Lecture 2 - Names & Functions

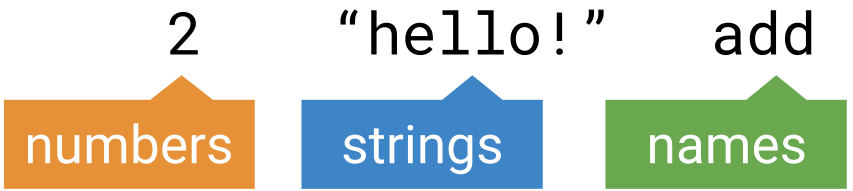
9 / 25 /20

Slides adapted from Berkeley CS61a

Program Structure

Review - Expressions

Primitive Expressions:



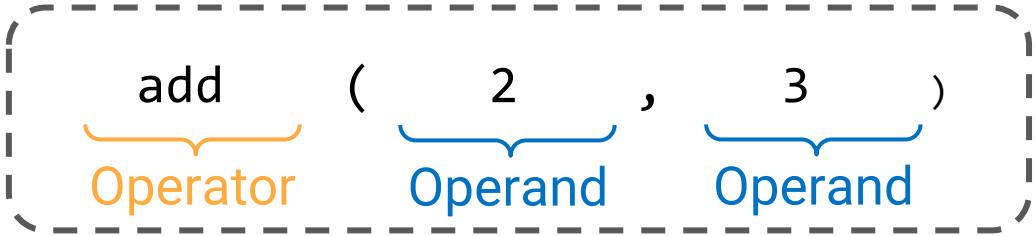
Arithmetic Expressions:

```
1 + 2
15 // 3
```

