K map

A \ BC	00	01	11	10
0		1	1	
1				

$A'B'C$ $\quad$ $A'BC$

11 $\quad$ 10 $\quad$ 00

Adjacent cells.

$F = A'C$

	00	01	11	10
0	1			1
1	1			1

logical adjacency.

A \ BC	00	01	11	10
0	1_0	1_1	$_3$	1_2
1	1_4	$_5$	1_7	1_6

$$f(A,B,C) = \Sigma(0,1,2,4,6,7)$$

$$f = C' + AB + A'B'$$

A \ BC	00	01	11	10
0		1		1
1	1		1	

$B \oplus C = x$

$$f = A'B'C + A'BC' + AB'C' + ABC$$

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

$$A'(B \oplus C) + A(\overline{B \oplus C})$$

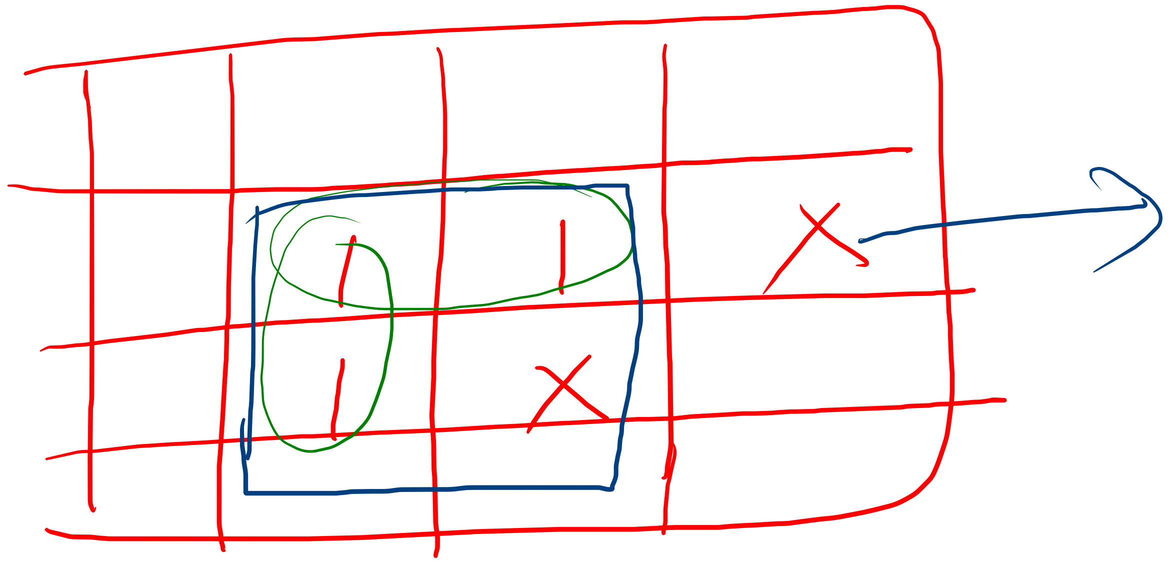
$$A \oplus B \oplus C = \text{Sum}$$

Don't care conditions

eg **Binary Coded Decimal**

Binary rep for each 0 — 9

4 bits



don't care

1010, 1011,

1100, 1101,

1110, 1111

0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

$$F = \Sigma(1, 5, 9, 11, 12, 13) + \Sigma_{\phi}(3, 10, 14, 15)$$

4 variable K map

AB \ CD	00	01	11	10
00	$_{0}$	1_{1}	X_{3}	$_{2}$
01	$_{4}$	1_{5}	$_{7}$	$_{6}$
11	1_{12}	1_{13}	X_{15}	X_{14}
10	$_{8}$	1_{9}	1_{11}	X_{10}

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

$$F = \Sigma(0, 7, 10) + \Sigma_{\phi}(2, 5, 8, 15)$$

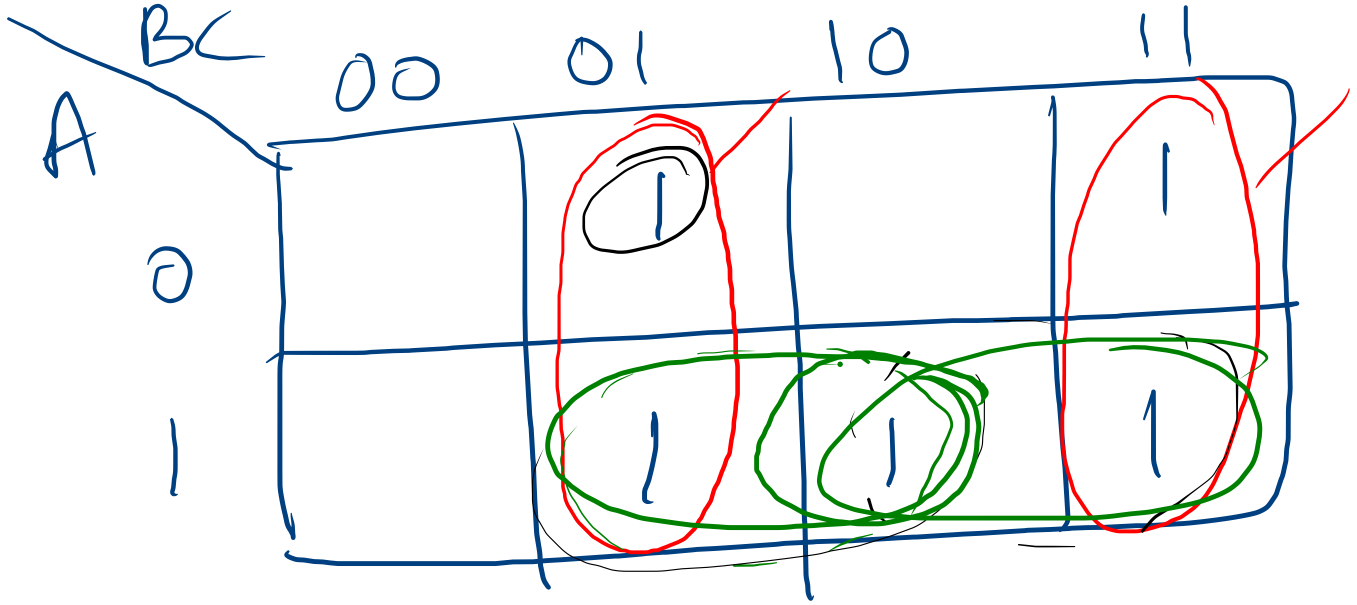
AB \ CD	00	01	11	10
00	1			X
01		X	1	
11			X	
10	X			1

