Formal Languages and Automata Theory
Exercise sheet 1: Pumping Lemma and Closure Properties for CFLs

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Exercise 1 *(4 points) Is the language $a^i b^k c^i d^n$ context free? If yes, provide a grammar. If no, use the pumping lemma to show it is not.*

Exercise 2 *(6 points) Is the language $a^i b^k c^i d^i$ context free? If yes, provide a grammar. If no, use the pumping lemma to show it is not.*

Exercise 3 *(4 points for union+concatenation+closure, 6 points for intersection+complement). Explore whether CFGs are closed under*

1. *union*

2. *concatenation*

3. *closure*

4. *intersection*

5. *complement*

Hint: *if yes, you should provide an algorithm to construct a CFG that accepts a the resulting language. If no, you should provide a proof that ultimately goes back to the pumping lemma.*