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Q1

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CS 340

Building Blocks 0b01

Updates

1. MP 0 - Setup due TOMORROW.
2. MP 1 - debugger due TODAY.
3. MP 2 - Linked-List in C due next Tuesday
4. If you added late, let us know ASAP for possible extensions
5. HW 1 Due Wednesday 11:59pm
    a. No debugger on PL

Review

```
22    void setString(char **str) {
23        *str="Hell0";
24    }
25
26    int main() {
27        char *s = "W0rld";
28        setString(&s);
29        printf("%s", s);
30        return 0;
31    }
```

Hello

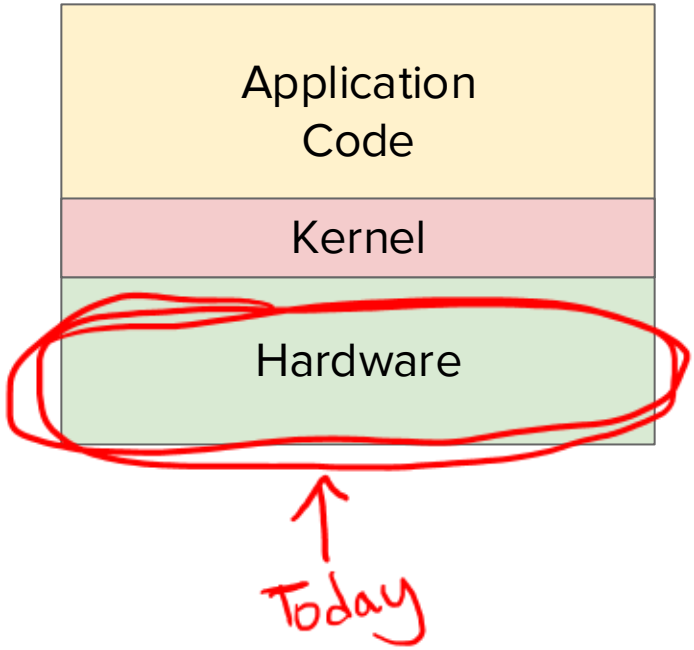
'0' = 48 '\0' = 0 ← end of c-string

Building Blocks 0b01

LG: Help you understand how logic is built using hardware

