Name:- Shivang-Shrivastava

Roll no :- 60.

Q1

Ans:-

$S \rightarrow 0A \mid 1B$

$A \rightarrow 0AA \mid 1S \mid 1$

$B \rightarrow 1BB \mid 0S \mid 0.$

$S \rightarrow 0A \rightarrow 00AA \rightarrow 001SA \rightarrow 0011S$

$\Rightarrow 0^2 1^2 0A \Rightarrow 0^2 1^2 01S \Rightarrow 0^2 1^2 010A \Rightarrow 0^2 1^2 0101.$

Leftmost Derivation

$S \rightarrow 0\underline{A}$

$S \rightarrow 00\underline{A}A$

$S \rightarrow 001\underline{S}A$

$S \rightarrow 0011\underline{B}A$

$S \rightarrow 00110\underline{S}A$

$S \rightarrow 001101\underline{B}A$

$S \rightarrow 0011010\underline{A}$

$S \rightarrow 00110101$

Leftmost Derivative

$S \rightarrow 0\underline{A}$

$S \rightarrow 00\underline{A}A$

$S \rightarrow 001A.$

$S \rightarrow 0011S$

$S \rightarrow 00110A$

$S \rightarrow 001101S$

$S \rightarrow 0011010A$

$S \rightarrow 00110101.$

There exist more than one leftmost derivative of the same string so the grammer is said to be ambigious.

Shrvang - Shrivastava (60)

Q2. $S \rightarrow Ab \mid aaB$

Solu:- $A \rightarrow a \mid Aa$

$B \rightarrow b.$

$S \rightarrow Ab \rightarrow Aab \rightarrow a^nb.$

$S \rightarrow aaB \rightarrow aab.$

~~So we take~~ $w = aaaab$

LMD (1).

$S \rightarrow \underline{A}b$

$S \rightarrow \underline{A}ab$

$S \rightarrow \underline{A}aab$

$S \rightarrow \underline{A}aaab$

$S \rightarrow aaaab.$

~~LMD~~ (2).

$w = aaab.$

LMD (1)

$S \rightarrow \underline{A}b$

$S \rightarrow Aab$

$S \rightarrow aab.$

LMD (2)

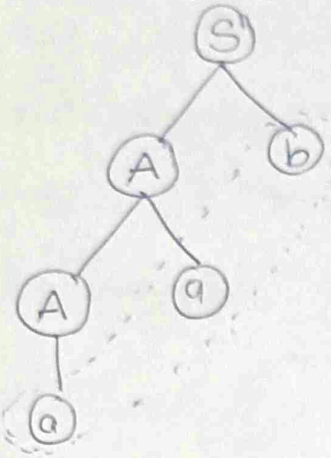
$S \rightarrow aa\underline{B}.$

$S \rightarrow aab.$

There exist more than 1 lmp of the same string so it is ambigious.

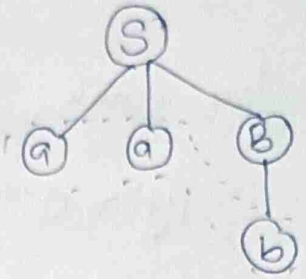
(b). LMD(1)

Derivation tree



LMD(2)

Derivation tree



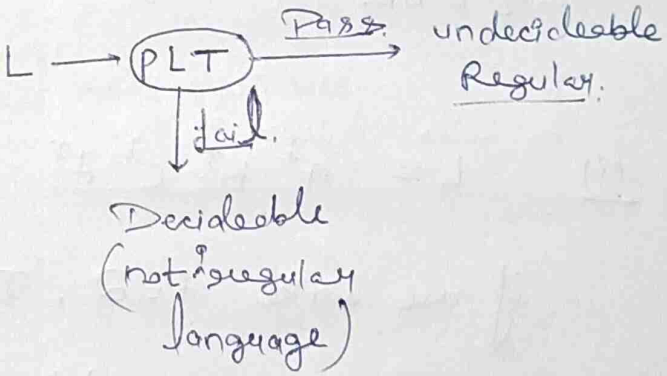
Q.3 (a) $L = \{ a^i b^j c^i d^j \mid i, j \geq 0 \}$.

