CE161-4-AU

UNIVERSITY OF ESSEX

Undergraduate Examinations 2014

DIGITAL SYSTEMS ARCHITECTURE

Time allowed: **TWO** hours

The following items are provided:
Graph paper (available on invigilator's desk)

Candidates are permitted to bring into the examination room:
Hand-held, non programmable calculators (containing no textual information)
NO BINARY, HEXADECIMAL OR OCTAL FUNCTIONS ON CALCULATOR

The paper consists of **FOUR** questions.

Candidates must answer **ALL** questions.

The questions **ARE** of equal weight.

The percentages shown in brackets provide an indication of the proportion of the total marks for the **PAPER** which will be allocated.

Please do not leave your seat unless you are given permission by an invigilator.
Do not communicate in any way with any other candidate in the examination room.
Do not open the question paper until told to do so.
All answers must be written in the answer book(s) provided.
All rough work must be written in the answer book(s) provided. A line should be drawn through any rough work to indicate to the examiner that it is not part of the work to be marked.
At the end of the examination, remain seated until your answer book(s) have been collected and you have been told you may leave.

Candidates must answer ALL questions.

Question 1

Note: Assume that all numbers are big-endian.

(a) Showing all steps involved (final answers without all the work will not be taken into account) convert the decimal number **14.35** to:

i) Binary, using 4 bits for the integer part and 3 bits for the fractional part. [5%]

ii) Hexadecimal, using 1 digit for the integer part and 2 for the fractional part. [3%]

(b) Consider two binary variables in *sign-magnitude* notation: A = 010110 and B = 011011. Showing all steps involved, calculate the following operations in binary format. Assume you only have six bits available for the answers.

i) A + B. [2%]

ii) B – A, using two's complement. [4%]

(c) Calculate the 8-bit two's complement of the 6-bit sign-magnitude number 110110. Show all your work. [3%]

(d) Transistors do not give perfect 0s or 1s. So, explain how transistors are used as the basic logic switches in digital systems. In your answer, include a diagram and an explanation of the term 'forbidden region'. [8%]

Question 2

As a memory aid, various Boolean identities are shown in the last page of this paper.

(a) Consider the Boolean expression $\mathbf{F = A\,B\,C + \overline{A}\,\overline{B}\,\overline{C}}$.

i) Draw the equivalent logic gate circuit diagram. [4%]

ii) Write the truth-table. [4%]

(b) Using Boolean algebra, prove that $\mathbf{X\,Y + \overline{X}\,Z + Y\,Z = X\,Y + \overline{X}\,Z}$. [7%]

(c) An unknown Boolean circuit has the following truth table, where F is the output:

A	B	C	D	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

i) From the truth table, draw the equivalent Karnaugh map with all its labels. [5%]

ii) Using the Karnaugh map you drew, find the simplest *sum of products* Boolean expression that would give the truth table above. Show all your work and explain your reasoning. [5%]

Question 3

(a) Design a Deterministic Finite State Automaton (DFA) according to the following specification: [13%]

- Its alphabet is {0, 1}.
- Its language consists of all words with an odd number of 1s.
- 0s will not be accepted (even if they are part of the alphabet).

(b) Can your design in part (a) be modified to accept the same language as in part (a) with the addition of the empty word? (The empty word is the word with no letters). If it can be modified, describe how. Otherwise, give a reason why it cannot be modified to accept the empty word. [6%]

(c) Draw a von Neumann machine and explain why this invention was significant. [6%]

<u>Question 4</u>

(a) In CDs and DVDs, in order to maximise use of space, data are recorded at the same density at the edge as at the centre of the disc. What consequence(s) does this have for random access? Assume that the disc reader is not modified for data access. [4%]

(b) Give two potential advantages and two disadvantages of using CDs for data storage. [4%]

(c) Explain the process of memory management based on paging. Include an explanation of the term 'logic address'. [7%]

(d) List and briefly describe <u>five</u> essential functions provided by an OS. [10%]

Some Boolean Rules

$A \bullet B = B \bullet A$	$A + B = B + A$
$A \bullet (B + C) = (A \bullet B) + (A \bullet C)$	$A + (B \bullet C) = (A + B) \bullet (A + C)$
$1 \bullet A = A$	$0 + A = A$
$A \bullet \overline{A} = 0$	$A + \overline{A} = 1$
$0 \bullet A = 0$	$1 + A = 1$
$A \bullet A = A$	$A + A = A$
$A \bullet (B \bullet C) = (A \bullet B) \bullet C$	$A + (B + C) = (A + B) + C$
$\overline{A \bullet B} = \overline{A} + \overline{B}$	$\overline{A + B} = \overline{A} \bullet \overline{B}$

$X + X \bullet Y = X$

$X + \overline{X} \bullet Y = X + Y$

$X \bullet Y + \overline{X} \bullet Z + Y \bullet Z = X \bullet Y + \overline{X} \bullet Z$

$X (X + Y) = X$

$X (\overline{X} + Y) = X \bullet Y$

$(X + Y) (X + \overline{Y}) = X$

$(X + Y) (\overline{X} + Z) = X \bullet Z + \overline{X} \bullet Y$

$(X + Y) (\overline{X} + Z) (Y + Z) = (X + Y) (\overline{X} + Z)$

$\overline{X\ Y\ Z} = \overline{X} + \overline{Y} + \overline{Z}$

END OF PAPER CE161-4-AU