6.045J/18.400J: Automata, Computability and Complexity Prof. Nancy Lynch

Recitation 3: Regular Expressions and Non-regular Languages

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Problem 1: **Key terms.** Regular expression, generalized NFA, pigeon-hole principle, pumping lemma, pumping length, pumping up, pumping down.

Problem 2: **True or False?**

1. If L_1 and L_2 are regular, then $L_1 \cup L_2$ is regular.
2. If L_1 and L_2 are non-regular, then $L_1 \cap L_2$ is non-regular.
3. If L_1 is regular and L_2 is non-regular, then $L_1 \cup L_2$ is non-regular.
4. If L_1 is regular, L_2 is non-regular, and $L_1 \cap L_2$ is regular, than $L_1 \cup L_2$ is non-regular.

Problem 3: **Regular Expressions.** Write regular expressions for the following languages. The alphabet is $\{0, 1\}^*$.

1. $A_1 = \{w|w$ contains at least two 0's$\}$.
2. $A_2 = \{w|w$ contains an even number of 0's$\}$.
3. $A_3 = \{w|w$ does not contain 100 as a substring$\}$.

Problem 4: **Proving non-regularity: the Pumping Lemma.** Prove that the following languages are not regular.

1. $L_1 = \{0^i 1^j 0^k \,|\, k > i + j\}$.
2. $L_2 = \{0^i 1^j |\, j$ is a multiple of $i\}$.
3. $L_3 = \{0^i 1^j \mid i > j\}$.

Problem 5: **Proving non-regularity using closure properties**

1. $L_5 = \{0^i 1^j, i \neq j\}$