

## 61A Lecture 2

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## Announcements

```
# Assignment
radius = 10
2 * radius
area, circ = pi * radius * radius, 2 * pi * radius
radius = 20
```

```
# User-defined functions
def square(x):
    return mul(x, x)
```

```
square(21)
square(add(2, 5))
square(square(3))
```

```
def sum_squares(x, y):
    return add(square(x),
square(y))
sum_squares(3, 4)
sum_squares(5, 12)
```

## Names, Assignment, and User-Defined Functions

```
# this = that
def this():
    return that
# this()
that = 100
this()
```

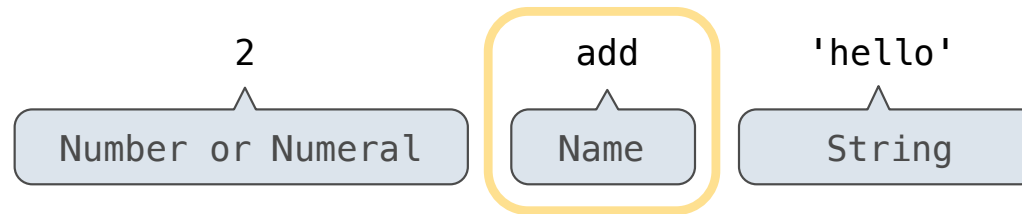
```
# Name conflicts
def square(square):
    return mul(square, square)
square(4)
```

(Demo)

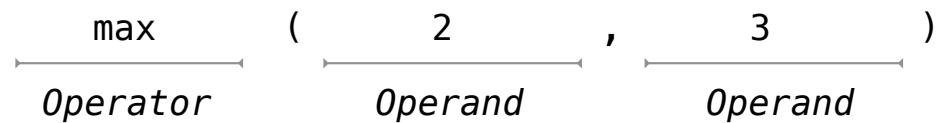
```
# Function values
max
max(3, 4)
f = max
f
f(3, 4)
max = 7
f(3, 4)
f(3, max)
f = 2
# f(3, 4)
__builtins__.max
```

## Types of Expressions

**Primitive expressions:**



**Call expressions:**



An operand can also be a call expression

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

## Discussion Question 1

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

```
>>> f = min
```

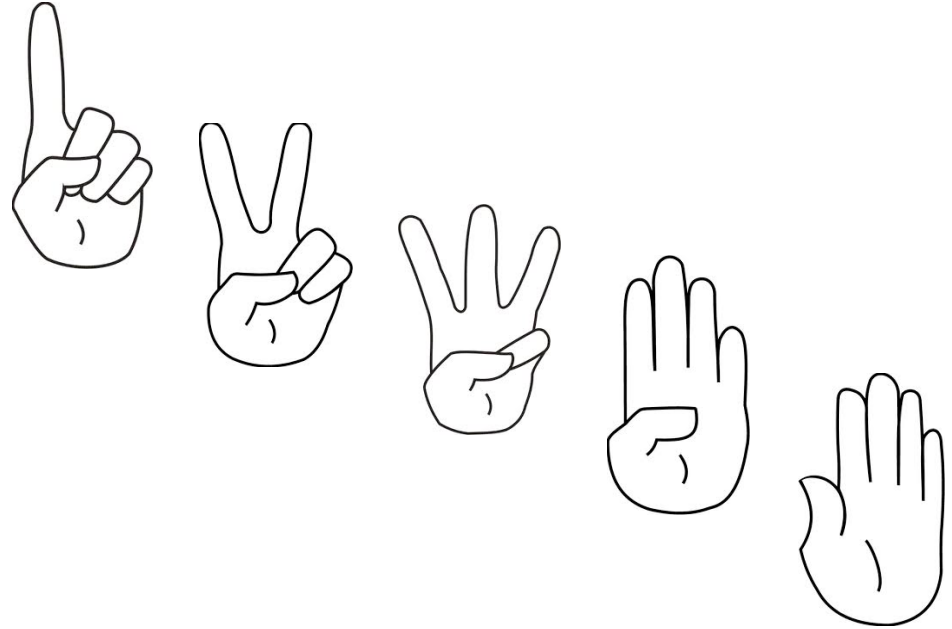
```
>>> f = max
```

```
>>> g, h = min, max
```

```
>>> max = g
```

