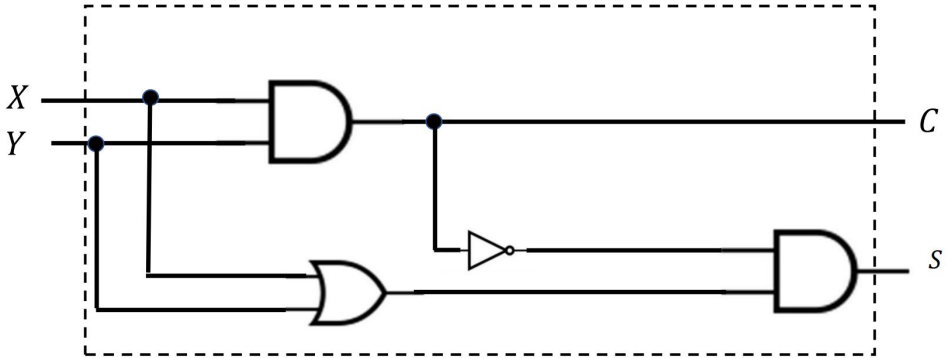
Circuits

250H

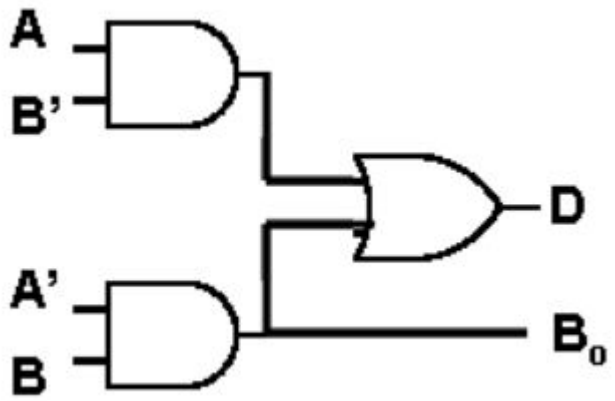
Half Adders

X	Y	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0



Half Subtractors

X	Y	D	B
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0



Exclusive OR

X	Y	X ⊕ Y
0	0	**0**
0	1	**1**
1	0	**1**
