International Islamic University Chittagong

Department of Computer Science & Engineering

Program: B.Sc.(Engg.) in CSE

Final Examination, Spring-2019

Course Code: CSE-3609/2425 **Course Title: Theory of Computing**

Time: 2 hour and 30 mins. **Total Marks: 50**

[Answer any *two* questions from **Group-A** and any *three* questions from **Group-B**; Separate answer script must be used for Group-A and Group-B.]

Group-A

1. a) Construct a Deterministic Finite Automata , Σ = {a,b} and L(M)= {ω| ω starts and ends with different symbol }. 5
   b) Construct a NFA with state transition table , where second symbol from RHS (right hand side) is 'a' and also convert from NFA to DFA. Assume the input alphabets are a,b. 5

2. a) Define Grammar. 2+3=5
   Suppose, L (G) = $\{a^m b^n \mid m \geq 0$ and $n > 0\}$. We have to find out the grammar G which produces L(G).
   b) According to Noam Chomosky, mention the types of Grammar with examples. 5

3. a) Construct push down automaton from the following grammar: 4
   $S \rightarrow aTb \mid b$
   $T \rightarrow Ta \mid \varepsilon$
   b) Using the pumping lemma show that the following languages are not context free: 3+3
   i) $\{ a^n b^n c^n \mid n>=0\}$
   ii) $\{ a^i b^j c^k \mid 0<=i<=j<=k \}$

Group-B

4. a) Describe the ***Church Turing thesis***? 5
   Let Σ = {0,1}. Draw the state transition diagram for a Turing Machine whose language is L= {w ∈ Σ^* | w contains *01* as substring}
   b) Remove null production from the following grammar: 5
   S---->ABAC , A--→aA|Є , B-→bB|Є , C---→c

5. a) Show that E_{DFA} and EQ_{DFA} are decidable languages. 3+3
   b) Show that the set of rational numbers is countable. 4

6. a) Differentiate among finite state machine , pushdown automata and turing machine. Write down the rules of operation for turing machine. 2+3=5
   b) Define ambiguous grammar. Design a turing machine which recognizes the language, L=01*0 105P 2+3=5

7. a) Show that every Non-deterministic Turing Machine has an equivalent Deterministic Turing Machine. 5
   b) Prove that the Halting Problem for Turing Machine is undecidable. 5

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Department of Computer Science and Engineering

B. Sc. In CSE Final Examination, Autumn 2021

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

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

Group-A

1.

a) Convert the following regular expressions to NFA. CO DL

i) a(aa)* U (bb)*

ii) a(a U b)*a U b(a U b)*b 2 CO1 A

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

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

c) Show how to derive the string **aabab** using this CFG using a left-most derivation. Draw the parse tree for the string. 5 CO2 A

Or

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

2.

a) Differentiate between DFA and NFA. 5 CO1 A

Construct a DFA that recognize the following language. In all parts , the alphabet is {0,1}: *{w |w begins with a 1 and ends with 0 }*

Or

Construct a Deterministic Finite Automata , ∑ = {a,b} and L(M)= {ω| ω Starts and ends with different symbol}.

b) Define simplification of CFG with types. Write down the procedure for removal of unit production with example. 5 CO2 R

Group-B

3.

a) i) Using pumping lemma for context free languages show that the following language is not context free. 2+4 CO2 A

$L = \{w \mid w \in a^n b^n b^n\}$

ii) Convert any one of the following CFG into an equivalent CFG in Chomsky normal form.

$R \rightarrow aRb \mid bRb \mid S$
$S \rightarrow aTa \mid bTa$
$T \rightarrow XTX \mid X \mid \varepsilon$
$X \rightarrow a \mid b$

Or

b) Prove the theorem: A language is context free iff some pushdown automata recognize it. 6 CO2 E

b) Remove null production from the following grammar: 4 CO1 N

S---->ABAC , A--→aA|Є , B-→bB|Є , C---→c

Or

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

$R \rightarrow XRX \mid S$
$S \rightarrow aTa \mid bTb$
$T \rightarrow bTa \mid abTb \mid X \mid \varepsilon$
$X \rightarrow a \mid b$

4.