Mental Models Developed

How a computer works at a physical level



Agenda

1. Circuit and Gate Basics
2. Binary

Not a physics class

Circuit and Gate Basics

Idea 1: Nodes Hold Voltage

Node - example - wire - ends of a battery

Voltage - a state - electric potential energy

Current - movement - charge moving to equalize voltage between nodes

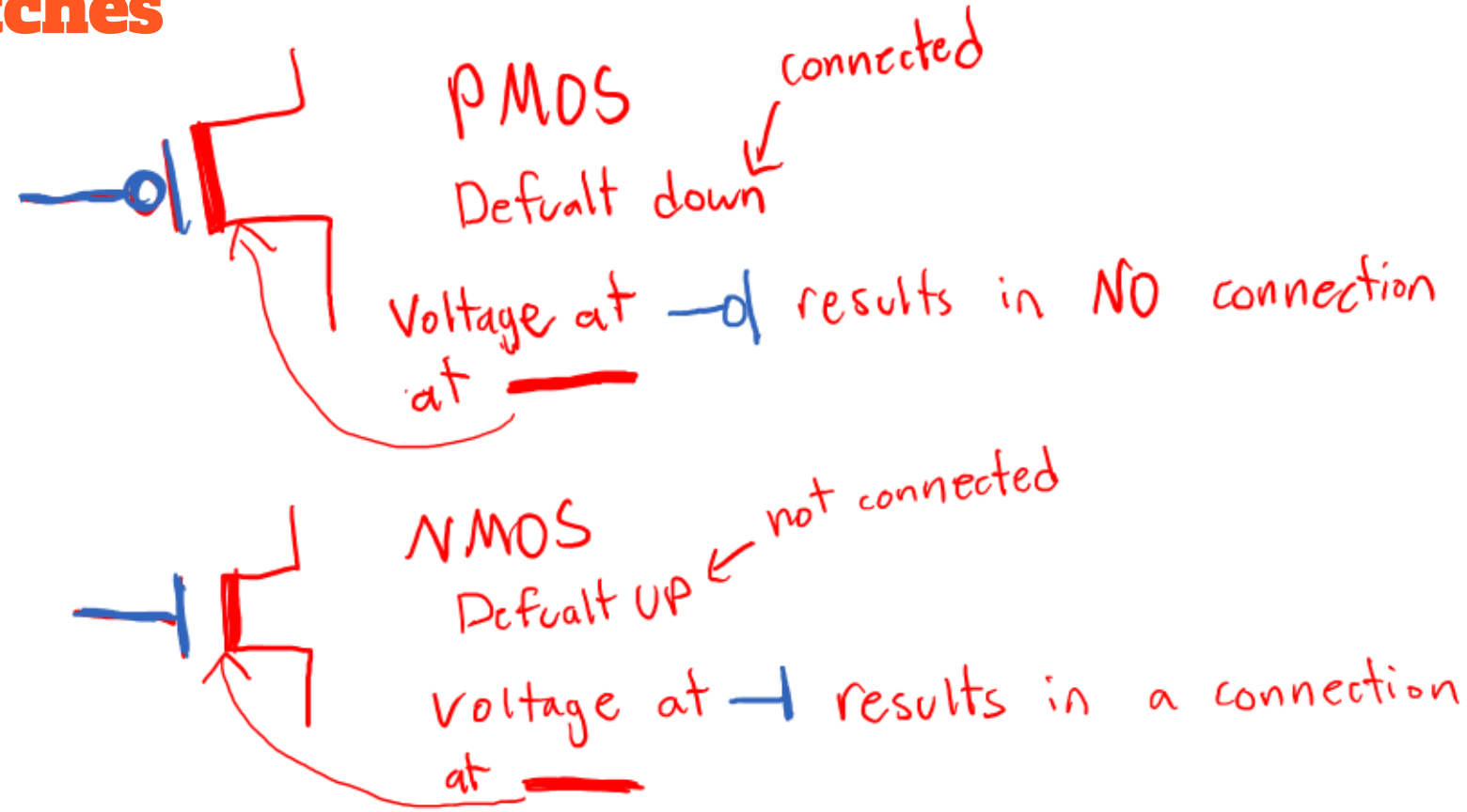
Idea 2: Two Important Nodes

Power - V, high, 1 pushes charge away

Ground - G, low, 0 pulls charge towards it

if directly connected it will short circuit
* too much current!

Idea 3: Transistors are voltage-controlled switches



Big Ideas

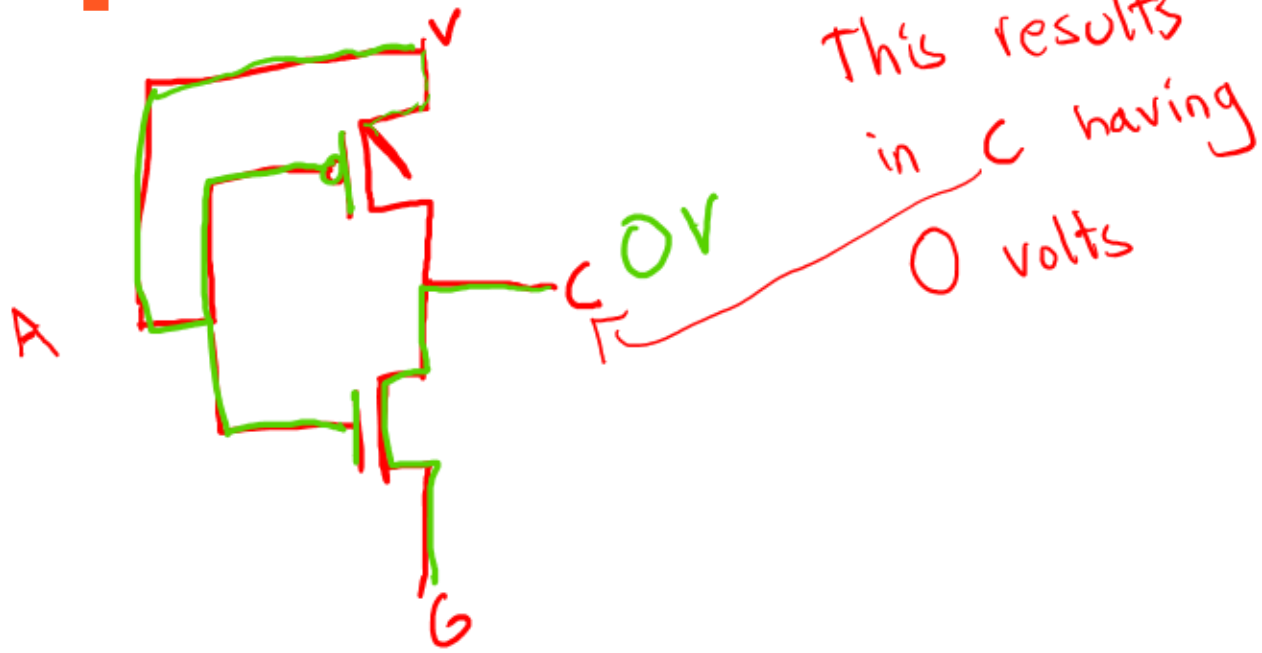
Nodes hold voltage.

Current flows from high to low voltage to equalize voltage.

