Theme: Regular or context free grammar

Laboratory tasks:

1. For the formal grammar $G=(V_N, V_T, P, S)$ need be obtained five strings, that belong to the language $L(G)$, that is generated by this grammar. The length of strings must be no lesser than the number of characters from the alphabet V_N+2.
2. For each string build the noninverted (derivation) tree and derivation table.
3. Convert regular grammar to Finite Automaton (FA).
4. Determine the grammar type by the Chromsky classification.

Theoretical notions

A **grammar** is an ordered quadruple $G = (V_N, V_T, P, S)$, where*:*

- V_N is the alphabet of **variables** (or **nonterminal symbols**),

- V_T is the alphabet of **terminal symbols.**

- $P \subseteq (V_N \cup V_T)^* V_N (V_N \cup V_T)^* \times (V_N \cup V_T)^*$, P - set of *productions*, which are rules for replacing (or rewriting) nonterminal symbols (on the left side of the production) in a string with other nonterminal or terminal symbols (on the right side of the production).

- $S \in V_N$, S - **start symbol,** which is a special nonterminal symbol that appears in the initial string generated by the grammar.

If $(\alpha, \beta) \in P$, then this production is denoted: $\alpha \to \beta$ and this mean that α is replaced by the β.

A grammar represents a way of specifying a language. Let is given the grammar $G = (V_N, V_T, P, S)$. On the set $(V_N \cup V_T)^*$ is defined the binary relations:

=> (direct derivation);

$\overset{k}{\Rightarrow}$ (k derivation);

$\overset{+}{\Rightarrow}$ (+ derivation);

$\overset{*}{\Rightarrow}$ (* derivation).

The language generated by the grammar $G = (V_N, V_T, P, S)$ is the set

$$L(G) = \left\{ w \middle| w \in V_T^*, S \overset{*}{\Rightarrow} w \right\}.$$

So $L(G)$ contains all words over the alphabet V_T which can be derived from the start symbol S using the productions from P.

Let $G = (V_N, V_T, P, S)$ be a grammar. If $S \overset{*}{\Rightarrow} x$ and $x \in (V_N \cup V_T)^*$ then x is a ***sentential form.*** A sentential form that not contains nonterminal symbols is called **phrase.**

Two grammars G_1 and G_2 are **equivalent,** and this is denoted if they generate the same language, so $L(G_1) = L(G_2)$.

By the Chomsky the grammar is classified in 4 types:

1. A grammar *G* is of type 0 (**phrase-structure grammar**) if there are no restrictions on productions.

2. A grammar *G* is of type 1 **(context-sensitive grammar)** if all of its productions are of the form $\alpha_1 A \alpha_2 \to \alpha_1 \beta \alpha_2$, where $\alpha_1, \beta, \alpha_2 \in (V_N \cup V_T)^*$, $A \in V_N$.

The **left-context-** and **right-context**-sensitive grammars are defined by restricting the rules to just the form $\alpha A \to \alpha\gamma$ and to just $A\beta \to \gamma\beta$, respectively, where $\alpha, \beta, \gamma \in (V_N \cup V_T)^*$, $A \in V_N$.

We have Type 1 $\subseteq$ Type 0.

3. A grammar *G* is of type 2 **(context-free grammar)** if all of its productions are of the form $A \to \beta$, where $A \in V_N$, $\beta \in (V_N \cup V_T)^*$.

We have Type 2 $\subseteq$ Type 1

4. A grammar *G* is of type 3 **(regular grammar)** if its productions are of the form

1. $A \to aB$;

2. $A \to b$,

where $a, b \in V_T$ and $A, B \in V_N$.

If a grammar *G* is of type *i* then language *L*(*G*) is also of type *i*.

We have Type 3 $\subseteq$ Type 2.

In this way we have Type 3 $\subset$ Type 2 $\subset$ Type 1 $\subset$ Type 0.

