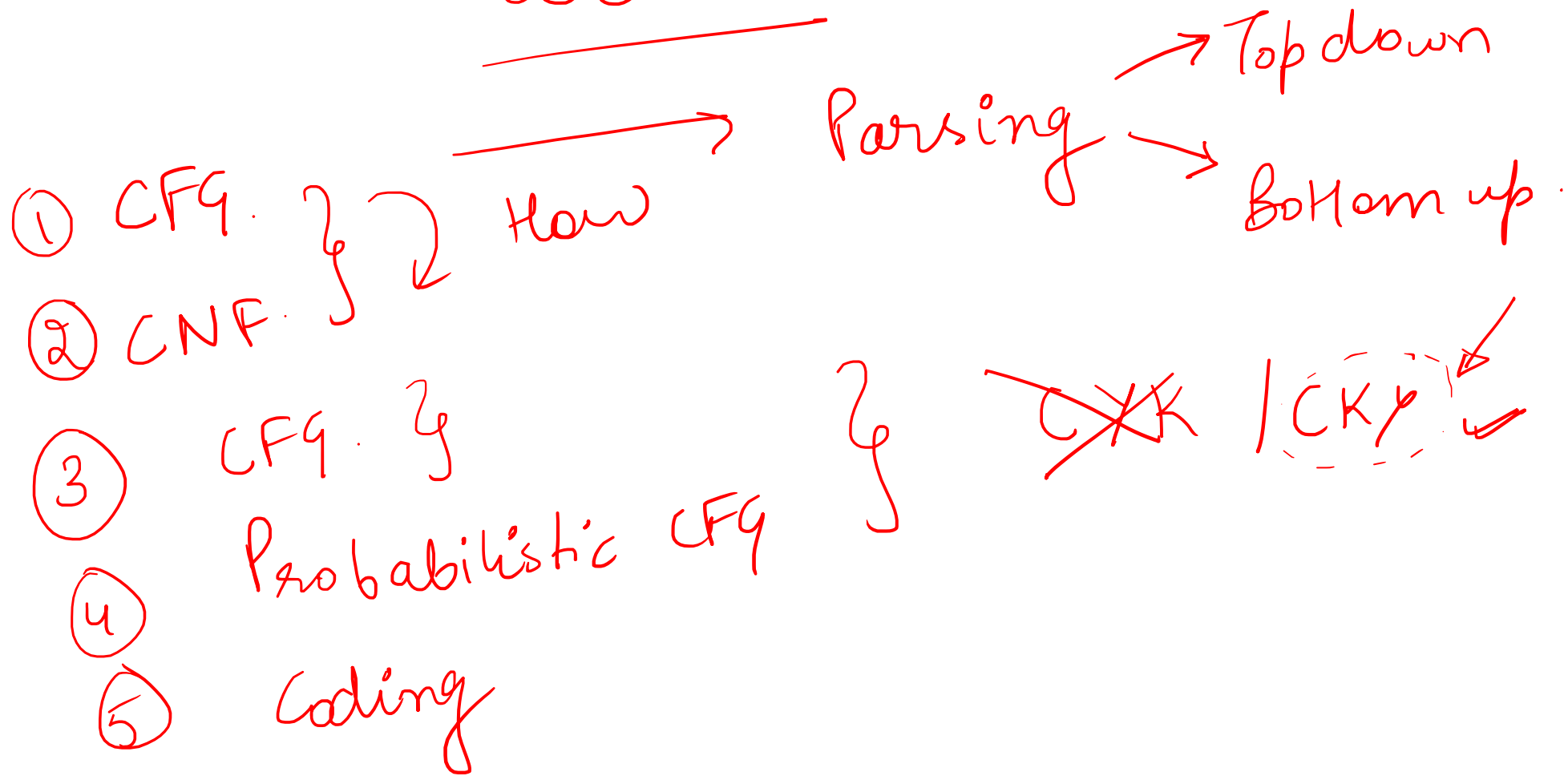


Week 5



CFG → context free grammar

(NLP) : ability of computer ^{hw} (software) to understand

human / natural language

• Each language has its own structure hierarchy

videos
photos
memes
audio
↑