a) Give the implementation-level description of Turing machine that decides the following languages (any two) 6 CO3 C

i. $\{w \mid w$ contains three times as many 1s as 0s$\}$
ii. $B = \{0^m 1^n 2^{m-n} \mid m, n > 0$ and $m > n\}$
iii. $\{w \mid w$ is a string with 0s and 1s and contains 1s in a multiple of 3$\}$
iv. $C = \{0^i 1^j 2^k \mid i+k = 2^*j$ and $i,j,k > 0\}$

b) Define decidable language. Find out whether the following problem is decidable or not: Is a number 'm' prime? 4 CO1 A

5.

a) Differentiate between a finite automaton and a Turing machine 2 CO4 U

b) Define the classes P, NP and NP-complete. Why NP-complete class is significant regarding the question whether P = NP? 3 CO5 U

c) Show the relationship among the following types of language in a diagram: Regular language, context free language, decidable language. 2 CO4 U

d) 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. 3 CO4 E

Shahriar Alvi

International Islamic University Chittagong

Department of Computer Science and Engineering

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Bloom's Taxonomy Levels (Cognitive Domain)						
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Group-A

			CO	DL
1.				
a)	Construct a Context-Free Grammar (CFG) for the regular expression (0 + 1)*0 1*, that is, any combination of 0 and 1 followed by a single 0 and ending with any number of 1. **OR,** Construct a CFG for the regular expression 0*1(0 + 1)*, that is, any number of 0 followed by a single 1 and ending with any combination of 0 and 1.	3	CO1	A
b)	Consider G whose productions are **S → aAS/a,** **A → SbA/SS/ba.** Show that **S → aabbaa** by constructing a derivation tree, by rightmost derivation, whose yield is **aabbaa**.	2	CO2	A
c)	Consider the grammar **S → iCtS/iCtSeS/a** **C → b** This grammar is ambiguous. Show in particular that the string **ibtibtaea** has two: (i) parse trees, (ii) leftmost derivations, (iii) rightmost derivations.	5	CO2	N
2.				
a)	How do you use the pumping lemma to determine if a language is context-free? **OR** Can you describe a regular language using context-free grammar? Illustrate using an example.	3	CO1	N

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b) Can you give a context-free grammar (CFG) for the following languages over the alphabet Σ ={a,b}:- 3 CO2 E

All strings in the language **L: $\{a^n b^{2n} c^{4n} \mid n \geq 0\}$**

If you cannot, justify the reason.

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

- All strings in the language **L: $\{a^n b^{2n} \mid n \geq 0\}$**
- All nonempty strings that read the same from left or right.

OR

How can Context-Free Grammar (CFG) be simplified? Write down the procedure for eliminating unit productions from a CFG. Remove the unit productions from the following grammar:
$S \rightarrow AB,\ A \rightarrow a,\ B \rightarrow C/b,\ C \rightarrow D,\ D \rightarrow E,\ E \rightarrow a.$

Group-B

3.

a) What are ε-rule and unit rules? 2 CO2 U

b) Construct a pushdown automaton that recognizes the following language **L: $\{a^n b^{2n} \mid n \geq 0\}$** 4 CO3 C/E

OR

Suppose the PDA **P = ({p, q, f}, {0, 1}, {0, 1, Z_0}, δ, q, Z_0, {f})** has the following transition functions:

$\delta(q, 0, Z_0) = \{(q, XZ_0)\}$, **$\delta(q, 0, X) = \{(q, XX)\}$,**
$\delta(q, 1, X) = \{(p, \varepsilon)\}$, **$\delta(p, 1, X) = \{(p, \varepsilon)\}$,**
$\delta(p, \varepsilon, Z_0) = \{(f, Z_0)\}$.

Starting from the initial ID **(q, w, Z_0)**, show all the reachable ID's when the input w is:
(i) **00001111**
(ii) **00011**

