CS & IT ENGINEERING

Theory of Computation

Lecture No.- 01

Mallesham Devasane Sir

Topics to be Covered

Topic Regular Expression

Regular Expression: NAT

Q1. Consider the following regular expressions:

$r_1 = (a + b)^* = \Sigma^*$

$r_2 = (ab^*a + b^*)$

$r_3 = (ab^+ a + b^+ + \in) = ab^+a + b^*$

if $r_4 = \underbrace{r_1 \cap r_2}_{r_2} \cap r_3$ then the number of strings in r_4 which not contain "bbb" are

___

$ab^*a \cap ab^+a$

aa, ab^+a

$r_1 \cap r_2 = r_2$

$r_2 \cap r_3 = ab^+a + b^*$

aba, $abba$

ε, b, bb

$= 5$ //

Regular Expression: $\cancel{\text{MCQ}}$ MSQ

Q2. $(a+b)^*$ is equivalent to

A. $(aa^*+bb^*)^* = (a+b)^*$

B. $(aa+bb)^*$ $<$ ε ✓, a ✗

C. $(aaa+bbb)^*$ $<$ ε ✓, a ✗

D. $(a\underline{b}^*+b\underline{a}^*)^* = (a+b)^*$

Regular Expression: MSQ

Q3. Which of the following is/are correct?

$a, aba, ababa, \ldots$

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

$a, aba, ababa, \ldots$

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

C. $a + ba = (a+b)(a+a)$

aa

D. $\phi^* = \in$

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

$(a^*b)^* \begin{cases} \varepsilon ✓ \\ a ✗ \end{cases}$

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

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

Regular Expression: MSQ

Q4. $a(a+b)^*$ is equivalent to

$a(a+b)^* \Rightarrow \{a, aa, ab, \ldots\}$

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

B. $(aa^*+ab^*)^* \longrightarrow \varepsilon$ (invalid)

C. $(ab^*)^*$

D. $a(ab^*)^*$ — a ✓, aa ✓, ab ✗

Regular Expression: MCQ

Q5. Consider the following regular expression on input symbol {a, b}:

Regular expression $R = \boxed{(b + aa^* b)} + \boxed{(b + aa^* b)(a + ba^*b)^* (a + ba^* b)}$

Which of the following string is not generated by R?

A. epsilon $\notin R$

B. a $\notin R$

C. b $\in R$

D. ab $\in R$

b

ab

aab

$b.\varepsilon.a = ba$

$b.a.a = baa$

Slide 7

Regular Expression: MCQ

$\{w \mid w \in \{0,1\}^*,\ n_1(w) = \text{even}\}$

Q6. Which of the following represents set of all binary numbers with even number of 1's ?

$\{\underbrace{\varepsilon, 0, 00}_{\text{Zero no. of 1s}}, \underbrace{11, 110, 011, 101}_{\text{Two 1s}}, 000, \ldots\}$

some strings

A (11)* → 0, 110

some

B (01010)* → 0

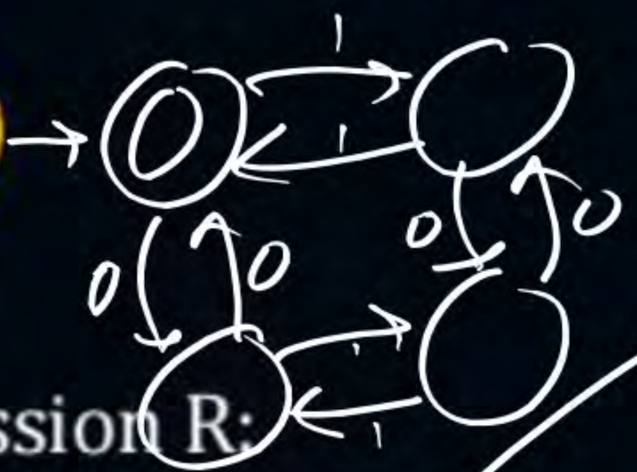
C (0*10*10*)*

~~D~~ None of these.

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

Slide

Regular Expression: NAT



***Q7. Consider the following regular expression R:

$R = (00 + 11 + (01 + 10)(00 + 11)^*(01 + 10))^*$

$(\ )^0 = \varepsilon$ ✓

00 ✓

11 ✓

0101 ✓

0110 ✓

0000 ✓

0011 ✓

1100 ✓

⋮

What is the language represented by R?

A. ~~Set of all binary strings~~ — ε ✓ — $\boxed{0}$?

B. ~~Set of all binary strings starting with 00~~ — ε ?

C. Set of all binary strings having even 0's and even 1's ✓

D. None of these.

Slide

Regular Expression: MCQ

Q8. Consider the regular expression R:

$$R = \in + a + b + (aa + ba + bb)\,(a + b)^*$$

$(a+b)^+$

The language recognize by R is

A {∈ {a, b}*| all strings of a and b not starting with a or not end with b} ✗

B {w∈ {a, b}*| all strings of a and b not starting with ab} ✓

C {w∈ {a, b}*| all the strings of a and b contain either a or b as a substring} ✗

D {w∈ {a , b}*| all the strings of a and b are not ending with ab} ✗

Regular Expression: MSQ

Q9. $L = \{ \omega \mid \omega \in \{0,1\}^*, \underbrace{n_1(\omega)}_{} \text{ is divisible by } 3 \}$

No.of 1s in ω

$\#_1(\omega)$

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

A $(111)^*$

B $(01010)^*$

C $(0^*10^*10^*)^*$

D None of these

Regular Expression: MSQ

Q10.

$A \to (00)^*$ $\longrightarrow$ $\{\varepsilon, 00, 0^4, 0^6, \ldots\}$

$B \to 0(00)^*$ $\longrightarrow$ $\{0^3, 0^5, 0^7, 0^9, \ldots\}$

$C \to A + B$

$D \to A \cap B$

$A \cap B = \phi$

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A. Even zero's

B. odd no. of 0's

C. All strings

D. Empty set

Regular Expression: MSQ

Q11. $(a+b)^* =$

A $a^*(ba^*)^*$

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

C $b^*(ab^*)^*$

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

Regular Expression: MSQ

Q12. $a(a+b)^* = \{a, aa, ab, aaa, aab, aba, abb, \ldots\}$

A $(ab^*)^+$

B $(a^+b^*)^* = \{\varepsilon, \ldots\}$

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

D $(ab^*)^* = \{\boxed{\varepsilon} \ldots\}$

Slide 14

Regular Expression: MCQ

Q13. Which of the following regular expression describes the language over {a, b} consisting of strings that do not start with 'a' or do not end with 'b'.

A. $b(a + b)^* + (a + b)^*a + \in$

B. $ab\,(a + b)^* + \in$

C. $(a + b)\,(a + b)^* + \in$

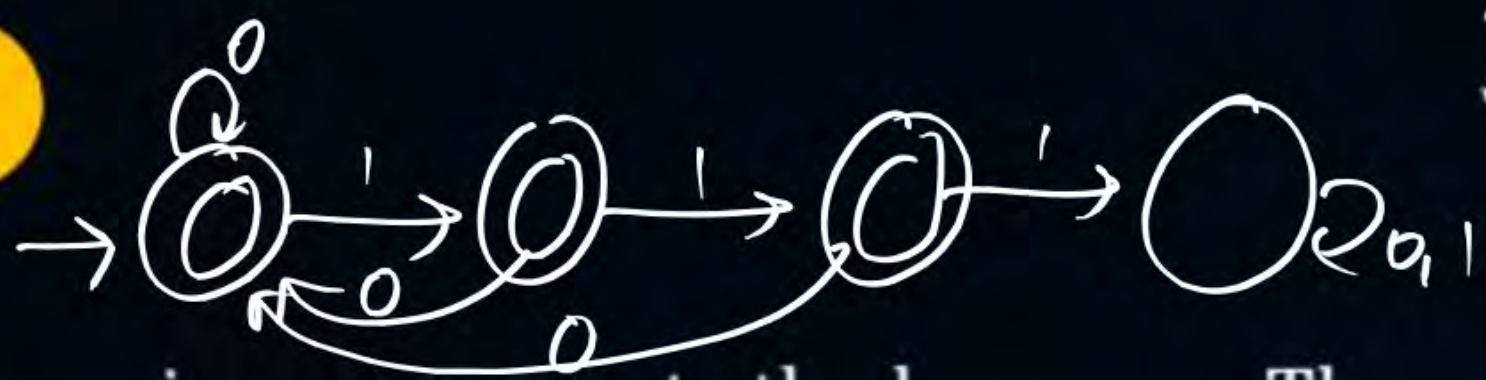
D. $b(a + b)^* + (a + b)^*\,a + a + b + \in$

$b\Sigma^* + \varepsilon + \quad + \quad \Sigma^* a + \varepsilon$

b
ba
bb

a
aa
ba

Regular Expression: MSQ



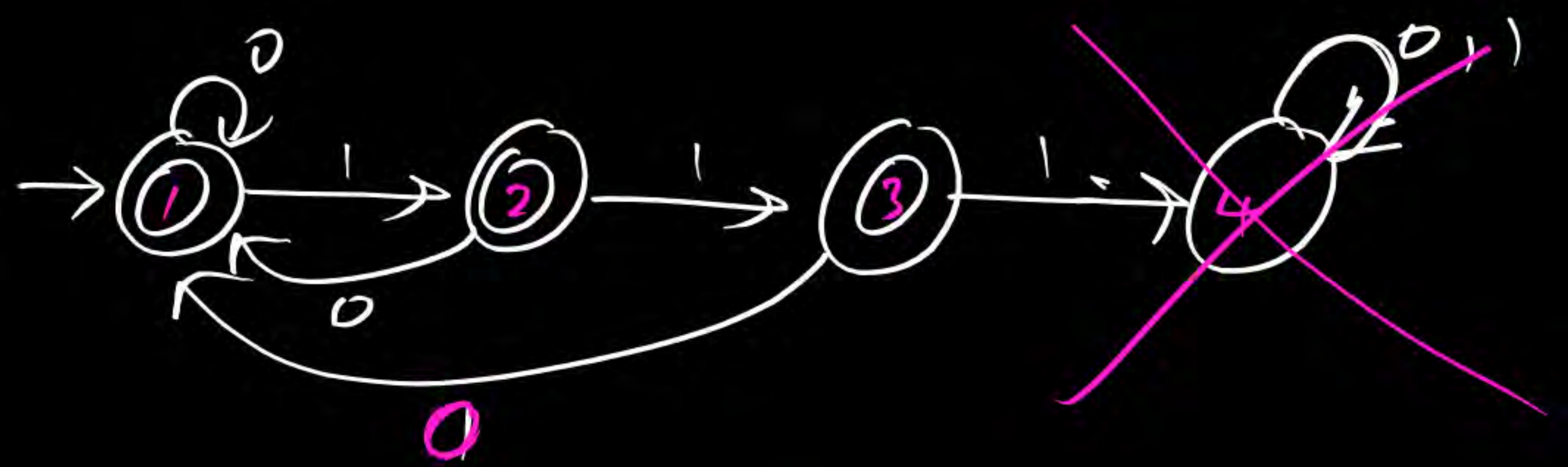
Q14. Which of the following regular expressions represents the language: The set of all binary strings $\boxed{\text{not having three consecutive 1's?}}$

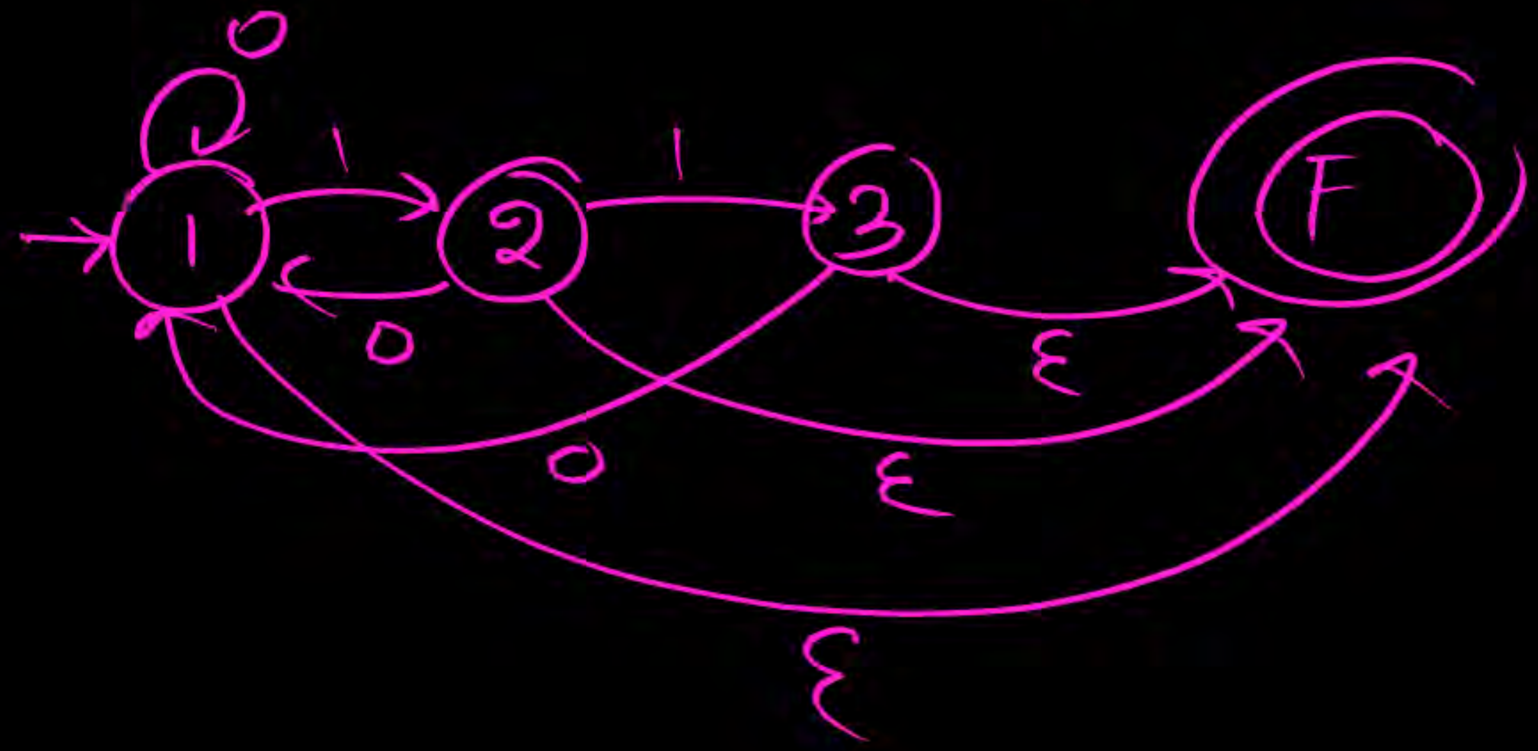
A $(110 + 10 + 0)^* (\in + 11 + 1)$ $\rightarrow$ $\{\varepsilon, 0, 1, 00, 01, 10, 11, 000, 001, 010, 011, 100, 101, 110, \cancel{111}, \ldots\}$

B $(\in + 11 + 1)(110 + 10 + 0)^*$ $\rightarrow$ $\underline{1110}$

C $(011 + \boxed{01} + 0)^* (\in + \boxed{11} + 1)$ $\rightarrow$ 0111

D $(\in + 11 + 1)(011 + 01 + 0)^*$





Eliminate state 2 and state 3

Regular Expression: MCQ

Q15. Consider the following regular language L:

$L = \{w \mid \text{number of a's } (w) \bmod 3 \neq 1 \text{ where } w \in (a, b)^*\}$

Which one of the following represents above language L?

A $(\in + b^* ab^* ab^* + ab^*) (a + b)^*$

B $[(b^* ab^* ab^* ab^*)^* + b^*] (b^*ab^*ab^*)$

C $[(b^*a\, b^*a\, b^*ab^*)^* + (b^* + \in + b^*ab^*ab^*)]$

D $[b^*a\, b^*ab\, ^*\, ab^*)^* + b^*] (\in + b^*ab^*ab^*)]$

Regular Expression: MCQ

Q16. Which of the following represents set of all strings starts and ends with different symbols over a's and b's?

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

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

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

D None of these

Regular Expression: MCQ

Q17. Which of the following is TRUE?

(A) $1(11)^* = (1(11)^*)^*$

(B) $(11)^* = (1(11)^*)^*$

(C) $(1(11)^*)^* = 1^*$

(D) $(11)^* = 1^*$

Regular Expression: MCQ

Q18. Consider the following regular expression given below:

$R_1 = (01 + (1 + 01)0)^* (1 + 01)$

$R_2 = (01)^* (1 + 01) (0(01)^* (0 + 01))^*$

Which of the following is correct about R_1 and R_2?

A. String "0110" generated by R_2 but not R_1.

B. String "0110" generated by R_1 but not R_2.

C. Both expression generates the same language.

D. None of these

Regular Expression: MCQ

Q19. Suppose the length of language $|L_1| = 5$ and $|L_2| = 4$ then, which of the following is correct?

A $|L_1 . L_2| \geq 5$

B $|L_1 . L_2| \geq 20$

C $|L_1 . L_2| \geq 9$

D $|L_1 . L_2| \leq 20$

Regular Expression: MCQ

Q20. Choose correct statement.

A) $R + \phi = R \cdot \phi$

B) $R + R = R \cdot R$

C) $R + \varepsilon = R + \phi$

D) $R + R = R \cdot \varepsilon$

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 02

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Topics to be Covered

Topic Regular Expression

Topic Finite Automata

Regular Expression & Finite Automata

Regular Language

Regular Exp $\cong$ FA $\cong$ Regular Grammar

Regular Exp & FA : MCQ

$L = \{\varepsilon, b^*, aa, b^*ab^*ab^*, \ldots\}$

Q15. Consider the following regular language L:

L = {w | number of a's (w) mod 3 ≠ 1 where w ∈ (a, b)*}

DEVA SIR PW

Which one of the following represents above language L?

$\boxed{n_a(\omega) \% 3 = 0 \text{ or } 2}$

~~A~~ $(\in + b^*ab^*ab^* + ab^*)(a+b)^* = (a+b)^*$

~~B~~ $[\underbrace{(b^*ab^*ab^*ab^*)^* + b^*}_{\varepsilon}]\,\underbrace{(b^*ab^*ab^*)}_{aa}$

5 a's not possible

\#a's = 0, 2, 3, 5, 6, 8, ...

~~C~~ $[\underbrace{(b^*ab^*ab^*ab^*)^*}_{3k} + (\underbrace{b^* + \in}_{0 \text{ a's}} + \underbrace{b^*ab^*ab^*}_{2 \text{ a's}})]$

$n_a(\omega) \% 3 \neq 1$

D $[\underbrace{b^*ab^*ab^*ab^*)^* + b^*}_{\varepsilon\, a\, \varepsilon\, a\, \varepsilon\, a\, b}]\,\underbrace{(\in + b^*ab^*ab^*)]}_{\varepsilon}$

\#a's ≠ 1, 4, 7, 10, ...

$$\boxed{\#a\text{'s} \% 3 = 0 \text{ or } 2}$$

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

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

$$= ((b^*ab^*ab^*ab^*)^* + b^*)(\varepsilon + b^*ab^*ab^*)$$

Q16. Which of the following represents set of all strings starts and ends with different symbols over a's and b's?

$$a\Sigma^* b + b\Sigma^* a$$

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

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

C $\boxed{a(a + b)^* b} + \boxed{b(a + b)^* a}$

D None of these

Q17. Which of the following is TRUE ?

(A) $\underbrace{1(11)^*}_{\text{Min}=1} = \underbrace{(1(11)^*)^*}_{\text{Min}=\varepsilon}$

(B) $\overbrace{\underbrace{(11)^*}_{1 \text{ not possible}}}^{\varepsilon,\,11} = \overbrace{(1(11)^*)^*}^{\varepsilon,1,11,}$

(C) $\underbrace{(1(11)^*)^*}_{\varepsilon,1,11,111,\dots} = \underbrace{1^*}_{\varepsilon,1,11,111,\dots}$

(D) $\underbrace{(11)^*}_{\text{even}} = \underbrace{1^*}_{\text{All}}$

Regular Exp & FA : MCQ

Q18. Consider the following regular expression given below:

$R_1 = (01 + (1 + 01)0)^* (1 + 01)$

$R_2 = (01)^* (1 + 01) (0(01)^* (0 + 01))^*$

Which of the following is correct about R_1 and R_2?

A String "0110" generated by R_2 but not R_1.

B String "0110" generated by R_1 but not R_2.

C Both expression generates the same language.

D None of these

Regular Exp & FA : MCQ

Q19. Suppose the ~~length~~ size of language $|L_1| = 5$ and $|L_2| = 4$ then, which of the following is correct?

$|L_1 L_2| \geq 8$

$L_1 = \{a, b, c, d, e\}$

$L_2 = \{f, g, h, i\}$

$L_1 L_2 = \{\underbrace{\square\square}_{5 \times 4}, \ldots\}$

20 strings

$\boxed{8 \leq |L_1 L_2| \leq 20}$

A. $|L_1 . L_2| \geq 5$

B. $|L_1 . L_2| \geq 20$

C. $|L_1 . L_2| \geq 9$

D. $|L_1 . L_2| \leq 20$

Regular Exp & FA : MCQ

Q20. Choose correct statement.

A $\overbrace{R+\phi}^{R} = \overbrace{R.\phi}^{\phi}$ ✗

B $\underbrace{R+R}_{R} = \underbrace{R.R}_{R^2}$ ✗

C $R+\varepsilon = \underbrace{R+\phi}_{R}$ ✗

D $\underbrace{R+R}_{R} = \underbrace{R\cdot\varepsilon}_{R}$ ✓

Regular Exp & FA : MCQ

Q20. ~~Choose correct statement.~~

Which of the following is possible for some R ?

A. $R + \phi = R . \phi$ possible when $R = \phi$ $\quad \underbrace{\phi + \phi}_{\phi} = \underbrace{\phi . \phi}_{\phi}$

B. $R + R = R . R$ possible when $R = \varepsilon$

C. $R + \varepsilon = R + \phi$

D. $R + R = R . \varepsilon$

Regular Exp & FA : NAT

Q21. Consider the following regular expressions R:

$R = \underbrace{(ab^* + ba^*)^*}\ \underbrace{(ba^* + ab^*)} = (a+b)^+ \Longrightarrow 2$ states

Number of states are needed to design a DFA for above expression R is _____.

H.W.:

$R = (ab^+ + ba^+)^* (ba^* + ab^*)$

$\underset{\times}{\varepsilon}, \underset{\checkmark}{a}, \underset{\checkmark}{b}, \underset{\times}{aa}, \underset{\checkmark}{ab}, \underset{\checkmark}{ba}, \underset{\times}{bb}, \ldots$

Regular Exp & FA : MCQ

Q22. Consider the following deterministic finite automata (DFA):

In above DFA {S} is starting state and $\boxed{F_1 \text{ and } F_2 \text{ are final states.}}$

Which of the following language belong to above DFA?

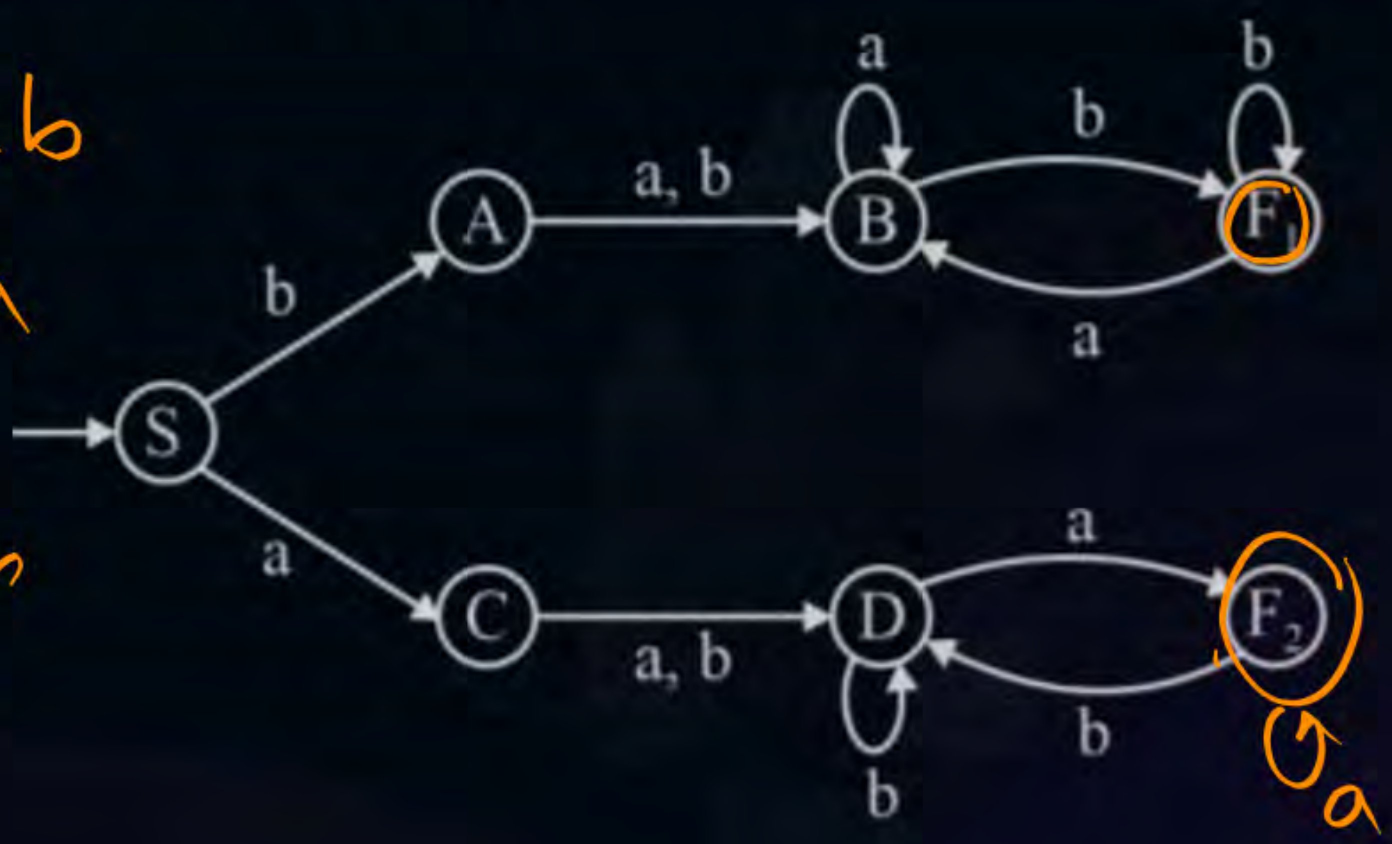
A $L = \{wxw^R \mid w, x \in (a, b)^+\}$ $= axa + bxb$

B $L = \{ww^Rx \mid w, x \in (a, b)^+\}$ $\Rightarrow$ No DFA

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

$\rightarrow$ ◎ a, b

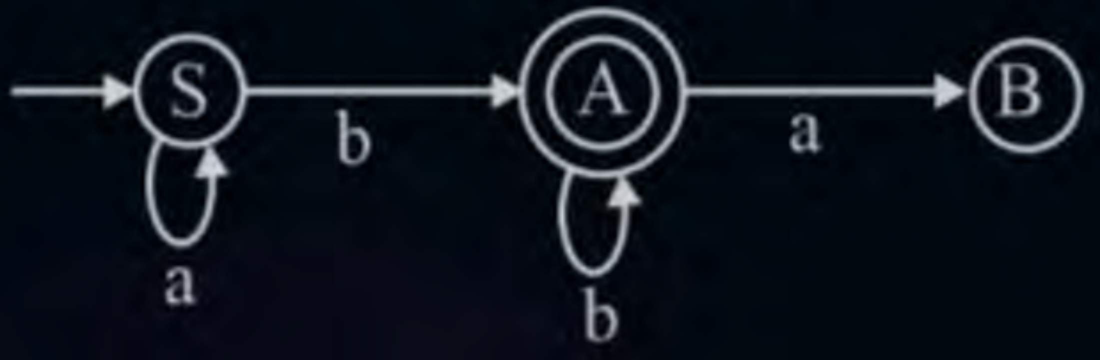
D None of these.



Slide 11

Regular Exp & FA : MSQ

Q23. Consider the following finite automaton F:



$= a^* b b^*$

In above finite automata S is starting state and A is final state. Which of the following is/are correct regular expression for above finite automata?

A ~~A~~ a^*bb^*a

B ✓ a^*b^+

C ✓ $(b + aa^*b) + (b + aa^* b)\, bb^*$

$b + aa^*b + bbb^* + aa^*bbb^*$ ✓

bb, bbb, a^+bb^+

D ✓ a^*bb^*

$a^0 b^+$ ✓

$a^+ b^+$

Slide 12

Regular Exp & FA : NAT

Q24. Consider the language L on $\Sigma = \{0, 1\}$:

$L = \{0^m 1^n \mid m + n = \text{even and } m, n \geq 1\}$ = {01, 0011, 0111, 0001, . . .}

The minimum number of states needed for DFA of language L is _____.

= 6

Regular Exp & FA : NAT

Q25. Consider the following regular expression R:

$R = (00 + 11 + (01 + 10)(00 + 11)^*(01 + 10))^*$

Minimum number of states are needed in DFA for above regular expression R is ____.

$2 \times 2 = 4$ states

$L = \{ w \mid w \in \{0,1\}^*, \; n_0(w) = \underbrace{\text{even}}_{\text{div by 2}}, \; n_1(w) = \underbrace{\text{even}}_{\text{div by 2}} \}$

Regular Exp & FA : MSQ

$|w| \% 3 \leq 1$

Q26. Consider the Language L:

$L = \{w \mid |w| \% 99 \leq 27 \text{ where, } w \in \{a, b\}^*\}$

$(a+b)^3 (\varepsilon+a+b)$

What is the regular expression for above language L?

A) $((a + b)^{27})^* (a + b)^{99}$ $|w| = 27k+99, k \geq 0$

B) $((a + b)^{99})^* (a + b)^{27}$ $|w| = 99k+27, k \geq 0$

C) $\boxed{((\in + a + b)^{99})^*} \boxed{(\in + a + b)^{27}}$ $= (a+b)^*$ $|w| \geq 0$

D) $(\underbrace{(a + b)^{99})^*}_{\varepsilon} \underbrace{(\in + a + b)^{27}}_{\varepsilon}$ $|w| = 99k + m, k \geq 0, m \leq 27$

$$\underbrace{|w| \% 99 \le 27}$$

$$(\Sigma^{99})^* (\varepsilon + \Sigma)^{27}$$

$|w| \% 99 = 0$

OR

$|w| \% 99 = 1$

OR

$|w| \% 99 = 2$

OR

$|w| \% 99 = 3$

OR

$|w| \% 99 = 27$

$$|w| \% 99 = \underbrace{27}_{\text{remainder}}$$

$$(\Sigma^{99})^* \Sigma^{27}$$

$$((a+b)^{99})^* (a+b)^{27}$$

$$\underbrace{|w| \% 99 = 0}_{\text{multiple of } 99}$$

$$(\Sigma^{99})^*$$

$$\underbrace{|w| \% 99 = 1}$$

$$|w| = 99k + 1$$

$$(\Sigma^{99})^* \Sigma$$

$$|w| \% 99 \le 1$$

$$(\Sigma^{99})^* (\varepsilon + \Sigma)$$

$$|w| \% 3 \leq 1$$

$$|w| = 0, 1, \cancel{2}, 3, 4, \cancel{5}, 6, 7, \cancel{8}, \ldots$$

$$rem = 0, 1, 2$$

✓ ✓ ✗

$$\underbrace{\left((\varepsilon+a+b)^{99}\right)^{*}}_{=(a+b)^{*}}$$

- ε ✓
- $a = \left((\quad)^{99}\right)^{1} = \underbrace{\left((a)^{1}(\varepsilon)^{98}\right)^{1}}_{a}$
- b ✓
- aa ✓
- ab _

$$\left((a+b)^{99}\right)^{*}$$

- ε
- $(a+b)^{99}$

Regular Exp & FA : MCQ

Q27. Which of the following regular expression represents the no two consecutive zeros ending with 1?

A. $(01 + 10 + 11 + 1)^*$ → ε ✓ → 0 ×

B. $(01 + 1)^+$ → ε ×

C. $(01+10+11+1)^*0$ → ε ×

D. None of these

$L = \{\varepsilon, 0, 1, 00, 01, 10, 11, 000, \cancel{001}, \ldots\}$

Regular Exp & FA : MCQ

$\Sigma^* 00 \Sigma^* + \Sigma^* 11 \Sigma^*$

Q28. Consider the following regular expression R.

