Section (Circle One): Monday/Tuesday

NAME: SOLUTIONS **UNumber:**____________________ **Computer Logic Design**
Duration: 120 Minutes **CDA 3201** **December 5, 2015**
Closed Book, Notes, HW **Final Exam** **R. Kasturi**

SHOW ALL WORK TO GET PARTIAL CREDIT (except for True/False questions)
Make reasonable assumptions.
One sheet of Letter size paper written on front and back is allowed.

I Answer True or False (one point each).

T a. If 110000 and 001111 are in 6-bit 2's complement form its sum is equal to negative 1.

F b. Row matching method cannot be used for Mealy finite state machines.

T c. $\sum m(1,3,5,6,7)$ and $\prod(1,3,5,6,7)$ are complements of each other.

T d. In a Mealy machine the output responds to changes in the input without waiting for the registers to change state at the next clock pulse.

T e. The output from a Mealy circuit must be read just prior to active clock edge to avoid *false outputs* that may occur before the input changes.

T f. An 8x1 multiplexer can be realized by using seven 2x1 multiplexers.

F g. Every *Don't Care* term must be a part of at least one product term in the final result of Quine McCluskey method.

F h. When an even number of inverters are cascaded (i.e., output of the first inverter is connected to input of the second and so on and the output of the last inverter connected back to the input of the first one) we get an oscillating circuit with a period of oscillation equal to cumulative propagation delay of all inverters.

T i. $(AC + AD + ABC + ABD)(\overline{C} + E) = ACE + A\overline{C}D.$

F j. Every state of a Moore Finite State Machine must have direct arcs to every other state.

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II (10 points) Use the **Quine-McCluskey Method** to find the minimum sum of products form for the Boolean expression $F(W,X,Y,Z) = \boldsymbol{\Sigma m}(0,5,9,10,15) + \boldsymbol{\Sigma d}(2,8,11)$

Quine-McCluskey Implication Table

Groups	Column 1	Column 2	Column 3
0	0000 ✓	00–0 ✓	
2	0010 ✓	–000 ✓	–0–0 *
8	1000 ✓	–010 ✓	
5	0101 *	100– ✓	
9	1001 ✓	10–0 ✓	
10	1010 ✓	10–1 ✓	10–– *
		101– ✓	
11	1011 ✓		
15	1111 ✓	1–11 *	

KMap (optional for reference)

YZ \ WX (PQ/RS)	00	01	11	10
00	(0) 1	(4) 0	(12) 0	(8) X
01	(1) 0	(5) 1	(13) 0	(9) 1
11	(3) 0	(7) 0	(15) 1	(11) X
10	(2) X	(6) 0	(14) 0	(10) 1

Prime Implicant Chart

Prime Implicants \ Minterms		0	5	9	10	15	EPI?
5	0101		⊗				✓
(11,15)	1–11					⊗	✓
(0,2,8,10)	–0–0	⊗			X		✓
(8,9,10,11)	10––			⊗	X		✓

Final Boolean Expression, $F(W,X,Y,Z) = \overline{W}X\overline{Y}Z + WYZ + \overline{X}\,\overline{Z} + W\overline{X}$

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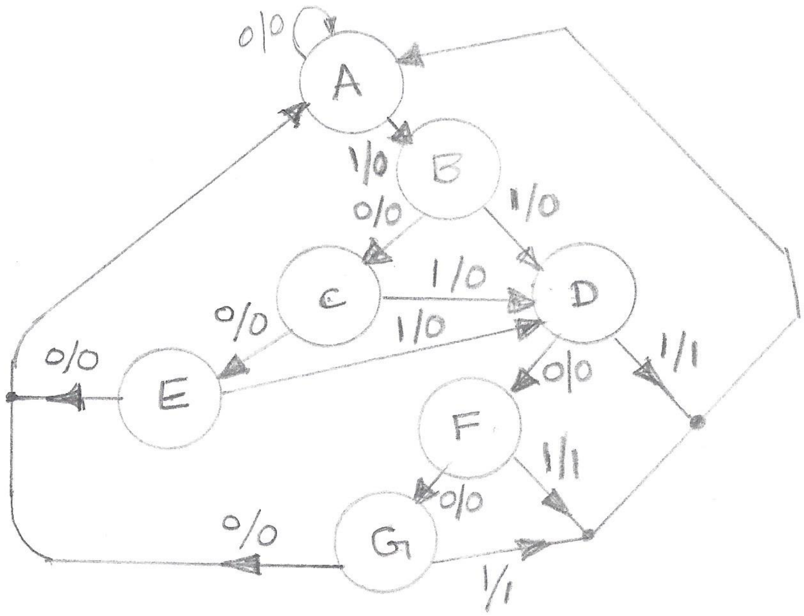
III a. (5 points) Draw the State Graph of a Mealy Finite State Machine which has one input X and one output Z. It starts in State A (Reset state) and returns to A when three consecutive 0s are received. It outputs a 1 and returns to State A when the number of 1s received since previous Reset is equal to 3. Note that the 1s need not be consecutive. Label the states as A, B, C etc. (Hint: Full credit for solutions requiring no more than a total of 7 states).



