Lecture 2: Functions

CS 61A - Summer 2024

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$$20 + 24 \qquad 2^{100} \qquad \sin \pi$$

$$\lim_{x \to \infty} \frac{1}{x} \qquad f(x) \qquad \frac{20}{24} \qquad \sum_{i=1}^{n} i$$

$$\log x \qquad \sqrt{2024} \qquad \binom{n}{x} \qquad -2024$$

An **expression** describes a computation and evaluates to a value.

Types of Expressions

Primitive Expressions:

`2` `3.5` `'hello!'` `True`

numbers | strings | booleans

Call Expressions:

`add` (`2` , `3`)

Operator | Operand | Operand

Call Expressions

Evaluation procedure for **call expressions**

1. Evaluate the **operator**
2. Evaluate the **operands** from left to right
3. **Apply** the operator (a **function**) to the evaluated operands (**arguments**)

Operators and operands are also expressions

So they also *evaluate to values*

```
add(add(6, mul(4, 6)), mul(3, 5))
```

Operator

Operand

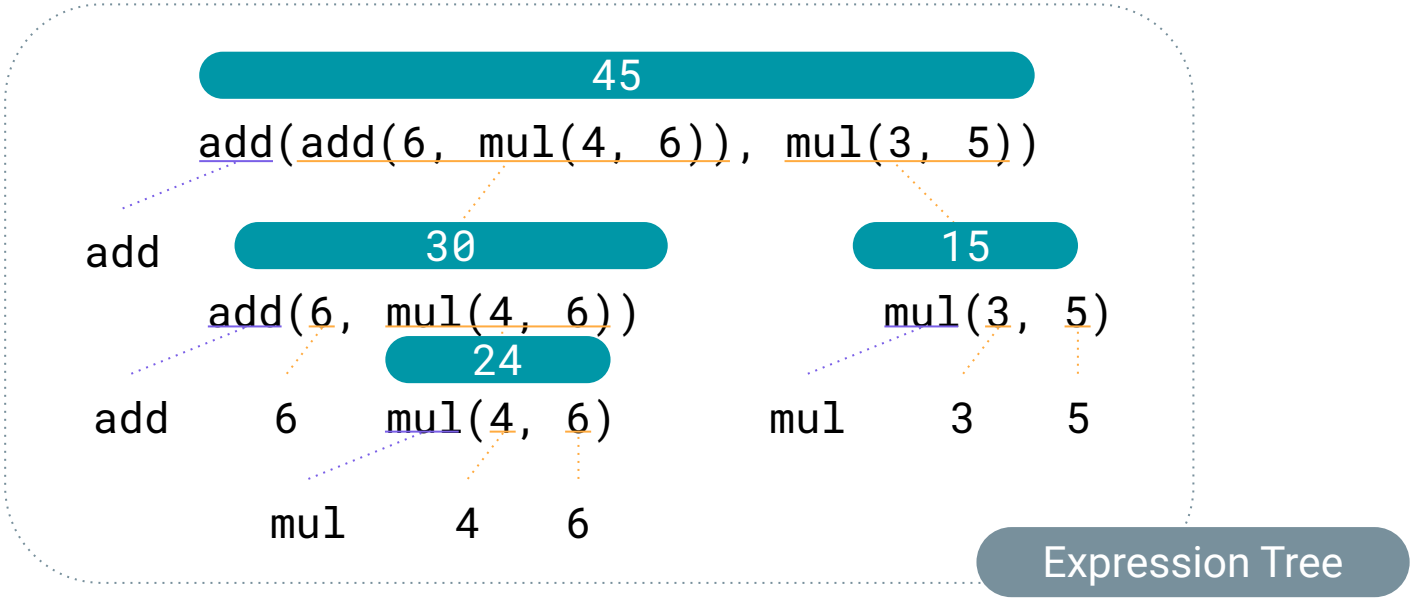
Operand

Nested Call Expressions

1 Evaluate operator

2 Evaluate operands

3 Apply!



Assignment Statements

In Python, we can bind expressions to variables.

