

# First & Follow in Syntax Analysis

## ❑ FIRST Set in Syntax Analysis

$\text{First}(\alpha)$  is a set of terminal symbols that begin in strings derived from  $\alpha$ .

Consider the production rule:

$$A \rightarrow abc \ / \ def \ / \ ghi$$

Then, we have-

$$\text{First}(A) = \{ a , d , g \}$$

### Rules For Calculating First Function-

#### Rule-01:

For a production rule  $X \rightarrow \epsilon$ ,

$$\text{First}(X) = \{ \epsilon \}$$

#### Rule-02:

For any terminal symbol 'a',

$$\text{First}(a) = \{ a \}$$

#### Rule-03:

For a production rule  $X \rightarrow Y_1 Y_2 Y_3$ ,

### Calculating First(X)

If  $\epsilon \notin \text{First}(Y_1)$ , then  $\text{First}(X) = \text{First}(Y_1)$

If  $\epsilon \in \text{First}(Y_1)$ , then  $\text{First}(X) = \{ \text{First}(Y_1) - \epsilon \} \cup \text{First}(Y_2 Y_3)$

### Calculating First( $Y_2 Y_3$ )

If  $\epsilon \notin \text{First}(Y_2)$ , then  $\text{First}(Y_2 Y_3) = \text{First}(Y_2)$

If  $\epsilon \in \text{First}(Y_2)$ , then  $\text{First}(Y_2 Y_3) = \{ \text{First}(Y_2) - \epsilon \} \cup \text{First}(Y_3)$

Similarly, we can make expansion for any production rule  $X \rightarrow Y_1 Y_2 Y_3 \dots Y_n$ .

# First & Follow in Syntax Analysis

## ❑ FOLLOW Set in Syntax Analysis

Follow( $\alpha$ ) is a set of terminal symbols that appear immediately to the right of  $\alpha$ .

### Rules For Calculating Follow Function-

#### Rule-01:

For the start symbol S, place \$ in Follow(S).

#### Rule-02:

For any production rule  $A \rightarrow \alpha B$ ,  
Follow(B) = Follow(A)

#### Rule-03:

For any production rule  $A \rightarrow \alpha B \beta$ ,

If  $\epsilon \notin \text{First}(\beta)$ , then Follow(B) = First( $\beta$ )

If  $\epsilon \in \text{First}(\beta)$ , then Follow(B) = { First( $\beta$ ) -  $\epsilon$  }  $\cup$  Follow(A)

### Important Notes-

#### Note-01:

$\epsilon$  may appear in the first function of a non-terminal.

$\epsilon$  will never appear in the follow function of a non-terminal.

#### Note-02:

Before calculating the first and follow functions, eliminate **Left Recursion** from the grammar, if present.

#### Note-03:

We calculate the follow function of a non-terminal by looking where it is present on the RHS of a production rule.

# First & Follow in Syntax Analysis

## PRACTICE PROBLEMS BASED ON CALCULATING FIRST AND FOLLOW-

**Problem-01:** Calculate the first and follow functions for the given grammar-

$S \rightarrow aBDh$

$B \rightarrow cC$

$C \rightarrow bC / \epsilon$

$D \rightarrow EF$

$E \rightarrow g / \epsilon$

$F \rightarrow f / \epsilon$

**Solution-** The first and follow functions are as follows-

<u>First Functions-</u>	<u>Follow Functions-</u>
$\text{First}(S) = \{ a \}$	$\text{Follow}(S) = \{ \$ \}$
$\text{First}(B) = \{ c \}$	$\text{Follow}(B) = \{ \text{First}(D) - \epsilon \} \cup \text{First}(h) = \{ g, f, h \}$
$\text{First}(C) = \{ b, \epsilon \}$	$\text{Follow}(C) = \text{Follow}(B) = \{ g, f, h \}$
$\text{First}(D) = \{ \text{First}(E) - \epsilon \} \cup \text{First}(F) = \{ g, f, \epsilon \}$	$\text{Follow}(D) = \text{First}(h) = \{ h \}$
$\text{First}(E) = \{ g, \epsilon \}$	$\text{Follow}(E) = \{ \text{First}(F) - \epsilon \} \cup \text{Follow}(D) = \{ f, h \}$
$\text{First}(F) = \{ f, \epsilon \}$	$\text{Follow}(F) = \text{Follow}(D) = \{ h \}$

**Problem-02:** Calculate the first and follow functions for the given grammar-

$S \rightarrow (L) / a$

$L \rightarrow SL'$

$L' \rightarrow ,SL' / \epsilon$

**Solution-** The first and follow functions are as follows-

<u>First Functions-</u>	<u>Follow Functions-</u>
$\text{First}(S) = \{ (, a \}$	$\text{Follow}(S) = \{ \$ \} \cup \{ \text{First}(L') - \epsilon \} \cup \text{Follow}(L) \cup \text{Follow}(L') = \{ \$, ,, ) \}$
$\text{First}(L) = \text{First}(S) = \{ (, a \}$	$\text{Follow}(L) = \{ ) \}$
$\text{First}(L') = \{ ,, \epsilon \}$	$\text{Follow}(L') = \text{Follow}(L) = \{ ) \}$

# First & Follow in Syntax Analysis

**Problem-03:** Calculate the first and follow functions for the given grammar-

$S \rightarrow A$

$A \rightarrow aB / Ad$

$B \rightarrow b$

$C \rightarrow g$

**Solution-** We have-

- The given grammar is left recursive.
- So, we first remove left recursion from the given grammar.