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

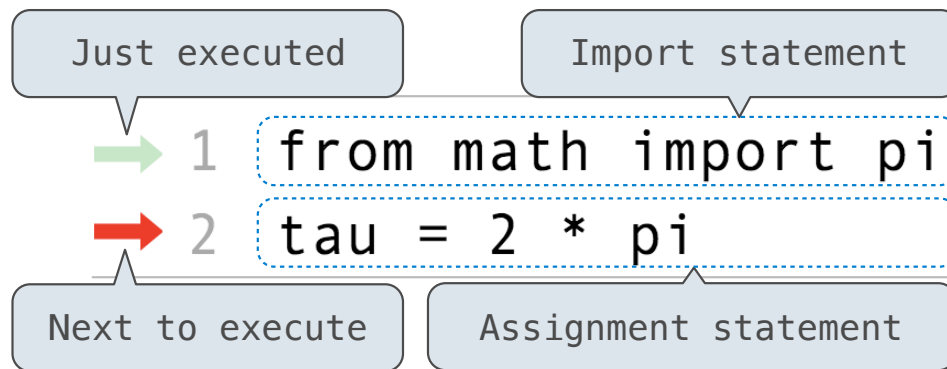
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## Environment Diagrams

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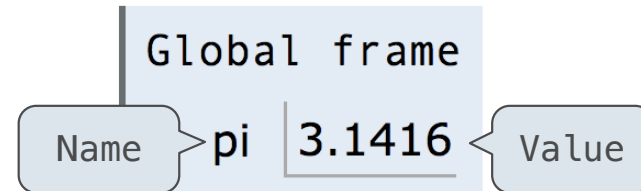
Environment diagrams visualize the interpreter's process.



### Code (left):

Statements and expressions

Arrows indicate evaluation order



### Frames (right):

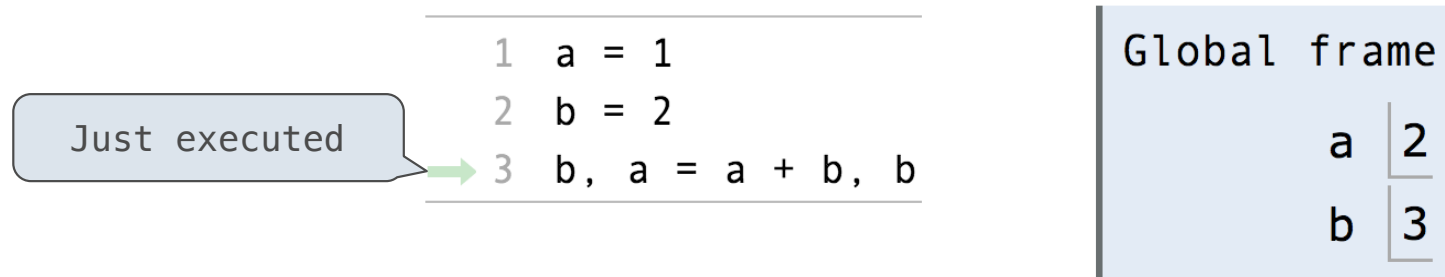
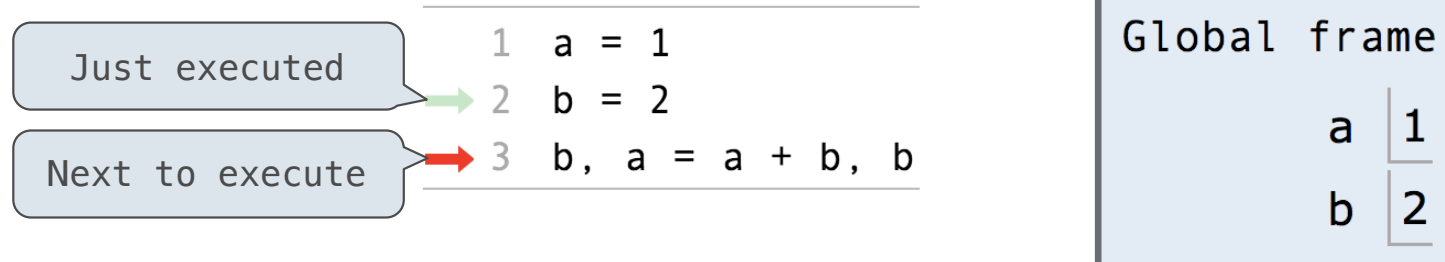
Each name is bound to a value

Within a frame, a name cannot be repeated

(Demo)

Interactive Diagram

## Assignment Statements



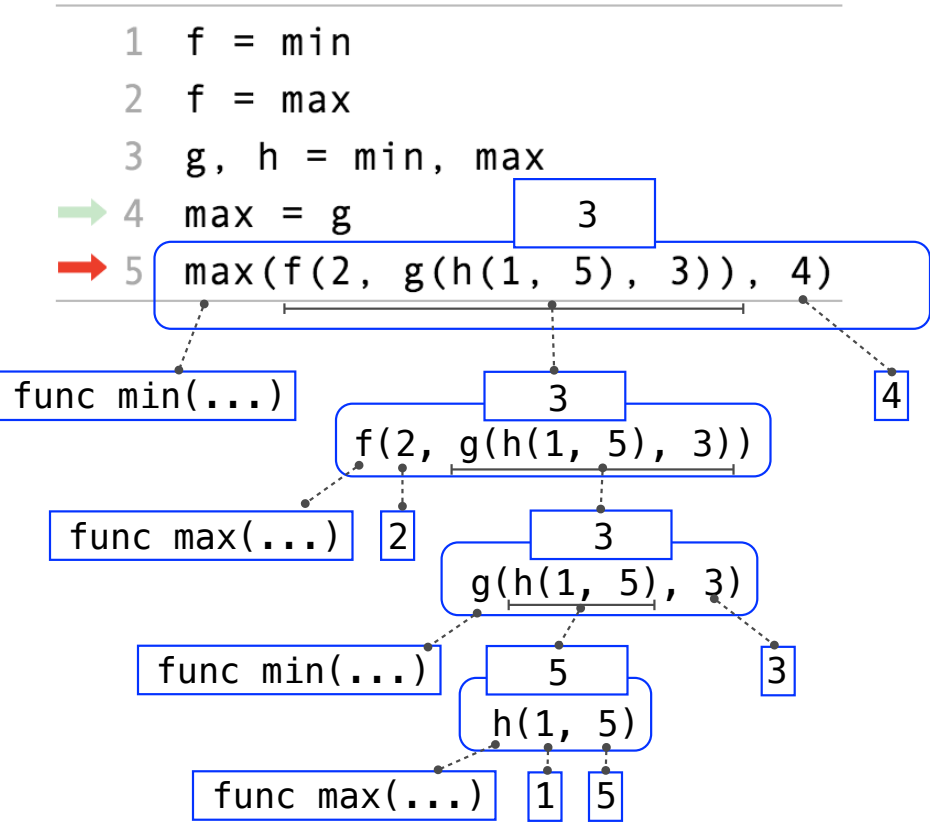
### Execution rule for assignment statements:

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.

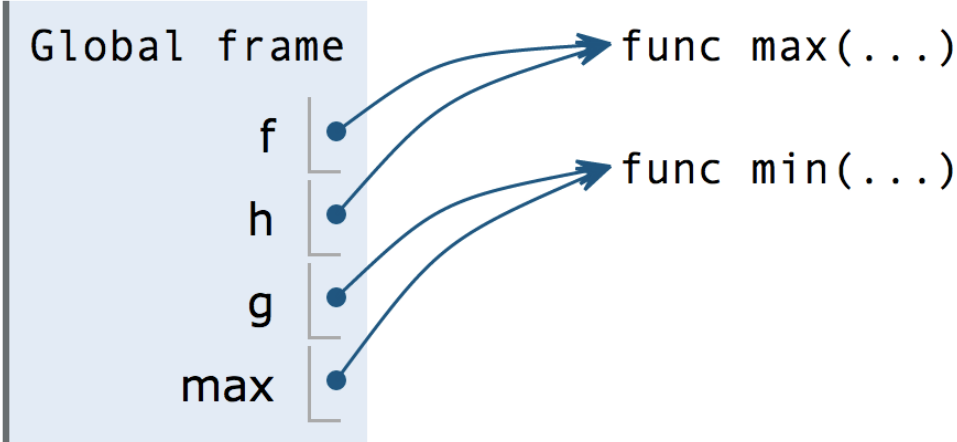
Interactive Diagram



Discussion Question 1 Solution



(Demo)



