CS & IT ENGINEERING

Theory of Computation

Push Down Automata:

Practice on CFLs

Lecture No. 7

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TOPICS TO BE COVERED

01 GATE PYQs

02

03

04

05

Q

Which of the following are decidable? Last chapter

1. Whether the intersection of two regular languages is infinite
2. Whether a given context-free language is regular
3. Whether two push-down automata accept the same language
4. Whether a given grammar is context-free

[2008: 1 Marks]

(A) 1 and 2

(B) 1 and 4

(C) 2 and 3

(D) 2 and 4

Q

Consider the language

not reg $\left\{ \begin{array}{l} L1 = \{0^i 1^j \mid i \neq j\}, \\ L2 = \{0^i 1^j \mid i = j\}, \\ L3 = \{0^i 1^j \mid i = 2j + 1\}, \\ L4 = \{0^i 1^j \mid i \neq 2j\}. \end{array} \right.$

DCFL $\{a^m b^n \mid m<n \text{ or } m>n\}$

$= \{0^{2j+1} 1^j\}$

Which one of the following statements is true? [2010: 2 Marks]

(A) Only L2 is context free

(B) Only L2 and L3 are context free

(C) Only L1 and L2 are context free

(D) All are context free

Q

Consider the languages L1, L2 and L3 as given below:

$L1 = \{0^p1^q \mid p, q \in N\}$, $= 0^+1^+ \rightarrow$ Regular but not finite

$L2 = \{0^p1^q \mid p, q \in N \text{ and } p = q\}$ and $\rightarrow$ DCFL but not reg

$L3 = \{0^p1^q0^r \mid p, q, r \in N \text{ and } p = q = r\} \rightarrow$ CSL but not CFL

Which of the following statements is NOT TRUE [2011: 2 Marks]

TRUE (A) Push Down Automata (PDA) can be used to recognize L1 and L2.

TRUE (B) L1 is a regular language.

FALSE (C) All the three languages are context free. ✓

TRUE (D) Turing machines can be used to recognize all the languages.

Practice on CFLs

a^m push

b^n

$b, Z_0 \rightarrow$ b's more than a's, push remaining b's, for c's pop b's

$c, Z_0 \rightarrow$ b's = a's, push all c's, for d's: pop c's

c, a b's < a's, push c's, for d's: pop c's, next pop a's

Q

Consider the following languages:

*** I. $\{a^m b^n c^p d^q \mid m + p = n + q, \text{ where } m, n, p, q \geq 0\}$

II. $\{a^m b^n c^p d^q \mid m = n \text{ and } p = q, \text{ where } m, n, p, q \geq 0\}$ → DCFL but not reg

III. $\{a^m b^n c^p d^q \mid m = n = p \text{ and } p \neq q, \text{ where } m, n, p, q \geq 0\}$ → CSL but not CFL

IV. $\{a^m b^n c^p d^q \mid mn = p + q, \text{ where } m, n, p, q \geq 0\}$

Which of the language above are context-free?

