# Control

# Announcements

# Print and None

(Demo)

# None Indicates that Nothing is Returned

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```
>>> def does_not_return_square(x):
...     x * x
...
```

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>>> def does_not_return_square(x):
...     x * x
...
>>> does_not_return_square(4)
```

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No **return**

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>>> def does_not_return_square(x):
...     x * x
...
>>> does_not_return_square(4)
>>> sixteen = does_not_return_square(4)
```

No **return**

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>>> def does_not_return_square(x):
...     x * x
...
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>>> sixteen = does_not_return_square(4)
```

No **return**

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The name **sixteen** is now bound to the value **None**

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```
>>> def does_not_return_square(x):
...     x * x
...
>>> does_not_return_square(4)
>>> sixteen = does_not_return_square(4)
>>> sixteen + 4
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for +: 'NoneType' and 'int'
```

No **return**

**None** value is not displayed

The name **sixteen** is now bound to the value **None**

# Pure Functions & Non-Pure Functions

**Pure Functions**
*just return values*

**Non-Pure Functions**
*have side effects*

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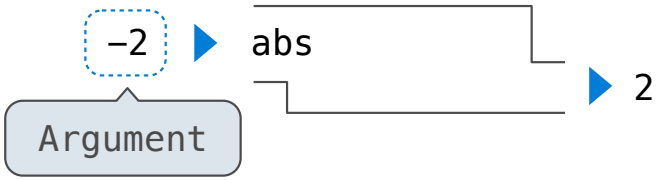


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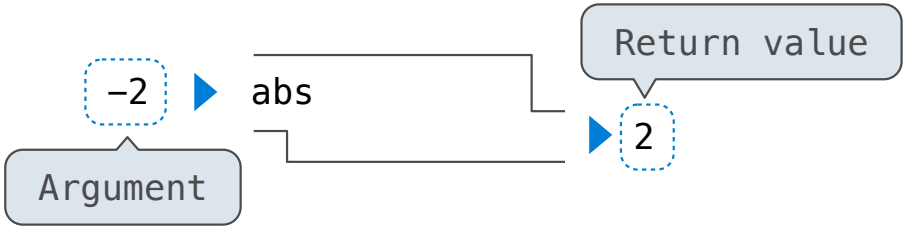


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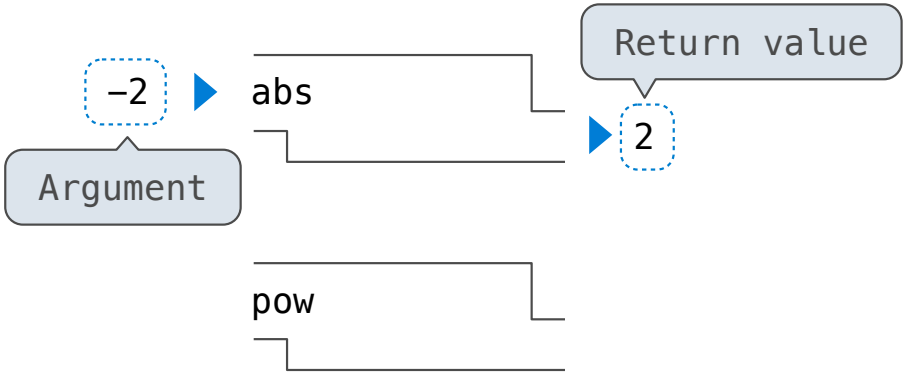


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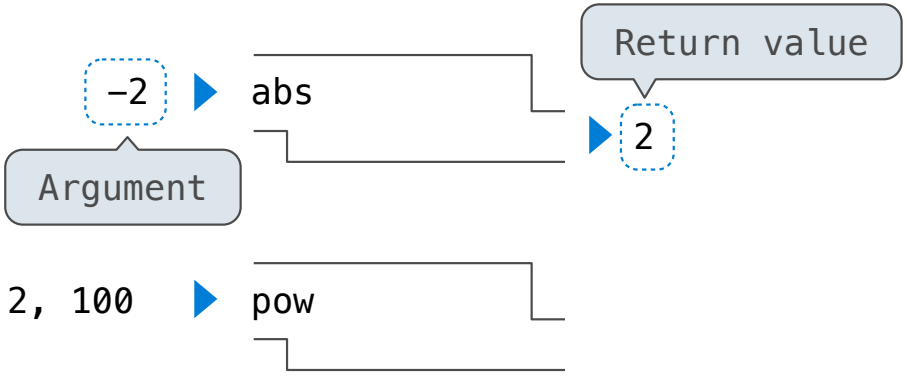


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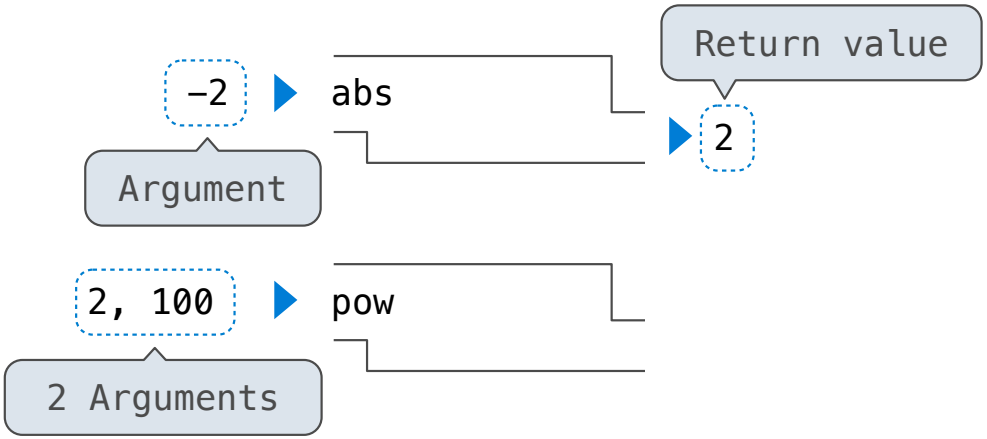


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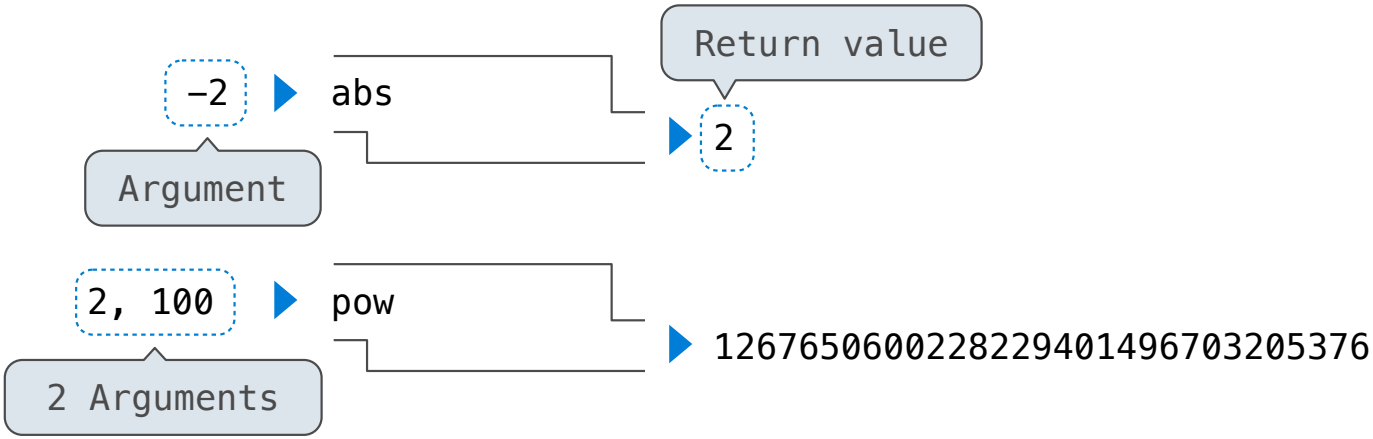


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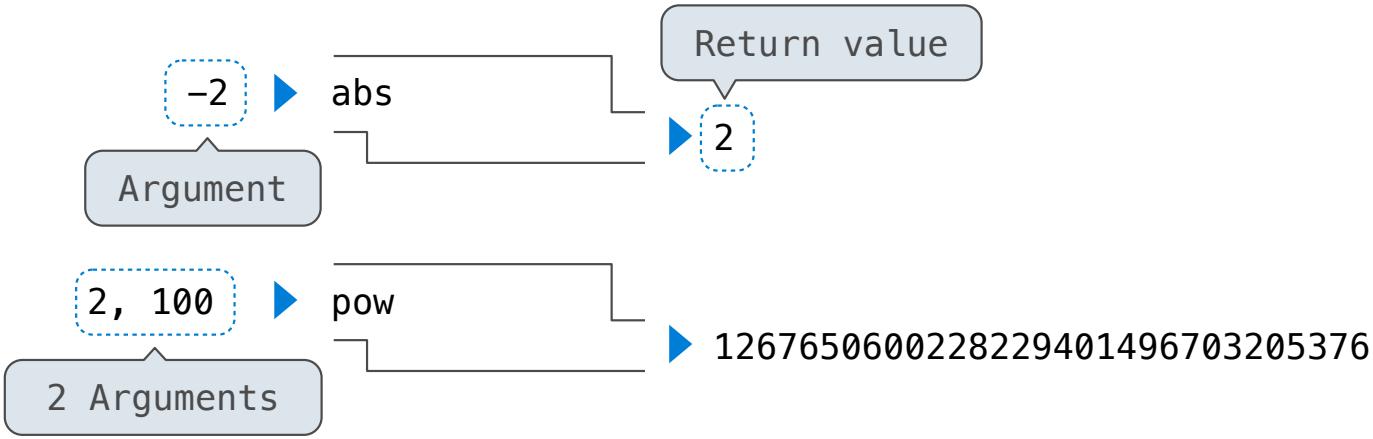


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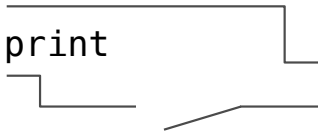

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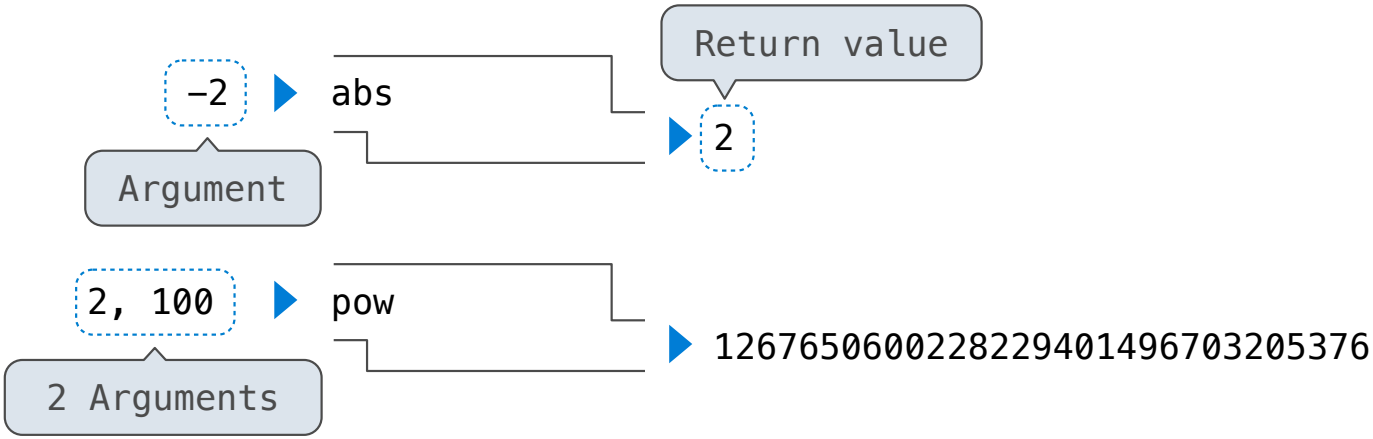


