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Lecture 19: Subclasses & Inheritance (Chapter 18)

CS 1110

Introduction to Computing Using Python

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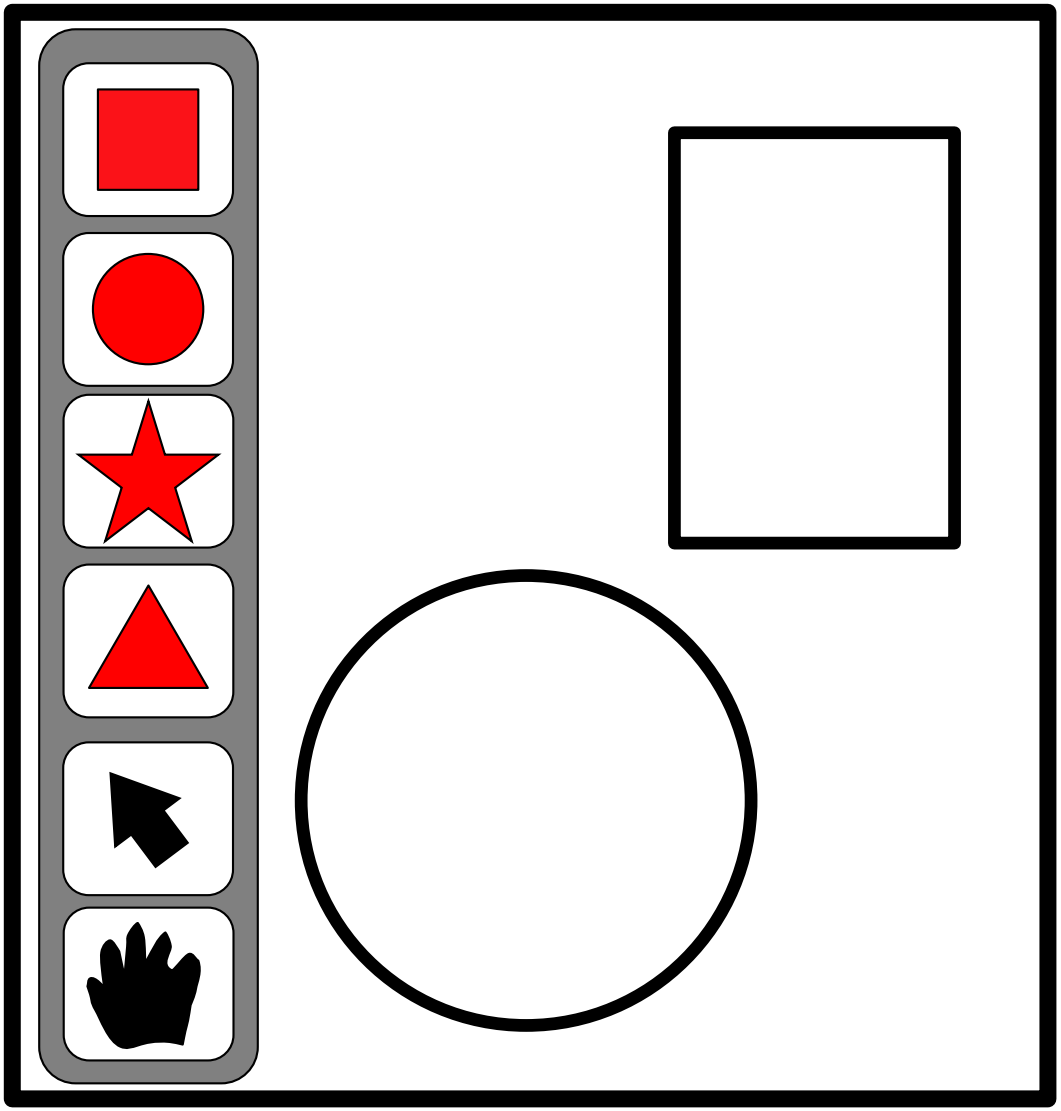
Announcements

- More recursion examples on the Lectures page
- A3 is being graded this week
- A4 *coming soon!*
- Prelim 2
  - Tuesday, April 24th, 7:30-9:00pm
  - Please go to the same room you went for Prelim 1
  - Conflicts assignment on CMS, due 11:59pm Thurs.
- Lab 11 is out (there is no Lab 10)

Goal: Make a drawing app



Rectangles, Stars, Circles, and Triangles have a lot in common, but they are also different in very fundamental ways….

Sharing Work

Problem: Redundant code.

(Any time you copy-and-paste code, you are likely doing something wrong.)

