5 Programming in C and C++ (djg11+am21)

(a) 14-bit words are used to represent a certain set of natural numbers including zero. The least-significant five bits contain an unsigned binary-encoded mantissa value. The remaining nine bits represent an unsigned binary-encoded, bitwise left shift to be applied to the mantissa to obtain the represented value.

(i) Give two functions, coded in C, that respectively convert an encoded value to its nearest 32-bit unsigned integer and to its nearest double-precision floating-point number. What problem(s) arise? [6 marks]

(ii) A packed array of such 14-bit words is stored in memory. Packed means no memory bits are unused, so the stored words may cross byte boundaries. Write a C function to implement the update operation for a 14-bit word held in the array. Its three arguments are an unsigned char * pointer to the base of the packed array, an integer index and an integer holding the 14-bit word to be stored. You may assume unaligned loads and stores of 32-bit words is supported. [6 marks]

(b) All calls to malloc() in a user program in C are to be replaced with calls to my_malloc.

(i) Provide an implementation of void *my_malloc(size_t) that invokes the system’s underlying malloc but which adds 16 bytes of padding at the start and end of each allocated region which is initialised with a distinctive bit pattern. [3 marks]

(ii) Provide a companion my_free function that checks for any changes to the starting pattern, reporting appropriately, or else continues to invoke the system’s free. [3 marks]

(iii) What might be the motivation for introducing my_malloc? [2 marks]