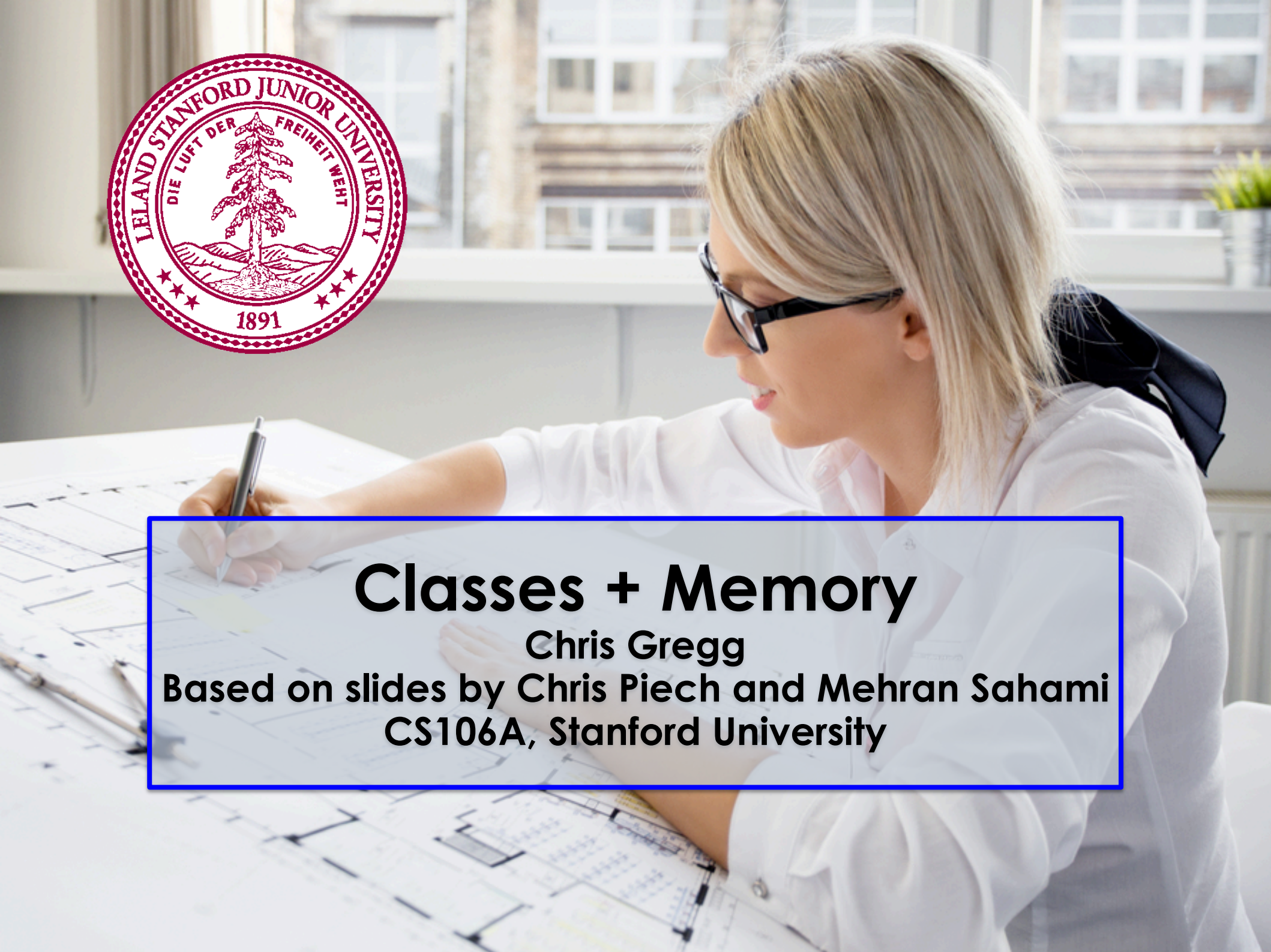
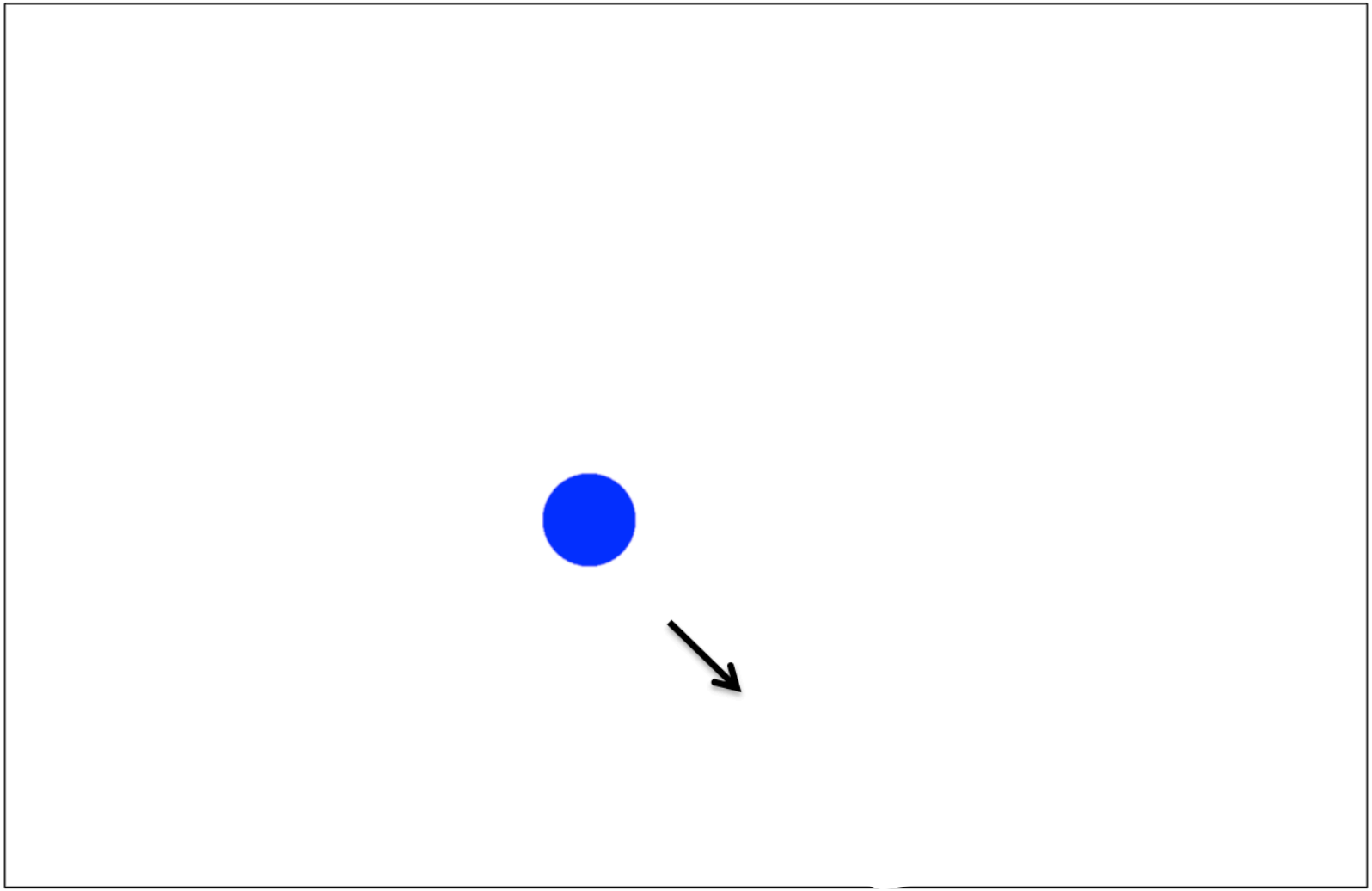


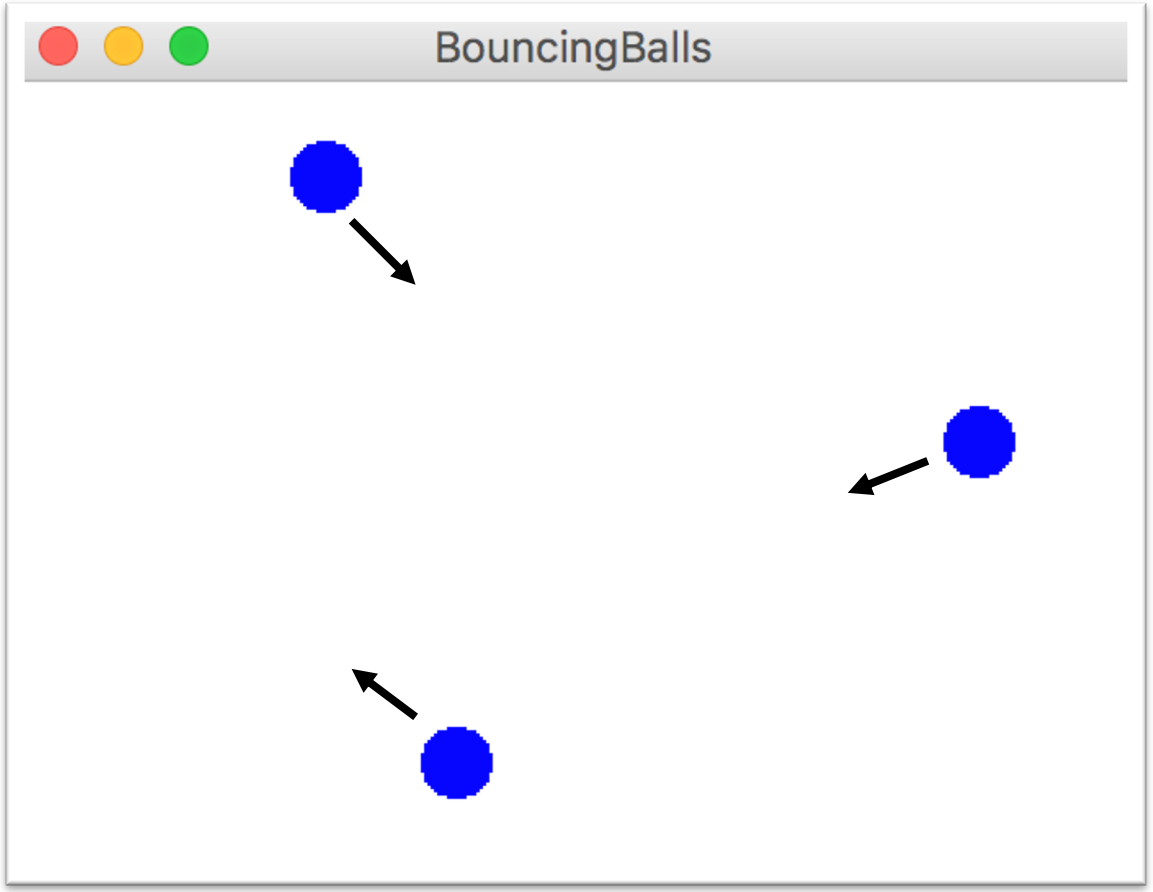
Classes + Memory

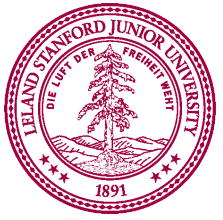
Chris Gregg
Based on slides by Chris Piech and Mehran Sahami
CS106A, Stanford University

Remember this?



Bouncing Balls





Learning Goals

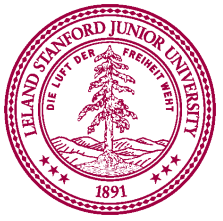
1. Practice with classes
2. See how to trace memory with classes

Guiding question for today:

what does it take to go from
what you know to writing
big-scale software?

Some *large* programs are in Python

YouTube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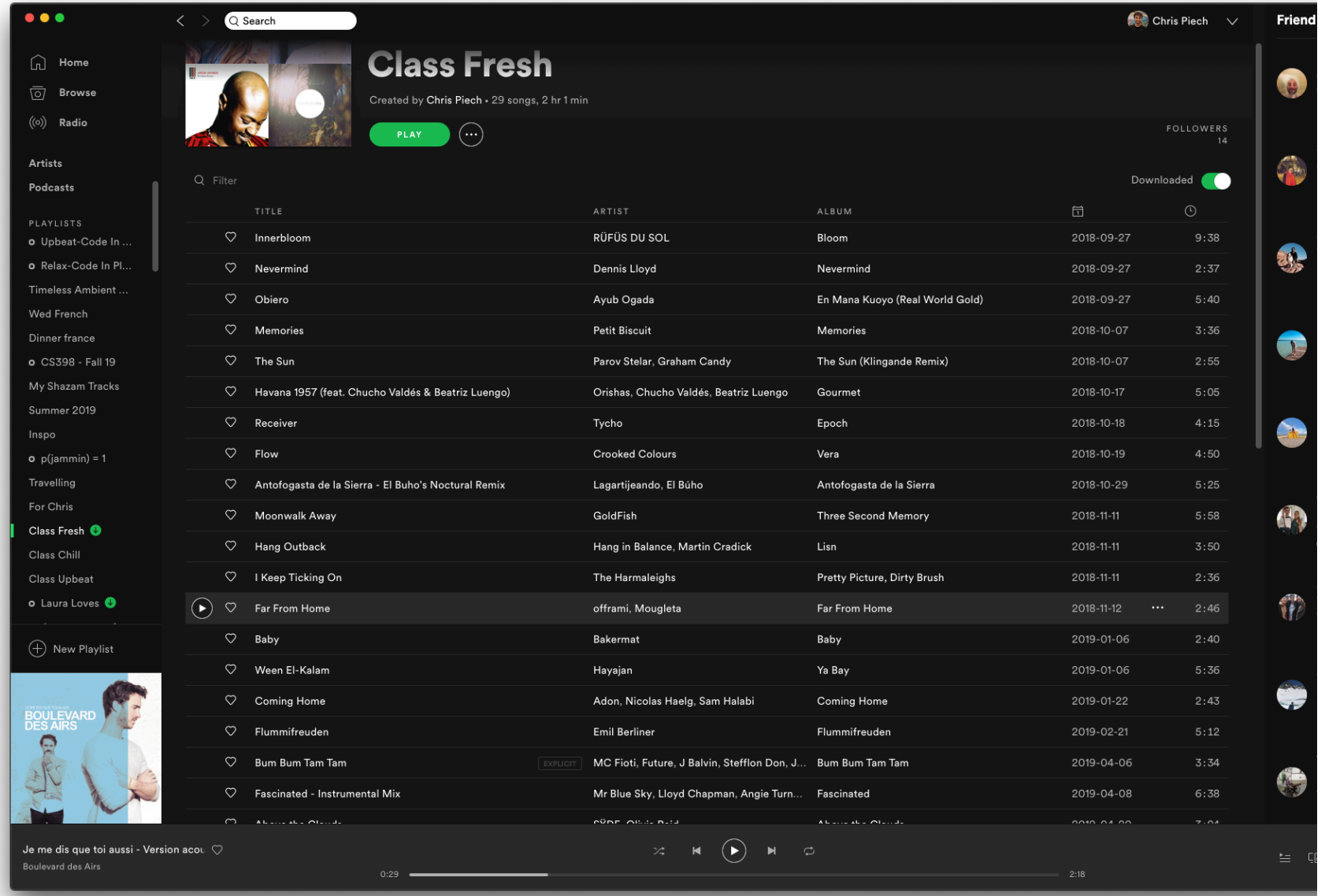


How?

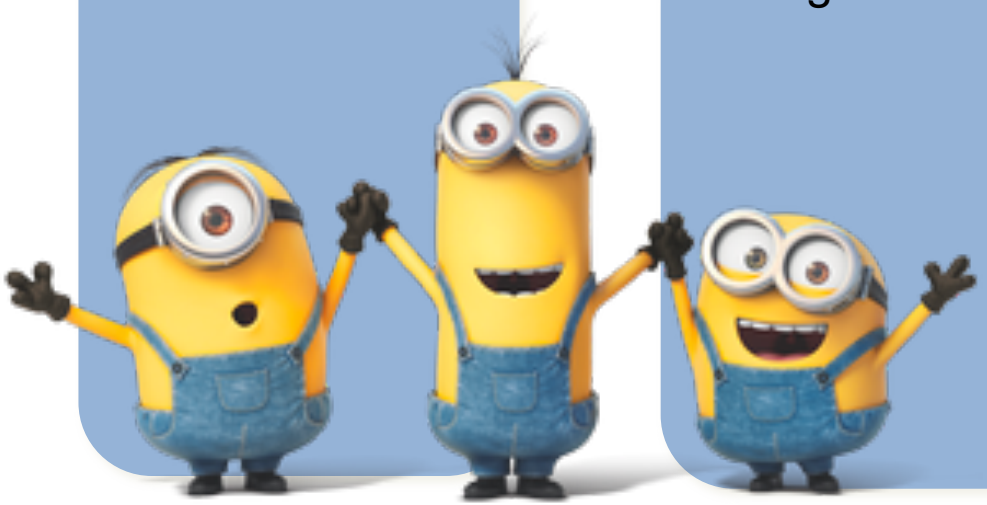
Define New Variable Types

Song

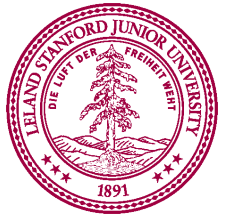
Playlist

User

Song Player

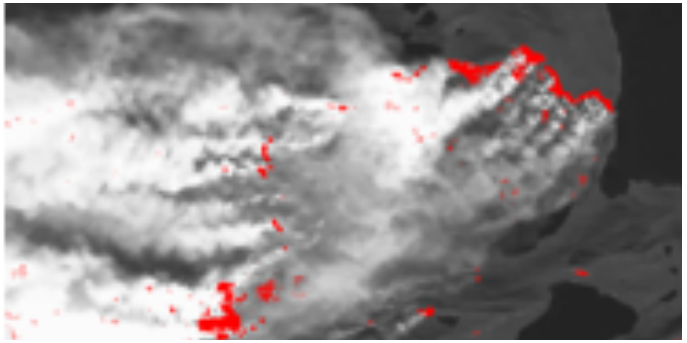


Song Retriever

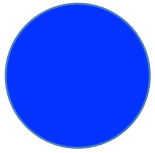


You Have Been *Using* Variable Types

`SimpleImage`



`Canvas`

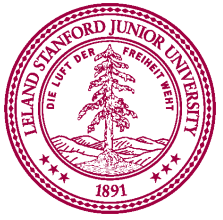


`Karel`

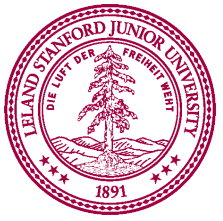
`String`

`int`

What would it take to define your own?