Solution: Create a *parent* class with shared code

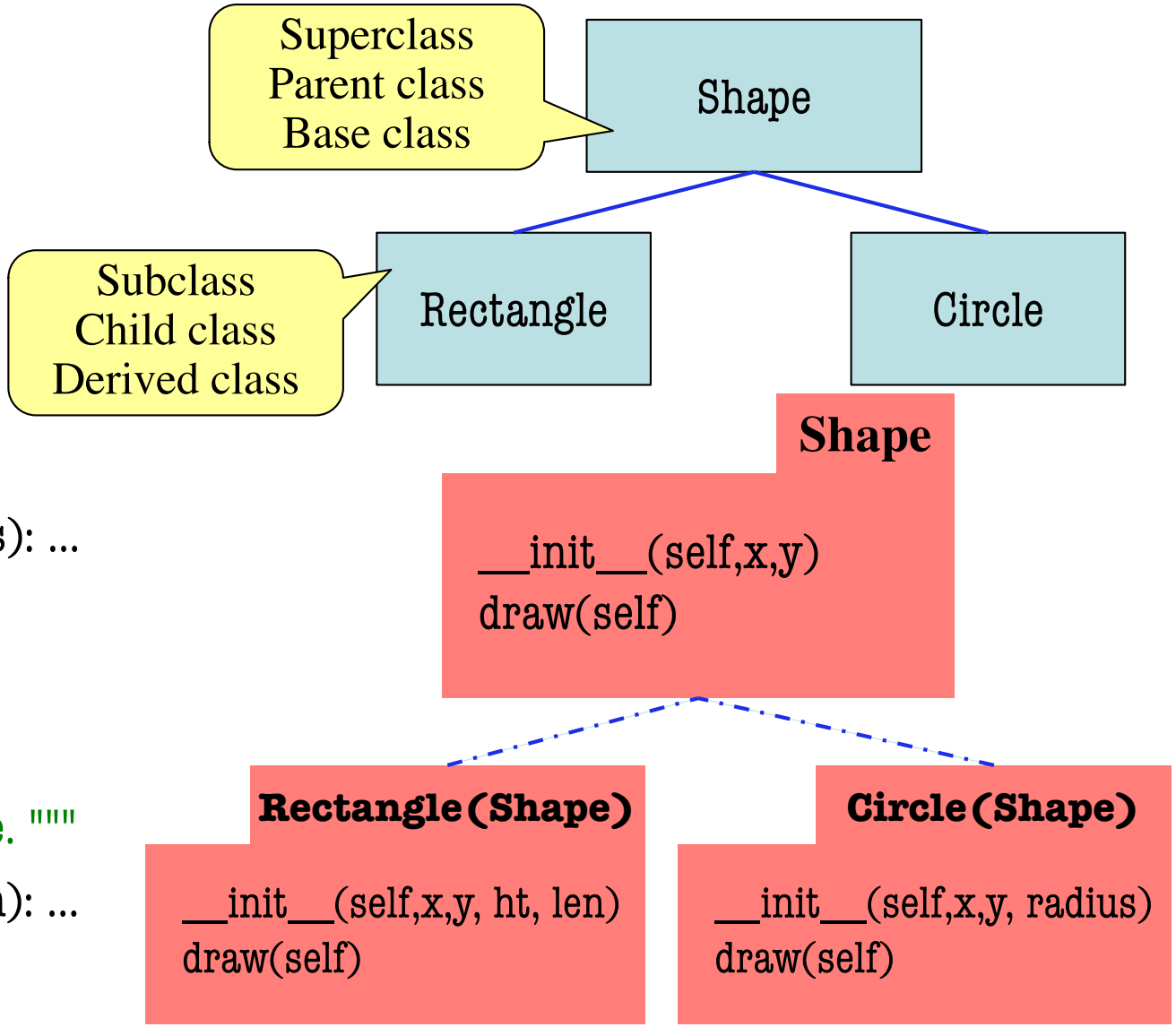
- Then, create *subclasses* of the *parent* class

Defining a Subclass

```
class Shape():
    """A shape located at x,y """
      def __init__(self, x, y): ...
      def draw(self): ...

class Circle(Shape):
    """An instance is a circle."""
    def __init__(self, x, y, radius): ...
    def draw(self): ...

class Rectangle(Shape):
    """An in stance is a rectangle. """
    def __init__(self, x, y, ht, len): ...
    def draw(self): ...
```



Extending Classes

class <*name*>(<superclass>):

```
    """Class specification"""
    class variables
    initializer (__init__)
    methods
```

Class to extend
(may need module name)

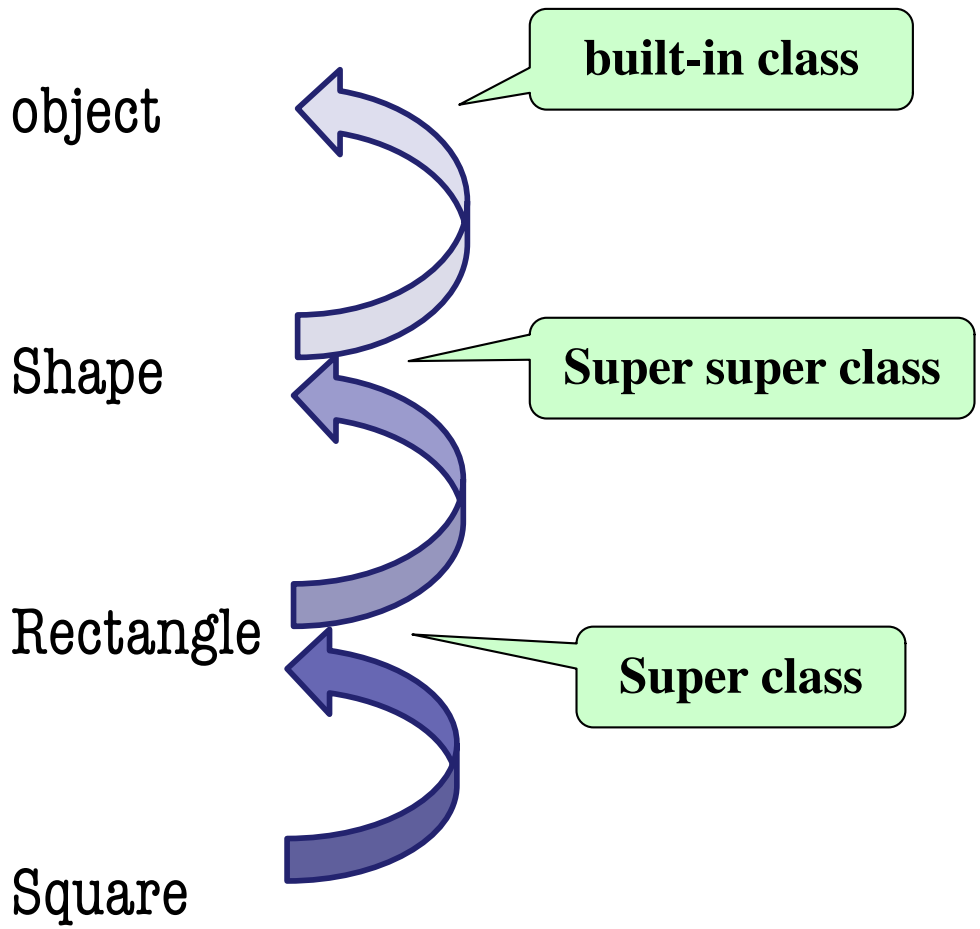
So far, classes have implicitly extended object

