Control

Announcements

Print and None

(Demo)

None Indicates that Nothing is Returned

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

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>>> def does_not_return_square(x):
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No **return**

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

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

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)
```

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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**

None value is not displayed

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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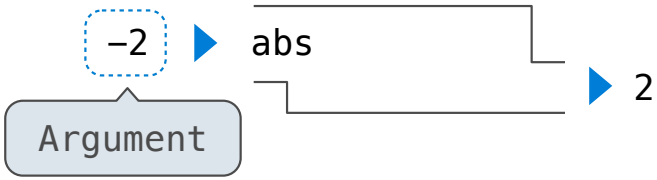

Non-Pure Functions
have side effects

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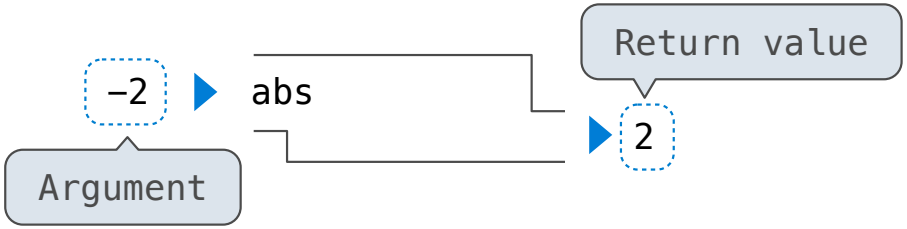

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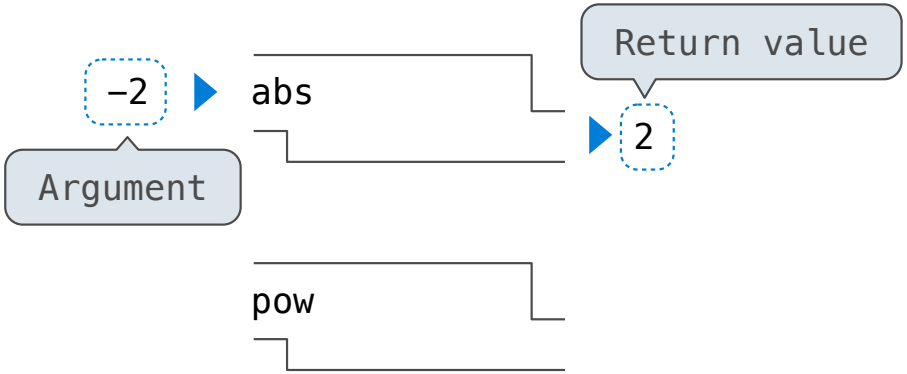

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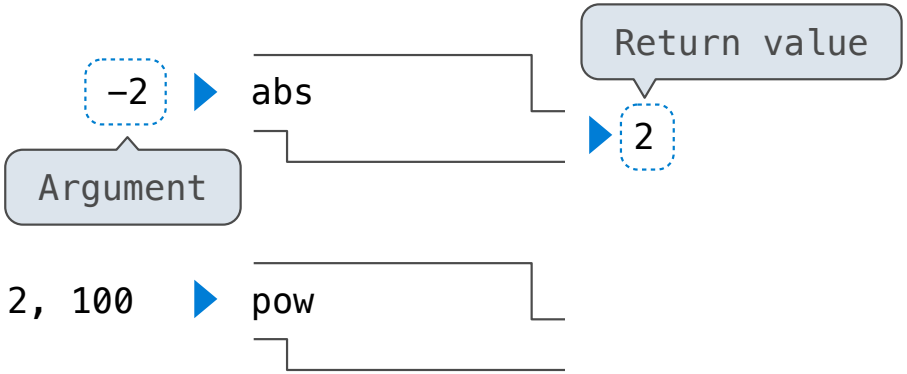

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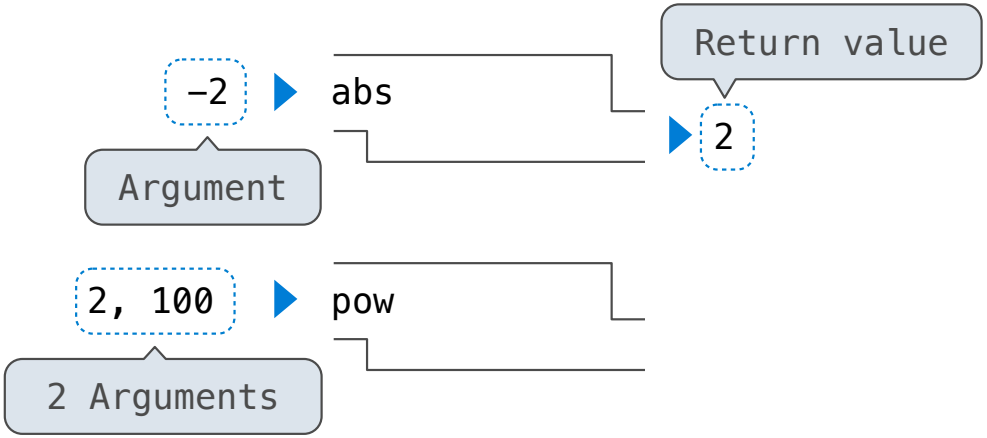

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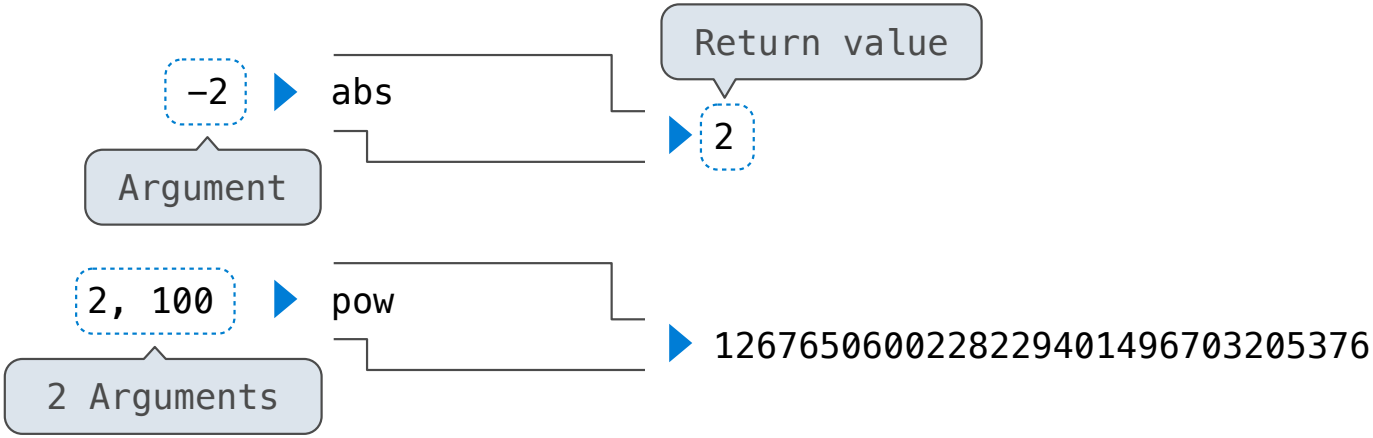

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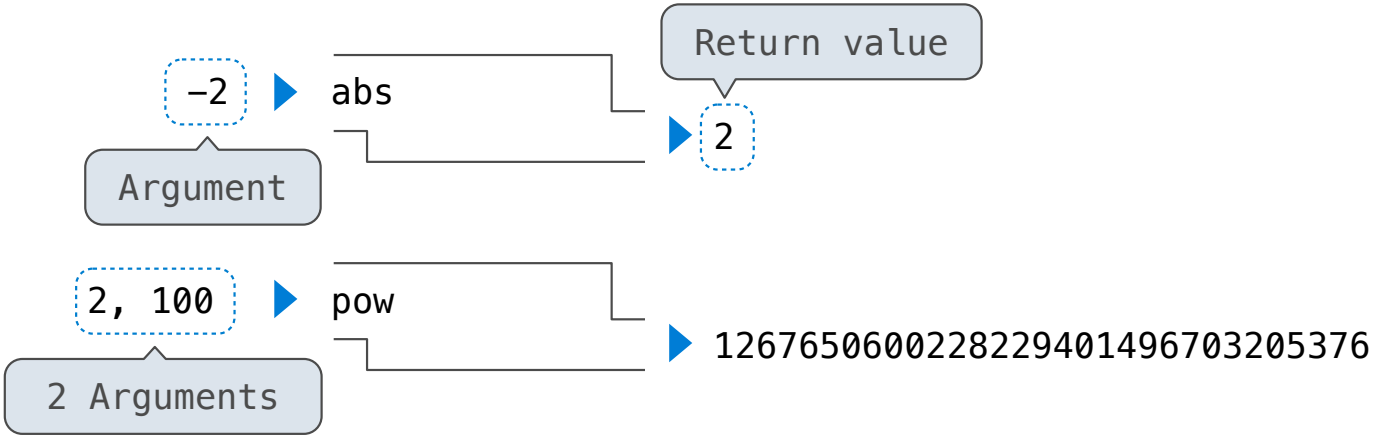

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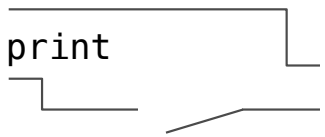

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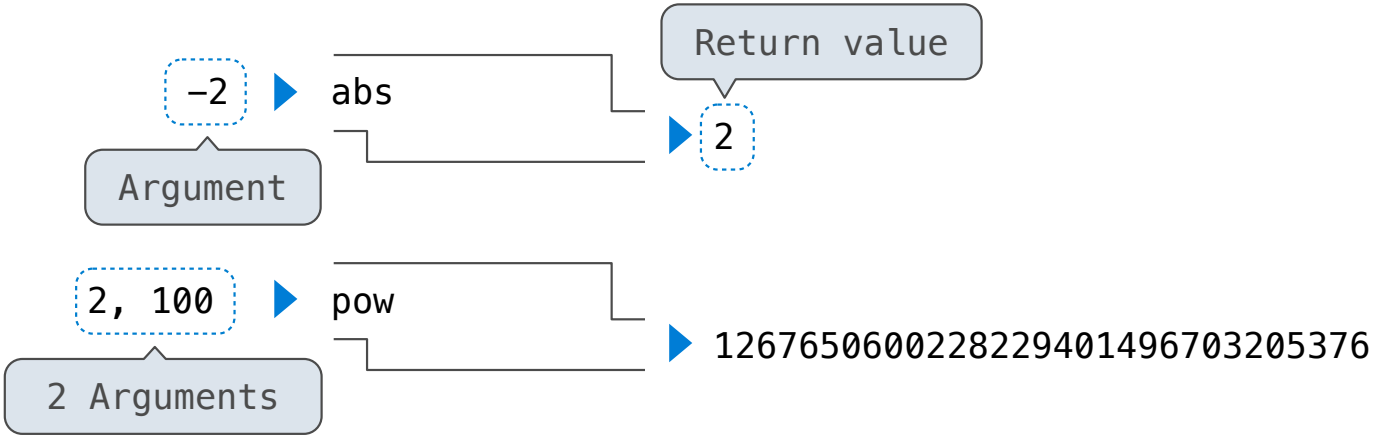

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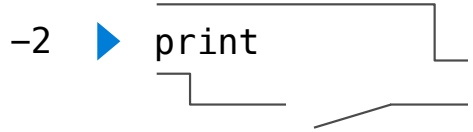

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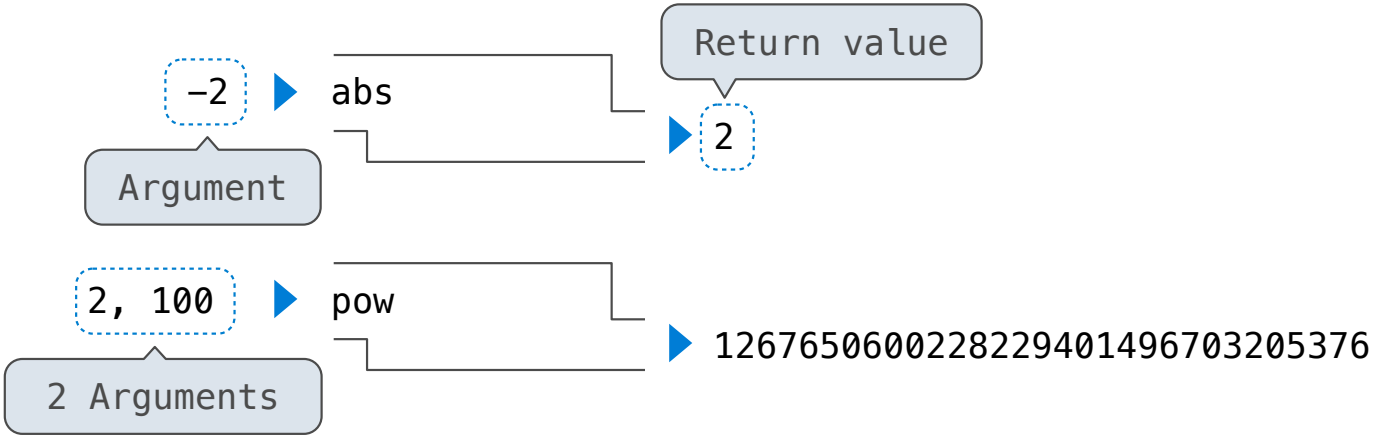

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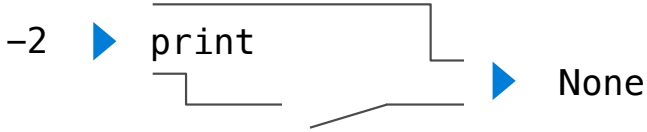

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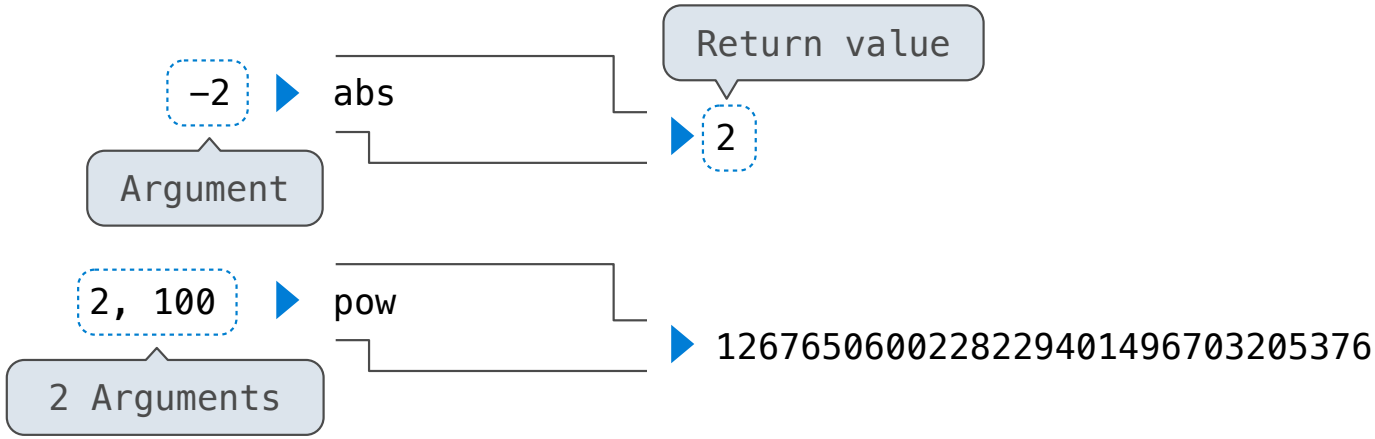