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

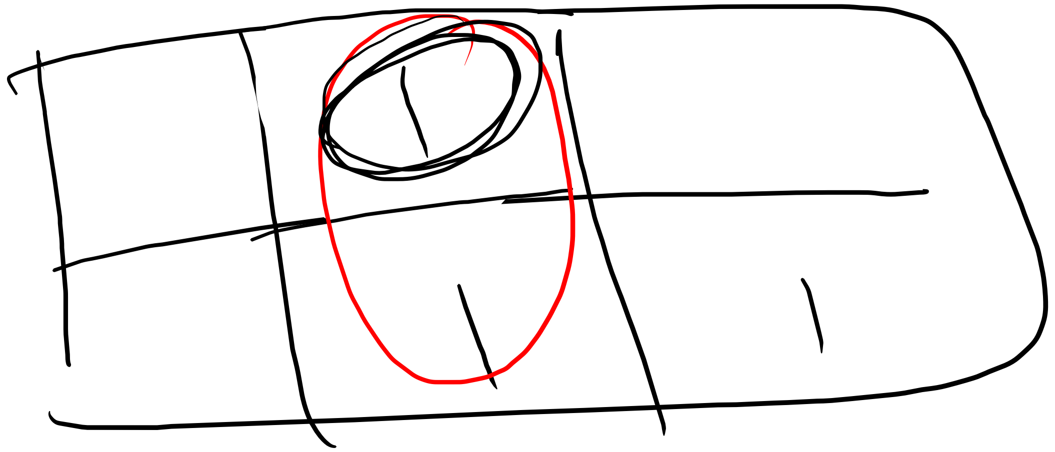
BCD

Prime Implicant

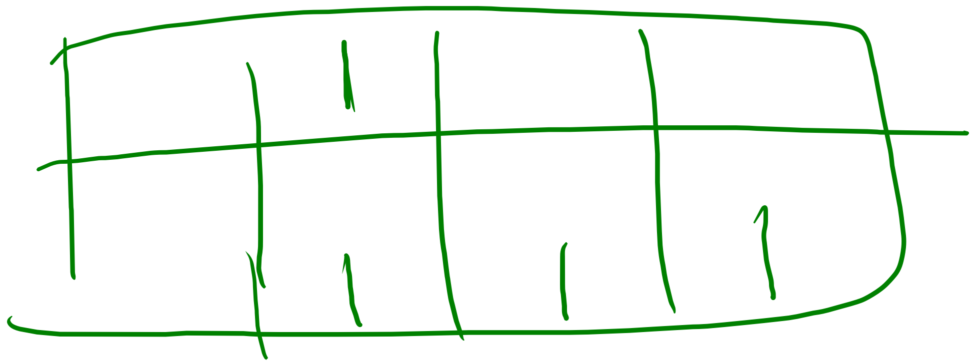
— A product term that is obtained by making the largest possible cube (group) for a minterm