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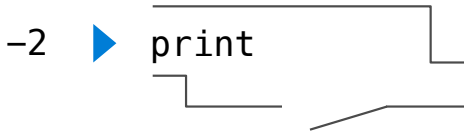

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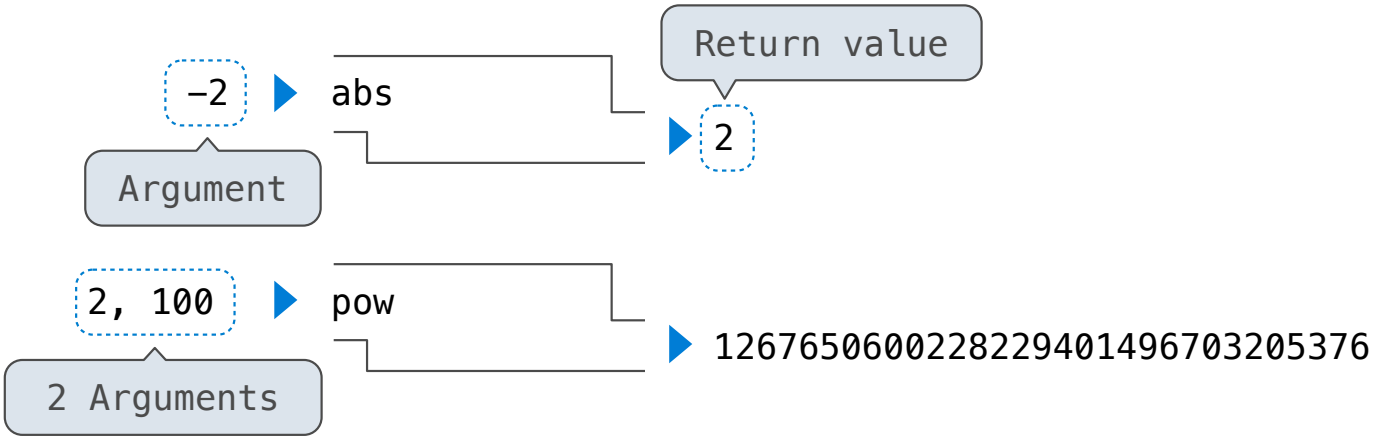


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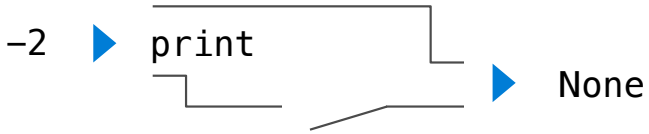

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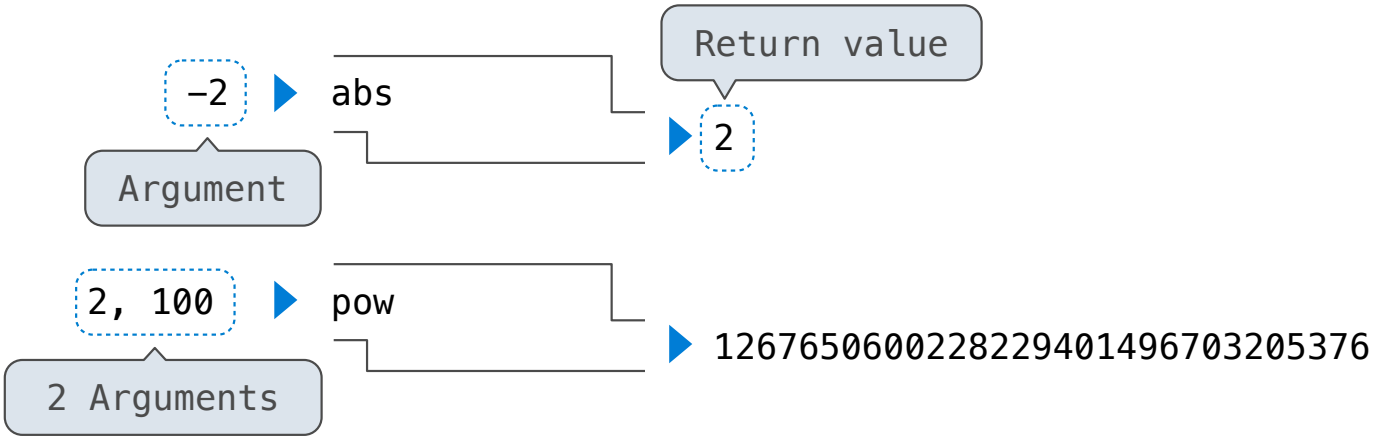


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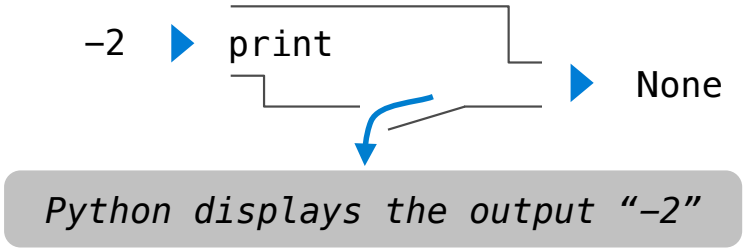

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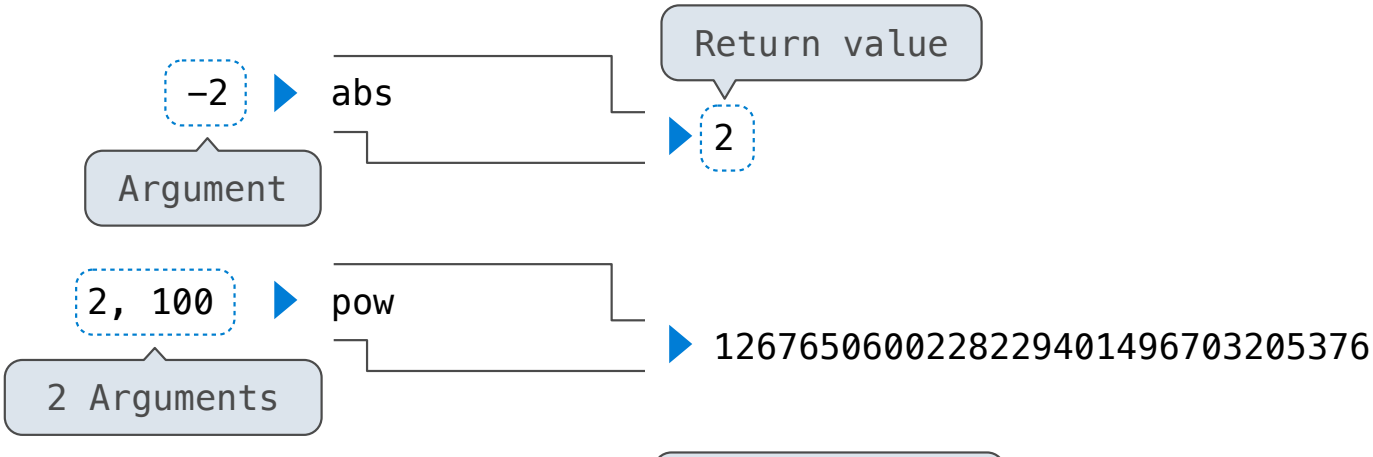


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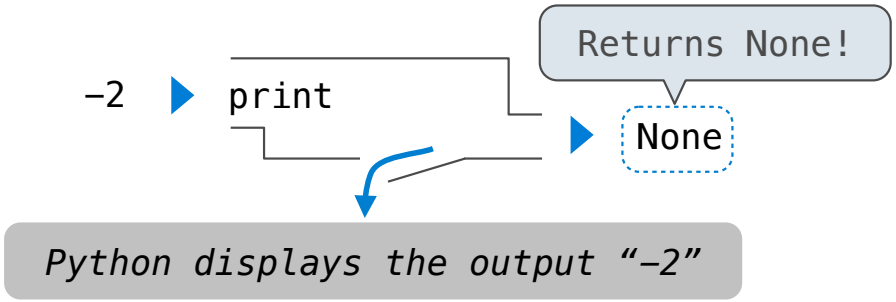

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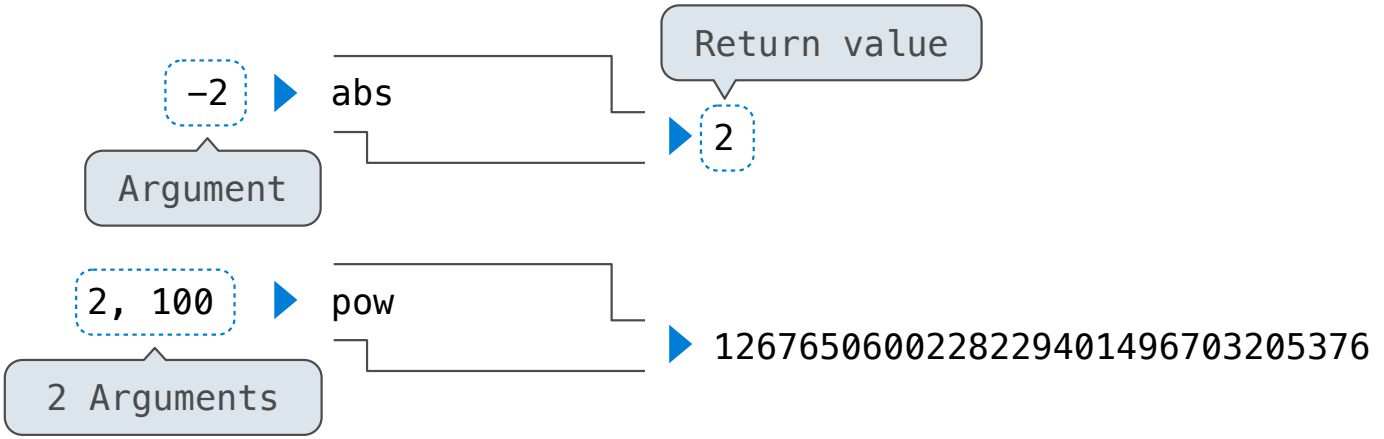


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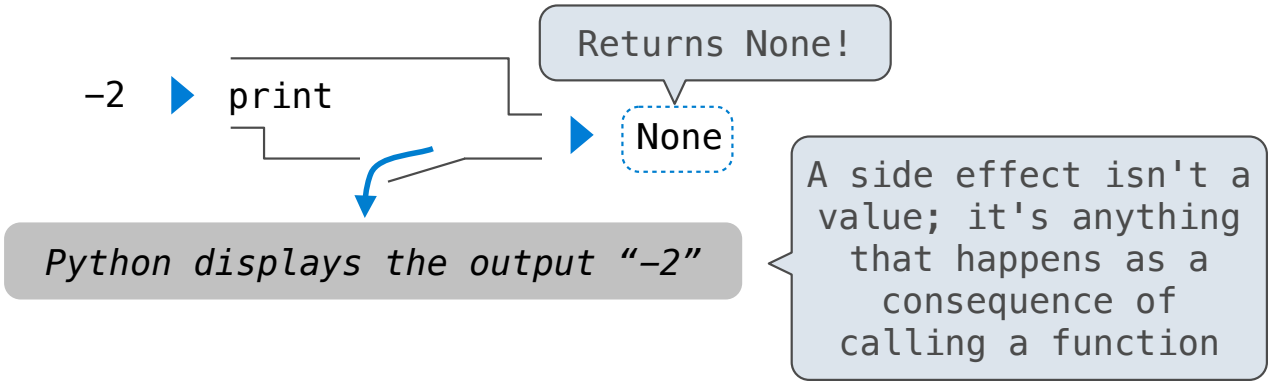

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>>> print(print(1), print(2))
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None None
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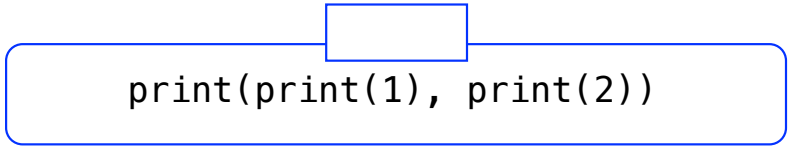

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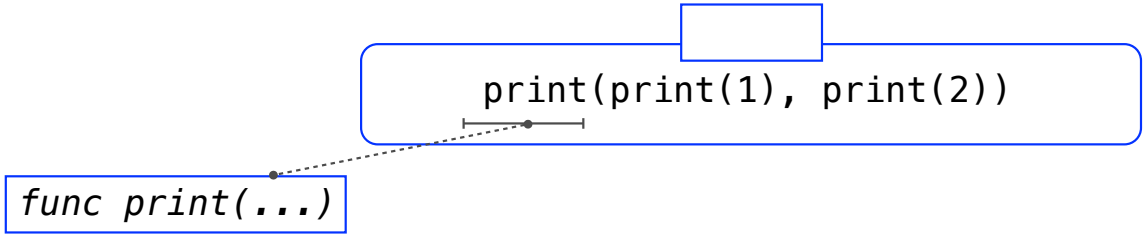

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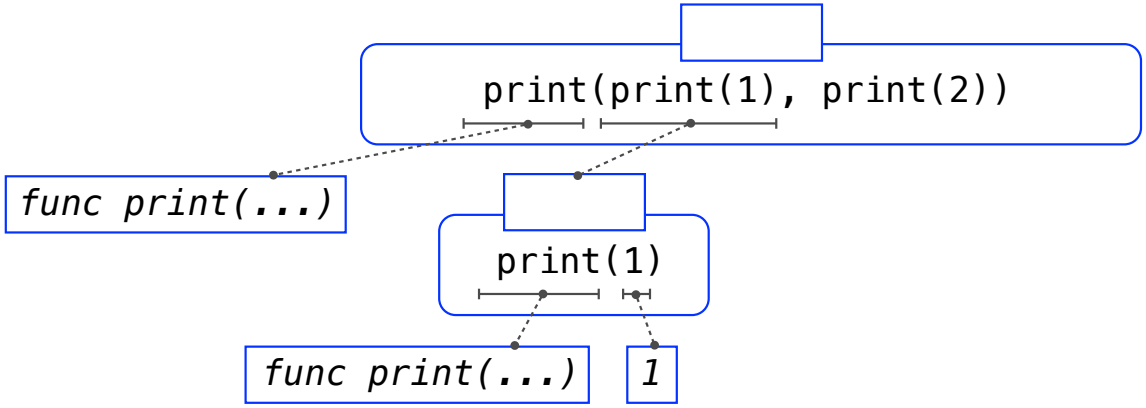

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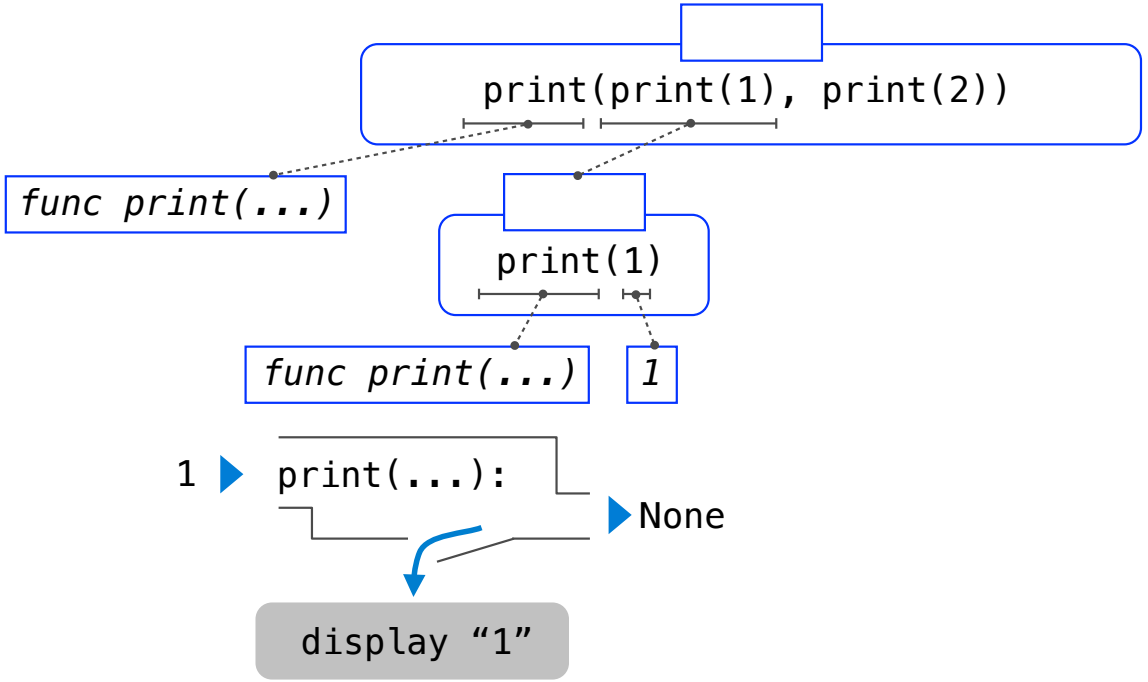

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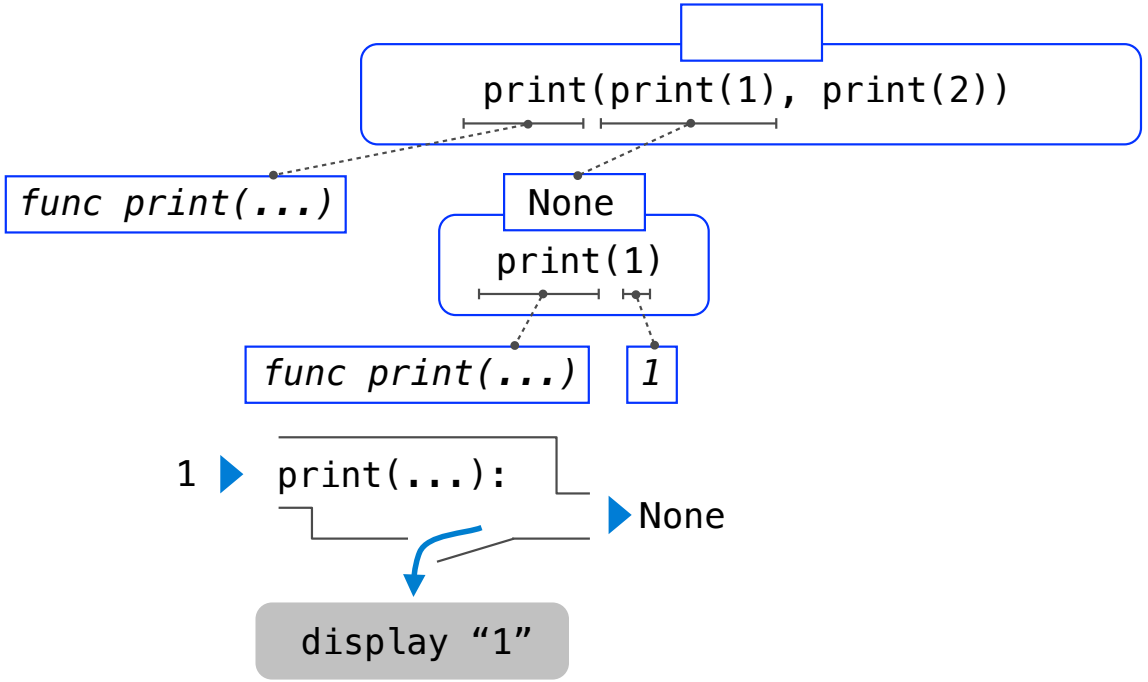

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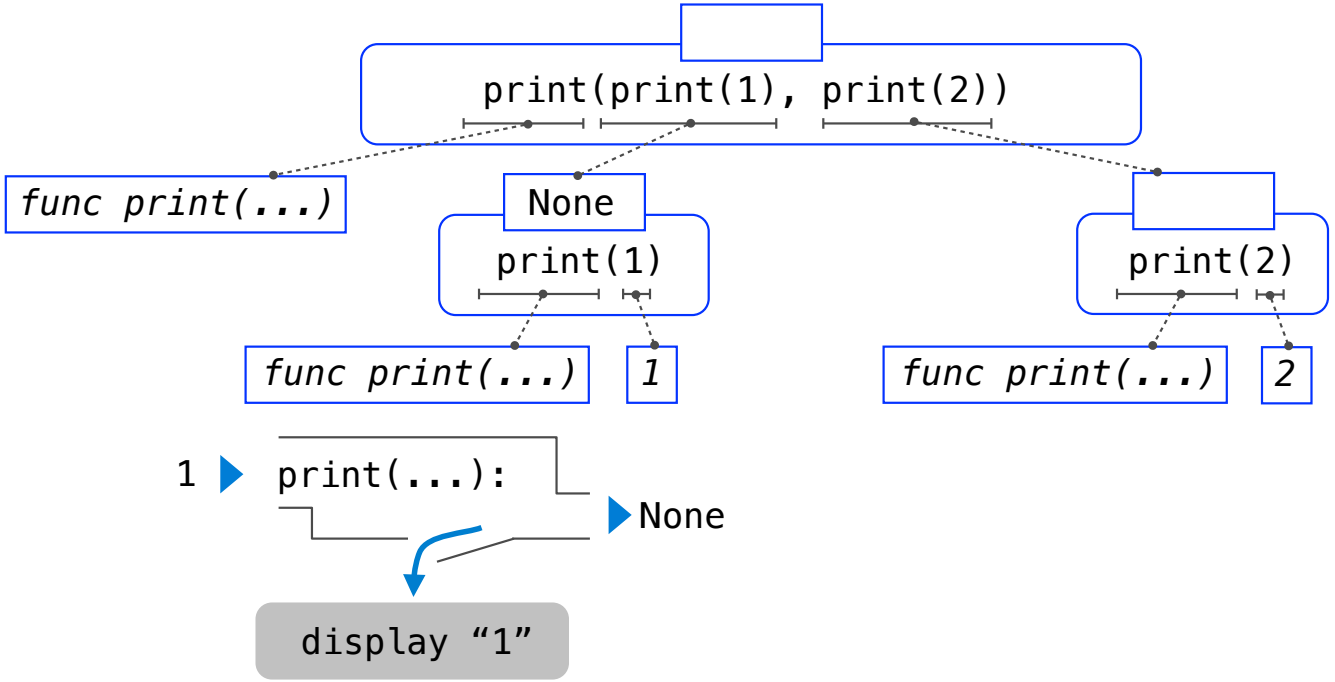

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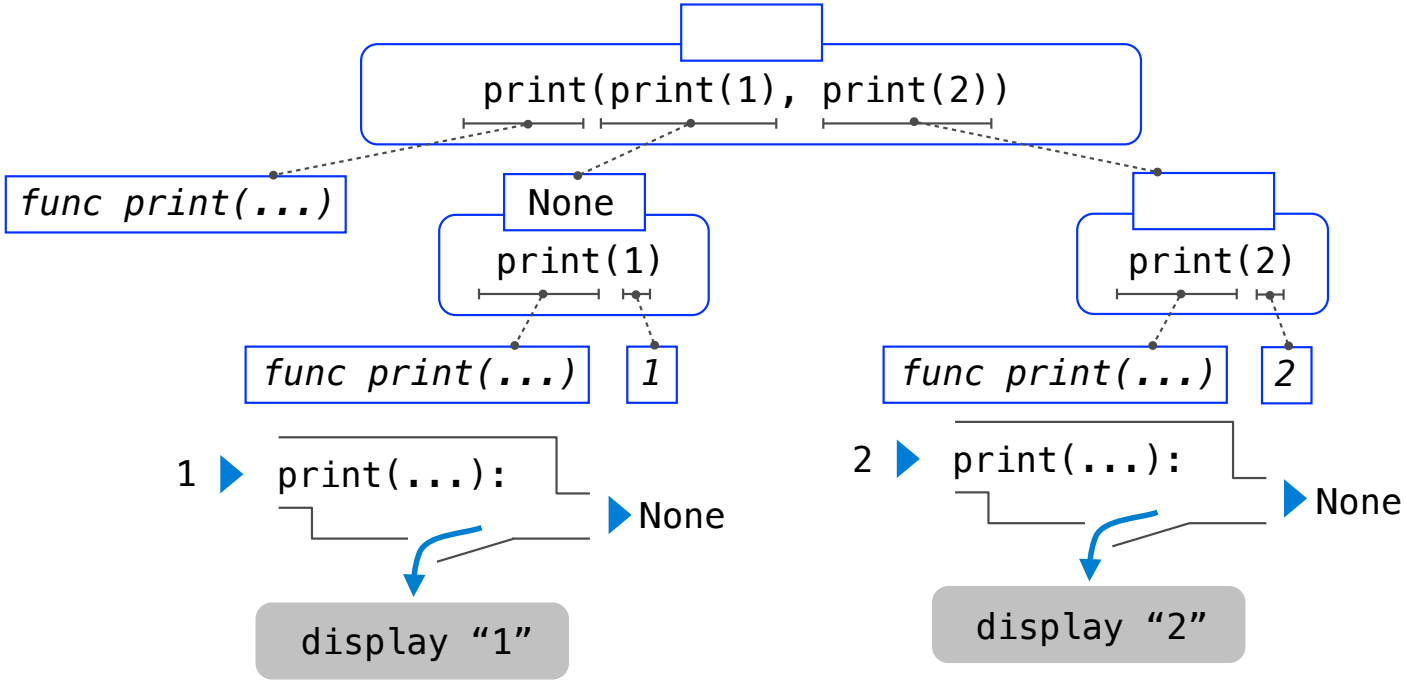

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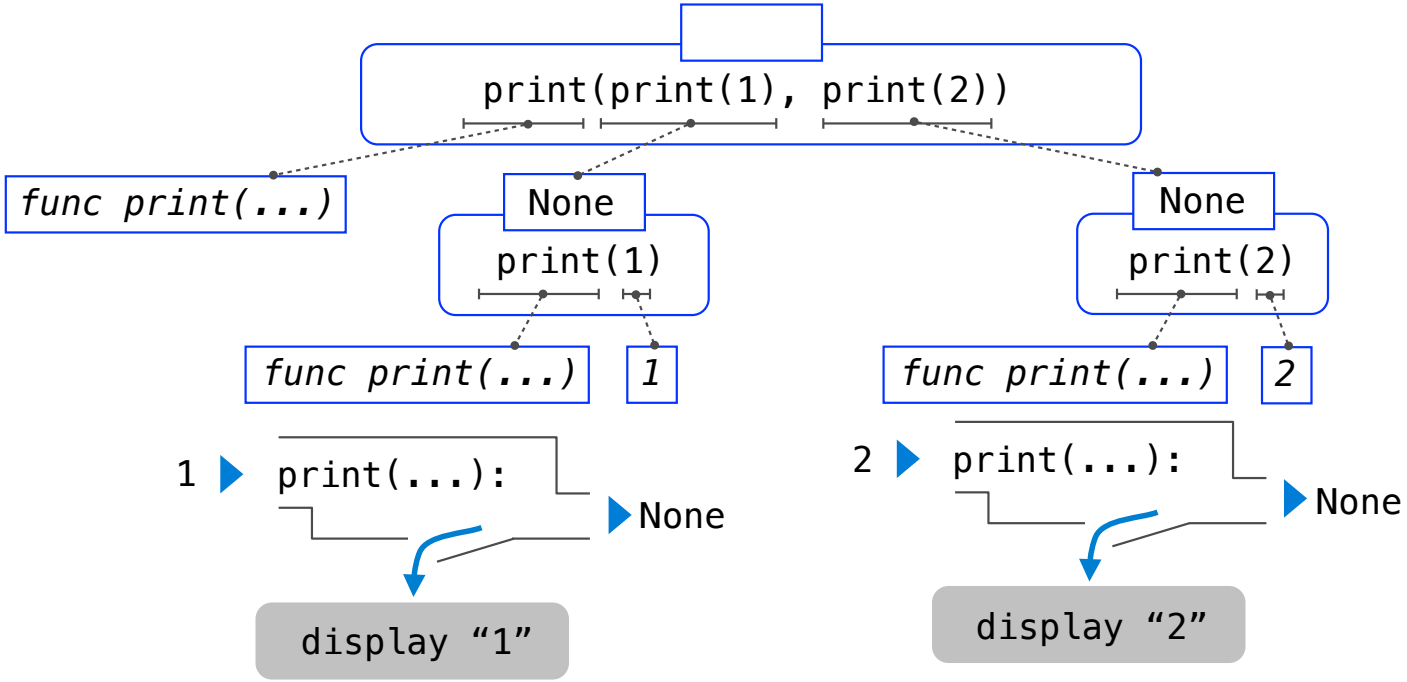

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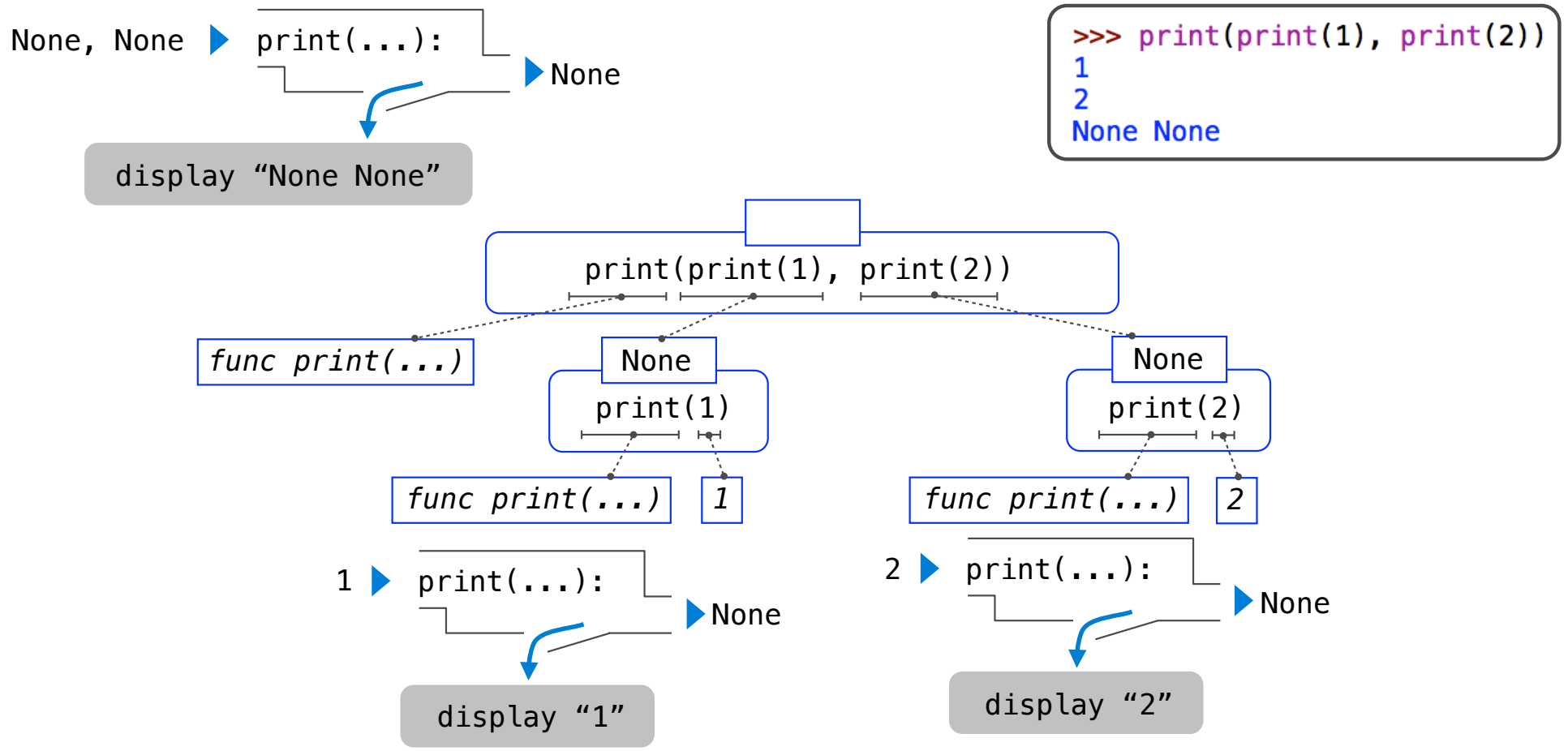

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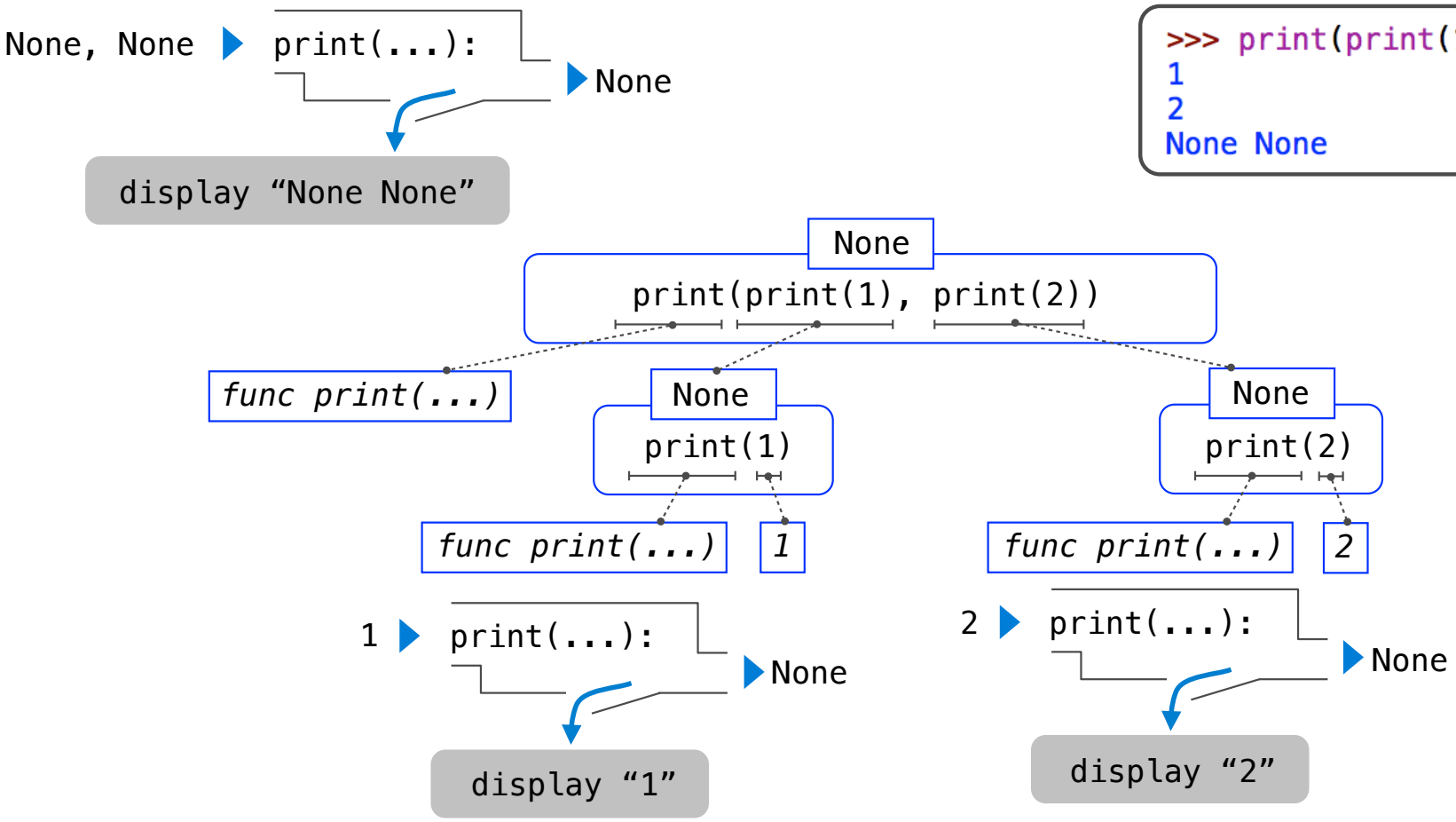

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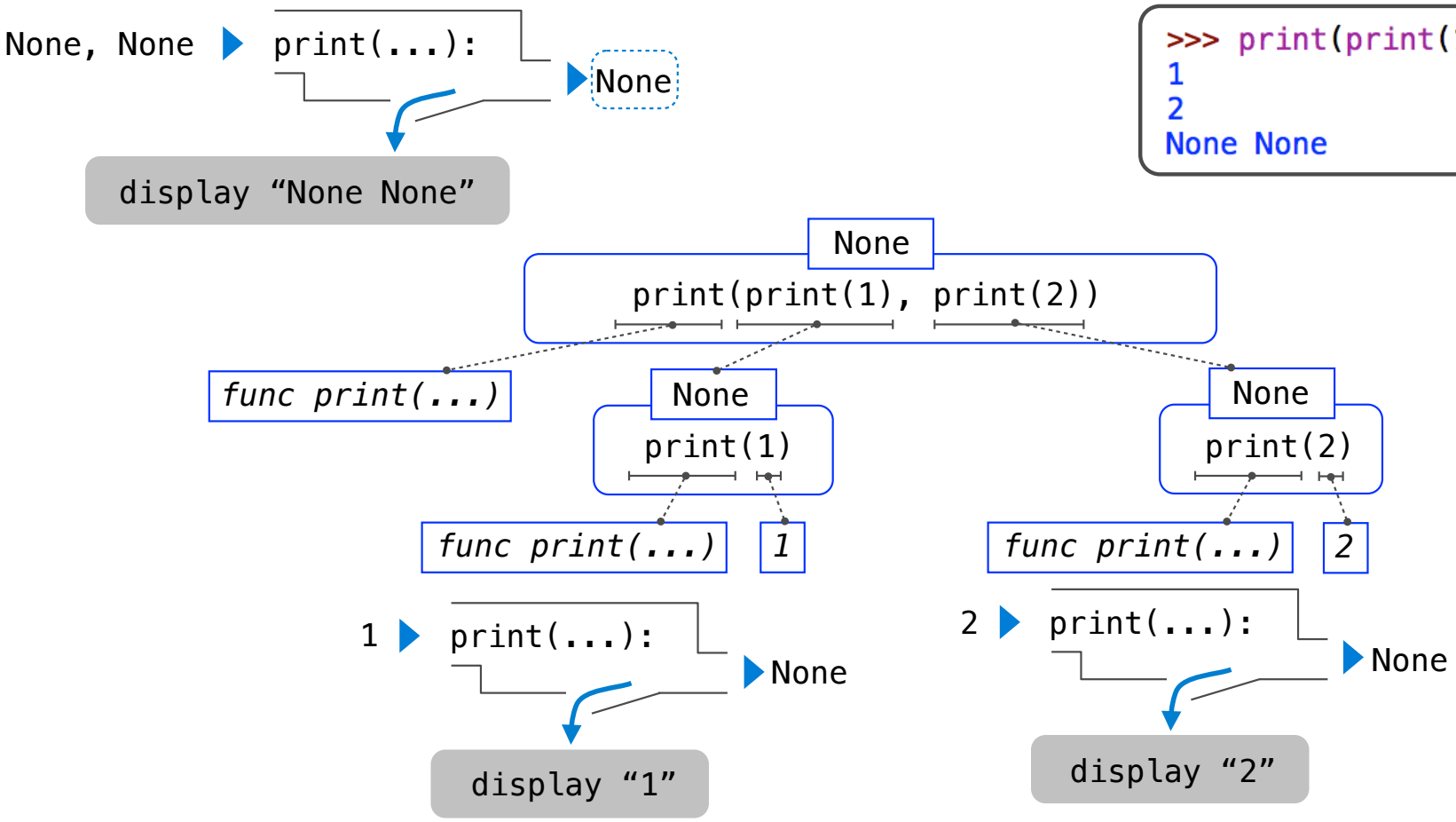

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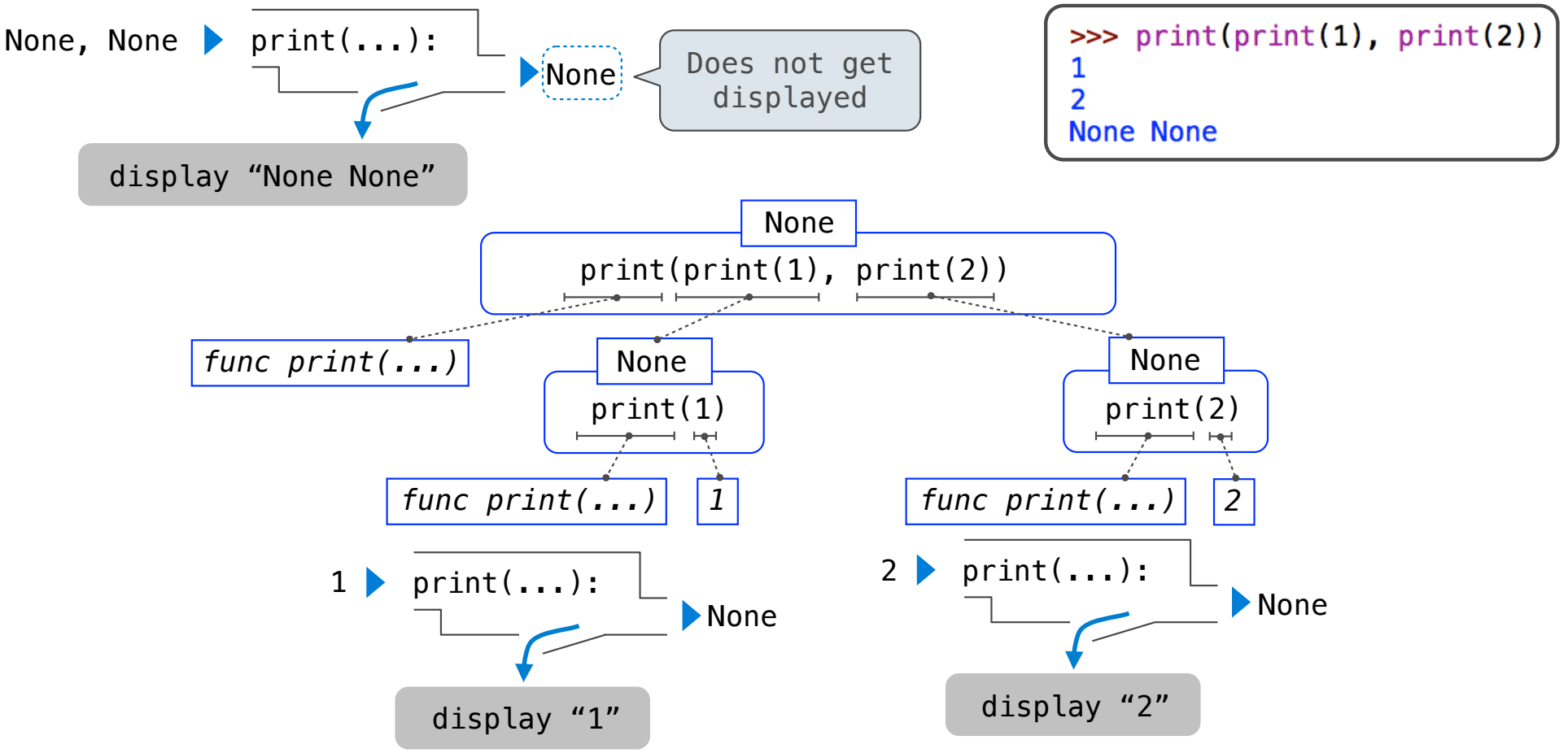

# Multiple Environments

# Life Cycle of a User-Defined Function

**What happens?**

**Def statement:**

**Call expression:**

**Calling/Applying:**

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**What happens?**

**Def statement:**

