Weather: Temperatures around 1100000°_{2} F

Sports: CS Professor runs 100_2 meter dash in under 3_{10} seconds!

CS 101_2 Today

News Briefs

Spam proven to be even healthier than chocolate (page 1100101_2)

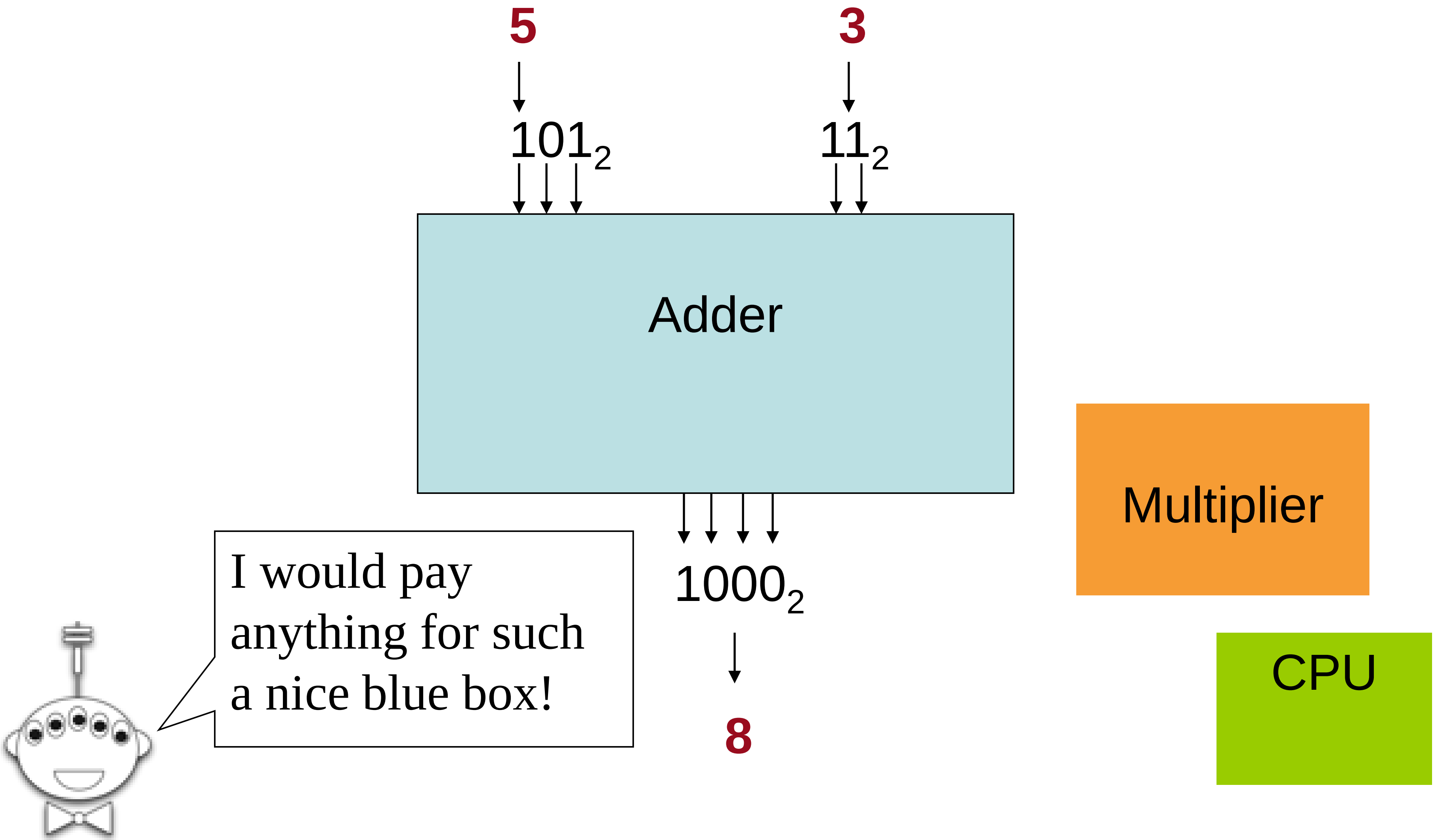
Hoch-Shanahan to use Spam in all its dishes (page 1000101_2)

Proof of Spam's merits proven to be false (page 110101_2)

Harvey Mudd to adopt Base 2 as Official Number System

(Claremont, AP): Harvey Mudd College, a small science and engineering college in Los Angeles county, has announced that it will henceforth exclusively use base 2. "One obvious advantage is that there will now be 11000 hours in each day." said a CS professor who first proposed that the college adopt the binary system. Other professors happily noticed that their monthly paychecks are now on the order of $1000000000000. Students too were excited that they would be able to take 10000 units per semester without overloading. However, one disgruntled student complained that he flexed a friend into the dining hall and he was charged over $110 for the meal. "The food here is good, but $110 for lunch is outrageous!"

Computing Digitally



From Description to Circuit!

Abstract → Concrete

Words

f is a function of TWO binary (Boolean) variables s.t. the output is *1* if and only if exactly one of the two inputs is *1*

Table

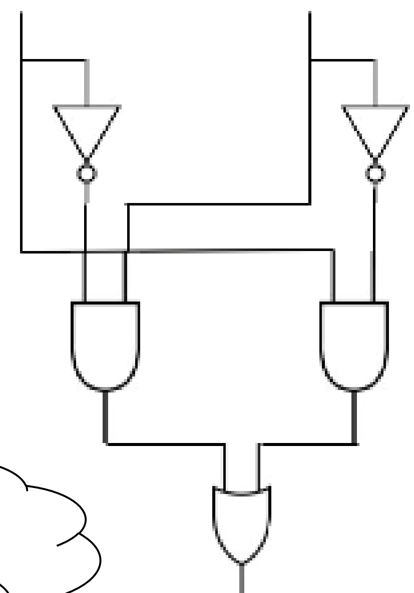
x	*y*	*f(x,y)*
0	0	0
0	1	1
1	0	1
1	1	0

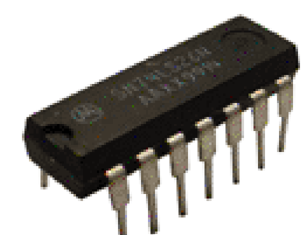
Formula

$\bar{x}y + x\bar{y}$

Circuit

x *y*





That is nothin' but a two-bit adder!

