Compsci 101, Functions

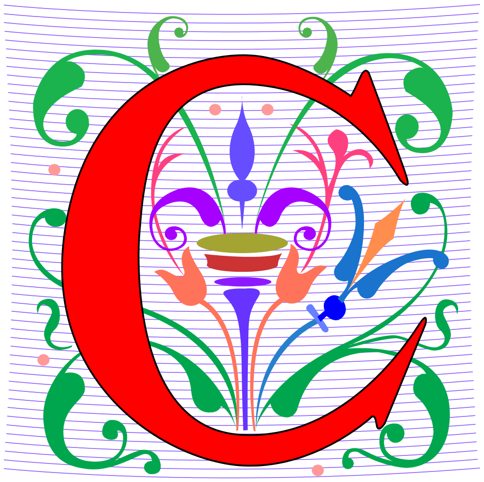
Owen Astrachan

Kristin Stephens-Martinez

January 23, 2018

C is for …

- **Computer Science and Computing**
  - It's what we do
- **Collaboration**
  - Review the policy
- **Cookies**
  - Good for the web and for …
- **CSV**
  - Comma Separated Values: Data



PFTD and toward PFTW

- Functions in Python
  - Decomposition, parameters, calling
- Flow of Control
  - How does a program execute, how do function calls work?
- Program Development and Execution
  - How do you run a program, test a program, debug a program

Where were we?

- **Last time we read/solved the BMI APT**
  - Project, Module, Code, Fail/Red, Pass/Green

- **The function calculate was in the BMI module**
  - The function call can be from elsewhere
  - The APT framework imports BMI module and calls the function you wrote

BMI dissected

- What is formula? How to use and re-use?
  - Functions allow code to be re-used
  - Square root, len, BMI.calculate
- How do we validate/test our code?
  - APT testing harness

call replaced by return value, why use function?

```
def bmi(weight, height):
    return 703.07 * weight/(height*height)

if bmi(170,72) < 18.5:
  print ("underweight")
```

Understanding Execution

- Using PythonTutor: https://goo.gl/7R1zUK
  - How are functions defined?
  - Where does execution begin?
  - What is the global frame?
  - What is a local/function frame?

- What is **`if __name__ == “__main__”:`**
  - Where execution begins
  - Optional but useful for APTs

Anatomy of Return Statement

- Execution is one line/statement at a time
  - After one statement, next statement
  - Calling a function transfers control to function
    - When finished? Control transferred back
- Return value replaces function call

```
x = math.sqrt(25)
if bmi(170,72) < 18.5:
   print("underweight")
```

- None returned by default!

What PythonTutor Demonstrates

- What happens when program is first “executed”?
  - Functions are referenced in global frame
  - Execution begins in main program block

- What happens when function called?
  - Arguments passed as parameters to function
    - See green and red arrows when executing
  - Control passes to function which executes
  - Return value replaces function call

What we saw, learned

- Variable names are local to a function
  - Use useful names when possible

- Parameter names v argument names
  - Argument can be value/expression
  - Types must agree! Int to float? Ok. Int to String?

- Understand and visualize your code
  - Helps in debugging, need mental model

WOTO Redux

http://bit.ly/101spring18-jan16-2

Testing BMI.calculate

- The function calculate is in Module BMI
  - Wrote the function, how to call it?
  - You can test if you provide main!
  - Alternatively, import into PyDev Console

- In PyDev console
  - Must write import BMI
  - Must call BMI.calculate(3,2) for example

APT Testing and Submission

- You wrote the code, how is it tested?
  - Submit .py module with function to server
  - Server tests and checks by calling your function

- The APT testing framework calls your code!
  - Don't call us, we'll call you: *Hollywood principle*

