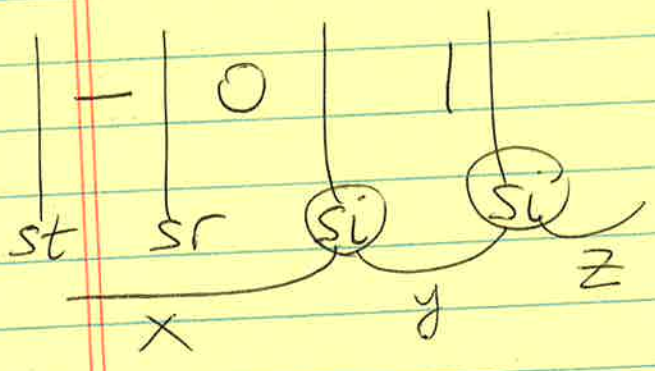
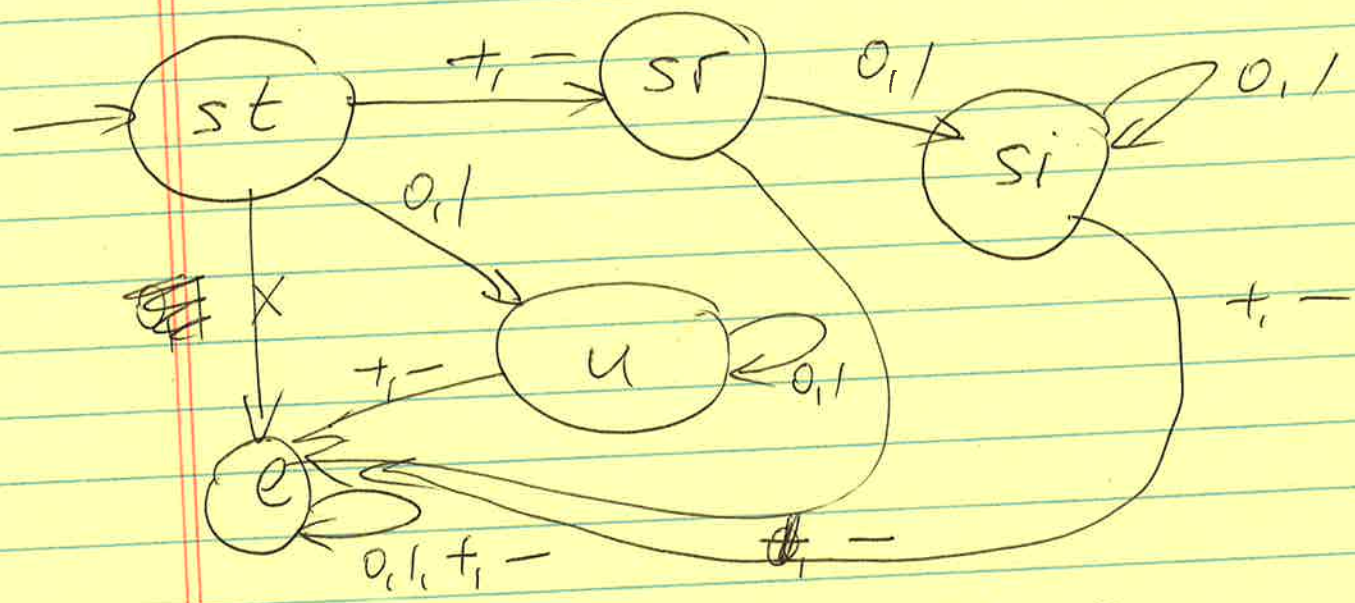


