CS & IT ENGINEERING

THEORY OF COMPUTATION

Grammar

[redacted]

Lecture - 01

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Recap of Previous Lecture

Mealy machine

Topic ????? &

Moore Machine

Topics to be Covered

Topic Grammar

Topic ??

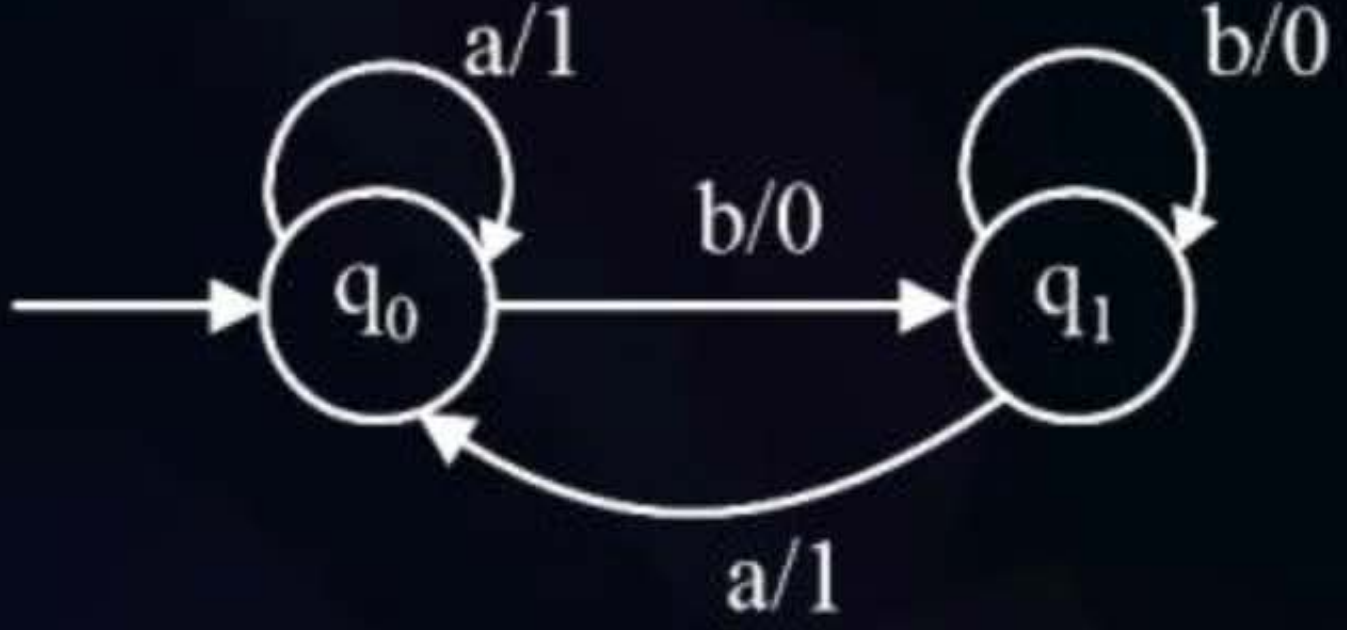
Topic ??

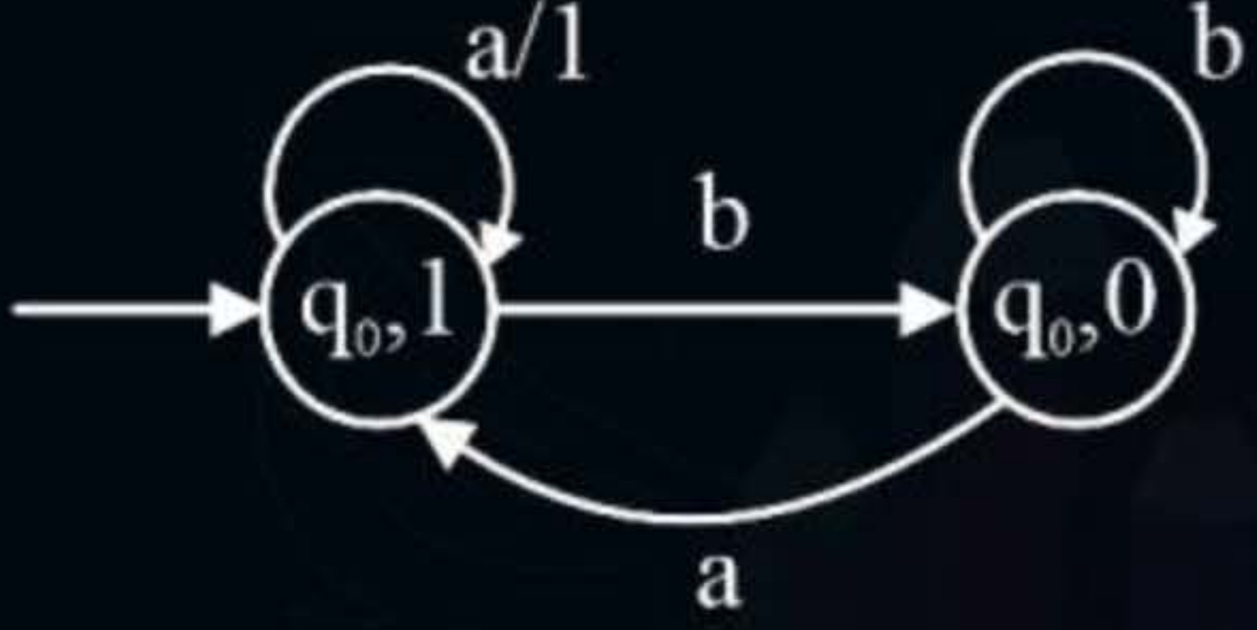
Topic ??

F.A with output

Mealy Machine

Moore Machine





- Mealy Machine:
- It is a mathematical model in which output is associated
- with transition.

- Moore Machine:
- It is a mathematical model in which output is associated
- with state.

[NAT]

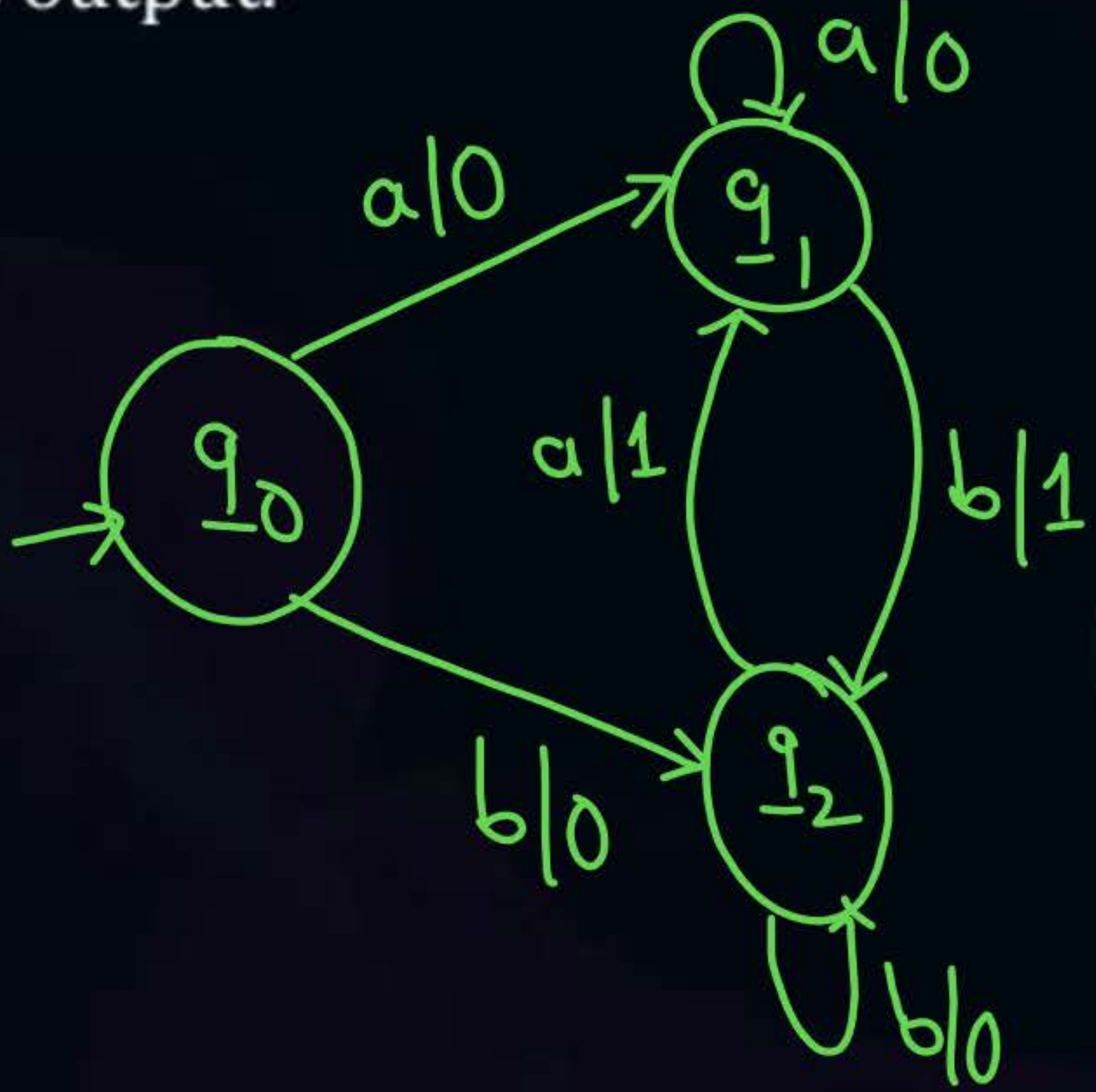
#Q. Construct mealy machine that takes all strings of a's and b's as input and produces 1 as output if last two symbols in the input are same otherwise produces 0 as output.

[NAT]

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

$\Delta = \{0, 1\}$

#Q. Construct mealy machine that takes all strings of a's and b's as input and produces 1 as output if last two symbols in the input are different otherwise produces 0 as output.

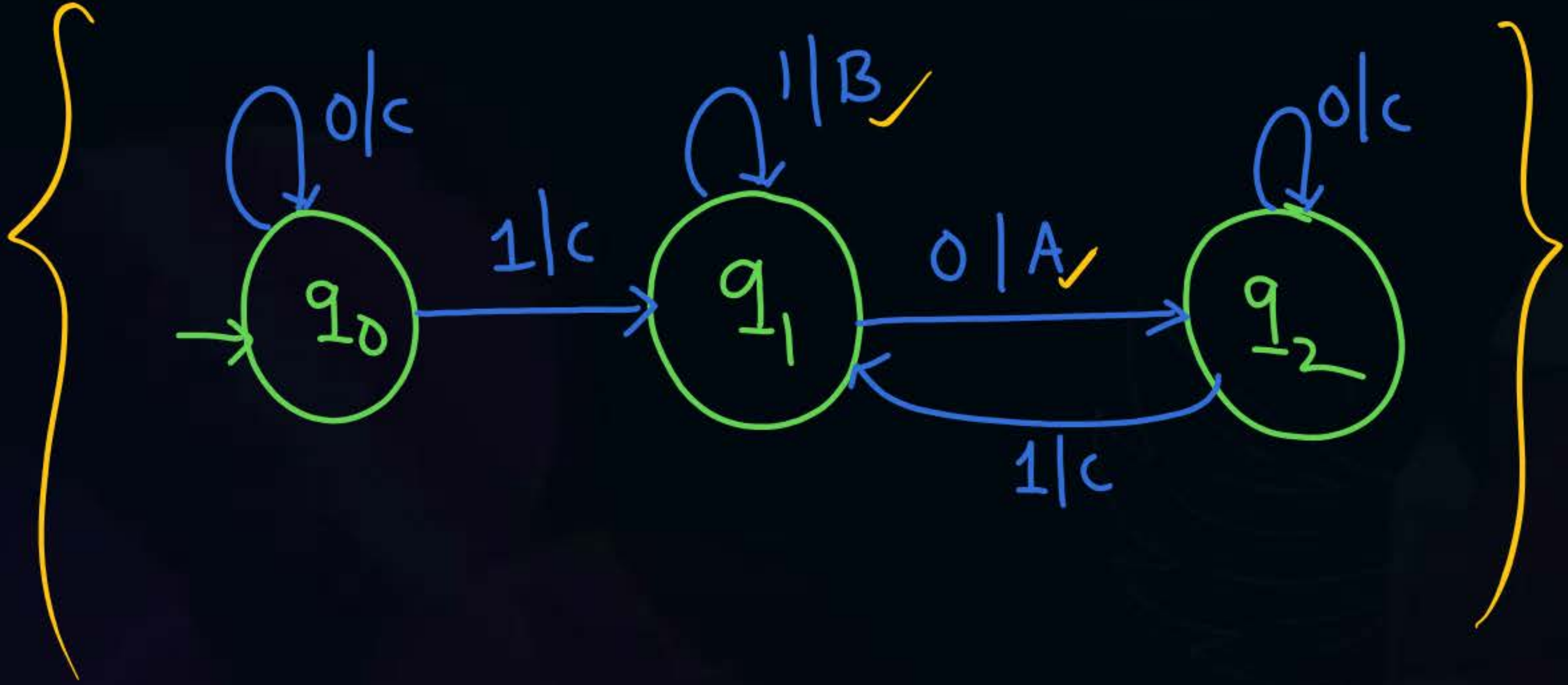


$ab \to 1$

$\left.\begin{array}{l} a \\ b \\ aa \\ bb \end{array}\right\} 0$

[NAT] No final States ''''''

#Q. Construct mealy machine that takes all strings of 0's and 1's as input and produces A as output if input ending with 10 or produces B as output if input ending with 11 otherwise produces output C.



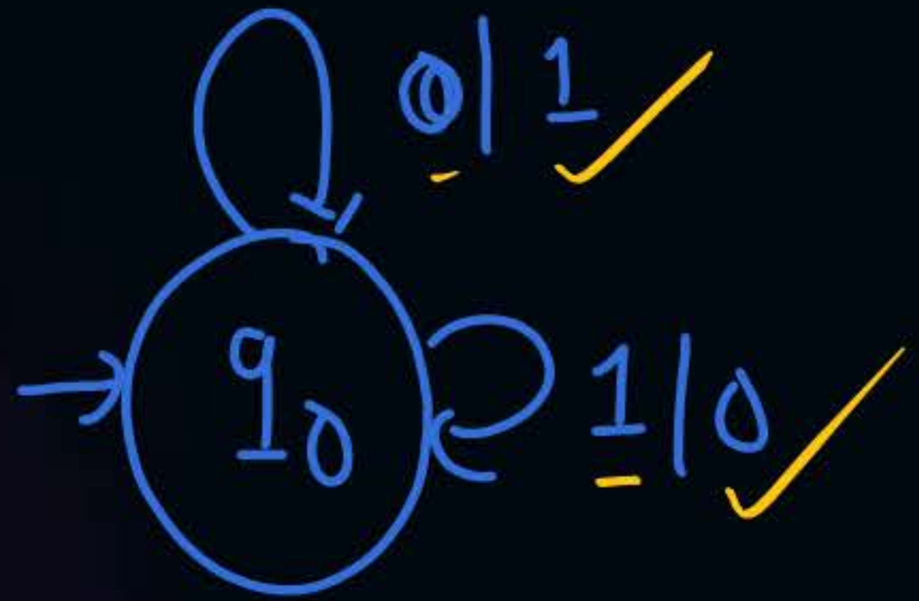
10 → A

11 → B

other → c

[NAT]

#Q. Construct mealy machine that produces 1's complement of given binary number as output.



0101

1010

[NAT]

#Q. Construct mealy machine that produces 2's complement of given binary number as output.(assume we are reading string from LSB to MSB)

[NAT]

4)

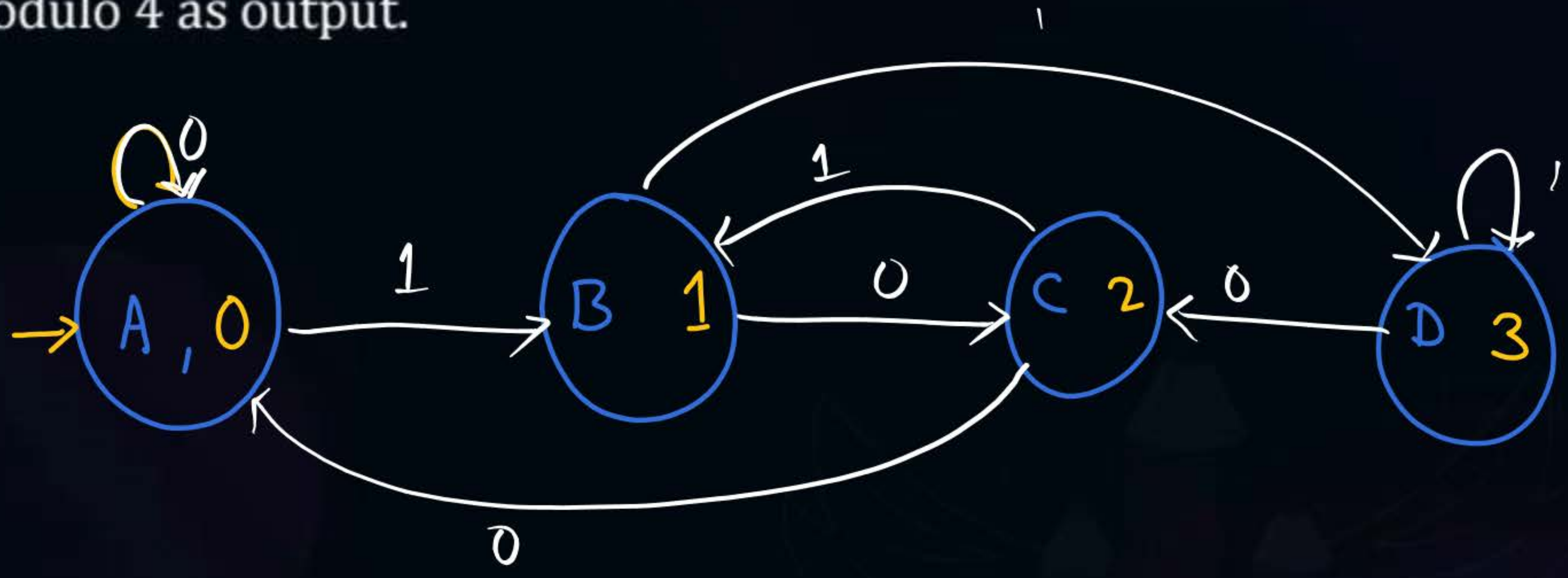
$\Delta = \{0,1,2,3\}$

$000 \rightarrow 0$

$001 \rightarrow 1$

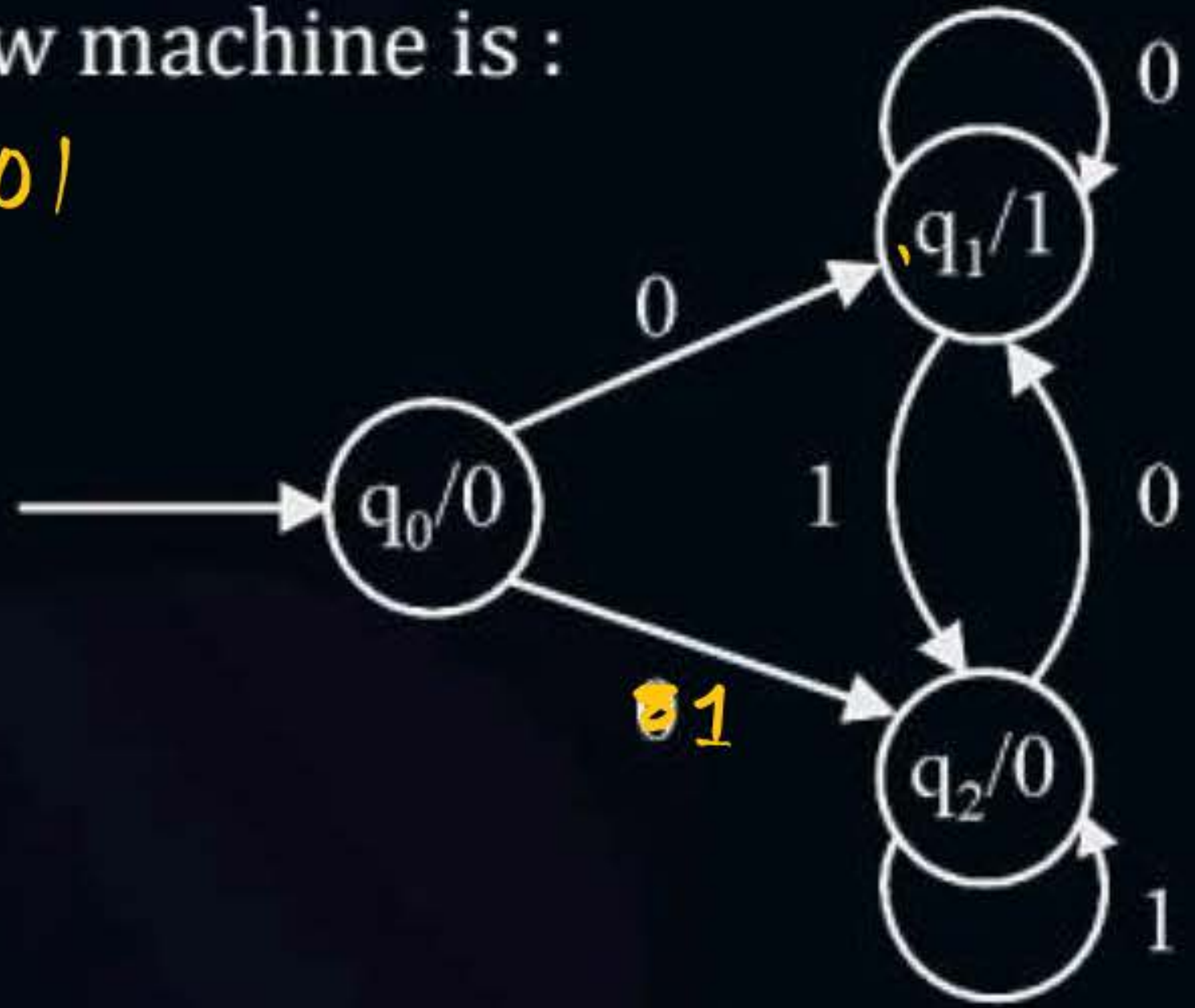
#Q. Construct Moore machine that takes all binary strings as input and produces Residue modulo 4 as output.

	0	1
→A	A	B
B	C	D
C	A	B ✓
D	C	D



#Q. The below machine is :

0101



0101

1010

1's Complement

A A Mealy machine to find 2's complement of a number

B A Moore machine to find 2's complement of a number

C A Mealy machine to find 1's complement of a number

[✓ D] A Moore machine to find 1's complement of a number

[MCQ]

#Q. A finite state machine with the following state table has a single input x and a single output z.

	Present state x = 1	Next state, z x = 0
A	D, 0	B, 0
B	B, 1	C, 1
C	B, 2	D, 1
D	B, 1	C, 0

If the initial state is unknown , then the shortest input sequence to reach the final state C is :

A 0 1

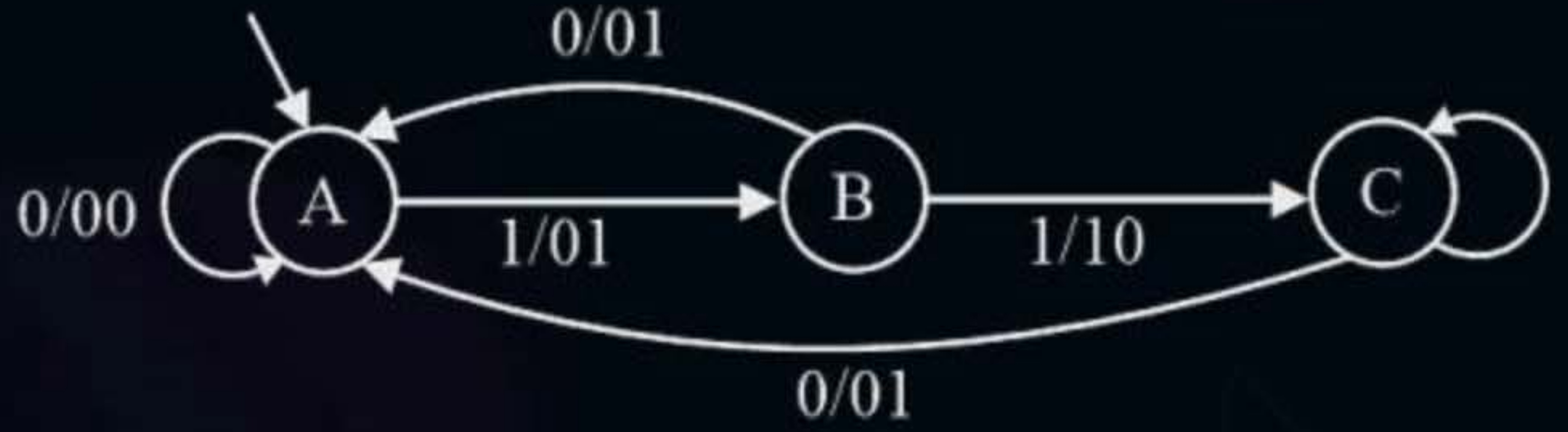
B 10

C 101

D 110

[MCQ]

#Q. The Finite state machine described by the following state diagram with A as starting state, where an arc label is x/y and x stands for 1-bit input and y stands for 2-bit output.



A Outputs the sum of the present and the previous bits of the input

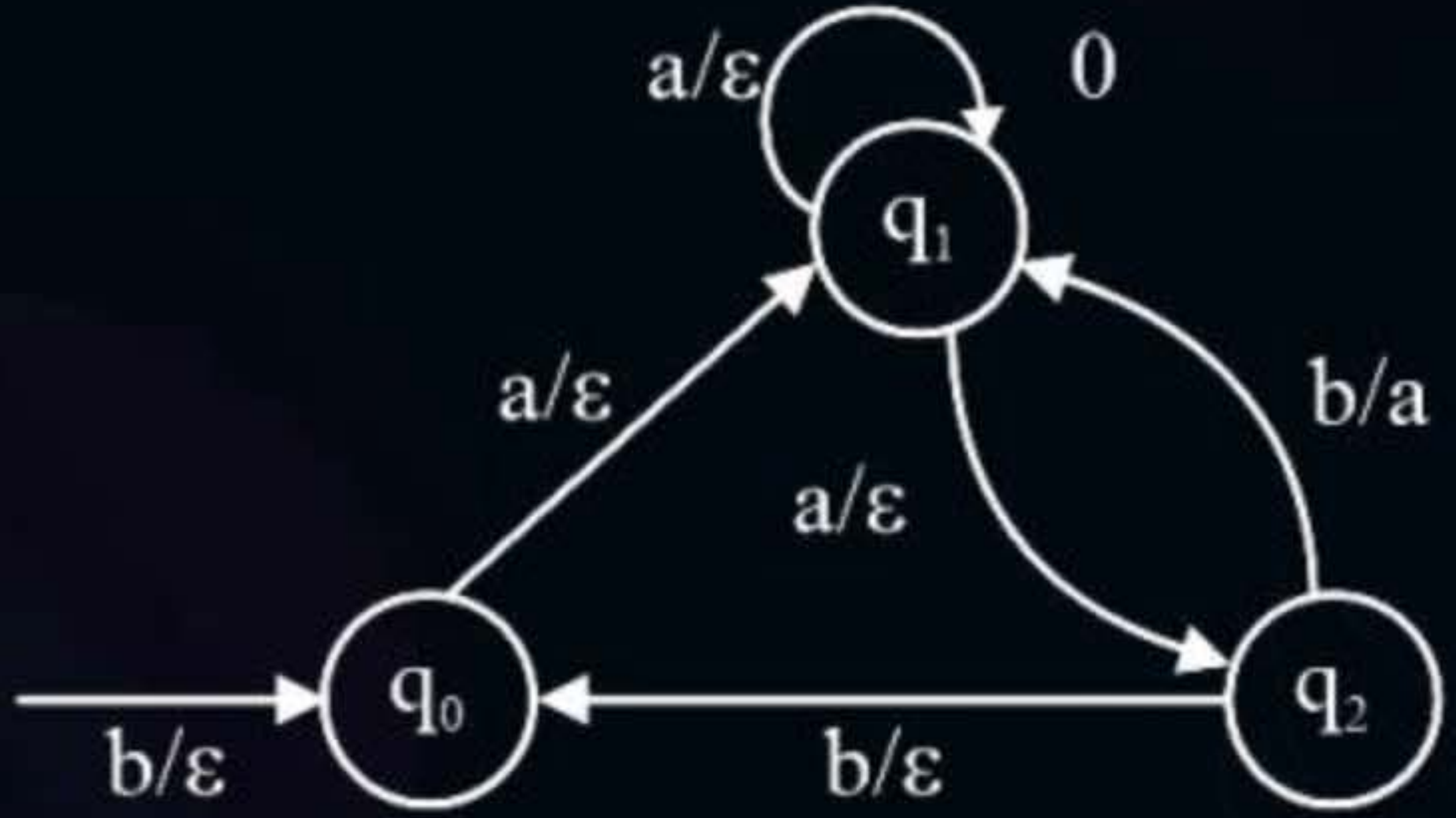
B Outputs a "01" whenever the input sequence contain "11"