1	1	**0**

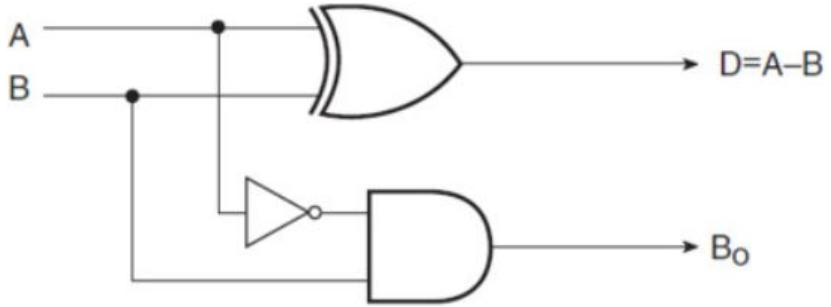
Exclusive OR

X	Y	X ⊕ Y
0	0	0
0	1	1
1	0	1
1	1	0

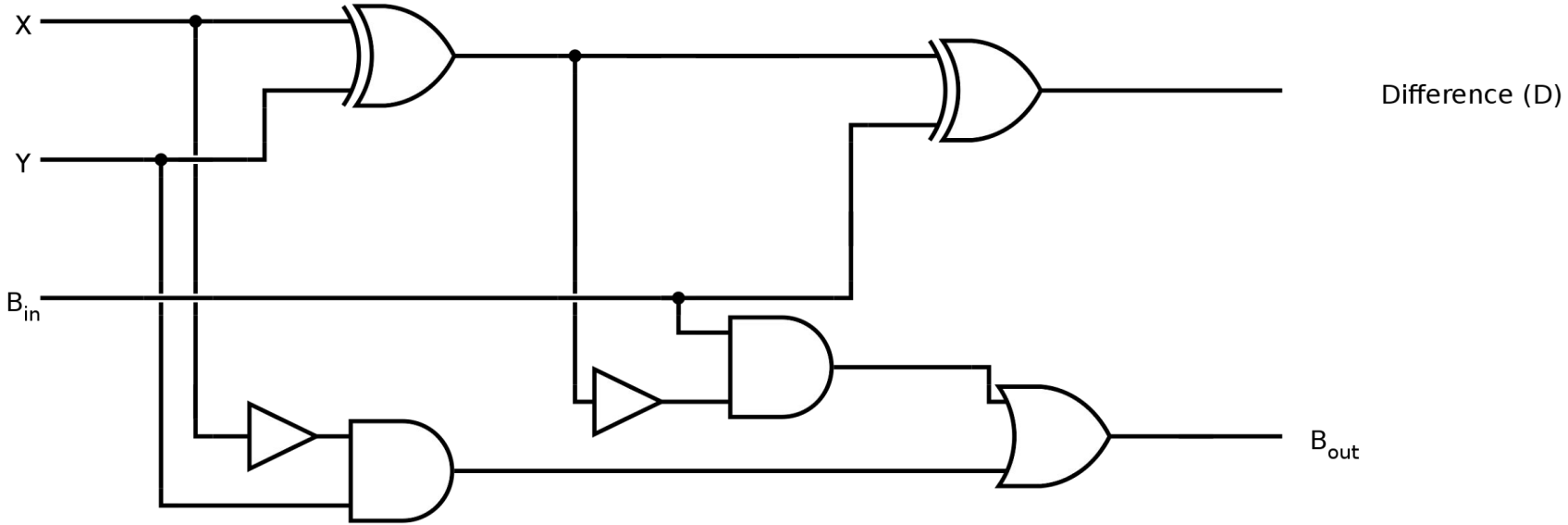
Wait didn’t we just see that column

Half Subtractors

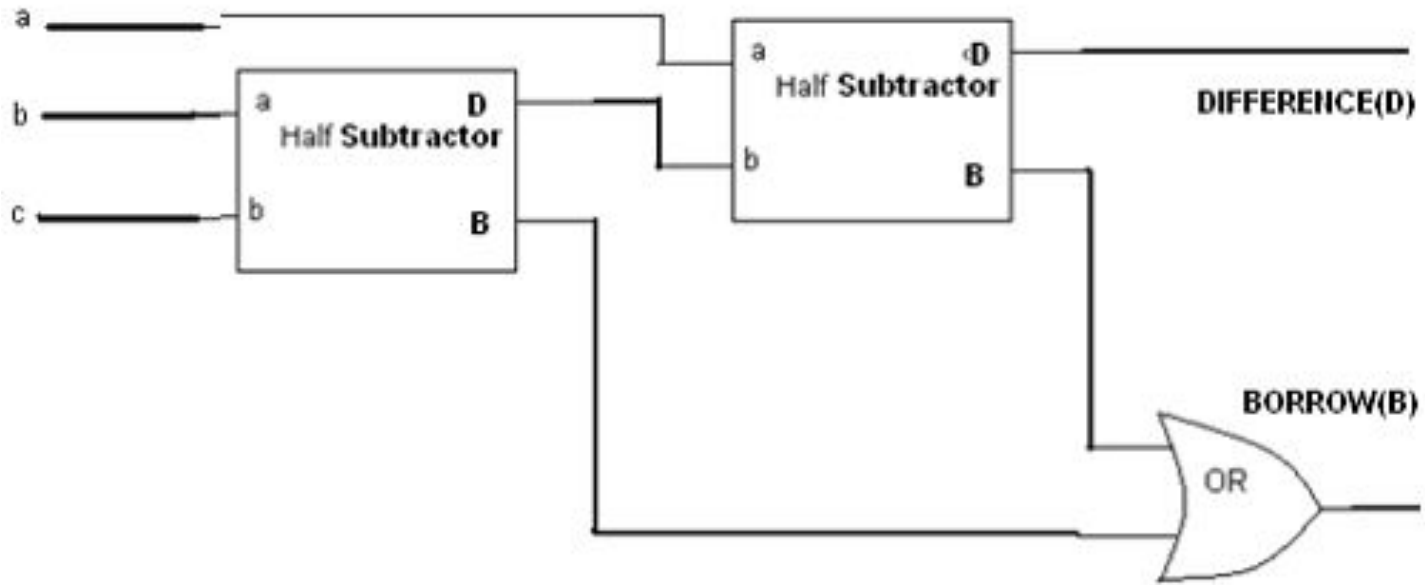
X	Y	D	B
0	0	**0**	**0**
0	1	**1**	**1**
1	0	**1**	**0**
1	1	**0**	**0**



