19 Tuesday MAY

April '20

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

2020

Wk 21 • 140-226

8.00

MODULE-4

9.00

CONTEXT FREE GRAMMAR AND LANGUAGE (CFG)

10.00

Declaration of Production :-

11.00

$V \rightarrow V_1 V_2$

12.00

$V \rightarrow T V_1$

$V \rightarrow T$

1.00

$V \rightarrow T_1 T_2 T_3$

2.00

3.00

Definition :-

4.00

* It is a formal grammar used to generate all possible patterns of string in a given

5.00

finite language.

6.00

* CFG can be represented by 'G' and this 'G' has four tuples.

7.00

$G = (V, T, P, S)$

V - Variable of non-terminal

T - Terminal

Notes

P - Production rule

S - Start symbol

2020

Wk 21 • 141-225

June '20

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Wednesday MAY 20

8.00

* Instead of V, 'N' is used since Non-terminal 'V'.

9.00

* Terminal will be small letters whereas non-terminal be capital letters.

10.00

V - ASE

11.00

T - abc */

12.00

* In production rule, on LHS you will have non-terminal and on RHS have (non-terminal, terminal).

1.00

* Start symbol 'S', either variable or non

2.00

Terminal (capital).

3.00

Problem

6m 1. Construct CFG for the language that has number of a's over the set $\Sigma = \{a\}$. Derive the input = "aaaaaa".

8m

4.00

5.00

$\Sigma = \{a\}$

$G = (V, T, P, S)$

6.00

$L = \{\varepsilon, a, aa, aaa, aaaa, \ldots\}$

7.00

$V \rightarrow S$

$T \rightarrow \varepsilon, a$

$P \rightarrow S \rightarrow aS \rightarrow ①$, $S \rightarrow \varepsilon \rightarrow ②$

$S \rightarrow S$

Notes

8.00 S (S → aS)
aS (S → aS)
9.00 aaS (S → aS)
aaaS (S → aS)
10.00 aaaaS (S → aS)
aaaaaS (S → aS)
11.00 aaaaaaS (S → ε)
↓
12.00 aaaaaaε.

1.00 = aaaaaaa.

2.00 2. Construct CFG for a language given by where $L = \{ wcw^R \mid$ where $w \in (a,b)^* \}$. w^R ↓ Reverse
3.00 Derive input = "abbcbba".

4.00 $G = (V, T, P, S)$
W → String
C → Constant
WR → Reverse of String

W can take any number of a's and b's

5.00 $L = \{aca, bcb, abcba, bacab, \ldots\}$

V → S
T → a, b, c
S → S
P → S → aSa → ①
S → bSb → ②
S → C → ③

Notes

8.00 input = "abbcbba"

9.00 S (S → aSa)
↓
10.00 aSa (S → bSb)
↓
11.00 abSba (S → bSb)
↓
12.00 abbSbba (S → C)
↓
1.00 abbcbba.

2.00 3. $L = \{a^n b^{2n}\}$ where $n \geq 1$. Derive input "aaabbbbbb".

3.00 $L = \{a^n b^{2n}\}$ $n \geq 1$

4.00 $G = (V, T, P, S)$

5.00 $L = \{abb, aabbbb, aaabbbbbb, \ldots\}$

6.00 V → S
7.00 T → a, b
P → S → aSbb → ①
S → abb → ②

S → S

Notes

23 Saturday MAY

April '20

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

2020 Wk 21 • 144-222

8.00 S (S → aSbb)

9.00 aSbb (S → aSbb)

10.00 aaSbbbb (S → abb)

11.00 aaabbbbbb

12.00 4. $L = \{a^n b^n\}$ where $n \geq 1$. Derive input "aaabbb".

