Conversion of Mealey machine to Moore machine and vice-versa in form of tables.

	I=0 Next	I=0 O/P	I=1 Next	I=1 O/P
$\rightarrow q_0$	q_1	0	q_2	1
q_1	q_2	0	q_3	1
q_2	q_3	0	q_1	0
q_3	q_0	1	q_2	0

Mealey Machine

इस table को transition [illegible] द्वारा हैं।

इस table में q_2 का entries है।

State	O/P	i=0	i=1
$\rightarrow q_0$	1	q_1	q_{21}
q_1	0	q_{20}	q_{31}
q_{20}	0	q_{30}	q_1
q_{21}	1	q_{30}	q_1
q_{30}	0	q_0	q_{20}
q_{31}	1	q_0	q_{20}

Moore Machine

NOTE:-

Mealey Machine $\left\{ \begin{array}{l} n \text{ states} \\ m \text{ outputs symbols} \end{array} \right\}$ $\Rightarrow$ Maximum states in Moore $\boxed{n \times m}$

NOTE -

For the given n length input sequence output length produced by Moore is $n+1$.

For the given n length input sequence output length produced by Mealey is n

Cases

State	O/P	i=0	i=1
→ A	b	B	A
B	b	B	C
C	a	B	A

Moore Machine

	I=0		I=1	
	Next	O/P	Next	O/P
→ A	B	b	A	b
B	B	b	C	a
C	B	b	A	b

Mealey Machine

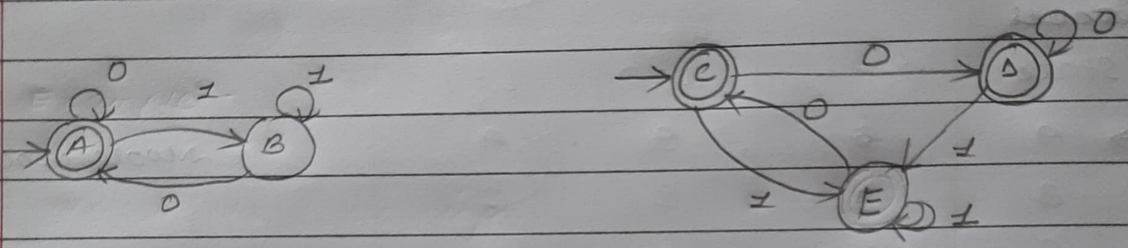
O/P associated with B in Moore table

17-06-21

DECISION PROPERTIES OF FINITE AUTOMATA
(Decidable Problems of Finite Automata)

[1] Equivalence Problem - Two FAs accepts same language (or) not?

Q. verify following two automata accepts same language or not.

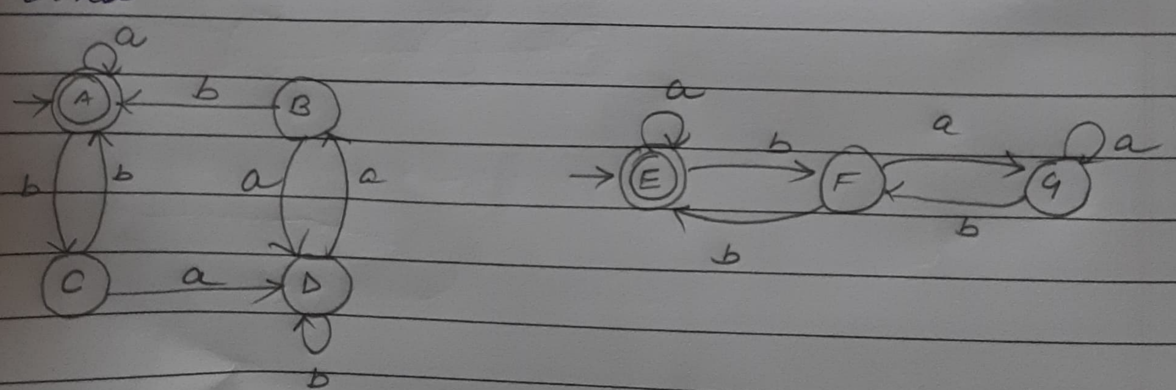


comparison table

States	0	1
(A, C)	(A, D)	(B, E)
(A, D)	(A, D)	(B, E)
(B, E)	A, C	(B, E)

यदि दोनों Final हैं या फिर दोनों Non-final हैं, तो चलेगा।
यदि (F, NF) तो Equivalence नहीं है।

Q. verify following two automata accepts same language or not.

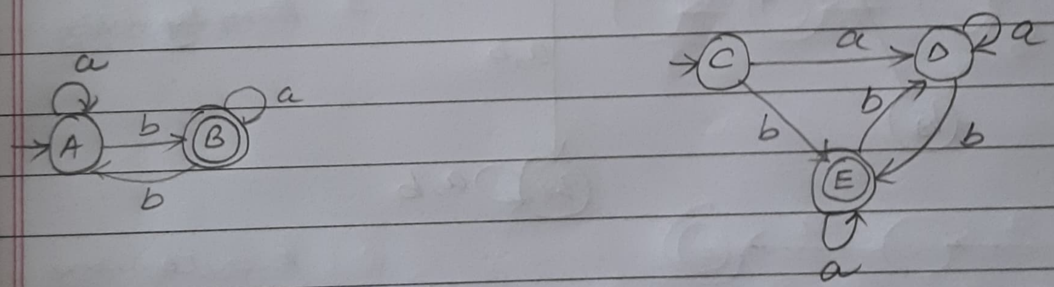


Comparison table

States	a	b
(A, E)	(A, E)	(C, F)
(C, F)	(D, G)	(A, E)
(D, G)	(B, G)	(D, F)
(B, G)	(D, G)	(A, F) → (F, NF)

NO equivalence.
Doesnot accept the Same language

Q. verify following two automata accepts same language or not.



aaabbba
aaa bbb

Comparison table.

accepts same language

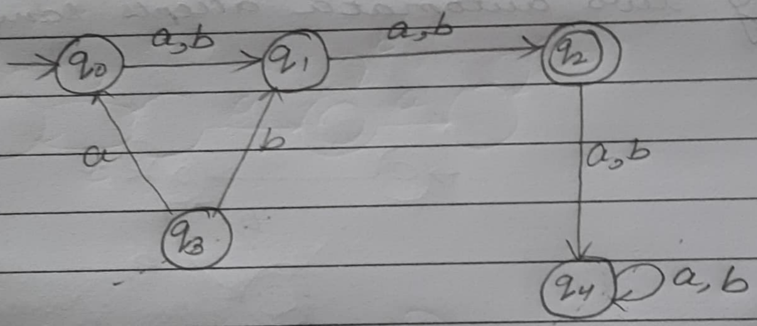
States	a	b
(A, C)	(A, D)	(B, E)
(A, D)	(A, D)	(B, E)

[2] Finiteness Problem - Language accepted by the language is finite or not.

Algorithm -

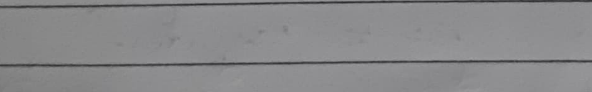
a) Eliminate all inaccessible states.
b) Eliminate the states from which we can't reach final state.
c) Resultant finite Automata contains loop or cycle then automata accepts infinite language.

Example:-

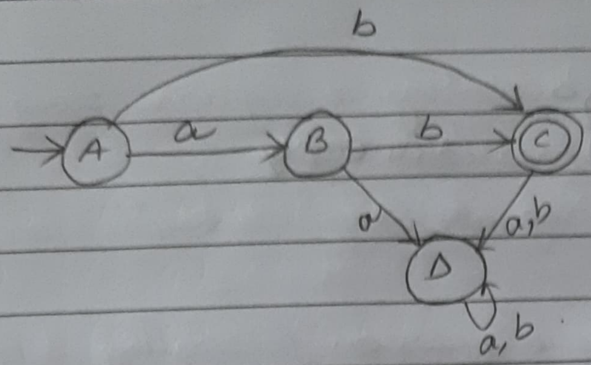


1) Remove q_3
2) Remove q_4
3) No loop or cycle

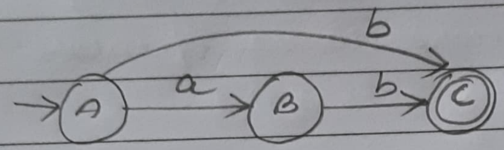
$\Rightarrow$ finite



Example -

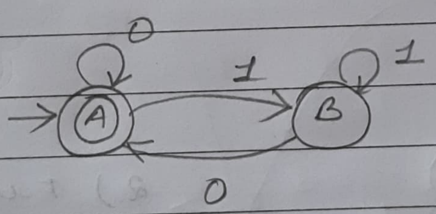


Remove D



Finite ✓

Example -



Infinite

[3] Emptyness Problem -

$L_1 = \{\ \}$ Empty language

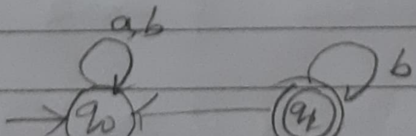
$L_2 = \{\epsilon\}$ Finite language

Algorithm -

STEP 1 - Eliminate all inaccessible states

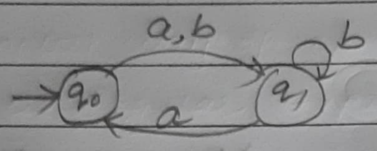
STEP 2 - Resultant automata contains atleast one final state then it accepts non-empty language.

Example -



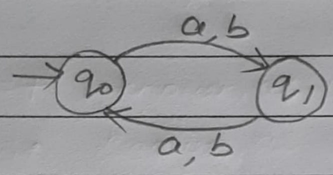
Empty

Example-



Non-empty

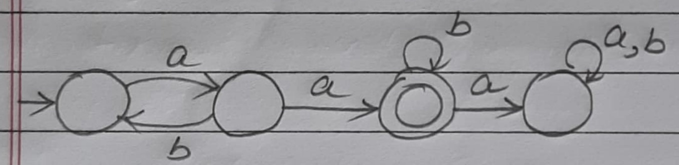
Example-



Empty

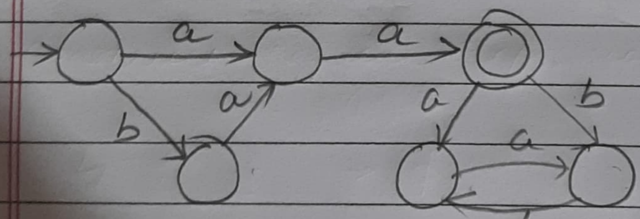
Q. Match the following

A)



1. Empty language

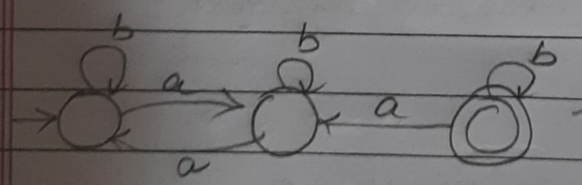
B)



2) Finite language

3) Infinite language

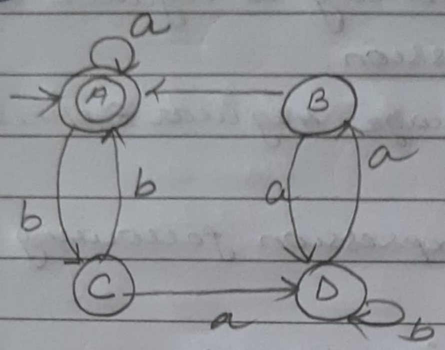
C)



{A-3, B-2, C-1}

[4] Membership Problem - String accepted or not.

Example -



String - baab
accepted

Hence, member

17-06-21

* REGULAR EXPRESSION

1) The simplest way of representing a regular language is known as Regular Expression.
2) For every regular language regular expression can be constructed
3) To construct regular expression following 3 operators are used:-

Lowest precedence (OR) + known as union operator

(and) $\cdot$ known as concatenation operator

$*$ known as kleene closure operator

Highest precedence $(a+b)^* = (a+b)^0 + (a+b)^1 + (a+b)^2 + \ldots$

NOTE-

\# For one regular language many no. of regular expressions can be possible.

\# One regular expression can generate only one regular language.

18-06-21

Q Construct Regular Expressions for the following languages.

$L_1 = \{ \ \} \rightarrow \phi$

$L_2 = \{ \epsilon \} \rightarrow \epsilon$

$L_3 = \{ a \} \rightarrow a$

Basic Regular Expressions

$L_4 = \{ a, b \} \rightarrow a+b$

$L_5 = \{ a, aa, aaa, \ldots \} \rightarrow a^+$

$L_6 = \{ \epsilon, a, aa, aaa, \ldots \} \rightarrow a^*$

classmate

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$L_1 = \{a^n b^m \mid n<m\}$ Not Regular (comparison exists)

$L_2 = \{a^n b^m \mid n,m \geq 0\} = a^* b^*$

$L_3 = \{a^n b^m \mid n \geq 3, m \geq 2\} = aaaa^* bbb^*$

or $aaa^+ bb^+$

$L_4 = \{a^n b^m \mid n \neq m\}$ Not Regular (comparison exists)

$L_5 = \{a^n b^m \mid n>m \text{ and } n<m\} = \{\phi\}$

$m>n$ and $m<n$ Empty language

ϕ

$L_6 = \{a^n b^m \mid (n>m) \text{ or } (n<m)\}$ Not Regular

$n \neq m$ same as L_4

$L_7 = \{a^n b^m \mid n \geq m \text{ and } n \leq m\}$ Not Regular

$n=m$

$L_8 = \{a^n b^m \mid n \geq m \text{ (or) } n \leq m\} = a^* b^*$

$\{aab, abb, aabb \ldots\}$

$L_9 = \{a^n b^m \mid (n+m) \text{ is even}\}$

a is even and b is even

or

a is odd and b is odd

$= \underbrace{(aa)^* (bb)^*}_{\text{Even as and bs}} + \underbrace{a(aa)^* b(bb)^*}_{\text{odd as and bs}}$

$L_{10} = \{ a^n b^m \mid (n+m) \text{ is odd} \}$

a and b either should be odd

$= \underbrace{a(aa)^*(bb)^*}_{\text{odd as even bs}} + (aa)^* b(bb)^*$

odd as even bs — even as odd bs

✗ $L_{11} = \{ 1, 2, 4, 8, 16 \ldots\ldots 2^n \ldots\ldots \}$
all these numbers written in binary

$= 0^* 1 0^*$

✗ $L_{12} = \{ 1, 2, 4, 8, \ldots\ldots 2^n \ldots\ldots \}$
all these numbers written in unary

Example : $\Sigma \{1\}$ $1 \to 1$ $4 \to 1111$
$2 \to 11$

NO common difference
Hence, not regular

Q. For which of the following languages Regular Expression is possible?

(A) $L = \{ a^p \mid p \text{ is a prime no.} \}$

(B) $L = \{ a^{2^n} \mid n \geq 1 \}$

(C) $L = \{ a^{n^n} \mid n \geq 1 \}$

✓ (D) $L = \{ a^k \mid k \text{ is odd numbers} \} = a(aa)^*$

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*Q For which of the following Regular Expression is possible.

