Name: ___________ SOLUTION ______________ **Section:** 1 2 3 4 5

As you complete EACH problem, ask a student assistant to check your answer AT THAT TIME!

Throughout these problems:

- **Use the boxes we supplied**; just ***add labels*** and ***arrows*** for variables and ***data*** for non-container objects.
- Assume the existence of a ***Point*** class with just two instance variables (***x*** and ***y***).
- Assume the existence of a ***Circle*** class with just two instance variables (***center*** and ***radius***, where *center* is a Point object). Assume that a Circle object stores, as its center, a ***reference*** to the Point object that it is given and ***not a copy*** of that Point.

As a reminder, here are the four rules for drawing box-and-pointer diagrams, followed by an example from the video.

__Rule 1__: Draw a ***NON-container object*** by putting its value inside a box.

__Rule 2__: Draw a ***variable*** (aka ***name***) using a box labeled with the variable's name and with arrows from the box to the object to which the variable currently refers.

__Rule 3__: Draw a ***CONTAINER object*** by making a box for it, and then creating sub-boxes that are drawn as if they were variables, but with names for the ***instance variables*** of an object and indices for items of a sequence. (We will talk about sequences later in the course.)

__Rule 4__: When code RE-assigns a variable, as in `x = blah`:

- Evaluate the expression on the right-hand-side. If it is a new object, draw a box for it.
- Cross through the existing arrow (if any) from the variable.
- Draw a NEW arrow from the variable to the object to which the right-hand-side evaluated.

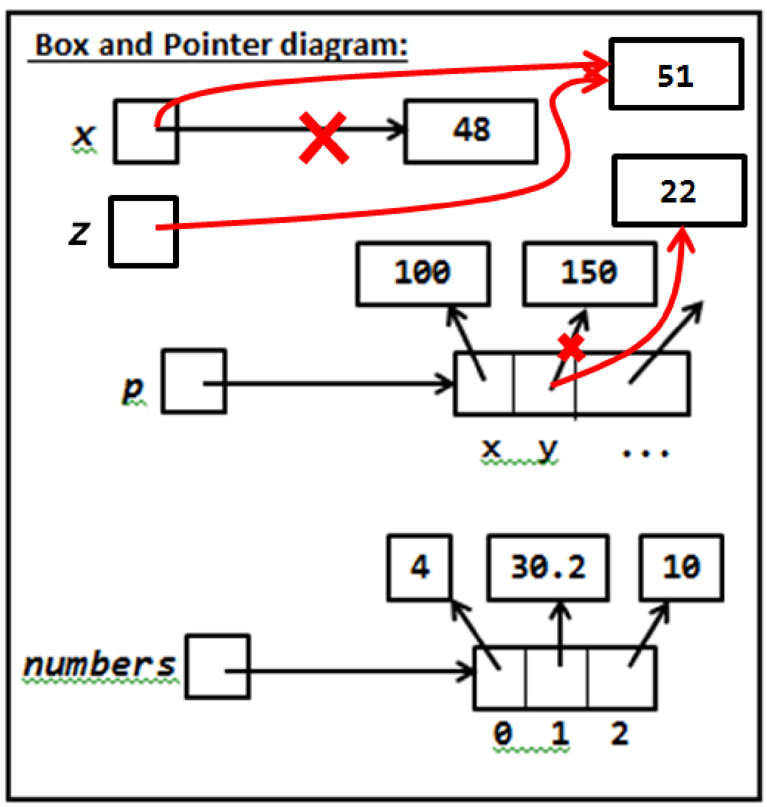
Arrows ALWAYS go:

from a ***variable's*** box

to an ***object's*** box.

Arrows NEVER go from a ***variable's*** box to ***another variable's*** box.

```
x = 48
p = Point(100, 150)
numbers = [4, 30.2, 10]
x = x + 3
p.y = 22
z = x
```



