Indian Institute of Information Technology Sri City, Chittoor

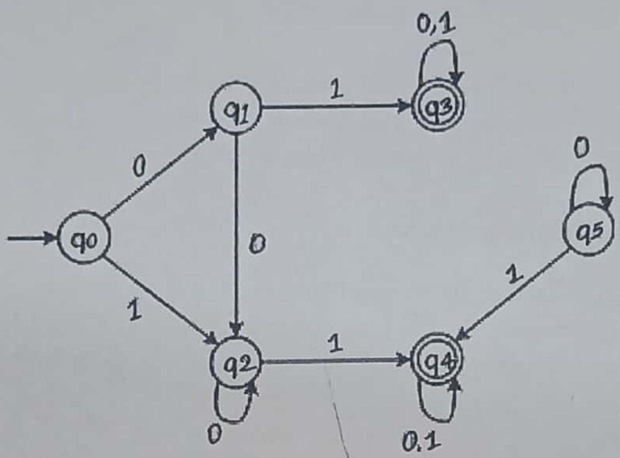
Theory of Computation – Spring 2023 | Mid 2 Examination

Duration: 90 Minutes | Date: 11/03/2023 | Maximum Marks : 60

- It is a closed book exam.
- No electronic devices, books, any kind of material is allowed.

Q1. Answer the following:

Q1.(a). Apply Myhill-Nerode Theorem (the Table Filling Method) to minimize the following DFA. In the given DFA, **Q={q0, q1, q2, q3, q4, q5}, F={q3, q4}, and** $\sum = \{0, 1\}$. [8 Marks]



Q1.(b) Convert the following CFG to CNF (Chomsky Normal Form). [10 Mark]

S→ASB, A→aAS|a|ϵ **, B→SbS|A|bb**

Q1.(c) Consider the following languages (L1, L2, L3, and L4) over $\sum = \{0, 1\}$. For which of the following languages, we can construct DPDA accepted by an empty stack? [2 mark]

(i) **L1 = 0*** (ii) **L2 = 0*1** (iii) **L3 =** $\{0^n1^n \mid n \geq 0\}$ (iv) **L4 =** $\{0^n1^n \mid n \geq 1\}$

Q2. For the given CFG apply CYK algorithm to find whether the strings (i) *abbabab* and (ii) *baabab* are in the language of the CFG or not. Students should strictly use the table filling algorithm given by the CYK method.

$S \to XB|YA,\ X \to a,\ Y \to b,\ B \to b|YS|CB,\ C \to XB,\ A \to a|XS|DA,\ D \to YA$ [10+10 = 20Marks]

Q3. Let $\Sigma = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$ be an alphabet. We know that the operation *(mod 3)* is an equivalence relation and it divides the strings into three equivalence classes, denoted as $[0], [1], [2]$. We define each class as $[x] = \{y \in \Sigma^* \mid y \ (mod\ 3) = x\}$, where $x \in \{0, 1, 2\}$, for example, $[0] = \{0, 3, 6, 9, 12, 15, ...\}$. Assume that the strings w over Σ are identified as equivalent non-negative integers. If a string w = 001232, then the machine should skip (but, not avoid reading symbols from string) the starting 0s, that is, w will be identified as equivalent to number 1232 by the machine.

Finding the remainder using the number division method is defined with operation [x].y = xy (mod 3), where $x \in \{0, 1, 2\}$ and $y \in \Sigma$. We find the value of *857 (mod 3)* as follows. Note that we read strings from left to right.

- **Read 8 (first symbol):** $8 = 08 = [0].8 = 08 \ (mod\ 3) = 2$, this implies, $8 \in [2]$
- **Read 5:** $85 = [2].5 = 25 \ (mod\ 3) = 1$, this implies, $25 \in [1]$
- **Read 7:** $857 = [1].7 = 17 \ (mod\ 3) = 2$, this implies, $857 \in [2]$

Assume "$" is stack start symbol and the language is defined as $L = \{w \in \Sigma^* \mid w \text{ contains at least two non-overlapping substrings } s, \text{ with } s \ (mod\ 3) = 1 \text{ and } |s| > 0\}$. For example, consider the string *220392072* is in the language *L*. Then, **22** and **207** are two non-overlapping substrings yielding remainder *1 (mod 3)*.

Using above theory, answer the following questions:

Q3.(a). Explain clearly the logic step-wise to develop PDA to recognize the language L.[5M]
Q3.(b).Draw state transition diagram of PDA N(P), accepting by empty stack, for the language L. [10M]
Q3.(c). Give all execution states that show the string 220392072 will accept by N(P). [5M]

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