(a) $L = \{ a^p \mid p \text{ is a Prime number} \}$

(b) $L = \{ a^p \mid p \text{ is product of two prime numbers} \}$

✓(c) $L = \{ (a^p)^* \mid p \text{ is a Prime number} \}$

$\downarrow$

(d) none. $(a^2)^* \Rightarrow \epsilon, a^2, a^4, a^6$

ϵ
$a^2\ a^3\ a^4$
$a^5\ a^6$

$\therefore\ = \boxed{\epsilon + a \cdot a^*}$

*Q. For which of the following regular expression is possible.

(a) $L = \{ a^{n^2} \mid n \geq 1 \}$

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

✓(c) $L = \{ a^{m^n} \mid m > n,\ n \geq 1 \}$ Regular

(d) $L = \{ a^{2^n} \mid n \geq 1 \}$

$\{a^{m^1}\} = \{ a^{2^1}, a^{3^1}, a^{4^1}, a^{5^1}, \ldots \}$ $a a^+$

$\cup$

$\{a^{m^2}\} = \{ a^{3^2}, a^{4^2}, a^{5^2} \ldots \}$ these 2 would obviously be in the first set

$\cup$

$\{a^{m^3}\} = \{ a^{4^3}, a^{5^3}, a^{6^3} \ldots \}$

hence, $a a^+$

$\therefore$ Regular Expression $\Rightarrow a \cdot a^+$

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Q. Construct a regular expression that generates set of all even length palindrome strings over $\{a\}$.

$$(aa)^* = \{\epsilon, aa, a^4, a^6 \ldots\}$$

Q. Construct a regular expression that generates set of all odd length palindrome strings over $\{a\}$

$$a(aa)^* = \{a, aaa, a^5 \ldots\}$$

Q. Construct regular expression that generates set of all even length palindrome strings over $\{a, b\}$.

$\{\epsilon, abba, aa, bb, baab, aaaa \ldots\}$

NOTE -

1. Palindrome languages over more than one symbol are not regular. Hence regular expression not possible.
2. Palindrome languages over one symbol are regular.

$\therefore$ $L = \{WW^R \mid W \in \{a,b\}^*\}$
CFL, not regular

Q. Construct regular expression that generates set of all length palindrome strings of Hindi Language.

NOT POSSIBLE - NOT A REGULAR LANGUAGE

classmate

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Q. Construct Regular expression for the following language.

$L_1 = \{ ww^R \mid w \in \{a\}^* \} = (aa)^*$

Even length Palindrome $\{ \epsilon, aa, a^4, a^6, a^8 \ldots \}$

$L_2 = \{ wbw^R \mid w \in \{a\}^* \}$ = NOT POSSIBLE

Deterministic CFL $\{ b, aba, aabaa, a^3ba^3 \ldots \}$

a^*ba^* {Not possible}
a^2ba also included

$L_3 = \{ wxw^R \mid w \in \{a,b\}^* \}$ = NOT POSSIBLE

Deterministic CFL $\{ x, abxba \quad \}$

compare

$L_4 = \{ wxw^R \mid w, x \in \{a,b\}^* \} = (a+b)^*$

Regular

why?

↓

If $w = \epsilon$, $w^R = \epsilon$

$\{x\} = (a+b)^*$

$L_5 = \{ ww^R x \mid w, x \in \{a,b\}^* \} = (a+b)^*$

If $w = \epsilon$, $w^R = \epsilon$

$\{x\} = (a+b)^*$ Superset

$L_6 = \{ ww^R x \mid w \in \{a,b\}^* \}$ = NOT POSSIBLE

CFL

$L_7 = \{ wxw^R \mid w, x \in \{a,b\}^+ \}$

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

$= a(a+b)^+a +$
$b(a+b)^+b$

$\{ \underset{w}{a}\underbrace{babaaaaaabab}_{x}\underset{w^R}{a} \}$

$L_8 = \{ wxw^R \mid w \in \{a+b\}^+ \}$ = NOT POSSIBLE

DCFL

Palindrome Problem

$L_9 = \{ ww \mid w \in \{a,b\}^* \}$ = NOT POSSIBLE

CSL

$\{ \epsilon, aa, abab, abbabb \}$

$L_{10} = \{ ww \mid w \in \{a\}^* \} = (aa)^*$

$\{ \epsilon, aa, aaaa, a^6 \ldots \}$

$L_{11} = \{ wxw \mid w \in \{a\}^* \}$ = NOT POSSIBLE

DCFL

$\{ x, axa, aaxaa \ldots \}$

$L_{12} = \{ wxw^R \mid w \in \{a,b\} \}$

$axa + bxb$

$L_{13} = \{ wxw \mid w, x \in \{a,b\}^* \} = (a+b)^*$

If $w = \epsilon$

$\{ x \} = \{ a+b \}^*$

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Properties of Regular Expression

1. $R+\phi = \phi+R = R$

Treat $\phi = 0$
$\epsilon = 1$

2. $R\cdot\phi = \phi\cdot R = \phi$

3. $R+\epsilon = \epsilon+R \neq R$

4. $R\cdot\epsilon = \epsilon\cdot R = R$

5. $(R^*)^* = (R^*)^+ = (R^+)^* = R^*$

6. $R\cdot R^* = R^+ = R^* R$ $\overset{R^*=}{\{\epsilon, R, RR \}}\cdot\{R, RR, R\} = R^+$ $\{\epsilon R = R\}$

7. $\epsilon^* = \epsilon$

8. $\epsilon^+ = \epsilon$

9. $\phi^* = \epsilon$

10. $\phi^+ = \phi$

11. $(a+b)^* \neq a^* b^*$

12. $(a+b)^* \neq a^* + b^*$

13. $a(ba)^* = (ab)^* a$

14. $(a+b)^* = (a+b^*)^* = (a^*+b)^* = (a^*+b^*)^* = (a^* b^*)^*$

15. $a^* + a^* = a^* = a^* a^*$

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16. $a+b=b+a$

17. $a.b \neq b.a$

18. $R+R=R$

19. $R.R \neq R$

20. $r_1(r_2+r_3) = r_1 r_2 + r_1 r_3$

Q. Consider the following regular expressions:

1. $(a^*+b)^*$
2. $(a^*b^*)^*$
3. $(a+b)^*$
4. $(a^*+b)^*$
5. $(a+b^*)^*$
6. $(b^*a+a^*b)^*$
7. $(a+ab)^*$ only b not possible
8. $(ba+ab)^*$ only a only b not possible

Which of the following is true?

(a) Only 1, 2, 3, 4 are equivalent

(b) all R Exp. except 6, 7, 8 are equivalent

(c) all except 8 are equivalent

✓ (d) all except 7 and 8 are equivalent

Q. The expression $a^*b^*(a^*b^*)^*$ is equivalent to which one?

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

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

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

✓ (d) $(a+b)^*$

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

$\epsilon\ \epsilon$

$(a+b)^*$

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Q Identify language accepted by following regular expression.

$$b^*(a^* \cdot \phi \cdot b + ab + a \cdot \phi^* b^*)(b+\phi)^*$$

(a) exactly one a

(b) atleast one a

(c) atmost one a

(d) none.

$$b^*[a^* \cdot \phi \cdot b + ab + a \cdot \phi^* b^*][b+\phi]^*$$

$$b^*[\phi + ab + ab^*][b]^*$$

$$b^*[ab + ab^*]b^*$$

$$b^*[a[b+b^*]]b^*$$

$$b^*[ab^*]b^*$$

$$b^* a b^*$$

Q. which of the following regular expressions are equivalent?

1. $(a+ba)^* (b+\epsilon)$ ϵ can be generated

2. $(a^*(ba)^*)^* (b+\epsilon) + a^*(b+\epsilon) + (ba)^* (b+\epsilon)$ ϵ generates

3. $(a+ba)(a+ba)^* (b+\epsilon)$ a minimum string

$(a+ba)^+ (b+\epsilon)$

a) 1 and 2 only b) 1 and 3 only

c) 2 and 3 only d) 1, 2 & 3.

use elimination.

(2) $(a^*(ba)^*)(b+\epsilon) + \boxed{a^*(b+\epsilon) + (ba)^*(b+\epsilon)}$

$(a+ba)^* (b+\epsilon)$

these both can be generated by this only

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Q. Which of the following Regular Expressions are equivalent?

(i) $(00)^* (\epsilon + 0)$ {Even, odd} zeros
(ii) $(00)^*$ Even zeros
(iii) 0^* {Even, odd} zeros
(iv) $0(00)^*$ Odd zeros

(a) (i) and (ii) (b) (ii) and (iii)
✓(c) (i) and (iii) (d) (iii) and (iv)

Q. Which of the following pair of regular expressions are not equal.

a) $(r^*)^*$ and $(r^+)^*$
b) $(r+\epsilon)^*$ and r^*
✓c) $(rr+\epsilon)^*$ and r^* Single r not generated
d) None of the above

Q. Which of the following represents binary strings with no two consecutive zero's?

$r_1 = (0+\lambda)(1+10)^*$
$r_2 = (1+01)^*(0+\lambda)$
$r_3 = (1+\lambda)(0+01)^*$
$r_4 = (0+10)^*(1+\lambda)$

✓(a) r_1 and r_2 only (b) r_3 and r_4 only
(c) r_1, r_2, r_3 & r_4 (d) none.

Q $R_1 = 11(0+1)^*$ 110 110011 $\cap$

$R_2 = (0+1)^* 11$ 0011 110011

$R_3 = 11(0+1)^* 11 + 111 + 11$ ✓

which is true ?

a) $L(R_1) = L(R_2) = L(R_3)$

b) $L(R_1) \cup L(R_2) = L(R_3)$

c) $L(R_1) \subseteq L(R_3)$

✓ d) $L(R_1) \cap L(R_2) = L(R_3)$

R1 = Starting with 11 {110

R2 = Ending with 11 {011}

R_3 = Starting and ending with 11

classmate

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Finite Automata To Regular Expression

Q. Construct regular expression that generates all strings of 0's and 1's where

(i) lengths of the string exactly 4

$$(0+1)(0+1)(0+1)(0+1)$$

(ii) Number of 0s exactly 4

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

(iii) Length string atleast 3

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

(iv) ~~Leas~~ Number of 0's atleast 2

$$1^*01^*0(0+1)^* \text{ or } (0+1)^*0(0+1)^*0(0+1)^*$$

Q How many states in min DFA that accepts

(i) $(0+1)(0+1)(0+1)(0+1)(0+1) \Rightarrow$ 7 states

(ii) $0^*10^*10^*10^* \Rightarrow$ 5 states

exactly 3 ones

(iii) $(0+1)^*1(0+1)^*1(0+1)^*1(0+1)^* \Rightarrow$ 4 states

atleast 3 ones

(iv) $1^*(0+\epsilon)1^*(0+\epsilon)1^*(0+\epsilon)1^* \Rightarrow$ 5 states

atmost 3 0s

(v) $[(0+1)(0+1)]^*(0+1) \Rightarrow$ 2 states

odd length

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Q. Construct regular Expression that generates all strings over 0 and 1 where

1) Length of the string atmost 4

$$[0+1+\epsilon]^4$$

2) Number of 1's atmost 3

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

3) Length of the string even

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

4) Length of the string odd

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

5) Number of 0's divisible by 3

$$[1^*01^*01^*01^*]^* + 1^*$$

6) Each string having 000 or 111 substring

$$(0+1)^*(000+111)(0+1)^*$$

7) 4th input symbol is 0 from RHS

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

8) 5^{th} input symbol is 1 from LHS

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

Q. How many states in the minimal DFA.

1) $[0^*10^*10^*10^*10^*]^* + 0^*$ ⇒ 4 states
1's divisible by 4

2) $(0+1)^* 0 (0+1)(0+1)(0+1)$ ⇒ 2^4 ⇒ 16 states
Fourth i/p from RHS is 0

3) $(0+1)(0+1)(0+1)1(0+1)^*$ ⇒ $n+2$ ⇒ 6 states
Fourth from LHS is 1

4) $(0+1)^* 0101 (0+1)^*$ ⇒ $n+1 = 4+1$ ⇒ 5 states
Substring 0101

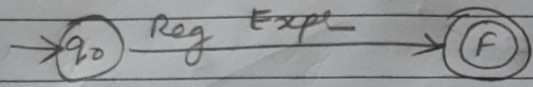
5) $(0+1)^* 0101$ ⇒ $n+1 = 4+1$ ⇒ 5 states
Ending with 0101

FINITE AUTOMATA TO REGULAR EXPRESSION

3 methods -

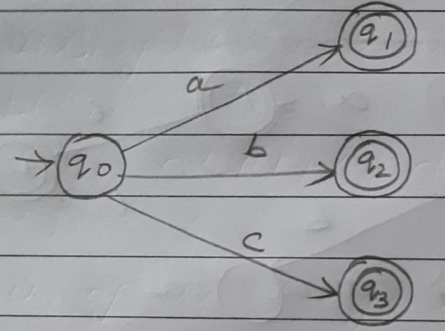
1) R_{ij}^{k} method
2) Arden's method
3) State elimination method

State Elimination method -

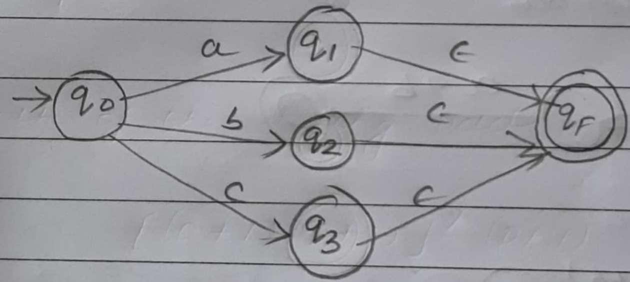


Example -

1)

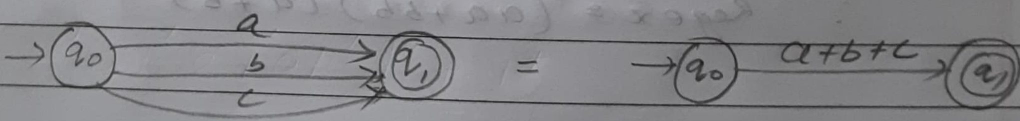


Since three final states.