Rules
 ↓

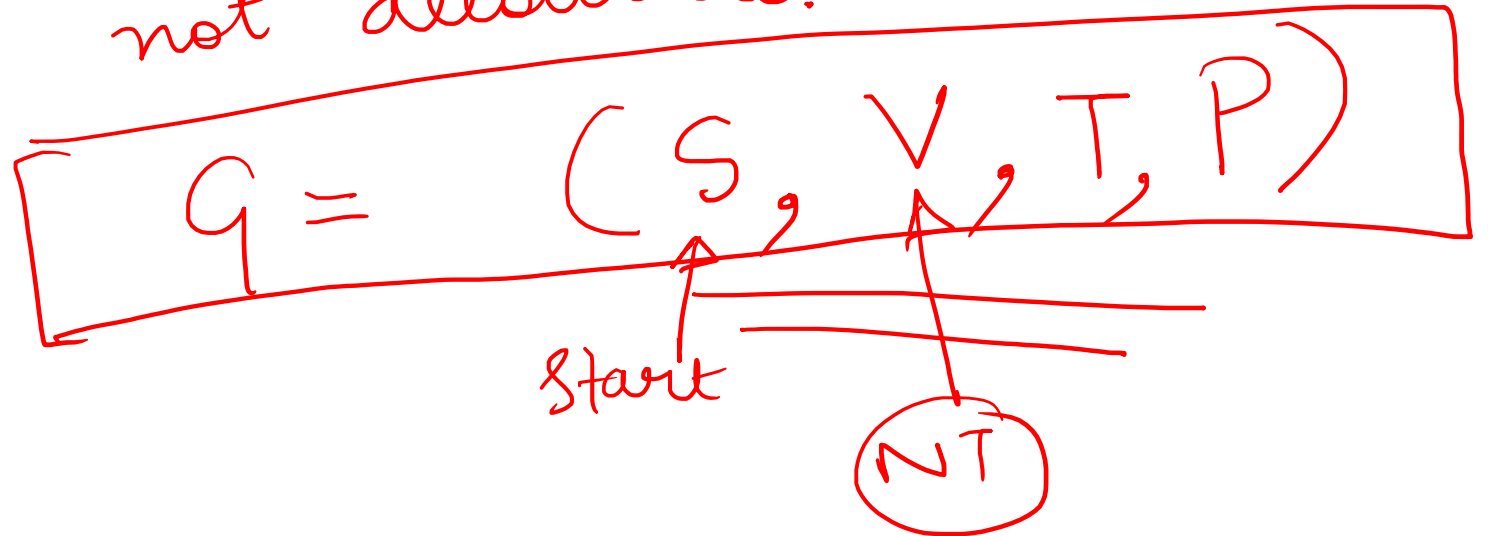
eg: I eat a mango
 SVO

eg: मैं 31111 खाता खाती हूँ।
 ↓
 S O ✓

Grammar (Set of rules that determine how
the lang. is structured)

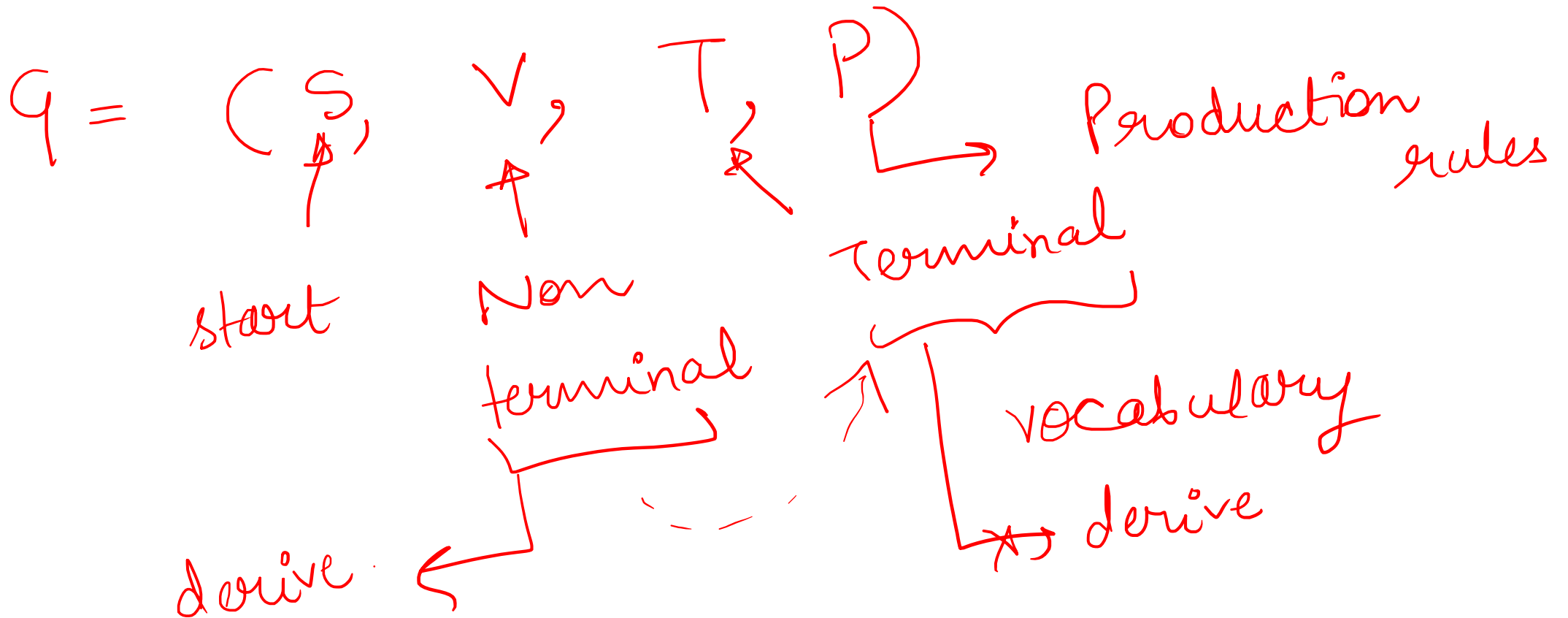
↳ what is allowable?