type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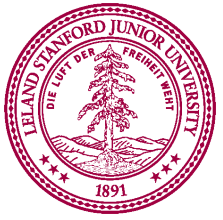
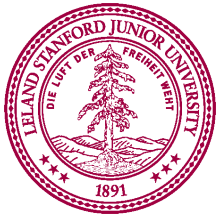
Classes define new variable *types*



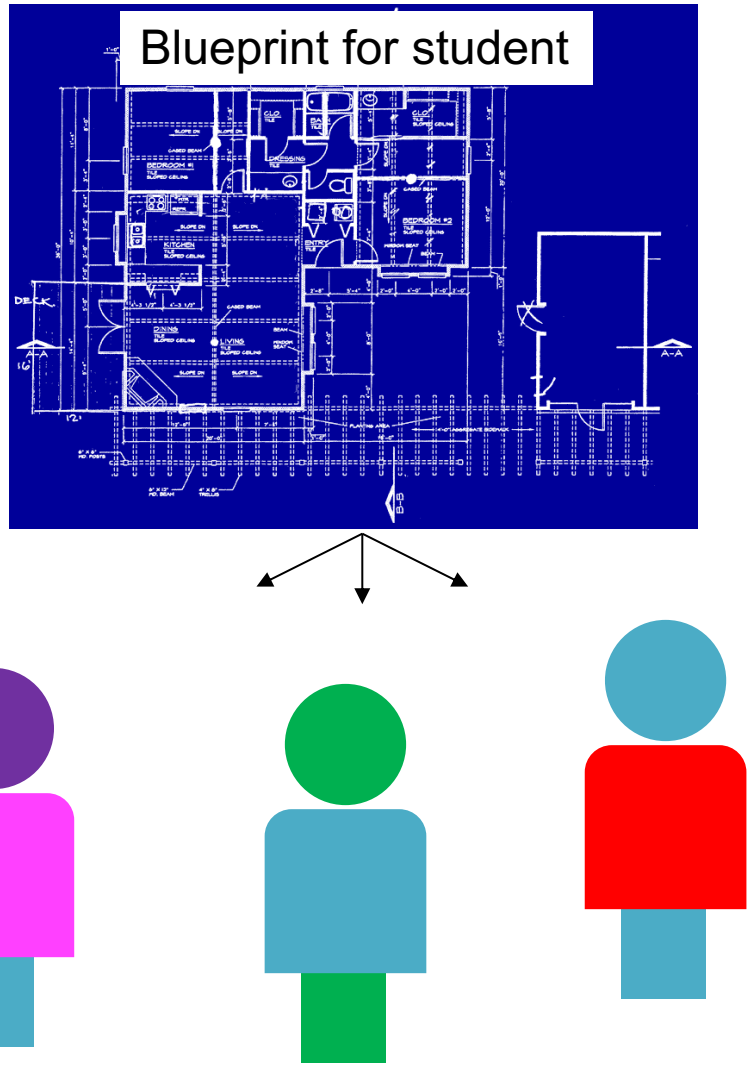
Classes decompose your program across files



Classes are like blueprints

class: A template for a new type of variable.

A blueprint is a helpful analogy



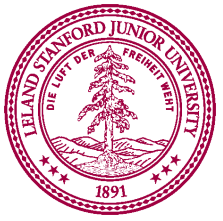
You must define three things

1. What **variables** does each instance store?

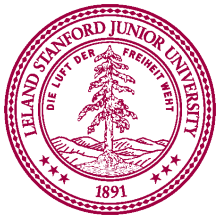
2. What **methods** can you call on an instance?

3. What happens when you make a **`new`** one?

*details on how to define these three things coming soon



.__dict__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Classes Review

Dog.py

```
class Dog:
    def __init__(self):
        self.times_barked = 0

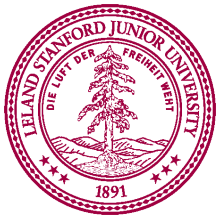
    def bark(self):
        print('woof')
        self.times_barked += 1
```

life.py

```
def main():
    jupiter = Dog()
    juno = Dog()

    jupiter.bark()
    juno.bark()
    jupiter.bark()

    print(jupiter.__dict__)
    print(juno.__dict__)
```



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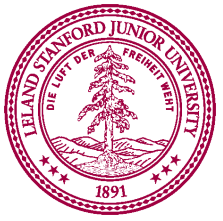
1. What **variables** does each instance store?



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    juno.bark()
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    print(jupiter.__dict__)
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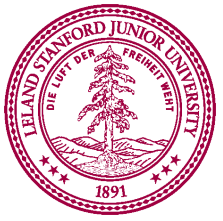
```

2. What **methods** can you call on an instance?



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    jupiter.bark()
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    print(jupiter.__dict__)
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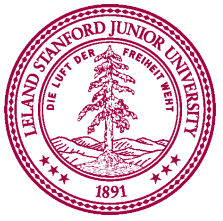
```

3. What happens when you make a **new** one?



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    juno.bark()
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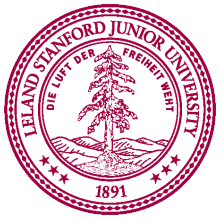
    print(jupiter.__dict__)
    print(juno.__dict__)
```

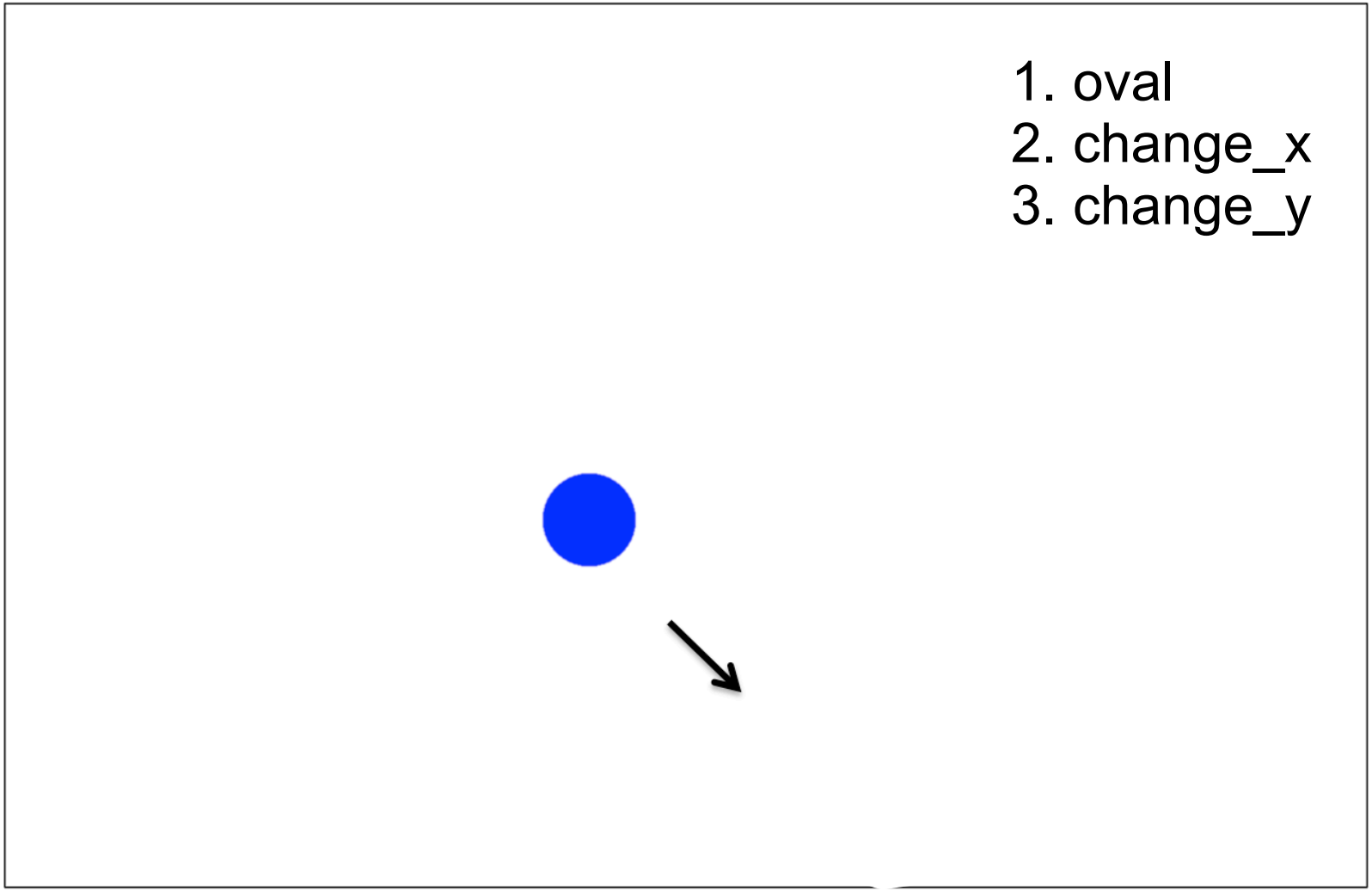
Did I mention that a class is like a fancy dictionary?



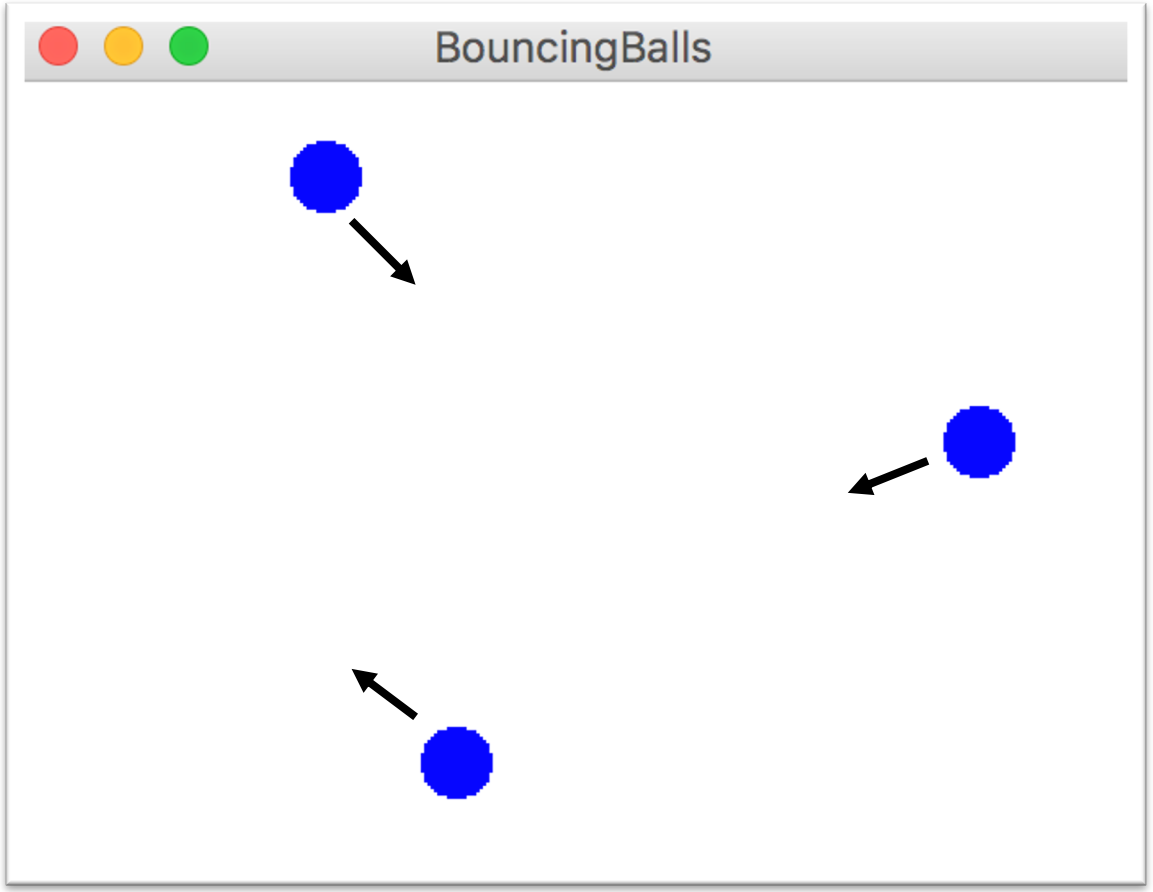
What is a class?

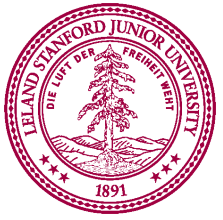
A class defines a new variable type

How many variables for the ball?



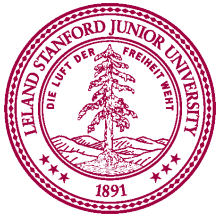
Bouncing Balls





1: Store a list of dictionaries

2: Store a list of Balls

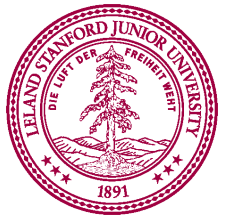


Next step in writing large programs:
Better understand memory

You are now ready…

What does this do?

```
def main():
    x = 5
    print(id(x))
    x += 1
    print(id(x))
```



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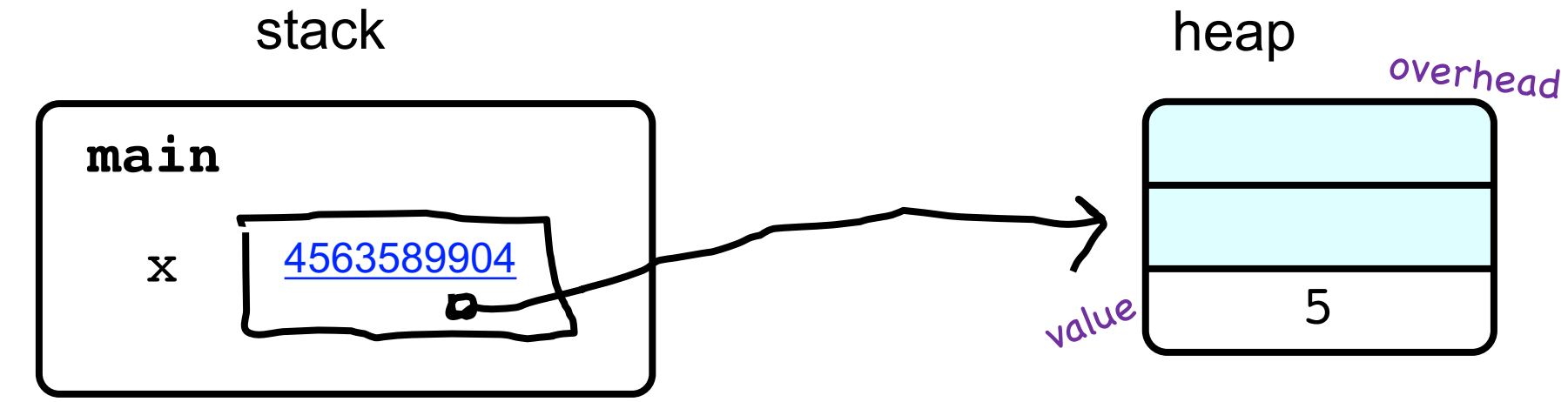

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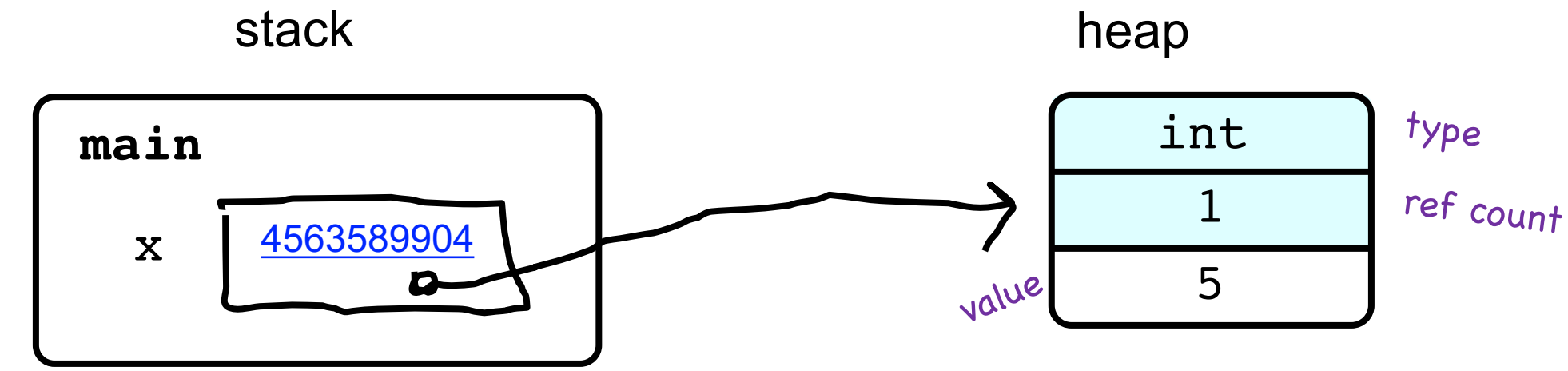

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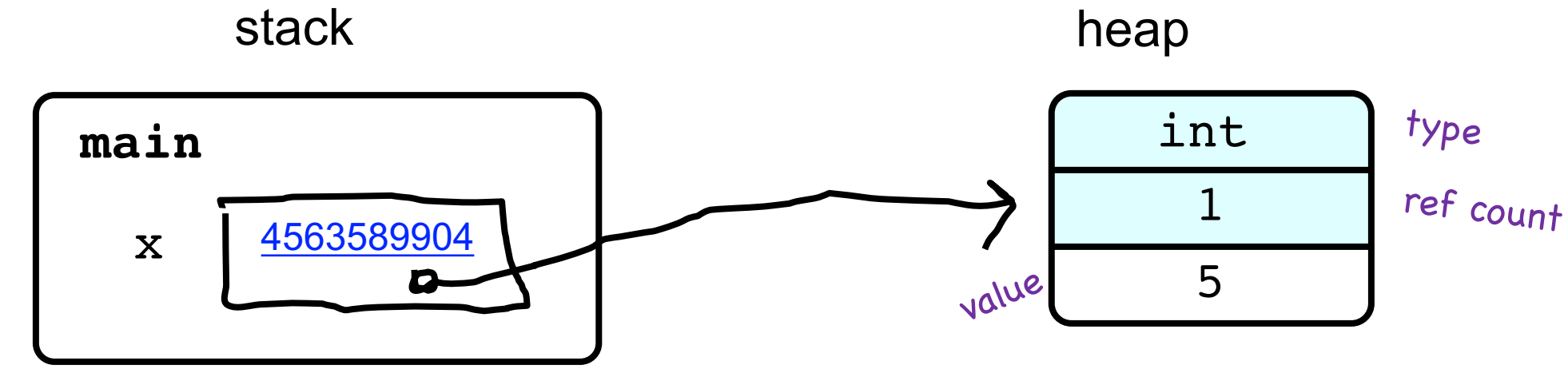

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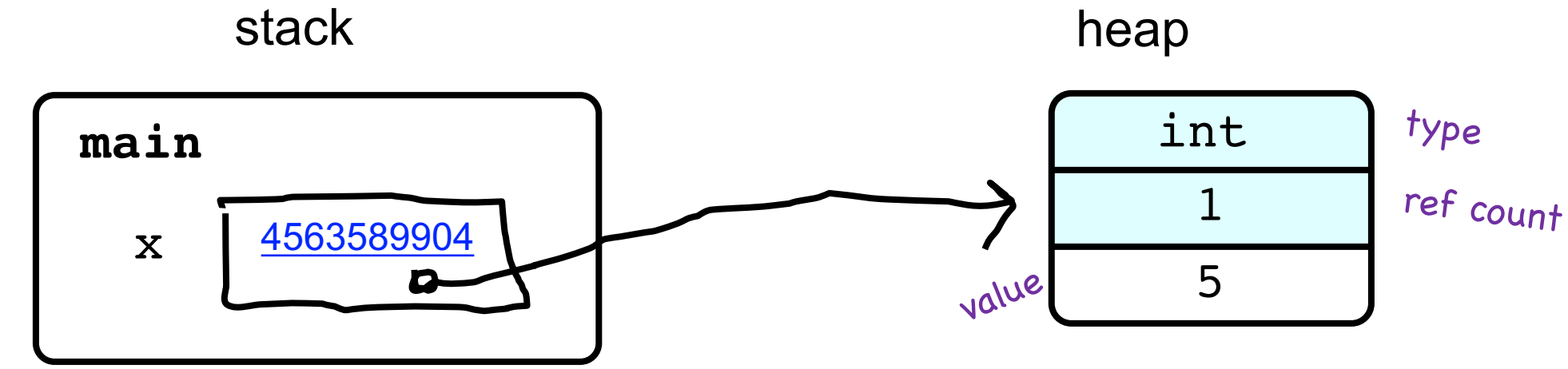
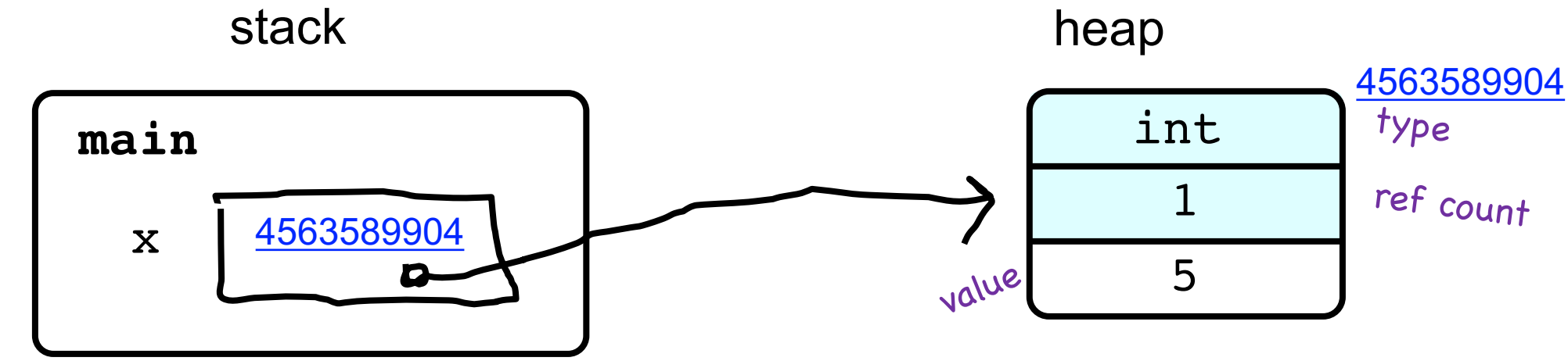


What does this do?

