
BUUUUUGS
IIIIIN SPAAAAAACE!!!!!!

Colin Fulton

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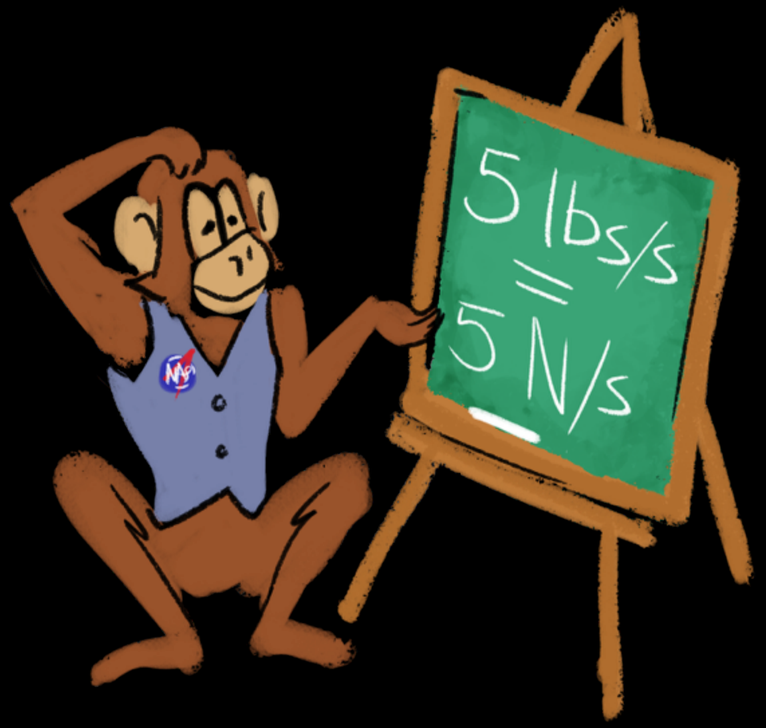
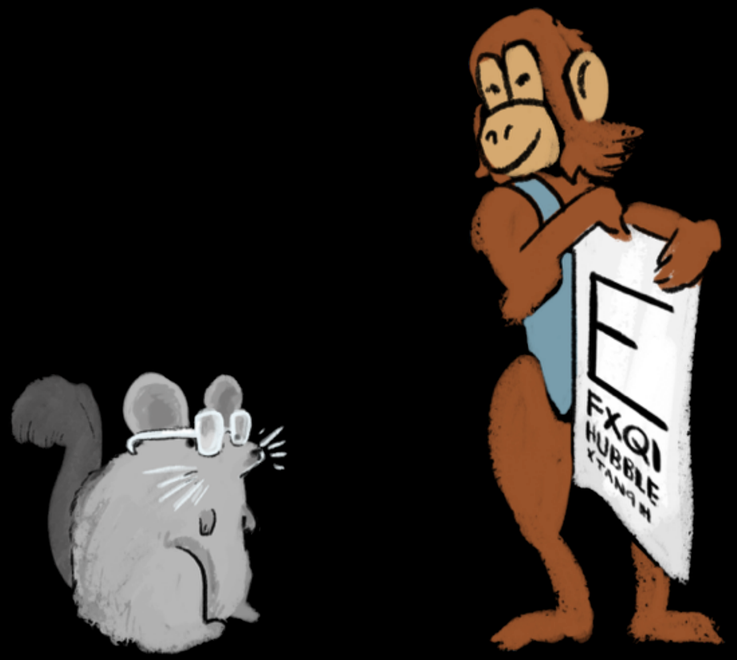

