# Homework Assignment #8

## Due Time/Date

This assignment is due 2:10PM Tuesday, May 19, 2020. Late submission will be penalized by 20% for each working day overdue.

## How to Submit

Please use a word processor or scan hand-written answers to produce a single PDF file. Name your file according to this pattern: "b057050xx-hw8". Upload the PDF file to the Ceiba course site for Theory of Computing 2020: https://ceiba.ntu.edu.tw/1082theory2020. You may discuss the problems with others, but copying answers is strictly forbidden.

## Problems

(Note: problems marked with "Exercise X.XX" or "Problem X.XX" are taken from [Sipser 2013] with probable adaptation.)

1. (10 points) Give a formal definition (with a state diagram) of a Turing machine that shifts the input string one tape cell to the right and put a $\sqcup$ (blank symbol) in front of the input. The input alphabet is $\{0, 1\}$.

2. (Exercise 3.4; 10 points) Give a formal definition of an enumerator (like that of an NFA, PDA, or Turing machine). Consider it to be a type of two-tape Turing machine that uses its second tape as the printer. Include a definition of the enumerated language.

3. (Problem 3.11; 20 points) Show that single-tape TMs that cannot write on the portion of the tape containing the input string recognize only regular languages.

4. (Problem 3.13; 20 points) Show that a language is decidable iff some enumerator enumerates the language in the standard string order (the usual lexicographical order, except that shorter strings precede longer strings) .

5. (Exercise 4.3; 10 points) Let $ALL_{\text{DFA}} = \{\langle A\rangle \mid A \text{ is a DFA and } L(A) = \Sigma^*\}$. Show that $ALL_{\text{DFA}}$ is decidable.

6. (10 points) Let $A = \{\langle R, S\rangle \mid R \text{ and } S \text{ are regular expressions and } L(R) \subseteq L(S)\}$. Show that $A$ is decidable.

7. (Problem 4.4; 20 points) Let $A\varepsilon_{\text{CFG}} = \{\langle G\rangle \mid G \text{ is a CFG that generates } \varepsilon\}$. Show that $A\varepsilon_{\text{CFG}}$ is decidable.