Name: _____ **Section:** 1 2 3 4 5

As you complete each problem, ask a student assistant to check your answer.

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*** 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.

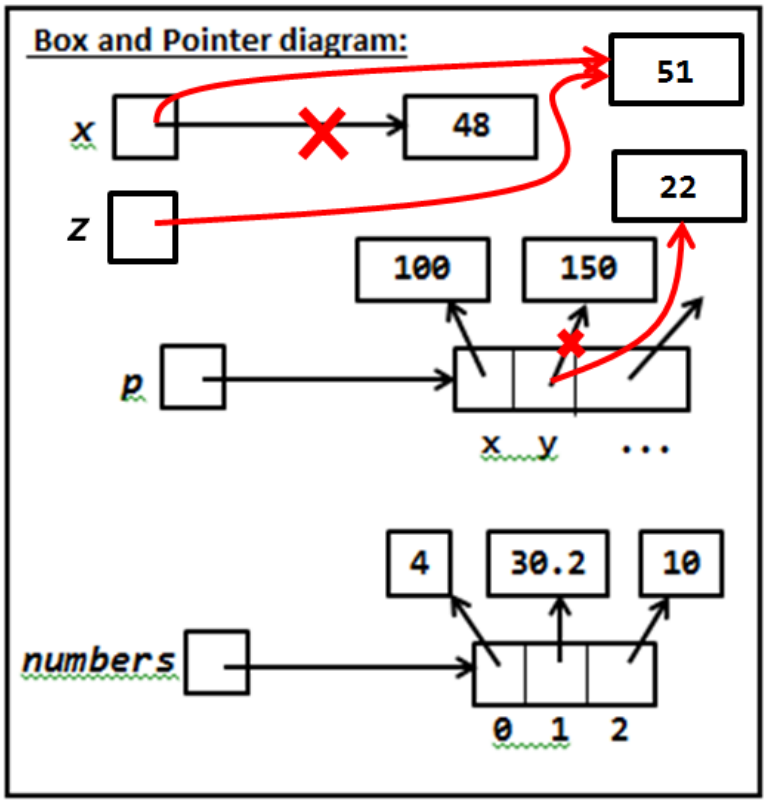
Rule 4: When code RE-assigns a variable, as in `x = blah`:

- 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 = rg.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. Note that **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: _____

