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Unit 3
Grammar

Grammar :—

Standard way of representing a language

$G = \{V, T/\Sigma, P, S\}$

V = Variable (capital letters), for use again again

Σ/T = Terminals (small letters), for terminating a string

P = Production Rule

S = Starting Symbol

ex ⇒ $G = \{\{S\}, \{a, b\}, \{S \to aSb, S \to \lambda\}, S\}$
Find L(G)

⇒ $S \to aSb / \lambda$

$\{\lambda, ab, aabb, aaabbb ----\}$

$L(G) = a^n b^n, n \geq 0$

ex ⇒ $G = \{\{S, C\}, \{a, b\}, P, S\}$, where P consists of $S \to aCa$, $C \to aCa/b$. Find $L(G)$.

⇒ {aba, aabaa, aaabaaa ---}

$L(G) = a^n b a^n$, $n > 0$

ex ⇒ If G is $S \to aS/bS/a/b$ find $L(G)$

{a, b, ab, aab, ba, aba ---}

$L(G) = (a+b)^+$

Language to grammar :-

ex ⇒ $L = \{aa, ab, ba, bb\}$

$RE = (a+b)(a+b)$

$S \to AB$
$A \to a/b$
$B \to a/b$

$G = \{\{S, A, B\}, \{a, b\}, P, \{S\}\}$

$P = S \to AB$
$A \to a/b$
$B \to a/b$

ex ⇒ $L = a^n, n \geq 0$

$L = \{\lambda, a, aa, aaa \ldots\}$

$S \rightarrow aS / \varepsilon$

ex ⇒ $L = (a+b)^*$

$S \rightarrow aS / bS / \lambda$

ex ⇒ $L = a^m b^n ; m, n \geq 0$

$RE = a^* b^*$

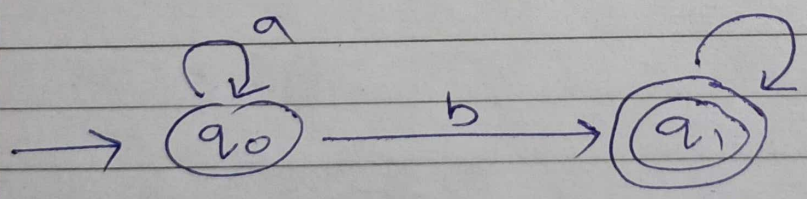
$S \rightarrow AB$

$A \rightarrow aA / \lambda$

$B \rightarrow bB / \lambda$

* RE to RG :-

ex ⇒ $P = a^* b (a+b)^*$



$G = \{\{A_0, A_1\}, \{a, b\}, P, A_0\}$

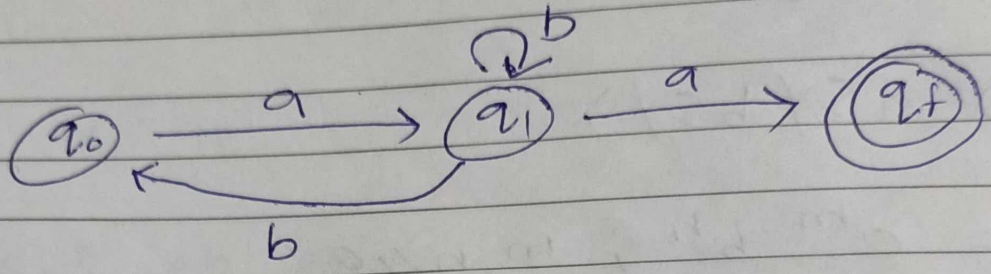
P is ⇒ $A_0 \rightarrow aA_0$ $A_0 \rightarrow b$ $A_0 \rightarrow bA_1$

$A_1 \rightarrow a$ $A_1 \rightarrow b$ $A_1 \rightarrow aA_1$ $A_1 \rightarrow bA_1$

* RG to FA (RE) :-

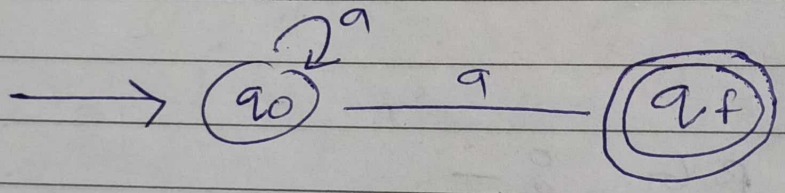
ex => G => $(\{A_0, A_1\}, \{a, b\}, P, A_0)$

P => $A_0 \rightarrow aA_1$
$A_1 \rightarrow bA_1 / bA_0 / a$



ex => $S \rightarrow aS / a$

$S \rightarrow aS$
$S \rightarrow a$



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* Chomsky Classification of Languages

Type	Grammar	Lang	Automata
0	Unrestricted Grammar / Recursively enumerable Grammar	REL	Turing Machine
1	Context Sensitive Grammar	CSL	Linear Bounded automata (LBA)
2	Context free Grammar	CFL	Push Down Automata (PDA)
3	Regular Grammar	RL	finite Automata (FA)

* Type - 0 / Recursively Enumerable Grammar (REG)

Production Rule

$\alpha \rightarrow \beta$

$\alpha \in (T \cup V)^* \; V \; (T \cup V)^*$

$\beta \in (T \cup V)^*$

ex=> $S \rightarrow A$ $S \rightarrow a$ $A \rightarrow BB$

$S \rightarrow aAb$ $A \rightarrow Aa$ Anything

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* Type 1 / CSG

$\alpha \rightarrow \beta$

$\alpha \rightarrow (T \cup V)^* \; V \; (T \cup V)^*$

$\beta \rightarrow (T \cup V)^+$

$|\alpha| \leq |\beta|$

ex ⇒ $A \rightarrow \varepsilon$

$|A| \rightarrow |\varepsilon|$

1 0 Not possible

$\therefore \beta \in (T \cup V)^+$

ex ⇒ $AaB \rightarrow aa$

$|AaB| \rightarrow |aa|$

$3 \not\leq 2$ (Not type 1)

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ex⇒ $xAy \rightarrow a$

$aAb \rightarrow c$

* As type 2 and type 3 accepts ε, type 1 must accept ε.

$S \rightarrow \varepsilon$ [Exception]

(i) Only start symbol can produce ε.

(ii) 'S' can not come on right side.

* Type – 2 / CFG

$\alpha \rightarrow \beta$

$\alpha \in V$ [restriction on α]

$|\alpha| = 1$

$\beta \in (T \cup V)^*$

ex⇒ $S \rightarrow aSb$

$S \rightarrow ab$

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* Type 3 / RG

Left linear grammar

$A \rightarrow a / Ba$

$A, B \in V$

$|A| = |B| = 1$

$a \in T^*$

Right linear grammar

$A \rightarrow a / aB$

$A, B \in V$

$|A| = |B| = 1$

$a \in T^*$

eg ⇒ $A \rightarrow BC$ {Two variables (BC), not type 3, only one required}

$A \rightarrow Bc$ [Yes, $B \in V$ and in extreme left]

$A \rightarrow aBa$ [No, B should be either left or right].