

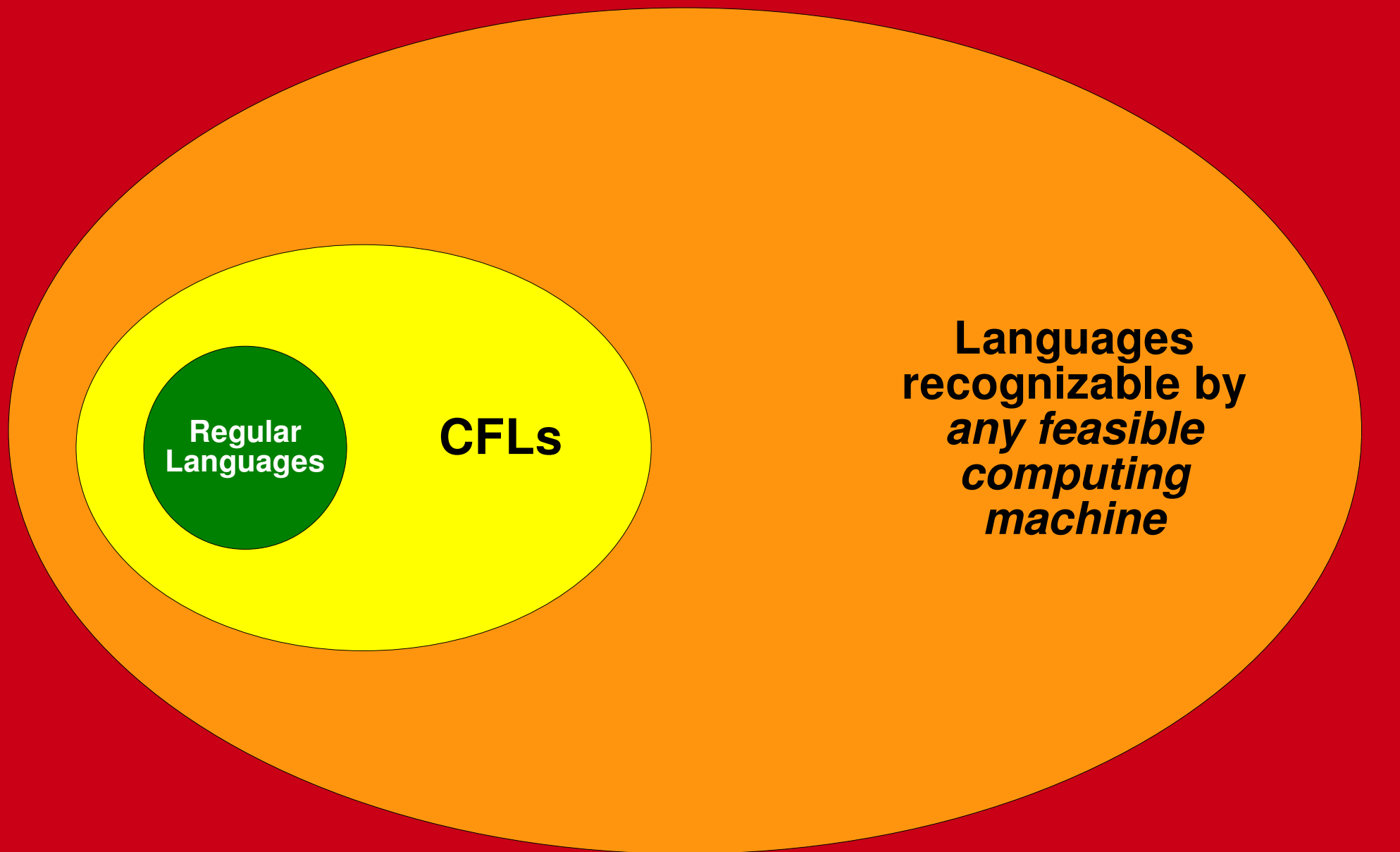
CS103
WINTER 2025



Lecture 20: **Turing Machines**

Part 1 of 3

What problems can we solve with a computer?



Languages
recognizable by
*any feasible
computing
machine*

Regular
Languages

CFLs

All Languages

That same drawing, to scale.

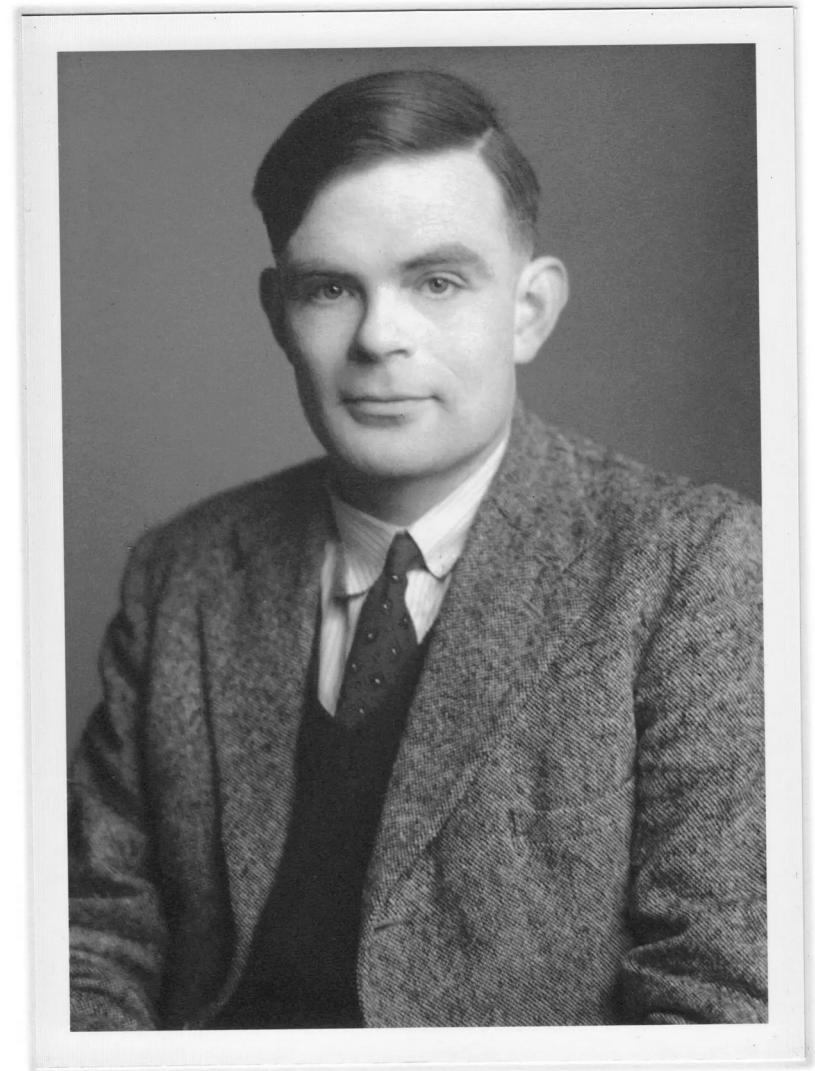
The Problem

- Finite automata accept precisely the regular languages.
- We may need unbounded memory to recognize context-free languages.
 - e.g. $\{ \mathbf{a}^n \mathbf{b}^n \mid n \in \mathbb{N} \}$ requires unbounded counting.
- How do we model a computing device that has unbounded memory?

A Brief History Lesson

Turing Machines

- In March 1936, Alan Turing (aged 23!) published a paper detailing the ***a-machine*** (for ***automatic machine***), an automaton for computing on real numbers.
- They're now more popularly referred to as ***Turing machines*** in his honor.
- He also later made contributions to computational biology, artificial intelligence, cryptography, etc. Seriously, Google this guy.



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 + 31415926535897 \\
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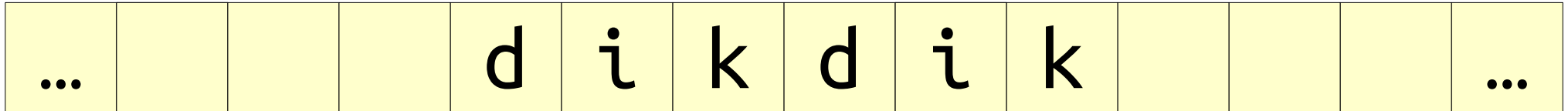
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Key Idea: Even if you need huge amounts of scratch space to perform a calculation, at each point in the calculation you only need access to a small amount of that scratch space.

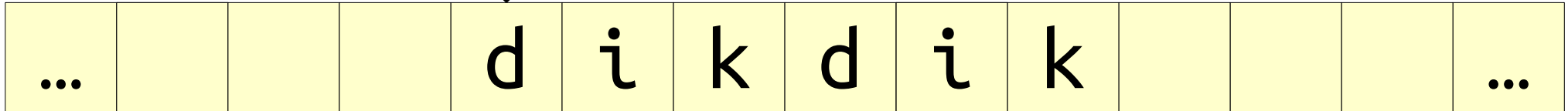
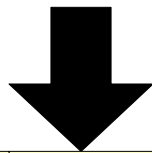
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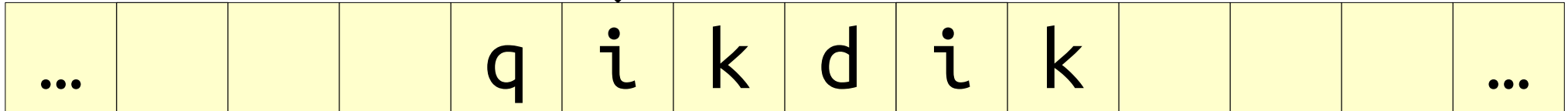
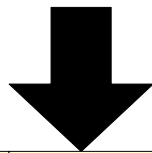
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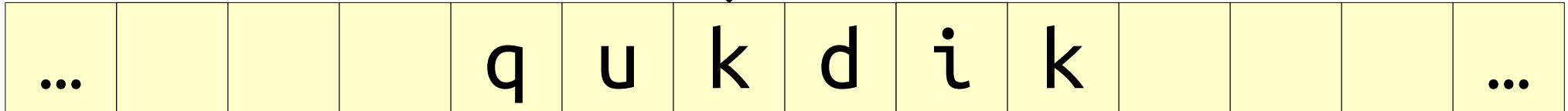
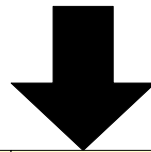
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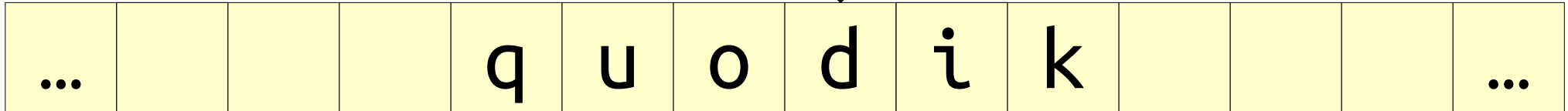
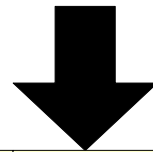
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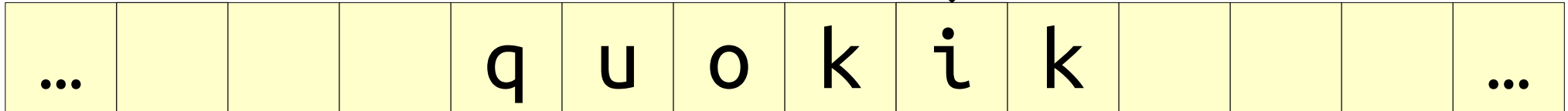
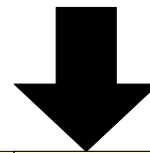
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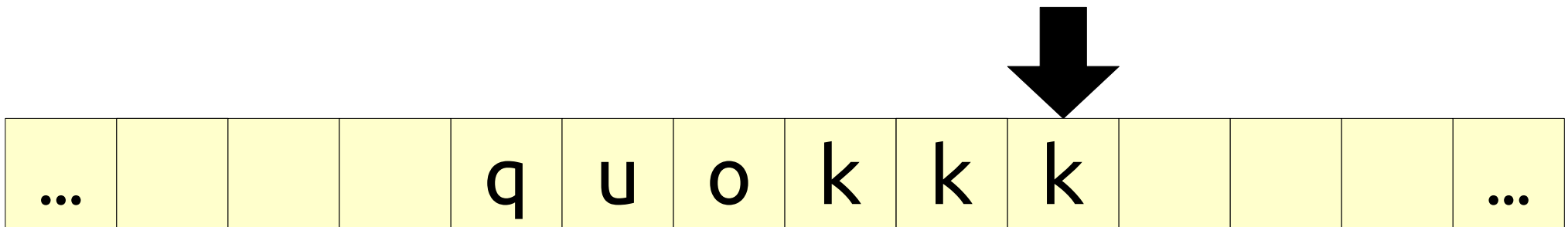
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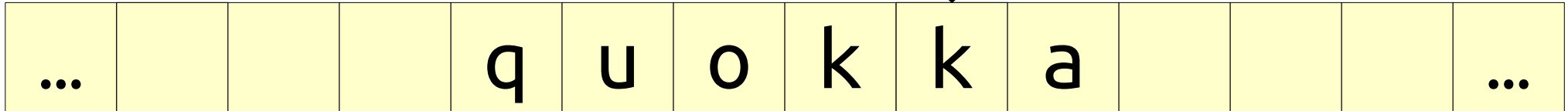
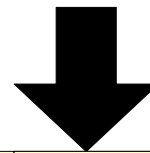
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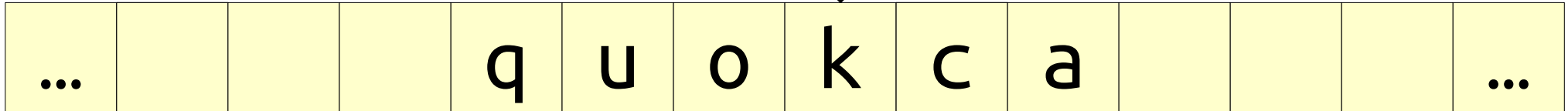
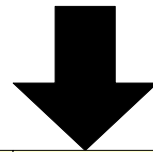
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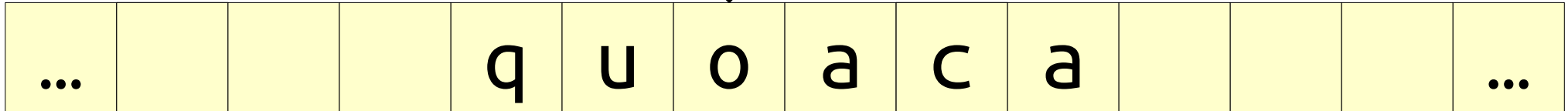
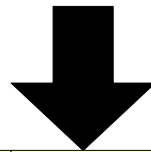
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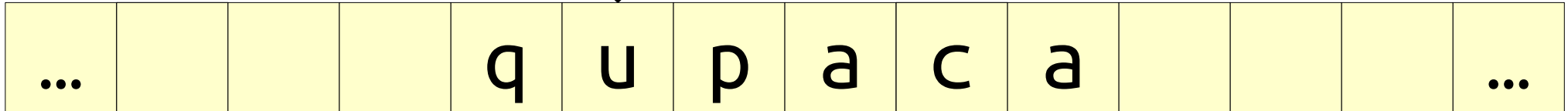
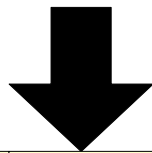
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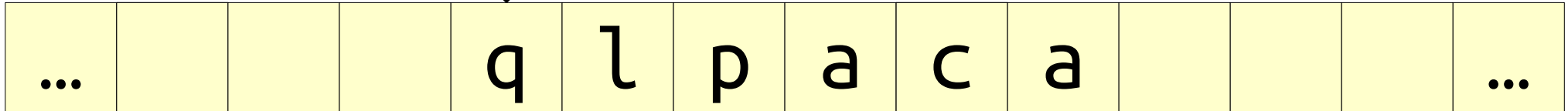
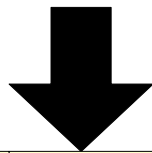
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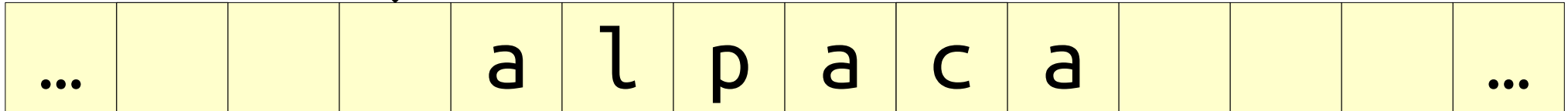
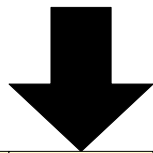
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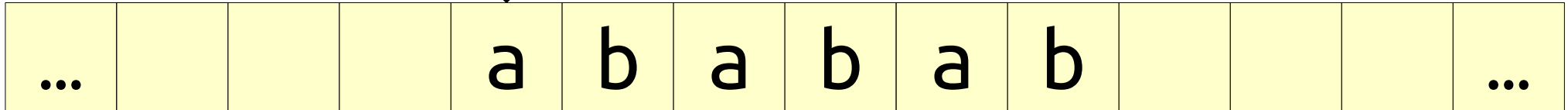
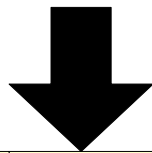
- Over the years, there have been many simplifications and edits to Turing's original automata.
 - In practice, electronic computers are written in terms of individual instructions rather than states and transitions.
 - Turing's original paper deals with computing individual real numbers; we typically want to compute functions of inputs.
- What we're going to present as "Turing machines" in this class differ significantly from Turing's original description, while retaining the core essential ideas.
 - (Our model is closer to Emil Post's *Formulation 1* and Hao Wang's *Basic Machine B*, for those of you who are curious.)
- If you'd like to learn more about Turing's original version of the Turing machine, come chat with us after class!

Turing Machines

- A TM is a series of instructions that control a tape head as it moves across an infinite tape.
- The tape begins with the input string written somewhere, surrounded by infinitely many blank cells.
 - Rule: The input string cannot contain blank cells.
- The tape head begins above the first character of the input. (If the input is ϵ , the tape head points somewhere on a blank tape.)

Start:

```
If Blank Return True
If 'b' Return False
Write 'x'
Move Right
If Not 'b' Return False
Write 'x'
Move Right
Goto Start
```

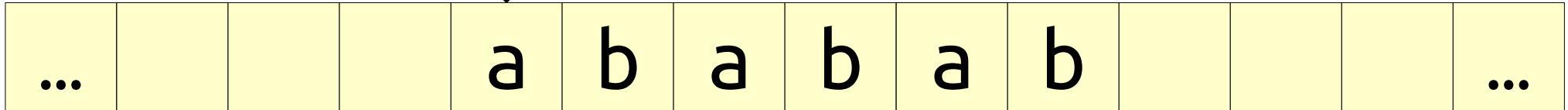
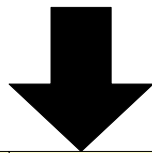


Turing Machines

- We begin at the Start label.
- Labels indicate different sections of code. The name Start is special and means “begin here.”
- Labels have no effect when executed. We just move to the next line.

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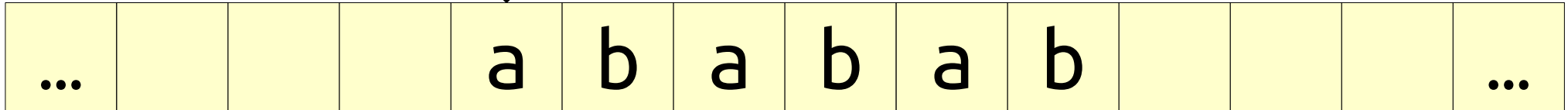
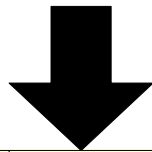


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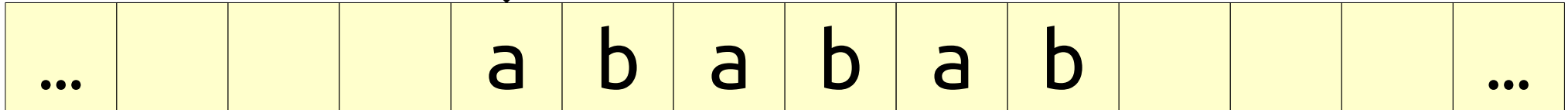
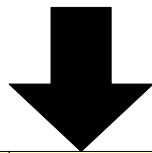
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Turing Machines

- A statement of the form
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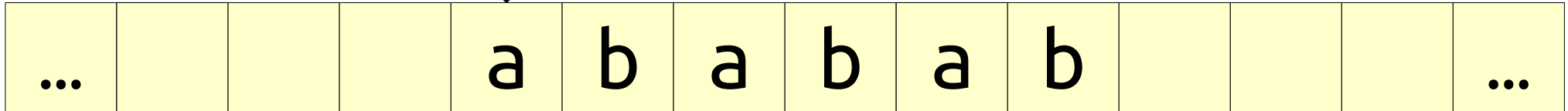
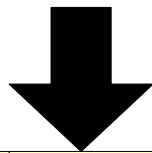
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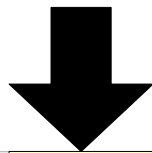
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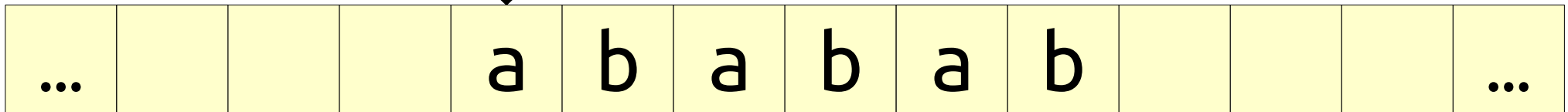
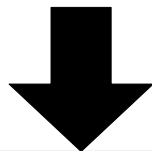
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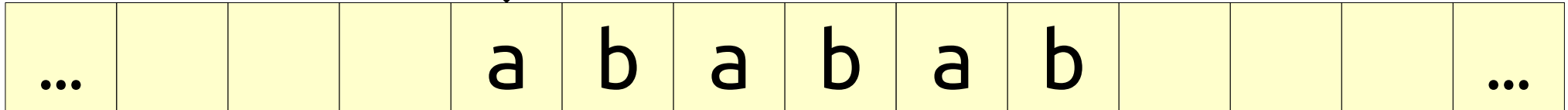
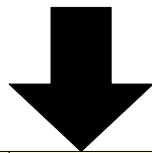
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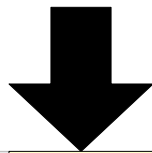
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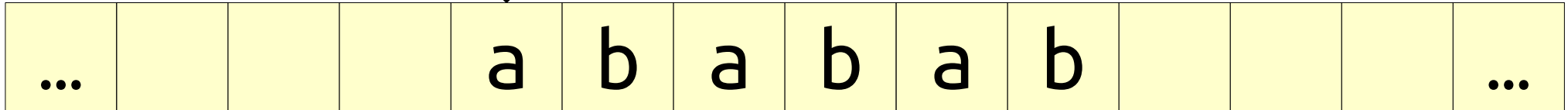
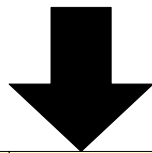
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A statement of the form
If *symbol command*
checks if the character
under the tape head is
symbol.
- If so, it executes
command.
- If not, nothing happens.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

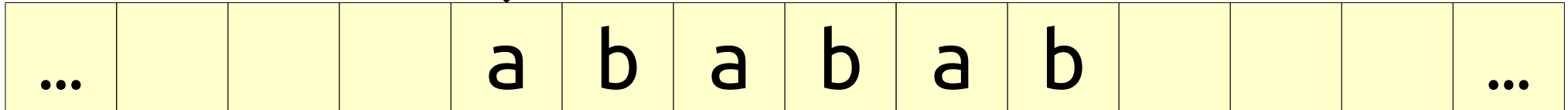
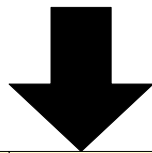
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The statement
Write *symbol*
writes *symbol* to the
cell under the tape
head.
- The *symbol* can
either be Blank or a
character in quotes.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

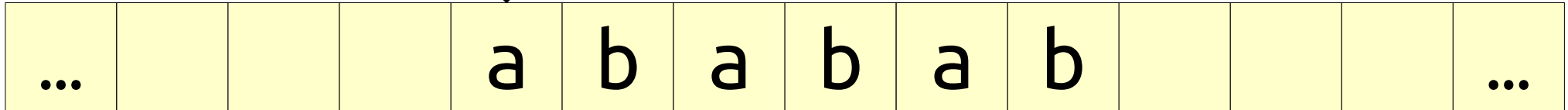
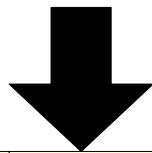
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The statement
Write *symbol*
writes *symbol* to the
cell under the tape
head.
- The *symbol* can
either be Blank or a
character in quotes.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

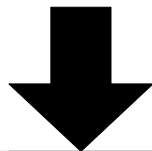
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The statement
Write *symbol*
writes *symbol* to the
cell under the tape
head.
- The *symbol* can
either be Blank or a
character in quotes.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

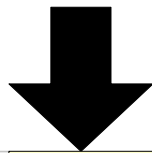
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The statement
Write *symbol*
writes *symbol* to the
cell under the tape
head.
- The *symbol* can
either be Blank or a
character in quotes.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

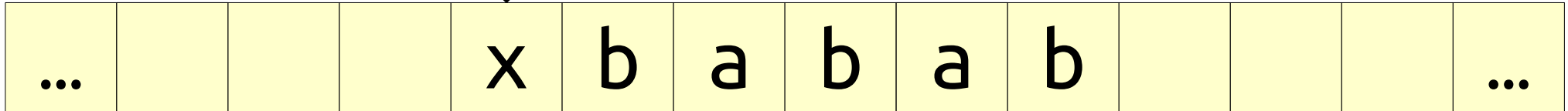
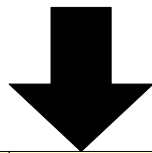
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The statement
Write *symbol*
writes *symbol* to the
cell under the tape
head.
- The *symbol* can
either be Blank or a
character in quotes.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

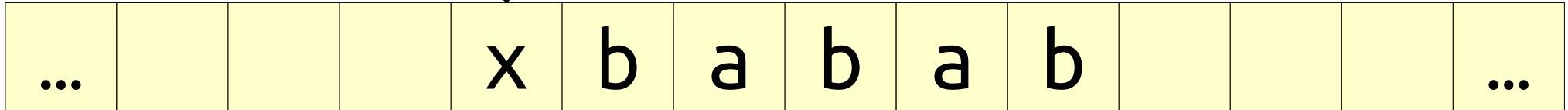
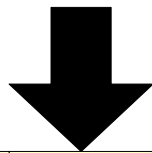
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The command
Move *direction*
moves the tape head one step in the indicated direction (either Left or Right).

Start:

If Blank Return True

If 'b' Return False

Write 'x'

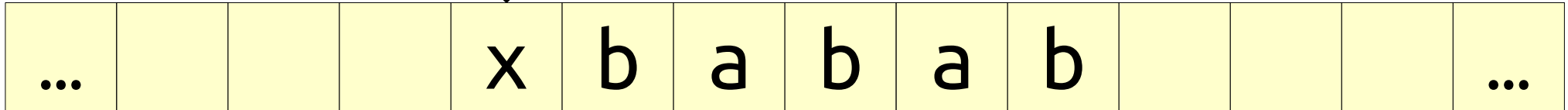
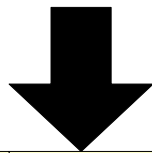
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The command
Move *direction*
moves the tape head one step in the indicated direction (either Left or Right).

Start:

If Blank Return True

If 'b' Return False

Write 'x'

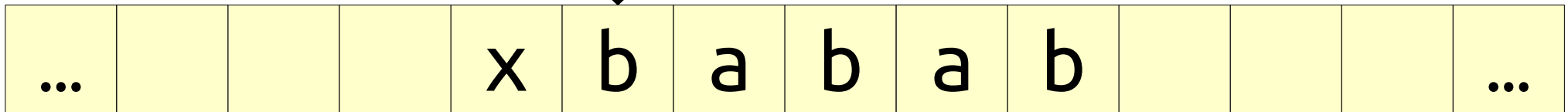
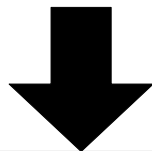
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- The command
Move *direction*
moves the tape
head one step in
the indicated
direction (either
Left or Right).

Start:

If Blank Return True

If 'b' Return False

Write 'x'

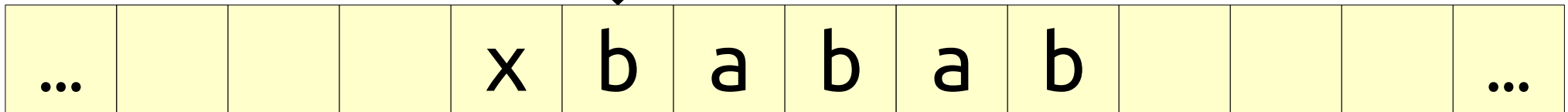
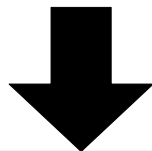
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A statement of the form
If Not *symbol command*
sees if the cell under
the tape head holds
symbol.
- If so, nothing happens.
- If not, it executes
command.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

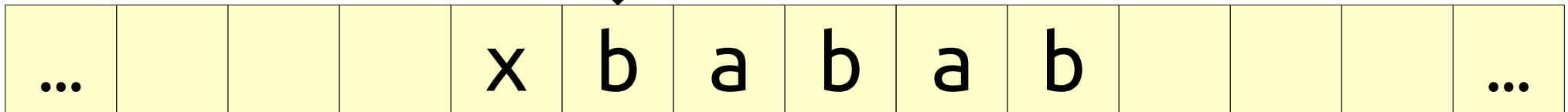
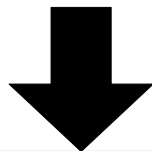
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A statement of the form
If Not *symbol command*
sees if the cell under
the tape head holds
symbol.
- If so, nothing happens.
- If not, it executes
command.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

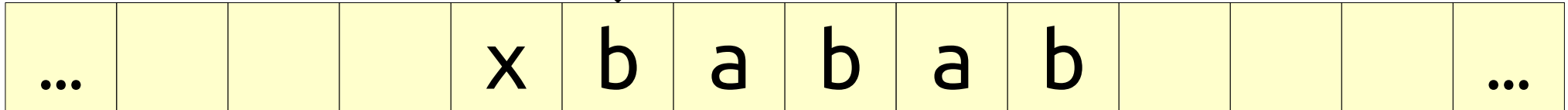
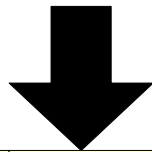
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A statement of the form
If Not *symbol command*
sees if the cell under
the tape head holds
symbol.
- If so, nothing happens.
- If not, it executes
command.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

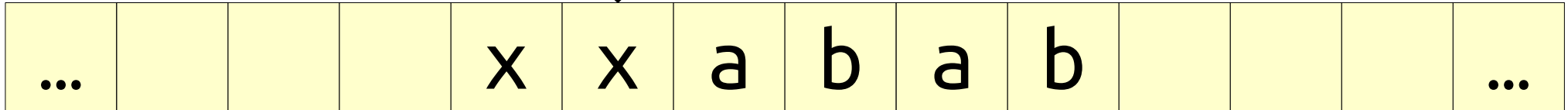
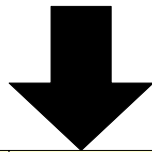
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A statement of the form
If Not *symbol command*
sees if the cell under
the tape head holds
symbol.
- If so, nothing happens.
- If not, it executes
command.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

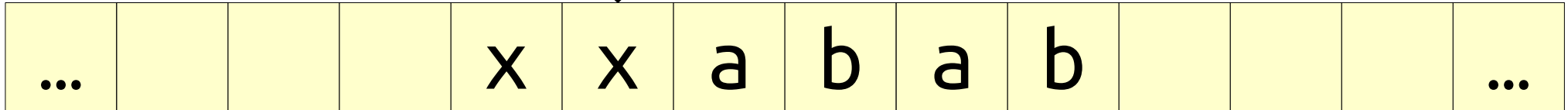
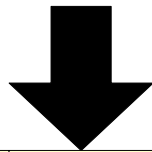
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A statement of the form
If Not *symbol* *command*
sees if the cell under
the tape head holds
symbol.
- If so, nothing happens.
- If not, it executes
command.

Start:

If Blank Return True

If 'b' Return False

Write 'x'

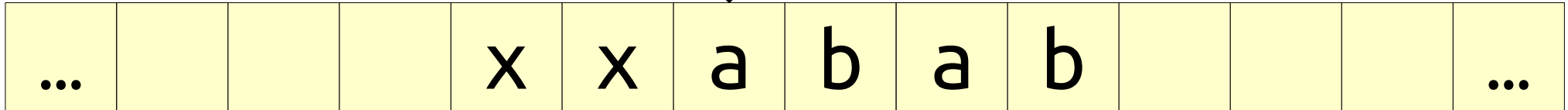
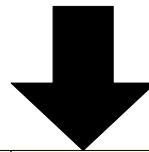
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start

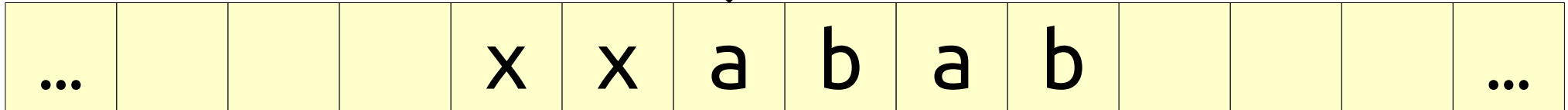
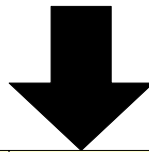


Turing Machines

- A statement of the form
If Not *symbol* *command*
sees if the cell under
the tape head holds
symbol.
- If so, nothing happens.
- If not, it executes
command.

Start:

```
If Blank Return True  
If 'b' Return False  
Write 'x'  
Move Right  
If Not 'b' Return False  
Write 'x'  
Move Right  
Goto Start
```

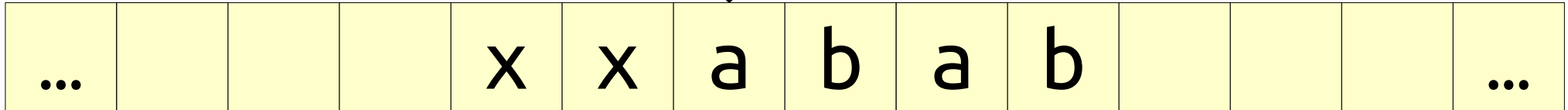
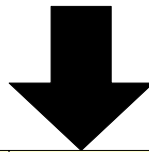


Turing Machines

- The command
Goto *label*
jumps to the indicated label.
- This program just has a Start label, but most interesting programs have other labels beyond this.

Start:

```
If Blank Return True  
If 'b' Return False  
Write 'x'  
Move Right  
If Not 'b' Return False  
Write 'x'  
Move Right  
Goto Start
```

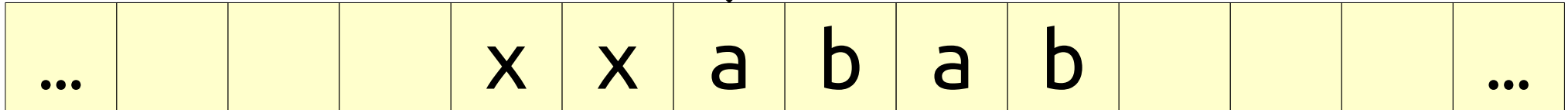
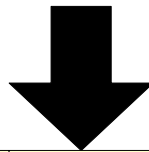


Turing Machines

- The command
Goto *label*
jumps to the indicated label.
- This program just has a Start label, but most interesting programs have other labels beyond this.

Start:

```
If Blank Return True  
If 'b' Return False  
Write 'x'  
Move Right  
If Not 'b' Return False  
Write 'x'  
Move Right  
Goto Start
```

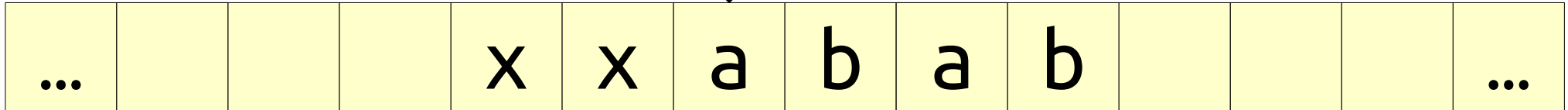
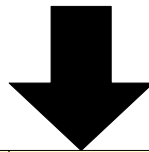


Turing Machines

- A TM stops when executing the
Return *result*
command.
- Here, *result* can be either True or False.
- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

```
If Blank Return True
If 'b' Return False
Write 'x'
Move Right
If Not 'b' Return False
Write 'x'
Move Right
Goto Start
```



Turing Machines

- A TM stops when executing the
Return *result*
command.
- Here, *result* can be either True or False.
- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

If Blank Return True

If 'b' Return False

Write 'x'

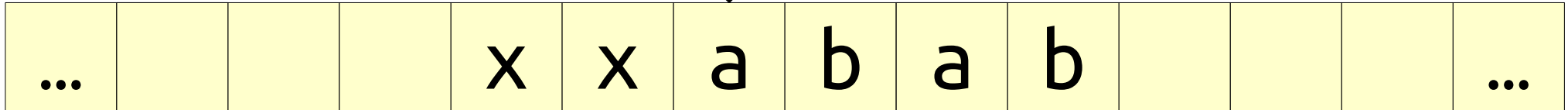
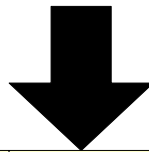
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A TM stops when executing the
Return *result*
command.
- Here, *result* can be either True or False.
- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

If Blank Return True

If 'b' Return False

Write 'x'

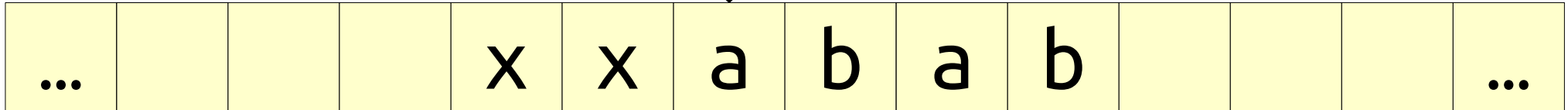
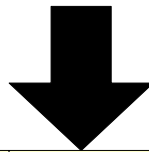
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



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Return *result*
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If Blank Return True

If 'b' Return False

Write 'x'

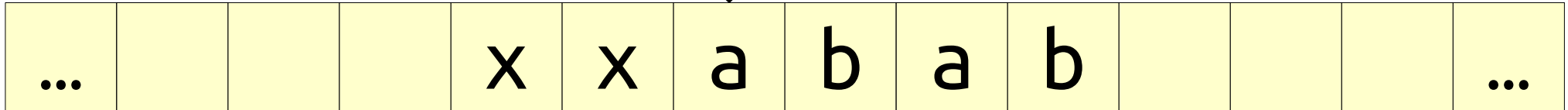
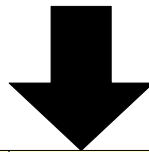
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A TM stops when executing the
Return *result*
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- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

If Blank Return True

If 'b' Return False

Write 'x'

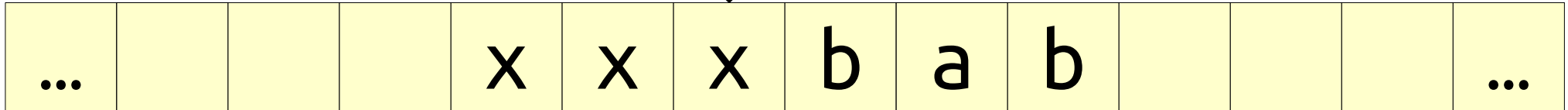
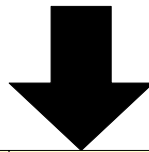
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A TM stops when executing the
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command.
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- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

If Blank Return True

If 'b' Return False

Write 'x'

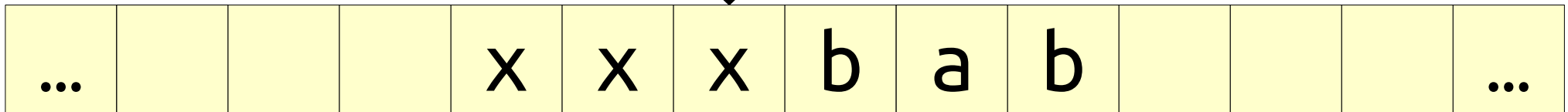
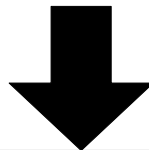
Move Right

If Not 'b' Return False

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Move Right

Goto Start



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- A TM stops when executing the
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- Here, *result* can be either True or False.
- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

If Blank Return True

If 'b' Return False

Write 'x'

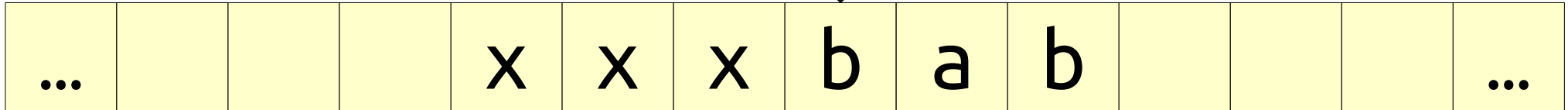
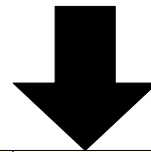
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



Turing Machines

- A TM stops when executing the
Return *result*
command.
- Here, *result* can be either True or False.
- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

If Blank Return True

If 'b' Return False

Write 'x'

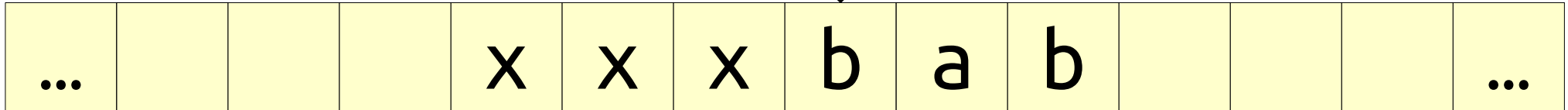
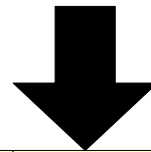
Move Right

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Goto Start



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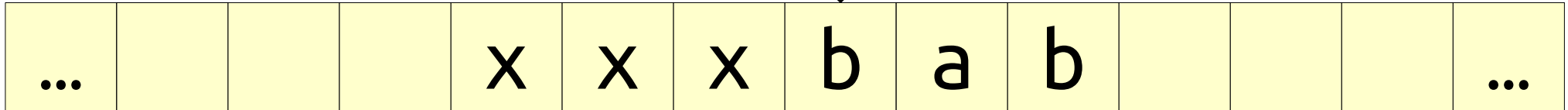
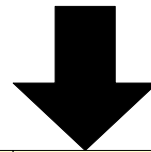
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



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command.
- Here, *result* can be either True or False.
- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

Start:

If Blank Return True

If 'b' Return False

Write 'x'

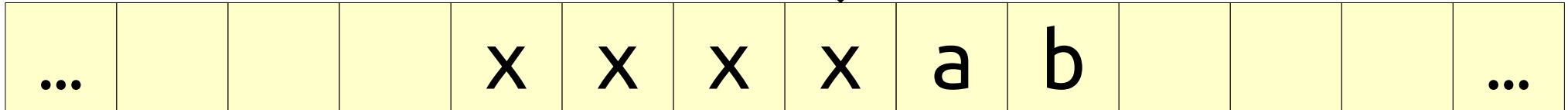
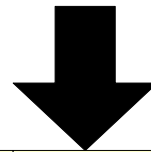
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



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Return *result*
command.
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- (If we “fall off” the bottom of the program, the TM acts as though it executes the Return False command.)

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If Blank Return True

If 'b' Return False

Write 'x'

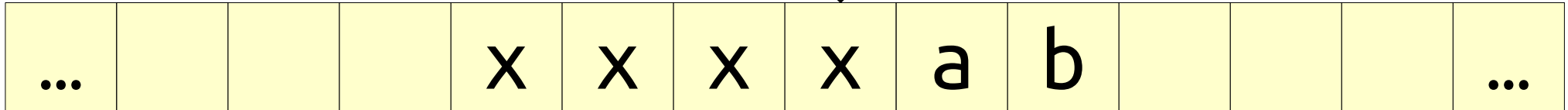
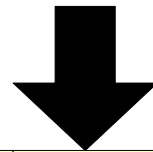
Move Right

If Not 'b' Return False

Write 'x'

Move Right

Goto Start



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Write 'x'

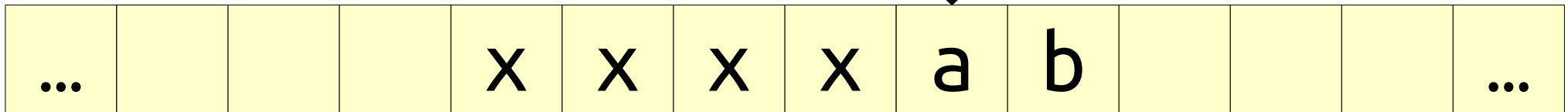
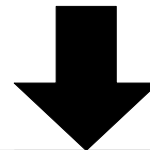
Move Right

If Not 'b' Return False

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Move Right

Goto Start

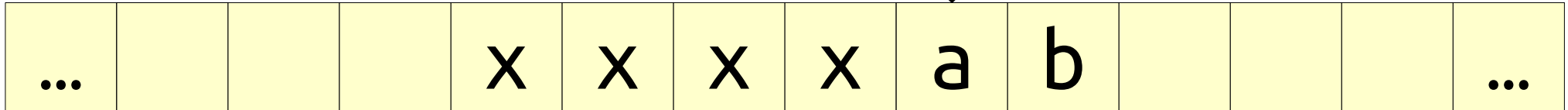
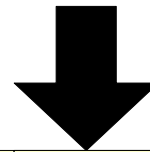


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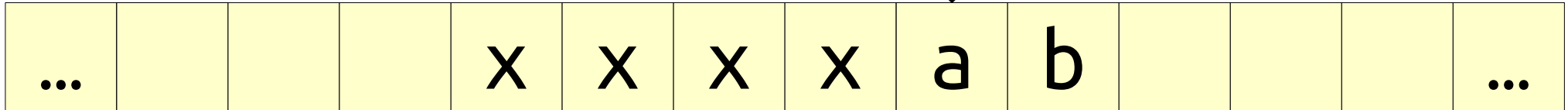
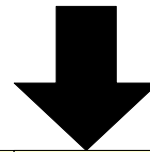


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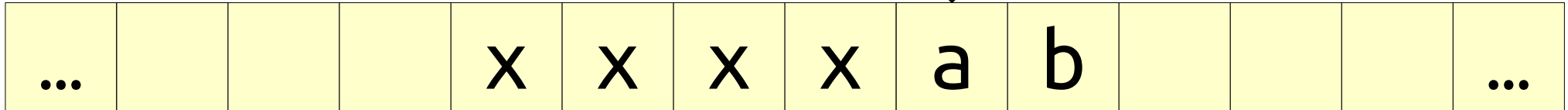
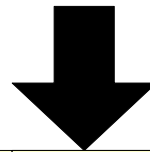
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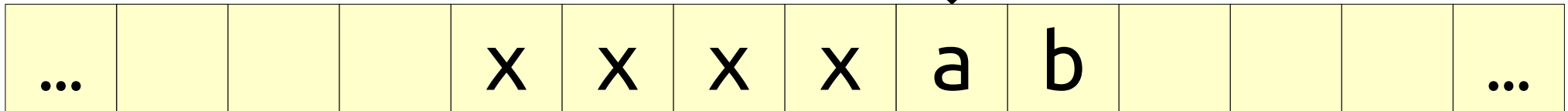
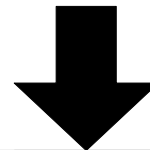
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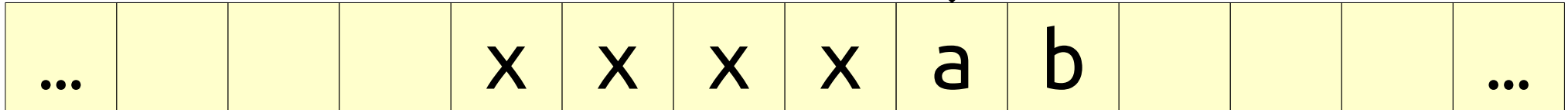
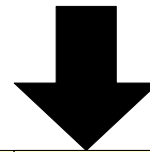
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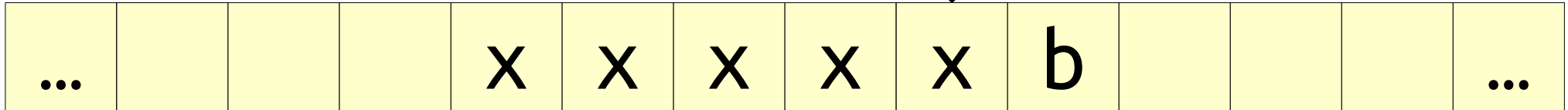
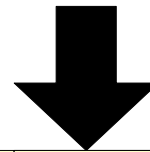
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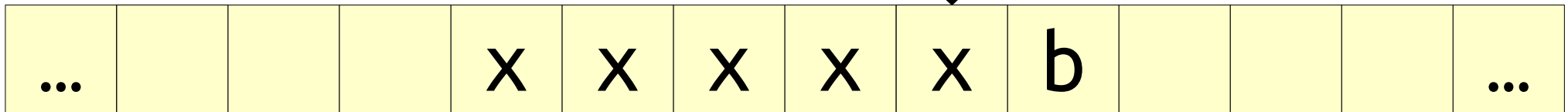
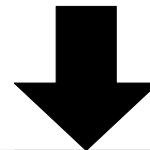
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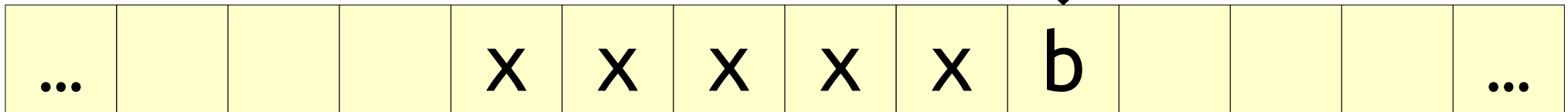
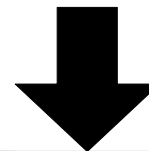
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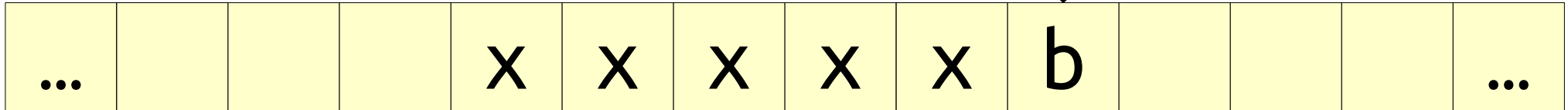
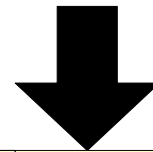
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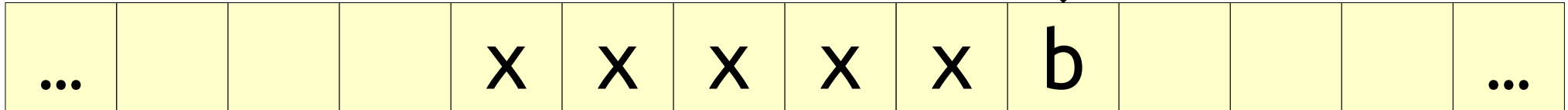
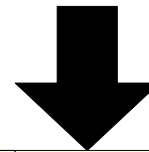
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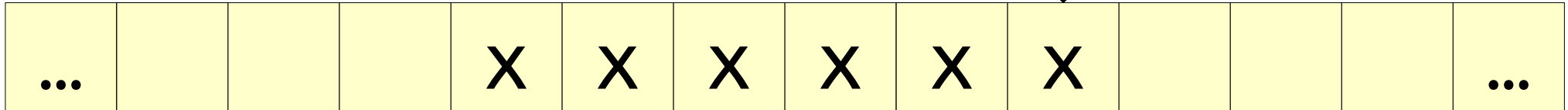
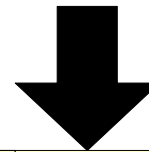
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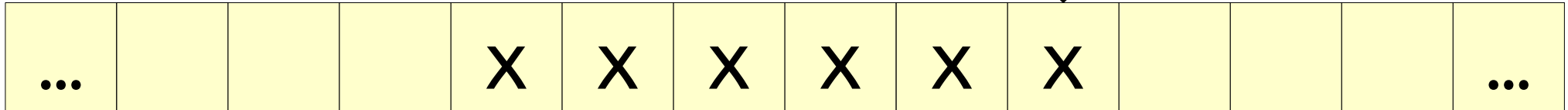
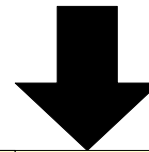
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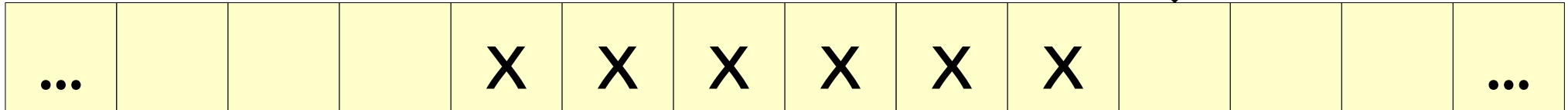
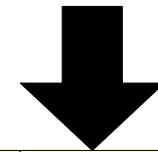
Move Right

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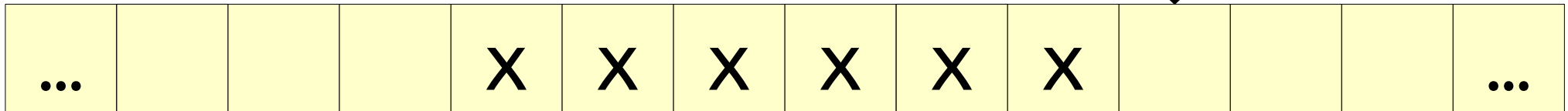
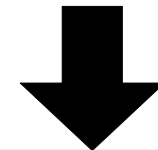


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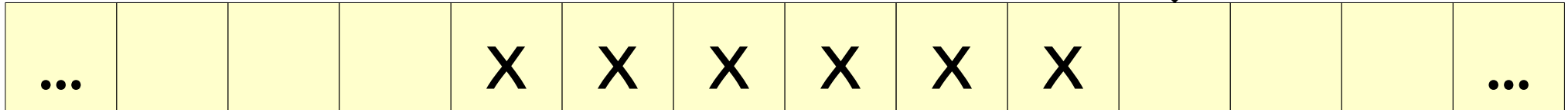
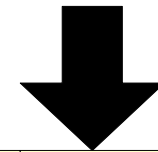


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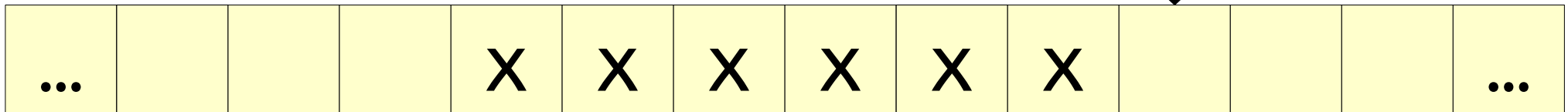
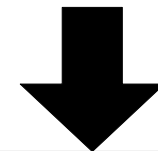
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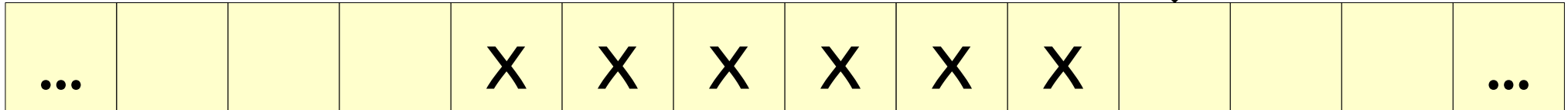
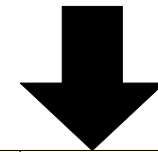
Move Right

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Move Right

Goto Start



Turing Machines

- This TM initially started up with the string ababab on its tape, so this means that TM returns true on the input ababab, not xxxxxx.
- An intuition for this: we gave this program an input. It therefore returned true with respect to that input, not whatever internal data it generated in making its decision.

Start:

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Write 'x'

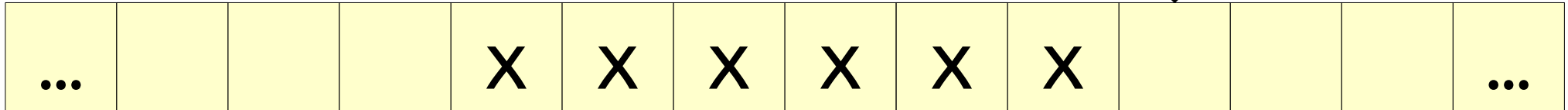
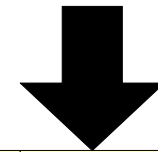
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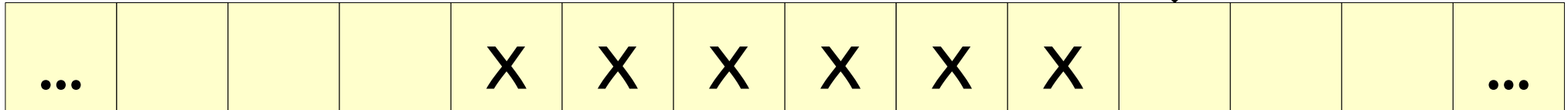
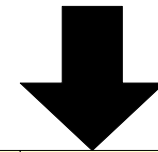


Turing Machines

- To summarize, we only have six commands:
 - Move *direction*
 - Write *symbol*
 - Goto *label*
 - Return *result*
 - If *symbol command*
 - If Not *symbol command*
- Despite their simplicity, TMs are *surprisingly* powerful. The rest of this lecture explores why.

Start:

```
If Blank Return True
If 'b' Return False
Write 'x'
Move Right
If Not 'b' Return False
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Move Right
Goto Start
```

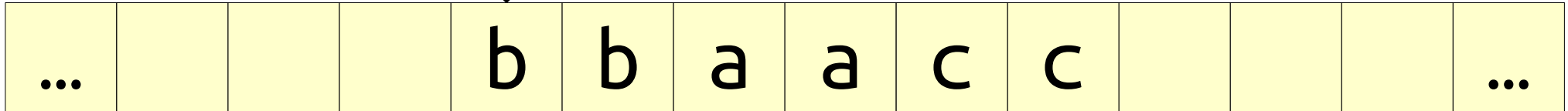
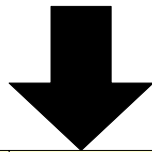


Your Turn!

- Does this TM accept or reject bbaacc?
- More generally, what does this TM do?

Answer at

<https://cs103.stanford.edu/pollev>



Start:

If 'a' Goto Mirth

If Blank Return False

Move Right

Goto Start

Mirth:

If 'b' Return True

If Blank Return False

Move Right

Goto Mirth

Programming Turing Machines

Our First Challenge

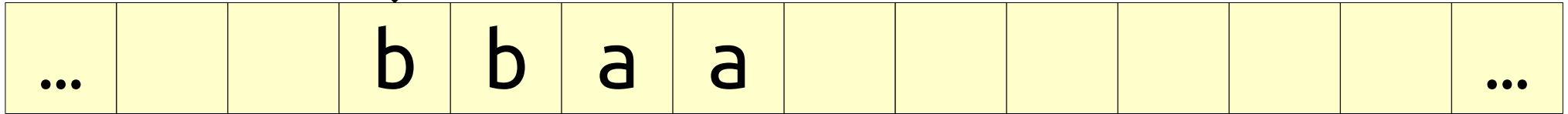
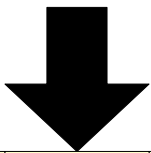
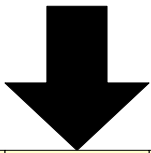
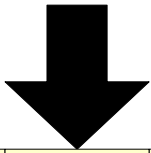
- The language

$$\{ \mathbf{a}^n \mathbf{b}^n \mid n \in \mathbb{N} \}$$

is a canonical example of a nonregular language. It's not possible to check if a string is in this language given only finite memory.

- Turing machines, however, are powerful enough to do this. Let's see how.

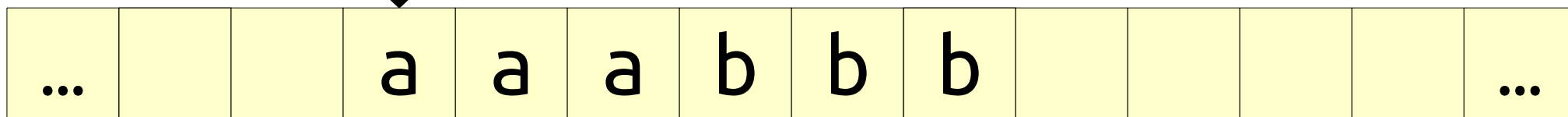
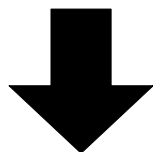
$$L = \{ \mathbf{a}^n \mathbf{b}^n \mid n \in \mathbb{N} \}$$



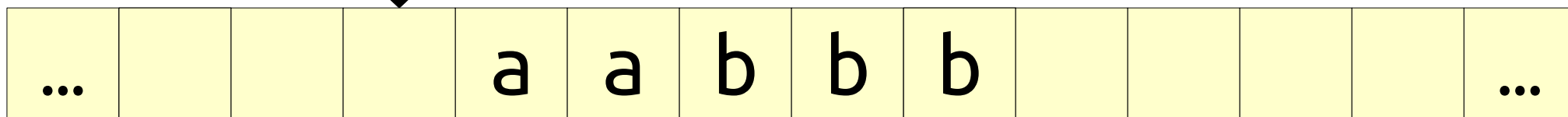
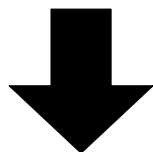
A Recursive Approach

- We can process our string using this recursive approach:
 - The string ε is in L .
 - The string **a** w **b** is in L if and only if w is in L .
 - Any string starting with **b** is not in L .
 - Any string ending with **a** is not in L .
- All that's left to do now is write a TM that implements this.

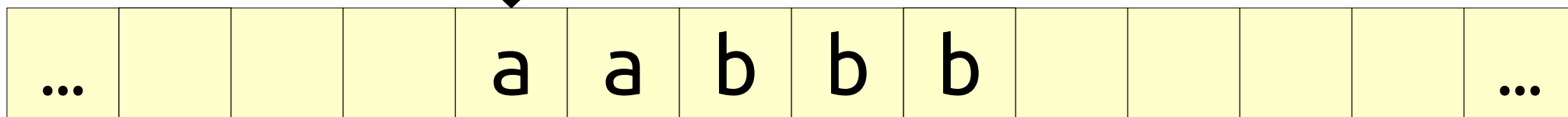
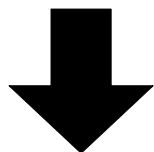
A Sketch of our TM



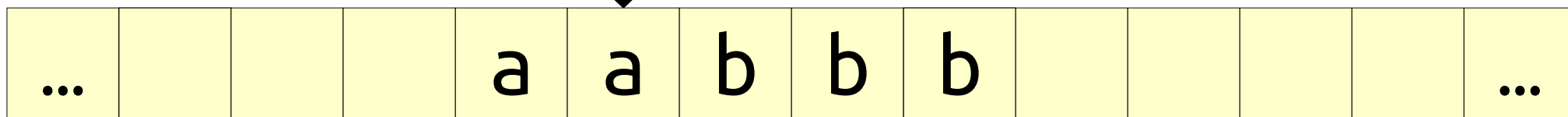
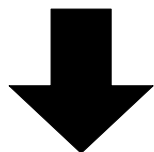
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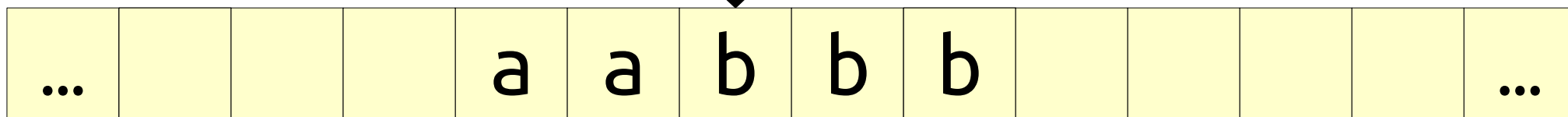
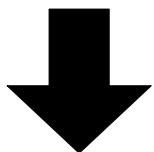
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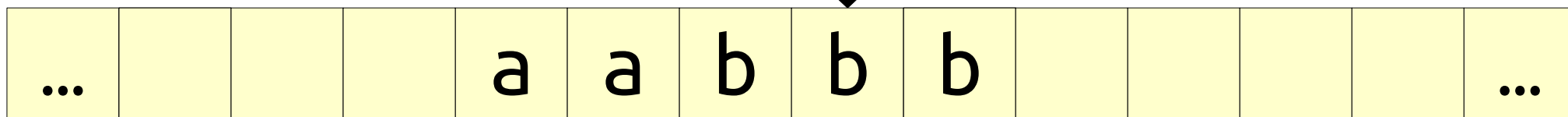
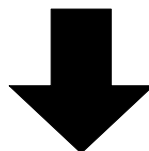
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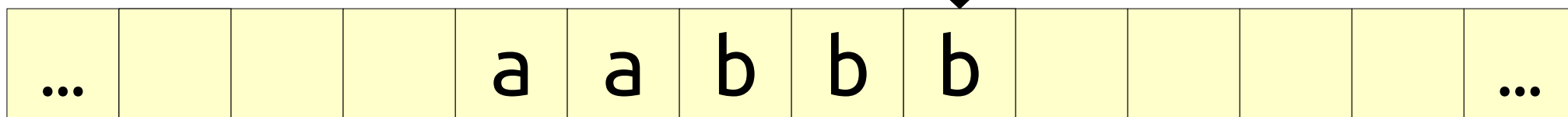
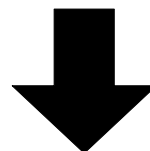
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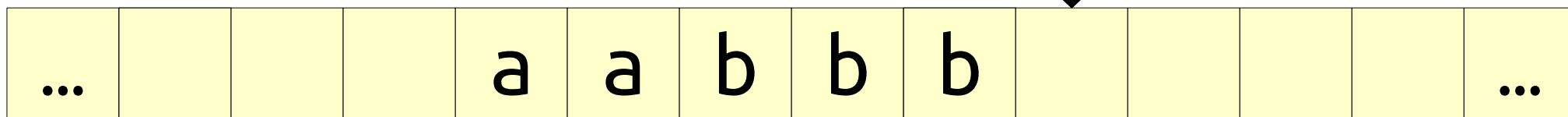
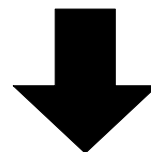
A Sketch of our TM



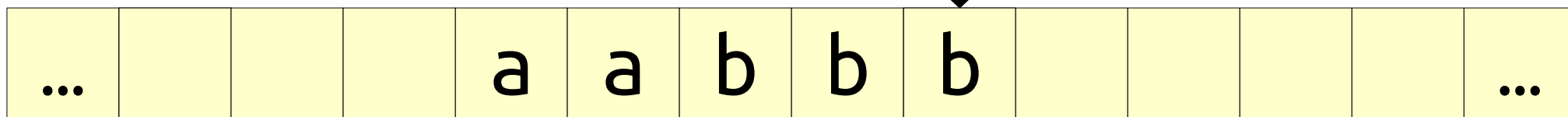
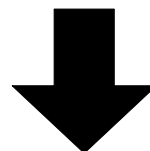
A Sketch of our TM



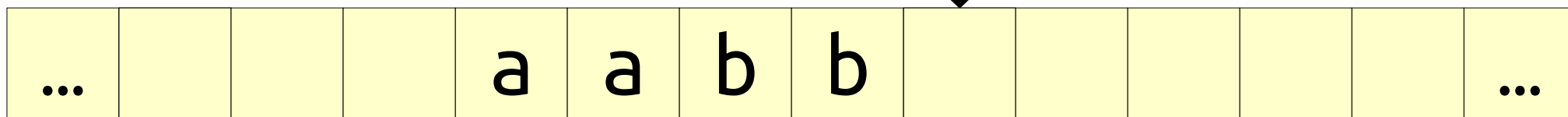
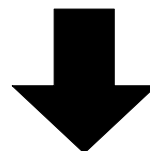
A Sketch of our TM



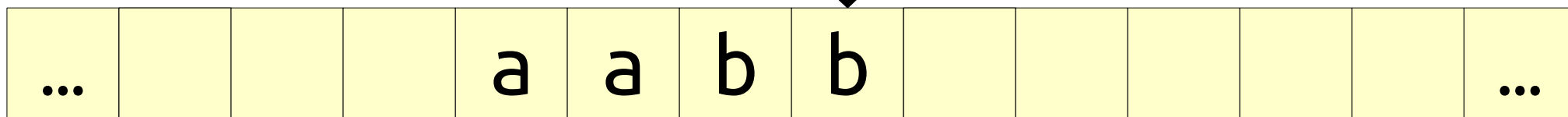
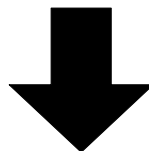
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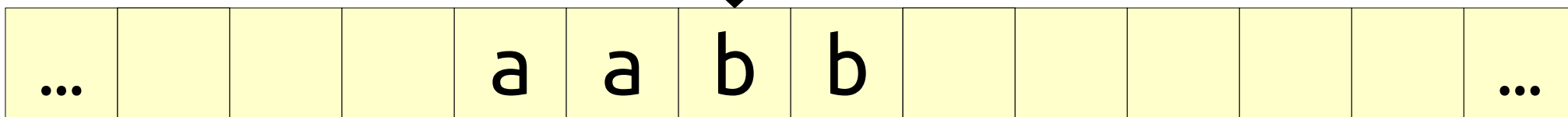
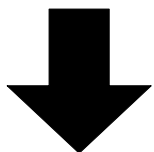
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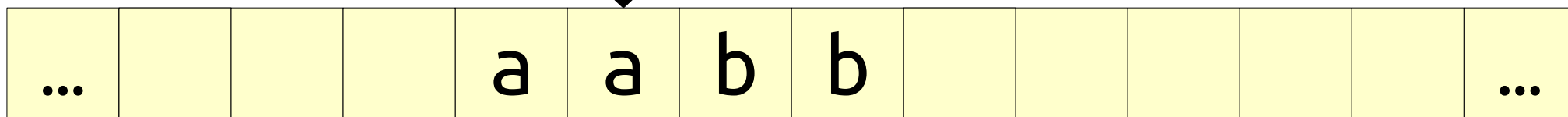
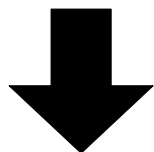
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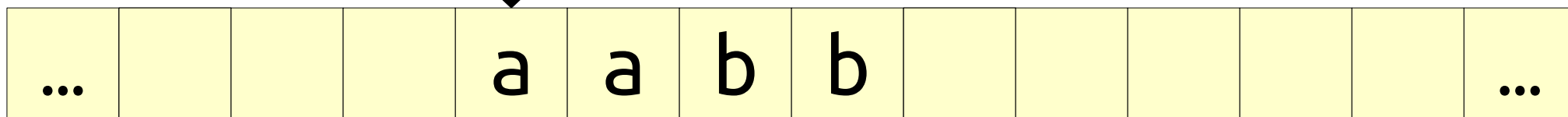
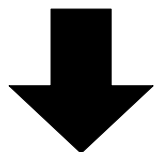
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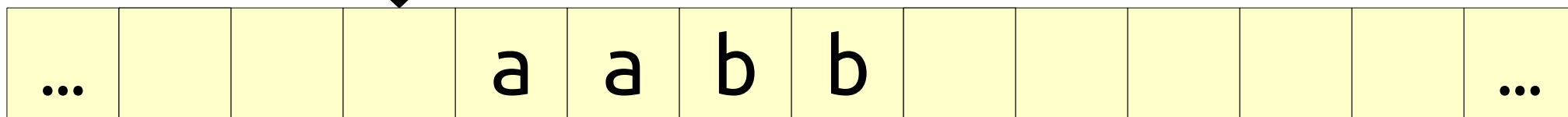
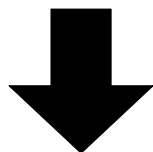
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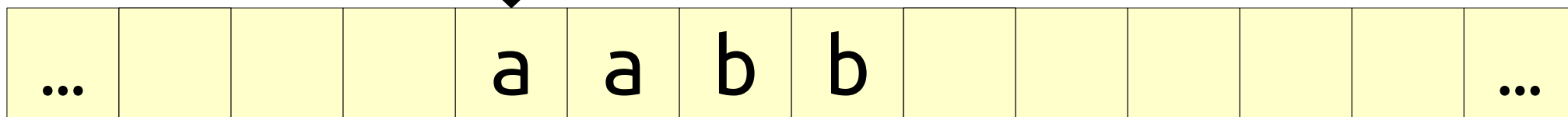
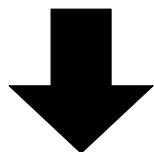
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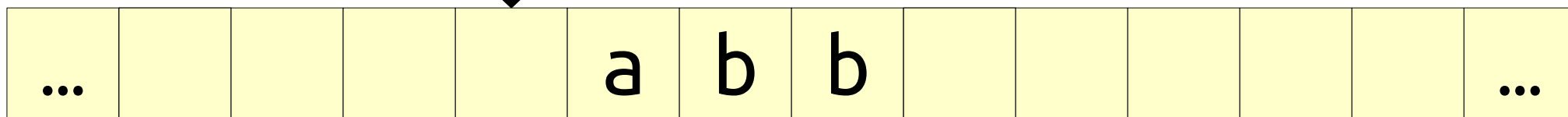
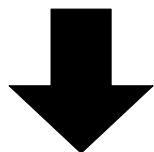
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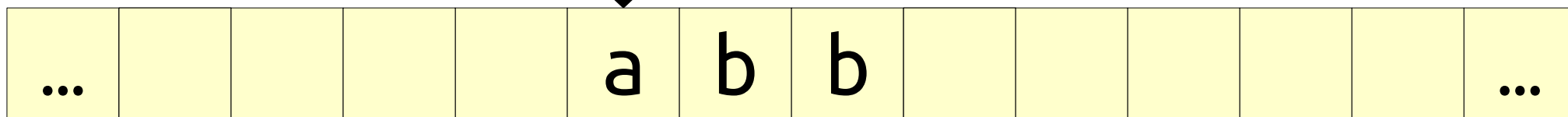
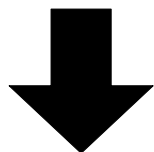
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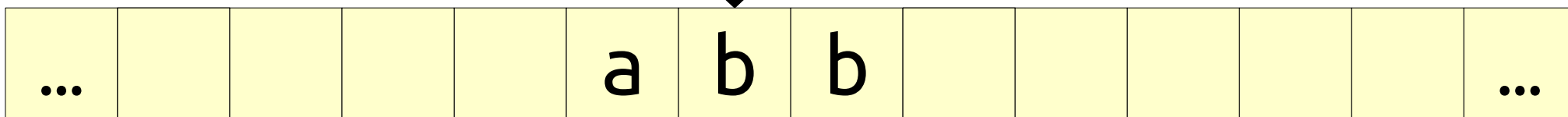
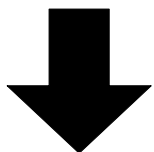
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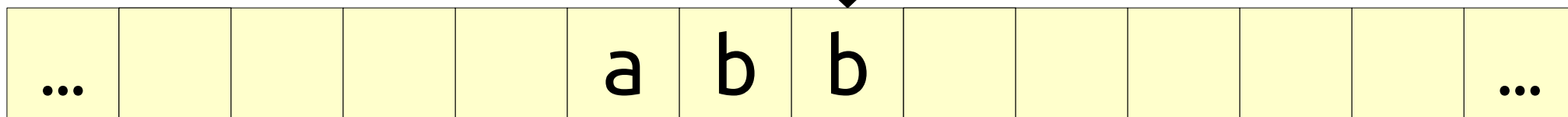
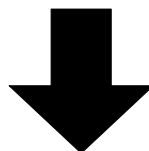
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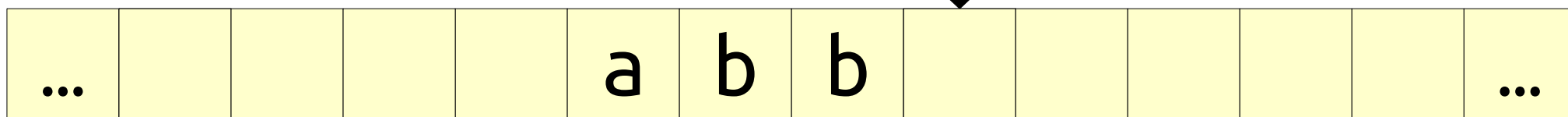
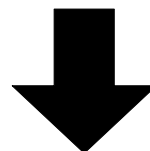
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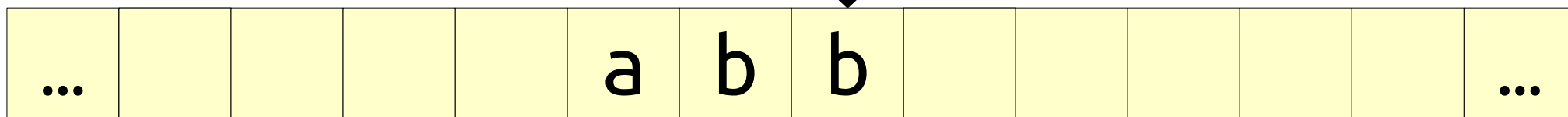
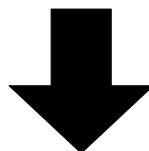
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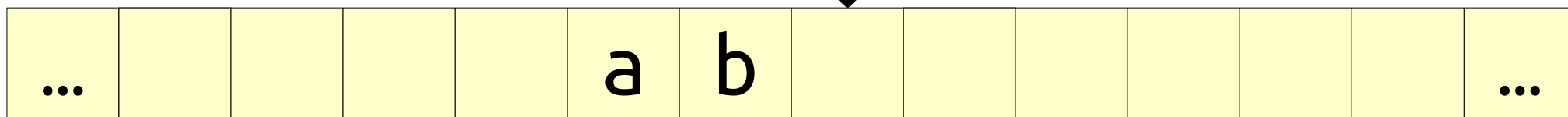
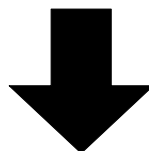
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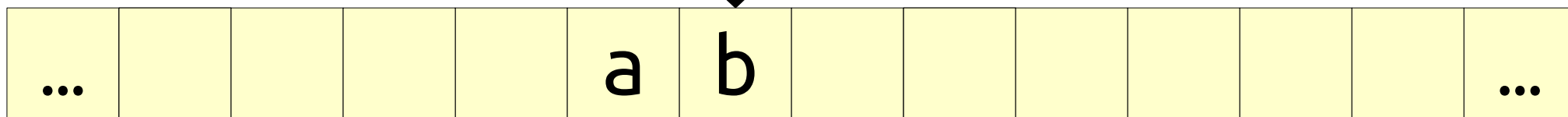
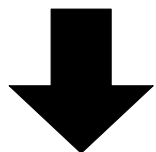
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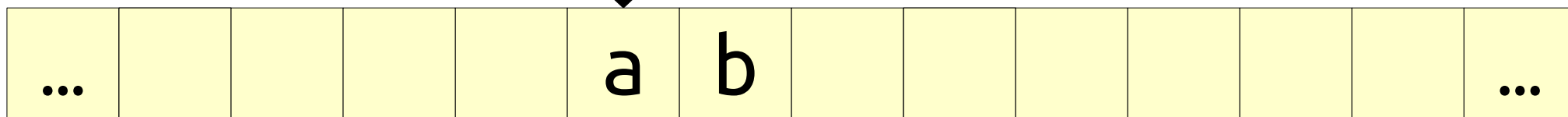
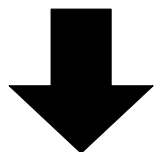
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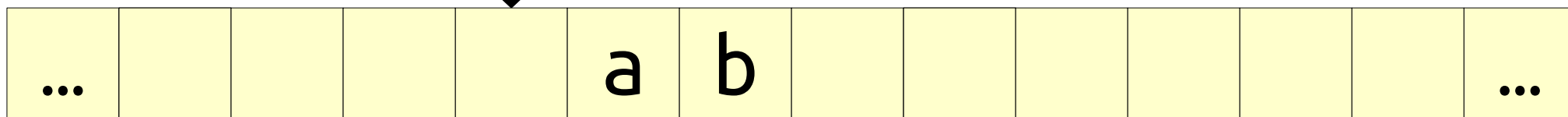
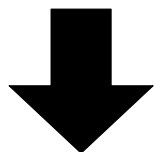
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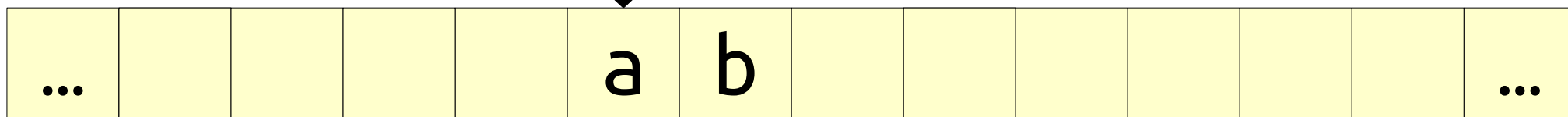
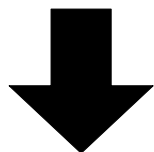
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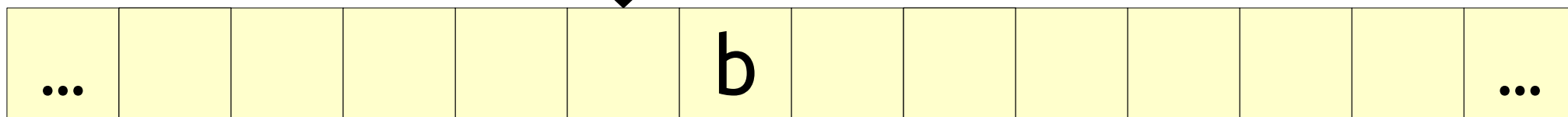
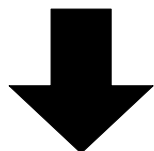
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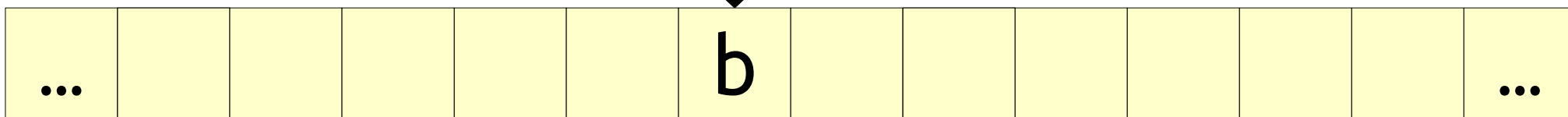
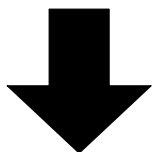
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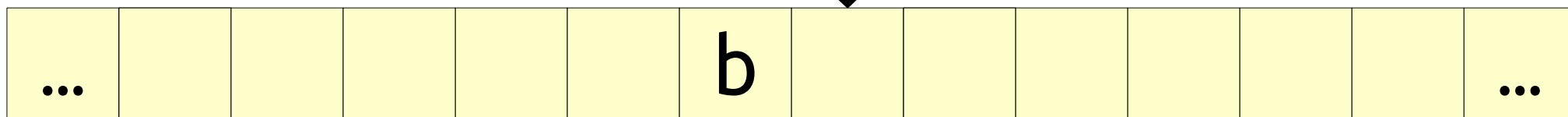
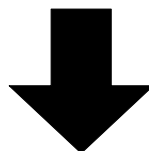
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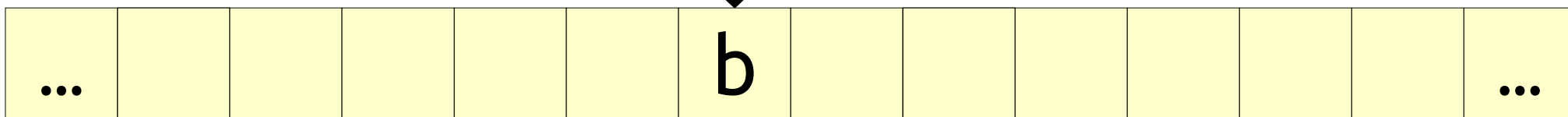
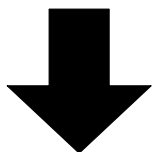
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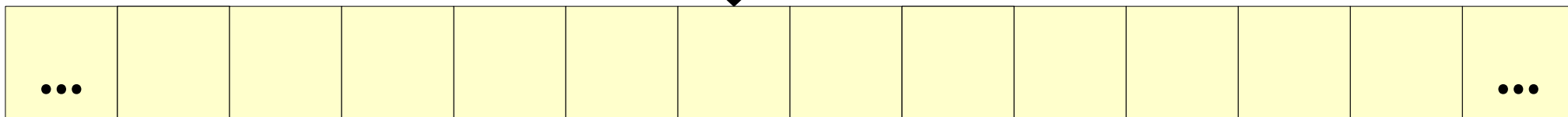
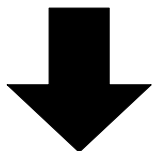
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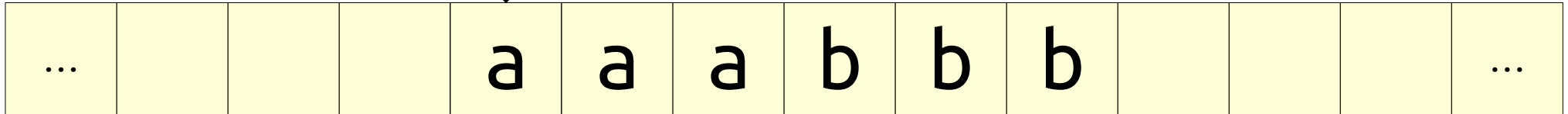
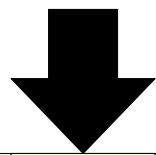


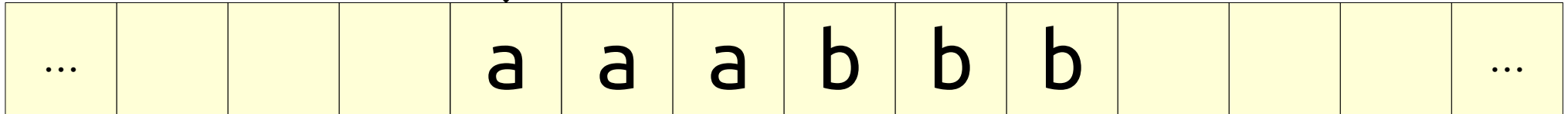
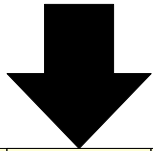
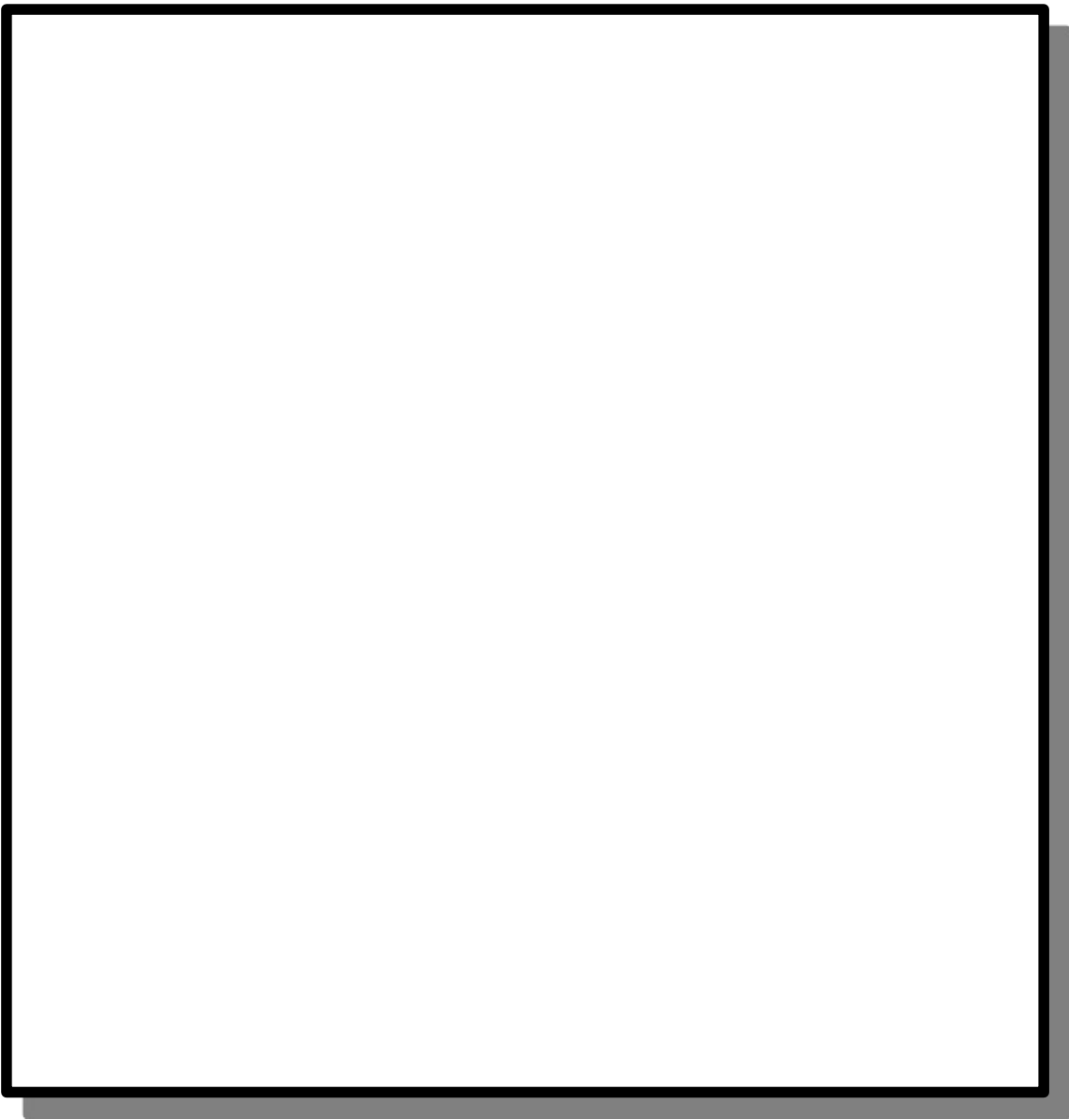
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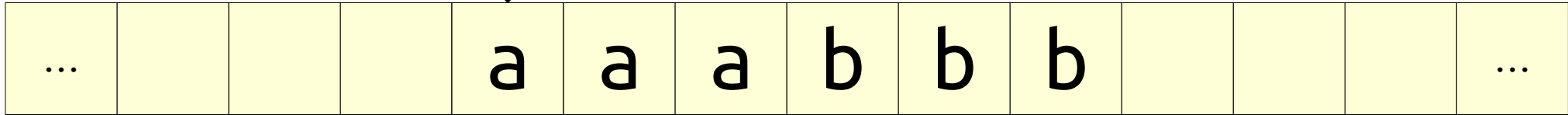
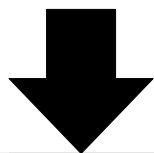
A Sketch of our TM



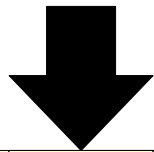




Start:



Start:



...

a

a

a

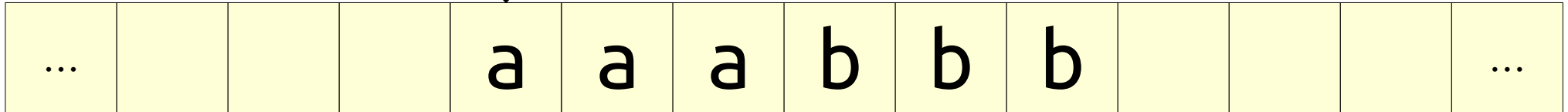
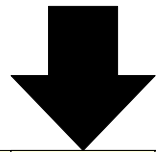
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b

b

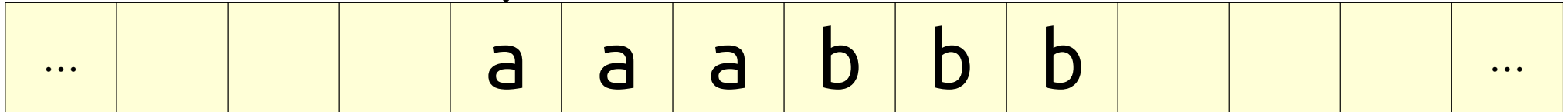
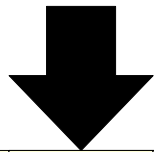
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Start:

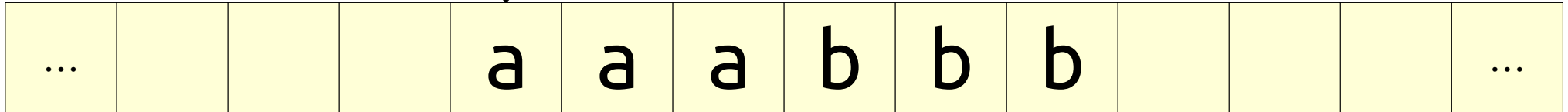
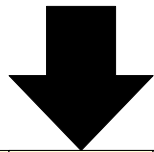


Start:

If Blank Return True



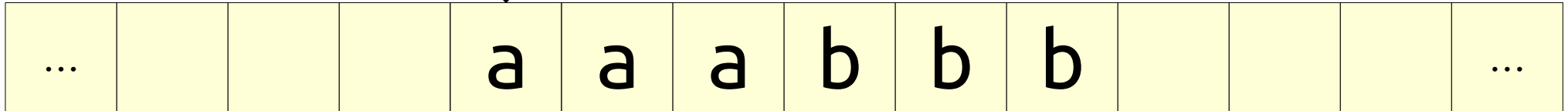
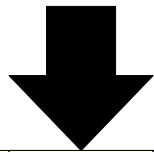
Start:
If Blank Return True



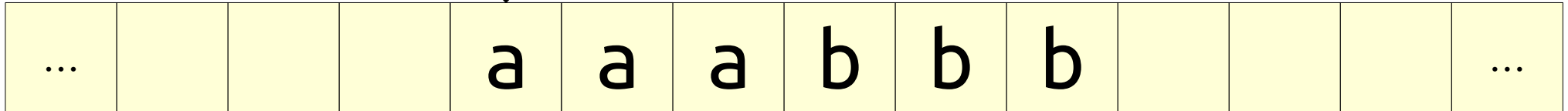
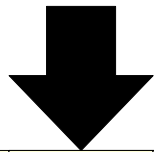
Start:

If Blank Return True

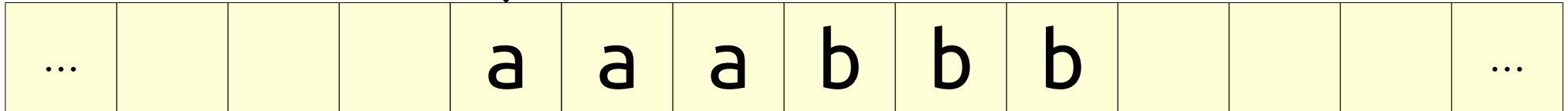
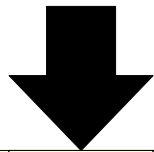
If 'b' Return False



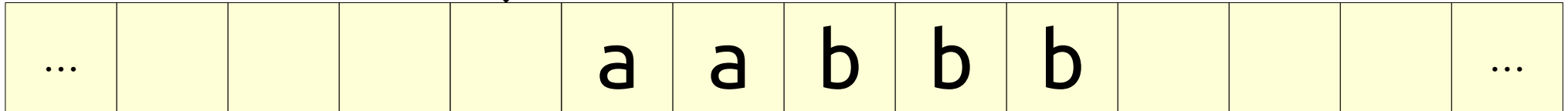
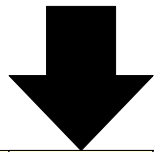
Start:
If Blank Return True
If 'b' Return False



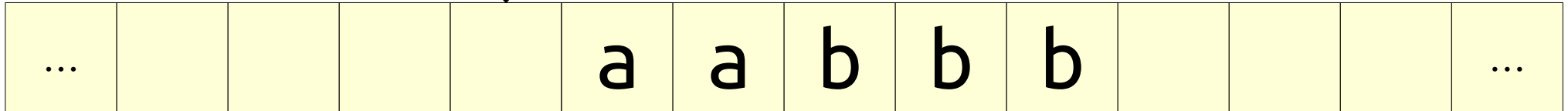
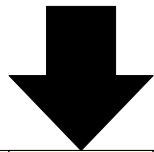
Start:
If Blank Return True
If 'b' Return False
Write Blank



Start:
If Blank Return True
If 'b' Return False
Write Blank

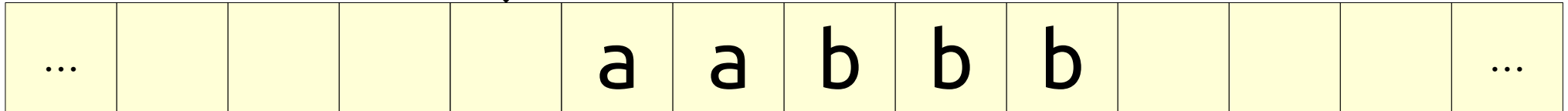
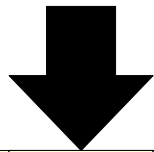


Start:
If Blank Return True
If 'b' Return False
Write Blank



```
Start:  
  If Blank Return True  
  If 'b' Return False  
  Write Blank
```

ZipRight:



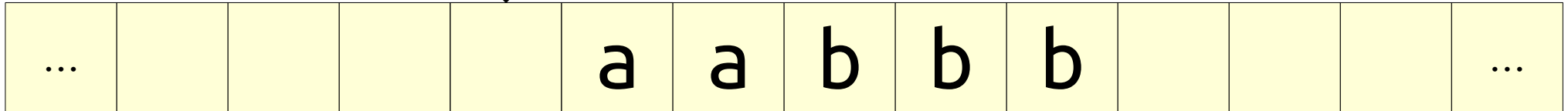
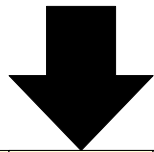
Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:



Start:

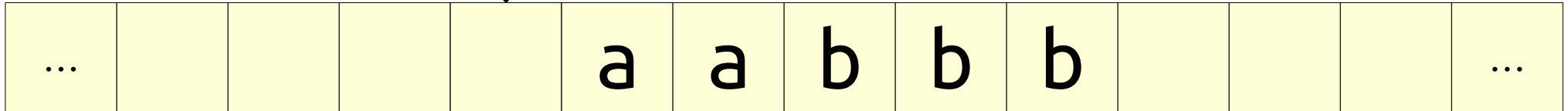
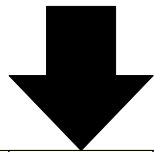
If Blank Return True

If 'b' Return False

Write Blank

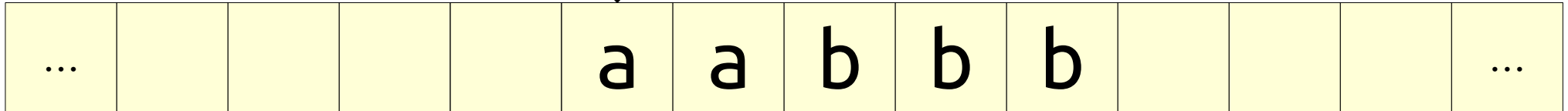
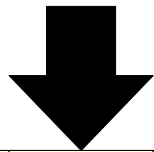
ZipRight:

Move Right



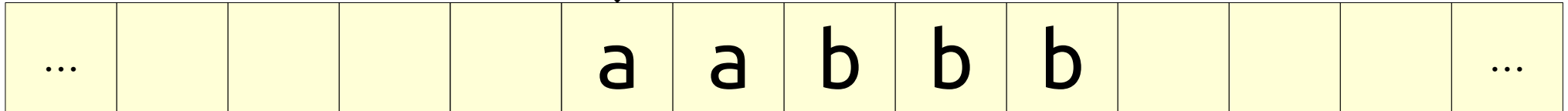
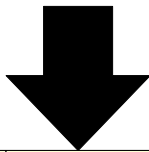
```
Start:  
  If Blank Return True  
  If 'b' Return False  
  Write Blank
```

```
ZipRight:  
  Move Right
```



```
Start:  
  If Blank Return True  
  If 'b' Return False  
  Write Blank
```

```
ZipRight:  
  Move Right
```



Start:

If Blank Return True

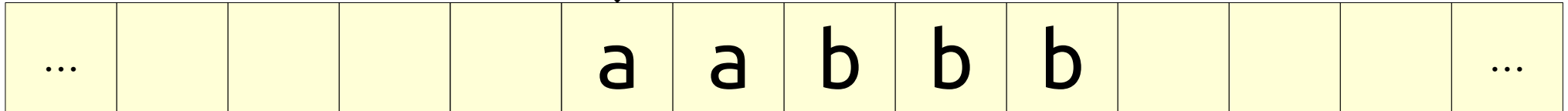
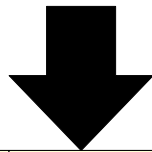
If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight



Start:

If Blank Return True

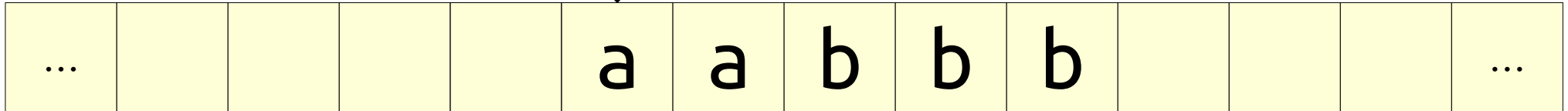
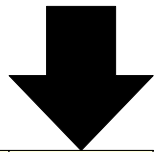
If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight



Start:

If Blank Return True

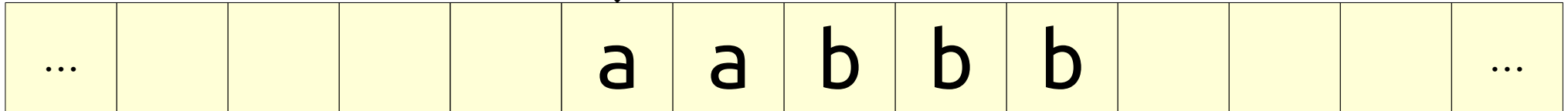
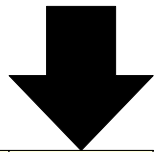
If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight



Start:

If Blank Return True

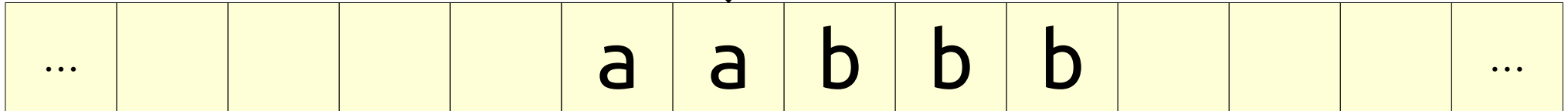
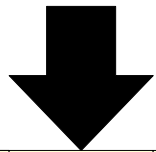
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Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight



Start:

If Blank Return True

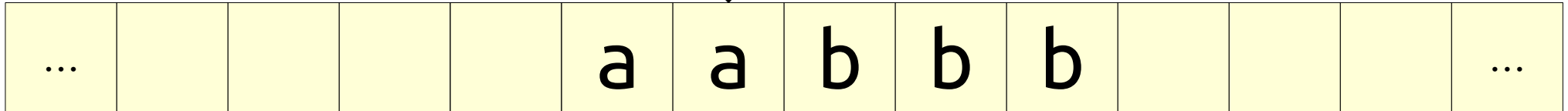
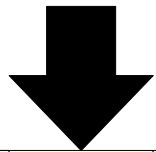
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Move Right