5 lbs/s
=
5 N/s

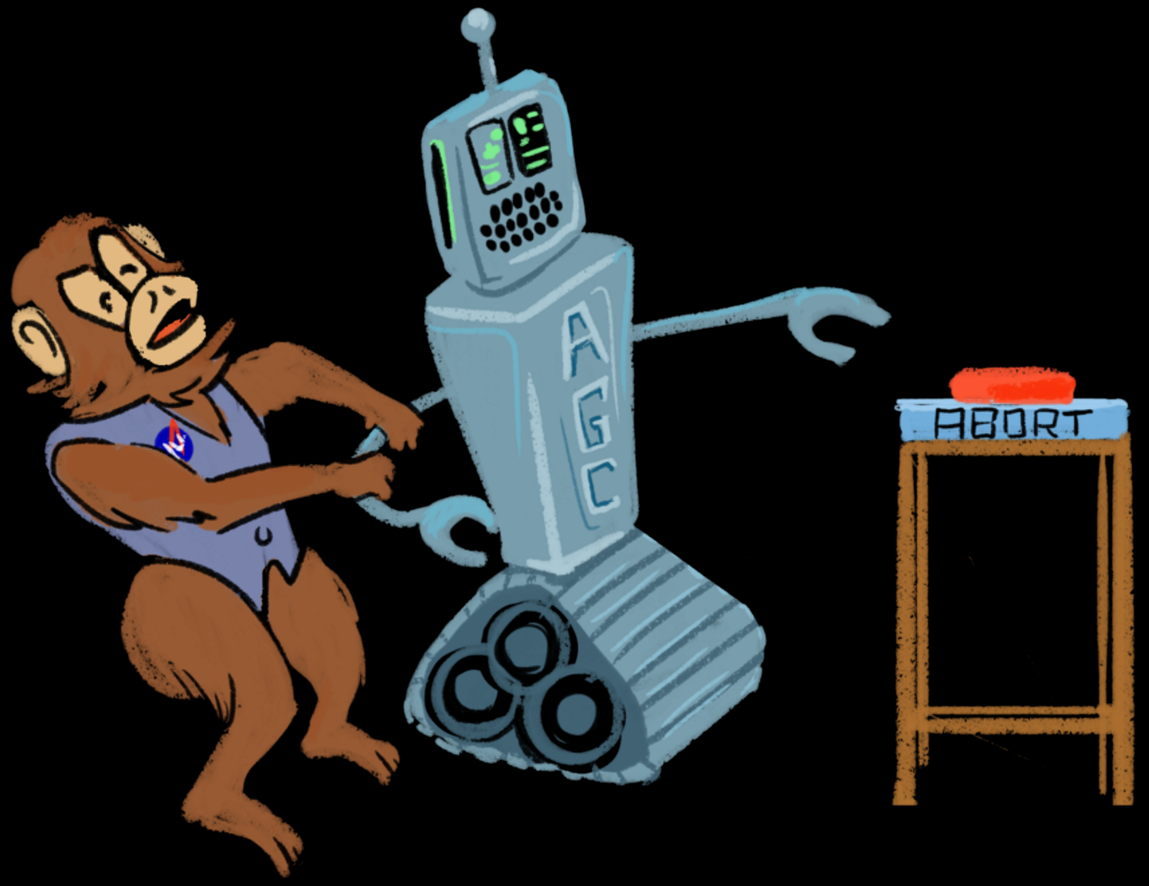

FXQ
HUBBLE

Four Stories

We can send a man to the moon, but …

Apollo 14


ABORT


AGC
ABORT

```
10,11    CA       FLAGWRD9  # IS THE LETABORT FLAG SET ?
         MASK     LETABBIT
         EXTEND
         BZF      LANDISP   # NO. PROCEED TO R10.
```

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         MASK     LETABBIT
         EXTEND
         BZF      LANDISP   # NO. PROCEED TO R10.
```

```
10,11 ➡ CA      FLAGWRD9  # IS THE LETABORT FLAG SET ?
        MASK    LETABBIT
        EXTEND
        BZF     LANDISP   # NO. PROCEED TO R10.
```

```
10,11    CA       FLAGWRD9  # IS THE LETABORT FLAG SET ?
      ➡ MASK     LETABBIT
         EXTEND
         BZF      LANDISP   # NO. PROCEED TO R10.
```

```
10,11    CA      FLAGWRD9  # IS THE LETABORT FLAG SET ?
         MASK    LETABBIT
      ➡  EXTEND
         BZF     LANDISP   # NO. PROCEED TO R10.
```

```
10,11    CA      FLAGWRD9  # IS THE LETABORT FLAG SET ?
         MASK    LETABBIT
         EXTEND
      ➡ BZF     LANDISP   # NO. PROCEED TO R10.
```

Set the LETABORT flag!

Nope …

```
10,11     CA       FLAGWRD9  # IS THE LETABORT FLAG SET ?
          MASK     LETABBIT
          EXTEND
          BZF      LANDISP   # NO. PROCEED TO R10.

P71NOW?   CS       MODREG    # YES.  ARE WE IN P71 NOW?
          AD       1DEC71
          EXTEND
          BZF      LANDISP   # YES.  PROCEED TO R10.
```

Set the MODREG!


ACL
ABORT

Monkey patching is a great tool when you *need* it

(even if you almost never need it)

One Line of Code

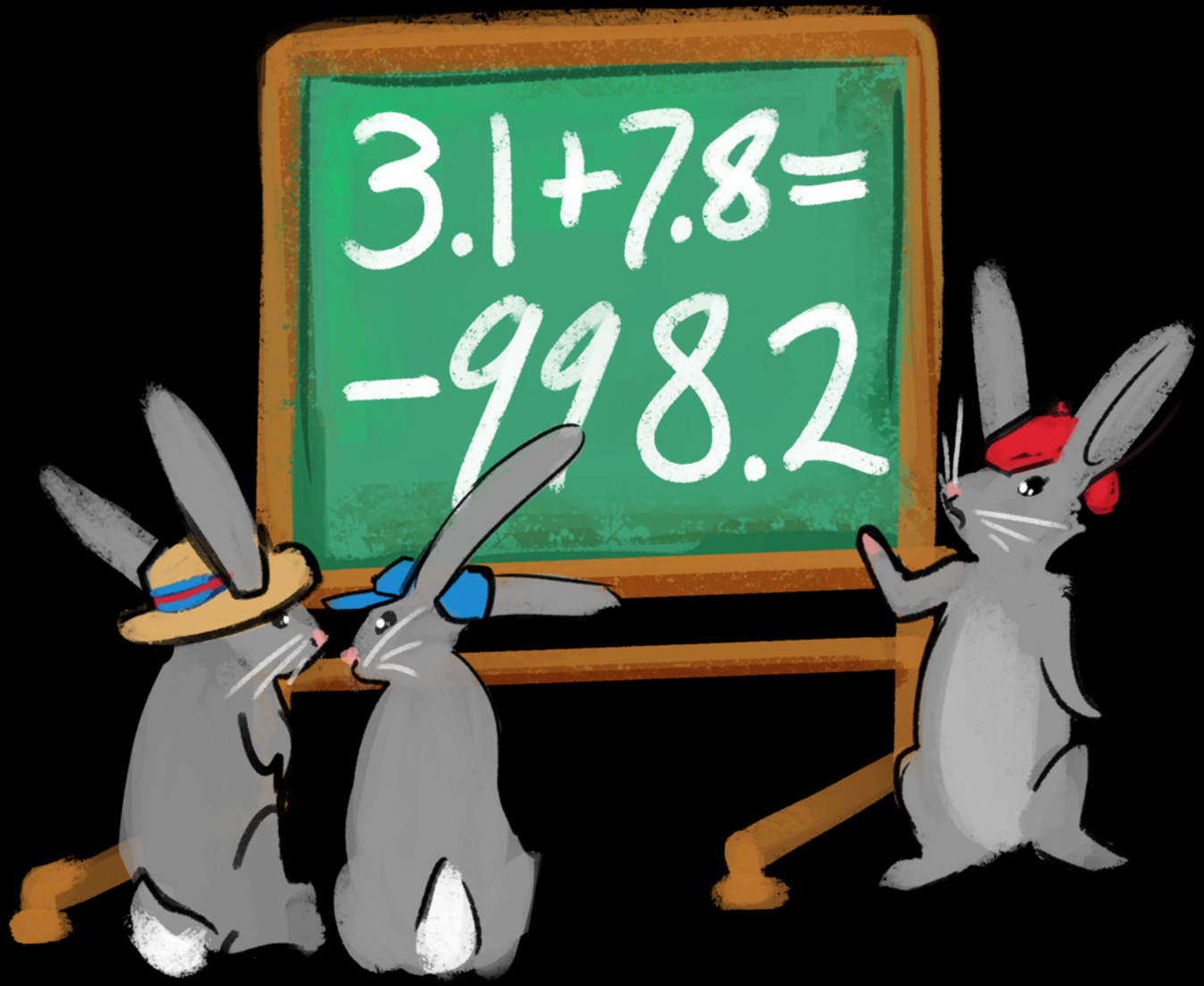
Ariane 5 Flight 501

$7,000,000,000

(our bunny friend is okay,
they are just embarrassed)

