UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2016

IS51009C
Fundamentals of Computer Science

Duration: 3 hours

Date and time:

This paper is in two parts: part A and part B. You should answer ALL questions from part A and THREE questions from part B. Part A carries 40 marks, and each question from part B carries 20 marks. The marks for each part of a question are indicated at the end of the part in [.] *brackets.*

There are 100 marks available on this paper.

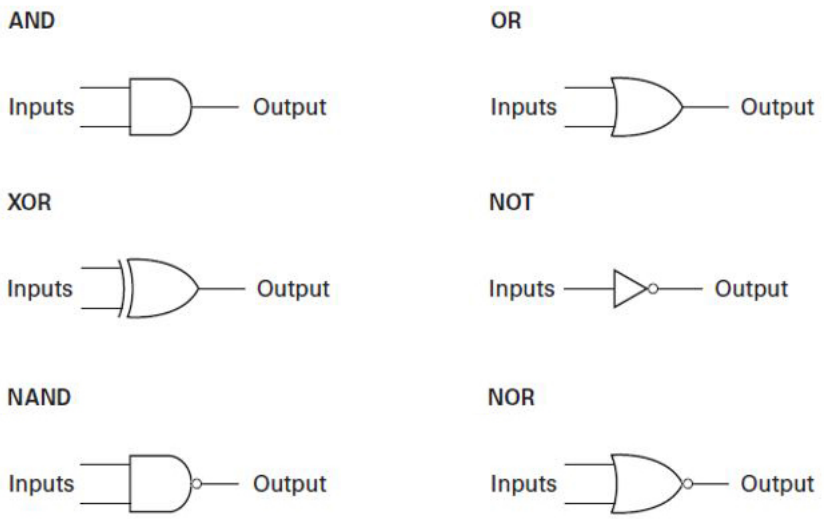
THIS PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM

Part A

Answer all questions.

Question 1

This figure should remind you of the descriptive shapes of the four basic logic gates along with the NAND and NOR gates.



(a) Which of the following applies to virtual memory?

i. Represents the main memory of a virtual reality device.
ii. Utilizes the mass storage to compensate for main memory shortages.
iii. Overclocks the main memory to achieve greater speed.
iv. None of the above.

[4]

(b) The AND gate outputs a 1 only if both inputs are 1. The OR gate outputs 1 if any of the inputs is 1.

i. True
ii. False
iii. True for AND gate, false for OR gate
iv. False for AND gate, true for OR gate

[4]

(c) Which of the following devices is able to connect networks which may have incompatible characteristics?

i. Switch

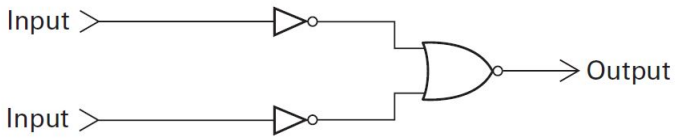
ii. Bridge

iii. Repeater

iv. Router

[4]

(d) What boolean operation is produced by the following circuit?



i. AND

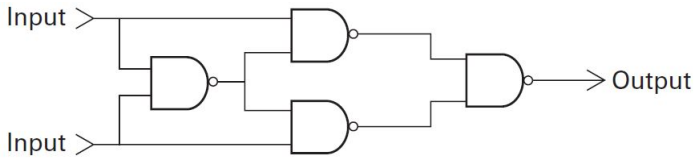
ii. OR

iii. XOR

iv. None of the above

[4]

(e) What is the output of the following circuit when (i) the upper input is 1 and the lower 0, and (ii) when the upper input is 0 and the lower input is 1.



i. (i) 0 (ii) 0

ii. (i) 1 (ii) 0

iii. (i) 0 (ii) 1

iv. (i) 1 (ii) 1

[4]

(f) Say we have N number of bits. How many different bit patterns can we obtain by changing the values of the bits?

i. $2^N - 1$

ii. 2^N

iii. 2^{N-1}

iv. None of the above

[4]

(g) Say we have N number of bits, and we set them all to the value 1. What is the decimal value obtained?

i. $2^N - 1$

ii. 2^N

iii. 2^{N-1}

iv. None of the above

[4]

(h) While executing a program, the CPU goes through the machine cycle which consists of the fetch, decode and execute phases. In which of the following do we increment the program counter?

i. During fetch

ii. During decode

iii. During execute

iv. None of the above.

