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, 2004

Read this before starting!

- The total possible score for this test is 100 points.
- This test is ***closed book and closed notes***
- You may ***NOT*** use a calculator. Leave all numeric answers in the form of a formula.
- You may use one sheet of scrap paper that you must turn in with your test.
- 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.
- Statement regarding academic misconduct from Section 5.7 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. $A + 0 = A$	**7.** $A \cdot A = A$
2. $A + 1 = 1$	**8.** $A \cdot \overline{A} = 0$
3. $A \cdot 0 = 0$	**9.** $\overline{\overline{A}} = A$
4. $A \cdot 1 = A$	**10.** $A + AB = A$
5. $A + A = A$	**11.** $A + \overline{A}B = A + B$
6. $A + \overline{A} = 1$	**12.** $(A + B)(A + C) = A + BC$

DeMorgan's Theorem: $\overline{(AB)} = (\overline{A} + \overline{B})$ $\quad$ $\overline{(A + B)} = (\overline{A} \bullet \overline{B})$

Short-ish Answer (2 points each unless otherwise noted)

1. Calculate the frequency of a periodic pulse train with a period of 1 millisecond ($1\text{x}10^{-3}$ seconds).

$$\text{Frequency} = \frac{1}{\text{Period}} = \frac{1}{1\text{x}10^{-3}\text{ seconds}} = 1\text{ kHz}$$

2. True or False: A signal's frequency can be calculated from its duty cycle alone.

   The duty cycle is a ratio of the pulse width to the period. Although the period depends on the frequency, it is a ratio, and the frequency is not involved in the final answer. Therefore, the answer is **FALSE**.

3. A digital signal with a duty cycle of 100%: (select the ***best*** answer)

   a.) has a constant frequency   b.) is not possible   c.) is a constant logic 0
   d.) is a constant logic 1   e.) never stops pulsing   f.) none of the above

   Although a digital signal with a duty cycle implies that the signal has a frequency, a duty cycle of 100% is a constant logic 1. Therefore, the best answer is **D**.

4. For each of the following binary representations, what is the smallest/lowest value that can be represented using 10 bits. (2 points each)

   a.) unsigned binary: the lowest value is $0000000000_2 = 0_{10}$

   b.) 2's complement: the lowest value is $1000000000_2 = -(2^{(10-1)}) = -512_{10}$

   c.) signed magnitude: the lowest value is $1111111111_2 = -(2^{(10-1)} - 1) = -511_{10}$

5. How many bits does each of the following terms represent? (1 point each)

   a.) nibble ____**4**____   b.) byte ____**8**___   c.) word _**16 or 32**_

6. What is the **minimum** number of bits needed to represent $+255_{10}$ in signed magnitude representation?

   You can do this a number of ways. First, you could look at the binary value for 255_{10} which is 11111111_2. Notice that the most significant 1 is in the 8^{th} bit position. Since signed magnitude requires a sign bit, then 255_{10} needs to be written 011111111_2. **Therefore, 9 bits are needed.** The other way you could do it is to use the formula to calculate the maximum value of a signed magnitude number and apply it to different numbers of bits.
   5 bits = $2^{5-1}-1 = 15$
   6 bits = $2^{6-1}-1 = 31$
   7 bits = $2^{7-1}-1 = 63$
   8 bits = $2^{8-1}-1 = 127$
   9 bits = $2^{9-1}-1 = 255$
   This shows that 9 bits will do the trick.

7. True or False: The number 01100101011110010111 is a valid BCD number.

First, let's create the conversion table between binary, hex, and BCD noting that the last 6 bit patterns do not have BCD equivalents.

Binary				Hexadecimal	BCD
0	0	0	0	0	0
0	0	0	1	1	1
0	0	1	0	2	2
0	0	1	1	3	3
0	1	0	0	4	4
0	1	0	1	5	5
0	1	1	0	6	6
0	1	1	1	7	7
1	0	0	0	8	8
1	0	0	1	9	9
1	0	1	0	A	
1	0	1	1	B	
1	1	0	0	C	
1	1	0	1	D	
1	1	1	0	E	
1	1	1	1	F	

Next, divide the bit pattern from the problem into nibbles so we can see what the conversion to BCD would be.

0110 0101 0111 1001 0111

Each of these nibbles has a corresponding BCD value, so the bit pattern is a valid BCD number. Therefore the answer is **TRUE**.

8. True or False: The 8-bit value 01101011_2 has the same value in both signed magnitude and 2's complement form.

The binary representation for a positive number is the same for all binary representations. Therefore the answer is **TRUE**.

9. 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

The following two questions are based on the 8-bit binary addition shown below.

```
1   11101011
   +11110010
    11011101
```

Carry out

10. True or False: If the addition above is considered 8-bit 2's complement, an overflow has occurred.

An overflow in 2's complement is indicated when two numbers with the same sign are added and result has a different sign. This is not the case with the above example, so the answer is **FALSE**.

11. True or False: If the addition above is considered 8-bit unsigned, an overflow has occurred.

An overflow in unsigned binary is indicated when a carry occurs out of the MSB. This has happened in the above example, so the answer is **TRUE**.

12. True or false: There is an algorithm that allows us to add BCD numbers without converting.

Yes, two BCD numbers can be added. If the addition of two nibbles results in either an illegal BCD value or a carry, adding six (the nibble 0110) to the result will fix the problem. Therefore, the answer is **TRUE**.

13. How many possible combinations of ones and zeros do 5 boolean variables have?

a.) 15 b.) 64 c.) 32 d.) 16 e.) 31 f.) None of the above

The number of possible combinations of ones and zeros with 5 bits is $2^5 = 32$, answer **C**.