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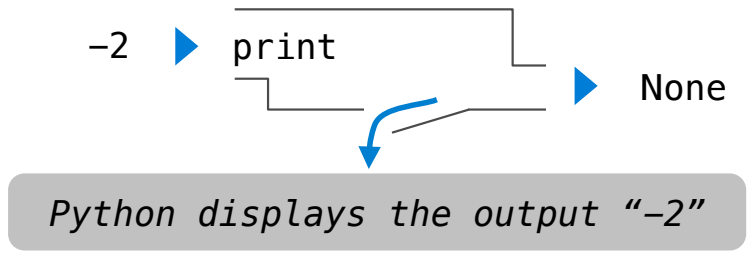

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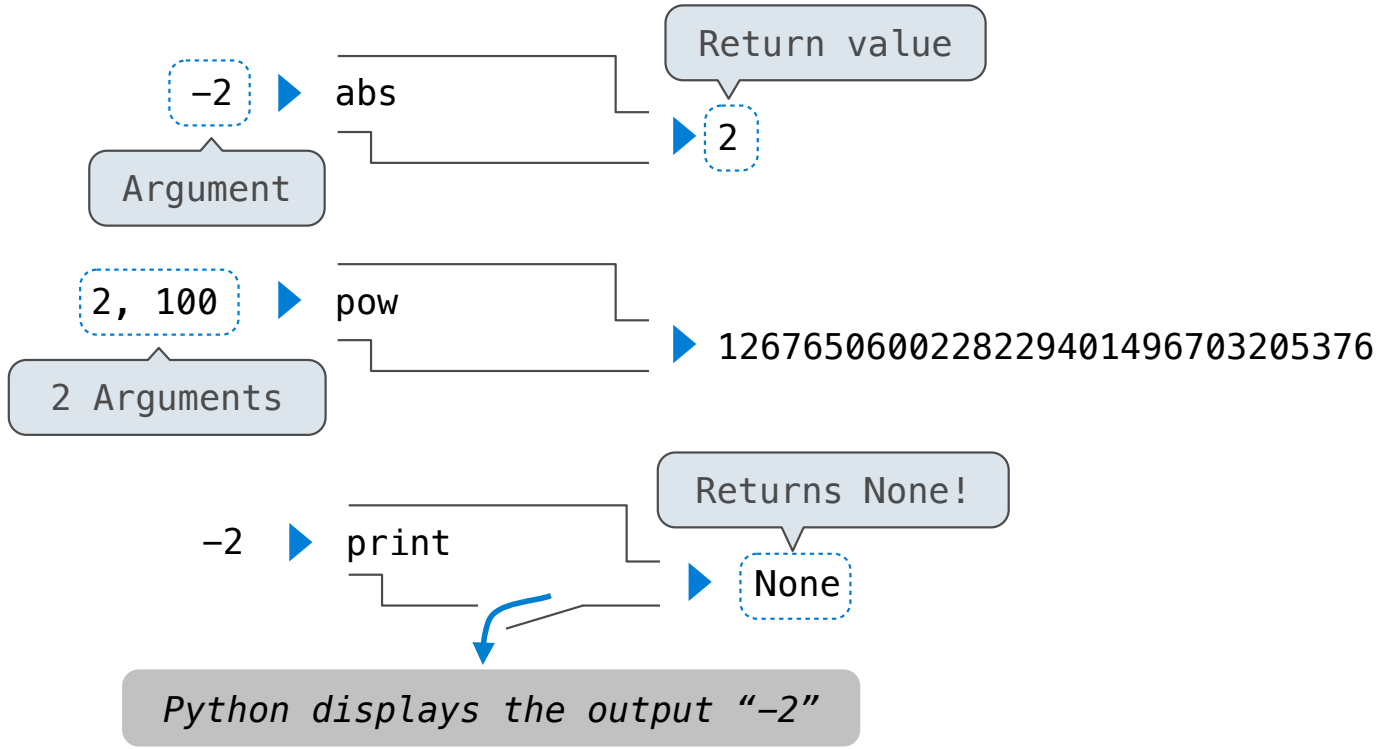

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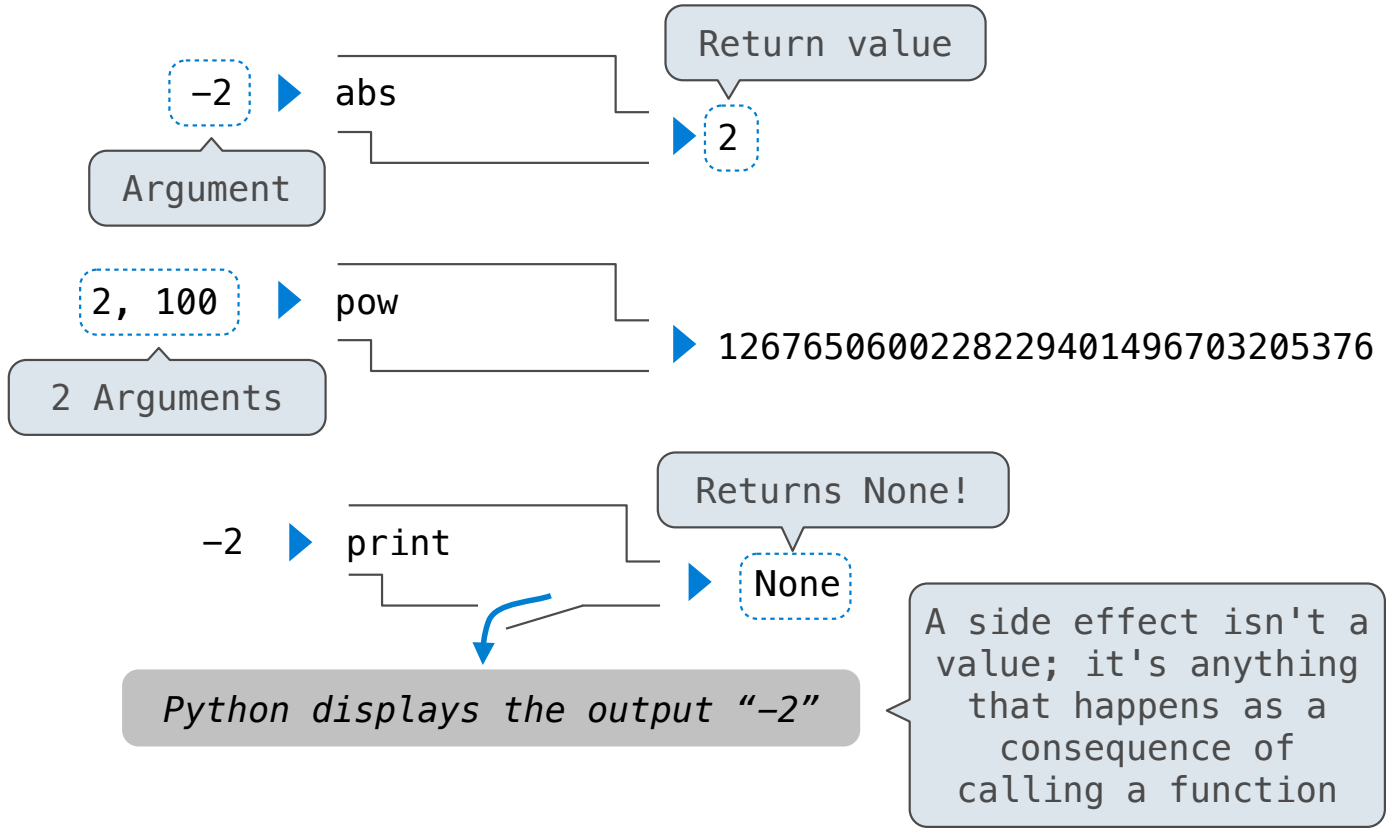

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Nested Expressions with Print

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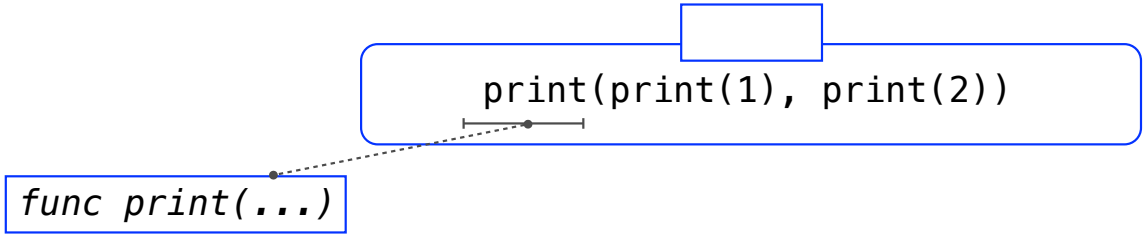

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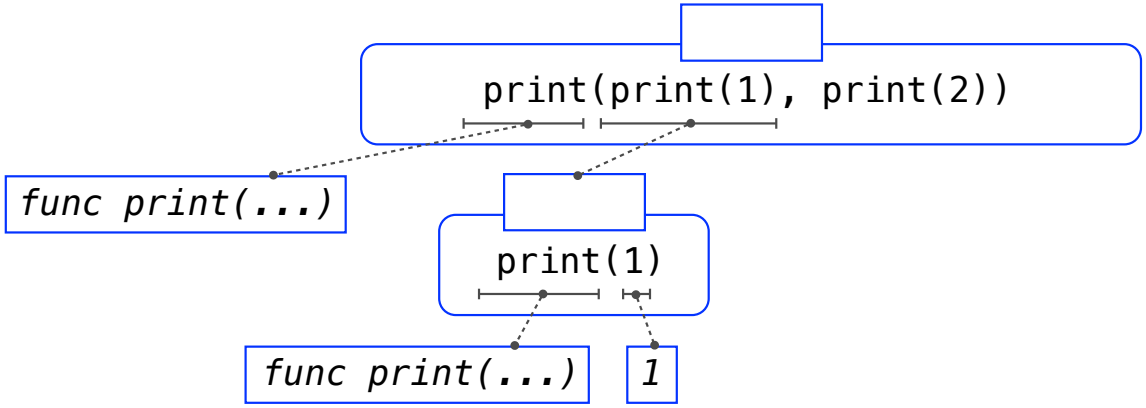

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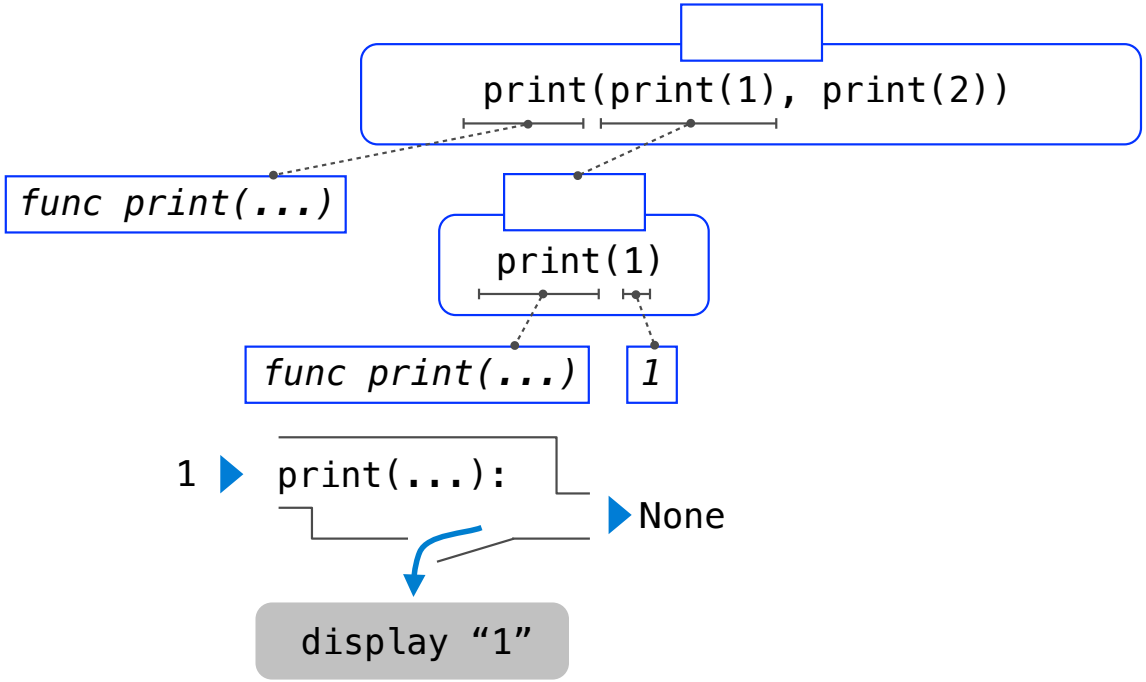

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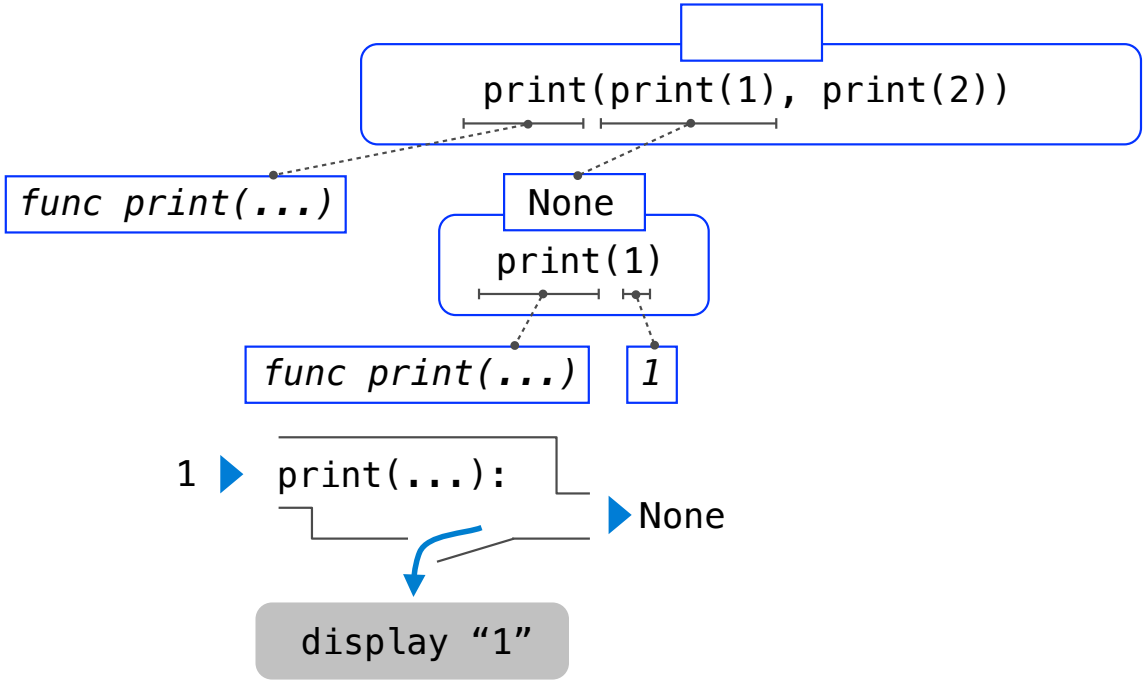

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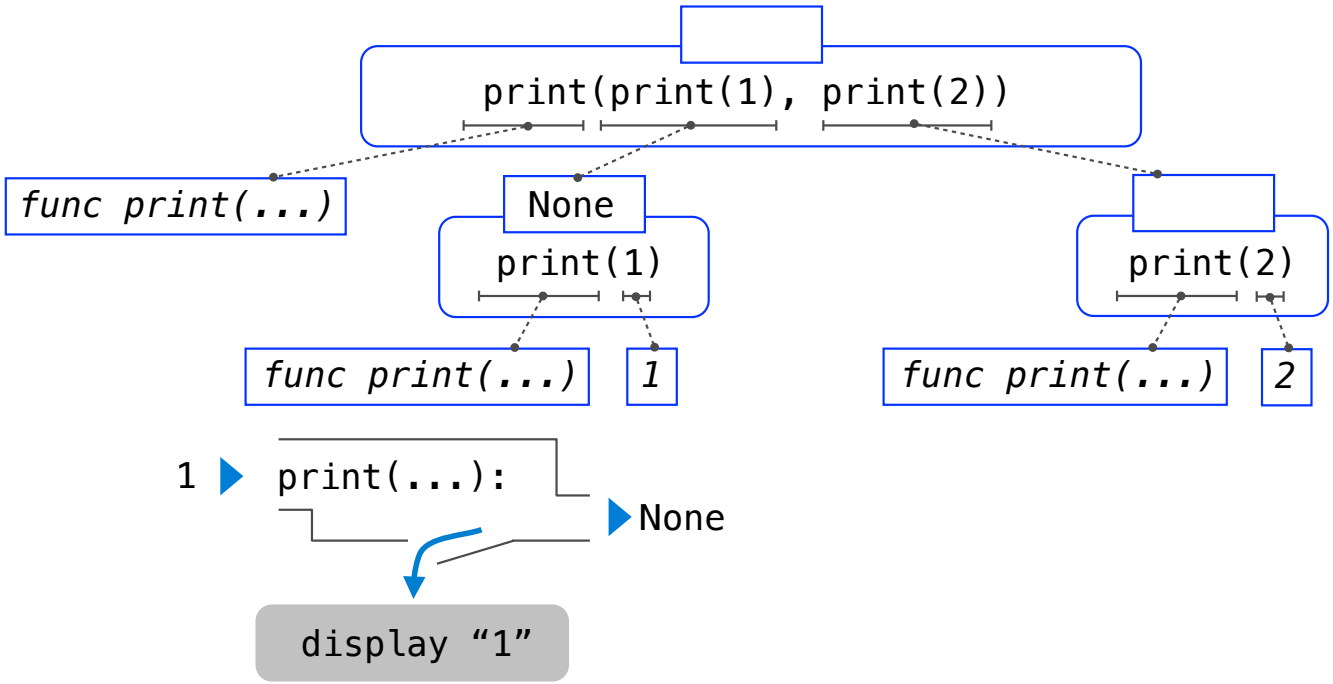

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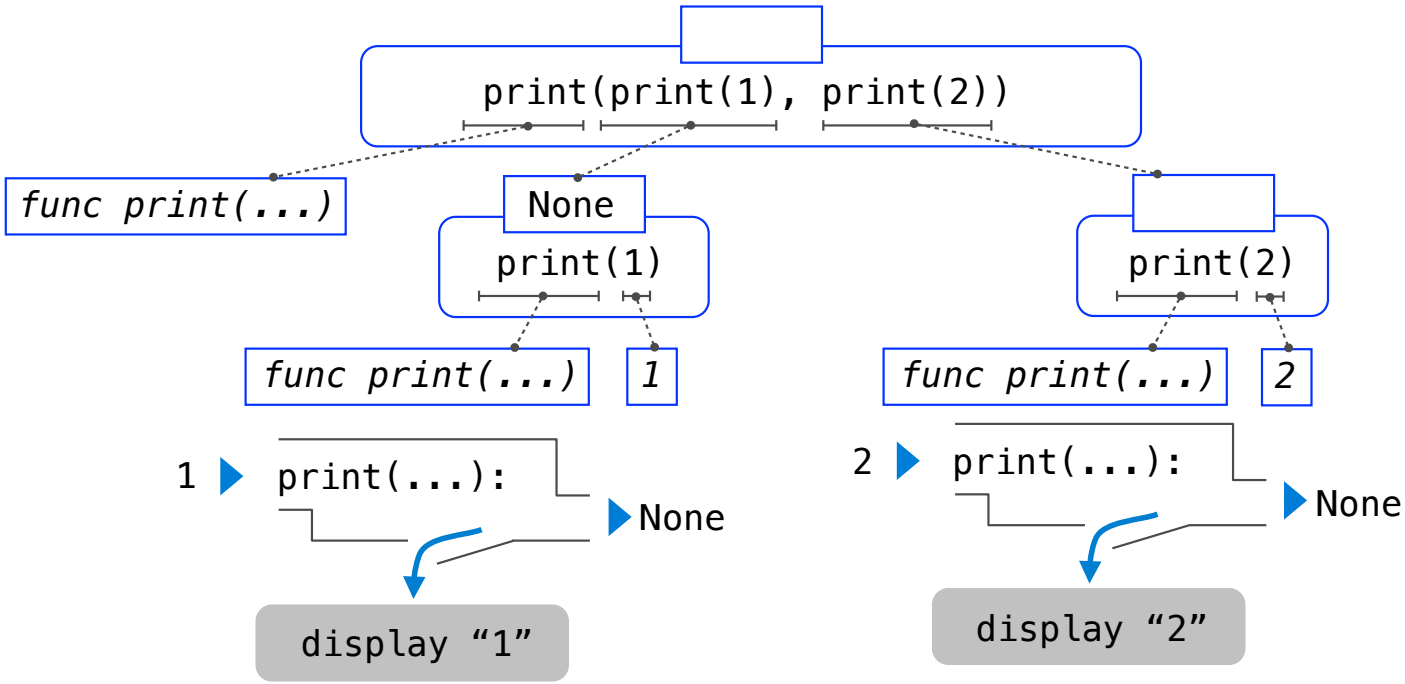

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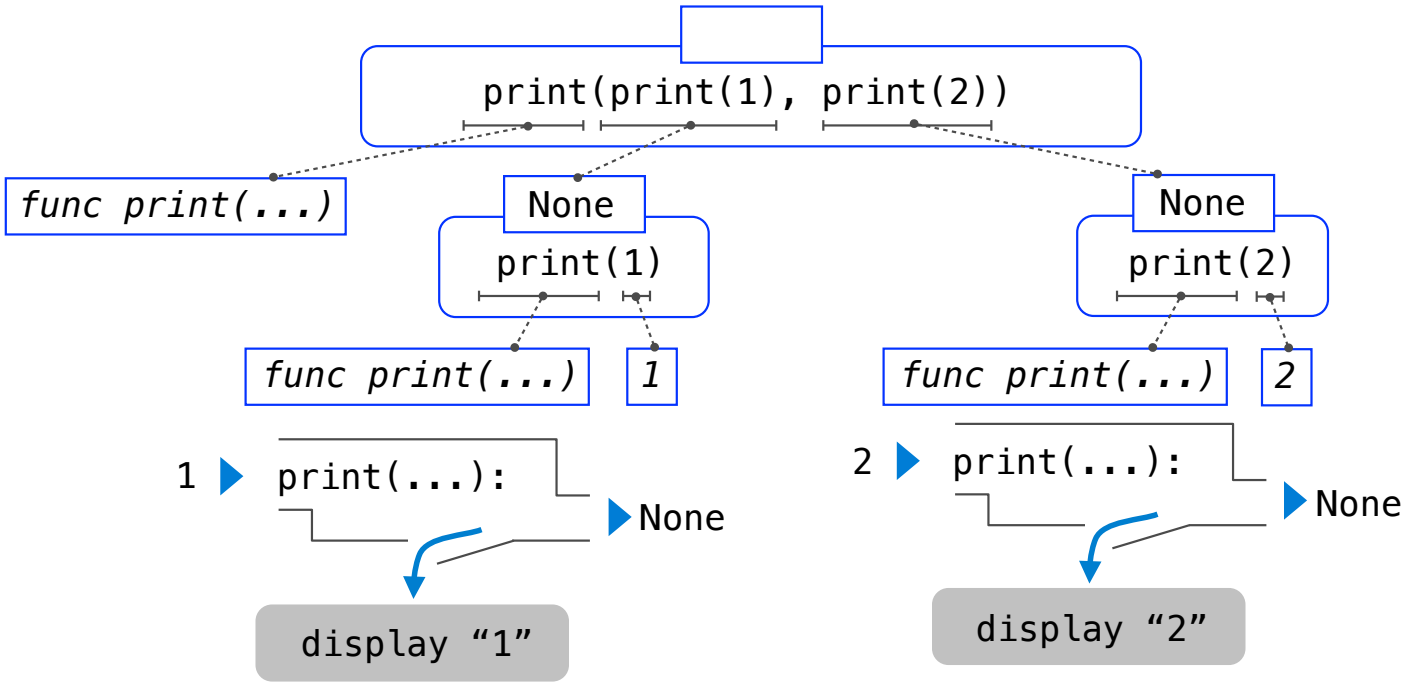

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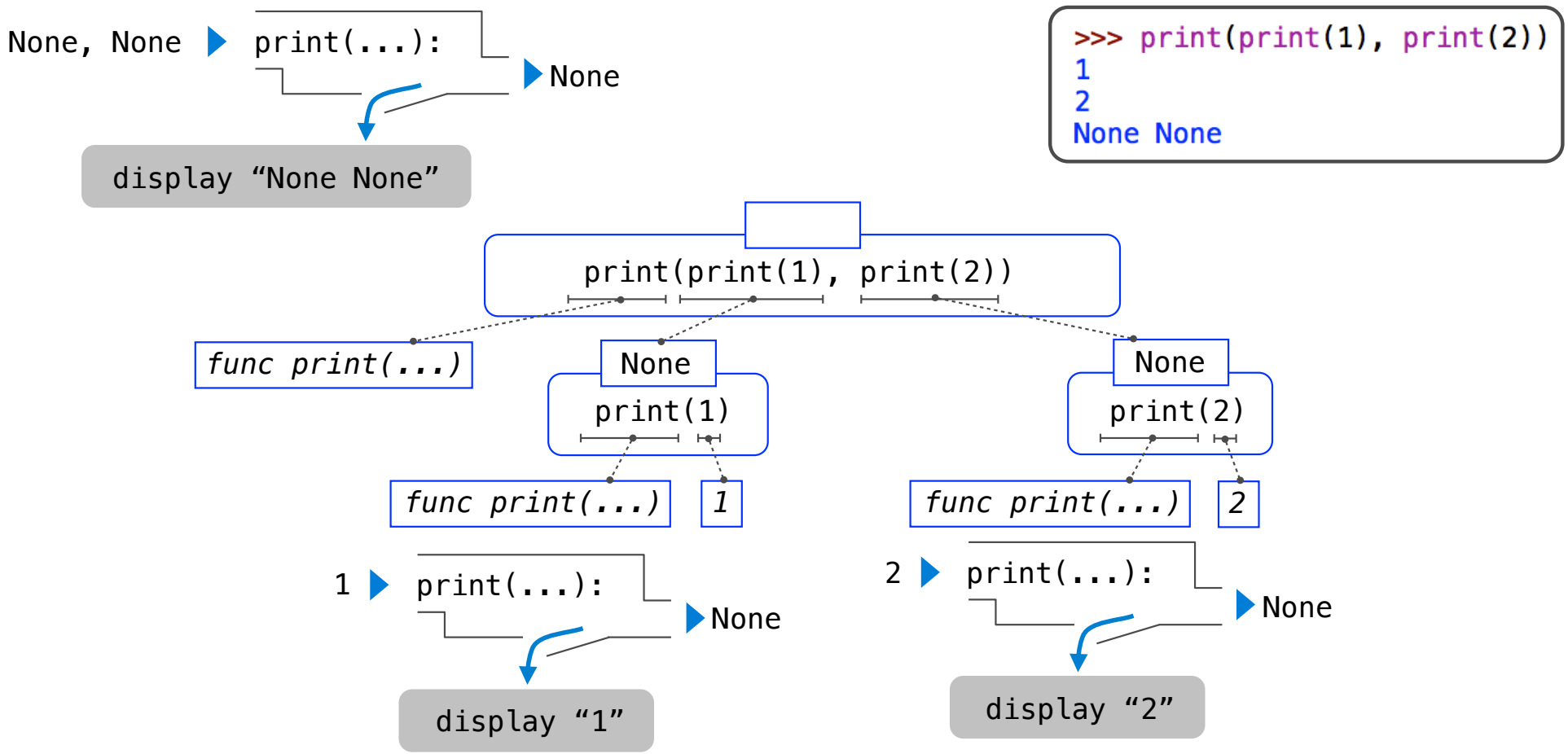

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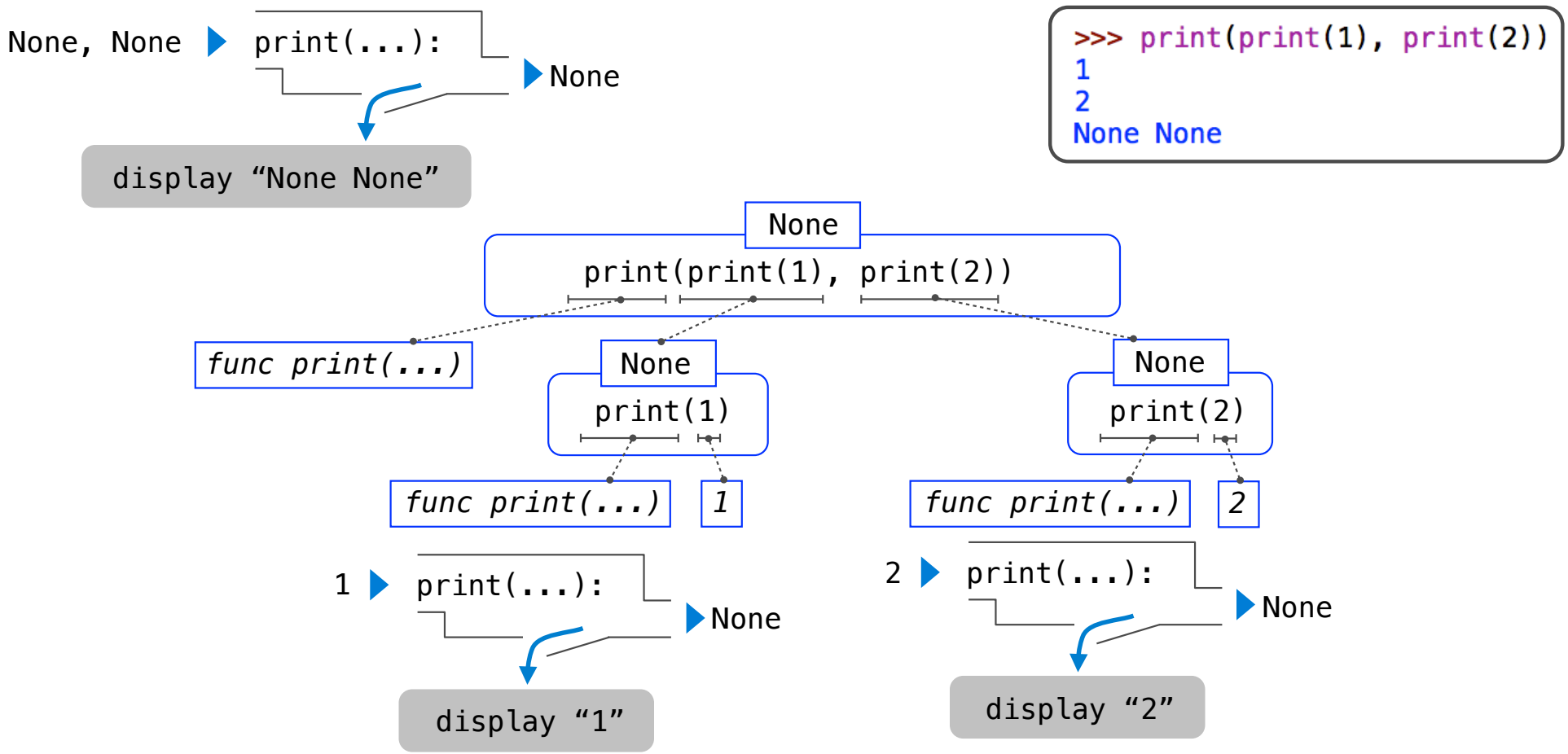

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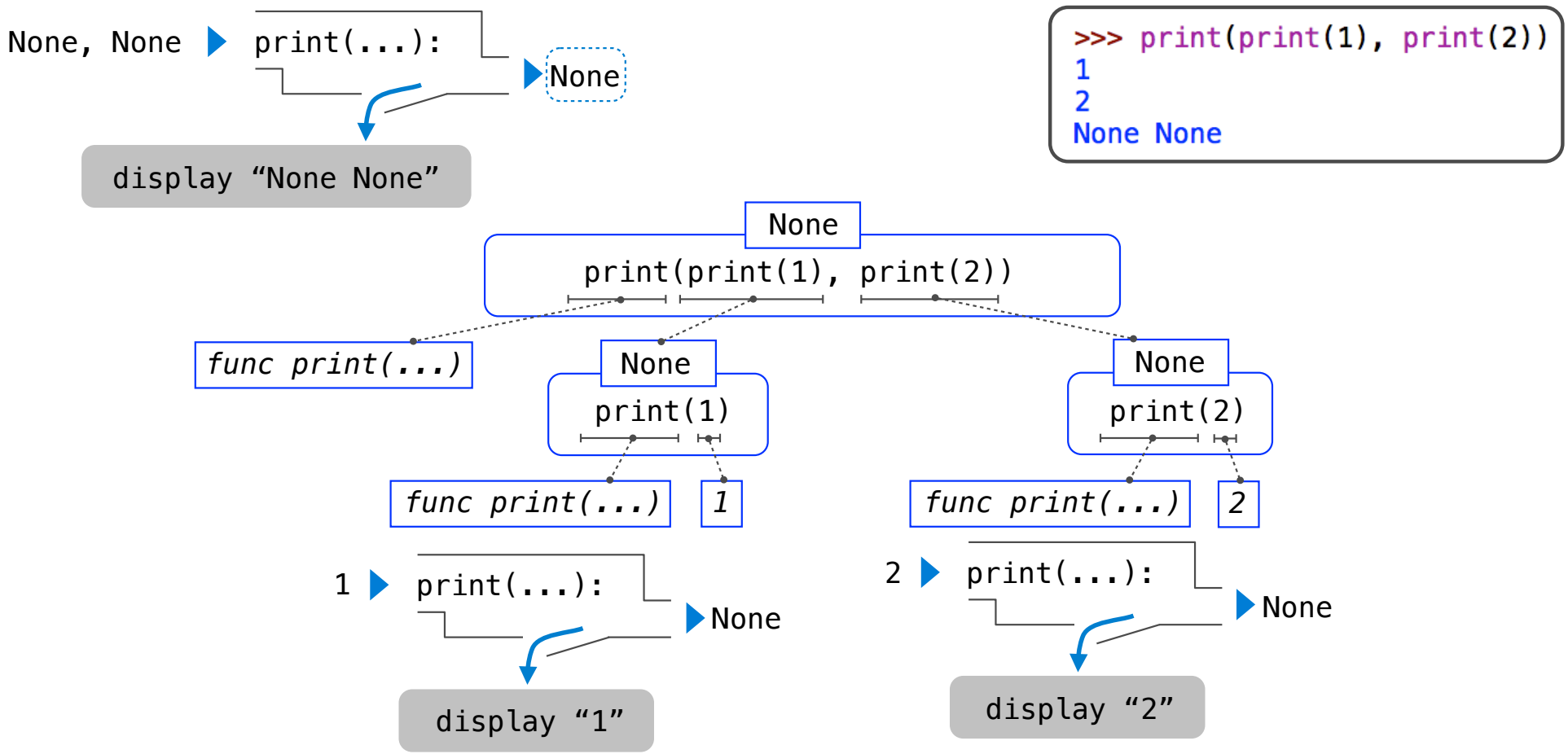

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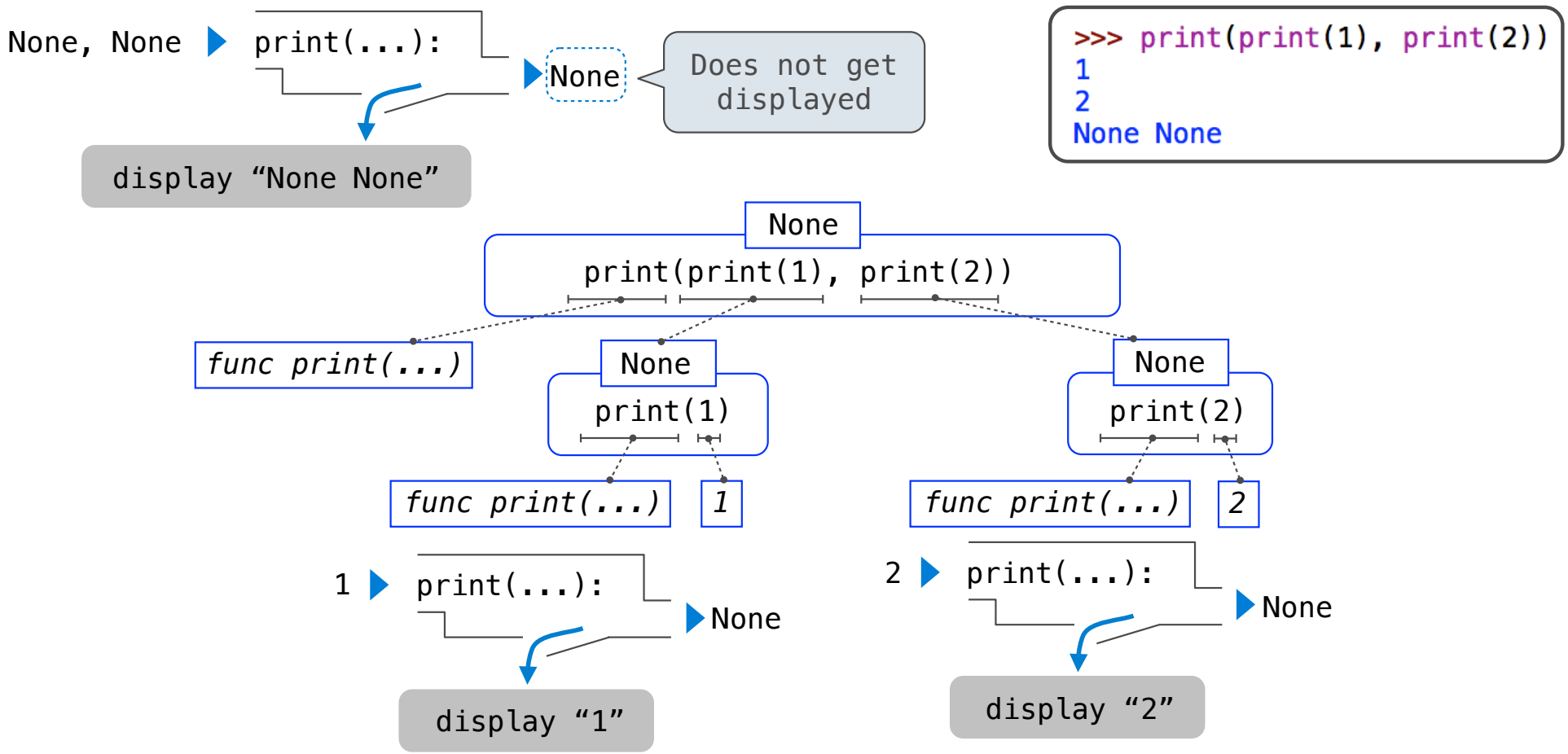

Multiple Environments

Life Cycle of a User-Defined Function

What happens?

Def statement:

Call expression:

Calling/Applying:

Life Cycle of a User-Defined Function

What happens?

Def statement:

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

Call expression:

Calling/Applying:

Life Cycle of a User-Defined Function

What happens?

Def statement:

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

Def statement

Call expression:

Calling/Applying:

Life Cycle of a User-Defined Function

What happens?

Def statement:

Name

Def statement

