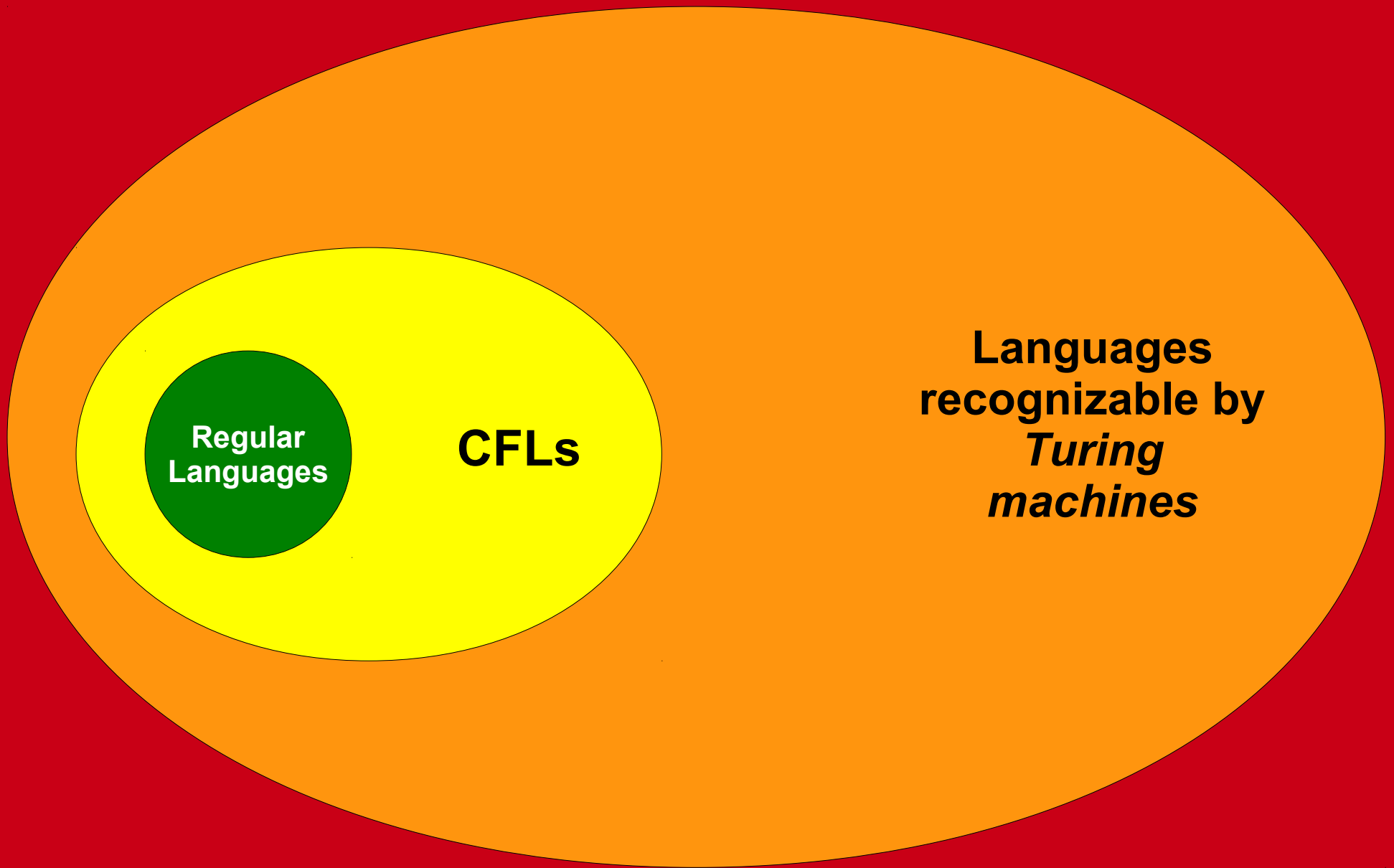


What problems can we solve with a computer?  
Turing Machine?



Regular  
Languages

**CFLs**

Languages  
recognizable by  
*Turing*  
*machines*

**All Languages**

That same drawing, to scale.

