CSC148-Section:L0301
Week#2-Wednesday

Instructed by

AbdulAziz Al-Helali

a.alhelali@mail.utoronto.ca

Office hours: Wednesday 11-1, BA2230.

Slides adapted from Professor Danny Heap and Jacqueline Smith slides winter17

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Outline

- Inheritance vs Composition
  - Review Father/Son example
  - Designing Square and RightAngleTriangle without inheritance
  - Using inheritance to build
    - Shape – Super class
    - Square and RightAngleTriangle – as subclasses

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Intro: Inheritance vs Composition

Composition

- Making use of other data types or objects of other classes

Inheritance

- A subclass inherits all attributes and methods (behavior) from superclass. Why?
  - to reuse code of existing class
- A subclass can extend, overload attributes and methods for a supercalss
- Subclass can be called child class
- Supper class can be called parent class

Example:

```
class Father:
    x: int = 10
    y: int = 20

    def m1(self) -> None:
        print('Father m1')

    def m2(self) -> None:
        print('Father m2')
```

Super class
Or
Parent class

```
class Son(Father):
    z: int = 30

    def m1(self) -> None:
        print('Son m1')
```

subclass
Or
child class

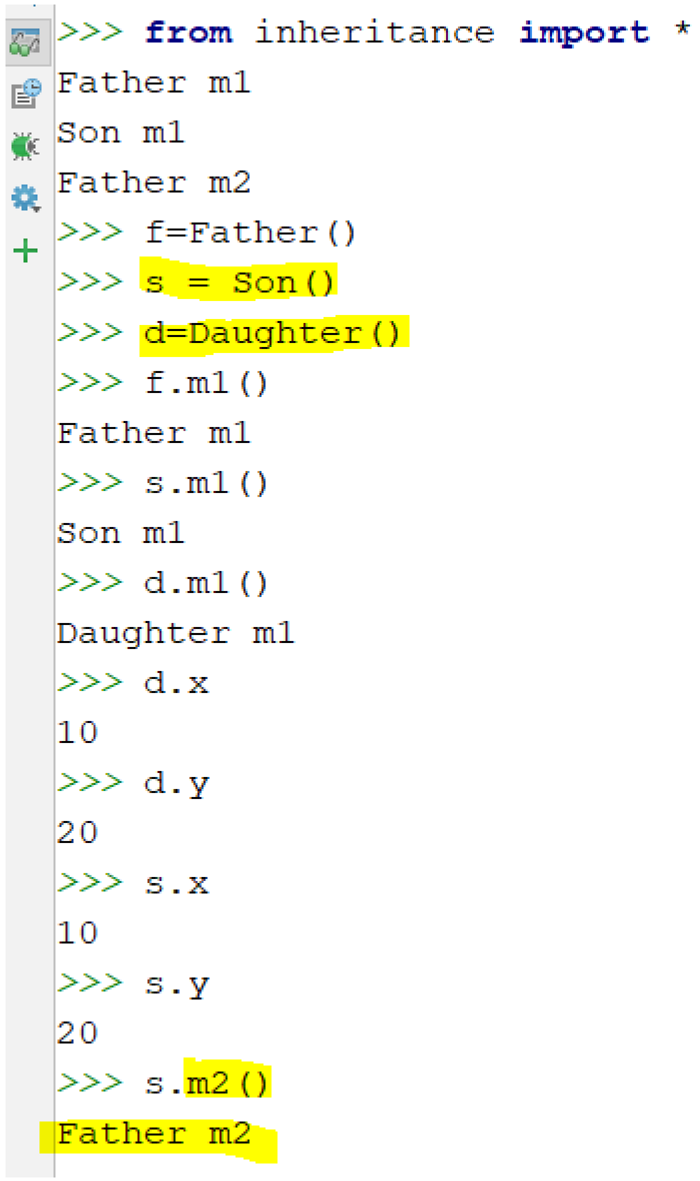
```
class Daughter(Father):
    z: int = 30

    def m1(self) -> None:
        print('Daughter m1')
```

subclass
Or
child class

```
f=Father()
s = Son()
f.m1()
s.m1()
s.m2()
```

Son subclass is extending the attributes of Father

Son subclass is overriding m1() of Father



```
>>> from inheritance import *
Father m1
Son m1
Father m2
>>> f=Father()
>>> s = Son()
>>> d=Daughter()
>>> f.m1()
Father m1
>>> s.m1()
Son m1
>>> d.m1()
Daughter m1
>>> d.x
10
>>> d.y
20
>>> s.x
10
>>> s.y
20
>>> s.m2()
Father m2
```

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Design Square class

Squares have ***four vertices (corners)*** *have a perimeter, an area, can move themselves by adding an offset point to each corner, and can draw themselves.*

Use composition to build Square has_a relationship

- Why use composition?
  - We want to get abilities of existing classes (reusing our code=> save our time)
  - For drawing capabilities;
    - Use instance of Point to represent vertices and use distance method
    - Use instance (object) of Turtle to use its drawing capabilities (see next slide)

  - Therefore:
    - Square **has a** Turtle.
    - Square **has a** Point.

