ELEC 2607 ('13) **Midterm 1** - Feb 9th 75 Marks

Answer all 10 questions. Write your answers in the space provided on the question paper. Anything written on the reverse side won't be marked.

Authorized Memoranda: One crib sheet allowed per student; maximum letter-size paper. Crib sheet can be filled on both sides. Calculators are NOT allowed.

Name:

Student No.:

Section:

Instructors
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Question	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Marks											

1. Find the inverse for the following functions such that there are bars only on single letters. 4 Marks

(a) $\overline{a\bar{b}(\overline{\overline{cd}+e})}$ $= \overline{a\bar{b}} + (\bar{c}\bar{d}+e)$

$= \bar{a}+b+\bar{c}+\bar{d}+e$

(b) $\overline{(a+b)(\overline{c+d})+\bar{e}}$ $= \overline{(a+b)(\overline{c+d})}\cdot e = [\overline{(a+b)}+(c+d)]e$

$= (\bar{a}\bar{b}+c+d)e$

2. Perform conversion between number systems and fill out the empty boxes. All numbers are unsigned. Each entry in this question will be marked independently. 9 Marks

Binary	Octal	Decimal	Hex
1101110.1	156.4	110.5	6E.8
110101101.11	655.6	429.75	1AD.C
11001000.01	310.2	200.25	C8.4

3. Let $A = 01100010 = (+98)_{10}$, $B = 11011101 = (-35)_{10}$ in 8-bit 2's complement system. Perform the following operations to obtain the 8-bit answers and indicate if there is an overflow (i.e. answer not valid).

8 Marks

(a) $A - B$

overflow

$$\begin{array}{r} 01100010 \\ 00100011 \\ \hline 10000101 \end{array} \qquad \begin{array}{r} 98 \\ -(-35) \\ \hline 133 \end{array}$$

(b) $A + B$

$$\begin{array}{r} 01100010 \\ 11011101 \\ \hline 00111111 \\ \textcircled{1} \end{array} \qquad \begin{array}{r} 98 \\ -35 \\ \hline 63 \end{array}$$

(c) $B - A$

$$\begin{array}{r} 11011101 \\ 10011110 \\ \hline 01111011 \\ \textcircled{1} \end{array} \qquad \begin{array}{r} -35 \\ -98 \\ \hline -133 \end{array}$$

overflow

(d) $B + B$

$$\begin{array}{r} 11011101 \\ 11011101 \\ \hline 10111010 \\ \textcircled{1} \end{array} \qquad \begin{array}{r} -35 \\ -35 \\ \hline -70 \end{array}$$

4. Simplify the following expressions using Boolean algebra.

10 Marks

(a) $z = \bar{a}d\bar{c} + \bar{a}bd + abd + a\bar{b}\bar{c}d + \bar{b}cd$ to 1 literal

$$= d(\bar{a}\bar{c} + \bar{a}b + ab + a\bar{b}\bar{c} + \bar{b}c)$$

$$= d(\bar{a}\bar{c} + (\bar{a}+a)b + (a\bar{c}+c)\bar{b})$$

$$= d(\bar{a}\bar{c} + b + (a+c)\bar{b}) = d(\bar{a}\bar{c} + b + a + c)$$

$$= d(\bar{a} + b + a + c) = d$$

(b) $z = (x+z)(w+y) + wxz$ to 4 literals

$z = xw + xy + zw + zy + wxz$

$= xw(1+z) + xy + zw + zy$

$= xw + xy + zw + zy = x(w+y) + z(w+y)$

$= (x+z)(w+y)$

5. Use exhaustive proof to show whether the following equations are valid. 6 Marks

(a) $\overline{a+b+c} = \bar{a}\bar{b}\bar{c}$

a b c	$\overline{a+b+c}$	$\bar{a}\bar{b}\bar{c}$
0 0 0	1	1
0 0 1	0	0
0 1 0	0	0
1 0 0	0	0
1 0 1	0	0
1 1 0	0	0
1 1 1	0	0

valid.

(b) $\overline{ab+c} = \bar{a} + \bar{b}\bar{c}$

a b c	$\overline{ab+c}$	$\bar{a} + \bar{b}\bar{c}$
0 0 0	1	1
0 0 1	0	1
0 1 0	1	1
0 1 1	0	1
1 0 0	1	1
1 0 1	0	0
1 1 0	0	0
1 1 1	0	0

not valid.

