CS310

Pumping Lemma

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Quick Review

• Pumping Lemma

• If $A$ is a regular language, then there is a number $p$ where, if $s$ is any string in $A$ of length at least $p$, then $s$ may be divided into three pieces, $s = xyz$, satisfying the following conditions:

1. $i \geq 0$, $xy^iz \in L(M)$
2. $|y| > 0$ (x, z may be $\epsilon$)
3. $|xy| \leq p$
Motivation

• This is a regular language:
  \[ 1^*00 \]
  How do we know it is regular?

Draw a DFA

Find a string, s, whose length is \( \geq p \)

\[ p = |Q| \]

Determine: \( s = xyz \)

What is y? Where is the unbounded repetition?

1. \( i \geq 0, \ xy \ z \in L(M) \)
2. \( |y| > 0 \)
3. \( |xy| \leq p \)
Regular vs Non-Regular

\{ 1^* \}

\{ 1^*0^* \}

\{ 1^n | n \geq 0 \}

\{ 0^n1^n | n \geq 0 \}
Examples Galore!

- $L = \{ a^n b^m : m > n \}$
- $L = \{ a^n b^m : m < n \}$
- $L = \{ a^n b^m : m == n \}$
- $L = \{ a^{2n} : n > 0 \}$
- $L = \{ a^n : n is \ prime \}$
- $L = \{ a^n b^m c^n + m : n, m > 0 \}$
- $L = \{ a^n b a^n : n >= 0 \}$
- $L = \{ wbbw | w \in \{a, b\}^* \}$
- $L = \{ (ac)^n b^m : n > m >= 0 \}$
- $L = \{ a^n b^m : m, n > 0 \}$

Show for each language:
- A string that does pump
- A string that does not pump
- Are any of these languages regular?
  
  Can we write any of them as a regular expression?

How many are CFL?