Level 0x0A

Binary Tricks

Topics

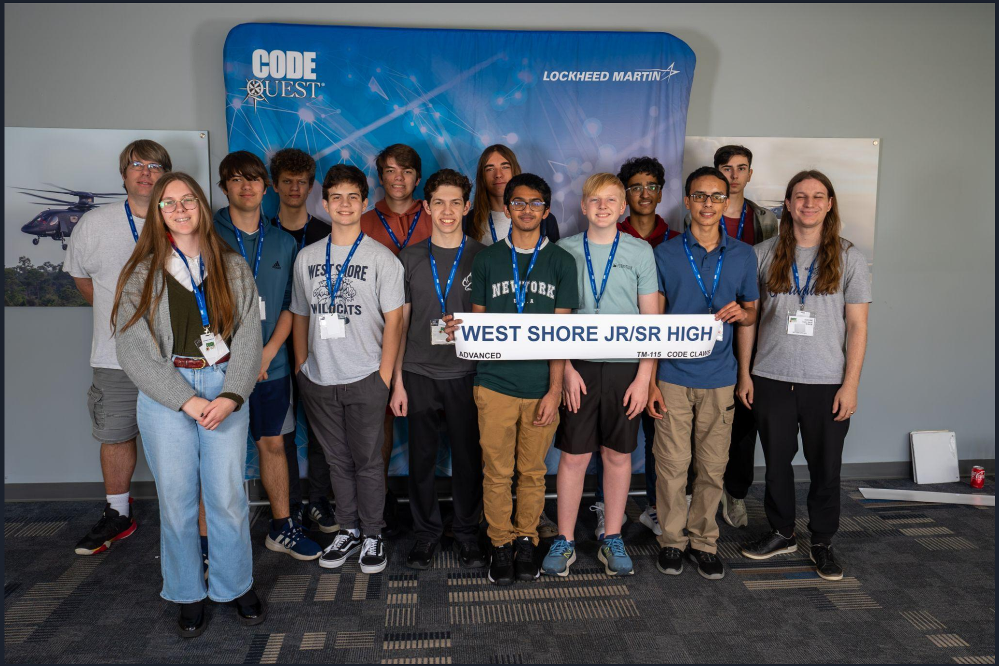
- Events
- Hacker History
- Ones and Zeros

Ongoing Events

- December hacking contests
  - Advent of Cyber - [TryHackMe.com]
  - Sans Institute [Holiday Hack Challenge] - Less CTF, more game, probably more incident responder and defender focused
  - [Advent of Code] - Programming challenges. Used to be 25 2-parters, now reducing down to 12 days of challenges
  - [Pwn.College] is going to do an Advent of Pwn

Cyber Quest and Code Quest

- Code Quest
  - Saturday, Feb 28th
  - Registration Nov 17th -
- Spring Break
  - March 23rd - 27th
- Cyber Quest
  - Saturday, March 28th
  - Registration Jan 5th -



Code Quest

- Details
    - Saturday, February 28th, 9:00 - 1:30 ish
    - Teams are 2-3 students each, 4 teams max per school
    - 1 computer / laptop per team (one keyboard and one mouse too 😛)
    - No cell phones inside, no cameras (not even outside)
    - No buses, must provide your own transportation (they can't stay on site during the competition)
    - Breakfast and Lunch provided
- What you need to provide me
    - Team members and teams (team names)
    - Birthday (must be 11 yrs and older, middle-school officially allowed)
    - Citizenship (not related to ICE current politics, standard procedure for military contractors)
    - Return 2 Lockheed forms (Liability and Photo Release)
    - Return 1 school permission slip

Cyber Quest

- Details:
    - Saturday, March 28th, 9:00 - 1:30 ish
    - Teams are 3-5 students each, 4 teams max per school
    - Very large monitors discouraged
    - No cell phones inside, no cameras (not even outside)
    - No buses, must provide your own transportation (they can’t stay on site during the competition)
    - Breakfast and Lunch provided
- What you need to provide me
    - Team members and teams (team names)
    - Birthday (must be 14 yrs and older)
    - Citizenship (not related to ICE current politics, standard procedure for military contractors)
    - Return 2 Lockheed forms (Liability and Photo Release)
    - Return 1 school permission slip