```
P_M_DERIVE(T_ALG.E_BH) := UC_16S_EN_16NS(
  TDB.T_ENTIER_16S((1.0 / C_M_LSB_BV) *
  G_M_INFO_DERIVE(T_ALG.E_BH)));
```

```
P_M_DERIVE(T_ALG.E_BH) := UC_16S_EN_16NS(
  TDB.T_ENTIER_16S((1.0 / C_M_LSB_BV) *
  G_M_INFO_DERIVE(T_ALG.E_BH)));
```


3.1+7.8=
-998.2

Protect against random faults
and design faults

Assume software is faulty
until it is demonstrated to be correct

Don’t only focus on the code;
documentation matters

Remove dead code

Postscript

Agile in the USSR

The US won the space race

First people to orbit the moon

First people on the moon

The US won the space race*

First object in orbit

First living creature in orbit

First person in space (and he *orbited*)

First woman in space

First space walk

First three person spacecraft

First mission without spacesuits

First object on the moon

First object to softly land on the moon

First satellite to orbit the moon

First image of the "dark" side of the moon

Why did the USSR never send a person to the moon?

Getting to the moon is *hard*

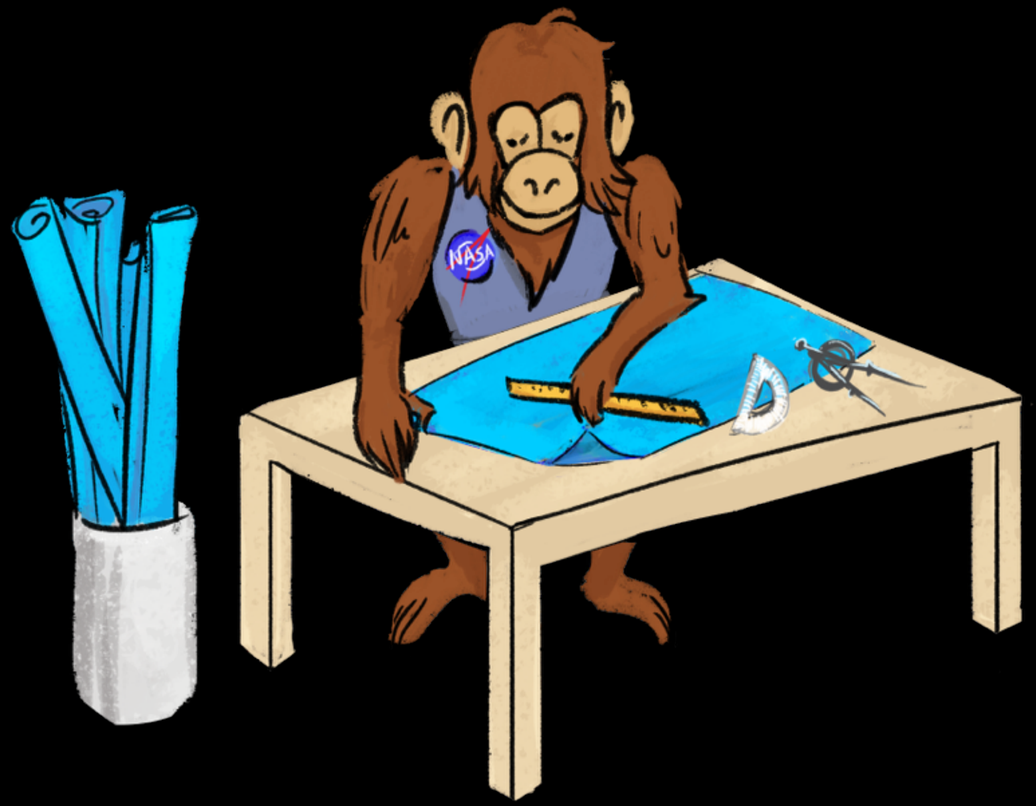
F-1

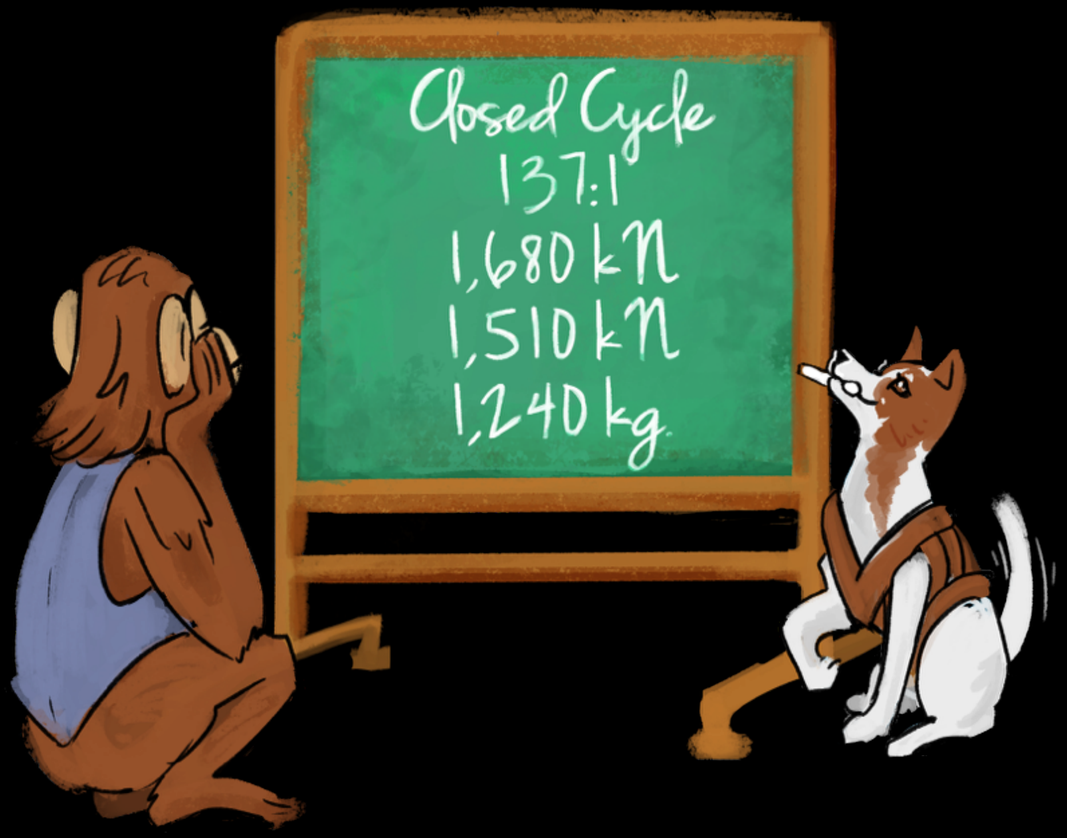
5 of them!

The USSR lacked the US's industrial capabilities

NK-33