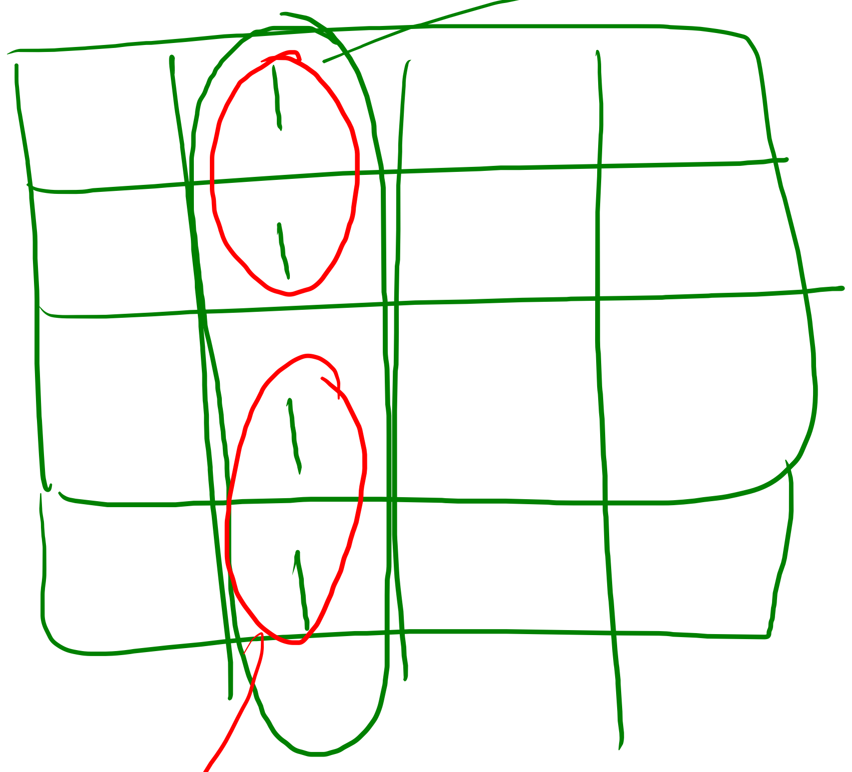


essential PI



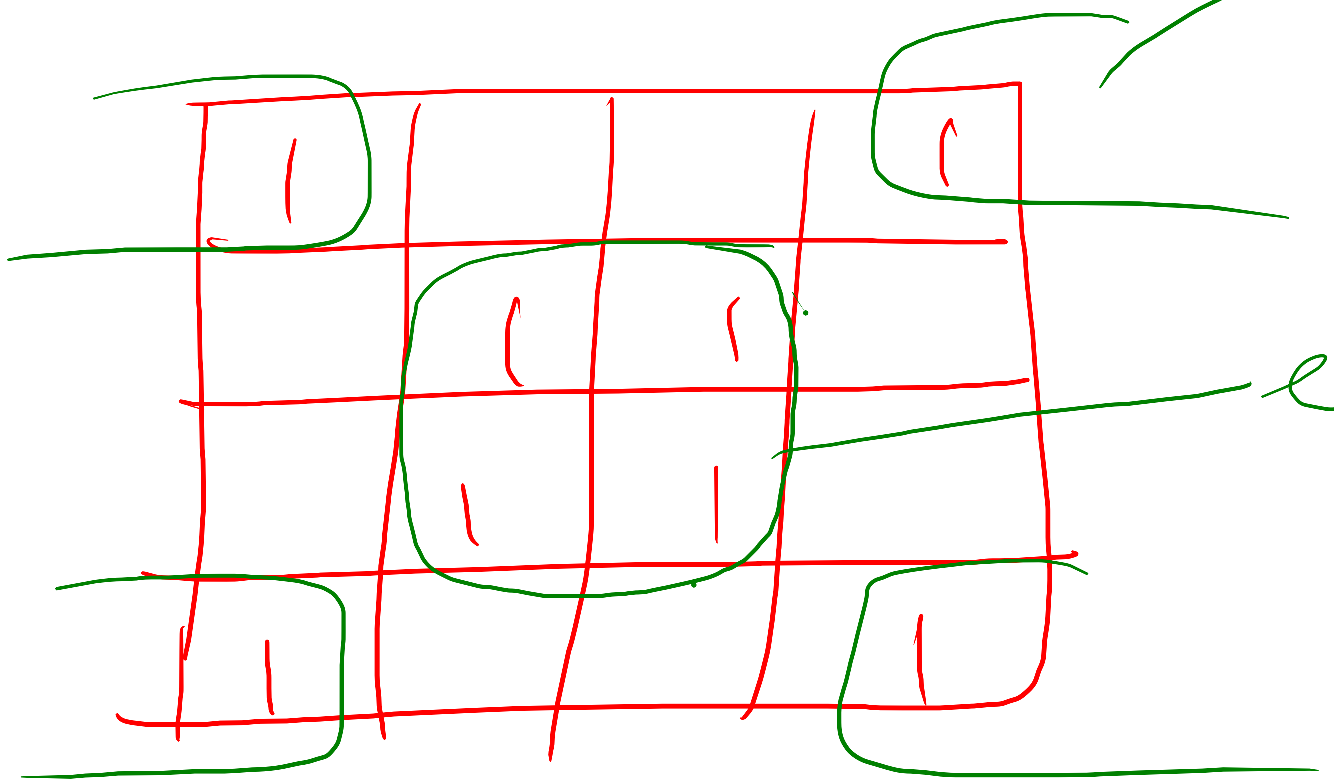
nonessential PI





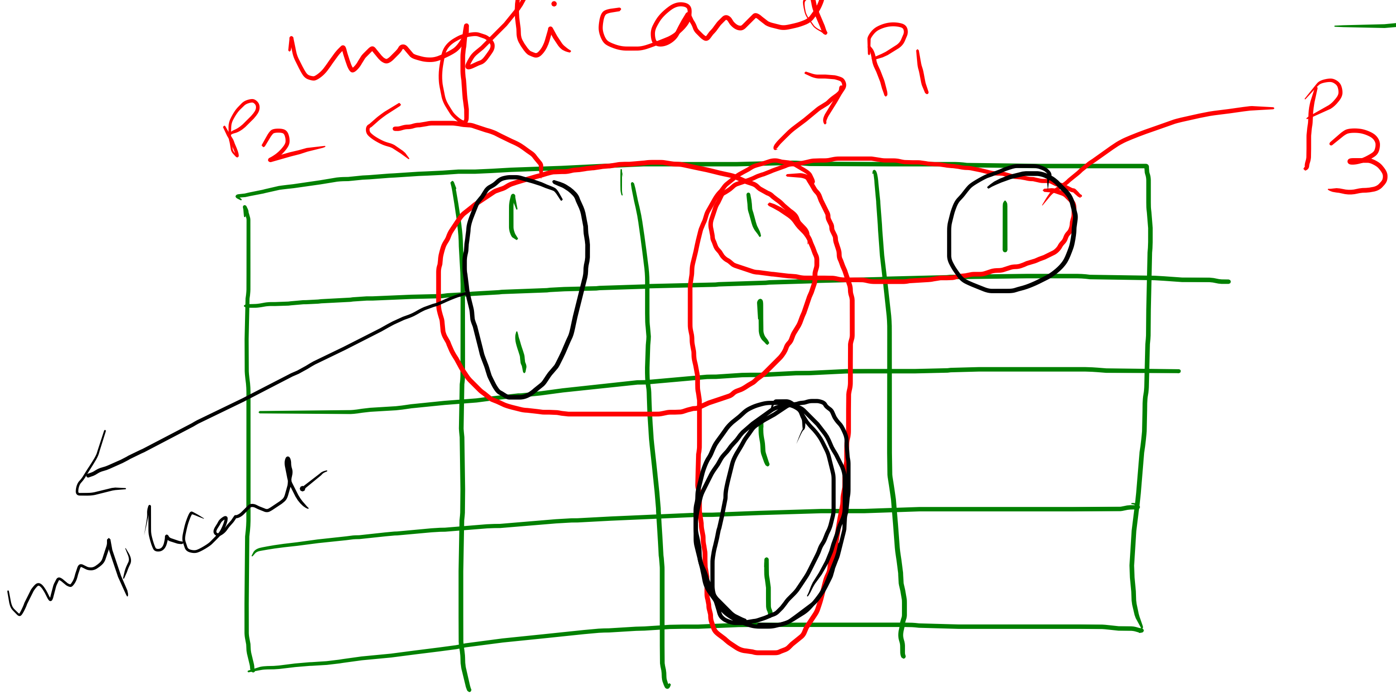
PI .