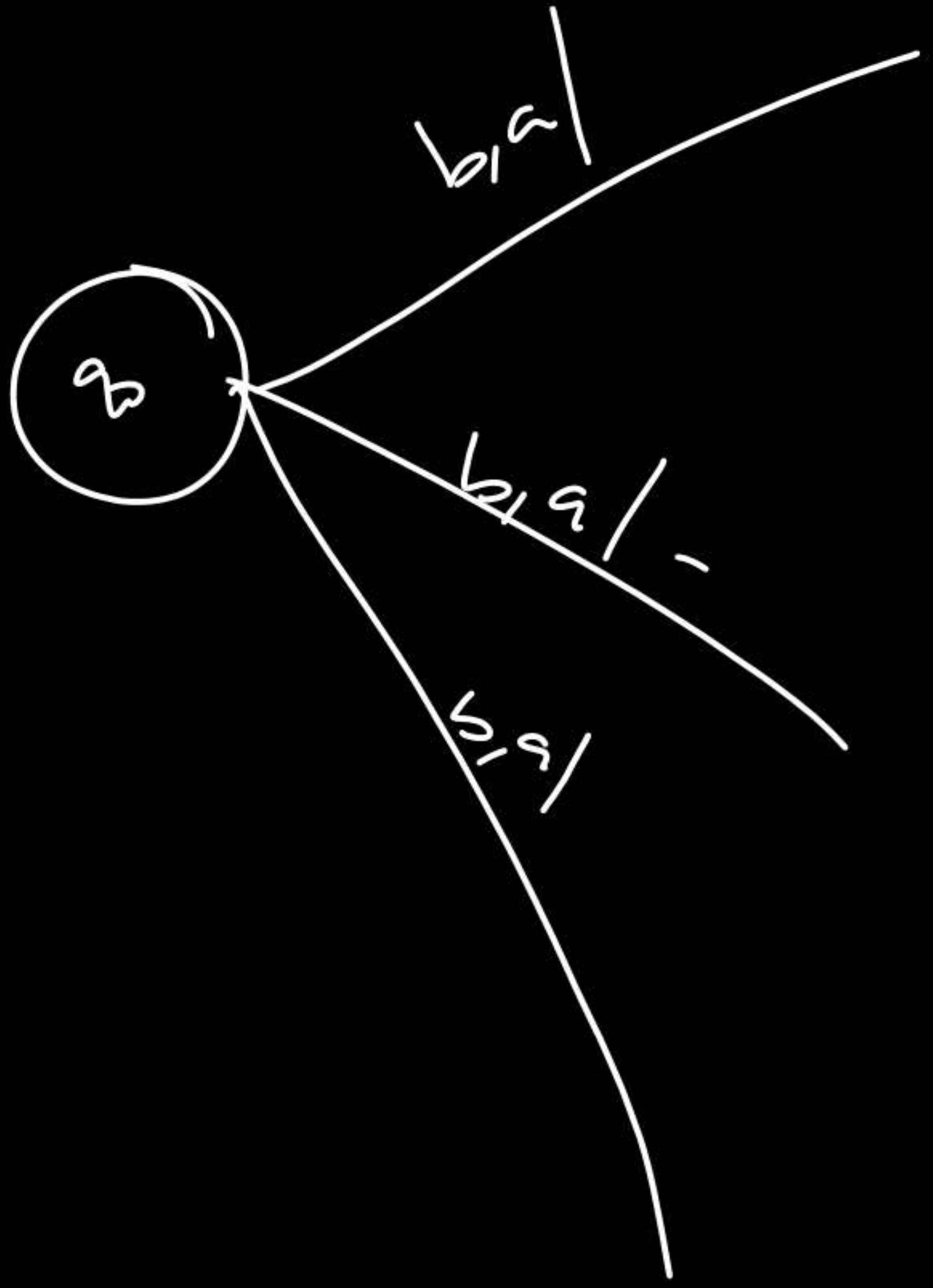
[2012: 2 Marks]