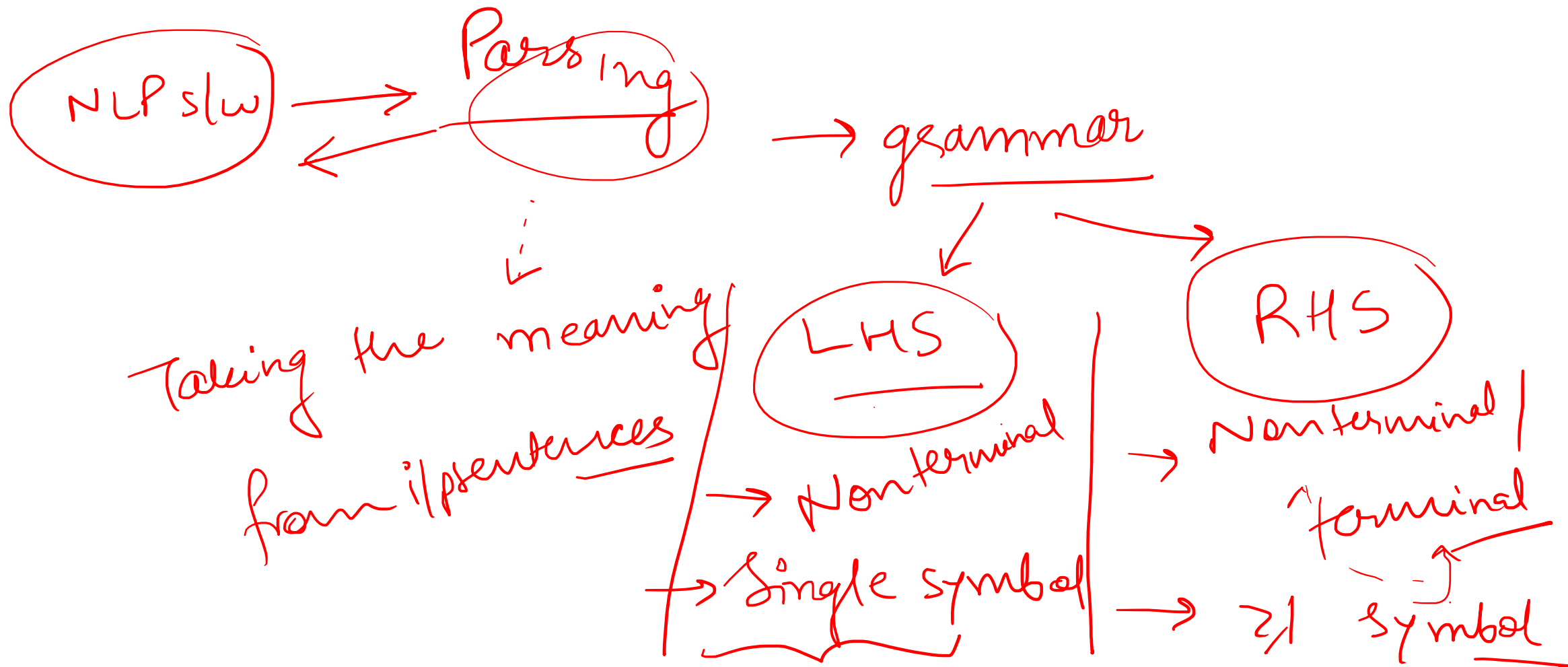
↳ what is not allowable?



