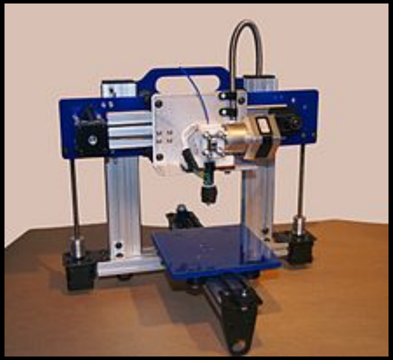
UC Berkeley EECS
Sr Lecturer SOE
Dan Garcia

The Beauty and Joy of Computing

Lecture #2 : Functions



3D PRINTING… WOW!

Cheap 3D Printers are making it possible for designers, tinkerers, students, etc. to render their designs in physical space. It's reduced the design-test-debug cycle time by a hundred fold!

3D PRINTING… IP?!

Have they considered how much work it is to design a 3D model? The current technology "gives" it all away when sent to another to print. If I sell it to you, you get my intellectual property!

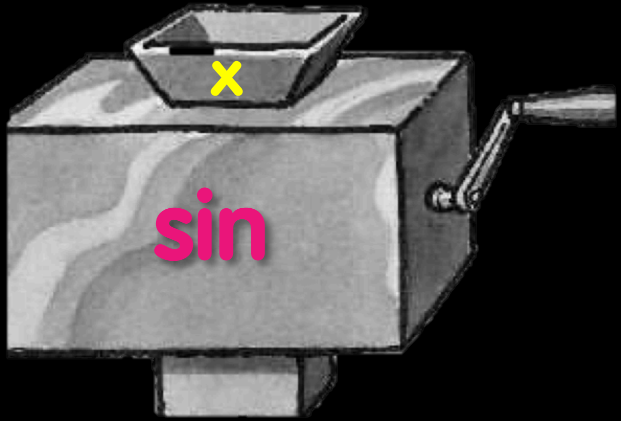
www.technologyreview.com/news/518591/copy-protection-for-3-d-printing-aims-to-prevent-a-piracy-plague/

Generalization (in CS10) REVIEW

- You are going to learn to write functions, like in math class:

