# The CS 5 Times

## Dormitory Destroyed

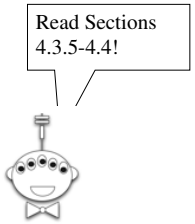
Claremont (PP): A Harvey Mudd College dormitory was left in shambles Tuesday after an unexpected low-frequency resonance caused it to self-destruct.

"I didn't mean any harm," reported a shaken student. "I was doing my CS lab, and I thought it would be cool to share my sounds with the other Westies, so I hooked my computer up to the dorm speakers. Who knew that 42 Hertz was a special frequency?"

Rescuers worked frantically to recover the student's hard drive, which reportedly contained notes for an upcoming physics exam. At press time, the drive remained buried under tons of rubble, and hope for a positive outcome was fading. "I'd give anything for a copy of the Lorentz velocity transformation equations," wailed the distraught student.

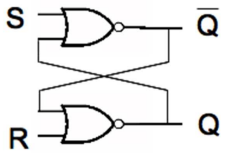
Upon hearing of this offer, North dorm residents

"West" dormitory after unfortunate incident.




# A 1-Bit Memory


OR + NOT = NOR

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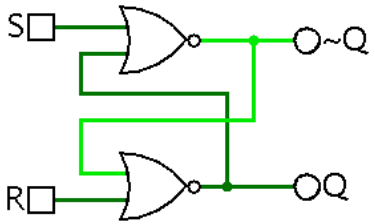
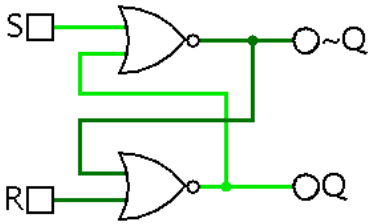
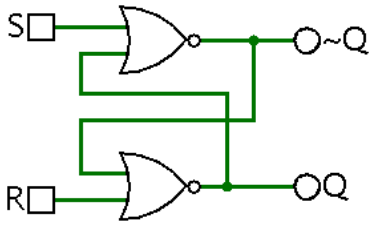


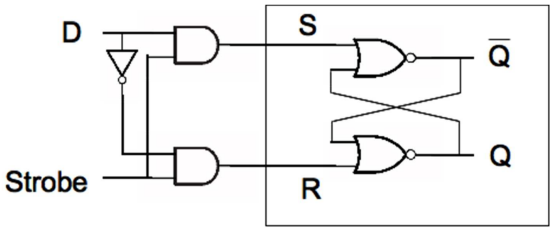

# Setting a 1-Bit Memory



# Initializing a 1-Bit Memory



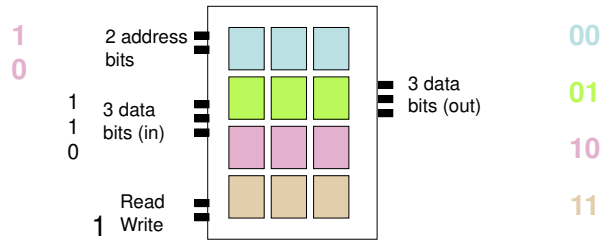

# From S-R Latches to D-Latches





Worksheet!

# A Random Access Memory (RAM)

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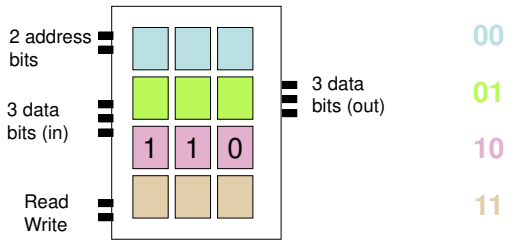

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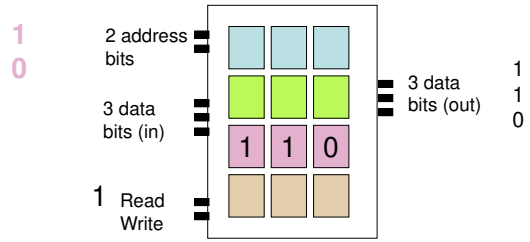