```
>>> def square( x ):
        return mul(x, x)
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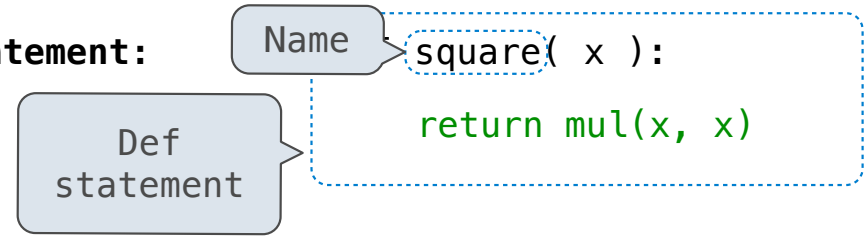


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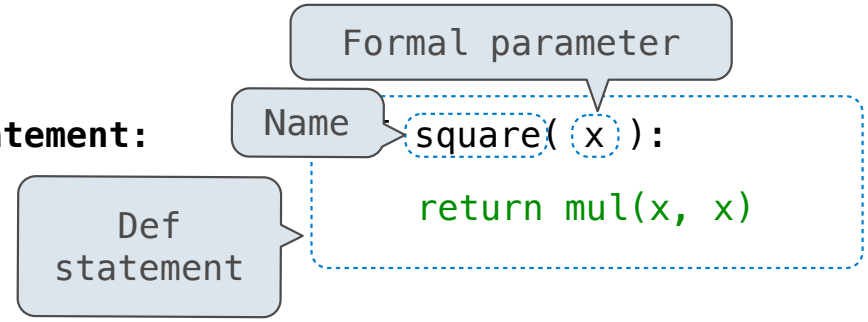


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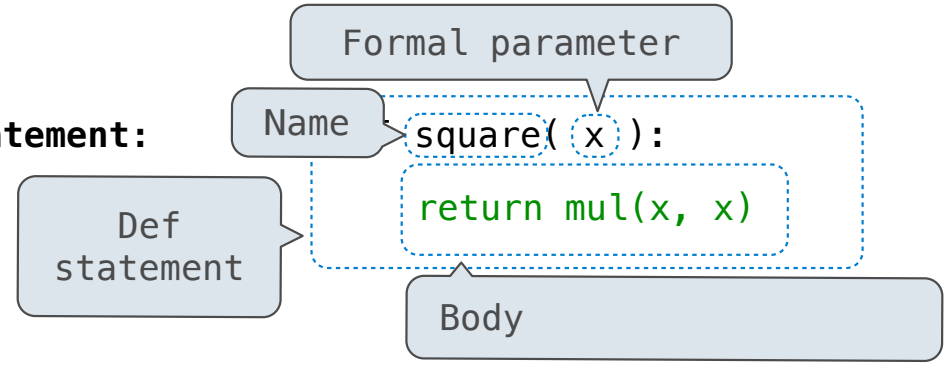


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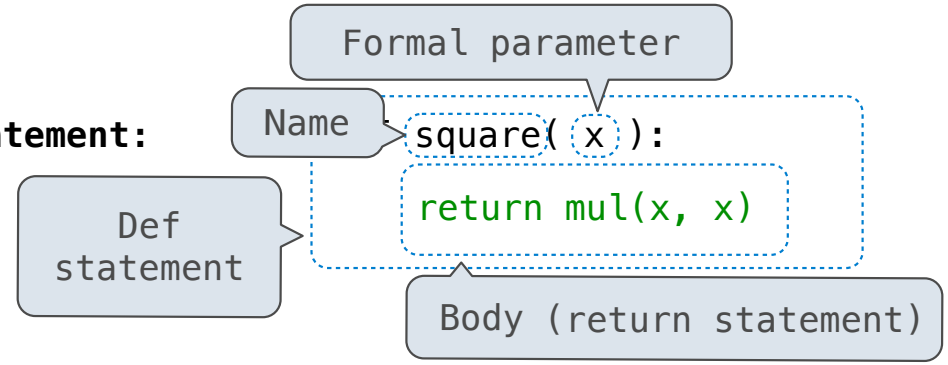


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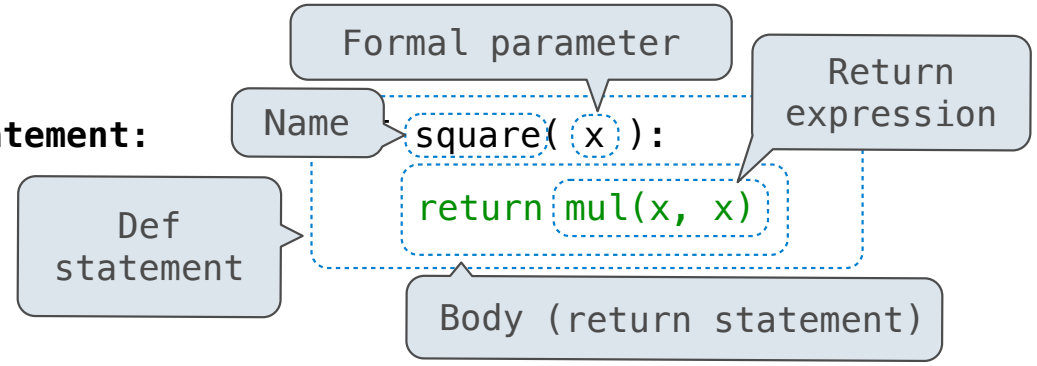


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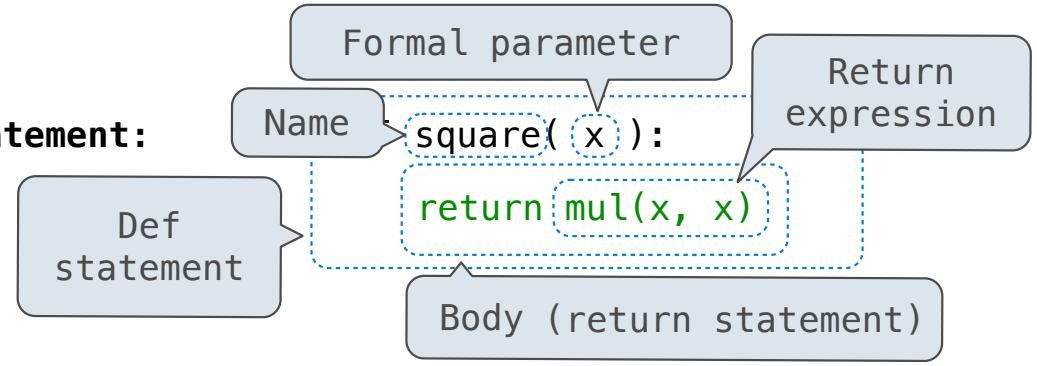


**What happens?**

A new function is created!

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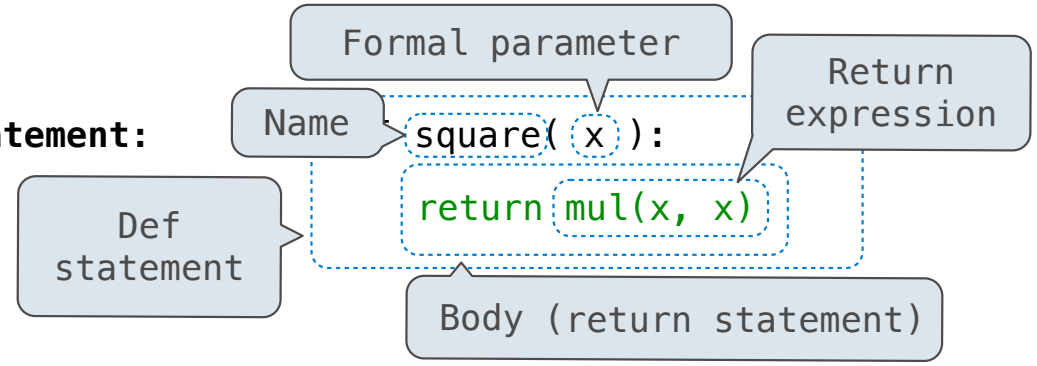


**What happens?**

A new function is created!

Name bound to that function in the current frame

**Call expression:**

**Calling/Applying:**

# Life Cycle of a User-Defined Function

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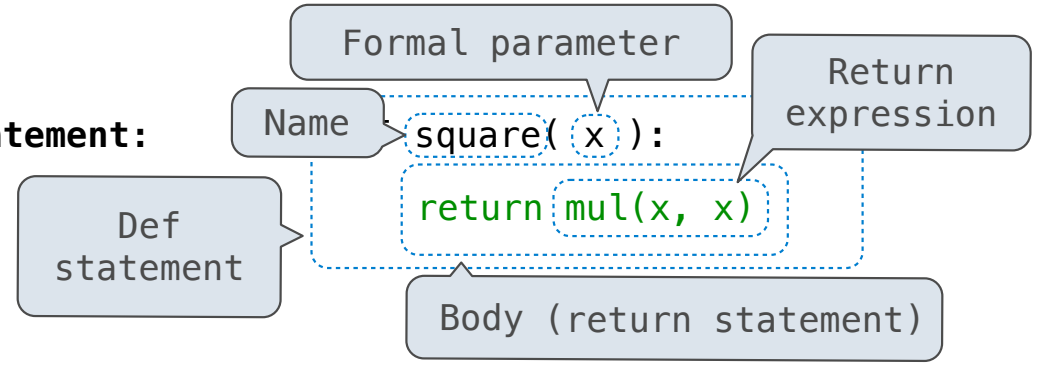


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**Call expression:** square(2+2)

**Calling/Applying:**

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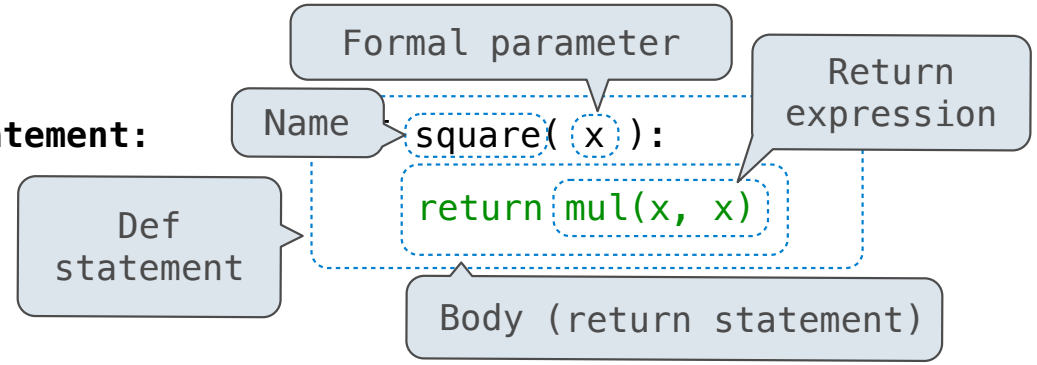


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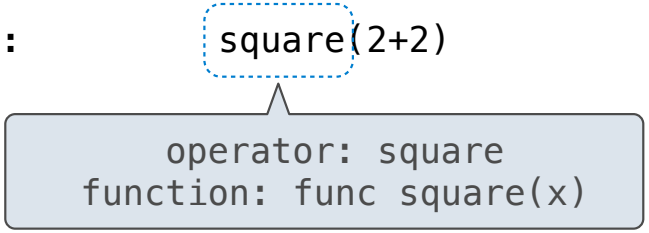


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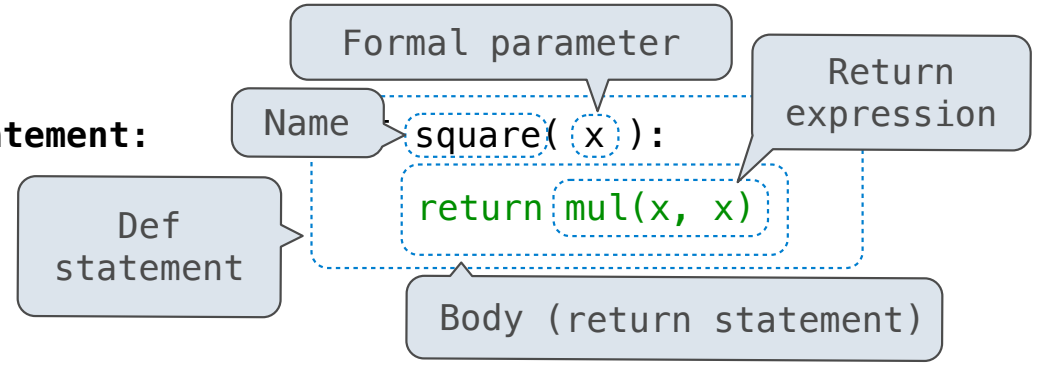


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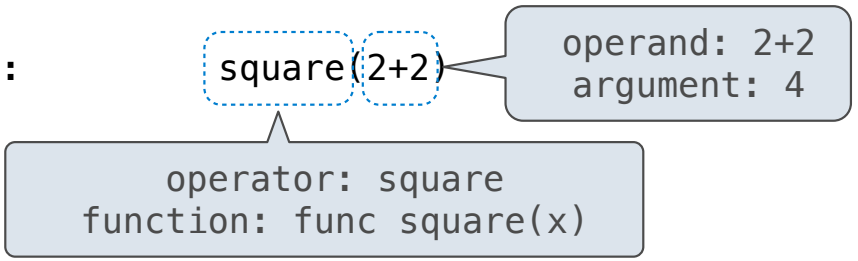


**Calling/Applying:**

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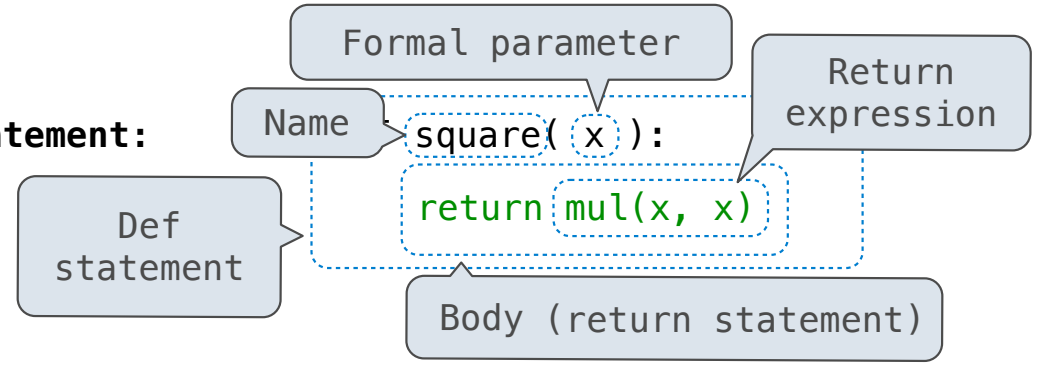
A new function is created!

