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COMPUTER SCIENCE & IT

Objective Practice Sets

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1 CHAPTER

Grammars, Languages & Automata

Multiple Choice Questions & NAT Questions

Q.1 Suppose $L_1 = \{10, 1\}$ and $L_2 = \{011, 11\}$. How many distinct elements are there in $L = L_1 L_2$.

(a) 4 (b) 3
(c) 2 (d) None of these

Q.2 In a string of length n, how many proper prefixes can be generated

(a) 2^n (b) n
(c) $\frac{n(n+1)}{2}$ (d) $n - 1$

Q.3 Let $u, v, \in \Sigma^*$ where $\Sigma = \{0, 1\}$. Which of the following are TRUE?

1. $|u.v| = |v.u|$
2. $u.v = v.u$
3. $|u.v| = |u| + |v|$
4. $|u.v| = |u|\,|v|$

(a) 1 and 3 (b) 1, 2 and 3
(c) 2 and 4 (d) 1, 2 and 4

Q.4 How many odd palindromes of length 11 are possible with alphabet $S = \{a, b, c\}$

(a) 3^6 (b) 2^5
(c) 2^6 (d) 3^5

Q.5 The number of distinct subwords present in 'MADEEASY' are ________.

Q.6 Consider the following statements:

1. Type 0 grammars generate all languages which can be accepted by a Turing machine.
2. Type 1 grammars generate the languages which can all be recognized by a push down automata.
3. Type 3 grammars have one to one correspondence with the set of all regular expressions.
4. There are some languages which are not accepted by a Turing machine.

Which of the above statements are TRUE?

(a) 1, 2 and 3 (b) 1, 2 and 4
(c) 1, 3 and 4 (d) 2, 3 and 4

Q.7 Consider the following table of an FA:

δ	a	b
start	q_1	q_0
q_0	q_1	q_0
q_1	q_2	q_1
q_2	q_3	q_2
q_3	q_4	q_3
q_4	q_4	q_4

If the final state is q_4, the which of the following strings will be accepted?

1. *aaaaa*
2. *aabbaabbbbb*
3. *bbababababbb*

(a) 1 and 2 (b) 2 and 3
(c) 3 and 1 (d) All of these

Q.8 Which of the following statements is correct?

(a) Some finite automata accept non regular languages.
(b) A grammar with recursion always generates infinite languages.
(c) An infinite language can be generated by a non recursive grammar.
(d) A deterministic push down automata cannot generate all context free languages.

Q.9 The grammar with start symbol S over $\Sigma = \{a, b\}$
$S \to aSbb \mid abb$ belongs to the class

(a) Type 0 (b) Type 1
(c) Type 2 (d) Type 3

Q.10 What is the language generated by the grammar where S is the start symbol and the set of terminals and non terminals is $\{a\}$ and {A, B} respectively?

$S \to Aa$
$A \to B$
$B \to Aa$

(a) Set of strings with atleast one a
(b) Set of strings with even number of a's
(c) Set of strings with odd number of a's
(d) Empty language

Q.11 How many even palindromes of length atmost 10 are possible with alphabet $\Sigma = \{0, 1, 2\}$?

(a) $\frac{3^5 - 1}{2}$ (b) $3^5 - 1$

(c) $\frac{3^6 - 1}{2}$ (d) $3^6 - 1$

Q.12 Consider the languages $L_1 = \phi$ and $L_2 = \{1\}$. Which one of the following represents $L_1^* U L_2^* L_1^*$?

(a) $\{\lambda\}$ (b) $\{\lambda, 1\}$

(c) ϕ (d) 1^*

Q.13 Given language, $L_1 = \{a^n b^n\}$ and $L_2 = \{a^{2n}\ b^{2n}\}$. Identify the statements which are TRUE.

1. The language obtained by intersection of languages L_1 and L_2 is same as L_2.
2. The language obtained by performing $L_1 - L_2$ is given by $L_3 = \{a^{2n+1}\ b^{2n+1}\}$
3. The language obtained by union of L_1 and L_2 is same as L_1.
4. The language obtained by performing $L_2 - L_1$ is empty.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1 and 3

(c) 3 and 4 (d) All are correct

Q.14 Let, $L_1 = \{a^n\ b^n\ c^n \mid n \geq 0\}$

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

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

(a) $L_1 \subseteq L_2$ and $L_3 \subseteq L_2$

(b) $L_2 \subseteq L_1$ and $L_2 \subseteq L_3$

(c) $L_2 \subseteq L_1$ but $L_2 \not\subset L_3$

(d) $L_1 \subseteq L_2$ and $L_2 \subseteq L_3$

Q.15 Let $L = \{ab, aa, baa\}$. How many of the following strings are in L^*?