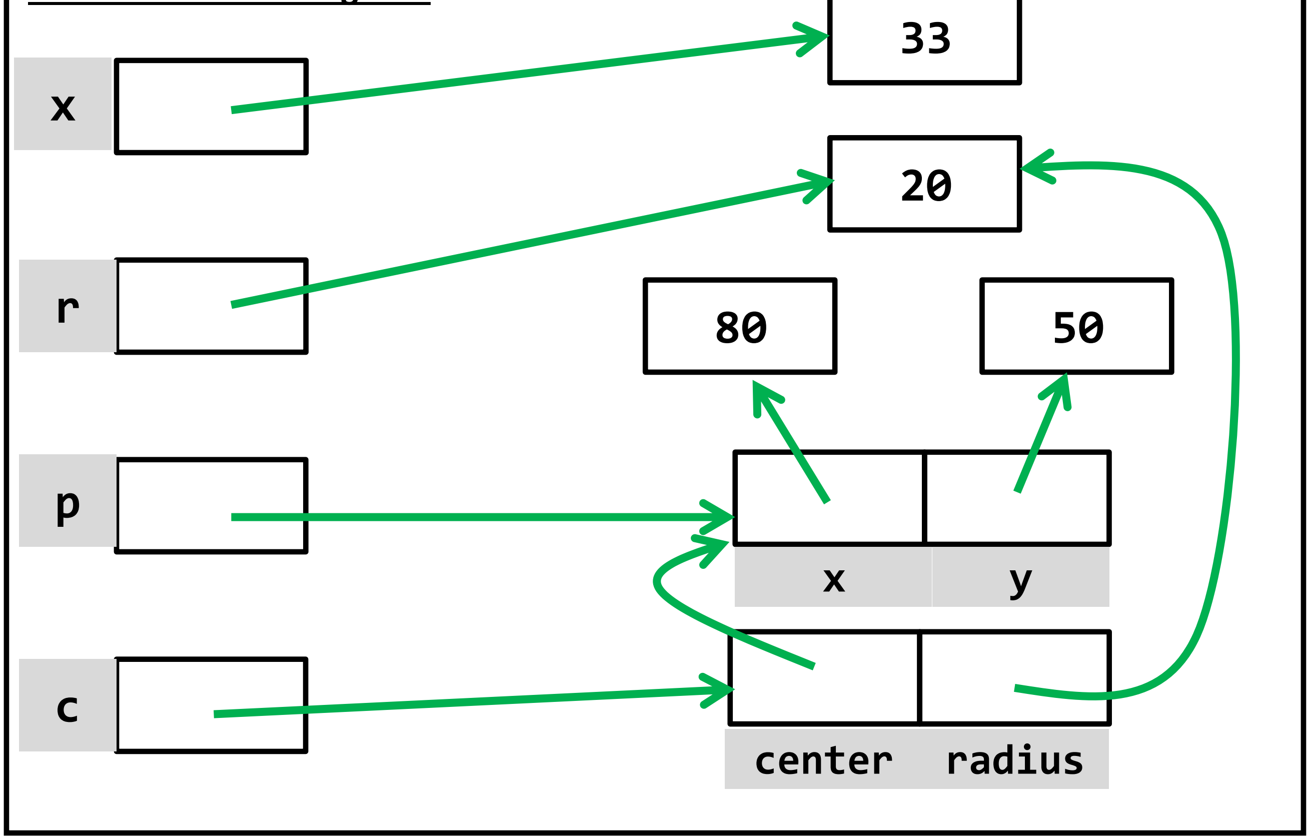
1. Using the diagram at the bottom of this page, ***draw a Box-and-Pointer diagram*** that shows what happens when the following statements execute. ***Then indicate what output is printed***. We already supplied the boxes for the diagram; you label them and draw arrows.

```
x = 33
r = 20
p = Point(80, 50)
c = Circle(p, r)

print('x:',   x)
print('r:',   r)
print('p.x:', p.x)
print('p.y:', p.y)
print('c.center.x:', c.center.x)
print('c.center.y:', c.center.y)
print('c.radius:',   c.radius)
```

Output:

```
x:            33
r:            20
p.x:          80
p.y:          50
c.center.x:   80
c.center.y:   50
c.radius:     20
```

Box and Pointer diagram:



2. This problem continues the previous one. We have drawn a ***SOLUTION*** to the previous problem below. Use it to check your answer to the previous problem. Then augment the box-and-pointer diagram below to include the new statements in the code below. Also indicate what output is printed by the *print* statements that follow that new code.

```
x = 33
r = 20
p = Point(80, 50)
c = Circle(p, r)
<same print statements as in problem 1>

r = 77
p.x = 44

<same print statements as in problem 1,
repeated here>
```

Previous problem printed these numbers.

