

Lecture 4

Defining Functions

Academic Integrity Quiz

- **Remember:** quiz about the course AI policy
 - Have posted grades for completed quizzes
 - Right now, missing ~62 enrolled students
 - If did not receive 9/10 (~86 students), take it again
- If you are not aware of the quiz
 - Go to <http://www.cs.cornell.edu/courses/cs1110/>
 - Click **Academic Integrity** under **Assessments**
 - Read and take quiz in CMS

Reminder: Partner Finding Social



CornellBowers
College of Computing + Information Science



CIS Partner Finding Social

Thursday, September 3rd
4:30 – 5:30 PM
Gates 114

TODAY!

- For **assignments**
 - Can be done in **pairs**
 - Can work with anyone in class (in any section)
 - Can change partners every assignment
- Find the right course
 - This is for all CS courses
 - Make sure you locate the 1110 group

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
 - Pulsar 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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>>> plus(23)
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```

```
>>>
```

Function
Header

Function Definition

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Function Call

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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
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Docstring
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```
    Parameter n: number to add to  
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```

```
    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):  
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    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
- 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!

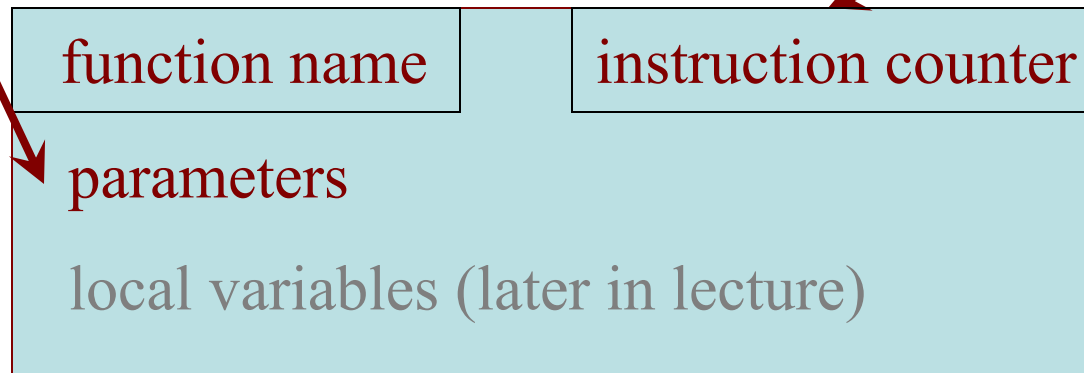
E: I do not know

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 line no. of body**

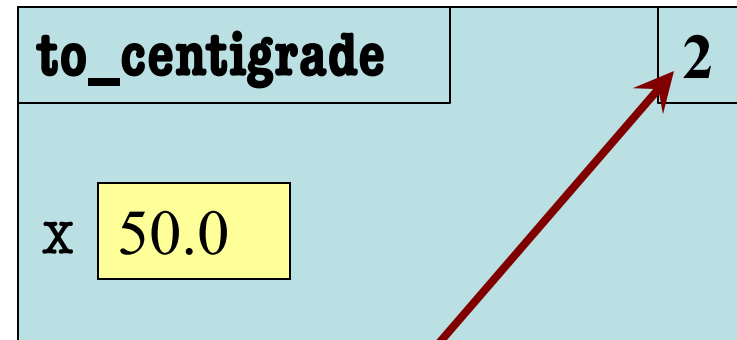


Example: to_centigrade(50.0)

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

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

Initial call frame
(before exec body)



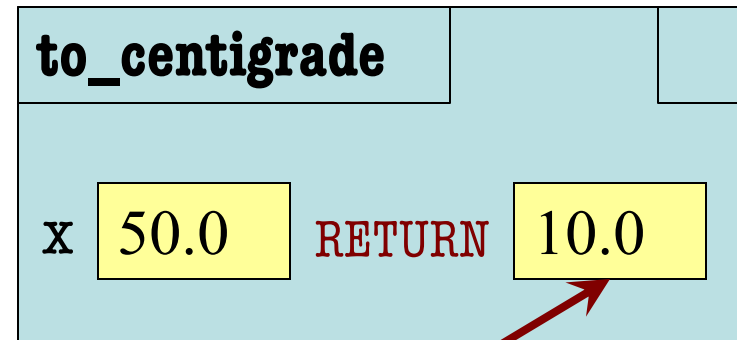
next line to execute

Example: to_centigrade(50.0)

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

Executing the
return statement



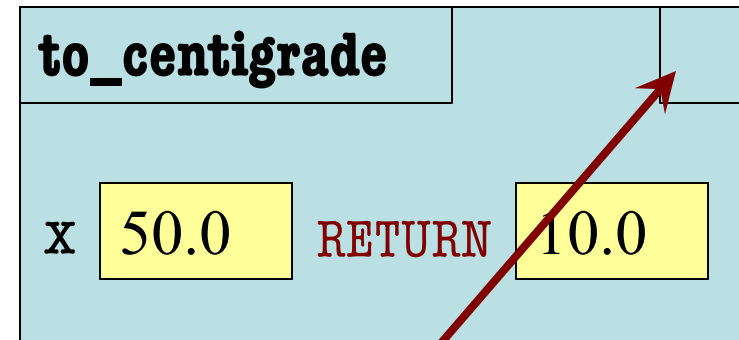
Return statement creates a
special variable for result

Example: to_centigrade(50.0)

1. Draw a frame for the call
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 - Look for variables in the frame
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```
1 def to_centigrade(x):  
2     | 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):  
2     | return 5*(x-32)/9.0
```