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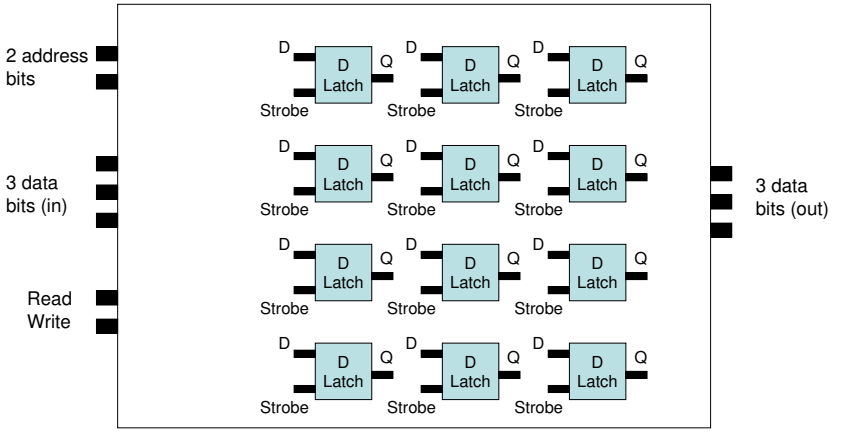


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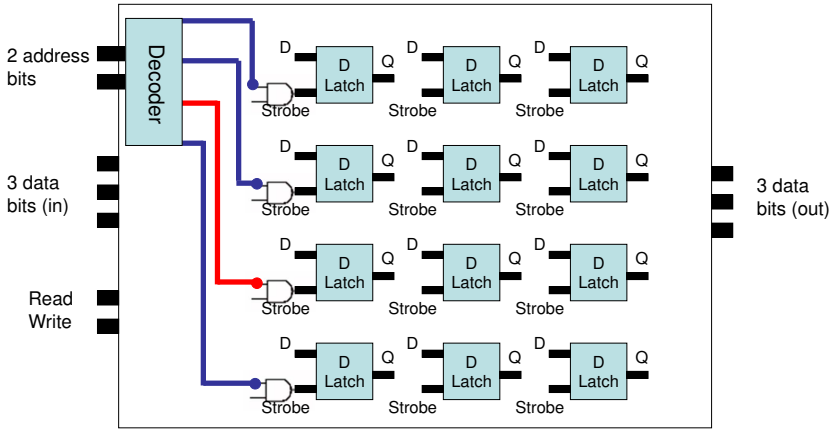


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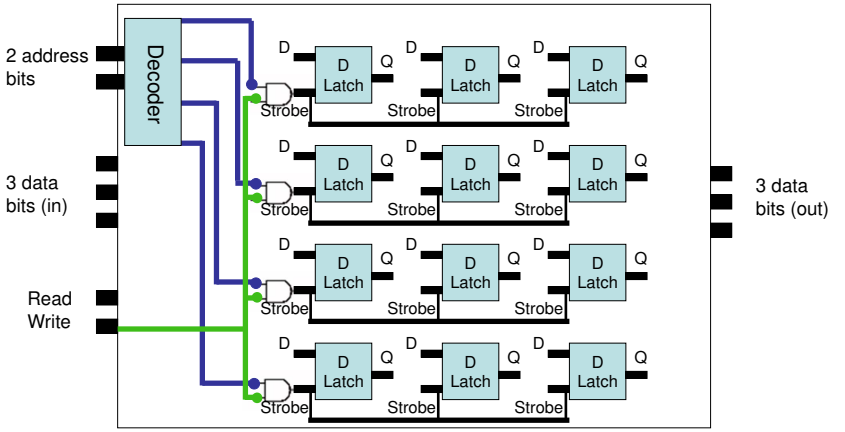