r: _____

p.x: _____

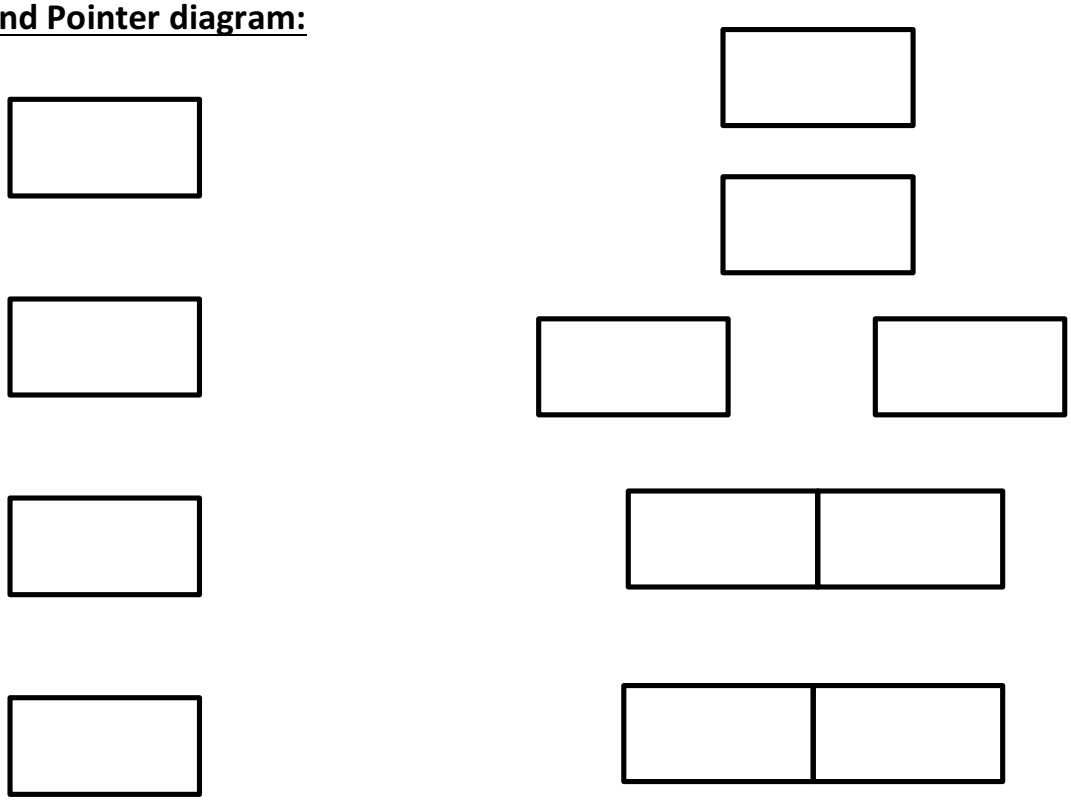
p.y: _____

c.center.x: _____

c.center.y: _____

c.radius: _____

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 2nd set of *print* statements:

x: _____

r: _____

p.x: _____

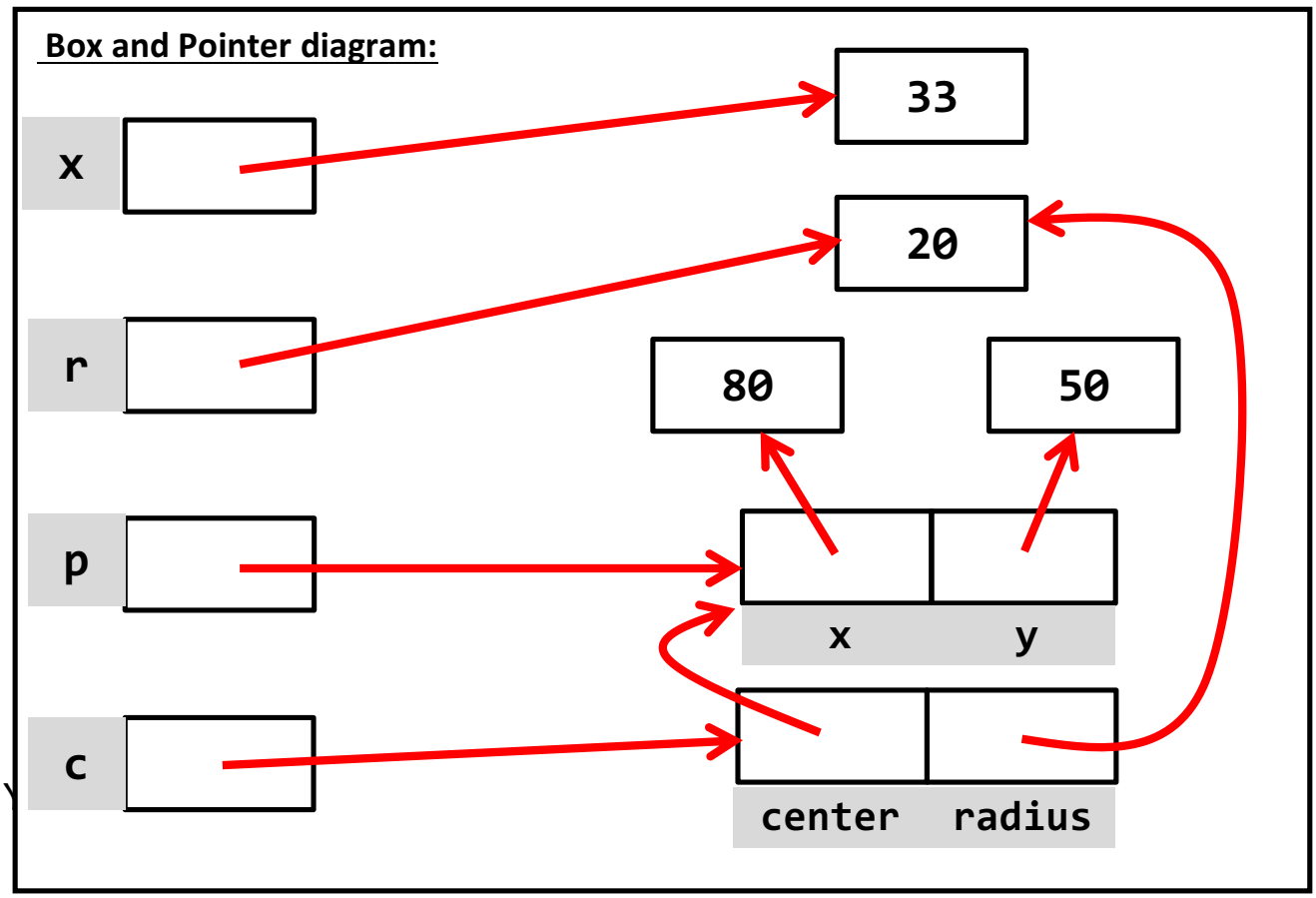
p.y: _____

c.center.x: _____

c.center.y: _____

c.radius:

Box and Pointer diagram:



A ***function call*** creates a new ***namespace*** in which the function will run. The function's ***parameters*** are variables in that namespace, as are all variables assigned values with assignment in that function.[1]

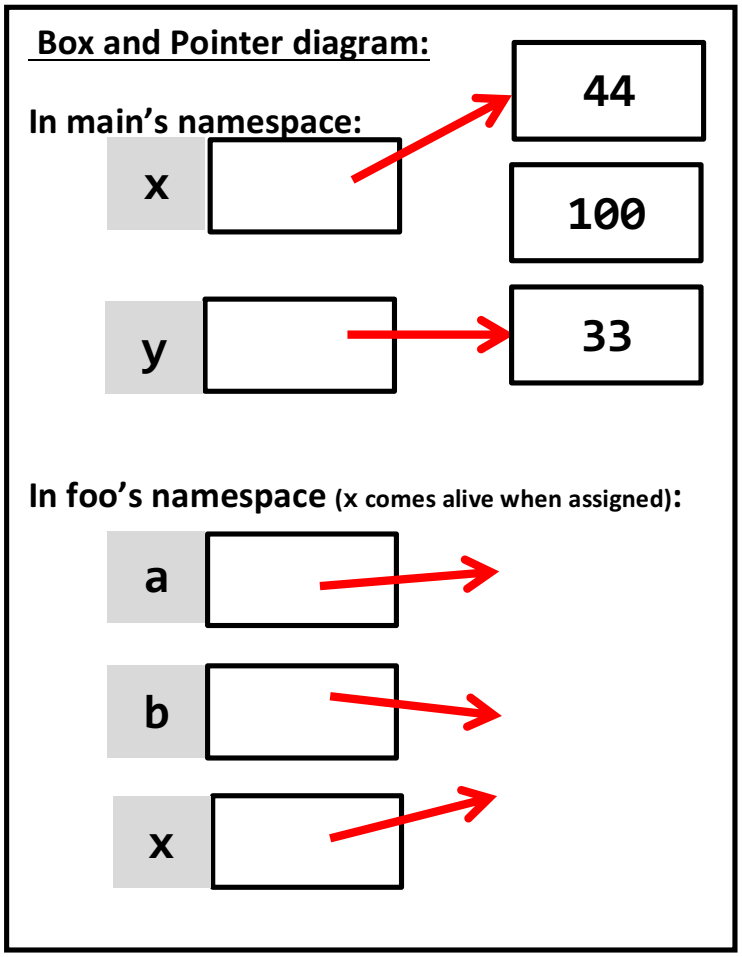
So for example, in the code snippet to the right, when function ***foo*** is called, the box-and-pointer diagram will gain 3 new variables labeled ***a***, ***b*** and ***x***, respectively. These are ***in addition to*** any variables by the same name that are in ***main***'s namespace. That is, after **foo** is called in the snippet to the right, the box-and-diagram will look like the one shown below on the LEFT, in part.