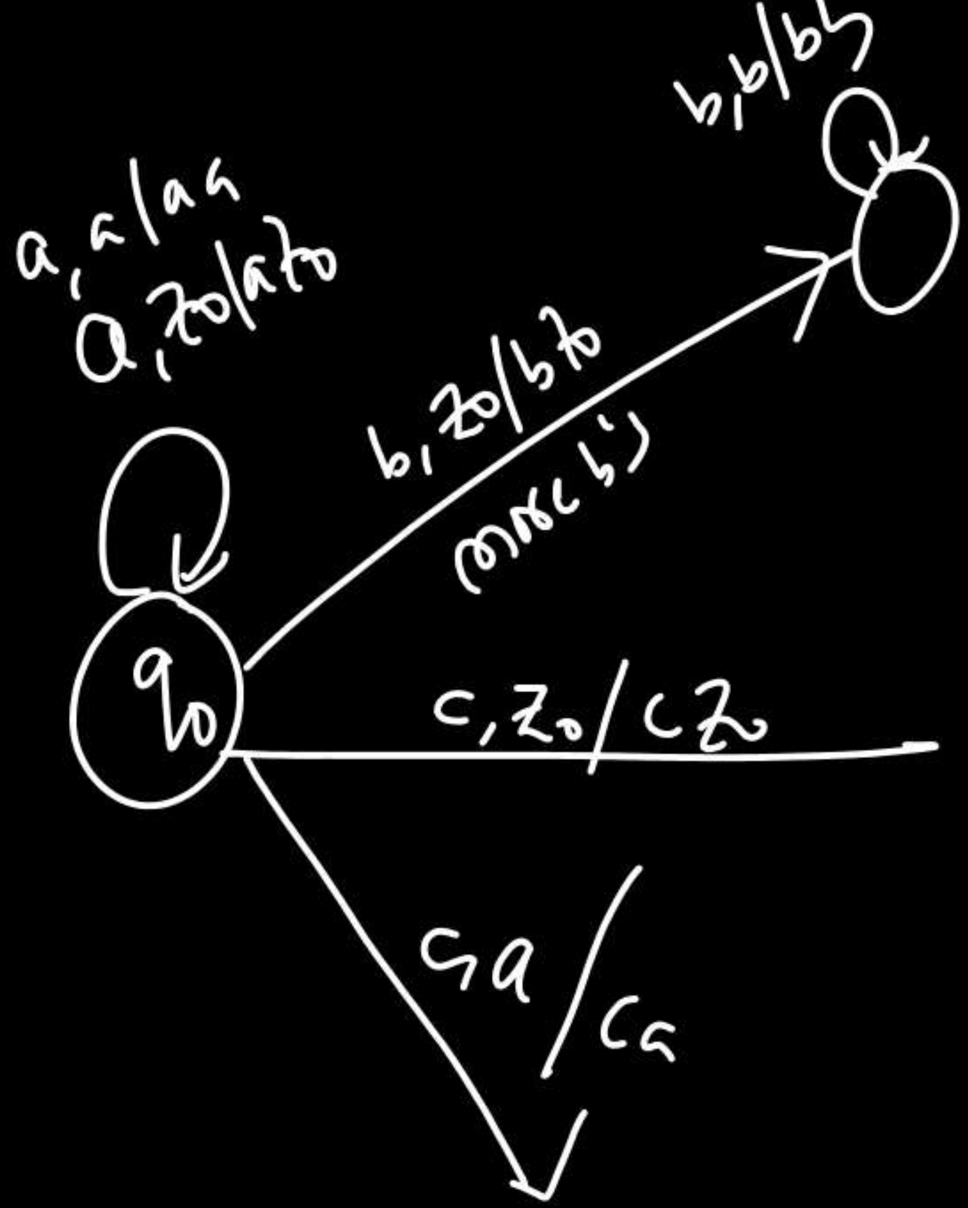
(A) I and IV only

(B) I and II only

(C) II and III only

(D) II and IV only


q0
b, a /
b, a / –
b, a /


a, a / aa
a, Z0 / aZ0
b, Z0 / bZ0
b, b / bb
q0
c, Z0 / cZ0
c, a / ca

Q

Consider the following languages

$L1 = \{0^p 1^q 0^r \mid p, q, r \geq 0\} = 0^* 1^* 0^* \rightarrow$ Regular but not finite

$L2 = \{0^p 1^q 0^r \mid p, q, r \geq 0, p \neq r\} \rightarrow$ DCFL but not reg

Which one of the following statements is FALSE?

[2013: 2 Marks]

(A) L2 is context-free (T)

T (B) $L1 \cap L2$ is context-free $L_1 \cap L_2 = L_2$

T (C) Complement of L2 is recursive

False (D) Complement of L1 is context-free but not regular

$\overline{L_1} \rightarrow$ reg

$\overline{L_2} \rightarrow$ DCFL

Q

Consider the following languages over the alphabet $\Sigma = \{0, 1, c\}$:

$L_1 = \{0^n 1^n \mid n \geq 0\}$ → DCFL but not reg

$L_2 = \{wcw^r \mid w \in \{0, 1\}^*\}$

$L_3 = \{ww^r \mid w \in \{0, 1\}^*\}$ → CFL but not DCFL

Here, w^r is the reverse of the string w. Which of these languages are deterministic Context-free languages?

[2014-Set3: 2 Marks]

