Problem 1: Key terms. Regular expression, generalized NFA, pigeon-hole principle, pumping lemma, pumping length, pumping up, pumping down.

Problem 2: True or False?
1. If $L_1$ and $L_2$ are regular, then $L_1 \cup L_2$ is regular.
2. If $L_1$ and $L_2$ are non-regular, then $L_1 \cap L_2$ is non-regular.
3. If $L_1$ is regular and $L_2$ is non-regular, then $L_1 \cup L_2$ is non-regular.
4. If $L_1$ is regular, $L_2$ is non-regular, and $L_1 \cap L_2$ is regular, then $L_1 \cup L_2$ is non-regular.
5. The following language is regular: The set of strings in $\{0, 1\}^*$ having the property that the number of 0’s and the number of 1’s differ by no more than 2.
6. The following language is regular: The set of strings in $\{0, 1\}^*$ having the property that in every prefix, the number of 0’s and the number of 1’s differ by no more than 2.

Problem 3: Proving non-regularity: the Pumping Lemma. Prove that the following languages are not regular.
1. $L_1 = \{0^i1^j0^k \mid k > i + j\}$.
2. $L_2 = \{0^i1^j \mid j \text{ is a multiple of } i\}$.
3. $L_3 = \{0^i1^j \mid i > j\}$.
4. $L_4 = \{0^i1^j2^k \mid i, j, k \geq 0 \text{ and if } i = 1 \text{ then } j = k\}$.

Problem 4: The size of the minimal DFA for a regular language $L$. Consider the regular language $L = \{w \mid w \text{ contains at least three } 1's\}$. Prove that any DFA for this language has at least 4 states.