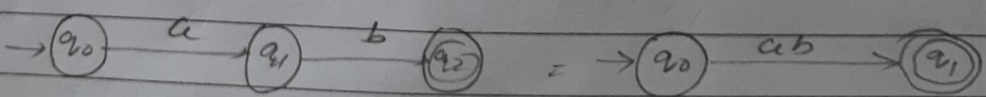


Converted to one initial one final

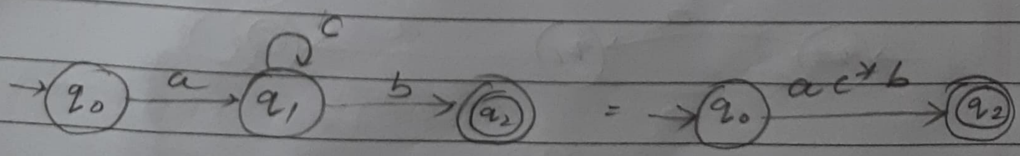
2) If



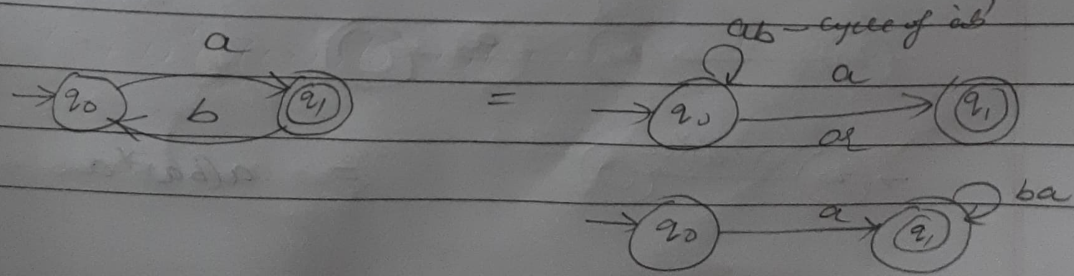
3) If



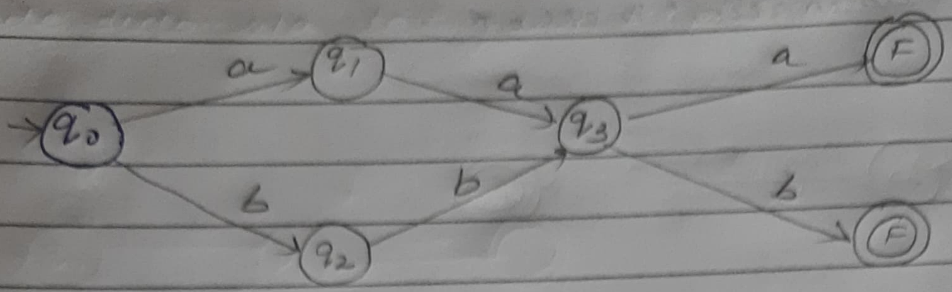
4) If

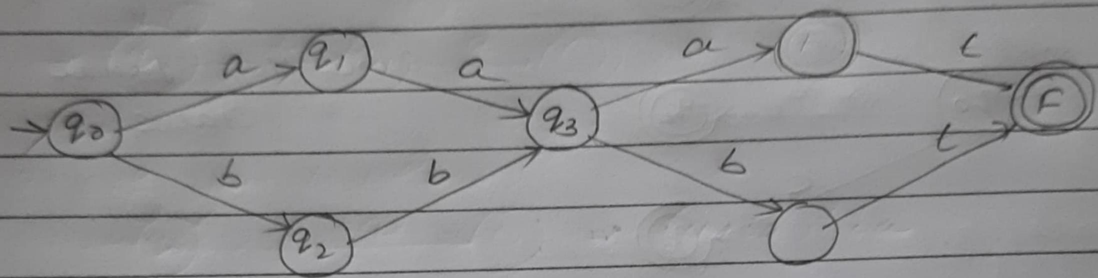


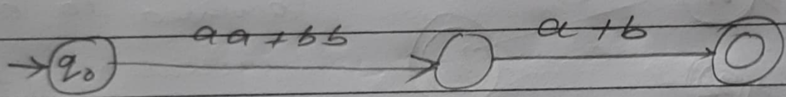
5) If

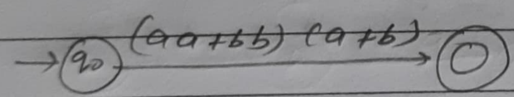


G.



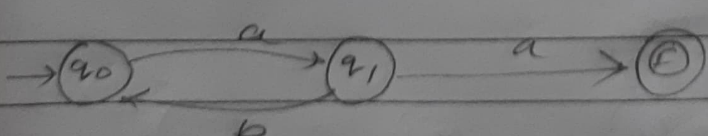


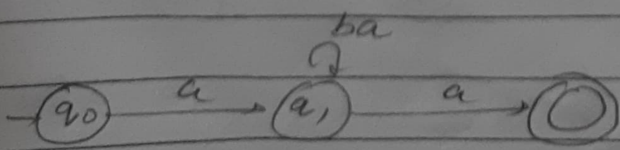


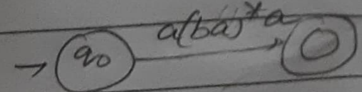


$\therefore$ Regex = $(aa+bb)(a+b)$

9.

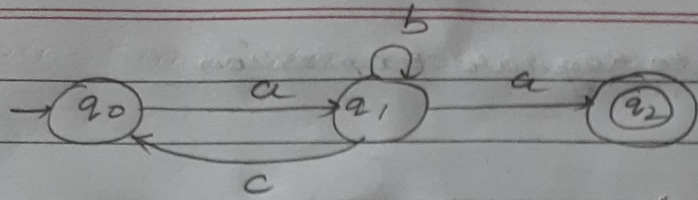






$= a(ba)^*a$

Q.



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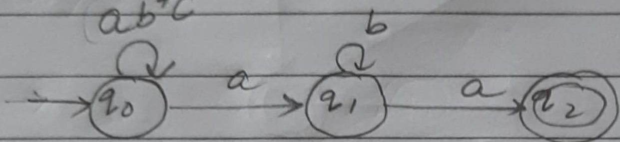
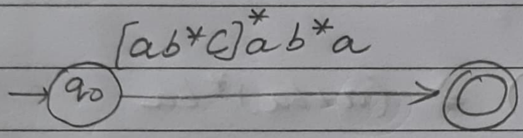
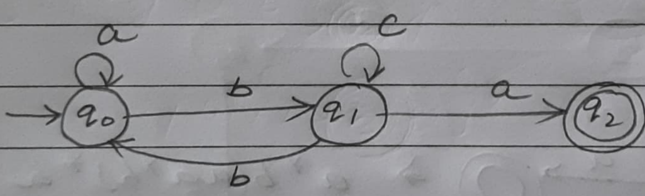




$= (ab^*c)^* ab^*a$

Q.



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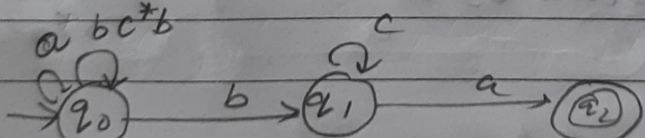
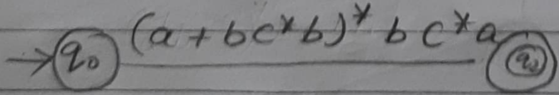


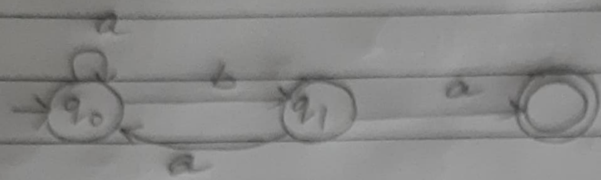


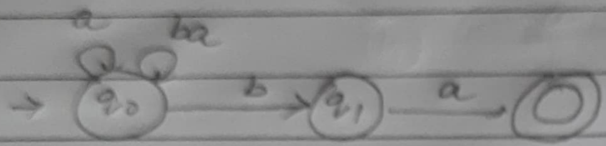
$= (a+bc^*b)^* bc^*a$

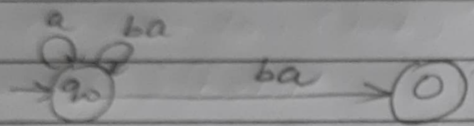
24-06-21

Finite automata to Regular Expression

Q.



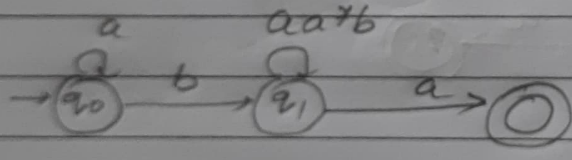




$\Rightarrow (a+ba)^* ba$

$= (a+ba)^* ba$

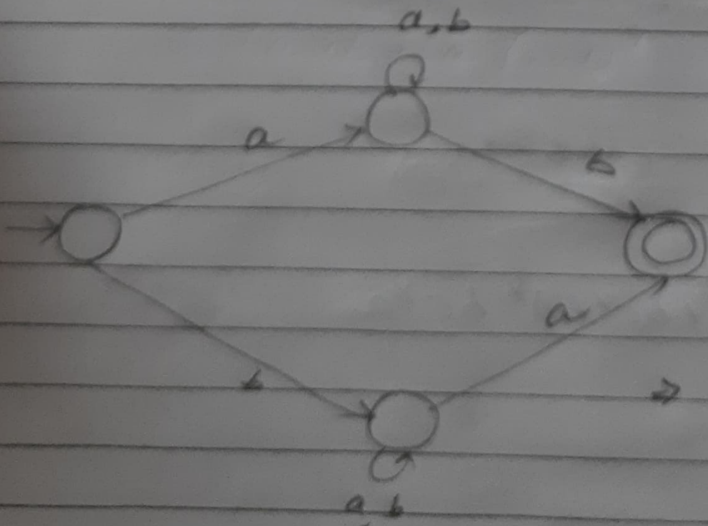
or



$\Rightarrow a^* b (aa^* b)^* a$

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

Q.



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

$+$

$b(a+b)^* a$

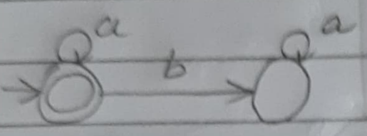
$\Rightarrow a(a+b)^* b + b(a+b)^* a$

classmate

Date ______
Page ______

Q. Match List 1 with List 2 and select the correct answer using codes given below:-

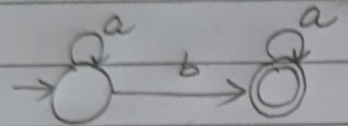
LIST I | LIST II

A) 

a^*

1. $(a+ba^*a)^*$

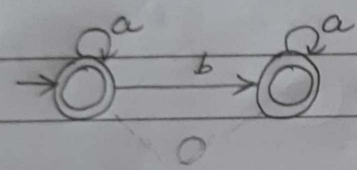
2. $a^*(\epsilon+ba^*)$

B) 

a^*ba^*

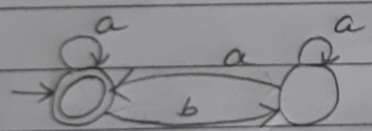
3. a^*ba^*

4. a^*

C) 

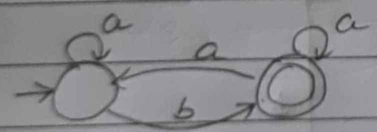
$a^*+a^*ba^*$

5. $(a+ba^*a)^*+a^*b(a+aa^*b)^*$

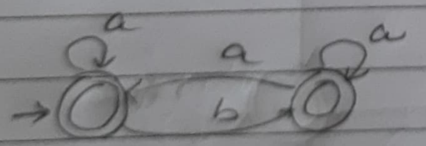
D) 

$(a+ba^*a)^*$

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

E) 

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

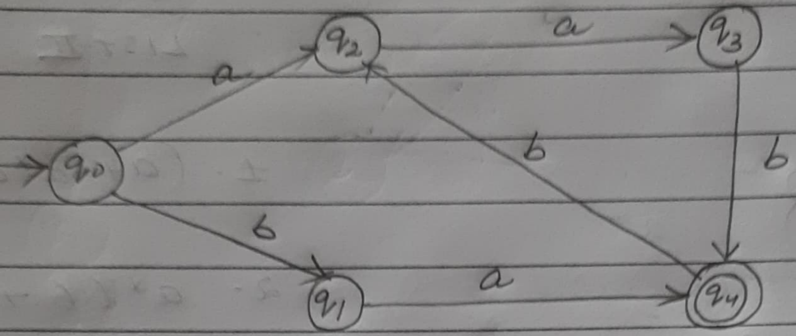
F) 

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

CODES :-

	A	B	C	D	E	F
(a)	1	2	3	4	5	6
(b)	4	3	2	1	6	5
(c)	4	3	2	6	1	5
(d)	4	3	1	2	5	6

Q. The language recognised by the following finite automata is

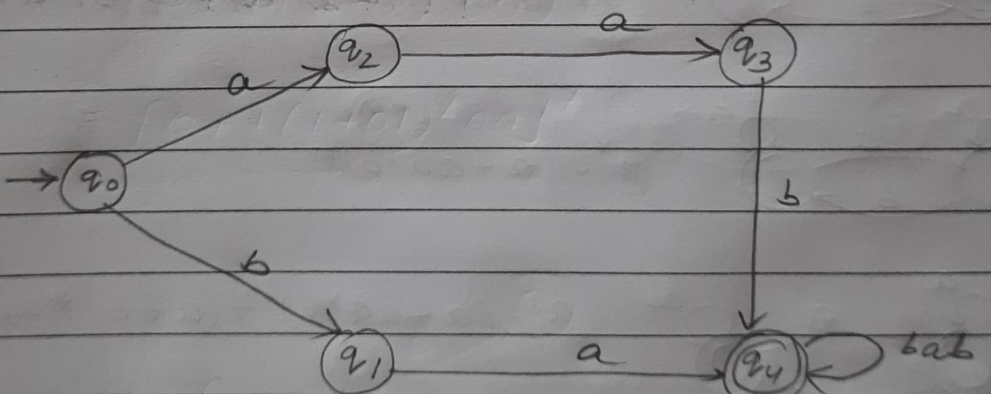


(a) $(aa+\epsilon)(b+ba)(bab)^*$ ×

✓(b) $(aab+ba)(bab)^*$

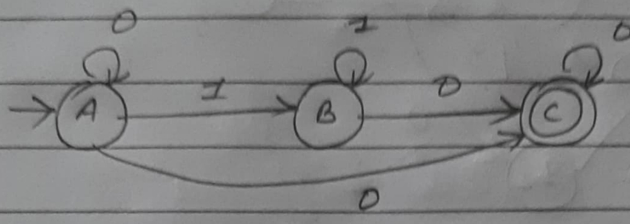
(c) $(aab)(bab)^*+(bab)^*$

(d) $(aab)(\epsilon+(bab)^*))^*$



$(aab+ba)(bab)^*$

Q. What is the language accepted by the following NFA?



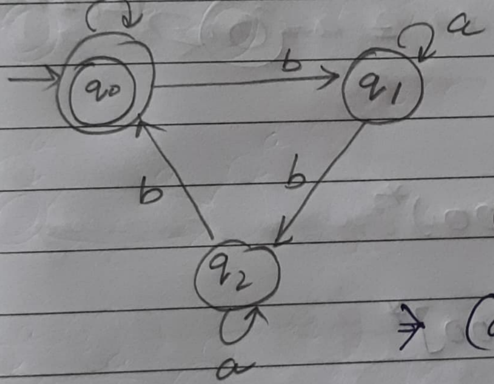
(a) $(0+1)^*0$ not accepting 01010

(b) $0^*1^*0^*$ Not accepting ϵ

✓(c) $0^*1^*0^*0$

(d) $(0+1)^+$ Not accepting 1

Q.

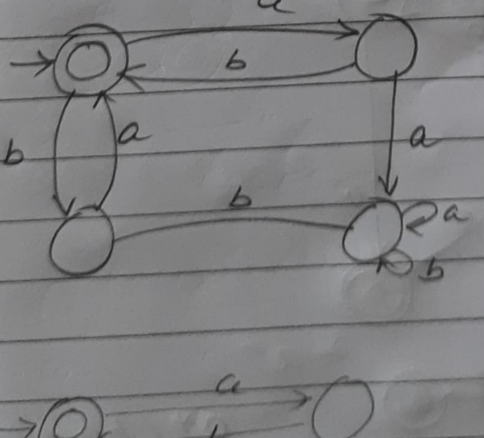


ba^*ba^*b

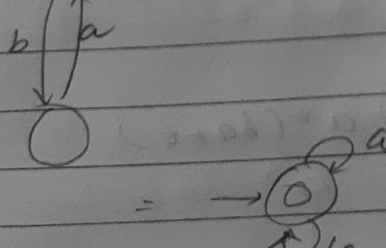
$(a+ba^*ba^*b)^*$

$\Rightarrow (a+ba^*ba^*b)^*$

Q.