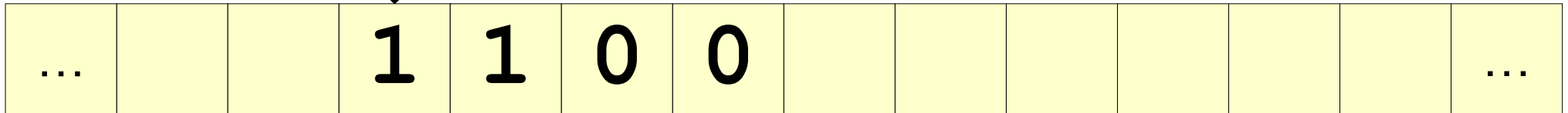
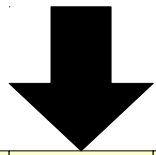
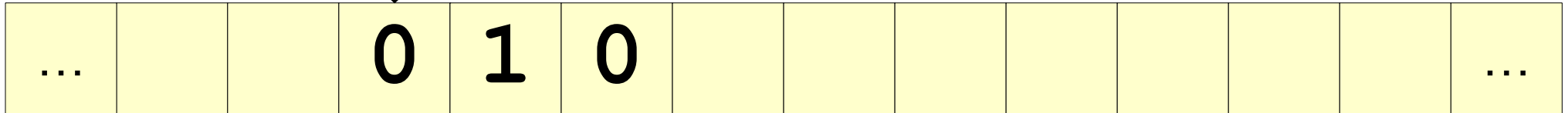
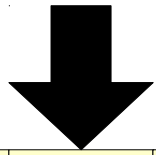
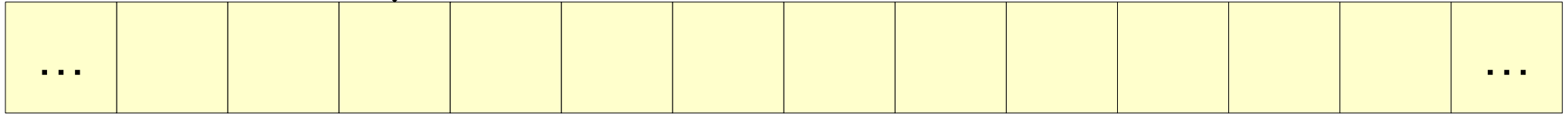
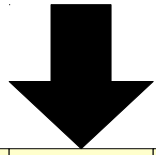
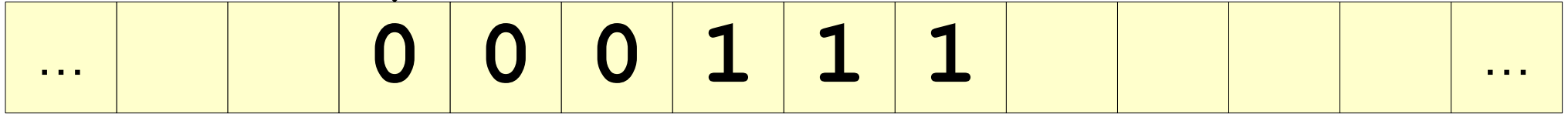
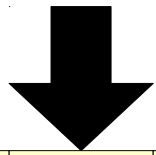
# Designing Turing Machines

- Despite their simplicity, Turing machines are very powerful computing devices.
- Today's lecture explores how to design Turing machines for various languages.

# Designing Turing Machines

- Let  $\Sigma = \{0, 1\}$  and consider the language  $L = \{0^n 1^n \mid n \in \mathbb{N}\}$ .
- We know that  $L$  is context-free.
- How might we build a Turing machine for it?

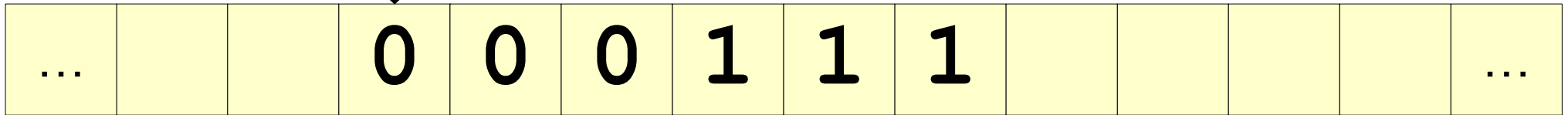
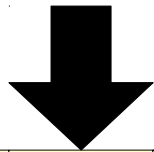
$$L = \{0^n 1^n \mid n \in \mathbb{N}\}$$



