

[GRAMMER]

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① $(a+b)^*$

$$S \rightarrow aS$$

$$S \rightarrow bS$$

$$S \rightarrow \text{null}$$

② $(a+b)^+$

$$S \rightarrow a$$

$$S \rightarrow b$$

③ $(a+b)^* a$

$$S \rightarrow aS$$

$$S \rightarrow bS$$

$$S \rightarrow a$$

④ $(a+b)^* \text{aaa} (a+b)^*$

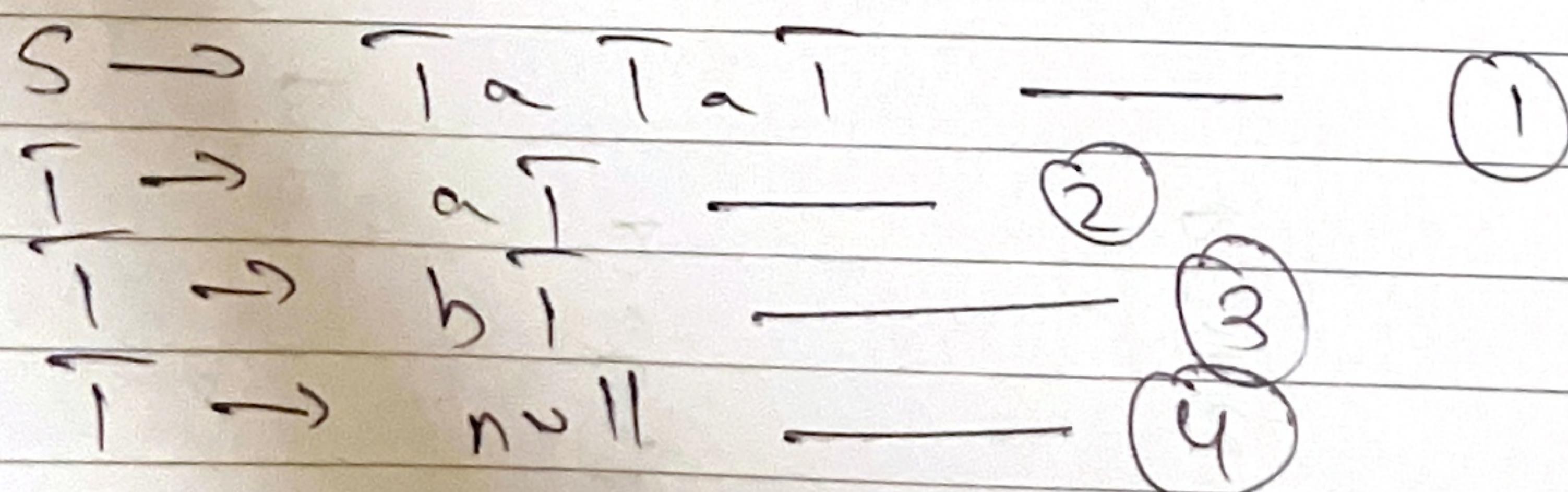
$$S \rightarrow X \text{aaa} X$$

$$X \rightarrow aX$$

$$X \rightarrow bX$$

$$X \rightarrow \text{null}$$

⑤ ATLEAST TWO "aa", NOT CONSECUTIVE
 $(a+b)^* a$ $(aab)^*$ a $(aab)^*$



Ex. abaab

$$\begin{aligned}
 S &\rightarrow X a X a X & (1) \\
 &\rightarrow a X a X a X & (2) \\
 &\rightarrow a b X a X a X & (3) \\
 &\rightarrow a b a X a X & (4) \\
 &\rightarrow a b a a X & (4) \\
 &\rightarrow a b a a b & (5) \\
 &\rightarrow a b a a b & (6)
 \end{aligned}$$

