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Lecture 22: Subclasses & Inheritance (Chapter 18)

CS 1110

Introduction to Computing Using Python

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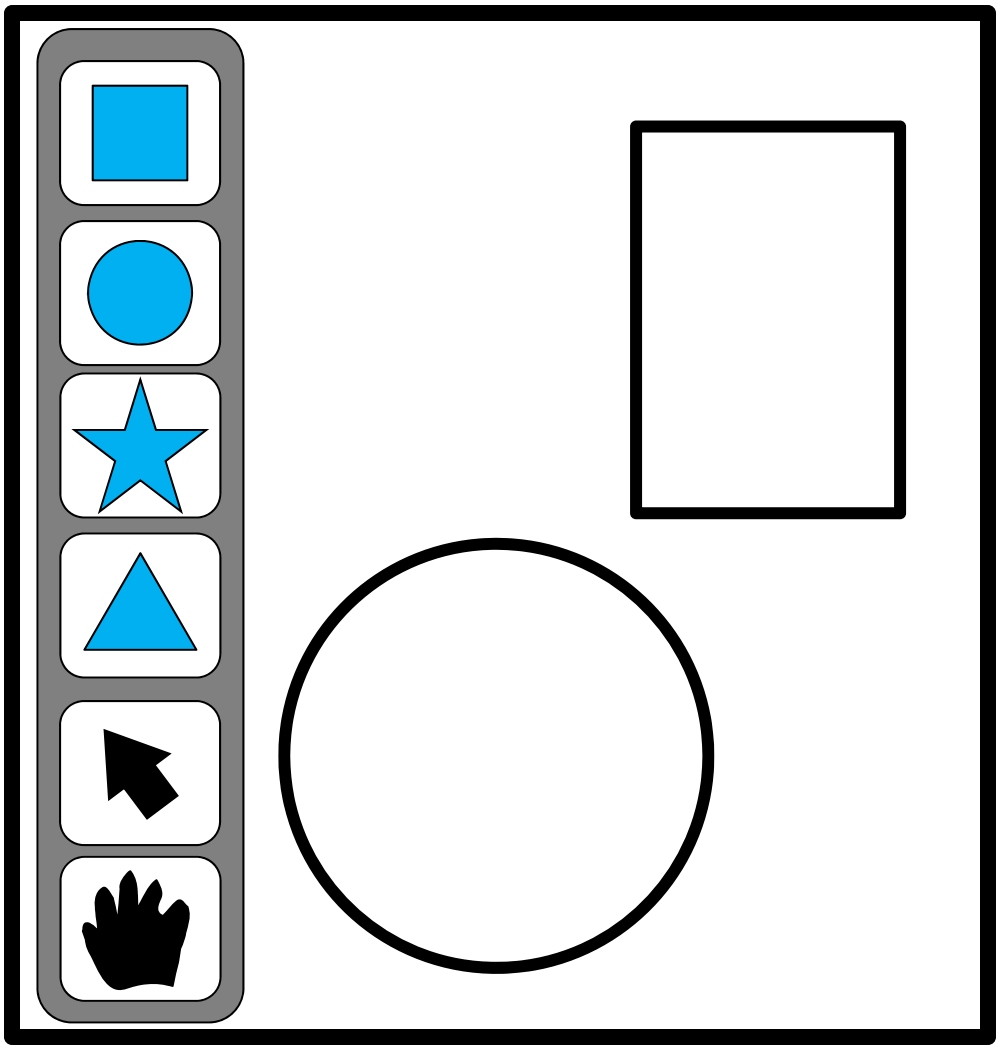
Goal: Make a drawing app



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

Sharing Work

Problem: Redundant code.

