CS 134 Lecture 3: Functions

Check-in After First Lab!

- You have all survived your first computer science lab session
  - **Congratulations!**
- Software tools that you used:
  - **VS Code** as a text editor for code
  - **Terminal** as a text-based interface to the computer
  - **Git** for retrieving & submitting your work
  - **Python**, of course!

Do You Have Any Questions?

Announcements & Logistics

Can work in **TCL 216/217A** anytime there is no scheduled class

- **Lab 1**
  - Due today at 10 pm (for Mon labs), tomorrow at 10 pm (for Tues labs)
  - How to submit: make sure your work is up-to-date on evolene.cs.williams.edu
- **HW 2** will be released today, due next Monday at 10 pm
  - Open book/notes/computer. There is no time limit.
- ***Optional*** Personal machine setup (Mac/Windows): Step-by-step guide on website
- Lots of helps hours if you have questions!
  - Today noon-4 pm, 4-6 pm and 7-10 pm (in **TCL 216**)
  - Tomorrow 1-4 pm, 4-6 pm and 7-10 pm (in **TCL 216**)

Do You Have Any Questions?

Last Time

- Discussed **data types** and **variables** in Python
  - `int`, `float`, `boolean`, `string`
- Learned about basic **operators**
  - arithmetic, assignment
- Experimented with built-in Python functions
  - **`input(), print(), int()`**
- Discussed different ways to run and interact with Python
  - Create a file using an editor (VS Code), run as a script from Terminal
  - Interactively execute Python from Terminal

Today's Plan

- Discuss functions in greater detail
- Review the built-in functions we (briefly) saw last time and in lab
    - `input()`, `print()`, `int()` all expect **argument(s)** within the parens
    - We will examine these a bit more today
- Learn how to define our own functions

Jupyter Notebook

- Last class we did examples in interactive python
- Upsides: low overhead, easy to use, can explore as you go
- Downsides:
    - No record of what we did
    - Can't pre-type examples to run in class
- For today, we will try using Jupyter Notebook for lecture examples
    - Jupyter notebook is an "enhanced" way to use interactive python
    - Installed on lab machines & included in personal machine setup guide
- Anything we do in Jupyter notebook can be done in Interactive Python!
- Regardless of format, all examples will be posted on the website

Review:
Python Built-in Functions

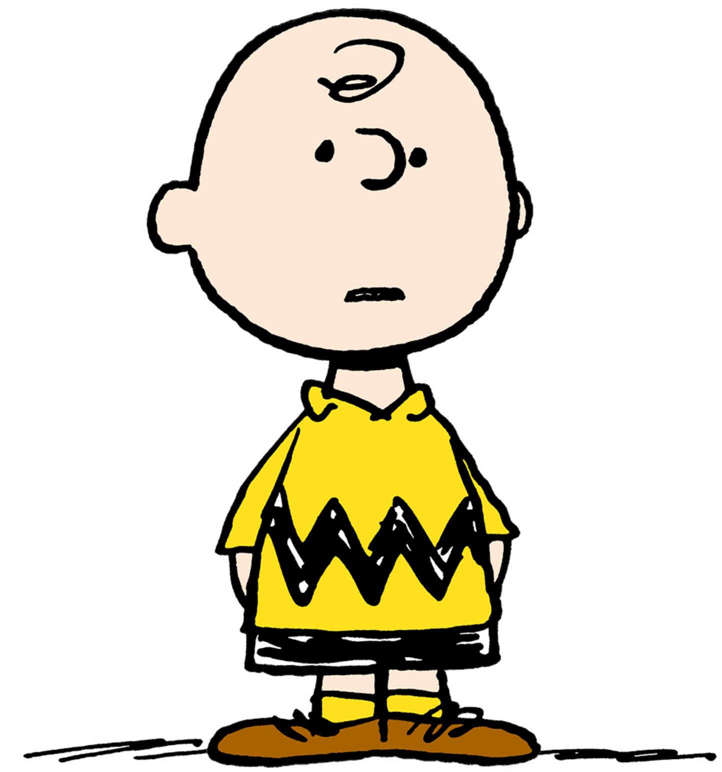
`input(), print()`

`int(), float(), str()`

Built-in functions: input()

- `input()` displays its single argument as a prompt on the screen and waits for the user to input text, followed by **Enter/Return**
- It interprets the entered value as a **string** (a sequence of characters)

```
>>> input('Enter your name: ')
Enter your name: Charlie Brown
'Charlie Brown'
>>> age = input('Enter your age: ')
Enter your age: 8
>>> age
'8'
```



Prompts in Maroon. User input in blue.
Inputted values are by default a **string**

Built-in functions: print()

- `print()` displays a character-based representation of its argument(s) on the screen/Terminal.

```
>>> name = 'Peppermint Patty'
>>> print('Your name is', name)
Your name is Peppermint Patty
>>> age = input('Enter your age : ')
Enter your age: 7
>>> print('The age of ' + name + ' is ' + age)
The age of Peppermint Patty is 7
```