But don't actually
erase on an exam

Call Frames vs. Global Variables

The specification is a **lie**:

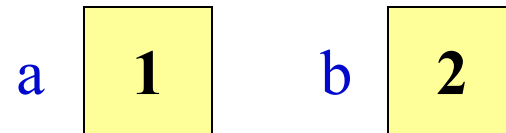
```
1 def swap(a,b):  
2     """Swap global a & b"""  
3     tmp = a  
4     a = b  
5     b = tmp
```

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

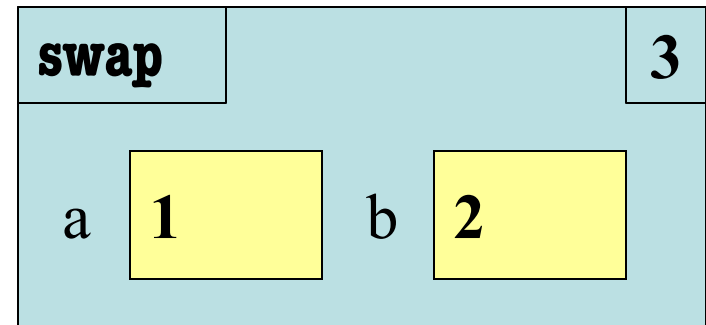
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>>> b = 2
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```
>>> swap(a,b)
```

Global Variables



Call Frame



Call Frames vs. Global Variables

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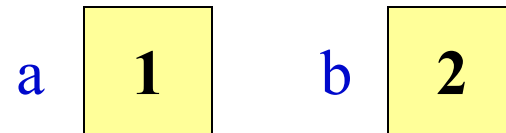
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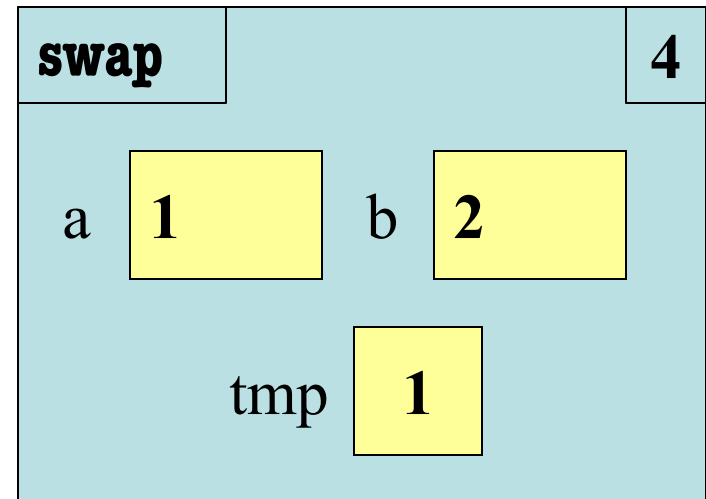
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>>> b = 2
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```
>>> swap(a,b)
```

