Logic Gates & Circuits

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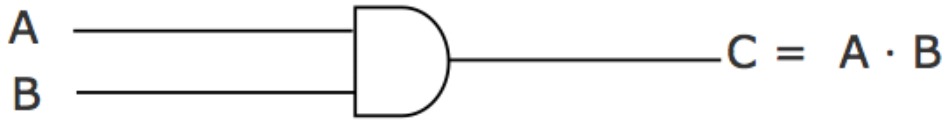
Logic Gates

- **Logic gates** are electronic circuits that operate on **one or more input signals** to produce standard output signal
- Are the building blocks of all the circuits in a computer
- Some of the most basic and useful logic gates are -
  - AND,
  - OR,
  - NOT,
  - NAND and
  - NOR gate

AND Gate

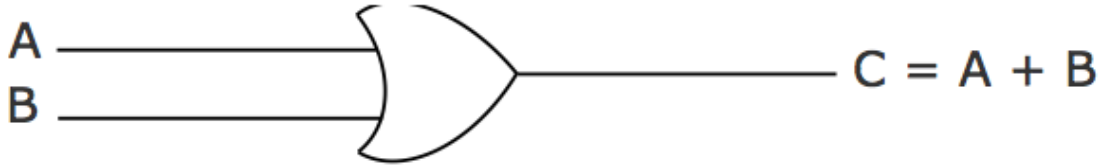
- Physical realization of **logical multiplication** (AND) operation
- Generates an output signal of 1 only if all input signals are also 1
- AND Gate **(Block Diagram Symbol and Truth Table)**



Inputs		Output
A	B	C = A · B
0	0	0
0	1	0
1	0	0
1	1	1

OR Gate

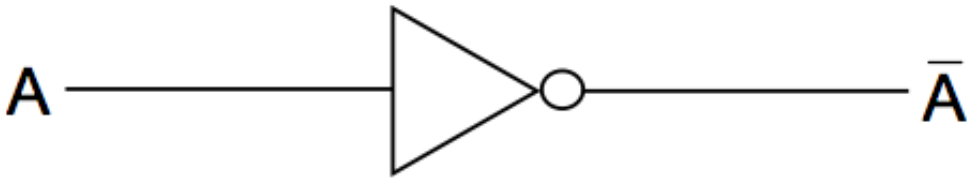
- Physical realization of logical addition (OR) operation
- Generates an output signal of 1 if at least one of the input signals is also 1
- OR Gate (Block Diagram Symbol and Truth Table)



Inputs		Output
A	B	C = A + B
0	0	0
0	1	1
1	0	1
1	1	1

NOT Gate

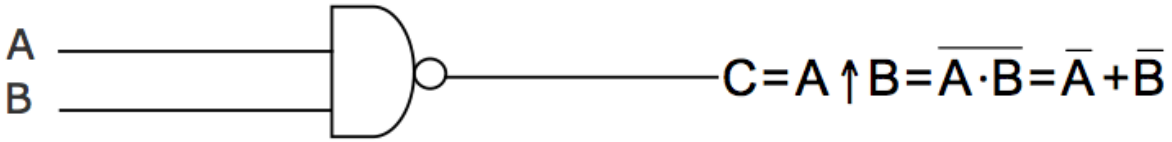
- Physical realization of complementation operation
- Generates an output signal, which is the reverse of the input signal



Input	Output
A	$\bar{A}$
0	1
1	0

NAND Gate

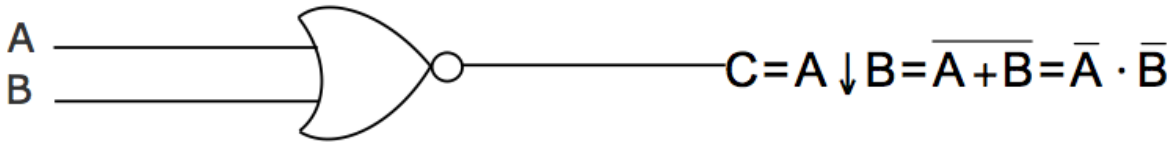
- Complemented AND gate
- Generates an output signal of:
  ① 1 if any one of the inputs is a 0
  ② 0 when all the inputs are 1



Inputs		Output
A	B	$C=\overline{A}+\overline{B}$
0	0	1
0	1	1
1	0	1
1	1	0

NOR Gate

- Complemented OR gate
- Generates an output signal of:
  ① 1 only when all inputs are 0
  ② 0 if any one of inputs is a 1

