Computational Structures in Data Science

Lecture 2:
Abstraction and Functions

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For fun: Stable Diffusion demo (link)

- Prompt: “A dog learning how to program Python and SQL for Data C88C, a data science course. high definition hd 1080p high quality good lighting high resolution”

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Announcements

- Join the EECS 101 and DATA 001 Ed Discussions!
  - https://eecs.link/join-ed
  - https://eecs.link/data-ed
  - Optional resources for finding additional help on course material.
- Hopefully not needed! *Please,* report any concerns about class / campus climate to the department, CS or DS. *You* are welcome here!
- https://eecs.link/climate

Announcements – Waitlist

- Enrolled stats (as of 2024-06-17 11:40 pm pst)
  - 117 / 136 students enrolled, 4 waitlisted
  - CalCentral:
  - You need to be in a section to to be enrolled.
  - Please reach out to **advisors** about enrollment q's.

Links

- Q&A Thread: https://edstem.org/us/courses/59252/discussion/5048437
- Self-Check: https://www.gradescope.com/courses/786589/assignments/4509835/
- Website Google Calendar: https://c88c.org/su24/weekly-schedule.html
- Tip: https://c88c.org now redirects to https://c88c.org/su24

Computational Structures in Data Science

Abstraction

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Abstraction

- Detail removal

  "The act of leaving out of consideration one or more properties of a complex object so as to attend to others."

- Generalization

  "The process of formulating general concepts by abstracting common properties of instances"

- Technical terms: Compression, Quantization, Clustering, Unsupervized Learning

Henri Matisse *"Naked Blue IV"*

Experiment – **Where are you from?**

Where are you from?

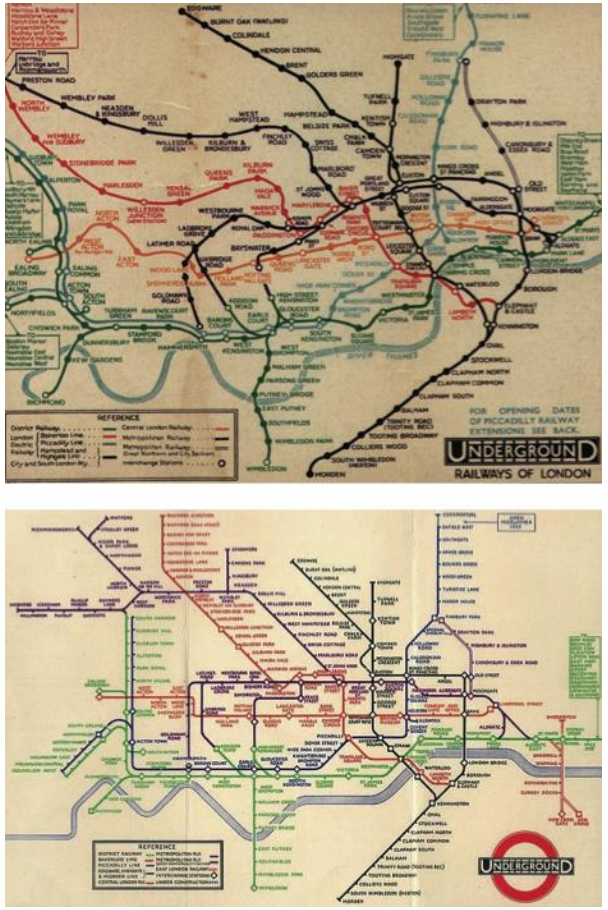
Possible Answers:

- Planet Earth
- Europe
- California
- The Bay Area
- San Mateo
- 1947 Center Street, Berkeley, CA
- 37.8693° N, 122.2696° W

All correct but different levels of abstraction!

Detail Removal (in Data Science)

- You'll want to look at only the interesting data, leave out the details, zoom in/out…
- Abstraction is the idea that you focus on the essence, the cleanest way to map the messy real world to one you can build
- Experts are often brought in to know what to remove and what to keep!



