CS2810 Homework 3 – 73 points - Due by midnight September 21. Submit this homework through Eagle.

For this homework assignment you may work individually or in a group of up to 3 students. If working in a group, be sure that when you turn in your homework through Eagle you include the names of everyone in the group.

**Questions 1-6 (Fill in the blank) 1 point for each blank (8 points total)**

1.) There are two kinds of digital logic circuits they are _____ logic circuits and _____ logic circuits

Order does not matter – combinational, sequential

2.) Of the two types of digital logic circuits, both are the same except one has a _____ while the other does not.

Memory

3.) There are _____ different functions of 3 variables.

256

4.) A truth table for a 4 bit input will have _____ rows

16

5.) In the Boolean system, variables can have one of _____ values.

Two or 2

6.) AND and NOT form a _____ _____ complete set of operators.

Logically complete

**Question 7: 2 points each part (10 points total)**

7.) In each case, give the decimal equivalent value of the given number. The radix or base of the number is given as a subscript, e.g. $74_8$ is a base 8 value. (2 points each)

a. $735.5_{10}$

735.5

b. $23.2_4$

11.5

c. $1101101.101_2$

109.625

d. $7521_8$

3584

e. $AF23_{16}$

412266

**Questions 8-12: 2 points each (10 points total)**

8.) (True/False) A Boolean variable in a decimal system can have one of 10 different values.

False

9.) The NAND function is a logically complete Boolean function.
True

10.) The exclusive-or function is a logically complete Boolean function.

False

11.) Our decimal number system is a system whose values are in positional notation.

True

12.) Roman numerals are not a positional format notation system.

True

**Questions 12-16: 5 points each part (45 points total)**

13.) Give the truth table for a function with 3 inputs A,B,C and one output F(A,B,C). F is a one if exactly two of the three inputs are 1; otherwise, it is a 0.

Solution on separate page

14.) For the preceding truth table (problem 13), give the canonical sum of products Boolean expression for F(A,B,C).

F(A,B,C)= A"BC + AB" + ABC'

15.) For the preceding truth table (problem 13), give the canonical product of sums Boolean expression.

F(A,B,C) = (A+B+C)(A+B+C')(A+B'+C)(A'+B+C)(A'+B'+C')

16.) Given the following Boolean expression

F(W,X,Y,Z) = W'X + WXY + (W + Y')(X + Y)

What is the Boolean expression for F'

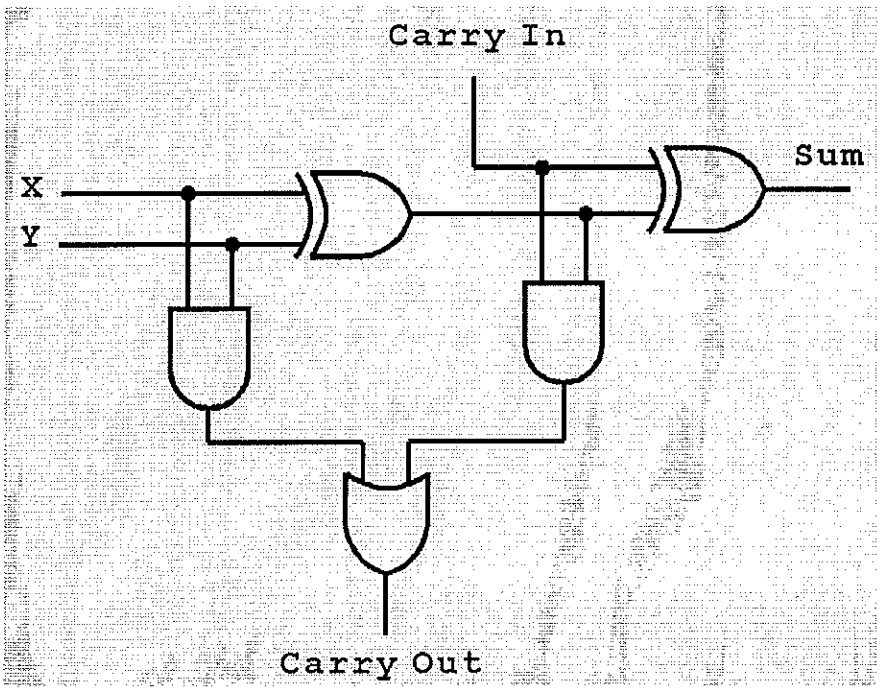
Solution on separate page

17.) Consider the following Boolean function F(X,Y,Z) = XY + YZ + X'Y + X'Y'Z'.

a. Without doing any minimization of the function and using only AND, OR, and NOT Gates which allow only 1-2, 1-2, and 1 input respectively, implement (draw) the circuit that represents this function.
b. If each device (gate) in your circuit takes 5 ns, what is the maximum rate ate which the inputs to the circuit can change?
c. Using only NAND gates with up to 4 inputs, and with the minimum number of NAND gates, implement (draw) the circuit for the function F(X,Y,Z).

