EE 266

Final: May 2, 1995

Complete this page, but do not open the test until you are instructed to do so. You will have one hundred-twenty (120) minutes to complete the exam. The exam is closed book and notes. No calculators are allowed. Make sure you budget your time well. Strategy statements are not required unless specifically requested (problems 10010 and 10101).

Check which section you are in: 8:30 ____ or 11:30 ____
Write down your seat assignment: Row ____ Number ____

Scores:

Problem	Possible	Attained
00001	30	____
00010-01011	40	____
01100-10000	25	____
10001	30	____
10010	15	____
10011	20	____
10100	15	____
10101	25	____
Total	200	

00001. (2 pts. each) Circle either T — if the statement is always true, or F — if the statement is false.

T F A student's Social Security number, student ID number, and course ID number are all the same number.

T F An AND gate is the same as an OR gate with its inputs complemented.

T F Taking a Boolean expression's dual is the same as applying DeMorgan's Law.

T F A Full Adder has 3 inputs and 3 outputs.

T F Any Boolean function can be generated using only AND and OR gates.

T F Any Boolean function can be generated using demultiplexers alone.

T F The difference between a programmable logic array (PLA) and programmed array logic (PAL) is that the PLA has an OR array that cannot be personalized while the PAL does.

T F Static zero hazards never occur in SOP circuits.

T F Synchronous control inputs are sampled only on a clock edge.

T F A clocked S-R Latch holds the present state when the clock is inactive regardless of the changes on the latch's S and R inputs.

T F A master/slave FF samples its inputs on one edge of the clock while it changes its output on the other edge.

T F An edge triggered J-K Flip-Flop is susceptible to one's catching.

T F A Moore Machine usually has fewer states than an equivalent Mealy Machine.

T F One problem with a standard Mealy Machine is that its output changes are not synchronized to the changes in the clock.

T F Correct use of the Minimum-Bit-Change heuristic provides an optimal state assignment for state machines with fewer than 8 states.

Multiple choice (4 pts. per problem). Circle the most appropriate answer.

00010. A certain "black box" has four inputs and 16 outputs. Only one of the 16 outputs is asserted for each unique combination of the inputs. What is the black box called?

a) 4:16 encoder
b) 16:4 encoder
c) 16:4 decoder
d) 16:4 multiplexer
e) None of the above

00011. A sequential circuit is to output a "1" if and only if an even number of 1's are input. The minimum number of states required is:

a) 0
b) 1
c) 2
d) 3
e) None of the above

00100. When a J-K Flip-Flop is constructed from an S-R Flip-Flop which one of the following is true?

a) $S = JQ$ and $R = K + J\overline{Q}$
b) $S = J$ and $R = K + \overline{Q}$
c) $S = JQ$ and $R = K\overline{Q}$
d) $S = J\overline{Q}$ and $R = KQ$
e) None of the above

00101. A J-K Flip-Flop has its J input connected to logic level 1 and its K input connected to the Q output. A clock pulse is fed into is clock input. The Flip-Flop will:

a) change its state at each clock pulse.
b) set $Q = 1$ and stay there.
c) set $Q = 0$ and stay there.
d) retain the previous value of Q.
e) None of the above

00110. Given a Mealy machine with 5 inputs, 6 state Flip-Flops, and 12 outputs. What is the maximum possible number of transition arrows that can leave a single state?

a) 16
b) 32
c) 64
d) 384
e) None of the above

00111. Given a Mealy machine with 5 inputs, 6 state Flip-Flops, and 12 outputs. What is the maximum possible number of output patterns that this machine can produce?

a) 12×2^6
b) 5×2^6
c) 2^{11}
d) 12×2^{11}
e) None of the above

01000. If the binary number 1101 is interpreted using sign magnitude, one's complement and two's complement notation, its decimal equivalent is, respectively:

a) $(-13, -2, -3)$
b) $(13, -2, -3)$
c) $(-5, -2, -3)$
d) $(13, -3, -2)$
e) $(-5, -3, -2)$

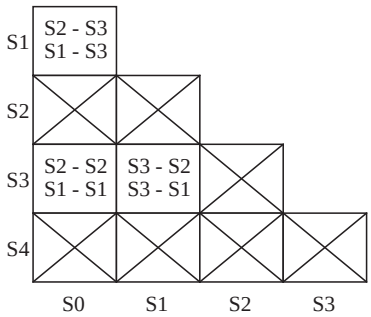
01001. What is the minimum number of states the row-matching method would yield for the state machine described by the following table?

a) 3
b) 5
c) 6
d) 7
e) None of the above

Present State	Next State $X=0$	Next State $X=1$	Output $X=0$	Output $X=1$
S_0	S_2	S_3	0	1
S_1	S_3	S_3	0	0
S_2	S_2	S_3	0	1
S_3	S_1	S_0	0	0
S_4	S_6	S_6	1	1
S_5	S_2	S_5	0	1
S_6	S_6	S_6	0	1

01010. Given the initial implication chart below, what is the minimum number of states possible?

a) 3
b) 4
c) 5
d) 6
e) None of the above



01011. For the initial implication chart in the previous problem,

a) We know with absolute certainty that S_2 has a different next state than all of the other states.
b) We know with absolute certainty that S_2 has a different output than all of the other states.
c) We do not have enough information to know whether S_2 has a different output than all of the other states.
d) Two of the above are true.
e) None of the above

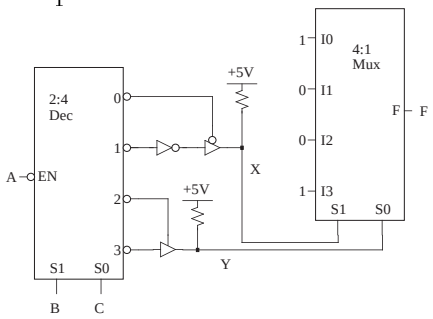
Multiple choice (5 pts. per problem). Circle the most appropriate answer.

01100. Which of the following Boolean expressions is *not* logically equivalent to all the rest?

a) $AB\overline{C} + A\overline{D} + ABCD + A\overline{C}D$
b) $A(B + \overline{C} + \overline{D})$
c) $AB + A\overline{C} + A\overline{D}$
d) $A + B + \overline{C} + \overline{D}$
e) None of the above

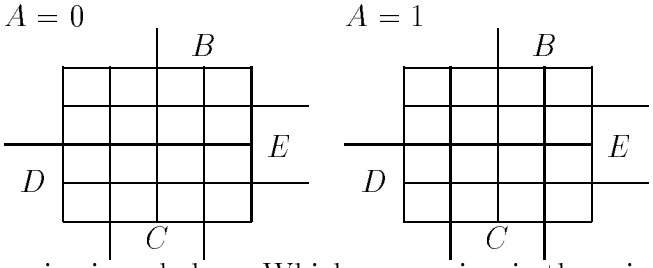
01101. Given $ABC = 011$ the circuit below will produce $XYF =$

a) 111
b) 101
c) 100
d) 001
e) None of the above



01110. $F(A,B,C,D,E) = \Pi M(0,2,5,6,7,8,10,12,13,14,15,16,18,24,26,28,29,30,31)$
Which choice best describes the minimized function?

a) $\overline{A}\,\overline{C}E + \overline{A}\,\overline{B}\,\overline{C}\,\overline{D}\,\overline{E} + A\overline{B}C + A\overline{C}E$
b) $\overline{A}BC + \overline{A}D\overline{E} + \overline{C}\,\overline{E} + CE$
c) $\overline{C}\,\overline{E} + BC + \overline{A}CE + \overline{A}D\overline{E}$
d) $\overline{C}E + A\overline{B}C + \overline{B}C\overline{D}\,\overline{E}$
e) None of the above



01111. Consider the function whose K-map is given below. Which expression is the minimum sum of products representation?

a) $\overline{B}C + \overline{A}\,\overline{C}D + B\overline{C}\,\overline{D}$
b) $\overline{B}C + \overline{A}BD + \overline{A}B\overline{C} + B\overline{C}\,\overline{D}$
c) $\overline{B}C + AB$
d) $\overline{B}C + \overline{A}\,\overline{C}\,\overline{D} + A\overline{C}D$
e) None of the above

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

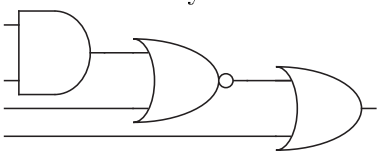
10000. What is the best hazard-free representation of the function in the previous problem.

