ENGR 101
Engineering Technology

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Victoria University of Wellington

Victoria
UNIVERSITY OF WELLINGTON
Te Whare Wānanga
o te Ūpoko o te Ika a Māui
CAPITAL CITY UNIVERSITY

Week 8 Lecture 13a

- Test 1 Revision
- Assignment 2 – submit before midnight Monday
- Course web page:

  https://ecs.wgtn.ac.nz/Courses/XMUT101_2021T1/

- kerese@ecs.vuw.ac.nz

Topics covered

1. Number systems
2. Number system conversions
3. Logic gates
4. Simplifying Boolean expressions
    1. Boolean Laws
    2. Karnaugh Maps
5. Logic circuits
6. Combinational logic

Student's Name: ..... ID number: .....

ENGR101

ENGINEERING TECHNOLOGY

Practice Test (April, 2021)

Time allowed: 70 MINUTES

CLOSED BOOK
You will be supplied with additional printed resources that you may use.
(Appendix section on pages 10-11)

Permitted materials: Non-programmable calculators are allowed.

Only printed dictionaries are allowed.

Printed foreign to English language dictionaries are allowed.

Instructions: There are 5 questions. Attempt ALL questions.

Space for working out your solutions is provided at the end of every question.

Question	Topic	Allocated Marks	Obtained Marks	Comments
1	Number systems	12		
2	Boolean Algebra	8		
3	Logic circuit	8		
4	Karnaugh Map	8		
5	Logic circuit application	14		
	TOTAL	**50**		

ID Number: .....

Question 1 – Number systems **12 marks**

a) Convert the decimal number 853 to binary number (2 marks).

853_{10} | | | | | | | | | | | |

Show your calculations in the space below. Write your answer in the grid shown above, starting from the right-hand side box. Refer to part b) below.

b) Convert the binary number 0100 1010 1001 to decimal number (2 marks).

0	1	0	0	1	0	1	0	1	0	0	1	____

Show your calculations in the space below. Write your answer in the space provided above.

c) Convert the decimal number 123 to a hexadecimal number (2 marks).

123_{10} | | | | |

Show your calculations in the space below. Write your answer in the grid shown above starting from the right-hand side box.

ID Number: .....

Question 1 – Number systems **12 marks**

a) Convert the decimal number 853 to binary number (2 marks).

853_{10} | | | | | | | | | | | |

Show your calculations in the space below. Write your answer in the grid shown above, starting from the right-hand side box. Refer to part b) below.

853/2 = 426 R 1 → R means Remainder
426/2 = 213 R 0
213/2 = 106 R 1
106/2 = 53 R 0
53/2 = 26 R 1
26/2 = 13 R 0
13/2 = 6 R 1
6/2 = 3 R 0
3/2 = 1 R 1
1/2 = 0 R 1 → 10 1010 1011

b) Convert the binary number 0100 1010 1001 to decimal number (2 marks).

0	1	0	0		1	0	1	0		1	0	0	1		_____

Show your calculations in the space below. Write your answer in the space provided above.

c) Convert the decimal number 123 to a hexadecimal number (2 marks).

123_{10} | | | | |

Show your calculations in the space below. Write your answer in the grid shown above starting from the right-hand side box.

ID Number: .....

Question 1 – Number systems **12 marks**

a) Convert the decimal number 853 to binary number (2 marks).

853_{10} | | | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 |

Show your calculations in the space below. Write your answer in the grid shown above, starting from the right-hand side box. Refer to part b) below.

853/2 = 426 R 1 → R means Remainder
426/2 = 213 R 0
213/2 = 106 R 1
106/2 = 53 R 0
53/2 = 26 R 1
26/2 = 13 R 0
13/2 = 6 R 1
6/2 = 3 R 0
3/2 = 1 R 1
1/2 = 0 R 1 → 10 1010 1011

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0	1	0	0	1	0	1	0	1	0	0	1	____

Show your calculations in the space below. Write your answer in the space provided above.

c) Convert the decimal number 123 to a hexadecimal number (2 marks).

