Homework 4
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1- **Given $F_1 = \sum m(0,2,5,7,9)$ and $F_1 = \sum m(2,3,4,7,8)$ find the minterm expression for F_1+F_2. State a general rule for finding the expression for F_1+F_2 given the minterm expansions for F_1 and F_2. Prove your answer by using the general form of the minterm expansion.**

F1 + F2 = Σm(0, 2, 3, 4, 5, 7, 9)

Rule: You can add the minterm expressions because each minterm is or'ed together, and since F1 and F2 are also or'ed together, by the associative property, you can combine everything and or it all together.

F1 =

0000	a'b'c'd' +
0010	a'b'cd' +
0100	a'bc'd' +
0111	a'bcd +
1001	ab'c'd

F2 =

0010	a'b'cd' +
0011	a'b'cd +
0100	a'bc'd' +
0111	a'bcd +
1000	ab'c'd'

Therefore, F2 = a'b'c'd' + a'b'cd' + a'bc'd' + a'bc'd' + a'bcd + ab'c'd' + ab'c'd
Which is Σm(0, 2, 3, 4, 5, 7, 9).

2- Given: F(a,b,c,d)=(a+b+c'+d')(a'+b'+c')(a+b+d)(a'+c)

(a) Express F as a minterm expansion. (use m-notation)
(b) Express F as a maxterm expansion. (use M-notation)
(c) Express F' as a minterm expansion. (use m-notation)
(d) Express F' as a maxterm expansion. (use M-notation)

First I will put all the variables in each term by multiplying by 1.

(a+b+c'+d')(a'+b'+c')(d+d')(a+b+d)(c+c')(a'+c)(b'+b)(d'+d) Identity

{(a+b+c'+d)(a'+b'+c'+d))(a'+b'+c' + d')(a+b+c+d)(a+b+c'+d)
(a' + b' + c + d') (a' + b' + c + d) (a'+b + c+d') (a'+b + c + d)} Distributive

Your Maxterm values:
1101, 0001, 0000, 1111, 1101, 0010, 0011, 0110, 0111

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Sorted Maxterm values:
0000, 0001, 0010, 0011, 0110, 0111, 1101, 1111

a)
$F = \Sigma\, m(4, 5, 8, 9, 10, 11, 12, 14)$

b)
All values not minterm
$F = \prod M(0, 1, 2, 3, 6, 7, 13, 15)$

c)
$F' = \Sigma m(0, 1, 2, 3, 6, 7, 13, 15)$

d)
$F' = \prod m(4, 5, 8, 9, 10, 11, 12, 14)$

3- Find the minterm expansion of f(a,b,c,d)=a'(b'+d)+acd' and then design the result.

a'(b' + d) + acd'	Given
a'b' + a'd + acd'	Distributive
a'b' (c+c')(d+d') + a'd(c+c')(b+b') + acd'(b+b')	Identity
a'b'c(d+d') + a'b'c'(d+d') + a'cd (b+b') + a'c'd(b+b') + abcd' + ab'cd'	Distributive

a'b'cd + a'b'cd' + a'b'c'd + a'b'c'd' + a'bcd + a'b'cd + a'bc'd + a'b'c'd + abcd' + ab'cd'

Thus you have the values
0011, 0010, 0001, 0000, 0111, 0011, 0101, 0001, 1110, 1010
Sorted values:
0000, 0001, 0010, 0011, 0101,0111,1010
$F = \Sigma m(0, 1, 2, 3, 5, 7, 12)$

DESIGN – See Attached Paper

4- **Design a combinational logic circuit which has one output Z and a 4-bit input ABCD representing a binary number. Z should be 1 if the input is at least 5, but is no greater than 11. Use one OR gate (three input), and three AND gates.**

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DESIGN – See Attached Paper

5- A half adder is a circuit that adds two bits to give a sum and a carry. Give the truth table for a half adder, and design the circuit using only two gates. Then design a circuit which will find the 2's complement of a 4-bit binary number. Use four half adders and any additional gates. (Hint: recall that one way to find the 2's complement of a binary number is to complement all bits, and then add 1)

AB	BC	Carry	Sum
00	00	0	0
01	01	1	0
10	10	1	0
11	11	1	0

DESIGN – See Attached Paper

6- Find the minimum sum of products for each function using a Karnaugh map.
(a) $f_1(a, b, c) = m_0 + m_2 + m_5 + m_6$
(b) $f_2(d, e, f) = \sum m(0, 1, 2, 4)$
(c) $f_3(x, y, z) = xz' + x'y' + x'y$
(d) $f_4(r, s, t) = M_0 \cdot M_5$

See Attached Paper for 6-12