$R = \epsilon + 0\,(10)^*\,(\epsilon + 1) + 1\,(01)^*\,(\epsilon + 0)$

which one of the following languages over the alphabet {0,1} is described by the above regular expression R?

(A) Set of all binary strings having either 00 or 11 as a substring. → ε is invalid

(B) Set of all binary strings not having 00 as a substring. ε, 0, 1, ~~00~~, 01, 10, 11

(C) Set of all binary strings not having 11 as substring. → 00 should be in R if this option is correct

$00 \notin R$

(D) Set of all binary strings neither having 00 nor 11 as a substring.

Slide 17

Regular Exp & FA : MCQ

Q29. Suppose $L_1 = 0^*$

$L_2 = 10$

$L_3 = \{1^m 0^m \mid m \geq 0\}$

$L_4 = 1^*$

If $L_5 = ((L_2/L_1) - L_4) - \overline{L_3}$ Then, the language L_5 will be:

A. ϕ

B. $\{10\}$

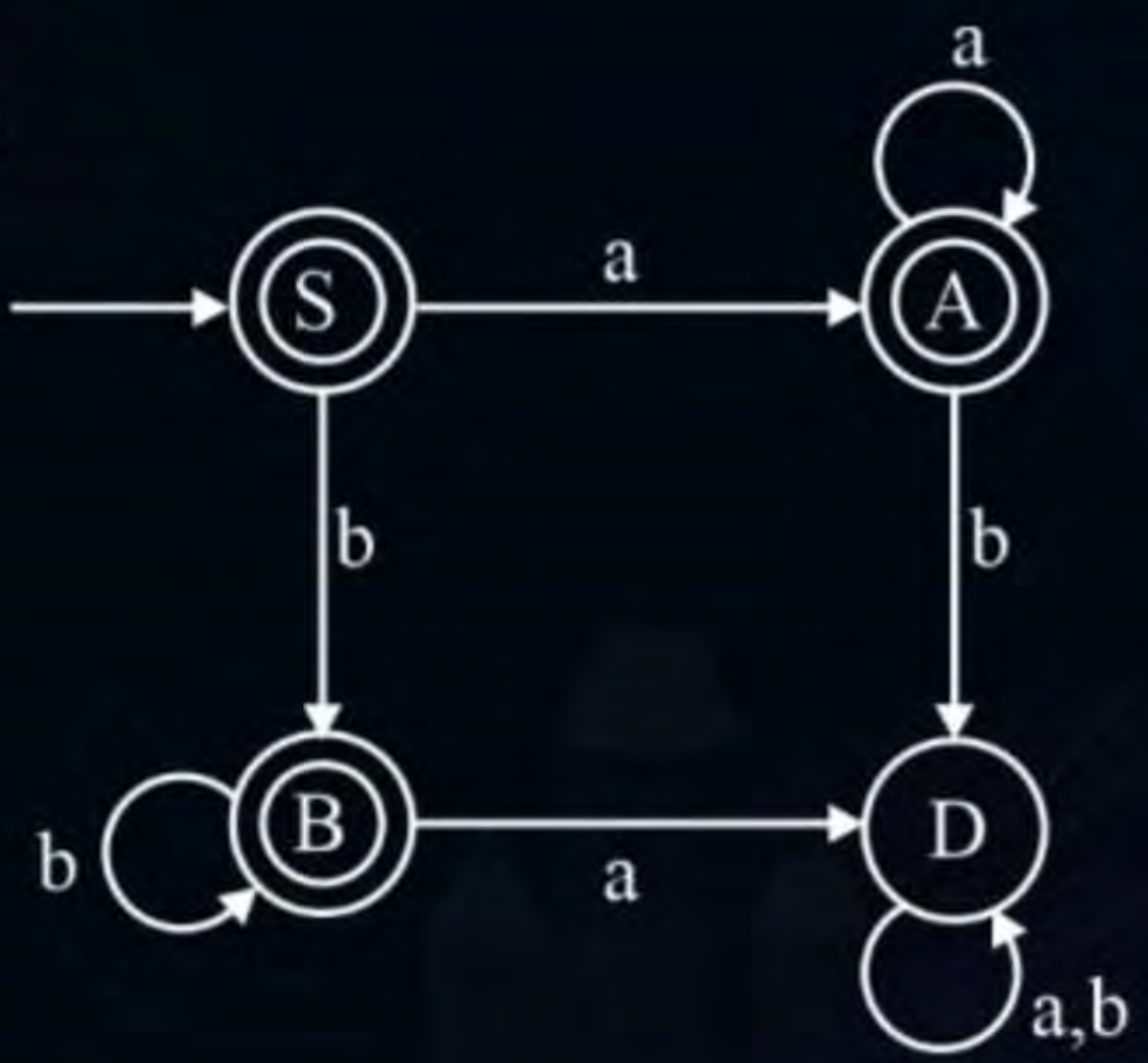
C. 1^*

D. $\{\in\}$

Q30. The number of states in the minimum sized DFA that accepts the language defined by the regular expression $(00 + 111)^*$ is_______.

Regular Exp & FA : MSQ

Q31. Which of the following regular expression is equivalent to the finite automaton?



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

B. $a^* + b^*$

C. $\in + a^+ + b^+$

D. $\in + aa^* + bb^*$

Q32. Consider grammar G:

G:

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

Let $L = \{w \mid w \in L(G) \text{ and } |w| = 14\}$

Then how many strings are possible in L? ____.

Regular Exp & FA : MCQ

Q33. Consider two languages L_1 and L_2 on $= \Sigma\{a, b\}$.

$L_1 = \{aa, ab\}$ and $L_2 = \{aa, ab, abab\}$ then which of the following is true?

A $L_1^* \subset L_2^*$

B $L_2^* \subset L_1^*$

C $L_1^* = L_2^*$

D $(L_1 \cup L_2)^* = (a+b)^*$

Regular Exp & FA : MSQ

Q34. Which of the following is/are correct regular expression for L = {starting and ending whit a}?

A) a (a + b)* a

B) a (a + b)* a + a

C) a (a + bb*a)*

D) a (a + bb*a + aa)*

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 03

Mallesham Devasane Sir

Topics to be Covered

- **Topic** Regular Expression
- **Topic** Finite Automata
- **Topic** Regular Grammar

Regular Languages : MCQ

Q29. Suppose $L_1 = 0^*$

$L_2 = 10$

$L_3 = \{1^m 0^m \mid m \geq 0\}$

$L_4 = 1^*$

If $L_5 = ((L_2/L_1) - L_4) - \overline{L}_3$ Then, the language L_5 will be:

A. ϕ

B. $\{10\}$

C. 1^*

D. $\{\in\}$

$L_2/L_1 = 10/0^* = \{\underbrace{10/\varepsilon}_{10}, \underbrace{10/0}_{1}, \underbrace{10/00, \cdots}_{\phi}\}$

$= \{10, 1\}$

$[(L_2/L_1) - L_4] = \{10, 1\} - 1^* = \{10\}$

$\{10\} - \overline{L}_3 = \{10\}$

Slide 3

$L_3 = 1^n 0^n$

$= \{\varepsilon, \boxed{10}, 1100, 111000, 11110000, \ldots\}$

$\overline{L_3} = \underbrace{(0+1)^* - L_3}_{0}$

$\{10\} - \overline{L_3} = \{10\}$

$$10/0 = 1$$

$$\boxed{uv/v = u}$$

$$10.\varepsilon/\varepsilon = 10$$

$$1\boxed{0}/\boxed{0} = 1$$

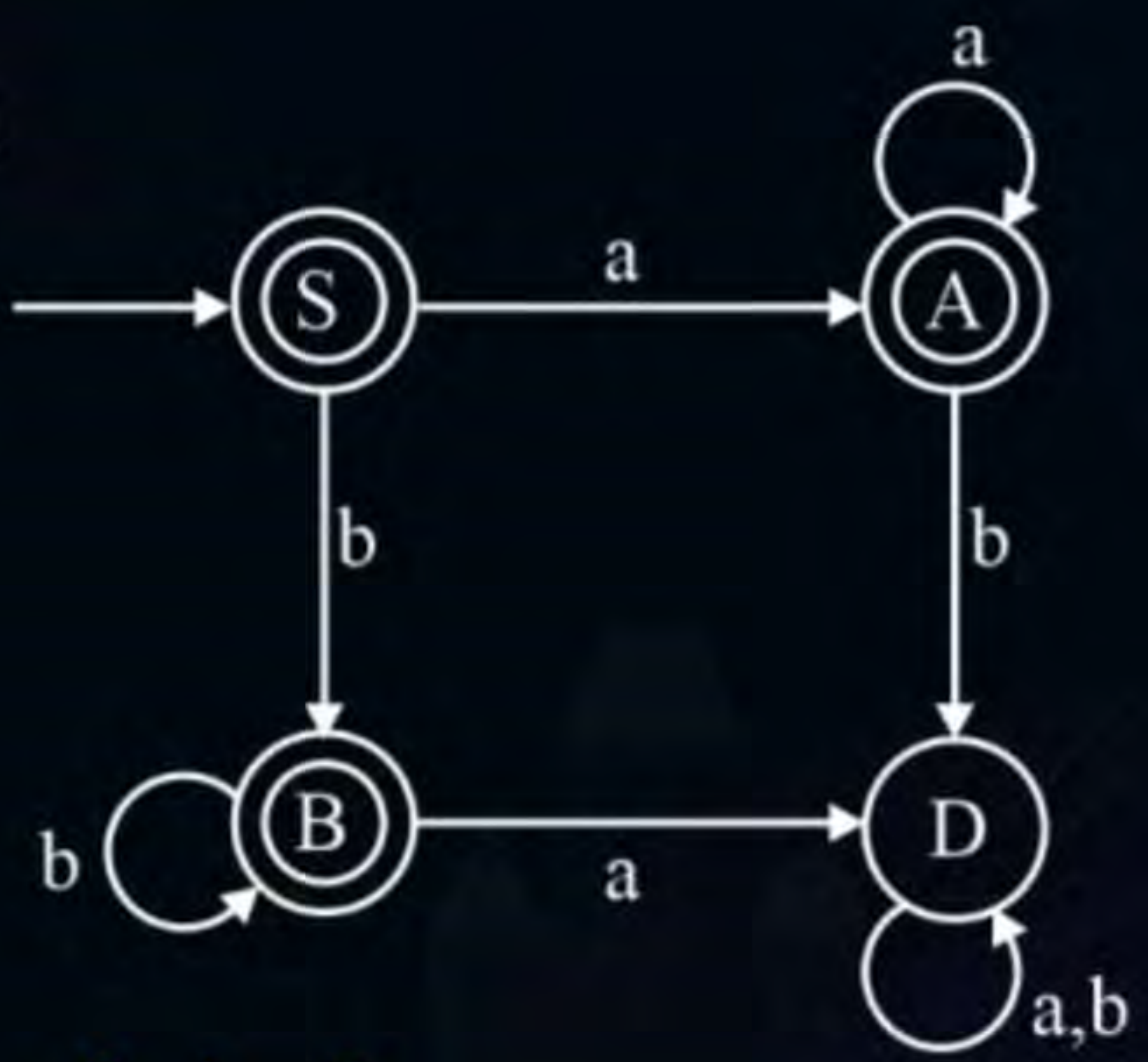
$$\varepsilon.\boxed{11}/\boxed{11} = \varepsilon$$

Regular Languages : NAT

Q30. The number of states in the minimum sized DFA that accepts the language defined by the regular expression $(00 + 111)^*$ is_______.

Regular Languages : MSQ

Q31. Which of the following regular expression is equivalent to the finite automaton?



A $\underbrace{(a+b)^*}\,a + \underbrace{(a+b)^*}\,b$

B $a^* + b^*$

C $\in + a^+ + b^+$

D $\in + aa^* + bb^*$

S + A + B

$\varepsilon + aa^* + bb^*$

Regular Languages : NAT

Q32. Consider grammar G:

$a^7 S a^7 \Rightarrow a^{14}$

$S \to \varepsilon$

G:

$S \to aSa \mid a \mid b \mid \epsilon$

Let $L = \{w \mid w \in L(G) \text{ and } |w| = 14\}$

Then how many strings are possible in L? ____1____.

Regular Languages : MCQ

Q33. Consider two languages L_1 and L_2 on $= \Sigma\{a, b\}$.

(a)

$L_1 = \{aa, ab\}$ and $L_2 = \{aa, ab, abab\}$ then which of the following is true?

$L_1 \subset L_2$

A $L_1^* \subset L_2^*$

B $L_2^* \subset L_1^*$

C $L_1^* = L_2^*$

D $(L_1 \cup L_2)^* = (a+b)^*$

$L_1^* = (aa+ab)^*$

$L_2^* = (aa+ab+abab)^* = L_1^*$

Regular Languages : MCQ

Q33. Consider two languages L_1 and L_2 on $= \Sigma\{a, b\}$.

(b)

$L_1 = \{aa, ab\}$ and $L_2 = \{aa, ab, abab\}$ then which of the following is true?

A $L_1^* \subseteq L_2^*$

B $L_2^* \subseteq L_1^*$

C $L_1^* = L_2^*$

D $(L_1 \cup L_2)^* = (a+b)^*$

Regular Languages : MSQ

Q34. Which of the following is/are correct regular expression for L = {starting and ending ~~whit~~ wilk a}?

$L = \{ w \mid w \in \{a,b\}^*, w$ starting & ending wilk 'a' $\}$

a is missing $= \{a, aa, aaa, aba, \ldots\}$

A. $a(a+b)^*a \longrightarrow$ a is missing

B. $\boxed{a(a+b)^*a} + \boxed{a}$

C. $a(a+bb^*a)^*$ — a ✓, aa ✓, aaa ✓, aba ✓

D. $a(a+bb^*a+aa)^*$

$\underbrace{a(a+b)^*a}_{}$ $\Rightarrow$ min = aa

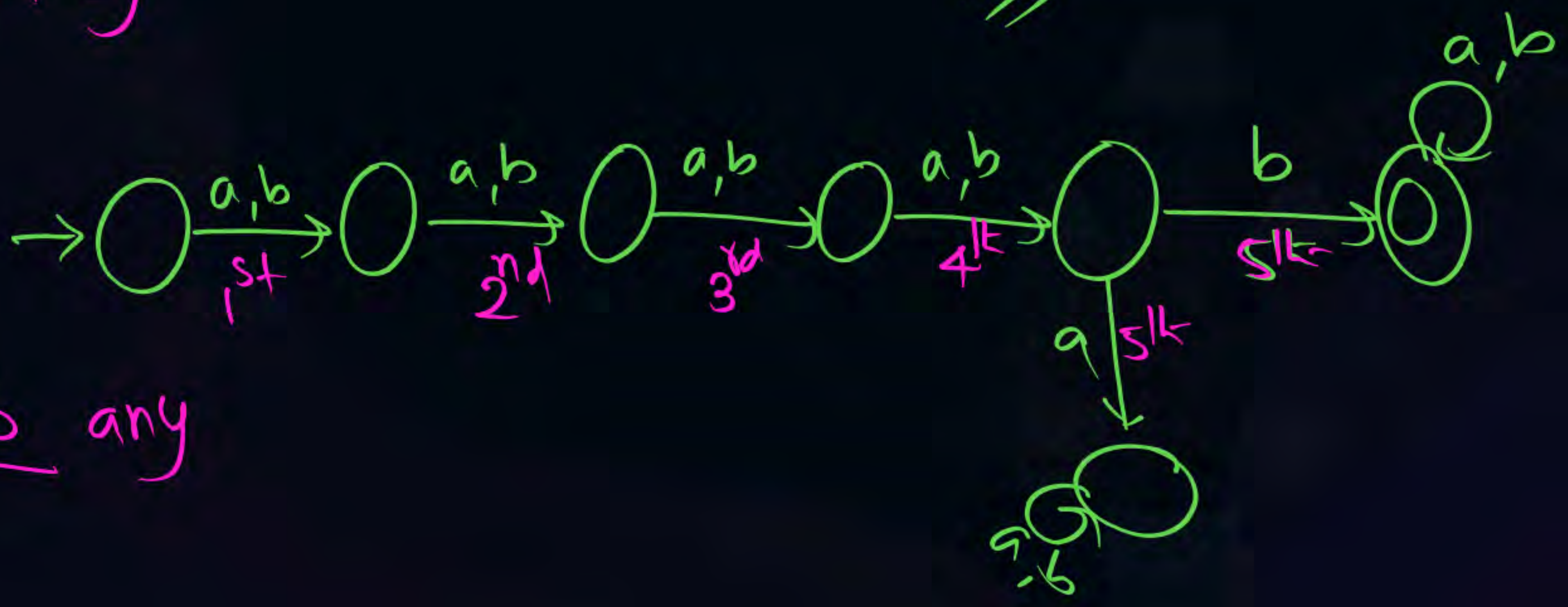
It can't generate all strings

$\boxed{\text{a is missing}}$

Q35. How many minimal states are needed in DFA to design a language over $\Sigma = \{a, b\}$ where 5^{th} symbol from left is b?____

$(a+b)^4 b (a+b)^*$

$5 + 2 = 7$



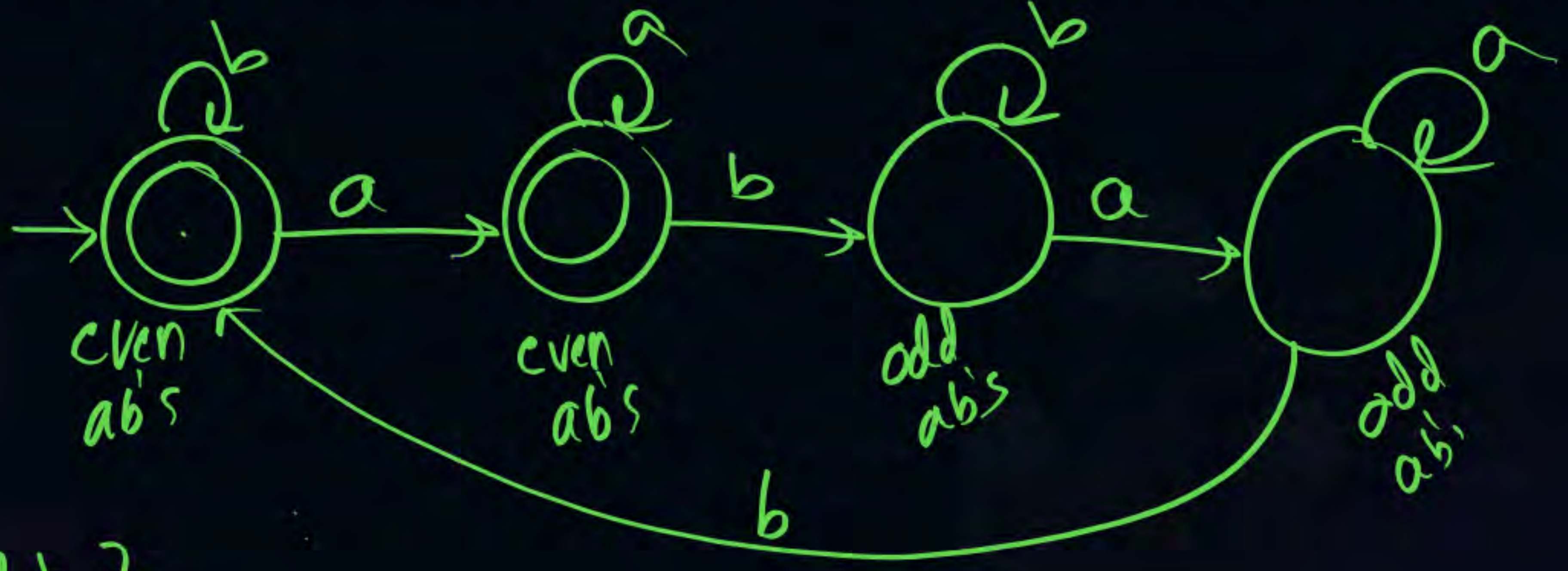
a/b a/b a/b a/b b any

Q36. The number of minimal states in DFA that accepts all the strings over $\Sigma = \{a, b\}$. Where "$\underbrace{\boxed{\text{2nd}}}_{K}$ symbol from right hand side is a" are____.

$$2^K = 2^2 \Rightarrow 4$$

Regular Languages : NAT

Q37. Construct a minimal DFA that accepts all the strings over $\Sigma = \{a, b\}$. where, number of occurrence of substring "ab" is even. If number of trap states are x, number of final states are y and number of non-final states are z then the value of "xy + z" is ____.



$x = 0$

$y = 2$

$z = 2$

$xy + z$

$0 + 2 = 2$

$$L = \{\varepsilon, a, b, aa, \cancel{ab}, ba, bb, aaa, \cancel{aab}, \dots\}$$

$$= \{w \mid n_{ab}(w) = \text{even}\}$$

$$\underbrace{\#_{ab}(w) = \text{even}}_{= 0, 2, 4, 6, 8, \dots}$$

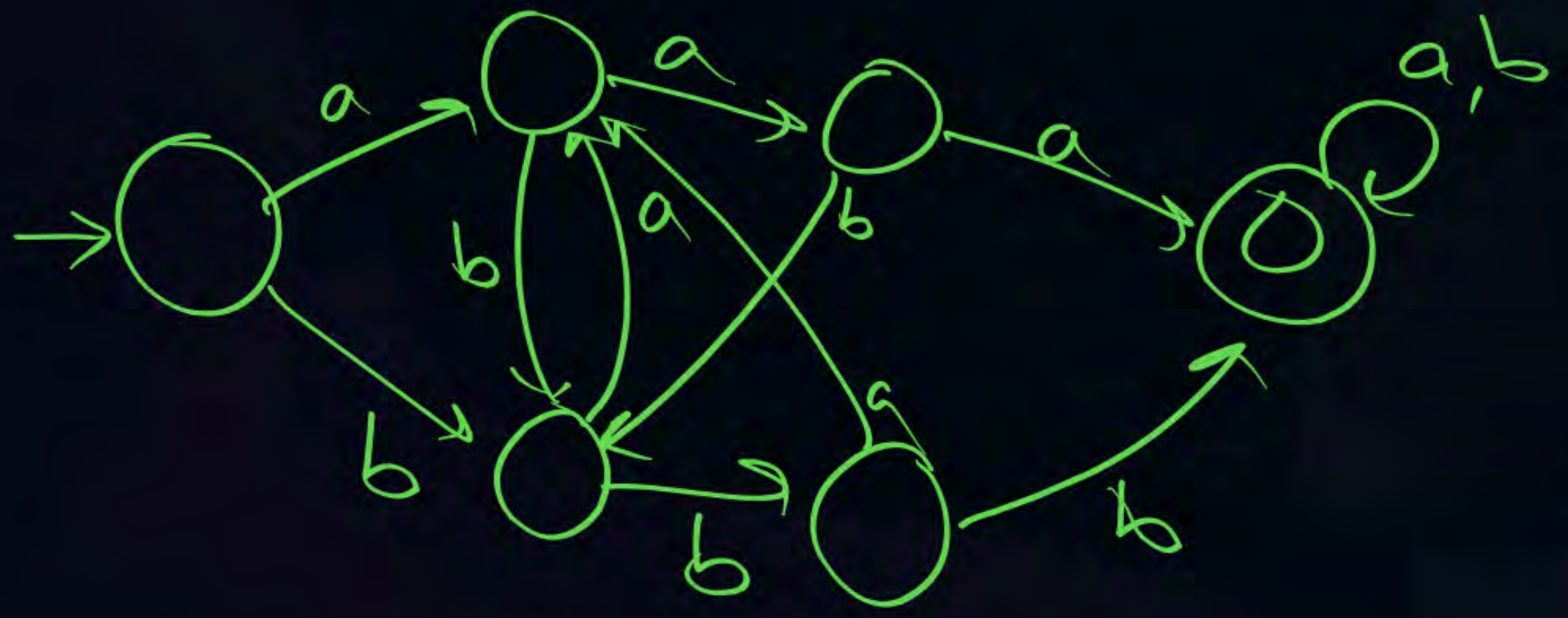
Regular Languages : NAT

Q38. How many minimal states are needed to design a DFA that accepts language over $\Sigma = \{a, b\}$. Where each string contains "aaa or bbb" as a substring? ____

(a)

$L = \{aaa, bbb, \dots\}$

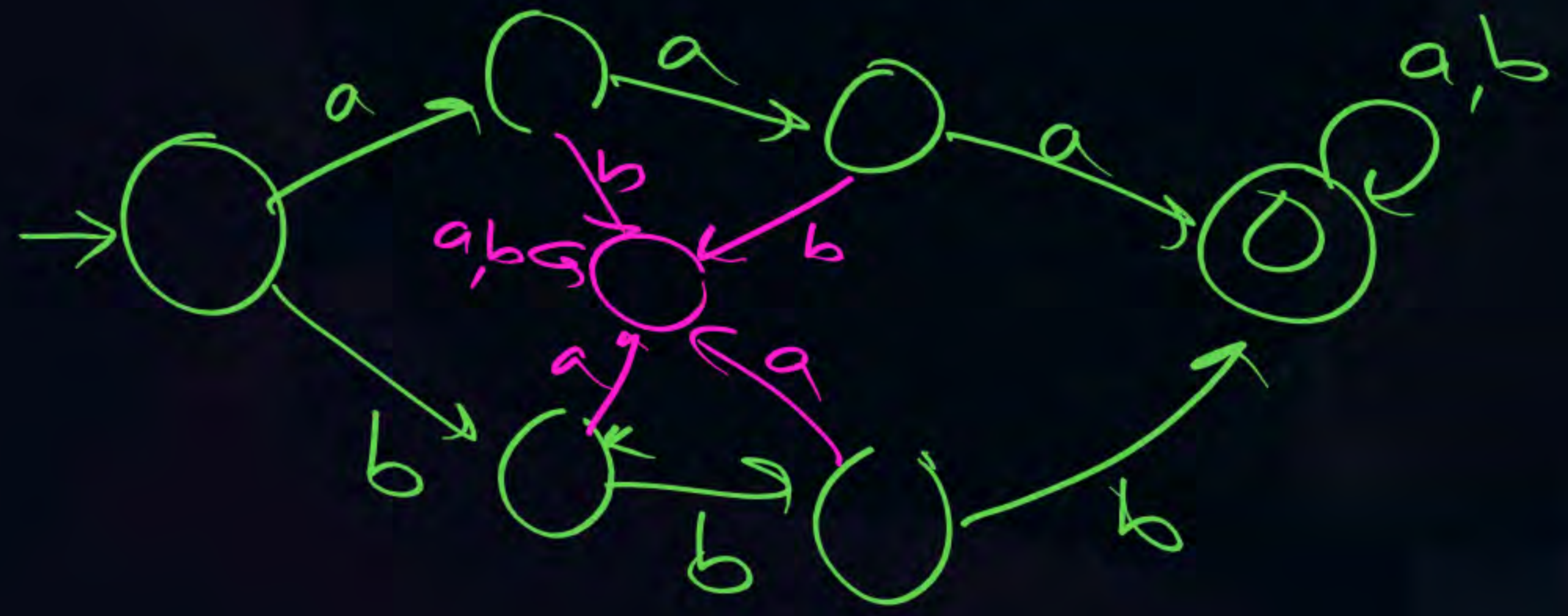
$= 6$ //



Regular Languages : NAT

Q38. How many minimal states are needed to design a DFA that accepts language
(b) over Σ = {a, b}. Where each string ~~contains~~ starts with "aaa or bbb" as a substring? ____

= 7



Regular Languages : NAT

Q38. How many minimal states are needed to design a DFA that accepts language
(c) over $\Sigma = \{a, b\}$. Where each string ~~contains~~ ends with "aaa or bbb" as a substring? ____

$L = \{aaa, bbb, \ldots\}$

$= 7$ //

Slide 12

Regular Languages : NAT

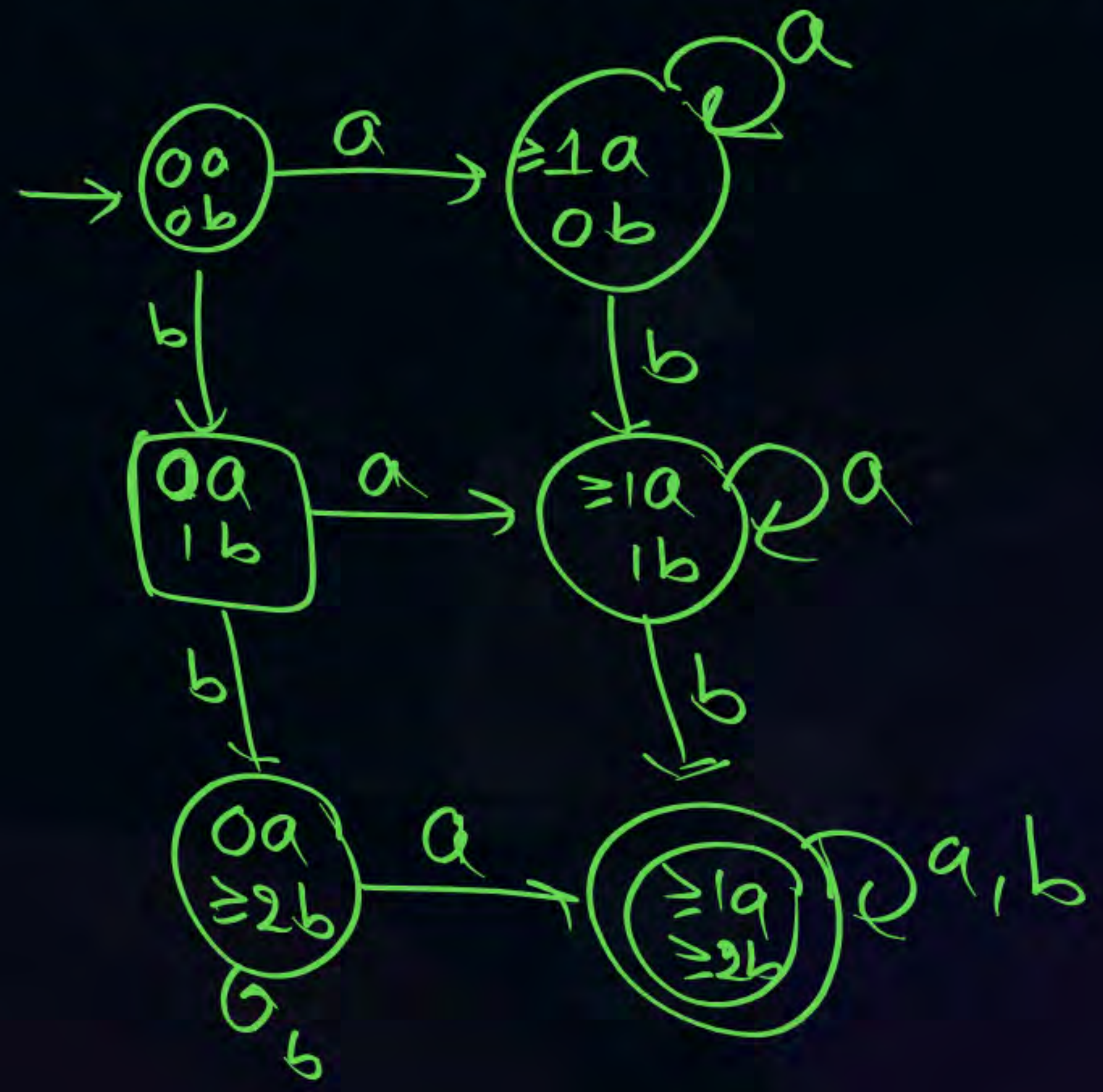
Q39. Consider the language (L) over $\Sigma = \{a, b\}$ if number of a's in a string ~~are~~ is at least 1 $\boxed{\text{and}}$ number of b's in a string ~~are~~ is at least 2 then total number of states in a minimal DFA is ______

$\#a\text{'s} \geq 1$

$\#b\text{'s} \geq 2$

$L = \{abb, bab, bba, \ldots\}$

$= 6$

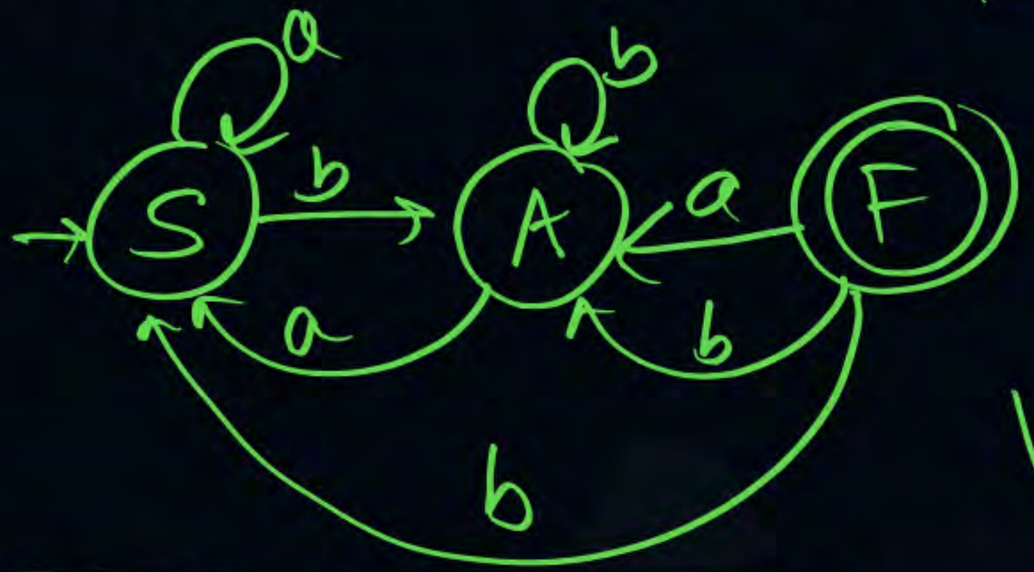


Regular Languages : MCQ

Q40. Consider the following transition table (T) on input alphabet {a, b} for NFA.