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Assignment Statement

```
x = 1 + 2
```

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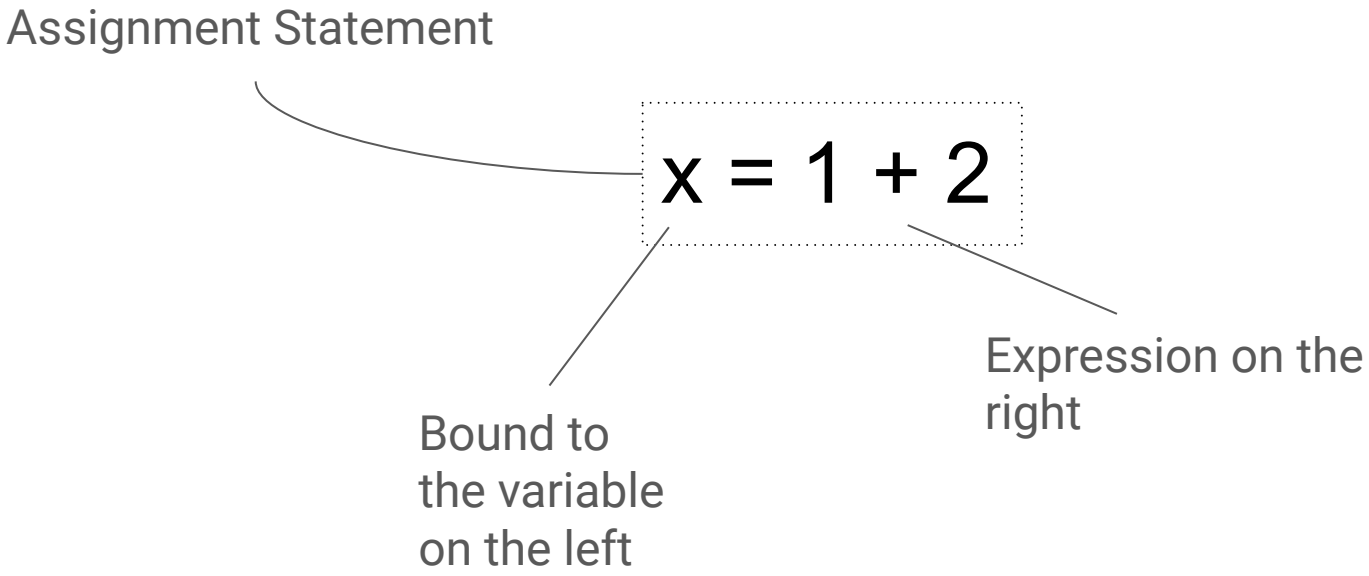

Assignment Statements

In Python, we can bind expressions to variables.

Incorrect!

~~1 + 2 = x~~

Assignment Statement

x = 1 + 2

Bound to the variable on the left

Expression on the right

Assignment Statements – Example

```
>>> x = 2
>>> y = x + 1
>>> y
3
>>> x = 5
>>> y
3
```

Assignment Statements – Example

```
>>> x = 2
>>> y = x + 1
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>>> x = 5
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```

y still retains its original value after x has been reassigned!

Demo: Assignment of Python builtin functions

User Defined Functions

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```
def square(x):
    """
    Takes an input x and squares it.
    >>> square(3)
    9
    """
    return pow(x, 2)
```

User Defined Functions

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A function's ***signature*** is denoted as the name of the function and the arguments it takes in.

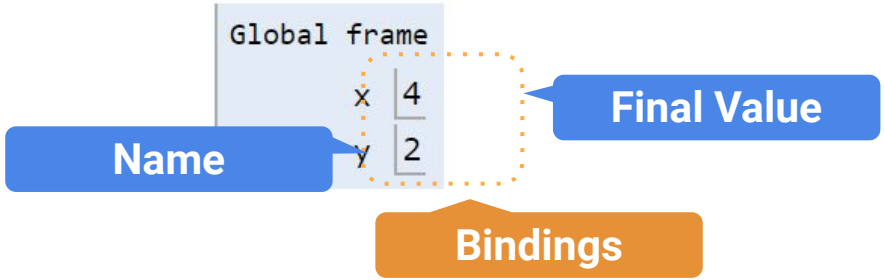
Environment Diagrams

Demo

Visualizing Assignment

Names are bound to **values** in an environment

```
1  x = 1
2  y = 2
3  x = y * 2
```