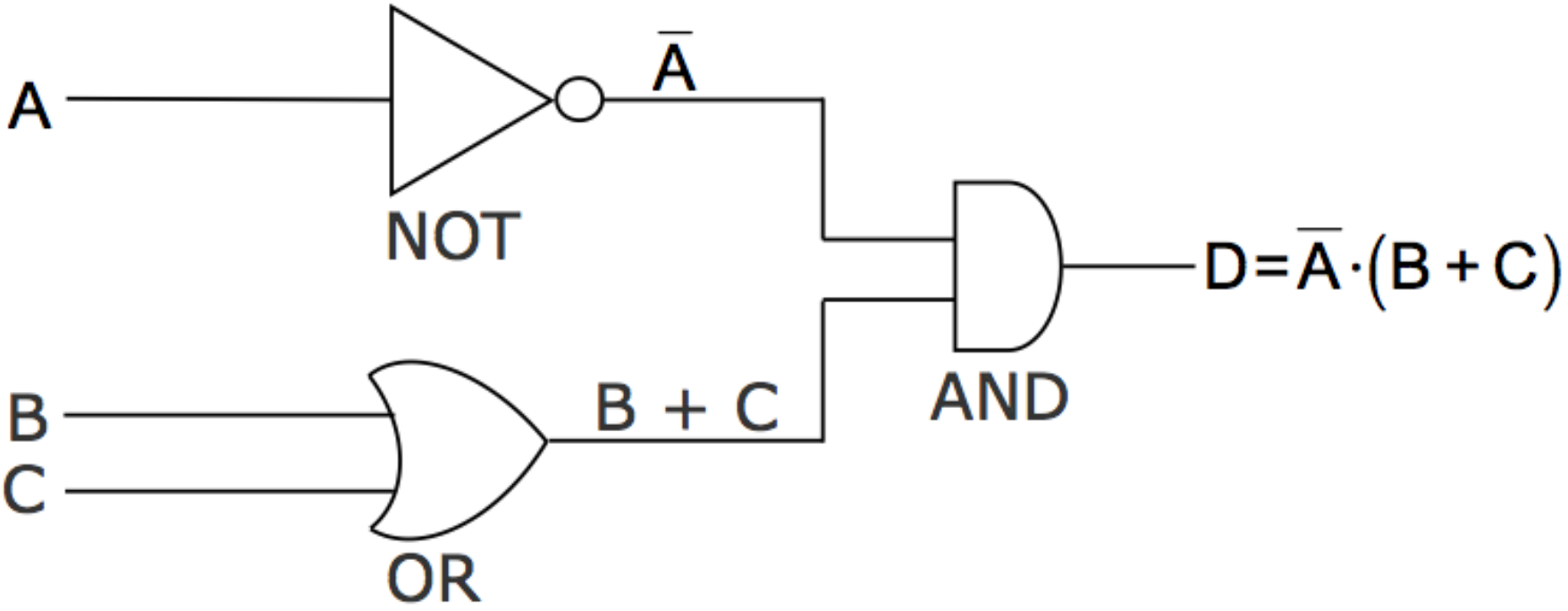


Inputs		Output
A	B	$C=\overline{A}\cdot\overline{B}$
0	0	1
0	1	0
1	0	0
1	1	0

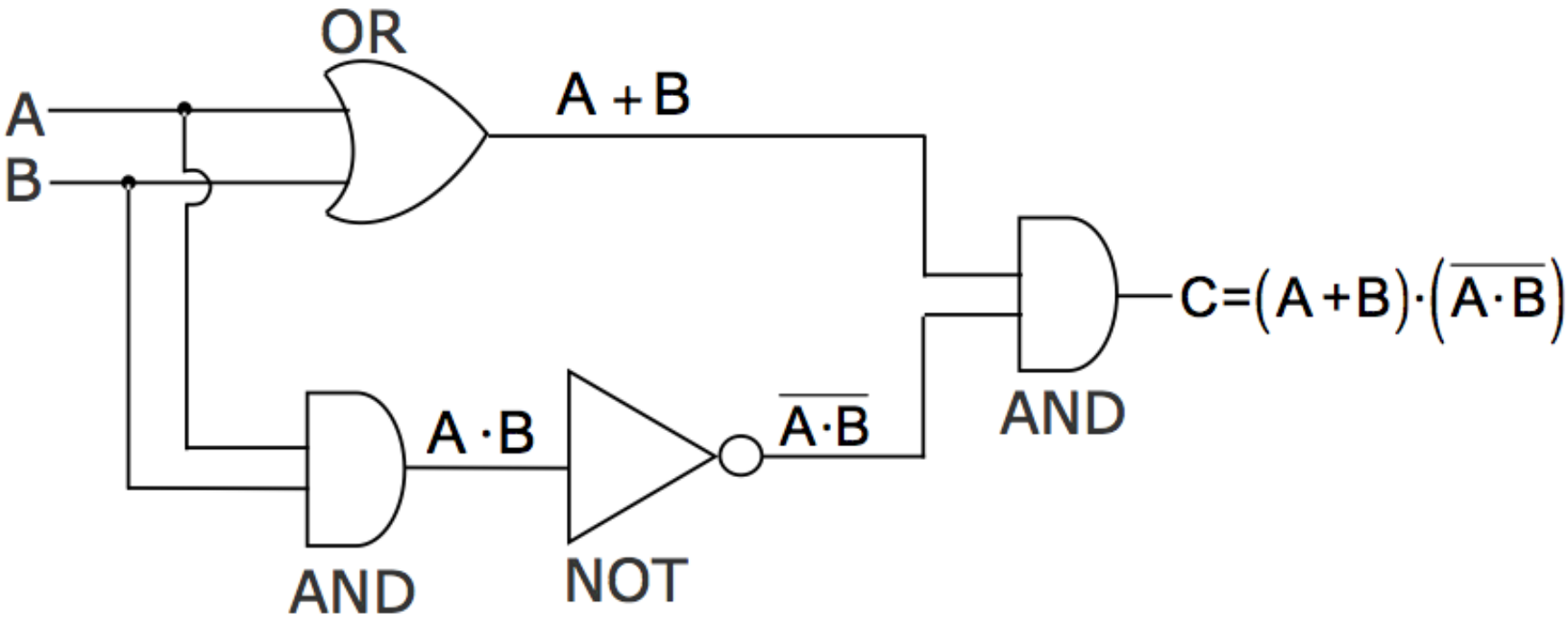
Logic Circuits

- When logic gates are interconnected to **form a gating / logic network**, it is known as a ***combinational logic circuit***
- The Boolean algebra expression for a given logic circuit can be derived by systematically progressing from input to output on the gates
- The **three logic gates** (**AND, OR, and NOT**) are logically complete because any Boolean expression can be realized as a logic circuit using only these three gates

Finding Boolean Expression of a Logic Circuit (Example 1)

