4. (a) Caches have become fundamental to the performance of computer systems.

   i. Explain why memory access time is considered to have become a performance bottleneck in computer systems. [2]

   ii. Explain the role of caches in the memory heirarchy. Your answer should explain how caches exploit *spatial locality* and *temporal locality*. [6]

   (b) Explain how parity codes enable the detection of errors in the transmission of binary messages, giving a simple example that uses odd parity. [6]

   (c) Microprocessors consist of a set of components that interact to provide function.

   i. Explain what is meant by the term *von Neumann architecture*. [2]

   ii. Explain the roles of the arithmetic logic unit (ALU), program counter (PC) and instruction register (IR) in program execution. [5]

   iii. Explain how a control unit can be implemented using a hardwired approach, giving the advantages and disadvantages of the approach. [4]