Robert Morris

- Created the first internet worm (not the first worm)
  - Worm = malware that replicates and spreads itself
- Father (also Robert Morris) worked at Bell Labs and NSA
- Grad school student at Cornell
- Morris Worm spread by exploiting
  - Bug in **`sendmail`** debug mode
  - Buffer overflow in **`fingerd`** (gives you info about other users)
  - Weak user passwords
- First person to ever be prosecuted by Computer Fraud and Abuse Act
  - Govt: Tens of thousands of infections, $200-$50,000 per computer to fix
  - 3 yrs probation, 400 hrs community service, $10,000 fine
  - Could have been a much harsher sentence per guidelines
  - Leniency because he never intended to cause damage

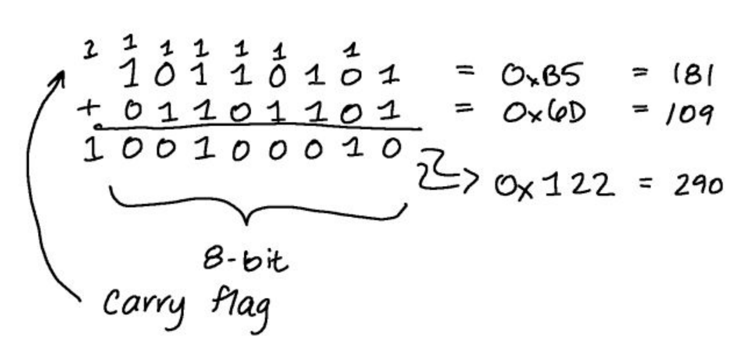
Binary Numbers

10110101 = 0xB5 = 181

01101101 = 0x6D = 109

Addition

- Online 6502 Assembler and Emulator
    - https://skilldrick.github.io/easy6502/

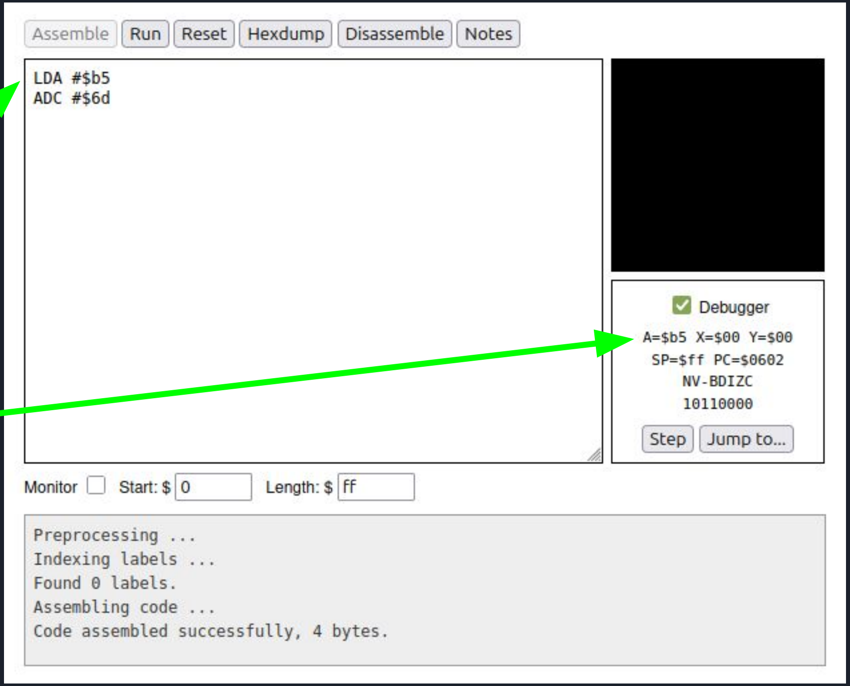


Let's Try It Out

- Assemble program
- Reset CPU
- Toggle on Debugger
- Step instruction 1 instruction