object and the Subclass Hierarchy

- Subclassing creates a **hierarchy** of classes
  - Each class has its own super class or parent
  - Until `object` at the "top"
- `object` has many features
  - Default operators: `__init__`, `__str__`, `__repr__`, `__eq__`

Which of these need to be replaced?

Example



__init__

```
class Shape():
    """Instance is shape @ x,y"""
    def __init__(self, x, y):
        self.x = x
        self.y = y
```

- Want to use the original version of the method?
  - New method = original+more
  - Do not want to repeat code from the original version
- Call old method **explicitly**

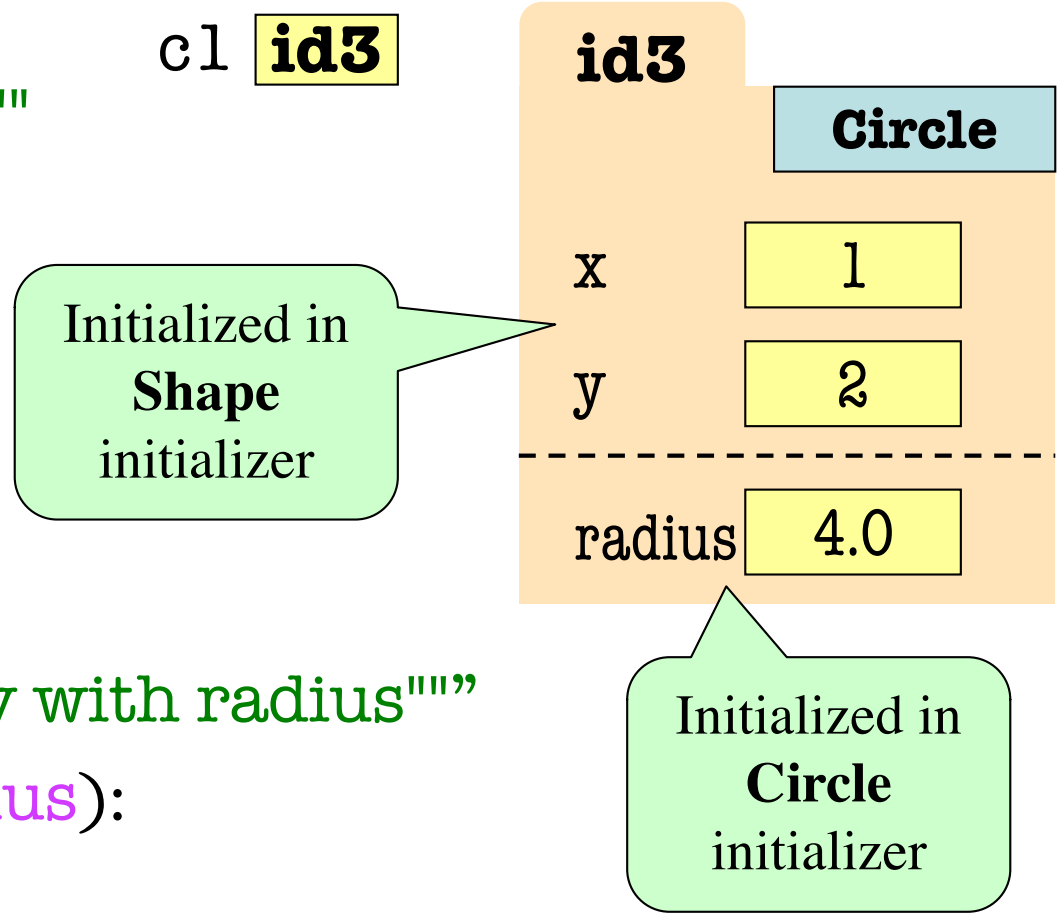
```
class Circle(Shape):
    """Instance is a Circle @ x,y with radius"""
    def __init__(self, x, y, radius):
        self.radius = radius
        super().__init__(x, y)
```

Object Attributes can be Inherited

```
class Shape():
    """Instance is shape @ x,y"""
    def __init__(self,x,y):
        self.x = x
        self.y = y

class Circle(Shape):
    """Instance is a Circle @ x,y with radius"""
    def __init__(self, x, y, radius):
        self.radius = radius
        super().__init__(x,y)

cl = Circle(1, 2, 4.0)
```



More Method Overriding

```
class Shape():
  """Instance is shape @ x,y"""
   def __init__(self,x,y):
   def __str__(self):
       return "Shape @ ("+str(self.x)+", "+str(self.y)+")"
   def draw(self):...
```

double underscore methods are in class object

object

__init__(self)
__str__(self)
__eq__(self)

Shape

__init__(self,x,y)
__str__(self)

```
class Circle(Shape):
  """Instance is a Circle @ x,y with radius"""
   def __init__(self,x,y,radius):
   def __str__(self):
       return "Circle: Radius="+str(self.radius)+" "+Shape.__str__(self)
   def draw(self):...
```