Global Variables



Call Frame



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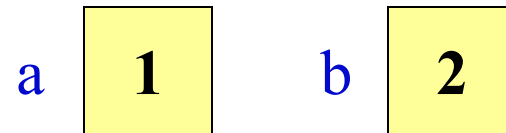
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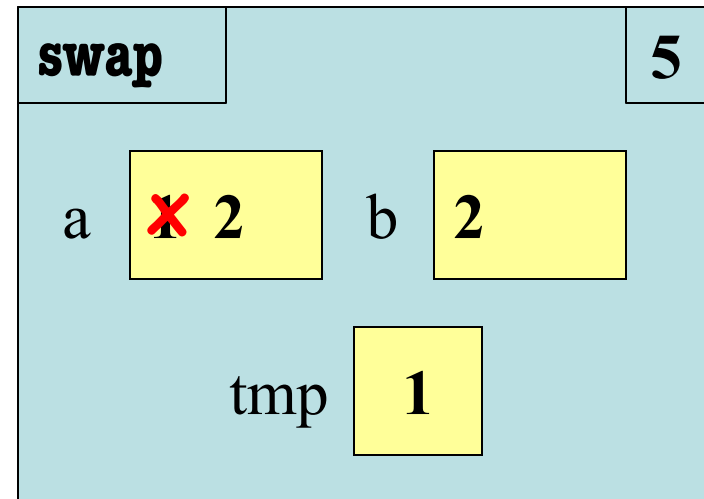
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>>> swap(a,b)
```

Global Variables



Call Frame



Call Frames vs. Global Variables

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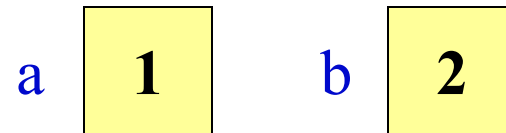
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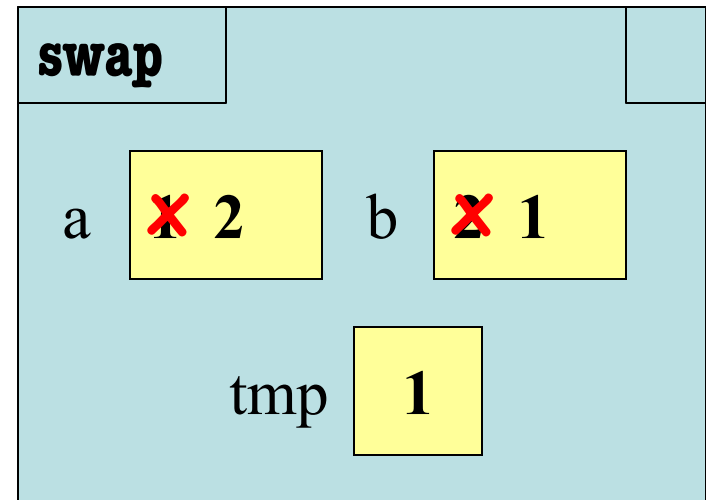
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```
>>> swap(a,b)
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Global Variables



Call Frame



Call Frames vs. Global Variables

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```
>>> a = 1
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```
>>> b = 2
```

