

# Theory of Computation

## Push Down Automata

DPP 01

## [MCQ]

1. Consider the following grammar:

$$S \rightarrow abSba|bSb|aSa|a|b| \epsilon$$

What is the language generated by above grammar?

- (a) CFG that generates all palindromes over alphabet (a, b).
- (b) CFG that generates all palindromes over alphabet (a, b) that do not contain substring "ab".
- (c) CFG that generates all palindromes over alphabet (a, b) that contain substring "aa".
- (d) CFG that generates all palindromes over alphabet (a, b) that do not contain substring "aa".

## [MCQ]

2. Consider the following grammars:

$$G_1: S \rightarrow aSc | \$ B$$

$$B \rightarrow bBc | \$$$

$$G_2: S \rightarrow aaScc | \$ B$$

$$B \rightarrow bBc | \$$$

$$G_3: S \rightarrow aSc | \$ B$$

$$B \rightarrow bbBcc | \$$$

Which of the following is true regarding  $G_1$ ,  $G_2$  and  $G_3$ ?

- (a)  $L(G_1) \subseteq L(G_2)$ ,  $L(G_2) \subseteq L(G_3)$
- (b)  $L(G_2) \subseteq L(G_3)$ ,  $L(G_1) \subseteq L(G_3)$
- (c)  $L(G_1) \subseteq L(G_3)$ ,  $L(G_3) \subseteq L(G_2)$
- (d)  $L(G_2) \subseteq L(G_1)$ ,  $L(G_3) \subseteq L(G_1)$

## [MCQ]

3. Consider the following context free grammar:

$$S \rightarrow aA | aBB$$

$$A \rightarrow aaA | \epsilon$$

$$B \rightarrow bB | bbC$$

$$C \rightarrow B$$

What will be the equivalent simplified CFG for the given grammar?

- (a)  $S \rightarrow aA | a$   
 $A \rightarrow aaA | aa | b$
- (b)  $S \rightarrow aA | a$   
 $A \rightarrow aaA | aa$
- (c)  $S \rightarrow aAa | B$   
 $A \rightarrow aaA | aa$   
 $B \rightarrow bB | bb$
- (d)  $S \rightarrow aAa | B$   
 $A \rightarrow aA | b$   
 $B \rightarrow bB | bb | a$

## [MSQ]

4. Consider the following grammar:

$$S \rightarrow AB$$

$$A \rightarrow BaB | a$$

$$B \rightarrow bbA$$

Which of the following is true regarding given grammar?

- (a) Every string of the above grammar have at least two a's.
- (b) Every string have three consecutive a's.
- (c) Every string have alternate a and b.
- (d) Every string have b's in multiple of 2.

## [NAT]

5. Consider the following grammar G:

$$S \rightarrow XA | BB$$

$$B \rightarrow b | SB$$

$$X \rightarrow b$$

$$A \rightarrow a$$

After converting above grammar into GNF how many productions are there in the grammar?

**[MSQ]**

6. Which of the following is true
- (a) A grammar is called ambiguous if  
(No. of parse tree's = No. of left most derivation  
= Number of Right most derivation)  $> 1$
  - (b) Production of the form  $A \rightarrow a$  is known as unit production.
  - (c) CNF is also known as binary standard form.
  - (d) In left-most derivation, right most non-terminal is substituted with its production to derive a string.

**[MCQ]**

7. Given the following two grammars:

**G<sub>1</sub>:**  $S \rightarrow AB \mid aaB$

$A \rightarrow a \mid Aa$

$B \rightarrow b$

**G<sub>2</sub>:**  $S \rightarrow aSbS \mid bSaS \mid \epsilon$

What is true regarding above grammars?

- (a) Both  $G_1$  and  $G_2$  are ambiguous.
- (b) Both  $G_1$  and  $G_2$  are unambiguous.
- (c) Only  $G_1$  is ambiguous.
- (d) Only  $G_1$  is unambiguous.

**[MCQ]**

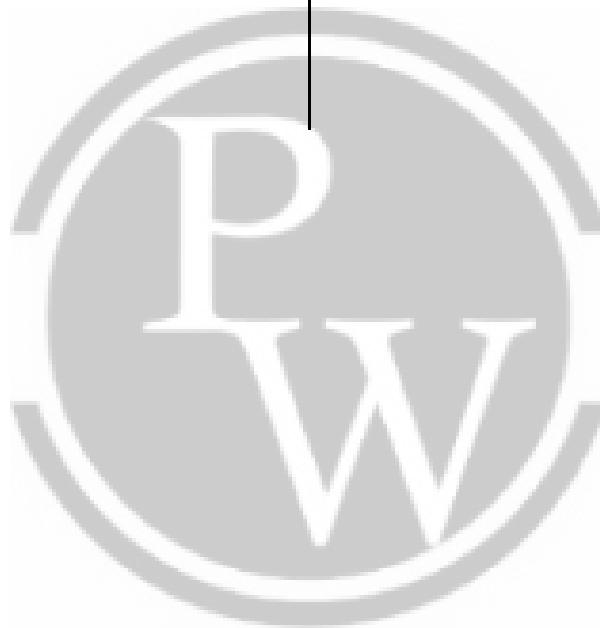
8. Consider the following languages

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

$L_2 = \{a^p b^q c^{p+q} \mid p, q \geq 0\}$

Which of the following is true?

