Problem 1:

(10pts) (a) Using the DeMorgan's theorem, find the complement of

$F = (\overline{A}(B + C) + \bar{C})(A + B) + \overline{ABC}$ (hint: you can't leave any double inversions)

$\bar{F} = [(A + (B'C'))C + A'B'](\cancel{A+B+C})$

or

(ABC)

we let both answers be ok
because of ambiguous line

Missing

-4 incorrect step early on

-7 completely wrong technique

-1~-2 parenthesis missing

(10pts) (b) Simplify $F = (B + C)(A + B)(A + 1) + A\bar{C}$

$F = (A+B)(C+B) + A\overline{C}$

$= (AC + B) + A\overline{C}$

$= A + B$

Missing

-1 $A+1 = 1$

One step short

-2 in simplification

-4 2 steps short

-3 2 mistakes

0001
0010
0011
0100
0101

Problem 2:

Consider $F(A,B,C,D) = \Pi M(1,2,3,4,5)$

(8pts) (a) Write down the Boolean expression of F in the canonical 'product of sums' (i.e. maxterm) form.

$$F = (A+B+C+D')(A+B+C'+D)$$
$$(A+B+C'+D')(A+B'+C+D)$$
$$(A+B'+C+D')$$

-1 inverse flipped

-1 missing 0

-6 not canonical

(6pts) (b) For a canonical 'product of sums' logic circuit, how many OR and AND gates do you need? Also specify the number of inputs for those OR and AND gates you use (so your answer should be in the form of "three 3-input OR gates", for example). (hint: if you are unsure, draw a schematic of the circuit so that partial credit may be given)

Five 4 input OR gates
One 5 input AND gates

(6pts) (c) Now do the same as (b) for a canonical "sum of products' logic circuit. How many OR and AND gates do you need? Also specify the number of inputs for those OR and AND gates.

$16-5=11$

-2 not enough terms
-2 still wrong

Eleven 4-input AND gates
One 11-input OR gate.

missing POS (-3)

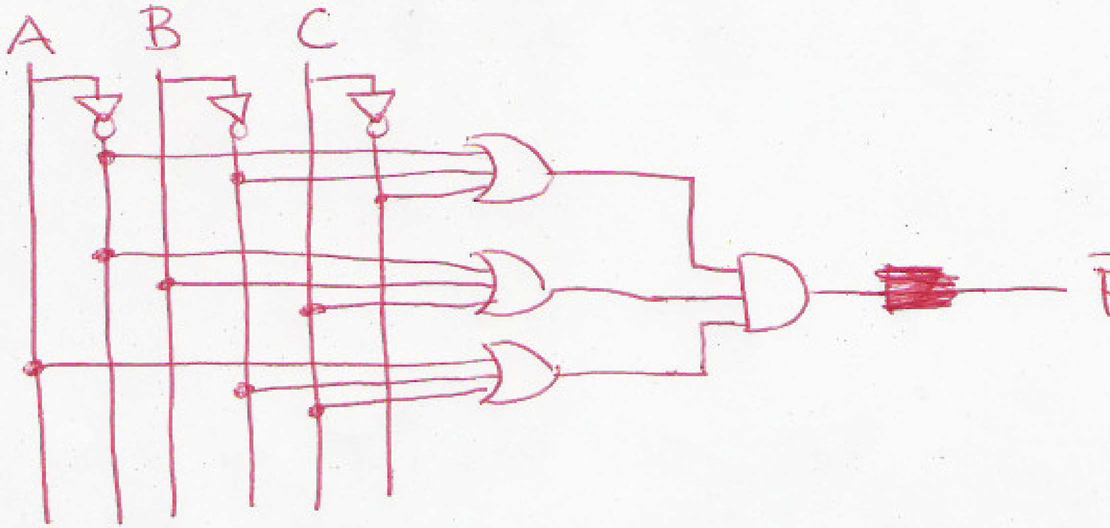
Problem 3:

Given $F = ABC + A\overline{BC} + \bar{A}B\bar{C}$, draw a logic gate circuit for $\bar{F}$ (inverted F) in 'product of sums" form.

eqn wrong (-2)

(10pts) (a) With OR/AND gates only (can use inverters)