Name bound to that function in the current frame

# Life Cycle of a User-Defined Function

**Def statement:**

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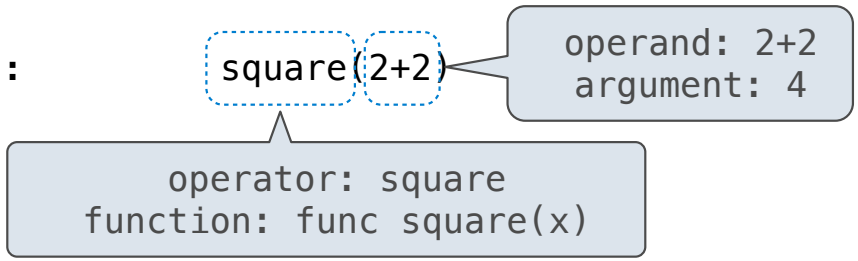


Operator & operands evaluated

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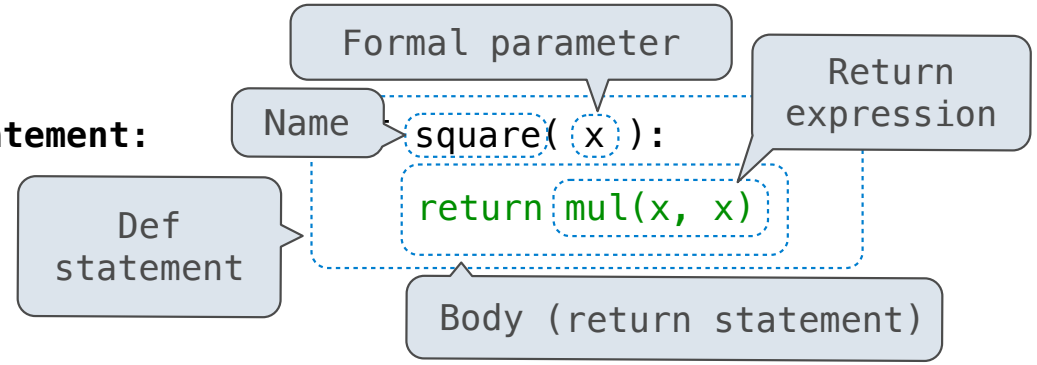


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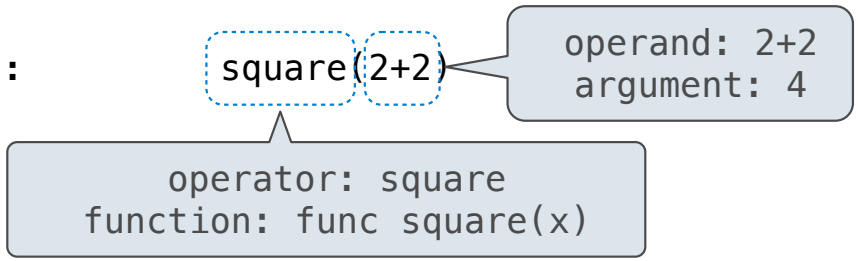


Operator & operands evaluated

Function (value of operator) called on arguments (values of operands)

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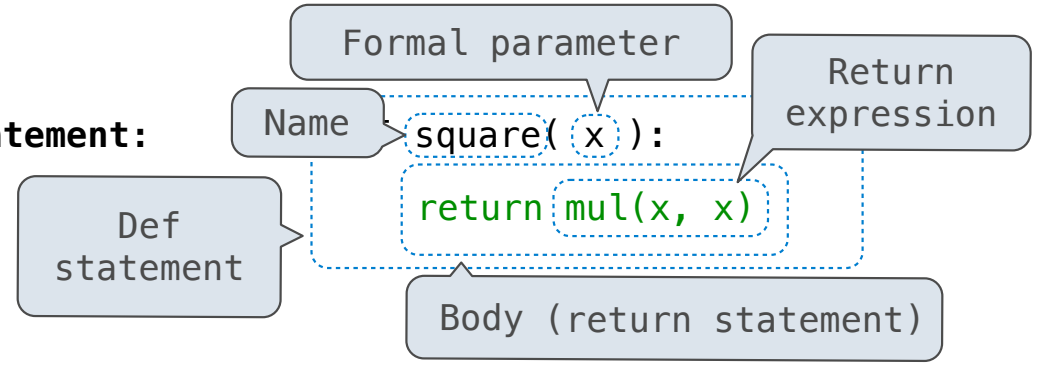


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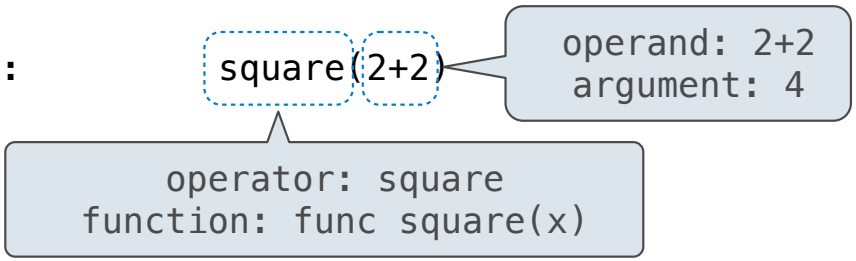


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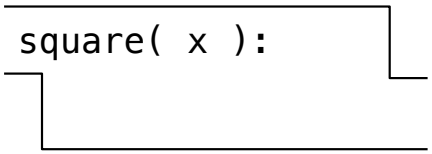


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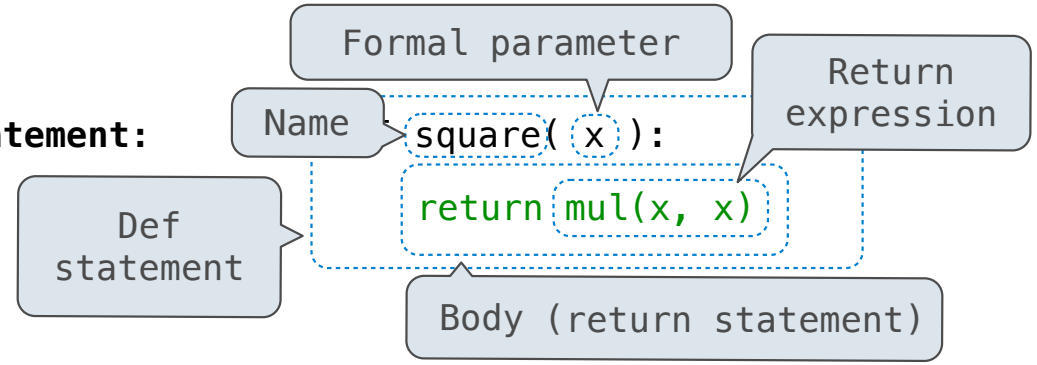


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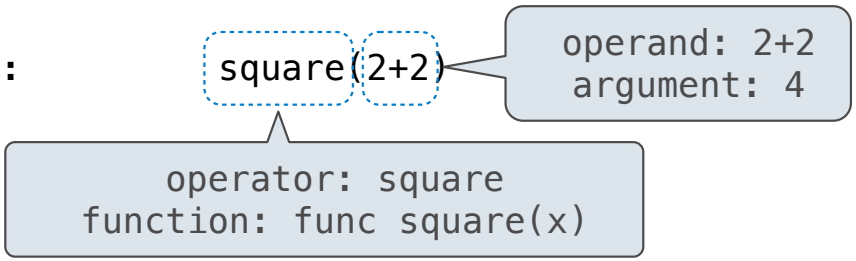


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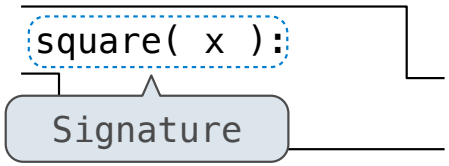


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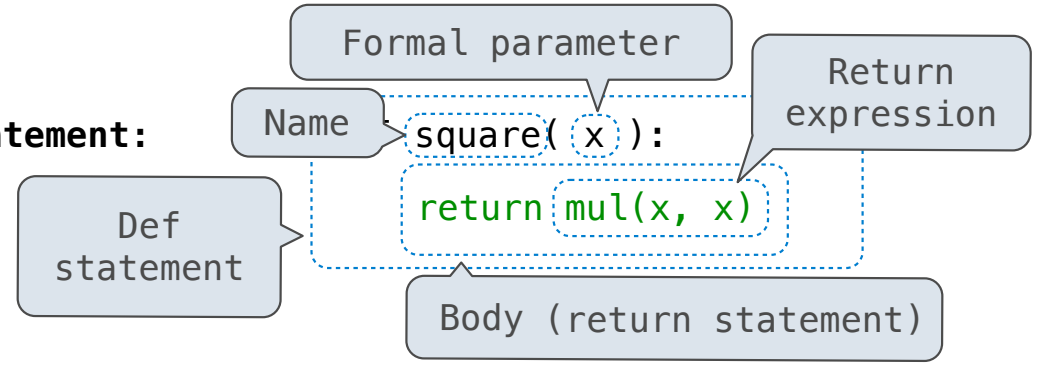


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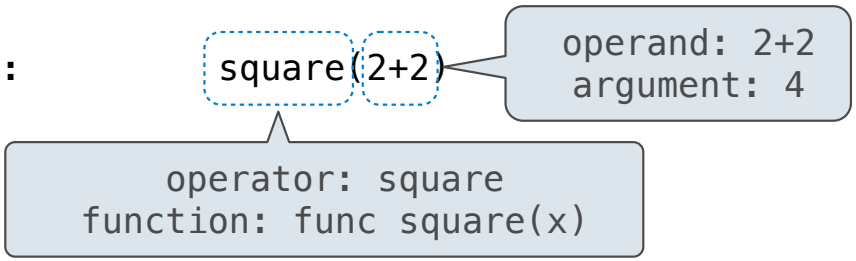


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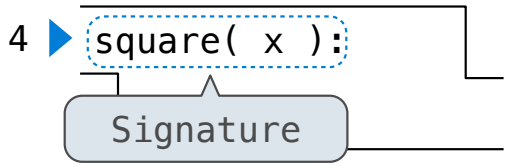


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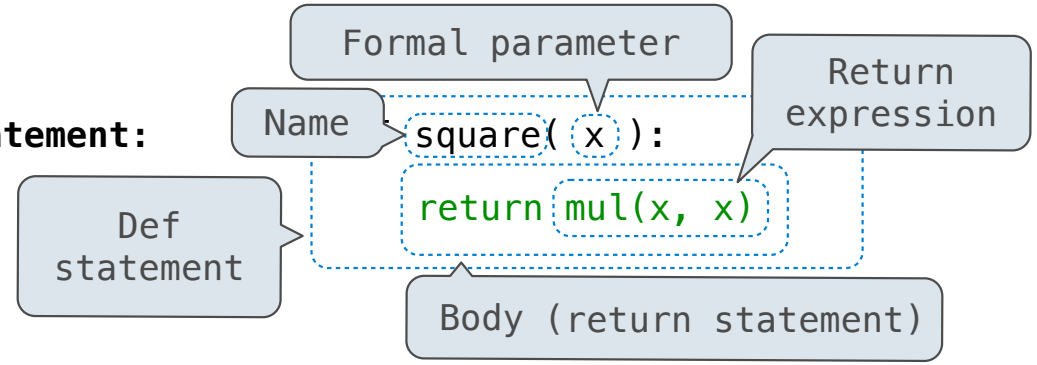


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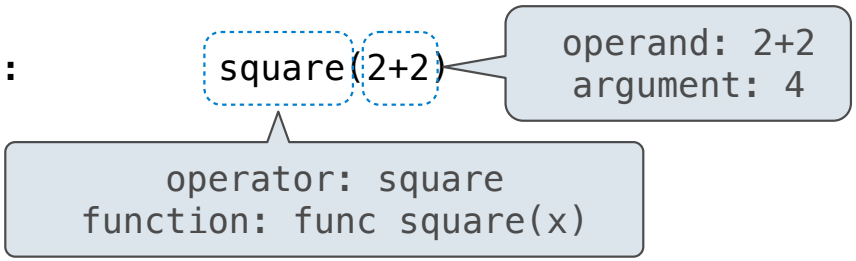


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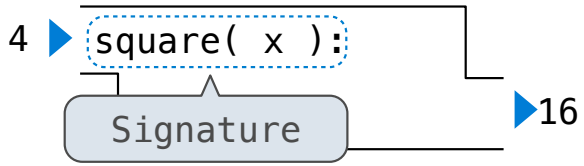


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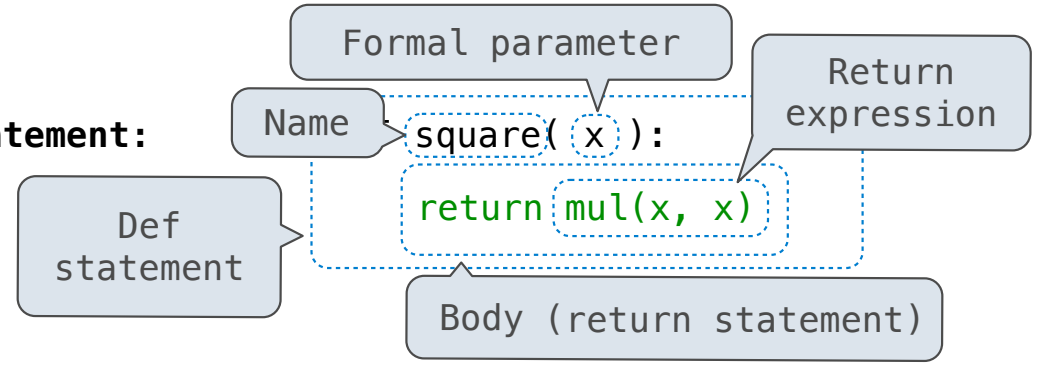


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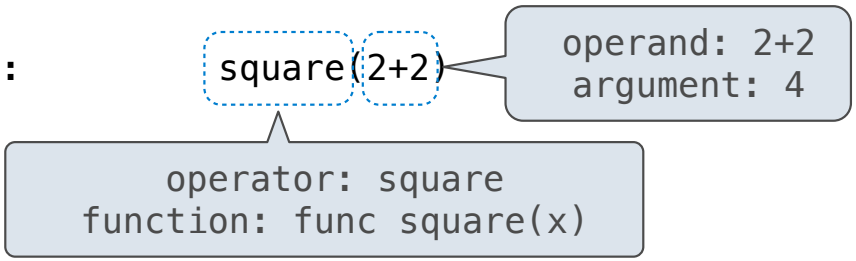


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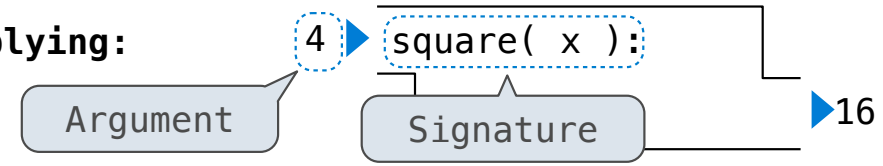


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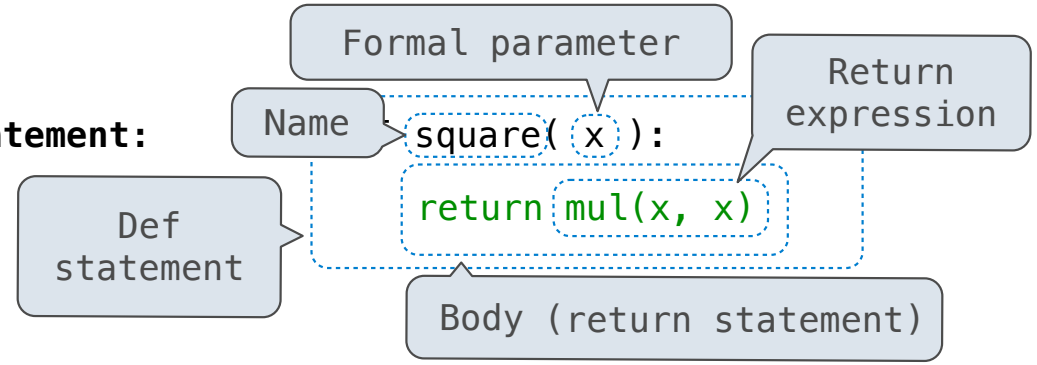


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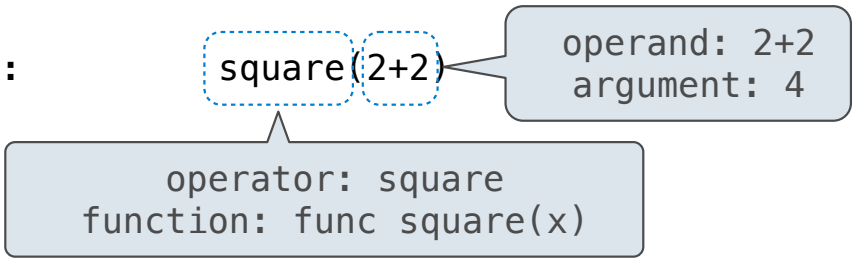


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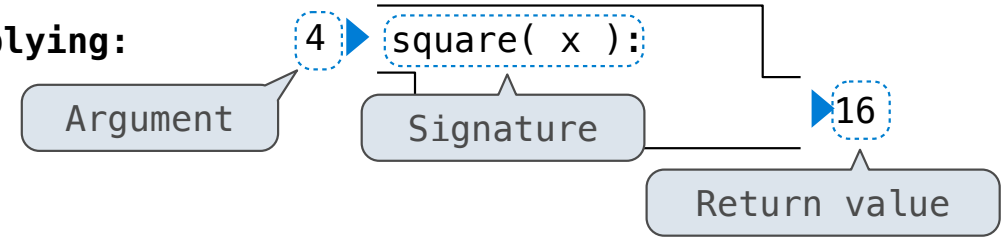


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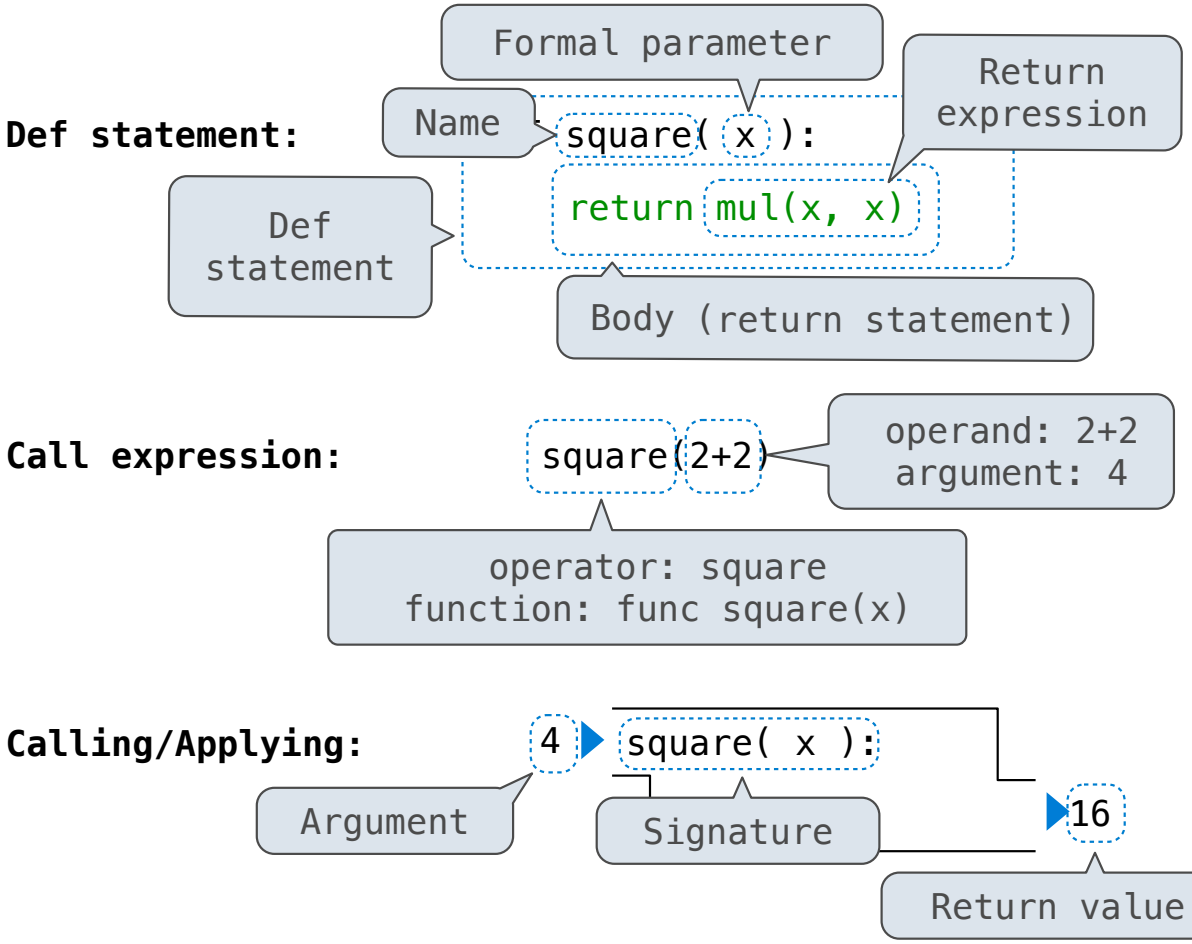


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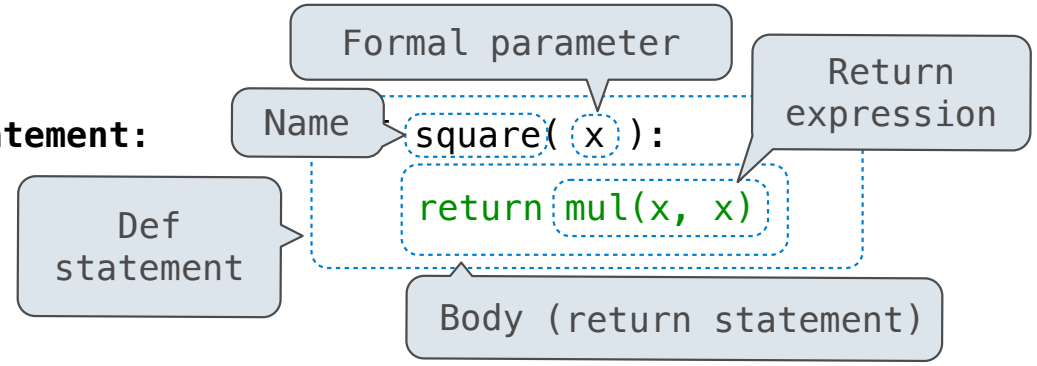


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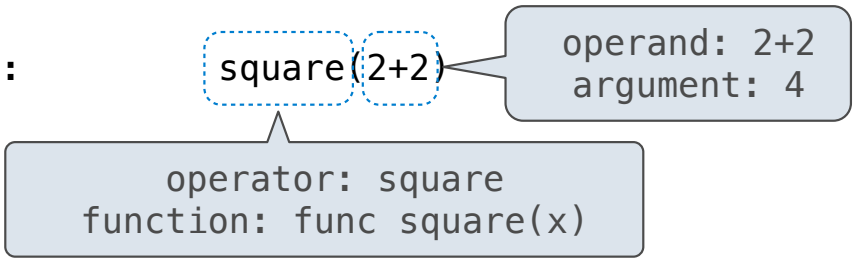


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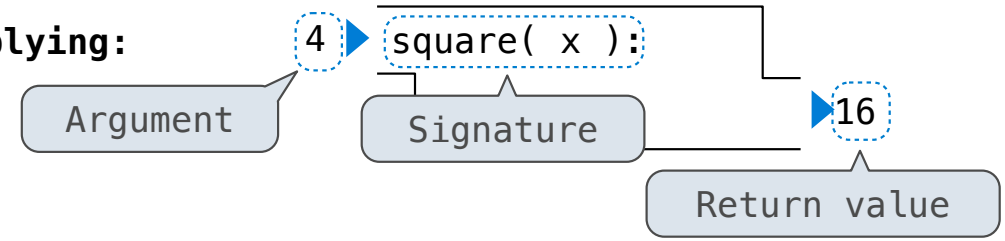


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A new function is created!

Name bound to that function in the current frame

Operator & operands evaluated

Function (value of operator) called on arguments (values of operands)

A new frame is created!

