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# Indian Institute of Information Technology, Lucknow

End-Semester Examination November 2024

Regular and Back

**Theory of Automata (TOA3300C)**

**B.Tech. (IT/CS/CSAI/CSB)-3rd Semester**

**QPS: Dr. Soumendu Chakraborty**

**Max Time: 3 Hours** **Max Marks: 70**

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**Note:** This question paper contains ***SIX*** questions and ***ONE*** page. Attempt ***ALL*** questions. Some of the questions have sub-parts. Carefully read all the questions before answering. Answers to all the questions and their sub-parts should be written in the same order as of the respective questions. Marks are indicated against each question. Assume the suitable data and mention in the answer sheet clearly, if found missing.

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**Q.1.** **a)** Define an operation third on strings and languages as

*Third (a1 a2 a3 a4 a5 a6 ...) = a3 a6 ...*

with the appropriate extension of this definition to languages. Prove the closure of the family of regular languages under this operation.

**b)** Find a regular grammar for the language

$\mathbf{L = \{a^n b^m | : n + m \text{ is even}\}}$ **[6+4]**

**Q.2.** Convert the following regular expressions to non-deterministic finite automata.

**(a)** L = L (ab*a*)∪L ((ab)* ba) **(b)** L = L (ab*a*)∩L ((ab)* ba).

**[4+6]**

**Q.3.** Show that there will be a repetition of variable in the derivation tree, if the length of the string is at least $2^n$. The total number of variables in the context free grammar is n.

**[7]**

**Q.4.** **a)** Prove that, if a language is context free, then some pushdown automata recognize it.

**b)** Suppose that G = (V, T, S, P) is a context-free grammar that does not have any rules of the form $A \rightarrow \lambda$, or $A \rightarrow B$, where $A, B \in V$. Then the exhaustive search parsing method can be made into an algorithm which, for any $w \in \Sigma^*$, either produces a parsing of w or tells us that no parsing is possible.

**[9+6]**

**Q.5.** **a)** Find context-free grammar for the following language (with $n \geq 0$, $m \geq 0$, $k \geq 0$).

$\mathbf{L = \{a^n b^m c^k : n = m \text{ or } m \leq k\}}$.

**b)** Design NPDA for the following language

$\mathbf{L = \{w : n_a(w) + n_b(w) = n_c(w)\}}$.

**[8+7]**

**Q.6.** **a)** Design Turing machine for the following language

$\mathbf{L = \{a^n b^m c^k : k = n \times m;\ n, m, k \geq 1\}}$.

**b)** Design a Turing machine over $\Sigma = \{a, b\}$, and $\Gamma = \{a, b, \sqcup\}$ to shift the input string to the right by one square. The design should include transition graph and transition function.

**[6+7]**