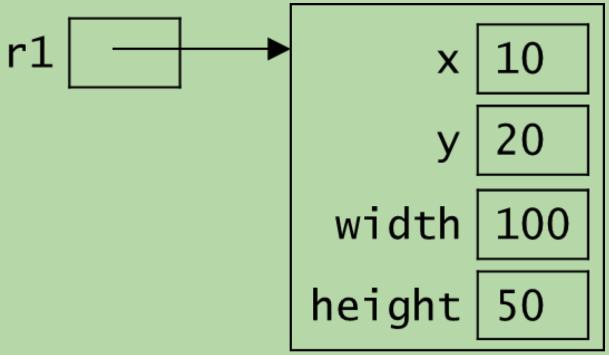
Lecture 11
More Object-Oriented Programming

Unrelated but do you see how happy dogs make Milla???

based in part on notes from the CS-for-All curriculum developed at Harvey Mudd College

Recall: Our Rectangle Class

```
# rectangle.py

class Rectangle:
    def __init__(self, init_width, init_height):
        self.x = 0
        self.y = 0
        self.width = init_width
        self.height = init_height

    def grow(self, dwidth, dheight):
        self.width += dwidth
        self.height += dheight

    def area(self):
        return self.width * self.height

    def perimeter(self):
        return 2*self.width + 2*self.height

    def scale(self, factor):
        self.width *= factor
        self.height *= factor
```



Original Client Program...

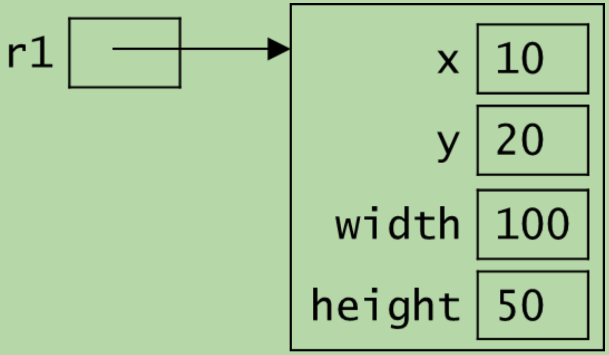
```
from rectangle import *

# construct two Rectangle objects
r1 = Rectangle(100, 50)
r2 = Rectangle(75, 350)

# print dimensions and area of each
print('r1:', r1.width, 'x', r1.height)
area1 = r1.width * r1.height
print('area =', area1)

print('r2:', r2.width, 'x', r2.height)
area2 = r2.width * r2.height
print('area =', area2)

# grow both Rectangles
r1.width += 50
r1.height += 10
r2.width += 5
r2.height += 30

# print new dimensions
print('r1:', r1.width, 'x', r1.height)
print('r2:', r2.width, 'x', r2.height)
```

Simplified Client Program

```
from rectangle import *

# construct two Rectangle objects
r1 = Rectangle(100, 50)
r2 = Rectangle(75, 350)

# print dimensions and area of each
print('r1:', r1.width, 'x', r1.height)
print('area =', r1.area())

print('r2:', r2.width, 'x', r2.height)
print('area =', r2.area())

# grow both Rectangles
r1.grow(50, 10)
r2.grow(5, 30)

# print new dimensions
print('r1:', r1.width, 'x', r1.height)
print('r2:', r2.width, 'x', r2.height)
```

Recall: Our Rectangle Class

```
# rectangle.py

class Rectangle:
    def __init__(self, init_width, init_height):
        self.x = 0
        self.y = 0
        self.width = init_width
        self.height = init_height

    def grow(self, dwidth, dheight):
        self.width += dwidth
        self.height += dheight

    def area(self):
        return self.width * self.height

    def perimeter(self):
        return 2*self.width + 2*self.height

    def scale(self, factor):
        self.width *= factor
        self.height *= factor
```



What is the output of this program?

```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

r1.scale(2)
print(r1.width, r2.width, r3.width)
```

A. 40 40 40

B. 80 40 40

C. 80 40 80

D. 80 80 80

E. none of these

What is the output of this program?

```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

r1.scale(2)
print(r1.width, r2.width, r3.width)
```