30 of them!!!!!

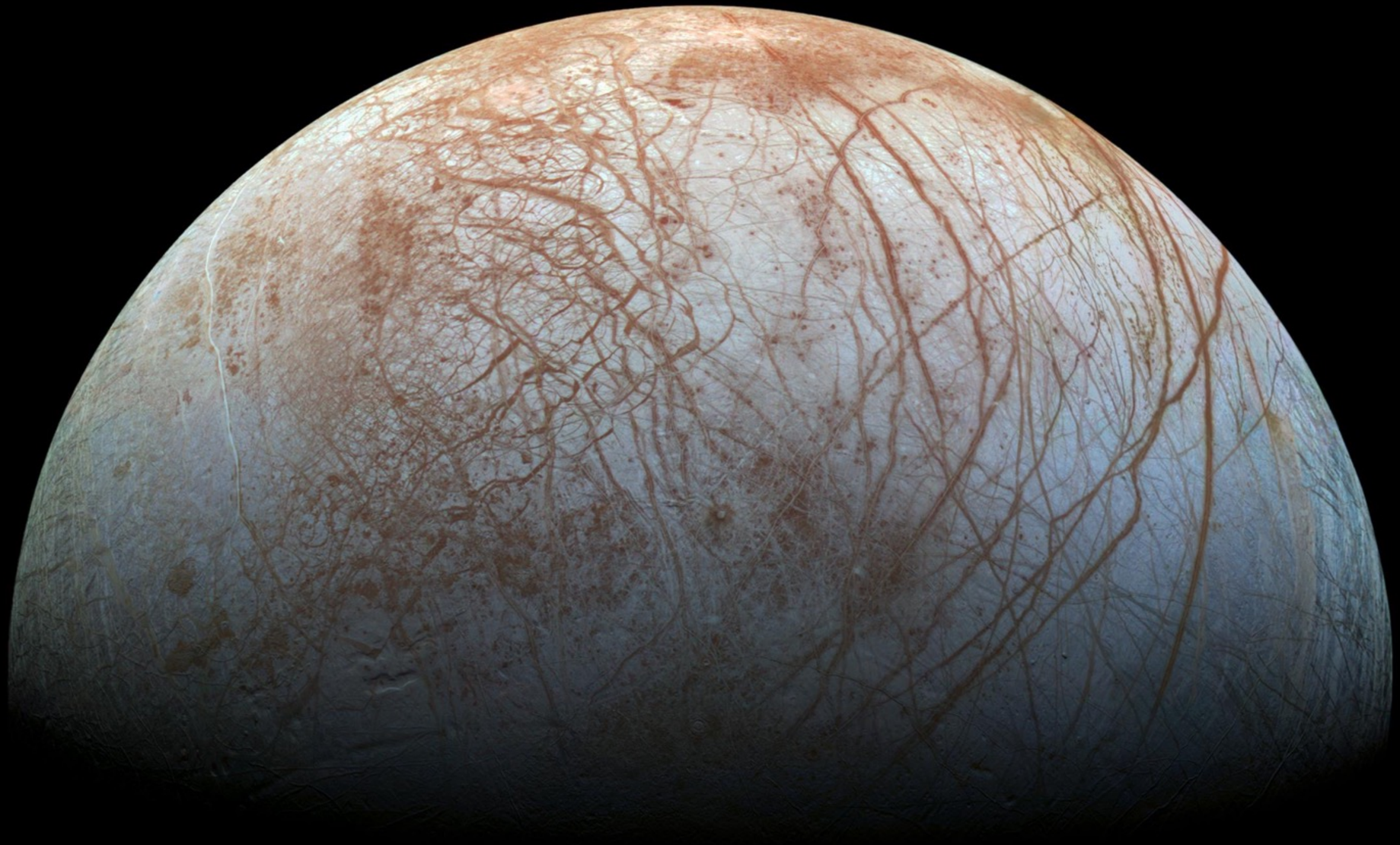

NASA

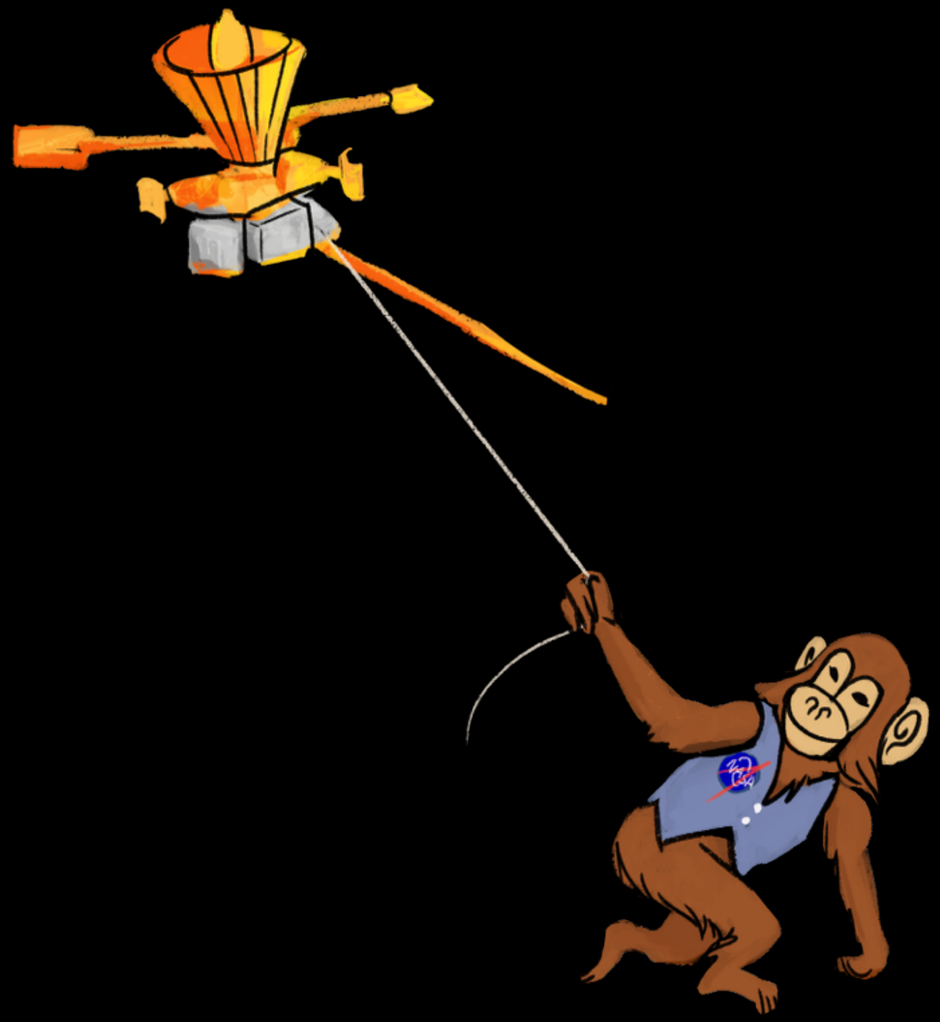

Closed Cycle
137:1
1,680 kN
1,510 kN
1,240 kg

And yet …

One Bad Byte

Galileo






NASA

Put yourself in JPL's shoes …

You have the code!

And it was written in… Forth?

Using a development environment
for the Apple II

But you got rid of all your Apple II's

… nor do you have the
development environment

How would you be feeling upon hearing this?

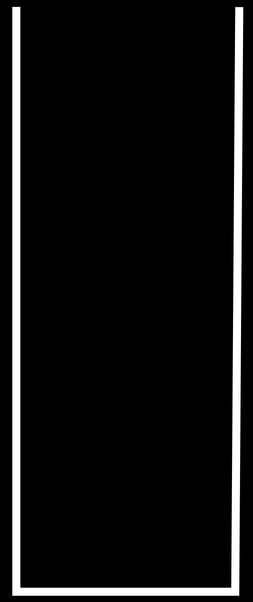
Enter Ron Garret

1802

Forth

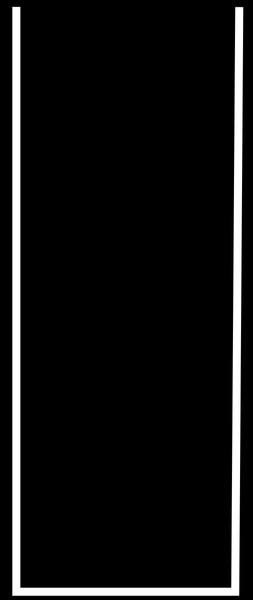
```
4 5 2 + * .
```

