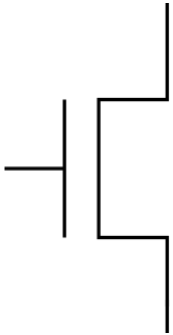
COMPUTER SYSTEMS AND ORGANIZATION

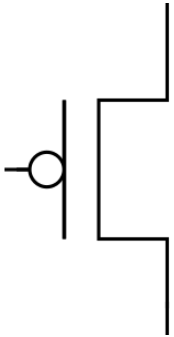
Part 1

Daniel Graham

REVIEW

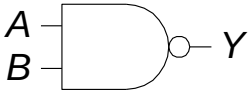


push to close



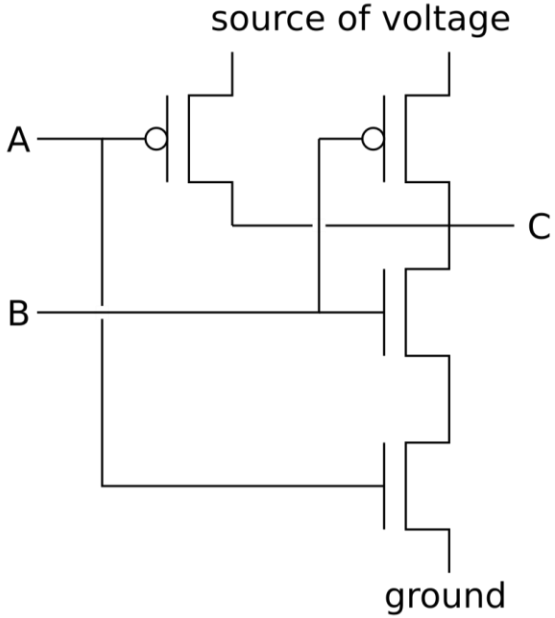
push to open

NAND



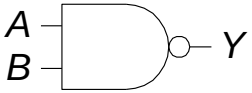
$Y = \overline{AB}$

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0



Y

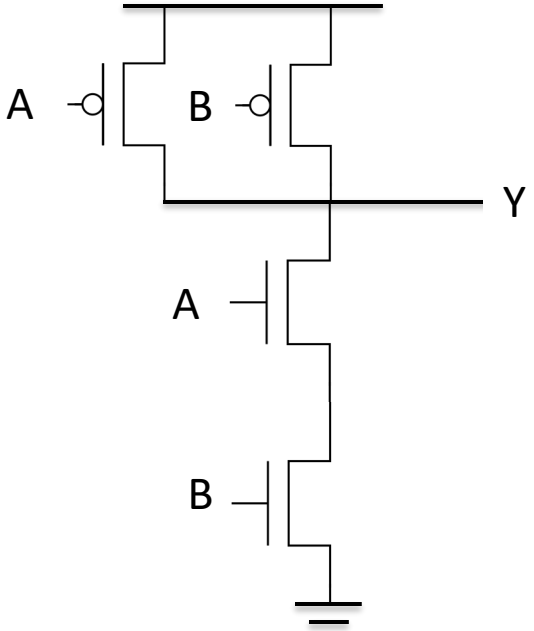
NAND



$Y = \overline{AB}$

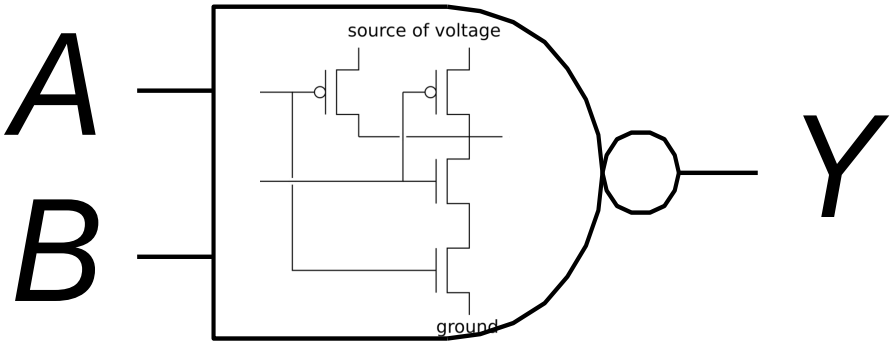
A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Source of Voltage (VDD)