```
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Call expression:

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Life Cycle of a User-Defined Function

What happens?

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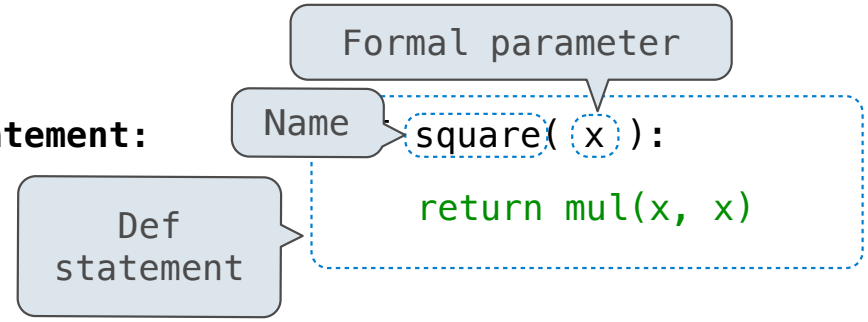

Call expression:

Calling/Applying:

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What happens?

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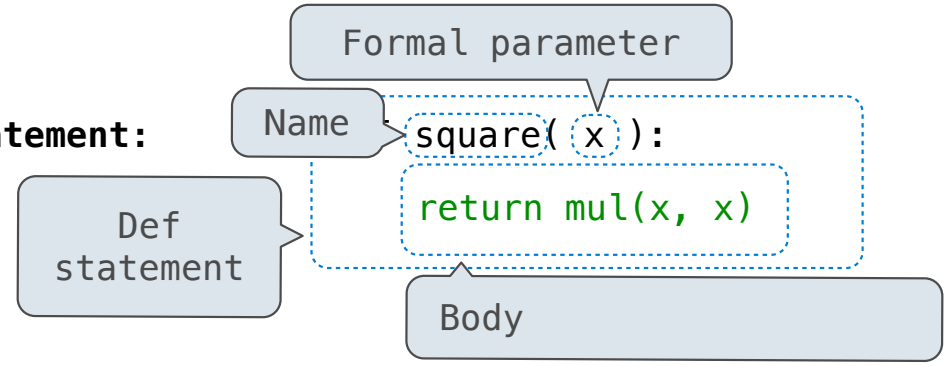

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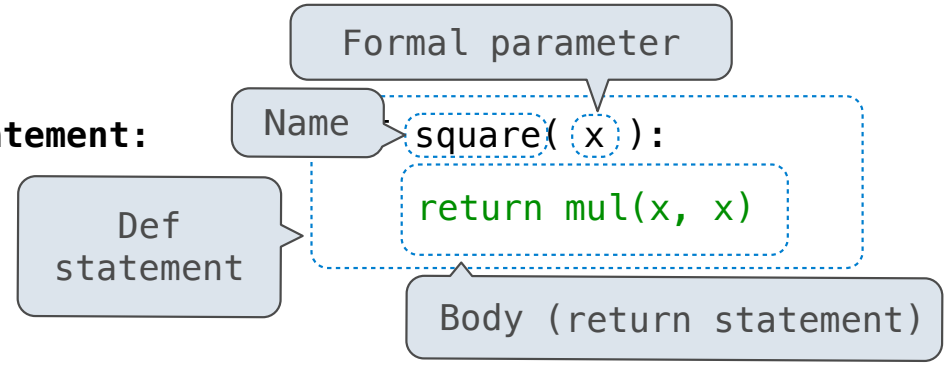

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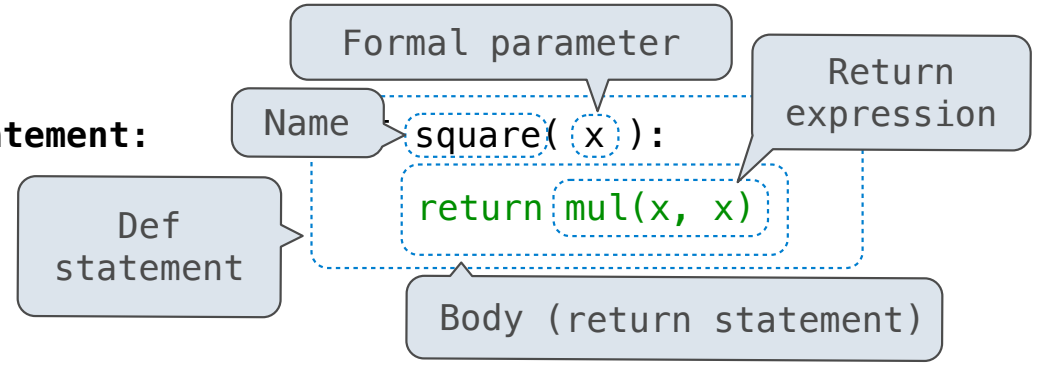

Call expression:

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Life Cycle of a User-Defined Function

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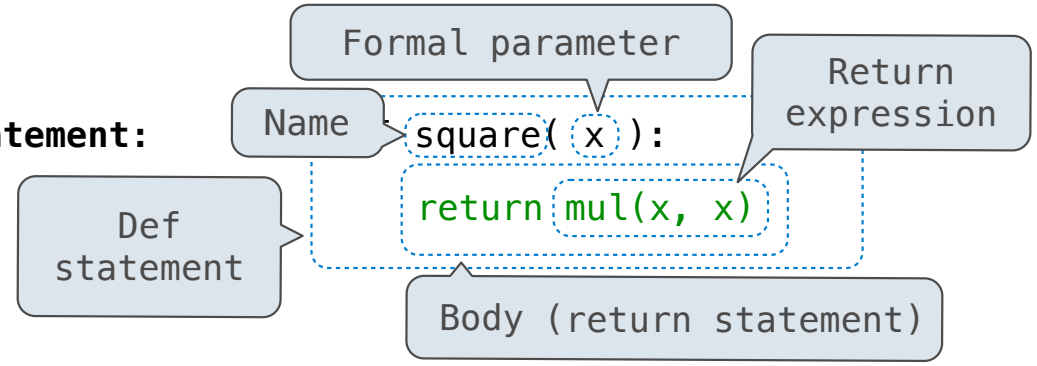


What happens?

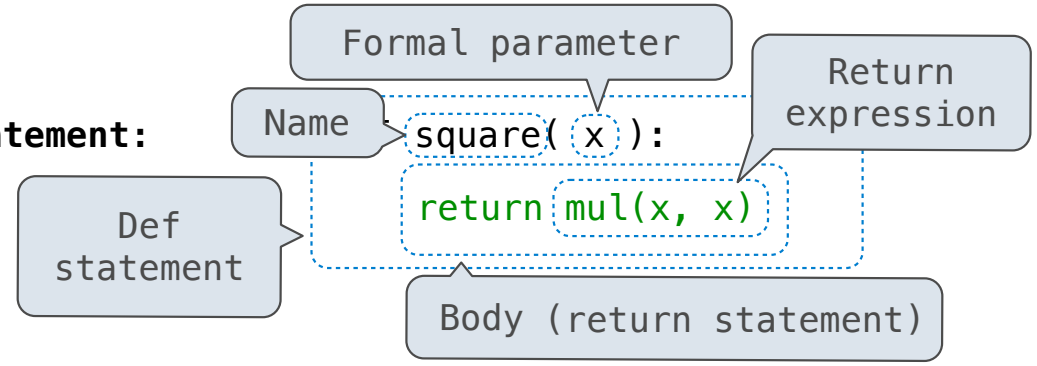
A new function is created!

Call expression:

Calling/Applying:

Life Cycle of a User-Defined Function

Def statement:



What happens?

A new function is created!

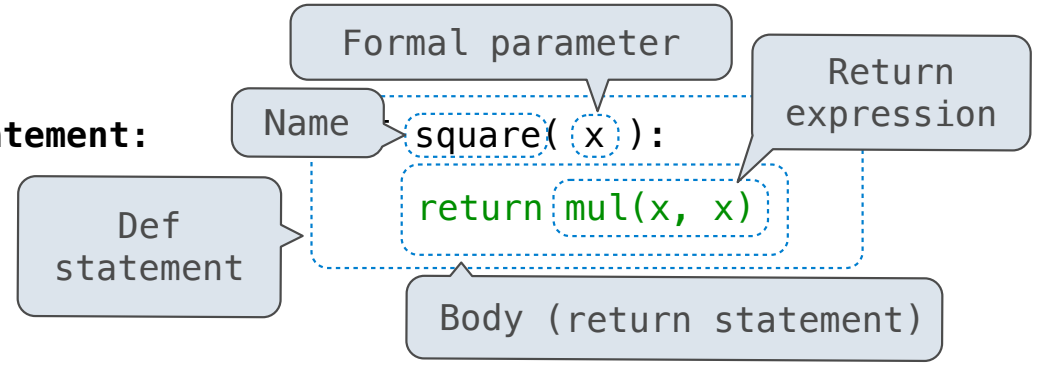
Name bound to that function in the current frame

Call expression:

Calling/Applying:

Life Cycle of a User-Defined Function

Def statement:



What happens?

A new function is created!

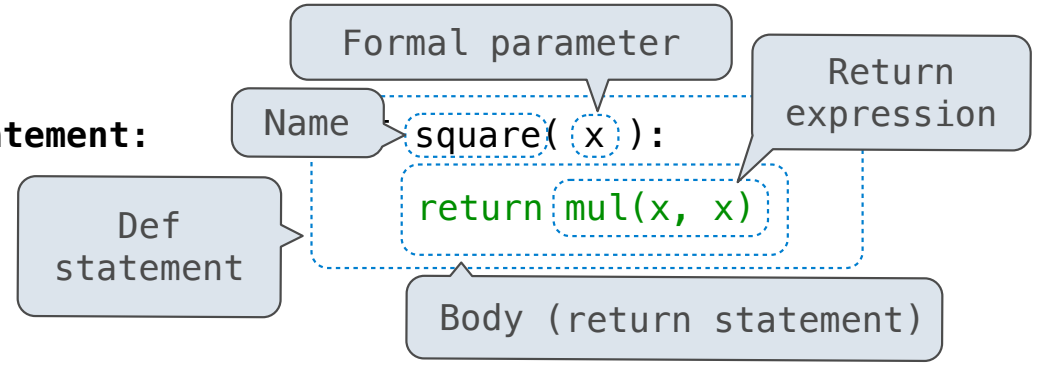
Name bound to that function in the current frame

Call expression: `square(2+2)`

Calling/Applying:

Life Cycle of a User-Defined Function

Def statement:



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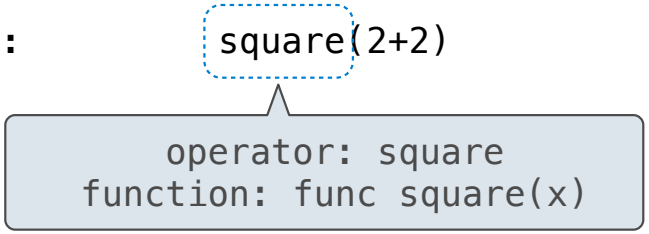

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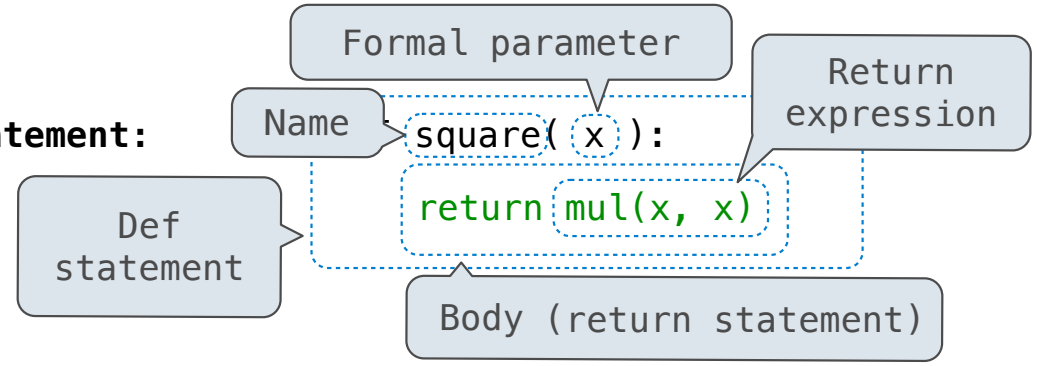

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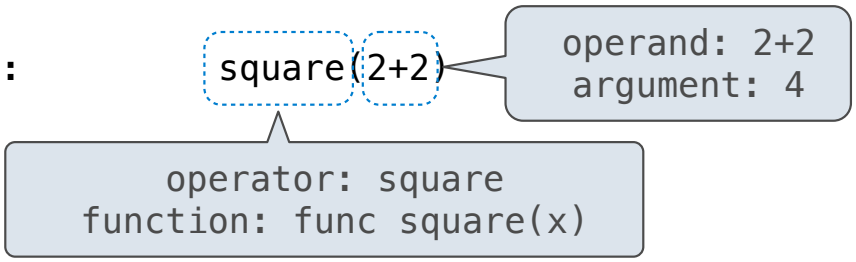

Calling/Applying:

What happens?

