

Lecture 4

Defining Functions

Academic Integrity Quiz

- **Remember:** quiz about the course AI policy
 - Have posted grades for completed quizzes
 - Right now, missing ~90 enrolled students
 - If did not receive perfect, take it again
- If you are not aware of the quiz
 - Go to <http://www.cs.cornell.edu/courses/cs11110/>
 - Click **Academic Integrity** in side bar
 - Read and take quiz in CMS

Recall: Modules

- Modules provide extra functions, variables
 - **Example:** math provides `math.cos()`, `math.pi`
 - Access them with the `import` command
- Python provides a lot of them for us
- **This Lecture:** How to make modules
 - Komodo Edit to *make* a module
 - Python to *use* the module



Two different
programs

We Write Programs to Do Things

- Functions are the **key doers**

Function Call

- Command to **do** the function

```
>>> plus(23)
```

```
24
```

```
>>>
```

Function Definition

- Defines what function **does**

```
def plus(n):
```

```
    return n+1
```

- **Parameter**: variable that is listed within the parentheses of a method header.
- **Argument**: a value to assign to the method parameter when it is called

We Write Programs to Do Things

- Functions are the **key doers**

Function Call

- Command to **do** the function

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24
```

```
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Function
Header

Function Definition

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Function Call

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```
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```

Function
Header

Function Definition

- Defines what function **does**

```
def plus(n):
```

```
    return n+1
```

Function
Body
(indented)

- **Parameter:** variable that is listed within the parentheses of a method header.
- **Argument:** a value to assign to the method parameter when it is called

We Write Programs to Do Things

- Functions are the **key doers**

Function Call

- Command to **do** the function

```
>>> plus(23)
```

```
24
```

argument to
assign to n

Function Definition

- Defines what function **does**

Function
Header

```
def plus(n):
```

```
    return n+1
```

declaration of
parameter n

Function
Body
(indented)

- **Parameter**: variable that is listed within the parentheses of a method header.
- **Argument**: a value to assign to the method parameter when it is called

Anatomy of a Function Definition

name

parameters

```
def plus(n):
```

Function Header

```
    """Returns the number n+1
```

Docstring
Specification

```
    Parameter n: number to add to  
    Precondition: n is a number"""
```

```
    x = n+1
```

```
    return x
```

Statements to
execute when called

Anatomy of a Function Definition

name

parameters

```
def plus(n):
```

Function Header

```
    """Returns the number n+1
```

Docstring
Specification

```
    Parameter n: number to add to  
    Precondition: n is a number"""
```

```
    x = n+1
```

Statements to
execute when called

```
    return x
```

The vertical line
indicates indentation

Use vertical lines when you write Python
on **exams** so we can see indentation

The **return** Statement

- **Format:** `return <expression>`
 - Used to evaluate *function call* (as an expression)
 - Also stops executing the function!
 - Any statements after a **return** are ignored
- **Example:** temperature converter function

```
def to_centigrade(x):
```

```
    """Returns: x converted to centigrade"""
```

```
    return 5*(x-32)/9.0
```

A More Complex Example

Function Definition

```
def foo(a,b):  
    """Return something  
       Param a: number  
       Param b: number"""  
  
    x = a  
    y = b  
    return x*y+y
```

Function Call

```
>>> x = 2
```

```
>>> foo(3,4)
```

x

?

What is in the box?

A More Complex Example

Function Definition

```
def foo(a,b):  
    """Return something  
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    x = a  
    y = b  
    return x*y+y
```

Function Call

```
>>> x = 2
```

```
>>> foo(3,4)
```

x

?

What is in the box?

A: 2

B: 3

C: 16

D: Nothing!

E: I do not know

A More Complex Example

Function Definition

```
def foo(a,b):  
    """Return something  
    Param a: number  
    Param b: number"""  
  
    x = a  
    y = b  
    return x*y+y
```

Function Call

```
>>> x = 2
```

```
>>> foo(3,4)
```

x

?

What is in the box?

A: 2 **CORRECT**

B: 3

C: 16

D: Nothing!

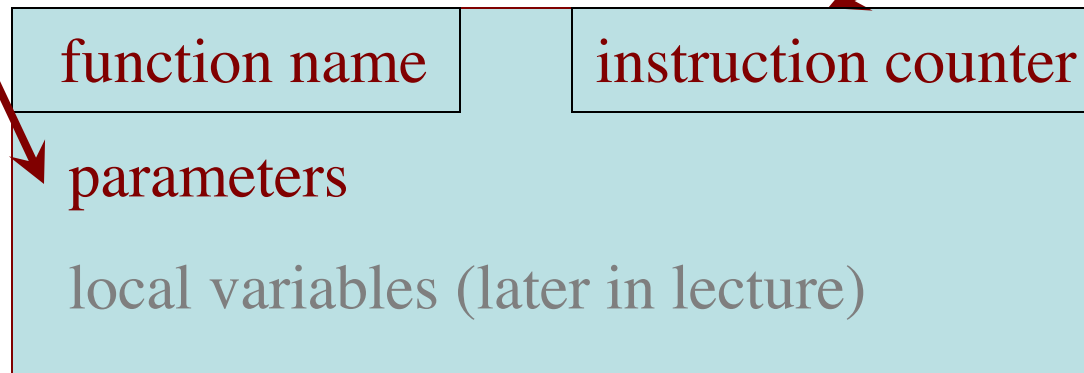
E: I do not know

Understanding How Functions Work

- **Function Frame**: Representation of function call
- A **conceptual model** of Python

Draw parameters
as variables
(named boxes)

- Number of statement in the
function body to execute next
- **Starts with 1**



Text (Section 3.10) vs. Class

Textbook

to_centrigrade

$x \rightarrow 50.0$

This Class

to_centrigrade

1

x 50.0

Definition:

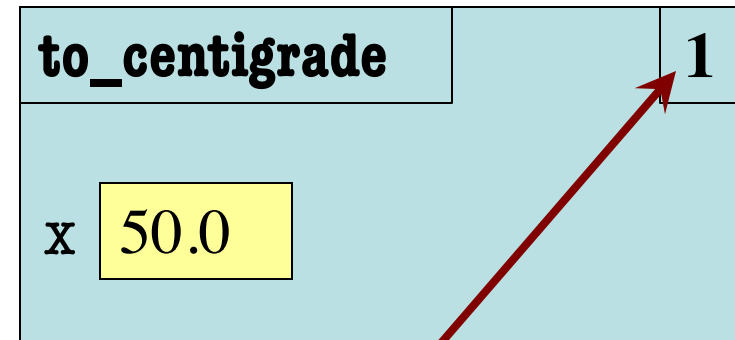
```
def to_centrigrade(x):  
    | return 5*(x-32)/9.0
```

Call: to_centrigrade(50.0)

Example: to_centigrade(50.0)

1. Draw a frame for the call
2. Assign the argument value to the parameter (in frame)
3. Execute the function body
 - Look for variables in the frame
 - If not there, look for global variables with that name
4. Erase the frame for the call

Initial call frame
(before exec body)



next line to execute

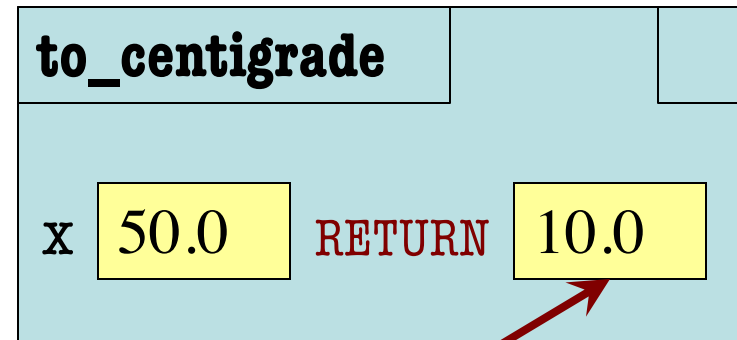
```
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1 | return 5*(x-32)/9.0
```


Example: to_centigrade(50.0)

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```
def to_centigrade(x):  
1 |   return 5*(x-32)/9.0
```

Executing the
return statement



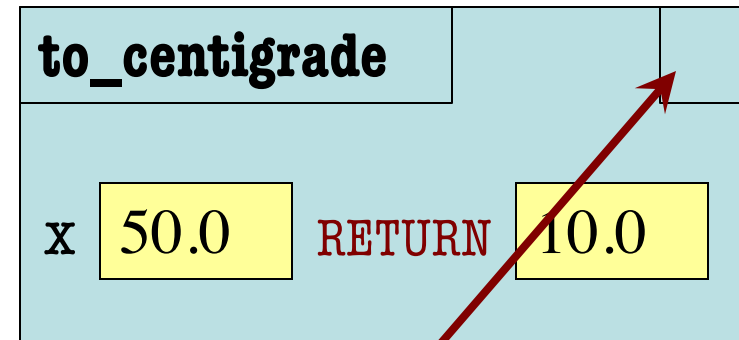
Return statement creates a
special variable for result

Example: to_centigrade(50.0)

1. Draw a frame for the call
2. Assign the argument value to the parameter (in frame)
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4. Erase the frame for the call

```
def to_centigrade(x):  
1 |   return 5*(x-32)/9.0
```

Executing the
return statement



The return terminates;
no next line to execute

Example: to_centigrade(50.0)

1. Draw a frame for the call
2. Assign the argument value to the parameter (in frame)
3. Execute the function body
 - Look for variables in the frame
 - If not there, look for global variables with that name
4. Erase the frame for the call

ERASE WHOLE FRAME

```
1  def to_centigrade(x):  
    |   return 5*(x-32)/9.0
```

But don't actually
erase on an exam

Call Frames vs. Global Variables

The specification is a **lie**:

```
def swap(a,b):  
    """Swap global a & b"""  
1    tmp = a  
2    a = b  
3    b = tmp
```

```
>>> a = 1
```

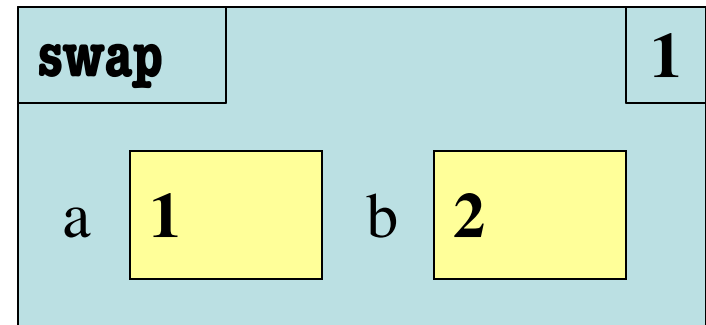
```
>>> b = 2
```

```
>>> swap(a,b)
```

Global Variables

a **1** b **2**

Call Frame



Call Frames vs. Global Variables

The specification is a **lie**:

```
def swap(a,b):  
    """Swap global a & b"""  
1   tmp = a  
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```

```
>>> a = 1
```

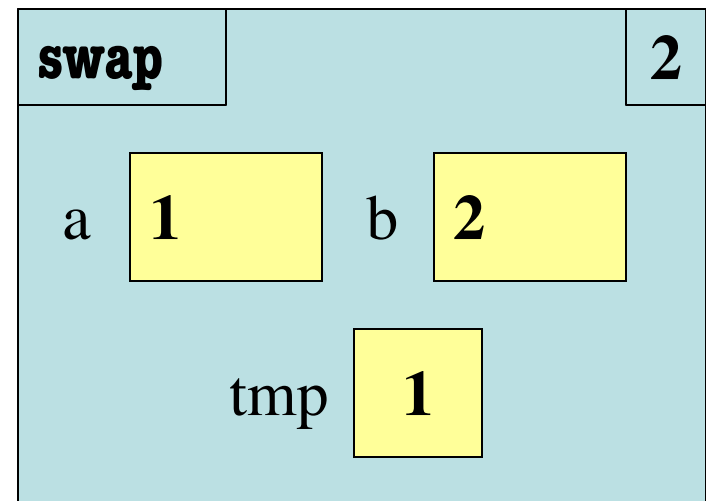
```
>>> b = 2
```

```
>>> swap(a,b)
```

