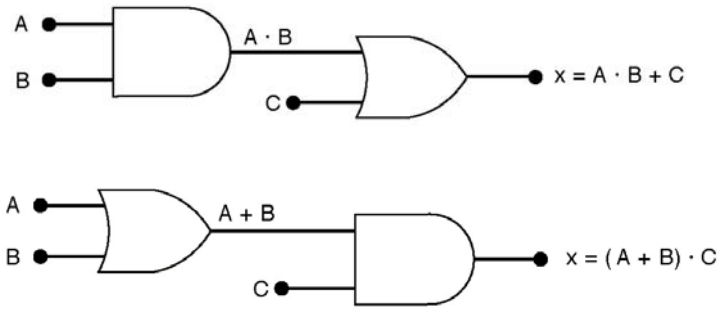
3-6 Describing Logic Circuits Algebraically

- The three basic Boolean operations (OR, AND, NOT) can describe any logic circuit.
- Operator Precedence:
  - If an expression contains both AND and OR gates the AND operation will be performed first, unless there is a parenthesis in the expression.

3-6 Describing Logic Circuits Algebraically

- Examples of Boolean expressions for logic circuits:

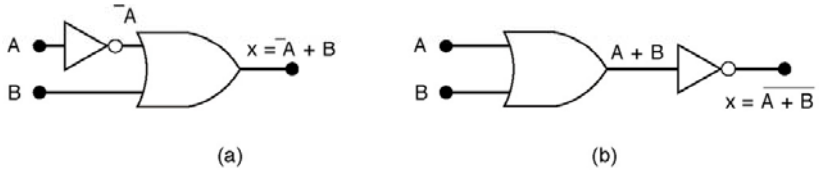


Example - continued

A	B	C	X= AB+C	X=(A+B).C
0	0	0	0	0
0	0	1	1	0
0	1	0	0	0
0	1	1	1	1
1	0	0	0	0
1	0	1	1	1
1	1	0	1	0
1	1	1	1	1

3-6 Describing Logic Circuits Algebraically

- The output of an inverter is equivalent to the input with a bar over it. Input A through an inverter is $\overline{A}$
- Examples using inverters.
- Is A+B equivalent to $\overline{A}+\overline{B}$?



3-7 Evaluating Logic Circuit Outputs

- Rules for evaluating a Boolean expression:
  - Perform all inversions of single terms.
  - Perform all operations within parenthesis.
  - Perform AND operation before an OR operation unless parenthesis indicate otherwise.
  - If an expression has a bar over it, perform the operations inside the expression and then invert the result.

3-7 Evaluating Logic Circuit Outputs

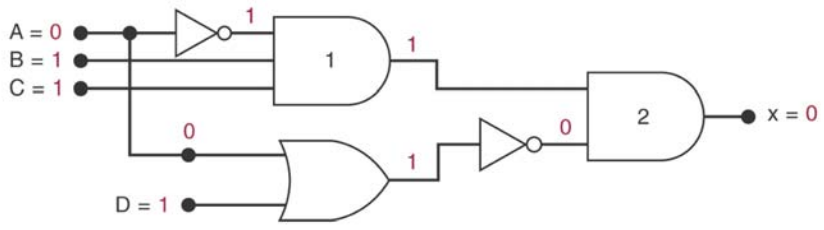
- Evaluate Boolean expressions by substituting values and performing the indicated operations:

$$A = 0, B = 1, C = 1, \text{ and } D = 1$$
$$x = \overline{A}BC\overline{(A + D)}$$
$$x = \overline{0} \cdot 1 \cdot 1 \cdot \overline{(0 + 1)}$$
$$x = 1 \cdot 1 \cdot 1 \cdot \overline{(0 + 1)}$$
$$x = 1 \cdot 1 \cdot 1 \cdot \overline{(1)}$$
$$x = 1 \cdot 1 \cdot 1 \cdot 0$$
$$x = 0$$

3-7 Evaluating Logic Circuit Outputs

- Output logic levels can be determined directly from a circuit diagram without using the Boolean expression.
- Easy to use method.
- The output of each gate is noted until a final output is found.
- Start from input and proceed through each gate, writing down the corresponding output until the final output is reached

Example



3-8 Implementing Circuits From Boolean Expressions

- It is important to be able to draw a logic circuit from a Boolean expression.
- The expression

$$x = A \cdot B \cdot C$$

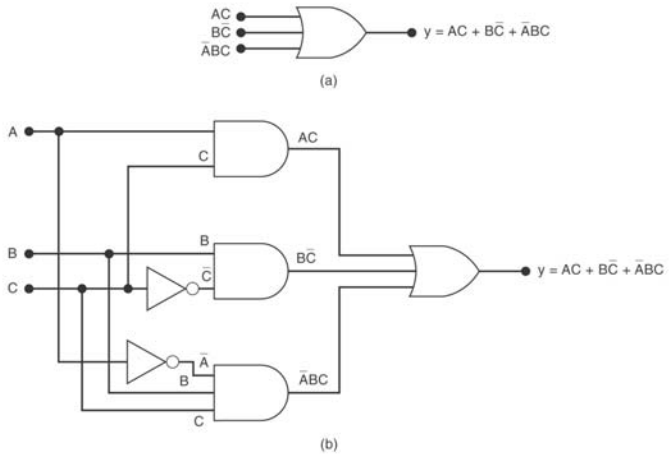
Could be drawn as a three input AND gate.

