Points missed: _____ Student's Name: ___________________________________

Total score: _____ /100 points

East Tennessee State University
Department of Computer and Information Sciences
CSCI 2150 (Tarnoff) – Computer Organization
TEST 1 for Fall Semester, 2003

Section 001

Read this before starting!

- The total possible score for this test is 100 points.
- This test is closed book and closed notes
- You may use one sheet of scrap paper that you will turn in with your test.
- You may NOT use a calculator
- **All answers must have a box drawn around them. This is to aid the grader (who might not be me!) Failure to do so might result in no credit for answer. Example:**

  $\boxed{32F1_{16}}$

- **1 point will be deducted** per answer for missing or incorrect units when required. **No** assumptions will be made for hexadecimal versus decimal, so you should always include the base in your answer.
- If you perform work on the back of a page in this test, indicate that you have done so in case the need arises for partial credit to be determined.

"Fine print"

Academic Misconduct:

Section 5.7 "Academic Misconduct" of the East Tennessee State University Faculty Handbook, June 1, 2001:

"Academic misconduct will be subject to disciplinary action. Any act of dishonesty in academic work constitutes academic misconduct. This includes plagiarism, the changing of falsifying of any academic documents or materials, cheating, and the giving or receiving of unauthorized aid in tests, examinations, or other assigned school work. Penalties for academic misconduct will vary with the seriousness of the offense and may include, but are not limited to: a grade of 'F' on the work in question, a grade of 'F' of the course, reprimand, probation, suspension, and expulsion. For a second academic offense the penalty is permanent expulsion."

Basic Rules of Boolean Algebra:	**1.** $\mathbf{A + 0 = A}$	**7.** $\mathbf{A \cdot A = A}$
	2. $\mathbf{A + 1 = 1}$	**8.** $\mathbf{A \cdot \overline{A} = 0}$
	3. $\mathbf{A \cdot 0 = 0}$	**9.** $\mathbf{\overline{\overline{A}} = A}$
	4. $\mathbf{A \cdot 1 = A}$	**10.** $\mathbf{A + AB = A}$
	5. $\mathbf{A + A = A}$	**11.** $\mathbf{A + \overline{A}B = A + B}$
	6. $\mathbf{A + \overline{A} = 1}$	**12.** $\mathbf{(A + B)(A + C) = A + BC}$
DeMorgan's Theorem:	$\overline{(AB)} = (\overline{A} + \overline{B})$	$\overline{(A + B)} = (\overline{A}\ \overline{B})$

Short-ish Answer (2 points each)

1.) How many combinations of 1's and 0's can a 5-bit number (i.e., 5 binary variables) have?

a.) 15 b.) 16 c.) 31 d.) 32 e.) 63 f.) None of the above

\# of combinations = 2^5 = 32, therefore, the answer is d.

2.) True or False: The expression $(A{\bullet}\overline{C}) + (\overline{B}{\bullet}C) + (\overline{A{\bullet}B}{\bullet}C)$ is in correct Sum-of-Products form.

Since an inversion sign crosses both A and B of the last product, this is an invalid S.O.P. Therefore the answer is False.

3.) Circle the function that would first be performed in the following expression.

$$A\cdot(B + C\cdot(D+E) + F)$$

4.) True or False: The number 1010111100101100011 is a valid BCD number.

Dividing the number into nibbles gives us: 0101 0111 1001 0110 0011. Note that one leading zero needed to be added because the nibbles must be created from right to left. If you'll look at a table of BCD values, you'll see that every value is valid. Not that this is part of the answer, but the converted number is 57963. The answer is 'True'.

5.) True or False: The 8-bit number 10010101_2 represents the same decimal value in unsigned binary as it does in 2's complement.

False, the number is a positive number in unsigned binary and a negative number in 2's comp.

6.) What is the **minimum** number of bits needed to represent 64_{10} in signed magnitude representation?

a.) 5 b.) 6 c.) 7 d.) 8 e.) 9 f.) None of the above

The largest number that can be represented with n-bits in signed magnitude representation is $2^{(n-1)}-1$. For n=5, this is $2^4-1 = 15$. For n=6, this is $2^5-1=31$. For n=7, this is $2^6-1=63$. For n=8, this is $2^7-1=127$. Therefore, at least 8 bits are needed, and the answer is d.

7.) Which of the following is the lowest possible value for a 9-bit 2's complement binary number?

a.) 0 b.) -512 c.) -256 d.) -511 e.) -255 f.) -127 g.) None of the above

The lowest possible value for an n-bit 2's complementary number is $-(2^{(n-1)})$. For n=9, this is $-2^8 = -256$. Therefore, the answer is c.

8.) Write the complete truth table for a 2-input NAND gate.