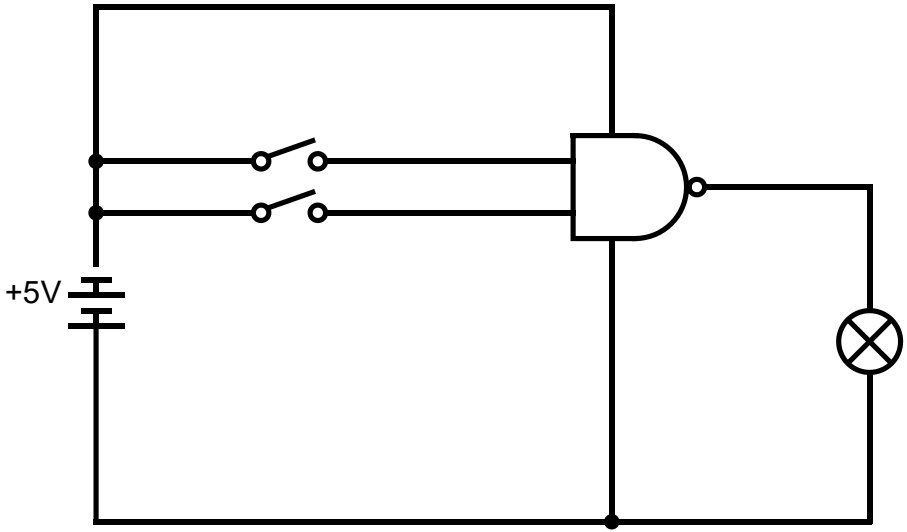
Ground

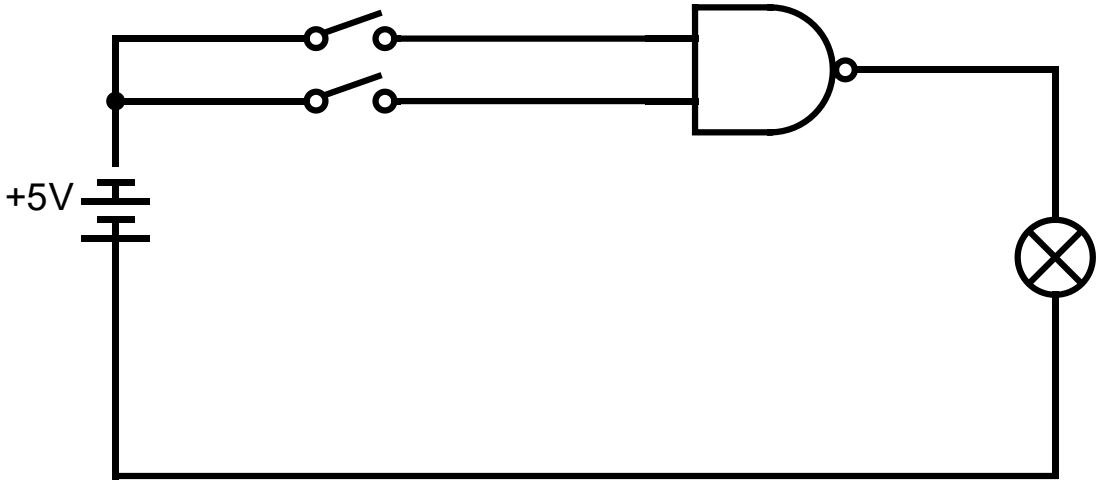
NAND



$$Y = \overline{AB}$$

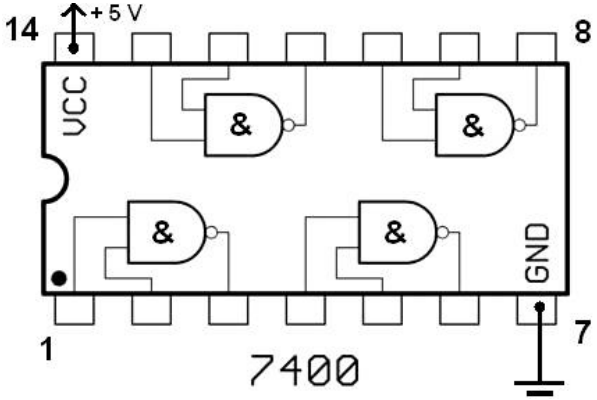
Circuit with a NAND Gate

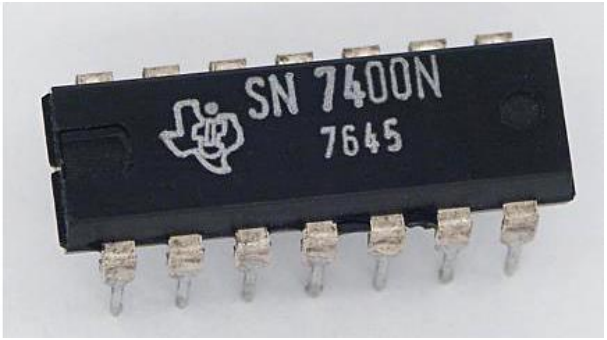


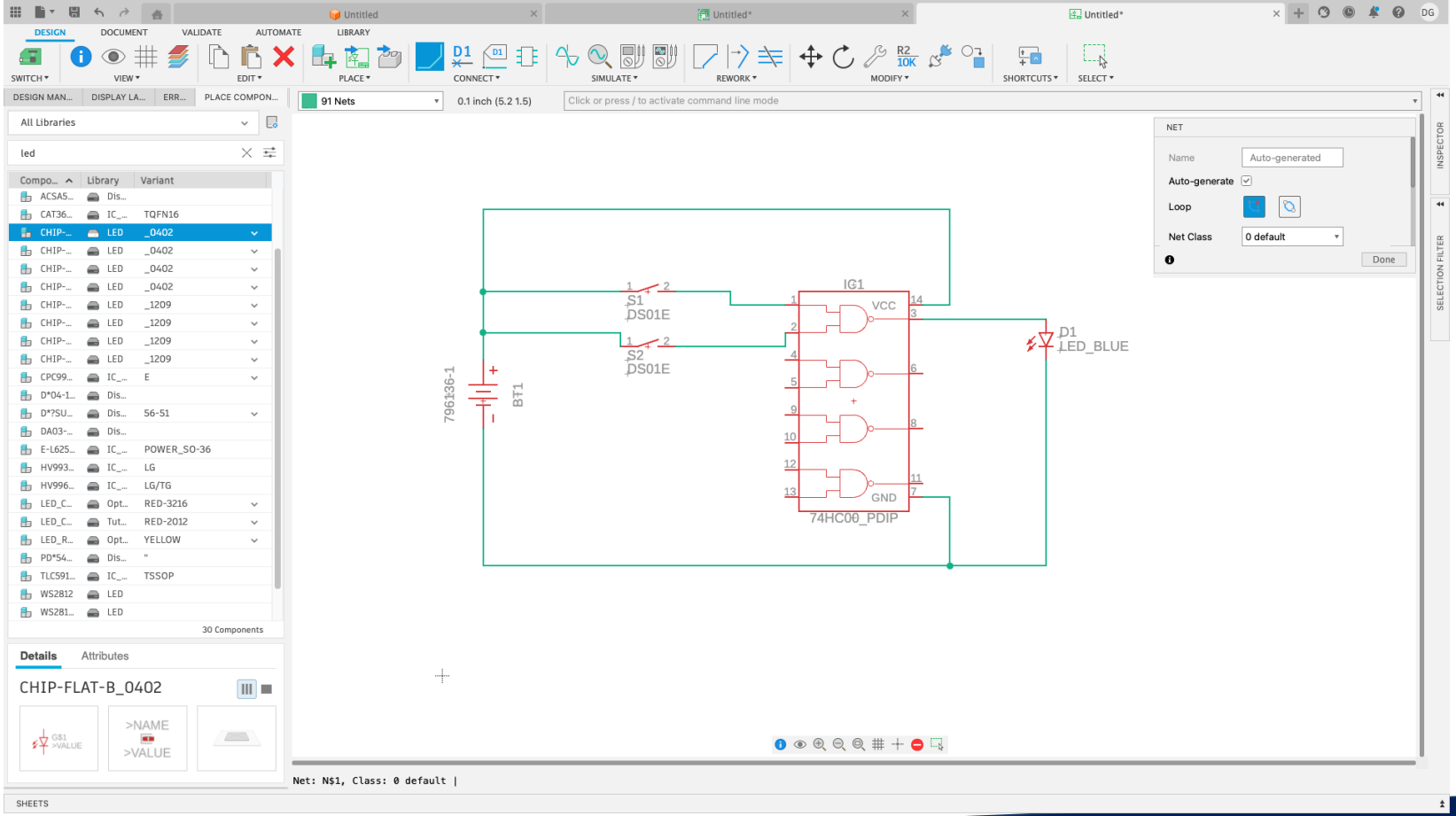


We don’t normally draw the voltage and ground with gates. So, you will normally see circuits that look like this.