Global Variables

a **1** b **2**

Call Frame



Call Frames vs. Global Variables

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def swap(a,b):  
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    2    a = b  
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```

```
>>> a = 1
```

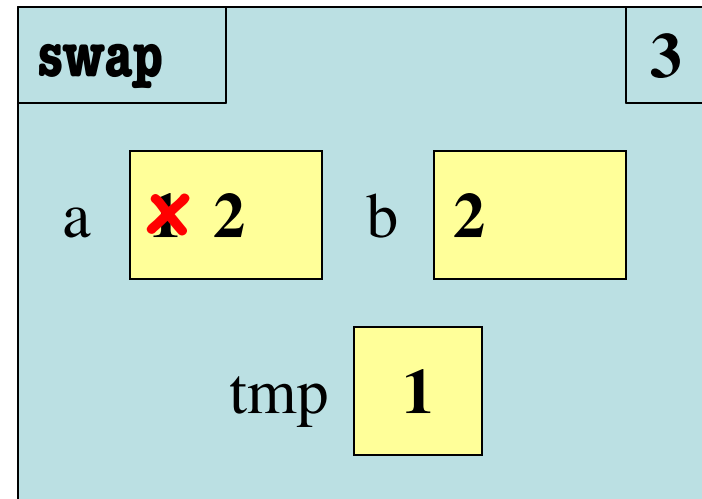
```
>>> b = 2
```

```
>>> swap(a,b)
```

Global Variables

a **1** b **2**

Call Frame



Call Frames vs. Global Variables

The specification is a **lie**:

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```
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```

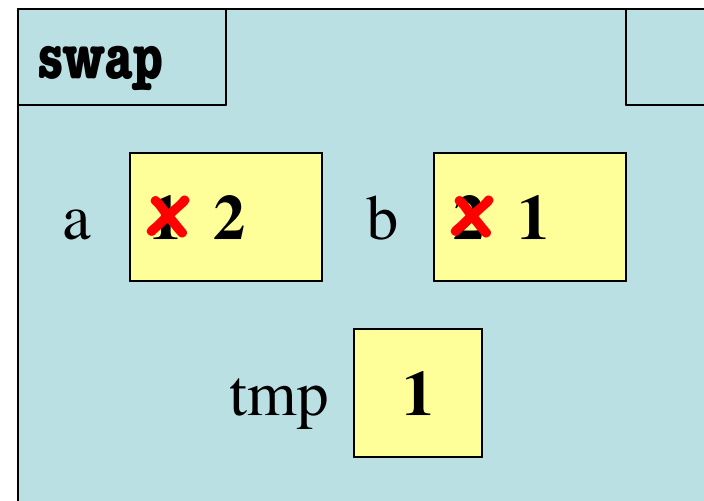
```
>>> b = 2
```

```
>>> swap(a,b)
```

Global Variables

a **1** b **2**

Call Frame



Call Frames vs. Global Variables

The specification is a **lie**:

```
def swap(a,b):  
    """Swap global a & b"""  
1    tmp = a  
2    a = b  
3    b = tmp
```

```
>>> a = 1
```

```
>>> b = 2
```

```
>>> swap(a,b)
```

Global Variables

a	1	b	2
---	---	---	---

Call Frame

ERASE THE FRAME

Function Access to Global Space

- All function definitions are in some module
- Call can access global space for **that module**
 - `math.cos`: global for `math`
 - `temperature.to_centigrade` uses global for `temperature`
- But **cannot** change values
 - Assignment to a global makes a new local variable!
 - Why we limit to constants

Global Space
(for `globals.py`) `a` 4

get_a		1

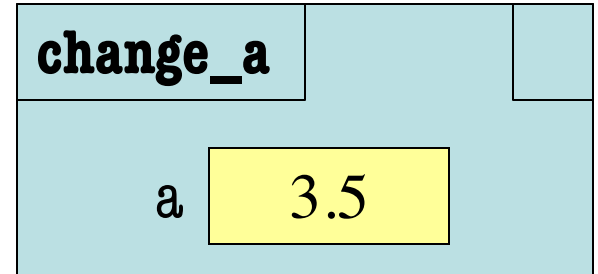
```
# globals.py
"""Show how globals work"""
a = 4 # global space

def get_a():
    |     return a # returns global
```

Function Access to Global Space

- All function definitions are in some module
- Call can access global space for **that module**
 - `math.cos`: global for `math`
 - `temperature.to_centigrade` uses global for `temperature`
- But **cannot** change values
 - Assignment to a global makes a new local variable!
 - Why we limit to constants

Global Space
(for `globals.py`) `a` 4



```
# globals.py
"""Show how globals work"""
a = 4 # global space
def change_a():
    a = 3.5 # local variable
    return a
```

Exercise Time

Function Definition

```
def foo(a,b):  
    """Return something  
    Param x: a number  
    Param y: a number"""  
1   x = a  
2   y = b  
3   return x*y+y
```

Function Call

```
>>> x = foo(3,4)
```

What does the
frame look like
at the **start**?

Which One is Closest to Your Answer?

A:

foo		0
a	3	b 4

B:

foo		1
a	3	b 4

C:

foo		1
a	3	b 4
x	3	

D:

foo		1
a	3	b 4
x		y

Which One is Closest to Your Answer?