III b. (5 points) Using K-Map simplify the function

$$f(A, B, C, D, E) = \sum(3,7,12,14,15,16,19,23,24,27,28,29,31) + \sum d(4,5,6,13,18,26,30)$$

A=0

DE \ BC	00	01	11	10
00	0	X	1	0
01	0	X	X	0
11	1	1	1	0
10	0	X	1	0

A=1

DE \ BC	00	01	11	10
00	1	0	1	1
01	0	0	1	0
11	1	1	1	1
10	X	0	X	X

$f(A,B,C,D,E) =$

$BC + \overline{B}DE + A\overline{C}\overline{E} + (ABD \text{ OR } ADE)$

We need one of these two.

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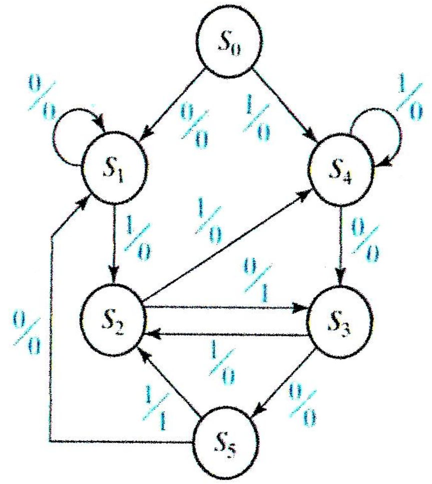
IV a. Consider the following State Graph.



Present State	Next State X=0	Next State X=1	Output X=0	Output X=1
S0	S_1	S_4	0	0
S1	S_1	S_2	0	0
S2	S_3	S_4	1	0
S3	S_5	S_2	0	0
S4	S_3	S_4	0	0
S5	S_1	S_2	0	1

Q2Q3 \ Q1	0	1
00	S_0	
01	S_1	S_2
11	S_3	S_4
10	S_5	

State Assignment

(i) (1 point) Complete the State Transition and Output Table shown above

(ii) (3 points) List all sets of adjacent states suggested by the three State Assignment Guidelines

Guideline 1: (S_0, S_1, S_5), (S_2, S_4), (S_0, S_2, S_4), (S_1, S_3, S_5)

Guideline 2: (S_1, S_4), $(S_1, S_2)\times 2$, $(S_3, S_4)\times 2$, (S_3, S_5)

Guideline 3: $(S_0, S_1, S_3, S_4, S_5)$, $(S_0, S_1, S_2, S_3, S_4)$

(iii) (2 point) Complete the State Assignment Table shown above which satisfies as many guidelines as possible.

IV b. One-Hot State Assignment is used to build the following sequential circuit.

Present State	Next State X=0	Next State X=1	Present Output	One-Hot State Assignment
A	B	A	0	1000
B	C	A	0	0100
C	B	D	0	0010
D	D	D	1	0001

Let the FFs be labeled as $Q_A Q_B Q_C Q_D$ for A B C D Respectively.

(i) (2 points) How many flip flops are required for this design? Enter the binary code representing each state in the last column above.

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(ii) (2 points) By inspection, write the Boolean expressions for D input of each flip-flop.

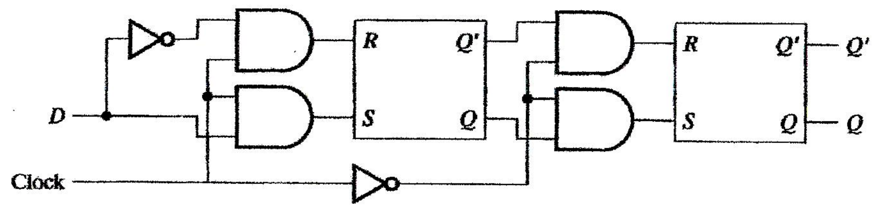
$$Q_A^+ = D_A = (A+B)\cdot X = (Q_A+Q_B)\cdot X$$