6. Write the duals of the following expressions such that there are bars only on single letters. 4 Marks

(a) $\{a\bar{b}\} + \{\bar{c}a\} + \{bc\}$

dual → $(a+\bar{b})(\bar{c}+a)(b+c)$

(b) $\{ab(\overline{cd+e})\}$

dual → $\{a+b+(\overline{\{c+d\}\cdot e})\} = a+b+\overline{(c+d)\cdot e}$

$= a+b+\overline{c+d}+\bar{e} = a+b+\bar{c}\bar{d}+\bar{e}$

7. Prove the following identities using Boolean algebra. 9 Marks

(a) Distributive Law: $XY + Z = (X + Z)(Y + Z)$

$$RHS = (X+Z)(Y+Z) = XY + XZ + ZY + Z \cdot Z$$
$$= XY + XZ + ZY + Z = XY + (X + Y + 1)Z$$
$$= XY + Z = LHS$$

(b) Consensus Theorem: $XY + YZ + \bar{X}Z = XY + \bar{X}Z$

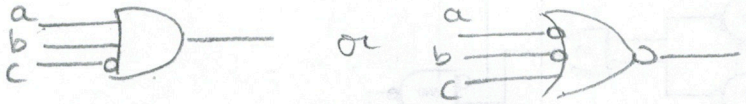
$$LHS = XY + YZ \cdot 1 + \bar{X}Z$$
$$= XY + YZ(X + \bar{X}) + \bar{X}Z$$
$$= XY + YZX + YZ\bar{X} + \bar{X}Z$$
$$= XY(1 + Z) + \bar{X}Z(Y + 1)$$
$$= XY + \bar{X}Z$$

(c) $(\bar{X} + Z)(X + Y)(X + Z) = Z(X + Y)$

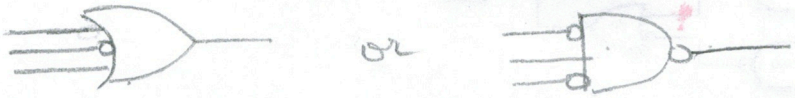
$$LHS = (\bar{X}X + \bar{X}Z + ZX + ZZ)(X + Y)$$
$$= (\bar{X}Z + ZX + Z)(X + Y)$$
$$= Z(X + Y) = RHS$$

8. Draw the simplest logic gate or circuit for the following descriptions. The inputs are a, b, c and the output is z.

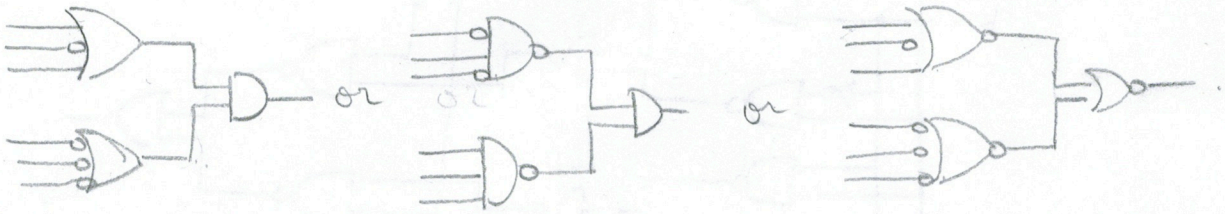
(a) $z = 1$ only when $abc = 110$ 2 Marks