A:

foo	0
a 3	b 4

B:

foo	1
a 3	b 4

E:

~_(\ツ)_/

C:

foo	
a 3	
x 3	

	1
b 4	
x	y

Exercise Time

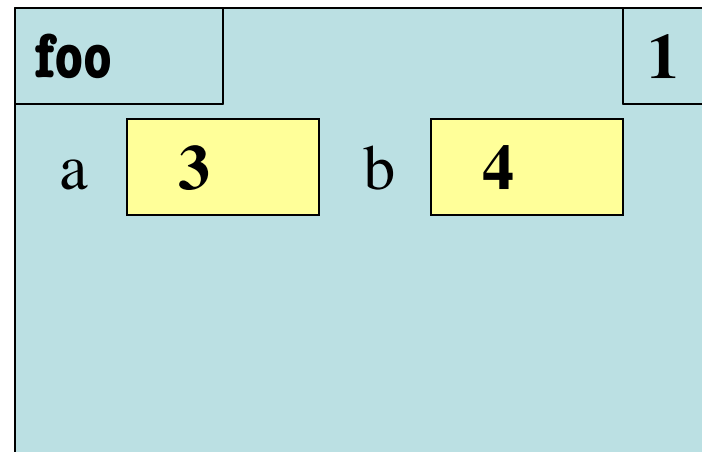
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```

Function Call

```
>>> x = foo(3,4)
```

B:



Exercise Time

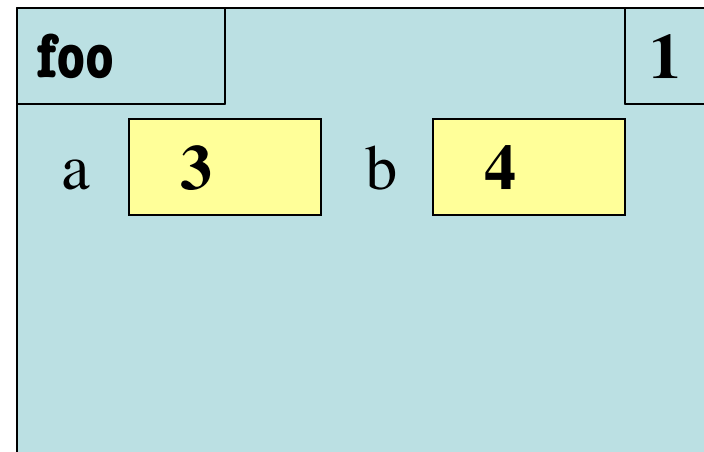
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```

Function Call

```
>>> x = foo(3,4)
```

B:



What is the **next step**?

Which One is Closest to Your Answer?

A:

foo		2
a	3	b 4

B:

foo		1
a	3	b 4
x	3	

C:

foo		2
a	3	b 4
x	3	

D:

foo		2
a	3	b 4
x	3	y

Exercise Time

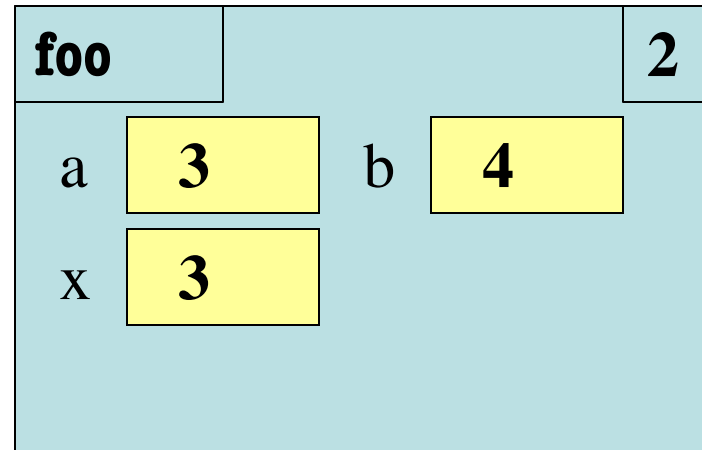
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3   return x*y+y
```

Function Call