New code is here

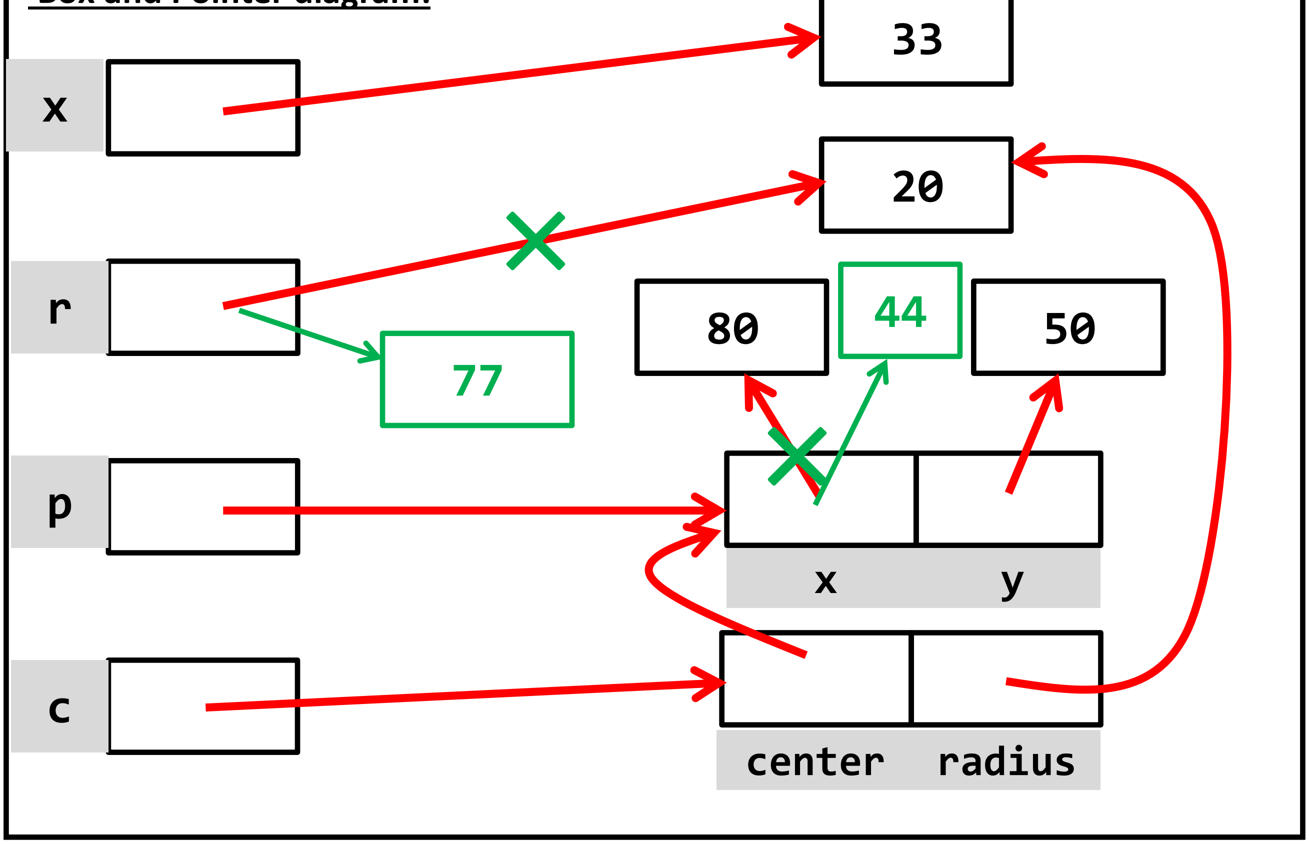
33
20
80
50
80
50
20

Output from 2^nd set of print statements:

Especially check the circled ones!

x:	33
r:	77
p.x:	44
p.y:	50
c.center.x:	44
c.center.y:	50
c.radius:	20

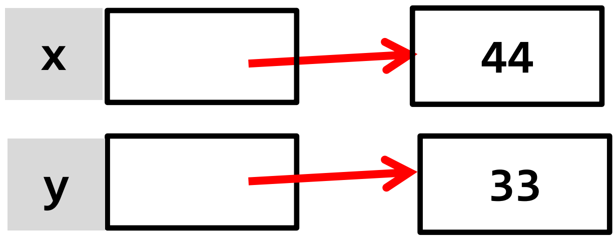
Box and Pointer diagram:



READ THIS page carefully, asking questions as needed!

```
def main():
    x = 44
    y = 33

    foo(100, x)


def foo(a, b):
    ...
    x = 70

main()
```

