1. Consider the decision problem of testing whether a DFA and a regular expression are equivalent. Express this problem as a language and show that it is decidable.

2. Consider the decision problem of testing whether a CFG generates the empty string. Express this problem as a language and show that it is decidable.

3. Let $\Sigma = \{0, 1\}$, and consider the decision problem of testing whether a regular expression with alphabet $\Sigma$ generates at least one string $w$ that has 111 as a substring. Express this problem as a language and show that it is decidable.

4. Consider the emptiness problem for Turing machines:

   $$E_{TM} = \{ \langle M \rangle | M \text{ is a Turing machine with } L(M) = \emptyset \}.$$  

   Show that $E_{TM}$ is co-Turing-recognizable. (A language $L$ is co-Turing-recognizable if its complement $\overline{L}$ is Turing-recognizable.) Note that the complement of $E_{TM}$ is

   $$\overline{E_{TM}} = \{ \langle M \rangle | M \text{ is a Turing machine with } L(M) \neq \emptyset \}.$$  

   (Actually, $\overline{E_{TM}}$ also contains all $\langle M \rangle$ such that $\langle M \rangle$ is not a valid Turing-machine encoding, but we will ignore this technicality.)