

## Lecture 14.2: CFG Definitions, Terminologies, Examples-2

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In this lecture, you will learn some more terminologies related to context-free grammar.

Recall, the following grammar you learned in the previous lecture for valid mathematical expressions:

$$\begin{aligned}
 E &\rightarrow (E) \\
 E &\rightarrow E + E \\
 E &\rightarrow E - E \\
 E &\rightarrow E \times E \\
 E &\rightarrow E \div E \\
 E &\rightarrow \text{Num} \\
 \text{Num} &\rightarrow 0|1|2|3|4|5|6|7|8|9
 \end{aligned}$$

### Derivation, Sentential form and Sentence

You should already have a basic idea about the term **derivation**. Recall, we usually say  $S$  *derives a string*  $w$  if we can reach to  $w$  starting from  $S$  by a number of replacements or substitutions. Let's see an alternative derivation of the expression  $4 \times 3 - 2$ :

$4 \times 3 - 2$	Derivation Step
$E$	Sentential Form
$\Rightarrow E - E$	Sentential Form
$\Rightarrow E \times E - E$	Sentential Form
$\Rightarrow \text{Num} \times \text{Num} - \text{Num}$	Sentential Form
$\Rightarrow 4 \times 3 - 2$	Sentential Form
	Sentence

In the above Example we say:

- $E$  derives the string  $4 \times 3 - 2$  and we express it as  $E \xRightarrow{*} 4 \times 3 - 2$ .
- A **sentential form** is any string derivable from the start symbol. Thus, in the derivation of  $4 \times 3 - 2$ ; each intermediate line i.e.  $E - E$ ,  $E \times E - E$ ,  $\text{Num} \times \text{Num} - \text{Num}$  etc. are all sentential forms along with  $E$  and  $4 \times 3 - 2$  themselves.
- A **sentence** is a sentential form consisting only of terminals such as  $4 \times 3 - 2$  in the above example.

## Summary

We can express the derivation of  $w$  from a start symbol  $S$  as  $S \Rightarrow u_1 \Rightarrow u_2 \dots \Rightarrow u_{n-1} \Rightarrow w$  or simply  $S \xRightarrow{*} w$ , where  $S, u_1, u_2 \dots, u_{n-1}, w$  each of this is a sentential form and  $w$  is the sentence.

Now, we can define the language of a CFG formally as  $L = \{w \in \Sigma^* \mid S \xRightarrow{*} w\}$ .

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