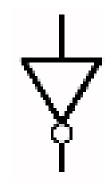
actually, it's called a 1-bit adder!

Digital Logic Gates

x	NOT x
0	1
1	0

Also written
$\bar{x}$

x

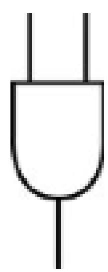


$\bar{x}$

x	y	x AND y
0	0	0
0	1	0
1	0	0
1	1	1

Also written
xy

x y

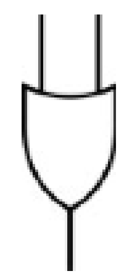


x AND y

x	y	x OR y
0	0	0
0	1	1
1	0	1
1	1	1

Also written
$x+y$

x y



x OR y

Try building circuits for these…

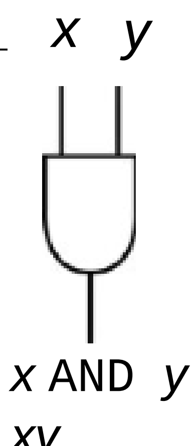
x	y	output
0	0	1
0	1	0
1	0	0
1	1	0

Circuit 1

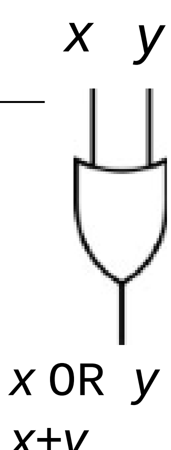
x	y	output
0	0	1
0	1	0
1	0	0
1	1	1

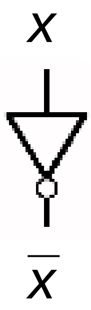
Circuit 2

x	y	x AND y
0	0	0
0	1	0
1	0	0
1	1	1



x	y	x OR y
0	0	0
0	1	1
1	0	1
1	1	1





x	NOT x
0	1
1	0

Try This One

Consider this function…

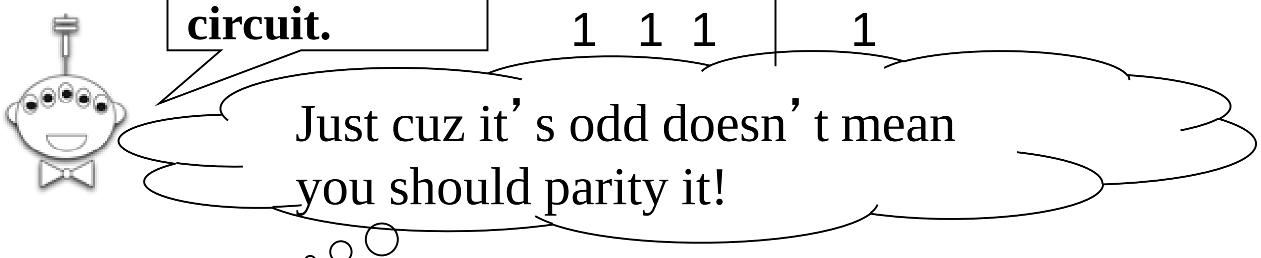
Words | Truth Table | Formula

A function of THREE binary inputs *x,y,z* where the output is 1 iff the number of 1's is odd

x	*y*	*z*	output
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

Circuit

This is called an "odd" "parity" circuit.



A Circuit for Adding!

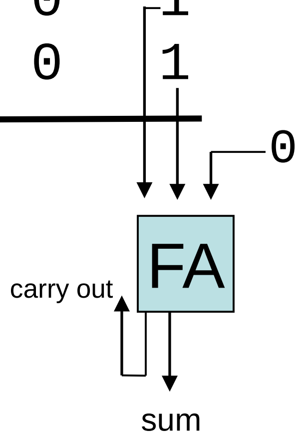
Base 2 Addition

```
    0   1   0   1
+   1   0   0   1
```

A Circuit for Adding!

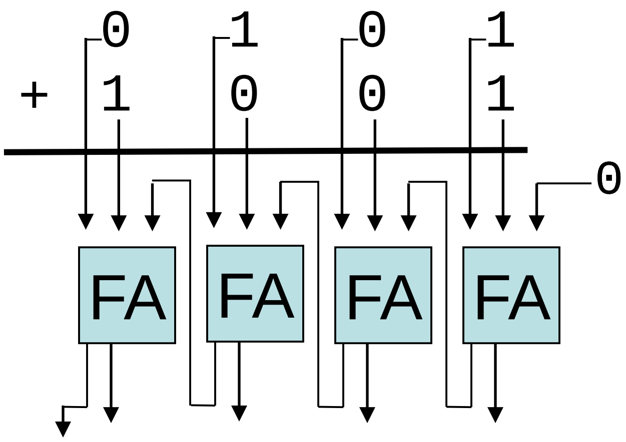
Base 2 Addition

```
    0   1   0   1
+   1   0   0   1
```



A Circuit for Adding!

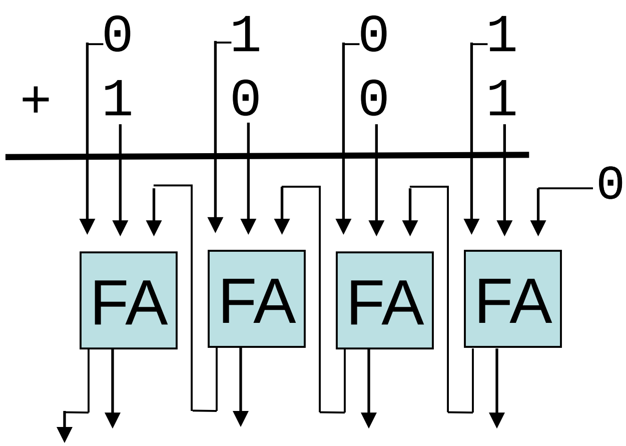
Base 2 Addition

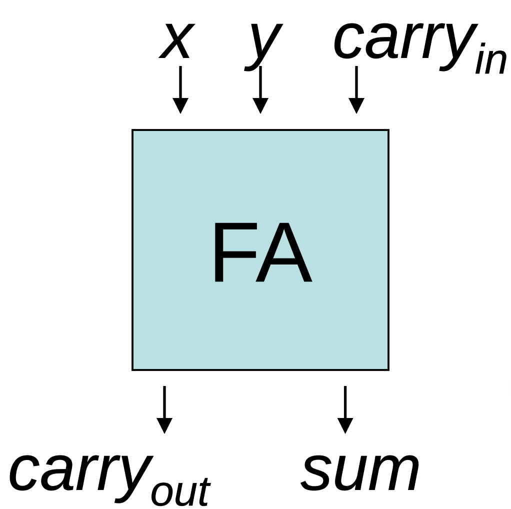


Cool, but how do we build a FA?

A Circuit for Adding!

Base 2 Addition





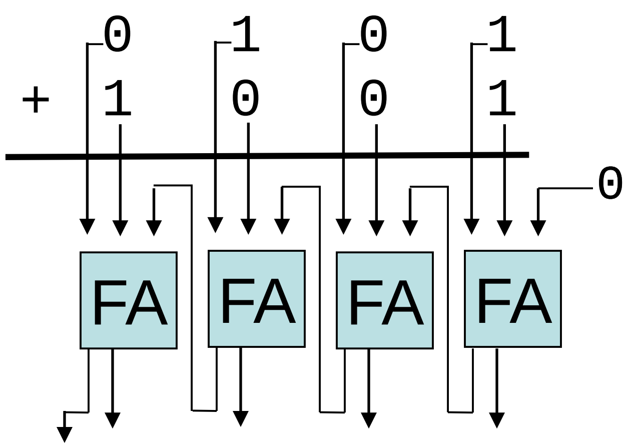
x	y	$carry_{in}$	sum	$carry_{out}$
0	0	0	0	0
0	0	1	1	0

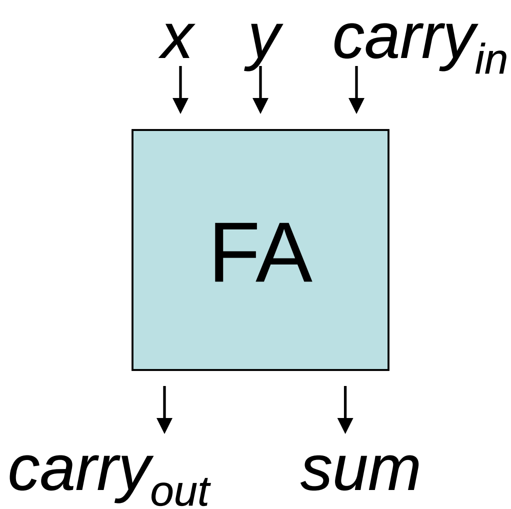
Fill the rest of this table in your *NOTES*. Then, start building the circuit with AND, OR, NOT gates! (The next slide is blank for your work)

This Slide for Rent
(Call 1-800-CS5 Black)

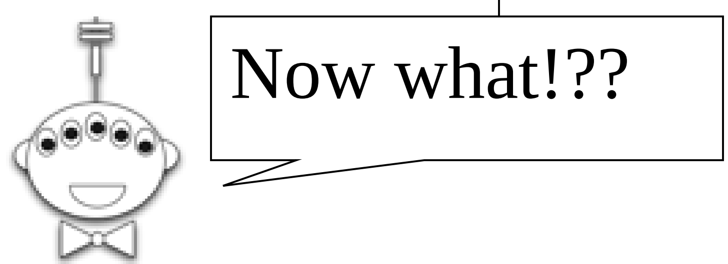
A Circuit for Adding!

Base 2 Addition



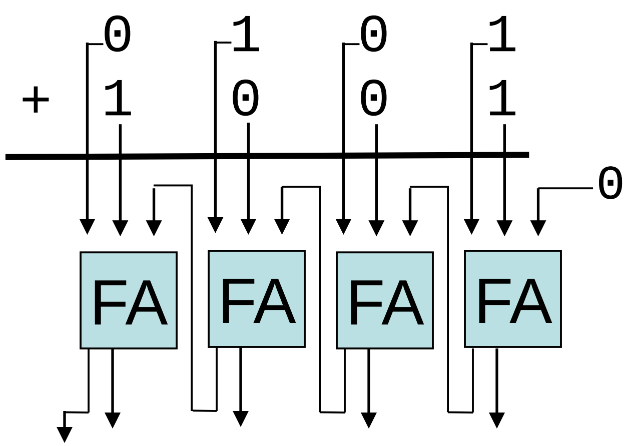


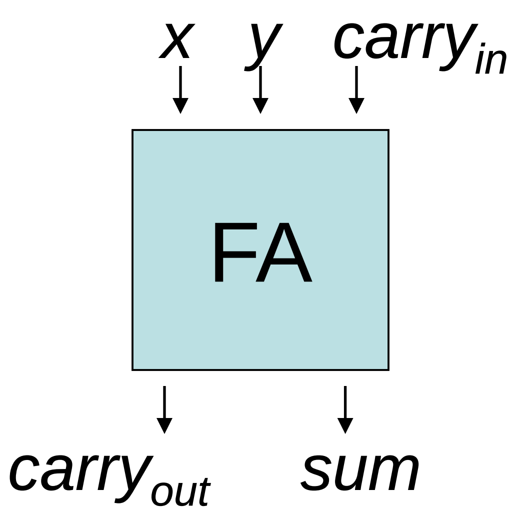
x	y	$carry_{in}$	sum	$carry_{out}$
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



A Circuit for Adding!

Base 2 Addition



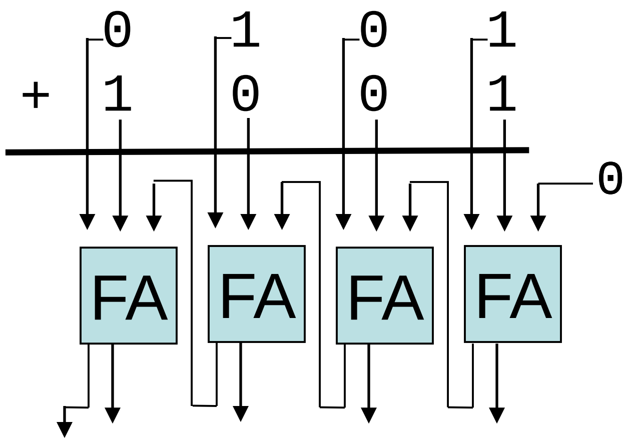


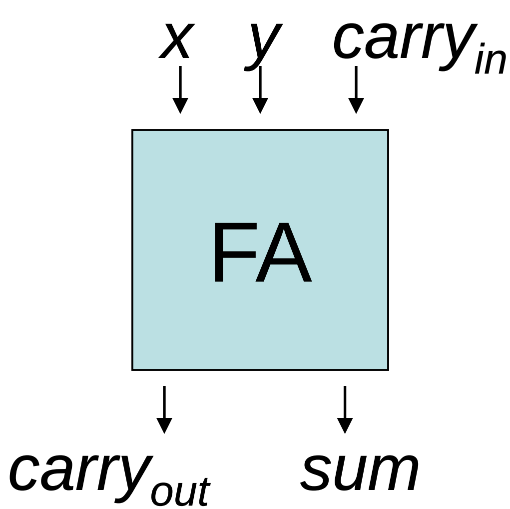
x	y	$carry_{in}$	sum	$carry_{out}$
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

This looks vaguely familiar…

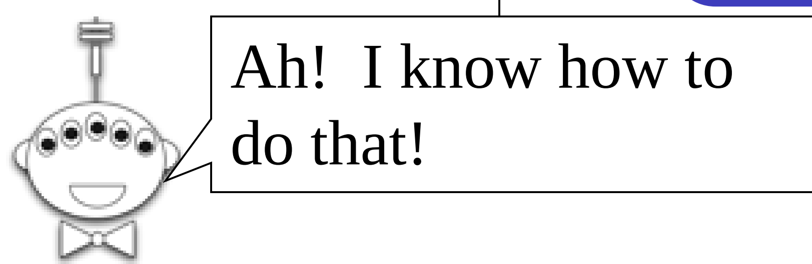
A Circuit for Adding!

Base 2 Addition

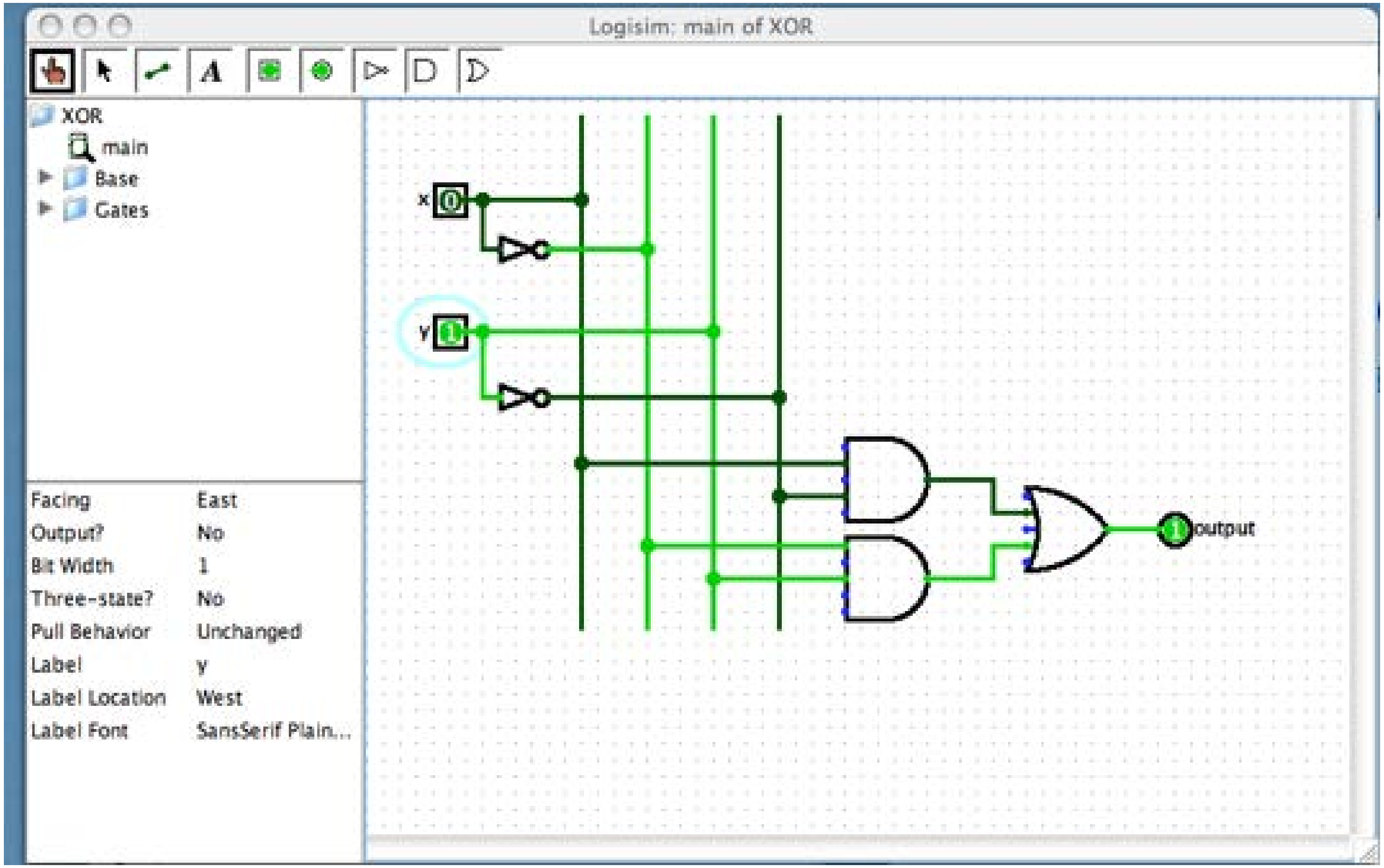




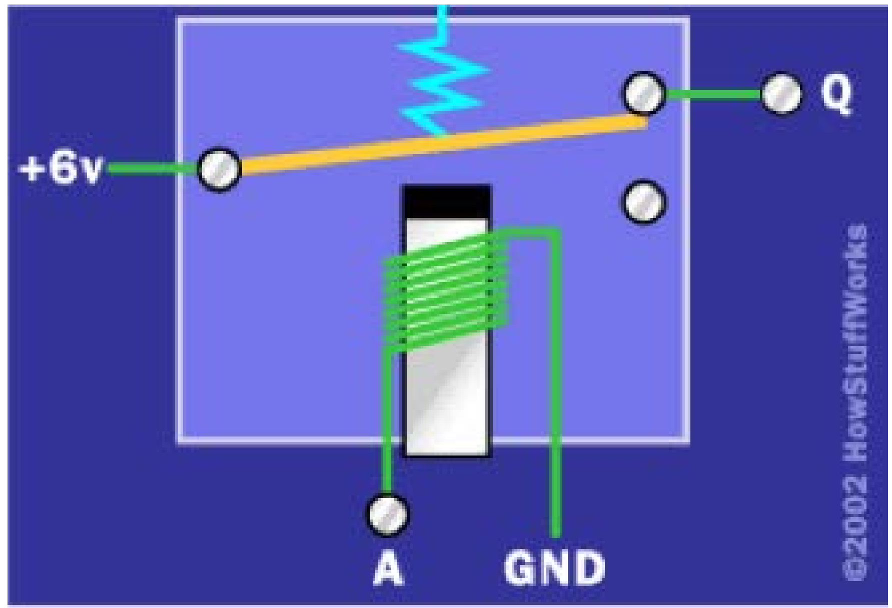
x	y	$carry_{in}$	sum	$carry_{out}$
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1



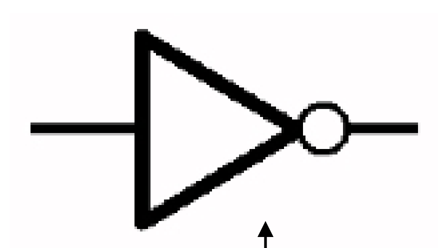
