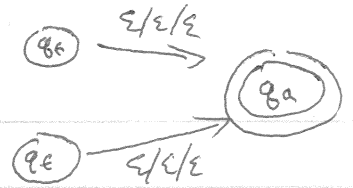
Assumptions about PDA:

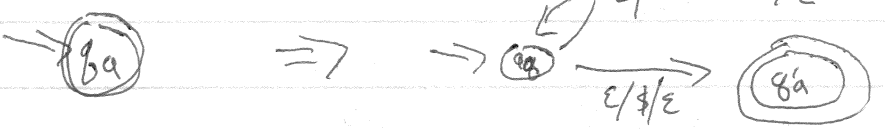
- Single accept state, q_a



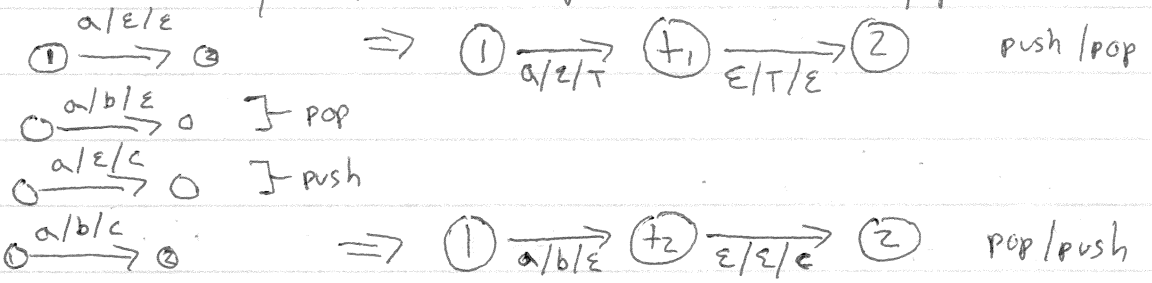
$\forall q_f \in F$

- Assume initializes stack with $

- Assume stack is empty on accept



- Assume every transition pushes xor pops



Idea: V_{pq} $\forall p, q \in Q$

$V_{pq} \Rightarrow^* w$] derive w from V_{pq}

iff $p \overset{w}{\underset{\varepsilon}{\Rightarrow}}{}^* q$] run machine from p to q on w & stack

1 $\forall p$.

$V_{pp} \to \varepsilon$ $\quad S = V_{(q_0)(q_a)}$

2 $\forall p, q, r$

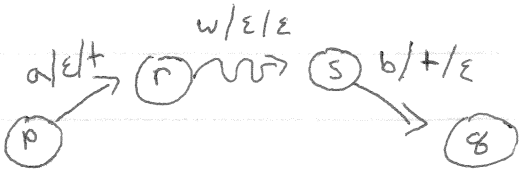
$V_{pq} \to V_{pr} V_{rq}$

$V_{pr} \Rightarrow^* w_1$ $\quad V_{rq} \Rightarrow^* w_2$

$V_{pq} \Rightarrow^* w_1 w_2$ $\quad \varepsilon[p] w_1 w_2 \Rightarrow^* \varepsilon[r] w_2 \Rightarrow^* \varepsilon[q] \varepsilon$

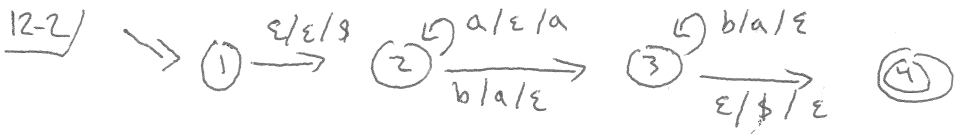
3

$$\frac{(r, t) \in \delta(p, a, \varepsilon) \quad (q, \varepsilon) \in \delta(s, b, t)}{V_{pq} \to a\, V_{rs}\, b}$$



$a, b \in \Sigma_\varepsilon$ $\quad t \in \Gamma$

12-2/



[1]	1 → 2	push $
	3 → 4	pop $
[2]	2 → 2	push a
	2 → 3	pop a
[3]	2 → 2	push a
	3 → 3	pop a

$S = V_{14}$

$V_{11} \to \varepsilon$

$V_{12} \to V_{11}V_{12} \mid V_{12}V_{22} \mid V_{13}V_{32} \mid V_{14}V_{42}$

V_{13}

$V_{14} \to V_{11}V_{14} \mid V_{12}V_{24} \mid V_{13}V_{34} \mid V_{14}V_{44} \mid \varepsilon V_{23} \varepsilon$ [1]

V_{21}

$V_{22} \to \varepsilon$

$V_{23} \to V_{21}V_{13} \mid V_{22}V_{23} \mid V_{23}V_{33} \mid V_{24}V_{43} \mid a V_{22} b \mid a V_{23} b$

V_{24}

V_{31}

V_{32}

$V_{33} \to \varepsilon$

V_{34}

V_{41}

V_{42}

V_{43}

$V_{44} \to \varepsilon$

$V_{14} \to V_{23}$

$V_{23} \to a V_{22} b \mid a V_{23} b$ $\Big)$ — $a^n b^n \quad n>0$

$V_{22} \to \varepsilon$

$A = \{ w w^R \mid w \in \{0,1\}^* \}$

$S \to 0S0 \mid 1S1 \mid \varepsilon$

$\in$ CFL

$0110 \in \quad 0101 \notin$

$s = 0^p 110^p$

$xy = 0^a \quad z = 0^b 110^p$

$\notin$ REG

$B = \{ ww \mid w \in \{0,1\}^* \}$

$s = 0^p 10^p 1$