Sol:

Pumping-lemma :-

→ used to check language is regular or no.

→ It is negative test.



Statement:

If l is a Infinite language there exist some positive integer 'n' (Pumping length) such that any string $w \in L$ has length greater than equal to 'n', i.e. $|w| \geq n$ then w can be divided into 3 parts : x, y, and z.

than it has to follow 3 conditions.

(i). for each $i \geq 0$, $xy^i z \in L$

(ii) $|y| > 0$ and

(iii) $|xy| \leq n$

$w \rightarrow x, (y), z$

$x\ yyyy\ z$.

Ex: $L = a^n b^{2n}$ $n \geq 0$

$w = aa\,bbbb$ $(n=2)$.

$w \in L$.

$x \in aa$

$y \in bb$

$z \in bb$.

$xy^i z$

$w = \underbrace{aa}_{x}\ \underbrace{bbbb}_{y}\ \underbrace{bb}_{z}$

$w \notin L$.

So it is not regular.

(i) $L = a^i b^j c^i d^j$ / $i, j \geq 0$.

if we take $i=2$, $j=2$.

so $w = aabbccdd$ $(w \in L)$.

$x \in aa$

$y \in bb$

$z \in ccdd$.

if we Pump y.

xy^iz

$w = \underbrace{aa}_{x}\ \underbrace{bbbb}_{y}\ \underbrace{ccdd}_{z}$.

$w \notin L$.

It is not satisfy pumping lemma test so it is not a regular language.

(ii) $L = \{ a^q b^i c^j \mid i \geq 1 \}$.

$i = 2$.

$w = aabbcc$.

$x \in aa$

$y \in bb$

$z \in cc$.

$x\, y^i\, z$

$w = aa\,bbbb\,cc \quad (i = 2)$.

$w \notin L$

So it is not a regular language.

Q.4 Eliminate null production

(i) $S \rightarrow aSb \mid aAb \mid ab \mid a$

$A \longrightarrow \varepsilon$

Shivang(60)

Solu: (i) make a set of null able variables.

$\omega_1 = \{ A \}$.

$\omega_2 = \{ A \}$

$\omega_{k+1} = \omega_k$.

$S \rightarrow aSb \mid ab \mid a$

(Shrvang - Shrivastava (60))

Q.5 $S \rightarrow AB$

$A \rightarrow aAA \mid a \mid \wedge$

$B \rightarrow bBB \mid \wedge$

Soln: $\omega_1 = \{A, B\}$

$\omega_2 = \{A, B, S\}$

$\omega_3 = \{A, B, S\}$

$\therefore [\omega_2 = \omega_2]$

$S \rightarrow AB \mid A \mid B$

$A \rightarrow aAA \mid a \mid A$

$B \rightarrow bBB \mid b \mid bB.$

(ii) $S \rightarrow aXbX$

$X \rightarrow aY \mid bY \mid \wedge$

$Y \rightarrow X \mid d$

$\omega_1 = \{X\}$

$\omega_2 = \{X, Y\}$

$\omega_3 = \{X, Y\}$

$S \rightarrow aXbX \mid aXb \mid ab \mid abX$

$X \rightarrow aY \mid bY \mid a \mid b.$

$Y \rightarrow X \mid d$

Q6. (Dout)

Soln.

$S \rightarrow OS \mid 1AA$

$A \rightarrow 0 \mid 1A \mid 0B$

$B \rightarrow 1 \mid 0BB$

for string 0100110.

P.T G is ambiguous.

(LMD)(1).

