

**23MT2014**

## **THEORY OF COMPUTATION**

Topic:

# **More Problems on PDA**

**Session – 14-a**

# 4:

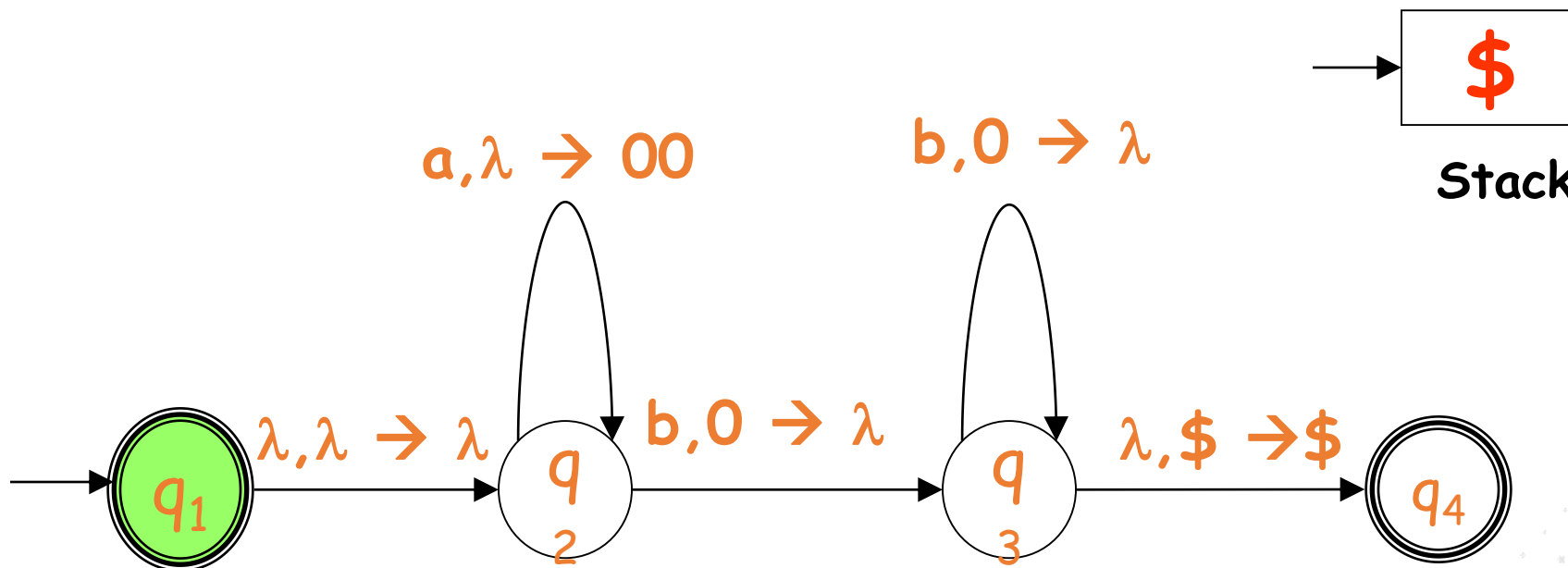
Design a NPDA to accept the following Language:

$$L(M) = \{ a^n b^{2n}, n \geq 0 \}$$



$a, \lambda \rightarrow 00$

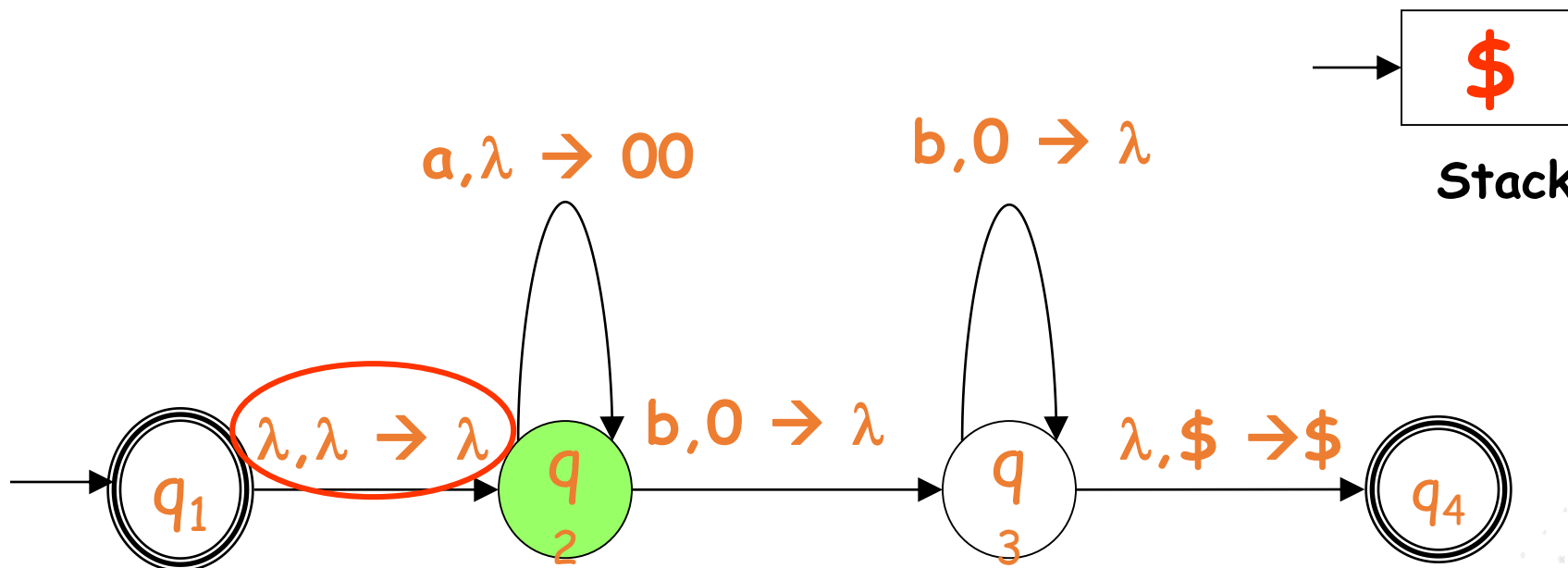
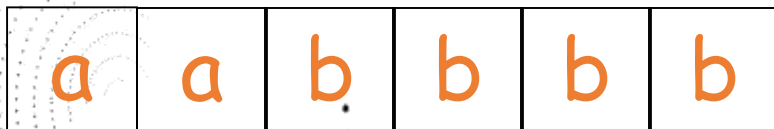
$b, 0 \rightarrow \lambda$

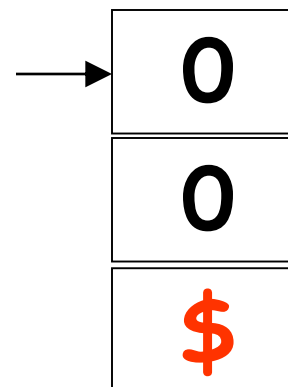
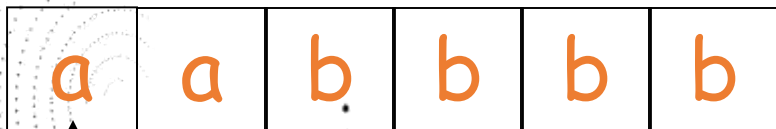