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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

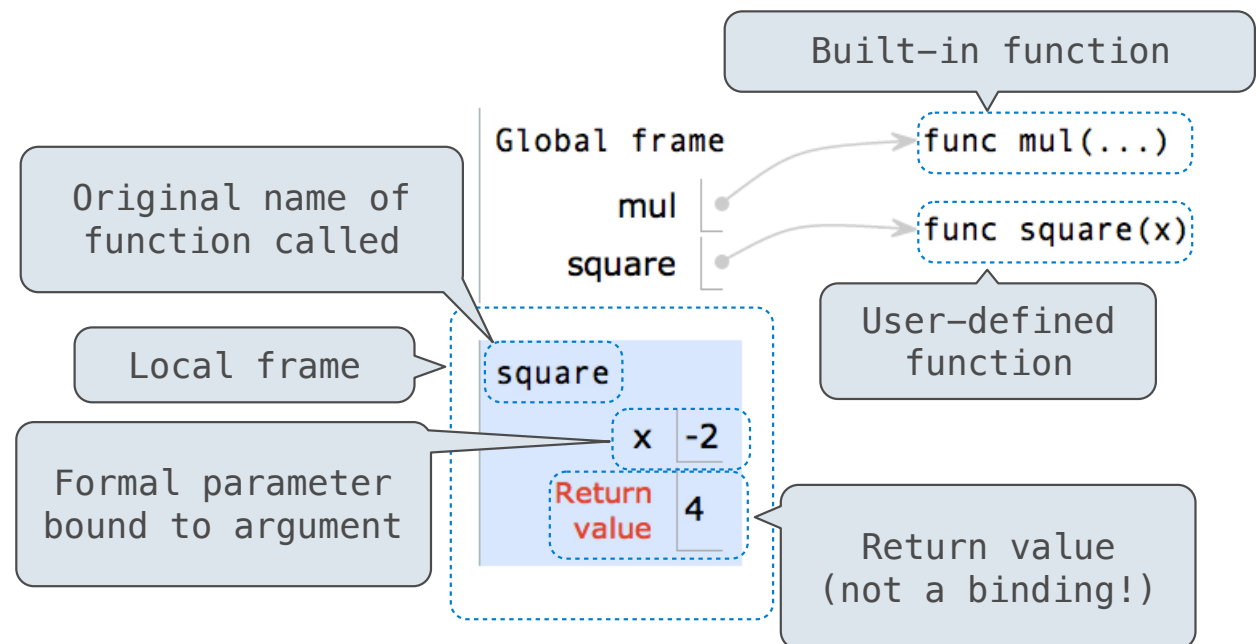
Abstraction is the process of taking something complex, giving it name and treating it as a whole without worrying about all of its details.

## 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

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



Interactive Diagram

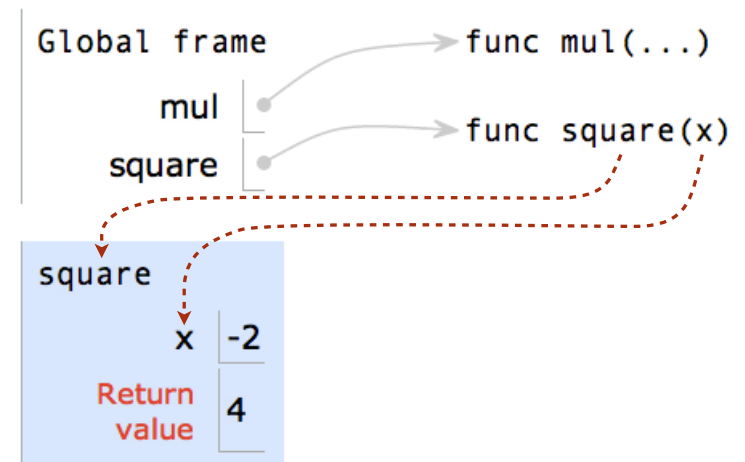
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A function's signature has all the information needed to create a local frame



## 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.)

(Demo)

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 diagram.