(A) None of the languages

(B) Only L_1

(C) Only L_1 and L_2

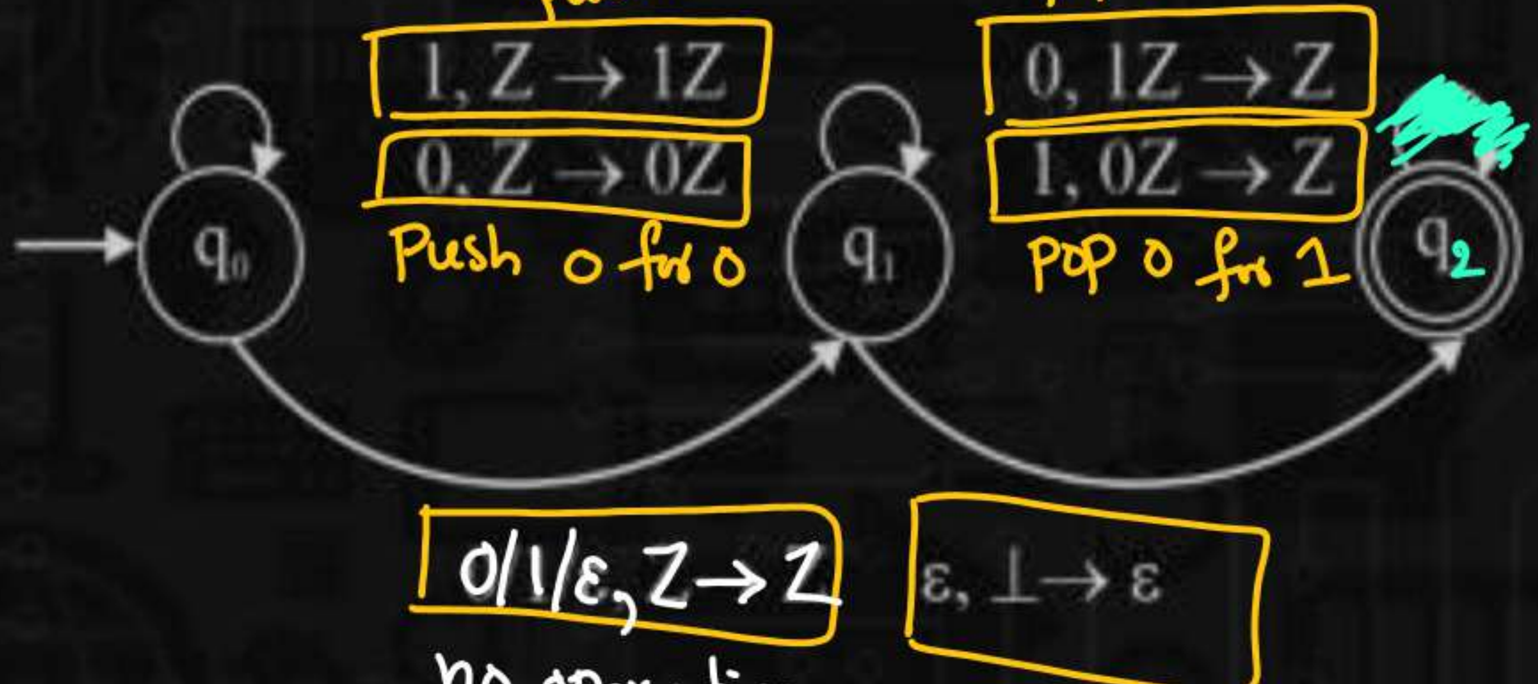
(D) All the three languages

Q

Consider the NPDA $\langle Q = \{q_0, q_1, q_2\}, \Sigma = \{0, 1\}, \Gamma = \{0, 1, \perp\}, \delta, q_0, \perp, F = \{q_2\} \rangle$, where (as per usual convention) Q is the set of states, Σ is the input alphabet, Γ is stack alphabet, δ is the state transition function, q_0 is the initial state, $\perp$ is the initial stack symbol, and F is the set of accepting states, The state transition is as follows:

Push 1 for 'input 1'

Pop 1 for i/p 0



no operation

input = 0/1/ε

Which of the following sequences must follow the string 101100 so that the overall string is accepted by the automaton?

[2015-Set1: 2 Marks]

10010ε

skip

10110$\boxed{0}$10010 ∈ L

push skip pop opposite

(A) 10110

(B) 10010 ✓

(C) 01010

(D) 01001

$\underbrace{1, X}_{\text{any}} / 1X$

$1, \text{any} / 1\,\text{any}$

$1, Z / 1Z$

$1, Y / 1Y$

$0, \underbrace{1Z \rightarrow Z}_{\text{Pop } 1}$

$\boxed{\text{for i/p } 0, \text{ Pop } 1}$

Practice on CFLs

push push pop pop

Q

Which of the following languages are context-free?