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$$a^n = \underbrace{a \dots a}_{n \text{ times}}$$

$$C^n = \underbrace{C \dots C}_{n \text{ times}}$$



$$x = 0$$

$$y = 1$$

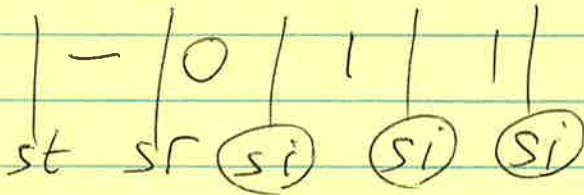
$$z = 1$$

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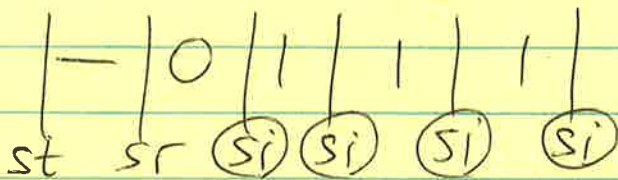
-2-

$$x = -0 \quad y = 1 \quad z = \Lambda$$

$$xyyz = -011$$



$$xyyz = -0111$$



$$\{a^n b^n\} = \{\Lambda, ab, aabb, \dots\}$$

Pushdown automaton \equiv a finite automaton which can also push & pop into a stack

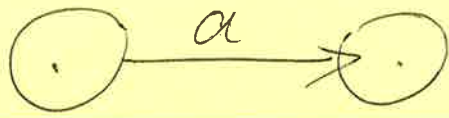
Idea: we see a , we push
we see b , we pop

Minor problem: checking for empty stack. Solution: we push a special symbol, then at the end if it pops we know the stack was empty