Point class, we need to add two methods

- The Point class implementation from last week does not implement:
  - def distance and __add__ which we will need while implementing Square
  - We need to add them to the Point class

```
def distance(self, other: 'Point') -> 
float:
    """
    Return the distance between Point self 
and Point other.

    >>> print(Point(3, 4).distance(Point(6, 
8)))
    5.0
    """
    return ((self.x - other.x) ** 2 + 
(self.y - other.y) ** 2) ** (1 / 2)
```

```
def __add__(self, other: 'Point') -> 'Point':
    """
    Return sum of Point self and Point other.

    >>> p1 = Point(3, 4)
    >>> p2 = Point(4, 3)
    >>> print(p1.__add__(p2))
    (7.0, 7.0)
    """
    return Point(self.x + other.x, self.y + 
other.y)
```

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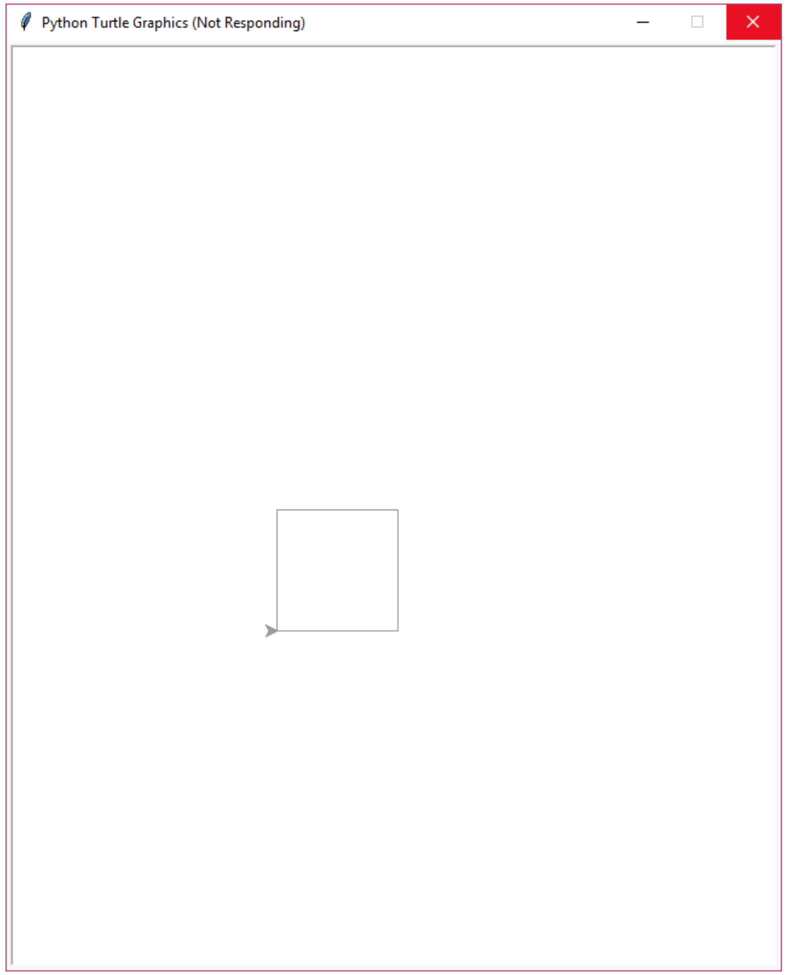
Turtle class

- Turtle is a built in class in Python
- Can be used to draw things:
- Try to run the code next in the console

```
>>> from turtle import Turtle
>>> t=Turtle()
>>> t.penup()
>>> t.goto(0,0)
>>> t.goto(10,0)
>>> t.goto(100,0)
>>> t.goto(100,100)
>>> t.goto(-100,100)
>>> t.goto(-100,-100)
>>> t.pendown()
>>> t.goto(-100,0)
>>> t.goto(0,0)
>>> t.goto(0,-100)
>>> t.goto(-100,-100)
```



