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)
$(\overline{A} + \overline{B}).(\overline{A} + \overline{C}) + \overline{A}.\overline{B}.C$	$\overline{A} + \overline{B}.\overline{C}$
$\overline{\overline{B}.D} \cdot \overline{A.D} \cdot (A + D).A.B$	$A.B.\overline{D}$
$(A + \overline{B} + C).(A + \overline{C}).(\overline{A} + \overline{B})$	$A.\overline{B} + \overline{B}.\overline{C}$
$\overline{\overline{A}.B} \cdot (A + B) + C.\overline{A.\overline{B}}$	$A + C$
$A + \overline{\overline{B} + \overline{D}} + \overline{A}.\overline{(B \cdot D)}.(A.C + D)$	$A + D$

Exercise 2 (5 points)

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

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

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

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

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.**

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

S1 \ BA	00	01	11	10
C = 0	1	0	1	0
C = 1	0	0	1	1

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

S2 \ BA	00	01	11	10
C = 0	1	Φ	0	1
C = 1	1	Φ	0	1

S2 = $\overline{A}$

2. 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, 4, 5, 6, 7, 9, 11
   - S4 = 1 when N = 0, 1, 2, 3, 4, 6, 8, 9, 10, 11
   - S5 = 1 when N = 0, 2, 4, 5, 6, 8, 12, 13, 14 and S5 is undefined when N = 10, 11, 15
   - S6 = 1 when N = 2, 3, 6, 7, 10, 11, 14, 15 and S6 is undefined when N = 1, 4, 5, 9, 12, 13

S3 \ BA	00	01	11	10
DC = 00	1	1	0	0
DC = 01	1	1	1	1
DC = 11	0	0	0	0
DC = 10	0	1	1	0

S3 = $\overline{D}.C + \overline{D}.\overline{B} + D.\overline{C}.A$

S4 \ BA	00	01	11	10
DC = 00	1	1	1	1
DC = 01	1	0	0	1
DC = 11	0	0	0	0
DC = 10	1	1	1	1

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

S5 \ BA	00	01	11	10
DC = 00	1	0	0	1
DC = 01	1	1	0	1
DC = 11	1	1	Φ	1
DC = 10	1	0	Φ	Φ

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

S6 \ BA	00	01	11	10
DC = 00	0	Φ	1	1
DC = 01	Φ	Φ	1	1
DC = 11	Φ	Φ	1	1
DC = 10	0	Φ	1	1

S6 = B

Exercise 4 (4 points)

Let us consider two tanks: *R1* and *R2*. The liquid level of each tank is checked by two sensors: a high-level sensor (*A* for *R1*, *B* for *R2*) and a low-level sensor (*C* for *R1*, *D* for *R2*). The values of *A*, *B*, *C*, *D* are 1s when there is some liquid in front of the sensor; otherwise they are 0s. Three indicator lights (*V1*, *V2*, *V3*) are set according to the following conditions:

- *V1* = 1, if *R1* and *R2* are full.
- *V2* = 1, if *R1* and *R2* are empty.
- *V3* = 1, in any other cases.

1. Complete the truth table below. *A*, *B*, *C*, and *D* are the inputs. *V1*, *V2*, and *V3* are the outputs. If some cases are not possible for the outputs, use the symbol "Φ" (phi) which means 0 or 1.

A	B	C	D	V1	V2	V3	
0	0	0	0	0	1	0	
0	0	0	1	0	0	1	
0	0	1	0	0	0	1	
0	0	1	1	0	0	1	
0	1	0	0	Φ	Φ	Φ	← Impossible
0	1	0	1	0	0	1	
0	1	1	0	Φ	Φ	Φ	← Impossible
0	1	1	1	0	0	1	
1	0	0	0	Φ	Φ	Φ	← Impossible
1	0	0	1	Φ	Φ	Φ	← Impossible
1	0	1	0	0	0	1	
1	0	1	1	0	0	1	
1	1	0	0	Φ	Φ	Φ	← Impossible
1	1	0	1	Φ	Φ	Φ	← Impossible
1	1	1	0	Φ	Φ	Φ	← Impossible
1	1	1	1	1	0	0	

2. Complete the Karnaugh maps below (**circles included**) and give the most simplified expressions for *V1*, *V2* and *V3*. **No points will be given to an expression if its Karnaugh map is wrong.**

V1 (AB \ CD)	00	01	11	10
00	0	0	0	0
01	Φ	0	0	Φ
11	Φ	Φ	1	Φ
10	Φ	Φ	0	0

V1 = A.B

V2 (AB \ CD)	00	01	11	10
00	1	0	0	0
01	Φ	0	0	Φ
11	Φ	Φ	0	Φ
10	Φ	Φ	0	0

V2 = $\overline{C}.\overline{D}$

V3 (AB \ CD)	00	01	11	10
00	0	1	1	1
01	Φ	1	1	Φ
11	Φ	Φ	0	Φ
10	Φ	Φ	1	1

V3 = $\overline{A}.D + \overline{B}.C$

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