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

1. $\left\{\mathtt{0}^{2^n} \;\middle|\; n \geq 0\right\}$

2. $\{\mathtt{0}^{2n}\mathtt{1}^n \mid n \geq 0\}$

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

4. Strings over $\{\mathtt{0}, \mathtt{1}\}$ where the number of $\mathtt{0}$s is exactly twice the number of $\mathtt{1}$s.

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 $n \geq 2$, where each substring w_i is a string in $\{\mathtt{0}, \mathtt{1}\}^*$, and some pair of substrings w_i and w_j are equal.

Work on these later:

7. $\left\{\mathtt{0}^{n^2} \;\middle|\; n \geq 0\right\}$

8. $\{w \in (\mathtt{0} + \mathtt{1})^* \mid w \text{ is the binary representation of a perfect square}\}$