CHIPS WITH NAND GATES






Untitled
Untitled*
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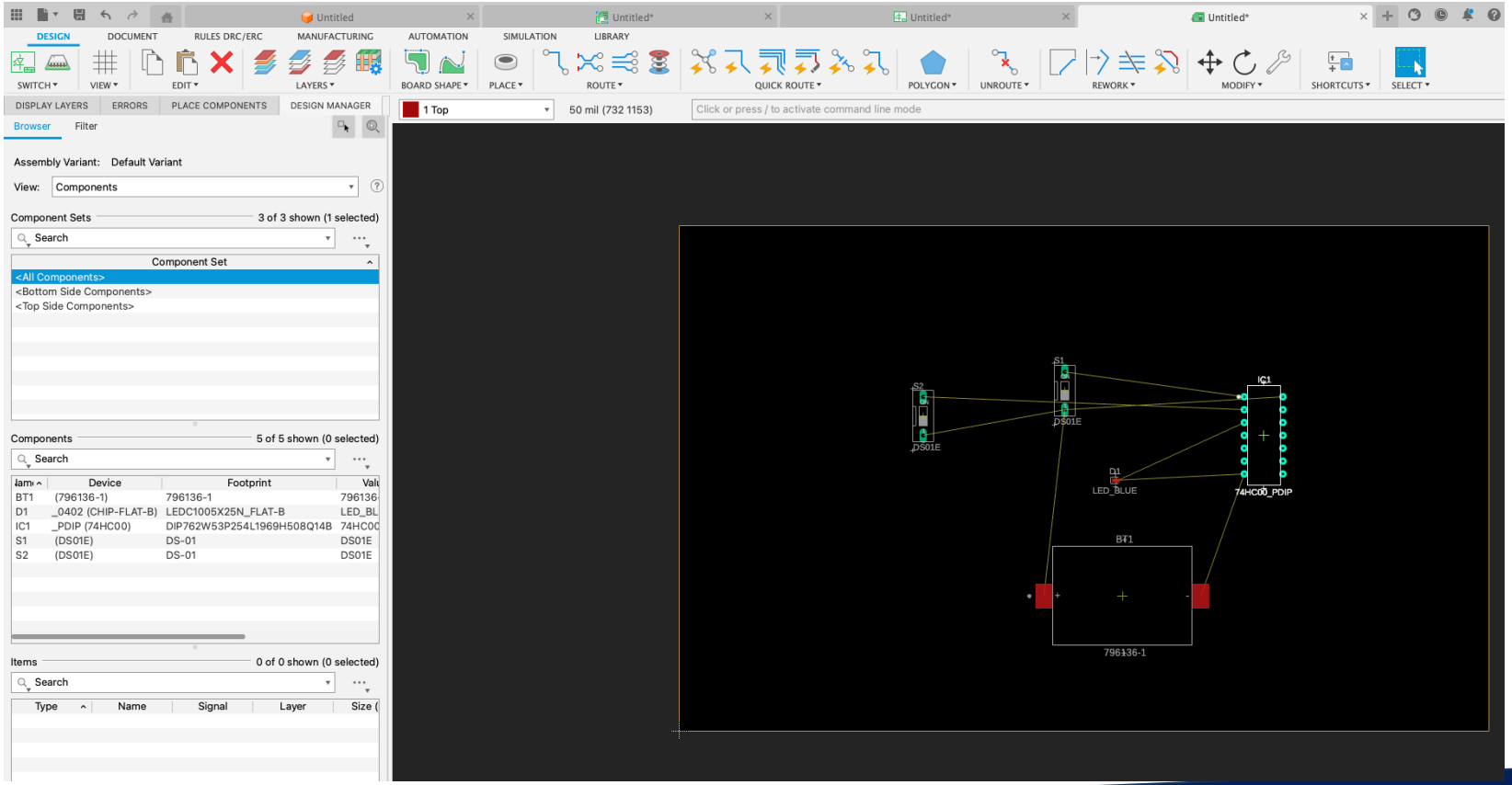
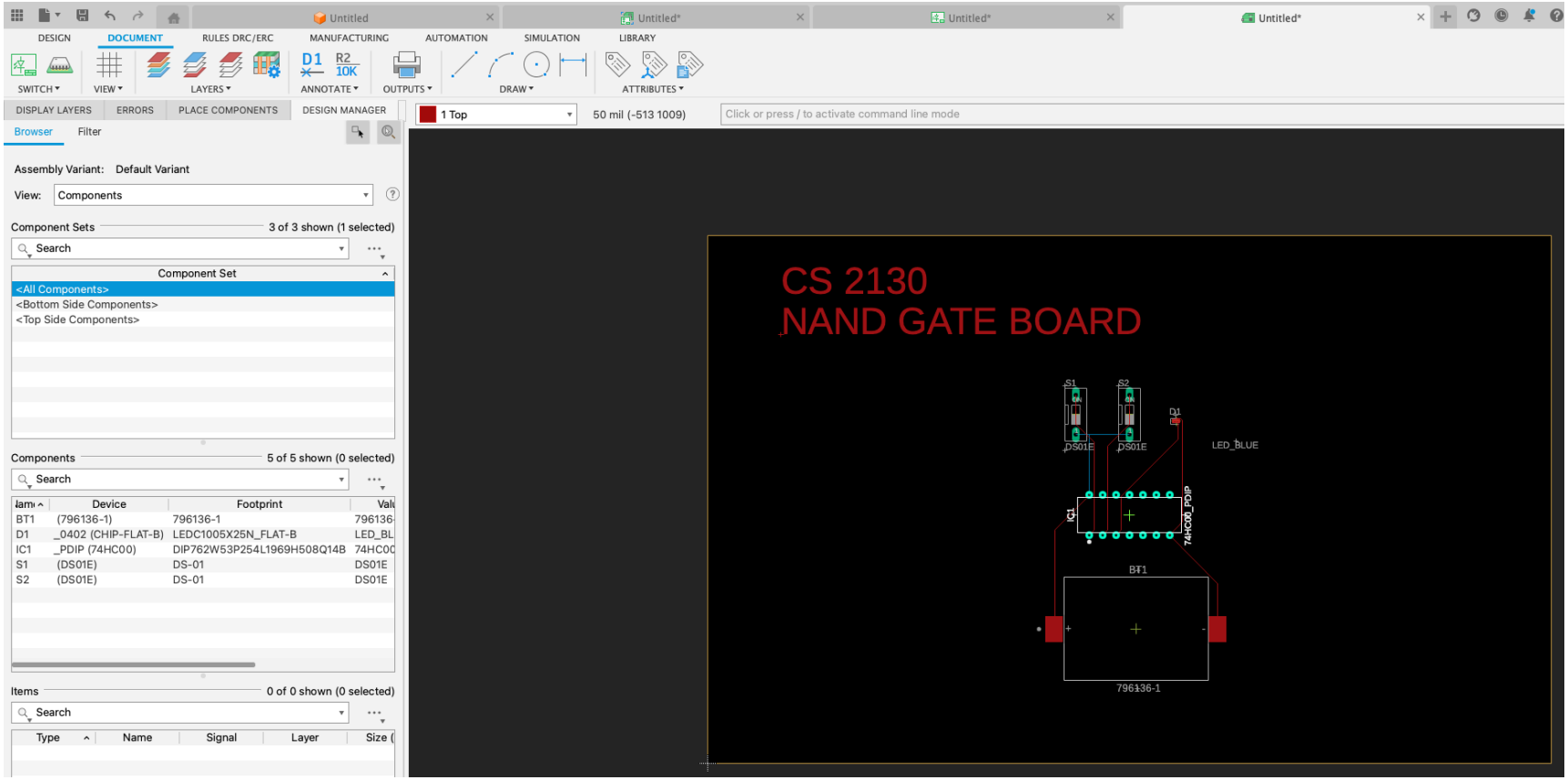
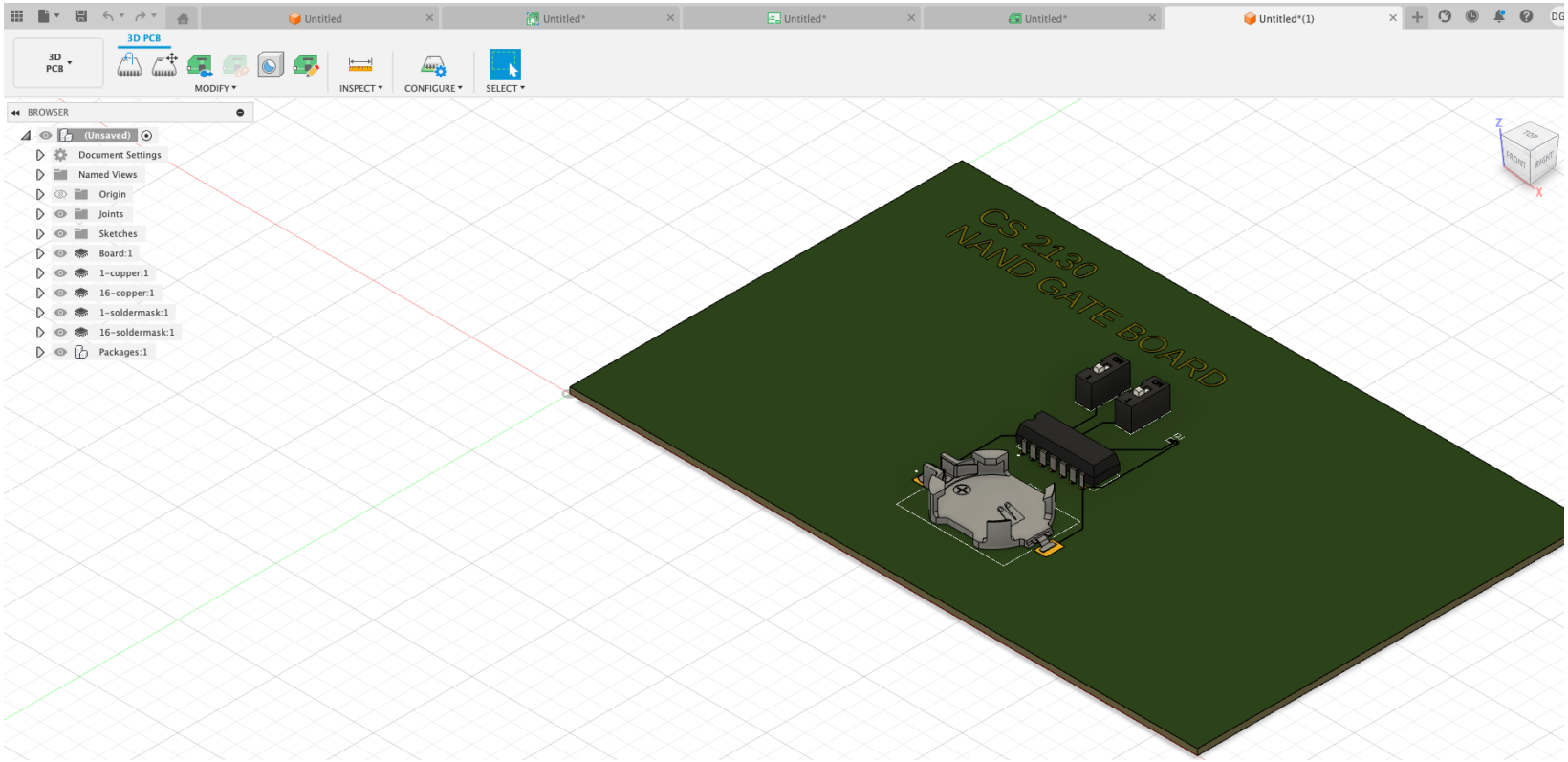
DESIGN
DOCUMENT
VALIDATE
AUTOMATE
LIBRARY
SWITCH
VIEW
EDIT
PLACE
CONNECT
SIMULATE
REWORK
MODIFY
SHORTCUTS
SELECT
DESIGN MAN...
DISPLAY LA...
ERR...
PLACE COMPON...
91 Nets
0.1 inch (5.2 1.5)
Click or press / to activate command line mode
All Libraries
led
Compo...
Library
Variant
CHIP-...
LED
_0402
30 Components
Details
Attributes
CHIP-FLAT-B_0402
>NAME
>VALUE
NET
Name
Auto-generated
Auto-generate
Loop
Net Class
0 default
Done
INSPECTOR
SELECTION FILTER
S1
DS01E
S2
DS01E
IG1
VCC
GND
74HC00_PDIP
D1
LED_BLUE
BT1
796136-1
Net: N$1, Class: 0 default |
SHEETS






