

Attempt all the questions.

PART-1

Instruction: Maximum time for Part-1 is 1.5 hrs. You can get Part-2 after returning Part-1.

[CLO 1: Identify formal language classes and prove language membership properties. (1) (2)]

[45 marks]

Q1: Multiple choice question

Only the Table on the last Page will be marked.

1: Which of the following is a correct definition of a finite automaton?

- a) A machine that can recognize regular languages
- b) A machine that can recognize context-free languages
- c) A machine that can recognize all languages
- d) A machine that can recognize recursive languages

2. What is the minimum number of states required in a deterministic finite automaton (DFA) that recognizes the language containing all strings over the alphabet $\{0, 1\}$ with an odd number of 1s?

- a) 1
- b) 2
- c) 3
- d) 4

3. Which of the following statements about non-deterministic finite automata (NFA) is true?

- a) NFAs can recognize more languages than DFAs
- b) NFAs and DFAs recognize the same set of languages
- c) NFAs can recognize context-free languages
- d) NFAs cannot recognize regular languages

4. The power of a pushdown automaton (PDA) lies in its ability to:

- a) Recognize context-free languages
- b) Recognize regular languages
- c) Recognize recursively enumerable languages
- d) Recognize all languages

5. Which of the following is a property of a regular language?

- a) Closed under complementation
- b) Closed under union
- c) Closed under intersection
- d) All of the above

6. The language $L = \{a^n b^n \mid n \geq 0\}$ is:
- Regular
 - Context-free
 - Context-sensitive
 - None of the above
7. Which of the following is NOT a regular expression given $\Sigma = \{a, b\}$?
- $(a + b)^*$
 - abc^*
 - $a^* + b^*$
 - $(ab)^*$
8. Which of the following statements is true about the Chomsky hierarchy?
- Regular languages are a subset of context-free languages
 - Context-free languages are a subset of regular languages
 - Context-sensitive languages are a subset of recursively enumerable languages
 - Recursively enumerable languages are a subset of context-sensitive languages
9. Which of the following is a correct definition of the pumping lemma for regular languages?
- Every regular language can be pumped to generate an infinite language
 - Every regular language can be partitioned into a set of pumping lengths
 - Every regular language can be expressed using regular expressions
 - Every regular language can be pumped to generate longer strings within the language
10. The language $L = \{a^n b^n c^n \mid n \geq 0\}$ is:
- Regular Language
 - Context-free Language
11. Which of the following automata models has the least computational power?
- Finite automaton
 - Pushdown automaton
 - Turing machine
 - Non-deterministic finite automaton
12. The difference between a deterministic PDA and a Non-deterministic PDA lies in:
- The number of stack used
 - The size of the input alphabet
 - The presence of multiple possible path from a state for given symbol
 - The availability of a stack for memory storage
13. Which of the following automata models is equivalent in power to a Turing machine?
- Pushdown automaton
 - Finite automaton
 - Non-deterministic finite automaton
 - Two-stack pushdown automaton
14. The language $L = \{a^n b^m c^n \mid n, m \geq 0\}$ is:
- Regular
 - Context-free
 - Context-sensitive
 - None of the above
15. The regular expression $(aa + bb)$ represents the language:
- $\{\epsilon, aa, bb, aaaa, bbbb, aaaa, bbbb, \dots\}$
 - $\{aa, bb\}$