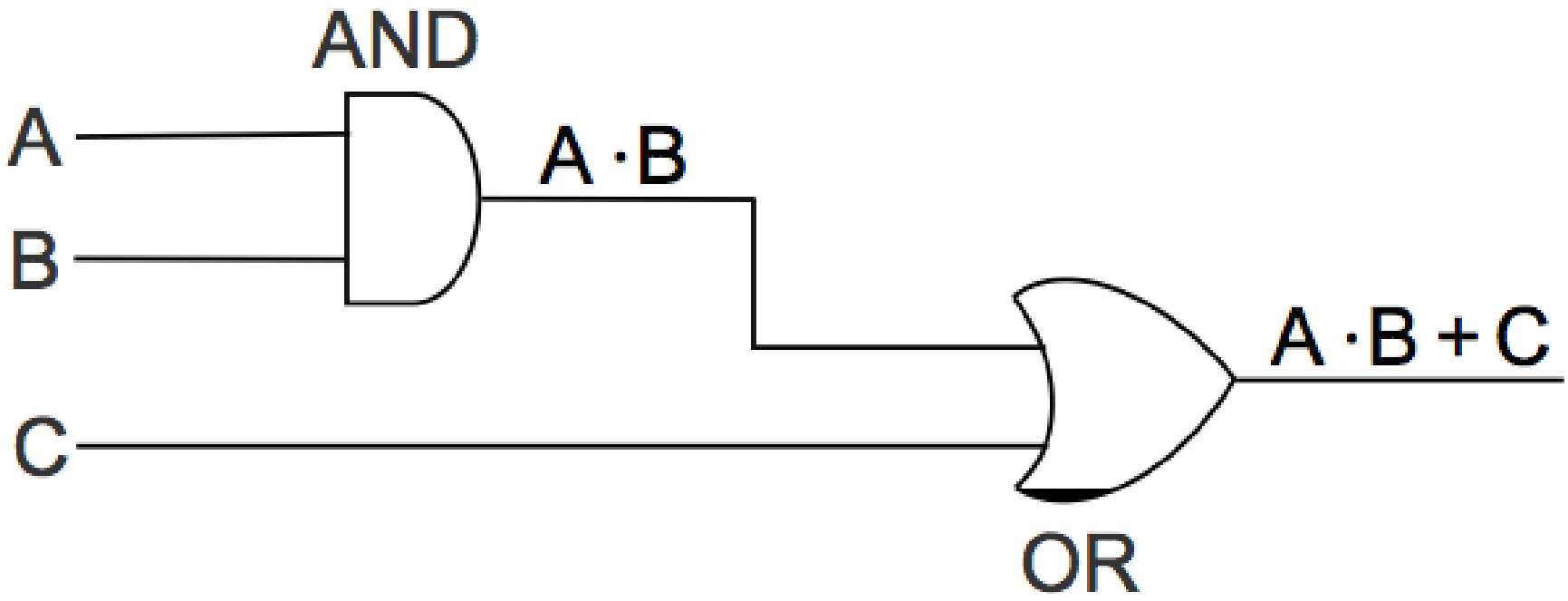


Finding Boolean Expression of a Logic Circuit (Example 2)