Logisim: A Digital Logic Simulator



Implementing Gates with Relays



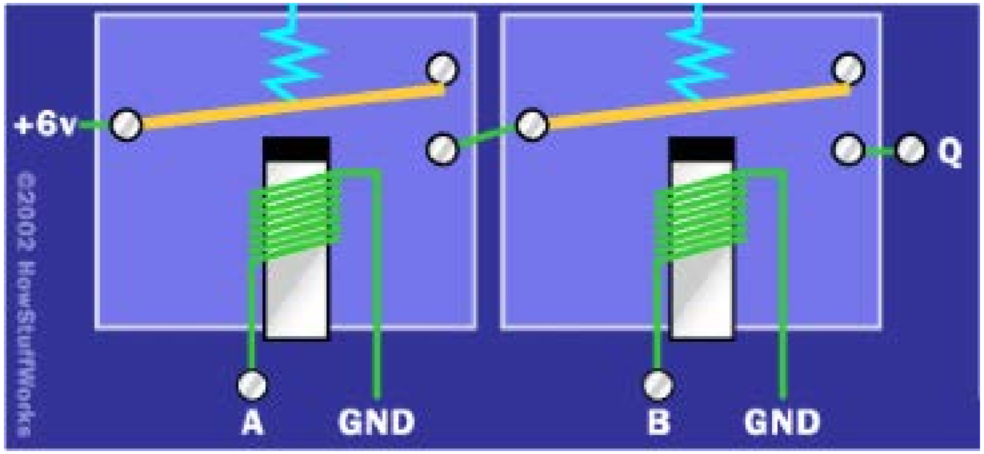
NOT Gate

A  $Q = \underline{A}$

6v power

Figures courtesy of HowStuffWorks.com

And AND…



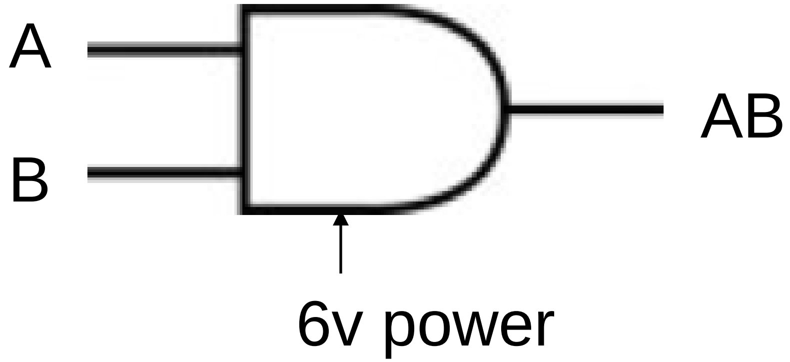
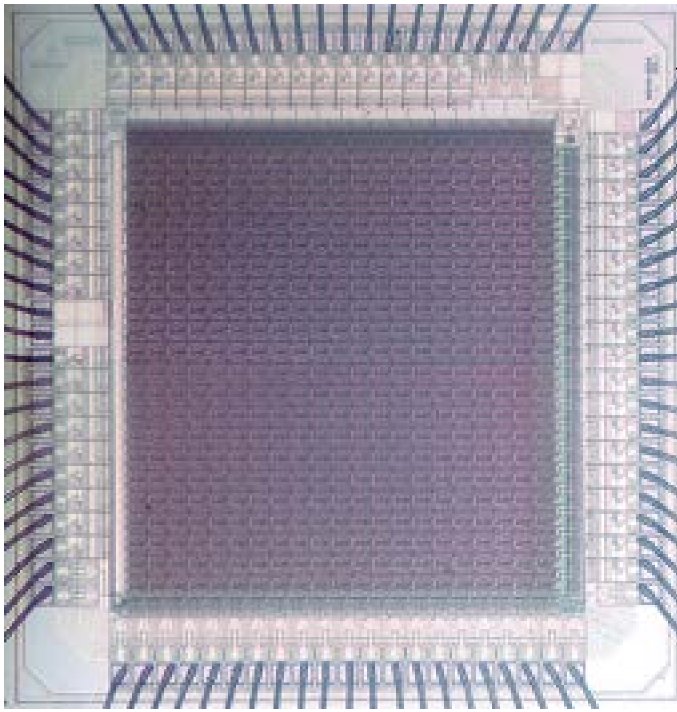