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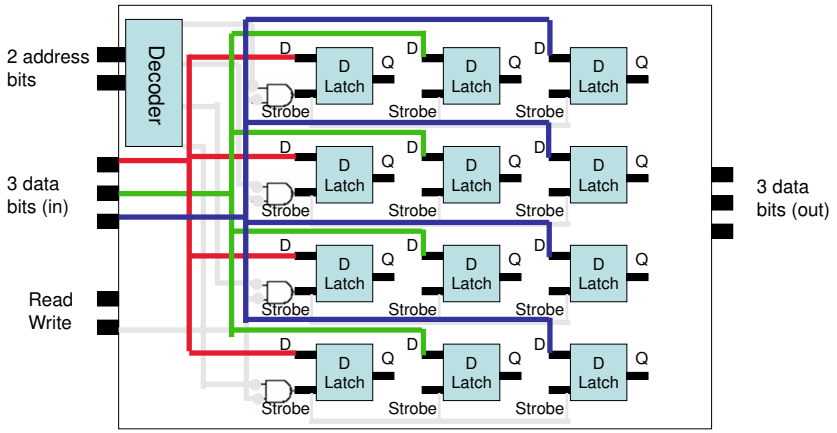
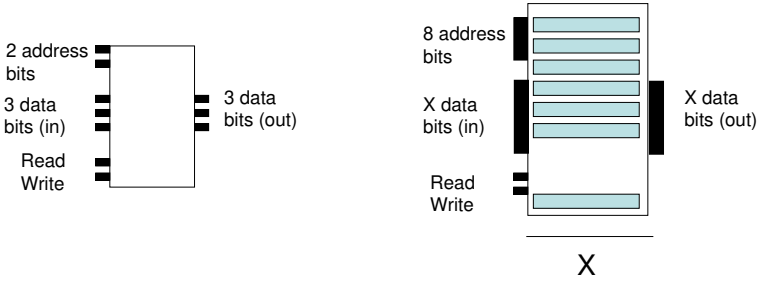
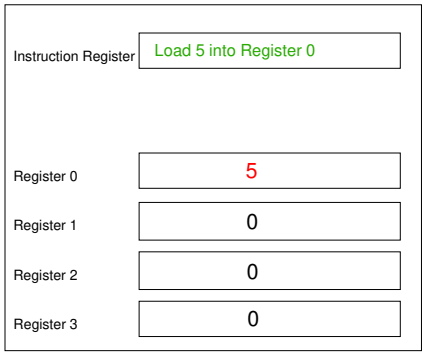



# Small Memory, "Big" Memory…




# A "Calculator"

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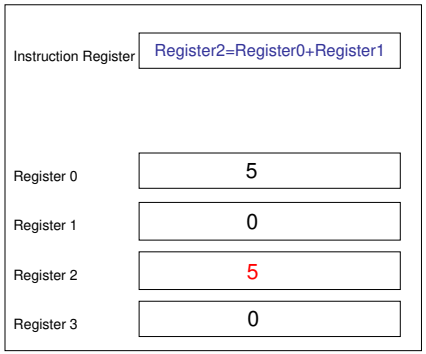

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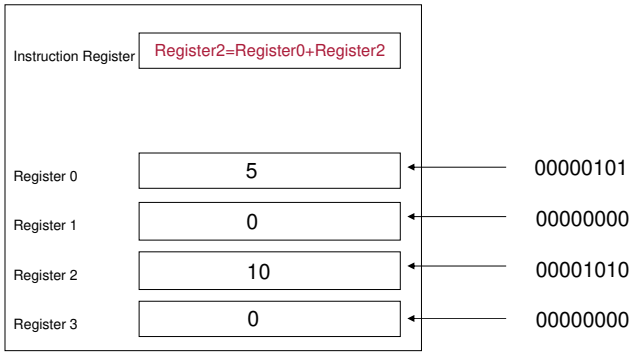
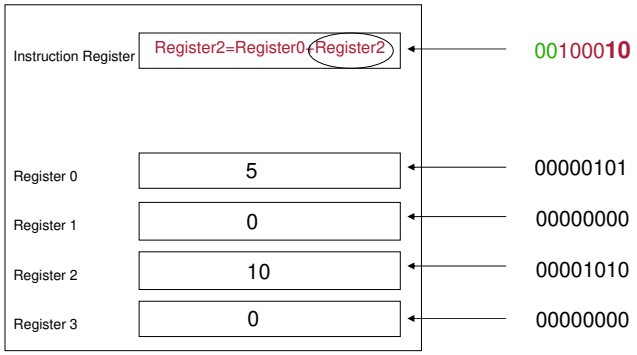


