CS207 Digital Logic Fall 2023 Midterm Examination

No.	1	2	3	4	5	6	7
Points	18	20	9	9	18	16	10

This exam paper contains ___7____questions and the score is ___100____ in total. (Please hand in your exam paper, answer sheet, and your scrap paper to the proctor when the exam ends.)

1. Fill-in question

1.1 (12 points) Convert the following numbers to corresponding bases, retain maximum two digits after the radix point if necessary (Just write the final answer, no need to round)

	Binary	Decimal	Base 5	Hexadecimal
Number 1	010010.01	(a) _____	(b) _____	(c) _____
Number 2	(d) _____	269	(e) _____	(f) _____

1.2 (2 points) There are _____ different input combinations which produce a HIGH output on a three-input OR gate.

1.3 (4 points) List 8 Verilog keywords (keywords are predefined words in Verilog programming language.) _____

2. Single-choice question

2.1 (2 points) In a 4-variable K-map, how many adjacent squares covered in a circle would result in a term with a single literal?

A. 2
B. 4
C. 8
D. 16

2.2 (2 points) Which of the following Boolean equations is in product of maxterms form for the function F(A,B,C)?

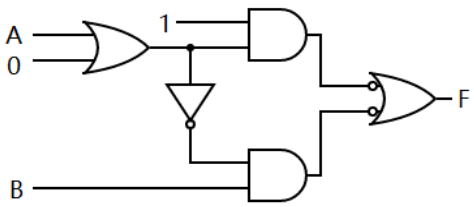
A. F = (A' B C) (A B C') (A B C)
B. F = (A + B + C) (A' + B + C) (A + B' + C)
C. F = (A' + B + C') (A' + C) (A + B' + C)
D. F = A B' C + A' BC' + A' B C'

2.3 (3 points) Determine the base of the numbers for $\sqrt{41} = 5$ to be correct:

A. 16
B. 12
C. 8
D. 6
E. None of the above

2.4 (3 points) The output F of the circuit equals:

A. A'+B'
B. A+B
C. B'
D. 1



2.5 (5 points) The simplified Boolean function of F(A,B,C,D) = $\sum$ (0, 2, 3, 6, 7, 10, 11, 12, 15) is:

A. C'D + A'C + AB'C + A'B'D + ABC'D'
B. C'D + A'C + AB'C + A'B'D' + ABC'D'
C. CD' + A'C + AB'C + A'B'D' + ABC'D'
D. CD' + A'C + AB'C + A'B'D + ABC'D'
E. None of the above.

2.6 (5 points) The simplified Boolean function of F(A,B,C,D) = $\prod$(0, 2, 6, 11, 13, 14, 15) with don't care conditions d(1, 9, 10, 12) is:

A. (A + B + C)(A' + D')(C' + D)
B. (A + B + C)(A + D')(C' + D)
C. (A + B + C)(A' + D)(C' + D)
D. (A + B + C)(A + D)(C' + D)
E. None of the above.

3. Multiple-select questions (More than one choice is correct)

3.1 (3 points) Any Boolean function can be implemented with

A. NAND gates only
B. NOR gates only
C. XOR gates only
D. Combination of AND, OR, NOT gates

3.2 (3 points) For the boolean function f(x,y,z) = ∏(0,2,4,7), which of the following expressions are equivalent:

A. f(x,y,z) = ∑(1,3,5,6)
B. f(x,y,z) = x'y'z' + x'yz' + xy'z' + xyz
C. f(x,y,z) = ∑(0,2,4,7)
D. f(x,y,z) = M0+M2+M4+M7
E. f'(x,y,z) = ∑(0,2,4,7)

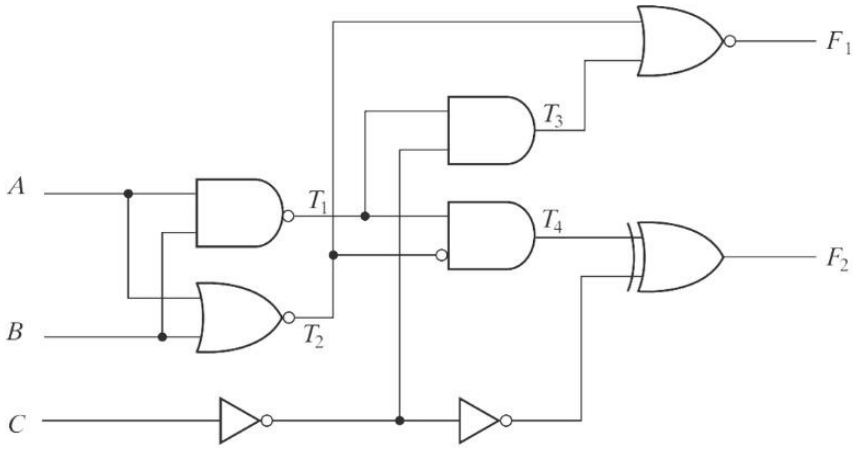
3.3 (3 points) Each of the following received sequences contains an ODD parity bit. Find the sequences that FAIL the parity check, considering no error or a maximum of single error occurs during transmission.

A. 100110010
B. 101111011
C. 011111010
D. 110001101

4. (18 points 3+5+5+5) Design a circuit that performs the following operation: input A ($A_2A_1A_0$), and output B ($B_2B_1B_0$) are both 3 bits unsigned binary number: If A is an EVEN number, B = A' (1's complement of A). If A is an ODD number, B = A + 1 (A plus 1). (To check if A is even or odd, you can convert it to decimal for help, overflow after adding is truncated)

a) Show the truth table for this circuit containing all inputs and all outputs
b) Implement $\mathbf{B_2}$ using 4 NOR gates. Draw the logic diagram. (multi-input nor gate is allowed, and input in complement form can be directly written using ')
c) Implement $\mathbf{B_1}$ using TWO 2-to-4 decoders with enable, and external logic gates, draw the block diagram. (You should denote the input and output variables)
d) Implement $\mathbf{B_0}$ using ONE 4:1 Multiplexer and external logic gates, where A_2 and A_1 are selection bits S1 and S0. Draw the block diagram.

5. (16 points 6+4+6) Consider the combinational circuit below



a) Write down the Boolean expressions for T1, T2, T3, T4, and the outputs F1 and F2 as a function of the inputs. (Write down the full expression, don't simplify)

b) Simplify expression of F1 and F2 **algebraically,** F1 to minimum sum of product form, F2 to expression with minimum number of literals.

c) Fill up the following truth table.

A	B	C	T1	T2	T3	T4	F1	F2
0	0	0						
0	0	1						
0	1	0						
0	1	1						
1	0	0						
1	0	1						
1	1	0						
1	1	1						

6. (9 points) Design a 2-bit comparator that outputs a 1 when A≥B, where A and B are 2-bits unsigned binary numbers expressed using A_1A_0 and B_1B_0. Use TWO 4:1 MUX and ONE 2:1 MUX to implement your design and draw the block diagram. You should clearly denote the selection bits.

7. (10 points) Simplify the Boolean function F(A, B, C, D) = $\sum$(1, 3, 5, 7, 9, 15) + d(4, 6, 12, 13)

a) Simplify into sum of product form using k-map

b) Implement the simplified expression using NAND gates only