```
def main():
    x = 5
    print(id(x))
    x = x + 1
    print(id(x))
```



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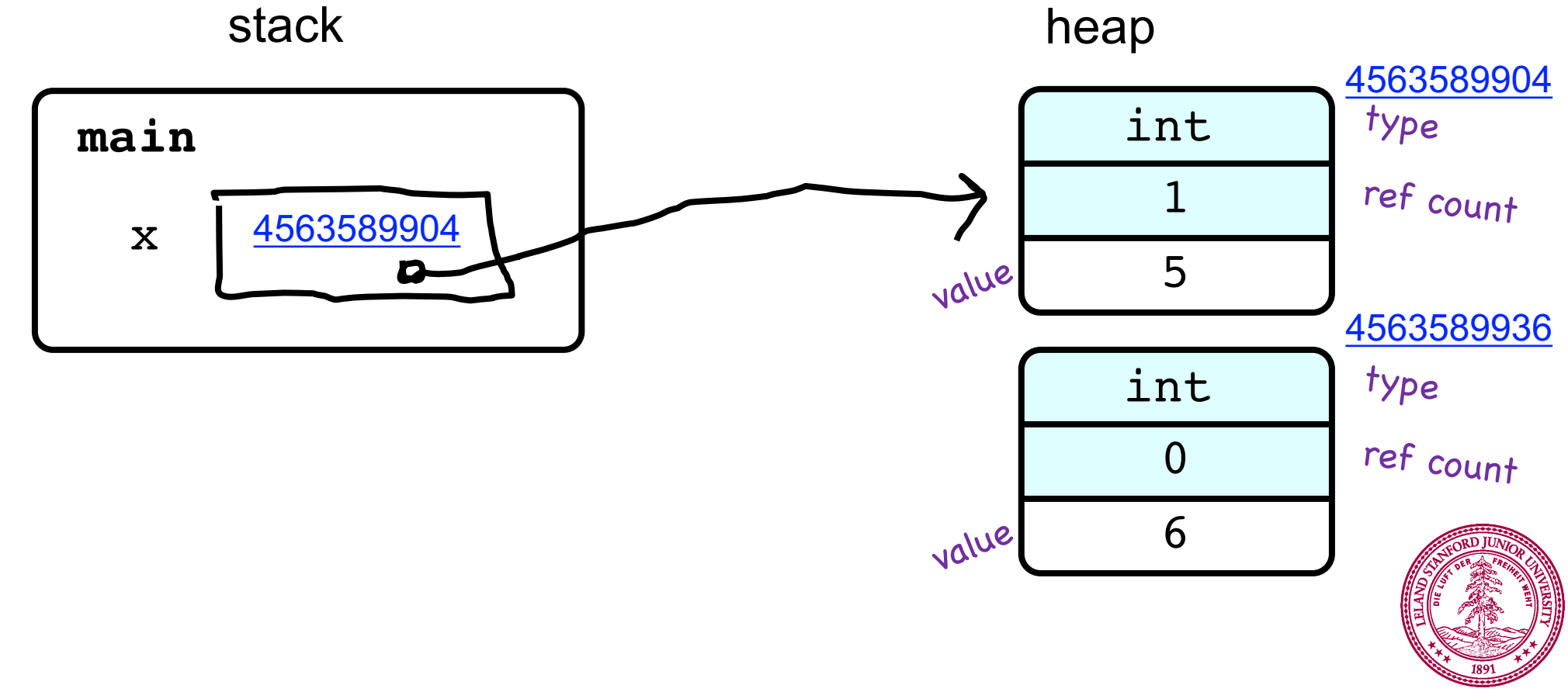

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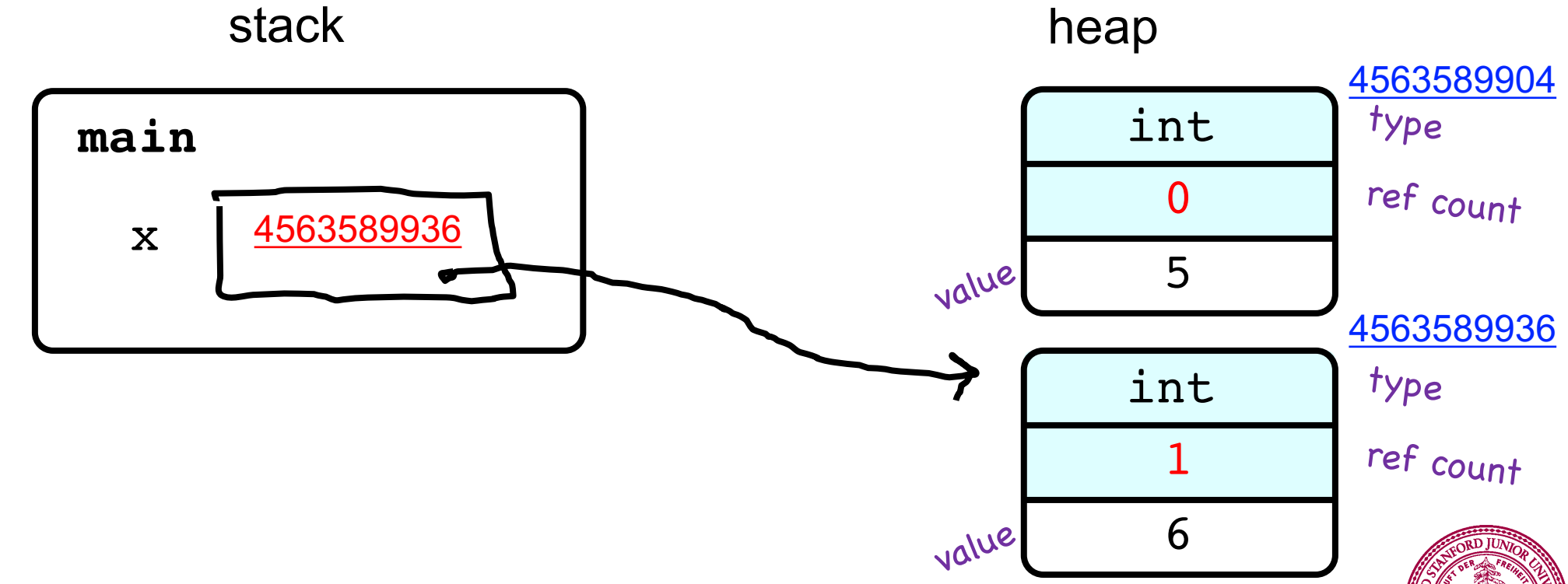

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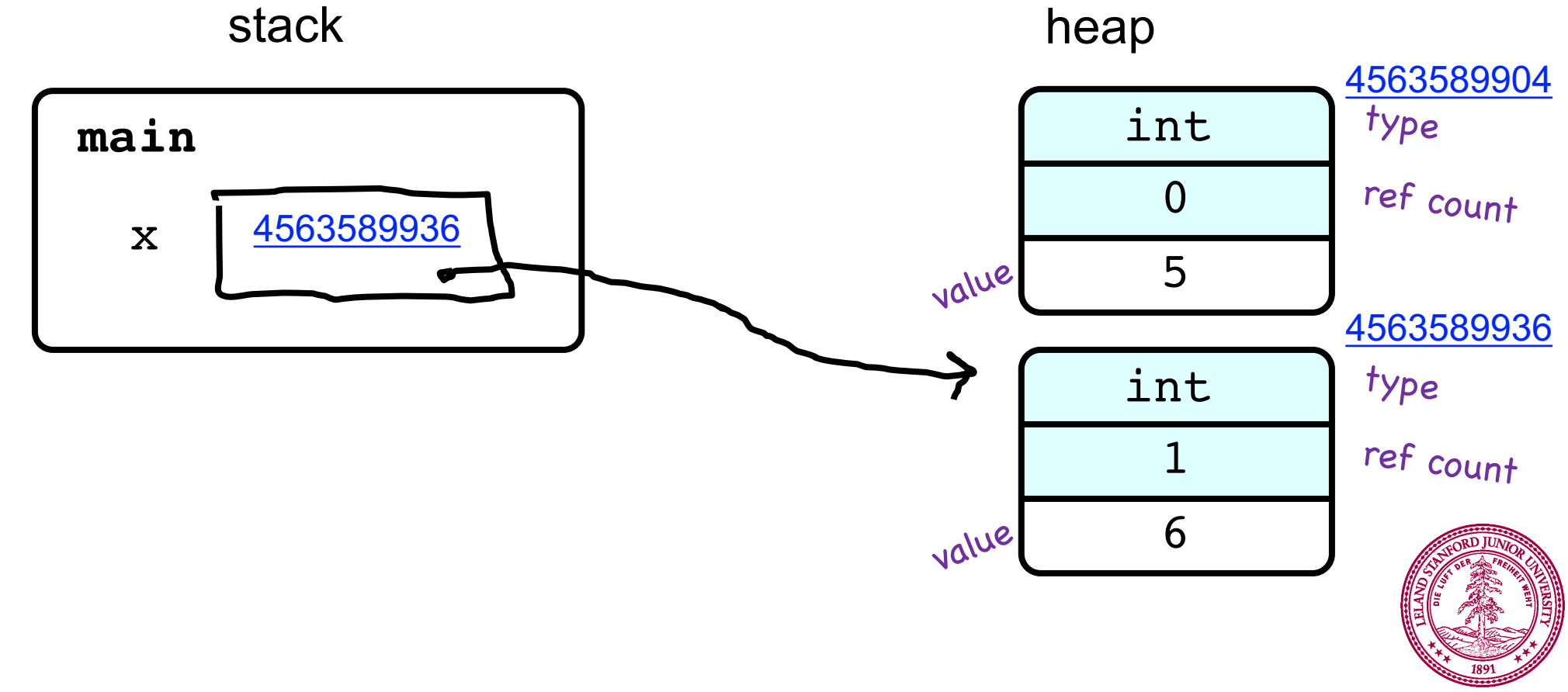
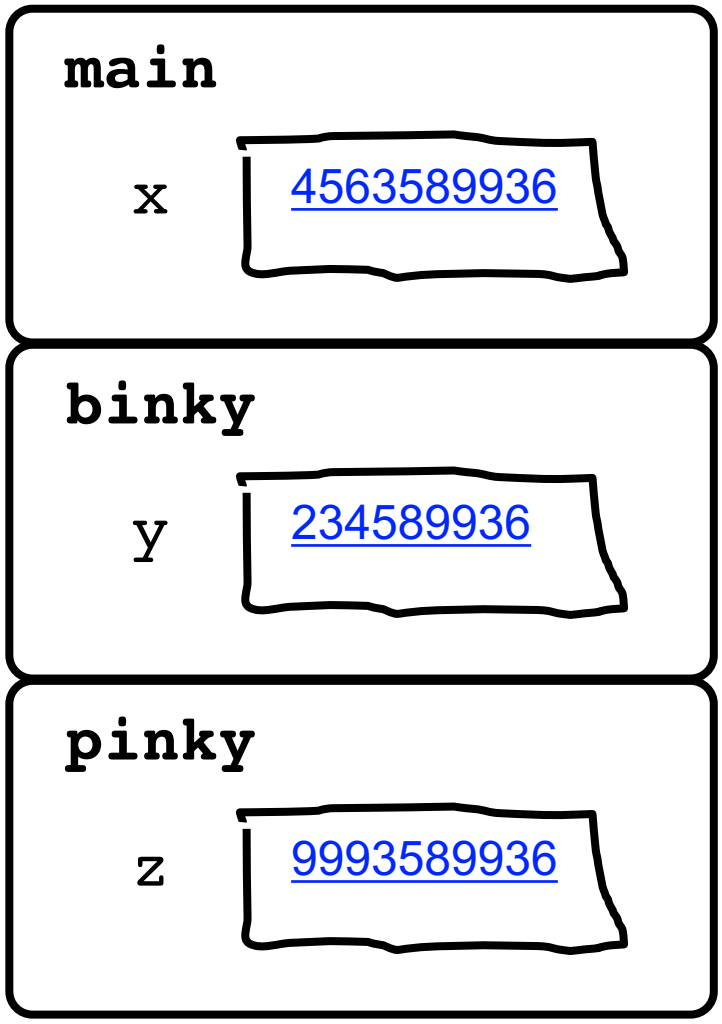
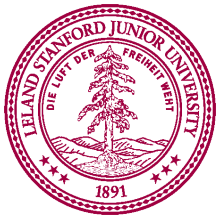


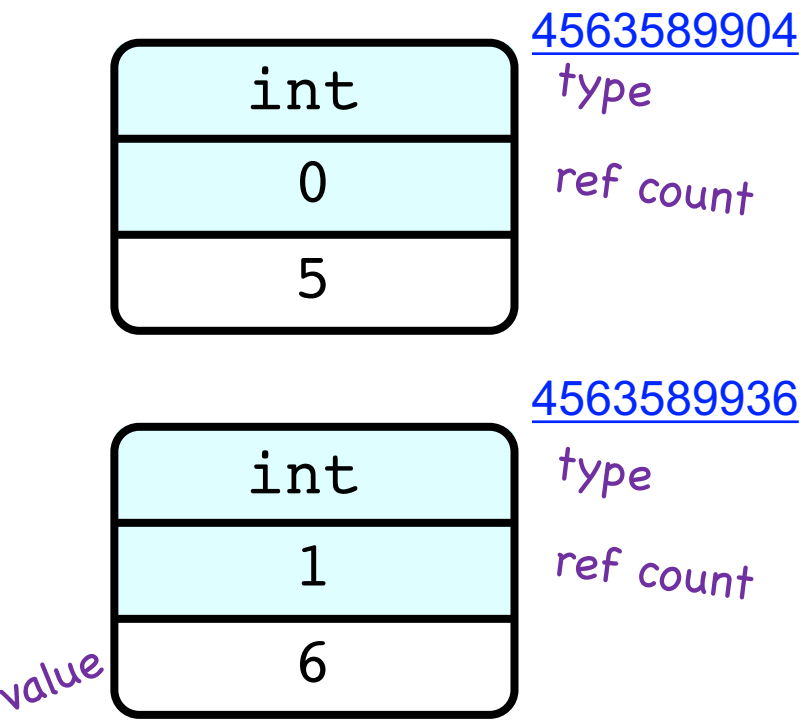
The stack



- Each time a function is called, a new frame of memory is created.
- Each frame has space for all the local variables declared in the function, and parameters
- Each variable has a reference which is like a URL
- When a function returns, its frame is destroyed.



The heap

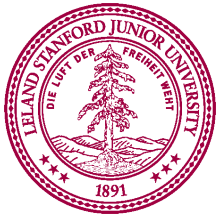


Where values are stored

Every value has an address (like a URL address)

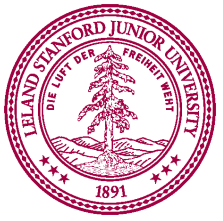
Values don't go away when functions return

Memory is recycled when its no longer used.



Deconstructed Samosa

```
def main():
    x = 5
    x = x + 1
```

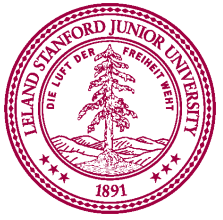


What does this do?

