

Review 6

Classes and Subclasses

Class Definition

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

"""Class specification"""

getters and setters

initializer (`__init__`)

definition of operators

definition of methods

anything else

Class type to extend
(may need module name)

- Every class must extend *something*
- Mosts classes will extended *object*

Attribute Invariants

- What are the attribute invariants below?
- Why are they there?

```
class Time(object):
```

```
    """An instance is a time of day
```

```
        hr: hour of the day [int in range 0..23]
```

```
        min: minute of the hour [int in range 0..59]
```

```
    """
```

```
    ...
```

Attribute Invariants

- Attribute invariants are important for programmer
 - Can look at them when writing methods
 - Any reader of the code will benefit as well

```
class Time(object):
```

```
    """An instance is a time of day
```

```
        hr: hour of the day [int in range 0..23]
```

```
        min: minute of the hour [int in range 0..59]
```

```
    """
```

```
    ...
```

Enforcing Invariants

- Attribute invariants are the purpose of constructors
- They initialize the attributes to satisfy invariants

```
class Time(object):
```

```
...
```

```
def __init__(self,t):
```

```
    """Initializer: makes an instance with time t.
```

```
    Param t is in minutes, in range 0..24*60-1"""
```

```
    self.hr = t / 60
```

```
    self.min = t % 60
```

- Without seeing the invariants, might write `self.min = t`

Enforcing Invariants

- Restrict attribute access
 - Make attributes hidden
 - Force access through methods: getter & setter
- **Getter**: Read attribute
 - Just return attribute
- **Setter**: Change attribute
 - Checks that new value satisfies the invariant
 - If so, changes attribute

```
class Time(object):  
    """Instance Attributes:  
        _hr [int in range 0..23]  
        _min [int in range 0..59]"""  
    ...  
    def getHour(self):  
        """Returns: hour of the day"""  
        return self._hr  
  
    def setHour(self,value):  
        """Sets hour to value"""  
        assert type(value) == int  
        assert value >= 0 and value <= 23  
        self._hr = value
```

Special Methods

- Start/end with underscores
 - `__init__` for initializer
 - `__str__` for `str()`
 - `__repr__` for `repr()`
- Actually defined in object
 - You are overriding them
 - Many more of them
- For a complete list, see
<http://docs.python.org/reference/datamodel.html>

```
class Point(object):
    """Instances are points in 3D space"""
    ...

    def __init__(self,x=0,y=0,z=0):
        """Initializer: makes new Point"""
        ...

    def __str__(self):
        """Returns: string with contents"""
        ...

    def __repr__(self):
        """Returns: unambiguous string"""
        ...
```

Modified Question from Fall 2010

- An object of class `Course` (next slide) maintains a course name, the instructors involved, and the list of registered students, sometimes called the roster.
 1. State the purpose of an initializer. Then complete the body of the initializer of `Course`, fulfilling this purpose.
 2. Complete the body of method `add` of `Course`
 3. Complete the body of method `__eq__` of `Course`. If you write a loop, you do not need to give a loop invariant.
 4. Complete the body of method `__ne__` of `Course`. Your implementation should be a single line.

Modified Question from Fall 2010

```
class Course(object):
```

```
    """An instance is a course at Cornell.
    Maintains the name of the course, the roster
    (list of netIDs of students registered for it),
    and a list of netIDs of instructors.
```

```
        name: Course name [str]
```

```
        instructors: instructor net-ids
                     [nonempty list of string]
```

```
        roster: student net-ids
                [list of string, canbe empty]"""
```

```
def __init__(self,name,b):
```

```
    """Instance w/ name, instructors b, no students.
    It must COPY b. Do not assign b to instructors.
    Pre: name is a string, b is a nonempty list"""
    # IMPLEMENT ME
```

```
def add(self,n):
```

```
    """If student with netID n is not in roster, add
    student. Do nothing if student is already there.
    Precondition: n is a valid netID."""
    # IMPLEMENT ME
```

```
def __eq__(self,ob):
```

```
    """Return True if ob is a Course with the same
    name and same set of instructors as this;
    otherwise return False"""
    # IMPLEMENT ME
```

```
def __ne__(self,ob):
```

```
    """Return False if ob is a Course with the same
    name and same set of instructors as this;
    otherwise return True"""
    # IMPLEMENT ME IN ONE LINE
```

