

$$\{a^i b^j c^k \mid i=j, j=k \text{ or } i=k\}$$

$$S \rightarrow A \mid B \mid C$$

$$A \rightarrow DE$$

$\swarrow \quad \nwarrow$
 $a^i b^j \quad c^k$

$$D \rightarrow aD \mid b \mid \epsilon$$

$$E \rightarrow cE \mid \epsilon$$

$$B \rightarrow FG$$

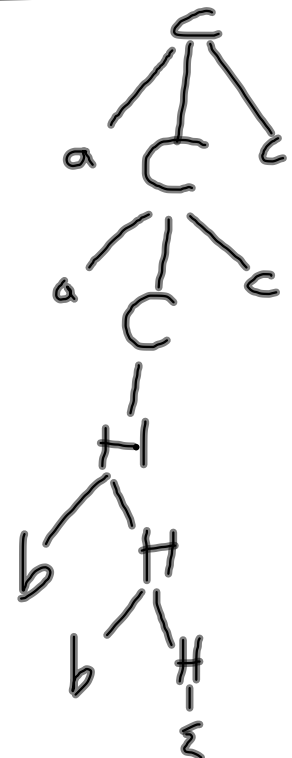
$\swarrow \quad \nwarrow$
 $a^i \quad b^j c^k$

$$F \rightarrow aF \mid \epsilon$$

$$G \rightarrow bG \mid c \mid \epsilon$$

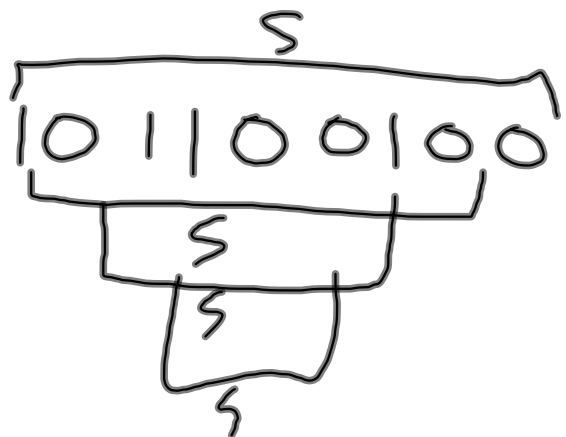
$$C \rightarrow aC \mid c \mid H$$

$$H \rightarrow bH \mid \epsilon$$



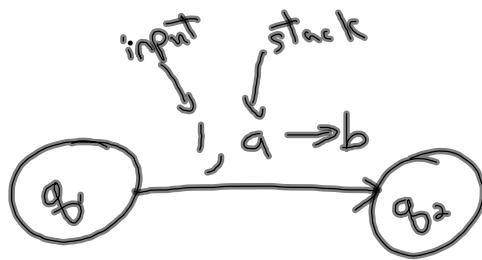
$\{ w \mid \text{the length is odd and its middle symbol is } \emptyset \}$

$S \rightarrow \underline{1S1} \mid \emptyset S \emptyset \mid \underline{1S\emptyset} \mid$
 $\emptyset S \underline{1} \mid \emptyset$



Push Down Automata (PDA)

- nfa
- stack - infinite
- push/pop
- recognize CFL

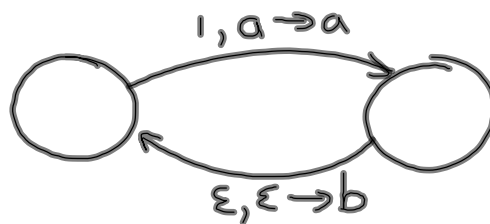


in q_0 w/ input 1
and top of stack a,
pop a, push b
go to q_2

$1, a \rightarrow \epsilon$
don't push
 $1, \epsilon \rightarrow b$
don't check
top and
don't pop anything

$1, a \rightarrow a$

want to push b
if input is 1 and
stack top is a



PDA \rightarrow

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

Q : set of states

Σ : input alphabet

Γ : stack alphabet

$$\delta: Q \times \Sigma_{\epsilon} \times \Gamma_{\epsilon} \rightarrow \mathcal{P}(Q \times \Gamma_{\epsilon})$$

q_0 : start state $q_0 \in Q$

F : set of final states $F \subseteq Q$

$\{0^n 1^n \mid n \geq 0\}$