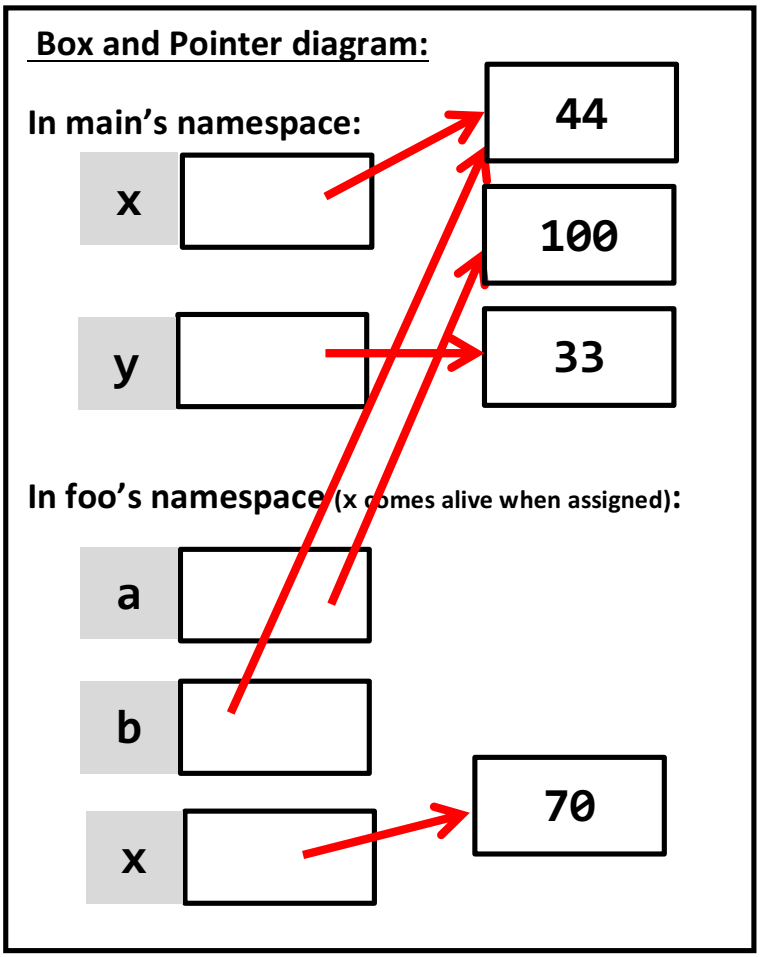
```
def main():
    x = 44
    y = 33
    foo(100, x)

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

Furthermore, when a function is called, each parameter is assigned the ***value*** of the corresponding actual argument.

For example, in the code snippet above, when **foo(100, x)** executes, the parameter **a** is assigned the value **100**, just as if the statement **a = 100** were executed, and the parameter **b** is assigned the value of the variable **x**, just as if the statement **b = x** were executed. The diagram on the RIGHT shows the effects of those assignments. Study that picture carefully!





[1] This is not the entire truth, but it will do. For example, there is an exception to this regarding global variables, but we won't be using global variables, as their use is a practice that does NOT scale up to real-sized programs.

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

Output:

a: _____

b: _____

z: _____

p1.x: _____

p1.y: _____

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

```
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
```

Box and Pointer diagram: