

Concepts of Programming Languages, CSCI 305, Fall 2021
Homework #5, complete by Oct. 15

1. You have already done part (a) of exercise 2.9 from the text (page 107). Do parts (b) and (c).
 - a. Part a. Describe in English the language defined by the regular expression $a^*(ba^*ba^*)^*$. Your description should be a high-level characterization-one that would still make sense if we were using a different regular expression for the same language.

Any string of a's and b's containing an even number, possibly 0, of b's.
 - b. Write an unambiguous context-free grammar that generates the same language.
 - c. Using your grammar for part (b), give a canonical (right-most) derivation of the string $baabab$.

2. Do exercise 2.10 from the text.
Give an example of a grammar that captures right associativity for an exponent operation (e.g. `**` in Fortran).

3. Do exercise 2.13, parts (a) and (b)

Grammar:

1. $\text{stmt} \rightarrow \text{assignment}$
2. $\text{stmt} \rightarrow \text{subr_call}$
3. $\text{assignment} \rightarrow \text{id} := \text{expr}$
4. $\text{subr_call} \rightarrow \text{id} (\text{arg_list})$
5. $\text{expr} \rightarrow \text{primary expr_tail}$
6. $\text{expr} \rightarrow \text{op expr}$
7. $\text{expr} \rightarrow \epsilon$
8. $\text{expr_tail} \rightarrow \text{op expr}$
9. $\text{expr_tail} \rightarrow \epsilon$
10. $\text{primary} \rightarrow \text{id}$
11. $\text{primary} \rightarrow \text{subr_call}$
12. $\text{primary} \rightarrow (\text{expr})$
13. $\text{op} \rightarrow + \mid - \mid * \mid /$
14. $\text{arg_list} \rightarrow \text{expr args_tail}$
15. $\text{args_tail} \rightarrow , \text{arg_list}$
16. $\text{args_tail} \rightarrow \epsilon$

- a.) Construct a parse tree for the input string `foo(a,b)`,

- b.) Give a canonical (right-most) derivation of this same string.

4. Give a context free grammar for the language on $\Sigma = \{a,b\}$ defined by $L = \{w \mid (n_a(w) > n_b(w))\}$.

The set of strings over the alphabet $\{a,b\}$ with more a's than b's

$n_a(w)$ is the number of a's in the string w .

$n_b(w)$ is the number of b's in the string w .

5. Give a context-free grammar generating the language

$$L = \{x_1 \# x_2 \# \dots \# x_k \mid k \geq 1, \text{ each } x_i \in \{a,b\}^*, \text{ and for some } i \text{ and } j, x_i = x_j^R\}$$

Hint - it is helpful to break the above problem into cases:

Case 1: x_i appears at the front of the string and x_j appears at the end of the string.

Case 2: x_i appears at the front, but x_j does not appear at the end.

Case 3: x_i does not appear at the front, but x_j appears at the end.

Case 4: x_i does not appear at the front, and x_j does not appear at the end of the string.