1. (20 points) Prove that the following languages are not regular.
   (a) \{0^n1^m0^n|m, n \geq 0\}
   (b) \{0^m1^n|m \neq n\}

2. (20 points)
   (a) Let \(B = \{1^k y | y \in \{0, 1\}^* \text{ and } y \text{ contains at least } k \text{ 1s, for any integer } k \geq 1\}\). Show that \(B\) is a regular language.
   (b) Let \(C = \{1^k y | y \in \{0, 1\}^* \text{ and } y \text{ contains at most } k \text{ 1s, for any integer } k \geq 1\}\). Show that \(C\) is not a regular language.

3. (20 points) Define a two-dimensional Turing machine to be a TM where each of its tapes is an infinite grid (and the machine can move not only Left and Right but also Up and Down). Show that for every (time-constructible) \(T : \mathbb{N} \rightarrow \mathbb{N}\) and every Boolean function \(f\), if \(f\) can be computed in time \(T(n)\) using a two-dimensional TM, then it can also be computed by a standard (one-dimensional) TM in time \(O(T(n)^2)\). \textbf{Note:} You may assume that the tapes of the two-dimensional TM start at \((0, 0)\) and can only access points with non-negative integer coordinates.

4. (20 points) Let \(T = \{\langle M \rangle | M \text{ is a TM that accepts } \alpha^R \text{ whenever it accepts } \alpha\}\). Show that \(T\) is undecidable. \textbf{Note:} \(\alpha^R\) is the reverse string of \(\alpha\). You may assume the alphabet is \(\{0, 1\}\).