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The Beauty and Joy of Computing

Lecture #2 Functions

Chip Design Savings from Functional Language?

A new functional language (you'll learn what that means today) *"makes it possible a chip design transformation is completely error-free"*. Huge potential cost-savings!
"Functional Programming is not part of the standard curriculum".
It is alive and well in Snap!, yay!

(xkcd.com/1270)

www.utwente.nl/en/newsevents/!/2015/1/167544/massive-chip-design-savings-to-be-realized

(Cal) When Do You Learn Things in CS10?

- **Lecture**
  - Computing in the News + Discussion
  - Big ideas, Inspiring Introductions, Demos
  - **NOT THE CODING DETAILS**
- **Lab, Homework, Projects**
  - Coding, Collaboration, Deep Learning
- **Reading**
  - Context, Impact of Computing, Current Events
- **Discussion**
  - Clarify week's material, Unplugged Activities

(Cal) Office Hours and Discussions

- **You can go to as many office hours and discussions as you wish!**
  - You're not just limited to your TA
- **Please check the schedule on cs10.org, as that will have the currently correct times.**
- **THIS WEEK ONLY: Dan's OH will start 30m late due to a conference call (10:30-11am) in 777 soda.**

Abstraction: Generalization REVIEW

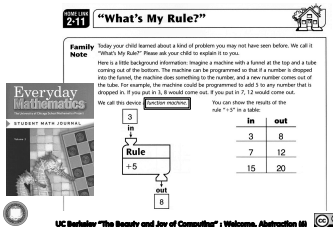
- **You are going to learn to write functions, like in math class:**

$$y = plus5(n)$$

  - plus5 is the function
  - n is the input, a number
  - It returns a single value, here a number 5 more than the input.

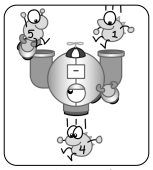
Function machine
(*Simply Scheme*, Harvey)

Functions in 2nd Grade Math Curricula!



Function Definition

- **Functions take in 0 or more inputs, 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)



Function Metaphor
(*CS Illustrated*, Ketrina Yim)

(Cal) Which is NOT a function?

a) pick random ◯ to ◯
b) ▯ < ▯
c) length of ▯
d) sqrt of ◯
e) true

Data Types (more later; you'll make too!)

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, #
Letter	• A-Z,a-z only • E.g., h

Domain and Range (from Math)

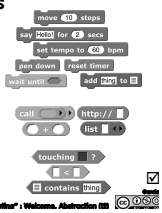
Domain
- The "class" of input a function accepts
- **Examples**
  - Sqrt of
    - Non-negative numbers
  - Length of
    - Sentence, word, number
  - _ < _
    - Sentence, word, number
  - _ and _
    - Boolean

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)

Types of Blocks in Snap!

Procedures, Subroutines

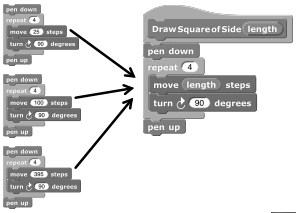
- **Command**
  - No outputs, meant for side-effects
  - Not a function…
- **Reporter (Function)**
  - Any type of output
- **Predicate (Function)**
  - Boolean output
    - (true or false)



(Cal) Domain, Range of…

	Domain	Range
a)	Integer ≥ 1, Number	Digit
b)	Integer ≥ 1, Word	Letter
c)	Integer ≥ 1, Word	Character
d)	Integer ≥ 1, Sentence	Letter
e)	Integer ≥ 1, Sentence	Character

Why Use Functions? (1/3)



Why Use Functions? (2/3)

- **They allow for generalization of code!**
- **The building blocks of our programs**
- **They can be composed together to make even more magnificent things.**
- **Breaking big problems down into smaller ones is functional**

Why Use Functions? (3/3)

en.wikipedia.org/wiki/Functional_programming

- **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 easy to parallelize computation.**
  - Functional programming is a great model for writing software that runs on multiple systems at the same time.

Cabinet Aisle in a Datacenter
(*Wikipedia*, Robert Harker)

Quick Preview: Recursion

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

This is one of our Big Ideas!

Recursion in Screen Recording Program
(*Wikipedia*, Hidro)

Functions Summary

- **Abstraction: Generalization**
- **Computation is the evaluation of functions**
  - Plugging pipes together
  - Function: ≥ 0 inputs, 1 output
  - Functions can be input!
- **Features**
  - No state
    - E.g., variable assignments
  - No mutation
    - E.g., changing variable values
  - No side effects
    - E.g., nothing else happens

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