

Lecture 4

Defining Functions

Announcement: Partner Finding Social

- **Reminder:** Assignments can be done in **pairs**
 - Can work with anyone in class (in any section)
 - Can change partners every assignment
- Having a mixer to help find a partner
 - 4-6pm Friday (**TOMORROW**), September 1st
 - **MOVED:** Now outside Gates G01
- If cannot make it will have other opportunities
 - Will ask for people who still need partners at A1
 - Will group those students up randomly

Academic Integrity Quiz

- **Remember:** quiz about the course AI policy
 - Have posted grades for completed quizzes
 - Right now, missing ~95 enrolled students
 - If did not receive 9/10 (~188 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

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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```
>>>
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Function
Header

Function Definition

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We Write Programs to Do Things

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Function Call

- Command to **do** the function

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>>> plus(23)
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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  
       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!

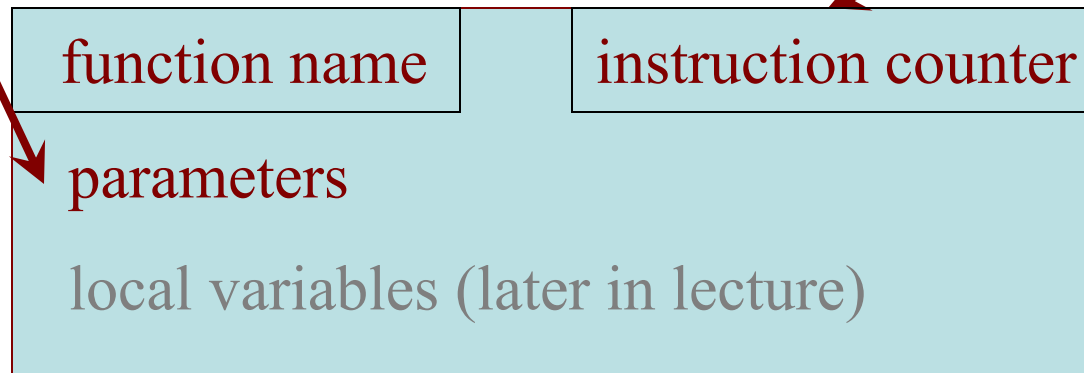
E: I do not know

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**

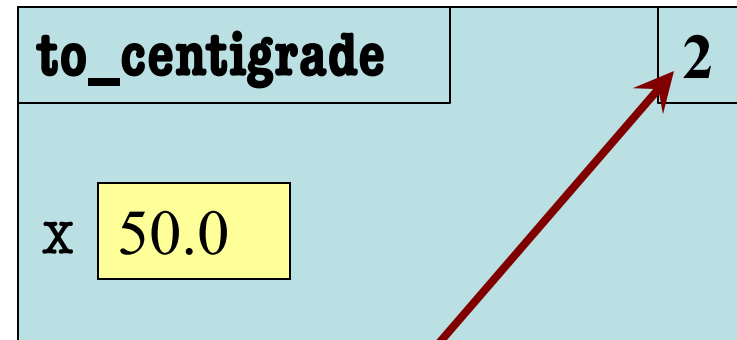


Example: to_centigrade(50.0)

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)



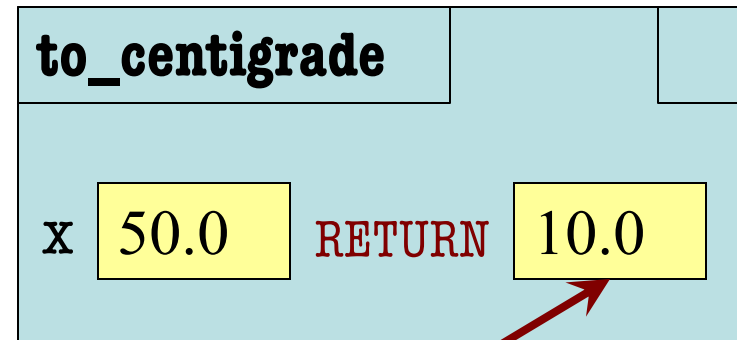
next line to execute

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



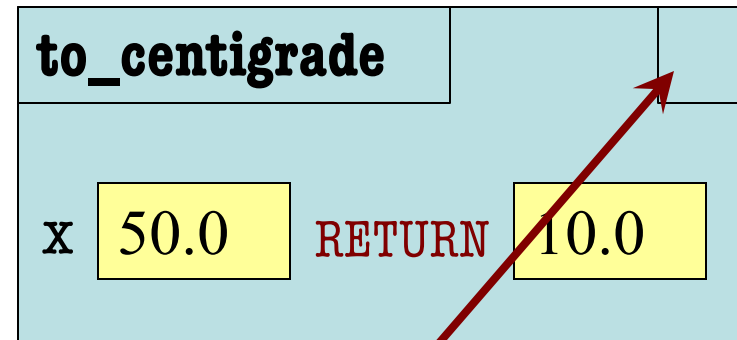
Return statement creates a
special variable for result