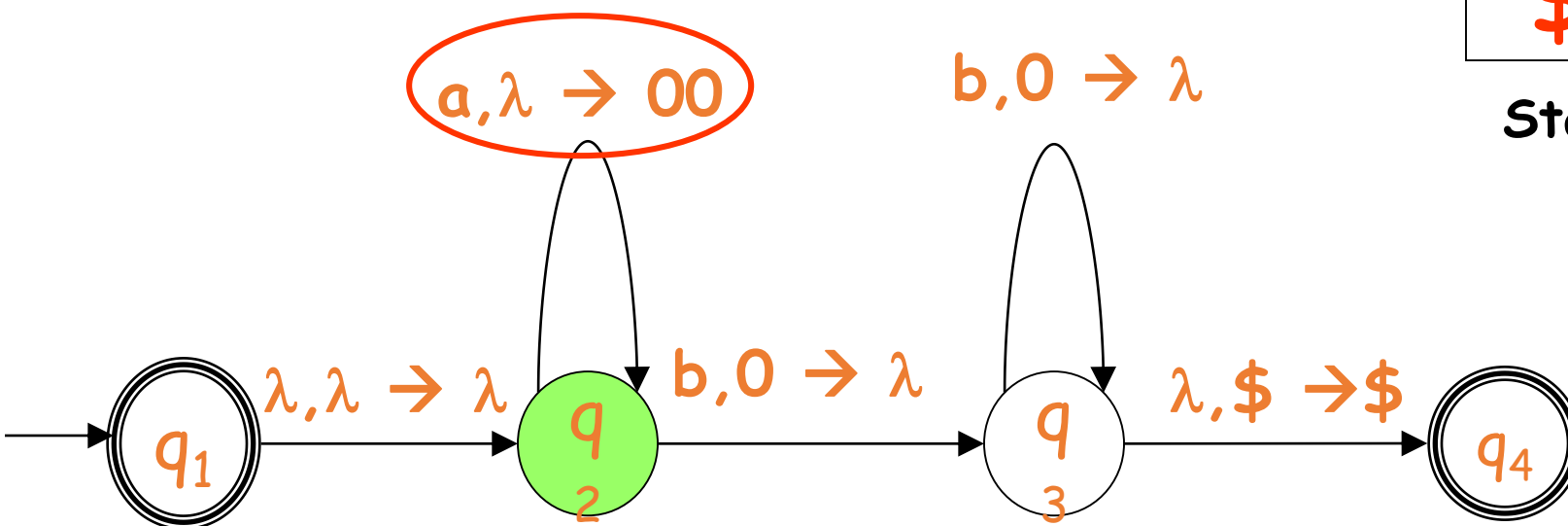
Input String

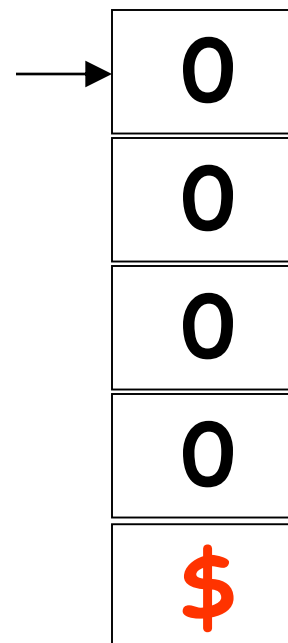
Time - 1



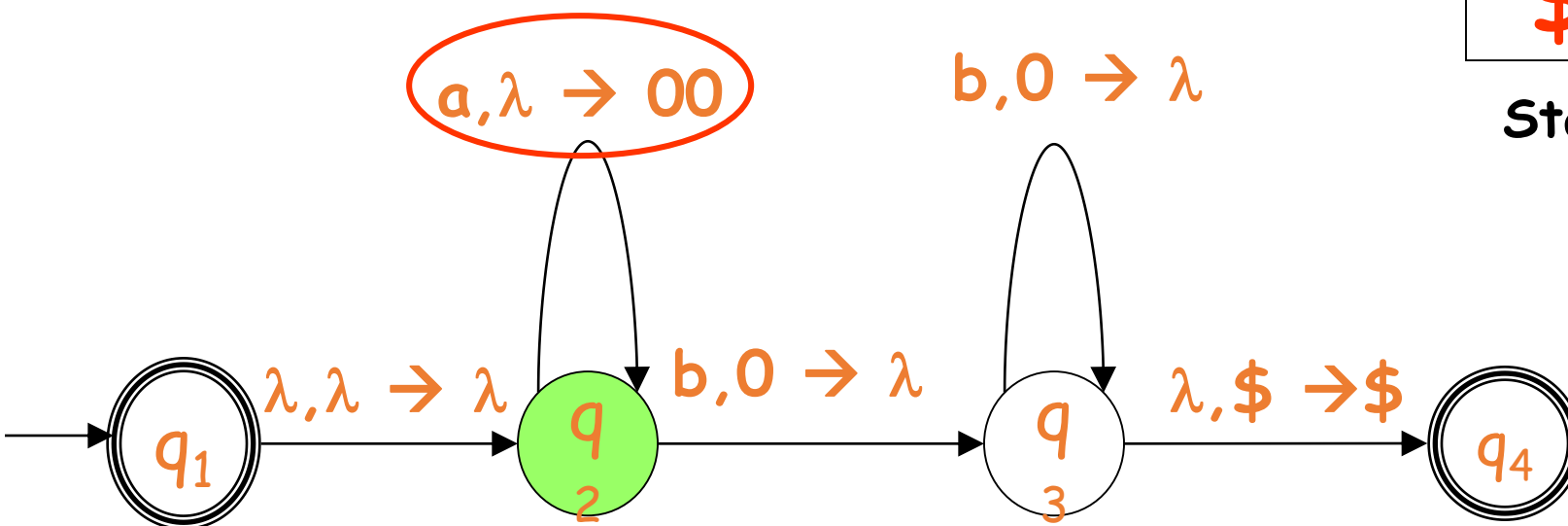


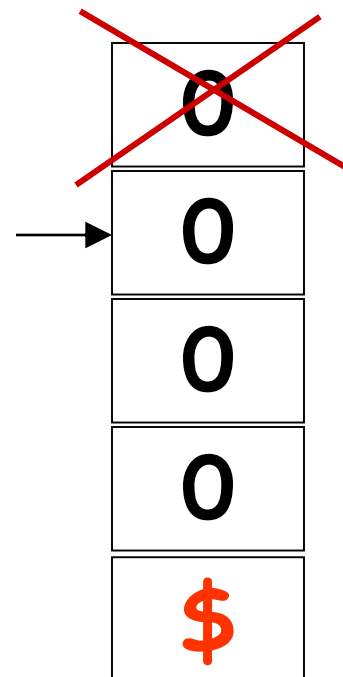
Stack





Stack

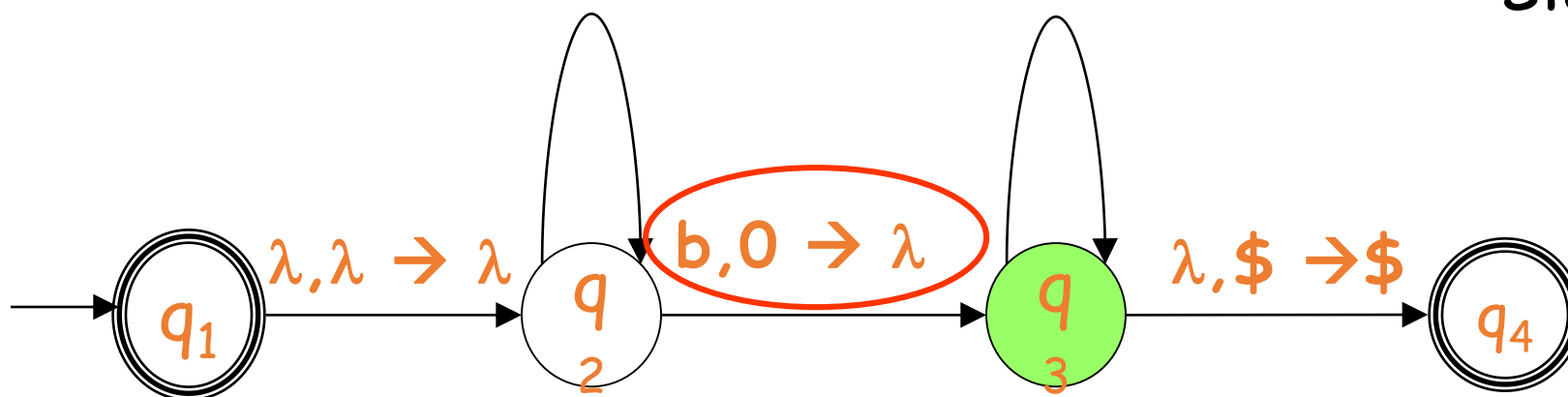


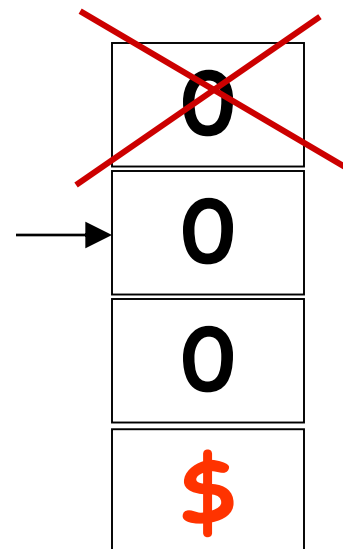


Stack

$a, \lambda \rightarrow 00$

$b, 0 \rightarrow \lambda$

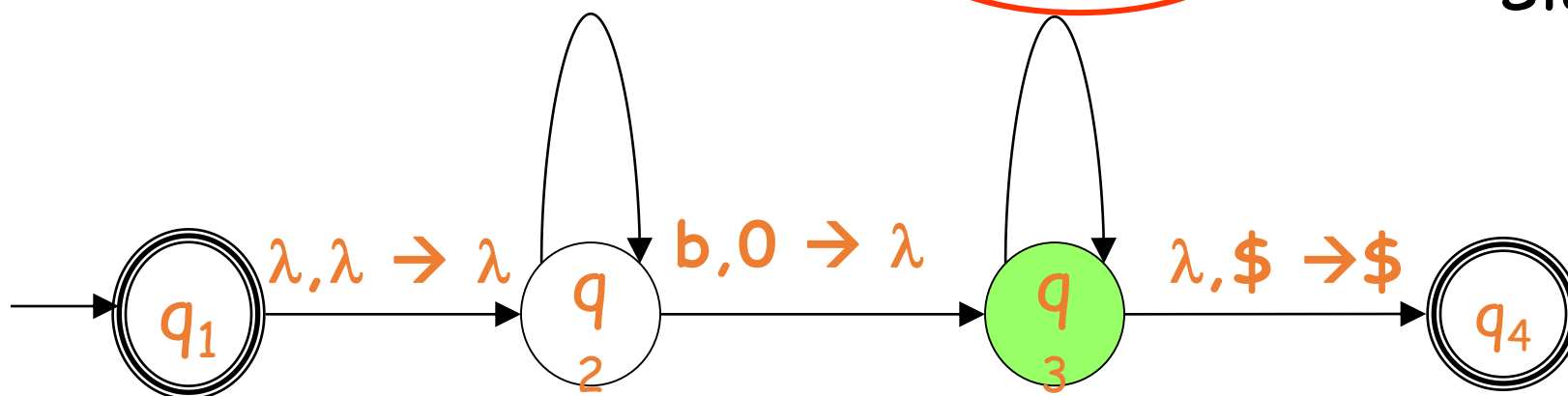




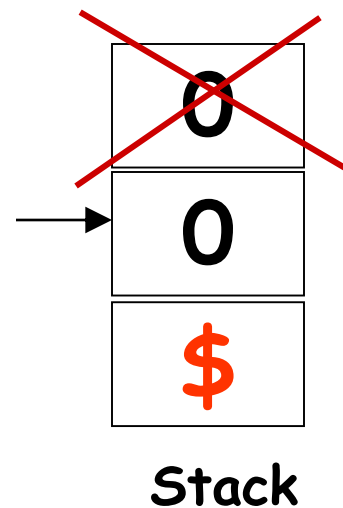
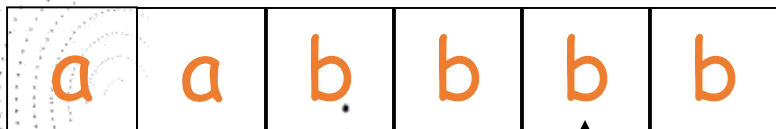
Stack

$a, \lambda \rightarrow 00$

$b, 0 \rightarrow \lambda$

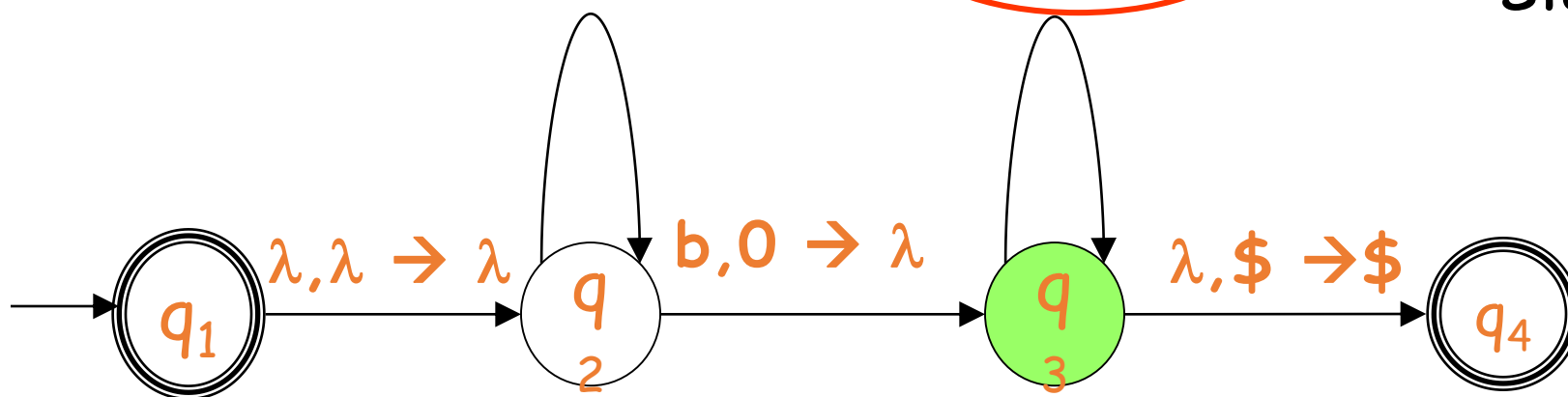


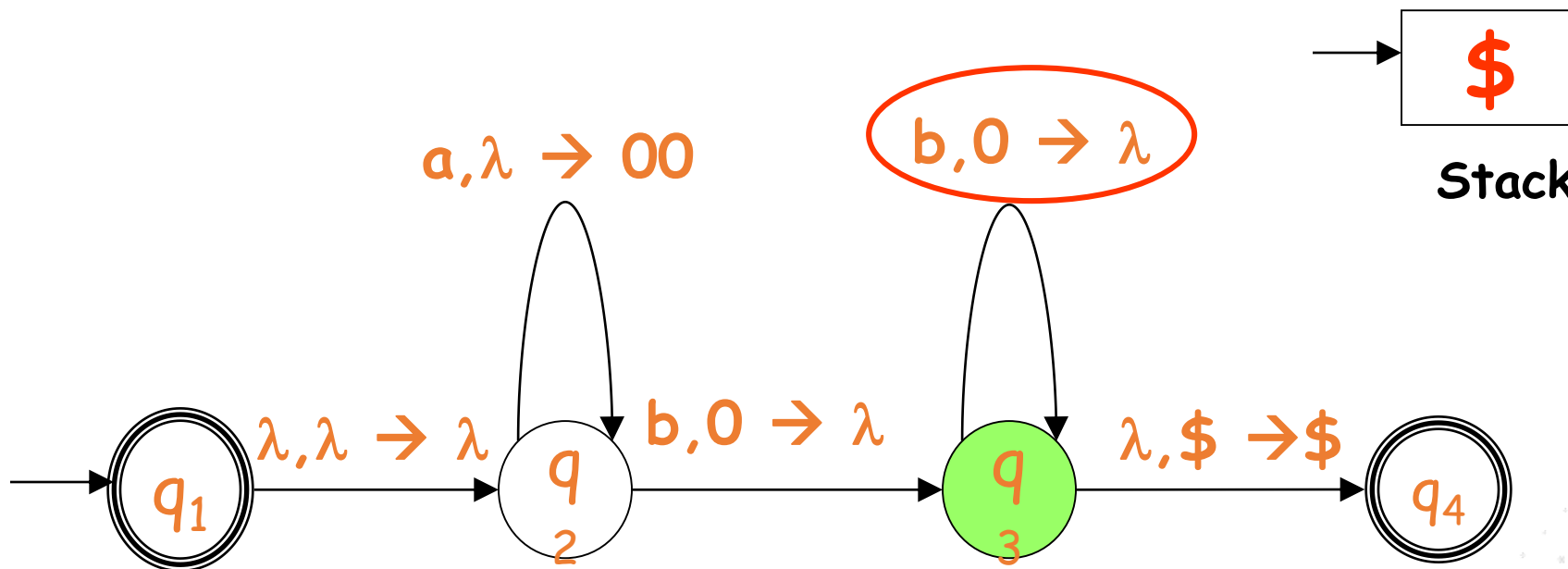
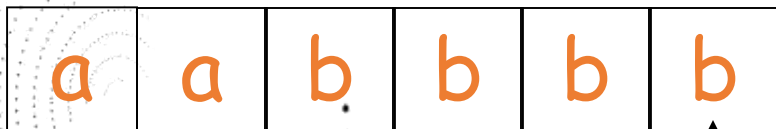


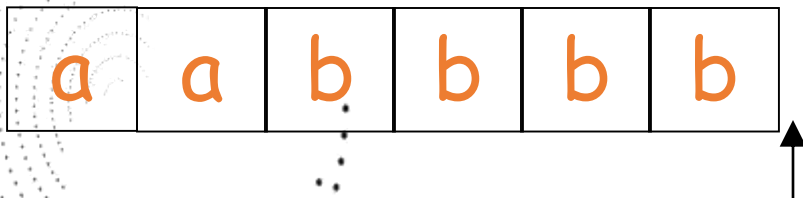


$a, \lambda \rightarrow 00$

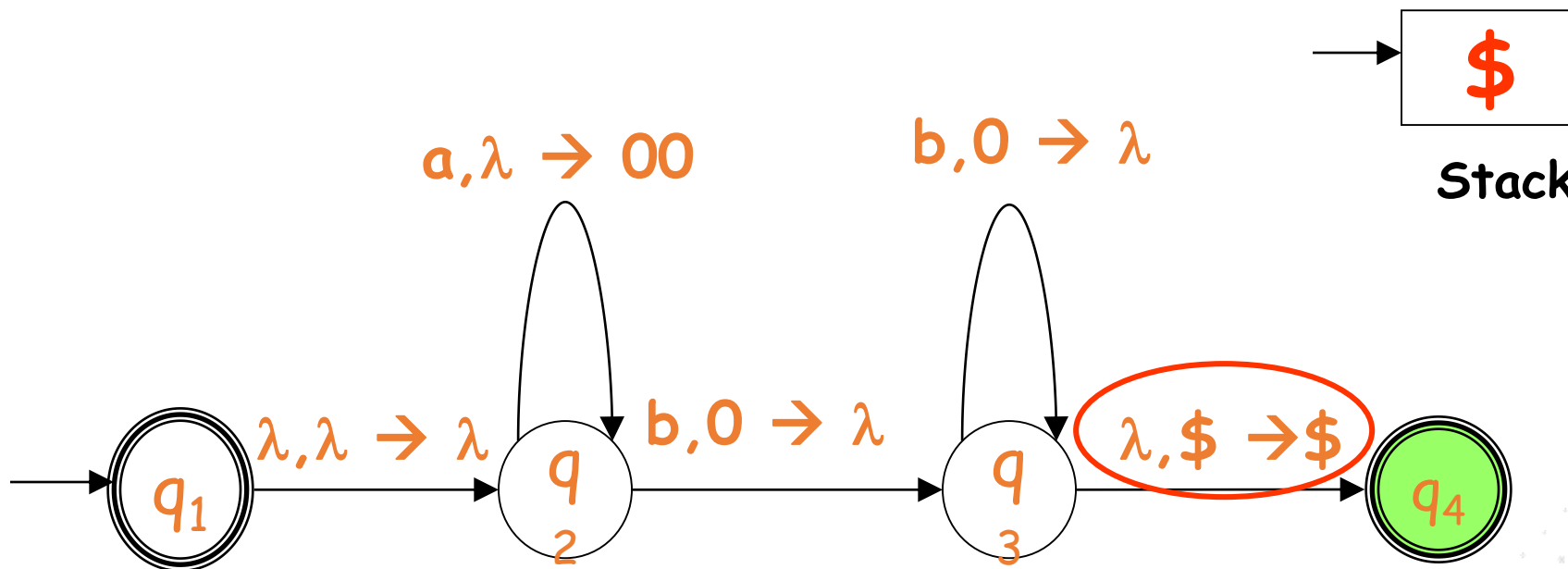
$b, 0 \rightarrow \lambda$







"Accept"

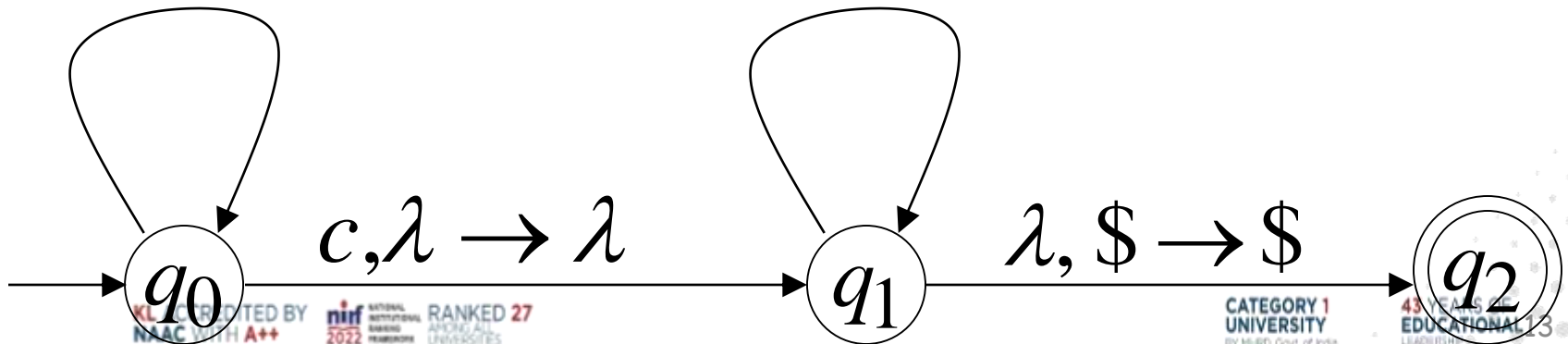


# 5:

Design a NPDA to accept the following Language:

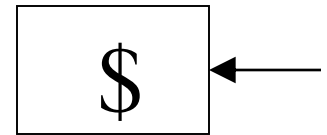
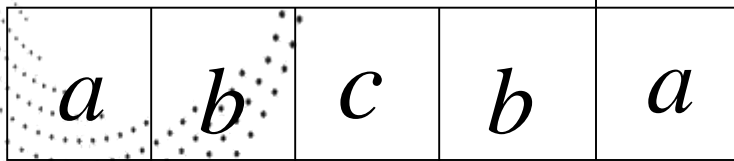
$$L(M) = \{ wcw^R, w \in \{a,b\}^* \}$$

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$$a, \lambda \rightarrow a$$
$$a, a \rightarrow \lambda$$
$$b, \lambda \rightarrow b$$
$$b, b \rightarrow \lambda$$


