

introduction (week 1+)

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Introduction

Administrative trivia

- Instructor: Ben Bolker
 - `bolker@mcmaster.ca`: please include `1mp3` in Subject:
 - `http://www.math.mcmaster.ca/bolker`
 - HH 314 (sometimes LSB 336); office hours TBA
- TA: Brydon Eastman (`eastmab@mcmaster.ca`) and Peter Tait (`taitpa@mcmaster.ca`).
- Grading:
 - midterm 20%
 - final 30%
 - in-class CodeLab assignments 15% (drop lowest 4)
 - weekly assignments 15%
 - project 20%
- Laptop policy
- Course material on Github and Avenue
- Expectations of professor and students
- Textbook (optional); also see resources
- Course content: reasonable balance among
 - nitty-gritty practical programming instruction:
 - ... I just sat down in front of a text editor, with nothing but thoughts, and ended up with a program that did exactly what I wanted it to a few hours later ... (ankit panda)
 - conceptual foundations of computing/computer science
 - context/culture of mathematical/scientific computing
 - interesting applications

Installing Python

- CodeLab: `http://www.turingscraft.com/go.html`
- PythonAnywhere
- Everyone must have access to a computer with Python3 installed.
 - See installation instructions

More interesting stuff

Using computers in math and science

- math users vs. understanders vs. developers
- develop conjectures; draw pictures; write manuscripts
- mathematical proof (e.g. four-color theorem and other examples); computer algebra
- applied math: cryptography, tomography, logistics, finance, fluid dynamics, ...
- applied statistics: bioinformatics, Big Data/analytics, ...

- discrete vs. continuous math

Fun!

Hello, world (always the first program you write in a new computer language)

```
print('hello, python world!')
```

```
## hello, python world!
```

Python as a fancy calculator:

```
print(62**2*27/5+3)
```

```
## 20760.6
```

reference: Python intro section 3.1.1

Interlude: about Python

- programming languages
 - Python: scripting; high-level; glue; general-purpose; flexible
 - contrast: *domain-specific* scripting languages (MATLAB, R, Mathematica, Maple)
 - contrast: *general-purpose* scripting languages (Perl, PHP)
 - contrast: general-purpose *compiled* languages (Java, C, C++) (“close to the metal”)
- relatively modern (1990s; Python 3, 2008)
- currently the 5th most popular computer language overall (up from 8th in 2015); most popular for teaching
- well suited to mathematical/scientific/technical (NumPy; SciPy; Python in Finance)
- ex.: Sage; BioPython

the “prime walk” (from math.stackexchange.ca)

1. start at the origin, heading right, counting up from 1
2. move forward one space, counting up, until you find a prime
3. turn 90° clockwise
4. repeat steps 2 and 3 until you get bored


(example)

Note:

- easier to understand/modify than write from scratch
- build on existing components (*modules*)

Interfaces

- command line/console (PyCharm: Tools/Python Console)
- programming editor
- integrated development environment (IDE)

- **not** MS Word! 

Features

- syntax highlighting
- bracket-matching
- hot-pasting
- integrated help
- integrated debugging tools
- integrated project management tools
- **most important:** maintain reproducibility; well-defined **workflows**

Assignment and types (PP §2.4)

- superficially simple
 - set aside *memory* space, create a symbol that *points to* that space
 - = is the **assignment operator** (“gets”, not “equals”)
 - `<variable> = <value>`
 - variable names
 - * what is legal? (names include letters, numbers, underscores, must start with a letter)
 - * what is customary? convention is **variables_like_this** (“snake case”)
 - * what works well? `v` vs. **temporary_variable_for_loop**
 - * same principles apply to file, directory/folder names
- variables are of different **types**
 - built-in: integer (**int**), floating-point (**float**), complex, **Boolean** (**bool**: **True** or **False**),
 - *dynamic* typing
 - * Python usually “does what you mean”, converts types when sensible
 - (relatively) *strong* typing
 - * try `print(type(x))` for different possibilities (`x=3`; `x=3.0`; `x="a"`)
 - * *what happens if you try `x=a`?*
 - * **don’t be afraid to experiment!**

```
x=3
y=3.0
z="a"
q=complex(1,2)
type(x+y)    ## mixed arithmetic
type(int(x+y)) ## int(), float() convert explicitly
type(x+z)
type(q)
type(x+q)
type(True)
type(True+1) ## WAT
```

[^2](As Dive into Python says in a similar context, “Ew, ew, ew! Don’t do that. Forget I even mentioned it.”)