```
>>> x = foo(3,4)
```

C:



Exercise Time

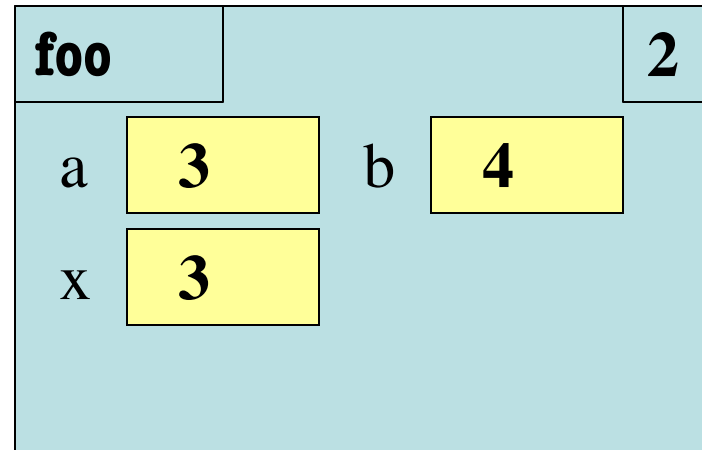
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Function Call

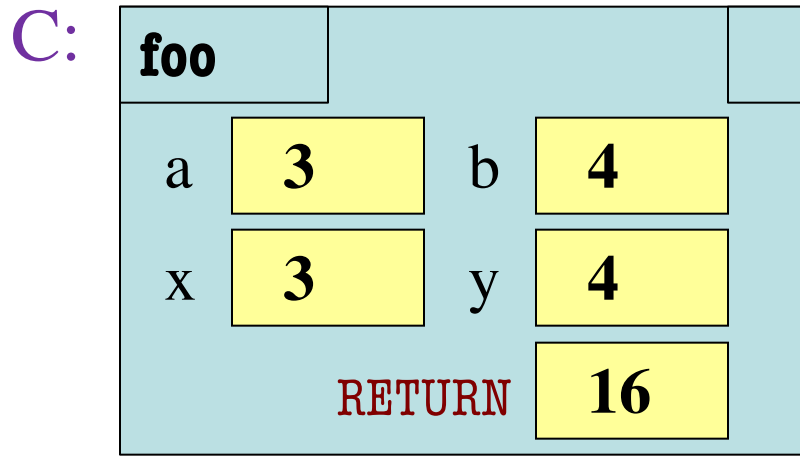
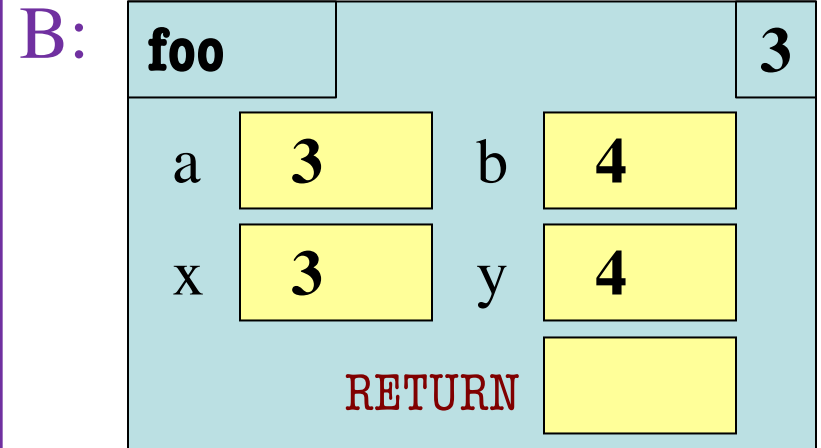
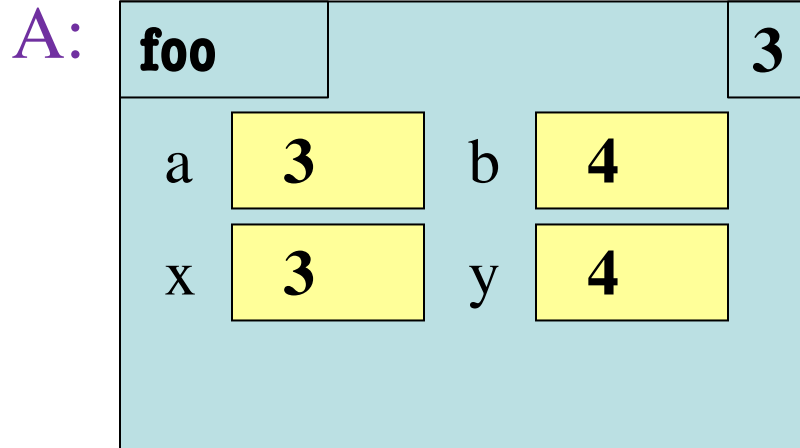
```
>>> x = foo(3,4)
```

C:



What is the **next step**?

Which One is Closest to Your Answer?



D:

ERASE THE FRAME

Exercise Time

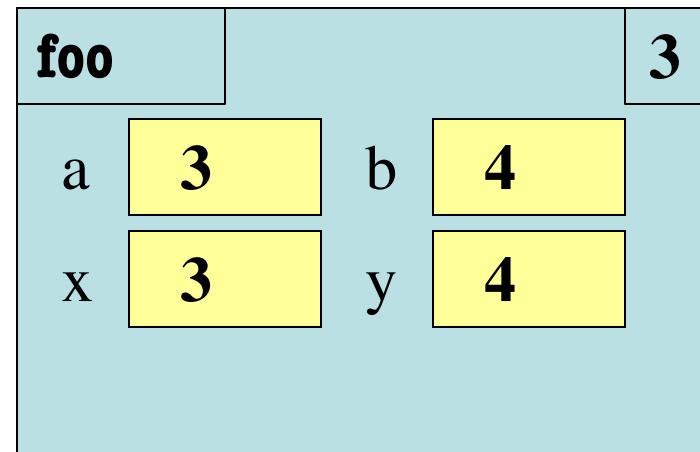
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```

Function Call