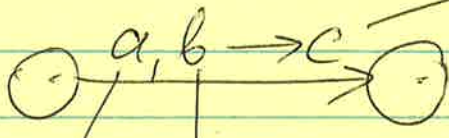
This symbol is $\textcircled{\$}$

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PDA



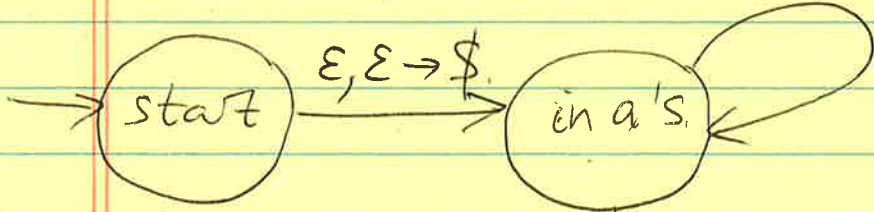
what we push



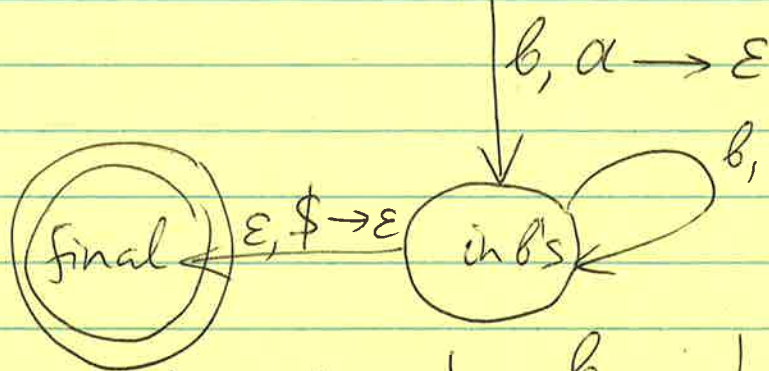
input symbol

what is on top of the stack

$\alpha, \epsilon \rightarrow \alpha$

