

CS & IT ENGINEERING



Theory of Computation

DFA

Lecture No.- 02



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Recap of Previous Lecture



Topic

Introduction

(7-10)

Topic

Finite Automata

Topics to be Covered



Topic

Finite Automaton & Regular Languages.

Topic

Pushdown Automata & Context free Languages.

Topic

Turing Machine & Recursive Enumerable Languages.

Topic

Undecidability.

BOOKS:



1

PETER LINZ

2

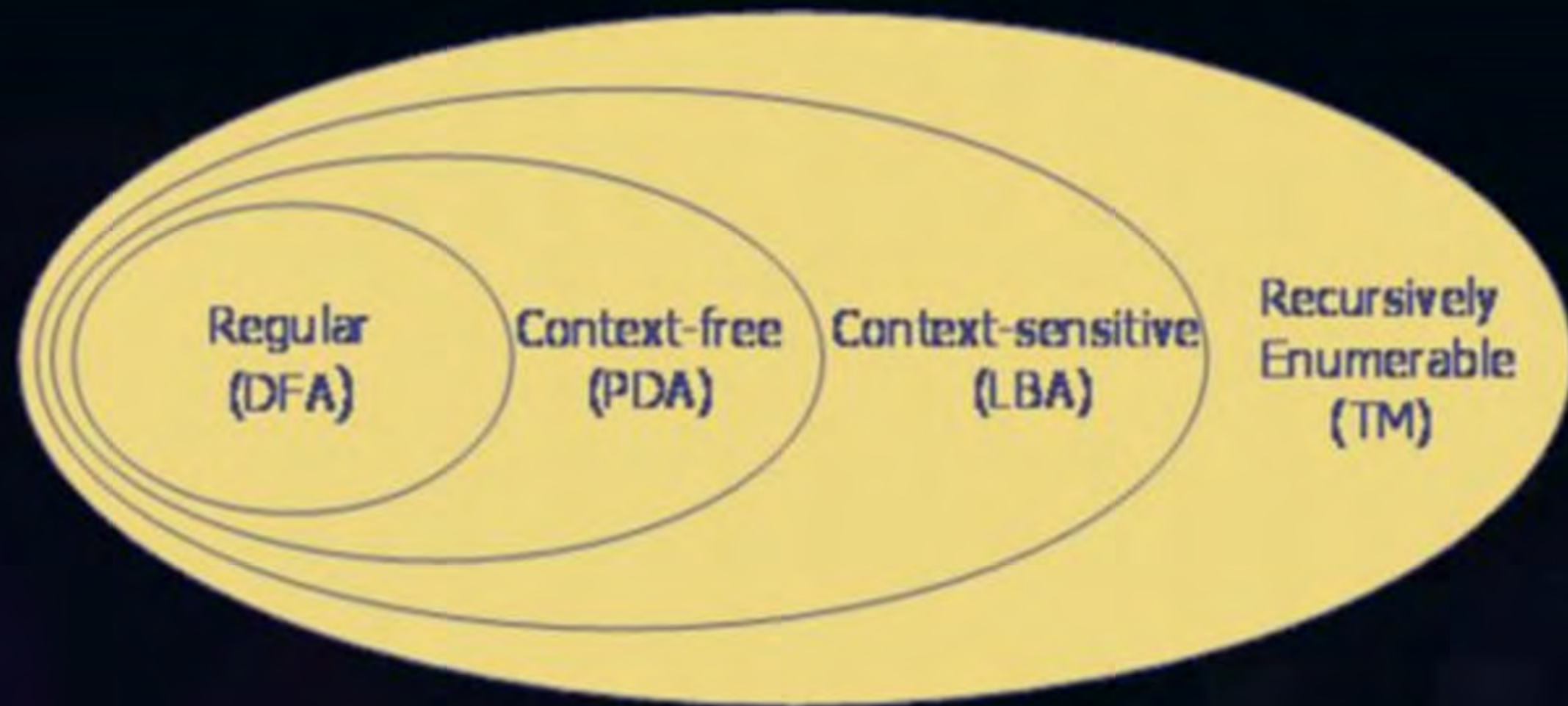
MICHAEL SIPSER

3

HOPCROFT & ULLMAN



Topic : Theory of Computation





Topic : Introduction:

It is the mathematical study of computing machines and their capability

or

It is the study of automata theory and formal languages.



Topic : Introduction:

Applications of Theory of Computation:

- Algorithm design and analysis ✓
- Compiler design ✓
- Cryptography and network security
- Artificial intelligence and machine learning
- Database systems and query optimization
- Software verification and model checking



Topic : Introduction:



Decidable Problem

Undecidable Problem



Topic : Terminologies:

Alphabet(Σ): Finite non-empty set of symbols

Ex:- $\{a, b\}$ –

$\{a, 1, 2\}$ –

$\{\}$ –

$\{\overline{a}, a\}$ ✓
 $\{a, \overline{a}, \perp\}$ ✓



Topic : Terminologies:

Alphabet(Σ): Finite non-empty set of symbols

Ex:- $\{a, b\}$ –

$\{a, 1, 2\}$ –

$\{\}$ –



Topic : String:

String: Finite sequence of symbols over the given alphabet Σ .

Ex:-



Topic : String:

Language :- Any set of strings over the given alphabet $\Sigma = \{a, b\}$.

$L_1 = \{ab, ba, abab\}$ -

$L_2 = \{a, ab, aba, \dots\}$ -

$L_3 = \{\}$ - \rightarrow Empty Language.

$L_4 = \{\epsilon\}$ - \rightarrow finite language.

$L_5 = \{a\}$ -

$L_6 = \{\epsilon, a, b, aa, ab, ba, bb, \dots\}$ \rightarrow infinite language
Complete language.



Topic : String:

Sub - String : Consecutive sequence of symbols over the given string.