A. 40 40 40

B. 80 40 40

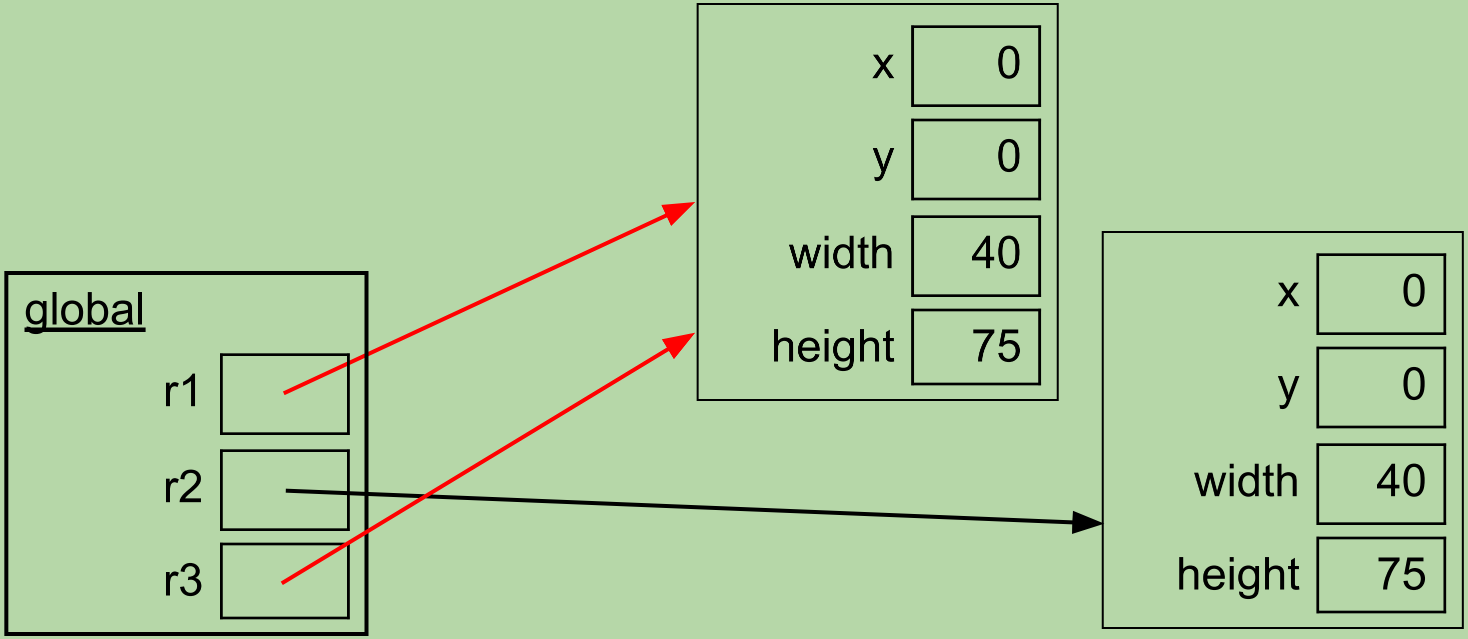
C. **80 40 80**

D. 80 80 80

E. none of these

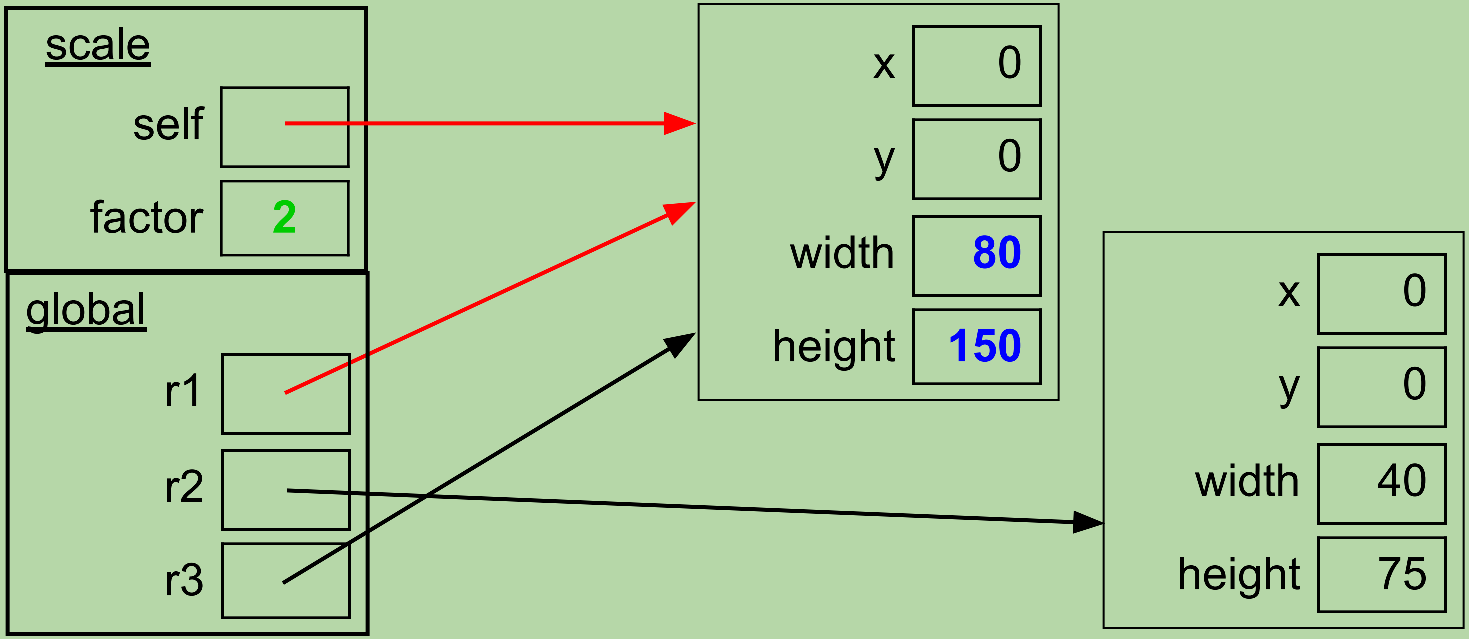
What is the output of this program?

```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

r1.scale(2)
print(r1.width, r2.width, r3.width)
```



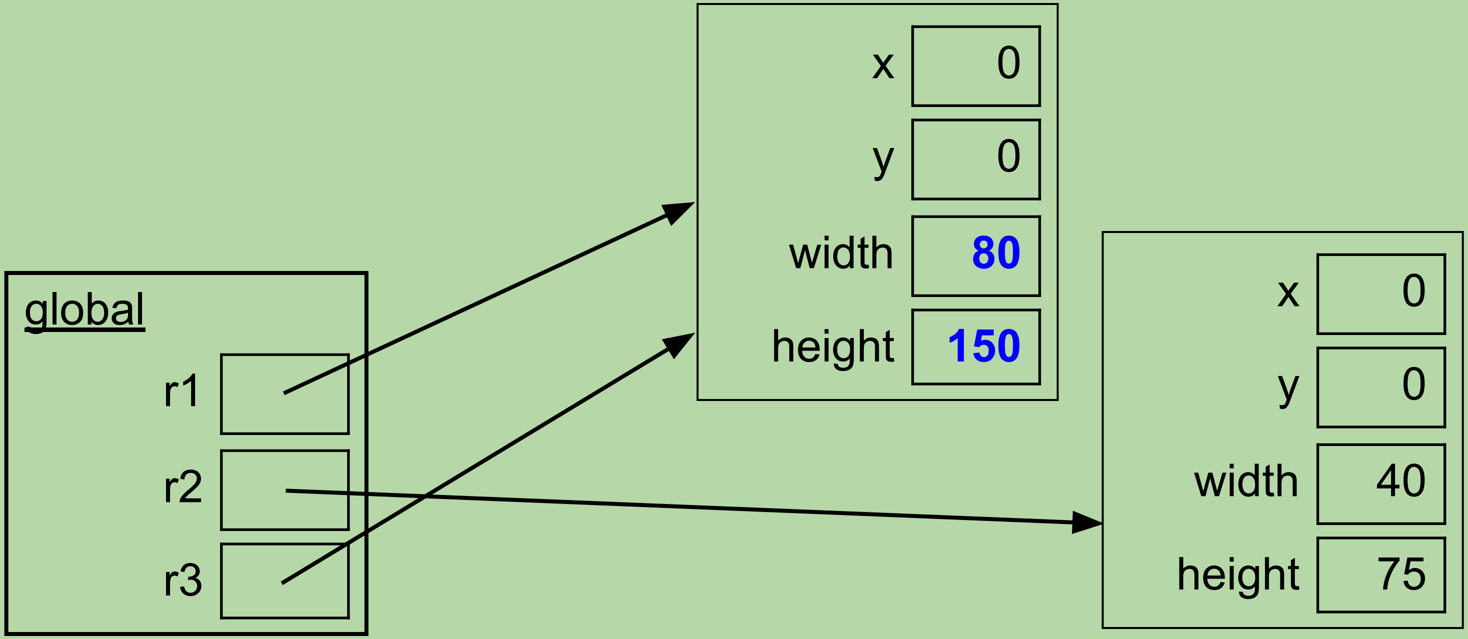
What is the output of this program?

```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

r1.scale(2)
print(r1.width, r2.width, r3.width)
```