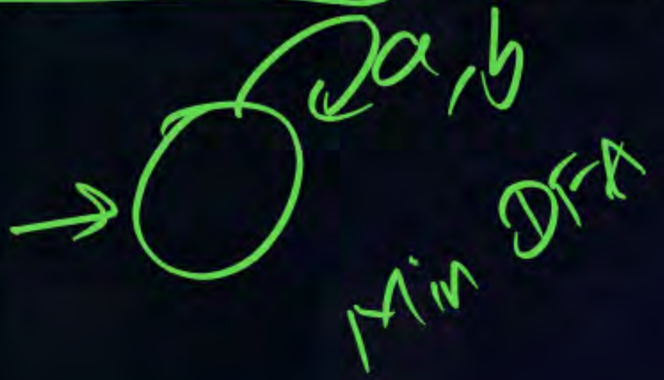
T:

δ	a	b
$\rightarrow$S	{S}	{A}
A	{S}	{A}
*F	{A}	{S,A}



$L = \phi$

How many states are needed to design equivalent minimal DFA for above NFA?



A 4

B 1

C 2

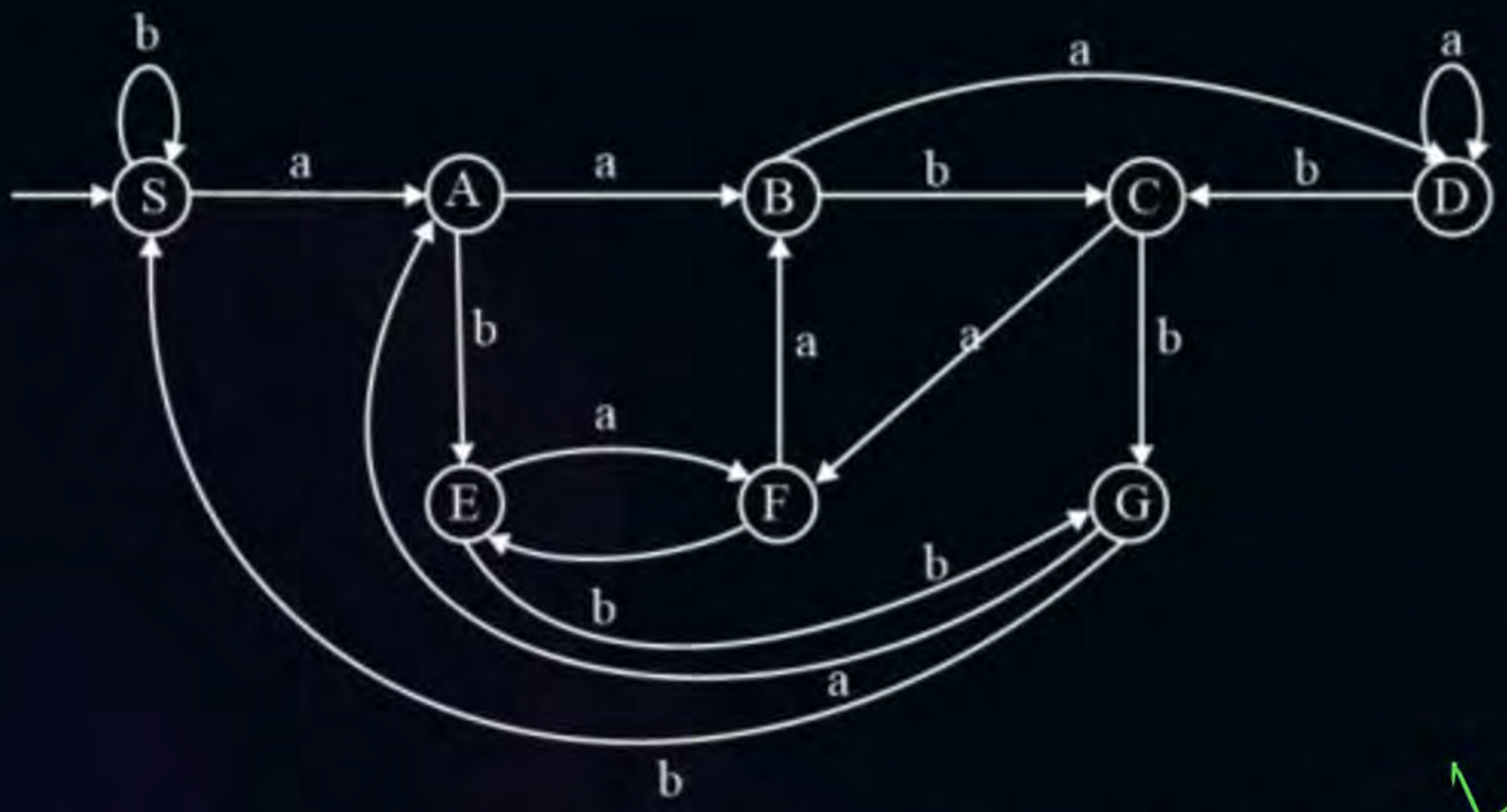
D 3

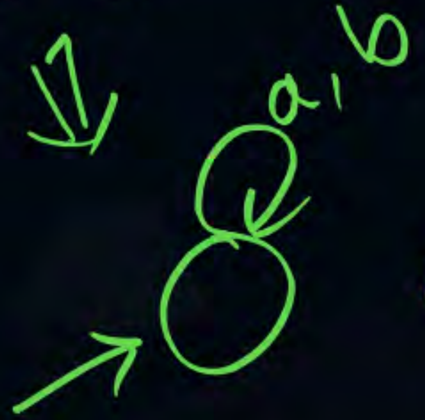
Q41. Consider the following DFA.

All are non finals

⇓ Language is empty

⇓





How many states are possible in minimal DFA? ___ = 1

Regular Languages : MSQ

Q42. Which of the following is/are correct?

A. $(r + \epsilon)^* = r^*$

B. $(r^* s^*)^* (rs + \epsilon)\, \underbrace{(r + s)^*}_{} + s^*r^* = (r + s)^*$

C. $\epsilon + rss^* + rss^* (r + s)^* = (rss^*)^*$

D. $(r^*s^*)^+ = (r^+ s^+)^*$

$\varepsilon \cdot \varepsilon \cdot (r+s)^* + \text{Any} = (r+s)^*$

$(rss^*)^*$

$(rs\varepsilon)(rs \ldots)$

Slide 16

$$(r^* s^*)^+ = \{ \underbrace{(r^0 s^0)^1}_{\varepsilon}, \underbrace{(r^1 s^0)^1}_{r}, \underbrace{(r^0 s^1)^1}_{s}, \ldots \}$$

$$(\underline{r^+}\,\underline{s^+})^* = \{ \varepsilon, rs, rrs, rss, rsrs, \ldots \}$$

$$\boxed{r + \varepsilon \neq r} \qquad \boxed{r \cdot \varepsilon = r}$$

Regular Languages : MSQ

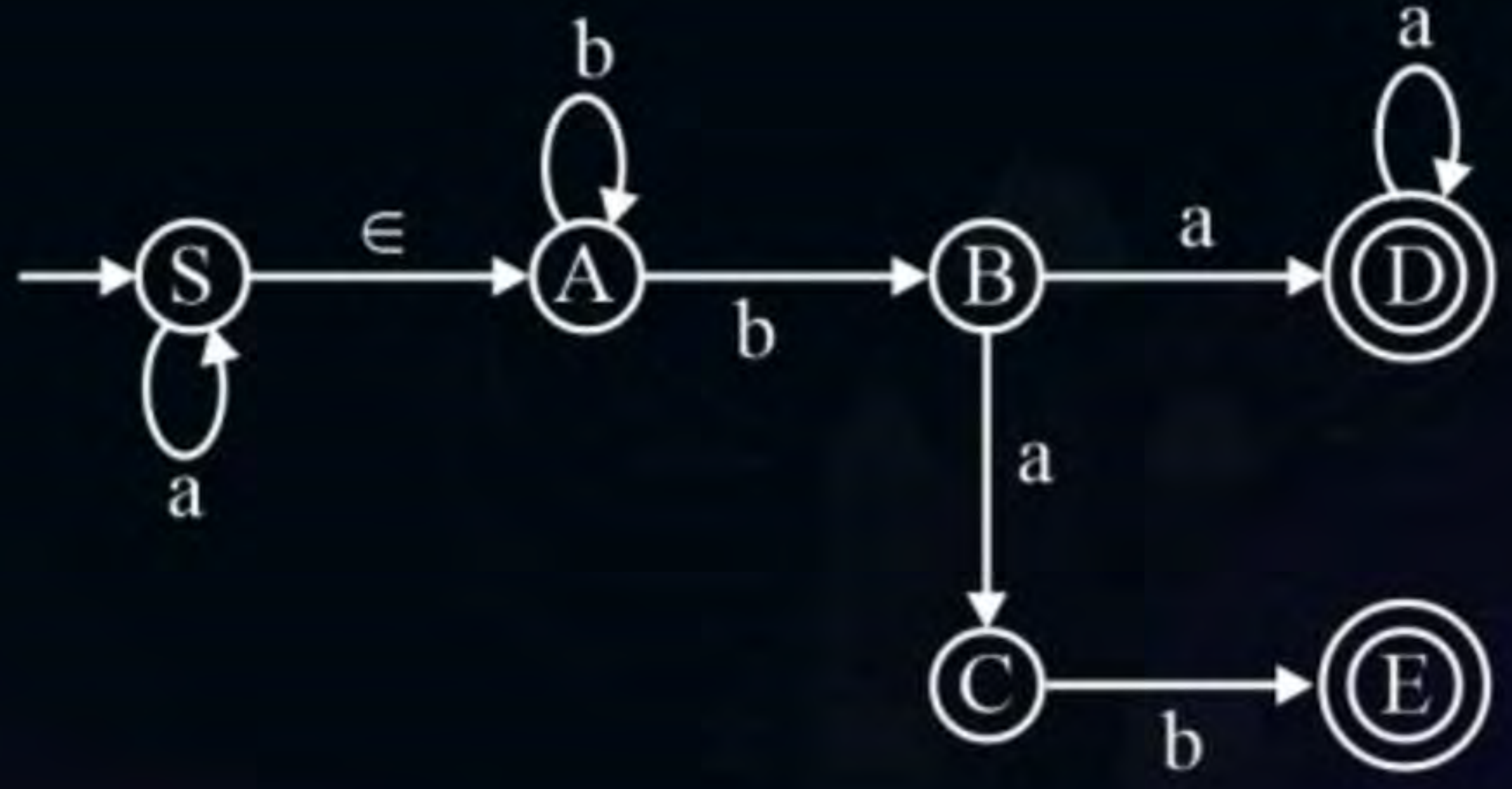
Q43. Consider the following $\in$-NFA:
Which of the following strings are accepted?

A abab

B baab

C bbaa

D abaa



Regular Languages : MCQ

[MCQ]

Q44. let L be the set of all the languages accepted by all grammars where every production is in the form of $V \rightarrow VT^*$ or $V \rightarrow T^*$.
Let Q be the set of all languages accepted by all grammars where every production of grammar is in the form of $V \rightarrow T^*V$ or $V \rightarrow T^*$
Which of the following is correct?
(Note: T is terminals and V is non-terminals)

A. $L \geq Q$

B. $L \leq Q$

C. $L = Q$

D. $L \neq Q$

Regular Languages : MSQ

Q45. Consider the following grammar G:

G: $S \rightarrow aS \mid bS \mid aaS \mid bbS \mid a$

Which of the following is correct regular expression for above grammar G?

A $(a + b)^* a$

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

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

D None of these

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 04

Mallesham Devasane Sir

Topics to be Covered

- **Topic** Regular Expression
- **Topic** Finite Automata
- **Topic** Regular Grammar
- **Topic** Closure Properties

Regular Languages : MSQ

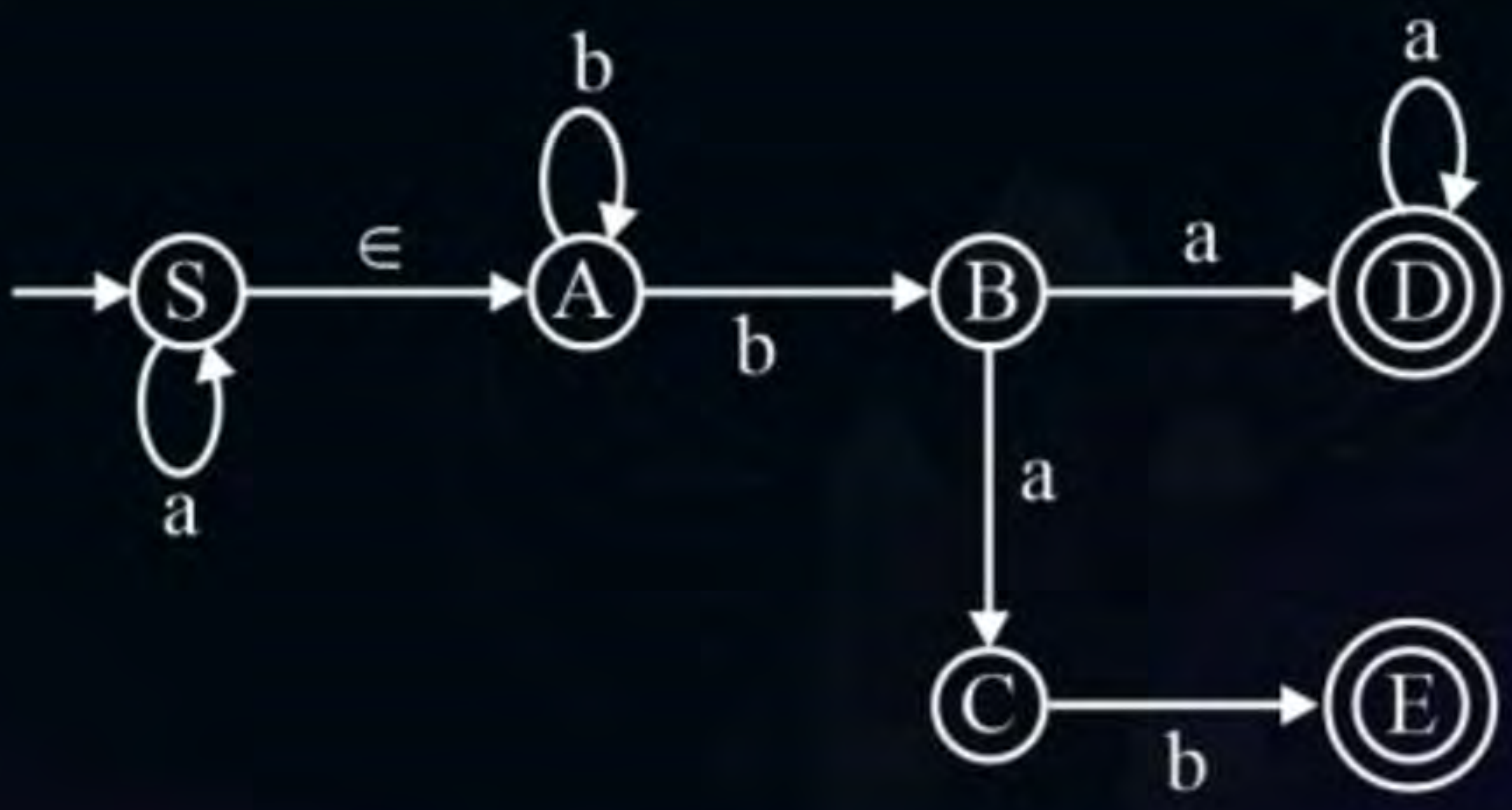
Q43. Consider the following $\in$-NFA:
Which of the following strings are accepted?

A. abab ✓ $a\varepsilon bab$

B. baab

C. bbaa ✓ $\varepsilon bbaa$

D. abaa ✓ $a\varepsilon baa$



Regular Languages : MCQ

L = Set of all languages generated by LLGs

[MCQ]

Q44. let L be the set of all the languages accepted by all grammars where every production is in the form of $\boxed{V \to VT^* \text{ or } V \to T^*}$.

LLG

Let Q be the set of all languages accepted by all grammars where every production of grammar is in the form of $\boxed{V \to T^*V \text{ or } V \to T^*}$

RLG

Which of the following is correct?

(Note: T is terminals and V is non-terminals)

Q = Set of all languages generated by RLGs

A) $L \geq Q$

B) $L \leq Q$

C) $L = Q$

D) $L \neq Q$

$L_s(LLG_s) = L$

$L_s(RLG_s) = Q$

$\boxed{L = Q}$

L = Q = Set of all regular languages

Regular Languages : MSQ

Q45. Consider the following grammar G:

G: $S \rightarrow aS \mid bS \mid a\cancel{a}S \mid b\cancel{b}S \mid a$ $(a+b)^* a$

Which of the following is correct regular expression for above grammar G?

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

B. $(a + b + aa + bb)^* a$ $= (a+b)^* a$

C. $(a + b + aa + bb + ba)^* a$ $= (a+b)^* a$

D. None of these

Regular Languages : MCQ

Q46. Consider the following deterministic finite automaton (DFA).

000
001
⋮
111

} 8 strings

The number of strings of length 3 accepted by the above automaton is____.

A 2

B 4

C 6

D 8

Regular Languages : MCQ

Q47. Consider the following DFA.

Which one of the following language L accepted by above DFA?

A $L = \{w \in \{0, 1\}^* \mid w \text{ ends with } 011\}$

B $L = \{w \in \{0, 1\}^* \mid w \text{ starts with } 011\}$

C $L = \{w \in \{0, 1\}^* \mid w \text{ has substring } 011\}$

D $L = \{w \in \{0, 1\}^* \mid w \text{ ends with } 11\}$

Regular Languages : MSQ

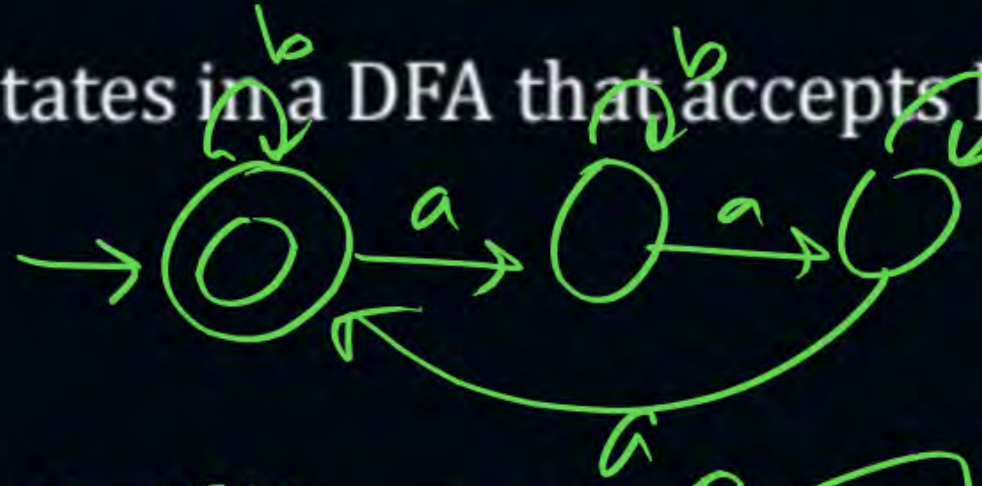
Q48. Consider the following language:

$\div 3$ //

div by 3

$L = \{x \mid x \in \{a, b\}^*$, number of a's in x is $\boxed{\text{divisible by 3 or divisible by 6}}\}$

The minimum number of states in a DFA that accepts L is ____.



a's is div by 3

a's = 0, 3, 6, 9, 12, 15, 18, . . .

a's is div by 6

a's = 0, 6, 12, 18, . . .

$n_a(w) = 3$

$n_a(w) = 6$

a's is div by 3
OR
b's is div by 6

3×6 = 18

Regular Languages : NAT

Q49. Consider the following statements:

I. If $L_1 \cup L_2$ is regular, then both L_1 and L_2 must be regular. → F
II. If $L_1 \cap L_2$ is regular, then both L_1 and L_2 must be regular. → F
III. If Complement of L is regular, then L must be regular. → True
IV. If L_1 - L_2 is regular, then both L_1 and L_2 must be regular. → False
V. If L^* is regular, then L must be regular. → False

How many of above statements are FALSE?

= 4 //

L^* is Reg

$\Downarrow\!\!\!\!/$

L need not be Reg

$\{a^{\text{Prime}}\}^*$ is Reg

$\Downarrow\!\!\!\!/$

a^{prime} is not reg

$L_1 - L_2$ is Reg

$\not\Downarrow$

L_1 and L_2 need not be Regular

$a^n b^n - a^n b^n \Rightarrow \phi$

$L_1 \cap L_2$ = Regular

$$\Downarrow$$

L_1 and L_2 need not be Regular

$$a^n b^n \;\bigcap\; b^n a^n \Rightarrow \underset{\{\epsilon\}}{\text{Reg}}$$

If $\underbrace{L_1 \cup L_2}$ is Regular then L_1 need not be reg

L_2 need not be reg

$\{a^n b^n\} \cup \overline{\{a^n b^n\}} \Rightarrow$ Regular

$(a+b)^*$

$$\boxed{L \cup \bar{L} = \Sigma^*}$$

Regular Languages : MCQ

$\Sigma = \{f_1, f_2\}$

Q50. Let $\sum$ be the set of all bijections from $\{1, 2\}$ to $\{1, 2\}$, where *id* denotes the identity function, i.e. $id(j) = j, \forall j$.
Let $\circ$ denote composition on functions.
For a string $x = x_1 x_2 \ldots x_n \in \sum^n$, $n \geq 0$, let $\pi(x) = x_1 \circ x_2 \circ \ldots \circ x_n$.
Consider the language $L = \{x \in \sum^* \mid \pi(x) = id\}$.
The minimum number of states in any DFA accepting L is _____.

Identity Function ✓
Bijective Function. ✓
Composition.

$$L = \{ x \mid \pi(x) = id \}$$

Bijective Function: [one to one correspondence]

↳ It is $\underbrace{\text{Injective}}_{\text{one to one func}}$ & $\underbrace{\text{Surjective}}_{\text{onto func}}$

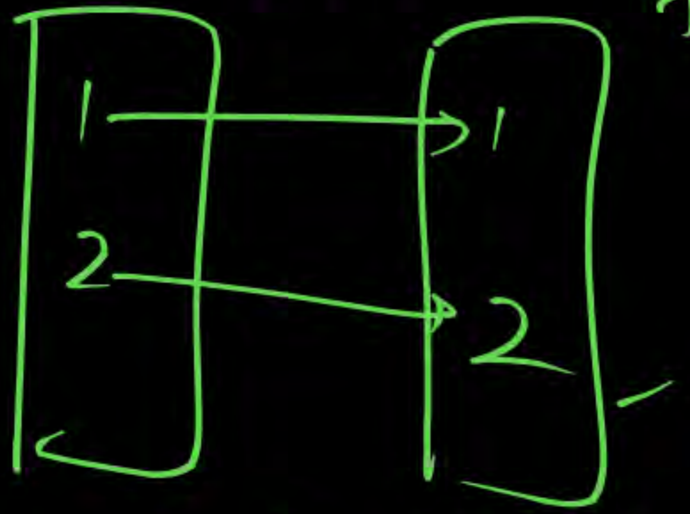
Set
↓
function
↙ ↘
$\underbrace{\text{Inj} \qquad \text{Surj}}_{\text{Bij}}$

$$\Sigma = \{ \overset{id}{\boxed{f_1}}, f_2 \} = \{a, b\}$$

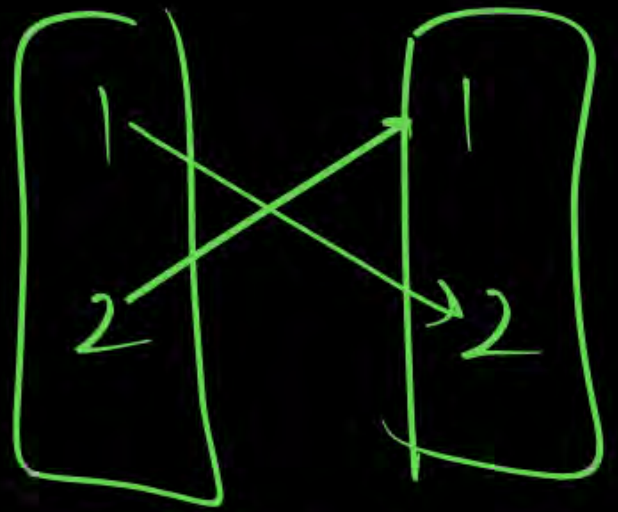
$$\Sigma^* = \{\varepsilon, \underset{a}{f_1}, \underset{b}{f_2}, \underset{aa}{f_1 f_1}, \underset{ab}{f_1 f_2}, \underset{ba}{f_2 f_1}, \underset{bb}{f_2 f_2}, \ldots\}$$

Id

$f_1 = id$

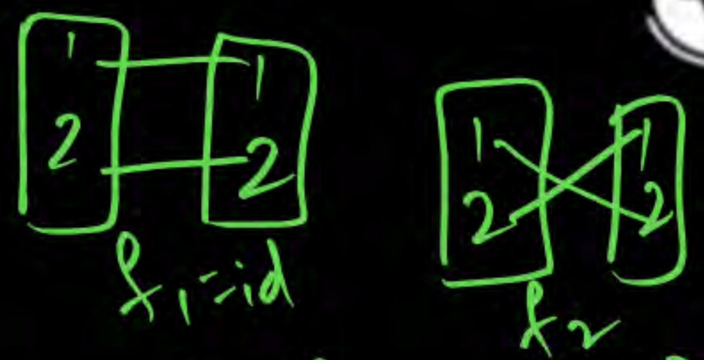


f_1



f_2

$$\Sigma = \{f_1, f_2\} = \{a, b\}$$



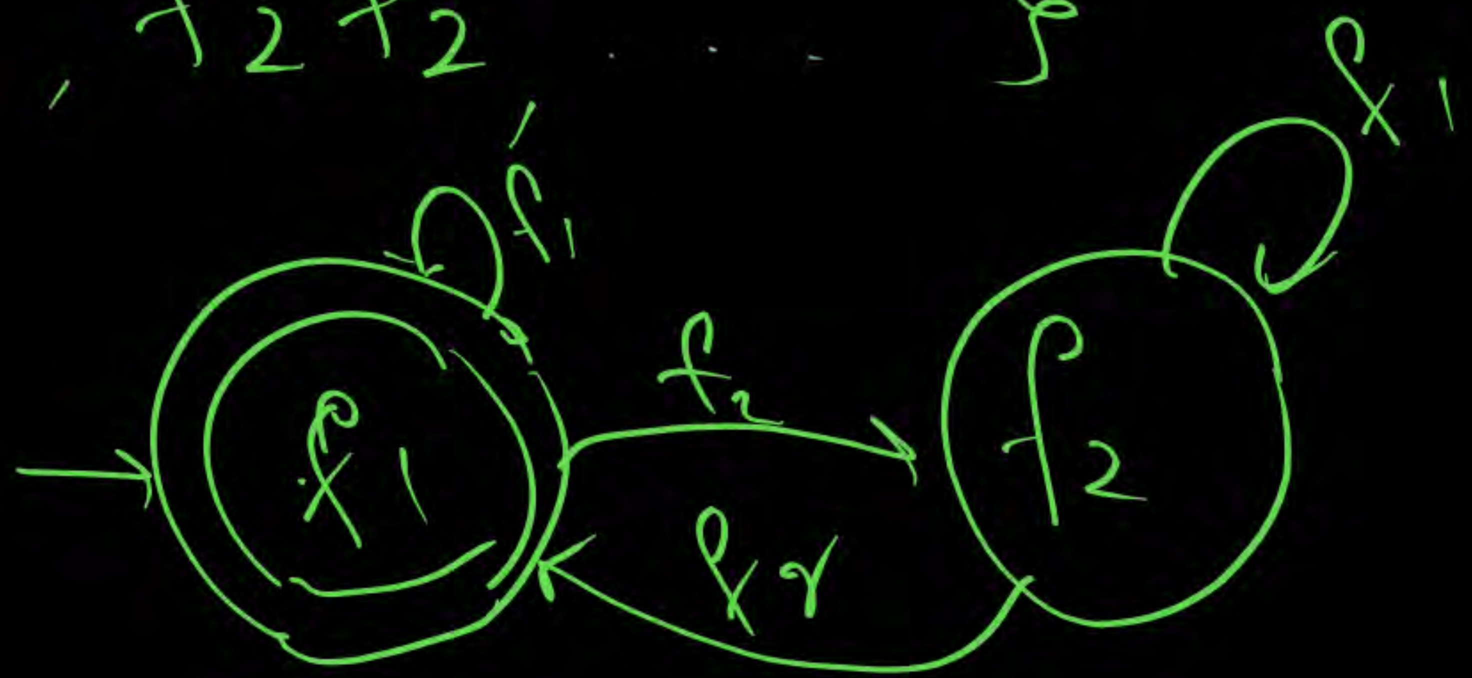
$$\Sigma^* = \{\varepsilon, f_1, f_2, f_1f_1, f_1f_2, f_2f_1, f_2f_2, \dots\}$$

✓, a ✓, b ✗, aa ✓, ab ✗, ba ✗, bb ✓

$$L = \{\underbrace{\varepsilon}_{\text{choice}}, f_1, f_1f_1, f_2f_2, \dots\}$$

$$\Downarrow$$

$$\pi(f_1) = id$$



Regular Languages : MSQ

Q51. If L is a regular language over $\Sigma = \{a, b\}$, which one of the following languages is TRUE?

$y \in L^R$

A. $\{xy \mid x \in L, y^R \in L\}$ is Regular $L \cdot L^R$ is Reg

B. $\{y \in \Sigma^* \mid \exists x \in \Sigma^*$ such that $x\boxed{y} \in L\}$ is Regular Suffix(L)

C. $\{x \in \Sigma^* \mid \exists y \in \Sigma^*$ such that $\boxed{x}y \in L\}$ is Regular prefix(L)

D. $\{ww^R \mid w \in L\}$ is Regular is FALSE

$$\text{Suffix}(L) = \{ y \mid xy \in L,\ x \in \Sigma^* \}$$

$$= \{ y \in \Sigma^* \mid \exists x \in \Sigma^* \ni xy \in L \}$$

$$\text{Prefix}(L) = \{ x \mid xy \in L,\ y \in \Sigma^* \}$$

$$\{xy \mid x \in L,\ y^R \in L\} = \{xy \in LL^R\}$$

$$\{xy \mid x \in \underline{L},\ y \in \underline{L^R}\}$$

$$L \cdot L^R$$

Given L is Reg

$\Downarrow$

L^R is also Reg

$\Bigg\}$ $L \cdot L^R$ is Reg

Regular Languages : ~~NAT~~ MCQ

Q52. For $\Sigma = \{a, b\}$, let us consider the regular language $L = \{x \mid x = a^{5+3k}, k \geq 0\}$. Which one of the following can be a pumping length (the constant guaranteed by the pumping lemma) for L?