essential PI



essential PI

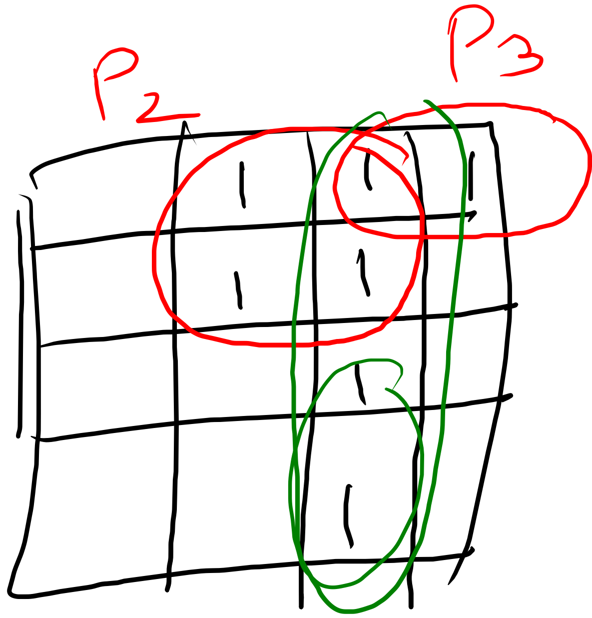
implicant

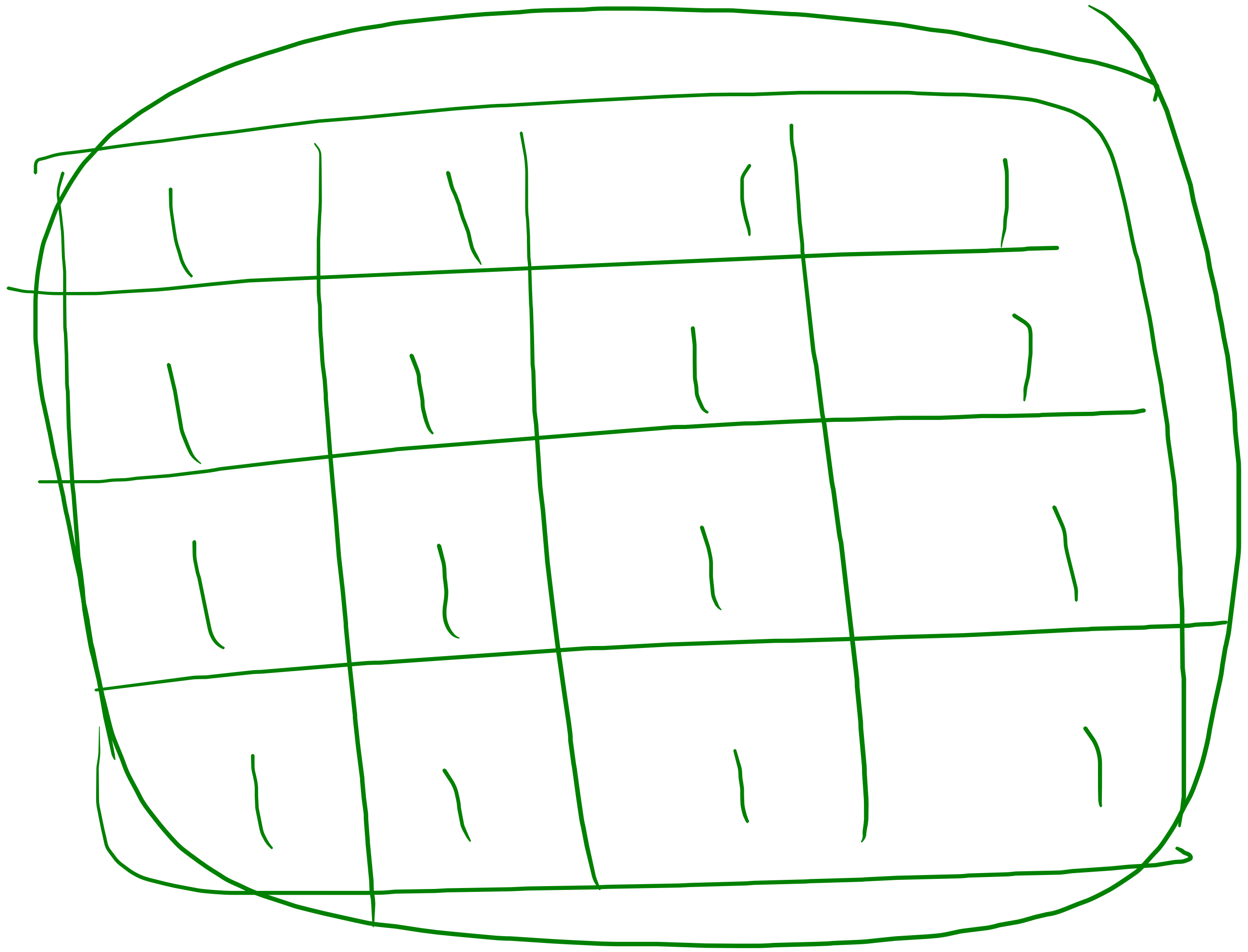


P_1 - essential

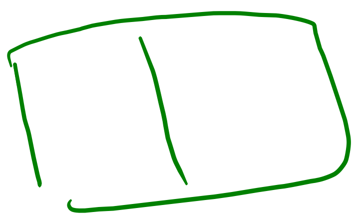
P_2 - essential

P_3





$F = 1$



AB

K - map (POS)

$A \leftarrow 0$

$A' \leftarrow 1$

$$F = \Sigma(1, 4, 5, 6, 11, 12, 13, 14, 15)$$

$$= \Pi(0, 2, 3, 7, 8, 9, 10)$$

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

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

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

POS & SOP are equivalent.

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

$$= ABC'(A + A') + AB'(C' + C) + AB(C' + C)$$

$$= BC' + AB' + AB = BC' + A(B' + B)$$

$$= BC' + A$$

A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0

Max terms

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

$$\overline{F} = \overline{A}\,\overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,C + \overline{A}\,B\,C$$

$$F = \underbrace{(A+B+C)\,(A+B+\overline{C})}_{A}\;\underbrace{(A+B'+C')\,(A+B+\overline{C})}_{B}$$

A $(A+B+C)\,(A+B+\overline{C})$

$$AA + AB + AC + AB + BB + BC + A\overline{C} + B\overline{C} + \cancel{C\overline{C}}$$

$$A + AB + AC + B + BC + A\overline{C} + B\overline{C}$$

$$A(1\cancel{+B}) + A(\cancel{C+\overline{C}}) + B(\cancel{C+\overline{C}}) + B$$