- Test, Submit, Reflect
  - Make sure you do all three! See web pages

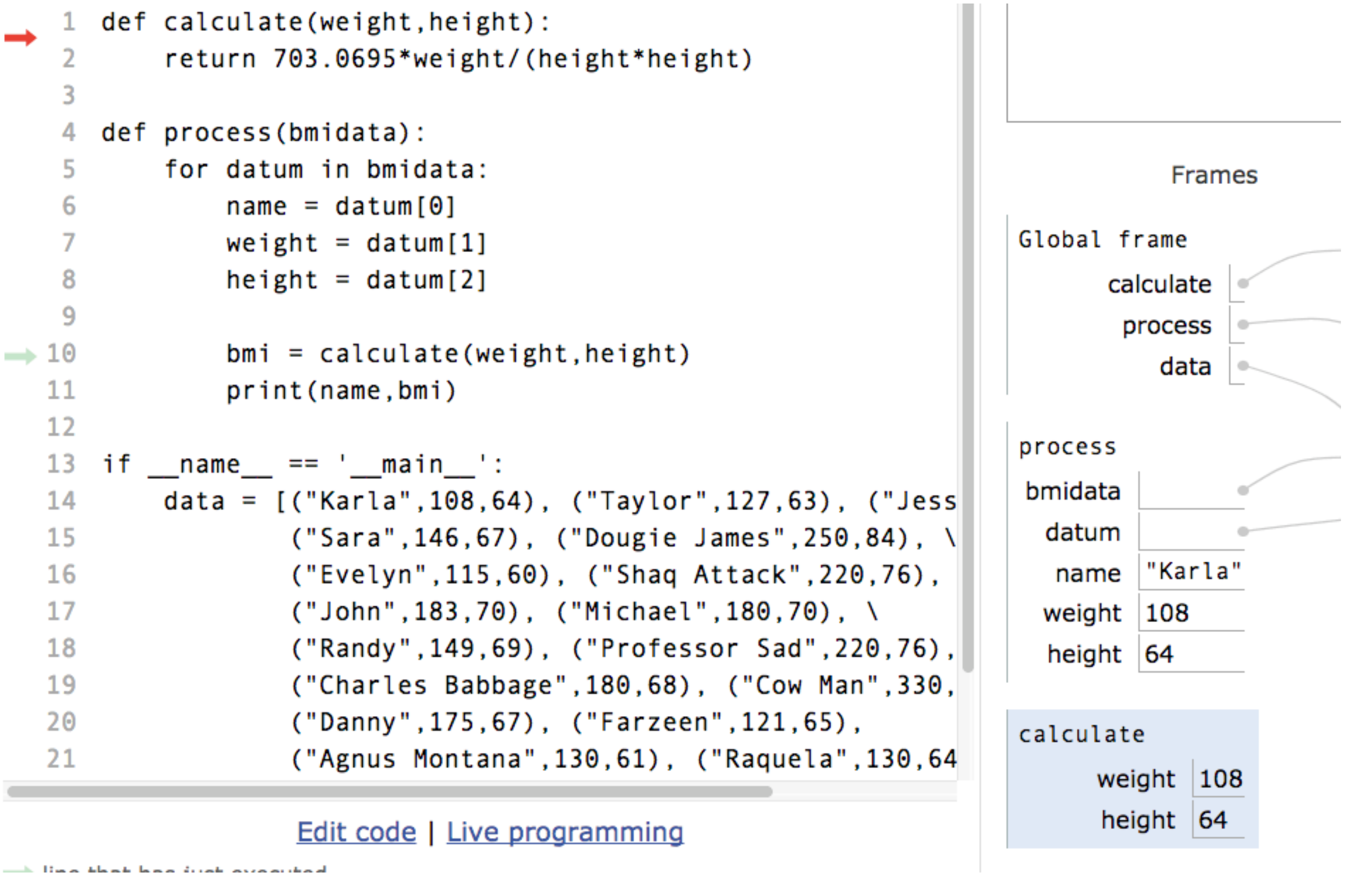
Organization Matters

https://www.youtube.com/watch?v=1ve57l3c19g

BMI on "real" data

- Preview of what's coming
  - How do we process data from class?
  - Read a file that's line-oriented
  - Extract data from each line
  - Clean/process the data
  - Use the BMI.calculate function
  - Make decisions based on return value
- Open, Loop, Convert, Index, Select

PythonTutor Captured in this Screenshot? https://goo.gl/g45obn



```
def calculate(weight,height):
    return 703.0695*weight/(height*height)

def process(bmidata):
    for datum in bmidata:
        name = datum[0]
        weight = datum[1]
        height = datum[2]

        bmi = calculate(weight,height)
        print(name,bmi)

if __name__ == '__main__':
    data = [("Karla",108,64), ("Taylor",127,63), ("Jess
            ("Sara",146,67), ("Dougie James",250,84), \
            ("Evelyn",115,60), ("Shaq Attack",220,76),
            ("John",183,70), ("Michael",180,70), \
            ("Randy",149,69), ("Professor Sad",220,76),
            ("Charles Babbage",180,68), ("Cow Man",330,
            ("Danny",175,67), ("Farzeen",121,65),
            ("Agnus Montana",130,61), ("Raquela",130,64
```

Frames

Global frame
calculate
process
data

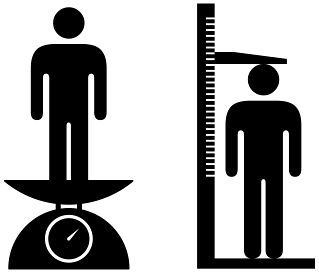
process
bmidata
datum
name "Karla"
weight 108
height 64

calculate
weight 108
height 64

Preview of Flow of Control

- There’s a loop in the function process
    - “examine” each datum in parameter bmidata
    - In the body of the loop use datum

- What are the types of name, weight, height?
    - How can you tell? Where do you look?