(6) $\Sigma = \{a, b\}$, "a" CAN BE CONSECUTIVE
BUT NO CONSECUTIVE "b"

$$\begin{aligned}
 S &\rightarrow a S \\
 b &\rightarrow b X \\
 X &\rightarrow a S \\
 S &\rightarrow \text{null} \\
 X &\rightarrow \text{null}
 \end{aligned}$$

(7) GENERATE A BINARY EVEN NUMBER

$$\begin{aligned}
 S &\rightarrow 0S \\
 S &\rightarrow 1S \\
 S &\rightarrow \text{null}
 \end{aligned}$$

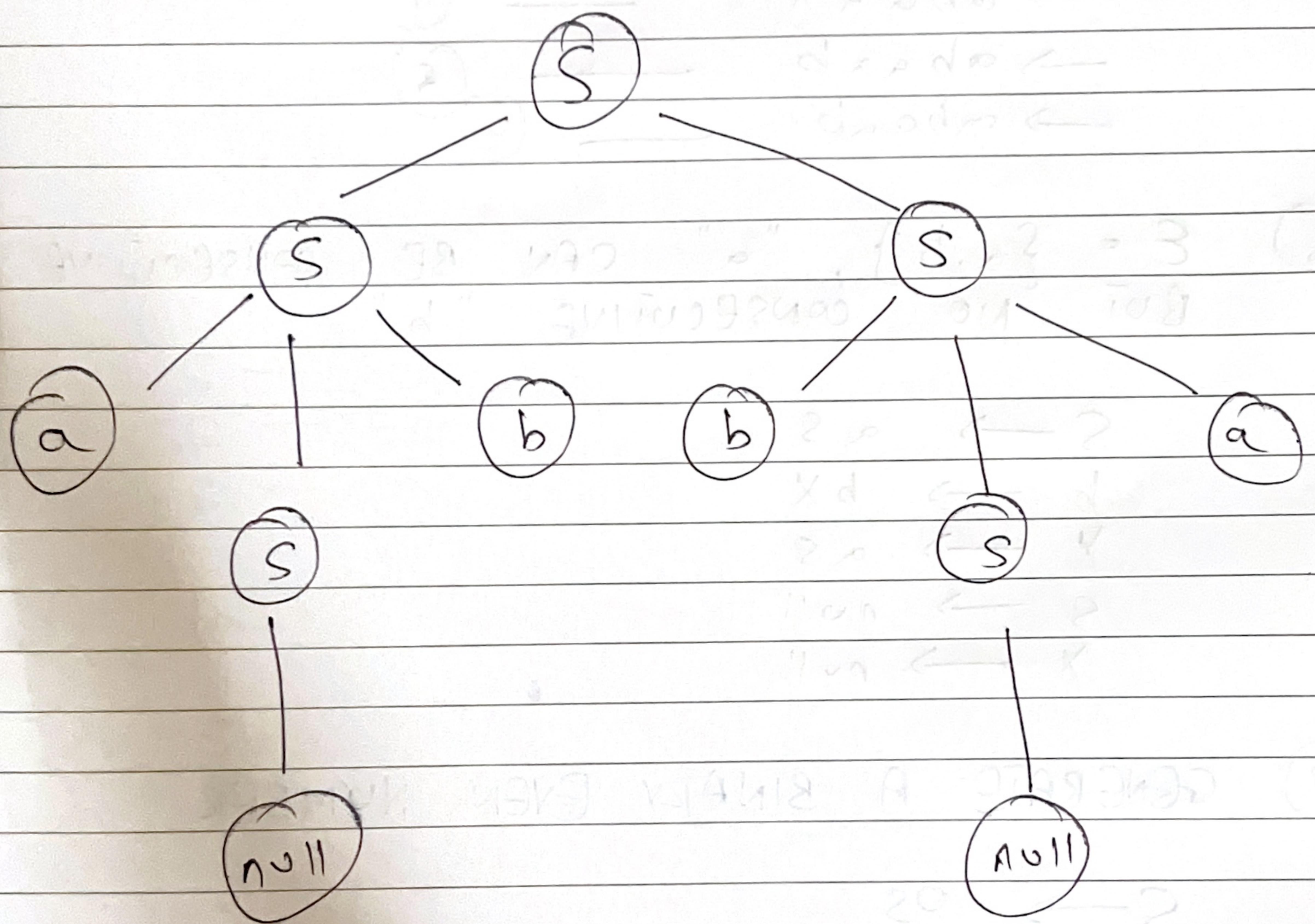
⑧ EQUAL a's AND b's

$S \rightarrow aSb$

$S \rightarrow bS^*a$

$S \rightarrow SS$

$S \rightarrow \text{null}$



⑨ WGLU FORMGDNES PARANTHESIS —

$$S \rightarrow (S)$$

$$S \rightarrow SS$$

$$S \rightarrow \text{null}$$

⑩ NO 3 CONSECUTIVE b's, $\Sigma = \{a, b\}$ —

$$S \rightarrow aS$$

$$S \rightarrow bX$$

$$X \rightarrow aS$$

$$X \rightarrow bY$$