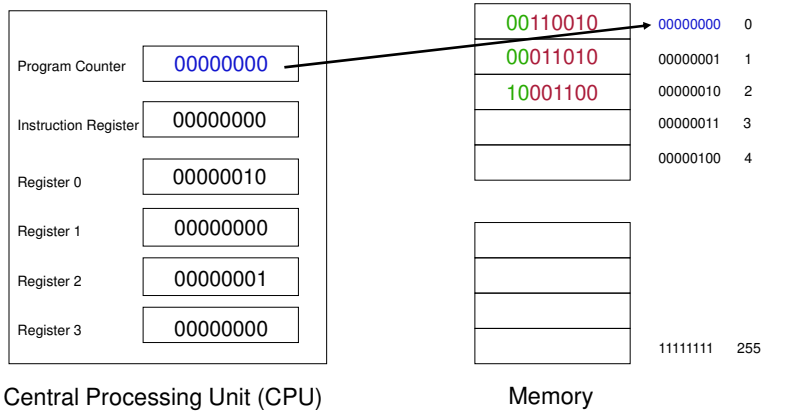

# A “Calculator”

00 add
01 subtract
10 multiply
11 divide




# A Computer!

00 add
01 subtract
10 multiply
11 divide

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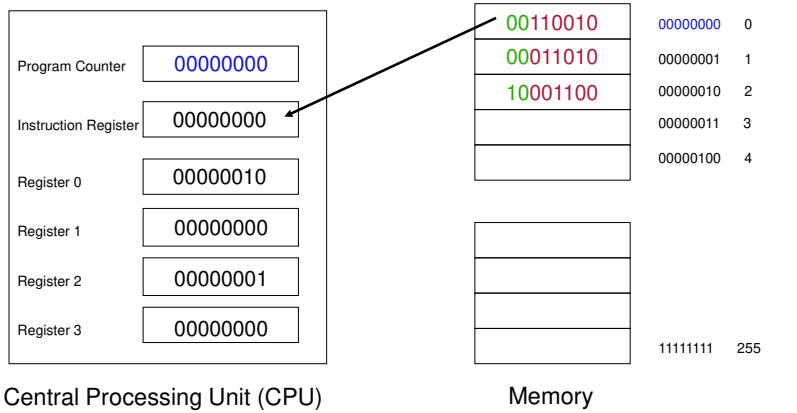
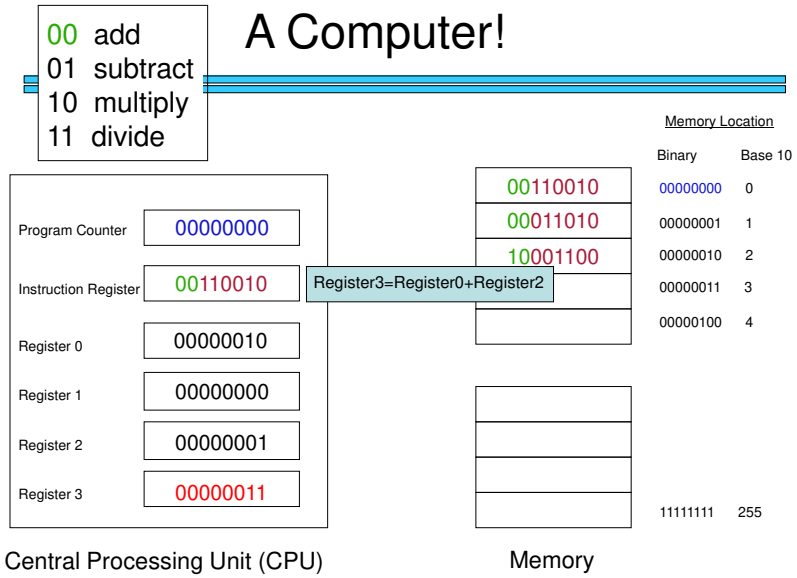
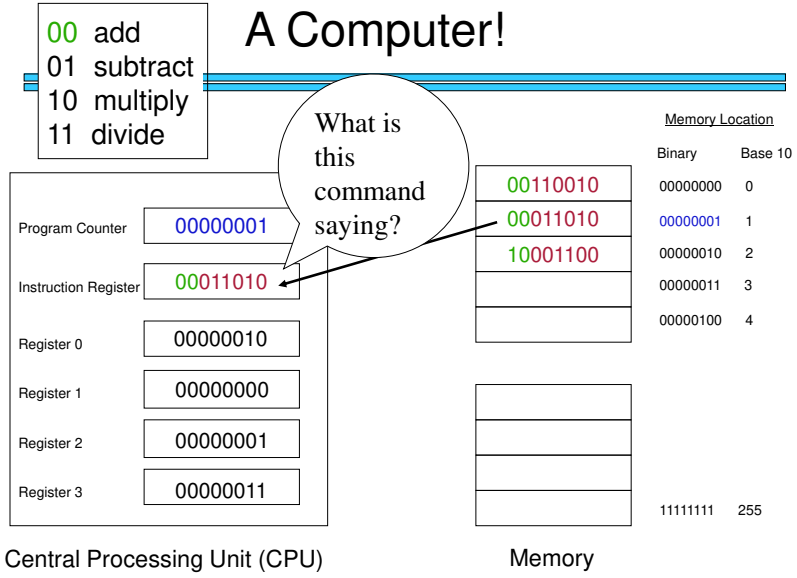
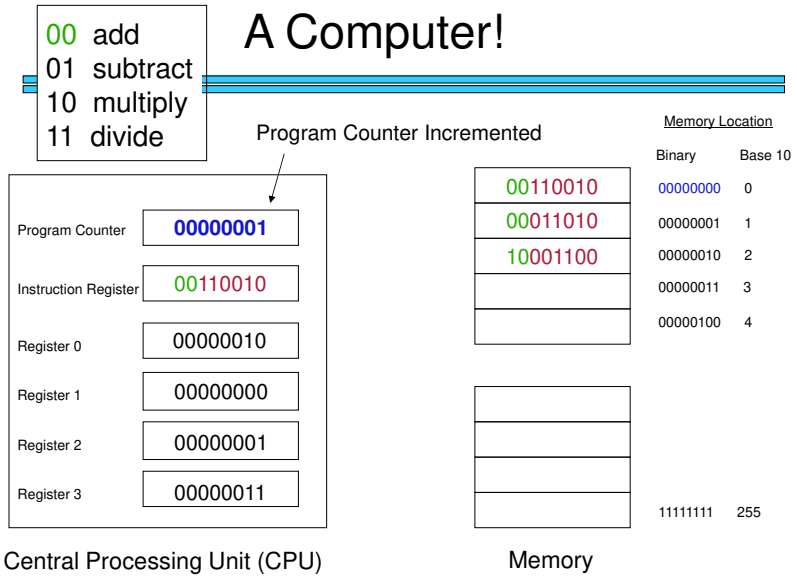
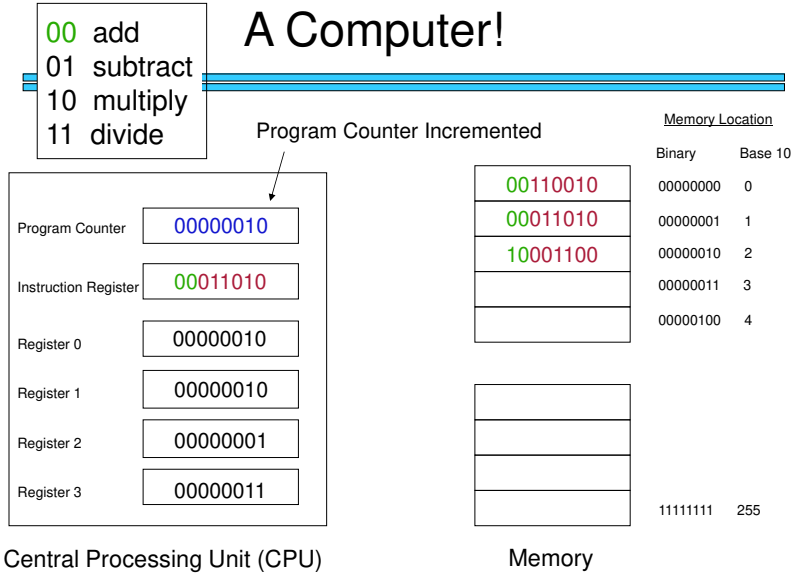