Square class
No Inheritance

```
from turtle import Turtle
from point import Point

class Square:
    def __init__(self, corners: [Point])->None:
        self.corners = corners[:]
        self._turtle = Turtle()
        self._set_perimeter()
        self._set_area()

    def _set_perimeter(self) -> None:
        distance_list = []
        for i in range(len(self.corners)):
            distance_list.append(self.corners[i].distance(self.corners[i-1]))
        self._perimeter = sum(distance_list)

    def _set_area(self)->None:
         self._area = self.corners[0].distance(self.corners[1]) ** 2

    def _get_perimeter(self)->float:
        return self._perimeter

    def _get_area(self)->float:
        return self._area

    def move_by(self, offset_point: Point)->None:
        self.corners = [c + offset_point for c in self.corners]

    def draw(self):
        self._turtle.penup()
        self._turtle.goto(self.corners[-1].x, self.corners[-1].y)
        self._turtle.pendown()
        for i in range(len(self.corners)):
            self._turtle.goto(self.corners[i].x, self.corners[i].y)
        self._turtle.penup()
        self._turtle.goto(0, 0)
```

List comprehension
See next slide

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List comprehension example:

```
>>> mylist = [1, 2, 3]
>>> result = [c+3 for c in mylist]
>>> mylist
[1, 2, 3]
>>> result
[4, 5, 6]
```

Creates new list

The for loop will go through mylist every round putting a new value for c. Then c+3 will be evaluated and the value will be put in the result list as follows:
[1+3, 2+3, 3+3]
The result will be
[4, 5, 6]

```
self.corners =[c + offset_point for c in self.corners]
```

+ calls __add__ in Point class
The resulting is a list of Points

more Square-like classes

What if we decided to devise a RightAngleTriangle class with similar characteristics to Square? There is an implementation of RightAngleTriangle, but it has a problem:

There's a lot of duplicate code. What do you suggest?

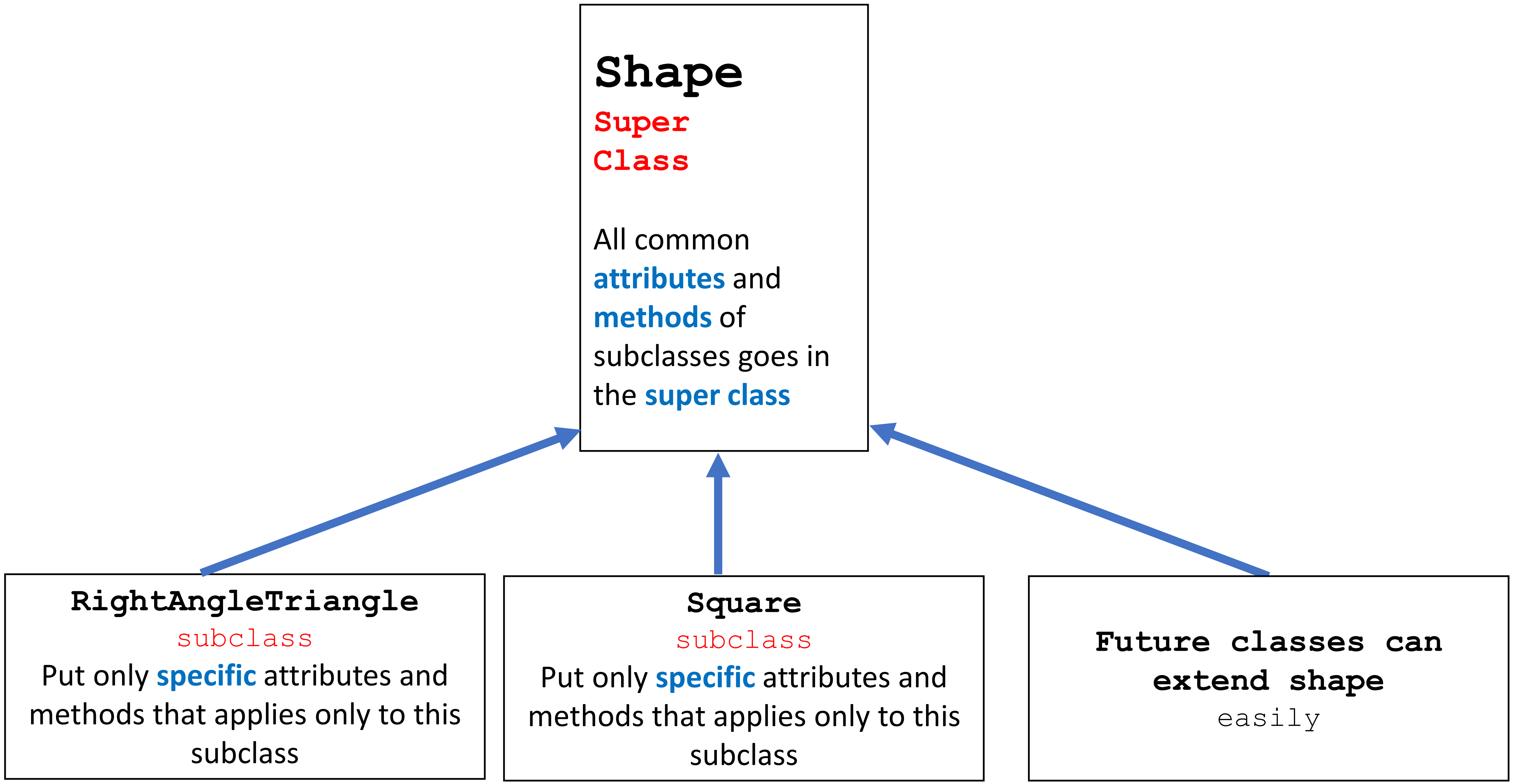
Where Can I find the code presented in class

