



3) (10 points) What is the range of numbers which can be represented by 12 bits if we are representing two's complement integers? (express as the formula and as decimal numbers)

5 points Formula:  $-2^{n-1}$  to  $2^{n-1} - 1$   
 5 points Decimal:  $-2048$  to  $2047$

4) (15 points) Perform the operation 0x5F2 divided by 0x24. Show your result in binary (hint: Perform the division in binary). Show your work below.

Answer: ~~1010~~ 101010 Rem 1010

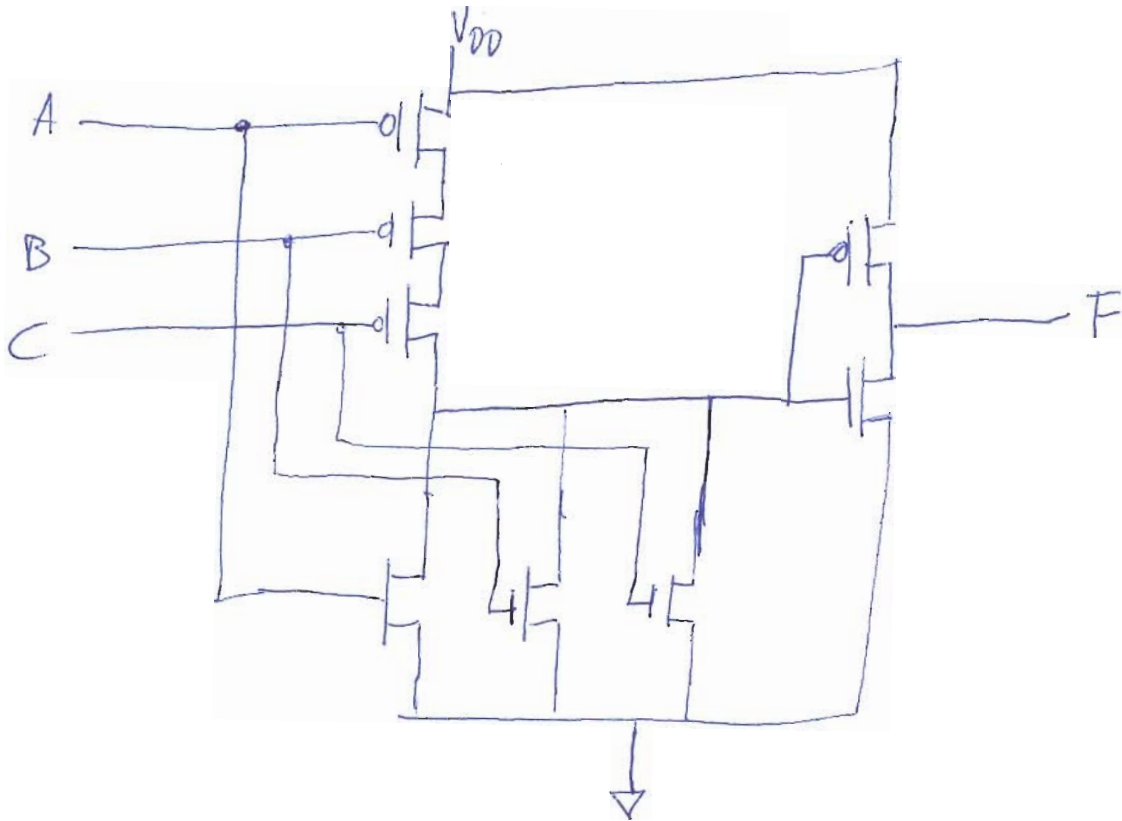
100100

|        |   |   |   |   |   |   |
|--------|---|---|---|---|---|---|
|        | 1 | 0 | 1 | 0 | 1 | 0 |
| 100100 | 1 | 0 | 1 | 1 | 1 | 0 |
|        | 1 | 0 | 0 | 1 | 0 | 0 |
|        |   | 1 | 0 | 1 | 1 | 0 |
|        |   | 1 | 0 | 0 | 1 | 0 |
|        |   |   | 1 | 0 | 0 | 1 |
|        |   |   | 1 | 0 | 1 | 0 |
|        |   |   |   | 1 | 0 | 1 |

Correct math 5 points  
 Correct method 5 points  
 Correct Quotient 3pts  
 Correct Remainder 2pts

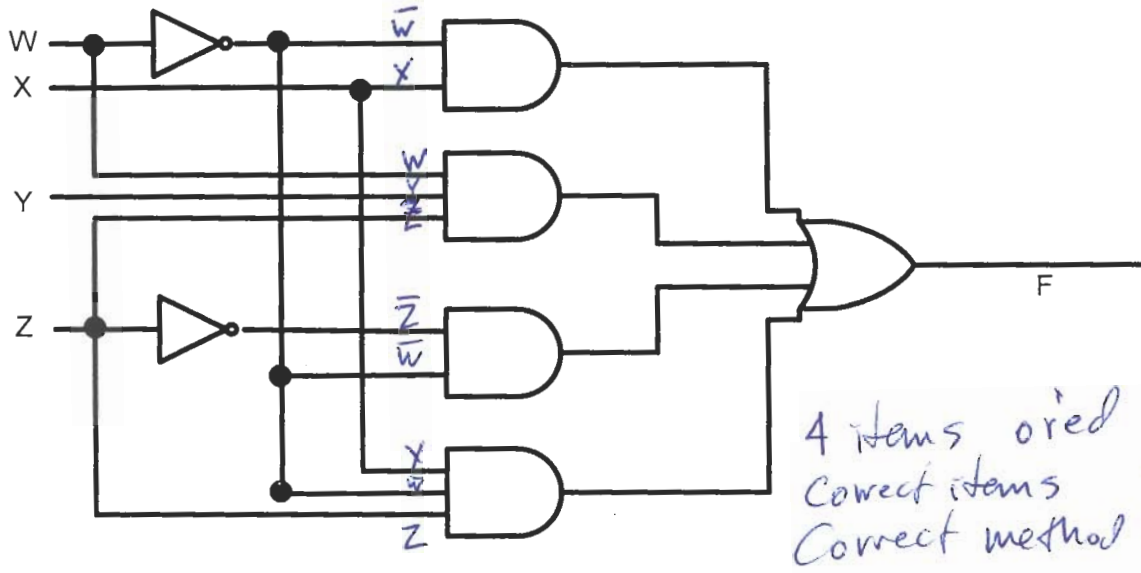
**Long Answer**

5) (20 points) Draw a Transistor-Level Schematic Diagram of a three-input OR Gate, similar to what was done in the homework assignment.



5pts p channel at top, series  
5pts n channel at bottom parallel  
5pts inverter at end  
5pts labeled correctly

- 6) (15 pts.) Combinational Circuit Analysis. Write a logic expression for the output F of the circuit below as a function of the circuit inputs (W, X, Y, and Z). Derive the expression directly from the structure of the circuit; do not simplify.



4 items or'ed 5pts  
 Correct items 5pts  
 Correct method 5pts

F =  $\bar{W}X + WYz + \bar{Z}\bar{W} + \bar{W}XZ$

- 7) (15 pts.) Complete the Truth Table for the following function:  $F = \Sigma A,B,C(0,1,5,7)$  and give the Canonical Sum representation.

| Row | A | B | C | F | Minterm                       |
|-----|---|---|---|---|-------------------------------|
| 0   | 0 | 0 | 0 | 1 | $A\bar{B}\bar{C}$ or $A'B'C'$ |
| 1   | 0 | 0 | 1 | 1 | $A\bar{B}C$ or $A'B'C$        |
| 2   | 0 | 1 | 0 | 0 |                               |
| 3   | 0 | 1 | 1 | 0 |                               |
| 4   | 1 | 0 | 0 | 0 |                               |
| 5   | 1 | 0 | 1 | 1 | $AB\bar{C}$ or $AB'C$         |
| 6   | 1 | 1 | 0 | 0 |                               |
| 7   | 1 | 1 | 1 | 1 | $ABC$                         |

Only minterms which are 1's 5pts  
 F column 5pts  
 Correct ~~equation~~  
 equation 5pts

F =  $A'B'C' + A'B'C + AB'C + ABC$



- 8) (20 pts.) Combinational Circuit Minimization. Using a Karnaugh map, find a minimal sum of products expression for the function from the previous question:  $F = \Sigma A,B,C(0,1,5,7)$ . Show all of your work (draw and label the entire table).