$L_1 = \{a^m b^n a^n b^m \mid m, n \geq 1\}$ → DCFL

$L_2 = \{a^m b^n \boxed{a^m} b^n \mid m, n \geq 1\}$ → not CFL

$L_3 = \{a^m b^n \mid m = 2n + 1\}$ → DCFL

[2015(Set-3): 1 Marks]

(A) L_1 and L_2 only

(B) L_1 and L_3 only

(C) L_2 and L_3 only

(D) L_3 only

$L_4 = \{a^m b^n a^n b^m \mid m, n \geq 0\}$ → CFL but not DCFL

Push b   Pop a

$\underbrace{aa}_{\text{push}}\ \boxed{b}$

a^*b^+

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

Q

Consider the following context-free grammars:

b^+

G_1: $S \rightarrow aS \mid B$, $B \rightarrow b \mid bB$

b^*

G_2: $S \rightarrow aA \mid bB$, $A \rightarrow aA \mid B \mid \varepsilon$, $B \rightarrow bB \mid \varepsilon$

Which one of the following pairs of languages is generated by G_1 and G_2, respectively?

$a^* \; b^* \; b^*$

aa^*b^*

$a^+b^* \cup b^+$ $\quad bb^*$

[2016(Set-1): 2 Marks]

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

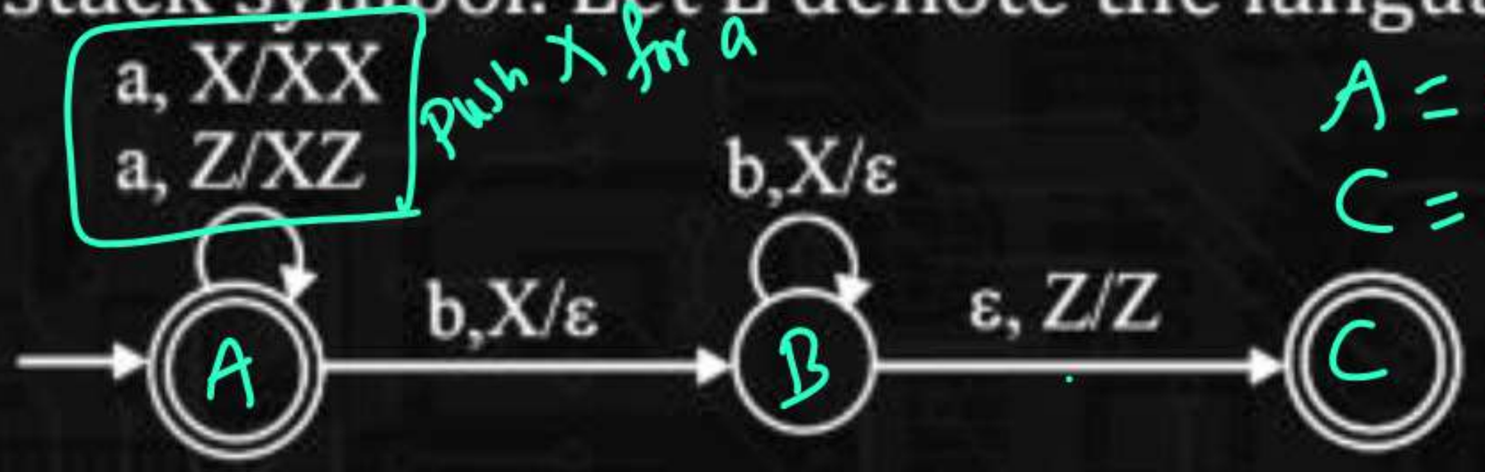
(B) $\{a^m b^n \mid m > 0 \text{ and } n > 0\}$ and $\{a^m b^n \mid m > 0 \text{ or } n \geq 0\}$.

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

Q

Consider the transition diagram of a PDA given below with input alphabet $\Sigma = \{a, b\}$ and stack alphabet $\Gamma = \{X, Z\}$. Z is the initial stack symbol. Let L denote the language accepted by the PDA.



$A = a^*$

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

$\perp$

Which one of the following is TRUE?

