Sequential Logic Systems

Concepts:
- Expressions
- Networks (logic circuits)
- Truth Tables
- Timing Diagrams
- Canonical Forms
  - Minterms
  - Maxterms
- Boolean Algebra - algebraic manipulation

Variables: A, B, C, X, Y, Z, etc. (or X1, X2, X3, etc.)

Values: 0 and 1 -- or could be False/True or Low/High (voltage) or Purple/Yellow, etc.
It is convenient to think of in terms of binary numbers because of the similarity between Boolean algebra and "ordinary" algebra

Operations: AND, OR, COMPLEMENT

AND or ● or ∧ (Like a product)

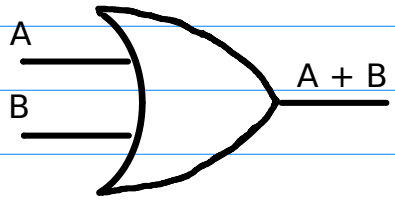
Truth Table:

Inputs → output

A	B	AB
0	0	0
0	1	0
1	0	0
1	1	1

"Switch" logic

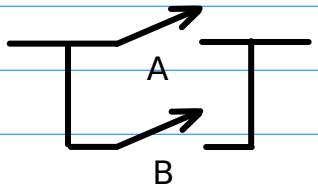
OR or + or ∨ (Like a sum)



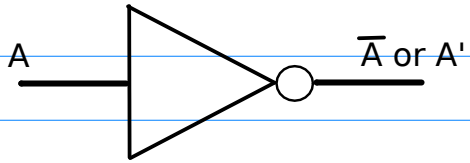
Truth Table:

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

"Switch" logic



COMPLEMENT or NOT or INVERTER

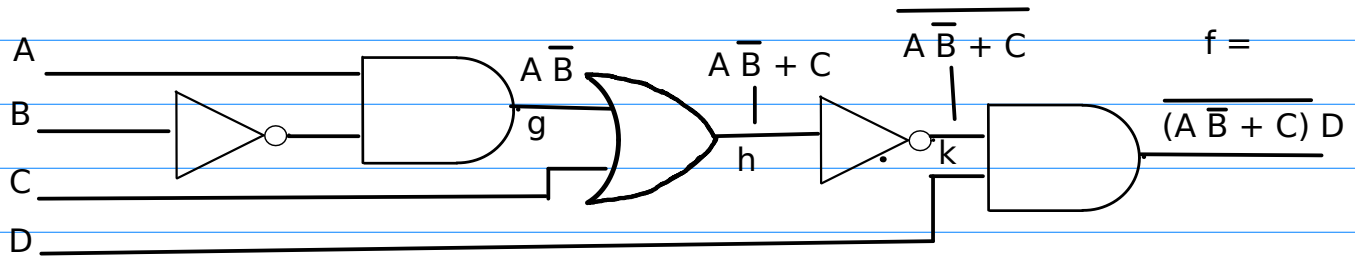


Truth Table:

A	$\overline{A}$
0	1
1	0

* Expressions: combinations of variables, values and operators

$f = \overline{(A\,\overline{B} + C)\,D}$ Equivalent to ⟺ Network *



As in "ordinary" algebra operators have "precedence" and parentheses can be used to change the order

* Truth tables (and K-maps, discussed later)

A B C D	g	h	k	f	
0 0 0 0	0	0	1	0	ROW 0
0 0 0 1	0	0	1	1	<-- ROW 1
0 0 1 0	0	1	0	0	
0 0 1 1	0	1	0	0	
0 1 0 0	0	0	1	0	
0 1 0 1	0	0	1	1	<-- ROW 5
0 1 1 0	0	1	0	0	
0 1 1 1	0	1	0	0	
1 0 0 0	1	1	0	0	
1 0 0 1	1	1	0	0	
1 0 1 0	1	1	0	0	
1 0 1 1	1	1	0	0	
1 1 0 0	0	0	1	0	
1 1 0 1	0	0	1	1	<-- ROW 13
1 1 1 0	0	1	0	0	
1 1 1 1	0	1	0	0	

* Minterms: essentially a list of rows where the function is TRUE

Shorthand

$f = m_1 + m_5 + m_{13} = \sum m(1,5,13)$

* Maxterms: essentially a list of rows where the function is FALSE

$f = M_0 \bullet M_2 \bullet M_3 \bullet M_4 \bullet M_6 \bullet M_7 \bullet M_8 \bullet M_9 \bullet M_{10} \bullet M_{11} \bullet M_{12} \bullet M_{14} \bullet M_{15}$