Check out the Python tutor for these examples

Arithmetic operators, precedence

- exponentiation (******)
- negation (“unary minus”) (**-**)

- multiplication/division (*,/,//=integer division,%=remainder (“modulo”))
- addition/subtraction (+, - (“binary”))

Use parentheses when in doubt!

Puzzle: what is `-1**2`? Why?

Logical operators (PP §5.1)

- comparison: (`=`, `!=`)
- inequalities: `>`, `<`, `>=`, `<=`,
- basic logic: (`and`, `or`, `not`)
- remember your truth tables, e.g. `not(a and b)` equals `(not a) or (not b)`

```
a = True; b = False; c=1; d=0
a and b
not(a and not b)
a and not(b>c)
a==c  ## careful!
not(d)
not(c)
```

- **operator precedence:** same issue as order of operations in arithmetic; `not` has higher precedence than `and`, `or`. When in doubt use parentheses ...

From CodingBat:

We have two monkeys, `a` and `b`, and the parameters `a_smile` and `b_smile` indicate if each is smiling. We are in trouble if they are both smiling or if neither of them is smiling. Return `True` if we are in trouble.

```
monkey_trouble(True, True) → True
monkey_trouble(False, False) → True
monkey_trouble(True, False) → False
```

More CodingBat problems:

- `squirrel_play`
- `cigar_party`

String operations (PP chapter 4)

reference: Python intro section 3.1.2

- Less generally important, but fun
- `+` concatenates
- `*` replicates and concatenates
- `in` searches for a substring

```
a = "xyz"
b = "abc"
a+1  ## error
a+b
b*3
(a+" ")*5
b in a
```

CodingBat problems:

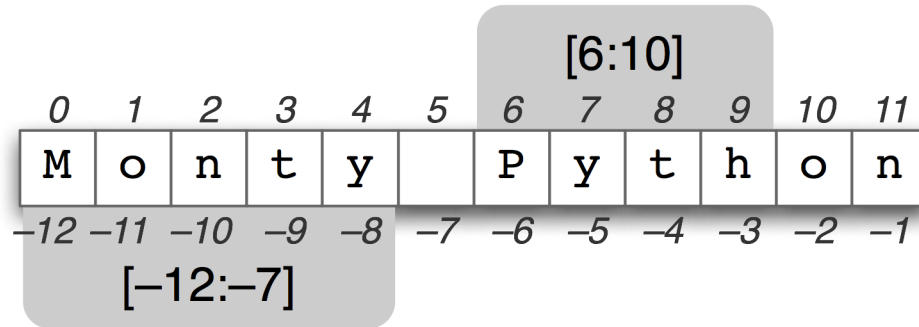


Figure 1: slicing

- make_abba
- make_tags

One more useful string operation: `len(s)` returns the length (number of characters)

Indexing and slicing

Indexing

- Extracting elements is called **indexing** a list
- Indexing starts from zero
- Negative indices count backward from the end of the string (-1 is the last element)
- Indexing a non-existent element gives an error

Slicing

- Extracting (consecutive) sets of elements is called **slicing**
- Slicing non-existent element(s) gives a truncated result
- Slicing specifies *start*, *end*, *step* (or “stride”)
- Leaving out a bit goes from the beginning/to the end
- Slicing works on strings too!

```
x[:]      # everything
x[a:b]    # element a (zero-indexed) to b-1
x[a:]     # a to end
x[:b]     # beginning to b-1
x[a:b:n]  # from a to b-1 in steps of n
```

- generate a list of odd numbers from 3 to 15
- reverse a string?