$$A + A + B = A+B$$

B $(A+C')$

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

$$= AA + AB + AC' + BC'$$

$$= \underbrace{A + AB} + AC' + BC'$$

$$= A(1+\cancel{B}) + AC' + BC'$$

$$= \underbrace{A + AC'} + BC'$$

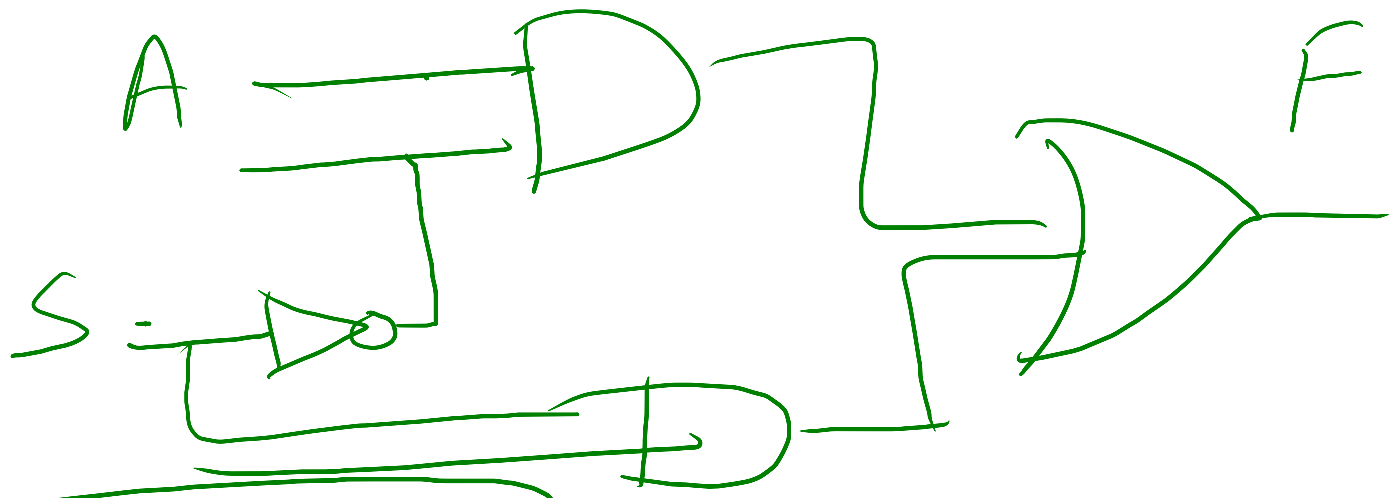
$$= A(1+\cancel{C'}) + BC'$$

$$= \underline{\underline{A + BC'}}$$

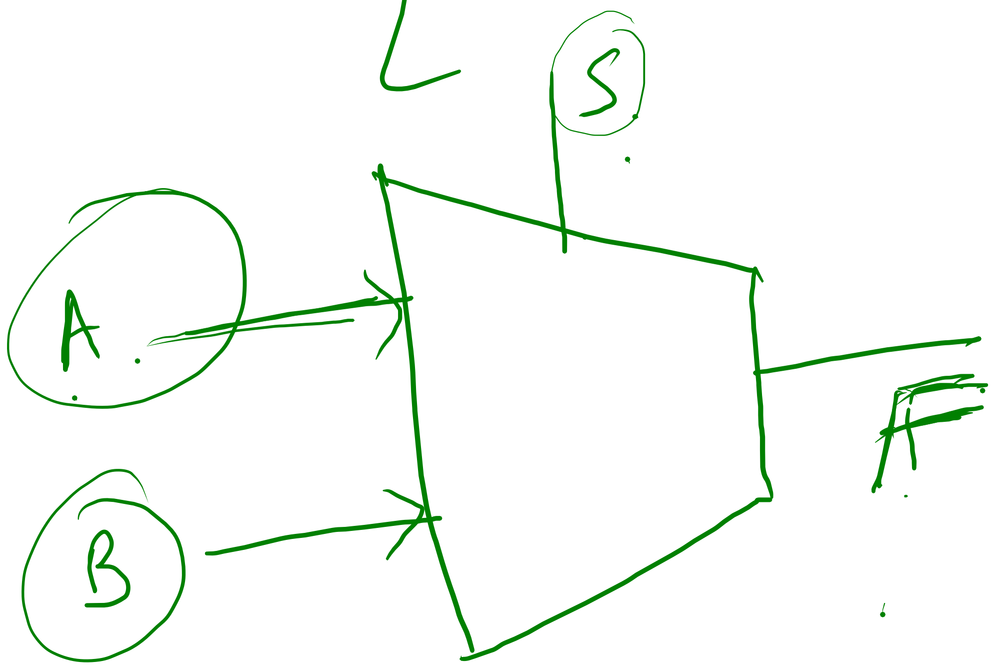
Functional Completeness

NAND, NOR, AND-NOT, OR-NOT

Multiplexer(MUX) 2x1 MUX



$\{2\times1 \text{ MUX}, 1, 0\}$



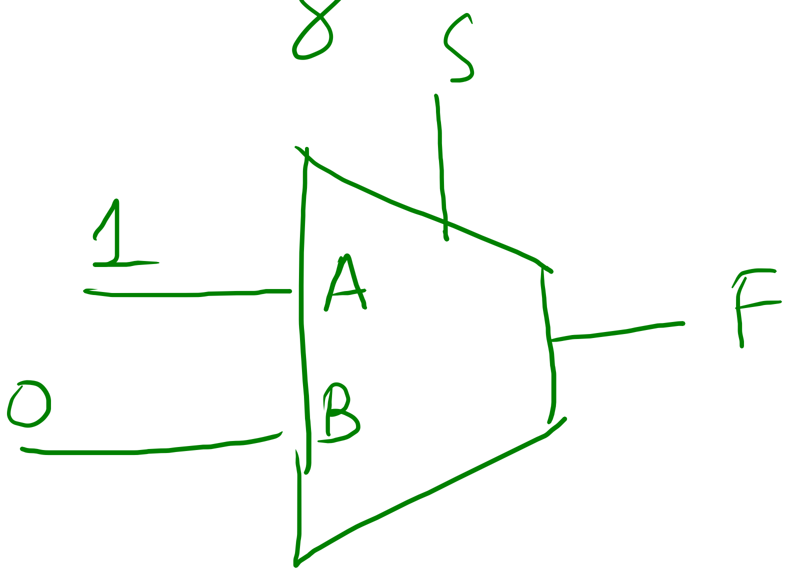
$$\boxed{F = A\bar{S} + BS}$$

If $S=0$ $\quad F = A\cdot 1 + \cancel{B\,0}$

$= A$

$S=1$ $\quad F = \cancel{A\cdot 0} + B\cdot 1 = B$

Realize a NOT gate using mux

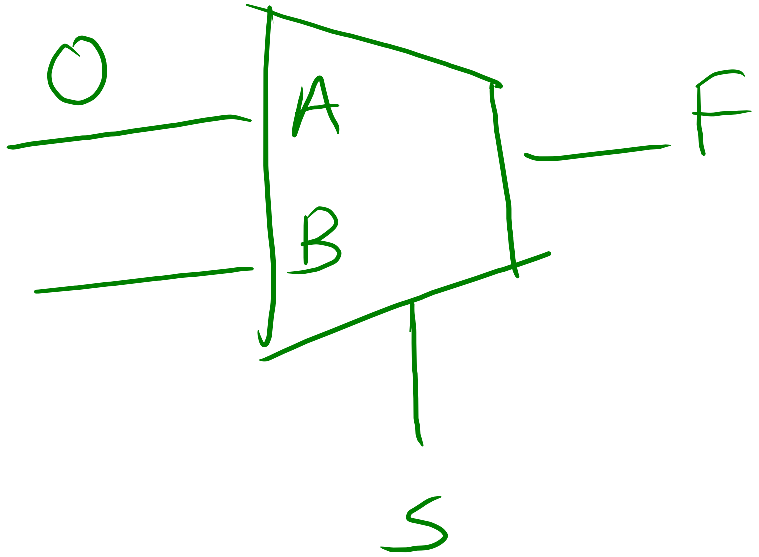


$$F = A\bar{S} + BS$$
$$= \bar{S}$$

$\{2 \times 1 \text{ MUX}, 1, 0\}$

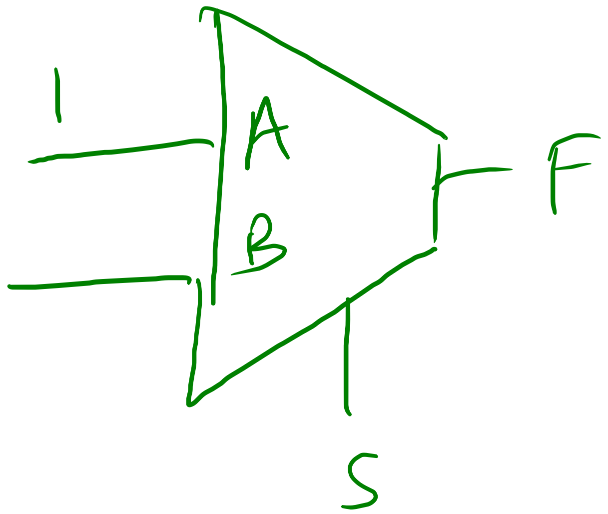
AND.

$$F = \cancel{A\bar{S}} + BS$$
$$= BS$$



$$\boxed{\begin{aligned} x + x'y &= x + y \\ x' + xy &= x' + y \end{aligned}}$$

OR



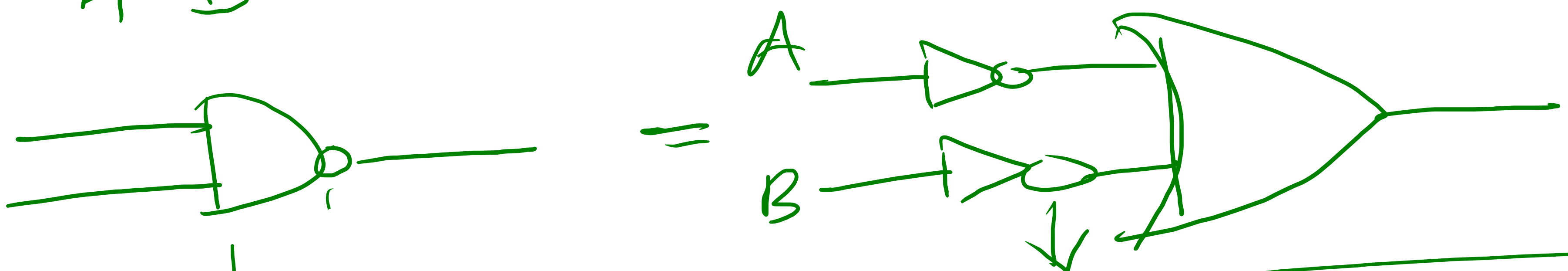
$$F = A\bar{S} + BS$$
$$= \bar{S} + BS = \bar{S} + B \quad \text{(Absorption law)}$$