If Not Blank Goto ZipRight



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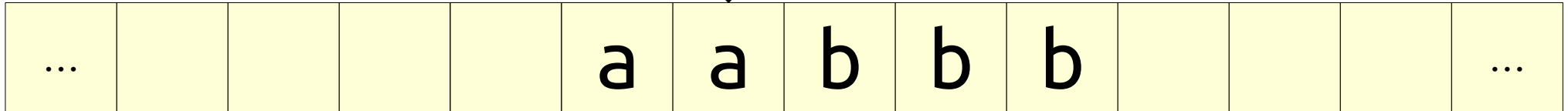
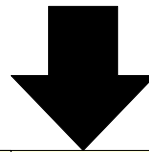
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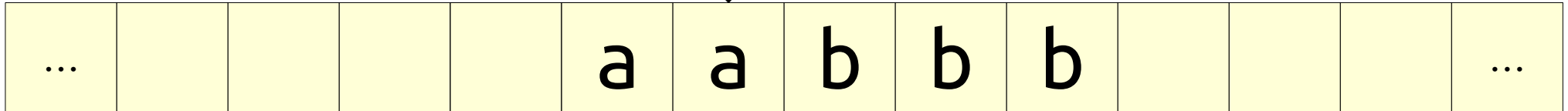
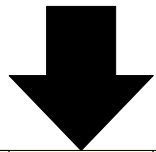
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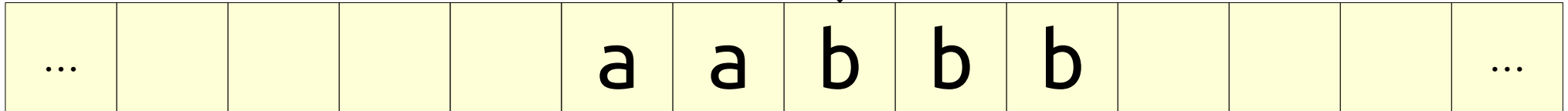
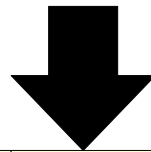
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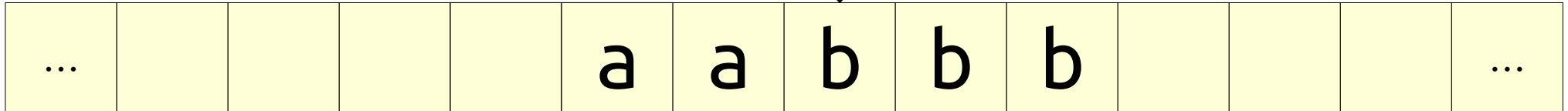
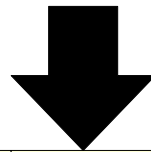
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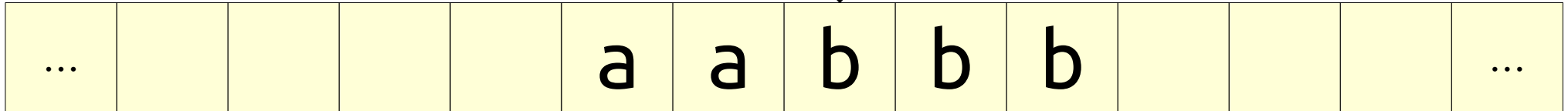
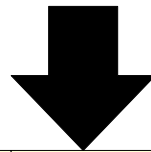
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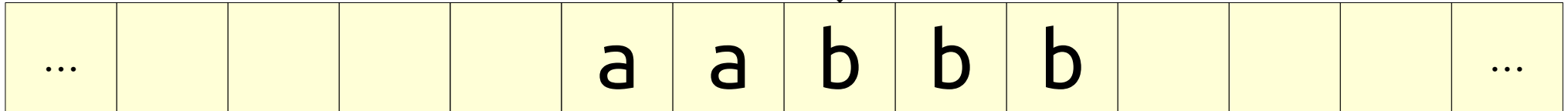
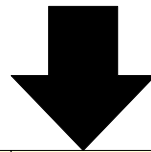
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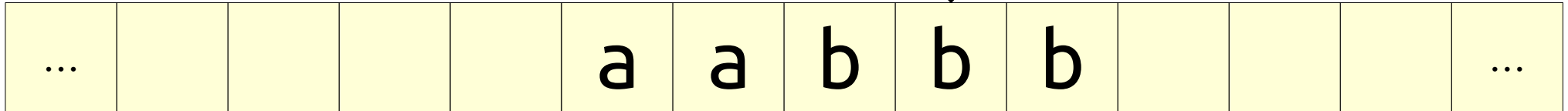
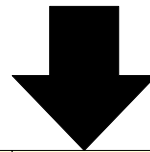
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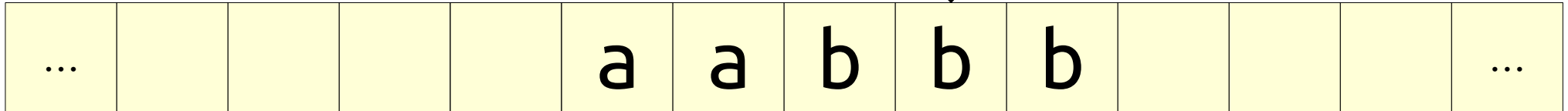
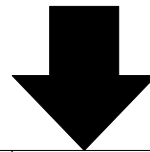
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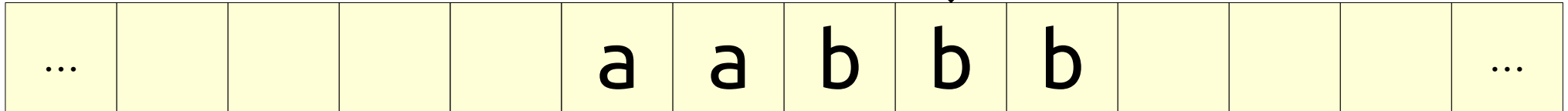
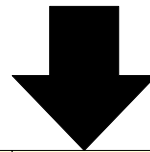
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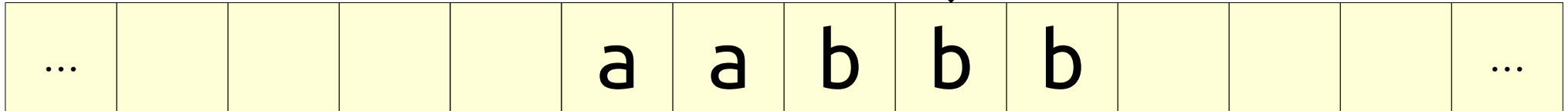
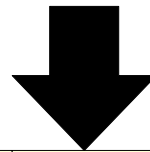
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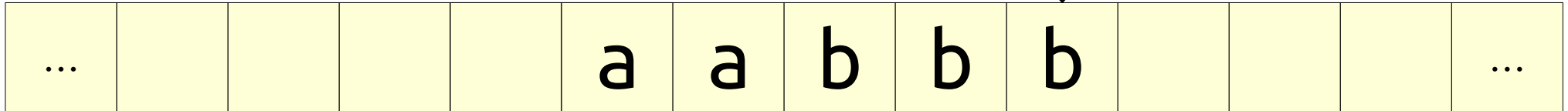
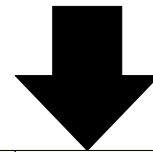
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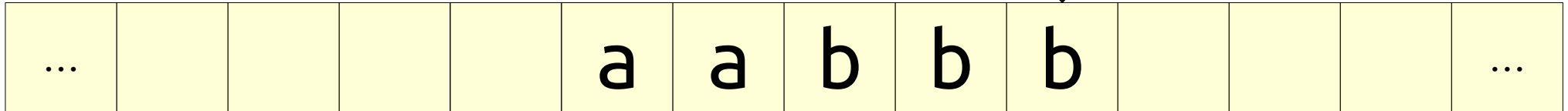
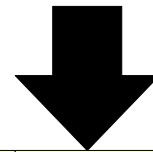
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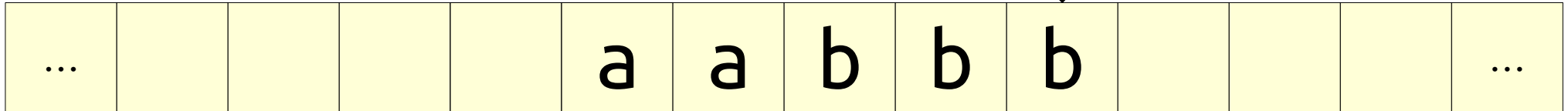
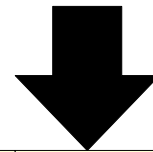
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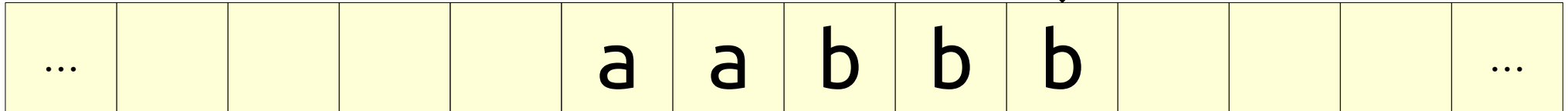
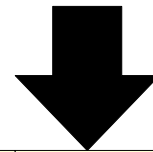
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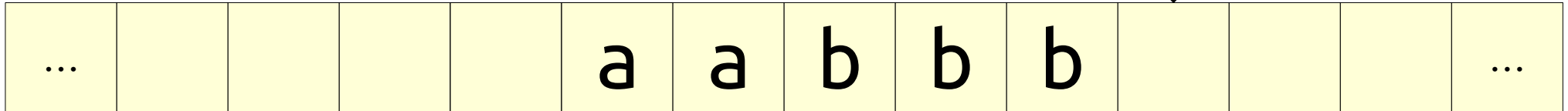
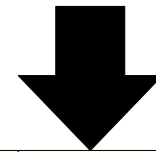
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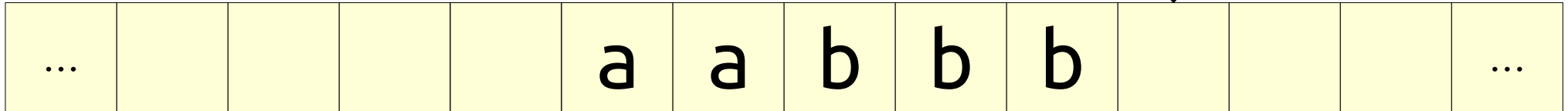
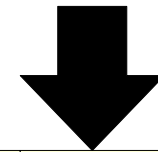
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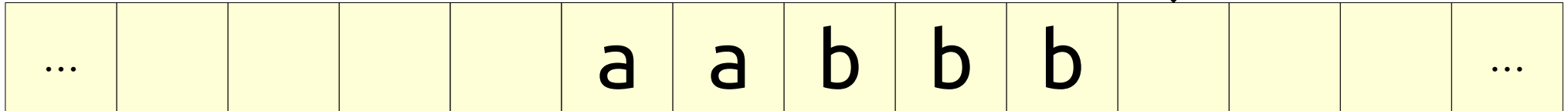
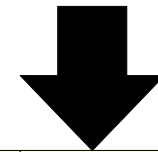
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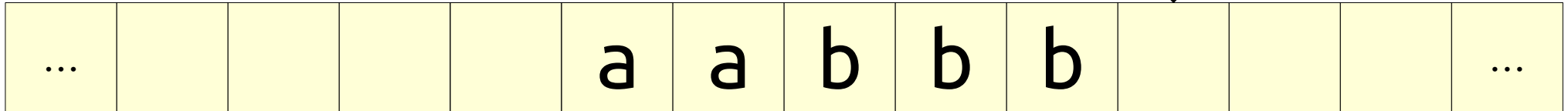
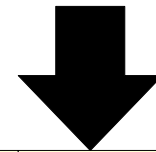
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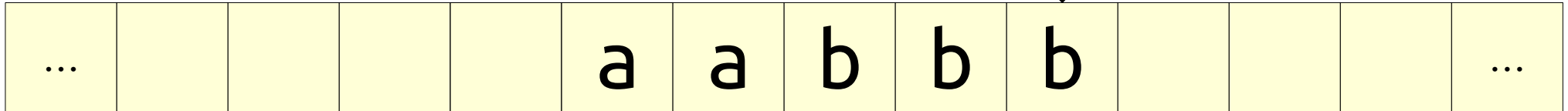
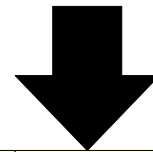
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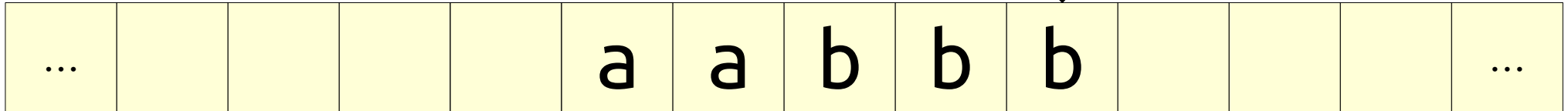
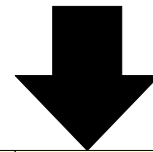
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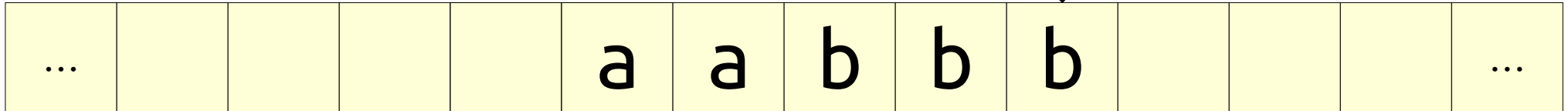
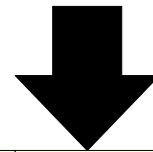
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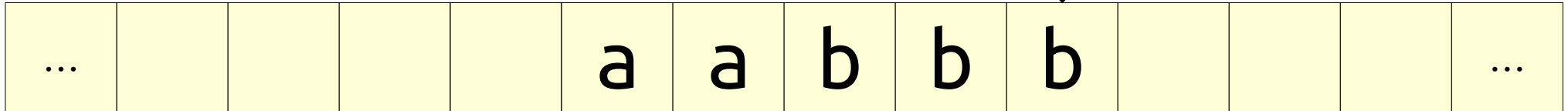
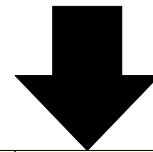
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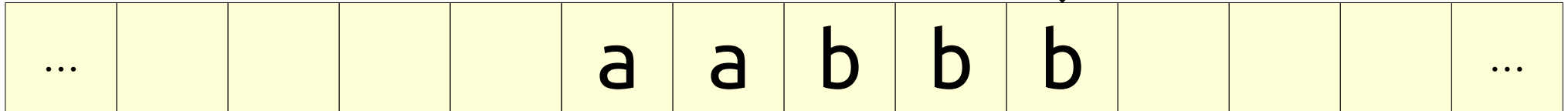
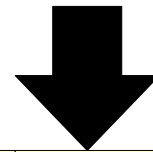
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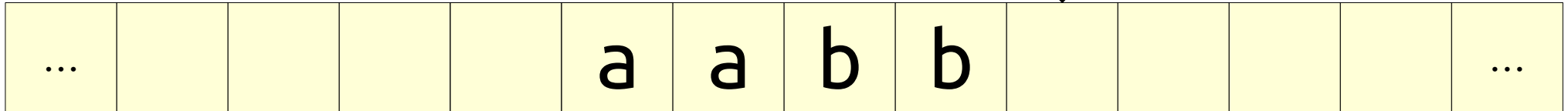
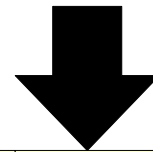
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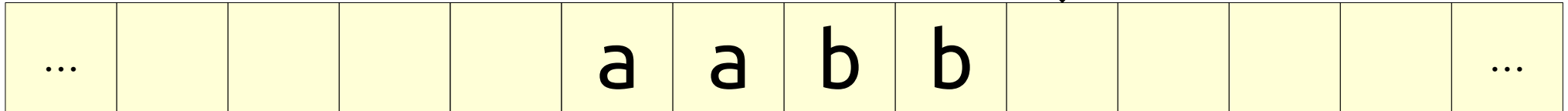
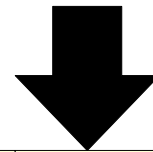
Move Right

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Move Left

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Start:

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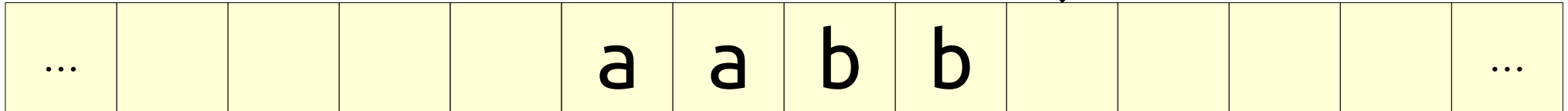
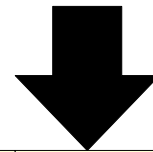
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If Not Blank Goto ZipLeft



Start:

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Move Left

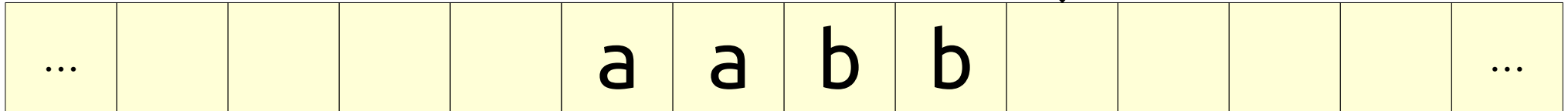
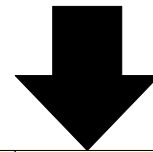
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If Not Blank Goto ZipLeft



Start:

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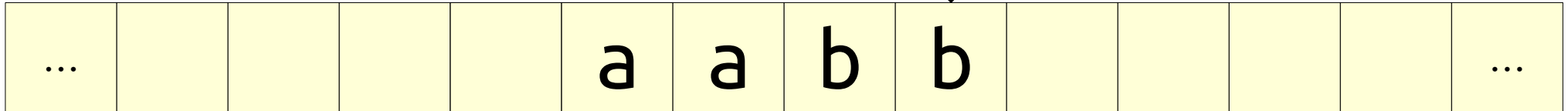
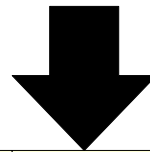
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If Not Blank Goto ZipLeft



Start:

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If Not Blank Goto ZipRight

Move Left

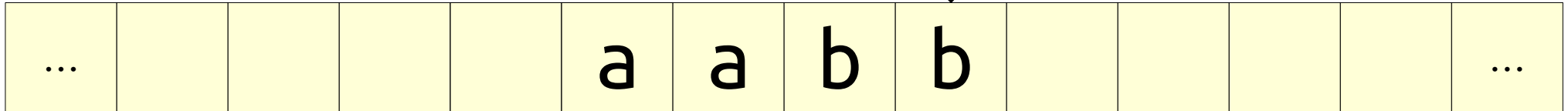
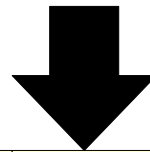
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If Not Blank Goto ZipLeft



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Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

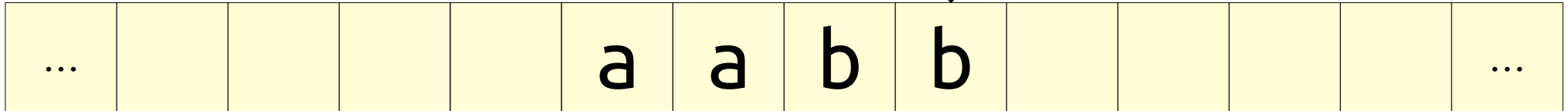
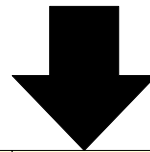
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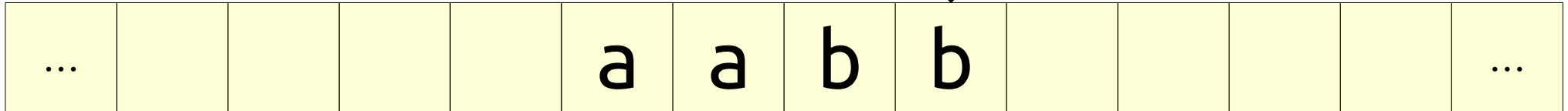
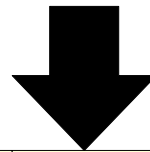
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Start:

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Move Left

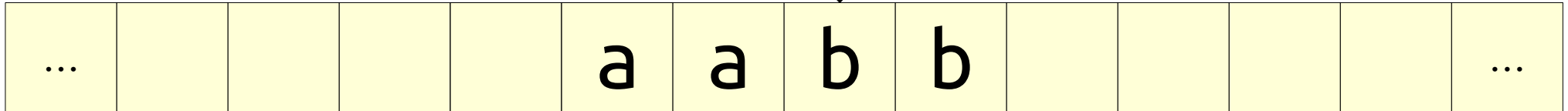
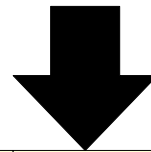
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If Not Blank Goto ZipLeft



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Move Left

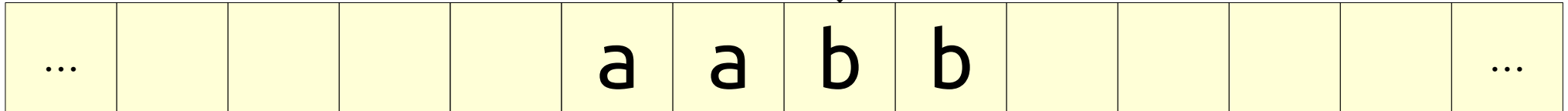
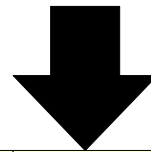
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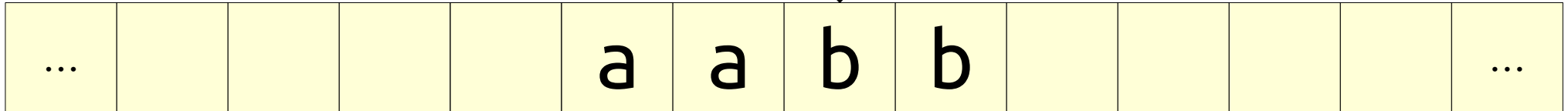
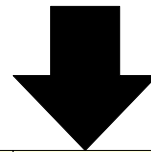
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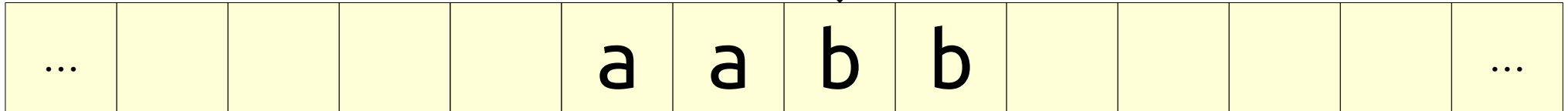
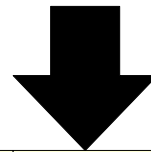
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

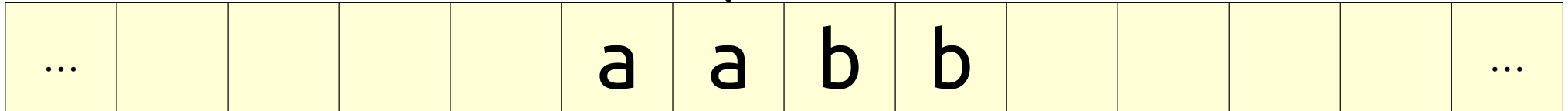
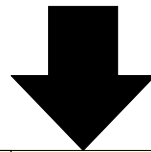
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

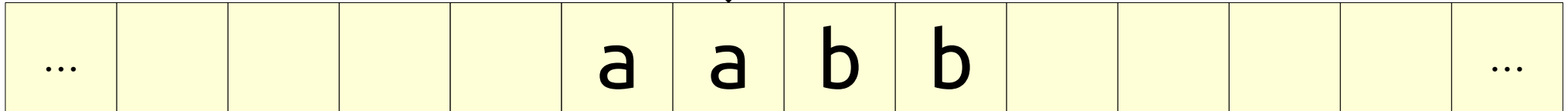
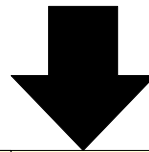
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

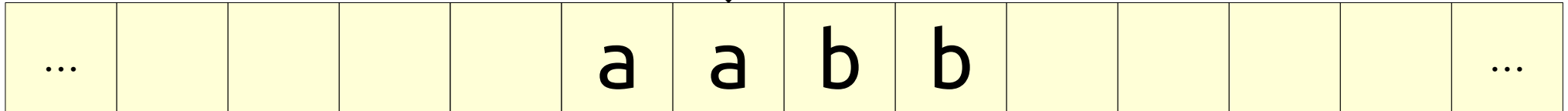
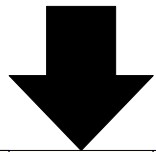
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Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

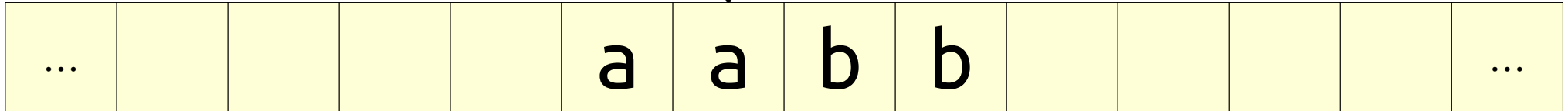
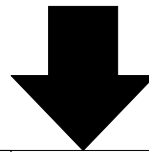
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

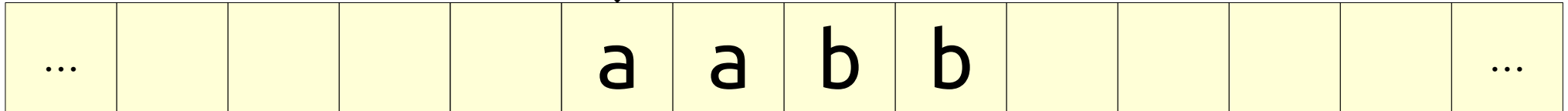
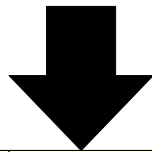
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

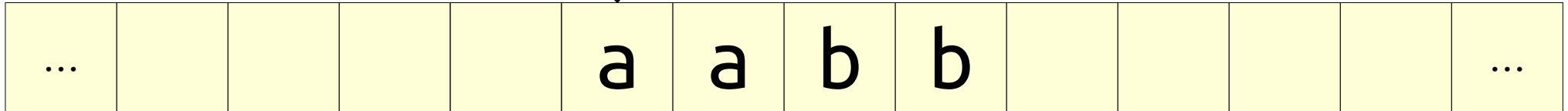
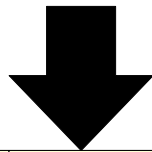
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

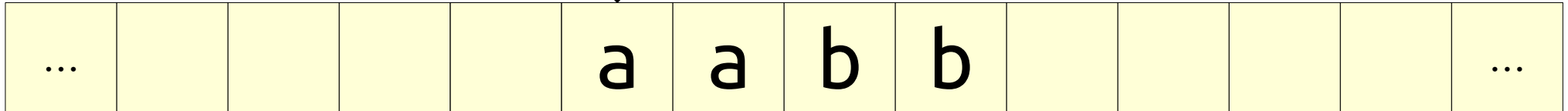
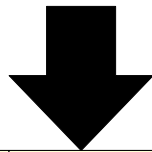
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Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

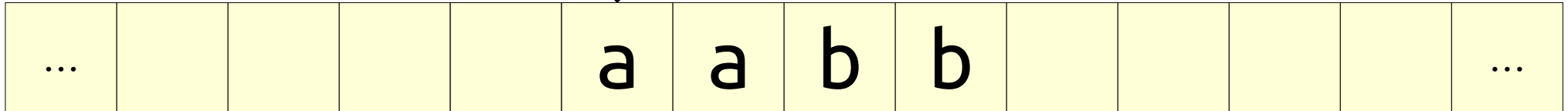
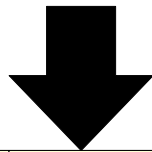
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ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

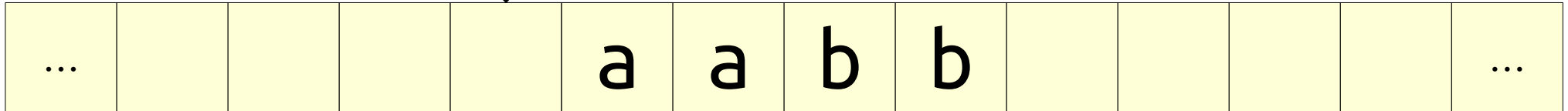
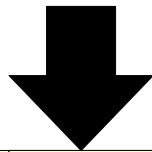
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

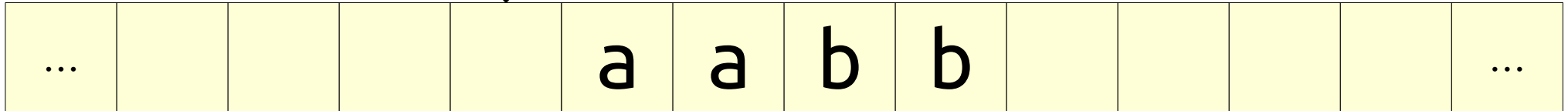
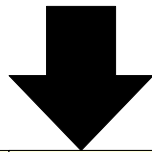
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

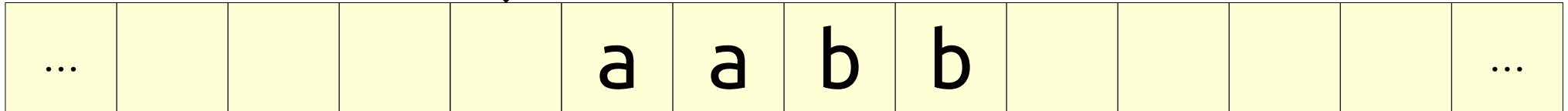
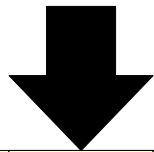
If Not 'b' Return False

Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

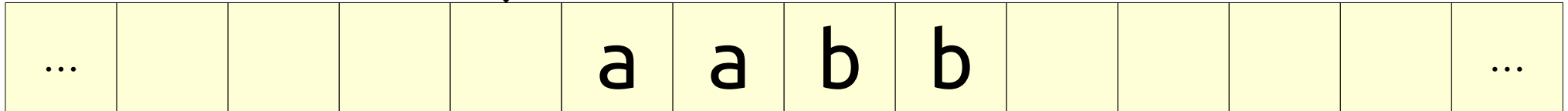
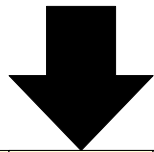
Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

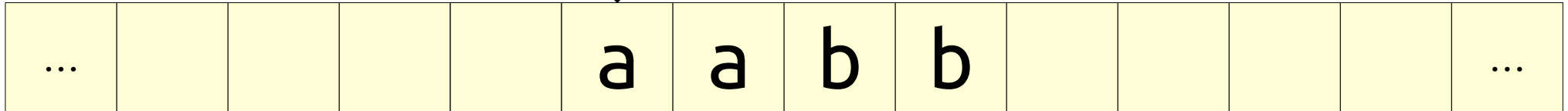
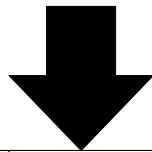
Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

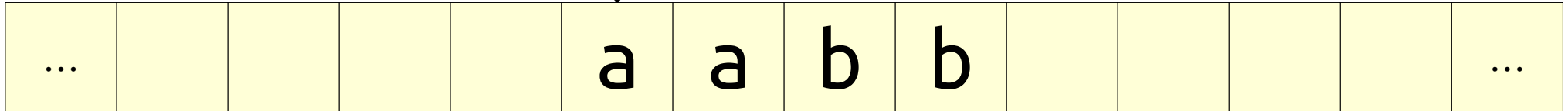
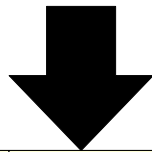
Write Blank

ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

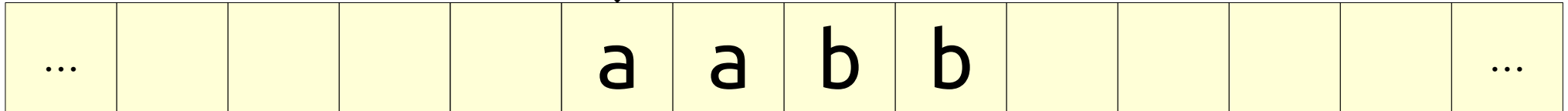
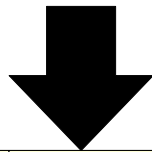
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

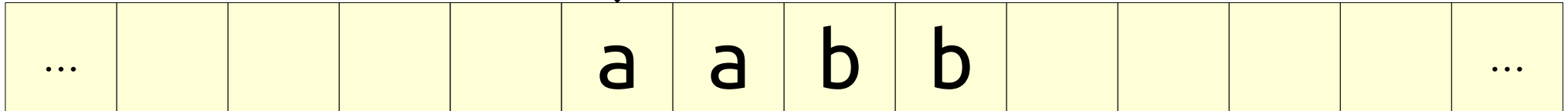
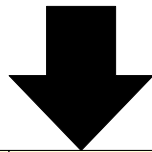
```
If Blank Return True  
If 'b' Return False  
Write Blank
```

ZipRight:

```
Move Right  
If Not Blank Goto ZipRight  
Move Left  
If Not 'b' Return False  
Write Blank
```

ZipLeft:

```
Move Left  
If Not Blank Goto ZipLeft  
Move Right  
Goto Start
```



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

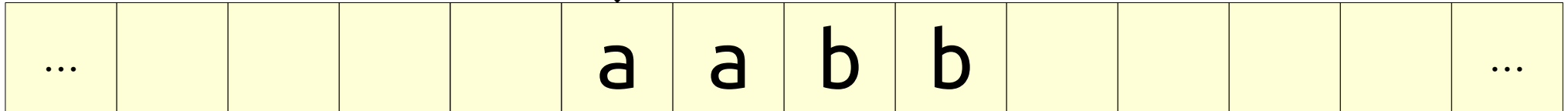
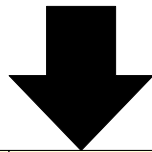
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

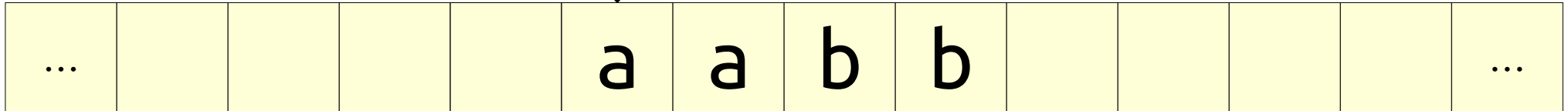
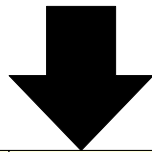
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

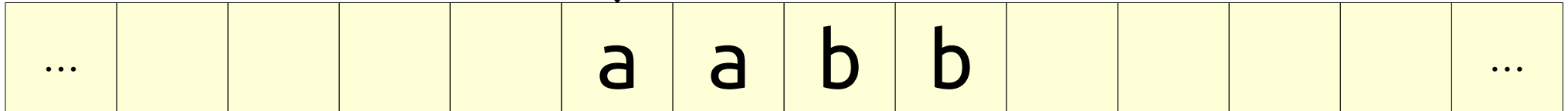
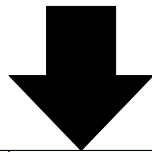
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

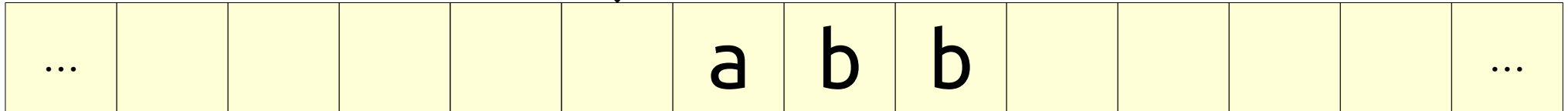
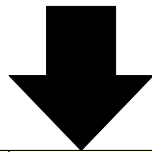
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

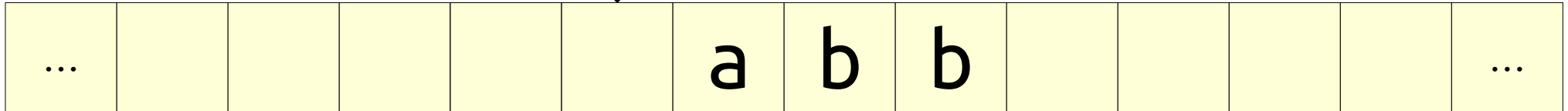
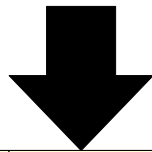
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

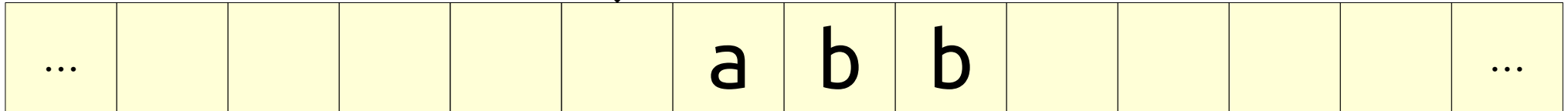
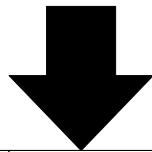
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

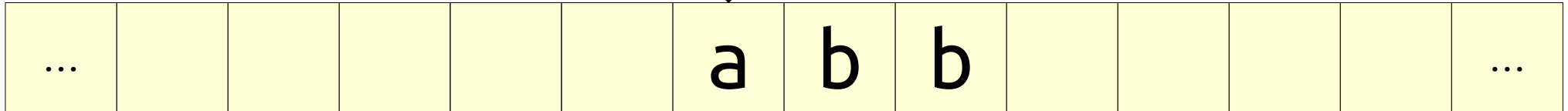
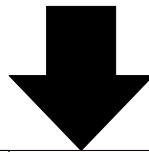
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

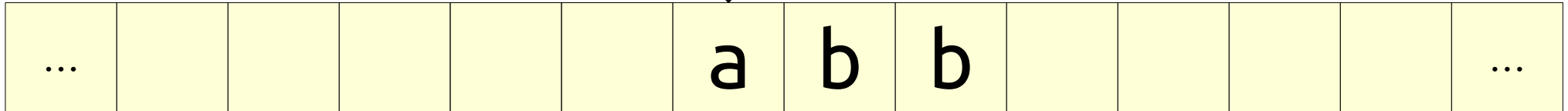
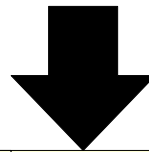
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

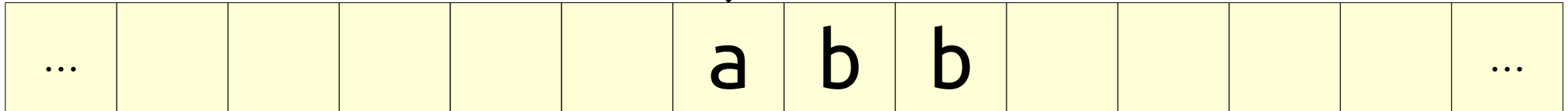
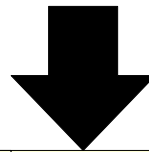
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

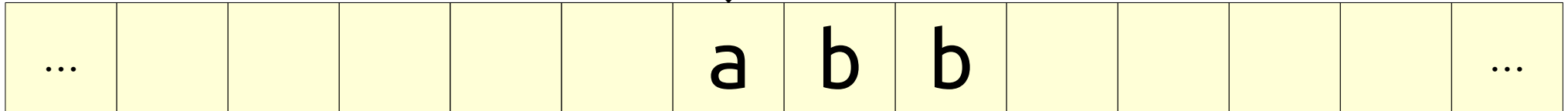
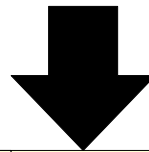
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

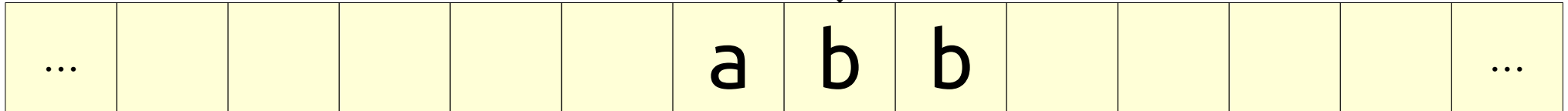
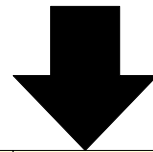
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

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If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

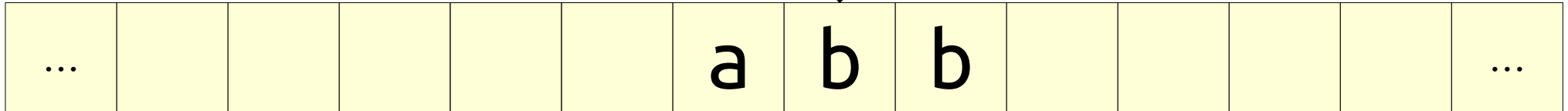
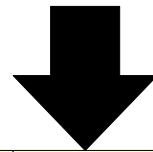
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

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If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

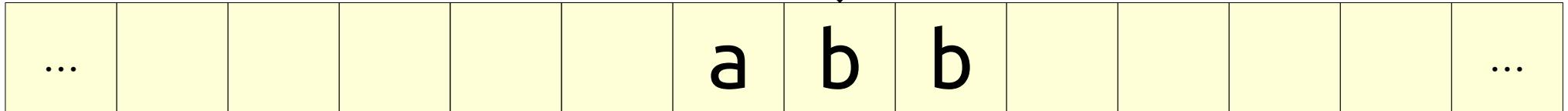
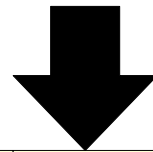
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

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If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

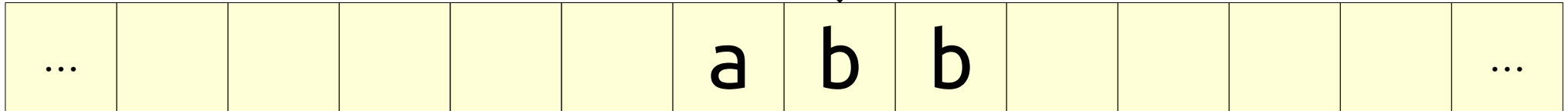
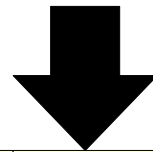
ZipLeft:

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If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

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If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

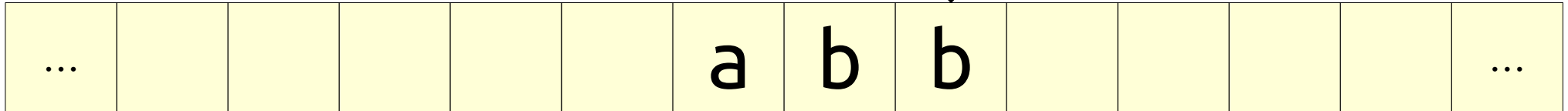
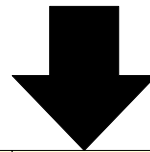
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

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If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

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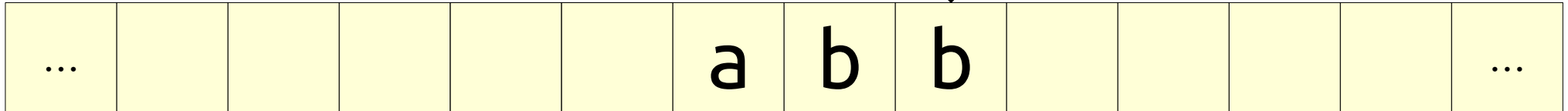
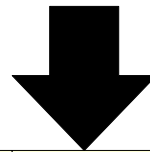
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

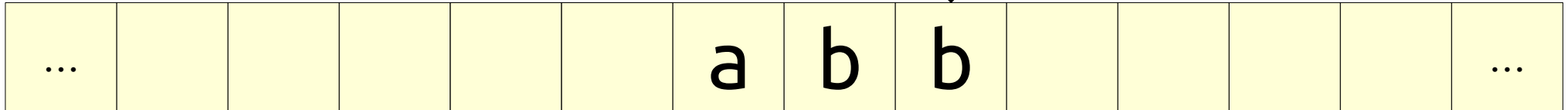
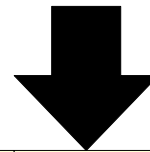
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

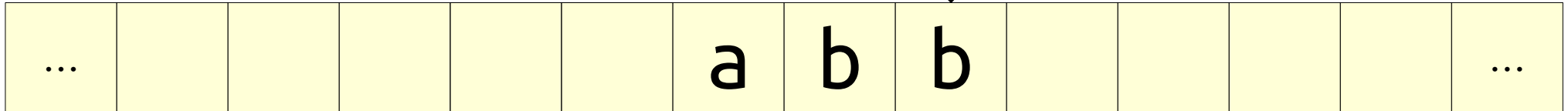
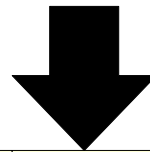
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Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

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If 'b' Return False

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ZipRight:

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Move Left

If Not 'b' Return False

Write Blank

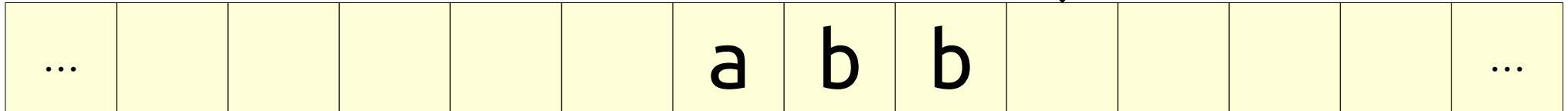
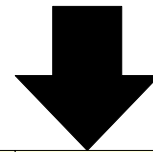
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If Not Blank Goto ZipLeft

Move Right

Goto Start



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If 'b' Return False

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ZipRight:

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If Not Blank Goto ZipRight

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Write Blank

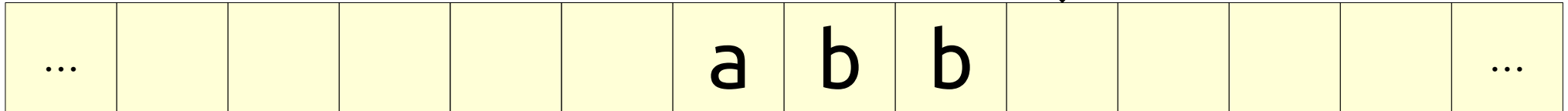
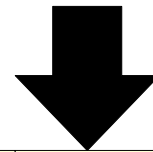
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If Not Blank Goto ZipLeft

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ZipRight:

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If Not Blank Goto ZipRight

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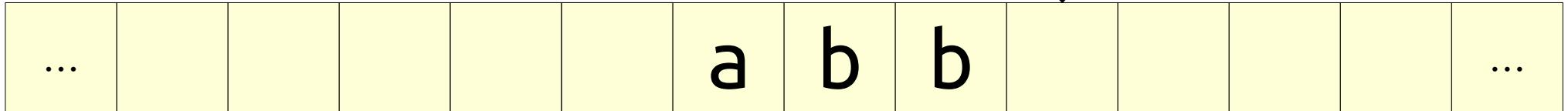
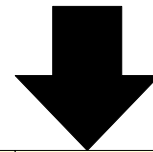
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If Not Blank Goto ZipLeft

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ZipRight:

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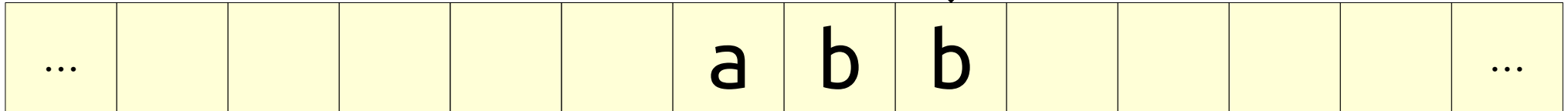
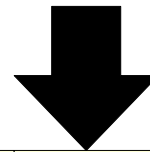
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If Not Blank Goto ZipLeft

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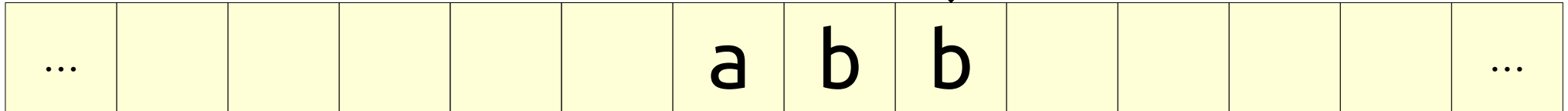
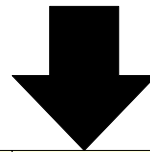
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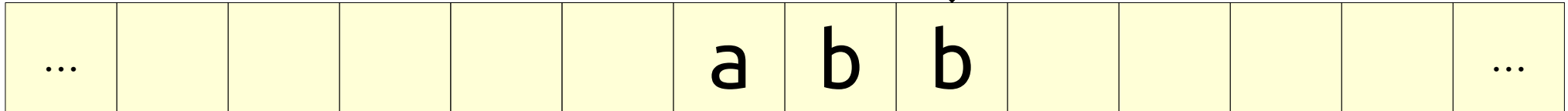
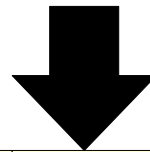
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If Not Blank Goto ZipLeft

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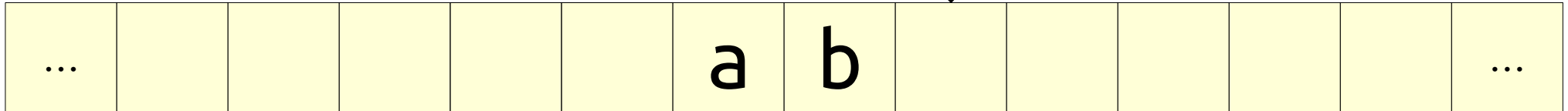
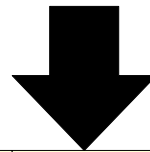
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If Not Blank Goto ZipLeft

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If 'b' Return False

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If Not Blank Goto ZipRight

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If Not 'b' Return False

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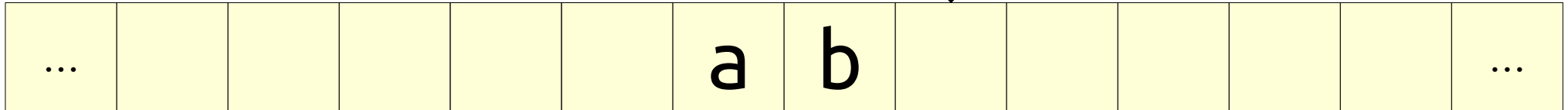
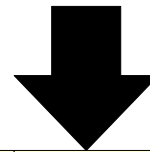
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If Not Blank Goto ZipRight

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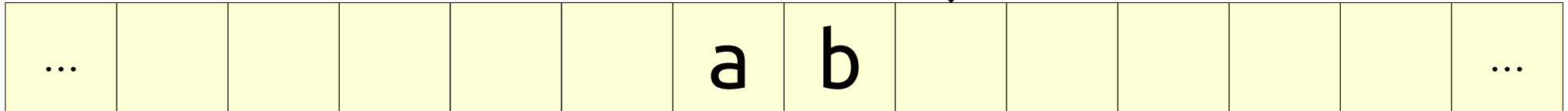
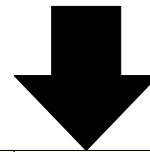
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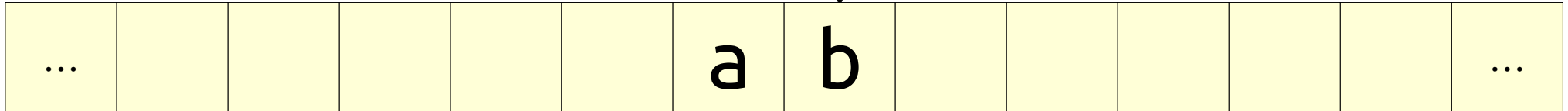
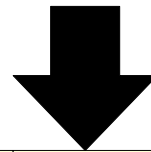
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If 'b' Return False

