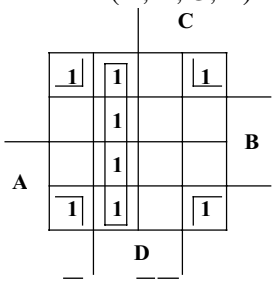
The University of Alabama in Huntsville
ECE Department
CPE/EE 422/522 01
Midterm Exam Solution

1. (4 points) In general, what are static hazards in a combinational network.

   Static hazards occur when an output has the wrong value temporarily due to propagation delay difference down multiple paths or simultaneous changes on multiple inputs.

2. (5 points) Obtain a minimum sum of products expression for the following function:

   $f(A, B, C, D) = \Sigma m(0, 1, 2, 5, 8, 9, 10, 13)$



$f = \overline{C}D + \overline{B}\overline{D}$

3. (7 points) Write a short VHDL description of a negative edge-triggered D flip-flop using a VHDL process.

```
entity DFF is
  port (D, CLK : in bit;
        Q, QBAR  : out bit);
end DFF;

architecture DFF of DFF is
begin
  process (CLK)
  begin
    if (CLK'event and CLK = '0') then
      Q <= D;
      QBAR <= not D;
    end if;
  end process;
end DFF;
```

4. (15 points) In the following VHDL process A, B, C, and D are all integers that have a value of 0 at time – 10 ns. If E changes from '0' to '1' at time 20 ns, specify the time(s) at which each signal will change and the value to which it will change. List these changes in chronological order. List any delta delays as a separate entry.

```
P1: process
begin
  wait on E;
  A <= 1 after 5 ns;
  B <= A + 1;
  wait for 0 ns;
  C <= B after 10ns;
  D <= A after 3 ns;
  A <= A + 5 after 15 ns;
```

```
  B <= B + 7;
end process P1;
```

Time	A	B	C	D	E
10 ns	0	0	0	0	0
20 ns	0	0	0	0	1
20 + Δns	0	1	0	0	1
20 + 2Δns	0	8	0	0	1
23 ns	0	8	0	0	1
30 ns	0	8	1	0	1
35 ns	5	8	1	0	1

5. (6 points) What are the differences between signals and variables in VHDL? Where can signals and variables be used within a typical VHDL model?

Signals

- Declared in entities (ports), architectures, blocks
- Values are scheduled to occur at a certain time, each signal has a queue of scheduled transactions
- Can be used to communicate between processes

Variables

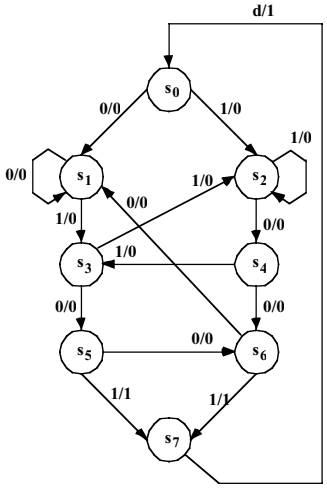
- Declared in processes, procedures, functions
- Assignments take effect immediately
- Can be used inside processes

6. (15 points) A synchronous sequential network has one input and one output. If the input sequence 1001 or 0101 occurs, an output of two successive 1s will occur. The first of these 1s should occur coincident with the last input of the 1001 or 0101 sequence. The network should reset when the second 1 output occurs. For example,

Input sequence: 01101100010010 1101010
Output sequence: 00000000000011 0000011

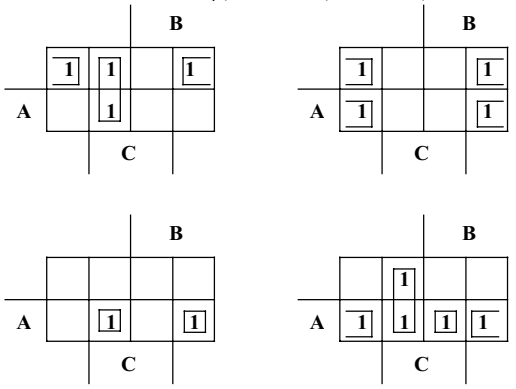
Derive a Mealy state graph and table with a minimum number of states (8 states

	Next State		Output	
Present State	X=0	X=1	X=0	X=1
S0	S1	S2	0	0
S1	S1	S3	0	0
S2	S4	S2	0	0
S3	S5	S2	0	0
S4	S6	S3	0	0
S5	S6	S7	0	1
S6	S1	S7	0	1
S7	S0	S0	1	1



8. (10 points) Find a minimum-row PLA table to implement the following sets of functions.