C Outputs a “00” whenever the input sequence contains "10"

D None of the above

[MCQ]

#Q. Consider the following finite state transducer where the label on an edge x/t denotes if the input is x, follow the arrow and emit t



For the input, aabbbaaabbbbabaabb the output is :

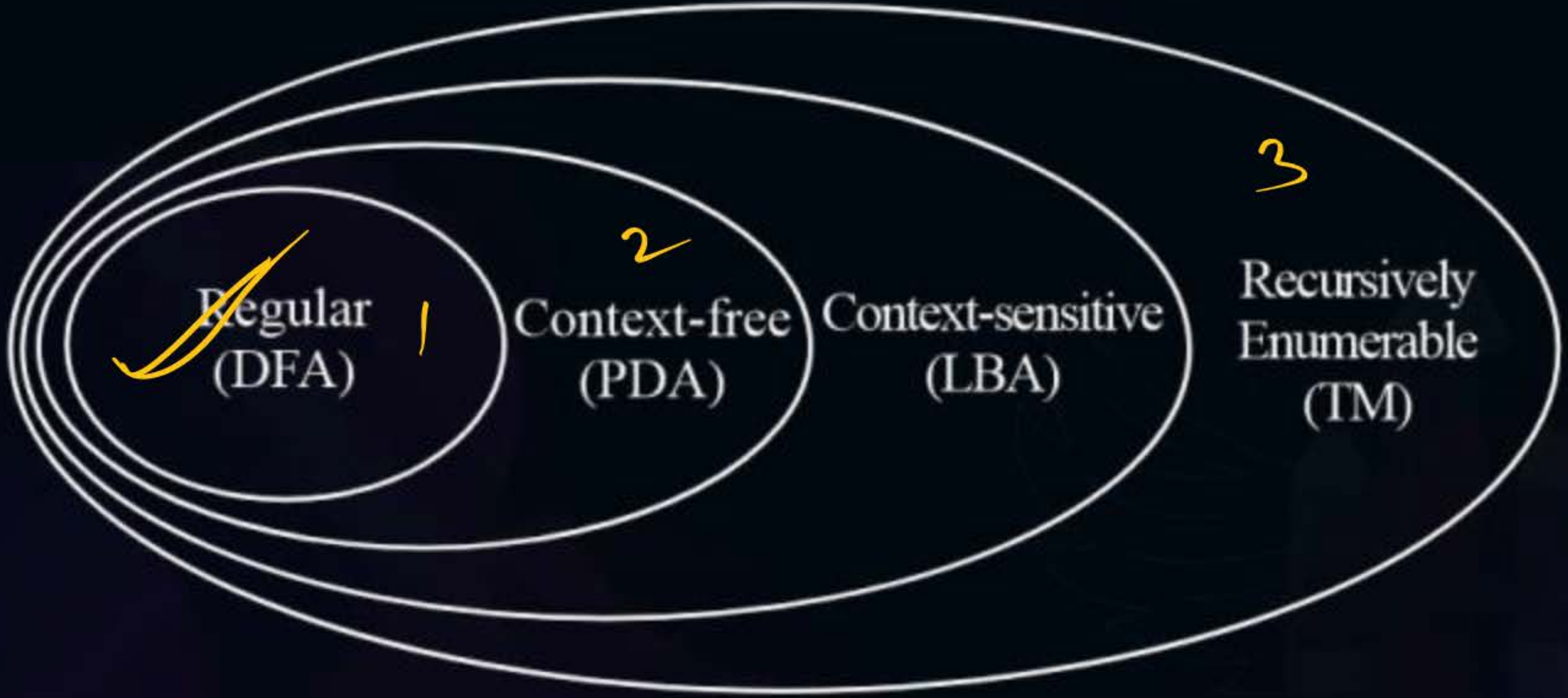
A aaaa

B aaaaaaaaa

C ab ab ab ab

D abbbabbbbababb

Topic : Regular expression



DFA

NFA

∈-NFA

Regular Expressions

Regular Language Detection

Closure propertiey

F.A With o/p

50%

Topic : Grammar

c →

java →

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

G=(N, T, P, S) $\{S, A, B, C\}$

- N :- non terminals or variables
- T :- Terminals → $\{a, d, b\}$
- P :- no. of productions → 4.
- S :- Starting symbol

$1.\ S \xrightarrow{1} ABC$ -1

$A \xrightarrow{2} a \mid e$ -2

$B \xrightarrow{3} d \mid a$ -2

$C \xrightarrow{4} b \mid c$ -2

7

$\alpha \longrightarrow \beta$

$X \longrightarrow Y$

DFA = Language = Reg Expression

Grammar = Language

Topic : Grammar

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

$L = \{a^n b^n\}$ — Grammar

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

$\alpha = \beta$

$\alpha \downarrow \beta$

For a given language many no·of grammars can be Constructed.

1. $$\begin{tikzcd} & G_1 \\ \text{Language} \arrow[ur] \arrow[r, dash] \arrow[dr, dash] & G_2 \\ & \vdots \end{tikzcd}$$

2. $\text{Grammar} \xrightarrow{1} \text{Language}$

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.

$S \rightarrow ABD$

$A \rightarrow b$

$B \rightarrow c$

$D \rightarrow a$

L.M.D

L. S.F

S ①

A B D ②

b B D ③

b c D ④

b c a ⑤

R.M.D

RS.F

S

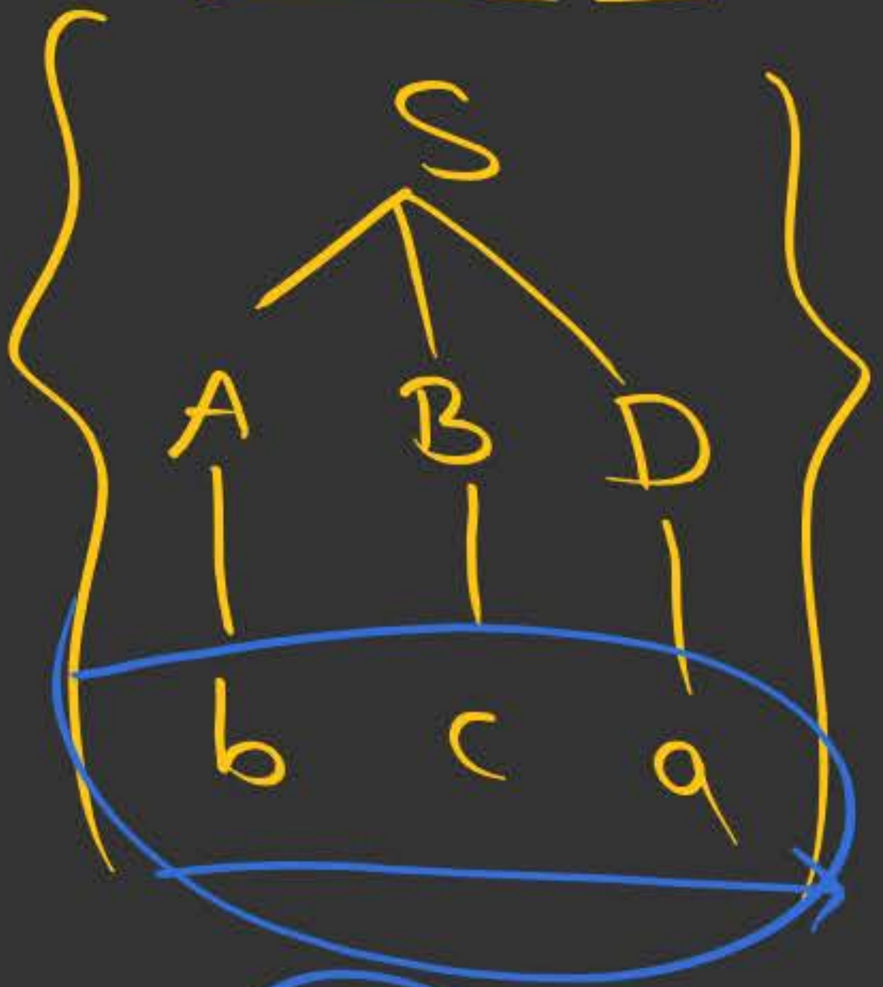
A B D

A B a

A c a

b c a

*** Parse tree



yield

bca

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.