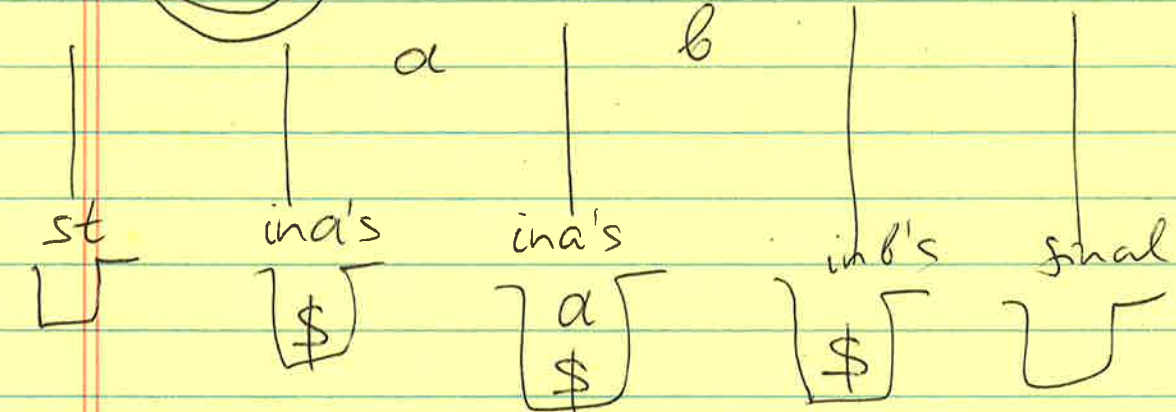


A word is accepted if we end up in a final state with an empty stack

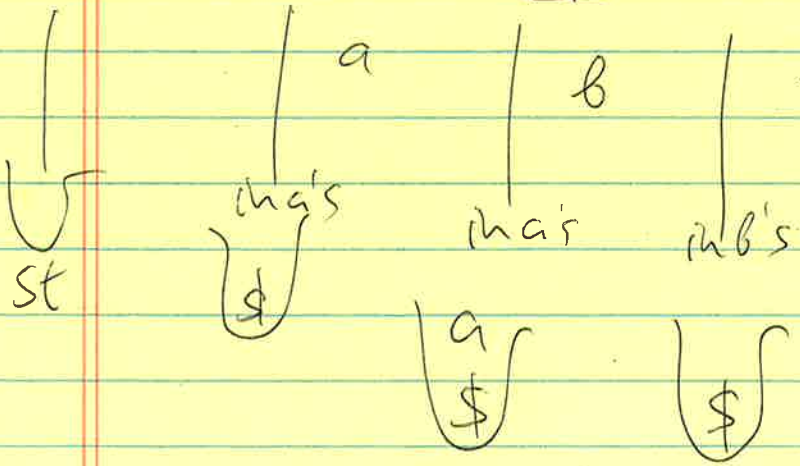


$\epsilon, \$ \rightarrow \epsilon$

$a \ b$

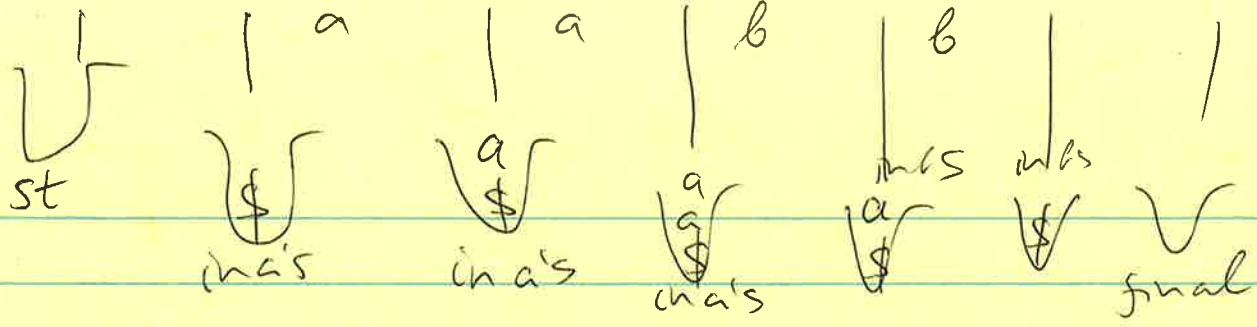


$a \ b \ b$

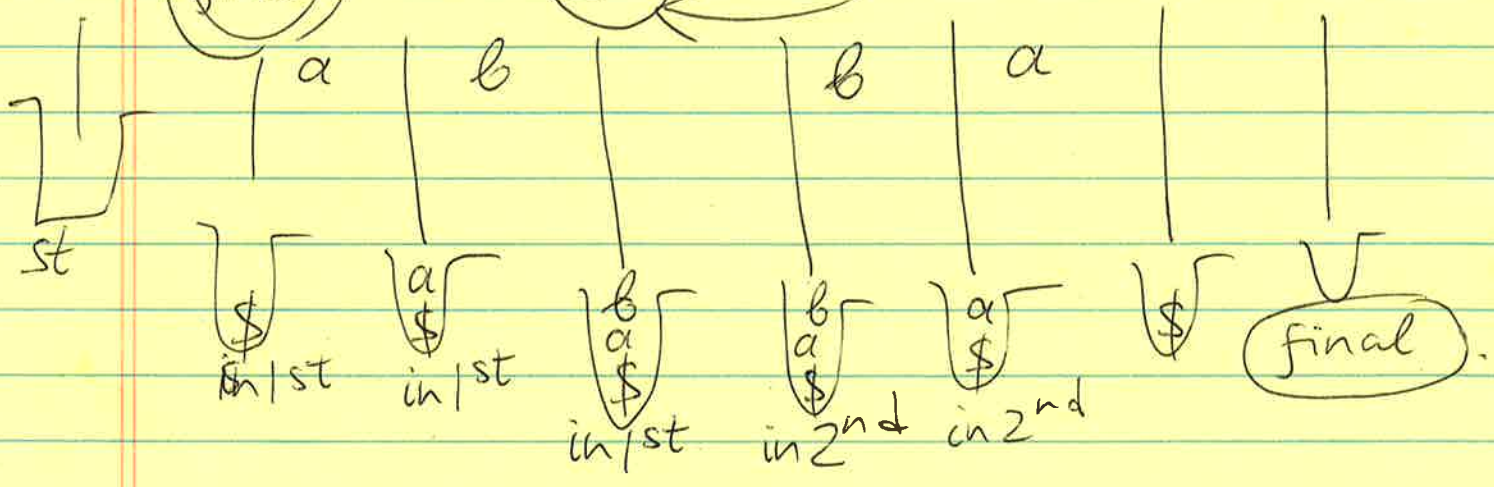
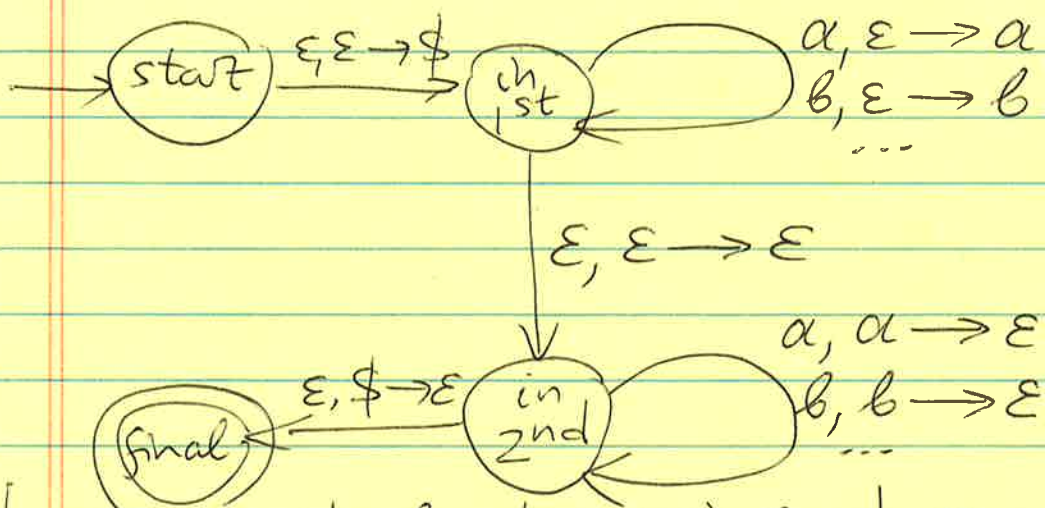