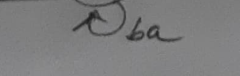
Remove deadstate



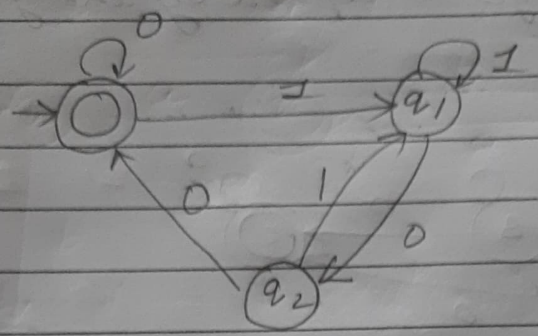
$(ab+ba)^*$

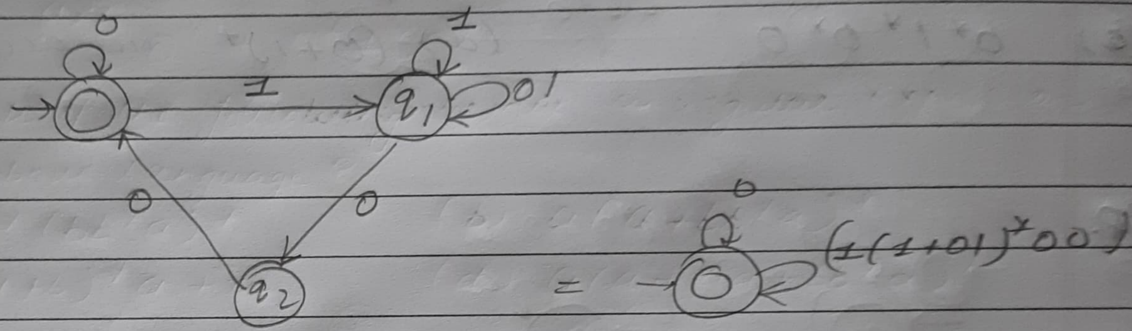
$= (ab+ba)^*$

=



Q.

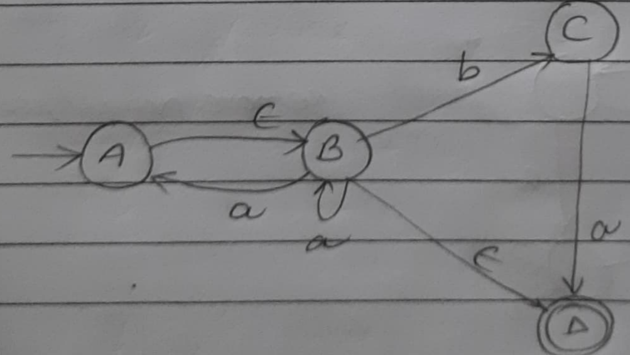


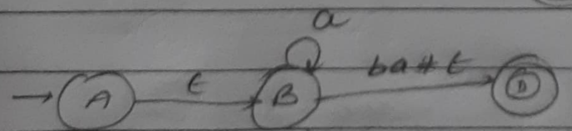


$(0+1(1+01)^*00)^*$

$= [0+1(1+01)^*00]^*$

Q

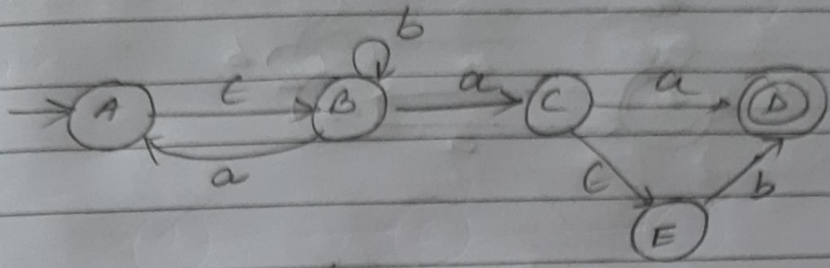


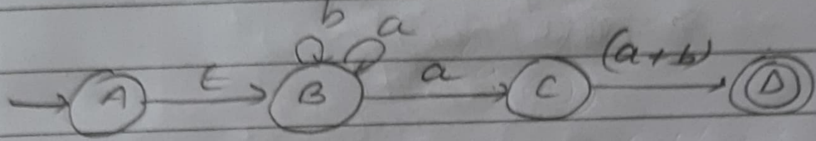


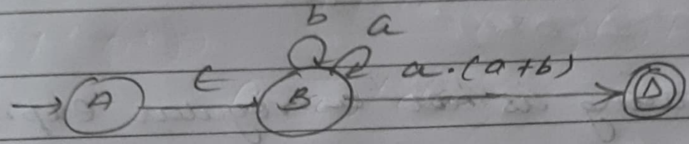
$a^*(ba+\epsilon)$

$= a^*(ba+\epsilon)$

Q.

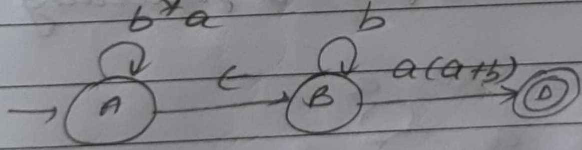






$$(b+a)^* a \cdot (a+b)$$

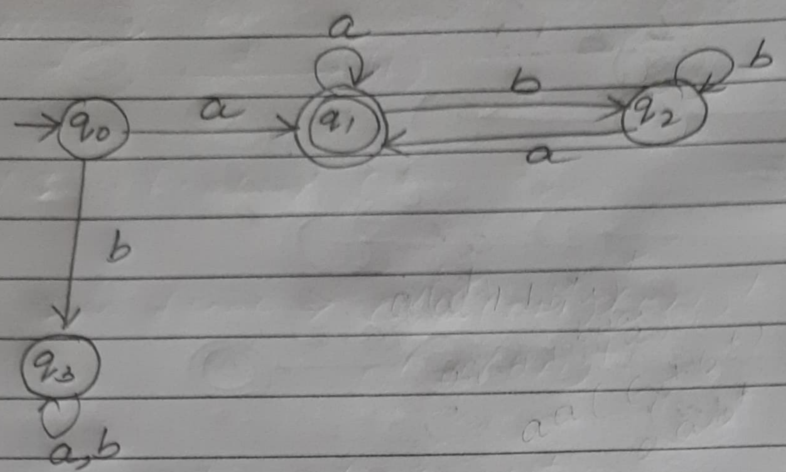
or



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

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

Q.



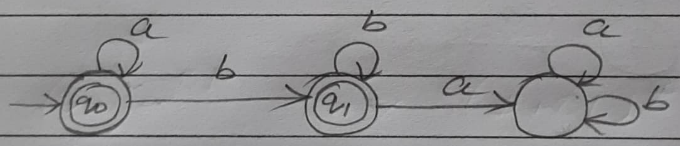
which of the following is not a regular expression for above language?

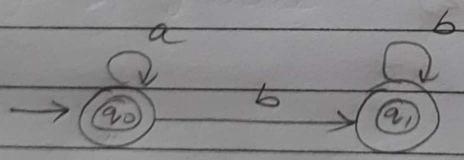
(a) $aa^*(bb^*a)^*$ (b) $a(a+bb^*a)^*$

(c) $a(a+b)^*a+a$ (d) $a(a+aa+bb^*a)^*$

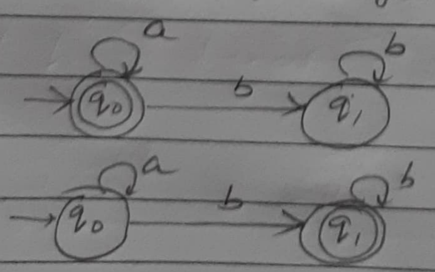
25-06-21

Q. Construct Regular Expression for the following automata





assume q_0 is final



$\Rightarrow a^*$

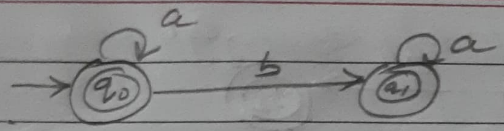
$+$

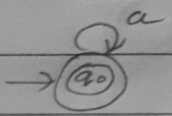
$\Rightarrow a^*bb^*$

$a^* + a^*bb^*$

$a^*(\epsilon + bb^*) = a^*(\epsilon + b^+) = a^*b^*$

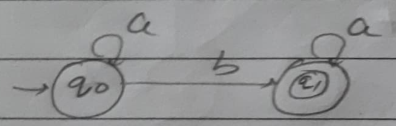
Q.





$\Rightarrow a^*$

$+$



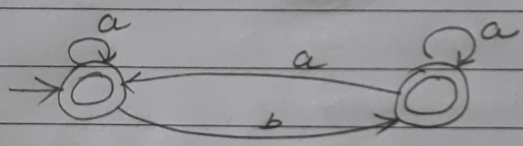
$\Rightarrow a^*ba^*$

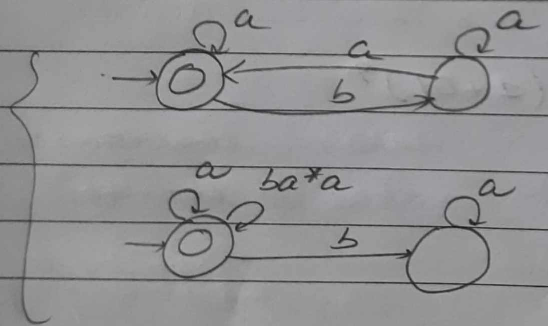
$a^* + a^*ba^*$

$a^*(\epsilon + ba^*)$

$\Rightarrow a^*(\epsilon + ba^*)$

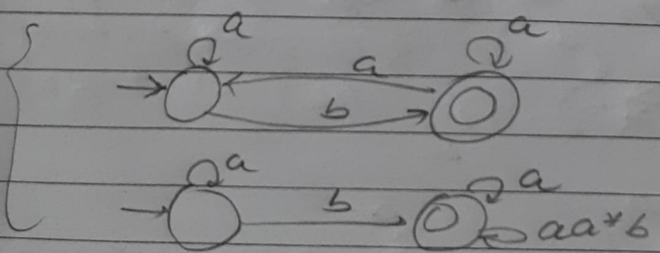
Q





$(a+ba^*a)^*$

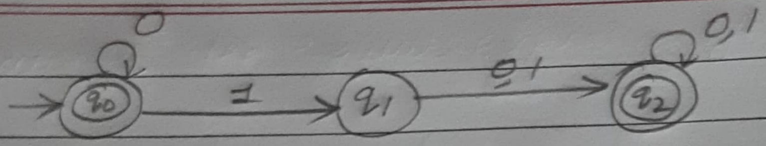
$+$



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

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

Q.



If q_0 is final $\Rightarrow$ 0^*

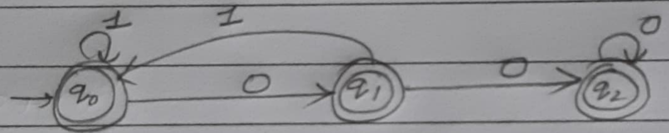
If q_2 is final $\Rightarrow$ $0^* 1 (0+1)(0+1)^*$

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

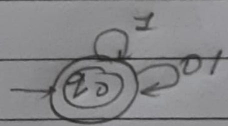
$\therefore$ $0^* + 0^* 1 (0+1)^+$

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

Q.

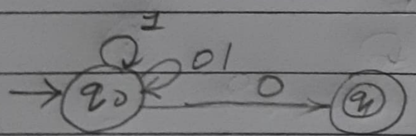


If q_0 is final



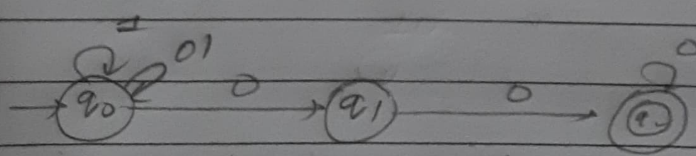
$\Rightarrow$ $(1+01)^*$

If q_1 final



$\Rightarrow$ $(1+01)^* 0$

If q_2 is final

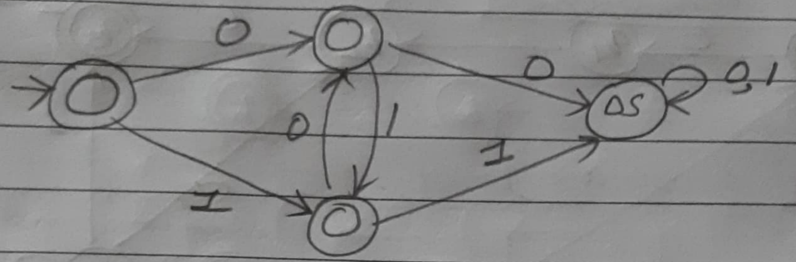


$\Rightarrow (1+01)^* 000^*$

$(1+01)^* + (1+01)^* 0 + (1+01)^* 000^*$

$(1+01)^* (\epsilon + 0 + 000^*) \Rightarrow (1+01)^* 0^*$

Q. Language accepted by following DFA?



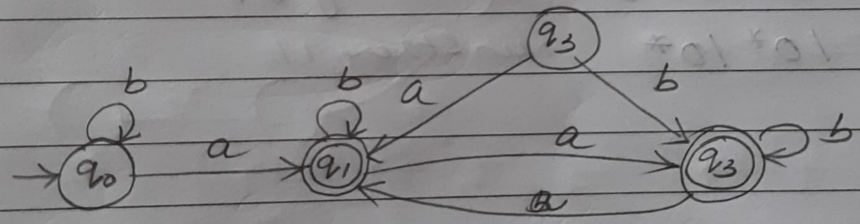
a) $(0+1)^*$ Does not accept 00

b) $(0+1)(0+1)^*$ Does not accept 00

c) $(0(10)^*0 + 1(01)^*1)(0+1)^*$ Does not accept 00

✓ d) None.