- c) $\{a, b\}$
d) $\{\epsilon, aa, bb\}$
16. The regular expression $(aa + bb)^*$ represents the language:
a) $\{\epsilon, aa\}$
b) $\{aa, bb\}$
c) $\{a, b\}$
d) $\{\epsilon, aa, bb, aabb, \dots\}$
17. In the Turing Machine, the tape header can move in which direction
a) Left to Right
b) Right to Left
c) both
d) None of the above
18. In the two Push Down Automata, the tape header can move in which direction
a) Left to Right
b) Right to Left
c) both
19. Is it compulsory for CFG to be in Chomsky Normal Form (CNF) to convert it into PDA
a) True
b) False
c) Sometimes
- 20) Which of the following is NOT a Chomsky Normal Form (CNF) component?
a) Terminal symbols
b) Non-terminal symbols
c) Production rules
d) Regular expressions
- 21) Regular expression for all the strings starts with ab and ends with bba is
a) aba^*b^*bba
b) $ab(ab)^*bba$
c) $ab(a+b)^*bba$
d) All of the mentioned
- 22) If we select a string w such that $w \in L$, and $w = xyz$. Which of the following portions cannot be an empty string (Hint: Pumping lemma) ?
a) x
b) y
c) z
d) all of the mentioned
- 23) Which among the following cannot be accepted by a regular grammar?
a) L is a set of numbers divisible by 2
b) L is a set of binary complement
c) L is a set of string with odd number of 0
d) L is a set of $a^n b^n$
- 24) What is the output for the given language?
Language: A set of strings over $\Sigma = \{a, b\}$ is taken as input and it prints 1 as an output "for every occurrence of ab as its substring. (INPUT: $abaaab$)
a) 010001
b) 101010

- c) 111010
- d) 010000

25) Which of the following is a correct 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) All of the mentioned

26) Finite automata requires minimum _____ number of stacks.

- a) 1
- b) 0
- c) 2
- d) None of the mentioned

27) A push down automaton employs _____ data structure.

- a) Queue
- b) Linked List
- c) Hash Table
- d) Stack

28) Which of the operations are eligible in PDA?

- a) Push
- b) Delete
- c) Insert
- d) Add

29) Languages are proved to be regular or non-regular using pumping lemma

- a) True
- b) False

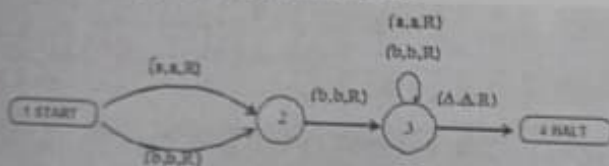
30) Which statement is true?

- a) The tape of Turing machine is infinite.
- b) The tape of Turing machine is finite.
- c) The tape of Turing machine is infinite when the language is regular
- d) The tape of Turing machine is finite when the language is non-regular.

31) In TM, Which of the following refers to halt state?

- a) Accept and reject
- b) Accept and read
- c) Accept and start
- d) Accept and write

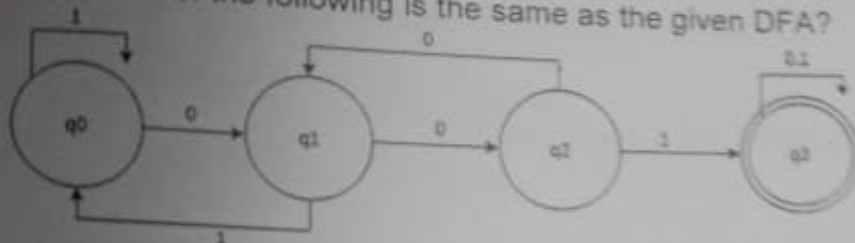
32) The given machine is a:



- a) Finite automata
- b) Turing machine
- c) Transition graph
- d) None of the above

- 33) Turing machine (TM) is more powerful than FAs because
- tape movement is confined to one direction
 - it has no finite state
 - it has the capability to remember arbitrarily long sequences of input symbols
 - none of these

34) Which of the following is the same as the given DFA?



- $(0+1)^*001(0+1)^*$
- $1^*001(0+1)^*$
- $(01)^*(0+0+1)(01)^*$
- None of the mentioned

35) $(a+b)^*$ is equivalent to

- b^*a^*
- $(a^*b^*)^*$
- a^*b^*
- none of the mentioned

36) Consider the following Languages:

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

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

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

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

Which languages are regular?

- Only L_1 and L_2
- Only L_2 , L_3 and L_4
- Only L_3 and L_4
- Only L_3

37) Power of 2 PDA is equal to

- Turing Machine
- PDA
- None of the above

38) In PDA input is read from

- Tape
- Stack
- None of the above

39) The language that can be expressed by any regular expression is called a regular language

- True
- False

40) Which is not the part of mechanical diagram of Turing machine?

- Input Tape

- b) Read-Write head
- c) Finite Control
- d) Stack

41) Which of the following is not possible Algorithmically?

- a) RE to CFG
- b) NFA to DFA
- c) CFG to PDA
- d) NPDA to DPDA

42) How many derivation trees are possible for aabbab string?

Consider the following grammar:

$S \rightarrow aB \mid bA \mid bAA$

$A \rightarrow a \mid aS$

$B \rightarrow b \mid bS \mid aBB$

- a) 3
- b) 2
- c) 4
- d) none of the above

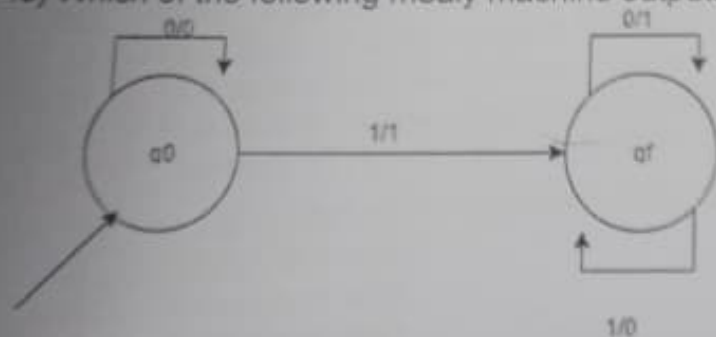
43) XX^* can be expressed in which of the forms:

- a) X^+
- b) X^-
- c) $X^+ \cup X^-$
- d) X

44) For a give Moore Machine, Given Input='101010', thus the output would be of length:

- a) $|Input|+1$
- b) $|Input|$
- c) $|Input|-1$
- d) Cannot be predicted

45) Which of the following mealy machine outputs?



- a) 9's Complement
- b) 2's Complement
- c) 1's Complement
- d) 10's Complement

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Course Section

Student Signature

Attempt all the questions.

PART-2

Instruction: Return the Question Paper along with the answer sheet.

[CLO 2: Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on non-regular, regular, context-free languages using automata (DFA, NFA, PDA) and Turing Machines. (3)(3)]

[10 marks]

Q1: For the language $a^n b^{2n} c^{3n} d^n e^n$, where $n \geq 0$, design a 2-PDA.

[CLO 2: Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on non-regular, regular, context-free languages using automata (DFA, NFA, PDA) and Turing Machines. (3)(3)]

Q2: Design a Turing Machine for DoubleWord = $\{\Delta, aa, bb, aaaa, abab, baba, bbbb, aaaaaa, aabaab, abbabb, abaaba, baabaa, babbab, bbbbbb, \dots\}$. You are not allowed to use any subprograms.

[15 marks]

[CLO 3: Prove and disprove theorems establishing key properties of formal languages and automata (3)(3)]

Q3: Convert to CNF and show all the intermediary steps in the order studied.

[15 marks]

- $S \rightarrow SS \mid AB \mid B$
- $A \rightarrow aAAa$
- $B \rightarrow bBb \mid bb \mid \Delta$
- $C \rightarrow CC \mid a$
- $D \rightarrow aC \mid bb \mid E$
- $E \rightarrow aE \mid EE$

[CLO 4: Demonstrate a fundamental understanding of core concepts relating to the theory of computation and computational models including decidability and intractability (3)(2)]

Q4: Design a Turing machine that takes input from a positive number x and performs the computable function $f(x) = x^2$. Assume the input is in unary notation, the tape head points at the start of the input. You must leave the tape head at the first letter of the output string when the computation is done, though cleaning of the intermediate steps is not needed. You are not allowed to use any sub-programs. An example is given below for your understanding:

[15 marks]

Status of tape on input:

#	1	1	1	Δ	Δ	.	.	.
---	---	---	---	---	---	---	---	---

Status of the tape at output:

#	1	1	1	1	1	1	1	1	1	Δ	.
---	---	---	---	---	---	---	---	---	---	---	---