The Beauty and Joy of Computing

Lecture #2 : Functions

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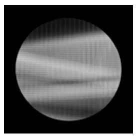
Get iClickers in Lab

Reading Quiz in first lab

INTEL BUILDS SPECIALIZED CHIPS FOR MOBILE SPEECH RECOGNITION

http://www.technologyreview.com/news/530491/hello-computer-intels-new-mobile-chips-are-always-listening/

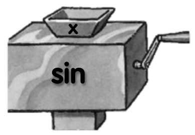


Abstraction (in CS10) REVIEW

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

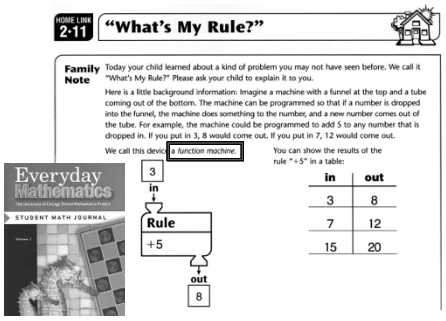
  y = sin(x)

  - 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.

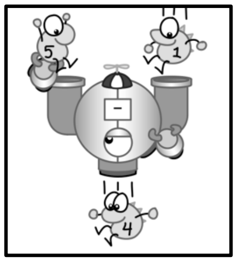
We call this device a *function machine.*

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

in	out
3	8
7	12
15	20

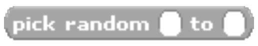
Function basics

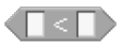
- **Functions take in 0 or more inputs and return exactly 1 output**
- **The same inputs MUST yield same outputs.**
  - Output function of input only
- **Other rules of functions**
  - No state (prior history)
  - No mutation (no variables get modified)
  - No side effects (nothing else happens)

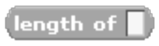


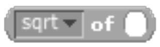
CS Illustrated function metaphor

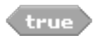
Which is NOT a function?

a) 

b) 

c) 

d) 

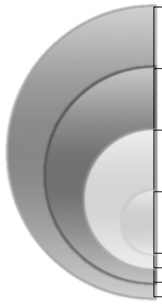
e) 

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

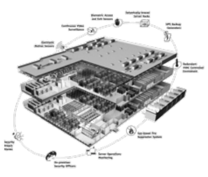
Types of input (there are more)



Sentences	• 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!

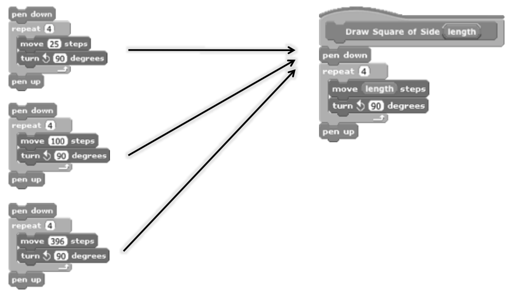
- **If a function only depends on the information it gets as input, then nothing else can affect the output.**
  - It can run on any computer and get the same answer.
- **This makes it incredibly easy to parallelize functions.**
  - Functional programming is a great model for writing software that runs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


Datacenter

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
```

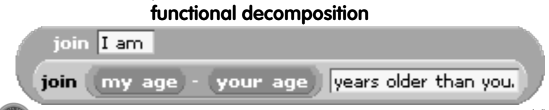
The power of generalization!

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.

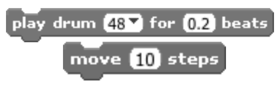
We call the process of breaking big problems down into smaller tasks functional decomposition



```
join I am
join (my age - your age) years older than you.
```

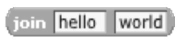
Types of Blocks

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



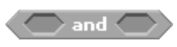
```
play drum 48 for 0.2 beats
move 10 steps
```

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



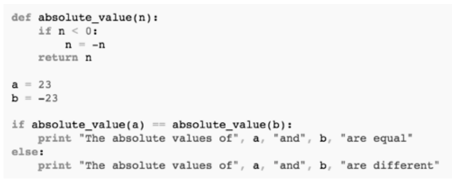
```
join hello world
```

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



```
and
```

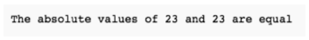
Quick Preview: Python



```
def absolute_value(n):
    if n < 0:
        n = -n
    return n

a = 23
b = -23

if absolute_value(a) == absolute_value(b):
    print "The absolute values of", a, "and", b, "are equal"
else:
    print "The absolute values of", a, "and", b, "are different"
```



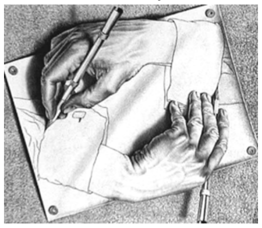
```
The absolute values of 23 and 23 are equal
```

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*



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**

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