(a) abaabaaabaa (b) baaaaabaa

(c) baaaaabaaaab (d) aaaabaaaa

Q.16 The prefix of a language is defined as

prefix $(L) = \{x : xy \in L$ for some $y \in \Sigma^*\}$

and the suffix is defined as

suffix $(L) = \{y : xy \in L$ for some $x \in \Sigma^*\}$

Which of the following statements is always correct?

(a) prefix(L) $\cap$ suffix (L) = ϕ

(b) prefix(L) $\cap$ suffix (L) $\supseteq (\Sigma, L)$

(c) prefix(L) $\cap$ suffix (L) $\subseteq (\Sigma, L)$

(d) prefix(L) $\cap$ suffix (L) = (Σ, L)

Q.17 Let, L_1 = (Strings with any number of a's followed by any number of b's) and $L_2 = (ba)$. L_3 = Prefix $(L_1^* \cap L_2)$. The number of strings in L_3. will be ________.

Q.18 What language does the grammar with these productions generate?

$S \rightarrow aaA$

$A \rightarrow aA | \varepsilon$

(a) strings with even number of a' s

(b) strings with odd number of a' s

(c) strings with atmost 2 a' s

(d) strings with atmost 2 a' s

Q.19 Let, $L_1 = \{a^* b^*\}$ and $L_2 = \{b^* a^*\}$. The language $L = L_1\ n\ L_2$ is represented by

(a) ϕ (b) $a^* + b^*$

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

Q.20 Let $L_1 = \{a^n | \ n \geq 0$ and $L_2 = \{b^n | \ n \geq 0\}$. Then L is given by $L_1 L_2$. Which of the following statement(s) is/are true about L?

1. L is the language of strings with equal number of a's followed by an equal number of b's.
2. L is a context free language but not regular.
3. L is regular.
4. $L = \{a^n b^n \mid n \geq 0\}$

(a) 1, 2 and 4 (b) 1, 3 and 4

(c) 1 and 4 (d) 3 only

Q.21 How many of the following statements are correct?

1. Both L and $\overline{L}$ can be finite
2. $(\overline{L^*}) = (\overline{L})^*$
3. $(L_1 L_2)^R = (L_2)^R (L_1)^R$
4. $(L^*)^* = L^*$

(a) Only 1 (b) Only 2

(c) 1 and 2 (d) All of the above

Q.22 Given $L = \{a^n \mid n \geq 0\}$ over $\Sigma = \{a\}$. What is the language represented by L^2?

(a) Set of all strings over Σ with odd length

(b) Set of all strings over Σ with even length

(c) Set of all strings over Σ

(d) None of these

Q.23 Let, $L = \{\lambda, 0, 01, 10\}$. Which of the following strings does not belong to L^5?

(a) 110 010 (b) 101001001

(c) 100100 (d) 01101001

Q.24 Which of the following conversions is not possible?
(a) Regular grammar to context free grammar
(b) NFA to DFA
(c) Non deterministic PDA to deterministic PDA
(d) Non deterministic Turing machine to deterministic Turing machine

Q.25 If $S = \{ab, ba\}$, which of the following is true?
(a) S^* contains finite no of strings of infinite length.
(b) S^* has no strings having '*aaa*' or '*bbb*' as substring.
(c) S^* has no strings having aa as substring.
(d) If $T = \{a, b\}$, then $S^* \not\subseteq T^*$,

Multiple Select Questions (MSQ)

26. Given the language $L = \{\text{ab, aa, baa}\}$, which of the following strings are in L^*?
(a) abaabaaabaa
(b) aaaabaaaa
(c) baaaaabaaaab
(d) baaaaabaa

■■■■

Answers Grammars, Languages & Automata

1. (b)	2. (b)	3. (a)	4. (a)	5. (34)	6. (c)	7. (a)	8. (d)	9. (c)
10. (d)	11. (c)	12. (d)	13. (d)	14. (c)	15. (c)	16. (b)	17. (3)	18. (d)
19. (b)	20. (d)	21. (b)	22. (c)	23. (a)	24. (c)	25. (b)	26. (a, b, d)	

Explanations Grammars, Languages & Automata

1. (b)

$$L_1 = \{10, 1\},$$
$$L_2 = \{011, 11\}$$

By concatenation of L_1 and L_2 we get

$$L_1 \cdot L_2 = \{10011, 1011, 1011, 111\}$$

Hence, 3 distinct elements are there.

2. (b)

Suppose, $S = aaab$, $|s| = 4$. The prefixes are $S_p = \{\lambda, a, aa, aaa, aaab\}$. Here aaab is not a proper prefix.

Note: The proper prefix of string S is a prefix, which is not same as string S.

A string of length 4 has 4 proper prefixes. A string of length 5 has 5 proper prefixes. For a string of length n, therefore we can have 'n' proper prefixes.