What is the output of this program?

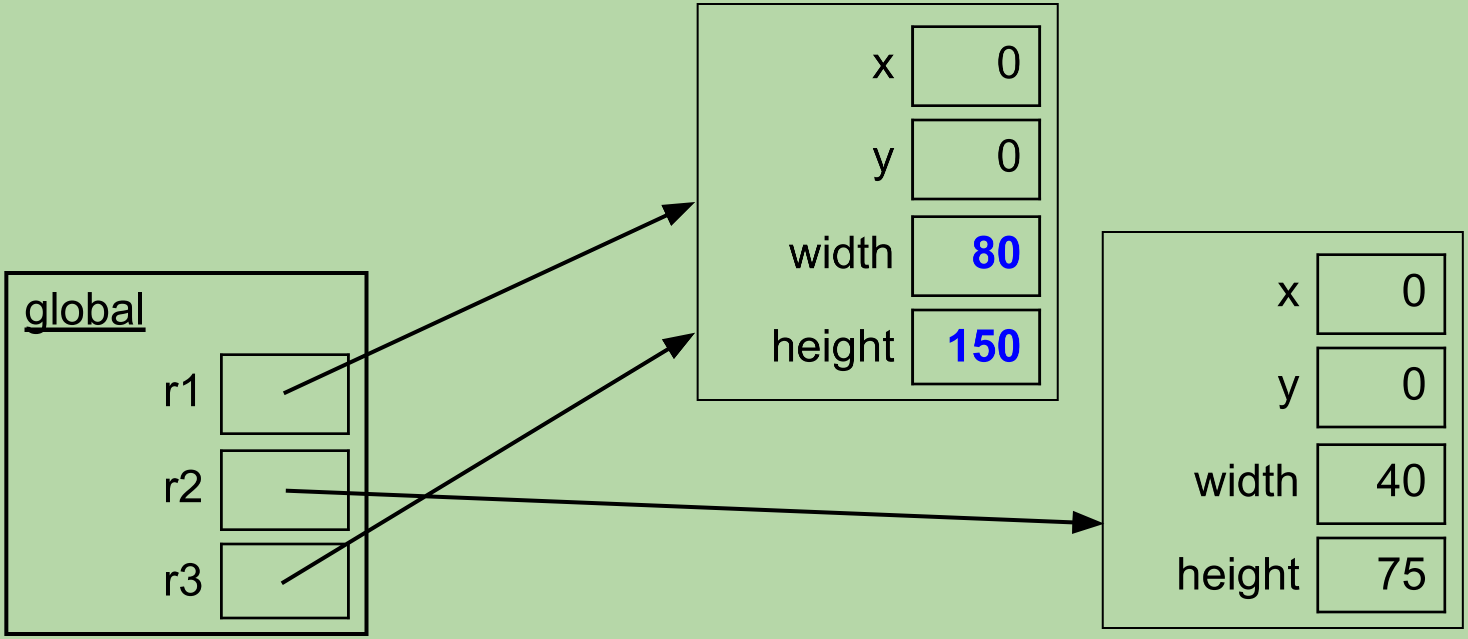
```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

r1.scale(2)   # changes are still inside the object!
print(r1.width, r2.width, r3.width)
```



What is the output of this program?