# Execution Example: Time 0

Input



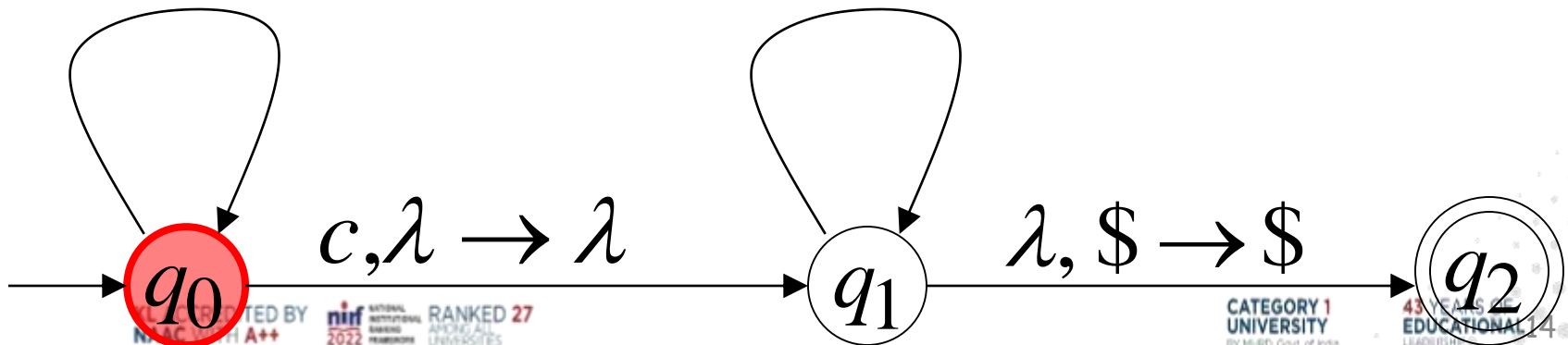
Stack

$a, \lambda \rightarrow a$

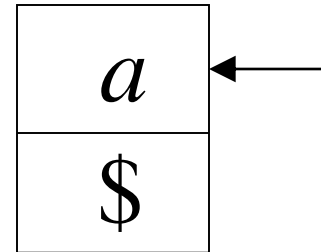
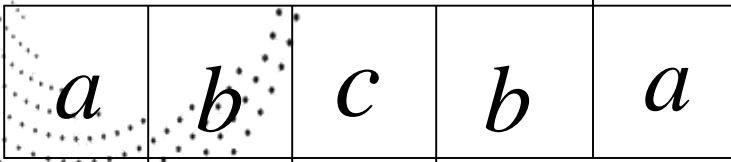
$a, a \rightarrow \lambda$

$b, \lambda \rightarrow b$

$b, b \rightarrow \lambda$



Input



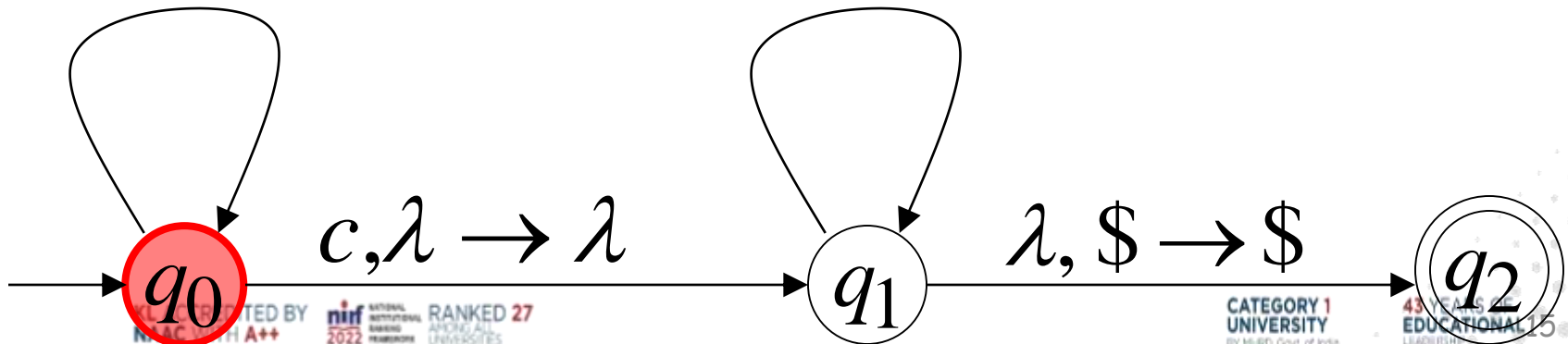
Stack

$a, \lambda \rightarrow a$

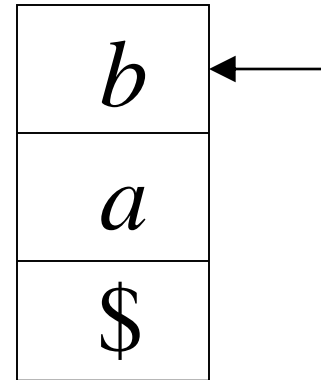
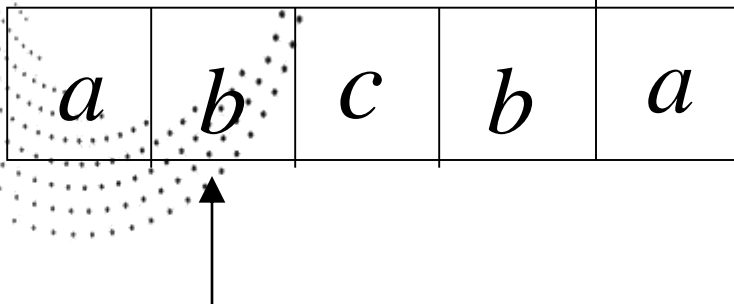
$b, \lambda \rightarrow b$

$a, a \rightarrow \lambda$

$b, b \rightarrow \lambda$



Input



Stack

$a, \lambda \rightarrow a$

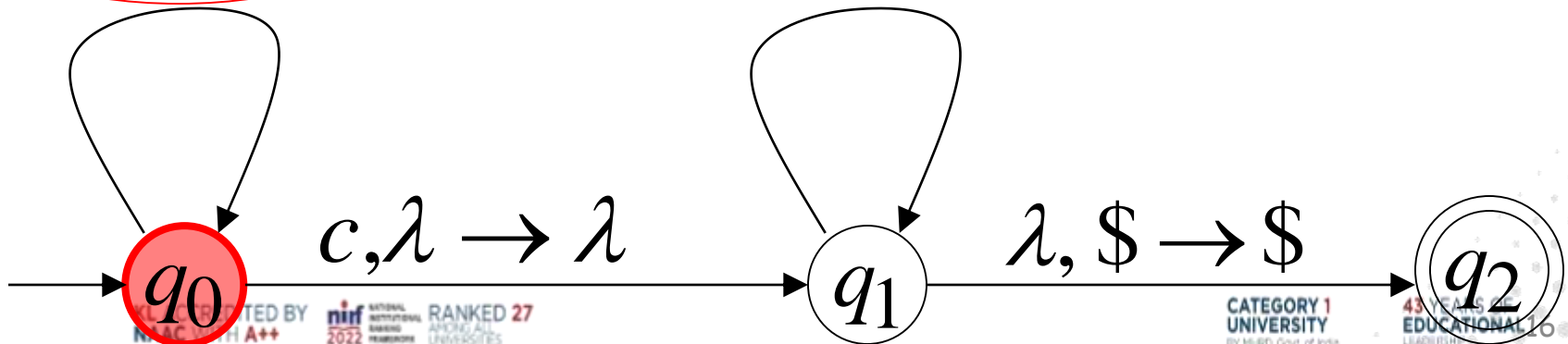
$a, a \rightarrow \lambda$

$b, \lambda \rightarrow b$

$b, b \rightarrow \lambda$

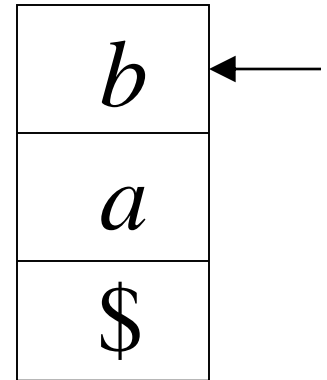
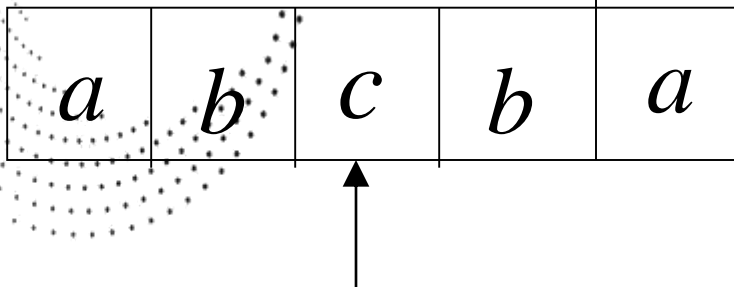
$c, \lambda \rightarrow \lambda$

$\lambda, \$ \rightarrow \$$





Input



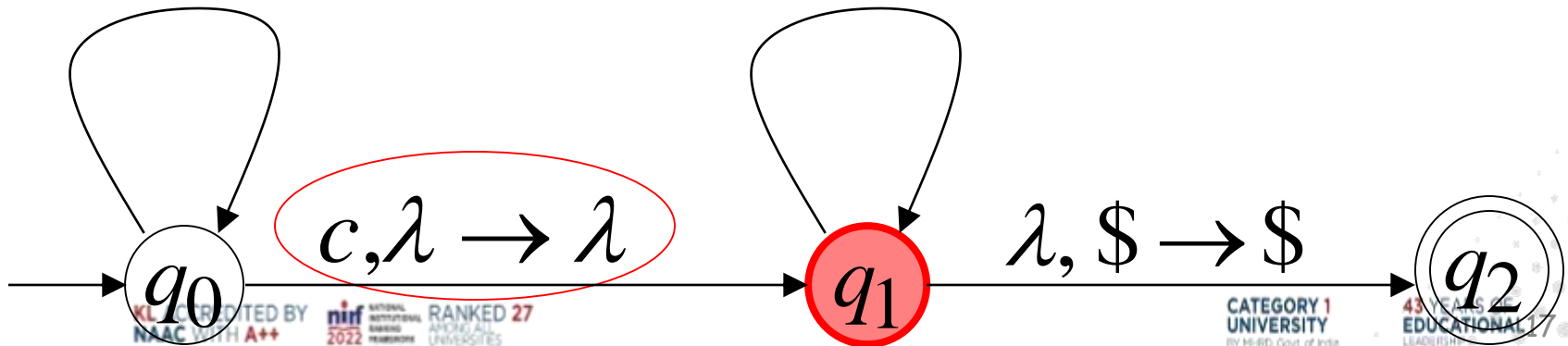
Stack

$a, \lambda \rightarrow a$

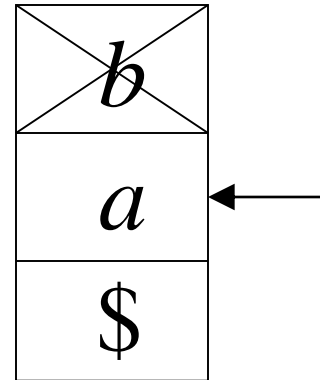
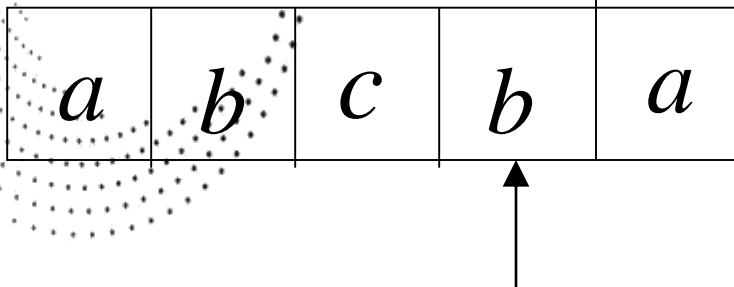
$a, a \rightarrow \lambda$

$b, \lambda \rightarrow b$

$b, b \rightarrow \lambda$



Input



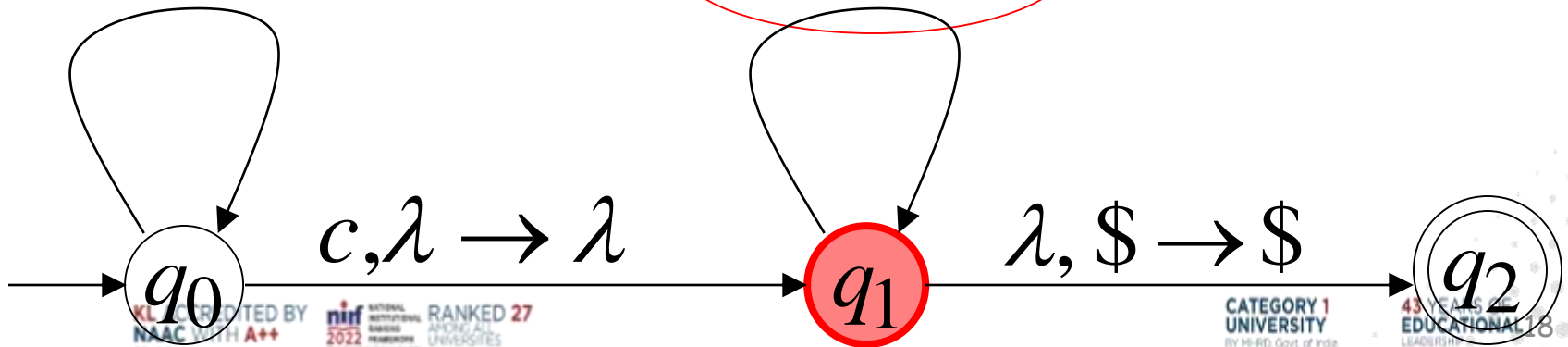
Stack

$a, \lambda \rightarrow a$

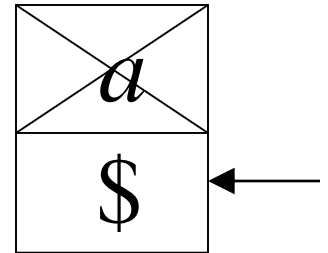
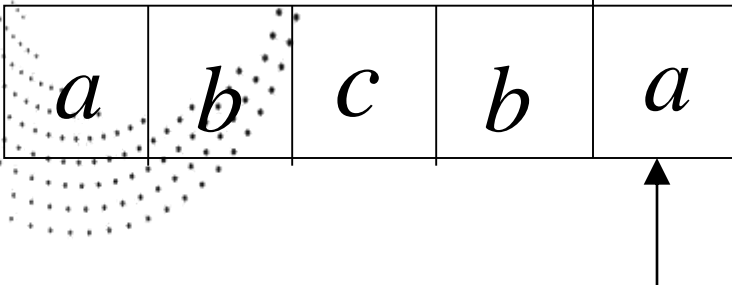
$b, \lambda \rightarrow b$

$a, a \rightarrow \lambda$

$b, b \rightarrow \lambda$



Input



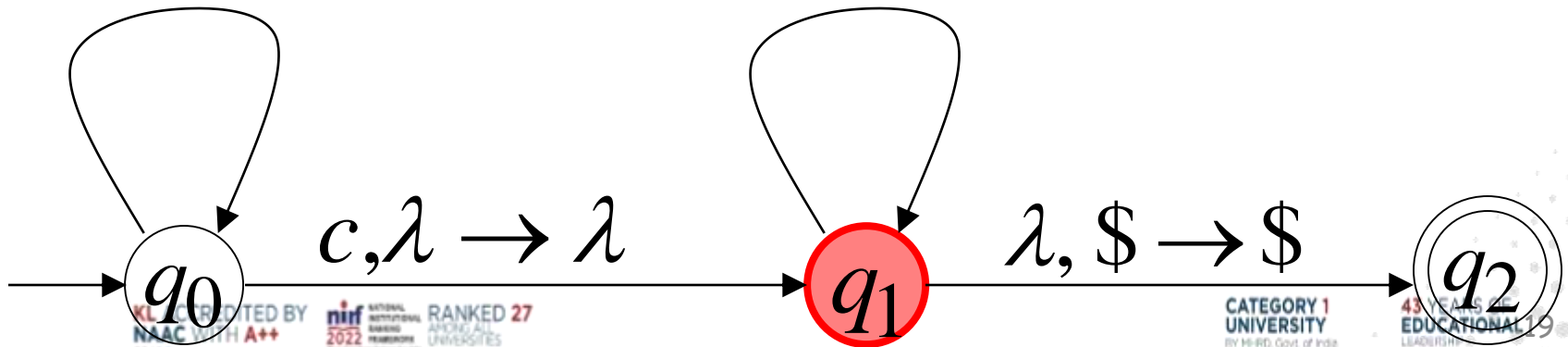
Stack

$a, \lambda \rightarrow a$

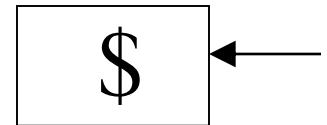
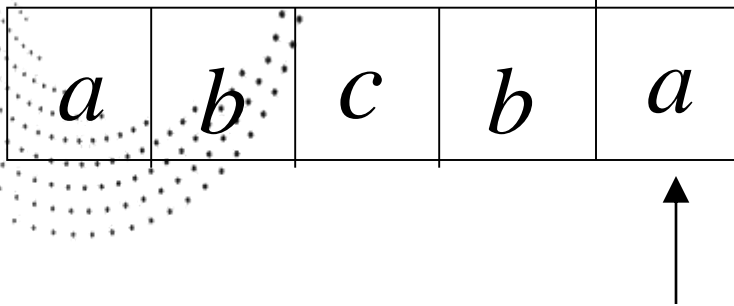
$b, \lambda \rightarrow b$

$a, a \rightarrow \lambda$

$b, b \rightarrow \lambda$



Input



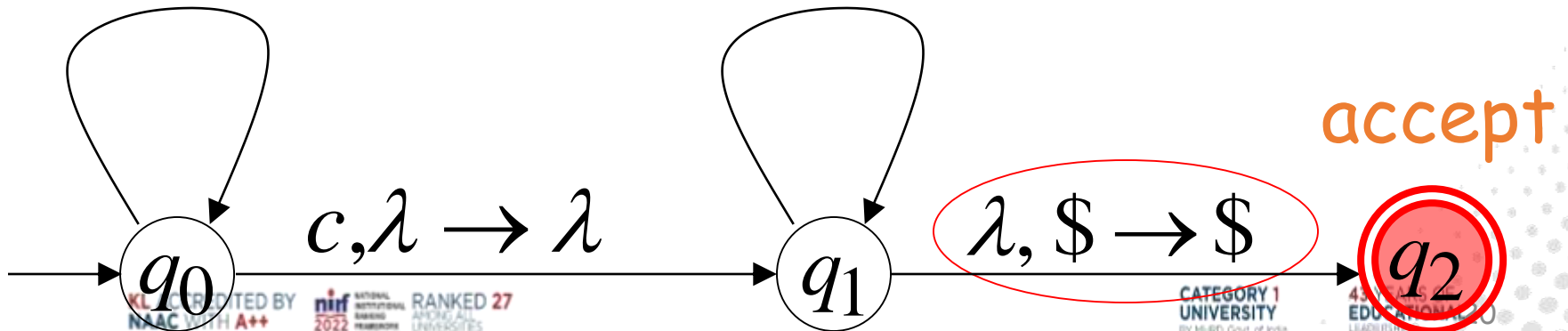
Stack

$a, \lambda \rightarrow a$

$a, a \rightarrow \lambda$

$b, \lambda \rightarrow b$

$b, b \rightarrow \lambda$



accept

# 6:

Design a NPDA to accept the following Language:

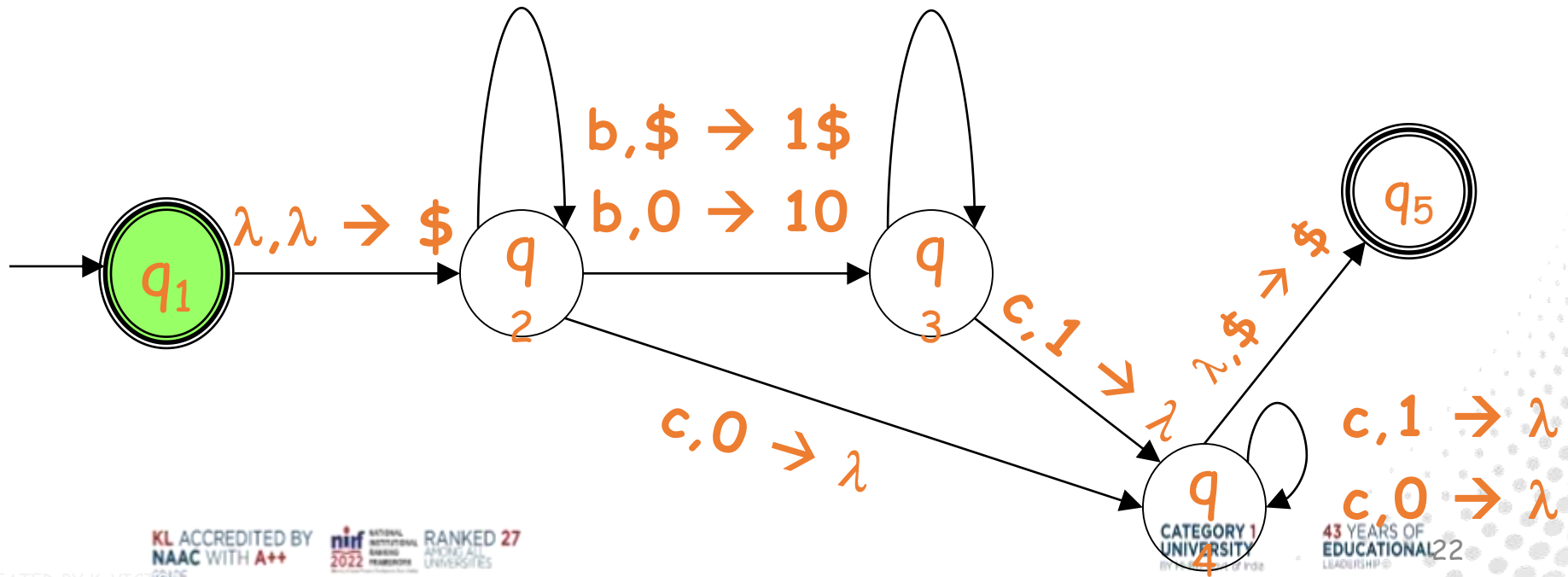
$$L(M) = \{ a^n b^m c^{n+m}, n \geq 0, m \geq 0 \}$$

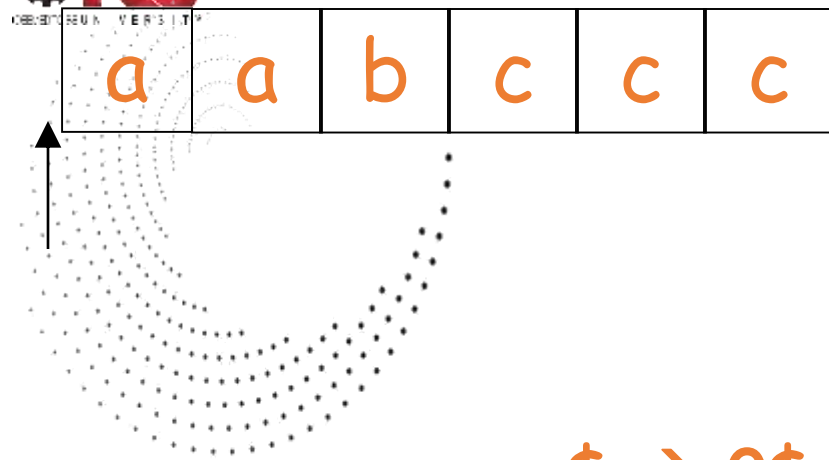
$$L(M) = \{ a^n b^m c^{n+m}, n \geq 0, m \geq 0 \}$$

$a, \$ \rightarrow 0\$$

$a, 0 \rightarrow 00$

$b, 1 \rightarrow 11$

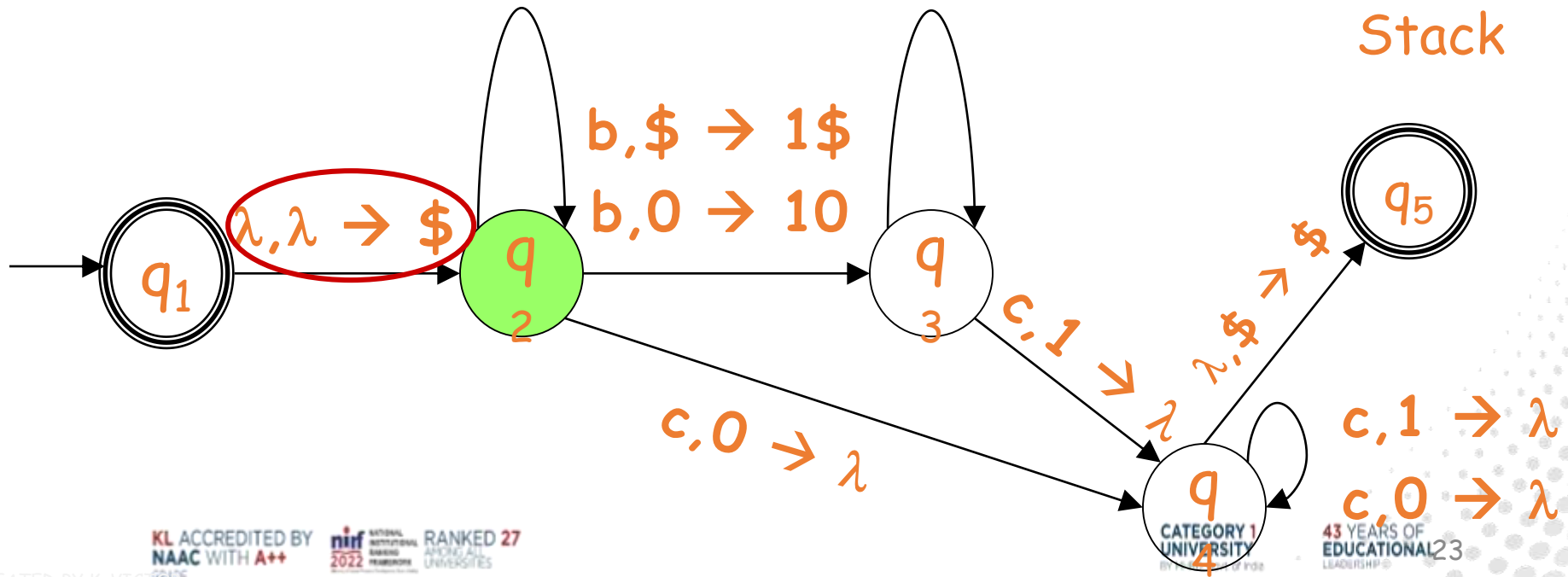
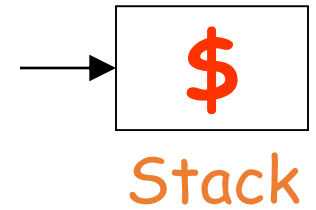




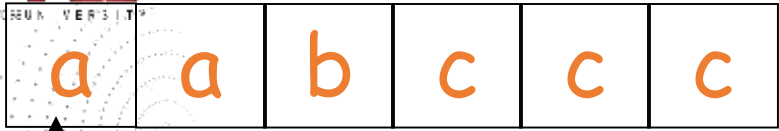
$a, \$ \rightarrow 0\$$

$a, 0 \rightarrow 00$

$b, 1 \rightarrow 11$



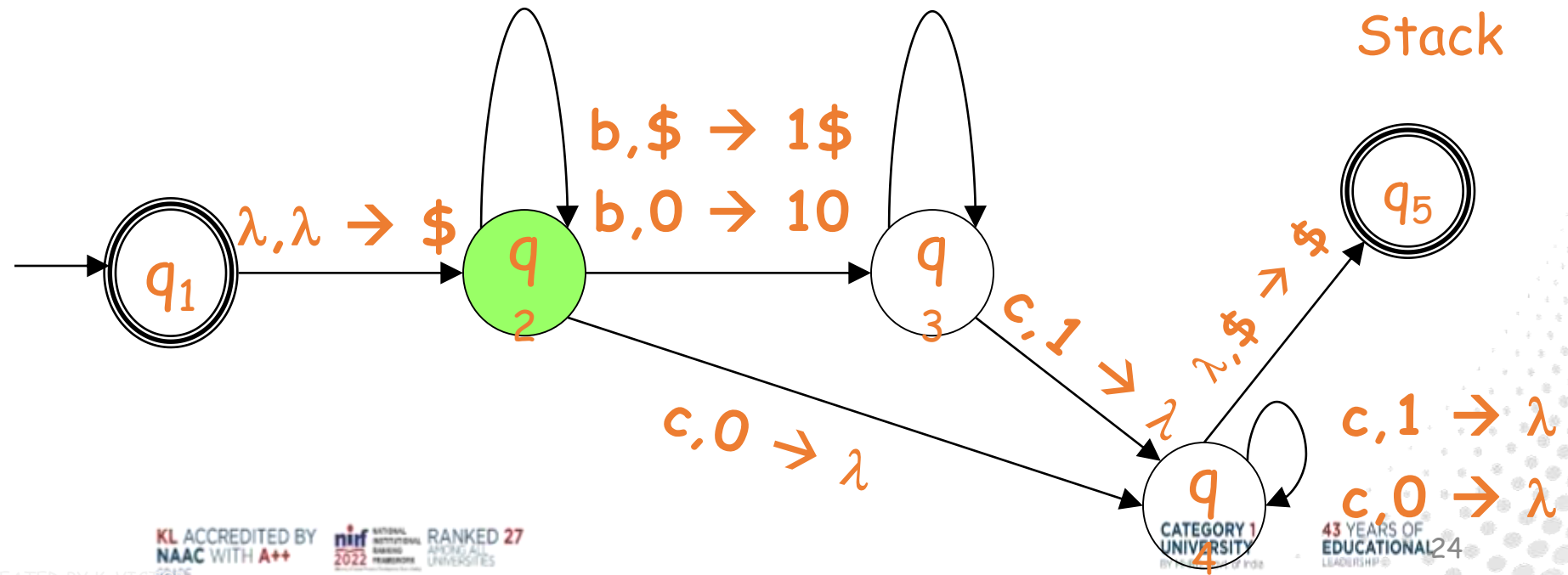
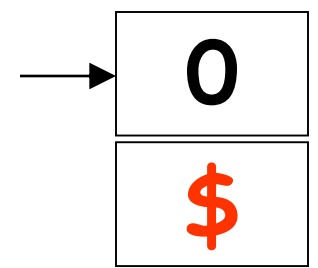
Time 1