```
4 5 2 + * .
```



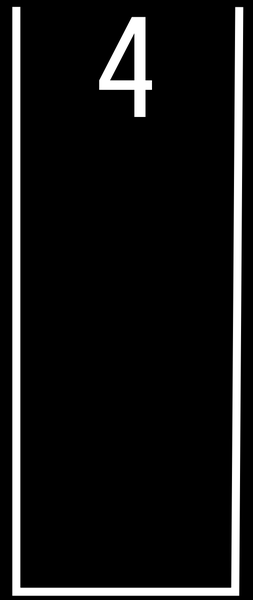
STACK

4 5 2 + * .

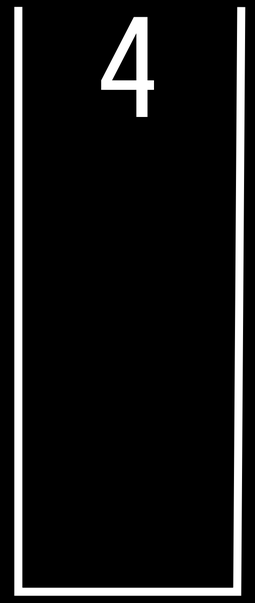


STACK

4 5 2 + * .

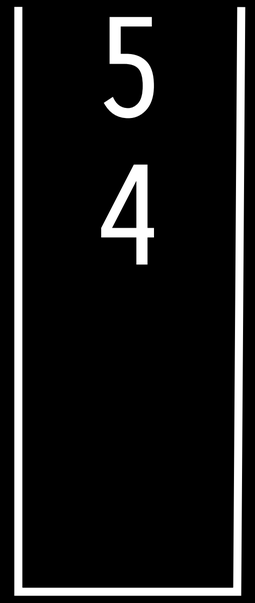


4 5 2 + * .



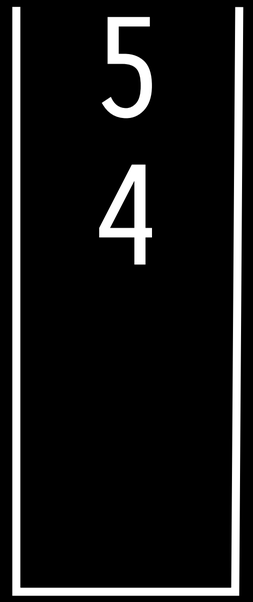
STACK

4 5 2 + * .



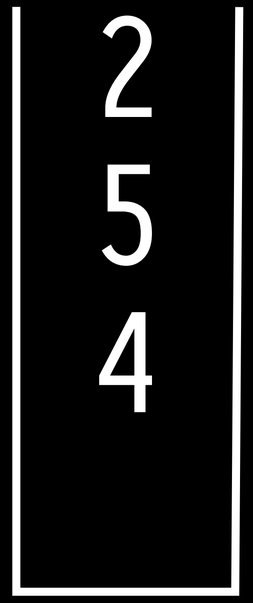
STACK

4 5 2 + * .



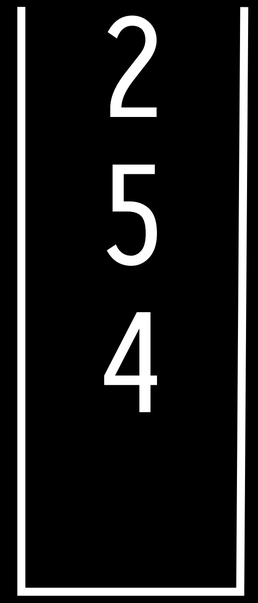
STACK

4 5 2 + * .



STACK

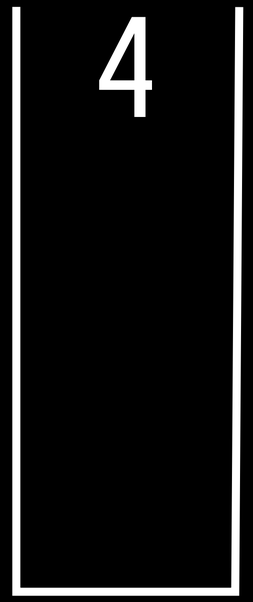
4 5 2 + * .



STACK

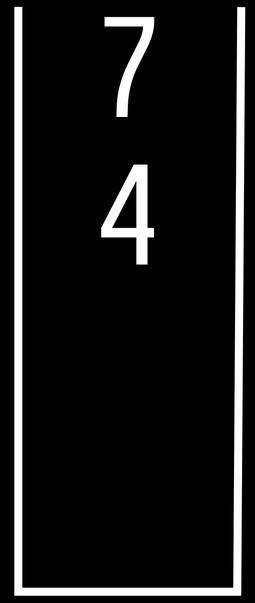
4 5 2 + * .

5 2



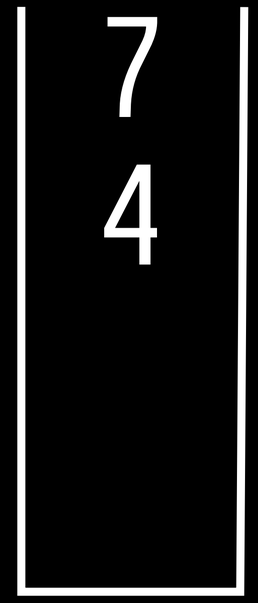
STACK

4 5 2 + * .



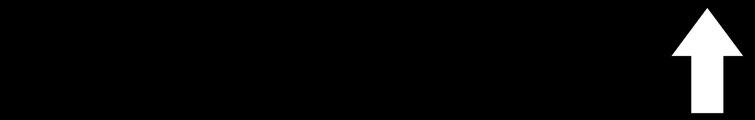
STACK

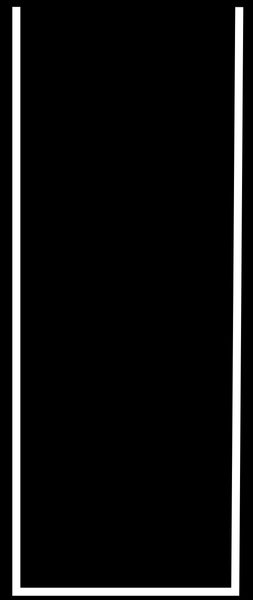
4 5 2 + * .



STACK

4 5 2 + * .

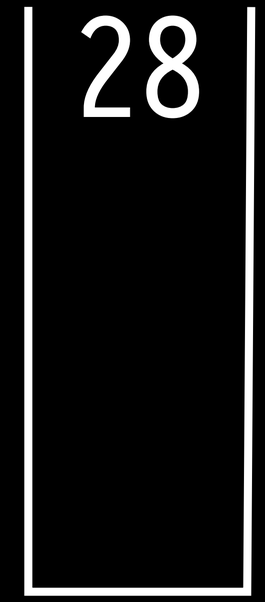




4 7

STACK

4 5 2 + * .



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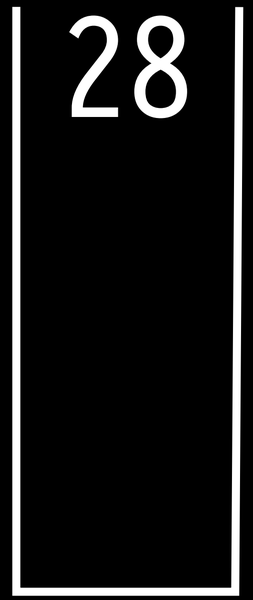
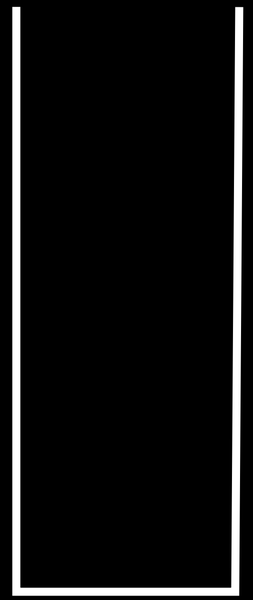
4 5 2 + * .



STACK

28

4 5 2 + * .



STACK