Untitled
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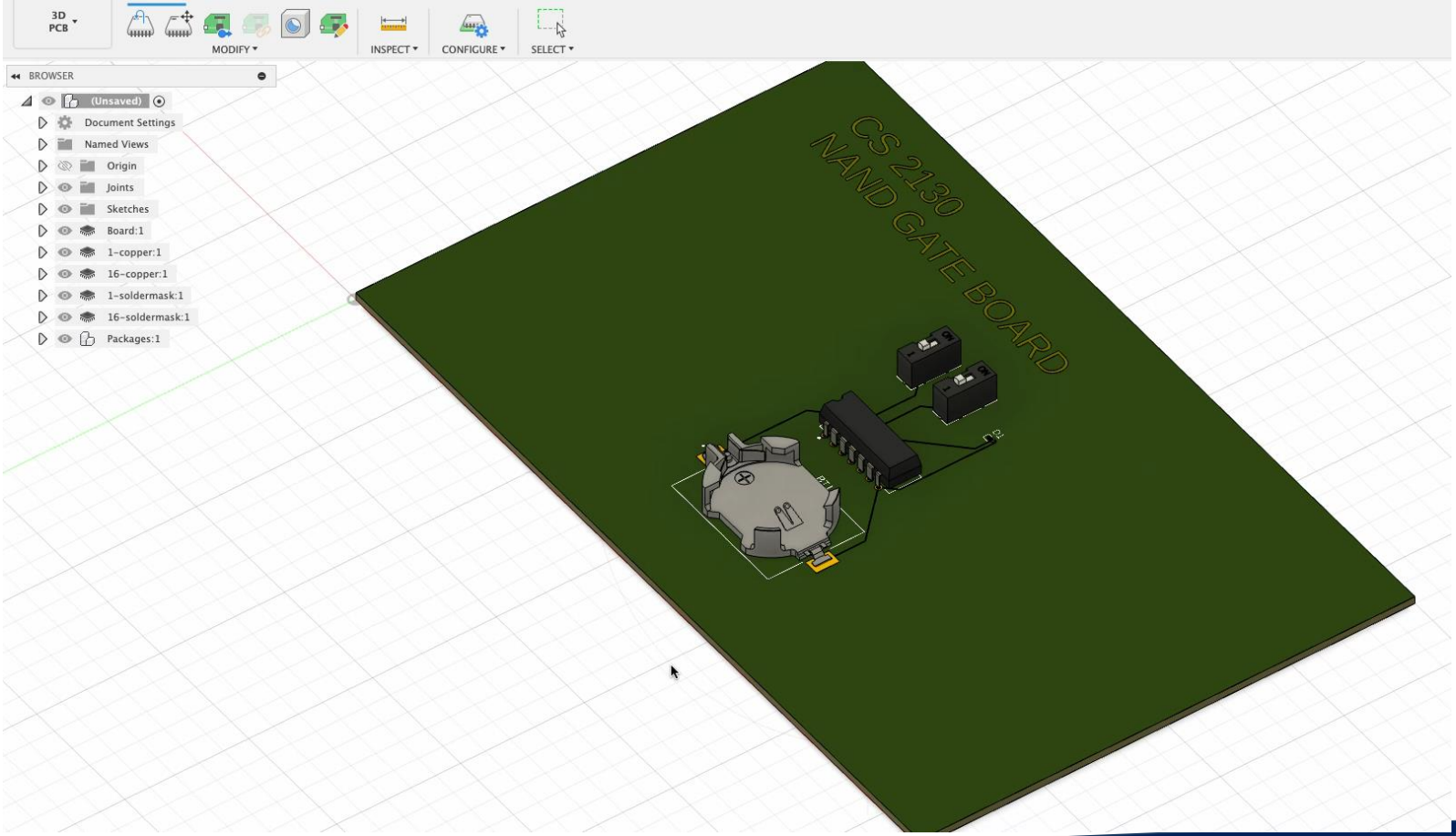
Untitled*(1)
3D PCB
MODIFY
INSPECT
CONFIGURE
SELECT
BROWSER
(Unsaved)
Document Settings
Named Views
Origin
Joints
Sketches
Board:1
1-copper:1
16-copper:1
1-soldermask:1
16-soldermask:1
Packages:1
CS 2130
NAND GATE BOARD