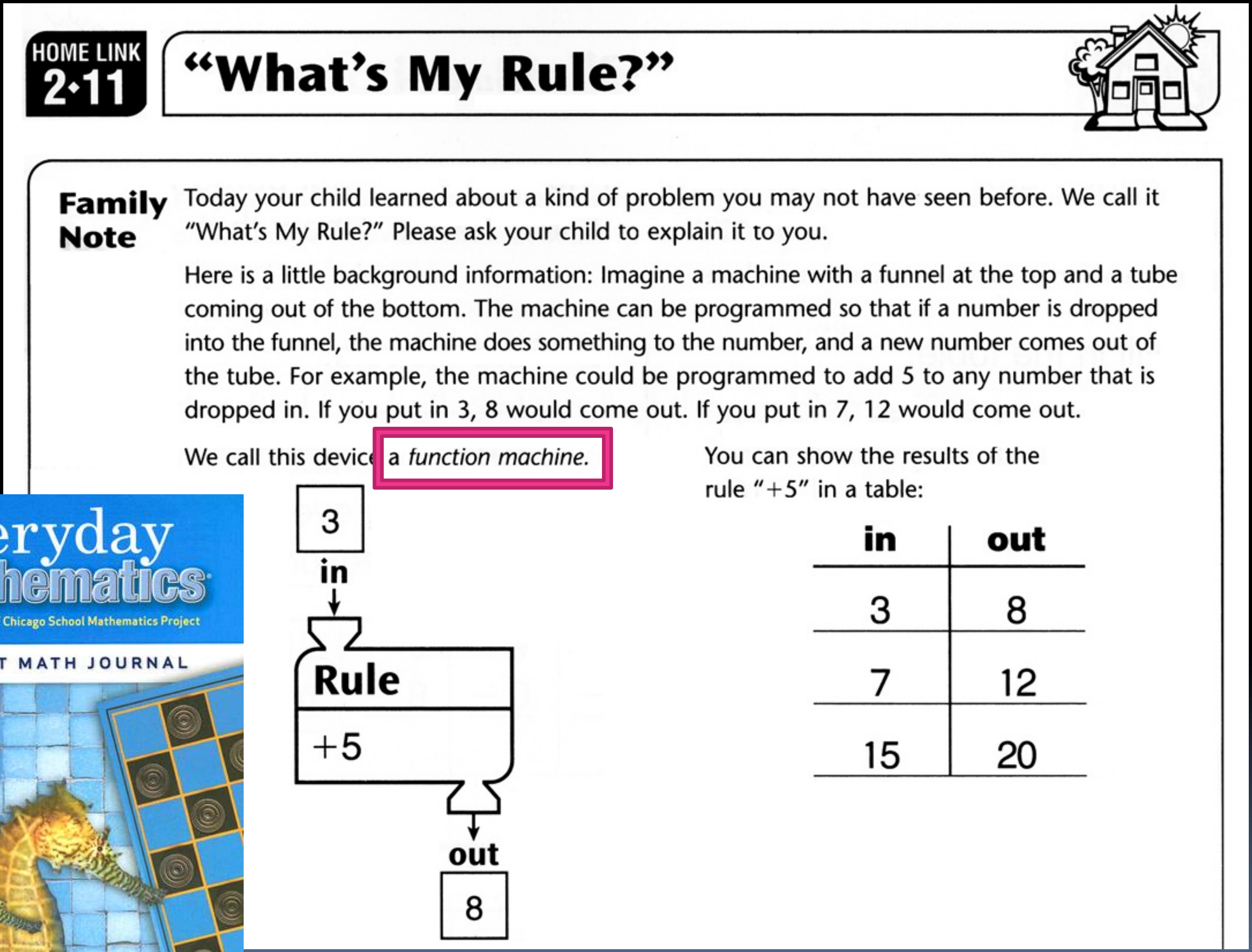
$$y = \sin(x)$$

  - sin is the function
  - x is the input
  - It returns a single value, a number



“Function machine” from *Simply Scheme* (Harvey)

Dan's kid's 2nd grade HW!



HOME LINK 2·11

"What's My Rule?"

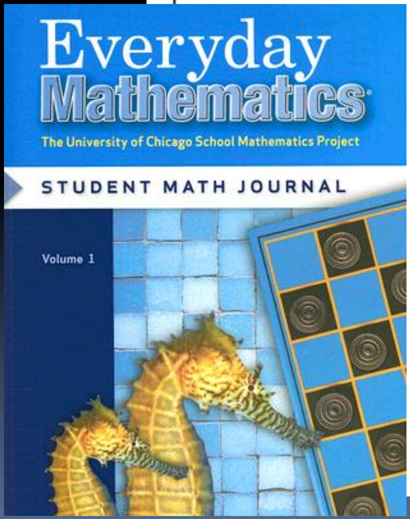
Family Note Today your child learned about a kind of problem you may not have seen before. We call it "What's My Rule?" Please ask your child to explain it to you.

Here is a little background information: Imagine a machine with a funnel at the top and a tube coming out of the bottom. The machine can be programmed so that if a number is dropped into the funnel, the machine does something to the number, and a new number comes out of the tube. For example, the machine could be programmed to add 5 to any number that is dropped in. If you put in 3, 8 would come out. If you put in 7, 12 would come out.

