11- Convert the following boolean function from Sum-of-Products form to a simplified Product-of-Sums form.

$F(x, y, z) = \Sigma(0, 1, 2, 5, 8, 10, 13)$

wx \ yz	00	01	11	10
00	1	1	0	1
01	0	1	0	0
11	0	1	0	0
10	1	0	0	1

$F' = x'z + y'z' + w'xz'$

$= w'xz' + x'z + y'z'$

$F' \rightarrow F$

$\therefore F = (w'xz' + x'z + y'z')'$

$= (w + x' + z)(x + z')(y + z)$

12- Simplify the following boolean function:

(b) $F(A, B, C, D) = \Sigma(1, 3, 6, 9, 11, 12, 14)$.

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

$\therefore F = ABD' + BCD' + B'D$

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13- Simplify the following expression to
(1) Sum-of-Products
(2) Products-of-Sums :

(b) $F = ACD' + C'D + AB' + ABCD$

(1) Sum-of-Products

$F = AB' + AC + C'D$

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

(2) Products-of-sums

$F' = BC'D' + A'D' + A'C$ # SOP

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

$= (BC'D')'(A'D')'(A'C)'$

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

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

F = POS

$F' = AB'D + ABC + ABC' + BC'D$

(1) Sum-of-Products

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

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

(2) Product-of-Sums

$F' = BC'D + AB + AD$

$F = (AB + AD + BC'D)'$

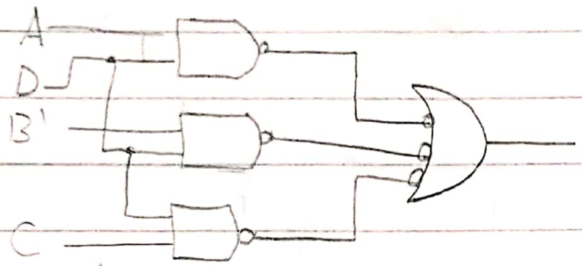
$= (A'+B')(A'+D')(B'+C+D')$

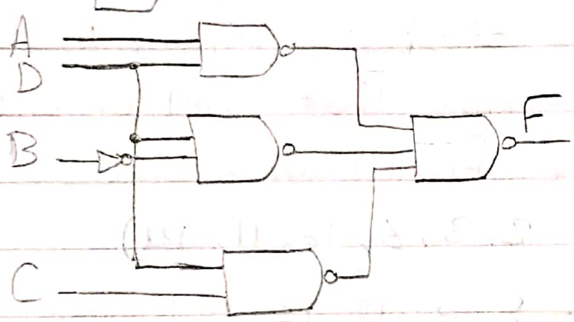
16- Simplify the following functions, and implement them with two-level NAND gate circuits :-

(b) $F(A,B,C,D) = A'B'C'D + CD + AC'D$

$F = AD + B'D + CD$

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



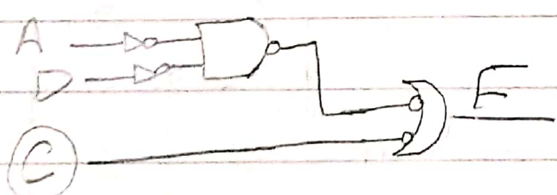


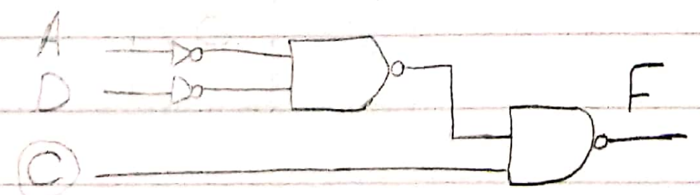
(c) $F(A,B,C,D) = (A'+C'+D')(A'+C')(C'+D') \rightarrow POS$ #

$F' = ACD + AC + CD$

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

$F = C' + A'D'$





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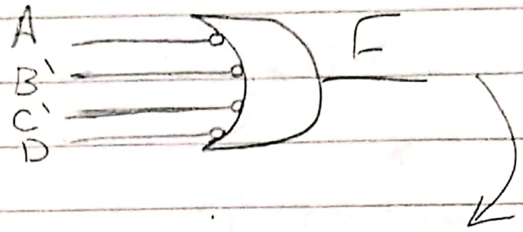
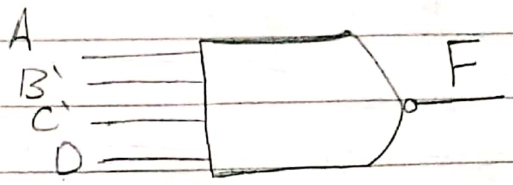
(d) $F(A,B,C,D) = A' + B + D' + B'C$

apply absorbtion rule

$\therefore F = A' + B + D' + C$

To draw it with NAND gate, we should change each input condition.