Chomsky demonstrated that:

a) Exist languages Type 0 that are not Type 1.

b) Exist languages Type 1 that are not Type 2.

c) Exist languages Type 2 that are not Type 3.

Variant 1.

V_N={S, P,Q },
V_T={a, b,c,d,e,f } ,
P= {
1. S → aP
2. S → bQ
3. P → bP
4. P → cP
5. P → dQ
6. P → e
7. Q → eQ
8. Q → fQ
9. Q → a }

Variant 2.

V_N={S, R,L },
V_T={a, b,c,d,e,f } ,
P= {

1. S → aS
2. S → bS
3. S → cR
4. S → dL
5. R → dL
6. R → e
7. L → fL
8. L → eL
9. L → d }

Variant 3.

V_N={S, D,R },
V_T={a, b,c,d,f } ,
P= {

1. S → aS
2. S → bD
3. S → fR
4. D → cD
5. D → dR
6. R → bR
7. R → f
8. D → d }

Variant 4.

V_N={S, L,D },
V_T={a, b,c,d,e,f,j} ,
P= {

1. S → aS
2. S → bS
3. S → cD
4. S → dL
5. S → e
6. L → eL
7. L → fL
8. L → jD
9. L → e
10. D → eD
11. D → d}

Variant 5.

V_N={S, F,L },
V_T={a, b,c,d } ,
P= {

1. S → bS
2. S → aF
3. S → d
4. F → cF
5. F → dF
6. F → aL
7. L → aL
8. L → c

9. $F \rightarrow b$ }

Variant 6.

V_N={S, I,J,K },
V_T={a,b,c,e,n,f,m} ,
P= {
1. $S \rightarrow cI$
2. $I \rightarrow bJ$
3. $I \rightarrow fI$
4. $J \rightarrow nJ$
5. $J \rightarrow cS$
6. $I \rightarrow eK$
7. $K \rightarrow nK$
8. $I \rightarrow e$
9. $K \rightarrow m$ }

Variant 7.

V_N={S, D,E,F,L },
V_T={a, b,c,d } ,
P= {
1. $S \rightarrow aD$
2. $D \rightarrow bE$
3. $E \rightarrow cF$
4. $F \rightarrow dD$
5. $E \rightarrow dL$
6. $L \rightarrow aL$
7. $L \rightarrow bL$
8. $L \rightarrow c$ }

Variant 8.

V_N={S, D,E, J},
V_T={a, b, c, d, e} ,
P= {
1. $S \rightarrow aD$
2. $D \rightarrow dE$
3. $D \rightarrow bJ$
4. $J \rightarrow cS$
5. $E \rightarrow e$
6. $E \rightarrow aE$
7. $D \rightarrow aE$ }

Variant 9.

V_N={S, B,D, Q },
V_T={a, b, c, d } ,
P= {
1. $S \rightarrow aB$
2. $S \rightarrow bB$
3. $B \rightarrow cD$
4. $D \rightarrow dQ$
5. $Q \rightarrow bB$
6. $D \rightarrow a$
7. $Q \rightarrow dQ$ }

Variant 10.

V_N={S, B, L},
V_T={a, b, c } ,
P= {

1. S → aB
2. B → bB
3. B → cL
4. L → cL
5. L → aS
6. L → b }

Variant 11.

V_N={S, B,D },
V_T={a, b,c } ,
P= {

1. S → aB
2. S → bB
3. B → bD
4. D → b
5. D → aD
6. B → cB
7. B → aS }

Variant 12.

V_N={S,F,D},
V_T={a, b, c } ,
P= {

1. S → aF
2. F → bF
3. F → cD
4. S → bS
5. D → cS
6. D → a
7. F → a }

Variant 13.

V_N={S,B, D },
V_T={a, b, c } ,
P= {

1. S → aB
2. B → aD
3. B → bB
4. D → aD
5. D → bS
6. B → cS
7. D → c }

Variant 14.