We call this device a *function machine.*

You can show the results of the rule "+5" in a table:

in	out
3	8
7	12
15	20



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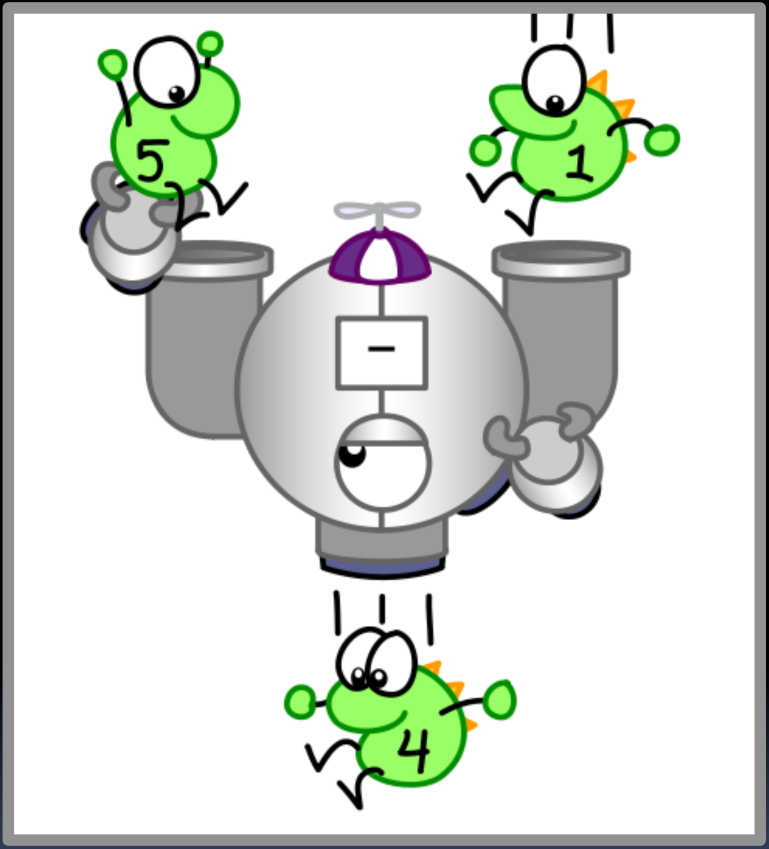
Function basics

- Functions take in **0 or more inputs** and return **exactly 1 output**
- The same inputs MUST yield same outputs.
  - Output function of input only
- Other rules of functions
  - No state (prior history)
  - No mutation (no variables get modified)
  - No side effects (nothing else happens)



CS Illustrated function metaphor

Which is NOT a function?

a) pick random ( ) to ( )

b) [ ] < [ ]

c) length of [ ]

d) sqrt ▾ of ( )

e) true

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More Terminology (from Math)

- **Domain**
  - The "class" of input a function accepts
- **Examples**
  - Sqrt of
    - Positive numbers
  - Length of
    - Sentence, word, number
  - _ < _
    - Both: Sentence, word, number
  - _ and _
    - Booleans
  - Letter _ of _
    - Number from 1 to input length
    - Sentence, word, number

- **Range**
  - All the possible return values of a function
- **Examples**
  - Sqrt of
    - Non-negative numbers
  - Length of
    - Non-negative integer
  - _ < _
    - Boolean (true or false)
  - _ and _
    - Boolean (true or false)
  - Letter _ of _
    - Letter

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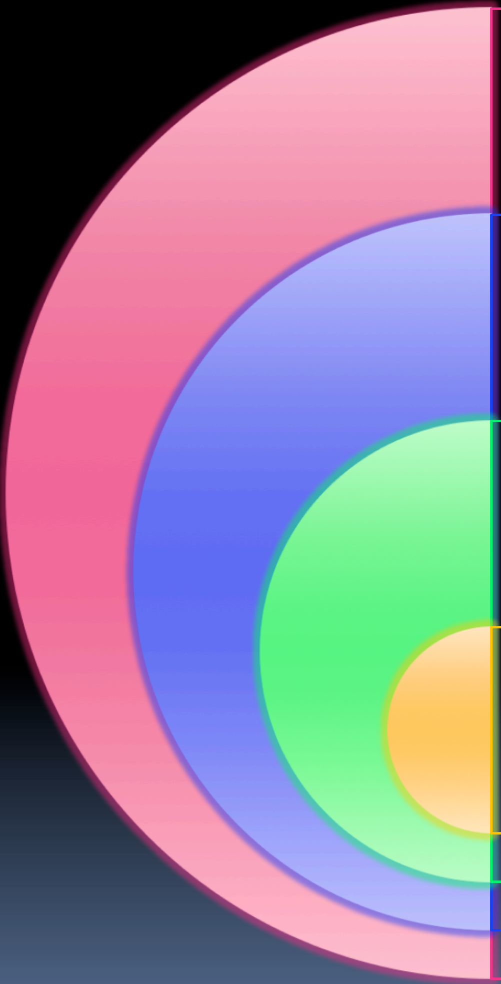
Types of input (there are more)



