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# Derivation Tree

Derivation tree is a graphical representation for the derivation of the given production rules for a given CFG. It is the simple way to show how the derivation can be done to obtain some string from a given set of production rules. The derivation tree is also called a parse tree.

Parse tree follows the precedence of operators. The deepest sub-tree traversed first. So, the operator in the parent node has less precedence over the operator in the sub-tree.

A parse tree contains the following properties:

1. The root node is always a node indicating start symbols.
2. The derivation is read from left to right.
3. The leaf node is always terminal nodes.
4. The interior nodes are always the non-terminal nodes.

## Example 1:

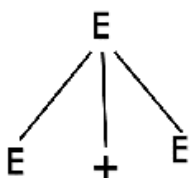
**Production rules:**

$E = E + E$   
 $E = E * E$   
 $E = a \mid b \mid c$

**Input**

$a * b + c$

**Step 1:**



**Step 2:**



Note: We can draw a derivation tree step by step or directly in one step.

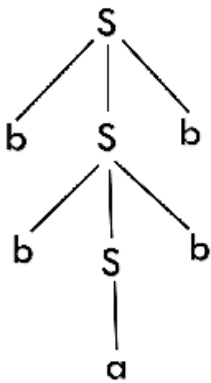
### Example 2:

Draw a derivation tree for the string "bab" from the CFG given by

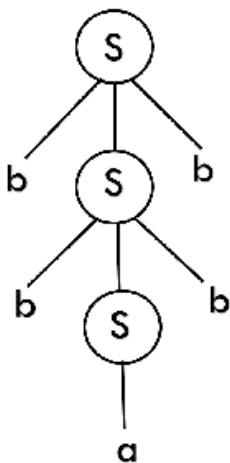
$S \rightarrow bSb \mid a \mid b$

**Solution:**

Now, the derivation tree for the string "bbabb" is as follows:



The above tree is a derivation tree drawn for deriving a string bbabb. By simply reading the leaf nodes, we can obtain the desired string. The same tree can also be denoted by,



### Example 3:

Construct a derivation tree for the string aabbabba for the CFG given by,

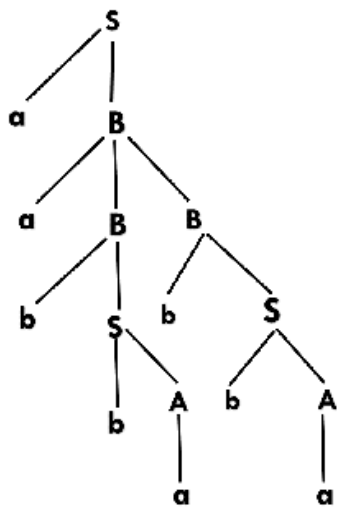
$S \rightarrow aB \mid bA$   
 $A \rightarrow a \mid aS \mid bAA$   
 $B \rightarrow b \mid bS \mid aBB$

#### Solution:

To draw a tree, we will first try to obtain derivation for the string aabbabba

S  
aB  
a aBB  
aa bS B  
aab bA B  
aabb a B  
aabba bS  
aabbab bA  
aabbabb a

Now, the derivation tree is as follows:



### Example 4:

Show the derivation tree for string "aabbbaa" with the following grammar.

```

S → AB | ε
A → aB
B → Sb

```

**Solution:**

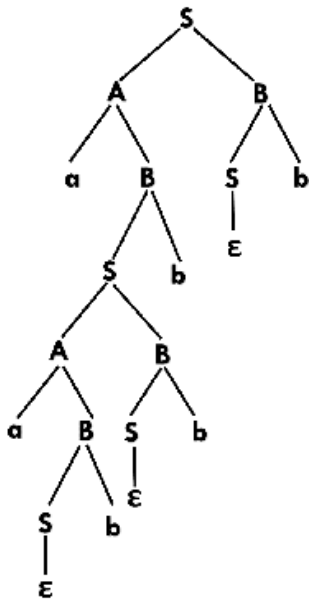
To draw a tree we will first try to obtain derivation for the string aabbbaa

```

S
AB
aB B
a Sb B
a AB bB
a aB BbB
aa Sb BbB
aa ε bBbB
aab Sb bB
aab ε bbB
aabb Sb
aabb ε b
aabbbaa

```

Now, the derivation tree for the string "aabbbaa" is as follows:



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