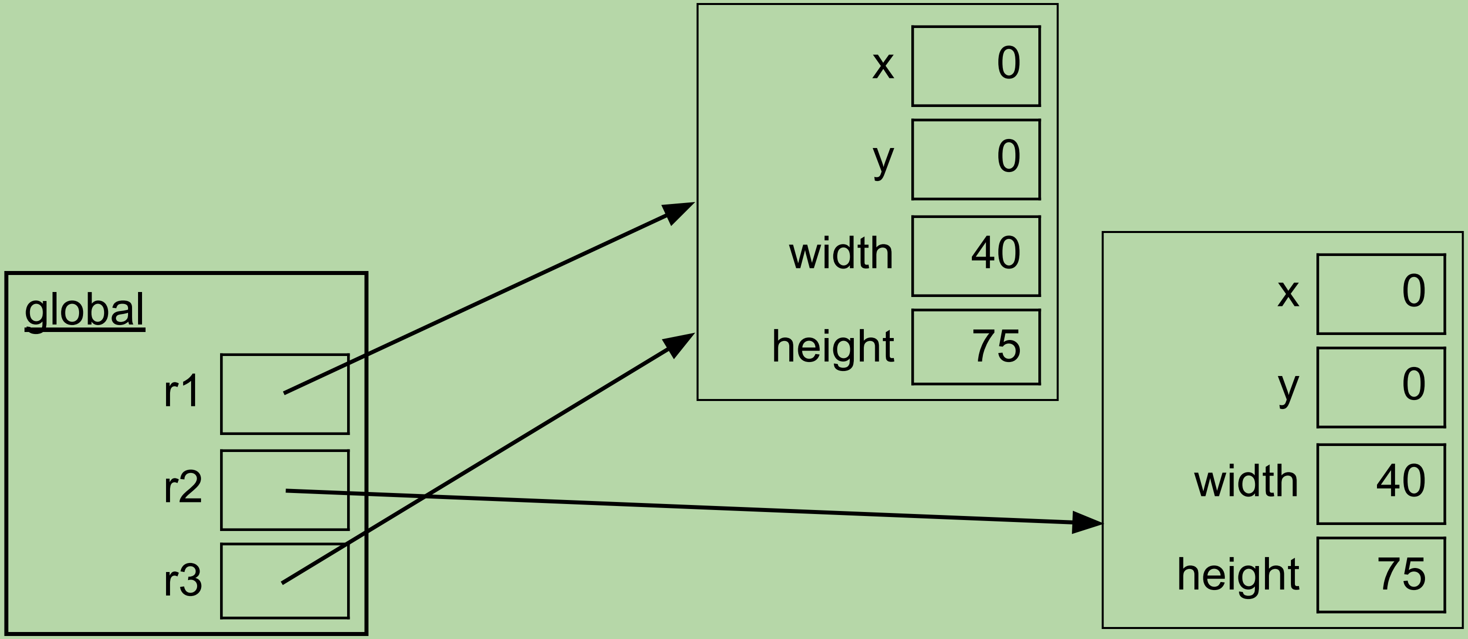
```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

r1.scale(2)
print(r1.width, r2.width, r3.width)
```

output: 80 40 80



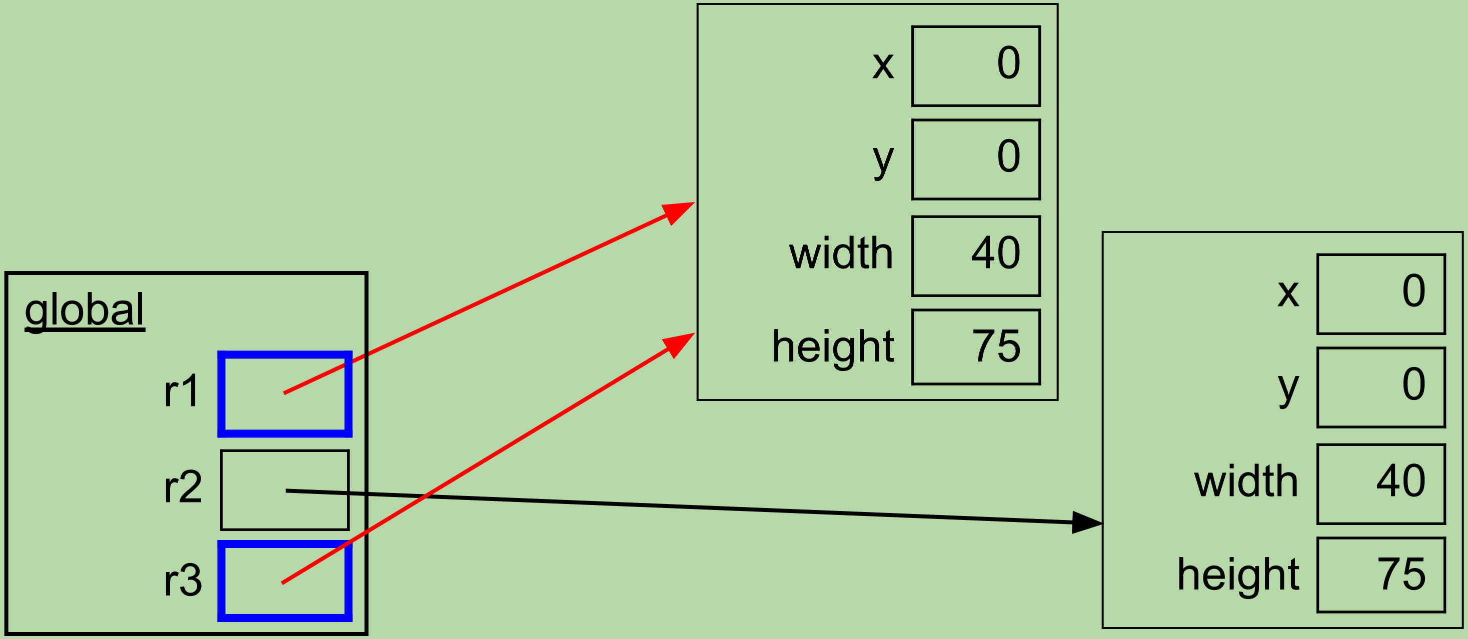
What about this program?

```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

print(r1 == r2)
print(r1 == r3)
```



What is the output of this client program?

```
from rectangle import *

r1 = Rectangle(40, 75)
r2 = Rectangle(40, 75)
r3 = r1

print(r1 == r2)     # outputs False
print(r1 == r3)     # outputs True
```



__eq__ (Implementing Our Own ==)

- The __eq__ method of a class allows us to implement our own version of the == operator.

- If we don't write a __eq__ method for a class, we get a default version that compares the object's memory addresses
  - see the previous example!

__eq__ Method for Our Rectangle Class

```
class Rectangle:
    ...                r1     r2
    def __eq__(self, other):
        if self.width == other.width and
           self.height == other.height:
            return True
        else:
            return False
```

```
>>> r1 = Rectangle(40, 75)
>>> r2 = Rectangle(40, 75)

>>> print(r1 == r2)
True
```

__repr__ (Printing/Evaluating an Object)

- The __repr__ method of a class returns a string representation of objects of that class.