Sentences
- Words separated by N spaces, N ≥ 0
- E.g., CS 10 is great

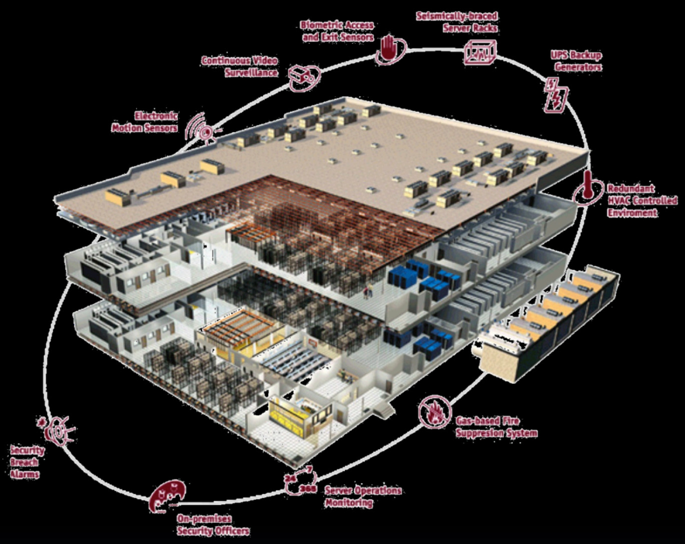
Word
- Length ≥ 1, no spaces
- Cal, 42, CS10

Character
- Length = 1
- E.g., A, 3, #

Digit
- 0-9 only
- E.g., 7

Why functions are great!

- If a function only depends on the information it gets as input, then nothing else can affect the output.
  - It can run on any computer and get the same answer.
- This makes it incredibly easy to parallelize functions.
  - Functional programming is a great model for writing software that runs on multiple systems at the same time.


Biometric Access and Exit Sensors
Seismically-braced Server Racks
Continuous Video Surveillance
UPS Backup Generators
Electronic Motion Sensors
Redundant HVAC Controlled Enviroment
Gas-based Fire Suppresion System
Security Breach Alarms
24 7 365
Server Operations Monitoring
On-premises Security Officers