1.00 $L = \{a^n b^n\}$ $n \geq 1$

2.00 $G = \{V, T, P, S\}$

3.00 $L = \{ab, aabb, aaabbb, \ldots\}$

4.00 V → S

5.00 T → a, b

S → S

6.00 P → S → aSb → ①

S → ab → ②

7.00

24 SUNDAY

S (S → aSb)

↓

aSb (S → aSb)

↓

aaSbb (S → ab)

↓

aaabbb

Notes

2020 Wk 22 • 146-220

June '20

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Monday MAY 25

8.00 PARSE TREE or DERIVATION TREE :-

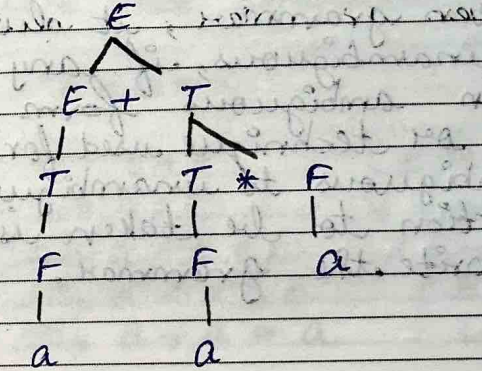
9.00 $E \rightarrow E+T \,/\, T$

$T \rightarrow T * F \,/\, F$

10.00 $F \rightarrow a$

11.00 Construct "a + a * a".

12.00



1.00

2.00

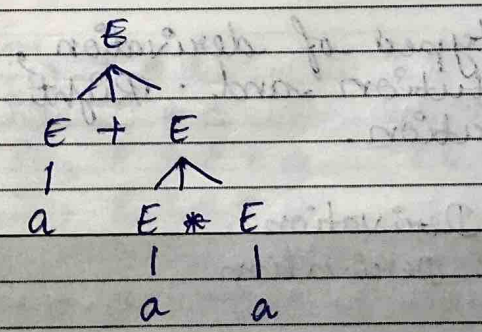
3.00

4.00

5.00 $E \rightarrow E+E \,/\, E*E \,/\, a$

6.00 Construct "a + a * a".

7.00



Notes

Ambiguity :-

* If we are able to derive more than one parse tree or more than one derivation then it is Ambiguous.

* For the given grammar, it always should be in unambiguous, if any grammar is in ambiguous form, there is no method or technique used for converting ambiguous to unambiguous.

* The only action to be taken is we ~~can~~ have to rewrite the grammar.

Types of Derivation :-

There are 2 types of derivation, left most substitution and Right most substitution.

1. Left Most Derivation
2. Right Most Derivation

1. Left most derivation is a derivation in which the substitution starts from left to right.

2. Right most derivation is a derivation in which the substitution starts from right to left.

Left Most Derivation :-

"a + a * a"

$E \xrightarrow{LM} E+E$ $(E \to a)$
$E \xrightarrow{LM} a+E$ $(E \to E*E)$
$E \xrightarrow{LM} a+E*E$ $(E \to a)$
$E \xrightarrow{LM} a+a*E$ $(E \to a)$
$E \xrightarrow{LM} a+a*a$

Right Most Derivation :-

"a + a * a"

$E \xrightarrow{RM} E*E$ $(E \to a)$
$E \xrightarrow{RM} E*a$ $(E \to E+E)$
$E \xrightarrow{RM} E+E*a$ $(E \to a)$
$E \xrightarrow{RM} E+a*a$ $(E \to a)$
$E \xrightarrow{RM} a+a*a$

Notes

8.00 CHOMSKY NORMAL FORM (CNF) :-

9.00 STEP-1: Elimination of useless symbol.

10.00 i) Non Generating Symbol
ii) Not Reachable Symbol

11.00 STEP-2: Elimination of ε-Production.

12.00 STEP-3 :- Elimination of unit Production.

1.00 Non Generating Symbol :-

2.00 * On substitution, if we get non-terminal then it is non generating symbol.

3.00 Generating Symbol :-

4.00 * On substitution, if we get terminals then it is called generating symbol.

5.00 Not Reachable Symbol :-

6.00 * Not Reachable Symbol is one which cannot be reached from starting state or starting symbol.

Reachable Symbol :-

* Reachable Symbol is one which can be reached from starting state or starting symbol.