$= \prod M(0,2,3,4,6,7,8,9,10,11,12,14,15)$

AND Maxterms

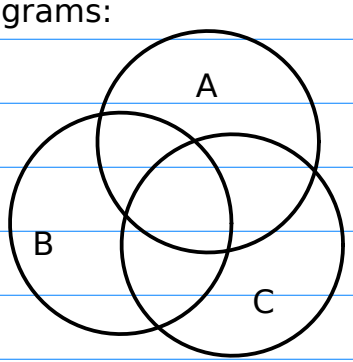
A B C D	M0	M2	M3	M4	M6	f
0 0 0 0	0	1	1	1	1	0
0 0 0 1	1	1	1	1	1	1
0 0 1 0	1	0	1	1	1	0
0 0 1 1	1	1	0	1	1	0
0 1 0 0	1	1	1	0	1	0
0 1 0 1	1	1	1	1	1	1
0 1 1 0	1	1	1	1	0	0

etc

etc

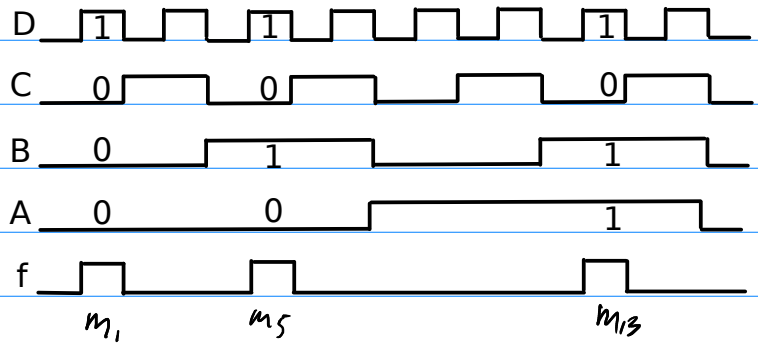
etc

* Venn diagrams:



For 3 variables

* Timing diagrams:



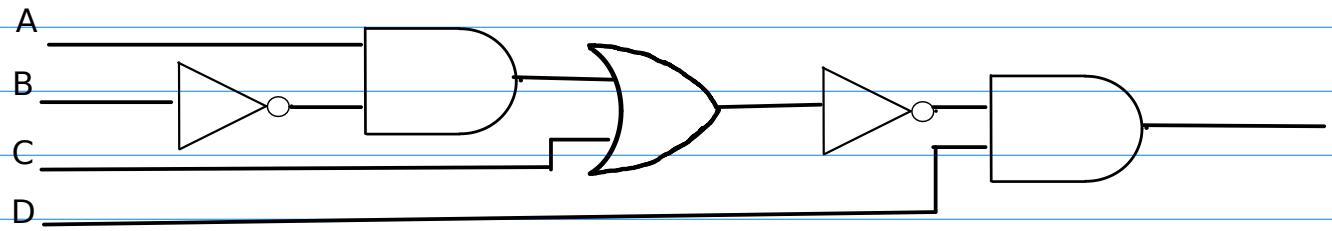
* All these are different ways to express a function. You should start getting comfortable at working with the different forms and converting between them.

Analysis (as opposed to design)

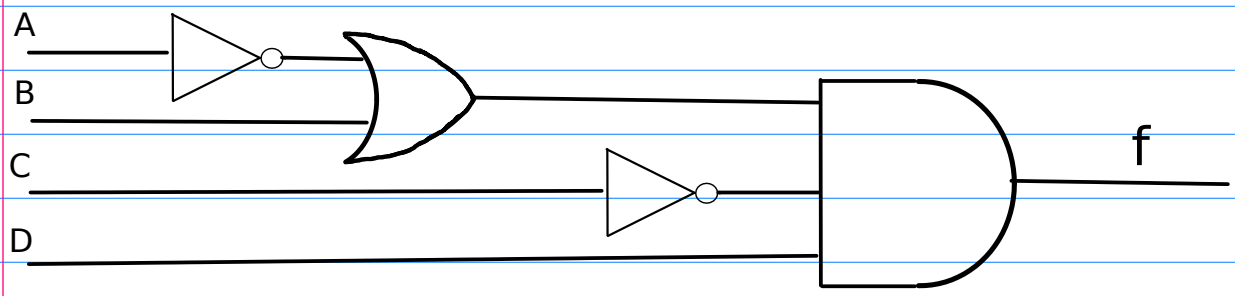
Given a circuit, what does it do?

You could generate a truth table

You could solve algebraically (simplify)



Functionally equivalent networks:



This network behaves exactly the same -- they have the same truth table

How can you tell?

Which one is best?

Can we transform one into the other?

Boolean Algebra gives us some rules for changing one expression into an equivalent expression