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If Not Blank Goto ZipRight

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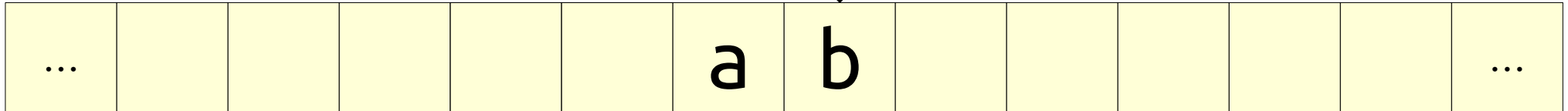
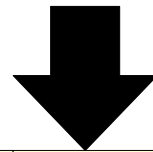
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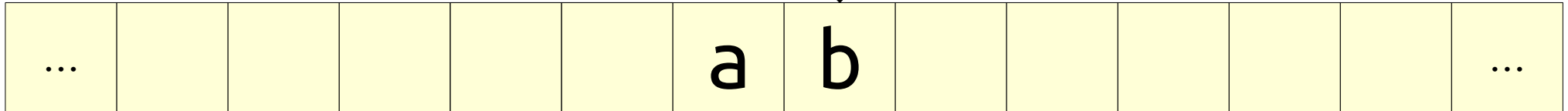
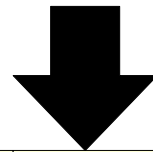
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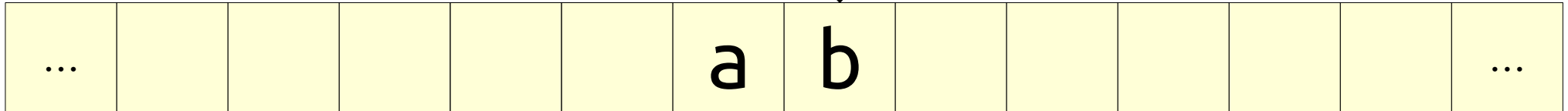
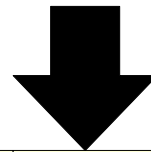
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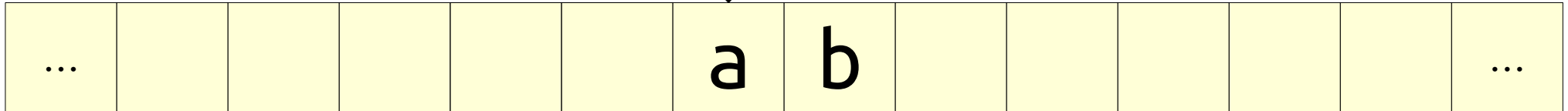
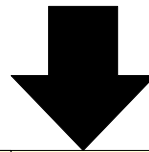
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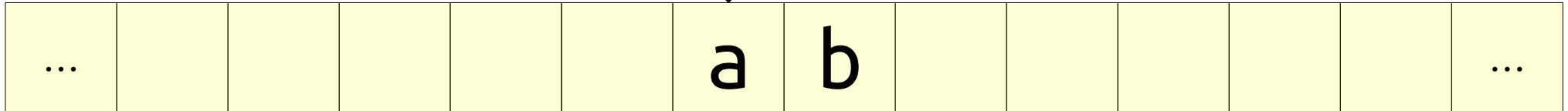
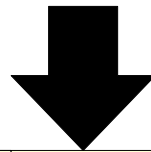
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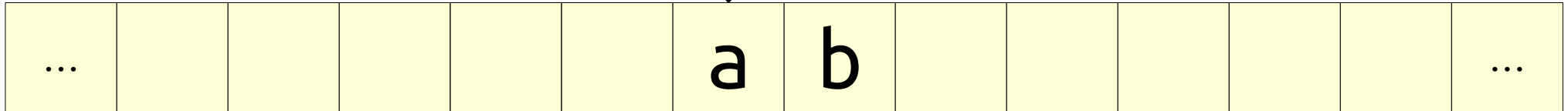
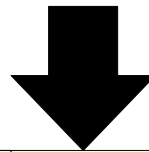
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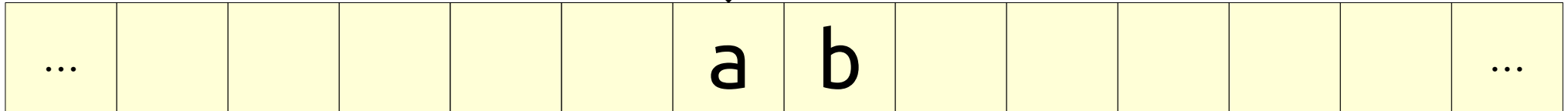
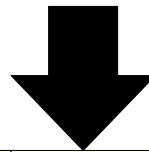
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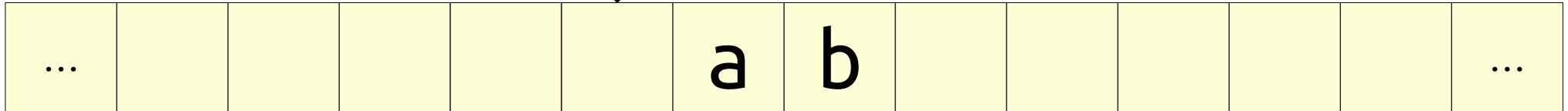
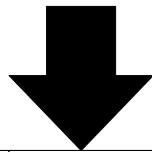
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If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

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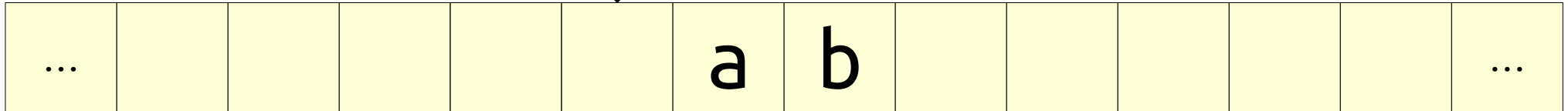
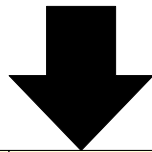
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Goto Start



Start:

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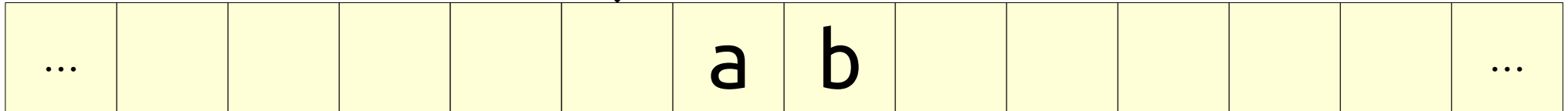
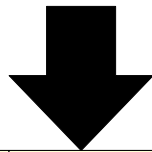
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Start:

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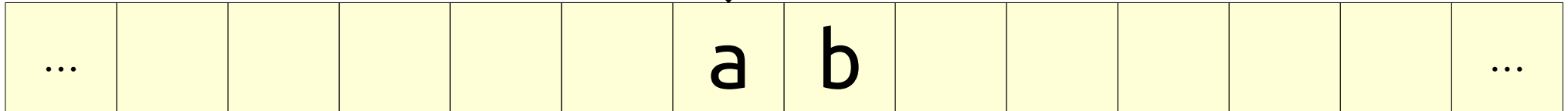
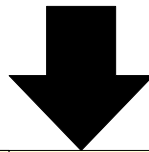
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Move Right

Goto Start



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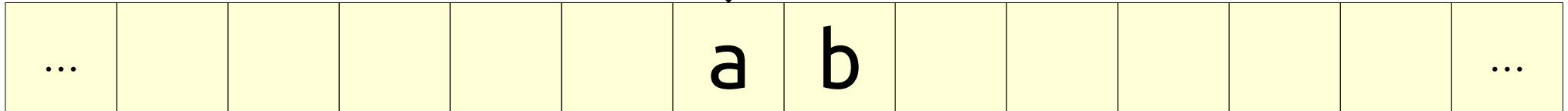
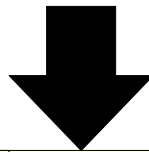
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Goto Start



Start:

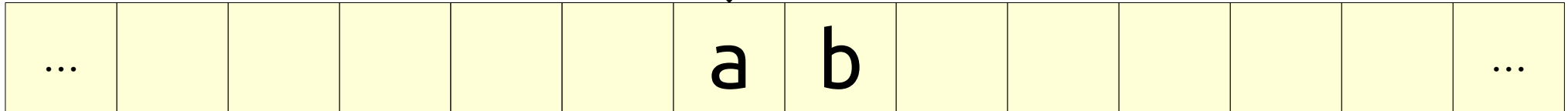
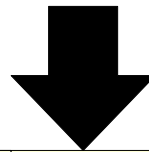
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If Blank Return True  
If 'b' Return False  
Write Blank
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ZipRight:

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Move Right  
If Not Blank Goto ZipRight  
Move Left  
If Not 'b' Return False  
Write Blank
```

ZipLeft:

```
Move Left  
If Not Blank Goto ZipLeft  
Move Right  
Goto Start
```



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

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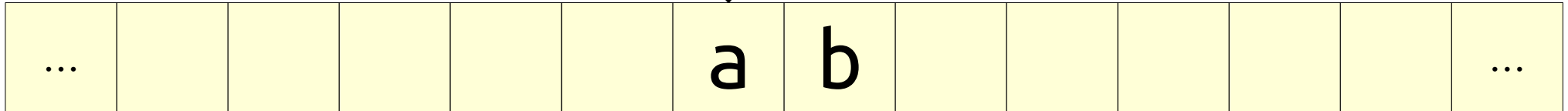
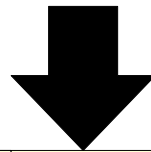
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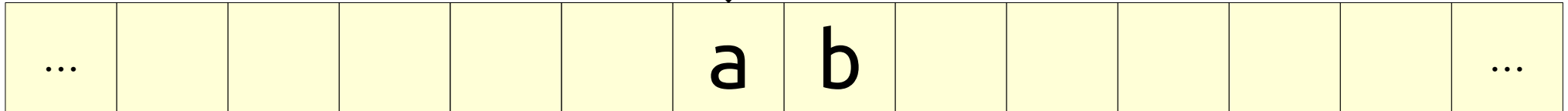
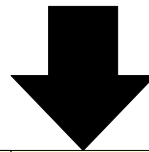
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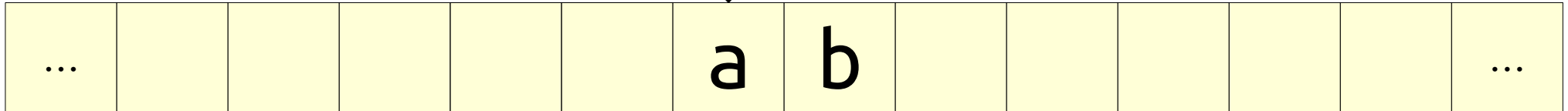
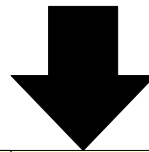
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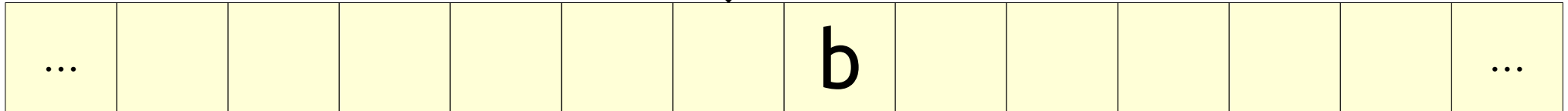
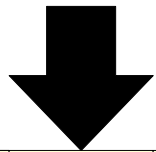
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ZipRight:

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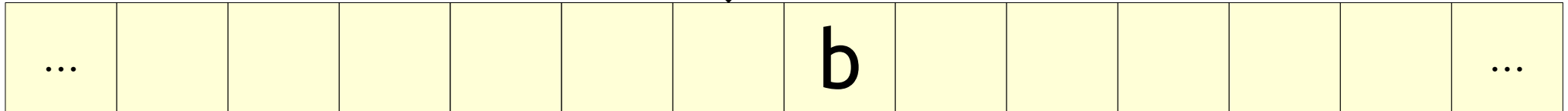
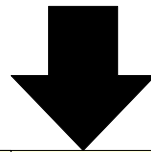
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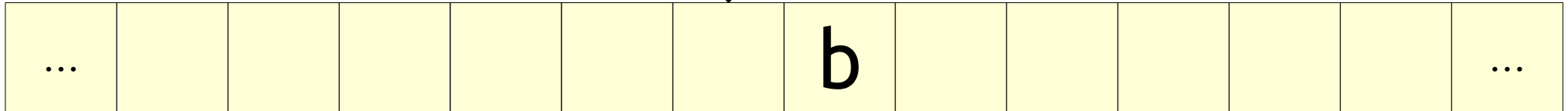
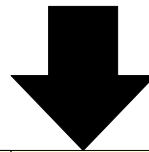
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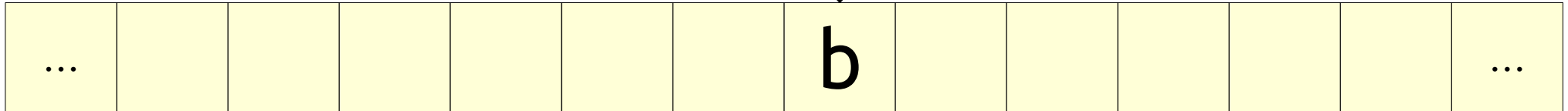
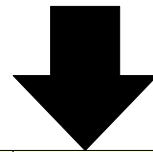
ZipLeft:

Move Left

If Not Blank Goto ZipLeft

Move Right

Goto Start



Start:

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If 'b' Return False

Write Blank

ZipRight:

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If Not Blank Goto ZipRight

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If Not 'b' Return False

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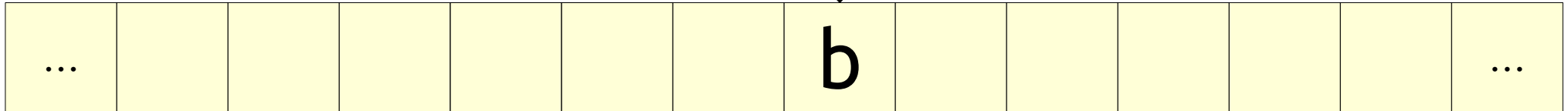
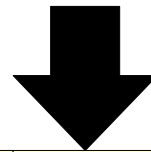
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If Not Blank Goto ZipLeft

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Goto Start



Start:

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If 'b' Return False

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ZipRight:

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If Not Blank Goto ZipRight

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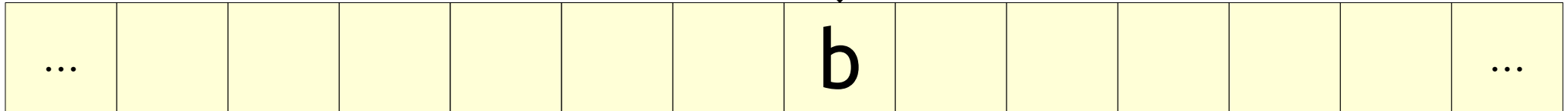
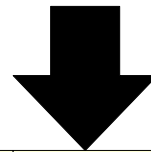
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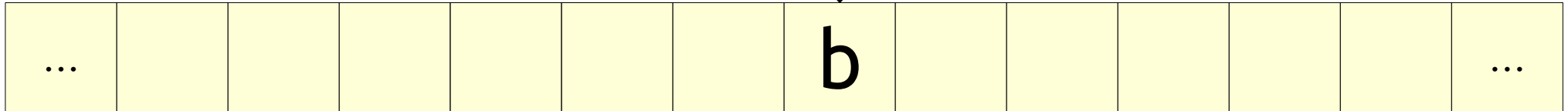
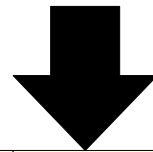
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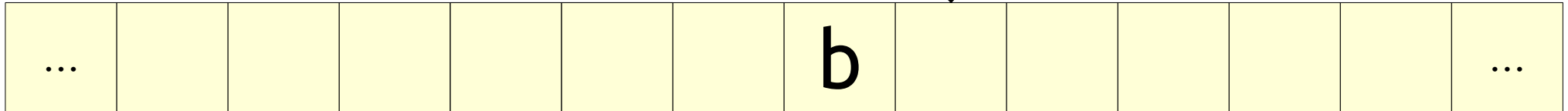
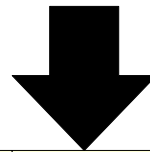
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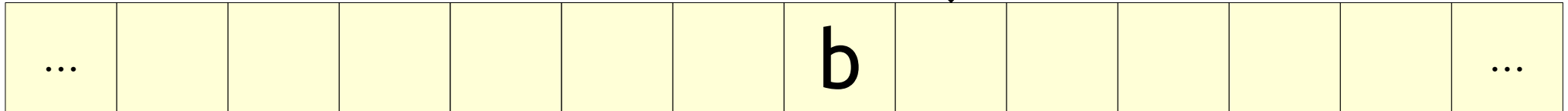
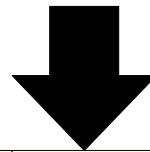
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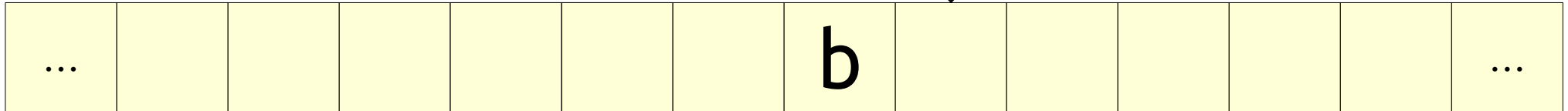
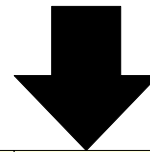
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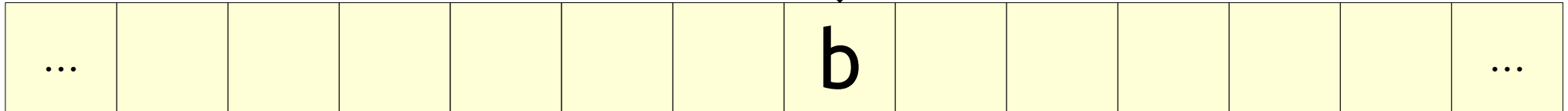
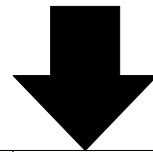
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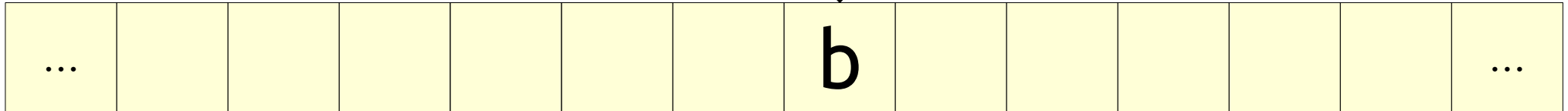
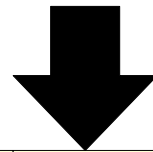
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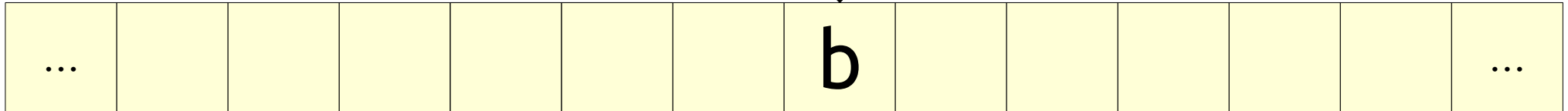
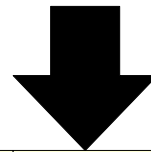
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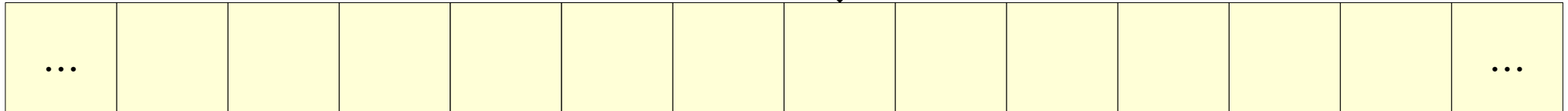
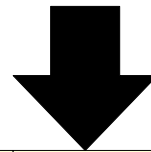
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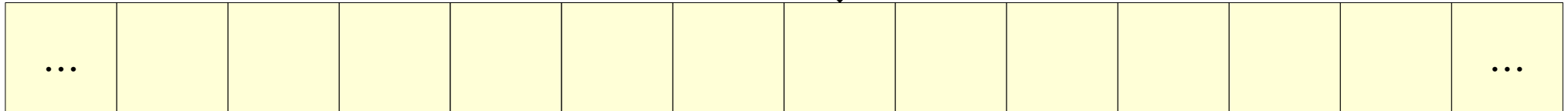
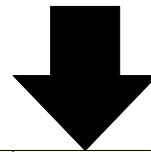
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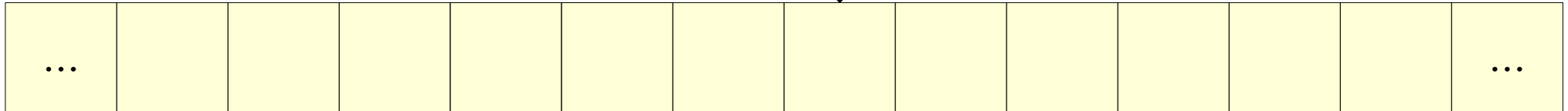
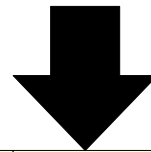
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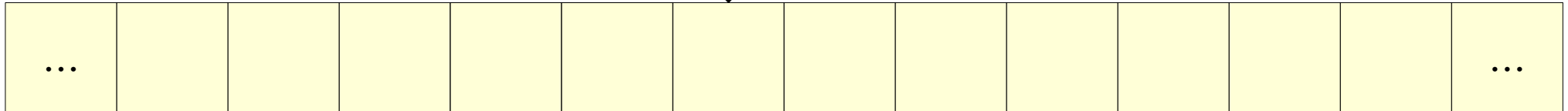
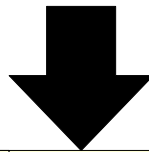
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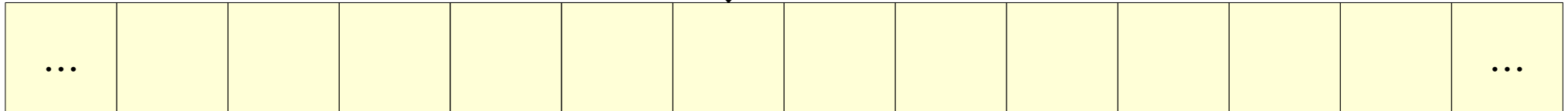
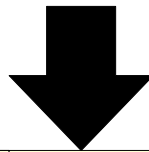
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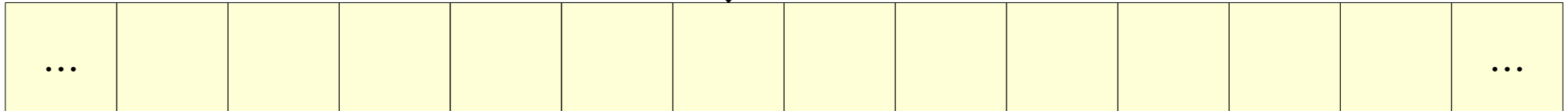
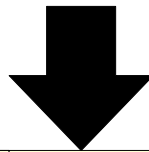
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Write Blank

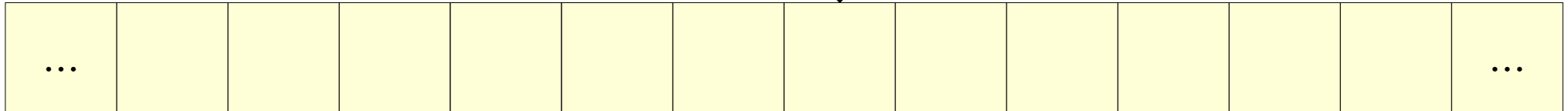
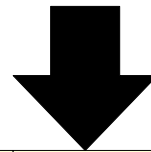
ZipLeft:

Move Left

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Move Right

Goto Start



Start:

If Blank Return True

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Write Blank

ZipRight:

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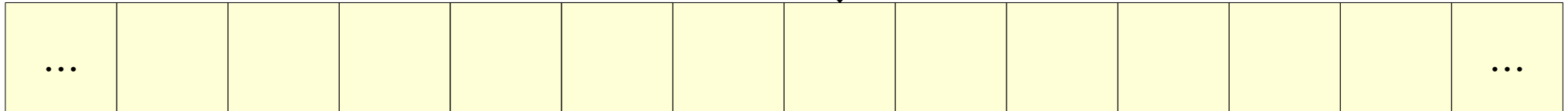
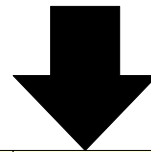
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Start:

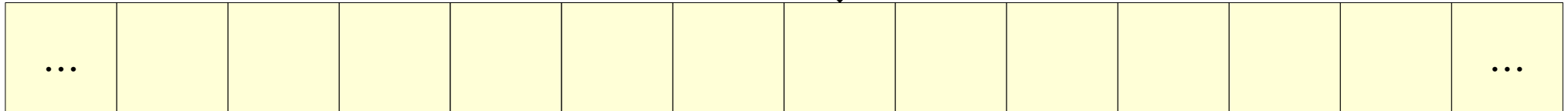
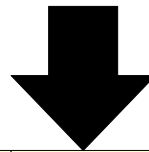
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If Blank Return True  
If 'b' Return False  
Write Blank
```

ZipRight:

```
Move Right  
If Not Blank Goto ZipRight  
Move Left  
If Not 'b' Return False  
Write Blank
```

ZipLeft:

```
Move Left  
If Not Blank Goto ZipLeft  
Move Right  
Goto Start
```



Start:

If Blank Return True

If 'b' Return False

Write Blank

ZipRight:

Move Right

If Not Blank Goto ZipRight

Move Left

If Not 'b' Return False

Write Blank

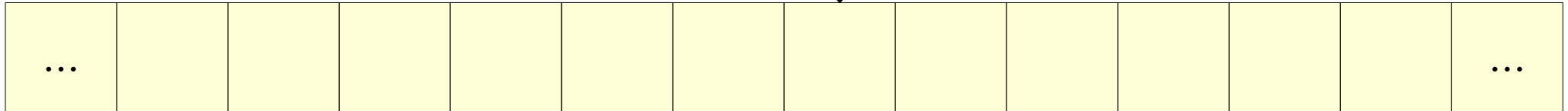
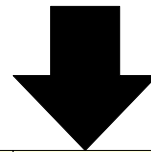
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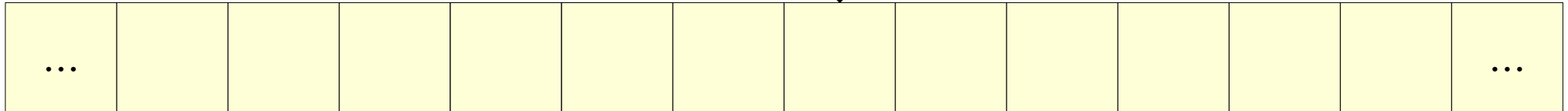
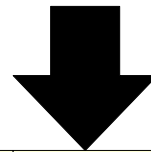
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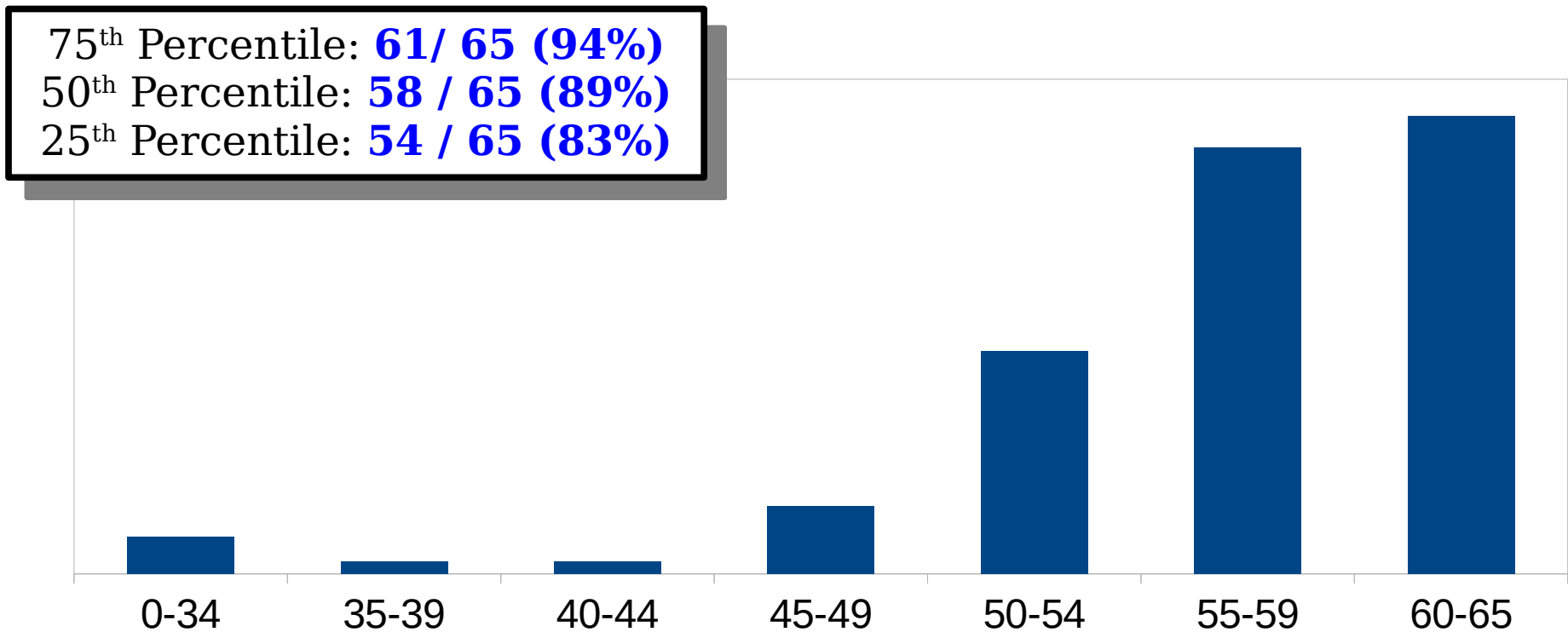
Time-Out for Announcements!

The State of Things

- Exam grading this weekend.
- Exam solutions and grades to be posted early next week.
- ***Do not withdraw or change your grading basis*** unless you have run some projections about your raw score!

Problem Set 6 Graded

- Regrade requests run Friday through Wednesday.



Back to CS103!

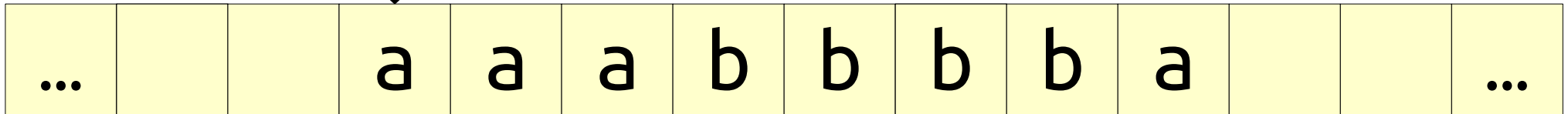
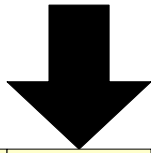
Our Next Challenge

- Let's now take aim at this more general language:

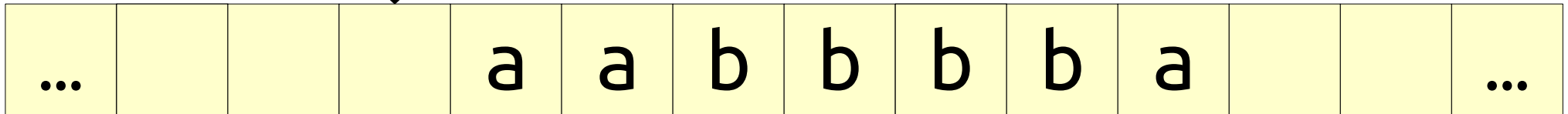
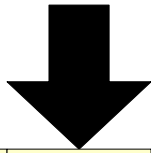
$$\{ w \in \{\mathbf{a}, \mathbf{b}\}^* \mid w \text{ has an equal number of } \mathbf{a}'\text{s and } \mathbf{b}'\text{s} \}$$

- This language is not regular (do you see why?)
- It is context-free, but it's a bit tricky to write a CFG for it. (This is a great exercise!)
- Let's see how to design a TM for it.

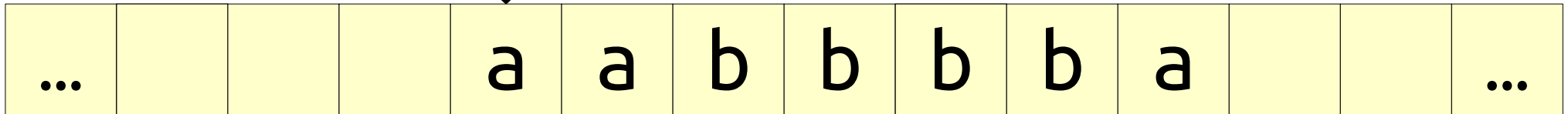
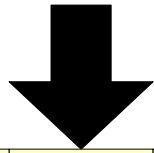
A Caveat



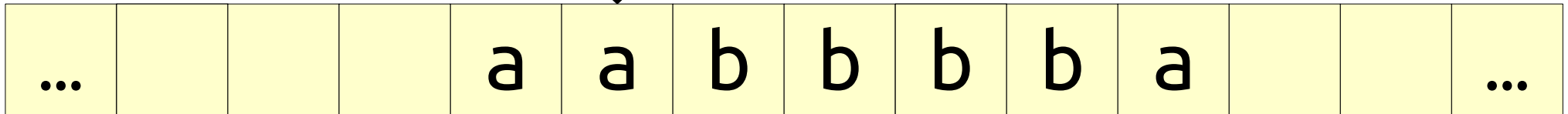
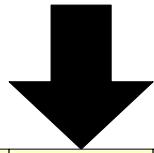
A Caveat



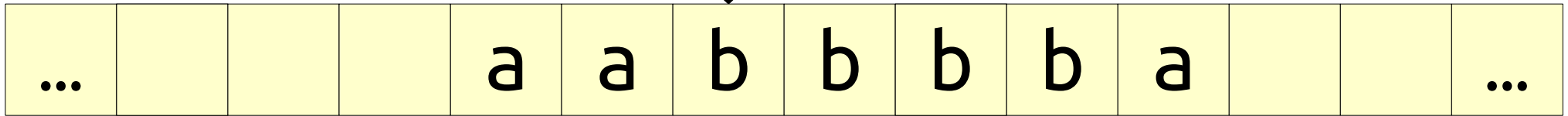
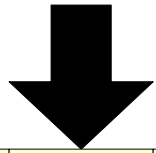
A Caveat



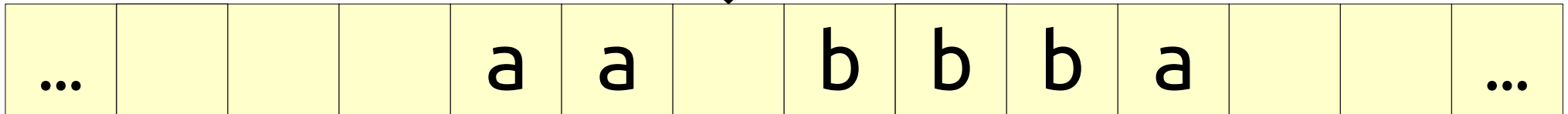
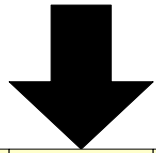
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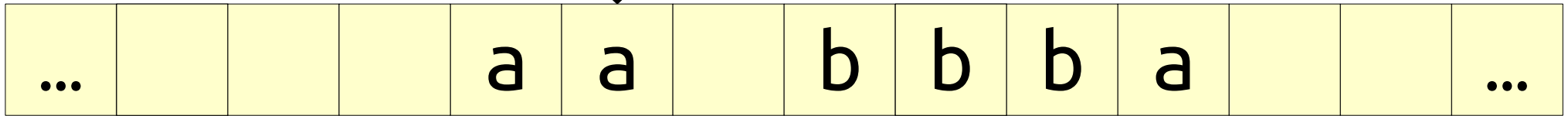
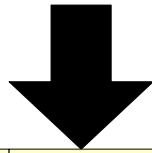
A Caveat



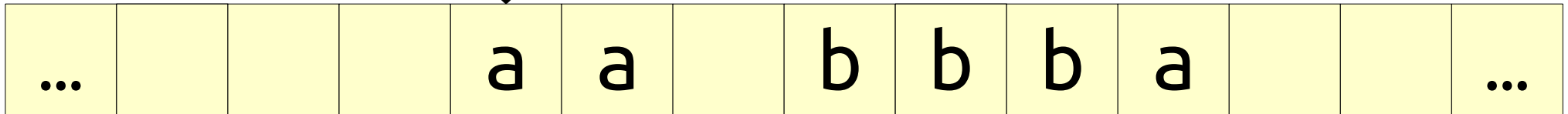
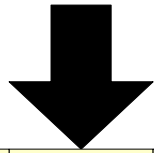
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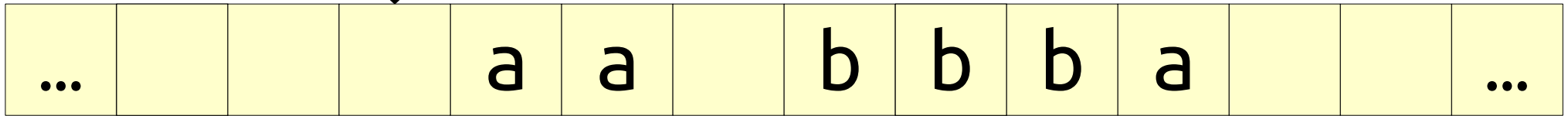
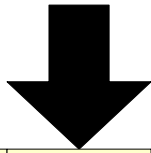
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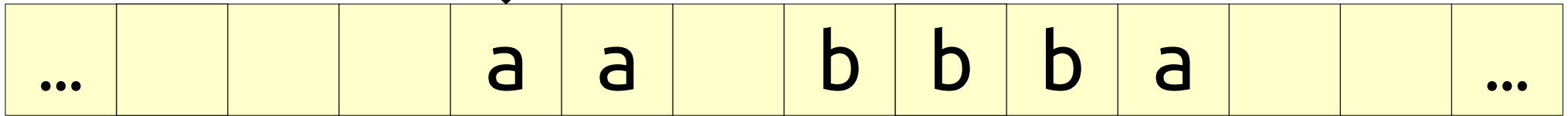
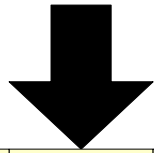
A Caveat



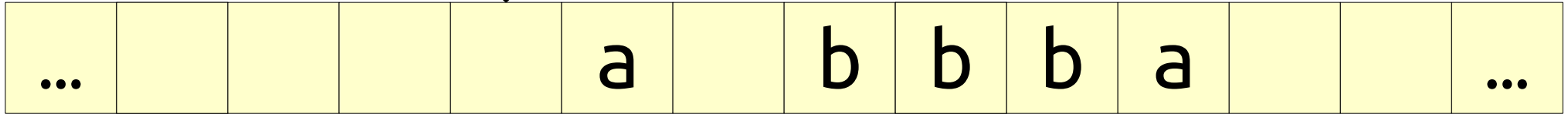
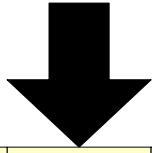
A Caveat



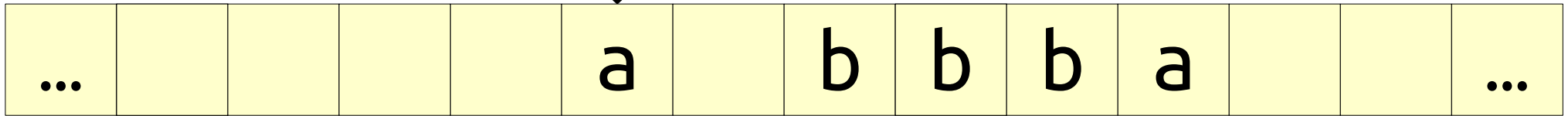
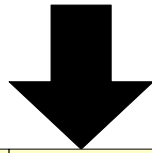
A Caveat



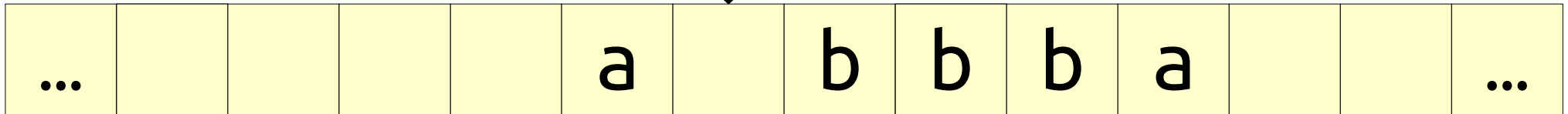
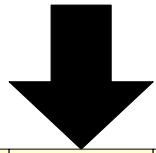
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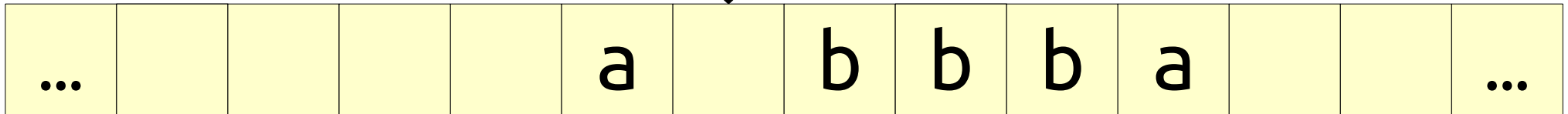
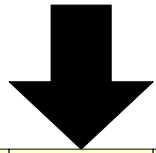
A Caveat



A Caveat

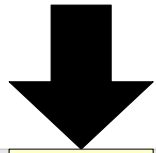


A Caveat



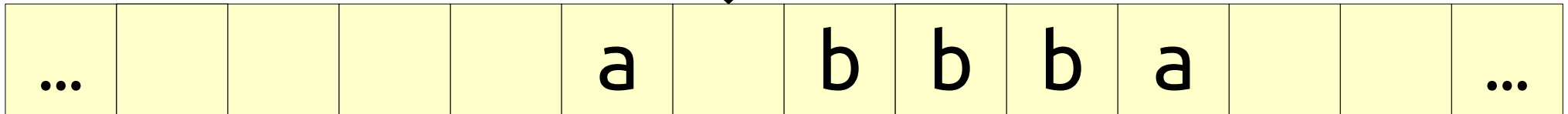
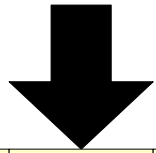
How do we know that
this blank isn't one of
the infinitely many
blanks after our input
string?

A Caveat



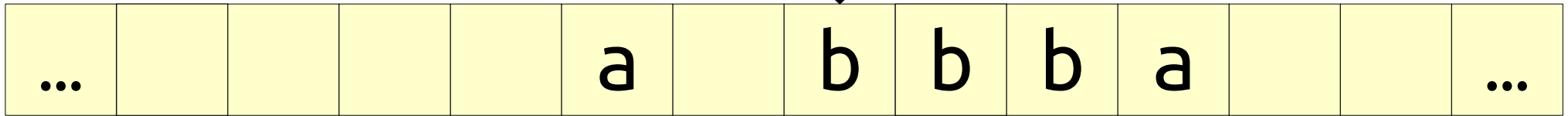
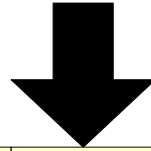
How do we know that
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A Caveat

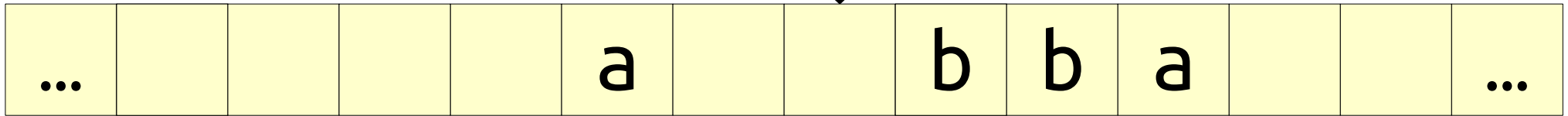
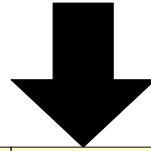


How do we know that
this blank isn't one of
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string?

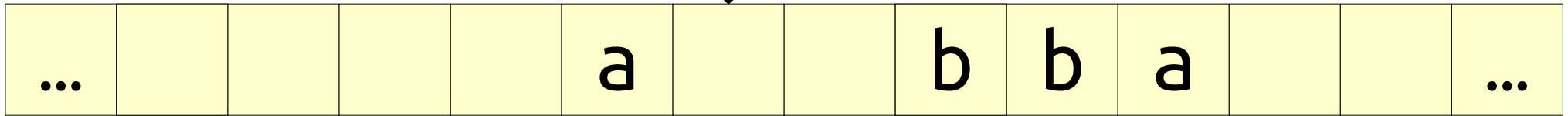
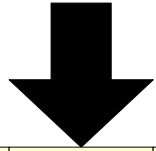
A Caveat



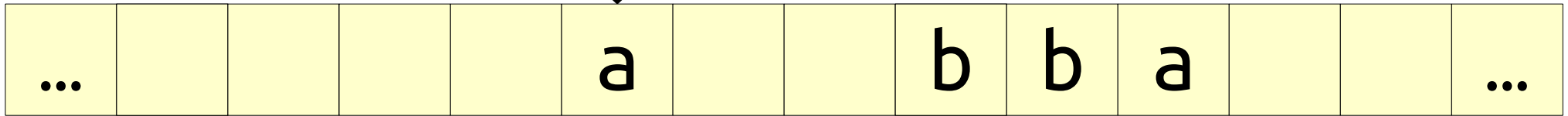
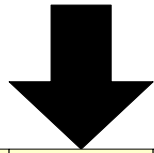
A Caveat



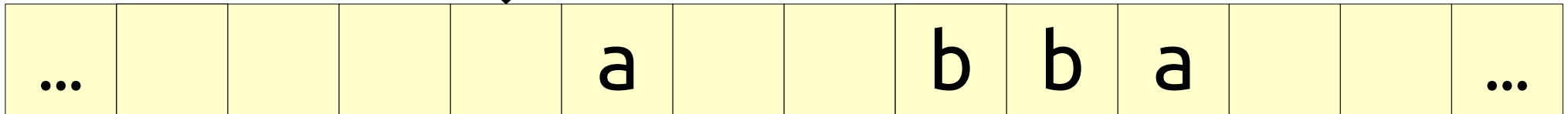
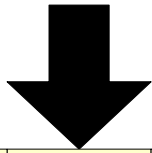
A Caveat



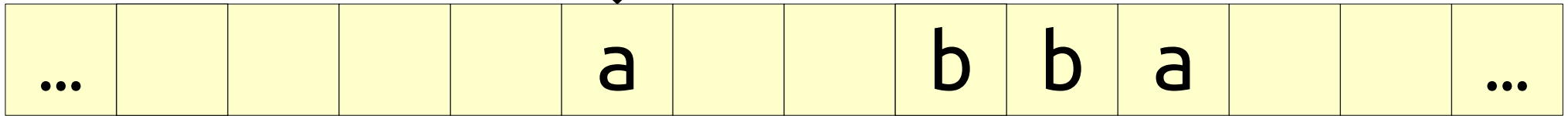
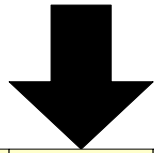
A Caveat



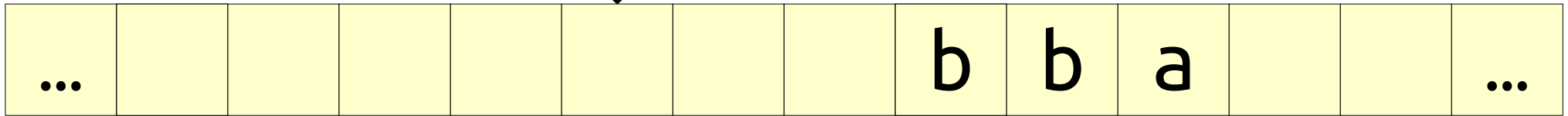
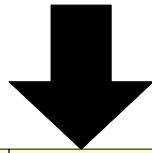
A Caveat



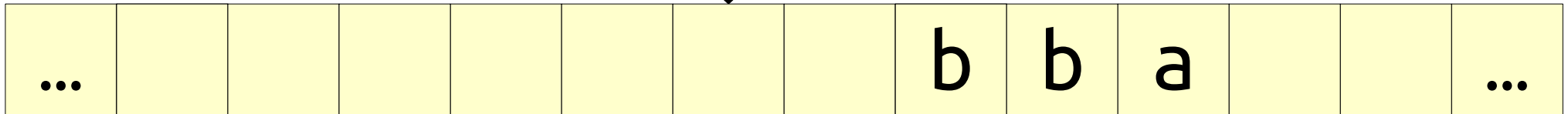
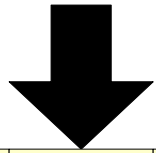
A Caveat



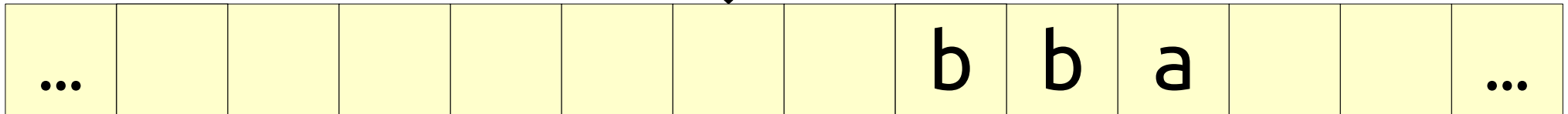
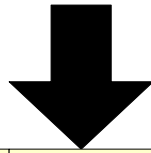
A Caveat



A Caveat

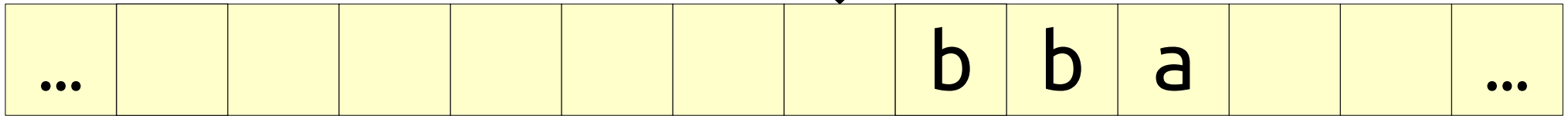
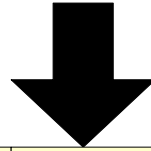


A Caveat

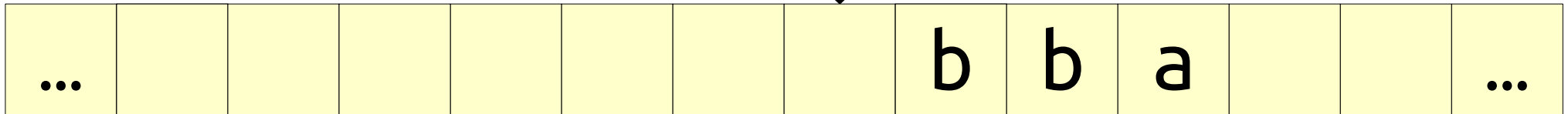
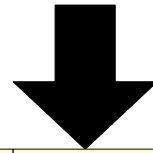


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A Caveat

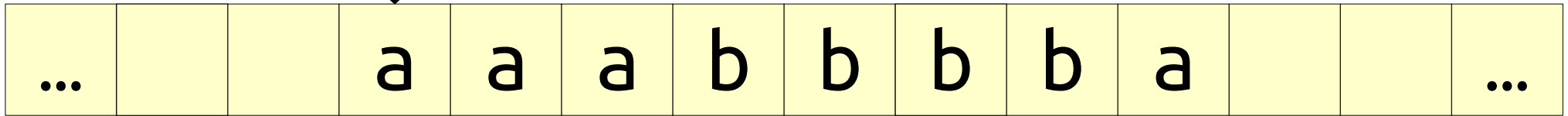
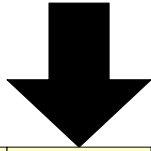


A Caveat

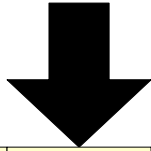


How do we know that
this blank isn't one of
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string?

