

LAST NAME, NAME :

CSE 140, Winter 2005

Midterm 2
Thursday 02/24/2005

1	5
2	8
3	7
4	5
5	5
6	5
Total	35

1. Represent these numbers in 4-bit 2's complement or indicate that it is not possible.
(5 pts)

a) $-8 = 1000$

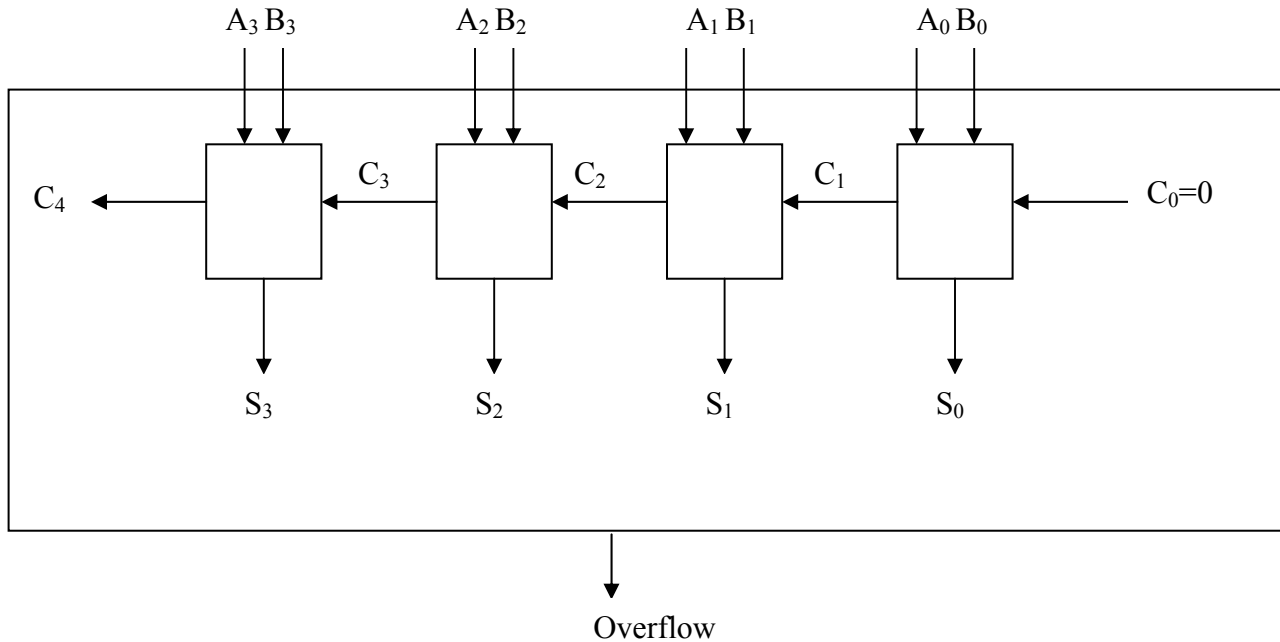
b) $8 = \text{not possible}$

c) $5 = 0101$

d) $-6 = 1010$

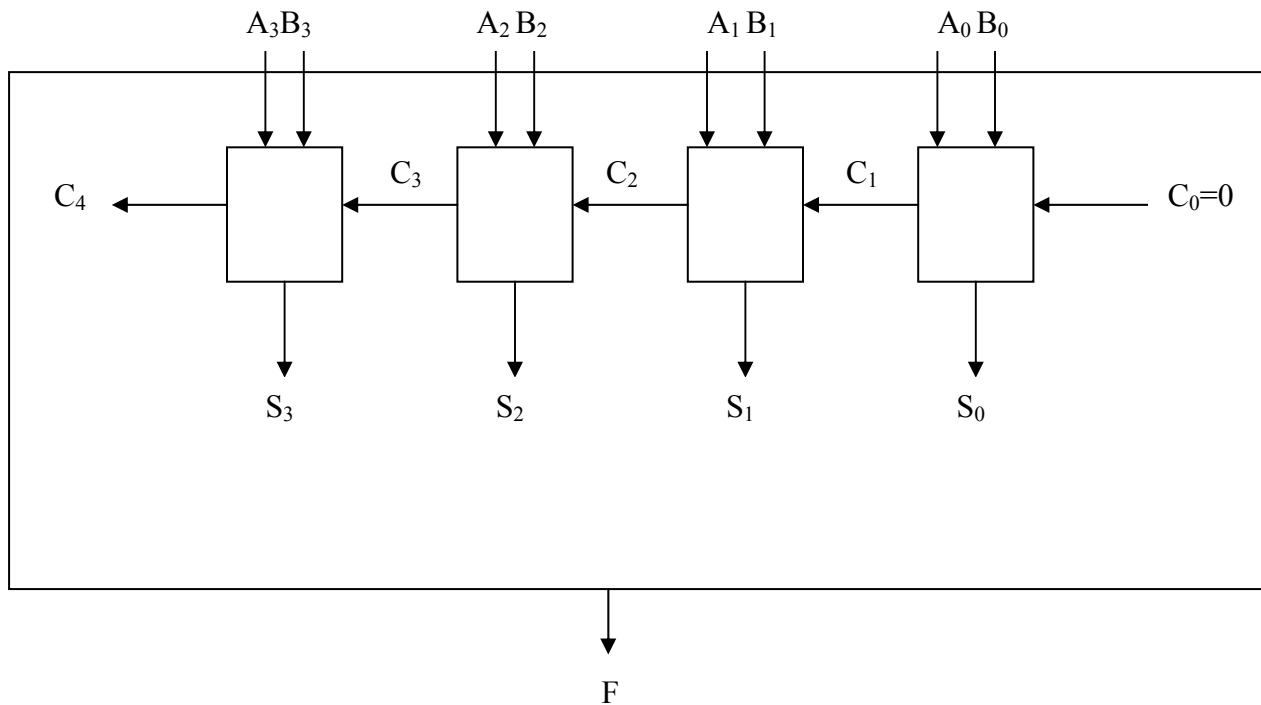
e) $15 = \text{not possible}$

2. a) Given a 4-bit 2's complement binary adder, add the minimum amount of logic to detect an "overflow". A and B are 2's complement numbers, possibly negative numbers. (3 pts)



$$\text{Overflow} = C_4 \text{ XOR } C_3 = C_4' C_3 + C_4 C_3'$$

b) What is the minimum amount of logic that has to be added to implement the $A \geq -B$ comparison operation so that F is 1 when this inequality holds? **(5 pts)**
 (Hint: You will need to use the “overflow” condition from part (a). Make sure that your solution satisfies these test cases: $7 \geq -7$, $7 \geq 1$)



SEE NEXT PAGE ...

QUESTION 2b ANSWER

ANSWER BASED ON DETECTING POSITIVE AND NEGATIVE NUMBERS.

4 cases:

- 1) if both A and B are positive, $A \geq -B$ is guaranteed to be TRUE
- 2) if A is positive, but B is negative, we need to test if $A + B \geq 0$
- 3) if A is negative, but B is positive, we also need to test if $A + B \geq 0$
- 4) if both A and B are negative, $A \geq -B$ is guaranteed to be FALSE

For (1), can test by $A_3' B_3'$ (both have most significant bit = 0 for positive numbers).

For (2) and (3), can detect one is positive, and one is negative by testing $A_3 \text{ XOR } B_3$, and can test $A + B \geq 0$ by testing S_3' (most significant bit of SUM is 0 for positive).

Combined, the solution is

$$\mathbf{F = A_3' B_3' + (A_3 \text{ XOR } B_3) S_3'}$$

MORE NEXT PAGE ...

QUESTION 2b ANSWER CONTINUED ...

ANSWER BASED ON DETECTING OVERFLOW

Detect overflow by

$$\mathbf{OF = C4 \text{ XOR } C3}$$

2 cases

1) if there is no overflow, just test if $A + B \geq 0$

2) if there is an overflow, we need to test directly or indirectly that A and B are both positive.

