ENGR101

ENGINEERING TECHNOLOGY

Practice Exam (June 12, 2024)

Time allowed: 120 MINUTES

CLOSED BOOK
You will be supplied with additional printed resources that you may use.
(Appendix section on pages 11-12)

Permitted materials: Non-programmable calculators are allowed.

Only printed dictionaries are allowed.

Printed foreign to English language dictionaries are allowed.

Instructions: There are 4 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	25		
2	Boolean Algebra and K-Maps	25		
3	Logic Circuit Application	25		
4	Logic Circuit Application	25		
	TOTAL	**100**		

This blank space can be used to write your answers in case there is insufficient space in the allocated space after each question.

ID Number: ……..…

Question 1 – Number systems **25 marks**

a) Convert the binary number 0 0 1 0 1 0 1 0 to its decimal number equivalent. (3 marks)

0	0	1	0	1	0	1	0

Answer : _____

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

b) Convert the decimal number 170 to its hexadecimal number equivalent. (2 marks)

$(170)_{10}$ | | | | |

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 following octal number to a decimal number. (2 marks)

123_8 _____

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

d) Complete the following **binary** number **subtraction**: (4 marks)

1 0 0 1 0 1 1 - 1 1 0 1 0 1

e) Convert the decimal number $(-12)_{10}$ to 6-bit binary representation using (9 marks)

i. signed magnitude

ii. one's complement

iii. two's complement

f) Represent $(0.45)_{10}$ in binary. Stop after 4 decimal places and find the % rounding error. (5 marks)

ID Number: ……..…

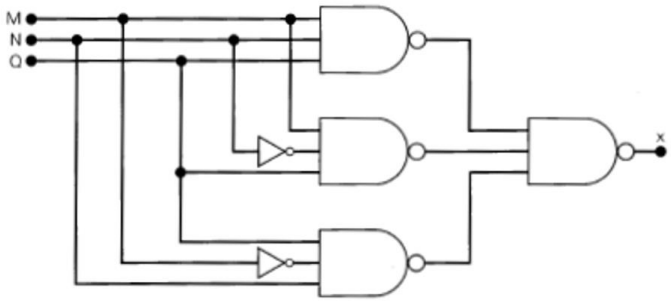
Question 2 – Boolean Algebra and K-Maps **25 marks**
(Refer to Appendix for Boolean Laws summary)

a) Use Boolean algebra to simplify (5 marks)

$$X = AB + A(\bar{B} + C) + AB\bar{C}$$

b) Repeat a) but this time using a K-map. (5 marks)

c) Write the expression for the output x and simplify it using Boolean Algebra (5 marks)



d) Simplify the following K-map and *write the resulting Boolean expression*. (5 marks)

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	**1**	**0**	**1**	**1**
$\bar{A}B$	**0**	**0**	**0**	**1**
AB	**1**	**0**	**1**	**1**
$A\bar{B}$	**1**	**0**	**0**	**1**

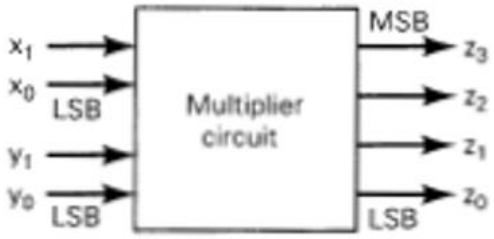
e) Simplify the following K-map and write the resulting Boolean expression. (5 marks)

	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	**1**	**0**	**1**	**1**
$\bar{A}B$	**1**	**0**	**x**	**0**
AB	**0**	**1**	**x**	**x**
$A\bar{B}$	**0**	**x**	**1**	**1**

ID Number: ……..…

Question 3 – Logic Circuit Applications **(25 marks)**

Figure below shows a multiplier circuit that takes *two 2-bit binary numbers* x_1x_0 and y_1y_0, and produces an output binary number $z_3z_2z_1z_0$ that is equal to the **product of the input numbers**..



a) Produce a truth table for outputs z_3, z_2, z_1 and z_0. (10 marks)

x_1	x_0	y_1	y_0	z_3	z_2	z_1	z_0

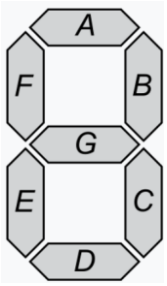
b) Write the SOP expressions for the outputs z_3, z_2, z_1 and z_0. (5 marks)

c) If needed, simplify the expressions for z_3, z_2, z_1, z_0. You don't have to use K-maps. (10 marks)

ID Number: ……..…

Question 4 – Logic Circuit Applications **25 marks**

We want to design a logic circuit for a 7-segment LED display shown below.



The inputs are 4 binary digits **d**, **c**, **b**, **a**, which represent the number to be displayed on the LED. Bit **d** is the most significant bit (MSB), and **a** is the least significant bit (LSB). Each LED segment (labelled A, B, C, … G on the diagram) has its own logic. For example, LED E is ON when **dcba** represent decimal numbers 0, 2, 6 or 8.

d) Produce a truth table to drive LED labelled **C.** (6 marks)

d	**c**	**b**	**a**	**C**

e) Write the sum-of-products (SOP) expression for C (4 marks)

f) Use a K-map to simplify the logic expression for C. (8 marks)

(Write your answer in the table provided below. Clearly mark the loop(s) of adjacent 1s.

C =

g) Draw a logic diagram for G using as **few gates as possible**. (7 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.	$\overline{XY} = \overline{X} + \overline{Y}$	

Standard Logic Symbols

Used in lectures

Used in text book