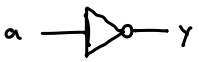
Reading 5

6.1 Gates

- A logic gate (or gate) is a transistor circuit that implements a logic function.

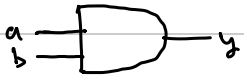
- A NOT gate, or inverter, outputs 1 if the gate's input is 0 and outputs 0 if the input is 1.

  ↳ general symbol:



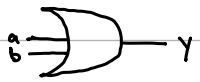
- An AND gate outputs 1 only if both of the gate's inputs are 1s.

  ↳ general symbol:



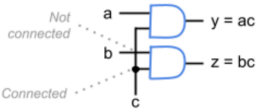
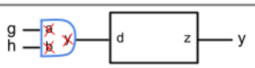
- An OR gate outputs 1 if either or both of the gate's inputs is a 1.

  ↳ general symbol:



6.2 Basic circuit drawings conventions

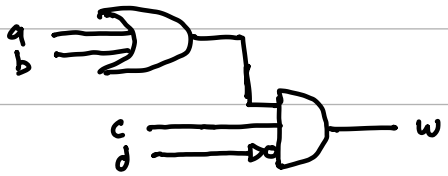
Figure 6.2.1: Circuit drawing conventions.

Convention	Illustration
Crossing wires only connect at filled circle.	
Inverter often drawn as circle at gate input.	
One output wire splitting is OK. Multiple input wires connecting is not.	
Input labels are sometimes duplicated to simplify a drawing.	
Gate inputs are not labeled (other components may be).	

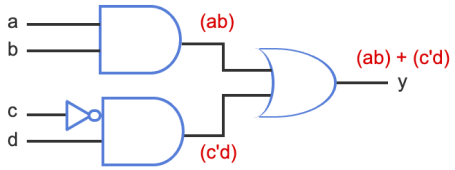
6.3 Equations to/from circuits

- Converting behavior (like an equation) to a circuit is called design.
  - ↳ Always convert inside parentheses first
  - ↳ convert NOT before converting AND (or OR)
  - ↳ convert AND / OR

Ex: $w = (a+b)cd'$



- Converting a circuit to a behavior (like an equation) is called analysis.



y = (ab) + (c'd)

- A circuit whose output value is determined by the present combination of input values is called a combinational circuit.
  - ↳ Ex: if one or more people are in a room, turn on the lights.

- A circuit whose output values may depend on the past sequence of input values, and not just the present input values, is called a sequential circuit.
  - ↳ Ex: If the sleep mode button is pressed and released, turn phone ringer off until the sleep mode button is pressed again.

6.4 Truth Tables

- A truth table lists all possible variable value combinations on the left side and lists the function's value for each combination on the right.
  - ↳ Each row corresponds to a possible minterm.
    - ↳ NOTE! Minterms are written as m0, m1, ..., indicating their row's decimal equivalent: a'b'c' is 000, or m0
      a'b'c is 001, or m1, etc.
  - ↳ Generating all combinations is done by counting up in binary.
  - ↳ A function with N variables has a truth table with 2^N rows.
  - ↳ Ex:

		a	b	f(a, b)
m0	a'b'	0	0	1
m1	a'b	0	1	0
m2	ab'	1	0	0
m3	ab	1	1	1

- Converting a truth table to an equation:
  - ↳ can be done by summing the minterms in rows that output a 1.
    - ↳ This equation can then be converted to a circuit.
  - ↳ Ex:

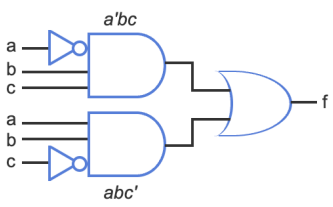
Truth table

a	b	c	f
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

Equation

f = a'bc + abc'

Circuit



- Sometimes a designer wants to convert an equation to a truth table. Such conversion first transforms the equation to sum-of-minterms. The designer then places a 1 in each minterm's row in the truth table.

6.5 Top-down design + examples

Designers commonly follow a two-step design process:

1. Capture : The task of precisely describing a circuit's desired behavior.
2. Convert (aka implement) : The task of translating captured behavior into a circuit, possibly involving simplification.

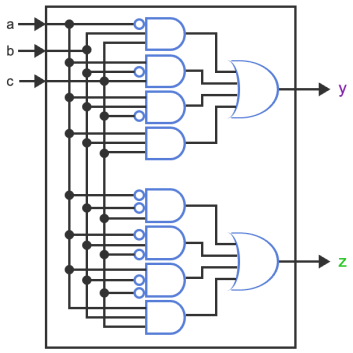
6.6 Multiple Outputs

Ex!

a	b	c	y	z
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

y = a'bc + ab'c + abc' + abc

z = a'b'c + a'bc' + ab'c' + abc



- A 7-segment display is a common display device having 7 light segments that can be lit in different patterns to represent numbers 0-9 and some letters too.

6.7 Timing Diagrams

- A timing diagram graphically shows a circuit's output values for a given input values that change over time. Each signal (input or output) name is listed on the left. Time proceeds to the right. Each signal is drawn as a high line (1) or a low line (0).
  - Ex: AND gate