For (1), can test no overflow by OF' and $A + B \geq 0$ by $S3'$: together $OF' S3'$

For (2), we can test if A and B are both positive in three ways:

i) Test $A3' B3'$

ii) Test $OF S3$

iii) Test $OF C4'$

Thus, the possible solutions based on overflow detection are:

$$\mathbf{F = OF' S3' + A3' B3'}$$

$$\mathbf{F = OF' S3' + OF A3' B3'}$$

$$\mathbf{F = OF' S3' + OF S3 = OF \text{ XNOR } S3}$$

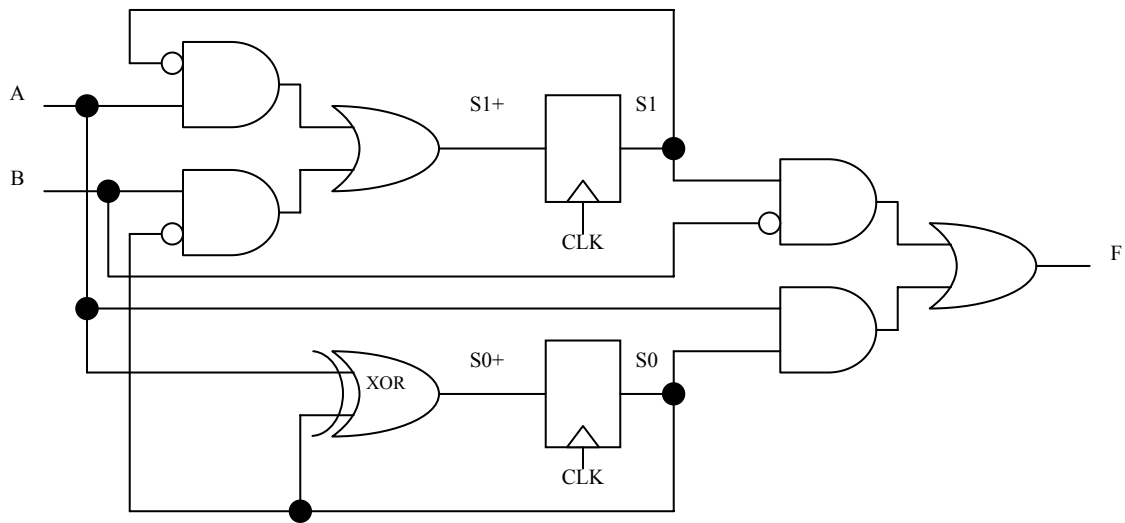
$$\mathbf{F = OF' S3' + OF C4'}$$

$$\mathbf{F = OF' S3' + OF (C4' + S3)}$$

$$\mathbf{F = OF' S3' + C4' C3}$$

3. Consider the following sequential circuit.

a) Derive the state table assuming that the initial state is **00**. (5 pts)



SEE NEXT PAGE STATE TABLE ...

$$F = A S0 + B' S1$$

$$S1+ = A S1' + B S0'$$

$$S0+ = A \text{ XOR } S0 = A S0' + A' S0$$

b) Is this a Moore or Mealy machine? (2 pts)

Mealy

QUESTION 3 ANSWER

STATE TABLE (ALL STATES REACHABLE FROM STATE 00)

I	PS	NS	F

00	00	00	0
01		10	0
10		11	0
11		11	0

00	01	01	0
01		01	0
10		10	1
11		10	1

00	10	00	1
01		10	0
10		01	1
11		11	0

00	11	01	1
01		01	0
10		00	1
11		00	1

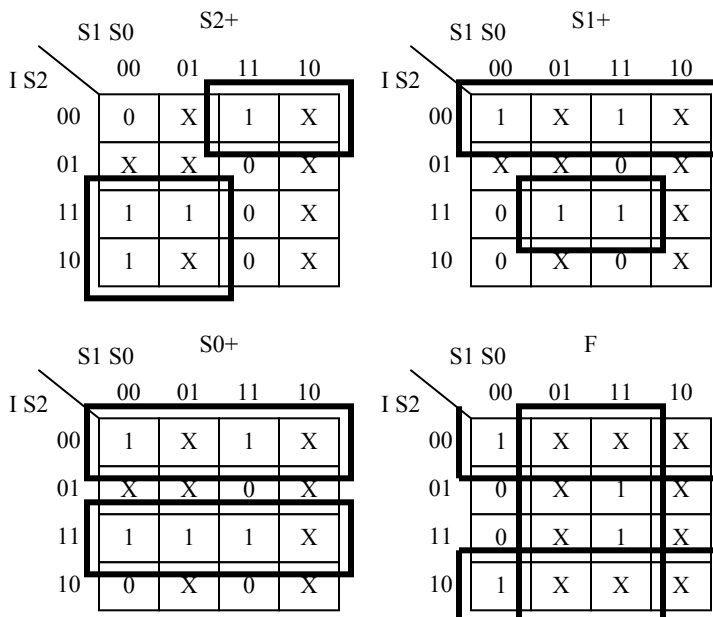
4. Consider the following incompletely-specified Moore machine (“X” is don’t care).

