61A Lecture 6

Friday, September 12

Announcements

- Homework 2 due Monday 9/15 @ 11:59pm
- Project 1 due Wednesday 9/17 @ 11:59pm
- Optional Guerrilla section Saturday 9/13 @ 12:30pm in 306 Soda about higher-order functions
  - Organized by Andrew Huang and the readers
  - Work in a group on a problem until everyone in the group understands the solution
- Project party on Monday 9/15, 3pm-4pm in Wozniak Lounge and 6pm-8pm in 2050 VLSB
- Midterm 1 on Monday 9/22 from 7pm to 9pm
  - Details and review materials will be posted next week
  - There will be a web form for students who cannot attend due to a conflict
- There's a pinned Piazza thread to find partners

Lambda Expressions

(Demo)

Lambda Expressions

```
>>> x = 10
>>> square = x * x
>>> square = lambda x: x * x
>>> square(4)
16
```

An expression: this one evaluates to a number

Also an expression: evaluates to a function

Important: No "return" keyword!

A function

with formal parameter x

that returns the value of "x * x"

Must be a single expression

Lambda expressions are not common in Python, but important in general

Lambda expressions in Python cannot contain statements at all!

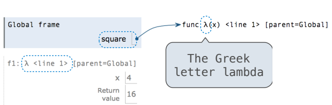
Lambda Expressions Versus Def Statements

```
square = lambda x: x * x
```

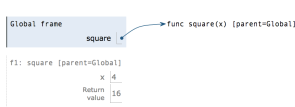
VS

```
def square(x):
    return x * x
```

- Both create a function with the same domain, range, and behavior.
- Both functions have as their parent the frame in which they were defined.
- Both bind that function to the name square.
- Only the def statement gives the function an intrinsic name.



The Greek letter lambda



Currying

Function Currying

```
def make_adder(n):
    return lambda k: n + k
```

```
>>> make_adder(2)(3)
5
>>> add(2, 3)
5
```

There's a general relationship between these functions

(Demo)

Curry: Transform a multi-argument function into a single-argument, higher-order function.

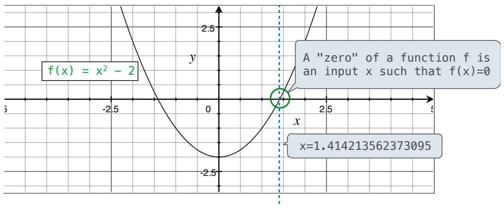
Currying was discovered by Moses Schönfinkel and re-discovered by Haskell Curry.

Schönfinkeling?

Newton's Method

Newton's Method Background

Quickly finds accurate approximations to zeroes of differentiable functions!



Application: a method for computing square roots, cube roots, etc.

The positive zero of $f(x) = x^2 - a$ is $\sqrt{a}$. (We're solving the equation $x^2 = a$.)

Newton's Method

Given a function f and initial guess x,

Repeatedly improve x:

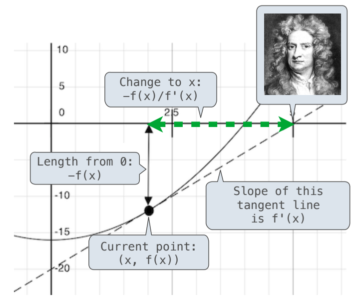
Compute the value of f at the guess: f(x)

Compute the derivative of f at the guess: f'(x)

Update guess x to be:

$$x - \frac{f(x)}{f'(x)}$$

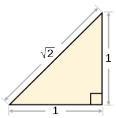
Finish when f(x) = 0 (or close enough)



http://en.wikipedia.org/wiki/File:NewtonIteration_Ani.gif

Using Newton's Method

How to find the square root of 2?

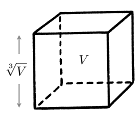


```
>>> f  = lambda x: x*x - 2
>>> df = lambda x: 2*x
>>> find_zero(f, df)
1.4142135623730951
```

$f(x) = x^2 - 2$
$f'(x) = 2x$

Applies Newton's method

How to find the cube root of 729?



```
>>> g  = lambda x: x*x*x - 729
>>> dg = lambda x: 3*x*x
>>> find_zero(g, dg)
9.0
```

$g(x) = x^3 - 729$
$g'(x) = 3x^2$

Iterative Improvement

Special Case: Square Roots

How to compute square_root(a)

Idea: Iteratively refine a guess x about the square root of a

Update: $$x = \frac{x + \frac{a}{x}}{2}$$

Babylonian Method

Implementation questions:

What guess should start the computation?

How do we know when we are finished?

Special Case: Cube Roots

How to compute cube_root(a)

Idea: Iteratively refine a guess x about the cube root of a

Update: $$x = \frac{2 \cdot x + \frac{a}{x^2}}{3}$$

Implementation questions:

What guess should start the computation?

How do we know when we are finished?

Implementing Newton's Method

(Demo)