Modified Question from Fall 2010

1. State the purpose of a initializer. Complete the body of the constructor of Course, fulfilling this purpose.
 - The purpose is to initialize instance attributes so that the invariants in the class are all satisfied.

```
def __init__(self,name,b):  
    """Instance w/ name, instructors b, no students.  
    Pre: name is a string, b is a nonempty list"""  
    self.name = name  
    self.instructors = b[:] # Copies b  
    self.roster = []      # Satisfy the invariant!
```

Modified Question from Fall 2010

2. Complete the body of method add of Course

```
def add(self,n):  
    """If student with netID n is not in roster, add  
    student. Do nothing if student is already there.  
    Precondition: n is a valid netID."""  
    if not n in self.roster:  
        self.roster.append(n)
```

Modified Question from Fall 2010

3. Complete body of method `__eq__` of `Course`.

```
def __eq__(self,ob):  
    """Return True if ob is a Course with the same name and same  
    set of instructors as this; otherwise return False"""  
    if not (isinstance(ob,Course)):  
        | return False  
    # Check if instructors in ob are in this  
    for inst in ob.instructors:  
        | if not inst in self.instructors:  
            | return False  
    # If instructors of ob are those in self, same if length is same  
    return self.name==ob.name and len(self.instructors)==len(ob.instructors)
```

Modified Question from Fall 2010

4. Complete body of method `__ne__` of `Course`.
Your implementation should be a single line.

```
def __ne__(self,ob):  
    """Return False if ob is a Course with the same name and  
    same set of instructors as this; otherwise return True"""  
    # IMPLEMENT ME IN ONE LINE  
    return not self == ob # Calls __eq__
```

Modified Question from Fall 2010

- An instance of Course always has a lecture, and it may have a set of recitation or lab sections, as does CS 1110. Students register in the lecture and in a section (if there are sections). For this we have two other classes: Lecture and Section. We show only components that are of interest for this question
- Do the following:
 - Complete the constructor in class Section
 - Complete the method add in Section
- Make sure invariants are enforced at all times

Modified Question from Fall 2010

```
class Lecture(Course):
```

```
    """Instance is a lecture, with list of sections
       seclist: sections associated with lecture.
               [list of Section; can be empty]
    """
```

```
def __init__(self, n, ls):
```

```
    """Instance w/ name, instructors ls, no students.
       It must COPY ls. Do not assign ls to instructors.
       Pre: name is a string, ls is a nonempty list"""
    super().__init__(n, ls)
    self.seclist = []
```

```
class Section(Course):
```

```
    """Instance is a section associated w/ a lecture"""
    mainlecture: lecture this section is associated.
                [Lecture; should not be None]"""
```

```
def __init__(self, n, ls, lec):
```

```
    """Instance w/ name, instructors ls, no
       students AND primary lecture lec.
       Pre: name a string, ls list, lec a Lecture"""
    # IMPLEMENT ME
```

```
def add(self,n):
```

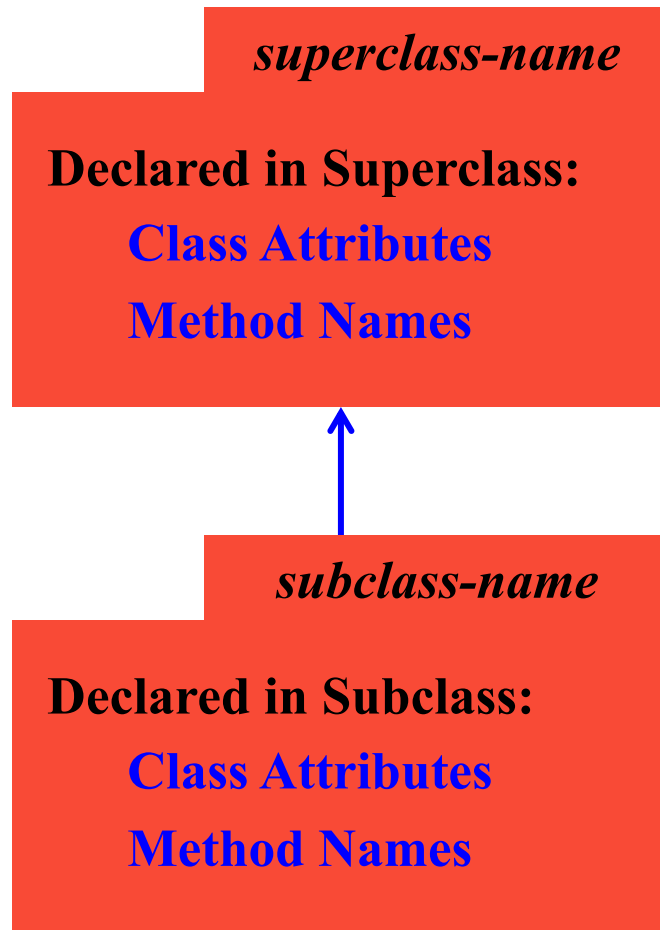
```
    """If student with netID n is not in roster of
       section, add student to this section AND the
       main lecture. Do nothing if already there.
       Precondition: n is a valid netID."""
    # IMPLEMENT ME
```