123_{10} | | | | |

Show your calculations in the space below. Write your answer in the grid shown above starting from the right-hand side box.

RHS of the binary number

b) Convert the binary number 0100 1010 1001 to decimal number (2 marks).

Show your calculations in the space below. Write your answer in the space provided above.

2^{10} 2^{7} 2^{5} 2^{3} 2^{0}

$(1 \times 2^{10}) + (1 \times 2^{7}) + (1 \times 2^{5}) + (1 \times 2^{3}) + (1 \times 2^{0})$

$= (1 \times 1024) + (1 \times 128) + (1 \times 32) + (1 \times 8) + (1 \times 1)$

$= 1193$

c) Convert the decimal number 123 to a hexadecimal number (2 marks).

123_{10}

Show your calculations in the space below. Write your answer in the grid shown above starting from the right-hand side box.

RHS of the binary number

b) Convert the binary number 0100 1010 1001 to decimal number (2 marks).

0	1	0	0		1	0	1	0		1	0	0	1
10	9	8			7	6	5	4		3	2	1	0

1193

Show your calculations in the space below. Write your answer in the space provided above.

2^{10} 2^{7} 2^{5} 2^{3} 2^{0}

$(1 \times 2^{10}) + (1 \times 2^{7}) + (1 \times 2^{5}) + (1 \times 2^{3}) + (1 \times 2^{0})$

$= (1 \times 1024) + (1 \times 128) + (1 \times 32) + (1 \times 8) + (1 \times 1)$

$= 1193$

c) Convert the decimal number 123 to a hexadecimal number (2 marks).

123_{10}

Show your calculations in the space below. Write your answer in the grid shown above starting from the right-hand side box.

c) Convert the decimal number 123 to a hexadecimal number (2 marks).

123_{10}

		7	B

Show your calculations in the space below. Write your answer in the grid shown above starting from the right-hand side box.

123/16 = 7 Remainder 11
7/16 = 0 Remainder 7 → 7 11 → 7 B

ID Number: .....

d) Convert the following hexadecimal number to a decimal number (2 marks).

ACE_{16} _____

Show your calculations in the space below. Write your answer in the space provided above.

A C E

16^2 16^1 16^0

$(10 \times 16^2) + (12 \times 16^1) + (14 \times 16^0)$

$= (10 \times 256) + (12 \times 16) + (14 \times 1)$

$= 2560 + 192 + 14 =$ **2766**

ID Number: .....

d) Convert the following hexadecimal number to a decimal number (2 marks).

ACE_{16} ____ **2 7 6 6**

Show your calculations in the space below. Write your answer in the space provided above.

A C E

16^2 16^1 16^0

$(10 \times 16^2) + (12 \times 16^1) + (14 \times 16^0)$

$= (10 \times 256) + (12 \times 16) + (14 \times 1)$

$= 2560 + 192 + 14 =$ **2766**

e) Convert the following decimal number to an octal number (2 marks).

1193_{10} _____

Show your calculations in the space below. Write your answer in the space provided above.

To answer this question, you need to convert the decimal number to binary first.

The binary equivalent for 1193 is given in part b) above which is

100 1010 1001

The next thing to do is to write the binary number in 3-bit blocks

010 010 101 001

Now we write each 3-bit block in octal format.

Beginning from LHS we have: 2 2 5 1

e) Convert the following decimal number to an octal number (2 marks).

1193_{10} **2 2 5 1**

Show your calculations in the space below. Write your answer in the space provided above.

To answer this question, you need to convert the decimal number to binary first.

The binary equivalent for 1193 is given in part b) above which is

100 1010 1001

The next thing to do is to write the binary number in 3-bit blocks

010 010 101 001

Now we write each 3-bit block in octal format.