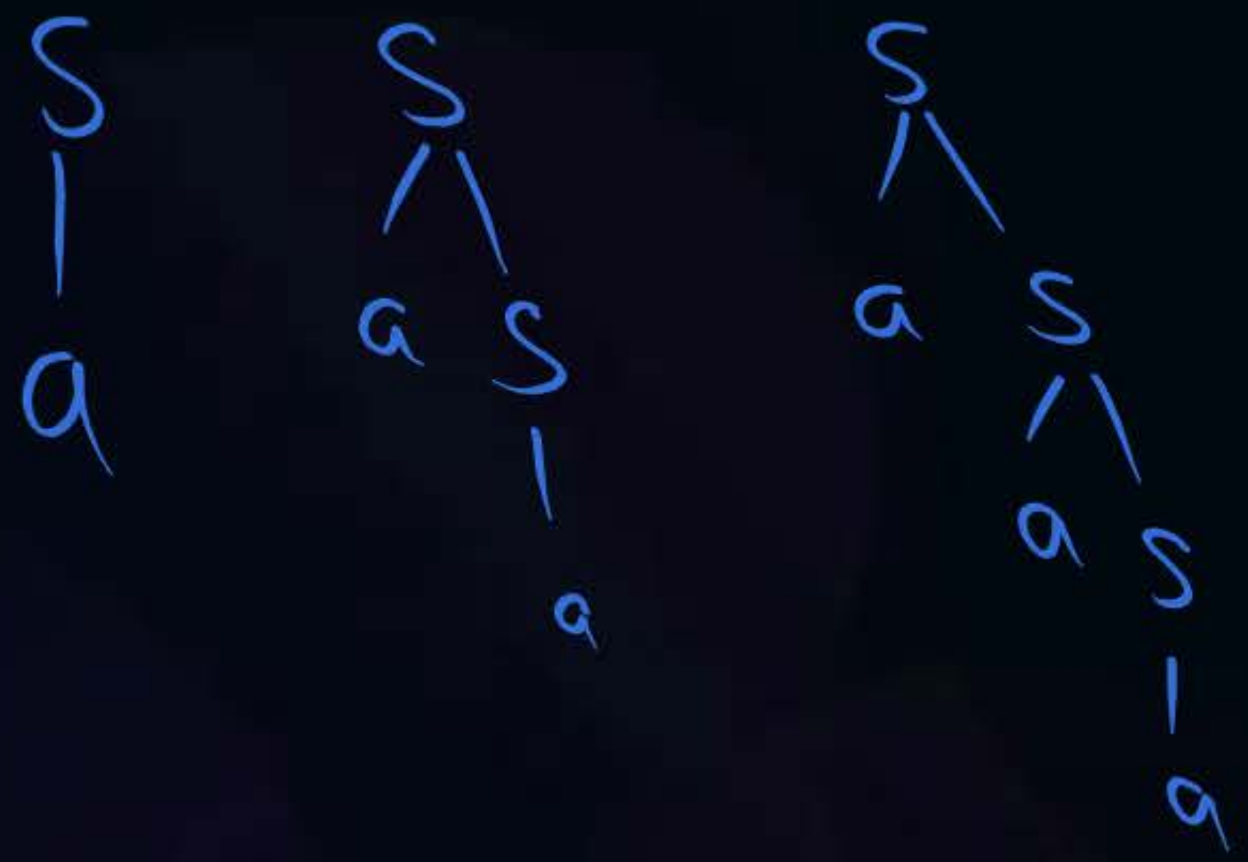
- Context free language there exist a grammar known as context free grammar.
- Context sensitive language there exist a grammar known as context sensitive grammar.
- For recursive enumerable language there exist a grammar known as unrestricted grammar.

[NAT]

#Q. Identify language generated by following grammar.

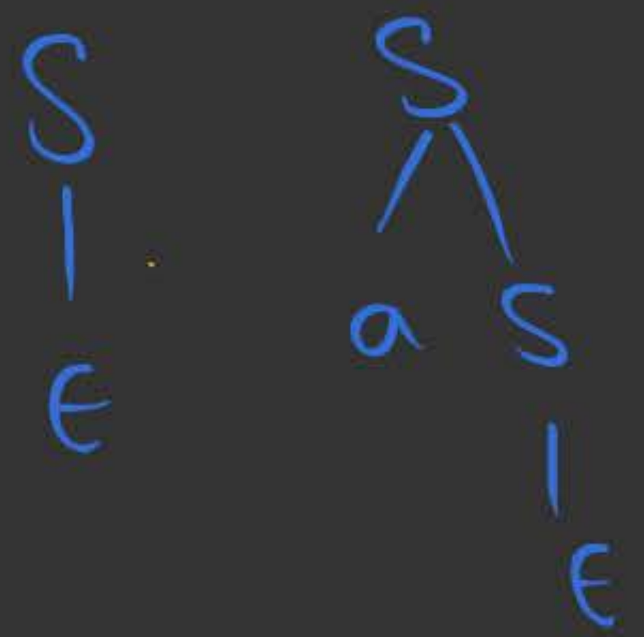
recursive

① $S \rightarrow aS \mid a = \{a, a^2, a^3 \text{ ---}\} = \boxed{a^+}$



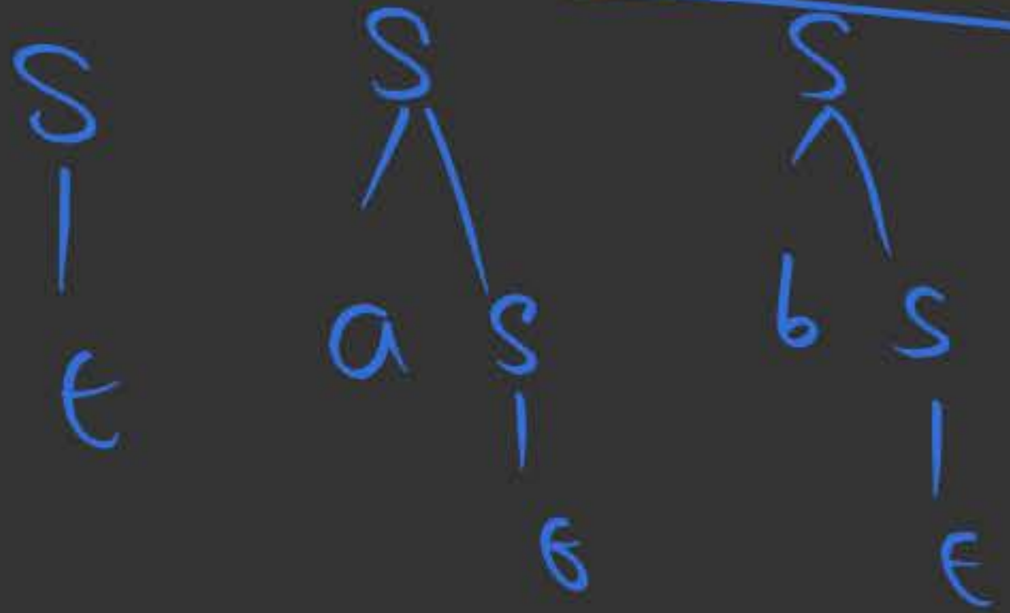
② $S \to aS \mid \epsilon$ = language ?