V_N={S,B,D },
V_T={a, b,c,d} ,

P= {
1. S → aS
2. S → bB
3. B → cB
4. B → d
5. B → aD
6. D → aB
7. D → b }

Variant 15.
V_N={S, A, B}, V_T={a, b, c},
P={
1. S →aS
2. S → bS
3. S → cA
4. A → aB
5. B →aB
6. B →bB
7. B → c }

Variant 16.
V_N={S, A, B}, V_T={a, b, c, d},
P={
1. S →bS
2. S →dA
3. A → aA
4. A →dB
5. B →cB
6. A →b
7. B → a }

Variant 17.
V_N={S, A, B, C}, V_T={a, b, c, d},
P={
1. S →dA
2. A → aB
3. B →bC
4. C →cB
5. A →bA
6. B →aB
7. B →d }

Variant 18.
V_N={S, A, B, C}, V_T={a, b},
P={
1. S →aA
2. A → bS
3. S →aB
4. B →aC
5. C →a
6. C →bS}

Variant 19.
V_N={S, A, B, C}, V_T={a, b},
P={
1. S →aA
2. A → bS
3. A →aB
4. B →bC
5. C →aA
6. C →b }

Variant 20.
V_N={S, A, B, C}, V_T={a, b, c, d},
P={
1. S →dA
2. A → d
3. A →aB
4. B →bC
5. C →cA
6. C →aS }

Variant 21.
V_N={S, B, C, D}, V_T={a, b, c},
P={
1. S →aB
2. B →bS
3. B →aC
4. B →b
5. C →bD
6. D →a
7. D →bC
8. D →cS }

Variant 22.
V_N={S, D, F}, V_T={a, b, c, d},
P={
1. S →aS
2. S → bS
3. S → cD
4. D → dD
5. D → bF
6. D → a
7. F → bS
8. F → a }

Variant 23.
V_N={S, B, C}, V_T={a, b, c},
P={
1. S → aB
2. B → aC
3. C → bB

4. C → c
5. C → aS
6. B → bB }

Variant 24.
V_N={S, A, C, D}, V_T={a, b},
P={
1. S → aA
2. A → bS
3. A → dD
4. D → bC
5. C → a
6. C → bA
7. D → aD }

Variant 25.
V_N={S, A, B}, V_T={a, b, c, d},
P={
1. S → bS
2. S → dA
3. A → aA
4. A → dB
5. B → cB
6. A → b
7. B → a }

Variant 26.
V_N={S, A, B, C}, V_T={a, b, c, d},
P={
1. S → dA
2. A → aB
3. B → bC
4. C → cB
5. B → d
6. C → aA
7. A → b }

Variant 27.
V_N={S, A, B}, V_T={a, b, c},
P={
1. S □ aA
2. A □ bS
3. S □ bB
4. A □ cA
5. A □ aB
6. B □ aB
7. B □ b }

Variant 28.
V_N={S, A, B, C}, V_T={a, b},
P={
1. S → aA

2. A → bS
3. A → aB
4. B → bC
5. C → aA
6. B → aB
7. C → b }

Variant 29.
V_N={S, A, B, C}, V_T={a, b},
P={
1. S → bA
2. A → b
3. A → aB
4. B → bC
5. C → cA
6. A → bA
7. B → aB }

Variant 30.
V_N={S, B, C, D}, V_T={a, b, c},
P={
1. S → aB
2. B → bS
3. B → aC
4. B → c
5. C → bD
6. D → c
7. D → aC }

Variant 31.
V_N={S, D, R}, V_T={a, b, c},
P={
1. S → aS
2. S → bS
3. S → cD
4. D → bD
5. D → cR
6. D → a
7. R → b }

Variant 32.
V_N={S, D, R}, V_T={a, b, c},
P={
1. S → aS
2. S → cD
3. D → bR
4. R → aR
5. R → b
6. R → cS }