CS & IT ENGINEERING

THEORY OF COMPUTATION

Grammar

[redacted]

Lecture - 02

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Recap of Previous Lecture

Topic

?????

Grammar Def

Grammar Construction

Terminology
- Derivation
- L.M.D
- R.M.D
- Parsetree

Topics to be Covered

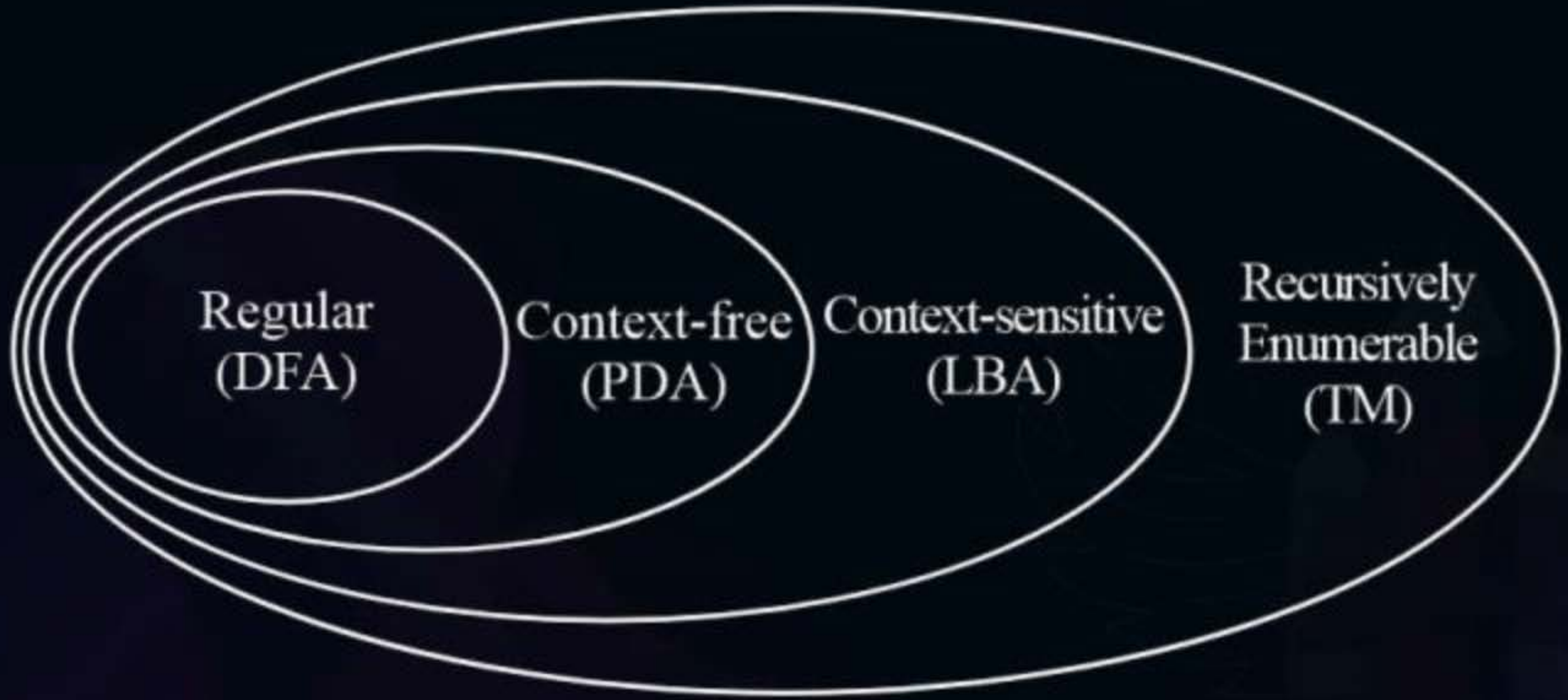
Topic — Types of Grammar (0,1,2,3)

Topic ?? Ambigous Grammar

Topic ?? Regular Grammar

Topic ??

Topic : Regular expression



Topic : Grammar

- Set of rules used to describe strings of a language is known as grammar.
- Formal definition of grammar is

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

- N :- non terminals (or) variables
- T :- Terminals
- P :- no. of productions
- S :- Starting symbol

Topic : Grammar

only one

- For every language grammar exit & every grammar generates one language.
- All grammars is of a from α replacement of α→ β, where β is replacement of α

$$\alpha \rightarrow \beta$$

$$\alpha = \beta$$

Topic : Derivation

- The process of deriving strings from the given grammar known as derivation.
- The derivation can be either left most derivation or right most derivation

- **Left most derivation:**
  It is the derivation in which left most non terminal is replaced by its R.H.S part at every step.

- **Right most derivation:**
  It is a derivation in which right most non terminal is replaced by its R.H.S part at every step.

Derivation Tree (or)Parse Tree

- Tree representation of the derivation is known as derivation tree.
- All leaf node of the parse tree is known as yield of parse tree .
- while reading yield from left to right sentence of the grammar can be generate.