Beginning from LHS we have: 2 2 5 1

f) Convert the following octal number to a decimal number (2 marks).

263_8 _____

Show your calculations in the space below. Write your answer in the space provided above.

2 6 3

8^2 8^1 8^0

$(2 \times 8^2) + (6 \times 8^1) + (3 \times 8^0)$

$= (2 \times 64) + (6 \times 8) + (3 \times 1)$

$= 128 + 48 + 3 =$ **179**

f) Convert the following octal number to a decimal number (2 marks).

263_8 **1 7 9 $_{10}$**

Show your calculations in the space below. Write your answer in the space provided above.

2 6 3

8^2 8^1 8^0

$(2 \times 8^2) + (6 \times 8^1) + (3 \times 8^0)$

$= (2 \times 64) + (6 \times 8) + (3 \times 1)$

$= 128 + 48 + 3 =$ **179_{10}**

ID Number: .....

Question 2 – Simplifying Boolean Algebra **8 marks**

Use Boolean algebra to minimize the given expression. (see Appendix on page 10)

a) $\overline{A}\,B\,\overline{C} + A\,B\,\overline{C}$ (4 marks)

Fundamental Laws and Theorems of Boolean Algebra

1.	$X + 0 = X$	OR operations
2.	$X + 1 = 1$	
3.	$X + X = X$	
4.	$X + \overline{X} = 1$	
5.	$X \cdot 0 = 0$	AND operations
6.	$X \cdot 1 = X$	
7.	$X \cdot X = X$	
8.	$X \cdot \overline{X} = 0$	
9.	$\overline{\overline{X}} = X$	Double complement
10.	$X + Y = Y + X$	Commutative laws
11.	$XY = YX$	
12.	$(X + Y) + Z = X + (Y + Z)$	Associative laws
13.	$(X \cdot Y) \cdot Z = X \cdot (Y \cdot Z)$	
14.	$X(Y + Z) = XY + XZ$	Distribution Law
15.	$X + Y \cdot Z = (X + Y) \cdot (X + Z)$	Dual of Distributive Law
16.	$X + XZ = X$	Laws of absorption
17.	$X(X + Z) = X$	
18.	$X + \overline{X}Y = X + Y$	Identity Theorems
19.	$X(\overline{X} + Y) = XY$	
20.	$\overline{X + Y} = \overline{X} \cdot \overline{Y}$	De Morgan's Theorems
21.	$\overline{XY} = \overline{X} + \overline{Y}$	

Boolean Algebra Laws

	Name of Law	Properties
1.	Identity Law	A+0=A; A+1=1; A.0=0; A.1=A
2.	Commutative Law	A.B = B.A; A+B = B+A
3.	Associative Law	A.(B.C) = A.B.C; A+(B+C) = A+B+C
4.	Idempotent Law	A.A = A; A+A = A
5.	Double Negative Law	A'' = A
6.	Complement Law	A.A' = 0; A+A' = 1
7.	Law of Union	A+1 = A; A+0 = A
8.	DeMorgan's Theorem	(AB)' = A'+B'; (A+B)' = A'.B'
9.	Distributive Law	A.(B+C) = (A.B) + (A.C); A+(BC) = (A+B).(A+C)
10.	Absorption Law	A.(A+B) = A; A+(A.B) = A
11.	Common Identities Law	A.(A'+B) = AB; A+(A'B) = A+B

ID Number: .....