$\{\epsilon, a, a^2, a^3 --- \} = a^*$



3 $S \to aS \mid bS \mid \epsilon$ = Language ? = $(a+b)^*$ ✓

$\{\epsilon, a, b, a^2, a^3 \ldots a^2bb$
$b^2, b^3 \ldots b^2a^2 \ldots\}$

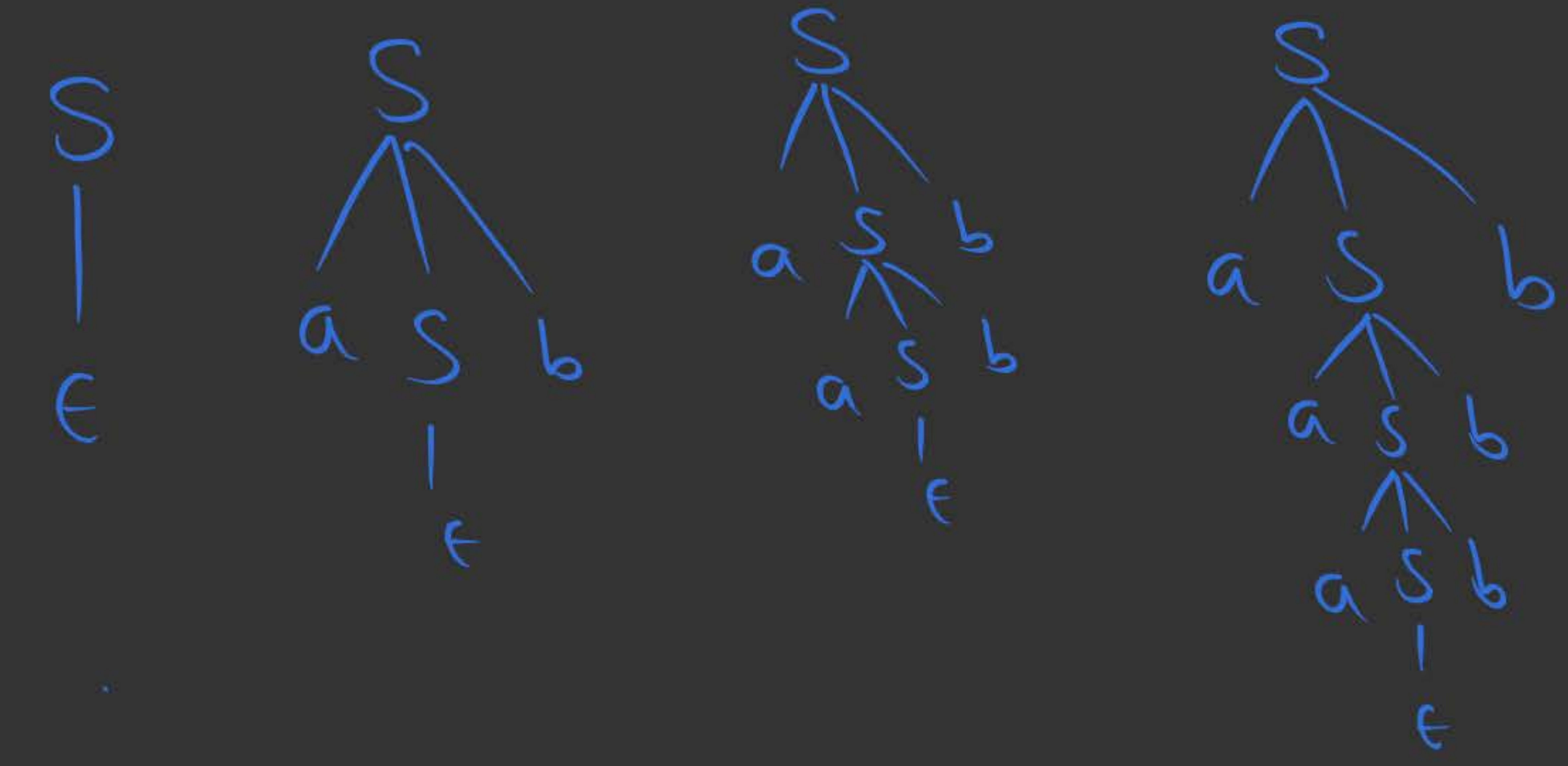


Complete Language ✓

4 $S \rightarrow aSb \mid \epsilon$ = language? $\{a^n b^n \mid n \geq 0\}$

$\{\epsilon, ab, a^2b^2, a^3b^3 \ldots\}$

$\{a^n b^n\}$



⑤

$S \to \overset{a^*}{A}\,\overset{b^*}{B}$

$A \to aA \mid \epsilon \longrightarrow a^*$

$B \to bB \mid \epsilon \longrightarrow b^*$

Language ?

$S = a^* b^*$

⑥ $S \rightarrow a\underline{A}b \mid bAa$ → language ?

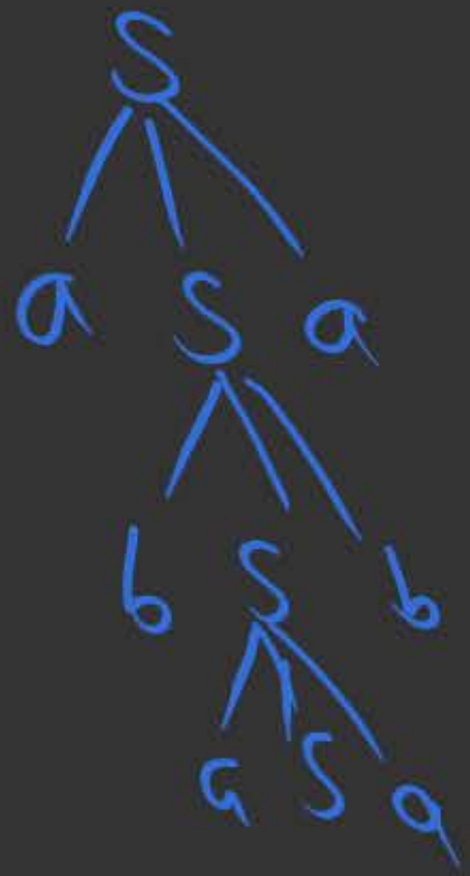
$A \rightarrow aA \mid bA \mid \epsilon \leftrightarrow (a+b)^*$

$$S = \boxed{a(a+b)^*b + b(a+b)^*a}$$

Starting and ending with different Symbol.

⑦ $\boxed{S \rightarrow aSa \mid bSb \mid \epsilon}$ = language? $L = \{ww^R \mid w \in (a+b)^*\}$

$\{\epsilon, aa, abaaba \ldots\} =$



even length palindrome.

⑧ $\boxed{S \to aSa \mid bSb \mid a \mid b}$ Language = ?