Modified Question from Fall 2010

```
def __init__(self, n, ls, lec):  
    """Instance w/ name, instructors ls  
    no students AND main lecture lec.  
    Pre: name a string, ls list,  
    lec a Lecture"""  
    super().__init__(n,ls)  
    self.mainlecture = lec
```

```
def add(self,n):  
    """If student with netID n is not in  
    roster of section, add student to  
    this section AND the main lecture.  
    Do nothing if already there.  
    Precondition: n is a valid netID."""  
    # Calls old version of add to  
    # add to roster  
    super().add(self,n)  
    # Add to lecture roster  
    self.mainlecture.add(n)
```


Diagramming Subclasses

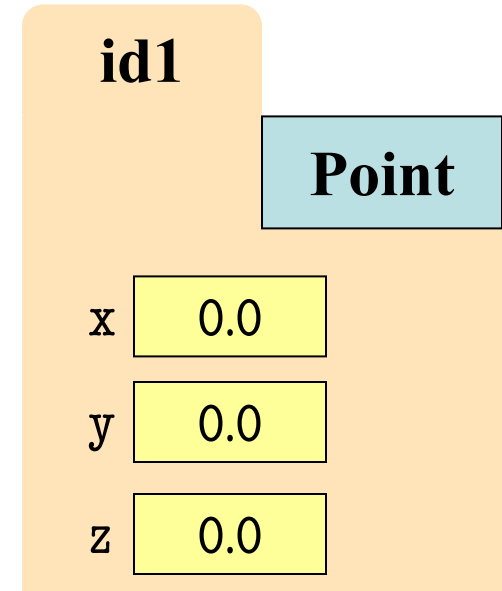
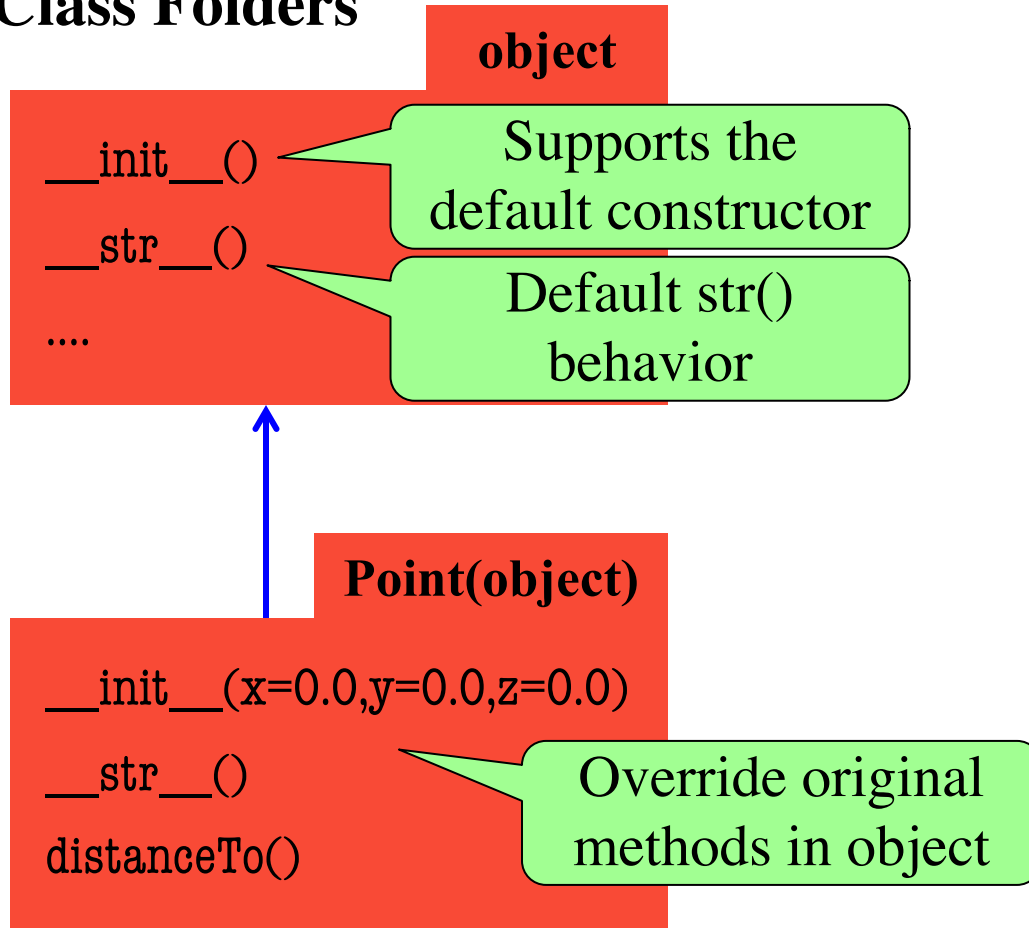