$f_1(A, B, C) = \Sigma m(0, 1, 2, 5)$
$f_2(A, B, C) = \Sigma m(0, 2, 4, 6)$
$f_3(A, B, C) = \Sigma m(5, 6)$
$f_4(A, B, C) = \Sigma m(1, 4, 5, 6, 7)$



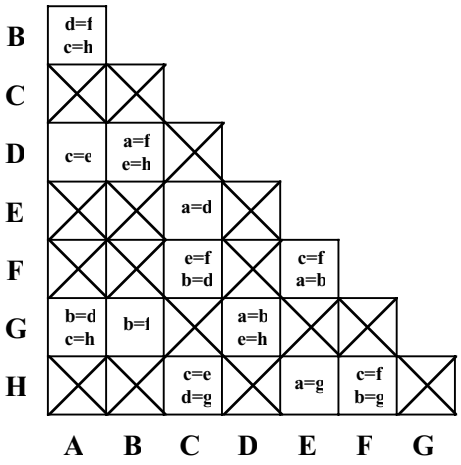
$f_1 = \overline{B}C + \overline{A}\overline{C}$
$f_2 = \overline{A}\overline{C} + A\overline{C}$
$f_3 = A\overline{B}C + AB\overline{C}$
$f_4 = \overline{B}C + A\overline{C} + ABC$

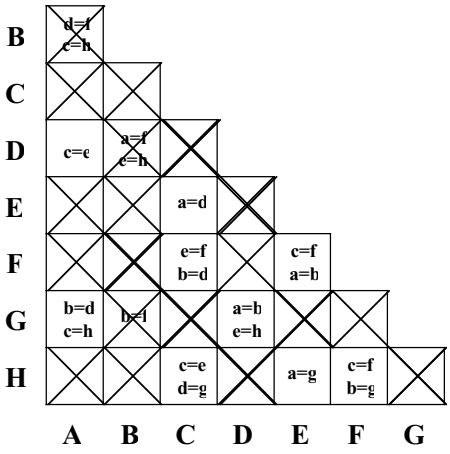
A	B	C	f_1	f_2	f_3	f_4
-	0	1	1	-	-	1
0	-	0	1	1	-	-
1	-	0	-	1	-	1
1	0	1	-	-	1	-
1	1	0	-	-	1	-
1	1	1	-	-	-	1

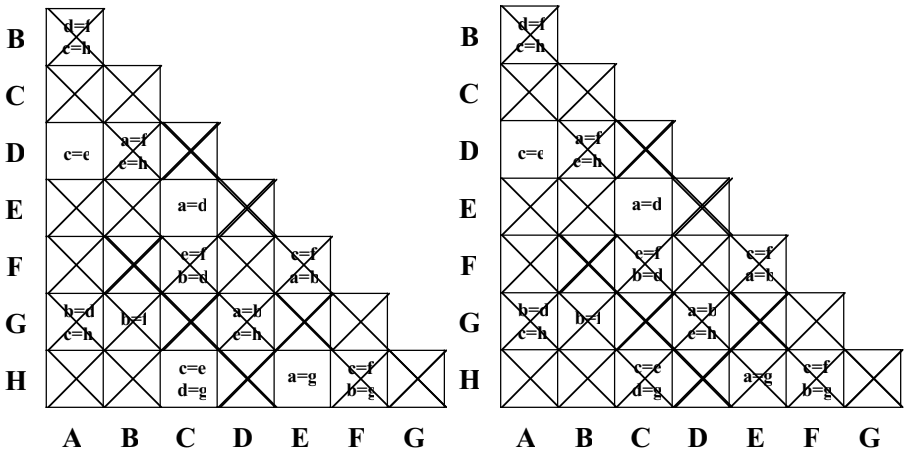
7. (10 points) Reduce the following state table to a minimum number of states. Show all your work in determining the state equivalents.

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

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







9. (5 points) Write out the truth table for the following equation.

F = (A + B')•(C + D)

A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

10. (5 points) What is the difference between combinational and sequential logic?

Sequential logic depends on both present inputs and previous inputs (state)
Combinational logic depends on present inputs only

11. (5 points) What is the purpose of the architecture and entity sections of a VHDL model? How do they differ?

An entity defines the interface – signals and their directions.
An architecture defines the internal functionality associated with the entity.

12. (1 point) An entity X, when used in another entity, becomes a _component_ for the entity Y.

13. (12 points) Draw the state diagram for the following state machine. Is it a Moore machine or a Mealy machine?

```
ENTITY state_machine IS
   PORT (sig_in ; IN BIT; clk : IN
BIT;
         sig_out : OUT BIT);
END state_machine;

ARCHITECTURE state_machine OF
state_machine IS
   TYPE state_type IS (a, b, c, d,
e);
   SIGNAL current_state, next_state
: state_type;
BEGIN
   PROCESS (sig_in, current_state)
   BEGIN
      sig_out <= '0';
      next_state <= b;
      CASE current_state
      WHEN a =>
         IF sig_in = '0' THEN
            next_state <= a;
         ELSE
            next_state <= d;
         END IF;
         sig_out <= '1';
      WHEN b =>
         IF sig_in = '0' THEN
            next_state <= b;
         ELSE
            next_state <= c;
         END IF;
     WHEN c =>
       IF sig_in = '1' THEN
          next_state <= a;
       ELSE
          next_state <= d;
       END IF;
         sig_out <= '1';
      WHEN d =>
        IF sig_in = '0' THEN
            next_state <= e;
        END IF;
      WHEN e =>
        IF sig_in = '1' THEN
           next_state <= c;
        END IF;
       END CASE;
   END PROCESS;
   PROCESS (clk)
   BEGIN
      IF (clk'EVENT AND clk = '1')
THEN
          current_state <=
next_state;
      END IF;
   END PROCESS;
END state_machine;
```

Moore