$L = A \cup C$

[2016(Set-1): 2 Marks]

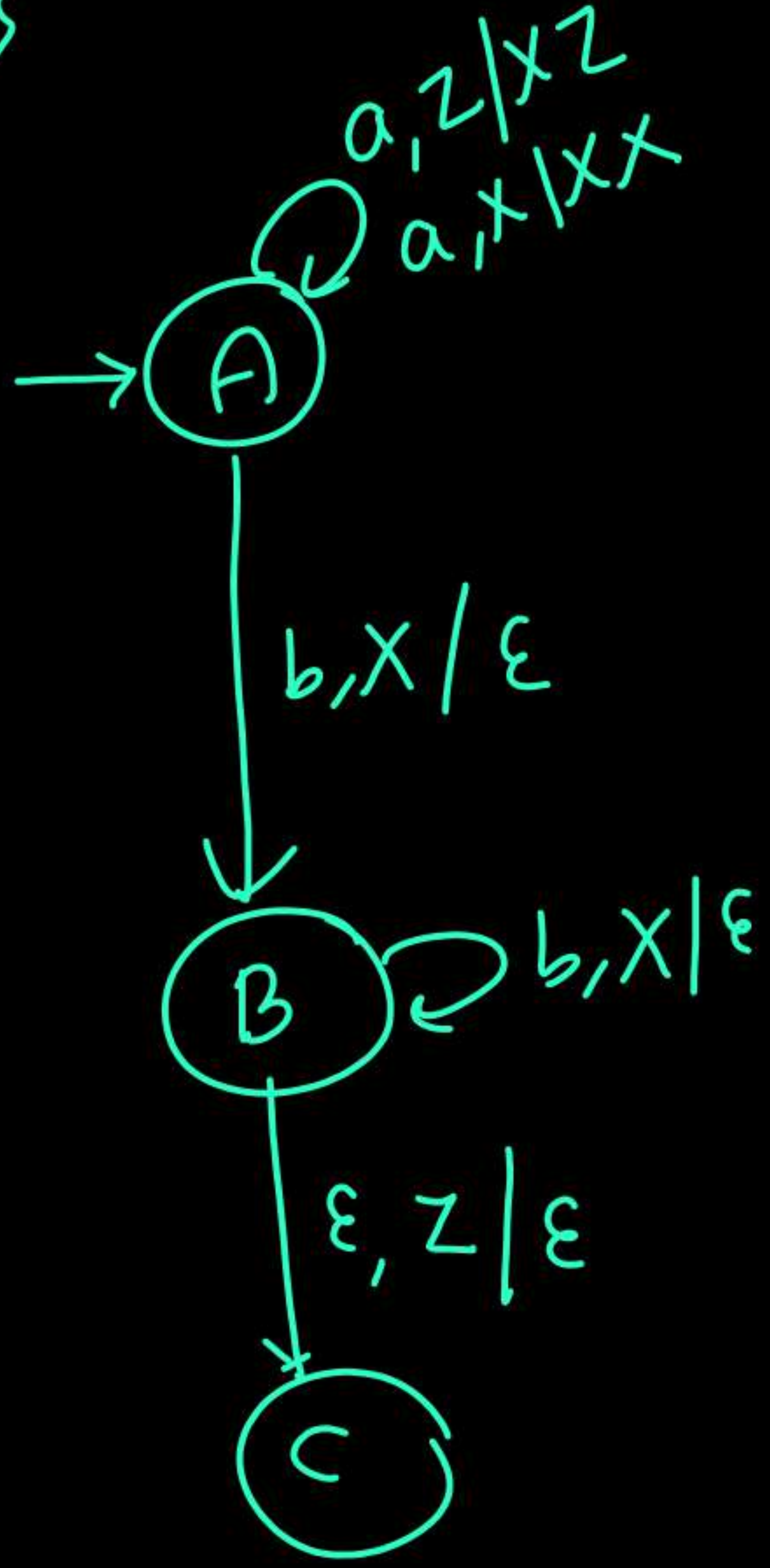
(A) $L = \{a^n b^n \mid n \geq 0\}$ and is not accepted by any finite automata.

(B) $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is not accepted by any deterministic PDA.

(C) L is not accepted by any Turing machine that halts on every input.

(D) $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is deterministic context-free.

Z is initial tos



If PDA uses empty stack acceptance mechanism, what is language accepted by PDA ?

$$L = \{ a^n b^n \mid \underbrace{n > 0}_{\text{same as } n \geq 1} \}$$

Q

Consider the following languages:

$L_1 = \{a^n b^m c^{n+m} : m, n \geq 1\}$

$L_2 = \{a^n b^n c^{2n} : n \geq 1\}$

Which one of the following is TRUE?

[2016(Set-2): 2 Marks]

(A) Both L_1 and L_2 are context-free.

(B) L_1 is context-free while L_2 is not context-free

(C) L_2 is context-free while L_1 is not context-free

(D) Neither L_1 nor L_2 is context-free

Q.