Question 2 – Simplifying Boolean Algebra **8 marks**

Use Boolean algebra to minimize the given expression. (see Appendix on page 10)

a) $\overline{A}\,B\,\overline{C} + A\,B\,\overline{C}$ (4 marks)

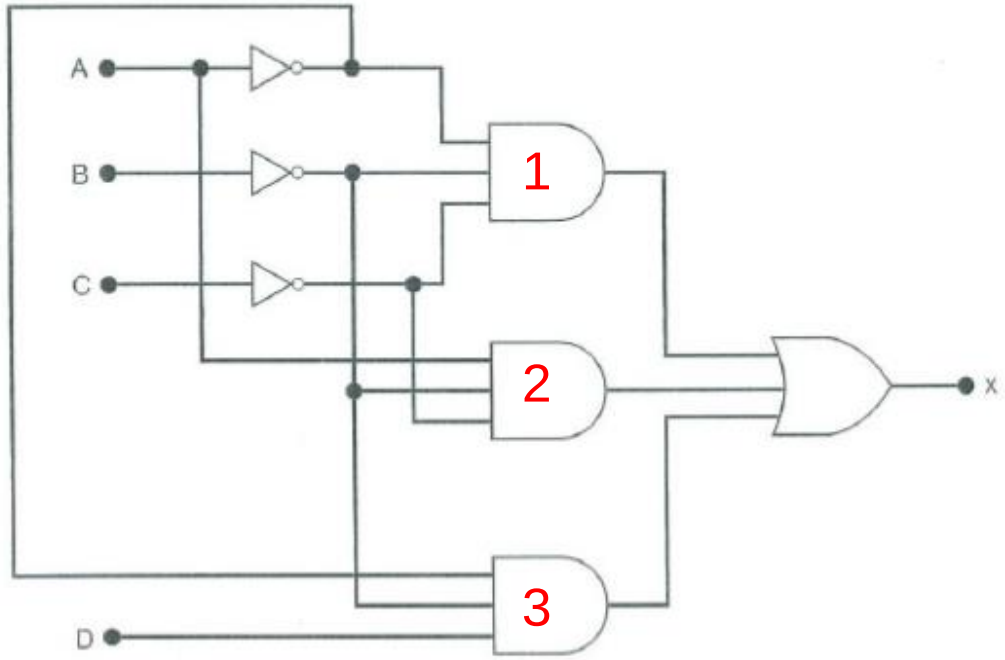
A'BC' + ABC' = (A + A')BC'	Distributive Law
= (1)BC'	Complement Law
= BC'	

b) $(X + Y)(\overline{X} + Y)(\overline{X} + Z)$ (4 marks)

$(X + Y)(X' + Y)(X' + Z)$	
$= (XX' + XY + X'Y + YY)(X' + Z)$	Distributive Law
$= (0 + Y(X + X') + Y)(X' + Z)$	Complement, Idempotent
$= (Y(1) + Y)(X' + Z)$	Complement
$= (Y + Y)(X' + Z)$	Idempotent
$= Y(X' + Z)$	
$= X'Y + YZ$	

Question 3 – Electronic Circuits **8 marks**

a) Write the Boolean expression for the following logic circuit shown below. (see Appendix on page 11 for symbols) (4 marks)