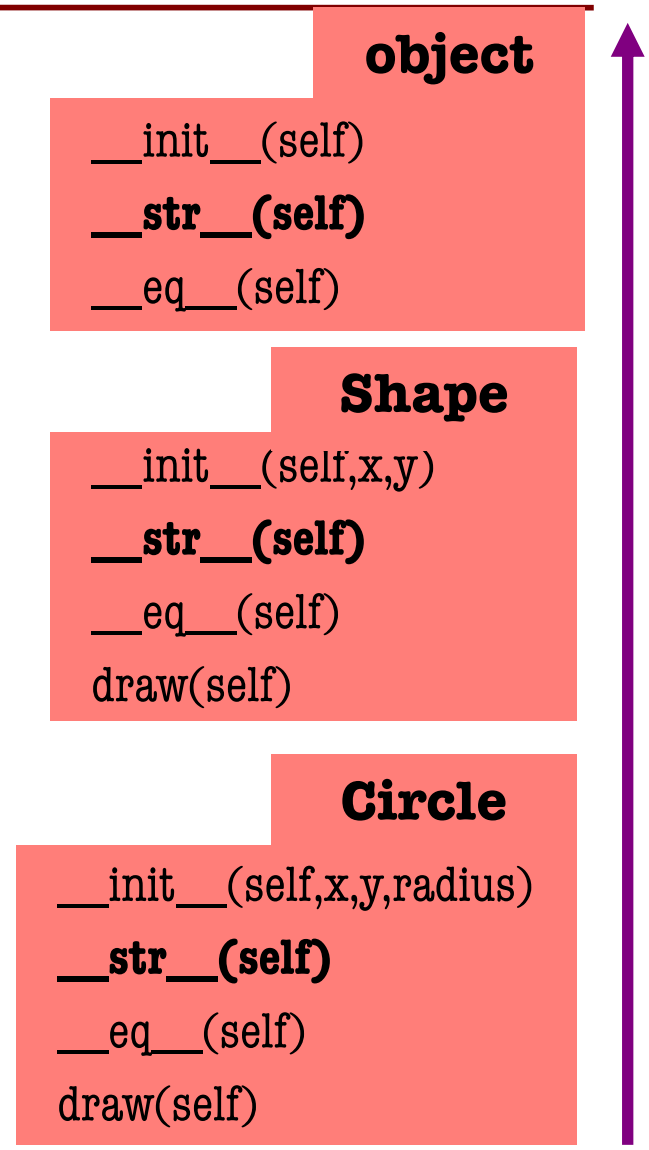
Circle

__init__(self,x,y,radius)
__str__(self)

Understanding Method Overriding

```
c1 = Circle(1,2,4.0)
print(str(c1))
```

- Which __str__ do we use?
  - Start at bottom class folder
  - Find first method with name
  - Use that definition
- Each subclass automatically ***inherits*** methods of parent.
- New method definitions **override** those of parent.

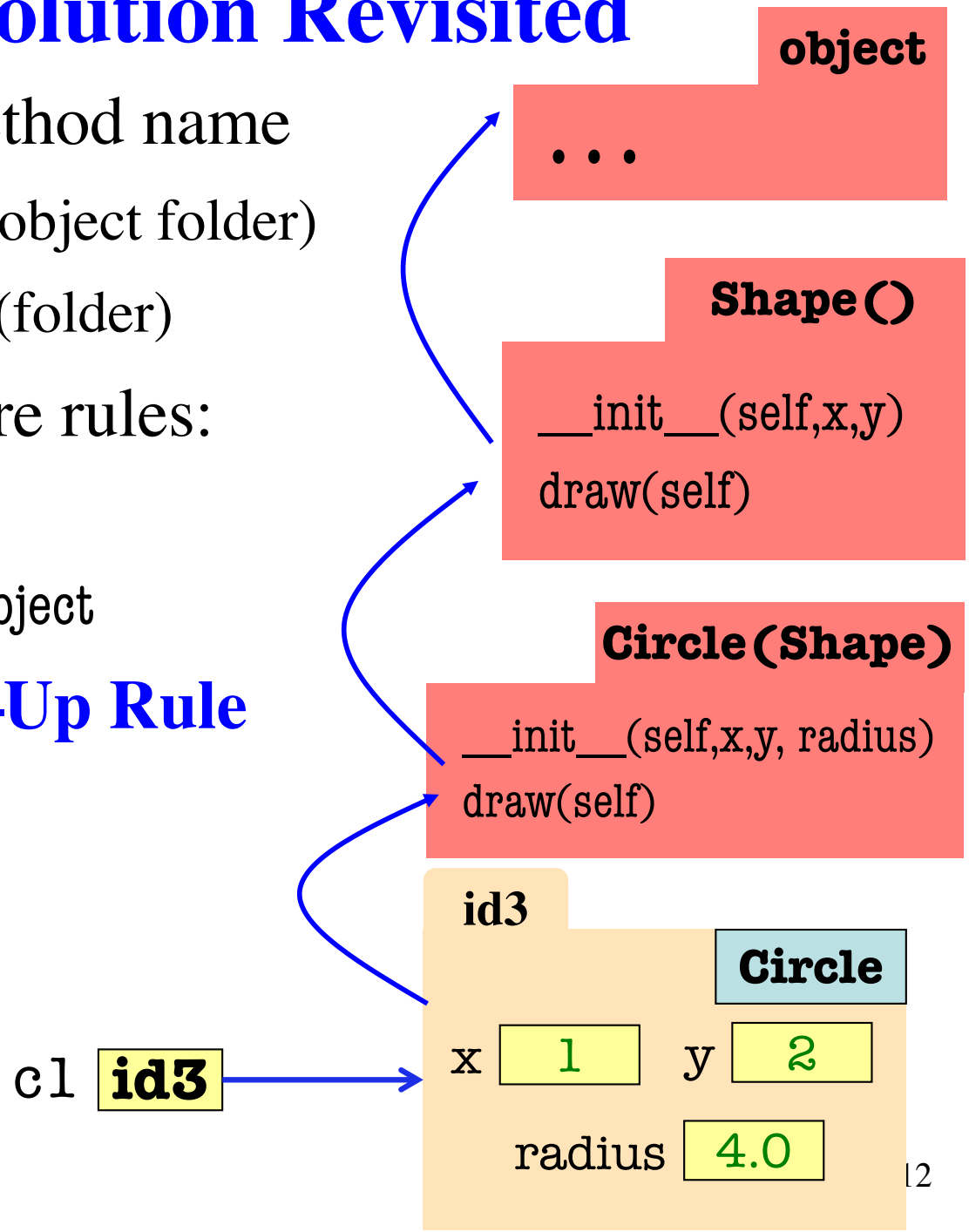


Name Resolution Revisited

- To look up attribute/method name
  1. Look first in instance (object folder)
  2. Then look in the class (folder)
- Subclasses add two more rules:
  3. Look in the superclass
  4. Repeat 3. until reach `object`

Often called the **Bottom–Up Rule**

```
cl = Circle(1,2,4.0)
r = cl.radius
cl.draw()
```



Q1: Name Resolution and Inheritance

```
class A():

    def f(self):
        return self.g()

    def g(self):
        return 10


class B(A):

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of a.f()?

A: 10
B: 14
C: 5
D: **ERROR**
E: I don't know

A1: Name Resolution and Inheritance

```
class A():

    def f(self):
        return self.g()

    def g(self):
        return 10


class B(A):

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of a.f()?

A: 10 **CORRECT**
B: 14
C: 5
D: **ERROR**
E: I don't know

Q2: Name Resolution and Inheritance

```
class A():

    def f(self):
        return self.g()

    def g(self):
        return 10


class B(A):

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of b.f()?

A: 10
B: 14
C: 5
D: **ERROR**
E: I don't know

A2: Name Resolution and Inheritance

```
class A():

    def f(self):
        return self.g()

    def g(self):
        return 10


class B(A):

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of b.f()?

A: 10
B: 14 **CORRECT**
C: 5
D: **ERROR**
E: I don't know

Accessing the "Original" draw

```
class Shape():
    def draw(self):
        turtle.penup()
        turtle.setx(self.x)
        turtle.sety(self.y)
        turtle.pendown()

class Circle(Shape):
    def draw(self):
        super().draw()
        turtle.circle(self.radius)
```

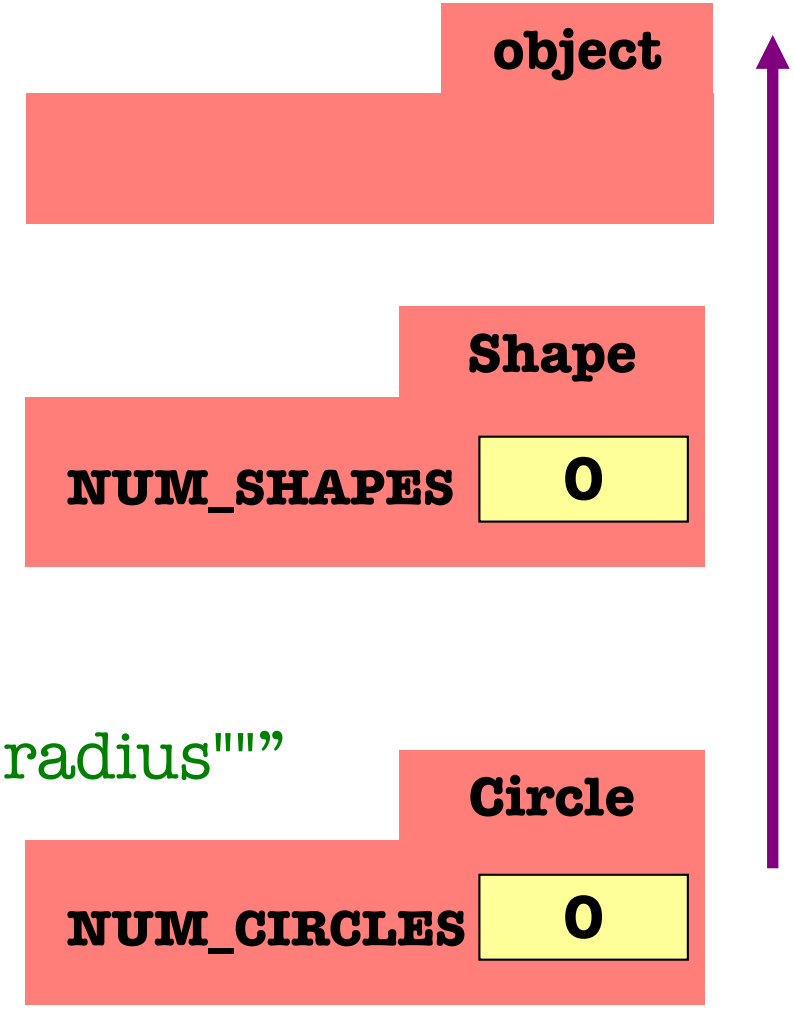
Note: we've imported the turtle module which allows us to move a pen on a 2D grid and draw shapes.