- It gets called when you:
  - evaluate an object in the Shell:

```
>> r1 = Rectangle(100, 80)
>> r1                    # calls __repr__
```

  - apply str():

```
>> r1string = str(r1)    # also calls __repr__
```

  - print an object:

```
>> print(r1)             # also calls __repr__
```

__repr__   (Printing/Evaluating an Object)

- If we don't write a __repr__ method for a class, we get a default version that isn't very helpful!

```
    >>> r2 = Rectangle(50, 20)
    >>> r2
  <__main__.Rectangle object at 0x03247C30>
```

__repr__ Method for Our Rectangle Class

```
class Rectangle:
    ...
    def __repr__(self):
        return str(self.width) + ' x ' + str(self.height)
```

- Note: the method does *not* do any printing.

- It returns a string that can then be printed or used when evaluating the object:

```
    >>> r2 = Rectangle(50, 20)

    >>> print(r2)
50 x 20

    >>> r2
50 x 20
```

Updated Rectangle Class

```
class Rectangle:
    def __init__(self, init_width, init_height):
        ...
    def grow(self, dwidth, dheight):
        self.width += dwidth
        self.height += dheight
    def area(self):
            return self.width * self.height
    def perimeter(self):
            return 2*self.width + 2*self.height
    def scale(self, factor):
            self.width *= factor
            self.height *= factor
    def __eq__(self, other):
            if self.width == other.width and self.height == other.height:
               return True
          return False
    def __repr__(self):
            return str(self.width) + ' x ' + str(self.height)
```

Simplifying the Client Program Again...

```
from rectangle import *

# Construct two Rectangle objects
r1 = Rectangle(100, 50)
r2 = Rectangle(75, 350)

# Print dimensions and area of each
print('r1:', r1.width, 'x', r1.height)
print('area =', r1.area())

print('r2:', r2.width, 'x', r2.height)
print('area =', r2.area())

# grow both Rectangles
r1.grow(50, 10)
r2.grow(5, 30)

# Print new dimensions
print('r1:', r1.width, 'x', r1.height)
print('r2:', r2.width, 'x', r2.height)
```

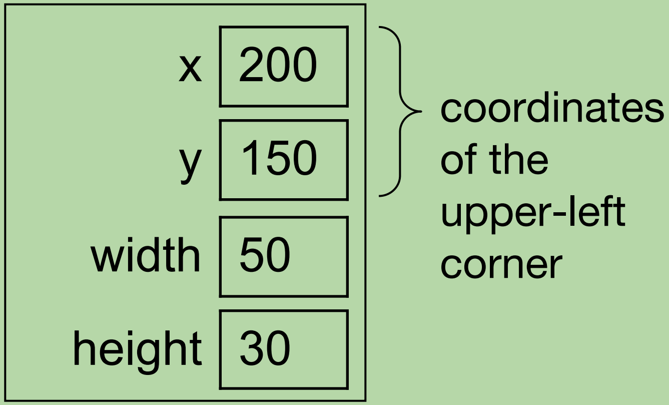
Simplifying the Client Program Again...

```
from rectangle import *

# Construct two Rectangle objects
r1 = Rectangle(100, 50)
r2 = Rectangle(75, 350)

# Print dimensions and area of each
print('r1:', r1)
print('area =', r1.area())

print('r2:', r2)
print('area =', r2.area())

# grow both Rectangles
r1.grow(50, 10)
r2.grow(5, 30)

# Print new dimensions
print('r1:', r1)
print('r2:', r2)
```

More Practice Defining Methods

- Write a method that moves the rectangle to the right by some amount.
  - sample call: r.move_right(30)

```
def move_right(self, _________):
```



x 200

y 150

width 50

height 30

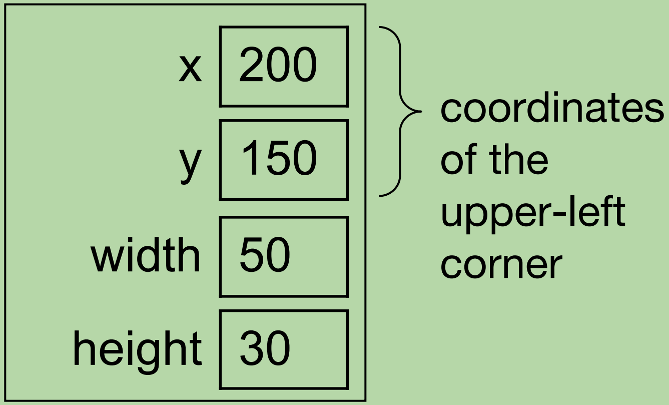
coordinates of the upper-left corner

- Write a method that determines if the rectangle is a square.
  - return True if it is, and False otherwise
  - sample call: r1.is_square()

More Practice Defining Methods

- Write a method that moves the rectangle to the right by some amount.
  - sample call: r.move_right(30)

```
def move_right(self, amount):
    self.x += amount

    # do we need to return something?
      # no! the changes will still be in the object
      # after the method returns!
```



x	200
y	150
width	50
height	30

coordinates of the upper-left corner

- Write a method that determines if the rectangle is a square.
  - return True if it is, and False otherwise
  - sample call: r1.is_square()

```
def is_square(self):
    if self.width == self.height:
        return True
    else:
        return False
```