```
>>> x = foo(3,4)
```

A:



Exercise Time

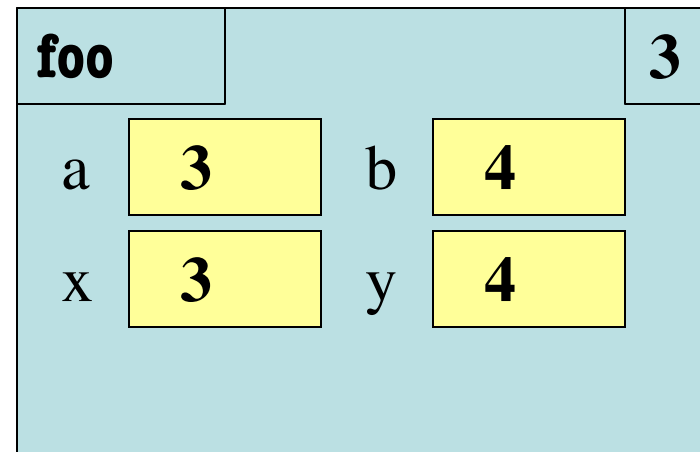
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Function Call

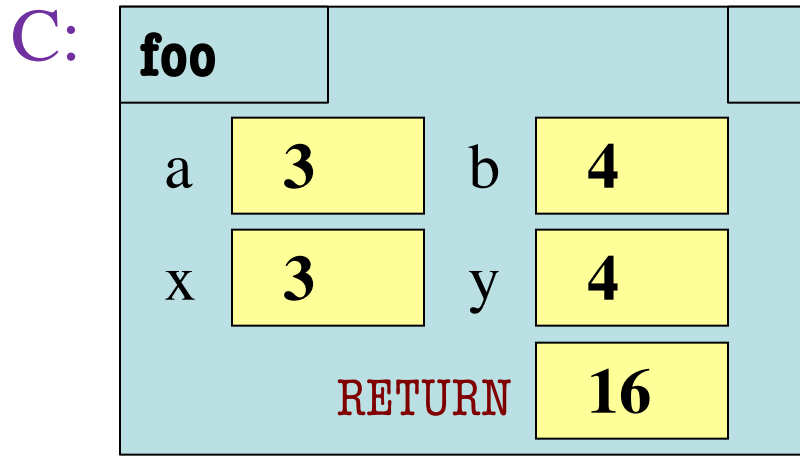
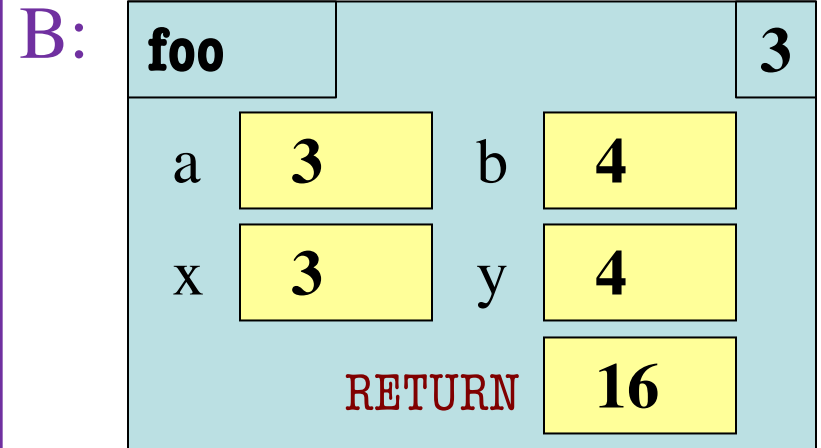
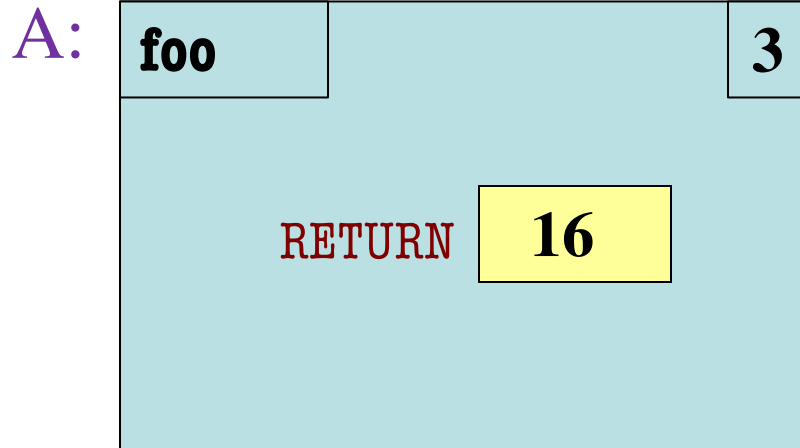
```
>>> x = foo(3,4)
```

A:



What is the **next step**?

Which One is Closest to Your Answer?



D:

ERASE THE FRAME

Exercise Time

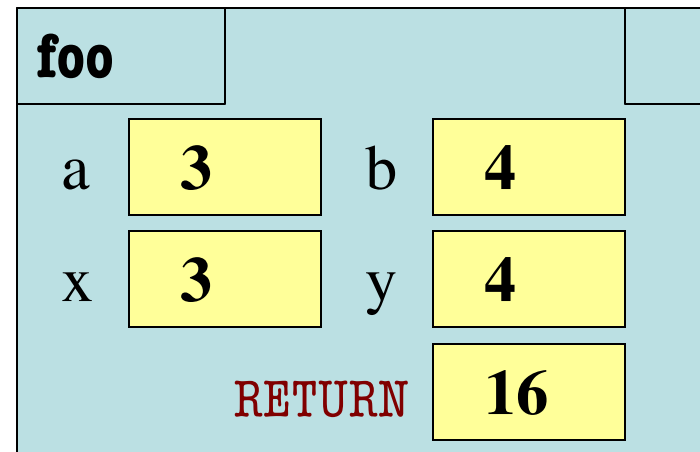
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```

Function Call

```
>>> x = foo(3,4)
```

C:



Exercise Time

Function Definition

```
def foo(a,b):
```

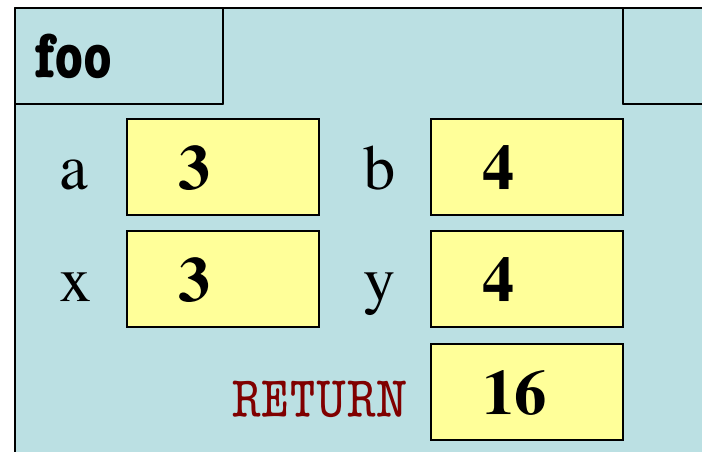
```
    """Return something  
    Param x: a number  
    Param y: a number"""
```

```
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2  y = b  
3  return x*y+y
```

Function Call