The London Underground 1928 Map & the 1933 map by Harry Beck.

The Power of Abstraction, Everywhere!

- Examples:
  - Math Functions (e.g., sin x)
  - Hiring contractors
  - Application Programming Interfaces (APIs)
  - Technology (e.g., cars)

- Amazing things are built when these layer
  - And the abstraction layers are getting deeper by the day!

We only need to worry about the interface, or specification, or contract NOT how (or by whom) it's built

Above the abstraction line

Abstraction Barrier (Interface)
(the interface, or specification, or contract)

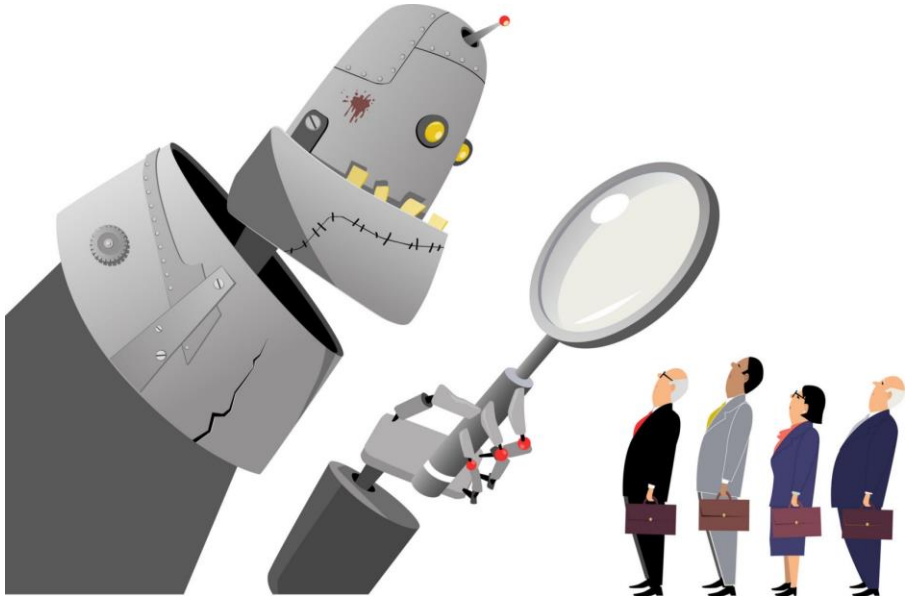
Below the abstraction line

This is where / how / when / by whom it is actually built, which is done according to the interface, specification, or contract.

Abstraction: Pitfalls

- Abstraction is not universal without loss of information (mathematically provable). This means, in the end, the complexity can only be “moved around”

- Abstraction makes us forget how things actually work and can therefore hide bias. Example: AI and hiring decisions.



- Abstractions can formalize a design or pattern. When something doesn't follow that pattern–perhaps a new use case emerges–it can be a burden to adapt.

Data or Code? Abstraction→ Take CS61C

Human-readable code (programming language)