Example: to_centigrade(50.0)

1. Draw a frame for the call
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4. Erase the frame for the call

```
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
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 - 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**:

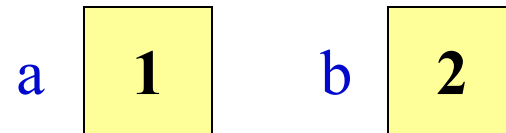
```
1 def swap(a,b):  
2     """Swap global a & b"""  
3     tmp = a  
4     a = b  
5     b = tmp
```

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

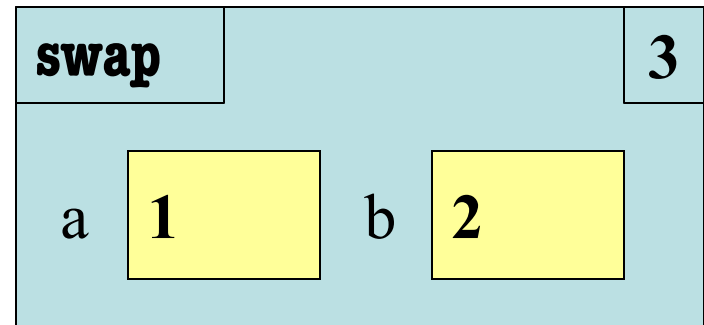
```
>>> b = 2
```

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

Global Variables



Call Frame



Call Frames vs. Global Variables

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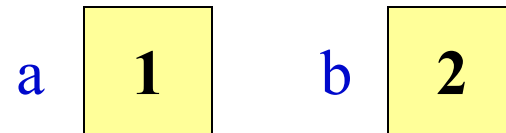
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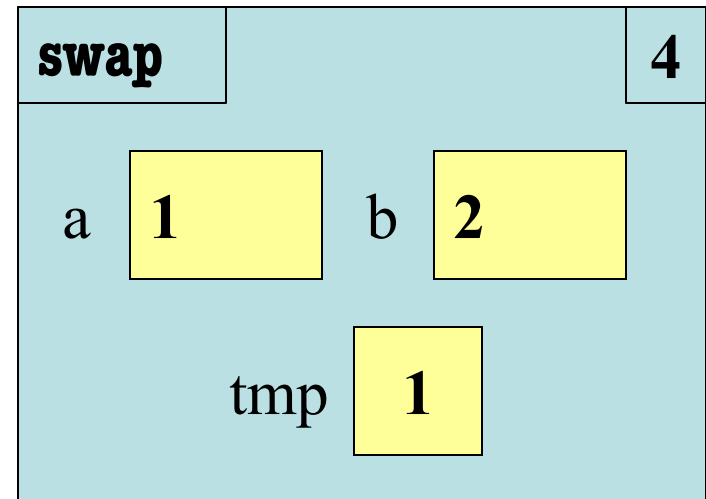
```
>>> b = 2
```

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

Global Variables



Call Frame



Call Frames vs. Global Variables

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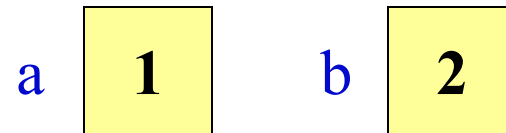
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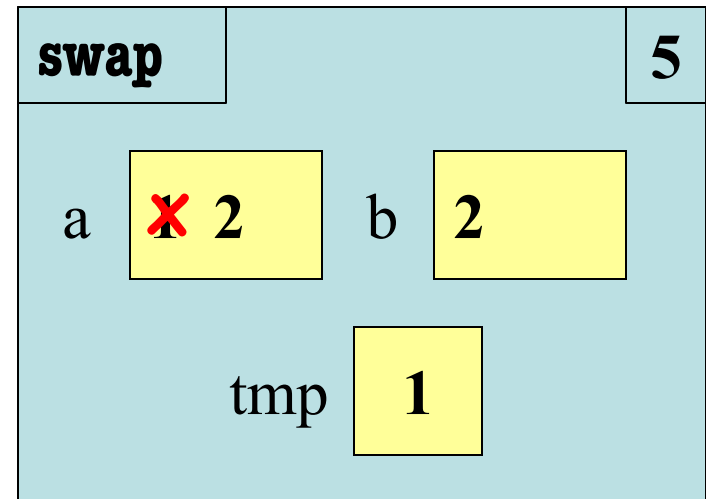
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```
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```

Global Variables



Call Frame



Call Frames vs. Global Variables

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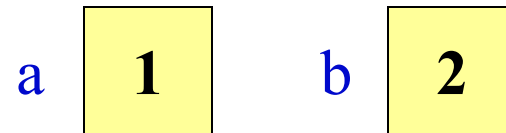
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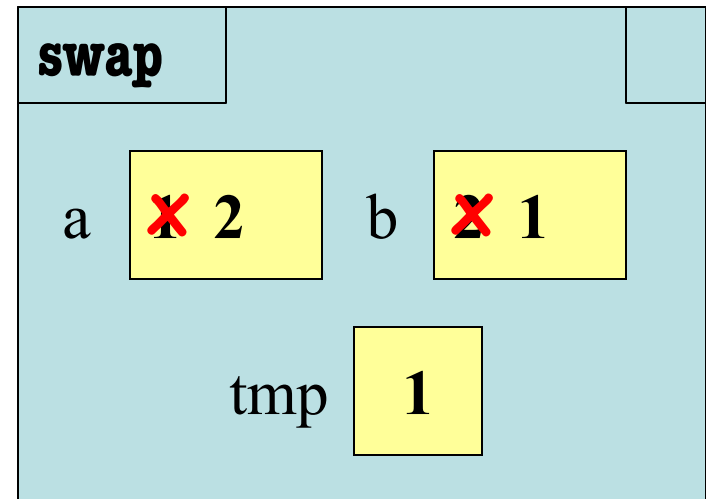
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```
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Global Variables



Call Frame



Call Frames vs. Global Variables

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

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

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

Global Variables

a 1 b 2

Call Frame

ERASE THE FRAME

Exercise Time

Function Definition