Language L_1 is defined by the grammar: $S_1 \rightarrow aS_1b|\varepsilon$
Language L_2 is defined by the grammar: $S_2 \rightarrow abS_2|\ \varepsilon$
Consider the following statements:
P: L_1 is regular
Q: L_2 is regular
Which one of the following is TRUE?

[2016(Set-2): 1 Marks]

(A) Both P and Q are true

(B) P is true and Q is false

(C) P is false and Q is true

(D) Both P and Q are false

Q

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

$S \rightarrow abScT \mid abcT$

$T \rightarrow bT \mid b$

Which one of the following represents the language generated by the above grammar?

[2017(Set-1): 1 Marks]

A. $\{(ab)^n(cb)^n \mid n \geq 1\}$

B. $\{(ab)^n cb^{m_1} cb^{m_2} \ldots cb^{m_n} \mid n, m_1, m_2, \ldots, m_n \geq 1\}$

C. $\{(ab)^n(cb^m)^n \mid m, n \geq 1\}$

D. $\{(ab)^n(cb^n)^m \mid m, n \geq 1\}$

Q

Consider the following language over the alphabet $\Sigma = \{a, b, c\}$.

Let $L_1 = \{a^n b^n c^m \mid m, n \geq 0\}$ and

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

Which of the following are context-free languages?

I. $L_1 \cup L_2$

II. $L_1 \cap L_2$

[2017(Set-1): 2 Marks]

A) I only

B) II only

C) I and II

D) Neither I nor II

Q

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

$G_1: S \rightarrow aSb \mid T,\ T \rightarrow cT \mid \epsilon$

$G_2: S \rightarrow bSa \mid T,\ T \rightarrow cT \mid \epsilon$

The language $L(G_1) \cap L(G_2)$ is [2017-Set1: 1 Mark]

(A) Finite

(B) Not finite but regular

(C) Context-free but not regular

(D) Recursive but not context-free

Q

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

$S \rightarrow XY$

$X \rightarrow aX \mid a$

$Y \rightarrow aYb \mid \epsilon$

[2017(Set-2): 1 Marks]

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

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

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

(D) $\{a^m b^n \mid m > n, n > 0\}$

Q

Let L_1, L_2 be any two context-free languages and R be any regular language. Then which of the following is/are CORRECT?

I. $L_1 \cup L_2$ is context-free

II. $\overline{L_1}$ is context-free

III. $L_1 - R$ is context-free

IV. $L_1 \cap L_2$ is context-free

[2017(Set-2): 1 Marks]

(A) I, II and IV only

(B) I and III only

(C) II and IV only

(D) I only

Q

Consider the following languages:

$L_1 = \{a^p \mid p \text{ is a prime number}\}$

$L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$

$L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$

$L_4 = \{a^n b^n \mid n \geq 1\}$

Which of the following are CORRECT?

I. L_1 is context-free but not regular.

II. L_2 is not context-free.

III. L_3 is not context-free but recursive.

IV. L_4 is deterministic context-free.

[2017(Set-2): 2 Marks]

(A) I, II and IV only

(B) II and III only

(C) I and IV only

(D) III and IV only

Q

Which one of the following languages over $\Sigma = \{a, b\}$ is NOT context-free?

[2019: 2 Marks]

(A) $\{a^n b^i \mid i \in \{n, 3n, 5n\}, n \geq 0\}$

(B) $\{w a^n w^R b^n \mid w \in \{a, b\}^*, n \geq 0\}$

(C) $\{w w^R \mid w \in \{a, b\}^*\}$

(D) $\{w a^n b^n w^R \mid w \in \{a, b\}^*, n \geq 0\}$

Q

Consider the following languages:

$L_1 = \{wxyx \mid w, x, y \in (0 + 1)^+\}$

$L_2 = \{xy \mid x, y \in (a + b)^*, |x| = |y|, x \neq y\}$

Which of the following is TRUE

[2020: 2 Marks]

(A) L_1 is regular and L_2 is context-free.

(B) L_1 is context-free but L_2 is not context-free.

(C) Neither L_1 nor L_2 is context-free.

(D) L_1 is context-free but not regular and L_2 context-free.

