CENG213 Theory of Computation Final Exam January 21^{st}, 2020

Answer the questions in two hours.

1. **(30 points)** Let $L = \{x^R \# y : x, y \in \{0,1\}^*$ and x is a substring of $y\}$

   1. Show a context-free grammar for L.
   2. Show a natural PDA that accepts L.

2. **(30 points)** Construct a standard Turing machine to decide the following language:

   $L = \{w \in \{a,b,c,d\}^* : \#_b(w) \geq \#_c(w) \geq \#_d(w) \geq 0\}$

3. **(30 points)** Construct a DFA for the following language:

   $\{w \in \{a,b\}^* | w$ has exactly three a's and at least two b's$\}$

4. **(20 points)** What is the reflexive transitive closure R^* of the relation $R = \{(a,b),(a,c),(a,d),(d,c),(d,e)\}$? Draw a directed graph representing R^*.