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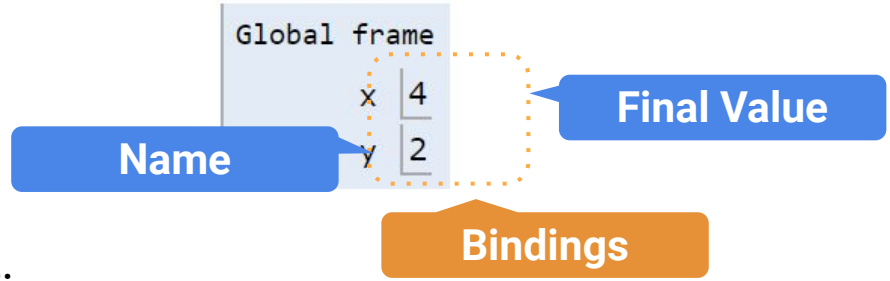

To execute an assignment statement:

1. **Evaluate** the expression to the right of **=**.
2. **Bind** the value of the expression to the name to the left of **=** in the current environment.

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Write code in Python 3.6 and display frames of exited functions.

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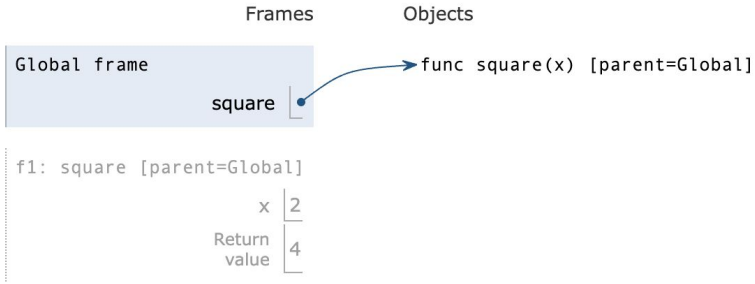

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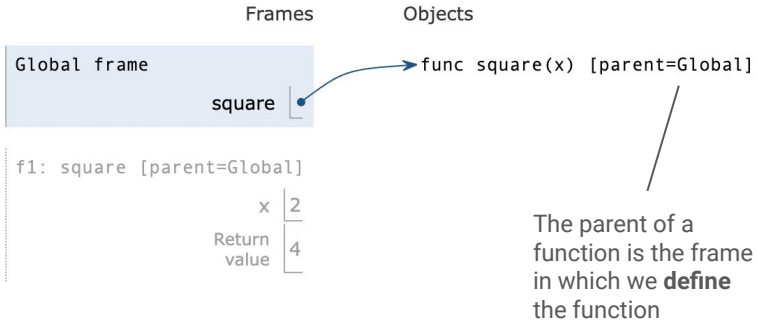

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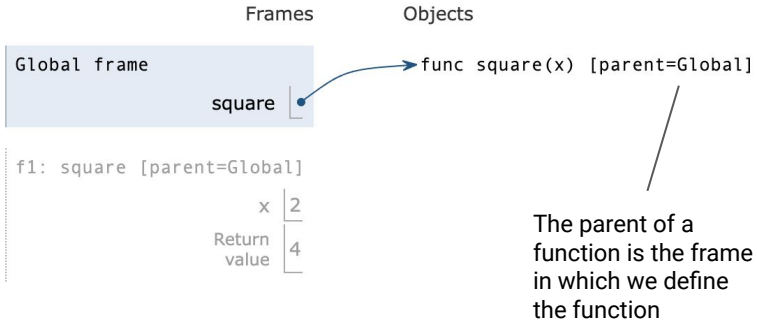

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*A function's signature has all the information needed to create a local frame

*Except argument values

Break time!

What if we have variables with the same name in different parts of our program?

```
x = 1
def my_func():
    x = 100
    print(x)

my_func() # What value gets displayed here?
```

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Answer: 100

Looking Up Names in Environments

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1. ***An environment is a sequence of frames.***

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Every expression is evaluated in the context of an environment.

Our programs always begin with a *global* frame, and then new *local* frames are created when we make a function call.