Solution on separate page

18.) Consider a ripple carry full adder for 16-bit arithmetic. Assume that every gate in the device has a propagation delay of 1ns (that's $1X10^{-9}$ seconds).What is the maximum number of adds that this adder can perform per second?




The above diagram is for a full adder. The circuit is a 2-level circuit for both the sum and the carry. Therefore, they can operate in parallel and thus the time for it to do an add is 2 ns. Since there are 16 of these full adders in the circuit, the total time for an add will be 16ns/add (minimum). Thus, the adder can perform 1/16ns adds/second or

$$0.0625 \text{ X } 10^9 \text{ adds/second} = 62{,}500{,}000 \text{ adds/second}$$

19.) Using only a single 2X4 multiplexor, show how to use this multiplexer to implement the Boolean function defined in the following truth table. In other words, draw and label the multiplexer so that its output is F().

| A | B | C | F(A,B,C) |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |

Solution on separate page

#13.) Solution

| A | B | C | F |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |

#14.) $F(A,B,C) = \bar{A}BC + A\bar{B}C + AB\bar{C}$

#15.) $F(A,B,C) = (A+B+C)(A+B+\bar{C})(A+\bar{B}+C)$
$(\bar{A}+B+C)(\bar{A}+\bar{B}+\bar{C})$

#16) $F(w,x,y,z) = \overline{w}x + wxy + (w+\overline{y})(x+y)$

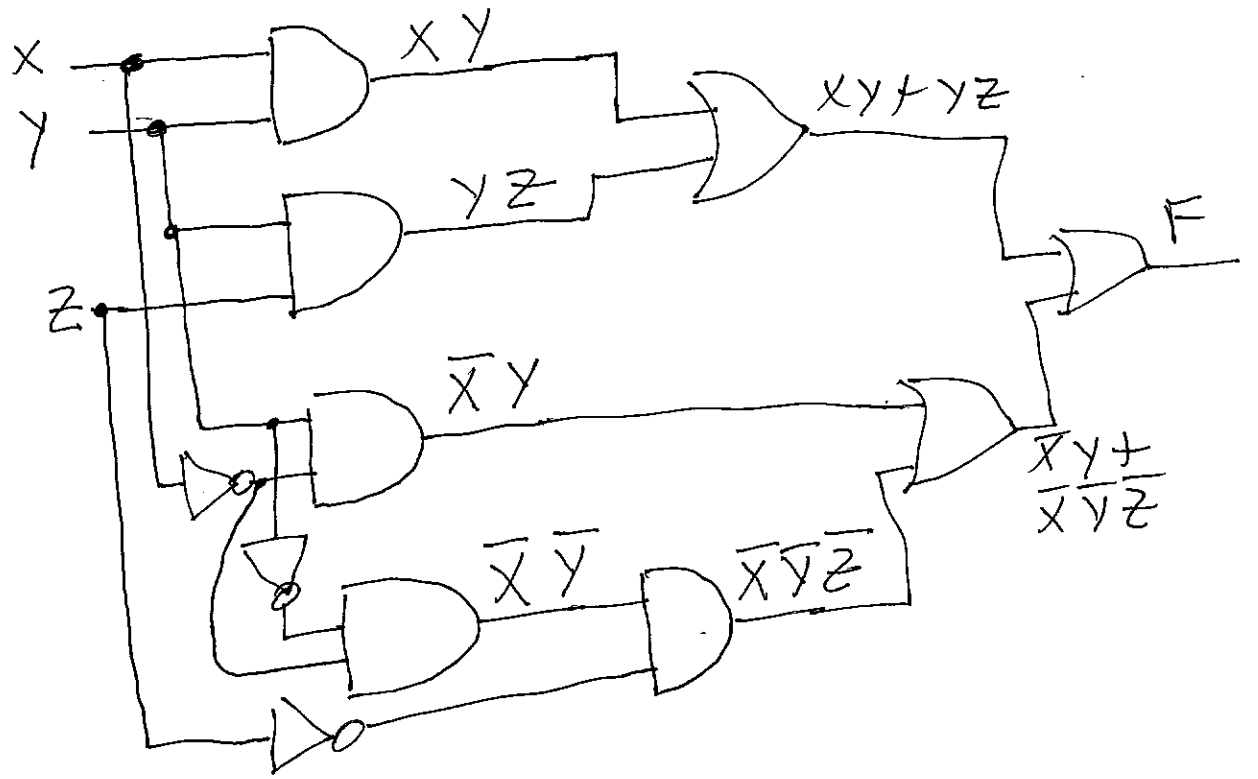
$$\overline{F}( ) = \overline{(\overline{w}x)}\,\overline{(wxy)}\,\overline{(w+\overline{y})(x+y)}$$

$$= (w+\overline{x})(\overline{w}+\overline{x}+\overline{y})\left(\overline{(w+\overline{y})} + \overline{(x+y)}\right)$$

$$= (w+\overline{x})(\overline{w}+\overline{x}+\overline{y})\left((\overline{w}y) + \overline{x}\,\overline{y}\right)$$

#17.) $F(X,Y,Z) = XY + YZ + \bar{X}Y + \bar{X}\bar{Y}\bar{Z}$

a.)




