You are expected to solve homework problems individually. If needed, you may seek help from your friends. However, do not copy. Show all steps with your solutions for full credit.

Name: **/ 50**

1. (4+2+2+2 points) Construct a truth table for a half-adder. Write reduced SOP expressions for the two outputs of a half-adder.

A	B	Sum	Cout
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

$Sum = A'B + AB'$

$= A \oplus B$

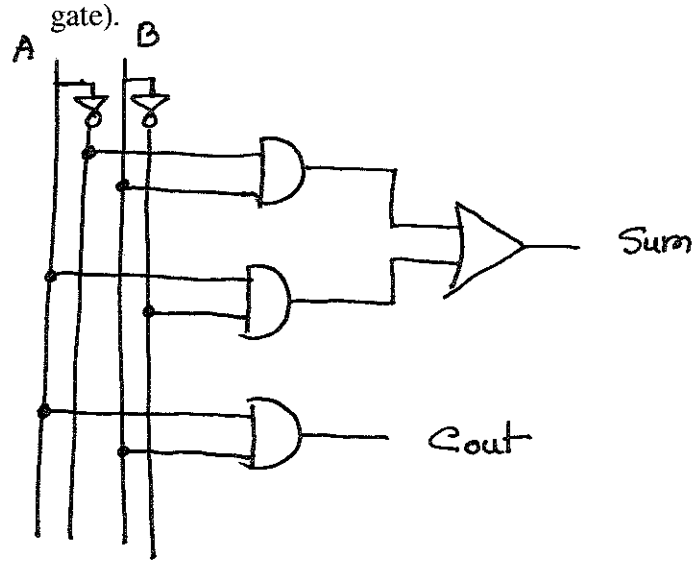
$Cout = AB$

a. Show algebraic expression in sum of minterms form

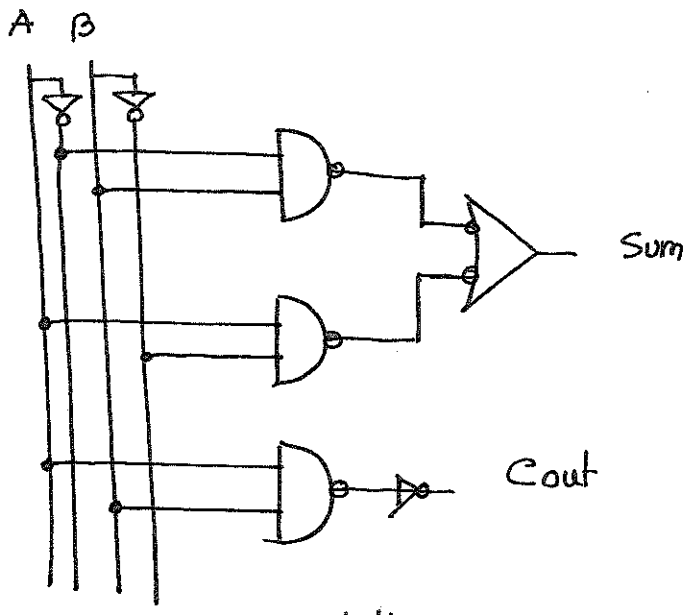
$Sum = \Sigma m(1, 2)$

$Cout = \Sigma m(3)$

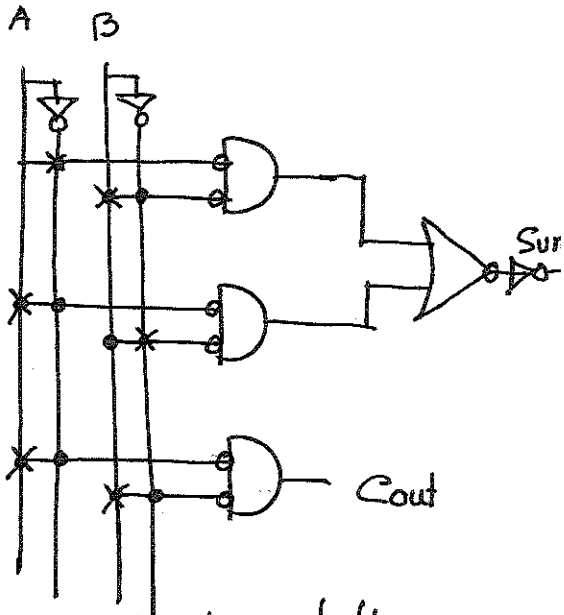
b. Draw the circuit (half-adder) using **AND, OR and NOT** gates (do not use XOR gate).



c. Design a NAND (or NOR) gate implementation for the circuit.



NAND Implementation



NOR implementation

2. (2+8) points) Construct a truth table for a full-adder. Write reduced SOP expressions for the two outputs of a **full-adder**. Show your work

A	B	Cin	Sum	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

$Sum = A \oplus B \oplus Cin$

$Cout = Cin(A \oplus B) + AB$

A \ BCin	00	01	11	10
0	0	1	0	1
1	1	0	1	0

$$Sum = A'B'Cin + A'BCin' + AB'Cin' + ABCin$$

$$= Cin'(A'B + AB') + Cin(A'B' + AB)$$

$$= Cin'(A \oplus B) + Cin\,\overline{(A'B' + AB)}$$

$$= Cin'(A \oplus B) + Cin\,\overline{((A+B)\cdot(A'+B'))}$$

$$= Cin'(A \oplus B) + Cin\,(AA' + AB' + A'B + BB')$$

$$= Cin'(A \oplus B) + Cin\,(A'B + AB')$$

$$= Cin \oplus A \oplus B$$

$$= A \oplus B \oplus Cin$$

A \ BCin	00	01	11	10
0	0	0	1	0
1	0	1	1	1

$$Cout = AB'Cin + A'BCin + AB$$

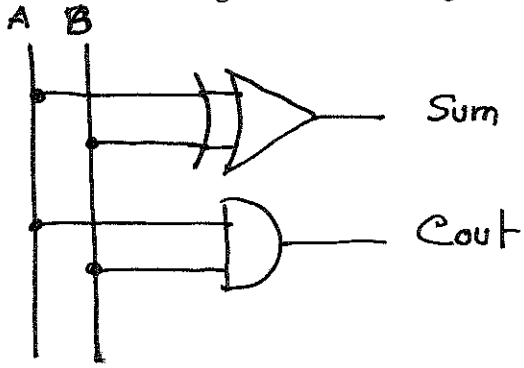
$$= Cin(A'B + AB') + AB$$

$$= Cin(A \oplus B) + AB$$

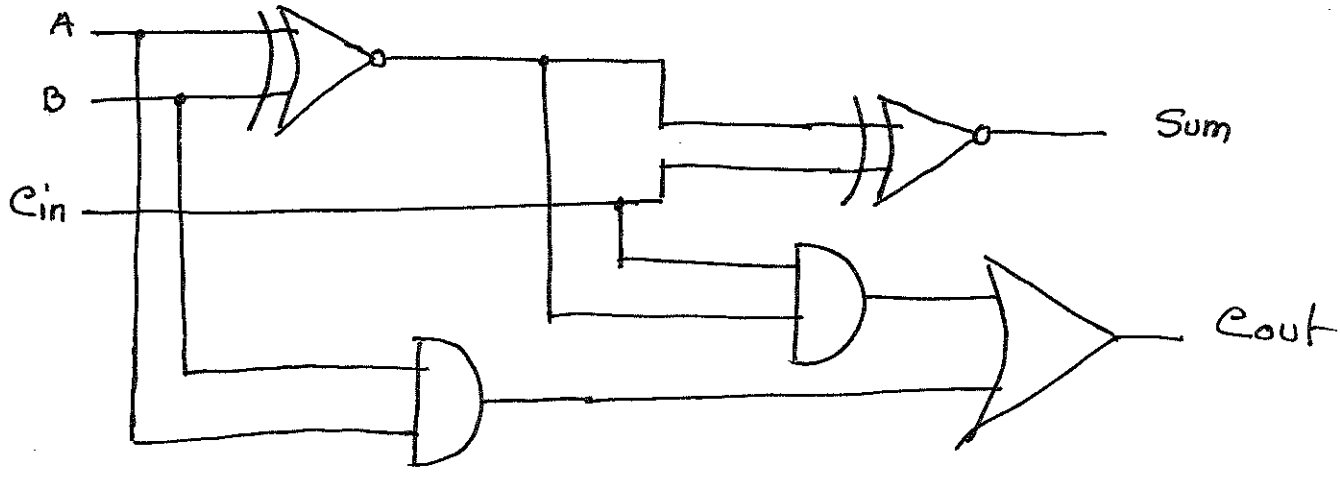
3. (1+1+8 points) Write the truth table for the **exclusive-OR (XOR) gate**.