Datacenter

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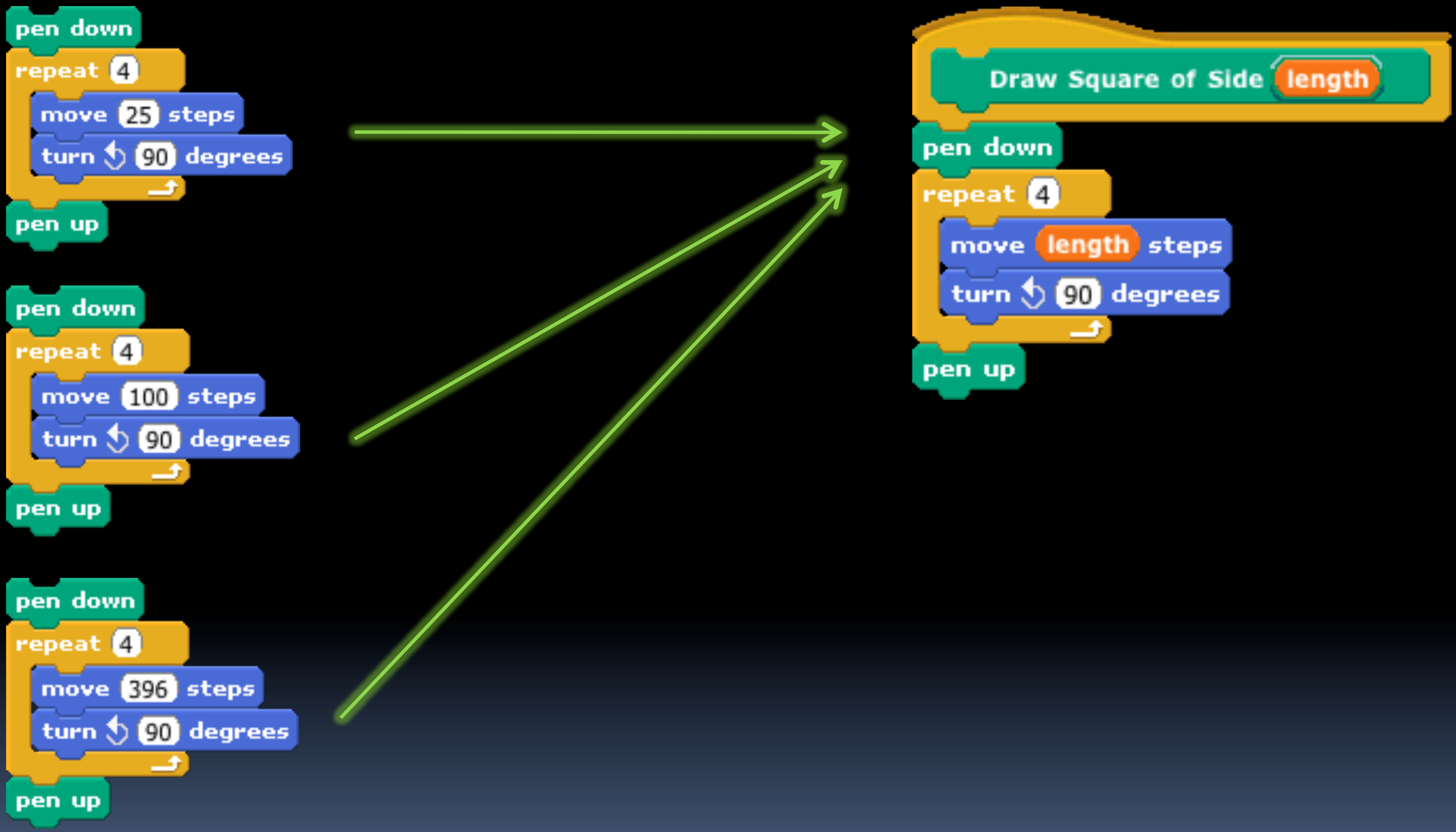
Scratch → BYOB (Build Your Own Blocks)

- **Scratch**
  - Invented @ MIT
  - Maintained by MIT
  - Huge community
  - Sharing via Website
  - No functions ☹
  - Scratch 2.0 in Flash
    - No iOS devices. ☹
  - scratch.mit.edu

- **BYOB (and *SNAP!*)**
  - Based on Scratch code
  - Maintained by jens & Cal
  - Growing community
  - No sharing (yet) ☹
  - Functions! ☺ … "Blocks"
  - Snap! Is in HTML5
    - All devices ☺
  - snap.berkeley.edu/run

Why use functions? (1)



```
pen down
repeat 4
    move 25 steps
    turn ↺ 90 degrees
pen up
```

```
pen down
repeat 4
    move 100 steps
    turn ↺ 90 degrees
pen up
```

```
pen down
repeat 4
    move 396 steps
    turn ↺ 90 degrees
pen up
```

```
Draw Square of Side length
pen down
repeat 4
    move length steps
    turn ↺ 90 degrees
pen up
```

