Middle East Technical University Department of Computer Engineering

CENG 280

Formal Languages and Abstract Machines

Spring 2022-2023

Homework 3

Regulations (Please Read!)

1. The homework is due by **23:59 on April 24th, 2023**. Late submission is not allowed.
2. Submissions will be collected via ODTUClass. Do not send your homework via e-mail.
3. You can use any typesetting tool (LaTex, Word, etc.) while writing the homework. However, you must upload the homework as a **searchable pdf file**. Other formats (e.g handwriting etc.) will **not** be considered for grading.
4. Name the PDF file you submit as **HW3_yourStudentID.pdf** (e.g. HW3_1234567). Submissions violating the naming convention will be penalized.
5. Write your name and student ID number to the top of your solution sheets. A grade reduction will be applied to the solution sheets without a name and ID on them.
6. Send an e-mail to **both garipler@metu.edu.tr** and **bugra@ceng.metu.edu.tr** if you need to get in contact.
7. Please give as neat and as brief answers as possible.
8. **This is an individual homework, which means you have to answer the questions on your own. Any contrary case including but not limited to getting help from automated tools, sharing your answers with each other, extensive collaboration etc. will be considered as cheating and university regulations about cheating will be applied.**

Question 1 (45 pts)

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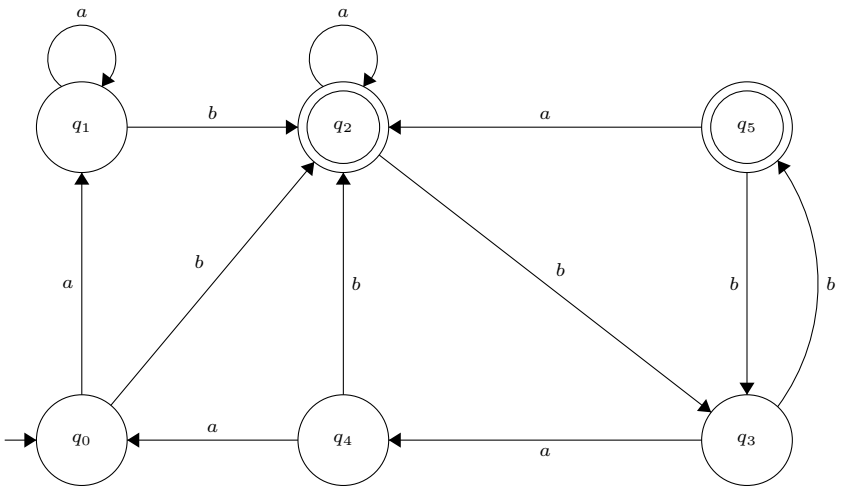

Figure 1. M_1

1. Using the state minimization algorithm you have learned, find and draw the minimal DFA that is equivalent to M_1. **Show each step of your solution clearly.**

2. Define each equivalence class of the automaton you have found at part-a with regular expressions. **Hint&Remark:** In your regular expressions, you are allowed to use the symbol L to denote all strings recognized by the automaton (e.g. $[\epsilon] = Lbaa$).

3. Use MyHill-Nerode Theorem to **prove** that the language $L' = \{a^n b^m c^k d^u : m + n = k + 2u \text{ and } m, n, k, u \in \mathbb{N}\}$ is not regular.

Question 2 (33 pts)

Give context-free grammars generating the following languages:

1. The strings over the alphabet $\{a, b\}$ with more $b's$ than $a's$.

2. $A = \{0^i 1^j 2^k \mid i + k = j \textit{ and } i, j, k \geq 0\}$

3. $B = \{w \mid \textit{the length of } w \textit{ is odd and } w \in \{0,1\}^*\}$ and draw parse tree for string 0011100.

Question 3 (22 pts)

Give the (context-free) languages generated by each of the given grammars:

1. 1. $G_1 = (V_1, \Sigma, R_1, S_1)$ where $V_1 = \{S_1, A\} \cup \Sigma$, $\Sigma = \{0, 1\}$ and
   $R_1 =$ {`S1 -> 0A0 | 1A1 | e`
   `A -> 0A | 1A | e` }

2. $G_2 = (V_2, \Sigma, R_2, S_2)$ where $V_2 = \{S_2, B\} \cup \Sigma$, $\Sigma = \{0, 1\}$ and
   $R_2 =$ {`S2 -> B1B1B`
   `B -> 0B | 1B | e` }