DEPARTAMENTO DE INFORMÁTICA
UNIVERSIDAD CARLOS III DE MADRID

Grado en Informática
Formal Languages and Automata Theory

Formal Languages and Automata Theory
Exercises Languages and Formal Grammars
Unit 4 – Part 2

1. [Isasi, Martínez, Borrajo; pp. 16-19] Determine the language generated and the type of the following grammars:

   a) G1 = ({0,1}, {A,B,S},S, P),
      P = {S::=A0, A0::=1B1, 1A::=0B0, B::=λ | 1 | 0}
   b) G2 = ({0,1}, {A,B},A, P),
      P = {A::=1B1 | 11, 1B1::=101 | 111}
   c) G3 = ({0,1}, {A,B},A, P),
      P = {A::=1B1 | 11, B::=0 | 1}
   d) G4 = ({0,1}, {A,B, C},A, P),
      P = {A::=1B, B::= 1 | 0C | 1C, C::=1)}

2. Given the grammar G:

   G = ({a,b,c,d,e,f,0,1,2,3,4}, {G,H,I,J}, G, P),
   P = {abcG::=abcJ, Gdef::=Idef, J::=10H01, 2H4::=234, 2H4::=24, I::=1}

Determine its type in the Chomsky Hierarchy, and carry out the required modifications to obtain an equivalent grammar G' of the most restricted type in this hierarchy (i.e., from type-0 to type-1, from type-1 to type-2, or from type-2 to type-3).

3. Obtain an equivalent well-formed grammar for the following one:

   G = ({a,b,c,d}, {X,Y,Z,O,P,Q,A}, Z, P),
   P = {Z::=Z, Q::=OP, X::=aa, Z::=aX, Y::=aa, Z::=Ya, O::=b, Z::=aaa, P::=QO,
   Q::=d, P::=c, O::=PQ}

4. [Alfonseca, 1997; p. 210] Given the grammar G = ({0,1}, {S,A,B,C},S, P), where

$$P = \{\ S::=AB \mid 0S1 \mid A \mid C$$
$$A::=0AB \mid \lambda$$
$$B::=B1 \mid \lambda\ \}$$

Obtain an equivalent well-formed grammar.

5. [Isasi, Martínez, Borrajo; exercise 4.7] Given the grammar = ({0,1}, {S,A,B,C,D,E,F},S, P), where

$$P = \{S::=AB \mid 0E \mid A \mid CS1$$
$$A::=0AS \mid \lambda \mid A0 \mid C$$
$$B::=B1 \mid 1$$
$$D::=B1 \mid \lambda \mid 1F$$
$$E::=E1$$
$$F::=0D\}$$

Obtain an equivalent well-formed grammar.

6. Given the following left-linear grammar G, obtain an equivalent right-linear G' grammar.

$$G=(\{0,1\},\{A,S\},S,P)$$
$$P=\{\ S ::= 1 \mid A1;\ A ::= S0\}$$

7. Obtain an equivalent grammar in Chomsky Normal Form (CNF) equivalent to the following one:

$$G = (\{a,b,c\},\{S, Q, R\}, S, P)$$
$$P = \{\quad S ::= Rba \mid Q$$
$$Q ::= Qb \mid b$$
$$R ::= cRQb \mid cb$$
$$\}$$

8. Given the grammar G:

$$G = (\{e,f,g,z,a,b,d\}, \{Y, X, E, A, D, I, G\}, A, P),$$
$$P = \{\ A::=a$$
$$E::=b$$
$$A::=azb$$
$$A::=aX$$
$$E::=E$$
$$G::=g$$
$$X::=XE$$
$$D::=eI$$
$$X::=z$$
$$Y::=b$$
$$I::=fG$$
$$X::=Xb$$
$$E::=d\ \ \}$$

   a) Transform to CNF detailing the process followed.
   b) Determine whether the words 'abz' y 'azdbb' are included in the language generated by G. If this is the case, generate a parse tree for the included words. If not, justify the not inclusion in the language.

9. Obtain a grammar in CNF equivalent to the following grammar:

G = ({a, b, c},{S, A, B, C, D, E), S, P)
P = { S::=AaB | Cbb | B
A::=Aa | cD
B::=a | Ba | λ
C::=Sa | a | abB
D::=aaA
E::=aa }

10. [Alfonseca, 1997; p. 217] Given the grammar G, calculate its equivalent Greibach Normal Form (FNG).

G = ({a,b}, {A,B,C}, A, P), where P = {A::=BC, B::=CA | a, C::=AB | b}

11. [Exercise Exam September 1999] Given the grammar G calculate an equivalent grammar in GNF.

G = ({a,b}, {S}, S, P), where P = {S::=aSb | SS | λ}

12. [Isasi, Martínez, Borrajo] Exercises 4.21- 4.25. Calculate the equivalent grammars in GNF.

13. [Exercise Exam September 1998] Design a grammar in Greibach Normal Form to generate mathematical expressions having the form:

*number + (number / number) – number * (number + number)*

14. [Exercise Exam September 1997] Given an *if* sentence included in a high-level programming language with the following restrictions:

- There are only two instructions in each *if* sentence: the *if* part **only consists of one sentence**. The *then* part is the assignment of a number to a variable.
- Nested *if* sentences are allowed.
- The condition that is evaluated is a Boolean variable.
- Therefore, the set of terminal symbols set of the grammar must be:

$$\Sigma_T = \{if, then, else, ::=, var, num, cond\}$$

Transform the obtained grammar into GNF.