No matter the shape, we want to pick up the pen, move to the location of the shape, put the pen down. Only the shape subclasses know how to do the actual drawing, though.

Class Variables can also be Inherited

```
class Shape(object):
    """Instance is shape @ x,y"""
    # Class Attribute
    NUM_SHAPES = 0
    . . .

class Circle(Shape):
    """Instance is a Circle @ x,y with radius"""
    # Class Attribute
    NUM_CIRCLES = 0
    . . .
```



Q3: Name Resolution and Inheritance

```
class A():
    x = 3 # Class Variable
    y = 5 # Class Variable

    def f(self):
        return self.g()

    def g(self):
        return 10

class B(A):
    y = 4    # Class Variable
    z = 42   # Class Variable

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of b.x?

A: 4
B: 3
C: 42
D: **ERROR**
E: I don't know

A3: Name Resolution and Inheritance

```
class A():
    x = 3 # Class Variable
    y = 5 # Class Variable

    def f(self):
        return self.g()

    def g(self):
        return 10

class B(A):
    y = 4    # Class Variable
    z = 42   # Class Variable

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of b.x?

A: 4
B: 3 **CORRECT**
C: 42
D: **ERROR**
E: I don't know

Q4: Name Resolution and Inheritance

```
class A():
    x = 3 # Class Variable
    y = 5 # Class Variable

    def f(self):
        return self.g()

    def g(self):
        return 10

class B(A):
    y = 4    # Class Variable
    z = 42   # Class Variable

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of a.z?

A: 4
B: 3
C: 42
D: **ERROR**
E: I don't know

A4: Name Resolution and Inheritance

```
class A():
    x = 3 # Class Variable
    y = 5 # Class Variable

    def f(self):
        return self.g()

    def g(self):
        return 10

class B(A):
    y = 4    # Class Variable
    z = 42   # Class Variable

    def g(self):
        return 14

    def h(self):
        return 18
```

- Execute the following:

```
>>> a = A()
>>> b = B()
```

- What is value of a.z?

A: 4
B: 3
C: 42
D: **ERROR** **CORRECT**
E: I don't know

Why override __eq__ ?

```
class Shape():
  """Instance is shape @ x,y"""
   def __init__(self,x,y):
   def __eq__(self, other):
        """If position is the same, then equal as far as Shape knows"""
        return self.x == other.x and self.y == other.y

class Circle(Shape):
  """Instance is a Circle @ x,y with radius"""”
   def __init__(self,x,y,radius):
   def __eq__(self, other):
      """If radii are equal, let super do the rest"""
      return self.radius == other.radius and super().__eq__(other)
```

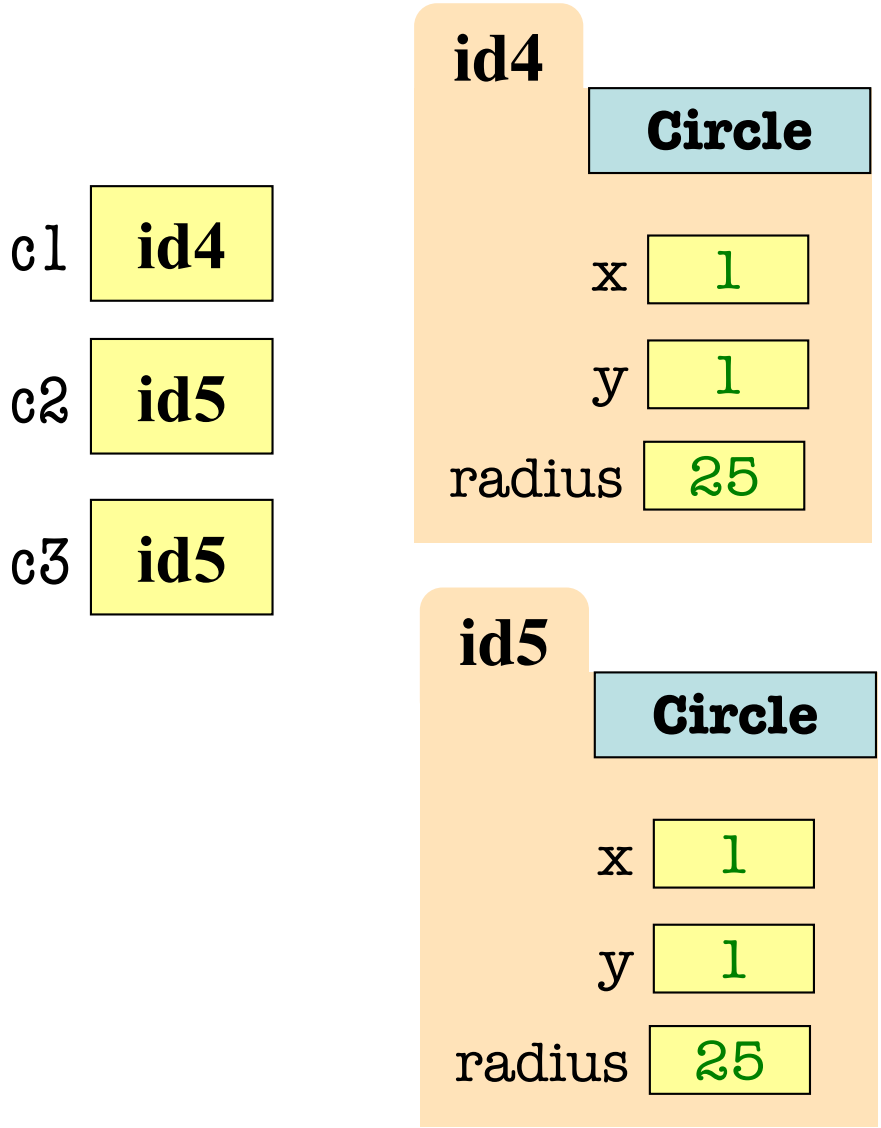
eq vs. is

== compares **equality**

is compares **identity**

```
c1 = Circle(1, 1, 25)
c2 = Circle(1, 1, 25)
c3 = c2
```

```
c1 == c2 ?
c1 is c2 ?
c2 == c3 ?
c2 is c3 ?
```

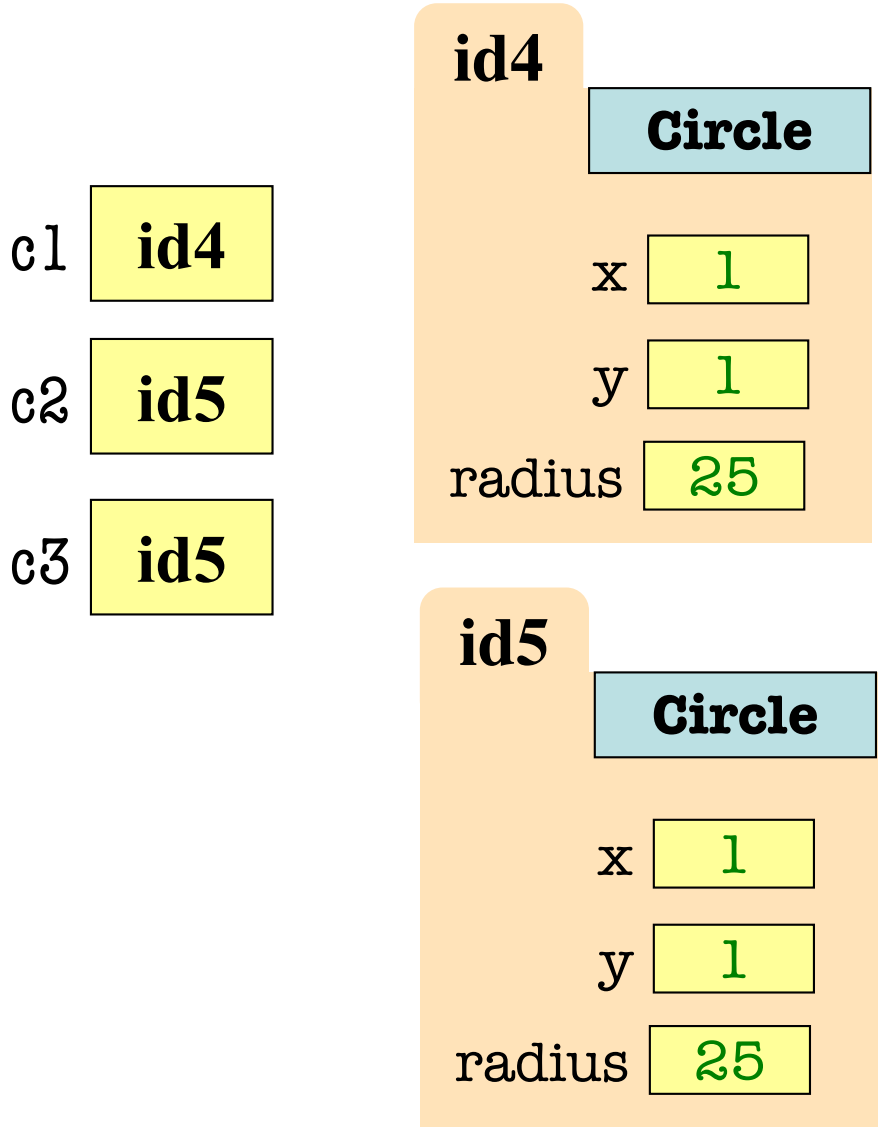


eq vs. is

== compares **equality**

is compares **identity**