Important Details:

- Draw a line from subclass to the parent class
- Do not duplicate inherited methods and attributes
- Include initializer and operators with methods
- Method parameters are always optional
- Class attributes are a box with (current) value

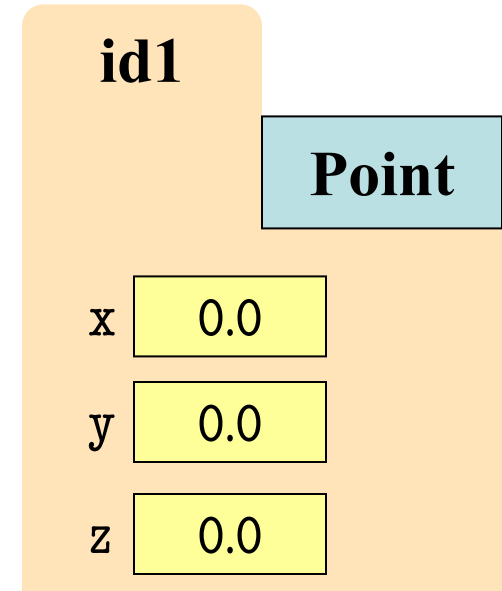
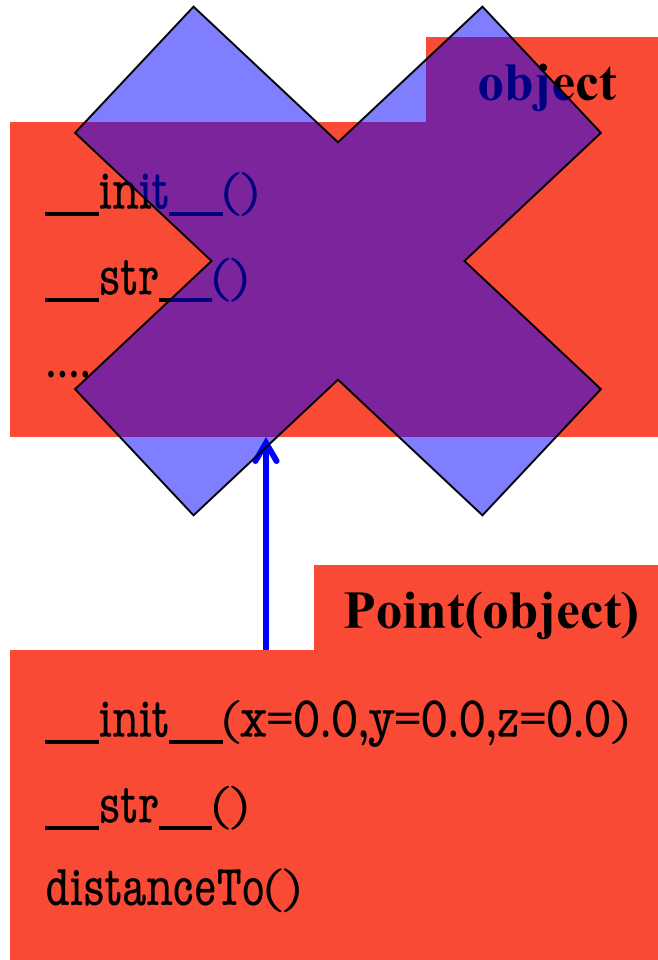
Example: Class Point

