

GREIBACH NORMAL FORM



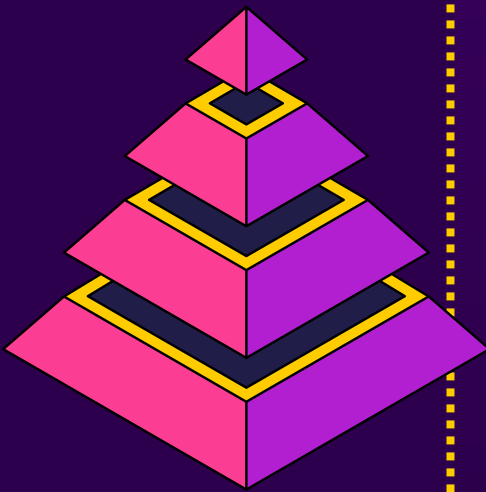
Introduction



Greibach Normal Form (GNF) is a specific type of normal form used in the context of formal languages and automata theory. It was introduced by Sheila Greibach in 1965.

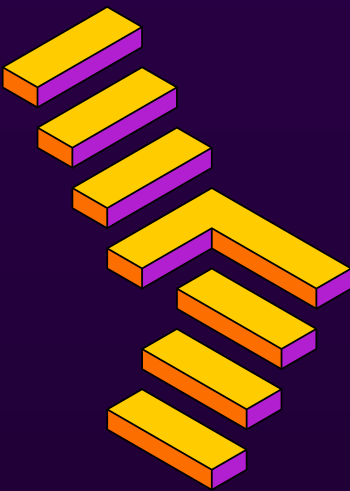
Definition

A grammar is said to be in Greibach Normal Form if all production rules have a specific form. In other words, the right-hand side of each production in GNF must either consist of a single terminal symbol or a single nonterminal symbol followed by a string of terminal symbols.



Rules

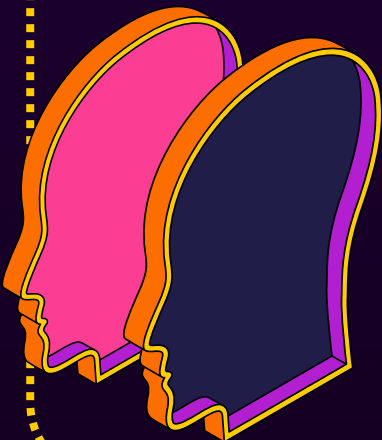
- A start symbol generating ϵ . For example, $S \rightarrow \epsilon$.
- A non-terminal generating a terminal. For example, $A \rightarrow a$.
- A non-terminal generating a terminal which is followed by any number of non-terminals. For example, $S \rightarrow aASB$.



A context-free grammar is in Greibach normal form, if all production rules are of the form:

$$A \rightarrow aA_1A_2\dots A_n$$

Example



1. $G_1 = \{S \rightarrow aAB \mid aB, A \rightarrow aA \mid a, B \rightarrow bB \mid b\}$
2. $G_2 = \{S \rightarrow aAB \mid aB, A \rightarrow aA \mid \epsilon, B \rightarrow bB \mid \epsilon\}$

Solved Problem

Problem:
 $S \rightarrow XB \mid AA$
 $A \rightarrow a \mid SA$
 $B \rightarrow b$
 $X \rightarrow a$

Solution:
Step 1: Convert to CNF
 $S \rightarrow aB \mid AA$
 $A \rightarrow a \mid aBA \mid AAA$
 $B \rightarrow b$
 $X \rightarrow a$

Step 2: Remove left recursion
 $S \rightarrow aB \mid AA$
 $A \rightarrow aC \mid aBAC$
 $C \rightarrow AAC \mid \epsilon$
 $B \rightarrow b$
 $X \rightarrow a$
Remove null productions \longrightarrow
 $S \rightarrow aB \mid AA$
 $A \rightarrow aC \mid aBAC \mid a \mid aBA$
 $C \rightarrow AAC \mid AA$
 $B \rightarrow b$
 $X \rightarrow a$

Step 3: Convert to GNF
 $S \rightarrow aB \mid aCA \mid aBACA \mid aA \mid aBAA$
 $A \rightarrow aC \mid aBAC \mid a \mid aBA$
 $C \rightarrow AAC$
 $C \rightarrow aCA \mid aBACA \mid aA \mid aBAA$
 $B \rightarrow b$
 $X \rightarrow a$
 \longrightarrow
 $S \rightarrow aB \mid aCA \mid aBACA \mid aA \mid aBAA$
 $A \rightarrow aC \mid aBAC \mid a \mid aBA$
 $C \rightarrow aCAC \mid aBACAC \mid aAC \mid aBAAC$
 $C \rightarrow aCA \mid aBACA \mid aA \mid aBAA$
 $B \rightarrow b$
 $X \rightarrow a$

Steps for CFG to GNF

Step 1: Convert the grammar into CNF

Step 2: If the grammar exists left recursion, eliminate it.

Step 3: In the grammar, convert the given production rule into GNF form.