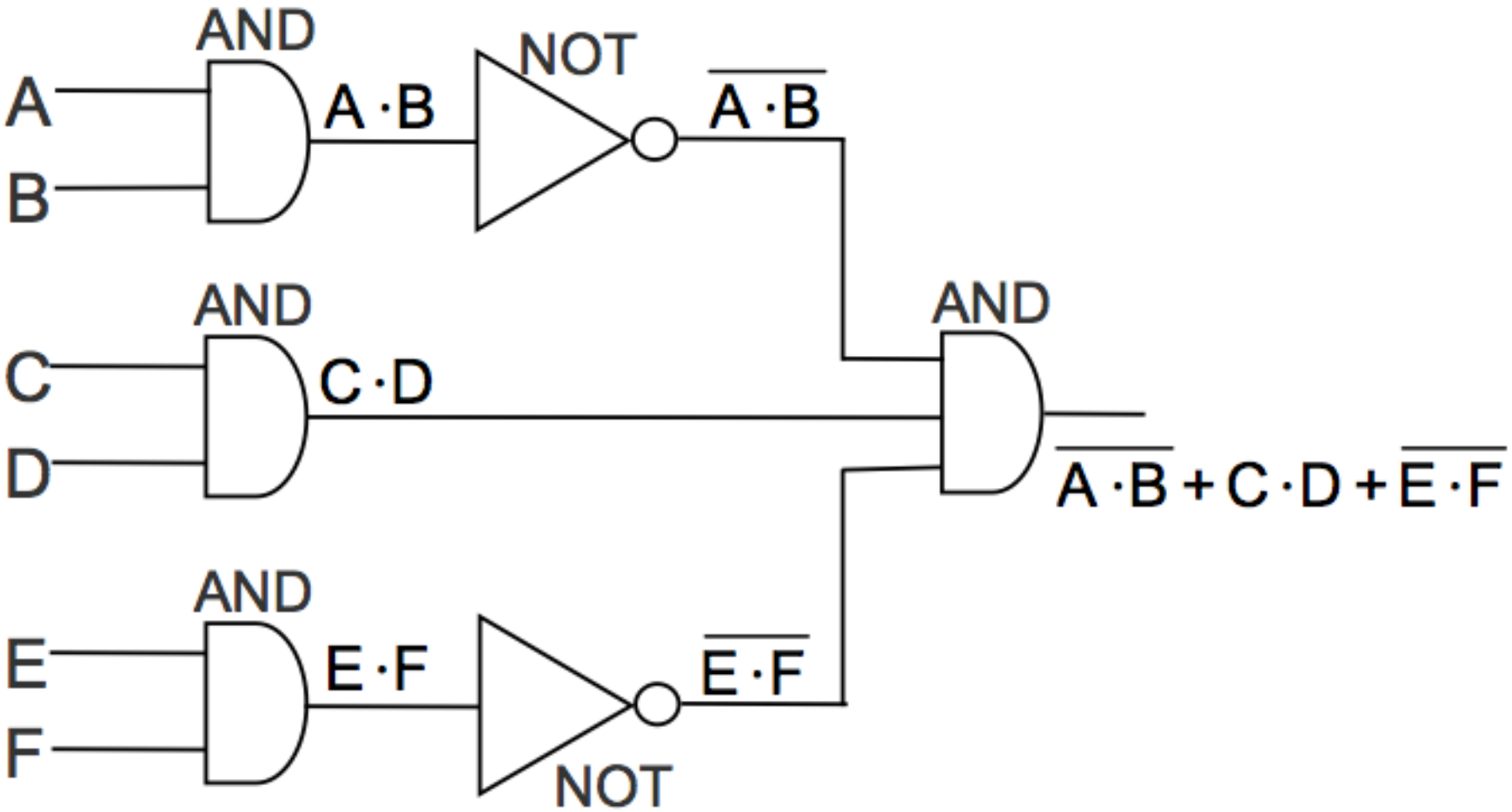
Constructing a Logic Circuit from a Boolean Expression (Example 1)