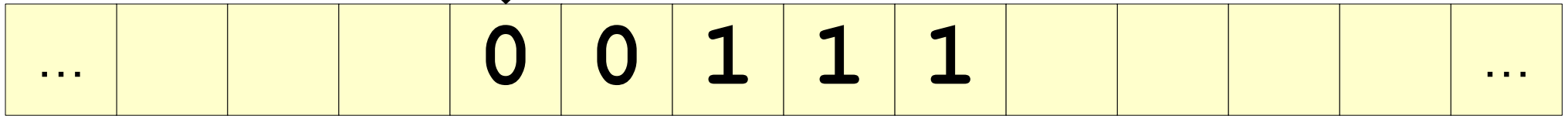
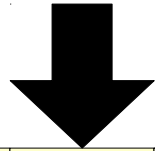
# A Recursive Approach

- The string  $\varepsilon$  is in  $L$ .
- The string  $0w1$  is in  $L$  iff  $w$  is in  $L$ .
- Any string starting with  $1$  is not in  $L$ .
- Any string ending with  $0$  is not in  $L$ .

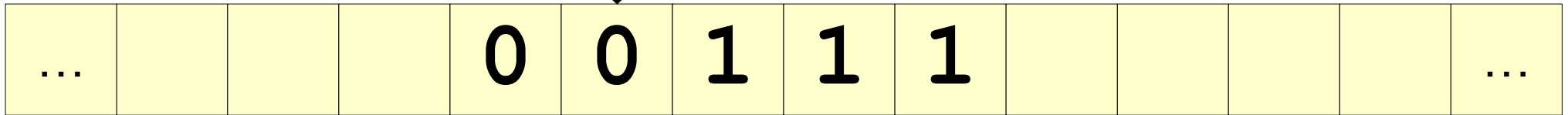
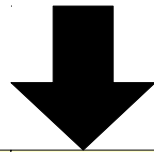
# A Sketch of the TM