$S \rightarrow 0\underline{S}$

$S \rightarrow 01\underline{A}A$

$S \rightarrow 010\underline{B}A$

$S \rightarrow 0100\underline{B}BA$

$S \rightarrow 01001\underline{B}A$

$S \rightarrow 0100110\underline{A}$

$S \rightarrow 0100100$

(LMD)(2).

$S \rightarrow 0\underline{S}$

$S \rightarrow 01\underline{A}A$

$S \rightarrow 010\underline{A}$

$S \rightarrow 0100\underline{B}$

$S \rightarrow 0100$

(Sarvang Go)

$S \rightarrow 0\underline{S}$

$S \rightarrow 01AA$

$S \rightarrow 01$

(Shivang Goa)

Q7. $S \rightarrow aAS \mid a$

$A \rightarrow SbA \mid SS \mid ba$

To generate string aabaaabbaaa

(a) LMD.

$S \rightarrow \underline{a}AS$

$S \rightarrow a\underline{S}bAS$

$S \rightarrow aab\underline{A}S$

$S \rightarrow aabS\underline{S}S$

$S \rightarrow aabaA\underline{S}S$

$S \rightarrow aabaaA\underline{S}S$

$S \rightarrow aabaaabbaS\underline{S}$

$S \rightarrow aabaaabbaa\underline{S}$

$S \rightarrow aabaaabbaaa$

(b) RMD.

$S \rightarrow aA\underline{S}$

$S \rightarrow aAaA\underline{S}$

$S \rightarrow aAaA\underline{a}$

$S \rightarrow aAaS\underline{S}a$

$S \rightarrow aAaaa$

(Shivang Go)

(b) RMD.

$S \rightarrow aAS$

$S \rightarrow aAa$

$S \rightarrow aSbAa$

$S \rightarrow aSbSSa$

$S \rightarrow aSbSaaa$

$S \rightarrow aSbaaaa$

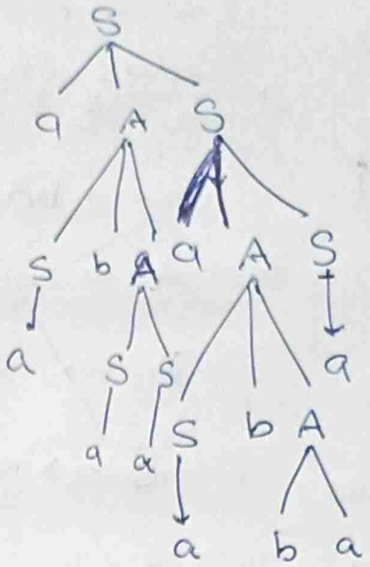
$S \rightarrow aaASbaaaa$

$S \rightarrow aaAaASbaaaa$

$S \rightarrow aaAaAbaaaa$

$S \rightarrow aaabaaaabbaaaa$

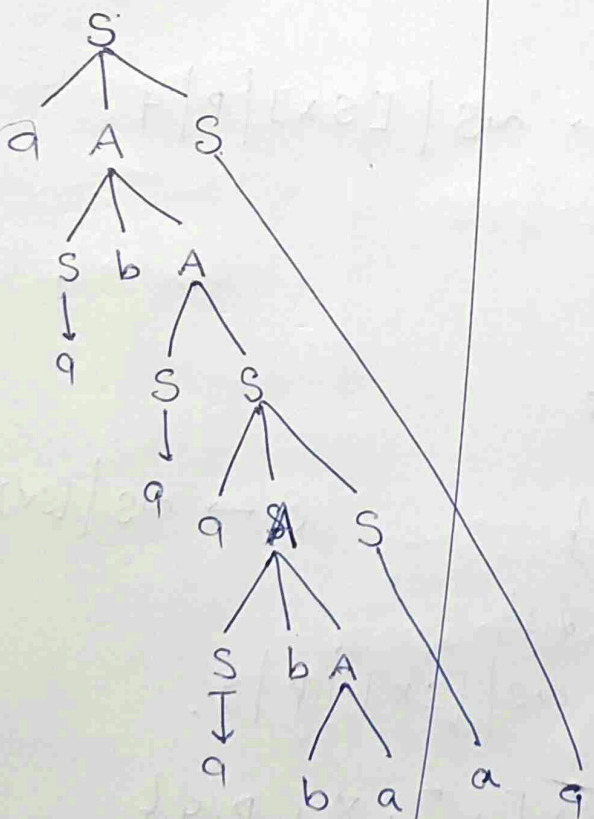
RMD.



aab aaa b baaa

(c) Parse tree

LMD.