The 4 Pillars of OOP

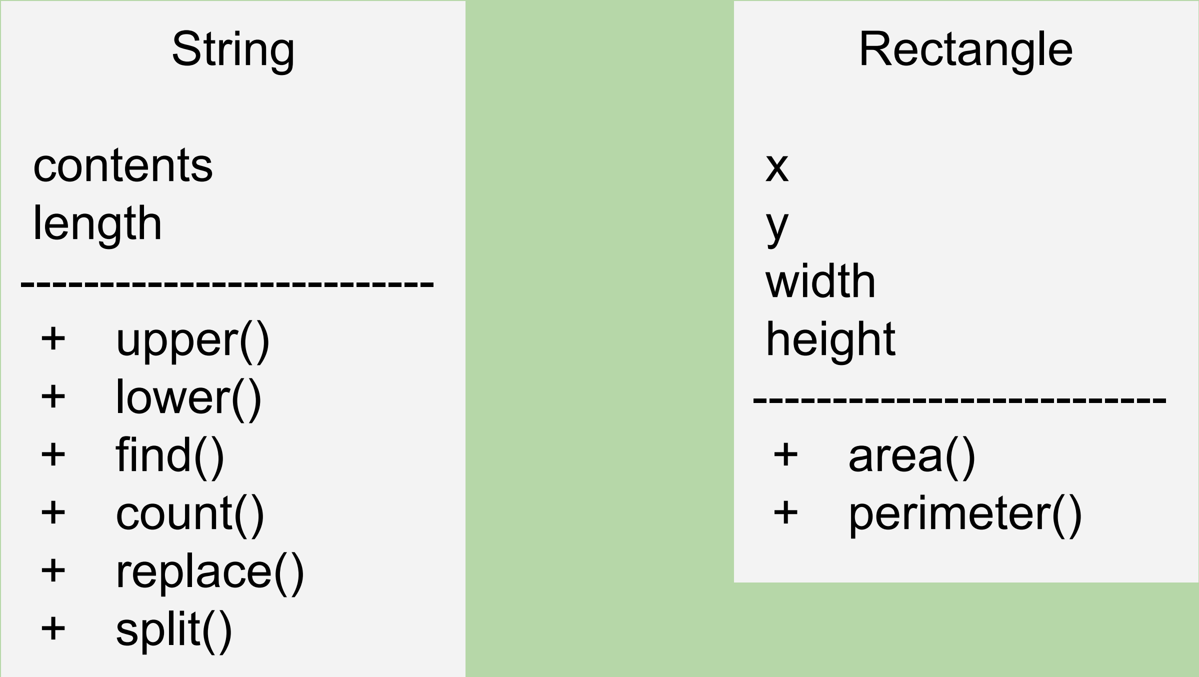
1. **Encapsulation**
2. **Abstraction**
3. **Inheritance**
4. **Polymorphism**

This is a common interview question for software developers!

The 4 Pillars of OOP

1. Encapsulation

Grouping related functions and variables together into objects



String

contents
length

+ upper()
+ lower()
+ find()
+ count()
+ replace()
+ split()

Rectangle

x
y
width
height

+ area()
+ perimeter()

The 4 Pillars of OOP

2. Abstraction

Hiding code complexity from an object’s interface

Before OOP

```
area1 = r1.width * r1.height
area2 = r2.width * r2.height
area3 = r3.width * r3.height
```

After OOP

```
area1 = r1.area()
area2 = r2.area()
area3 = r3.area()
```

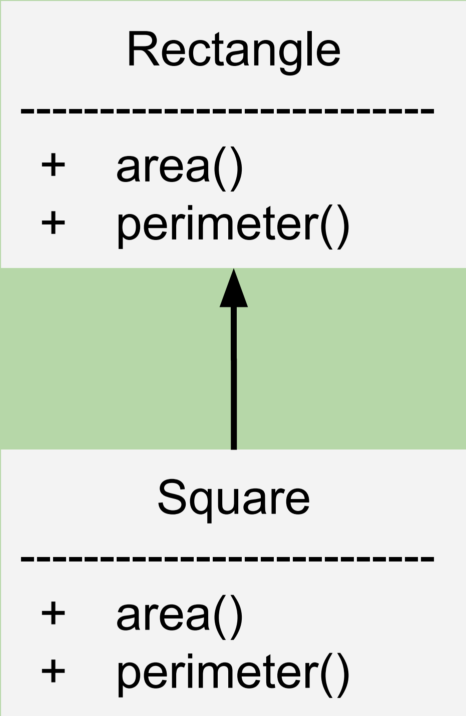
Users of Rectangle don’t care how the area is calculated, only that it is

What if we wanted to change how area is calculated?

The 4 Pillars of OOP

3. Inheritance

Reducing redundant code by combining common features



Rectangle

+ area()
+ perimeter()

Square

+ area()
+ perimeter()

Where do we define the area & perimeter of a Square?

We will cover inheritance next class

The 4 Pillars of OOP

4. Polymorphism

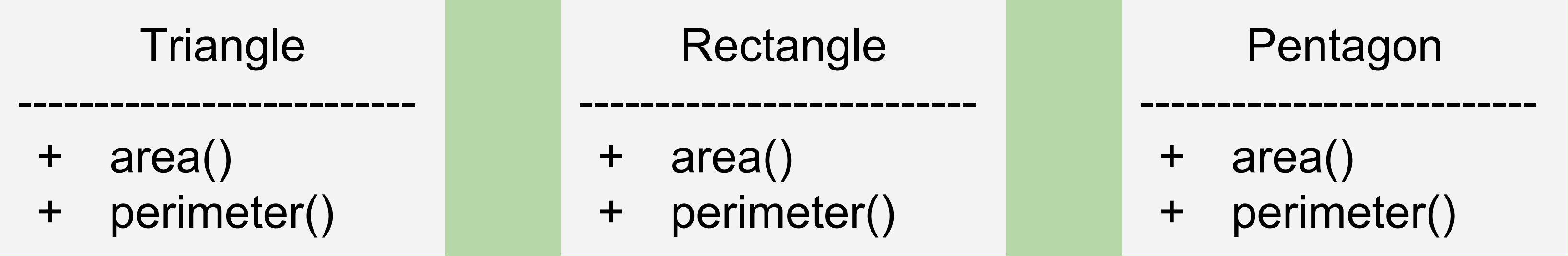
Enabling a common interface for many different data types

Before OOP

```
a1 = area_triangle(b,h)
a2 = area_rectangle(w,h)
a3 = area_pentagon(a)
```

After OOP

```
a1 = tri.area()
a2 = rec.area()
a3 = pen.area()
```



```
Triangle
---------------------------
+   area()
+   perimeter()
```

```
Rectangle
---------------------------
+   area()
+   perimeter()
```

```
Pentagon
---------------------------
+   area()
+   perimeter()
```

The 4 Pillars of OOP

What are the main benefits of these OOP concepts?