Class Folders



Object Folder

Example: Class Point



Because it is always there, typically omit the object partition

Two Example Classes

```
class A(object):
    x=3
    y=5
    def __init__(self,y):
        self.y = y
    def f(self):
        return self.g()
    def g(self):
        return self.x+self.y
```

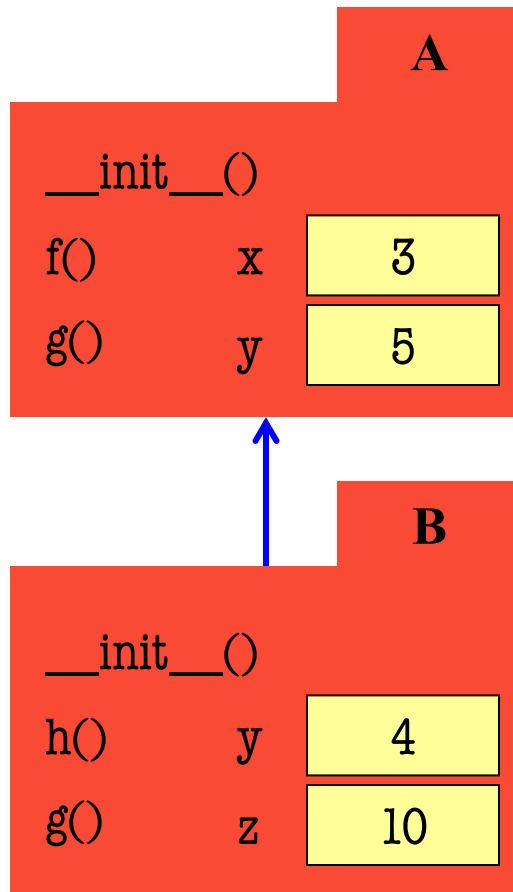
```
class B(A):
    y=4
    z=10
    def __init__(self,x,y):
        self.x = x
        self.y = y
    def g(self):
        return self.x+self.z
    def h(self):
        return 42
```

Execute:

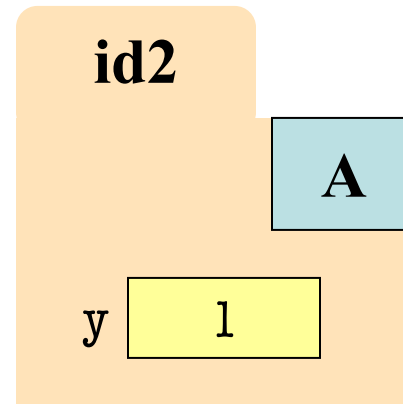
```
>>> a = A(1)
```

```
>>> b = B(7,3)
```