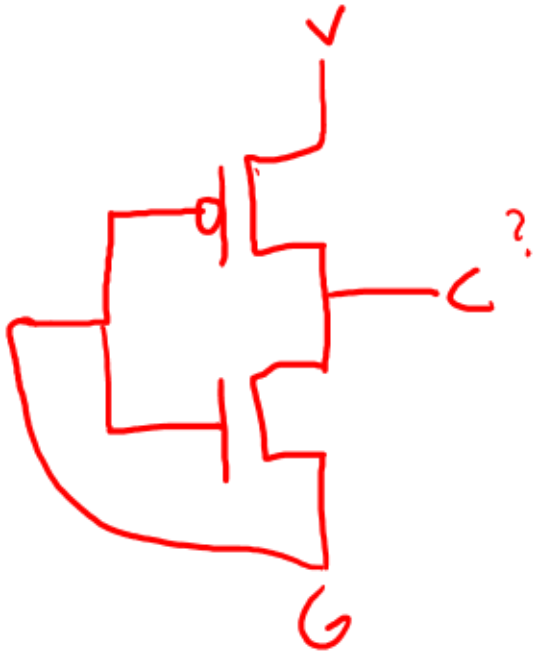
Power and ground are two important nodes needed.

Transistors are voltage-controlled switches.

Example Circuit



What voltage does the node C hold?



a) high
b) low
c) undetermined

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Gates

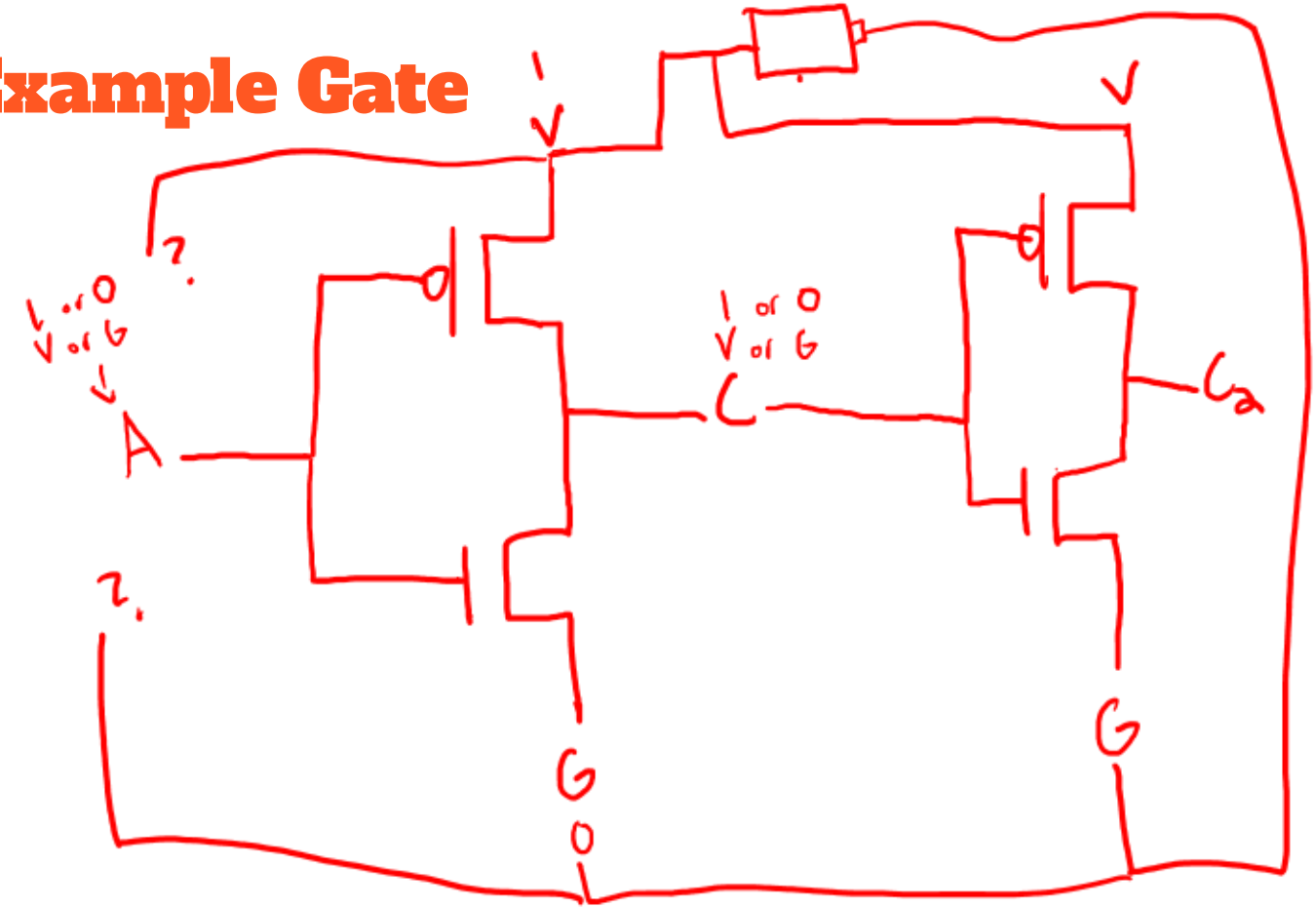
Take input(s) voltage and result in... high or low voltage at the output