One Solution

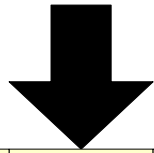


One Solution



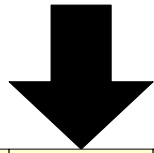
...			x	a	a	b	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



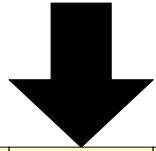
...			x	a	a	b	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



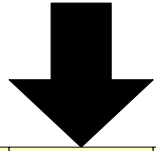
...			x	a	a	b	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



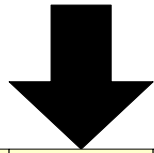
...			x	a	a	b	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



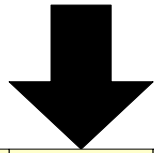
...			x	a	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



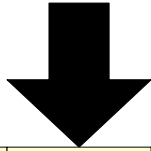
...			x	a	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



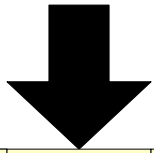
...			x	a	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



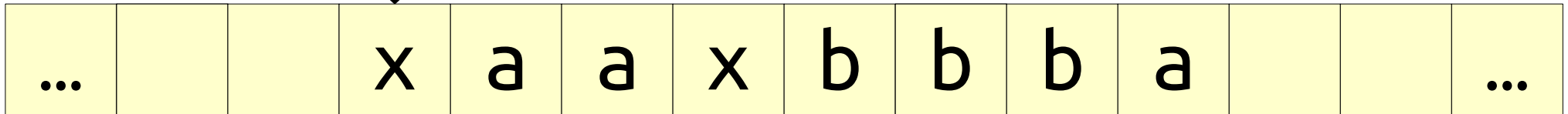
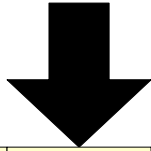
...			x	a	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution

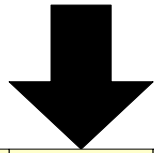


...			x	a	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution

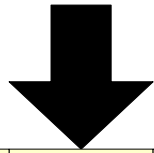


One Solution



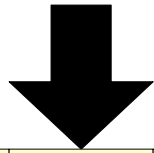
...			x	a	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution



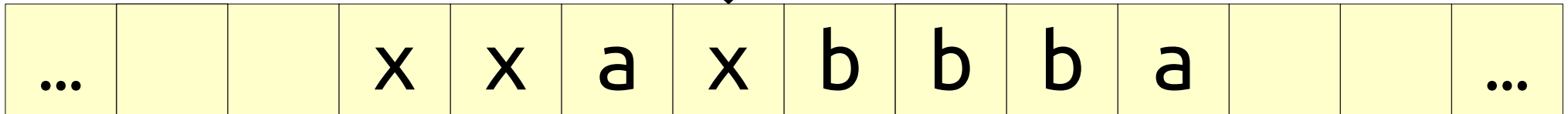
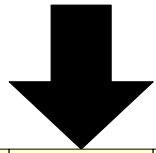
...			x	x	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution

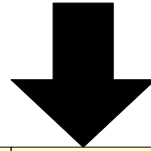


...			x	x	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution

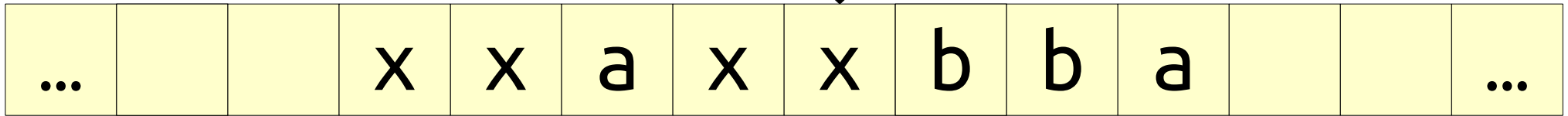
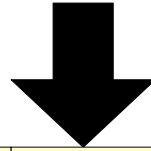


One Solution

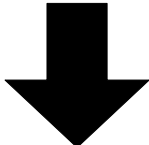


...			x	x	a	x	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

One Solution

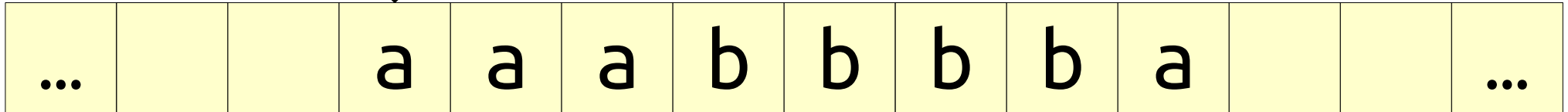
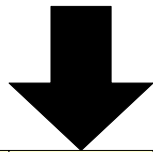


Start:

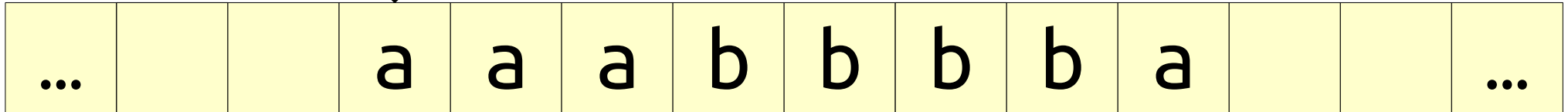
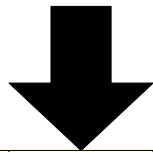


...			a	a	a	b	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

Start:

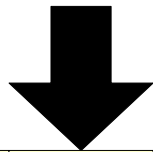


Start:



Start:

If 'a' Goto FoundA

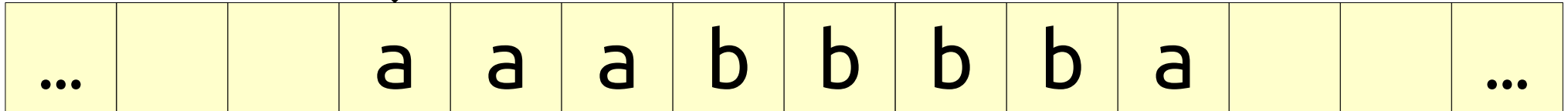
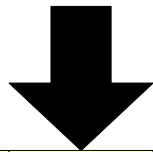


...			a	a	a	b	b	b	b	a			...
-----	--	--	---	---	---	---	---	---	---	---	--	--	-----

Start:

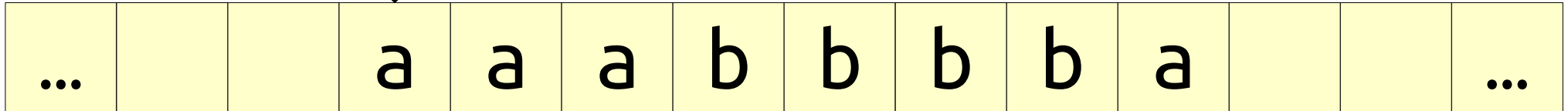
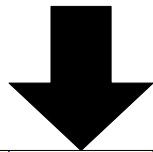
If 'a' Goto FoundA

FoundA:



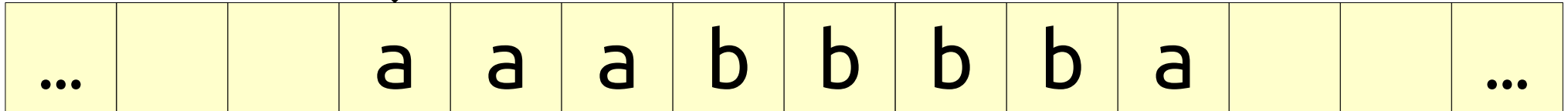
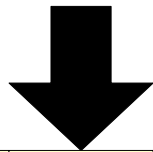
Start:
If 'a' Goto FoundA

FoundA:



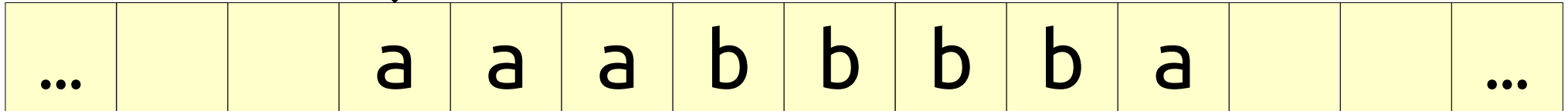
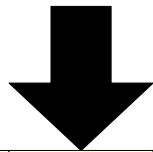
Start:
If 'a' Goto FoundA

FoundA:



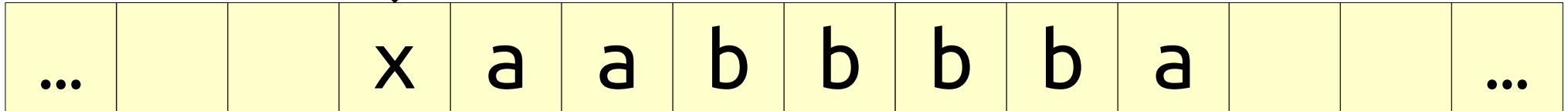
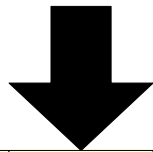
```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```



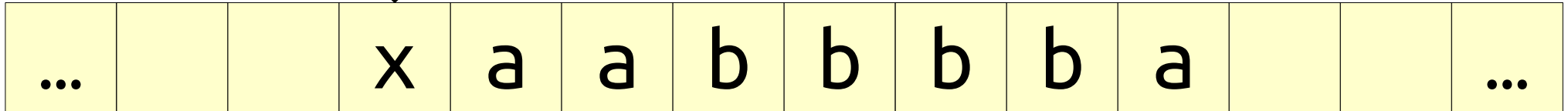
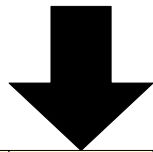
```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```



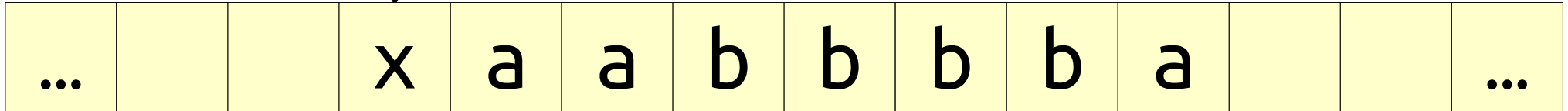
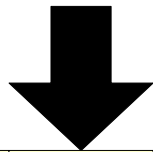
```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```



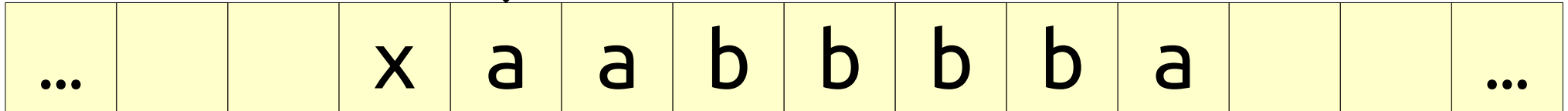
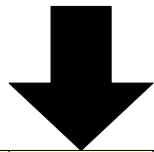
```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'  
  Move Right
```



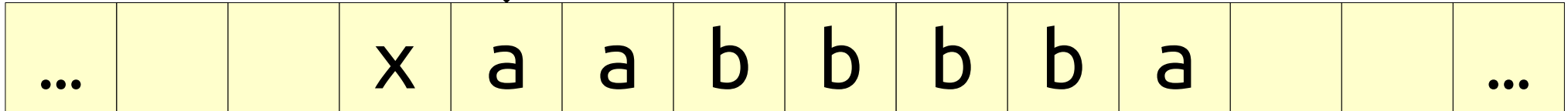
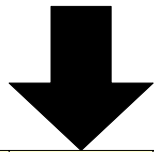
```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'  
  Move Right
```



```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'  
  Move Right  
  If 'a' ?
```

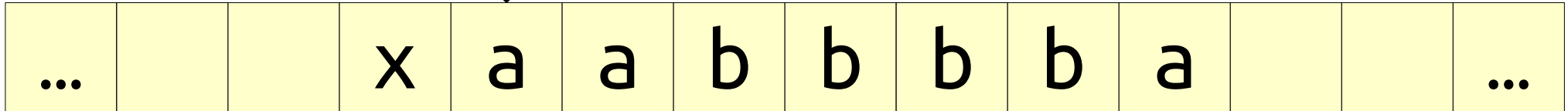
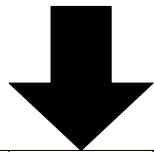


```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```

```
  Move Right
```

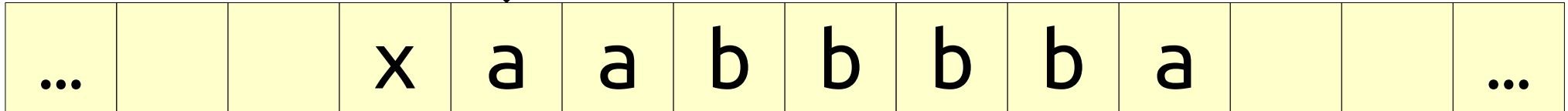
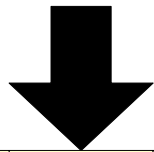
```
  If 'a' ?
```



```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```

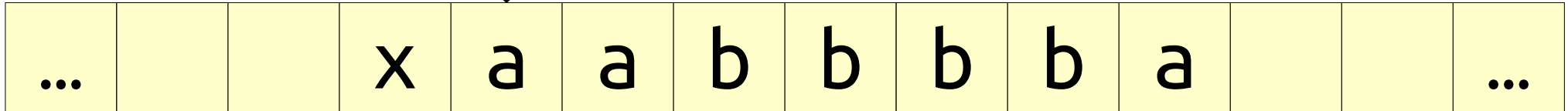
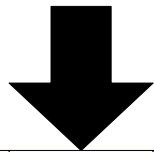
```
LoopA:  
  Move Right  
  If 'a' ?
```



```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```

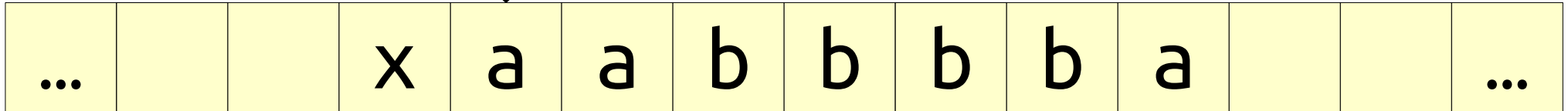
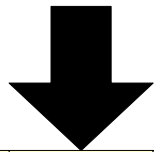
```
LoopA:  
  Move Right  
  If 'a' Goto LoopA
```



```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```

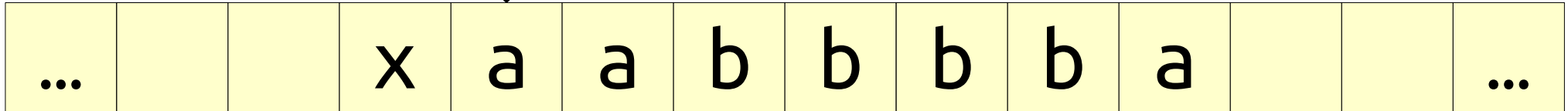
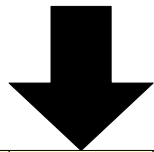
```
LoopA:  
  Move Right  
  If 'a' Goto LoopA
```



```
Start:  
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```

```
FoundA:  
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```

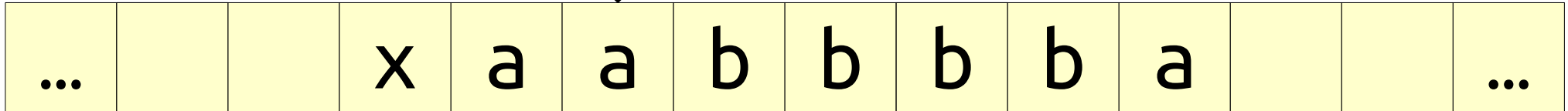
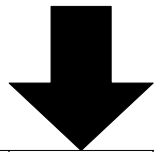
```
LoopA:  
  Move Right  
  If 'a' Goto LoopA
```



```
Start:  
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```

```
FoundA:  
  Write 'x'
```

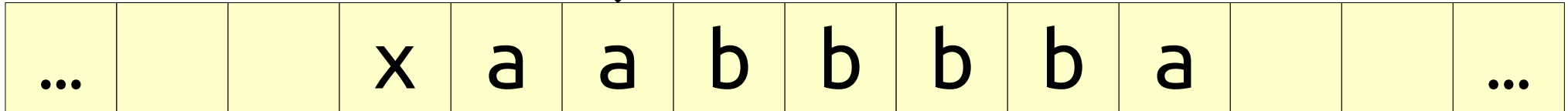
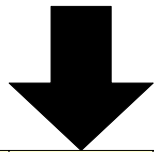
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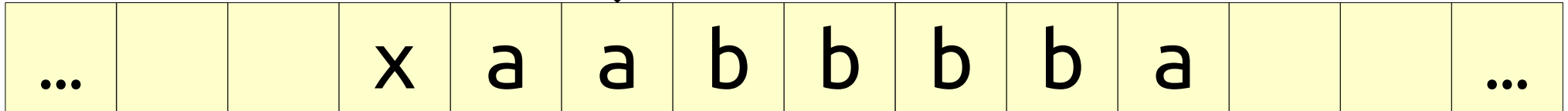
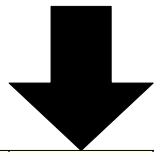
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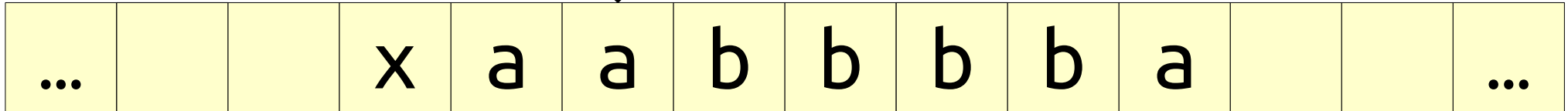
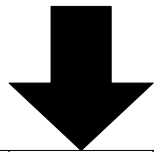
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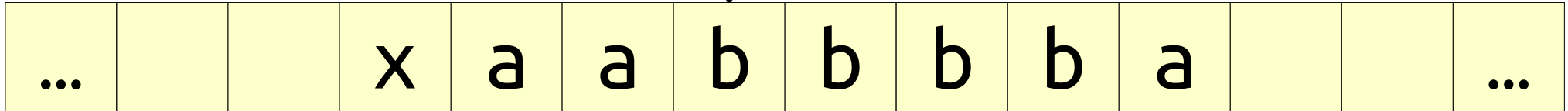
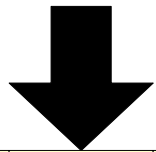
```
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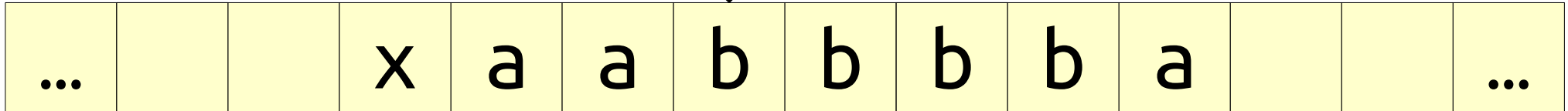
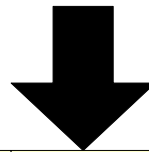
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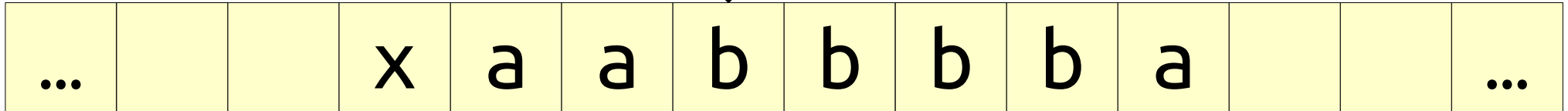
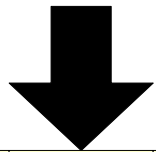
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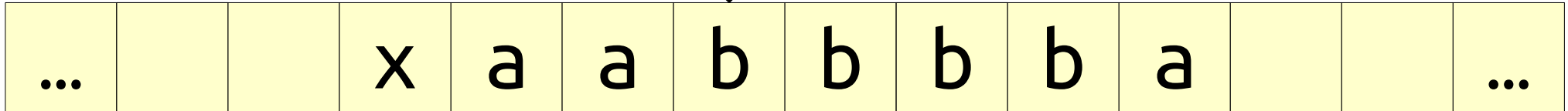
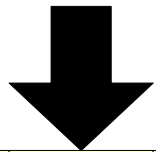
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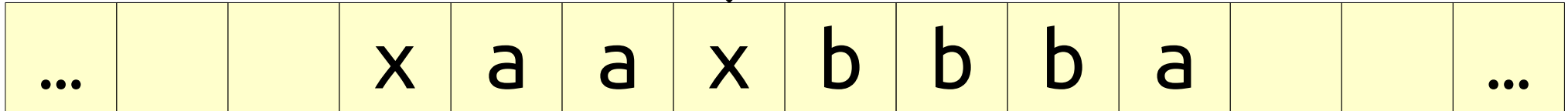
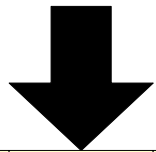
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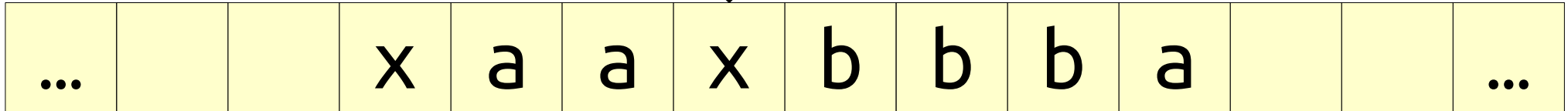
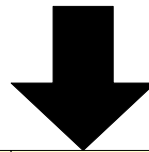
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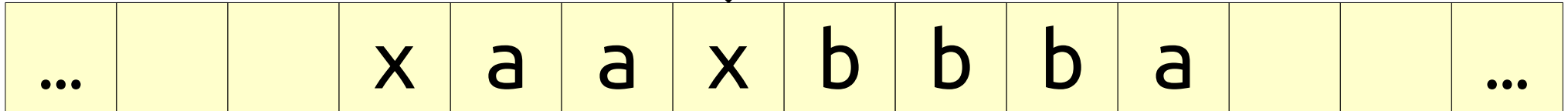
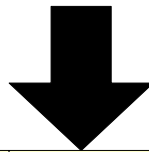
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  If 'a' Goto FoundA
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FoundA:  
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LoopA:  
  Move Right  
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  Write 'x'  
  Goto GoHome
```

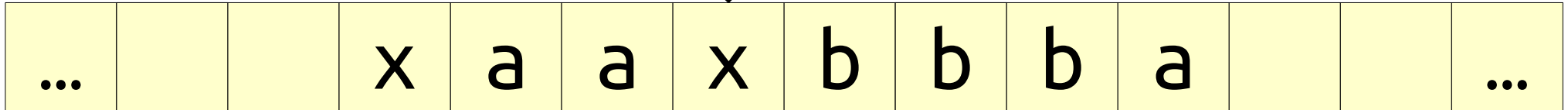
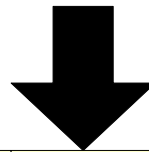


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  If 'a' Goto FoundA
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FoundA:  
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```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```



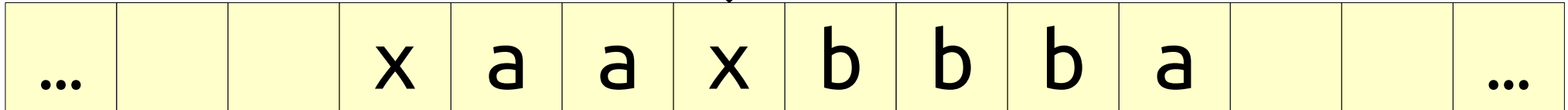
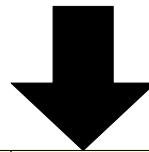
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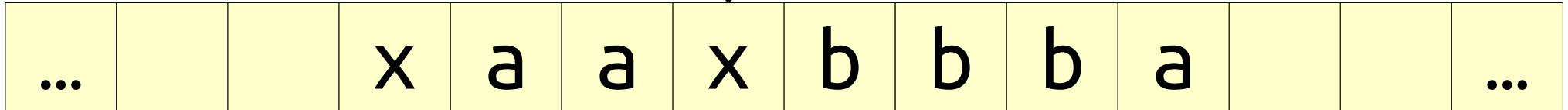
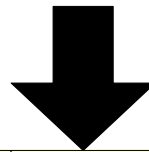


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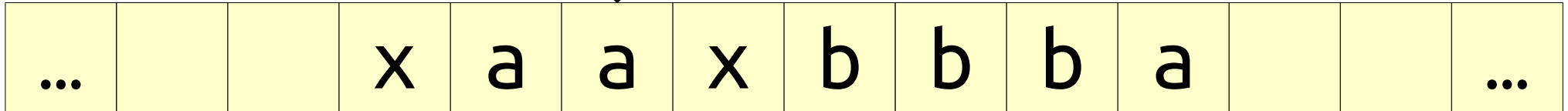
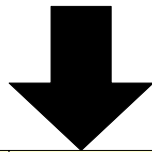


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GoHome:
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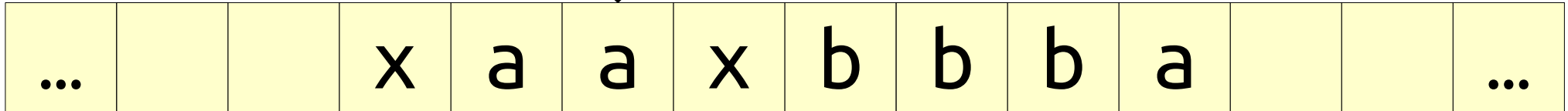
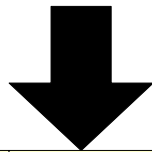


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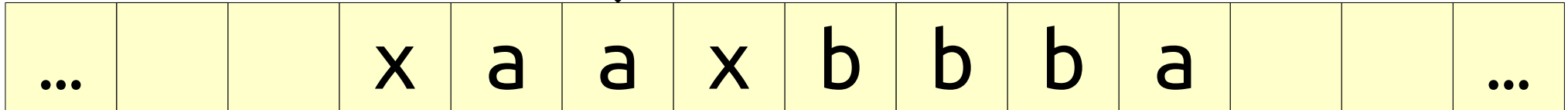
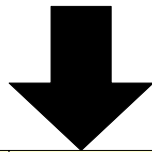
GoHome:

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 Move Right

 Goto Start

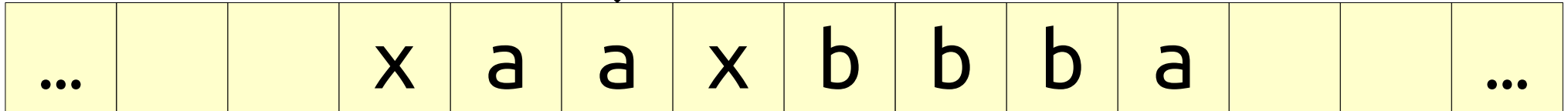
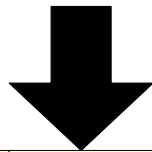


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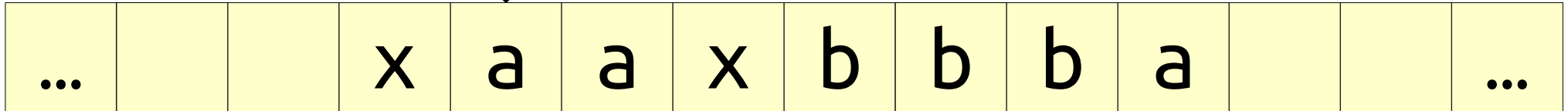
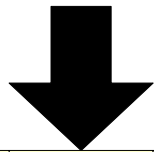


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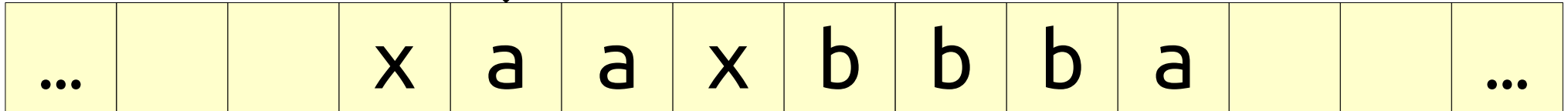
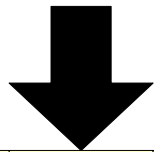


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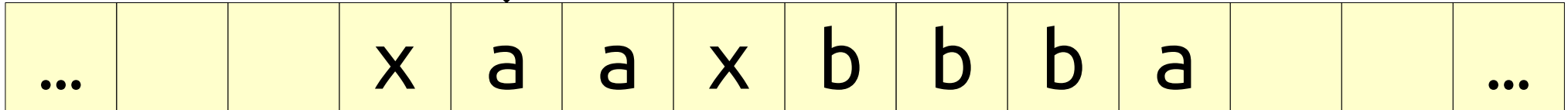
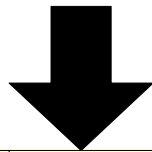
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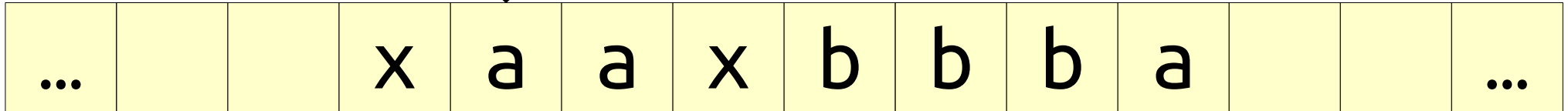
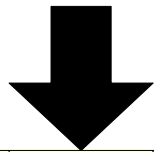


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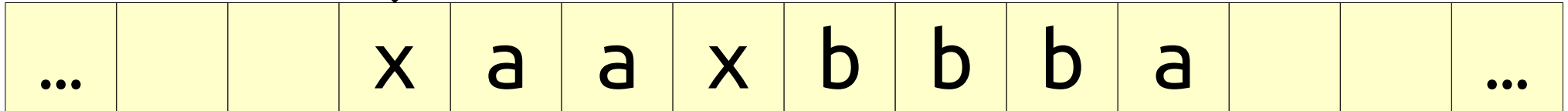
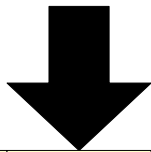


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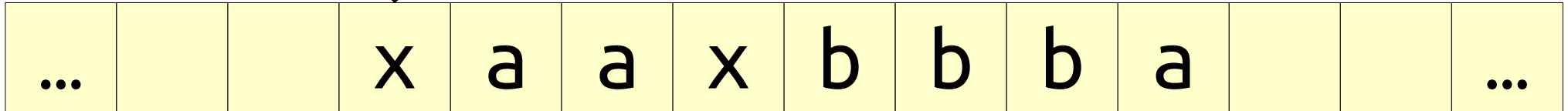
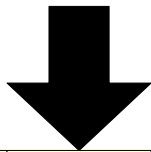


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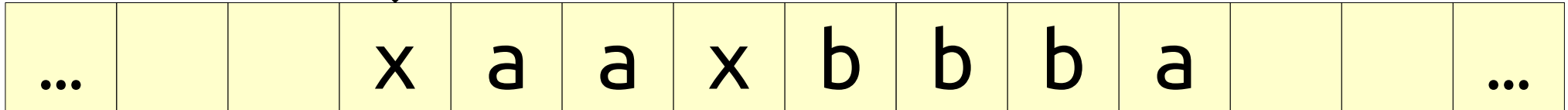
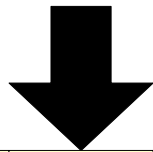
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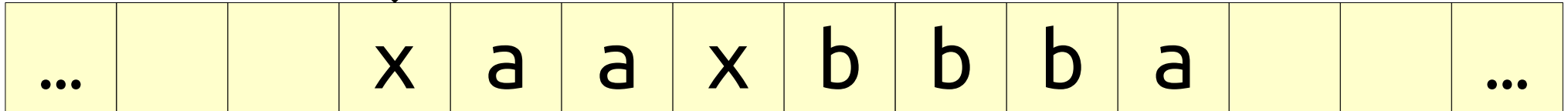
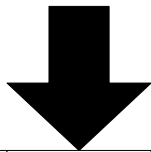


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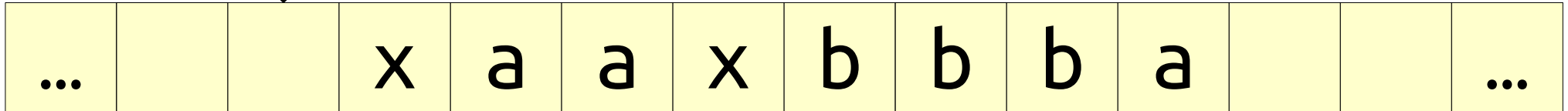
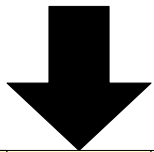


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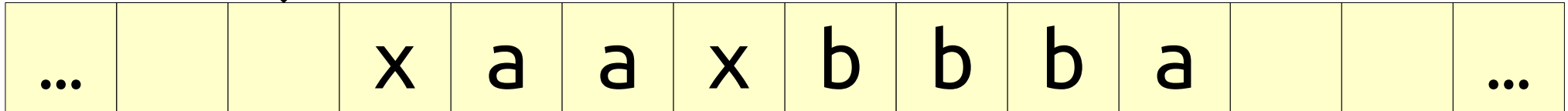
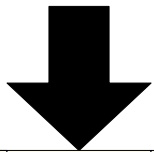


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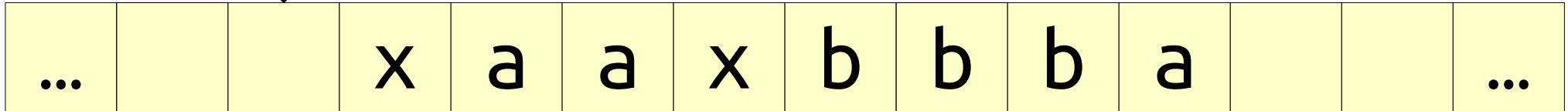
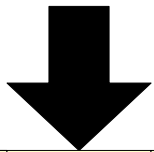


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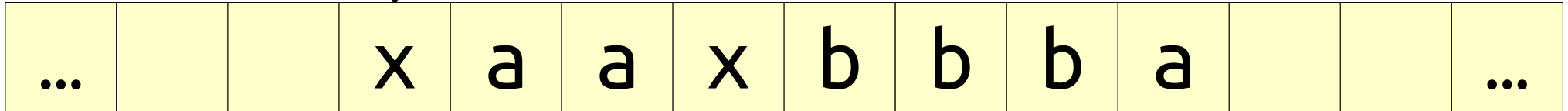
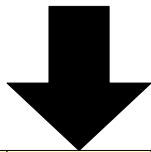


```
Start:  
  If 'a' Goto FoundA
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```

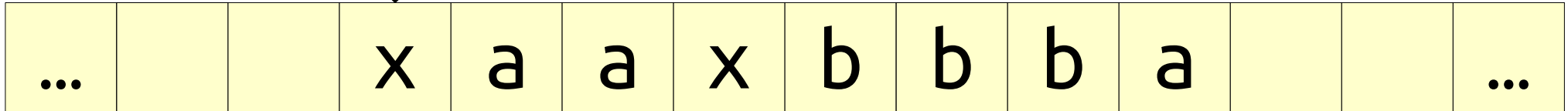
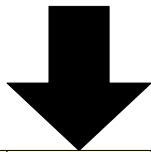


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Start:

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LoopA:

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If 'a' Goto LoopA

Write 'x'

Goto GoHome

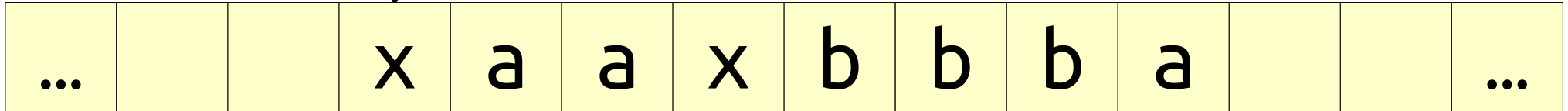
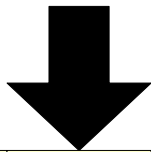
GoHome:

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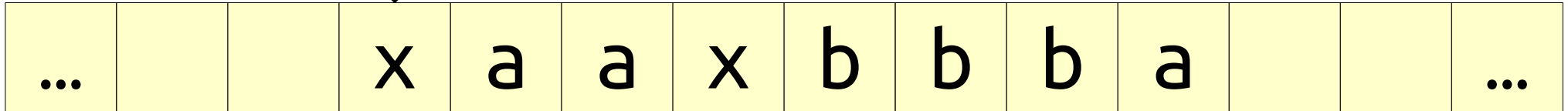
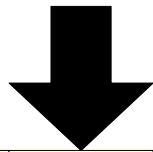
GoHome:

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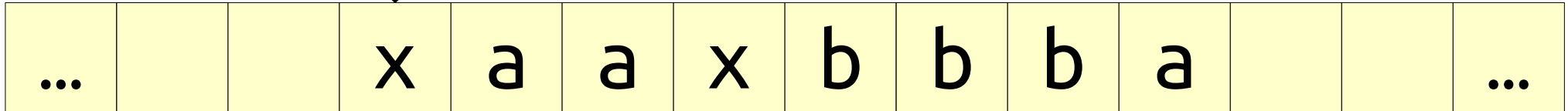
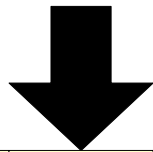


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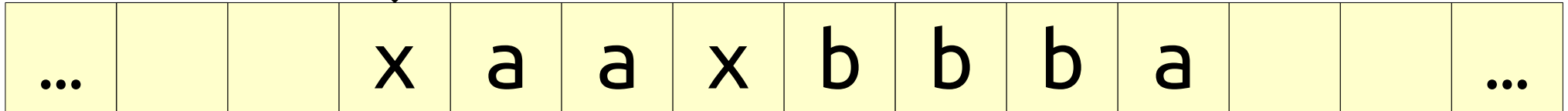
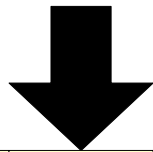
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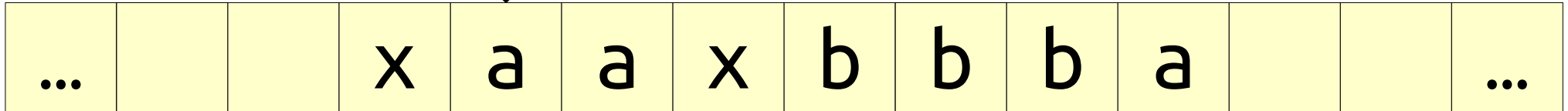
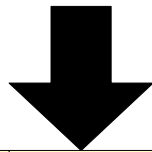
GoHome:

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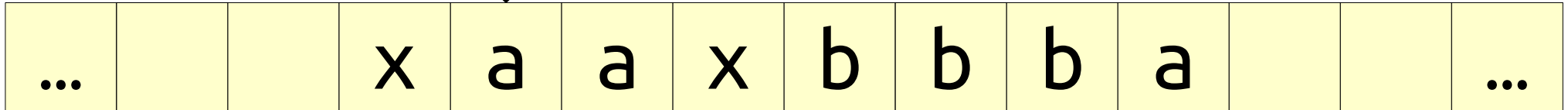
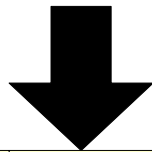
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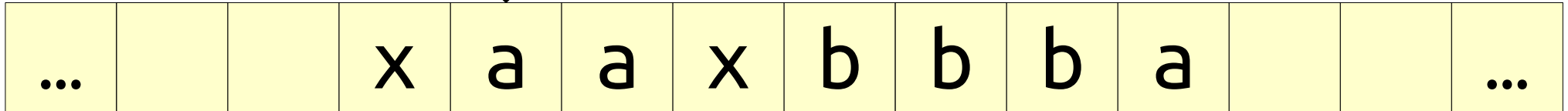
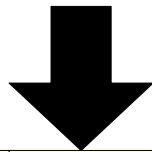
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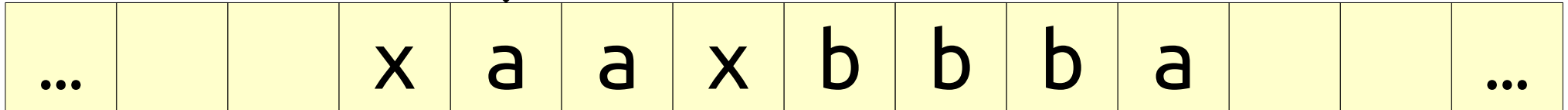
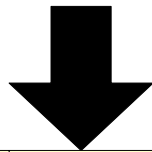
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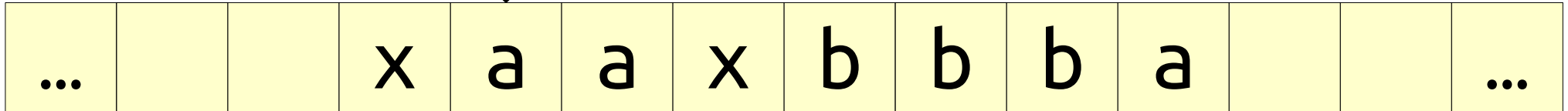
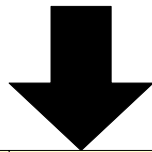
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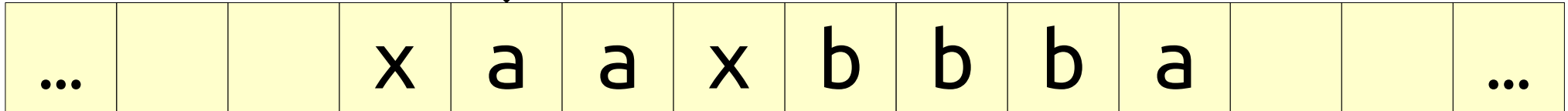
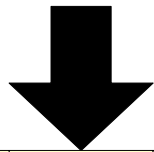


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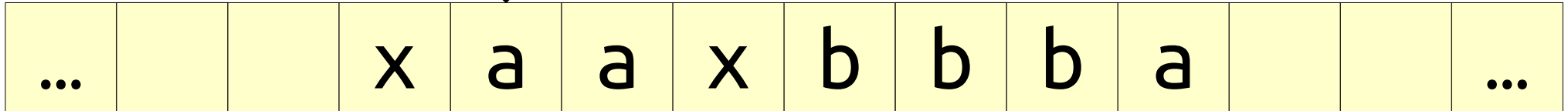
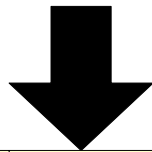


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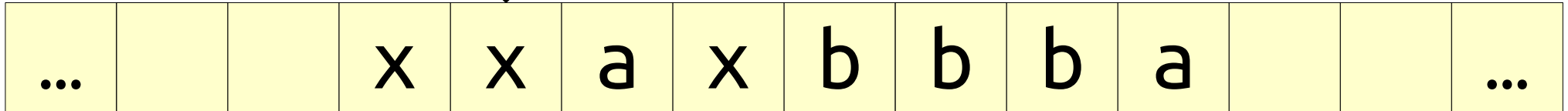
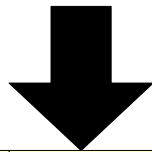


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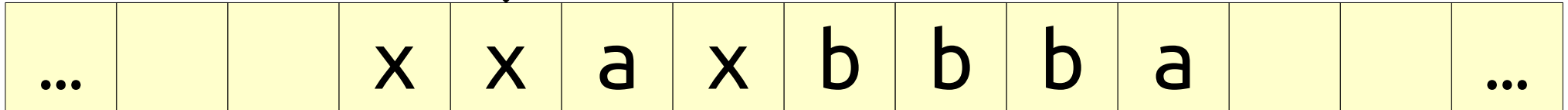
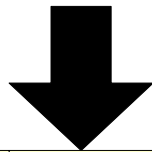


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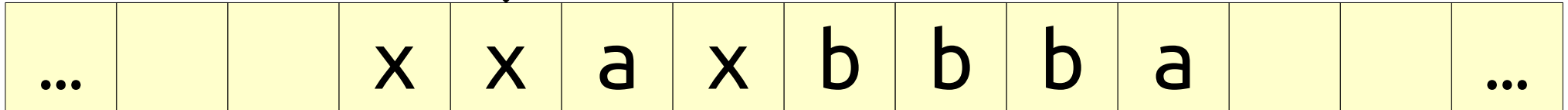
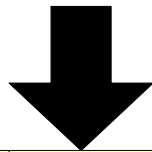
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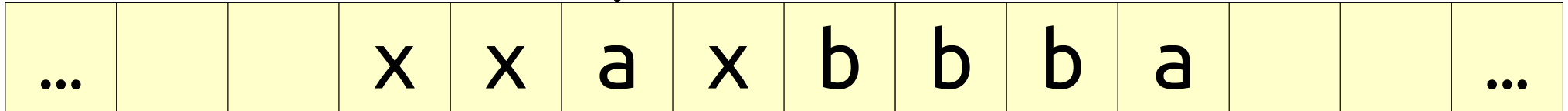
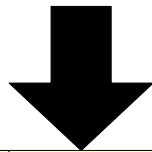
GoHome:

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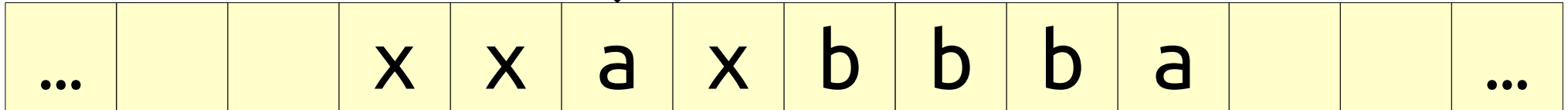
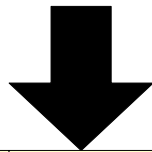
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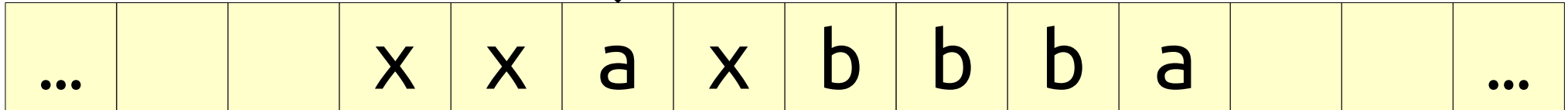
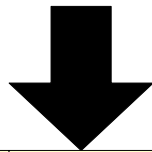
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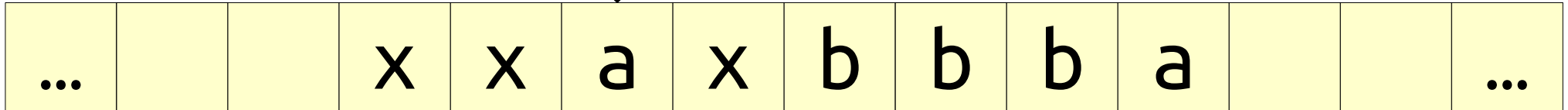
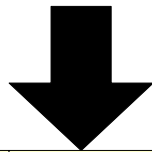
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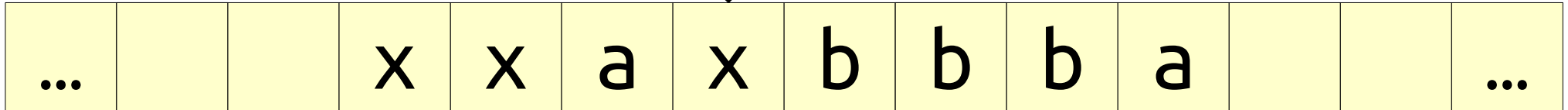
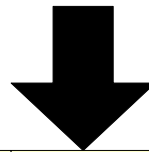
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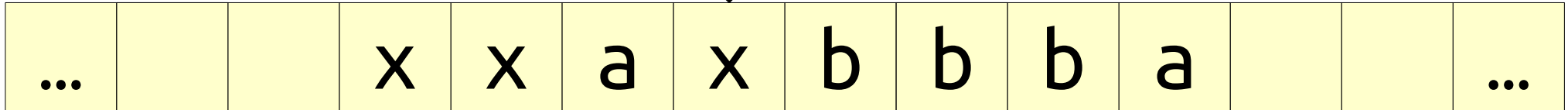
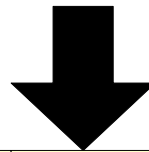
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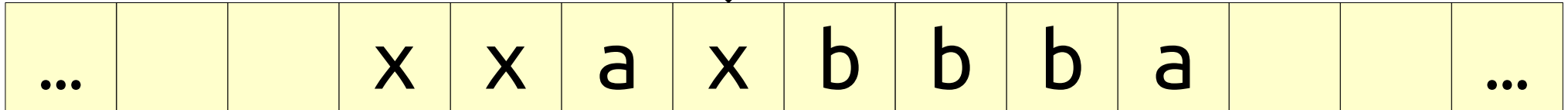
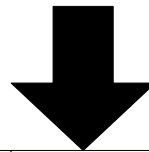
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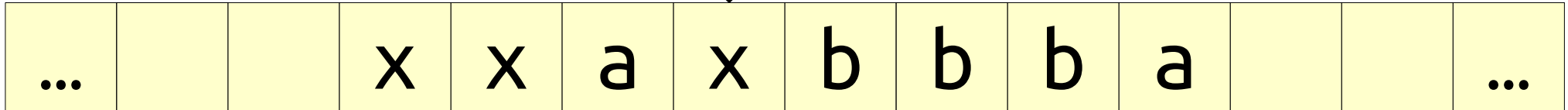
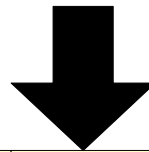
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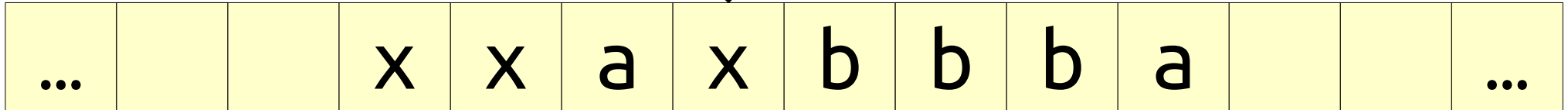
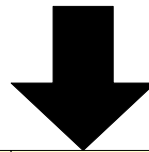
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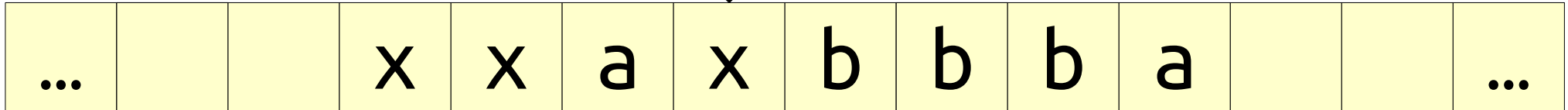
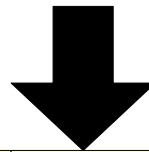
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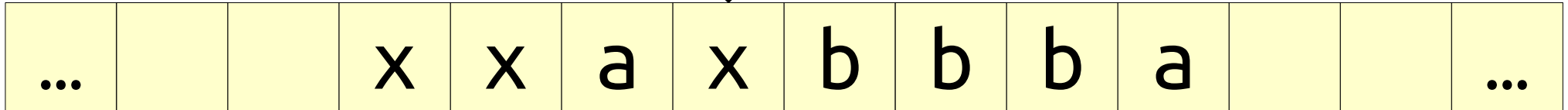
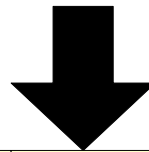
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```

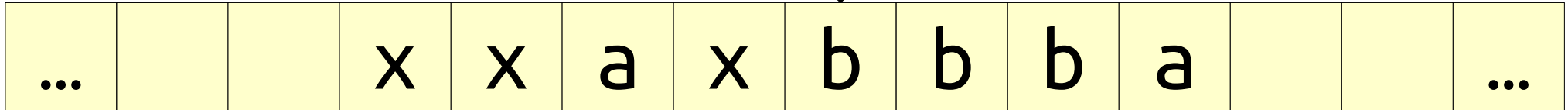
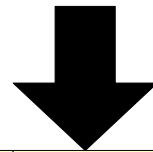


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  If 'x' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

```
Move Right
```

```
If 'a' Goto LoopA
```

```
If 'x' Goto LoopA
```

```
Write 'x'
```

```
Goto GoHome
```

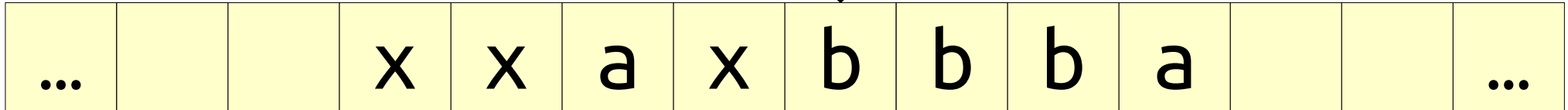
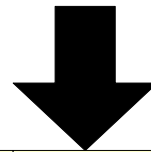
GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome
```

```
Move Right
```

```
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

```
Move Right
```

```
If 'a' Goto LoopA
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```
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```

```
Write 'x'
```

```
Goto GoHome
```

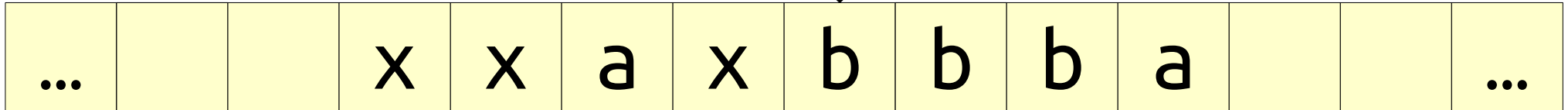
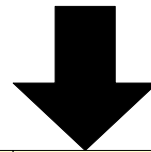
GoHome:

```
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Move Right
```

```
Goto Start
```

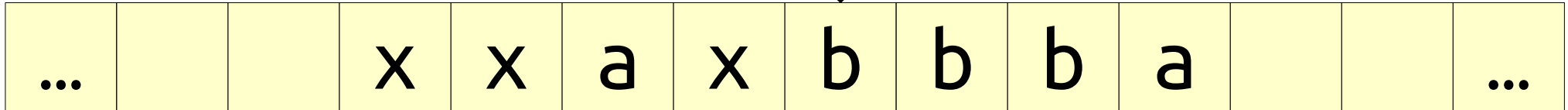
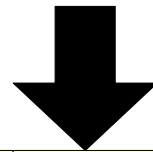