Consider the code to the right. ***A function call* creates a new *namespace* in which the function will run.** Hence, when ***main*** is called, a namespace is created and then names (variables) ***x*** and ***y*** are created and assigned values. The box-and-pointer diagram after the assignments to ***x*** and ***y*** (but before the call to ***foo***) is:

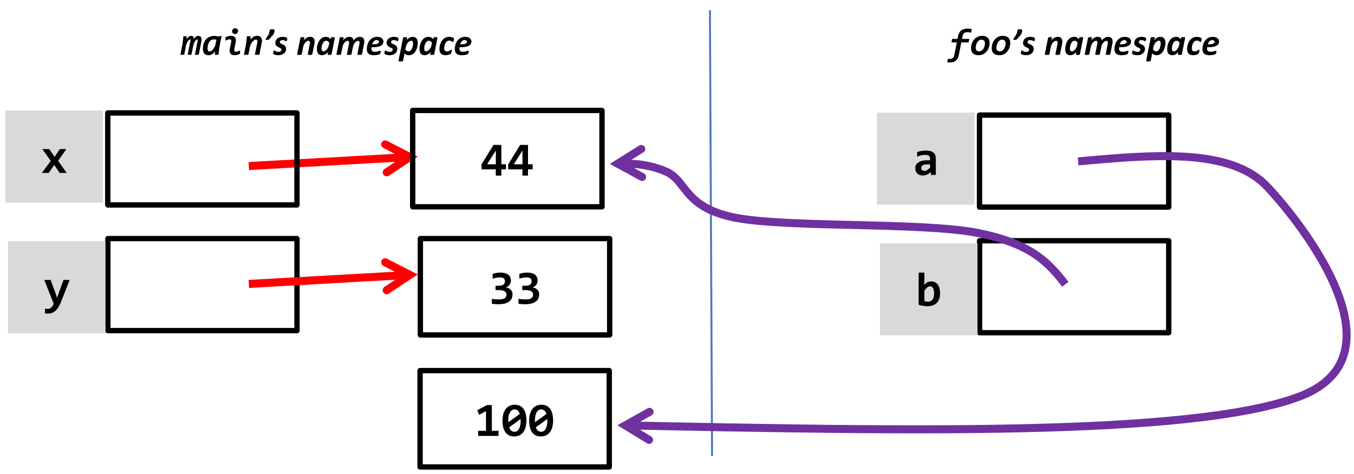


When a function is called, the function's parameters are added to the function's namespace. Each parameter is assigned the ***value*** of the corresponding actual argument. For example, when the call to function ***foo*** occurs in the code to the right, it is as if the following assignments occur:

`a` (in ***foo***) `= 100` (in ***main***)

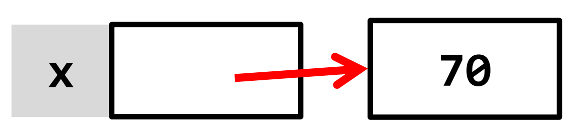
`b` (in ***foo***) `= x` (in ***main***) which is ***44***

So, after the call to ***foo***, the box and pointer has TWO parts (for the TWO namespaces), as shown below:



Note that the* variables *in foo point to* values *in main.

Also, note that the constant `100` appears in ***main***, so we have drawn it in ***main***'s namespace.



When the statement

`x = 70`

in ***foo*** runs, ***foo***'s namespace acquires its own variable ***x***, as shown to the right.

3. Draw a Box-and-Pointer diagram that shows what happens when ***main*** executes. Then indicate what output is printed, assuming appropriate ***print*** statements.

```
def main():
    a = 44
    b = 33
    z = 22
    p1 = Point(100, 200)

    foo(a, b, z, p1)

    <print statements here>

def foo(x, y, z, p):
    x = 10 * x
    y = 88
    p.x = 1
    p = Point(300, 400)
    p.y = 2
```

Output:

