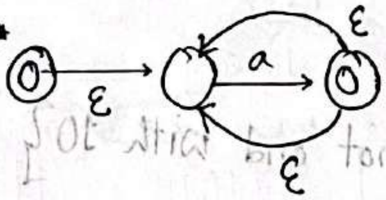
Problem 3:

$ba^* + \varepsilon$ same as $ba^* \cup \varepsilon$

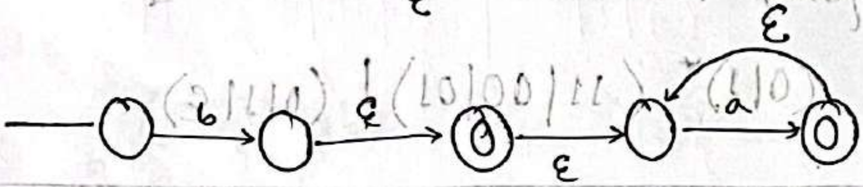
ε 

b 

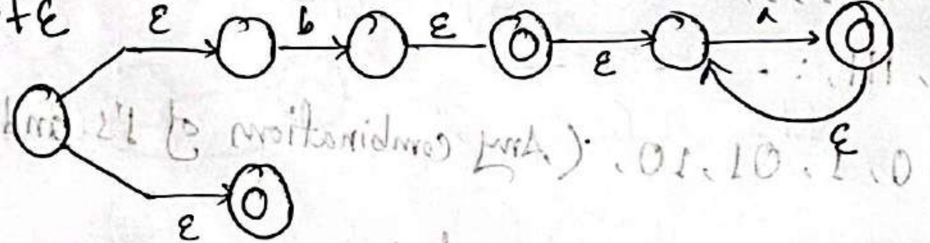
a 

a^* 

ba^*

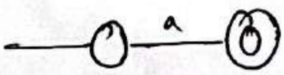


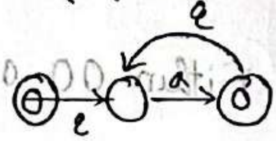
$ba^* + \varepsilon$

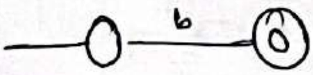


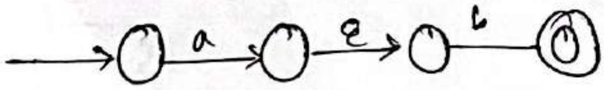
Problem 4:

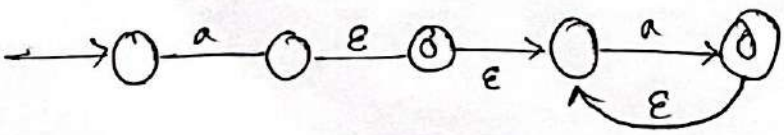
$a^+ \cup (ab)^+ = aa^* \cup ab(ab)^*$

a 

a^* 

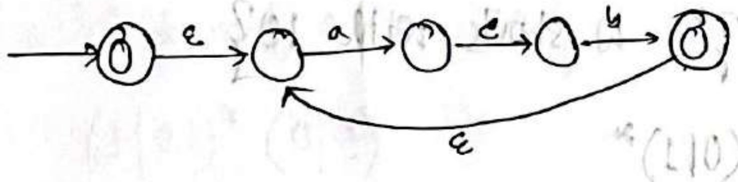
b 

ab 

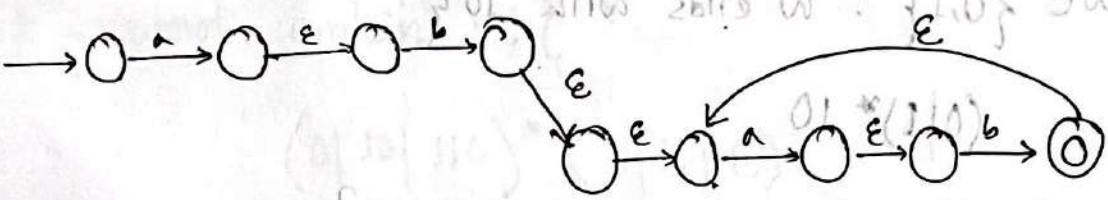
aa^* 

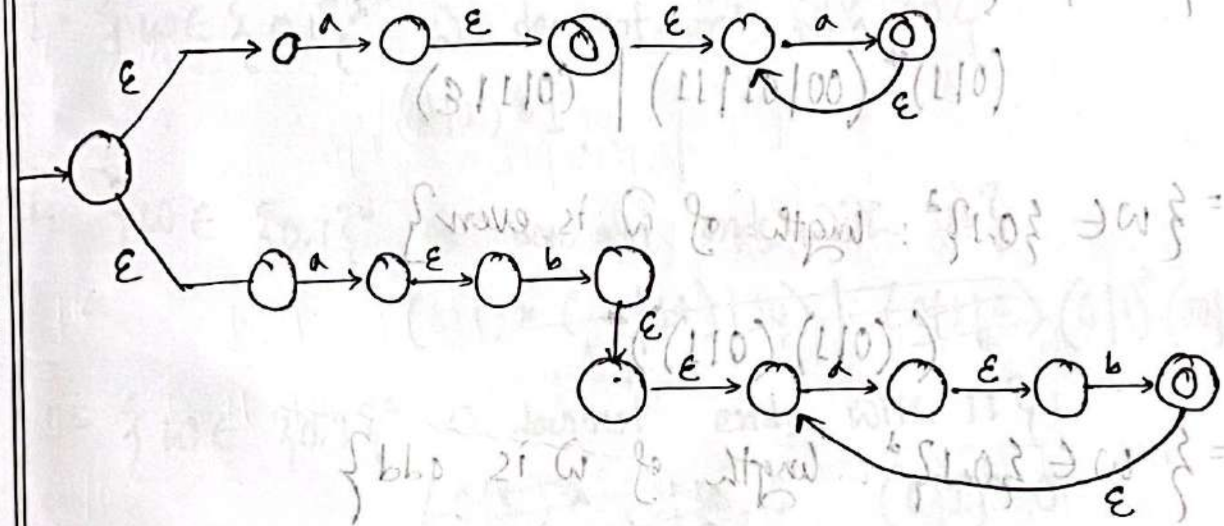
Subject : Date :

ab^*



$ab(ab)^*$





Subject: Date:

(1) $L = \{ \omega \in \{0,1\}^* :$ ω starts with 10$\}$

$10(0|1)^*$

(2) $L = \{ w \in \{0,1\}^* :$ ω ends with 10$\}$

$(0|1)^* 10$

(3) $L = \{ w \in \{0,1\}^* :$ ω doesnot end with 10$\}$

$(0|1)^* (00|01|11) \,|\, (0|1|\varepsilon)$

(4) $L = \{ w \in \{0,1\}^* :$ length of ω is even$\}$

$((0|1)(0|1))^*$

(5) $L = \{ w \in \{0,1\}^* :$ length of ω is odd$\}$

$((0|1)(0|1))^* (0|1)$

(6) $L = \{ w \in \{0,1\}^*$ ω contains 101 as substrings$\}$

$(0|1)^* 101 (0|1)^*$

(7) $L = \{ w \in \{0,1\}^*$ doesnot contains 11$\}$

$(0|10)^* (1|\varepsilon)$

(8) $L = \{ w \in \{0,1\}^* \text{ doesnot contain } 00 \}$

$$(1|01)^* (0|\varepsilon)$$

(9) $L = \{ \text{dousnot contain } 111 \}$

$$(0|10|110)^* (1|11|\varepsilon)$$

(10) $L = \{ w \in \{0,1\}^* : w \text{ does not ends with } 00 \}$

$$(0|1)^* 1$$

(11) $L = \{ w \in \{0,1\}^* \; w \text{ does not ends with } 01 \}$

$$\cancel{(0|1)^* (00|11|10) \mid (0|1|\varepsilon)} \; (0|1)^* (00|11|10|0)$$

(12) $L = \{ w \in \{0,1\}^* \; w \text{ doesnot ends with } 11 \}$

$$\cancel{(0|1)^* (0|10)} \; 0 \quad (0|1)^* 0$$

(13) $L = \{ w \in \{0,1\}^* \text{ doesnot contains } 10 \}$

$$0^* 1^*$$

(14) $L = \{ w \in \{0,1\}^* \text{ doesnot contains } 01 \}$

$$1^* 0^*$$

(15) $L = \{ w \in \{0,1\}^* \text{ doesnot contains } 00 \}$

$$(1|01)^*$$

Subject: | Date:

(16) $L = \{\text{length expressed as } 3K+2\}$

$$((0|1)(0|1)(0|1))^*(0|1)(0|1)$$

(17) $L = \{\text{length expressed as } 2K+1\}$

$$((0|1)(0|1))^*(0|1)$$

(18) $L = \{\omega \text{ contains } 00 \text{ or } 11\}$

$$(0|1)^* 00 (0|1)^* \mid (0|1)^* 11 (0|1)^*$$

(19) $L = \{\omega \text{ contains at least two } 1\text{'s}\}$

$$(0|1)^* 1 (0|1)^* 1 (0|1)^*$$

(20) $L = \{\omega \text{ contains at least two } 0\text{'s}\}$

$$(0|1)^* 0 (0|1)^* 0 (0|1)^*$$

(21) $L = \{\omega \text{ contains at least } 1 \text{ zeros}\}$

$$(0|1)^* 0 (0|1)^*$$

(22) $L = \{\omega \text{ contains at least } 2 \text{ '01'}\}$

$$(0|1)^* 01 (0|1)^* 01 (0|1)^*$$

Subject:　　　　Date:

(23) $L = \{ w$ contains exactly two 1's $\}$

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

(24) $L = \{ w$ contains exactly two 0 $\}$

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

(25) $L = \{ w$ contains exactly 1 '0' $\}$

$$1^* 0 1^*$$

(26) $L = \{ w$ contains exactly three 0s $\}$

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

(27) $L = \{ w$ contains at most two 1's $\}$

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

(28) $L = \{ w$ contains at most three 0's $\}$

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

(29) $L = \{ w$ contains at most one 1 $\}$

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

(30) $L = \{$ length of w is not multiple of 3 $\}$

$$((0|1)(0|1)(0|1))^* (0|1) \; (0|1|\varepsilon)$$

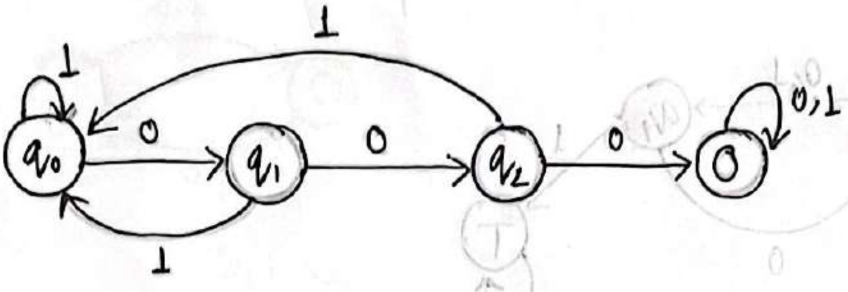
(31) $L = \{$ length is multiple of 3 $\}$

$$((0|1)(0|1)(0|1))^*$$

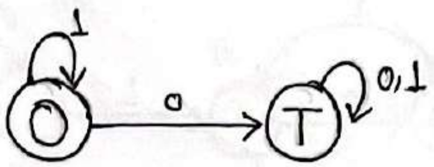
Subject :

Date :

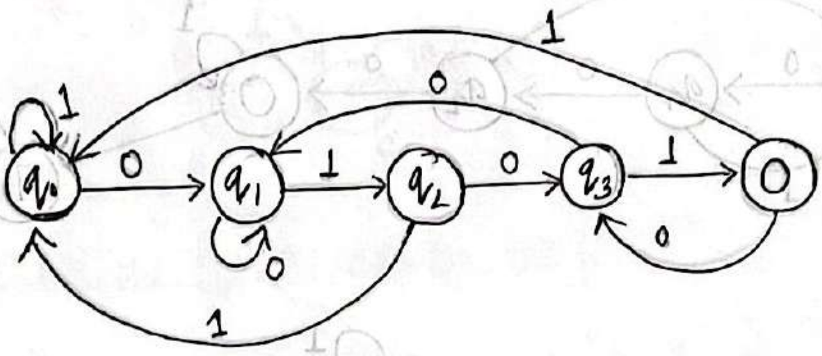
1. (a)



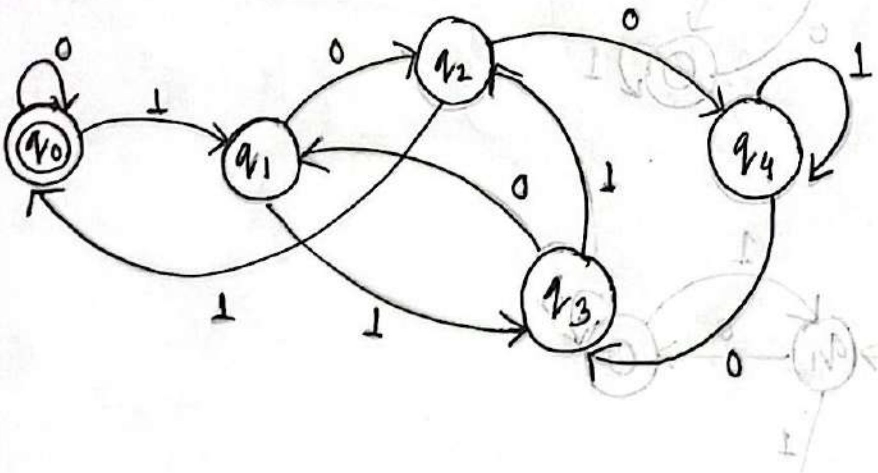
(b)



(c)



(d)

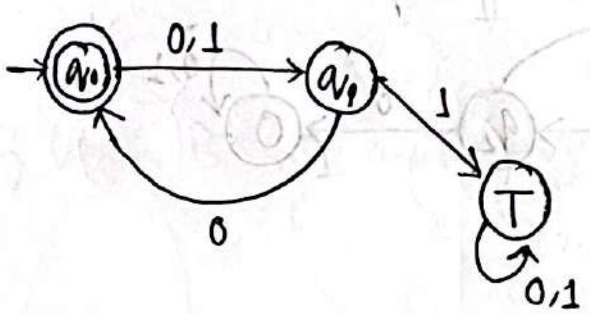


	0	1
q_0	q_0	q_1
q_1	q_2	q_3
q_2	q_4	q_0
q_3	q_1	q_2
q_4	q_3	q_4

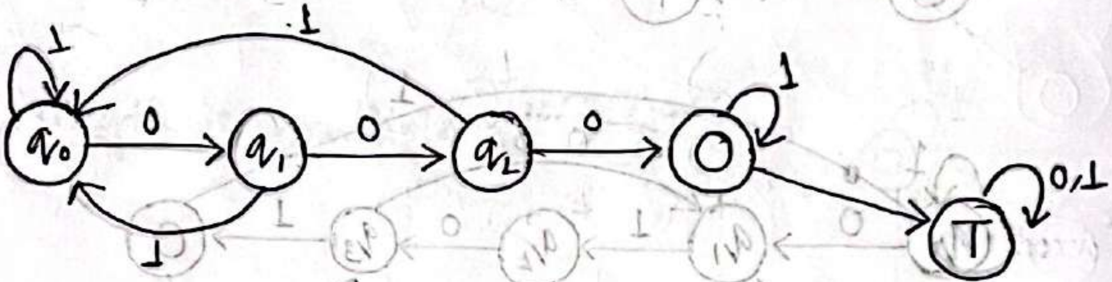
Subject : Date :

101 1010

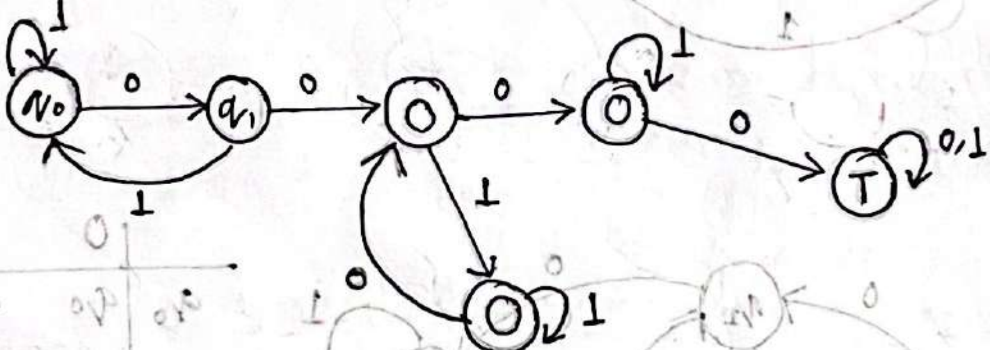
(e)



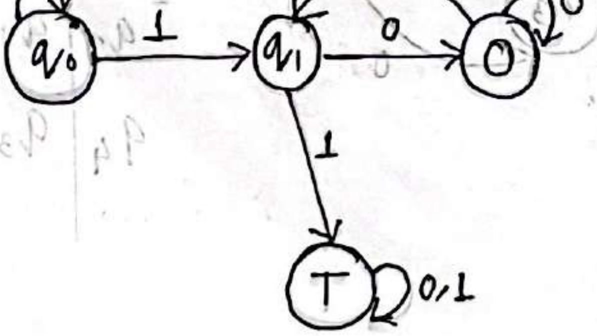
(f)



(g)

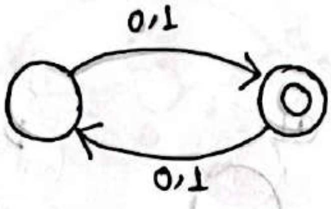


2 (a)



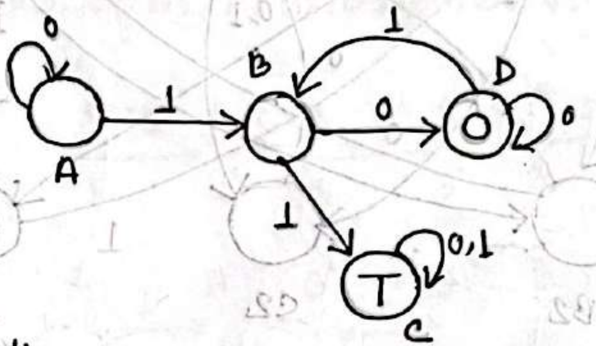
Subject : Date :

(b)

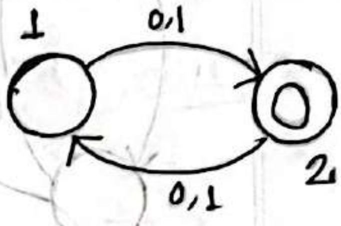


(c)

$L_1 =$



$L_2 =$



Combinations =

$\{A1, A2, B1, B2, C1, C2, D1, D2\}$

$A1 \xrightarrow{0} A2 \quad A1 \xrightarrow{1} B2 \quad C1 \xrightarrow{0} C2 \quad C1 \xrightarrow{1} C2$

$A2 \xrightarrow{0} A1 \quad A2 \xrightarrow{1} B1 \quad C2 \xrightarrow{0} C1 \quad C2 \xrightarrow{1} C1$

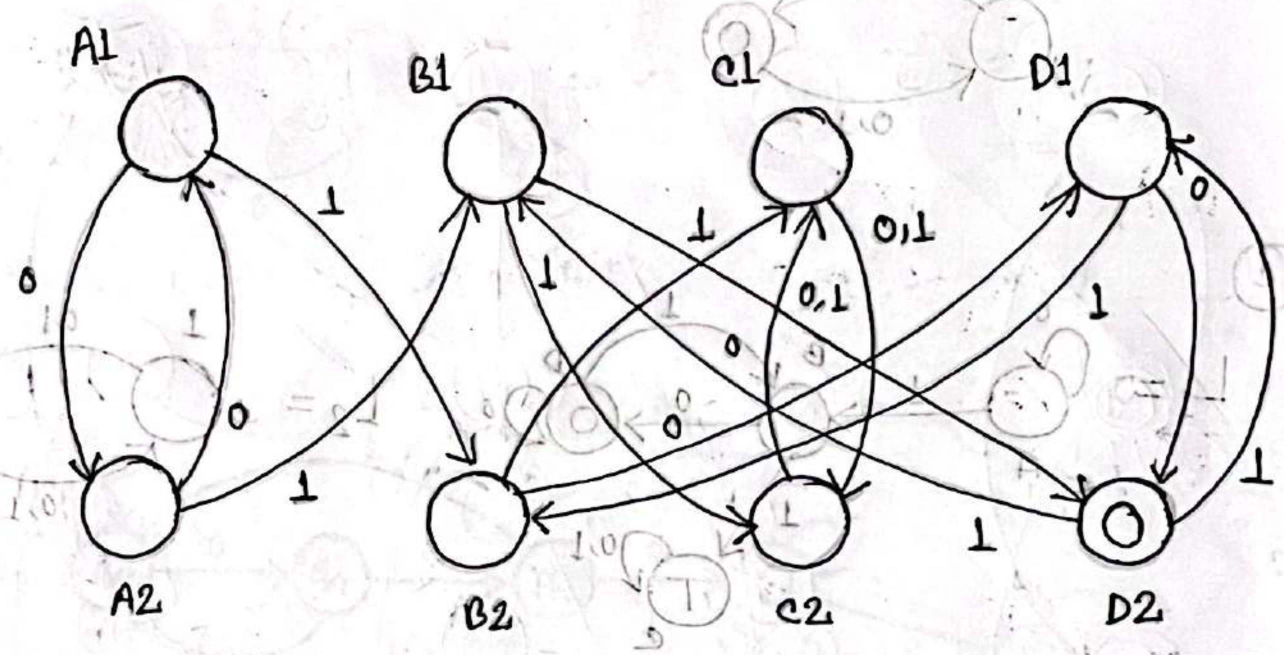
$B1 \xrightarrow{0} D2 \quad B1 \xrightarrow{1} C2 \quad D1 \xrightarrow{0} D2 \quad D1 \xrightarrow{1} B2$

$B2 \xrightarrow{0} D1 \quad B2 \xrightarrow{1} C1 \quad D2 \xrightarrow{0} D1 \quad D2 \xrightarrow{1} B1$

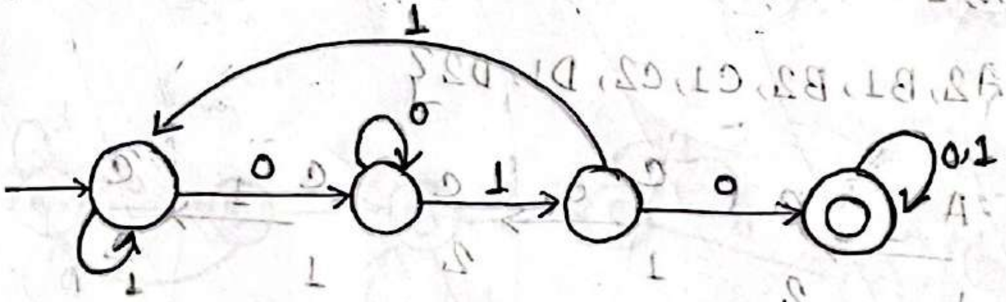
Subject :

Date :

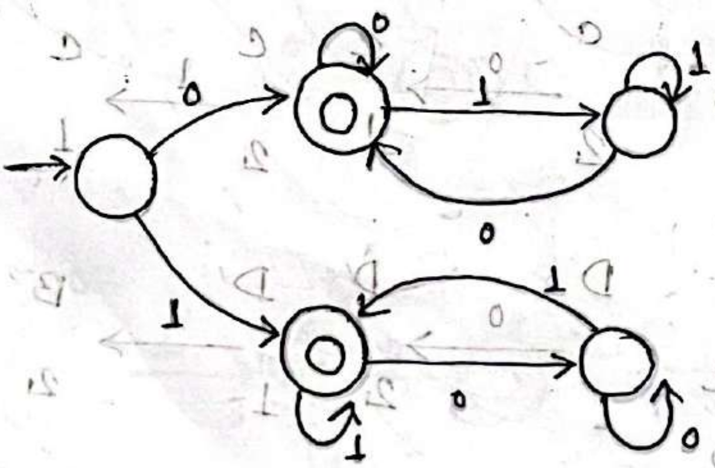
$L_3 = L_1 \cap L_2$



(d)

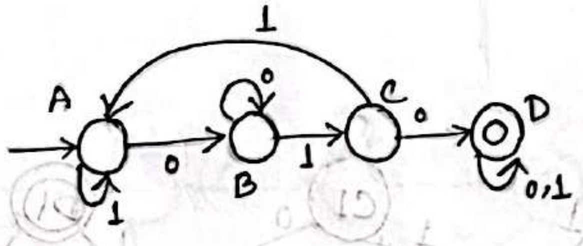


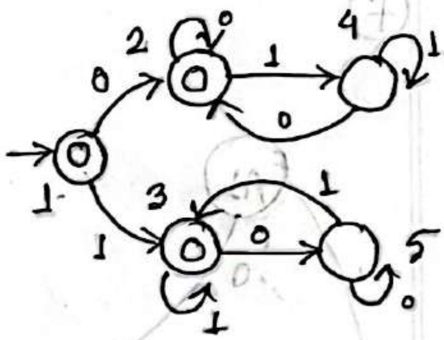
(e)



Subject: Date:

7

$L_4 =$ 

$L_5 =$ 

Combinations:

{A1, A2, A3, A4, A5, B1, B2, B3, B4, B5, C1, C2, C3, C4, C5, D1, D2, D3, D4, D5}

$A1 \xrightarrow{0} B2$ $\quad A1 \xrightarrow{1} A3$ $\quad B3 \xrightarrow{0} B5$ $\quad B3 \xrightarrow{1} C3$ $\quad C5 \xrightarrow{0} D5$ $\quad C5 \xrightarrow{1} A3$

$A2 \xrightarrow{0} B2$ $\quad A2 \xrightarrow{1} A4$ $\quad B4 \xrightarrow{0} B2$ $\quad B4 \xrightarrow{1} C4$ $\quad D1 \xrightarrow{0} D2$ $\quad D1 \xrightarrow{1} D3$

$A3 \xrightarrow{0} B5$ $\quad A3 \xrightarrow{1} A3$ $\quad B5 \xrightarrow{0} B5$ $\quad B5 \xrightarrow{1} C3$ $\quad D2 \xrightarrow{0} D2$ $\quad D2 \xrightarrow{1} D4$

$A4 \xrightarrow{0} B2$ $\quad A4 \xrightarrow{1} A4$ $\quad C1 \xrightarrow{0} D2$ $\quad C1 \xrightarrow{1} A3$ $\quad D3 \xrightarrow{0} D5$ $\quad D3 \xrightarrow{1} D3$

$A5 \xrightarrow{0} B5$ $\quad A5 \xrightarrow{1} A3$ $\quad C2 \xrightarrow{0} D2$ $\quad C2 \xrightarrow{1} A4$ $\quad D4 \xrightarrow{0} D2$ $\quad D4 \xrightarrow{1} D4$

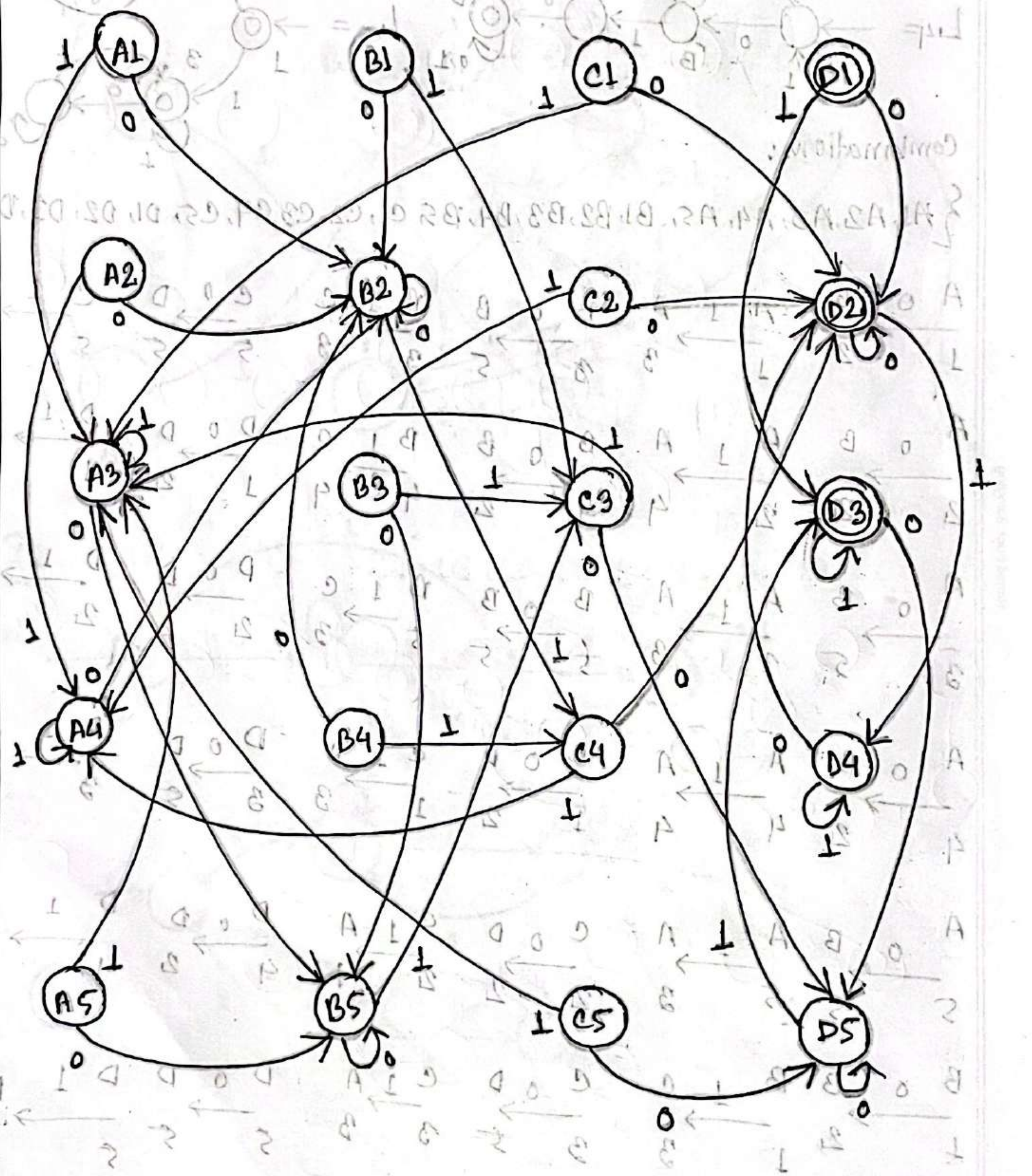
$B1 \xrightarrow{0} B2$ $\quad B1 \xrightarrow{1} C3$ $\quad C3 \xrightarrow{0} D5$ $\quad C3 \xrightarrow{1} A3$ $\quad D5 \xrightarrow{0} D5$ $\quad D5 \xrightarrow{1} D3$

$B2 \xrightarrow{0} B2$ $\quad B2 \xrightarrow{1} C4$ $\quad C4 \xrightarrow{0} D2$ $\quad C4 \xrightarrow{1} A4$

Subject :

Date :

F

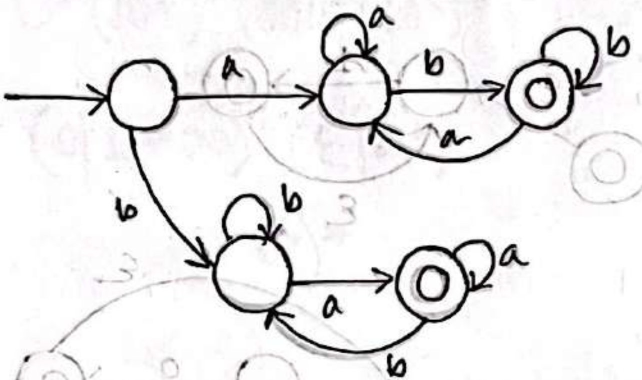


Subject :

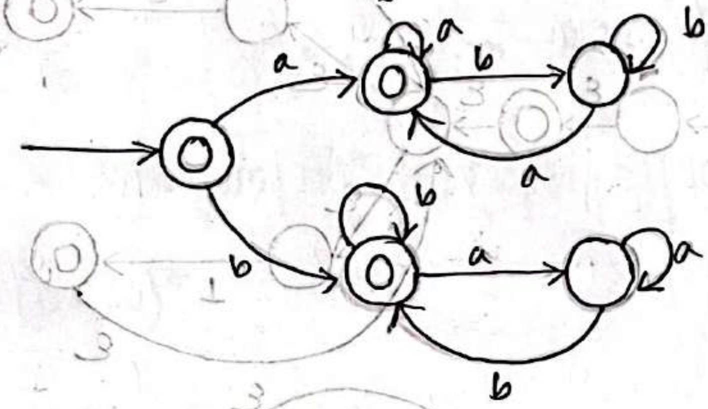
Date :

3.

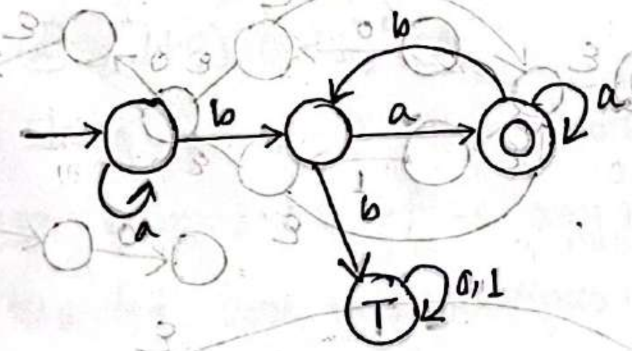
(a)



(b)



(c)

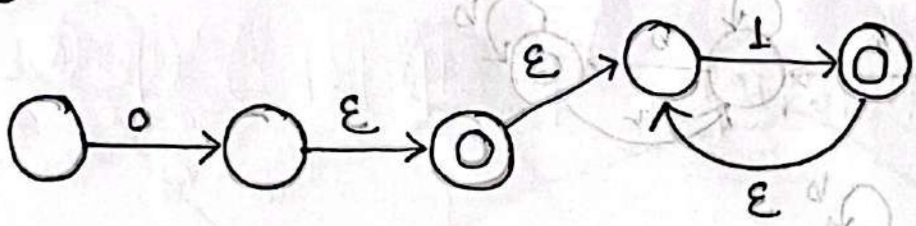


Subject :

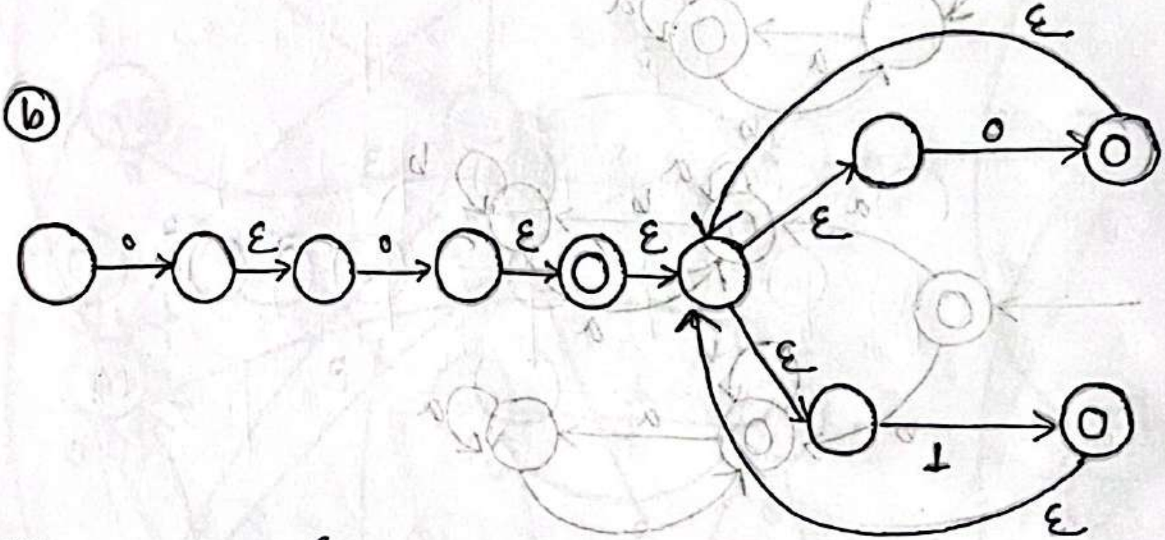
Date :

6

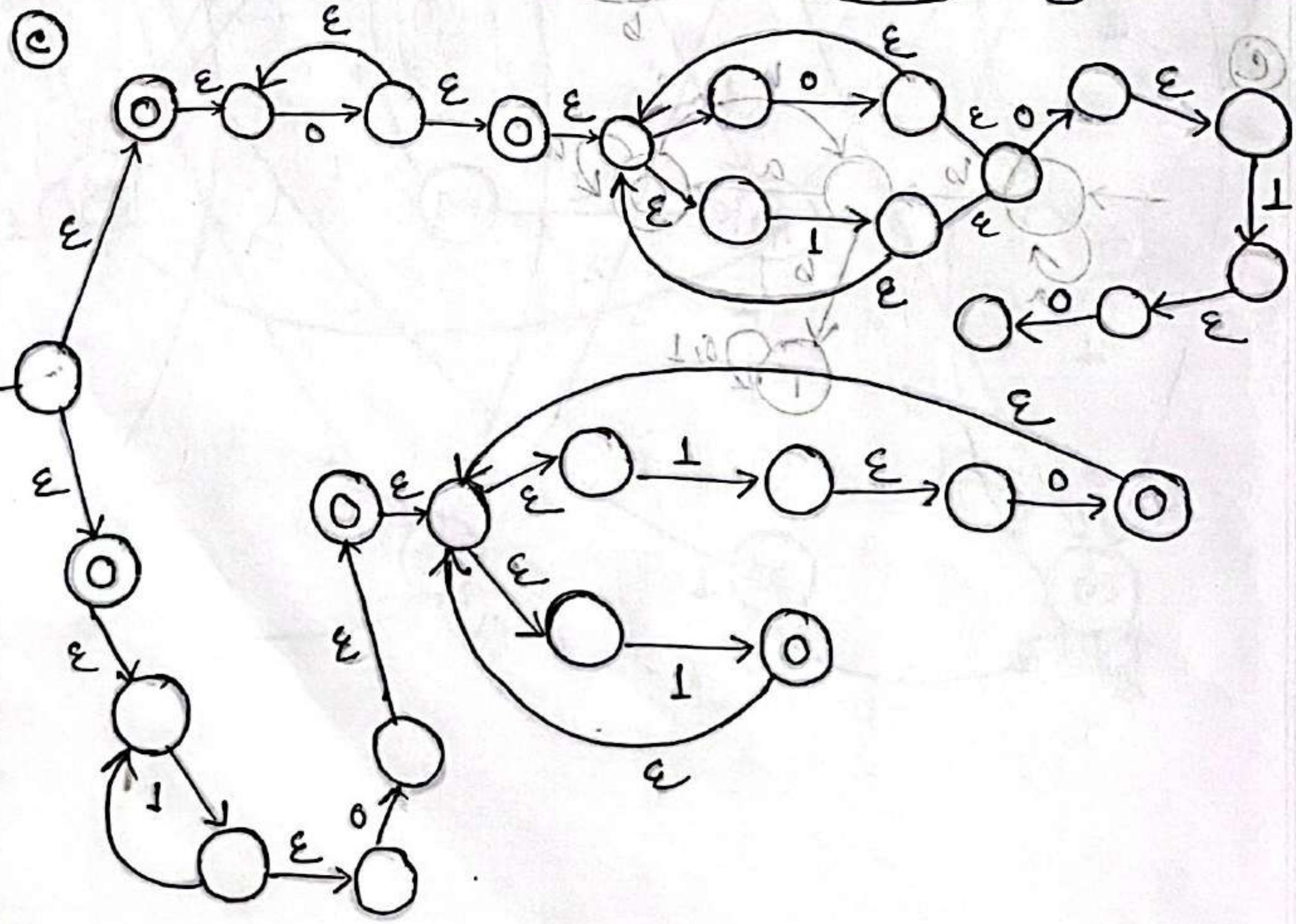
(a)



(b)



(c)



Subject: Date:

4.

(a) $0^*(10^*)^*(000^*(10^*)^*)^*(111^*)^*$

(b) $(0|11^*00)^*(\varepsilon|11^*)$

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

(d) $b^*(ab^*|\varepsilon)$

(e) $(0|1)^*1(0|1)^*1(0|1)^*$

(f) $0(00|01|10|11)^* \mid 1(00|11|01|10)^*$

(g) $(01|10)^*$

5. (a) $(1+\varepsilon)(00^*1)^*0^*$

The string can start either nothing or with 1. zero can be asign before 1 or before any number of zeros, which might be repeated zero or more times. At the end, any number of zeros canbe appear.

(b) $(0+10)^*1^*$

A sequnce of single zero or '10' canbe appear either zero or more times before any number of 1's.

Subject: Date:

4. (a) $(0+10)^*(1+01)^*(0+\varepsilon)$

(b) $(0|1)^*((00|01|10|11)(0|1)^*(00|01|10|11))^*$

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

(d) $b^*(a^+b^+|\varepsilon)$

(e) $(0|1)^*\,1\,(0|1)^*\,1\,(0|1)^*$

(f) $0((0|1)(0|1))^* \mid 1(0|1)((0|1)(0|1))^*$

(g) $(01|10)^*$

Subject: RE Date:

1. $L = \{ w \in \{0,1\}^* \; w \text{ starts with } 10 \}$

$10(0|1)^*$

2. $L = \{ w \in \{0,1\}^* \; w \text{ ends with } 10 \}$

$(0|1)^* 10$

3. $L = \{ w \in \{0,1\}^* \text{ doesnt end with } 00 \}$

$(0|1)^* 1$

4. $L = \{ w \in \{0,1\}^* \text{ doesn't end with } 01 \}$

$(0|1)^* (00|10|11) \mid (1|0|\varepsilon)$

5. $L = \{ w \in \{0,1\}^* \text{ doesn't end with } 10 \}$

$(0|1)^* (00|01|11) \mid (1|0|\varepsilon)$

6. $L = \{ w \in \{0,1\}^* \text{ doesn't end with } 11 \}$

$(0|1)^* 0$

7. $L = \{ w \in \{0,1\}^* \text{ doesn't end with } 000 \}$

$(0|1)^* (001|010|011|100|101|110|111|0|1)$

8. $L = \{ w \in \{0,1\}^* \text{ doesn't end with } 001 \}$

$(0|1)^* (000|010|011|100|101|110|111|0|1)$

Dsnt start with 00

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

Dsnt start with 11

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

Dsnt start with 01

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

Dsnt start with 10

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

Subject : Date :

9. L = { W ∈ {0,1}* length of ω is even }

$((0|1)(0|1))^*$

10. L = { W ∈ {0,1}* length of ω is odd }

$((0|1)(0|1))^* (0|1)$

11. L = { length expressed as 3K+2 }

$((0|1)(0|1)(0|1))^* (0|1)(0|1)$

12. L = { length expressed as 2K+1 }

$((0|1)(0|1))^* (0|1)$

13. L = { count of 1's is even }

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

14. L = { count of 0's is odd }

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

15. L = { W ∈ {0,1}* ω contains 101 as substring }

$(0|1)^* 101 (0|1)^*$

16. L = { W ∈ {0,1}* ω contains 11 as substring }

$(0|1)^* 11 (0|1)^*$

Subject: | Date:

17. $L = \{ w \in \{0,1\}^*$ doesnot contain 00 as substring $\}$

$\cancel{(0|1)^* 0 (0|1)^* 1 (0|1)^*}$ $(1|01)^* (0|\varepsilon)$

18. $L = \{ w \in \{0,1\}^*$ doesnot contain 01 as substring $\}$

$\cancel{(0|1)^* 0^* (0|1)^*}$ / $1^* 0^*$

19. $L = \{ w \in \{0,1\}^*$ doesnot contain 10 as substring $\}$

$\cancel{(0|1)^* 1^* (0|1)^*}$ / $0^* 1^*$

20. $L = \{ w \in \{0,1\}^*$ doesnt contain 11 as substring $\}$

$\cancel{(0|1)^* 0^* (0|1)^*}$ $(0|10)^* (1|\varepsilon)$

21. $L = \{$ contains 00 or 11 as substrings $\}$

$(0|1)^* 00 (0|1)^* \mid (0|1)^* 11 (0|1)^*$

22. $L = \{ w$ contains at least two 0's $\}$

$(0|1)^* 0 (0|1)^* 0 (0|1)^*$

23. $L = \{ w$ contains at least 1 zero $\}$

$(0|1)^* 0 (0|1)^*$

24. $L = \{ w$ contains at least two 01 $\}$

$(0|1)^* 01 (0|1)^* 01 (0|1)^*$

Subject: Date:

17. $L = \{ w \in \{0,1\}^* \text{ doesnot contain } 00 \text{ as substring} \}$

$$\cancel{(0|1)^* 0 (0|1)^* 1 (0|1)^*} \quad (1|01)^* (0|\varepsilon)$$

18. $L = \{ w \in \{0,1\}^* \text{ doesnot contain } 01 \text{ as substring} \}$

$$\cancel{(0|1)^* 0^* (0|1)^*} \;/\; 1^* 0^*$$

19. $L = \{ w \in \{0,1\}^* \text{ doesnot contain } 10 \text{ as substring} \}$

$$\cancel{(0|1)^* 1^* (0|1)^*} \;/\; 0^* 1^*$$

20. $L = \{ w \in \{0,1\}^* \text{ doesnt contain } 11 \text{ as substring} \}$

$$\cancel{(0|1)^* 0^* (0|1)^*} \quad (0|10)^* (1|\varepsilon)$$

21. $L = \{ \text{contains } 00 \text{ or } 11 \text{ as substrings} \}$

$$(0|1)^* 00 (0|1)^* \mid (0|1)^* 11 (0|1)^*$$

22. $L = \{ w \text{ contains at least two 0's} \}$

$$(0|1)^* 0 (0|1)^* 0 (0|1)^*$$

23. $L = \{ w \text{ contains at least 1 zero} \}$

$$(0|1)^* 0 (0|1)^*$$

24. $L = \{ w \text{ contains at least two } 01 \}$

$$(0|1)^* 01 (0|1)^* 01 (0|1)^*$$

Subject :　　　　Date :

25. $L = \{ \omega$ contains at most two 1's $\}$

$$0^* + 0^*10^* + 0^*10^*10^*$$

26. $L = \{ \omega$ contains at most three 0's $\}$

$$1^* + 1^*01^* + 1^*01^*01^* + 1^*01^*01^*01^*$$

27. $L = \{ \omega$ contains exactly two 1's $\}$

$$0^*10^*10^*$$

28. $L = \{ \omega$ contains exactly two 0's $\}$

$$1^*01^*01^*$$

29. $L = \{$ length of ω is multiple of 3 $\}$

$$((0|1)(0|1)(0|1))^*$$

30. $L = \{$ length of ω is not multiple of 3 $\}$

$$((0|1)(0|1)(0|1))^*(0|1)(0|1|\epsilon)$$

31. $L = \{$ length of ω is multiple of 5 $\}$

$$((0|1)(0|1)(0|1)(0|1)(0|1))^*$$

32. $L = \{$ length of ω is not multiple of 5 $\}$

$$((0|1)(0|1)(0|1)(0|1)(0|1))^*(0|1)(0|1|\epsilon)$$

Subject : | Date :

33. {L={ count of 1 is multiple of 3}

$0^* | (0^*10^*10^*10^*)^*$

34. L={ w starts and ends with the same symbol}

$0(0|1)^*0 \mid 1(0|1)^*1 \mid 0 \mid 1$

35. L={ w starts and ends with different symbol}

$0(0|1)^*1 \mid 1(0|1)^*0$

36. L={ w contains 0 at every 3rd position}

$((0|1)(0|1)0)^*(0|1)(0|1) \mid ((0|1)(0|1)0)^*(0|1) \mid ((0|1)(0|1)0)^*$

37. L={ w have 0's and 1's in alternates}

$(1|\varepsilon)(01)^*(0|\varepsilon) \mid (0|\varepsilon)(10)^*(1|\varepsilon)$

38. L={ w divisible by 3}

$((0|1)(0|1)(0|1))^*$

39. L={Every second letter is zero}

$((0|1)0)^*(0|1|\varepsilon)$

Scanned with CamScanner

Subject: Date:

40. L = { string that have neigther consecutive 1's, nor consicutive 0's }

$$(0|\varepsilon)(10)^*(1|\varepsilon)$$

41. L = { string that might have consiecutive 1's, or consiecutive 0's but not both }

$$(1|01)^*(0|\varepsilon)$$

42. L = { 1 doesnot appear at any even position in ω }

43. L = { every 1 is followed by at least one 0 }

44. L = { every 1 is followed by at most one 0 }

45. L = { every 1 is followed by exactly one 0 }

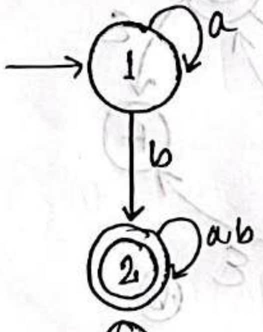
46 L = { every second letter is zero }

47. L = { 01 appears even number of times }

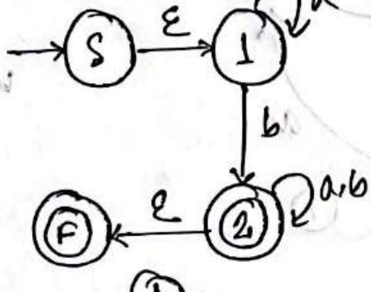
Subject : Date :

DFA → Regular Expression

1.

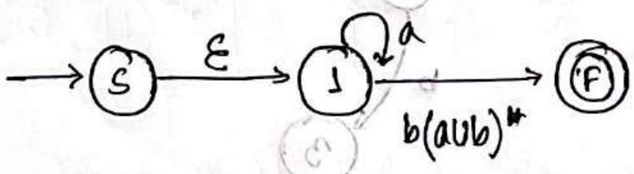


(a)



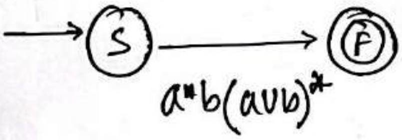
(b)

$1 \rightarrow 2 \rightarrow$ final $= ab(a \cup b)^*$



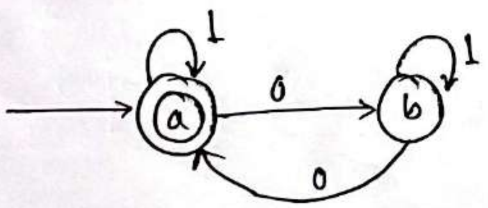
(c)

Start → 1 → Finish = $a^* b(a \cup b)^*$

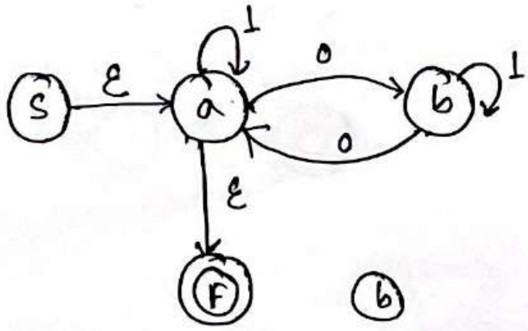


(d)

2.

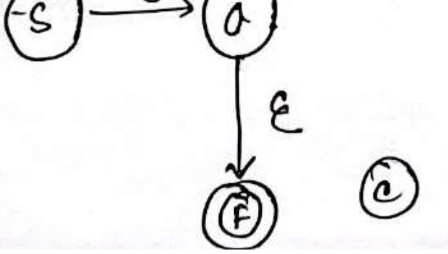


(a)

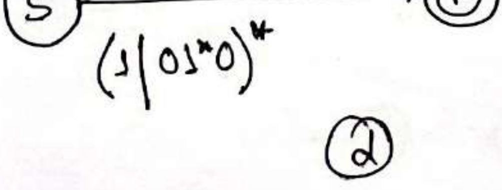


(b)

$a \rightarrow b \rightarrow a = 01^*0$



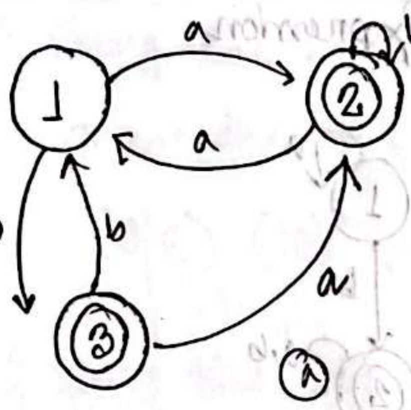
(c)



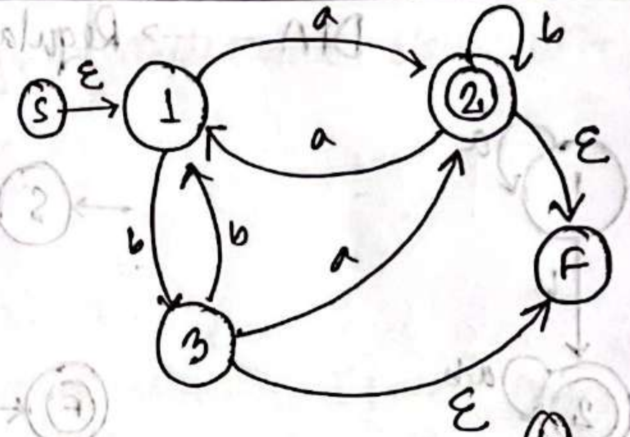
(d)

Subject : Date :

3.



(a)



(b)

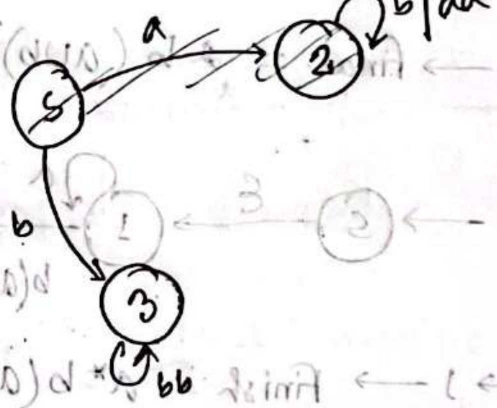
~~1 → 2 → Final = ab*~~

1 → 2 → 1 = ab*a

1 → 3 → 1 = bb

2 → 1 → 2 = aa

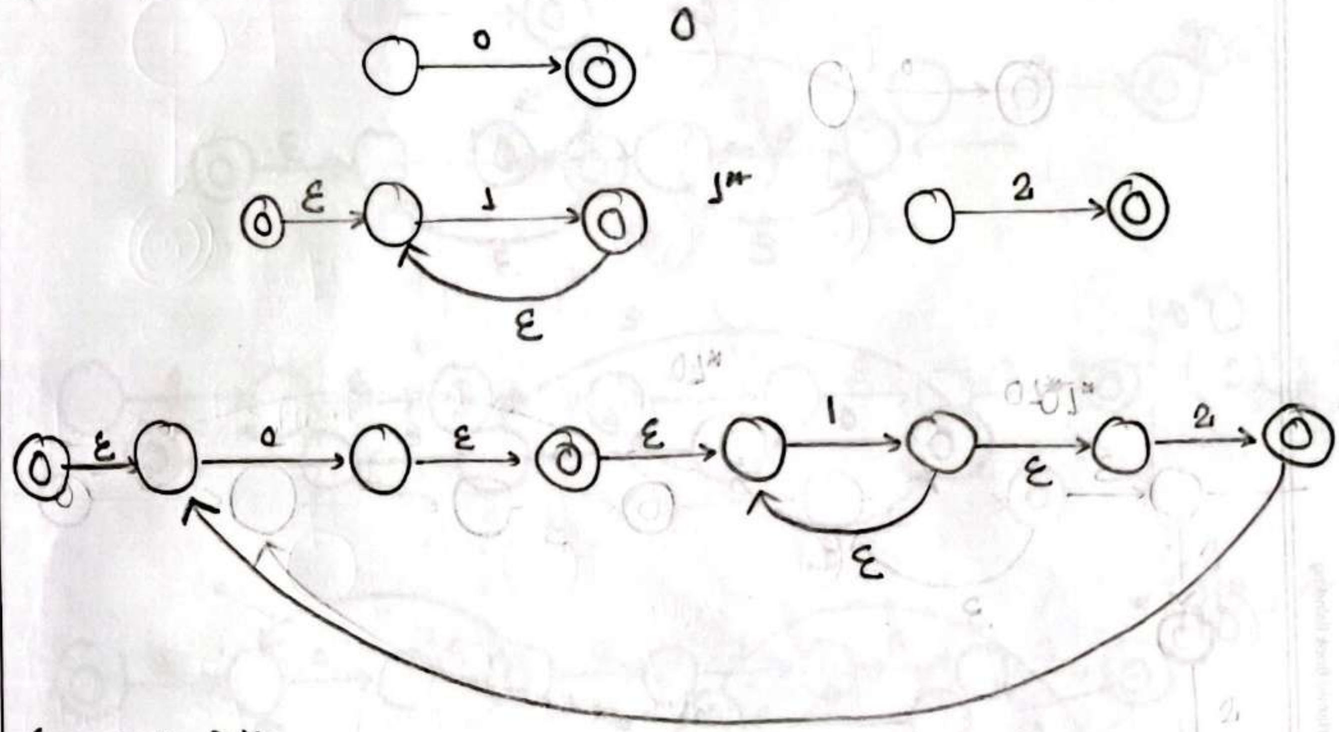
3 → 1 → 3 = bb



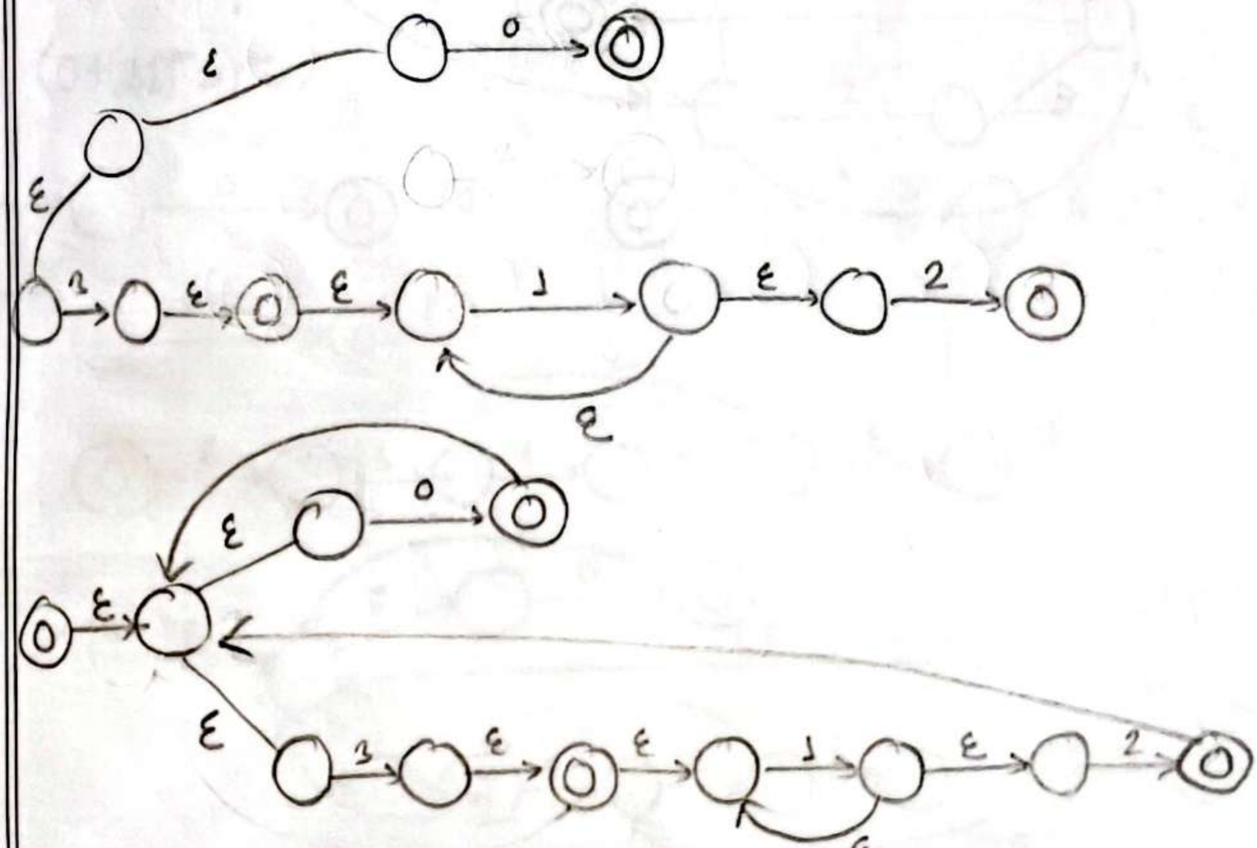
Subject : Date :

RE to NFA

$(01^*2)^*$



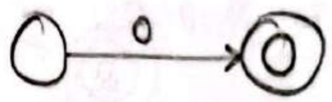
$(0+31^*2)^*$



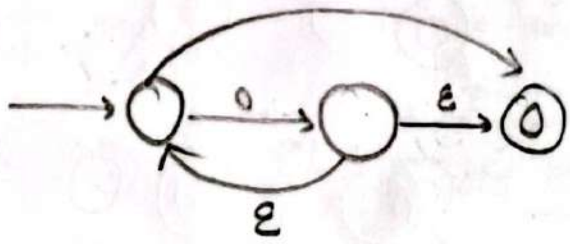
Subject :

Date :

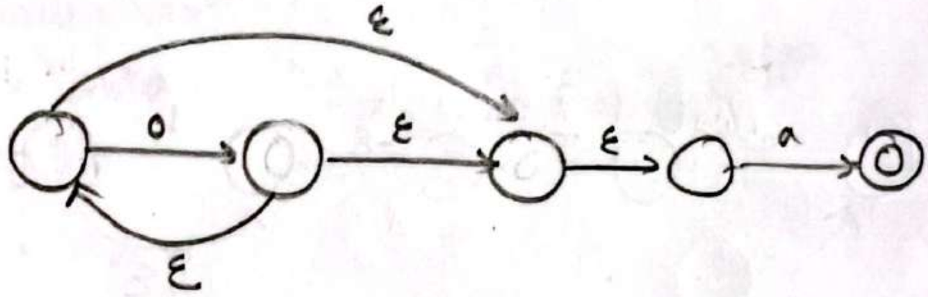
0



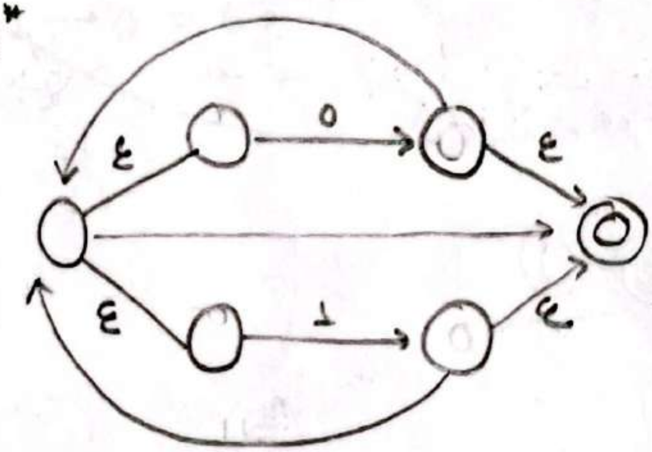
0^*



0^*a

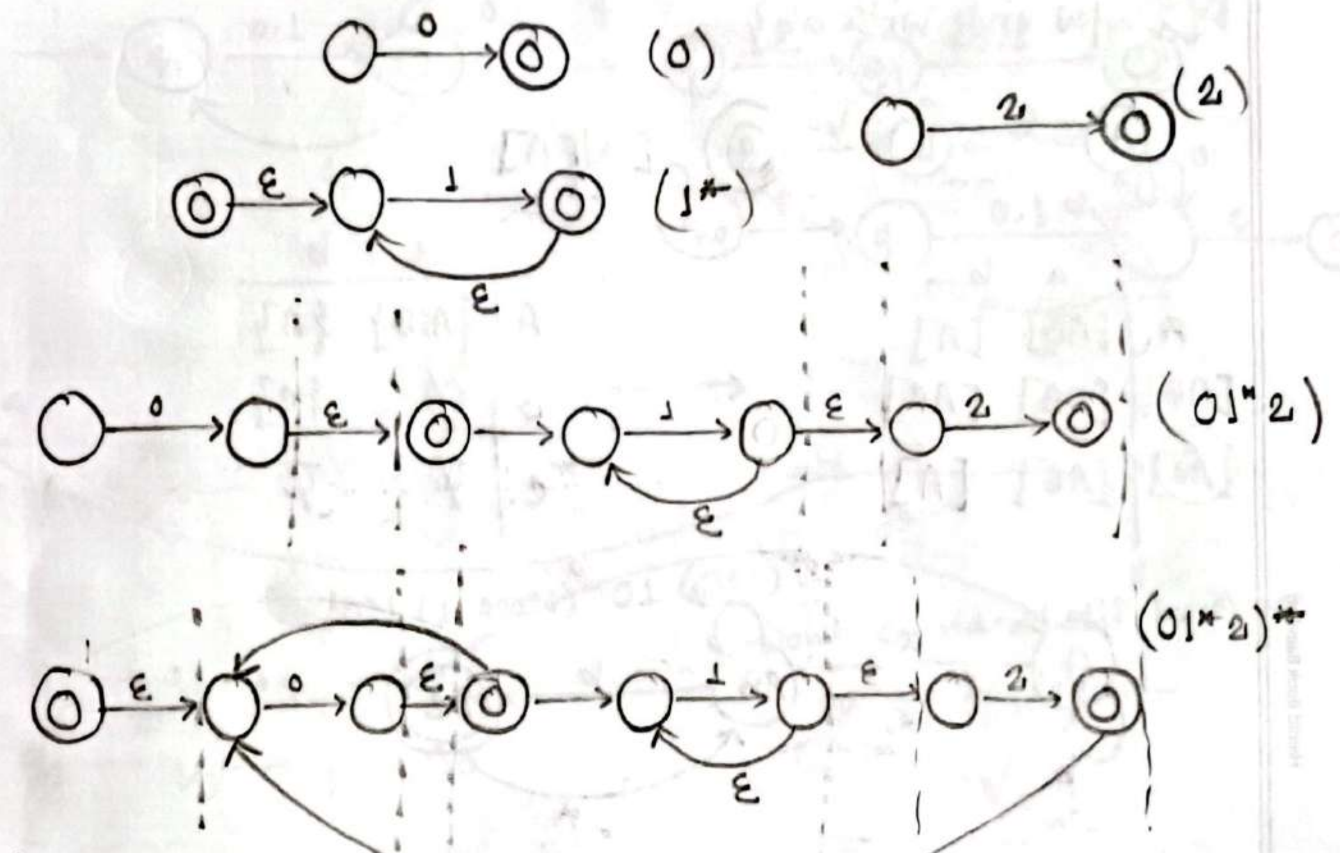


$(0+1)^*$

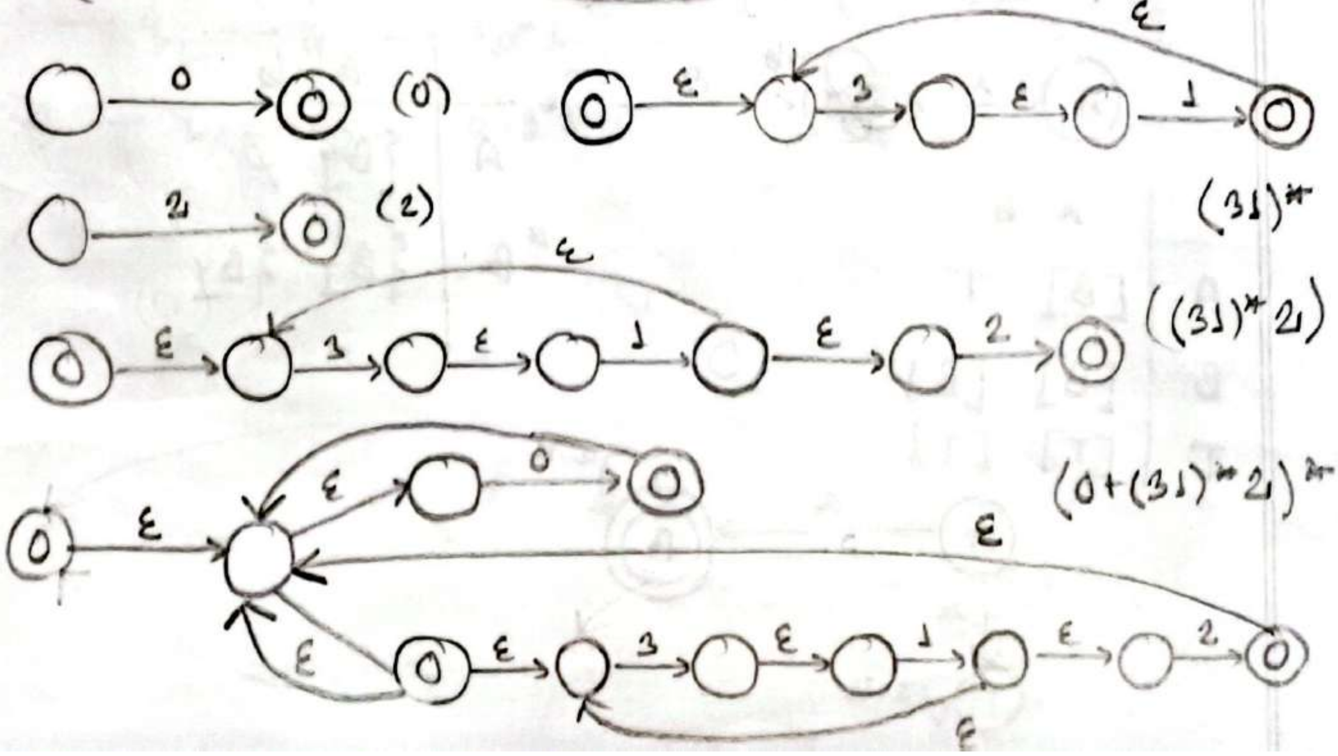


Subject : | Date :

$(01^*2)^*$



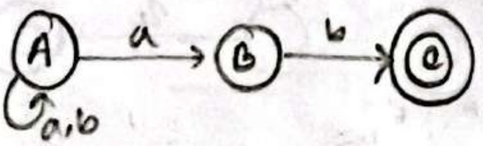
$(0+(31)^*2)^*$



Subject : Date :

NFA TO DFA

L = { W | W ends with ab }

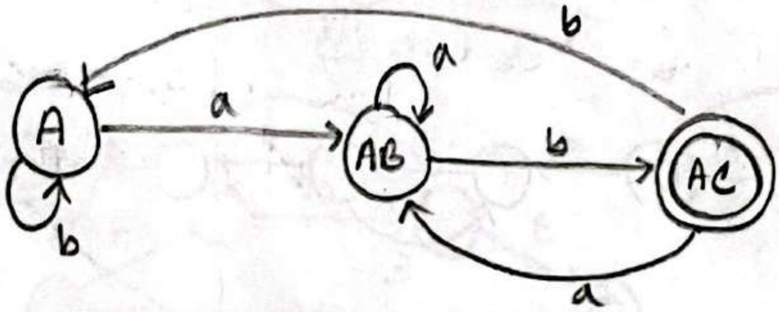


[NFA]

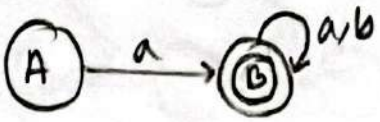
	a	b
A	[AB]	[A]
[AB]	[AB]	[AC]
[AC]	[AB]	[A]

←

	a	b
A	{A,B}	{A}
B	∅	{C}
*C	∅	∅

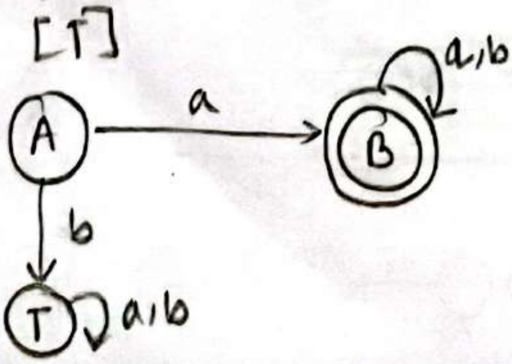


L = { W | W starts with 'a' }

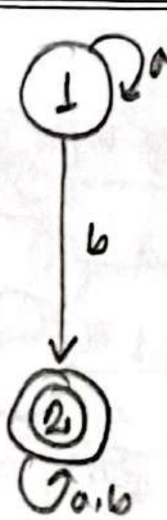


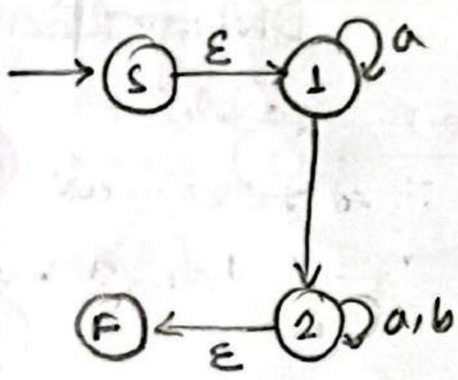
	a	b
A	{B}	∅
*B	{B}	{B}

	a	b
A	[B]	T
B	[B]	[B]
T	[T]	[T]

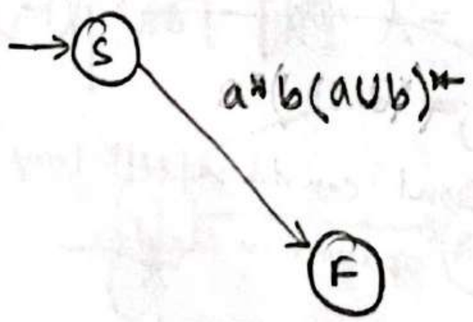


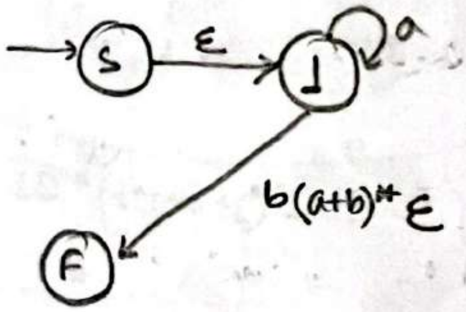
Subject: Date:

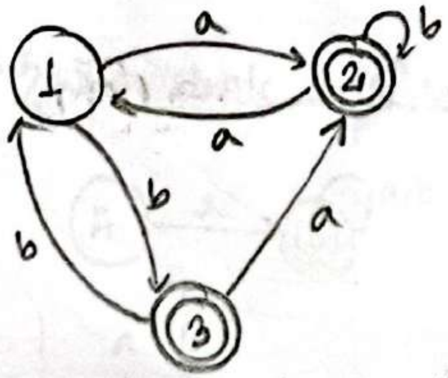


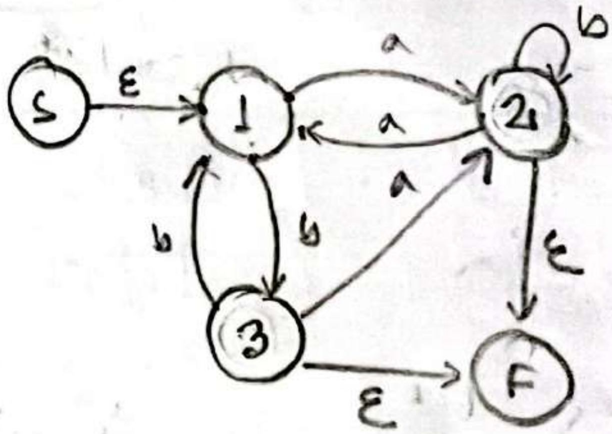


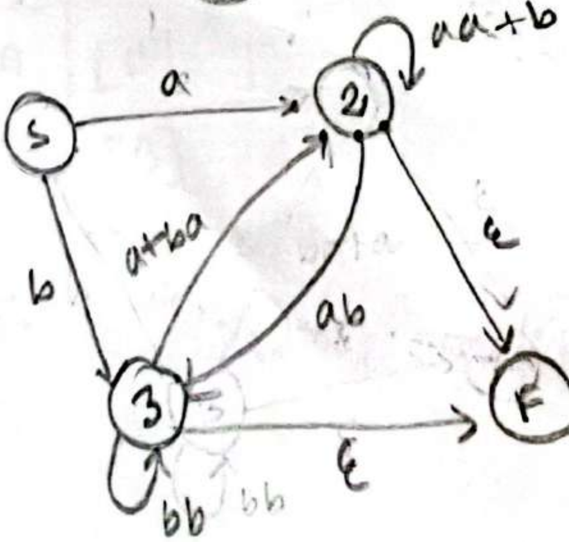
$1 \to 2 \to F \to b(a+b)^* \varepsilon$











$S \to 1 \to 2 = a$

$S \to 1 \to 3 = b$

$3 \to 1 \to 2 = ba$

$3 \to 1 \to 3 = bb$

$2 \to 1 \to 2 = aa$

$2 \to 1 \to 3 = ab$

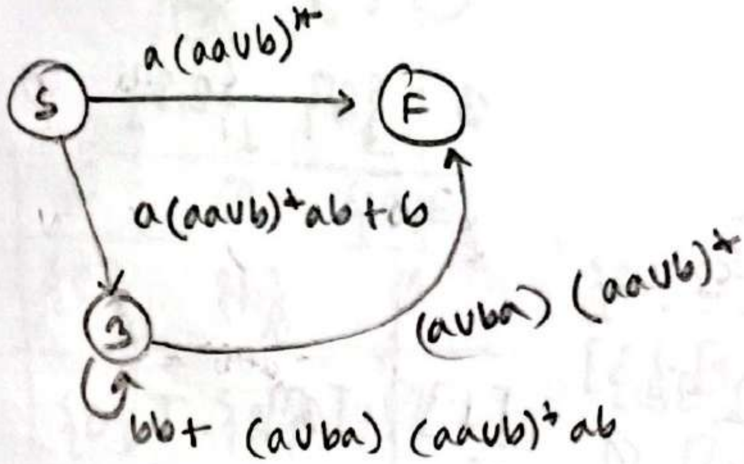
Subject :   Date :

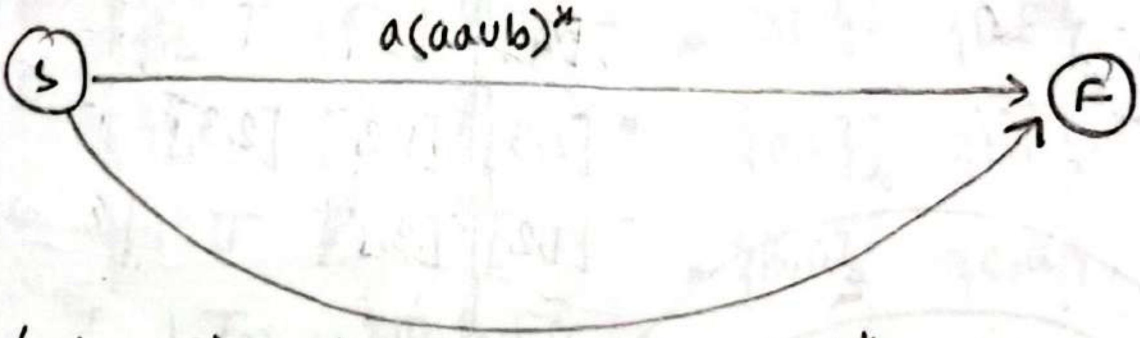
$S \rightarrow 2 \rightarrow F = a(aa \cup b)^*$

$S \rightarrow 2 \rightarrow 3 = a(aa \cup b)^* ab$

$3 \rightarrow 2 \rightarrow F = (a \cup ba)(aa \cup b)^*$ ✓

$3 \rightarrow 2 \rightarrow 3 = (a \cup ba)(aa \cup b)^* ab$





$(a(aa \cup b)^* ab \cup b)(bb \cup (a \cup ba)(aa \cup b)^* ab)^* (a \cup ba)(aa \cup b)^*$

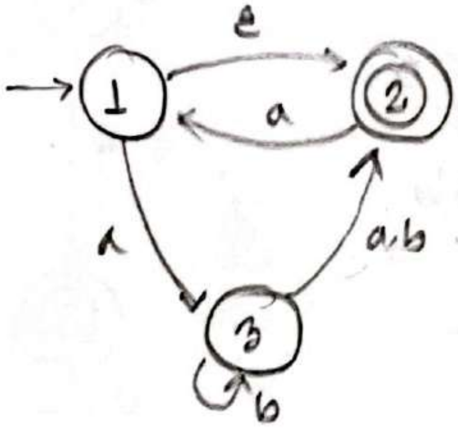
$a(aa \cup b)^* \cup ((a(aa \cup b)^* ab \cup b)(bb \cup (a \cup ba)(aa \cup b)^* ab)^* (a \cup ba)(aa \cup b)^*$

Hamid Book Bainding

Subject :

Date :

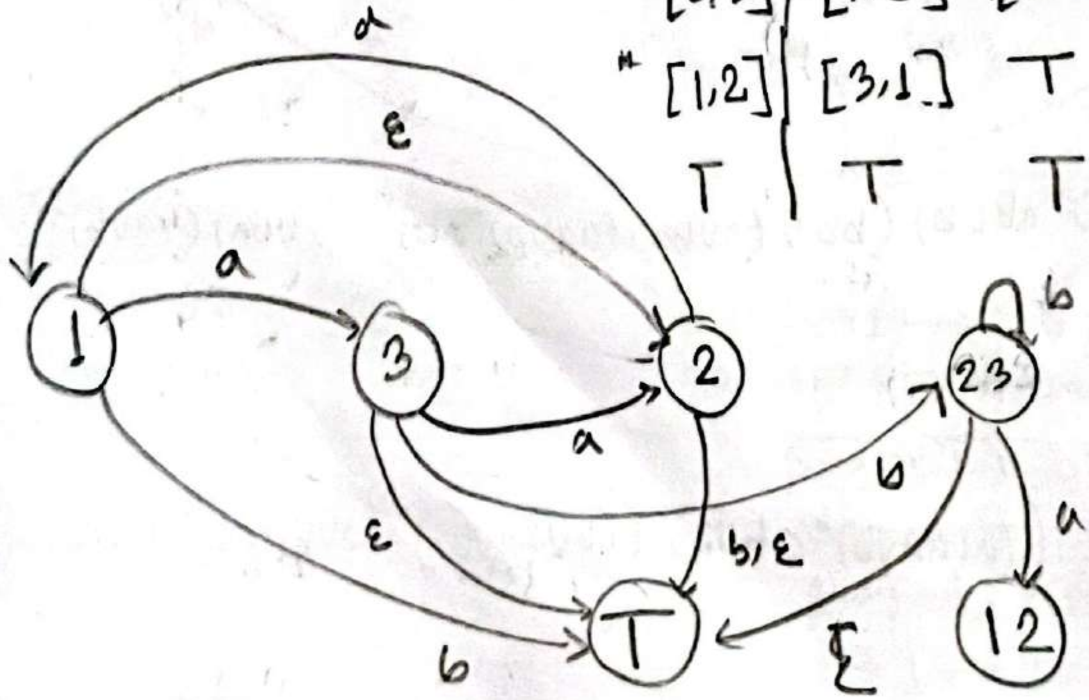
NFA → DFA



	a	b
1	{3}	φ
*2	{1}	φ
3	{2}	{2,3}

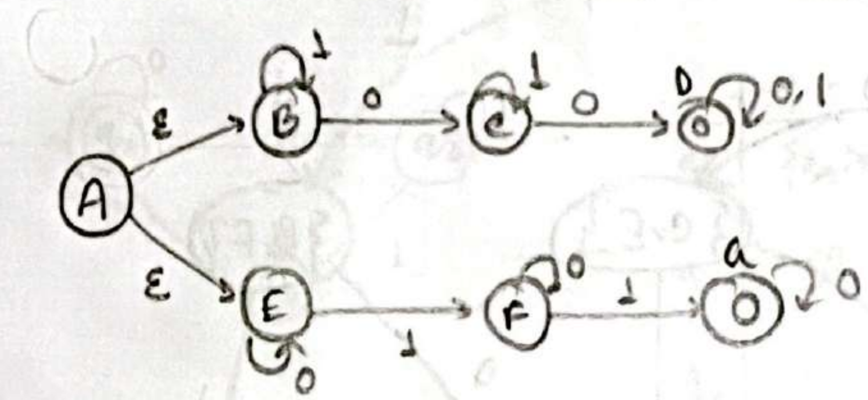
	a	b	ε
[3,1]	[3,2]	[2,3]	[2]
[3,2]	[1,2]	[2,3]	φ

	a	b
[1]	[3]	T
[3]	[2]	[2,3]
*[2]	[1]	T
*[2,3]	[1,2]	[2,3]
*[1,2]	[3,1]	T
T	T	T



Subject :

Date :



	0	1	ε
A	φ	φ	{B, E}
B	{C}	{B}	φ
C	{D}	{C}	φ
D	{D}	{D}	φ
E	{E}	{F}	φ
F	{F}	{G}	φ
G	{G}	φ	φ

ε closure (A) = {A, B, E}

ε closure (B) = {B}

ε closure (C) = {C}

ε closure (D) = {D}

ε closure (E) = {E}

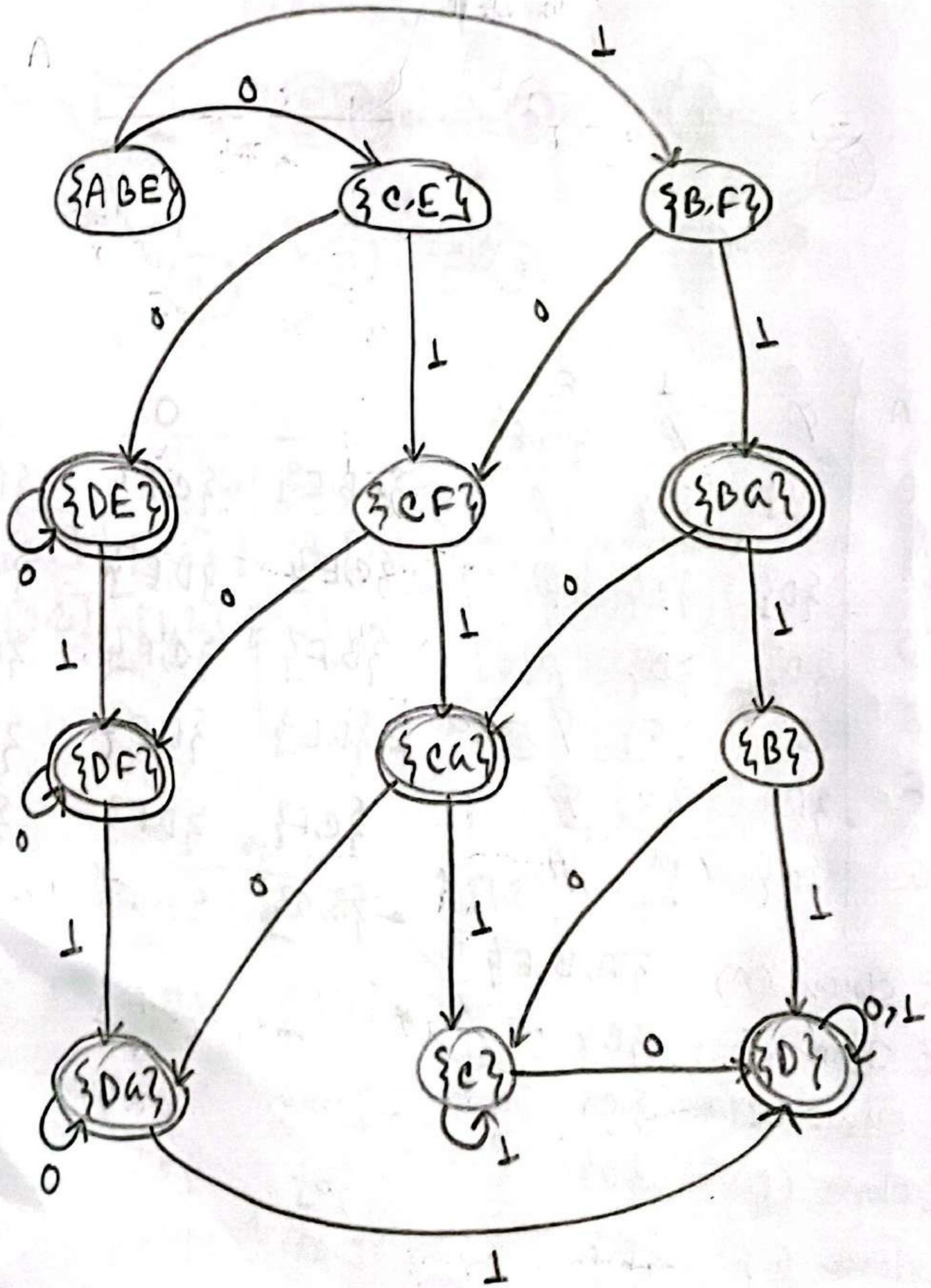
ε closure (F) = {F}

ε closure (G) = {G}

	0	1
{A, B, E}	{C, E}	{B, F}
{C, E}	{D, E}	{C, F}
{B, F}	{C, F}	{D, G}
* {D, E}	{D, E}	{D, F}
{C, F}	{D, F}	{C, G}
* {B, G}	{C, G}	{B}
* {D, F}	{D, F}	{D, G}
* {C, G}	{D, G}	{C}
{B}	{C}	{B}
* {D, G}	{D, G}	{D}
{C}	{D}	{C}
* {D}	{D}	{D}

Subject :

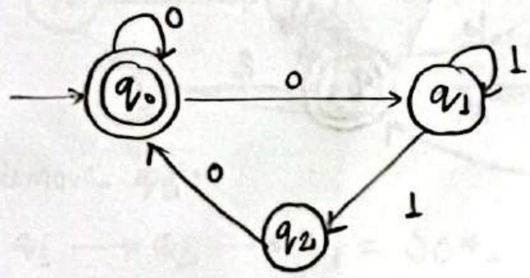
Date :



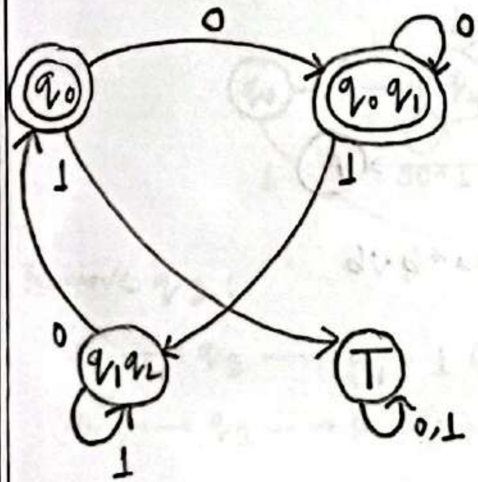
Subject : Date :

NFA TO DFA

1.

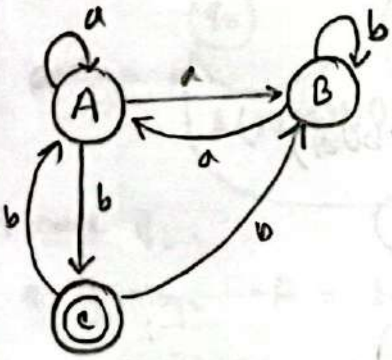


	0	1
q_0	$\{q_0, q_1\}$	ϕ
q_1	ϕ	$\{q_1, q_2\}$
q_2	q_0	ϕ



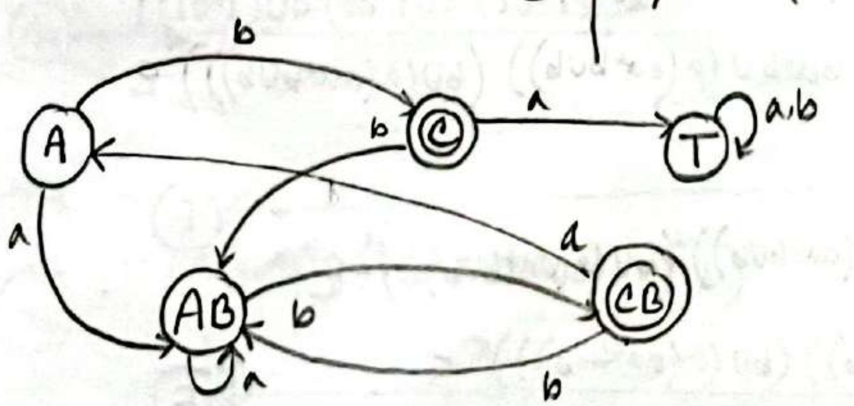
	0	1
* $[q_0]$	$[q_0, q_1]$	T
* $[q_0, q_1]$	$[q_0, q_1]$	$[q_1, q_2]$
$[q_1, q_2]$	$[q_0]$	$[q_1, q_2]$
[T]	T	T

2.



	a	b
A	{A,B}	{C}
B	{A}	{B}
*C	ϕ	{A,B}

	a	b
[A]	[A,B]	[C]
[A,B]	[A,B]	[C,B]
*[C]	T	[A,B]
*[C,B]	[A]	[A,B]
T	T	T

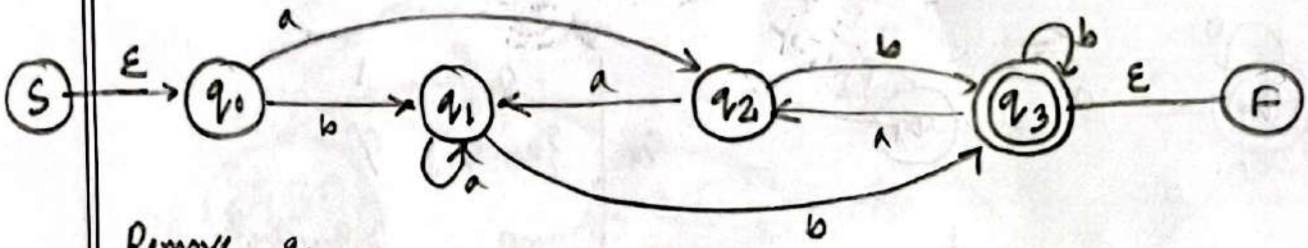


Subject:

SUMMER-22

Date:

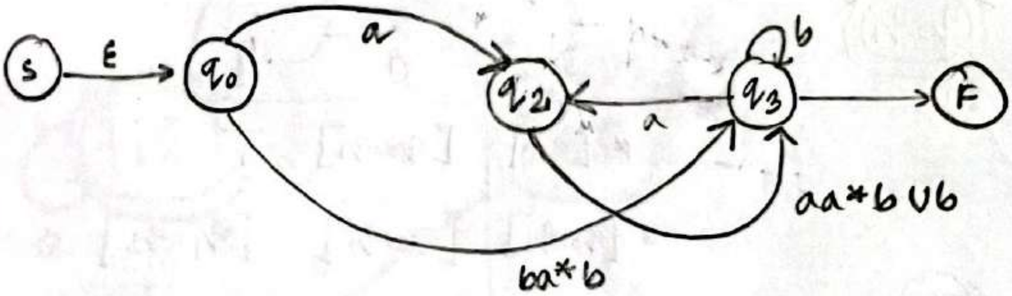
1. DFA to RE (Mid Question)



Remove q_1

$q_0 \longrightarrow q_1 \longrightarrow q_3 = ba^*b$

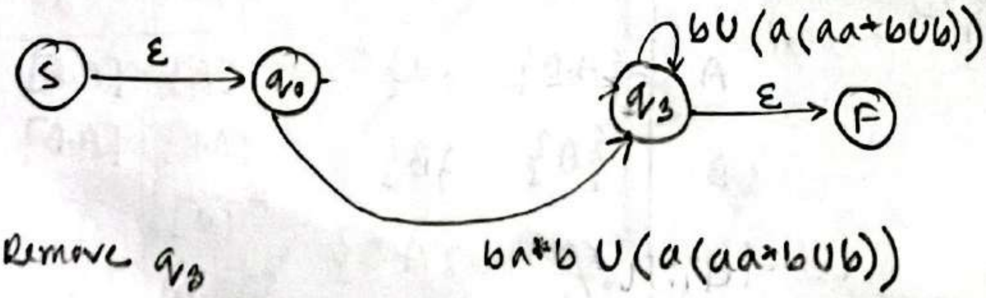
$q_2 \longrightarrow q_1 \longrightarrow q_3 = aa^*b$



Remove q_2

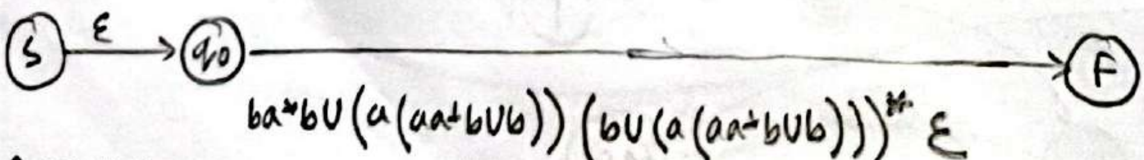
$q_0 \longrightarrow q_2 \longrightarrow q_3 = a(aa^*b \cup b)$

$q_3 \longrightarrow q_2 \longrightarrow q_3 = a(aa^*b \cup b)$

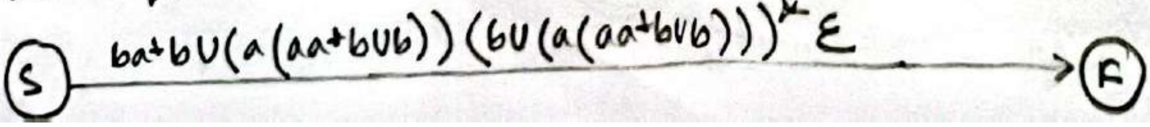


Remove q_3

$q_0 \longrightarrow q_3 \longrightarrow F = ba^*b \cup (a(aa^*b \cup b))\,(b \cup (a(aa^*b \cup b)))^*\,\varepsilon$

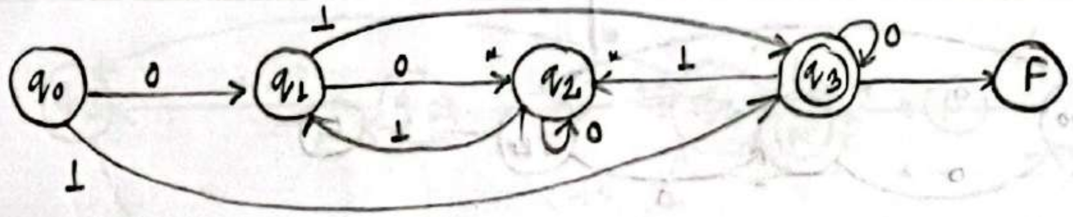


Remove q_0



Subject: FALL-22 Date:

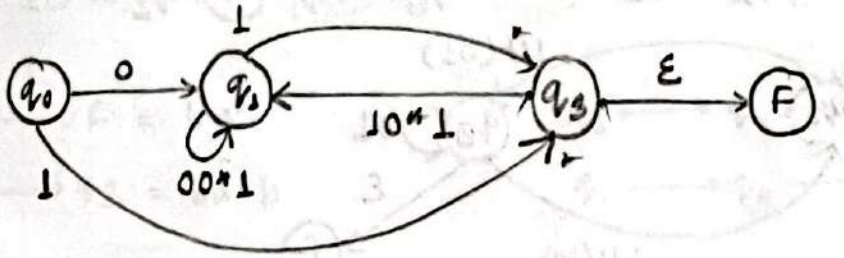
2.



Remove q_2:

$q_1 \longrightarrow q_2 \longrightarrow q_1 = 00^*1$

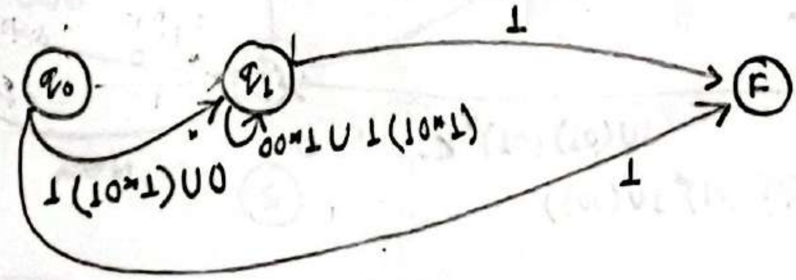
$q_3 \longrightarrow q_2 \longrightarrow q_1 = 10^*1$



Remove q_3:

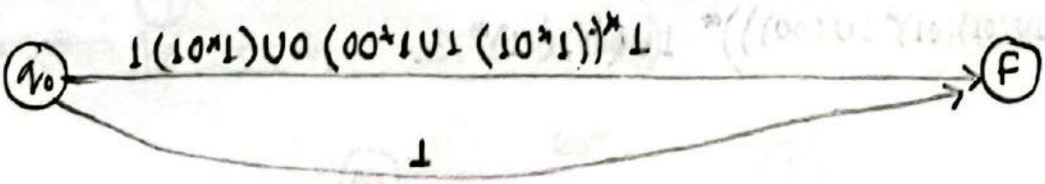
$q_1 \longrightarrow q_3 \longrightarrow q_1 = 1(10^*1)$ $\qquad$ $q_0 \longrightarrow q_3 \longrightarrow q_1 = 1(10^*1)$

$q_1 \longrightarrow q_3 \longrightarrow F = 1$ $\qquad$ $q_0 \longrightarrow q_3 \longrightarrow F = 1$

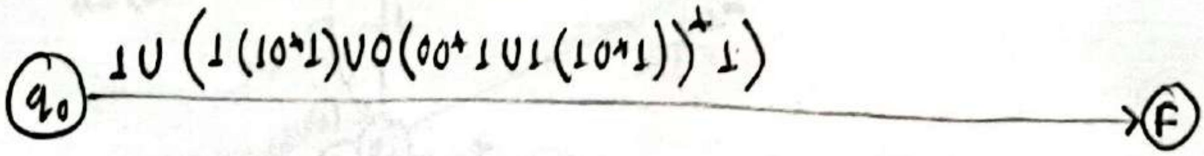


Remove q_1:

$q_0 \longrightarrow q_1 \longrightarrow F = 1(10^*1)\cup 0\,(00^*1\cup 1(10^*1))^* 1$

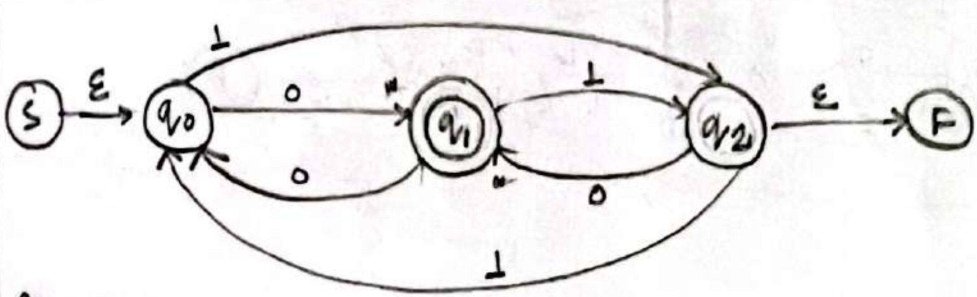


Finally



Subject: SPRING-23 Date:

3.



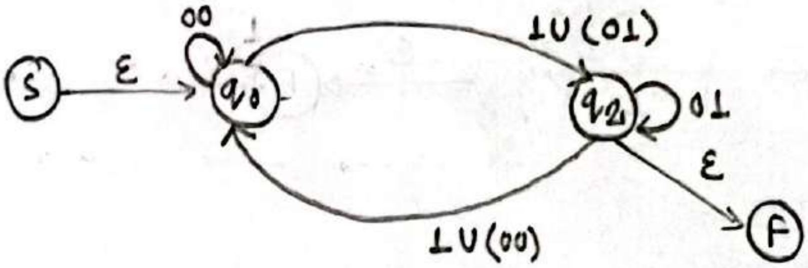
Remove q_1:

$q_0 \longrightarrow q_1 \longrightarrow q_0 = 00$

$q_0 \longrightarrow q_1 \longrightarrow q_2 = 01$

$q_2 \longrightarrow q_1 \longrightarrow q_0 = 00$

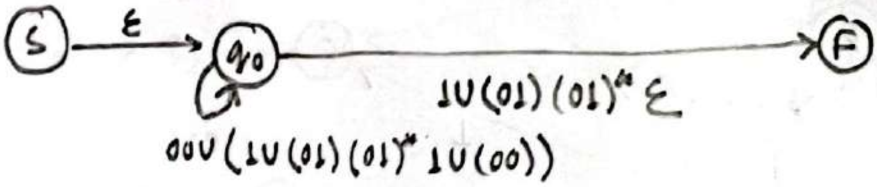
$q_2 \longrightarrow q_1 \longrightarrow q_2 = 01$



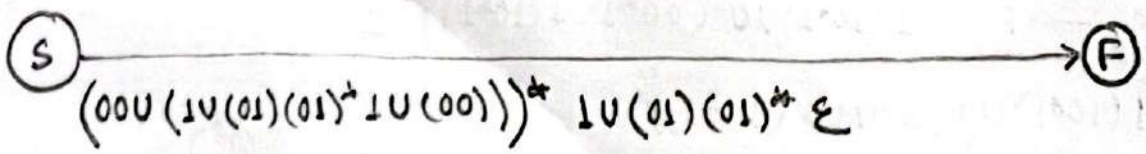
Remove q_2:

$q_0 \longrightarrow q_2 \longrightarrow q_0 = 1U(01)(01)^* 1U(00)$

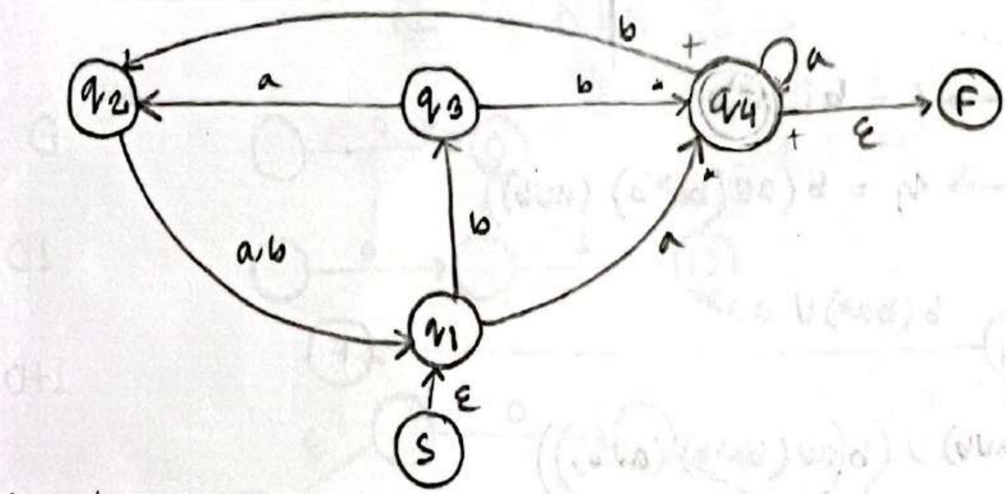
$q_0 \longrightarrow q_2 \longrightarrow F = 1U(01)(01)^* \varepsilon$



Remove q_0:



Subject : FALL-23 Date :



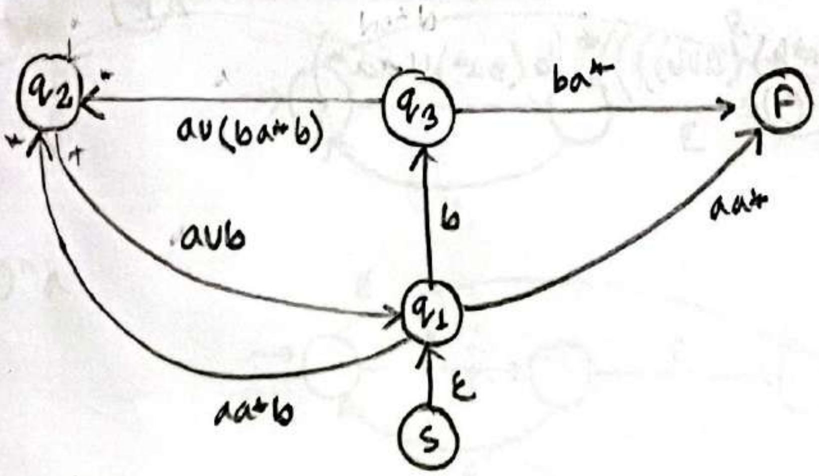
Remove q_4:

$q_3 \longrightarrow q_4 \longrightarrow F = ba^*$

$q_3 \longrightarrow q_4 \longrightarrow q_2 = ba^*b$

$q_1 \longrightarrow q_4 \longrightarrow F = aa^*$

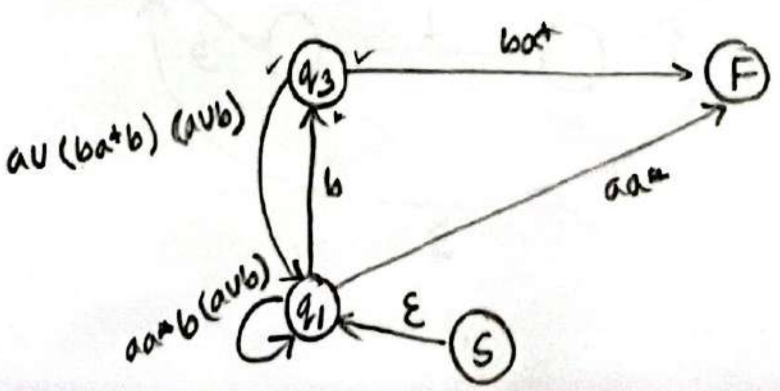
$q_1 \longrightarrow q_4 \longrightarrow q_2 = aa^*b$



Remove q_2:

$q_1 \longrightarrow q_2 \longrightarrow q_1 = aa^*b\,(a \cup b)$

$q_3 \longrightarrow q_2 \longrightarrow q_1 = a \cup (ba^*b)\,(a \cup b)$



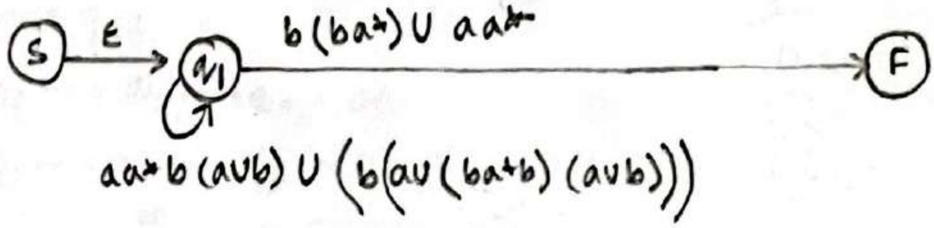
Subject :

Date :

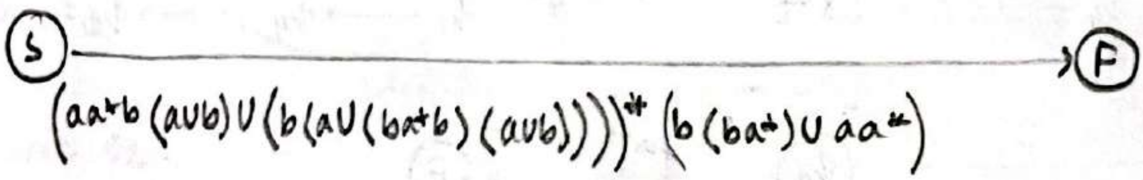
Remove q_3:

$q_1 \longrightarrow q_3 \longrightarrow F = b(ba^*)$

$q_1 \longrightarrow q_3 \longrightarrow q_1 = b(a \cup (ba^*b)(a \cup b))$



Remove q_1:

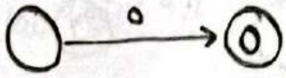


Subject :

Date :

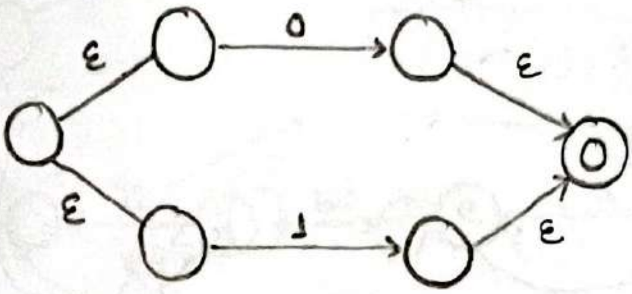
RE to NFA

1. 0

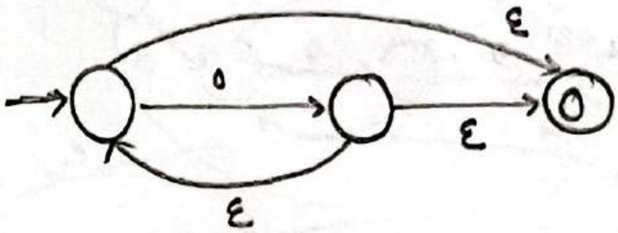


01

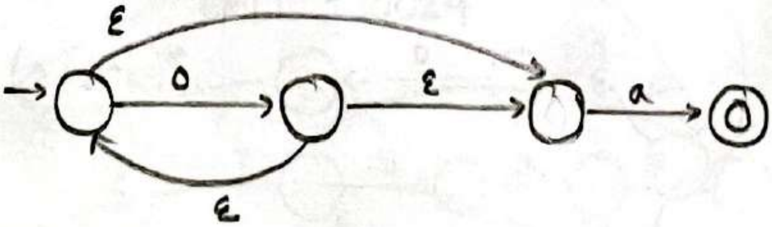
$0+1$



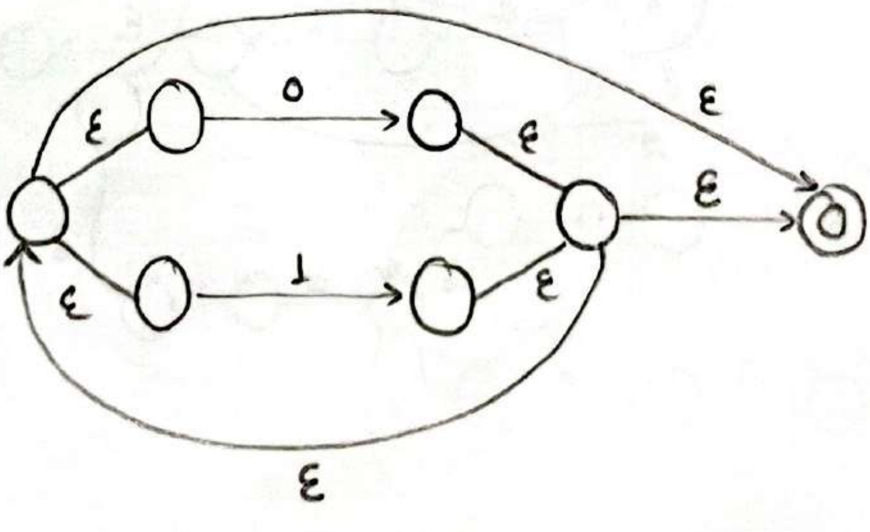
0^*



0^*a



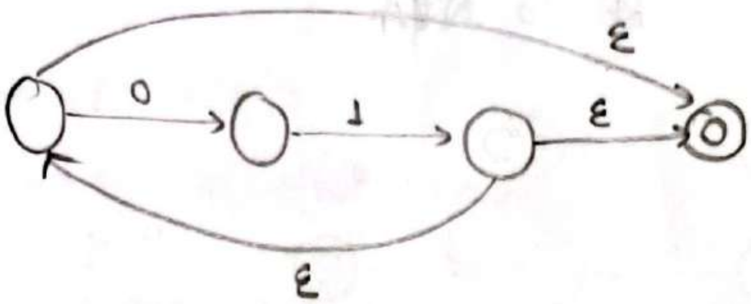
$(0+1)^*$



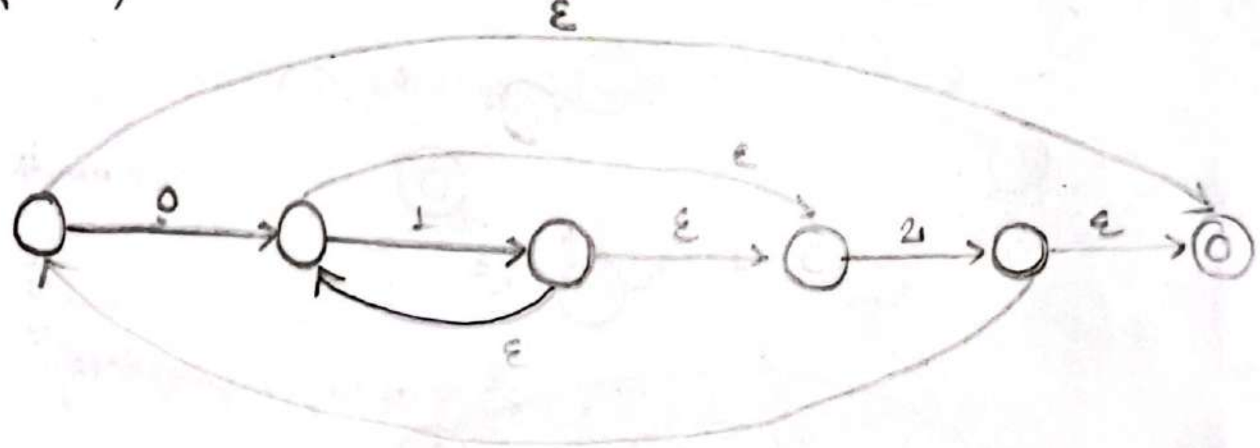
Subject :

Date :

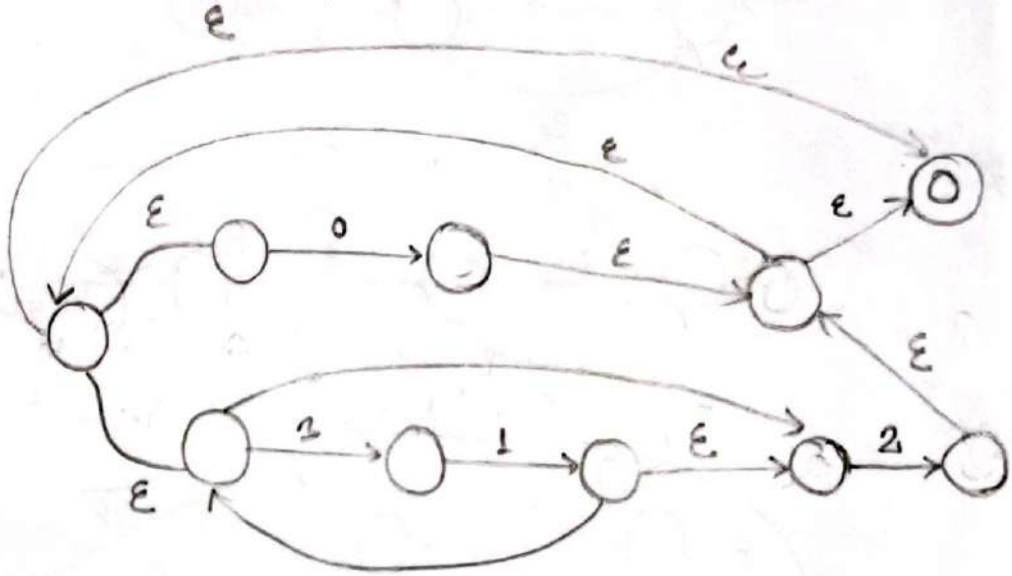
$(01)^*$



$(01^*2)^*$



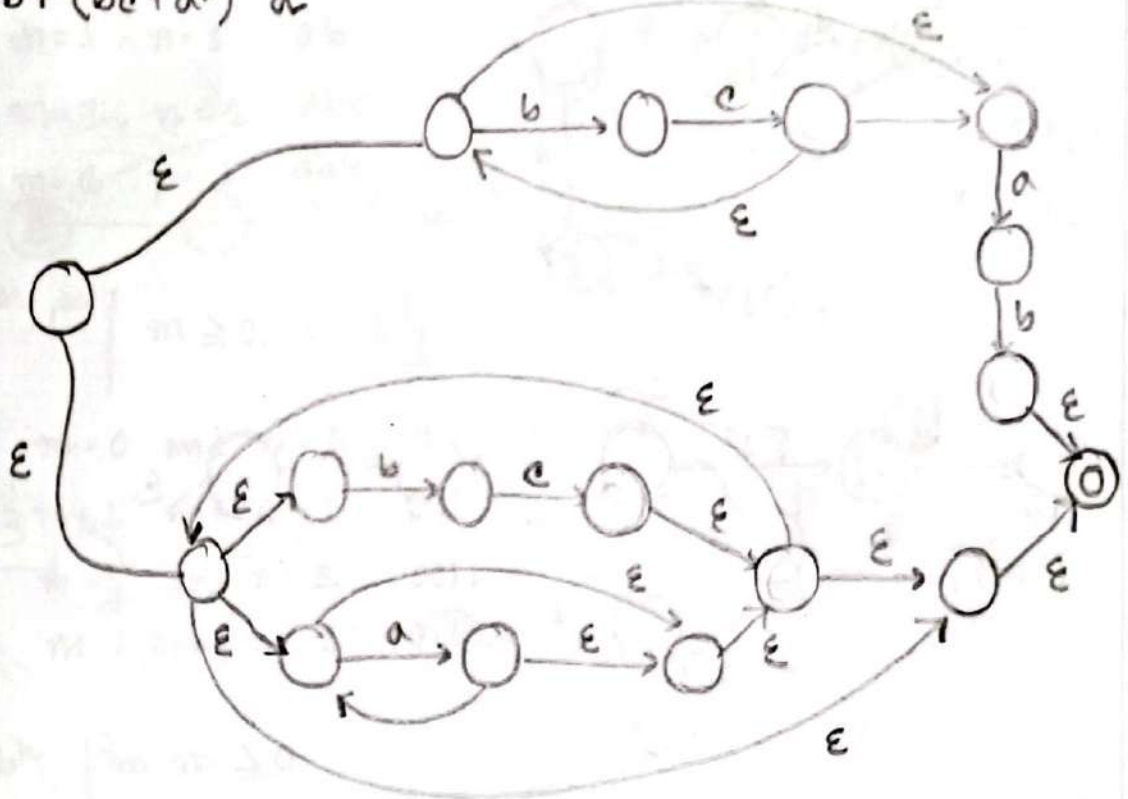
$(0+(31)^*2)^*$



Subject : SUMMER - 2023 Date :

1. RE $\longrightarrow$ NFA

$(bc)^* ab + (bc + a^*)^* a$



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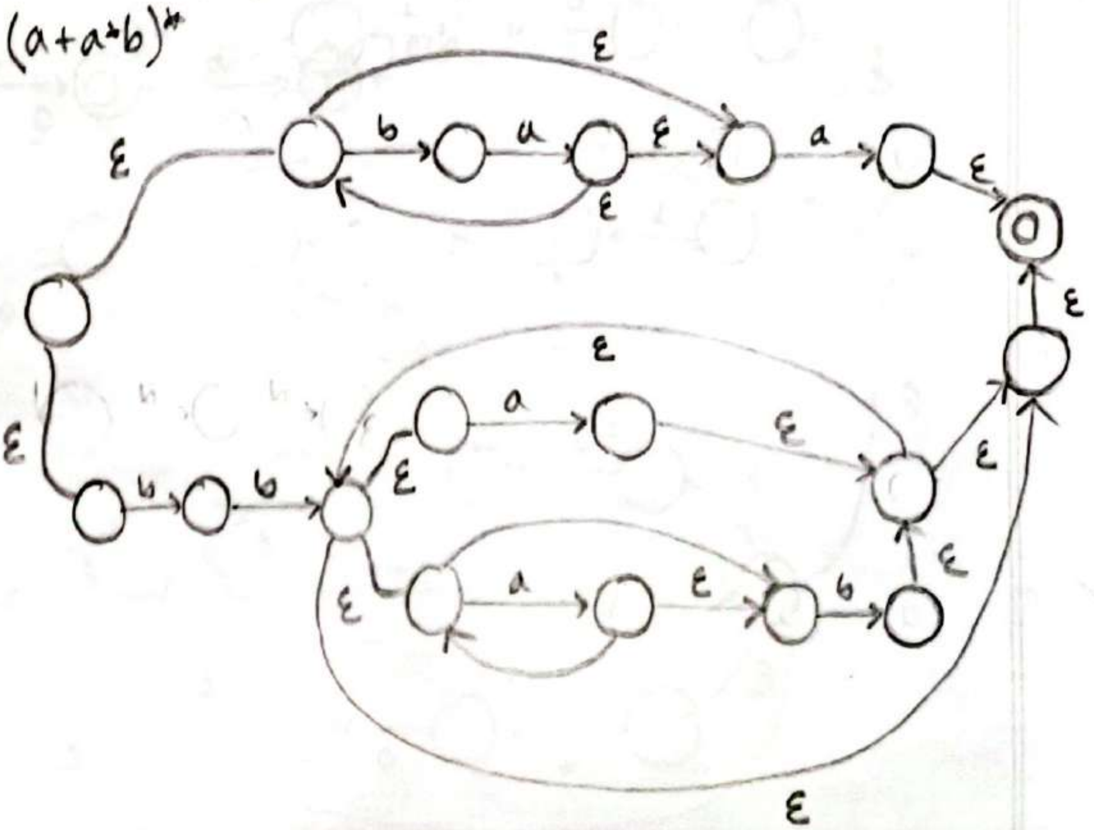
$(ba)^* a + bb\,(a + a^* b)^*$



Subject :

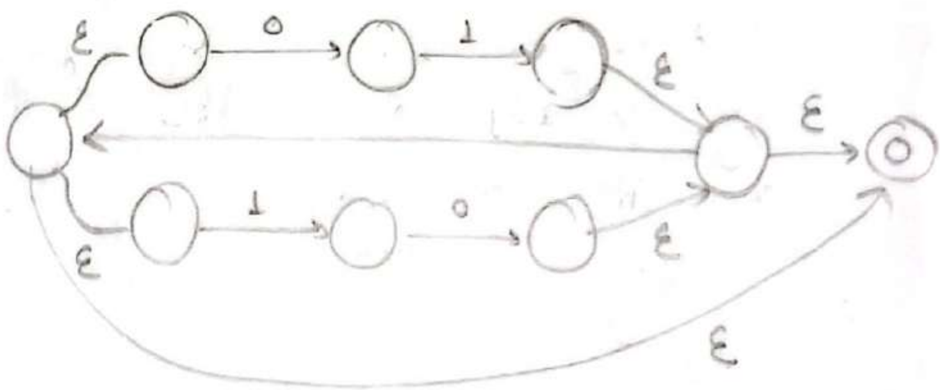
Date :

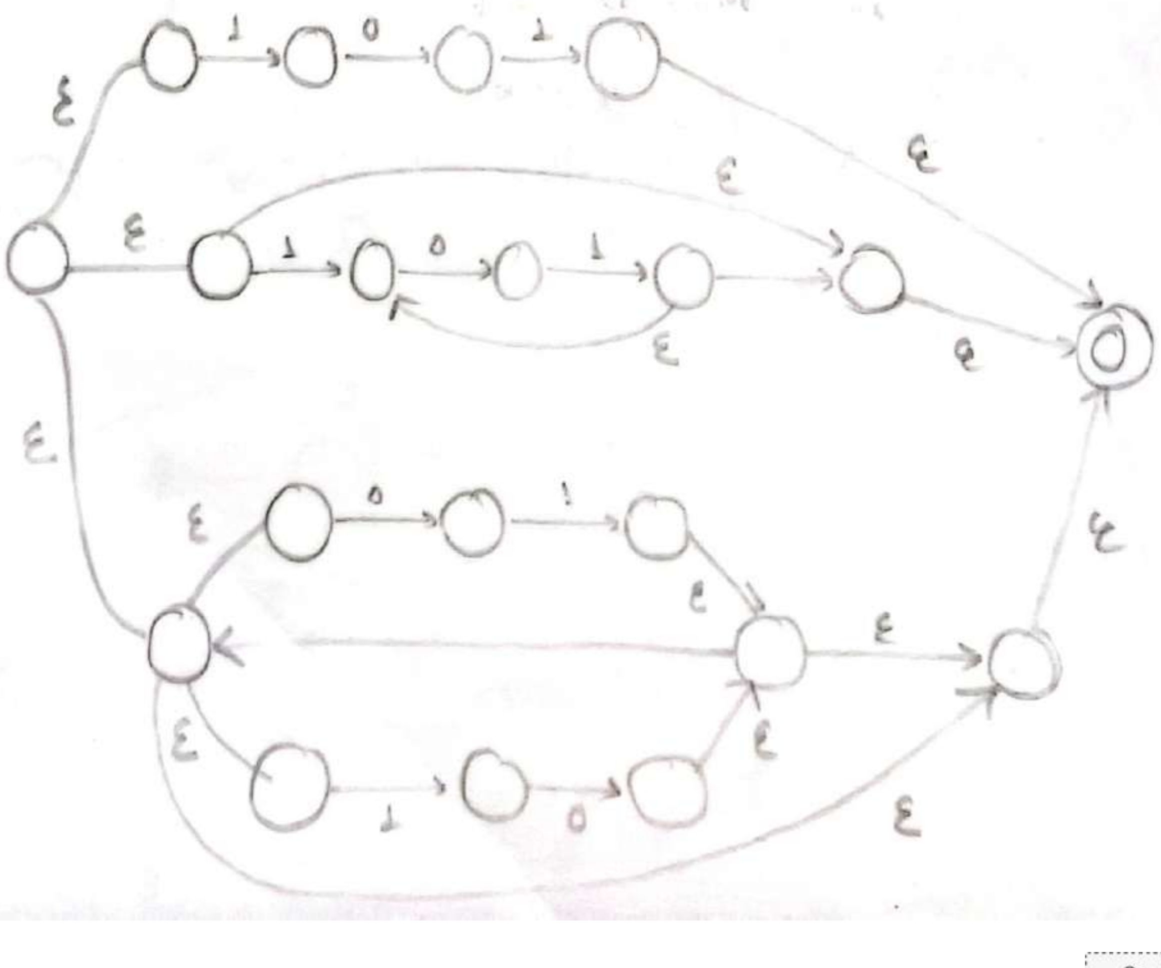
$101 + 1(01)^* + (01 + 10)^*$

(101)

$1(01)^*$

$(01+10)^*$





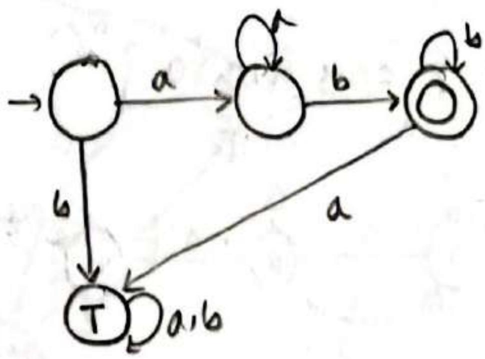
DFA

$L = a^m b^n \mid m,n \geq 1$

When, $m=1$, $n=1$ ab

$m=1$, $n=2$ abb

$m=2$ $n=1$ aab



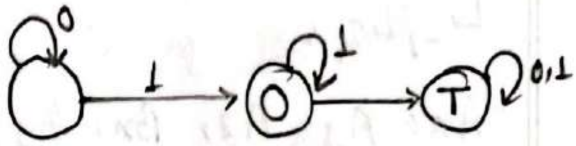
$L = \{0^m, 1^m \mid m \geq 0, n \geq 1\}$

When, $m=0$ and $n=1$ 1

$m=1$ and $n=1$ 01

$m=2$ and $n=2$ 0011

$m=1$ and $n=2$ 011



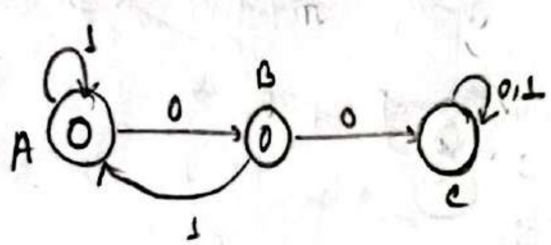
$L = a^m b^n \mid m,n \geq 0$

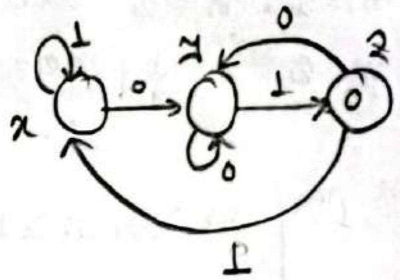
$\{\varepsilon, a, b, ab, aab, abb, aabb \ldots\}$

Subject: | Date:

$L_1 = \{ w,\ 00 \text{ is not a substring of } w \}$

$L_2 = \{ \text{ends with } 01 \}$





L_1 / L_2 :

$Ax,\ Ay,\ Az,\ Bx,\ By,\ Bz,\ Cx,\ Cy,\ Cz$

$\begin{matrix}A\\x\end{matrix} \xrightarrow{0} \begin{matrix}B\\y\end{matrix} \qquad \begin{matrix}A\\x\end{matrix} \xrightarrow{1} \begin{matrix}A\\x\end{matrix} \qquad \begin{matrix}C\\x\end{matrix} \xrightarrow{0} \begin{matrix}C\\y\end{matrix} \qquad \begin{matrix}C\\x\end{matrix} \xrightarrow{1} \begin{matrix}C\\x\end{matrix}$

$\begin{matrix}A\\y\end{matrix} \xrightarrow{0} \begin{matrix}B\\y\end{matrix} \qquad \begin{matrix}A\\y\end{matrix} \xrightarrow{1} \begin{matrix}A\\z\end{matrix} \qquad \begin{matrix}C\\y\end{matrix} \xrightarrow{0} \begin{matrix}C\\y\end{matrix} \qquad \begin{matrix}C\\y\end{matrix} \xrightarrow{1} \begin{matrix}C\\z\end{matrix}$

$\begin{matrix}A\\z\end{matrix} \xrightarrow{0} \begin{matrix}B\\y\end{matrix} \qquad \begin{matrix}A\\z\end{matrix} \xrightarrow{1} \begin{matrix}A\\x\end{matrix} \qquad \begin{matrix}C\\z\end{matrix} \xrightarrow{0} \begin{matrix}C\\y\end{matrix} \qquad \begin{matrix}C\\z\end{matrix} \xrightarrow{1} \begin{matrix}C\\x\end{matrix}$

$\begin{matrix}B\\x\end{matrix} \xrightarrow{0} \begin{matrix}C\\y\end{matrix} \qquad \begin{matrix}B\\x\end{matrix} \xrightarrow{1} \begin{matrix}A\\x\end{matrix}$

$\begin{matrix}B\\y\end{matrix} \xrightarrow{0} \begin{matrix}C\\y\end{matrix} \qquad \begin{matrix}B\\y\end{matrix} \xrightarrow{1} \begin{matrix}A\\z\end{matrix}$

$\begin{matrix}B\\z\end{matrix} \xrightarrow{0} \begin{matrix}C\\y\end{matrix} \qquad \begin{matrix}B\\z\end{matrix} \xrightarrow{1} \begin{matrix}A\\x\end{matrix}$

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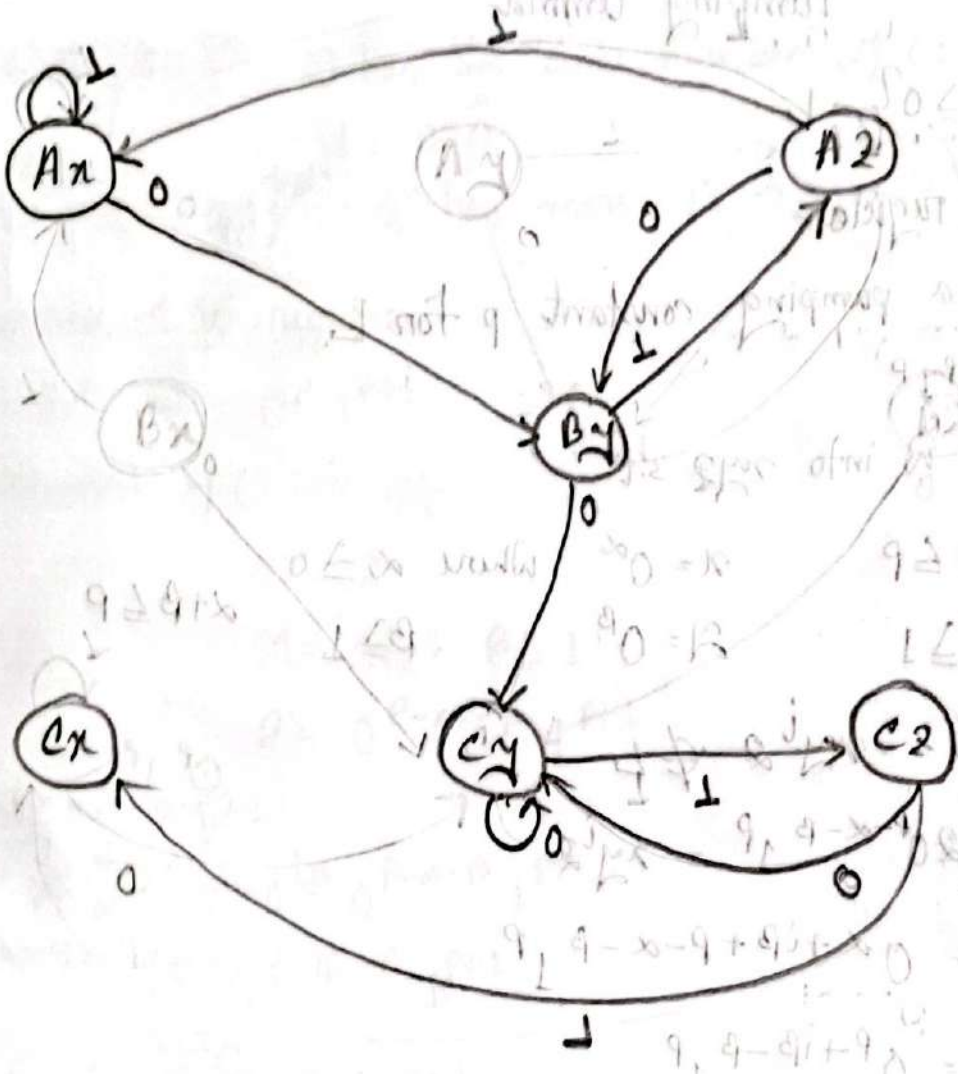

Hamid Book Bainding

Subject: 	Date:

Pumping lemma

1. $\{0^n 1^n : n \geq 0\} = L$

$\overset{\alpha}{0}00111$ — p

Suppose L is regular

→ There exist a pumping constant p for L

→ Choose $w = 0^p 1^p$

→ Decomposed of w into xyz s.t.

(a) $|xy| \leq p$ $\quad x = 0^\alpha$ where $\alpha \geq 0$ $\quad \alpha+\beta \leq p$

(b) $|y| \geq 1$ $\quad y = 0^\beta$ $\quad \beta \geq 1$

→ Choose an i $\quad xy^iz \notin L$

$0^\alpha 0^{i\beta} 0^{p-\alpha-\beta} 1^p = xy^iz$

or, $xy^iz = 0^{\alpha + i\beta + p - \alpha - \beta} 1^p$

$= 0^{p+i\beta-\beta} 1^p$

Choose i such that $p + i\beta - \beta \neq p$

$\Rightarrow i\beta - \beta \neq 0$

$\therefore i \neq 1$

$\therefore L$ is not regular.

$0^p 1^p$

$0^\alpha 0^\beta \cancel{\ } 0^{p-\alpha-\beta} 1^p$

$\cancel{0^{\alpha+\beta+p-\alpha-\beta} 1^p}$

$\cancel{0^p 1^p}$

xy^iz

$0^\alpha 0^{i\beta} 0^{p-\alpha-\beta} 1^p$

$0^{\alpha+i\beta+p-\cancel{\alpha}-\beta} 1^p$

$0^{p+i\beta-\beta} 1^p$

$0^{\cancel{\beta(p}\cdot p+\beta(i-1)} 1^p$

$p+\beta(i-1) \neq p$

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2. $\{ \omega \in \{0,1\}^* : \omega$ has the same number of 0's, 1's $\}$

3. $L = \{ \omega \in \{0,1\}^* : \omega$ has more 1's than 0's $\}$

Suppose L is regular

Choose $\omega = 0^p 1^{p+1}$

Decomposed of ω into xyz:

$$x = 0^\alpha$$

$$y = 0^\beta \qquad \beta \geq 1$$

$$z = 0^{p-\alpha-\beta} 1^{p+1}$$

Look at xy^iz:

$$xy^iz = 0^\alpha 0^{i\beta} 0^{p-\alpha-\beta} 1^{p+1}$$

$$= 0^{p-i\beta-\beta} 1^{p+1}$$

in L iff $p+i\beta-\beta < p+1$

$$i\beta - \beta < 1$$

$$\beta(i-1) < 1$$

Subject : | Date :

4. $L = \{0^{2n} 1^n : n \geq 0\}$

Choose $w = 0^{2p} 1^p$

Decomposed : xyz : $x = 0^\alpha$, $y = 0^\beta$. $z = 0^{2p-\alpha-\beta} 1^p$

$xy^iz = 0^\alpha 0^{i\beta} 0^{2p-\alpha-\beta} 1^p$

$= 0^{2p-\beta+i\beta} 1^p$

$2p + i\beta - \beta = 2p$

$i\beta - \beta = 0$

$(i-1) = 0$

$i = 1$

5. $L = \{0^n 1 0^n : n \geq 0\}$

Choose $w = 0^p 1 0^p$

Decomposed xyz : $x = 0^\alpha$, $y = 0^\beta$, $z = 0^{p-\alpha-\beta} 1 0^p$

$xy^iz = 0^\alpha 0^{i\beta} 0^{p-\alpha-\beta} 1 0^p$

$= 0^{p+i\beta-\beta} 1 0^p$

$p + i\beta - \beta = p$

$i\beta - \beta = 0$

$i = 1$

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6. $L = \{0^n 1^m : n \neq m\}$

Suppose L were regular.

$W = 0^p 1^{p+p!}$

$x = 0^\alpha$, $y = 0^\beta$, $z = 0^{p-\alpha-\beta} 1^{p+p!}$

$xy^iz = 0^\alpha 0^{i\beta} 0^{p-\alpha-\beta} 1^{p+p!}$

$= 0^{\alpha+i\beta+p-\alpha-\beta} 1^{p+p!}$

$= 0^{p+i\beta-\beta} 1^{p+p!}$

$p+i\beta-\beta \neq p+p!$ $\quad 0^p 1^{p+p!}$

$\beta(i-1) \neq p!$

$i \neq \frac{p!}{\beta}+1$

$x\ 0^\alpha$

$y\ 0^\beta$

$z\ 0^{p-\alpha-\beta}$

7. $L = \{0^n 1^m : n < 3m\}$

Suppose L were regular

$W = 0^{3p-1} 1^p$

$x = 0^\alpha$, $y = 0^\beta$, $z = 0^{3p-1-\alpha-\beta}$

$xy^iz = 0^\alpha 0^{i\beta} 0^{3p-1-\alpha-\beta} 1^p$

$= 0^{3p+i\beta-1-\beta} 1^p$ $\quad 0^p 1^p$

$3p+i\beta-1-\beta < 3p$

$i\beta-1-\beta < 0$

$\beta(i-1) < 1$

9. $L = \{0^{2^n} : n \geq 0\}$

$W = 0^{2^p}$

$x = 0^\alpha$, $y = 0^\beta$, $z =$

$xy^iz = 0^\alpha 0^{i\beta} 0^{2^p-\alpha-\beta}$

$= 0^{2^p+(i-1)\beta}$

Choose $i = 2$

$2^p < 2^p+\beta \leq 2^p+p < 2^p 2^p = 2^{p+1}$

8. $L = \{0^{n^2} : n \geq 0\}$

$W = 0^{p^2}$

$x = 0^\alpha$, $y = 0^\beta$ $z = 0^{p^2-\alpha-\beta}$

$xy^iz = 0^\alpha 0^{2\beta} 0^{p^2-\alpha-\beta}$

$= 0^{p^2+\beta}$

$p^2 < p^2+\beta \leq p^2+p < (p+1)^2$

Subject : Date :

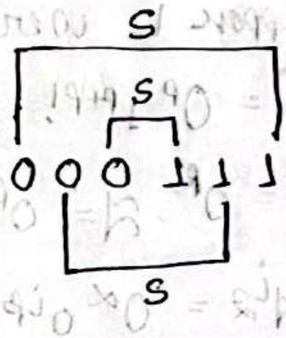
CFG

Examples:

(a) $0^n 1^n$

$S \rightarrow 0S1$
$S \rightarrow \varepsilon$

S
$\Rightarrow 0S1$
$\Rightarrow 00S11$
$\Rightarrow 000S111$
$\Rightarrow 000111$



(b) $0^n 1^{2n}$

$S \rightarrow 0S11$
$S \rightarrow \varepsilon$

S
$\Rightarrow 0S11$
$\Rightarrow 00S1111$

(c) $0^{3n} 1^{5n}$

$S \rightarrow 000S11111$
$S \rightarrow \varepsilon$

Subject: Date:

1. $\{w \mid w \text{ contains at least three 1's}\}$

$$(0|1)^* 1 (0|1)^* 1 (0|1)^* 1 (0|1)^*$$

$S \rightarrow A1A1A1A$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

2. $\{w \mid w \text{ starts and ends with same symbol}\}$

$$0(0|1)^*0 \mid 1(0|1)^*1$$

$S \rightarrow 0A0 \mid 1A1$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

3. $\{w \mid w \text{ the length of } w \text{ is odd}\}$

$$((0|1)(0|1))^* (0|1)$$

$S \rightarrow AB$

$A \rightarrow BBA \mid \varepsilon$

$B \rightarrow 0 \mid 1$

4. $\{w \mid \text{the length of } w \text{ is odd and its middle symbol is } 0\}$

$S \rightarrow 0S0 \mid 1S1 \mid 0S1 \mid 1S0 \mid 0$

$S \Rightarrow$
$\Rightarrow 1S1$
$\Rightarrow 10S01$
$\Rightarrow 10001$

5. $\{w \mid w = w^R,\ w \text{ is a palindrome}\}$

$S \rightarrow 0S0 \mid 1S1 \mid 1 \mid 0 \mid \varepsilon$

Subject: | Date:

6. $\{W \mid 0^i 1^j 2^k,\ i=j \text{ or } j \neq k\}\}$ $\cancel{j \neq k}\}$

For $j=i$

$$\underbrace{0^i 1^j}_{P}\ \underbrace{2^k}_{Q} \qquad \underbrace{i=j}_{A}\ \underbrace{j \neq k}_{B}$$

$S \rightarrow A \mid B$

$A \rightarrow PQ$

$Q \rightarrow 2Q \mid \varepsilon$

$P \rightarrow 0P1 \mid \varepsilon$

For $j \neq k$

$$\underbrace{0^i}_{W}\ \underbrace{1^j 2^k}_{X} \qquad \underbrace{i=j}_{A} \text{ or } \underbrace{j \neq k}_{B}$$

B: $j>k$, $j<k$

$B \rightarrow WX$

$W \rightarrow 0W \mid \varepsilon$

$X \rightarrow Y \mid Z$

$Y \rightarrow 1Y2 \mid M$

$M \rightarrow 2M \mid \varepsilon$

$Z \rightarrow 1Z2 \mid N$

$N \rightarrow 1N \mid \varepsilon$

7. $W_1 \# W_2$

number of 0's in W_1 = no of 1's in W_2

$S \rightarrow 1S \mid S0 \mid 0S1 \mid \#$

8. $A = \{W \in \{0,1\}^* :$ W contains odd no of 1's$\}$

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

$A \rightarrow BC1C$

$C \rightarrow 0C \mid \varepsilon$

$B \rightarrow DB \mid \varepsilon$

$D \rightarrow C1C1$

Subject : Date :

9. $L_1 = \{1^i 0 2^j 1^k \mid i,j,k \geq 0, i=k\}$

$S \rightarrow 1S1 \mid A$

$A \rightarrow 0B$

$B \rightarrow 2B \mid \varepsilon$

10. $\{1^i 0 2^j 1^k \mid i,j,k \geq 0,\ k = i+2j\}$

$S \rightarrow \cancel{\varepsilon} \mid 1S1 \mid C$

$C \rightarrow 0G$

$G \rightarrow 2G11 \mid \varepsilon$

11. $L_3 = \{1^i 0^j 2^k \mid i,j,k \geq 0,\ k = 2i+3j\}$

$S \rightarrow 1S22 \mid 0S222 \mid \varepsilon$

12. $L_4 = \{1^i 0^j 2^k \mid i,j,k \geq 0,\ k = 3i+j\}$

$S \rightarrow 1S222 \mid 0S2 \mid \varepsilon$

13. $L_5 = \{0^i 2^j 1^k \mid i,j,k \geq 0,\ k = 2i+2j\}$

$S \rightarrow 0S11 \mid 2S11 \mid \varepsilon$

14. $L_6 = \{2^i 0^j 1^k \mid i,j,k \geq 0,\ k = 3i+2j\}$

$S \rightarrow 2S111 \mid 0S11 \mid \varepsilon$

Subject: | Date:

15. Starts with 10

$S \rightarrow 10A$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

16. Ends with 10

$S \rightarrow A10$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

17. Contains 101 as substring

$S \rightarrow A101B$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

$B \rightarrow 0B \mid 1B \mid \varepsilon$

18. zero at 3rd position

$S \rightarrow XX0A$

$X \rightarrow 0 \mid 1$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

19. Even number of zeros

$S \rightarrow 0A \mid 1S \mid \varepsilon$

$A \rightarrow 0S \mid 1A$

20. Odd number of ones'

$S \rightarrow 1E \mid 0S$

$E \rightarrow 1S \mid 0E$

21. length is Even

$S \rightarrow 0A \mid 1A \mid \varepsilon$

$A \rightarrow 0S \mid 1S$

22. length is odd

$S \rightarrow 0A \mid 1A$

$A \rightarrow 0S \mid 1S \mid \varepsilon$

23. Atmost 2 zeros

$S \rightarrow A \mid 0A \mid 0A0A$

$A \rightarrow 1A \mid \varepsilon$

24. Exactly 3 ones

$S \rightarrow A1A1A1A$

$A \rightarrow 0A \mid \varepsilon$

25. Atleast 2 zeros

$S \rightarrow 00A0$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

26. Number of zero is multiple of 2

$S \rightarrow$

Scanned with CamScanner

Subject : Date :

27. $a^n b^n$, $L = \{$

No regected recognizable

$S \rightarrow aAb$

$A \rightarrow aAb \mid \varepsilon$

28. $A = \{ w \in \{0,1\}^* :$ w contains at least two 0s $\}$

$S \rightarrow 0A0$

$A \rightarrow 0A \mid 1A \mid \varepsilon$

$L = \{ w \in \{0,1\}^* : w = 0^{3i} A 1^{2i}$ and $i \geq 0 \}$

$S \rightarrow 000S11 \mid A$

$A \rightarrow 0B0$

$B \rightarrow 0B \mid 1B \mid \varepsilon$

29. $L = \{ w \in \Sigma^* :$ w is an odd length palindrome $\}$

$S \rightarrow aSa \mid bSb \mid a \mid b$

30. $L = \{ w \in \Sigma^* :$ w is an even length palindrome $\}$

$S \rightarrow aSa \mid bSb \mid \varepsilon$

31.

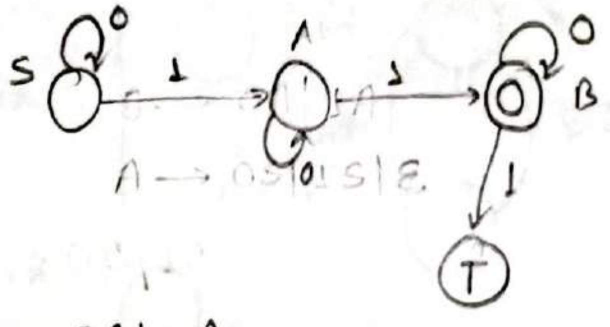
$S \rightarrow A11B$

$A \rightarrow 0C \mid 1C$

$C \rightarrow 0A \mid 1A \mid \varepsilon$

$B \rightarrow 0D \mid 1D$

$D \rightarrow 0B \mid 1B \mid \varepsilon$



$S \rightarrow 0S \mid 1A$

$A \rightarrow 0A \mid 1B$

$B \rightarrow 0B \mid \varepsilon$

Subject : Date :

1. ⓐ $L = \{ w \in \{a,b,c\}^* \mid w = a^i b^j c^k,\ j = 2i+k,\ k = 2i+2j,\ i,j,k \geq 0 \}$

$a^i b^{2i+k} c^k$ $a^i b^j c^{2i+2j}$

$a^i b^{2i} b^k c^k$ $a^i b^j c^{2i} c^{2j}$

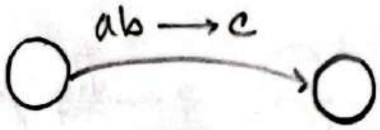
$S \to XY \mid bb$ $S \to XY$

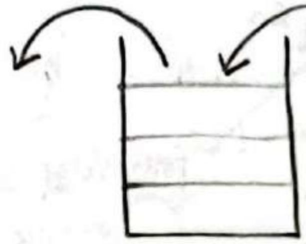
$X \to aXbb \mid \varepsilon$ $X \to aXcc \mid Y$

$Y \to bYc$ $Y \to bYcc \mid \varepsilon$

Subject : Date :

PDA





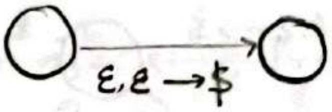
stack

a = read from the string

b = pop element from stack

c = push element from stack

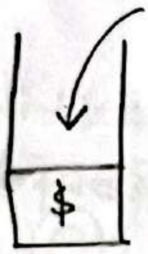
Default state



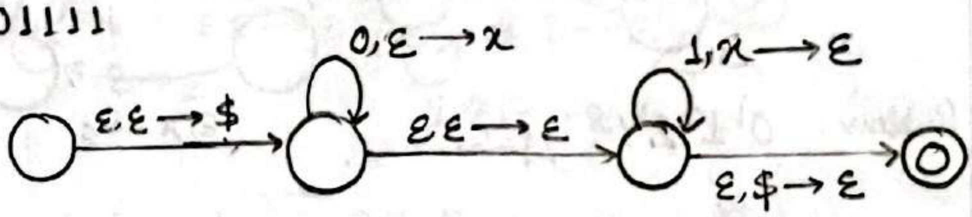
$ = when to stop

Problem: $0^n 1^n$ (equal 0 and 1)

example: 00001111

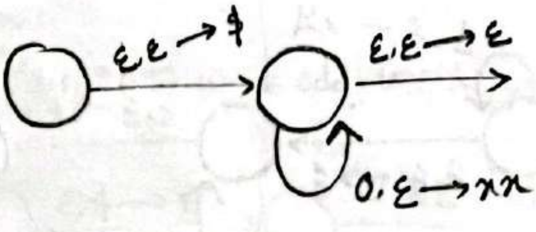


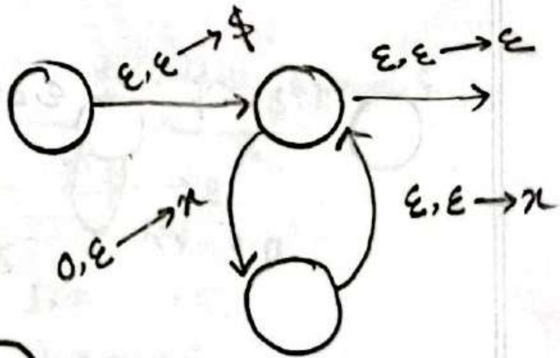
stack



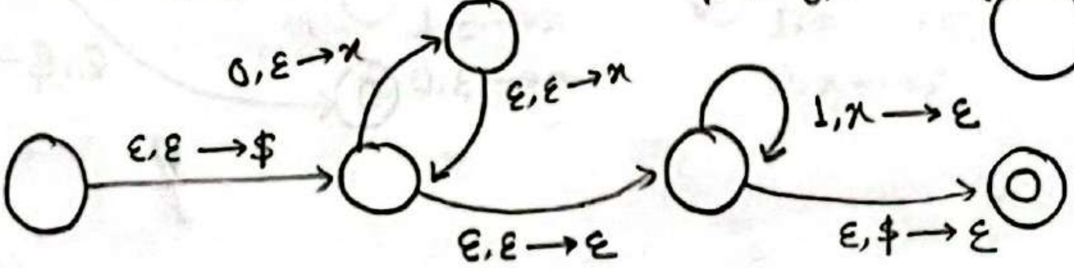
Now, what about n and 2n, $0^n 1^{2n}$

for every zero we need to push two x in the stack and for every one we need to pop only one x.





Problem: $0^n 1^{2n}$

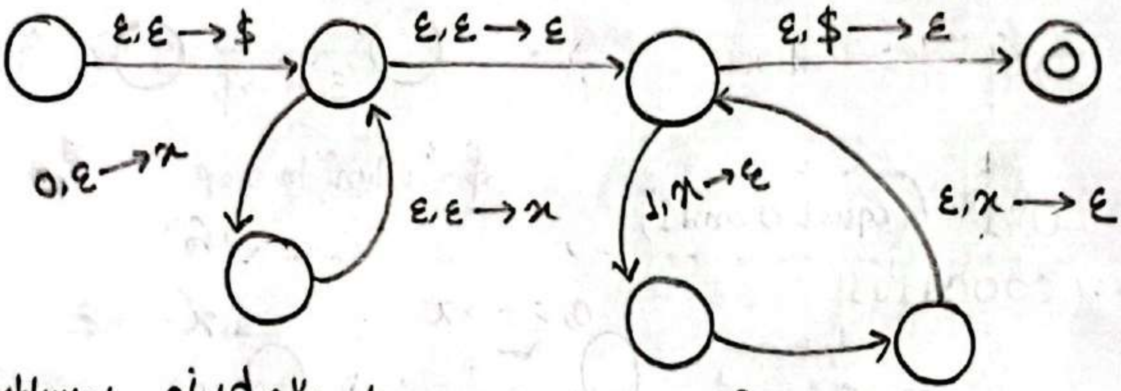


Subject: Date:

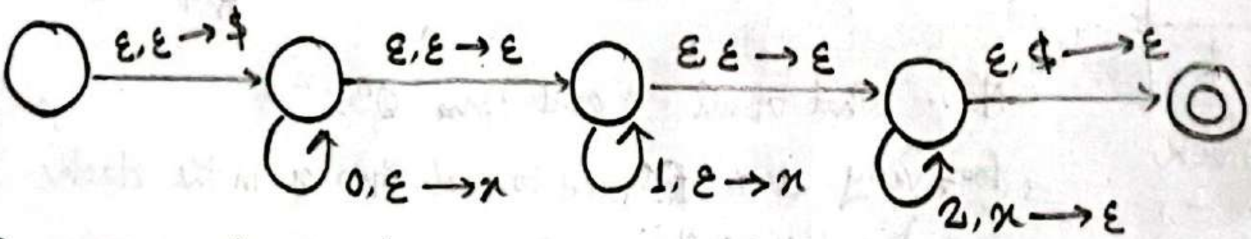
Problem: $0^{3n}1^{2n}$

for every zero, we need to push 2 one into the stack

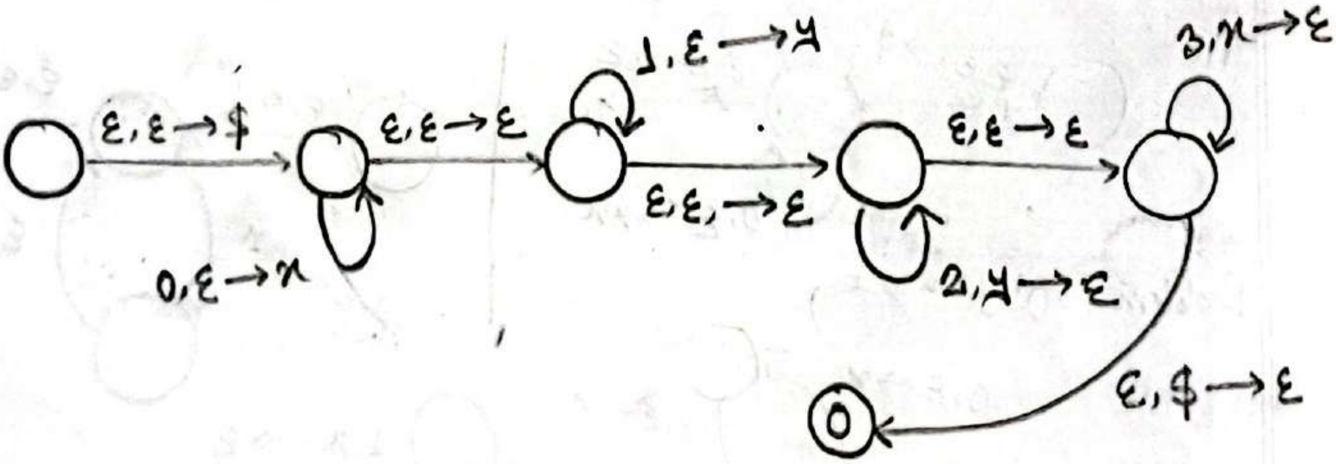
for every one, we need to pop 3 zeros from the stack



Problem: $0^i 1^j 2^k$, $i+j=k$



Problem: $0^i 1^j 2^j 3^i$



Subject :

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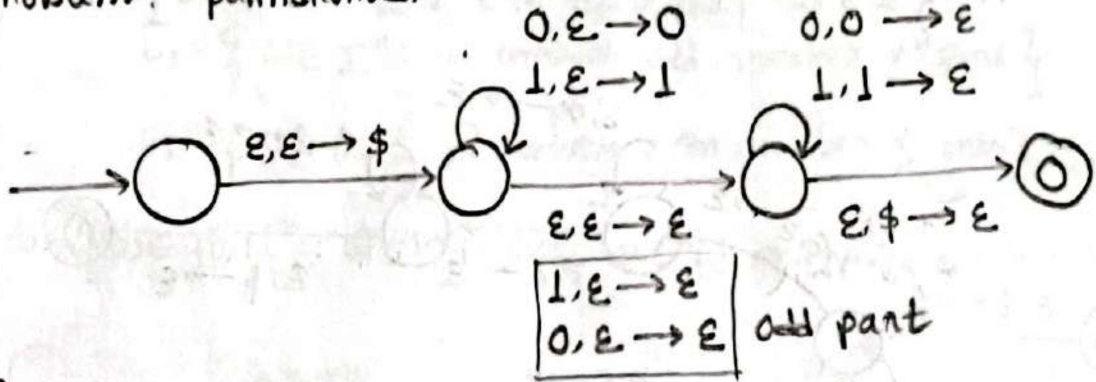
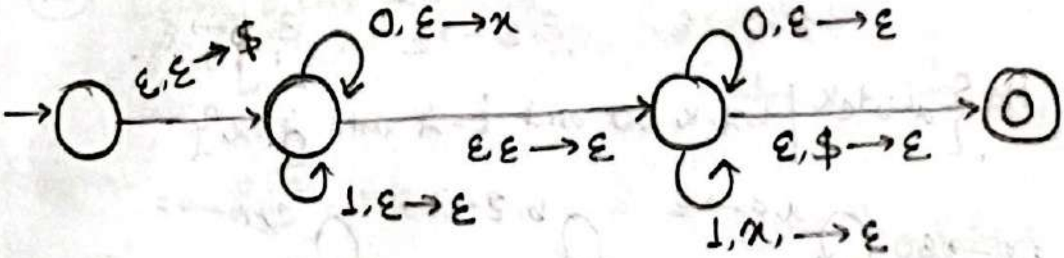
Problem : palindrome :

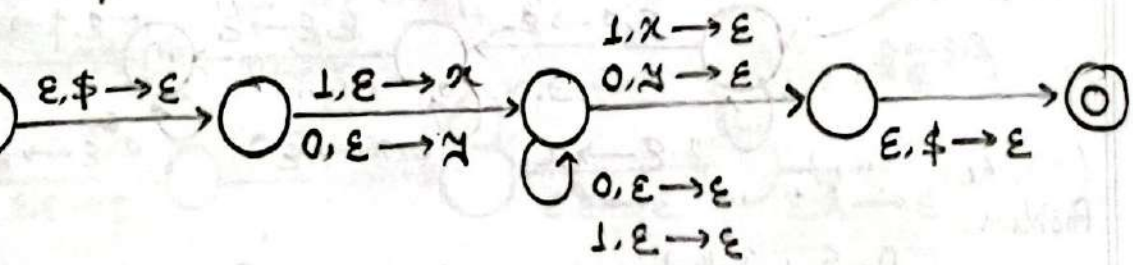


Problem: $\omega_1 \# \omega_2$ where, no. of 0's in ω_1 = no. of 1's in ω_2



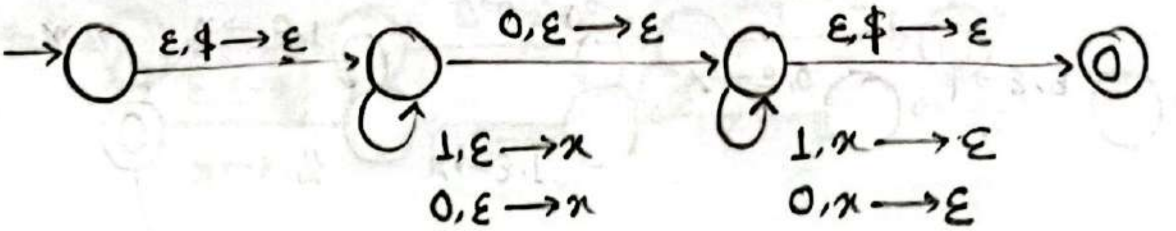
Problem :

$\{ w \in \{0,1\}^* \mid w$ starts and ends with the same symbol$\}$



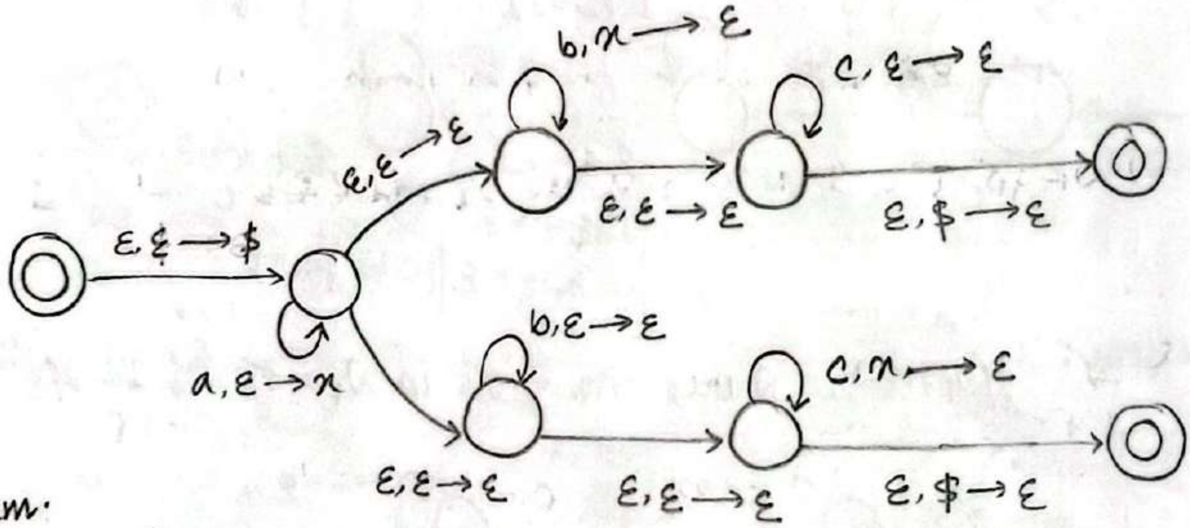
Problem :

$\{ w \in \{0,1\}^* \mid w$ is of odd length and has 0 as its middle symbol$\}$



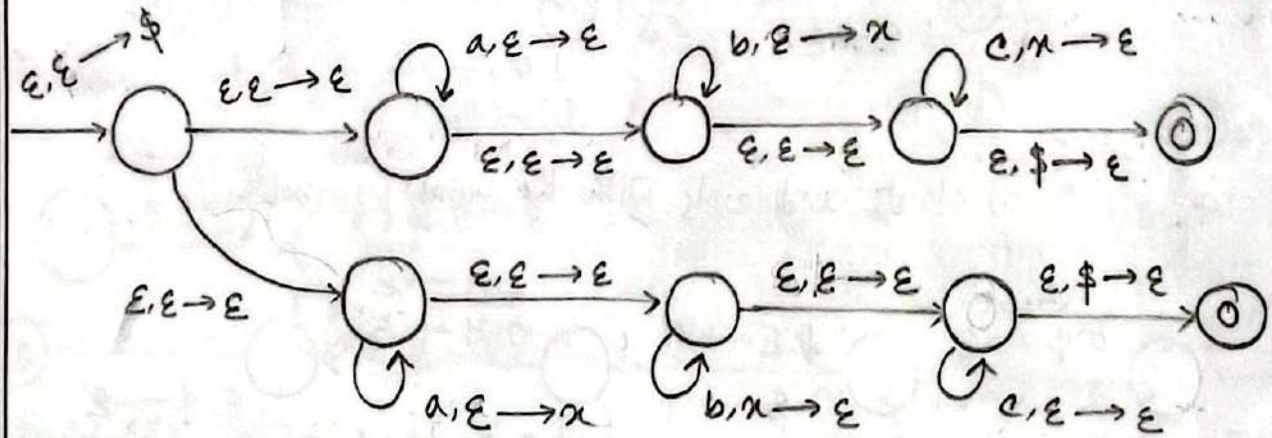
Subject : Date :

Problem: $A = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i = j \text{ and } i = k\}$



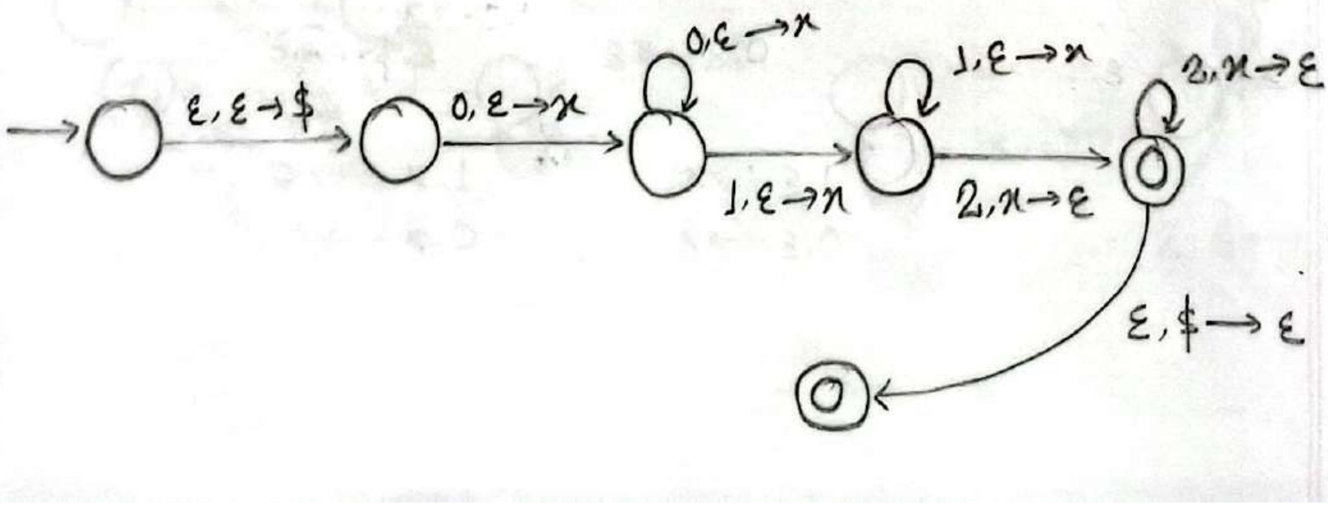
Problem:

$A = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i = j \text{ and } j = k\}$



Problem:

$A = \{0^i 1^j 2^k \mid i + j \geq k \text{ and } i, j, k \geq 0\}$



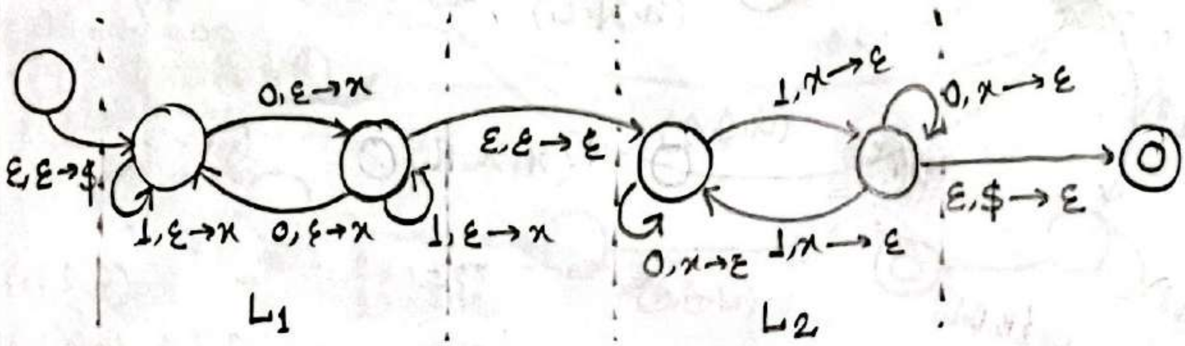
Subject: Date:

Problem:

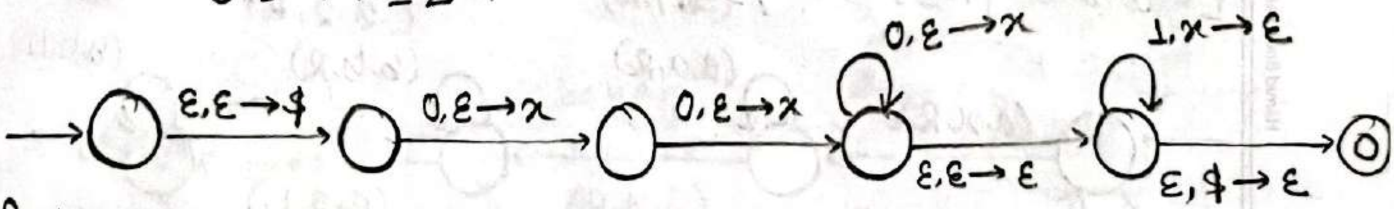
$L_1 = \{ w \in \Sigma^* : w$ contains odd number of zero$\}$

$L_2 = \{ w \in \Sigma^* : w$ contain even number of ones$\}$

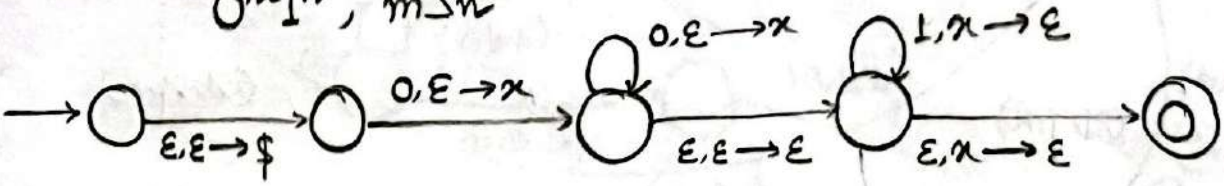
$L = \{ w \in \{0,1\}^* : w = uv$, where $u \in L_1$ and $v \in L_2$, $|u| = |v| \}$



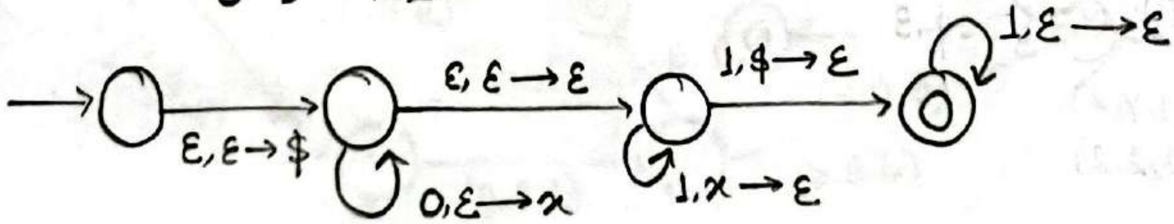
Problem: $0^n 1^n$, $n \geq 2$



Problem: $0^m 1^n$, $m > n$



Problem: $0^m 1^n$ $m < n$

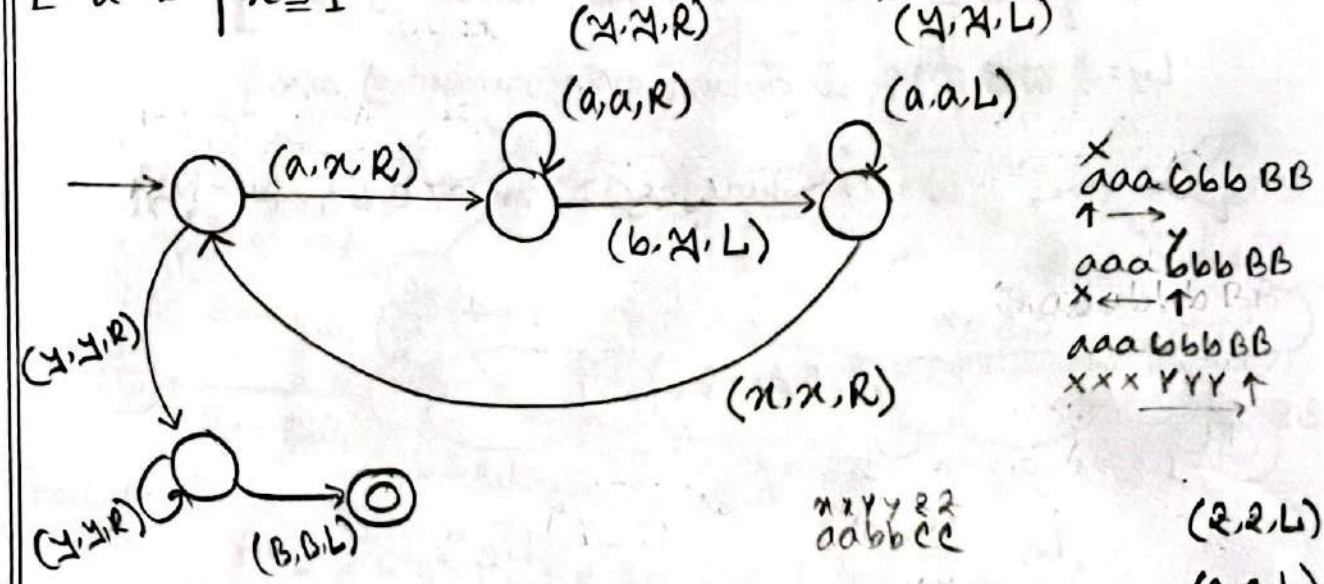


Subject :

Date :

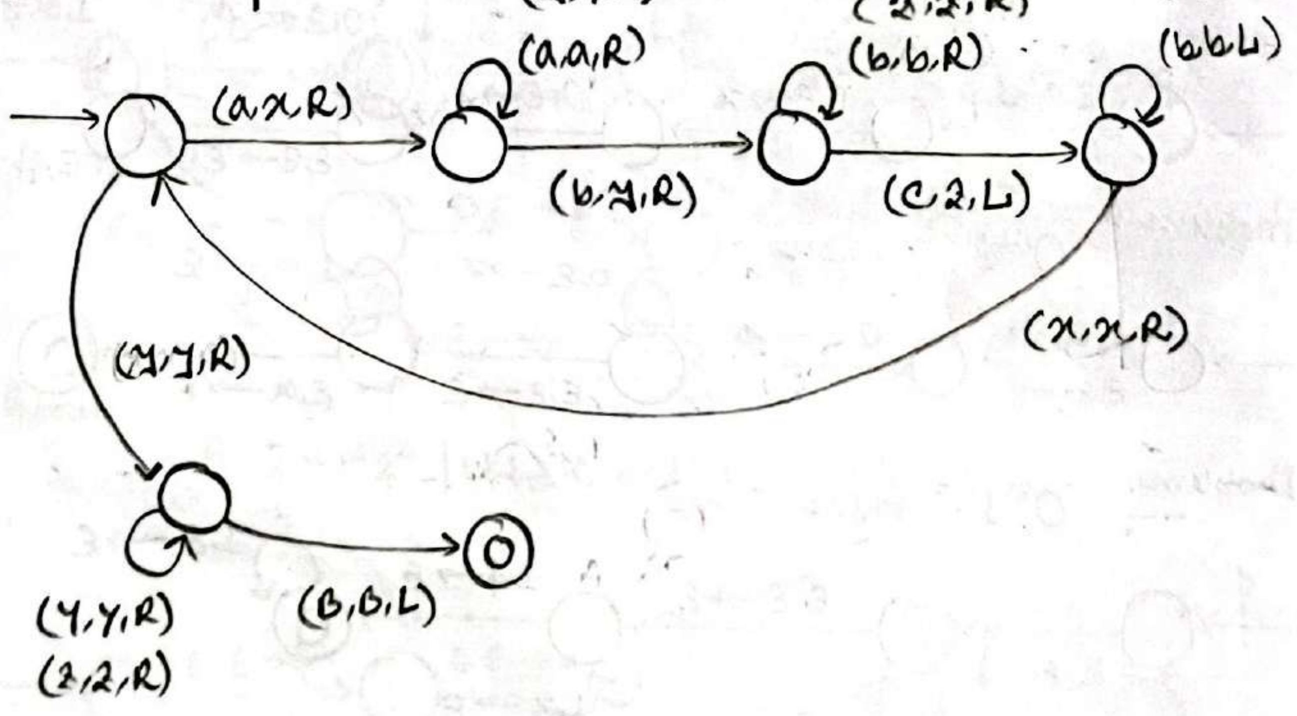
Turing Machine

$L = a^n b^n \mid n \geq 1$



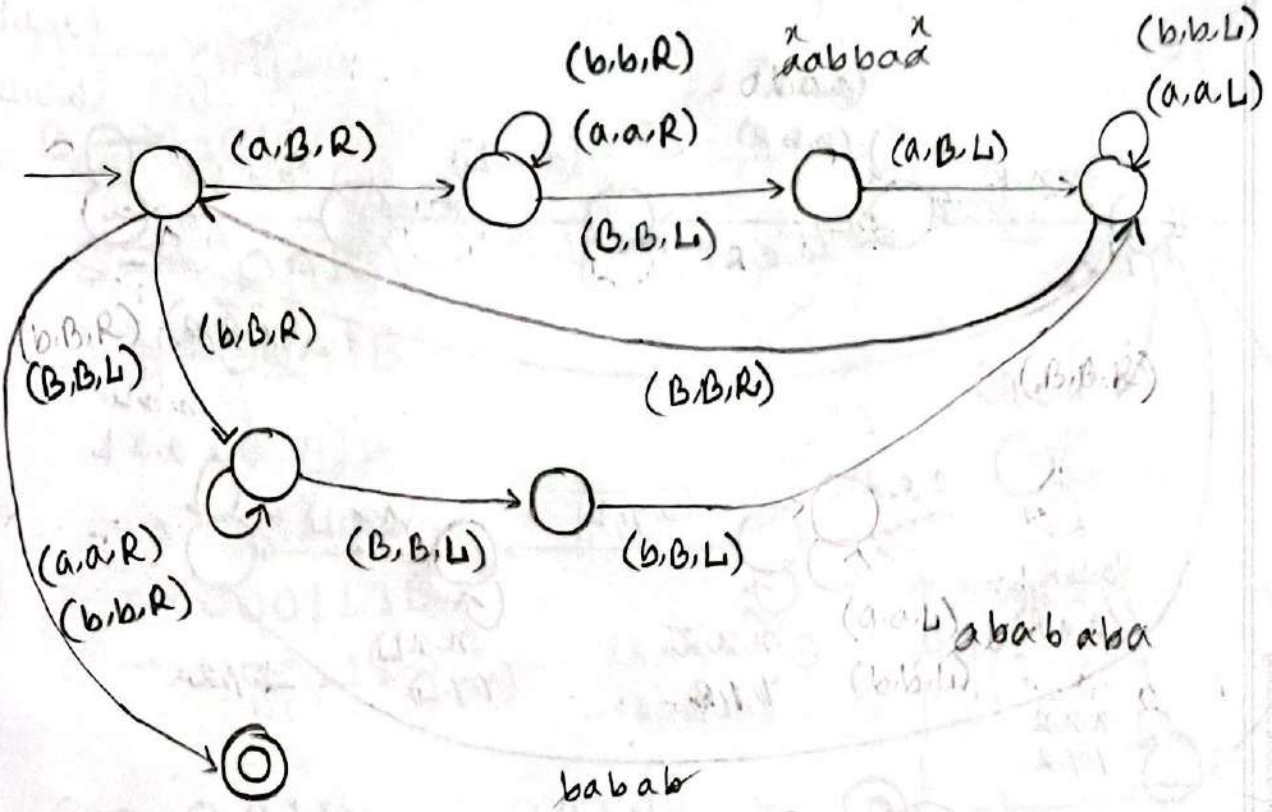
xxyyzz
aabbcc

$L = a^n b^n c^n \mid n \geq 1$



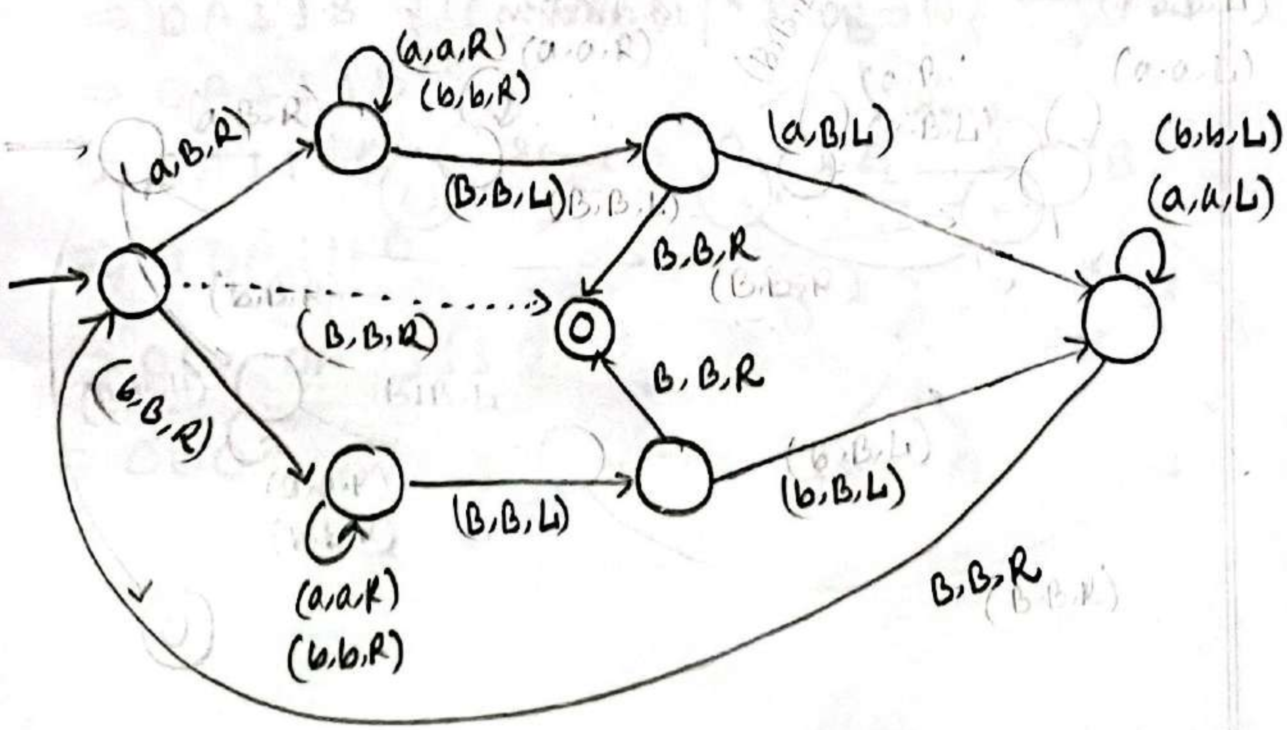
Subject :	Date :

L = WW^R W ∈ {a,b} Even



L = WaW^R [Odd]

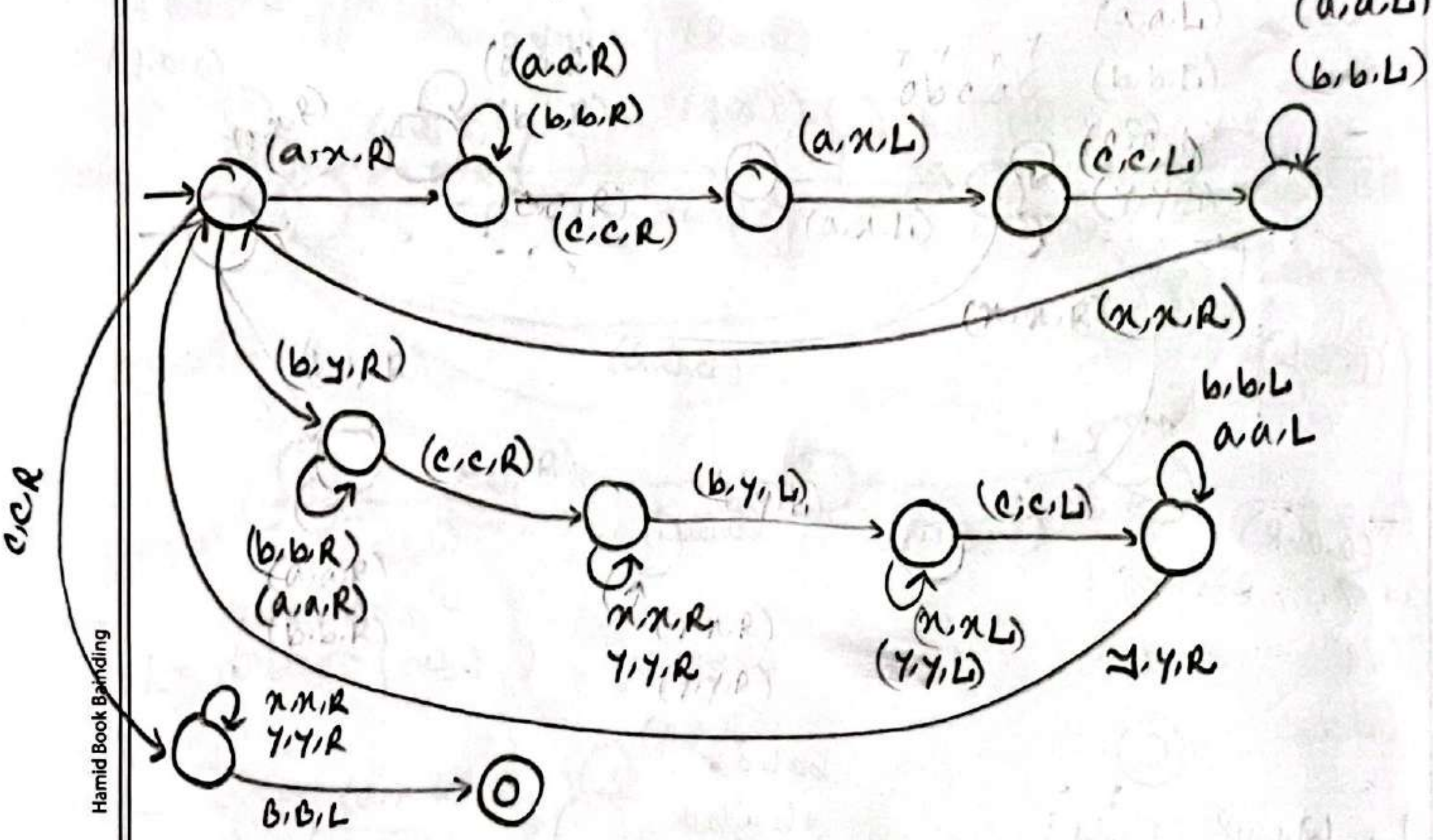
babab
ababa



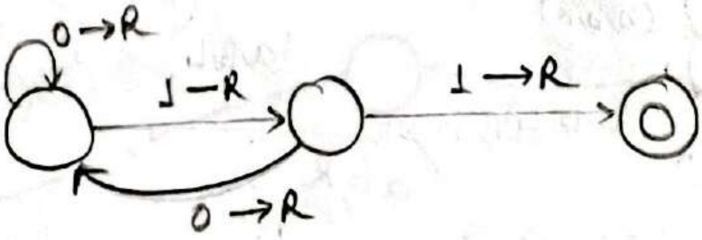
Subject:

Date:

$L = wcw \mid w \in \{a,b\}^*$



$L(M) \longrightarrow \{w \in \{0,1\}^* \mid w \text{ contains } 11\}$



Subject :

Date :

0001110

$S \rightarrow 0A1B$

$A \rightarrow 0A|1$

$B \rightarrow 1B|0$

left

$S \Rightarrow 0A1B$

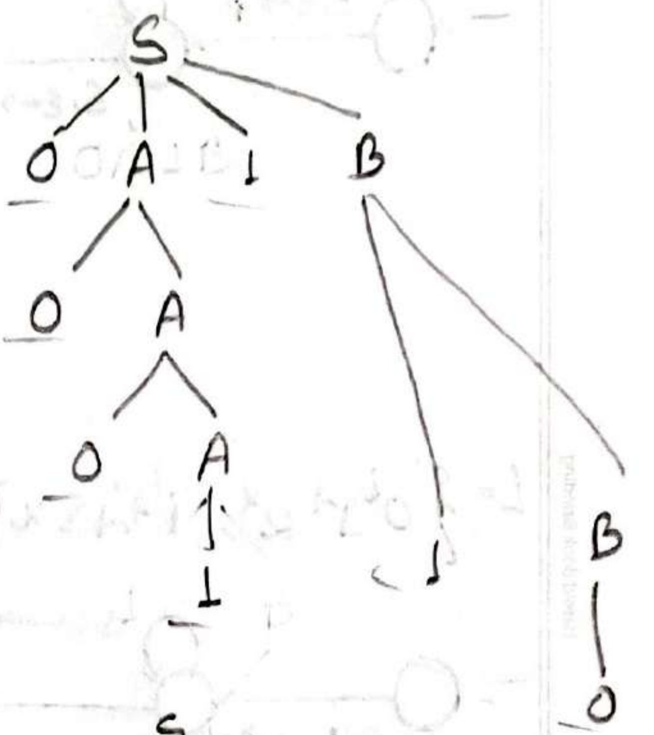
$\Rightarrow 00A1B$

$\Rightarrow 000A1B$

$\Rightarrow 00011B$

$\Rightarrow 000111B$

$\Rightarrow 0001110$



$S \Rightarrow 0A1B$ 0A1B

$\Rightarrow 0A11B$

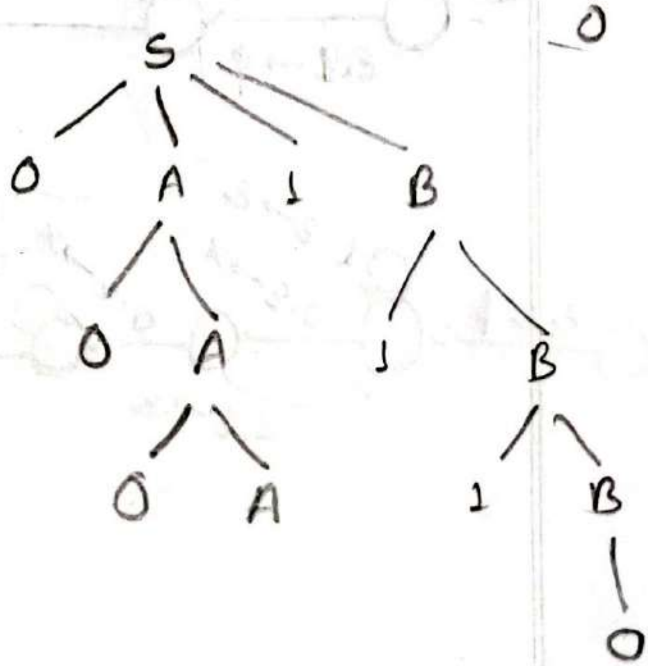
$\Rightarrow 0A111B$

$\Rightarrow 0A1110$

$\Rightarrow 00A1110$

$\Rightarrow 00\ 0A\ 1110$

$\Rightarrow 000$

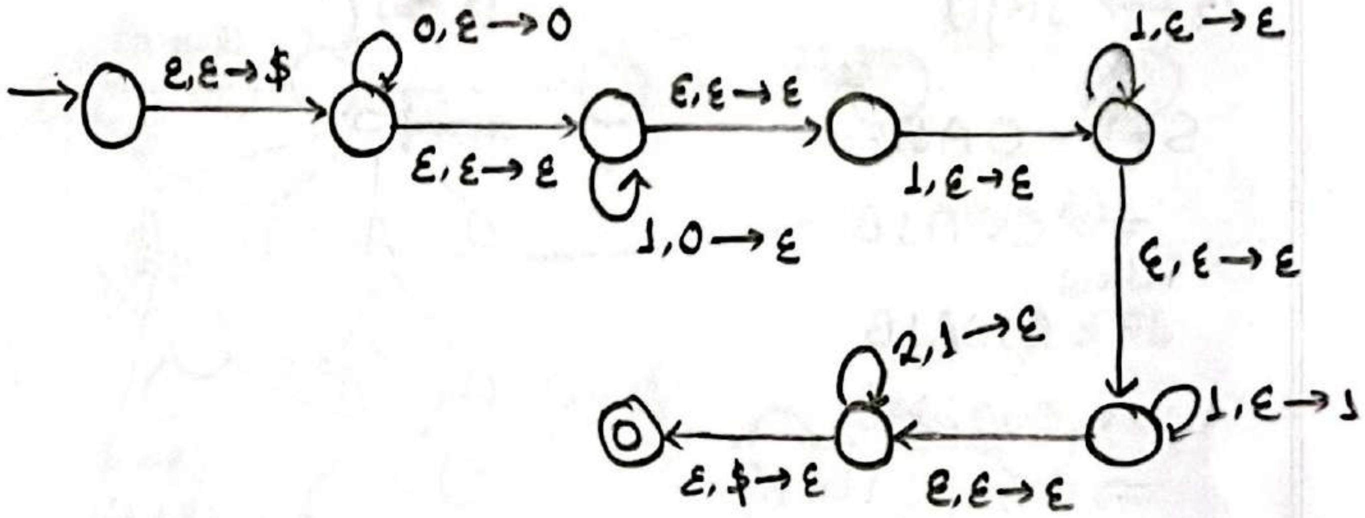


Subject :

Date :

PDA

$L = \{ 0^i 1^j 2^k ; \ j \geq i+k \}$



$L = \{ 0^i 1^j 2^k , \ i+j \geq k \}$