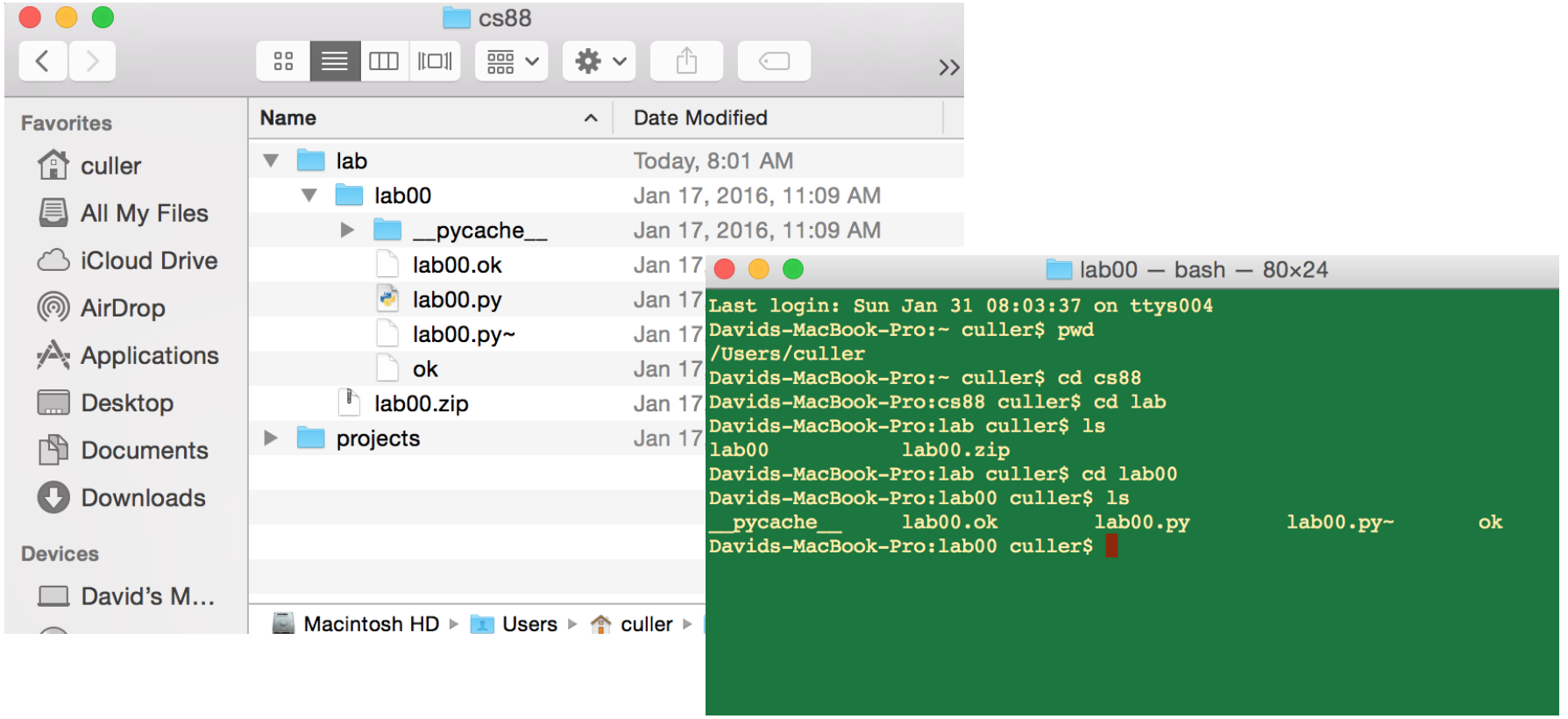
```
def add5(x):
    return x+5

def dotwrite(ast):
    nodename = getNodename()
    label=symbol.sym_name.get(int(ast[0]),ast[0])
    print ' %s [label="%s' % (nodename, label),
    if isinstance(ast[1], str):
        if ast[1].strip():
            print '= %s"];' % ast[1]
        else:
            print '"]'
    else:
        print '"];'
        children = []
        for n, child in enumerate(ast[1:]):
            children.append(dotwrite(child))
        print ' %s -> {' % nodename,
        for name in children:
            print '%s' % name,
```

Machine-executable instructions (byte code)

Compiler or Interpreter

Here: Python

Computers Are Built On Abstractions



- Big Idea: Layers of Abstraction
  - The *GUI* look and feel is built out of files, directories, system code, etc.

Review:

- Abstraction:
  - Detail Removal or Generalizations
- Code:
  - Is an abstraction!

Computer Science is the study (and building) of abstractions

Computational Structures in Data Science

Python:
Expressions and Statements

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Eric Kim | UC Berkeley |

Learning Objectives

- Evaluate expressions in Python
- *Name* data so it can be used later.
- Get practice with the Python Interpreter

Demo!

- Run the Python interpreter (`python3`) on your computer
- Practice seeing the results of expressions
- Use Control-L to clear the screen
- Use Control-D or type `exit()` to exit Python.
- The interpreter does not save any work!

Let’s talk Python

Expression

Call expression

Variables

Assignment Statement

Define Statement

Control Statements

Comments

```
max(88, 61)
```

```
greeting
```

```
greeting = <expression>
```

```
def name(<arguments>):
```

```
if, else, for, while …
```

```
# Text are a # is
ignored.
```

```
8 * 11
```

Expressions

An *expression* is code that produces or *evaluates* to a value.

A *call expression* simply means that expression involves calling a function.

```
8 * 11
8 + 80
max(88, 61)
len('Berkeley')
```

Names and Statements

- *Statements* are code that does something, but does not produce a value!
- *Assignment Statements* bind some value to a *name* which can be used later. (A *variable)*

```
print('Welcome to 88C!')
course = '88C'
print('Welcome to ' + course + '!')
```

Numbers (`int` and `float`)

- Numbers come in two types: integers, and decimals
  - Why? Partially historical reasons, partially for speed
- Python is forgiving!
  - In most cases you can mix them up just fine.
- Numbers support many common operations:
  - +, -, /, *, ** (power), % (modulus), // (floor division)
- Try: `import math`
- Lots of math examples

Strings and Text

- Data inside quotes "" is called a *string*
- Python allows single quotes or double quotes
- Strings support useful operations like concatenation with +
- "f-strings" allow us to nicely format text

- `f"Hello, {course}!"`
- `f"2 times 2 is {2*x}"`

Boolean Expressions

- Booleans are Yes/No values.
  - In Python: `True` and `False`
- `>, <, ==, !=, >=, <=, and, or`
  - Note the the "double equals"
- These expressions all return only True or False.
- `3 < 5` # returns True
- You can write `3 < 5 == True` – but this is redundant.
- We'll keep practicing over time

Boolean Expressions: and and or

- And and Or tell us the result of combining Boolean expressions
- `and` evaluates to `True` when both `a` and `b` are True
- `or` evaluates to `True` when either `a` or `b` is True

Expression	Result
`True and True`	`True`
`True and False`	`False`
`False and True`	`False`
`False and False`	`False`

Expression	Result
`True or True`	`True`
`True or False`	`True`
`False or True`	`True`
`False or False`	`False`

Statements and Expressions: Review

- Expressions evaluate to a result
- We can combine expressions for more complex problems
- We assign names to values using =

Live Coding Demo

- Open Terminal on the Mac
- Type `python3`
  - We are now in the "interpreter" and can type code.
- Python runs each line of code as we type it.
  - After each line, we see a result. This happens *only* in the interpreter.
- It's a very useful calculator.
- We can also run files!
- `python3 -i 02-Functions.py`
  - `-i :` This means open the interpreter after running the file. It's optional
- `python3 ok …`
  - This runs the file "ok" which is included with each lab / homework.

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Function Definitions

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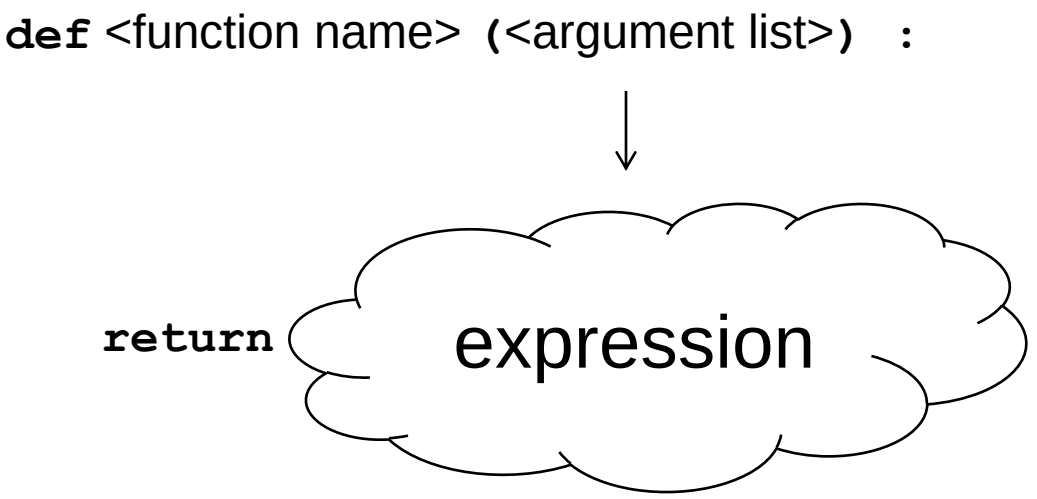
Defining Functions

- Abstracts an expression or set of statements to apply to lots of instances of the problem
- A function should do one thing well



Functions: Example

- Let's write a simple function which returns 8 more than the number.

- We will call this function by writing add_8(80).
- Inside, the name num will become the value 80.

```
def add_8(num):
    """add 8 to the input num
    >>> add_8(80)
    88
    """
    return 8 + num
```

Functions in Python

- We "define" them with def
- We typically name_them_using_underscores ("Snake case")
- The first line ends in a :
- The body is indented by 4 spaces (or 1 tab)
- Arguments (parameters) create 'names' that exist only in our function
- All functions return some value
  - We usually use `return`
  - If we omit return, the value is `None`

Function Arguments

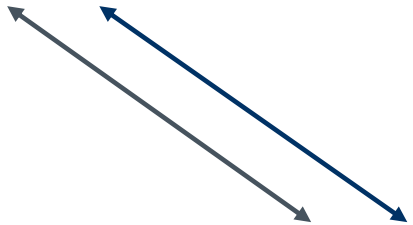
- When we define a function, we provide 0 or more *arguments*
- Arguments define names that exist only within the function
- When we call a function, we pass *parameters* to the function
- Each parameter is mapped 1-to-1, left-to-right to an argument

```
def is_even(x):
    return x % 2 == 0

is_even(2)
```


Functions: Example

```
>>> y = 5
>>> x = 3
>>> z = max(x, y)
>>> z
5
```



```
def max(x, y):
    if x > y:
        return x
    else:
        return y
```

How to Write a Good Function

- Give a descriptive name
  - Function names should be lowercase. If necessary, separate words by underscores to improve readability. Names are extremely suggestive!
- Chose meaningful parameter names
  - Again, names are extremely suggestive.