```
def main():
    x = 5
    x = x + 1
```

When a variable is “assigned” you are changing its **reference**

You know a variable is being assigned to if it is on the left hand side of an = sign

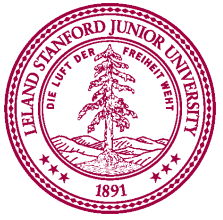


What does this do?

```
def main():
    x = 5
    x = x + 1
```

When a variable is “used” you are accessing its **value**

You know a variable is being used to if it is **not** on the left hand side of an = sign

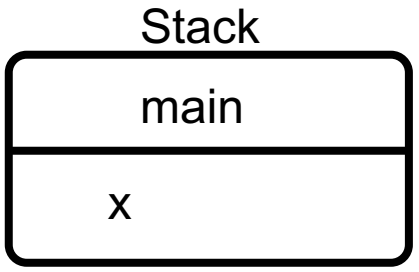


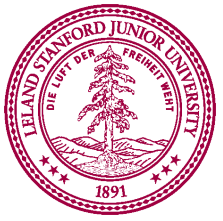
What does this do?

```
def main():
    x = 5
    binky(9)

def binky(y):
    pinky(y)

def pinky(z):
    print(z)
```





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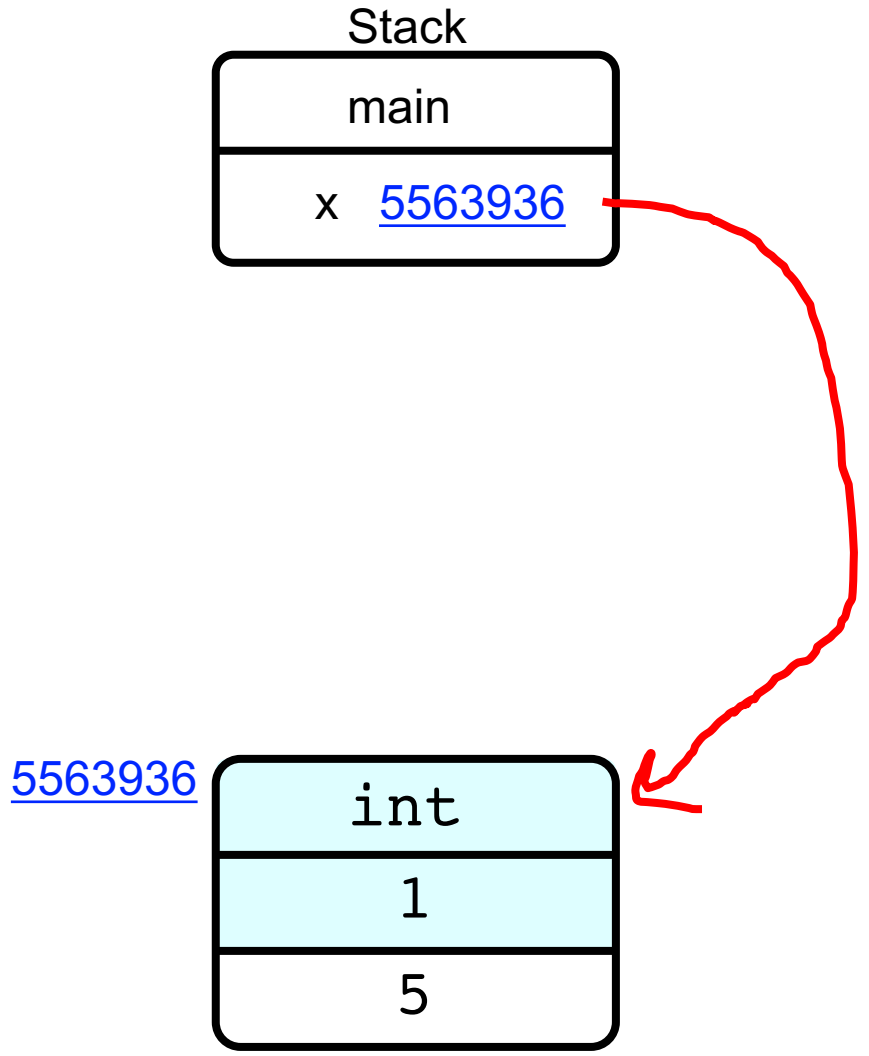

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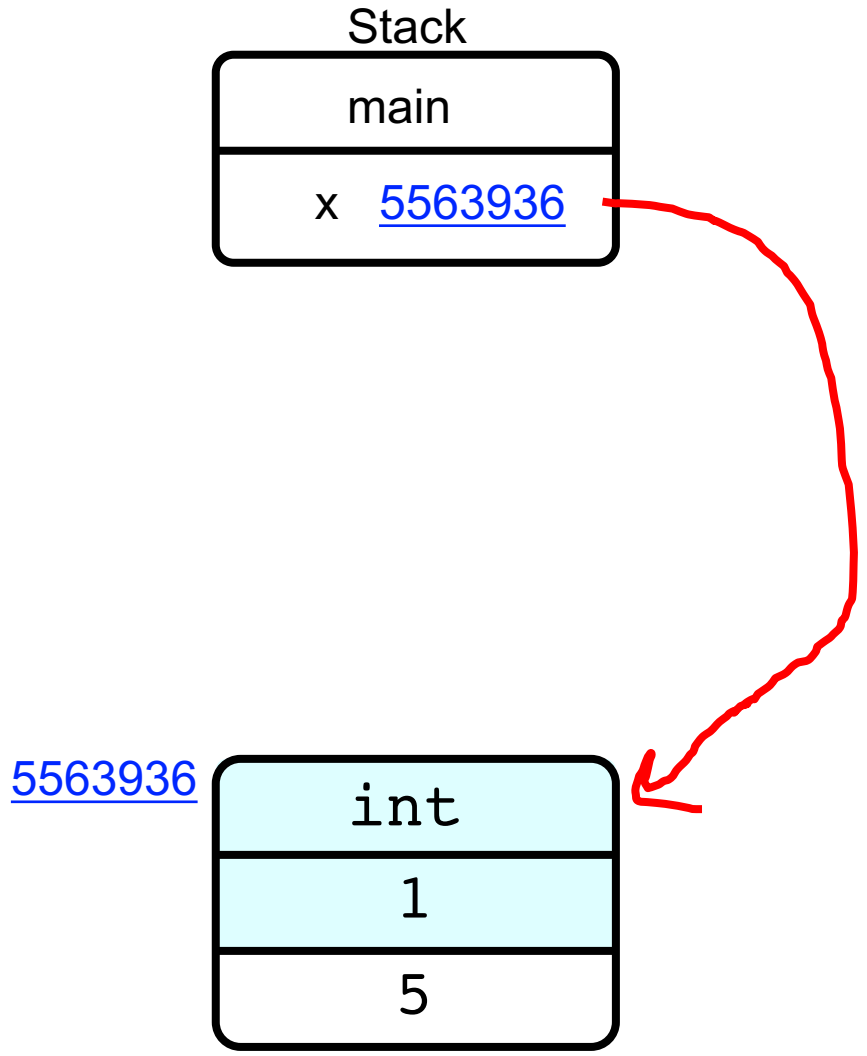
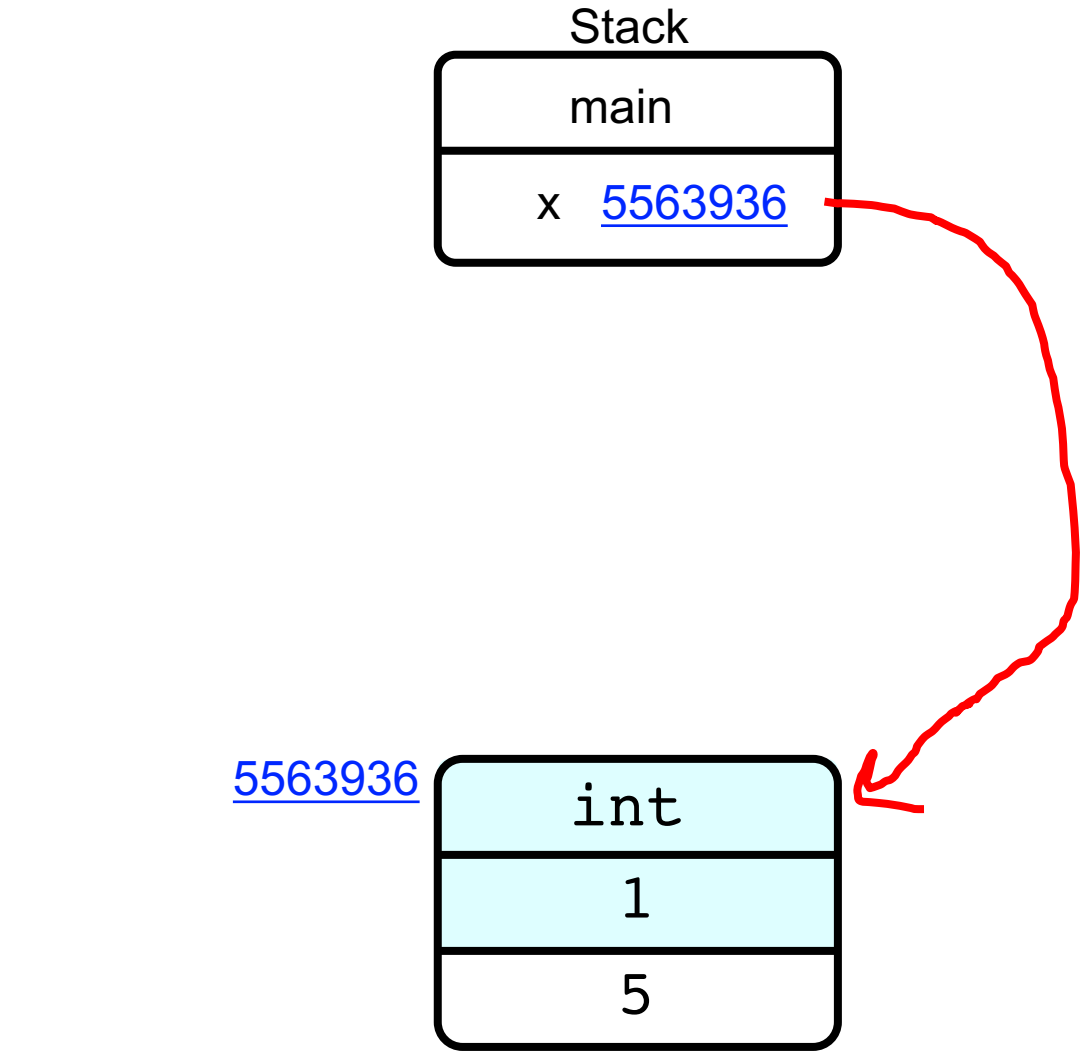


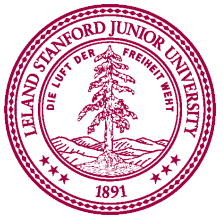
What does this do?

```
def main():
    x = 5
    binky(9)

def binky(y):
    pinky(y)