~~2/~~

$$G = C$$

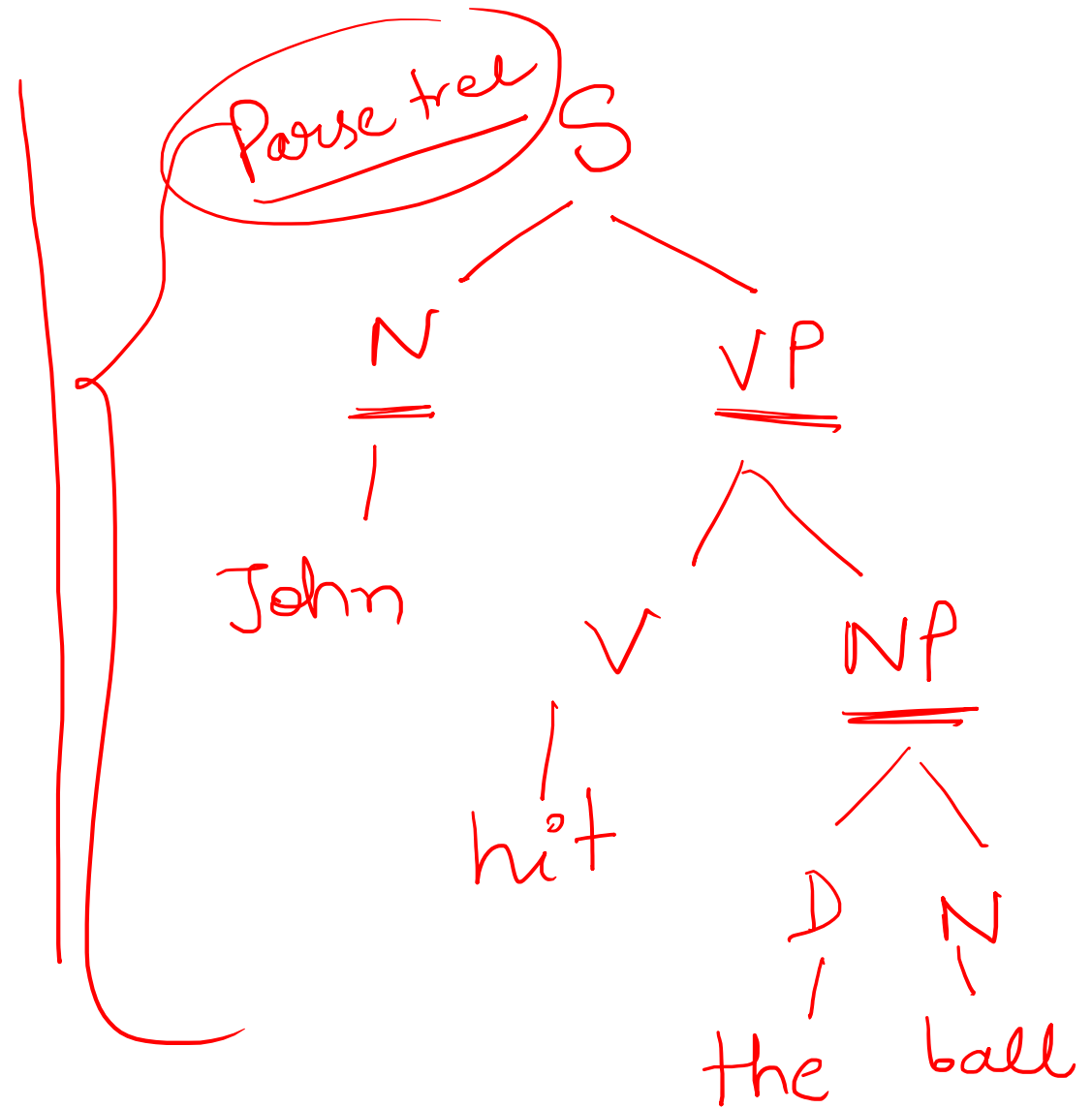




eg: John hit the ball
(N) (V) (D) (N)

Production Rules

$S \rightarrow NP VP$
 $\cancel{VP} \rightarrow \cancel{V} \cancel{NP}$
 $\cancel{NP} \rightarrow N$
 $NP \rightarrow D N$



CFG (Context free grammar)

① Phrase structure grammar

② Backus Naur Form (BNF)

CFG: Formal grammar which is used to generate all possible strings in a given language.

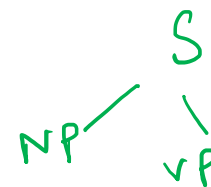
Rules for CFG

$$\textcircled{1} \quad \alpha \rightarrow \beta$$

$$\textcircled{2} \quad \alpha \rightarrow V$$

$$\textcircled{3} \quad \beta \rightarrow (V + T)^*$$

eg: the man read this book ✓
(D) (Noun) (V) Det (N)



Rules : (P) :