⑪ (CFG) FOR $a^n b^n$, $n \geq 1$ —

$$S \rightarrow aSb$$

~~RECURSIVE DEFINITION~~

$$S \rightarrow \text{null}$$

⑫ $a^n b^m c^{n+m}$, $n, m > 0$

$$S \rightarrow aSc$$

$$S \rightarrow X$$

$$X \rightarrow b \not\in XC$$

$$X \rightarrow \text{null}$$

g] SOME a's FOLLOWED BY SOME b's AND LENGTH IS ODD

$$\begin{aligned}
 S &\rightarrow aA / C & \text{--- } ① \\
 A &\rightarrow aaA / B & \text{--- } ② \\
 B &\rightarrow bbB / \lambda & \text{--- } ③ \\
 C &\rightarrow aaA / D & \text{--- } ④ \\
 D &\rightarrow bbbD / E & \text{--- } ⑤ \\
 E &\rightarrow b & \text{--- } ⑥
 \end{aligned}$$

Eg ~~abab~~

$$\begin{aligned}
 S &\rightarrow aA & \text{--- } ① \\
 S &\rightarrow aAC \\
 S &\rightarrow aBC \\
 S &\rightarrow aC \\
 S &\rightarrow aD \\
 S &\rightarrow abbb
 \end{aligned}$$

(LEFT)

