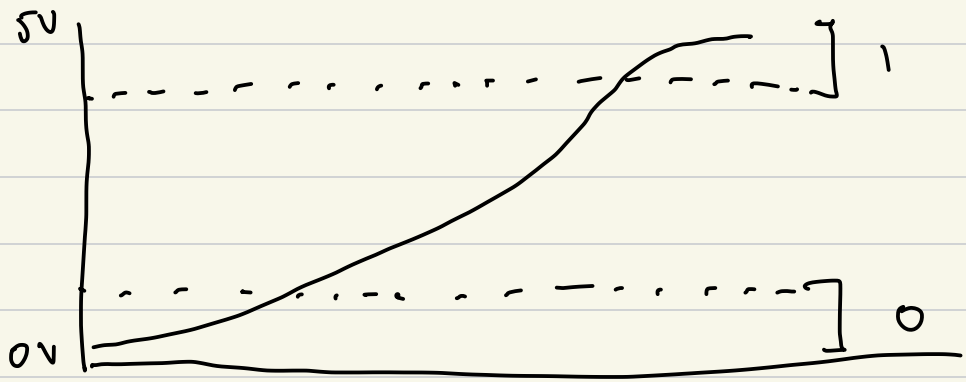
CS 315-02 Lab Intro to Digital Design

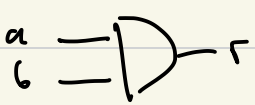
Digital Design

Analog → Digital



Wires

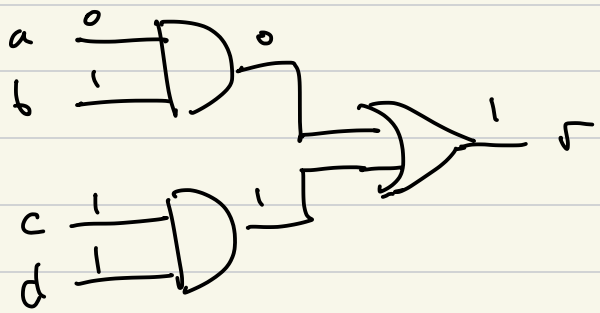
devices → gates

	AND	OR	NOT
			
C code	r = a && b	r = a | b	r = ~a
boolean algebra	r = a · b	r = a + b	r = $\overline{a}$
Logic	r = a ∧ b	r = a ∨ b	r = ¬a