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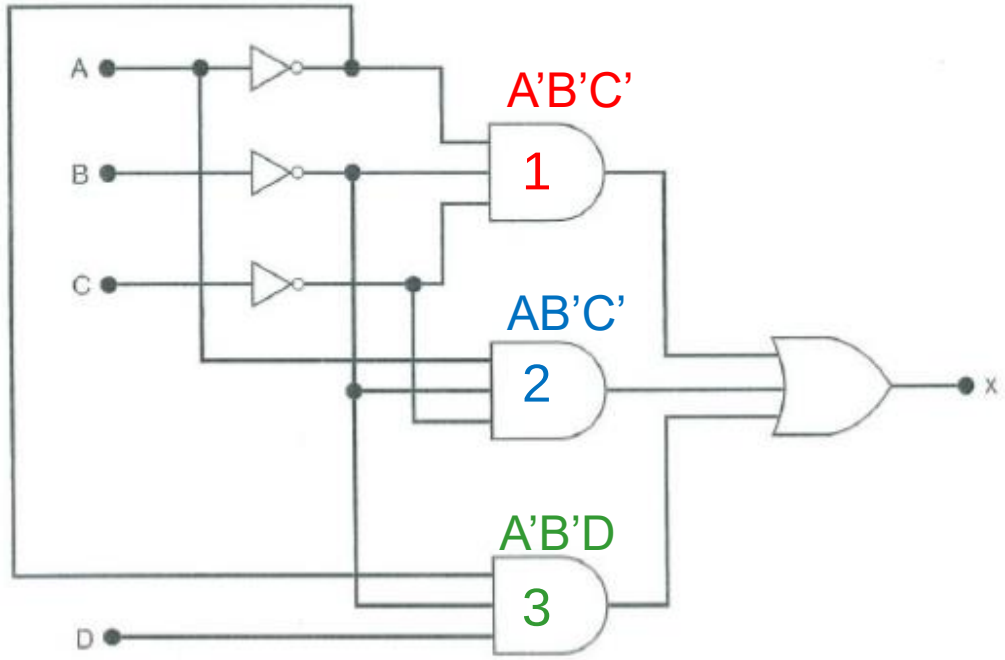
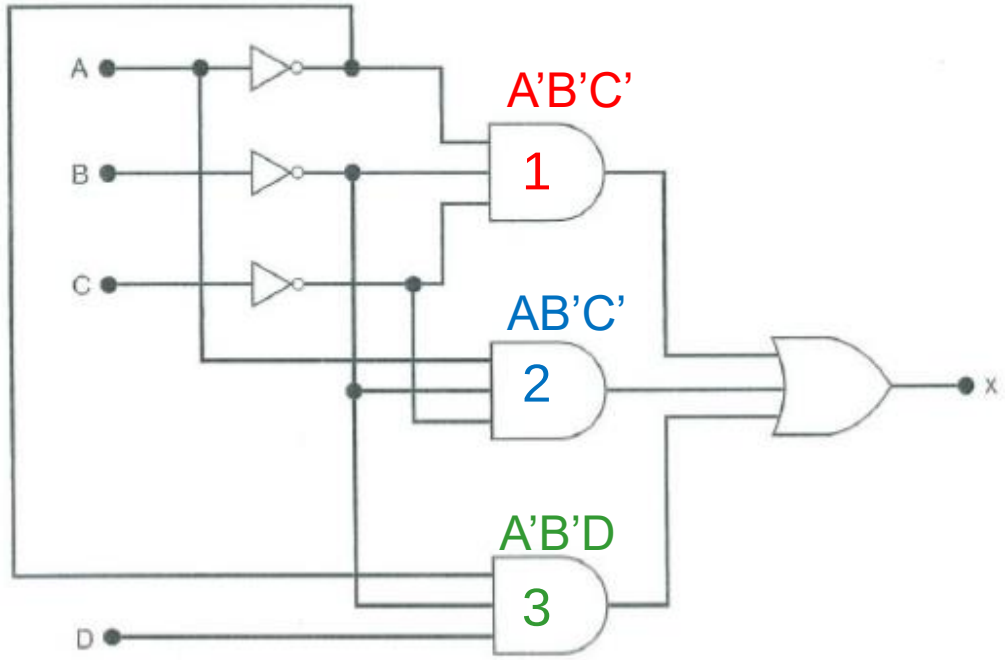


A'B'C'
+ AB'C'
+ A'B'D

Question 3 – Electronic Circuits **8 marks**

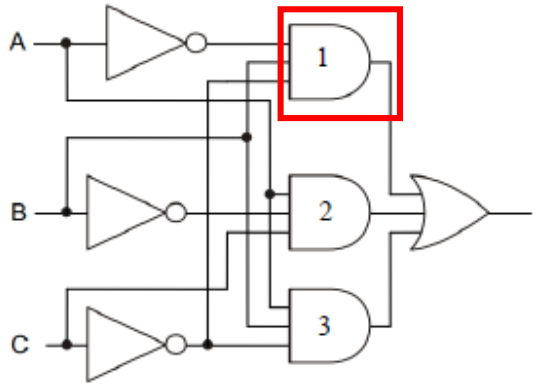
a) Write the Boolean expression for the following logic circuit shown below. (see Appendix on page 11 for symbols) (4 marks)