Call Expressions:

```
add(3, 4)
max(add(2, 3), 5 * min(-1, 4))
```

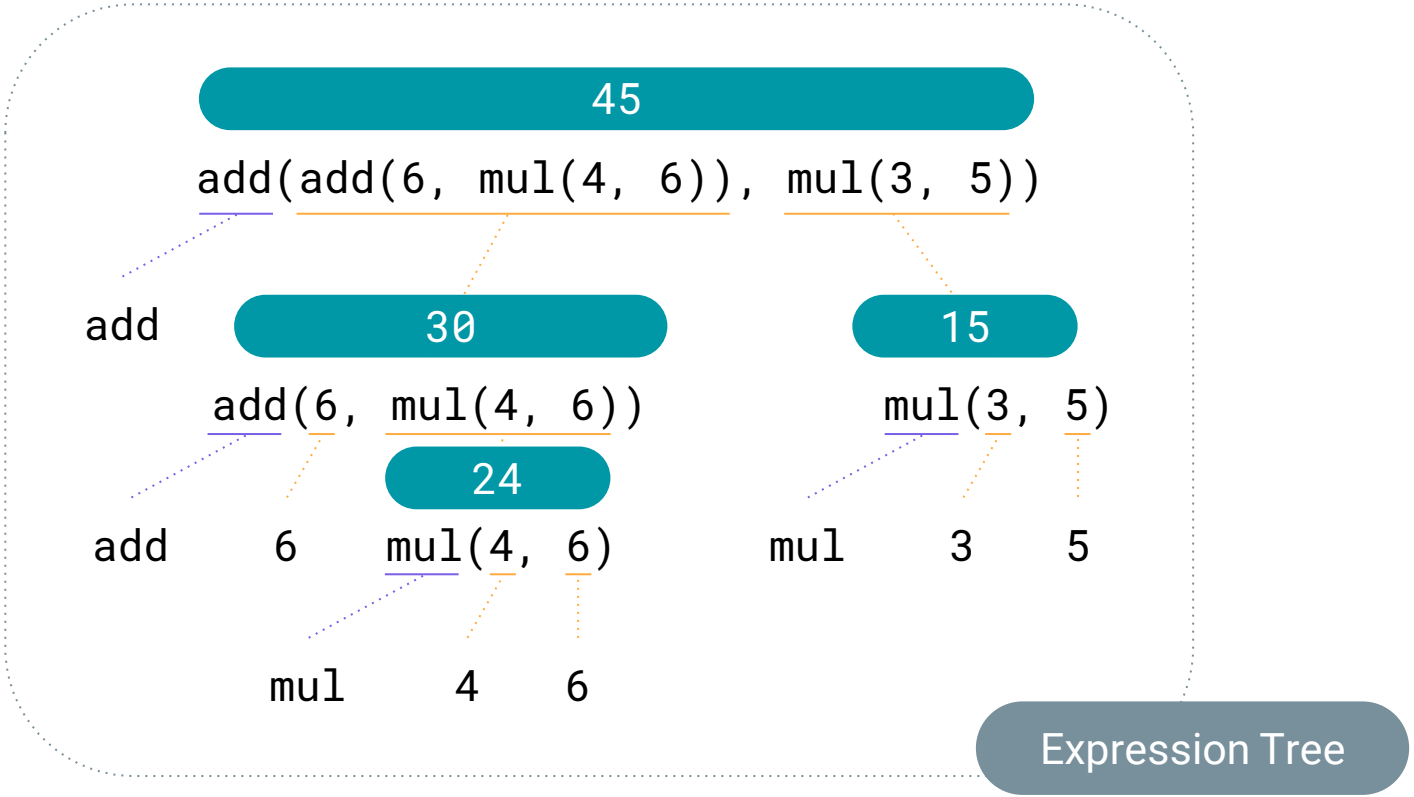
Review - Evaluating Call Expressions



1. Evaluate
    a. Evaluate the operator subexpression
    b. Evaluate each operand subexpression
2. Apply
    a. Apply the value of the operator subexpression to the values of the operand subexpression

Nested Call Expression

1 Evaluate operator 2 Evaluate operands 3 Apply!



Values

Programs manipulate values

Values represent different types of data

Integers: `2` `44` `-3`

Strings: `“hello!”` `“cs61a”`

Floats: `3.14` `4.5` `-2.0`

Booleans: `True` `False`

Expressions & Values

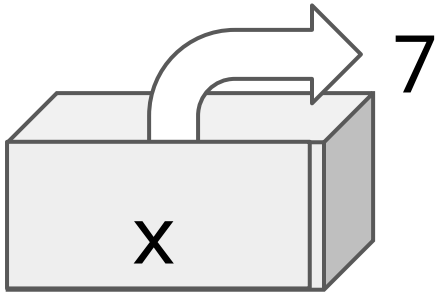
Expressions evaluate to values in one or more steps

Expression:	**Value:**
`'hello!'`	`'hello!'`
`7 / 2`	`3.5`
`add(1, max(2, 3))`	`4`

Names

Demo

Values can be assigned to **names** to make referring to them easier.



A name can only be bound to a single value.

One way to introduce a new name in a program is with an **assignment statement**.

```
x = 1 + 2 * 3 - 4 // 5
```

Name Expression

Statements affect the program, but do not evaluate to values.

Check Your Understanding

```
>>> f = min
>>> f = max
>>> g, h = min, max
>>> max = g
>>> max(f(2, g(h(1, 5), 3)), 4)
```

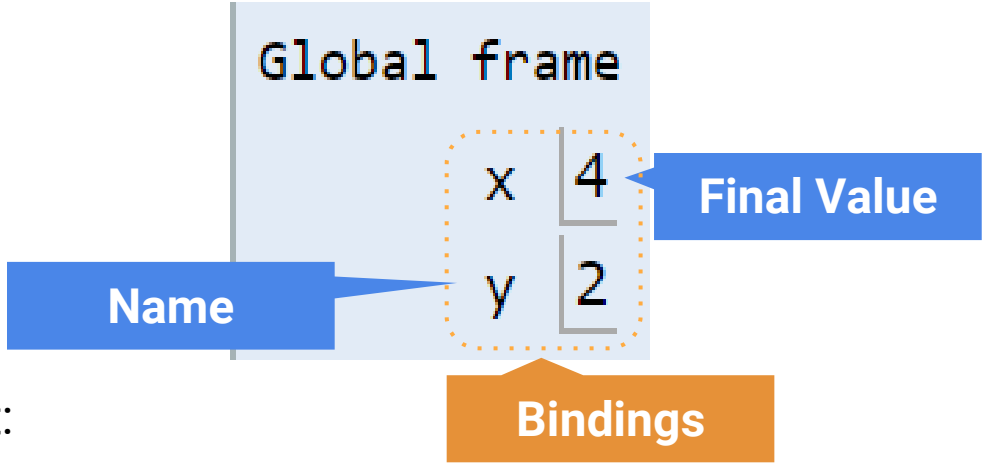
???

