Assignment 3
(Full Score: 100 points)
(Due in class, **3/25/Friday**,)

Your name:	Score:

1. Analyze the 4-bit SN74181 ALU chip by completing the following table:
Given the data A = 1101 and B = 1011 in two's complement (for arithmetic data) or unsigned (for logic data) representation, and $(C_{-1})'$ equal to 0 or 1 in two different cases, calculate by hand the output of the ALU in each case with the condition given in each row of the table below.

					Output (results) of the ALU F3 F2 F1 F0		Function of SN74181
M	s_3	s_2	s_1	s_0	$\overline{C}_{-1} = 1$	$\overline{\ \ } C_{-1} = 0$	
1	0	1	1	0			
0	1	1	0	0			
0	1	1	1	0			
1	0	0	1	1			
1	1	0	0	0			
0	0	0	0	0			
1	1	0	0	1			
1	0	0	0	1			
0	1	1	1	1			
0	0	0	1	1			
1	1	0	1	0			
1	1	1	1	0			
0	0	1	1	1			
0	0	0	0	1			
1	1	1	1	1			

2. Design a 4-bit ALU based on a SN74181 ALU chip to implement the following function table:

f_2	f_1	f_0	ALU Functions	Meaning
0	0	0	$\overline{OP1}$	inverse OP1
0	0	1	OP1 $\oplus$ OP2	logic XOR
0	1	0	OP1 $\wedge$ OP2	logic AND
0	1	1	OP1 $\vee$ OP2	logic OR
1	0	0	OP1 plus Cin	OP1 incremented by Cin=1 or 0
1	0	1	OP1 minus OP2 minus $\overline{Cin}$	OP1 minus OP2 minus borrow
1	1	0	OP1 plus OP2 plus Cin	OP1 plus OP2 plus carry
1	1	1	OP1 plus 1111	OP1 decremented by 1

Note: The input operands, OP1 and OP2, along with the input carry signal, Cin, perform the ALU operations specified in the function table.

(a) Derive the truth table with function select codes, f_2, f_1, and f_0, as the independent variables and the input parameters of SN74181 as the dependent variables. The format is shown below:

f_2	f_1	f_0	M	s_3	s_2	s_1	s_0		Ai	Bi	$\overline{C_{-1}}$	Function of SN74181
0	0	0	1	0	0	0	0		OP1	X	X	(Ai)'
0	0	1	...	...	...	...	...	...		.....		
…												
…												

Note: The given operands, OP1 and OP2, are always connected to the inputs A and B, respectively, of the SN74181 chip.

(b) Derive the simplest expressions for M, s_3, s_2, s_1, s_0 and $\overline{C_{-1}}$ so that they can be implemented with a minimum number of gates. Draw the circuit diagram for the ALU you have designed.

3. Using the method described in Section 5.4.1, Example 5.1, design a 4-bit ALU for implementation of the following function table with 3-bit function select code, $f_2f_1f_0$.

f_2	f_1	f_0	Function	Meaning
0	0	0	F = OPA	transfer
0	0	1	F = - OPA	negate
0	1	0	F = OPA $\wedge$ OPB	logic AND
0	1	1	F = OPA $\oplus$ OPB	logic XOR
1	0	0	F = OPA + 1	increment
1	0	1	F = OPA - 1	decrement
1	1	0	F = OPA + OPB	add
1	1	1	F = OPA - OPB	subtract

where OPA = $OPA_3OPA_2OPA_1OPA_0$ and OPB = $OPB_3OPB_2OPB_1OPB_0$ are two 4-bit signed numbers (for arithmetic operations) or unsigned numbers (for logic operations) to the inputs of the ALU; C_{-1} is the carry input to the LSB of the adder; while the outputs of the ALU should be F = $S_3S_2S_1S_0$ and the four statuses, N, V, Z, C.

The ALU in this problem is implemented by a 4-bit adder using multiplexers on the input A to receive operands through external gates for logic operations, while on the inputs B and C_{-1} of the adder, for economical reason, it is required to use a minimum number of basic gates to supply the operands.

Give the design procedure and draw the circuit diagram.

(**For Bonus 20 point—continued from Question 3)** After you have designed the ALU, add a shifter to the output of it so that the shifter can implement additional functions on the ALU result according to the following function table:

h_1	h_0	Function
0	0	No shift
0	1	Arithmetic shift right one bit
1	0	Rotate ALU left one bit with C status
1	1	Rotate ALU right one bit with C status

Give the design procedure and draw the circuit diagram.