17- Draw a NAND logic diagram that implements the complement of the function:-

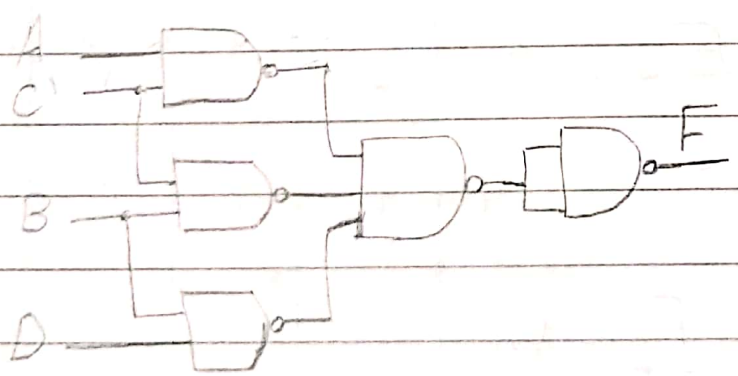
$F(A,B,C,D) = \Sigma m(0,1,2,3,6,10,11,14)$

Then $F' = \Sigma m(4,5,7,8,9,12,13,15)$

AB \ CD	00	01	11	10
00	0	1	3	2
01	4: 0	5: 0	7: 0	6
11	12: 0	13: 0	15: 0	14
10	8: 0	9: 0	11	10

$F' = AC' + BC' + BD$

$F = (AC')'(BC')'(BD)'$



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18- Draw a logic diagram using only two-input NOR gates to implement :-

$F(A,B,C,D) = (A \oplus B)' \, (C \oplus D')$

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

$= (AB')'(A'B)'(CD' + C'D)$

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

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

$= (\underline{AA'} + AB + A'B' + \underline{BB'})(CD' + C'D)$

$= (AB + A'B')(CD' + C'D)$

$= AB(CD' + C'D) + A'B'(CD' + C'D)$

$= ABCD' + ABC'D + A'B'CD' + A'B'C'D \rightarrow SOP$

$F' = AB' + A'B + C'D' + CD$

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

$= [\{(A' + B)(A + B')(C + D)(C' + D')\}']'$

$= [AB' + A'B + C'D' + CD]'$

$= [(A + A'B)(B' + A'B) + (C' + CD)(D' + CD)]''$

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

AB \ CD	00	01	11	10
00	(0) 0	(1) 1	(3) 0	(2) 1
01	(4) 0	(5) 0	(7) 0	(6) 0
11	(12) 0	(13) 1	(5) 0	(14) 1
10	(8) 0	(9) 0	(11) 0	(10) 0

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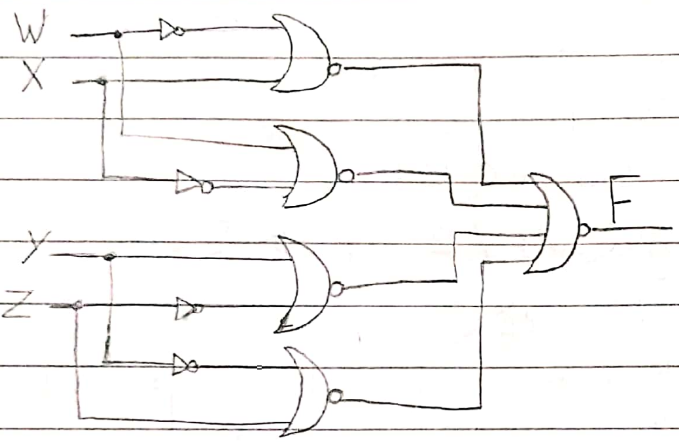
19. Simplify the following functions, and implement them with two-level NOR gate circuits:-