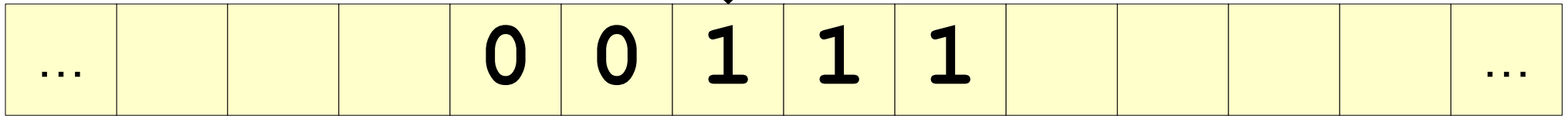
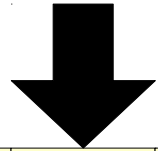
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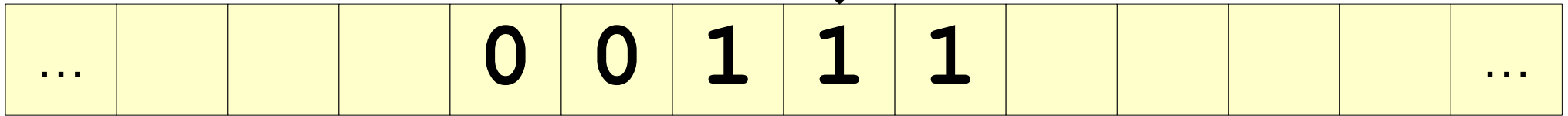
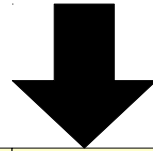
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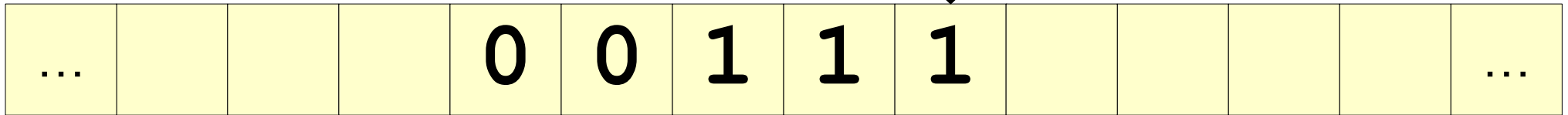
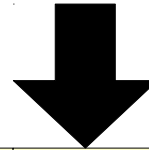
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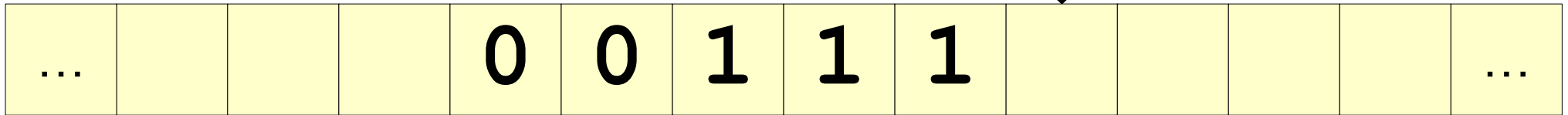
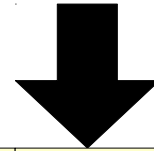
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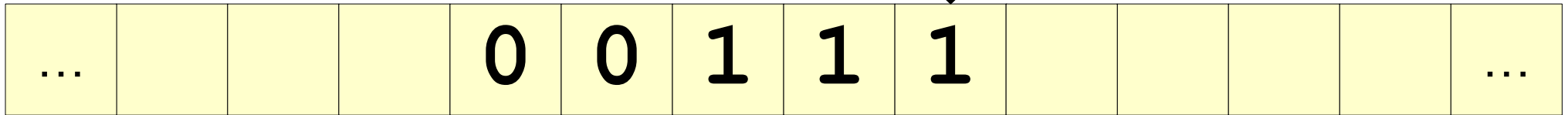
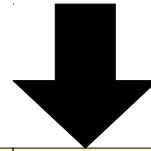
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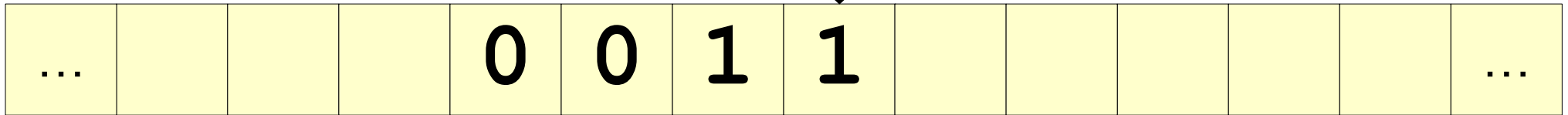
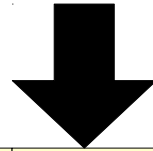