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LoopA:

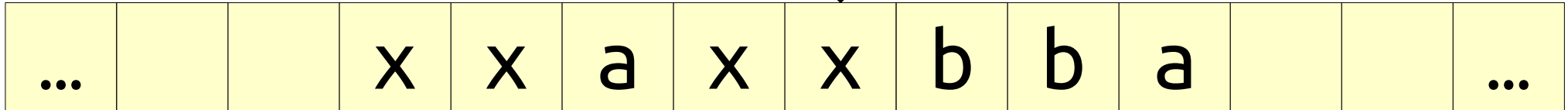
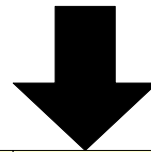
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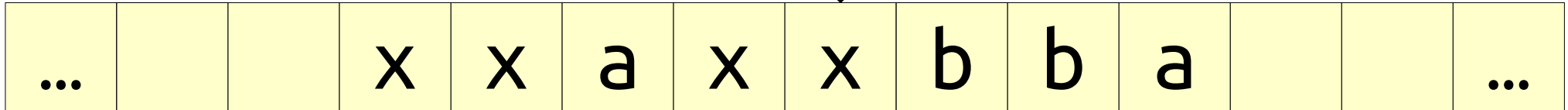
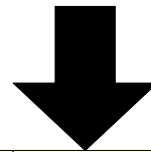


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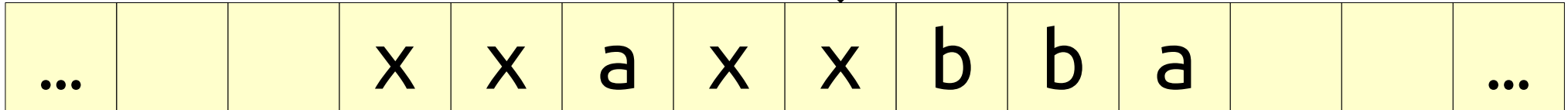
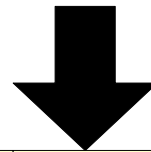
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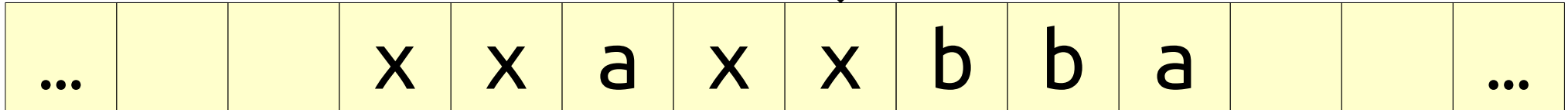
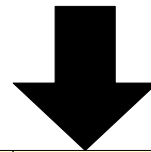
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Goto Start
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FoundA:

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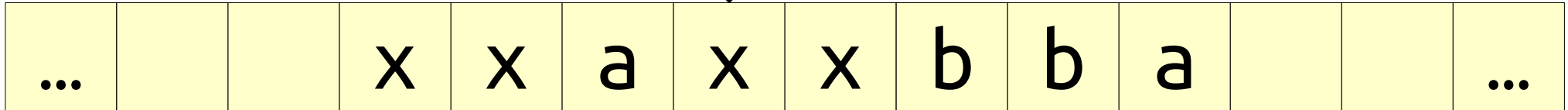
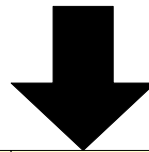
LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
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GoHome:

```
Move Left
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```
If Not Blank Goto GoHome  
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Goto Start
```

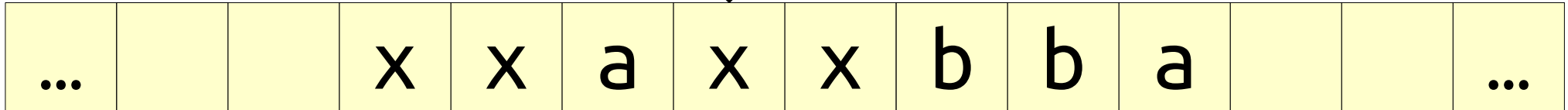
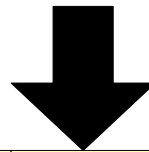


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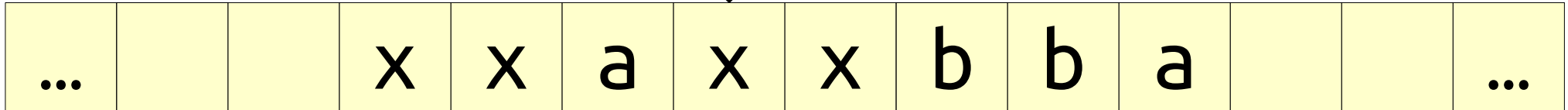
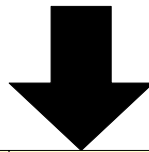
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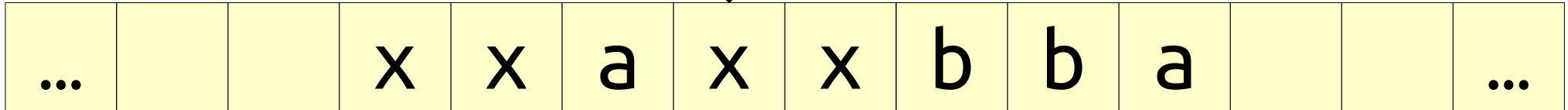
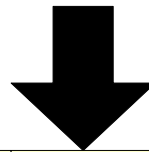
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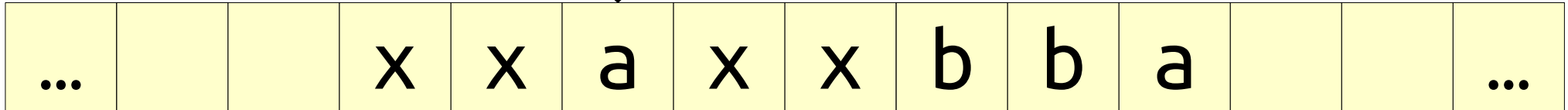
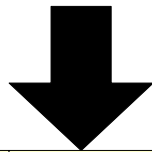
LoopA:

```
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```
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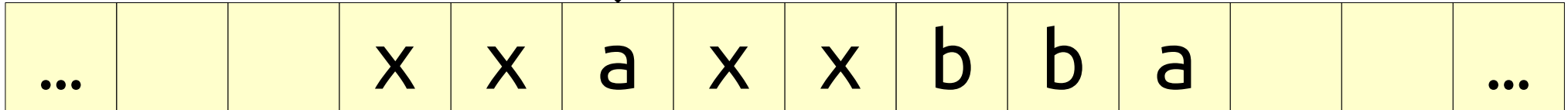
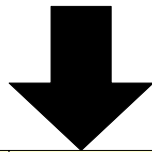


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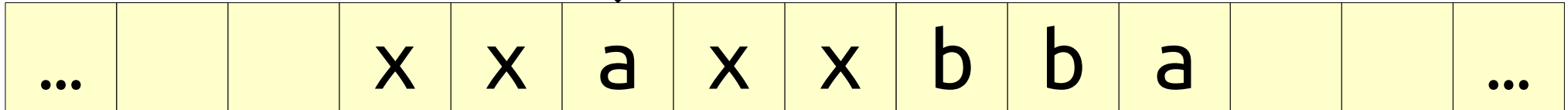
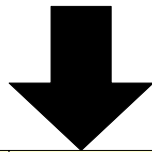
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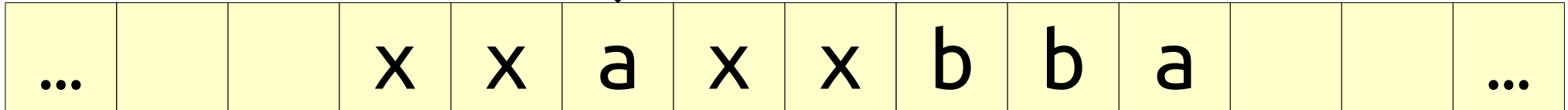
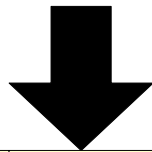
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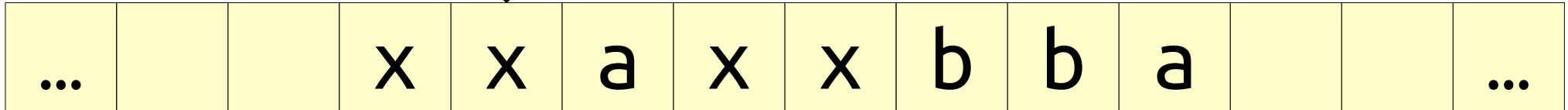
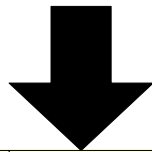
LoopA:

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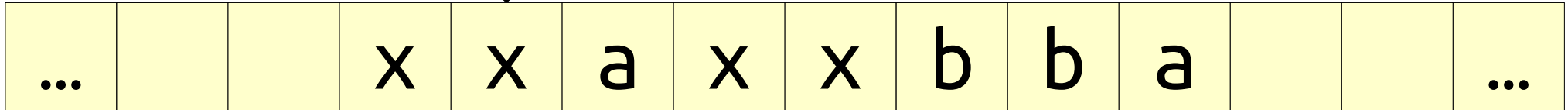
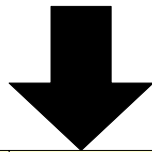


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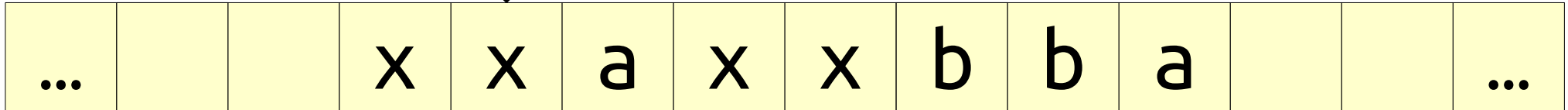
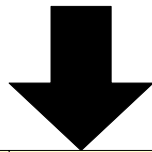
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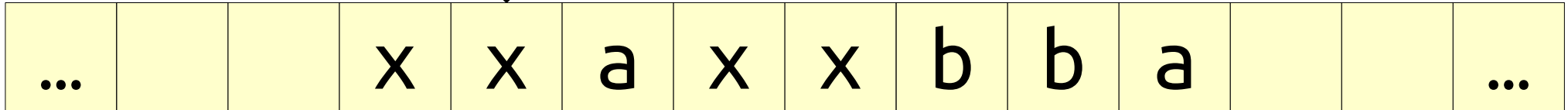
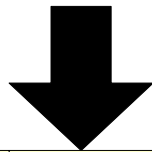
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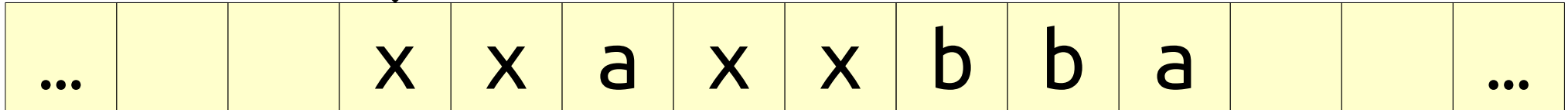
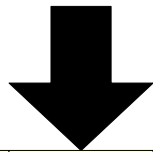
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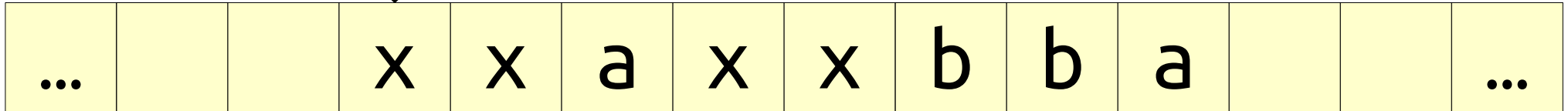
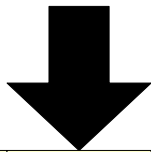


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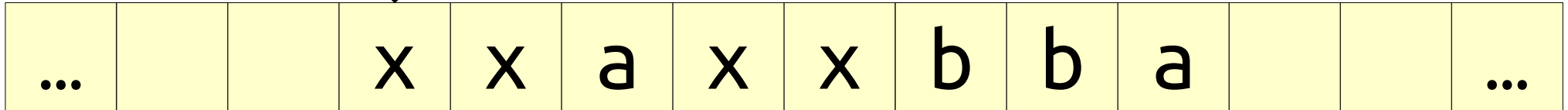
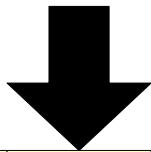
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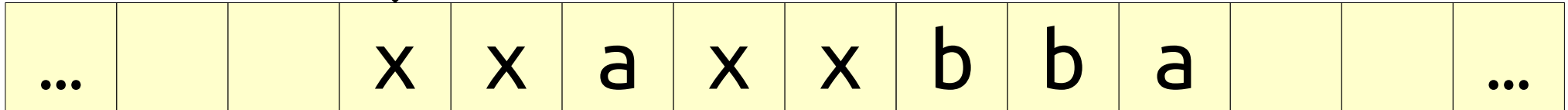
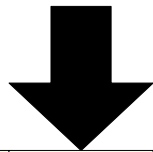
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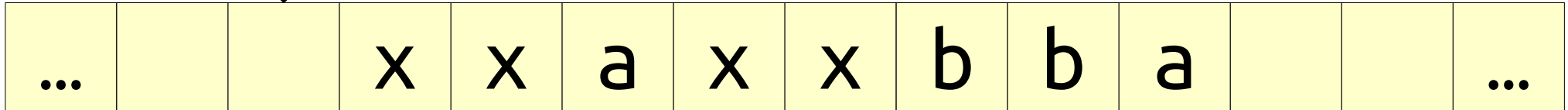
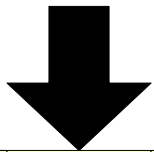


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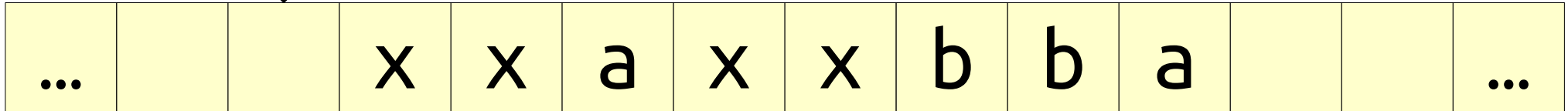
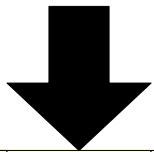


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```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```

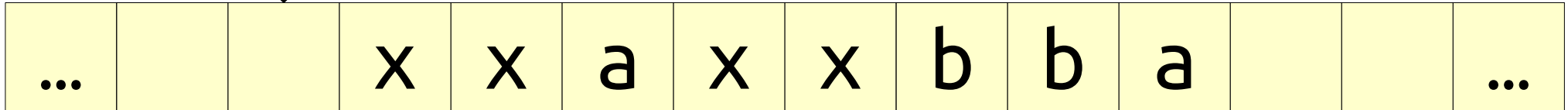
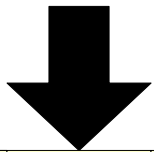


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  If 'x' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```

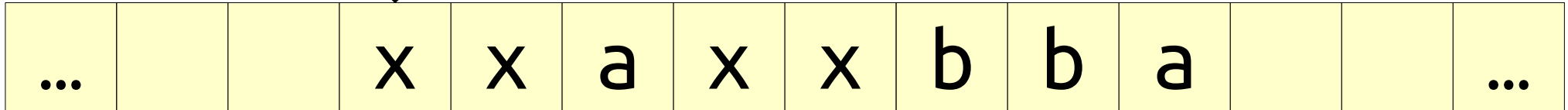
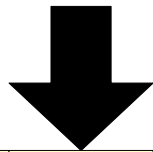


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
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  If 'a' Goto LoopA  
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  Write 'x'  
  Goto GoHome
```

```
GoHome:  
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  Goto Start
```

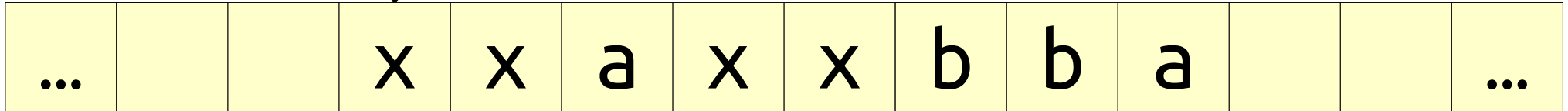
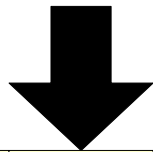


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Start:  
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GoHome:  
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Start:

```
If 'a' Goto FoundA  
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Goto Start
```

FoundA:

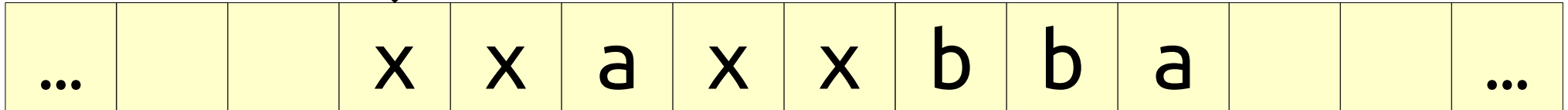
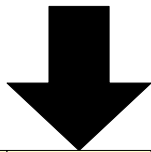
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
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GoHome:

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Start:

If 'a' Goto FoundA

Move Right

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FoundA:

Write 'x'

LoopA:

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Write 'x'

Goto GoHome

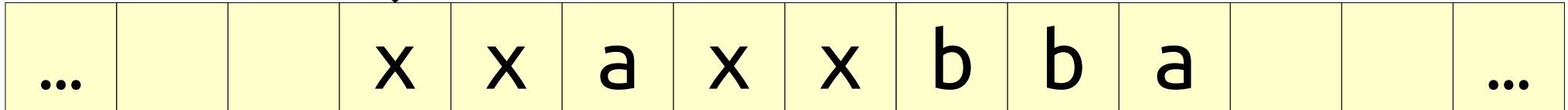
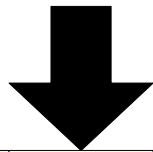
GoHome:

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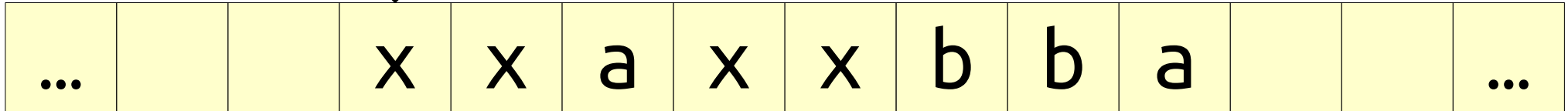
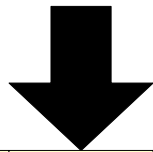
GoHome:

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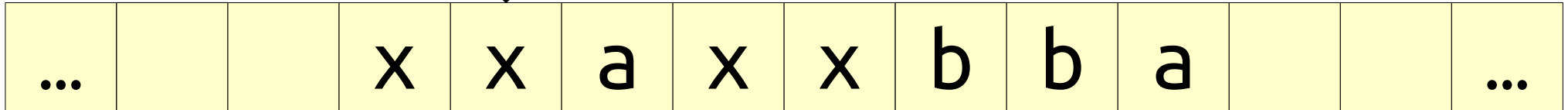
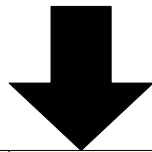
GoHome:

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Move Right

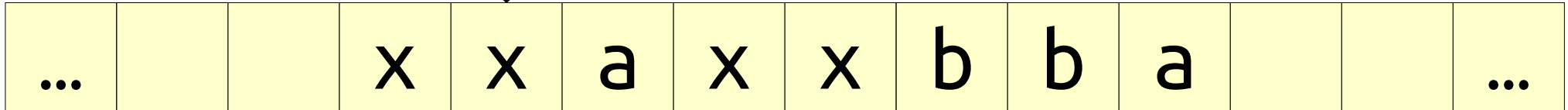
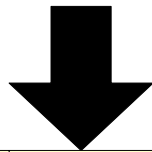
Goto Start



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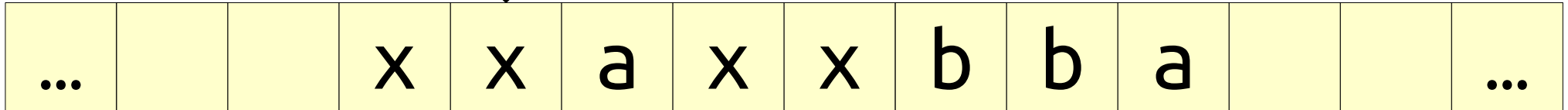
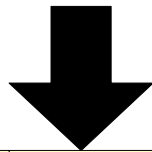
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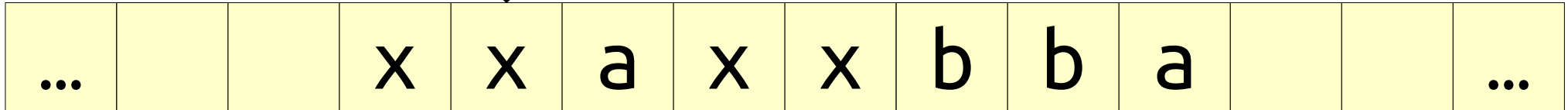
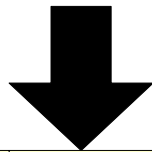
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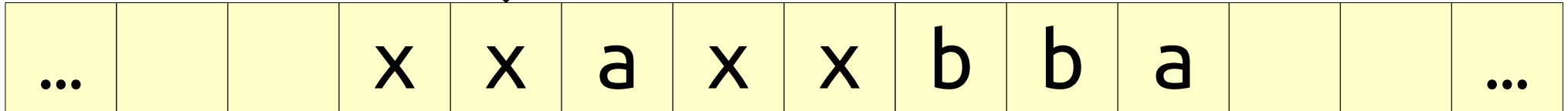
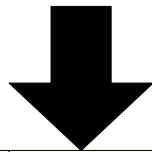
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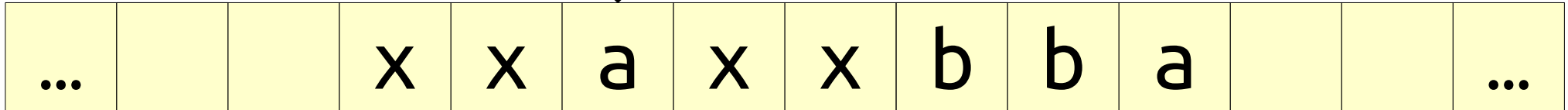
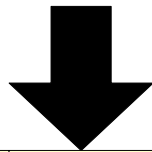
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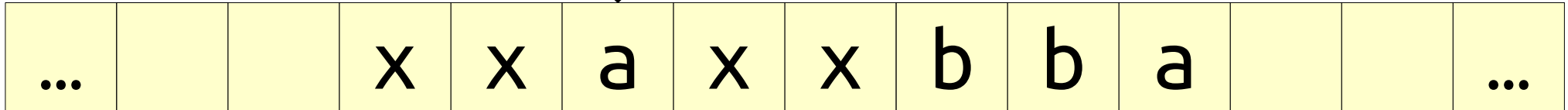
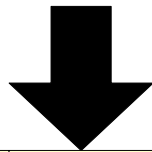
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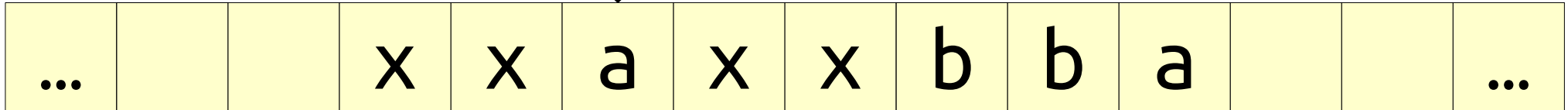
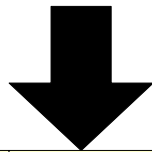
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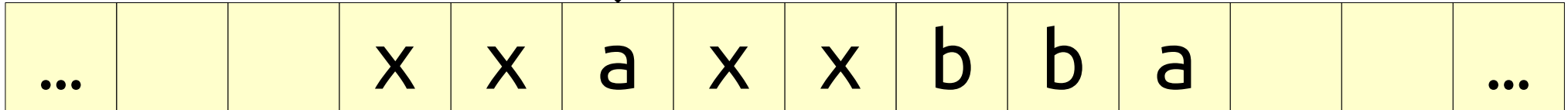
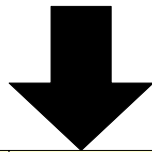
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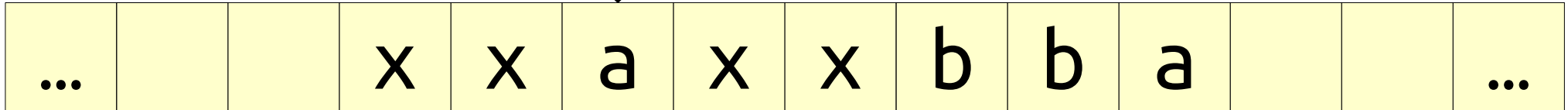
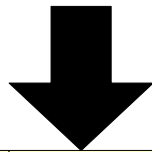
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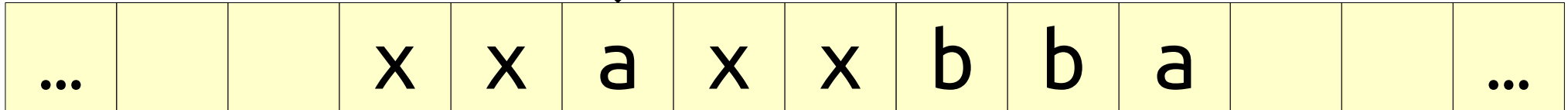
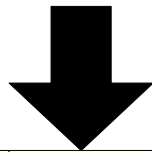
Write 'x'

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Start:

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```

FoundA:

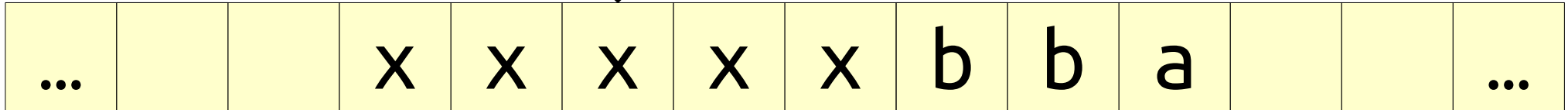
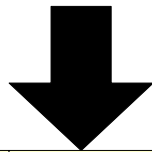
Write 'x'

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Start:

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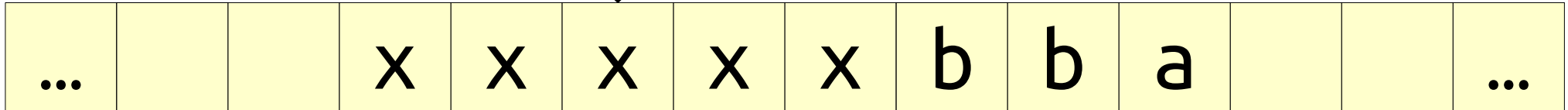
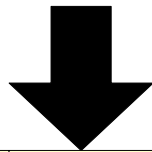
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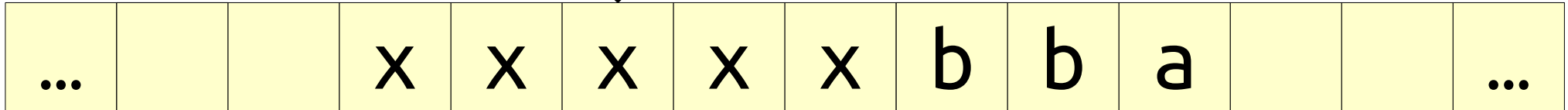
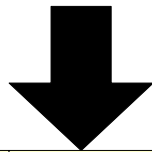
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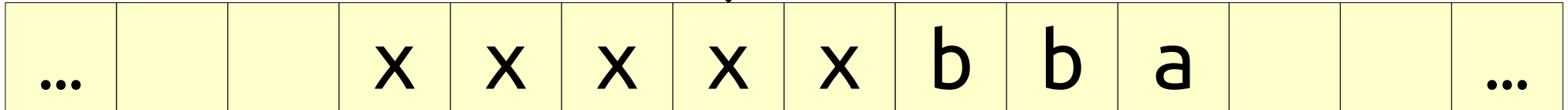
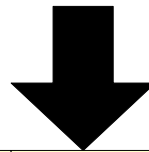
GoHome:

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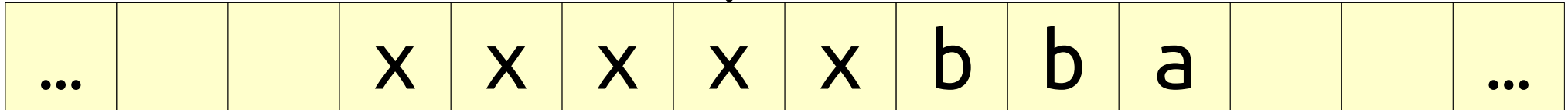
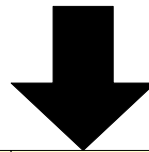
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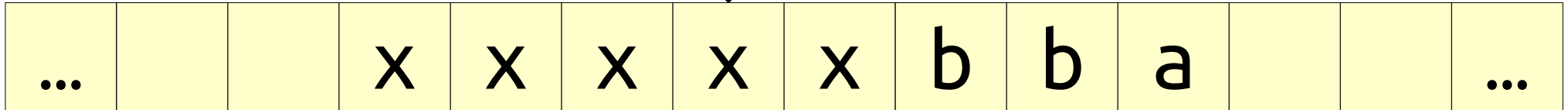
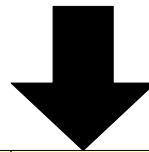
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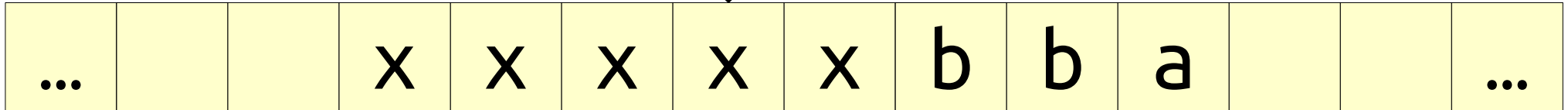
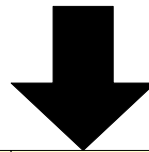
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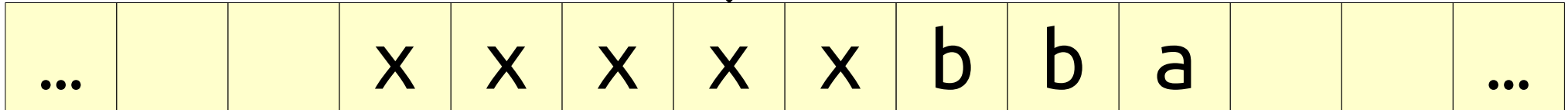
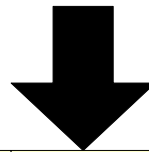
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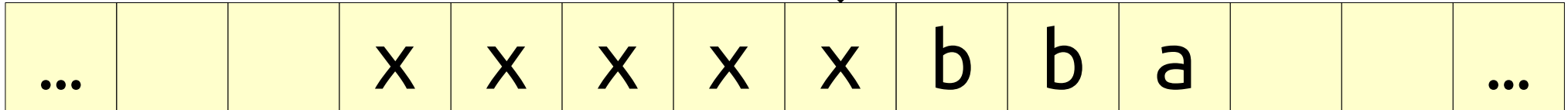
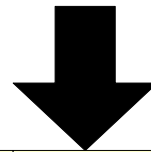


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```

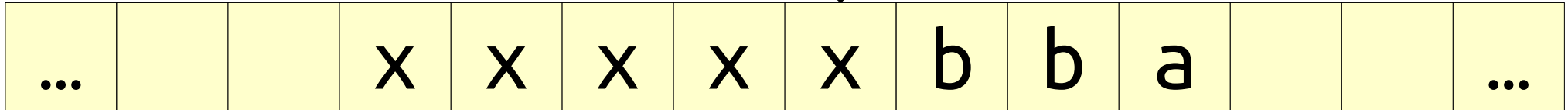
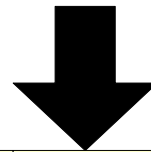
GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome
```

```
Move Right
```

```
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

```
Move Right
```

```
If 'a' Goto LoopA
```

```
If 'x' Goto LoopA
```

```
Write 'x'
```

```
Goto GoHome
```

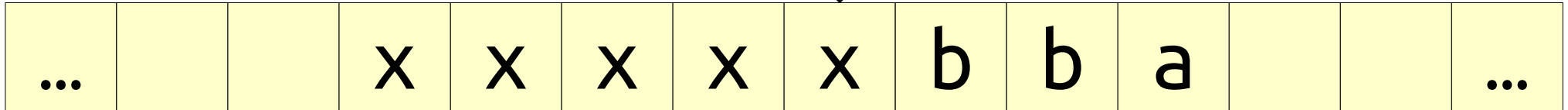
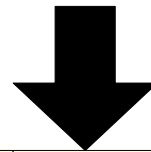
GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome
```

```
Move Right
```

```
Goto Start
```

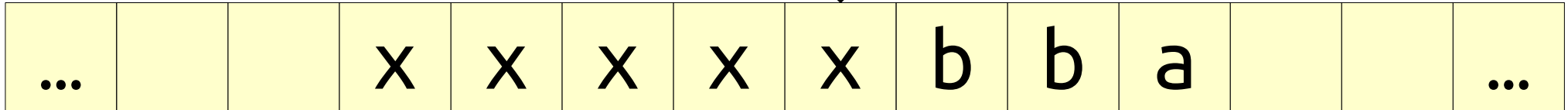
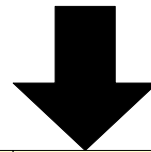


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  If 'x' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```

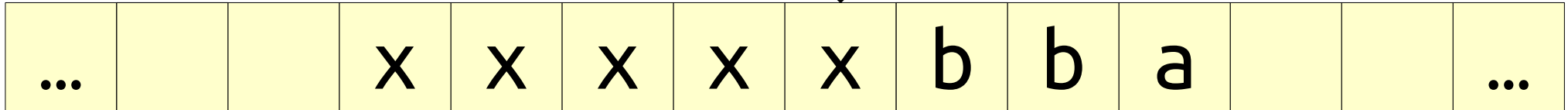
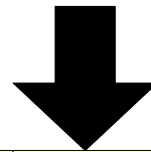


```
Start:
  If 'a' Goto FoundA
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
```

```
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

```
Move Right
```

```
If 'a' Goto LoopA
```

```
If 'x' Goto LoopA
```

```
Write 'x'
```

```
Goto GoHome
```

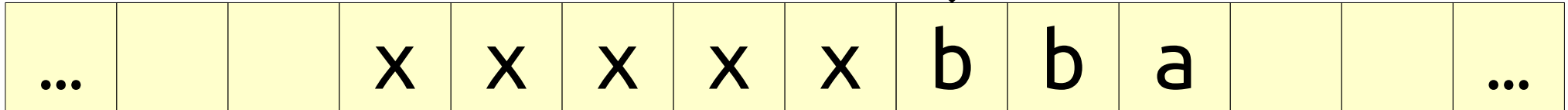
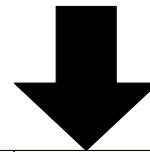
GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome
```

```
Move Right
```

```
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

```
Move Right
```

```
If 'a' Goto LoopA
```

```
If 'x' Goto LoopA
```

```
Write 'x'
```

```
Goto GoHome
```

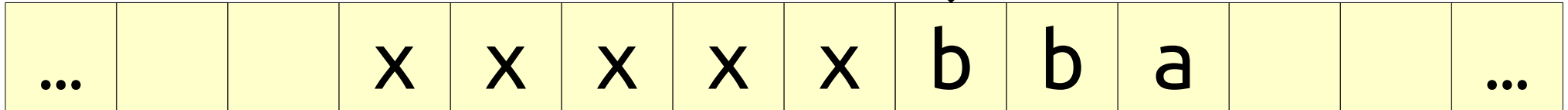
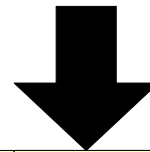
GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome
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```
Move Right
```

```
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

```
Move Right
```

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If 'a' Goto LoopA
```

```
If 'x' Goto LoopA
```

```
Write 'x'
```

```
Goto GoHome
```

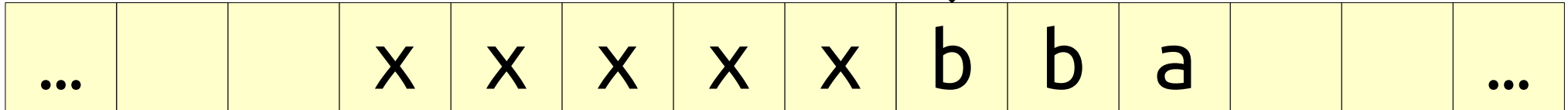
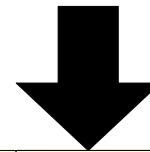
GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome
```

```
Move Right
```

```
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

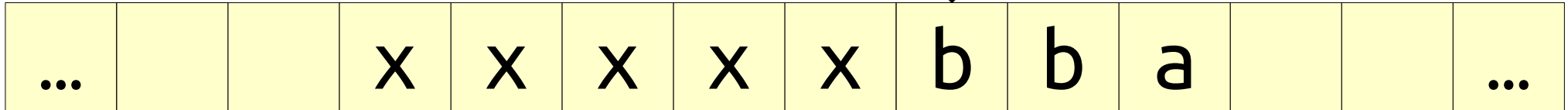
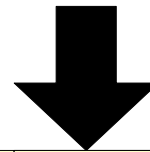
```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA
```

```
Write 'x'
```

```
Goto GoHome
```

GoHome:

```
Move Left  
If Not Blank Goto GoHome  
Move Right  
Goto Start
```

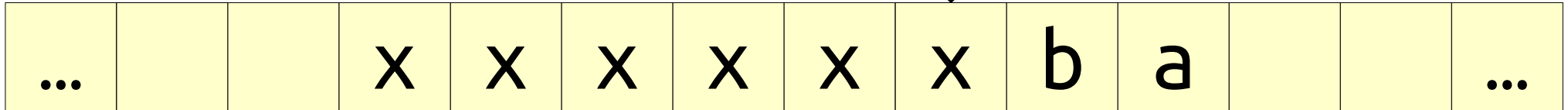
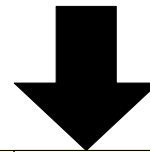


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  If 'x' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```

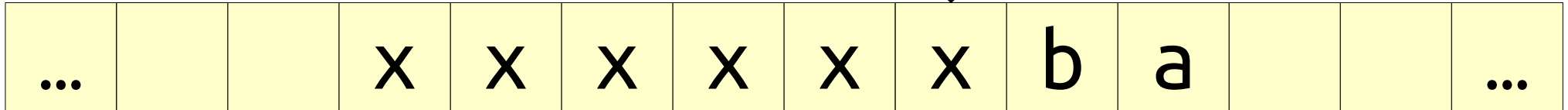
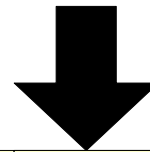


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  If 'x' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

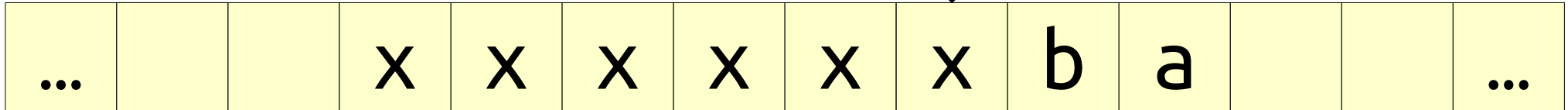
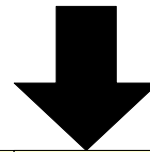
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
Move Left  
If Not Blank Goto GoHome  
Move Right  
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

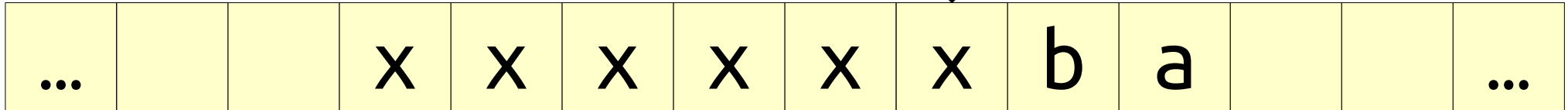
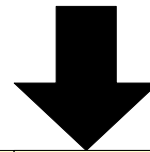
LoopA:

```
Move Right  
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Write 'x'  
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GoHome:

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Move Left
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If Not Blank Goto GoHome  
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```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

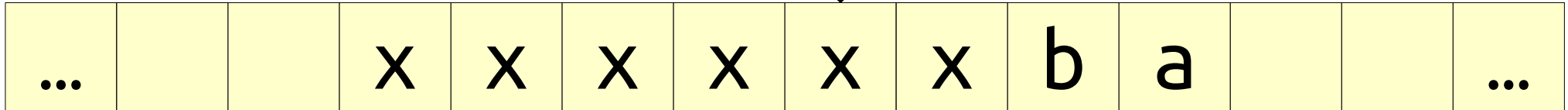
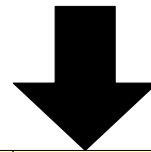
LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
Move Left
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If Not Blank Goto GoHome  
Move Right  
Goto Start
```

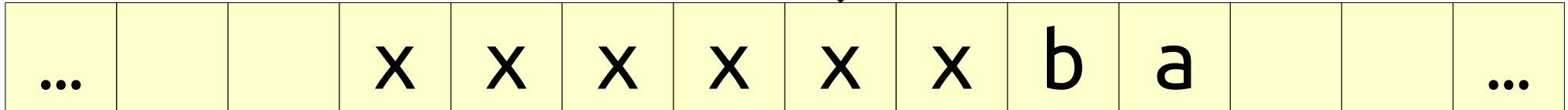
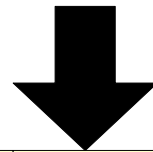


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  If 'x' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

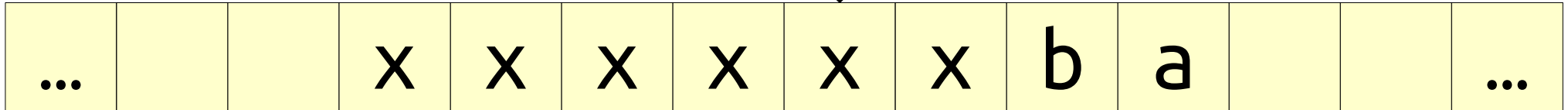
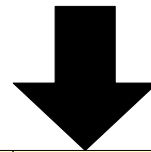
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

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Move Left  
If Not Blank Goto GoHome  
Move Right  
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

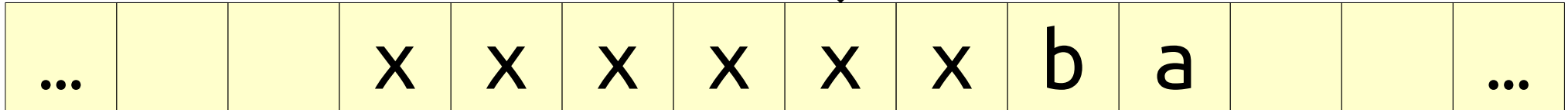
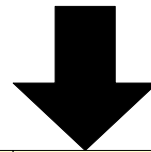
LoopA:

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GoHome:

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```



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If 'a' Goto FoundA  
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Goto Start
```

FoundA:

```
Write 'x'
```

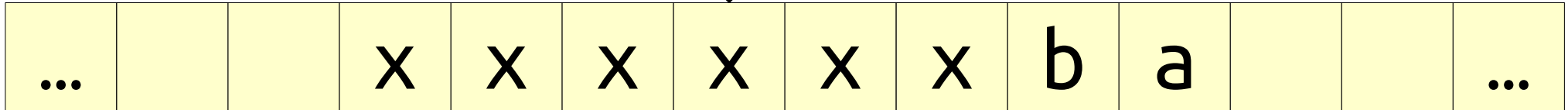
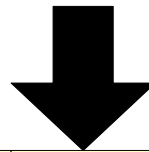
LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome  
Move Right  
Goto Start
```

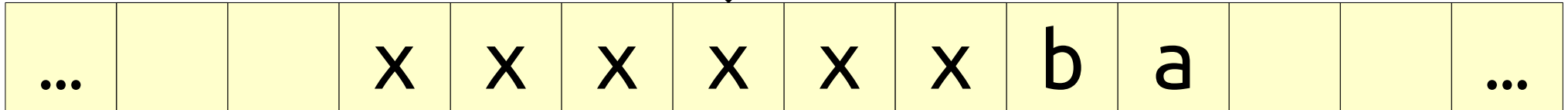
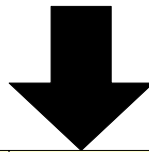


```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'
```

```
LoopA:  
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```



Start:

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If 'a' Goto FoundA  
Move Right  
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```

FoundA:

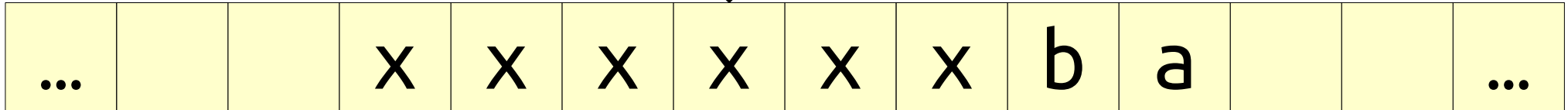
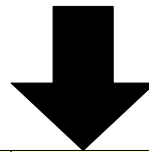
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
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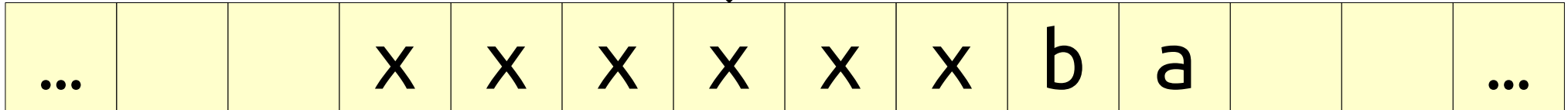
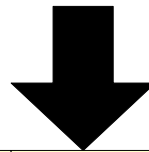
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Start:

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Goto Start
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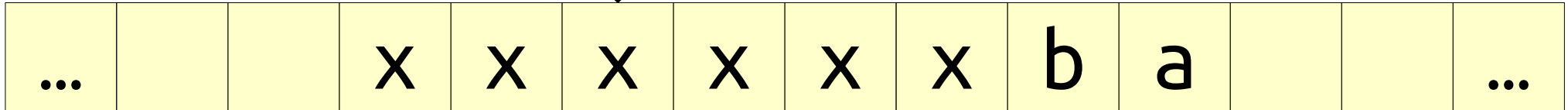
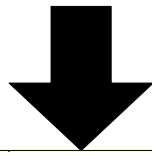
LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
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```

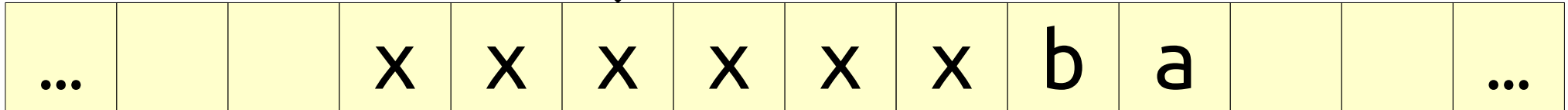
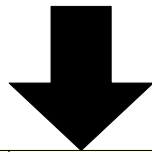


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FoundA:  
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If 'a' Goto FoundA  
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FoundA:

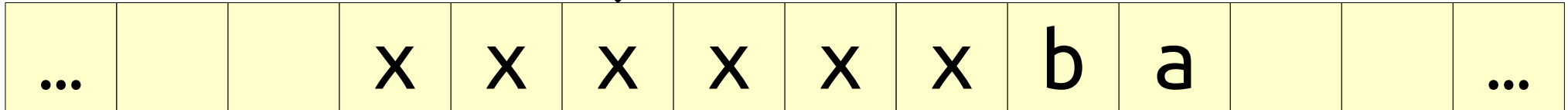
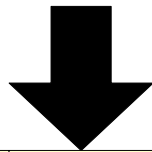
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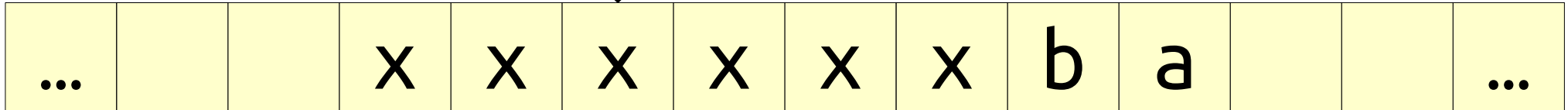
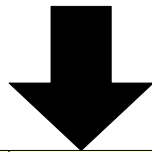
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```

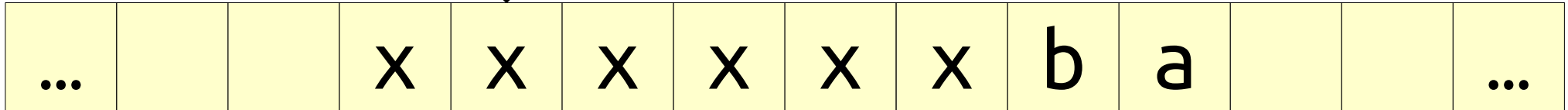
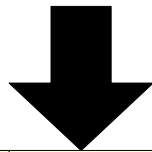
LoopA:

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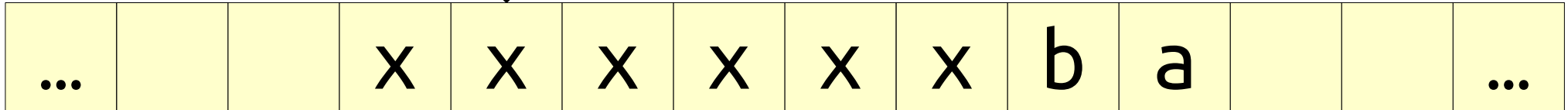
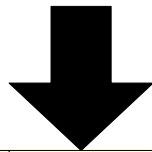


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```

FoundA:

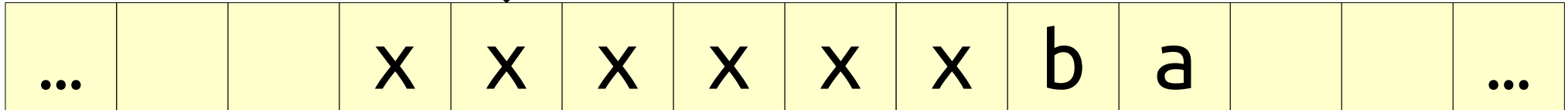
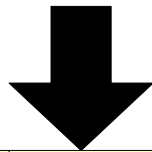
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
Move Left  
If Not Blank Goto GoHome  
Move Right  
Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

```
Write 'x'
```

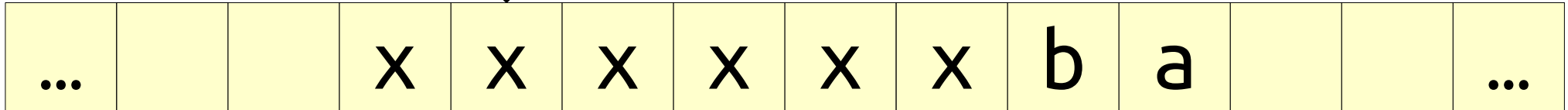
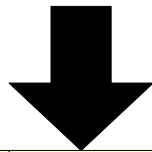
LoopA:

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Goto GoHome
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GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome  
Move Right  
Goto Start
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Start:

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If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

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```

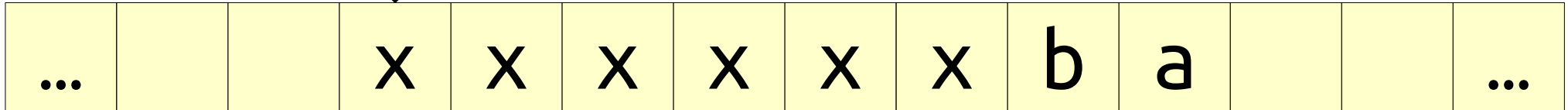
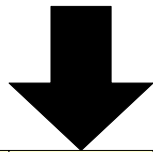
LoopA:

```
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If 'a' Goto LoopA  
If 'x' Goto LoopA  
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Goto GoHome
```

GoHome:

```
Move Left
```

```
If Not Blank Goto GoHome  
Move Right  
Goto Start
```