$a \ a \ b \ b$

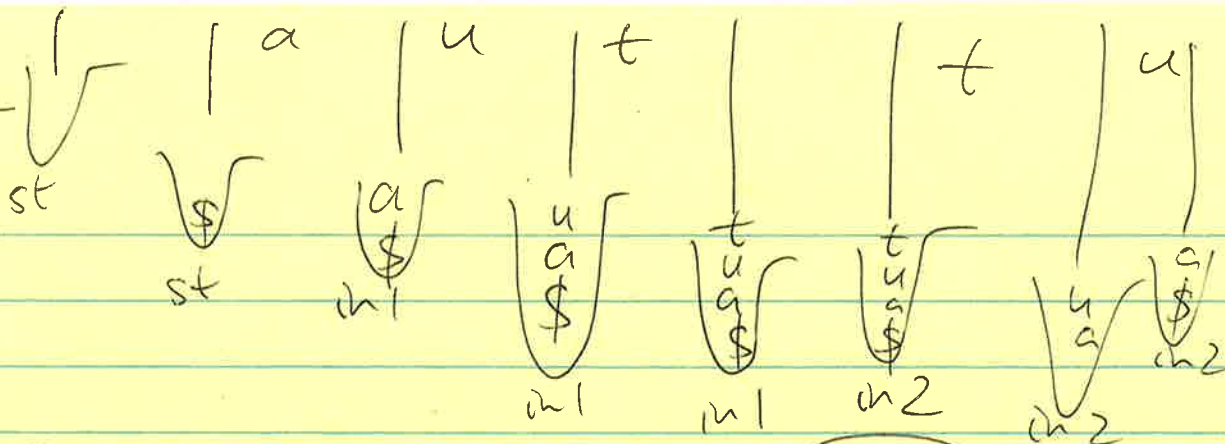
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$$\{ww^R\} = \{ \underbrace{abba}_w \underbrace{abba}_{w^R}, \underbrace{auntua}_w \underbrace{auntua}_{w^R}, \dots \}$$



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Context-Free grammars (CFG)

$\langle \text{if-statement} \rangle = \text{if} (\langle \text{condition} \rangle) \langle \text{statement} \rangle$

$\langle \text{if-statement} \rangle = \text{if} (\langle \text{condition} \rangle) \langle \text{statement} \rangle$
 else $\langle \text{statement} \rangle$

$\langle \text{if-st} \rangle, \langle \text{cond} \rangle, \dots$ - variables

if(- terminal symbols

In automata theory, variables - capital letters, term. symbols \rightarrow small letters

$I \rightarrow \text{if} (C) S$

$I \rightarrow \text{if} (C) S \text{ else } S$

yacc

FA \leftrightarrow RL
 PDA \leftrightarrow CFG

NDFAs \leftrightarrow FA

NPDAs \leftrightarrow PDA

$(a \cup b)^*$

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CFG for $L = \{a^n b^n\}$

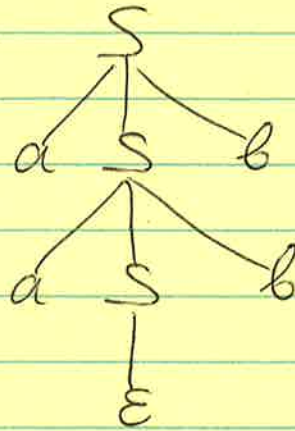
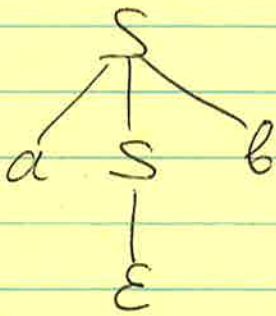
- 1) $S \rightarrow \epsilon$ empty string is a word of this language
2) $S \rightarrow aSb$ if we have a word from L , we add a to the left, b to the right, we get a word

(ϵ)

$S \rightarrow \epsilon$ | $S \rightarrow aSb \rightarrow ab$
| $abab$

$S \rightarrow aSb \rightarrow aaSbb \rightarrow aabb$

S
|
 ϵ



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Madam, I'm Adam.

- $S \rightarrow \epsilon$
 - $S \rightarrow a$
 - $S \rightarrow b$
 - \vdots
 - $S \rightarrow z$
- $S \rightarrow aSa$
 - $S \rightarrow bSb$
 - \dots
 - $S \rightarrow zSz$

m|m

h	a	n	n	a	h
↓	↑	↑	↑	↑	↓