```
1 def foo(a,b):  
2     """Return something  
3     Param x: a number  
4     Param y: a number"""  
5     x = a  
6     y = b  
7     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				4
a	3	b	4	

B:

foo				5
a	3	b	4	

C:

foo				5
a	3			

D:

foo				5
a	3	b	4	
x		y		

Which One is Closest to Your Answer?

A:

foo		4
a	3	b 4

B:

foo		5
a	3	b 4

E:

(ツ)

C:

foo	
a	3

5

b 4

x

y

Exercise Time

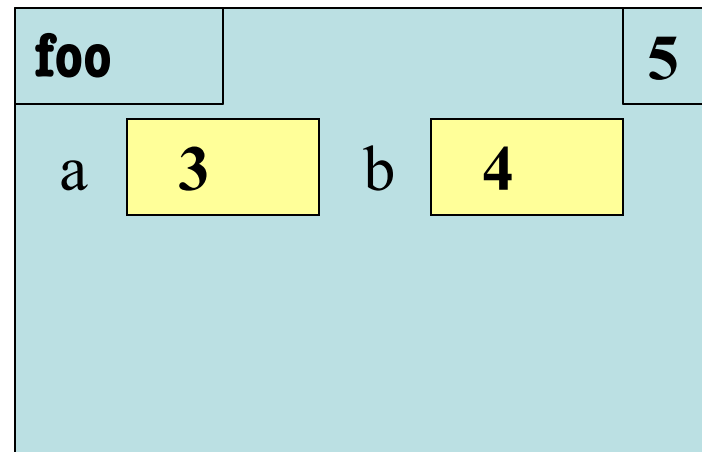
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Function Call

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

B:



Exercise Time

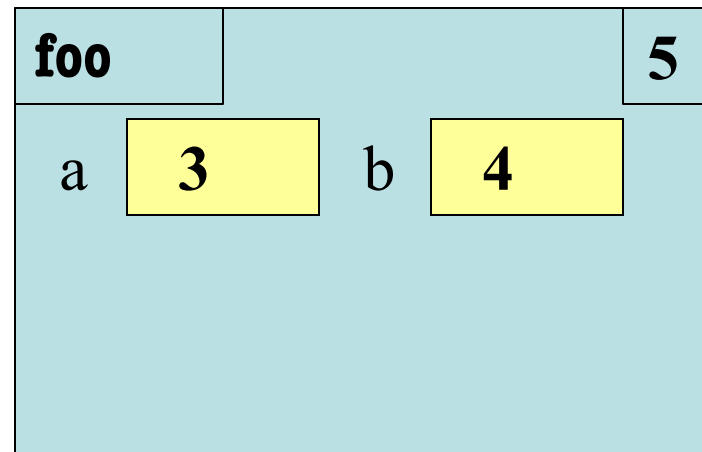
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Function Call