(b) $F(w,x,y,z) = \sum m(0,3,12,15)$

$F' = wx' + w'x + y'z + yz'$

$F = (w'+x)(w+x')(y+z')(y'+z)$

$wx \backslash yz$	00	01	11	10
00	1	0	1	0
01	0	0	0	0
11	1	0	1	0
10	0	0	0	0



(c) $F(x,y,z) = [(x+y)(x+z)]'$

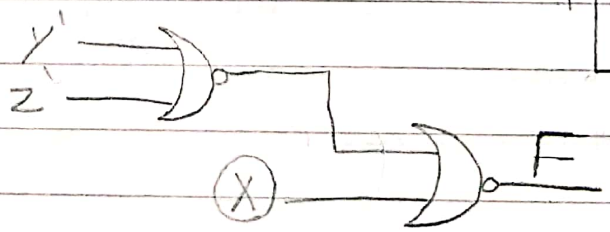
$F = (x+y)' + (x+z)'$

$= x'y' + x'z' \rightarrow SOP$

$x \backslash yz$	00	01	11	10
0	1	1	0	1
1	0	0	0	0

$F' = x + yz$

$F = x'(y'+z')$



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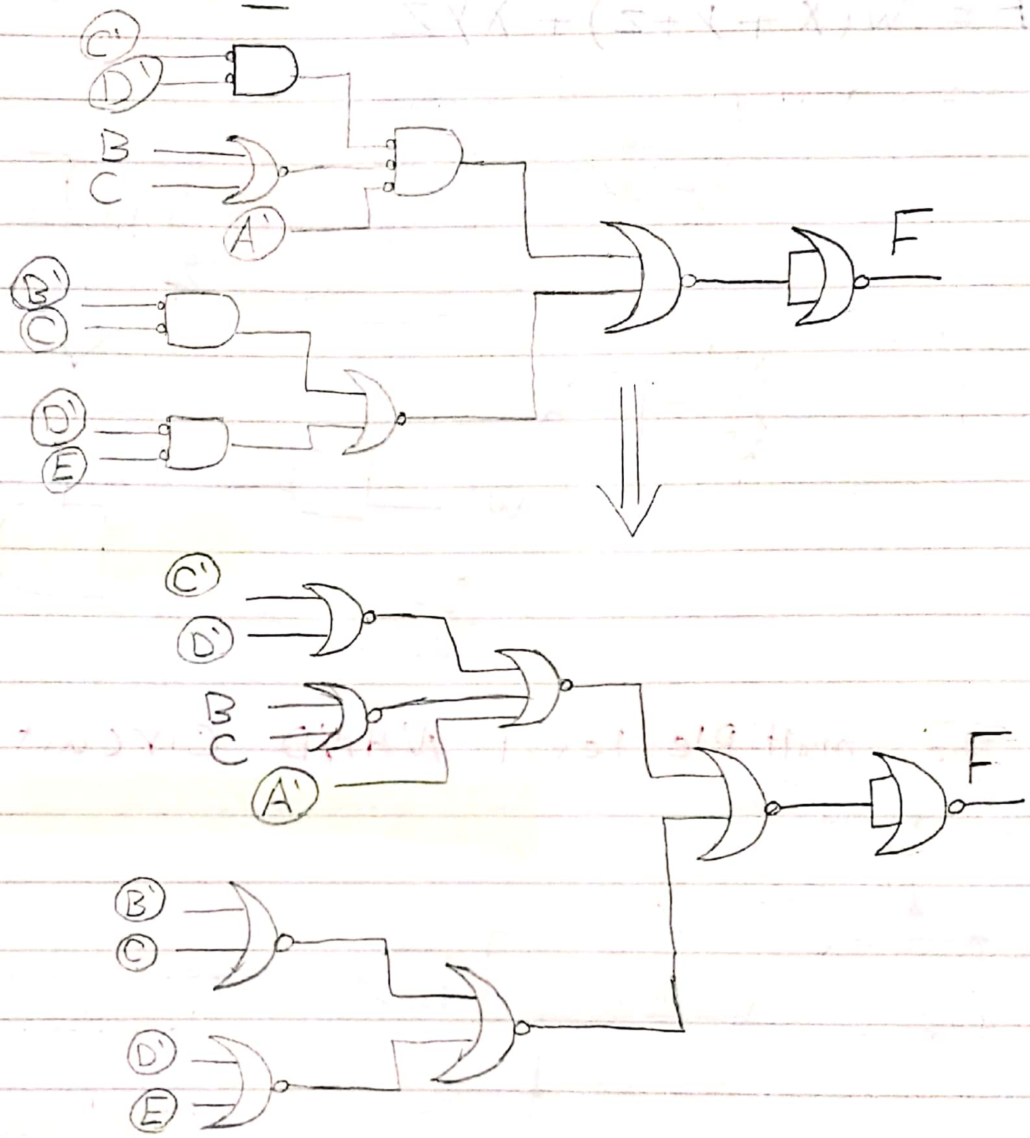
20_ Draw the multi-level NOR circuit for the following expression:-