Q. Consider the following Finite Automata



The language accepted by this automation is given by the regular expression

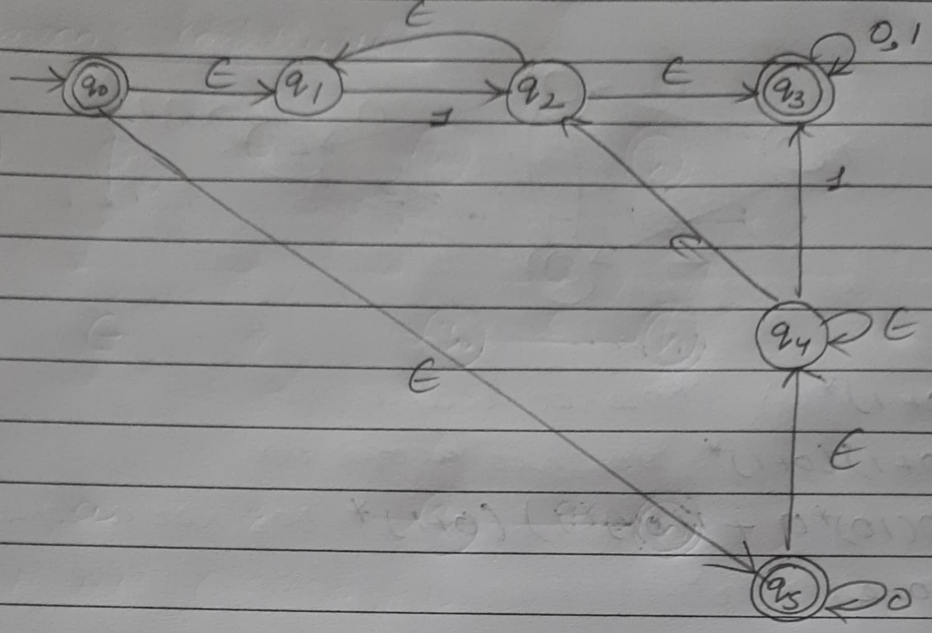
(a) $b^* a b^* a b^* a b^*$ min string generated = aaa

(b) $(a+b)^*$ b not accepted

✓ (c) $b^* a (a+b)^*$

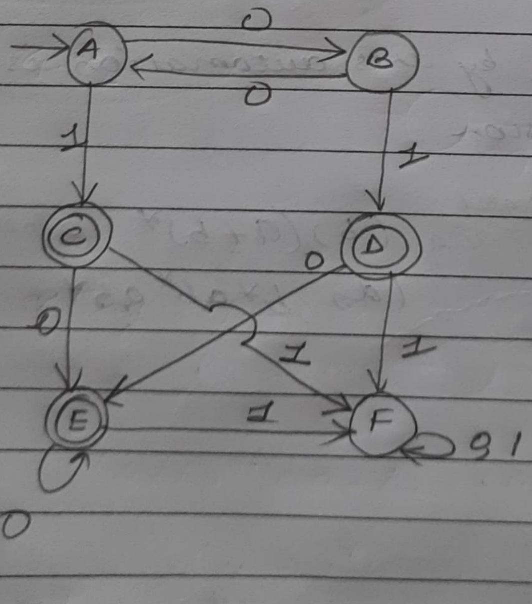
(d) $b^* a b^* a b^*$ min string aa

Q. what is the regular expression for the following



✓(a) $(0+1)^*$
(b) $(0+1)^* 01 (0+1)^*$ min string 01
(c) $(0+1)^* 10^* 10^*$ min string 11
(d) None

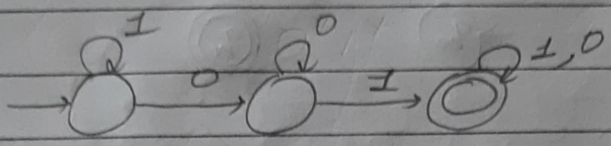
Q.



what is the regex for the following.

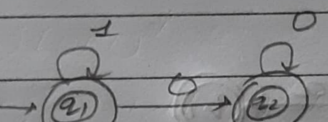
min string ε
(a) $0^* 1^* 0^* 1^* (0+1)^*$ ×
(b) $0^* 1 (0+1)^*$ 0101 not accepted
✓(c) $0^* 1 0^*$
(d) $0^* 1^* 0^* 1^*$

Q. Construct Regular expression that generates all string of 0's & 1's where each string does not contain substring 01.



{01 substring}

Complement



when q_1 is final $\quad 1^*$

when q_2 is final $\quad 1^*00^*$

$$\Rightarrow \quad 1^* + 1^*00^*$$
$$= 1^*(\epsilon + 00^*)$$
$$= 1^*(\epsilon + 0^+)$$
$$= 1^*0^*$$

Q. Which of the following RE generates all strings of 0's & 1's where number of 1's even.

Even 1's

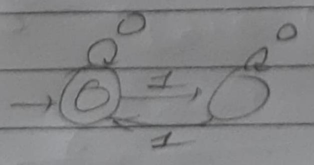
a) $0^*(10^*1)^*$ — 00011 0000111111

b) $0^*(10^*1)^*0$ — 000101010

c) $(0^*10^*10^*)^*$ — 00011011

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

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



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

$(a + b)^*$

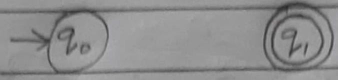
26-06-21

Regular Expression to Finite Automata

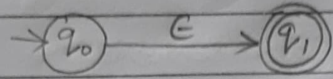
NOT PART OF GATE

Thomson's Construction

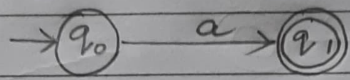
1) ϕ $\Rightarrow$



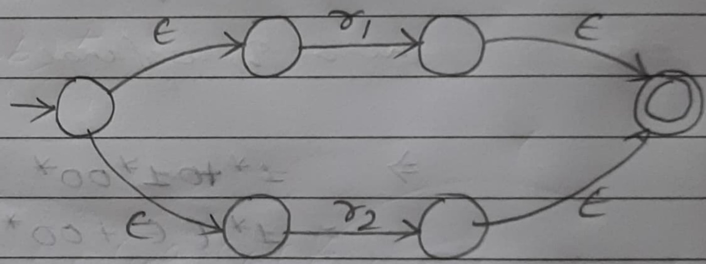
2) ϵ $\Rightarrow$



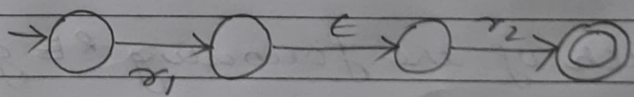
3) a $\Rightarrow$



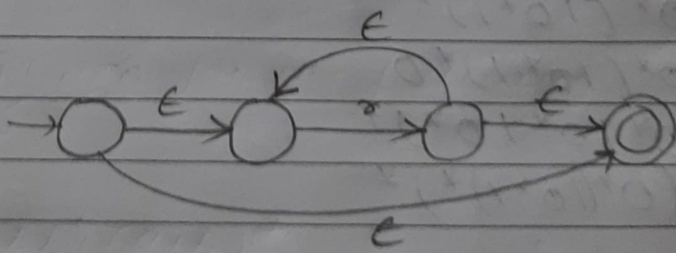
4) $r_1 + r_2$ $\Rightarrow$



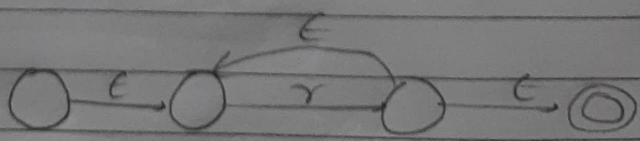
5) $r_1 . r_2$ $\Rightarrow$



6) r^* $\Rightarrow$

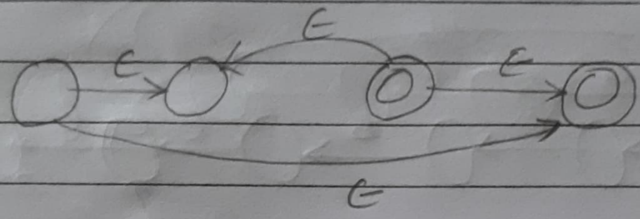


7) r^+ $\Rightarrow$

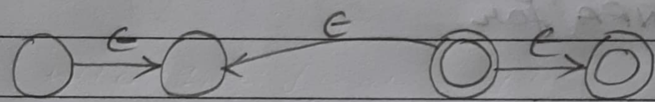


Example -

1. $\phi^* = \epsilon$

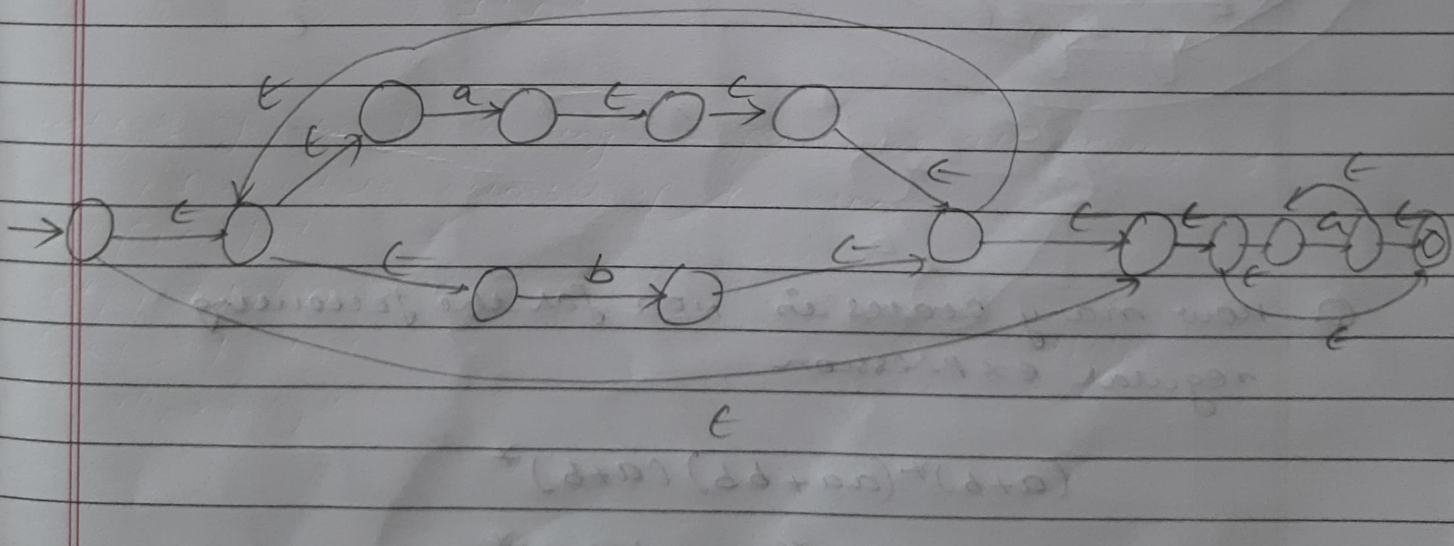


2. $\phi^+ = \phi$



Q. Construct ε-NFA for the following Regular Expression.

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



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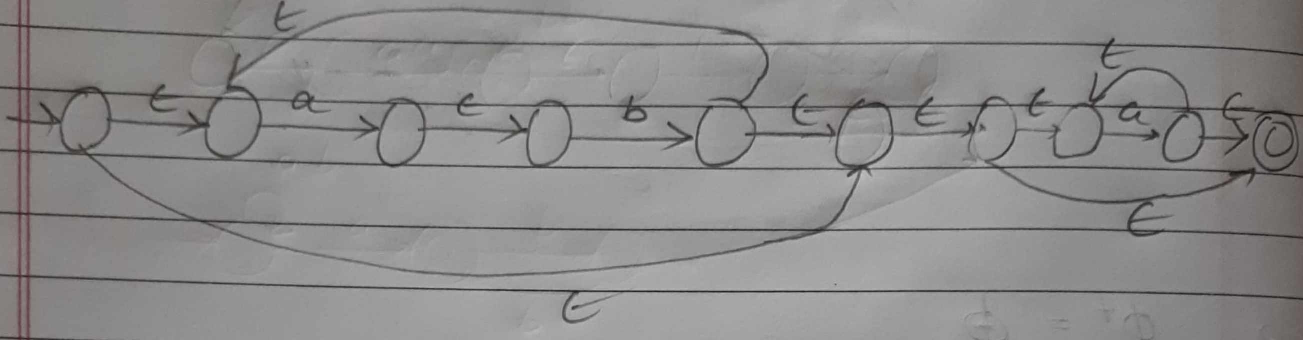
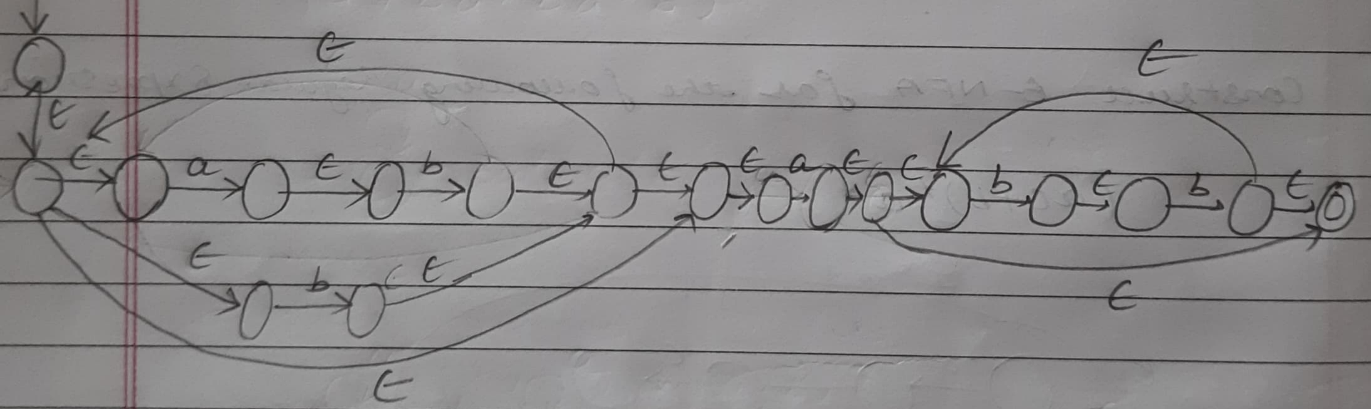
Q. Construct ε-NFA for

$(ab)^* a^*$



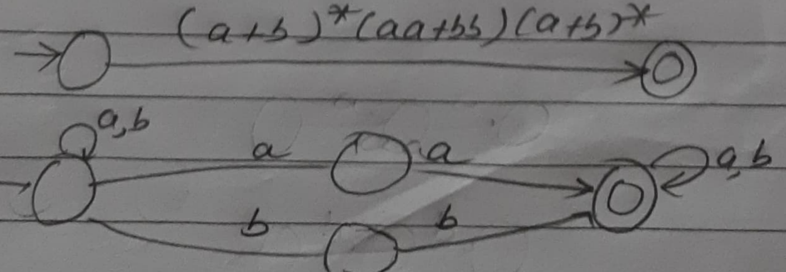
Q. Construct ε-NFA for

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



Q. How many states is NFA for the following regular expression.

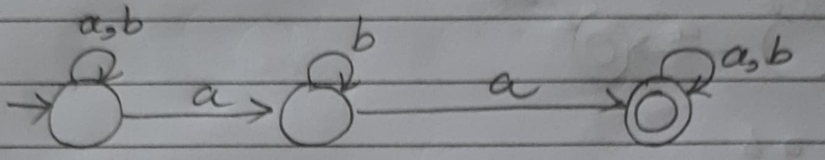
$(a+b)^*(aa+bb)(a+b)^*$



★ GATE → Regular Expression to DFA

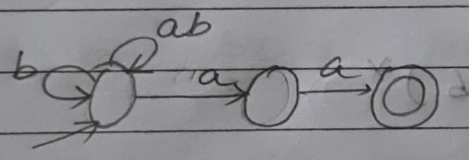
Q. Construct NFA for the following Regular Expression.