Present State	Next State		Output Logic
	I = 0	I = 1	
A	B	C	1
B	E	A	X
C	X	D	0
D	X	E	X
E	A	B	1

Suppose we use the following state encoding with 3 state variables (S2, S1, S0).

State	S2 S1 S0
A	000
B	011
C	100
D	101
E	111

Derive the K-maps and minimized two-level logic for next-state logic (S2+, S1+, S0+) and output logic (F). You can minimize each logic equation separately. (5 pts)



UNREACHABLE STATE CODES: 001, 010, 110

$$S2+ = I' S2' S1 + I S1'$$

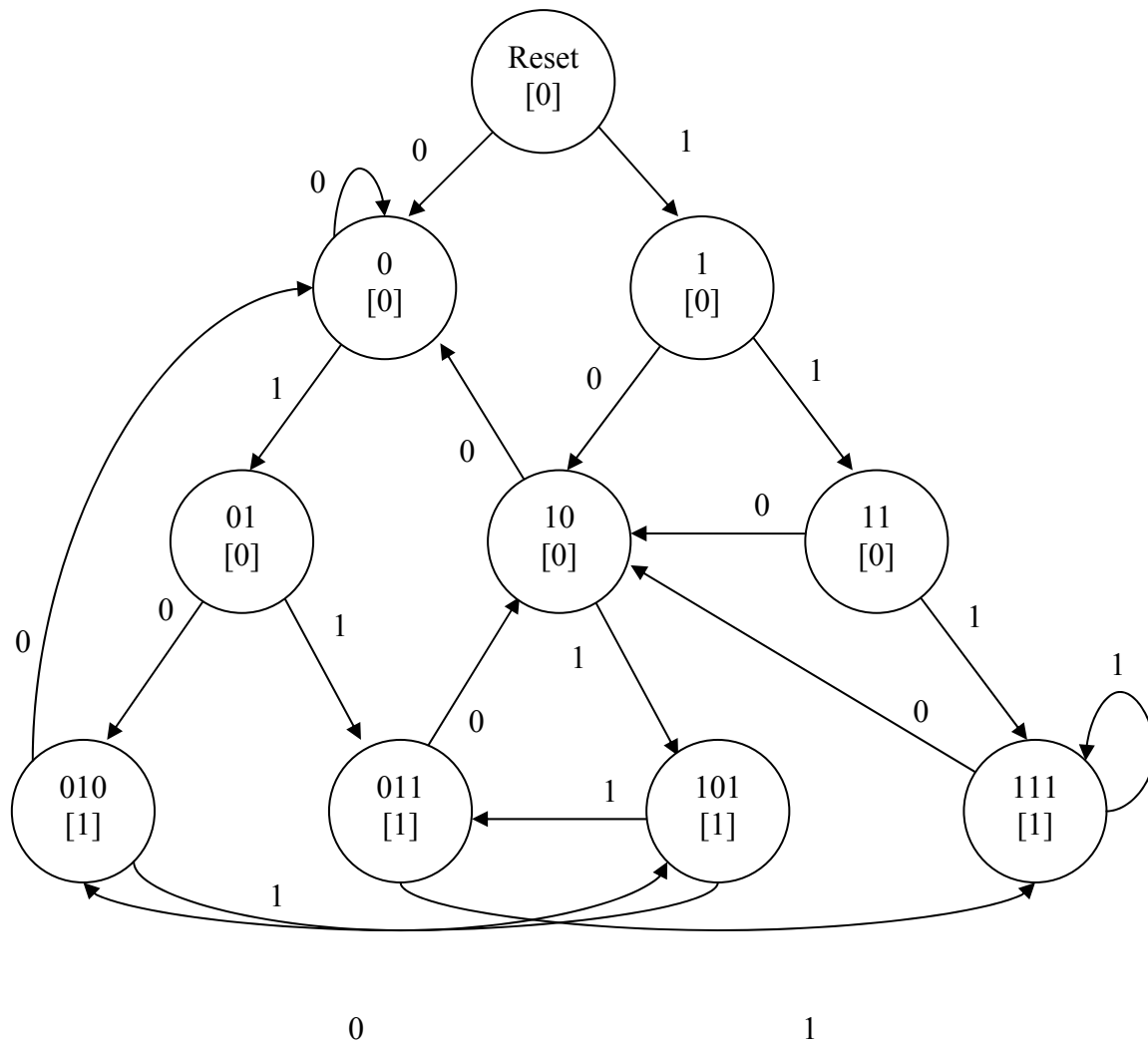
$$S0+ = I' S2' + I S2 = I \text{ XNOR } S2$$