Parameters bound to arguments

# Life Cycle of a User-Defined Function

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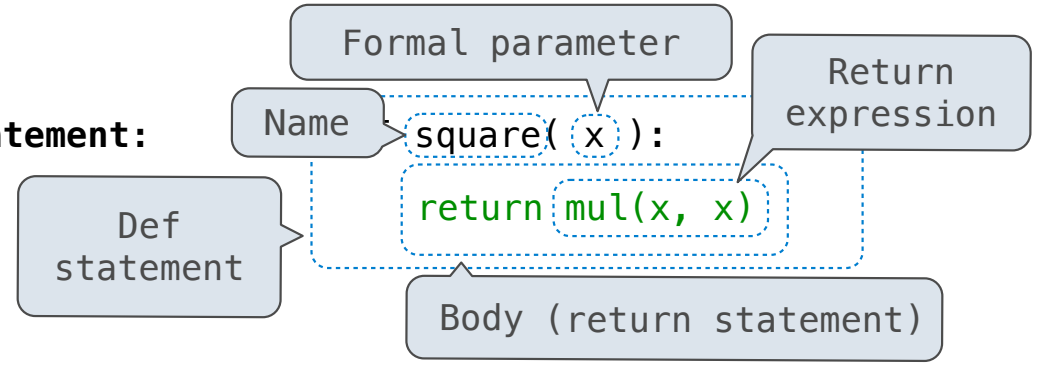


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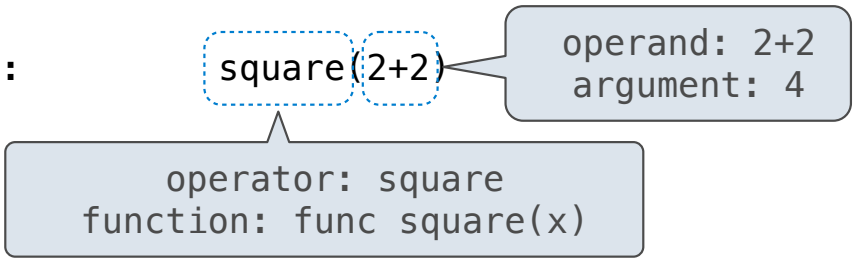


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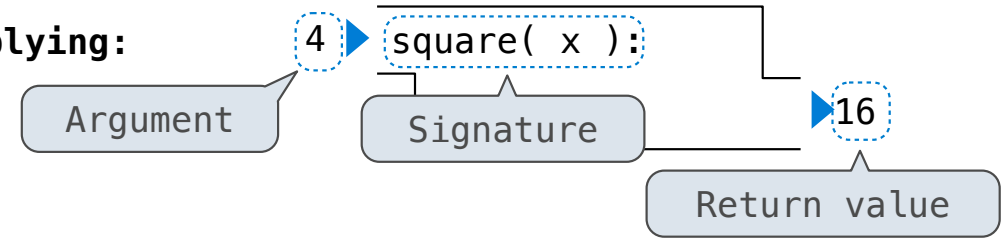


**What happens?**

A new function is created!

Name bound to that function in the current frame

Operator & operands evaluated

Function (value of operator) called on arguments (values of operands)

A new frame is created!

Parameters bound to arguments

Body is executed in that new environment

# Multiple Environments in One Diagram!

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

http://pythontutor.com/composingprograms.html#code=from%20operator%20import%20mul%0Adef%20square%28x%29%3A%0A%20%20%20%20return%20mul%28x,%20x%29%0Asquare%28square%283%29%29&cumulative=true&curInstr=0&mode=display&origin=composingprograms.js&py=3&rawInputLstJSON=%5B%5D

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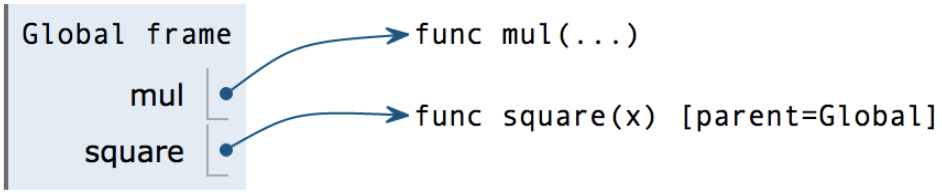


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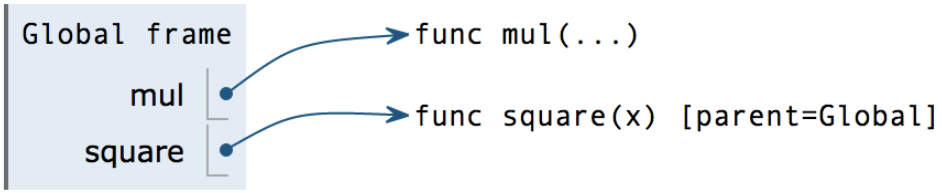


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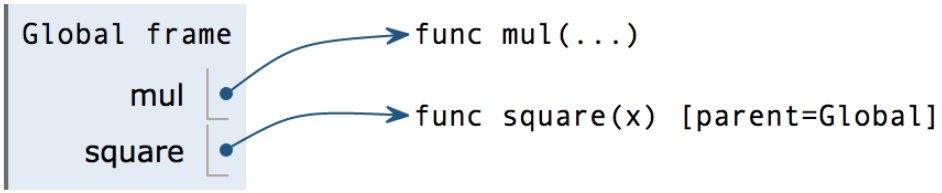


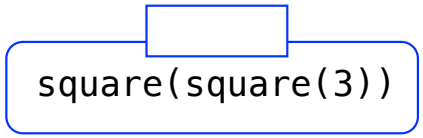


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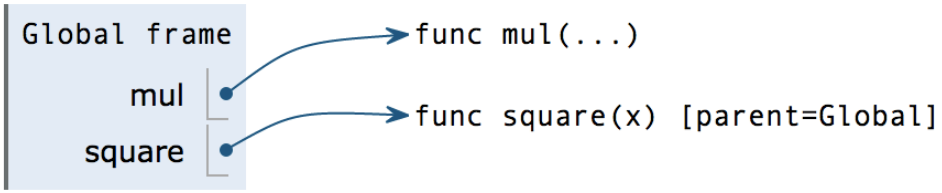


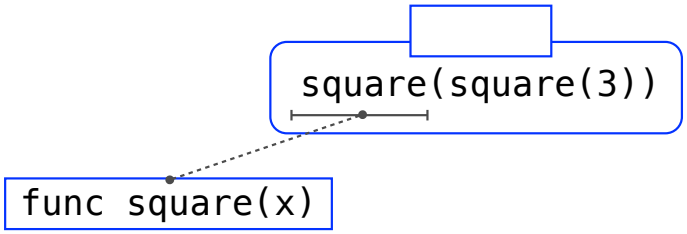


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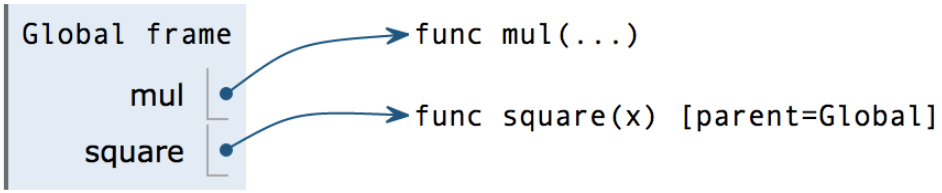


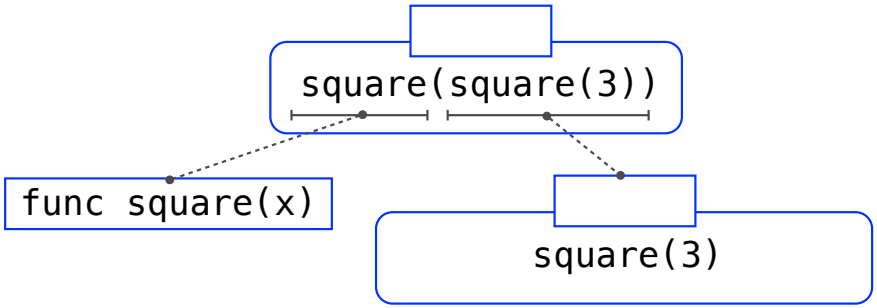


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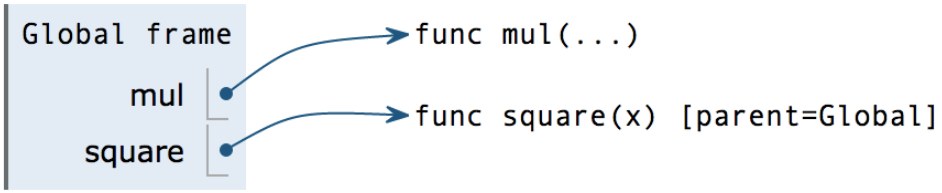


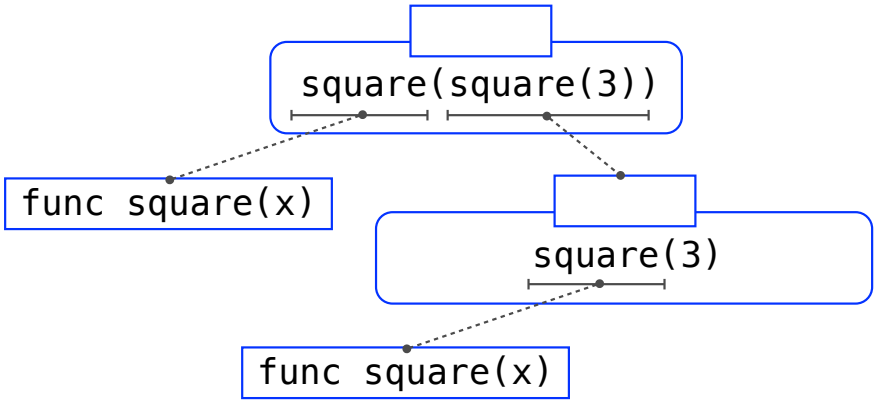


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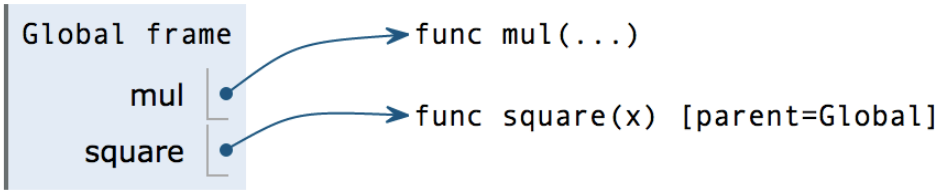


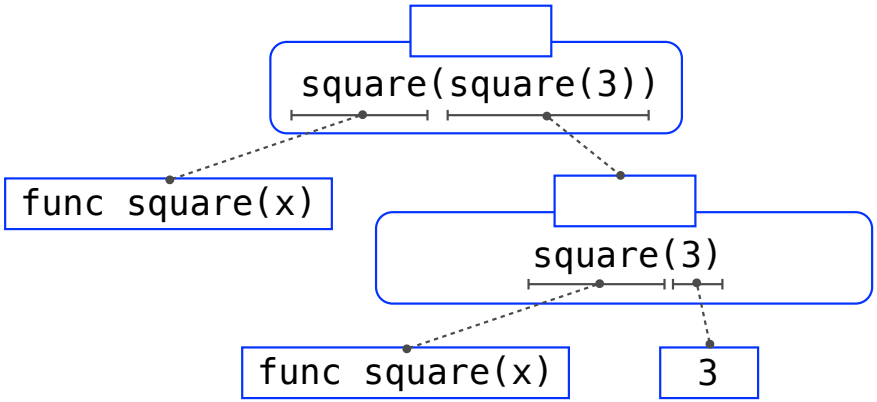


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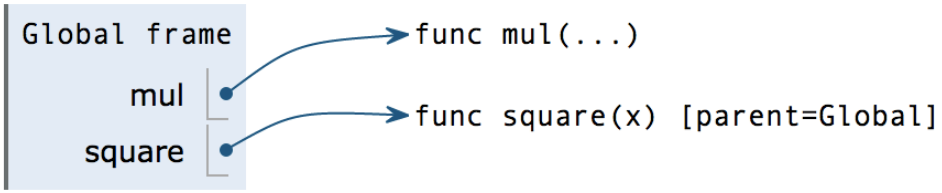


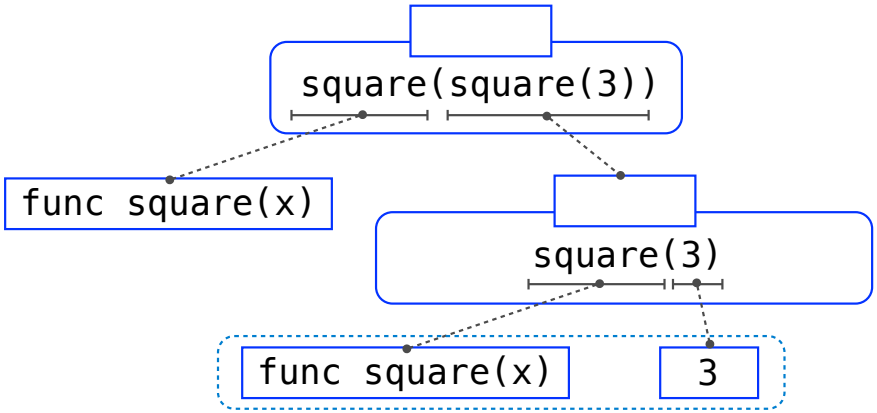


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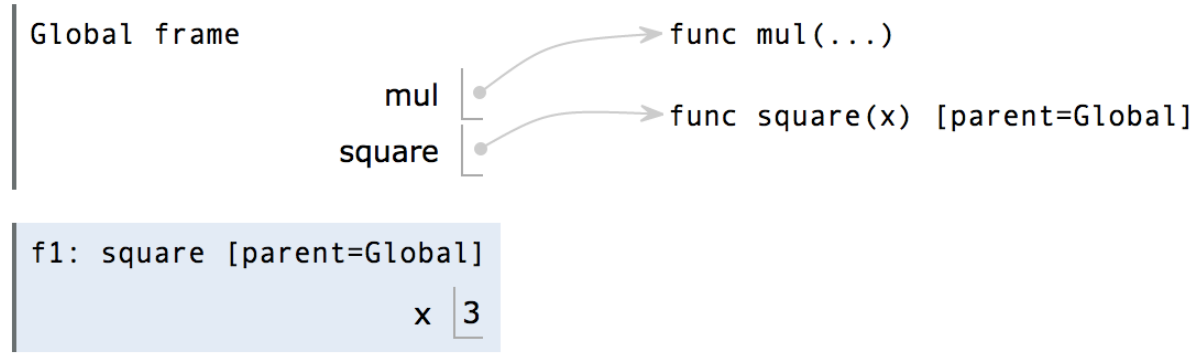


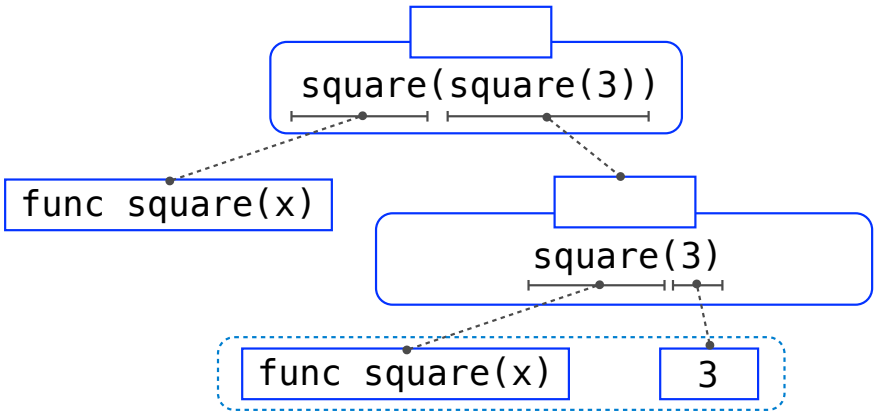


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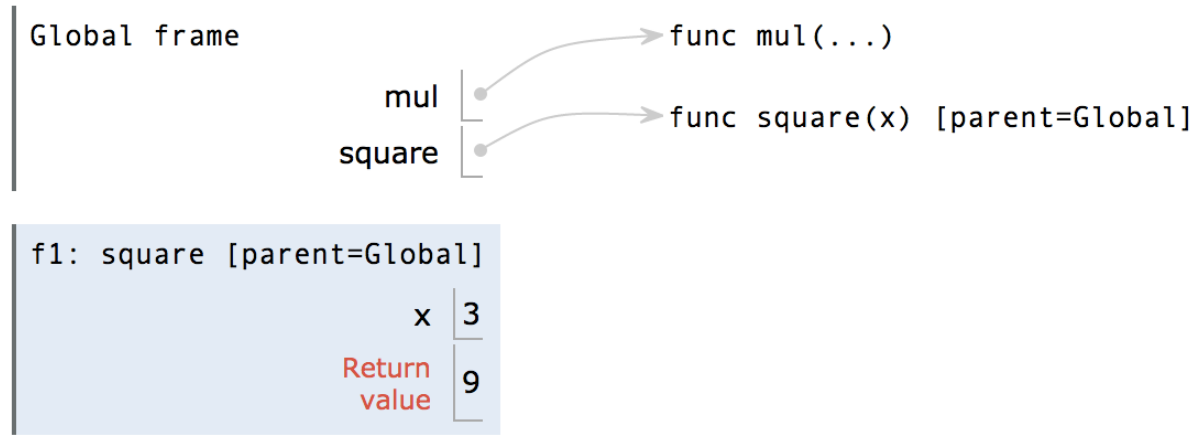


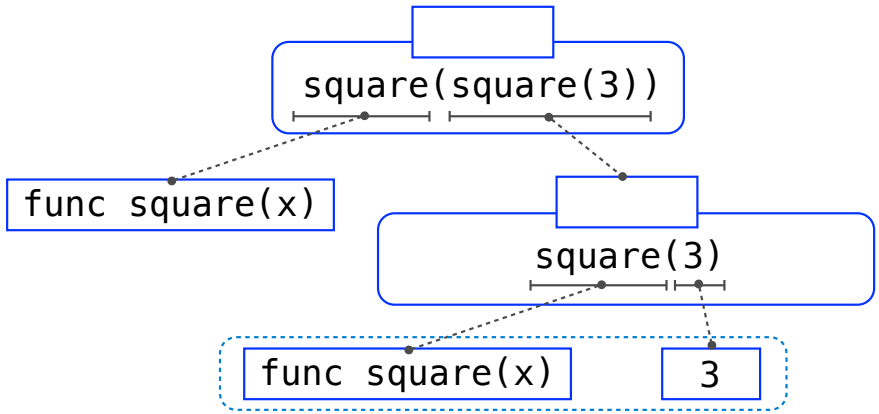


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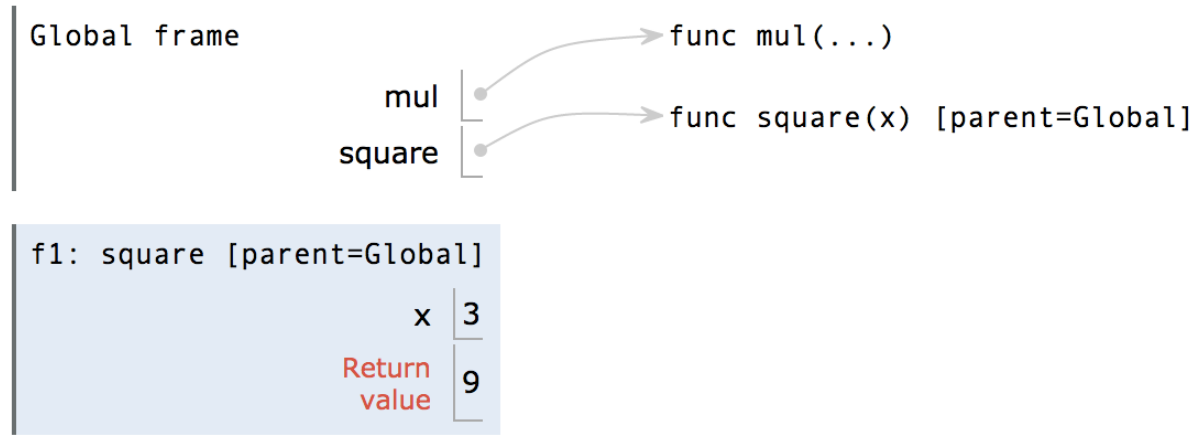


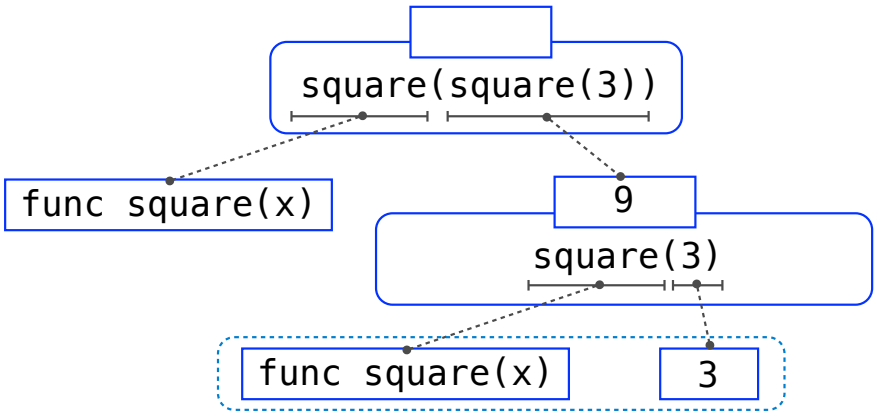


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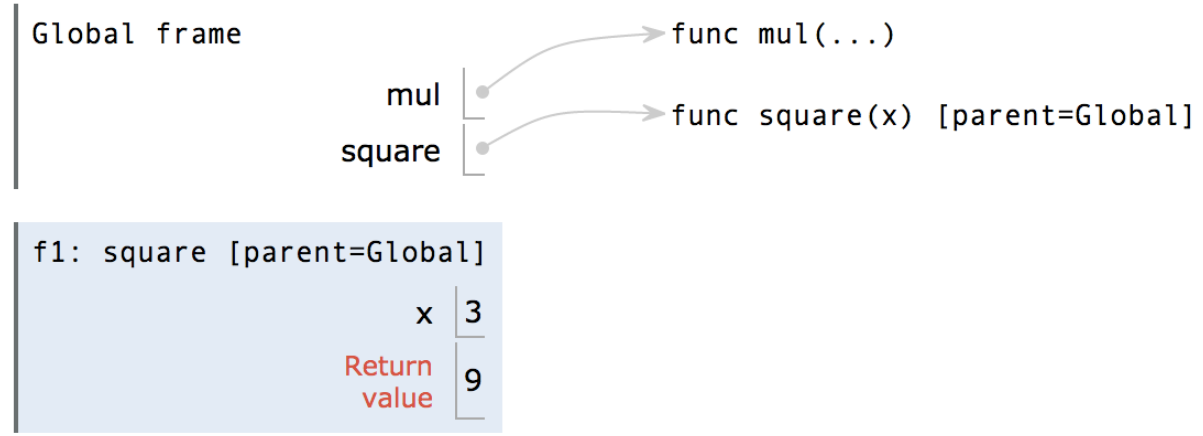


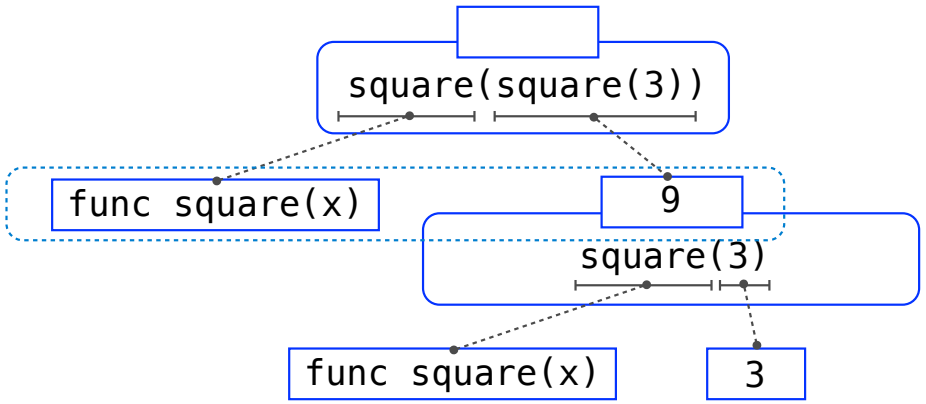


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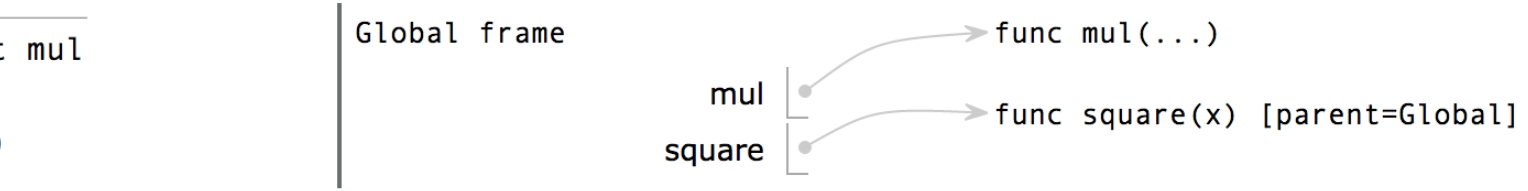