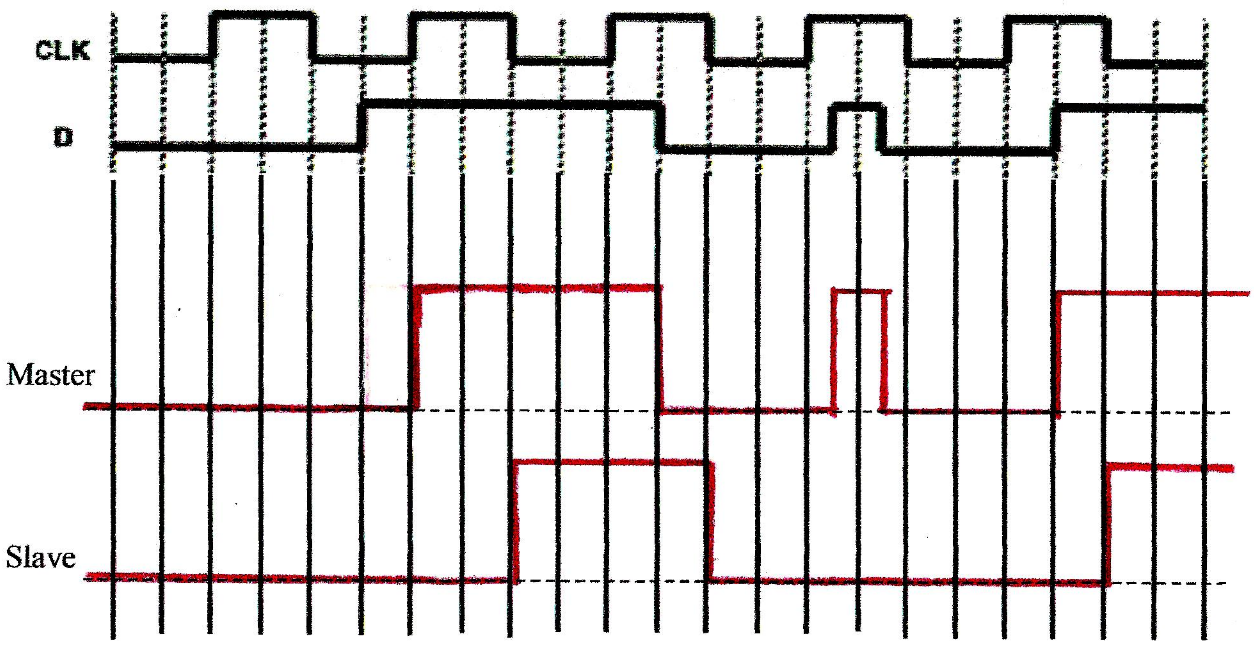
$$Q_B^+ = D_B = (A+C)\cdot \overline{X} = (Q_A+Q_C)\cdot \overline{X}$$

$$Q_C^+ = D_C = B\overline{X} = Q_B\overline{X}$$

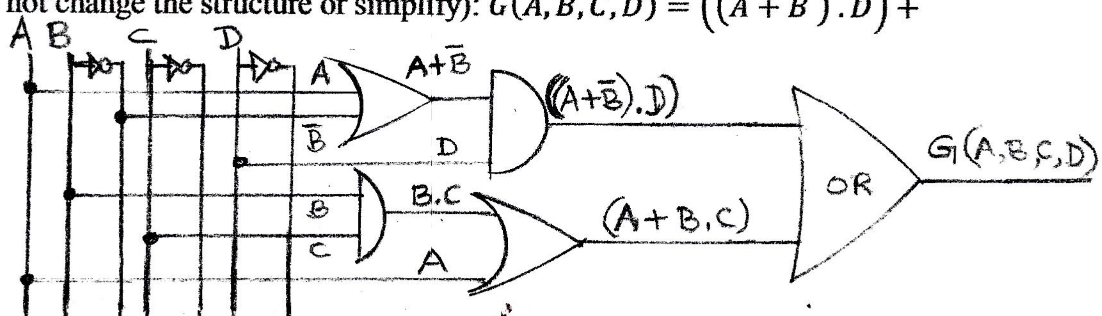
$$Q_D^+ = D_D = CX + D = Q_C X + Q_D$$

V a. (6 points) For the input and clock transitions to the Master-Slave flip-flop shown below, draw the corresponding Q outputs of Master and Slave states. Assume that all delays are negligible.