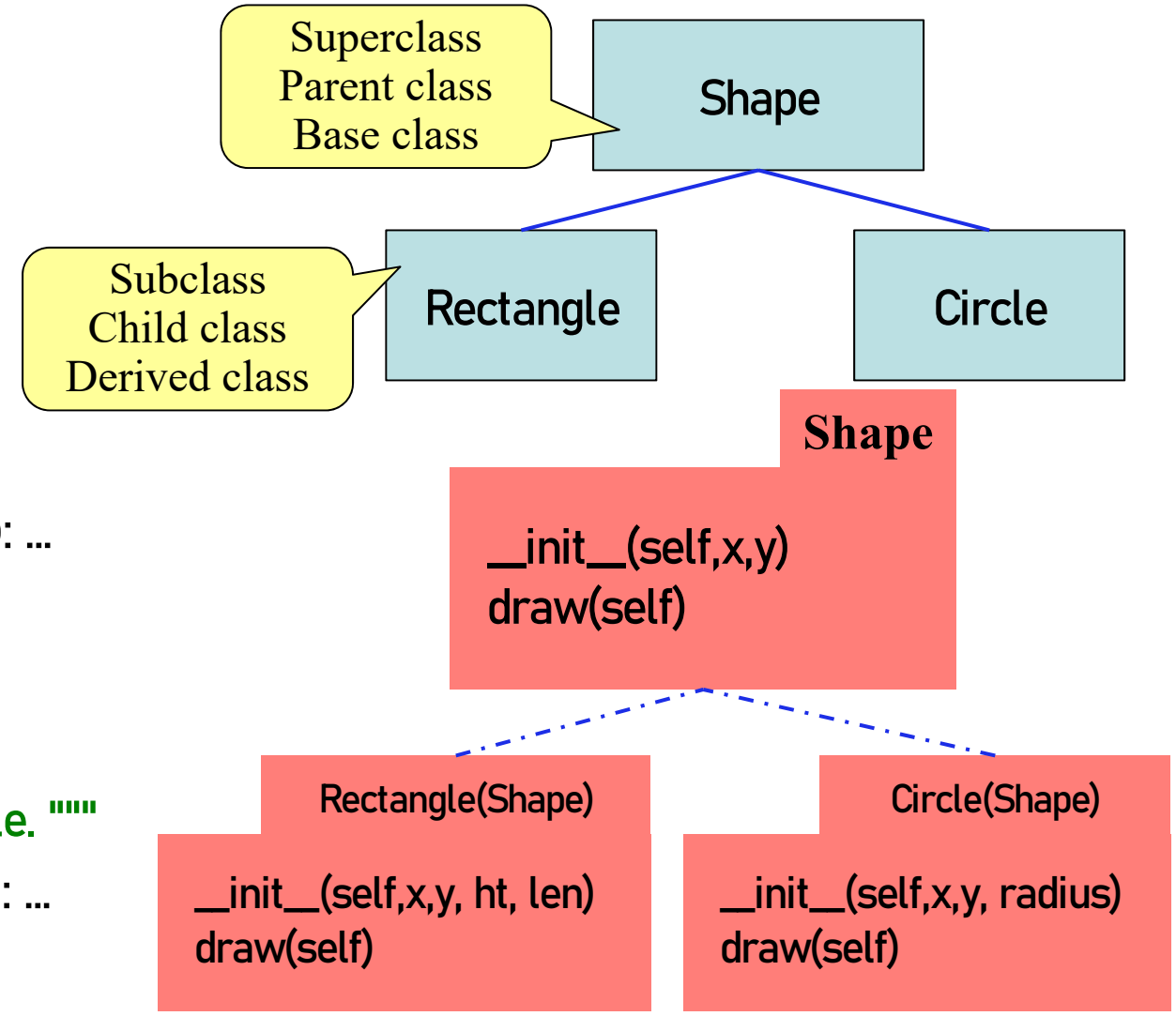
(Any time you copy-and-paste code, you are likely doing something wrong.)