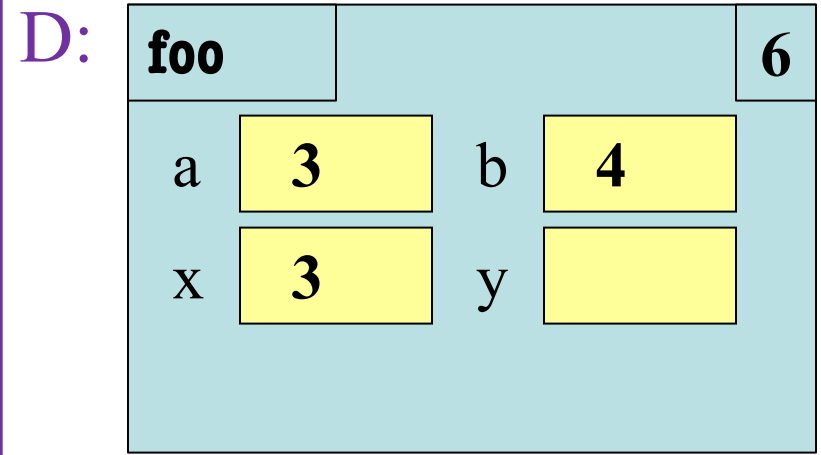
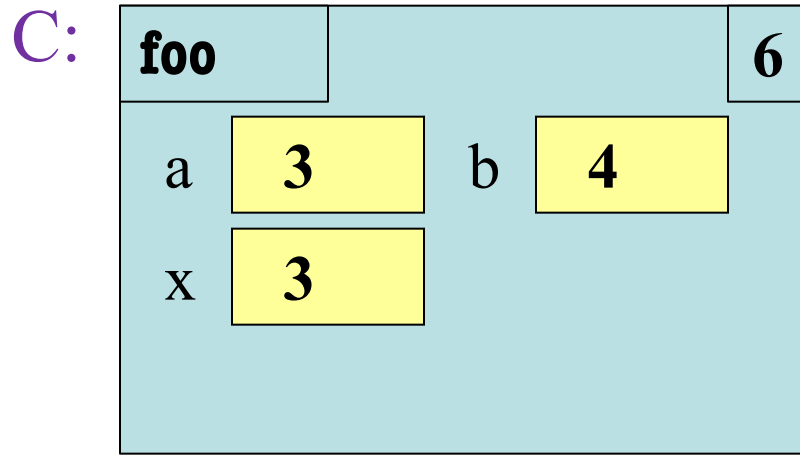
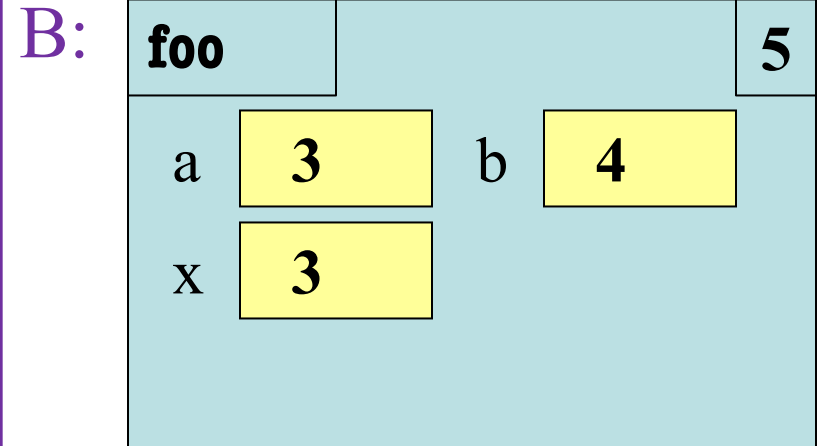
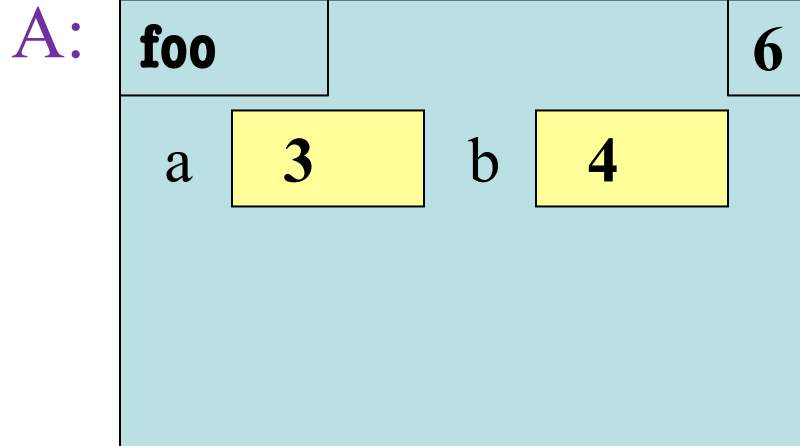
```
>>> x = foo(3,4)
```

B:



What is the **next step**?

