UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2016/2017

TITLE OF PAPER: DIGITAL ELECTRONICS

COURSE NUMBER: P411

TIME ALLOWED: THREE HOURS

INSTRUCTIONS: ANSWER ANY FOUR OUT OF FIVE QUESTIONS.

EACH QUESTION CARRIES 25 MARKS.

MARKS FOR DIFFERENT SECTIONS ARE SHOWN ENCLOSED IN SQUARE BRACKETS.

A SHEET OF SELECTED FORMULAE IS ATTACHED

THIS PAPER HAS SEVEN (7) PAGES INCLUDING THE COVER PAGE

THE LAST PAGE CONTAINS DATA THAT MAY BE USEFUL IN SOME QUESTIONS

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE CHIEF INVIGILATOR

QUESTION 1

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a) Determine the decimal equivalent of the octal number 137.21_8 and the hexadecimal number $1E0.2A_{16}$ [4]

b) Find the binary equivalent of 374.26_8 and $3F2_{16}$ [4]

c) Evaluate the following;

(i) $101_2 + 1110_2$ [3]

(ii) $25_{16} - C_{16}$ [3]

d) Convert -23_{10} to its eight-bit 2's complement representation [5]

e) Find the gray code equivalent of the decimal 13 [3]

and the decimal equivalent of gray code 1111 [3]

QUESTION 2 133

a) Give brief statements that would help one remember the truth table of AND, NAND, OR, NOR and EX-OR logic gate functions, irrespective of the number of inputs used. [5]

b) Explain why NAND gates are considered universal gates. [2]

c) Refer to the logic arrangement of Figure 2.1. Write the logic expression for the output Y. [6]

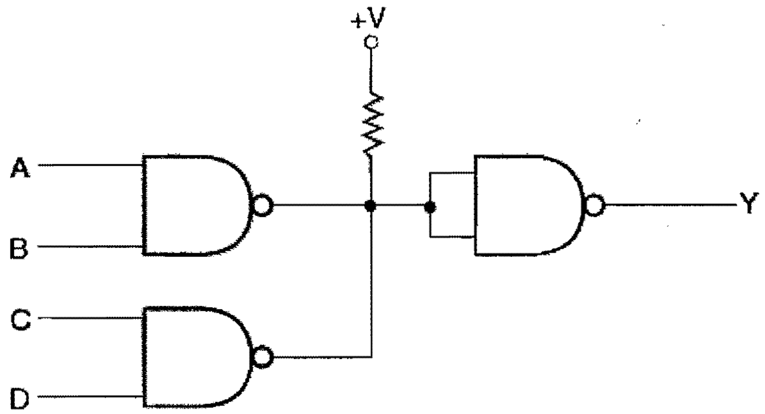

Figure 2.1

d) Simplify the following Boolean expressions using Boolean algebra:

i) $F = ABC + AB\bar{C} + A\bar{B}C + \bar{A}BC + A\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}$ [4]

ii) $F = (\bar{A} + B + \bar{C})(\bar{A} + B + C)(C + D)(C + D + E)$ [4]

e) Give the maxterm Boolean function expressed by

$$F(A, B, C) = \prod M(0,3,7)$$ [4]

QUESTION 3

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a) Derive the simplified minterm Boolean expression for the Karnaugh Map in Figure 3.1 below. [6]

F =

CD \ AB	00	01	11	10
00	1	1	1	1
01	0	0	0	0
11	0	1	1	0
10	1	1	1	1

Figure 3.1

b) Using the Karnaugh Map, find a minimum sum-of-products expression for the following logic function

$$F(W,X,Y,Z) = \Sigma\, \mathrm{m}(0,1,3,5,14) + \mathrm{d}(8,15)$$ [6]

c) The logic diagram of Figure 3.2 performs the function of a very common arithmetic building block. Identify the logic function circuit and give the respective Boolean expressions [7]

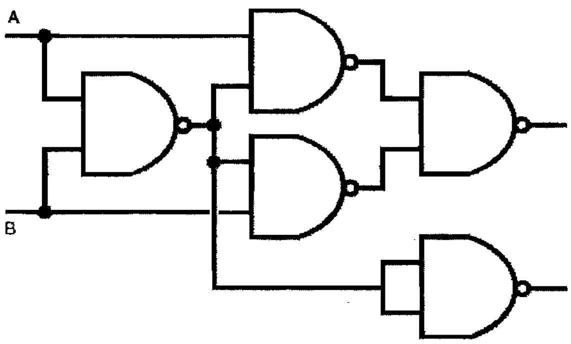


Figure 3.2

d) An arithmetic module compares the magnitude of two 3-bit unsigned numbers $A_2A_1A_0$ and $B_2B_1B_0$. It produces a logic '1'on outputs X, Y and Z if A<B, A=B and B<A respectively. Derive the Boolean expressions for X, Y and Z [6]

QUESTION 4

(a) A combinational circuit is defined by $F = \sum m(0,2,4,6,7)$.
Implement the Boolean function F with a suitable decoder and an external OR/NOR gate having the minimum number of inputs. [5]

(b) (i) Find the input for a rising-edge-triggered D flip-flop that would produce the output Q as shown in Figure 4. Fill in the timing diagram. [5]
(ii) Repeat for a rising-edge-triggered T flip-flop. [5]

