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NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA
(An Autonomous Institute Affiliated to AKTU, Lucknow)

B.Tech

SEM: IV - THEORY EXAMINATION (2025 - 2026)

Subject: Theory of Computation

Time: 3 Hours

Max. Marks: 100

General Instructions:

IMP: Verify that you have received the question paper with the correct course, code, branch etc.

1. This Question paper comprises of **three Sections -A, B, & C**. It consists of Multiple Choice Questions (MCQ's) & Subjective type questions.
2. Maximum marks for each question are indicated on right -hand side of each question.
3. Illustrate your answers with neat sketches wherever necessary.
4. Assume suitable data if necessary.
5. Preferably, write the answers in sequential order.
6. No sheet should be left blank. Any written material after a blank sheet will not be evaluated/checked.

SECTION-A

20

1. Attempt all parts:-

- (1.1) Select the correct statement regarding DFA and NFA equivalence. (CO1,K1) 1
- (a) NFA is more powerful than DFA
 - (b) DFA is more powerful than NFA
 - (c) Both are equally powerful
 - (d) NFA cannot be minimized
- (1.2) Select the language that is NOT regular from the following options. (CO1,K2) 1
- (a) $L = \{a^n \mid n \geq 0\}$
 - (b) $L = \{a^n b^n \mid n \geq 0\}$
 - (c) $L = (ab)^*$
 - (d) $L = \{\epsilon, a, aa\}$
- (1.3) The regular expression $(a|b)^*$ denotes:(CO2,K1) 1
- (a) All strings that contain only 'a'
 - (b) All strings over $\{a,b\}$ including ϵ
 - (c) Only strings of length 1
 - (d) Only strings starting with 'a'
- (1.4) Which of the following is NOT a basic operation in regular expressions. (CO2,K1) 1
- (a) Concatenation
 - (b) Kleene star
 - (c) Union
 - (d) Intersection
- (1.5) Production rule in CFG has the form. (CO3,K2) 1

- (a) $A \rightarrow aB$
 (b) $A \rightarrow \alpha$
 (c) $AB \rightarrow a$
 (d) $a \rightarrow A$
- (1.6) Among the following select false statement.(CO3,K1) 1
 (a) Context free language is the subset of context sensitive language
 (b) Recursively enumerable language is the super set of regular
 (c) Context sensitive language is a subset of context free language
 (d) Regular language is the subset of context sensitive language
- (1.7) What does the acronym LR stand for in LR parsing techniques.(CO4,K1) 1
 (a) Logical reduction process
 (b) Left recursion removal
 (c) Linear representation
 (d) Left to right scan with rightmost derivation
- (1.8) In the reduce operation of shift-reduce parsing, what transformation takes place.(CO4,K4) 1
 (a) A substring is replaced by a non-terminal
 (b) A non-terminal is replaced by terminals
 (c) Input is appended to stack
 (d) Stack is cleared
- (1.9) Identify the role of the transition function in a Turing Machine [CO5,K1] 1
 (a) Stores symbols (b) Defines computation steps
 (c) Moves tape left only (d) Halts execution
- (1.10) Apply constant folding to expression $3+5$. (CO5,K3) 1
 (a) 5 (b) 3 (c) 8 (d) 15

2. Attempt all parts:-

- (2.1) Design an NFA for the language of all strings ending with "01" over $\{0,1\}$.(CO1,K2) 2
- (2.2) Define regular Expression and Regular set .(CO2,K1) 2
- (2.3) List types of productions removed during CFG simplification.(CO3,K2) 2
- (2.4) Compute FOLLOW for the grammar: $S \rightarrow AB$, $A \rightarrow a \mid \epsilon$, $B \rightarrow b$. (CO4,K3) 2
- (2.5) Define Tape Alphabet and explain its role in TM. (CO5,K2) 2

SECTION-B

30

Answer any one of the following:-

- (3.1) Construct Following Finite automaton. (CO1,K3) 6
 i) Design a DFA that accepts all the strings for input alphabet $\{a,b\}$ containing exactly 2 a's.
 ii) Design a NFA that accepts all the strings for input alphabet $\{a,b\}$ containing the substring "abba".
- (3.2) Describe the language processing system with a neat diagram. Explain the role of preprocessor, compiler, assembler, linker, and loader.(CO1,K2) 6

Answer any one of the following:-

- (3.3) Differentiate between Right Linear Grammar and Left Linear Grammar with suitable examples. Construct a Right Linear Grammar and a Left Linear Grammar for the language accepted by the regular expression $(ab)^*a$.(CO2,K2) 6
- (3.4) Define Lexical Error also explain the various function of the tokenizer.(CO2,K2) 6

Answer any one of the following:-

- (3.5) Draw the transition diagram for a PDA accepting $L = \{ a^n b^m c^m \mid n, m \geq 1 \}$.(CO3,K3) 6
- (3.6) Given the following CFG: (CO3,K3) 6
- $S \rightarrow aA \mid bB \mid C$
 $A \rightarrow a \mid aA \mid B$
 $B \rightarrow b \mid Bb \mid C$
 $C \rightarrow cC \mid c$
- a) Identify and remove the useless symbols from the grammar.
b) Eliminate unit productions from the resulting grammar.

Answer any one of the following:-

- (3.7) Explain synthesized and inherited attributes in detail. Using a suitable syntax tree, demonstrate how both types of attributes are evaluated.(CO4,K2) 6
- (3.8) For the expression $x = (a + b) * (c + d)$, generate three-address code and represent it using quadruples, triples, and indirect triples. Compare the representations. (CO4,K3) 6

Answer any one of the following:-

- (3.9) Design the turing machine for 2's compliment for the given input string: 1011101. Trace the output. (CO5,K3) 6
- (3.10) Write short notes on: 6
1. Loop Unrolling
 2. Loop Jamming [K2] [CO5]

SECTION-C

4. Answer any one of the following:-

- (4.1) Discuss the importance of Theory of Automata and formal Language in the following a) Compiler Design b) Natural Language processing System C) Speech recognition System (CO1,K2) 10
- (4.2) Design a DFA over $\Sigma(0,1)$ such that (CO1,K3) 10
- a) Odd number of 0's and even number of 1's
 - b) Even number of 0's and even number of 1's
 - c) Odd number of 0's and odd number of 1's
 - d) Even number of 0's and odd number of 1's

5. Answer any one of the following:-

- (5.1) Define Epsilon NFA and Convert the Regular Expression $(0+1)^*01(0+1)$ into an equivalent NFA with proper steps.(CO2,K3) 10
- (5.2) State and prove Arden's theorem. Give a regular expression for the Finite Automaton $M = \{A, B, C, D\}, \{a, b\}, \delta, A, \{A\}$ where δ is given below: (CO2,K3) 10

Given transitions:

For input a:

$\delta(A, a) = B$

$\delta(B, a) = D$

$\delta(C, a) = A$

$\delta(D, a) = D$

For input b:

$\delta(A, b) = C$

$\delta(B, b) = A$

$\delta(C, b) = D$

$\delta(D, b) = D$

6. Answer any one of the following:-

(6.1) Design a Pushdown Automaton for balanced parentheses and describe its working with stack operations. (CO3,K3) 10

(6.2) Simplify the CFG by removing null, unit, and useless productions with stepwise procedure. Explain with suitable example. (CO3,K2) 10

7. Answer any one of the following:-

(7.1) Given the grammar: $E \rightarrow TE'$, $E' \rightarrow +TE' \mid \epsilon$, $T \rightarrow FT'$, $T' \rightarrow *FT' \mid \epsilon$, $F \rightarrow (E) \mid id$ (CO4,K3) 10

a. Compute FIRST and FOLLOW sets

b. Construct the LL(1) parsing table

c. Show parsing steps for input: $id + id * id$

(7.2) For the grammar $S \rightarrow AA$, $A \rightarrow aA \mid b$, construct the LR(0) parsing table. Identify any conflicts and justify whether the grammar is LR(0). (CO4,K3) 10

8. Answer any one of the following:-

(8.1) Write short note on the following: 10

1. Universal Turing Machine

2. Multi Head Turing Machine

3. Multi Tape Turing Machine

4. Multi Dimension Turing Machine (CO5,K2)

(8.2) Consider the following three address code segments : 10

PROD : = 0

1. $l := 1$

2. $T1 := 4 * l$

3. $T2 := \text{addr}(A) - 4$

4. $T3 := T2[T1]$

5. $T4 := \text{addr}(B) - 4$

6. $T5 := T4[T1]$

7. $T6 := T3 * T5$

8. $\text{PROD} := \text{PROD} + T6$

9. $l := l + 1$

10. If $l \leq 20$ goto (3)

a. Define basic block and Find the basic blocks and flow graph of above sequence.

b. Optimize the code sequence by applying function preserving transformation optimization technique. (CO5,K4)