- You can find the full code for Square, and RightAngleTriangle with NO inheritance in the course website under section **MWF2 (L0301)**
- with the following file names:
  - square_no_inh.py
  - right_angle_triangle_no_inh.py
  - test_no_inh_classes
    - This is a client code to test the above classes

- Download them Try different things with them and practice
  - Do not be afraid of doing mistakes

we could try:

- 1. cut-paste-modify Square → RightAngleTriangle?
- 2. include a Square in the new class to get at its attributes
- and services??
- We really need a **general Shape** with the features that are **common** to both Square and RightAngleTriangle, and perhaps other shapes that may come along



Shape

Super Class

All common **attributes** and **methods** of subclasses goes in the **super class**

RightAngleTriangle

subclass

Put only **specific** attributes and methods that applies only to this subclass

Square

subclass

Put only **specific** attributes and methods that applies only to this subclass

Future classes can extend shape

easily

```python
from turtle import Turtle
from point import Point

class Square:

    corners: [Point]
    perimeter: float
    area: float

    def __init__(self, corners: [Point])->None:

    def _set_perimeter(self) -> None:

    def _set_area(self)->None:
        self._area =
self.corners[0].distance(self.corners[1]) ** 2

    def _get_perimeter(self)->float:

    def _get_area(self)->float:

    def move_by(self, offset_point: Point)->None:

    def draw(self):
```

```python
from turtle import Turtle
from point import Point

class RightAngleTriangle:

    corners: [Point]
    perimeter: float
    area: float

    def __init__(self, corners: [Point])->None:

    def _set_perimeter(self) -> None:

    def _set_area(self)->None:
        leg1 = self.corners[-1].distance(self.corners[0])
        leg2 = self.corners[0].distance(self.corners[1])
        self._area = (leg1 * leg2) / 2.0

    def _get_perimeter(self)->float:

    def _get_area(self)->float:

    def move_by(self, offset_point: Point)->None:

    def draw(self):
```

abstract class Shape

- most of the features of Square are identical to RightAngleTriangle. Indeed I (blush) cut-and-pasted a lot...

- the differences are the class names (Square, RightAngleTriangle) and the code to calculate the area.

- put the common features into Shape, with unimplemented set area as a place-holder...
- declare Square and RightAngleTriangle as subclasses of Shape, inheriting the identical features by declaring:

```
        class Square(Shape): ...
```

Shape Super Class

```python
from point import Point
from turtle import Turtle

class Shape:
    """
    A Shape shape that can draw itself, move, and report area and perimeter.

    corners - corners of this Shape
    perimeter - length to traverse corners
    area - area of this Shape
    """
    corners: [Point]
    perimeter: float
    area: float
    #TODO implement the __eq__ and __str__

    def __init__(self, corners: [Point])->None:
        """ Create a new Shape self with corners.

        Assume that the corners are traversed in order, that the sides are equal
        and the sides are of equal length, and the vertices are right angles.
        """
        # we want to copy of the corners list using [:] not reference to them
        # so that if we change them we do not change the original list user
        # provided
        self.corners = corners[:]
        # a private attribute _turtle
        self._turtle = Turtle()
        self._set_perimeter()
        self._set_area()
```