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Name bound to that function in the current frame

Life Cycle of a User-Defined Function

Def statement:

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

Formal parameter

Name

Return expression

Def statement

Body (return statement)

What happens?

A new function is created!

Name bound to that function in the current frame

Call expression:

```
square(2+2)
```

operand: 2+2
argument: 4

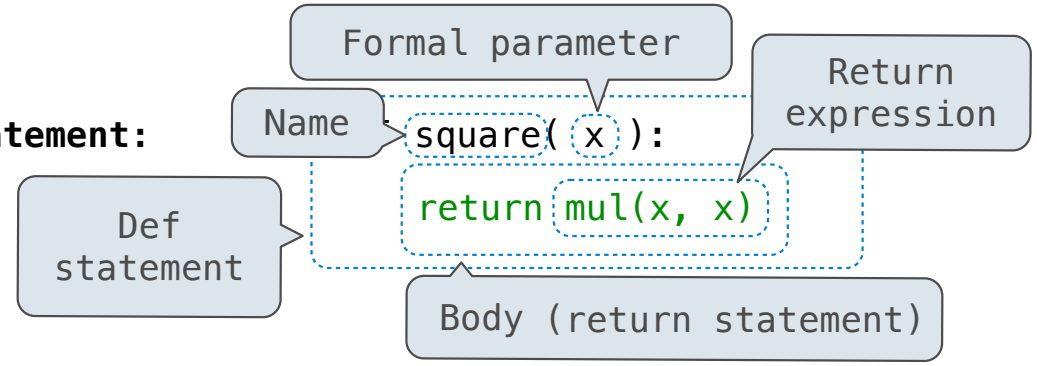
operator: square
function: func square(x)

Operator & operands evaluated

Calling/Applying:

Life Cycle of a User-Defined Function

Def statement:



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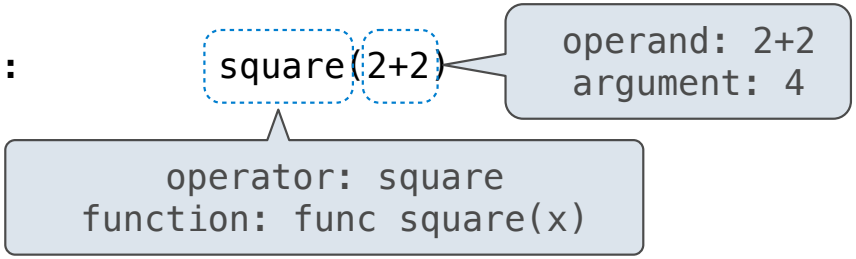


Calling/Applying:

What happens?

A new function is created!

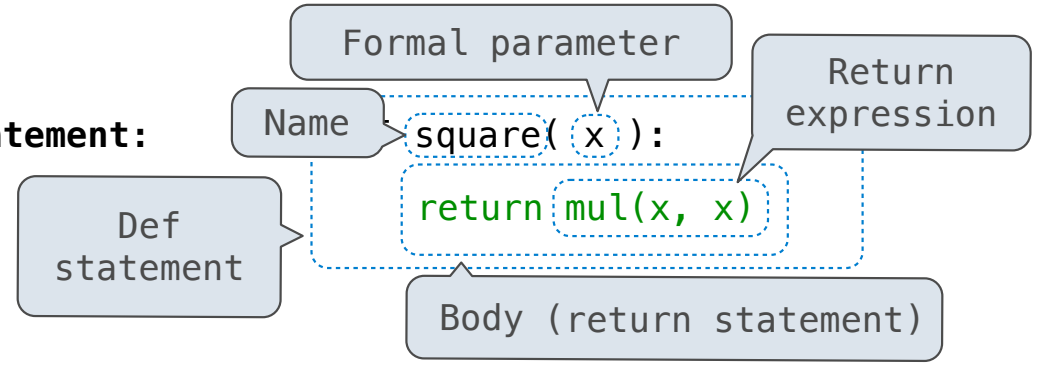
Name bound to that function in the current frame

Operator & operands evaluated

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

Life Cycle of a User-Defined Function

Def statement:



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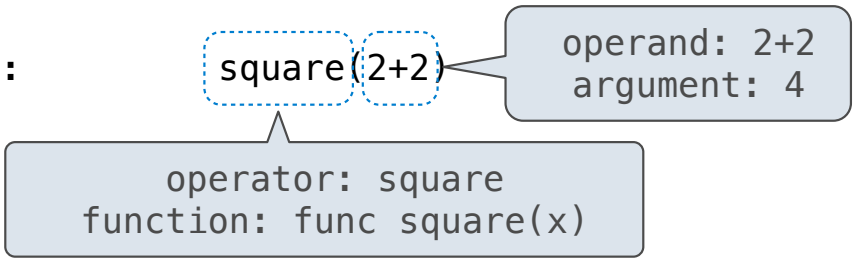

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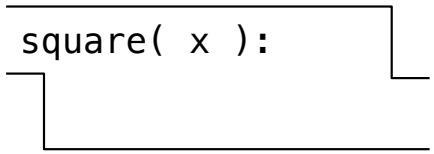

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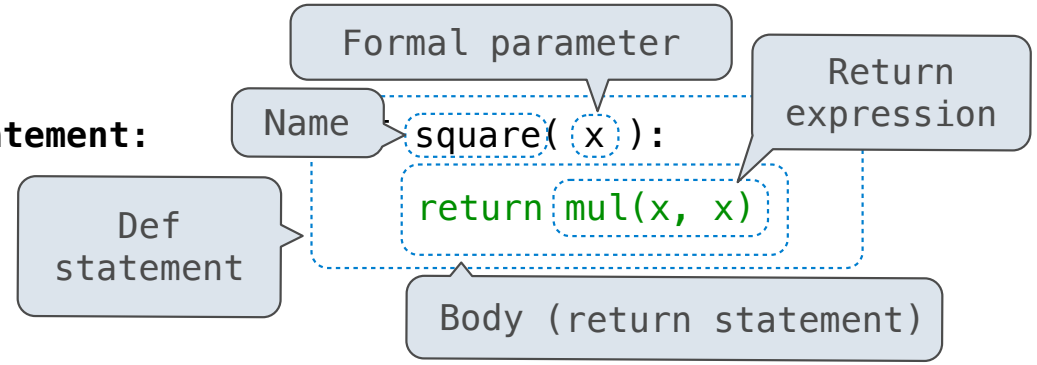

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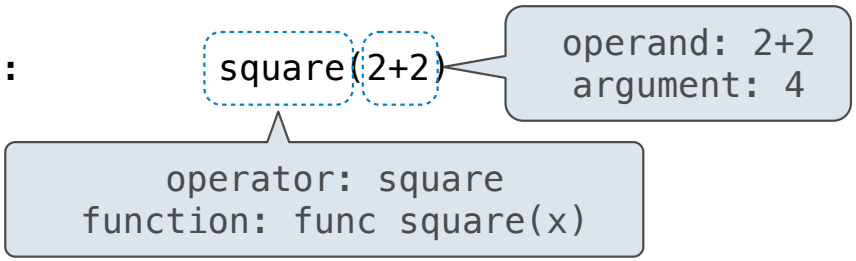

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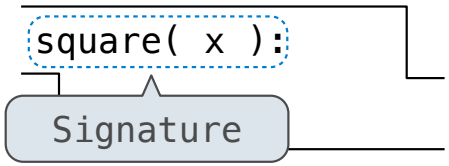

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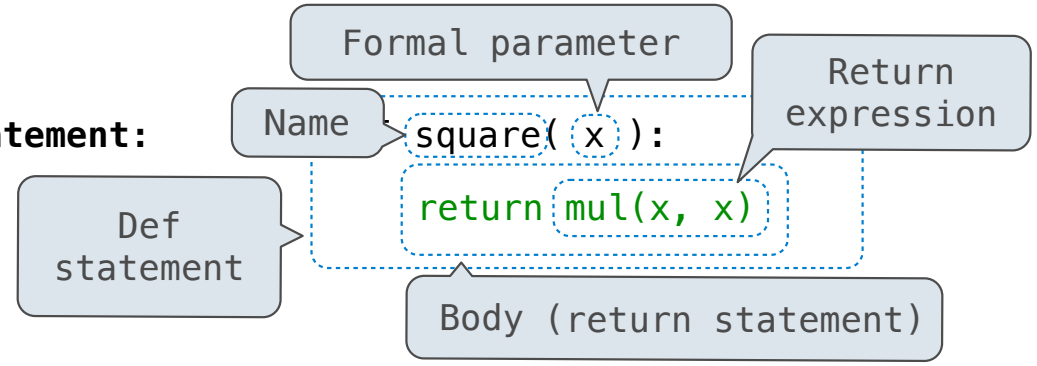

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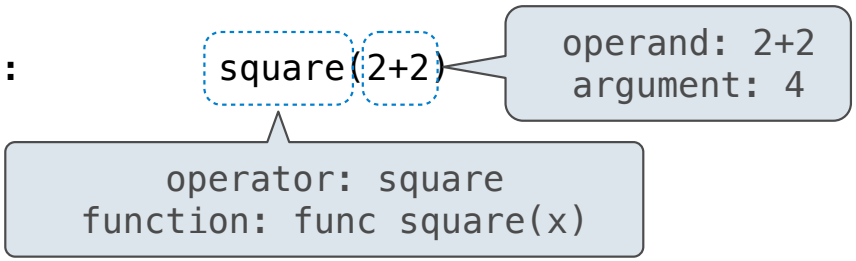

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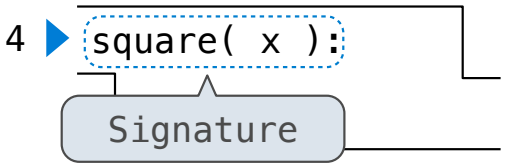

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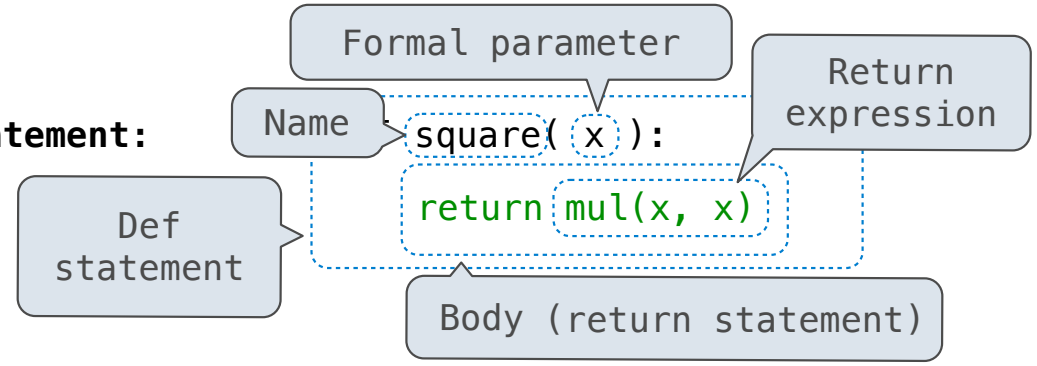

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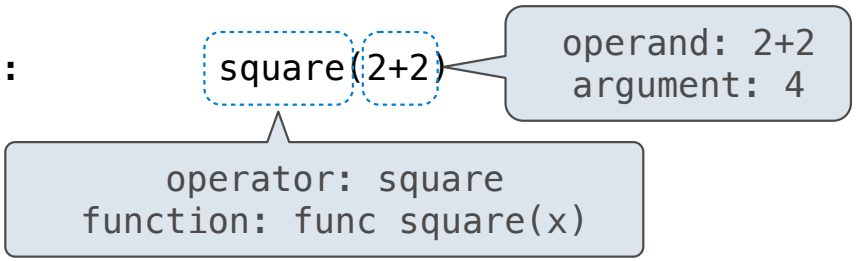

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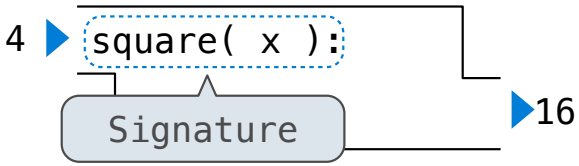

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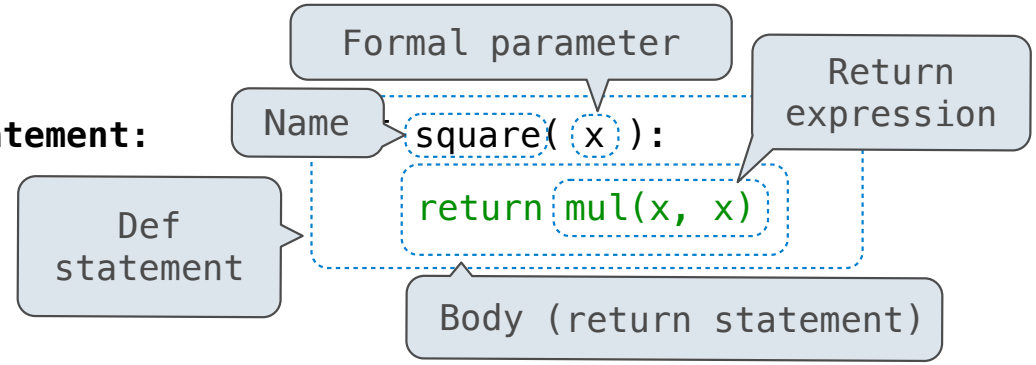

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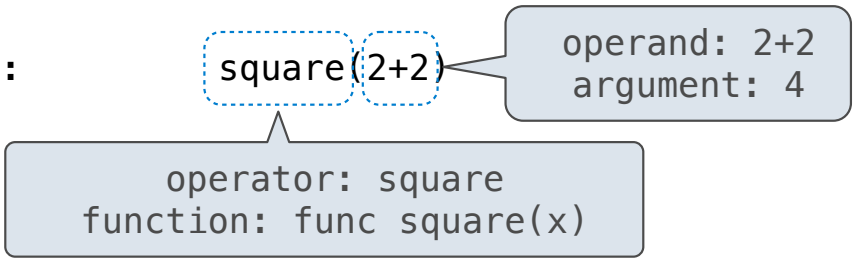

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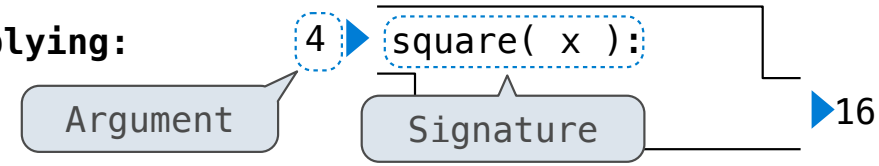

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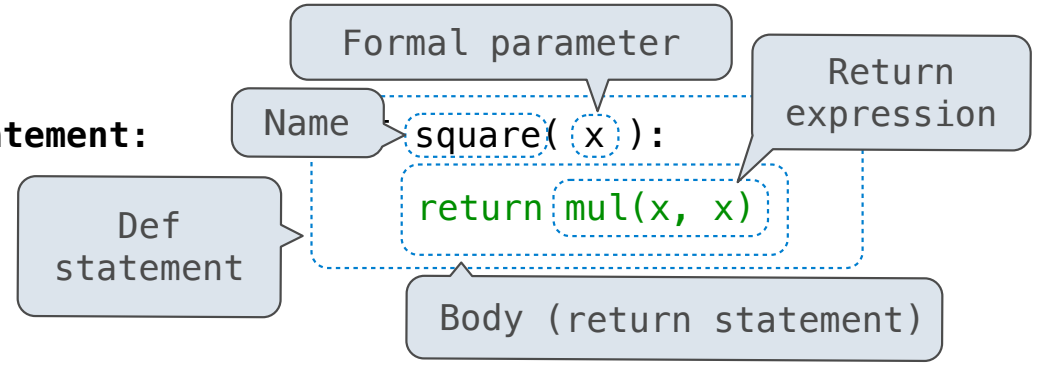

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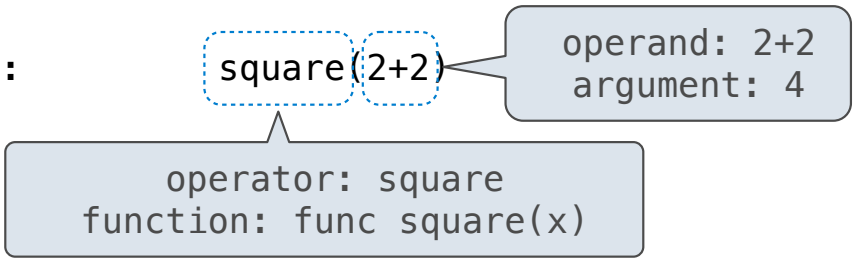

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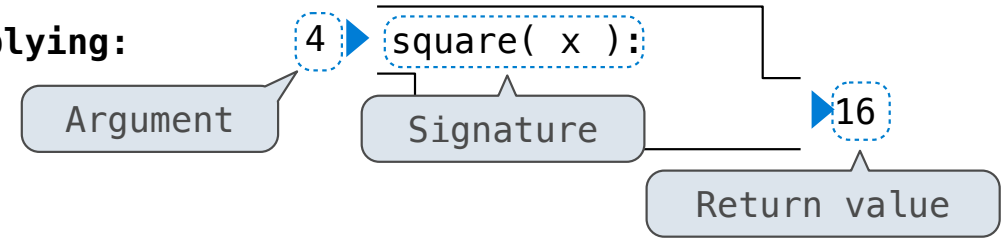

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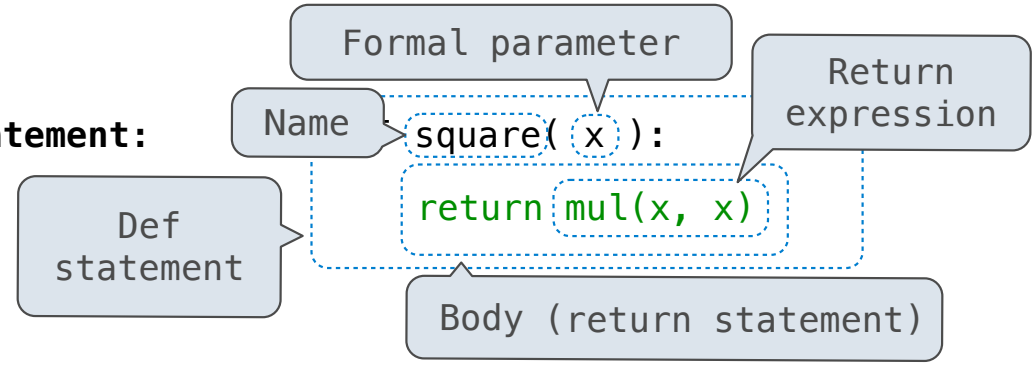

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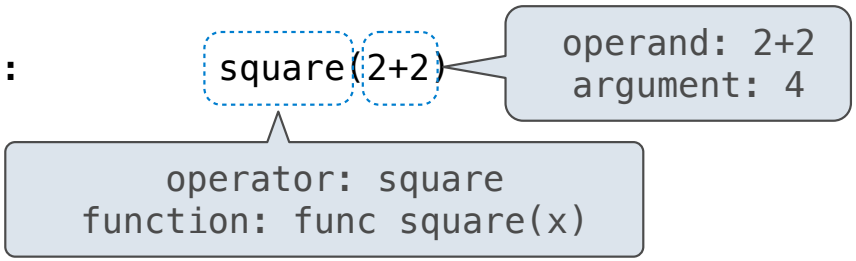

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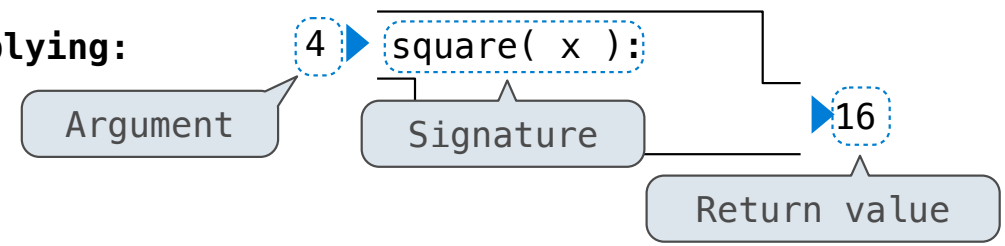

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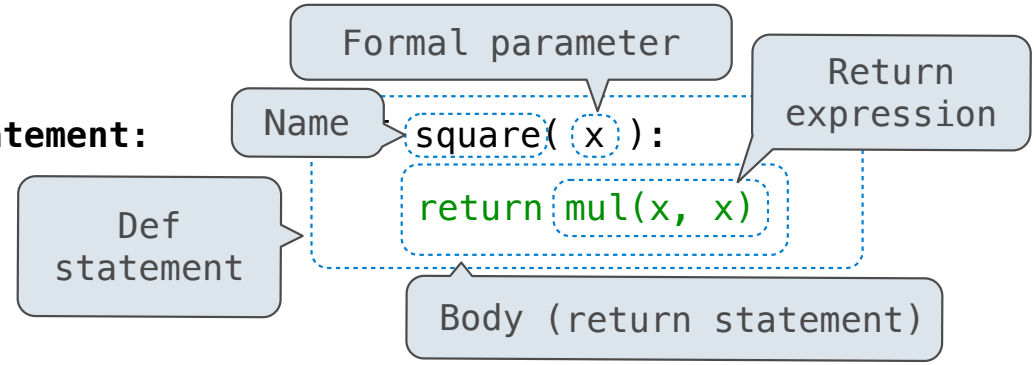