Gates use... transistors with input voltage to control output voltage

Gates can be used to... implement logic –

AND, OR, NOT, NAND, NOR, XOR

Example Gate



What is the voltage at C if A is 1 (high voltage)

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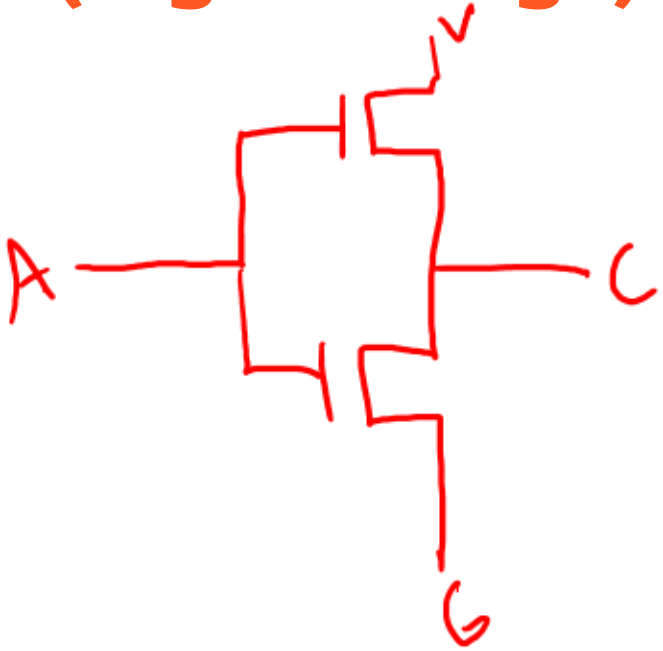
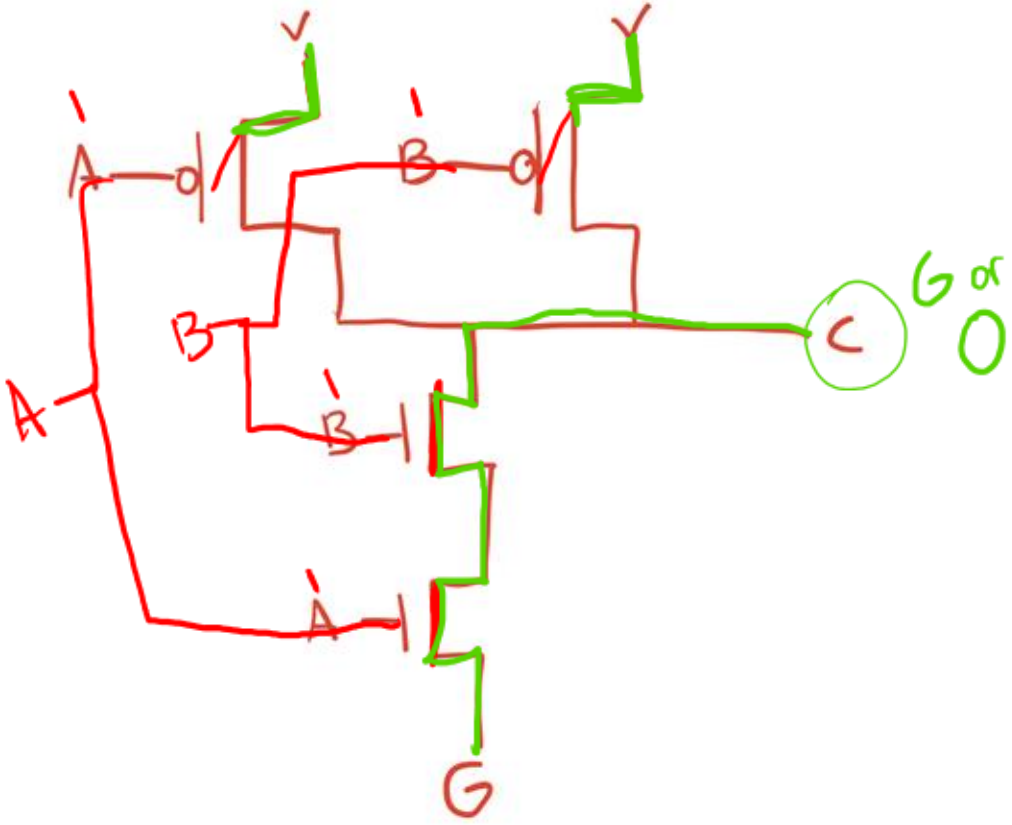