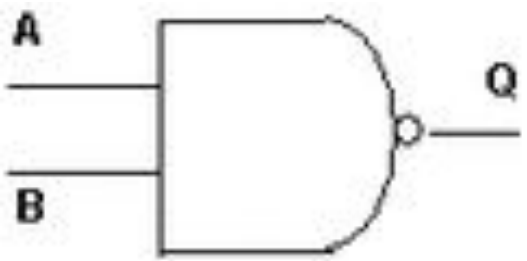
Full Subtractors



Full Subtractors

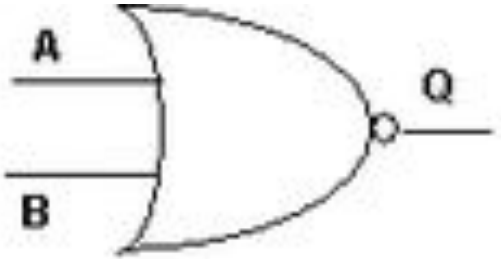


NAND and NOR



NAND

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0



NOR

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

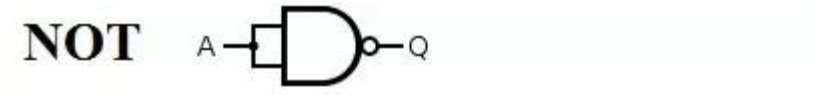
NAND and NOR

- Any circuit can be created with only **NAND** and **NOR** gates

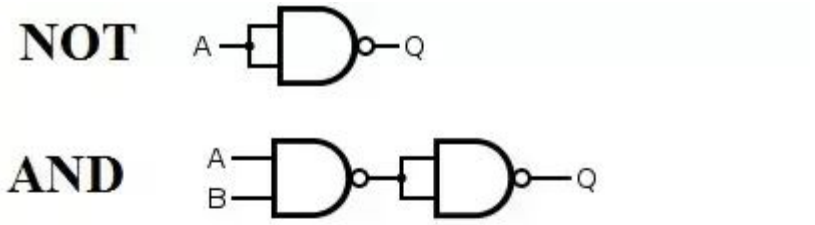
NAND and NOR

- Any circuit can be created with only **NAND** and **NOR** gates
- Try and create **NOT**, **AND**, and **OR** using only **NAND** gates
  - This one was my fault
  - MAKE FRIENDS AND TALK TO EACH OTHER!!!!
  - STOP BEING ME