$F = CD(B+C)A + (BC' + DE')$



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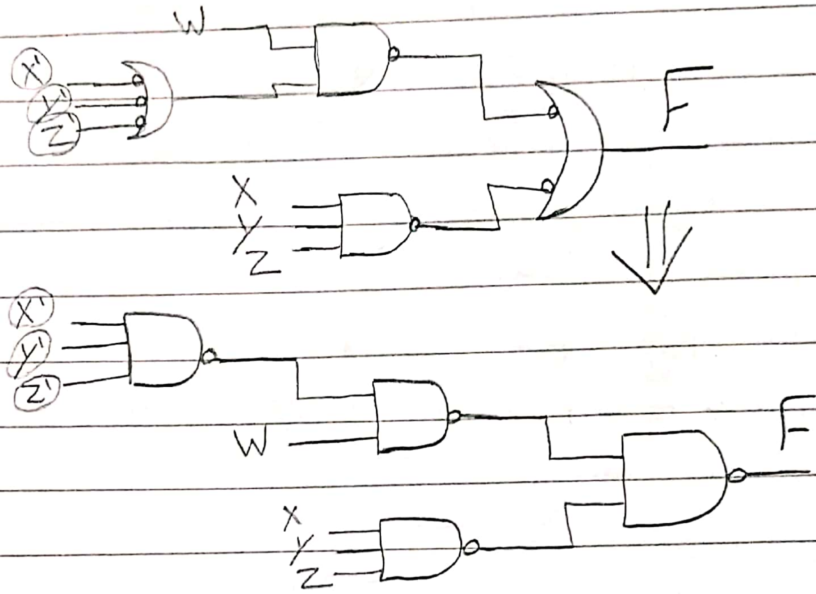
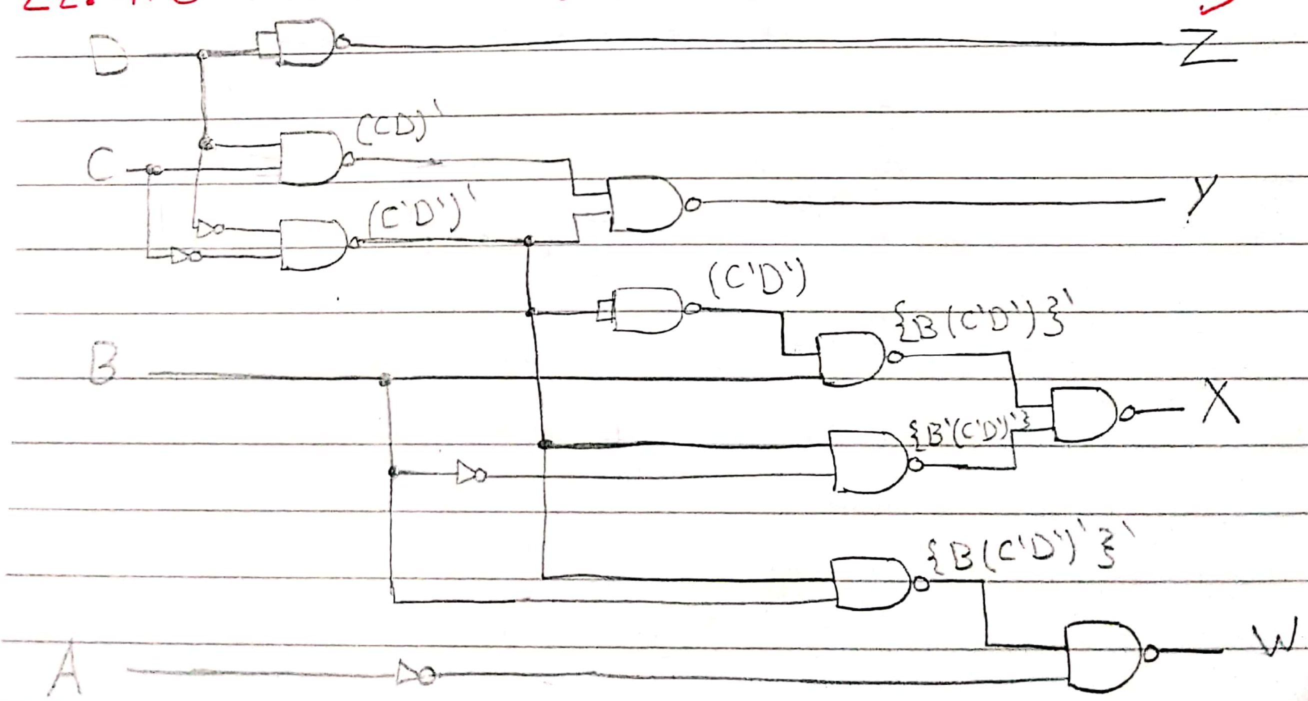
21- Draw the multiple-level NAND Circuits for the following expression:-