a) high

b) low

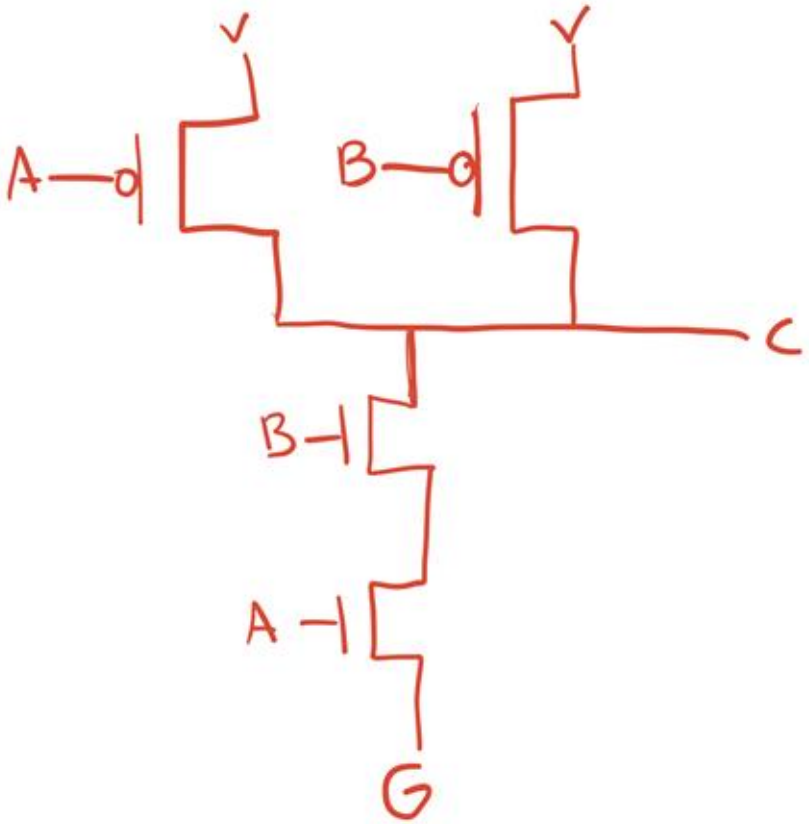
c) short circuit

Example Gate



A	B	C
1	1	0
0	0	1
0	1	1
1	0	1

Example Gate



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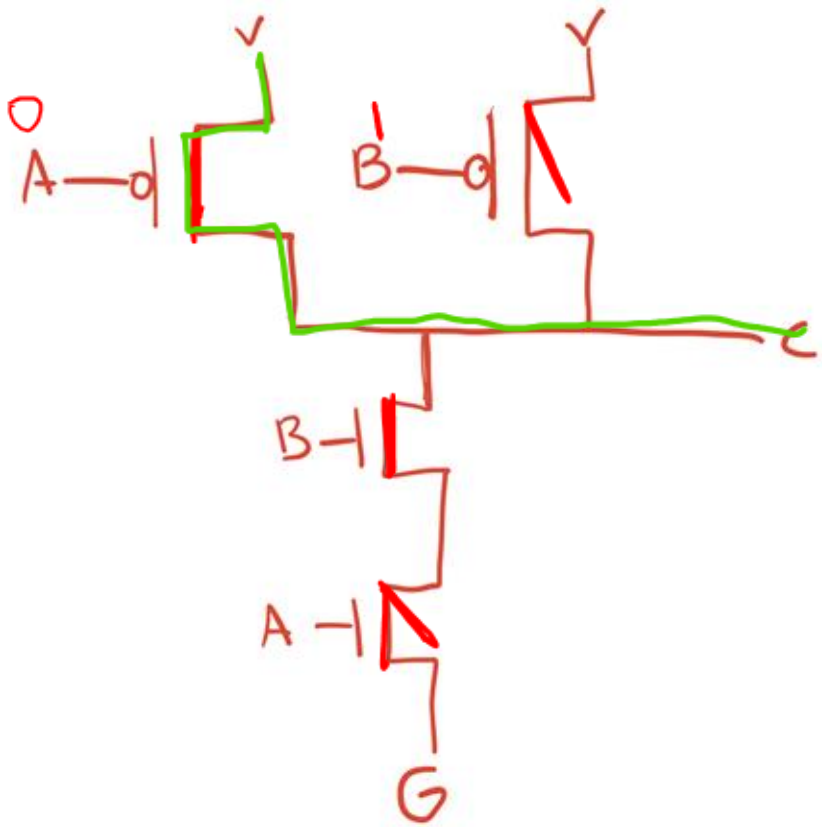
if A is 0 and B is 0?
what is C?