Comma as a separator adds a space

Can also add spaces through string *concatenation*

Built-in functions: int()

When given a string that's a sequence of digits, optionally preceded by `+` or `–`, `int()` returns the corresponding *integer*

- On any other string, `int()` raises a `ValueError`
- When given a *float*, `int()` returns the integer that results after truncating the fractional part (rounds towards zero)
- When given an integer, `int()` returns that same integer

```
>>> int('42')
42
>>> int('-5')
-5
>>> int('3.141')
ValueError
```

Built-in functions: float()

When given a string that's a sequence of digits, optionally preceded by **+** or **–**, and optionally including one decimal point, **`float()`** returns the corresponding floating point number.

- On any other string **`float()`** raises a **`ValueError`**
- When given an *integer*, **`float()`** converts it to a floating point number.
- When given a floating point number, float returns that number

```
>>> float('3.141')
3.141
>>> float('-273.15')
-273.15
>>> float('3.1.4')
ValueError
```

Built-in functions: str()

- Converts a given type to a `string` and returns it
- Returns a syntax error when given invalid input

```
>>> str(3.141)
'3.141'
>>> str(None)
'None'
>>> str(134)
'134'
>>> str($)
SyntaxError: invalid syntax
```

Today:
User-Defined Functions

Organizing Code with Functions

- So far we have:
  - Written simple **expressions** in Python
  - Created small scripts to perform concrete tasks
- This is fine for small computations!
- Need more organization and structure for larger problems
- Structured code is good for:
  - Keeping track of which part of our code is doing what actions
  - Keeping track of what information needs to supplied where
  - **Reusability!** Specifically, reusing blocks of code

Abstracting with Functions

- **Abstraction**: Reduce code complexity by ignoring (or hiding) some implementations details
    - Allows us to **decompose** and **reuse** parts of our code
- **Real life example**: a video projector
    - We know how to switch it on and off **(public interface)**
    - We know how to connect it to our computer **(input/output)**
    - We don't know how it works internally **(information hiding)**
- **Key idea:** We don't need to know much about the internals of a projector to be able to use it
    - Same is true with **functions**!

Decomposition

- Divide **individual tasks** in our code into **separate functions**
    - Functions are **self-contained** and **reusable**
        - Each function is a **small piece** of a **larger task**
        - Keeps code **organized** and **coherent**
- We have already seen some built-in examples (`int(), input(), print()`, etc.)
- Now we will learn how to **decompose** our Python code and hide small details using **user-defined functions**
- Later we will learn a new abstraction which achieves a greater level of decomposition and information hiding: **classes**

Anatomy of a Function

- Function **definition** characteristics:
  - Has a **header** consisting of:
    - **name** of the function
    - **parameters** (optional)
    - **docstring** (optional, but strongly recommended)
  - Has a **body** (indented and required)
  - Always **returns** something (with or without an explicit `return` statement)
- Statements within the body of a function are not run in a program until they are "called" or "invoked" through a **function call** (like calling `print()` or `int()` in your program)

Function Example

Function definition

Function's **name** is `square`

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

Notice the indentation.
This whitespace is very important!

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

`square` has one **parameter**, `x`, which is the expected input to the function.

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

This is the **docstring**, which is enclosed in triple quotes. It is a short description of the function.

Function definition

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

All of this is the function's header

Function definition

```
def square(x):
    '''Takes a number x and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

> This is the body of the function. Notice the use of an explicit **return** statement.

```
def square(x):
    '''Takes a number and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

```
def square(x):
    '''Takes a number and returns its square'''
    return x*x
```

When we call/invoke the function,
5 is the **argument** value.
Function is evaluated using x=5.

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Function Example

Function definition

```
def square(x):
    '''Takes a number and returns its square'''
    return x*x
```

Function Calls/Invocations

```
>>> square(5)
25
>>> square(-2)
4
```

Summary:

- Indent in function body (required)
- Colon after function name (required)
- Docstring (recommended, good style)
- `x` in function definition is a parameter
- Single line body which returns the result of the expression `x * x`
- `return` always ends execution!
- A function is defined once and can be called any number of times!

A Closer Look At Parameters

- **Parameters** are "placeholders" in the body of a function that will be filled in with **argument values** during each invocation
- A particular name for a parameter is irrelevant, as long as we use it consistently in the body (just like *f(x)* and *f(y)* in math)
  - All **`square`** function definitions below work exactly the same way!
  - Invocation would also look exactly the same: `square(5)`