3. (a)

Let, $u = 1001$ and $v = 001$

$u.v = 1001001$ and $v.u = 001\ 1001$

$|u, v| = |v, u| = |u| + |v|$

But, $u.v \neq v.u$

4. (a)

Palindromes can be represented by

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

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

Since, we need to count the number of odd palindromes of length 11, the number of possible w's of length 5 are $|\Sigma|^5$ i.e. 3^5

Number of possible ways for $x = 3$

$\therefore$ Number of odd palindromes of length

$$11 = 3^5 \times 3 = 3^6$$

Number of odd palindromes of length,

$$n = |\Sigma|^{\frac{n-1}{2}} \times |\Sigma| = |\Sigma|^{\frac{n+1}{2}}$$

5. (34)

Distinct subwords of

Length 1 = 6	Length 5 = 4
Length 2 = 7	Length 6 = 3
Length 3 = 6	Length 7 = 2
Length 4 = 5	Length 8 = 1

$\therefore$ Total = 34

2 CHAPTER Regular Languages & Finite Automata

Multiple Choice Questions & NAT Questions

Q.1 Consider the following finite automata:

$M = (Q, \Sigma, \delta, q_i, F)$

Which of the following statements is/are true?

I. If F = Q and M is a deterministic finite automata, then language accepted is Σ^*.

II. If F = Q and M is a non-deterministic finite automata, then language accepted is Σ^*.

III. If $F = \phi$ and M is a deterministic finite automata, then language accepted is ϕ.

IV. If $F = \phi$ and M is a non-deterministic finite automata, then language accepted is ϕ.

(a) II and III (b) II, III and IV
(c) I, III and IV (d) I and IV

Q.2 If $r1$, $r2$ and $r3$ are the accepting power of DFA, NFA and λ-NFA respectively, then

(a) $r1 = r2 = r3$ (b) $r1 = r2 < r3$
(c) $r1 < r2 = r3$ (d) $r1 \neq r2 \neq r3$

Q.3 Let L be a regular language on alphabet Σ. The union of the Myhill-Nerode equivalence classes is always ______, and the pairwise intersection of the Myhill-Nerode equivalence classes is always _______. Fill up the blanks

(a) ϕ, ϕ (b) ϕ, Σ^*
(c) Σ^*, ϕ (d) L, ϕ

Q.4 Which of the following regular expressions corresponds to the language of all strings over the alphabet $\{a, b\}$ that contains exactly two a's?

(i) aa **(ii)** ab^*a
(iii) $b^* ab^*a$

(a) (i) and (ii) only (b) (ii) and (iii) only
(c) (i) and (iii) only (d) None of these

Q.5 Consider the following statements:

I. Some non regular languages satisfy the pumping lemma for regular languages.

II. For some context free languages, thee exists a finite automata that accept it.

III. For every regular language, there exists a NFA with single final state.

IV. For every regular language, there exists a DFA with a single final state.

Which of the above statements are true?

(a) Only IV (b) I and II
(c) I, II and III (d) I, II, III and IV

Q.6 $L = \{w \mid w$ is a binary number whose decimal value is a multiple of $n\}$. How many states are there in a minimal DFA that accepts L?

(a) n^2 (b) n
(c) $n + 1$ (d) $n + 2$

Q.7 Consider the DFA given below:

	u	d
$\rightarrow q_0$	q_1	q_2
q_1	q_2	q_1
$\boxed{q_2}$	q_3	q_2
q_3	q_3	q_3

Which of the following is true about the DFA given?

(a) The DFA accepts no strings on alphabet $\{u, d\}$
(b) The DFA accepts infinite number of strings on the alphabet $\{u, d\}$
(c) The DFA accepts a finite number of strings on the alphabet $\{u, d\}$
(d) None of the above

Q.8 Which of the following is false?

(a) $(r^*)^* \equiv r^*$
(b) $r_1^*(r_1 + r_2)^* \equiv (r_1 + r_2)^*$
(c) $(r_1 r_2)^* \equiv r_1^* r_2^*$
(d) $(r_1 r_2 + r_1)^* r_1 \equiv r_1(r_2 r_1 + r_1)^*$

Q.9 Let $L1$ be the language accepted by DFA $D1$ and $L2$ be the language accepted by DFA $D2$. Similarly $L3$ and $L4$ languages are accepted by NFA $N1$ and $N2$ respectively.

1. $D2$ is obtained by swapping the accepting and non-accepting states of $D1$.

112. Let L and L' be languages over the alphabet Σ. Left quotient L by L' is $L/L' = \{w \in \Sigma^* : wx \in L$ for some $x \in L'\}$. Which is true?
(a) If L/L' is regular, then L' is regular.
(b) If L is regular, then L/L' is regular.
(c) If L/L' is regular, then L is regular.
(d) If L/L' and L' are regular, then L is regular.

