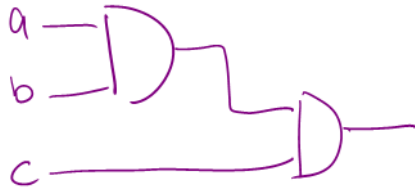


# Computer Systems and Organization 1

Warm up!

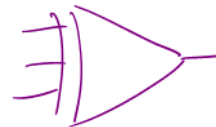
Can I <sup>make</sup> ~~build~~ an  $n$ -input AND  
from 2-input AND gates?

$n = 3$



Warm up!

What about XOR gates?



# Adder, Clocks

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CS 2130: Computer Systems and Organization 1

September 9, 2022

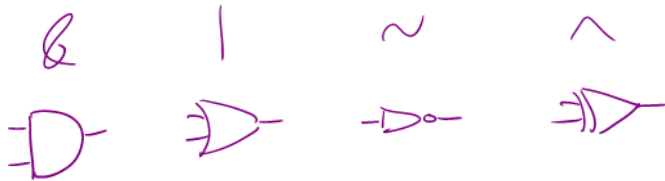
# Announcements

- Quiz 2 out at 5pm, due Monday at 8am
- Homework 1 due Monday
- New Location! **Gilmer 301** on Monday **It's official!**

# Review

- Transistors
- Information modeled by voltage through wires (1 vs 0)

• Gates

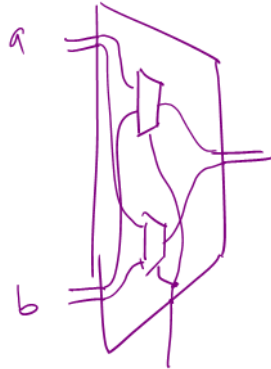


- Examples of AND, NOT gates
- Multi-bit values: representing integers
  - Signed and unsigned
- Floating point

How to do the work of multi-bit?

# Multi-bit Mux

Our first multi-bit example: mux



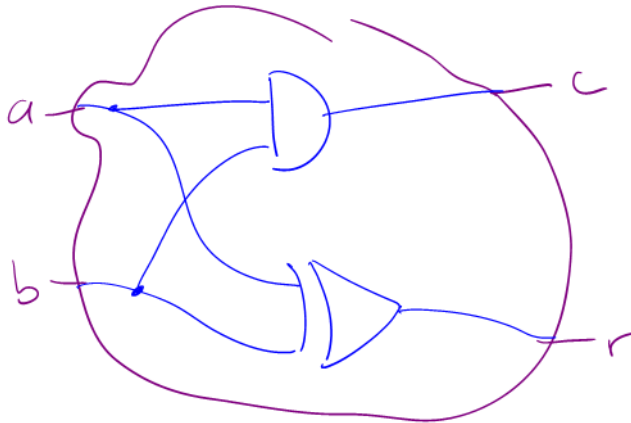
# Adder

$10_2$

Add 2 1-bit numbers:  $a, b$

$$\begin{array}{r} a \\ + b \\ \hline cr \end{array}$$

$ab$	$cr$
00	00
01	01
10	01
11	10





# Adder

What is missing? Consider:

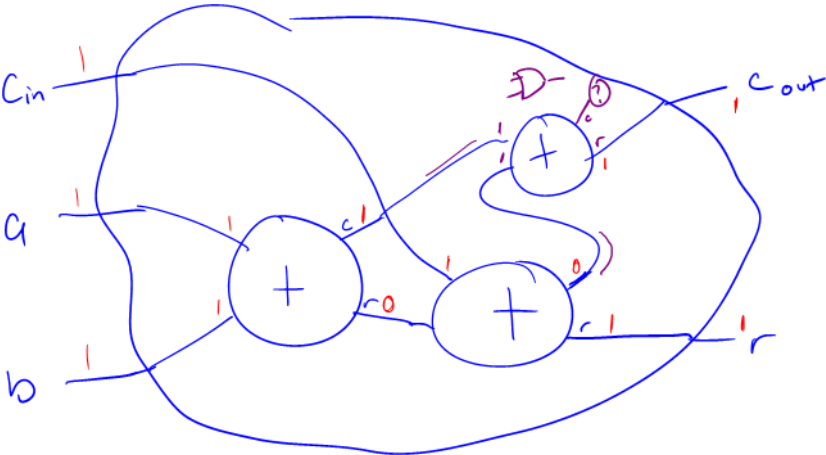
A handwritten diagram illustrating a binary addition. The numbers 11 and 01 are stacked vertically, with a plus sign to the left of the 01. A horizontal line is drawn below the 01. The result 100 is written below the line. A blue box encloses the 11 and 01, with a blue '3' written above it. The result 100 is also written in blue.