Q. Reduce the given CFG into CNF: [Strong-Shrivastava(60)]

$S \rightarrow \sim S \mid [SX] \mid p \mid q$

$A \rightarrow a$

$A \rightarrow BC$

Step 1: Eliminate unit and null production.

Step 2. Eliminate RHS terminal

$S \rightarrow \sim S$ $\quad C_a \rightarrow \sim$

$S \rightarrow C_a S$

. . . . . .

$S \rightarrow [SX]$

$S \rightarrow C_[S C_x C_]$ $\quad C_[\rightarrow [$

$C_x \rightarrow X$

$C_] \rightarrow]$

. . . . . .

Step 3. Reduce no of variable from RHS.

$S \rightarrow C_[S C_x C_]$

$C_{12} \rightarrow C_[S$

$S \rightarrow C_{12} C_{34}$

$C_{34} \rightarrow C_x C_]$

find production

$S \rightarrow \sim S$

$C_a \rightarrow \sim$

$S \rightarrow C_a S$

$C_[\rightarrow [$

$C_x \rightarrow X$

$C_] \rightarrow]$

$S \rightarrow p$

$S \rightarrow q$.

$S \rightarrow C_{12} C_{34}$

$C_{12} \rightarrow C_[S$

$C_{34} \rightarrow C_x C_]$.

Q1. Reduce the given CFG into CNF. [Shivang - Shrivastava (60)]

(1) $S \rightarrow bA \mid aB$

$A \rightarrow bAA \mid aS \mid a$

$B \rightarrow aBB \mid bS \mid b$

Solu:- Step 1:- Eliminate unit and null production.

Step 2: Eliminate RHS terminal.

$S \rightarrow bA$

$S \rightarrow C_bA \quad C_b \rightarrow b$

$S \rightarrow aB$

$S \rightarrow C_aB \quad C_a \rightarrow a$

$A \rightarrow bAA$

$\boxed{A \rightarrow C_bAA}$

$A \rightarrow aS$

$A \rightarrow C_aS$

$B \rightarrow aBB$

$\boxed{B \rightarrow C_aBB}$

$B \rightarrow bS$

$B \rightarrow C_bS$

Step 3 Reduction of Variable.

$A \rightarrow C_bAA \quad C_{12} \rightarrow AA$

$A \rightarrow C_bC_{12}.$

$B \rightarrow C_aBB \quad C_{34} \rightarrow BB$

$B \rightarrow C_aC_{34}$

Final Production.

$S \rightarrow C_bA$

$C_b \rightarrow b$

$C_a \rightarrow a$

$S \rightarrow C_aB$

$A \rightarrow C_aS$

$A \rightarrow a$

$B \rightarrow b$

$B \rightarrow C_bS$

$C_{12} \rightarrow AA$

$A \rightarrow C_bC_{12}.$

$C_{34} \rightarrow BB$

$B \rightarrow C_aC_{34}.$

(ii) $S \rightarrow ASA \mid bA$

$A \rightarrow B \mid S$

$B \rightarrow a$

After,

(i) Eliminate unit and null Productions.

$S \rightarrow ASA \mid bA$

$A \rightarrow a \mid ASA \mid bA$

$B \rightarrow a.$

(ii) Eliminate terminals from RHS.