LDA = LoaD Accumulator

- Accumulator = 0xB5

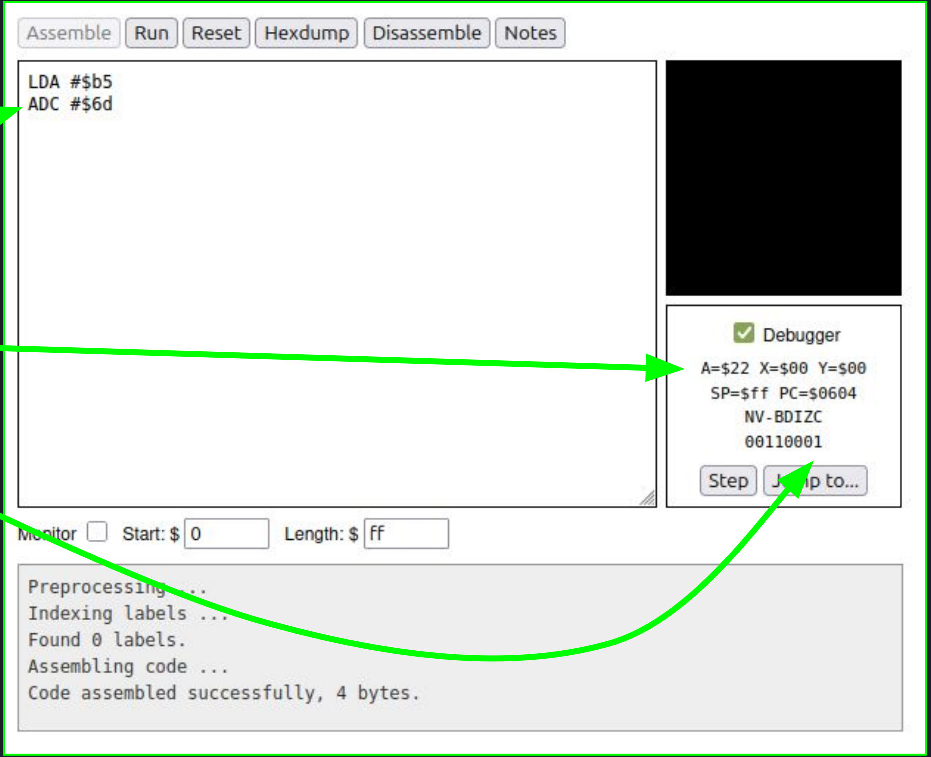


Let's Try It Out

- Step instruction 1 more

ADC = ADd with Carry

- Accumulator = 0x22
- Carry Flag is set to 1



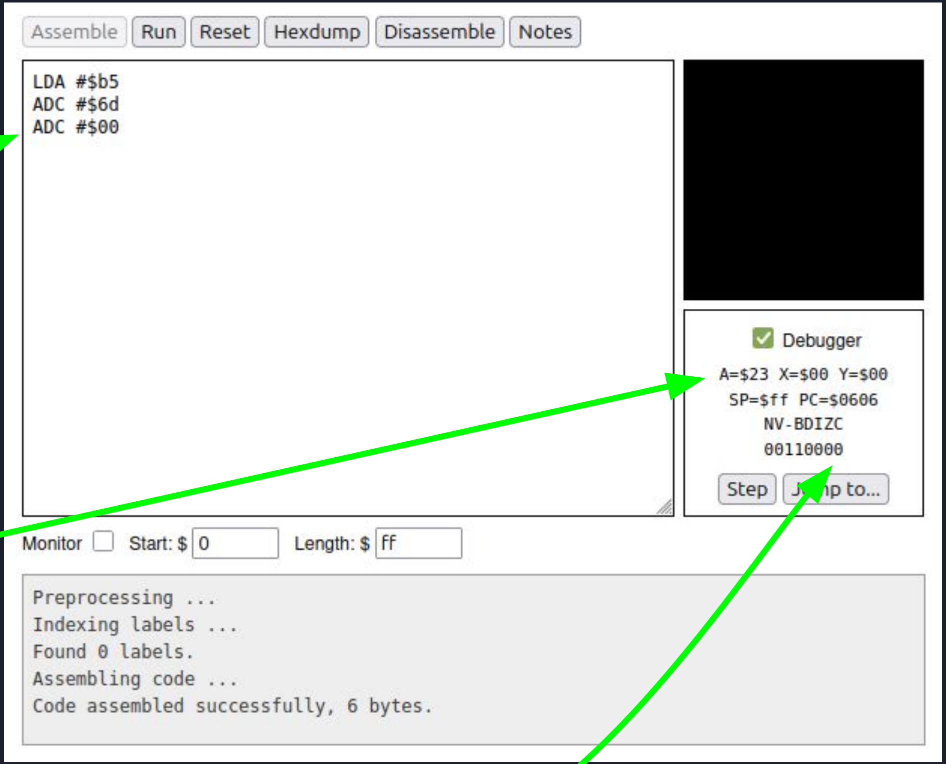
What does "with Carry" mean?

