B2 Examination
Computer Architecture

Duration: 1 hr 30 min.

Family Name ..... First Name ..... Class.....UID.....

Answer on the worksheet.
Do not show any calculation unless you are explicitly asked.
Do not use a pencil or red ink.

Exercise 1 (4 points)

Simplify the expressions below as much as possible. The result must not contain parentheses.

Non-simplified expression	Most simplified expression (no parentheses)
$(A + \overline{B}.\overline{C}).\overline{A.B}$	
$\overline{A.B + \overline{A}.\overline{B} + \overline{A}.B}$	
$A + B.C + \overline{A}.(\overline{B} + \overline{C}).(A.D + C)$	
$\overline{A}.\overline{B}.\overline{C}.\overline{D} + \overline{A}.\overline{B}.C.\overline{D} + A.\overline{B}.\overline{C}.\overline{D} + A.\overline{B}.C.\overline{D}$	

Exercise 2 (4 points)

1. Write down the minterm canonical form for the following expressions.

Expression	Minterm canonical form
$A + \overline{B}$	
$(A + \overline{C}).(\overline{A} + C + \overline{D}).B.\overline{C}$	

2. Write down the maxterm canonical form for the following expressions.

Expression	Maxterm canonical form
$(A + \overline{B}).(\overline{B} + C)$	
$A + B.\overline{C}$	

Exercise 3 (5 points)

1. Complete the Karnaugh maps below (**circles included**) and give their most simplified expressions. **No points will be given to an expression if its Karnaugh map is wrong.** Do not simplify by using the EXCLUSIVE-OR operator. Let us consider *N*, a 4-bit binary number (*D*, *C*, *B*, *A*). *A* is the least significant bit.
   - *S1* = 1 iff *N* = 2, 3, 6, 7, 10, 11, 12 ou 13
   - *S2* = 1 iff *N* = 0, 4, 6, 8, 12 or 14 and *S* is undefined iff *N* = 3, 5, 7, 10, 13 or 15
   - *S3* = 1 iff *N* = 0, 1, 4, 5, 8, 9, 12 or 13 and *S* is undefined iff *N* = 3, 7, 11 or 15
   - S4 = 1 iff N = 8, 10, 14 or 15 and S is undefined iff N = 0, 1, 2, 3, 4, 5, 6 or 7

BA

S1 / **DC**	**00**	**01**	**11**	**10**
00				
01				
11				
10				

S1 =

BA

S2 / **DC**	**00**	**01**	**11**	**10**
00				
01				
11				
10				

S2 =

BA

S3 / **DC**	**00**	**01**	**11**	**10**
00				
01				
11				
10				

S3 =

BA

S4 / **DC**	**00**	**01**	**11**	**10**
00				
01				
11				
10				

S4 =

2. Simplify *S1* by using the EXCLUSIVE-OR operator.

S1 =

Exercise 4 (4 points)

A tank of 1,000 liters is fitted with three sensors: *C1*, *C2* and *C3*.

- *C1* is placed at the first quarter of the tank (at 250 liters).
- *C2* is placed at the middle of the tank (at 500 liters).
- *C3* is placed at the third quarter of the tank (at 750 liters).

A sensor generates a 1 when there is some liquid in front of it. Otherwise, it generates a 0. The instrument panel has five indicator lights: *L0*, *L1*, *L2*, *L3* and *L4*. Let V be the volume of liquid in the tank.

- *L1* is switched on when: V < 250 liters.
- *L2* is switched on when: 250 liters ≤ V < 500 liters.
- *L3* is switched on when: 500 liters ≤ V < 750 liters.
- *L4* is switched on when: V ≥ 750 liters.
- *L0* is switched on when an error occurs (the indicator lights from *L1* to *L4* are then automatically switched off). For instance, if the tank is full and *C3* is 1 and *C2* is 1 and *C1* is 0, it means that the *C1* sensor has a defect. Therefore, the *L0* indicator light is switched on.

1. Complete the truth table below.
2. Give the most simplified expressions of *L1*, *L2*, *L3* and *L4* (you do not have to use Karnaugh maps).
3. Complete the Karnaugh map for L0 (also draw **circles**) and give its most simplified expression.

C3	C2	C1	L1	L2	L3	L4	L0
0	0	0					
0	0	1					
0	1	0					
0	1	1					
1	0	0					
1	0	1					
1	1	0					
1	1	1					

L1 =	**L3 =**
L2 =	**L4 =**

C2 C1

C3 \ **L0**	**00**	**01**	**11**	**10**
0				
1				

L0 =

Exercise 5 (3 points)

Design the AND, OR and XOR gates by using only NAND gates. The maximum number of gates is given below.

AND (2 gates)	
OR (3 gates)	
XOR (5 gates)	

Feel free to use the blank space below if you need to: