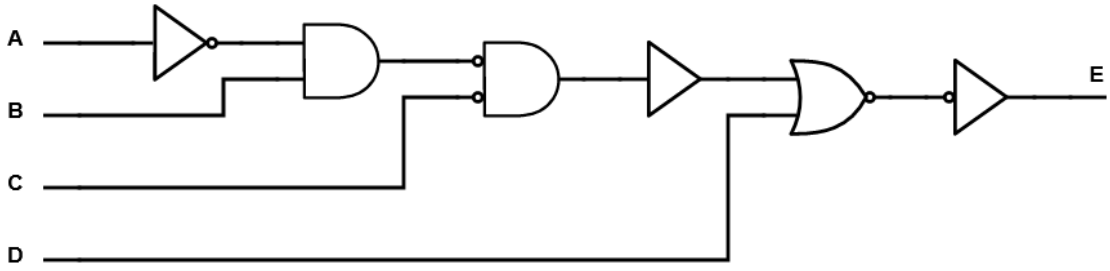
Problem 1 (8+12 points):

a) Write the Boolean expression represented by this gate schematic. Do not simplify or otherwise manipulate anything; the expression should be what is directly represented here.



E = $\overline{A} \cdot B \cdot \overline{C} + D$

b) Fill in the truth table for the logic in a) above. The table is separated into two sections just to fit better on the page.

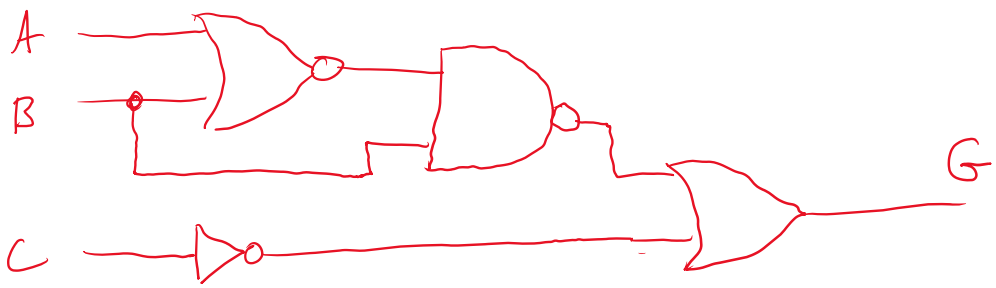
A	B	C	D	E
0	0	0	0	1
0	0	0	1	1
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1

A	B	C	D	E
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	0
1	1	1	1	1

Problem 2 (10 points):

Draw a gate schematic that directly implements this Boolean expression (i.e. do not algebraically change anything).

$$G = \overline{\overline{A + B} \cdot B} + \overline{C}$$



Problem 3 (18 points):

Implement the following Boolean expression in proper CMOS (N-FETs and P-FETs). Assume that inputs and their complements are available (i.e. you may use something like $\overline{C}$ as an input to a FET if needed).

$$F = \overline{\overline{A} \cdot \overline{\overline{B} \cdot C}}$$

Derive expressions for the pull-up and pull-down switch networks (p.u. and p.d.) here:

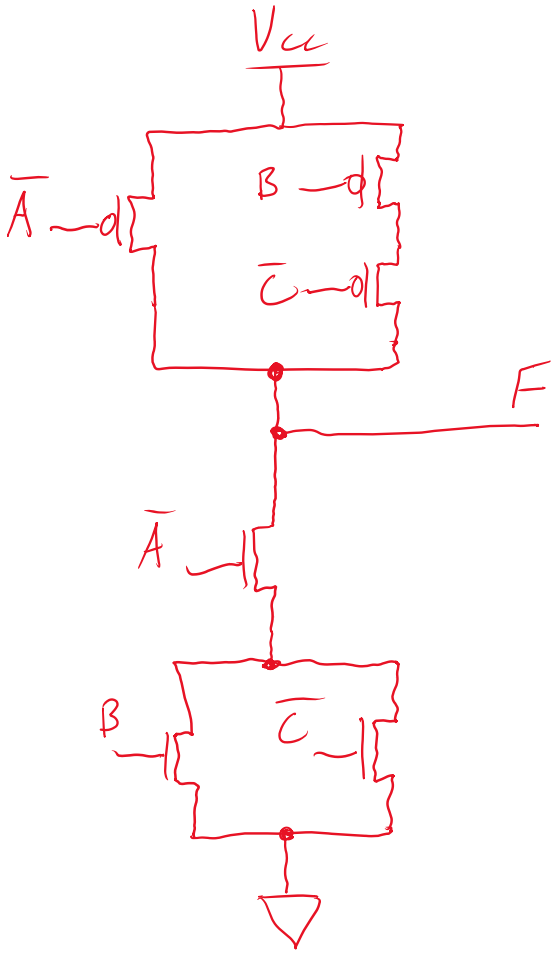
$\overline{\overline{A} \cdot \overline{\overline{B} \cdot C}}$

$A + \overline{B} \cdot C$

p.u. = $A + \overline{B} \cdot C$

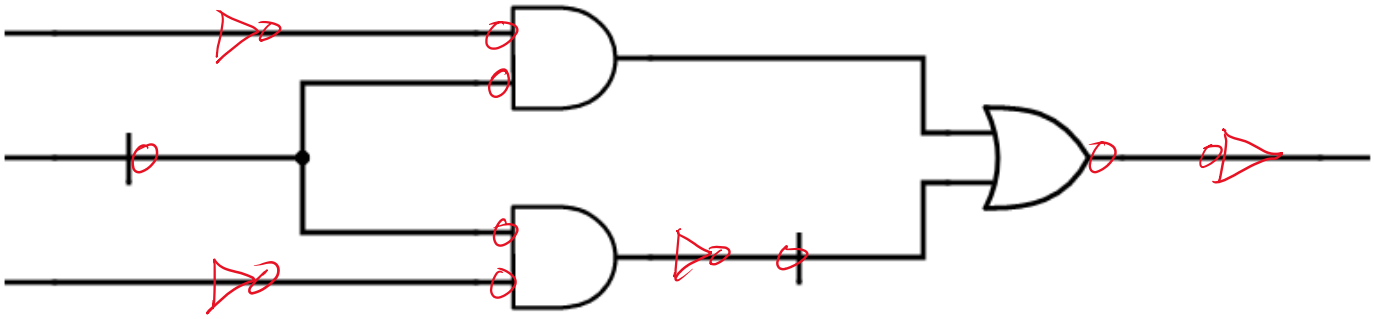
p.d. = $\overline{A} \cdot (B + \overline{C})$

Draw CMOS here:

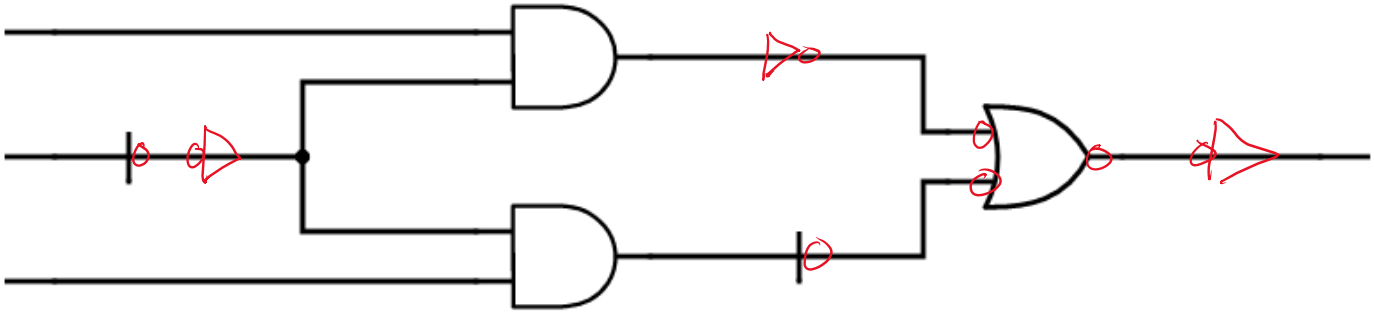


Problem 4 (16+4 points):

a) Manipulate the following mixed-logic schematic to implement it using only **NORs** and **inverters**. Minimize the number of inverters.



b) This time, implement it using only **ANDs** and **inverters**. Minimize the number of inverters.



c) If the circuits above (after your manipulations) were built, how many of the following types of gates would be required?

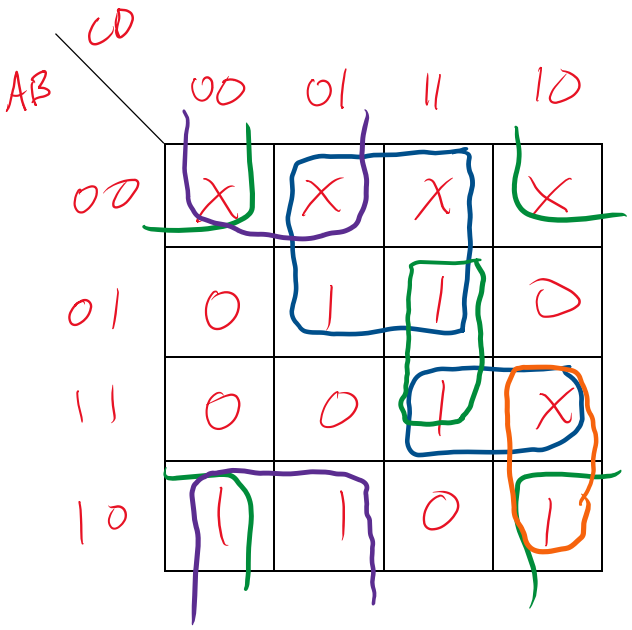
Gate type	# needed for a)	# needed for b)
NOT	4	3
AND	0	3
OR	0	0
NAND	0	0
NOR	3	0

Problem 5 (18+4 points):

a) Using the truth table below, create a K-map and solve for a minimal sum-of-products expression.

A	B	C	D	Y
0	0	0	0	X
0	0	0	1	X
0	0	1	0	X
0	0	1	1	X
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	1
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	X
1	1	1	1	1

Label the rows and columns of the K-map appropriately.



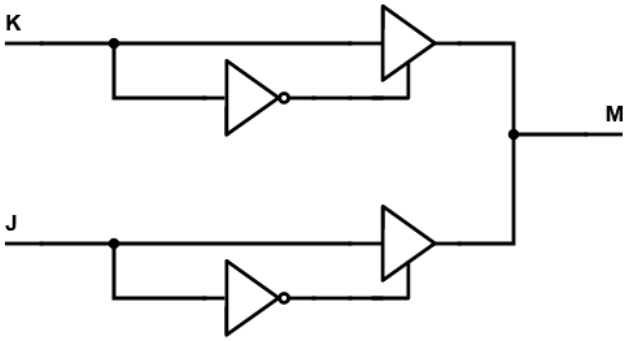
Y = $\bar{A} \cdot D + \bar{B} \cdot \bar{C} + \bar{B} \cdot \bar{D} + A \cdot B \cdot C$ (or $B \cdot C \cdot D$)

b) List all of the essential prime implicants in the above K-map:

$\bar{A} \cdot D$, $\bar{B} \cdot \bar{C}$

Problem 6) (10 points)

Complete the truth table for this circuit.



K	J	M
0	0	0
0	1	0
1	0	0
1	1	1