a) $\overline{B}C + \overline{A}\,\overline{C}D + B\overline{C}\,\overline{D} + \overline{A}\,\overline{B}D + \overline{A}B\overline{C}$
b) $\overline{B}C + \overline{A}BD + \overline{A}B\overline{C} + B\overline{C}\,\overline{D}$
c) $\overline{B}C + \overline{A}\,\overline{C}D + B\overline{C}\,\overline{D} + \overline{A}\,\overline{B}D$
d) $\overline{B}C + \overline{A}\,\overline{C}\,\overline{D} + A\overline{C}D + \overline{A}\,\overline{B}D + \overline{A}B\overline{C}$
e) None of the above

10001. (5 pts. per part) There will be no partial credit on this question.

(a) List all maxterms possible for a two-input function, $F(A, B)$.

(b) Convert the following circuit into a circuit consisting of NAND gates only. (Place a box around your final answer.)



(c) How many prime implicants are in the following K-map? _____

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

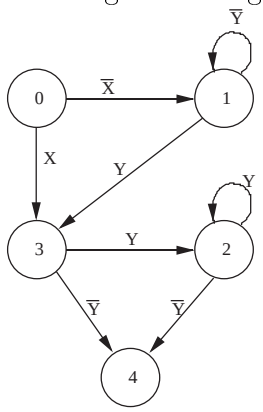
(d) Clearly show the essential prime implicants for the following K-map.

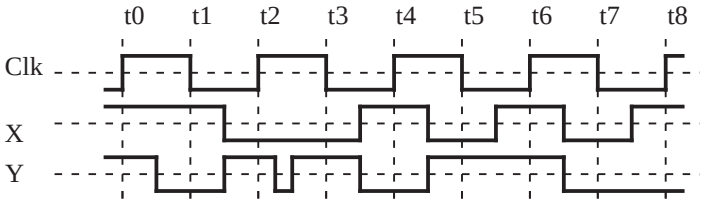
C \ AB	00	01	11	10
00	1	0	1	1
01	1	0	0	0
11	1	1	1	1
10	1	0	1	1

(e) Use DeMorgan's Law to write an expression for the complement of $F = Z + \overline{X}Y$ in terms of AND and OR gates only. Assume that you have all the literals available to you.

(f) Rewrite the following expression in its simplest form:
$F = (\overline{W} + Y)(\overline{W} + X)\overline{(WY)}\,\overline{(WX)}$

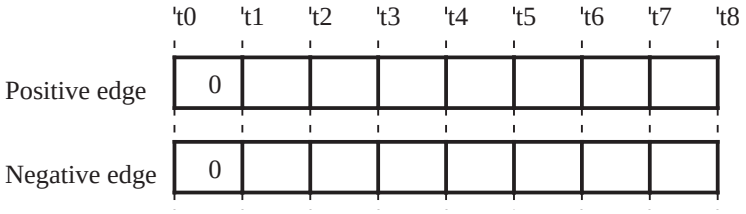
10010. (15 pts.) You are given the following state diagram and timing waveform.





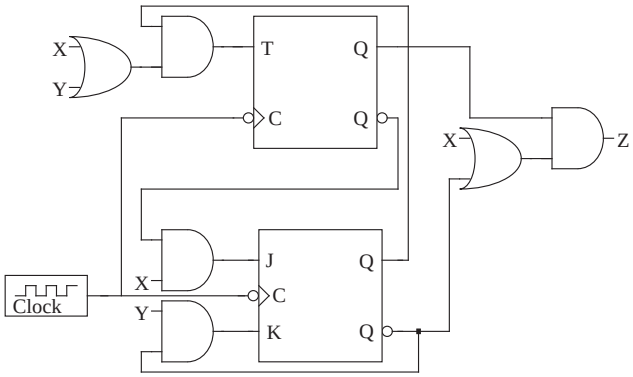
Between time t_0 and t_1, the FSM is in state 0. Fill in the following tables, giving the state the machine is in for each of the indicated time intervals. The first table assumes that the state Flip-Flops are positive edge triggered while the second table assumes the Flip-Flops are negative edge triggered.

Strategy: (4 pts.)



10011.