$S \rightarrow ASA$

$S \rightarrow bA$

$S \rightarrow C_bA.$

$C_b \rightarrow b.$

$A \rightarrow ASA$

$A \rightarrow bA$

$A \rightarrow C_bA$

(iii) Reduction of variable.

$S \rightarrow ASA$

$S \rightarrow AC_{12}.$

$A \rightarrow AC_{12}.$

$C_{12} \rightarrow SA$

CNF Productions.

$C_b \rightarrow b$

$S \rightarrow C_bA$

$A \rightarrow a$

$A \rightarrow C_bA.$

$B \rightarrow a.$

$C_{12} \rightarrow SA$

$A \rightarrow AC_{12}$

$S \rightarrow AC_{12}.$

(Shivang - 60)

Q.1o Convert the grammar into GNF.

S, A, B.

(1) $S \rightarrow AB$.

$A \rightarrow BS \mid a$

$B \rightarrow SA \mid b$.

Step:1 Convert to CNF.

→ It is already in CNF.

Step:2 Rename the variable.

$A_1 \longrightarrow A_2 A_3$

$A_2 \longrightarrow A_3 A_1 \mid a$

$A_3 \longrightarrow A_1 A_2 \mid b$.

let The production $A_1 \longrightarrow A_2 A_3$ and

$A_2 \rightarrow A_3 A_1 \mid a$ are in required form.

$\boxed{A_3 \longrightarrow b}$ are in required form.

Apply lemma 1 in $A_3 \rightarrow A_1 A_2$ (lemma 1) [$\because A \rightarrow BY$]

Replace A_1 with its production.

$A_3 \longrightarrow A_2 A_3 A_2$

~~$A_3 \rightarrow$~~ Apply lemma 1.

~~$A_3 \rightarrow A_3 A_2 \mid$~~ .

$A_3 \longrightarrow A_3 A_1 A_3 A_2$.

$\boxed{A_3 \rightarrow b}$

~~$A_3 \rightarrow a A_3$~~

$\boxed{A_3 \rightarrow a A_3 A_2}$

we have to apply lemma 2 on

$A_3 \rightarrow A_3 A_1 A_3 A_2$. $\quad [A \rightarrow A\alpha]$.

Let Z be a new variable

$Z \rightarrow \alpha$.

$Z \rightarrow A_1 A_3 A_2$.

$Z \rightarrow A_1 A_3 A_2 Z$.

~~$A_3 \rightarrow aA_3A_2Z \mid Zb$.~~

$A_3 \rightarrow aA_3A_2Z \mid aA_3A_2 \mid bZ \mid b$.

$A_2 \rightarrow A_3 A_1 \mid a$ [By applying lemma 1].

$A_2 \rightarrow a \mid aA_3A_2ZA_1 \mid aA_3A_2A_1 \mid bZA_1 \mid bA_1$

$A_1 \rightarrow A_2 A_3$.

By Applying lemma 1.

$A_1 \rightarrow aA_3 \mid aA_3A_2ZA_3 \mid aA_3A_2A_1A_3 \mid bZA_1A_3 \mid bA_2A_3$

Z Production are

$Z \rightarrow A_1 A_3 A_2$.

$Z \rightarrow A_1 A_3 A_2 Z$.

Shivang(6)

$Z \rightarrow aA_3A_3A_2 \mid aA_3A_2ZA_1A_3A_3A_2 \mid aA_3A_2A_1A_3A_3A_2$

$\mid bZA_1A_3A_3A_2 \mid bA_2A_3A_3A_2.$

$Z \rightarrow aA_3A_3A_2Z \mid aA_3A_2ZA_1A_3A_3A_2Z \mid aA_3A_2A_1A_3A_3A_2Z$

$\mid bZA_1A_3A_3A_2Z \mid bA_2A_3A_3A_2Z$

(ii) $S \rightarrow ABb \mid a$

$A \rightarrow aaA$

$B \rightarrow bAb.$

$A \rightarrow a$

$A \rightarrow AB.$

Solu: Step 1: Convert in CNF.