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

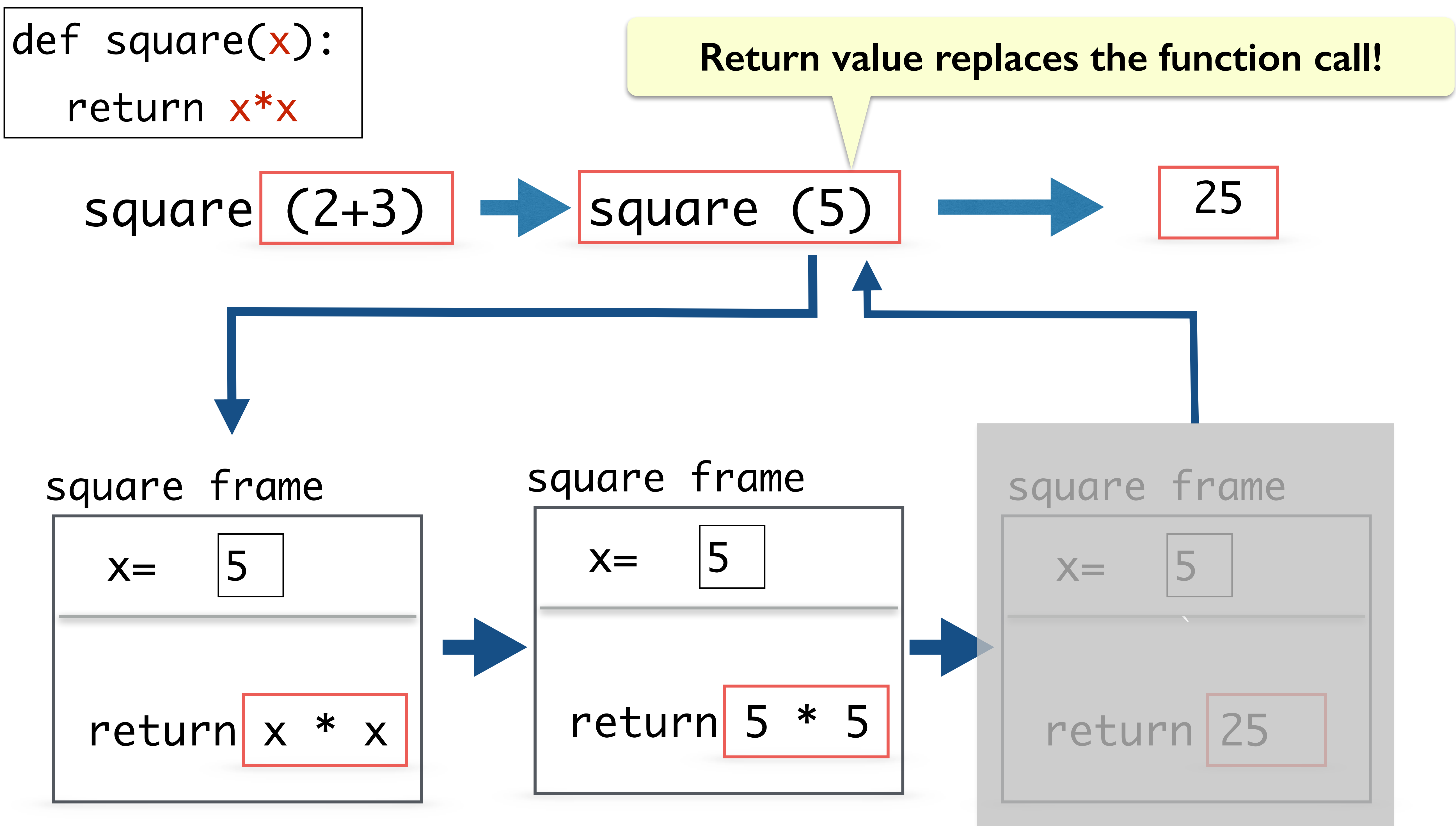
```
def square(apple):
    return apple*apple
```

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

Rule of thumb: Choose parameter names that make sense and convey meaning

Python Function Call Model

Function frame: Model for understanding how a function call works



Function Call Replaced by Return Value

```
17 + square(2+3)
       ↓
17 + square(5)
       ↓
17 + 25
       ↓
42
```

Print() vs Functions that Return Values

- Notice that the `print()` function does not *return* any value:
  - No `Out[]` cell when we print in Jupyter
- In contrast to `print()`:
  - `input()` function returns the value inputted by user as a str
  - `int()` function returns the given value as type int
  - `type()` function returns the type of given value, etc
- Functions that do not explicitly return a value, implicitly return **None**

Value vs. None Returning Functions

We call functions that return a None value **None-returning functions**. Such functions are invoked to perform an action (e.g., print something, change state). They do **not compute and return a result.**

We call functions that return a value other than None **value returning functions.**

Value Returning

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

None-Returning

```
def printHW():
  print('Hello World')
```

What if I run `print(printHW)` or `print(print((printHW))`?

Return Statements

- `return` only has meaning *inside* of a function definition
- A function definition may have multiple returns, but only the first one encountered is executed!
- Any code that exists after a return statement **is unreachable** and will not be executed
- The value returned by the function's return statement replaces the function call in a computation
- Functions without an explicit return statement implicitly return **None**