

## Automata Theory Midterm Exam Solution 08 30 10 00 Am

Automata Theory Midterm Exam Solution 08 30 10 00 Am Automata Theory Midterm Exam Solution 08301000 AM This document provides a comprehensive solution to the Automata Theory midterm exam held on August 30th 2010 at 1000 AM It covers the essential concepts of finite automata regular expressions and contextfree grammars providing detailed explanations and solutions to the exam questions Note The actual exam questions might be different from those presented here This document aims to provide a general understanding of the concepts tested and how to approach similar questions

Question 1 Finite Automata a Construct a DFA that accepts all strings over the alphabet  $a, b$  that contain at least two consecutive  $b$ s Solution The DFA can be constructed as follows States  $q_0, q_1, q_2, q_3$  Start state  $q_0$  Accepting state  $q_3$  Transitions  $q_0 \xrightarrow{a} q_0, q_0 \xrightarrow{b} q_1, q_1 \xrightarrow{a} q_0, q_1 \xrightarrow{b} q_2, q_2 \xrightarrow{a} q_0, q_2 \xrightarrow{b} q_3, q_3 \xrightarrow{a} q_3, q_3 \xrightarrow{b} q_3$  Explanation 2 State  $q_0$  represents the initial state where no  $b$  has been encountered yet State  $q_1$  represents the state where one  $b$  has been encountered State  $q_2$  represents the state where two consecutive  $b$ s have been encountered State  $q_3$  is the accepting state and remains in this state upon encountering any further  $b$ s b Convert the DFA in part a to a regular expression Solution The regular expression can be obtained using the state elimination method

- 1 Eliminate  $q_1$  Replace the transition from  $q_0$  to  $q_1$  with the expression  $b$  Replace the transition from  $q_1$  to  $q_2$  with the expression  $b$  Remove  $q_1$  and its transitions
- 2 Eliminate  $q_2$  Replace the transition from  $q_0$  to  $q_2$  with the expression  $bb$  Replace the transition from  $q_2$  to  $q_3$  with the expression  $b$  Remove  $q_2$  and its transitions
- 3 Final expression The remaining

transitions are  $q_0 \xrightarrow{a} q_0$ ,  $q_0 \xrightarrow{b} q_3$ ,  $q_3 \xrightarrow{a} q_3$ ,  $q_3 \xrightarrow{b} q_3$ . This can be represented by the regular expression  $ab^*ab^*$ . Question 2 Regular Expressions a Give a regular expression that accepts all strings over the alphabet  $\{a, b\}$  that contain an even number of  $a$ 's and an odd number of  $b$ 's. Solution The regular expression can be constructed as follows: Even  $a$ 's:  $(ba)^*$  Odd  $b$ 's:  $b(a^*b)^*$  The complete expression is  $(ba)^*b(a^*b)^*$ . 3 Explanation The first part  $(ba)^*$  ensures an even number of  $a$ 's by accepting any combination of  $ba$ 's followed by two  $a$ 's. The second part  $b(a^*b)^*$  ensures an odd number of  $b$ 's by starting with a  $b$  and then accepting any combination of  $a$ 's followed by a  $b$ . b Show that the language accepted by the regular expression  $ab^*$  is a subset of the language accepted by the regular expression  $a^*b^*$ . Solution To prove this we need to show that any string accepted by  $ab^*$  is also accepted by  $a^*b^*$ . This expression accepts strings consisting of any number of repetitions of the substring  $ab$ . This expression accepts any string containing  $a$ 's and/or  $b$ 's. Since any string composed solely of  $ab$  repetitions is also a combination of  $a$ 's and  $b$ 's, any string accepted by  $ab^*$  is also accepted by  $a^*b^*$ . Therefore the language accepted by  $ab^*$  is a subset of the language accepted by  $a^*b^*$ . Question 3 ContextFree Grammars a Construct a CFG that generates the language  $\{a^n b^m c^m \mid n \geq 1, m \geq 0\}$ . Solution The CFG can be constructed as follows:  $S \rightarrow aSc \mid T$ ,  $T \rightarrow bTc \mid \epsilon$ . Explanation  $S$  The start symbol representing the entire language.  $T$  Represents the substring of  $b$ 's and  $c$ 's.  $aSc$  Generates strings with an equal number of  $a$ 's and  $b$ 's followed by any number of  $c$ 's.  $bTc$  Generates strings with any number of  $b$ 's followed by any number of  $c$ 's.  $\epsilon$  Represents the empty string allowing for zero  $c$ 's in the language. b Show that the language  $\{a^n b^n c^n \mid n \geq 1\}$  is not contextfree. 4 Solution We can use the Pumping Lemma for contextfree languages to prove this. Pumping Lemma For any contextfree language  $L$  there exists a pumping length  $p$  such that for any string  $s$  in  $L$  with length greater than or equal to  $p$ ,  $s$  can be decomposed as  $s = uvxyz$  where  $|vwx| \leq p$ ,  $|vx| \geq 1$ . For all  $i \geq 0$ ,  $uv^i xy^i z$  is also in  $L$ . Proof Let's assume the language  $\{a^n b^n c^n \mid n \geq 1\}$  is contextfree. Then there exists

a pumping length  $p$ . Choose a string  $s = a^p b^p c^p$ . Since  $|s| = 3p \geq p$ ,  $s$  can be pumped according to the Pumping Lemma. According to the lemma, we can decompose  $s$  as  $s = uvxyz$  where  $|vwx| \leq p$  and  $|vx| \geq 1$ . This means that either  $v$  or  $x$  must contain at least one  $a$  or  $b$ , as they cannot contain only  $c$ 's because  $|vwx| \leq p$  and the first  $p$  symbols are all  $a$ 's and  $b$ 's. Now consider the string  $uv^2xy^2z$ . If  $v$  contains an  $a$ , then  $uv^2xy^2z$  will have more  $a$ 's than  $b$ 's. If  $v$  contains a  $b$ , then  $uv^2xy^2z$  will have more  $b$ 's than  $a$ 's. In either case,  $uv^2xy^2z$  will not be in the language  $\{a^n b^n c^n \mid n \geq 1\}$ . Therefore, we have reached a contradiction, proving that our initial assumption that  $\{a^n b^n c^n \mid n \geq 1\}$  is context-free is incorrect. Hence, the language is not context-free.

**Conclusion:** This document provided a detailed solution to a hypothetical Automata Theory midterm exam. It demonstrated how to construct finite automata, convert them to regular expressions, and use regular expressions to represent languages. Additionally, it covered the construction of context-free grammars and the use of the Pumping Lemma to prove that certain languages are not context-free. Note: This document is meant as a guide and should not be used as a substitute for proper learning and understanding of Automata Theory. It is recommended to study relevant textbooks and practice solving various problems to gain a comprehensive understanding of the subject.

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