00 add
01 subtract
10 multiply
11 divide
A Computer!
Memory Location
Binary
Base 10
Program Counter
00000000
Instruction Register
00110010
Register3=Register0+Register2
Register 0
00000010
Register 1
00000000
Register 2
00000001
Register 3
00000011
00110010
00011010
10001100
00000000 0
00000001 1
00000010 2
00000011 3
00000100 4
11111111 255
Central Processing Unit (CPU)
Memory


00 add
01 subtract
10 multiply
11 divide
A Computer!
What is this command saying?
Memory Location
Binary
Base 10
Program Counter
00000001
Instruction Register
00011010
Register 0
00000010
Register 1
00000000
Register 2
00000001
Register 3
00000011
00110010
00011010
10001100
00000000 0
00000001 1
00000010 2
00000011 3
00000100 4
11111111 255
Central Processing Unit (CPU)
Memory


00 add
01 subtract
10 multiply
11 divide
A Computer!
Program Counter Incremented
Memory Location
Binary
Base 10
Program Counter
00000001
Instruction Register
00110010
Register 0
00000010
Register 1
00000000
Register 2
00000001
Register 3
00000011
00110010
00011010
10001100
00000000 0
00000001 1
00000010 2
00000011 3
00000100 4
11111111 255
Central Processing Unit (CPU)
Memory


00 add
01 subtract
10 multiply
11 divide
A Computer!
Program Counter Incremented
Memory Location
Binary
Base 10
Program Counter
00000010
Instruction Register
00011010
Register 0
00000010
Register 1
00000010
Register 2
00000001
Register 3
00000011
00110010
00011010
10001100
00000000 0
00000001 1
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00000011 3
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11111111 255
Central Processing Unit (CPU)
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# A Computer!

00 add
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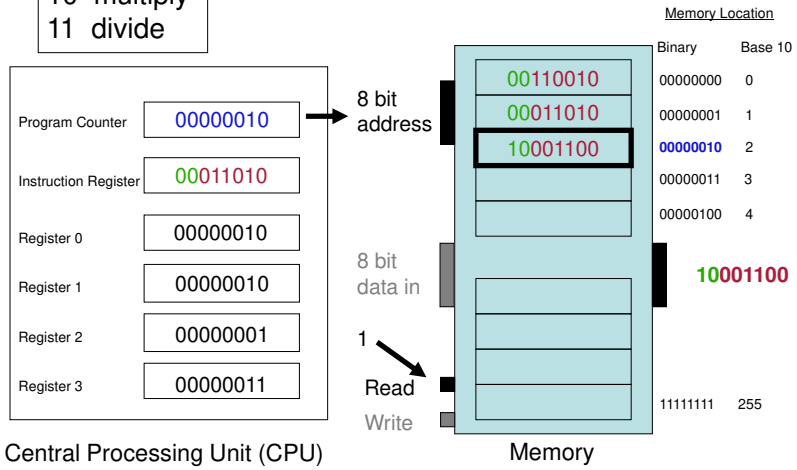