A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

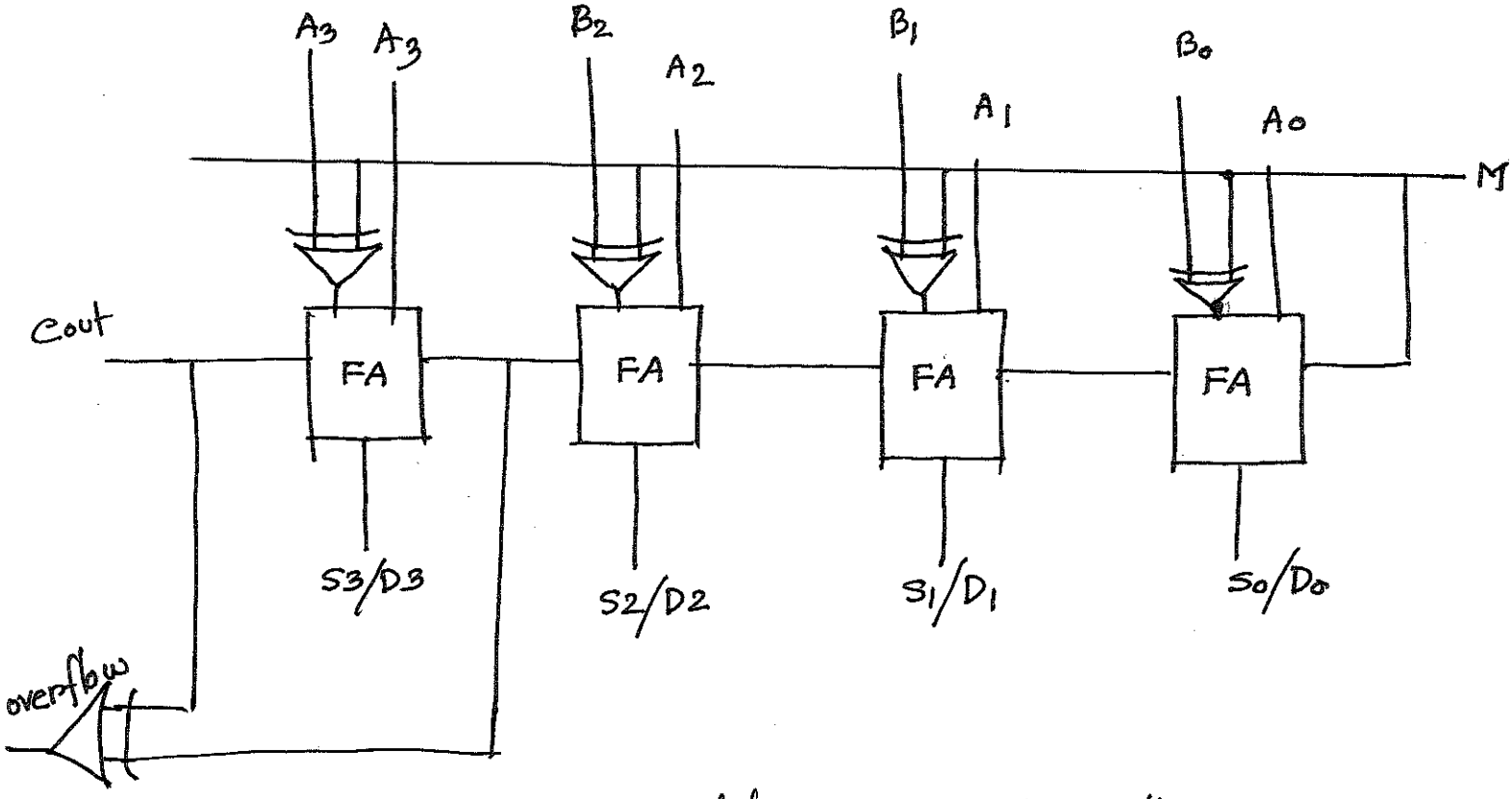
a. Design a **half-adder** using XOR and AND gates. Draw the circuit.



b. Design a **full-adder** using XOR, AND and OR gates. Show that a full-adder can be built using two half-adders and one OR gate. Draw the circuit.



4. (10 points) Design a 4-bit adder/subtractor module. Please use the block diagram for the full adder.



4-bit adder subtractor with overflow

5. (10 points) The adder–subtractor circuit has the following values for mode input *M* and data inputs *A* and *B*.

	M	*A*	*B*
(a)	0	0111	0110
(b)	0	1000	1001
(c)	1	1100	1000
(d)	1	0101	1010
(e)	1	0000	0001

In each case, determine the values of the four *SUM* outputs, the carry *C*, and overflow *V*.

	Output	*C*	*V*
(a)	1101	0	1
(b)	0001	1	1
(c)	0100	1	0
(d)	1011	0	1
(e)	1111	0	0