L = odd length Palindrome

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

$$L = \left\{ WXW^R \;\middle|\; \begin{array}{l} W \in (a+b)^* \\ X \in (a+b) \end{array} \right\}$$

(9)

$S \rightarrow AB$

$A \rightarrow aAb \mid ab$

$B \rightarrow bB \mid b$

$\{a^n b^n\}$

Language = ?

b^+

$S = a^n b^n b^+$

Non Regular

$L = \{a^n b^m \mid n < m\}$

$n, m \geq 1$

(10) $S \rightarrow aSd \mid a\boxed{A}d$

$A \rightarrow bAc \mid bc = \underline{\{b^n c^n\}}$

<u>Language</u> ??

$\underline{a^m d^m b^n c^n}$ ✗

$$L = \{a^m b^n c^n d^m \mid n, m \geq 1\}$$

[NAT]

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

#Q. Construct grammar for the following languages.

① $L = a^*$

$$\boxed{S \rightarrow \underline{a}S \mid \epsilon}$$

$\underline{2}$ production

② $L = \underline{\underline{a}}^* \, \underline{\underline{b}}^*$

Grammar = ?

5 productions

$S \to AB$

$A \to aA \mid \epsilon$

$B \to bB \mid \epsilon$

③ $L = \underline{(a+b)}^* b$

$S \to aS/bS/b$

$$\boxed{\begin{array}{l} S \to Ab \\ A \to aA|bA|\epsilon \end{array}}$$

$(a+b)^*$

4 $L = \{a^n b^m \mid (n+m) \text{ is even}\}$

10 am

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

not Regular

$S \rightarrow AB \mid aAbB$

$A \rightarrow aaA \mid \epsilon$ $(aa)^*$

$B \rightarrow bbB \mid \epsilon$ $(bb)^*$

Home Work

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

$a(aa)^*(bb)^* + (aa)^*b(bb)^*$

⑥ $L = \{a^n b^{2n} \mid n \geq 1\}$

$$S \rightarrow aSbb \mid abb$$

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

$$S \rightarrow aSb \mid ab$$

7 $L = \{ a^n b^n c^m \mid n, m \geq 1 \}$ ✓

$N.T = \{S, A, B\}$

$S \rightarrow AB$

$A \rightarrow aAb \mid ab$

$B \rightarrow cB \mid c$

$a^n b^n$

c^m

⑧ $L = \{ a^{n+m} b^m c^n \mid n, m \geq 1 \}$

$a^n a^m b^m c^n$

$S \to aSc \mid aAc$

$A \to aAb \mid ab$

⑨ $L = \{a^n b^m c^m d^n / n, m \geq 1\}$

$$S \rightarrow aSd \mid aAd$$

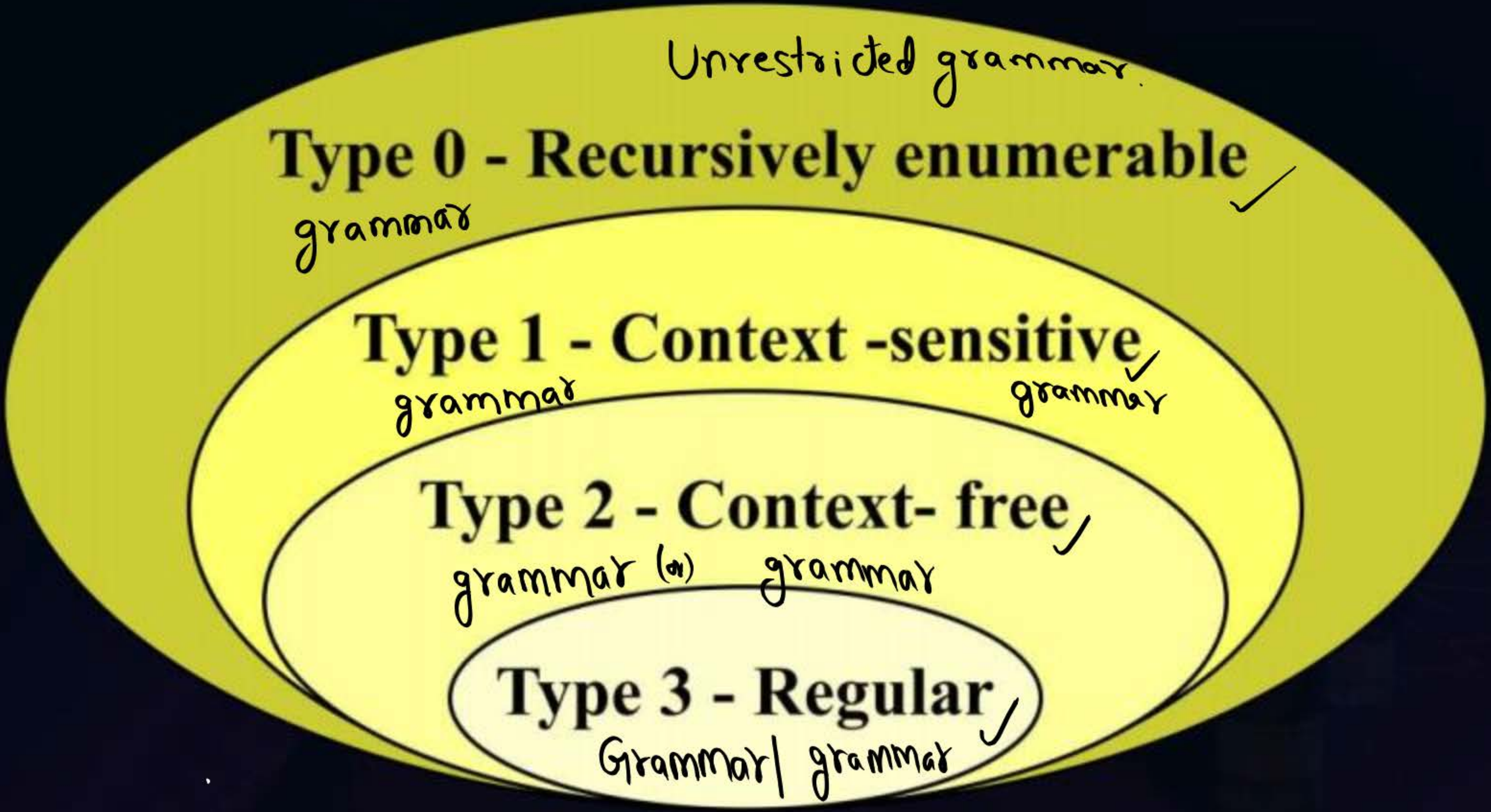
$$A \rightarrow bAc \mid bc$$

(10) $L = a(a+b)^* a + b(a+b)^* b + a + b$

Home Work

Types of Grammar

Type	Language (Grammers)	From of Productions	Accepting Dived
3	Regular	$A \rightarrow aB, A \rightarrow A$	Finite Automaton
2	Context –free	$A \rightarrow \alpha$	Pushdown Automaton
1	Context sensitive	$A \rightarrow \beta$ With $\|\alpha\| \geq \|\beta\|$	LBA
0	Unrestricted	$\alpha \rightarrow \beta$	Turing machine



Unrestricted grammar.

Type 0 - Recursively enumerable ✓

grammar

Type 1 - Context -sensitive ✓

grammar grammar

Type 2 - Context- free ✓

grammar (or) grammar

Type 3 - Regular ✓

Grammar| grammar

1. Grammar → Language

2. Language → Grammar Construction.

2 mins Summary

Topic One

Topic Two

Topic Three

Topic Four

Topic Five

10 am

THANK - YOU