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

Global Variables

a 1 b 2

Call Frame

ERASE THE FRAME

Exercise Time

Function Definition

```
8 def foo(a,b):  
...     """Return something  
        Param x: a number  
        Param y: a number"""  
15     x = a  
16     y = b  
17     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		14	
a	3	b	4

B:

foo		15	
a	3	b	4

C:

foo		15	
a	3	b	4
x	3		

D:

foo		15	
a	3	b	4
x		y	

Which One is Closest to Your Answer?

A:

foo		14	
a	3	b	4

B:

foo		15	
a	3	b	4

E:

(ツ)

C:

foo			
a	3		
x	3		

15

		15	
b	4		
x		y	

Exercise Time

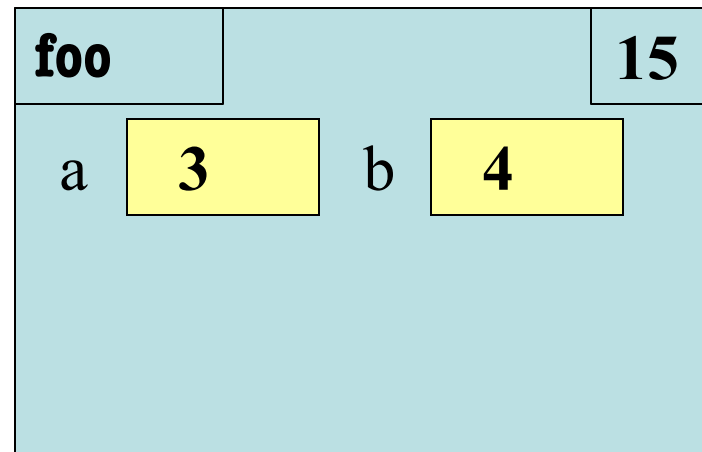
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Function Call

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B:



Exercise Time

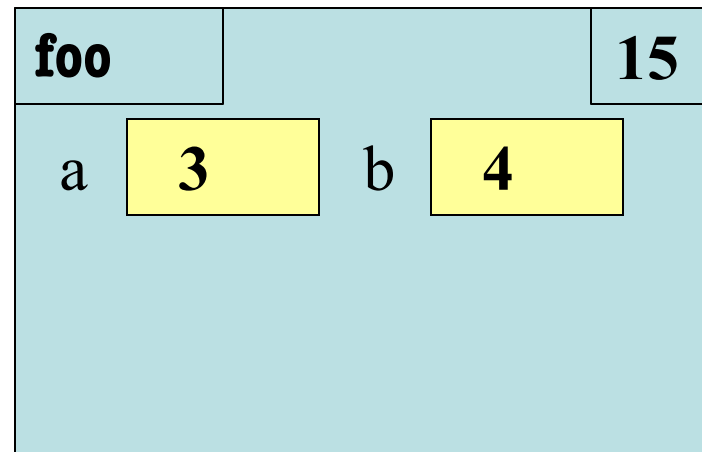
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```

Function Call

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