2 level AND - OR circuit is equivalent to NAND-NAND

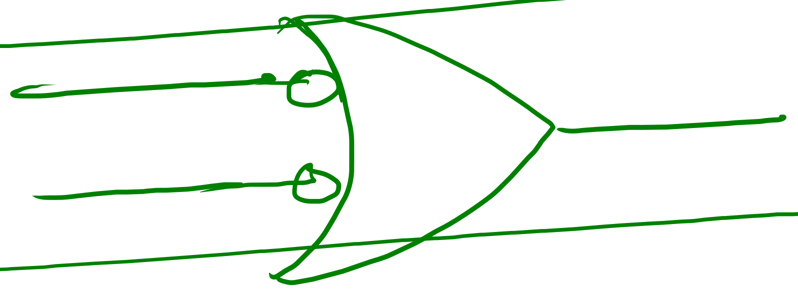
De Morgan's law

$5 + x = y + 5$

$\overline{A \cdot B} = \bar{A} + \bar{B}$



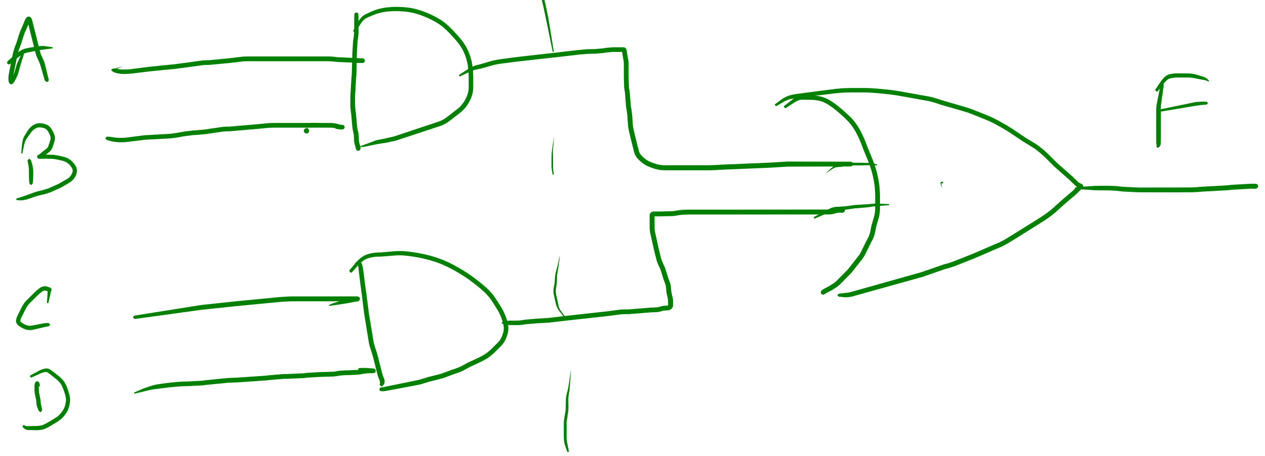
NAND =

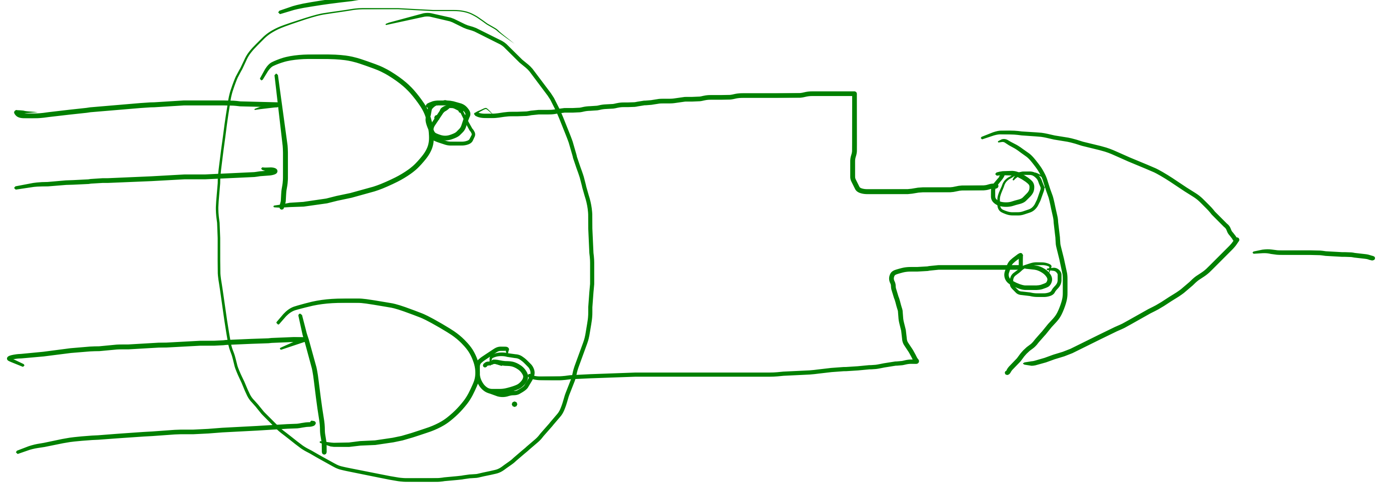


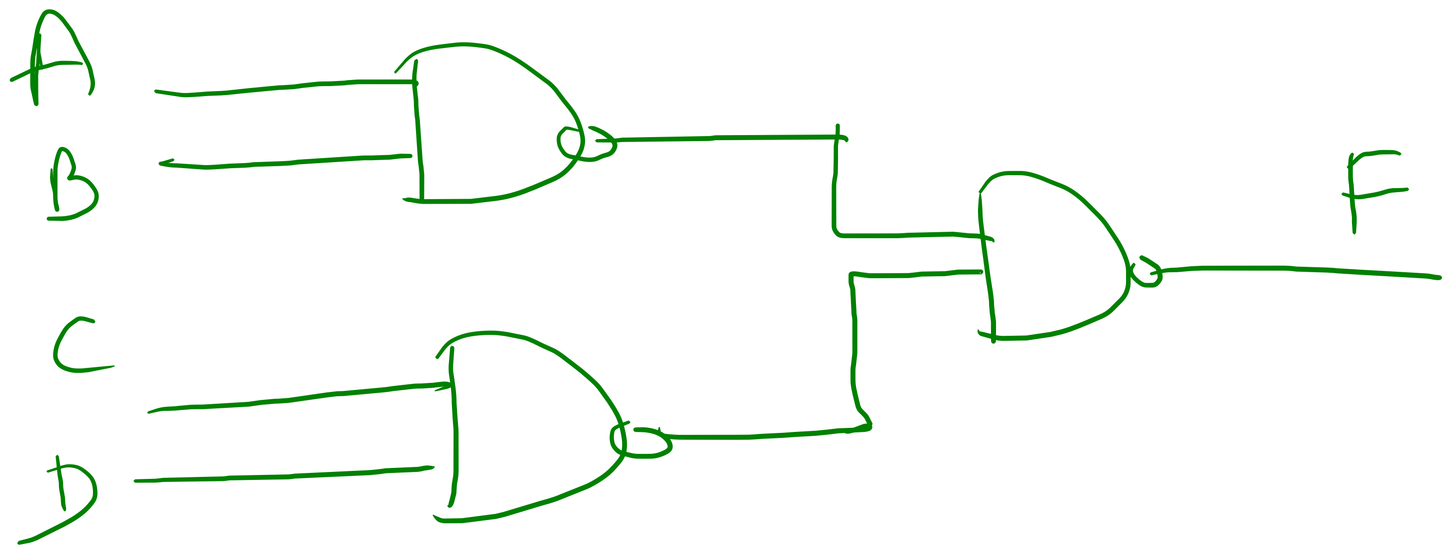
invert-OR

NAND