1. **Encapsulation**

   Reduces complexity and improves reusability

2. **Abstraction**

   Reduces complexity and minimizes impact of changes

3. **Inheritance**

   Eliminates redundant code

4. **Polymorphism**

   Simplifies object interfaces

The 4 Pillars of OOP

Which of the pillars matches the following definition?

Hiding code complexity from an object’s interface

A. Encapsulation
B. Abstraction
C. Inheritance
D. Polymorphism
E. None of the above

The 4 Pillars of OOP

Which of the pillars matches the following definition?

Hiding code complexity from an object’s interface

Before OOP

```
area1 = r1.width * r1.height
area2 = r2.width * r2.height
area3 = r3.width * r3.height
```

After OOP

```
area1 = r1.area()
area2 = r2.area()
area3 = r3.area()
```

A. Encapsulation
B. Abstraction
C. Inheritance
D. Polymorphism
E. None of the above

The 4 Pillars of OOP

Which of the pillars matches the following definition?

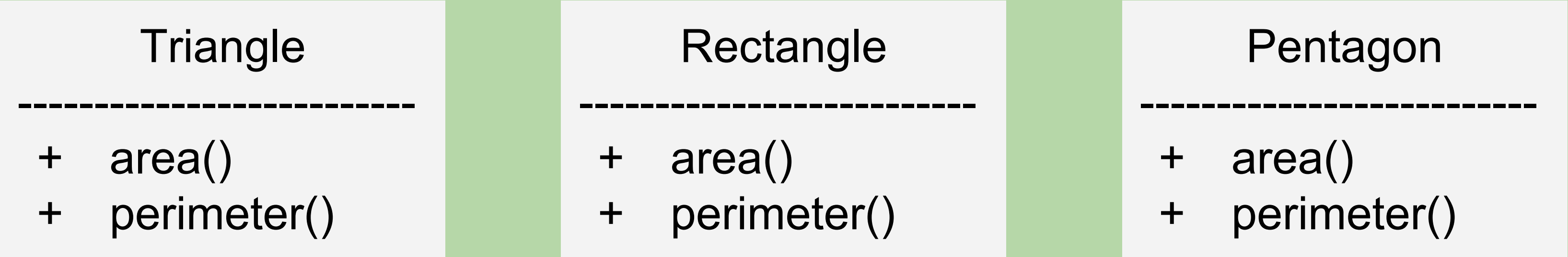
Enabling a common interface for many different data types

A. Encapsulation
B. Abstraction
C. Inheritance
D. Polymorphism
E. None of the above

The 4 Pillars of OOP

Which of the pillars matches the following definition?

Enabling a common interface for many different data types



Triangle
+ area()
+ perimeter()

Rectangle
+ area()
+ perimeter()

Pentagon
+ area()
+ perimeter()

A. Encapsulation
B. Abstraction
C. Inheritance
D. Polymorphism
E. None of the above

The 4 Pillars of OOP

Which of the pillars matches the following definition?

Reducing redundant code by combining common features

A. Encapsulation
B. Abstraction
C. Inheritance
D. Polymorphism
E. None of the above

The 4 Pillars of OOP

Which of the pillars matches the following definition?

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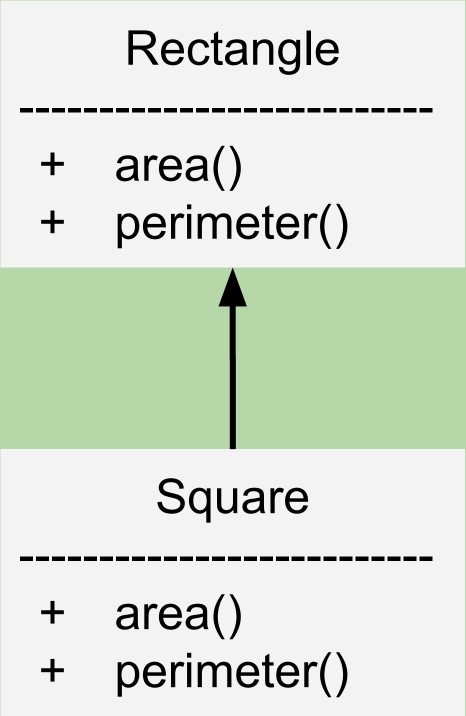

Rectangle

+ area()
+ perimeter()

Square

+ area()
+ perimeter()

The 4 Pillars of OOP

Which of the pillars matches the following definition?