a) 0
b) 1

Example Gate



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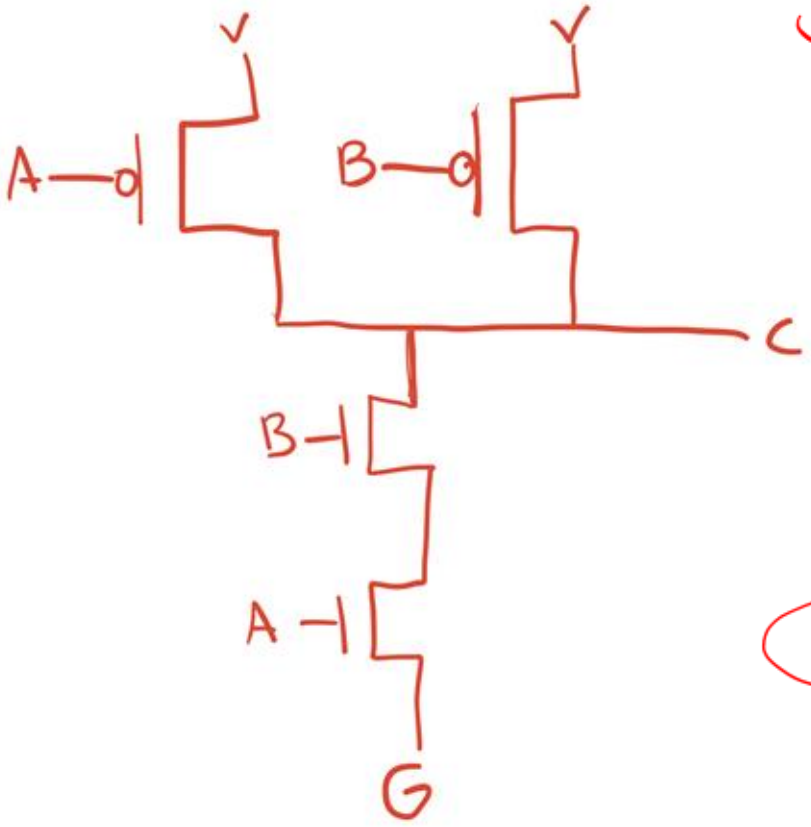
if A is 0 and B is 1
what is C?

a) 1
b) 0

Example Gate

what is the gate?



a) XOR
b) NOR
c) AND
d) NAND

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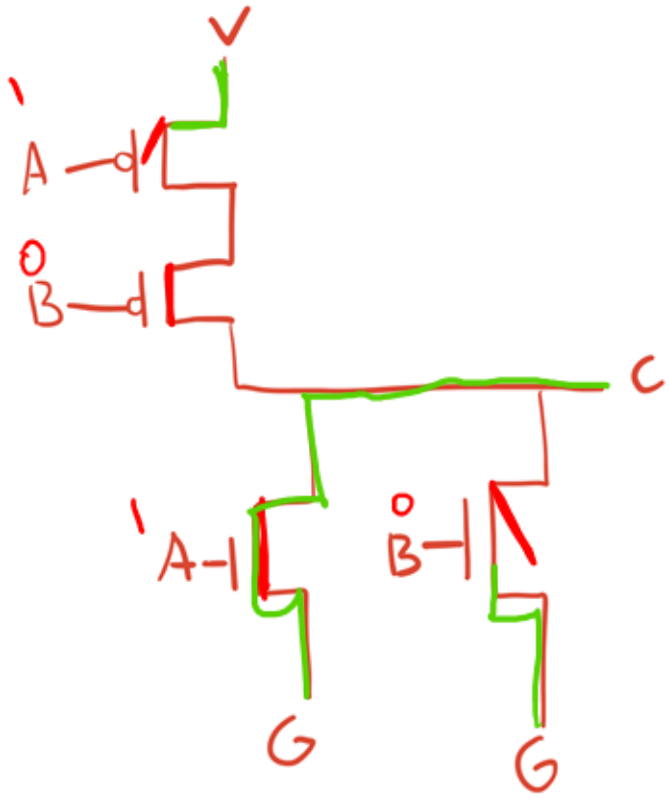
Example Gate