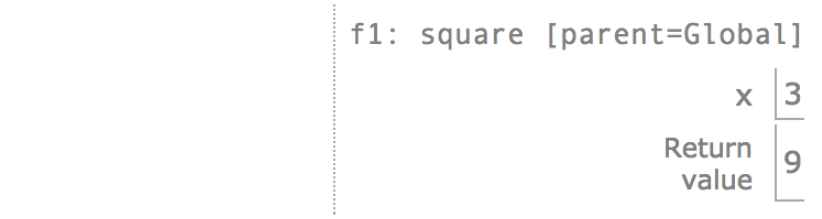


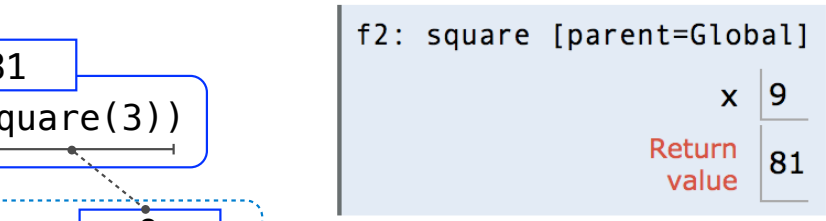


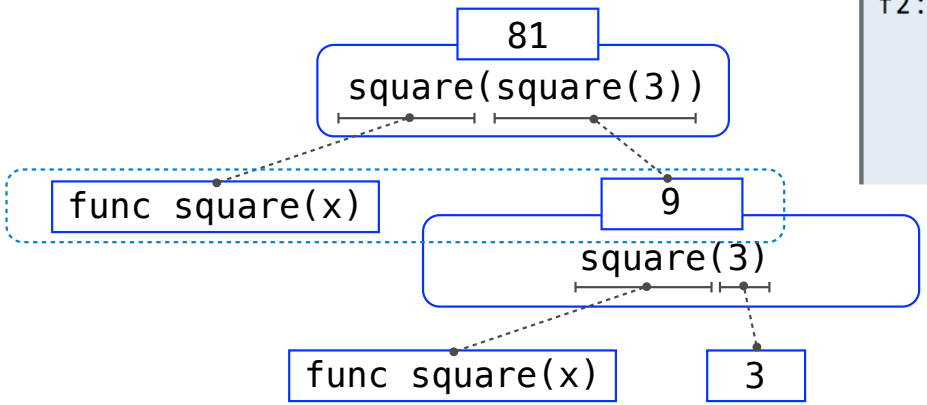


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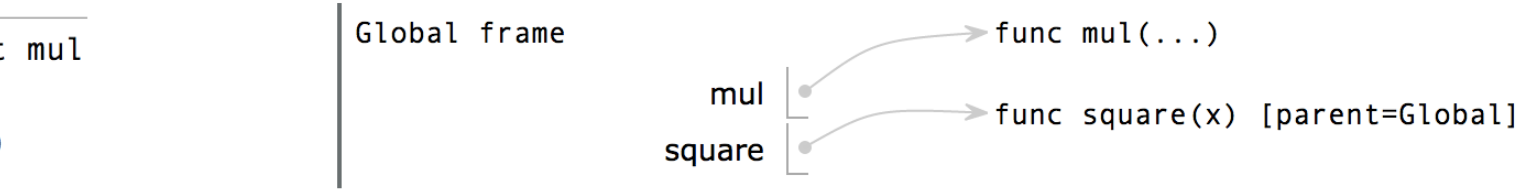


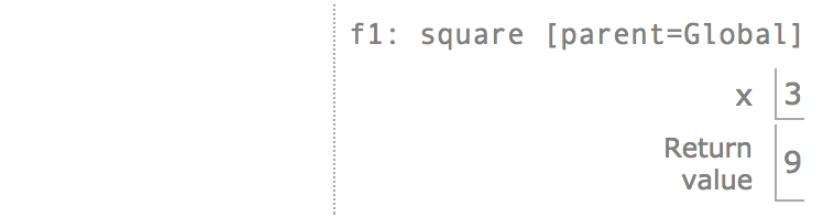


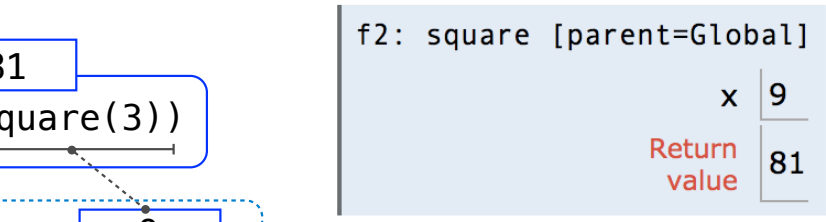


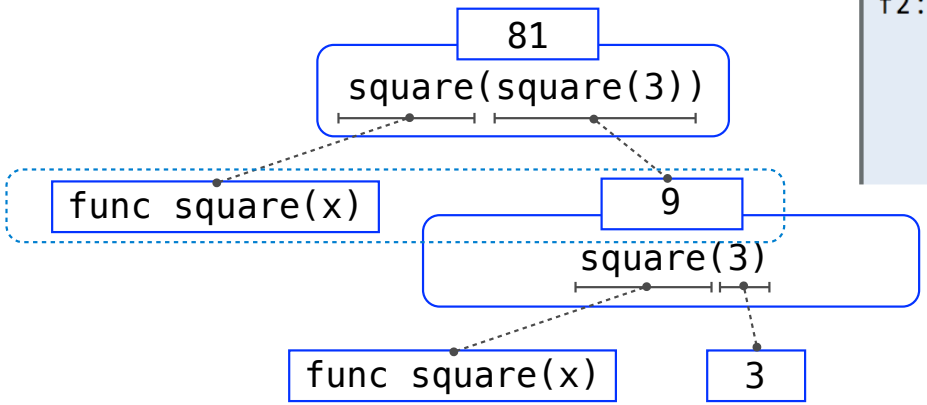


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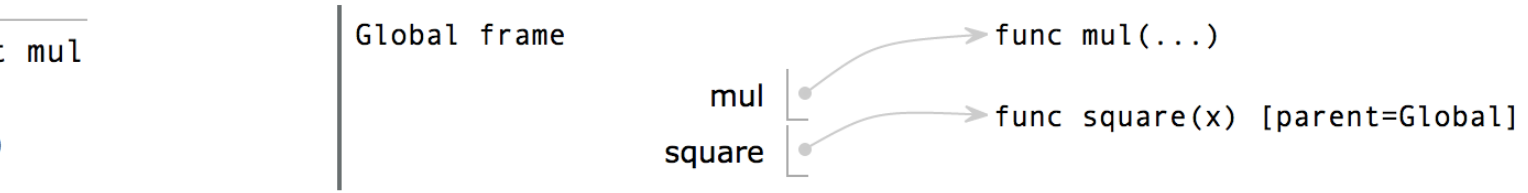


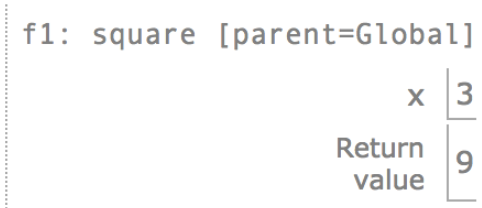


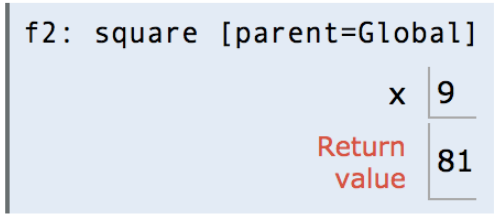


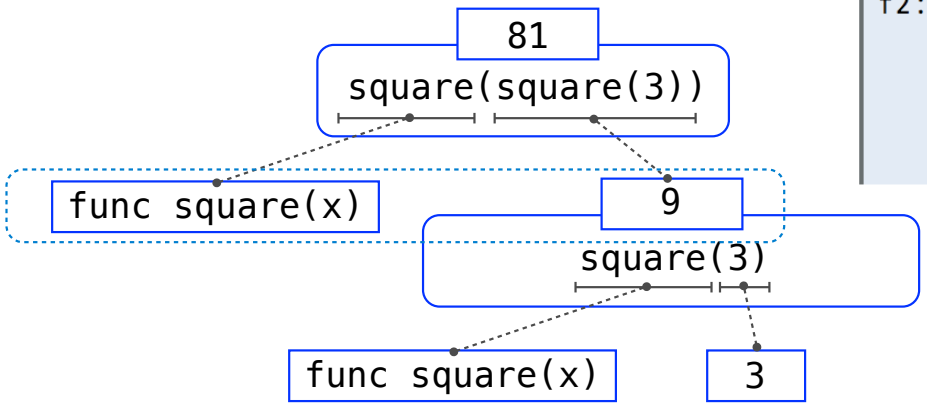


An environment is a sequence of frames.

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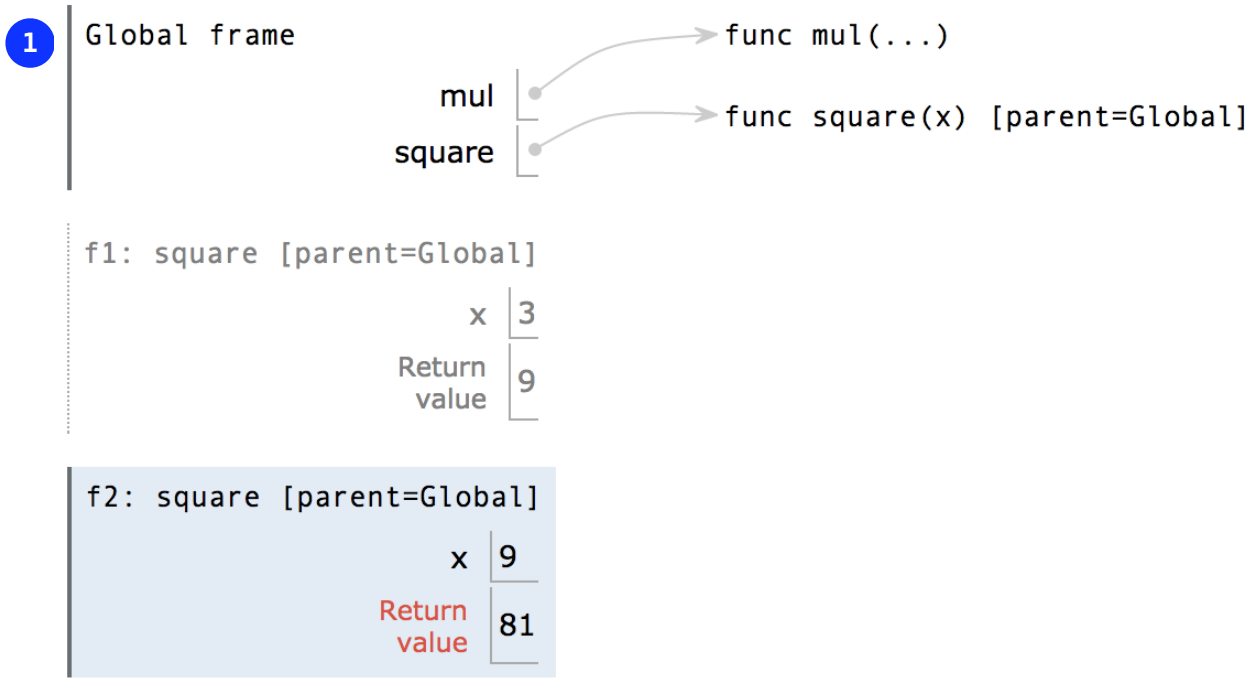


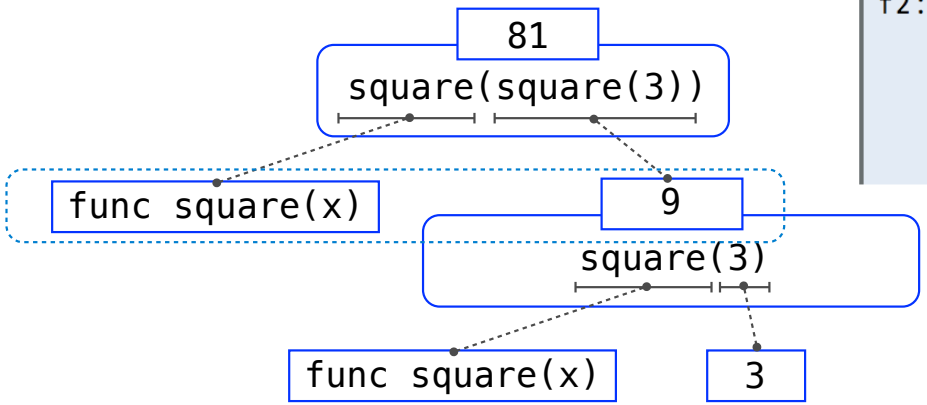


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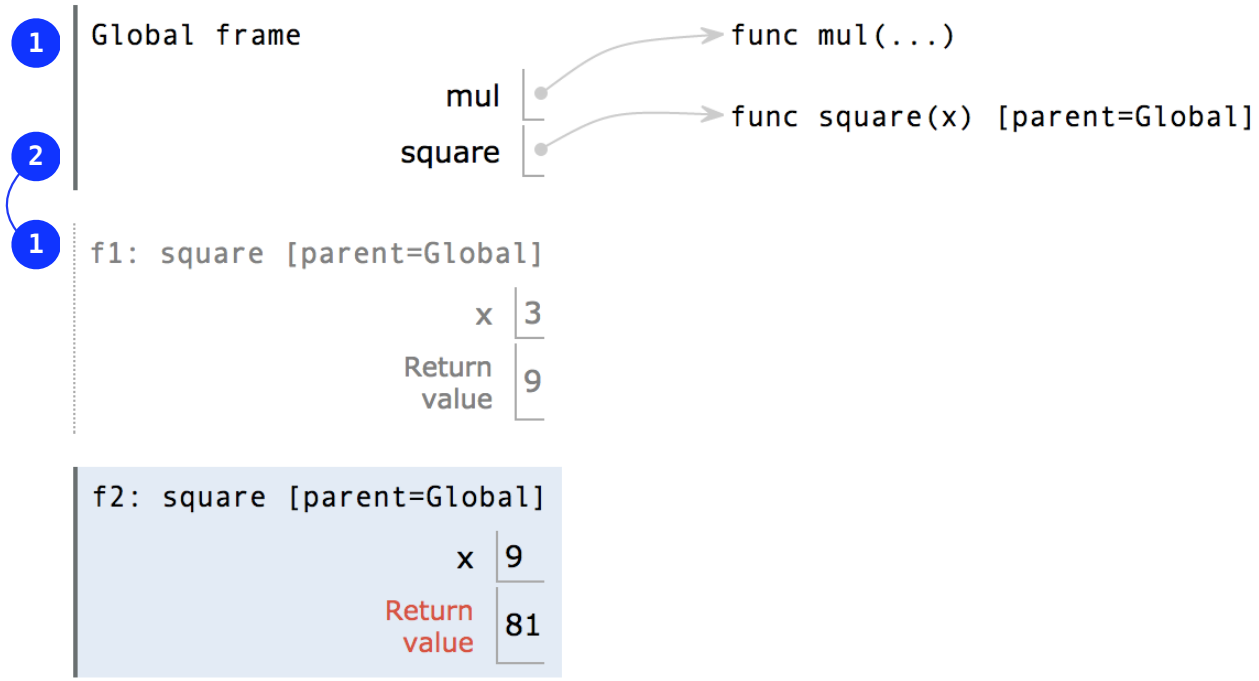


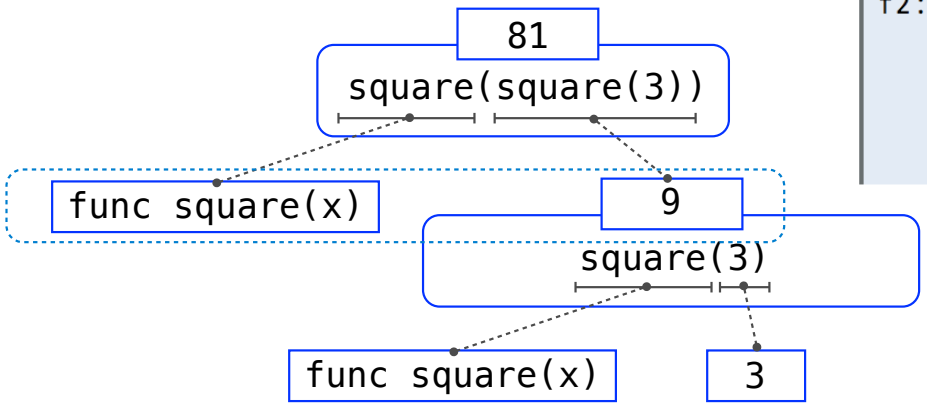


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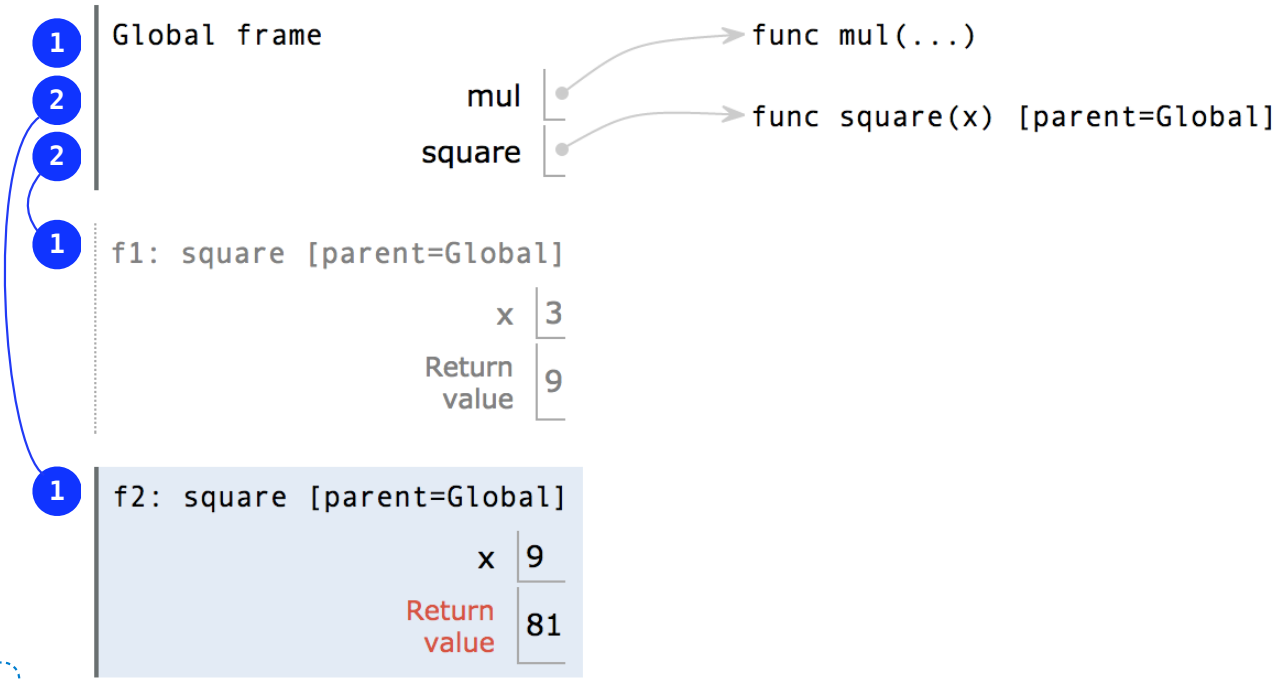


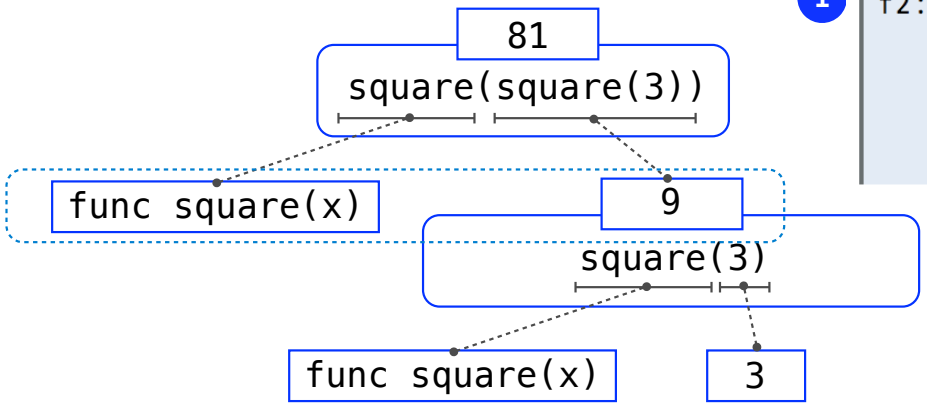


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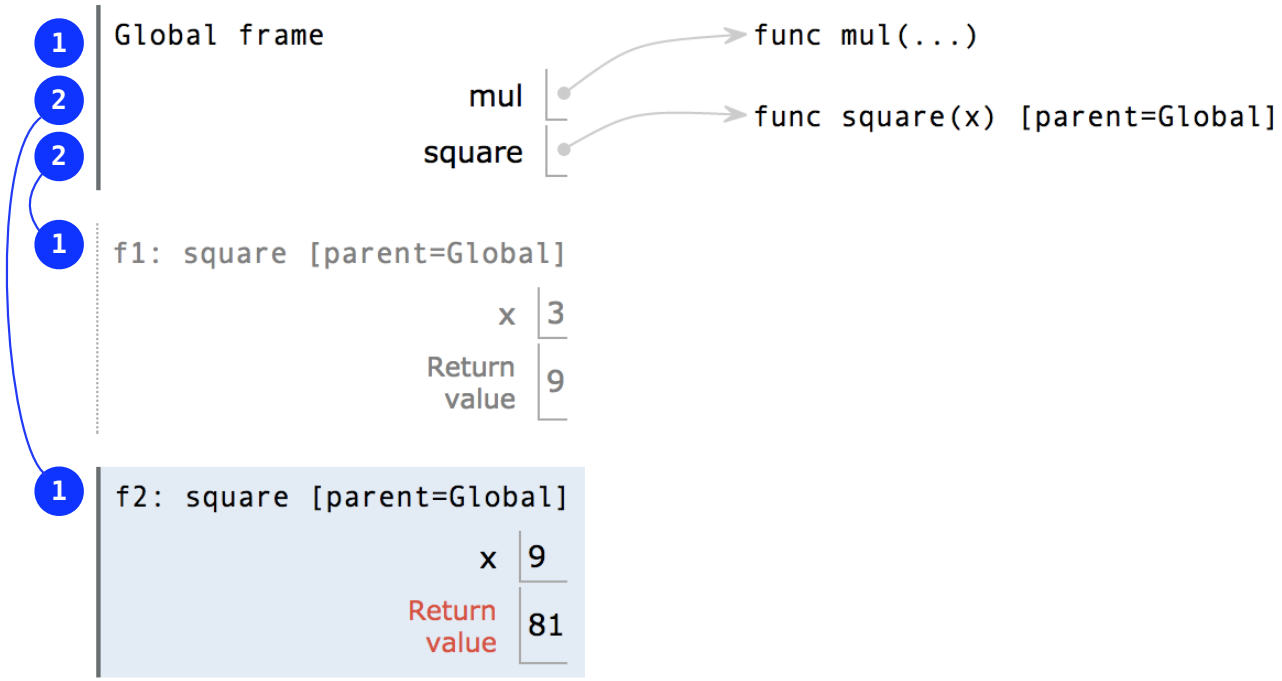


