All the subproblems carry equal weight. There are 5 subproblems in this examination.

I. Design the specified automaton for every one of the following languages.

1. A dfa for the language $L_1 = \{x \mid x \in \{a, b\}^*, \text{abb is a substring of } x, \text{ and } |x| \text{ is an even integer}\}.$

2. An npda for the language $L_2 = \{x \mid x \in \{a, b, c\}^*, \text{ and } #_a x = #_b x, \text{ or } x = x^R\}.$
3. A diba for the language $L_3 = \{a^i b^j c^k \mid i, j, k \geq 1$, $i$ and $j$ are even, and $i < j < 2k\}$.

4. A CFG for the language $L_4 = \{a^i b^j a^k b^\ell \mid i, j, k, \ell \geq 1$, and $(i = j$ and $k \neq \ell)$ or $(i = \ell$ and $j \neq k)\}$. 
II. Prove that the following language is not an FA language by applying the pumping lemma.

$L_5 = \{a^ib^j \mid i, j \geq 1, i \geq j \text{ or } 2i \leq j\}$. 