A	B	C
1	0	0
0	1	0
0	0	1
1	1	0

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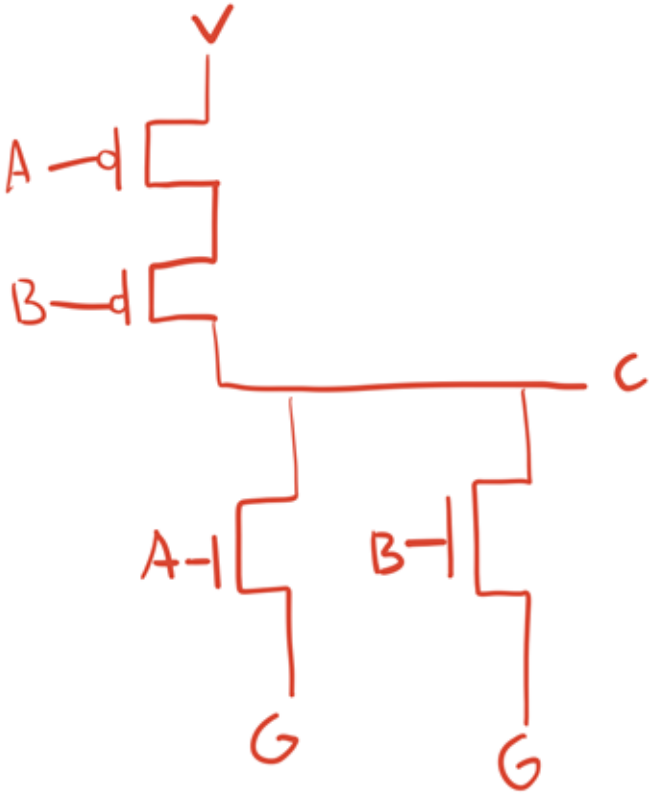
NOR

if A is 1 and B is 0 what is C?

a) 1

b) 0

Example Gate



what is the gate?

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NOR

Implications

electricity → logic gates → logic, math, selection

we can create any truth table logic
- AND, NAND, xOR .... ect

Gates work with ↑↓ voltage .... 1, 0 ....
so we use binary!

The Binary Number System

Number Systems

We have infinite amounts but finite digits.
To represent big numbers we combine digits.

Base-2 Number System

represent numbers using two digits, 0 and 1

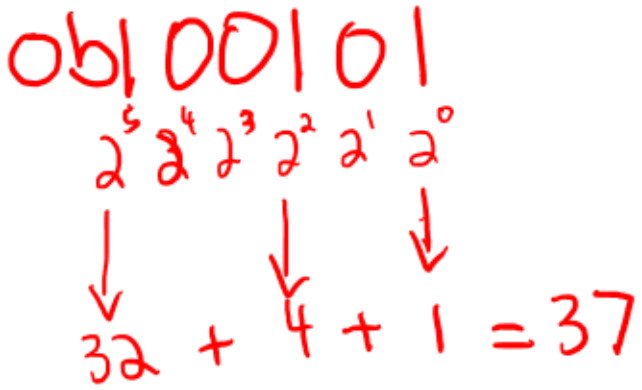
 = 0b01

indicates base-2

 = 0b11

↖ represents the amount of apples in base-2

Going from Binary to Decimal



Powers of 2 Practice....

What is 0b10111 in Decimal?

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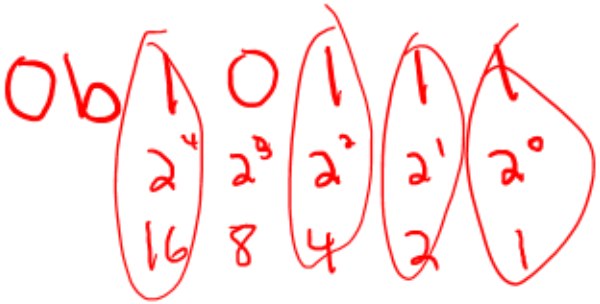
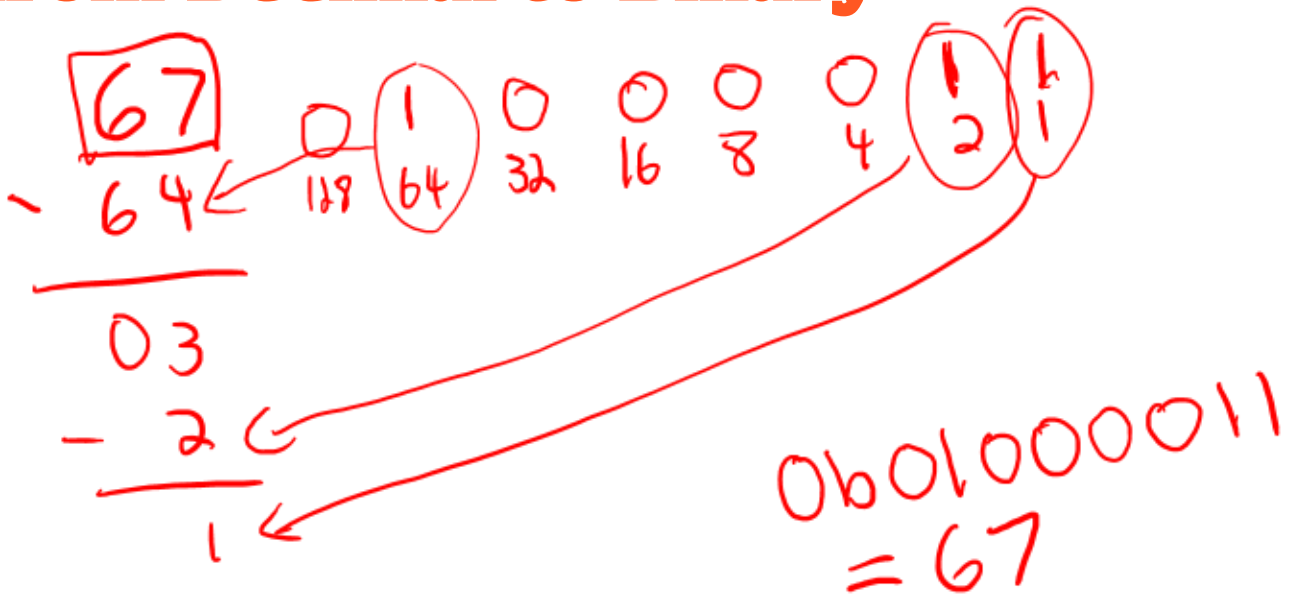