B:



What is the **next step**?

Which One is Closest to Your Answer?

A:

foo		16
a	3	b 4

B:

foo		15
a	3	b 4
x	3	

C:

foo		16
a	3	b 4
x	3	

D:

foo		16
a	3	b 4
x	3	y

Exercise Time

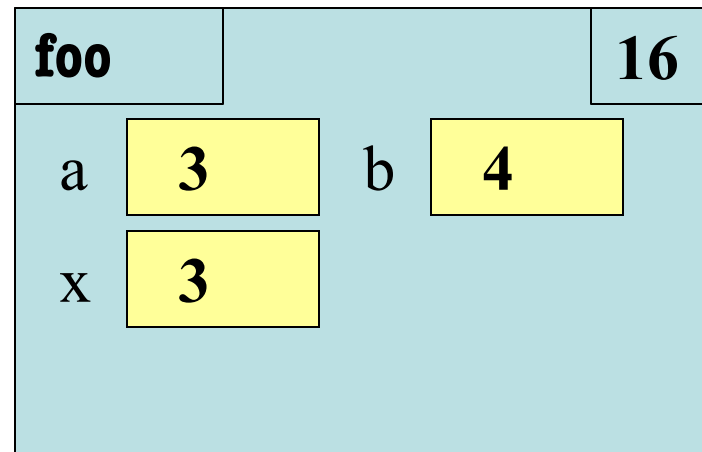
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Function Call

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```

C:



Exercise Time

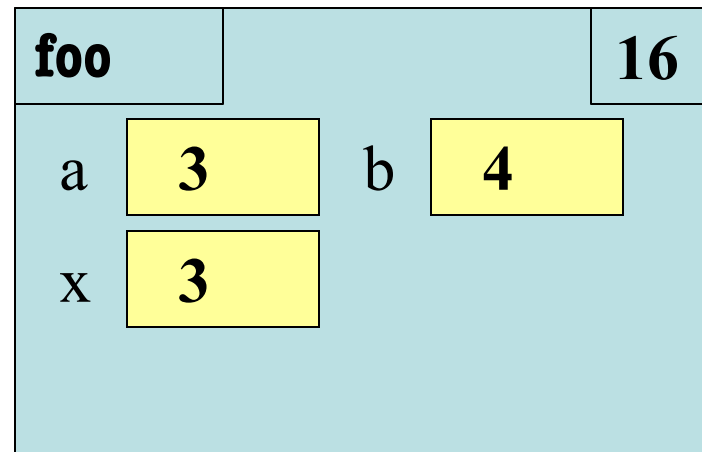
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Function Call

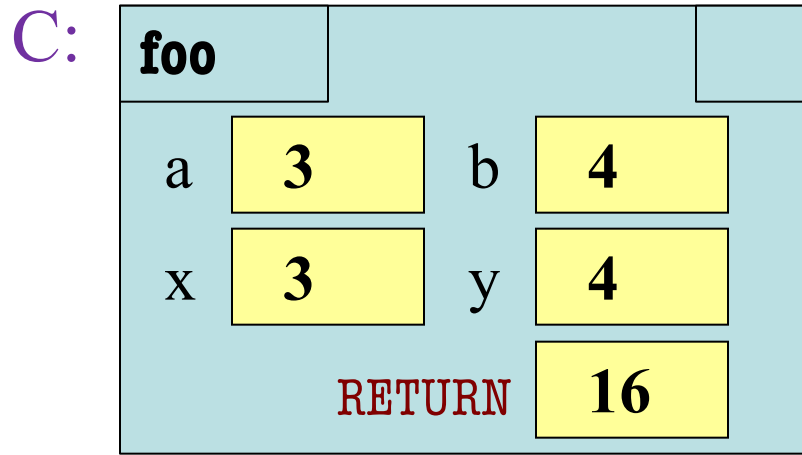
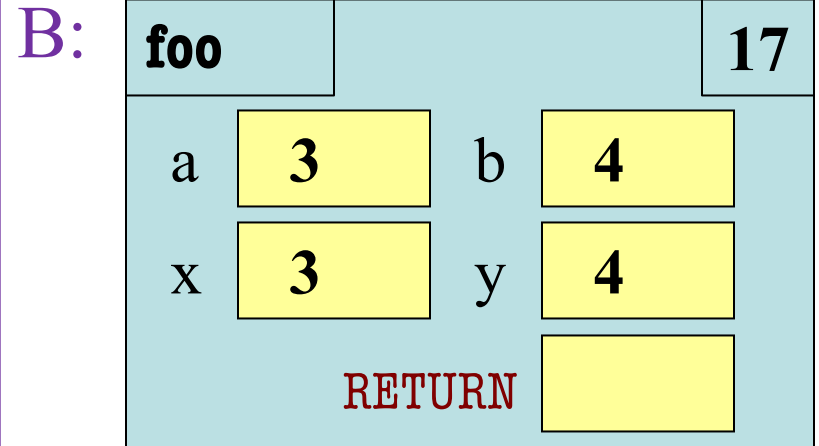
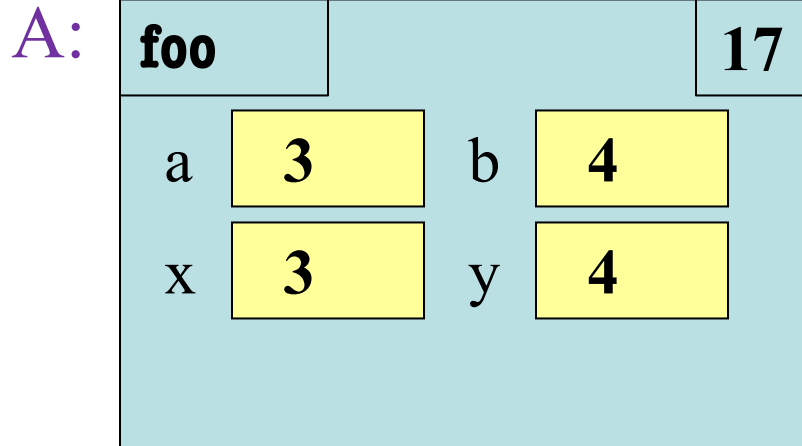
```
>>> x = foo(3,4)
```

C:



What is the **next step**?

Which One is Closest to Your Answer?



D:

ERASE THE FRAME

Exercise Time

Function Definition

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Function Call

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

A:

foo				17
a	3	b	4	
x	3	y	4	

Exercise Time

