

$$\{a^n b^m \mid m > n\}$$

$n \geq n$

$$S \rightarrow aSb \mid T$$

$$T \rightarrow bT \mid b$$

$$\{a^n b^n \mid n \text{ is even}\}$$

$$S \rightarrow aaSbb \mid \varepsilon$$

Concatenation:

$$S \rightarrow S_1 S_2$$

$$S_1 \rightarrow \dots$$

$$S_2 \rightarrow \dots$$

union:

$$S \rightarrow S_1 \mid S_2$$

$$S_1 \rightarrow \dots$$

$$S_2 \rightarrow \dots$$

Make a CFG:

$$\{a^n b^n a^m\} \rightarrow$$

$$\begin{cases} S \rightarrow S_1 S_2 \\ S_1 \rightarrow aS_1 b \mid \varepsilon \\ S_2 \rightarrow aS_2 \mid \varepsilon \end{cases}$$

$$\{b^m a^n b^{3m}\}$$

$$\{xx^R \mid x \in \{a,b\}^*\}$$

$$\{x \mid x = x^R\}$$

$$\{x \mid x \text{ has same \# of a's \& b's}\}$$

(try to derive abbbababab)

$$\frac{ab \quad ba}{\mid}$$

$$\sum_{\substack{w \\ x \neq x^R}} : S \rightarrow aSa \mid bSb \mid \epsilon$$

$$\sum_{x=x^R} S \rightarrow aSa \mid bSb \mid \epsilon \mid a \mid b$$

↑
abababa

$$\{x \mid x \text{ has same \# a's \& b's}\}$$

$$\begin{aligned} S &\rightarrow aSb \mid bSa \mid aTa \mid \epsilon \\ T &\rightarrow aTb \mid bTa \mid bSb \end{aligned}$$

S, A, B

S will make equal # a's & b's

A one extra a

B one extra b

$$S \rightarrow aBS \mid bAS \mid \epsilon$$

$$A \rightarrow a \mid bAA$$

$$B \rightarrow b \mid aBB$$

Derive abbbababaa

$$\begin{aligned} S &\Rightarrow aBS \Rightarrow abS \Rightarrow abbAS \Rightarrow abbbAAS \\ &\Rightarrow abbb aAS \Rightarrow abbbabAAS \end{aligned}$$

$\Rightarrow abbbabaa S \Rightarrow abbbaba = bAS$
 $\Rightarrow abbbabaaba$

A real-world grammar for
python

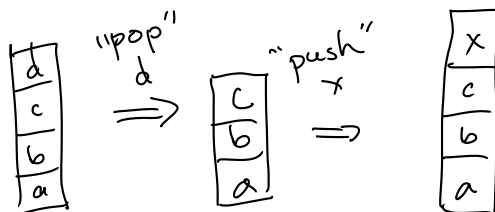
```
def square(x):  
    y = x*x  
    return y
```

Stack Machines

It has a memory organized in a stack

We start with an input string & an empty stack,
the machine reads the string one letter at a time,
each letter read will modify the stack.

The stack is a list of letters



if's not finite state.