Prove that each of the following languages is not regular.

1. \( \{ \theta^{2^n} \mid n \geq 0 \} \)

2. \( \{ \theta^{2n}1^n \mid n \geq 0 \} \)

3. \( \{ \theta^m1^n \mid m \neq 2n \} \)

4. Strings over \( \{\theta, 1\} \) where the number of \( \theta \)s is exactly twice the number of \( 1 \)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.

Work on these later:

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 \( \{\theta, 1\}^* \), and some pair of substrings \( w_i \) and \( w_j \) are equal.

7. \( \{ \theta^n^2 \mid n \geq 0 \} \)

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