g) $S \rightarrow X baa X - ①$
 $S \rightarrow a X - ②$

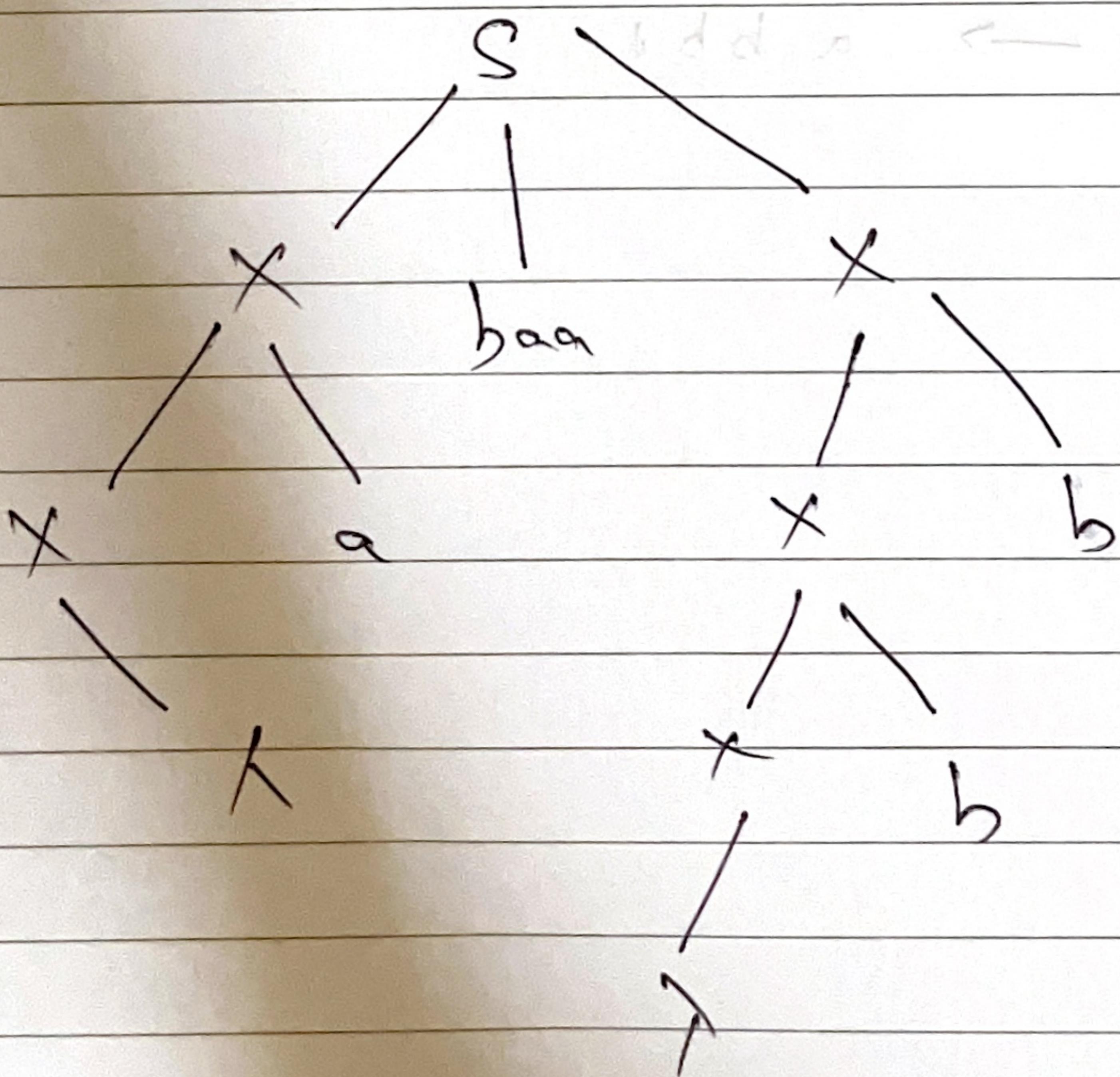
~~Set 2~~

$X \rightarrow Xa - ③$
 $X \rightarrow Xb - ④$
 $X \rightarrow \lambda - ⑤$

~~ababb~~
MAKE THE FOLLOWING [ababb]

$S \rightarrow Xbaa X - ①$
 $\rightarrow Xaba a X - ③$
 $\rightarrow abaa X - ⑤$
 $\rightarrow abaa X b - ④$
 $\rightarrow ab a a X bb - ④$
 $\rightarrow ab a a b b - ⑤$

(TREE)



[RICH]

$$\begin{aligned}
 S &\rightarrow XbaaX & - & \textcircled{1} \\
 &\rightarrow XbaaXb & - & \textcircled{4} \\
 &\rightarrow XbaaXbb & - & \textcircled{4} \\
 &\rightarrow Xbaabb & - & \textcircled{5} \\
 &\rightarrow ababb & - & \textcircled{3} \\
 &\rightarrow ababb & - & \textcircled{5}
 \end{aligned}$$

Hkl

[LEFT Q right]

$$\begin{aligned}
 S &\rightarrow aAs \\
 S &\rightarrow a \\
 A &\rightarrow SbA \\
 A &\rightarrow SS \\
 A &\rightarrow ba
 \end{aligned}$$

* [AMBIGUOUS GRAMMER]

