Michael Huang
CS 47 - Section 01
Homework 2

1A.
$5_{10} = 00101_2$
-10_{10} in signed 5-bit binary: $10_{10} = 01010_2$, invert it then $+1_2 \rightarrow -10_{10} = 10101_2 + 1_2 = 10110_2$

1B.
5 * -10 = -50, or 5 * 10 = 50, then 50 * -1 = -50.
5 = 00101, 10 = 01010.

01010 00101 01010	01010 00010|1 00000|0	01010 00001|01 01010|00	01010 00000|101 00000|000	01010 00000|0101 00000|0000	01010 00000|00101 00000|00000

0000010000
01010
000000
0101000
00000000
000000000
0000000000
0000110010

Find two's compliment: invert the result: $0000110010_2 \rightarrow 1111001101_2$, $+ 1_2 = 1111001110_2$.

1C-1. Zero extension from 5-bit to 8-bit:
$5_{10} = 00101_2$. Add zeros in the front of MSB until it is 8-bit: $00101_2 \rightarrow 00000101_2$.
$-10_{10} = 10110_2$. Add zeros in the front of MSB until it is 8-bit: $10110_2 \rightarrow 00010110_2$.

1C-2. Signed extension from 5-bit to 8-bit:
$5_{10} = 00101_2$. Number is positive, add zeros in the front of MSB until it is 8-bit:
$00101_2 \rightarrow 00000101_2$.
$-10_{10} = 10110_2$. Number is negative, add ones in the front of MSB until it is 8-bit:
$10110_2 \rightarrow 11110110_2$.

2A.
F(x, y, z) = x + y + z'

X	Y	Z	F(x, y, z)
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

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2B.

$F(x, y, z) = x'y' + yz$

X	Y	Z	F(x, y, z)
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

3A.

$x'z + y + xy' = x + y + z$
$x'z + (x + y)(y + y') = x + y + z$
$x'z + (x + y)(1) = x + y + z$
$x'z + (x + y) = x + y + z$
$x'z + x + y = x + y + z$
$(x + x')(x + z) + y = x + y + z$
$(1)(x + z) + y = x + y + z$
$x + y + z = x + y + z$

3B.

$abc' + bc'd' + bc + c'd = b + c'd$
$abc' + (bc'd' + c'd) + bc = b + c'd$
$abc' + (c'(bd' + d)) + bc = b + c'd$
$abc' + (c'((b + d)(d' + d))) + bc = b + c'd$
$abc' + (c'((b + d)(1))) + bc = b + c'd$
$abc' + (c'(b + d)) + bc = b + c'd$
$abc' + bc' + c'd + bc = b + c'd$
$b(ac' + c' + c) + c'd = b + c'd$
$b(ac' + (c' + c)) + c'd = b + c'd$
$b(ac' + (1)) + c'd = b + c'd$
$b(1) + c'd = b + c'd$
$b + c'd = b + c'd$

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4A.
f (A, B, C, D) = ∑m (0, 1, 5, 7, 8, 10, 14, 15)

ab \ cd	00	01	11	10
00	1	1		
01		1	1	
11			1	1
10	1			1

0000 0001 0111 1110
1000 0101 1111 1010
B’C’D’ + A’C’D + BCD + ACD’ = f (A, B, C, D)
<u>Prime implicants</u>: **B’C’D’**, **A’C’D**, **BCD**, **ACD’**, all groups listed are in their maximum groupings.
<u>Essential prime implicants</u>: There are no essential prime implicants, because there are no 1s in the vertical groupings not covered by the horizontal groupings.

4B.
f (W, X, Y, Z) = ∑m (2, 4, 9, 12, 15) + d (3, 5, 6, 13)

WX \ YZ	00	01	11	10
00			X	1
01	1	X		X
11	1	X	1	
10		1		

0100 1101 1101 0010
1100 1001 1111 0011
0101
1101
XY’ + WY’Z + WXZ + W’X’Y = f (W, X, Y, Z)
<u>Prime implicants</u>: **XY’, WY’Z, WXZ, W’X’Y**, because those are the maximum groupings available. A group of 4 followed by 3 groups of 2 are the maximum groupings available with adding addition terms (the red groups) to the answer.
<u>Essential prime implicants</u>: **XY’, WY’Z, WXZ, W’X’Y** are all essential prime implicants. 1100 in **XY’** expressed in any other groupings without decreasing the grouping’s size, so it is an essential prime implicant. 1001 in **WY’Z** cannot be grouped by any other way, so that is an EPI. 1111 in **WXZ** cannot be grouped in any other way, it is also an EPI. 0010 in **W’X’Y’** can be grouped with 0110 to form another group. You can select either group to be the essential prime implicant, but doing so will make the other group non-essential, so I chose to group it with 0011 to make **W’X’Y’** an EPI. Additionally, 0110 and 0011 are don’t cares, so if you choose to group with either of them, you can treat the non-grouped one as 0, eliminating the need to group it.

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5. Take a 4-bit number, return true if number is between (inclusive) 5 and 12, and if it's even.

Truth table:

Decimal	W	X	Y	Z	f(W, X, Y, Z)
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	1
7	0	1	1	1	0
8	1	0	0	0	1
9	1	0	0	1	0
10	1	0	1	0	1
11	1	0	1	1	0
12	1	1	0	0	1
13	1	1	0	1	0
14	1	1	1	0	0
15	1	1	1	1	0

K-Map:

WX \ YZ	00	01	11	10
00				
01				1
11	1			
10	1			1

1100   0110   1000
1000   1010
WY'Z'+W'XYZ'+WX'Z' = f(W, X, Y, Z)

Schematic diagram:

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