61A Lecture 2

Announcements

Names, Assignment, and User-Defined Functions
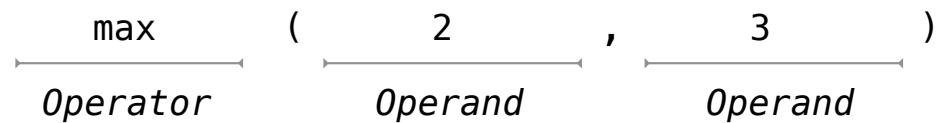
(Demo)

Types of Expressions

Primitive expressions:

2   add   'hello'

Number or Numeral   Name   String

Call expressions:

max (2 , 3)

Operator   *Operand*   *Operand*
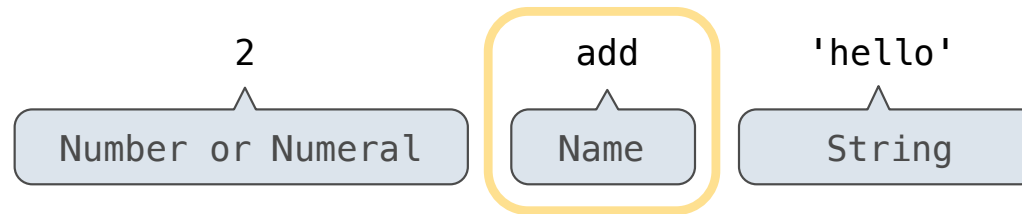
An operand can also be a call expression

max(min(pow(3, 5), −4), min(1, −2))

Discussion Question 1

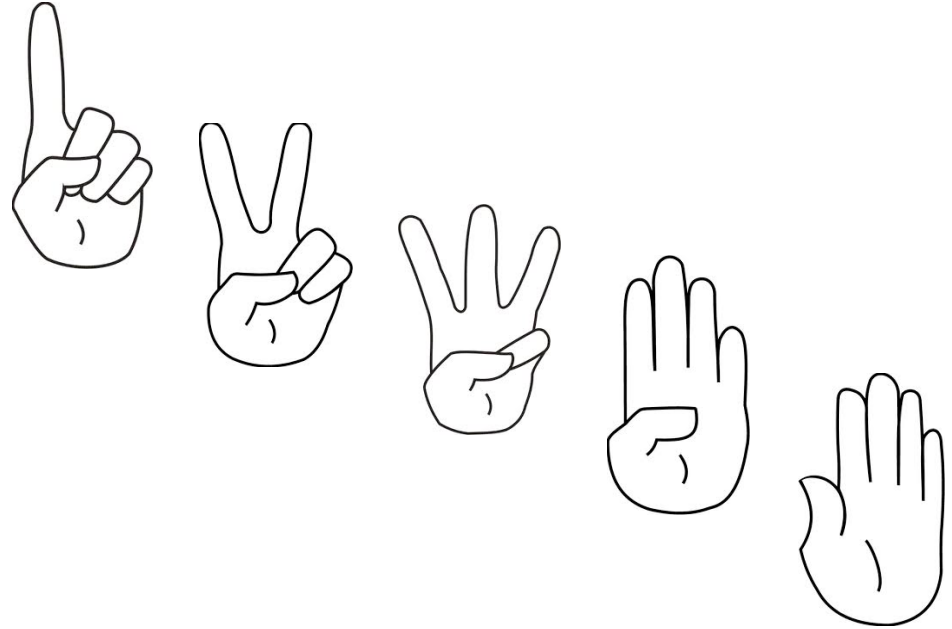What is the value of the final expression in this sequence?

```
>>> f = min

>>> f = max

>>> g, h = min, max

>>> max = g

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

???

Environment Diagrams
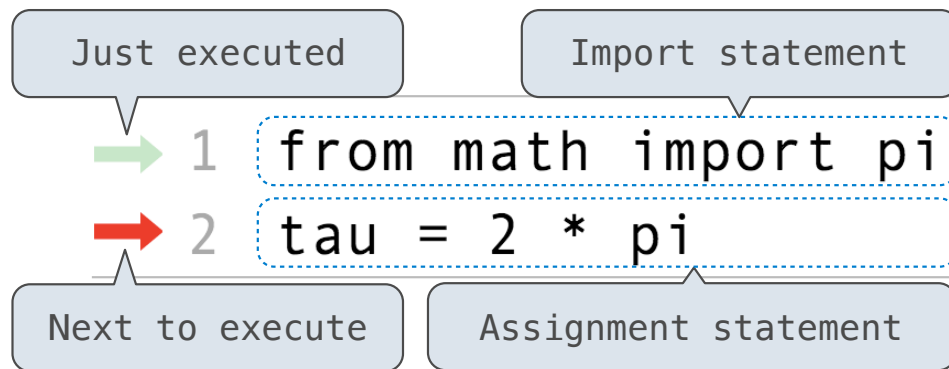
Environment Diagrams

Environment diagrams visualize the interpreter's process.

Just executed

Import statement

→ 1 `from math import pi`

→ 2 `tau = 2 * pi`

Next to execute

Assignment statement

Global frame

Name pi 3.1416 Value

Code (left):

Statements and expressions

Arrows indicate evaluation order
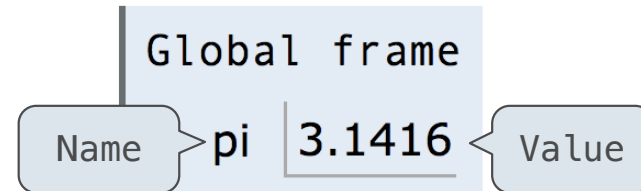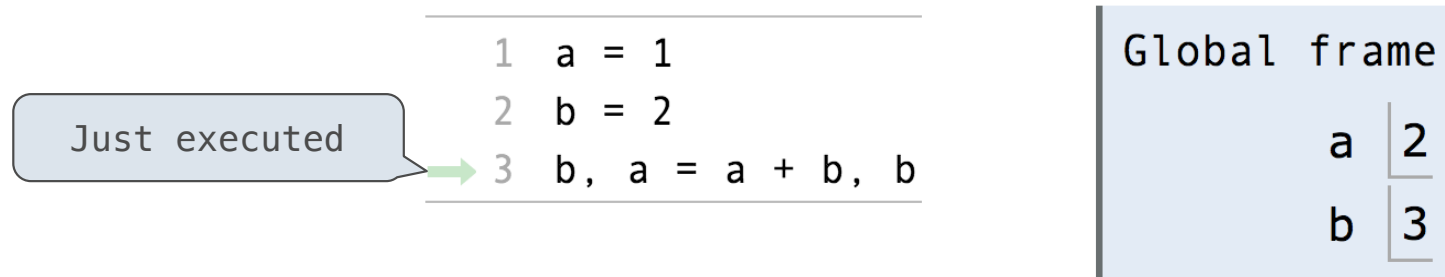
Frames (right):

Each name is bound to a value

Within a frame, a name cannot be repeated

(Demo)

Interactive Diagram

Assignment Statements

Just executed

Next to execute