3D PCB
MODIFY
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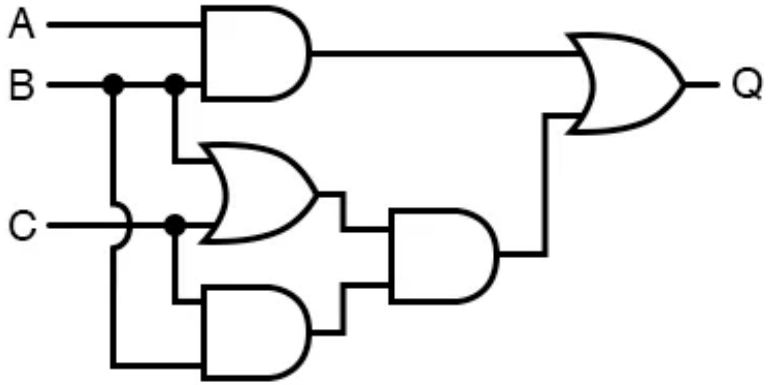
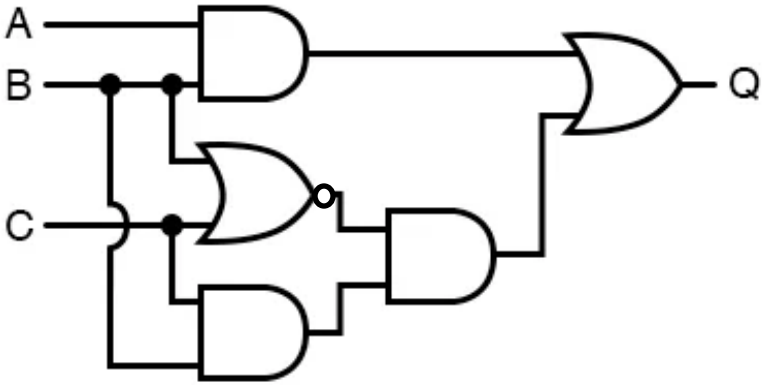
Joints
Sketches
Board:1
1-copper:1
16-copper:1
1-soldermask:1
16-soldermask:1
Packages:1
CS 2130
NAND GATE BOARD

A	*B*	C	Q
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	1

WHAT IS THE OUTPUT OF THIS CIRCUIT?



EXPRESS CIRCUIT AS AN EQUATION



Write the equation representing the circuit.

Note: I replaced the OR with a NOR.

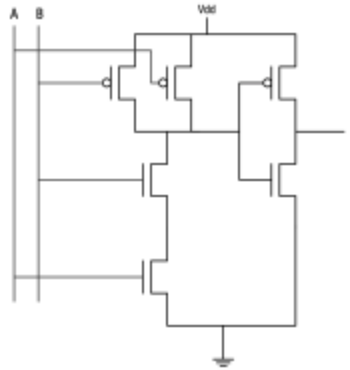
What's missing from the equation below:

(A and B) or ((B and C) & (B or C))

EXAM QUESTION

7. (2 points) Consider the following ~~push-pull~~ network. Which gate does it implement? (Hint: write out the truth table.)

Pull up pull down



Pull up pull down

Figure 1: ~~Push-Pull~~ Network, output is the unlabeled wire on the right.

- ○ AND
- ○ OR
- ○ NAND
- ○ XOR
- ○ NOR
- ○ None of the above

CREATIVE QUESTIONS

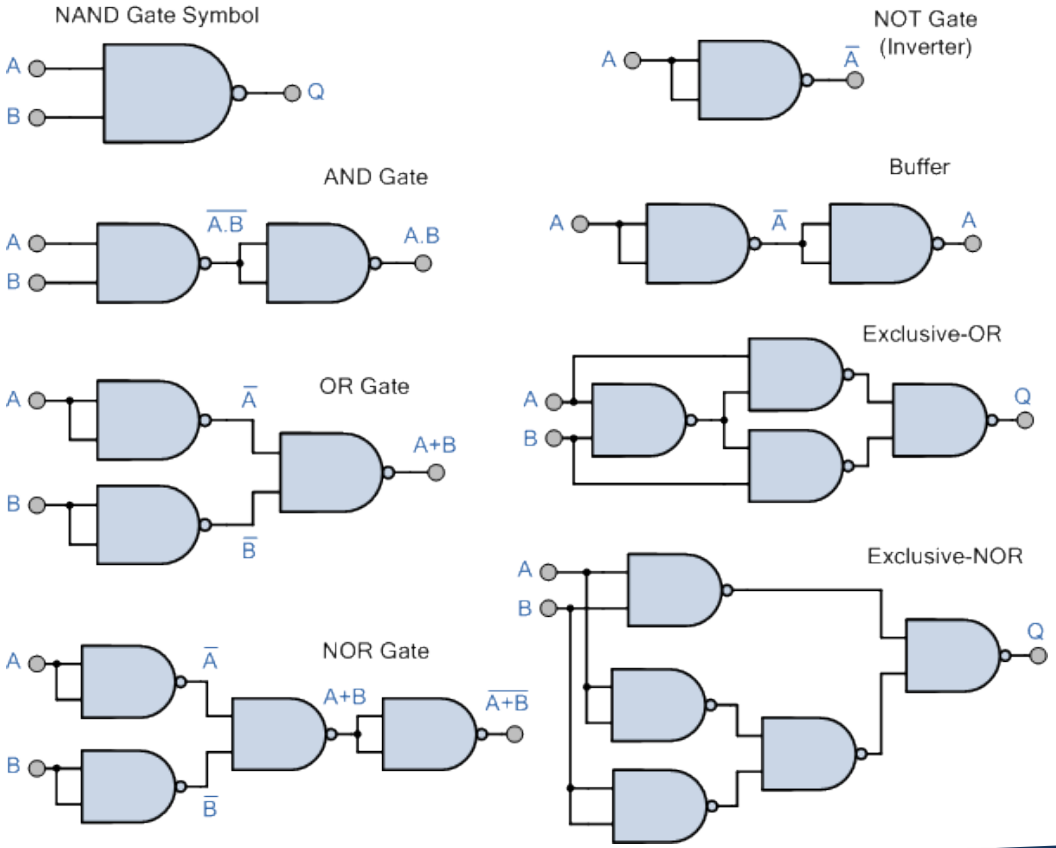
NAND GATES ARE TURNING COMPLETE

It is possible to implement every other gate by using a NAND. You can implement the complete RISC-V architecture using only NAND gates. What a beautiful building block right ☺

Use a NAND gate to implement the following gates:

1. NOT
2. AND
3. OR
4. NOR
5. XOR

Hint: Start by asking NOT what a NAND gate can do for you but what you can do with a NAND gate.



TODAY'S LECTURE

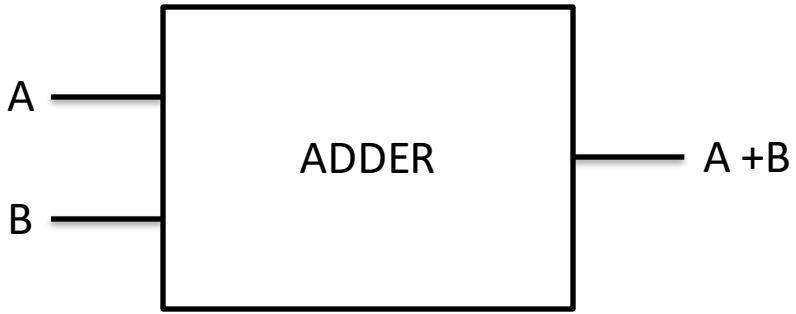
1. Towards building a digital adding machine
2. How can we represent numbers? (What about decimals and negative numbers)

GREAT WE HAVE GATES

NOW LET'S BUILD SOMETHING.

HOW ABOUT A MACHINE THAT ADDS NUMBERS?

THE IDEA



THE CHALLENGE

Our gates only support 0 and 1s.

How can we represent other decimal numbers?

How can we present negative numbers?

What about fractions ☺?

DECIMAL

- Decimal numbers

1000's column
100's column
10's column
1's column

$$5374_{10} = 5 \times 10^3 + 3 \times 10^2 + 7 \times 10^1 + 4 \times 10^0$$

five thousands
three hundreds
seven tens
four ones

BINARY

8's column 4's column 2's column 1's column

$$1101_2 = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 13_{10}$$

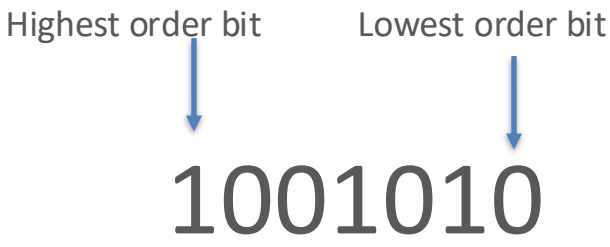
one eight | one four | no two | one one

BINARY CONVERSION EXAMPLES

Convert 74 to binary = 1001010

74 ÷ 2 = 37 remainder 0
37 ÷ 2 = 18 remainder 1
18 ÷ 2 = 9 remainder 0
9 ÷ 2 = 4 remainder 1
4 ÷ 2 = 2 remainder 0
2 ÷ 2 = 1 remainder 0
1 ÷ 2 = 0 remainder 1

Convert 10101 to Decimal



EXAM REVIEW

1 Binary and Hex

1. (2 points) Convert 45_{10} (base 10) to binary.
the box so that the grader can see it.)

3. (2 points) Write 132_{10} in base 5. Use the space below for rough work, but remember to write your final answer in the box.

$($ $)_5$

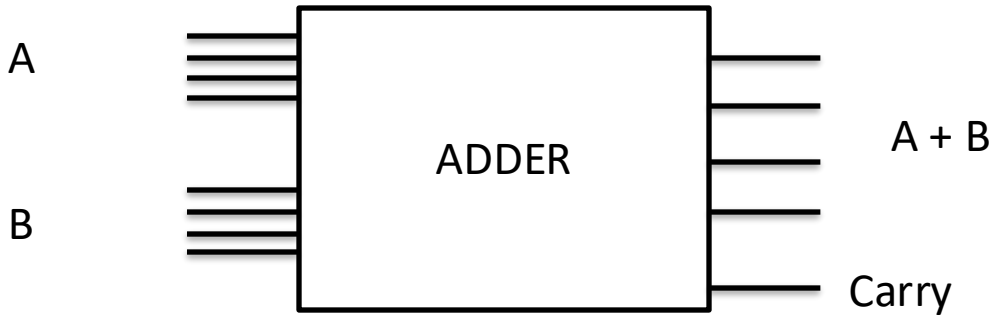
3. (2 points) Write 132_{10} in base 5. Use the space below for rough work, but remember to write your final answer in the box.