Sentential form

- Each step in the derivation is one sentential form.
- Hence sentential form is combination of terminals & non terminals (sentence also can be included)
- If the derivation is left most then sentential form is left sentential form.
- If the derivation is right most then sentential is right sentential form
- Every grammar represents only one language but for one language more than one grammar may exist.
- For regular languages there exist a grammar known as regular grammar.

- Context free language there exist a grammar known as context free grammar.
- Context sensitive language there exist a grammar known as context sensitive grammar.
- For recursive enumerable language there exist a grammar known as unrestricted grammar.

Types of Grammar

Noam Chomsky

Type	Language (Grammers)	From of Productions	Accepting Dived
3	Regular	A→ aB, A→A	Finite Automaton
2	Context –free	A→ α	Pushdown Automaton
1	Context sensitive	A→ β With |α| ≥ |β|	LBA
0	Unrestricted	α→ β	Turing machine

(R.E.L)

$$\boxed{\alpha \longrightarrow \beta}$$

$|\alpha| \geq 1$

α should Contain atleast one Nonterminal.

Type 0 Grammar (or) Unrestricted Grammar (or) Recursive Enumerable Grammar

$\alpha \rightarrow \beta$

any   any

$\alpha \in (V+T)^+$

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

Ex:

$S \rightarrow aAbB$

$aA \rightarrow a$

$bB \rightarrow ba$

Type 1 Grammar (or) Context sensitive Grammar

$$\alpha \rightarrow \beta$$

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

$$\alpha, \beta \in (V+T)^+$$

Ex:

$$\left.\begin{array}{l} S \rightarrow aAB \\ \underbrace{|aA|}_{2} \rightarrow \underbrace{ba}_{2} \\ B \rightarrow b \end{array}\right\} \text{Type 1}$$

Type 2 Grammar (or) Contextfree Grammar

$$A \to \alpha$$

$$\alpha \in (V+T)^*$$

1 → any

Ex:- 1

$S \to aAb$

$A \to abc$

2

$S \to ABCD$

$A \to a|b$

$B \to c|d$

$D \to \epsilon$

$C \to b$

Type 3 Grammar (or) Regular Grammar

$A \to xB$

$A \to Bx$

$\alpha \to \beta$

1 → almost 1 N.T

$\boxed{A \to xB \mid x}$

{Right Linear Grammar}

① Ex:-

$S \to aS$

$S \to bS$

$S \to a$

$\boxed{A \to Bx \mid x}$

{Left Linear Grammar}

Ex: ②

$S \to Sa$

$S \to Sb$

$S \to a$

③

$S \to aSb \mid a$

$S \to aSb \mid ab$

Linear

but not Regular

Regular ?

4

$$S \to aA$$
$$A \to bB$$
$$A \to a$$
$$B \to c$$

Regular?

$$\boxed{S \rightarrow \underbrace{aS}_{1} \mid \underbrace{bS}_{1} \mid \epsilon}$$

Regular Grammar ? ✓

(2) $S \to aS \mid Sb \mid a$ → Not regular

R.L.G | L.L.G

(a) Yes

(b) NO

NO

Regular Grammar?

$S \to aS$

$S \to Sb$

$S \to a$

Linear Grammar but not Regular grammar

Linear Grammar:

Any grammar having left hand side exactly one nonterminal and R.H.S having atmost one N.T it is called as Linear Grammar.

{Every Regular Grammar is Linear Grammar} not Regular

CFG

① $S \to AB$

$A \to a$

$B \to b$

3 ×

2 ✓ $\Rightarrow$ C.F.G.

1

0

2 $S \to aS \mid Sb \mid \epsilon$

3 $\longrightarrow$ ×

2 $\longrightarrow$ ✓ $\longrightarrow$ CFG

1

0

(2)