$x = A'B'C' + AB'C' + A'B'D$



A'B'C' +
AB'C' +
A'B'D

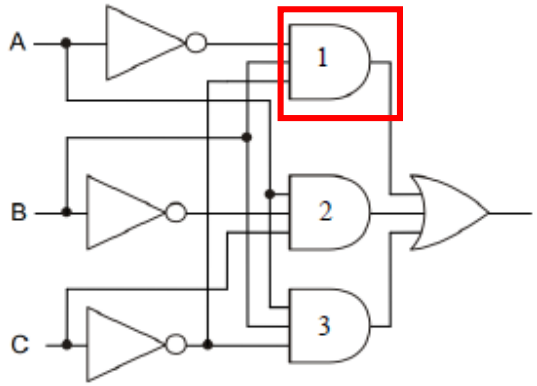
b) Show the behaviour of each AND gates (labelled 1, 2 and 3) and the OR gate in the circuit with a truth table: (4 marks)



A'BC'

	A	B	C	AND 1	AND 2	AND 3	OR
1st row →	0	0	0	0			
2nd row →	0	0	1	0			
3rd row →	0	1	0	1			
4th row →	0	1	1	0			
5th row →	1	0	0	0			
6th row →	1	0	1	0			
7th row →	1	1	0	0			
8th row →	1	1	1	0			

b) Show the behaviour of each AND gates (labelled 1, 2 and 3) and the OR gate in the circuit with a truth table: (4 marks)



				A'BC'	AB'C	ABC'	
	A	B	C	AND 1	AND 2	AND 3	OR
1st row →	0	0	0	0	0	0	0
2nd row →	0	0	1	0	0	0	0
3rd row →	0	1	0	1	0	1	1
4th row →	0	1	1	0	0	0	0
5th row →	1	0	0	0	0	0	0
6th row →	1	0	1	0	1	0	1
7th row →	1	1	0	0	0	1	1
8th row →	1	1	1	0	0	0	0

Question 4 – Karnaugh Map **8 marks**

a) Use K-Map to minimize the following Boolean expression:

$$F = \overline{A}\,\overline{B} + B\,\overline{C} + AC + AB + BC$$

Use the table below to write your answer. Clearly mark the group of adjacent 1s.

	$\overline{C}$	C
$\overline{A}\,\overline{B}$	1	1
$\overline{A}B$		
AB		
$A\overline{B}$		

Simplified Boolean expression:

Question 4 – Karnaugh Map **8 marks**

a) Use K-Map to minimize the following Boolean expression:

$$F = \overline{A}\,\overline{B} + \overline{B}\,\overline{C} + AC + AB + BC$$

Use the table below to write your answer. Clearly mark the group of adjacent 1s.

	$\overline{C}$	C
$\overline{A}\overline{B}$	11	1
$\overline{A}B$		1
AB	1	111
$A\overline{B}$	1	1

Simplified Boolean expression:

Question 4 – Karnaugh Map **8 marks**

a) Use K-Map to minimize the following Boolean expression:

$$F = \overline{A}\,\overline{B} + \overline{B}\,\overline{C} + AC + AB + BC$$

Use the table below to write your answer. Clearly mark the group of adjacent 1s.