Total no of substring for the given string = $n(n + 1)/2 + 1$

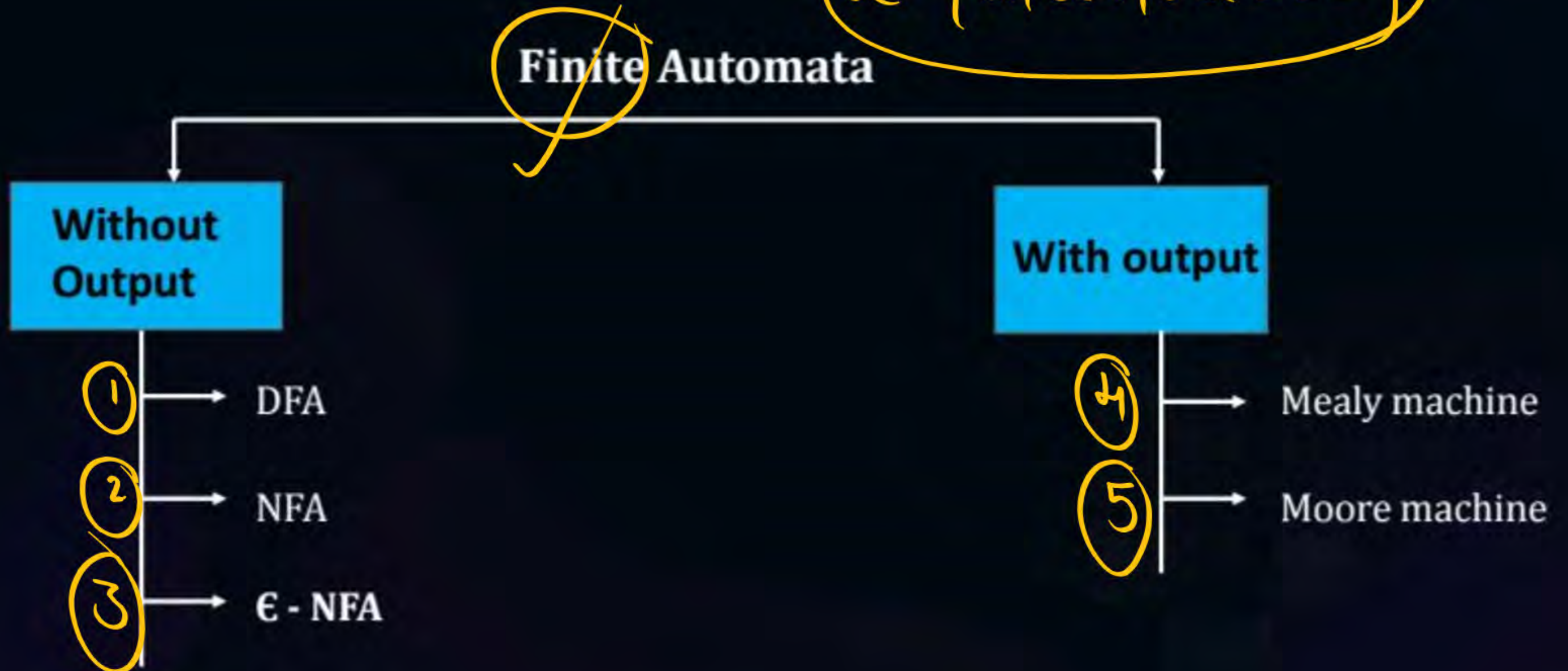
FINITE AUTOMATA



Topic : Finite Automata

It is a mathematical model which contains finite number of states and transitions.

$$L = \{a, aa, ba, \dots\}$$





Lexical Analysis:

String Matching

Network Protocol Analysis:

Digital Circuit Design:

Regular Expression Engines:

Natural Language Processing



Topic : Deterministic Finite Automata

DFA : It is a finite automata in which from every state on every input symbol exactly one transition should exits.



Topic : Deterministic Finite Automata

FORMAL DFA :

DFA is defined as

$$\text{DFA} = (Q, \Sigma, q_0, F, \delta)$$

Q : Finite set of states ✓

Σ : Input alphabet ✓

q_0 : Initial state

F : Set of final states

δ : Transition function $Q^* \Sigma \rightarrow Q$

{ any no. of
final states }

→ only one



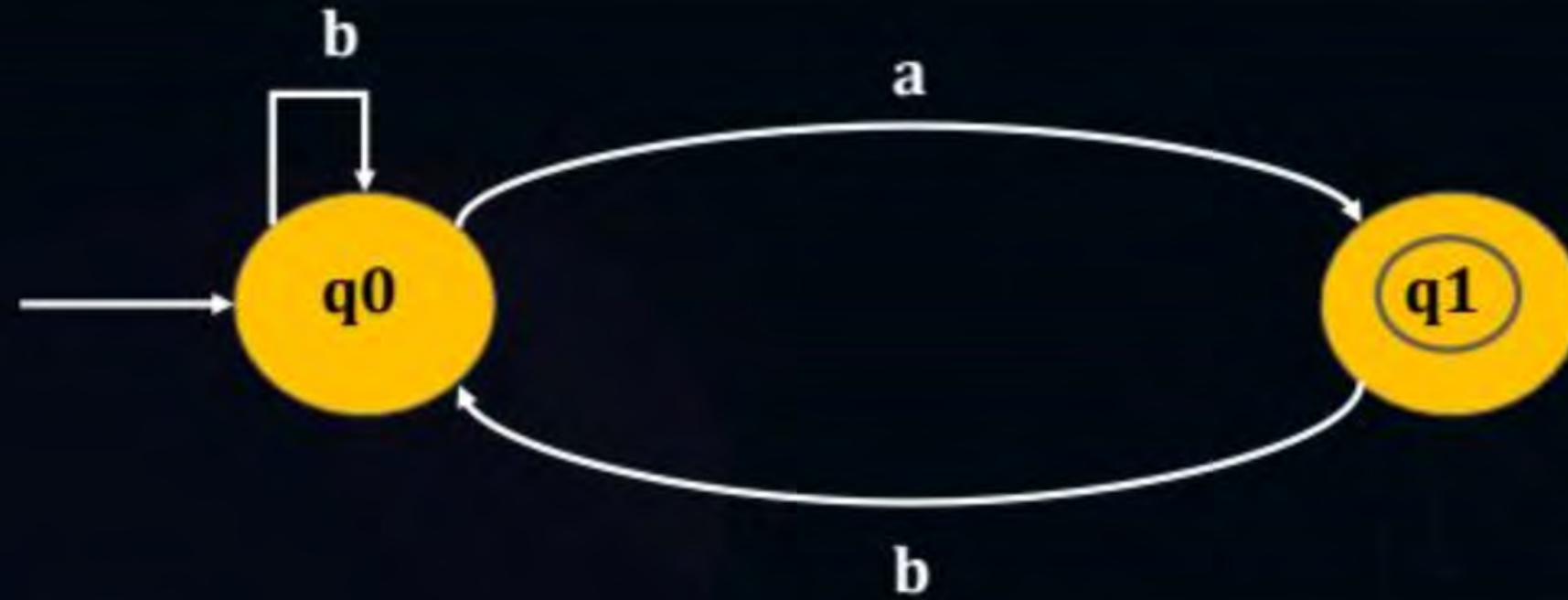
② Language \rightarrow DFA



Topic : Deterministic Finite Automata

Example of DFA :

(1)





Topic : Deterministic Finite Automata

Example of DFA :

(2)





Topic : Deterministic Finite Automata

Example of DFA :

(3)