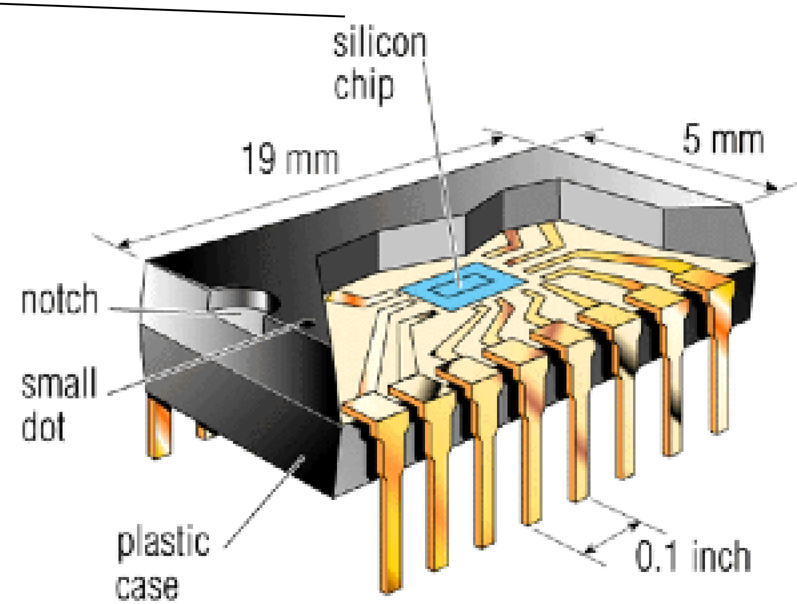
Figure courtesy of HowStuffWorks.com

Integrated Circuits



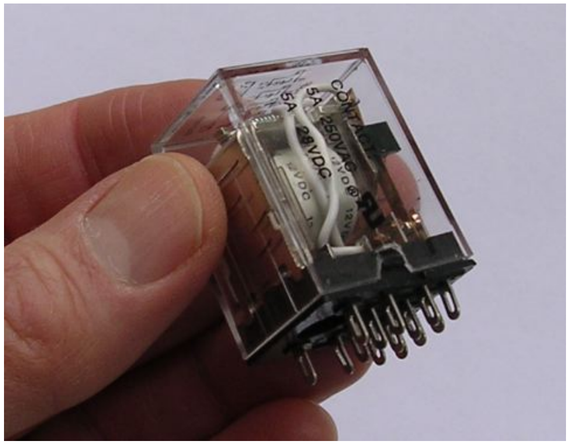
3mm

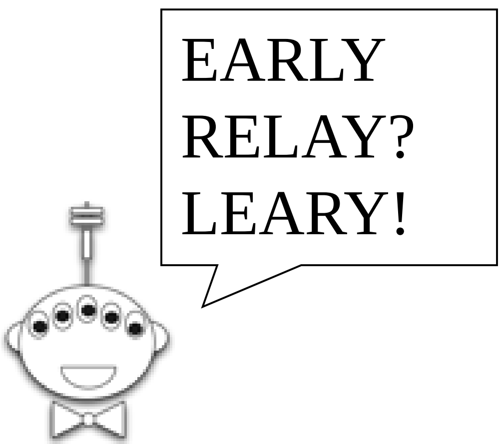
http://personalpages.manchester.ac.uk/staff/p.dudek/projects/scamp



http://www.helicon.co.uk

A real early relay computer

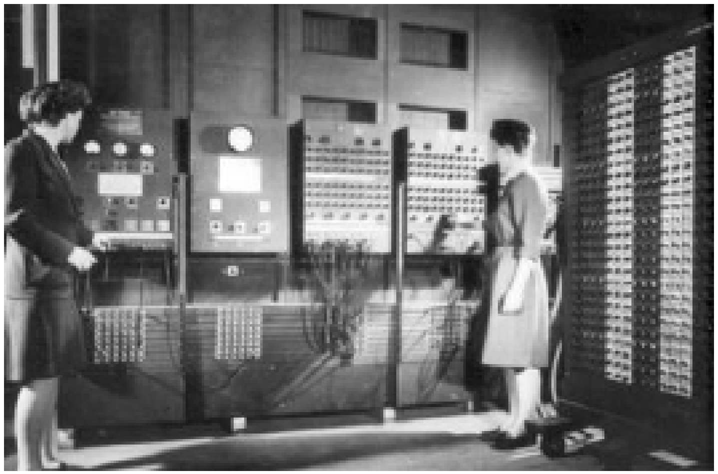


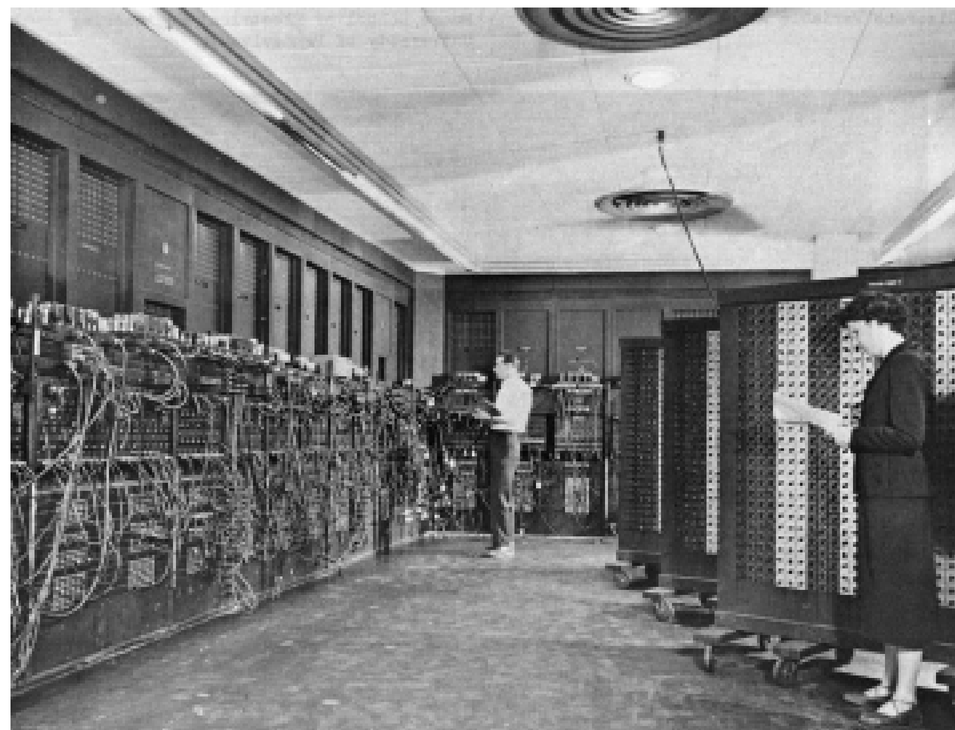


See the anagram solver at `http://www.ssynth.co.uk/~gay/anagram.html`

Relays to Vacuum Tubes, …

A vacuum tube





The ENIAC at U.Penn.
17,468 vacuum tubes.
30 tons.

