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**Second Midterm (30 pts)**

This is an open book exam. You are allowed to consult only Sudkamp text during the exam.

**1 Normal Forms (5 + 7)**

Express the following grammar in Chomsky Normal Form and in Griebach Normal Form. Write the intermediate steps clearly.

$$\begin{aligned} S &\rightarrow aA \mid ABa \\ A &\rightarrow AA \mid a \\ B &\rightarrow AbA \mid b \end{aligned}$$

(Nonterminals are S, A, and B. Terminals are 'a', 'b'. S is the start symbol.)

**2 Context-free grammars (5)**

Construct a grammar over  $\{a, b, c\}$  whose language is

$$\{ a^n b^m c^i \mid 0 \leq n + m \leq i \}.$$

**3 DFA Construction (8)**

Construct a DFA for the language over the alphabet  $\{0, 1, 2\}$  in which every 1 is immediately followed by at least one 2.

**4 NFA Construction (5 pts)**

Construct an NFA- $\lambda$  for the language of binary numerals (bit strings) that are divisible by 4. That is,  $0 \in \mathcal{L}$ ,  $0011100 \in \mathcal{L}$ ,  $\lambda \notin \mathcal{L}$ ,  $1001 \notin \mathcal{L}$ , etc.