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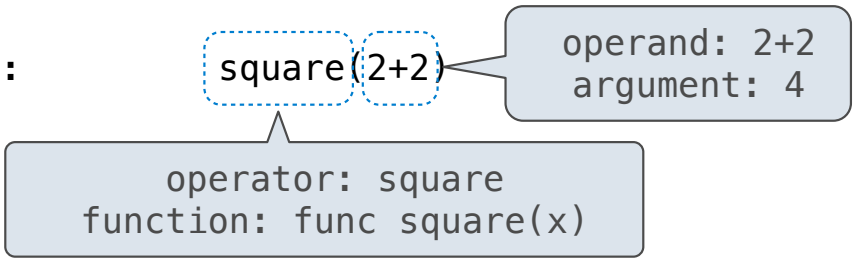

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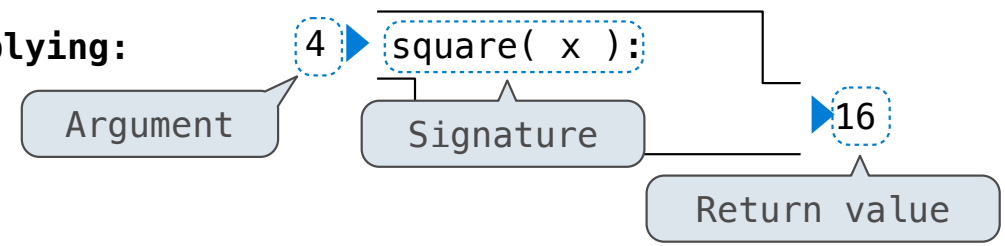

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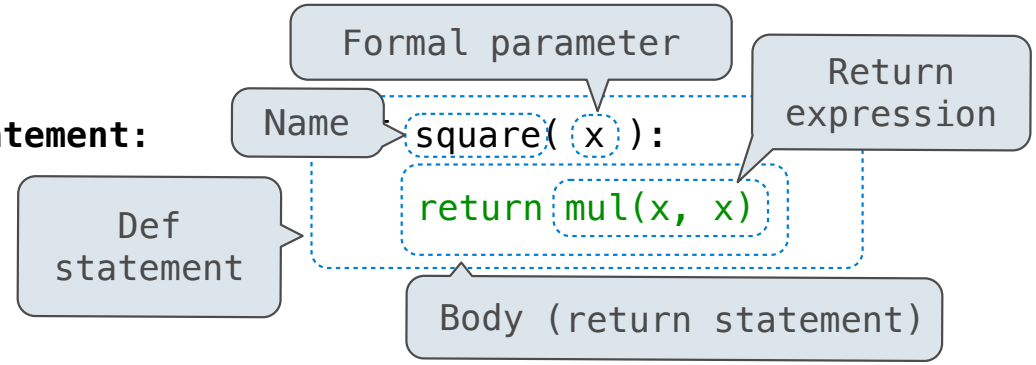

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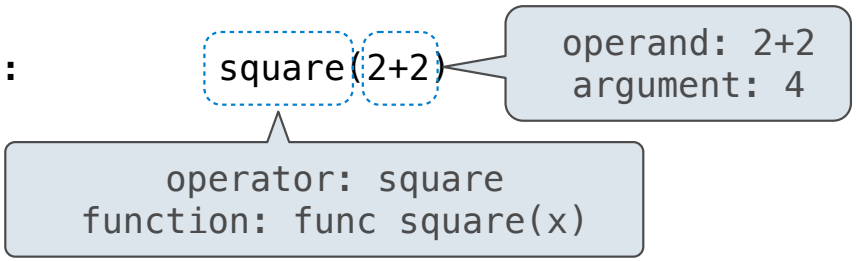

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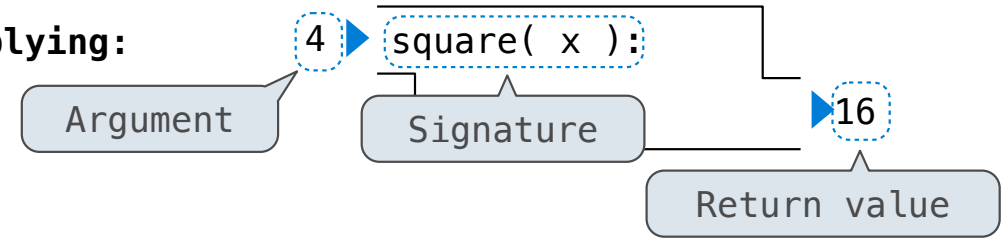

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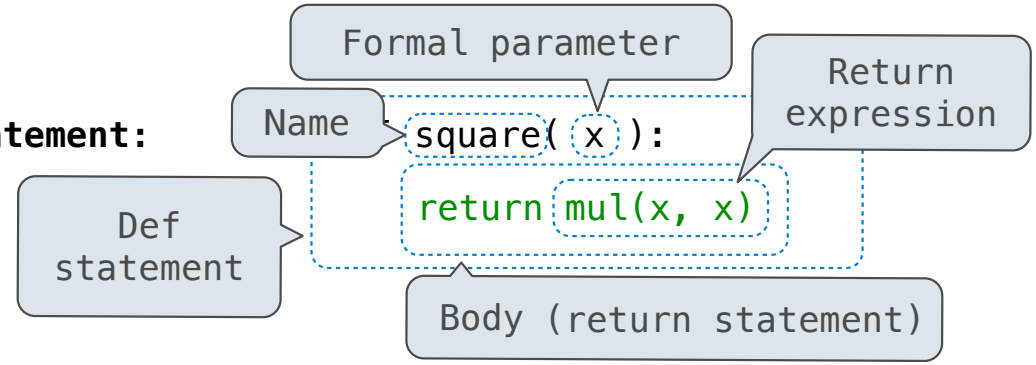

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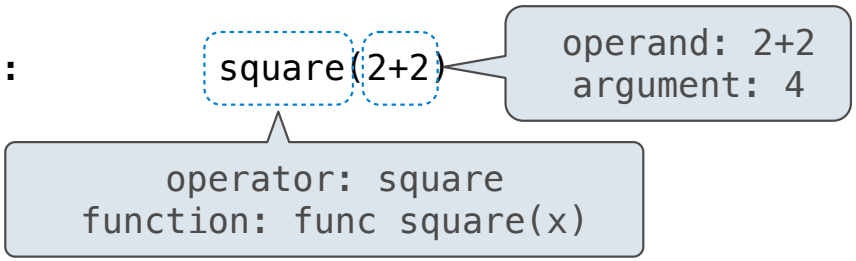

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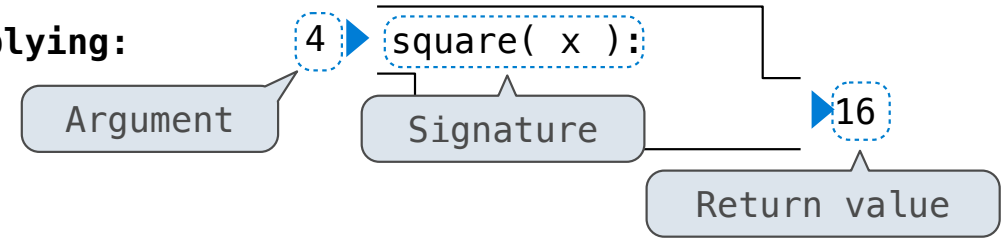

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(Demo)

Multiple Environments in One Diagram!

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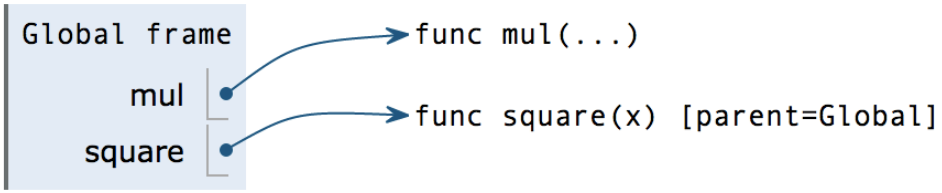

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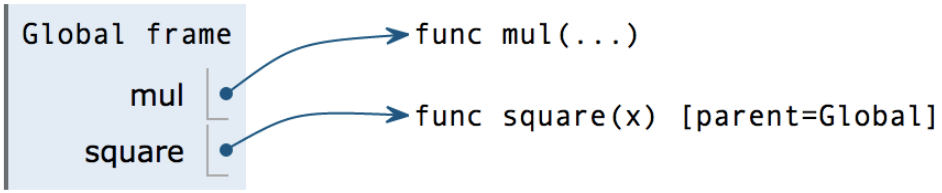


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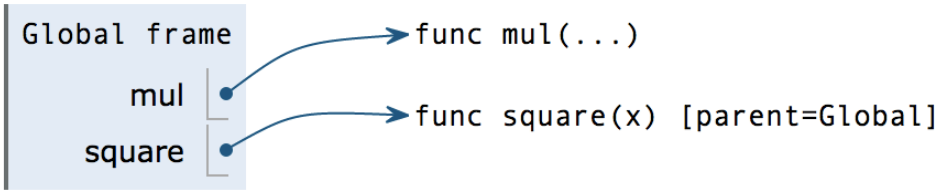

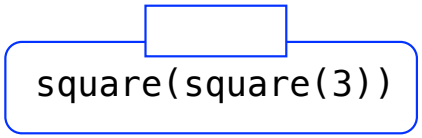

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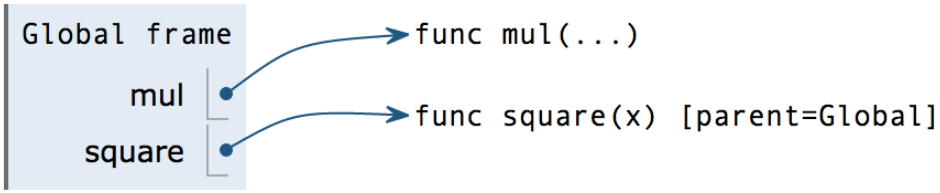

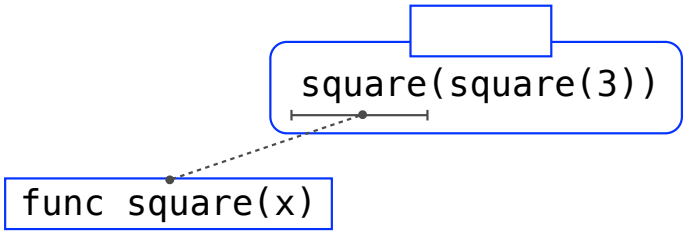

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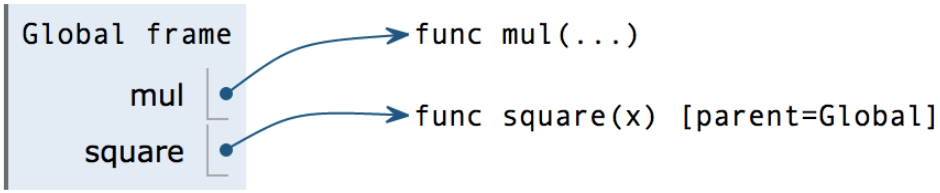

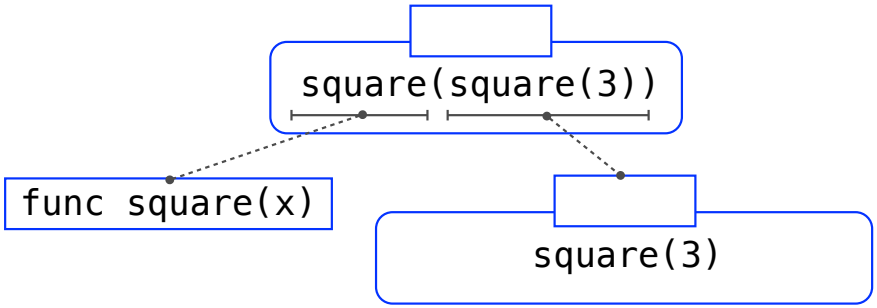

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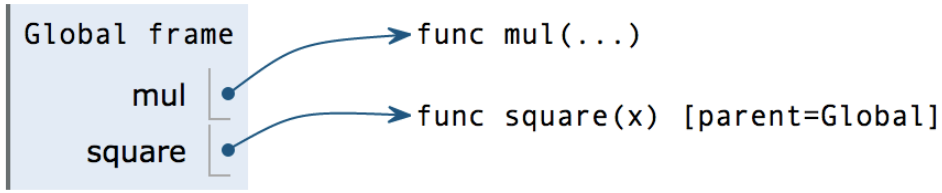

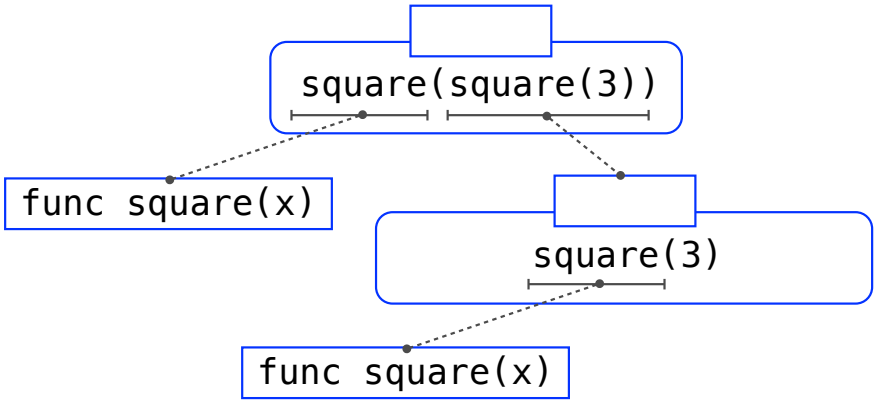

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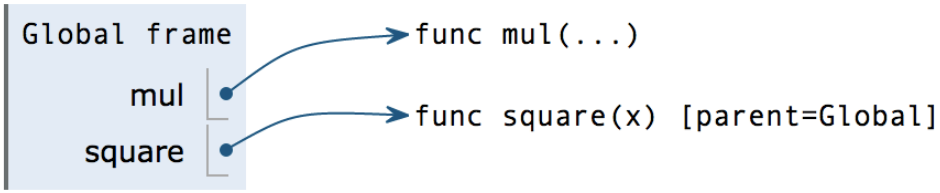

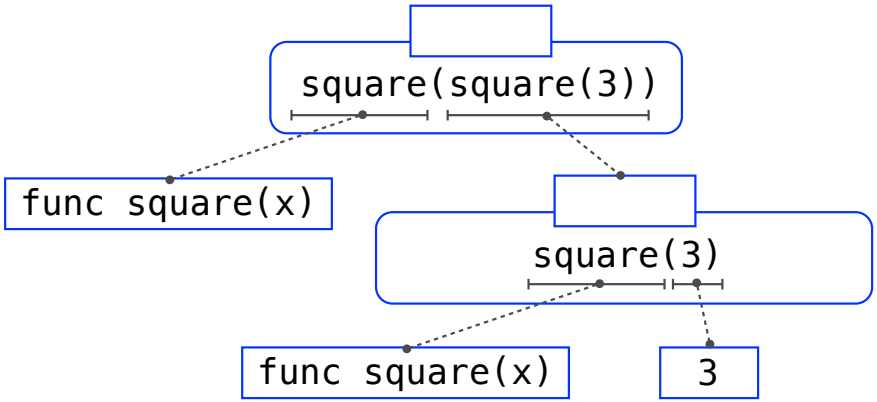

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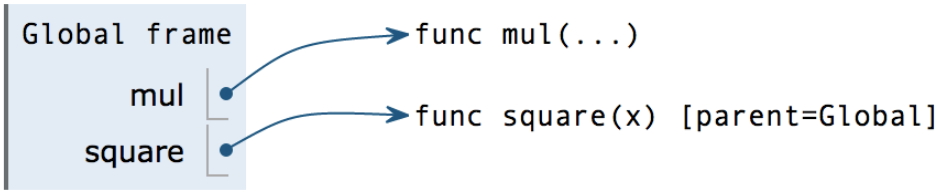

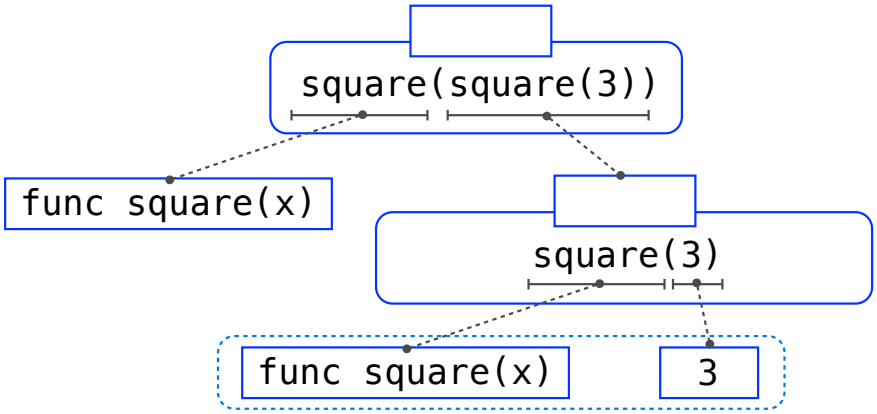

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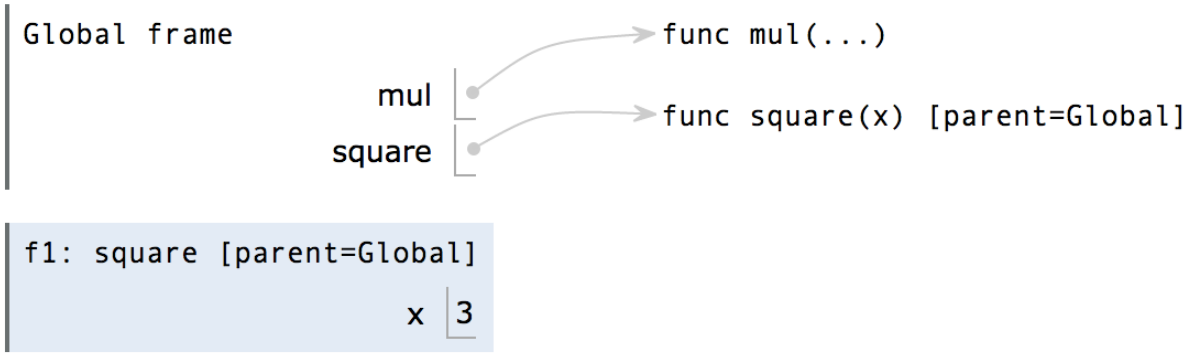

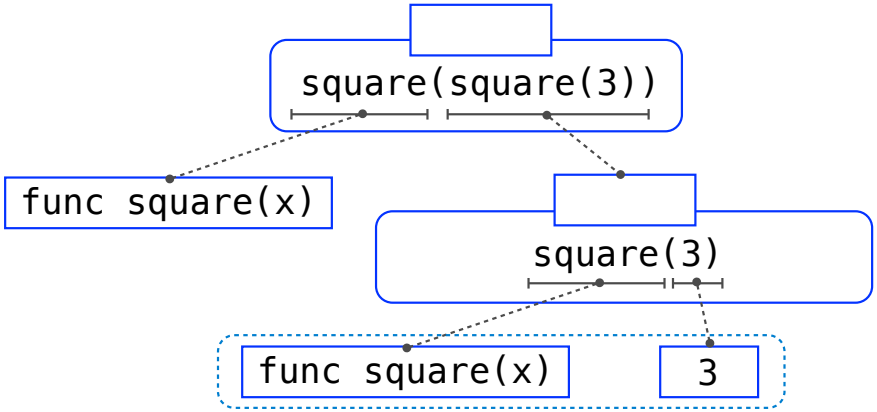

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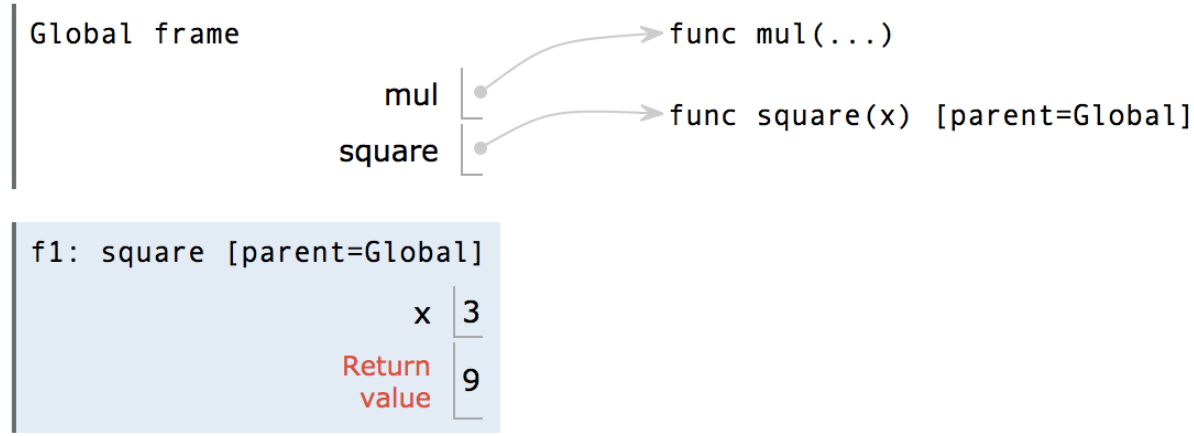