Q

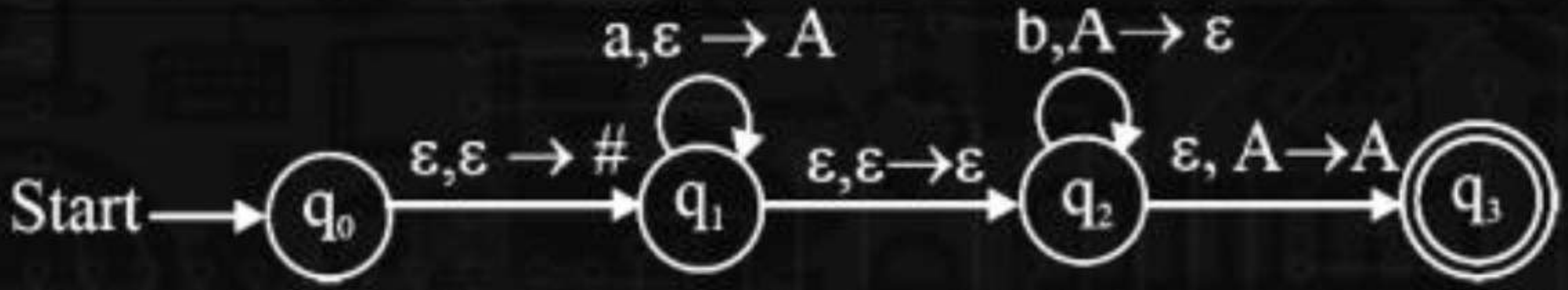
In a pushdown automaton $P = (Q, \Sigma, \Gamma, \delta, q_0, F)$, a transition of the form,

$$p \xrightarrow{a,\ X \to Y} q$$

Where $p, q, \in Q$, $a \in \Sigma \cup \{\epsilon\}$, and $X, Y \in \Gamma \cup \{\epsilon\}$represents

$(q, Y) \in \delta(p, a, X)$

Consider the following pushdown automaton over the input alphabet Σ={a, b} and stack alphabet $\Gamma = \{\#, A\}$.



The number of strings of length 100 accepted by the above pushdown automaton is ______.

[2021(Set-1): 2 Marks]

Q

Suppose that L_1 is a regular language and L_2 is a context-free language. Which one of the following languages is NOT necessarily context-free?

[2021(Set-1): 2 Marks]

A $L_1 \cdot L_2$

B $L_1 \cup L_2$

C $L_1 - L_2$

D $L_1 \cap L_2$

Q

For a string w, we define w^R to be the reverse of w. For example, if w = 01101 then w^R = 10110. Which of the following languages is/are context-free?

[2021(Set-2): 2 Marks]

A) $\{wxw^Rx^R \mid w, x \in \{0, 1\}^*\}$

B) $\{wxw^R \mid w, x \in \{0, 1\}^*\}$

C) $\{ww^Rxx^R \mid w, x \in \{0, 1\}^*\}$

D) $\{wxx^Rw^R \mid w, x \in \{0, 1\}^*\}$

Q

Let L_1 be a regular language and L_2 be a context-free language. Which of the following languages is/are context-free?

[2021(Set-2)MSQ: 1 Marks]

(A) $L_1 \cap \overline{L_2}$

(B) $\overline{\overline{L_1} \cup \overline{L_2}}$

(C) $L_1 \cup (L_2 \cup \overline{L_2})$

(D) $(L_1 \cap L_2) \cup (\overline{L}_1 \cap L_2)$

Q

Consider the following languages:

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

$L_2 = \{wxw^R \mid w, x \in \{a, b\}^*\}, |w|, |x| > 0\}$

Note that w^R is the reversal of the string w. Which of the following is/are TRUE?

[2022: MSQ: 2 Marks]

(A) L_1 and L_2 are regular.

(B) L_1 and L_2 are context-free.

(C) L_1 is regular and L_2 is context-free.

(D) L_1 and L_2 are context-free but not regular.

Q

Consider the following languages:

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

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

$L_3 = \{a^m b^n c^n \mid m, n \geq 0\}$

Which of the following statements is/are FALSE?

[2022: 2 Marks]

(A) L_1 is not context-free but L_2 and L_3 are deterministic context-free.

(B) Neither L_1 nor L_2 is context-free.

(C) L_2, L_3 and $L_2 \cap L_3$ all are context-free.

(D) Neither L_1 nor its complement is context-free

Summary

PYQs


THANK YOU GW
SOLDIERS !