A 5

B 3

C 7

D 4

$\underbrace{a^{3K+5}}$

$\Downarrow$

6 states in min DFA

$\boxed{\text{Constant} \geq 6}$

Slide 12

Regular Languages : NAT

TOC & Algo

Q53. Given a language L, define L^i as follows:

$$L^0 = \{\epsilon\}$$
$$L^i = L^{i-1} \cdot L \text{ for all } i > 0$$

The order of a language L is defined as the smallest k such that $L^k = L^{k-1}$.

Consider the language L_1 (over alphabet 0) accepted by the following FA.

$L^0 = \{\epsilon\}$

$L^1 = L^0 \cdot L = L = \epsilon + 0(00)^*$

$L^2 = L^1 \cdot L = (\epsilon + 0(00)^*) \cdot (\epsilon + 0(00)^*) = 0^*$

$L^3 = L^2 \cdot L = 0^* \cdot L = 0^*$

The order of L_1 is ____.

L^0

$\cancel{L^1 = L^0}$ $K=1$

$\cancel{L^2 = L^1}$ $K=2$

$\cancel{L^3 = L^2}$ $K=3$

$\boxed{=3}$

$\boxed{L^3 = L^2}$ $L^{\boxed{K}} = L^{K-1}$ for small K

$L = \epsilon + 0(00)^*$

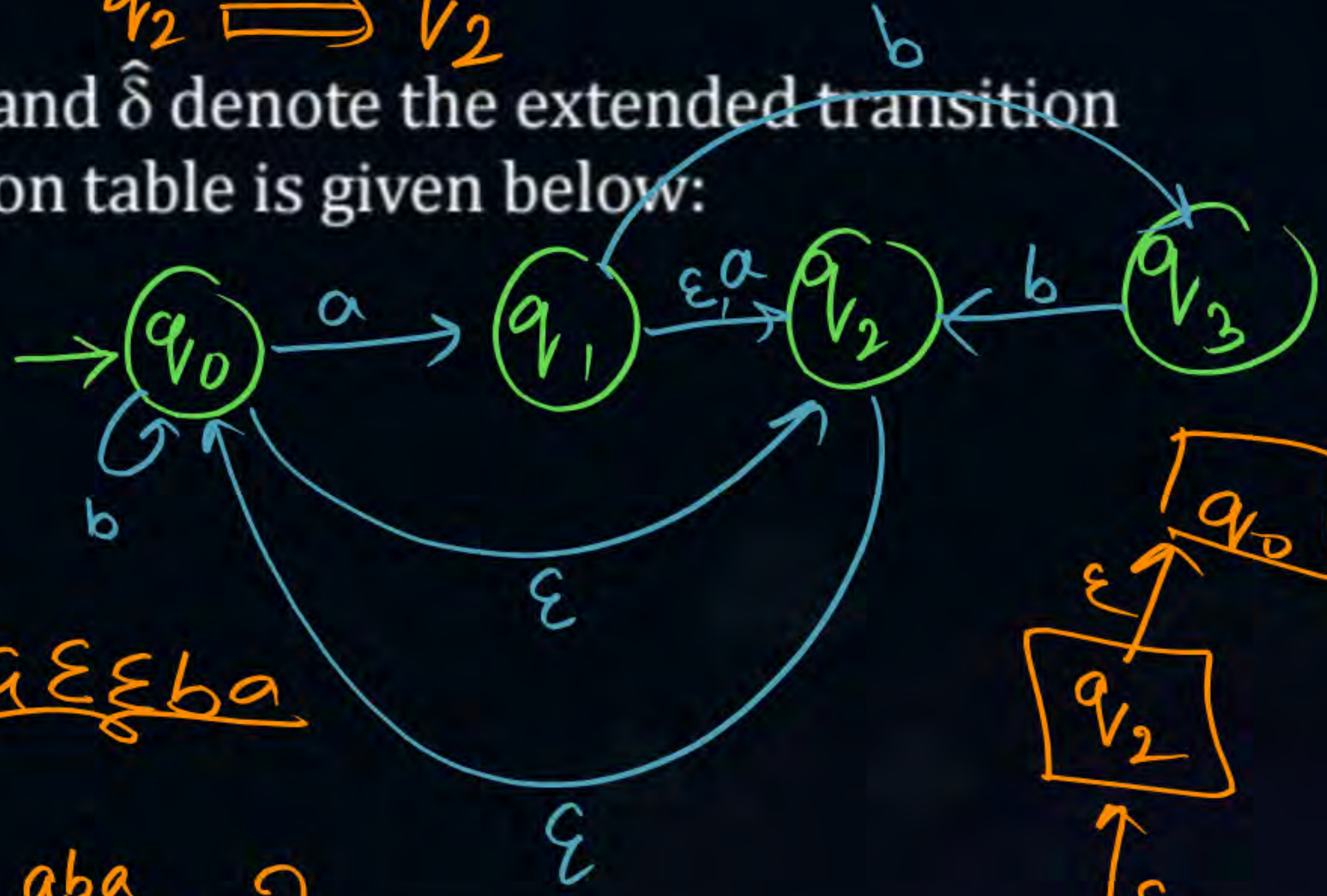
Slide 13

$q_2 \xrightarrow{aba} q_1$ $\quad$ $q_2 \xrightarrow{aba} q_0$

$q_2 \xrightarrow{aba} q_2$

Q54. Let δ denote the transition function and $\hat{\delta}$ denote the extended transition function of the ε-NFA whose transition table is given below:

δ	$\in$	a	b
$\rightarrow q_0$	$\{q_2\}$	$\{q_1\}$	$\{q_0\}$
q_1	$\{q_2\}$	$\{q_2\}$	$\{q_3\}$
q_2	$\{q_0\}$	ϕ	ϕ
q_3	ϕ	ϕ	$\{q_2\}$



$\underline{\varepsilon a \varepsilon \varepsilon b a}$

Then $\left|\hat{\delta}(q_2, aba)\right|$ is ______

$q_2 \xrightarrow{aba} ?$

$q_2 \xrightarrow{\varepsilon} q_0 \xrightarrow{a} q_1 \xrightarrow{\varepsilon} q_2 \xrightarrow{\varepsilon} q_0 \xrightarrow{b} q_0 \xrightarrow{a} \boxed{q_1} \xrightarrow{\varepsilon} \boxed{q_2} \xrightarrow{\varepsilon} \boxed{q_0}$

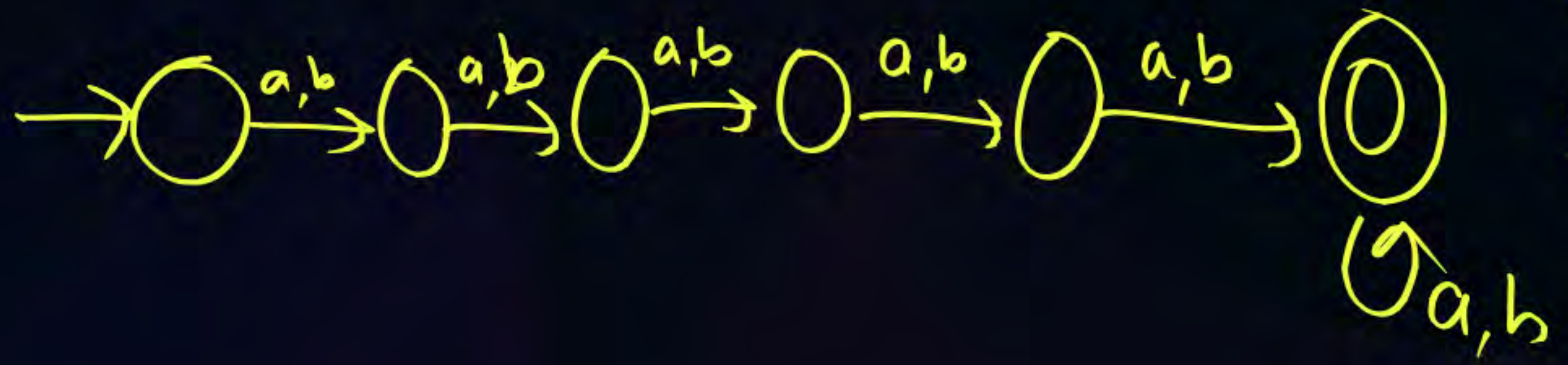
$\left|\{q_1, q_2, q_0\}\right| = 3$

Q55. Find the minimum possible number of states of a DFA that accepts the regular language $L = \{w_1\, w_2 \mid w_1, w_2 \in \{a, b\}^*, |w_1| \geq 2, |w_2| \geq 3\}$ is ____.

$\underbrace{\underset{\geq 2}{w_1}\ \underset{\geq 3}{w_2}}_{\geq 5}$

$\{w \mid w \in \{a, b\}^*, |w| \geq 5\}$

$\Downarrow$



$5 + 1 = 6$ states

Regular Languages : NAT

Q56. If G is a grammar with productions

$$S \to Sa \mid Sb \mid Saa$$

where S is the start variable, then which one of the following strings is not generated by G?

A abab

B aaab

C abbaa

D babba

Regular Languages : NAT

Q57. How many of the following languages are regular?

$L_1 = \{wxw^R \mid w, x \in \{a, b\}^*, w^R \text{ is the reverse of string } w\}$
$L_2 = \{a^n b^m \mid m, n \geq 0\}$
$L_3 = \{a^p b^q c^r \mid p, q, r \geq 0\}$
$L_4 = \{\omega \mid \omega \in \{0,1\}^*, \omega \text{ has equal number of } (00)\text{'s and } (11)\text{'s}\}.$

Regular Languages : NAT

Q58. If $L_1 = \{a^n \mid n \geq 0\}$and $L_2 = \{b^n \mid n \geq 0\}$, then how many of the following statements are TRUE?

I. $L_1 \cdot L_2$ is a regular language

II. L_1 / L_2 is a regular language

III. $L_1 U L_2$ is a regular language

Regular Languages : MCQ

Q59. Which one of the following is TRUE?

A. Kleene closure of $\{a^n b^n \mid n \geq 0\}$ is regular.

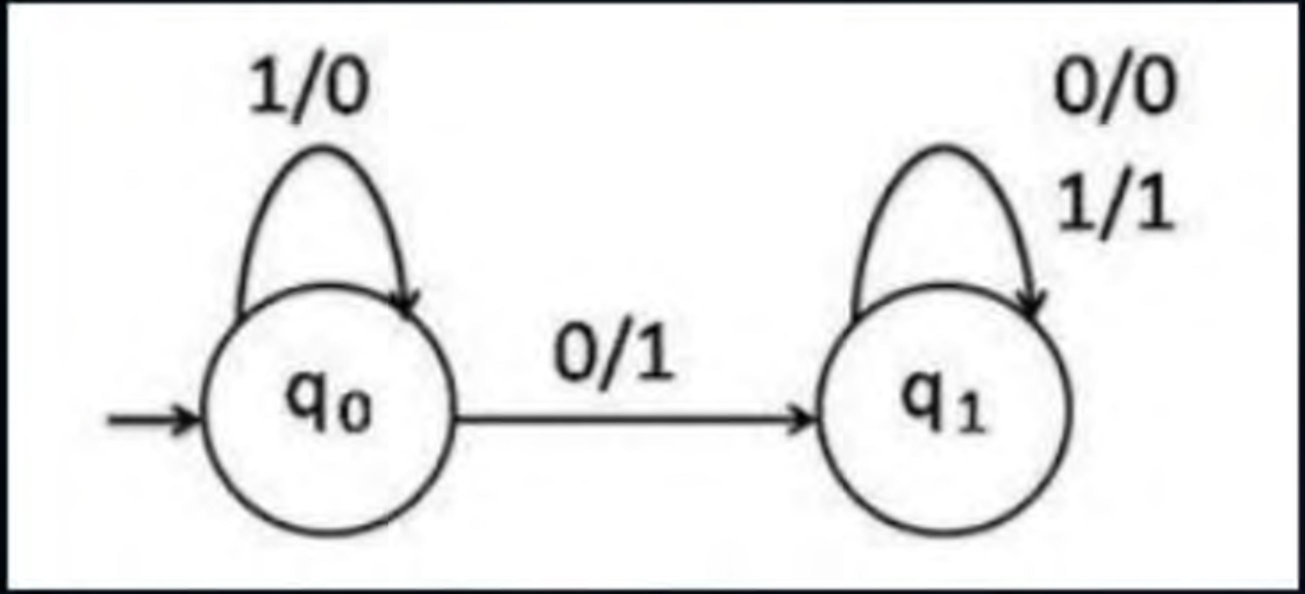
B. Kleene closure of $\{a^n \mid n \text{ is prime}\}$ is regular.

C. Kleene closure of $\{ww \mid w \in \Sigma^* \text{ with } \Sigma = \{0, 1\}\}$ is regular.

D. Kleene closure of $\{wxw \mid w, x \in \Sigma^* \text{ with } \Sigma = \{0, 1\}\}$ is regular.

Regular Languages : NAT

Q60. Consider the following FSM with output. It takes binary input in reverse order of actual binary number and produces binary output. To see actual output, produced output should be considered in reverse. Identify TRUE statement.



A. It increments given input

B. It decrements given input

C. It left shifts given input

D. It right shifts given input

$$\underbrace{a^n b^n}_{\text{DCFL}} \subset \underbrace{a^* b^*}_{\text{reg}}$$

$$\underbrace{\text{Set of regs} \subset \text{Set of DCFLs}}$$

$$\underset{\text{DCFL}}{a^n b^n} \supset \underset{\text{reg}}{\{ab\}}$$

$$\underset{\text{DCFL}}{a^*} = \underset{\text{Reg}}{a^*}$$

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 05

Mallesham Devasane Sir

Topics to be Covered

Topic Regular Languages

Topic Context Free Grammars

Regular Languages : MSQ

Q56. If G is a grammar with productions

$$S \rightarrow Sa \mid Sb \mid Saa$$

where S is the start variable, then which one of the following strings is not generated by G?

$L = \phi$

A. abab

B. aaab

C. abbaa

D. babba

$S \rightarrow Sa \mid Sb \mid Saa$

Useless

Regular Languages : NAT

Q57. How many of the following languages are regular?

Reg $(a+b)^*$ ⇐ $L_1 = \{wxw^R \mid w, x \in \{a, b\}^*, w^R \text{ is the reverse of string } w\}$

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

Reg $a^* b^* c^*$ ⇐ $L_3 = \{a^p b^q c^r \mid p, q, r \geq 0\}$

$L_4 = \{\omega \mid \omega \in \{0,1\}^*, \omega \text{ has equal number of } (00)\text{'s and } (11)\text{'s}\}$.

Not Reg

= 3 //

Regular Languages : NAT

Q58. If $L_1 \overset{= a^*}{=} \{a^n \mid n \geq 0\}$ and $L_2 \overset{= b^*}{=} \{b^n \mid n \geq 0\}$, then how many of the following statements are TRUE?

I. $L_1 \cdot L_2$ is a regular language ✓
II. L_1 / L_2 is a regular language ✓
III. $L_1 U L_2$ is a regular language ✓

$= 3$ //

Slide 5

Regular Languages : MSQ

Q59. Which one of the following is TRUE?

A. Kleene closure of $\{a^n b^n \mid n \geq 0\}$ is regular. $\{a^n b^n\}^*$ is not reg

B. Kleene closure of $\{a^n \mid n \text{ is prime}\}$ is regular. $\{a^{prime}\}^*$ is Reg

C. Kleene closure of $\{ww \mid w \in \Sigma^*$ with $\Sigma = \{0, 1\}\}$ is regular.

D. Kleene closure of $\underbrace{\{wxw \mid w, x \in \Sigma^* \text{ with } \Sigma = \{0, 1\}\}}_{(0+1)^*}$ is regular.

$$\{wxw \mid w, x \in \{0,1\}^*\} = (0+1)^*$$

$$w = \varepsilon, 0, 1, 00, 01, 10, \ldots$$

$$\varepsilon x \varepsilon \Rightarrow x \Rightarrow (0+1)^*$$

$$0x0 \Rightarrow 0(0+1)^*0$$

$$1x1 \Rightarrow 1(0+1)^*1$$

$$\left((0+1)^*\right)^* = (0+1)^*$$

$$\{a^{prime}\}^* = \{a^2, a^3, a^5, a^7, a^{11}, \ldots\}^*$$

$$= \{\varepsilon, a^2, a^3, a^4, a^5, a^6, a^7, a^8, \ldots\}$$

$$= \varepsilon + aaa^*$$

$$= \{a^n \mid n \neq 1\}$$

$$L = \{\underset{\varepsilon}{w}\underset{\varepsilon}{w} \mid w \in \{0,1\}^*\} = \{\varepsilon, 00, 11, 0000, 0101, 1010, \dots\}$$

$$L^* = \{ww\}^* = \{\varepsilon, 00, 11, 0000, 0101, 1010, \dots\}^*$$

$$= \{w_1w_1\ w_2w_2\ w_3w_3\ w_4w_4 \cdots w_kw_k\}$$

$$k \geq 1$$

$$L = \{a^n b^n\} = \{\varepsilon, ab, aabb, a^3b^3, \ldots\}$$

$$L^* = \{a^n b^n\}^* = \{\varepsilon, ab, aabb, a^3b^3, \ldots\}^*$$

$$= \{\varepsilon, ab, \underline{ab}\,\underline{ab}, \underline{aabb}, \ldots\}$$

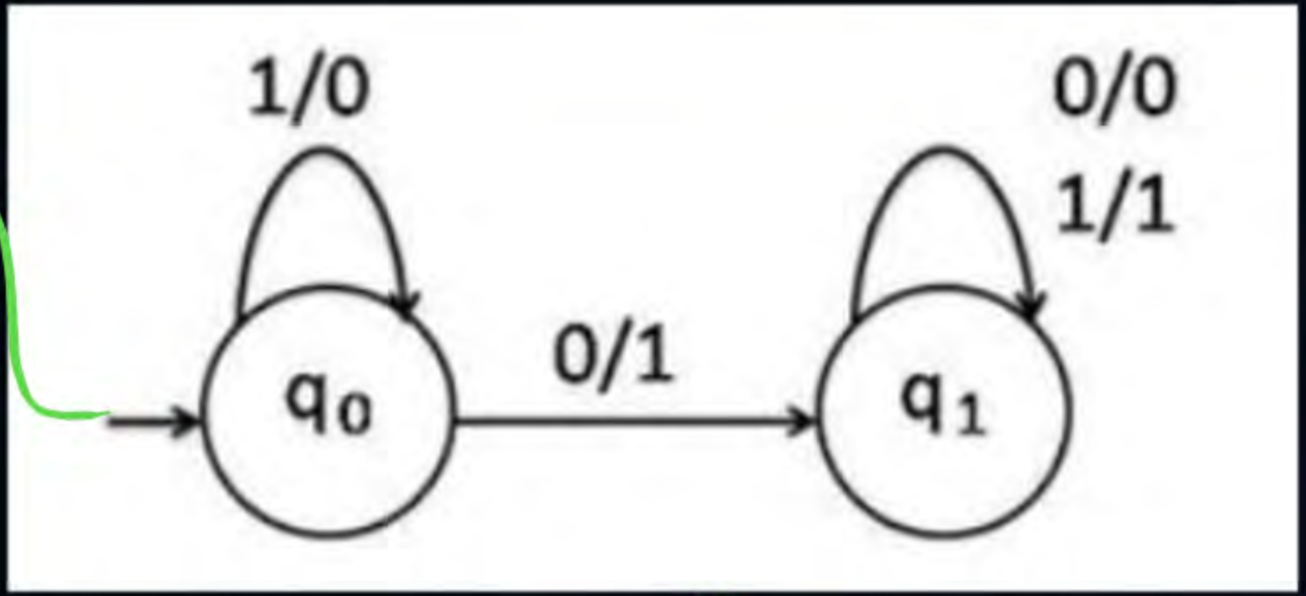
$$= \{a^{n_1} b^{n_1}\, a^{n_2} b^{n_2}\, a^{n_3} b^{n_3}\, a^{n_4} b^{n_4} \ldots a^{n_k} b^{n_k}\}$$

$$k \geq 1$$

Regular Languages : NAT

Q60. Consider the following FSM with output. It takes binary input in reverse order of actual binary number and produces binary output. To see actual output, produced output should be considered in reverse. Identify TRUE statement.

001 → □ → 100



A. It increments given input

001
010

B. It decrements given input

001
1
000

C. It left shifts given input

D. It right shifts given input

010 → 010

Regulars and CFGs : MSQ

Q61. Consider the following grammar:

$S \rightarrow Aa \mid Ab$ $\quad S = A(a+b) = (a+b)(a+b)^*(a+b)$

$A \rightarrow aB \mid bB$ $\quad A = (a+b)B = (a+b)(a+b)^*$

$B \rightarrow Ba \mid Bb \mid \text{epsilon}$ $\quad B = (a+b)^*$

What is the language generated by above CFG?

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

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

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

D. None of these

Regulars and CFGs : MSQ

Q62. Consider the following grammar G:

G :

$$S \rightarrow A \mid B$$
$$A \rightarrow aCb$$
$$C \rightarrow aC \mid bC \mid \in$$
$$B \rightarrow b\boxed{D}a$$
$$D \rightarrow bD \mid aD \mid \varepsilon$$

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

$C = (a+b)^*$

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

$D = (b+a)^*$

$S = A + B$

S is start symbol, A, B, C and D are non-terminals and a, b are terminals. The language generated by above grammar G is

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

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

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

D None of these

Regulars and CFGs : MSQ

Q63. Consider the following context-free grammars:

$G_1: S \to aS \mid A,\ \boxed{A \to \varepsilon \mid bA}$ $A = b^*$ $S \to aS \mid b^*$ $L = a^*b^*$

$G_2: S \to aA \mid B,\ \underbrace{A \to aA \mid \varepsilon}, \underbrace{B \to bB \mid \varepsilon}$

Which one of the following pairs of languages is generated by G_1 and G_2, respectively? $A = a^*$ $B = b^*$ $S \to aa^* \mid b^*$ $\Rightarrow a^+ + b^*$

A. $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$.

B. $\{a^m b^n \mid m \geq 0 \text{ and } n \geq 0\}$ and $\{a^m b^n \mid m > 0$ ~~and~~ or $n \geq 0\}$.

C. $\{a^m b^n \mid m \geq 0 \text{ or } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$.

D. $\{a^m b^n \mid m \geq 0 \text{ and } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ or } n > 0\}$.

Regulars and CFGs : NAT

Q64. Consider the following context-free grammar G over the alphabet $\Sigma = \{a, b, c\}$ with S as the start symbol

$$\left.\begin{aligned} S &\rightarrow abScT \mid abc \\ T &\rightarrow b \end{aligned}\right\} \Rightarrow S \rightarrow abScb \mid abc$$

Let L = { w | w is in L(G), length of w is less than 9}. Then size of L is __

$= \{abc, ababccb\}$

abc ✓

$abScb = ababccb$ ✓

$abScb = ababScbcb = \underbrace{ababab\text{c}cbcb}_{>9\ \text{length}}$

$= 2$

Regulars and CFGs : NAT

Q65. Consider the context-free grammars over the alphabet {a, b, c} given below. S and T are non-terminals.

$G_1: S \rightarrow abS \mid T, \underbrace{T \rightarrow cT \mid \epsilon}_{c^*}$ $L = (ab)^* c^*$

$G_2: S \rightarrow aSc \mid T, \underbrace{T \rightarrow bT \mid \epsilon}_{b^*}$

$a^n b^* c^n$

Number of strings in $L(G_1) \cap L(G_2)$ is ___ $= 2$

$(ab)^* c^* \cap a^n b^* c^n$

$\{\epsilon, \dots, abc, \dots\} \cap \{\epsilon, abc, \dots\}$

Regulars and CFGs : MSQ

Q66. Identify the language generated by the following grammar, where S is the start variable.

$$S \rightarrow XY$$
$$\boxed{X \rightarrow aX \mid a} \Rightarrow X = a^+$$
$$Y \rightarrow YX \mid \epsilon$$
$$Y \rightarrow Ya^+ \mid \epsilon \Rightarrow (a^+)^* = a^*$$

$$L = XY = a^+a^* = a^+$$

A. a^*

B. $aa^* = a^+$

C. $(aa)^*$

D. None of these

Regulars and CFGs : MCQ

Q67. Consider L1 = ab*

L2 = ba*

L3 = L1/ L2

Which of the following expression is equivalent to L3?

$L_1/L_2 = ab^*/ba^*$

$= \{ab^*/b, \; ab^*/ba, \; ab^*/baa, \; ab^*/baaa \ldots\}$

A L1

B L2

C a

D ab

a/b ×

$ab/b = a$

$abb/b = ab$

$abbb/b = abb$

$= ab^* = L_1$

Slide

$$ab^*/ba^* = \{\, ab^*/b \,,\; ab^*/ba \,,\; ab^*/baa \,,\; ab^*/baaa \,,\; \dots \}$$

$$ab^*/b \quad ab^*/ba \;\; \times \quad ab^*/baa \;\; \times \quad ab^*/baaa \;\; \times$$

$$\Downarrow$$

$$= \{\, a/b,\; ab/b,\; abb/b,\; ab^3/b \;\dots\dots \}$$

$$a/b \;\; \times \qquad ab/b \Rightarrow a \qquad abb/b \Rightarrow ab \qquad ab^3/b \Rightarrow ab^2$$

$$= ab^* = L_1$$

$$a\boxed{bb}/\boxed{bb} = a$$

$$\underline{u}\boxed{v}/\boxed{v} = u$$

$$ab/b = a$$

$$ab/a = \phi$$

Regulars and CFGs : MSQ

Q68. Consider L1 = ab*

L2 = ba*

L3 = L1 U L2 $= ab^* + ba^*$

Which of the following expression is equivalent to $\boxed{\text{L3*?}}$

$$L_3^* = (ab^* + ba^*)^*$$

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

A (ab)*

B (ab+ba)*

C (a+b)*

D None of these

Slide

Regulars and CFGs : MCQ

Q69. Consider the following CFG G.

$$G: \boxed{S} \rightarrow \underbrace{ab}_{\sigma}\underbrace{S}_{} \mid \in, \underbrace{\boxed{T \rightarrow abT \mid \in}}_{\text{useless}}$$

Which of the following is L(G) ?

$L = (ab)^*$

Note :

$S \rightarrow abT \mid \varepsilon$, $\underbrace{T \rightarrow abT \mid \varepsilon}_{}$

$S = ab(ab)^* + \varepsilon$ $\quad T = (ab)^*$

$= (ab)^+ + \varepsilon = (ab)^*$

A. $(ab)^*$

B. $(ab)^+$

C. $(a+b)^*$

D. None of these

Slide

Regulars and CFGs : NAT

Q70. If $L = \{b^n a^n \mid n \geq 0\}$, then how many following statements are TRUE?

$= 1$

$L = b^n a^n$

I. ~~I.~~ L^* is a regular language

II. ~~II.~~ Reversal of L is a regular language

III. ~~III.~~ Complement of L is a regular language

IV. Finite Subset of L is always regular language

I. $L^* = \{b^n a^n\}^*$ is not reg

II. $L^{Rev} = \{b^n a^n\}^{Rev} = a^n b^n$ is not reg

III. $\overline{L} = \overline{\{b^n a^n\}}$ is not reg

Regulars and CFGs : MCQ

Q71. How many of the following statements are correct?.

I. Every regular language is finite language FALSE
II. Every finite language is regular language TRUE
III. Every CFL is regular language FALSE
IV. Every regular language is CFL TRUE

A 4

B 3

C 2

D 1

Slide

Q72. How many of the following languages are regular?

$L_1 = \{wxw^R \mid w, x \in \{a, b\}^+, w^R \text{ is the reverse of string } w\}$
$L_2 = \{w \mid w, x \in \{a, b\}^*, \text{number of 01's in } w \text{ is even}\}$
$L_3 = \{w \mid w, x \in \{0, 1\}^*, \text{Dec}(w) \text{ is divisible by } 100\}$
$L_4 = \{w \mid w, x \in \{a, b\}^*, w \text{ has more 0's than 1's}\}$

.

Regulars and CFGs : MSQ

Q73. Choose FALSE statement.

A. Substitution is closed for regular languages

B. Substring is closed for regular languages

C. Subset is closed for regular languages

D. Finite subset is closed for regular languages

Regulars and CFGs : MCQ

Q74. Let $L = \{ w1w2w3 \mid w1, w2, w3 \in \{ a, b \}^*, |w1| = |w2| = |w3| \}$. Choose L from the following.

A. $(a+b)^*$

B. $(a+b)\,(a+b)^*\,(a+b)$

C. $(\,(a+b)\,(a+b)\,(a+b)\,)^*$

D. $(a+b)\,(a+b)^*$

Regulars and CFGs : MSQ

Q75. Which of the following operation is closed for finite languages but not closed for infinite languages?

A Kleene star

B Union

C Subset

D Substitution

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 06

Mallesham Devasane Sir

Recap of Previous Lecture

Topic Regular Languages

Topic Context Free Grammars

Topic

Topic

Topic

Topics to be Covered

Topic Regular Languages

Topic Context Free Languages

Regulars and CFGs : NAT

Q70. If $L = \{b^n a^n \mid n \geq 0\}$, then how many following statements are TRUE?

$= 1$

I. L^* is a regular language
II. Reversal of L is a regular language
III. Complement of L is a regular language $\overline{\{b^n a^n\}}$
IV. Finite Subset of L is always regular language

$L = b^n a^n$

$\bar{L} = \Sigma^* - L$

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

$= \boxed{\Sigma^* ab \Sigma^* \cup \{b^m a^n \mid m \neq n\}}$ is not reg

$L \cup \bar{L} = (a+b)^*$

Regulars and CFGs : MCQ

Q71. How many of the following statements are correct?.

I. Every regular language is finite language
II. Every finite language is regular language
III. Every CFL is regular language
IV. Every regular language is CFL

A) 4

B) 3

C) 2

D) 1

Regular Languages : NAT

Q72. How many of the following languages are $\boxed{\text{regular?}}$

$= axa + bxb$

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

- $L_1 = \{\boxed{wxw^R} \mid w, x \in \{a, b\}^+, w^R$ is the reverse of string $w\}$
- $L_2 = \{w \mid w, x \in \{a, b\}^*$, number of 01's in w is even$\}$
- $L_3 = \{w \mid w, x \in \{0, 1\}^*$, Dec(w) is divisible by 100$\}$
- $L_4 = \{w \mid w, x \in \{a, b\}^*$, w has more 0's than 1's$\}$

$n_0(w) > n_1(w)$

$= 3$

Regulars and CFGs : MSQ

Q73. Choose FALSE statement.

A Substitution is closed for regular languages T

B Substring is closed for regular languages T

C Subset is closed for regular languages F

D Finite subset is closed for regular languages T

Q74. Let L = { w1w2w3 | w1, w2, w3 ∈ { a, b }*, |w1| = |w2|= |w3| }. Choose L from the following.

$L = \{ w \mid |w| \text{ is div by } 3 \}$

w_1	w_2	w_3		
0	0	0	$\longrightarrow$	0
1	1	1	$\longrightarrow$	3
2	2	2	$\longrightarrow$	6
3	3	3	$\longrightarrow$	9
				⋮

A (a+b)*

B (a+b) (a+b)* (a+b)

C ((a+b) (a+b) (a+b))* ✓

D (a+b) (a+b)*

Regulars and CFGs : MSQ

Q75. Which of the following operation is closed for finite languages but not closed for infinite languages?

