Complexity Theory

(a) State and prove the time hierarchy theorem. [10 marks]

(b) For each of the following statements, state whether or not it can be derived as a consequence of the time hierarchy theorem. Give justification for your answer.

(i) There is a language in \( \text{TIME}(n^2) \) that is not in \( \text{TIME}(n \log n) \). [3 marks]

(ii) There is a language in \( \text{TIME}(2^n) \) that is not decidable in polynomial time. [4 marks]

(iii) There is a language in \( \text{TIME}(2^n) \) that is not in \( \text{NP} \). [3 marks]