Directions:

a. DO NOT OPEN YOUR EXAM BOOKLET UNTIL YOU HAVE BEEN TOLD TO BEGIN.

b. This exam booklet contains 30 questions, each of which will be weighted equally. The exam is worth 180 points (18% of your course grade).

c. You may use one 8.5" x 11" note sheet during the examination. No other reference materials or electronic devices (such as calculators) may be used during the examination.

d. You may not ask questions once the examination has begun.

If there is a structural problem with your exam booklet, such as a missing page or poorly printed page, please bring your exam booklet to the proctor.

If you believe that a question is ambiguous or contains a typographic error, write your interpretation of the question on the same page as the question, then put a note on the cover sheet of your exam booklet.

e. You should choose the single best alternative for each question, even if you believe that a question is ambiguous or contains a typographic error. If a question has more than one correct answer, full credit will be awarded for any correct answer.

f. Please fill in the requested information at the top of this exam booklet.

g. Use a #2 pencil to encode any information on your OMR form (bubble sheet).

h. Please encode the following on the OMR form:

   -- Last name and first initial
   -- MSU PID
   -- Exam form (1 X)

i. Only answers recorded on your OMR form will be counted for credit. Completely erase any responses on the OMR form that you wish to delete.

j. You must turn in this exam booklet and the OMR form when you have completed the exam. When leaving, please be courteous to those still taking the exam.

******************************************************
* Exam Key
  *
* 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 *
* C E E A D E A D A B D C C D B E A C B A E D C A *
*  *
* 25 26 27 28 29 30 *
* B B B E C B
******************************************************
01. Consider function $F$ shown below. What is the minterm list for $F$?

$$F(w,x,y,z) = wx'y'z' + wx'yz + wxy'z + wxyz'$$

A) $F(w,x,y,z) = m_1 + m_2 + m_4 + m_7$
B) $F(w,x,y,z) = m_7 + m_10 + m_12 + m_13$
C) $F(w,x,y,z) = m_8 + m_11 + m_13 + m_14$
D) $F(w,x,y,z) = m_9 + m_12 + m_14 + m_15$
E) None of the above.

02. Consider function $F$ shown below. How many gates are present in the unminimized circuit for $F$?

$$F(w,x,y,z) = wx'y'z' + wx'yz + wxy'z + wxyz'$$

A) 4 NOT gates, 4 AND gates, 1 OR gate
B) 4 NOT gates, 12 AND gates, 3 OR gates
C) 6 NOT gates, 4 AND gates, 1 OR gate
D) 6 NOT gates, 12 AND gates, 3 OR gates
E) None of the above.

03. Consider the following K-map for a Boolean function. What is the canonical sum of products expression for $G$?

| $G()$ | $w'x'$ | $w'x$ | $wx$ | $wx'$ |
|-------+---------+-------+-------+-------|
| $y'z'$ | 0       | 0     | 1     | 0     |
| $y'z$  | 0       | 0     | 0     | 0     |
| $yz$   | 0       | 0     | 1     | 0     |
| $yz'$  | 0       | 1     | 0     | 1     |

A) $G(w,x,y,z) = w'xyz + wx'y'z' + wx'yz + wx'yz' + wxy'z + wxyz'$
B) $G(w,x,y,z) = w'x'yz' + wx'y'z + wx'yz + wxyz'$
C) $G(w,x,y,z) = w'x'yz + wx'yz + wxy'z + wxyz'$
D) $G(w,x,y,z) = w'xyz' + wx'y'z' + wx'yz + wxyz'$
E) None of the above.