Images courtesy of en.wikipedia.org

Digital Logic with Water and Legos!

Hydraulic Logic Gates!

http://www.cs.princeton.edu/introcs/lectures/fluid-computer.swf

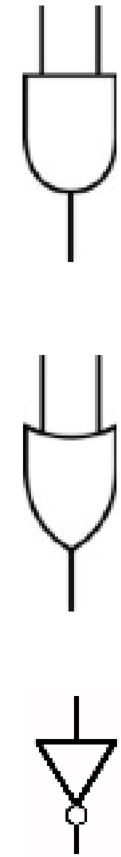
Lego Logic Gates!

http://goldfish.ikaruga.co.uk/logic.html

You’re Stranded on a Desert Island…

Yay! A Radio Shack!

And of course…



Can we implement *every possible* boolean function with AND, OR, and NOT gates alone???

`AND`, `OR`, `NOT` is a “Universal” Set!

x	y	z	Output
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
0	1	0	0
1	1	1	1

$\bar{x}\,\bar{y}\,\bar{z}$

The Minterm Expansion Principle Revisited!

x_1	x_2	x_3 …	x_{100}	output
0	0	0	0	1
0	0	0	1	1
…				
1	1	1	1	1

The Minterm Expansion Principle Revisited!

x_1	x_2	x_3 …	x_{100}	output
0	0	0	0	1
0	0	0	1	1
. . .				
1	1	1	1	1

"1" (6v)

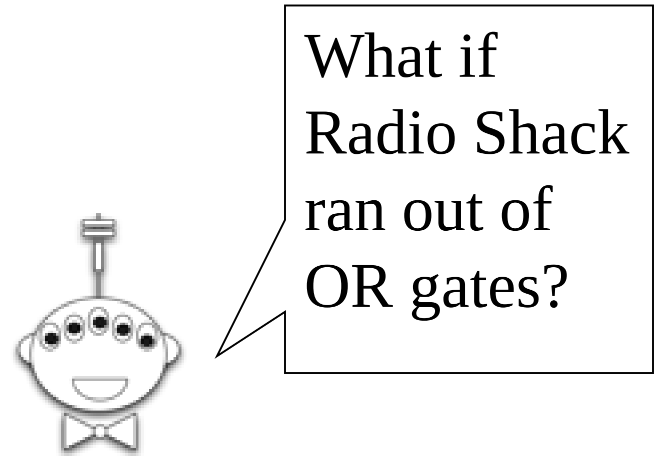
output

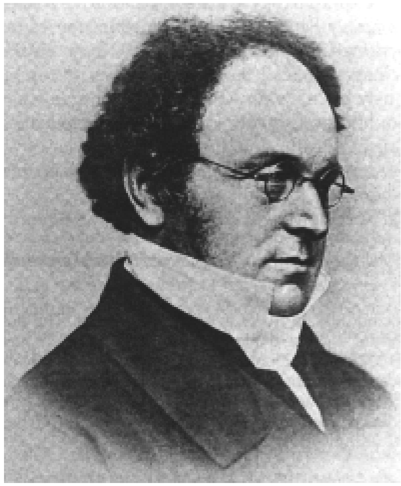
Are other Sets of Gates Universal?

De Morgan's Laws:

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

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





Augustus De Morgan: 1806-1871

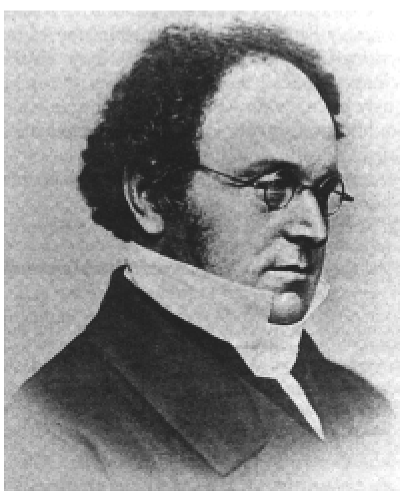
Are other Sets of Gates Universal?

What if Radio Shack ran out of OR gates?

De Morgan's Laws:

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

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

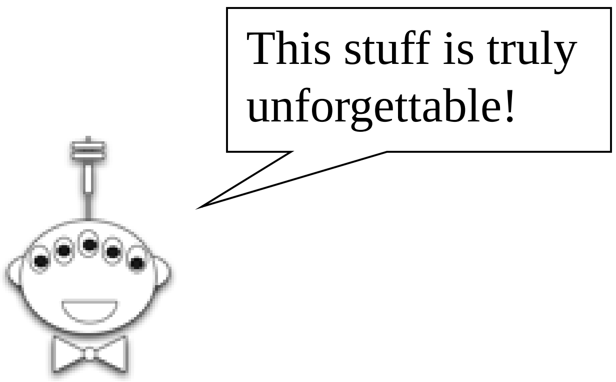


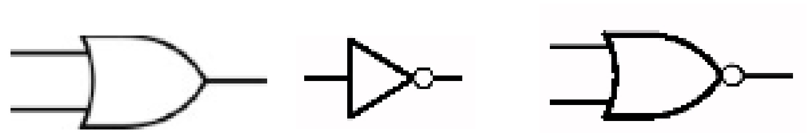
Augustus De Morgan: 1806-1871

x	y	$\overline{x\,y}$	$\overline{x} + \overline{y}$
0	0		
0	1		
1	0		
1	1		

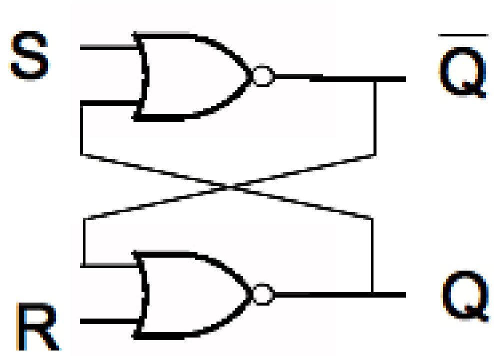
This Space for Rent

A 1-bit Memory

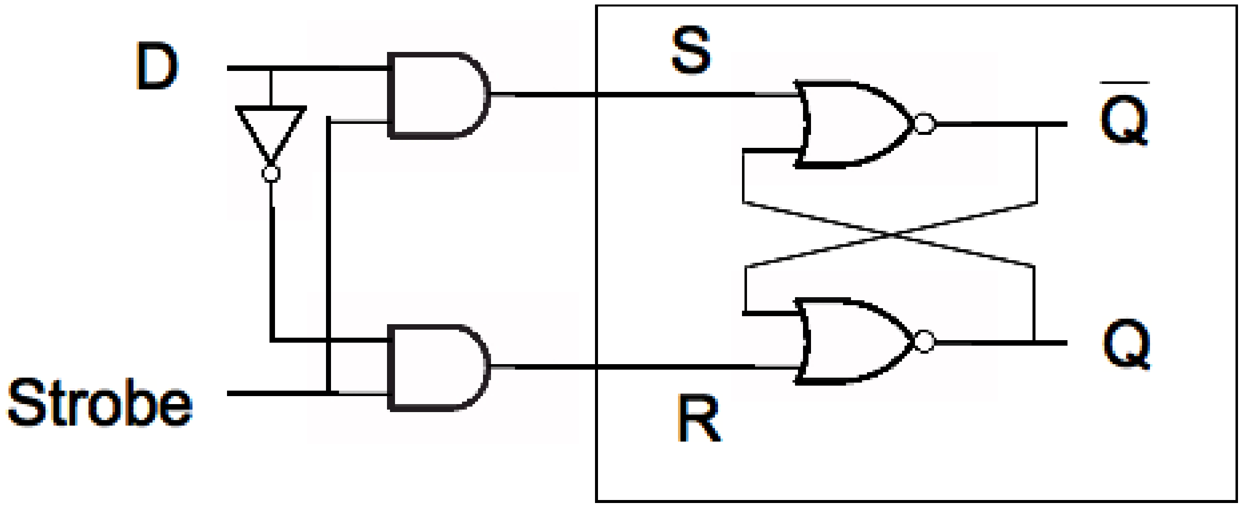


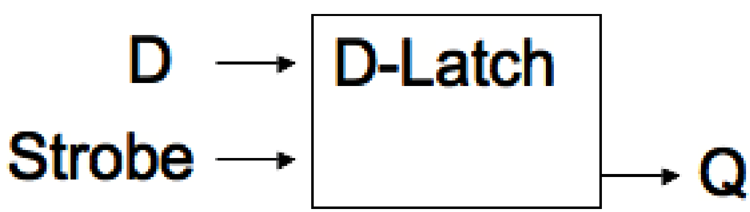


OR + NOT = NOR



From S-R Latches to D-Latches



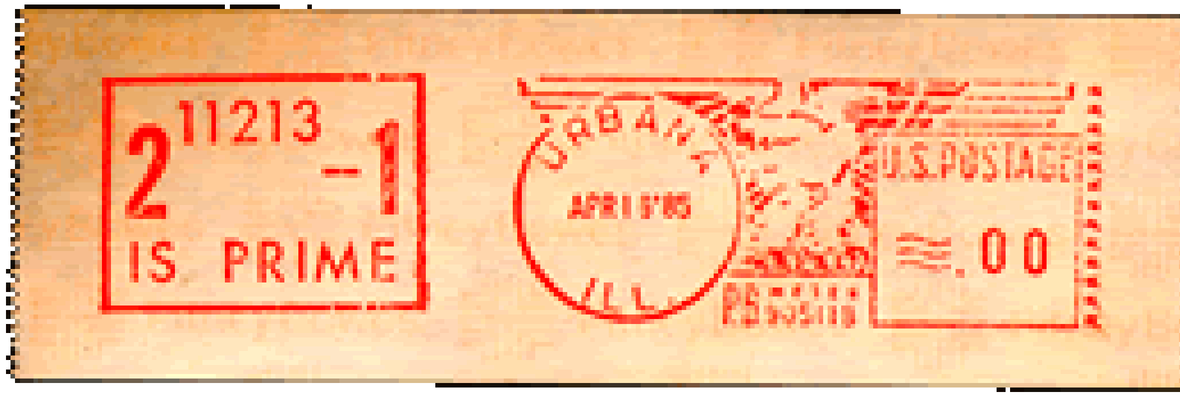


A Random Access Memory (RAM)

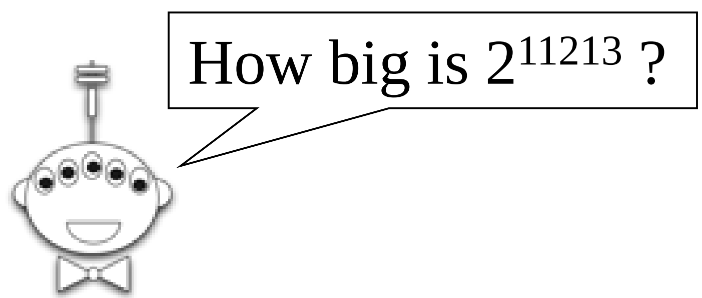
A 512K RAM
(About 4.2 million bits)

A True Story…

Donald Gillies Sr.

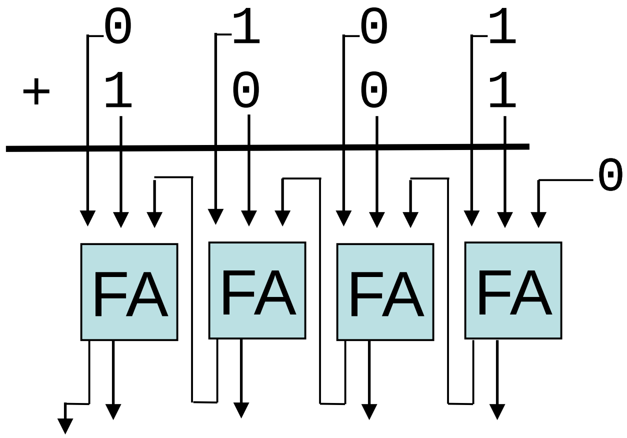


A prime example of Gillies' work!



Homework 101_2

0. Reading (Computing with DNA)
1. Lab: Building a Ripple-Carry Adder
2. Multiplier circuit
3. Division circuit



$$
\begin{array}{cccc}
 & 2^2 & 2^1 & 2^0 \\
\hline
 & 1 & 1 & 1 \\
\times & 1 & 0 & 1 \\
\hline
\end{array}
$$