def pinky(z):
    print(z)
```





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def pinky(z):
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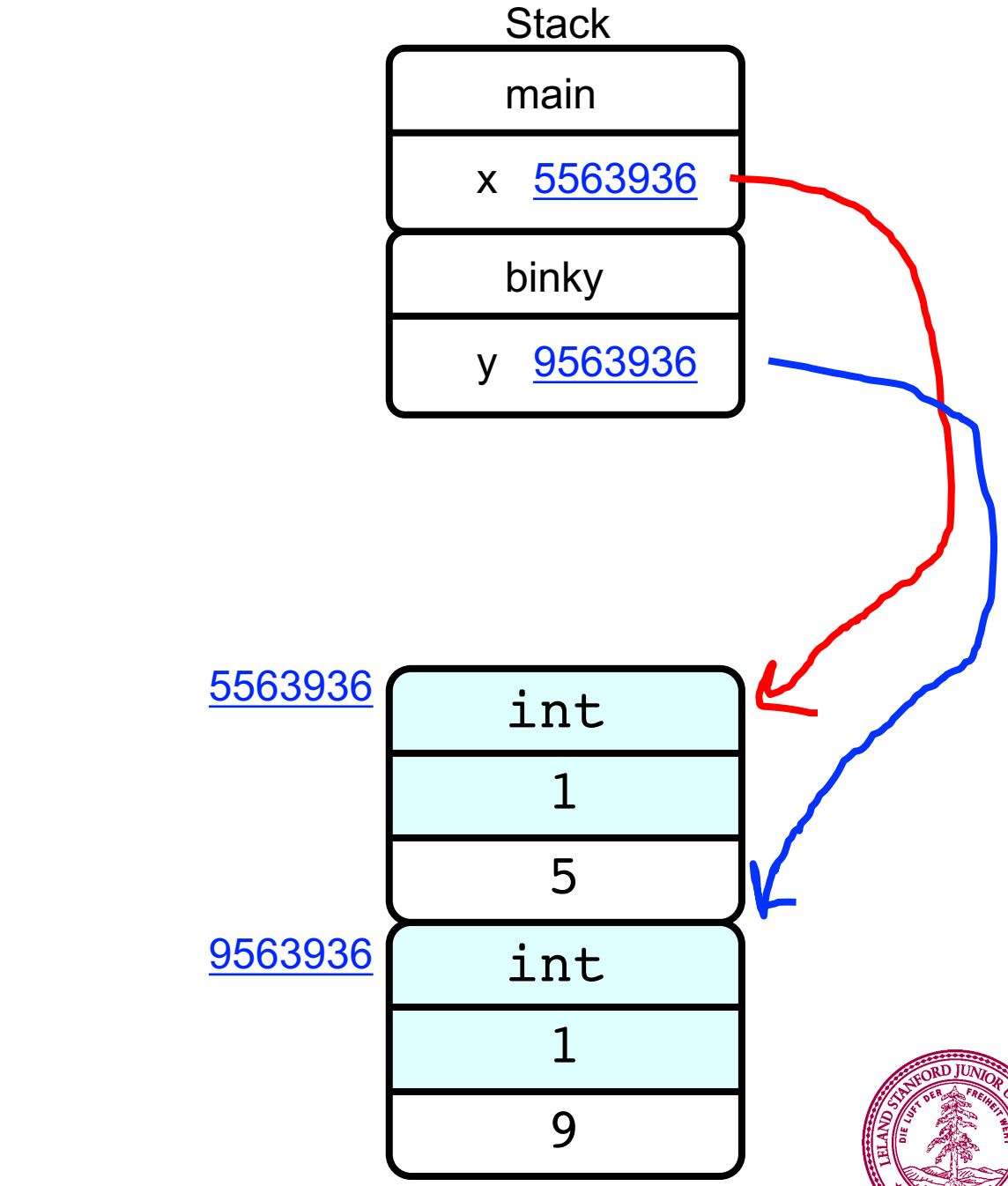

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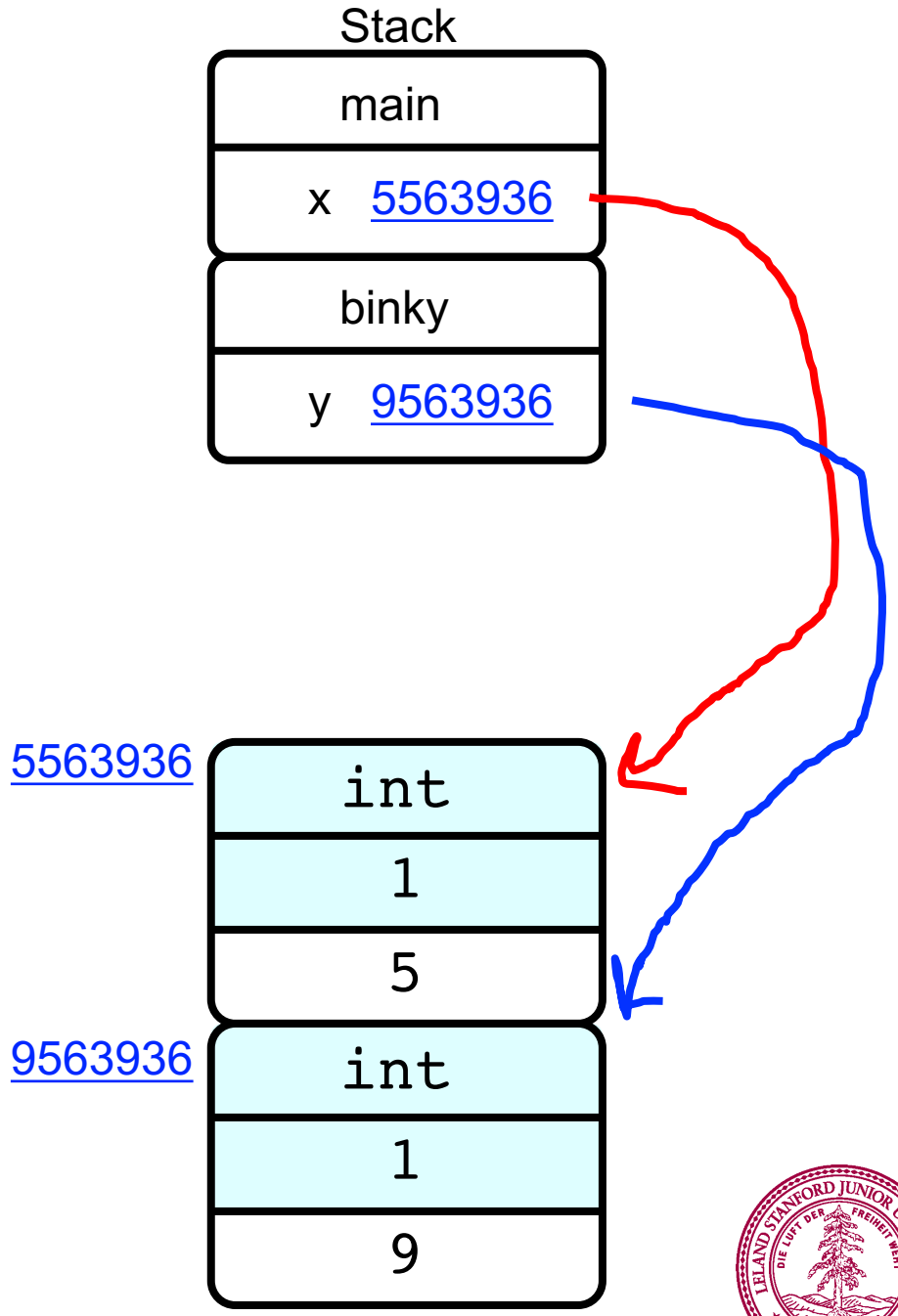

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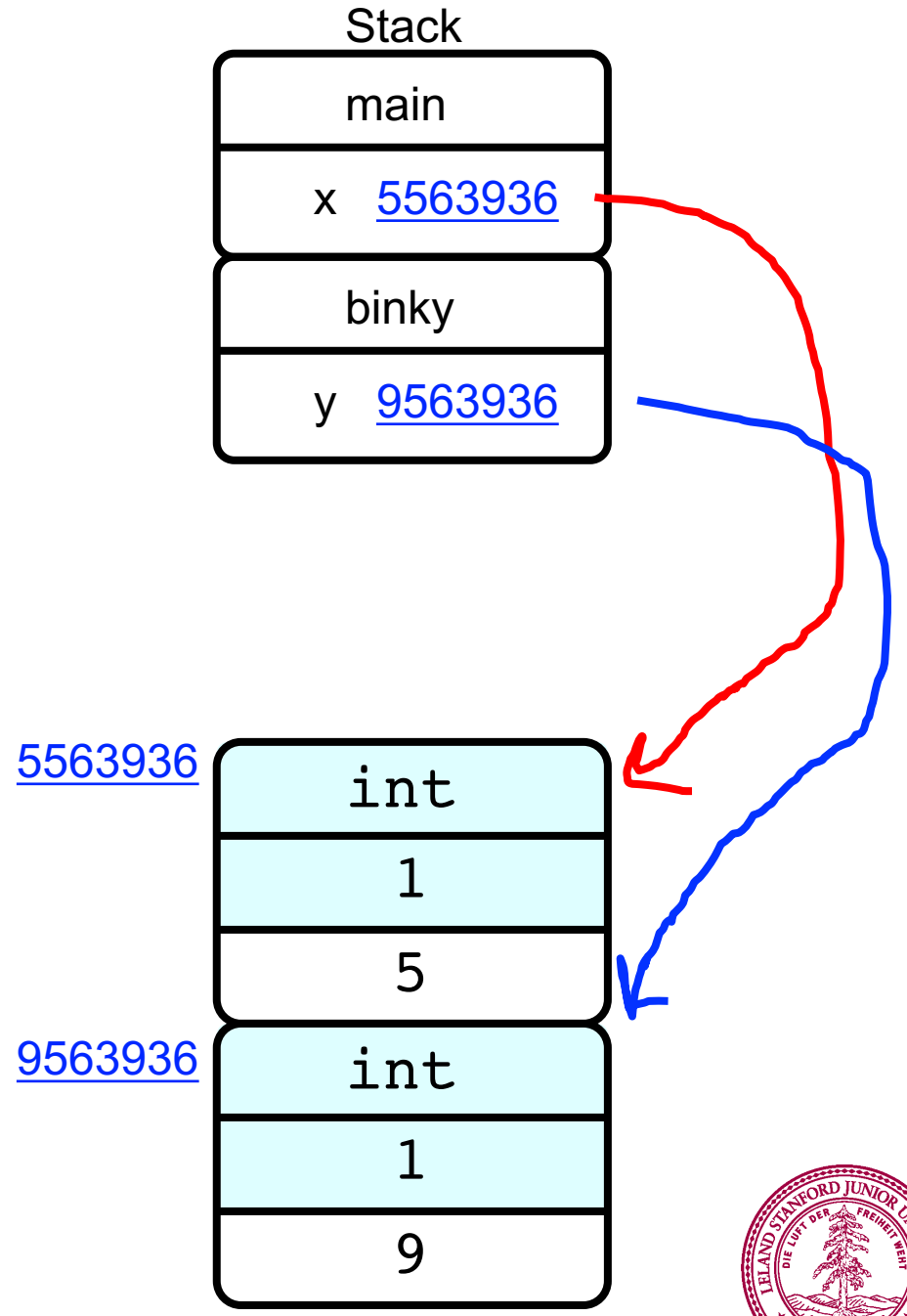

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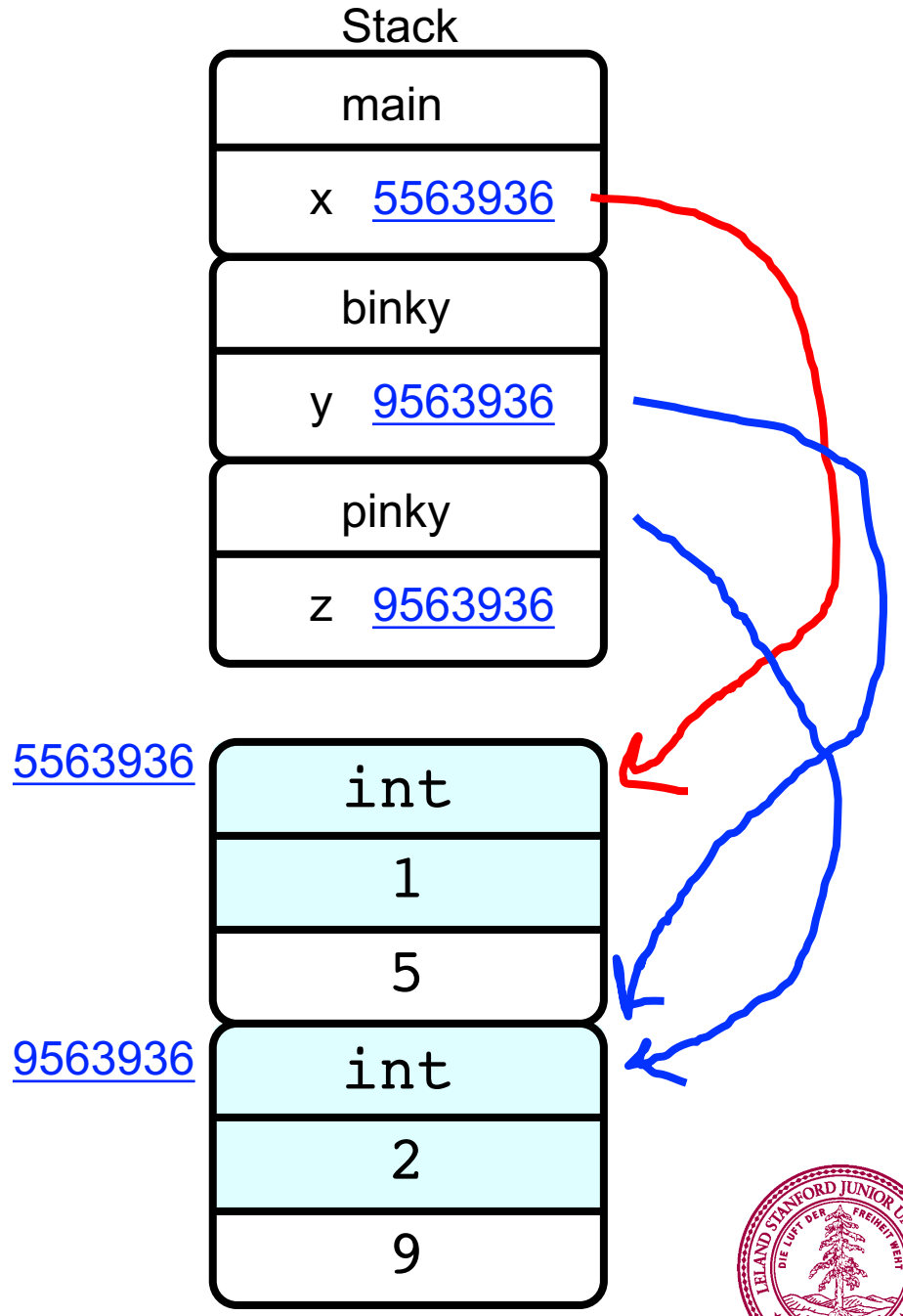

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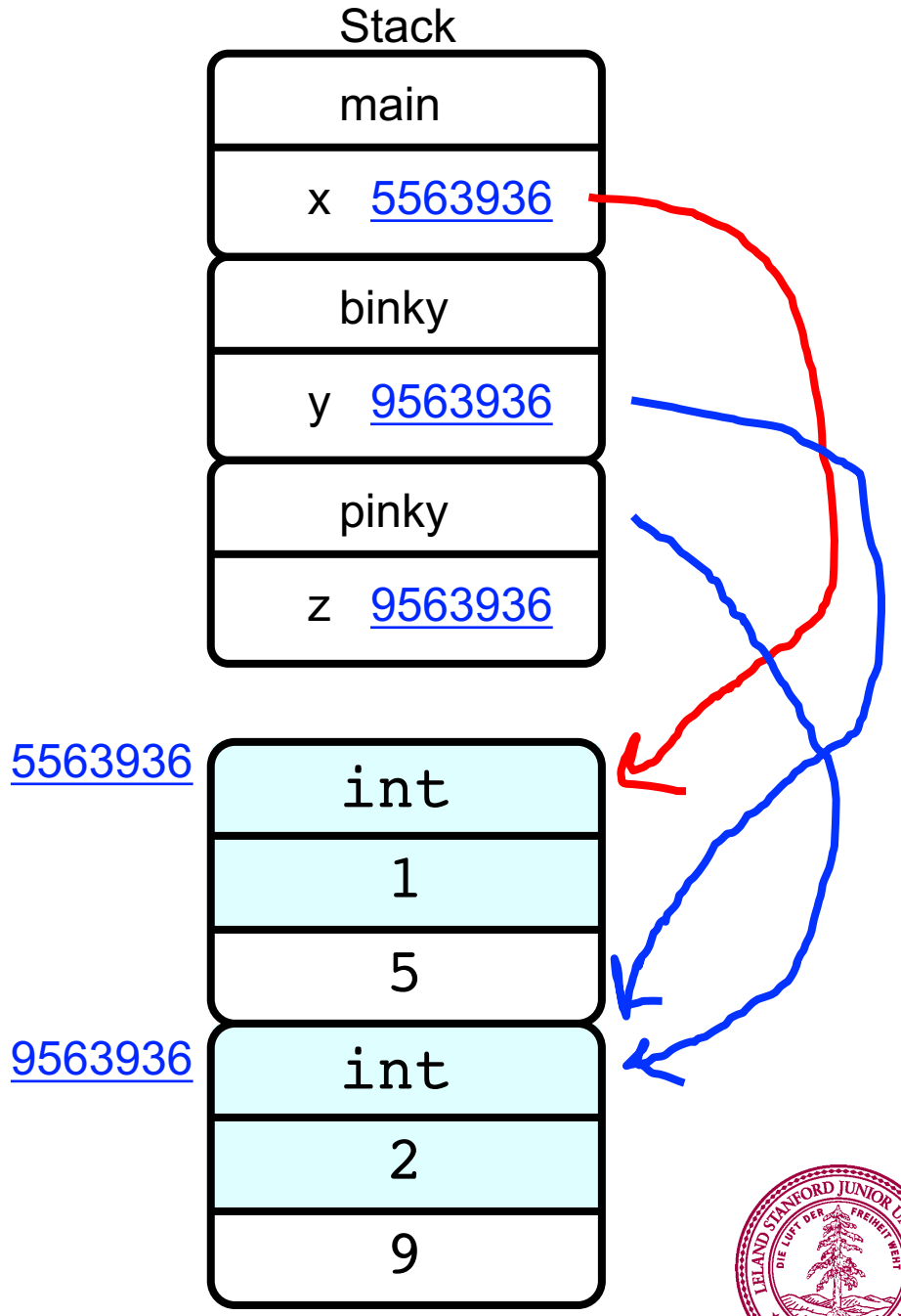

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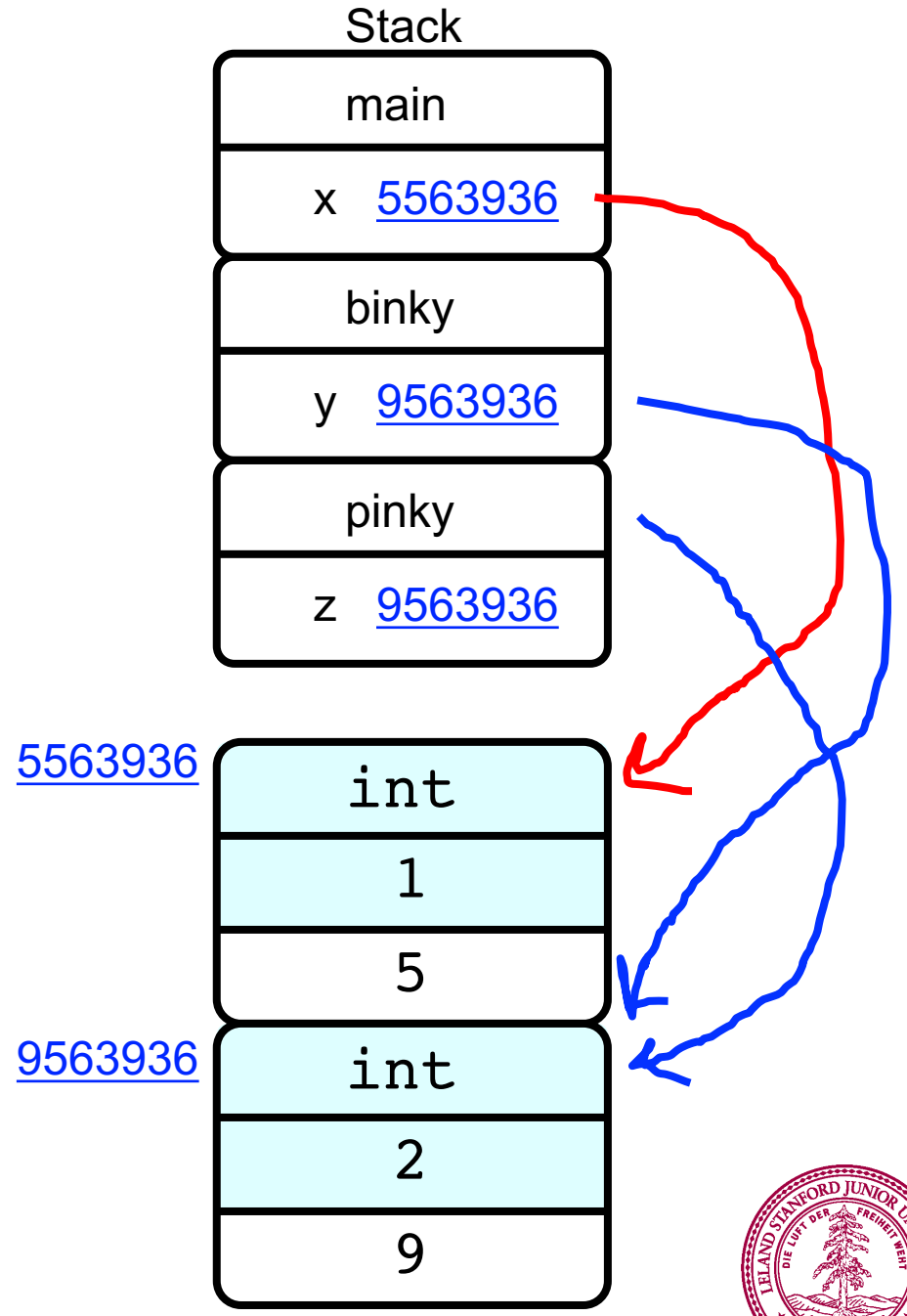