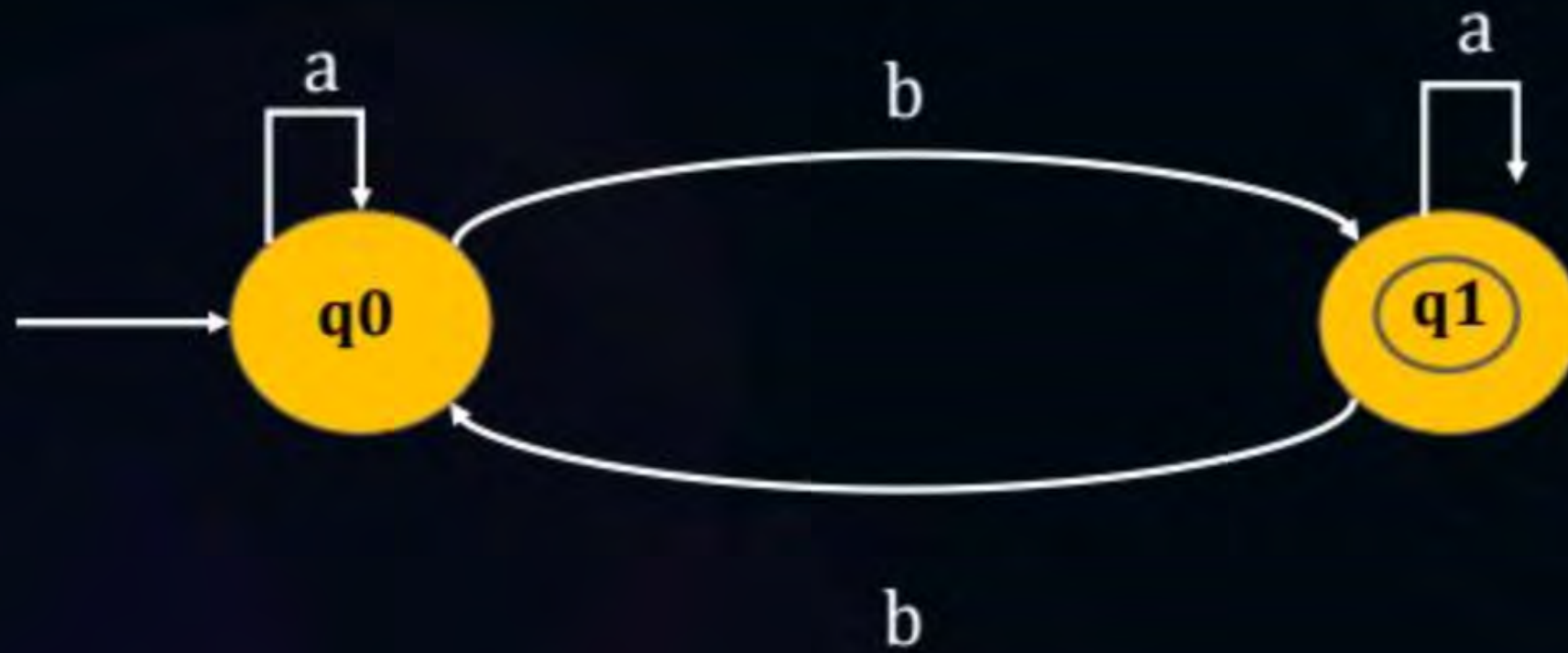




Topic : Deterministic Finite Automata

Example of DFA :

(4)

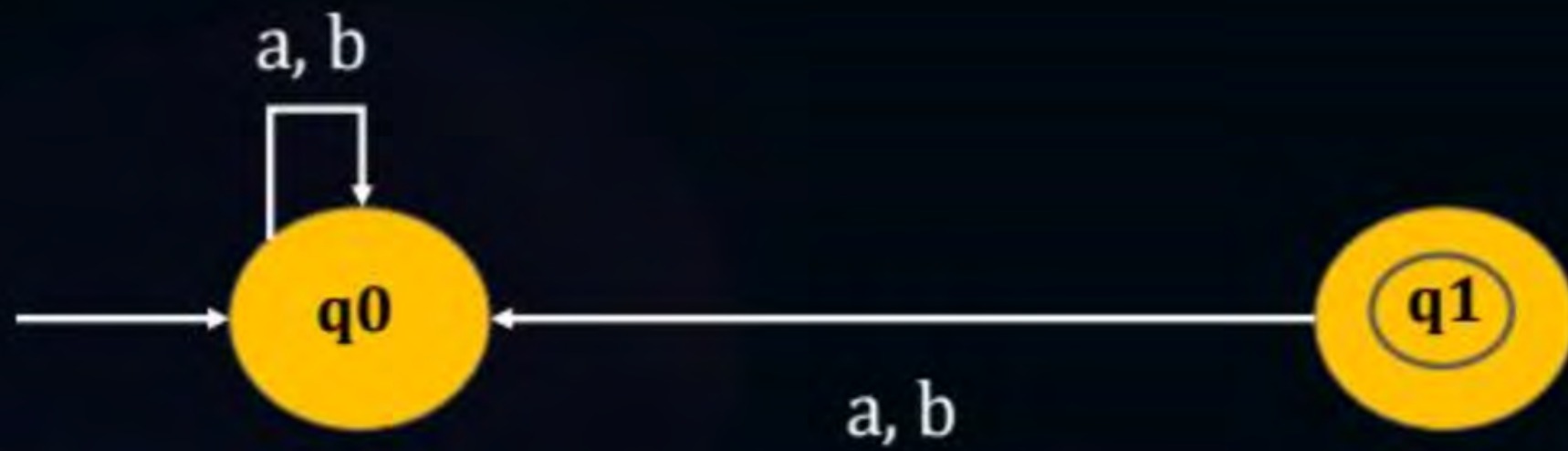


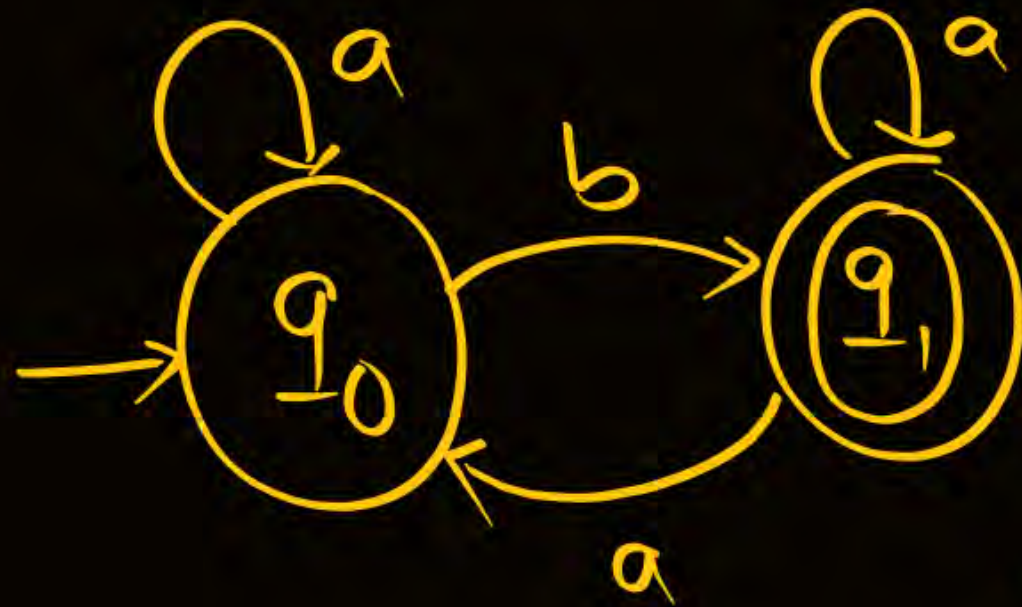


Topic : Deterministic Finite Automata

Example of DFA :