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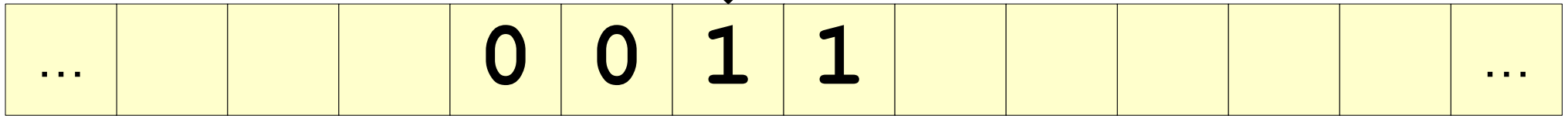
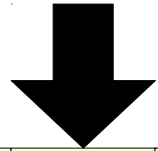
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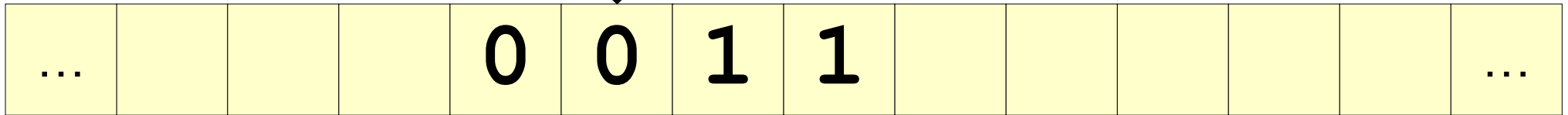
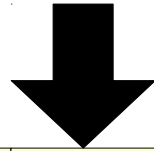
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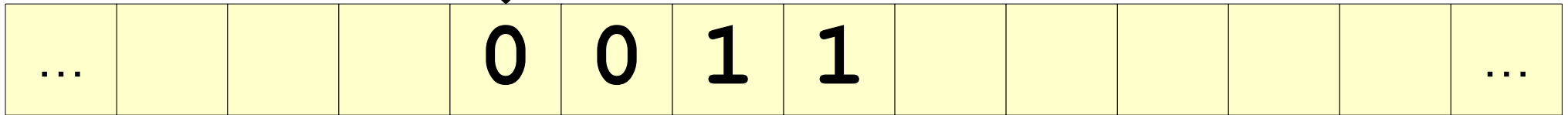
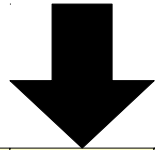
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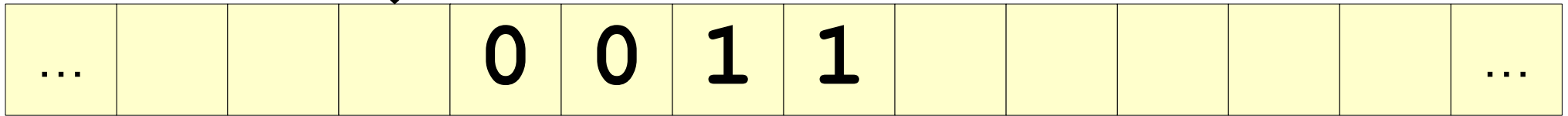
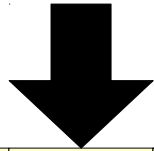
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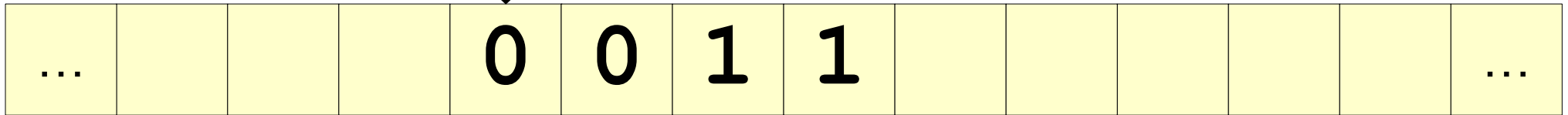
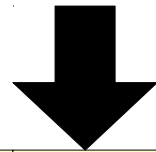
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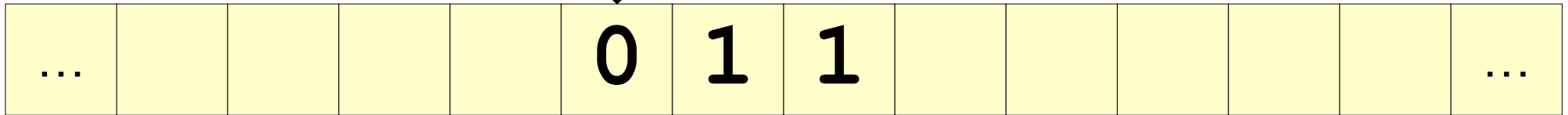
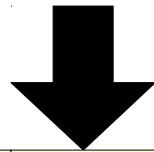