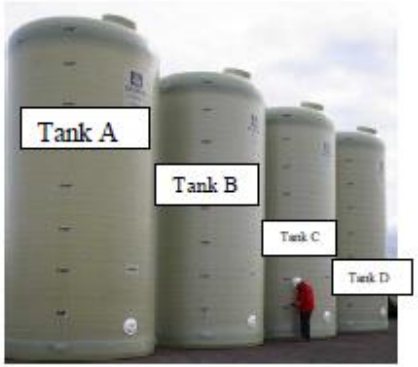
	$\overline{C}$	C
$\overline{A}\overline{B}$	11	1
$\overline{A}B$		1
AB	1	111
$A\overline{B}$	1	1

Simplified Boolean expression:

$$F = A + B' + C$$

Question 5 – Application **14 marks**

- A factory has four tanks of chemicals: A, B, C and D.
- Tanks A and B have pressure sensors to indicate whether the pressure in the tank is HIGH (1) or LOW (0).
- Tanks C and D have temperature sensors to indicate whether the temperature in the tank is HOT (1) or COLD (0).



Design a logic circuit to detect when both tank A and B are HIGH and either tank C or D is COLD.

a) Complete the following truth table to show the inputs and output for the circuit. (4 marks)

A	B	C	D	Output
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

Question 5 – Application **14 marks**

- A factory has four tanks of chemicals: A, B, C and D.
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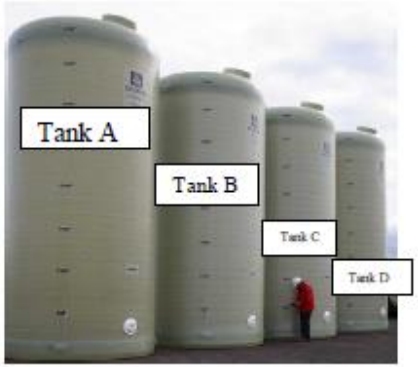


Design a logic circuit to detect when both tank A and B are HIGH and either tank C or D is COLD.

a) Complete the following truth table to show the inputs and output for the circuit. (4 marks)

A	B	C	D	Output
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	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	0

b) Write the SOP expression for the output. (2 marks)

Output = ABC'D' + ABC'D + ABCD'

c) Minimize the SOP expression by complete the K-Map shown below. (6 marks)

	C'D'	C'D	CD	CD'
A'B'				
A'B				
AB				
AB'				

d) Sketch the circuit (2 marks)

b) Write the SOP expression for the output. (2 marks)

Output = ABC'D' + ABC'D + ABCD'

