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 2 for Fall Semester, 2006

Read this before starting!

- The total possible score for this test is 100 points.
- This test is *closed book and closed notes.*
- *Please turn off all cell phones & pagers during the test.*
- **All** answers **must** be placed in space provided. Failure to do so may result in loss of points.
- **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.
- *Calculators are not allowed.* Use the tables below for any conversions you may need. Leaving numeric equations is fine too.

Binary	Hex
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7

Binary	Hex
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Power of 2	Equals
2^3	8
2^4	16
2^5	32
2^6	64
2^7	128
2^8	256
2^9	512
2^{10}	1K
2^{20}	1M
2^{30}	1G

"Fine print"

Short answers – 2 points each unless otherwise noted

For the following *four* circuits, identify the value of the output Q from the following choices. Consider the D-latch a *rising edge triggered latch*.

a.) 1   b.) 0   c.) Q_0 (stored value of Q)   d.) undefined/illegal   e.) can't tell

1.   0   Answer: _____

$0 \rightarrow$ D $\overline{\text{S}}$ Q $\rightarrow$

$1 \rightarrow$ CLK
$\overline{\text{R}}$

1

2.   1   Answer: _____

$0 \rightarrow$ D $\overline{\text{S}}$ Q $\rightarrow$

$\uparrow \rightarrow$ CLK
$\overline{\text{R}}$

1

3.   1   Answer: _____

$0 \rightarrow$ D $\overline{\text{S}}$ Q $\rightarrow$

$1 \rightarrow$ CLK
$\overline{\text{R}}$

1

4.   1   Answer: _____

$1 \rightarrow$ D $\overline{\text{S}}$ Q $\rightarrow$

$0 \rightarrow$ CLK
$\overline{\text{R}}$

0
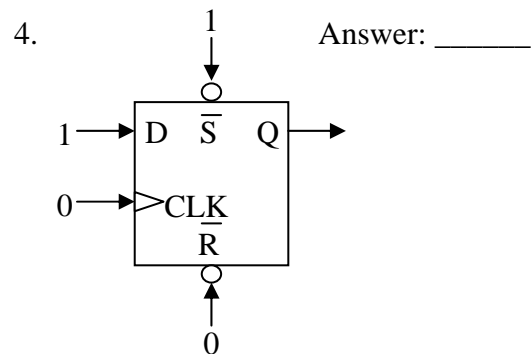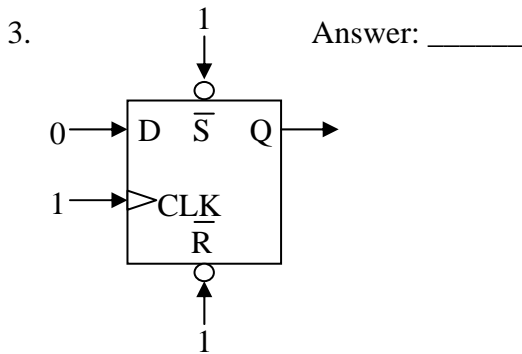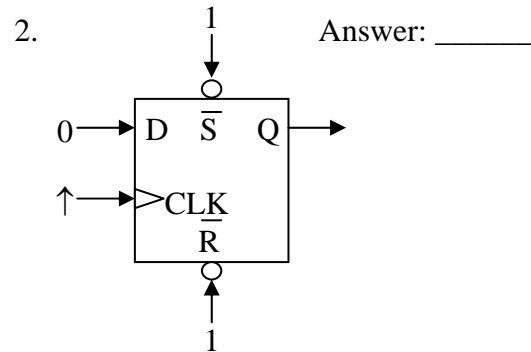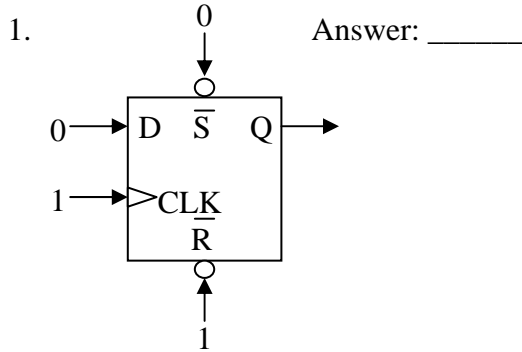
5. The expression $\overline{A}{\cdot}B{\cdot}C + A{\cdot}\overline{B}{\cdot}C + A{\cdot}B$ is not in proper Sum-of-Products format. What boolean algebraic operation would you need to apply first to begin to correct this?

   a.) Commutative Law   b.) Associative Law   c.) Use "F-O-I-L"
   d.) Take the inverse of the inverse   e.) DeMorgan's Theorem   f.) It can't be fixed