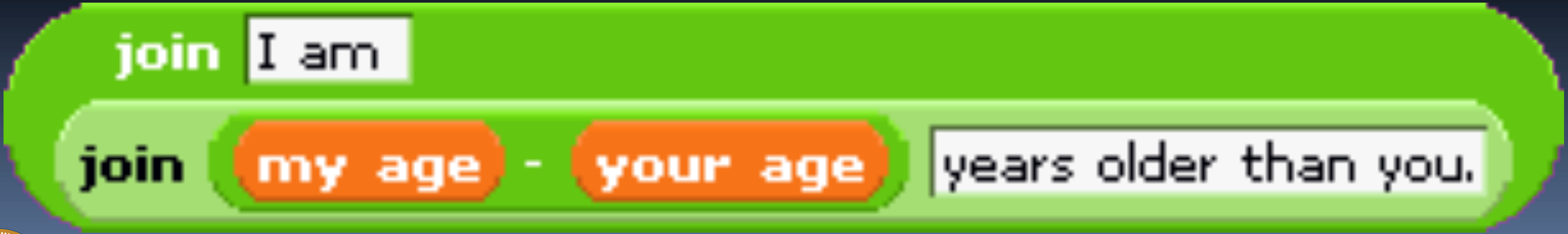
The power of **generalization**!

Why use functions? (2)

They can be **composed** together to make even more magnificent things.

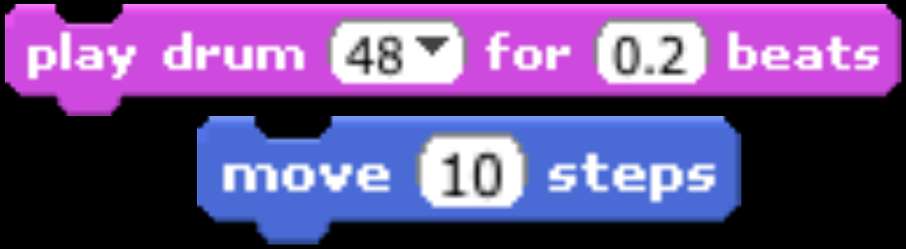
They are literally the **building blocks of almost everything** that we create when we program.

We call the process of breaking big problems down into smaller tasks **functional decomposition**

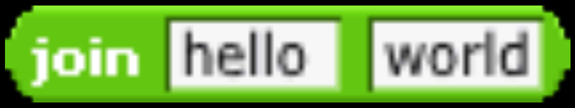


Types of Blocks

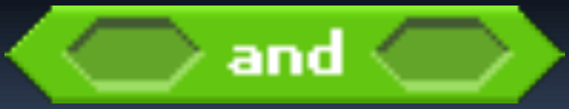
- **Command**
  - No outputs, meant for side-effects
  - Not a function…



- **Reporter (Function)**
  - Any type of output



- **Predicate (Function)**
  - Boolean output
    - (true or false)



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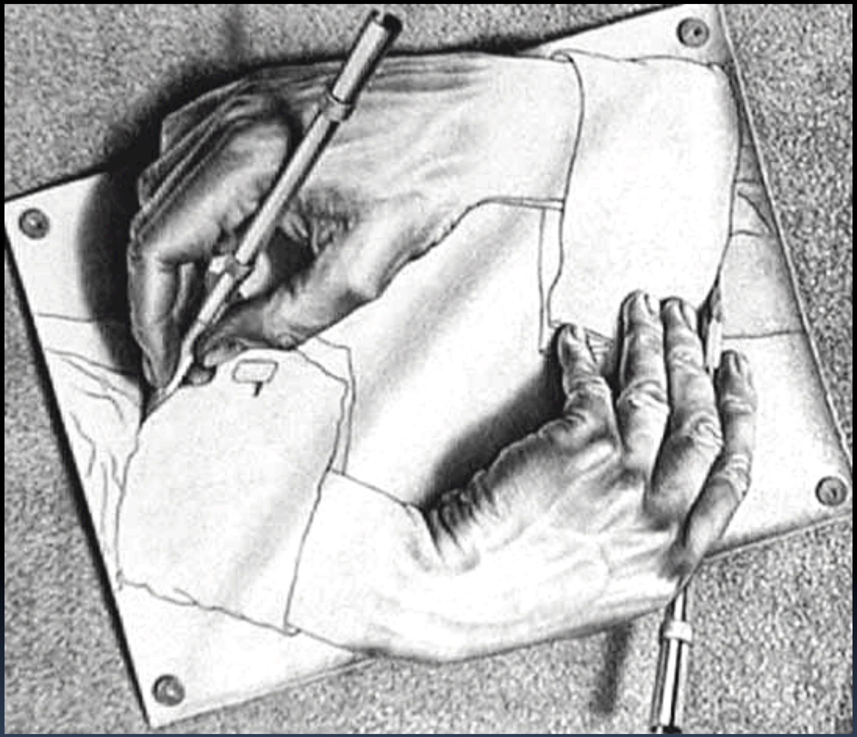
Quick Preview: Recursion

