Aufgabe 1 (Regular Languages). (12 Punkte)

(i) Which of the following claims hold? 3

(a) Nondeterministic finite automata (NFA) are strictly more expressive (i.e., describe more languages) than regular expressions.

☐ Yes ☐ No

(b) The class of all languages recognisable by deterministic finite automata (DFA) is closed under intersection.

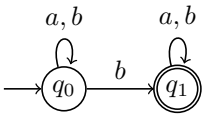
☐ Yes ☐ No

(c) The language $\{a^k b^{k+l} c^l \mid k, l \in \mathbb{N}\}$ is regular.

☐ Yes ☐ No

(ii) Construct a regular expression that describes the language of all finite words w over $\{a, b\}$ for which $|w|$ is divisible by 3. 2

(iii) Apply the powerset construction to turn the following nondeterministic finite automaton (NFA) $\mathfrak{A}$ into a deterministic finite automaton (DFA) $\mathfrak{A}'$. 4



(iv) Is $\mathfrak{A}'$ minimal? Please justify your answer in the following way: 3

"yes": give a distinguishing word for each pair of states;

"no": give two equivalent states and explain why they are equivalent.

Aufgabe 2 (Context-Free Languages). (13 Punkte)

(i) Which of the following claims hold? 3

(a) Every regular expression can be translated into an equivalent context-free grammar.

☐ Yes ☐ No

(b) The language $\{a^n b^n c^n \mid 1 \leq n\}$ is context-free.

☐ Yes ☐ No

(c) Context-free languages are closed under intersection.

☐ Yes ☐ No

(ii) Give a context-free grammar G which generates the language 4

$$L := \{a^n b^{n+m} c^m \mid k, l \geq 1\}.$$

(iii) Give a derivation of the word $aabbbc \in L$ from the start symbol of G. 1

(iv) Let G' be the following context-free grammar in Chromsky normal form: 5

$$\begin{aligned} S &\to AS \mid b \\ A &\to SA \mid a \end{aligned}$$

and let $w := bbaab$. Employ the CYK-Algorithm to show that $w \in L(G')$. Use the following table to compute the sets

$$N_{i,j} := \{A \in N \mid A \Rightarrow^* w[i,j]\} \qquad (1 \leq i \leq j \leq 5)$$

where $w[i,j] := a_i \dots a_j$ for $w = a_1 a_2 a_3 a_4 a_5$.

$i \backslash j$	1	2	3	4	5
1					
2	X				
3	X	X			
4	X	X	X		
5	X	X	X	X	