Live Coding Demo

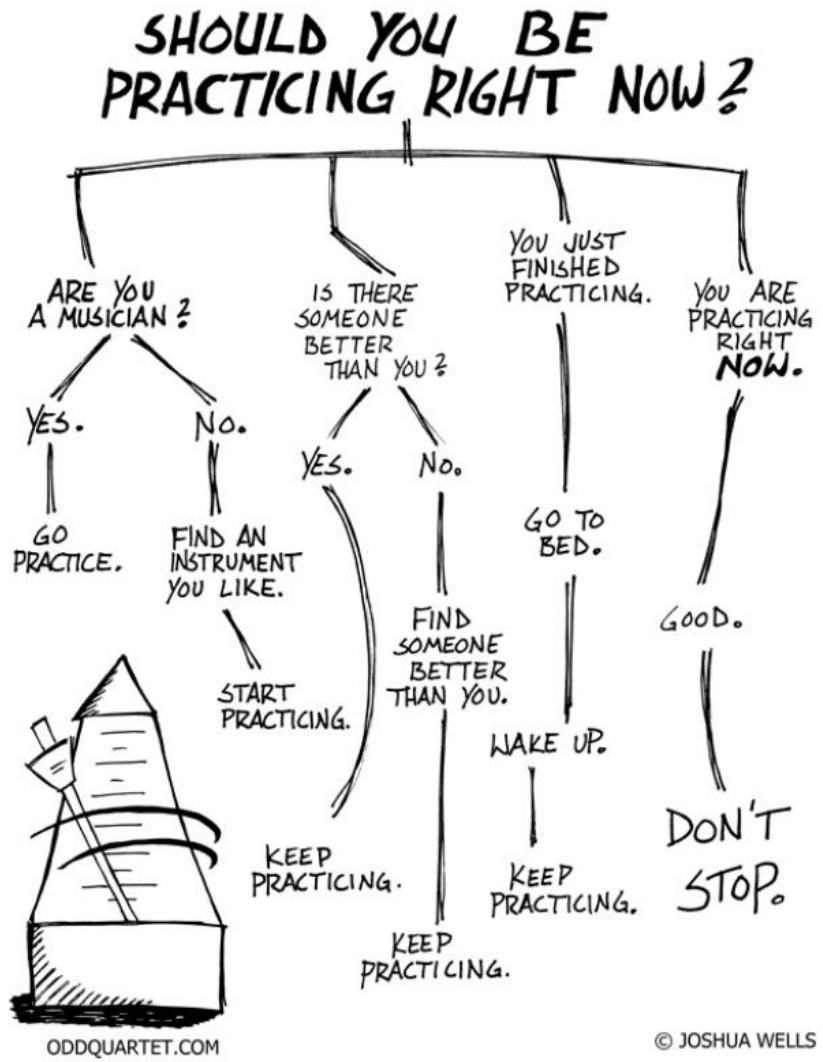
- Make and call simple functions

Outro

- Today we went over:
  - Abstractions
  - Intro to Python syntax
    - Expressions, Statements, Control Flow, Functions (preview)