Solution: Create a *parent* class with shared code

- Then, create *subclasses* of the *parent* class
- A subclass deals with specific details different from 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
```

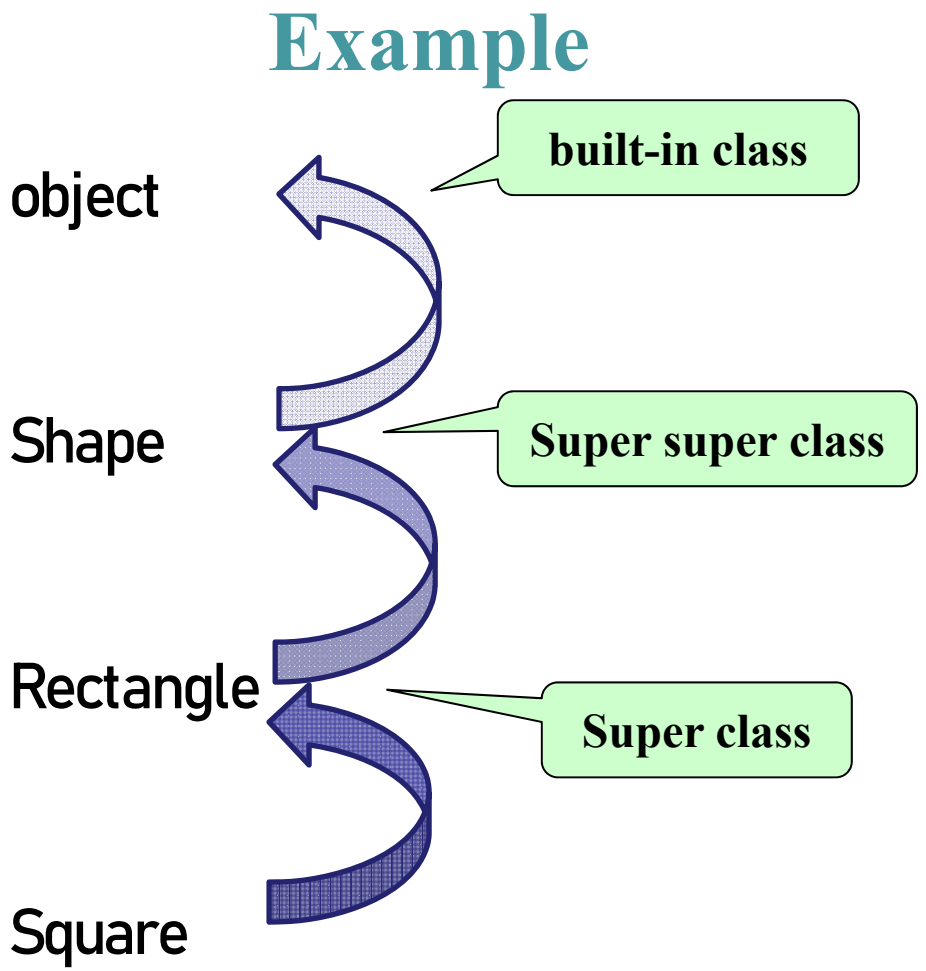
Class to extend
(may need module name:
<modulename>.<superclass>)

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__, __eq__

Which of these need to be replaced?



__init__: write new one, access parent's

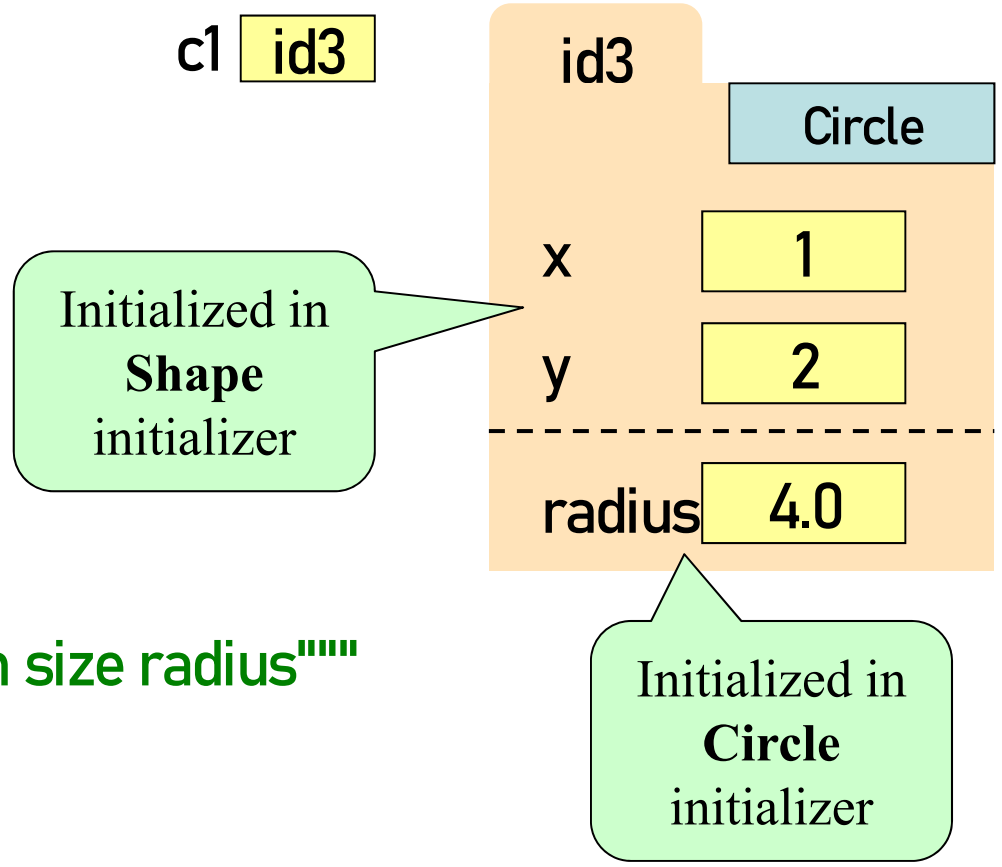
```
class Shape():