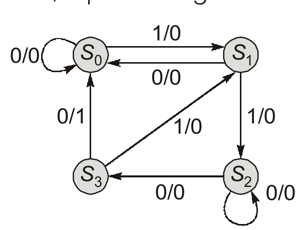
113. Consider the grammar:

$S \rightarrow AaB$
$A \rightarrow aC \mid \lambda$
$B \rightarrow aB \mid bB \mid \lambda$
$C \rightarrow aCb \mid \lambda$

What type of language is generated by the grammar?
(a) Regular (b) Context-free
(c) Context-sensitive (d) Recursive

114. $L = \{a^m b^n \mid m - n = \text{even}\}$
To which class of language does L belong?
(a) Regular language
(b) CFL
(c) CSL
(d) Recursive language

115. Consider O/P producing DFA:



Assume that I/P is 4 bits long.
Which of the following is true?
I. Last bit of O/P depends on start state.
II. If the I/P ends with 1100, then the O/P must end with 1.
III. O/P cannot end with 1 unless I/P ends with 1100.
(a) I only (b) II only
(c) II and III (d) I, II, III

116. Consider the languages A and B:
A = $\{1^k y \mid y \in \{0, 1\}^*$ and y contains at least k 1s for every $k \geq 1\}$
B = $\{1^k y \mid y \in \{0, 1\}^*$ and y contains atmost k 1s for every $k \geq 1\}$
Which of the following is regular?
(a) Neither A nor B (b) Both A and B
(c) Only A (d) Only B

Multiple Select Questions (MSQ)

117. Which of the following is/are incorrect statement?
(a) Moore machine has no accepting states.
(b) Mealy machine has accepting states.
(c) We can convert Mealy to Moore but not vice-versa.
(d) We can convert Moore to Mealy but not vice-versa.

118. Which of the following statement(s) is/are true?
(a) If L is a regular language and F is a finite language (i.e., a language with a finite number of words), then $L \cup F$ must be a regular language.
(b) If L is a regular language and F is a finite language (i.e., a language with a finite number of words), then $L \cup F$ may or may not be a regular language.
(c) Regular expressions that do not contain the star operator can represent only finite languages.
(d) Regular expressions that do not contain the star operator can represent infinite languages.

119. Consider the regular expression $R = (a + b)^* a(ab)^* + \in$. Which of the following are possible as subset of R?
(a) $(aa)^*$ (b) $(ba)^*$
(c) $(aa)^* (ba)^*$ (d) ϕ

120. DROP-ON $E(L) = \{xz \mid xyz \in L$ where $x, z \in \Sigma^*$ and $y \in \Sigma\}$. Which of following are true?
(a) Regular languages are closed under DROP-ON $E(L)$.
(b) For any regular language L, DROP-ON $E(L)$ is not regular.
(c) For some regular language L, DROP-ON $E(L)$ are not regular.
(d) For some regular languages L, DROP-ON $E(L)$ is regular but not all.

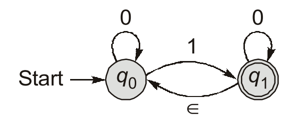
121. Which of following is/are true?
(a) For every regular language there exists a GNFA with atmost 2 states that accepts the language.

(b) Every GNFA can be converted to a regular expression such that both accept same language.
(c) Every DFA cannot be converted to a regular expression such that both accept same language.
(d) Every NFA can be converted to a regular expression such that both accept same language.

122. Which of following is/are true?
(a) A language accepted by a regular expression is also accepted by some NFA and some DFA.
(b) A language accepted by a regular expression is also accepted by some NFA but not necessarily accepted by a DFA.
(c) A language accepted by a regular expression is may not be accepted by any NFA or DFA.
(d) A language accepted by a regular expression is accepted by some DFA but not necessarily accepted by an NFA.

123. Regular languages are closed under:
(a) Concatenation (b) Union
(c) Intersection (d) Complement

124. What is the language accepted by following NFA?



(a) Strings with atleast one 1 in it.
(b) Complement of language can be given by regular expression 0*.
(c) Language accepted by regular expression 0*10*.
(d) Strings with exactly one 1 in it.

125. Which of following is/are true?
(a) NFA may have ε transitions but DFA does not.
(b) NFA and DFA both may have ε transitions.
(c) NFA computes on multiple paths but not simultaneously.
(d) NFA computes on multiple paths simultaneously.

126 Consider a language L = {ab, ba, abab} represented in the form of DFA machine. Then Which of the following strings present in the function INIT(L)?
(a) abab (b) aba
(c) aab (d) bab