$a, \$ \rightarrow 0\$$

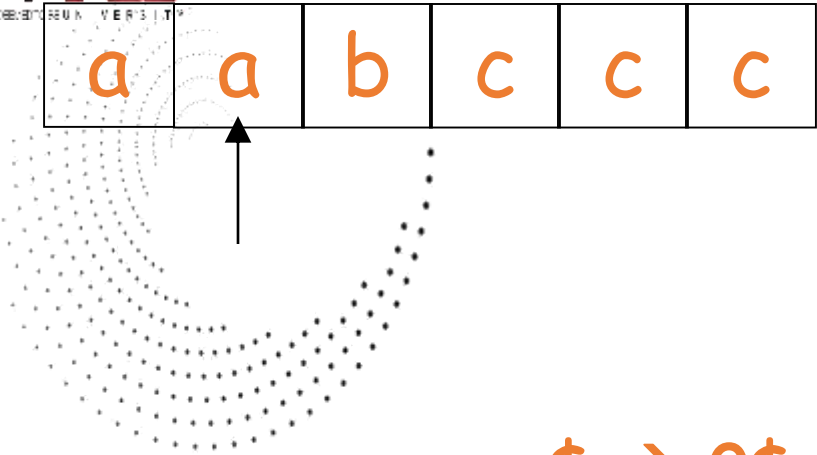
$a, 0 \rightarrow 00$

$b, 1 \rightarrow 11$



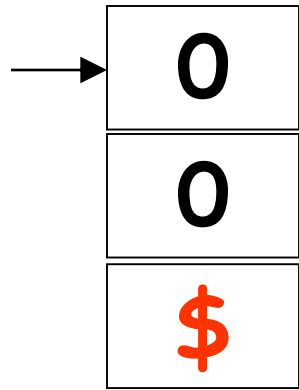


Time 2

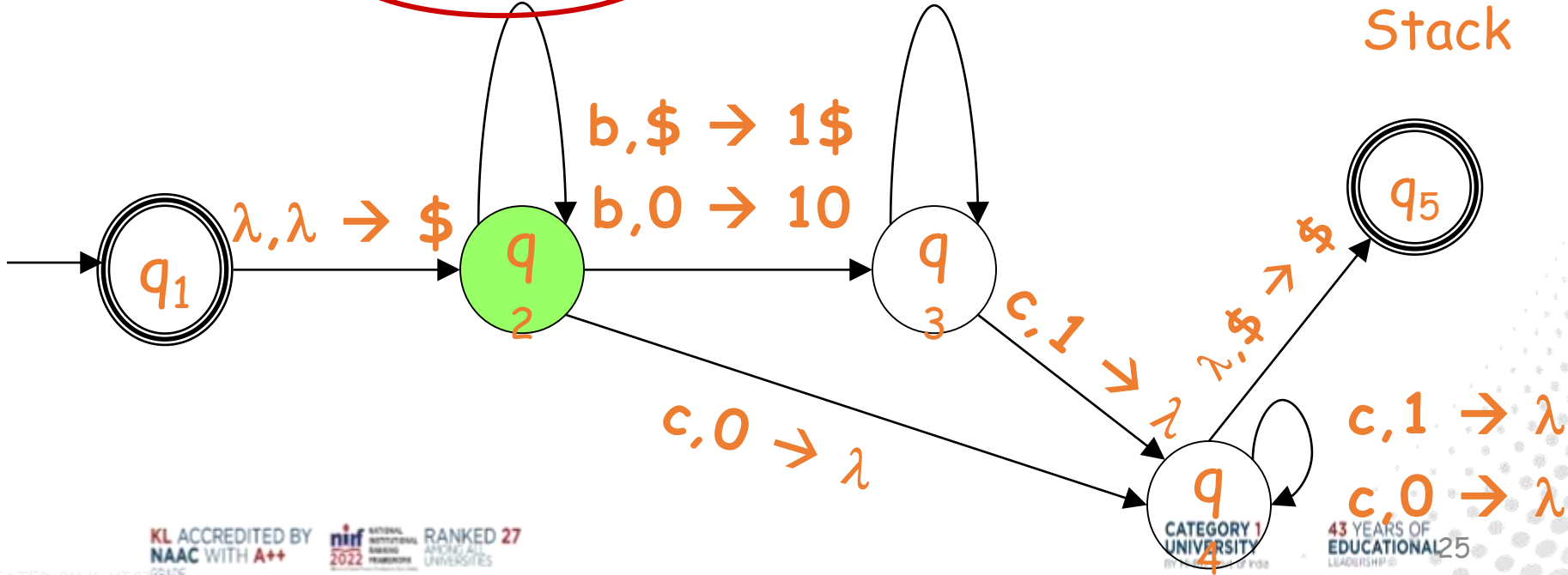


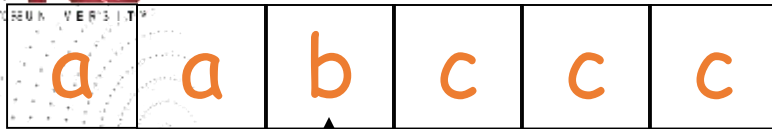
$a, \$ \rightarrow 0\$$   
 $a, 0 \rightarrow 00$

$b, 1 \rightarrow 11$



Stack

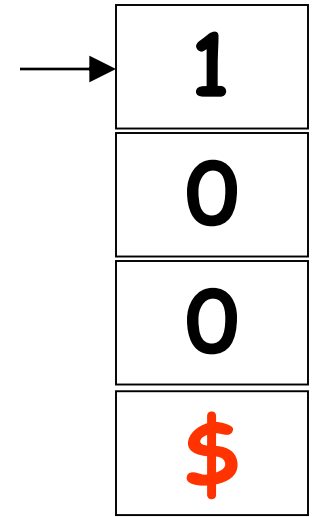




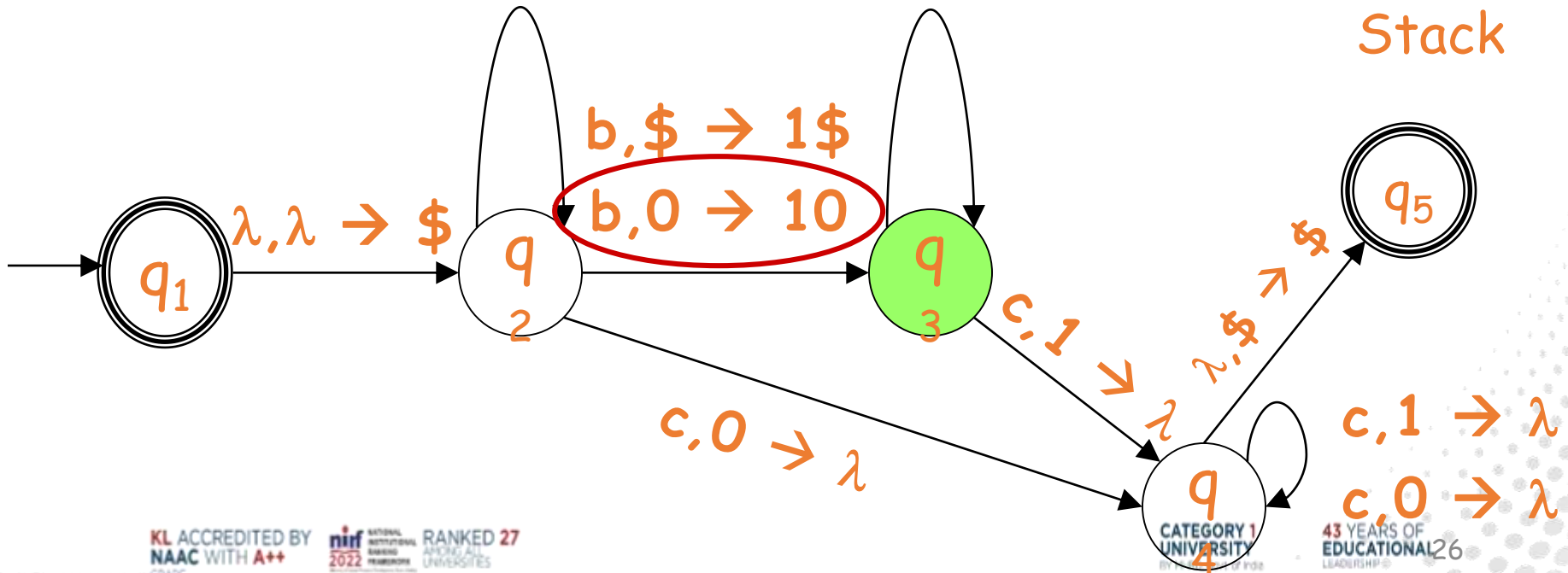
$a, \$ \rightarrow 0\$$

$a, 0 \rightarrow 00$

$b, 1 \rightarrow 11$



Stack

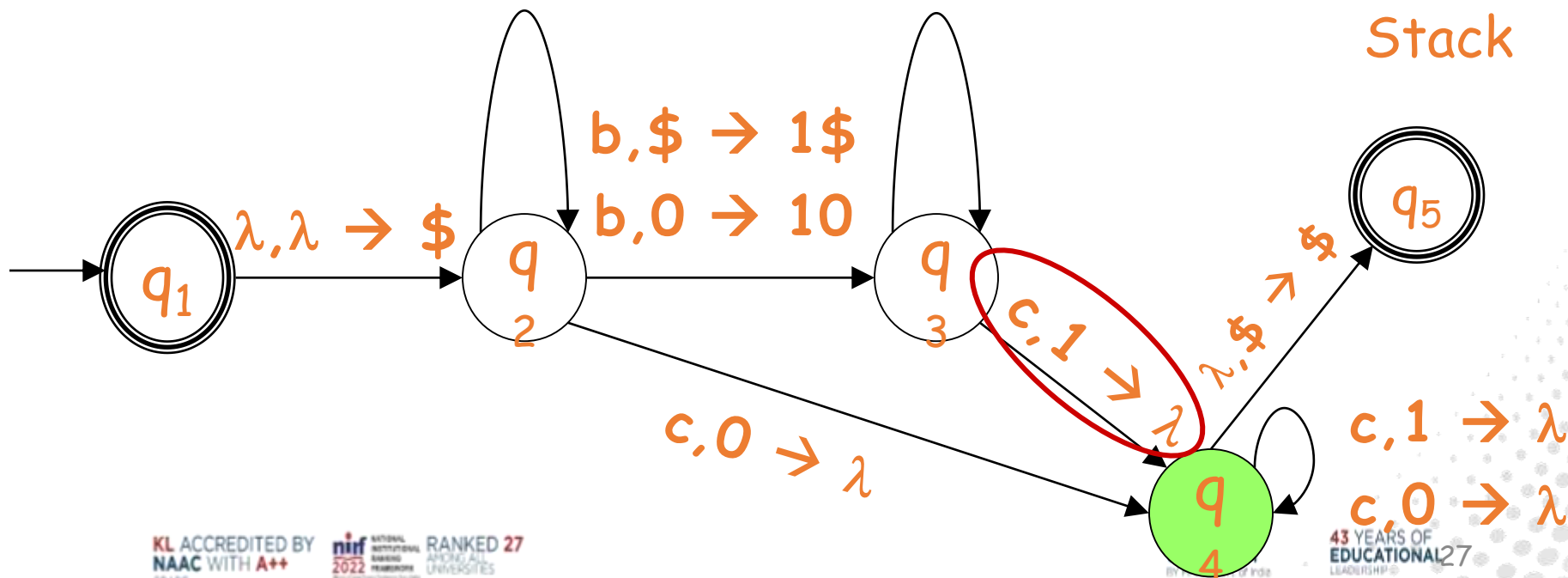
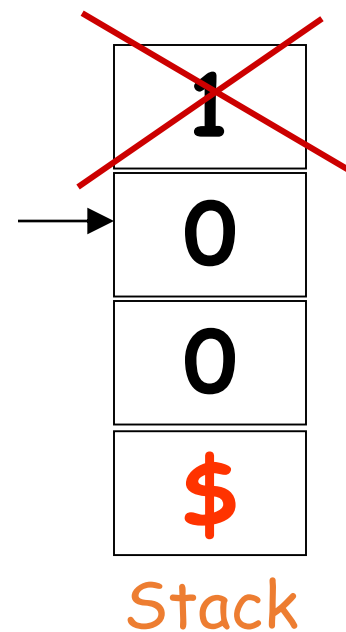