Option		Fin	Inf
A	Kleene star	X	✓
B	Union	✓	✓
C ✓	Subset	✓	X
D	Substitution	✓	✓

Subset of Inf lang is ___may or may not be Inf___

subset of fin lang is ___fin lang___

$F_1 = \phi$ $\quad$ $F_2 = \{a\}$

$F_3 = \{\varepsilon\}$ $\quad$ $F_4 = \{a, \varepsilon\}$

a^* I_1 $\quad$ b^* I_2 $\quad$ a^*b^* I_3

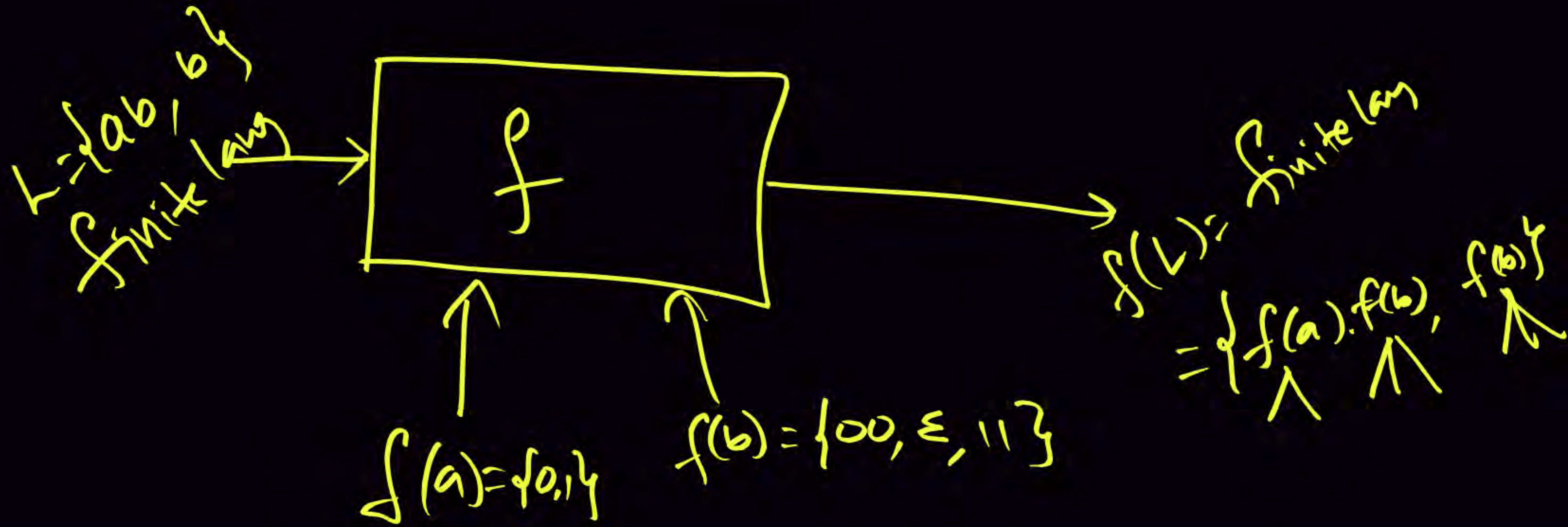
I_4 $\quad$ I_5 $\quad$ I_6

I_6 $\quad$ I_∂ $\quad$ I_7

a^* Inf lang

$\underbrace{\phi}_{\text{not Inf}}$ is subset of a^*

$\{\varepsilon, aa\}$ finite lang


L = {ab, b}
finite lang
f
f(a) = {0,1}
f(b) = {00, ε, 11}
f(L) = finite lang
= {f(a).f(b), f(b)}

[MSQ]

#Q76. Consider the following language L:

L = {a, b, ab, baa}

Which of the following strings are present in the $\underbrace{\text{INIT}}_{\text{prefix}(L)}$ of L?

A. $\in$

B. aa

C. ba

D. b

$L = \{a, b, ab, baa\}$

$\text{pref}(L) = \{\text{pref}(a), \text{pref}(b), \text{pref}(ab), \text{pref}(baa)\}$

$= \{\varepsilon, a, b, ab, ba, baa\}$

L satisfies prefix property

iff

Every string of L is not a prefix to every other string in L.

① $L = \{a, ba, bab\}$ not satisfies prefix property

② $L = \{ab, ac, bac\}$ satisfies prefix property.

[NAT]

#Q77. Consider the following statements:

[I]. Infinite union of regular languages is regular. Incorrect

[II]. Subset of finite language is regular. correct

[III]. Intersection of two non-regular languages $\boxed{\text{can}}$ be regular. possible correct

Total number of INCORRECT statements are $= 1$.

$$\underbrace{\{a^n b^n\}}_{\text{non reg}} \cap \underbrace{\{b^n a^n\}}_{\text{non reg}} = \underbrace{\{\varepsilon\}}_{\text{reg}}$$

[MSQ]

#Q78. Consider the following grammar G:

G: $S \rightarrow aAa \mid bAb$

$A \rightarrow aA \mid bA \mid a \mid b \Rightarrow (a+b)^+$

$B \rightarrow aA \mid bA \mid a \mid b \Rightarrow \boxed{(a+b)^+}$

$L = a(a+b)^+a + \underbrace{b(a+b)^+b}_{\text{reg lang}}$

The language generated by above grammar G is:

A. $L(G) = \{ww^R \mid w, x \in \{a, b\}^+\}$ ✓ $= \underbrace{axa + bxb}_{} + \underbrace{aaxaa + abxba + \dots}_{}$

B. $L(G) = \{wxw \mid w, x \in \{a, b\}^+\}$ not reg lang

C. $L(G) = \{a(a+b)^+a + b(a+b)^+b\}$ ✓

D. $L(G) = \boxed{L(G)}$ isCFL but not regular

[MCQ]

≥ 5

$\geq$ #states in minDFA (ignore dead)

#Q79. Consider the following regular expression:

$R = (aa)^* \cup (bb)^*$

Which of the following can't be the pumping length for L(R)?

A 2 ✓

B 5

C 7

D 9

[MSQ]

#Q80. Which of the following does not generate string 'baa'?

A. a* (ba)* b*

ε ba ___ ×

B. a* b* (ba)*a

ε ε ba a ✓

C. (ab* + a)* (ab)* b* a*

ε ε b aa ✓

D. (bba* + b)* a

b a ×

bbaa

[NAT]

#Q81. Consider the regular expression R:

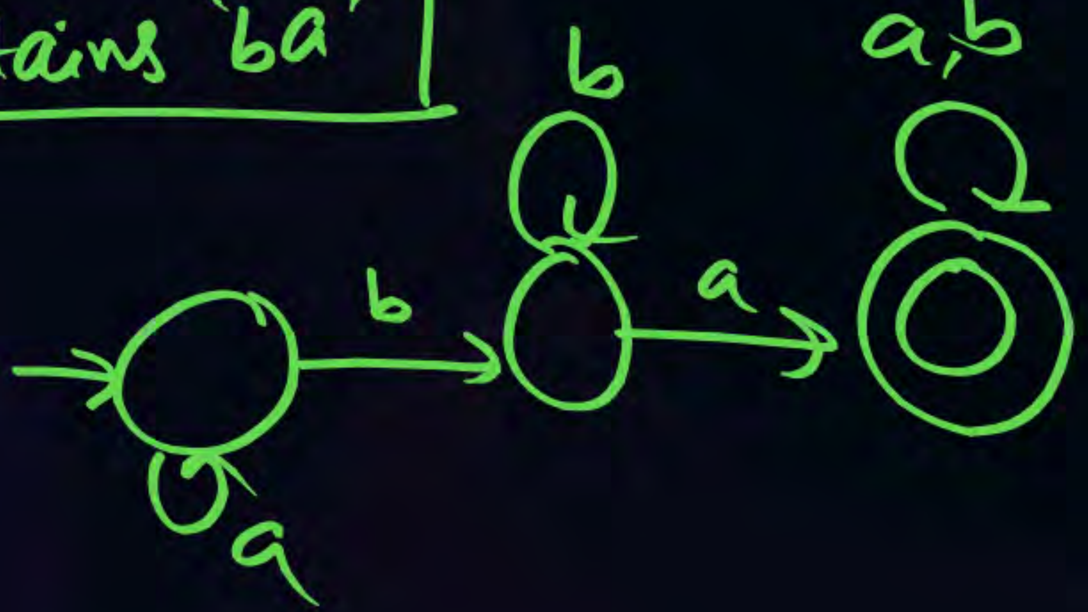
$R = (a + ba^*)^*\, ba\, (a + b)^*$

How many states are needed to design a DFA for above regular expression R?___

$R = (a+b)^*\, ba\, (a+b)^*$

$\boxed{\text{contains `ba'}}$

$= 3$ //



[MCQ]

$L = S = a^3 a^*(\epsilon+b)^4$ atmost 4 b's

#Q82. Consider the following grammar G:

G: $S \rightarrow aaaA$

$A \rightarrow aA \mid B$ $\quad A = a^* B = a^*(\epsilon+b)^4$

$B \rightarrow b \mid bb \mid bbb \mid bbbb \mid \epsilon$ $\quad B = \epsilon + b + \cdots + b^4 = (\epsilon+b)^4$

The language generated by above grammar G is

A $L(G) = \{a^m b^n \mid m \text{ divisible by } 3 \text{ and } n \geq 4\}$

B $L(G) = \{a^m b^n \mid m \geq 1 \text{ and } n < 5\}$

C $L(G) = \{a^m b^n \mid \underbrace{\boxed{m > 2}}_{m \geq 3} \text{ and } \boxed{n < 5}\}$

D None of these

[MSQ]

Every string should not be a prefix to another string

#Q83. Which of the following $\boxed{\text{language satisfy the prefix property}}$?

A. $L = \{a^n b^n \mid n \geq 1\}$ $= \{ab, aabb, aaabbb, \ldots\}$

B. $L = \{wxw^R \mid w, x \in \{a, b\}^*\}$ $= (a+b)^*$ ✗

C. $L = \{a^m b^{2m} \mid m \geq 1\}$ $= \{abb, aabbbb, \ldots\}$

D. $L = \{w \in \{0, 1\}^* \mid n_0(w) = n_1(w)\}$

$-- , 01, 0101$

[NAT]

#Q84. Consider a language $L = \{w \mid w \in \{a, b\}^*, 6^{th}$ symbol from end is 'a'$\}$.
If number of states in NFA is A and number of states in DFA is B then the value of $A \times B$ is _____.

Min DFA : $2^6 = 64$ states $= A$

Min DFA : $6+1 = 7$ states $= B$

$A \times B = 64 \times 7$

$= 448$

[MSQ]

$S \to 0A \mid 1B$
$A \to 10S$
$B \to 01A \mid 0$

#Q85. Consider the following grammars G_1 and G_2:

G_1: $S \to 0A \mid 1B$
$A \to \cancel{101C} \mid 10S$
$B \to 01A \mid 0$
$\cancel{D \to 00B \mid 10A}$

= Regular Grammar
↳ always generates reg lang

G_2: $S \to AB$
$A \to 01 \mid 10$
$B \to 00 \mid 11$

Not reg grammar $\Rightarrow$ {0100, 0111, 1000, 1011}
Finite lang

Which of the following is/are correct?

A. $L(G_1)$ is regular.

B. $L(G_2)$ is regular.

C. $L(G_2)$ is finite regular.

D. $L(G_1)$ is CFL but not regular.

G_2 is not reg
$L(G_2)$ is reg

[MCQ]

#Q86. Consider the following grammars on $\Sigma = \{0, 1, 2\}$

G_1: $S \to AB$

$A \to 0A1 \mid \in$

$B \to 1B2 \mid \in$

G_2: $S \to 0S1 \mid B$

$B \to 1\,B2 \mid \in$

G_3: $S \to AB \mid B$

$A \to 0A1 \mid 01$

$B \to 1B2 \mid \in$

Which of the following grammars are equivalent?

A. G_1 and G_2 only

B. G_2 and G_3 only

C. G_1 and G_3 only

D. G_1 and G_2 only

[MCQ]

#Q87. Consider the following statements:

S_1: Pumping lemma can be used to prove that some of the languages are not regular using contradition.

S_2: Language L satisfies the pumping lemma iff L is regular.

Which of the following is correct?

A. S_1 only

B. S_2 only

C. Both S_1 and S_2

D. None the these

[MCQ]

#Q88. Finite automata can be used in which of the following?

A String matching

C Text editing

B Lexical analysis

D Infix to prefix conversion

[MCQ]

#Q89. Let L consist of all binary strings start with 1 and decimal value of binary number is divisible by 3. Which of the following is true?

A) L can be recognized by NPDA

C) L can be recognized by DPDA

B) L can be recognized by DFA

D) L can be recognized by NFA

[MSQ]

#Q90. Consider the following grammar G:

$$S \rightarrow P \mid Q$$
$$P \rightarrow aPb \mid \lambda$$
$$Q \rightarrow aaQb \mid \lambda$$

Which of the following is/are True?

A. G is ambiguous and $\{\lambda\}$ has two parse tree.

C. L(G) is accepted by PDA but not by DPDA.

B. L(G) is inherently ambiguous.

D. None of these.

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 07

Mallesham Devasane Sir

Recap of Previous Lecture

Topic Regular Languages

Topic Context Free Languages

Topics to be Covered

Topic Regular Languages

Topic Context Free Languages

[MCQ]

#Q86. Consider the following grammars on $\Sigma = \{0, 1, 2\}$

G_1: $S \rightarrow AB$

$A \rightarrow 0A1 \mid \epsilon$ $\Rightarrow 0^n 1^n$

$B \rightarrow 1B2 \mid \epsilon$ $\Rightarrow 1^k 2^k$

$L_1 = 0^n 1^n 1^k 2^k$

G_2: $S \rightarrow 0S1 \mid B$

$B \rightarrow 1\,B2 \mid \epsilon$ $\Rightarrow 1^k 2^k$

$L_2 = 0^n B 1^n = 0^n 1^k 2^k 1^n$

G_3: $S \rightarrow AB \mid B$

$A \rightarrow 0A1 \mid 01$ $\Rightarrow 0^n 0 1 1^n$

$B \rightarrow 1B2 \mid \epsilon$ $\Rightarrow 1^k 2^k$

$L_3 = (A+\epsilon)B = 0^n 1^n . 1^k 2^k$

Which of the following grammars are equivalent?

A. G_1 and G_2 only

B. G_2 and G_3 only

C. G_1 and G_3 only

D. G_1 and G_2 only

[MCQ]

#Q87. Consider the following statements:

S_1: Pumping lemma can be used to prove that some of the languages are not regular using contradition. T

S_2: Language L satisfies the pumping lemma iff L is regular. T

Which of the following is correct?

A. S_1 only

B. S_2 only

C. Both S_1 and S_2

D. None of these

[MCQ]

#Q88. Finite automata can be used in which of the following?

A String matching

C Text editing

B Lexical analysis

D Infix to prefix conversion

[MSQ]

⇒ Regular

#Q89. Let L consist of all binary strings start with 1 and decimal value of binary number is divisible by 3. Which of the following is true?

A L can be recognized by NPDA ✓

C L can be recognized by DPDA ✓

B L can be recognized by DFA ✓

D L can be recognized by NFA ✓

[MSQ]

$S \Rightarrow P \Rightarrow \varepsilon$

$S \Rightarrow Q \Rightarrow \varepsilon$

#Q90. Consider the following grammar G:

$S \rightarrow P \mid Q$

$P \rightarrow aPb \mid \lambda \Rightarrow a^k b^k$

$Q \rightarrow aaQb \mid \lambda \Rightarrow a^{2n} b^n$

$L = \{a^k b^k\} \cup \{a^{2n} b^n\} \Rightarrow$ not DCFL

Which of the following is/are True?

A. G is ambiguous and {λ} has two parse tree. T

C. L(G) is accepted by PDA but not by DPDA. T

B. L(G) is inherently ambiguous. F

D. None of these.

empty string

ε

λ

Unambig CFG

$S \rightarrow P \mid Q$

$P \rightarrow aPb \mid ab$

$Q \rightarrow aaQb \mid \varepsilon$

L is Inherently ambiguous

iff

Every CFG that generates L is Ambiguous CFG.
(L has no equivalent unamb CFG)

$L = \{ a^m b^n c^k \mid m = n \text{ OR } n = k \}$ is Inherently Amb lang

[NAT]

#Q91. Consider the following grammar G:

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

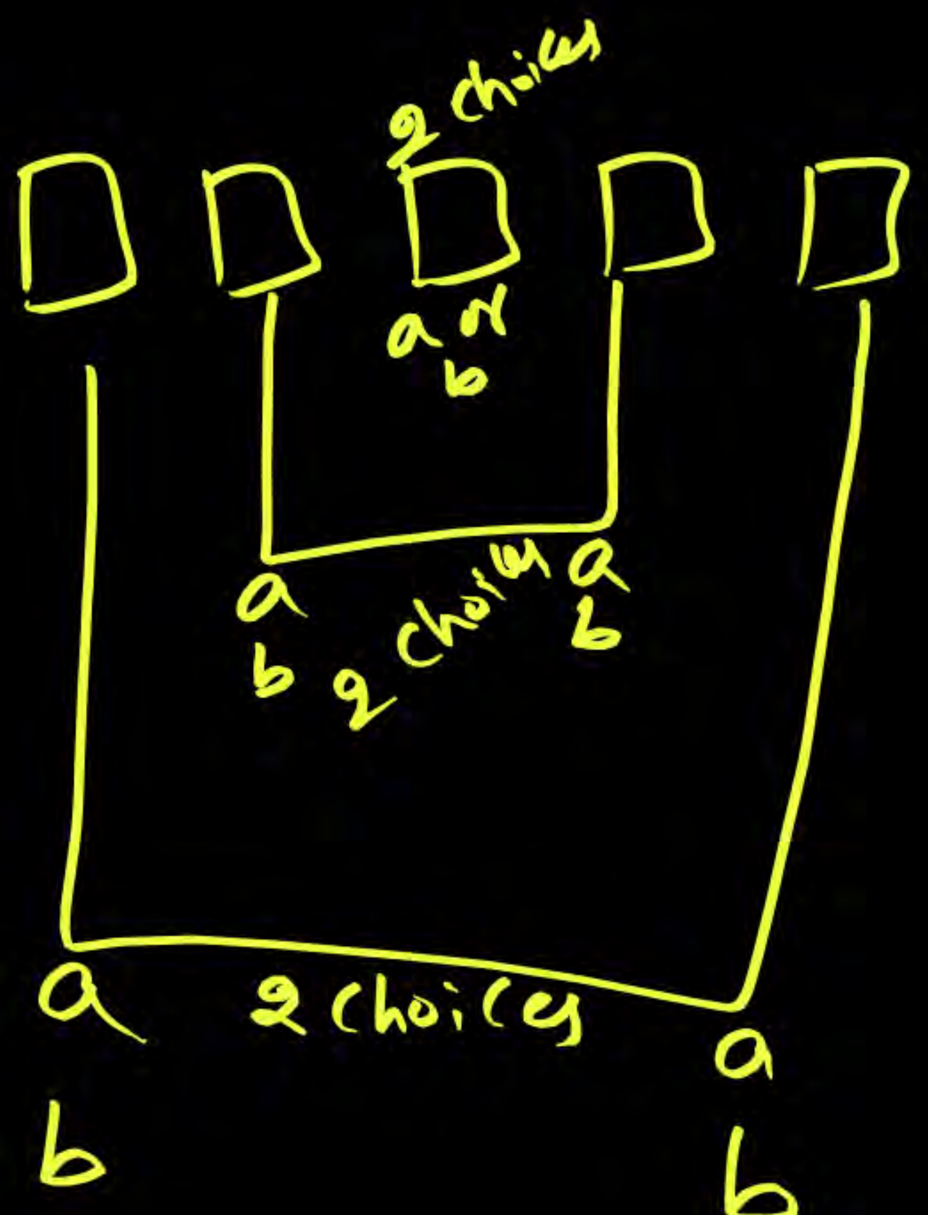
How many strings x belong to L(G) where $|x| \leq 11$? _____.

How many palindromes upto 11 length!

length	No. of strings
$0 \rightarrow$	1
$1 \rightarrow$	2
$2 \rightarrow$	2
$3 \rightarrow$	4
$4 \rightarrow$	4
$5 \rightarrow$	8 strings
$6 \rightarrow$	8 strings
$7 \rightarrow$	16 strin
$8 \rightarrow$	16 str
$9 \rightarrow$	32 str
$10 \rightarrow$	32 string
$11 \rightarrow$	64 string

$1+2+2+4+4+8+8+16+16+32+32+64$

$=189$



8 strings

b b b b b
a a a a a
a a b a a
a b a b a
a b b b a
b a a a b
b a b a b
b b a b b

[NAT]

#Q92. The length of the shortest string not in the language over $\Sigma = \{a, b\}$ for regular expression $a^* (b + ab)^* a^*$ is _____.

ε ✓

a ✓

b ✓

aa ✓

ab ✓

ba ✓

bb ✓

aaa ✓

aab ✓

aba ✓

abb ✓

baa ✓

bab ✓

bba ✓

bbb ✓

aaaa ✓

aaab ✓

aaba ✓

aabb ✓

abaa ✓

abab ✓

abba ✓

abbb ✓

baaa ✓

$\boxed{\text{baab}}$ ✗

[NAT]

No. of DFAs $= 2^P$

#Q93. The $\boxed{\text{number of DFA's}}$ with 5 states which can be constructed over the alphabet $\Sigma = \{0, 1\}$ with designated initial state [illegible], then the value of P is $\underline{= 5}$.

is $2^5 \times 5^{10}$

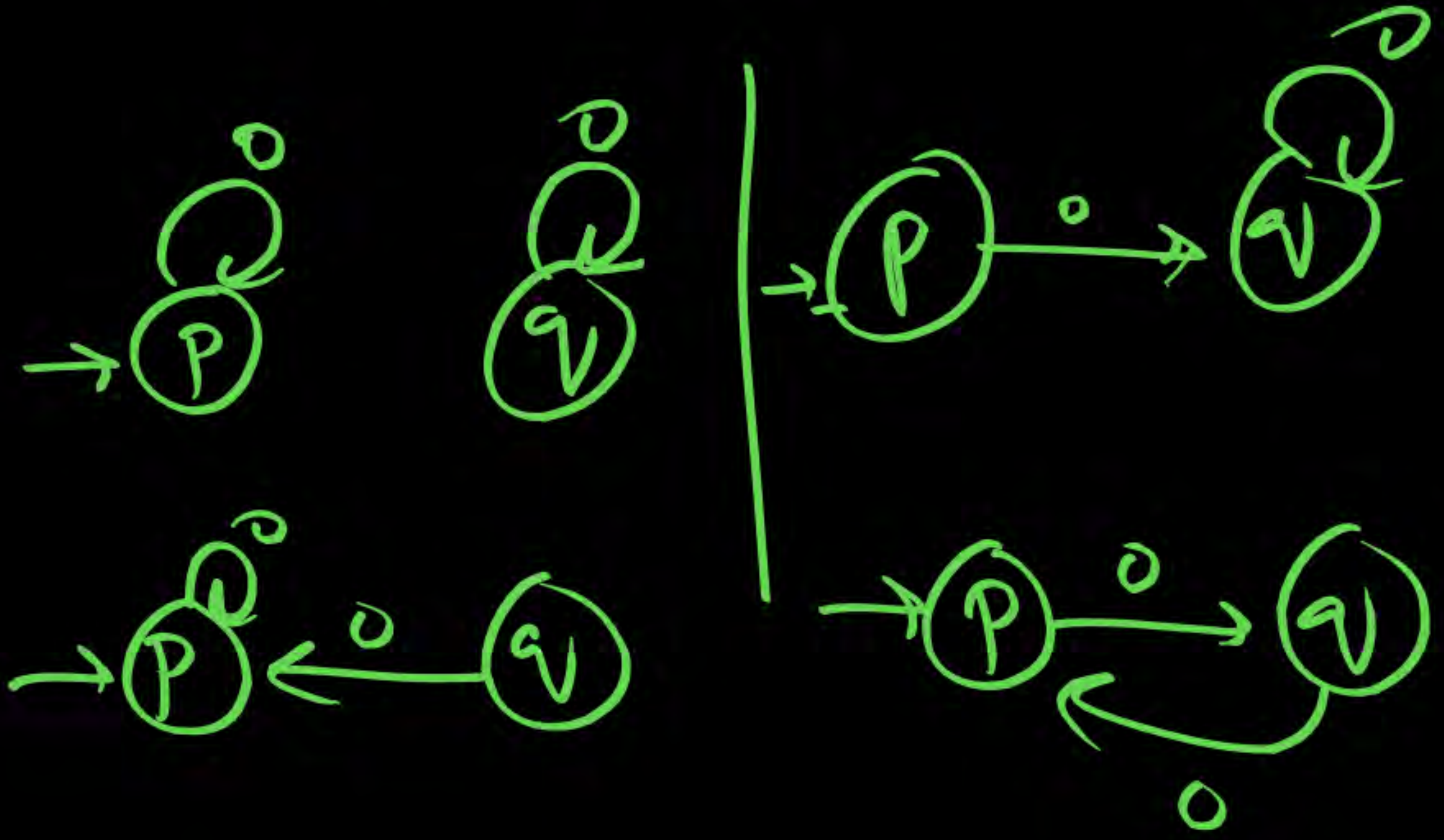
		0	1
2 choices	→ p	5	5
2 choices	q	5	5
2	r	5	5
2	s	5	5
2	t	5	5

$\underbrace{5^{10} \times 2^5 \text{ DFAs}}$

		0
q	→p	q
q	q	q

$\Sigma = \{0\}$

$Q = \{p, q\}$



$\underbrace{2^2}_{} \times 2^2 = 2^4 = 16$ DFAs

{ }

{p}

{q}

{p, q}

[MCQ]

$L = \{2, 02, 021, 002, 0021, 00211, \ldots\}$

#Q94. Consider the following CFG G over $\Sigma = \{0, 1, 2\}$:

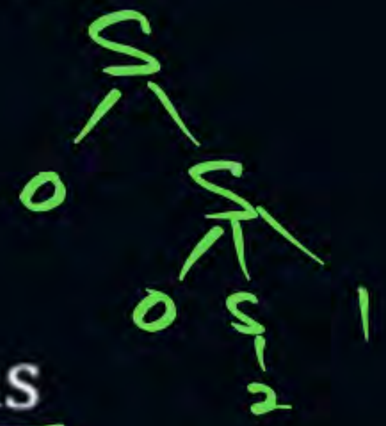
G: $S \rightarrow 2 \mid 0S \mid 0S1$

$= \{0^{m+n}\, \boxed{2}\, 1^n\} = \{0^i\, 2\, 1^j \mid i \geq j\}$

Which of the following is/are true?

$$\boxed{\begin{array}{l} S \rightarrow 0S1 \mid A \\ A \rightarrow 0A \mid 2 \end{array}}$$

A. G is ambiguous 0021

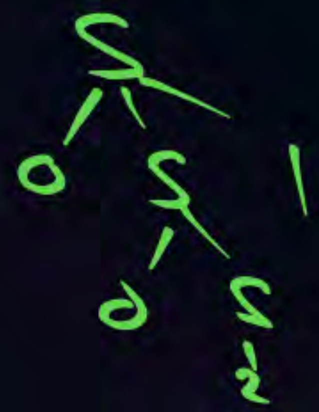


B. L (G) is inherently ambiguous

iff there no unamb CFG for L(G).

C. Both (a) and (b)

$A = 0^* 2$



$S = 0^n 0^* 2 1^n$

D. None of these.

CFG is Ambiguous

iff

$\exists w, > 1$ PT

L is Inherently Ambiguous

iff

Every CFG that generates L

is Amb

[NAT]

$S \to SS \mid a$

#Q95. Consider the following statements:

S_1: only unambiguous context free grammar can be converted into Chomsky normal form. False

S_2: A context free grammar can generate many languages but vice-versa is not true. False

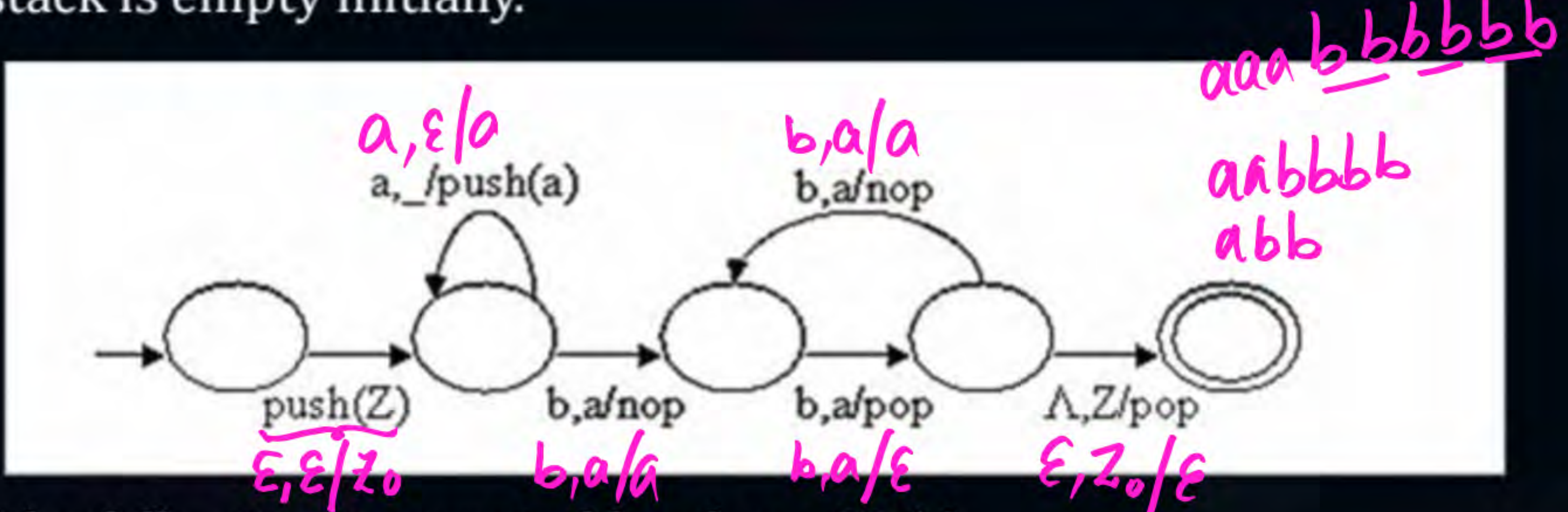
*** S_3: For every CFL, there exist a PDA with one state. True

How many statements are INCORRECT? ____ = 2

CFL ⟹ CFG ⟹ PDA with only 1 state

[~~NAT~~] MCQ

#Q96. Assume stack is empty initially.



Which of the following is accepted by above PDA?

A. $\{a^n b^n \mid n>0\}$

B. $\{a^n b^{2n} \mid n>0\}$

C. $\{a^{2n} b^n \mid n>0\}$

D. None of these

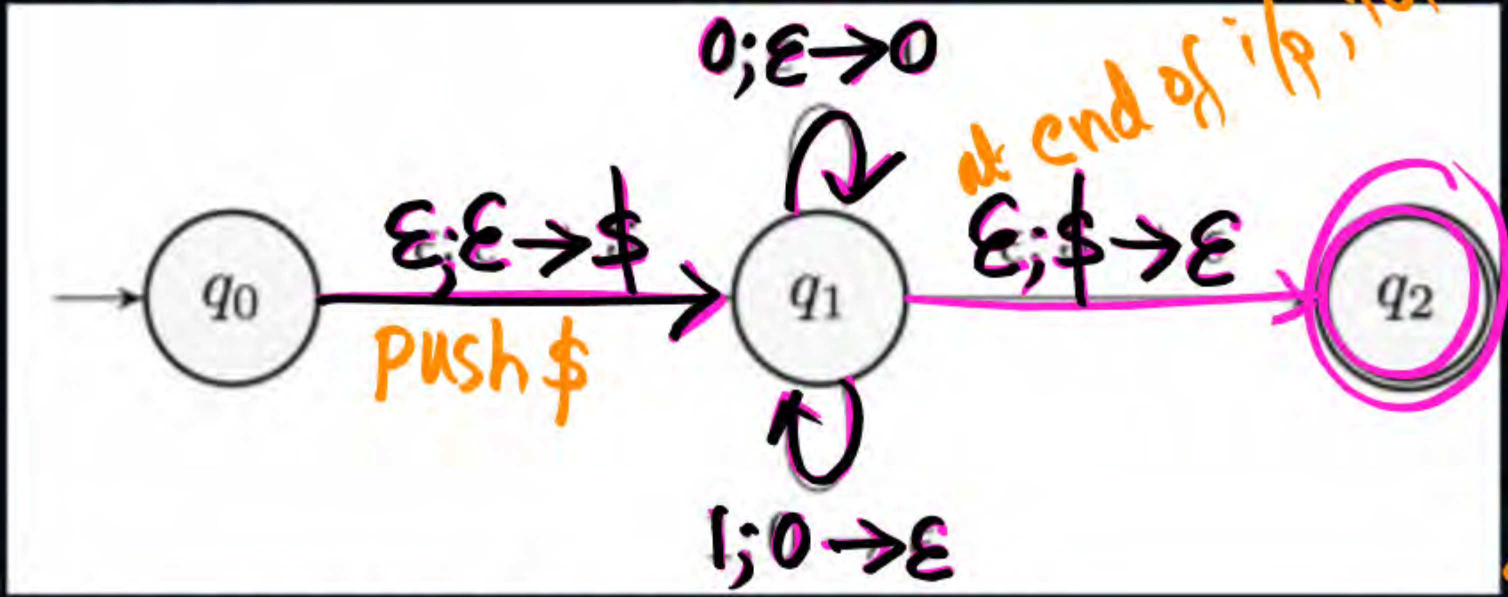
MCQ

#Q97. Consider the following PDA:

ε ✓
0 ✗
1 ✗
00 ✗
01 ✓

$

Push 0



at end of i/p, top of stack is $

10 ✗

Which of the following is accepted by above PDA?

Pop 0 for 1

$\{w \mid w \in \{0,1\}^*,$
$n_0(w) = n_1(w),$
every prefix of (w)
must contain
$n_0 \geq n_1$

A. $\{w \mid w \in \{0,1\}^*, n_0(w) >= n_1(w)\}$

B. $\{w \mid w \in \{0,1\}^*, n_1(w) >= n_0(w)\}$

C. $\{w \mid w \in \{0,1\}^*, n_0(w) = n_1(w)\}$

D. None of these ✓

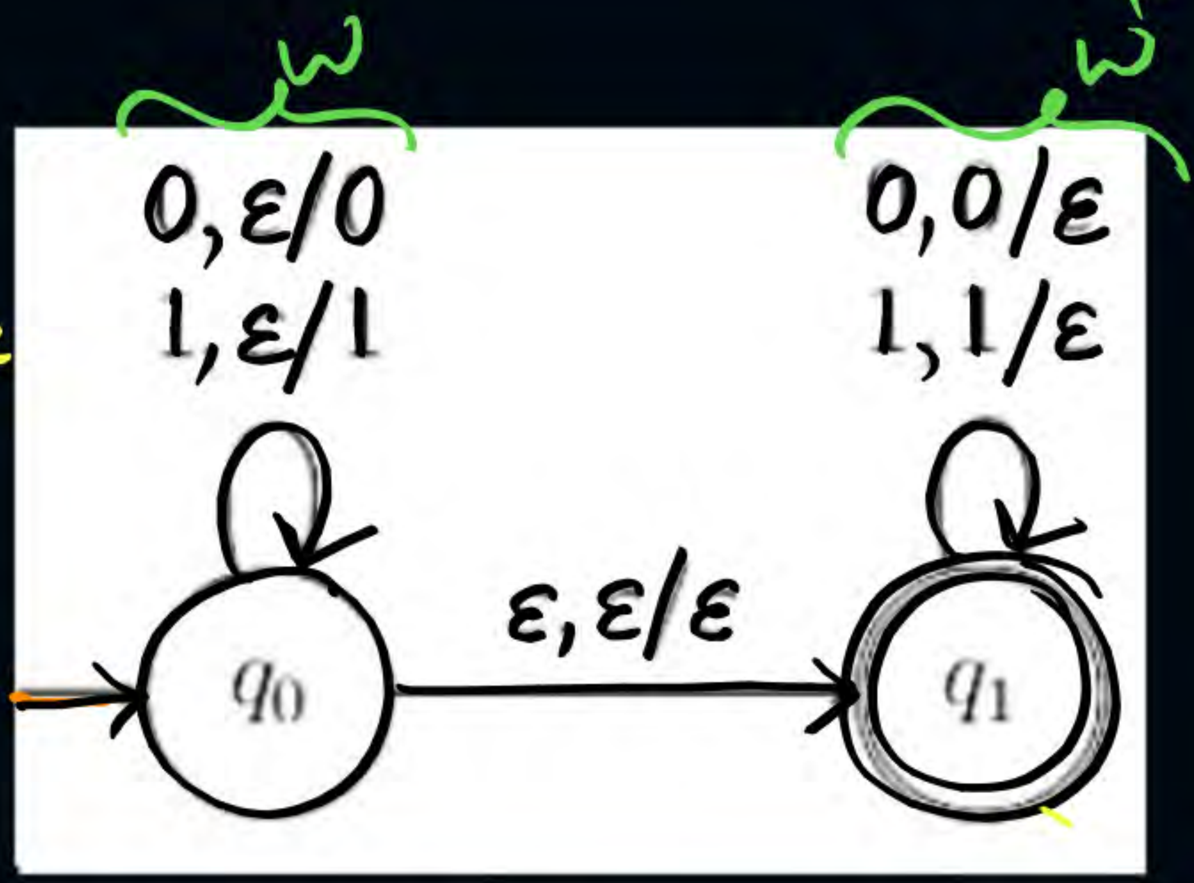
[MCQ]

Initially stack is empty.

#Q98. Consider the following PDA:

Method I : If PDA uses Final state then $L = (0+1)^*$

Method II : If PDA uses Empty stack then $L = ww^R$



Which of the following is accepted by above PDA?

A {ww| w∈{0,1}*}

B {w| w∈{0,1}*}

C {ww^R| w∈{0,1}*}

D None of these

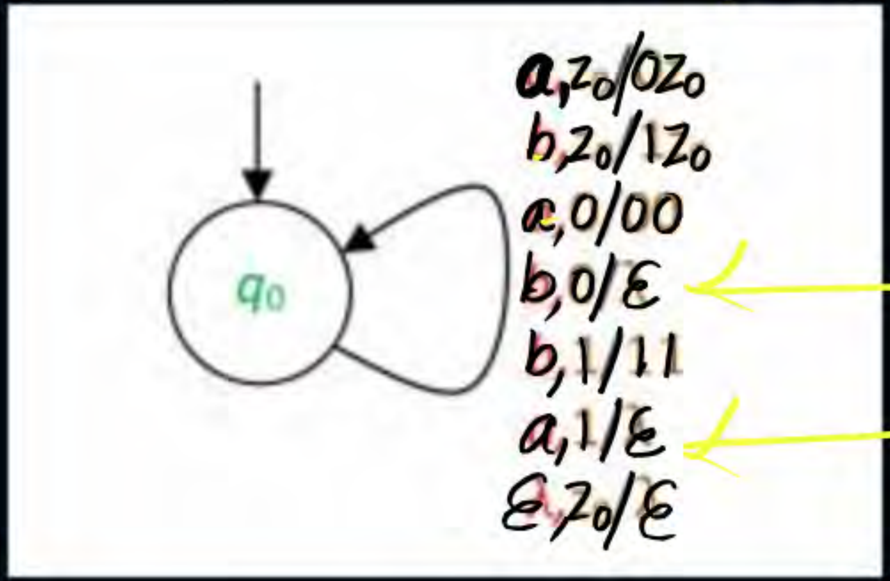
[NAT]

#Q99. Consider the following PDA:

a, 0
a, a

$\lambda = \varepsilon$

$a, z_0 / a z_0$
$b, z_0 / b z_0$
$a, a / aa$
$b, b / bb$
$a, b / \varepsilon$
$b, a / \varepsilon$
$\varepsilon, z_0 / \varepsilon$



Which of the following is accepted by above PDA if it uses empty stack mechanism?

A $\{w \mid w \in \{a,b\}^*\}$

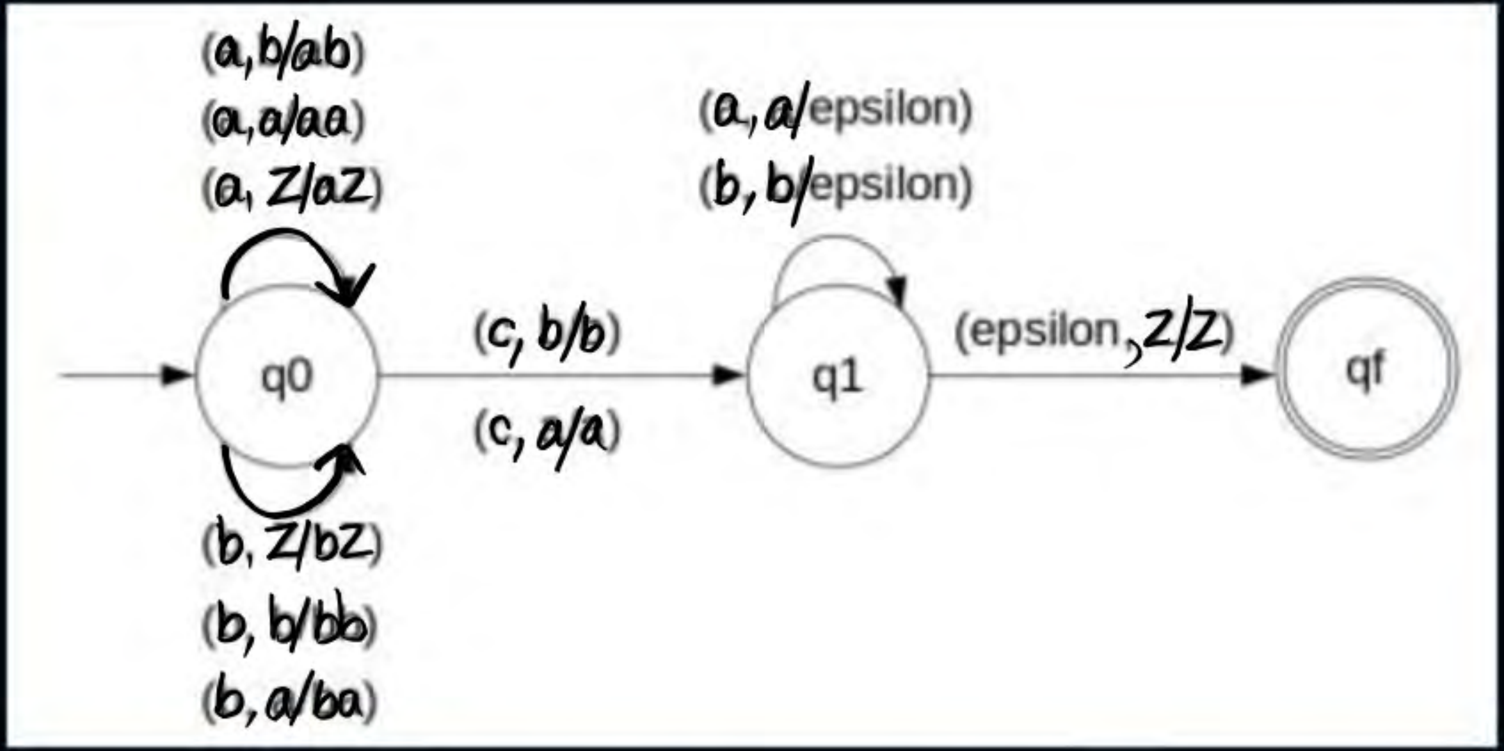
B $\{w \mid w \in \{a,b\}^*, n_a(w) = n_b(w)\}$

C $\{w \mid w \in \{a,b\}^*, n_a(w) != n_b(w)\}$

D None of these

[NAT]

#Q100. Consider the following PDA:



Which of the following is accepted by above PDA if it uses empty stack mechanism?

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

B $\{wcw^R \mid w \in \{a,b\}^*\}$

C $\{ww^R \mid w \in \{a,b,c\}^*\}$

D None of these

[NAT]

#Q101. Consider the following CFG:

$$
\begin{aligned}
S &\rightarrow S_1 \mid S_2 \\
S_1 &\rightarrow X \mid XXS_1 \\
S_2 &\rightarrow T_a T_b \mid T_b T_a \\
T_a &\rightarrow X T_a X \mid a \\
T_b &\rightarrow X T_b X \mid b \\
X &\rightarrow a \mid b
\end{aligned}
$$

Which of the following is represented by above CFG?

A. Complement of $\{ww \mid w \in \{a,b\}^*\}$

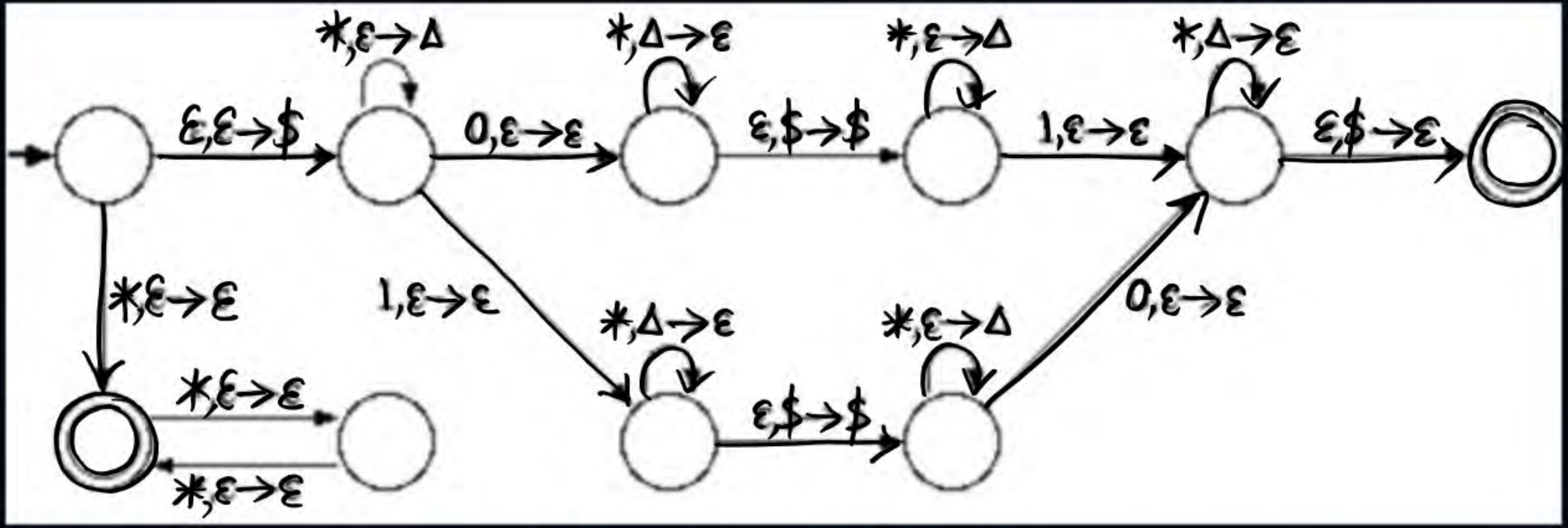
B. Complement of $\{ww^R \mid w \in \{a,b\}^*\}$

C. $\{ww^R \mid w \in \{a,b,c\}^*\}$

D. None of these

[NAT]

#Q102. Consider the following CFG: $ is bottom of stack symbol. * is either 0 or 1.



Which of the following is represented by above CFG?

A. Complement of {ww| w∈{a,b}*}

B. Complement of {ww^R| w∈{a,b}*}

C. {ww^R| w∈{a,b,c}*}

D. None of these

[NAT]

#Q103. Consider the following CFG..

$$S \rightarrow 0S1S1S \mid 1S0S1S \mid 1S1S0S \mid \in$$

Which of the following strings are generated by above CFG?

A. Binary strings with twice as many 1's as 0's.

B. Binary strings with twice as many 11's as 00's.

C. Binary strings with twice as many 0's as 1's.

D. None of these

[NAT]

#Q104. Consider the following CFG..

$$
\begin{aligned}
S &\rightarrow AB \mid BA \\
A &\rightarrow CAC \mid a \\
B &\rightarrow CBC \mid b \\
C &\rightarrow a \mid b
\end{aligned}
$$

Which of the following strings are generated by above CFG?

A. $\{xy \mid x,y \in \{0,1\}^*, |x|=|y|, x \neq y\}$.

B. $\{xy \mid x,y \in \{0,1\}^*, |x|=|y|\}$.

C. $\{xy \mid x,y \in \{0,1\}^*, x=y\}$.

D. $\{xy \mid x,y \in \{0,1\}^*, |x|=|y|, x=y\}$.

[NAT]

#Q105. Consider the following CFG..

$$\begin{aligned} S &\rightarrow 0A \mid 1B \\ A &\rightarrow 0AA \mid 1S \mid 1 \\ B &\rightarrow 1BB \mid 0S \mid 0 \end{aligned}$$

Which of the following language is generated by above CFG?

A. $\{w \mid w \in \{0,1\}^*, n_0(w) = n_1(w)\}$.

B. $\{w \mid w \in \{0,1\}^*, n_0(w) \neq n_1(w)\}$.

C. $\{w \mid w \in \{0,1\}^*, n_0(w) < n_1(w)\}$.

D. $\{w \mid w \in \{0,1\}^*, n_0(w) > n_1(w)\}$.

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 08

Mallesham Devasane Sir

Recap of Previous Lecture

Topic Regular Languages

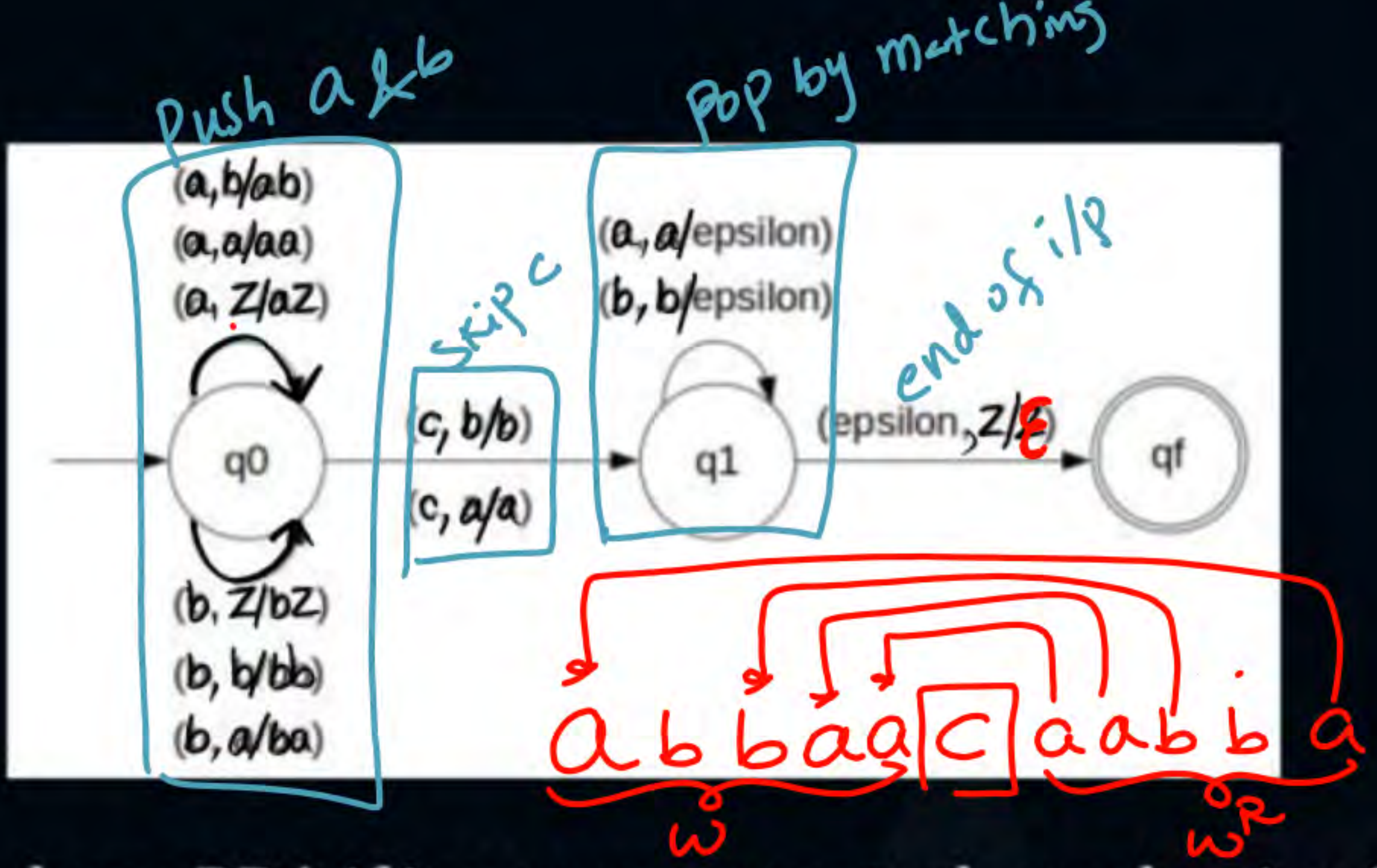
Topic Context Free Languages

Topics to be Covered

- **Topic** Regular Languages
- **Topic** Context Free Languages
- **Topic** Turing Machine
- **Topic** Undecidability Concepts

[NAT]

#Q100. Consider the following PDA:



Initially z is on stack.

Which of the following is accepted by above PDA if it uses empty stack mechanism?

A. $\{wcw \mid w \in \{a,b\}^*\}$ not CFL

B. $\{wcw^R \mid w \in \{a,b\}^+\}$

C. $\{ww^R \mid w \in \{a,b,c\}^*\}$

D. None of these

[NAT]

#Q101. Consider the following CFG:

$$\begin{aligned} S &\rightarrow S_1 \mid S_2 \\ S_1 &\rightarrow X \mid XXS_1 \\ S_2 &\rightarrow T_aT_b \mid T_bT_a \\ T_a &\rightarrow XT_aX \mid a \\ T_b &\rightarrow XT_bX \mid b \\ X &\rightarrow a \mid b \end{aligned}$$

S_2 guarantees
↳ generates even length
↳ not ww form

$S_1 \Rightarrow$ odd length strings

$S_2 \Rightarrow \{w_1w_2 \mid w_1, w_2 \in \{a,b\}^*, |w_1| = |w_2|, w_1 \neq w_2\}$

Which of the following is represented by above CFG?

A. $\boxed{\text{Complement}}$ of {ww| w∈{a,b}*} ✓

B. Complement of $\{ww^R \mid w \in \{a,b\}^*\}$

C. $\{ww^R \mid w \in \{a,b,c\}^*\}$

D. None of these

$L = \{ww \mid w \in \{a,b\}^*\} \implies$ not CFL

$\bar{L} = \overline{\{ww \mid w \in \{a,b\}^*\}} \implies$ CFL

$$L = \{ww \mid w \in \{a,b\}^*\} = \{\epsilon, aa, bb, aaaa, abab, baba, bbbb, \ldots\}$$

= set of all even length strings in ww form

$$\bar{L} = \Sigma^* - L = (a+b)^* - L$$

= Set of all odd length strings $\cup$ set of all even lengths not in ww form

[NAT]

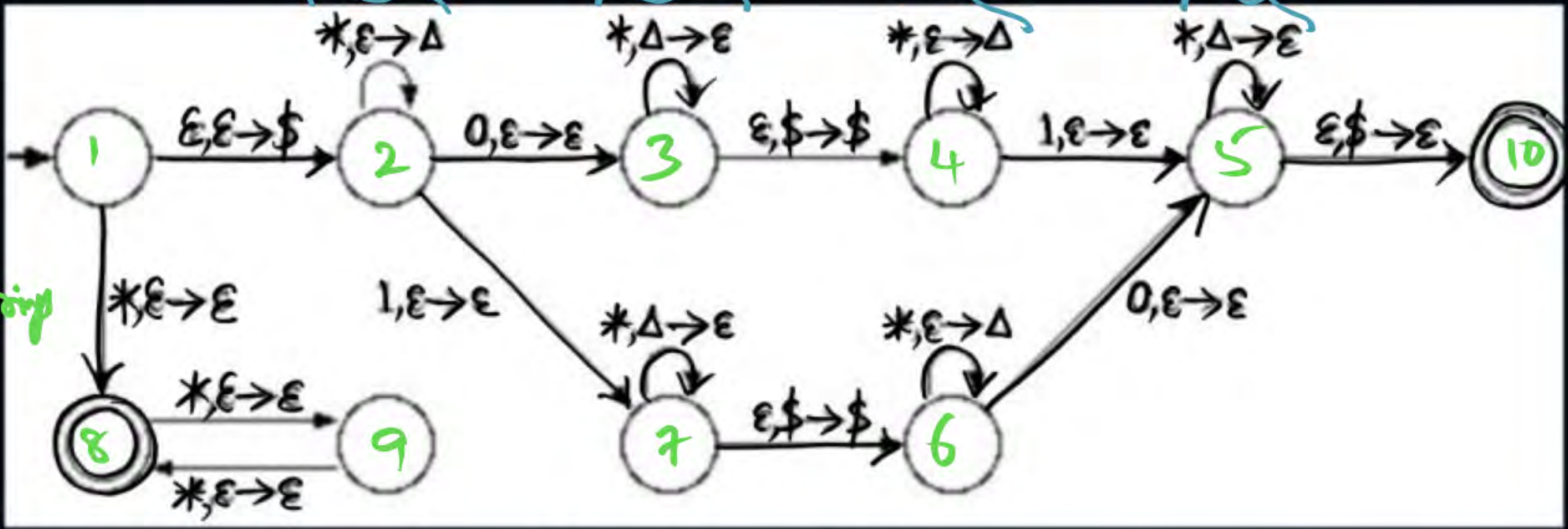
#Q102. Consider the following CFG. $ is bottom of stack symbol. * is either 0 or 1.

k symbols push

k symbols pop

n symbols push

n symbols pop



[8] = set of all odd length string

Which of the following is represented by above CFG?

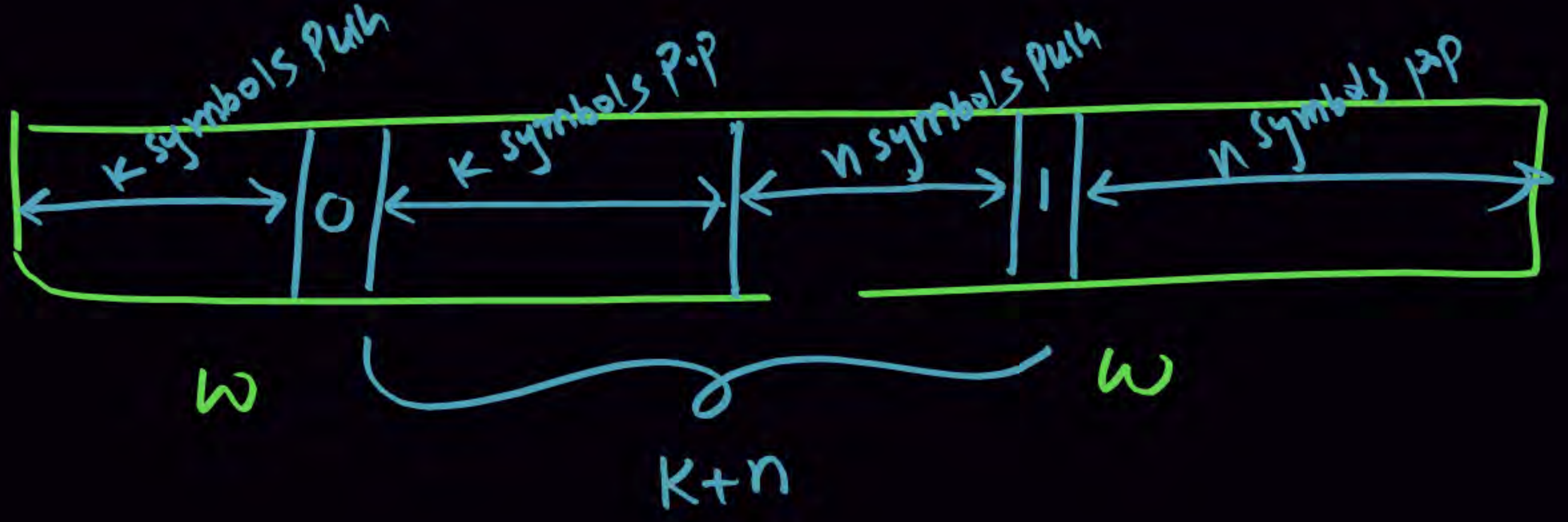
A. Complement of $\{ww \mid w \in \{0,1\}^*\}$

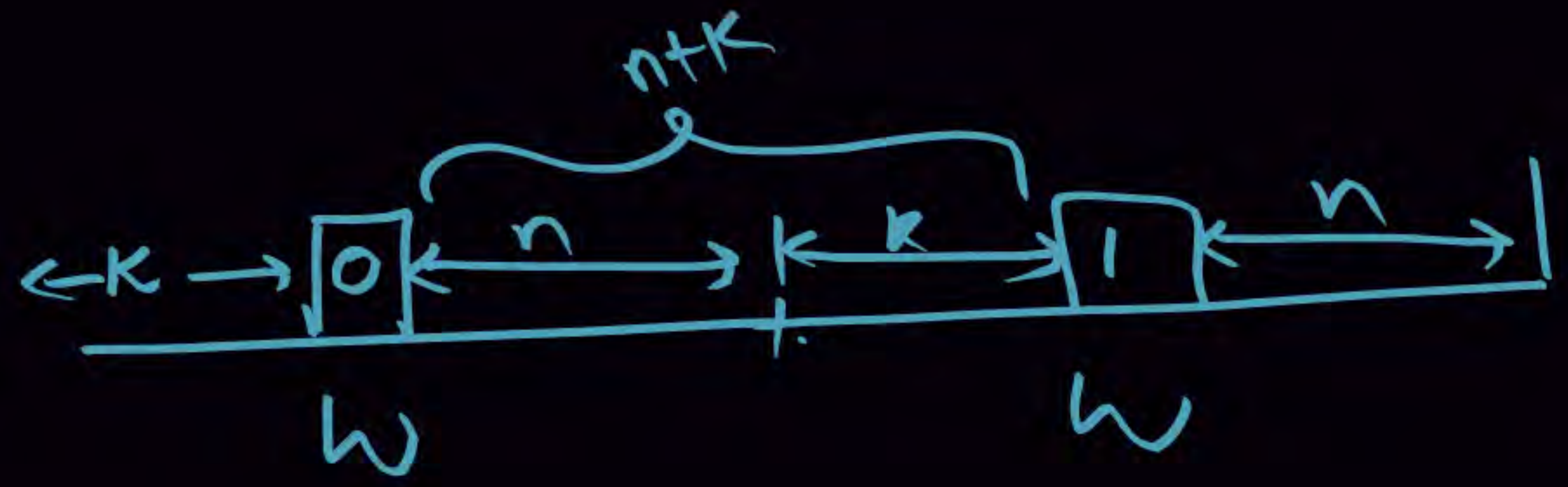
B. Complement of $\{ww^R \mid w \in \{0,1\}^*\}$

C. $\{ww^R \mid w \in \{0,1,2\}^*\}$

D. None of these

Even length
not in ww form





$w \in \{0,1\}^*$

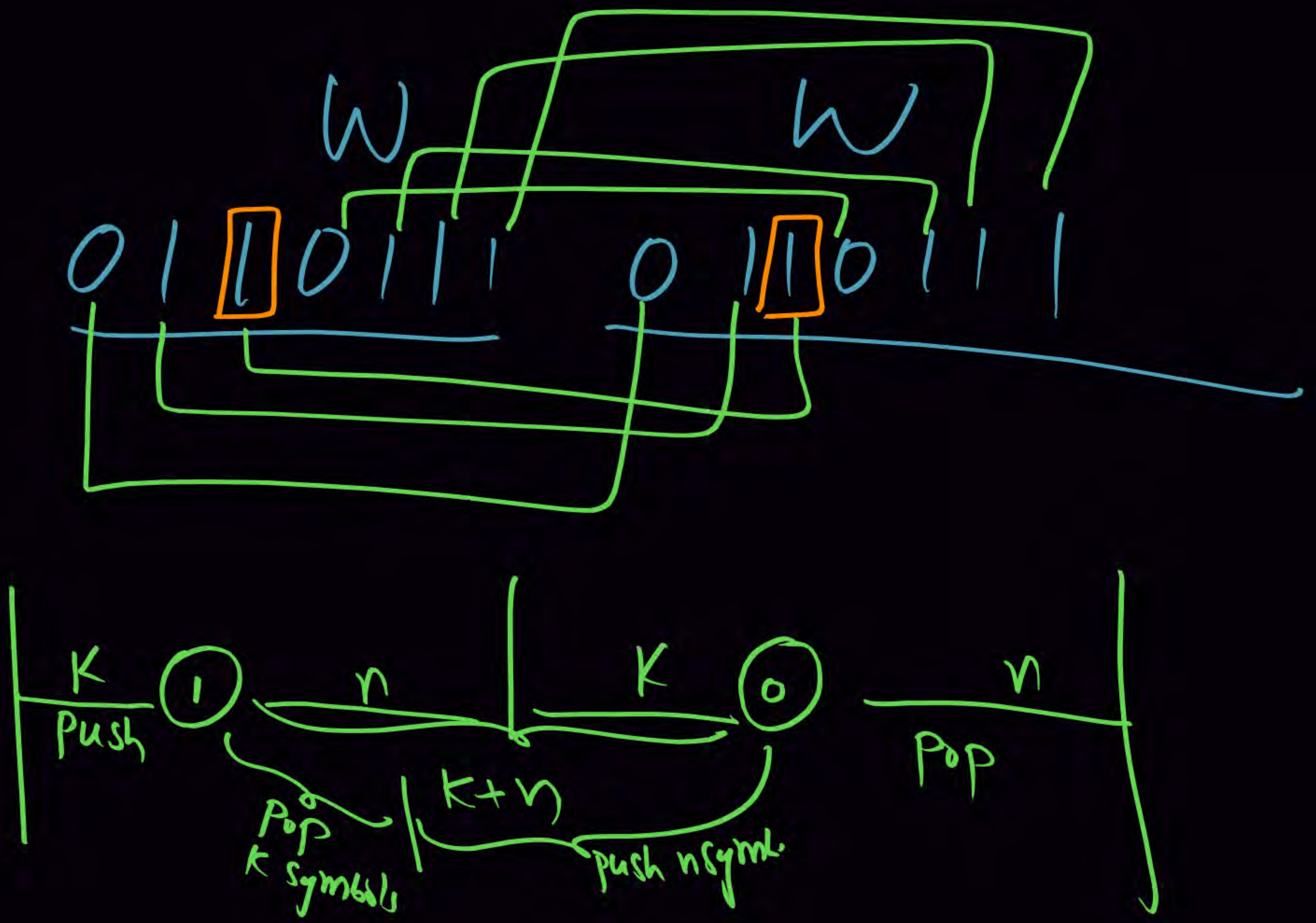
$\overline{ww}$

$\Downarrow$

All odd length strings

All even length strings not in ww form

ww



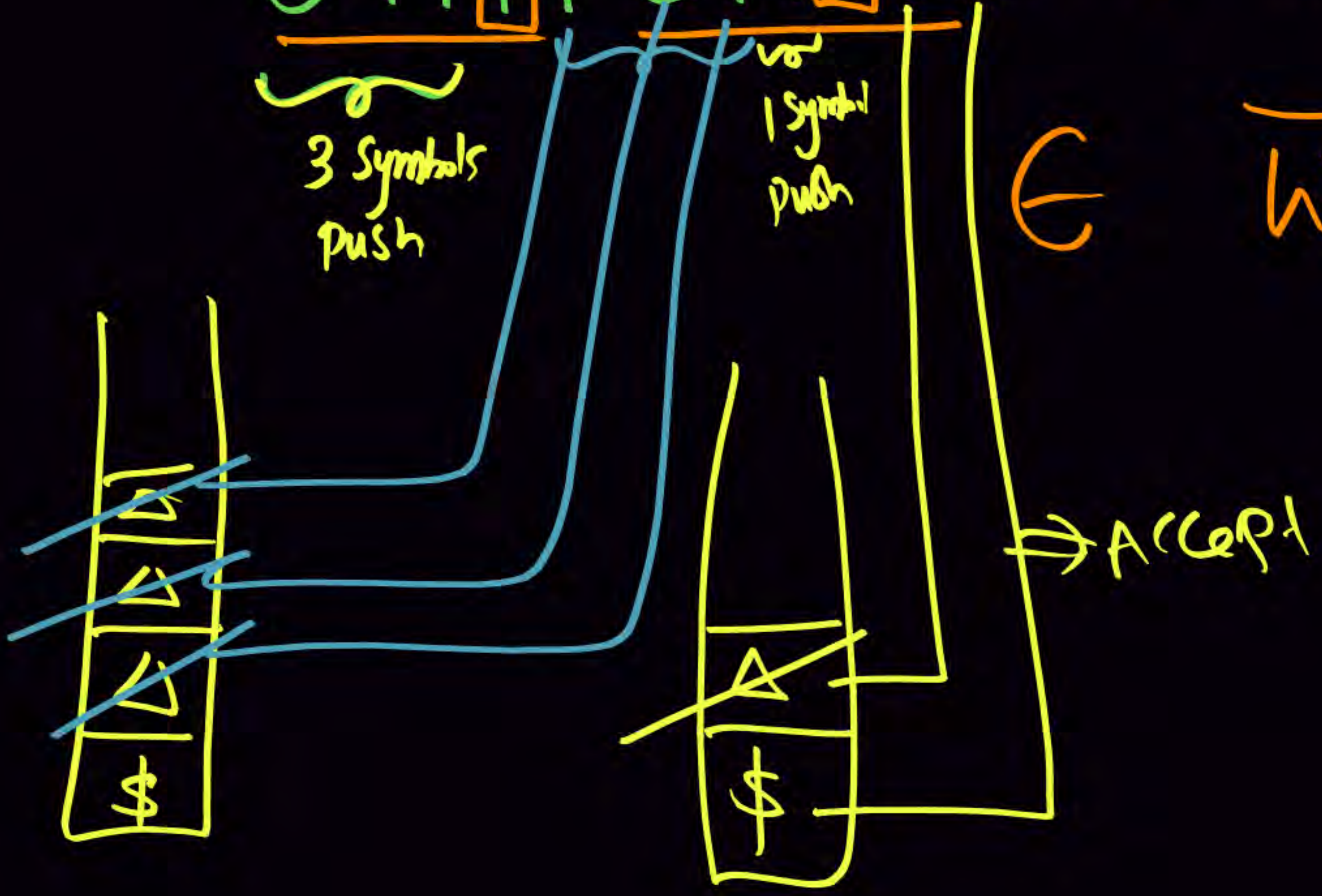
W
W
0 1 1 0 1 1 1
0 1 1 0 1 1 1
k
1
n
k
0
n
push
Pop
k+n
Pop
k symbols
push n symb.

0 1 1 1 1 0 1 1 0 1 ε is not in ww form

3 Symbols push

1 Symbol push

$\in \overline{WW}$



[MCQ]

#Q103. Consider the following CFG..

$$S \rightarrow 0S1S1S \mid 1S0S1S \mid 1S1S0S \mid \in$$

ε ✓

011 ✓

101 ✓

110 ✓

Which of the following strings are generated by above CFG?

$n_1(w) = 2\, n_0(w)$

A. Binary strings with twice as many 1's as 0's.

B. Binary strings with twice as many 11's as 00's.

C. Binary strings with twice as many 0's as 1's.

$n_0(w) = 2\, n_1(w)$

D. None of these

[MCQ]

#Q104. Consider the following CFG..

$$
\begin{aligned}
S &\rightarrow AB \mid BA \\
A &\rightarrow CAC \mid a \\
B &\rightarrow CBC \mid b \\
C &\rightarrow a \mid b
\end{aligned}
$$

Which of the following strings are generated by above CFG?

$|x|=|y|$	$|xy|$
44	8
33	6
22	4
11	2
00	0

$= [(0+1)^2]^*$

= Set of all even length string

A. $\{xy \mid x,y \in \{0,1\}^*, |x|=|y|, x \neq y\}$.

B. $\{xy \mid x,y \in \{0,1\}^*, |x|=|y|\}$.

C. $\{xy \mid x,y \in \{0,1\}^*, x=y\}$.

D. $\{xy \mid x,y \in \{0,1\}^*, |x|=|y|, x=y\}$.

[MCQ]

#Q105. Consider the following CFG..

$$S \rightarrow 0A \mid 1B$$
$$A \rightarrow 0AA \mid 1S \mid 1$$
$$B \rightarrow 1BB \mid 0S \mid 0$$

$L = \{01, 10, 0011, 1100, 0101, 0110, \ldots\}$

Which of the following language is generated by above CFG?

A $\{w \mid w \in \{0,1\}^+, n_0(w) = n_1(w)\}$.

B $\{w \mid w \in \{0,1\}^*, n_0(w) \neq n_1(w)\}$.

C $\{w \mid w \in \{0,1\}^*, n_0(w) < n_1(w)\}$.

D $\{w \mid w \in \{0,1\}^*, n_0(w) > n_1(w)\}$.

[MSQ]

#Q106. Suppose L1 and L2 are Turing Recognizable Languages.

Which of the following is Turing Recognizable?

$\cup$ ✓
$\cap$ ✓
$\cdot$ ✓

$-$ ✗

A. $L1 \cup L2 = REL_1 \cup REL_2 \Rightarrow REL$

B. $L1 \cap L2$

$REL_1 \cap REL_2 \Rightarrow REL$

C. $L1 - L2 = REL_1 - REL_2 \Rightarrow$ Need not be REL

$L_1 - L_2 = L_1 \cap \overline{L_2}$

D. $L1\,L2$

$REL_1 . REL_2 \Rightarrow REL$

CDSFI

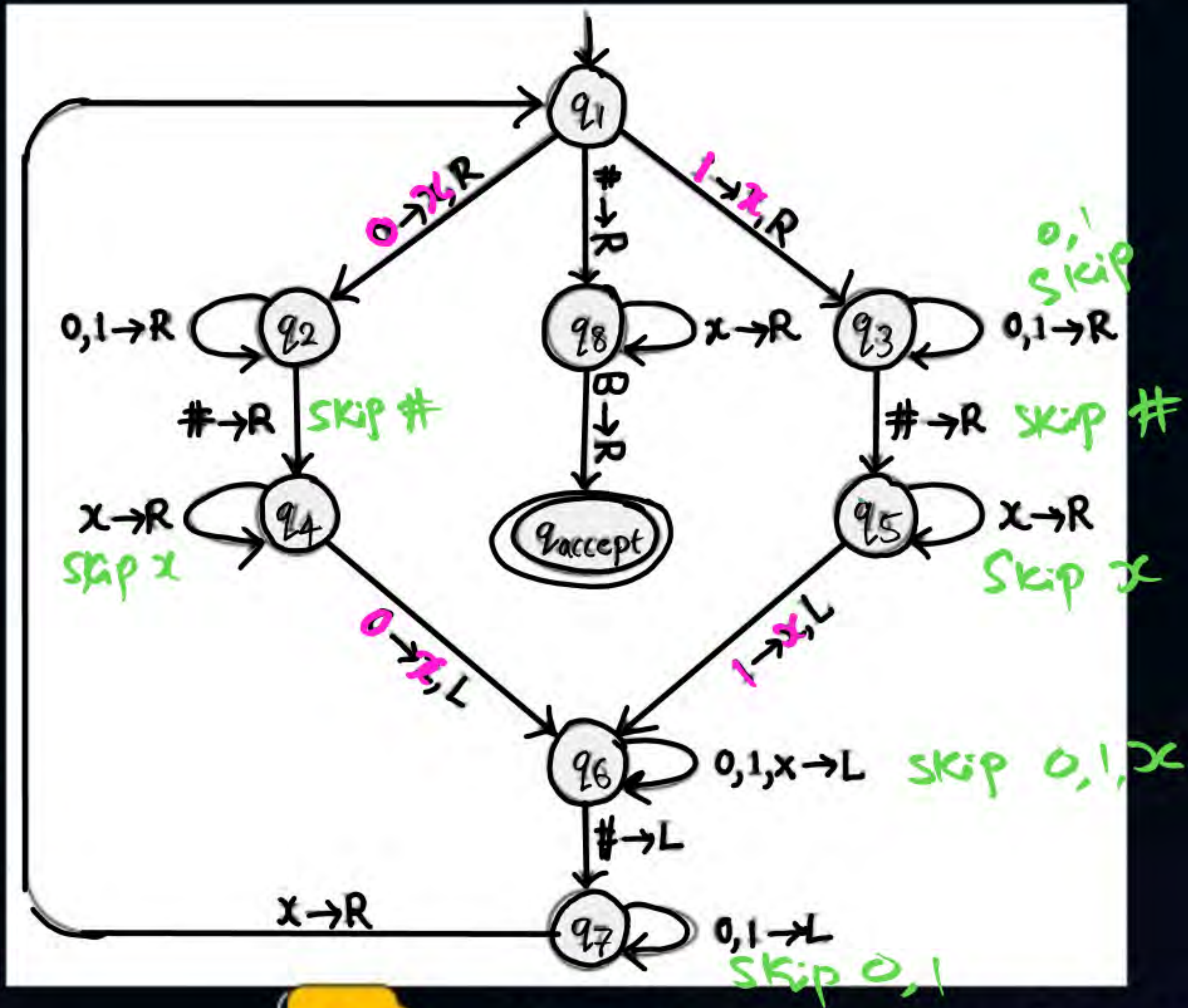
RELs
$\Downarrow$

Complement
Difference
Subset
Inf...
Finite Difference

Not closed

[MCQ]

#Q107. Language accepted by following TM is ____



$0\,0\,1\,1\,0 \;\#\; 0\,0\,1\,1\,0$

$\{w\#w \mid w \in \{0,1\}^*\}$

$= \{\#, 0\#0, 1\#1, \ldots\}$

A $\{ww \mid w \in \{a,b\}^*\}$

B Complement of $\{ww^R \mid w \in \{a,b\}^*\}$

C $\{ww^R \mid w \in \{a,b,c\}^*\}$

D None of these

[NAT]

#Q108. How many of the following statements are equivalent to TM?

1. Multi-tape Turing machines
2. Turingmachines with Bi-infinite Tape
3. Nondeterministic Turing machines
4. Postmachines or Queue automaton
5. PDAs with two stacks
6. Counter machines

= 6

Equivalent to TM

- DTM
- NTM
- UTM
- 2 stack PDA
- one way infinite tape TM
- 2-way " " TM
- Single head TM
- multi head TM
- 1-D Tape TM
- 2-D Tape TM
- ⋮

[MSQ]

#Q109. Which of the following does by Turing Machine?

A. Sorting a list

B. String Matching

C. Graph Search

D. Searching a list

Program

$\cong$

TM

$\cong$

Computer

Algorithm

$\cong$

Halting program

$\cong$

HTM

[MSQ]

#Q110. Which of the following is countable?

TM exist

It is also REL

$L = \{R_1, R_2, R_3, \dots\}$

$\{\varepsilon, 0, 1, 00, 01, 10, 11, \dots\}$

A Set of binary strings $= \Sigma^* = (0+1)^*$

B Set of regular languages

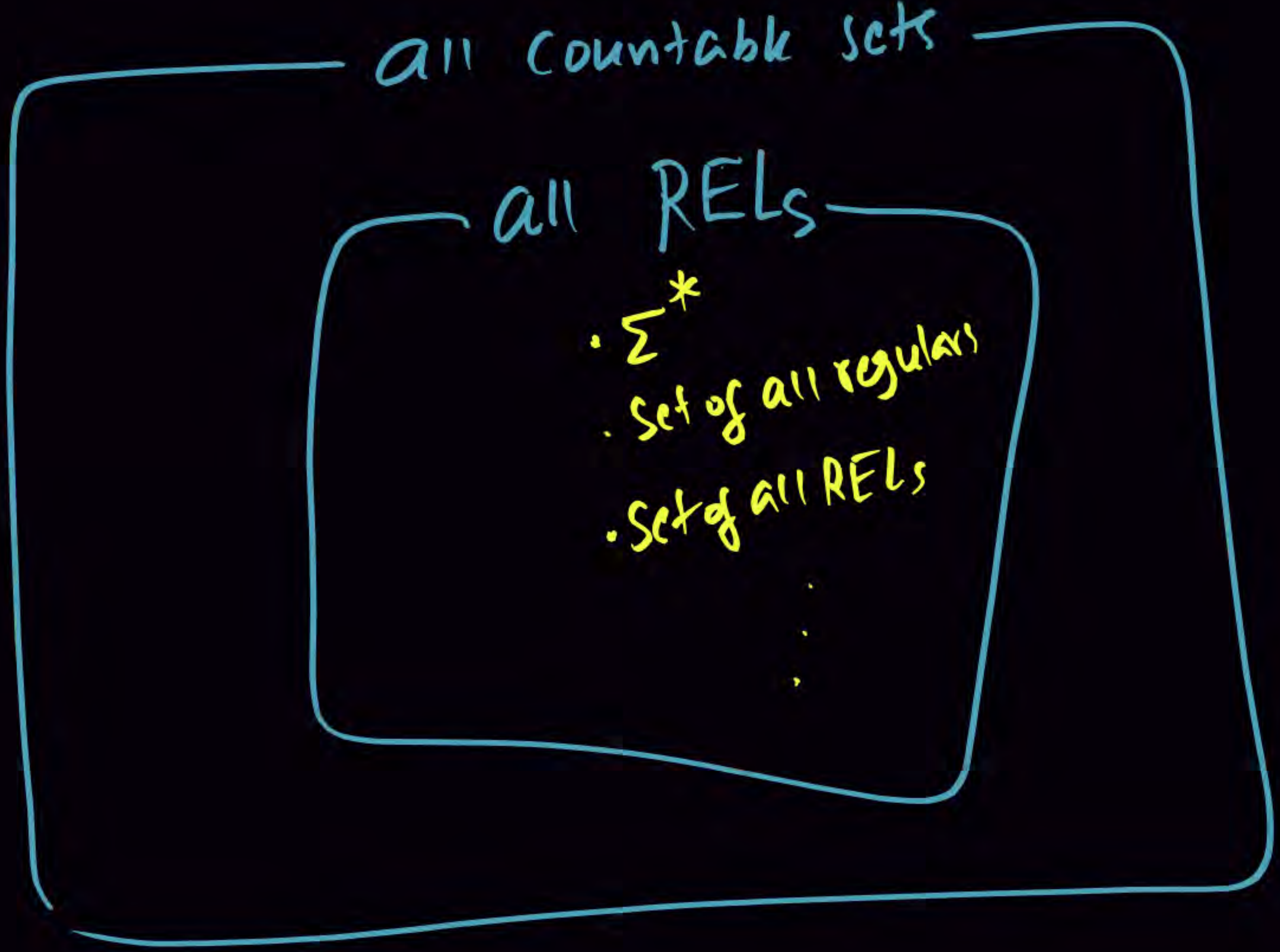
C Set of RELs

$L = \{REL_1, REL_2, REL_3, \dots\}$

It is also REL

TM exist

D None of these


all countable sets
all RELs
· Σ^*
· Set of all regulars
· Set of all RELs
⋮

[MCQ]

#Q111. Which of the following is TRUE?

1. If both L and complement of L are RE ,then L is recursive.
2. If L is recursive then so is the complement of L.

A Only 1

B Only 2

C Both 1 and 2

D None of these

[MSQ]

#Q112. Which of the following L is Recursively Enumerable Language?

A. L is Regular

B. L is Decidable

C. L is Enumerable

D. L is Undecidable

[MSQ]

#Q113. If L is recursive language, then complement of L is __

A Recursive

B Undecidable

C RE

D CFL

[MCQ]

#Q114. Consider the following statements.

I. Every decidable set is countable
II. Every RE set is countable
III. Every countable set is RE

How many of the above statements is/are true?

A 0

B 1

C 2

D 3

[MSQ]

#Q115. Complement of not REL is ________

A. Recursive

B. Undecidable

C. REL

D. None of these

X is countable set

iff

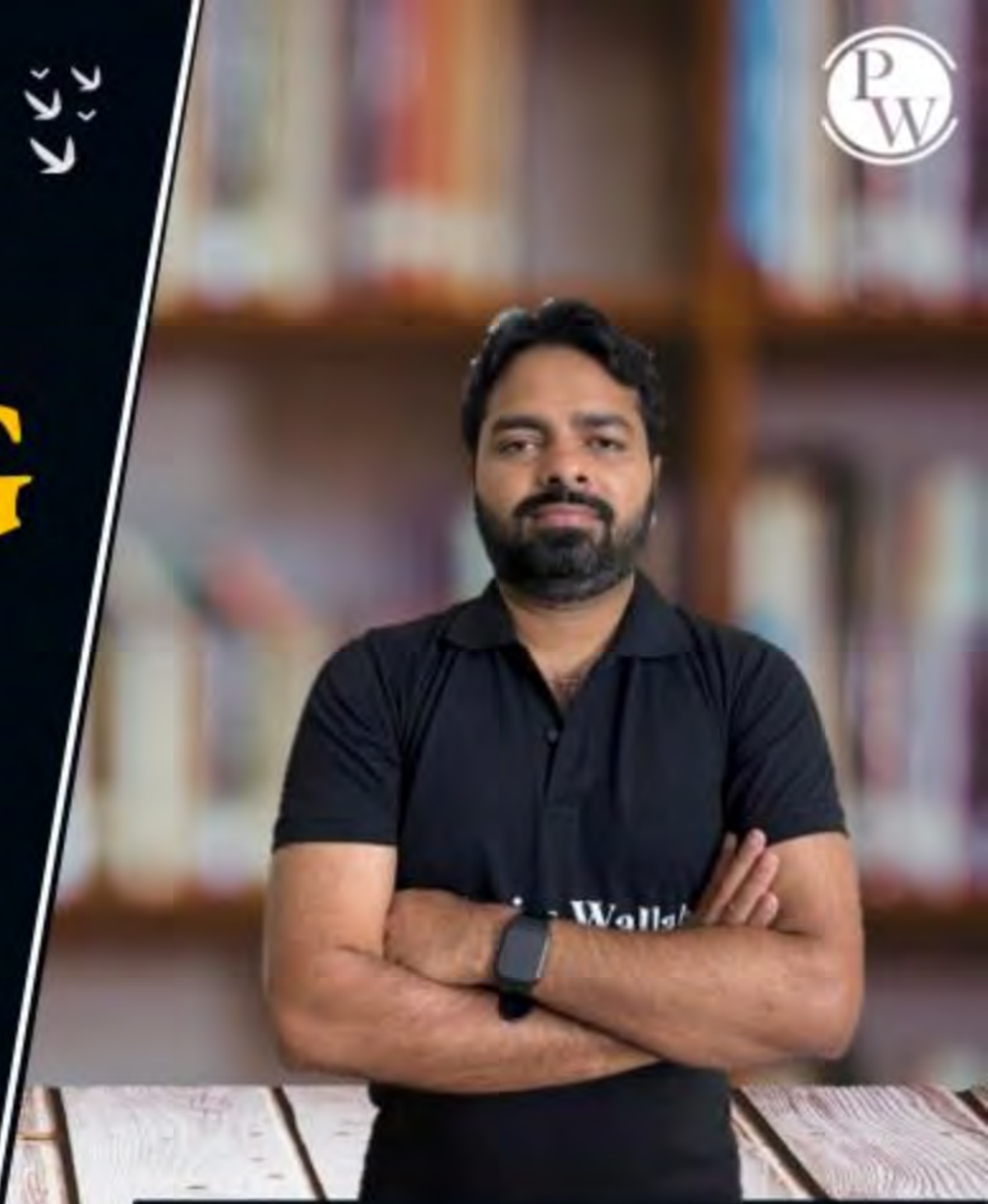
$f : X \to Y$ is Bijective

wher Y is known countabl.

THANK - YOU

CS & IT ENGINEERING

Theory of Computation



Lecture No.- 09

Mallesham Devasane Sir

Recap of Previous Lecture

Topic	Regular Languages
Topic	Context Free Languages
Topic	Turing Machine
Topic	Undecidability Concepts

Topics to be Covered

Topic — Regular Languages

Topic — Context Free Languages

Topic — Turing Machine

Topic — Undecidability Concepts

[MCQ]

#Q111. Which of the following is TRUE?

1. If both L and complement of L are RE ,then L is recursive. T
2. If L is recursive then so is the complement of L. T

A Only 1

B Only 2

C Both 1 and 2

D None of these

[MSQ]

Dec ✓
Reg ✓

#Q112. Which of the following L is Recursively Enumerable Language?

Enu ✓

~~Undec~~

A. L is Regular

B. L is Decidable

C. L is Enumerable

D. L is Undecidable

[MSQ]

#Q113. If L is recursive language, then complement of L is ___ Recursive

REL

A Recursive

B Undecidable

C RE

D CFL

[MCQ]

#Q114. Consider the following statements.

I. Every decidable set is countable T
II. Every RE set is countable T
III. Every countable set is RE False

How many of the above statements is/are true?

A 0

B 1

C 2

D 3

[MSQ]

#Q115. Complement of $\boxed{\text{not REL}}$ is ______

$\overline{\text{Not REL}} \Rightarrow$ RE but not rec OR Not REL $\}$ = Never be rec = UD = Not rec

A Recursive

B Undecidable

C REL

D None of these

[MSQ]

"State Entry problem"

Particular

#Q116. Given a TM 'M' and a state 'q' of M, does M ever enter state q on some input?

→ Yes : Reaches state q
↳ logic exist

→ No : Doesn't reach state q
↳ logic not exist

RE but not rec

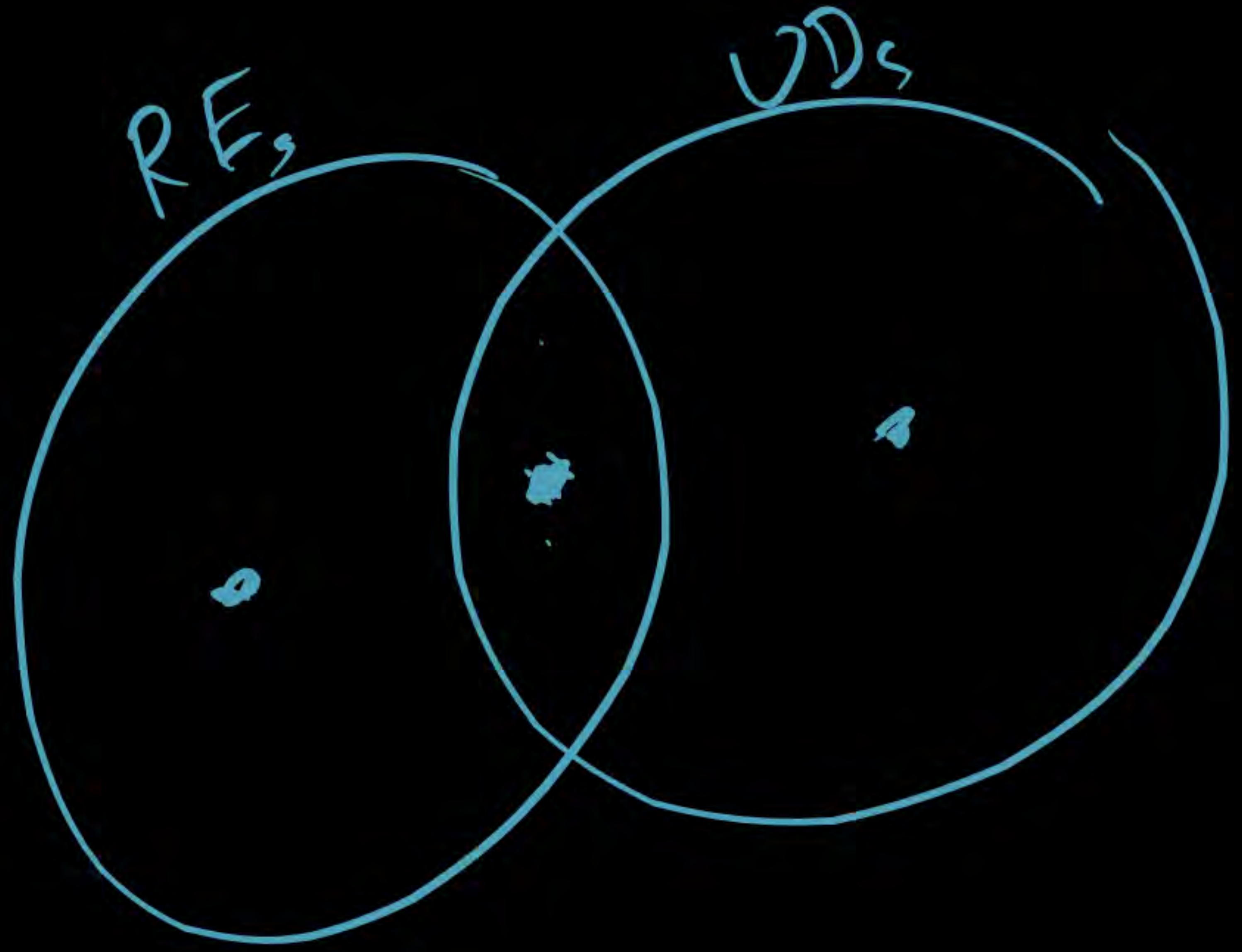
SD UD

A Recursive

B Undecidable (UD)

C RE (SD)

D RE but not recursive


REs
UDs

[MSQ]

TM

#Q117. Does 'M' ever enter state 'q' on $\boxed{\text{input 'abb'?}}$

RE but not rec
(SDUD)

A. Recursive

B. Undecidable

C. RE [redacted]

D. None of these

[MSQ]

#Q118. Does 'M' ever enter state 'q' on input 'abb' within 5 moves?

Transition steps

Yes :

No :

A. Recursive

B. Undecidable

C. REL

D. ~~None of these~~ RE but not Rec

[MSQ]

#Q119. "TM accepts epsilon" is ___

Is $\varepsilon \in L(TM)$?

Is TM accepts ε ?
(Membership)

Yes : ε accepted by TM logic ✓

No : ε not accepted by TM logic ✗

A Recursive

B Undecidable

C RE

D ~~None of these~~
RE but not recursive

[MSQ]

#Q120. "TM accepts only epsilon" is ___

IS $L(TM) = \{\varepsilon\}$?

Yes : TM should accept ε and TM should not accept any other string — logic ✗

NO : TM may accept nothing OR TM should accept some string other than ε. — logic ✗

Not RE

A Recursive

B Undecidable ✓

C REL

D None of these

[MCQ]

#Q121. Which of the following problem is Decidable for TM?

TMs

H
M
E
F
T
E
Φ
S

UD

A. Membership

B. Halting

C. Equivalence

D. None of these

[MSQ]

#Q122. Which of the following problem is RE but not recursive for TM?

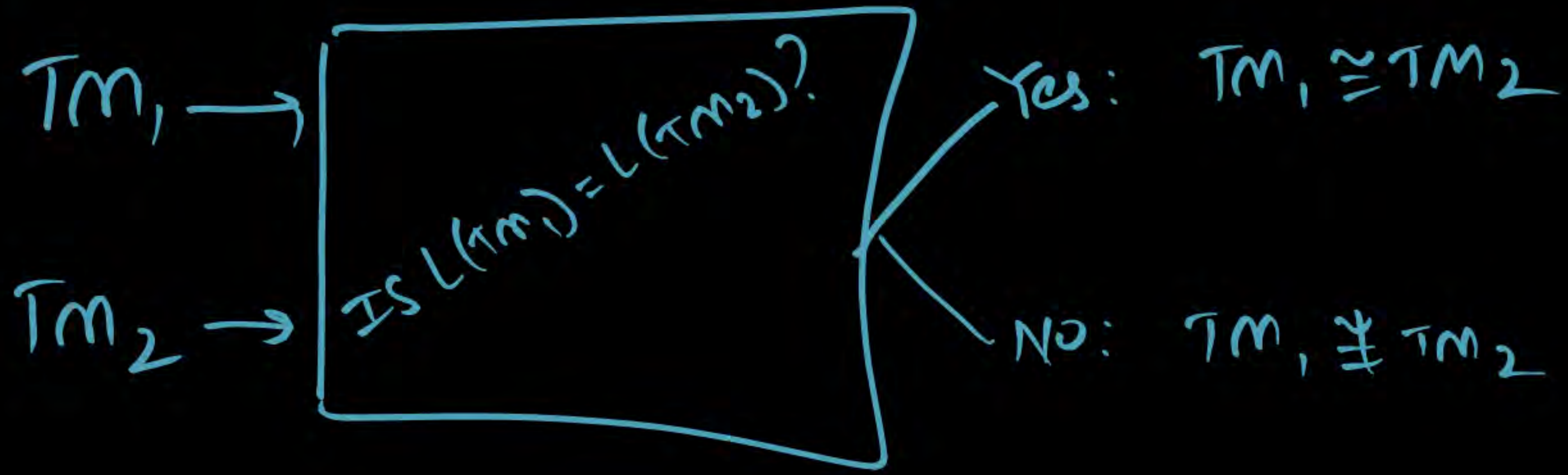
A Membership Yes ⇒ logic ✓ / No ⇒ logic ✗

B Halting Yes ⇒ logic ✓ / No ⇒ logic ✗

C Finiteness Yes ⇒ logic ✗ / NO ⇒ logic ✗

D ~~None of these~~ Equivalence Yes ✗ / NO ✗

Equivalence for TM



[MCQ]

#Q123. {M | L(M) is regular language}

Whether M accepts regular.

$\Downarrow$

Not RE

$$L = \{M_1, M_2, \ldots\}$$

$$\overline{L} = \{M_1', M_2', \ldots\}$$

A Recursive

B REL

C Regular

D None of these

IS TM accepts regular language ?

IS " " finite " ?

IS " " CFL ?

IS " " CSL ?

IS " " Recursive ? $\Rightarrow$ Not RE

Trivial $\boxed{\text{IS " " REL ?}}$ $\Rightarrow$ Decidable

[MSQ]

#Q124. $\{M \mid \underbrace{\text{M halts on all inputs}}\ \underbrace{\text{within 100 steps}}\}$

Yes: upto 100 lengths, all halts within 100 moves

No: atleast one string within 100 length strings takes 101th move.