Answers Regular Languages & Finite Automata

1. (c)	2. (c)	3. (c)	4. (d)	5. (c)	6. (b)	7. (b)	8. (c)	9. (b)
10. (d)	11. (b)	12. (c)	13. (d)	14. (b)	15. (4)	16. (3)	17. (d)	18. (d)
19. (b)	20. (d)	21. (c)	22. (b)	23. (d)	24. (a)	25. (5)	26. (a)	27. (d)
28. (d)	29. (c)	30. (c)	31. (b)	32. (b)	33. (b)	34. (3)	35. (a)	36. (d)
37. (4)	38. (b)	39. (a)	40. (1)	41. (d)	42. (a)	43. (c)	44. (b)	45. (b)
46. (c)	47. (a)	48. (c)	49. (7)	50. (896)	51. (c)	52. (2)	53. (b)	54. (a)
55. (a)	56. (5)	57. (c)	58. (c)	59. (d)	60. (3)	61. (1)	62. (b)	63. (a)
64. (c)	65. (b)	66. (c)	67. (b)	68. (a)	69. (c)	70. (d)	71. (d)	72. (a)
73. (c)	74. (d)	75. (b)	76. (d)	77. (c)	78. (d)	79. (a)	80. (c)	81. (b)
82. (d)	83. (9)	84. (3)	85. (4)	86. (7)	87. (a)	88. (3)	89. (3)	90. (d)
91. (a)	92. (c)	93. (a)	94. (a)	95. (c)	96. (d)	97. (8)	98. (1)	99. (4)
100. (c)	101. (d)	102. (4)	103. (c)	104. (b)	105. (20)	106. (d)	107. (a)	108. (a)
109. (20)	110. (c)	111. (d)	112. (b)	113. (a)	114. (a)	115. (c)	116. (c)	117. (b, c, d)
118. (a, c)	119. (a, b, c, d)	120. (a)	121. (a, b, d)	122. (a)	123. (a, b, c, d)	124. (a, b)		
125. (b, c, d)	126. (a, b)							

Explanations Regular Languages & Finite Automata

1. (c)

If the set of final states is empty, then no strings are accepted.

∴ Language recognized by both NFA and DFA would be empty.

If the set of final states comprises of all states, then the DFA recognizes complete language but NFA does not due to non-determinism.

2. (c)

DFA, NFA and λ-NFA all have same power.

3. (c)

Myhill-Nerode equivalence classes are pairwise disjoint and their union is always Σ^*.

4. (d)

All languages are accepting strings over the alphabet $\{a, b\}$ that contains exactly two a's but they are not accepting all strings like the first choice just accepts '*aa*'. The second choice can't accept '*baa*'. The third choice can't accept '*baab*'. The correct regular expression is $b^* \, a \, b^* \, a \, b^*$.

5. (c)

I. True: Pumping lemma is not a test for regularity of languages.

II. True: For context free languages, that are regular, there exists a FA.

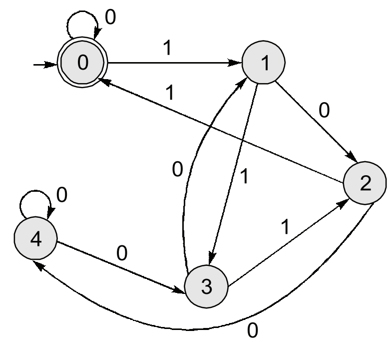
III. True: λ-transitions may be added from multiple final states leading to a single final state.

IV. False: Since a DFA does not allow λ-transitions, the multiple final states cannot be converted to a single final state.

6. (b)

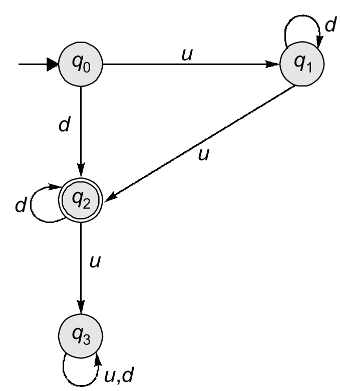
The DFA will have n states, one each to handle the n distinct residues when divided by n. The accepting state will be the starting state corresponding to residue 0.

For example for n = 5, the DFA with 5 states is shown below:



7. (b)

The state diagram for given DFA is:



Since there is a loop in the path from start state q_0 to the final state q_2, the language accepted has infinite number of strings.

8. (c)

All except (c) are true. Consider the regular expressions $(ab)^*$ and a^*b^*

$abab \in (ab)^*$ but $abab \notin a^*b^*$

$\therefore \quad (r_1r_2)^* \not\equiv r_1^* \, r_2^*$

9. (b)

Class of languages recognized by NFA's

$\cong$

Class of languages recognized by DFA's

$\cong$

Class of regular languages

$\Downarrow$

Closed under complement.

So option (b) is not correct statement.

Note: Given data is applicable to option (a) only.

3 CHAPTER

Context Free Languages & Push Down Automata

Multiple Choice Questions & NAT Questions

Q.1 Assume PDA stack is limited to 2^{10} symbols. Now stack can contain maximum of 2^{10} symbols. The language accepted by such PDA is ______.

(a) Regular language but not finite
(b) DCFL but not regular
(c) CFL but not DCFL
(d) None of these

Q.2 A language L satisfies the pumping lemma for context free languages but does not satisfy the pumping lemma for regular language. Which of the following statements about L is true?

(a) L is necessarily a context free language.
(b) L is necessarily a context free language but not necessarily a regular language.
(c) L is necessarily a non context free language.
(d) None of the above

Q.3 Consider the grammar with productions:

$S \to aaB$
$A \to bBb \mid \lambda$
$B \to Aa$

Which of the following strings is not in the language generated by this grammar?