Which One is Closest to Your Answer?



Exercise Time

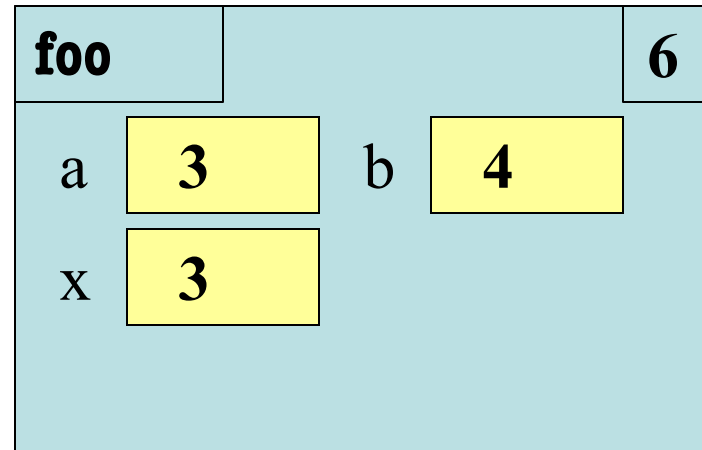
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Function Call

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

C:



Exercise Time

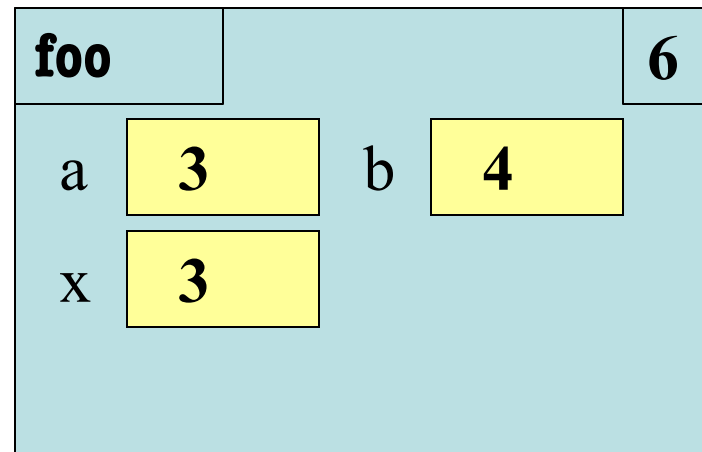
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```

Function Call

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

C:



What is the **next step**?

Which One is Closest to Your Answer?

A:

foo				7
a	3	b	4	
x	3	y	4	

B:

foo				7
a	3	b	4	
x	3	y	4	
RETURN				

C:

foo				
a	3	b	4	
x	3	y	4	
RETURN				16

D:

ERASE THE FRAME

Exercise Time

Function Definition

```
1 def foo(a,b):  
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Function Call

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Exercise Time

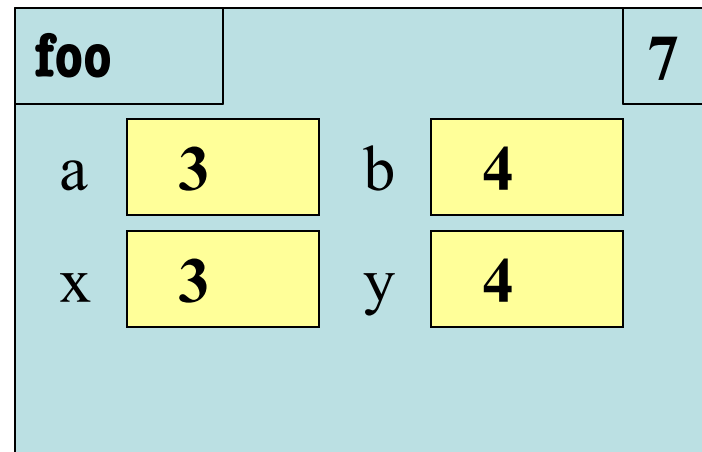
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Function Call

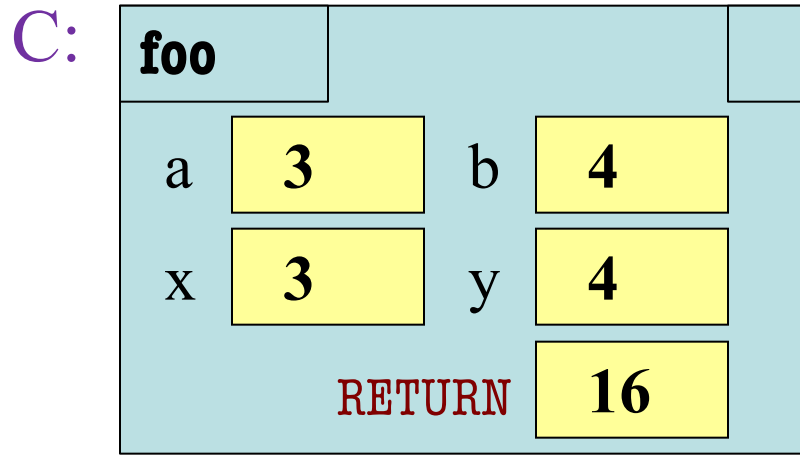
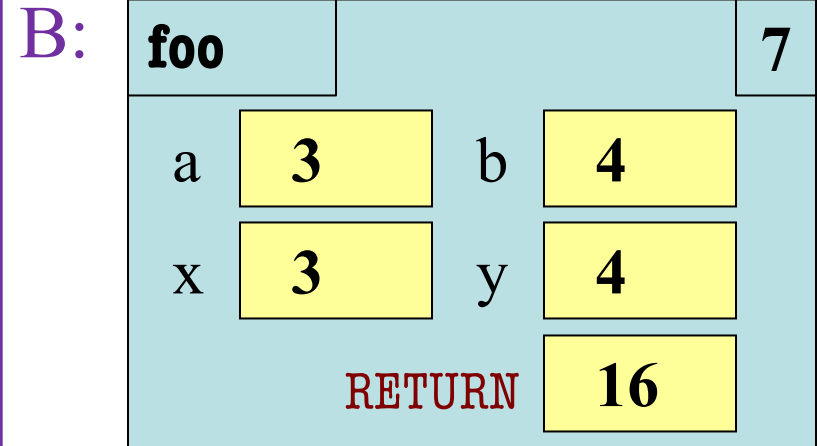
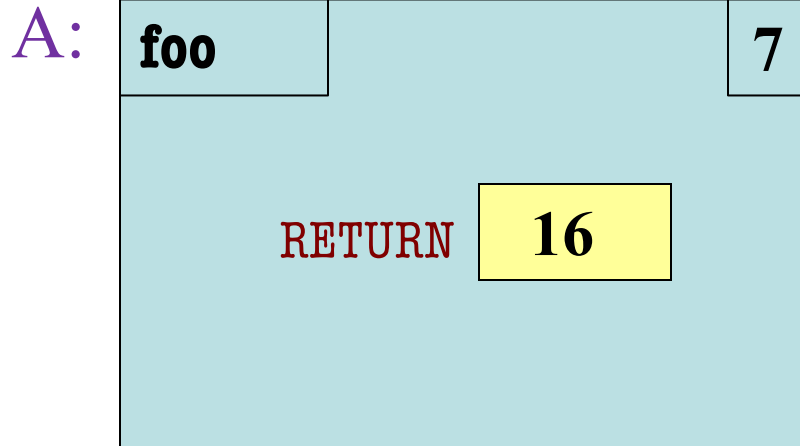
```
>>> x = foo(3,4)
```

A:



What is the **next step**?

Which One is Closest to Your Answer?



Exercise Time

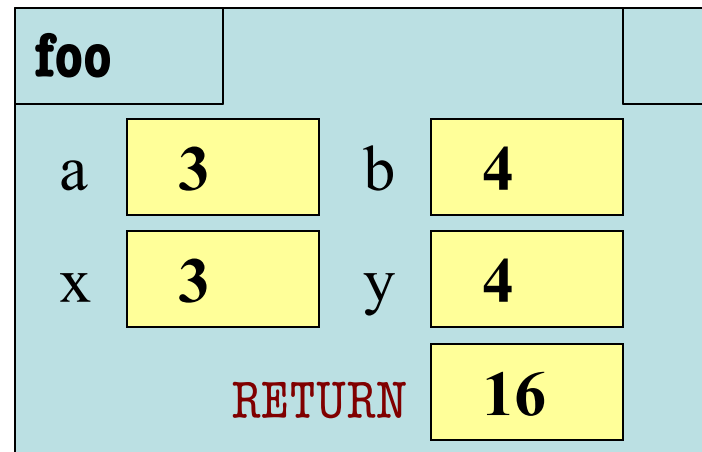
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Function Call