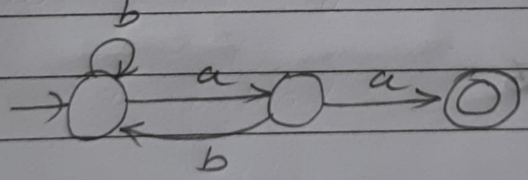
$$(a+b)^* ab^* a (a+b)^*$$



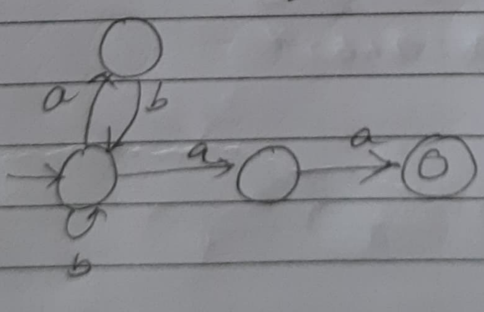
Q. Construct NFA for the following Regular Expression

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



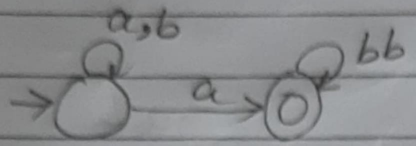


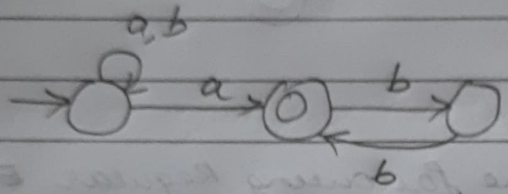
OR



Q. Construct NFA for

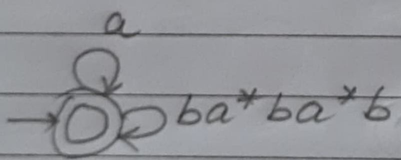
$(a+b)^* a (bb)^*$

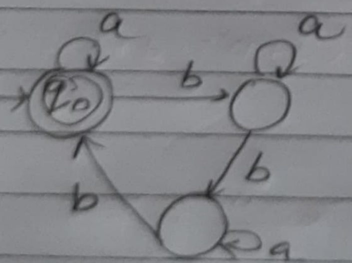




Q. Construct NFA for

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





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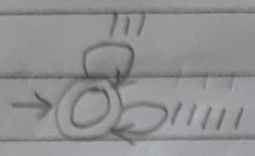
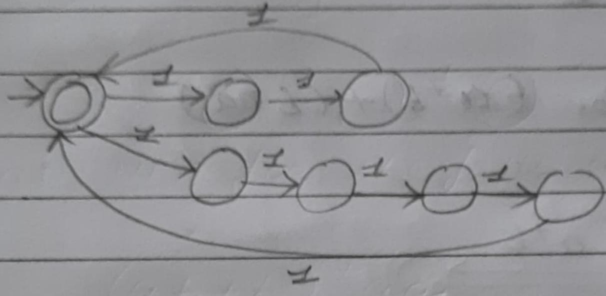
Q. Construct NFA for the Regular expression

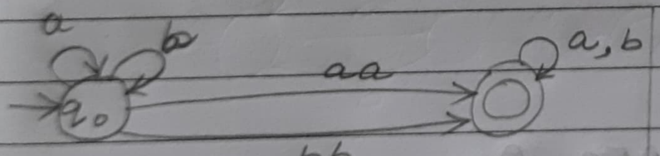
$L = (111 + 11111)^*$



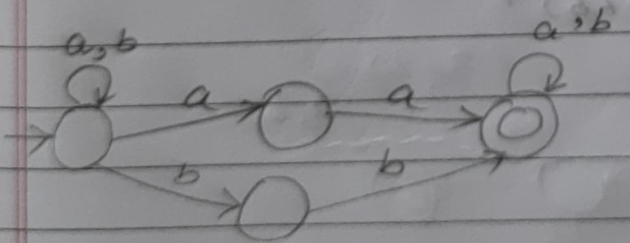


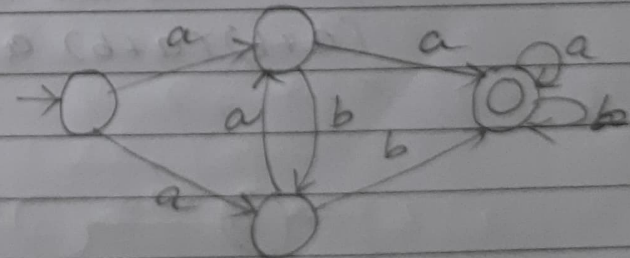
Q. Construct min. DFA for the following Regular Expression

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



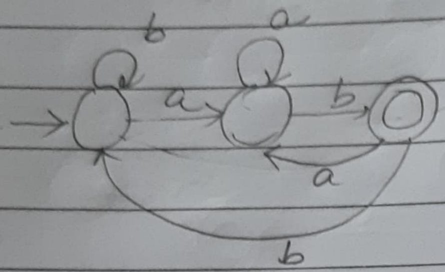
Substring aa & bb





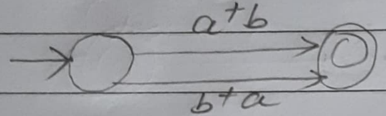
Now apply NFA to DFA

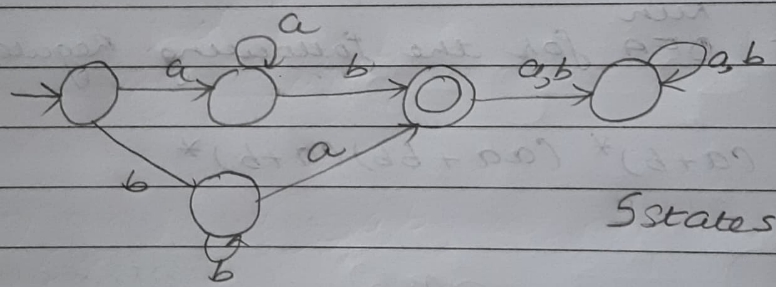
Q. Construct DFA for $(a+b)^*ab$



3 states

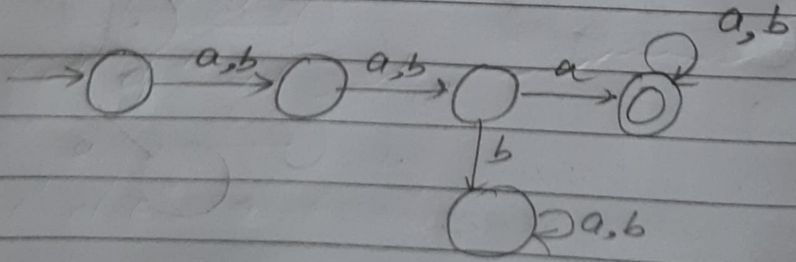
Q. Construct dfa for $(a+b)+(b+a)$





5 states

Q. Construct minimal DFA for
$(a+b)(a+b)a(a+b)^*$



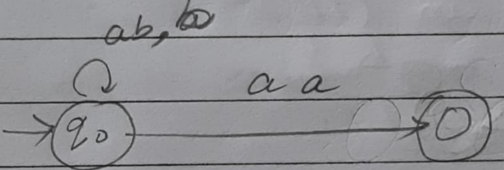
5 states.

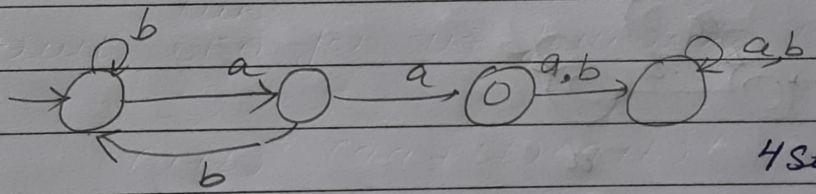
Q. Minimal DFA for $(a+b)^* a(a+b)(a+b)$

Third symbol from RHS is a

$\therefore \quad 2^3 = 8$ states

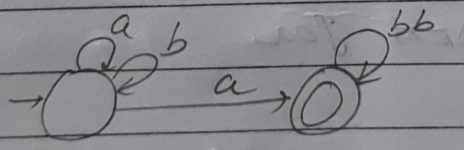
Q. Minimal DFA for $(ab+ba)^* aa$



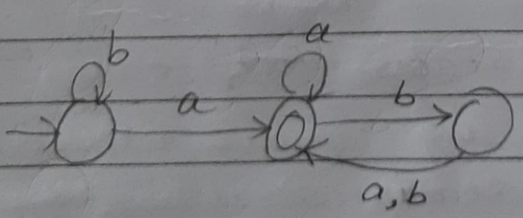


4 states.

Q. Minimal DFA for $(a+b)^* a(bb)^*$



3 states



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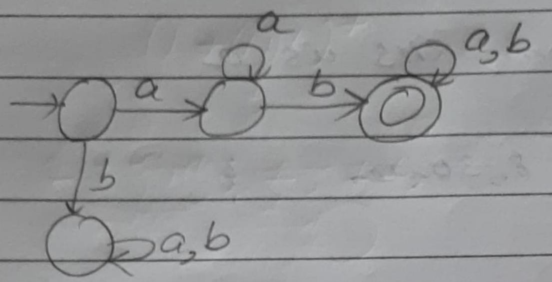
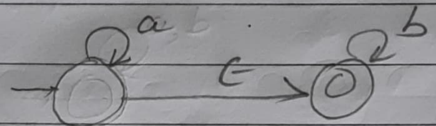
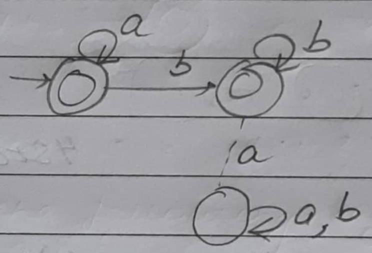
Q. Construct minimal DFA for $a^+b(a+b)^*$



4 states

Q. Construct minimal DFA for a^*b^*





Q. Construct minimal DFA for

(i) $a^*b^*c^*$ ⇒ 4 states (3+1)

(ii) $a^*b^*c^*d^*$ ⇒ 5 States

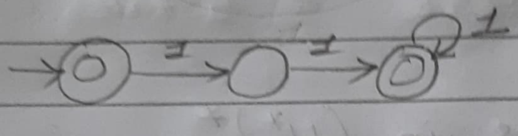
(iii) $a^*b^*c^*d^*e^*$ ⇒ 6 states

(iv) $a^*b^*c^* \ldots z^*$ ⇒ 27 states

Q. Construct minimal DFA for

$$r = (11 + 111)^*$$

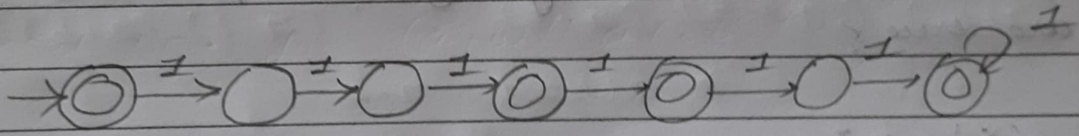
$$L = \{ \epsilon, 2, 3, 4, 5, 6, 7, \dots \}$$



Q. Construct minimal DFA for

$$r = (111 + 1111)^*$$

$$L = \{ \epsilon, 3, 4, \underbrace{6, 7, 8, 9, 10, 11}_{\text{sequence}} \dots \}$$



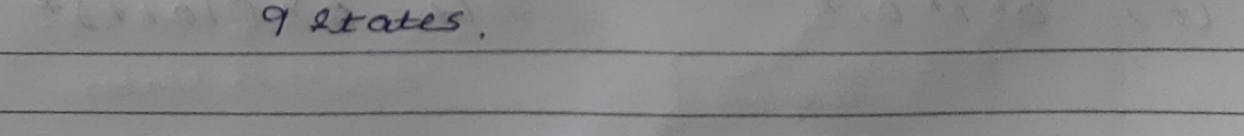
3 accepted - 4

Q. GATE

How many states in minimal DFA for the RE

$$r = (111 + 11111)^*$$

$$L = \{ \epsilon, 3, 5, 6, 8, 9, 10, 11 \dots \}$$



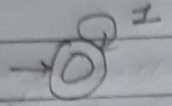
9 states.

Q. How many states in the minimal DFA for

$(1+(11)^*)^*$

↓

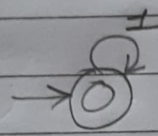
$L = \{1^*\}$



Q. minimal DFA States in $(11^*)^*$

ϵ

1^*



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Q. which of the following regular expressions identifies are true?

(a) $r(*) = r^*$

✓(b) $(r^* s^*)^* = (r^* + s^*)^*$

(c) $(r+s)^* = r^* + s^*$

(d) $r^* s^* = r^* + s^*$

2marks Gate PYQ

Q. which one of the following regular expressions over $\{0,1\}$ denotes the set of all strings not containing 100 as a substring

(a) $0^*(1+0)^*$ (b) 0^*1010^*

(c) $0^*1^*01^*$ ✓(d) $0^*(10+1)^*$

{ ϵ should be accepted }

Q. which one of the following regular expressions is NOT equivalent to the regular expression $(a+b+c)^*$?

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

✓(c) $((ab)^* + c^*)^*$ (d) $(a^* b^* + c^*)^*$

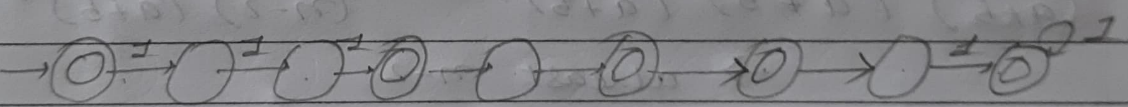
cannot generate
only a / only b

Q. Consider the regular language $L = (111 + 11111)^*$. The minimum number of states in any DFA accepting this language is

(a) 3 (b) 5 (c) 8 ✓(d) 9

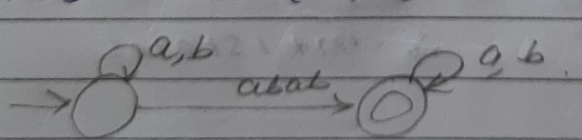
$L = (111 + 11111)^*$

$L = \{ \epsilon, 3, 5, 6, 8, 9, 10 \ldots \}$

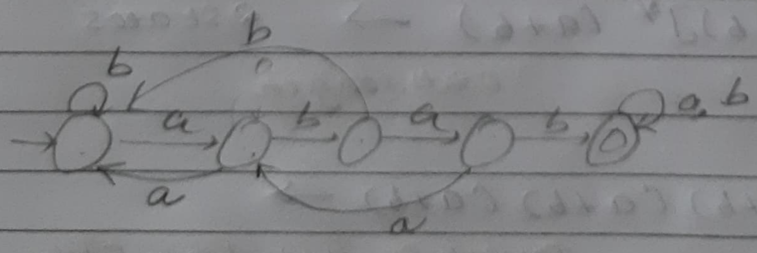


Q. How many states in minimal DFA for given RE?

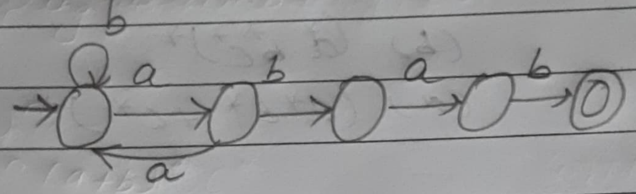
(a) $(a+b)^* abab (a+b)^*$



Substring (n)
$= n+1$
$= 5$ states



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



Ending with abab = 5 States

(c) $(a+b+\epsilon)^4 \longrightarrow$ 6 States.

atmost 4 length

(d) $(a+b)(a+b) \ldots n \rightarrow$ $n+2$ states

(e) $(a+b)(a+b) \ldots (n-2)$ times $\rightarrow$ n states

* (f) $(a+b)(a+b)(a+b) \ldots (n-2)(a+b)^*$

$\rightarrow$ atleast $n-2$

$\Rightarrow n-2+1 = n-1$ states

(g) $(a+b)(a+b)(a+b) \ldots (n-1)(a+b)^+$

$\rightarrow$ atleast n length

$\Rightarrow n+1$ States

(h) $[(a+b)(a+b)]^*(a+b) \longrightarrow$ 2 states

Odd length

(i) $(a+b)^* a(a+b)(a+b)(a+b) \longrightarrow$

fourth symbol from RHS

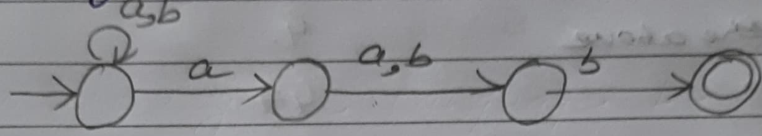
$= 2^4 = 16$ states

(j) $(a+b)(a+b)(a+b)(a+b)\, b\, (a+b)^*$

5th input symbol from LHS

= 7 states

Q. which regular expression best describes the language accepted by the non-deterministic automaton below?



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

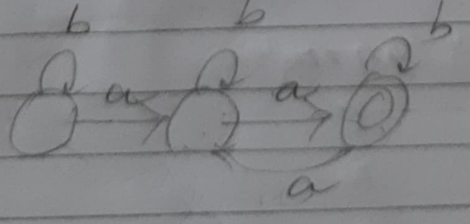
Q. Match the following

Regular Expression — No. of states in minimal DFA

1. $(a+b)^3 (a+b)^*$ (S) — P) 7
2. $a^* b^* c^* d^* e^* f^*$ (P) — Q) 6
3. $a(a+b)^* bb$ (R) — R) 5
4. $(a+b)^* ab^* ab^*$ (U) — S) 4

T) 8

U) 3



Q. which of the following regular expressions represents all strings of a's & b's where length the string is atmost 'n' is .

