

# International Islamic University Chittagong

## Department of Computer Science and Engineering

B. Sc. in CSE Final Examination, Autumn 2021

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

1. CO DL
- a) Convert the following regular expressions to NFA. 2 CO1 A
- i)  $a(aa)^* \cup (bb)^*$
- ii)  $a(a \cup b)^*a \cup b(a \cup b)^*b$
- b) What is ambiguity? Determine whether the following grammar is ambiguous. 3 CO2 N
- $S \rightarrow AB$   
 $A \rightarrow aA$   
 $A \rightarrow abA$   
 $A \rightarrow \epsilon$   
 $B \rightarrow bB$   
 $B \rightarrow abB$   
 $B \rightarrow \epsilon$
- 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. CO DL
- a) Differentiate between DFA and NFA. 5 CO1 A
- Construct a DFA that recognize the following language. In all parts, the alphabet is  $\{0,1\}$ :  $\{w \mid w \text{ begins with a 1 and ends with 0}\}$
- Or
- Construct a Deterministic Finite Automata,  $\Sigma = \{a,b\}$  and  $L(M) = \{\omega \mid \omega \text{ Starts and ends with different symbol}\}$ .
- 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+ CO2 A  
4
- $$L = \{w \mid w \in a^n b^n b^n\}$$
- ii) Convert any one of the following CFG into an equivalent CFG in Chomsky normal form.
- $$\begin{aligned} R &\rightarrow aRb \mid bRb \mid S \\ S &\rightarrow aTa \mid bTa \\ T &\rightarrow XTX \mid X \mid \epsilon \\ X &\rightarrow a \mid b \end{aligned}$$
- Or**
- 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
- $$S \rightarrow ABAC, A \rightarrow aA\epsilon, B \rightarrow bB\epsilon, C \rightarrow c$$
- Or**
- Convert any one of the following context-free grammar (CFG) to an equivalent pushdown automaton
- $$\begin{aligned} R &\rightarrow XRX \mid S \\ S &\rightarrow aTa \mid bTb \\ T &\rightarrow bTa \mid abTb \mid X \mid \epsilon \\ X &\rightarrow a \mid b \end{aligned}$$
- 4.
- a) Give the implementation-level description of Turing machine that decides the following languages (any two) 6 CO3 C
- $\{w \mid w \text{ contains three times as many 1s as 0s}\}$
  - $B = \{0^m 1^n 2^{m-n} \mid m, n > 0 \text{ and } m > n\}$
  - $\{w \mid w \text{ is a string with 0s and 1s and contains 1s in a multiple of 3}\}$
  - $B = \{0^i 1^j 2^k \mid i+k = 2*j \text{ and } i, j, k > 0\}$
- 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