14. How many positions must the number 000010101_2 be shifted left in order to multiply it by 16?

Each shift left is equivalent to a single multiplication by 2. Therefore, since $16 = 2^4$, you would need to shift left **4 times**. We can test this by converting 000010101_2 to decimal and then shifting it left by 4 bit positions and converting that result to decimal. If the second value equals 16 times the first value, then it must have worked.

$000010101_2 = 16 + 4 + 1 = 21_{10}$

$101010000_2 = 256 + 64 + 16 = 336_{10}$

$336 \div 16 = 21_{10}$

It worked!

Medium-ish Answer (5 points each)

15. Convert the floating-point number 11000001111010010101000000000000 to its binary exponential format, e.g., 1.1010110×2^{-12}, (which, by the way, is not the answer).

Sign bit	Exponent	Fraction
1	$10000011 = 131_{10}$	11010010101000000000000

$$-1.11010010101 \times 2^{131-127} = -1.11010010101 \times 2^4$$

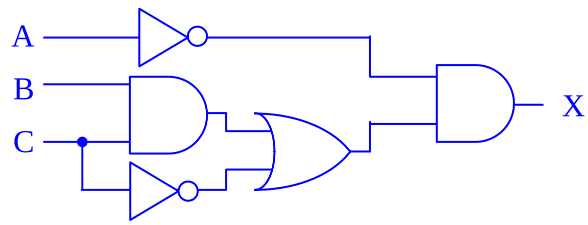
16. Convert 101**.**11 to decimal.

Point

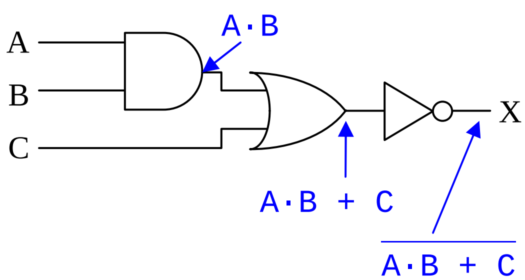
2^4	2^3	2^2	2^1	2^0	2^{-1}	2^{-2}	2^{-3}
0	0	1	0	1	1	1	0

$$2^2 + 2^0 + 2^{-1} + 2^{-2} = 4 + 1 + 0.5 + 0.25 = \mathbf{5.75}$$

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



18. In the space to the right, create the truth table for the circuit shown below.



A	B	C	A·B	A·B + C	$\overline{\text{A·B + C}}$
0	0	0	0	0	1
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	0	1	0
1	0	0	0	0	1
1	0	1	0	1	0
1	1	0	1	1	0
1	1	1	1	1	0

19. Convert 100110101101001001101_2 to hexadecimal.

Break the binary number into nibbles starting at the right side of the number, then use the table from problem 7 to convert the nibbles to hexadecimal. Notice that three leading zeros had to be added to make the first nibble.

0001	0011	0101	1010	0100	1101
1	3	5	A	4	D

The answer is $135A4D_{16}$.

20. List two benefits of a digital circuit that uses fewer gates.

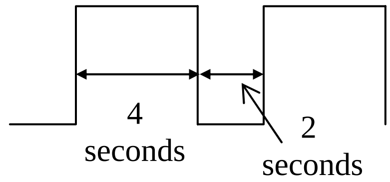
The benefits discussed in class included ***cheaper, faster, smaller circuit board, runs cooler, and more reliable***.

21. If an 8-bit binary number is used to represent an analog value in the range from -25^o to 115^o, what does the binary value 01100100_2 represent? (Leave your answer in the form of a fraction.)

Digital value = $01100100_2 = 100_{10}$
Minimum value = -25^o
Maximum value = 115^o
Range = Maximum value – Minimum value = 115 – (–25) = 140
Number of increments = $2^8-1 = 255$

$$\frac{(\text{max} - \text{min})}{(2^n - 1)}\cdot\text{binary value} + \text{min} = \frac{(115 + 25)}{(2^8 - 1)}\cdot 100 - 25 = 29.9^o$$

22. What is the duty cycle of the signal shown to the right?



Duty cycle = $\frac{t_h}{T}$ * 100% = $\frac{4.0}{6.0}$ * 100% = 67%

Longer Answers (Points vary per problem)

23. Mark each boolean expression as ***true*** or ***false*** depending on whether the right and left sides of the equal sign are equivalent. Show all of your work to receive partial credit for incorrect answers. (3 points each)

a.) $A \cdot \overline{B} \cdot B = A$ Answer: **False**

$A \cdot (\overline{B} \cdot B)$ (Using Associative Law)

$A \cdot 0$ (Using Rule 8)

0 (Using Rule 3)

b.) $ABC + \overline{A} + \overline{B} + \overline{C} = 1$ Answer: **True**

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

1 (Using Rule 6)

c.) $(A + B)(B + \overline{A}) = B$ Answer: **True**

$A \cdot B + A \cdot \overline{A} + B \cdot B + B \cdot \overline{A}$ (Using "F-O-I-L")

$A \cdot B + 0 + B \cdot B + B \cdot \overline{A}$ (Using Rule 8)

$A \cdot B + B \cdot B + B \cdot \overline{A}$ (Using Rule 1)

$A \cdot B + B + B \cdot \overline{A}$ (Using Rule 7)

$B + A \cdot B + B \cdot \overline{A}$ (Using Commutative Law)

$B + B \cdot (A + \overline{A})$ (Using Distributive Law)

$B + B \cdot 1$ (Using Rule 6)

$B + B$ (Using Rule 4)

B (Using Rule 5)

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
-34	**11011110**	**10100010**	**X (no negatives)**
150	**X (out of range)**	**X (out of range)**	**10010110**
96	**01100000**	**01100000**	**01100000**