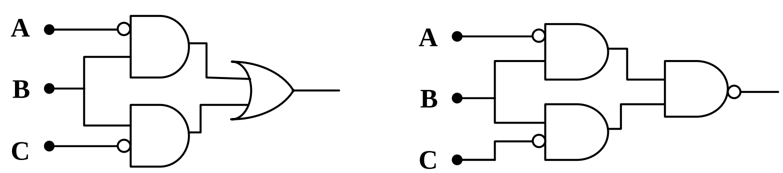
A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

9.) For the truth table to the right, would a Product-of-Sums or a Sum-of-Products expression have fewer terms?

A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Product-of-Sums uses the rows with zeros to create the expression, and therefore, a P.O.S. equation would have 5 terms. Sum-of-Products uses the rows with ones to create the expression, and therefore, an S.O.P. equation would have 3 terms. The answer is S.O.P.

10.) True or False: The two circuits below are equal.



False. DeMorgan's Theorem says that an S.O.P. circuit is equivalent to the same circuit with both the AND gates and the single OR gate replaced with NAND gates. In the circuit above, only the OR gate has been replaced with a NAND gate and therefore the two circuits are not equivalent.

11.) True or False: An overflow has occurred in the 2's complement addition shown to the right.

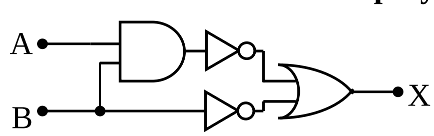
```
 10011011
+01110000
---------
 00001011
```

False. An overflow cannot occur if the sign bits of the two numbers being added are different.

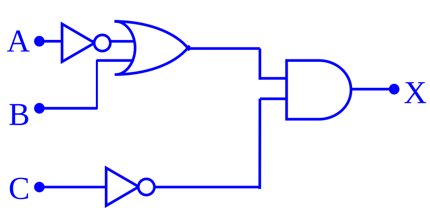
Medium-ish Answer (5 points each)

12.) Write the boolean expression exactly as it is represented by the circuit below. **Do not simplify!**

$\overline{(A \bullet B)} + \overline{B}$



13.) Draw the circuit exactly as it is represented by the Boolean expression $(\overline{A} + B)\bullet\overline{C}$.



14.) Convert 1010111101111000101_2 to hexadecimal.

To begin with, create the table of conversion for binary to decimal, hex, or BCD. (We'll use it again later.)

Binary	Decimal	Hex	BCD
0000	0	0	0
0001	1	1	1
0010	2	2	2
0011	3	3	3
0100	4	4	4
0101	5	5	5
0110	6	6	6
0111	7	7	7
1000	8	8	8
1001	9	9	9
1010	10	A	
1011	11	B	
1100	12	C	Invalid
1101	13	D	
1110	14	E	
1111	15	F	

Next, starting from the right side, divide the number into nibbles. Note that a leading zero had to be added. It is identified by the red 0.

0101 0111 1011 1100 0101

Next, using the table we created above, simply convert each of the nibbles to its value from the Hex column.

Nibble	Hex
0101	5
0111	7
1011	B
1100	C
0101	5

The final hex value is therefore $57BC5_{16}$.

15.) Convert the decimal number 96404 to BCD.

Using the table we created for problem 14, simply convert each of the decimal digits to its binary nibble.

Decimal	BCD
9	1001
6	0110
4	0100
0	0000
4	0100

String them together for the final answer: $1001\ 0110\ 0100\ 0000\ 0100_{BCD}$.

16.) If an 8-bit binary number is used to represent an analog value in the range from 32 to 212, what is the accuracy of the system, i.e., if the number is incremented by one, how much change in the analog range is represented?

$$\text{Accuracy} = \frac{\text{Max} - \text{Min}}{2^n - 1} = \frac{212 - 32}{2^8 - 1} = \frac{180}{255} = 0.706 \text{ units/step}$$

Note that the final answer could have been left as 180/255.

17.) If an 8-bit binary number is used to represent an analog value in the range from 0 to 100, what does the binary value 01100100_2 represent?

First, determine the accuracy.

$$\text{Accuracy} = \frac{\text{Max} - \text{Min}}{2^n - 1} = \frac{100 - 0}{2^8 - 1} = \frac{100}{255}$$

Next figure out how far 01100100_2 is into the range, i.e., convert it to decimal.

$$01100100_2 = 64 + 32 + 4 = 100$$

Lastly, multiple the decimal value by the accuracy and then add it to the low value of the range to determine the analog value 01100100_2 represents.

$$\text{Analog value} = (\text{accuracy} * \text{measurement}) + \text{Minimum value}$$

$$= \frac{100}{255} * 100 + 0 = \frac{10,000}{255}$$

18.) Apply DeMorgan's Theorem to distribute the inverse to the individual terms of the following equation. **Do not simplify.**

$$\overline{D\cdot C\cdot B(A + B)} = \overline{D} + \overline{C} + \overline{B} + \overline{(A + B)}$$

$$= \overline{D} + \overline{C} + \overline{B} + \overline{A}\cdot\overline{B}$$

19.) If a periodic binary signal has a period of 20 mS, how long must the logic '1' pulse portion of the signal be for the signal to have a duty cycle of 25%?