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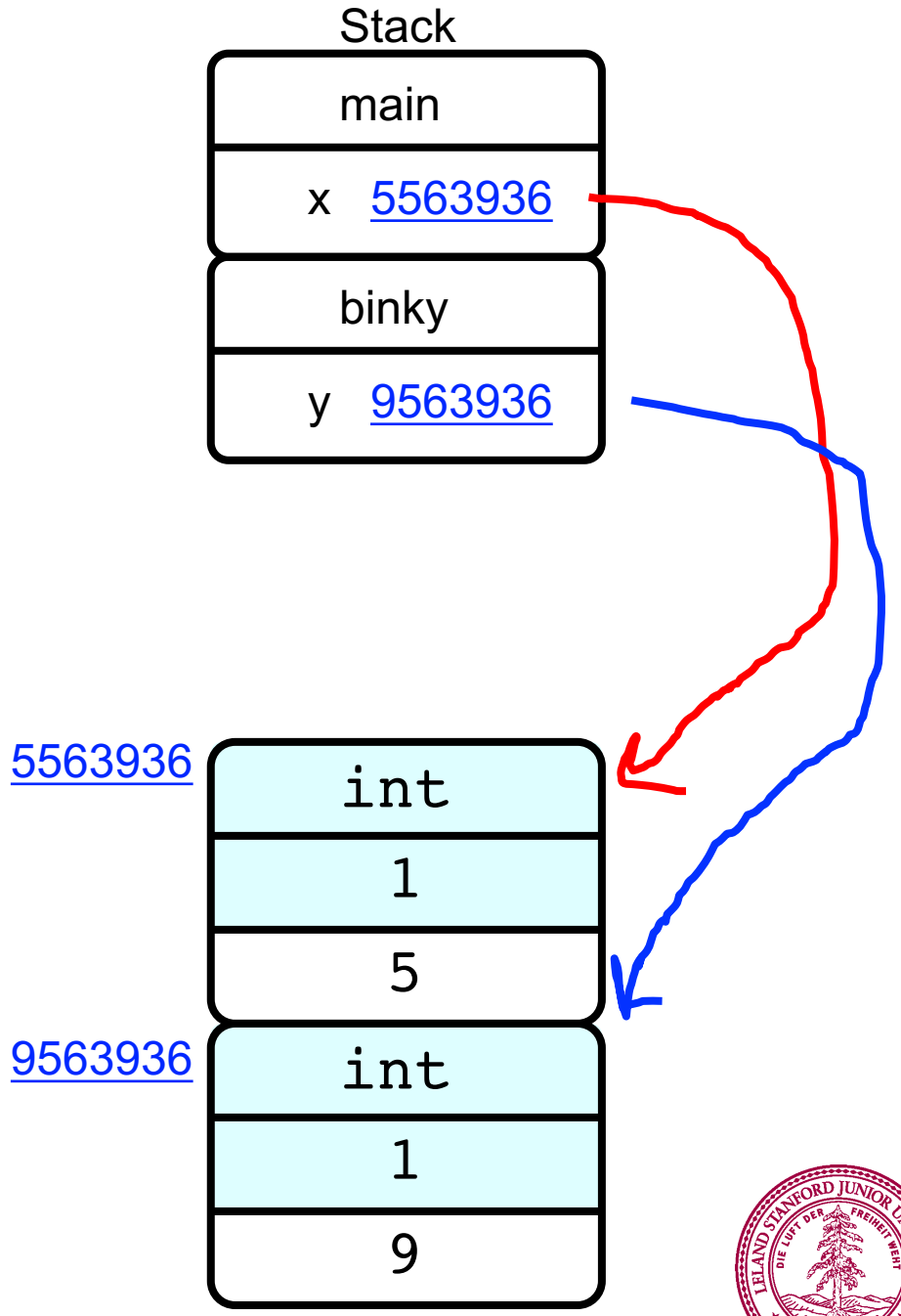

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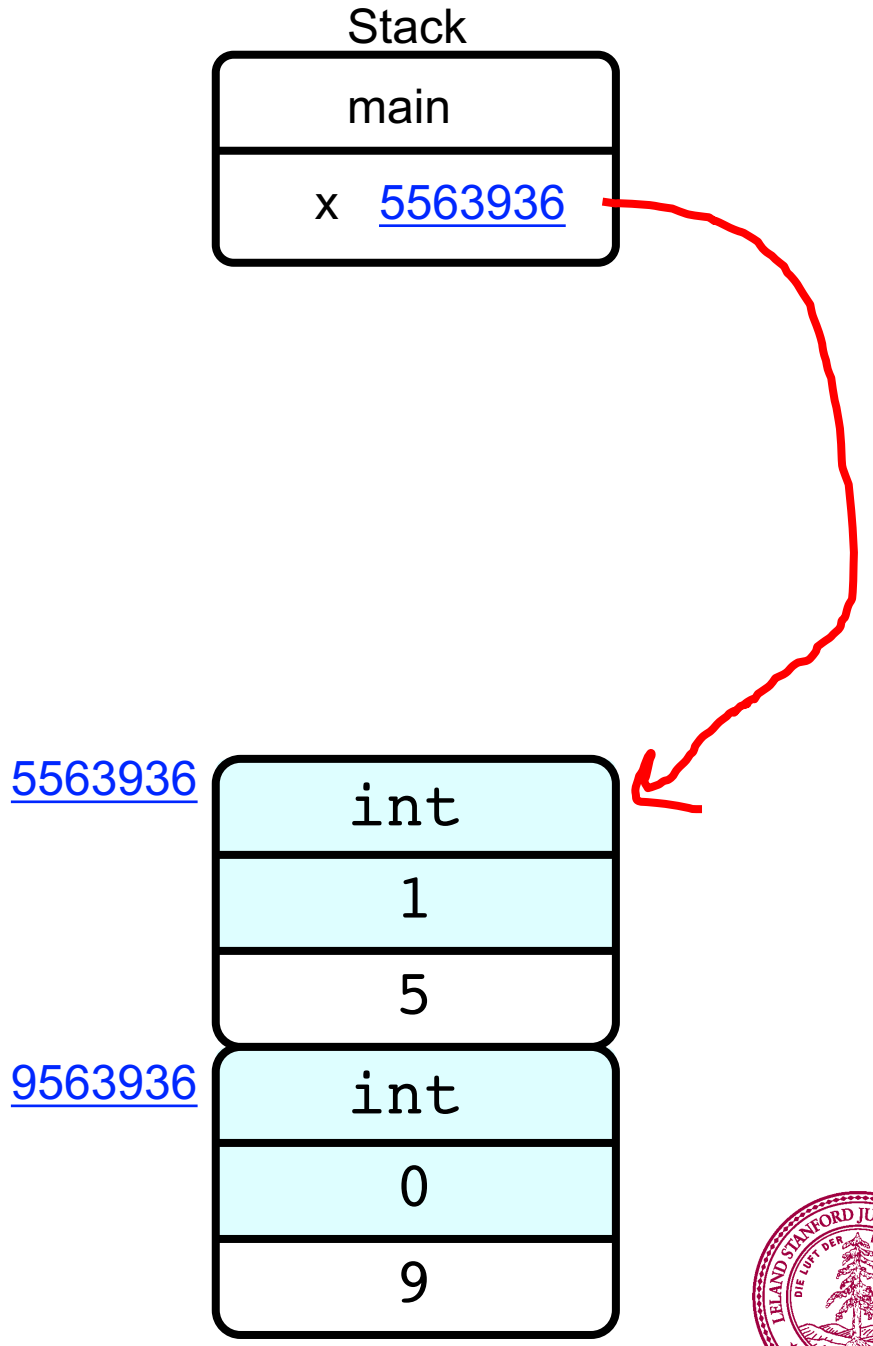

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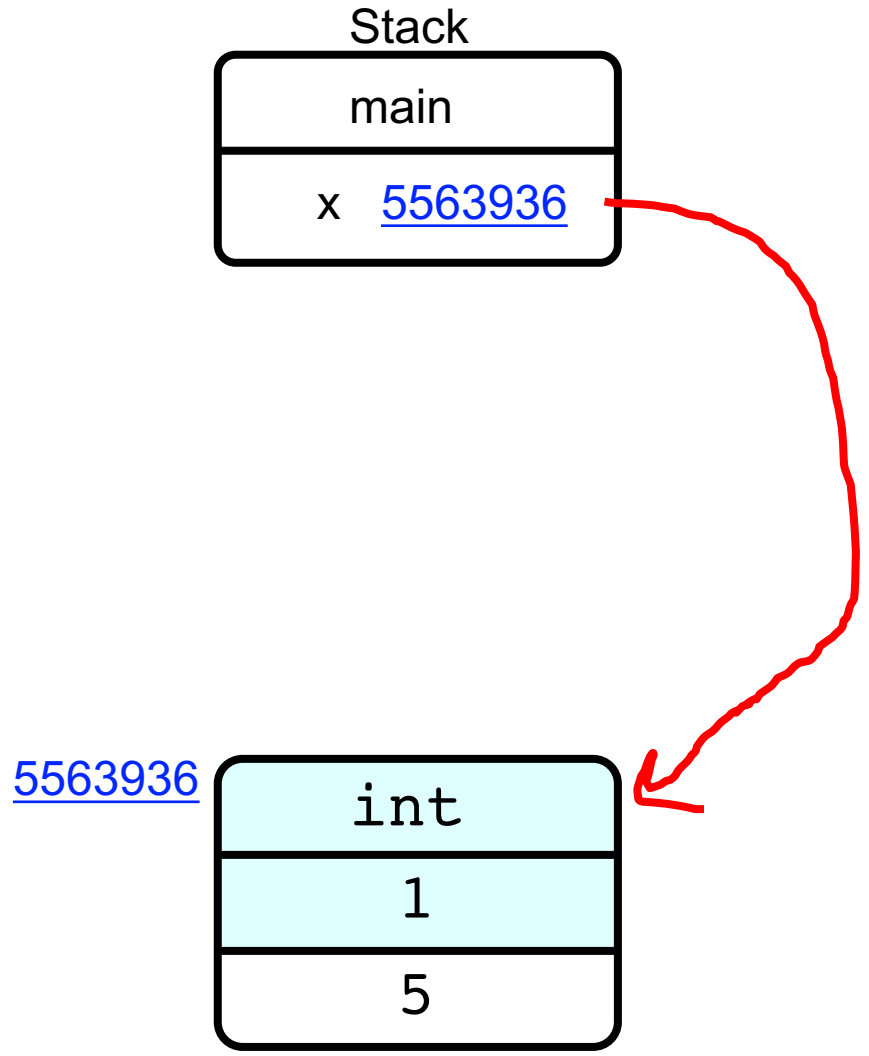

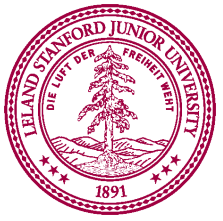

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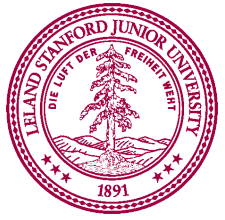
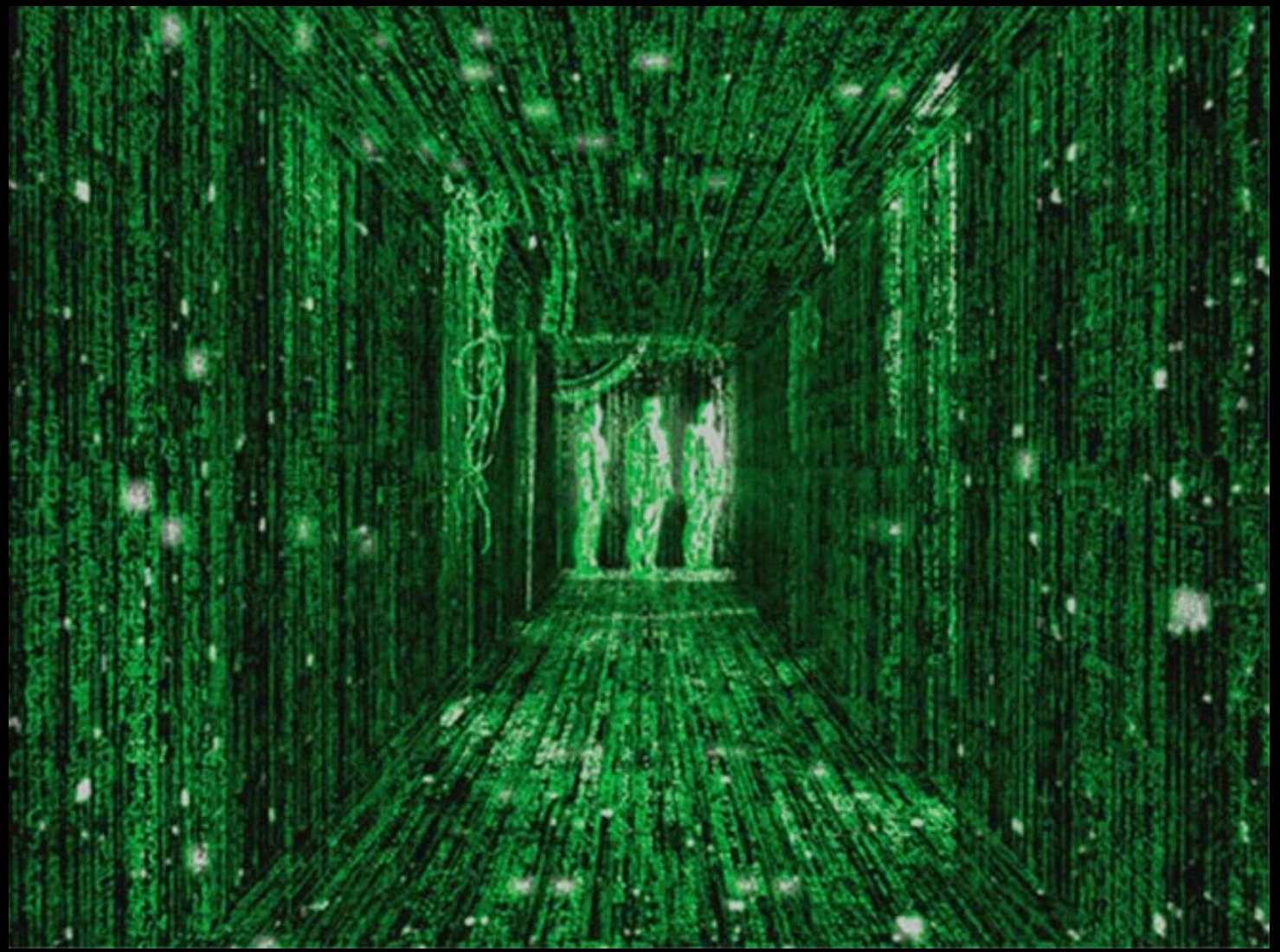


What is… the matrix?



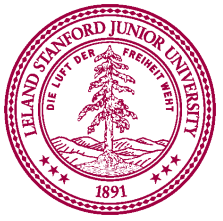
The matrix origins

http://www.pythontutor.com/visualize.html