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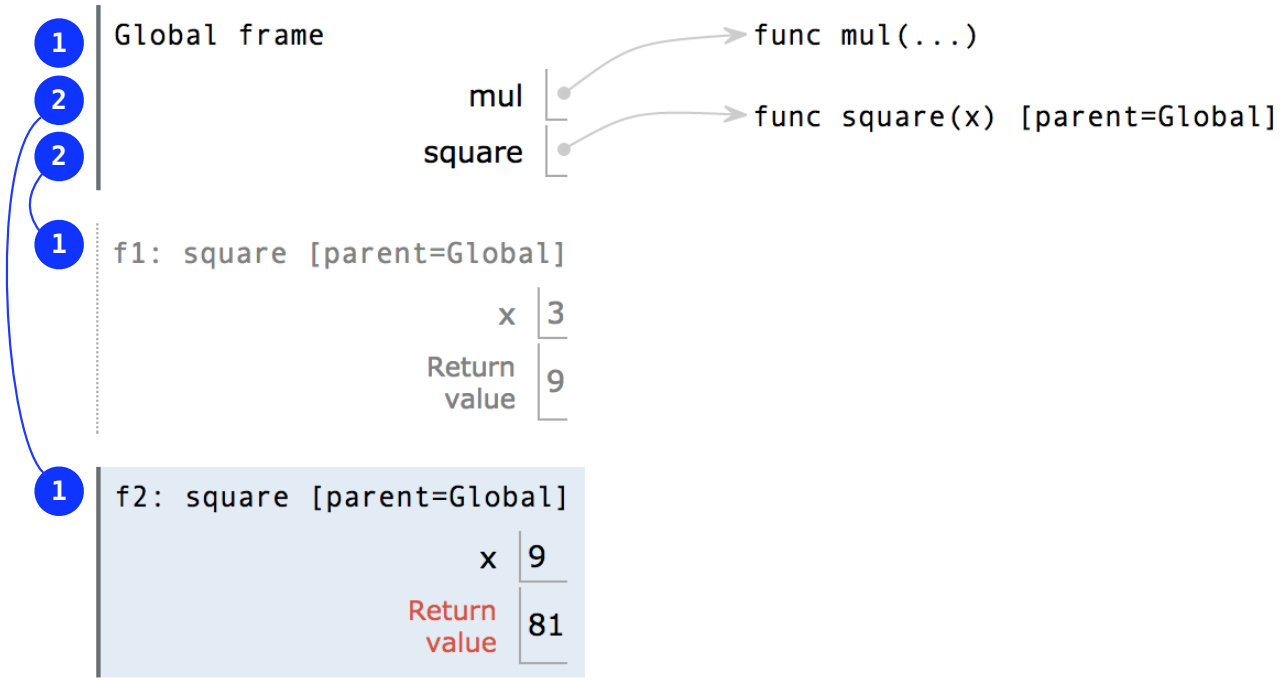


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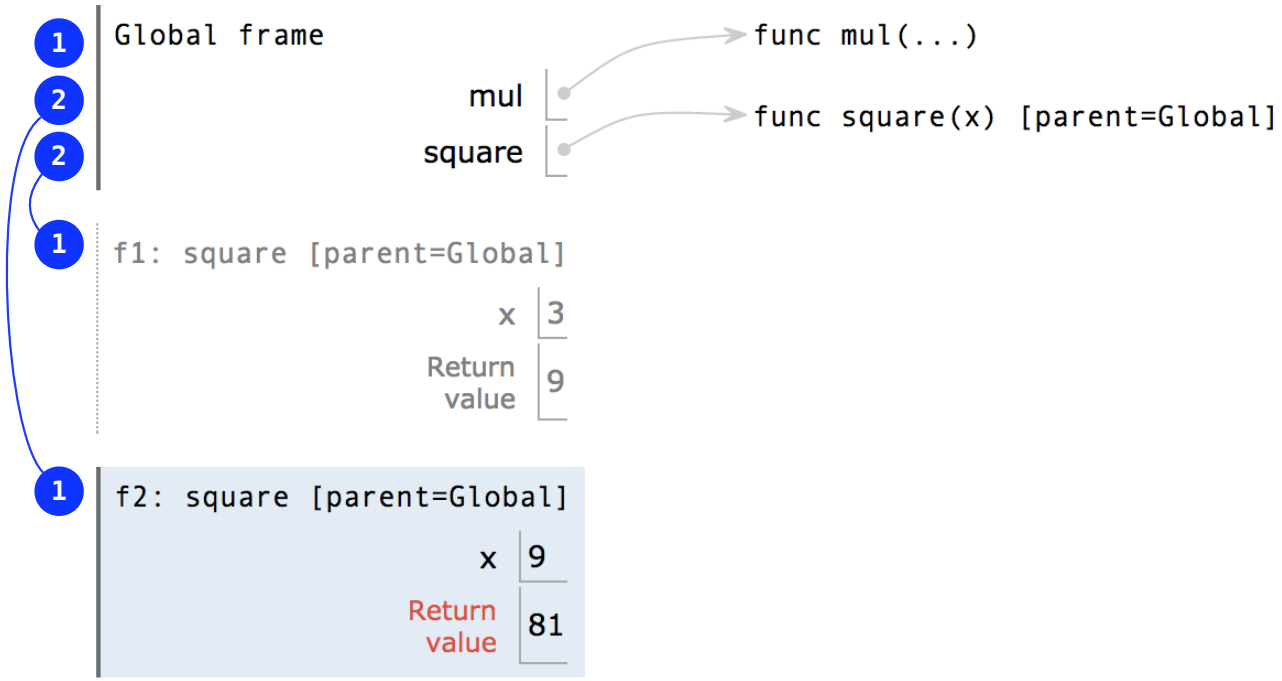


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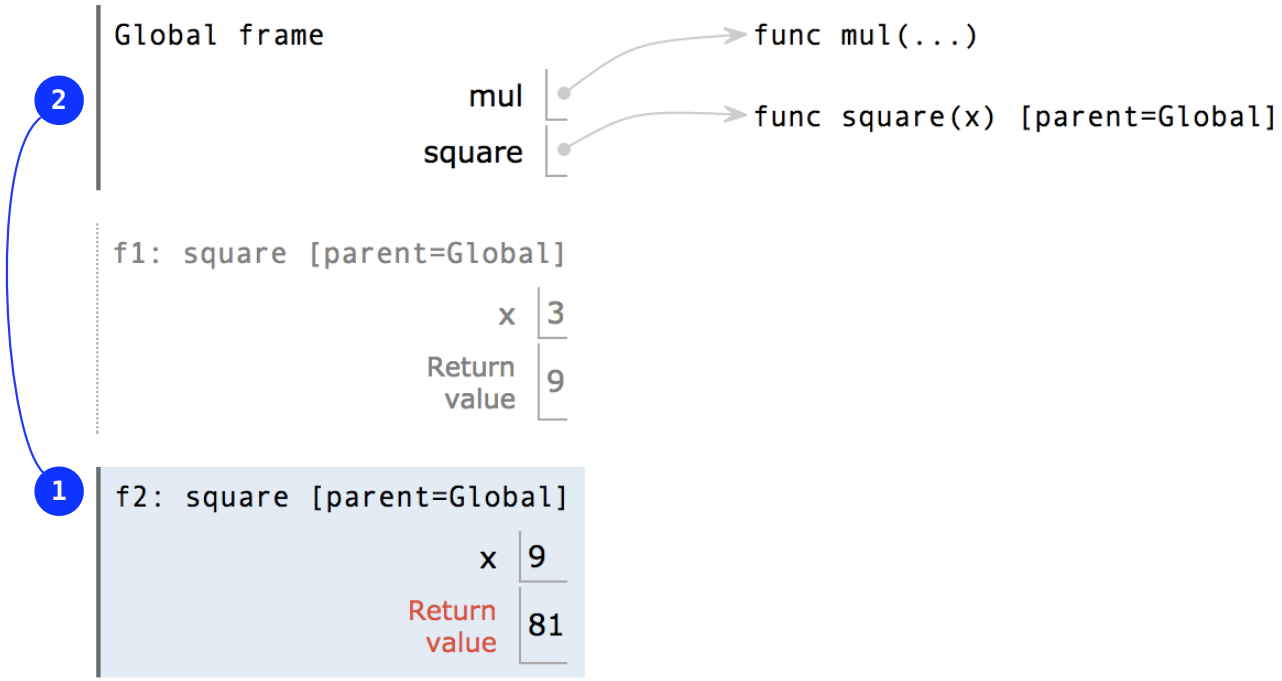


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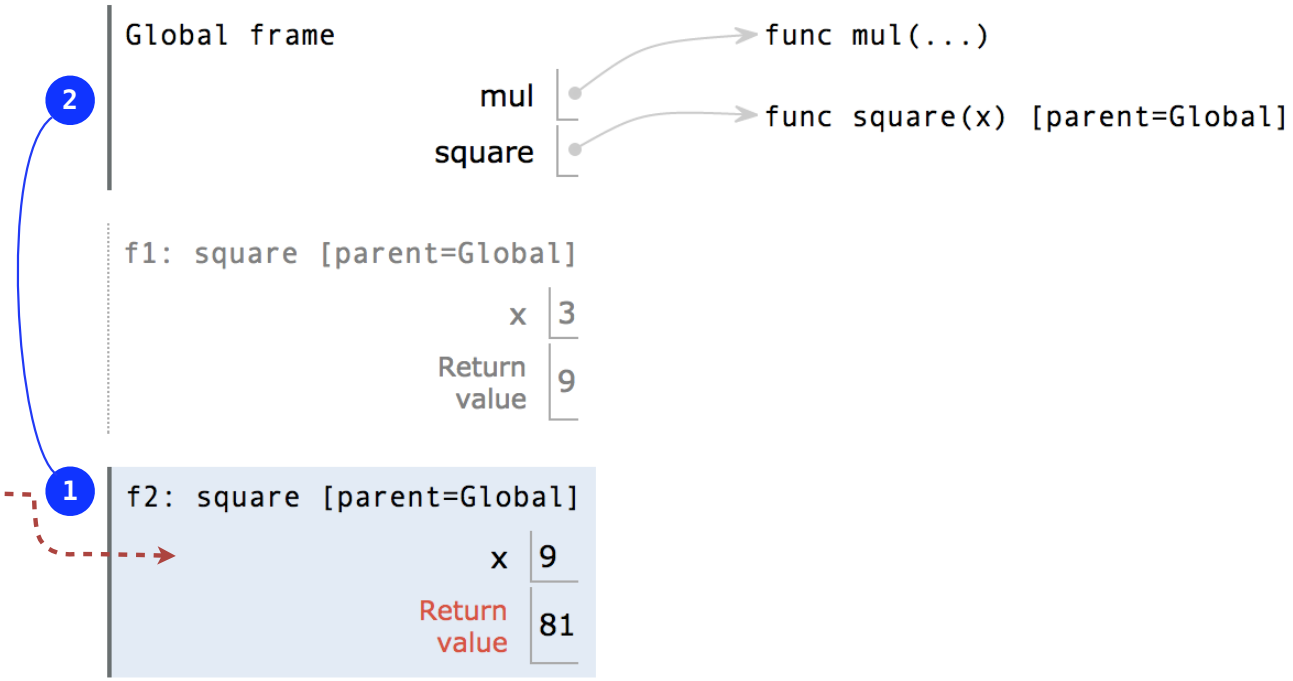


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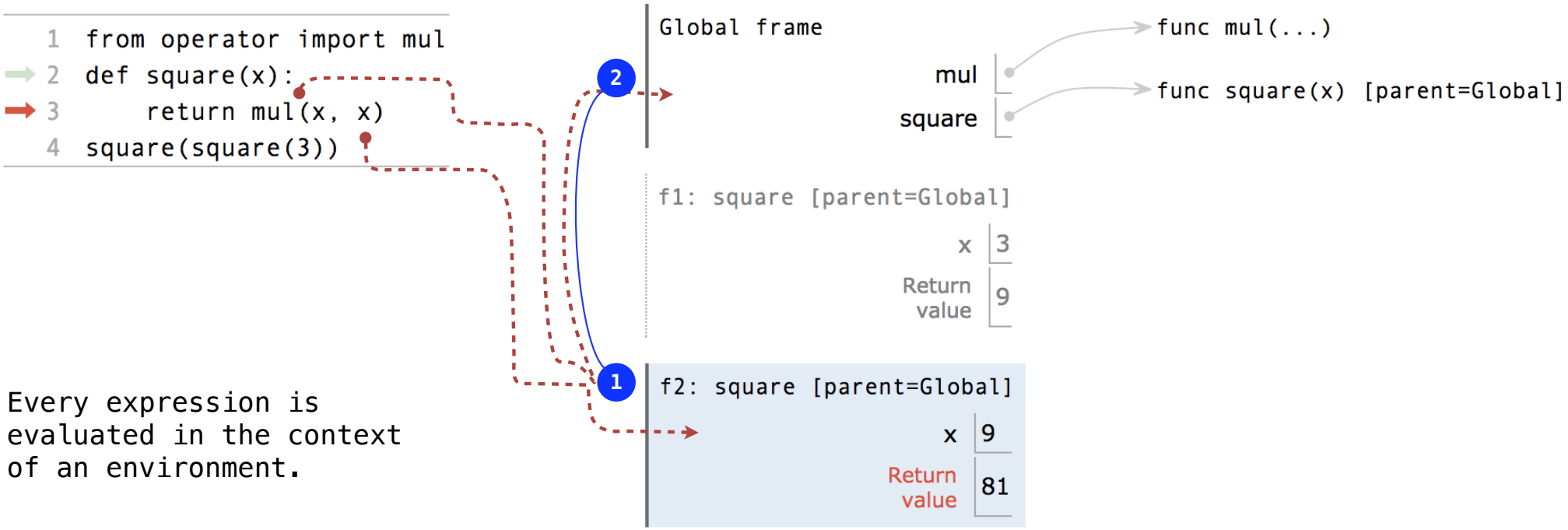


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A call expression and the body of the function being called are evaluated in different environments

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http://pythontutor.com/composingprograms.html#code=from%20operator%20import%20mul%0Adef%20square%28square%29%3A%0A%20%20%20%20return%20mul%28square,%20square%29%0Asquare%284%29&cumulative=true&curInstr=0&mode=display&origin=composingprograms.js&py=3&rawInputLstJSON=%5B%5D

# Names Have Different Meanings in Different Environments

A call expression and the body of the function being called are evaluated in different environments

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2  def square(square):
3      return mul(square, square)
4  square(4)
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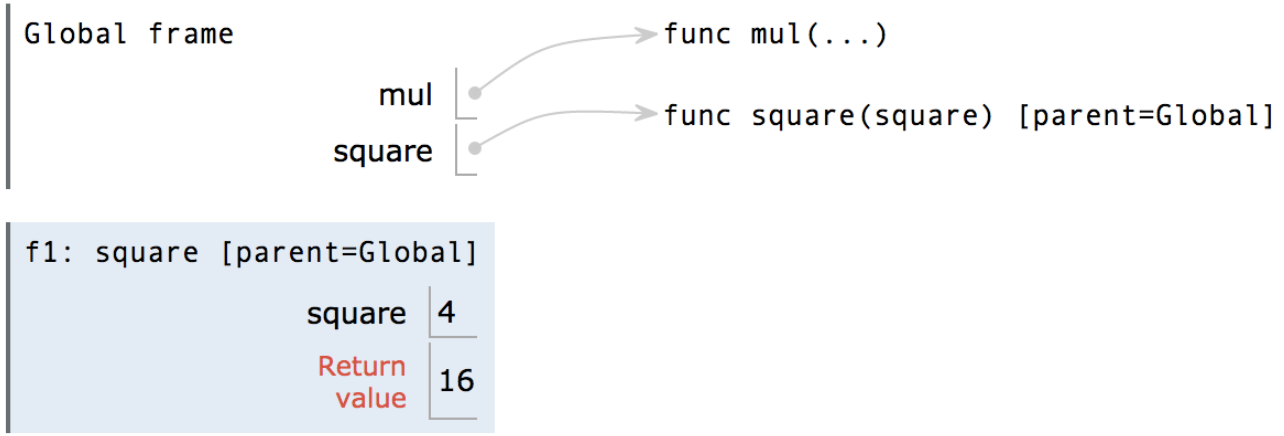


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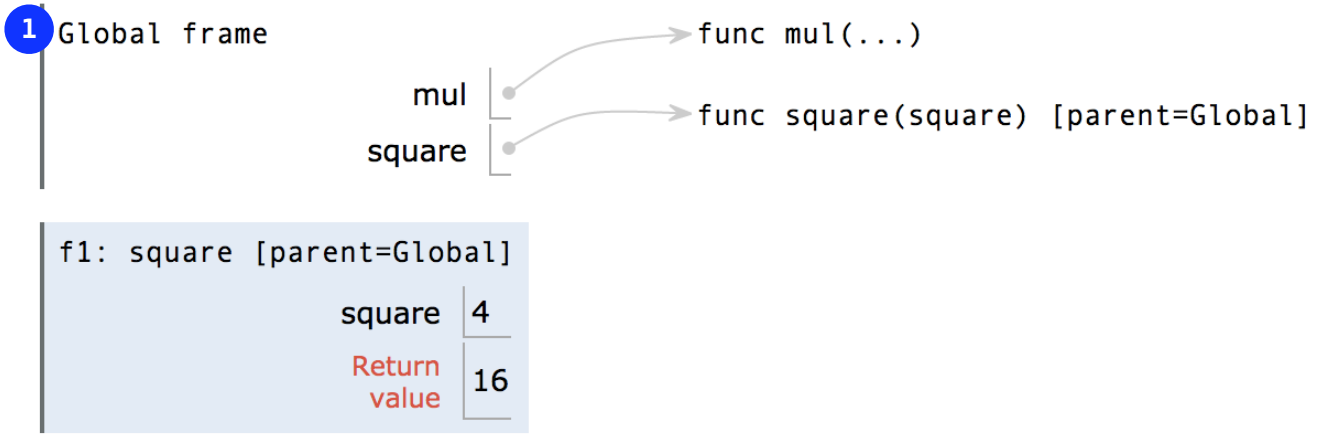


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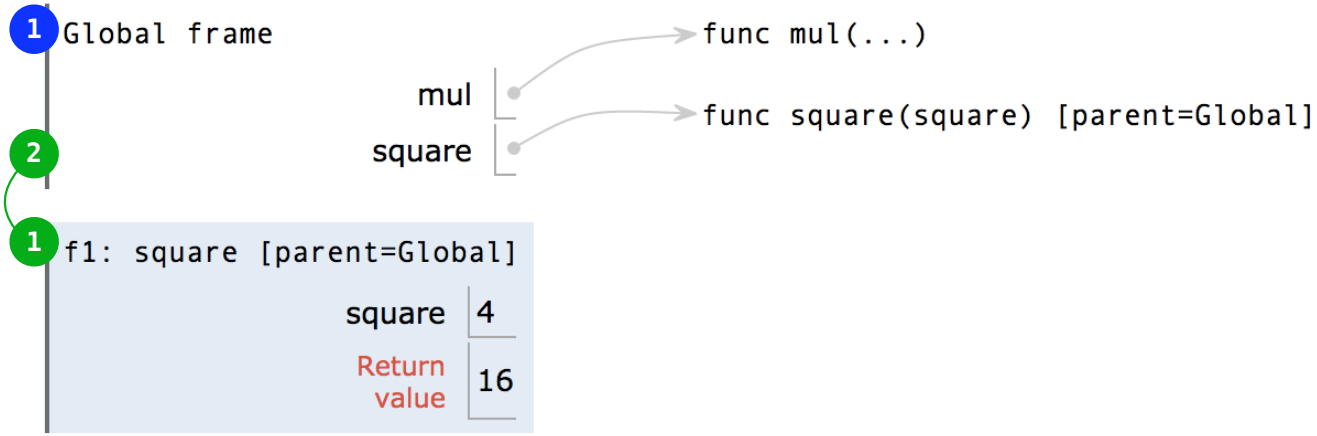


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# Miscellaneous Python Features

Division

Multiple Return Values

Source Files

Doctests

Default Arguments

(Demo)

# Conditional Statements

# Statements

A ***statement*** is executed by the interpreter to perform an action

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**Compound statements:**

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```

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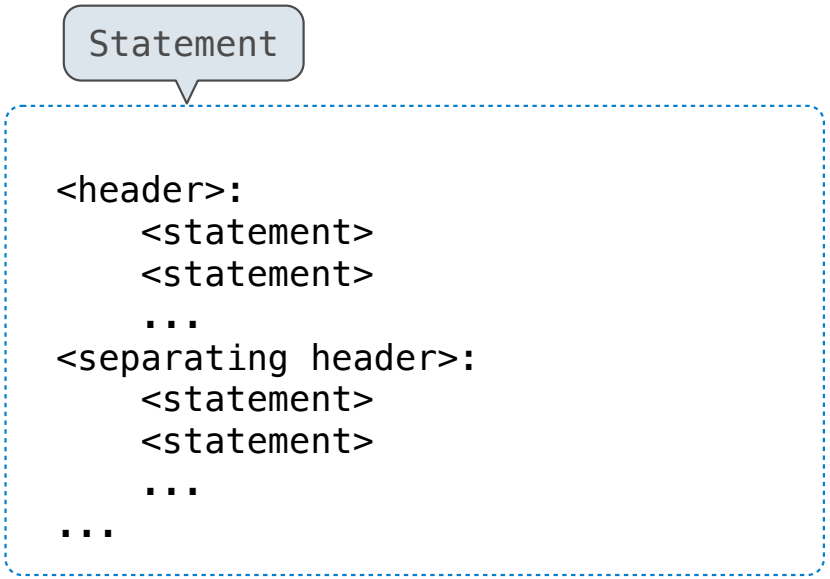

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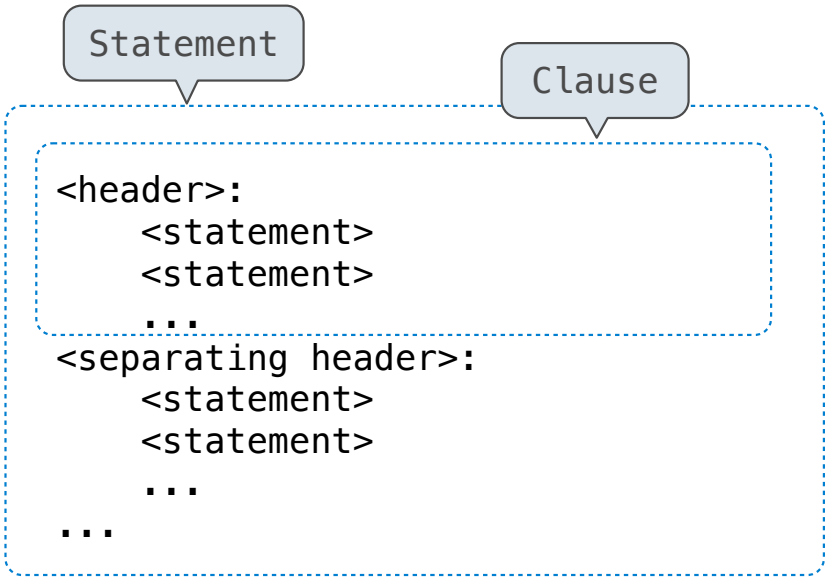

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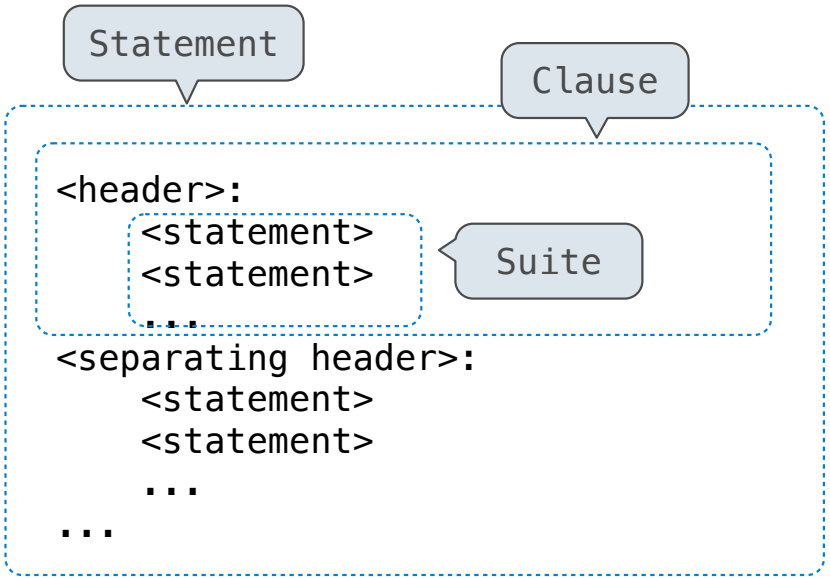