[4]

(i) Which of the following protocols is used in a STAR network?

i. CSMA/CD (Collision Detection)

ii. CSMA/CA (Collision Avoidance)

iii. Both

iv. None of the above.

[4]

(j) Which of the following is an undecidable problem

i. The halting problem

ii. The Traveling Salesman Problem (TSP)

iii. Both

iv. None of the above

[4]

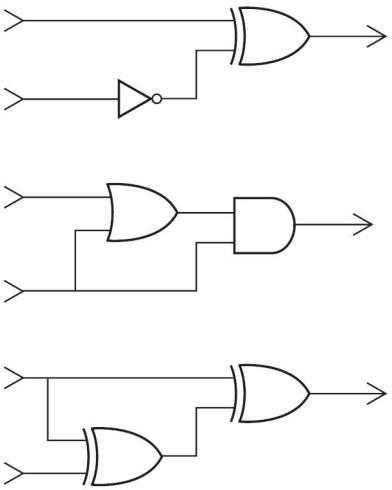
Part B

Question 2 Logic Gates & Flip-flops

(a) Briefly describe the purpose of a flip-flop. [2]

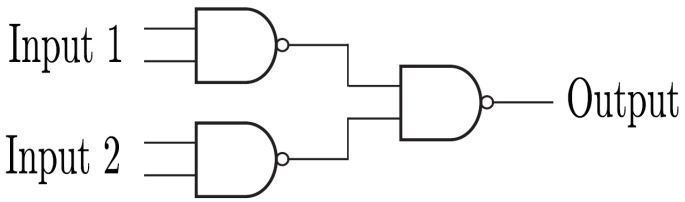
(b) Write the truth table for (i) the AND and (ii) the NAND gate [3]

(c) What is the output of each of the following circuits, assuming that the upper input is 1 and the lower input is 0? (show your work by redrawing the circuits and showing the values propagated)



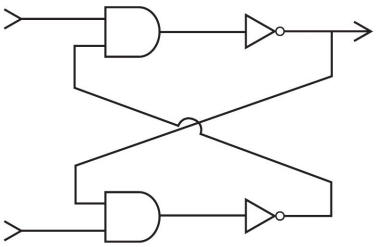
[3]

(d) You are given the circuit below.



(i) Write the truth table corresponding to this circuit. Is it similar to the output of any other logic gate you know of? [3]

(e) You are given the following circuit, with both inputs being 1.



(i) What happens when the upper input temporarily changes to 0 and then back to 1? (give a description in a couple of sentences) [2]

(ii) What happens when the lower input temporarily changes to 0 and then back to 1? (give a description in a couple of sentences) [2]

(iii) Would you say that this circuit is a flip-flop? If so, is triggered by 1s or 0s? [3]

(iv) Can you draw the same circuit using only one type of logic gates? [2]

Question 3 Data Storage

(a) You are given the fractions 100.0101 and 111.011 in binary. What is the decimal value represented? [3]

(b) In order to represent negative values in binary, we use the excess notation and two's complement notations. What is the advantage of: [3]

(i) excess notation over two's complement

(ii) two's complement over excess notation

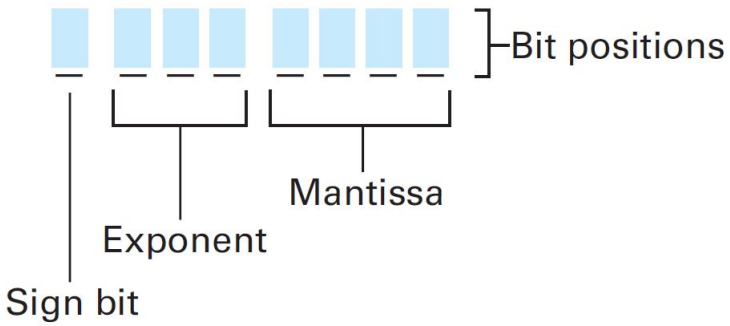
(c) Perform each of the following additions by assuming that the bit patterns are encoded in two's complement notation. Make sure you identify (i) when truncation happens, and (ii) when the result is incorrect due to overflow. You just need to give the result in binary.