```
def main():
  x = ['a', 'b', 'c']
  update(x)

def update(x):
  for v in x:
    print(type(v), v)
    v = v + '!'
    print(v)

if __name__ == '__main__':
    main()
```

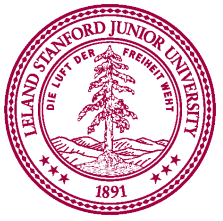


What is `self`?

What does this do?

```
class Dog:
   def __init__(self, name):
      print(self)
      self.name = new_name
      print(self.name)

# put in another file...
def main():
   first = Dog('jupiter')
   print(first)
   print(type(first))
   print(id(first))
   print(first.__dict__)
```



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    print(first)
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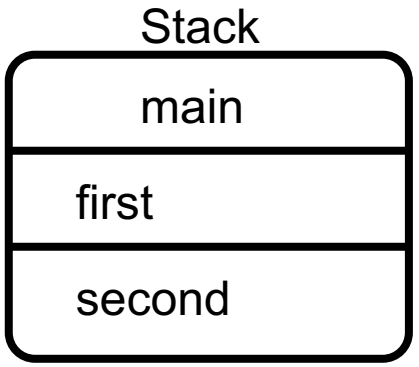

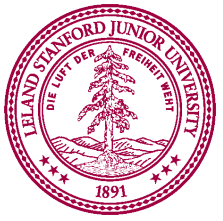

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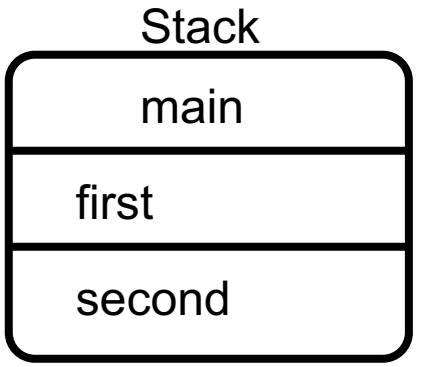

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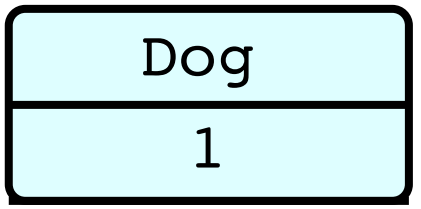

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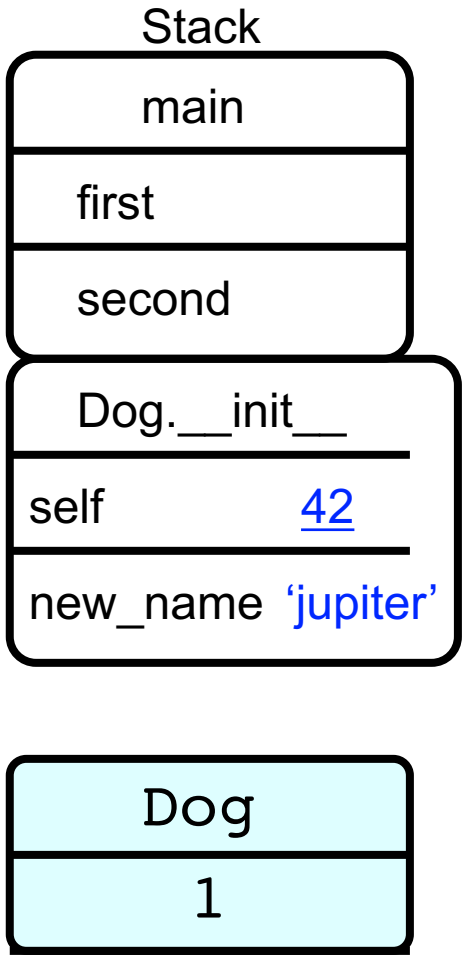

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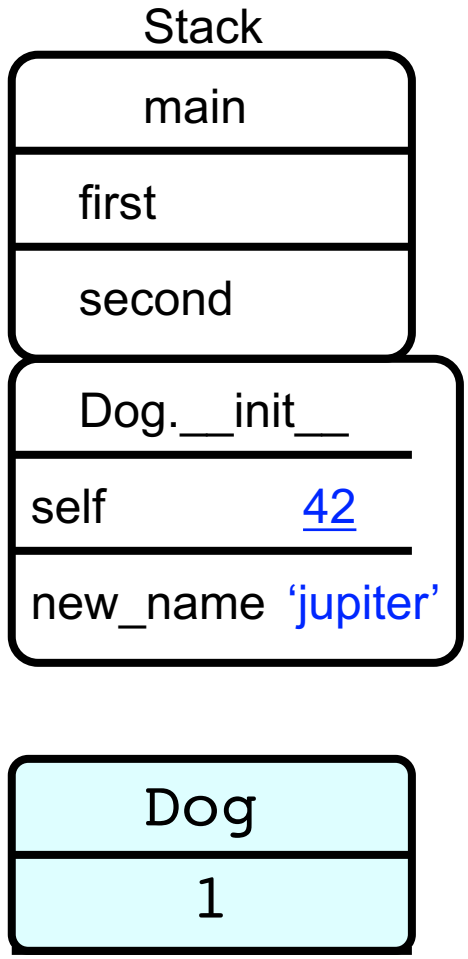

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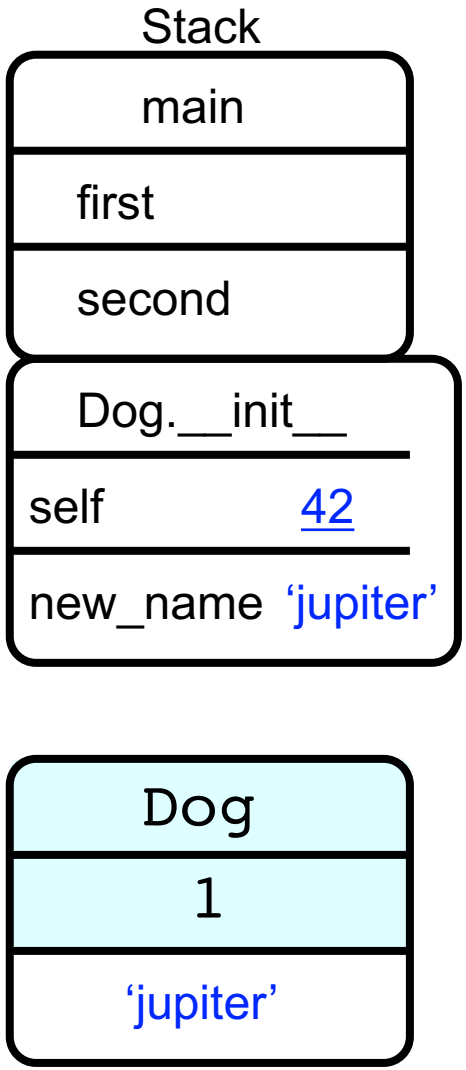

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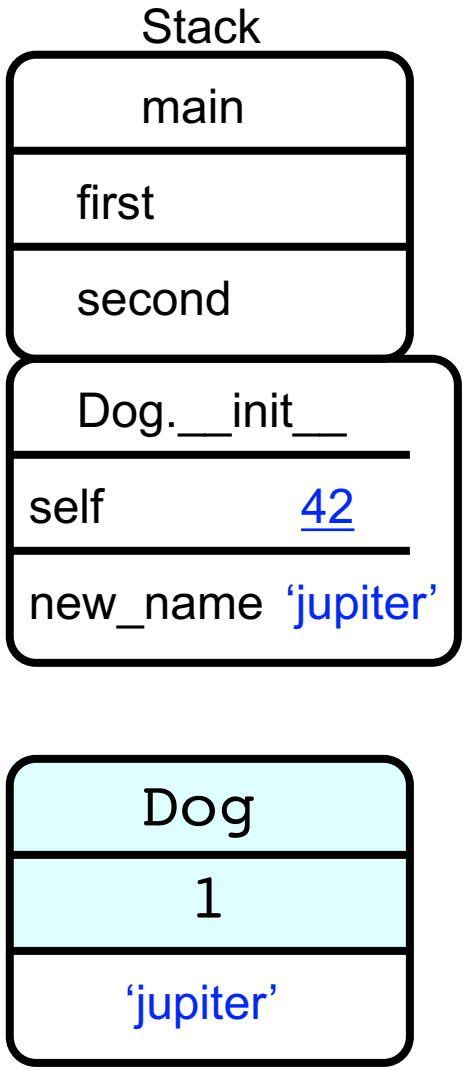

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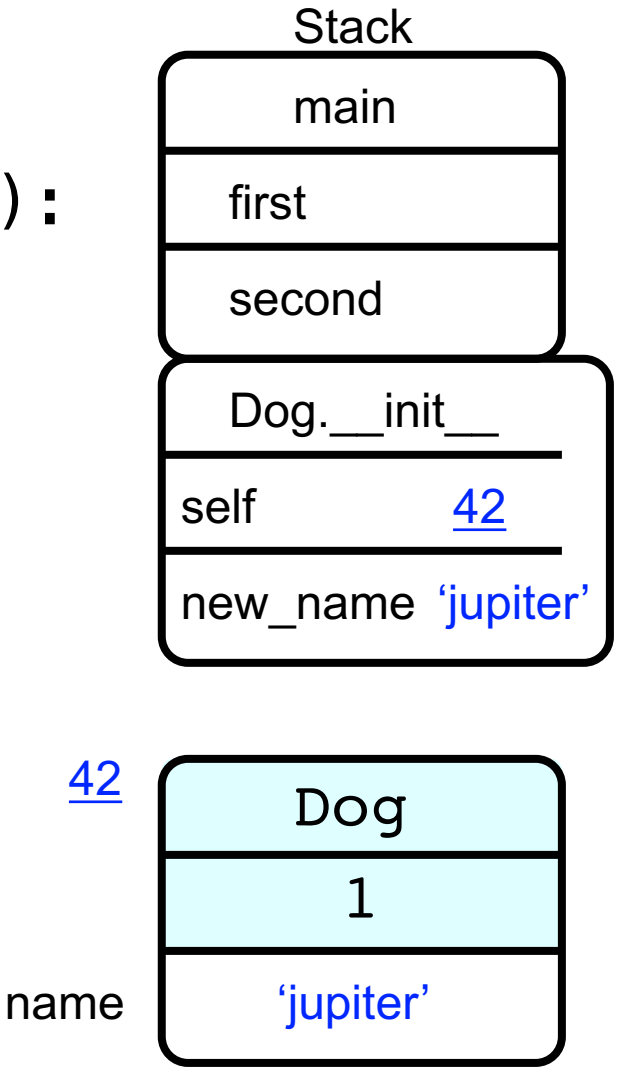

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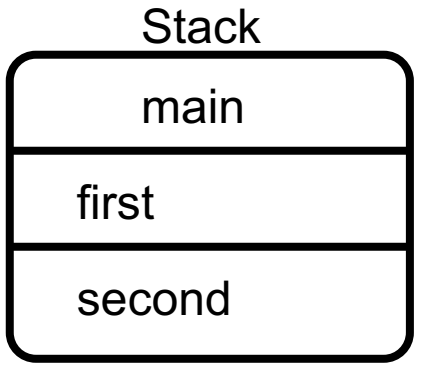

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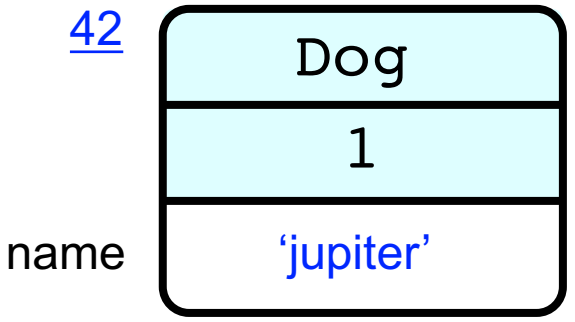

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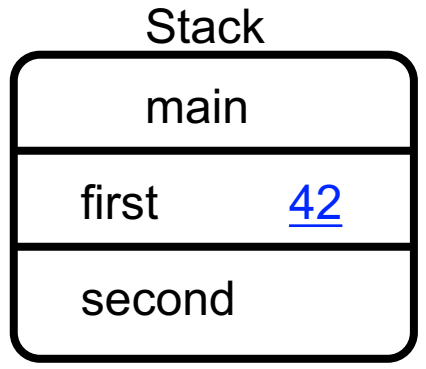

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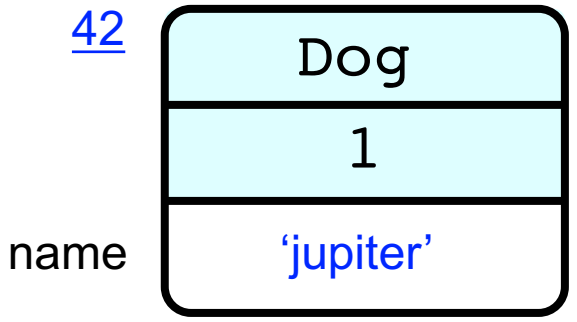

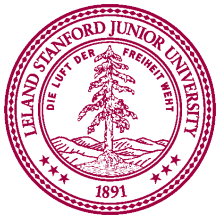

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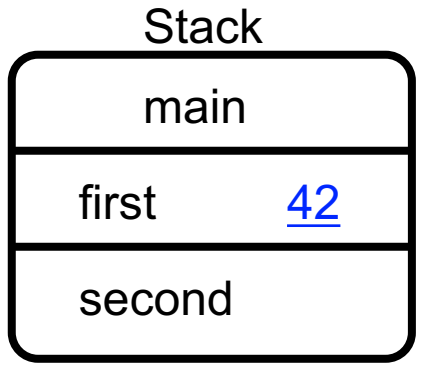

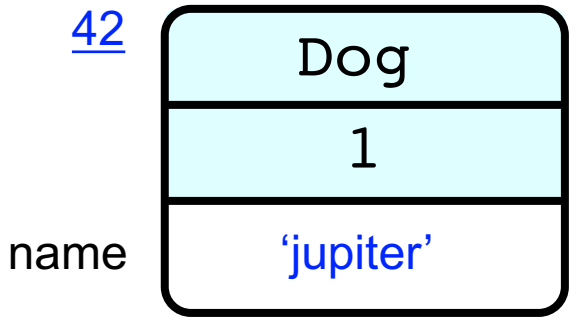