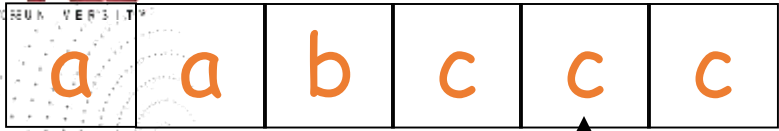


$a, \$ \rightarrow 0\$$

$a, 0 \rightarrow 00$

$b, 1 \rightarrow 11$

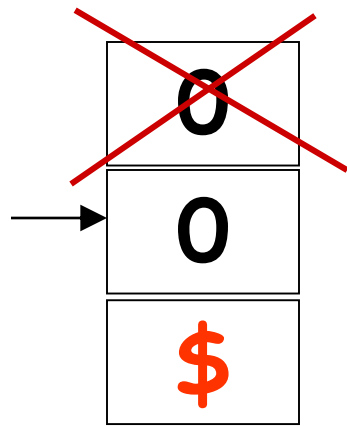




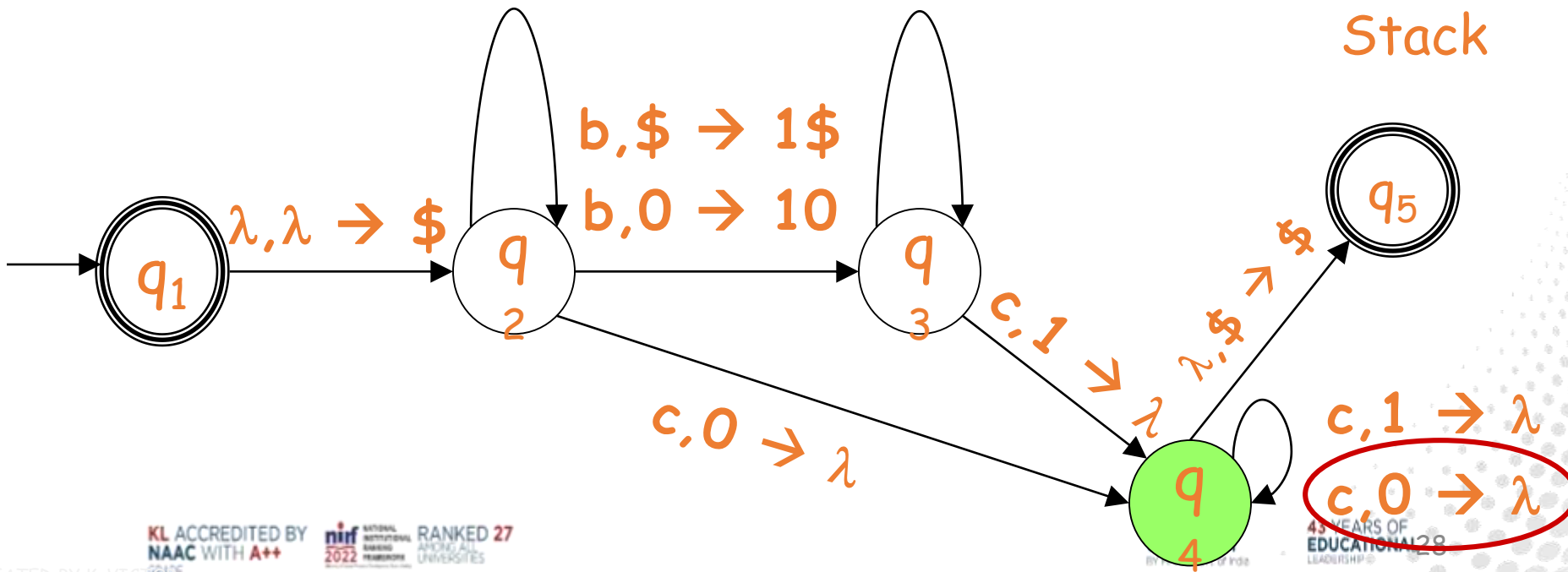
a,\$ → 0\$

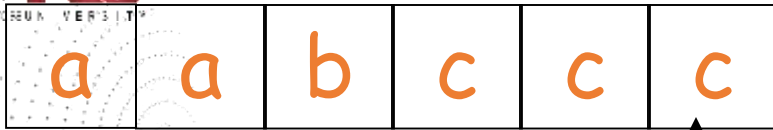
a,0 → 00

b,1 → 11



Stack

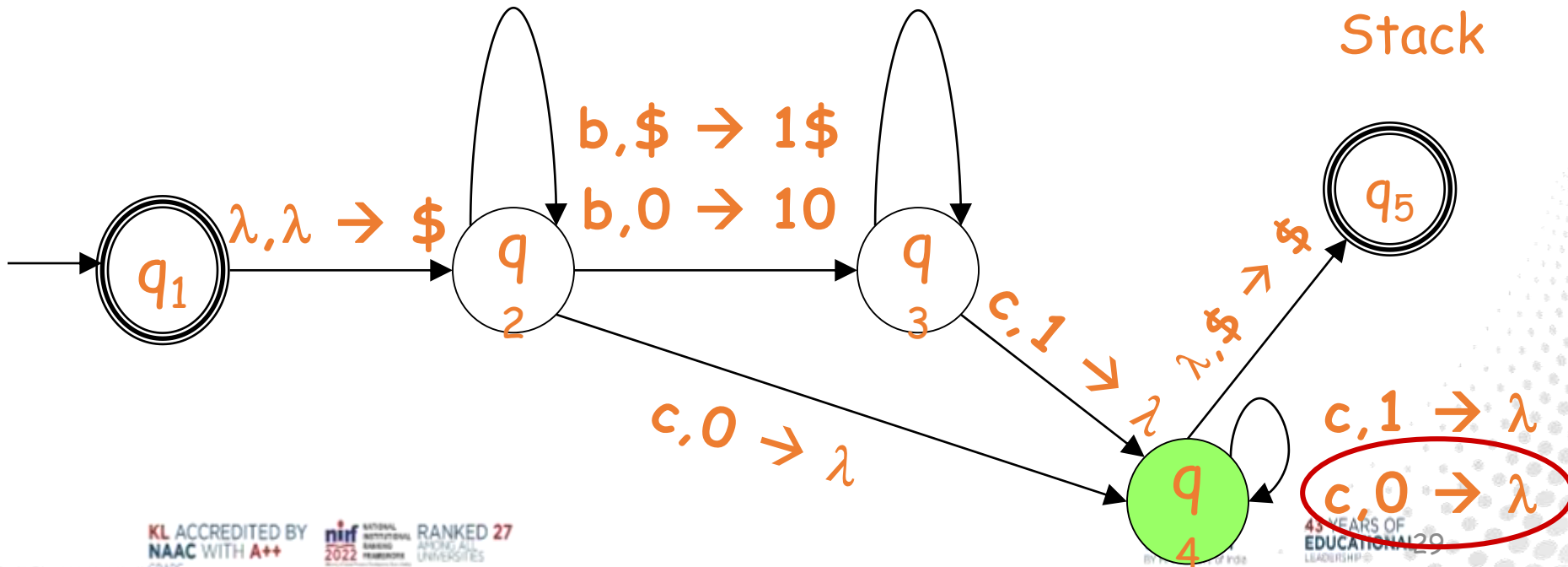
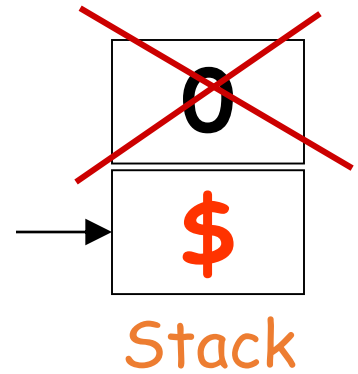


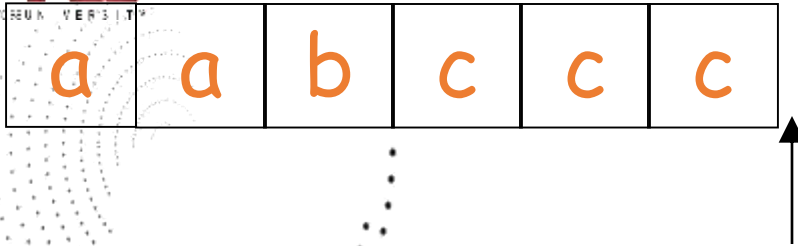


$a, \$ \rightarrow 0\$$

$a, 0 \rightarrow 00$

$b, 1 \rightarrow 11$

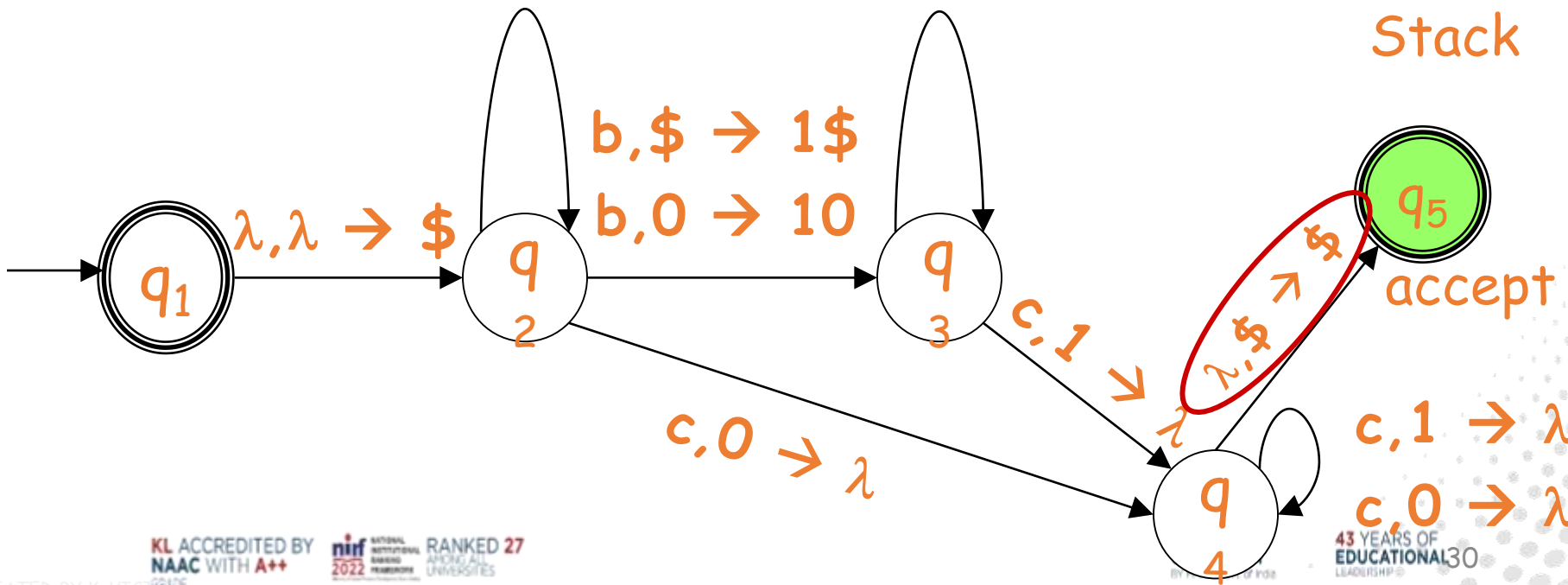
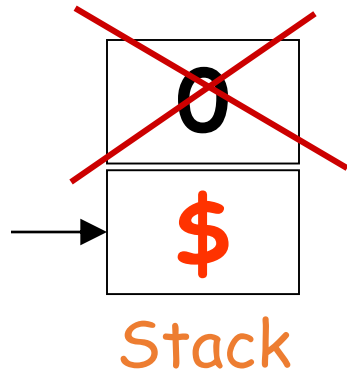




a,\$ → 0\$

a,0 → 00

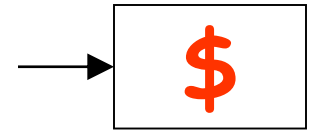
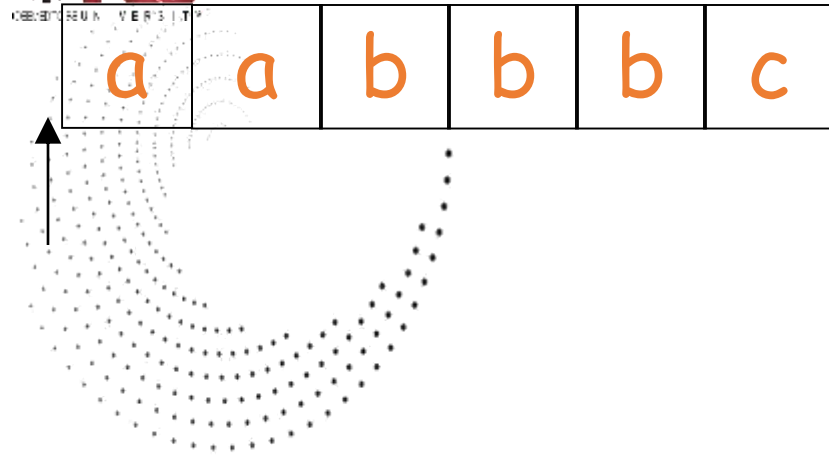
b,1 → 11



# 6:

Design a NPDA to accept the following Language:

$$L(M) = \{ a^n b^{n+m} c^m, n \geq 0, m \geq 1 \}$$



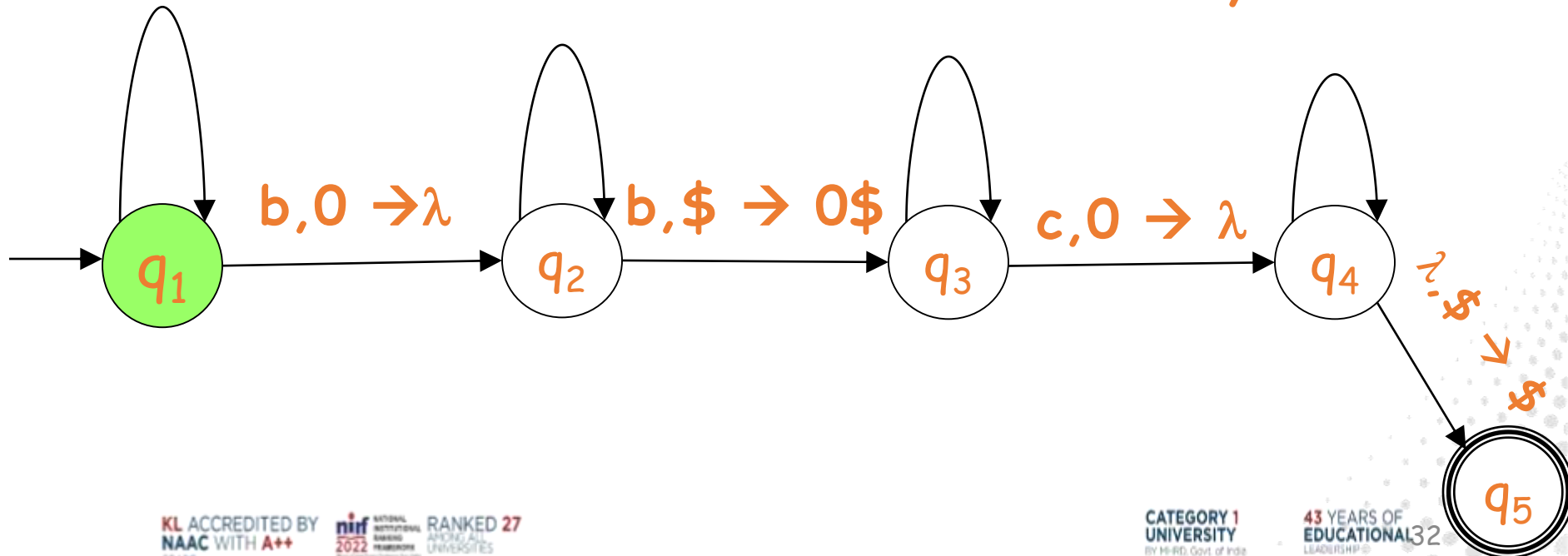
Stack

$a, \lambda \rightarrow 0$

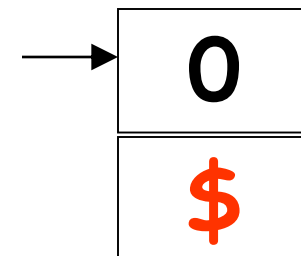
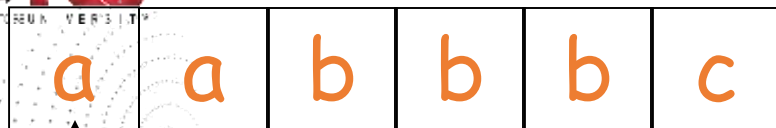
$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$