    """A shape @ location x,y """
    def __init__(self, x, y):
        self.x = x
        self.y = y
```

- Want to use the original version of the method?
  - New method = original+more
  - Don't repeat code from the original
- Call old method **explicitly**

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

Object Attributes can be Inherited

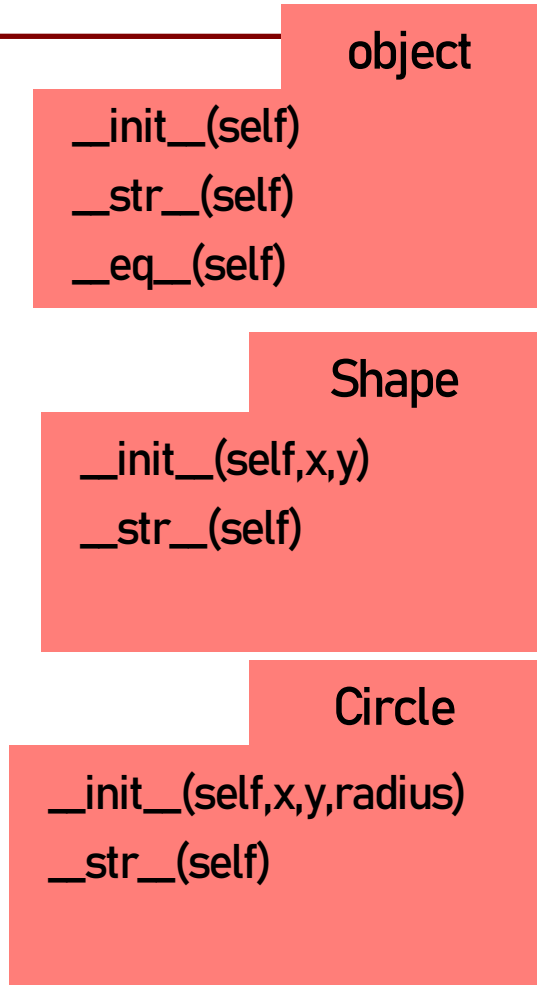
```
class Shape():
    """ A shape @ location x,y """
     def __init__(self,x,y):
          self.x = x
          self.y = y