```
1  a = 1
2  b = 2
3  b, a = a + b, b
```

Global frame

a | 1

b | 2

Just executed

```
1  a = 1
2  b = 2
3  b, a = a + b, b
```

Global frame

a | 2

b | 3
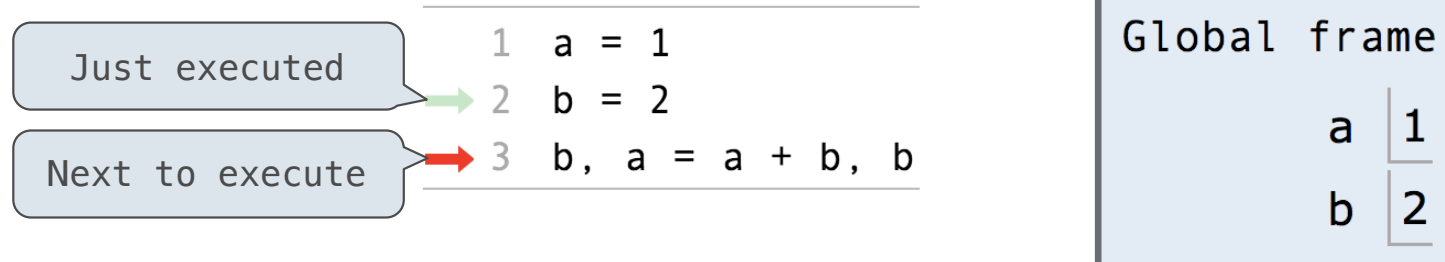
Execution rule for assignment statements:

1. Evaluate all expressions to the right of = from left to right.

2. Bind all names to the left of = to those resulting values in the current frame.

Interactive Diagram

Discussion Question 1 Solution

(Demo)

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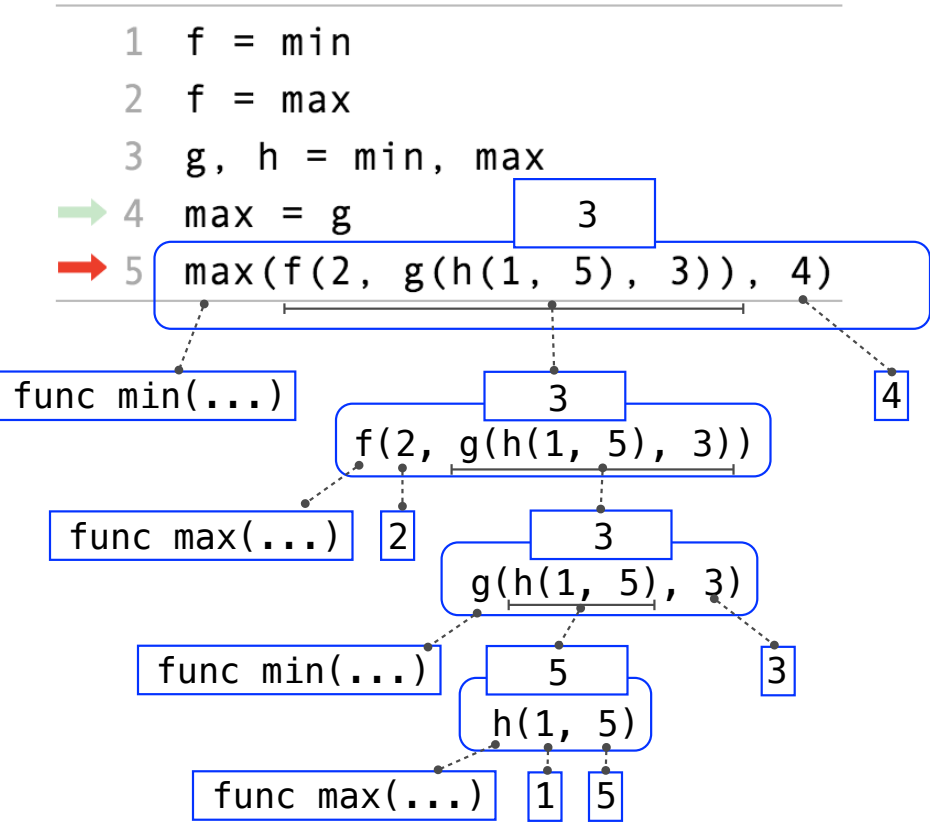
func min(...)   3   4
                f(2, g(h(1, 5), 3))

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

      func min(...)   5   3
                     h(1, 5)

        func max(...)   1   5

Global frame   func max(...)

              f   func min(...)

              h

              g

            max
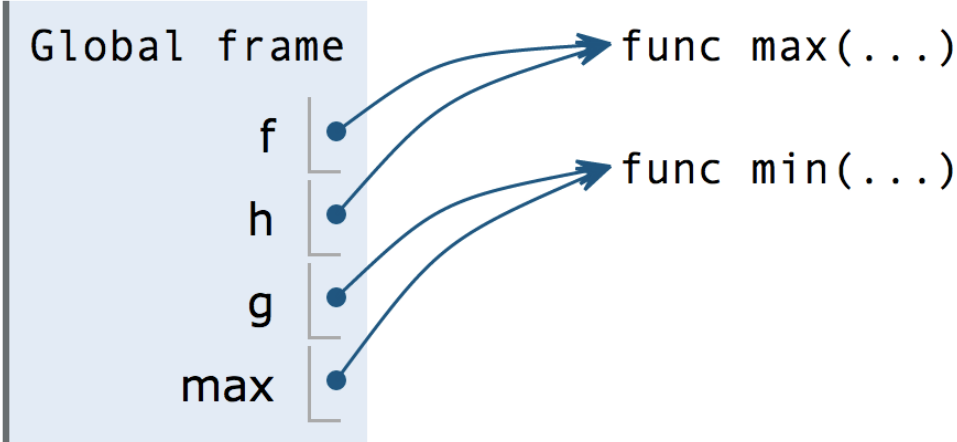
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Defining Functions

Defining Functions

Assignment is a simple means of abstraction: binds names to values

Function definition is a more powerful means of abstraction: binds names to expressions

> Function *signature* indicates how many arguments a function takes

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

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