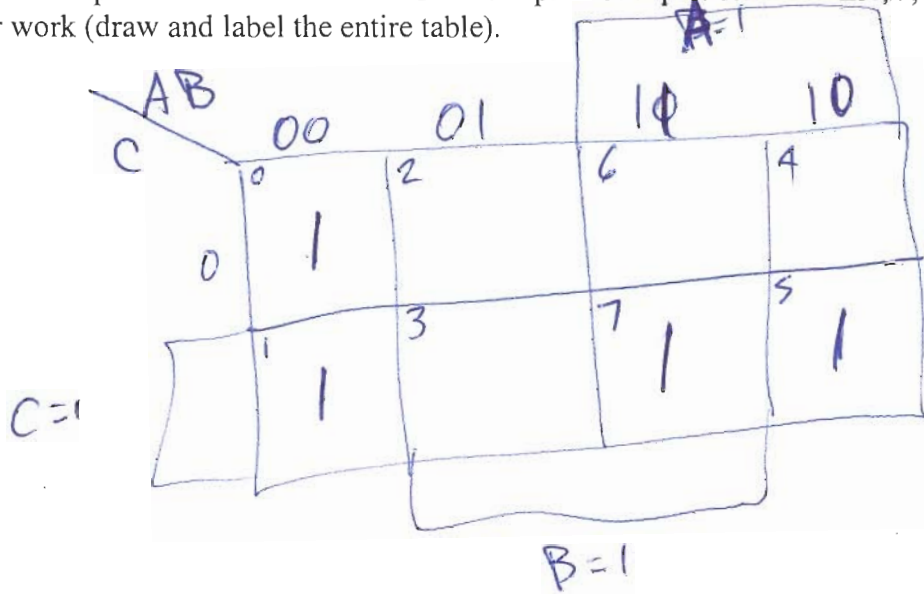


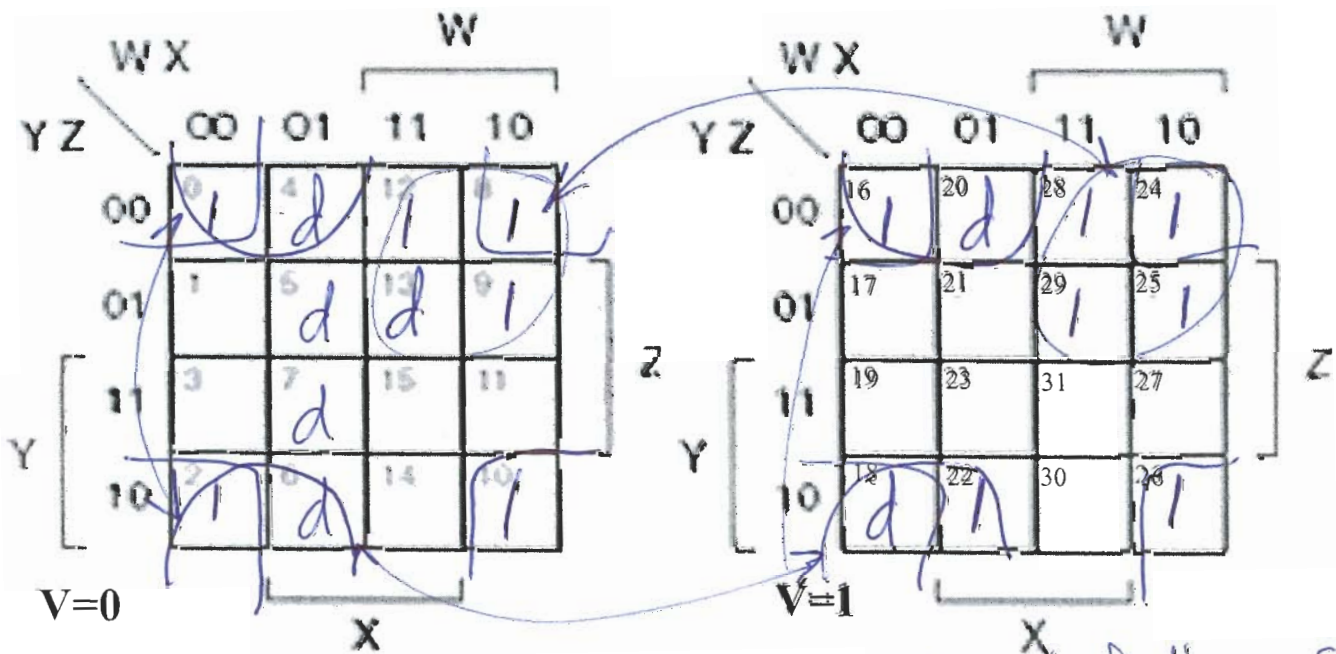
Table:  
Box of 3 vars 5pts  
labels for  
box 5pts  
1's in  
box 5pts

$F = A'B' + AC$

equation  
~~XXXXXX~~ 5pts

- 9) (40 pts.) Combinational Circuit Minimization. Fill in the Karnaugh map and find a minimal sum of products expression for the function:

$F = \Sigma W,X,Y,Z(0,2,8,9,10,12,16,22,24,25,26,28,29) + d(4,5,6,7,13,18,20)$



$F = W\bar{Y} + \bar{W}\bar{Z} + \bar{X}\bar{Z}$

placement of 1's 5pts  
placement of d's 5pts  
minimum solution 15pts  
all 1's included (circled) 5pts  
some d's left uncircled 5pts  
sum of products 5pts