Visualizing Assignment

Demo

Names are bound to **values** in an environment

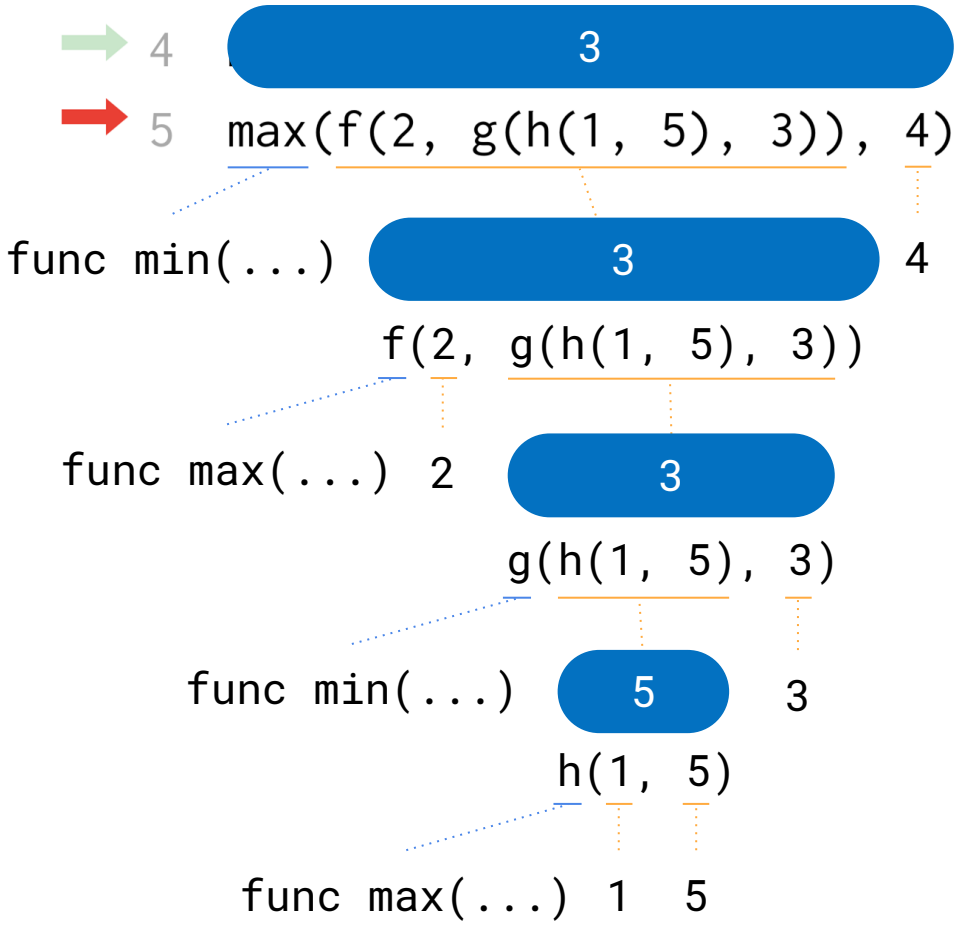
```
1  x = 1
2  y = 2
3  x = y * 2
```

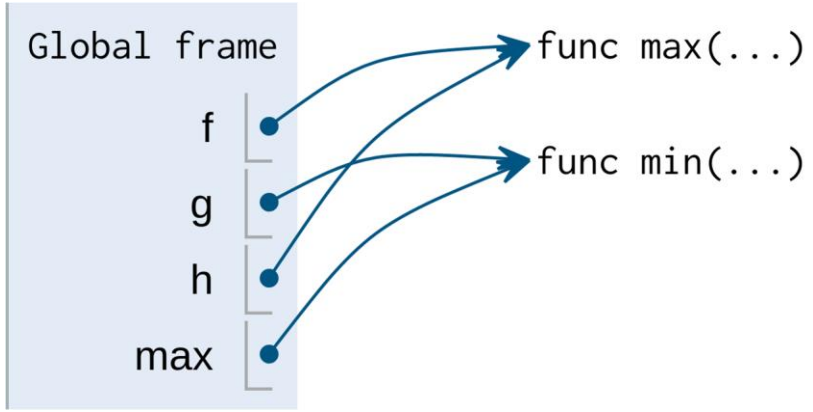


To execute an assignment statement:

1. **Evaluate** the expression to the right of **=**.
2. **Bind** the value of the expression to the name to the left of **=** in the current environment.

Demo


4
5
3
max(f(2, g(h(1, 5), 3)), 4)
func min(...)
3
4
f(2, g(h(1, 5), 3))
func max(...)
2
3
g(h(1, 5), 3)
func min(...)
5
3
h(1, 5)
func max(...)
1
5


Global frame
f
g
h
max
func max(...)
func min(...)

3

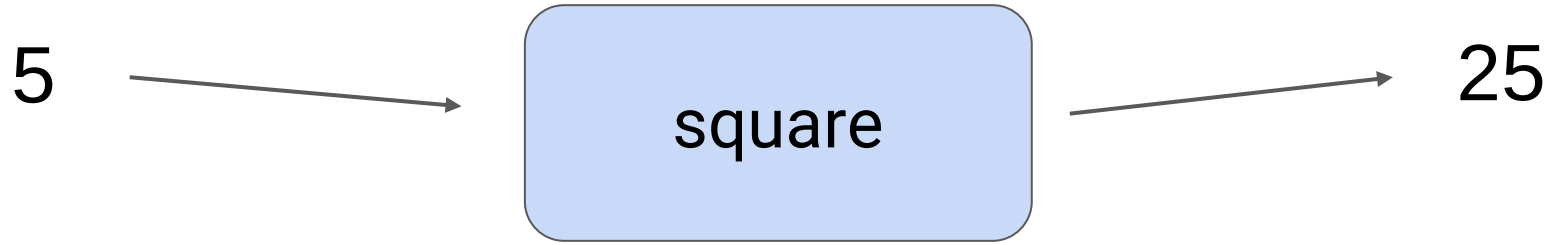
Functions

Functions