(5)





not a DFA

$$\delta(q_1, b) = q_0. \quad \times$$

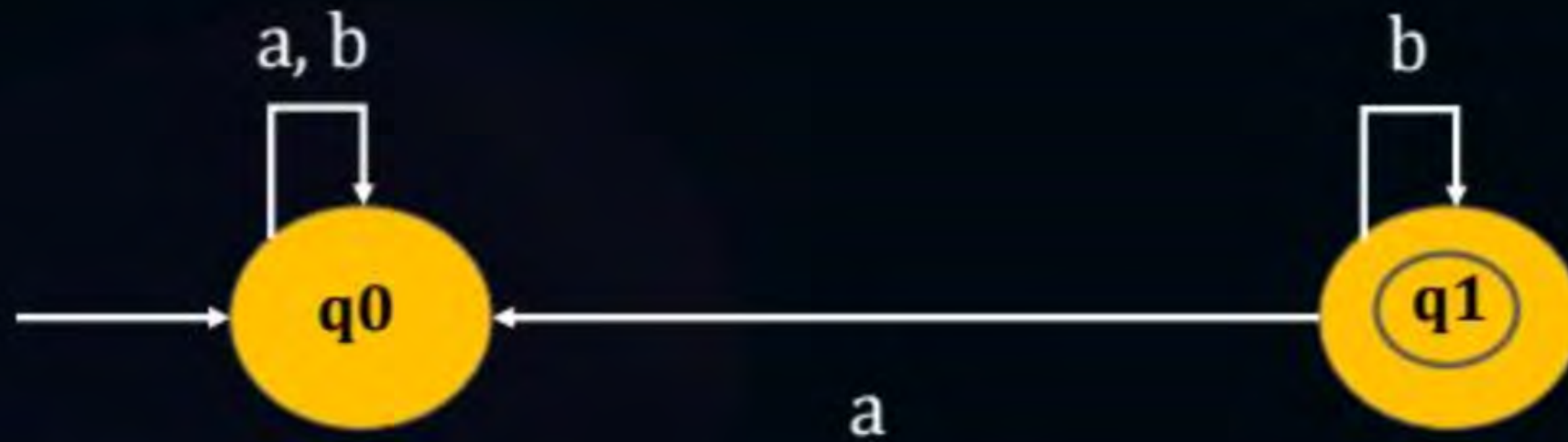
$$\delta(q_1, a) = \{q_0, q_1\} \quad \times$$



Topic : Deterministic Finite Automata

Example of DFA :

(6)

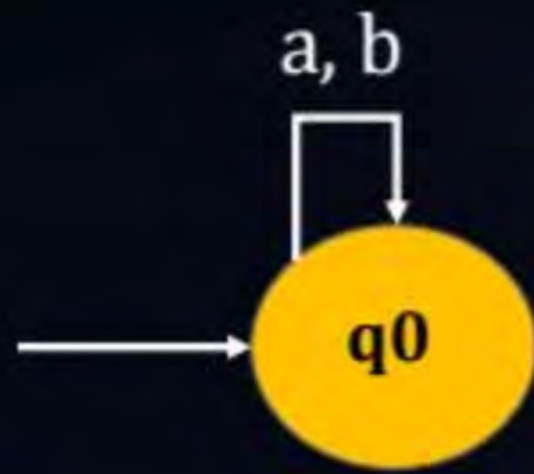




Topic : Deterministic Finite Automata

Example of DFA :

(7)

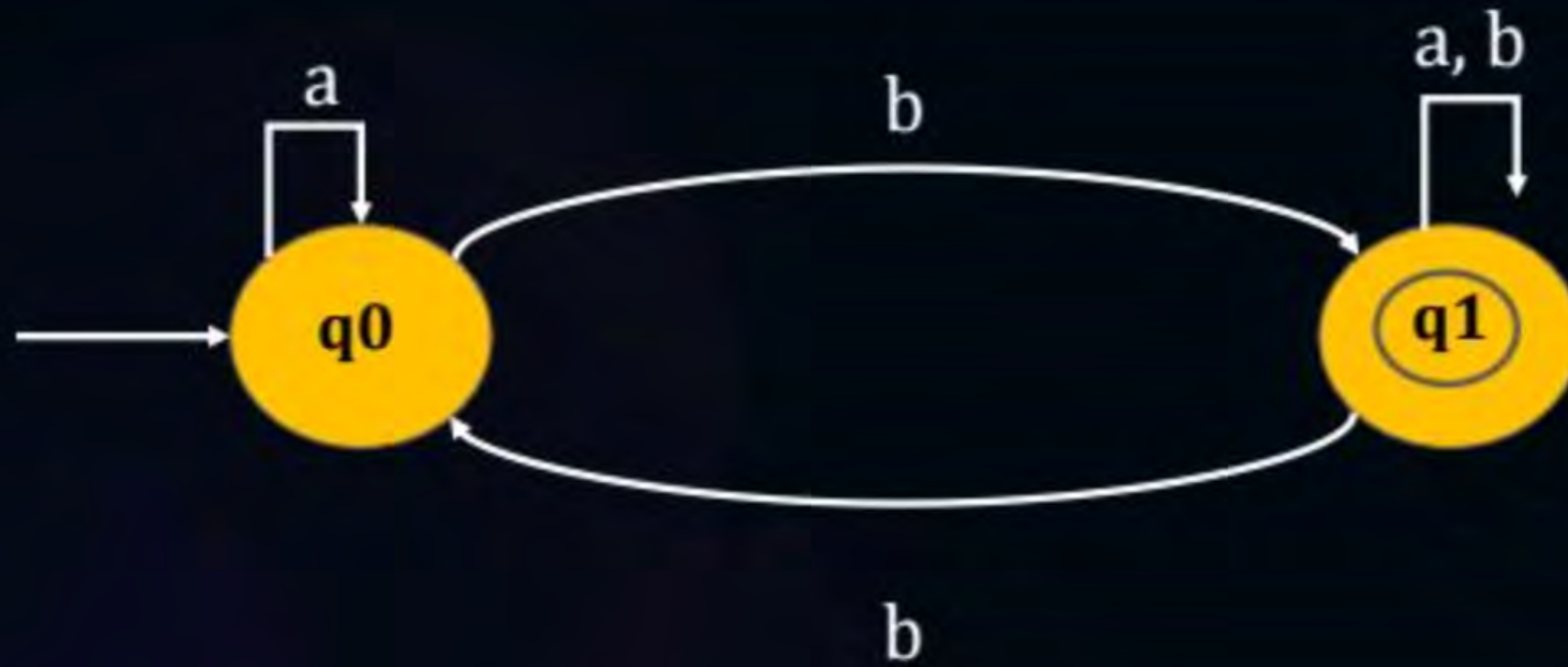




Topic : Deterministic Finite Automata

Example of DFA :

(8)