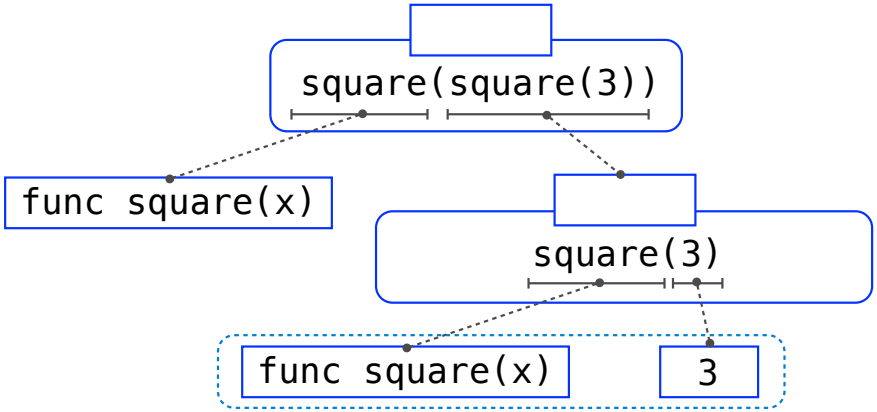

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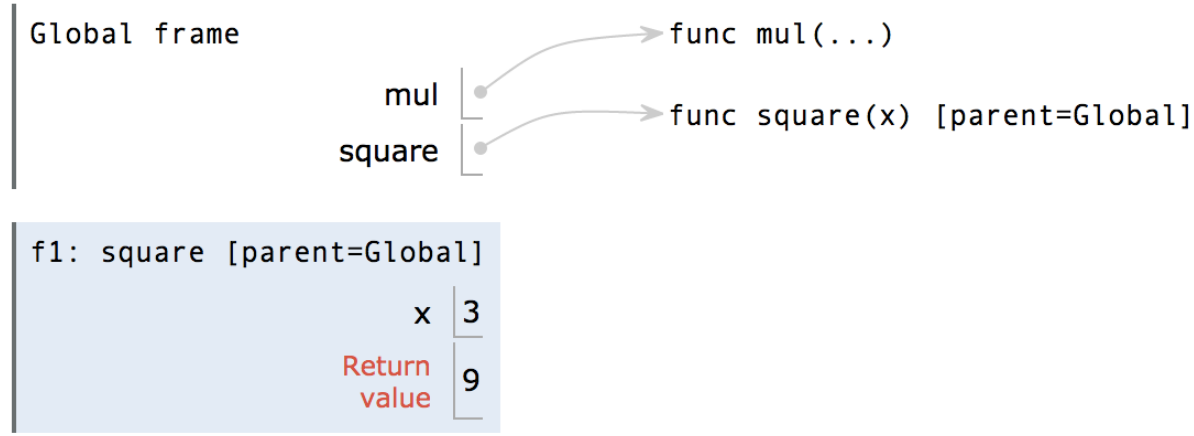

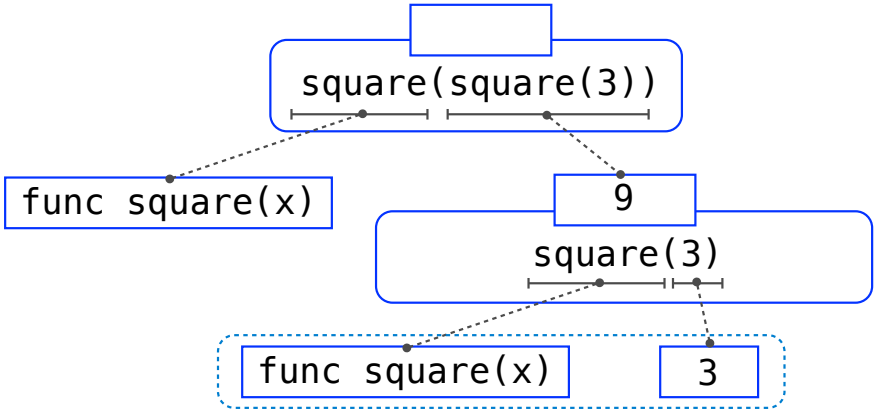

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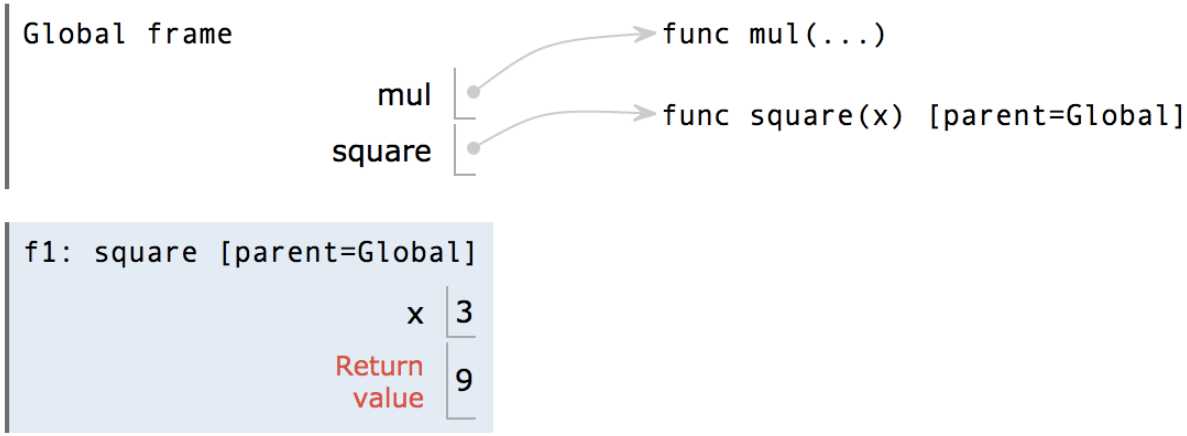

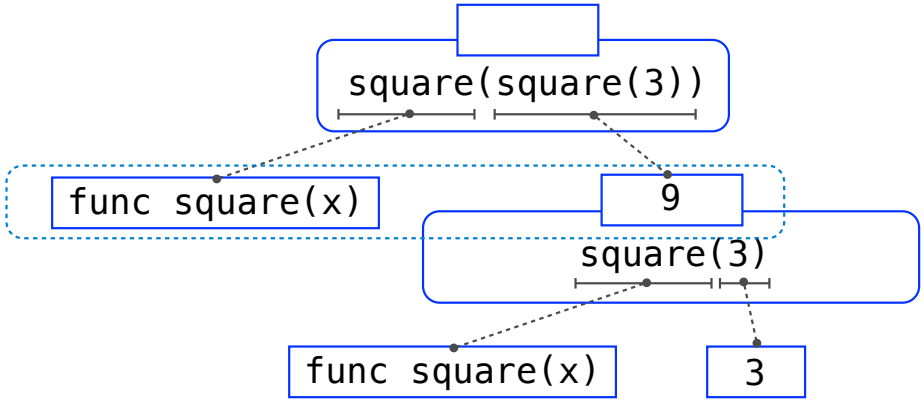

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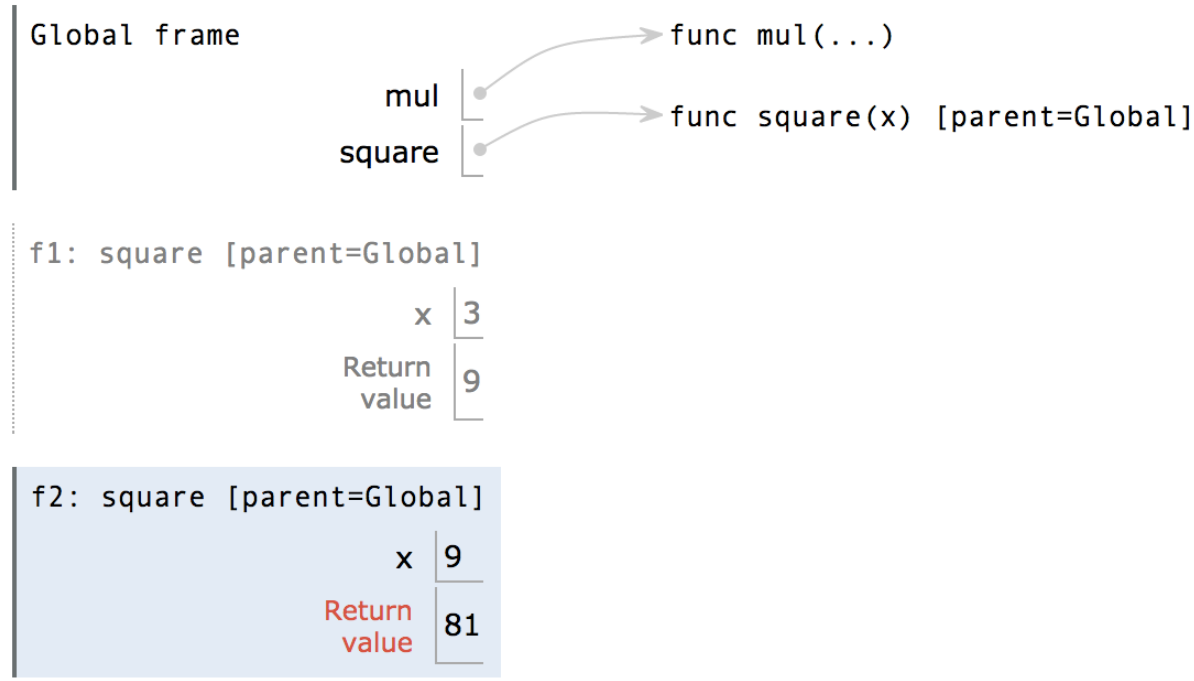

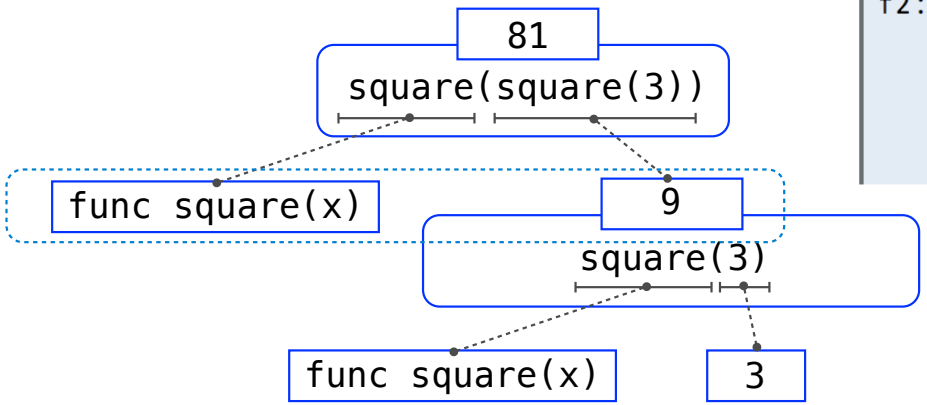

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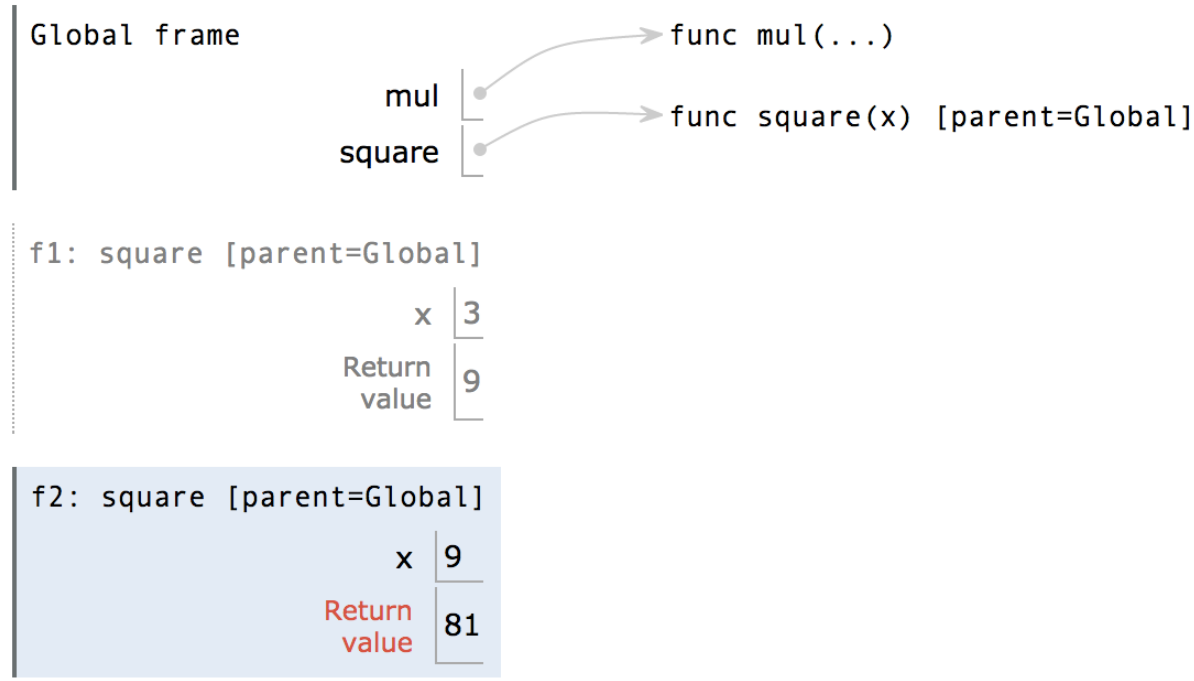

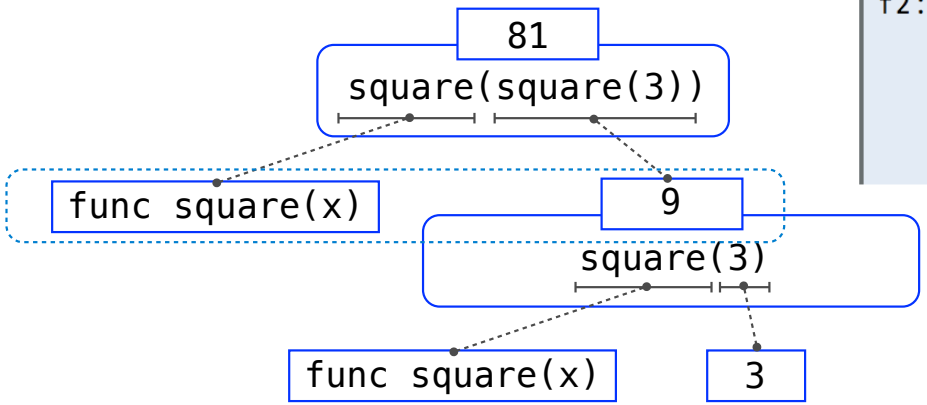

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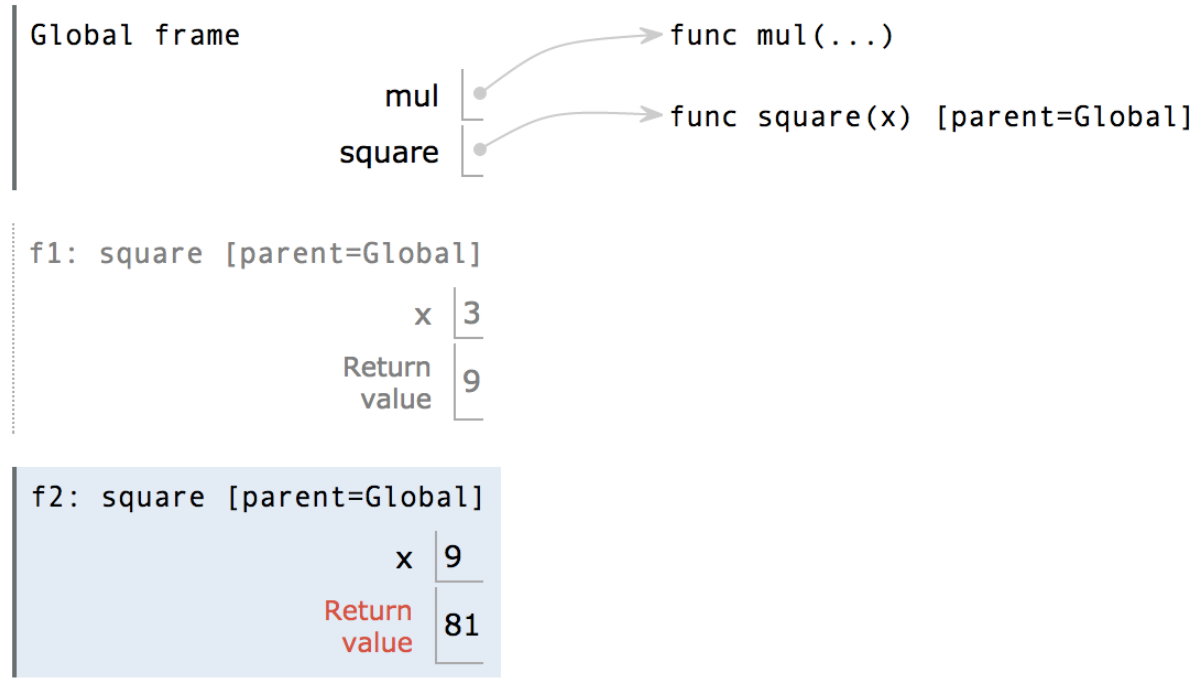

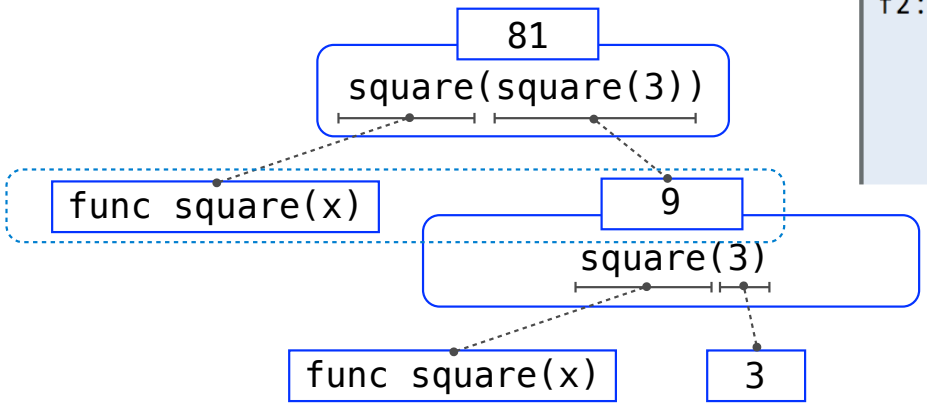

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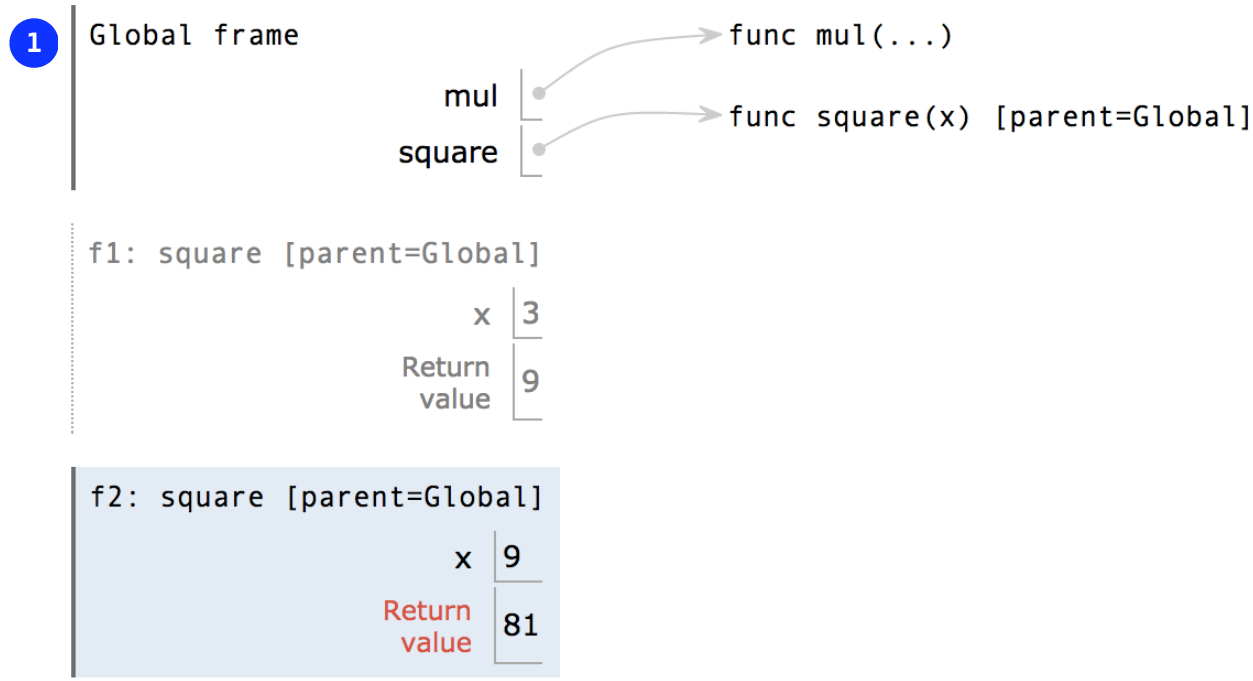

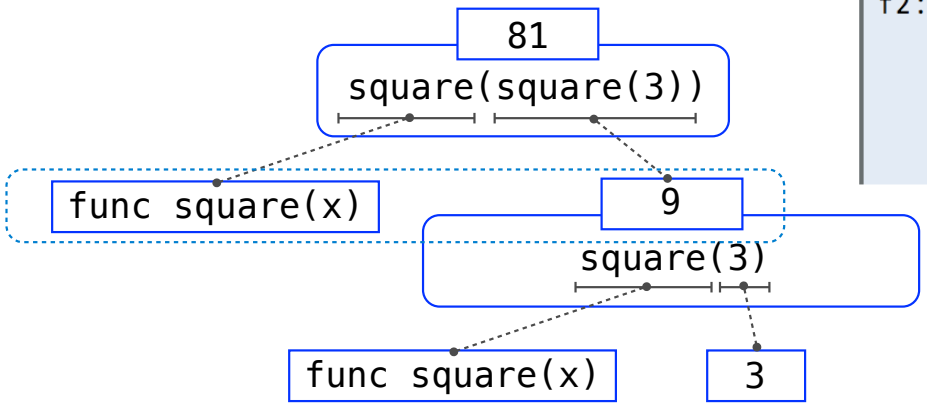

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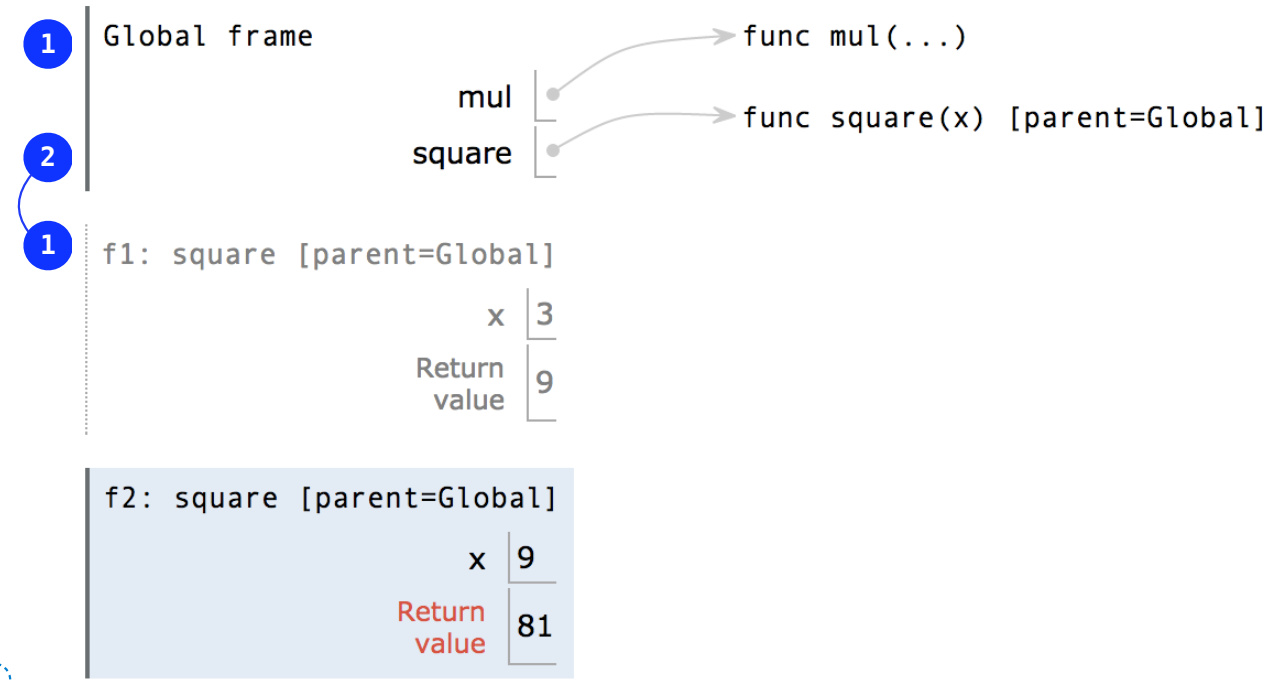

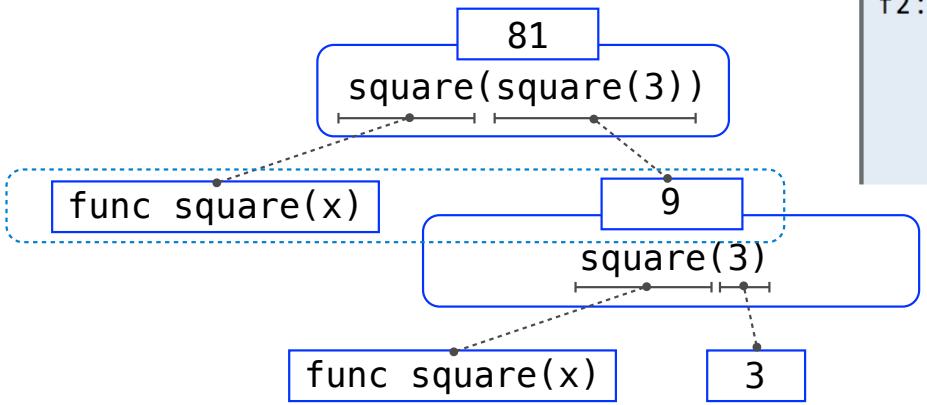

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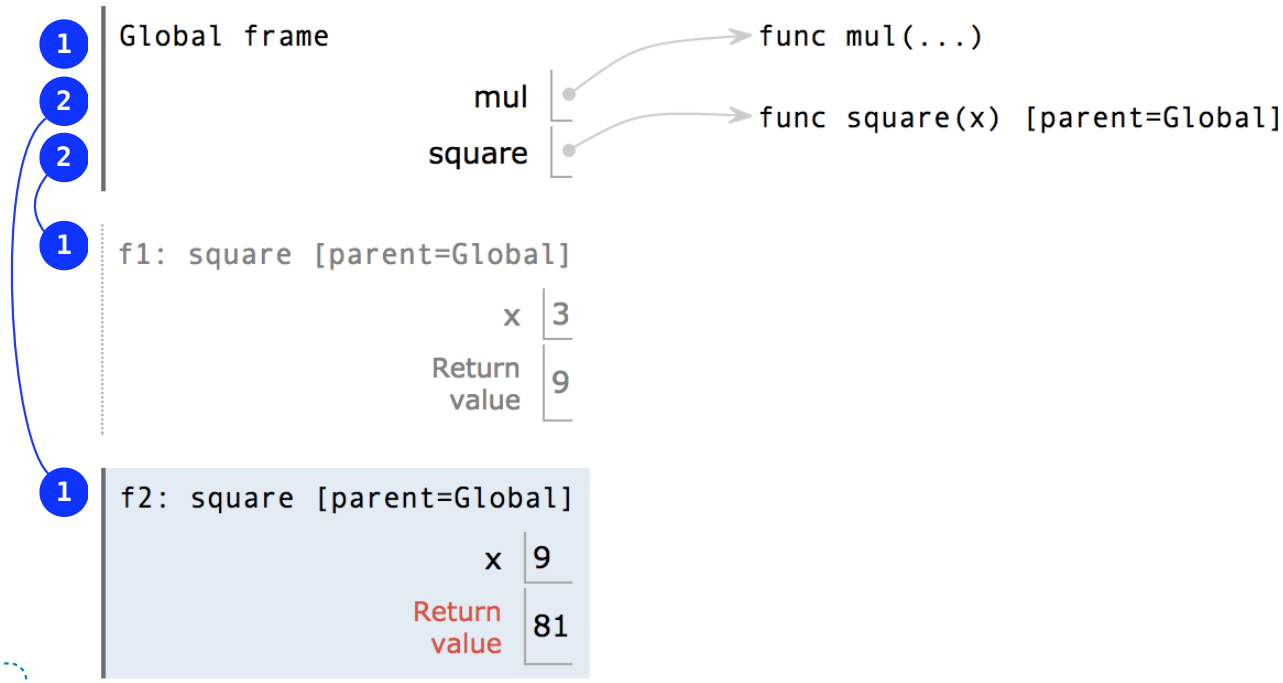

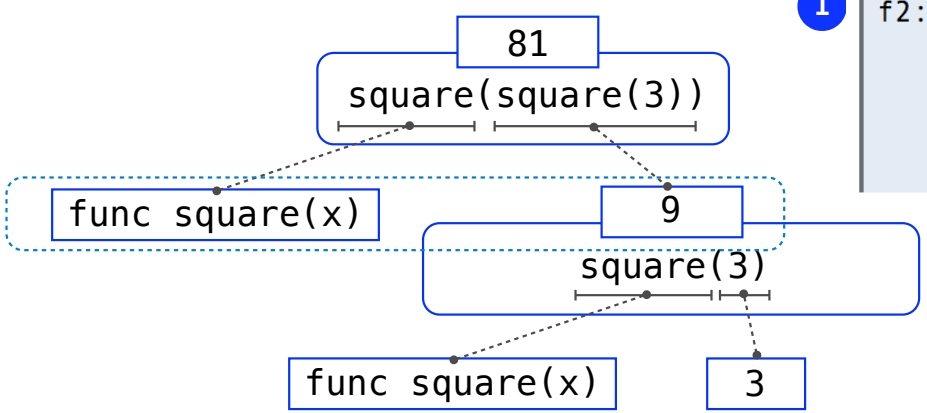

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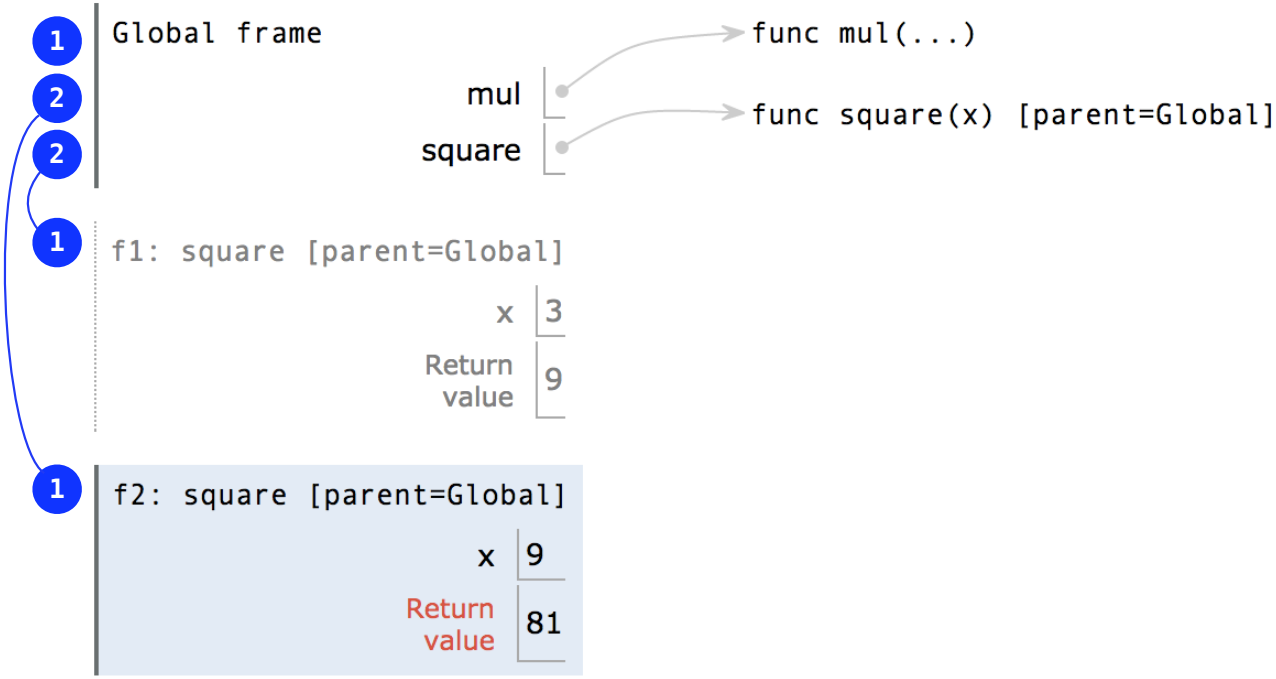

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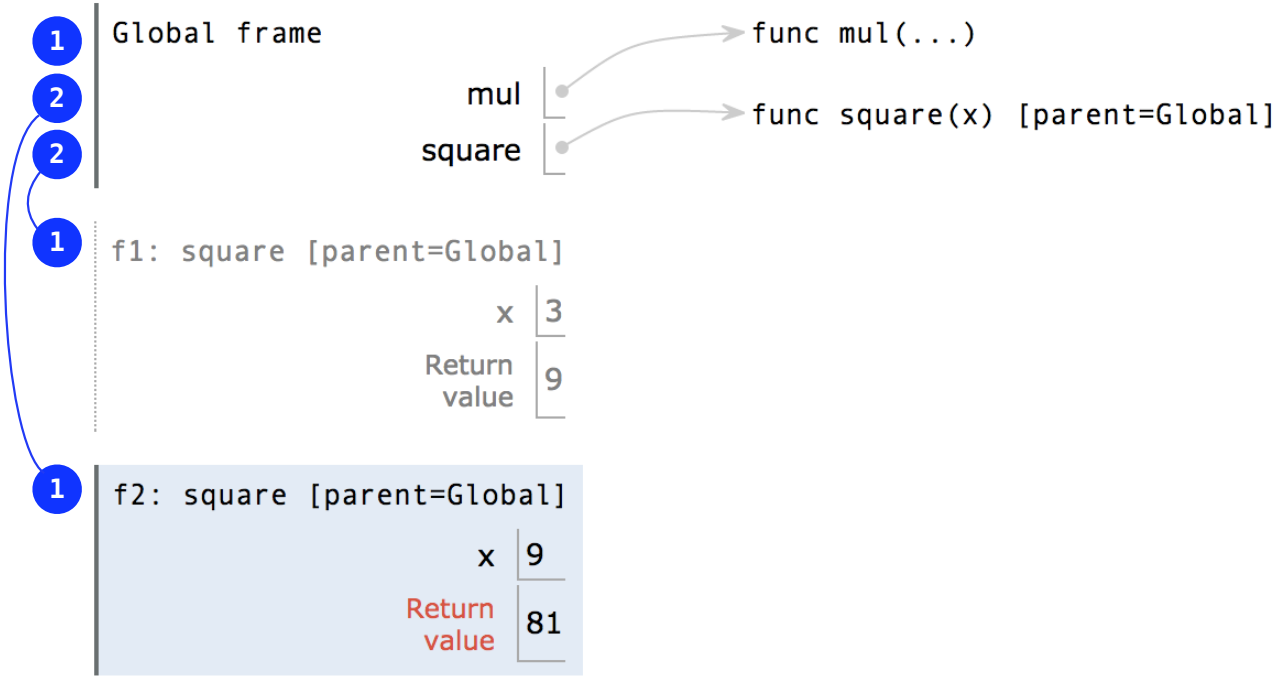

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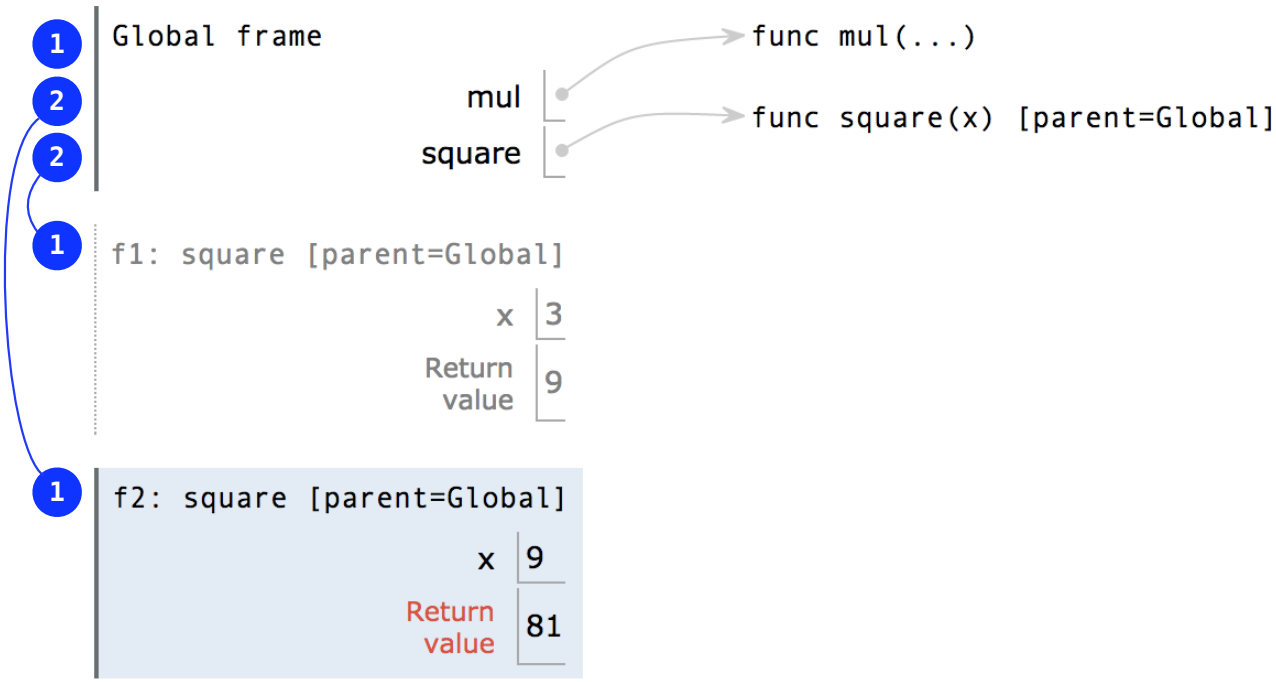

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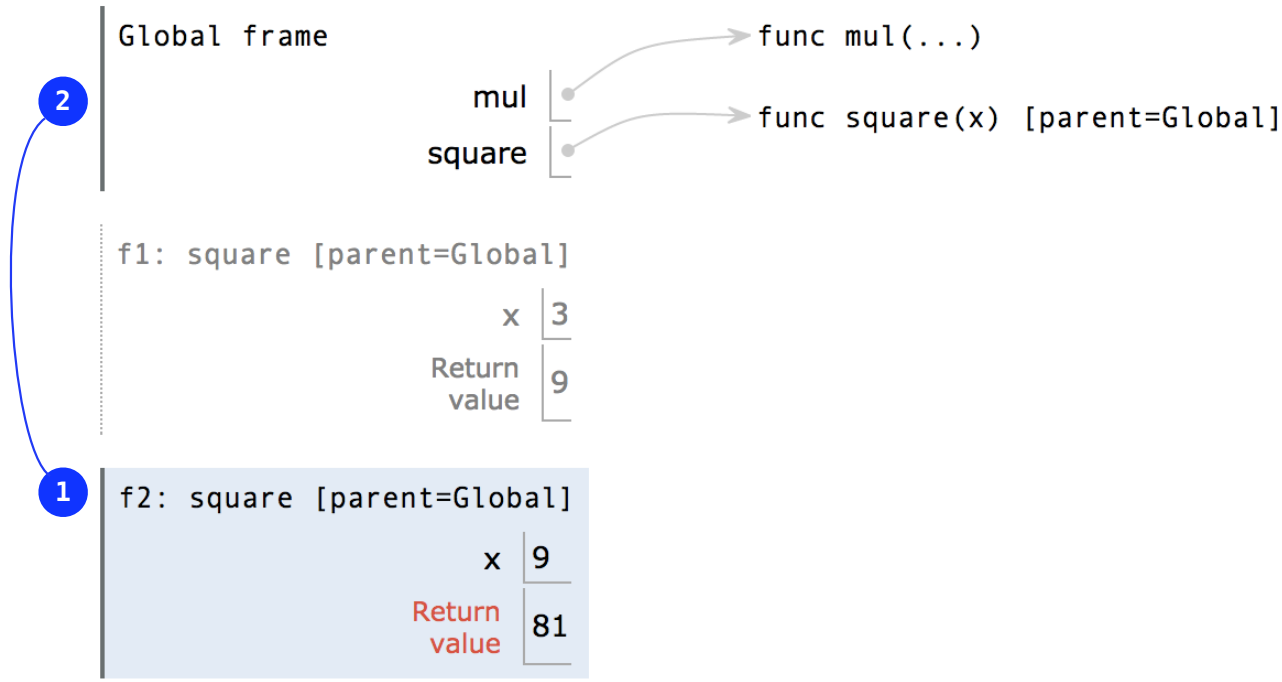

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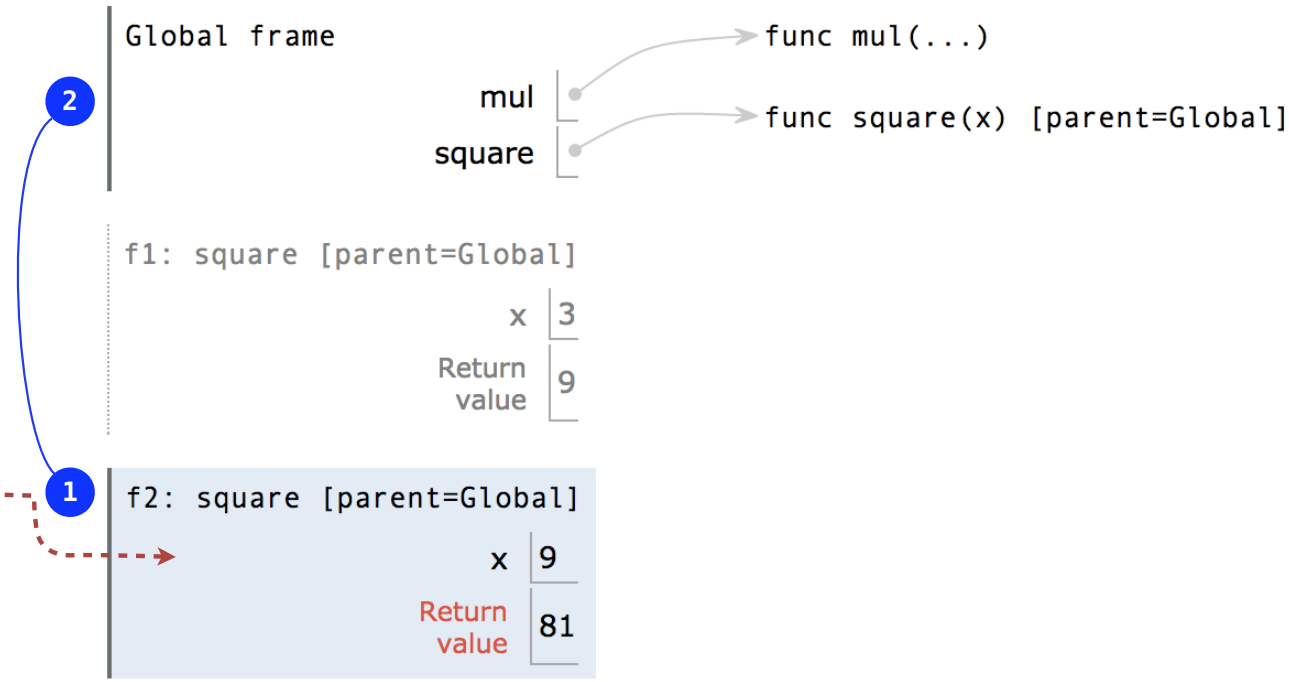