(a) *aabbabba*
(b) *aabbbabababa*
(c) *aabbbbabababababa*
(d) *aabbababa*

Q.4 Which of the following statements is true?

(a) A DCFL can be inherently ambiguous.
(b) Every LL grammar is unambiguous.
(c) There is a LL grammar for every DCFL.
(d) There are some DCFLs for which there is no LR(k) grammar.

Q.5 Let L be the language which is accepted by DPDA. Then identify L from the following

(a) $L = \{a^P \mid P \text{ is prime}\}$
(b) $L = \{a^m b^n c^k \mid m = n \text{ or } n = k\}$
(c) $L = \{a^m b^n c^k \mid m < n \text{ or } m > n\}$
(d) None of these

Q.6 Consider the following 3 languages:

$L_1 = \{w \mid w \in \{a, b\}^* \text{ and } w = w^R\}$
$L_2 = \{ww^R \mid w \in \{a, b\}^*\}$
$L_3 = \{w(a + b)\, w^R \mid w \in \{a, b\}^*\}$

What is the relation between L_1, L_2, L_3 and L_4?

(a) $L_2 \subset L_1$ and $L_3 \subset L_1$ and $L_1 = L_2 \cup L_3$
(b) $(L_2 = L_3) \subset L_1$
(c) $L_2 \cap L_1 = L_3$
(d) $L_2 \subset L_1$ and $L_3 \subset L_1$ but $L_1 \neq L_2 \cup L_3$

Q.7 Let $L_1 = \{a^i b^j c^k \mid i < j\}$, $L_2 = \{a^i b^j c^k \mid i < k\}$. L_1, L_2 and $L_1 \cap L_2$ are

(a) CFL, CFL and CFL respectively
(b) Regular, regular and not regular respectively
(c) CFL, CFL and not CFL respectively
(d) DCFL, DCFL, CFL respectively

Q.8 Given the following two statements:

I. $L = \{w \mid n_a(w) = n_b(w)\}$ is deterministic context free language, but not linear.
II. $L = \{a^n b^n\} \cup \{a^n b^{2n}\}$ is linear but not deterministic context free language.

Which of the following options is correct?

(a) Both I and II are false
(b) Both I and II are true
(c) I is true, II is false
(d) I is false, II is true

Q.9 Which of the following statements is not correct?

(a) For non-deterministic push down automata, set of all language accepted by empty stack is always a proper subset of set of all languages accepted by final state.
(b) For deterministic push down automata, set of all languages accepted by empty stack is always a proper subset of set of all languages accepted by final state.
(c) A grammar which generates a DCFL may be ambiguous.
(d) A deterministic context free grammar can never be ambiguous.

Q.10 What language is generated by the following grammar?

S → a | S + S | SS | S* | (S)

(a) Set of all mathematical expressions
(b) Set of all binary strings
(c) Set of all regular expressions
(d) None of these

Q.11 Recognize the language for the given context free grammar:

S → aB | bA
A → a | aS | bAA
B → b | bS | aBB

(a) Strings contain equal number of a's and b's
(b) Strings contain odd number of a's and odd number of b's
(c) Strings contain odd number of a's and even number of b's
(d) Strings contain even number of a's and even number of b's

Q.12 Match the following lists:
Conditions on $L = \{a^i\, b^j\, c^k\}$ are given in list-I and their respective grammars are given in list-II.

List-I		List-II
A. $k = i + j$	G_1	S → aSc | B; B → aBb | λ
B. $k = i + 2j$	G_2	S → aSc | B; B → bBcc | λ
C $i = j + k$	G_3	S → aSc | B; B → bBc | λ

(a) A - G_1, B - G_2, C - G_3
(b) A - G_3, B - G_2, C - G_1
(c) A - G_1, B - G_1, C - G_2
(d) A - G_3, B - G_1, C - G_2

Q.13 Which of the following grammars violates the Chomsky Normal Form?

I. S → AB, A → a, B → λ | b
II. S → AcB, A → a, B → b
III. S → AB, A → a, B → b

(a) All of the above (b) I only
(c) I and II only (d) II and III only

Q.14 The number of steps of any string (w) of length n to derive it, if the grammar is in CNF form and GNF form respectively?

(a) $2n - 1$ and n
(b) $2n$ and n
(c) $\lceil \log_2^{\,n} \rceil + 1$ and $2n - 1$
(d) $2n - 1$ and n

Q.15 Consider the following languages:

$L_1 = \{a^m b^n \mid m > n\}$
$L_2 = \{a^m b^n \mid n > m\}$

Which of the following statements is incorrect?