✓ S → NP VP

⊗ S → Aux NP VP

⊕ S → VP

→ NP → Det Noun

⊗ VP → verb

✓ VP → verb NP

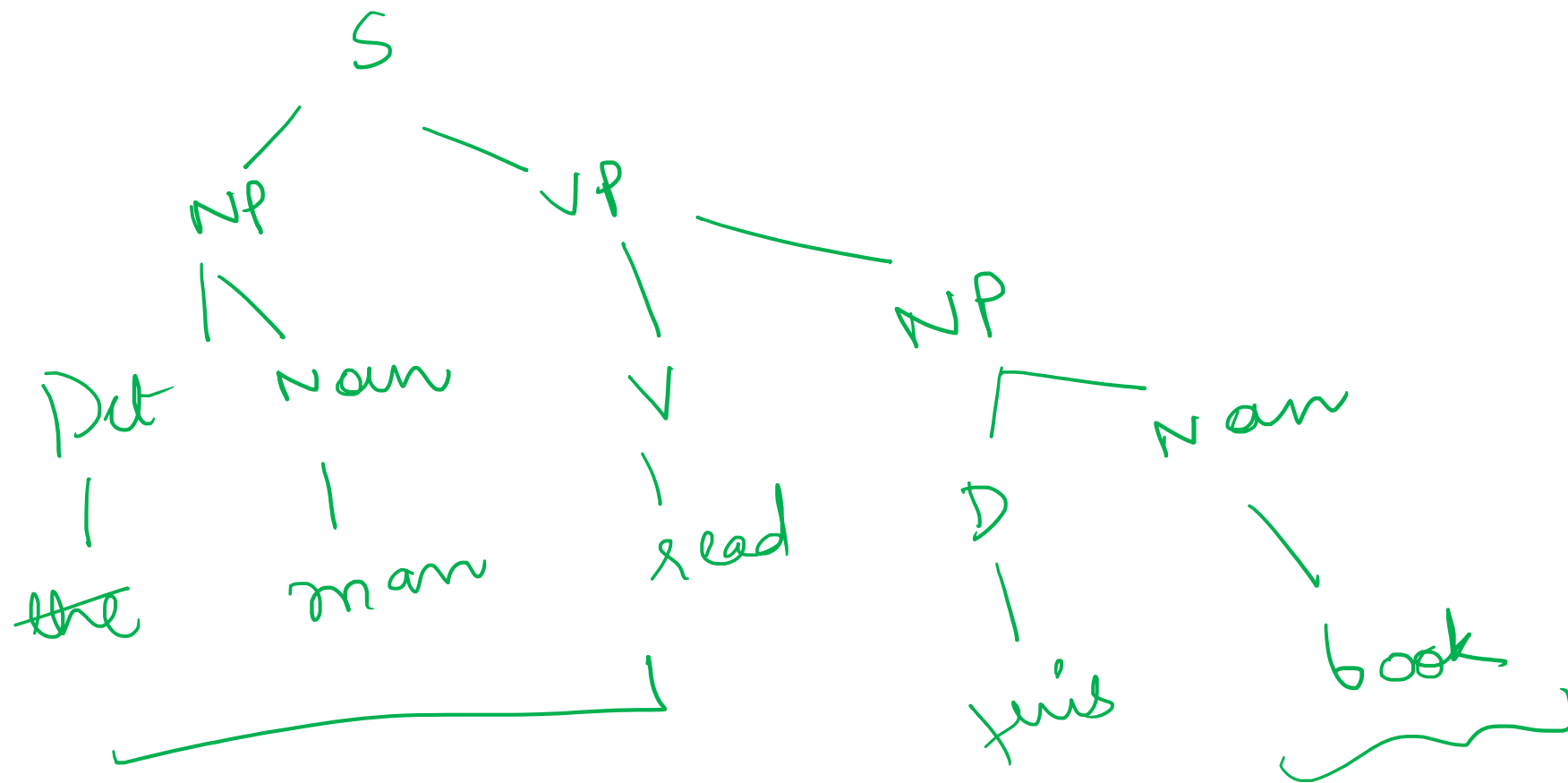
Det → this | that | a | the

Noun → book | flight | John | ball /
man / meal

verb → book | include | read

Aux → does | is

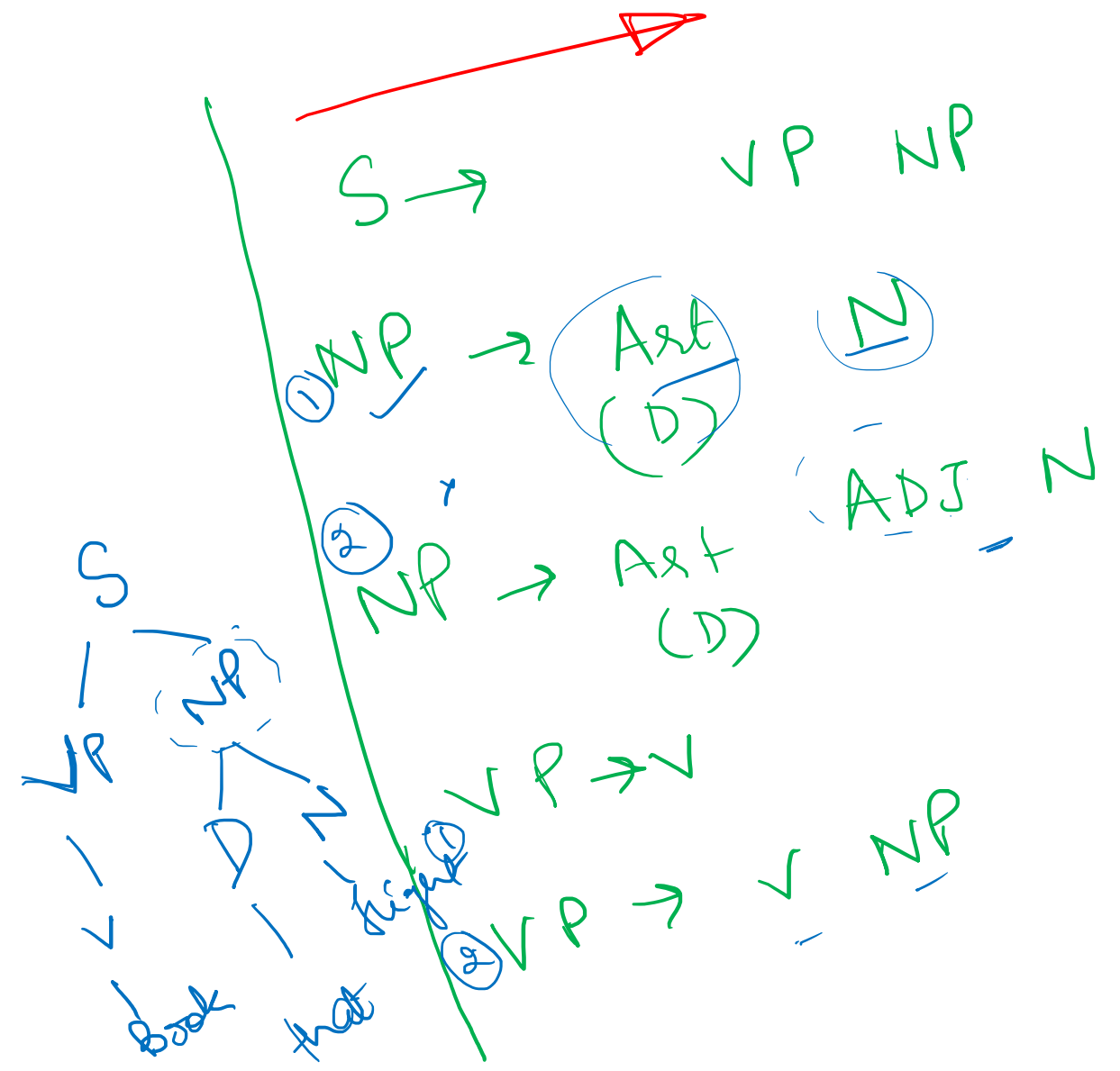
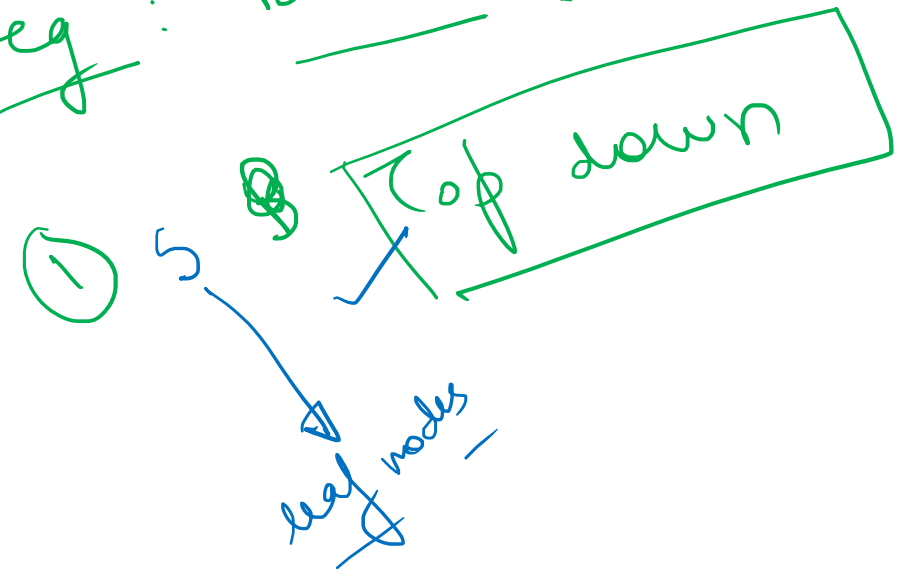
Ans:



- ① Top down
- ② Bottom up

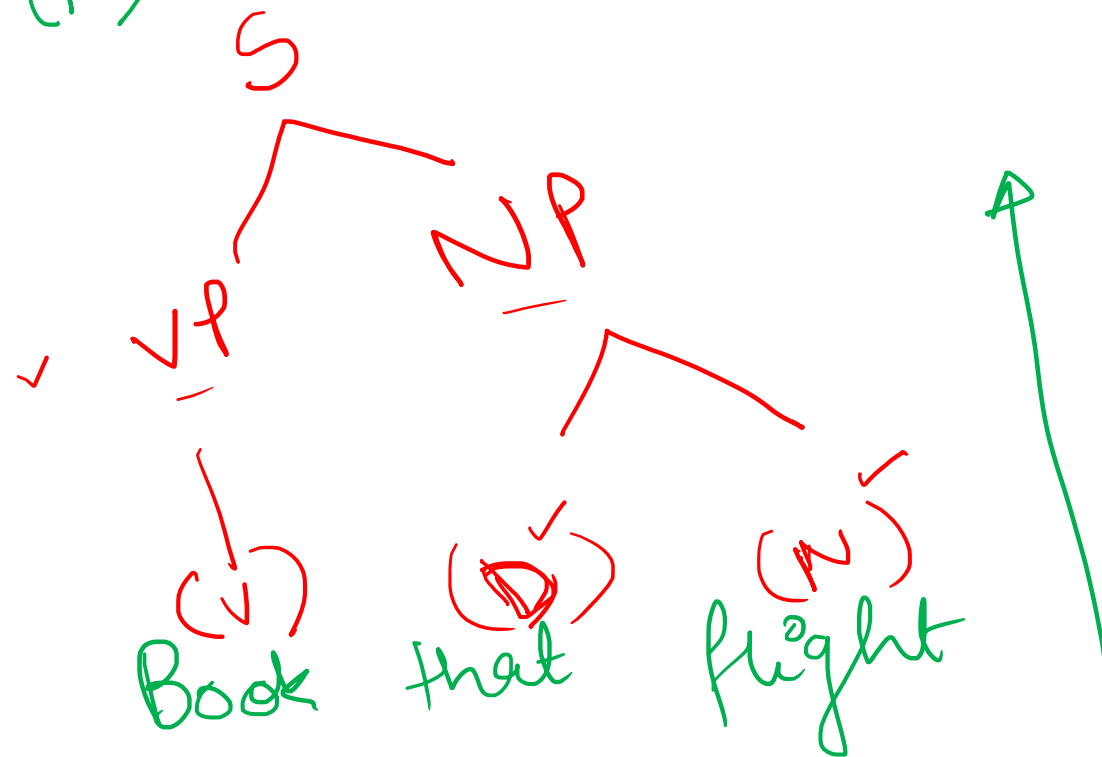
Book that flight

eg:



eg: Book that flight (BUP
 (V) (D) (N)

- ① S → VP NP
- ② NP → Art N
- ③ NP → Art Adj N
- ④ VP → V
- ⑤ VP → V NP



eg: Peter prefers the flight from Denver
 (N) (V) (D) (N) (P) (N)

