1. (a) An audio CD lasts for about 75 minutes. The sound is stored as two 16 bit samples taken 44100 times a second. Estimate the amount of data on a CD in MB and the rate at which data must be read in kB/s.

   (b) Explain what a bus[1] is and give three contrasting examples. Explain what the bandwidth of a bus is and say which of your examples would have the highest bandwidth.

   (c) Give pseudo code for raising an integer x to the power of another integer y modulo p in about $\log_2(y)$ steps. You can assume that x, y and p are small enough to fit into 16 bits.

2. *He's making a list, He's checking it twice,*
   He's going to find out who's naughty or nice,
   Santa Claus is coming to town.

   Santa and his elves are computerising. He is writing a program to track all the Christian children in the world. For each child he must remember their name (up to 100 characters), if they have been good, what presents they have asked for (Santa stocks 30000 types of present each with its own stock number) and where they live (latitude and longitude).

   (a) Design a C structure suitable for storing information about the children in a linked list.

   (b) Santa has split the list of children into two lists: `naughty` and `nice`. Write a function `brat_check` which looks for naughty children in the nice list and moves them to the head of the naughty list.

   (c) One of Santa's elves suggests that he use a hash table so that he can quickly find children in a given town. Explain the advantages of hash tables to Santa.

3. (a) Explain how a list of numbers from 0 – 127 are used to store a string in C.

   (b) Give a brief overview of the IEEE 754 floating point standard.

   (c) Show how the number $-\frac{1}{5}$ would be stored as a `float`. (A normalised float is written as $\pm 2^{e-127}(1.s)$ with 8 bits for e and 23 bits for s).

4. (a) Explain the term page-fault.

   (b) Give a description of direct-mapped, fully-associative and set-associative caches. What is thrashing (in the context of caches)?

   (c) Give an example of code which would cause a 16kB, 2 way set associative cache to thrash.

[1] Suggesting a bus is something that doesn't run on time in Dublin won't get you any marks.