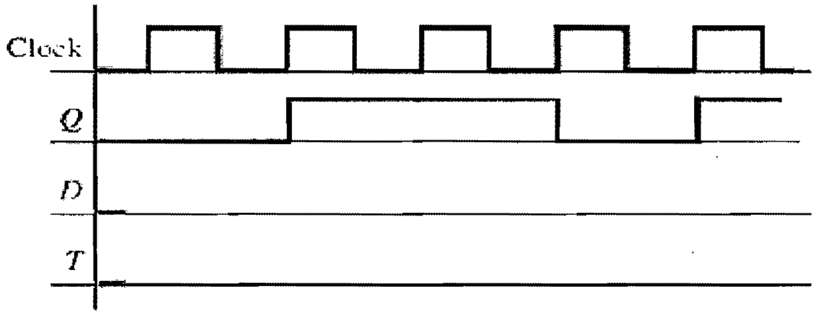


Figure 4.1

c) Draw the logic symbol of the flip-flop represented by the function table below [4]

PR	CL	CLK	J	K	Q_{n+1}	$\overline{Q_{n+1}}$
0	1	X	X	X	1	0
1	0	X	X	X	0	1
0	0	X	X	X	—	—
1	1	↑	0	0	Q_n	$\overline{Q_n}$
1	1	↑	1	0	1	0
1	1	↑	0	1	0	1
1	1	↑	1	1	Toggle	
1	1	0	X	X	Q_n	$\overline{Q_n}$

Table 4.1

d) Refer to the binary ripple counter in Figure 4.2. Explain how it operates and determine the modulus of the counter. [6]

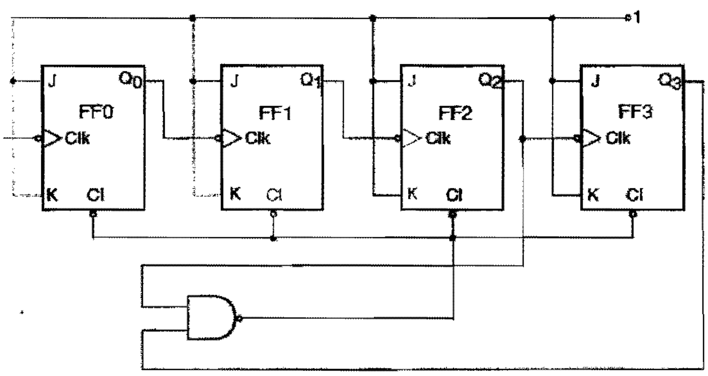


Figure 4.2

QUESTION 5

a) The diagram in Figure 5.1 shows a 4-bit shift register. The clock pulse, clear signal and data input are shown in a timing waveform diagram below the register. [8]

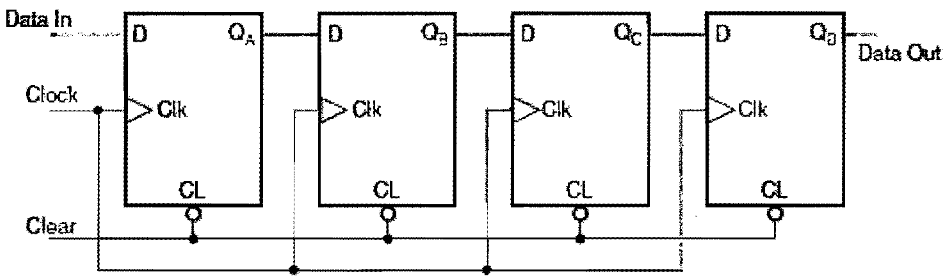
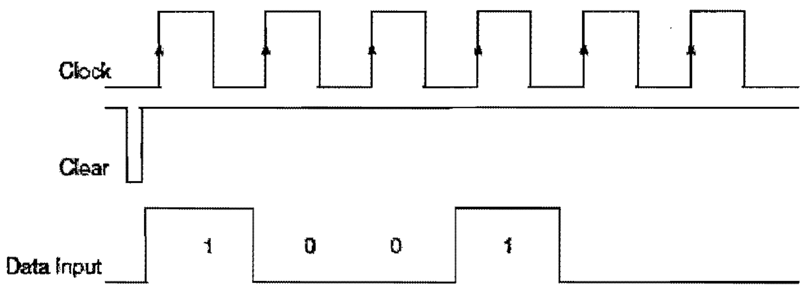


Figure 5.1



b) Draw with careful labelling, a simple resistive divider network for a three-bit D/A converter and give the general expression of the analogue output voltage V_A. [7]

c) What are the fundamental differences between a microprocessor and a microcontroller. [4]

d) Briefly describe the functional differences between an address bus, data bus and control bus in a microprocessor unit. [6]

Postulates and Theorems of Boolean Algebra		
Postulate 2	(a) $x + 0 = x$	(b) $x \cdot 1 = x$
Postulate 5	(a) $x + x' = 1$	(b) $x \cdot x' = 0$
Theorem 1	(a) $x + x = x$	(b) $x \cdot x = x$
Theorem 2	(a) $x + 1 = 1$	(b) $x \cdot 0 = 0$
Theorem 3, involution	$(x')' = x$	
Postulate 3, commutative	(a) $x + y = y + x$	(b) $xy = yx$
Theorem 4, associative	(a) $x + (y + z) = (x + y) + z$	(b) $x(yz) = (xy)z$
Postulate 4, distributive	(a) $x(y + z) = xy + xz$	(b) $x + yz = (x + y)(x + z)$
Theorem 5, DeMorgan	(a) $(x + y)' = x'y'$	(b) $(xy)' = x' + y'$
Theorem 6, absorption	(a) $x + xy = x$	(b) $x(x + y) = x$

END OF P411 MAIN EXAMINATION