The CS 5 Times

Professor Loses Drinking Contest in Local Bar

Penguin celebrates win over professor.

Pomona (Penguin Press): A little-known professor from a local college was found under the table here after coming in second in a game that required him to consume twice as many mugs of liquid as his opponent.

"His mistake was to agree to compete on the basis of mug count," explained the winner. "He left the choice of mugs up to me."

In other news, a second professor's dog was found soaking wet and yelping in a neighbor's back yard. "The odor was overpowering," said the neighbor. "We had to hose the animal down before we could approach it." Police are investigating a rumor that the canine had been attacked by a tuxedo-wearing street gang.

A Few Notes About CS 5

Changes are coming!

1. Restricted chats
2. Worksheets on Gradescope
3. Mid-semester course evaluations
4. Other revisions TBA

More on Circuits!

Last time…

1. String representation
2. From Boolean functions to digital circuits

Today…

1. A circuit for adding
2. A circuit simulator
3. How logic gates really work
4. Universality of logic gates
5. Memory

Finding the Formula!

The Minterm Expansion Principle

Consider this function…

Words	Truth Table			Formula
	x	y	x XOR y	
A function of TWO binary inputs x,y where the output is 1 iff $x \neq y$	0	0	0	
	0	1	1	$\bar{x}y$
	1	0	1	$x\bar{y}$
	1	1	0	

$$f(x,y) = \bar{x}y + x\bar{y}$$

You Try It!

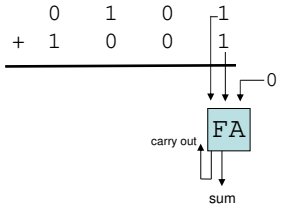
The Minterm Expansion Principle

Consider this function…

Words	Truth Table	Formula
A function of TWO binary inputs *x,y* where the output is 1 iff x ≥ y		Circuit

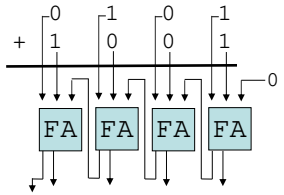
A Circuit for Adding!

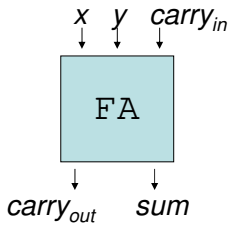
Base 2 Addition



A Circuit for Adding!

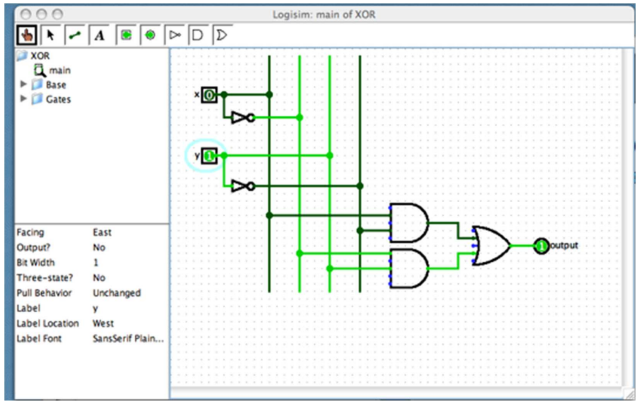
Base 2 Addition



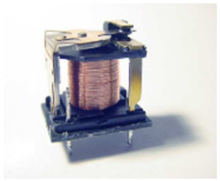


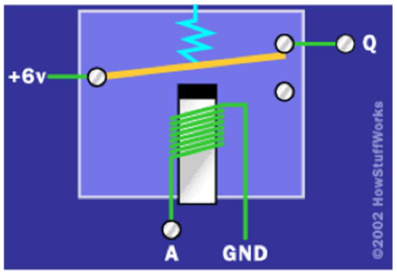
x	y	$carry_{in}$	sum	$carry_{out}$
0	0	0	0	0
0	0	1	1	0

Logisim: A Digital Logic Simulator

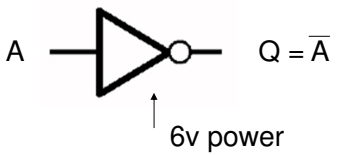


Implementing Gates with Relays



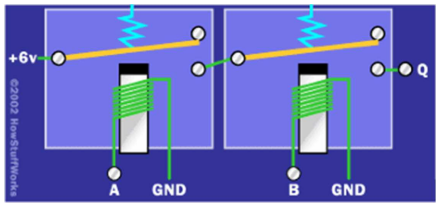


NOT Gate



Figures courtesy of HowStuffWorks.com

And AND…



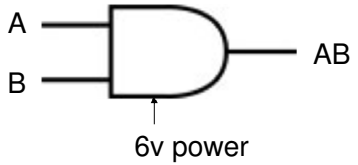
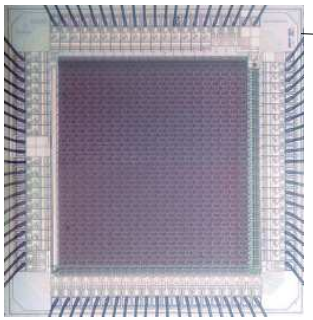


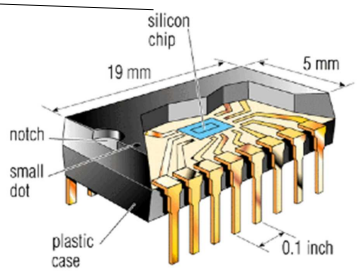
Figure courtesy of HowStuffWorks.com

Integrated Circuits



3mm

http://personalpages.manchester.ac.uk/staff/p.dudek/projects/scamp



http://www.helicon.co.uk

AND, OR, NOT Is a "Universal Set"

De Morgan's Laws:

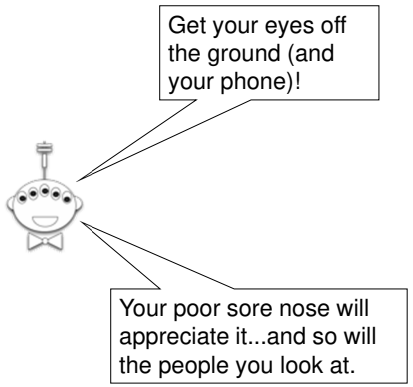
$$\overline{x\,y} = \overline{x} + \overline{y}$$

$$\overline{x+y} = \overline{x}\,\overline{y}$$

Augustus De Morgan
1806-1871

By Sophia Elizabeth De Morgan - Memoir of Augustus De Morgan, Public Domain
https://commons.wikimedia.org/w/index.php?curid=4722207

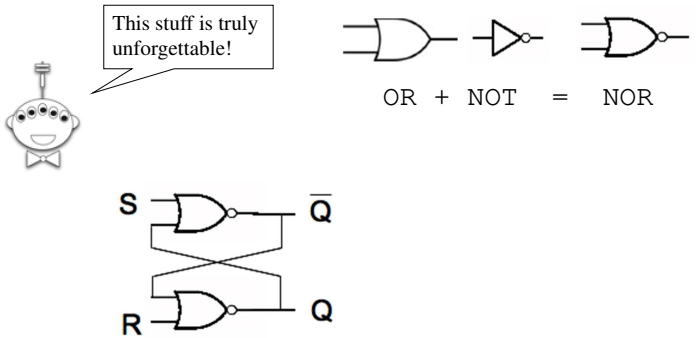
The Alien's Life Advice



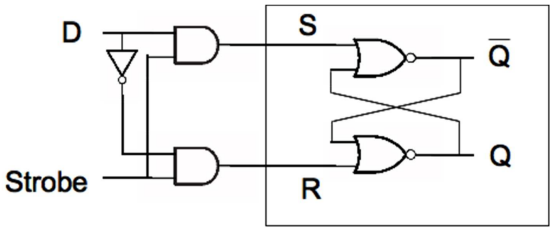
Sending a Message to Prof. Ben

Worksheet!

A 1-Bit Memory



From S-R Latches to D-Latches

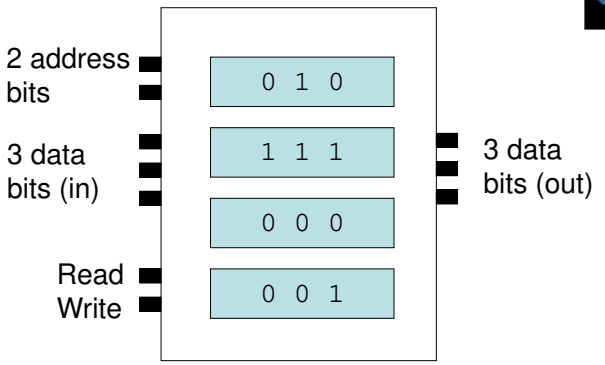


A Random-Access Memory (RAM)

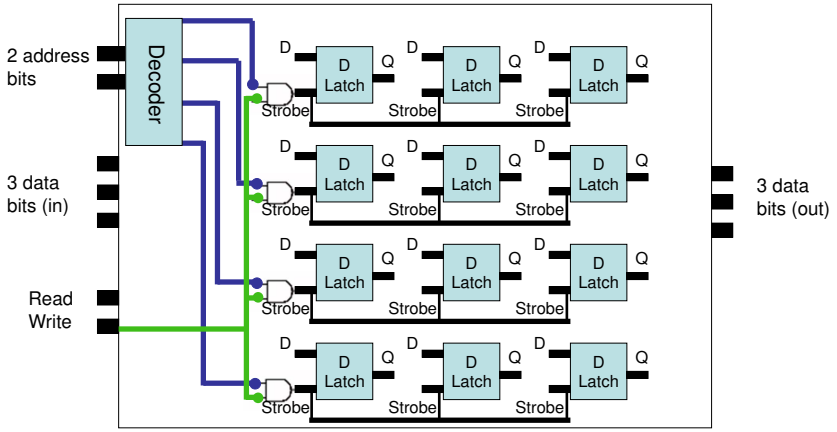
A 512K x 8 RAM
(About 4.2 million bits)

A Random-Access Memory (RAM)

small!



A Random-Access Memory (RAM)



A Random-Access Memory (RAM)