# NTIN071 A&G: Tutorial 7 – Chomsky normal form, The CYK algorithm

**Teaching goals:** The student is able to

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## In-class problems

**Problem 1** (Useless symbols)**.** Recall the process of converting a context-free grammar to Chomsky Normal Form. Then answer the following questions. Justify.

(a) Find an example of a grammar in which there is a generating variable only reachable via nongenerating variables.

(b) When reducing a grammar, which variables do we need to remove first: nongenerating or unreachable?

(c) Is it possible for a reachable generating variable to become nongenerating after the removal of unreachable variables?

**Problem 2** (Convert to ChNF)**.** Convert the following context-free grammars to Chomsky normal form:

(a)

$$\begin{aligned} G_1 &= (\{S, A, B\}, \{0, 1\}, S, \mathcal{P}) \\ \mathcal{P} &= \{S \to 0AB, \\ &\quad A \to 0A0 \mid 11, \\ &\quad B \to 0\} \end{aligned}$$

(b)

$$\begin{aligned} G_2 &= (\{S, A, B\}, \{0, 1\}, S, \mathcal{P}) \\ \mathcal{P} &= \{S \to 0A10B10, \\ &\quad A \to 1A0 \mid \epsilon, \\ &\quad B \to 1B00 \mid \epsilon\} \end{aligned}$$

**Problem 3** (The CYK algorithm)**.** Using the CYK algorithm determine if $w \in L(G)$.
$w = 0110$, $G = (\{S, A, B\}, \{0, 1\}, S, \mathcal{P})$,

$$\begin{aligned} \mathcal{P} = \{&S \to 0 \mid AB, \\ &A \to 1 \mid SA \mid SB, \\ &B \to AS \mid BA \mid 0\} \end{aligned}$$

## Extra Practice and Thinking

**Problem 4** (Convert to ChNF)**.** Convert the following context-free grammar to Chomsky normal form:

(a)

$$\begin{aligned} G &= (\{S, A, B\}, \{0, 1\}, S, \mathcal{P}) \\ \mathcal{P} &= \{S \to A \mid 0SA \mid \epsilon, \\ &\quad A \to 1A \mid 1 \mid B1, \\ &\quad B \to 0B \mid 0 \mid \epsilon\} \end{aligned}$$

(b)

$$\begin{aligned} G &= (\{S, E, F\}, \{(,), *, +, , 1\}, S, \mathcal{P}) \\ \mathcal{P} &= \{S \to (E), \\ &\qquad E \to F + F \mid F * F, \\ &\qquad F \to S \mid 1\} \end{aligned}$$

**Problem 5** (The CYK algorithm)**.** Using the CYK algorithm determine if $w \in L(G)$.

(a) $w = abcbb$, $G = (\{S, A, B, C\}, \{a, b, c\}, S, \mathcal{P})$,

$$\begin{aligned} \mathcal{P} = \{&S \to CA \mid CB, \\ &B \to CBA \mid CB \mid BA \mid BB, \\ &C \to ABC \mid BC, \\ &A \to a, B \to b, C \to c\} \end{aligned}$$

(b) $w = abcbb$, $G = (\{S, A, B, C\}, \{a, b, c\}, S, \mathcal{P})$,

$$\begin{aligned} \mathcal{P} = \{&S \to CA \mid CB, \\ &B \to CBA \mid CB \mid BA \mid BB, \\ &C \to ABC \mid BC, \\ &A \to a, B \to b, C \to c\} \end{aligned}$$