$$S1+ = I' S2' + I S2 S0$$

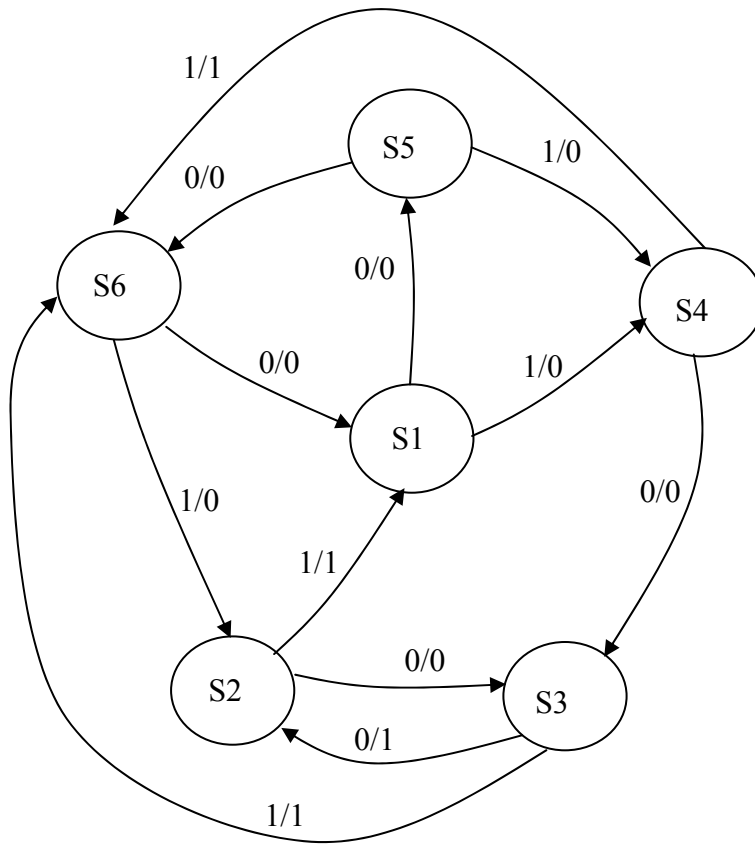
$$F = S2' + S0$$

5. Consider a Moore machine which recognizes the input sequences **011**, **111**, **101** and **010** by outputting a **1** every time that these sequences are encountered.

Draw the state diagram for this machine. (5 pts)

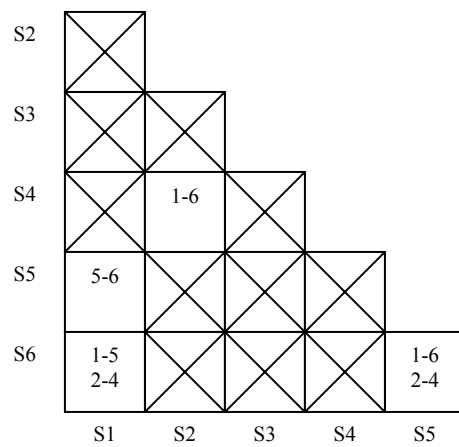


6. Minimize the number of states in the following Mealy machine. (5 pts)



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QUESTION 6 ANSWER



S1 = S5 = S6. Merged to S1'

S2 = S4. Merged to S2'

Final solution = 3 states

Reduced State Table

I	PS	NS	Z

0	S1'	S1'	0
1		S2'	0
0	S2'	S3	0
1		S1'	1
0	S3	S2'	1
1		S1'	1