King's College London

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the authority of the Academic Board.

Degree Programmes	BSc, MSci, BEng, MEng
Module Code	4CCS1CS1
Module Title	Computer Systems
Examination Period	January 2016 (Period 1)
Time Allowed	Three hours
Rubric	ANSWER ALL QUESTIONS, Write your answers on the question paper in the spaces provided.
Calculators	Calculators may be used. The following models are permitted: Casio fx83 / Casio fx85.
Notes	Books, notes or other written material may not be brought into this examination

PLEASE COMPLETE YOUR ANSWERS IN THIS BOOKLET AND PROVIDE YOUR CANDIDATE NUMBER BELOW	
CANDIDATE NUMBER	

HAND THIS PAPER IN TO THE INVIGILATOR AT THE END OF THE EXAMINATION

PLEASE DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

1. a. How many microseconds (ms) are in 0.05 milliseconds?

[1 marks]

b. How many kilobytes (KB) are in 2 gigabytes (GB)?

[1 marks]

2. a. Express 13 (decimal) in unsigned binary representation.

[2 marks]

b. Express 0.21875 in unsigned binary representation

[2 marks]

c. Express 111001101010 (binary) in hexadecimal digits

[2 marks]

3. a. Perform the following base conversion using subtraction or division-remainder: $777_{10} = \_\_\_\_\_{}_5$

[2 marks]

b. Name the main components of a von Neumann computer.

[2 marks]

4. How many bits are required to address a 8MB x 32-bit main memory if:

a. main memory is word (32 bit)-addressable?

[2 marks]

b. main memory is byte-addressable?

[2 marks]

5. Convert the following decimal fraction number 12.3125 to binary with a maximum of six places to the right of the binary point.

[3 marks]

6. **a.** Represent the decimal number -17 and 5 in binary using 6-bit signed magnitude, one's complement and two's complement.

[4 marks]

b. What is the range of values (in decimal) that can be represented in any given x number of bits using Signed magnitude, One's complement and Two's complement

[3 marks]

7. a. Evaluate the unsigned 6-bit binary sum 010011 + 010111

[2 marks]

b. Evaluate the unsigned 6-bit binary subtraction 011001 - 010111

[2 marks]

c. Evaluate the signed magnitude 6-bit binary sum 101001 + 100111

[2 marks]

d. Evaluate in 5-bit two's complement 00110-10111

[2 marks]

e. Will the overflow occur when calculating (-5)+(-13) using 5-bit two's complement form, give reason.

[2 marks]

8. Multiply 10111 (binary) by 11 (binary). Write down the procedure with partial product.

[2 marks]

9. a. Display the binary representation of -6.875 (decimal) according to the IEEE-754 single precision standard (1 sign bit, 8 exponent bits biased by 127, 23 significand bits with an implied normalising bit)

[3 marks]

Sign bit:
Exponent bits:

Significand bits (write down the first 6 bits):

b. Find the maximum absolute error of IEEE-754 single precision representation.

[2 marks]

c. What happens if a single-precision number is larger than this value?

[2 marks]

10. Consider a byte-addressable computer with 20-bit addresses, a cache capable of storing a total of 16K bytes of data, and blocks of 16 bytes. Show the format (include field names and sizes) of a 16-bit memory address for:

a. direct mapped, write down the number of bits in each field

[2 marks]

Tag:
block:
word:

b. fully associative, write down the number of bits in each field

[2 marks]

Tag:
word:

c. Where (which block or set) in cache would the memory address $F01DB_{16}$ be mapped for each of three mapping techniques above? You can specify the answer in binary.

[3 marks]

11. A digital computer has a memory unit with 24 bits per word. The instruction set consists of 150 different operations. All instructions have an operation code part (opcode) and an address part (allowing for only one address). Each instruction is stored in one word of memory.

a. How many bits are needed for the opcode?

[3 marks]

b. How many bits are left for the address part of the instruction?

[2 marks]

c. What is the maximum allowable size for memory?

[3 marks]

d. What is the largest unsigned binary number that can be accommodated in one word of memory?

[2 marks]

Question continues on the next page.

e. Write down the operations involved in executing `AddI FDE` using register transfer language.

[5 marks]

12. MARIE's Instruction Set contains the following instructions:

Opcode	Instruction	Opcode	Instruction
0000	`JnS X`	0111	`Halt`
0001	`Load X`	1000	`Skipcond`
0010	`Store X`	1001	`Jump X`
0011	`Add X`	1010	`Clear`
0100	`Subt X`	1011	`AddI X`
0101	`Input`	1100	`JumpI X`
0110	`Output`		

a. What is the length of the MARIE instruction `AddI FDE`? Write down the binary machine code for the address part of this instruction.

[2 marks]

b. Does `AddI FDE` use direct or indirect mode addressing? Name two other instructions from the MARIE Instruction Set that use indirect mode addressing.

[3 marks]

c. Write down the operations involved in executing `AddI FDE` using register transfer language.

[5 marks]

13. The bus carries data between components in a computer system. It consists of data lines, control lines, and address lines.

a. What two types of data bus are commonly found in computer systems?

[2 marks]

b. For each of the following, underline the bus arbitration scheme described:

- *Any device can try to use the bus. If its data collides with the data of another device, it tries again.*
  (i) Daisy chain, (ii) Centralised parallel, (iii) Distributed using self-detection, (iv) Distributed using collision detection.

[1 marks]

- *Permissions are passed from the highest priority device to the lowest.*
  (i) Daisy chain, (ii) Centralised parallel, (iii) Distributed using self-detection, (iv) Distributed using collision detection.

[1 marks]

Question continues on the next page.

c. Explain how a *Load-Store* Instruction Set Architecture can reduce the need for the bus when performing computations.

[4 marks]

14. Consider two computer systems. Computer system A has a clock speed of $400\,MHz$. Computer system B has a clock speed of $1.6\,GHz$. Both use the same instruction set.

a. If it takes $17.5\,ns$ to process an instruction on computer system A, how many clock cycles are required? How long would it take to execute 25 instructions in sequence?

[4 marks]

b. If computer system B uses the same number of clock cycles per instruction, how long would it take to execute the same set of 25 instructions?

[3 marks]

Computer system C has the same clock speed as computer system A, but processes the same instructions with a 5-segment pipeline.

c. Determine the time taken to process 25 tasks with the pipelined system.

[2 marks]

Question continues on the next page.

d. Why might computer system B still outperform computer system C when executing some programs?

[3 marks]

15. A computer with a single cache (access time 30ns) and main memory (access time 200ns) also uses the hard disk (average access time 0.01ms) for virtual memory pages. If it is found that the cache hit rate is 90% and the page fault rate is 1%

a. calculate the effective (average) access time (EAT) of this system for both sequential and parallel access system, and write down the equations for both parallel and sequential access.

[6 marks]

Parallel:

Sequential:

b. Assume this is a parallel access system, what is the speed-down due to the use of virtual memory, and write down the equation for calculation?

[4 marks]