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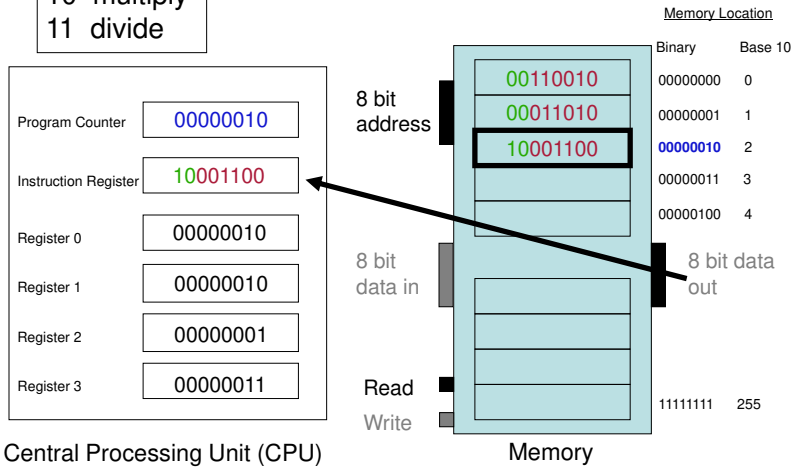
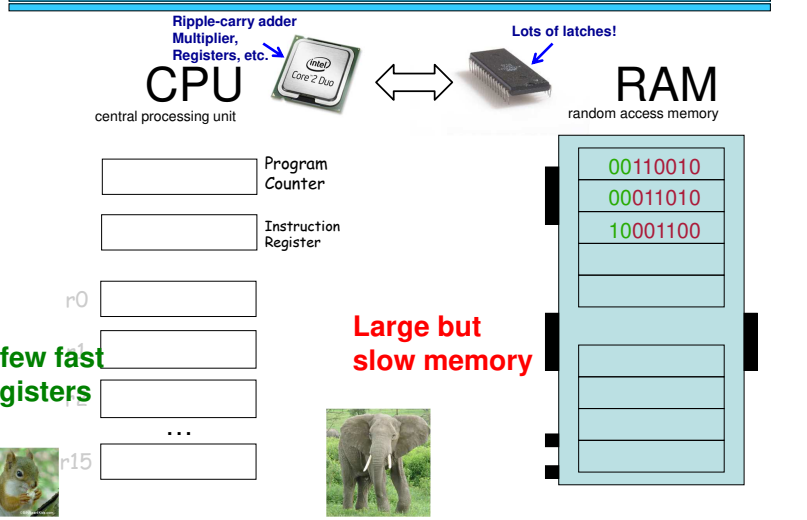
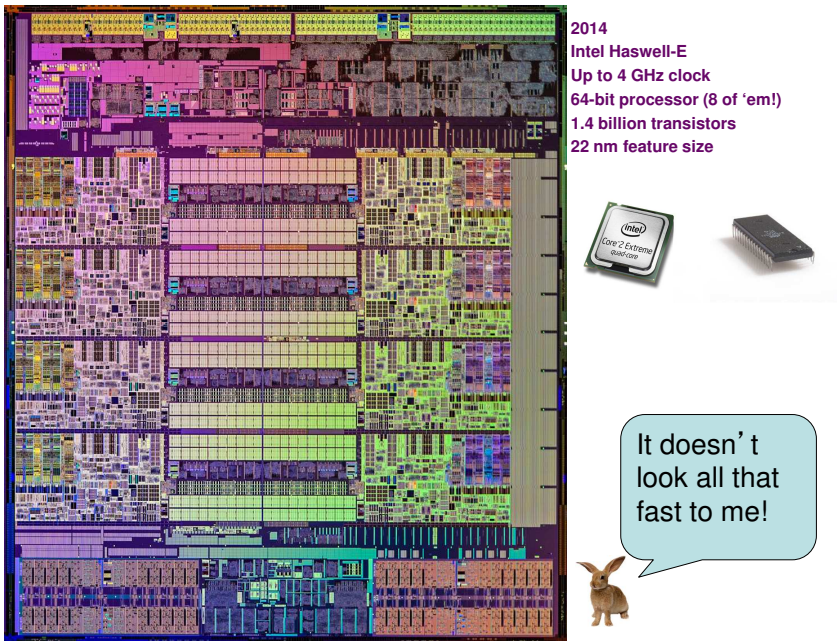



# The von Neumann "Architecture"

John von Neumann



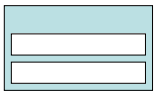
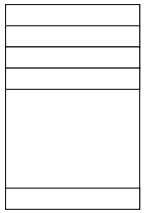
2014
Intel Haswell-E
Up to 4 GHz clock
64-bit processor (8 of 'em!)
1.4 billion transistors
22 nm feature size





It doesn't look all that fast to me!

# A Short Aside…

| | CPU | Main Memory (RAM) | Disk Drive |
|---|---|---|---|
| |  |  |  |
| | 16 Registers (“Bytes”) | $10^9$ “Bytes” of memory | $10^{12}$ “Bytes” of memory |
| | 1 cycle | 200 cycles | ? cycles |
| Actual time: | $<10^{-9}$ sec | $<10^{-7}$ sec | $<10^{-2}$ sec |
| If “cycle” = 1 sec | 1 sec | | |