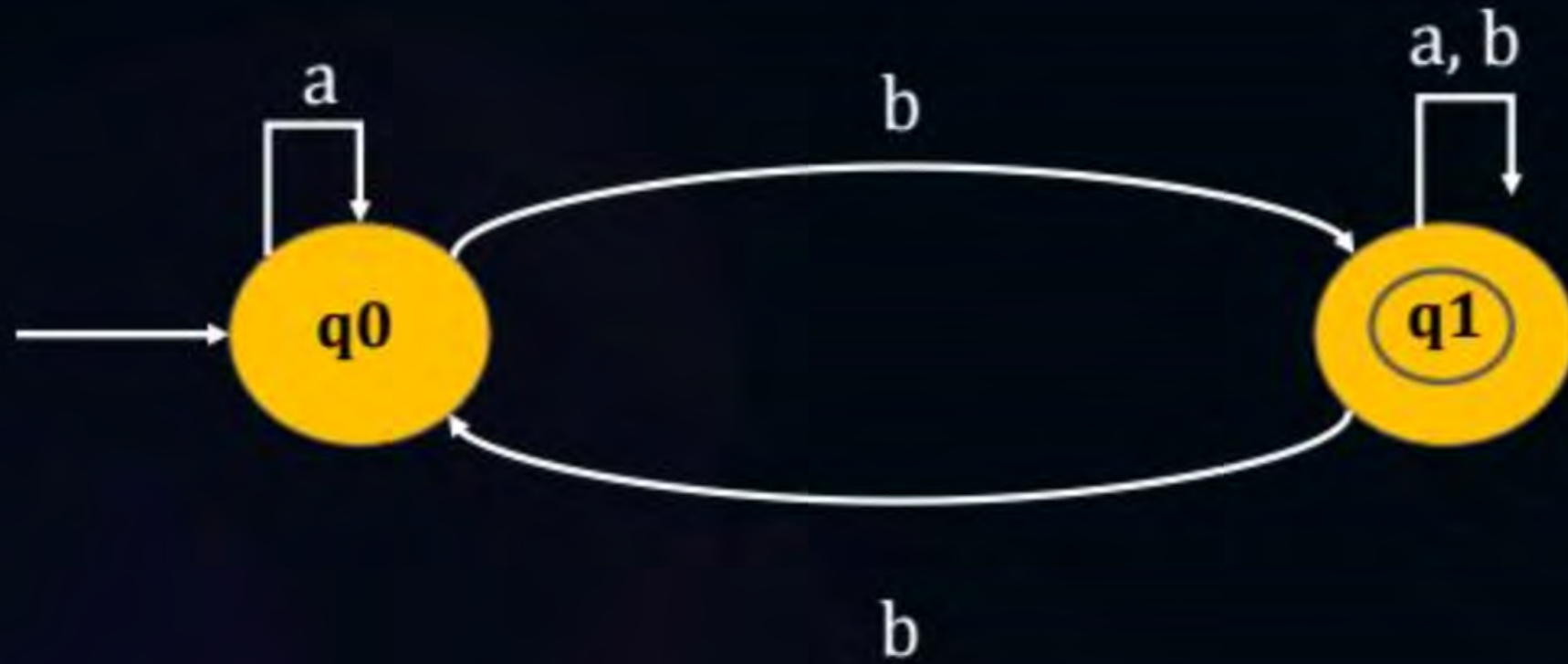




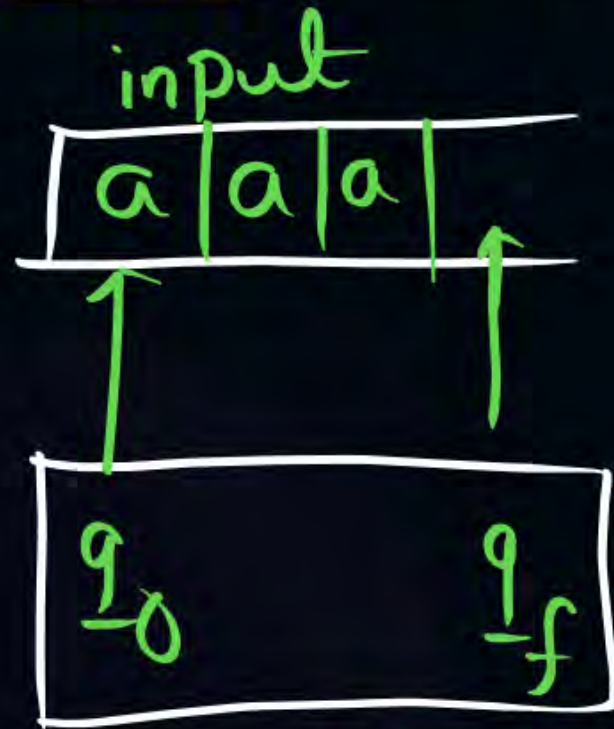
Topic : Deterministic Finite Automata

Example of DFA :

(8)



DFA acceptance method:



aba ✓

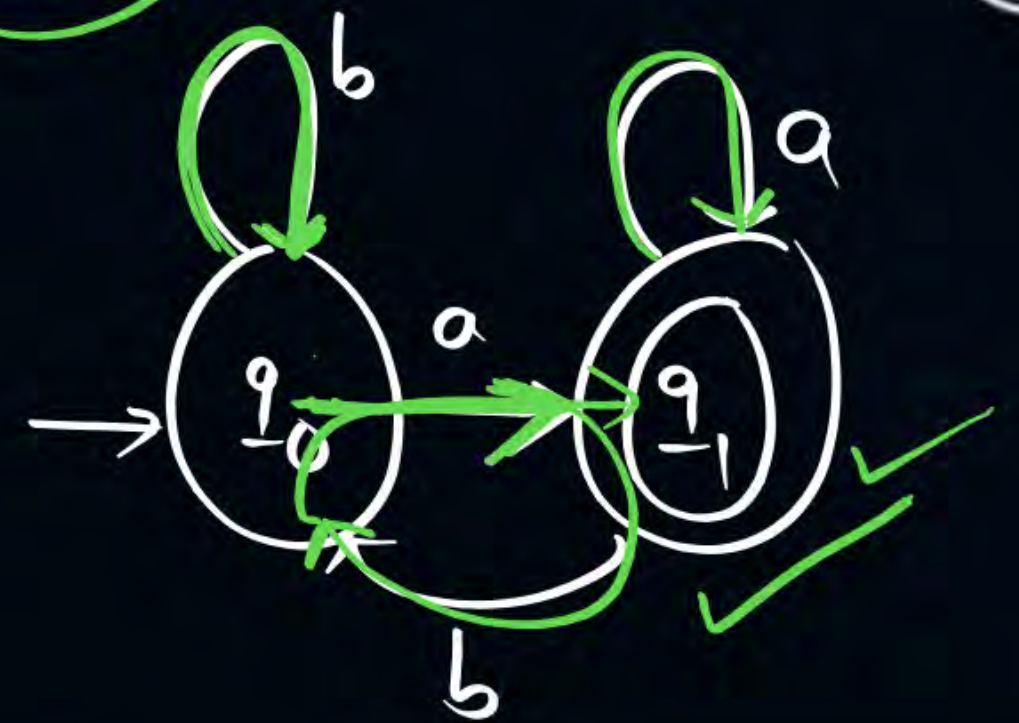
baaba ✓

aa
↑ ↑ ↑
q₀ q₁ (q₁)