8.00 Elimination of Useless Symbols :-

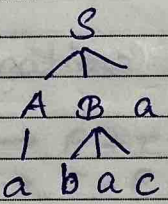
9.00 $S \rightarrow ABa \mid BC$
$B \rightarrow bac$

10.00 $C \rightarrow CA$
$D \rightarrow E$

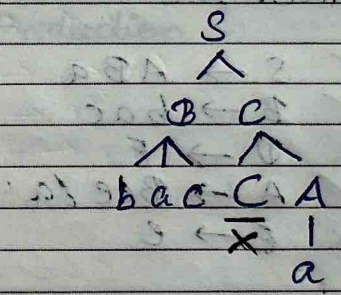
11.00 $A \rightarrow aC \mid Bee \mid a$
$E \rightarrow e$

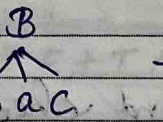
Terminal - small letters
Non-terminal - Capital letters

12.00 Generating Symbols :-

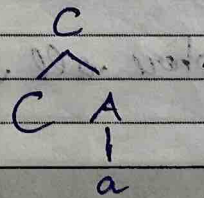
1.00 

Non Generating Symbols :-

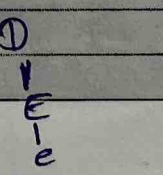


2.00 

– Generating Symbols.

3.00 

– Non Generating Symbols.

4.00 

– Generating Symbols

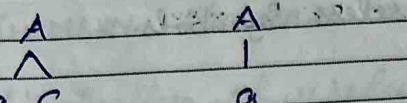
Notes

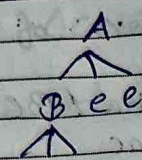
30 Saturday MAY

April '20

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

2020 Wk 22 • 151-215





Non Generating Generating Generating

E
|
e

- Generating Symbols.

After :-

✓ S → ABa
✓ B → bac
✗ D → E
✓ A → Bee / a
✗ E → e

Reachability :-

From 'S' → A (terminal). So go and check A → Bee / a, where 'B' finds terminal.

SUNDAY So, go to B → bac, where all are non-terminal.

Then eliminate others.

2020 Wk 23 • 153-213

July '20

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Monday 01 JUNE

Elimination of ε - Production :-

S → ACA / Aa
A → BB / ε
B → A / bc
C → b

Ex: ACA

ε is present in 'A' so substitute

S → ACA / CA / AC / C / Aa / a
A → BB / B
B → A / bc
C → b

A → BB / B

A → B B / ε

(Since all 'A' has been substituted with 'ε')

