

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

1. $\{0^{2^n} \mid n \geq 0\}$
2. $\{0^{2^n}1^n \mid n \geq 0\}$
3. $\{0^m1^n \mid m \neq 2n\}$
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.

Work on these later:

6. Strings of the form $w_1\#w_2\#\dots\#w_n$ for some $n \geq 2$, where each substring w_i is a string in $\{0, 1\}^*$, and some pair of substrings w_i and w_j are equal.
7. $\{0^{n^2} \mid n \geq 0\}$
8. $\{w \in (0 + 1)^* \mid w \text{ is the binary representation of a perfect square}\}$