Grouping related functions and variables together into objects

A. Encapsulation
B. Abstraction
C. Inheritance
D. Polymorphism
E. None of the above

The 4 Pillars of OOP

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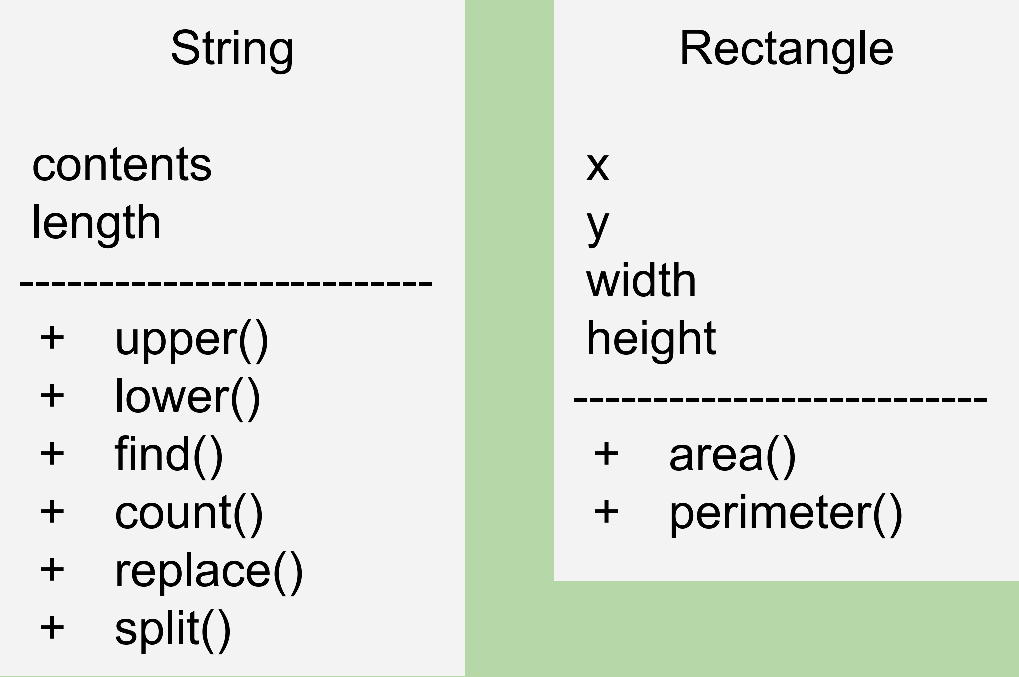
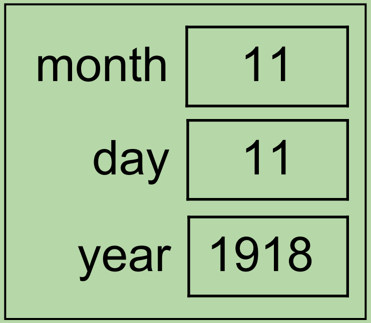


```
        String

 contents
 length
---------------------------
 +   upper()
 +   lower()
 +   find()
 +   count()
 +   replace()
 +   split()
```

```
        Rectangle

 x
 y
 width
 height
---------------------------
 +   area()
 +   perimeter()
```

hw06: Date Class

```
class Date:
    def __init__(self, new_month, new_day, new_year):
        """Constructor"""
        self.month = new_month
        self.day = new_day
        self.year = new_year

    def __repr__(self):
        """This method returns a string representation for the
           object of type Date that calls it (named self).
        """
        s =  "%02d/%02d/%04d" % (self.month, self.day, self.year)
        return s

    def is_leap_year(self):
        """ Returns True if the calling object is
            in a leap year. Otherwise, returns False.
        """
        if self.year % 400 == 0:
            return True
        elif self.year % 100 == 0:
            return False
        elif self.year % 4 == 0:
            return True
        return False
```



month 11

day 11

year 1918

Date Class (cont.)

- Example of how Date objects can be used:

```
>>> d = Date(12, 31, 2014)
>>> print(d)      # calls __repr__
12/31/2014
>>> d.tomorrow()     # a method you will write
01/01/2015         # a new date is returned!
>>> print(d)      # d has not been changed
12/31/2015
```

Methods Calling Other Methods

```
class Date:
    ...
    def incrementDay(self):
        """ moves the date ahead 1 day """

        days_in_month=[0,31,28,31,30,31,30,31,31,30,31,30,31]
        if self.is_leap_year() == True:
            days_in_month[2] = 29

        self.day += 1

        # advance month and year as needed
        if self.day ...
```

- The object calls is_leap_year() on itself!

Another Method You Will Add...

```
class Date:
    ...

    def is_before(self, other):    # buggy version!
        """ returns True if the called Date object (self)
            occurs before other, and False otherwise.
        """
        if self.year < other.year:
            return True
        elif self.month < other.month:
            return True
        elif self.day < other.day:
            return True
        else:
            return False
```

Which call(s) does the method get wrong?

```
class Date:
    ...
    def is_before(self, other):    # buggy version!
        """ returns True if the called Date object (self)
            occurs before other, and False otherwise.
        """
        if self.year < other.year:
            return True
        elif self.month < other.month:
            return True
        elif self.day < other.day:
            return True
        else:
            return False
```

```
d1 = Date(11, 10, 2014)
d2 = Date(1, 1, 2015)
d3 = Date(1, 15, 2014)
```

Extra: Can you think of any *other* cases that it would get wrong involving these dates?

A. d1.is_before(d2)

B. d2.is_before(d1)

C. d3.is_before(d1)

D. more than one

Which call(s) does the method get wrong?

```
class Date:
    ...
    def is_before(self, other):    # buggy version!
        """ returns True if the called Date object (self)
            occurs before other, and False otherwise.
        """
        if self.year < other.year: 2015 < 2014 (False)
            return True
        elif self.month < other.month: 1 < 11 (True)
            return True      # not the correct return value!
        elif self.day < other.day:
            return True
        else:
            return False
```

```
d1 = Date(11, 10, 2014)
d2 = Date(1, 1, 2015)
d3 = Date(1, 15, 2014)
```

A. d1.is_before(d2)

B. d2.is_before(d1)

C. d3.is_before(d1)

D. more than one

Which call(s) does the method get wrong?

```
class Date:
    ...
    def is_before(self, other):    # buggy version!
        """ returns True if the called Date object (self)
            occurs before other, and False otherwise.
        """
        if self.year < other.year:
            return True
        elif self.month < other.month and...:
            return True
        elif self.day < other.day and...:
            return True
        else:
            return False
```

```
d1 = Date(11, 10, 2014)
d2 = Date(1, 1, 2015)
d3 = Date(1, 15, 2014)
```

Extra: Can you think of any *other* cases that it would get wrong involving these dates?

A. d1.is_before(d2)

B. d2.is_before(d1)

C. d3.is_before(d1)

D. more than one

Which call(s) does the method get wrong?

```
class Date:
    ...
    def is_before(self, other):    # buggy version!
        """ returns True if the called Date object (self)
            occurs before other, and False otherwise.
        """
        if self.year < other.year:
            return True
        elif self.month < other.month and...:
            return True
        elif self.day < other.day and...:
            return True
        else:
            return False
```

```
d1 = Date(11, 10, 2014)
d2 = Date(1, 1, 2015)
d3 = Date(1, 15, 2014)
```

Extra: Can you think of any *other* cases that it would get wrong involving these dates?

```
    d1.is_before(d3)
    d2.is_before(d3)
```

A. d1.is_before(d2)

B. d2.is_before(d1)

C. d3.is_before(d1)

D. more than one

I feel so objectified!