

# How Can We Define Languages in Computer Science?

Several scientific methods have been developed to precisely define the syntactic rules of languages.

## Backus-Naur Form (BNF):

A **meta-language** used to describe the syntax of languages.

<name>	meta-symbol
::=	definition
	alternative
{expression}	repetition (minimum and maximum repetitions can be specified using subscripts)
GOTO	terminal symbol (in quotes for clarity, can also use apostrophes instead)

### 1. Example: Syntax of License Plates

Let's start with a few typical examples and try to generalize:

ABC-1234, GHT-234, HSD-333, AI-BB-654

Syntax definition:  $\$ \$ \langle \text{license\_plate} \rangle ::= \langle \text{newType} \rangle \mid \langle \text{oldType} \rangle \ \backslash \backslash \langle \text{oldType} \rangle ::= \{ \langle \text{letter} \rangle \}_3^3 - \{ \langle \text{number} \rangle \}_3^3 \ \backslash \backslash \langle \text{newType} \rangle ::= \{ \langle \text{letter} \rangle \}_2^2 - \{ \langle \text{letter} \rangle \}_2^2 - \{ \langle \text{number} \rangle \}_3^3 \ \backslash \backslash \langle \text{letter} \rangle ::= A|B|C\dots|Z \ \backslash \backslash \langle \text{number} \rangle ::= 0|1|2|3|4|5|6|7|8|9 \ \backslash \backslash \$ \$$

### 2. Example: Syntax of Phone Calls in Hungary

Let's list a few examples and try to generalize:

062012345, +36301234567, 0680460046

Syntax definition:  $\$ \$ \langle \text{phone call} \rangle ::= \{ \langle \text{prefix} \rangle \}_0^1 \langle \text{city} \rangle \langle \text{customer} \rangle \ \backslash \backslash \langle \text{prefix} \rangle ::= \{ + \}_0^1 36|06 \ \backslash \backslash \langle \text{city} \rangle ::= \{ \langle \text{number} \rangle \}_1^2 \ \backslash \backslash \langle \text{customer} \rangle ::= \{ \langle \text{number} \rangle \}_6^7 \ \backslash \backslash \langle \text{number} \rangle ::= 0|1|2|3|4|5|6|7|8|9 \ \backslash \backslash \$ \$$

### 3. Example: How can we describe the BNF formula using itself?

$\langle \text{BN formula} \rangle ::= \langle \text{rule} \rangle \ \backslash \backslash \langle \text{rule} \rangle ::= \langle \text{identifier} \rangle \ \backslash \backslash \langle \text{expression} \rangle \ \backslash \backslash \langle \text{identifier} \rangle ::= \langle \text{letter} \rangle \ \backslash \backslash \langle \text{letter} \rangle ::= \langle \text{digit} \rangle \ \backslash \backslash \langle \text{expression} \rangle ::= \langle \text{term} \rangle \ \backslash \backslash \langle \text{term} \rangle ::= \langle \text{factor} \rangle \ \backslash \backslash \langle \text{factor} \rangle \ \backslash \backslash \langle \text{factor} \rangle ::= \langle \text{identifier} \rangle \ \backslash \backslash \langle \text{terminal\_symbol} \rangle \ \backslash \backslash \langle \text{terminal\_symbol} \rangle ::= \langle \text{character} \rangle \ \backslash \backslash \langle \text{letter} \rangle ::= \langle \text{uppercase} \rangle \ \backslash \backslash \langle \text{uppercase} \rangle ::= A \ \backslash \backslash B \ \backslash \backslash C \ \backslash \backslash \dots \ \backslash \backslash Z \ \backslash \backslash \langle \text{lowercase} \rangle ::= a \ \backslash \backslash b \ \backslash \backslash c \ \backslash \backslash \dots \ \backslash \backslash z \ \backslash \backslash$

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$\text{\textit{lowercase}} \text{\textit{range}} ::= a \text{\textit{mid}} b \text{\textit{mid}} c \text{\textit{dots}} z \text{\textit{mid}} [ \text{\textit{range}} \text{\textit{digit}} \text{\textit{range}} ::= 0 \text{\textit{mid}} 1 \text{\textit{mid}} 2 \text{\textit{mid}} 3 \text{\textit{mid}} 4 \text{\textit{mid}} 5 \text{\textit{mid}} 6 \text{\textit{mid}} 7 \text{\textit{mid}} 8 \text{\textit{mid}} 9 ]$

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