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 Spring 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. (A subscript is fine)
- If you perform work on the back of a page or on your scrap paper, 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 possible combinations of ones and zeros do 5 boolean variables have?

a.) 4 b.) 8 c.) 16 d.) 32 e.) 48 f.) None of the above

Each variable has two possible values, 0 or 1, and therefore, the number of possible combinations is 2x2x2x2x2 = 2^5 = 32. The answer is ‘d’.

2) Write the complete truth table for a 2-input NAND gate using the table to the right.

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

3) What is the largest possible value that can be represented with a 6 bit unsigned binary number?

a.) 32 b.) 31 c.) 127 d.) 64 e.) 63 f.) 255 g.) None of the above

The largest possible value that can be represented with an n-bit unsigned binary number is 2^n-1. With n=6, the answer is 2^6-1 = 64-1 = 63. The answer is ‘e’.

4) What is the lowest possible value for a 10-bit binary number in 2’s complement representation?

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 binary number in 2’s complement representation is the most negative. This value is $-(2^{(n-1)})$. Therefore, with n=10, the answer is -2^9 = -512 which is ‘b’.

5) What is the **minimum** number of bits needed to represent 256_{10} in signed magnitude representation?

a.) 6 b.) 7 c.) 8 d.) 9 e.) 10 f.) None of the above

Signed magnitude representation looses a bit to the sign bit, which in the case of a positive number must be 0. Therefore, the largest positive value in an n-bit signed magnitude is the same as the largest value in an (n-1) bit unsigned binary value which would be $2^{(n-1)}$-1. For n=8, $2^{(8-1)}$-1 = 128-1 = 127 which is too small. For n=9, $2^{(9-1)}$-1 = 256-1=255 which is also too small. For n=10, $2^{(10-1)}$-1 = 512-1 = 511 which is big enough. Therefore, the answer is ‘e’.

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

True. The only thing that would cause a problem here is if an inverse spanned more than one ANDed term

7) An analogy was made in class between boolean algebra and mathematical algebra. Which boolean operation did not have an equivalent in mathematical algebra? (Don't consider XOR.)

The boolean inverse did not have an analogous mathematical expression.

8) True or False: The number 111010100000100001 is a valid BCD number.

Dividing the number into nibbles gives us: 0011 1010 1000 0010 0001. Note that two leading zeros needed to be added because the nibbles must be created from right to left. Since the nibble 1010 is not a valid BCD number, the original number is not BCD. The answer is 'False'.

9) In the boolean expression below, circle the first operation to be performed. **Do not simplify!**

$$B + C(E + AD)$$

10) How can you tell that an overflow in binary addition has occurred resulting in an incorrect sum?

If the sign of both of the numbers being added match, and the result has a different sign, there's been an overflow. I.e., if the numbers being added are both positive and the result is negative or if the numbers being added are both negative and the result is positive, then there's been an overflow.

11) In order to determine whether 10010110 is a negative number, you must be told what representation the number is in (e.g., 2's complement) and what else?

You must also know how many bits the number is being stored as. If it is more than 8 bits, then leading zeros would change it to a positive number.

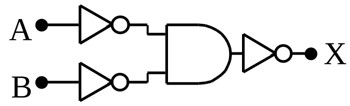
12) Shifting all the bits of a binary value three positions to the left is equivalent to what mathematical operation. Be as specific as you can.

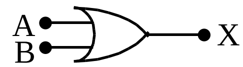
Multiplication by 8. Left shifts perform multiplication by powers of two while right shifts perform division.

13) What is the purpose behind the use of Binary Coded Decimal (BCD)?

A quick representation of numbers that are not used for mathematical purposes such as phone numbers or a student id.

14) True or False: The two circuits to the right are equivalent.





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

Invert both sides and we get $\overline{(\bar{A}\cdot\bar{B})} = (A + B)$

Therefore the answer is 'True'.

