

## 1 Closure Properties of CFLs

Are the CFLs closed under:

- Union?
- Concatenation?
- Kleene star?
- Complement?
- Intersection?
- Intersection with a *regular* language?

## 2 Sample languages

Are the following languages context-free?

- $\{www : w \in \Sigma^*\}$
- $\{w \in \{(,)\}^* : w \text{ is not properly parenthesized}\}$

## 3 PDAs

- Show that  $L = \{a^n b^{2n}\}$  is context-free by giving a PDA that accepts it. Draw the state diagram and write the 6-tuple  $(Q, \Sigma, \Lambda, \delta, q_0, F)$ .<sup>1</sup>

---

<sup>1</sup> $\Lambda$ , the stack alphabet, is a capital Lambda.