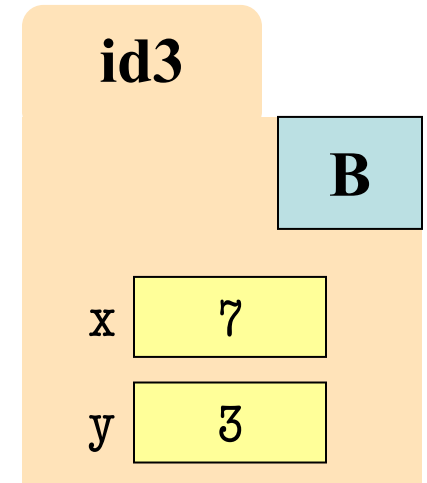
Example from Fall 2013



a **id2**



b **id3**

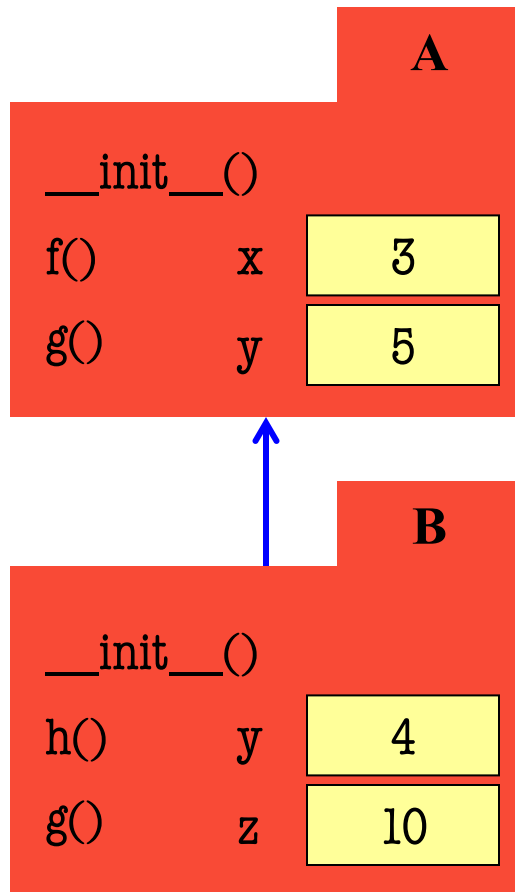


Execute:

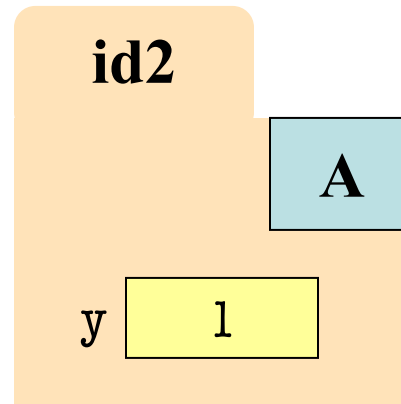
>>> a = A(1)

>>> b = B(7,3)

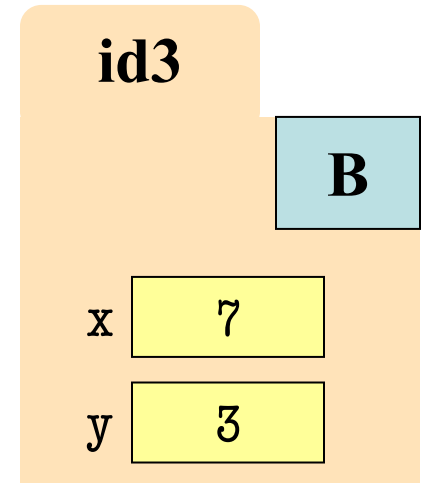
Example from Fall 2013



a **id2**



b **id3**



What is...