#17.)

b.) This is a 5 level circuit.

$X \rightarrow \bar{X} \rightarrow \bar{X}\bar{Y} \rightarrow \bar{X}\bar{Y}\bar{Z} \rightarrow \bar{X}Y + \bar{X}\bar{Y}\bar{Z} \rightarrow F$

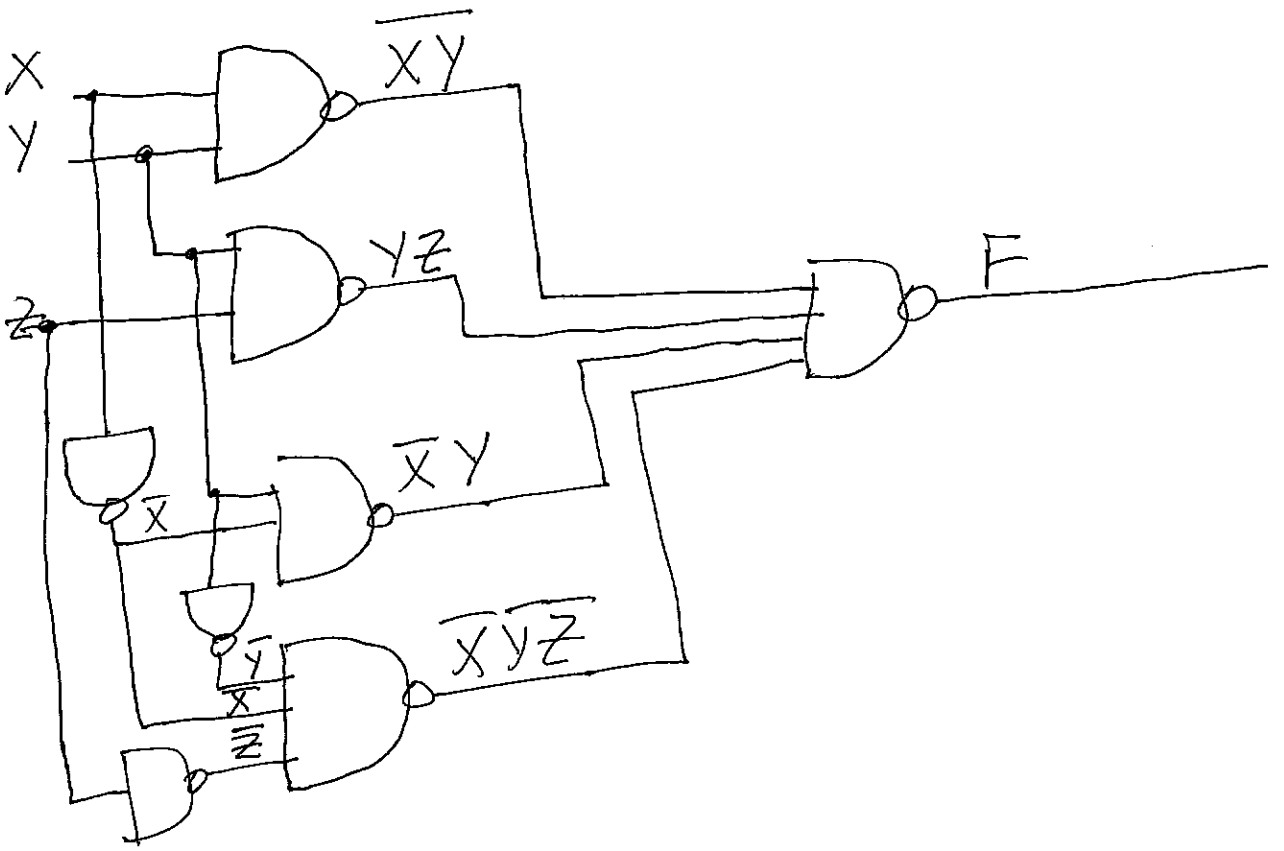
This @ 5 NS/ device level it requires 25 NS/add or

$$\frac{1}{25 \times 10^{-9}} = 0.04 \times 10^{9} \text{ adds/sec}$$

$$= 40{,}000{,}000 \text{ adds/sec}$$

or 40 MHz is the clock rate.

#17.) C.) a 2-level SOP can be implemented as a 2-level NAND-NAND circuit



19.)