ba ✓
↑

ab
↑ ↑ ↑
q₀ q₁ q₀ X

bab X

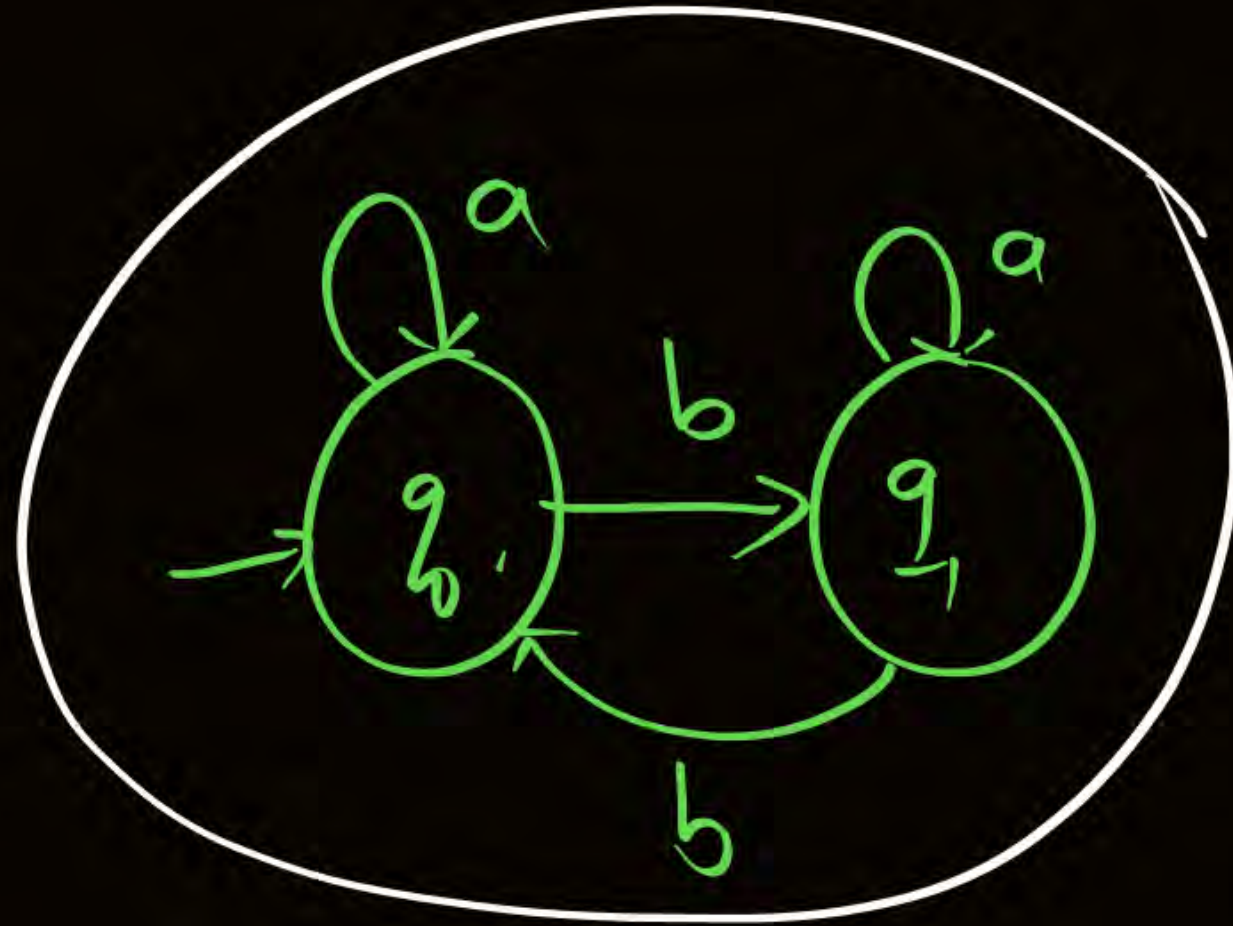


{ a, aa, ba, aba, --- }

all strings ends with a

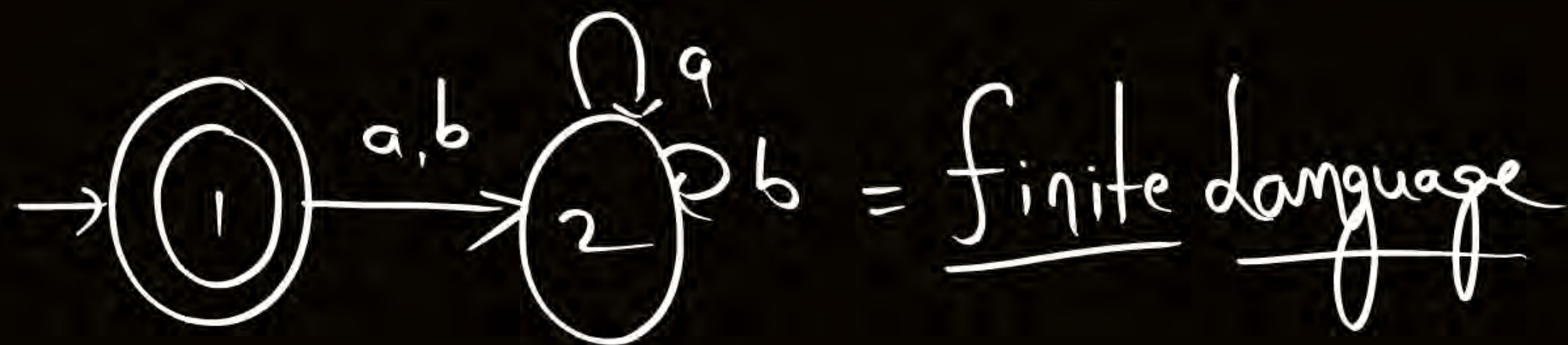
DFA acceptance method:

1. **Start at the Initial State:** Begin at the initial state of the DFA.
2. **Read Input Symbols:** For each symbol in the input string, read it one by one.
3. **Follow Transitions:** Based on the current state and the input symbol being read, follow the transition defined by the transition function of the DFA. This transition function specifies the next state of the automaton for each combination of current state and input symbol.
4. **Repeat Until End of Input:** Continue this process of reading input symbols and following transitions until you reach the end of the input string.
5. **Final State:** Once you have processed all input symbols, check the current state of the DFA. If it is one of the accepting states (states designated as final states), then the input string is accepted. Otherwise, it is rejected.
6. **Acceptance:** If the DFA halts in an accepting state after reading the entire input string, then the Input is accepted.



