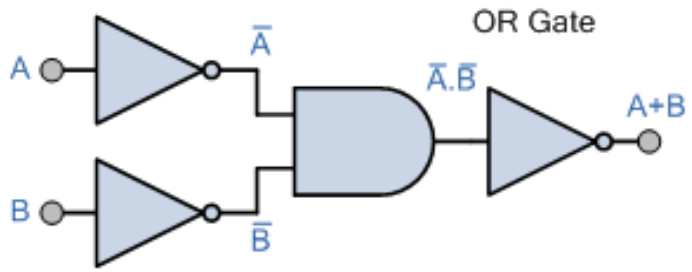
UNIVERSAL LOGIC GATES

Any logic gate which can be combined into a set to realize all other logical functions is said to be a universal gate.

- Individual gates connected in a group/set to form variety of switching functions.

Three most basic logic gates are the:

- AND, OR and NOT gates, and given this set of logic gates it is possible to implement all of the possible Boolean switching functions, thus making them a “full set” of **Universal Logic Gates**.
- In fact, it is possible to produce every other Boolean function using just the set of AND and NOT gates.
- For example: OR gate can be created using both these gates



Complete Sets of Logic Gates

- AND, OR and NOT (a Full Set)
- AND and NOT (a Complete Set)
- OR and NOT (a Complete Set)
- NAND (a Minimal Set)
- NOR (a Minimal Set)

Thus we can use these five sets of gates, together or individually as the building blocks to produce more complex logic circuits called *combinational logic circuits*

Disdvantages of using the complete sets of AND, OR and NOT

- To produce any equivalent logic gate or function we require two (or more) different types of logic gates as a combination.
- However, it can be done by using just one single type of universal logic gate, the NAND or the NOR gate, thereby reducing the number of different types of logic gates required, and also the cost.
- Therefore, NAND and the NOR gates are commonly referred to as **Universal Logic Gates**.

Rules of Boolean Algebra

Basic Rules of Boolean Algebra

1. $A + 0 = A$	7. $A \cdot A = A$
2. $A + 1 = 1$	8. $A \cdot \overline{A} = 0$
3. $A \cdot 0 = 0$	9. $\overline{\overline{A}} = A$
4. $A \cdot 1 = A$	10. $A + AB = A$
5. $A + A = A$	11. $A + \overline{A}B = A + B$
6. $A + \overline{A} = 1$	12. $(A + B)(A + C) = A + BC$

DeMorgan's Theorem

$$\overline{(AB)} = (\overline{A} + \overline{B}) \qquad \overline{(A + B)} = (\overline{A}\ \overline{B})$$

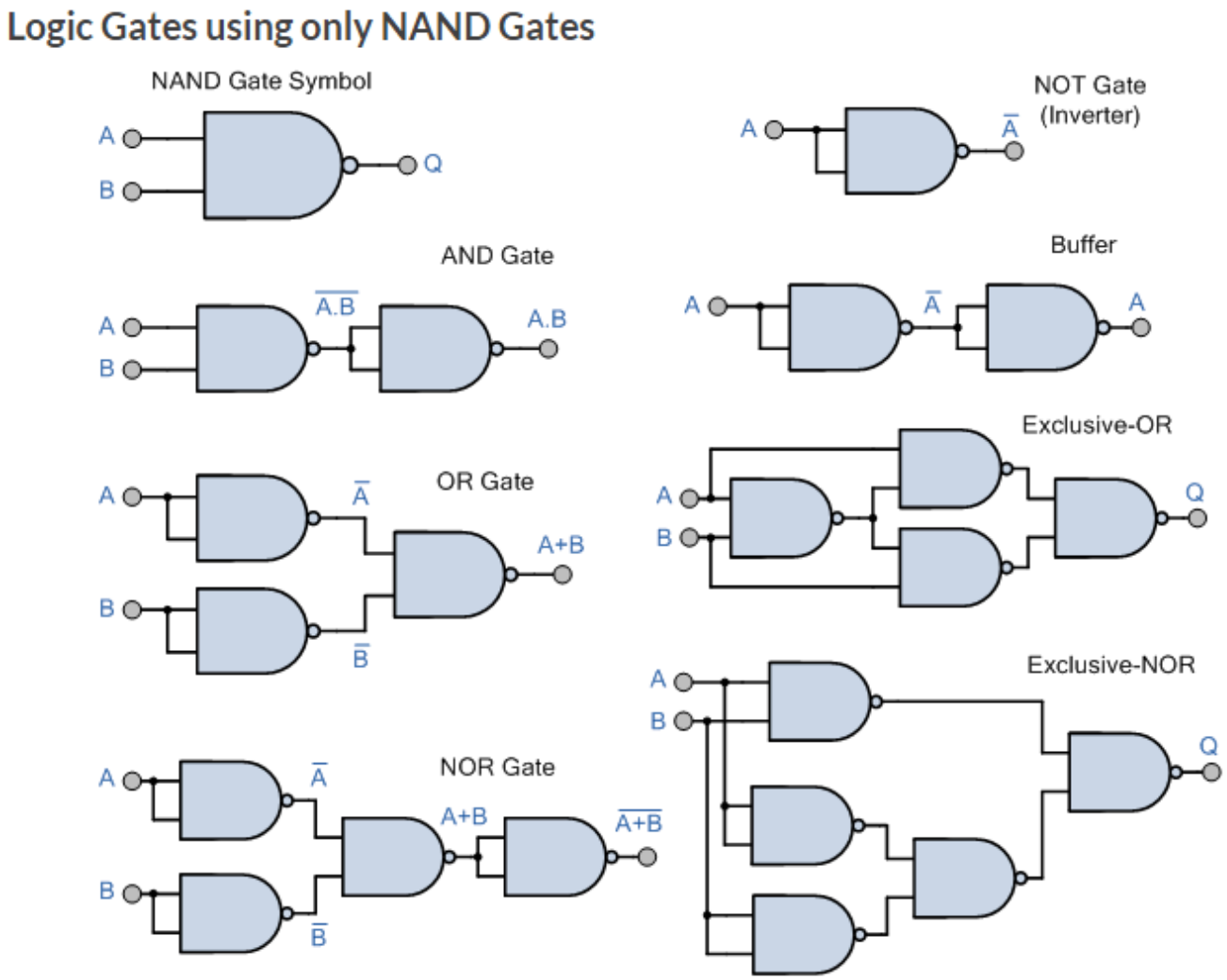
DeMorgan's Theorem

There are two "de Morgan´s" rules or theorems,

(1) Two separate terms NOR´ed together is the same as the two terms inverted (Complement) and AND´ed for example: $\overline{A+B} = \overline{A} \cdot \overline{B}$

(2) Two separate terms NAND´ed together is the same as the two terms inverted (Complement) and OR´ed for example: $\overline{A \cdot B} = \overline{A} + \overline{B}$

Using Only NAND Gates



Using Only NOR Gates