6. How many cells would a three-input Karnaugh Map have?

   a.) 2   b.) 4   c.) 6   d.) 8   e.) 12   f.) 16   g.) 32

7. What is the largest number of input variables a Karnaugh map can handle and still remain two-dimensional?

   a.) 2   b.) 3   c.) 4   d.) 5   e.) 6   f.) 7   g.) 8

8. In a 4-variable Karnaugh map, how many input variables (A, B, C, or D) does a product have if its corresponding rectangle of 1's contains 2 cells?

   a.) 1   b.) 2   c.) 3   d.) 4   e.) Cannot be determined

9. An active-high transparent latch copies data from the D input to the Q output:

   a.) as long as the clock equals a logic 0   b.) the instant the clock changes from a 1 to a 0
   c.) as long as the clock equals a logic 1   d.) the instant the clock changes from a 0 to a 1

10. True or False: The $\overline{\text{S}}$ and $\overline{\text{R}}$ inputs of a D-latch override any input from the D and clock inputs.

11. Make the connections to the latch in the figure to the right that makes a divide-by-two circuit, i.e., divides the frequency F in half at the output Q.
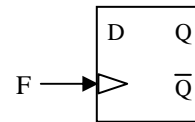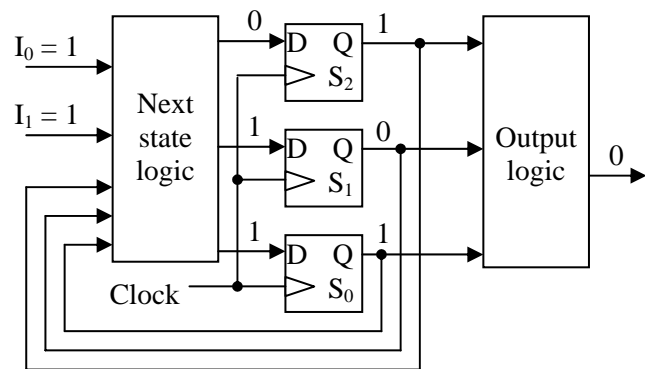

12. Which of the following expressions produces the truth table to the right?

a.) $A \cdot \overline{B} + C$

b.) $A + C$

c.) $A \cdot B + C$

d.) $B + C$

e.) $A + \overline{B} \cdot C$

f.) None of the above

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

The next five problems use the state machine circuit to the right. Assume that the states are numbered so that bit S_2 is the MSB and bit S_0 is the LSB.

13. What is the maximum number of states that this system can handle?

14. What is the current state of this system? Keep your answer in binary.

15. If the clock were to pulse right now, what would the next state be? Keep your answer in binary.

16. The truth table to the right represents the output logic truth table for the above state machine. Circle the row that identifies the current output condition of the system, i.e., which row is represented by the state of the logic in the diagram above?

S_2	S_1	S_0	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

17. If the clock were to pulse right now, what would the output be? Use the truth table from the previous problem to answer the question.

a.) 0   b.) 1   c.) Not enough information given

18. True or False: Renumbering the states of a state machine has no effect on the "next state" logic for the digital hardware implementation.

19. How many latches will a state machine with 23 states require?

a.) 3   b.) 4   c.) 5   d.) 6   e.) 7   f.) 8   g.) 9

20. If a group of four rows or columns in a Karnaugh map is identified with two variables, it is numbered 00, 01, 11, 10 instead of 00, 01, 10, 11. Why?

21. Identify the two errors in the state diagram to the right. The circuit is to have a single binary input B. Do not bother to correct the errors. (2 points each)

Reset   B=0   B=1

A / off   D / on
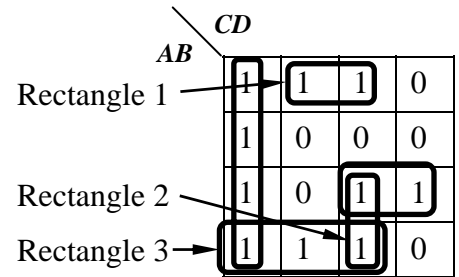
B=0   B=1

B / off   B=1   C / on   B=0

B=0
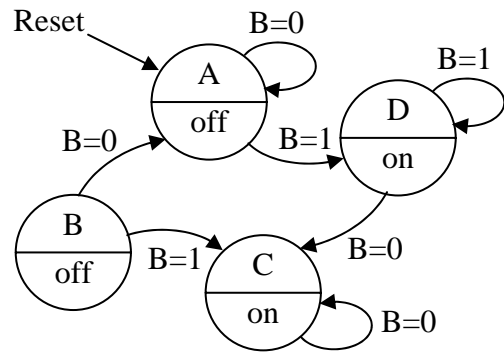
22. For the Karnaugh map to the right, identify the problems with each of the three rectangles shown. (2 points each)

Rectangle 1:
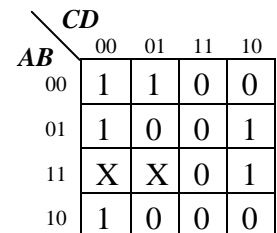
Rectangle 2:

Rectangle 3:

CD
AB

	1	1	0
1	0	0	0
1	0	1	1
1	1	1	0

Rectangle 1
Rectangle 2
Rectangle 3

Medium answers – 4 points each

23. Complete the truth table to the right with the values for the following sum-of-products expression:

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

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

24. In the Karnaugh map to the right, draw the best pattern of rectangles you can. *Do not derive the SOP expression.*

CD

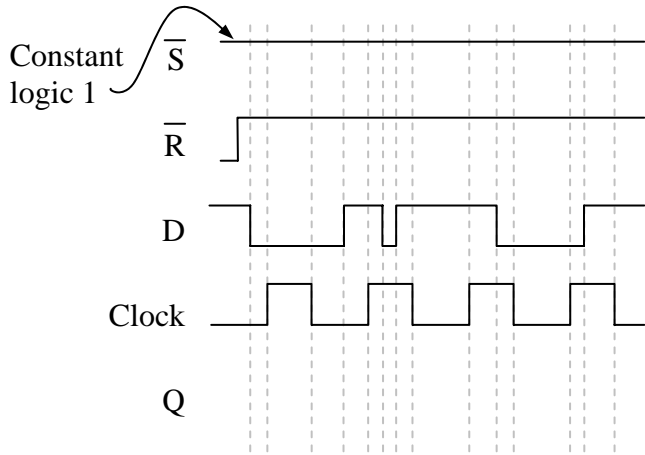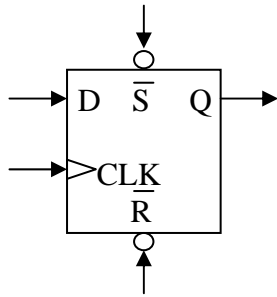| AB	00	01	11	10
00	1	1	0	0
01	1	0	0	1
11	X	X	0	1
10	1	0	0	0

25. In the space to the right, draw the decoding logic circuit with an active-low output that identifies when A = 1, B = 1, C = 1, D = 0, and E = 0.

26. Create a Karnaugh map from the truth table below. ***Do not worry about making the rectangles.***

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	1
1	1	0	0
1	1	1	0

27. Show the D latch output waveform Q based on the inputs D, $\bar{S}$, $\bar{R}$, and clock indicated in the graph to the right. Assume the latch captures on the rising edge. (The figure below is just for a reference.)


Longer answers – Points vary per problem

28. Make the state diagram that will output a '1' when the sequence '110' is detected in a serial stream of bits. For example, if the following binary stream is received:

0 0 1 1 1 0 1 0 1 0 1 1 1 1 0 0 0 0 1 1 0 1 1 1 0 0 1 0

then 1's will be output at these points. At all other times, the system will output zeros. Label the input D. (8 points)

Initial state

No digits
0
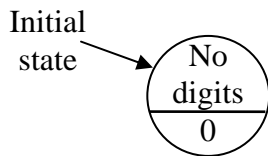
29. Derive the minimum SOP expression from the Karnaugh map below. (6 points)

AB\CD	00	01	11	10
00	0	0	0	1
01	1	1	0	1
11	1	1	0	1
10	1	1	1	1

30. Create the next state truth table and the output truth table for the state diagram to the right. Use the variable names S_1 and S_0 to represent the most significant and least significant bits respectively of the binary number identifying the state. Label the output 'X'. (8 points)

P=1   P=0

00 / 0   01 / 1

P=0   P=1   P=0   P=1

11 / 0   10 / 1

P=1   P=0
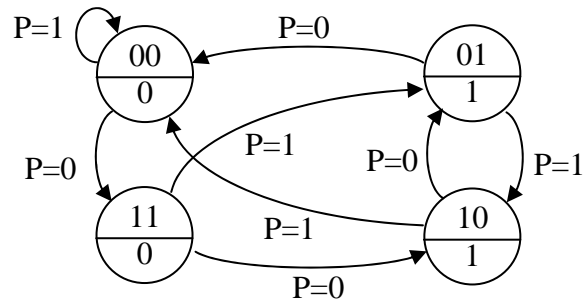
31. The three Boolean expressions below represent the *next state bits (S₀' and S₁')* and the *output bit X* based on the *current state (S₀ and S₁)* and the *input A*. Draw the logic circuit for the state machine including the latches and output circuitry. *Be sure to label the latch inputs and other signals.*
(8 points)

$$S_0' = S_1 + A \qquad\qquad S_1' = \overline{S_0} \cdot A \qquad\qquad X = S_1$$