(b) $z = 0$ only when $abc = 010$ 2 Marks

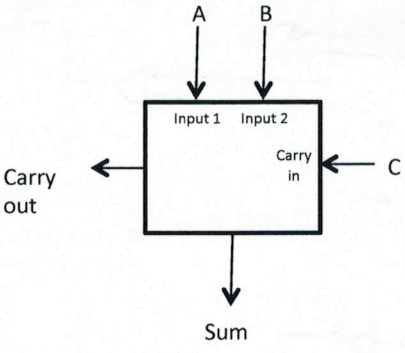


(c) $z = 0$ if $abc = 010$ or $abc = 111$ 3 Marks

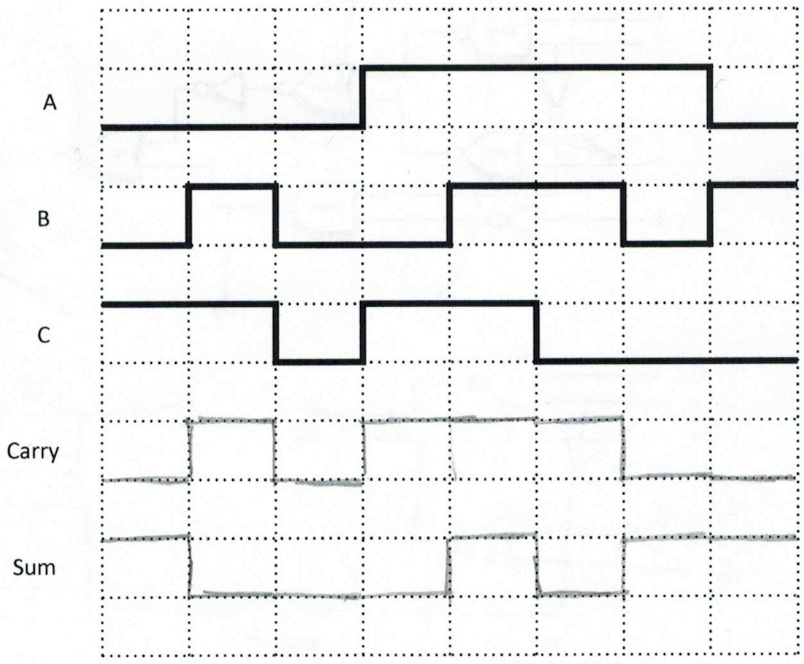


and several other alternatives

9. A 3-input full adder is being tested in a simulation. The following figure shows the waveforms for the inputs A, B and C. Determine the correct values of the output waveforms for Carry and Sum. 8 Marks

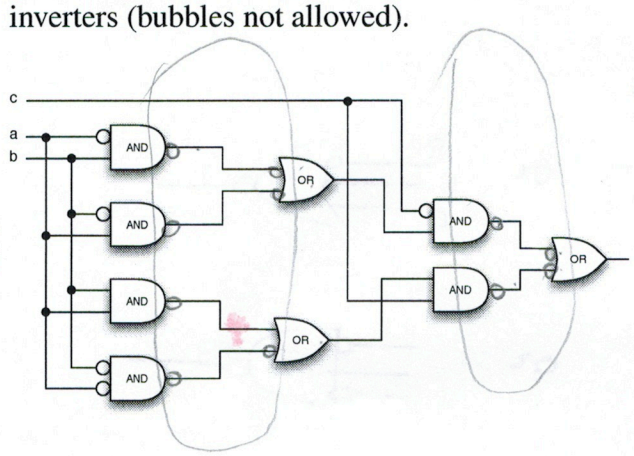


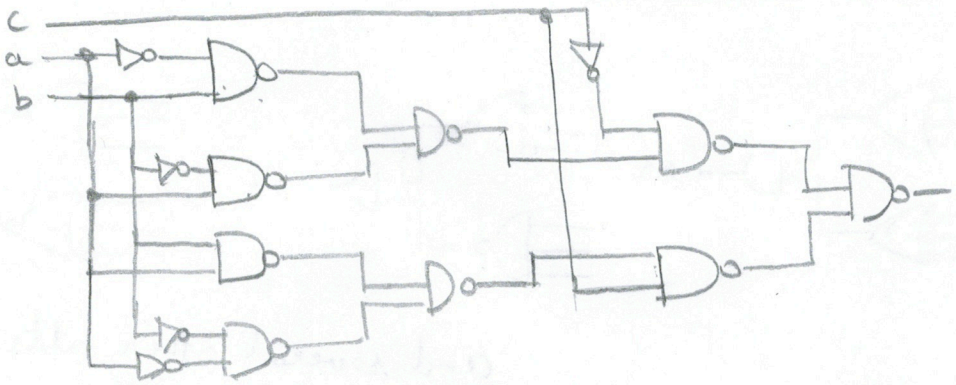
3-input full adder



10. (a) Convert the following AND-OR circuit to a circuit consisting of only 2-input NAND gates and inverters (bubbles not allowed).

6 Marks





(b) Convert the following NAND-NOR circuit to an AND-OR circuit (bubbles allowed). Skip the first and third layer during conversion.

4 Marks