



United International University

Department of Computer Science and Engineering

CSE 2233: Theory of Computation Final: Spring 2025

Total Marks: 40 Time: 2 hours

Any examinee found adopting unfair means will be expelled from the trimester / program as per UIU disciplinary rules.

Answer all the questions. The numbers on the right of the questions denote their marks.

1. Consider the following **Context-free grammars (CFG)** and answer according to it:

- (a) With the help of the leftmost derivation, derive the following string: (4)
if (a > b) { printf("Hello World!"); }

$$\begin{aligned} S &\rightarrow \text{if } P Q \mid \text{else } P Q \\ P &\rightarrow (X) \\ Q &\rightarrow \{Y\} \\ Y &\rightarrow \text{printf } P Z \\ X &\rightarrow X Z X \mid a \mid b \mid " \mid " \\ Z &\rightarrow > \mid < \mid \geq \mid \leq \mid \text{Hello World!} \mid ; \mid \varepsilon \end{aligned}$$

- (b) With the help of Top-Down Parse Trees, find out if the grammar is ambiguous or not for the string: (4)
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$$\begin{aligned} S &\rightarrow X Y \\ X &\rightarrow 0 X 1 \mid \varepsilon \\ Y &\rightarrow P Q \mid \varepsilon \\ P &\rightarrow 0 P \mid \varepsilon \\ Q &\rightarrow 1 Q \mid \varepsilon \end{aligned}$$

2. Design CFGs that generate the following languages

- (a) $L = \{a^n b^m c^o \mid m = 2n \text{ or } o = 3m, n, m, o \geq 0\}$ (2)
(b) $L = \{w \in \{0, 1\}^* \mid \text{every 1 is followed by two 0's}\}$ (2)
(c) $L = \{w \in \{x, y, z\}^* \mid \text{the 3rd last symbol of } w \text{ is } x\}$ (2)
(d) $L = \{w \in \{0, 1, 2\}^* \mid w \text{ has the substring } 000 \text{ in the middle}\}$ (2)

3. Convert the following CFG's into equivalent Chomsky Normal Form (CNF)

- (a) (4)

$$\begin{aligned} E &\rightarrow E O E \mid (E) \mid (E)(E) \mid D N \\ N &\rightarrow D N \mid \varepsilon \\ D &\rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9 \\ O &\rightarrow + \mid - \mid \times \mid \div \end{aligned}$$

- (b) (4)

$$\begin{aligned} X &\rightarrow W X W \mid Y b b \\ W &\rightarrow a a \mid b b \\ Y &\rightarrow b a b \end{aligned}$$

4. Draw the **Push Down Automata (PDA)** for the following languages:

- (a) (4)

$$L = \{x^n \# y^{3m} z^{2n} \mid n \geq 2, m \geq 0\}$$

- (b) (4)

$$L = \left\{ a^{2p} b^q c^r d^w \mid q = \frac{r}{3}, w = p + 2, p, q, r \geq 1 \right\}$$

5. (a) Draw a Turing Machine for the following language (4)

$$L = \{x^{3i} y^{2j} z^{2i} w^{3j} \mid i, j \geq 1\}$$

- (b) Show the Tape Traversal to validate the given input for the above language: (4)

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