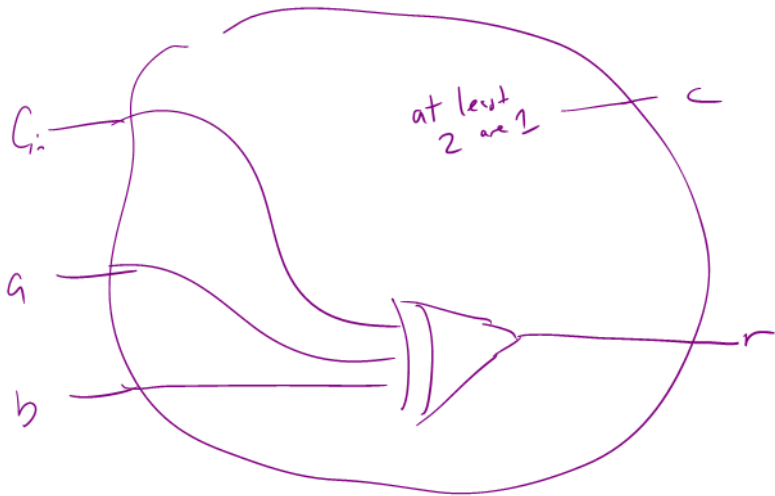
$$\begin{array}{r} 3 \\ \boxed{\begin{array}{r} 11 \\ + 01 \\ \hline \end{array}} \\ 100 \end{array}$$