$S \rightarrow NP VP$

$\checkmark NP \rightarrow \textcircled{N}$

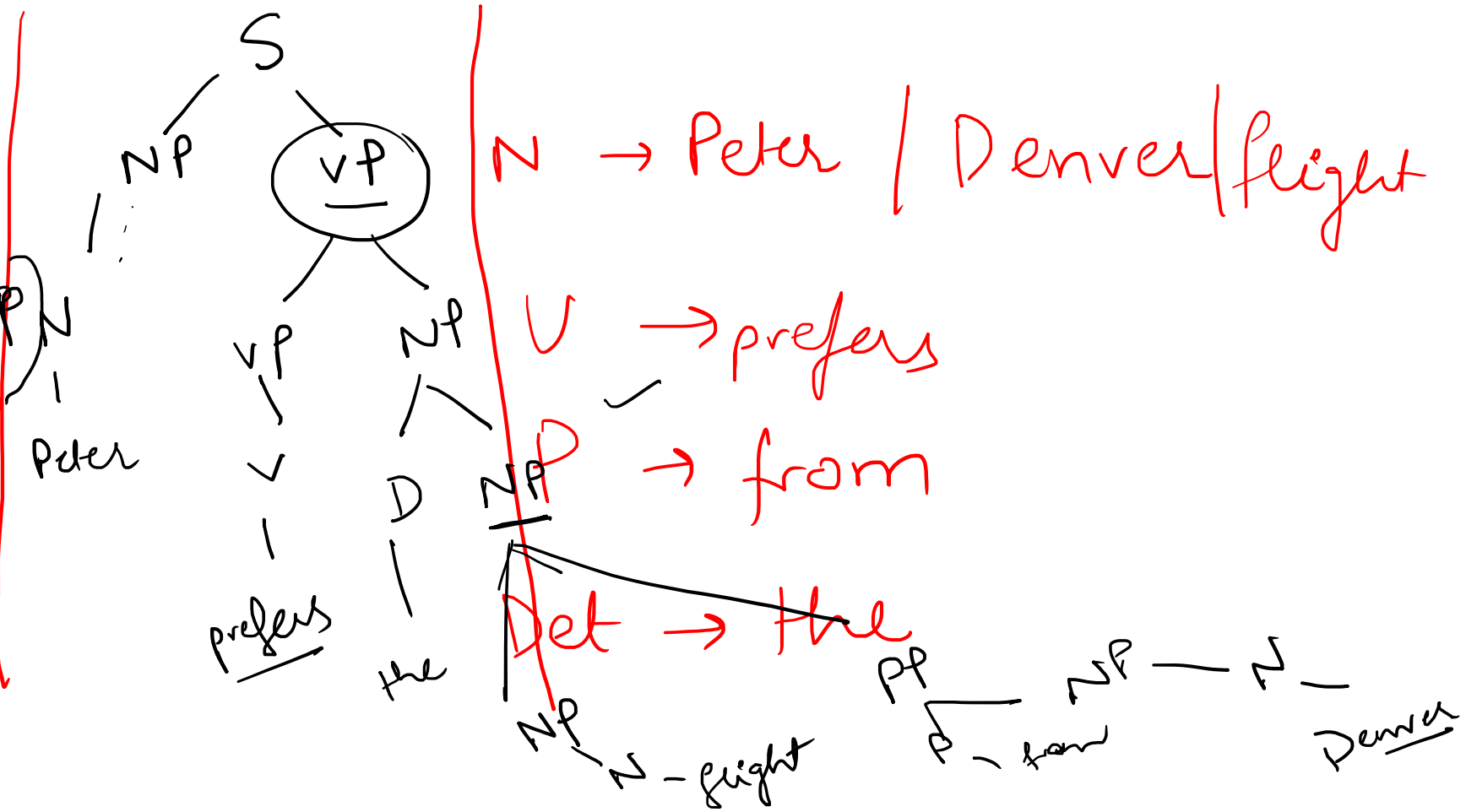
$\checkmark NP \rightarrow \text{Det } \underline{NP}$

$\checkmark NP \rightarrow \underline{NP} \underline{PP}$

$\checkmark VP \rightarrow \underline{VP} \textcircled{NP}$

$\checkmark PP \rightarrow \underline{P} \underline{NP}$

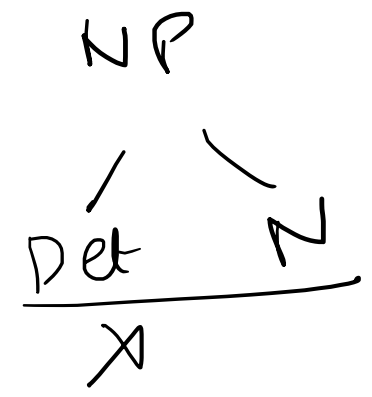
$\checkmark VP \rightarrow \underline{V}$