- Added a new instruction

ADC #$00 = ADd with Carry

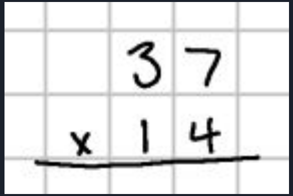
- We add 0 to the accumulator…
- Plus 1 for the Carry Flag

- Accumulator is now 0x23
- Carry flag is now 0



Multiplication

- How do we do multiplication in base-10 number system?



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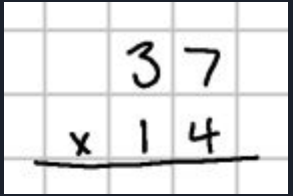
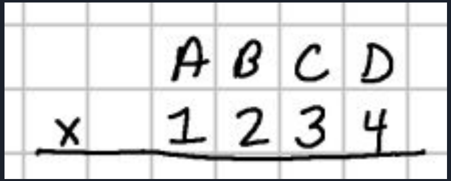
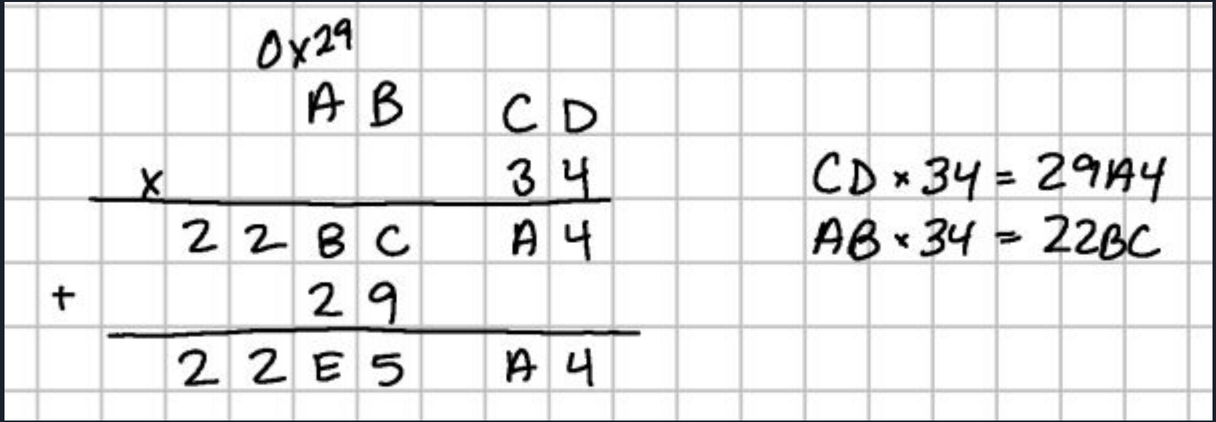




- What about binary or base-16?

It works in binary / hex too!