$\Sigma^* = \{\varepsilon,$
a, b,
aa, ab, ba, bb,
3 length,
4 length,
⋮
100 length,
⋮
$\}$

A Recursive

B REL

C Regular

D ~~None of these~~ REL but not recursive

[MSQ]

#Q125. {M | M halts on all inputs after 100 steps} ⇒ Check upto 100 length strings

M should not halt within 100 steps for every i/p

Verify each string should take 101th move

I will write GATE exam after year 2025.

→ I may write GATE after 2025 OR I may not write

I will check upto 2 years

A ~~Recursive~~

B ~~REL~~

C Regular

D None of these

THANK - YOU

CS & IT ENGINEERING

Theory of Computation

Lecture No.- 10

Mallesham Devasane Sir

Recap of Previous Lecture

Topic Regular Languages

Topic Context Free Languages

Topic Turing Machine

Topic Undecidability Concepts

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[MCQ]

#Q126. Which of the following is TRUE?

Myhill-Nerode Theorem

1. L is regular if and only if $\equiv_L$ has a finite number of equivalences classes.
2. L is not regular if and only if $\equiv_L$ has an infinite number of equivalences classes.

A. Only 1

B. Only 2

C. Both 1 and 2

D. None of these

[MSQ]

#Q127 . Which of the following is countable?

$\{L \mid L \text{ is finite}\}$

A Set of finite languages

uncountable

B Set of languages $= 2^{\Sigma^*} = P(\Sigma^*)$

C Set of regular languages

$\{L \mid L \text{ is Regular}\}$

D Set of strings $= \Sigma^*$

Set of Languages :

$$\left\{ \{\}, \{\varepsilon\}, \{a\}, \{b\}, \{aa\}, \{ab\}, \ldots, \{\varepsilon, a\}, \{\varepsilon, b\}, \{a, b\}, \{\varepsilon, aa\}, \ldots, \{\varepsilon, a, b\}, \{\varepsilon, a, aa\}, \ldots \right\}$$

Set of strings over Σ

$= \Sigma^*$

$= \{ \varepsilon, a, b, aa, ab, ba, bb, \ldots$

N: 1 2 3 4 5 6 7

$f : \Sigma^* \longrightarrow N$ is Bijective

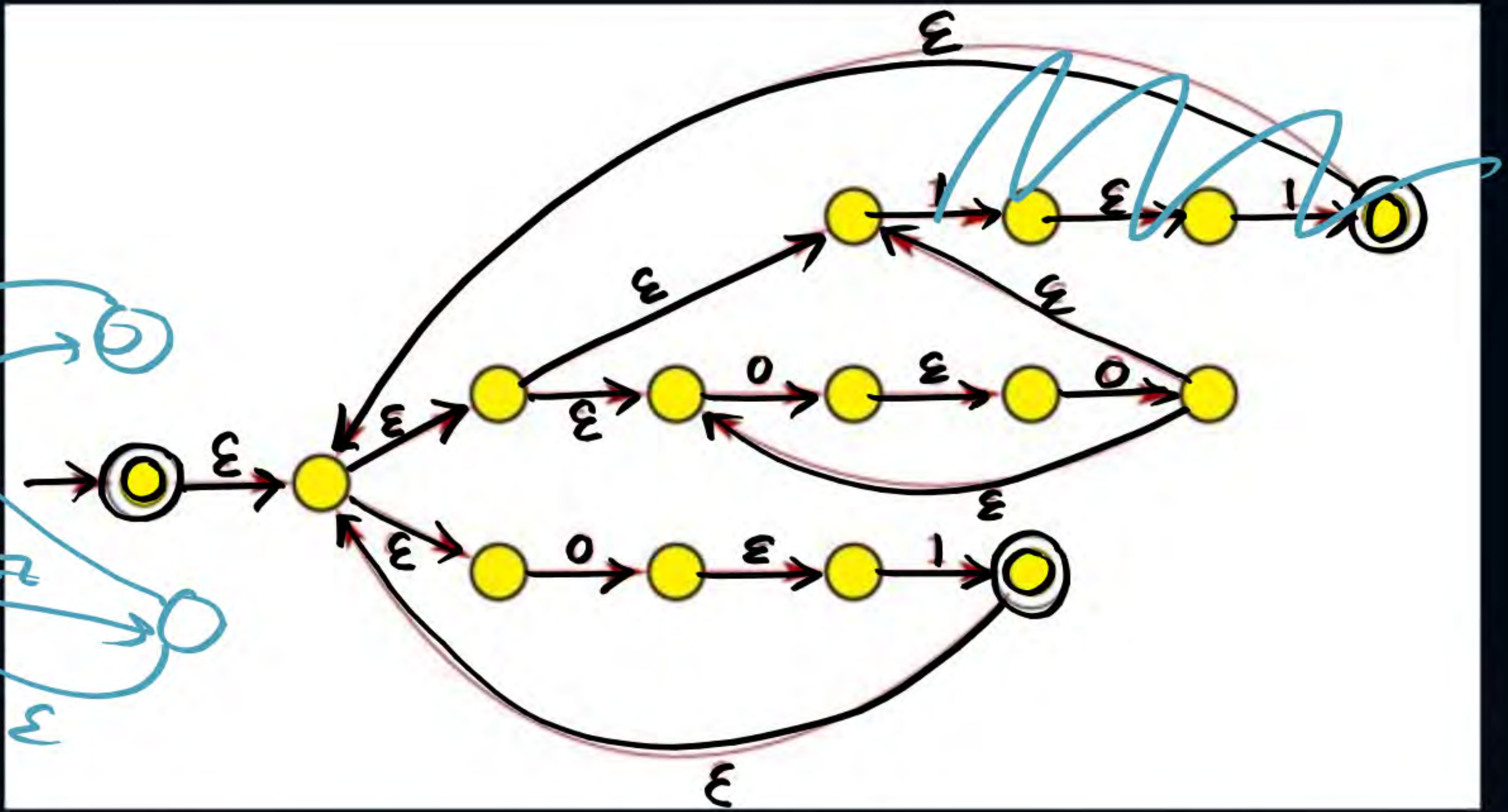
X is countable

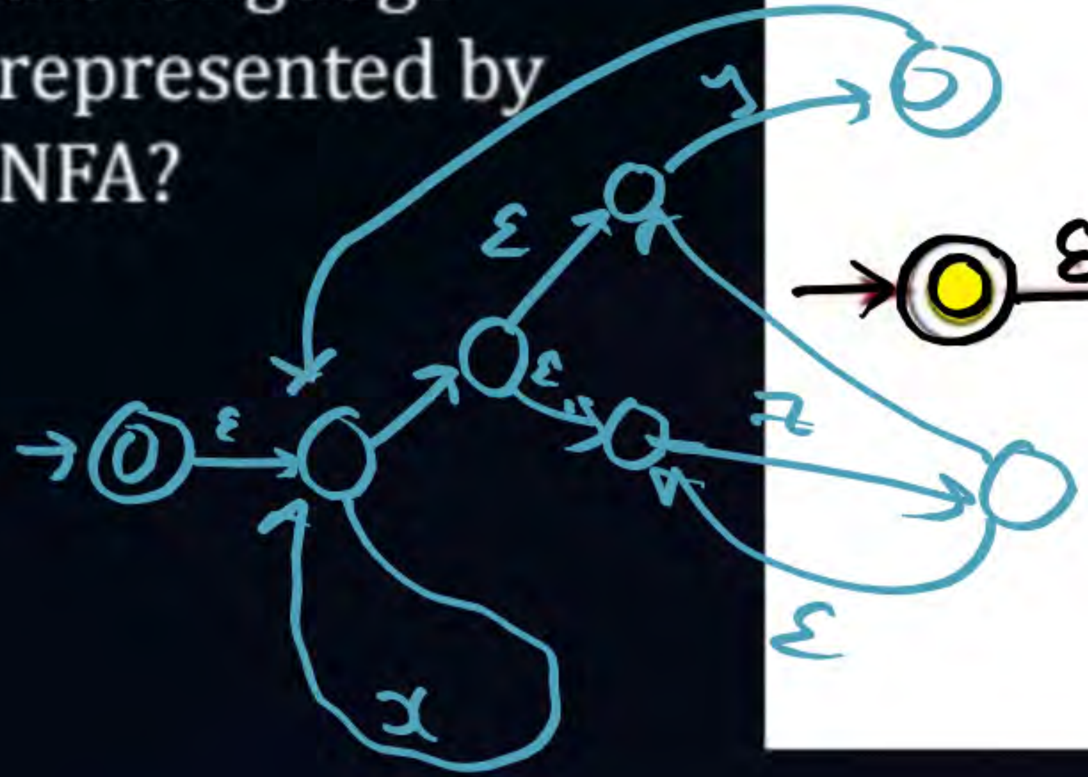
iff

$f: X \to$ known countable set is Bijective

[MCQ]

#Q128. What is the language represented by NFA?





A ((00)*+11+01)*

B ((00)*(11)+01)*

$(z^* y + x)^*$

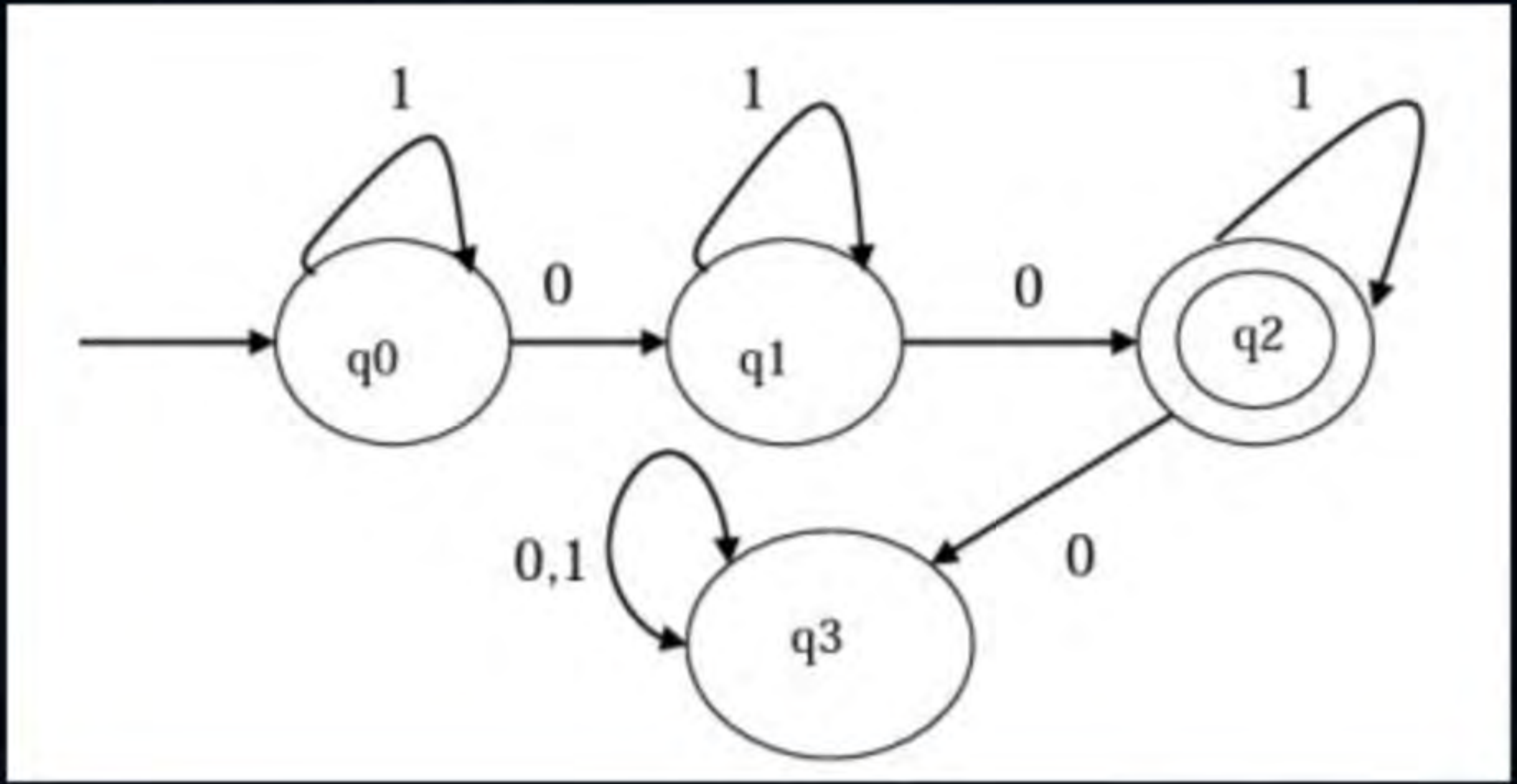
C ((00)*(11+01))*

D ((00)*(01)+11)*

[MCQ]

#Q129. What is the language accepted by FA?

$1^*01^*01^*$



A {w | w is binary, $n_0(w)$ =2}

B {w | w is binary, $n_0(w)$ >2}

C {w | w is binary, $n_1(w)$ =2}

D {w | w is binary, $n_1(w)$ >2}

[MSQ]

#Q130. Find the language generated by the following CFG.

$$\left.\begin{array}{ll} S \to AB & \\ A \to 0A|0 & A = 0^{+} \\ B \to 1B|\varepsilon & B = 1^{*} \end{array}\right\} L = S = AB = 0^{+}1^{*}$$

A) $0^*1^*1 = 0^*1^+$

B) $00^*1^* = 0^+1^*$ ✓

C) $0^*11^* = 0^*1^+$

D) $0^*01^* = 0^+1^*$ ✓

[MSQ]

#Q131. Find the language generated by the following CFG.

$S \rightarrow AC \mid CB$
$C \rightarrow aCb \mid \varepsilon$
$A \rightarrow aA \mid a$
$B \rightarrow bB \mid b$

$C = a^n b^n$
$A = a^+$
$B = b^+$

$S = AC + CB$

$\underbrace{a^+ a^n b^n}_{n_a > n_b}$ or $\underbrace{a^n b^n b^+}_{n_a < n_b}$

$n_a \neq n_b$

A $\{a^m b^n \mid m=n\}$

B $\{a^m b^n \mid m>=n\}$

C $\{a^m b^n \mid m<=n\}$

D $\{a^m b^n \mid m\neq n\}$

[NAT]

#Q132. How many of the following statements are TRUE? $= 1$

I. Complement of L is same as L FALSE

II. Kleene star of L is same as L FALSE

III. Complement of Complement of L is same as L

IV. Kleene star of Kleene star of L is same as L FALSE

$$\boxed{\overline{\overline{L}} = L}$$

$$\overline{L} = \Sigma^* - L$$

$$\boxed{L \neq \overline{L}}$$

$$((L^*)^*)^* = L^*$$

$L = \{a\}$	$L = \{\epsilon\}$
$L^* = a^*$	$L^* = \epsilon^* = \{\epsilon\}$
$L \neq L^*$	$L = L^*$

Note:

$$L^* = (L^*)^*$$

$$L^0 \qquad L^0$$

$$L^1 \qquad L^1$$

$$L^2 \qquad L^2$$

$\vdots$

[MSQ]

#Q133. Which of the following is correct?

A $(r + s)^* = r^* + s^*$ ✗

B $(r + s)^* = (r^* + s^*)^*$ ✓

C $(r + s)^* = r^*s^*$ ✗

D $(r + s)^* = (r^*s^*)^*$ ✓

[MSQ]

#Q134. Which of the following CFGs are in CNF?

CNF

$$\boxed{\begin{array}{c} V \rightarrow VV \\ \text{OR} \\ V \rightarrow T \end{array}}$$

A. $S \rightarrow \underset{\times}{\underline{aa}} \mid \underset{\checkmark}{\underline{SS}}$

B. $S \rightarrow \underset{\checkmark}{\underline{a}} \mid \underset{\checkmark}{\underline{SS}}$

C. $S \rightarrow \underset{\times}{\underline{abc}} \mid \underset{\checkmark}{\underline{SS}}$

D. $S \rightarrow \underset{\checkmark}{\underline{a}} \mid \underset{\times}{\underline{SSS}}$

[MSQ]

#Q135. Which of the following CFGs are in GNF?

$V \rightarrow T V^*$

A $S \rightarrow a \mid aSS$ ✓ ✓

B $S \rightarrow a \mid bSS$ ✓ ✓

C $S \rightarrow abc \mid aSS$ ✗ ✓

D $S \rightarrow a \mid SSS$ ✓ ✗

[MSQ]

#Q136. Union, Intersection, and Complement operations are closed for ___

✓ ✓ ✓

$\cup, \cap, \overline{L}$

A. Regular languages

✓ × ×

$\cup, \cap, \overline{L}$

B. CFLs

C. Decidable languages

$\cup, \cap, \overline{L}$

✓ ✓ ✓

D. RELs

$\cup, \cap, \overline{L}$

✓ ✓ ×

	∪	∩	complement
Finites	✓	✓	✗
Infinites	✓	✗	✗
Regulars	✓	✓	✓
DCFLs	✗	✗	✓
CFLs	✓	✗	✗
CSLs	✓	✓	✓
Recursives	✓	✓	✓
RELs	✓	✓	✗

[NAT]

#Q137. Number of states in Min DFA that accepts all binary strings ending with 111.

= 4

Min = 111

⇓

4 states

[MSQ]

#Q138. Which of the following are CFLs but not regular?

A. $\{w \mid w \text{ is binary}, n_0(w) = n_1(w)\}$

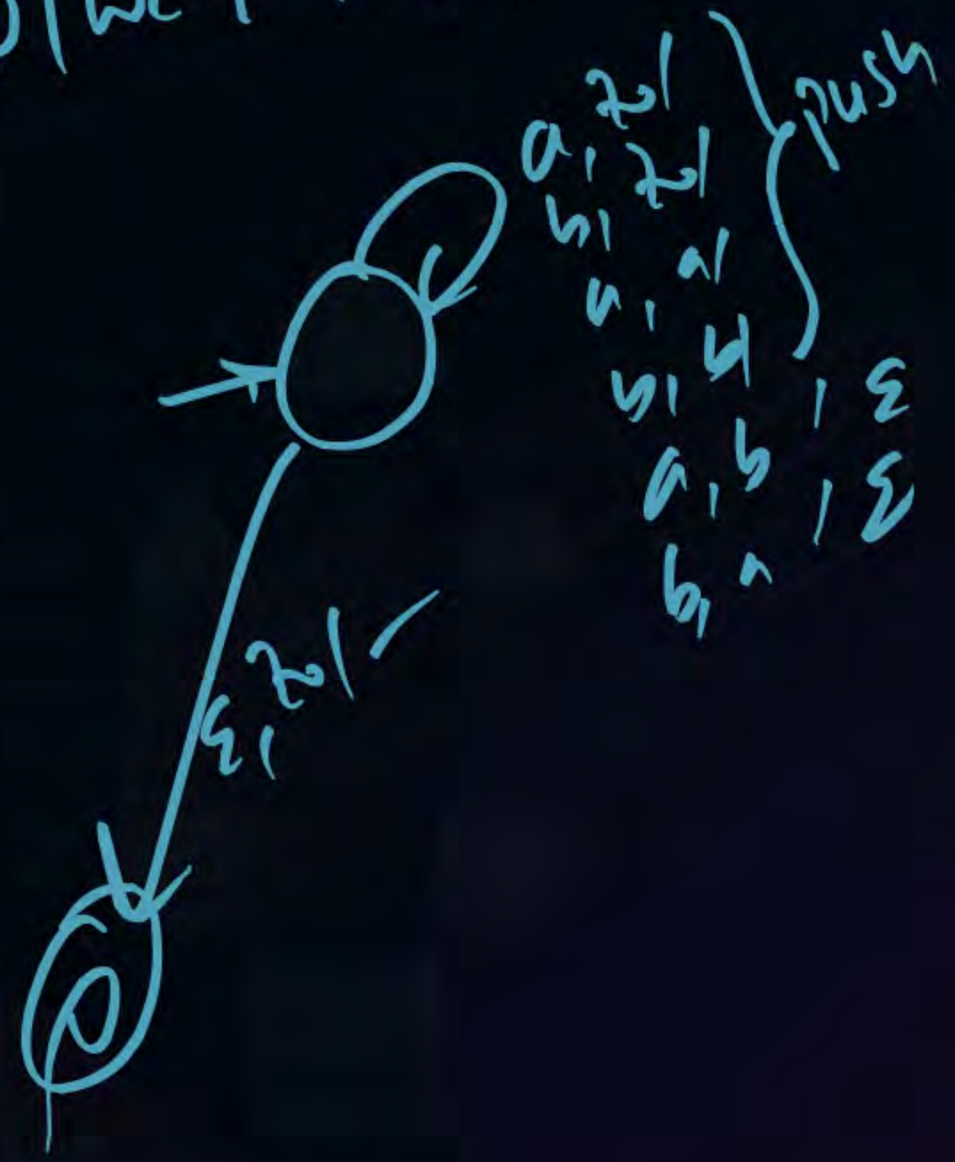
B. $\{w \mid w \text{ is binary}, n_0(w) > n_1(w)\}$

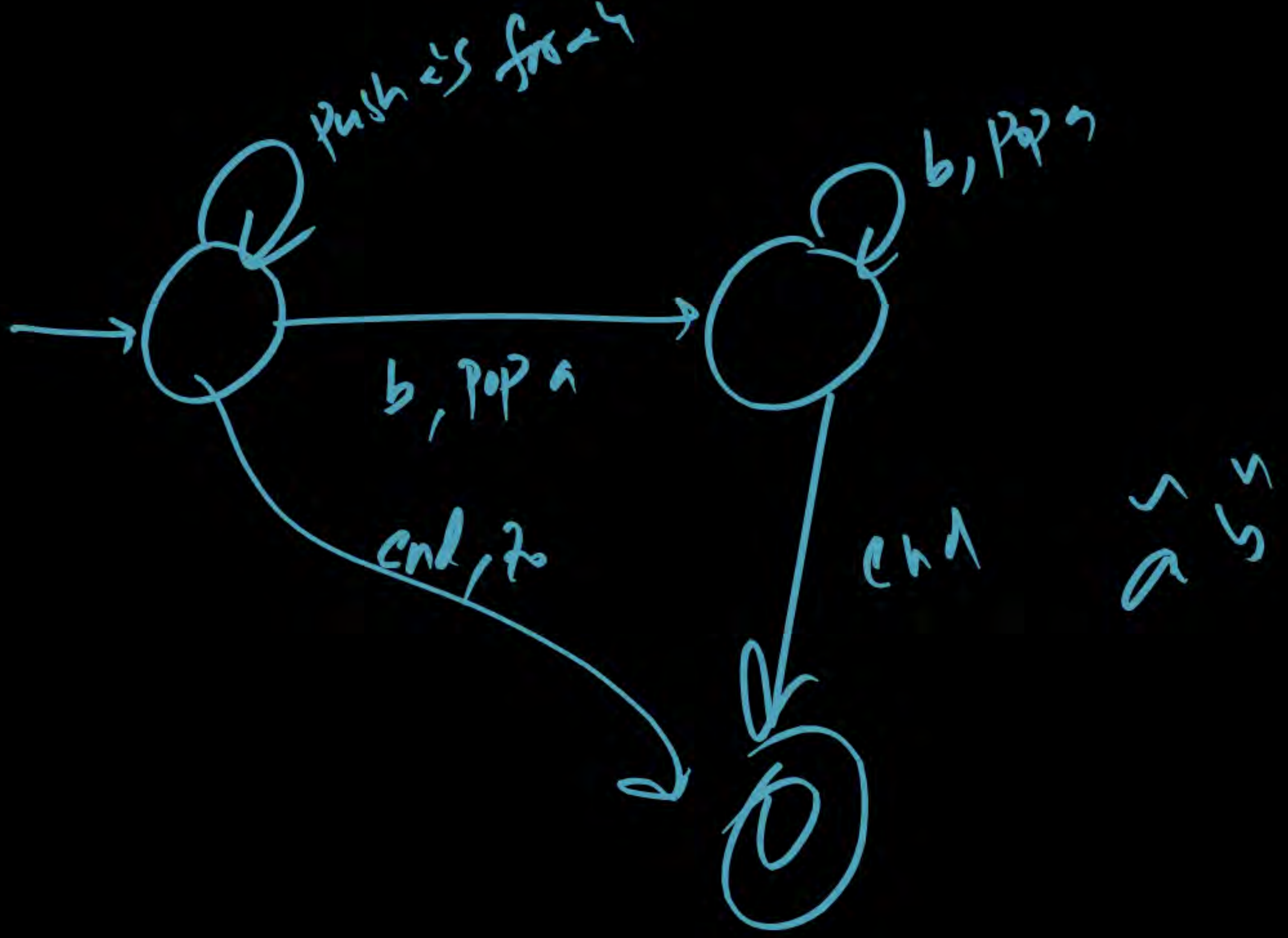
C. $\{w \mid w \text{ is binary}, n_0(w) < n_1(w)\}$

D. None of these

DCFLs not reg

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





push a's from ε
b, pop a
b, pop a
end, z₀
end
aⁿbⁿ

[MSQ]

#Q139. Which of the following is CFL?

***

$n=3 \Rightarrow (a^3b^3)(a^3b^3)(a^3b^3)$

$n=2 \quad k=3$

$(a^2b^2)^3 = a^2b^2\, a^2b^2\, a^2b^2$

A $\{ (a^n b^n)^n \mid n>=0\}$

$(a^2b^3)^4$

B $\{ (a^n b^n)^k \mid k, n>=0\}$

C $\{ (a^m b^n)^k \mid m,n,k>=0\}$

$m=2 \quad n=3 \quad k=4$

D $\{ (a^* b^*)^n \mid n>=0\}$ $= (a^*b^*)^* = (a+b)^*$

$n=2 \Rightarrow a^*b^*\, a^*b^*$

$\{ (a^m b^n)^k \mid m, n, k \geq 0 \}$

$\{ \{a^m b^n \mid m, n \geq 0\}^k \mid k \geq 0 \}$

$\{a^m b^n\}^2 = \{a^{m_1} b^{n_1}\}\{a^{m_2} b^{n_2}\}$

$a^* b^* \quad a^* b^*$

$m = 5$

$n = 2$

$k = 3$

$(a^5 b^2)(a^5 b^2)(a^5 b^2)$

CSL Vs Recursive Set

Every CSL is Recursive

$R_1 \Downarrow NFA_1 \Downarrow \min DFA_1$ $\quad$ $R_2 \Downarrow NFA_2 \Downarrow \min DFA_2$

$\{\langle R_1, R_2 \rangle \mid L(R_1) = L(R_2)\}$ is not CSL, is Recursive

Reg Exp

$a^n b^{n^2}$

a^{prime}

$a^n b^n c^n$

$wwww$

$a^{n!}$

CSL

[MCQ]

#Q140. {M | L(M) is empty language} = set of machines which accepts empty set

$\Downarrow$

Not REL

$= \{M_1, M_2, M_3, \ldots\}$

Whether given TM accepts empty language

- → Yes : $L(TM) = \Phi$ (No logic)
- → No : $L(TM) \neq \Phi$

A. Recursive

B. REL

C. Regular

D. None of these

[MSQ]

#Q141. {M | M accepts abb within 100 steps}

given M, given abb, given 100

IS M accepts abb within 100 steps ?

→ Yes : M $\boxed{\text{accepts}}$ abb within 100 steps.

→ NO : M $\boxed{\text{doesn't accepts}}$ abb within 100 steps

we will check upto 100 steps

→ Yes : If M halts at final within 100 steps

→ No: If M takes 101th step, it is guaranteed M will not accept within 100 steps

A Recursive

B REL

C Regular

D None of these

[MCQ]

#Q142. $\{M \mid \underbrace{M \text{ accepts abb after 100 steps}}\}$

M $\underbrace{\text{not accepts}}$ abb within 100 steps

A. Recursive

B. REL

C. Regular

D. None of these

[MSQ]

#Q143. Which of the following is decidable for PDA but not for HTM?

Decidable for both PDA & HTM

A Membership

B Emptiness

C Equivalence

Undecidable for both PDA & HTM

D Finiteness

H
M } upto HTM

E
F } Upto PDA

T
E } Upto DPDA

D
S } upto FA

FA DPDA PDA HTM TM

[MSQ]

#Q144. If set L is $\underbrace{\text{effectively enumerable}}_{\text{(Recursive) (Decidable)}}$ by an algorithm A, and X is reducible to L then X is ____

$X \leq \underbrace{L}_{\text{effectively enumerable}}$

Every Recursive is REL

$\underbrace{X}_{\text{may or may not be reg}} \leq \text{Decidable Set}$

A. ~~Recursive~~

B. ~~REL~~

C. Regular

D. None fo these

Polynomial Time

$\hookrightarrow O(n^p)$

$O(1)$

$\log n$

n

n^2

$n \log n$

n^3

n^{100}

Deterministic Algorithm

P-Problems

P - Problem: Solvable in polynomial by DTM

NP - problem: solvable in " by NTM
(Answer is verifiable in polynomial by DTM)

[NAT]

#Q145. How many of the following are Decidable Languages? = 2

Non-trivial Rice Theorem

1. { TM | L(TM) is regular language} "Whether given TM accepts Regular"
2. { TM | L(TM) is context free language} " " " " CFL
3. { TM | L(TM) is decidable language} " " " " Recursive

Trivial

4. { TM | L(TM) is enumerable language} " " " " $\boxed{\text{REL}}$ ⇒ Yes
5. { TM | L(TM) is not enumerable language} " " " " $\boxed{\text{not REL}}$ ⇒ NO

4. L = Set of all TMs
$\bar{L} = \phi$

5. L = ϕ
$\bar{L}$ = Set of all TMs

1. L = Set of some TMs
$\bar{L}$ = Set of some TMs
} non-triv

[MSQ]

#Q146. Which of the following is countable set?

A. Set of natural numbers

B. Set of integers

C. Set of rational numbers

D. Set of real numbers

[MSQ]

#Q147. Which of the following is True?

Turing Decidable
$\cong$
Recursive
$\cong$
Decidable

A. Every CFL is Turing decidable

B. Every Regular is Turing decidable

C. Every Recursive is Turing decidable

D. ~~Every REL is Turing decidable~~

Every CFL is Decidable

CFL is Decidable

$a^n b^n$ ✓

$a^* b^*$ ✓

Set of all CFLs is undecidable

$L = \{CFL_1, CFL_2, CFL_3, \ldots\} \rightarrow$ SDUD

D D D

undecidable

$\bar{L} = \{notCFL_1, notCFL_2, \ldots\} \rightarrow$ not RE

UD

$a^n b^n = \{\varepsilon, ab, a^2b^2, \ldots\}$ is CFL

HTM exist

$\{a^*, \phi, b^*, a^n b^n, \ldots$ all CFLs $\}$ is Set of all CFLs

CFL1 CFL2 CFL3 CFL4

HTM not exist

TM exist

[MSQ]

#Q148. Which of the following is $\underbrace{\text{not decidable}}_{\text{Undecidable}}$?

Algm not exist

UD

SDUD   Not RE

Recursive

~~(A)~~ Complement of decidable set

Sometime Recursive OR Not RE

need not be UD

~~(B)~~ Complement of REL

(C) ✓ Complement of not REL

$\underbrace{\text{not REL or SDUD}}_{\text{UD}}$

Decidable

Regular

~~(D)~~ Complement of regular

[MCQ]

#Q149. Kleene star is not closed for ____

$$L = \{c\,a^n b^n\} \cup \{a^k b^{2k}\} \text{ is DCFL}$$

$$L^* = \text{not DCFL}$$

$\boxed{\text{Kleene star of DCFL is need not be DCFL}}$

CFL $\Rightarrow$ (CFL)* $\Rightarrow$ CFL

CFL $\Downarrow$ CFG with S $\Rightarrow$ $\boxed{S' \to SS' \ \text{CFG}}$ $\Rightarrow$ (CFL)*

A. ~~DCFLs~~

B. CFLs

C. Decidable languages

D. RELs

$$L = \{ca^nb^n\} \cup \{a^kb^{2k}\}$$

caaabbb

$$\{ \quad \}^2 = \{c\}^1 \{a^3b^6\}$$

caaabbbbbbb

$$L^* = \{ \{ca^nb^n\} \cup \{a^kb^{2k}\} \}^*$$

$n=0$

c aaabbbb ✓

[MSQ]

#Q150. Which of the following is TRUE?

A. Some sets are not REL

B. Some sets are countable

C. Some sets are REL

D. Some sets are not countable

THANK - YOU