BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations (January 2020 Term)

Sub: **CSE 211** (Theory of Computation)

Full Marks: 180 Section Marks: 90 Time: 2 Hours (Sections A + B)

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – B

There are **EIGHT** questions in this section. Answer any **SIX**.

5. Give context-free grammars that generate the following languages for an alphabet, $\Sigma = \{0,1\}$: 7+8

   a) $\{w \mid w$ contains at least one 0 and at least one 1$\}$,

   b) The set of all strings with equal number of 0s and 1s.

6. Design a context-free grammar for an alphabet, $\Sigma = \{a,b,c,d\}$ that generates the language, 10+5

   $L=\{a^n b^n c^m d^m \mid n \geq 1,\ m \geq 1\} \cup \{a^n b^m c^m d^n \mid n \geq 1,\ m \geq 1\}$

   Show that the grammar you designed is ambiguous by giving two different parse trees for some string in the language.

7. The following are the productions of a grammar G in Chomsky Normal Form (S is the start symbol). 15

   $S \rightarrow BZ \mid CY \mid ZZ \mid YY$

   $B \rightarrow ZA$

   $C \rightarrow YA$

   $A \rightarrow ZA \mid YA \mid 0 \mid 1$

   $Z \rightarrow 0$

   $Y \rightarrow 1$

   Determine whether 10011 is in $L(G)$ using the CYK algorithm (you need to show the table).

8. Design a pushdown automaton (PDA) that recognizes the language $\{a^i b^j c^k \mid i, j, k \geq 0$ and $(i=j$ or $i=k)\}$. Show its transition diagram. Recall that, PDAs are non-deterministic. 15

9. Design a Turing machine (TM) that takes as input two numbers, w_1 and w_2 in binary of equal lengths and computes the logical XOR of the two numbers. The tape initially contains $w_1 c w_2 c$ where 'c' is a tape symbol that is used as the separator. Your TM should terminate with the XOR of the two numbers in binary after the second c. (You can use multiple tracks and storage in the state if you wish). 15

10. Briefly explain whether the following statements are true or false: 7+8

    i) A one-tape Turing machine with multiple tracks and storage in the state can simulate a multi-tape Turing machine.

    ii) A deterministic Turing machine can simulate n steps of a conventional computer in $P(n)$ steps, where $P(n)$ is some polynomial in n.

11. a) Define recursively enumerable (RE) languages and recursive languages. 7+8

    b) Give one example of the following (with definitions):

    i) A language that is not recursively enumerable (not RE),

    ii) A language that is RE but not recursive.

12. a) State Cook's theorem. Explain why finding a polynomial time algorithm for an NP-complete problem implies P=NP. 7+8

    b) Draw the Venn diagram showing the widely believed relationships (whether they are equal or which one is a subset of the other) among the classes of problems P, NP, PSPACE, NPSPACE and EXPTIME. Briefly justify your answer.