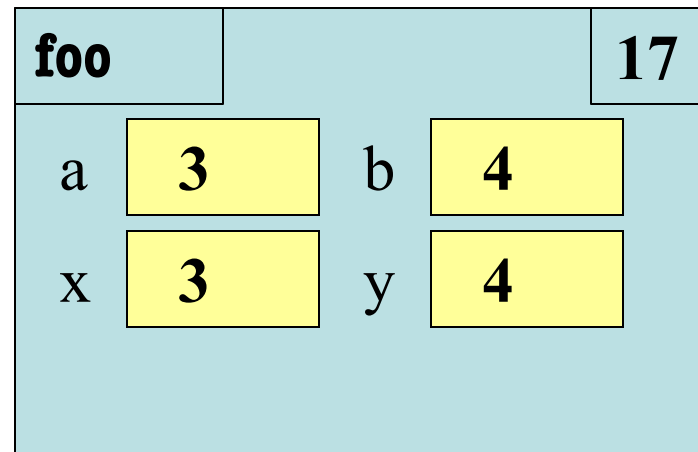
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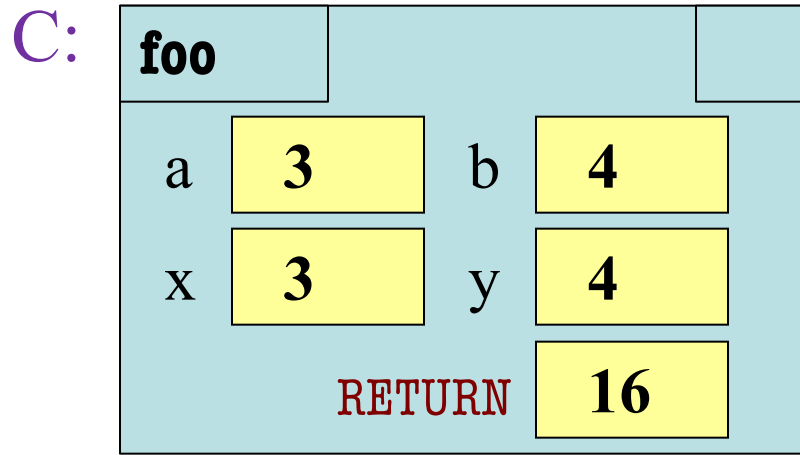
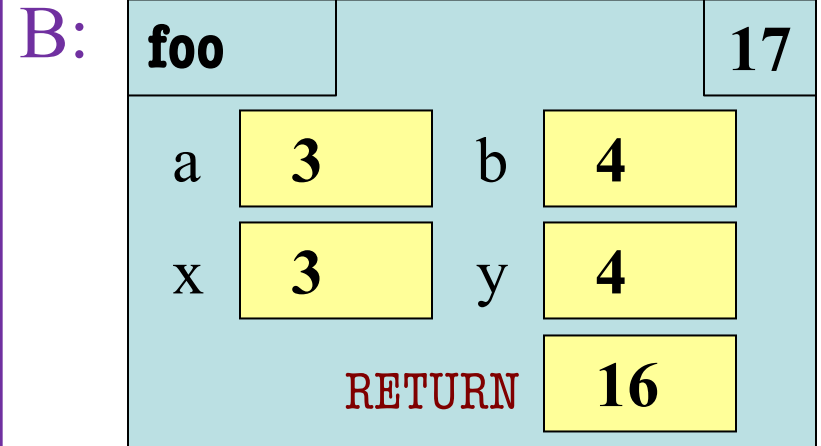
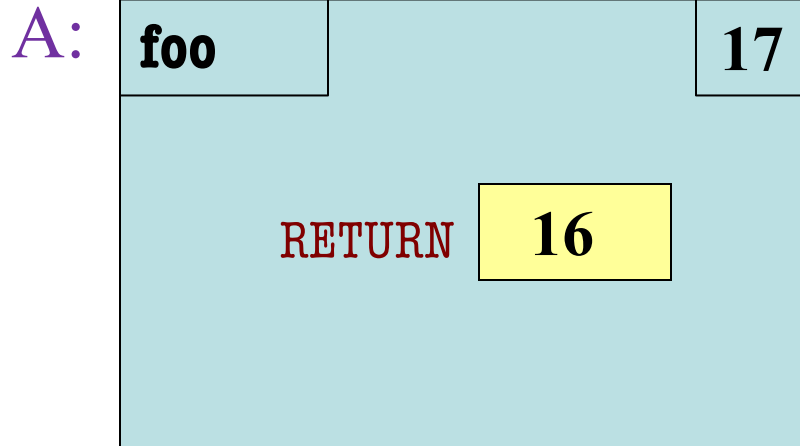
```
>>> x = foo(3,4)
```

A:



What is the **next step**?

Which One is Closest to Your Answer?



Exercise Time

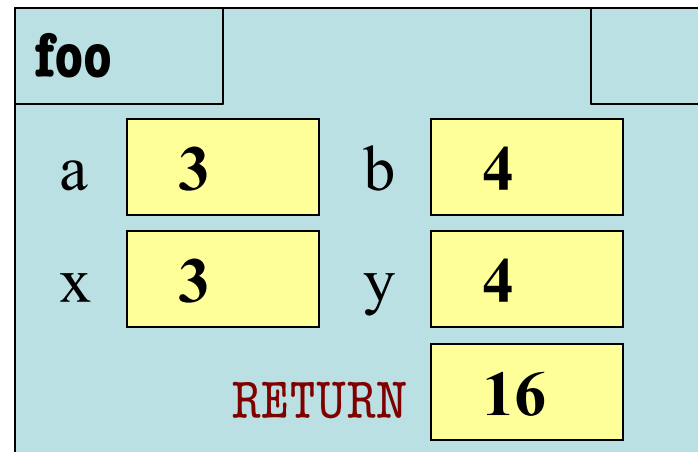
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Function Call

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>>> x = foo(3,4)
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C:



Exercise Time

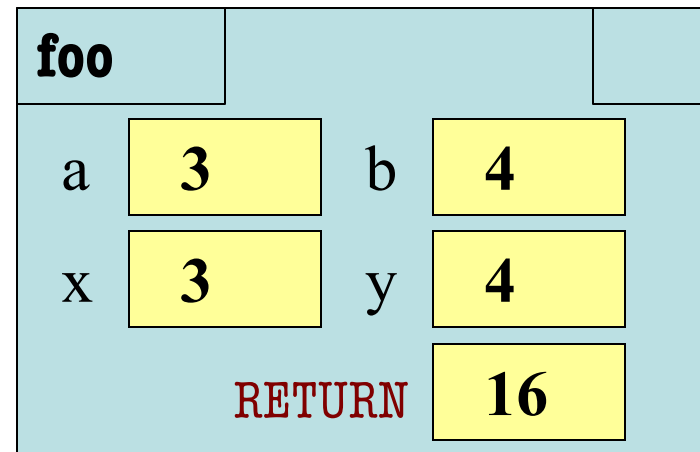
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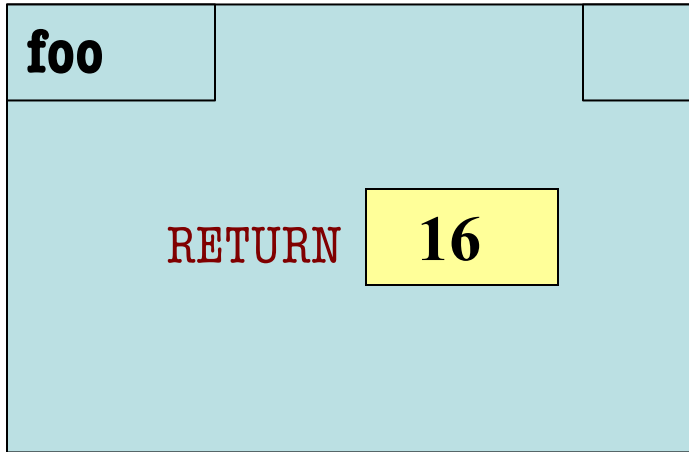
C:



What is the **next step**?

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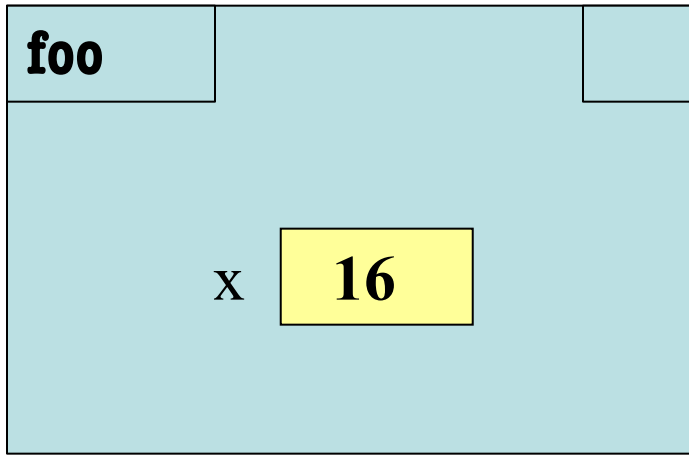
A:



B:

ERASE THE FRAME

C:



D:

x 16

ERASE THE FRAME

Exercise Time

Function Definition

