Logic gates

The seven gates: symbol, truth table and Boolean expression for each.

LearnEE
CHEAT SHEET

NOT (inverter)

$Q = \overline{A}$



A	Q
0	1
1	0

Output 1 when the input is 0. Chips: 74HC04, 4069

Reading the page

- **A · B** means A AND B, **A + B** means A OR B and **A ⊕ B** means A XOR B. In logic, 1 + 1 = 1.
- A **bar over** an expression means NOT: flip the answer.
- A **bubble** on an output is a NOT, so NAND, NOR and XNOR are AND, OR and XOR with every answer flipped.
- **NAND and NOR are universal:** either one alone can build every other gate.

AND

$Q = A \cdot B$

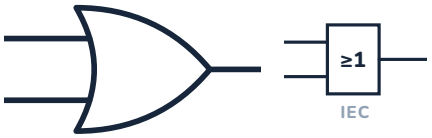


A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

Output 1 when every input is 1. Chips: 74HC08, 4081

OR

$Q = A + B$

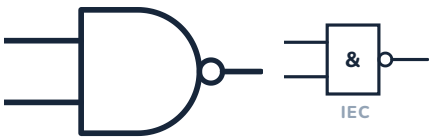


A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

Output 1 when any input is 1. Chips: 74HC32, 4071

NAND

$Q = \overline{A \cdot B}$

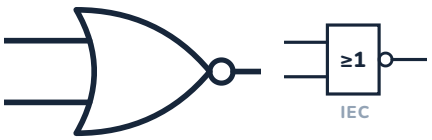


A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

Output 1 when any input is 0. Chips: 74HC00, 4011

NOR

$Q = \overline{A + B}$

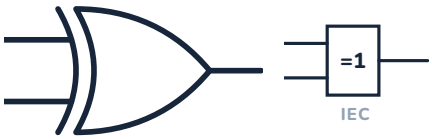


A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

Output 1 when every input is 0. Chips: 74HC02, 4001

XOR

$Q = A \oplus B$

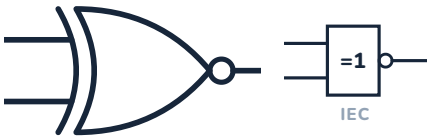


A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

Output 1 when the inputs differ. Chips: 74HC86, 4070

XNOR

$Q = \overline{A \oplus B}$



A	B	Q
0	0	1
0	1	0
1	0	0
1	1	1

Output 1 when the inputs match. Chips: 74HC7266, 4077

Handy rules

$\overline{A \cdot B} = \overline{A} + \overline{B}$ and $\overline{A + B} = \overline{A} \cdot \overline{B}$
De Morgan's laws: break the bar, change the sign

$A \oplus B = \overline{A} \cdot B + A \cdot \overline{B}$
XOR from AND, OR and NOT

NAND(A, A) = $\overline{A}$
a NAND with its inputs tied together is a NOT

n inputs → 2^n rows
two inputs have 4 rows, three have 8, four have 16

SUM = A ⊕ B, CARRY = A · B
a half adder adds two bits

XOR of three inputs
1 when an odd number of inputs are 1

74HC chips run from 2 to 6 V, 4000-series chips from 3 to 18 V. Tie every unused input to 0 V or the supply.