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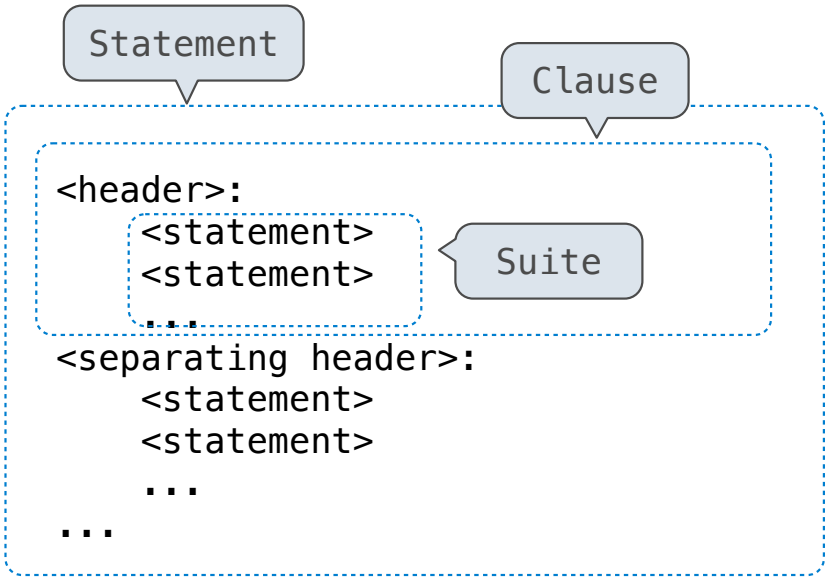


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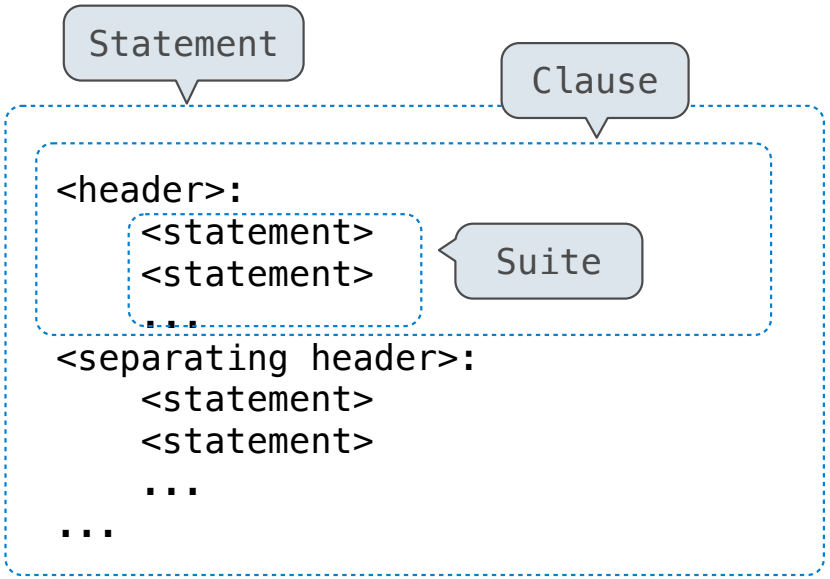


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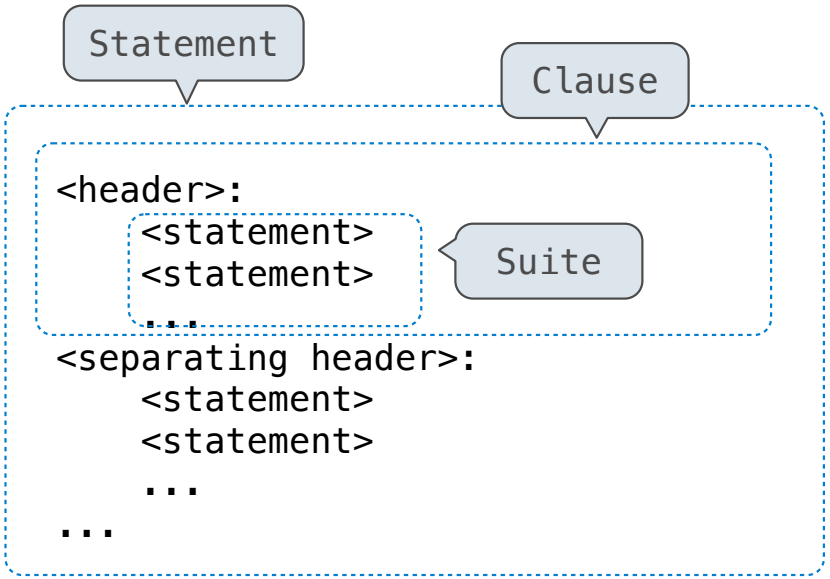


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def statements are compound statements

# Compound Statements

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<separating header>:
    <statement>
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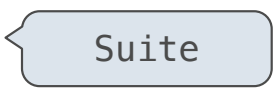


A suite is a sequence of statements

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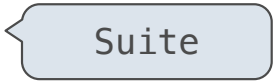


A suite is a sequence of statements

To “execute” a suite means to execute its sequence of statements, in order

# Compound Statements

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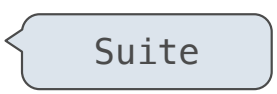


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To “execute” a suite means to execute its sequence of statements, in order

**Execution Rule for a sequence of statements:**

- Execute the first statement
- Unless directed otherwise, execute the rest

# Conditional Statements

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```
def absolute_value(x):
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    if x < 0:
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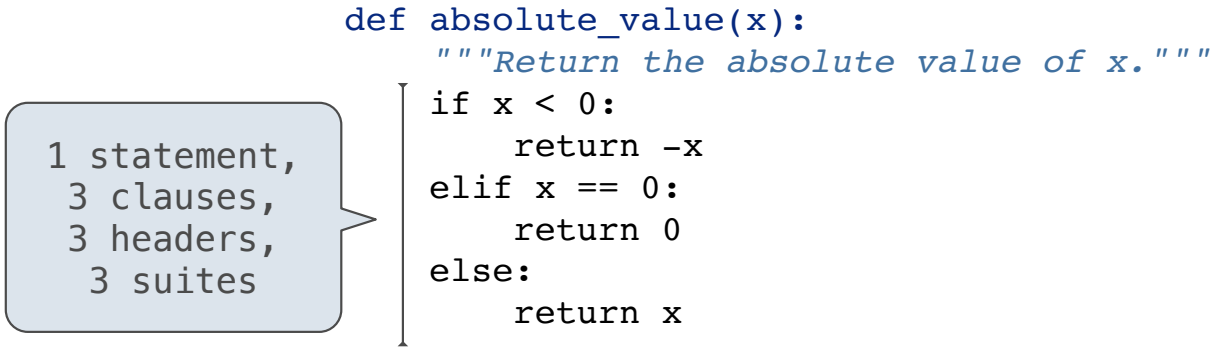

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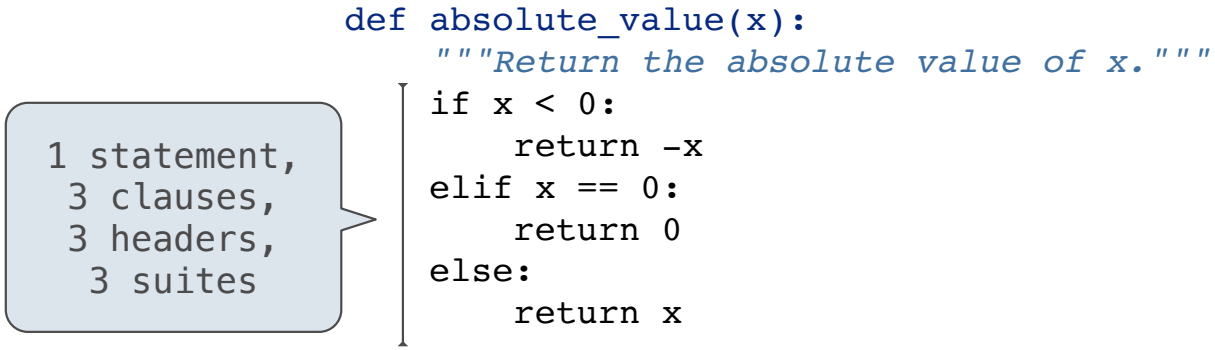


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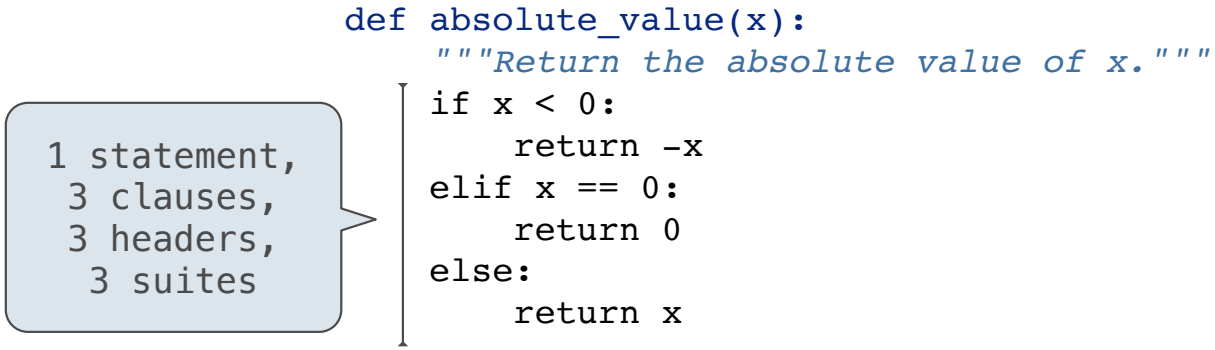


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Each clause is considered in order.

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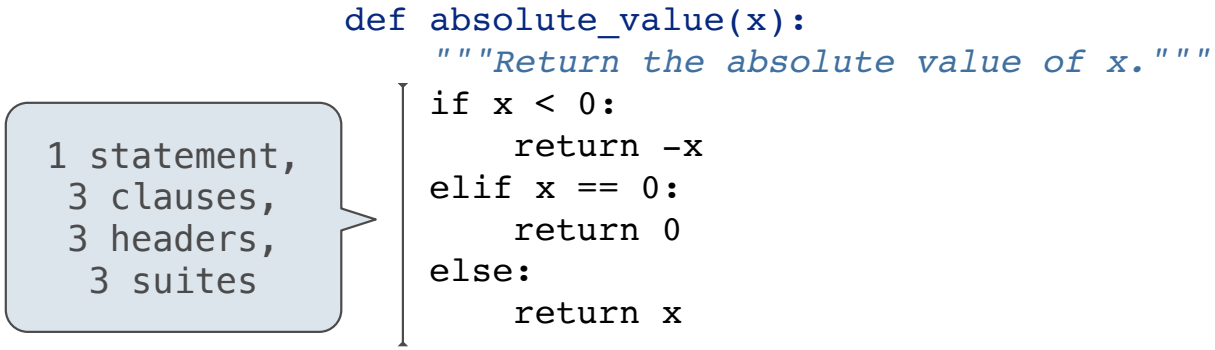


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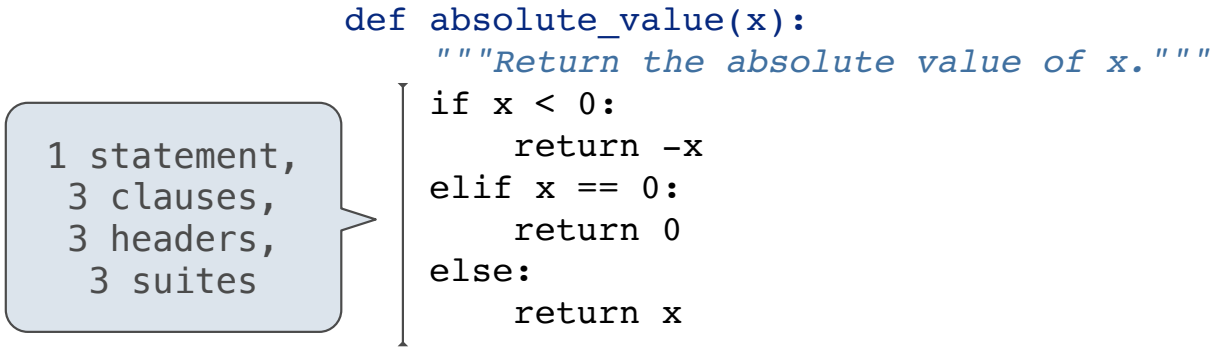


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Each clause is considered in order.

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**Syntax Tips:**

1. Always starts with "if" clause.
2. Zero or more "elif" clauses.
3. Zero or one "else" clause,
   always at the end.

# Boolean Contexts

*George Boole*

```
def absolute_value(x):
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    if x < 0:
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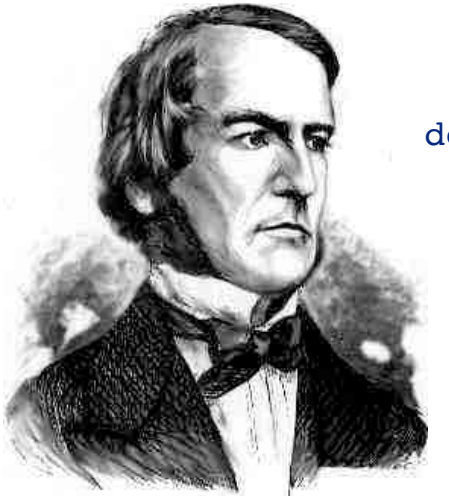

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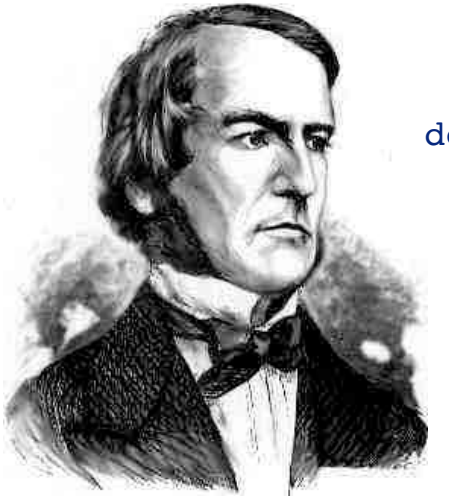

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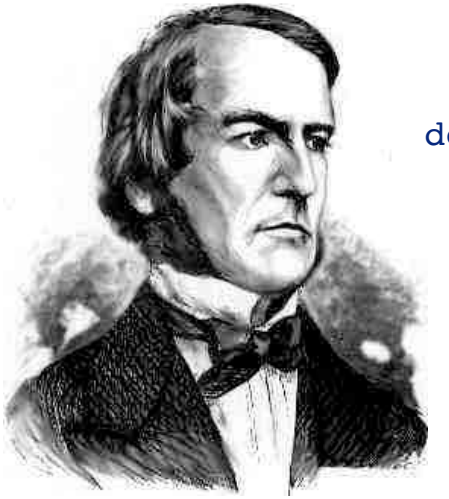

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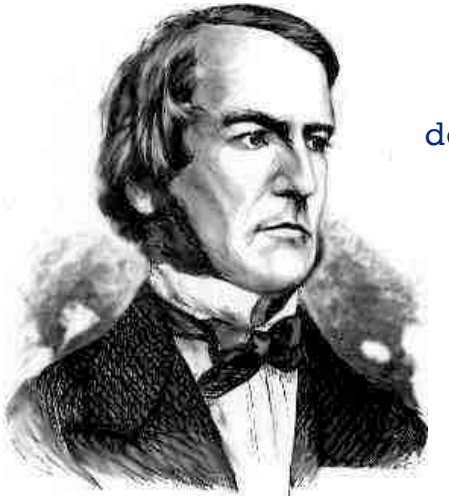

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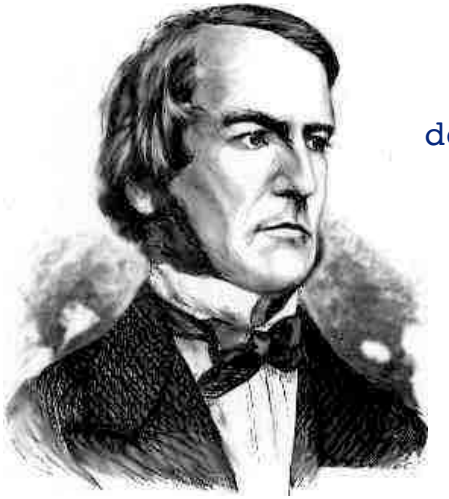

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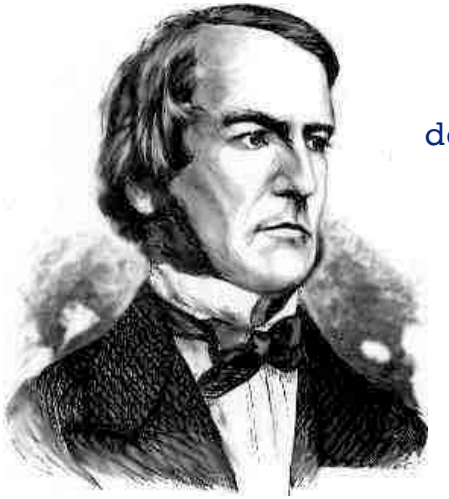

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**Read Section 1.5.4!**

Reading: http://composingprograms.com/pages/15-control.html#conditional-statements

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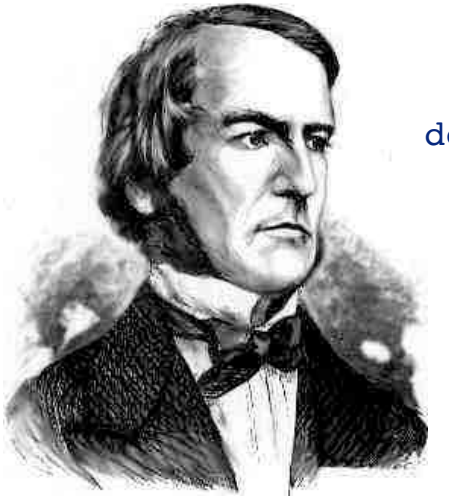

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(Demo)

Reading: http://composingprograms.com/pages/15-control.html#conditional-statements

# Iteration

# While Statements

(Demo)

# While Statements

(Demo)

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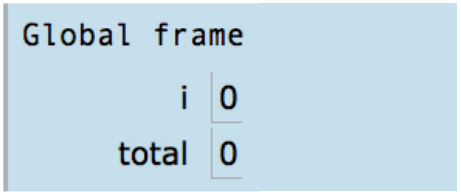


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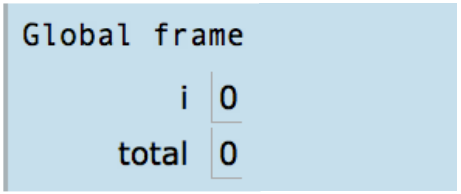


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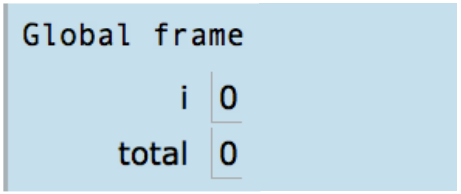


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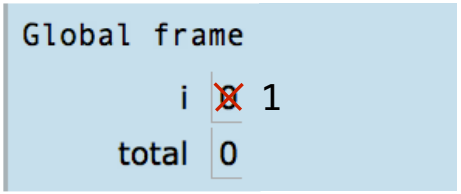


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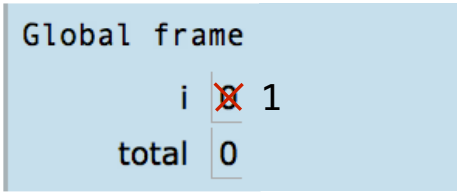


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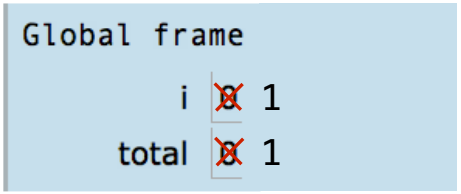


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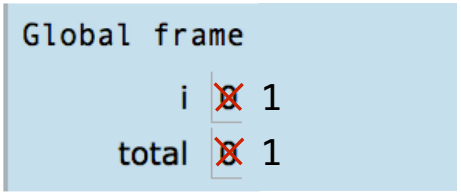


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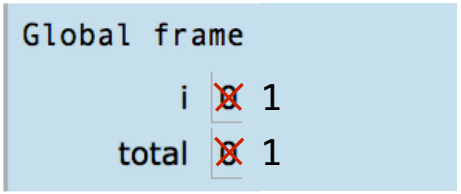


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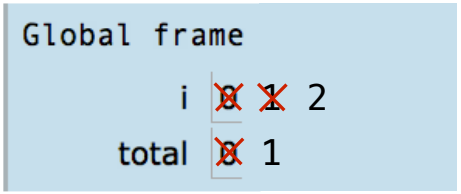


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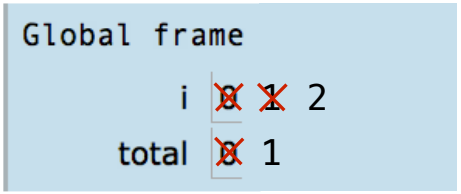


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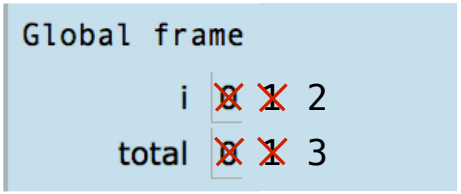


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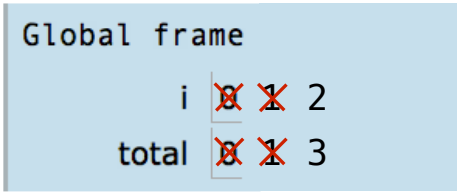


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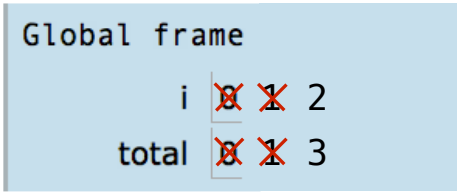


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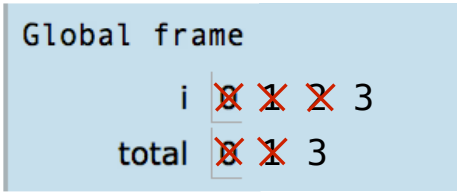


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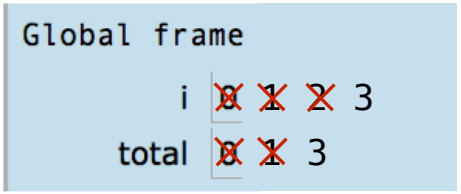


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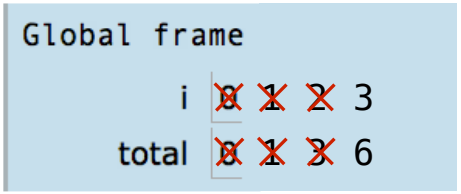


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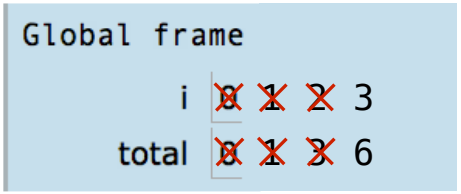


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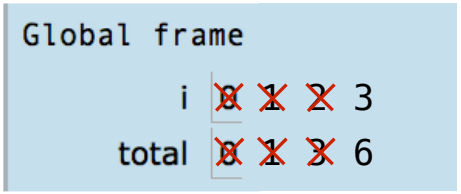


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# Example: Prime Factorization

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