(a) $(a+b)^n$
(b) $(a+b)^n (a+b)^*$
✓(c) $(a+b+\epsilon)^n$
(d) None of the above

Q. Consider the language S^*, where S is all strings of a's & b's with odd length. The other description of this language is -

(a) all strings of a's and b's
(b) All even length strings of a's & b's
(c) All odd length strings of a's & b's
(d) None

$$\left[\left[(a+b)(a+b) \right]^* (a+b) \right]^*$$

$$\Downarrow$$

$$\epsilon$$

$$(a+b)^*$$

*Q. Consider the following.

$L_1 = \{ w \in (a+b)^* \mid$ first and last symbols in w are same $\}$ → 5 states

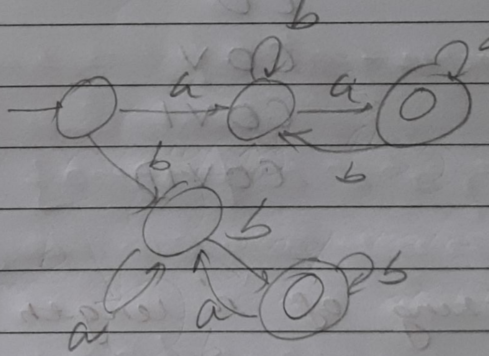
$L_2 = \{ w \in (a+b)^* \mid$ the last two symbols in w are same $\}$ → 5

$L_3 = \{ w \in (a+b)^* \mid$ the 3rd symbol in w from LHS is $a \}$ – 5 states

$L_4 = \{ w \in (a+b)^* \mid$ the first and last symbol in w are different $\}$

Let P, Q, R & S are the number of states in the minimal DFAs that accepts L_1, L_2, L_3 & L_4 resp. Then choose the correct statements for the following

a) $P < Q < R < S$
b) $Q < P < R = S$
c) $Q < P = R = S$
✓d) $Q = P = S = R$



Q. Number of states in minimal DFA and minimal NFA respectively, that accepts the language described by the regular expression

$$a^* b^* c^* \ldots z^*$$

✓a) 27, 26
b) 26, 27
c) 1, 2
d) 2, 1

Prefix of a String -

Sequence of leading symbols over the given String known as prefix.

Example -

"TOC"	"GATE"
ϵ	ϵ
TO	G
TO	GA
TOC	GAT
	GATE

"COVID" ϵ
C
CO
COV
COVI
COVID

A string of 'n' length has n+1 prefixes

Suffix of a String -

Sequence of trailing symbols over the the given String known as Suffix.

Example -

"TOC"	"GATE"
ϵ	ϵ
C	E
OC	TE
TOC	ATE
	GATE

A String of 'n' length has n+1 suffixes

Q. Construct Regular Expression that generates all prefixes of the string "enjoy".

ϵ + e + en + enj + enjo + enjoy	Prefixes

ϵ + y + oy + joy + njoy + enjoy	Suffixes

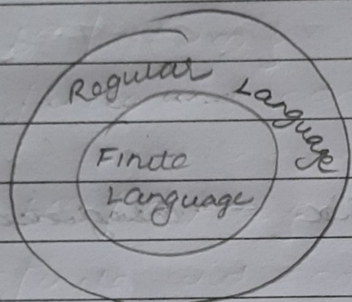
* Proper Prefix = Prefix − Original string

29-06-21

Regular Language Detection

The language for which DFA possible (or) Regular expression possible known as regular language.

* Any finite language is Regular; but every Regular language need not be finite.



Example -

$L_1 = \{ a^n b^n c^n \mid n = 100 \}$

Finite because n is finite

$L_2 = \{ a^n b^n c^n \mid n \geq 1 \}$

Infinite

$L_3 = \{ a^n b^n \}$

By default any given language is infinite language

Regular Language

Finite

$L_1 = \{a^n b^n \mid n = 10\}$

Infinite

$L_2 = \{a^n b^m \mid m, n \geq 1\}$

Infinite Languages

Regular

comparison does not exist (or) dependency does not exist.

Non-Regular.

Comparison exist (or) Dependency exist

Q. which of the following languages is Regular?

1) $L = \{a^n b^n \mid 1 \leq n \leq 10\}$

Finite ; Hence, Regular

2) $L = \{a^n b^n c^n \mid 1 \leq n \leq 1000\}$

Finite → Regular

3) $L = \{a^n b^m \mid n + m = 10\}$ $\{a^1 b^9, a^2 b^8, a^3 b^7, a^4 b^6, a^5 b^5, a^6 b^4, a^7 b^3, a^8 b^2, a^9 b\}$

Finite → Regular

dependency

4) $L = \{a^n b^m \mid n > m\}$

Infinite and non-Regular

5) $L=\{a^n b^m \mid n \neq m\}$

Infinite and Non-Regular

6) $L=\{a^n b^{2m} \mid n, m \geq 1\}$

Infinite and Regular

7) $L=\{a^n b^{2m} \mid n \geq 0 \text{ and } m \geq 0\}$

Infinite and Regular

8) $L=\{a^n b^m \mid n=2m\}$

Infinite and non-Regular

9) $L=\{a^n b^m \mid n \neq m\}$

Infinite and non-Regular

10) $L=\{a^{p-1} \mid p \text{ is prime}\}$

Infinite and non-Regular.

Languages over one Symbol

1. Common difference exist ⇒ Regular
2. No-common difference exist ⇒ Non-Regular

a) $L=\{a^n : n \geq 2 \text{ is a prime number}\}$

Non-Regular

b) $L=\{a^n : n \text{ is not a prime number}\}$

Non-Regular

c) $L=\{a^n : n=k^3 \text{ for some } k \geq 0\}$

Non-Regular

d) $L = \{ a^n : n = 2^k$ for some $k \geq 0 \}$

Non-Regular

e) $L = \{ a^n :$ n is the product of two prime numbers $\}$

Non-Regular

f) $L = \{ a^n :$ n is either prime or the product of two or more prime numbers $\}$

Regular

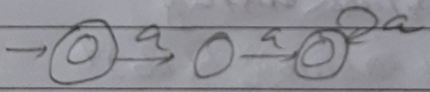
$\{ 2, 3, 4, 5, 6, 7, 8, 9 \ldots \}$

g) L^*, where L is the language in part (a)

Regular

$\{ (a^2)^*, (a^3)^*, (a^5)^*, (a^7)^* \ldots \}$

$\{ \epsilon, a^2, a^3, a^4, a^5, a^7, a^8 \ldots \}$



Q. Which of the following is Non-Regular?

a) $L = \{ a^k \mid k$ is odd number $\}$ $\quad \{ 1, 3, 5, 7, 9 \ldots \}$

b) $L = \{ a^{2n+1} \mid n \geq 0 \}$ $\quad \{ a^1, a^3, a^5, a^7 \ldots \}$

c) $L = \{ a^{m^n} \mid m > n, n \geq 1 \}$ $\quad \{ a^{m^1}, a^{m^2}, a^{m^3}, a^{m^4} \ldots \}$

$\cup \{ a^{3^2}, a^{4^2}, a^{5^2} \ldots$

$\{ a^{4^3}, a^{5^3} \ldots \}$

✓ d) None

$\Rightarrow \{ a^{m^1} \} = aa^+$

30-06-21

Q One of the following subsets of $\{a, b, \$\}^*$ is regular and the other is not. Which is which? Give proofs.

1) $\{xy \mid x, y \in \{a, b\}^*, \#a(x) = \#b(y)\}$

Regular $\Rightarrow$ Complete Language and

2) $\{x\$y \mid x, y \in \{a, b\}^*, \#a(x) = \#b(y)\}$

Not regular

1) $\Rightarrow$ $L = \{ \underset{x}{\epsilon}\underset{y}{\epsilon}, \underset{x}{\epsilon}\underset{y}{a}, \underset{x}{b}\underset{y}{\epsilon}, \underset{x}{\epsilon}\underset{y}{aa} \}$

2) $\{ \$, a\$b, aa\$bb \quad \ldots \}$

comparison

Q. 1) $L = \{a^n b^m \mid (n+m) \text{ is even}\}$

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

even as & bs $\quad$ Odd as & bs.

2) $L = \{a^n b^m \mid n+m = 100\}$

Finite & hence, regular

3) $L = \{a^n b^m \mid n-m = 3\}$

$n = m+3$

$\{a^{m+3} \cdot b^m\}$

$\{a^m \cdot a^3 \cdot b^m \mid m \geq 0\}$

Non-Regular

4) $L = \{ a^n b^m \mid n * m = 100 \}$

$1 * 100$

$2 * 50$

$\vdots$

$100 * 1$

Finite and Hence, regular.

5) $L = \{ a^n b^m \mid n > m \text{ and } n < m \}$

Regular

$\{ \} \Rightarrow$ Empty language $= \phi$

6) $L = \{ a^n b^m \mid n > m \text{ (or) } n < m \}$

$\{ n \neq m \}$

Non-Regular

7) $L = \{ a^n b^{m^2} \mid n, m \geq 1 \}$

Infinite

$\to$ CD

No common difference

Any symbol generated infinite times should have a common difference.

8) $L = \{ a^n b^{2m} \mid n, m \geq 1 \}$

CD $\quad$ $\to$ CD

Regular

9) $L = \{ x c x \mid x \in \{a, b\}^* \}$

Non-Regular

{ comparison exists }

10) $\{ x c y \mid x, y \in \{a, b\}^* \}$

Regular

{ No comparison }

11) $\{a^n b^{n+481} \mid n \geq 0\}$

Non- Regular

{Comparison exists}

12) $\{a^n b^m \mid n-m \leq 481\}$

Non - Regular

$n = 481 + m$

$\{a^{481+m} b^m\}$

Comparison exists

13) $\{a^n b^m \mid n \geq m \text{ and } m \geq 481\}$

~~Non-Regular~~

Non- Regular

14) $\{a^n b^m \mid n \geq m \ \& \ n \leq 481\}$ Comparisons are finite Hence regular

Regular Regular

$\{a+b + a^2 \cdot a^* b^2 + a^{481} a^* b^{481}\}$

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(i) $L((a^*b)^*a^*)$

Regular

(ii) $\{a^n b^n c^n \mid n \geq 0\}$

Non-Regular

Q Prove that the following languages are

a) $L = \{a^n b^l a^k : k \geq n+l\}$ ↳ comparison

Non-Regular

b) $L = \{a^n b^l a^k : k \neq n+l\}$ ↳ comparison

Non-Regular

c) $L = \{a^n b^l a^k : n = l \text{ (or) } l \neq k\}$ ↳ comparison

Non-Regular

d) $L = \{a^n b^l : n \leq l\}$ → comparison

Non-Regular

e) $L = \{w : n_a(w) \neq n_b(w)\}$

no memory

Non-Regular

f) $L = \{ww : w \in \{a,b\}^*\} = \{\epsilon, aa, bb, abab \dots\}$

Non-Regular

g) $L = \{wwww^R : w \in \{a,b\}^*\}$

Non-Regular.

1) $L_1 = \{ ww^R \mid w \in \{a\}^* \}$

$\{ \epsilon, aa, aaaa, \quad \}$

Regular

$(aa)^*$

2) $L_2 = \{ w\#w^R \mid w \in \{a\}^* \}$

$\{ \#, a\#a, aa\#aa, aaa\#aaa \ldots \}$

comparison

Non-Regular.

3) Which of the following is Regular?

(a) $L = \{ ww^R \mid w \in \{a,b\}^* \}$

(b) $L = \{ wxw^R \mid w \in \{a,b\}^* \}$

✓ (c) $L = \{ ww^R x \mid w, x \in \{a,b\}^* \}$

(d) $L = \{ wxw \mid w \in \{a,b\}^* \}$

4) Which of the following is Regular?

$aa(a+b)^+ + bb \quad a$

(a) $L = \{ ww^R x \mid w, x \in \{a+b\}^+ \}$

(b) $L = \{ xww^R \mid w, x \in \{a+b\}^+ \}$

✓ (c) $L = \{ wxw^R \mid w, x \in (a+b)^+ \}$

d) None.

$\overbrace{bab}^{w}\overbrace{abbabaaba}^{x}\overbrace{b}^{w^R}$

$\underbrace{b}_{w}\underbrace{abab\ldots bab}_{x}\underbrace{b}_{w^R}$

Q. Which of the following is Non-Regular

a) $L = \{ w w x w^R w \mid w, x \in \{a,b\}^* \}$

b) $L = \{ wwwwxww \mid w, x \in \{a,b\}^* \}$

c) $L = \{ wwwx www^R \mid w, x \in \{a,b\}^* \}$

✓ d) None

Q. Which of the following is Regular?

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

comparison

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

comparison

✓ c) $L = \{ w(w^R)^* \mid w \in \{a,b\}^* \}$

↳ यह ε हो जायेगा।

d) None.

Q. a) $L = \{ w\#w \mid w \in \{a\}^* \} = \{ \#, a\#a, aa\#aa \dots \}$

Compari..

✓ b) $L = \{ w\#w \mid w \in \{a\}^*, |w| < 100 \}$

finite

c) Both

d) Only b.

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Q. which of the following is Regular

a) $L = \{ x \mid x \in \{a,b\}^*, n_a(x) = n_b(x) \}$
comparison

b) $L = \{ x \mid x \in \{a,b\}^*, n_a(x) > n_b(x) \}$
comparison.

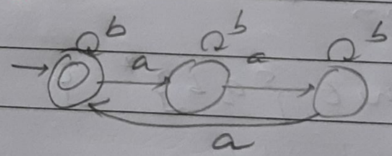
✓ c) $L = \{ x \mid x \in \{a,b\}^*, n_a(x) \bmod 3 > n_b(x) \bmod 3 \}$

d) None

06-07-21

Q. $L = \{ x \mid x \in \{a,b\}^*, n_a(x) \bmod 3 = 0 \}$

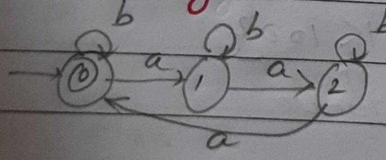
Regular



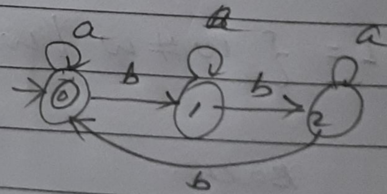
Q. $L = \{ x \mid x \in \{a,b\}^*, n_a(x) \bmod 3 = n_b(x) \bmod 3 \}$ Finite comparison

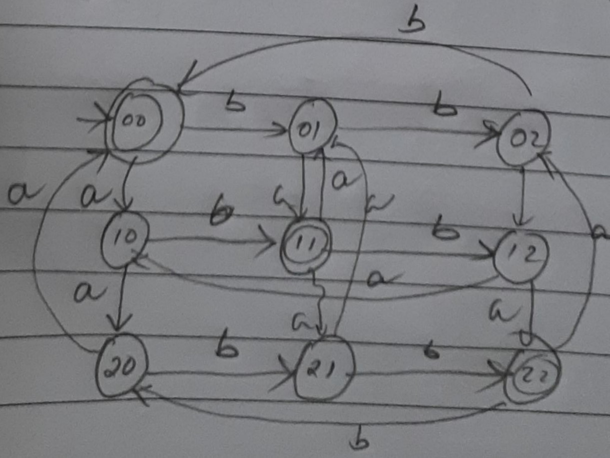
$\{0,1,2\}$ $\{0,1,2\}$

Regular



X





for $>$

Change the final States, where $a > b$
rem rem

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Q. Which of the following is Non-Regular?

a) $L = \{ x \mid x \in \{a,b\}^*, \ n_a(x) \bmod 3 > n_b(x) \bmod 3 \}$
finite comparison. rem.

b) $L = \{ x \mid x \in \{a,b\}^*, \ n_a(x) \bmod 3 < n_b(x) \bmod 3 \}$
finite rem comparisons.

✓ c) $L = \{ x \mid x \in \{a,b\}^*, \ n_a(x) = 3 n_b(x) \}$
infinite comparison.

d) None.

Q. Which of the following is Non-Regular?

a) Total population world in 2021
Finite

b) Total no. of covid patients in the world
Finite

c) Total property of Mukesh Ambani
Finite

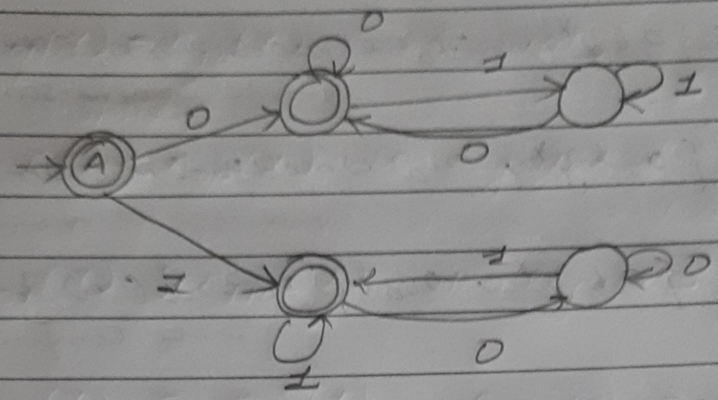
✓ d) None.

Q. Which of the following is Regular?

a) Set of all balanced parenthesis CFL क्योंकि Comparison है।
b) Equal no. of open & close paranthesis CFL
c) Set of all syntax Error CFL - Syntax tree
✓ d) Set of Lexical Errors

Important

* Q. Identify the language accepted by the following Automata
*



a) equal no. of 0 & 1 → comparison. Hence, non-regular.

b) Equal no. of Substrings 01 & 10 = { ε, 0, 0̲1̲0̲1̲0̲1̲0̲ ... }

c) Starting and Ending with same symbol

d) None

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

* ε Not accepted, but automata does.

Although comparison is happening; but no memory is required. Repetition string generated automatically generates the required string

Q.a) $L = \{ x \mid x \in \{a,b\}^*,\ n_{01}(x) = n_{11}(x) \}$

b) $L = \{ x \mid x \in \{0,1\}^*,\ n_{10}(x) = n_{11}(x) \}$

c) $L = \{ x \mid x \in \{0,1\}^*,\ n_{010}(x) = n_{011}(x) \}$

d) $L = \{ x \mid x \in \{0,1\}^*,\ n_{010}(x) = n_{001}(x) \}$

which of the above languages is regular?

Taking (a)

<u>01</u> <u>01</u> <u>01</u> <u>01</u> No '11' generated

Trick → generate one string type & check if the other is generated within that string.

Taking (b)

101010 '11' not generated

Taking (c)

<u>010</u><u>010</u><u>010</u> '011' not generated

Taking (d) will fail if $\underbrace{0101111 1010}$

Non-Regular

<u>010</u><u>010</u><u>010</u> '001' generated

but 010 is not reverse of 001

Hence not Regular.

Regular Suppose $n_{011}(x) = n_{110}(x)$

$\overline{011}\overline{011}\overline{011}$ If First String & Second String are reverse of each other → Regular

Eg 011 & 110

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Example-

$n_{01}(x) = n_{10}(x)$ Regular

Reverse

$n_{11}(x) < n_{00}(x)$ Non-Regular

$n_{001}(x) > n_{110}(x)$ Non-Regular

$n_{001}(x) = n_{100}(x)$ Regular

GATE 2Marks:-

Q. $L_1 = \{ w \in \{0,1\}^* \mid$ w has atleast as many (110)s as (011)s $\}$

$L_2 = \{ w \in \{0,1\}^* \mid$ w has atleast as many 000s as 111s $\}$ String comparison ⇒ Non-Regular

a) L_1, L_2 are regular

b) L_1, L_2 are non-Regular

✓c) Only L_1 is regular

d) Only L_2 is Regular

Q. which of the following is Regular ?

a) $L = \{ a^p \mid p$ is a prime no $\}$

b) $L = \{ a^{n^2} \mid n \geq 1 \}$ — No common difference

c) $L = \{ a^{n!} \mid n \geq 1 \}$

✓ d) None

Q. which of the following is Non-Regular ?

a) $L = \{ (a^p)^* \mid p$ is Prime $\}$ $\{ \epsilon, 2, 3, 4, 5, 6, 7, 8 \quad \}$

b) $L = \{ (a^{n^2})^* \mid n \geq 1 \}$

c) $L = \{ (a^{n!})^* \mid n \geq 1 \}$

Kleen closure on any non-regular language becomes regular

✓ d) None

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Q. Which of the following is Regular?

a) Set of all balanced paranthesis
b) Equal no. of open & close paranethesis
c) Even length palindrome strings of English Language
d) Odd length Palindrome Strings of Hindi Language
✓ e) None

2 Marks in GATE

Q. Consider the following Languages:

$L_1 = \{ ww \mid w \in \{a,b\}^* \}$ CFL

$L_2 = \{ ww^R \mid w \in \{a,b\}^*, w^R \text{ is the reverse of } w \}$ CFL

$L_3 = \{ 0^{2i} \mid i \text{ is an integer} \}$ Regular

$L_4 = \{ 0^{i^2} \mid i \text{ is an integer} \}$

Which of the languages are regular?

a) Only L_1 & L_2
b) Only L_2, L_3 & L_4
c) Only L_3 & L_4
✓ d) Only L_3

2 MARKS GATE

Q. which of the following are regular sets?

1. $\{a^n b^{2m} \mid n \geq 0, m \geq 0\}$

2. $\{a^n b^m \mid n = 2m\}$

3. $\{a^n b^m \mid n \neq m\}$

4. $\{xcy \mid x, y \in \{a, b\}^*\}$
$(a+b)^* c (a+b)^*$

✓a) 1 and 4 only
b) 1 and 3 only
c) 1 only
d) 4 only

Q. Which of the following languages is/are regular?

$L_1 : \{wxw^R \mid w, x \in \{a,b\}^* \text{ and } |w|, |x| > 0\}$
Suppose = $a\underbrace{ababbaab}_{x}a \Rightarrow a(a+b)^+a + b(a+b)^+b$

$L_2 : \{a^n b^m \mid m \neq n \text{ and } m, n \geq 0\}$

$L_3 : \{a^p b^q c^r \mid p, q, r \geq 0\}$

✓(a) L_1 and L_3 only
(b) L_2 only
(c) L_2 and L_3 only
(d) L_3 only

Q. which one of the following is TRUE?

a) The language $L=\{a^n b^n \mid n \geq 0\}$ is regular

b) The language $L=\{a^n \mid n \text{ is prime}\}$ is regular

✓ c) The language $L=\{w \mid w \text{ has } 3k+1 \text{ b's for some } k \in N\}$ with $\Sigma=(a,b)$ is regular.

d) The language $L=\{ww \mid w \in \Sigma^* \text{ with } \Sigma=\{0,1\}\}$ is regular

Q. which of the following is Non-regular.

a) $L=\{\underset{\epsilon}{w}\underset{\epsilon}{w}\underset{(a+b)^*}{x} \mid w, x \in \{a,b\}^*\}$

b) $L=\{\underset{\epsilon}{w}\underset{\epsilon}{w}\underset{(a+b)^+}{x} \mid w \in \{a,b\}^*, x \in \{a,b\}^+\}$

✓ c) $L=\{wwx \mid x, w \in \{a,b\}^+\}$

d) None

$$W_{min}\left\{ \begin{array}{c} aa(a+b)^+ \\ + \\ bb(a+b)^+ \end{array} \right\}$$

but

$abab(a+b)^+$

cannot be generated by W_{min}

W_{min} should generate all possible strings under L to be regular

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Q. Which of the following is Regular

a) $L = \{ wwx \mid w \in \{a,b\}^*, x \in \{a,b\}^+ \}$

$\in (a+b)^+$

b) $L = \{ wwx \mid w \in \{a,b\}^+, x \in \{a,b\}^* \}$

c) $L = \{ wwx \mid w, x \in \{a,b\}^+ \}$

d) None

Q. Which of the following is Non-Regular

a) $L = \{ xww \mid x, w \in \{a,b\}^* \}$ $(a+b)^*$

b) $L = \{ xww \mid w \in \{a,b\}^*, x \in \{a,b\}^+ \}$

$(a+b)^+$

c) $L = \{ xww \mid w, x \in \{a,b\}^+ \}$

Which doesn't cover all possibilities.

d) None

Q Which of the following is Non-Regular

a) $L = \{ wxw \mid w, x \in \{a,b\}^* \}$

b) $L = \{ wxw \mid w \in \{a,b\}^*, x \in \{a,b\}^+ \}$

c) $L = \{ wxw \mid w, x \in \{a,b\}^+ \}$

d) None

Q. Which of the following is Non-Regular?

a) $L = \{ xww^R \mid x, w \in \{a,b\}^* \}$

b) $L = \{ xww^R \mid w \in \{a,b\}^*, x \in \{a,b\}^+ \}$

✓ c) $L = \{ xww^R \mid w \in \{a,b\}^+, x \in \{a,b\}^* \}$

d) None

Q. Which of the following is Non-Regular?

a) $L = \{ wxw^R \mid w, x \in \{a,b\}^* \}$

$(a+b)^*$

b) $L = \{ wxw^R \mid w, x \in \{a,b\}^+ \}$

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

c) $L = \{ wxw^R \mid w \in \{a,b\}^*, x \in \{a,b\}^+ \}$

$(a+b)^+$

✓ d) None

Q. Which of the following is Non-Regular?

non-comparing element

a) $L = \{ wxwy \mid w, x, y \in \{a,b\}^+ \}$ Regular

b) $L = \{ xwyw \mid w, x, y \in \{a,b\}^+ \}$ Regular

✓ c) $L = \{ wxyw \mid w, x, y \in \{a,b\}^+ \}$

after before

या फिर min_w concept

d) All of these

$ab(a+b)^+(a+b)^+ab$

non regular

e) None

Q. Which of the following is Non-Regular?

a) $L = \{ wxwy \mid w,x,y \in \{a,b\}^* \}$ $(a+b)^*$

b) $L = \{ xwyw \mid w,x,y \in \{a,b\}^* \}$ $(a+b)^*$

c) $L = \{ wxyw \mid w,x,y \in \{a,b\}^* \}$ $(a+b)^*$

✓ d) None.

Q. Which of the following is Regular?

non-comparing elements

a) $L = \{ xwyw^R \mid w,x,y \in \{a,b\}^+ \}$ Non-Regular

before before

b) $L = \{ wxw^Ry \mid w,x,y \in \{a,b\}^+ \}$ Non-Regular

after

✓ c) $L = \{ wxyw^R \mid w,x,y \in \{a,b\}^+ \}$

Before after $a(a+b)^+(a+b)^+a + b(a+b)^+(a+b)^+b$

d) None

यदि wxyw पर यदि $wxyw^R$

after-after before after

Regular

NOTE:-

Before Before // After After

$wxwy$

Regular

xww^Ry

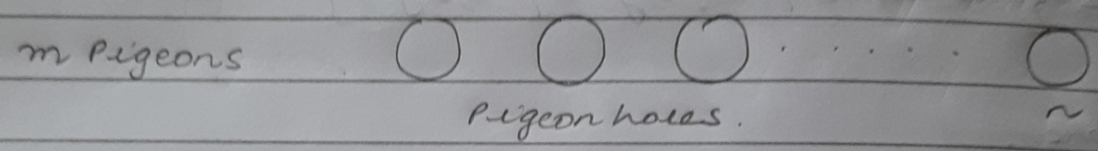
Before After // After Before.

07-07-21

✱ PUMPING LEMMA (of Regular Languages)

1. proof by contradiction
2. Uses Pigeon hole principle

Pigeon hole principle.



$m > n$.

At least one pigeon will be occupied by more than one pigeon.

STEPS -

1. Assume L is Regular
2. There exist F.A for L and n is the no. of states in that FA.
3. Select some string w from L such that $|w| > n$. (Loop exists)
4. Divide w into XYZ such that $|xy| <= n$ & $|y| > 0$.
5. Find a suitable integer i such that xy^iw is not in L.

Then L is not Regular

✱ P.L is very strong for proving non-Regular language as Non-Regular (One case is sufficient)

✱ P.L is weak for proving regular language. (Infinite cases)

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Q. Prove that the language $L = \{a^n b^n \mid n \geq 1\}$ is Non-Regular

⇒ 1) Assume L is regular.

2) F.A exists → n states.

3) $a^n b^n \rightarrow$ n
$2n$ (length)

4) a^{n-1} a b^n or $\underbrace{aa}_{x}\underbrace{ab}_{y}\underbrace{bb}_{z}$

$xy^iz \Rightarrow aaababbb \notin L$

5) $a^{n-1} \cdot a^2 \cdot b^n$
$a^{n+1} \cdot b^n \notin L$

Language is non-Regular

Q. There exist a Regular language L and ~~its~~ F.A all strings in the language having length less than no. of states of its finite Automata, Then the language is known as Finite Language

Example -