Recursion is a technique for defining functions that use themselves to complete their own definition.

We will spend a lot of time on this.

M. C. Escher : *Drawing Hands*



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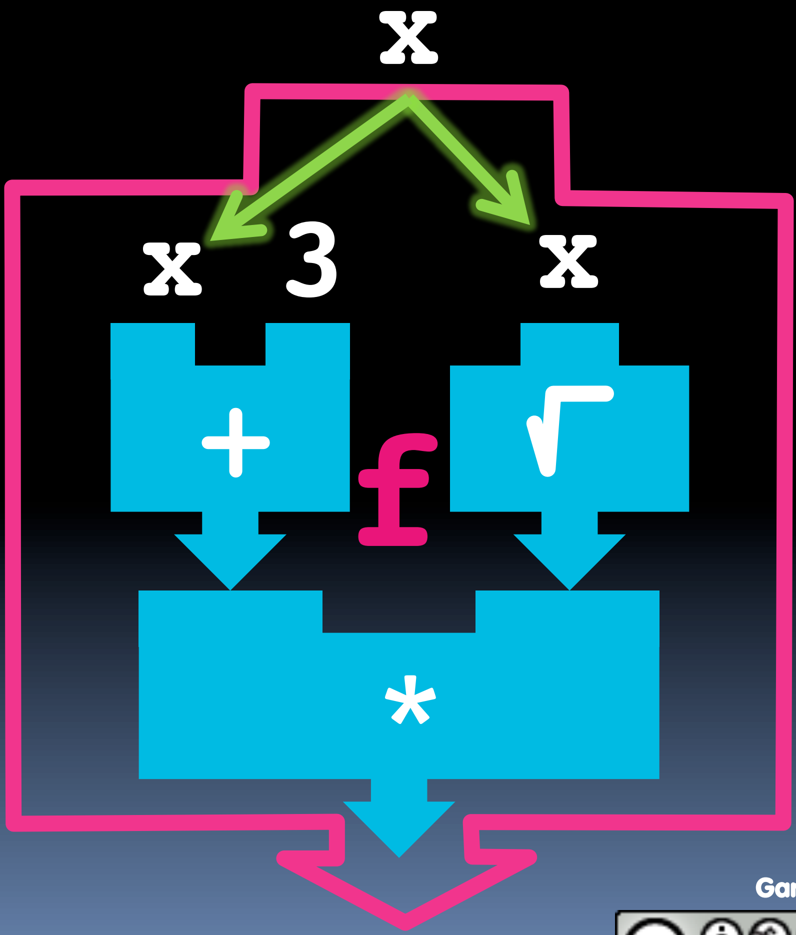
en.wikipedia.org/wiki/Functional_programming

Functions Summary

- Computation is the evaluation of functions
  - Plugging pipes together
  - Each pipe, or function, has exactly 1 output
  - Functions can be input!
- Features
  - No state
    - E.g., variable assignments
  - No mutation
    - E.g., changing variable values
  - No side effects
- Need BYOB/Snap!, and not Scratch 1.x

$$f(x)=(x+3)*\sqrt{x}$$



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