Boolean Expression = $A \cdot B + C$



Constructing a Logic Circuit from a Boolean Expression (Example 2)

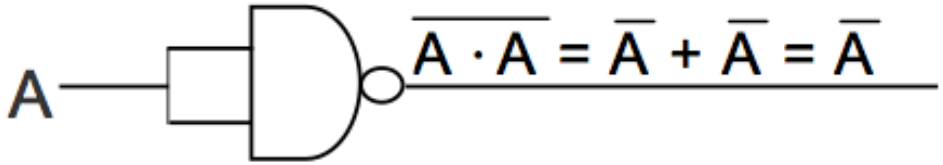
Boolean Expression = $\overline{A \cdot B} + C \cdot D + \overline{E \cdot F}$



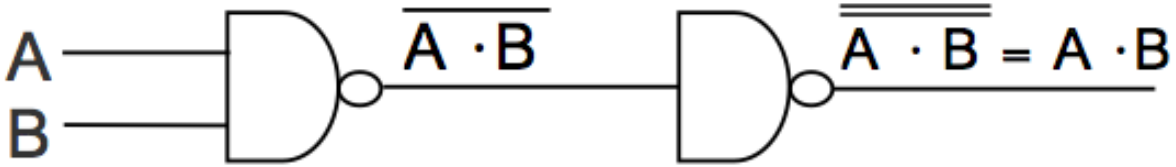
Universal NAND Gate

- NAND gate is an **universal gate**, it is alone sufficient to implement any **Boolean expression**
- To understand this, consider:
  - Basic logic gates (AND, OR, and NOT) are logically complete
  - Sufficient to show that AND, OR, and NOT gates can be implemented with NAND gates

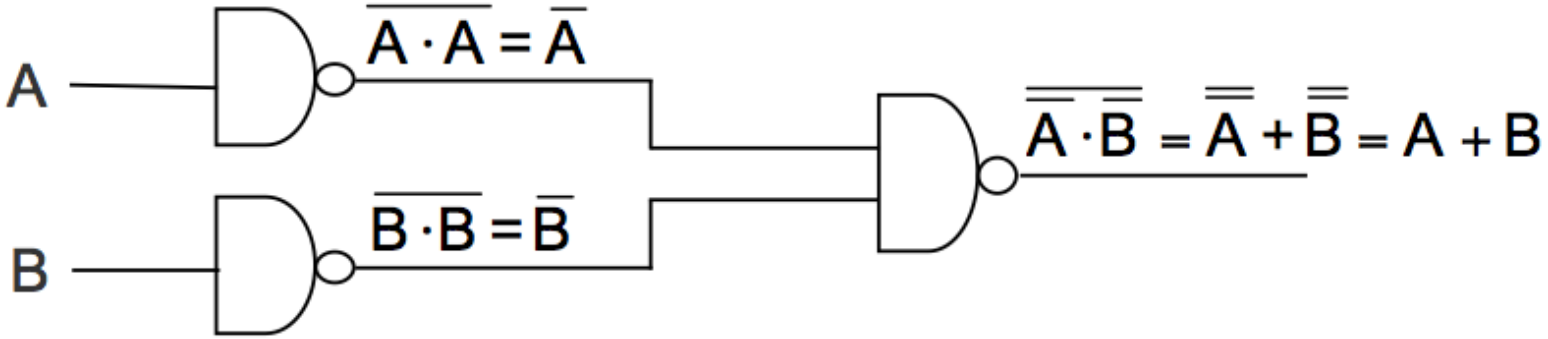
Implementation of NOT, AND and OR Gates by NAND Gates



(a) NOT gate implementation.



(b) AND gate implementation.