Sign Bit?

```
               0 E
              A B    C D
          x   1 2    3 4
        2 2   E 5    A 4
  0 C   0 6   6 A
    C   3 7   4 F    A 4
```

CD x 12 = 0E6A
AB x 12 = C06

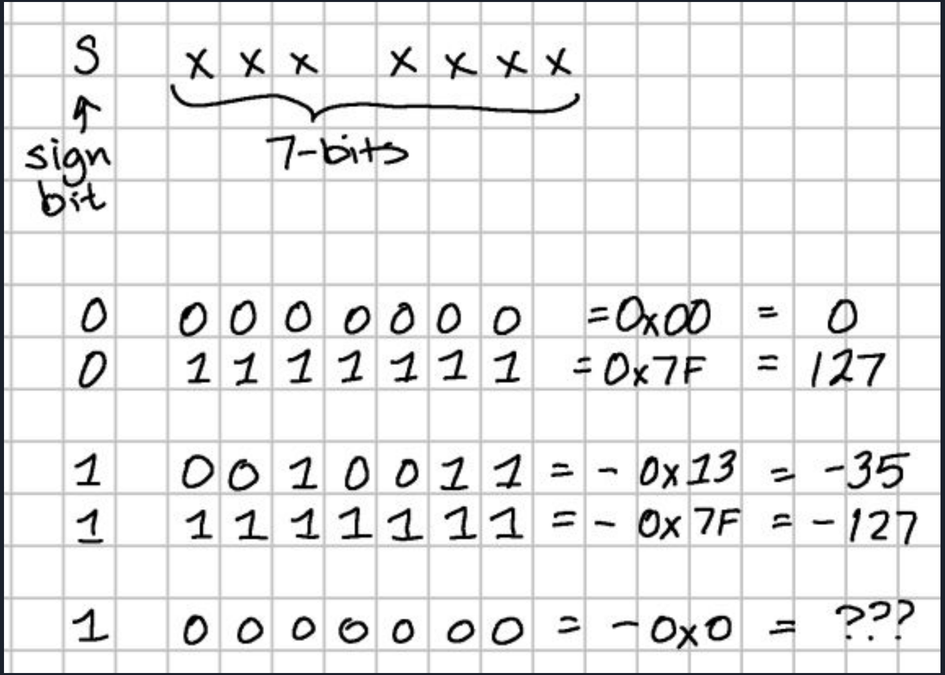
```
>>> hex(0xabcd * 0x1234)
'0xc374fa4'
```

Negative integers

- Let’s propose using the highest / top bit as a sign bit
  - 1 = negative
  - 0 = positive

- Could represent -127 to 127

- What is -0 ???