```
4 5 2 + * .
```

```
5 2 + 4 * .
```

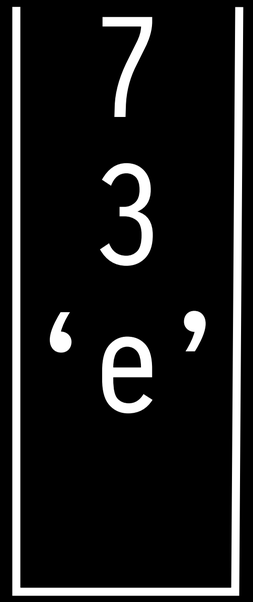
```
: SQUARE DUP * ;
```

```
: SQUARE DUP * ;
```

```
: SQUARE DUP * ;
```

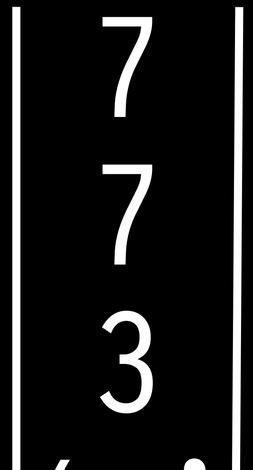

```
: SQUARE DUP * ;
```

```
: SQUARE DUP * ;
```



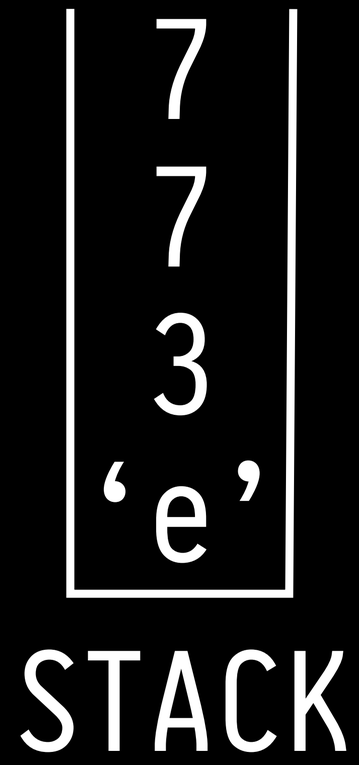
STACK

```
: SQUARE DUP * ;
```

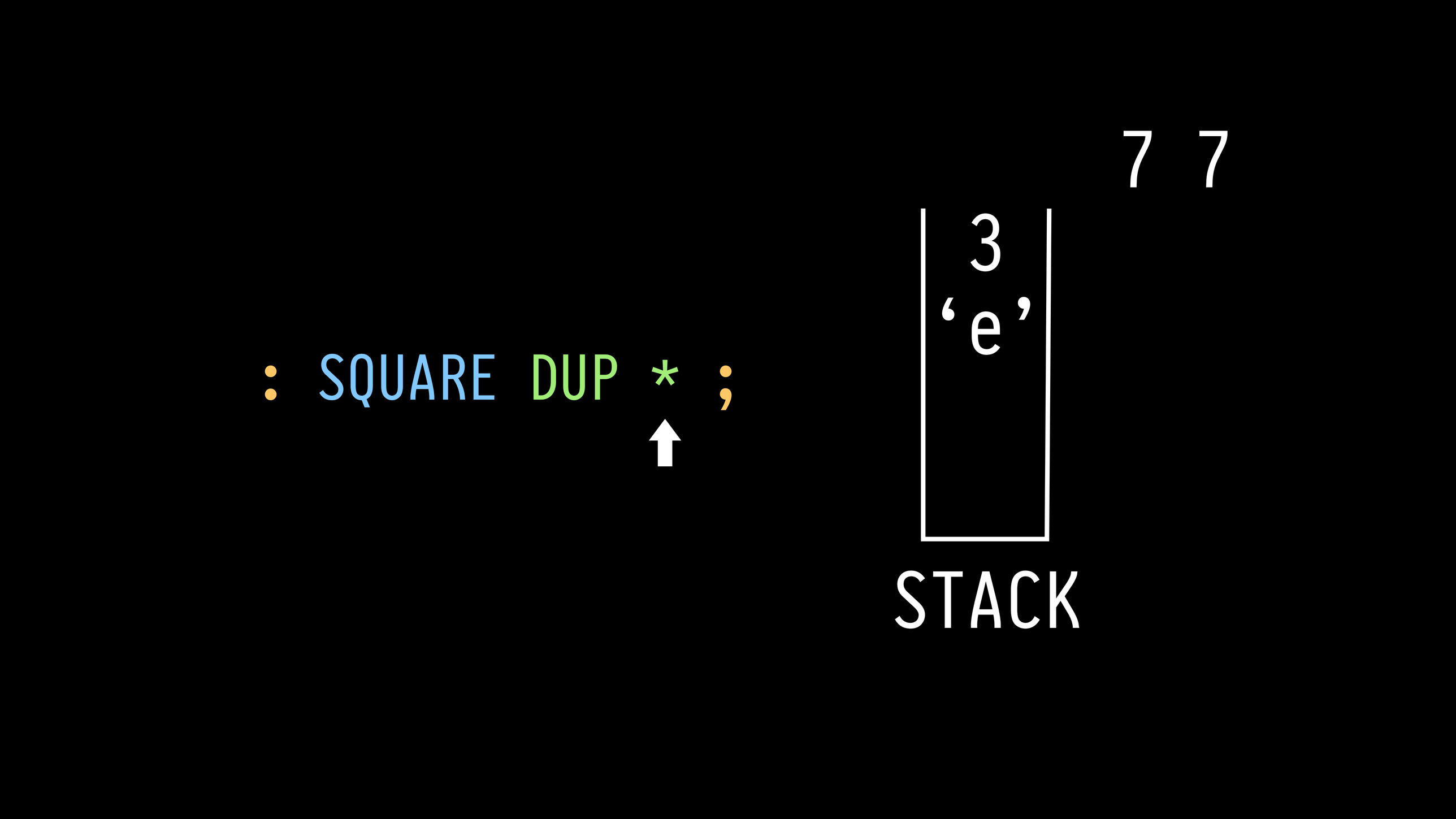


STACK

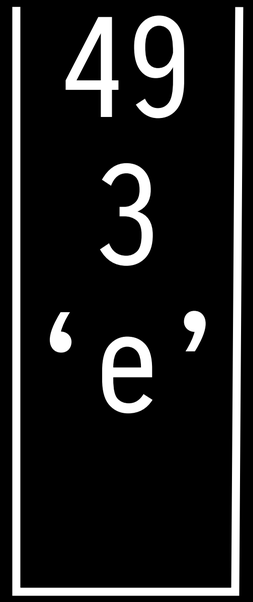
```
: SQUARE DUP * ;
```