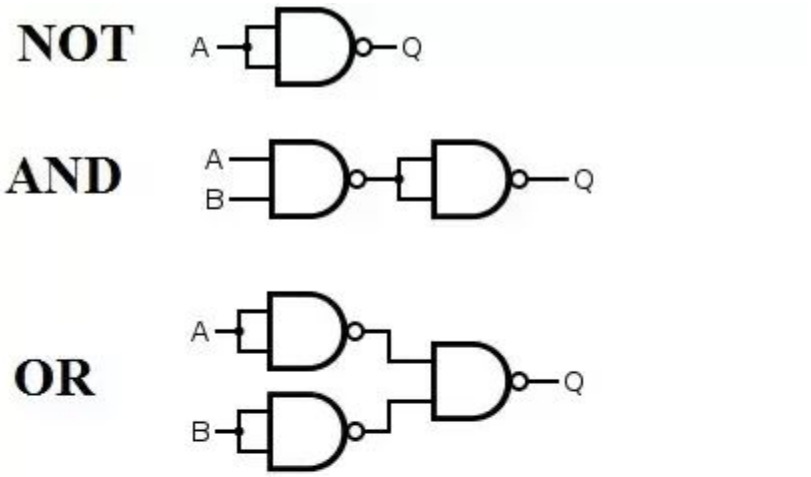
Building Gates with NAND



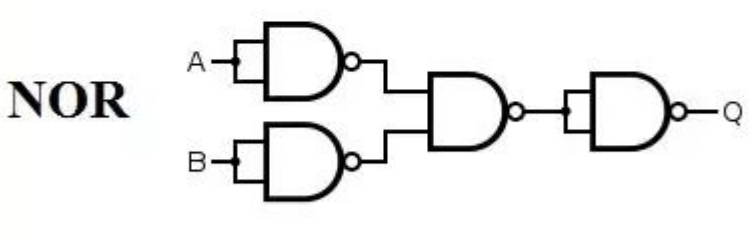
Building Gates with NAND



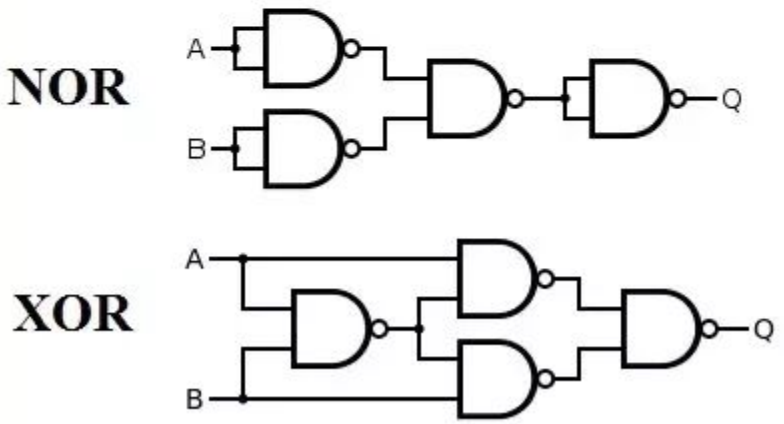
Building Gates with NAND



Building Gates with NAND



Building Gates with NAND



Boolean Algebra Identities

TABLE 3
Basic Identities of Boolean Algebra

1.	$X+0=X$	2.	$X\cdot 1=X$	
3.	$X+1=1$	4.	$X\cdot 0=0$	
5.	$X+X=X$	6.	$X\cdot X=X$	
7.	$X+\overline{X}=1$	8.	$X\cdot\overline{X}=0$	
9.	$\overline{\overline{X}}=X$			
10.	$X+Y=Y+X$	11.	$XY=YX$	Commutative
12.	$X+(Y+Z)=(X+Y)+Z$	13.	$X(YZ)=(XY)Z$	Associative
14.	$X(Y+Z)=XY+XZ$	15.	$X+YZ=(X+Y)(X+Z)$	Distributive
16.	$\overline{X+Y}=\overline{X}\cdot\overline{Y}$	17.	$\overline{X\cdot Y}=\overline{X}+\overline{Y}$	DeMorgan's

Prove using Algebraic Manipulation

1.	$X+0=X$	2.	$X\cdot 1=X$	
3.	$X+1=1$	4.	$X\cdot 0=0$	
5.	$X+X=X$	6.	$X\cdot X=X$	
7.	$X+\overline{X}=1$	8.	$X\cdot\overline{X}=0$	
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10.	$X+Y=Y+X$	11.	$XY=YX$	Commutative
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14.	$X(Y+Z)=XY+XZ$	15.	$X+YZ=(X+Y)(X+Z)$	Distributive
16.	$\overline{X+Y}=\overline{X}\cdot\overline{Y}$	17.	$\overline{X\cdot Y}=\overline{X}+\overline{Y}$	DeMorgan's

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}(\bar{Y} + Y) + Y(\bar{X} + X) = \bar{X} + Y$$

Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\left(\bar{Y} + Y\right) + Y\left(\bar{X} + X\right) = \bar{X} + Y$$

$$\bar{X}(1) + Y(1) = \bar{X} + Y$$

Prove using Algebraic Manipulation

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\bar{Y} + \bar{X}Y + \bar{X}Y + XY = \bar{X} + Y$$

$$\bar{X}\left(\bar{Y} + Y\right) + Y\left(\bar{X} + X\right) = \bar{X} + Y$$

$$\bar{X}(1) + Y(1) = \bar{X} + Y$$

$$\bar{X} + Y = \bar{X} + Y$$

Let’s Check with Truth Tables

X	$\overline{X}$	Y	$\overline{Y}$	$\overline{X}\overline{Y} + \overline{X}Y + XY$	$\overline{X} + Y$
0	1	0	1	**1**	**1**
0	1	1	0	**1**	**1**
1	0	0	1	**0**	**0**
1	0	1	0	**1**	**1**

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

Let’s Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?

Let’s Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8

Let’s Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8
- How many gates on the right?

Let’s Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8
- How many gates on the right?
  - 2

Let’s Make a Circuit

$$\bar{X}\bar{Y} + \bar{X}Y + XY = \bar{X} + Y$$

- How many gates on the left?
  - 8
- How many gates on the right?
  - 2
- 2 is much better than 8