$S \to Aa \mid Bb$

$A \to a$ ✓

$B \to b$ ✓

L.L.G

3, 2, 1, 0

Regular Grammar

3 → Regular Grammar

2

1

0

③ $\overset{1}{|S|} \rightarrow \overline{aAbB}^{4}$

$\overline{aA}^{2} \rightarrow \overline{aa}^{2}$

$\overline{bB}^{2} \rightarrow \overline{bb}^{2}$

3 ×

↓

2 ×

↓

1 → ✓ C.S.G ✓

↓

0 →

(4) $S \to aAB$

$\underline{aA} \to a$
$\quad 2 \qquad 1$

$B \to b$

3 ✗

2 ✗

1 ✗

0 ✓ → Unrestricted Grammar

What are the possible type number for this grammar

⑤ $\boxed{S \to aS \mid Sb \mid a}$

CFG

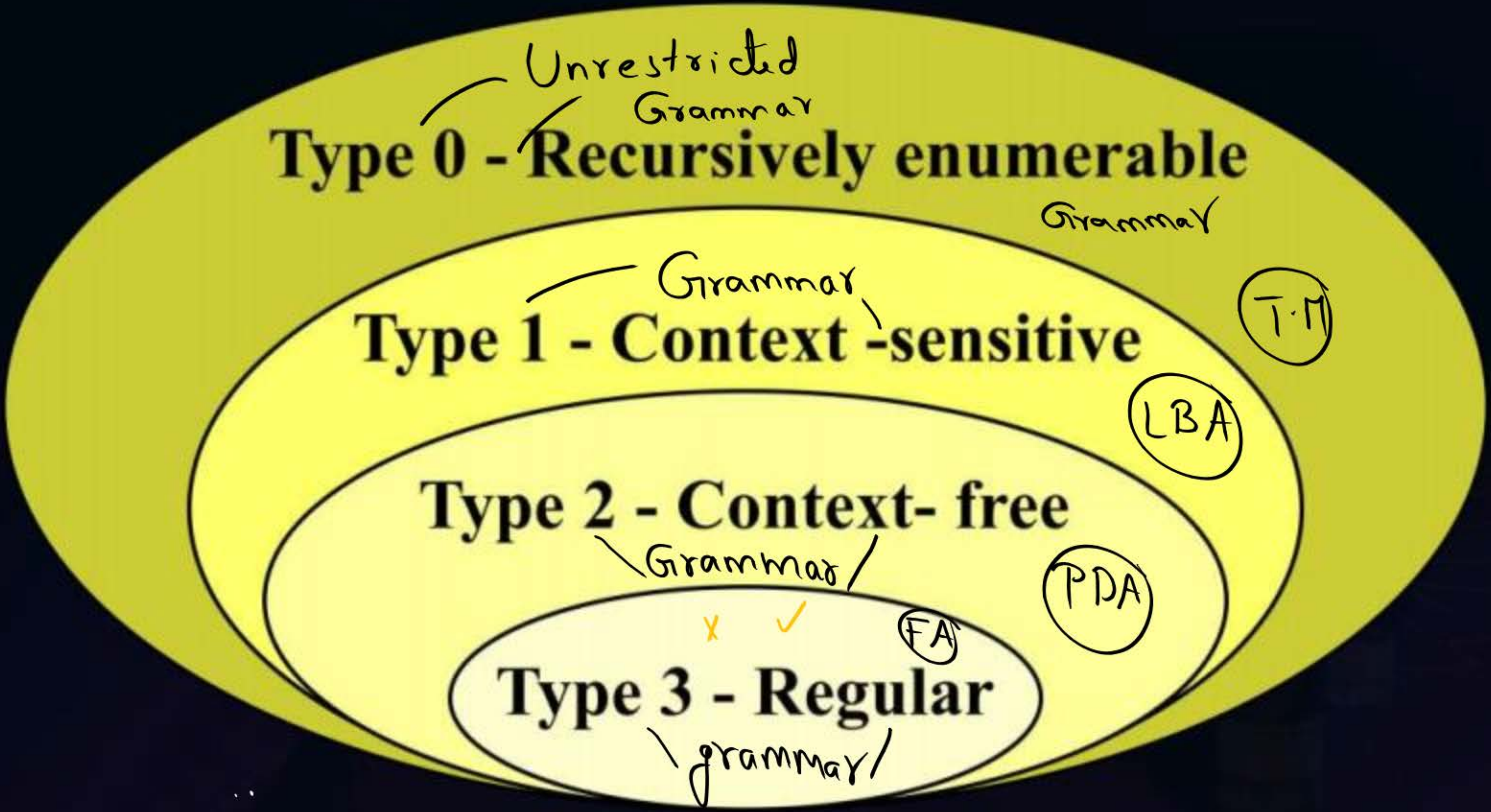
3 ✗

2 ✓

2, 1, 0

CFG ✓

Chomsky Hierarchy



F. A → Regular

Contextfree

PDA → Regular, CFG

LBA → CSG, CFG, Regular

T.M → REL, CSG, CFG, Regular.

Expressive Power :-

No. of languages accepted by Automata

$$\boxed{T.M > LBA > PDA > FA}$$

3, 2, 1, 0

$S \to aS \mid a$

3 ✓

2 ✓

1 ✓

0 ✓

Ambiguous Grammar : Grammar is ambiguous if

→ There exist a string from grammar that has more than 1 L.M.D

(or)

→ There exist a string from grammar that has more than 1 RMD

(or)

