CSE 370 MIDTERM 1 SOLUTIONS Spring 2009

1. (15 points)

   (a) What is the largest (most positive) 5-bit twos-complement number?

   $01111_2 = 15$

   (b) What is the smallest (most negative) 5-bit twos-complement number?

   15 positive numbers and zero make 16 non-negative numbers. 5 bits can represent 32 numbers. Thus, there are 16 negative numbers. -16 would be the most negative.

   (c) Using as many bits as are necessary, write -21 in twos-complement.

   Have to use 6 bits, because 5 bits ranges from -16 to 15.
   +21 is 010101, so -21 is 101011

2. (15 points) Add $3F4_{16} + 6C8_{16}$.

   (a) Write your answer in hexadecimal.

   ABC

   (b) Write your answer in octal.

   5274

   (c) Write your answer in binary.

   1010 1011 1100

3. (10 points) Find the complement of $(A+B+C)\overline{D}+\overline{EF}(G+\overline{H})$. Only simplify double negations. Do not simplify further.

   $(\overline{A}\,\overline{B}\,\overline{C}+D)(EF+\overline{G}H)$

4. (15 points) Simplify $F = J\bar{J} + H(OKRW + OW) + R + \bar{A}U + AU$ using Boolean algebra. Clearly show each step. You do not need to label the rules used.

$= 0 + H(OKRW + OW) + R + \bar{A}U + AU$
$= H(OKRW + OW) + R + \bar{A}U + AU$
$= H(OW(KR + 1)) + R + \bar{A}U + AU$
$= H(OW(1)) + R + \bar{A}U + AU$
$= HOW + R + \bar{A}U + AU$
$= HOW + R + (\bar{A} + A)U$
$= HOW + R + (1)U$
$= HOW + R + U$

5. (20 points) Let $F(A, B, C, D, E) = CDE + AB\bar{C}D + ABCDE$

   (a) Write the minterm expansion of F.

   $\bar{A}\bar{B}CDE + \bar{A}BCDE + A\bar{B}CDE + ABCDE + AB\bar{C}DE + AB\bar{C}D\bar{E}$

   (b) Write the shorthand (little m notation) expression for F.

   $\sum m(7,15,23,26,27,31)$

   (c) For the canonical *sum-of-products* form, how many OR and AND gates do you need? In your answer, specify the number of inputs for those gates (e.g. "one three-input OR gate and two two-input AND gates").

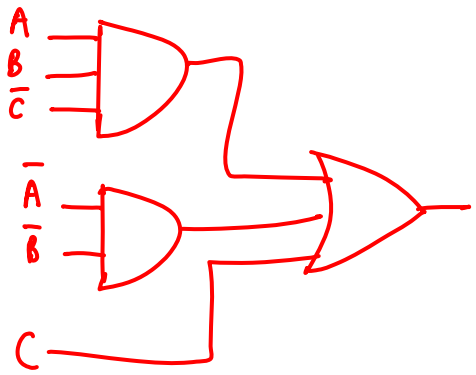
   6 5-input AND gates, 1 6-input OR gate

   (d) For the canonical *product-of-sums* form, how many OR and AND gates do you need? In your answer, specify the number of inputs for those gates.

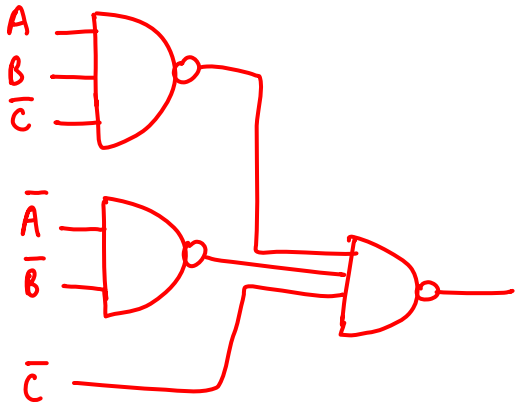
   26 5-input OR gates, 1 26-input AND gate

6. (20 points) Let $F(A,B,C) = AB\overline{C} + \overline{A}\overline{B} + C$. Draw the logic circuit for F. You may assume that variables and their complements are available as inputs.

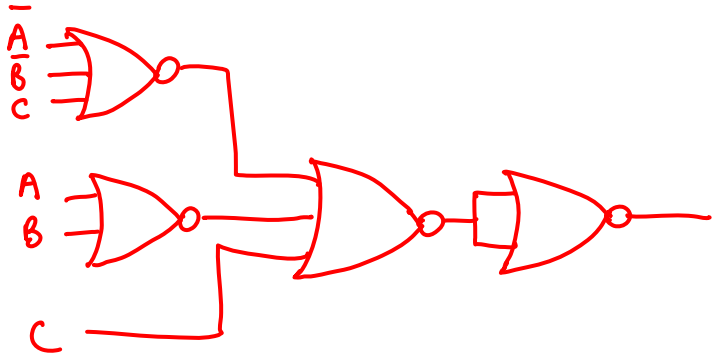
(a) Use only OR/AND gates.



(b) Use only NAND gates.



(c) Use only NOR gates.



7. (10 points) Draw the K-map for the following truth table.

A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	X
0	0	1	1	0
0	1	0	0	1
0	1	0	1	X
0	1	1	0	0
0	1	1	1	1
1	0	0	0	X
1	0	0	1	0
1	0	1	0	1
1	0	1	1	X
1	1	0	0	0
1	1	0	1	1
1	1	1	0	X
1	1	1	1	0

0	1	0	X
1	X	1	0
0	1	0	X
X	0	X	1

8. (10 points) Identify all the sub-cubes (max size, min number) in the following K-map and write the minimized *sum-of-products* expression. There may be more than one right answer.

0	1	X	0
1	0	X	X
1	X	0	X
X	0	0	X

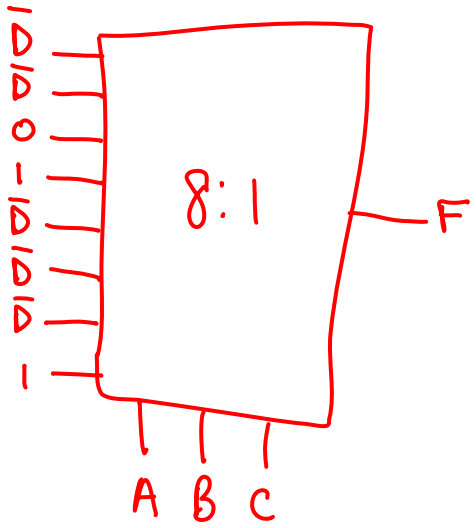
$\overline{B}D + B\overline{C}\overline{D}$

9. (10 points) Identify all the sub-cubes (max size, min number) in the following K-map and write the minimized *product-of-sums* expression. There may be more than one right answer.

0	1	X	0
1	0	X	X
1	X	0	X
X	0	0	X

$(\overline{B} + \overline{D})(B + D)(\overline{B} + \overline{C})$ or
$(\overline{B} + \overline{D})(B + D)(\overline{C} + D)$ [not shown]

10. (15 points) Let $F = \prod M(1,3,4,5,9,11,13)$. Express F using one 8:1 multiplexer. You may assume that variables and their complements are available as inputs.



11. (10 points) Let $F = \prod M(0,1,3,4,5,7)$. Express F using one demultiplexer and one OR gate. Don't forget the enable signal.