

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 $baabaaab$.

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.