Most important rules for environment diagrams:

1. ***An environment is a sequence of frames.***
2. ***A name evaluates to the value bound to that name in the earliest frame of the current environment in which that name is found***

A sequence of frames

Latest

Global

f1

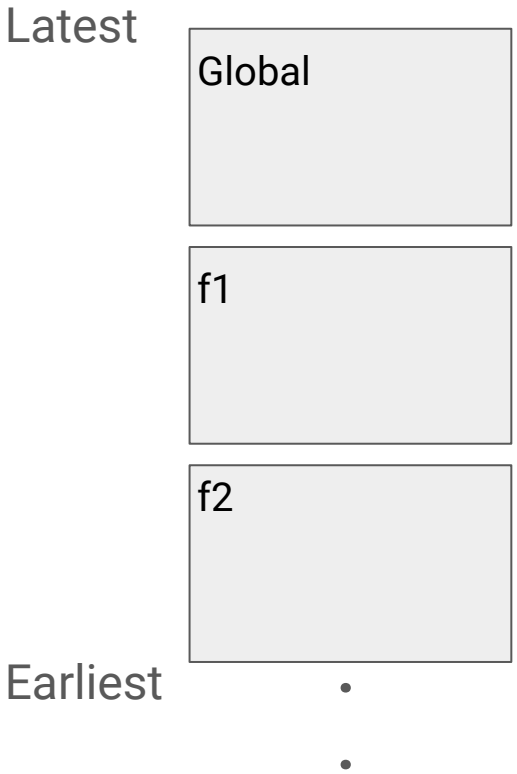
f2

Earliest

•

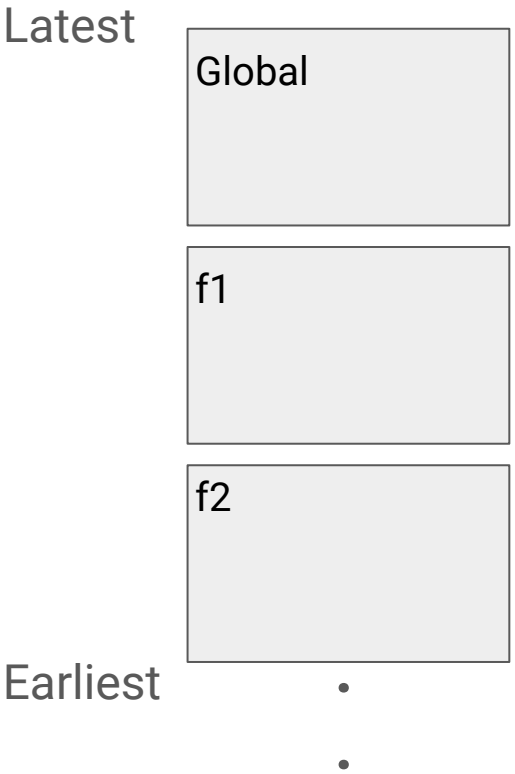
•

A sequence of frames



A sequence is a first frame, and then the rest of the sequence

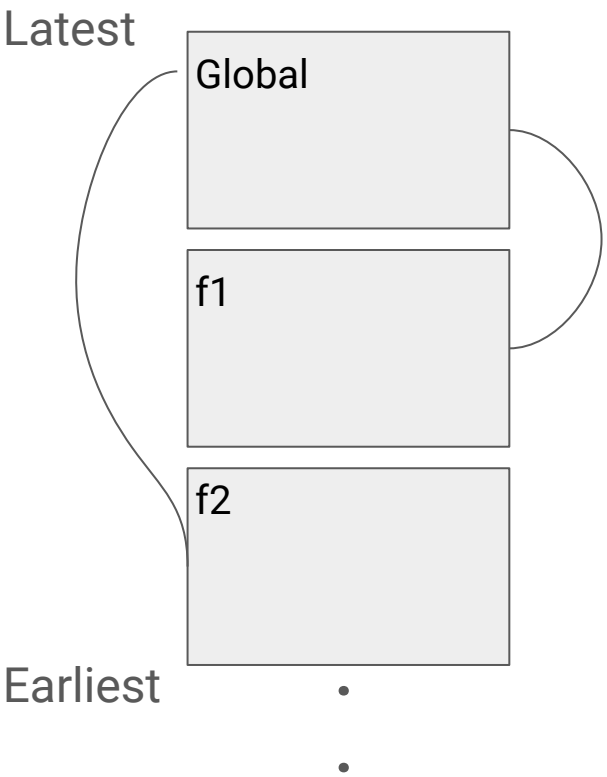
A sequence of frames



A sequence is a first frame, and then the rest of the sequence

Not every frame is part of the same environment, though each frame on the left is part of the **environment diagram**