(a) $L_1 \cup L_2$ is context free
(b) $L_1 \cap L_2$ is regular
(c) $(L_1 \cup L_2)^c = \{a^m b^n \mid m = n\}$
(d) $L_1 \cup L_2$ is unambiguous language

Q.16 CFLs are not closed under

(a) Union (b) Concatenation
(c) Closure (d) Intersection

Q.17 Which of the following is true?

(a) In an unambiguous grammar every string has exactly one derivation.
(b) There may exist an unambiguous grammar G, even though, the language $L(G)$ is ambiguous.
(c) If M is a PDA accepting L, by exchanging initial and final states we get $\bar{M}$ which accepts $\bar{L}$.
(d) If L_1 is a CFL and L_2 is regular, then $L_1 - L_2$ is a CFL.

Q.18 Consider $L = \{ww^R w \mid w \in \{(00)^*\}\}$ (w^R is reverse string of w). Then L is

(a) Regular (b) DCFL
(c) CFL (d) None of these

Q.19 Identify CFL generated by following CFG

$A \to aB \mid C \mid \lambda$
$B \to Ad \mid Cd$
$C \to bD \mid \lambda$
$D \to Cc$

(a) $\{a^m b^n c^k d^l \mid m = n, k = l\}$
(b) $\{a^m b^n c^k d^l \mid m = k, n = l\}$
(c) $\{a^m b^n c^k d^l \mid m = l, n = k\}$
(d) None of these

Q.20 Let $L = \left\{a^m b^n b^k d^\ell \mid if (n + k = \text{even}) \text{then } m = \ell\right\}$.
Which of the following is true about L?

(a) L is CFL but not DCFL
(b) L is regular but not CFL
(c) L is DCFL but not regular
(d) None of these

Answers Context Free Languages & Push Down Automata

1. (a)	2. (d)	3. (a)	4. (b)	5. (c)	6. (a)	7. (c)	8. (b)	9. (a)
10. (c)	11. (a)	12. (b)	13. (c)	14. (a)	15. (c)	16. (d)	17. (d)	18. (a)
19. (c)	20. (c)	21. (b)	22. (a)	23. (a)	24. (a)	25. (d)	26. (b)	27. (2)
28. (c)	29. (b)	30. (b)	31. (c)	32. (c)	33. (c)	34. (b)	35. (d)	36. (2)
37. (c)	38. (a)	39. (d)	40. (2)	41. (4)	42. (c)	43. (c)	44. (d)	45. (a)
46. (a)	47. (c, d)	48. (a, b)	49. (a, b, c)	50. (a, b)	51. (b, c)	52. (c, d)	53. (b, c)	54. (b, c, d)
55. (b, c, d)	56. (a, c)	57. (a, b)	58. (a, c, d)	59. (b, c)	60. (a, b, c)	61. (a, b, c)	62. (b, c, d)	
63. (a, c, d)	64. (a, c)							

Explanations Context Free Languages & Push Down Automata

1. (a)

stack has on 2^{10} symbols allowed, the stacks serves as finite memory. A non-regular language cannot be accepted by a finite memory.
$\therefore$ This functions as a finite automata. But the language accepted by a finite automata need not be finite.

2. (d)

A regular language satisfies the pumping lemma for regular languages but the converse i.e. all languages which satisfy the pumping lemma for regular languages are regular is not true. Same holds for context free languages with expect to the pumping lemma for context free languages.
$\therefore$ L is necessarily regular but it may or may not be CFL.

3. (a)

The grammar generates the strings of the from
$\{aab^n (ab)^n a \mid n \geq 0\}$
Option (a) does not satisfy this.

4. (b)

DCFL has a LR(k) grammar to recognize it. Since every LR(k) grammar is unambiguous.
$\therefore$ A DCFL cannot be inherently ambiguous.
There are some DCFLs for which LL grammar exist. Every LL grammar is unambiguous.

5. (c)

(a) $L = \{a^P \mid P \text{ is prime}\}$ is not CFL
(b) $L = \{a^m b^n c^k \mid m = n \text{ or } n = k\}$
$= \{a^i b^i c^j\} \cup \{a^p b^l c^l\}$ is CFL but not DCFL
(c) $L = \{a^m b^n c^k \mid m < n \text{ or } m > n\}$
$= \{a^m b^n c^k \mid m \,!= n\}$ is DCFL

6. (a)

L_2 is even palindromes on $\{a, b\}^*$
L_3 is odd palindromes on $\{a, b\}^*$
L_1 is any palindrome on $\{a, b\}^*$
Clearly $L_2 \subset L_1$, $L_3 \subset L_1$ and $L_1 = L_2 \cup L_3$.

7. (c)

Clearly L_1, L_2 are DCFL's and hence CFL's.
$L_1 \cap L_2 = \{a^i b^j c^k \mid i < j \text{ and } i < k\}$
is not a CFL, since 2 comparisons must be made before acceptance and this is not possible using a single stack.

8. (b)

II is not DCFL since it cannot be recognized by a deterministic push down automata.
I is not a linear language since it cannot be recognized by a linear grammar (grammar with atmost one variable on the right hand side of each production).