Remove terminal from RHS.

$S \rightarrow ABb$

$C_b \rightarrow b.$

$\boxed{S \rightarrow ABC_b.}$

$A \rightarrow aaA$

$C_a \rightarrow a$

$\boxed{A \rightarrow C_aC_aA.}$

$\boxed{B \rightarrow C_bAC_b}$

Reducing.

~~$S \rightarrow C_{12}C_b.$~~ ~~$C_{12} \rightarrow AB$~~

~~$A \rightarrow$~~ $S \rightarrow ABC_b$ ~~C_{34}~~

$S \rightarrow AC_{12}.$ $C_{12} \rightarrow BC_b$

[Productions after converting into CNF.].

$C_b \rightarrow b.$

$S \rightarrow a$ [illegible]

$C_a \rightarrow a$

$C_{12} \rightarrow$ [illegible] $BC_b.$

$S \rightarrow AC_{12}.$

$A \rightarrow C_aC_{23}$

$C_{23} \rightarrow C_aA.$

$B \rightarrow C_bC_{34}$

$C_{34} \rightarrow AC_b.$

Production after Converting into CNF

- $S \to a \mid AC_{12}$
- $C_b \to b$
- $C_a \to a$
- $C_{12} \to BC_b$
- $A \to C_a C_{23}$
- $C_{23} \to C_a A$
- $B \to C_b C_{34}$
- $C_{34} \to AC_b$

Renaming

A_1 A_2 A_3 A_4 A_5
$S, A, B, C_a, C_b,$
A_6 A_7 A_8
C_{12}, C_{23}, C_{34}

$A_1 \to a \mid A_2 A_6$

$A_5 \to b$

$A_4 \to a$

$A_6 \to A_3 A_5$

$A_2 \to A_4 A_7$

$A_7 \to A_4 A_2$

$A_3 \to A_5 A_8$

$A_8 \to A_2 A_5$

$A \to a \{V_N\}^*$ [Strong (60)].

let $A_1, A_2, A_3, \ldots A_7$ are in CNF:

$A_8 \to A_2 A_5$

Apply lemma 1.

$A_8 \to A_4 A_7 A_5$.

(lemma 1).

$\boxed{A_8 \to a A_7 A_5}$

$A_7 \to A_4 A_2$.

(l-1).

$\boxed{A_7 \to a A_2}$.

$A_6 \to A_3 A_5$.

(l-1)

$A_6 \to A_5 A_8 A_5$.

(l-1)

$\boxed{A_6 \to b A_8 A_5}$.

$\boxed{A_5 \to b}$

$\boxed{A_4 \to a}$

$A_3 \to A_5 A_8$. (l-1)

$\boxed{A_3 \to b A_8}$

[Shivang Shrivastava (60)]

$A_2 \longrightarrow A_4 A_7$

Apply (L-1).

$A_2 \longrightarrow a A_7$

$A_1 \longrightarrow a$

$A_1 \longrightarrow A_2 A_6.$

(L-1)

$A_1 \longrightarrow A_4 A_7 A_6.$

(L-1)

$A_1 \longrightarrow a A_7 A_6$

GNF Productions.

$A_1 \longrightarrow a \mid a A_7 A_6$

$A_2 \longrightarrow a A_7.$

$A_3 \longrightarrow b A_8$

$A_4 \longrightarrow a$

$A_5 \longrightarrow b.$

$A_6 \longrightarrow b A_8 A_5$

$A_7 \longrightarrow a A_2$

$A_8 \longrightarrow a A_7 A_5.$

Name: Shivang - Shrivastava (60)

$A \to \alpha$
$A \to A\beta$

(Doubt)

Q.11.

$$E \longrightarrow E + T \mid T$$

$$T \longrightarrow T * F \mid F$$

$$F \longrightarrow (E) \mid q$$

Convert into GNF

after.
Production Elimination of unit production.

$$E \longrightarrow E+T \mid T*F \mid (E) \mid q$$

$$T \longrightarrow T*F \mid (E) \mid q$$

$$F \longrightarrow (E) \mid q$$

Renaming the variable α.