a	b	r
0	0	0
0	1	0
1	0	0
1	1	1

a	b	r
0	0	0
0	1	1
1	0	1
1	1	1

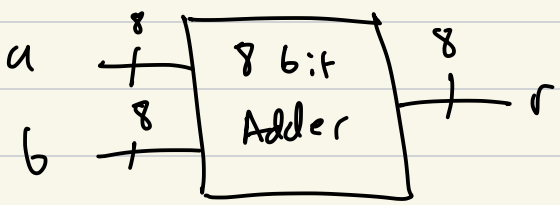
a	r
0	1
1	0



$$r = (a \cdot b) + (c \cdot d)$$

Abstraction

Goal



sum-of-products

sum of two 1-bit numbers

a	b	sum
0	0	0
0	1	1
1	0	1
1	1	0

XOR sum = $a \oplus b$

sum

$$SUM = (\bar{a} \cdot b) + (a \cdot \bar{b})$$

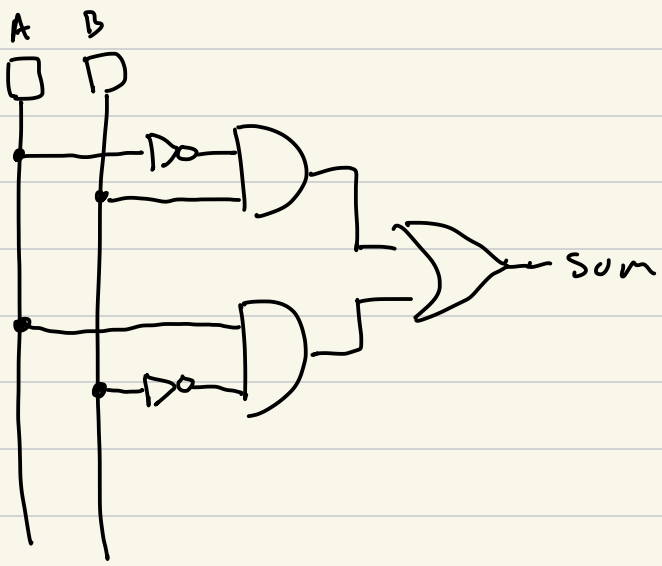
product term

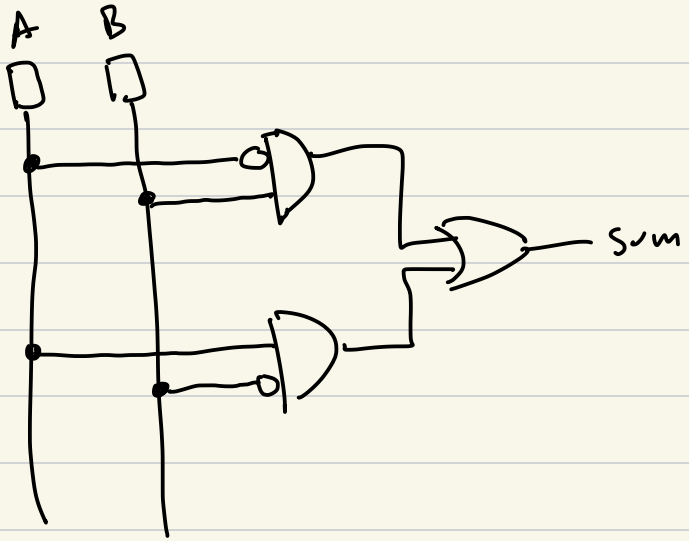
a=0 b=1

$$SUM = (\bar{0} \cdot 1) + (0 \cdot \bar{1})$$
$$= (1 \cdot 1) + (0)$$
$$= (1 \cdot 1)$$
$$= 1$$

SUM = 0

$$SUM = (\bar{a} \cdot b) + (a \cdot \bar{b})$$
$$\quad\;\; 1 \qquad\quad 0$$
$$\quad\;\; 0 \qquad\quad 1$$





Sum-of-products

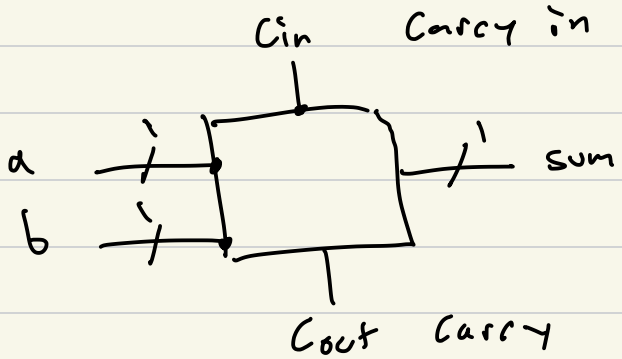
1) build truth table

2) Identify rows with output 1

3) Construct product (.) terms for each row
   a) don't invert if input is 1
   b) invert if input is 0

4) Sum (+) all product terms

1 bit full adder



	a	b	Cin	sum	Cout
	0	0	0	0	0
①	0	0	1	1	0
②	0	1	0	1	0
	0	1	1	0	1
③	1	0	0	1	0
	1	0	1	0	1
	1	1	0	0	1
④	1	1	1	1	1

$$sum = (\bar{a} \cdot \bar{b} \cdot c_{in}) + (\bar{a} \cdot b \cdot \bar{c_{in}}) + (a \cdot \bar{b} \cdot \bar{c_{in}}) + (a \cdot b \cdot c_{in})$$