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$S \rightarrow S + S$

$S \rightarrow S * S$

$S \rightarrow S - S$

$S \rightarrow S / S$

$S \rightarrow (S)$

$S \rightarrow \text{VARIABLE/CONSTANT}$

$[a * b + c]$

CASE 1

$S \rightarrow S + S$

$\rightarrow S * S + S$

$\rightarrow a * S + S$

$\rightarrow a * b + S$

$\rightarrow a * b + C$

CASE 2

$S \rightarrow S * S$

$\rightarrow S * S + S$

$\rightarrow a * S + S$

$\rightarrow a * b + S$

$\rightarrow a * b + C$

ad? ← A

?d? ← A

ad? ← A

[CHOMPSKY NORMAL FORM]

(1) $S \rightarrow aSa$
 $S \rightarrow bSb$
 $S \rightarrow a$
 $S \rightarrow b$
 $S \rightarrow aa$
 $S \rightarrow bb$

TO [CNF]

$S \rightarrow AR_1$
 $A \rightarrow a$
 $R_1 \rightarrow SA$
 $S \rightarrow BR_2$
 $B \rightarrow b$
 $R_2 \rightarrow SB$
 $S \rightarrow a$
 $S \rightarrow b$
 $S \rightarrow AA$
 $S \rightarrow BB$

② $S \rightarrow ABaC \quad \text{JAN-HOU} \quad [374] 01/01$

$A \rightarrow BC$

$B \rightarrow b/\lambda$

$C \rightarrow D/\lambda$

$D \rightarrow d$

[removing λ]

$S \rightarrow ABaC$

$S \rightarrow BaC$

$S \rightarrow AaC$

$S \rightarrow ABa$

$S \rightarrow aC$

$S \rightarrow Ba$

$S \rightarrow Aa$

$S \rightarrow a$

$A \rightarrow BC/b/d$

$B \rightarrow b$

$C \rightarrow d$

$b \leftarrow 2$

$d \leftarrow 2$

$a \leftarrow 2$

$d \leftarrow 2$

$a \leftarrow 2$

$dd \leftarrow e$

$[374] \quad 01$

$aSA \leftarrow 2$

$-a \leftarrow A$

$A2 \leftarrow ,S1$

$SA \leftarrow 2$

$d \leftarrow B$

$B2 \leftarrow ,S1$

$a \leftarrow 2$

$d \leftarrow 2$

$A1 \leftarrow 2$

$A2 \leftarrow 2$

③ $S \rightarrow A / Bb$
 $A \rightarrow B / Bc$
 $B \rightarrow a / aa$

[CLEANING]

$S \rightarrow a / aa / Bc / Bb$
 $A \rightarrow a / aa / Bc$
 $B \rightarrow a / aa$

④ $S \rightarrow ABac / Db$
 $A \rightarrow A C / ab$
 $B \rightarrow be$
 $C \rightarrow c$
 $E \rightarrow \lambda$

[CLEANING & REMOVING]

~~ABac + db~~

d ← 8
 B2 ← 59
 AA ← 2
 AB ← 2
 ac ← 2
 d ← 2

(5)

$$\begin{aligned} S &\rightarrow aSa \\ S &\rightarrow bSb \\ S &\rightarrow A \\ S &\rightarrow \lambda \\ A &\rightarrow a/b/\lambda \end{aligned}$$

da) A \rightarrow (8)
 da) B \rightarrow A
 da) a \rightarrow B
 da) b \rightarrow B
 da) $a/b/\lambda$ \rightarrow B

[REMOVING λ]

$$\begin{aligned} S &\rightarrow aSa \quad | \quad aS \\ S &\rightarrow bSb \quad | \quad bS \\ S &\rightarrow a/b \end{aligned}$$

da) aSa \rightarrow 2 (9)