A_1 A_2 A_3.
E T F

$$A_1 \longrightarrow A_1 + A_2 \mid A_2 * A_3 \mid (A_1) \mid q$$

$$A_2 \longrightarrow A_2 * A_3 \mid (A_1)$$

[First we have to Convert into CNF.].

Shivang(60).

Remove termial from RHS.

$E \rightarrow E + T$

$\boxed{E \rightarrow E\ C_+\ T}$ $\quad C_+ \rightarrow +$

$E \rightarrow T * F$

$\boxed{E \rightarrow T\ C_*\ F}$ $\quad C_* \rightarrow *$.

$E \rightarrow (E)$

$\boxed{E \rightarrow C_c\ E\ C_)}$ $\quad C_c \rightarrow ($, $C_) \rightarrow)$

$T \rightarrow T * F$

$\boxed{T \rightarrow T\ C_*\ F}$

$\boxed{T \rightarrow C_c\ E\ C_)}$

$\boxed{F \rightarrow C_c\ E\ C_)}$

Reduction.

$E \rightarrow E\ C_+\ T$

$C_{12} \rightarrow C_+ T$

$E \rightarrow E\ C_{12}$.

$E \rightarrow T\ C_*\ F$

$C_{23} \rightarrow C_* F$.

$E \rightarrow T\ C_{23}$.

$E \rightarrow C_c\ E\ C_)$

$C_{34} \rightarrow E C_)$

$E \rightarrow C_c\ C_{34}$

[Production after Converting into CNF].

$C_+ \rightarrow +$

$C_* \rightarrow *$.

$C_c \rightarrow ($

$C_) \rightarrow)$

$E \rightarrow 9 \mid E C_{12}. \mid T C_{23}. \mid C_c C_{34}$

$T \rightarrow 9 \mid T C_{23}. \mid C_c C_{34}$

$F \rightarrow 9. \mid C_c C_{34}$.

$C_{12} \rightarrow C_+ T$

$C_{23} \rightarrow C_* F$.

$C_{34} \rightarrow E C_)$

~~$E \rightarrow$ decimal~~

$T \rightarrow T\ C_*\ F$

$T \rightarrow T\ C_{23}$.

$T \rightarrow C_c\ E\ C_)$

$C_c\ C_{34}$.

$F \rightarrow C_c\ E\ C_)$

C_c

Shivang(60)

Renaming of Variable Produced by CNF.

A_1 A_2 A_3 A_4 A_5 A_6 A_7
E T F C+ C* C(C)

C_{13} C_{19} C_{14}
A_8 A_9 A_{10}

$A_1 \longrightarrow a \mid A_1 A_8 \mid A_2 A_9 \mid A_6 A_{10}$.

$A_2 \longrightarrow a \mid A_2 A_9 \mid A_6 A_{10}$.

$A_3 \longrightarrow a \mid A_6 A_{10}$.

$A_4 \longrightarrow +$

$A_5 \longrightarrow *$

$A_6 \longrightarrow ($

$A_7 \longrightarrow)$

$A_8 \longrightarrow A_4 A_2$.

$A_9 \longrightarrow A_5 A_3$.

$A_{10} \longrightarrow A_1 A_7$.

let A_1 to A_9 is in GNF..

$A_{10} \longrightarrow A_1 A_7$. $[A \to BY]$

(Apply I-1).

$A_{10} \longrightarrow a A_7$ ~

$A_{10} \longrightarrow A_1 A_8 A_7$.

$A_{10} \longrightarrow A_2 A_9 A_7$.

$A_{10} \longrightarrow a A_9 A_7$

$A_6 \longrightarrow A_2 A_9 A_9 A_7$.