# 3-input Adder

Add 3 1-bit numbers:  $a, b, c$

$$\begin{array}{r} + \\ c\ 1 \\ \hline c\ 1 \\ \hline a \end{array}$$



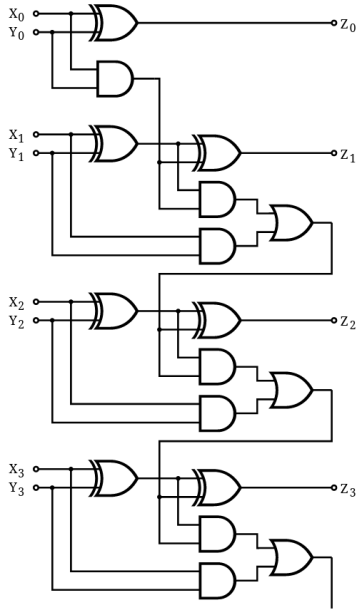


# Ripple-Carry Adder

$x_3 x_2 x_1 x_0$

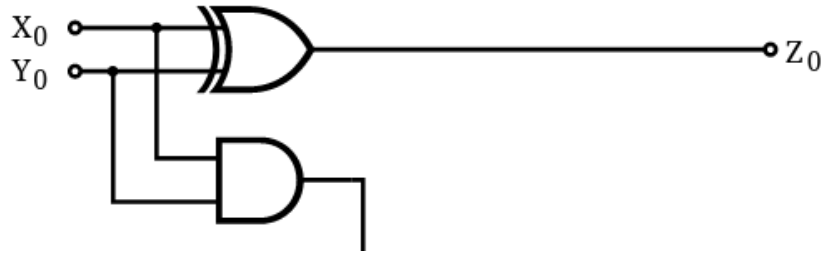
$y_3 y_2 y_1 y_0$

$x - y$   
≡

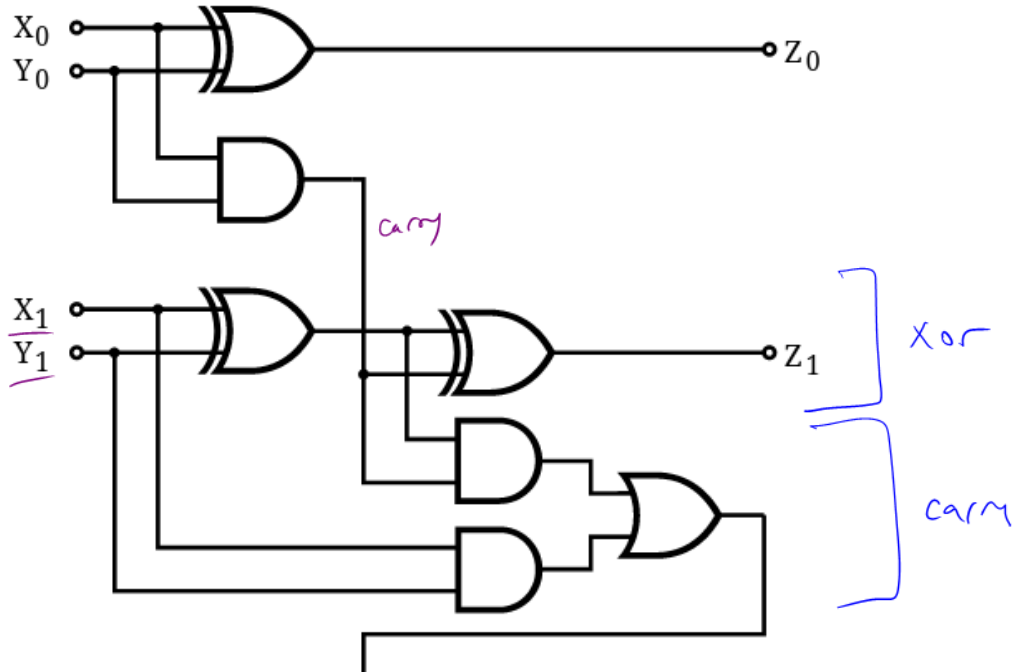


$z_3 z_2 z_1 z_0$

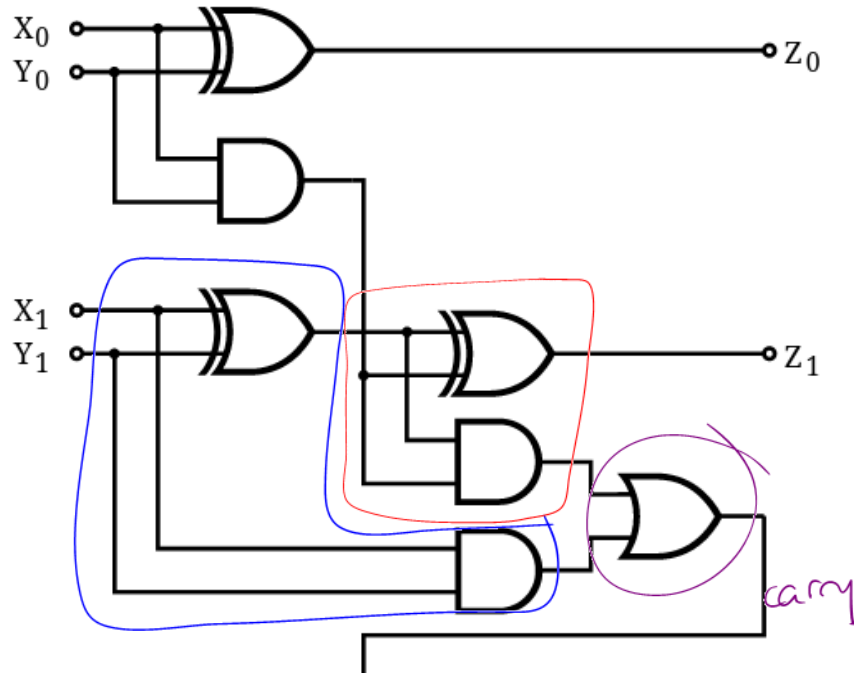
# Ripple-Carry Adder



# Ripple-Carry Adder



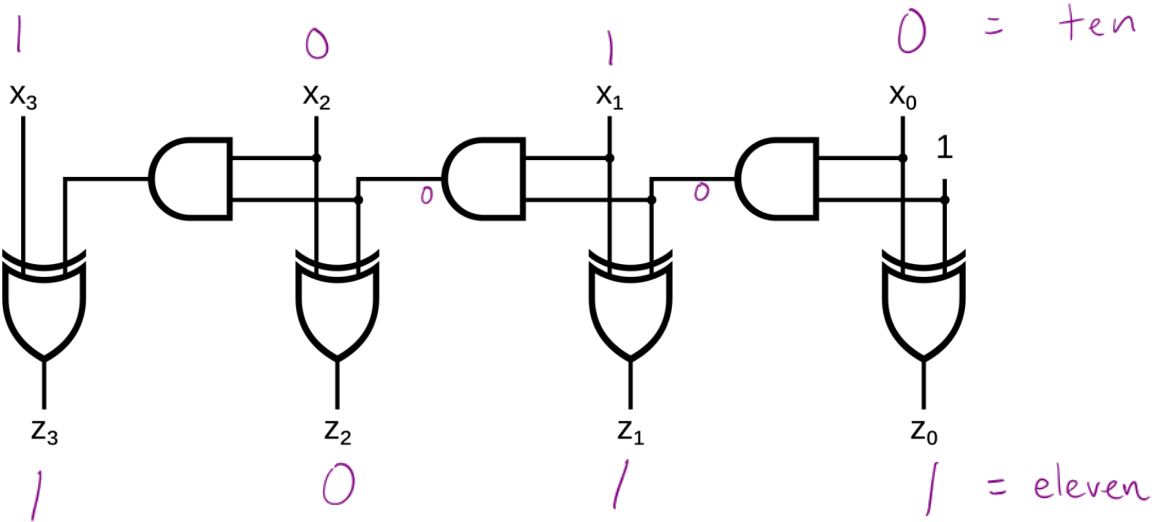