After eliminating left recursion, we get the following grammar-

$S \rightarrow A$

$A \rightarrow aBA'$

$A' \rightarrow dA' / \epsilon$

$B \rightarrow b$

$C \rightarrow g$

Now, the first and follow functions are as follows-

<u>First Functions-</u>	<u>Follow Functions-</u>
$\text{First}(S) = \text{First}(A) = \{ a \}$	$\text{Follow}(S) = \{ \$ \}$
$\text{First}(A) = \{ a \}$	$\text{Follow}(A) = \text{Follow}(S) = \{ \$ \}$
$\text{First}(A') = \{ d, \epsilon \}$	$\text{Follow}(A') = \text{Follow}(A) = \{ \$ \}$
$\text{First}(B) = \{ b \}$	$\text{Follow}(B) = \{ \text{First}(A') - \epsilon \} \cup \text{Follow}(A) = \{ d, \$ \}$
$\text{First}(C) = \{ g \}$	$\text{Follow}(C) = \text{NA}$

**Problem-04:** Calculate the first and follow functions for the given grammar-

$S \rightarrow AaAb / BbBa$

$A \rightarrow \epsilon$

$B \rightarrow \epsilon$

**Solution-** The first and follow functions are as follows-

<u>First Functions-</u>	<u>Follow Functions-</u>
$\text{First}(S) = \{ \text{First}(A) - \epsilon \} \cup \text{First}(a) \cup \{ \text{First}(B) - \epsilon \} \cup \text{First}(b)$ $= \{ a, b \}$	$\text{Follow}(S) = \{ \$ \}$
$\text{First}(A) = \{ \epsilon \}$	$\text{Follow}(A) = \text{First}(a) \cup \text{First}(b) = \{ a, b \}$
$\text{First}(B) = \{ \epsilon \}$	$\text{Follow}(B) = \text{First}(b) \cup \text{First}(a) = \{ a, b \}$

# First & Follow in Syntax Analysis

**Problem-05: Calculate the first and follow functions for the given grammar-**

$E \rightarrow E + T / T$

$T \rightarrow T \times F / F$

$F \rightarrow (E) / id$

**Solution-** We have-

- The given grammar is left recursive.
- So, we first remove left recursion from the given grammar.

After eliminating left recursion, we get the following grammar-

$E \rightarrow TE'$

$E' \rightarrow + TE' / \epsilon$

$T \rightarrow FT'$

$T' \rightarrow \times FT' / \epsilon$

$F \rightarrow (E) / id$

Now, the first and follow functions are as follows-

## First Functions-

$\text{First}(E) = \text{First}(T) = \text{First}(F) = \{ (, id \}$

$\text{First}(E') = \{ +, \epsilon \}$

$\text{First}(T) = \text{First}(F) = \{ (, id \}$

$\text{First}(T') = \{ \times, \epsilon \}$

$\text{First}(F) = \{ (, id \}$

## Follow Functions-

$\text{Follow}(E) = \{ \$, ) \}$

$\text{Follow}(E') = \text{Follow}(E) = \{ \$, ) \}$

$\text{Follow}(T) = \{ \text{First}(E') - \epsilon \} \cup \text{Follow}(E) \cup \text{Follow}(E') = \{ +, \$, ) \}$

$\text{Follow}(T') = \text{Follow}(T) = \{ +, \$, ) \}$

$\text{Follow}(F) = \{ \text{First}(T') - \epsilon \} \cup \text{Follow}(T) \cup \text{Follow}(T') = \{ \times, +, \$, ) \}$

**Problem-06: Calculate the first and follow functions for the given grammar-**

$S \rightarrow ACB / CbB / Ba$

$A \rightarrow da / BC$

$B \rightarrow g / \epsilon$

$C \rightarrow h / \epsilon$

**Solution-** The first and follow functions are as follows-

## First Functions-

$\text{First}(S) = \{ \text{First}(A) - \epsilon \} \cup \{ \text{First}(C) - \epsilon \} \cup \text{First}(B)$

$\cup \text{First}(b) \cup \{ \text{First}(B) - \epsilon \} \cup \text{First}(a)$

$= \{ d, g, h, \epsilon, b, a \}$

$\text{First}(A) = \text{First}(d) \cup \{ \text{First}(B) - \epsilon \} \cup \text{First}(C)$

$= \{ d, g, h, \epsilon \}$

$\text{First}(B) = \{ g, \epsilon \}$

$\text{First}(C) = \{ h, \epsilon \}$

## Follow Functions-

$\text{Follow}(S) = \{ \$ \}$

$\text{Follow}(A) = \{ \text{First}(C) - \epsilon \} \cup \{ \text{First}(B) - \epsilon \} \cup$

$\text{Follow}(S) = \{ h, g, \$ \}$

$\text{Follow}(B) = \text{Follow}(S) \cup \text{First}(a) \cup \{ \text{First}(C) - \epsilon \} \cup$

$\text{Follow}(A) = \{ \$, a, h, g \}$

$\text{Follow}(C) = \{ \text{First}(B) - \epsilon \} \cup \text{Follow}(S) \cup \text{First}(b) \cup$

$\text{Follow}(A) = \{ g, \$, b, h \}$