DFA ✓

$L = \{ \} \rightarrow \text{Empty Lang}$



$$L = \{\epsilon\}$$

#Q. Identify language accepted by given DFA

ababa
bab

elimination



Set of all strings

A ~~Starting with bb~~ → aaabb ✓

B ~~Ending with bb~~

C ~~Contains at least 2 b's~~ → ✗

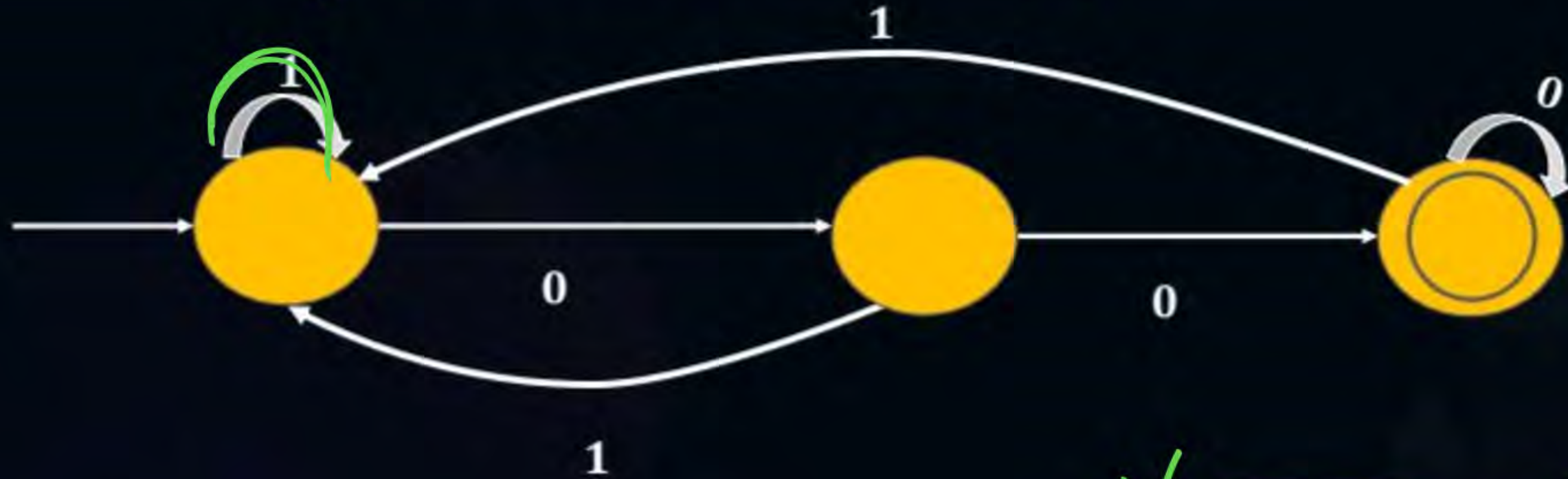
D None

bbaaa ✓

Set of all strings

#Q. Identify the language accepted by following DFA

ending with 0 = $\{0, 10, \dots\}$ ✓



~~001~~ ✓

100 ✓

1001 ✓

1010 ✗

~~A~~ Starting with 00 → 1100 ✓

~~B~~ Substring 00 → {0} ✓

~~C~~ Ending with 0 = $\{0, 00, 10, \dots\}$ ✓

~~D~~ None ✓

#Q. Identify language accepted by following DFA



$$\{a^n b^m \mid n \geq 1, m \geq 0\} = \{a \dots\}$$

b

A

$$L = \{a^n b^m \mid n, m \geq 1\} = \{ab \dots\}$$

B

$$L = \{a^n b^m \mid n \geq 1, m \geq 0\} = \{a, a^2, ab \dots\}$$

C

$$L = \{a^n b^m \mid n, m \geq 0\} = \{e \dots\}$$

D

None

#Q. Identify language accepted by following DFA



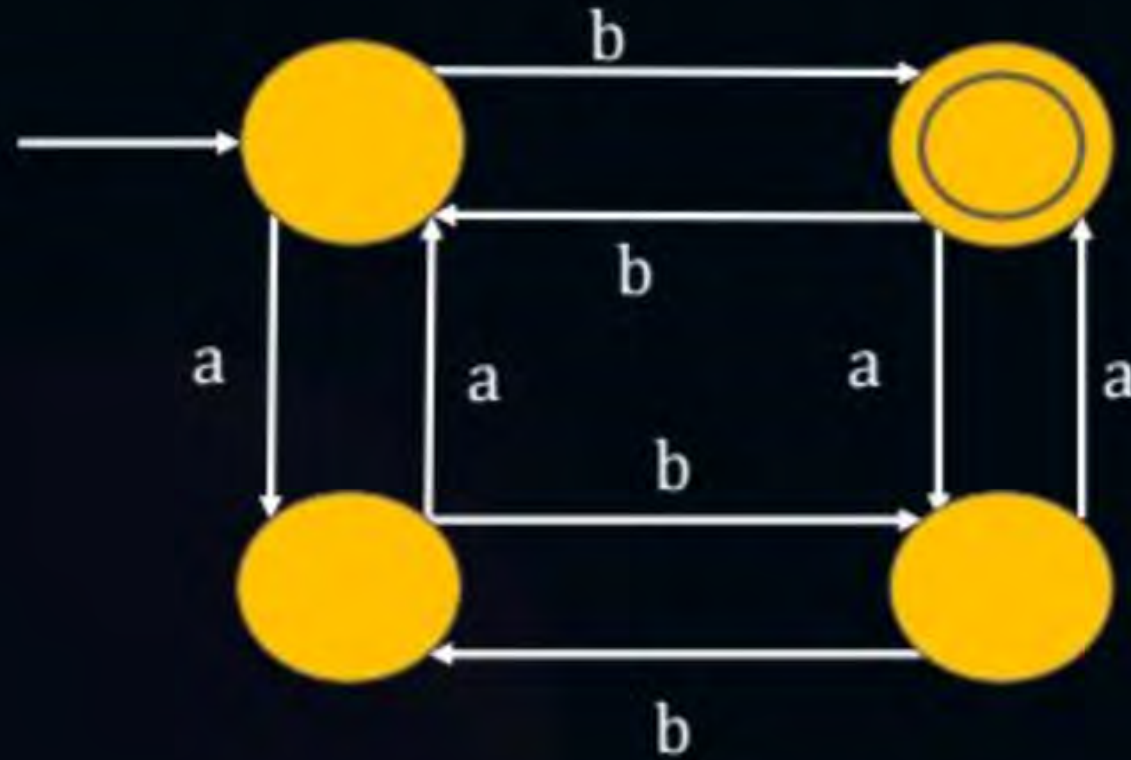
A $L = \{a^n b^m \mid n, m \geq 1\}$

B $L = \{a^n b^m \mid n \geq 1, m \geq 0\}$