The Unknown (no fear)

- Other variables in function process
  - Parameter: bmidata
  - Looped element: datum

- What can you do with these? Hypotheses and looking for something similar you do know
  - What's passed as argument to process?
  - What's done with datum in loop body?

WOTO

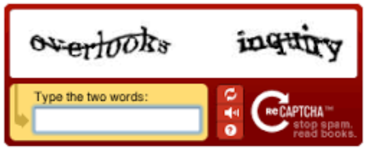
http://bit.ly/101spring18-jan23-2

- Sneak Preview: lists and tuples

Luis von Ahn, Duke 2000 and 2017

I build systems that combine humans and computers to solve large-scale problems that neither can solve alone. I call this Human Computation, but others sometimes call it Crowdsourcing.

ELIZABETH HOLMES: LA NUEVA ALIADA DEL MAGNATE CARLOS SLIM
Forbes
CENTROAMÉRICA
OCTUBRE / NOVIEMBRE • 2015
10 AUTOS INTELIGENTES
VEHÍCULOS QUE LLEGARON DEL FUTURO
GASODUCTO MÉXICO-CA
LAS VENAS DE LA ENERGÍA DEL ISTMO
UNIVERSIDADES A EXAMEN
HEADHUNTERS DECODIFICAN A LOS EGRESADOS
LUIS VON AHN
EL "PROFESOR" DE BILL GATES
EL FUNDADOR DE DUOLINGO QUIERE ENSEÑAR INGLÉS A TODA LATINOAMÉRICA POR MEDIO DE SU APLICACIÓN, EN LA CUAL APRENDE ESPAÑOL EL MILLONARIO NÚMERO UNO DEL MUNDO. LA EMPRESA DEL GUATEMALTECO YA SE VALÚA EN 500 MDD.

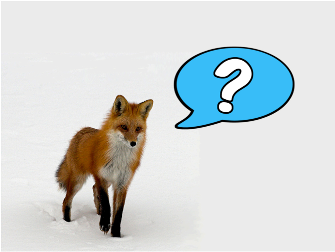


Why Use Functions?

- Re-use code/abstractions in multiple contexts
  - Sqrt, wordcount, URL-Webpage examples
- Test code/abstractions separately from their use
  - Develop independently, use with confidence
- Easier to change, re-use in different contexts
  - Relevant to Assignment 1: TotemPoles

Songs as Examples

- Modify for pig and oink, fox and ???



Old MacDonald had a farm, Ee-igh, Ee-igh, oh!
And on his farm he had a ***horse***, Ee-igh, Ee-igh, oh!
With a ***neigh neigh*** here
And a ***neigh neigh*** there
Here a ***neigh*** there a ***neigh*** everywhere a ***neigh neigh***
Old MacDonald had a farm, Ee-igh, Ee-igh, oh!

First Version

- BadBarnyard.py
- https://goo.gl/RVPiyk

- The first version is accessible as part of zip project
  - https://www2.cs.duke.edu/courses/spring18/compsci101/code/
  - See the main web page for tab

- Benefits? Easy to see it works?

Re-use and Use of code

- We provide code for discussion in class
    - We want you to be able to access it
    - Can provide all modules in online folder
    - Can provide zip file you can download and use

- Sometimes we'll use PythonTutor
    - Helps visualize program execution

Bundle Related Code in Function

- Create `cow()`, `pig()`, `horse()`, `fox()`
  - Grouping makes it easier to reason about
  - Grouping makes it easier to extract a more generalized/re-usable function