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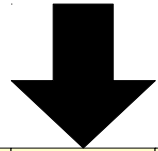
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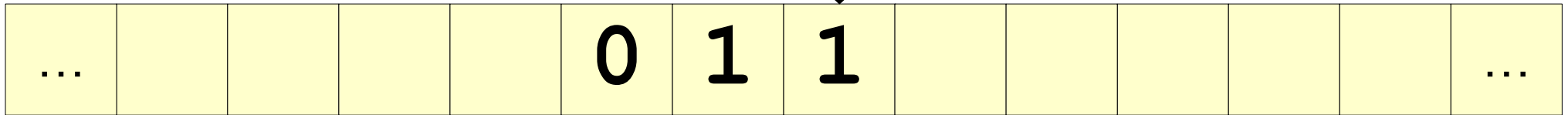
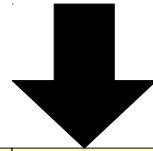
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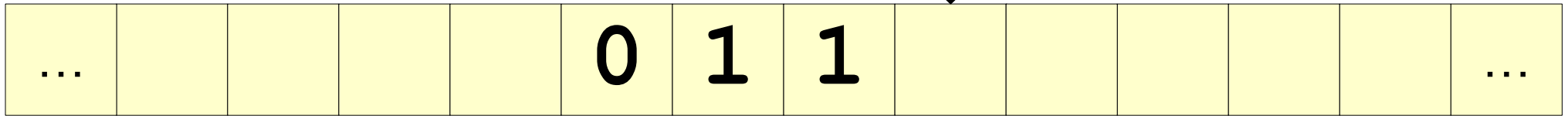
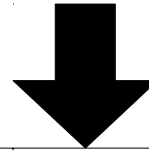
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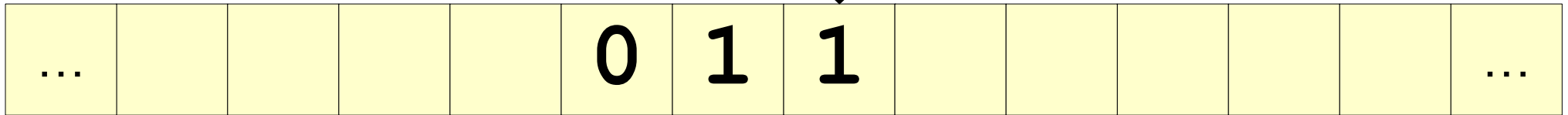
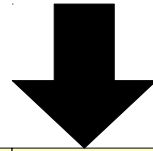
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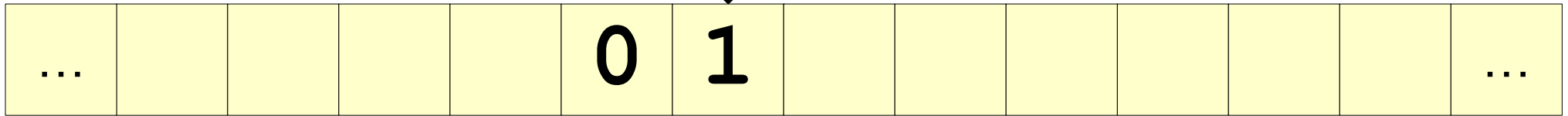
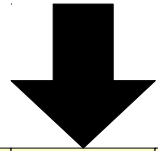
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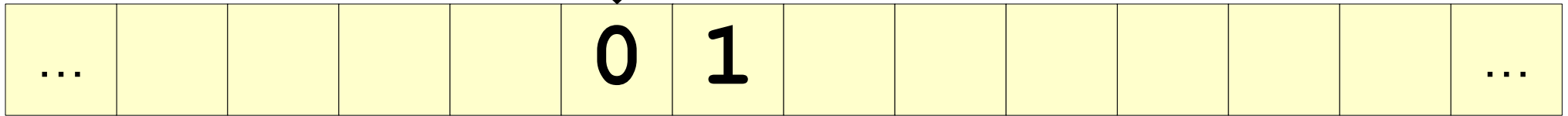
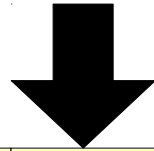
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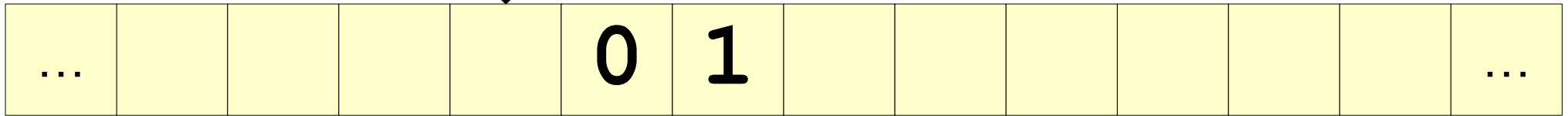