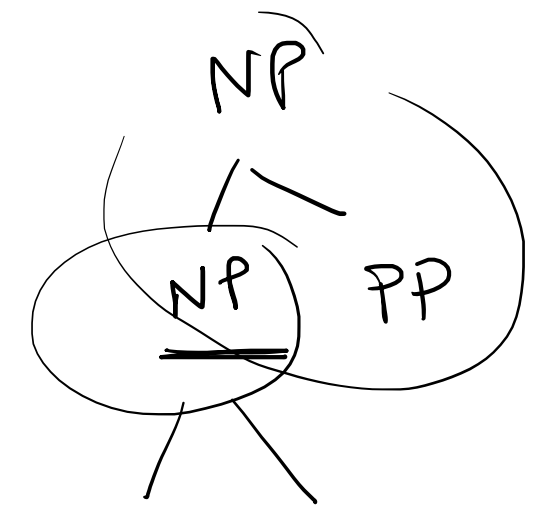
NP → N

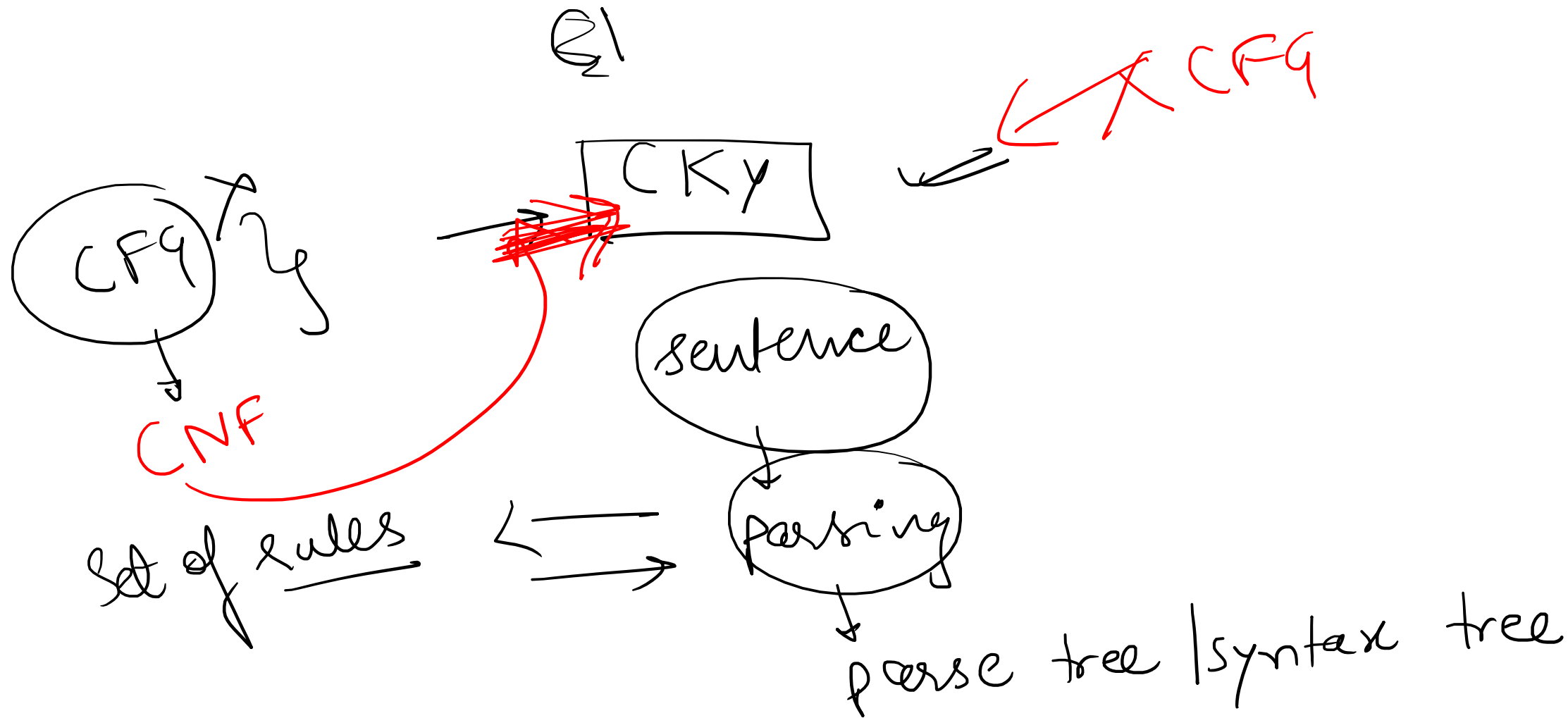
✓ NP → NP PP

✓ NP → Det N
✓



✓





CFG \rightarrow CNF $\xrightarrow{\quad}$ CY (?)

$A \rightarrow B$
 $B \rightarrow A$

Parsing

ambiguity (>1 syntax tree)

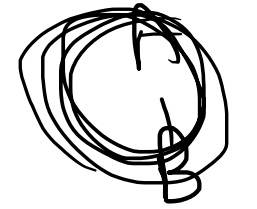
(solⁿ of intermediate subproblems)

Recursion

Repeated

space &

substructure
time complexity



B A

CKY

→ one of the earliest recognition & parsing algo.

→ only works with CNF (Chomsky Normal form)

TOC



CNF Rules

~~$S \rightarrow NP$~~

$A \rightarrow I$

CFG

$\alpha \rightarrow \beta$

$\alpha \rightarrow NT \mid (V)$

$\beta \rightarrow (V \mid T)^*$

① S

② LHS & RHS

③ LHS will have a non-terminal

④ RHS

(a) single terminal

* (b) Two non-terminal

~~(c)~~ combo of non-terminal & terminal

~~(d)~~ single non-terminal

① RHS



(a) single terminal (✓)

(b) only 2 non-terminals

(c) combo of NT & T

(d) single NT

(CNF)

✓ $A \rightarrow a$

PP: prep. phrase

NP: noun phrase

✓ VP: verb phrase

✓ $A \rightarrow BC$

✓ $NP \rightarrow \underline{N} \underline{PP}$

~~$NP \rightarrow \text{the } NP$~~

~~$NP \rightarrow \text{the Det Noun}$~~

~~$NP \rightarrow \underline{\text{Det}} \underline{\text{Noun}} \underline{PP}$~~

To use CKY, $CFG \rightarrow CNF$

①

$NP \rightarrow$ the NT

↓ how to convert to CNF?

Introduce some dummy ~~variable~~ non terminal
to original terminal

D \rightarrow the

$NP \rightarrow D$ (NT)

NP →

~~Det~~ ~~Noun~~ ~~PP~~

$A \rightarrow B$
 $B \rightarrow AB$
 $B \rightarrow b$

$A \rightarrow B$
 $A \rightarrow A$ / the

$B \rightarrow ?$

A
b → B

b

A

~~(A)~~

Det Noun

(I)

NP → A PP

A → Noun PP
NP → Det A

~~(I)~~

A
B
A
B
b

~~S~~ → DN

CNF Rules

(5x5)

the flight includes a meal

(D) (N) (V) (D) (N)

S → NP VP

NP → Det N

Syntactic Rules

VP → V NP

V → includes

Det → the

Det → a

N → meal

N → flight

Lexical Rules

NP V

N V

[0,1] → the

	1	2	3	4	5
0	D	NP			S
1		N			
2					
3					
4					

~~D~~ VP

N

✓ Det → the [a 0.4]

Probabilistic CKY

S → NP VP [0.80]

NP → Det N [0.3]

VP → V NP [0.20]

V → includes [0.05]

✓ Det → the ✓ [0.4]

✓ Det → a [0.4]

N → flight
N → meal

[0.01]
[0.02]

(0.3)
NP

D
(0.4)

N
(0.01)

VP

V

NP

0.3 NP

D (0.4)

N (0.02)

0.3 * 0.4 * 0.02

(D) (N) (V) (D) (N)
The flight includes a meal

0.3 * 0.4 * 0.01 = 0.0012



Det \rightarrow a
Det \rightarrow the
Det \rightarrow at the

~~Det \rightarrow a the~~

$B \rightarrow b$
 $B \rightarrow e$

$B \rightarrow$ ~~b~~ ~~e~~

~~$B \rightarrow b|e$~~

