Unless otherwise stated, or otherwise clear from context, all languages are over \( \Sigma = \{a, b\} \). Use the pumping lemma to prove that each of the following are non-regular. On the exam, \( \Sigma \) will be clear.

Recall the pumping lemma for regular languages:

If \( L \) is a regular language, then there is a number \( p \) (the pumping length) where if \( w \) is any string in \( L \) of length at least \( p \), then \( w \) may be partitioned into three pieces, \( w = xyz \), satisfying the following conditions:

- \( |xy| \leq p \)
- \( |y| > 0 \)
- for each \( i \geq 0 \), \( xy^iz \in L \)

1. Let \( L \) be the language \( \{ww \mid w \in \{a, b\}^*\} \)
2. Let \( L \) be the language \( \{a^n^2 \mid n \geq 0\} \) – that is, the set of strings whose length is a perfect square.
3. Let \( L \) be the language \( \{a^ib^k \mid i > k\} \)
4. \( \{a^{10^n} \mid n \geq 0\} \)
5. \( \{a^nb^n c^n \mid n \geq 0\} \)
6. Let \( L \) be the the set of odd-length strings in which the first, middle, and last symbols are the same.
7. **Challenge**: Let \( L \) be the set of odd-length strings where the middle symbol also appears elsewhere in the string.