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

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



Can override methods; can access parent's version

```
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):...
```

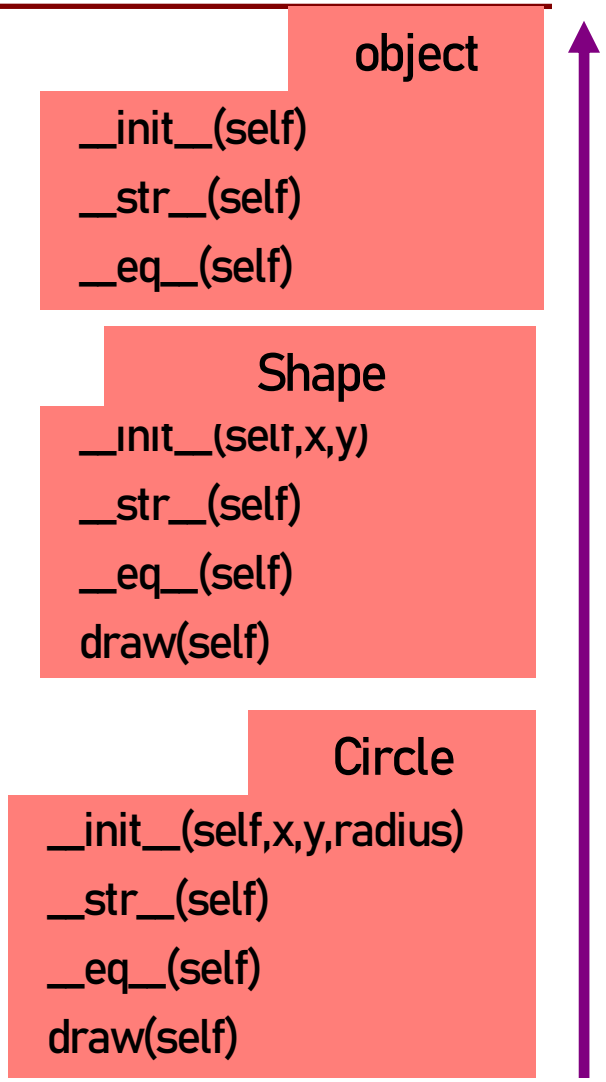
```
class Circle(Shape):
    """Instance is a Circle @ x,y with radius"""
    def __init__(self,x,y,radius):
    def __str__(self):
        return "Circle: Radius="+str(self.radius)+" "+super().__str__()
    def draw(self):...
```



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.

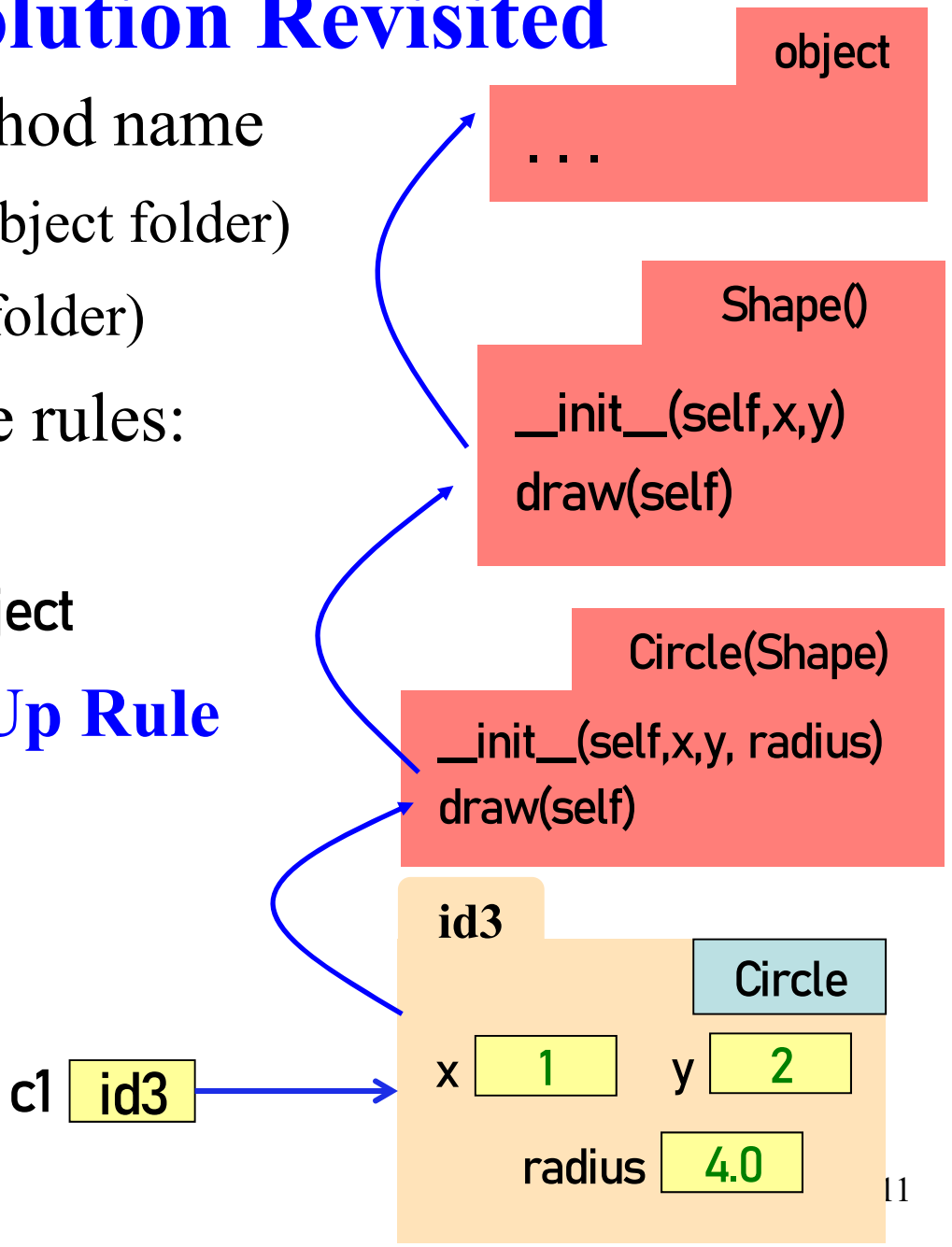


Name Resolution Revisited

- 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**

```
c1 = Circle(1,2,4.0)
r = c1.radius
c1.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*

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*

Start next video:

Design choices for method draw

Demo using Turtle Graphics

A turtle holds a pen and can draw as it walks! Follows simples commands:

- setx, sety – set start coordinate
- pendown, penup – control whether to draw when moving
- forward
- turn

Part of the turtle module in Python (docs.python.org/3.7/library/turtle.html)

- *You don't need to know it*
- Just a demo to explain design choices of `draw()` in our classes `Shape`, `Circle`, `Rectangle`, `Square`

Who draws what?

```
class Shape():
    """Moves pen to correct location"""
    def draw(self):
        turtle.penup()
        turtle.setx(self.x)
        turtle.sety(self.y)
        turtle.pendown()

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

Note: need to import the **turtle** module which allows us to move a pen on a 2D grid and draw shapes.

Job for Shape: No matter the shape, we want to pick up the pen, move to the location of the shape, put the pen down.

Job for subclasses: But only the shape subclasses know how to do the actual drawing.

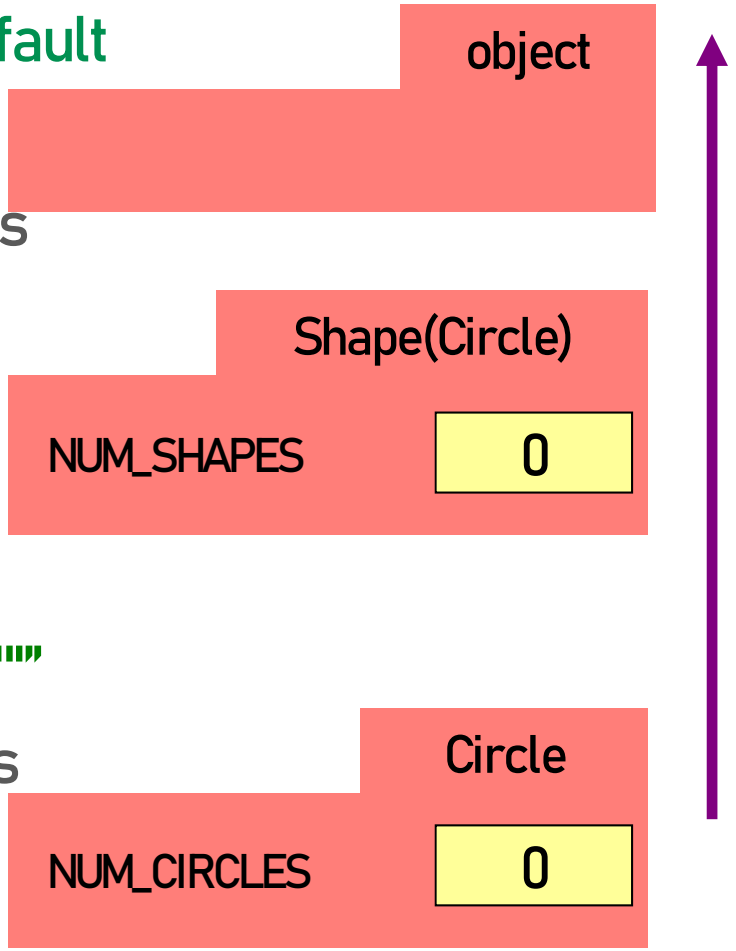
See **shapes.py**, **draw_shapes.py**

Start next video:

Class attributes

Class Variables can also be Inherited

```
class Shape():  # inherits from object by default
    """Instance is shape @ x,y"""
    # Class Attribute tracks total num shapes
    NUM_SHAPES = 0
    . . .

class Circle(Shape):
    """Instance is a Circle @ x,y with radius"""
    # Class Attribute tracks total num circles
    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*

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*

Why override __eq__ ? Compare equality

