Birkbeck

(University of London)

BSc/FD EXAMINATION

Department of Computer Science and Information Systems

Introduction to Computer Systems (BUCI008H4)

CREDIT VALUE: 15 credits

Summer 2018

Date of examination: Friday 1st June 2018
Duration of paper: 14.30 – 16.30

There are **nine** questions in this paper.
Answer all **nine** 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 binary numbers 1001 and 11001. Show the carries, if any. (**2** marks)

   (b) Subtract the binary number 1011 from the binary number 11101. Show the borrowed digits, if any. (**2** marks)

   (c) Multiply the binary numbers 101 and 1101. Show your working. (**4** marks)

   (d) Multiply the decimal numbers 101 and 1101. Show your working. (**2** marks)

2. (a) Obtain the four bit two's complement representations for the decimal integers 4 and 6. (**2** marks)

   (b) Obtain the four bit two's complement representation for the decimal integer -6 from the two's complement representation for 6. Explain your answer. (**4** marks)

   (c) Give a general method for obtaining the two's complement notation for an integer $-m$ from the two's complement notation for m. (**4** marks)

3. (a) Evaluate the following Boolean expressions for $A = True$ and $B = False$.

   i) $A\ OR\ B$

   ii) $A\ AND\ (6 > 3)$

   iii) $B\ OR\ (4 == 5)$

   iv) $NOT(A\ OR\ B)$

   (**4** marks)

   (b) Write out the truth table for the Boolean operator $==$, i.e. the truth table for $C\ ==\ D$, where C and D are Boolean variables. (**4** marks)

   (c) Two Boolean expressions are observed to have the same truth table. What is the consequence of this observation for calculations involving the two expressions. (**2** marks)

4. (a) 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.

Obtain the Brookshear representation for the binary fraction $-5/4$. Show clearly the values of the sign bit s, the decimal integer exponent r and the bit string t. (**6** marks)

(b) Find the values of r and t for the largest positive number that has an exact Brookshear representation. (**4** marks)

5. (a) A computer consists of a CPU connected to a memory. Describe the three parts of the machine cycle. (**3** marks)

(b) Describe the three types of register in the CPU and state how they are used in the machine cycle. (**6** marks)

(c) What is meant by the von Neumann bottleneck? (**1** mark)

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 S and T. Put the result in register R.
6	RST	Add (floating point) the bit patterns in registers S and T. Put the result in register R.
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) State the opcode for the instruction 9321. Which register or registers are used when this instruction is carried out? (**2** marks)

(b) Let s be a bit pattern with 8 bits. Let t be the bit pattern 11111111. The Exclusive Or of the bit patterns s and t produces the bit pattern obtained by reversing the bits in s. Write instructions to reverse the bits in the bit pattern stored in register 1 and put the resulting bit pattern in register 3. (**2** marks)

(c) Write instructions to load the contents of the memory cell 91 into a register, reverse the bits in the register and store the resulting bit pattern in memory cell 92. (**6** marks)

7. (a) Give an example of a 4×4 array with distinct integer values. (**2** marks)

(b) The i, jth value of an array A is $A[i, j]$. The indices i, j begin with $i = 0$, $j = 0$. Identify the value $A[1, 2]$, given that A is the array in part (a) of this question. Explain how the notation $A[1, 2]$ specifies a value in the array A. (**4** marks)

(c) Consider the following pseudo code

```
x = 100
row = 3
v = 100
i = 0
while i < 4
    if A[row, i] == 100
        print(100)
    endIf
   i = i + 1
endWhile
```

What is printed? Justify your answer. (**4** marks)

8. (a) State one advantage of using pseudo code. (**2** marks)

(b) Consider the following function

```
function temp(c)
   f = (9/5) * c + 32
   return f
endFunction
```

Identify the name of the function, the parameter of the function and the body of the function. (**4** marks)

(c) Use the function in part (b) of this question to make a function call with a parameter value of 5. Assign the return value to a variable ft. What is the return value? (**4** marks)

9. In the following code for the function $binarySearch$, L is a non-empty ordered list. The function $binarySearch$ returns $True$ if a is an element of L otherwise it returns $False$. List indexing begins with the index 0. The element of L with index 0 is written as $L[0]$.

```
function binarySearch(L, a)
  i1 = 0
  i2 = length(L) − 1
  while i2 > i1 + 1
    j = largest integer ≤ (i1 + i2)/2
    if L[j] == a
      return True
    endIf
    if a < L[j]
      i2 = j
    else
      i1 = j
    endIf
  endWhile
  return (a == L[i1] or a == L[i2])
endFunction
```

(a) Suppose that the length of L is 6. Find the value of j in the first iteration of the while loop. Justify your answer. (**2** marks)

(b) What happens if $binarySearch$ is called with L equal to the empty list? Justify your answer. (**4** marks)

(c) Suppose that $L = [a, b, c, d, e, f]$ and that the function call $binarySearch(L, b)$ is made. List the elements of L that are used to evaluate the expression $L[j] == b$ in each execution of the code in the while loop. Justify your answer. (**4** marks)