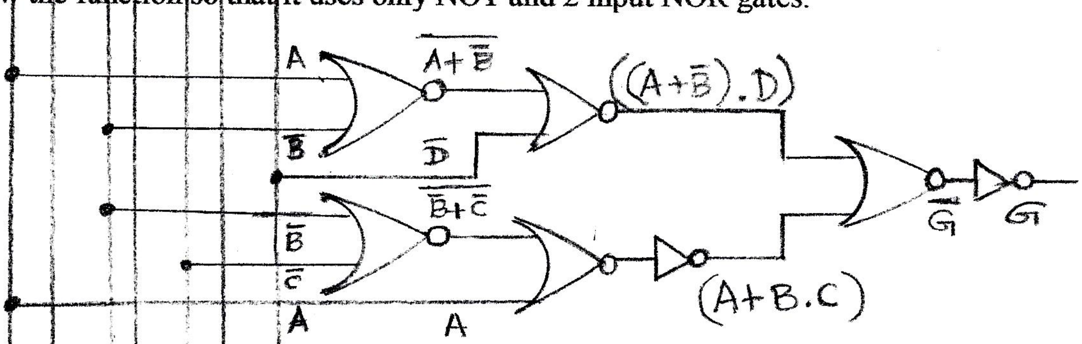


V b. (i) (2 points) Draw the gate level diagram for the following multi-level function as expressed (do not change the structure or simplify): $G(A,B,C,D) = \left((A+\overline{B}).D\right) + (A + B.C)$



(ii) (2 points) Redraw the function so that it uses only NOT and 2 input NOR gates.

- Using DeMorgan's Theorem we can change AND to ORs. Then add inverters as needed to realize the specified NOR-NOT realization.



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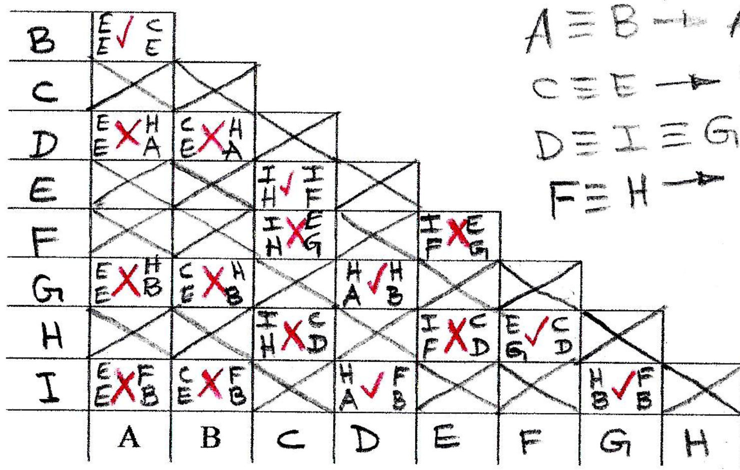
VI a. (i) (4 points) Reduce the following state table using **Implication Chart** method **(Do not use** Row Matching**).**

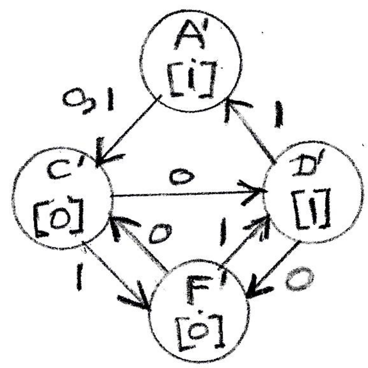
Present State	Next State X=0	Next State X=1	Present Output
A	E	E	1
B	C	E	1
C	I	H	0
D	H	A	1
E	I	F	0
F	E	G	0
G	H	B	1
H	C	D	0
I	F	B	1



$A \equiv B \to A'$
$C \equiv E \to C'$
$D \equiv I \equiv G \to D'$
$F \equiv H \to F'$

(ii) (2 points) Complete the **Reduced State Table** below and draw the **Reduced State Graph.**

Present State	Next State X=0	Next State X=1	Present Output
A'	C'	C'	1
C'	D'	F'	0
D'	F'	A'	1
F'	C'	D'	0



VI b. (4 points) Find the **minimized hazard free Sum of Products form** of the function
$F(A,B,C,D) = \prod M\,(1,3,4,5,7,9,10,11,13)$.

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

$F(A,B,C,D) = \bar{B}\bar{C}\bar{D} + A\bar{C}\bar{D} + ABC + \bar{A}C\bar{D}$
$+ \bar{A}\bar{B}\bar{D} + AB\bar{D} + BC\bar{D}$