International Islamic University Chittagong

Department of Computer Science and Engineering

B. Sc. in CSE Final Examination, Autumn 2022

Course Code: CSE-2425 Theory of Computing

Total marks: ***50*** *Time: 2 hours* ***30*** *minutes*

[Figures in the right-hand margin indicate full marks
Course Outcomes and Bloom's taxonomy levels are mentioned in additional columns]

Bloom's Taxonomy Levels (Cognitive Domain)						
Letter Symbols	R	U	A	N	E	C
Meaning	Remember	Understand	Apply	Analyze	Evaluate	Create

Group-A

CO DL

1.

a) Describe the components of context-free grammar. Is any of the components have a similarity with any of the components of regular language or finite automata? CO1 U 3

OR

Define and differentiate between the following.

a. Derivation and Parse Tree
b. Leftmost and Rightmost derivation

b) What is ambiguity? Determine whether the following grammar is ambiguous. CO2 N 3

$S \rightarrow AB$
$A \rightarrow aA \mid abA \mid \varepsilon$
$B \rightarrow bB \mid abB \mid \varepsilon$

c) Consider the following grammar CO2 A 4

$S \rightarrow SSx \mid SSy \mid SSz \mid a \mid b \mid c$

Show how to derive the string **cabxycz** using this grammar using a left-most derivation. Draw the parse tree for the string.

OR

Show how to derive the string **cabxycz** using this grammar using a right-most derivation. Draw the parse tree for the string.

2.

a) Show using the pumping lemma which of the following languages are context-free. CO2 N 3

i. $L1 = \{w \mid w \in a^nb^nc^{2n} \mid n \geq 0\}$
ii. $L2 = \{w \mid w \in a^nb^nc^n \mid n \geq 0\}$

OR

Describe the following languages using a context-free grammar.

a. 0*1*
b. 1(01)*
c. (11 U 0)*

b) Give a context-free grammar (CFG) for each of the following languages over the alphabet **Σ = {a,b}:-** CO2 C 4

i. $L = \{a^{2n}b^mc^n \mid n \geq 0\}$
ii. $L = \{a^mb^nc^{m+n} \mid n \geq 0\}$

c) Convert the following CFG into an equivalent CFG in Chomsky normal form. CO2 N 3

$R \rightarrow aSa \mid bRb \mid S$
$S \rightarrow aTb \mid bTa \mid aS$
$T \rightarrow XTX \mid X \mid \varepsilon$
$X \rightarrow a \mid b$

Group-B

3.

a) How ε-rules are removed when converting a grammar to Chomsky normal form? CO2 U 2

OR

Why do you think pushdown automata are more powerful than finite automata?

b) Construct a pushdown automaton that recognizes the following language CO3 C 4

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

OR

Construct a pushdown automaton that recognizes any arithmetic expression involving +, *, and any one-digit integer.

c) Convert any one of the following context-free grammar (CFG) to an equivalent pushdown automaton CO3 N 4

$S \rightarrow XYm \mid XYn$
$X \rightarrow aX \mid \varepsilon$
$Y \rightarrow bY \mid \varepsilon$

OR

$S \rightarrow aXbY$
$X \rightarrow aYa \mid \varepsilon$
$Y \rightarrow bXb \mid c \mid \varepsilon$

4.

a) What is the Church-Turing thesis? CO4 U 2

b) Can you run a nondeterministic algorithm on a deterministic machine instead of a nondeterministic one? If your answer is yes, then explain how you can do it and how the running time will be affected. If your answer is no, then explain why it will not be possible. CO5 E 4

c) Give the implementation-level description of a Turing machine that decides the following languages: $L = \{a^{2n}b^{n}c^{n} \mid n \geq 0\}$. CO3 A 4

5.

a) Let the language A_{DFA} = {(B, w) | B is a DFA that accepts input string w}. Prove that "A_{DFA} is a decidable language." CO4 E 3

b) Show that the set of infinitely long binary sequences is uncountable. CO4 N 3

c) What are N Let, CO5 N 4

A_{TM} = {<M,w> | M is a TM and M accepts w}

and

$HALT_{TM}$ = {<M,w> | M is a TM and M halts on input w}

Prove that if A_{TM} is undecidable then $HALT_{TM}$ is also undecidable.