$A_{10} \longrightarrow A_1 A_{10} A_7$

~~$A_2 A_9 A_7$. (Apply I-1).~~ $A_{10} \to (A_{10} A_7$.

~~$A_{10} \to A_2 A_9 A_7$.~~ $\xrightarrow{I_1}$

$A_{10} \longrightarrow A_6 A_{10} A_7$. $\xrightarrow{I_1}$ $A_{10} \to (A_{10} A_7$

Shivang(66).

$A_{10} \rightarrow A_1 A_8 A_7$ [l_1].

$A_{10} \rightarrow a A_8 A_7$

$A_{10} \rightarrow A_1 A_8 A_8 A_7 \mid A_2 A_9 A_8 A_7 \mid A_6 A_{10} A_8 A_7$.

~~$A_{10} \rightarrow a A_8 A_8 A_7$.~~

$A_{10} \rightarrow (A_{10} A_8 A_7$

$A_{10} \rightarrow a A_8 A_8 A_7$.

Q.12

$S \rightarrow AB$,
$A \rightarrow a$,
$B \rightarrow C \mid b$
$C \rightarrow D$
$D \rightarrow E$
$E \rightarrow a$

$S \rightarrow AB$
$A \rightarrow a$
$B \rightarrow b \mid a$
$C \rightarrow a$
$D \rightarrow a$
$E \rightarrow a$

Ans.

Q.13

$S \rightarrow aB \mid bX$
$A \rightarrow BAd \mid bSX \mid a$
$B \rightarrow aSB \mid bBX$
$X \rightarrow SBD \mid aBx \mid ad$

Shivang (60).

Q.13 Remove the useless symbol (Simplification).

Soln.

$S \rightarrow aB \mid bX$

$A \rightarrow BAd \mid bSX \mid a$

$B \rightarrow aSB \mid bBX$

$X \rightarrow SBD \mid aBx \mid ad$.

(i). Remove null production

null is already removed.

(ii) Remove unit production

unit is already removed

(iii). Reduction

(i). find W_1'

(a) V_1'

$V_1 = \{A,\}$

$V_2 = \phi$

W_1'

$W_1 = \{A, X\}$

$W_2 = \{A, X\}$

W_3 [illegible]

(iii) Reduction.

(i) find G'

$\omega_1 = \{A, X\}$

$\omega_2 = \{A, X, S\}$

$\omega_3 = \{A, X, S\}$.

$V_N' = \{A, X, S\}$.

$P' = \{ \quad S \rightarrow bX$

$A \rightarrow bSX \mid a$

$X \rightarrow ad \}$

II Theorem G''.

V''.

$\omega_1 = \{S\}$.

$\omega_2 = \{S, X\}$. $S \rightarrow bX$

$X \rightarrow ad$

$\omega_3 = \{S, X\}$.

$V_N'' = \{S, X\}$.

[$\because \omega_3 = \omega_2$].

$P'' = \{ \quad S \rightarrow bX,$

$A \rightarrow a \mid bSX$

$X \rightarrow ad \}$.

$\Sigma = \{b, a\}$

$G'' = \{V_N'', \Sigma, P'', S\}$.

(14) $S \rightarrow 1S1 \mid T$

$T \rightarrow 1X1 \mid X$

$X \rightarrow 0X0 \mid 1.$

(i) 1S1

1 1S1 1

1 1T 1 1

1 1 X 1 1

1 1 0X0 1 1

(1) → 1 1 0 1 0 1 1

(2) 1 1 1 1 1

(3) 1 1 1

(4) 1 1 0 0 1 0 0 1 1

(ii) $\omega \in \{0,1\}^*$

1 1 0 0 1 0 0 1 1.

(15)

Solution $L = \{x \in \{a,b\}^* / x$ starts and ends with different symbols $\}$.

$L = \{ab, ba, aab, baa, \ldots\}$

$S \rightarrow aAb \mid bAa$

$A \rightarrow aA \mid bA \mid \epsilon.$