[TO CNF]

$$S \rightarrow A R_1$$

$$A \rightarrow a$$

$$R_1 \rightarrow SA$$

$$S \rightarrow B n_2$$

$$B \rightarrow b$$

$$n_2 \rightarrow SB$$

$$S \rightarrow AA$$

$$S \rightarrow BB$$

$$S \rightarrow a$$

$$S \rightarrow b$$

(1) $S \rightarrow aSa$
 $S \rightarrow bSb$
 $S \rightarrow \lambda$

(2) ~ 2
 $T+2 \sim 2$
 $T-2 \sim 2$

[REMOVING λ]

$S \rightarrow aSa$
 $S \rightarrow aa$
 $S \rightarrow bSb$
 $S \rightarrow bb$

$a \leftarrow T$
 $b \leftarrow vav \leftarrow T$
 $T \leftarrow T$
 $vav \leftarrow T$
 $bb \leftarrow vav \leftarrow T$

[TO CNF]

$S \rightarrow A R_1$
 $A \rightarrow a$
 $R_1 \rightarrow SA$
 $S \rightarrow AA$
 $S \rightarrow B R_2$
 $B \rightarrow b$
 $R_2 \rightarrow SB$
 $S \rightarrow BB$

(2) ~ 2
 $T+2 \sim 2$
 $T-2 \sim 2$

$a \leftarrow T$
 $b \leftarrow vav \leftarrow T$

$vav \leftarrow T$
 $b \leftarrow vav \leftarrow T$

⑦ $S \rightarrow (S)$ $\text{pp} \leftarrow 2$
 $S \rightarrow S + T$ $dd \leftarrow 2$
 $S \rightarrow S - T$ $ff \leftarrow 2$
 $S \rightarrow T$
 $T \rightarrow T * F$ $\boxed{R} \quad \text{equation}$
 $\begin{cases} T \rightarrow T/F \\ T \rightarrow E \end{cases}$ — $\frac{T}{F} \leftarrow 2$
 $F \rightarrow \text{var/const}$ $pp \leftarrow 2$
 $dd \leftarrow 2$
 $ff \leftarrow 2$
 $\boxed{\text{CLEAN UP}}$

$S \rightarrow (S)$ $\boxed{fhi} \quad 0i$
 $S \rightarrow S + T$
 $S \rightarrow S - T$ $pla \leftarrow 2$
 $S \rightarrow T * F$ $lo \leftarrow A$
 $S \rightarrow T / F$ $hr \leftarrow AA$
 $\begin{cases} T \rightarrow \text{var/const} \\ T \rightarrow \text{var/const} \end{cases}$ $AA \leftarrow 2$
 ~~$E \rightarrow \text{var/const}$~~ $s, g \rightarrow \text{var/const}$
 ~~$E \rightarrow \text{var/const}$~~ $d \leftarrow B$
 ~~$E \rightarrow \text{var/const}$~~ $812 \leftarrow 81$
 ~~$E \rightarrow \text{var/const}$~~ $818 \leftarrow 2$
 ~~$S \rightarrow O_1$~~
 ~~$O_1 \rightarrow S_C$~~
 ~~$O_1 \rightarrow C$~~
 ~~$S \rightarrow S_{D_2}$~~
 ~~$D_2 \rightarrow PP$~~
 ~~$P \rightarrow X$~~
 ~~$S \rightarrow BD_3$~~
 ~~$D_3 \rightarrow MU$~~
 ~~$M \rightarrow -$~~

[TO CNF]

$S \rightarrow ON_1$

$O \rightarrow C$

$N_1 \rightarrow SC$

$C \rightarrow)$

ABA $\leftarrow 2$ (8)

AA_n $\leftarrow A$

AB_n $\leftarrow B$

[TU 49957]

$S \rightarrow SN_2$

$N_2 \rightarrow PT$

$P \rightarrow +$

$S \rightarrow SN_3$

$N_3 \rightarrow YT$

$Y \rightarrow -$

$S \rightarrow TL$

$L \rightarrow RF$

$R \rightarrow *$

$S \rightarrow TM$

$M \rightarrow NF$

$N \rightarrow I$