```
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        Param x: a number  
        Param y: a number"""  
15     x = a  
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```

Function Call

```
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```

D:

x

16

ERASE THE FRAME

Exercise Time

Function Definition

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17     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](#)

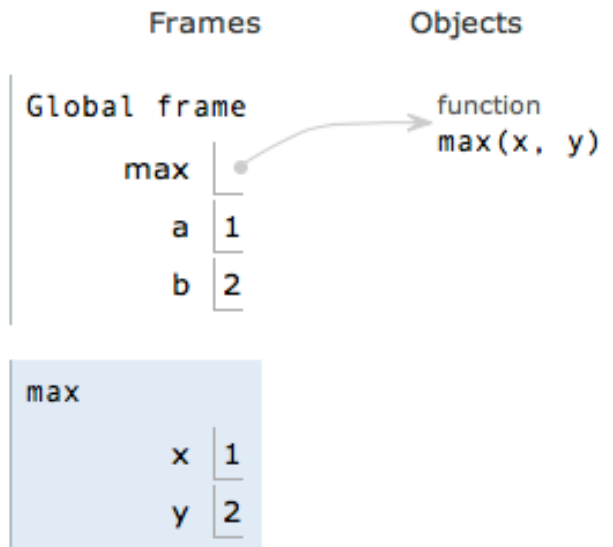
<< First

< Back