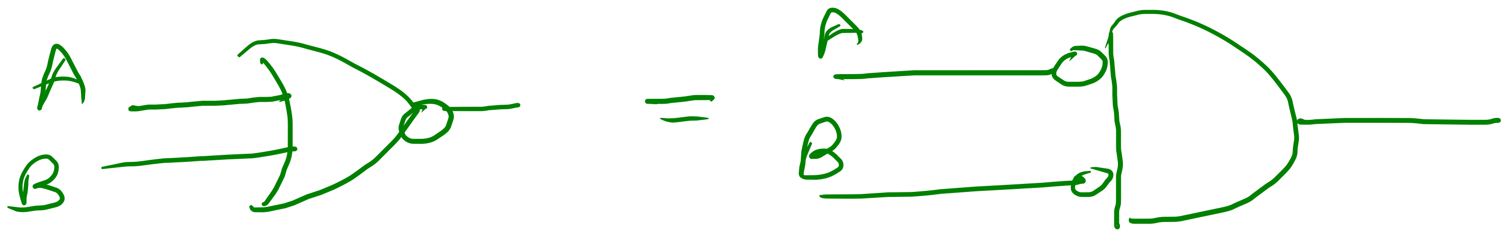
$F = A.B + C \cdot D$







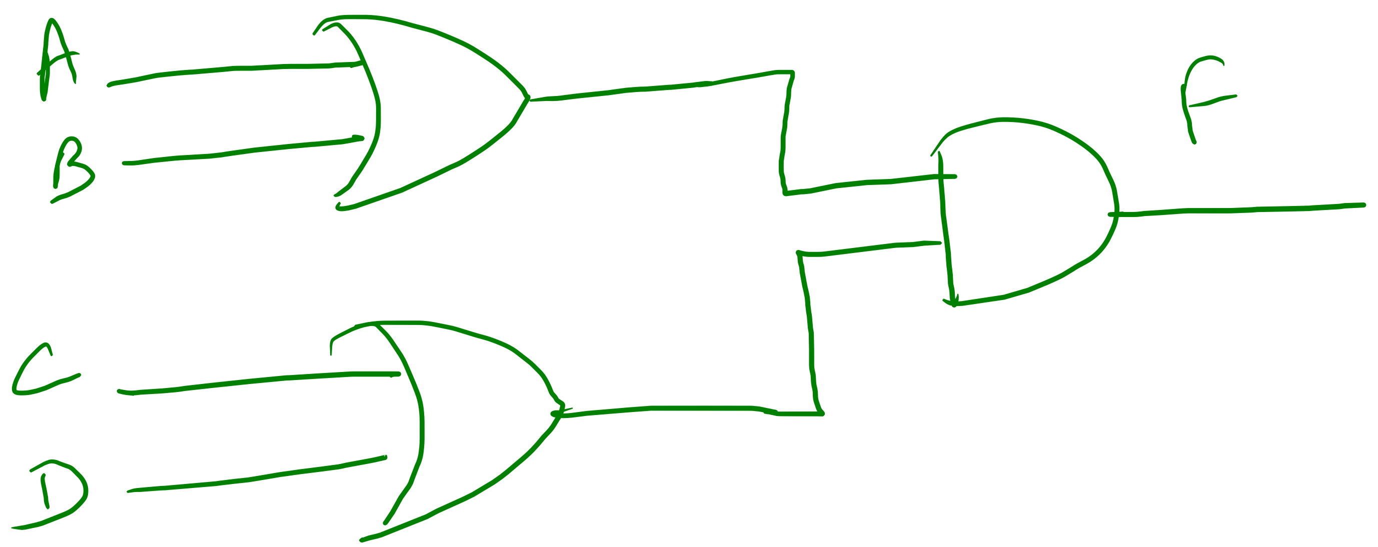
$$\overline{A+B} = A' \cdot B'$$

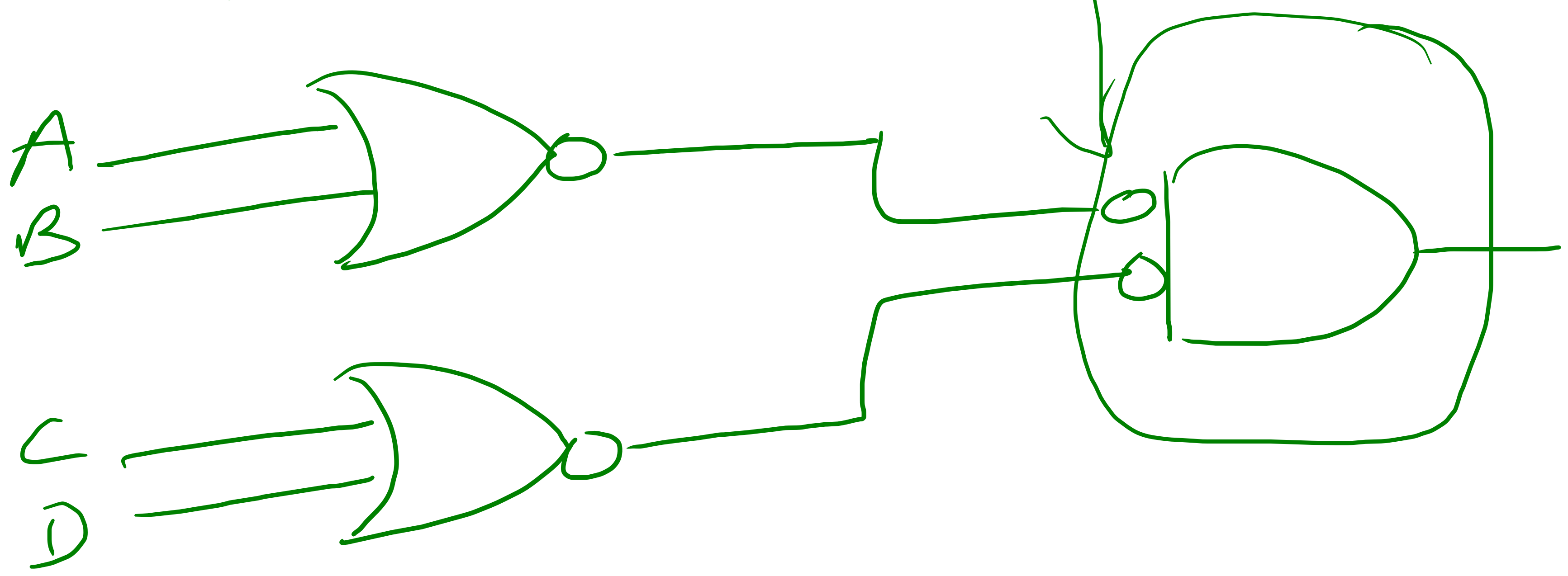


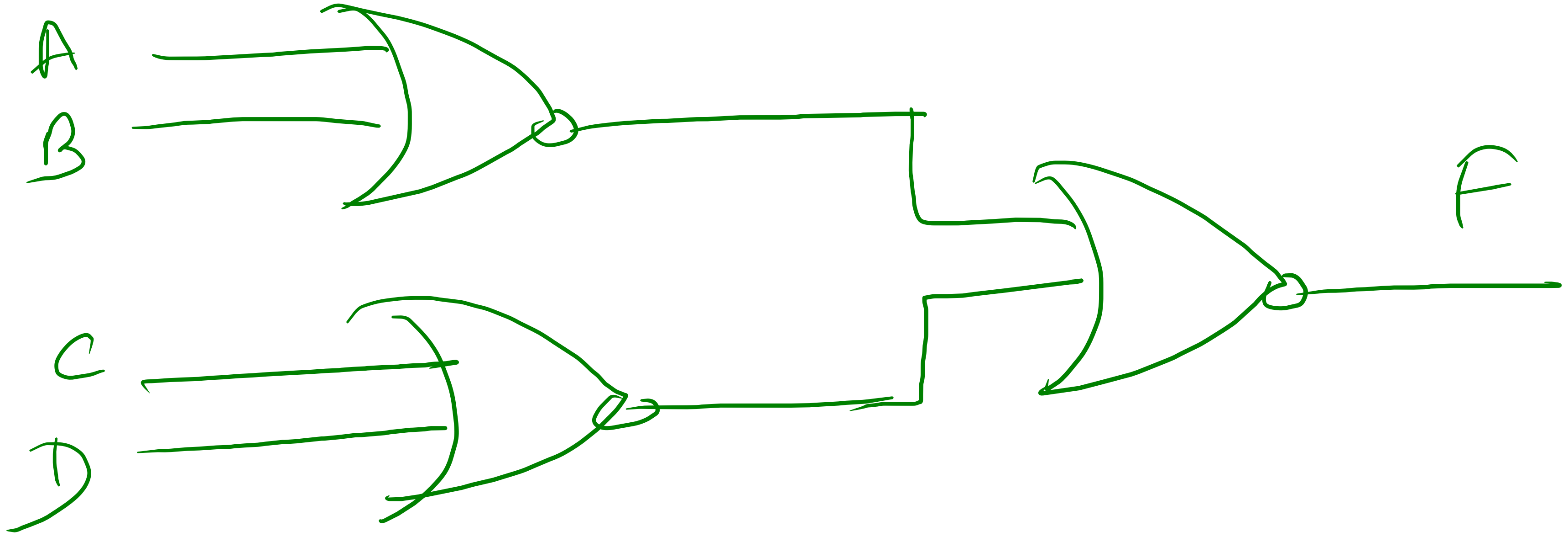
NOR = invert AND

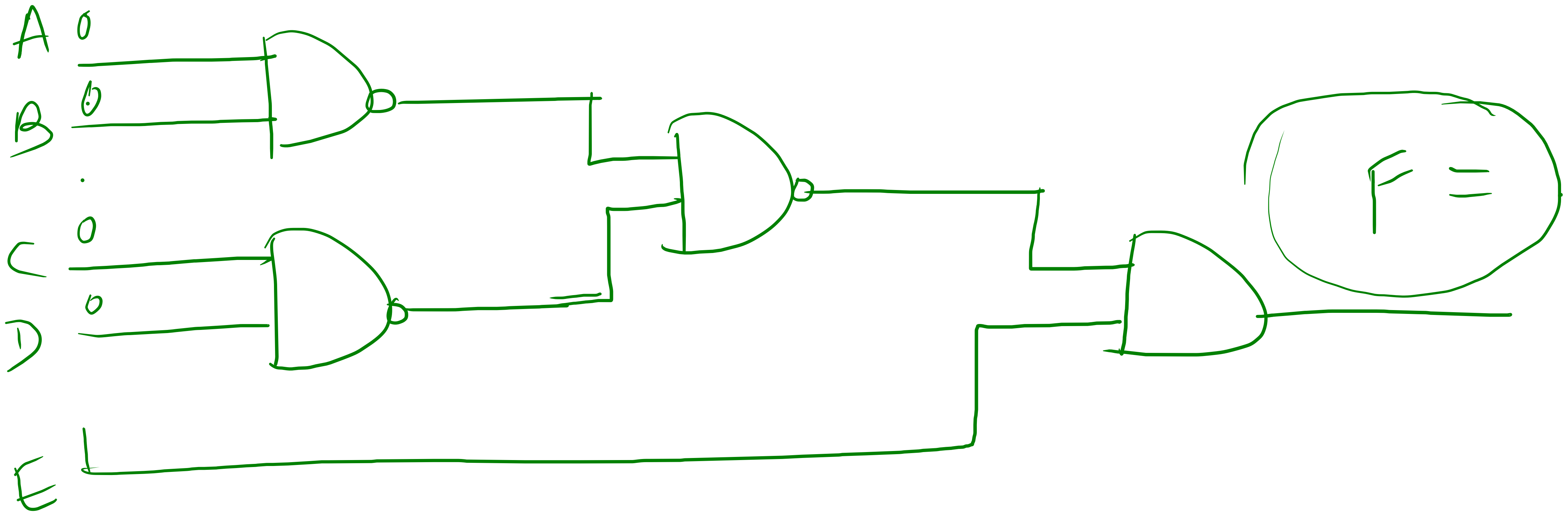
Two level OR - AND equivalent NOR - NOR

$$F = (A+B) \cdot (C+D)$$