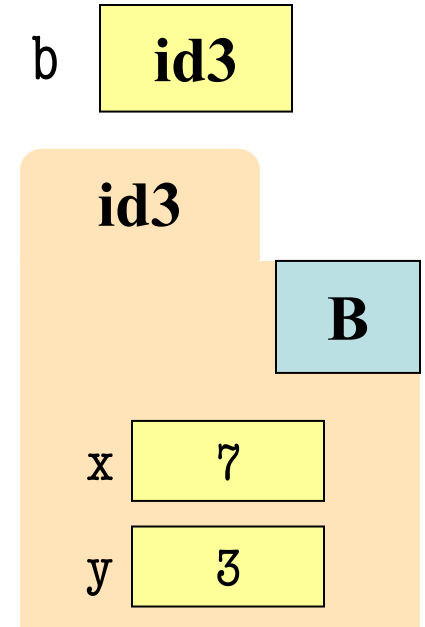
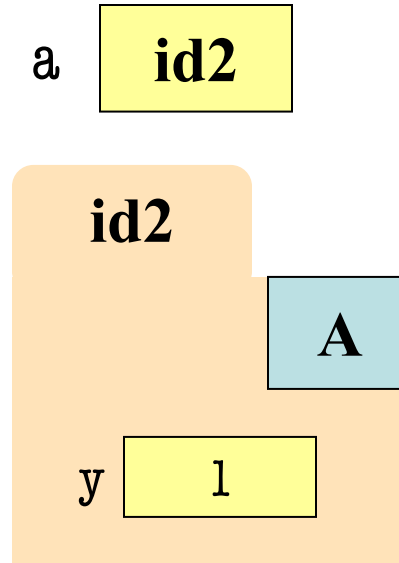
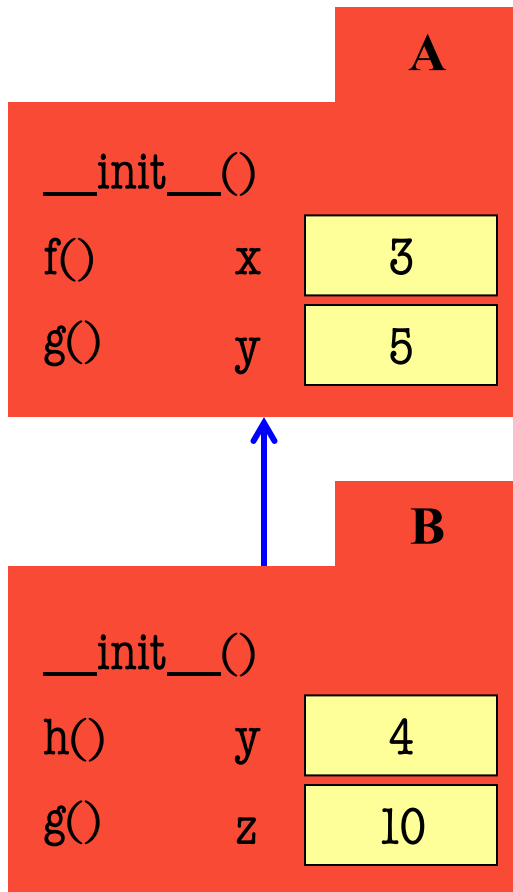
(1) a.y

(2) a.z

(3) b.x

(4) B.x

Example from Fall 2013



What is...

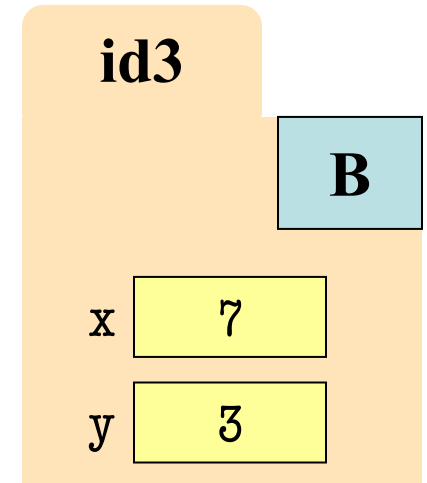
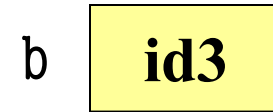
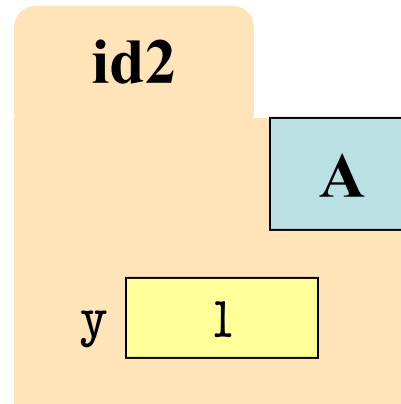
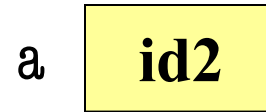
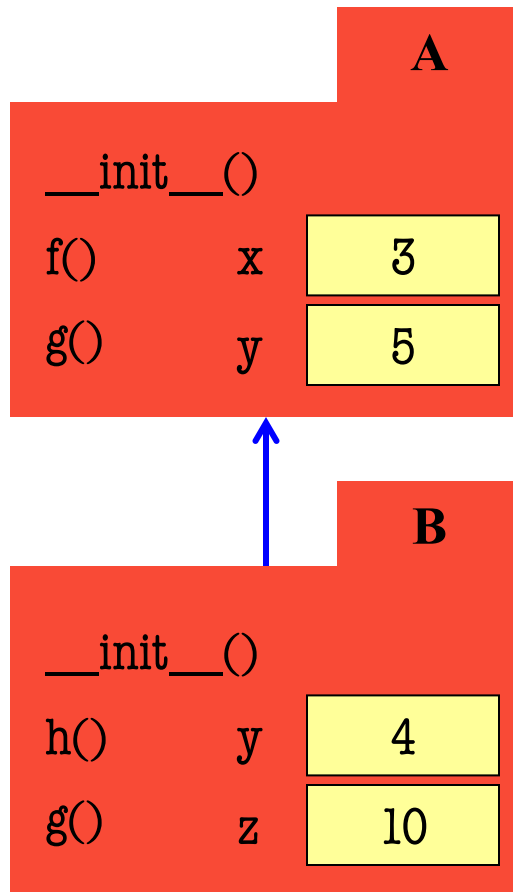
(1) a.y 1