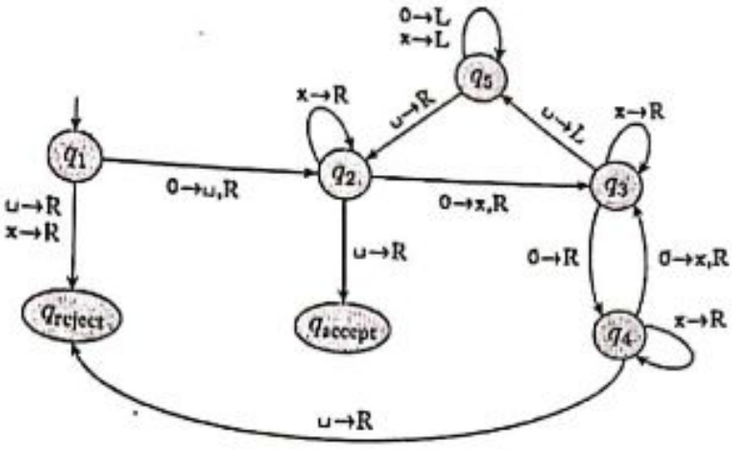
c) Convert any one of the following context-free grammar (CFG) to an equivalent pushdown automaton 4 CO1 N

$S \rightarrow aSb \mid bY \mid Ya$
$Y \rightarrow bY \mid aY \mid c \mid \varepsilon$

OR

$S \rightarrow aXbX$
$X \rightarrow aY \mid bY \mid \varepsilon$
$Y \rightarrow X \mid c$

4. a) Consider the following Turing machine. 4 CO3 A



Give the sequence of configurations that the machine enters when started with the following strings.

i. 0000
ii. 000000

b) Give the implementation-level description of Turing Machine that accepts the following languages (*any two*): 6 CO3 C

(i) **L = {w | w is the set of strings with an equal number of 0's and 1's}.**
(ii) **L = {ww^R | w is any string of 0's and 1's}.**
(iii) **L = n − 1, where n > 0.**

5. a) Convert any one of the following CFG into an equivalent CFG in Chomsky normal form. 4 CO2 A

$S \rightarrow aSb \mid bY \mid Ya$
$Y \rightarrow bY \mid aY \mid c \mid \varepsilon$

OR

$S \rightarrow aXbX$
$X \rightarrow aY \mid bY \mid \varepsilon$
$Y \rightarrow X \mid c$

b) Find out whether the following problem is decidable or not. 3 CO4 E

Is a number 'm' prime?

OR

Determining if a given graph G is connected.

c) What are NP-complete and NP-Hard problems? How can you show that a problem is NP-complete? 3 CO5 U

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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? **OR** Define and differentiate between the following. a. Derivation and Parse Tree b. Leftmost and Rightmost derivation	CO1	U	3
b)	What is ambiguity? Determine whether the following grammar is ambiguous. $S \rightarrow AB$ $A \rightarrow aA \mid abA \mid \varepsilon$ $B \rightarrow bB \mid abB \mid \varepsilon$	CO2	N	3
c)	Consider the following grammar $S \rightarrow SSx \mid SSy \mid SSz \mid a \mid b \mid c$ 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.	CO2	A	4
2.				
a)	Show using the pumping lemma which of the following languages are context-free. i. $L1 = \{w \mid w \in a^n b^n c^{2n} \mid n \geq 0\}$ ii. $L2 = \{w \mid w \in a^n b^n c^n \mid n \geq 0\}$ **OR** Describe the following languages using a context-free grammar. a. 0^*1^* b. $1(01)^*$ c. $(11 \cup 0)^*$	CO2	N	3
b)	Give a context-free grammar (CFG) for each of the following languages over the alphabet $\Sigma = \{a,b\}$:- i. $L = \{a^{2n} b^m c^n \mid n \geq 0\}$ ii. $L = \{a^m b^n c^{m+n} \mid n \geq 0\}$	CO2	C	4
c)	Convert the following CFG into an equivalent CFG in Chomsky normal form. $R \rightarrow aSa \mid bRb \mid S$ $S \rightarrow aTb \mid bTa \mid aS$ $T \rightarrow XTX \mid X \mid \varepsilon$ $X \rightarrow a \mid b$	CO2	N	3

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 $L = \{a^{2n}b^{m}c^{n} \mid n \geq 0\}$	CO3	C	4
	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 $S \rightarrow XYm \mid XYn$ $X \rightarrow aX \mid \varepsilon$ $Y \rightarrow bY \mid \varepsilon$ **OR** $S \rightarrow aXbY$ $X \rightarrow aYa \mid \varepsilon$ $Y \rightarrow bXb \mid c \mid \varepsilon$	CO3	N	4

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, 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.	CO5	N	4