04. Consider the following K-map for a Boolean function, where "X" represents an irrelevant input combination. What is the optimal expression for $G$?

| $G()$ | $w'x'$ | $w'x$ | $wx$ | $wx'$ |
|-------+---------+-------+-------+-------|
| $y'z'$ | 1       | 1     | 0     | 1     |
| $y'z$  | 1       | X     | 1     | 1     |
| $yz$   | X       | X     | 0     | 1     |
| $yz'$  | X       | 0     | 0     | 1     |

A) $G(w,x,y,z) = x' + w'y' + y'z$
B) $G(w,x,y,z) = wx' + w'y' + y'z$
C) $G(w,x,y,z) = x' + x'y' + w'z + y'z$
D) $G(w,x,y,z) = wx' + y'z + w'y'z'$
E) None of the above.
Consider the following characteristic table for a priority encoder:

<table>
<thead>
<tr>
<th>a b c d</th>
<th>E F G</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0 0</td>
<td>0 X X</td>
</tr>
<tr>
<td>0 0 0 1</td>
<td>1 0 0</td>
</tr>
<tr>
<td>0 0 1 X</td>
<td>1 0 1</td>
</tr>
<tr>
<td>0 1 X X</td>
<td>1 1 0</td>
</tr>
<tr>
<td>1 X X X</td>
<td>1 1 1</td>
</tr>
</tbody>
</table>

Function E indicates whether the result is valid or not, function F produces the most significant bit of the two-bit result, and function G produces the least significant bit of the two-bit result.

05. Consider the circuit described in Figure 1. Which of the following is the optimal expression for function E?

A) \( E(a,b,c,d) = a'b'c'd' \)
B) \( E(a,b,c,d) = a + a''b + a'b'd \)
C) \( E(a,b,c,d) = b + ab' + b'c \)
D) \( E(a,b,c,d) = a + b + c + d \)
E) None of the above.

06. Consider the circuit described in Figure 1. Which of the following is the optimal expression for function F?

A) \( F(a,b,c,d) = a + c \)
B) \( F(a,b,c,d) = a + a'b \)
C) \( F(a,b,c,d) = b + ab' \)
D) \( F(a,b,c,d) = d' + ad + bd \)
E) None of the above.

07. Consider the circuit described in Figure 1. Which of the following is the optimal expression for function G?

A) \( G(a,b,c,d) = a + b'c \)
B) \( G(a,b,c,d) = a + a''b'c \)
C) \( G(a,b,c,d) = ab + ab' + ab'c' \)
D) \( G(a,b,c,d) = ab + b'c + a'b'c \)
E) None of the above.
08. What combinational component does the following truth table represent?

<table>
<thead>
<tr>
<th>A B C</th>
<th>D E F G</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>0 0 1</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>0 1 0</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>0 1 1</td>
<td>0 0 0 0</td>
</tr>
<tr>
<td>1 0 0</td>
<td>0 0 0 1</td>
</tr>
<tr>
<td>1 0 1</td>
<td>0 0 1 0</td>
</tr>
<tr>
<td>1 1 0</td>
<td>0 1 0 0</td>
</tr>
<tr>
<td>1 1 1</td>
<td>1 0 0 0</td>
</tr>
</tbody>
</table>

A) a demultiplexer, where signal A is the control signal
B) a multiplexer, where signal A is the control signal
C) an encoder, where signal A is the enable signal
D) a decoder, where signal A is the enable signal
E) None of the above.

09. Consider a circuit to perform addition on two's complement values. It accepts two 8-bit operands; it produces an 8-bit sum and the NZVC status bits. What is the sum and NZVC status bits for the two operands below?

Operand A: 11001010
Operand B: 00110110

A) Sum: 00000000 NZVC: 0101
B) Sum: 10000000 NZVC: 1001
C) Sum: 01110000 NZVC: 0011
D) Sum: 11110000 NZVC: 1010
E) None of the above.

10. Consider a circuit to perform addition on two's complement values. It accepts two 8-bit operands; it produces an 8-bit sum and the NZVC status bits. What is the sum and NZVC status bits for the two operands below?

Operand A: 11011001
Operand B: 11001011

A) Sum: 01011011 NZVC: 0011
B) Sum: 10100100 NZVC: 1001
C) Sum: 00010010 NZVC: 0000
D) Sum: 10011100 NZVC: 1010
E) None of the above.
11. Consider a negative edge-triggered D Flip-flop, with two synchronous inputs (DATA and CLOCK) and two asynchronous inputs (SET and CLEAR). The asynchronous inputs are active high.