***

→ There exist a string from grammar that has more than 1 Parse tree

① $E \to E+E \mid E*E \mid n$

n

$n+n$

$n*n$

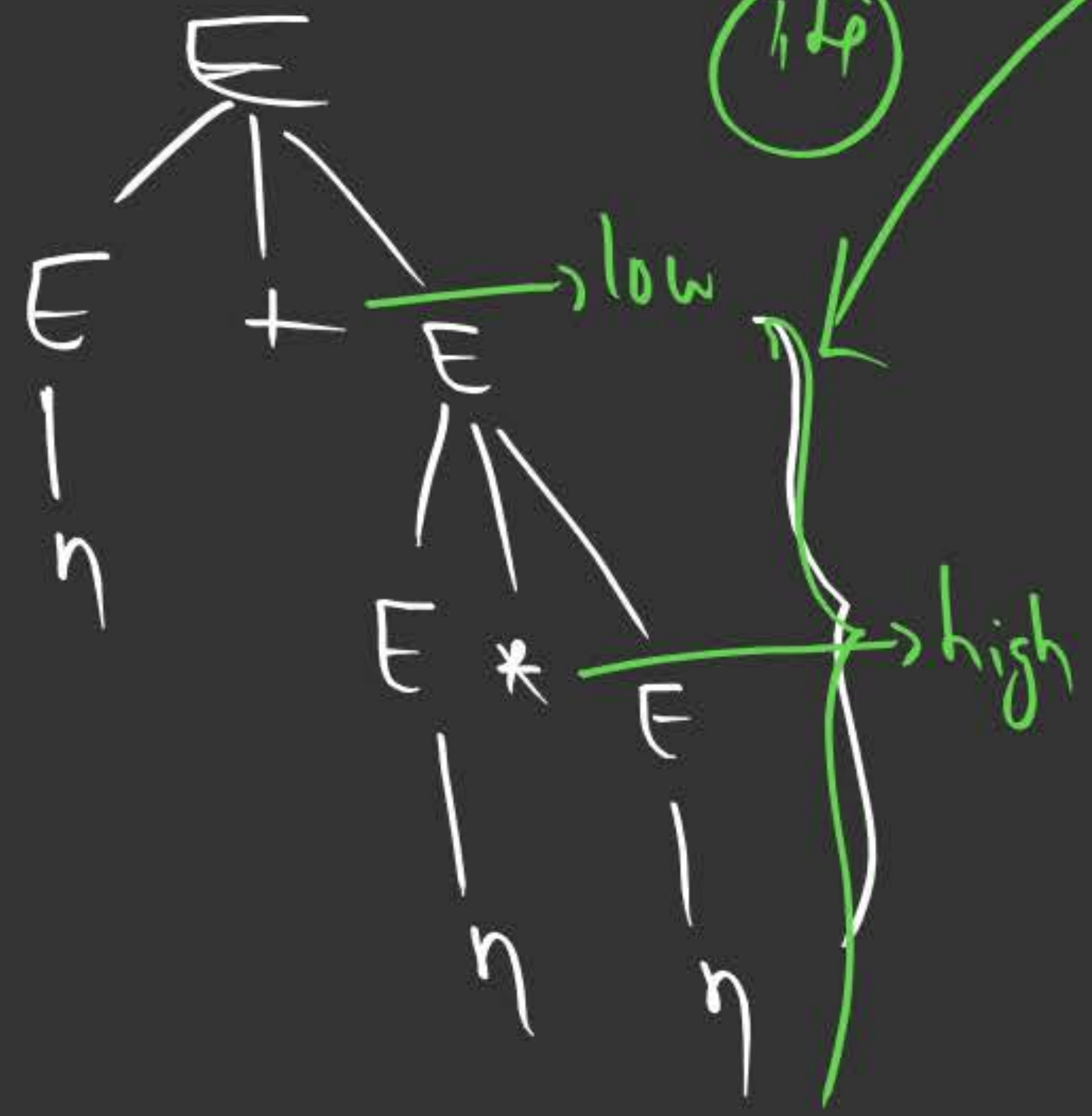