Execution procedure for def statements: If not called, not executed.

    1. Create a function with signature <name>(<formal parameters>)

    2. Set the body of that function to be everything indented after the first line

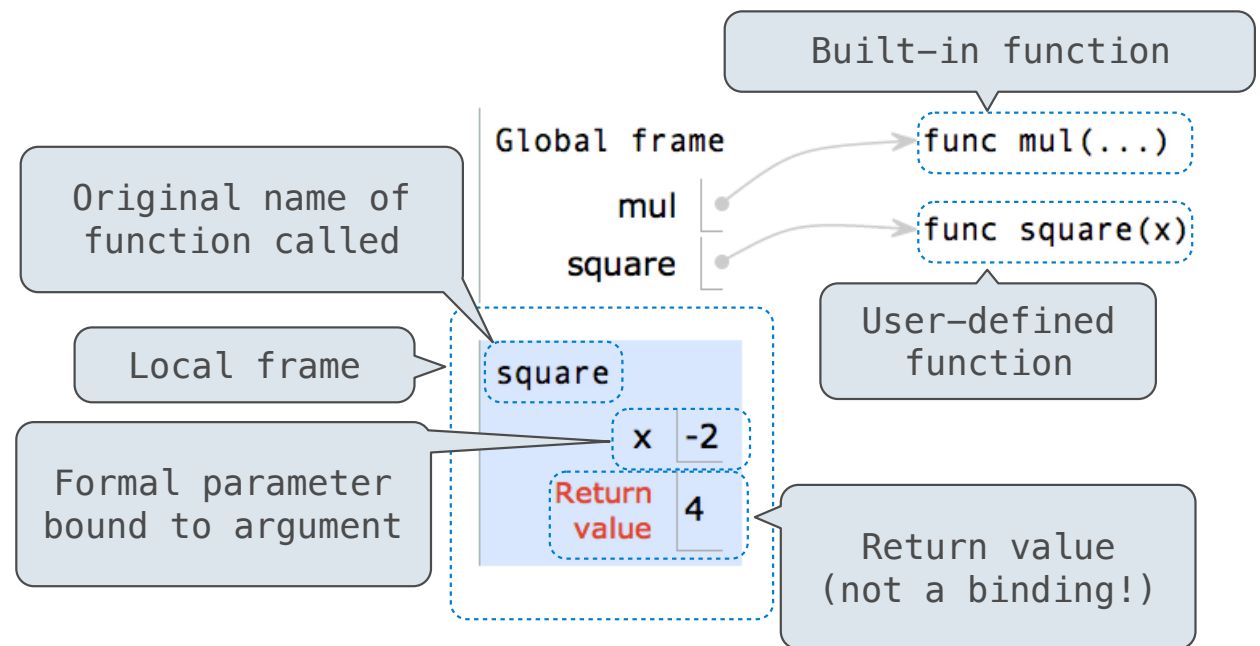   3. Bind <name> to that function in the current frame

Abstraction is the process of taking something complex, giving it name and treating it as a whole without worrying about all of its details.

Calling User-Defined Functions

Procedure for calling/applying user-defined functions (version 1):

1. Add a local frame, forming a new environment
2. Bind the function's formal parameters to its arguments in that frame
3. Execute the body of the function in that new environment

Built-in function

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

Original name of function called

Global frame

func mul(...)

mul

square

func square(x)

Local frame

square

User-defined function

Formal parameter bound to argument

x | -2

Return value | 4

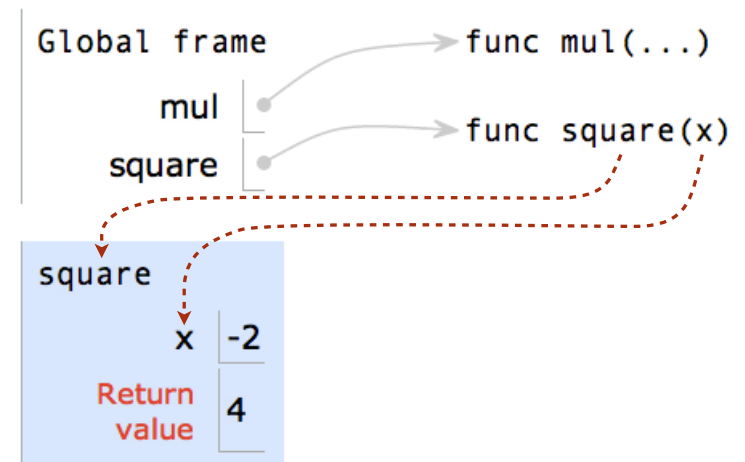Return value (not a binding!)

Interactive Diagram

Calling User-Defined Functions

Procedure for calling/applying user-defined functions (version 1):

1. Add a local frame, forming a new environment
2. Bind the function's formal parameters to its arguments in that frame
3. Execute the body of the function in that new environment

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

A function's signature has all the
information needed to create a local frame

Global frame   func mul(...)

         mul
                                func square(x)
      square

square

           x   -2

      Return
              4
      value

Interactive Diagram

Looking Up Names In Environments

Every expression is evaluated in the context of an environment.

So far, the current environment is either:

- The global frame alone, or

- A local frame, followed by the global frame.

> ***Most important two things I'll say all day:***
>
> An environment is a sequence of frames.
>
> A name evaluates to the value bound to that name in the earliest frame of the current environment in which that name is found.

E.g., to look up some name in the body of the square function:

- Look for that name in the local frame.

- If not found, look for it in the global frame.
  (Built-in names like "max" are in the global frame too,
   but we don't draw them in environment diagrams.)

<div align="center">(Demo)</div>

Environments are the memory that keep track of the correspondence between names and values.

A frame is a binding between names and values one of boxes in the environment digram.