Elimination of Unit Production :-

E → E + T / T
T → T * F / F
F → (E) / a

E → E + T / T * F / F

E → E + T / T * F / (E) / a

T → T * F / (E) / a

Notes

02 Tuesday JUNE

May '20

S	M	T	W	T	F	S
31					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

2020 Wk 23 • 154-212

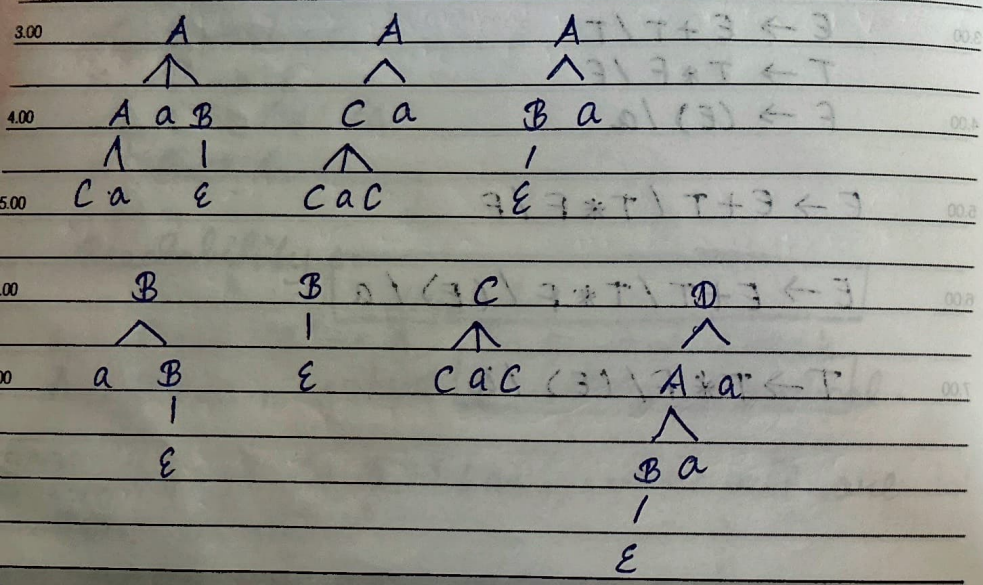
8.00 Chomsky Normal Form (CNF) :-

9.00 $A \to AaB / Ca / Ba$
$B \to aB / \varepsilon$
10.00 $C \to CaC$
$D \to Aa$

11.00 General Form of CNF :-

12.00 $A \to BC$
1.00 $A \to a$

2.00 STEP-1 :- Elimination of useless Symbol

3.00 

Notes

2020 Wk 23 • 155-211

July '20

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Wednesday 03 JUNE

8.00 Elimination of Non-reachable symbols :-

9.00 $A \to AaB / Ba$
$B \to aB / \varepsilon$
10.00

STEP-2 :- Elimination of ε-Production :-

11.00 $A \to AaB / Ba / Aa / a$
12.00 $B \to aB / a$

1.00 STEP-3 :- Elimination of unit Production :-

2.00 No unit Production.

3.00 Chomsky Normal Form :-

4.00 $A \to AaB / Ba / Aa / a$

5.00 $B \to aB / a$

$A \to BC$
$A \to a$

6.00 $X \to a$

7.00 $A \to AXB / BX / AX / a$

(If the $A \to Be$
$A \to a$ Condition
Satisfied, then that
is to be same a
$X \to a$)

Griebach Normal Form (GNF)

General Form of GNF

STEP-1 :-

The General form of GNF is

$A \to \alpha A_1 A_2 A_3 \ldots\ldots N$

$A \to \alpha$

$\alpha \to$ Terminal

$A, A_1, A_2, \ldots\ldots A_N \to$ Variables.

STEP-2 :-

The Given grammar has to be converted into Chomsky Normal Form.

STEP-3 :-

The LHS value should be greater than RHS. So we have to take that grammar and proceed.

STEP-4 :-

When the value of LHS and RHS are same we have to apply left factoring formula.

i.e If $A \to A\alpha / \beta$

then $A \to \beta A' / \beta$, $A' \to \alpha A' / \alpha$

STEP-5 :-

Following all the step convert the given grammar into GNF form.

Problem

1. $X \to SA / b$
   $S \to XA$
   $A \to a$

It is in Chomsky Normal Form.

Now, we are replacing the X, S, A.

$X \to A_1$ $\quad A_1 \to A_2 A_3 / b$

$S \to A_2$ $\quad A_2 \to A_1 A_3$

$A \to A_3$ $\quad A_3 \to a$

The LHS should be greater than RHS.

So, taking $A_2 \to A_1 A_3$

Substitute for A_1,

$A_2 \to A_1 A_3$

$A_2 \to A_2 \underline{A_3 A_3} / \underline{b A_3}$

$A \to A\alpha / \beta$

Notes

$A \to A_2$

$\alpha \to A_3 A_3$

$\beta \to b A_3$

8.00 Left factoring:-

9.00 If $A \to A\alpha / \beta$

10.00 then $A \to \beta A' / \beta$

11.00 $A' \to \alpha A' / \alpha$

12.00 Substitute in this formula,

1.00 $A_2 \to bA_3A' / bA_3$ → ①
$A' \to A_3A_3A' / A_3A_3$ → ②

2.00

.00 $A_1 \to A_2A_3 / b$

0 Substitute equation ①,

$\boxed{A_1 \to bA_3A'A_3 / bA_3A_3 / b}$

From equation ②,

$A' \to A_3A_3A' / A_3A_3$

UNDAY $\boxed{A' \to aA_3A' / aA_3.}$

8.00 Pumping Lemma for CFL (Context Free Language) :-

9.00

10.00 If a language L is context free then there exist some integer, $P \geq 1$ such that every string S in L has a length of P or more symbols $|S| \geq P$ (and this S and P) can written as $S = UVWXY$ with substring $U, V, W, X,$ and Y such that, there are 3 condition.