$\boxed{n+n*n}$

$2+3*4 = 14$

$2+12$

14

14

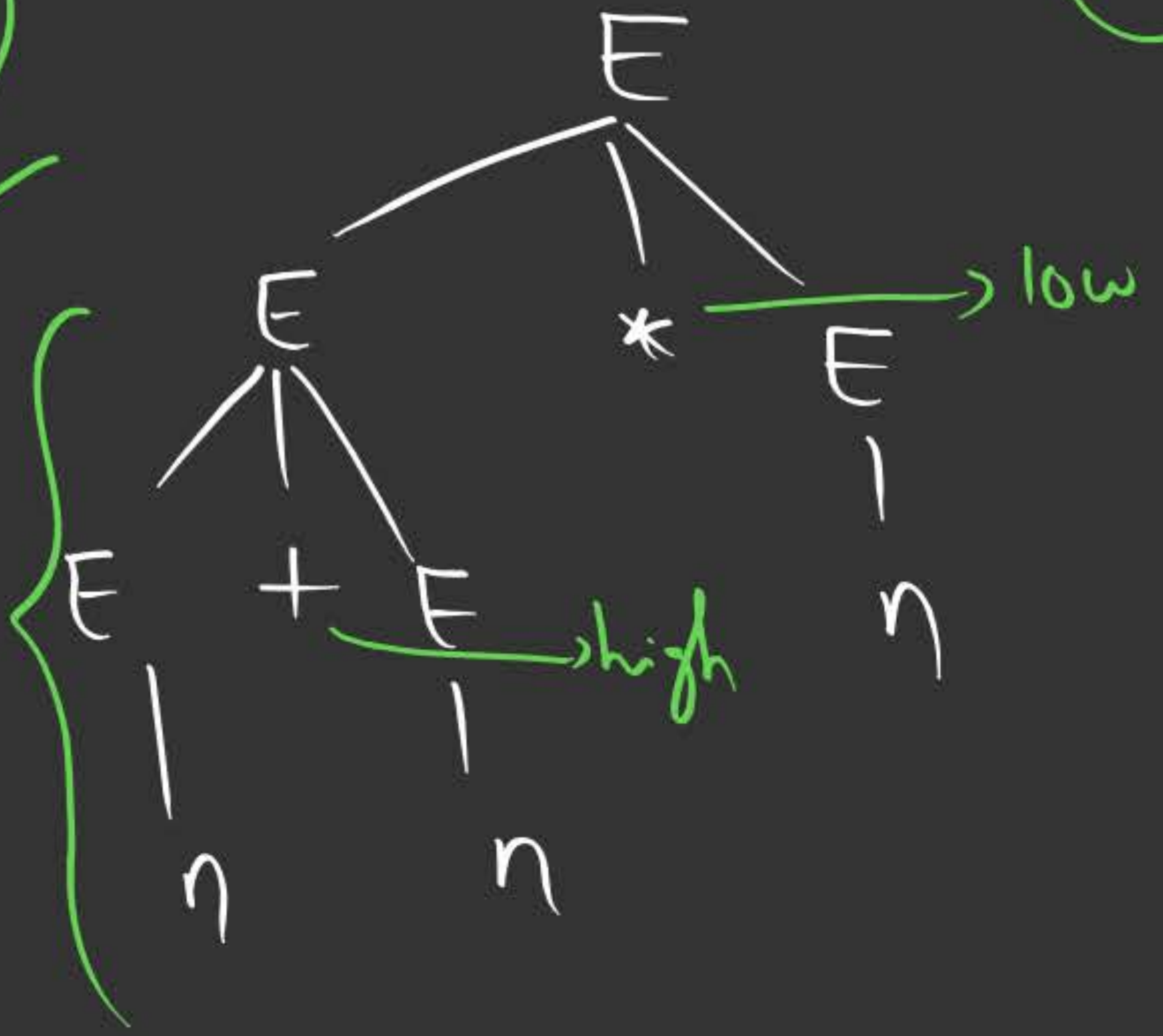


$\boxed{n+n*n}$

$5*4$

$(2+3)*4 = 20$

20



2,1,0

②

$S \to AA$

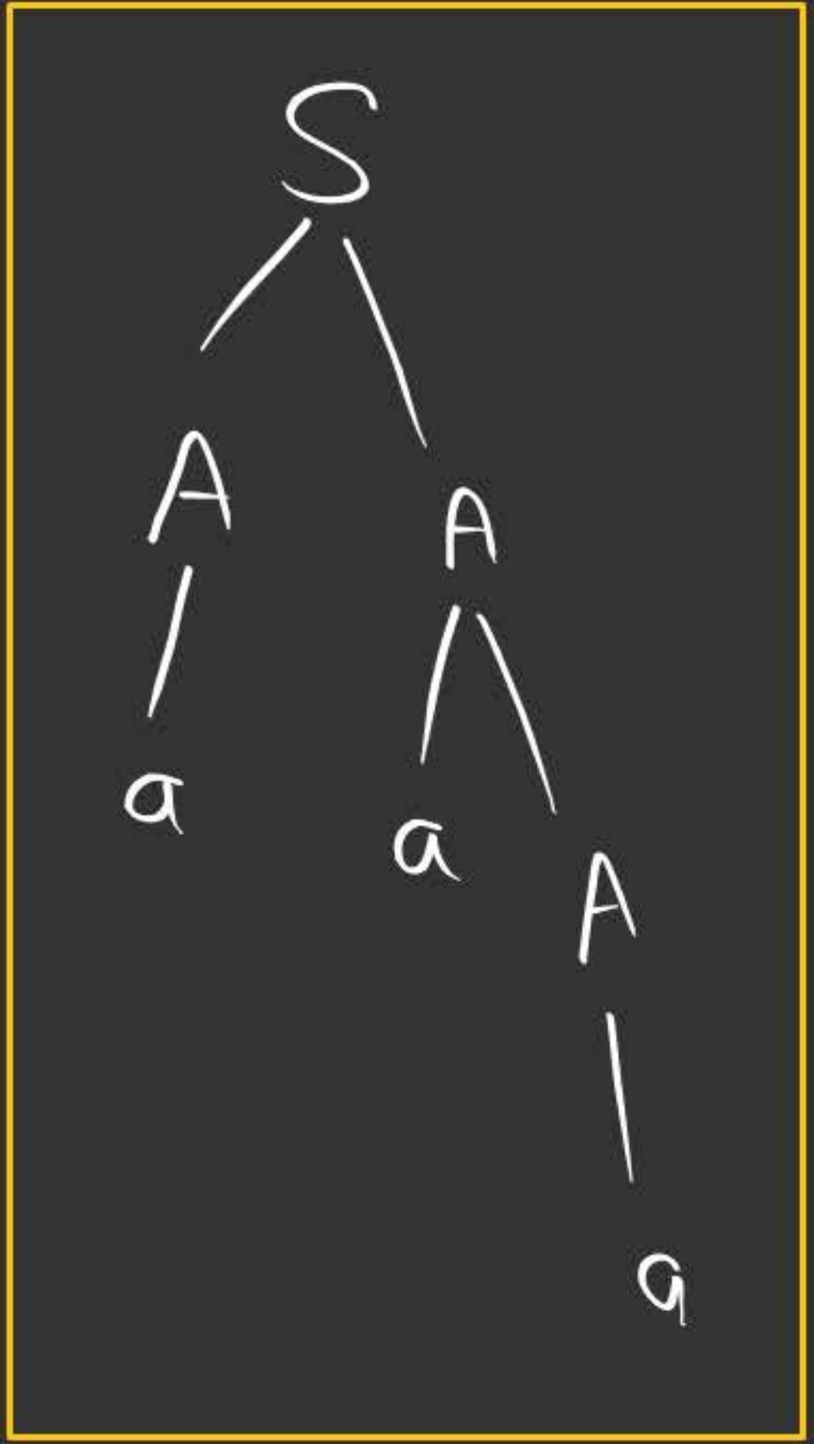
$A \to aA$

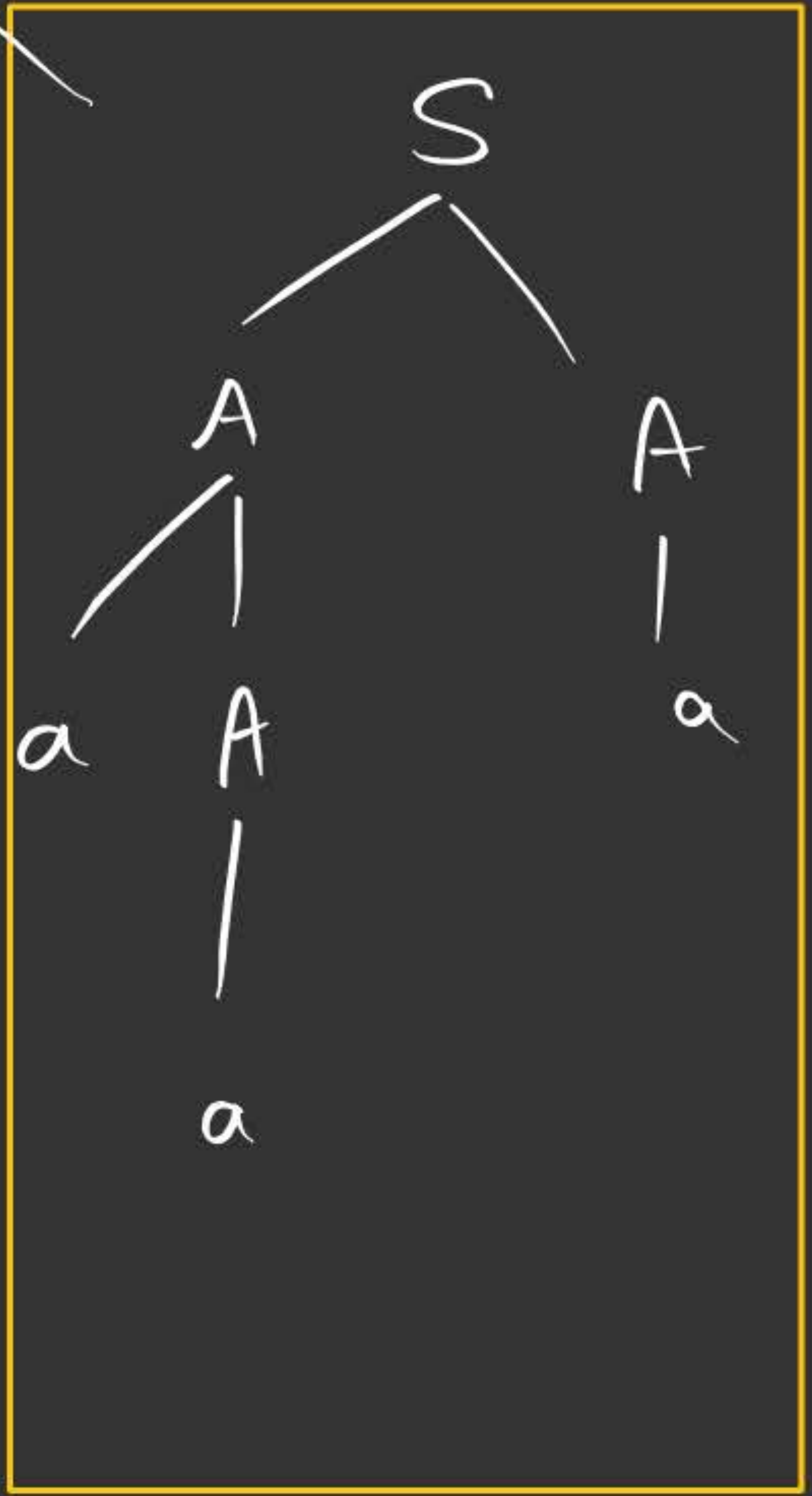
$A \to a$

This grammar is Ambiguous (or) not?