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Shape Super Class Cont.

```python
def __str__(self) -> str:
    """
    returns string representation
    """
    str_points = ",".join(str(c) for c in self.corners)

    return type(self).__name__+"([{}])".format(str_points)
def _set_perimeter(self)->None:
    """ Set Shape self's perimeter to the sum of the distances between
    corners.
    """
    distance_list = []
    for i in range(len(self.corners)):
        distance_list.append(self.corners[i].distance(self.corners[i-1]))
    self._perimeter = sum(distance_list)

def _set_area(self)->None:
    """ Set the area of Shape self to the Shape of its sides.
    """
    self._area = -1.0
    raise NotImplementedError("Set area in subclass!!!")

def get_perimeter(self)->float:
    """ Return the perimeter of this Shape
    """
    return self._perimeter

def get_area(self)->float:
    """ Return the area of this Shape
    """
    return self._area
```

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Shape Super Class Cont.

```
    def move_by(self, offset_point: Point)->None:
        """
        Move Shape self to a new position by adding Point offset_point to
        each corner.
        """
        self.corners = [c + offset_point for c in self.corners]
        # print('corners')
        # for x in self.corners:
        #     print(x)

    def draw(self)->None:
        """
        Draw Shape self.
        """
        self._turtle.penup()
        self._turtle.goto(self.corners[-1].x, self.corners[-1].y)
        # print('-1 stuff')
        # -1 in self.corners[-1] refers to the last element
        # print(self.corners[-1].x, self.corners[-1].y)
        self._turtle.pendown()
        for i in range(len(self.corners)):
            self._turtle.goto(self.corners[i].x, self.corners[i].y)
        self._turtle.penup()
        self._turtle.goto(0, 0)

if __name__ == "__main__":
    import doctest
    doctest.testmod()
    #s = Shape([Point(0, 0)])
```

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Square subclass

```python
from point import Point
from shape import Shape


class Square(Shape):
    """
    A Square Shape.
    """

    def __init__(self, corners: [Point]) -> None:
        """ Create Square self with vertices corners.
        Assume all sides are equal and corners are square.
        Extended from Shape.
        >>> s = Square([Point(0, 0), Point(1, 0), Point(1, 1), Point(0, 0)])
        """
        Shape.__init__(self, corners)

    def _set_area(self)->None:
        """
        Set Square self's area.
        Overrides Shape._set_area

        >>> s = Square([Point(0,0), Point(10,0), Point(10,10), Point(0,10)])
        >>> s.area
        100.0
        """
        self.area = self.corners[-1].distance(self.corners[0]) ** 2
```

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RightAngle Triangle subclass

```python
from shape import Shape
from point import Point

class RightAngleTriangle(Shape):
    """
    A RightAngleTriangle Shape.
    """
    def __init__(self, corners):
        """ Create RightAngleTriangle self with vertices corners.

        Assume corners[0] is the 90 degree angle.

        Extended from Shape.

        >>> s = RightAngleTriangle([Point(0, 0), Point(1, 0), Point(0, 2)])
        """
        Shape.__init__(self, corners)

    def _set_area(self) -> None:
        """
        Set RightAngleTriangle self's area.

        Overrides Shape._set_area

        >>> s = RightAngleTriangle([Point(0,0), Point(10,0), Point(0,20)])
        >>> s.area
        100.0
        """
        leg1 = self.corners[-1].distance(self.corners[0])
        leg2 = self.corners[0].distance(self.corners[1])
        self.area = (leg1 * leg2) / 2.0
```

Where Can I find the code presented in class

- You can find the full code for Shape, Square, and RightAngleTriangle with inheritance in the course website under section **MWF2 (L0301)**
- with the following file names:
  - shape.py
  - square.py
  - right_angle_triangle.py
  - shape_simple_client
    - This is a simple client code to test the above classes
  - shape_adv_client
    - This is a simple client code to test the above classes
- Download them Try different things with them and practice
  - Do not be afraid of doing mistakes

inherit, override, or extend?

- subclasses use three approaches to recycling the code from their superclass, using the same name
- methods and attributes that are used as-is from the superclass are inherited -- examples?
- methods and attributes that replace what's in the superclass overriden -- example?
- methods and attributes that add to what is in the superclass are extended -- example?

write general code

- client code written to use Shape will now work with subclasses of Shape -- even those written in the future.
- The client code can rely on these subclasses having methods such as move by and draw
- Here is some client code that takes a list objects from subclasses of Shape, moves each object around, and then draws it.