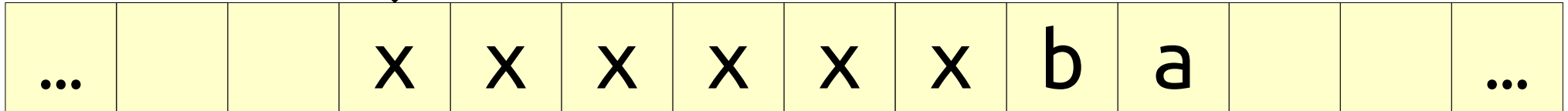
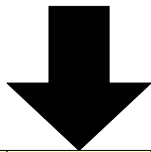


```
Start:
  If 'a' Goto FoundA
  Move Right
  Goto Start
```

```
FoundA:
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```
LoopA:
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  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
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```

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GoHome:
  Move Left
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  Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

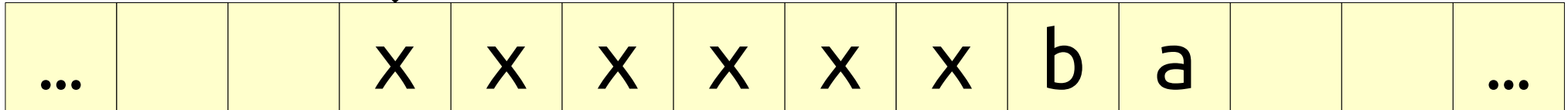
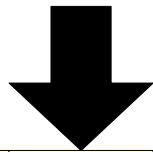
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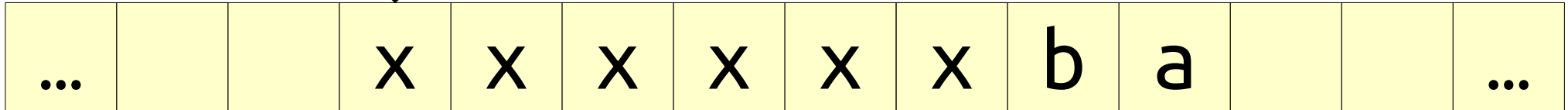
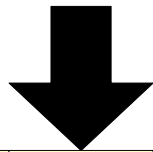
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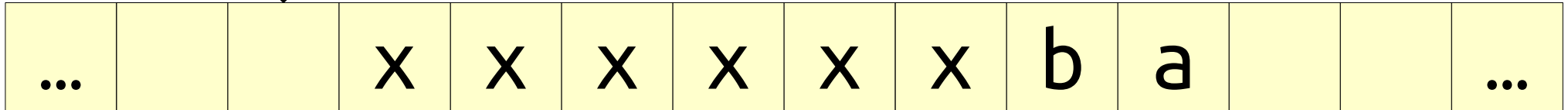
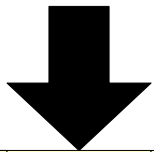


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  If 'a' Goto FoundA
  Move Right
  Goto Start
```

```
FoundA:
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LoopA:
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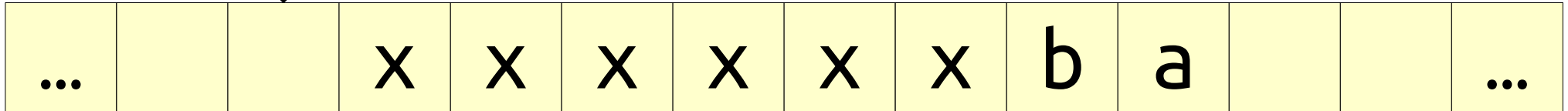
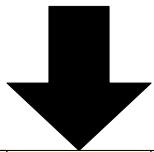


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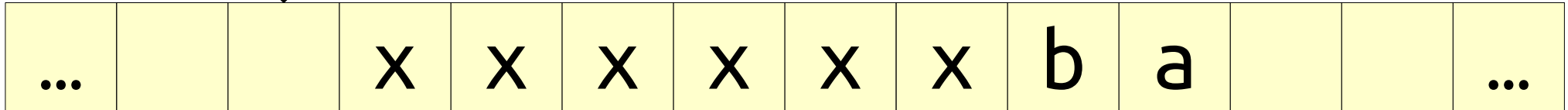
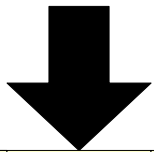


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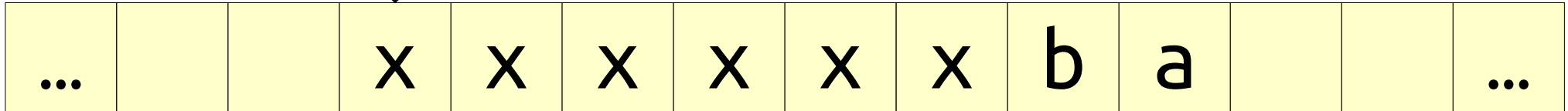
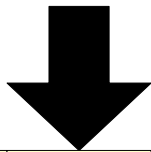


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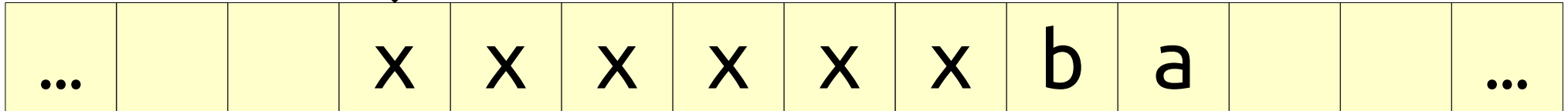
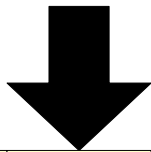


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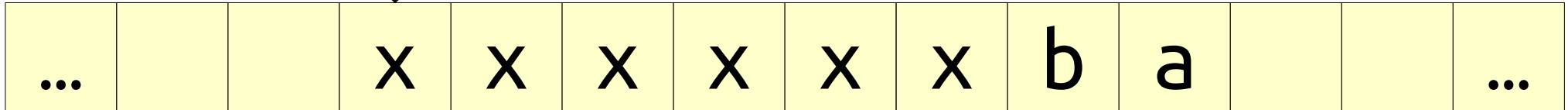
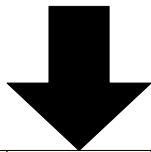
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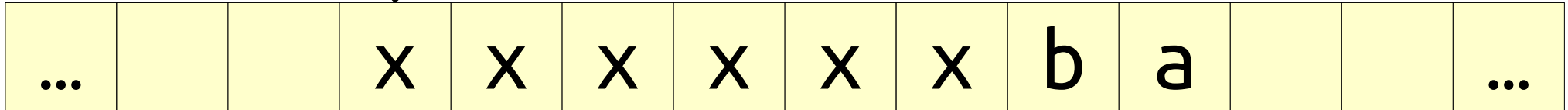
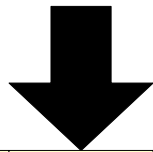
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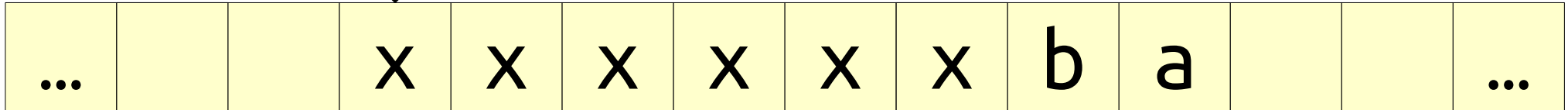
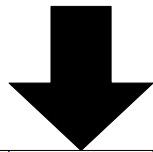
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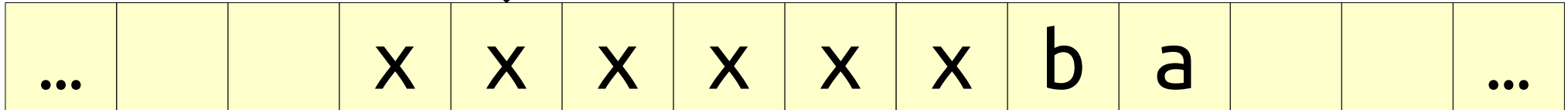
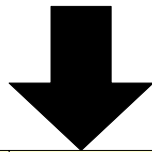
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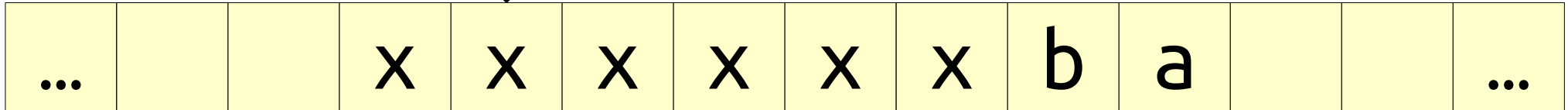
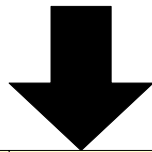
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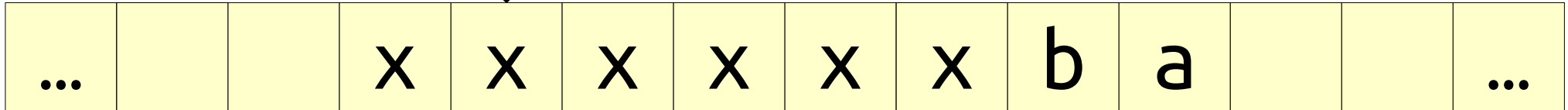
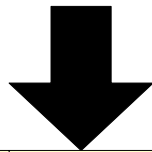
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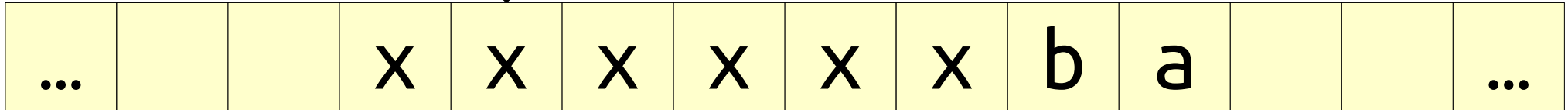
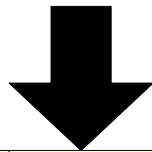
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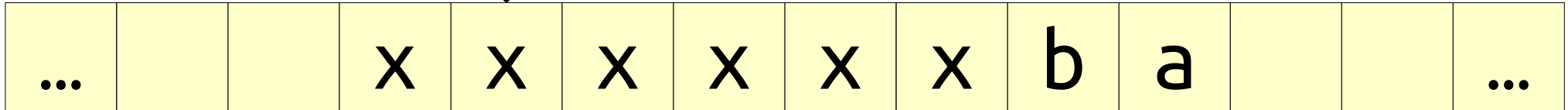
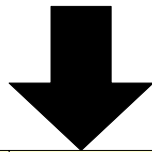
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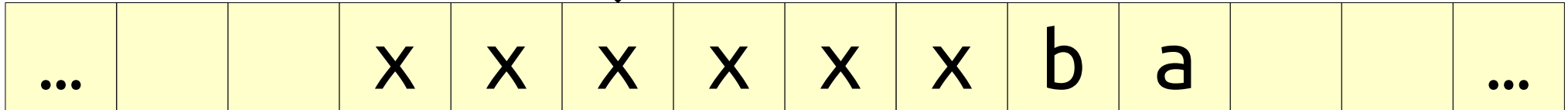
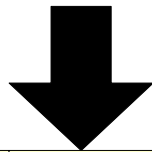
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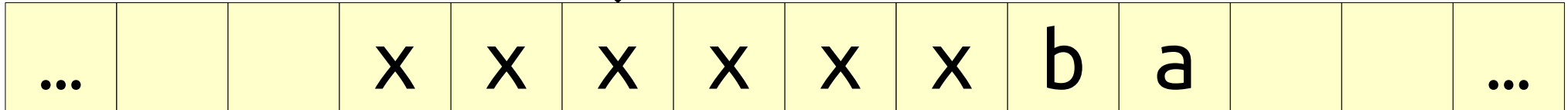
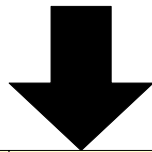
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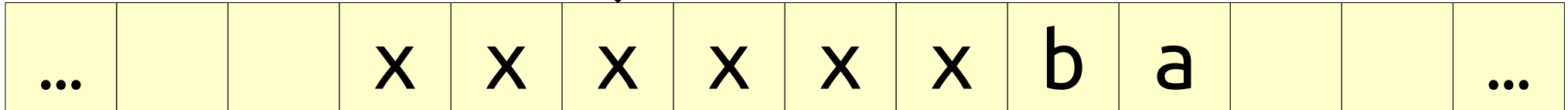
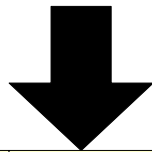
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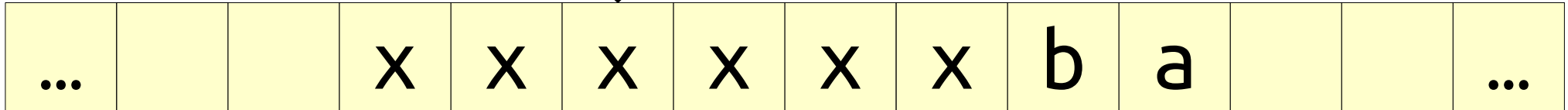
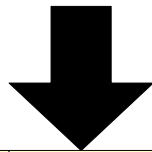
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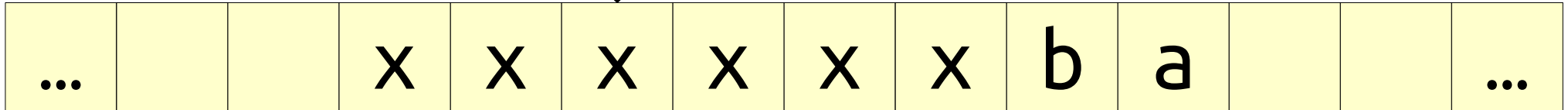
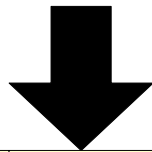
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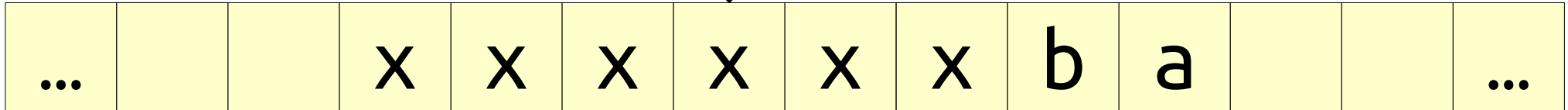
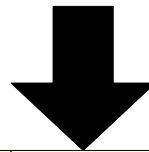
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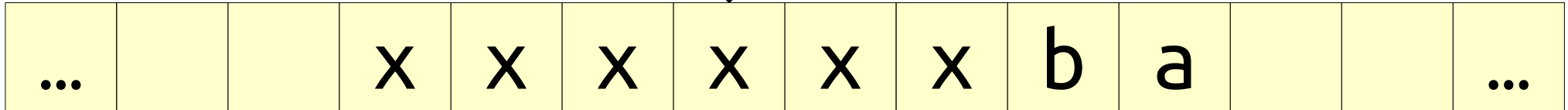
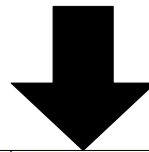
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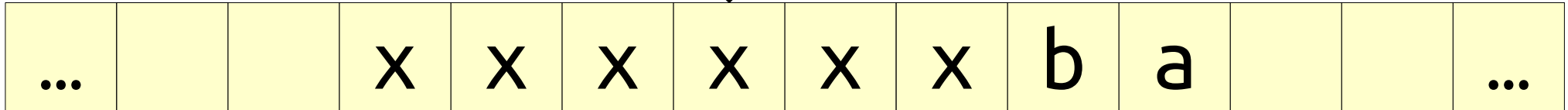
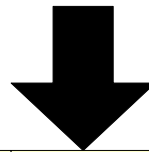
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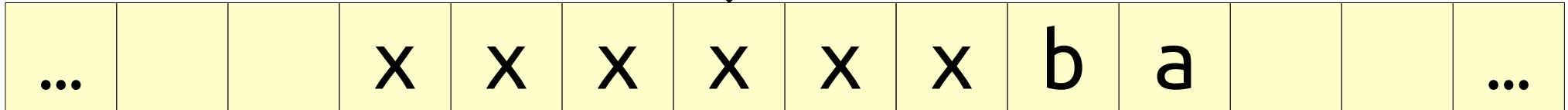
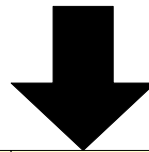
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Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

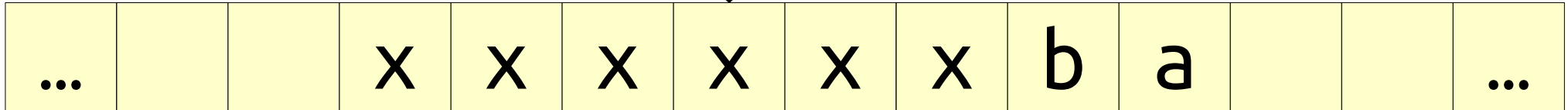
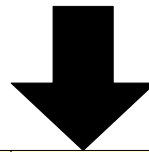
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

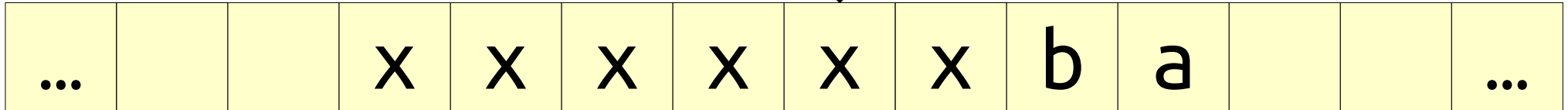
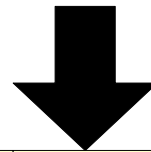
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

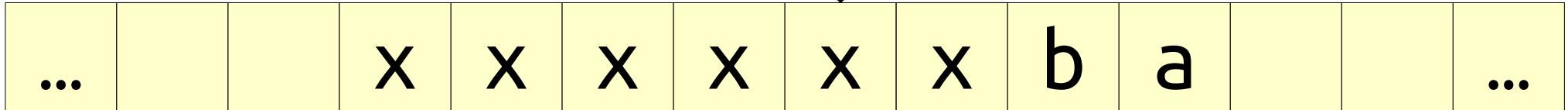
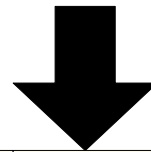
Goto Start



```
Start:  
  If 'a' Goto FoundA  
  Move Right  
  Goto Start
```

```
FoundA:  
  Write 'x'  
LoopA:  
  Move Right  
  If 'a' Goto LoopA  
  If 'x' Goto LoopA  
  Write 'x'  
  Goto GoHome
```

```
GoHome:  
  Move Left  
  If Not Blank Goto GoHome  
  Move Right  
  Goto Start
```



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

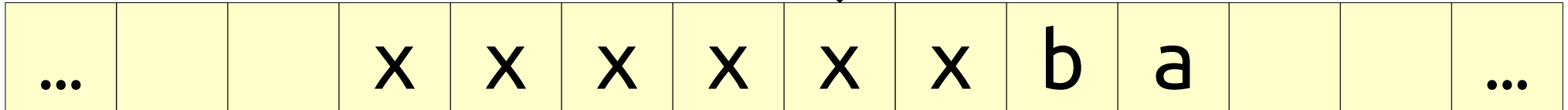
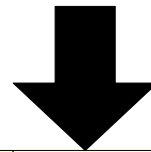
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
Move Left  
If Not Blank Goto GoHome  
Move Right  
Goto Start
```



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

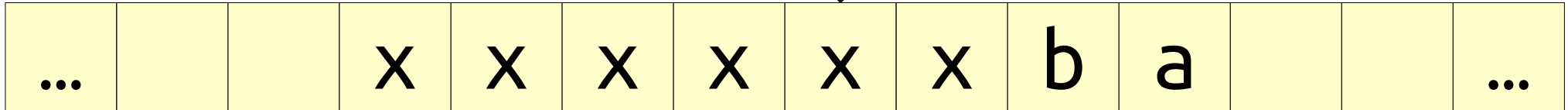
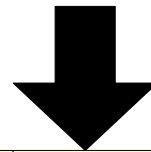
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

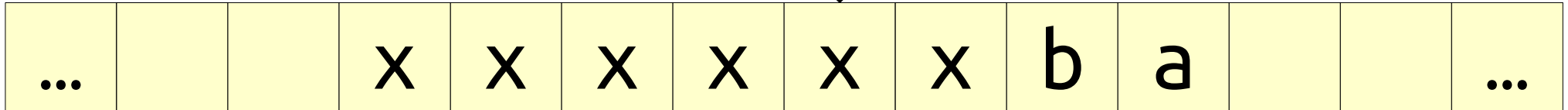
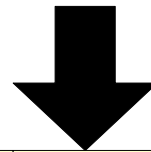
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

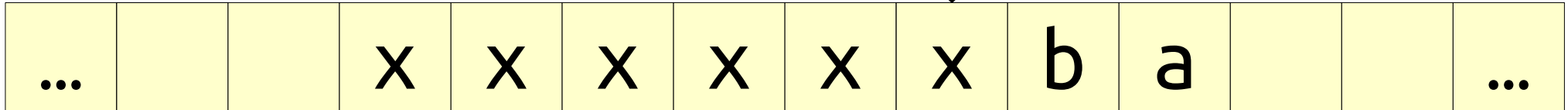
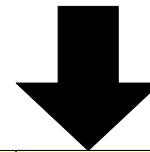
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

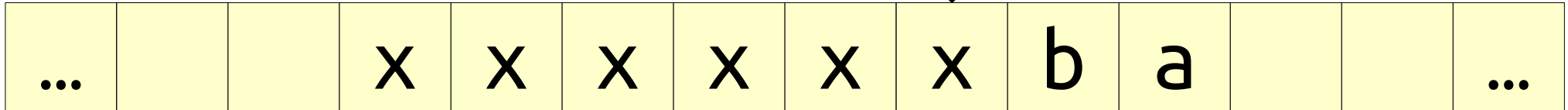
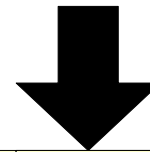
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

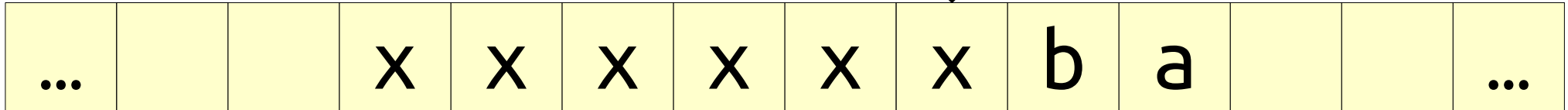
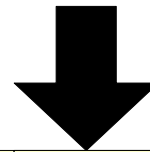
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
Move Left  
If Not Blank Goto GoHome  
Move Right  
Goto Start
```



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

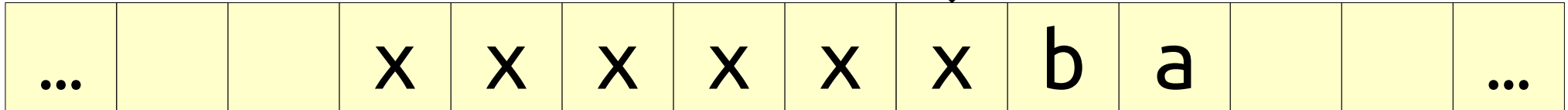
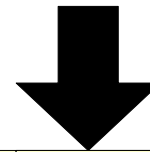
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

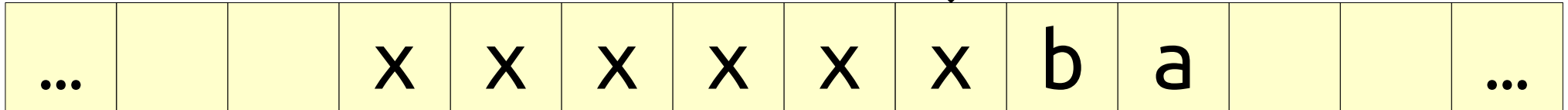
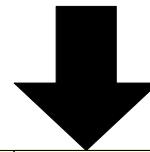
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

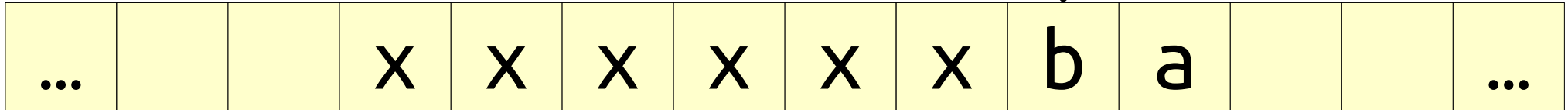
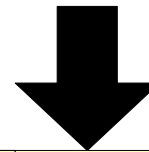
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

```
If 'a' Goto FoundA  
Move Right  
Goto Start
```

FoundA:

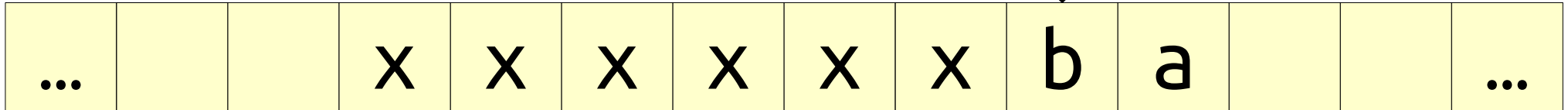
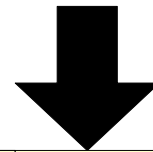
```
Write 'x'
```

LoopA:

```
Move Right  
If 'a' Goto LoopA  
If 'x' Goto LoopA  
Write 'x'  
Goto GoHome
```

GoHome:

```
Move Left  
If Not Blank Goto GoHome  
Move Right  
Goto Start
```



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

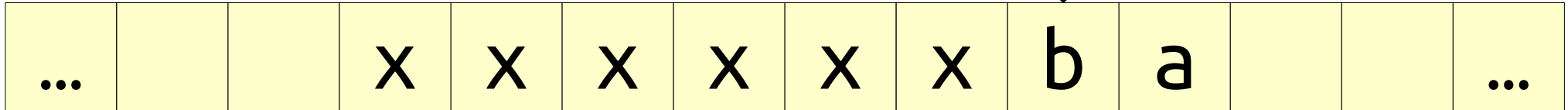
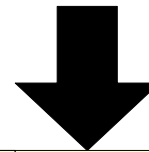
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

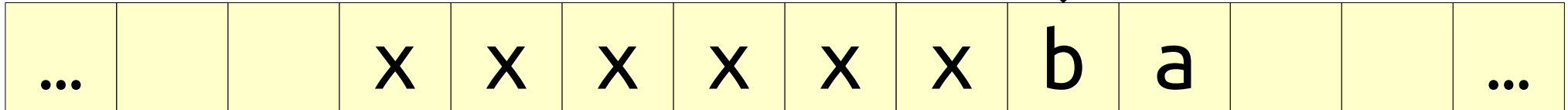
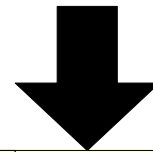
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

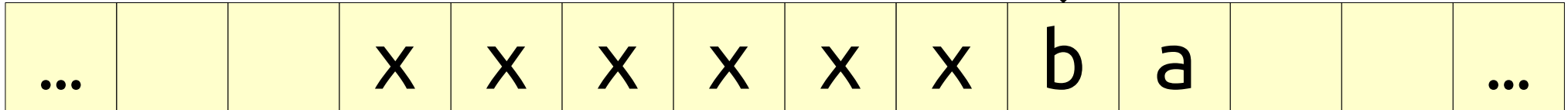
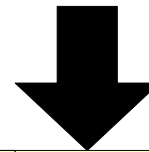
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

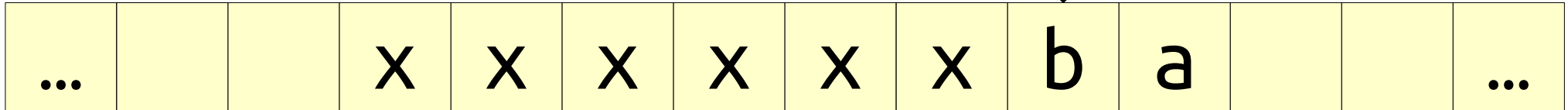
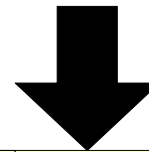
GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

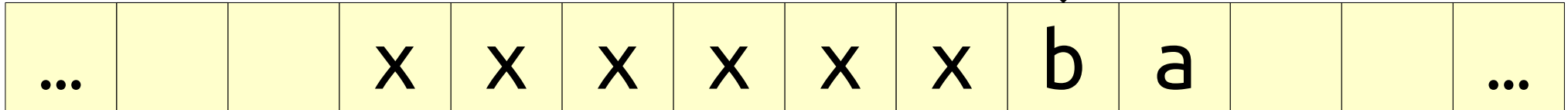
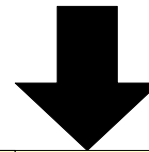
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome

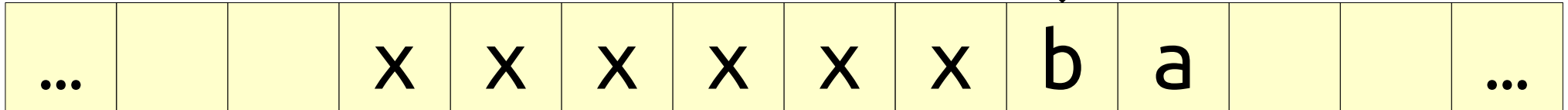
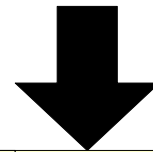


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

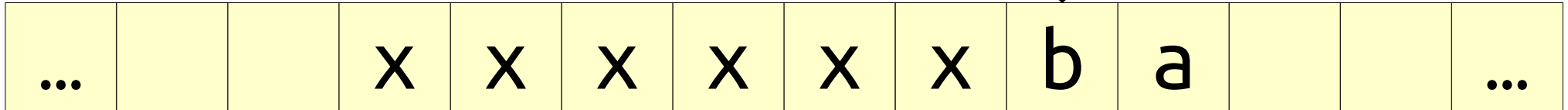
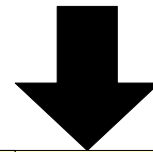


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

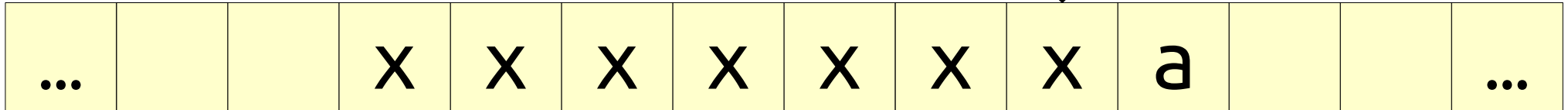
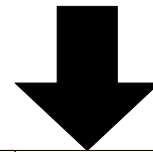


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

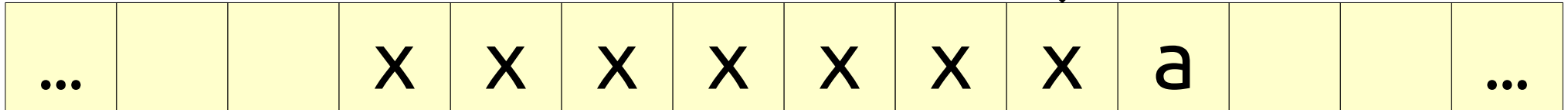
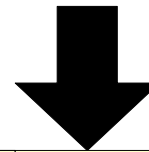


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

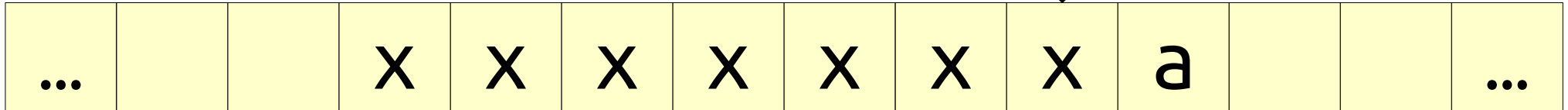
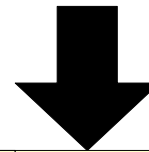


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

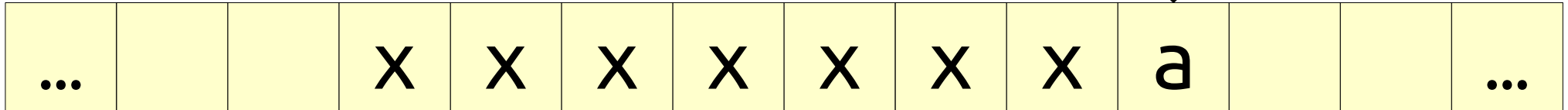
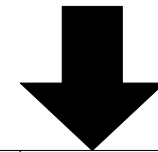


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

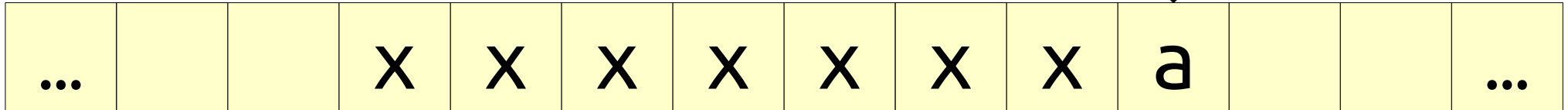
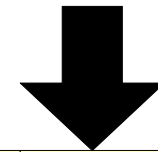


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

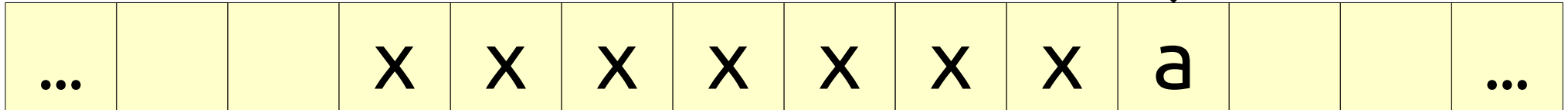
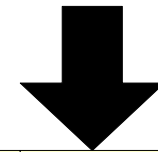


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
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LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```

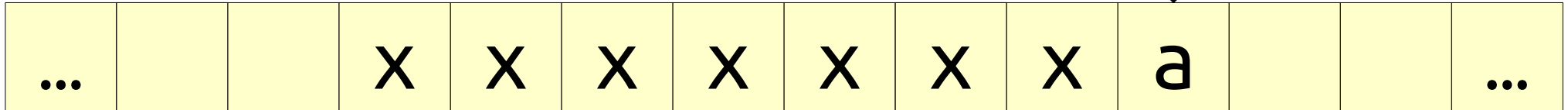
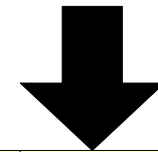


```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

```
FoundA:
  Write 'x'
LoopA:
  Move Right
  If 'a' Goto LoopA
  If 'x' Goto LoopA
  Write 'x'
  Goto GoHome
```

```
GoHome:
  Move Left
  If Not Blank Goto GoHome
  Move Right
  Goto Start
```

```
FoundB:
  Write 'x'
LoopB:
  Move Right
  If 'b' Goto LoopB
  If 'x' Goto LoopB
  Write 'x'
  Goto GoHome
```



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

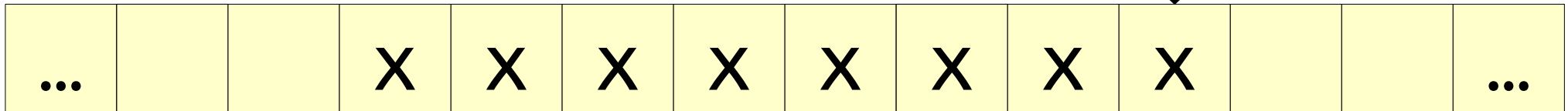
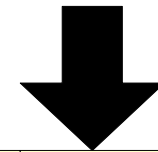
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

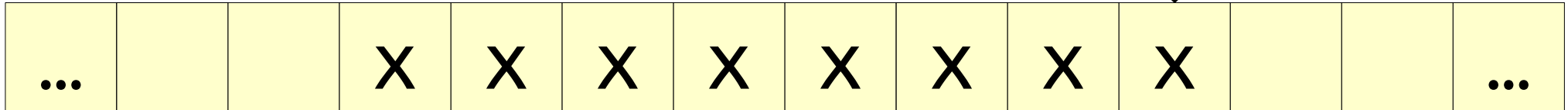
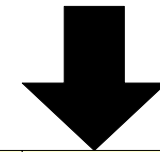
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Move Right

FoundA:

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

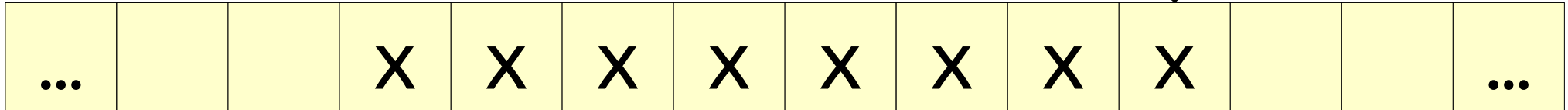
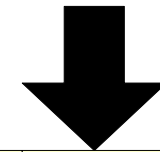
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

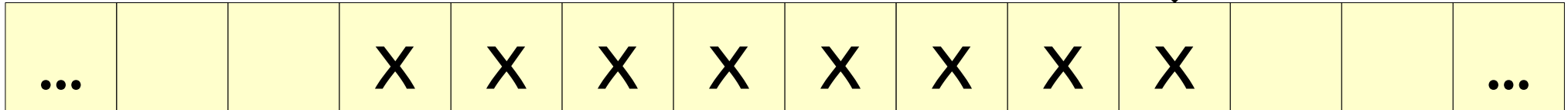
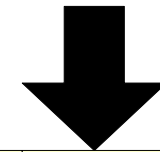
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

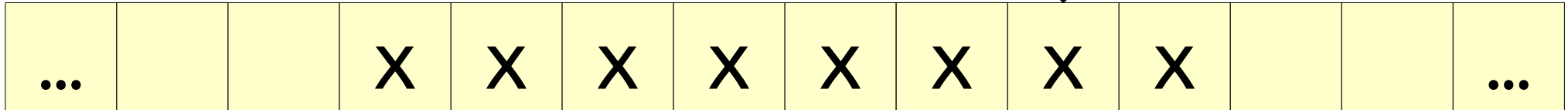
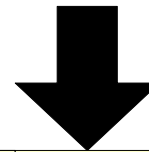
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

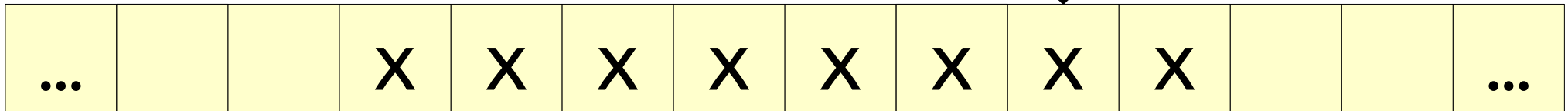
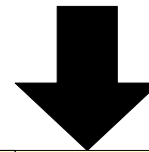
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Move Right

Goto Start

```
FoundA:
  Write 'x'
```

Write 'x'

LoopA:
Move Right

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome :  
    Move Left  
    If Not Blank Goto GoHome  
    Move Right  
    Goto Start
```

If Not Blank Goto GoHome

Move Right

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:
Move Right

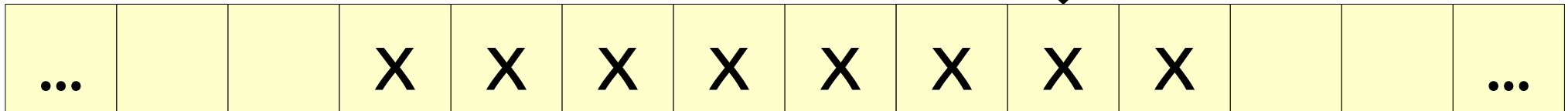
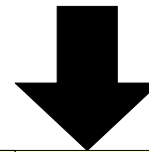
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

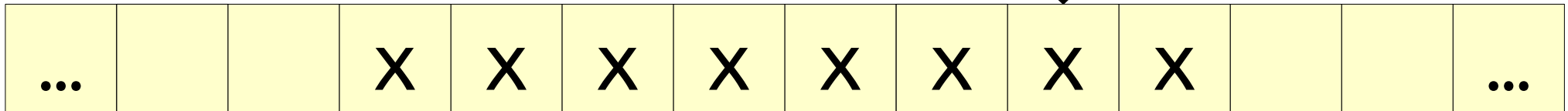
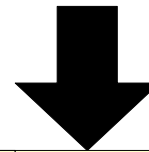
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

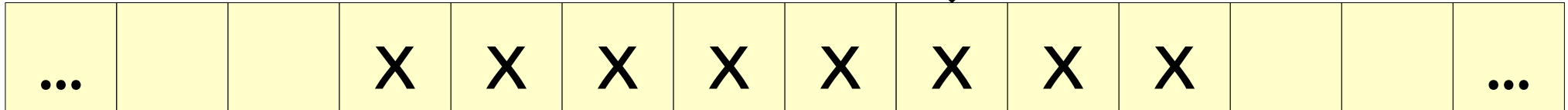
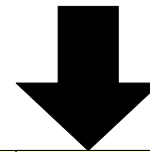
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

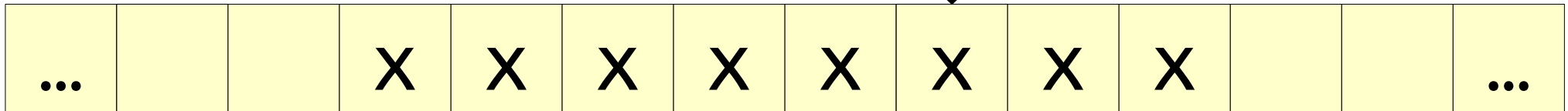
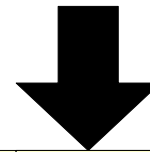
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

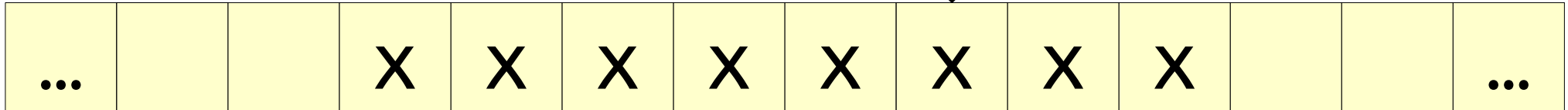
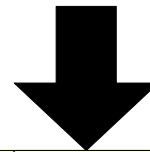
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

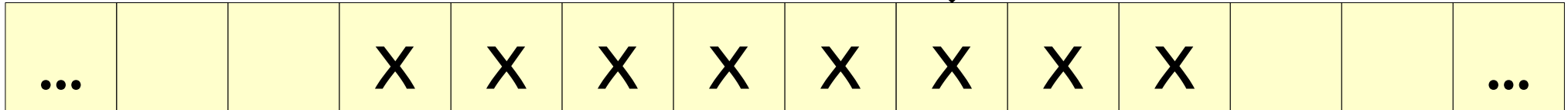
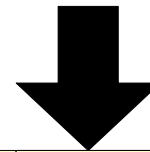
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

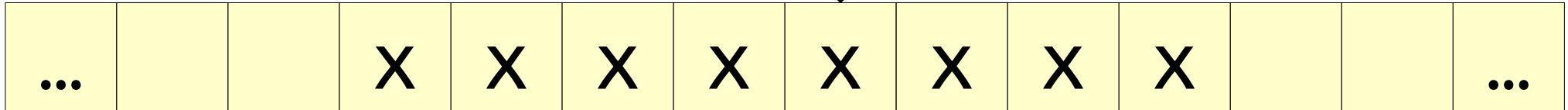
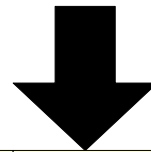
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

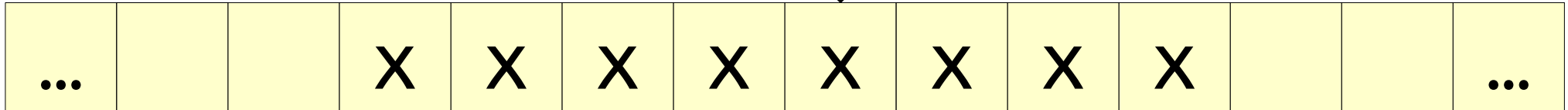
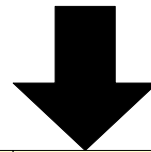
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Move Right

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

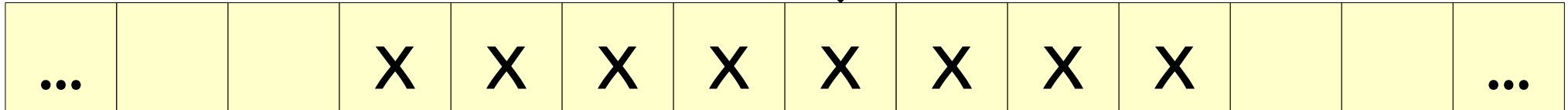
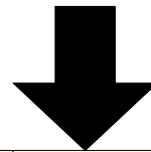
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

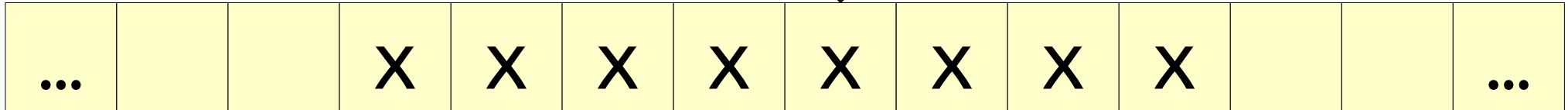
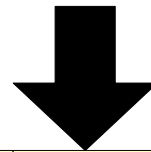
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

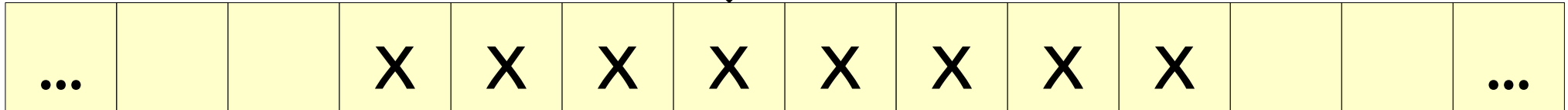
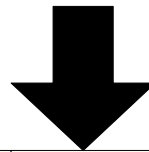
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

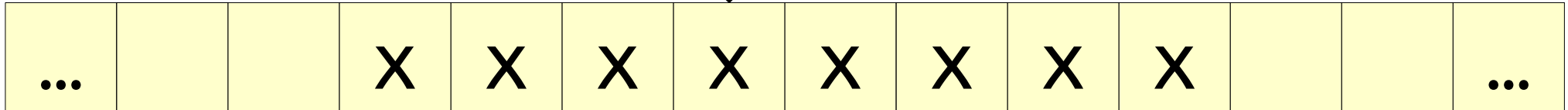
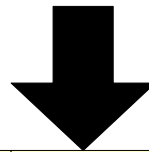
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

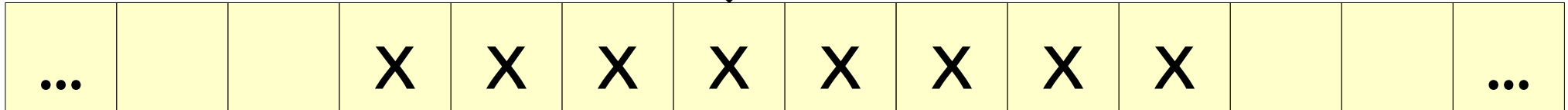
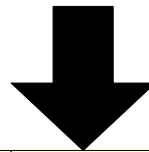
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

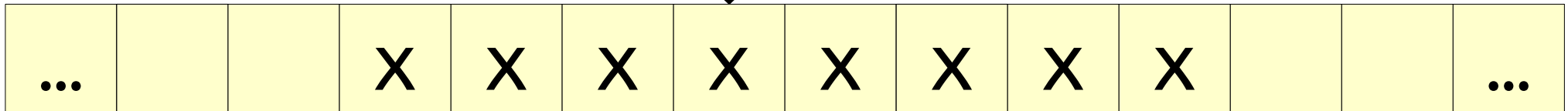
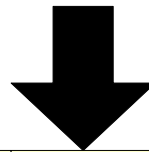
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

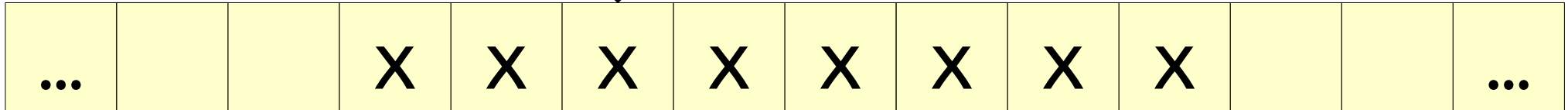
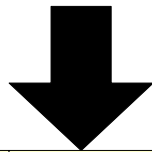
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

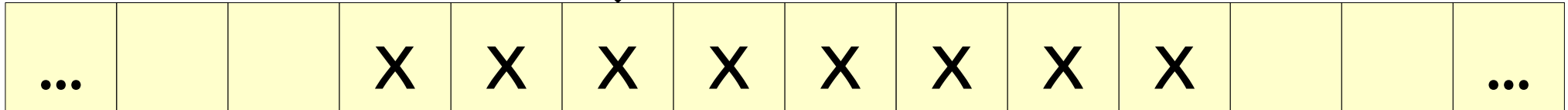
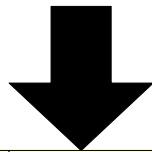
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

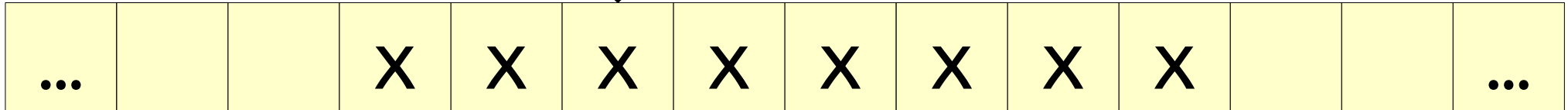
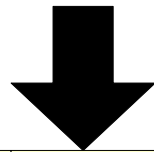
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

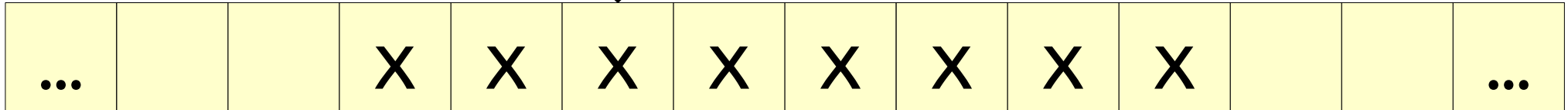
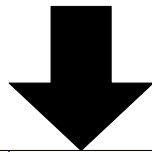
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

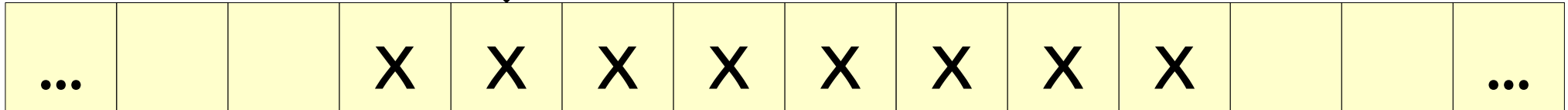
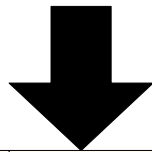
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

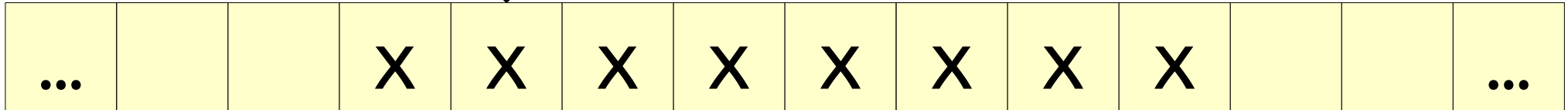
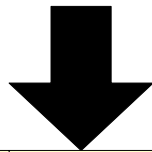
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

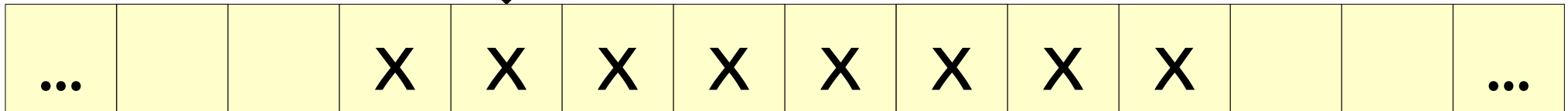
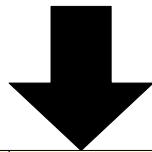
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

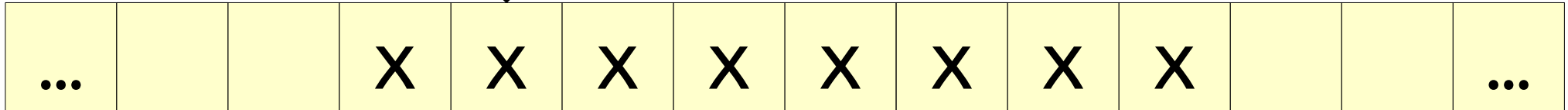
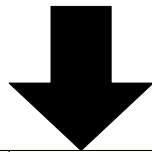
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

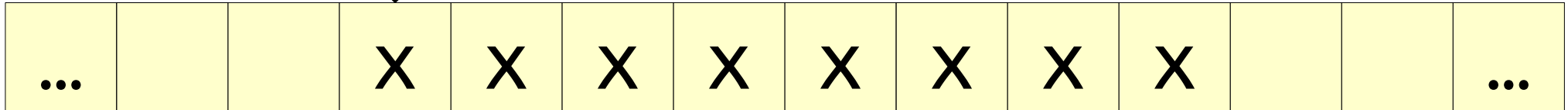
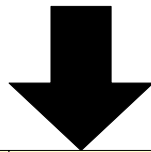
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

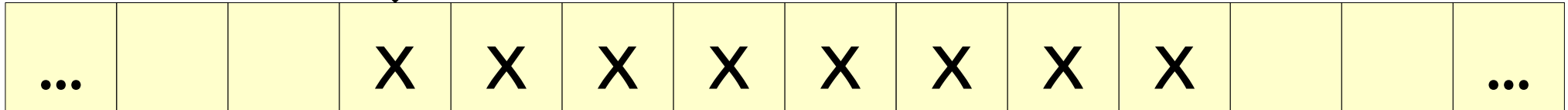
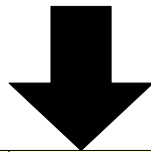
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

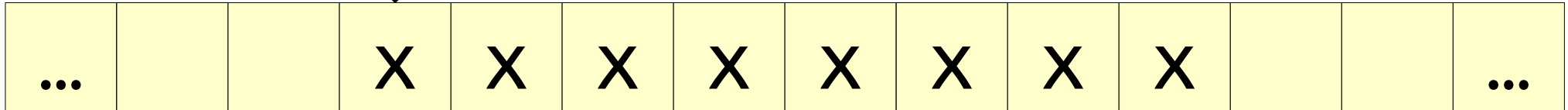
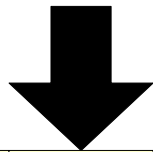
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

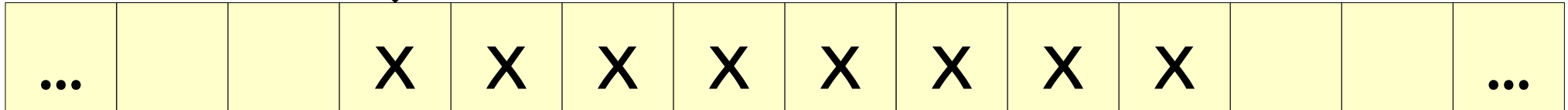
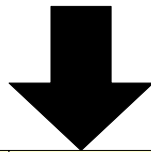
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

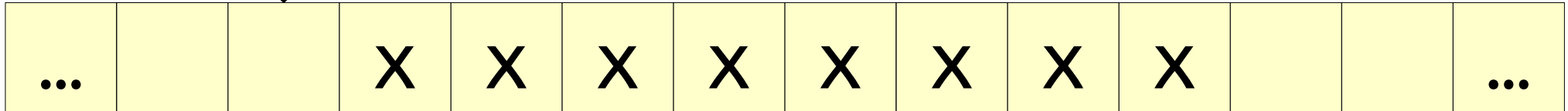
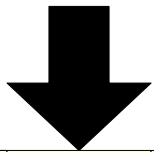
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

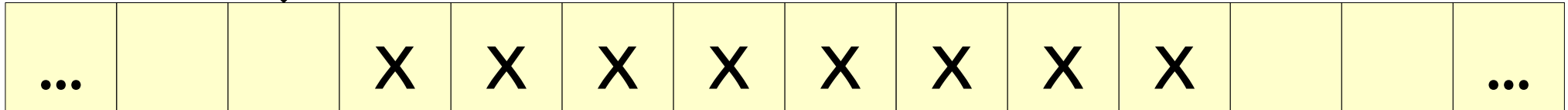
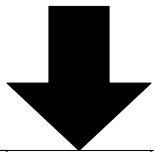
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

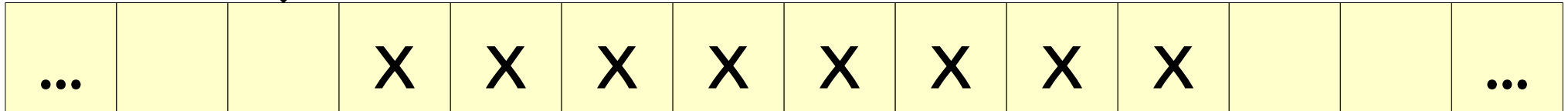
Write 'x'

Goto GoHome



