

$$E \rightarrow E+T \mid T$$

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$$E \rightarrow E+T$$

$$E \rightarrow T$$

$$A \rightarrow UV$$

$$U \rightarrow aU \mid \varepsilon \quad \text{some } a\text{'s}$$

$$V \rightarrow bVc \mid \varepsilon \quad b^n c^n$$

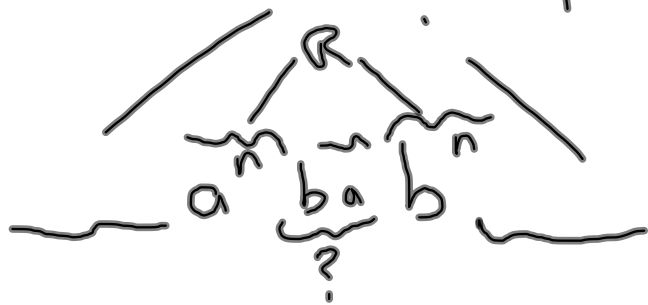
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$$C = \{ a^n b^m c^n \mid n, m \geq 0 \}$$

$$C \rightarrow aC_c \mid \varepsilon \mid W$$

$$W \rightarrow bW \mid \varepsilon$$

$S \rightarrow \cancel{aSb} \mid bSa \mid aSa \mid bSb$

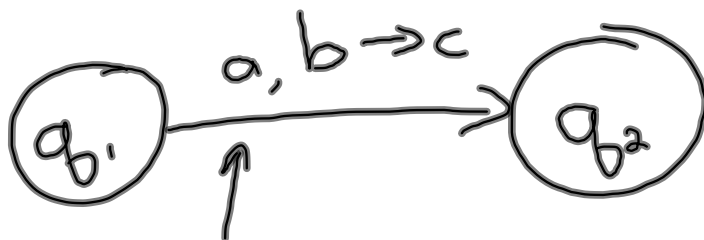


$R \rightarrow aRb$

aS  
bS  
Sa  
Sb

# Pushdown Automata

- like nfa
- has stack  $\left\{ \begin{array}{l} \text{push} \\ \text{pop} \end{array} \right.$



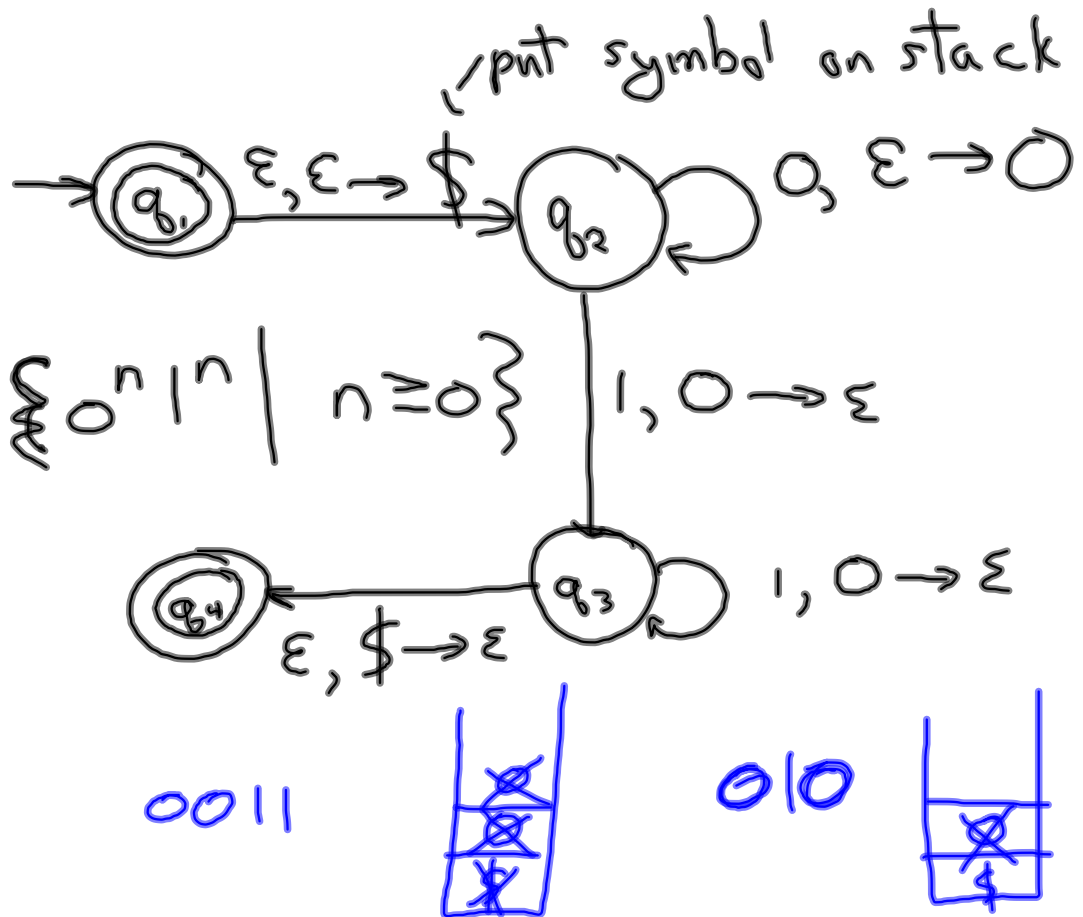
on input a

b is on top of the stack

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pop b  
push c  
go to  $q_2$

$a = \epsilon$   
don't use  
input  
 $b = \epsilon$   
 $c = \epsilon$



PDA  $(Q, \Sigma, \Gamma, \delta, q_0, F)$

$Q$ : states

$\Sigma$ : input symbols

$\Gamma$ : stack alphabet

$\delta: Q \times \Sigma \times \Gamma \rightarrow \mathcal{P}(Q \times \Gamma)$

↑ curr. state    ↑ input  $\Sigma$     ↑ stack symbol to pop  $\Sigma$     ↑ next state    ↑ stack symbol to push

$q_0 \in Q$  start  
 $F \subseteq Q$  final states