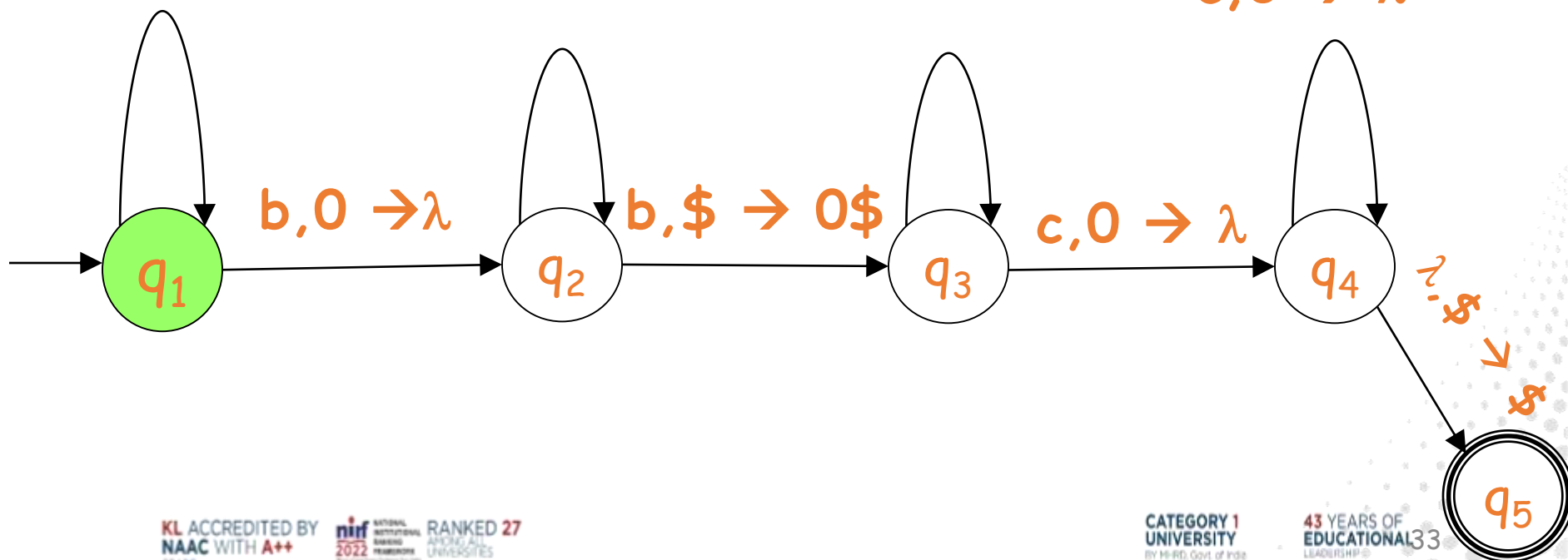
Stack

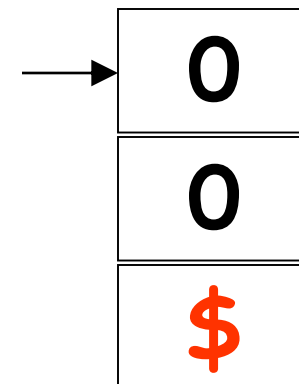
$a, \lambda \rightarrow 0$

$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$





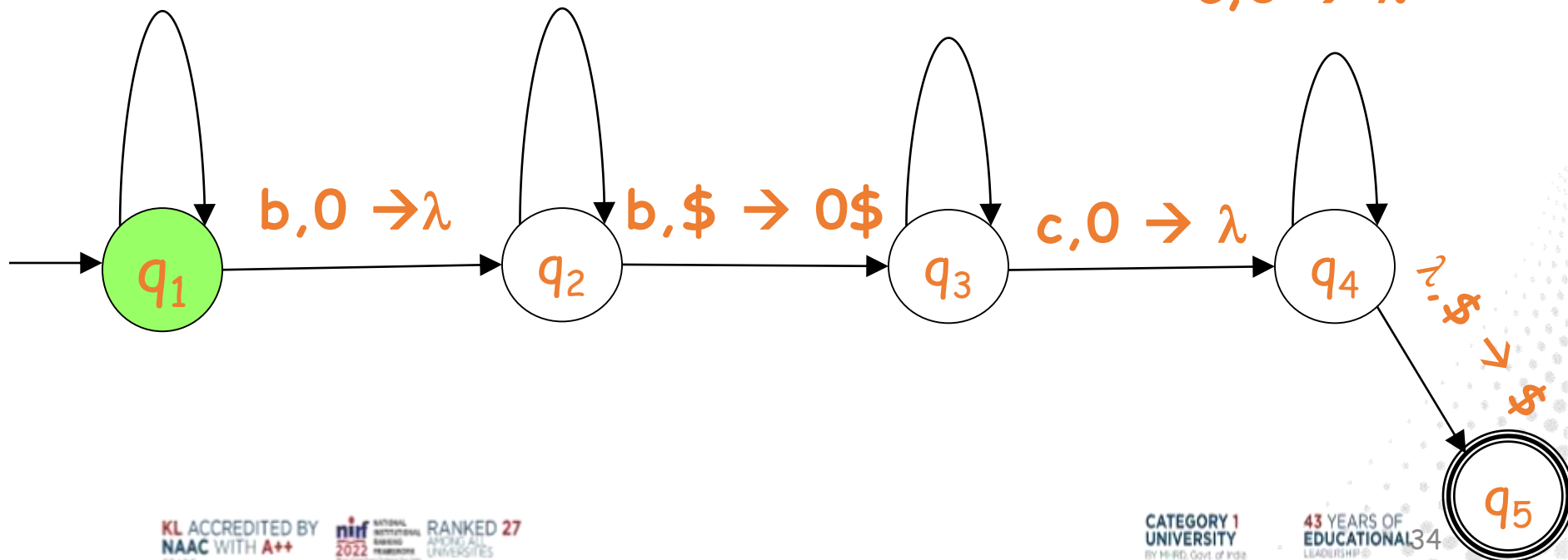
Stack

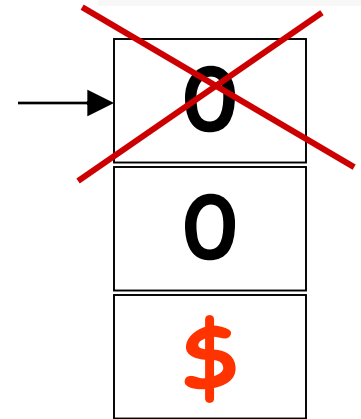
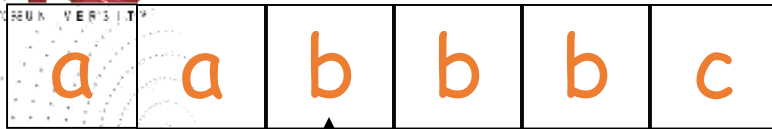
$a, \lambda \rightarrow 0$

$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$





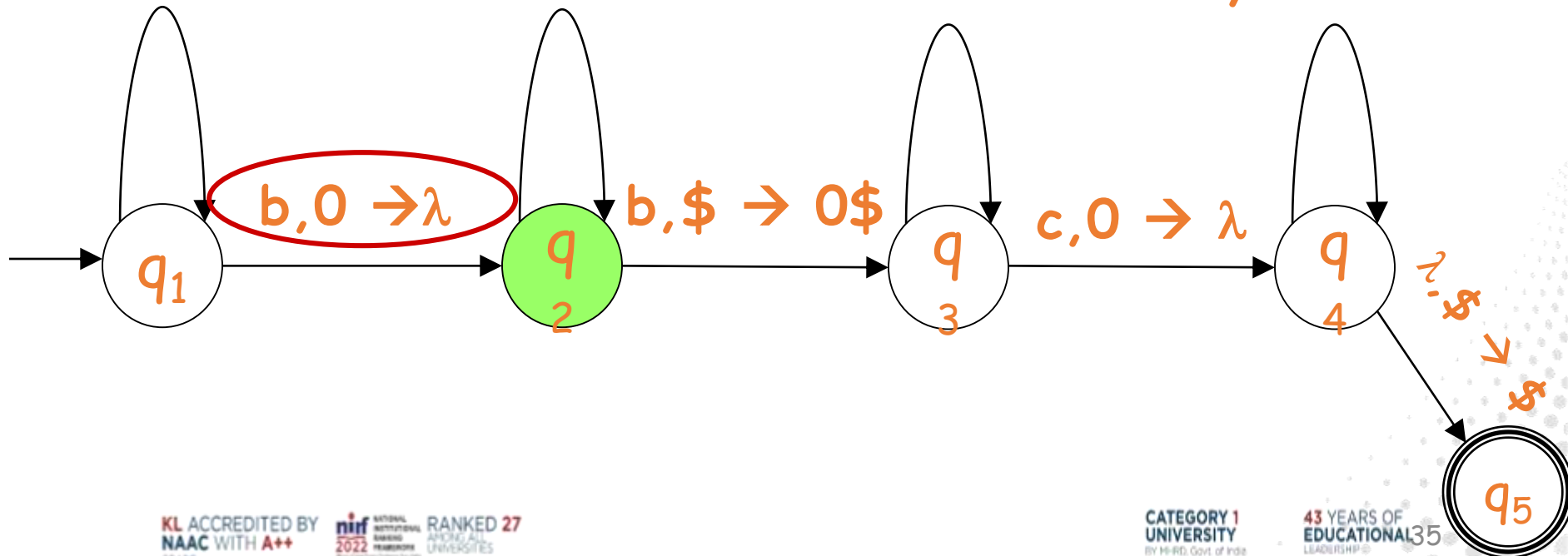
Stack

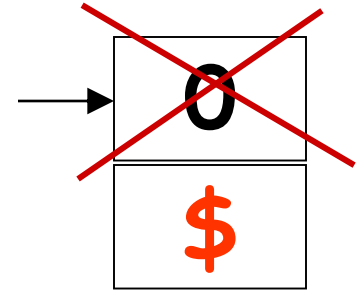
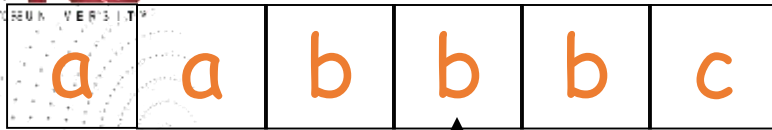
$a, \lambda \rightarrow 0$

$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$





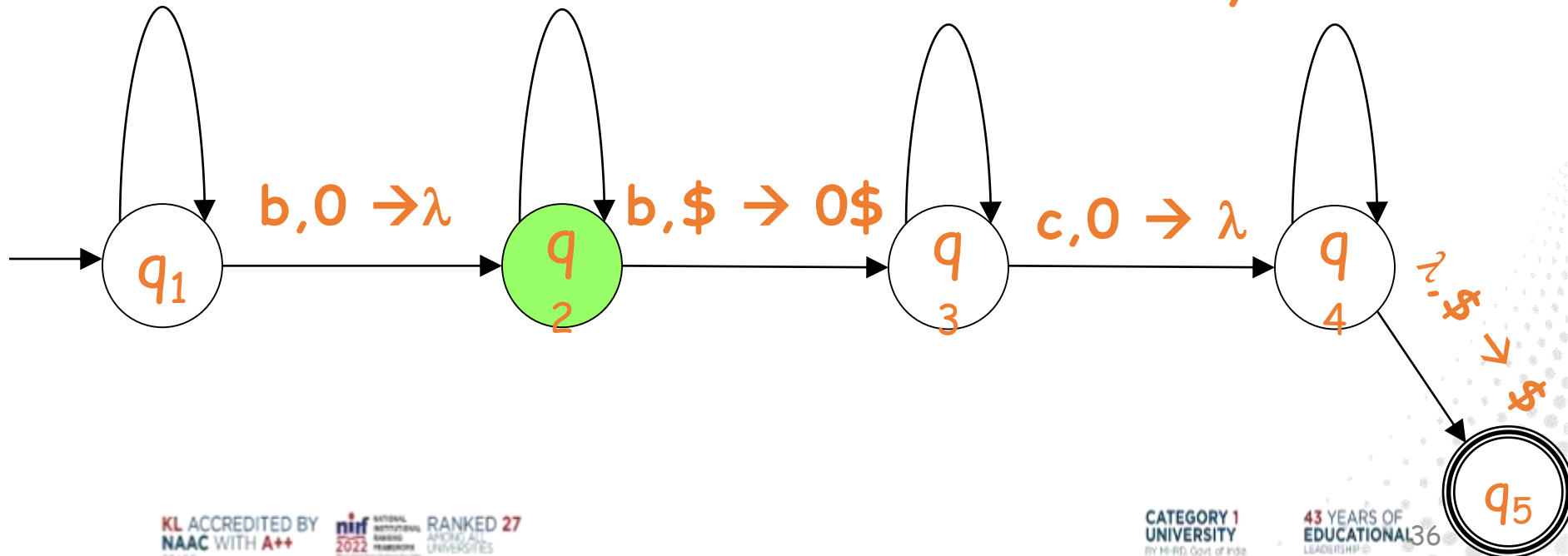
Stack

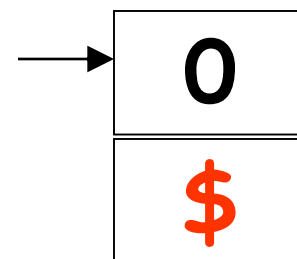
$a, \lambda \rightarrow 0$

$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$





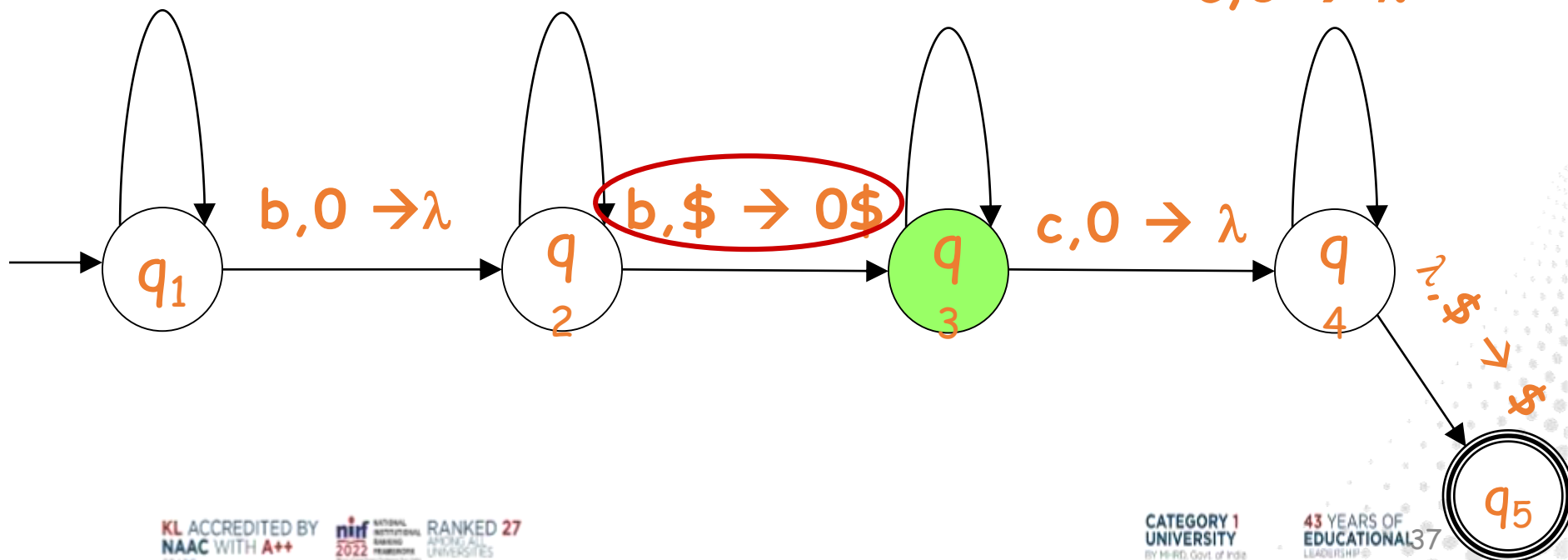
Stack

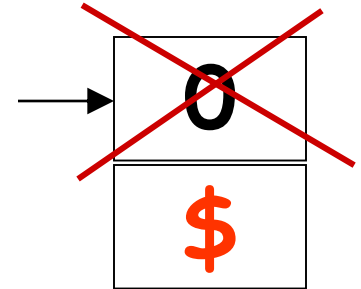
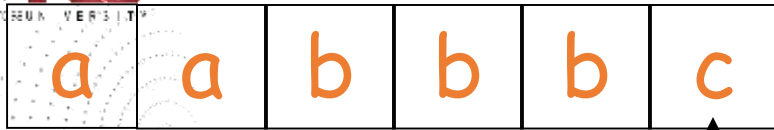
$a, \lambda \rightarrow 0$