```
FoundA:
    Write 'x'
LoopA:
    Move Right
    If 'a' Goto LoopA
    If 'x' Goto LoopA
    Write 'x'
    Goto GoHome
```

```
FoundB:
    Write 'x'
LoopB:
    Move Right
    If 'b' Goto LoopB
    If 'x' Goto LoopB
    Write 'x'
    Goto GoHome
```



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

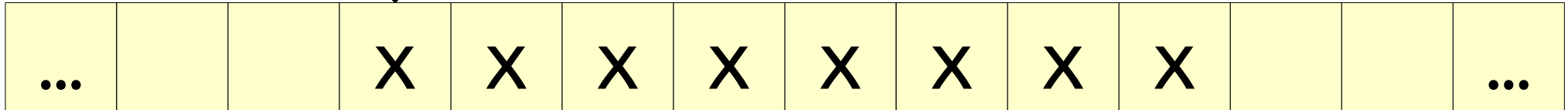
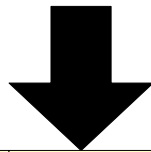
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

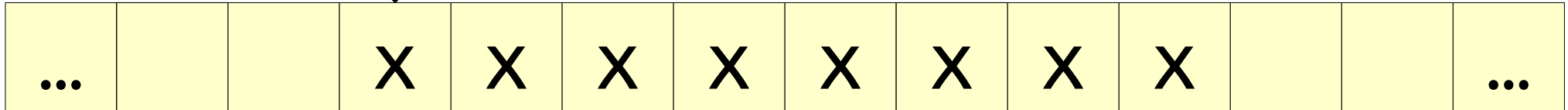
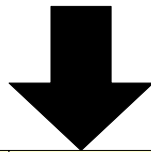
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

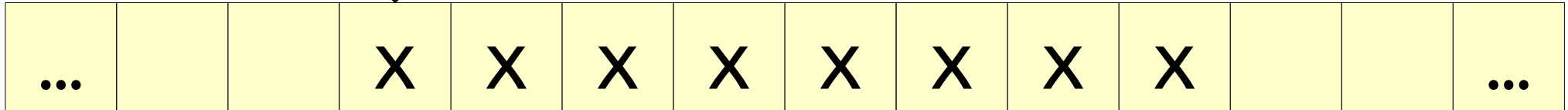
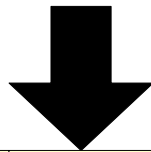
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

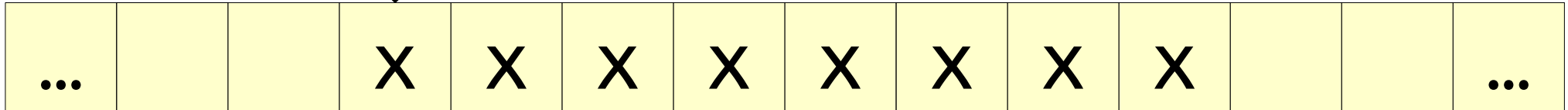
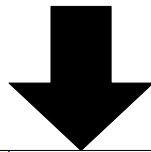
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

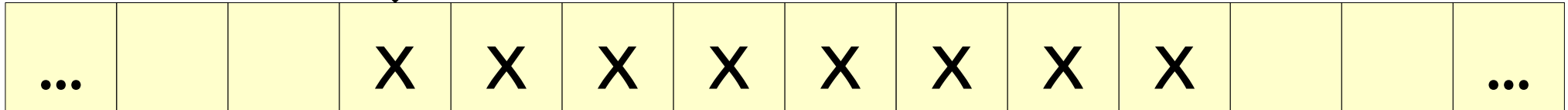
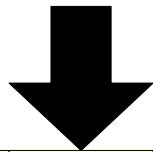
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

If 'x' Goto LoopA

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Goto Start

```
FoundB:
  Write 'x'
```

LoopB:

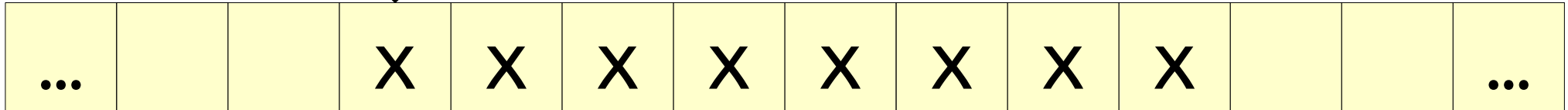
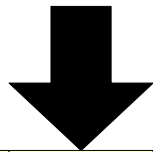
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

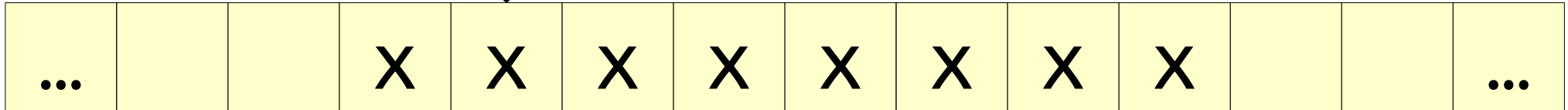
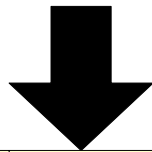
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
    If 'a' Goto FoundA
    If 'b' Goto FoundB
    Move Right
    Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Goto Start

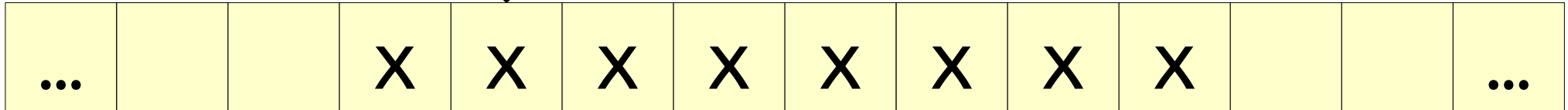
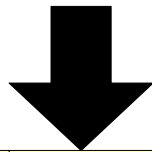
```
FoundB:
  Write 'x'
```

LoopB:

If 'b' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

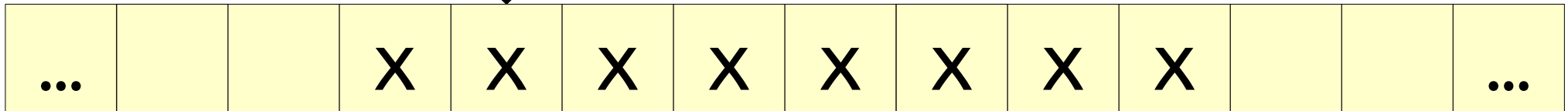
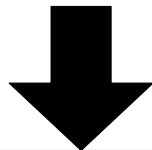
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

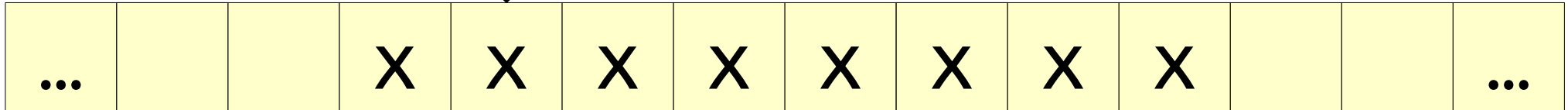
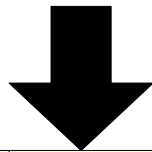
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

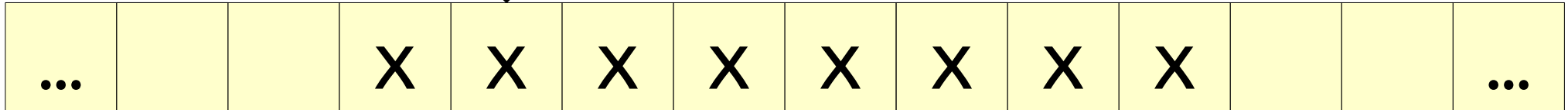
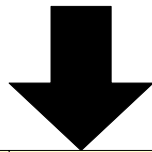
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
    If 'a' Goto FoundA
    If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

If 'x' Goto LoopA

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:

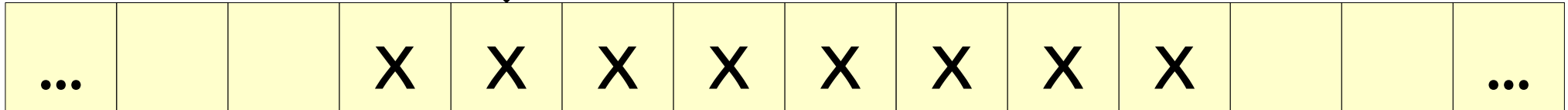
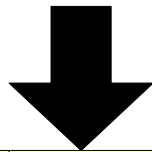
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Move Right

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:

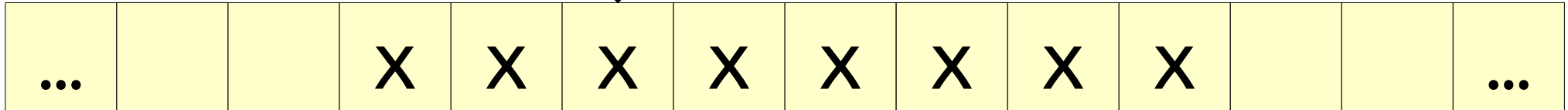
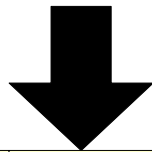
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:

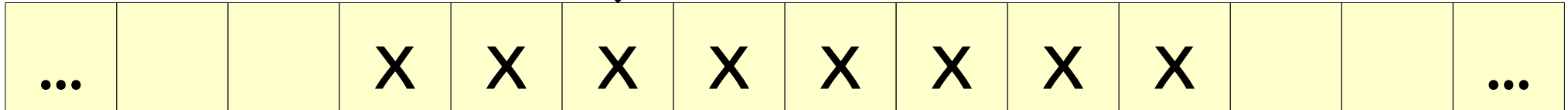
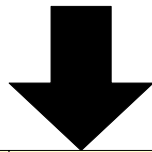
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

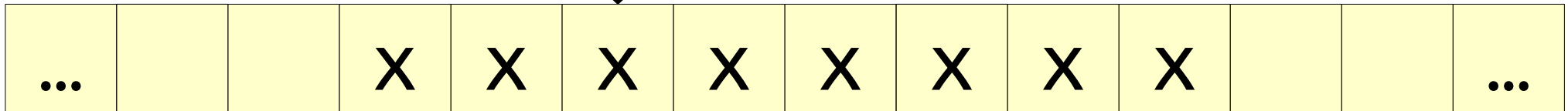
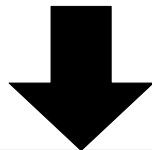
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

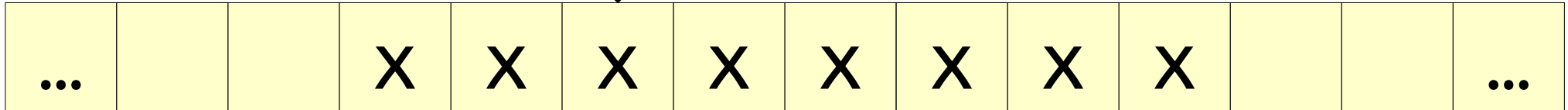
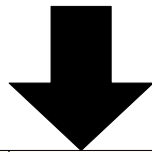
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

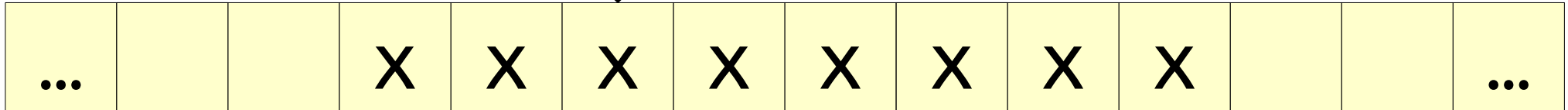
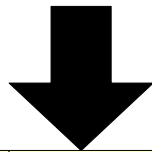
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
    If 'a' Goto FoundA
    If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Move Right

Goto Start

```
FoundA:
  Write 'x'
```

Write 'x'

LoopA:
Move Right

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:
Move Right

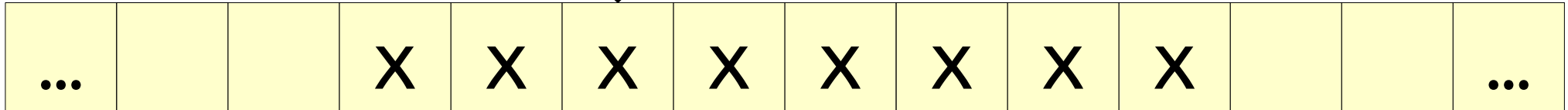
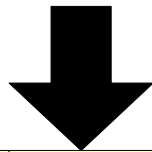
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Move Right

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:

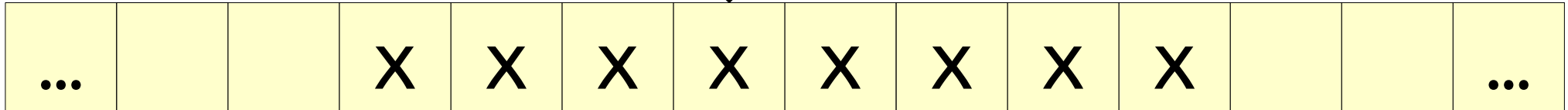
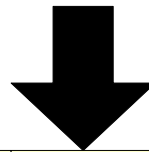
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
    If 'a' Goto FoundA
    If 'b' Goto FoundB
    Move Right
    Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Goto Start

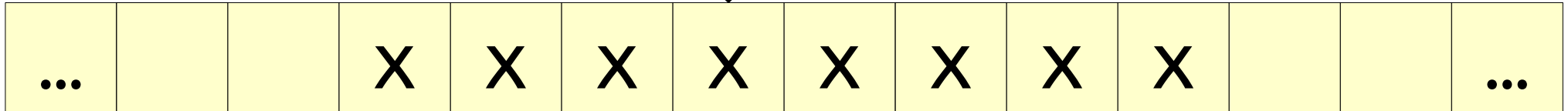
```
FoundB:
  Write 'x'
```

LoopB:

If 'b' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

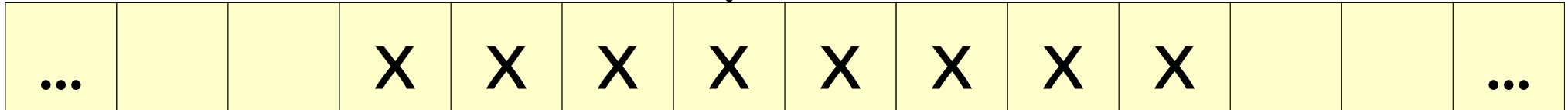
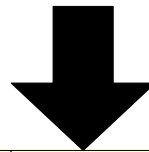
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

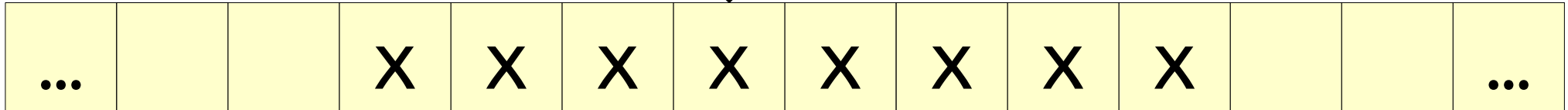
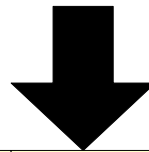
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

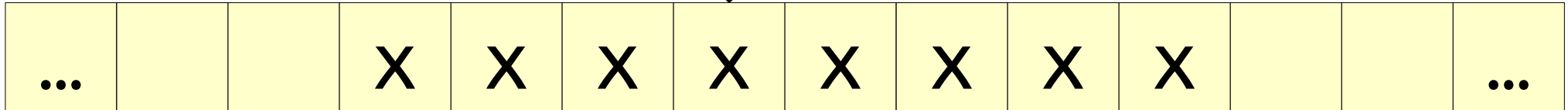
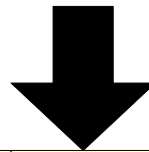
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

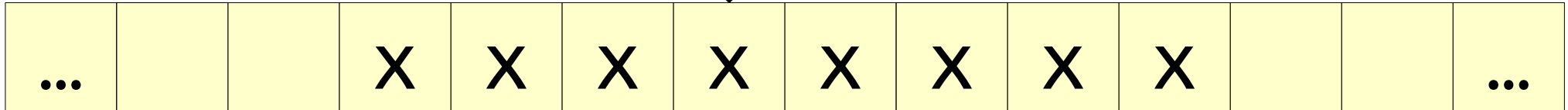
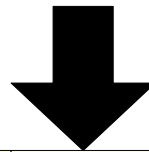
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

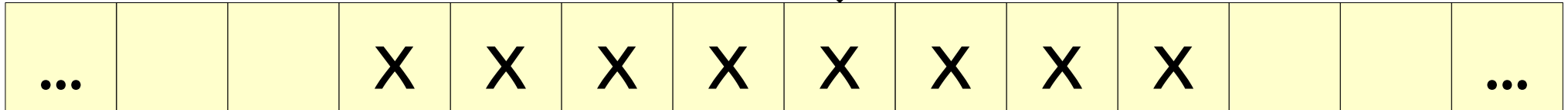
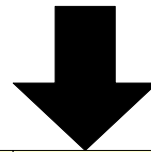
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

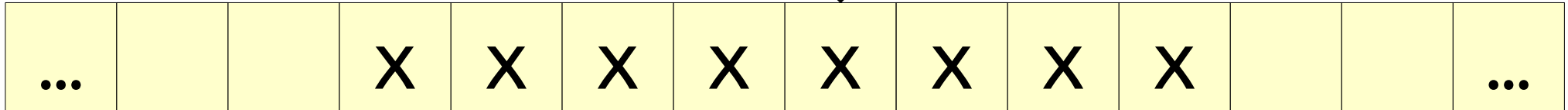
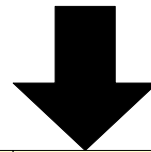
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

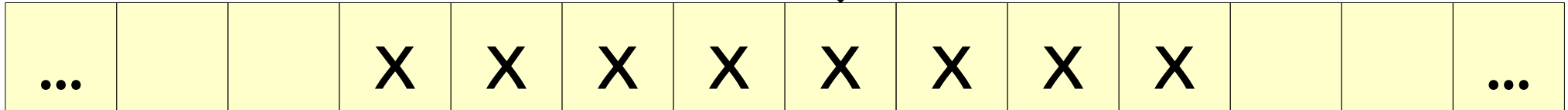
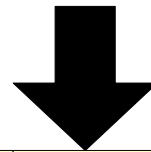
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

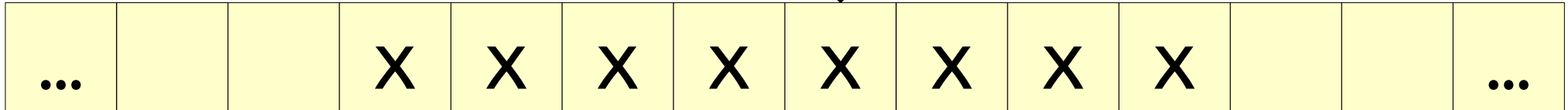
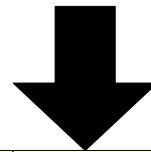
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

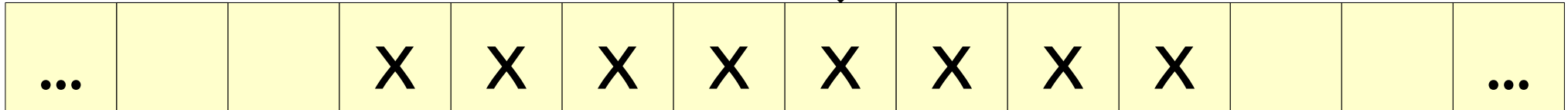
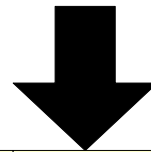
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
    If 'a' Goto FoundA
    If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

```
FoundA:
  Write 'x'
```

LoopA:

If 'a' Goto LoopA

If 'x' Goto LoopA

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
    Move Right
    Goto Start
```

If Not Blank Goto GoHome

Goto Start

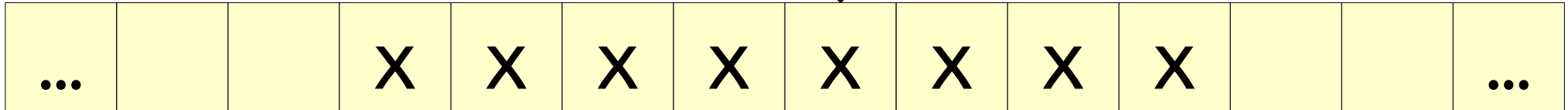
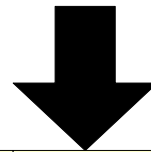
```
FoundB:
  Write 'x'
```

LoopB:

If 'b' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

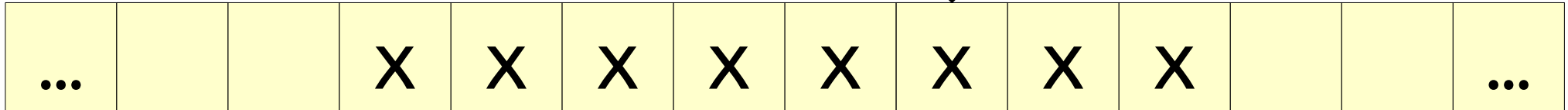
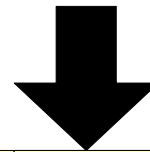
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

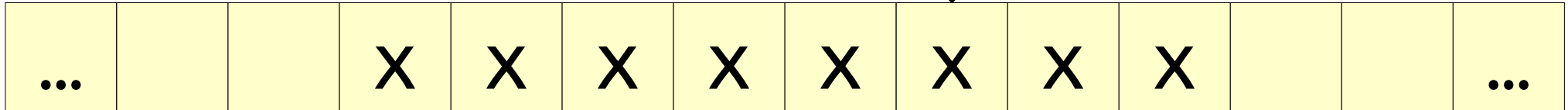
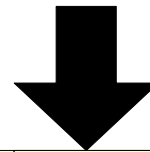
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

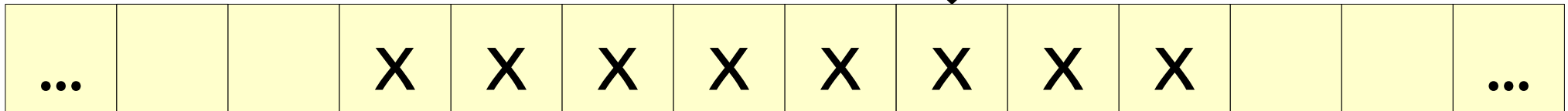
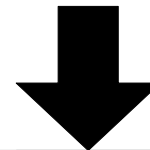
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

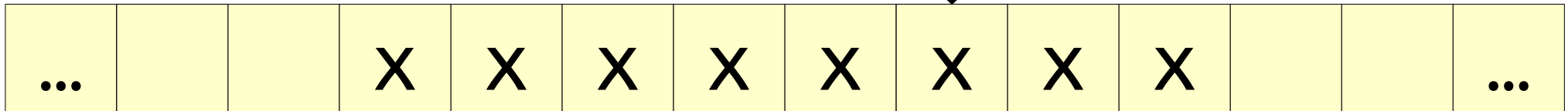
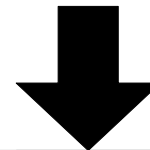
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

If Not Blank Goto GoHome

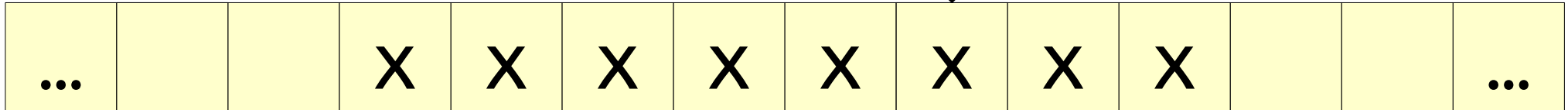
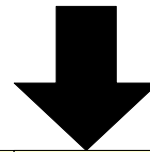
Goto Start

Write 'x'

Move Right

If 'x' Goto LoopB

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

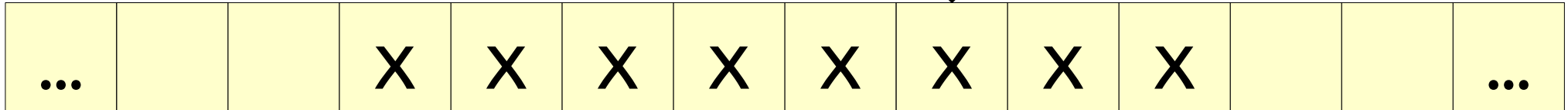
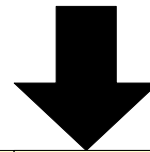
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

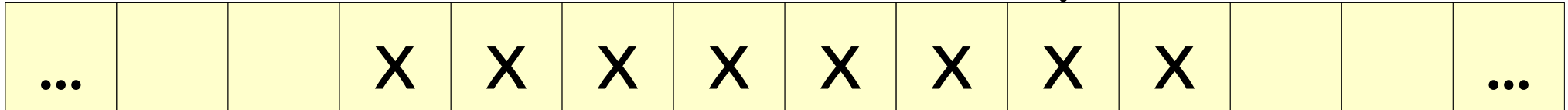
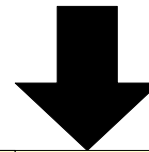
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

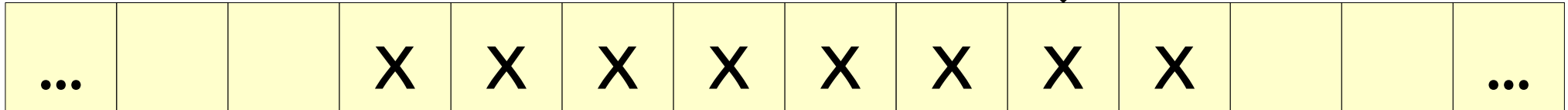
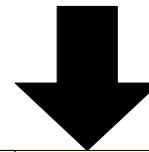
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

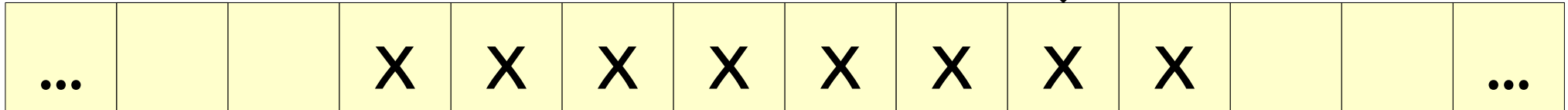
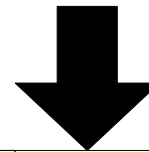
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

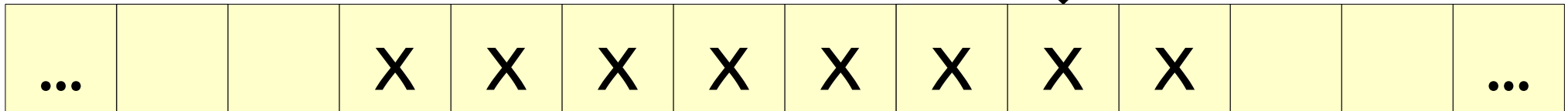
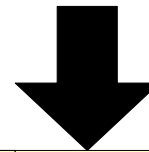
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

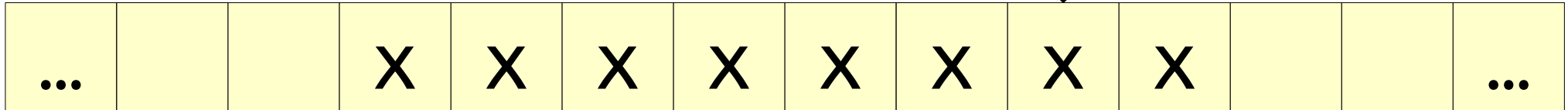
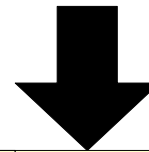
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

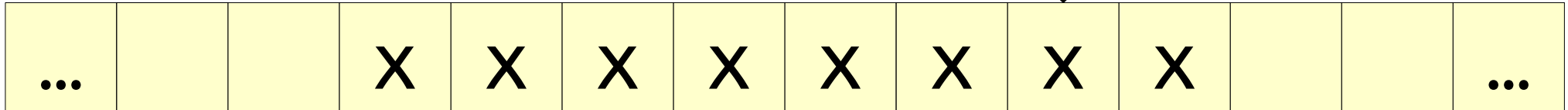
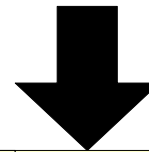
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

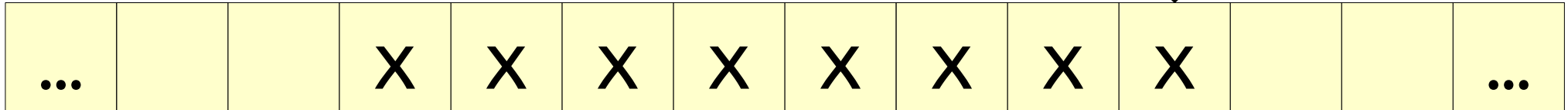
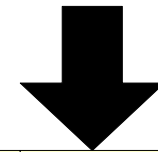
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

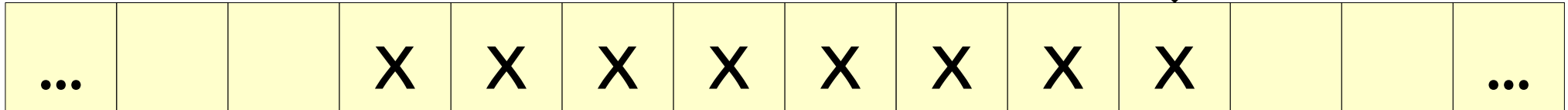
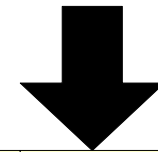
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

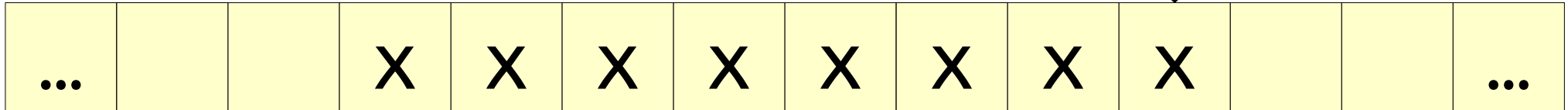
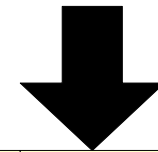
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

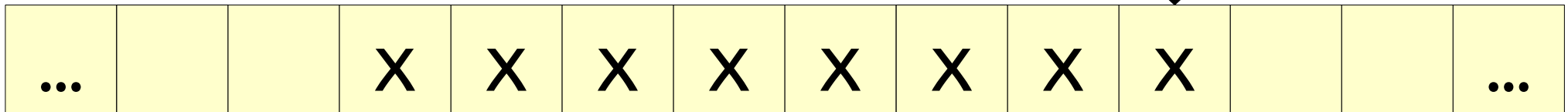
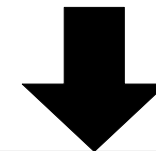
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
    If 'a' Goto FoundA
    If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

If Not Blank Goto GoHome

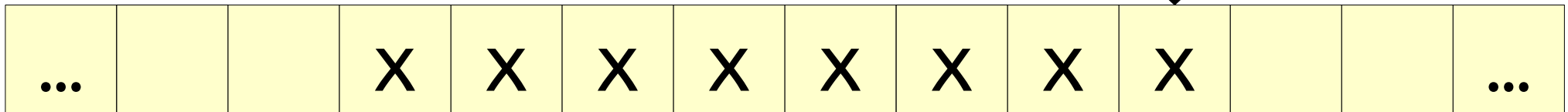
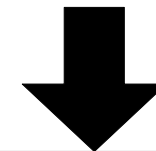
Goto Start

Write 'x'

Move Right

If 'x' Goto LoopB

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

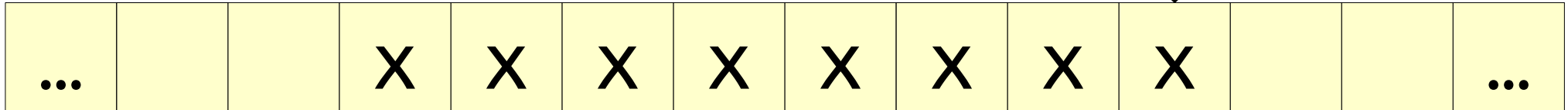
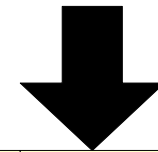
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

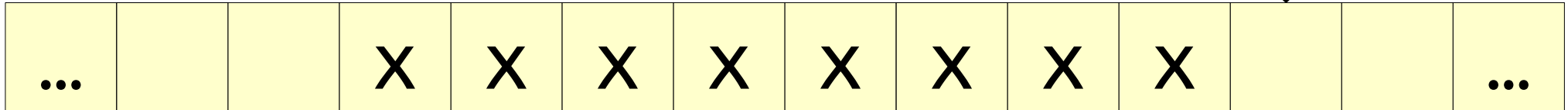
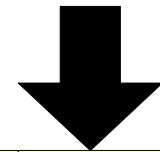
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
  Move Right
  Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'x' Goto LoopA

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

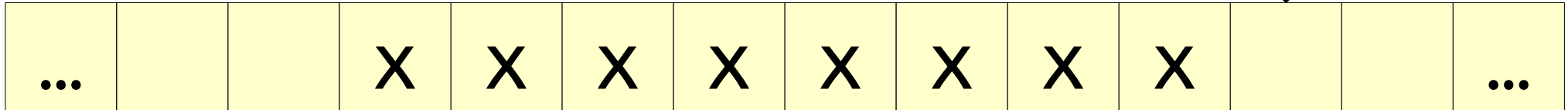
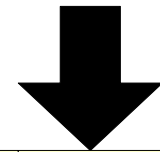
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
Move Right
Goto Start
```

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

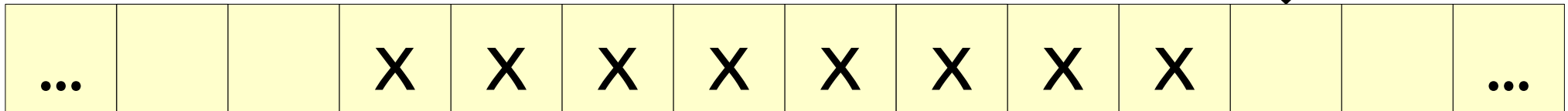
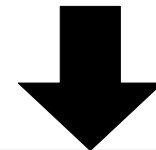
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

If 'a' Goto FoundA

If 'b' Goto FoundB

Move Right

Goto Start

FoundA:

Write 'x'

LoopA:

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

GoHome:

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

FoundB:

Write 'x'

LoopB:

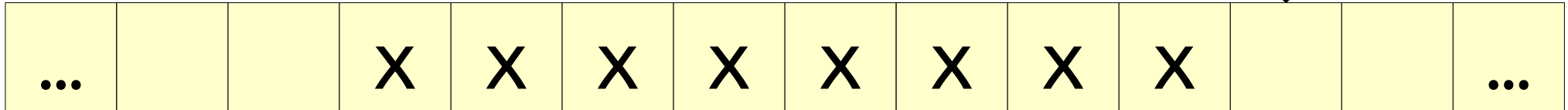
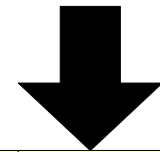
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
Move Right
Goto Start
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

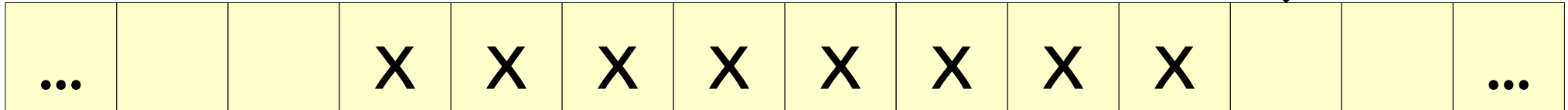
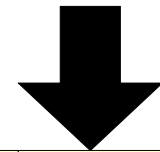
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
```

If 'b' Goto FoundB

Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

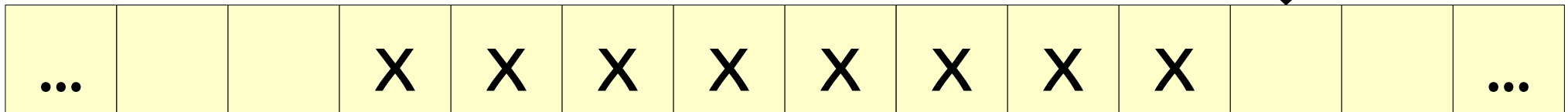
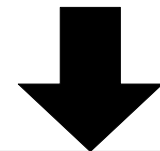
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
```

Move Right
Goto Start

Write 'x'

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

Write 'x'

LoopB:

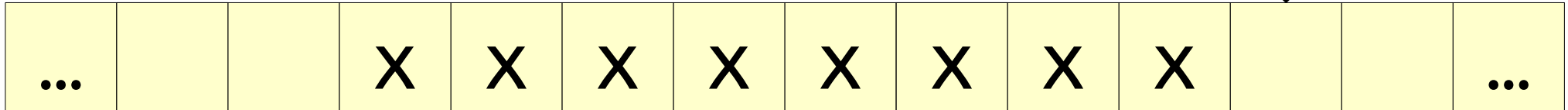
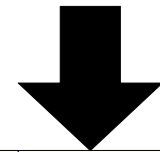
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
```

If 'b' Goto FoundB

If Blank Return True

Move Right

Goto Start

FoundA:
Write 'x'

Write 'x'

LoopA:
Move Right

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
```

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:
Move Right

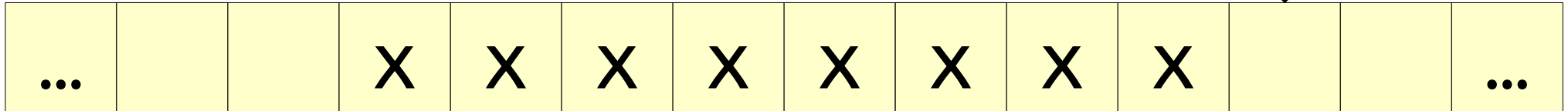
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



```
Start:
  If 'a' Goto FoundA
  If 'b' Goto FoundB
```

If 'b' Goto FoundB

If Blank Return True

Move Right

Goto Start

FoundA:
Write 'x'

Write 'x'

LoopA:
Move Right

Move Right

If 'a' Goto LoopA

If 'x' Goto LoopA

Write 'x'

Goto GoHome

```
GoHome:
    Move Left
    If Not Blank Goto GoHome
```

Move Left

If Not Blank Goto GoHome

Move Right

Goto Start

```
FoundB:
  Write 'x'
```

Write 'x'

LoopB:
Move Right

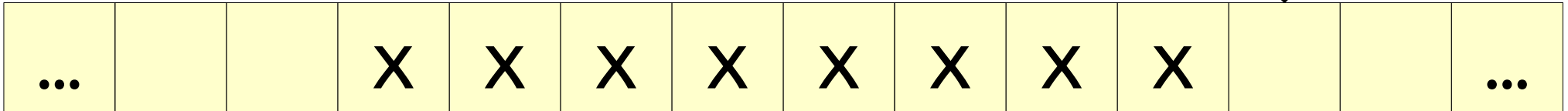
Move Right

If 'b' Goto LoopB

If 'x' Goto LoopB

Write 'x'

Goto GoHome



Start:

```
If 'a' Goto FoundA
If 'b' Goto FoundB
If Blank Return True
Move Right
Goto Start
```

FoundA:

```
Write 'x'
```

LoopA:

```
Move Right
If 'a' Goto LoopA
If 'x' Goto LoopA
Write 'x'
Goto GoHome
```

GoHome:

```
Move Left
If Not Blank Goto GoHome
Move Right
Goto Start
```

FoundB:

```
Write 'x'
```

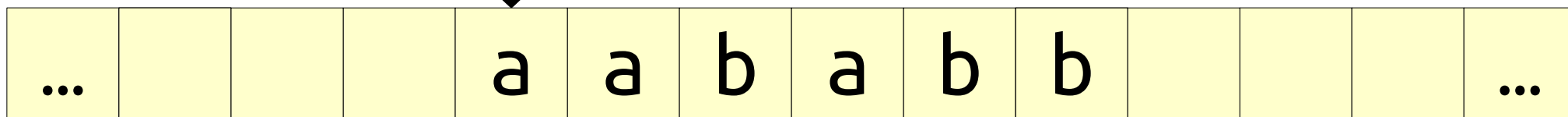
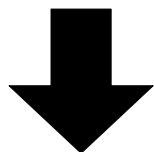
LoopB:

```
Move Right
If 'b' Goto LoopB
If 'x' Goto LoopB
Write 'x'
Goto GoHome
```

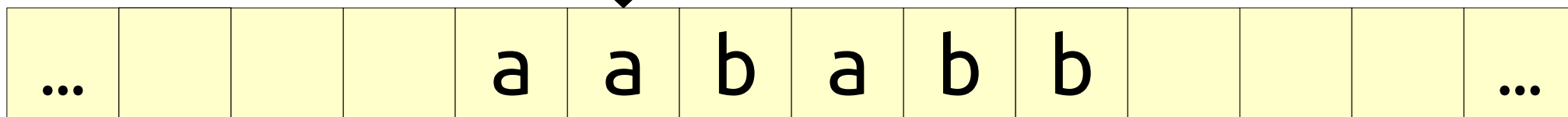
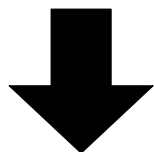

Another Idea

- We just built a TM for the language
$$\{ w \in \{\mathbf{a}, \mathbf{b}\}^* \mid w \text{ has the same number of } \mathbf{a}'\text{s and } \mathbf{b}'\text{s} \}.$$
- An observation: this would be a *lot* easier to test for if all the $\mathbf{a}$'s came before all the $\mathbf{b}$'s.
 - In fact, that would turn this into checking if the string has the form $\mathbf{a}^n\mathbf{b}^n$, which we already know how to do!
- **Idea:** Could we sort the characters of our input string?

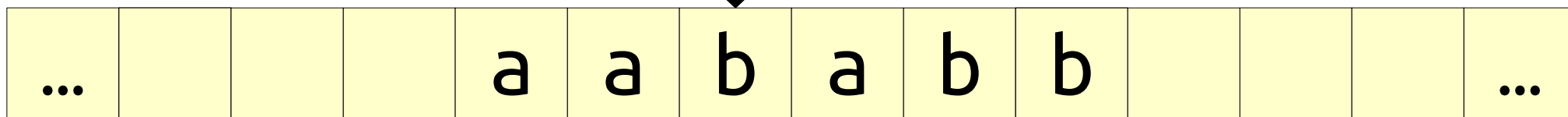
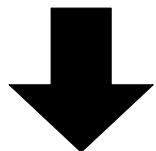
The Idea



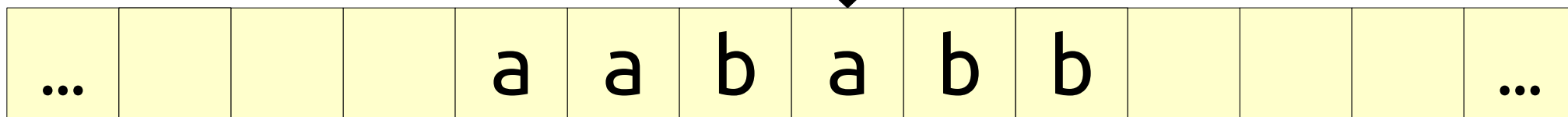
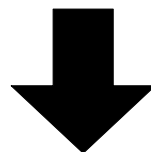
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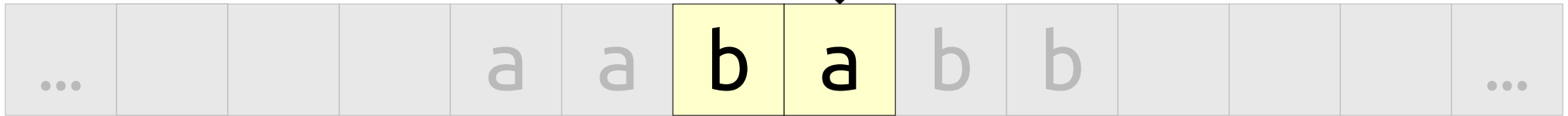
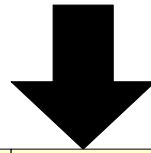
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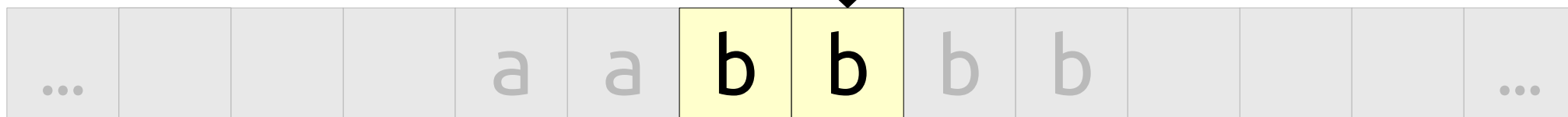
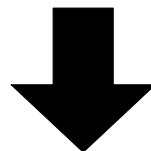
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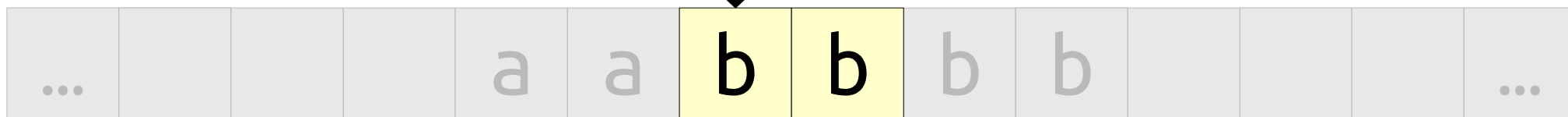
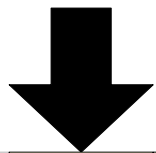
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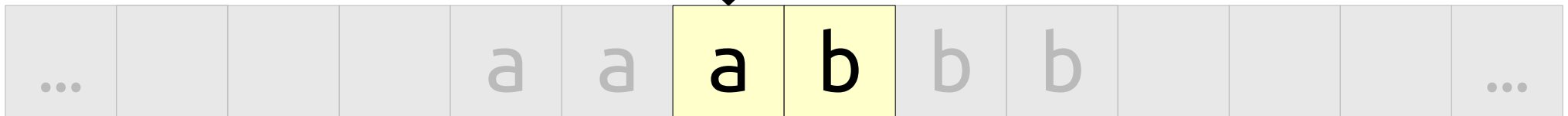
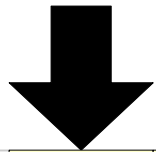
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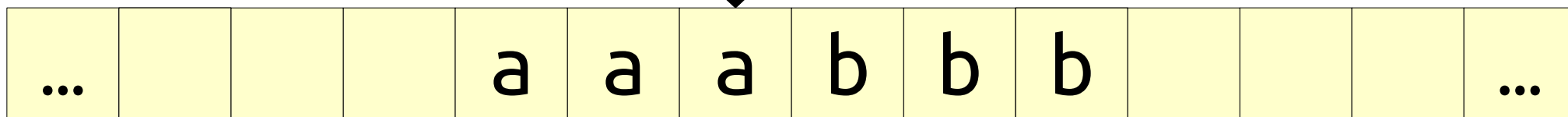
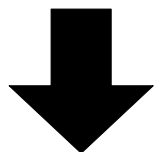
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The Idea



Exploring This Idea

Cool TM Tricks 1: ***Fibonacci Numbers***

Cool TM Tricks 2: ***Decimal Fibonacci***

Summary for Today

- Turing machines are abstract computers that issue commands to an infinite tape subdivided into cells.
- Each step of the TM can move the tape head, change what's on the tape, or jump to a different part of the program.
- TMs can be composed together to build larger TMs out of smaller ones.

Next Time

- ***The Church-Turing Thesis***
 - How powerful are Turing machines?
- ***Decidability and Recognizability***
 - Two notions of “solving a problem.”