$F = W(X+Y+Z) + XYZ$



22. The multiple-level NAND circuit ⟹



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22- Convert the logic diagram of the following circuits into a multiple-level NAND gates :-

$Z = D'$
$y = CD + (C+D)'$
$X = B(C+D)' + B'(C+D)$
$W = A + B(C+D)$

$Z = D'$
$y = [\{CD + (C+D)'\}']'$
$= [(CD)' \cdot (C'D')']'$
$X = [\{B(C+D)' + B'(C+D)\}']'$
$= [\{B(C'D')\}' \cdot \{B'(C+D)\}']'$
$\hookrightarrow \{(C+D)'\}' = \{C'D'\}' = (C'D')'$
$= [\{B(C'D')\}' \cdot \{B'(C'D')'\}']'$
$W = [\{A + B(C+D)\}']'$
$= [A' \cdot \{B(C+D)\}']'$
$\hookrightarrow \{(C+D)'\}' = \{(C'D')\}' = (C'D')'$
$= [A' \cdot \{B(C'D')'\}']'$

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24- Implement the following Boolean function F, using the two-level forms of logic

(a) NAND - AND
(b) AND - NOR
(c) OR - NAND
(d) NOR - OR

$$F = \sum m(0, 4, 8, 9, 10, 11, 12, 14)$$

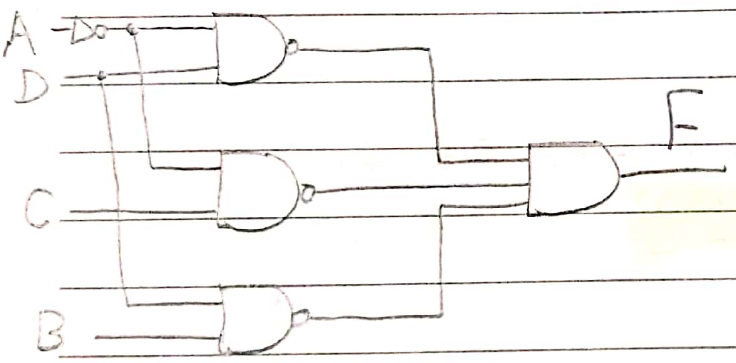
(a) NAND - AND

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

$F' = A'D + A'C + BD$

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

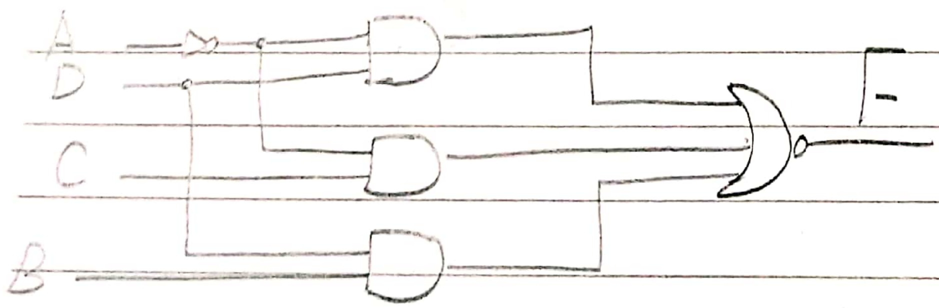
$= (A'D)' \cdot (A'C)' \cdot (BD)'$



(b) AND - NOR