```
c1 = Circle(1, 1, 25)
c2 = Circle(1, 1, 25)
c3 = c2
```



c1 == c2 ?	True
c1 is c2 ?	False
c2 == c3 ?	True
c2 is c3 ?	True

The isinstance Function

isinstance(<obj>,<class>)

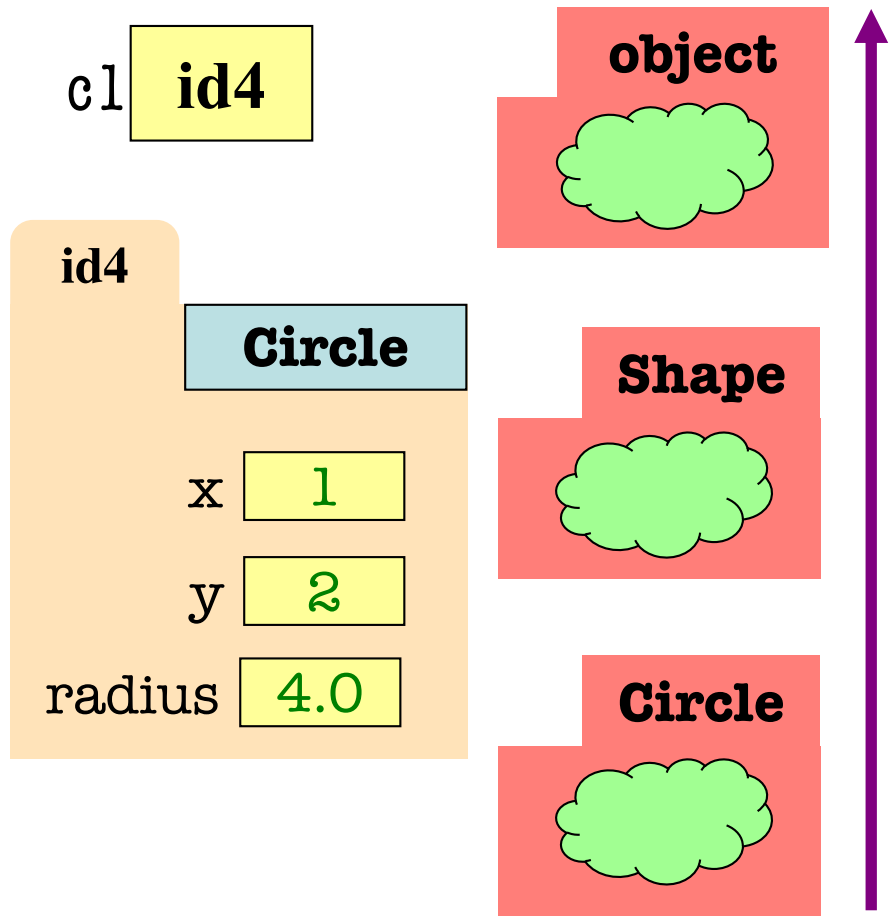
- True if <obj>'s class is same as or a subclass of <class>
- False otherwise

Example:

cl = Circle(1,2,4.0)

- isinstance(cl,Circle) is True
- isinstance(cl,Shape) is True
- isinstance(cl,object) is True
- isinstance(cl,str) is False

- Generally preferable to type
  - Works with base types too!

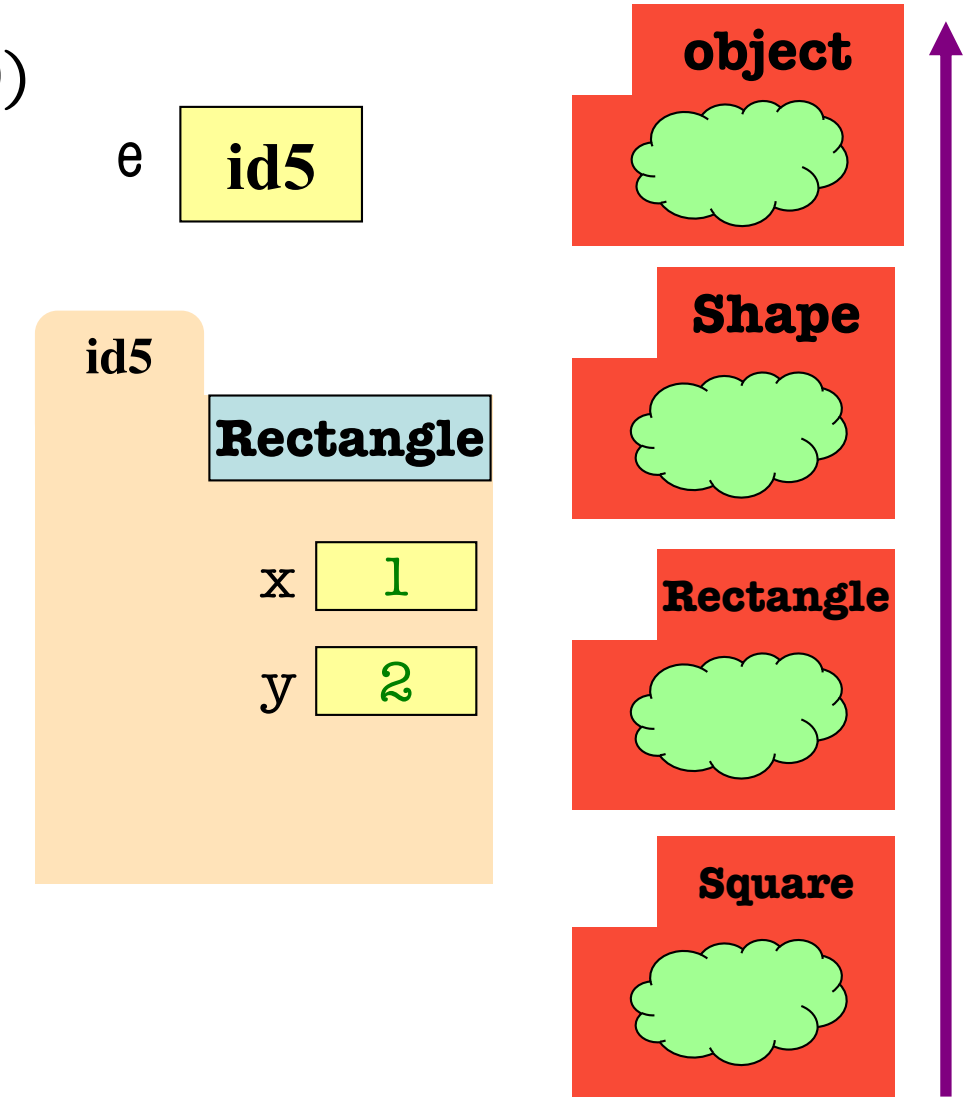


Q5: isinstance and Subclasses

```
>>> shape1 = Rectangle(0,0,10,10)
>>> isinstance(shape1, Square)
```

???

A: True
B: False
C: Error
D: I don't know



A5: isinstance and Subclasses

```
>>> shape1 = Rectangle(0,0,10,10)
>>> isinstance(shape1, Square)
```

???

A: True
B: False CORRECT
C: Error
D: I don't know