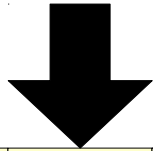
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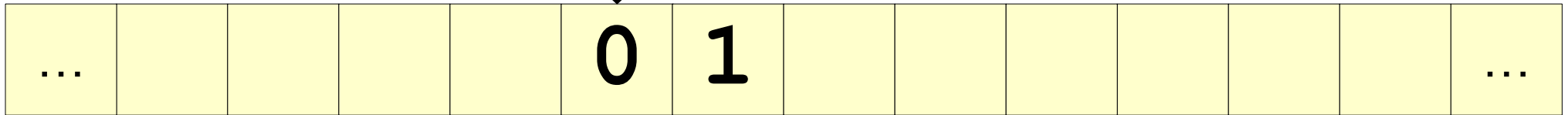
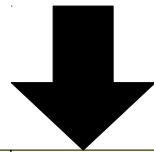
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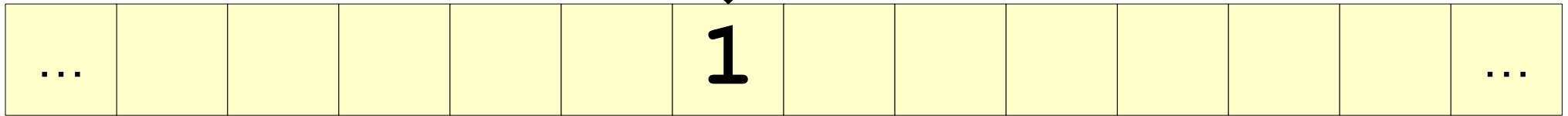
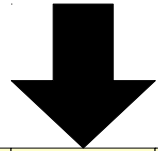
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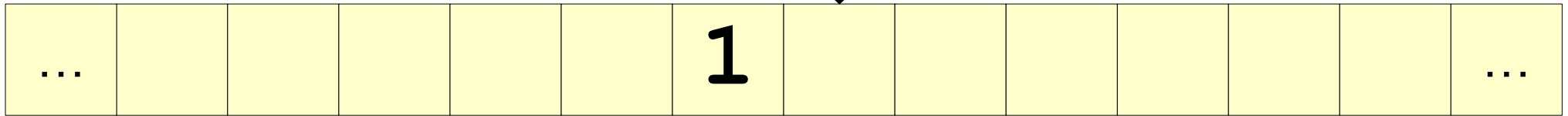
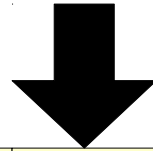
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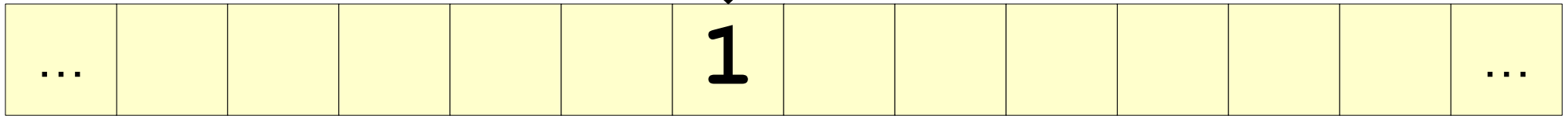
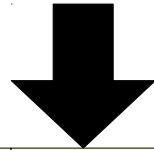
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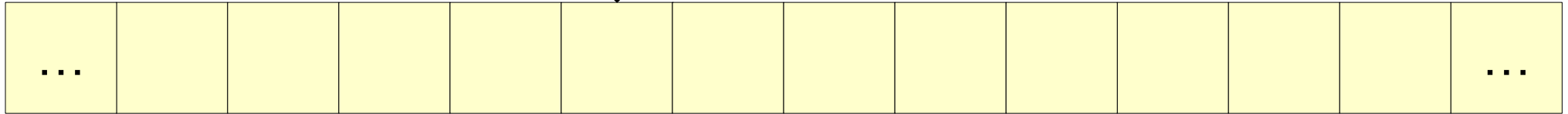
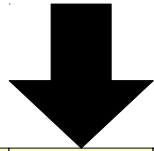
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