$$\text{Duty Cycle} = \frac{\text{high pulse duration}}{\text{period}} * 100\%$$

Solving for the high pulse duration gives us:

$$\text{high pulse duration} = \frac{\text{Duty Cycle}}{100\%} * \text{period} = \frac{25\%}{100\%} * 20\text{ mS}$$

$$\text{high pulse duration} = 0.25 * 20\text{ mS} = 5\text{ mS}$$

Longer Answers (Points vary per problem)

20.) Determine the Sum-of-Products expression for this truth table. (6 points)

A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

First, isolate the rows with 1's. The rows with ones are:

A=0, B=0, and C=0 which is the same as $\overline{A}$=1, $\overline{B}$=1, and $\overline{C}$=1

A=0, B=1, and C=0 which is the same as $\overline{A}$=1, B=1, and $\overline{C}$=1

A=0, B=1, and C=1 which is the same as $\overline{A}$=1, B=1, and C=1

A=1, B=0, and C=1 which is the same as A=1, $\overline{B}$=1, and C=1

This each one of the rows then converts to an AND expression with each element that was equal to a 0 inverted so that the final output of the AND is a 1 when that unique pattern occurs. OR all of the ANDed expressions together and we get:

$$X = (\overline{A}\cdot\overline{B}\cdot\overline{C}) + (\overline{A}\cdot B\cdot\overline{C}) + (\overline{A}\cdot B\cdot C) + (A\cdot\overline{B}\cdot C)$$

21.) Complete the truth table below with the output from the Product-of-Sums equation shown. (6 points)

$X = (\overline{A}+\overline{B}+C) \bullet (A+B+\overline{C}) \bullet (\overline{A}+\overline{B}+\overline{C})$

A	B	C	X
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

Place zeros in the rows corresponding to each OR such that the inverted inputs are set to 1 and the non-inverted inputs are set to 0. Fill in the rest of the table with 1's.

22.) Fill in the blank cells of the table below with the correct numeric format. ***For cells representing binary values, only 8-bit values are allowed!*** If a value for a cell is invalid or cannot be represented in that format, write "X". Use your scrap paper to do your work. (2 points per cell)

Decimal	2's complement binary	Signed magnitude binary	Unsigned binary
-108	**10010100**	**11101100**	**X**
48	**00110000**	**00110000**	**00110000**
195	**X**	**X**	**11000011**

23.) Mark each equation as ***true*** or ***false*** depending on whether the right and left sides of the equal sign are equivalent. (3 points each)

a.) $(A \cdot B + C)(A \cdot B + D) = A \cdot B + C \cdot D$ Answer: ___TRUE___

From rule 12, we know that $(A + B)(A + C) = A + BC$. Substitute $A \cdot B$ for A, C for B, and D for C and we get $(A \cdot B + C)(A \cdot B + D) = A \cdot B + C \cdot D$. Therefore, it's true.

b.) $\overline{(A \cdot B)} + B = 1$ Answer: ___TRUE___

$\overline{(A \cdot B)} + B = \overline{A} + \overline{B} + B$ DeMorgan's Theorem

$\overline{A} + \overline{B} + B = \overline{A} + 1$ Rule 6

$\overline{A} + 1 = 1$ Rule 2

c.) $\overline{A}\cdot\overline{B}\cdot\overline{C} + \overline{A}\cdot\overline{B}\cdot C + \overline{A}\cdot B\cdot\overline{C} + \overline{A}\cdot B\cdot C = \overline{A}$ Answer: ___TRUE___

$\overline{A}\cdot\overline{B}\cdot\overline{C} + \overline{A}\cdot\overline{B}\cdot C + \overline{A}\cdot B\cdot\overline{C} + \overline{A}\cdot B\cdot C = \overline{A}\cdot(\overline{B}\cdot\overline{C} + \overline{B}\cdot C + B\cdot\overline{C} + B\cdot C)$

$\overline{A}\cdot(\overline{B}\cdot\overline{C} + \overline{B}\cdot C + B\cdot\overline{C} + B\cdot C) = \overline{A}\cdot(\overline{B}\cdot(\overline{C} + C) + B\cdot(\overline{C} + C))$

$\overline{A}\cdot(\overline{B}\cdot(\overline{C} + C) + B\cdot(\overline{C} + C)) = \overline{A}\cdot(\overline{B}\cdot 1 + B\cdot 1) = \overline{A}\cdot(\overline{B} + B) = \overline{A}\cdot 1 = \overline{A}$