```
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)
```

Want to compare equality *of the values (data)* of two instances, not the id of the two instances!

eq vs. is

== compares **equality**

is compares **identity**

c1 = Circle(1, 1, 25)

c2 = Circle(1, 1, 25)

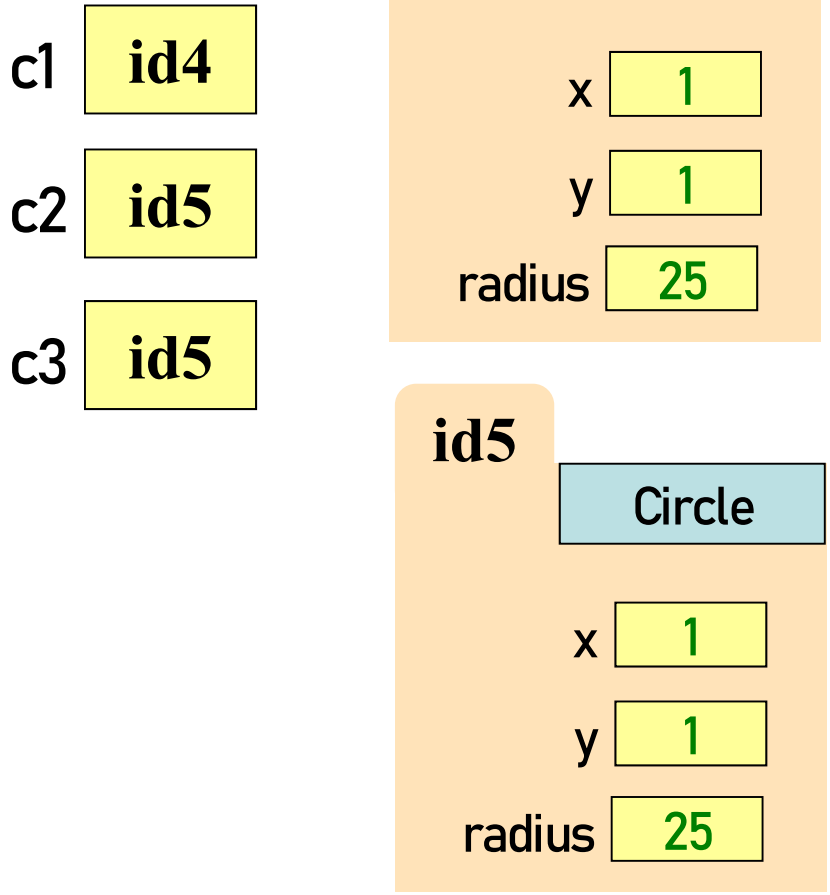
c3 = c2

c1 == c2 ?

c1 is c2 ?

c2 == c3 ?

c2 is c3 ?



The isinstance Function

isinstance(<obj>,<class>)

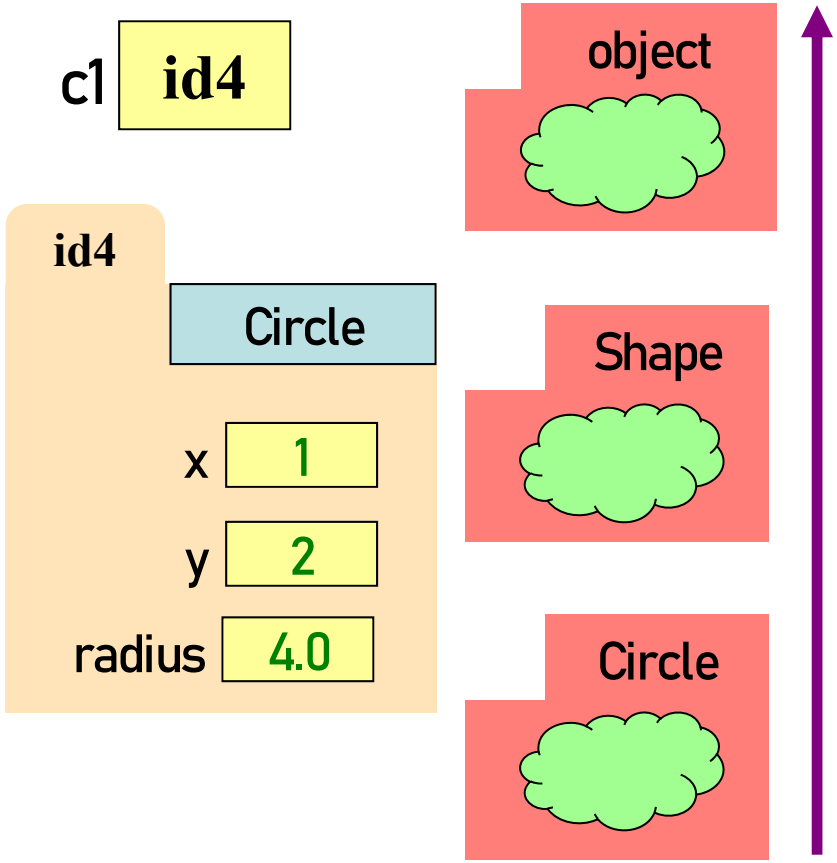
- True if <obj>'s class is same as or a subclass of <class>
- False otherwise

Example:

c1 = Circle(1,2,4.0)

- isinstance(c1,Circle) is True
- isinstance(c1,Shape) is True
- isinstance(c1,object) is True
- isinstance(c1,str) is False

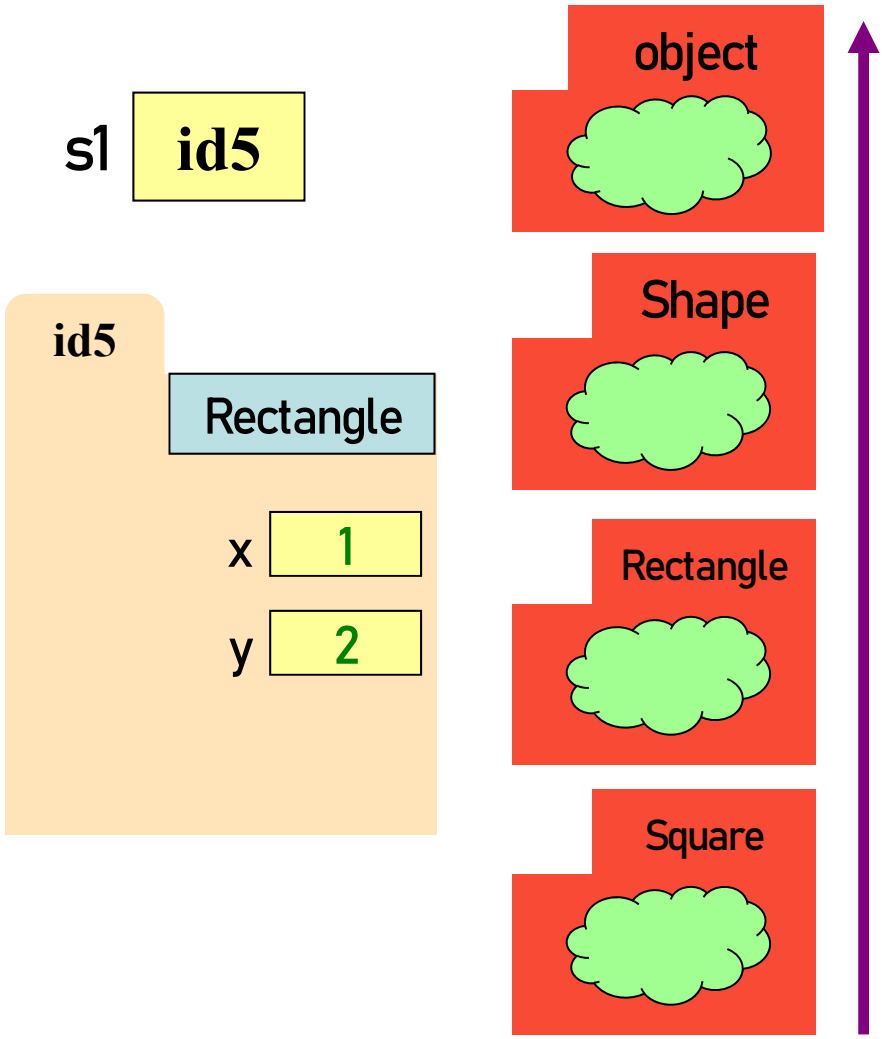
- Generally preferable to type
  - Works with base types too!



Q5: isinstance and Subclasses

```
>>> s1 = Rectangle(0,0,10,10)
>>> isinstance(s1, Square)
???
```

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



A5: isinstance and Subclasses

```
>>> s1 = Rectangle(0,0,10,10)
>>> isinstance(s1, Square)
```

???

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