12.00

1.00 i) $|VX| \geq 1$
ii) $|VWX| \leq P$ and
2.00 iii) $UV^nWX^nY \in L$ for all $n \geq 0$.

3.00 Problem

4.00 1. Prove that $L = \{a^P / P$ is prime number$\}$ is not CFL.

5.00

6.00 Proof :-

7.00 Let the language L be CFL, then

$L = \{a^2, a^3, a^5, a^7, \ldots\}$.

$L = \{aa, aaa, aaaaa, aaaaaaa, \ldots\}$.

Notes

$|S| \geq P$

09 Tuesday JUNE 2020 Wk 24 • 161-205

May '20

S	M	T	W	T	F	S
31					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Taking, $S = aaaaa$, $p=5$
$UVWXY$

$|S| \geq P$
$|5| \geq 5$
$5 \geq 5$

The condition is satisfied.

3 Condition :-

1. $|VX| \geq 1$
$|aa| \geq 1$
$2 \geq 1$ The Condition is satisfied.

$aaaaa$
$UVWXY$

2. $|VWX| \leq P$
$|aaa| \leq 3$
$3 \leq 3$ The Condition is satisfied.

3. $UV^nWX^nY \in L$ for all $n \geq 0$.

$UV^nWX^nY \Rightarrow aa^0aa^0a$

If $n=0$, $= a\varepsilon a^1 \varepsilon a$ $\quad a^0 = \varepsilon$
$= aaa \in L$ $\quad 3 \in L$ $\quad a\varepsilon = a$

If $n=1$, $= aa^1aa^1a$
$= aaaaa \in L$ $\quad 5 \in L$

2020 Wk 24 • 162-204

July '20

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Wednesday JUNE 10

If $n=2$, $= aa^2aa^2a$
$= aaaaaaaa \in L$ $\quad 7 \in L$

If $n=3$, $= aa^3aa^3a$
$= aaaaaaaaaa \notin L$ $\quad 9 \notin L$

Therefore it is not a CFL.

2. Show that $L = \{a^n b^n c^n / n \geq 1\}$ is not CFL.

$S = a^n b^n c^n$ $\quad |S| \geq P$

Here $n = P$, $n=1$ $\quad n$ is a constant

$S = abc$
$S = 3$ $\quad n=3$
$|3| \geq 3$

$S = \underbrace{UVWX}_{a^n\ b^n}\ Y$ $\quad c^n$

$|VWX| \leq P$ $\quad |VX| \geq 1$
$|bbb| \leq P$ $\quad |bb| \geq 1$
$|3| \leq 3$ $\quad |2| \geq 1$ $\quad VX = b^{n-m}$, $m < n$

Satisfied $\quad$ Satisfied

$uv^iwx^iy \Rightarrow uvwxy\, v^{i-1} x^{i-1}$

$= a^n b^n c^n (vx)^{i-1}$
$= a^n b^n c^n \cdot (b^{n-m})^{i-1}$

Notes

$= a^n b^n c^n (b^{ni-n-mi+m})$
$= a^n c^n (b^{n+ni-n-mi+m})$
$= a^n c^n (b^{ni-mi+m})$

Substitute $i=0$

$= a^n c^n (b^m)$
$= a^n c^n b^m$

Clearly understood that, $a^n c^n b^m$ is not CFL since $a^n b^n$ is like aaa...bbb.., 'm' must be less than 'n'; so if we substitute $n=3$, then m be 1 or 2.

Problems

1. $S \to AB$
   $A \to BS / a$
   $B \to SA / b$
   } GNF

2. $S \to ASA / AB / BA / AA$
   $A \to aA / b$
   $B \to bB / b$
   } GNF

$X_1 \to BA$
$X_2 \to a$
$X_3 \to b$

3. $S \to XA / BB$
   $B \to b / SB$
   $X \to b$
   $X \to a$
   } GNF

4. $S \to aAD$
   $A \to aB / bAB$
   $B \to b$
   $D \to d$
   } CNF

5. $S \to a / aA / B$
   $A \to aBB / \varepsilon$
   $B \to Aa / b$
   } CNF

6. $S \to ASB$
   $A \to aAS / a / \varepsilon$
   $B \to SbS / A / bb$
   } CNF

Notes