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Complexity theory and fixed parameter algorithms
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Exercise III

Problem 1
Recall that a 1-string input/output TM can w.l.o.g. be represented by a simpler mapping

$$\delta' : K \times \Sigma \to K \cup \{\text{'yes'}, \text{'no'}, \text{'halt'}\}.$$

Similarly, a non-deterministic 1-string I/O TM can be represented by a special relation on $K \times \Sigma \times K$.

a) Consider $L = \{x\sigma : \sigma \in \Sigma, x \in (\Sigma \setminus \{\sigma\})^*\}$. Describe a non-deterministic 1-string input/output TM that decides L.

b) Show that any non-deterministic 1-string I/O TM can be made deterministic.

Problem 2
Suppose M is a Turing Machine with $\text{space}_M(n) \in o(\log \log n)$. Show that this machine uses only constant space.

Problem 3
Describe languages for the following problems. Which of these languages are recursive, which recursively enumerable, which neither?

a) Decide whether a given graph contains a cycle.

b) Decide whether a given graph contains a cycle of a given size.

c) Decide whether a turing machine halts when started on the empty string.