C $L = \{a^n b^m \mid n, m \geq 0\}$

D None

#Q. Identify language accepted by following DFA



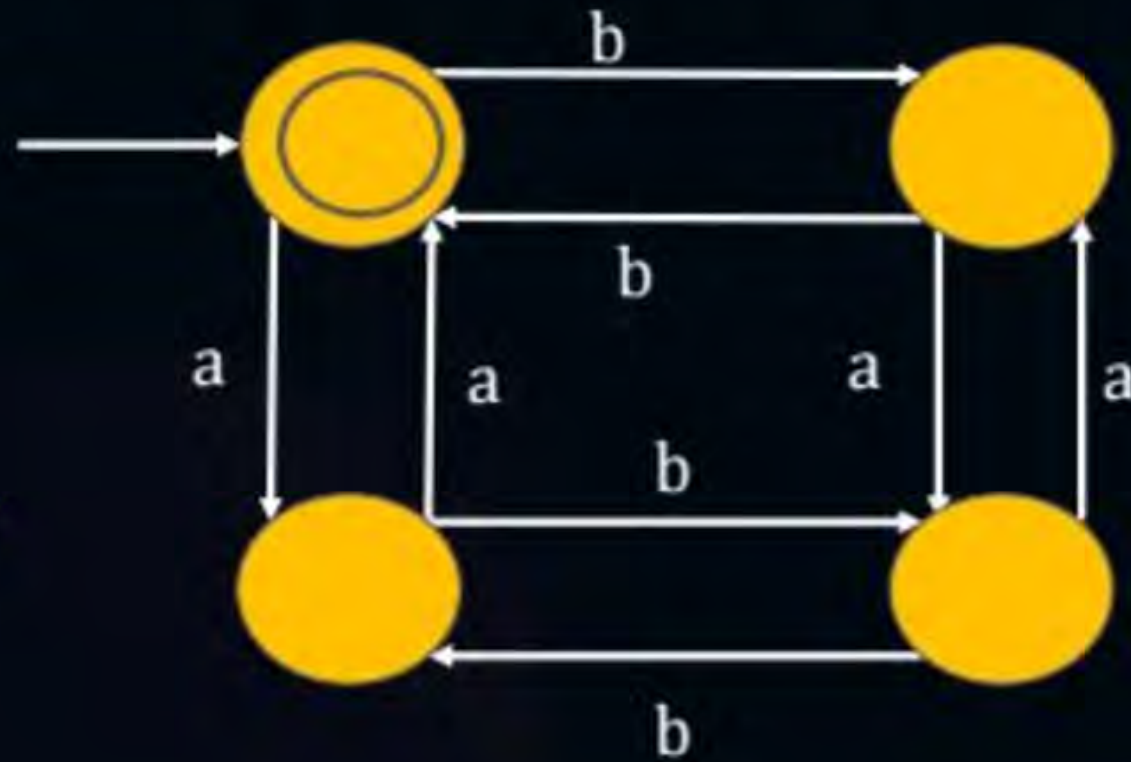
A # a's even and # b's even

B # a's odd and # b's even

C # a's odd and # b's odd

D # a's even and # b's odd

#Q. Identify language accepted by following DFA



$= \{\epsilon, \dots\}$

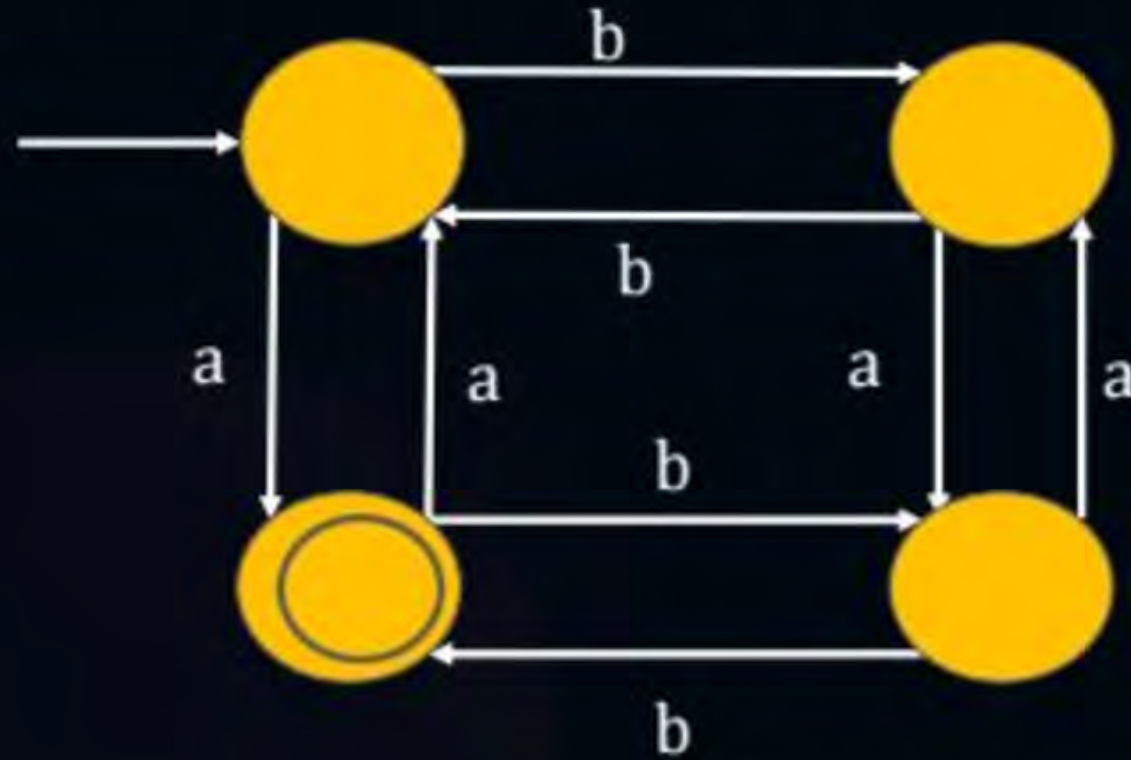
A # a's even and # b's even = $\{\epsilon, \dots\}$

B # a's odd and # b's even

C # a's odd and # b's odd $\{ab, ba, \dots\}$

D # a's even and # b's odd = $\{b, \dots\}$

#Q. Identify language accepted by following DFA



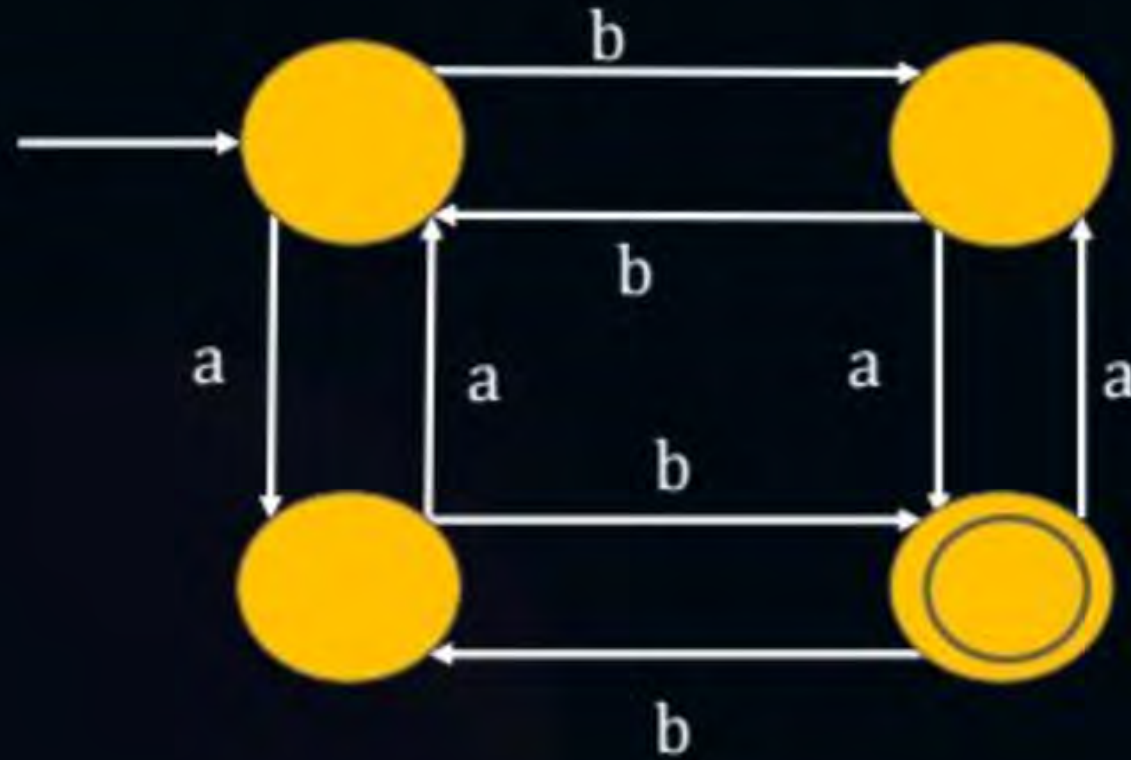
A # a's even and # b's even

B # a's odd and # b's even

C # a's odd and # b's odd

D # a's even and # b's odd

#Q. Identify language accepted by following DFA



A # a's even and # b's even

B # a's odd and # b's even

C # a's odd and # b's odd




D # a's even and # b's odd


not
DFA?



not
DFA?

- not
DFA?







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THANK - YOU