Functions allow us to abstract away entire expressions and sequences of computation

They take in some input (known as their arguments) and transform it into an output (the return value)

We can create functions using def statements. Their input is given in a function call, and their output is given by a return statement.



Defining Functions

Demo

Function **signature** indicates name and number of arguments

```
def <name>(<parameters>):
    return <return expression>
```

Function **body** defines the computation performed when the function is applied

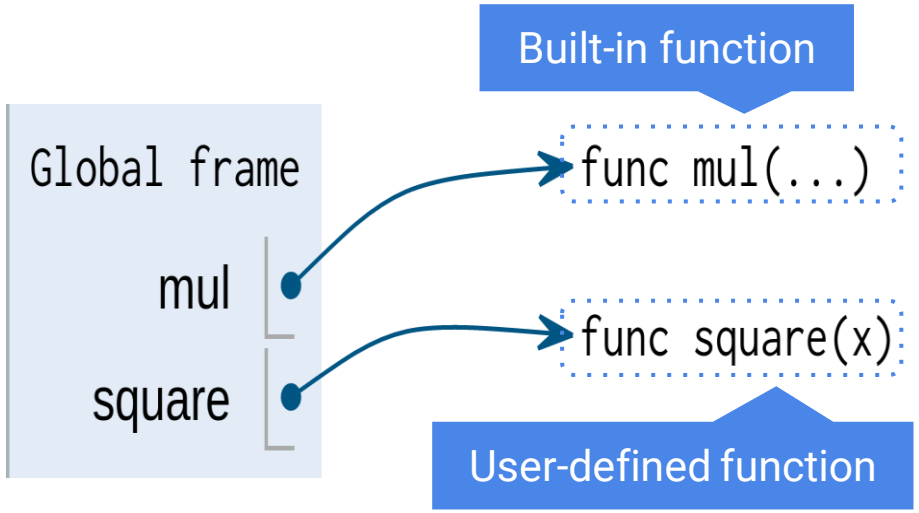
```
def square(x):
    return x * x
y = square(-2)
```