```
: SQUARE DUP * ;
```

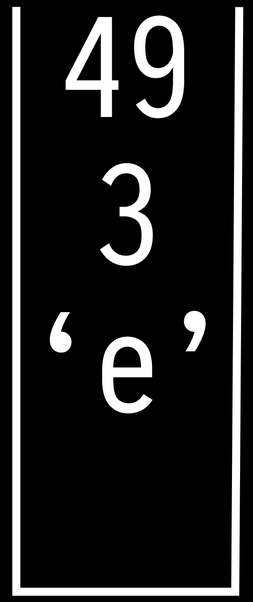


```
: SQUARE DUP * ;
```



STACK

```
: SQUARE DUP * ;
```

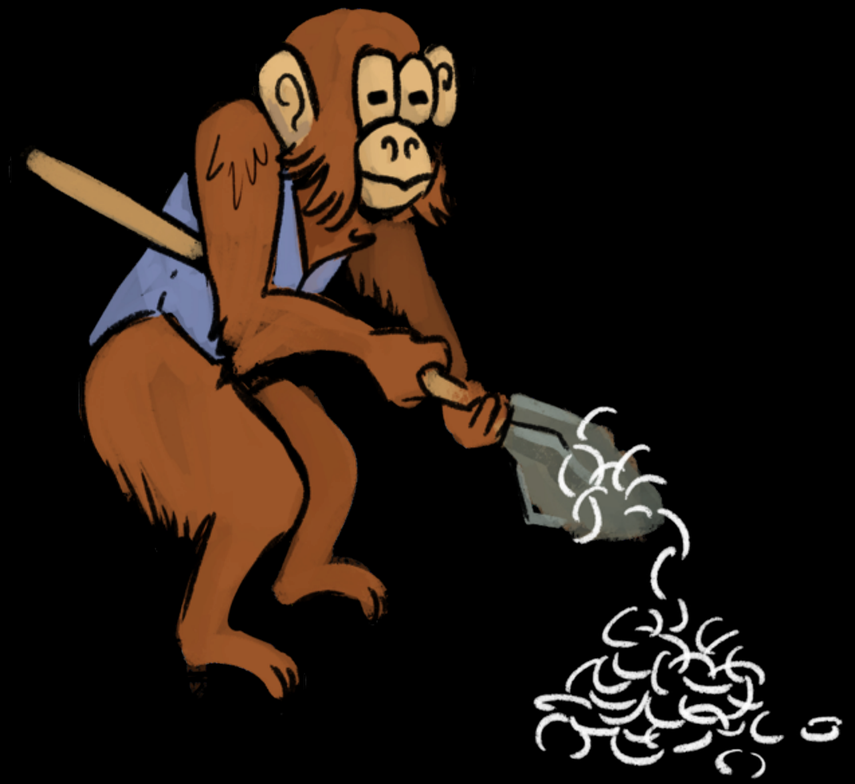


STACK

```
: SQUARE DUP * ;
```

Ron Garret

armed with `Lisp`*!*



```
: FIL! 1234 SWAP FILTF ;

44C8          00 CA 00 1F 12 34
44D0   01 71 44 A2 00 D5

: SDSPIN DUP 15 = IF 1ST-DSPVECTOR TS! THEN DUP 28 = IF
    ADDR-BUFFER DUP @ 20 + DUP 4CF8 > IF DROP 4800 THEN
    DUP ROT 2+ 20 MOVE ADDR-BUFFER ! THEN
    1 46FE +! 46FE @ 0= IF OPTST -7 46FE ! THEN
    DUP 0= IF MAT-LOAD 4FF0 C@ 20 - 2/ CMDPTR +! THEN ;

42B8                00 CA 01 60
42C0   00 2A 15 02 43 00 76 05
42C8   04 3B 41 63 01 60 00 2A
42D0   28 02 43 00 76 2C 40 50
42D8   01 60 01 95 00 2A 20 00
42E0   E9 01 60 00 1F 4C F8 02
42E8   37 00 76 07 01 6C 00 1F
42F0   48 00 01 60 02 B0 02 5D
42F8   00 2A 20 01 03 40 50 01
4300   A3 02 3F 00 1F 46 FE 01
4308   AF 00 1F 46 FE 01 95 01
4310   C0 00 76 0D 41 B8 00 1F
4318   FF F9 00 1F 46 FE 01 A3
4320   01 60 01 C0 00 76 14 42
4328   54 00 1F 4F F0 00 8A 00
4330   2A 20 00 F6 0E 3A 04 71
4338   01 AF 00 D5
```

Lessons?

“The main one is that
`Lisp` totally awesome”

Take aways?

History is awesome!

Want to learn more?

“The Remote Agent Experiment”

Google Tech Talk by Ron Garret

“Digital Apollo”

Book by David A. Mindell

Apollo 11 source code on GitHub!

“The Apollo Guidance Computer”

Book by Frank O’Brien

“Moon Machines”

Documentary Series

Special Thanks

Ron Garret

Rachel McGuffin

www.rachelmcguffin.com

Thank you!

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Email: justcolin@gmail.com
GitHub: @justcolin