(i) 00101+01000 [1]

(ii) 11111+00001 [1]

(iii) 01111+00001 [1]

(d) You are given the following floating point format



under the assumption that the exponent field is encoded in excess notation as follows

Bit pattern	Value represented
111	3
110	2
101	1
100	0
011	-1
010	-2
001	-3
000	-4

Questions:

(i) An excess notation system is called excess-N notation if it is shifted by N values. How many values is the system shown above shifted by? [2]

(ii) Decode the bit patterns 01011001 and 11001000 using the format above. What is the decimal value represented? [3]

(iii) Encode the values $-3\frac{3}{4}$ and $\frac{31}{32}$ using the floating-point format described above, indicating where truncation errors occur. [3]

(iv) What is the best approximation to the value $\frac{1}{10}$ using the floating point format above (also mention the decimal value). Would it be viable to use the system above to measure units in meters, e.g., 110cm? [3]

Question 4 Compression & Communication

(a) Describe the difference between lossless and lossy compression, giving one example for each case. [3]

(b) Briefly describe the following in a sentence or two.

(i) Run-length encoding [1]

(ii) Frequency-dependent encoding [1]

(iii) Dictionary-based encoding [1]

(iv) Relative encoding [1]

(c) What is the Hamming Distance between two strings? Give an example. [2]

(d) A text file contains the following letters and frequency of appearance:

Symbol	Frequency
e	12
o	10
h	2
l	8
a	14

(i) Assuming that the file is encoded in ASCII (8 bits per symbol), how many bytes would be required to simply store the file? [2]

(ii) Construct the Huffman tree for the above symbols, and estimate how many bits are required to store the file under this compression scheme . [4]

(iii) How would we deal with a tie while building a Huffman tree? (e.g., 3 nodes with the same value). If the symbols used were letters of the English alphabet, how could we use our knowledge of the overall frequency of appearance of these letters (say, in newspapers or online) in order to break the tie? [2]

(e) Assume the message `xxy yyx xxy yyx`. Show how this message would be encoded using LZW, starting with a dictionary containing x, y and space along with the final dictionary. Show your work. [3]

Question 5 Theoretical CS & AI

(a) Briefly describe the following terms:

(i) Artificial Neural Network [2]

(ii) Machine Learning [2]

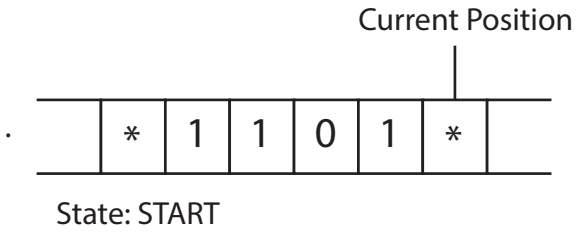
(b) Give a description of the Turing test and its purpose. [3]

(c) Someone gives you a program P and claims that given another program T as input, P will terminate with the variable $X = 1$ if the program T is self-terminating (terminates with itself given as input), and with $X = 0$ if the program is not self-terminating. How would you prove or disprove this claim? [5]

(d) You are given the following Turing machine and tape, that utilizes the symbols $*$, 1 and 0 (with $*$ indicating the beginning and end position of the symbols written on the tape, as seen below).

(i) Apply the machine to the tape, showing your work along with the final tape and position. [6]

(i) Describe the functionality of this Turing machine - what condition does it enforce on the bit-pattern written on the tape? [2]



Current State	Read	Write	Move	Next State
START	$*$	$*$	Left	STATE 1
STATE 1	0	0	Left	STATE 1
STATE 1	1	1	Left	STATE 2
STATE 2	0	0	Left	STATE 2
STATE 2	1	1	Left	STATE 1
STATE 1	$*$	$*$	No Move	HALT
STATE 2	$*$	1	Left	STATE 3
STATE 3	any	$*$	No Move	HALT