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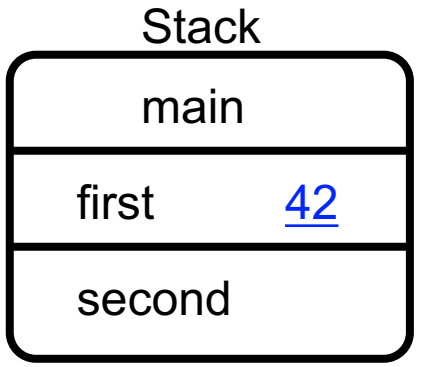

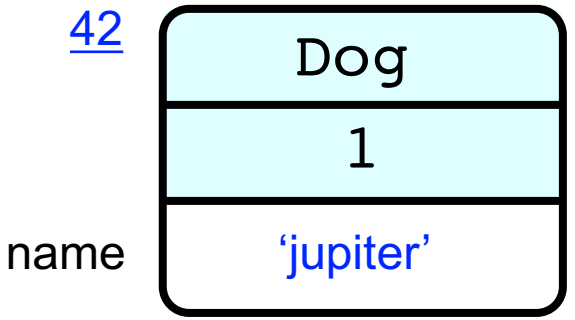

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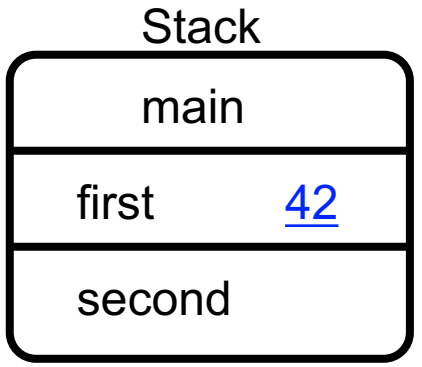

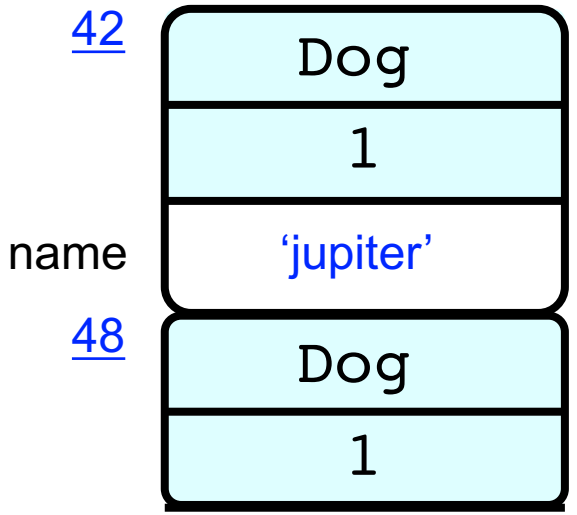

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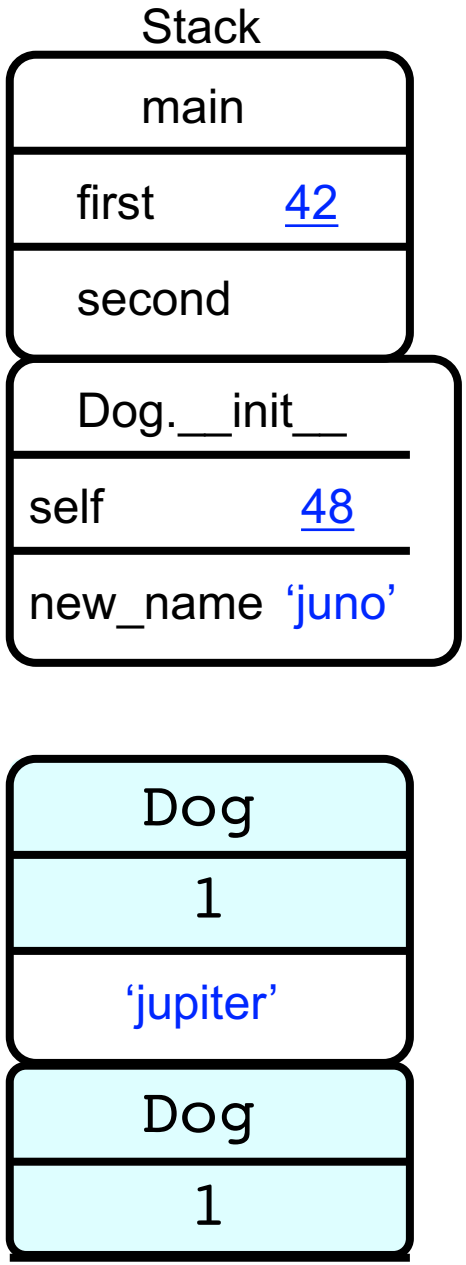

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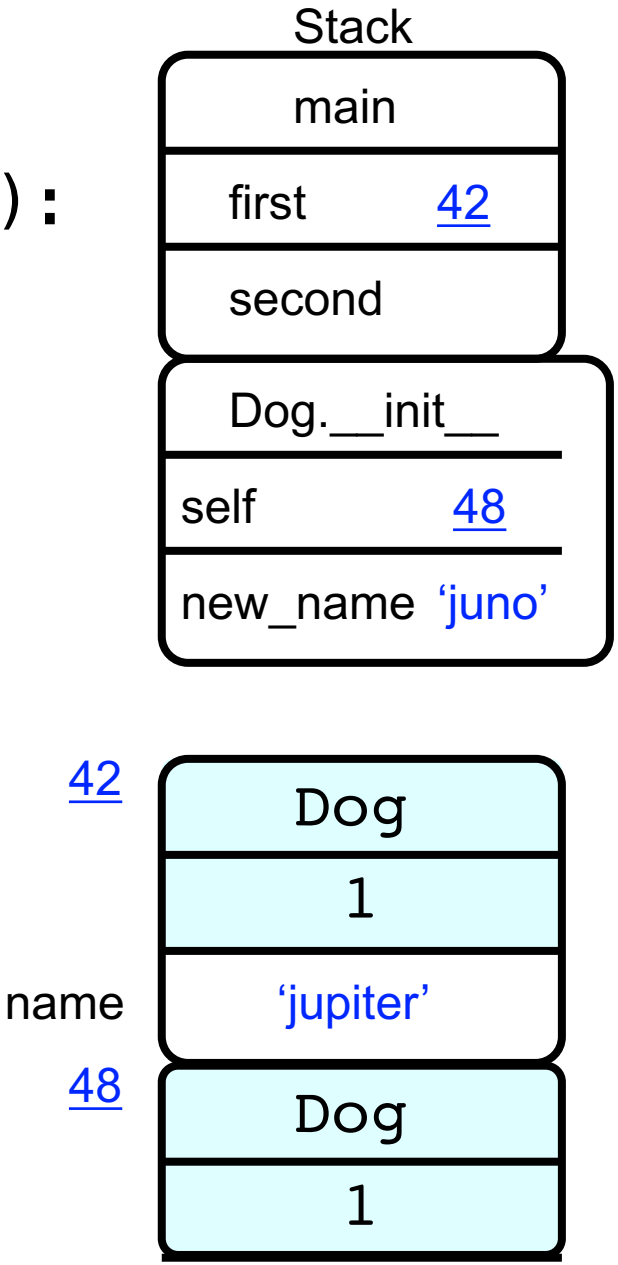

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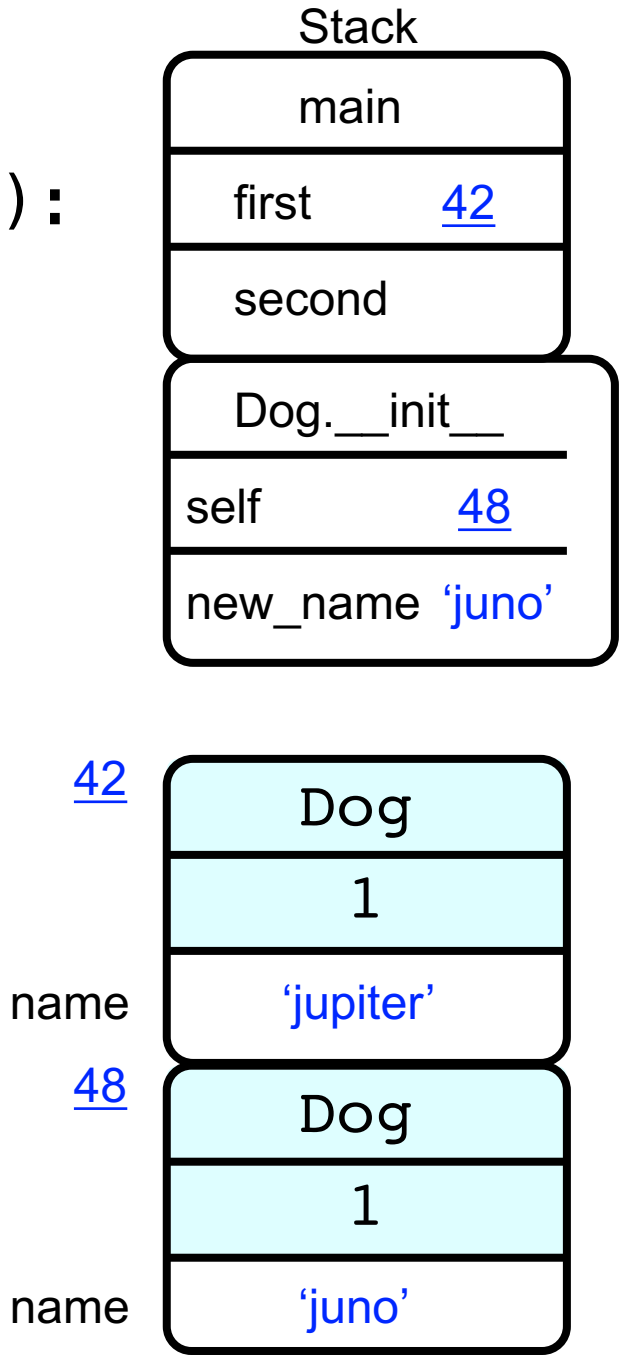

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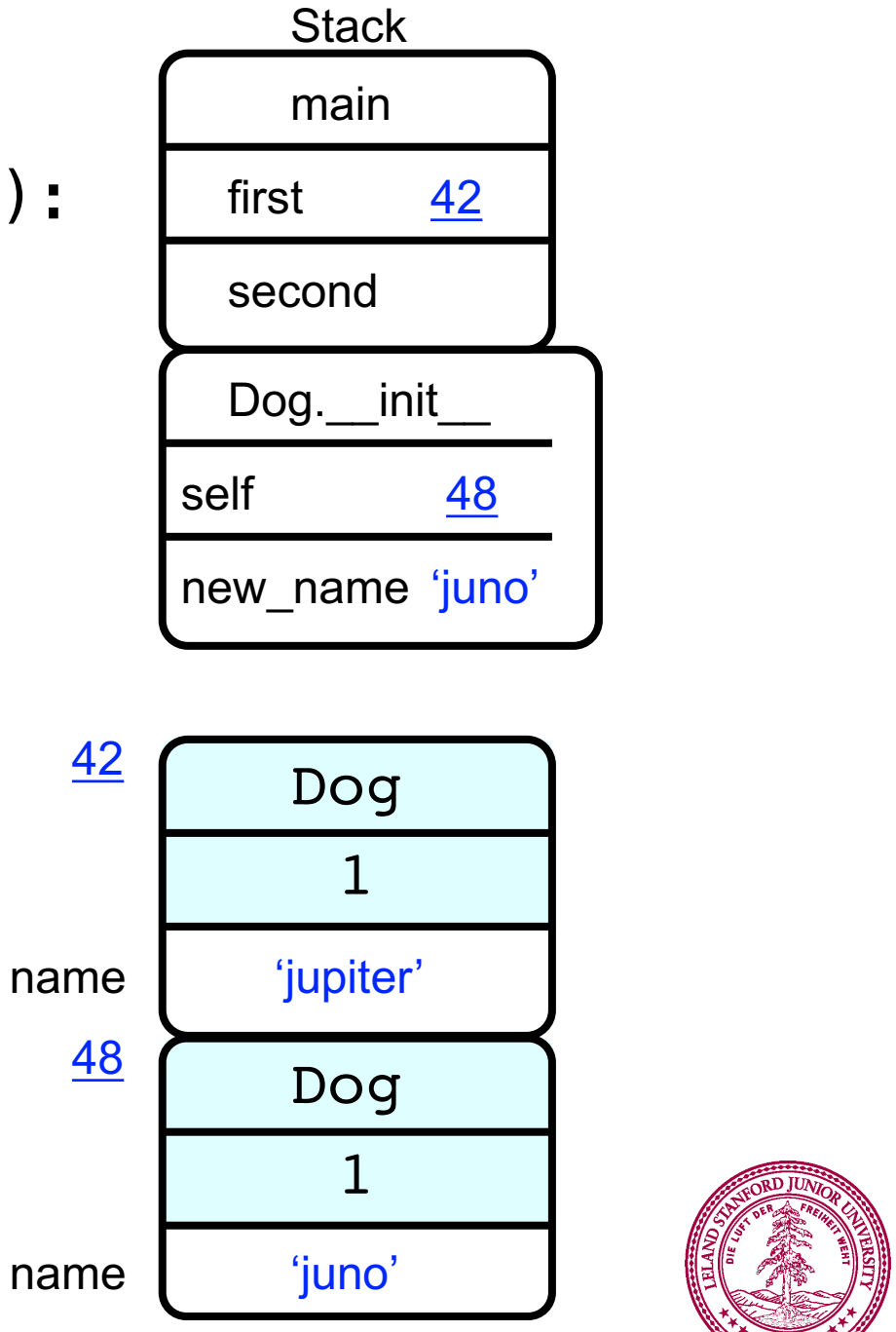

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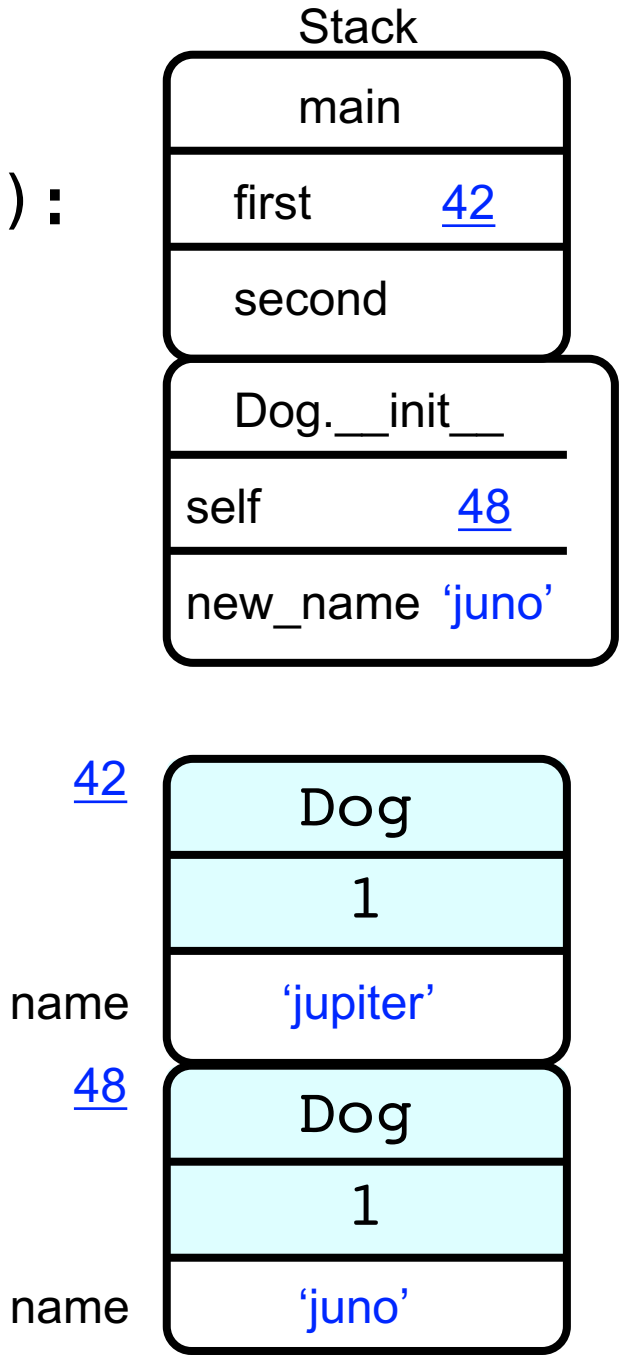

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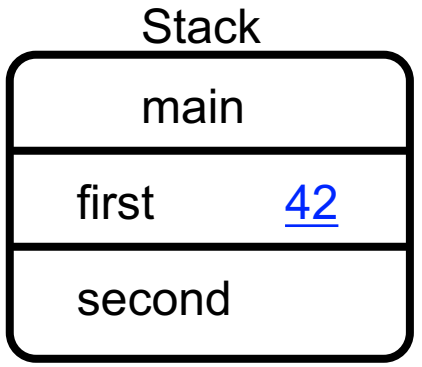

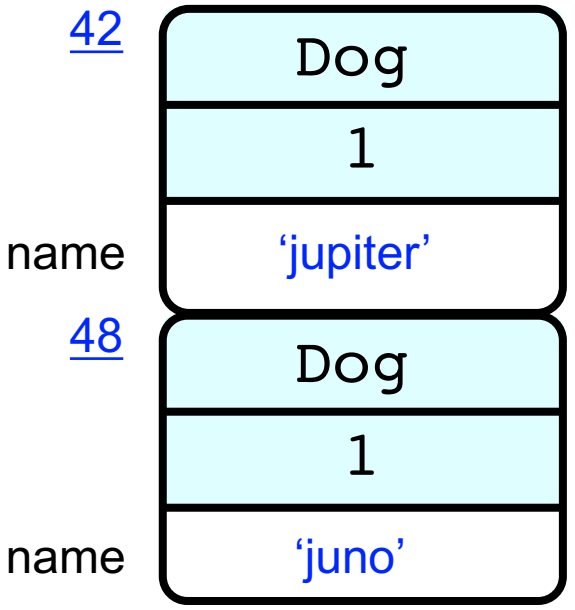

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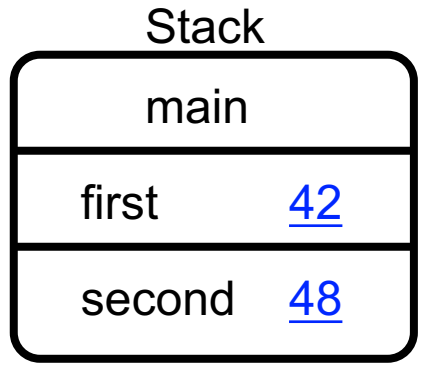

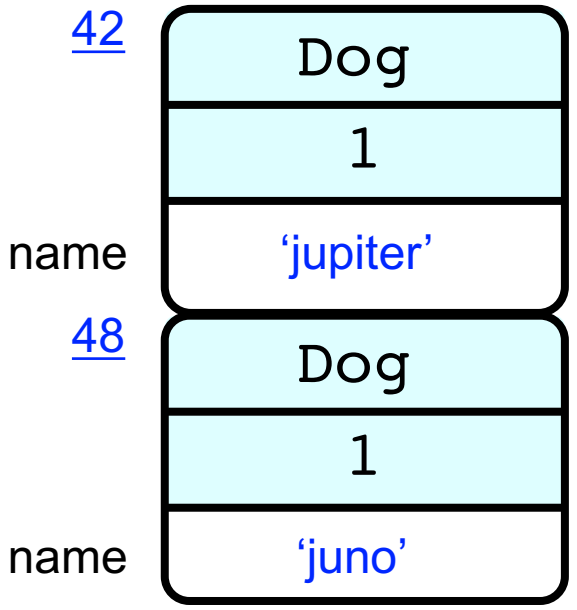

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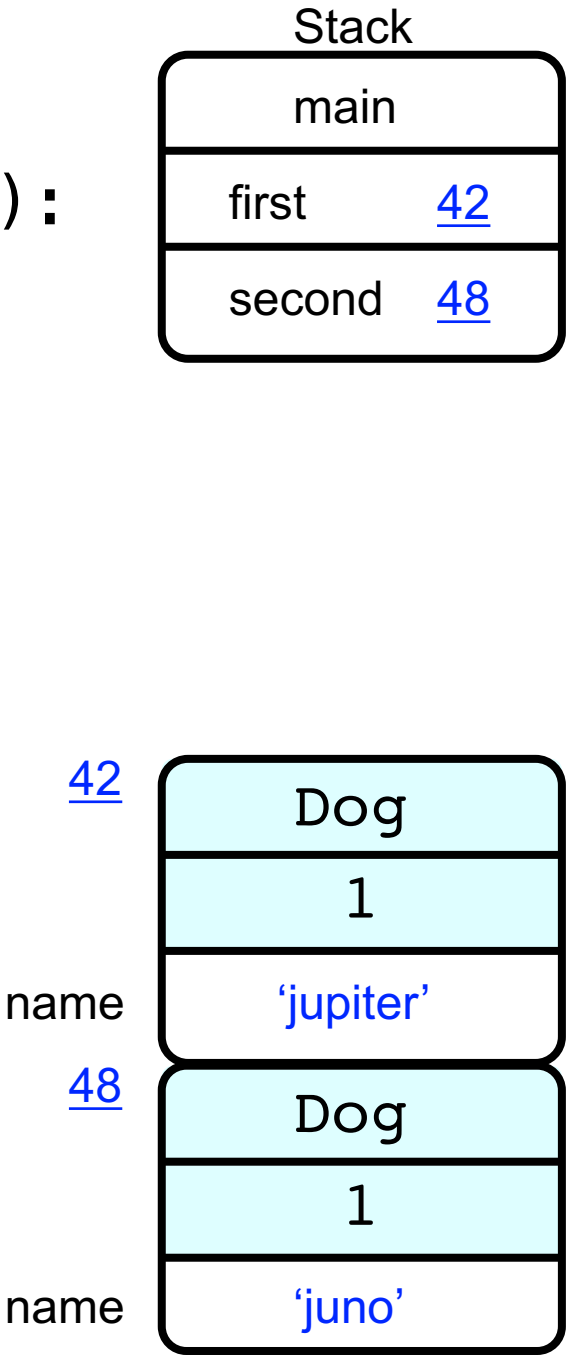

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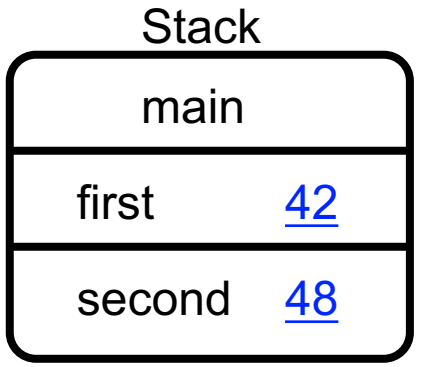

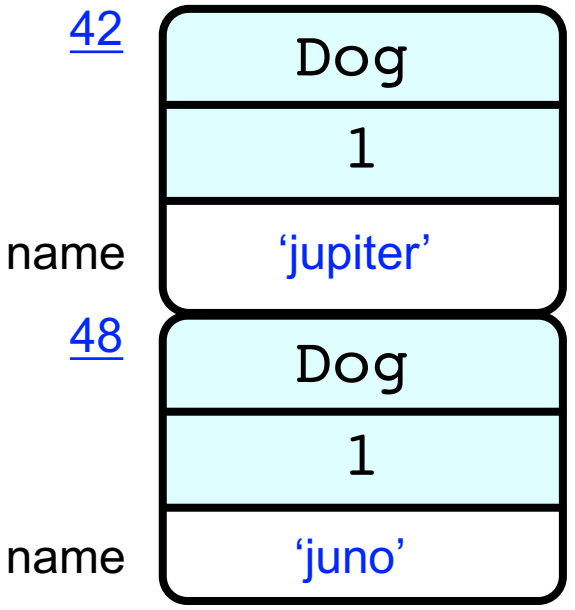

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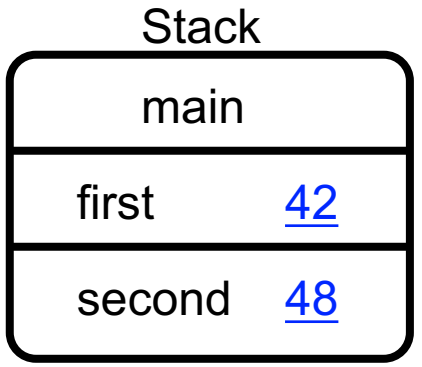

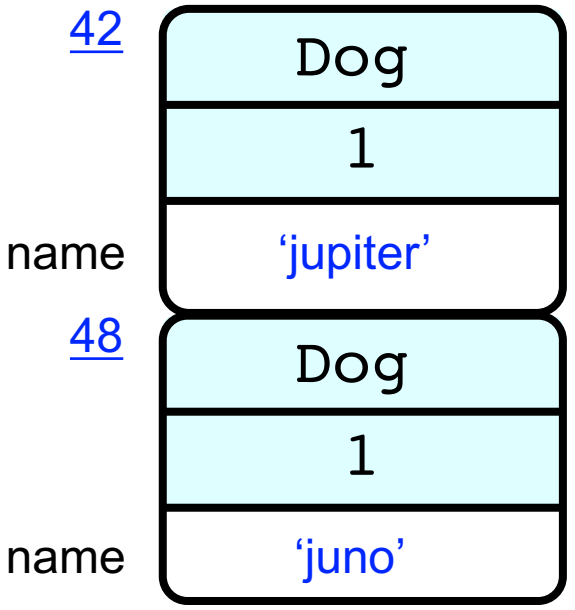

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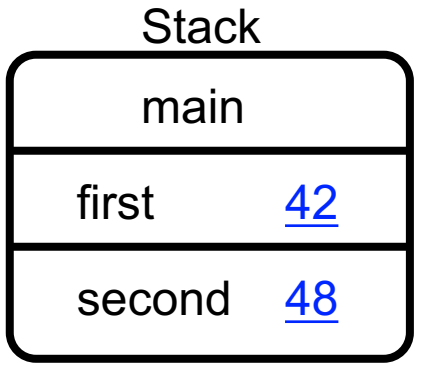
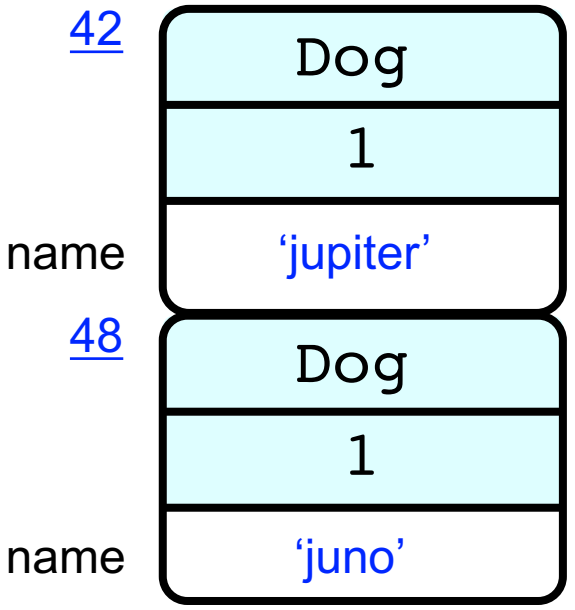




Challenge: Trace This!

Dog.py

```
class Dog:
    def __init__(self):
        self.times_barked = 0

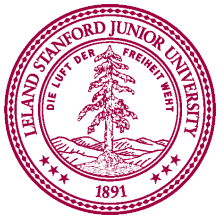
    def bark(self):
        print('woof')
        self.times_barked += 1
```

life.py

```
def main():
    jupiter = Dog()
    juno = Dog()

    jupiter.bark()
    juno.bark()
    jupiter.bark()

    print(jupiter.__dict__)
    print(juno.__dict__)
```



Learning Goals

1. Practice with classes
2. See how to trace memory with classes