Theory of Machines and Languages

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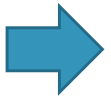
1403-1404

Pumping Lemma for Context-Free Languages

- **Exercise**
  - **Show that the language $L = \{a^n b^n : n \geq 0,\ n \text{ is not a multiple of } 5\}$ is context-free**
    - **L is the intersection of:**
      - **$\{a^n b^n : n \geq 0\}$, which is context-free**
      - **$\{a^n b^m : k \text{ is not a multiple of } 5\}$, which is regular**



L is context-free

- **Exercise**
  - **Show that the family of context-free languages is closed under reversal**
  - **Show that the family of context-free languages is closed under homomorphism**

Pumping Lemma for Context-Free Languages

- **Exercise**
  - Show that the language $L = \{a^n : n \text{ is a prime number}\}$ is not context-free.
  - Show that $L = \{ww^R w : w \in \{a,b\}^*\}$ is not a context-free language.
  - Determine whether or not the following languages are context-free:

(a) $L = \{a^n w w^R b^n : n \geq 0, w \in \{a,b\}^*\}$.

(b) $L = \{a^n b^j a^n b^j : n \geq 0, j \geq 0\}$.

(c) $L = \{a^n b^j a^j b^n : n \geq 0, j \geq 0\}$.

(d) $L = \{a^n b^j a^k b^l : n + j \leq k + l\}$.

(e) $L = \{a^n b^j a^k b^l : n \leq k, j \leq l\}$.

(f) $L = \{a^n b^n c^j : n \geq j\}$.

(g) $L = \{a^n b^n c^k, k = 2n\}$.