# Ripple-Carry Adder



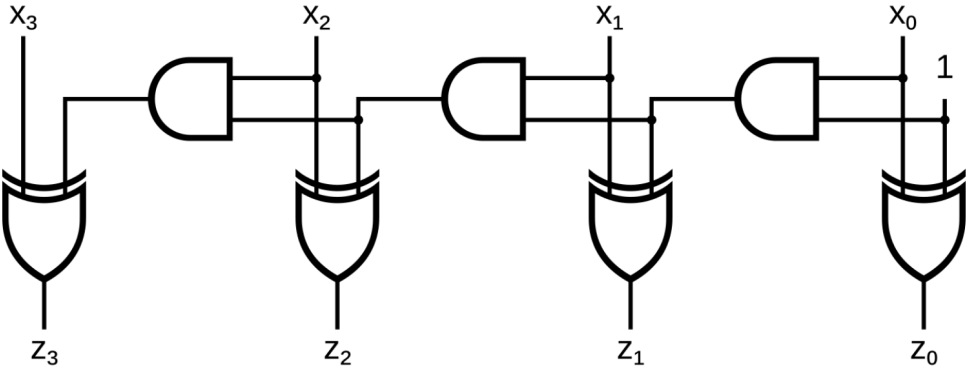




# What does this circuit do?

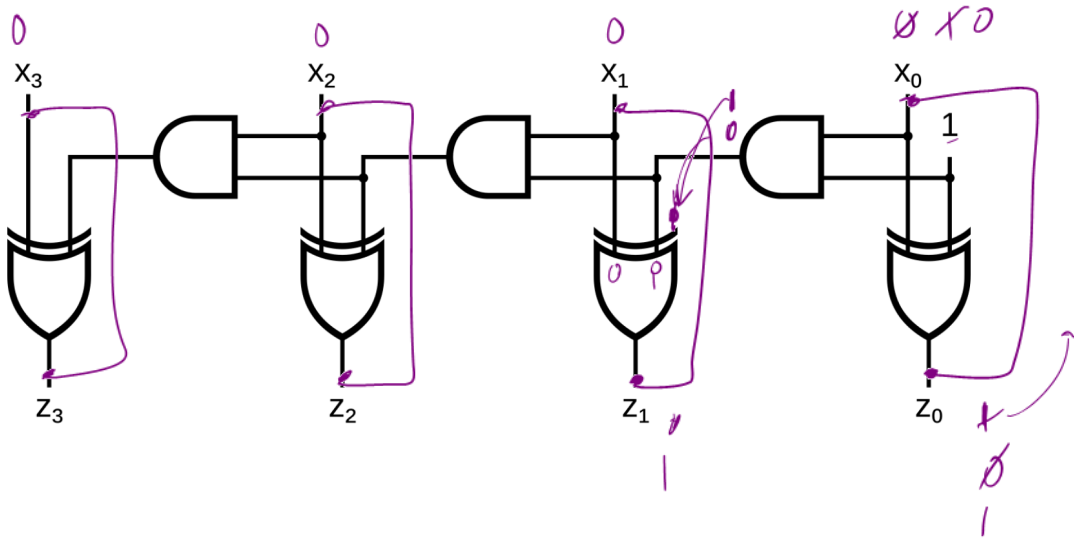


# What does this circuit do?

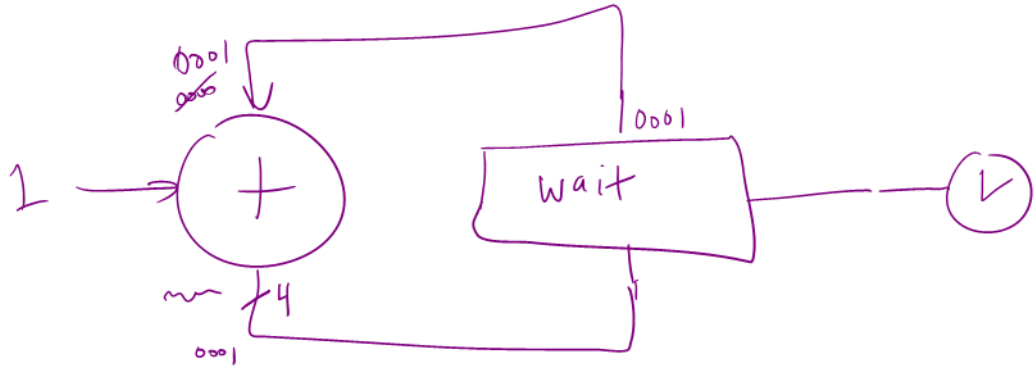


# Increment Circuit

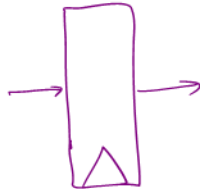
0000  
0001  
0010  
0011



# Building a Counter



register



# Gate Delay

What happens when I change my input?