aaa

aaa



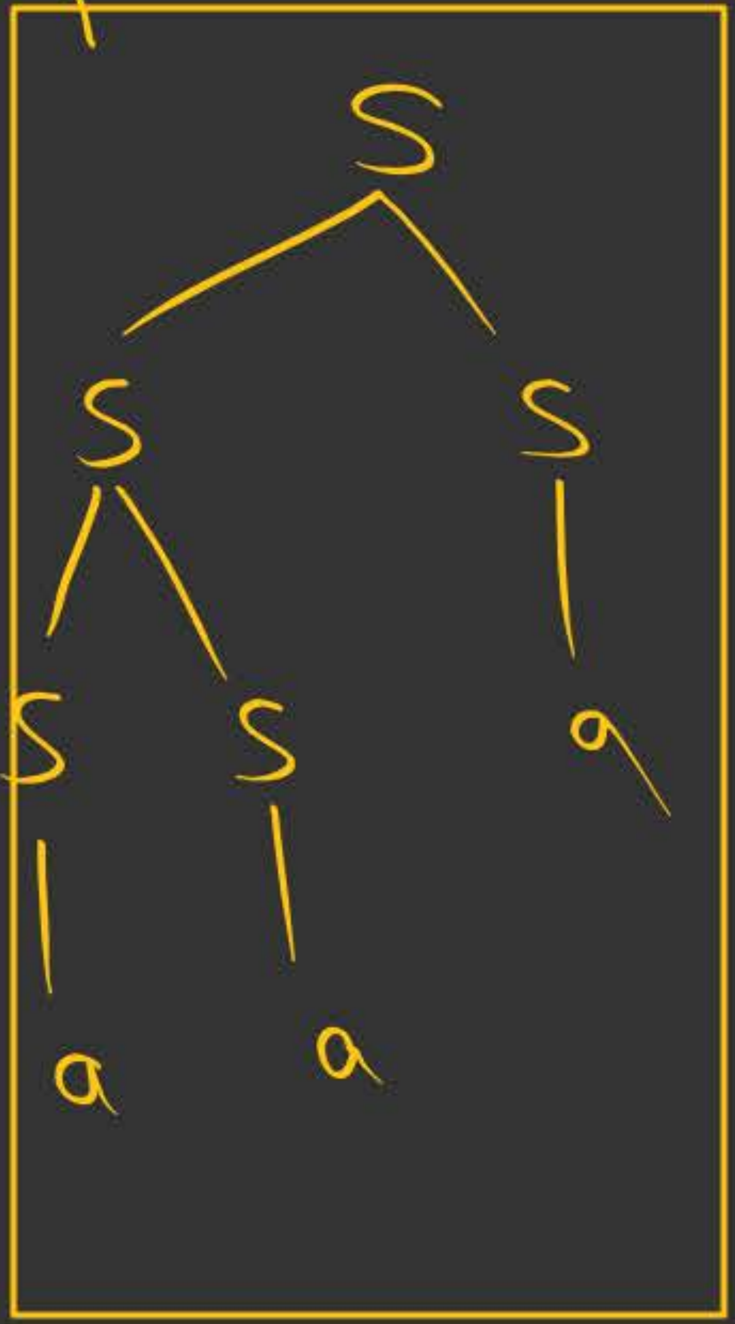


{Ambiguous Grammar}

a, aa, aaa

③ $S \to SS \mid a$ } Ambiguous

$\boxed{aaa}$



ⓐ Ambiguous

ⓑ Un Ambiguous

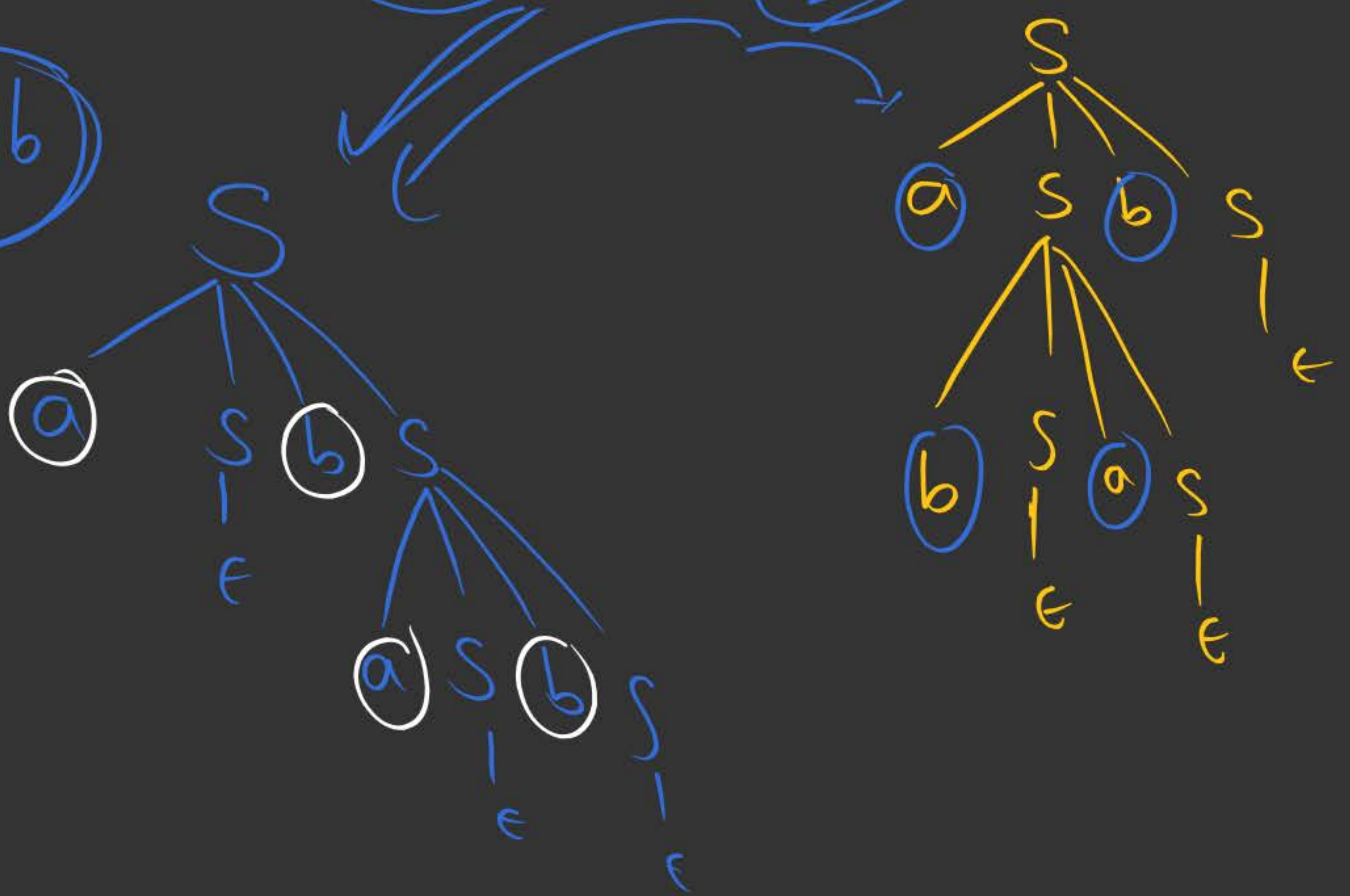
aa

(4) $S \rightarrow aSbS \mid bSaS \mid \epsilon$

2, 1, 0

abab

abab } Ambiguous Grammar



Elimination of Ambiguity

(a) Possible

(b) not possible

(5) $S \to AaAb \mid BbBa$

$A \to \epsilon$

$B \to \epsilon$

$\{ab, ba\}$

ab

ba

(a) Ambiguous

(b) Unambiguous

⑥

$S \rightarrow AB \mid BC$

$A \rightarrow BA \mid a$

$B \rightarrow CC \mid b$

$C \rightarrow AB \mid a$

Home work

⑦ $\boxed{S \to aSa \mid bSb \mid c}$

Home Work

Ambiguity problem is undecidable problem

No Algorithm exist to check Ambiguity of a grammar

Elimination of Ambiguity from Grammar

Undecidable problem

no solution exist

no algorithm exist

Unambiguous Grammar

→ Every string derived from grammar has exactly one LMD

(or)

" " " " " " one RMD

(or)

" " " " " one parse tree

2 mins Summary

Topic One

Topic Two

Topic Three

Topic Four

Topic Five

$L = \{a^n b^m \mid (n+m) \text{ odd}\}$

$\underline{a(aa)^*}(bb)^* + (aa)^* b(bb)^*$

$$\boxed{\begin{array}{ll} S \to aAB \mid AbB & \\ A \to aaA \mid \epsilon & (aa)^* \\ B \to bbB \mid \epsilon & (bb)^* \end{array}}$$

THANK - YOU