$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$





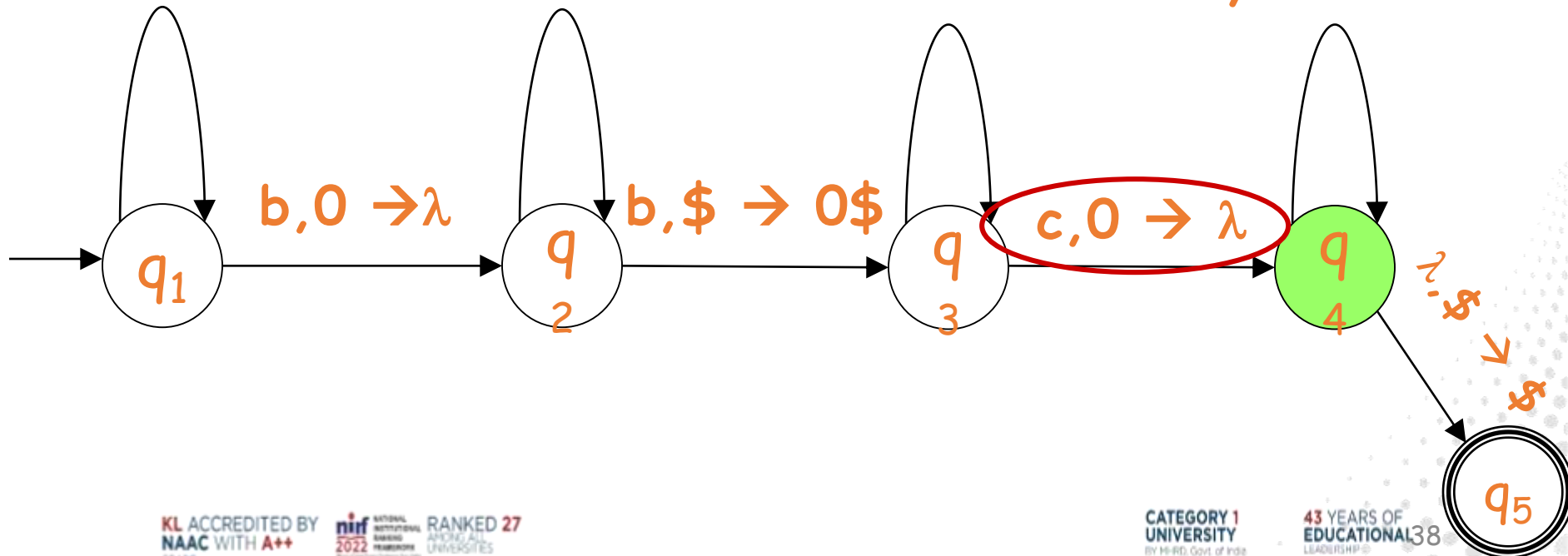
Stack

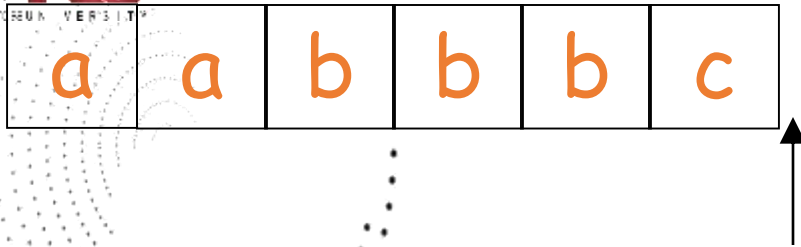
$a, \lambda \rightarrow 0$

$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$





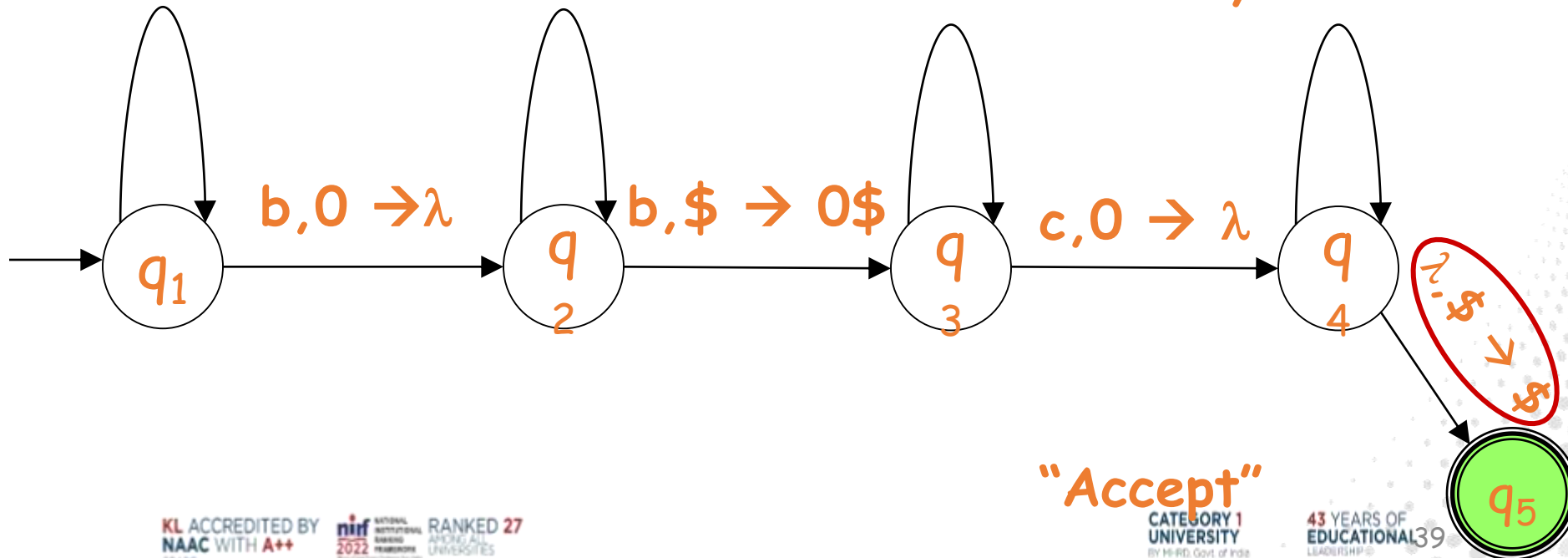
Stack

$a, \lambda \rightarrow 0$

$b, 0 \rightarrow \lambda$

$b, \lambda \rightarrow 0$

$c, 0 \rightarrow \lambda$



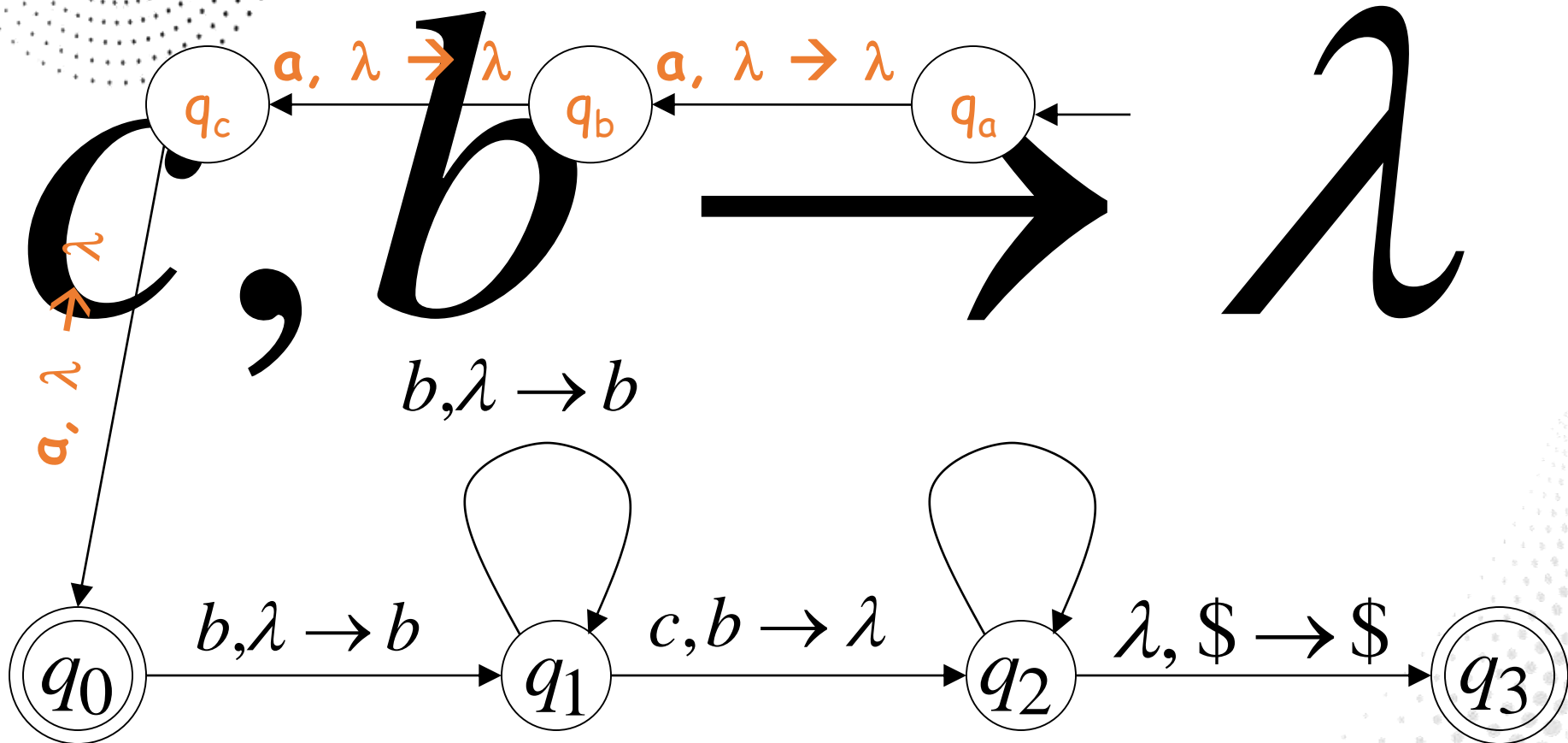
# 7:

Design a NPDA to accept the following Language:

$$L(M) = \{ a^3b^nc^n, n \geq 0 \}$$



$$L(M) = \{ a^3b^nc^n, n \geq 0 \}$$





# Representation of PDA By Flow chart Structure

# Shapes & Notations:

Start

Reject

Accept

Read

Push

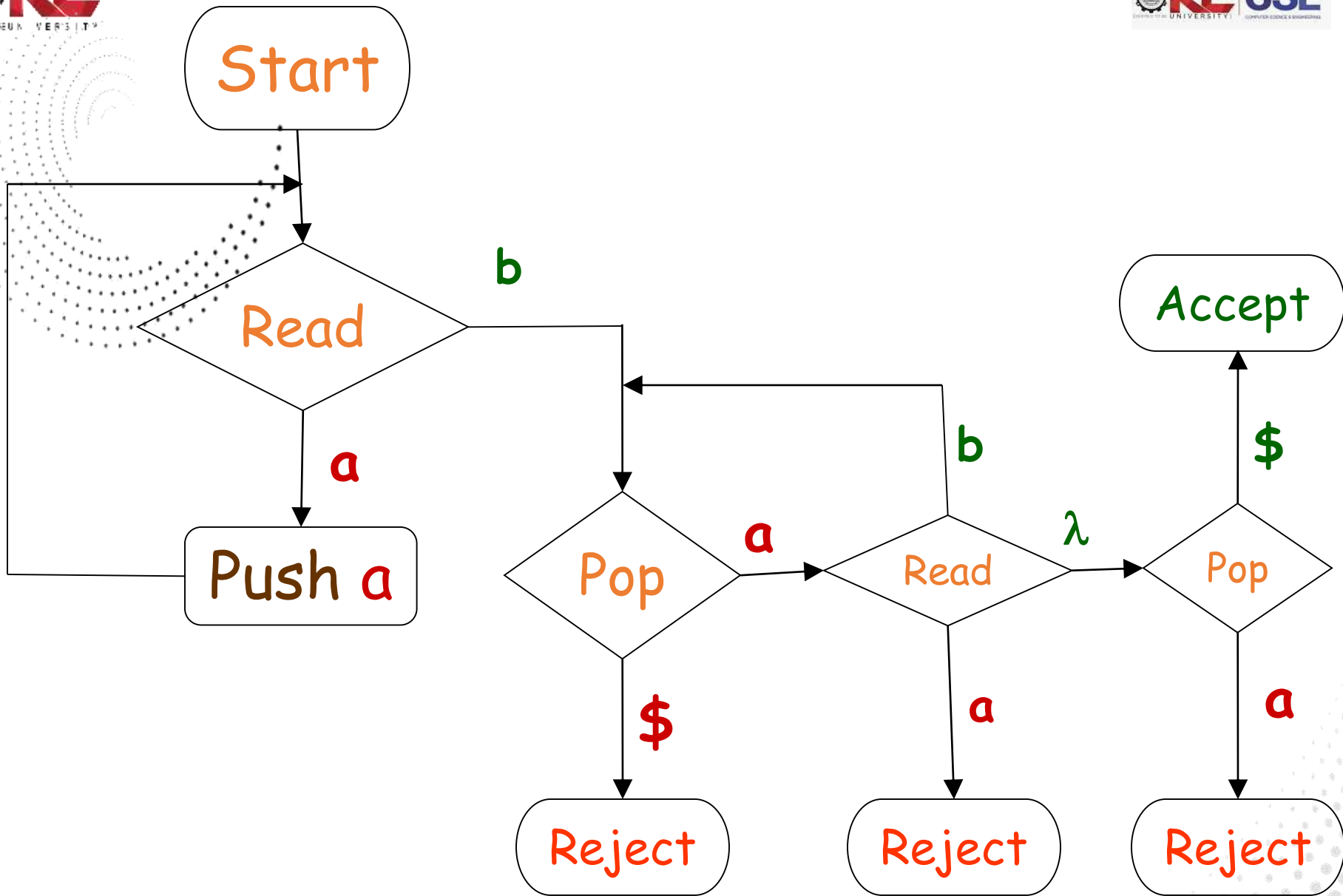
Pop

Example:

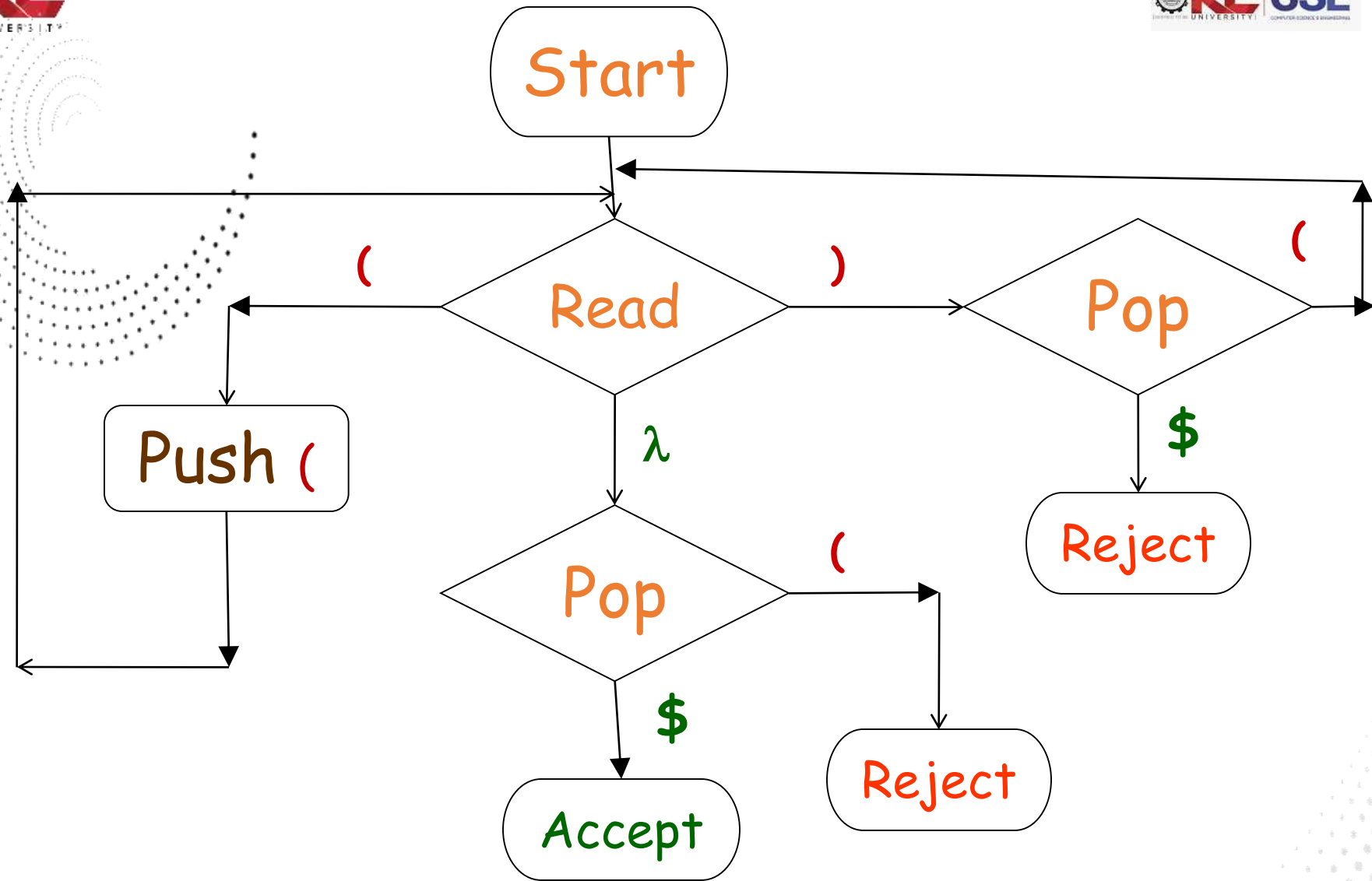
Design a PDA that accepts the Language

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

By flow chart method



Design a NPDA to check the well-formedness of parenthesis in the given string.



# Self Assessment Questions

Q.1. The Chomsky hierarchy class that includes context-free languages is:

- a) Type 0.
- b) Type 1.
- c) Type 2.
- d) Type 3.

Answer: c) Type 2.



# Self Assessment Questions

Q.2. The computational model of a Pushdown Automaton (PDA) was introduced by:

- a) John Hopcroft and Jeffrey Ullman.
- b) Alan Turing.
- c) Stephen Cook.
- d) Michael Sipser.

Answer: b) Alan Turing.

.

# Self Assessment Questions

Q.3. The language recognized by a Pushdown Automaton (PDA) is:

- a) Regular.
- b) Context-free.
- c) Context-sensitive.
- d) Recursively enumerable.

Answer: b) Context-free.

# Terminal Questions

Q.1 Describe the concept of language emptiness for Pushdown Automata (PDA). How is the emptiness of a PDA language determined?

Q.2 Discuss the limitations of Pushdown Automata (PDA) in terms of the languages they can recognize. Are there any language classes that PDAs cannot recognize?

Q.3 Explain the concept of closure properties for context-free languages. How do these properties relate to the operations performed by Pushdown Automata (PDA)?

THANK YOU



Team – TOC