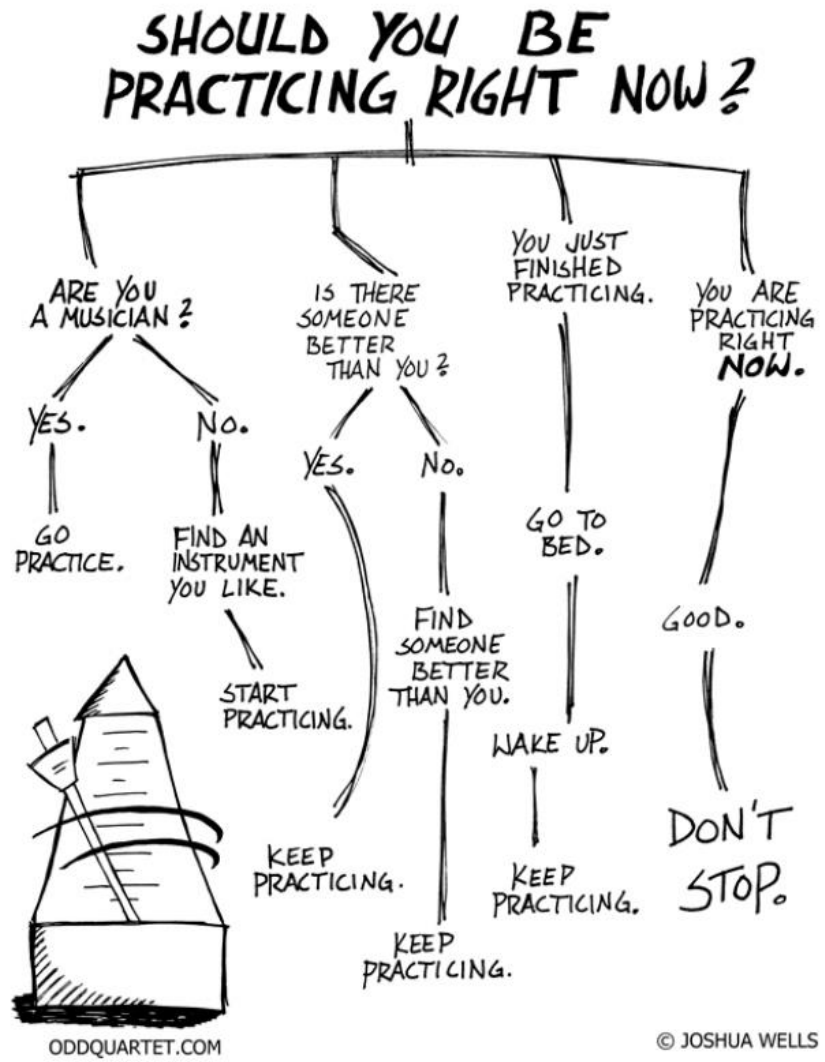
Outro

- You may feel like Python code is still a mystery…
  - …and you'd (probably) be right! And that's 100% OK!



Outro

- Learning to code requires HANDS-ON, deliberate practice. Like a craft (woodworking, music, etc)
- Good news: this is what Labs, HWs, and projects are for!
- So, keep up the practice, and stay curious + motivated ☺



Outro

- Exciting news: it's never been easier to get into coding/CS/AI/ML/data-science
- libraries like pytorch, tensorflow, pandas, scikit-learn, etc have **dramatically** lowered the barrier of entry in the past 7 years
  - Ex: In just a few hours of setup, an individual can conceivably start training a state-of-the-art ML model (modulo expensive $ GPU hardware)

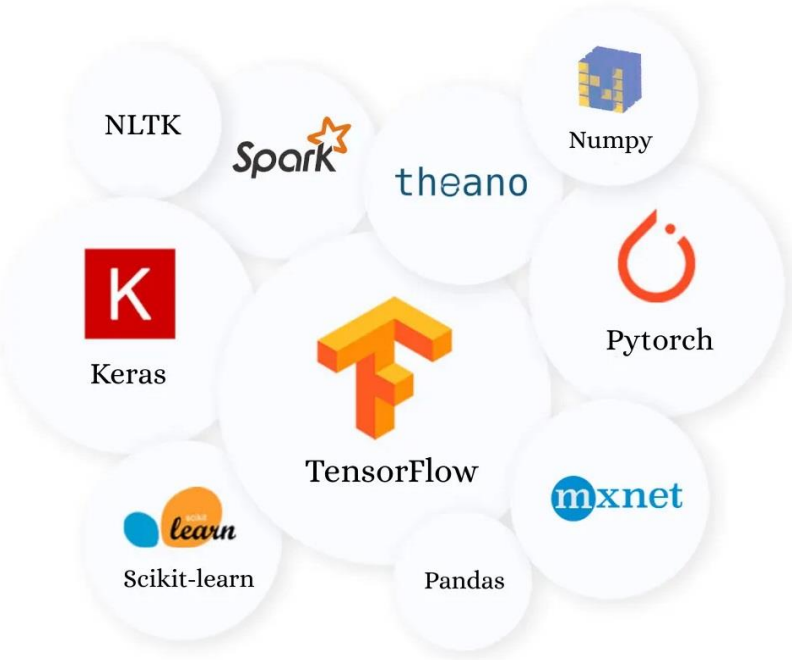


Image from: https://towardsdatascience.com/best-python-libraries-for-machine-learning-and-deep-learning-b0bd40c7e8c

Outro

- And, for what it's worth: a LOT of data science work (in both industry and academia) these days is done in Python + SQL.
  - Thus, all of your hard work this summer will be 100% worth it!
- Secret fun fact: a lot of work is also done in Excel / Google Sheets. Even in CompSci! Haha. Semi joking :P

Questions?

- Questions?

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Functions and Environments

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Functions: Calling and Returning Results

Python Tutor

```
def max(x, y):
    return x if x > y else y

x = 3
y = 4 + max(17, x + 6) * 0.1
z = x / y
```