- See Farmyard.py module

From Farmyard.py

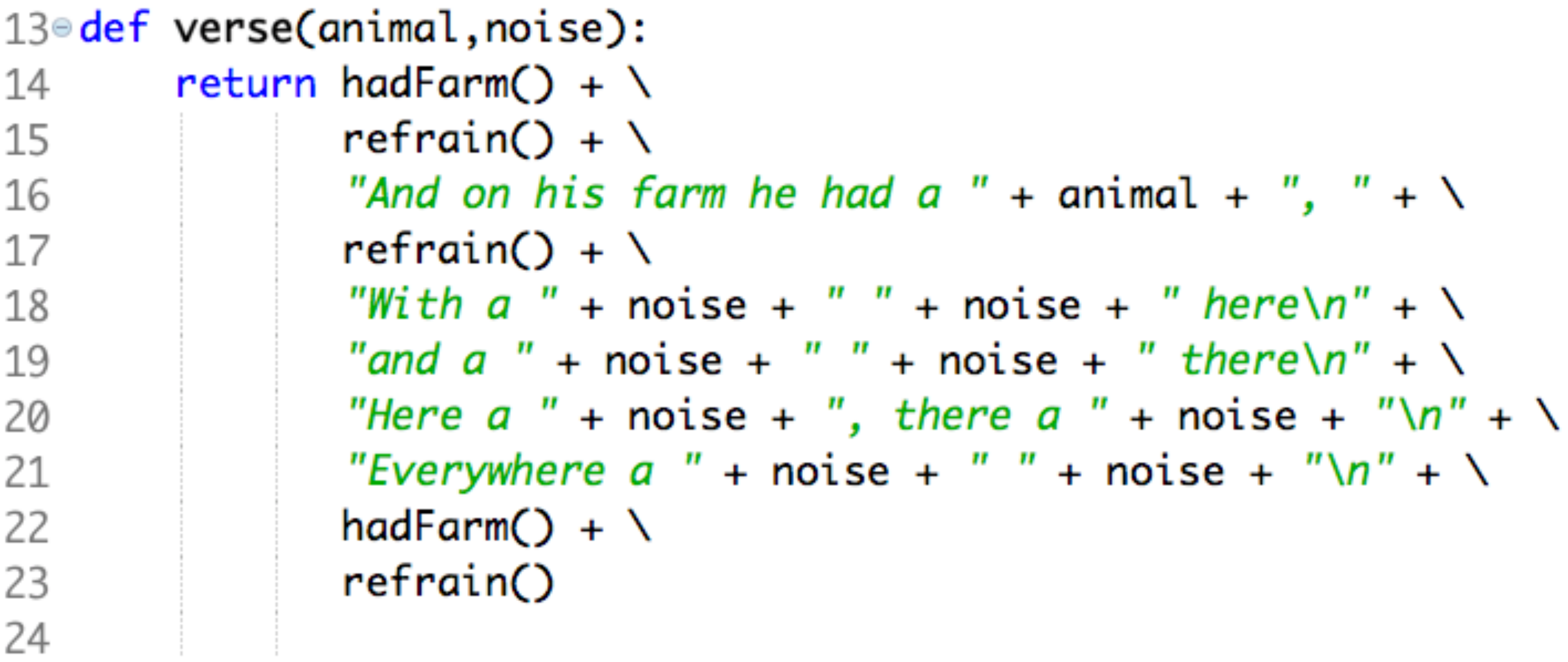
```python
def pigVerse():
  return hadFarm() + \
         refrain() + \
         "And on his farm he had a pig," + \
         refrain() + \
         "With an Oink Oink here\n" + \
         "and an Oink Oink there\n" + \
         "Here an Oink, there an Oink\n" + \
         "Everywhere an Oink, Oink\n" + \
         hadFarm() + \
         refrain()
```

Anatomy of multi-line return

- Lines that are extended to next line end in \
  - Used when long single line hard to read!
- The character ‘\n’ indicates a newline
  - AKA escape sequence, e.g., ‘\t’ and ‘\\’
  - Used to force newline when printing!
- Function returns a string, how do you know?
  - What are **`refrain()`** and **`hadFarm()`**
  - Name, type, value

Replace oink with variable

- pigVerse to verse, Farmyard to Farmyard2



```
def verse(animal,noise):
    return hadFarm() + \
           refrain() + \
           "And on his farm he had a " + animal + ", " + \
           refrain() + \
           "With a " + noise + " " + noise + " here\n" + \
           "and a " + noise + " " + noise + " there\n" + \
           "Here a " + noise + ", there a " + noise + "\n" + \
           "Everywhere a " + noise + " " + noise + "\n" + \
           hadFarm() + \
           refrain()
```

Functions Summarized

- Function call and Function definition related
  - Call must provide correct arguments
  - Names don't matter, types are important

- Functions help design, implement, organize
  - Without functions no APIs, no big programs
  - Opening a file would be 100's of lines, instead it's **`f = open(“hello.txt”)`**

Final WOTO

http://bit.ly/101spring18-jan23-3

Correctness counts