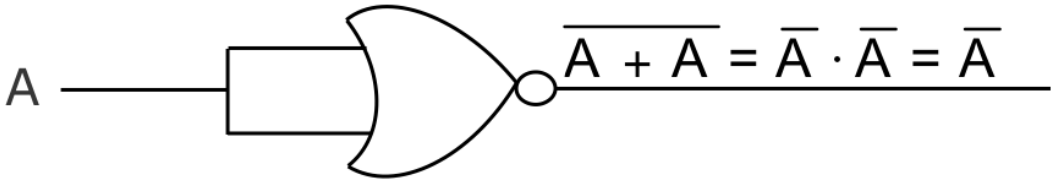


(c) OR gate implementation.

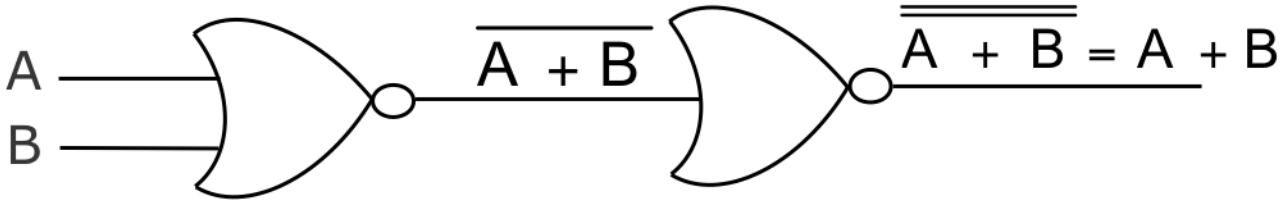
Universal NOR Gate

- NOR gate is **an universal gate**, it is alone sufficient to implement any Boolean expression
- To understand this, consider:
  - Basic logic gates (AND, OR, and NOT) are logically complete
  - Sufficient to show that AND, OR, and NOT gates can be implemented with NOR gates

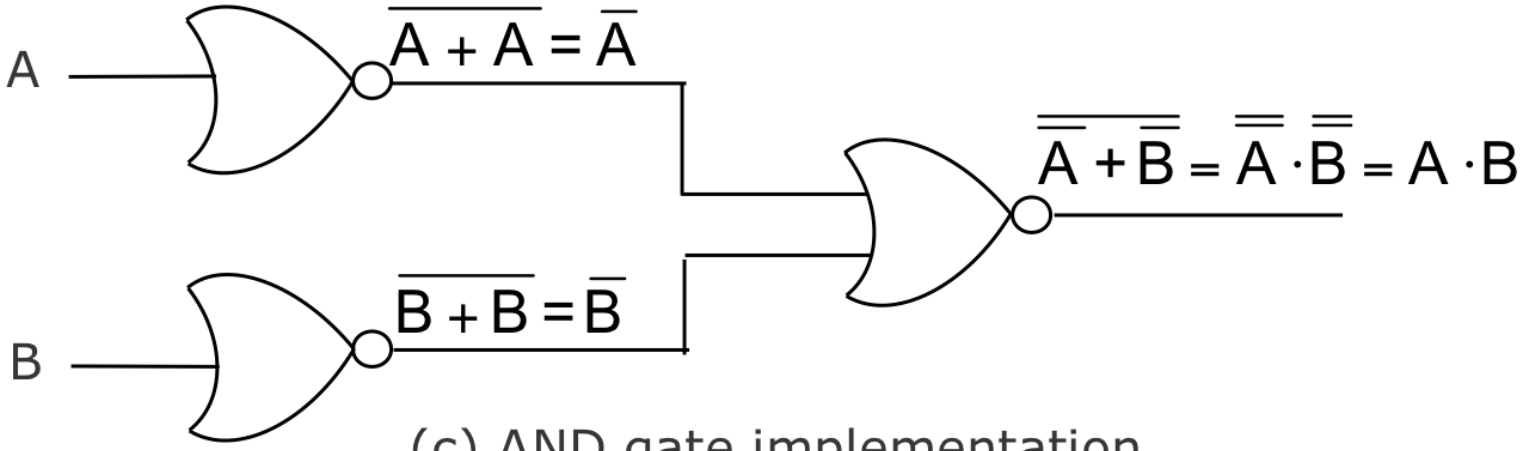
Implementation of NOT, OR and AND Gates by NOR Gates



(a) NOT gate implementation



(b) OR gate implementation.



(c) AND gate implementation.