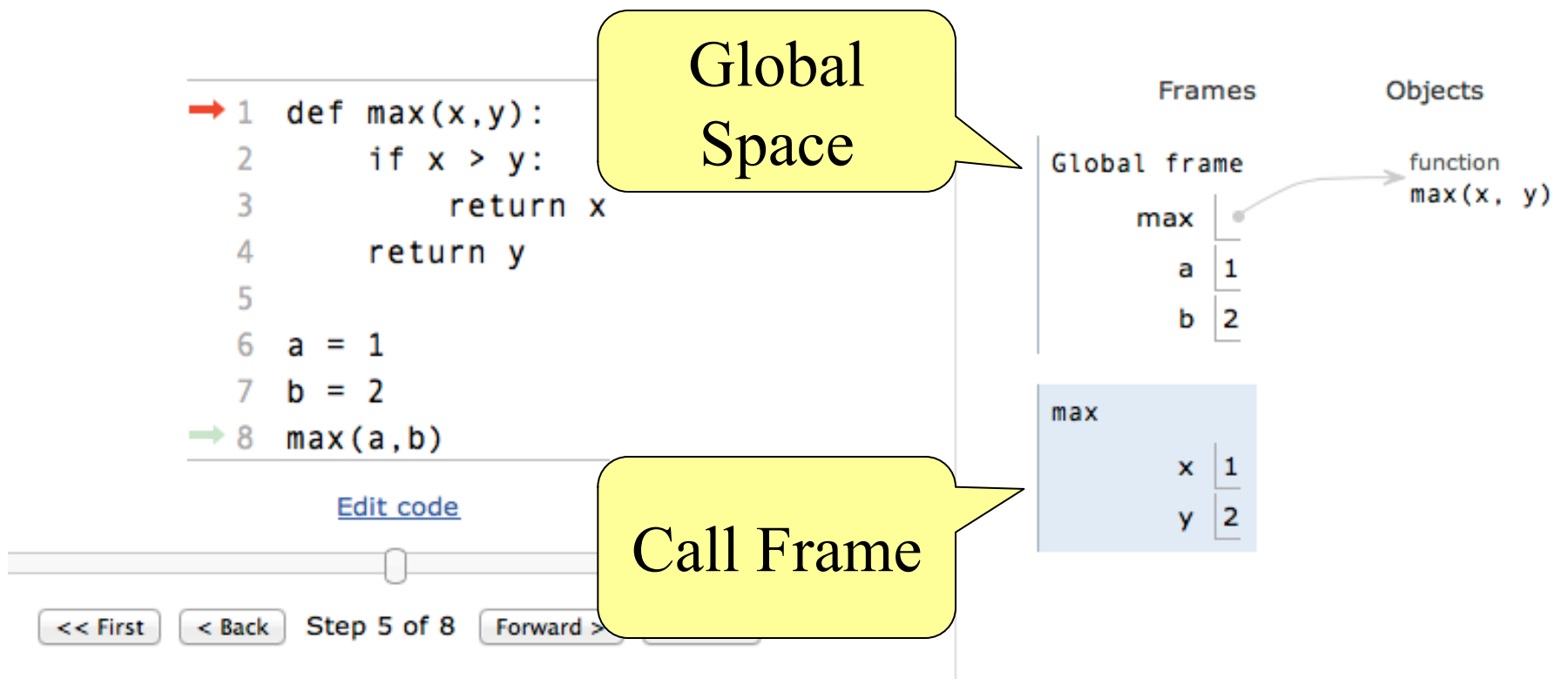
Step 5 of 8

Forward >

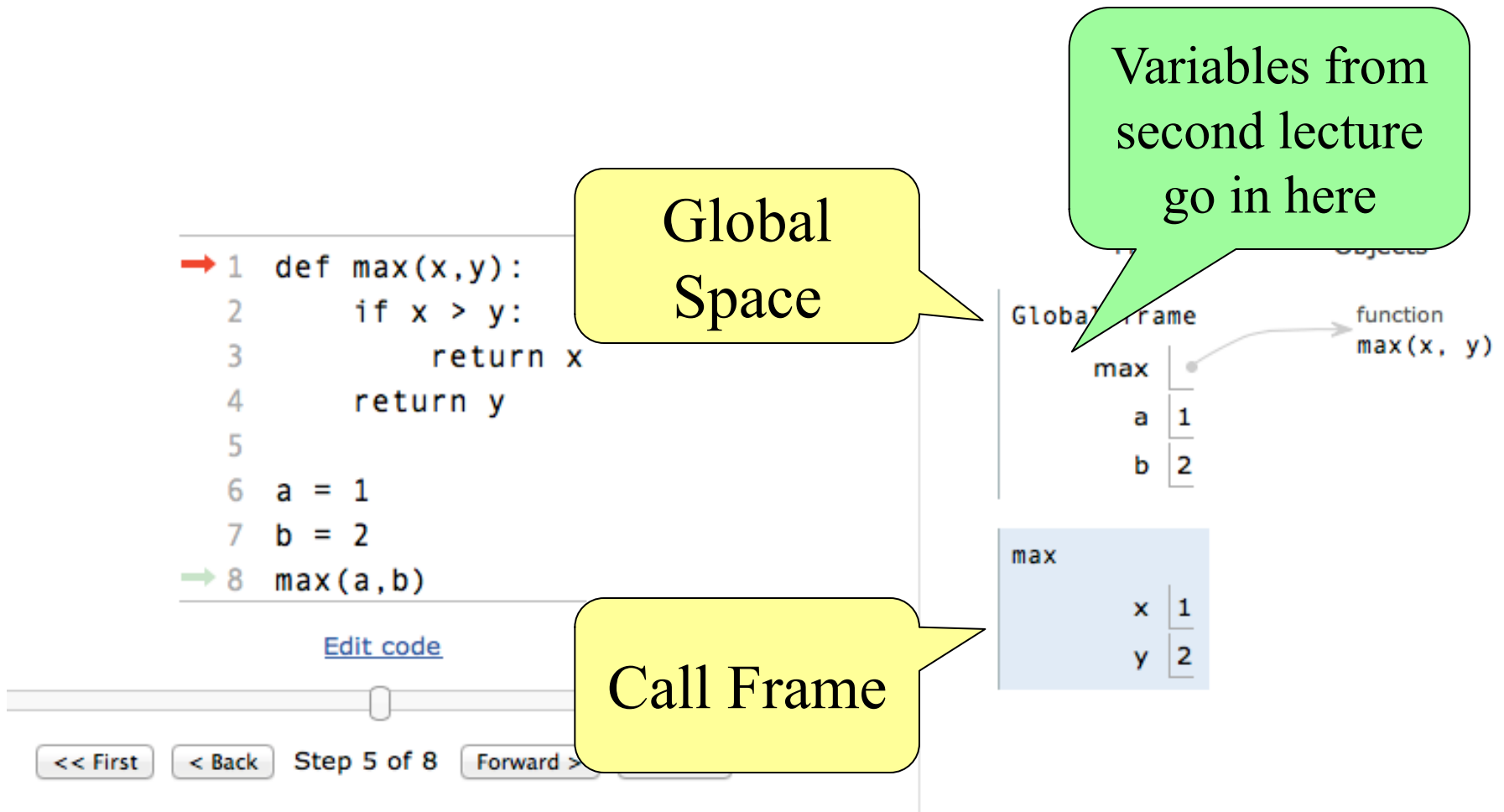
Last >>



Visualizing Frames: The Python Tutor



Visualizing Frames: The Python Tutor



Visualizing Frames: The Python Tutor

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```

[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):  
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→ 8 max(a,b)
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[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: Text Processing