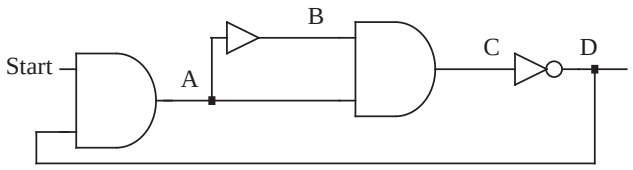
(a) (15 pts.) For the following circuit, determine the Boolean expressions for the next state and output in terms of the inputs and the current state.

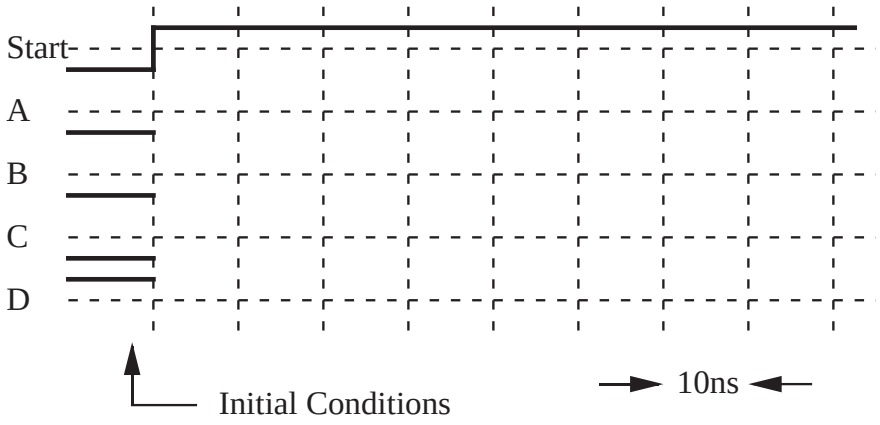


Let Q_1 be the T Flip-Flop and Q_2 be the J-K Flip-Flop.

(b) (5 pts.) Is this a Moore or Mealy machine? _____ Why?

10100. (15 pts.) Complete the timing diagram for the circuit. Assume each gate has a delay of 10 nanoseconds. NOTE: A DEPENDS ON D.





10101. In a small village on the edge of a fjord lives a population of trolls who love to watch Big Ten Basketball. The population is made up of two distinct groups: Group X who want Bobby Knight as their mayor and Group Y who want Gene Keady as their mayor. Trolls from Group X prefer burritos from *Taco Bell*, whereas trolls from Group Y prefer burritos from *La Bamba* ("Burritos as big as your head"). Trolls from Group X flip a fair coin *every* time they are asked a question and truthfully answer the question if the outcome is heads, but lie if the outcome is tails. Trolls in Group Y never tell a lie.

A troll is selected at random and asked the following four questions. The troll must answer either yes (1) or no (0) to each of the questions.

(A) Do you want Gene Keady to be your mayor?
(B) Do you prefer burritos from *Taco Bell* to burritos from *La Bamba*?
(C) If money grew on peach trees, would you call their seeds "Money pits"?
(D) Are you a troll from Group Y?

(a) (15 pts.) Complete the following truth table, where X is asserted if the troll is from Group X, Y is asserted if the troll is from Group Y, and Z is asserted if it is impossible to say with certainty which group the troll belongs to. HINT: CONSIDER THE FOLLOWING QUESTION: DOES THE ANSWER TO (C) HELP YOU DETERMINE WHICH GROUP THE TROLL IS FROM?

A	*B*	*C*	*D*	*X*	*Y*	*Z*
0	0	0	0			
0	0	0	1			
0	0	1	0			
0	0	1	1			
0	1	0	0			
0	1	0	1			
0	1	1	0			
0	1	1	1			
1	0	0	0			
1	0	0	1			
1	0	1	0			
1	0	1	1			
1	1	0	0			
1	1	0	1			
1	1	1	0			
1	1	1	1			

Strategy: (4 pts.)

(b) (10 pts.) Implement X, Y, and Z with three 3-input open collector NAND and as many 470Ω resistors as you need.

IF YOU ARE UNABLE TO IMPLEMENT THE X, Y, AND Z FROM PART (A), IMPLEMENT THE FOLLOWING FOR A MAXIMUM OF 7 POINTS. $X = C$, $Y(A, B, C, D) = \sum m(12, 13)$, AND $Z(A, B, C, D) = \prod M(12, 13)$. (*Do this ONLY if you are unable to implement your answer from part (a).*)

Strategy: (3 pts.)