- A more complex example such as

$$y = AC + B\overline{C} + \overline{A}BC$$

Could be drawn as 2, 2-input AND gates and 1, 3 input AND gate feeding into a 3 input OR gate. Two of the AND gates have inverted inputs.

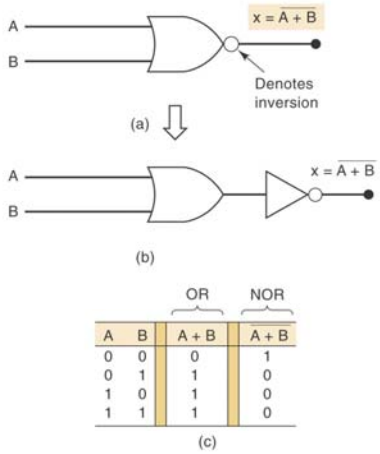
Example - continued



3-9 NOR Gates and NAND Gates

- Combine basic AND, OR, and NOT operations.
- The NOR gate is an inverted OR gate. An inversion “bubble” is placed at the output of the OR gate.
- The Boolean expression is, $x = \overline{A + B}$

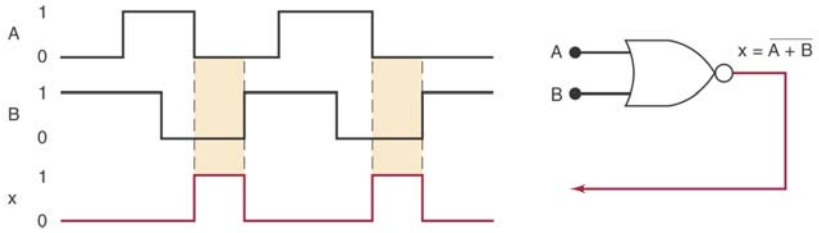
NOR - Gate



		OR	NOR
A	B	A + B	$\overline{A + B}$
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

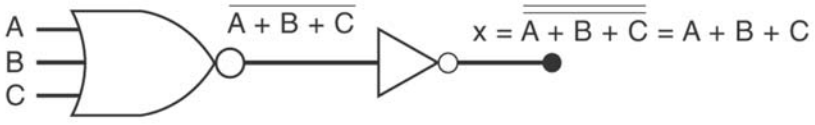
(c)

Example 3-8



Example 3-9

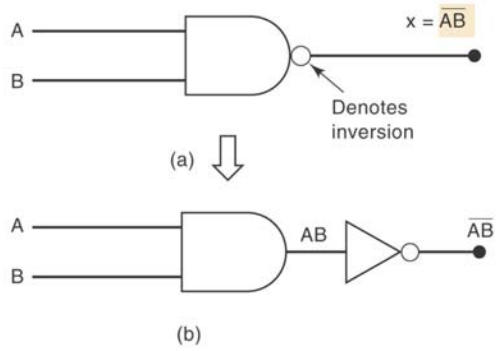
Determine the Boolean expression for 3-input NOR gate followed by inverter



3-9 NOR Gates and NAND Gates - NAND Gate

- The NAND gate is an inverted AND gate. An inversion "bubble" is placed at the output of the AND gate.
- The Boolean expression is, $x = \overline{AB}$

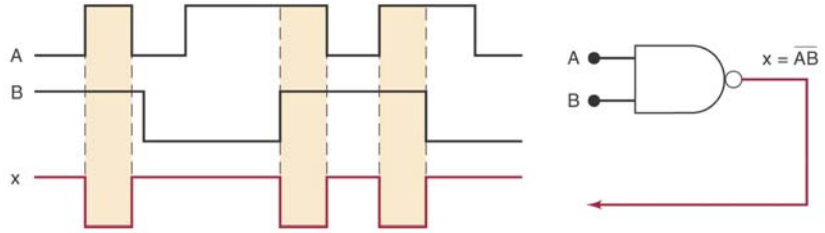
NAND Gate



		AND	NAND
A	B	AB	$\overline{AB}$
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

(c)

Example 3 -10

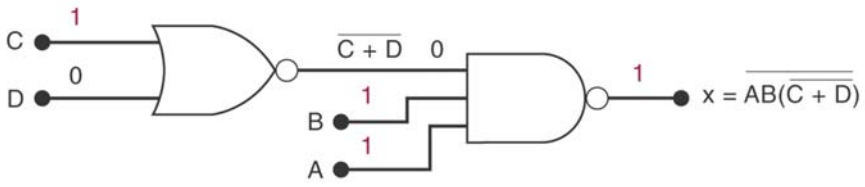


3-9 NOR Gates and NAND Gates

- The output of NAND and NOR gates may be found by simply determining the output of an AND or OR gate and inverting it.
- The truth tables for NOR and NAND gates show the complement of truth tables for OR and AND gates.

Example 3-11

- Implement the logic circuit $X = \overline{AB.(\overline{C+D})}$



- Determine the output for A=B=C=1 & D=0