$(\ 1012\ )_5$

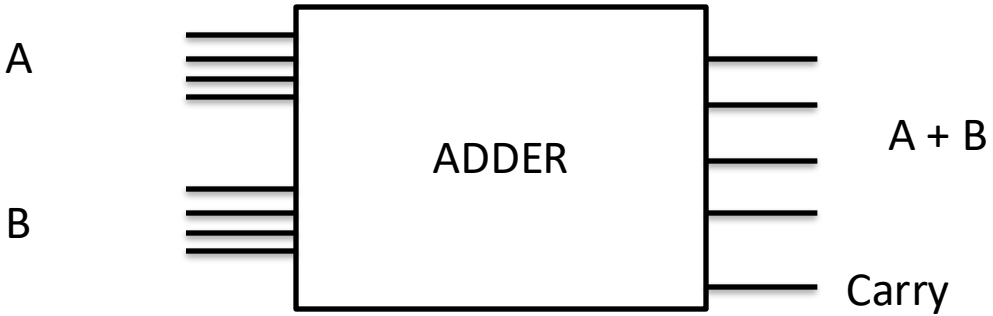
EXAM QUESTION SIMPLIFIED

NOW LET'S BUILD A MACHINE WITH GATES THAT WILL ADD

4-BIT ADDER



4-BIT ADDER



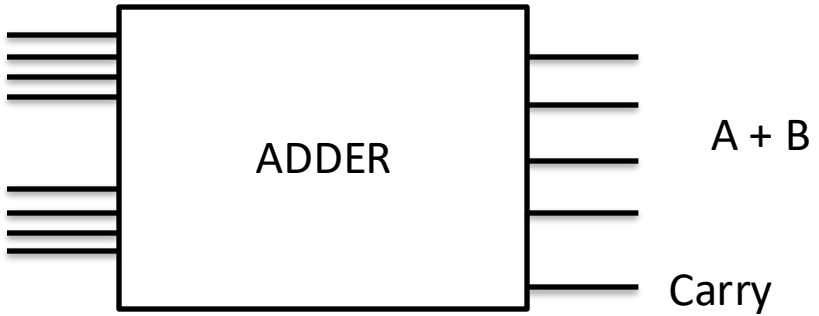
Let's Add 4 + 3 Manually in binary.

INPUTS AND OUTPUT OF OUR ADDER

What would the input be if we wanted to add 5, and 9?

Notice we need to pick and order for the wires.

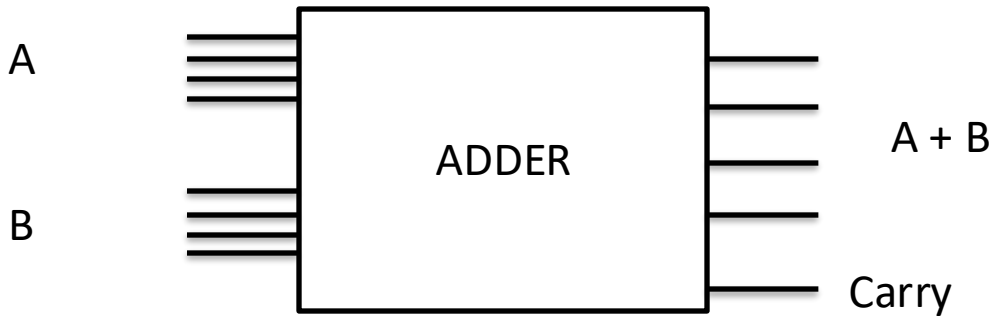
Which output lights would we want to light up?



INPUTS AND OUTPUT OF OUR ADDER

What if we now added 7 and 9?

What would our inputs be, and which lights do we expect to light up?



LET'S DESIGN THE CIRCUIT THAT WILL IMPLEMENT THIS ADDER

LET'S START A MACHINE THAT ADDS TWO BITS

Draw Half Adder

LET'S START SIMPLE (MACHINE THAT ADDS TWO BITS)

Let's start by building a half adder something that just adds two bits.

Let’s build a truth table.

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

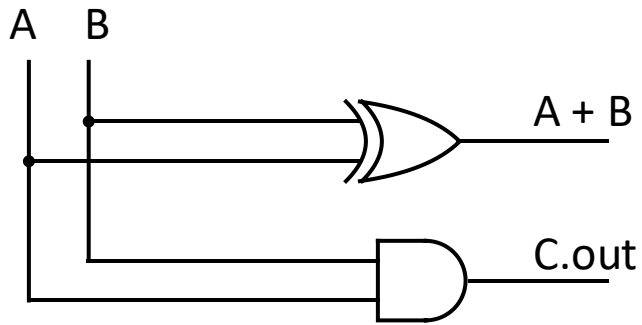
HALF ADDER

Let's start by building a half adder something that just adds two bits.

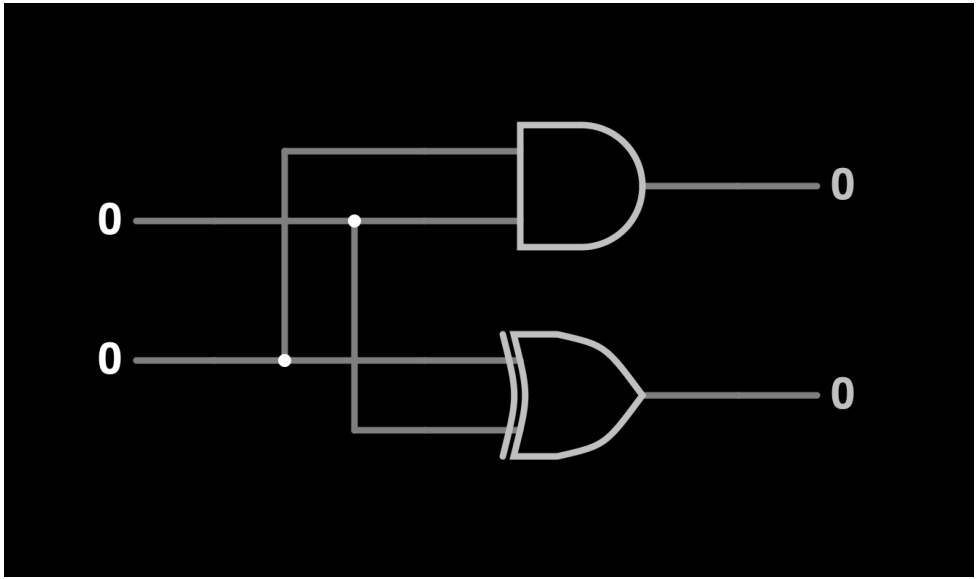
Let's build a truth table.

A	B	A + B	C.out
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

We can implement
A + B with an XOR gate
And the C.out (Carry out)
With an AND gate



HALF ADDER DEMO



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