String slicing practice

From CodingBat:

- first_two
- first_half

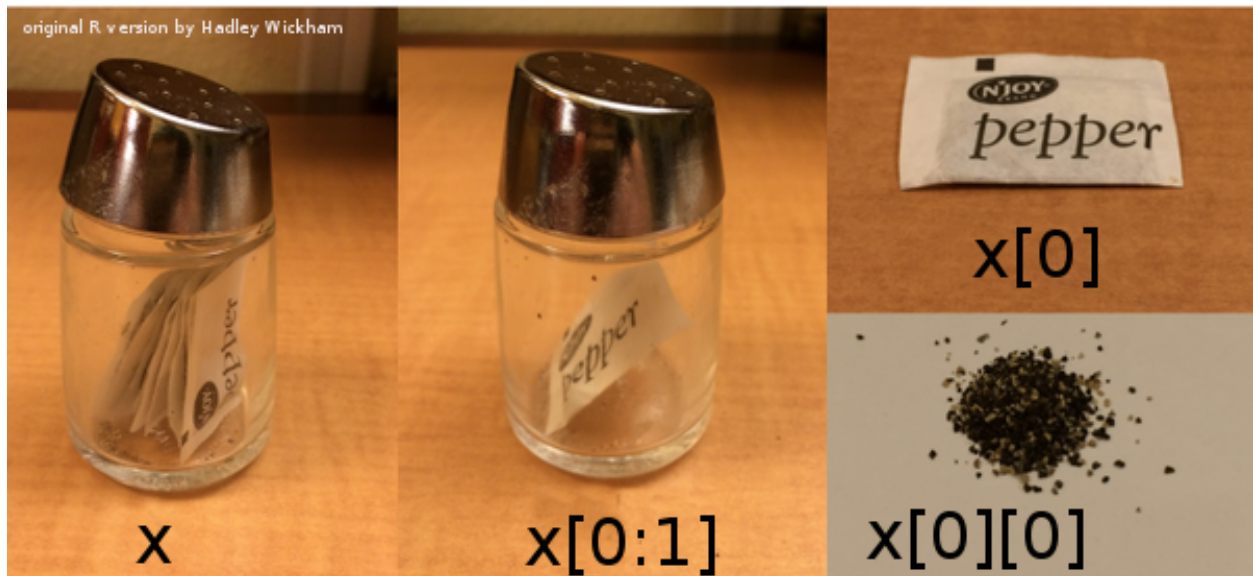


Figure 2:

Lists and indexing (PP chapter 8)

reference: Python intro section 3.1.3

Lists

- Use square brackets `[]` to set up a **list**
- Lists can contain anything but usually homogeneous
- Put other variables into lists
- `range()` makes a **range** but you can turn it into a list with `list()`
 - Set up a list that runs from 101 to 200
- Indexing and slicing lists works almost the same way as indexing and slicing ...
- Put lists into lists! (“yo dawg ...”)
 - difference between an *item from a list* (indexing, `x[0]`) and a *one-element list* (slicing, `x[0:1]`)

Other list operations

- Lots of things you can do with lists!
- Lists are **mutable**

```
x = [1,2,3]
y = x
y[2] = 17
print(x)
```

```
## [1, 2, 17]
```

Check it out at Python Tutor

- *operators* vs. *functions* vs. *methods* `x+y` vs. `foo(x,y)` vs. `x.foo(y)`
 - list *methods*
 - appending and extending:

```
x = [1,2,3]
y = [4,5]
x.append(y)
print(x)
```

```
## [1, 2, 3, [4, 5]]
```

```
x = [1,2,3] # reset x
y = [4,5]
x.extend(y)
print(x)
```

```
## [1, 2, 3, 4, 5]
```

Can use + and += as shortcut for extending:

```
x = [1,2,3]
y = [4,5]
z = x+y
print(z)
```

```
## [1, 2, 3, 4, 5]
```

- `x.insert(position,value)`: inserts (or `x=x[0:position]+[value]+x[position+1:len(x)]`)
- `x.remove(value)`: removes *first* value
- `x.pop(position)` (or `del x[position]` or `x=x[0:position]+x[position+1:len(x)]`)
- `x.reverse()` (or `x[::-1]`)
- `x.sort()`: what it says
- `x.count(value)`: number of occurrences of `value`
- `x.index(value)`: first occurrence of `value`
- `value in x`: does `value` occur in `x`? (or `logical(x.count(value)==0)`)
- `len(x)`: length

Note: pythonicity vs. TMTOWTDI