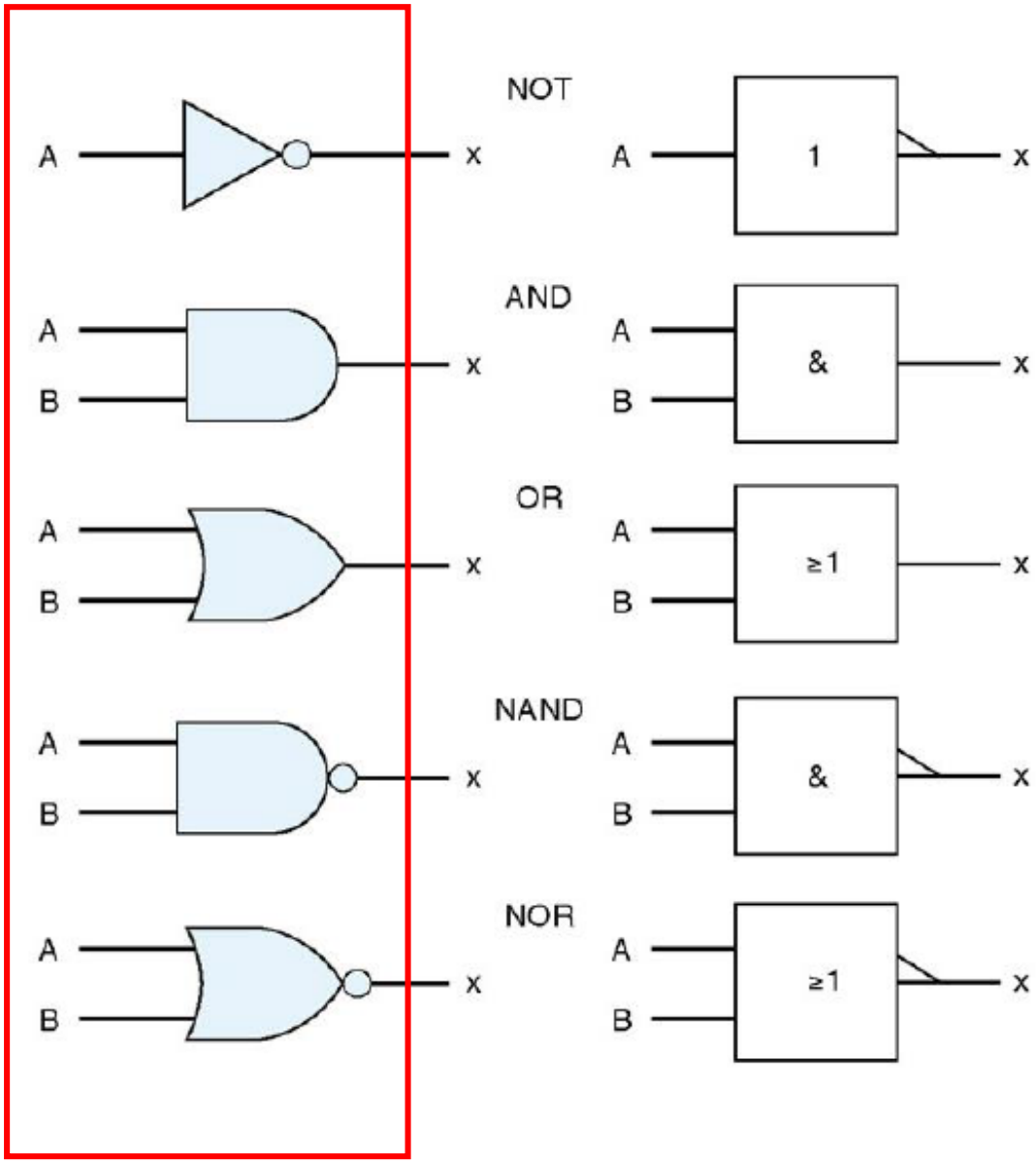
c) Minimize the SOP expression by complete the K-Map shown below. (6 marks)

	C'D'	C'D	CD	CD'
A'B'				
A'B				
AB	1	1		1
AB'				

Minimized expression is ABC' + ABD'

d) Sketch the circuit (2 marks)

Standard Logic Symbols



b) Write the SOP expression for the output. (2 marks)

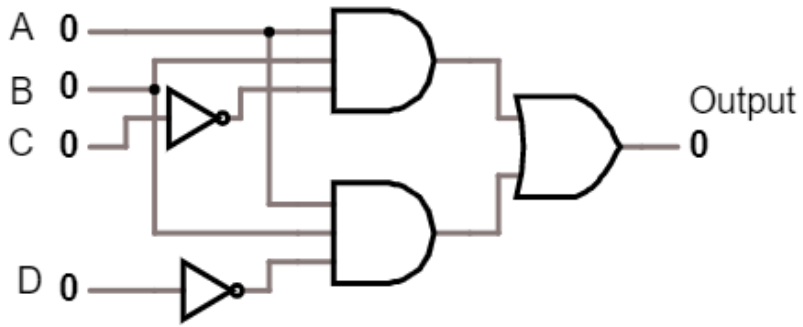
Output = ABC'D' + ABC'D + ABCD'

c) Minimize the SOP expression by complete the K-Map shown below. (6 marks)

	C'D'	C'D	CD	CD'
A'B'				
A'B				
AB	1	1		1
AB'				

Minimized expression is ABC' + ABD'

d) Sketch the circuit (2 marks)



Week 8 Lecture 13a

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