A sequence of frames



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f2 has a parent frame of Global, and f1 has a parent frame of Global

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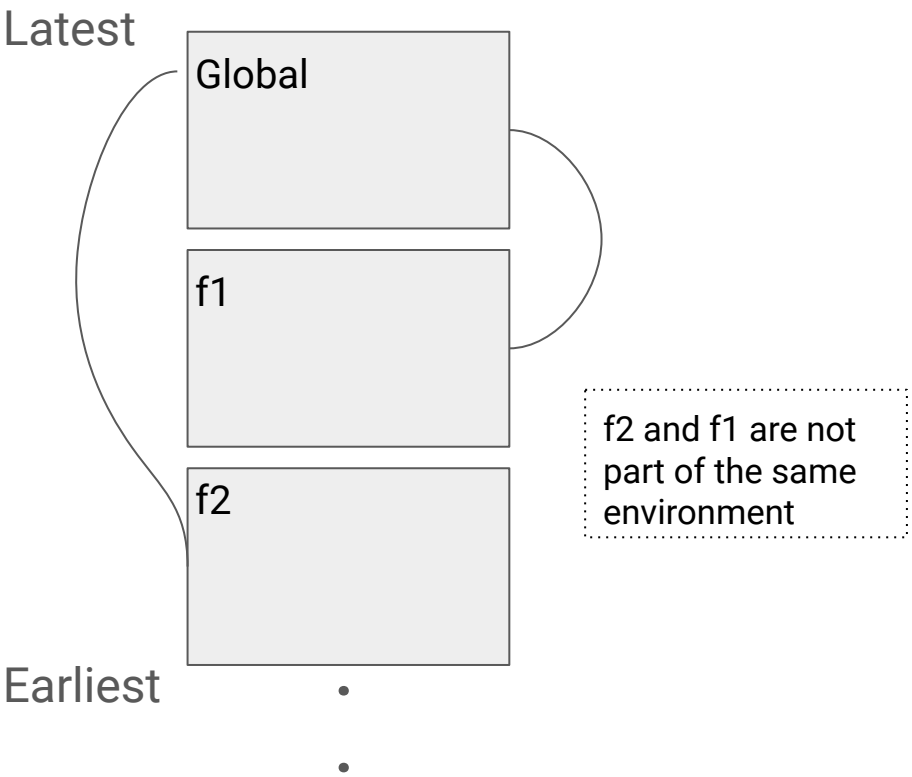

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f2 has a parent frame of Global, and f1 has a parent frame of Global

Example #1

```
x = 4
def f():
    x = 2
    return x + 1

def g():
    y = 2
    return x + y

f()
print(g()) # What value gets displayed here?
```

Example #1

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x = 4
def f():
    x = 2
    return x + 1

def g():
    y = 2
    return x + y

f()
print(g()) # What value gets displayed here?
```

Answer: 6

Example #2

```
from operator import mul

def square(square):
    return mul(square, square)

print(square(3))
```

Reminder: Rules for evaluating call expressions

Evaluation procedure for **call expressions**

1. Evaluate the **operator**
2. Evaluate the **operands** from left to right
3. **Apply** the operator (a **function**) to the evaluated operands (**arguments**)

It is not until we finish the first two steps and get to the third step that a new frame is opened, and operand values are bound to the argument names!

Example #2

```
from operator import mul

def square(square):
    return mul(square, square)

print(square(3))
```

Answer: 9

Summary

- An **expression** is anything that evaluates to a value in Python
  - Primitive and call expressions
- **Assignment statements** bind names to values
- Call expression evaluation follows a distinct set of rules
  - Evaluate the operator, evaluate the operand, and apply the operator onto the operands
- **Environment diagrams** allow us to visualize assignment
  - Use tutor.cs61a.org to try this out on your own programs!
- Each environment is a sequence of frames, and all frames in a program make up an environment diagram