# Homework: Context-Free Grammar

## Learning Objectives:

1. know terminologies: CFG, parsing, derivation, ambiguity, associativity, precedence
2. language design: understand and create grammars

## Instructions:

1. A total points: 40 pt
2. Early deadline: Sept 5 (Wed) 6:00 pm, Regular deadline Sept 7 (Fri) 6:00 pm
3. How to submit:
   - Submit your document to Canvas under Assignments → Homework 1
   - Please provide the complete solutions in one pdf file
   - You can write your solutions in latex or word and then convert it to pdf; or you can submit a scanned document with legible handwritten solutions

## Questions:

1. (10 pt) Consider the context free grammar G: $S \rightarrow SbS| * S|a + |c$ and string $a + b * c$
   (a) (2 pt) What are the terminals and non-terminals of the grammar?
   (b) (2 pt) Give a leftmost derivation for the string
   (c) (2 pt) Give a rightmost derivation for the string
   (d) (2 pt) Give a parse tree for the string
   (e) (2 pt) Write 3 strings using the terminals that do not belong to the language of the grammar $L(G)$
2. (10 pt) Consider the following grammar with:
   - terminals: $a, b, c, !, \&, <$
   - non-terminals: $S, E, F$
   - start symbol: $S$
   - production rules:
     $S \rightarrow E|c$
     $E \rightarrow E\ !\ F|F$
     $F \rightarrow F\ \&\ F|F < F|a|b$

(a) (2 pt) Draw two different parse trees for the string $b \,!\, a < b \,\&\, a$.

(b) (4 pt) Modify the grammar to remove ambiguity.

(c) (1 pt) Draw the parse tree for the string using new grammar

(d) (3 pt) Explain how your new grammar modifies the parse trees you drew in the first step to remove ambiguity

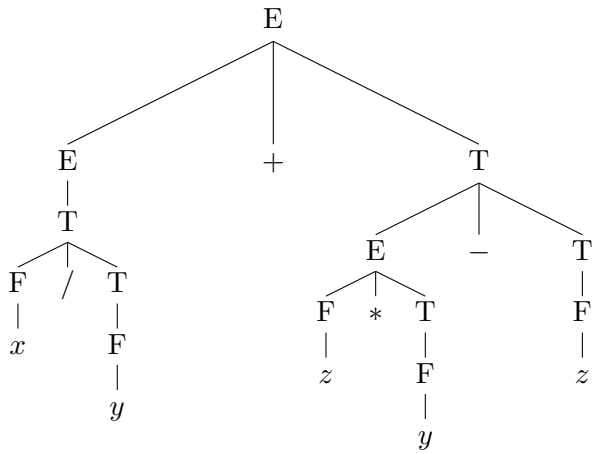
3. (10 pt) Consider the following grammar where $S$ is the start variable:

- terminals: $x, y, z, +, , *, /$
- non-terminals: $E, T, F, V$
- start symbol: $E$
- production rules:
  $E \to E + T | E - T | T$
  $T \to F * T | F / T | F$
  $F \to x | y | z$

(a) (4 pt) What is the associativity of the operators $+$, $-$, $*$ and $/$; explain why.

(b) (3 pt) What is the precedence of $+$,$-$, $*$ and $/$; explain why.

(c) (3 pt) Given a parse tree




Explain how the value of the string is generated.

4. (10 pt) Design CFGs for the given languages:

(a) (4 pt) Write a grammar that describes the strings $0^n 1^m$ where $m > n$.

(b) (6 pt) Write a grammar that describes a "baby language" and list two most interesting sentences he/she will say:

- the baby has very limited vocabularies "apple" "puppy" "owl" "eat" "mama" "baba" "big" "red"
- the baby knows a few basic rules to put together a sentence: (1) a sentence can be a noun, a verb or an adjective (2) a sentence can consist of a verb and one or more noun(s) (adjectives are optional), where a noun should be before the verb and/or after the verb, (3) an adjective only can be immediately before the noun.