Regular Languages and Finite Automata

(a) State the *Pumping Lemma* for regular languages. Is every language that satisfies the pumping lemma property a regular language? [5 marks]

(b) State, with justification, whether or not each of the following languages is regular. Any standard results you use should be clearly stated, but need not be proved.

(i) \( L_1 = \{ww \mid w \in \{a\}^*\} \) [3 marks]

(ii) \( L_2 = \{ww \mid w \in \{a, b\}^*\} \) [3 marks]

(iii) \( L_3 = \{w_1w_2 \mid w_1 \in \{a\}^* \text{ and } w_2 \in \{b\}^*\} \) [3 marks]

(iv) \( L_4 = \{w \mid w \in \{a, b\}^* \text{ and } w \text{ contains the same number of } a \text{ s and } b \text{ s}\} \) [3 marks]

(v) \( L_5 = \{w \mid w \in \{a, b\}^*, w \text{ contains the same number of } a \text{ s and } b \text{ s, and that number is no more than } 128\} \) [3 marks]