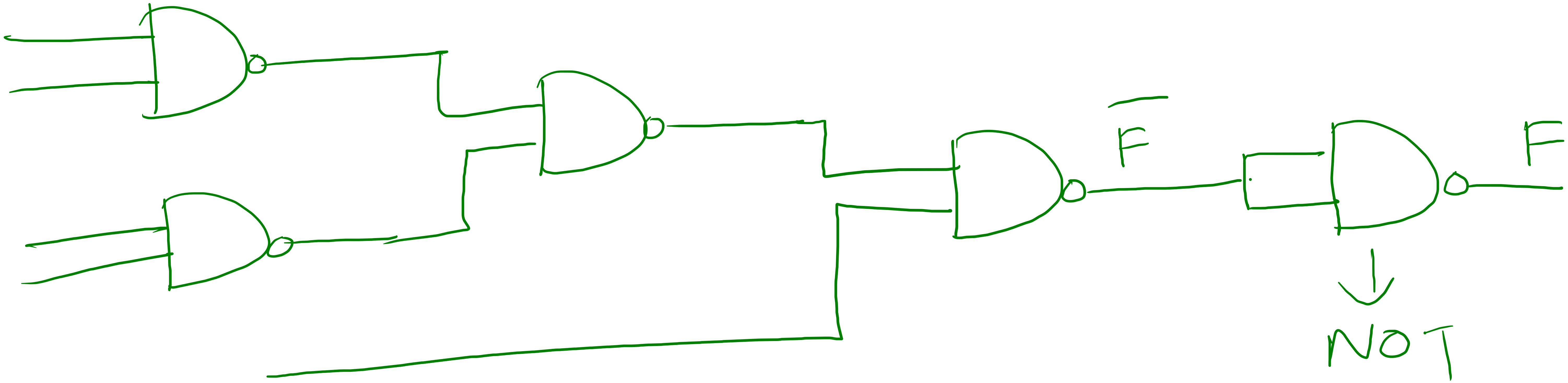





A
B
C
D
F



R ↑
Y
G
↓



Design of Combinational circuits

Adders, subtractors,
Multiplexer, Decoder

A	B	S	C
0	0	0	0
0	1	1 ✓	0
1	0	1 ✓	0
1	1	0	1 ✓

$$
\begin{array}{r}
1 \\
1\,0\,1 \\
+\;0\,0\,1 \\
\hline
0
\end{array}
$$

Half adders

$$S = A'B + AB' = A \oplus B$$

$$C = AB$$