Which of the following input combinations is invalid?

A) DATA = 0  CLOCK = 1  SET = 0  CLEAR = 0
B) DATA = 1  CLOCK = 0  SET = 0  CLEAR = 1
C) DATA = 0  CLOCK = 1  SET = 1  CLEAR = 0
D) DATA = 1  CLOCK = 0  SET = 1  CLEAR = 1
E) None of the above.

12. Consider a negative edge-triggered D Flip-flop, with two synchronous inputs (DATA and CLOCK) and two asynchronous inputs (SET and CLEAR). The asynchronous inputs are active high.

Which of the following input combinations will store 1 in the D flip-flop?

A) DATA = 0  CLOCK = 1  SET = 0  CLEAR = 0
B) DATA = 1  CLOCK = 0  SET = 0  CLEAR = 1
C) DATA = 0  CLOCK = 1  SET = 1  CLEAR = 0
D) DATA = 1  CLOCK = 0  SET = 1  CLEAR = 1
E) None of the above.

13. Consider the following timing diagram for a particular circuit. Assume that "CLOCK" and "DATA" represent the only two inputs to the circuit, and that "OUT" represents the only output signal.

```
<table>
<thead>
<tr>
<th></th>
<th>1111111</th>
<th>1111111</th>
<th>1111111</th>
<th>1111111</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0000</td>
<td>00000000</td>
<td>00000000</td>
<td>00000000</td>
</tr>
<tr>
<td>DATA</td>
<td>1111111111111</td>
<td>1111111111111</td>
<td>111 11111</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0000</td>
<td>0000000000000000 00  000000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OUT</td>
<td>1111111111111111111111111111111111</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>00000000000000000000000000000000000000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

What is the best characterization of this circuit?

A) Level-triggered sequential circuit
B) Positive edge-triggered sequential circuit
C) Negative edge-triggered sequential circuit
D) None of the above.
A circuit functions as a specialized three-bit counter, where the sequence of outputs from the circuit are:

001, 100, 111, 001, 100, 111, and so on.

The mapping of the current state to the next state uses the notation ABC, where A represents the most significant bit of the counter and C represents the least significant bit of the counter.

14. Consider the circuit described in Figure 2. Which of the following is the optimal expression for A?

A) $A = B'C' + A'C$
B) $A = AB'C' + A'B'C$
C) $A = AB' + A'C$
D) $A = B'$
E) None of the above.

15. Consider the circuit described in Figure 2. Which of the following is the optimal expression for B?

A) $B = B'C'$
B) $B = C'$
C) $B = AB'C'$
D) $B = AB'$
E) None of the above.

16. Consider the circuit described in Figure 2. Which of the following is the optimal expression for C?

A) $C = AB'C' + ABC$
B) $C = B + B'C'$
C) $C = BC + B'C'$
D) $C = B + C'$
E) None of the above.
# Figure 3 #

```c
#include <stdio.h>

int main()
{
    int aaa = 195
    int bbb = -194;
    int ccc = 0xb50000e3;
    int ddd = 0x4c00006d;

    printf( "%08x\n", aaa );    // Line 1
    printf( "%08x\n", bbb );    // Line 2
    printf( "%08x %08x\n", (ccc << 8), (ccc >> 12) );     // Line 3
    printf( "%08x %08x\n", (ddd << 16), (ddd >> 20) );    // Line 4
}
```

17. Which of the following statements about the C source code labeled "Line 1" in Figure 3 is correct?

A) It will display 000000c3 when the program is executed.
B) It will display 00000123 when the program is executed.
C) It will display 00000195 when the program is executed.
D) It will display 3c000000 when the program is executed.
E) None of the above.

18. Which of the following statements about the C source code labeled "Line 2" in Figure 3 is correct?

A) It will display ac000000 when the program is executed.
B) It will display 800000c2 when the program is executed.
C) It will display fffffff3e when the program is executed.
D) It will display ffffffe6a when the program is executed.
E) None of the above.

19. Which of the following statements about the C source code labeled "Line 3" in Figure 3 is correct?

A) It will display 0000e300 000b5000 when the program is executed.
B) It will display 0000e300 fffbf500 when the program is executed.
C) It will display 0000e3ff 000b5000 when the program is executed.
D) It will display 0000e3ff fffbf500 when the program is executed.
E) None of the above.

20. Which of the following statements about the C source code labeled "Line 4" in Figure 3 is correct?

A) It will display 006d0000 000004c0 when the program is executed.
B) It will display 006d0000 fffffff4c0 when the program is executed.
C) It will display 006dffff 00004c0 when the program is executed.
D) It will display 006dffff fffffff4c0 when the program is executed.
E) None of the above.
```c
#include <stdio.h>