(2) a.z ERROR

(3) b.x 7

(4) B.x 3

Example from Fall 2013



What is...

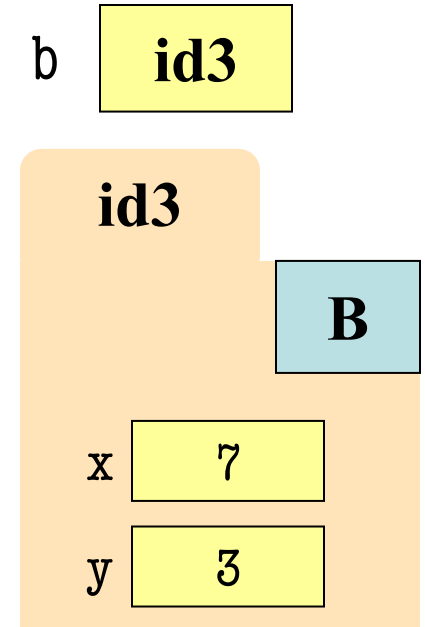
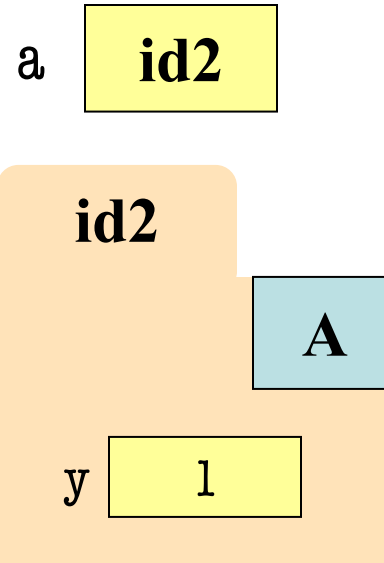
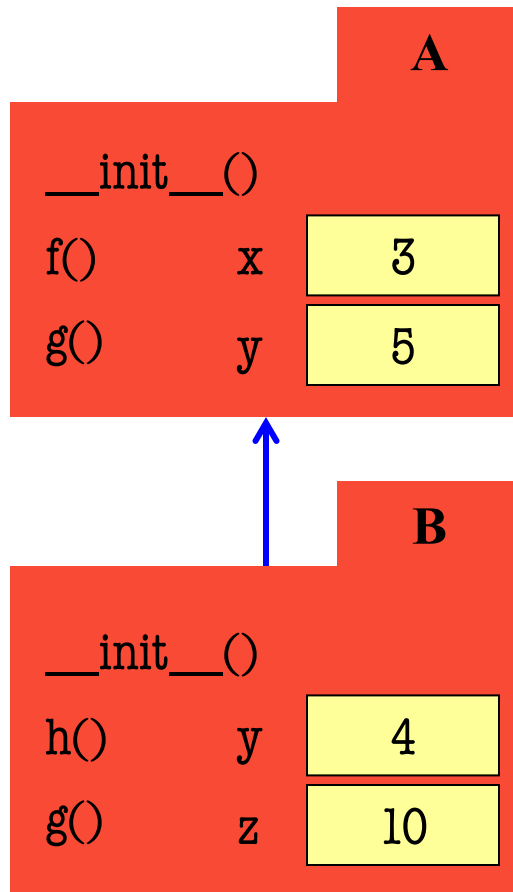
(1) `a.f()`

(2) `a.h()`

(3) `b.f()`

(4) `b.g()`

Example from Fall 2013



What is...

(1) `a.f()` 4

(2) `a.h()` ERROR

(3) `b.f()` 17

(4) `b.g()` 10