Execution rule for `def` Statements

1. Create a function with signature `<name>(<parameters>)`
2. Set the body of that function to be everything indented after the first line
3. Bind `<name>` to that function in the current frame

Functions in Environment Diagrams

```
1  from operator import mul
2  def square(x):
3      return mul(x, x)
4  y = square(-2)
```



def statements are a type of assignment that bind names to function values

Calling User-Defined Functions

Procedure for calling/applying user-defined functions (for now)

1. Create a new **environment frame**
2. Bind the function's parameters to its arguments in that frame
3. Execute the body of the function in the new environment

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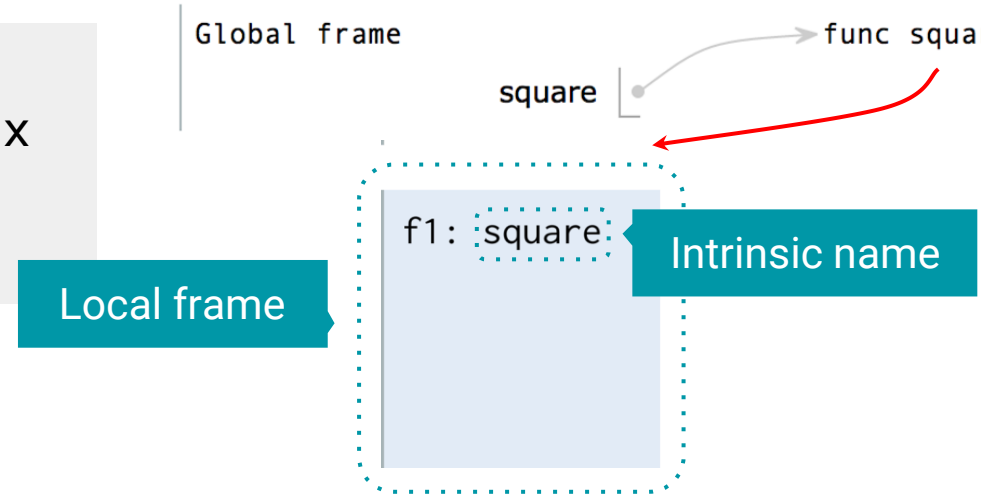

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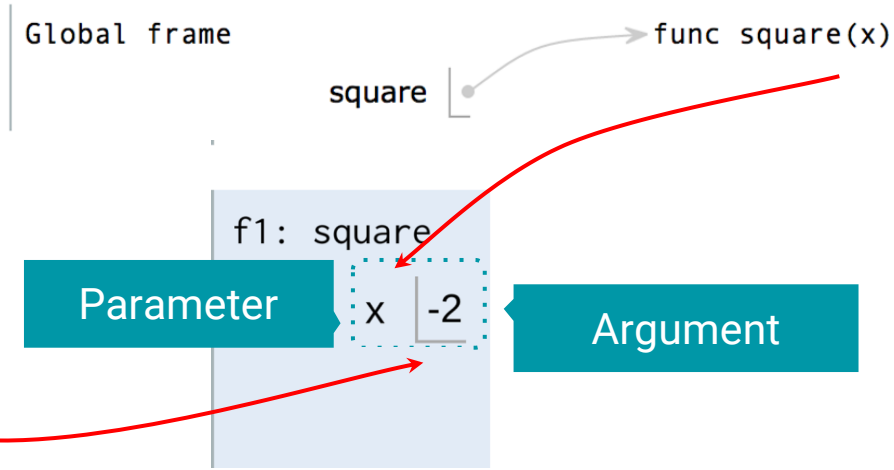