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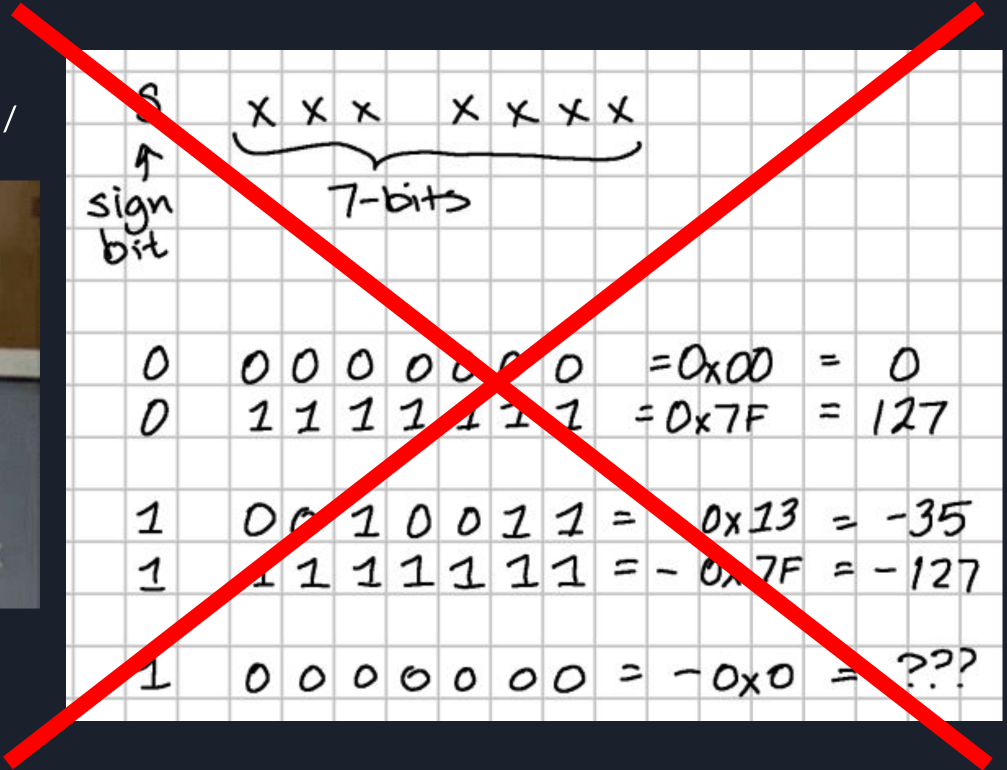
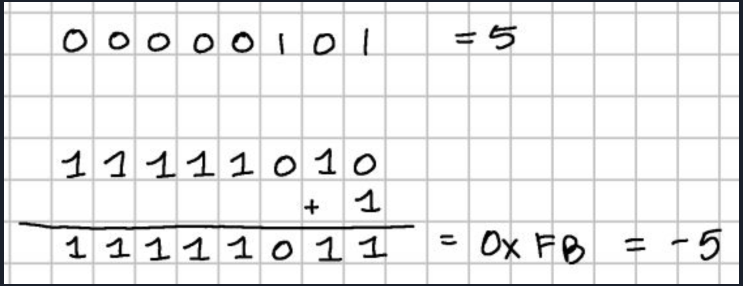
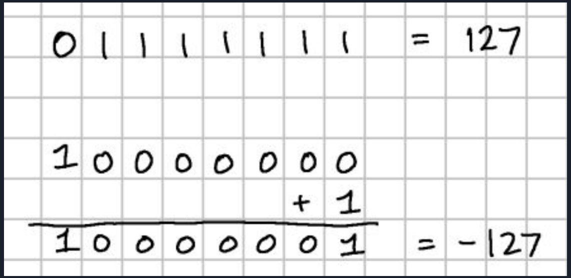


Two’s Complement

- To invert the sign of a number
  - Invert all the bits
  - Add 1
- That top bit is kind-of a sign bit
  - If it’s a 1, it’s a negative number
  - But we don’t have negative 0
- -2^N to 2^N-1 -128 to 127 for 8-bit

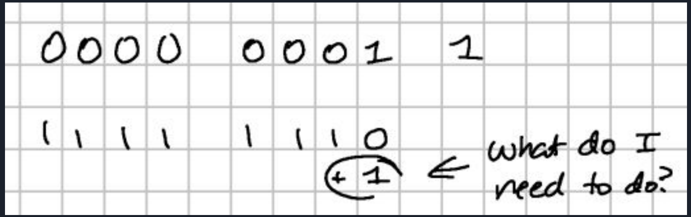




Two's Complement

- Negative 1 is always all 1's / all F's
  - 8 bit => 0b11111111 = 0xFF
  - 16-bit -> 0b1111111111111111 = 0xFFFF
  - And so on…

- If you forget how to do a 2's complement
  - Remember -1 is all F's
  - Remember invert all the bits



Example Math

Subtraction is essentially adding a negative number…

$$
\begin{array}{r}
85 \\
-\ 42 \\
\hline
43
\end{array}
\qquad = 0x55 \qquad 42 = 0x2a
$$

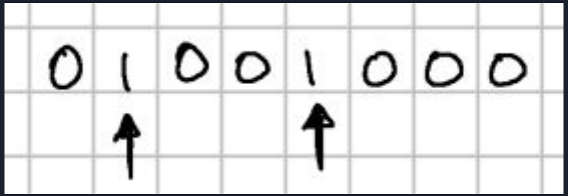
$$
\begin{array}{rl}
00101010 & 42 \\
11010101 & \\
+\ 1 & \\
\hline
11010110 & -42
\end{array}
$$

$$
\begin{array}{rl}
01010101 & = 0x55 = 81 \\
+\ 11010110 & = -42 \\
\hline
00101011 & \Rightarrow 0x2B = 43
\end{array}
$$