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

C:



Exercise Time

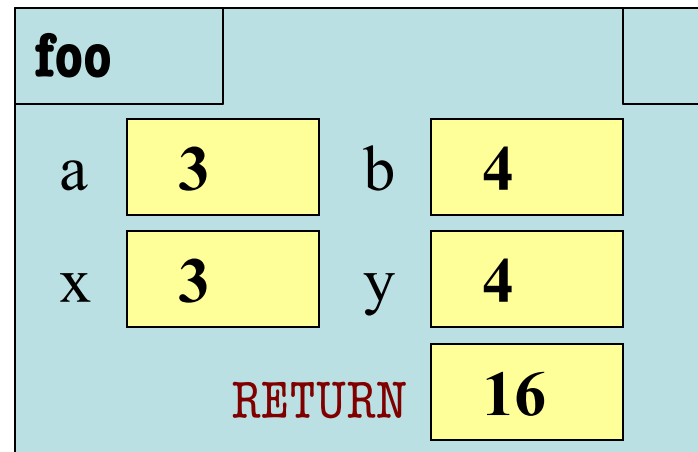
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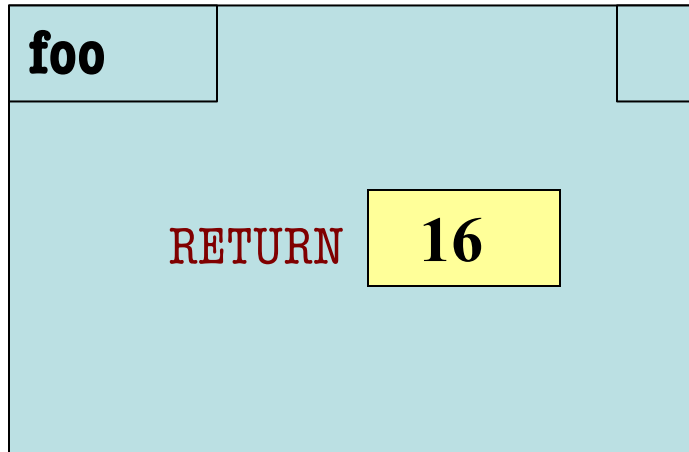
C:



What is the **next step**?

Which One is Closest to Your Answer?

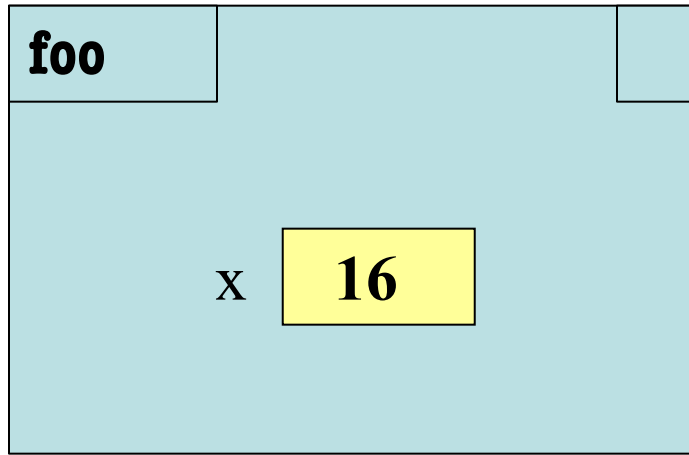
A:



B:

ERASE THE FRAME

C:



D:

x 16

ERASE THE FRAME

Exercise Time

Function Definition

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

Function Call

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

D:

x

16

ERASE THE FRAME

Exercise Time

Function Definition

```
1 def foo(a,b):  
2     """Return something  
3     Param x: a number  
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5     x = a  
6     y = b  
7     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](#)

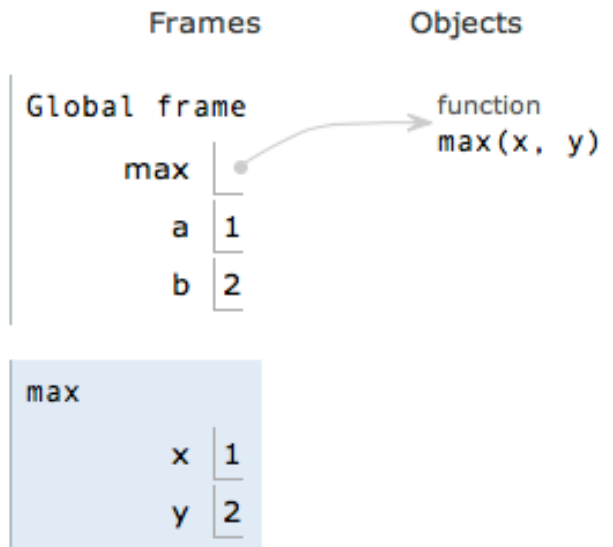
<< First

< Back

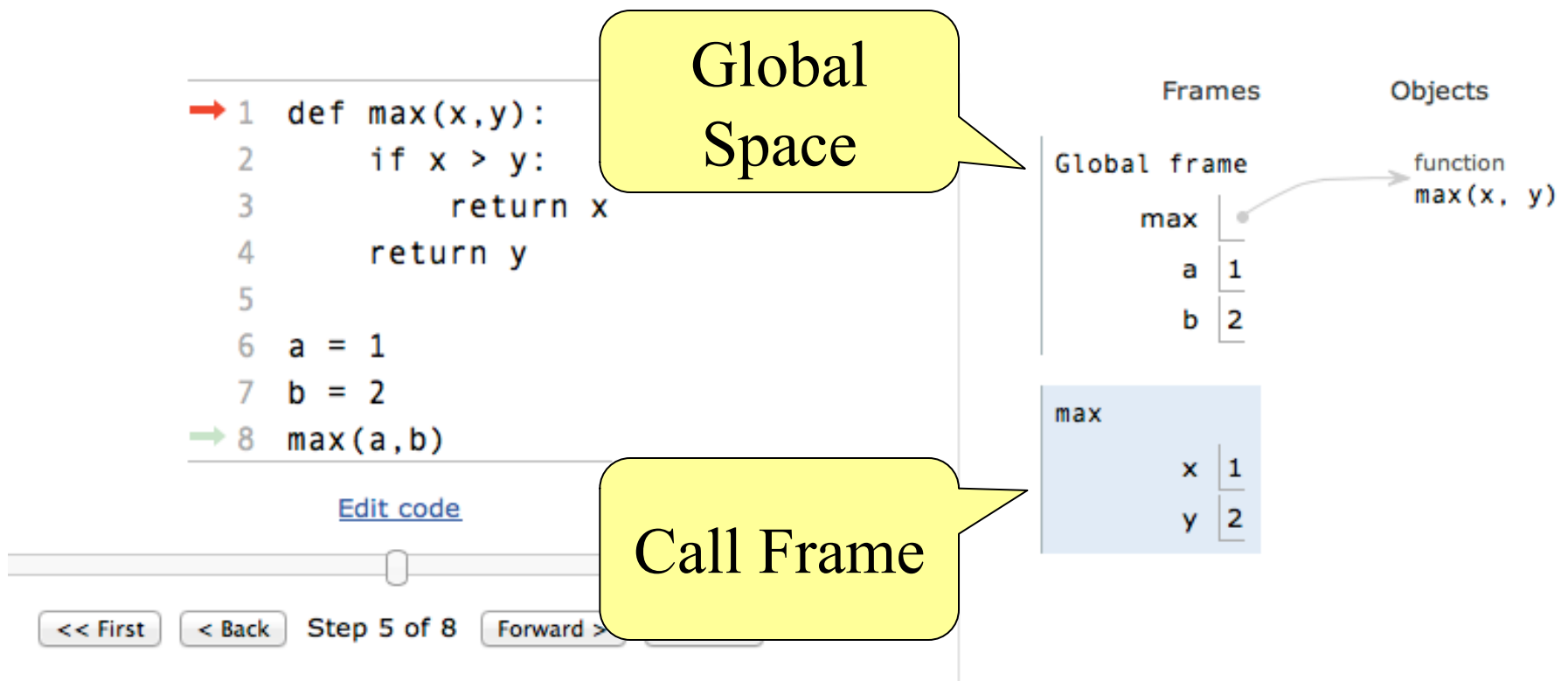
Step 5 of 8

Forward >

Last >>



Visualizing Frames: The Python Tutor



Visualizing Frames: The Python Tutor

The image shows a screenshot of the Python Tutor interface. On the left, a code editor displays the following code:

```
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)
```

Below the code editor is a slider and navigation buttons: "<< First", "< Back", "Step 5 of 8", "Forward >", and ">> Last".

On the right, the "Global Frame" is visualized as a table:

Global Frame	
max	function max(x, y)
a	1
b	2

Below the Global Frame is the "Call Frame" for the function `max`:

max	
x	1
y	2

Two yellow callout boxes are present:

- A yellow box labeled "Global Space" points to the Global Frame table.
- A yellow box labeled "Call Frame" points to the Call Frame table.

A green callout box labeled "Variables from second lecture go in here" points to the Global Frame table.

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 >>

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: Text Processing