$F' = A'D + A'C + BD$

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



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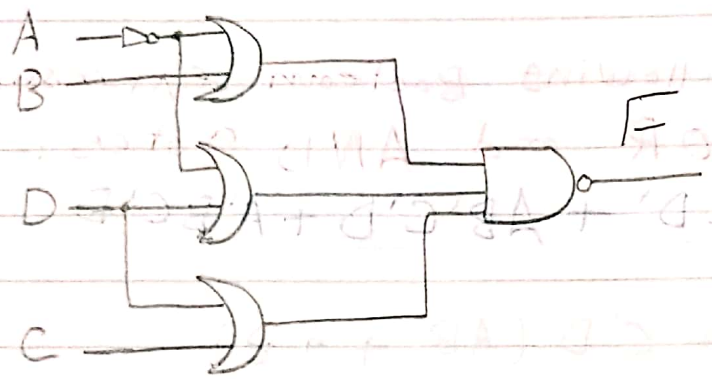
(c) OR- NAND

$F = AB' + AD' + C'D'$

$F = [\{AB' + AD' + C'D'\}']'$ Demorgan

$= [(AB')' \cdot (AD')' \cdot (C'D')']'$

$= [(A'+B) \cdot (A'+D) \cdot (C+D)]'$



(d) NOR-OR

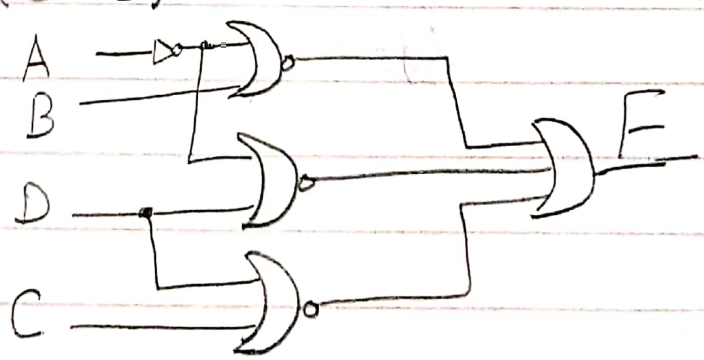
$F = AB' + AD' + C'D'$ Apply Demorgan twice

$= [\{AB' + AD' + C'D'\}']'$

$= [(AB')' \cdot (AD')' \cdot (C'D')']'$

$= [(A'+B) \cdot (A'+D) \cdot (C+D)]'$

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



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27- Show that the dual of the exclusive-OR is also its complement :-

$x \oplus y = xy' + x'y$

dual $= (x+y')(x'+y)$

$= (xx' + xy' + x'y' + y'y)$

$= (xy + x'y') = (x \oplus y)'$ #

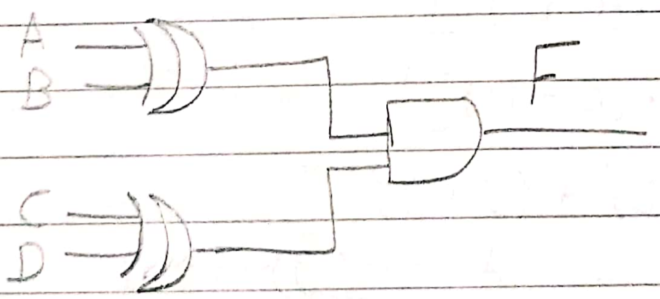
30- Implement the following Boolean expression with exclusive-OR and AND gates :-

$F = AB'CD' + A'BCD' + AB'C'D + A'BC'D$

$= CD'(AB' + A'B) + C'D(AB' + A'B)$

$= (AB' + A'B) + (CD' + C'D)$

$= (A \oplus B)(C \oplus D)$ #



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