int main()
{
    unsigned int xxx = 0xb50000e3;
    unsigned int yyy = 0x4c00006d;
    printf( "%08x\n", ~xxx );          // Line 1
    printf( "%08x\n", xxx | yyy );    // Line 2
    printf( "%08x\n", xxx ^ yyy );    // Line 3
    printf( "%08x\n", xxx & yyy );    // Line 4
}
```

21. Which of the following statements about the C source code labeled "Line 1" in Figure 4 is correct?

   A) It will display 04000061 when the program is executed.
   B) It will display 4a00001c when the program is executed.
   C) It will display f900008e when the program is executed.
   D) It will display fd0000ef when the program is executed.
   E) None of the above.

22. Which of the following statements about the C source code labeled "Line 2" in Figure 4 is correct?

   A) It will display 04000061 when the program is executed.
   B) It will display 4a00001c when the program is executed.
   C) It will display f900008e when the program is executed.
   D) It will display fd0000ef when the program is executed.
   E) None of the above.

23. Which of the following statements about the C source code labeled "Line 3" in Figure 4 is correct?

   A) It will display 04000061 when the program is executed.
   B) It will display 4a00001c when the program is executed.
   C) It will display f900008e when the program is executed.
   D) It will display fd0000ef when the program is executed.
   E) None of the above.

24. Which of the following statements about the C source code labeled "Line 4" in Figure 4 is correct?

   A) It will display 04000061 when the program is executed.
   B) It will display 4a00001c when the program is executed.
   C) It will display f900008e when the program is executed.
   D) It will display fd0000ef when the program is executed.
   E) None of the above.
25. Consider the 32-bit single precision floating point number whose internal representation is shown below (in hexadecimal).

7ff00000

Which of the following statements about that number is correct?

A) The bit pattern represents infinity.
B) The bit pattern represents not-a-number.
C) The bit pattern represents zero.
D) The bit pattern represents a denormal number.
E) The bit pattern represents a normalized number.

26. What is the decimal value of the 32-bit single precision floating point number whose internal representation is given below (in hexadecimal)?

bec00000

A) -0.25
B) -0.375
C) -4.0
D) -6.0
E) None of the above.

27. What is the 32-bit single precision internal representation (in hexadecimal) of the decimal value given below?

+9.625 (base 10)

A) 41cd0000
B) 411a0000
C) 3dcd0000
D) 3e1a0000
E) None of the above.
28. Consider the 64-bit double precision floating point number whose internal representation is shown below (in hexadecimal).

\[ 8010000000000000 \]

Which of the following statements about that number is correct?

A) The bit pattern represents infinity.
B) The bit pattern represents not-a-number.
C) The bit pattern represents zero.
D) The bit pattern represents a denormal number.
E) The bit pattern represents a normalized number.

29. What is the decimal value of the 64-bit double precision floating point number whose internal representation is given below (in hexadecimal)?

\[ 4010800000000000 \]

A) +0.125
B) +2.0625
C) +4.125
D) +8.25
E) None of the above.

30. What is the 64-bit double precision internal representation (in hexadecimal) of the decimal value given below?

\[-6.75 \text{ (base 10)}\]

A) c02d800000000000
B) c01b000000000000
C) bfcd800000000000
D) bfdb000000000000
E) None of the above.