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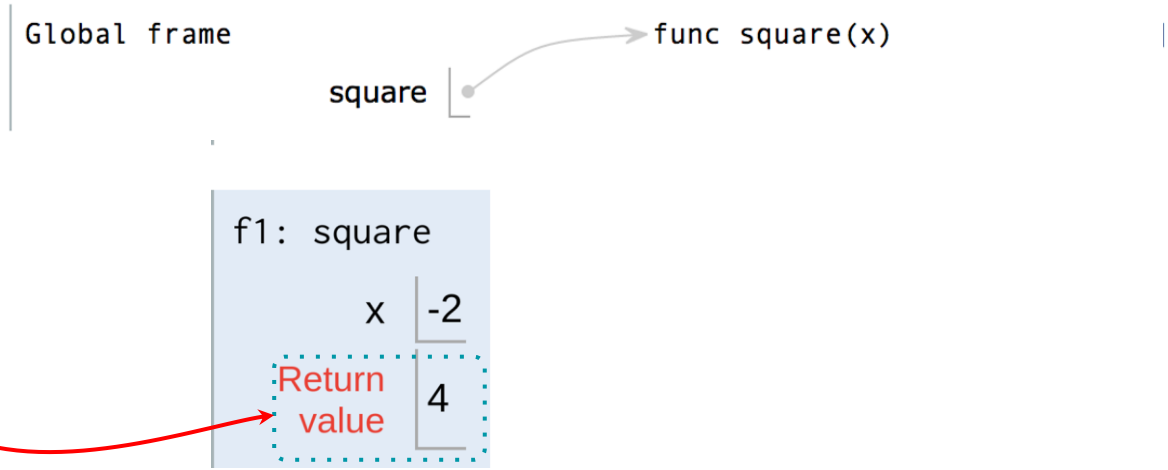

Putting it all together

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

1. Evaluate
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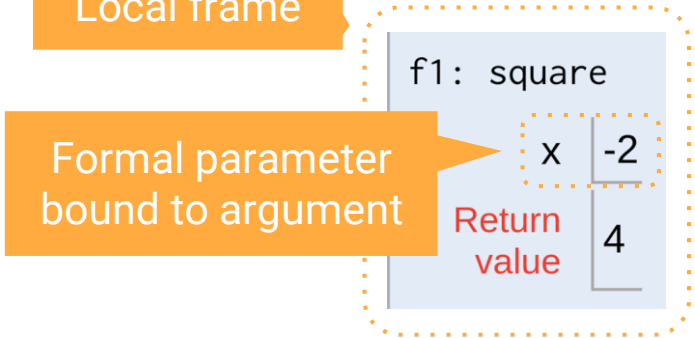
Operator: `square`
Function: `func square(x)`

```
square(1 - 3)
```

Operand: 1-3
Argument: -2

Local frame



Formal parameter bound to argument

Drawing Environment Diagrams

- Option 1: Python Tutor (tutor.cs61a.org)
  - Useful for quick visualization or for environment diagram questions
- Option 2: PythonAnywhere (editor.pythonanywhere.com)
  - Includes an integrated editor/interpreter
  - Good for more complicated code or if you want to debug
  - Developed by Rahul Arya

Summary

- Programs consist of **statements**, or instructions for the computer, containing **expressions**, which describe computation and evaluate to **values**.
- Values can be assigned to **names** to avoid repeating computations.
- An **assignment statement** assigns the value of an expression to a name in the current **environment**.
- **Functions** encapsulate a series of statements that maps **arguments** to a **return value**.
- A **`def` statement** creates a function object with certain **parameters** and a **body** and binds it to a name in the current environment.
- A **call expression** applies the value of its **operator**, a function, to the value(s) or its **operand**(s), some arguments.