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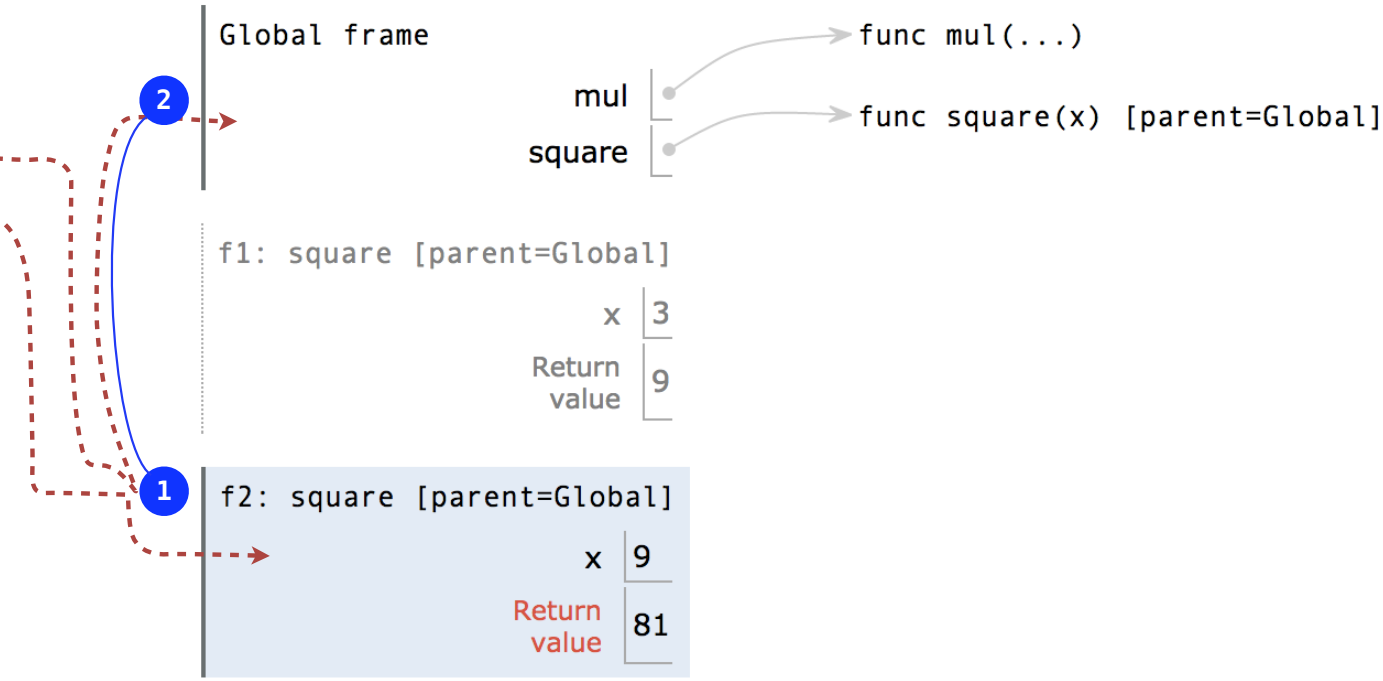

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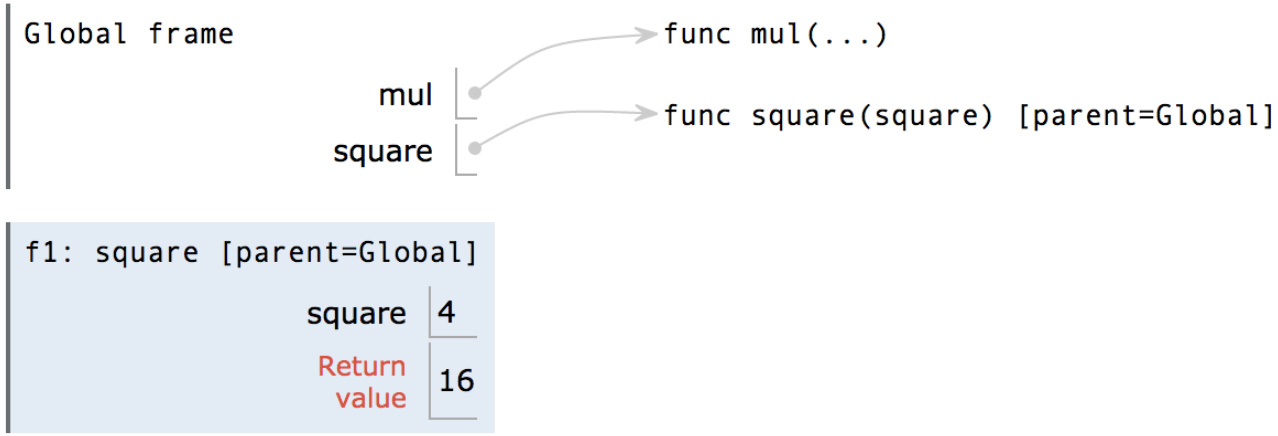

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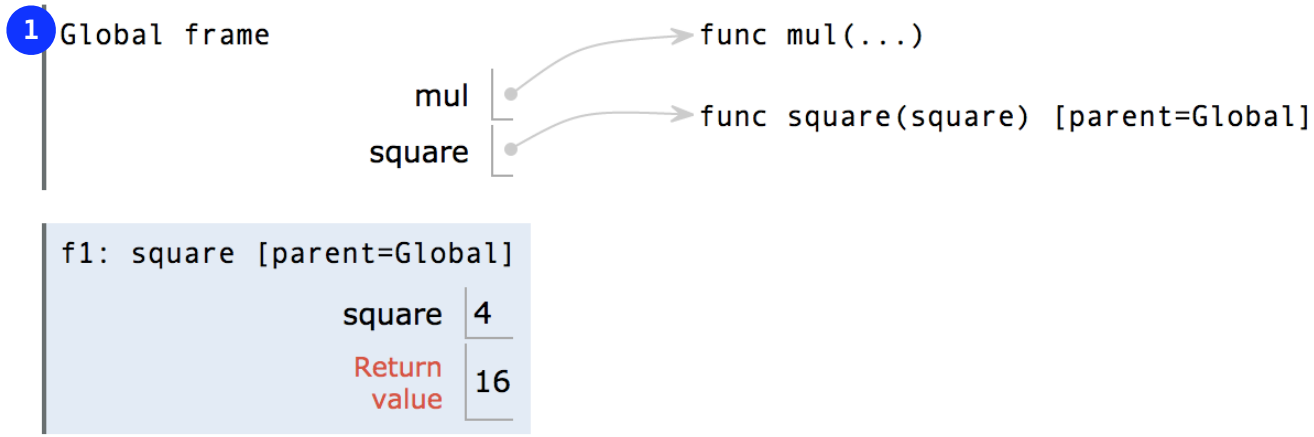

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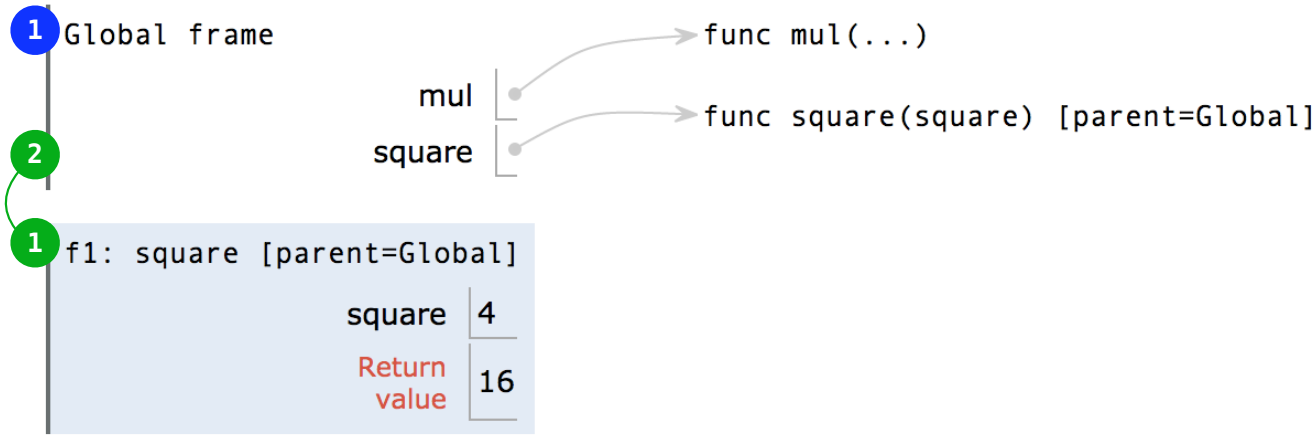

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Miscellaneous Python Features

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:

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Statements

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

Compound statements:

Statement

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Statements

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

Compound statements:

Statement

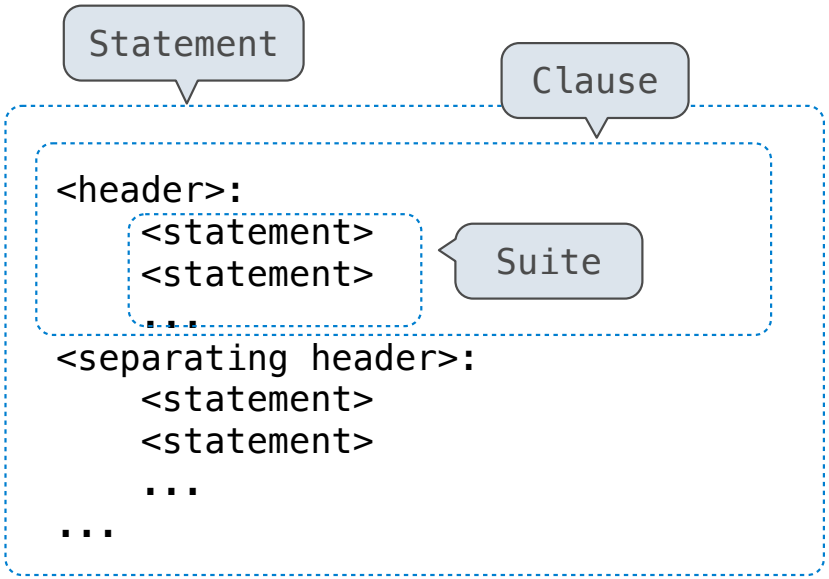
Clause

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Statements

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

Compound statements:



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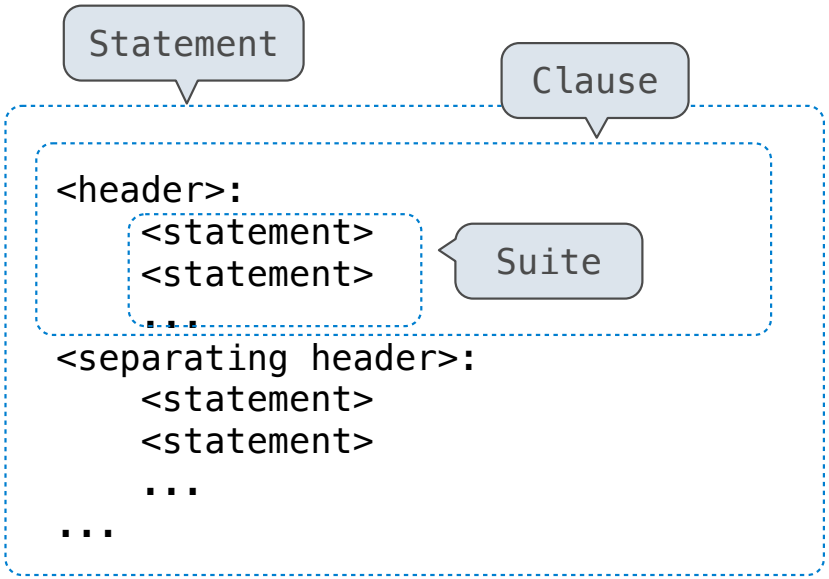

The first header determines a statement's type

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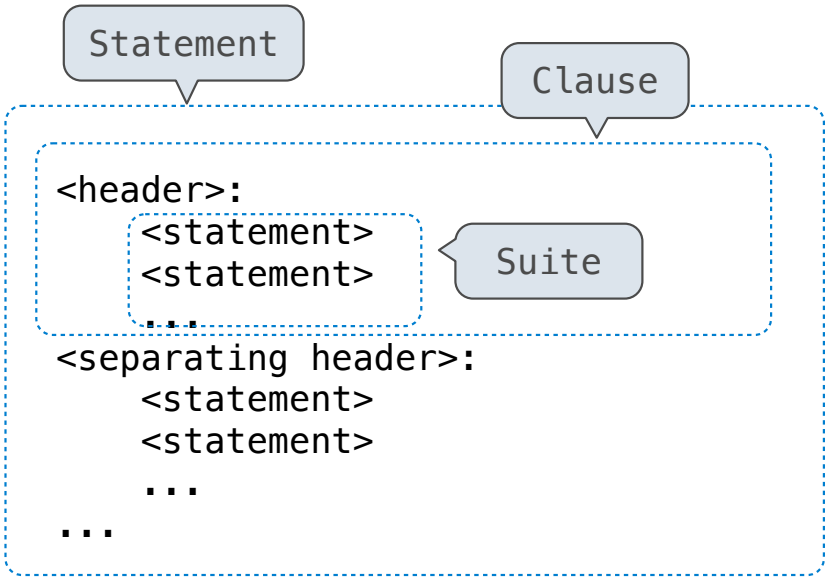

The first header determines a statement's type

The header of a clause "controls" the suite that follows

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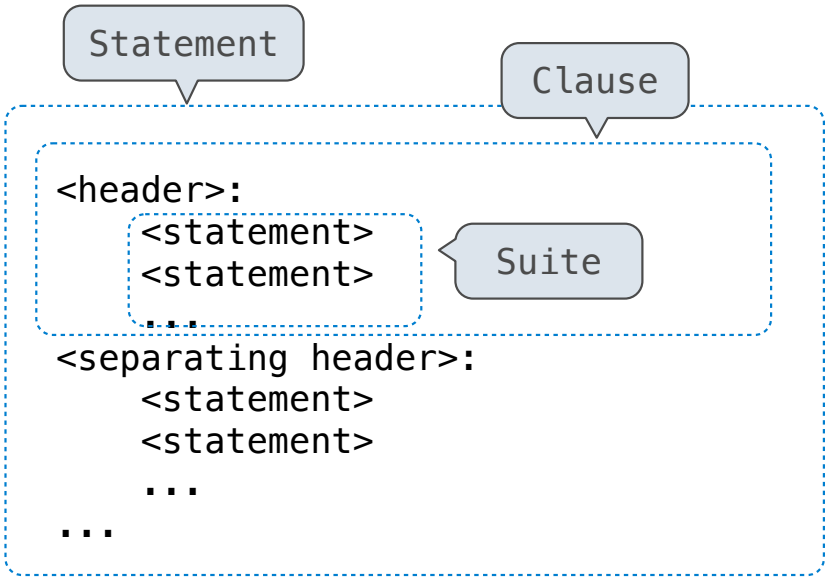
Compound statements:



The first header determines a statement's type

The header of a clause "controls" the suite that follows

def statements are compound statements

Compound Statements

Compound statements:

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Suite

Compound Statements

Compound statements:

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Suite

A suite is a sequence of statements

Compound Statements

Compound statements:

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Suite

A suite is a sequence of statements

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

Compound Statements

Compound statements:

```
<header>:
    <statement>
    <statement>
    ...
<separating header>:
    <statement>
    <statement>
    ...
...
```

Suite

A suite is a sequence of statements

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

Conditional Statements

```
def absolute_value(x):
    """Return the absolute value of x."""
    if x < 0:
        return -x
    elif x == 0:
        return 0
    else:
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1 statement,
3 clauses,
3 headers,
3 suites

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Execution Rule for Conditional Statements:

Conditional Statements

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1 statement,
3 clauses,
3 headers,
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Execution Rule for Conditional Statements:

Each clause is considered in order.

1. Evaluate the header's expression.

2. If it is a true value,
   execute the suite & skip the remaining clauses.

Conditional Statements

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Syntax Tips:

Conditional Statements

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1 statement,
3 clauses,
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Execution Rule for Conditional Statements:

Each clause is considered in order.

1. Evaluate the header's expression.
2. If it is a true value,
   execute the suite & skip the remaining clauses.

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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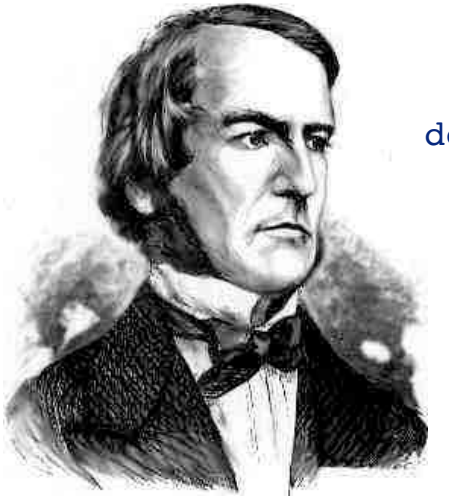
Boolean Contexts



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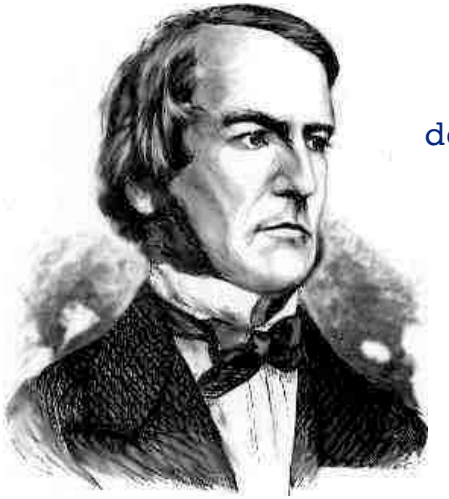

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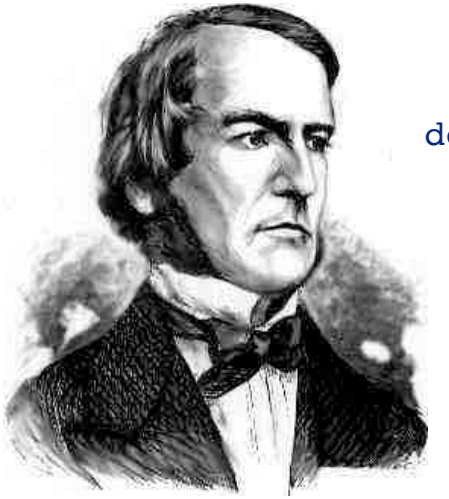

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False values in Python: False, 0, '', None

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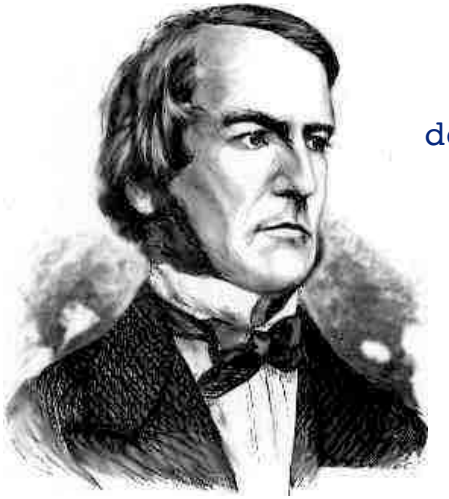

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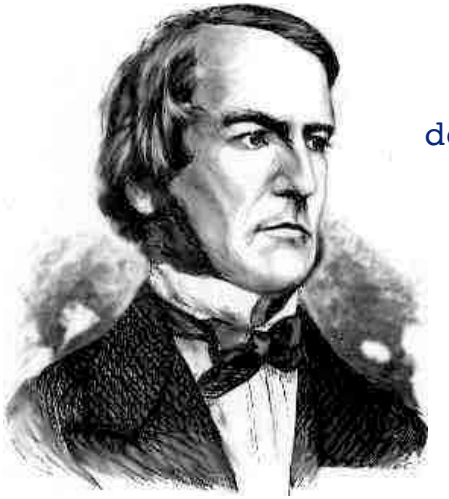

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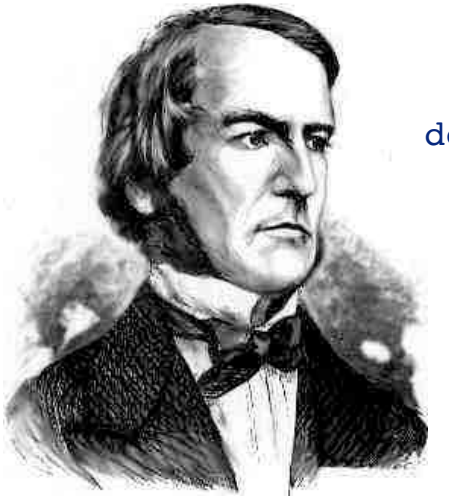

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Read Section 1.5.4!

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

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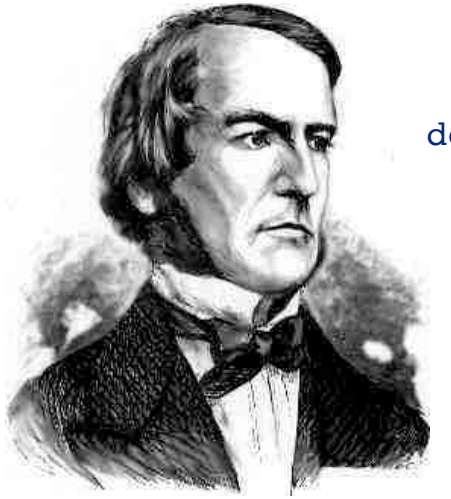

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(Demo)

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

Iteration

While Statements

(Demo)

While Statements

(Demo)

```
i, total = 0, 0
while i < 3:
    i = i + 1
    total = total + i
```

While Statements

(Demo)

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Execution Rule for While Statements:

1. Evaluate the header's expression.

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While Statements

George Boole

(Demo)

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While Statements

George Boole

(Demo)

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2  while i < 3:
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```

Global frame	
i	0
total	0

Execution Rule for While Statements:

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(Demo)

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Global frame

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total	0

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(Demo)

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While Statements

George Boole

(Demo)

```
1  i, total = 0, 0
2  while i < 3:
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4      total = total + i
```

Global frame

i	~~0~~ ~~1~~ 2
total	~~0~~ 1

Execution Rule for While Statements:

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While Statements

George Boole

(Demo)

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Global frame

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(Demo)

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Global frame	
i	~~0~~ ~~1~~ 2
total	~~0~~ ~~1~~ 3

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(Demo)

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```

Global frame				
i	~~0~~	~~1~~	~~2~~	3
total	~~0~~	~~1~~	~~3~~	6

Execution Rule for While Statements:

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While Statements

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(Demo)

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Global frame	
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Execution Rule for While Statements:

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(Demo)

Example: Prime Factorization

Prime Factorization

Prime Factorization

```
Each positive integer n has a set of prime factors: primes whose product is n
```

Prime Factorization

Each positive integer n has a set of prime factors: primes whose product is n

```
...
8  = 2 * 2 * 2
9  = 3 * 3
10 = 2 * 5
11 = 11
12 = 2 * 2 * 3
...
```

Prime Factorization

Each positive integer n has a set of prime factors: primes whose product is n

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One approach: Find the smallest prime factor of n, then divide by it

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858

Prime Factorization

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One approach: Find the smallest prime factor of n, then divide by it

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858  = 2 * 429
```

Prime Factorization

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One approach: Find the smallest prime factor of n, then divide by it

```
858  = 2 * 429  = 2 * 3 * 143
```

Prime Factorization

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(Demo)