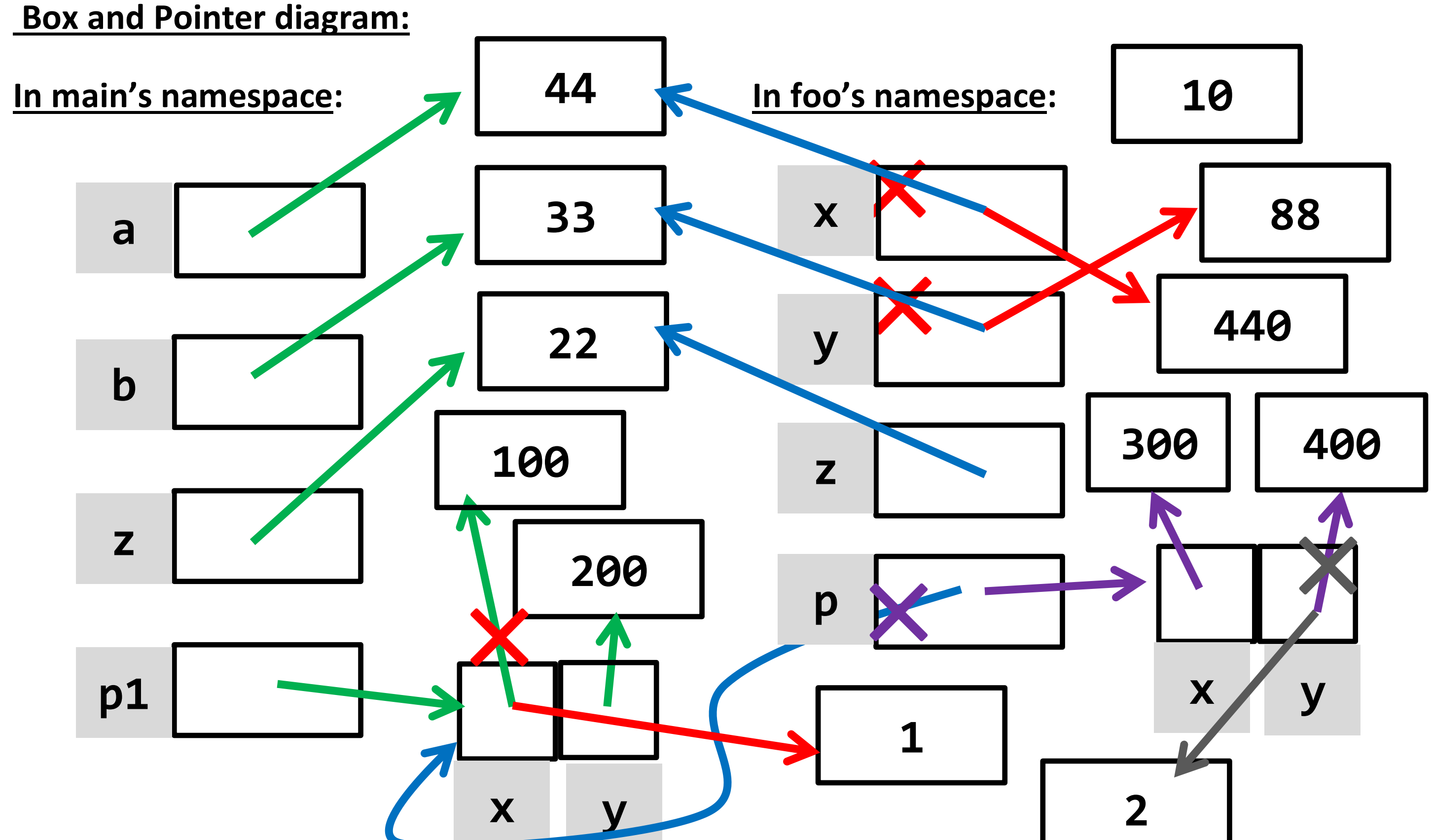
a:	44
b:	33
z:	22
p1.x:	1
p1.y:	200

Check this problem in color-coded order: ***green*** marks, then ***blue***, then ***red***, then ***purple***. Check the output last.

As soon as there is an error, stop there and help the student walk through the code to that point. Ask the student to try again on the error, helping as needed. Let the student go forth from there on her own, re-doing the rest of the problem.

We have already drawn all the boxes that you need. Just draw arrows (and eventually X's).

Box and Pointer diagram:



4. Draw a Box-and-Pointer diagram that shows what happens when ***main*** executes. Then indicate what output is printed, assuming appropriate ***print*** statements.