16 + 4 + 2 + 1 = 23

Going from Decimal to Binary



What is 14 in binary?

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16 8 4 2 1
0 1 1 1 0

14
− 8
6
− 4
2

0b1110

Counting in Binary

001 → 1

010 → 2

011 → 3

100 → 4

101 → 5

110 → 6

111 → 7

What is 0b0001 + 0b1001 in decimal?

0b1010
8 2 = 10

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What is 0b11111 in Decimal?

16 8 4 2 1
1 1 1 1 1

32 - 1 = 31

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Addition in Binary

Bits take up space in hardware. How many bits of space would I need to fully represent the result of 0b11011 + 0b11001?

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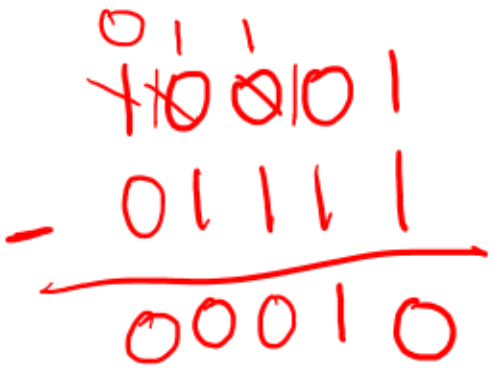
5 4 3 2 1

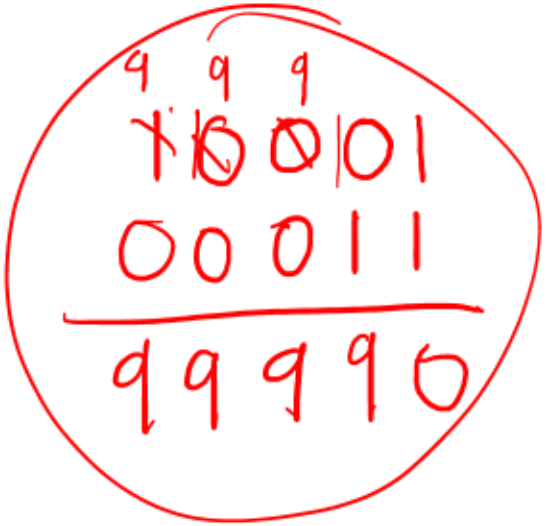
a) 4

b) 5

c) 6 ← extra bit

Subtraction in Binary





Big Takeaways

Computers are built with gates.

Gates work with high or low voltages.

We use binary to work with high or low
(1) (0)

What do these bits mean?

00100101

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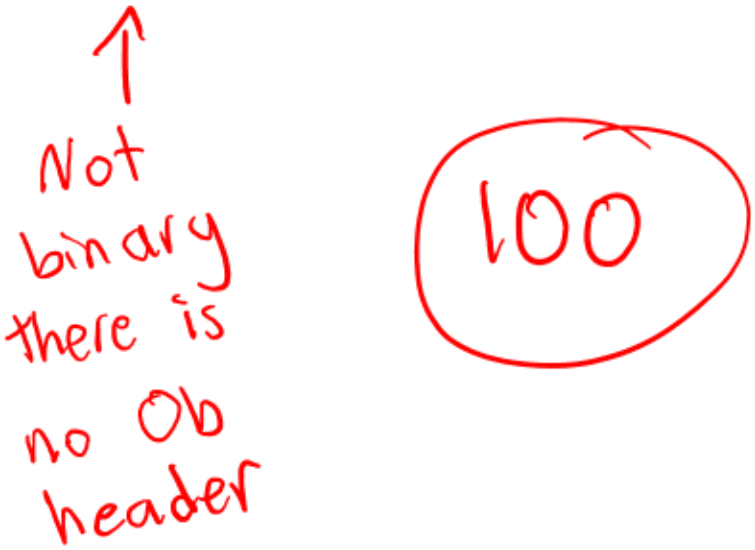
a) 37

b) part of a computer instruction.

c) Part of a internet packet

d) can't tell, need context

What is 100 in Decimal?



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