S1 – Key to Examination 2
Computer Architecture

Duration: 1 hr 30 min.

Family name: .... First name: .... Class: ....

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

Exercise 1 (5 points)

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

Non-simplified expression	Most simplified expression (no parentheses)
$\overline{(C + D) + (B + \overline{D})}$	0
$(B + \overline{D}).(\overline{A} + \overline{D}).(A + D).A.B$	$A.B.\overline{D}$
$\overline{A}.\overline{B}.\overline{C}.\overline{D} + \overline{A}.\overline{B}.C.\overline{D} + A.\overline{B}.\overline{C}.\overline{D} + A.\overline{B}.C.\overline{D}$	$\overline{B}.\overline{D}$
$\overline{A.B}.(A.B + C) + A.B.C$	C
$(B + \overline{D} + C.B).\overline{\overline{C}.B}.\overline{C.B}$	$\overline{B}.\overline{D}$

Exercise 2 (4 points)

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

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

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

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

Exercise 3 (6 points)

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.**

3. Let us consider *N*, a 3-bit binary number (*C*, *B*, *A*). *A* is the least significant bit.
   - S1 = 1 when N = 1, 3, 4, 5
   - S2 = 1 when N = 0, 2, 4, 5, 6, 7

BA, C

S1	00	01	11	10
0	0	1	1	0
1	1	1	0	0

BA, C

S2	00	01	11	10
0	1	0	0	1
1	1	1	1	1

S1 = $\overline{C}$.A + C.$\overline{B}$

S2 = $\overline{A}$ + C

4. Let us consider *N*, a 4-bit binary number (*D*, *C*, *B*, *A*). *A* is the least significant bit.
   - S3 = 1 when N = 0, 1, 2, 3, 4, 5, 6, 7, 9, 11, 13, 15
   - S4 = 1 when N = 0, 1, 4, 6, 8, 9, 12, 14
   - S5 = 1 when N = 0, 2, 8, 10 and S5 is undefined when N = 5, 7, 13, 15
   - S6 = 1 when N = 2, 6 and S6 is undefined when N = 0, 1, 4, 5, 8, 9, 12, 13

BA, DC

S3	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	1	1	0
10	0	1	1	0

BA, DC

S4	00	01	11	10
00	1	1	0	0
01	1	0	0	1
11	1	0	0	1
10	1	1	0	0

S3 = $\overline{D}$ + A

S4 = $\overline{C}$.$\overline{B}$ + C.$\overline{A}$

BA, DC

S5	00	01	11	10
00	1	0	0	1
01	0	Φ	Φ	0
11	0	Φ	Φ	0
10	1	0	0	1

BA, DC

S6	00	01	11	10
00	Φ	Φ	0	1
01	Φ	Φ	0	1
11	Φ	Φ	0	0
10	Φ	Φ	0	0

S5 = $\overline{C}$.$\overline{A}$

S6 = $\overline{D}$.$\overline{A}$

Exercise 4 (3 points)

Four managers at a company (A, B, C and D) can have access to a safe. They each have a different key. It has been decided that:

- A can only open the safe if at least one of the B or C managers is present.
- B, C and D can only open it if at least two of the other managers are present.

1. In the truth table below, we consider that:
   - A = 0 means that A is absent (same for B, C and D).
   - A = 1 means that A is present (same for B, C and D).
   - S = 0 means that the safe cannot be opened.
   - S = 1 means that the safe can be opened.

   Complete the truth table.

A	**B**	**C**	**D**	**S**
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

2. Give the most simplified expression for S (the result must be given without parentheses).

S = A.B + A.C + B.C.D

Exercise 5 (2 points)

We want to design a 1-bit comparator with the following inputs and outputs:

- Inputs: two bits to compare (*A* and *B*).
- Outputs: ‘A > B’, ‘A = B’ and ‘A < B’ with:
  - ‘A > B’ = 1 if and only if A > B.
  - ‘A = B’ = 1 if and only if A = B.
  - ‘A < B’ = 1 if and only if A < B.

1. Complete the following truth table.

A	**B**	**‘A > B’**	**‘A = B’**	**‘A < B’**
0	0	0	1	0
0	1	0	0	1
1	0	1	0	0
1	1	0	1	0

2. Give the most simplified expression for the outputs. **If possible, you must use the EXCLUSIF OR operator.**

'A > B' = $\mathbf{A.\overline{B}}$	**'A = B' =** $\mathbf{\overline{A \oplus B}}$	**'A < B' =** $\mathbf{\overline{A}.B}$

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