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 $+1_2$ → $-10_{10} = 10101_2 + 1_2 = 10110_2$

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 → 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 → 00000101_2.
$-10_{10} = 10110_2$. Add zeros in the front of MSB until it is 8-bit: 10110_2 → 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 → 00000101_2.
$-10_{10} = 10110_2$. Number is negative, add ones in the front of MSB until it is 8-bit:
10110_2 → 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>: They are in the same group as the prime implicants because none of the groupings overlap, and if you grouped them horizontally in addition to the vertical groupings, you would be adding additional term to your result. The horizontal groups would be non-essential if you chose the vertical groupings, and vice-versa.

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.

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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