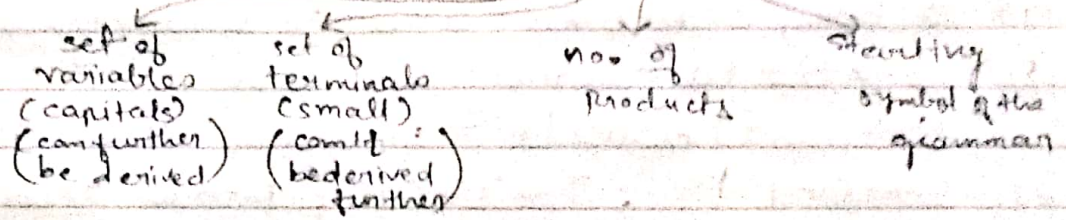


Every grammar has 5 tuples:- $G(V, T, P, S)$



Type-2 (Context free grammar): $A \rightarrow \alpha; \alpha \in (V \cup T)^*$, $A \in V$
 single variable

Type-1 (Context sensitive grammar): $\alpha \rightarrow \beta$; where $|\alpha| \leq |\beta|$
; $\alpha \in (V+T)^*$, $\beta \in (V+T)^*$

Type-0 (Recursive Enumerable grammar) :- $\alpha \rightarrow \beta$
; $\alpha \in (V+T)^*$, $\beta \in (V+T)^*$

- $S \rightarrow aS | bS | \epsilon \Rightarrow (a+b)^*$ | $S \rightarrow aS | bS | a | b \Rightarrow (a+b)^+$
- $S \rightarrow aSbS | bSaS | \epsilon \Rightarrow \eta_a(n) = \eta_b(n)$ [no. of a 's = no. of b 's]
- $S \rightarrow aSa | bSb | \epsilon \Rightarrow WW^R$ [W^R = reverse of W]
- $S \rightarrow aSa | bSb | \epsilon \Rightarrow WcW^R$
- $S \rightarrow 0S11 | 011 \Rightarrow L = \{0^n 1^{2n} / n \geq 1\}$
- $S \rightarrow aS | \epsilon \Rightarrow a^*$ | $S \rightarrow bS | \epsilon \Rightarrow b^*$
- $S \rightarrow aS | a \Rightarrow a^+$ | $S \rightarrow bS | b \Rightarrow b^+$

* Context free Grammar:-

Ambiguous CFG

- for one string more than one LMD/RMD/parse tree

Unambiguous CFG

- for one string one LMD & RMD & LMD parse tree = RMD parse tree.

* Examples of CFGs:-

- (1) $a = b + c; a = b + c * d; a = b \Rightarrow$ unambiguous CFG
- (2) $S \rightarrow SS \mid a \Rightarrow$ ambiguous CFG
- (3) $S \rightarrow aSbS \mid bSaS \mid \epsilon \Rightarrow$ ambiguous CFG
- (4) $E \rightarrow E + T \mid T; T \rightarrow T * F \mid F; F \rightarrow id \Rightarrow$ unambiguous CFG
- (5) $E \rightarrow E + E \mid E * E \mid id \Rightarrow$ ambiguous CFG

* Simplification of CFGs:-

- (1) Useless production elimination:- ^{production which doesn't terminate or not used in other productions}
- (2) Unit " ^{" - eliminate mediator productions & directly assign values}
- (3) null " ^{" - if there's an ϵ , try to put ' ϵ ' in every non-terminal possible step-by-step & then take them as productions}

Sequence of simplifying CFGs:-

null production elimination \rightarrow unit production elimination \rightarrow useless production elimination

* Normal Form \rightarrow CNF [Chomsky] \rightarrow in decision ^{problem} of CFG
 \rightarrow GNF [Greibach] \rightarrow in construction of PDA

* CNF:- $A \rightarrow BC$ or $A \rightarrow a$

* GNF:- $A \rightarrow a\alpha; \alpha \in V^*$