# CSC-257
# Theory Of Computation
(BSc CSIT, TU)

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# Left Recursive Grammar

- A grammar is said to be left recursive if it has a non-terminal A such that there is a derivation (A →* Ax) for some string x(which may variable or terminal).
- A production of grammar is said to have left recursion if the leftmost variable of its RHS is same as variable of its LHS.
- The top down parsing methods can not handle left recursive grammars, so a transformation that eliminates left recursion is needed.
- If a left recursion is present in any grammar then, during parsing in the the syntax analysis part of compilation there is a chance that the grammar will create infinite loop.
- This is because at every time of production of grammar A will produce another A without checking any condition

# Removal of Left Recursion

- Let $A \rightarrow A\alpha \mid \beta$, where $\beta$ does not start with A. Then, the left-recursive pair of productions could be replaced by the non-left-recursive productions as;

  $A \rightarrow \beta A'$

  $A' \rightarrow \alpha A' \mid \epsilon$

- Or equivalently, these productions can be rewritten after removing $\epsilon$- production as

  $A \rightarrow \beta A' \mid \beta$

  $A' \rightarrow \alpha A' \mid \alpha$

- No matter how many A-productions there are, we can eliminate immediate left recursion from them

# Removal of Left Recursion

- So, in general,
- If $A \rightarrow A\alpha_1 \mid A\alpha_2 \mid \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mid A\,\alpha_m \mid \beta_1 \mid \beta_2 \mid \ldots\ldots\ldots\ldots\ldots \mid \beta_n$; With $\beta_i$ does not start with A
- Then we can remove left recursion as :

  $A \rightarrow \beta_1 A' \mid \beta_2 A' \mid \ldots\ldots\ldots\ldots\ldots \mid \beta_n A'$

  $A' \rightarrow a_1 A' \mid a_2 A' \mid \ldots\ldots\ldots\ldots \mid a_m A' \mid \epsilon$

- Equivalently, these productions can be rewritten after removing Є-productions as:

  $A \rightarrow \beta_1 A' \mid \beta_2 A' \mid \ldots\ldots\ldots\ldots\ldots \mid \beta_n A' \mid \beta_1 \mid \beta_2 \mid \ldots\ldots\ldots\ldots \mid \beta_n$

  $A' \rightarrow a_1 A' \mid a_2 A' \mid \ldots\ldots\ldots\ldots \mid a_m A' \mid a_1 \mid a_2 \mid \ldots\ldots\ldots\ldots \mid a_m$

# Removal of Left Recursion

- **Example :** Remove left recursion from following grammar

  $S \rightarrow AA \mid 0$

  $A \rightarrow AAS \mid 0S \mid 1$

- **Solution :**

- Suppose $\alpha 1$ = AS, $\beta 1$ = 0S and $\beta 2$ = 1

- Here, the production $A \rightarrow AAS$ is immediate left recursive. So removing left recursion, we get

  $S \rightarrow AA \mid 0$

  $A \rightarrow 0SA' \mid 1A'$

  $A' \rightarrow ASA' \mid \epsilon$

# Removal of Left Recursion

- After removing Є-productions, it can be rewritten as :

  $S \rightarrow AA \mid 0$

  $A \rightarrow 0SA' \mid 1A' \mid 0S \mid 1$

  $A' \rightarrow ASA' \mid AS$

# Removal of Left Recursion

- Exercise : Remove left recursion from the following grammars

    1.

        $A \rightarrow ABd \mid Aa \mid a$

        $B \rightarrow Be \mid b$

    2.

        $S \rightarrow S0S1S \mid 01$