Birkbeck

(University of London)

BSc/FD EXAMINATION

Department of Computer Science and Information Systems

Introduction to Computer Systems (BUCI008H4)

CREDIT VALUE: 15 credits

Summer 2017 Examination

Date of examination: Wednesday 31 May 2017
Duration of paper: 2.30pm - 4.30pm

There are **ten** questions in this paper.

Answer all **ten** questions.

Each question carries **10** marks in total.

Calculators and other electronic devices are not permitted.

The examination is closed book.

No supplementary material is provided.

This paper is not prior disclosed.

1. (a) Add the decimal integers 15 and 27. Show your working. (**2** marks)

   (b) Subtract the binary number 101 from the binary number 11001. Show your working. (**2** marks)

   (c) Write out the binary representation of the number $2^6 + 2^4$. Justify your answer. (**2** marks)

   (d) Explain the way in which the binary representation of a number specifies that number as a sum of powers of 2. (**4** marks)

2. (a) Which of the following are examples of Boolean statements and which are not examples of Boolean statements.

   i) $(3 + 7) * 2$

   ii) $(3 + 7) == 2$

   iii) $C = 4$

   iv) $6 < 10$

   (**4** marks)

   (b) Write out the truth table for the Boolean operation $A\ OR\ B$. The truth values can be indicated by T, F or by 0, 1. (**4** marks)

   (c) Let x, y be two integers. Write out a Boolean expression that is true if x is strictly less than y or strictly greater than $y + 5$ and that is false otherwise. (**2** marks)

3. The Brookshear floating point representation for a binary fraction x consists of eight bits, labeled s, e_1, e_2, e_3, m_1, m_2, m_3, m_4 from left to right. If x is zero, then all eight bits are zero. If x is strictly negative, then the sign bit s is 1. If x is strictly positive, then the bit s is zero. Next, suppose x is not zero. To obtain the remaining seven bits, x is written in the form

$$\pm 2^r * 0.t$$

where r is an integer and t is a bit string such that the leftmost bit of t is 1. The bits e_1, e_2, e_3 together comprise the three bit excess notation for r and the bits m_1, m_2, m_3, m_4 of the mantissa are the leftmost four bits of t.

   (a) Obtain the Brookshear floating point representation for the decimal fraction $3+(1/4)$. Show clearly the values of the sign bit s, the decimal integer exponent r and the bit string t. (**6** marks)

   (b) What feature of floating point representation allows the representation of very large numbers and of very small numbers near to 0? (**4** marks)

4. (a) Explain the terms track and sector as applied to a hard drive (magnetic disk). Why do the tracks have a particular shape? (**6** marks)

   (b) A hard drive has a capacity of 4 Terabytes. The data rate for reading from the hard drive is 100 Megabytes per second. How many seconds will it take to read the entire disk? Justify your answer. (**4** marks)

5. (a) Give an example of a non-empty two dimensional array of integers. (**2** marks)

   (b) Explain how it is possible to store a two dimensional array in a memory consisting of a one dimensional list of cells. (**2** marks)

   (c) Write a pseudocode algorithm to add the numbers in a one dimensional array of integers and print the result. The name of the array is A, the array contains n elements, array indexing begins with 0 and the array is non-empty ($n > 0$). (**6** marks)

6. The table included below in this question describes instructions of length 16 bits, made by concatenating an op-code and an operand. The first four bits record the op-code. The remaining 12 bits record the operand. Four bits are required to specify a register R and eight bits are required to specify a memory location XY. Each register holds eight bits and each memory location holds eight bits.

Each 16 bit instruction is coded by four hexadecimal digits. For example, the four hexadecimal digits $37A9$ specify an instruction with op-code 3, in which the 7 refers to register 7 and $A9$ refers to the memory cell $A9$. The registers are numbered in hexadecimal from 0 to F.

All memory addresses in this question are given in hexadecimal notation.

Op code	**Operand**	**Description**
1	RXY	Load register R with the bit pattern in memory cell XY.
2	RXY	Load register R with the bit pattern XY.
3	RXY	Store the bit pattern in register R at memory cell XY.
4	$0RS$	Move the bit pattern in register R to register S.
5	RST	Add (two's complement) the bit patterns in registers R and S. Put the result in register T.
6	RST	Add (floating point) the bit patterns in registers R and S. Put the result in register T.
7	RST	Or the bit patterns in registers S and T. Put the result in register R.
8	RST	And the bit patterns in registers S and T. Put the result in register R.
9	RST	Exclusive Or the bit patterns in registers S and T. Put the result in register R.
A	$R0X$	Rotate the bit pattern in register R one bit to the right X times.
B	RXY	Jump to the instruction in memory cell XY if the bit pattern in register R is equal to the bit pattern in register 0.
C	000	Halt.

(a) Explain in detail the action of the instruction with op code 8. Include an example in your answer. (**4** marks)

(b) Write a program to load the contents of memory cell 91 into a register, set the right-most four bits equal to zero and then store the resulting bit string in memory cell 92. (**6** marks)

7. (a) Define the term algorithm. Why is algorithm an important concept in computer science? (**4** marks)

   (b) Explain why there is no algorithm for printing out all the integers less than or equal to 5. (**2** marks)

   (c) Describe a method for implementing a loop in a program. In addition to the description, write out in a small amount of pseudocode as an example. (**4** marks)

8. (a) A list of numbers is to be stored either in an array or in a linked list. Describe one advantage of using a linked list. Describe one disadvantage of using a linked list.

   (**2** marks)

   (b) Describe the way in which the head pointer and the null pointer are used in a linked list. (**4** marks)

   (c) Consider the following section of memory.

10	11	12	13	14	15	16	17	18	19
H	12	A	16	C	0	B	14	D	0

   The numbers 10 to 19 are addresses. The boxes are individual cells in the memory. The section of memory contains a linked list. Each element in the list consists of data and a pointer, stored in adjacent memory cells. For example, the element $(A, 16)$ consists of data A and the pointer 16. The data A are stored in cell 12 and the pointer is stored in cell 13. The items A, B, C, D are data, H is the head of the list and the null pointer is 0. The linked list with head H contains the data items A, B, C. Describe the actions on pointers required to replace the item B in the list with the item D. Draw a diagram to show the updated section of memory. (**4** marks)

9. (a) Explain why a sequential file is appropriate for storing music (audio) or video.

   (**2** marks)

   (b) Describe the structure of an index file. (**4** marks)

   (c) An indexed file contains at most 2^6 records. The indexed file is stored in a memory with 2^{14} cells. What is the maximum size of the index in bits? Justify your answer.

   (**4** marks)

10. Consider the following pseudocode for a function gcd. The arguments m, n are strictly positive integers such that $m \geq n$. The function gcd returns the greatest common divisor of m and n.

```
function gcd(m, n)
   while (m ≠ n)
      r = m − n
      m = maximum(n, r)
      n = minimum(n, r)
   endWhile
   return m
endFunction
```

(a) What happens if gcd is called with $m > 0$ and $n = 0$? Revise the pseudocode for gcd to produce a new function $gcd1$ that returns the greatest common divisor of m and n if $m \geq n > 0$ and returns m if $m > n = 0$. (**4** marks)

(b) The pseudocode for gcd fails if $m < n$. Revise the pseudocode for gcd to produce a new function $gcd2$ that takes strictly positive integers m, n as arguments and returns the greatest common divisor of m and n without making the assumption that $m < n$ or that $n < m$. In other words $gcd2(m, n)$ and $gcd2(n, m)$ both return the correct greatest common divisor of m and n. (**6** marks)