$$\bar{F} = (A'+B'+C')(A'+B+C)(A+B'+C)$$

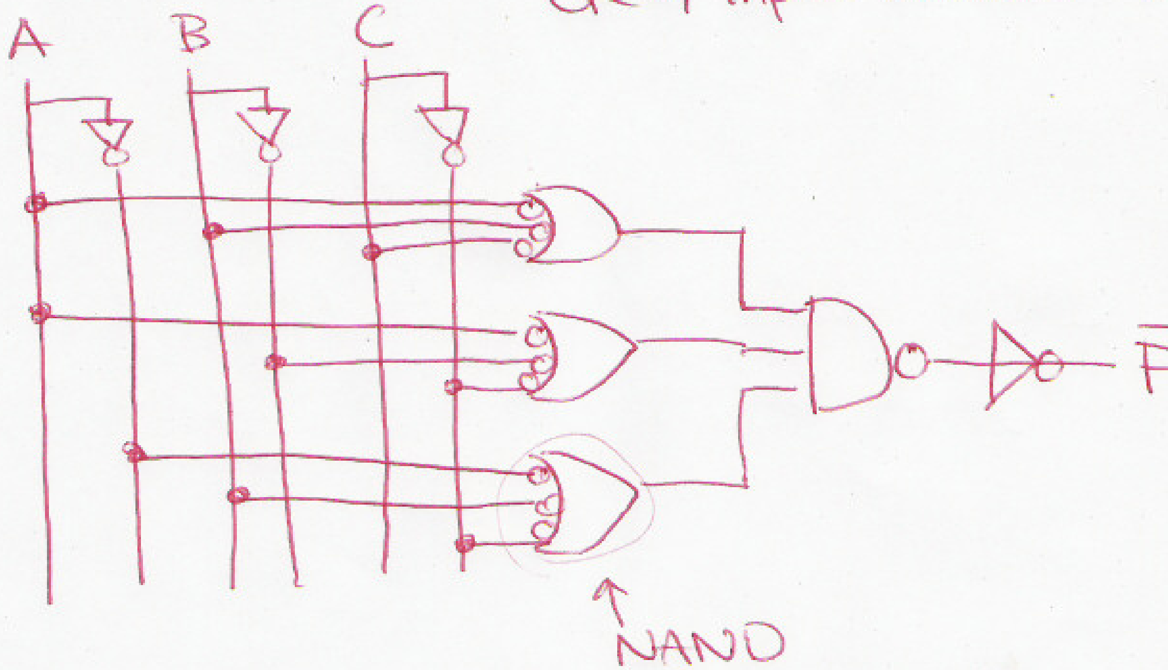


(10pts) (b) With NAND gates only (can use inverters) (hint: yes this is where you should push the bubbles)

forgetting to toggle (-2)

Toggle inputs & push bubbles & invert

OR w/ input bubbles = NAND



Problem 4:

For the following truth table,

(7 pts) (a) Build the Karnaugh map,

(7 pts) (b) identify all the sub-cubes (max size, min number) on your K-map (hint: to not mess up your nice K-map for (a), make another one for this part) , and

(6 pts) (c) provide the minimum canonical 'sum of products' expression.

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

(a)

CD \ AB	00	01	11	10
00	1	0	1	1
01	1	X	X	X
11	1	X	0	0
10	0	X	1	X

wrong entry
-2

(b)

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

① ② ① ③ ②

sub cube too small
-2

(c)

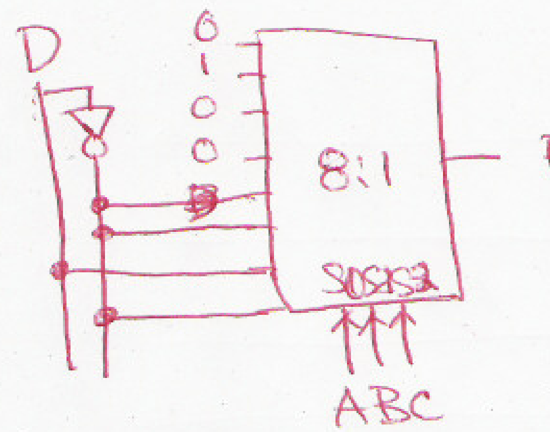
$$F = \underbrace{B'C'}_{1} + \underbrace{AD'}_{2} + \underbrace{A'D}_{3}$$

Problem 5:

Solve the following questions for fucntion $F(A,B,C,D) = \Sigma m(2,3,8,10,13,14)$.

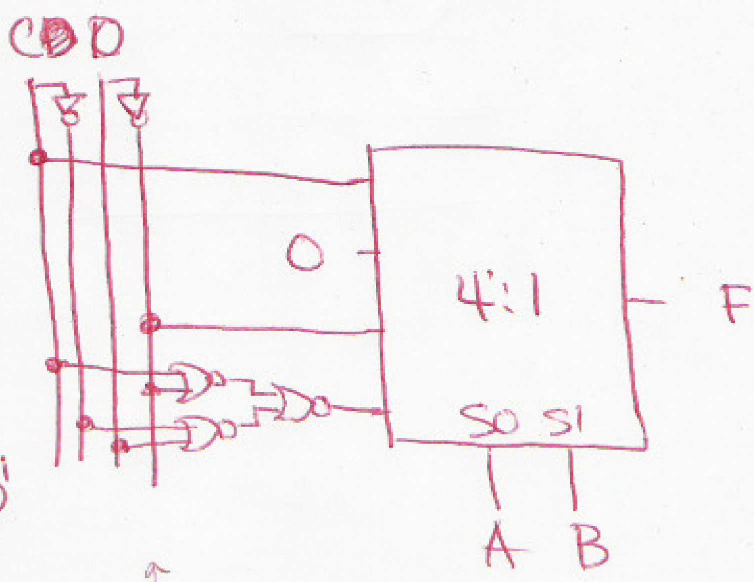
(10pts) (a) Express F using one 8:1 Multiplexer (can use inverters and NOR gates in addition)

ABCD	F	
0000	0	0
0001	0	
0010	1	1
0011	1	
0100	0	0
0101	0	
0110	0	0
0111	0	
1000	1	D'
1001	0	
1010	1	D'
1011	0	
1100	0	D
1101	1	
1110	1	D'
1111	0	



(10pts) (b) Express F using one 4:1 Multiplexer (can use inverters and NOR gates in addition)

ABCD	F	
0000	0	
0001	0	C
0010	1	
0011	1	
0100	0	
0101	0	0
0110	0	
0111	0	
1000	1	
1001	0	D'
1010	1	
1011	0	
1100	0	
1101	1	$C'D + CD'$
1110	1	
1111	0	



push bubbles to get to NOR structure