9. (a)

(a) False as for non-deterministic push down automata, languages accepted by empty stack = languages accepted by final state.
(b) True as for deterministic push down automata language accepted by empty stack is a subset of languages accepted by final state.
(c) An ambiguous grammar can generate DCFL though there always exists an unambiguous grammar for every DCFL.
(d) All DCFGs are always unambiguous.

10. (c)

For writing regular expressions, we need union, concatenation and Kleene closure. So this grammar, is used to write regular expressions.

$S \rightarrow a$

$S \rightarrow S + S \rightarrow$ Union/Addition

$S \rightarrow SS \rightarrow$ Concatenation

$S \rightarrow S^* \rightarrow$ Kleene closure

$S \rightarrow (S)$

11. (a)

(b) false since *aabb* is generated and

(c), (d) false *ab* is generated by the grammar.

12. (b)

$$L = \{a^i\, b^j\, c^{i+j}\} = \{a^i\, b^j\, c^j\, c^i\}$$

$G_3 = S \rightarrow aSc \rightarrow aaScc \rightarrow ..... a^i\, Sc^i$

$B \rightarrow bBc \rightarrow bbBcc \rightarrow ..... b^i\, Bc^j \rightarrow b^j c^j$

$S \rightarrow a^i\, b^j\, c^j\, c^i \rightarrow a^i\, b^j\, c^{i+j}$

$$L_2 = \{a^i\, b^j\, c^{i+2j}\} = \{a^i\, b^j\, c^{2j}\, c^i\}$$

$G_2 = S \rightarrow aSc \rightarrow aaScc \rightarrow ..... a^i\, Sc^i$

$B \rightarrow bBcc \rightarrow bbBcccc \rightarrow ..... b^i\, Bc^{2j} \rightarrow b^j c^{2j}$

$S \rightarrow a^i\, b^j\, c^{i+2j}$

13. (c)

Chomsky Normal Form is represented by

$V \rightarrow VV \mid T$

Only III satisfies CNF.

14. (a)

For CNF, using $n - 1$ rules of the form

$$V \rightarrow VV$$

We can construct a string containing n non terminals. On each non terminal, we have apply a rule

$$V \rightarrow T$$

$\therefore$ Total $= (n - 1) + n = 2n - 1$

For GNF, every derivation step introduces one terminal.

$\therefore$ To derive a string of n terminals, n derivation steps are required.

15. (c)

$L_1 \cup L_2 = \{a^m b^n \mid m! = n\}$ which is context free language

$L_1 \cap L_2 = \phi$ which is a regular language

$(L_1 \cup L_2)^c = \{a^m b^n \mid m = n\} \cup \{(a + b)^*\, ba(a + b)^*\}$

$(L_1 \cup L_2)$ is unambiguous. The grammar generating the language is

$S \rightarrow S_1 \mid S_2$

$S_1 \rightarrow aS_1 \mid aA$

$S_2 \rightarrow S_1 b \mid Ab$

$A \rightarrow aAb \mid \lambda$

16. (d)

It follows from the closure properties of CFL's. CFL's are closed under $\cup$, concatenation and, but not under $\cap$ and L^C.

17. (d)

Option (a) false

In an unambiguous grammar, every string has exactly one rightmost derivation or exactly one leftmost derivation.

Option (b) false

For an ambiguous language, there cannot exist an unambiguous grammar.

Option (c) false

Option (d) true

$$L_1 - L_2 = L_1 \cap L_2^c$$

Since L_2 is regular, L_2^c is also regular. Intersection of a CFL and regular language is CFL.

18. (a)

$$L = \{ww^R w \mid w \in (00)^*\}\}$$

w is any string containing an even number of zeroes w^R will be same as w.

$\therefore \quad L = \{\epsilon, 000000, 000000000000...\}$

$\quad = \{(000000)^*\}$

$\therefore$ L is regular.

19. (c)

$$\left.\begin{array}{l} A \rightarrow aB \mid C \mid \lambda \\ B \rightarrow Ad \mid Cd \end{array}\right\} \Rightarrow L(A) = \{a^m b^n c^n d^m \mid m, n \geq 0\}$$

$$\left.\begin{array}{l} C \rightarrow bD \mid \lambda \\ D \rightarrow Cc \end{array}\right\} \Rightarrow L(C) = \{b^n c^n \mid m, n \geq 0\}$$

$$L(A) = \{a^m b^n c^n d^m\}$$

$$= \{a^m b^n c^k d^l \mid m = l,\ n = k\}$$

20. (c)

$$L = \{a^m b^n b^k d^\ell \mid \text{if } n + k = \text{even then } m = \ell\}$$

$$= \{a^m b^{2n} d^m\} \cup \{a^m b^{2n+1} d^k\}$$

$$= \text{DCFL} \cup \text{regular} = \text{DCFL}$$