throw away

Bit Counter

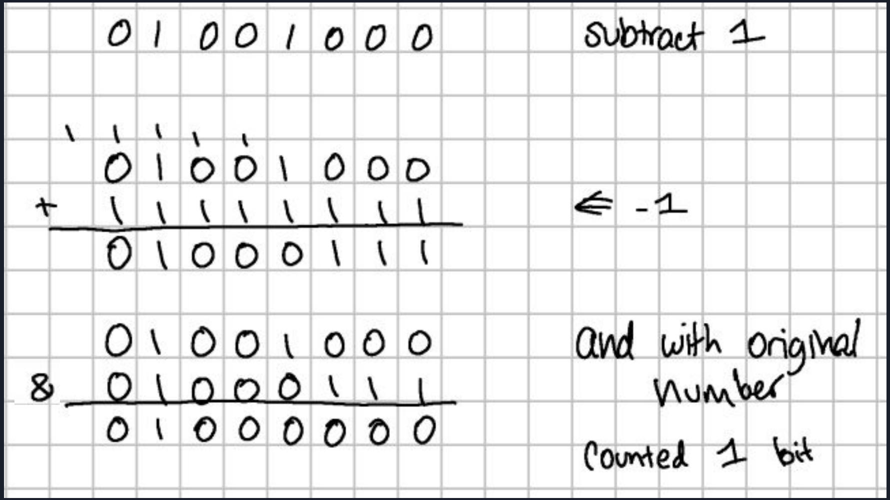
- How can I count the bits that are set in a number?
  - POPCNT on x86
- You could loop through all bits (shifting a 1) and test each bit
  - Takes a lot of loops for 64-bit values

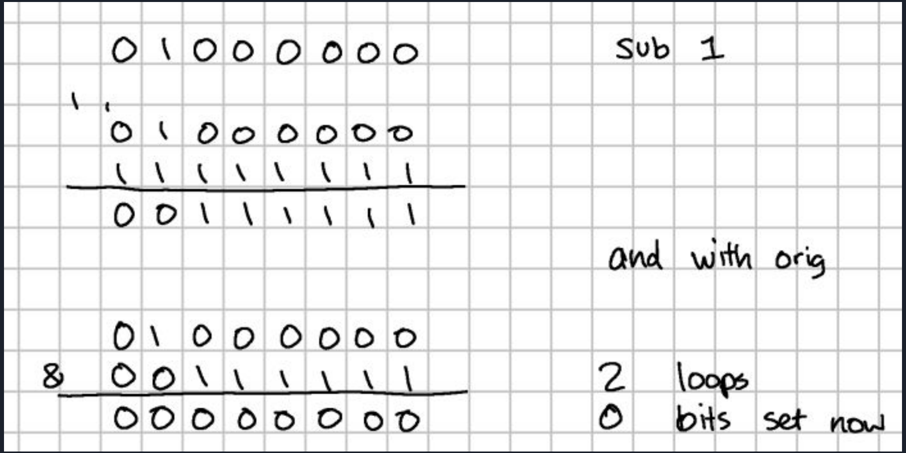



```c
unsigned int popcount_shift(uint32_t x)
{
    unsigned int count = 0;

    while (x != 0) {
        // Check lowest bit (LSB)
        if (x & 1u) {
            count++;
        }

        // Shift right by 1 bit, discarding LSB
        x >>= 1;
    }

    return count;
}
```

Try This...

- Subtract 1 from the number
- Bitwise-AND with the original number





Bit Twiddling Hacks

- https://graphics.stanford.edu/~seander/bithacks.html
    - Full of the most clever (evil) math / algorithms you will ever see

Counting bits set, Brian Kernighan's way

```
unsigned int v; // count the number of bits set in v
unsigned int c; // c accumulates the total bits set in v
for (c = 0; v; c++)
{
  v &= v - 1; // clear the least significant bit set
}
```

Links

- https://risky.biz/HTWGO1/ - About Robert Morris case
- https://skilldrick.github.io/easy6502/
- https://graphics.stanford.edu/~seander/bithacks.html