Medium-ish Answer (5 points each)

15) Determine the Sum-of-Products expression for the truth table to the right. **Do not simplify!**

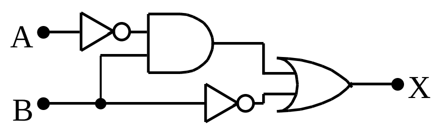
A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

First, note that my expression will use a ^ before a term to indicate an inverted value. This means that the second row (A=0, B=0, C=1) term is (^A ^B C). The fifth row's term (A=1, B=0, C=0) is (A ^B ^C). The sixth row's term (A=1, B=0, C=1) is (A ^B C). The eighth row's term (A=1, B=1, C=1) is (A B C). Therefore, the S.O.P expression is:

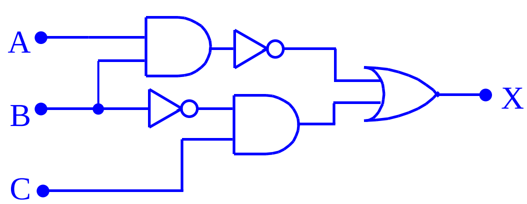
X = (^A ^B C) + (A ^B ^C) + (A ^B C) + (A B C)

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

X = (^A B) + ^B



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



18) Prove $A + A\bullet B = A$. Be sure to add enough detail to show that you understand the proof.

By truth table, notice that the last column equals the A column for every row.

A	B	$A\bullet B$	$A + A\bullet B$ (or A with 2nd column)
0	0	0	0 + 0 = 0
0	1	0	0 + 0 = 0
1	0	0	1 + 0 = 1
1	1	1	1 + 1 = 1

19) Convert 110110010100110110_2 to hexadecimal.

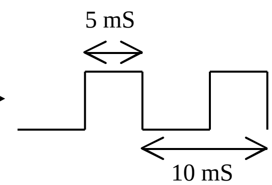
First, divide value into nibbles starting from the right side and adding leading zeros to beginning if needed. 0011 0110 0101 0011 0110. Next, convert each nibble to its hex value: 0011=3, 0110=6, 0101=5, 0011=3, and 0110=6. Answer: 36536_{16}

20) Complete the truth table below with the output from the Product-of-Sums equation shown.

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

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

21) What is the duty cycle of this periodic signal?



Duty cycle = (5ms/10ms)x100% = 50%

22) What is the frequency of the signal from problem 20? (Hint: 1 mS = 1 x 10^{-3} seconds) Do not bother to calculate the final decimal value. **Just put the values into the proper equation.**

Frequency = 1/period = $1/(1\text{x}10^{-3}) = 1\text{x}10^{3}$ = 1 kHz

23) Use DeMorgan's Theorem to distribute inverse to individual terms. **Do not simplify!** (6 points)

$$\overline{A\bullet B + C + B}$$

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

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

Longer Answers (Points vary per problem)

24) 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
83	**01010011**	**01010011**	**01010011**
-48	**11010000**	**10110000**	X (no negatives allowed)
-66	**10111110**	**11000010**	X (no negatives allowed)

25) 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.) $\overline{B}(A + \overline{A}\cdot B) = A\cdot\overline{B}$ Answer: TRUE

$\overline{B}\cdot A + \overline{B}\cdot A\cdot B$	Apply distributive law
$\overline{B}\cdot A + A\cdot\overline{B}\cdot B$	Apply associative law
$\overline{B}\cdot A + A\cdot 0$	Anything and-ed with itself is zero
$\overline{B}\cdot A + 0$	Anything and-ed with zero is zero
$\overline{B}\cdot A$	Anything or-ed with zero is itself
$A\cdot\overline{B}$	Apply associative law

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

$(\overline{A\cdot B})\cdot(\overline{\overline{A\cdot B}})$	Apply DeMorgan's Theorem
$(\overline{A\cdot B})\cdot(A\cdot B)$	The inverse of an inverse is the original value
0	Anything and-ed with its inverse is zero

c.) $(A + B)(\overline{B} + B) = 1$ Answer: FALSE

$(A + B)\cdot 1$	Anything or-ed with its inverse is one
$(A + B)$	Anything and-ed with one is itself