Output from printing in *foo*:

a: ___ 88 __

b: ___ 99 __

p.x: ___ 200 __

p.y: ___ 400 __

p1.x: ___ 77 __

p1.y: ___ 55 __

Output from printing in *main*:

a: ___ 98 __

b: ___ 55 __

p1.x: ___ 55 __

p1.y: ___ 100 __

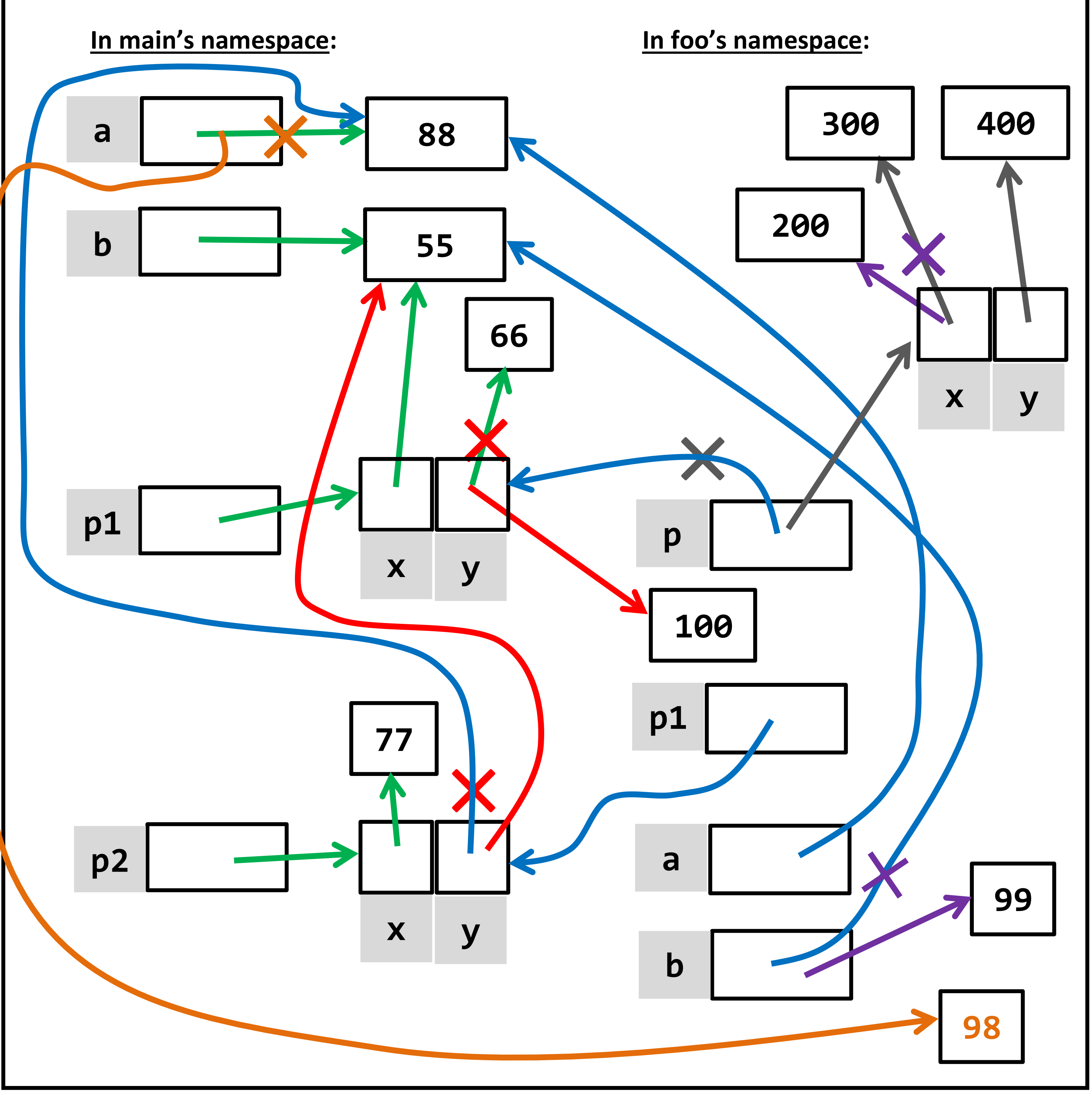
p2.x: ___ 77 __

p2.y: ___ 55 __

```
def main():
    a = 88
    b = 55
    p1 = Point(b, 66)
    p2 = Point(77, a)

    a = foo(p1, p2, a, b)

    <print statements here>


def foo(p, p1, a, b):
    p.y = 100
    p1.y = b
    p = Point(300, 400)
    p.x = 200
    b = 99

    <print statements here>

    return a + 10


main()
```

Draw the entire box-and-pointer diagram on a *separate* sheet of paper, then staple that sheet to this handout.

Box and Pointer diagram:



The arrows form in the following order:

green then *blue* then *grey* then *red* then *orange*