Prove that each of the following languages is *not* regular.

- 1. $\{\mathbf{0}^{2^n} \mid n \ge 0\}$
- 2. $\{\mathbf{0}^{2n}\mathbf{1}^n \mid n \ge 0\}$
- 3. $\{\mathbf{0}^m \mathbf{1}^n \mid m \neq 2n\}$
- 4. Strings over $\{0, 1\}$ where the number of 0s is exactly twice the number of 1s.
- 5. Strings of properly nested parentheses (), brackets [], and braces {}. For example, the string ([]) {} is in this language, but the string ([)] is not, because the left and right delimiters don't match.
- 6. Strings of the form $w_1 \# w_2 \# \cdots \# w_n$ for some $n \ge 2$, where each substring w_i is a string in $\{0, 1\}^*$, and some pair of substrings w_i and w_i are equal.

Work on these later:

- 7. $\{0^{n^2} \mid n \ge 0\}$
- 8. $\{w \in (\mathbf{0} + \mathbf{1})^* \mid w \text{ is the binary representation of a perfect square}\}$