```
>>> x = foo(3,4)
```

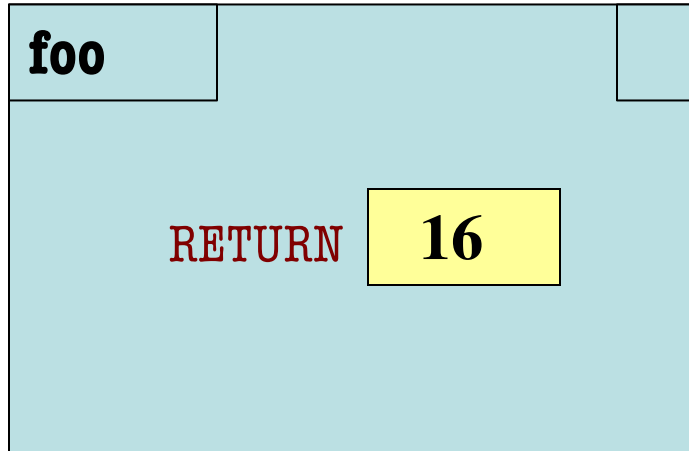
C:



What is the **next step**?

Which One is Closest to Your Answer?

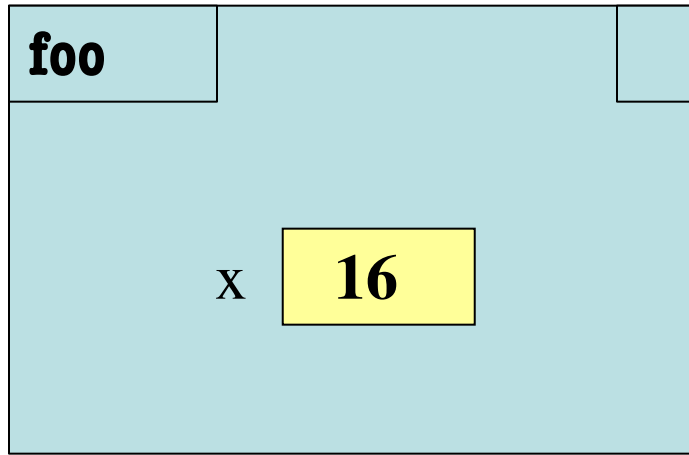
A:



B:

ERASE THE FRAME

C:



D:

x 16

ERASE THE FRAME

Exercise Time

Function Definition

```
def foo(a,b):  
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    Param y: a number"""  
1   x = a  
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3   return x*y+y
```

Function Call

```
>>> x = foo(3,4)
```

D:

x

16

ERASE THE FRAME

Exercise Time

Function Definition

```
def foo(a,b):  
    """Return something  
    Param x: a number  
    Param y: a number"""  
1   x = a  
2   y = b  
3   return x*y+y
```

Function Call

```
>>> x = foo(3,4)
```

D:

Variable in
global space

x

16

ERASE THE FRAME

Visualizing Frames: The Python Tutor

```
→ 1 def max(x,y):  
  2     if x > y:  
  3         return x  
  4     return y  
  5  
  6 a = 1  
  7 b = 2  
→ 8 max(a,b)
```

[Edit code](#)

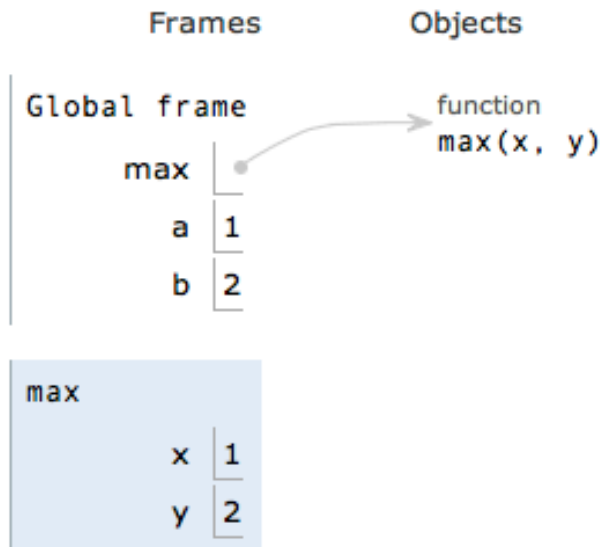
<< First

< Back

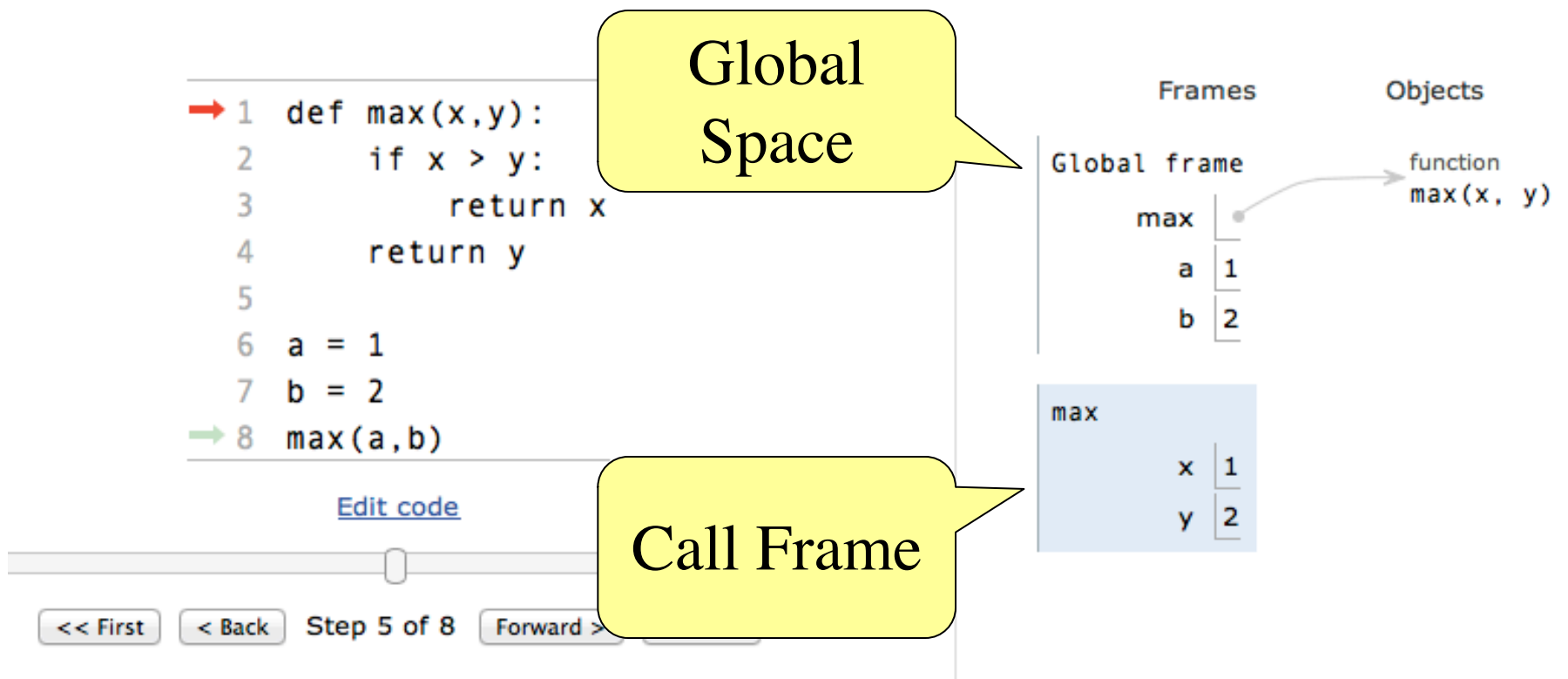
Step 5 of 8

Forward >

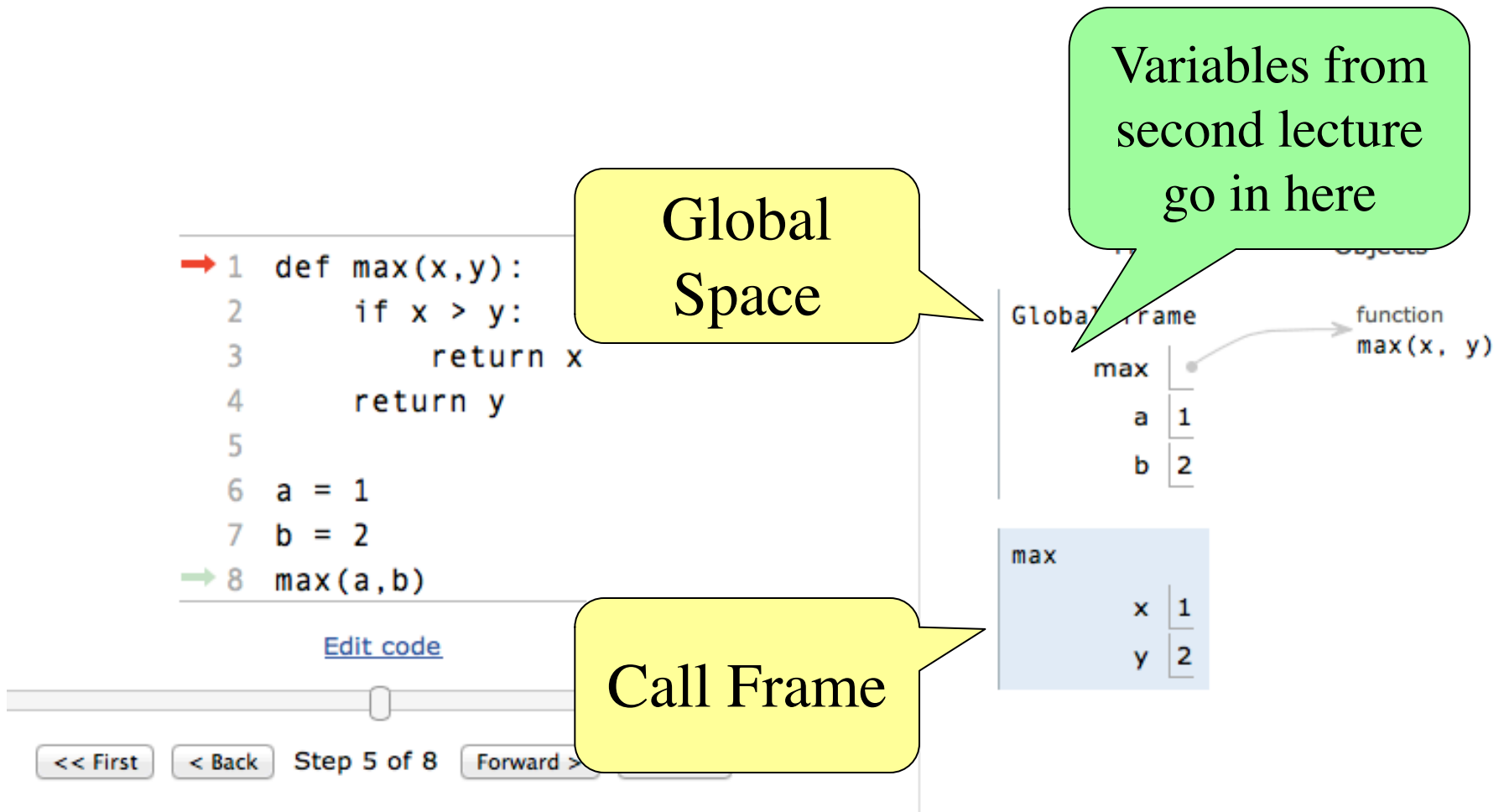
Last >>



Visualizing Frames: The Python Tutor



Visualizing Frames: The Python Tutor



Visualizing Frames: The Python Tutor

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→ 1 def max(x,y):  
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→ 8 max(a,b)
```

[Edit code](#)

<< First

< Back

Step 5 of 8

Forward >

Last >>

Frames

Objects

Global frame

max

a

b

max

x

1

y

2

Missing line numbers!

Visualizing Frames: The Python Tutor

Line number
marked here
(sort-of)

```
→ 1 def max(x,y):  
  2     if x > y:  
  3         return x  
  4     return y  
  5  
  6 a = 1  
  7 b = 2  
→ 8 max(a,b)
```

[Edit code](#)

<< First

< Back

Step 5 of 8

Forward >

Last >>

Frames

Objects

Global frame

max

a

b

max

x

1

y

2

Missing line
numbers!

Next Time: Concrete Examples