- (a) Only  $L_1$  is Regular.
- (b) Only  $L_2$  is Regular.
- (c) Both  $L_1$  and  $L_2$  are Regular.
- (d) None of these



## Answer Key

- |           |              |
|-----------|--------------|
| 1. (a)    | 5. (18)      |
| 2. (d)    | 6. (a, b, c) |
| 3. (b)    | 7. (a)       |
| 4. (a, d) | 8. (d)       |



## Hints & Solutions

### 1. (a)

Given

$$S \rightarrow abSba \mid bSb \mid aba \mid a \mid b \mid \epsilon$$

Strings formed using above grammar are:

$\{\epsilon, a, b, aa, bb, \dots\}$

This is the CFG that generates all palindromes over alphabet  $(a, b)$ .

So, option (a) is correct answer.

### 2. (d)

$$L(G_1) = \{a^m b^n c^{m+n} \mid m, n \geq 0\}$$

$$L(G_2) = \{a^{2m} b^n c^{2m+n} \mid m, n \geq 0\}$$

$$L(G_3) = \{a^m b^{2n} c^{m+2n} \mid m, n \geq 0\}$$

$\therefore$  It is clear,

$$L(G_2) \subseteq L(G_1), \text{ and}$$

$$L(G_3) \subseteq L(G_1)$$

Therefore, option d is correct.

### 3. (b)

Simplified CFG is a CFG without any null productions, unit-productions and useless symbol.

#### 1. Elimination of NULL Productions:

$$A \rightarrow \epsilon$$

Keep all the productions as it is and substitute  $\epsilon$  in place of A.

$$S \rightarrow aA \mid aBB \mid a$$

$$A \rightarrow aaA \mid aa$$

$$B \rightarrow bB \mid bbC$$

$$C \rightarrow B$$

#### 2. Eliminate Unit Productions: If the productions is of the form $A \rightarrow B$ , the production is known as unit production. Eliminate unit production by replacing equivalent derivations.

$$S \rightarrow aA \mid aBB \mid a$$

$$A \rightarrow aaA \mid aa$$

$$B \rightarrow bB \mid bbB$$

#### 3. Eliminate useless symbol: The variables that are not involved the derivation of any string is known as useless symbol.

In this question B is deriving  $bB \mid bbB$  which is entering into infinite loop. So, eliminating all productions of B.

$$S \rightarrow aA \mid a$$

$$A \rightarrow aaA \mid aa$$

Hence, options (b) is the correct answer.

### 4. (a, d)

The string produced by given grammar is

$\{abba, abbaabba, \dots\}$

So option (a) and (d) are the true statements.

### 5. (18)

After converting the given grammar to GNF.

The final grammar will be.

$$S \rightarrow bA \mid bB'B \mid bABB'B \mid bB \mid bABB$$

$$B \rightarrow bB' \mid bABB' \mid b \mid bAB$$

$$B' \rightarrow bB'BB' \mid bABB'BB' \mid bBB' \mid bABBB' \mid bB'B \mid bABB'B \mid bB \mid bABB$$

$$A \rightarrow a$$

So, the total productions are 18.

### 6. (a, b, c)

According to definition of Ambiguous grammar, if there exist more than are parse tree for a string, then it is ambiguous grammar, option a is correct.

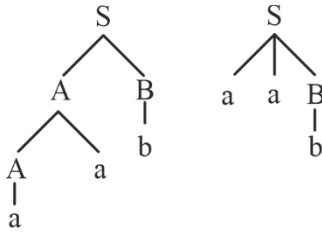
Production of the form  $A \rightarrow a$  is known as unit production.

CNF is also known as binary standard form because the parse tree in CNF is always a binary tree.

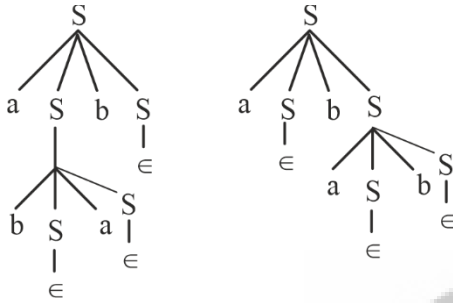
### 7. (a)

Both  $G_1$  and  $G_2$  are ambiguous, as both have multiple parse tree for same string.

$G_1$ : aab



$G_2$ : abab



8. (d)

$L_1 = \{ \epsilon, ab, bc, aabb, bbcc, \dots \}$

$L_2 = \{ \epsilon, ac, bc, aacc, bbcc, \dots \}$

Both the languages are CFL not regular.

Therefore option (d) is correct.



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