Review 2

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):
    """A class for a time of day
     Attribute hr: hour of the day,
    Invariant: hr is an int in range 0..23
     Attribute min: minute of the hour
    Invariant: min is an 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):
    """A class for a time of day
     Attribute hr: hour of the day,
    Invariant: hr is an int in range 0..23
     Attribute min: minute of the hour
    Invariant: min is an 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):
        """Initializes 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: an int in range 0..23
    # _min: an 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):
    """Class is a point in 3D space"""
    ...

    def __init__(self,x=0,y=0,z=0):
        """Initializes a 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):
    """Represents a course at Cornell.
    Maintains the name of the course, list of netids
    of registered students and netids of instructors.
    Attr name: course name. a str
    Attr instructors: instructor net-ids, a non-empty
    list of strings
    Attr roster: student net-ids, a (possibly empty)
    list of strings"""

    def __init__(self,name,b):
        """Initializes name, instructors b, no students.
        It must COPY b.  Do not assign b to instructors.
        Pre: name is a string, b is a nonemepty 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):
    """Initializes name, instructors b, no students.
    Pre: name is a string, b is a nonemepty 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):
    """Class is a lecture, with list of sections
       Attr seclist: sections associated with lecture.
       Inv: seclist is list of Section; can be empty
    """

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

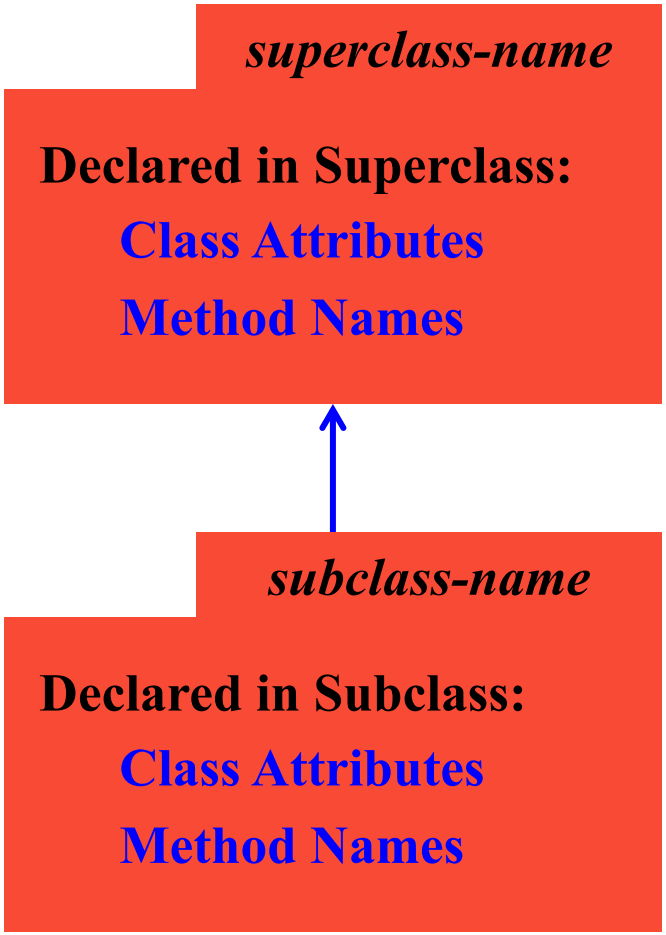
```
class Section(Course):
    """Class is a section associated w/ a lecture"""
       Attr mainlecture: lecture associated w/ this.
       Inv: is a Lecture; should not be None"""

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

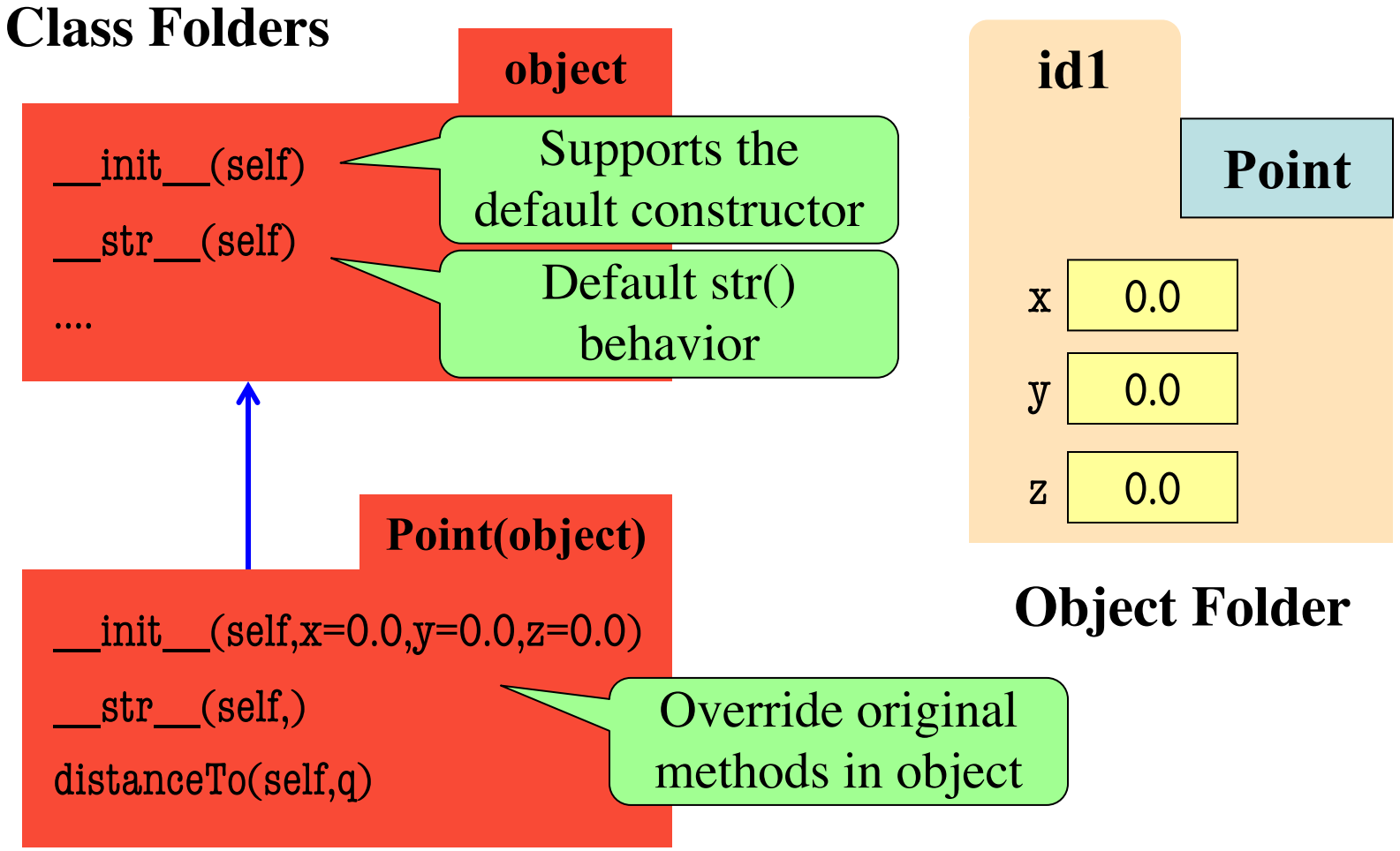
Diagramming Subclasses



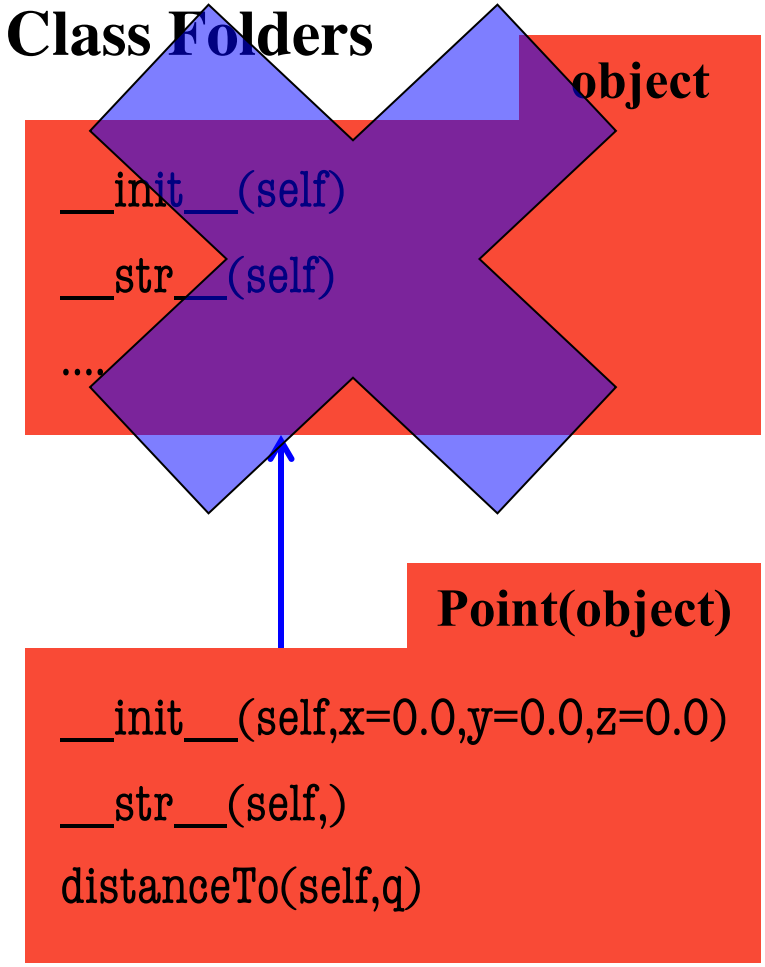
Important Details:

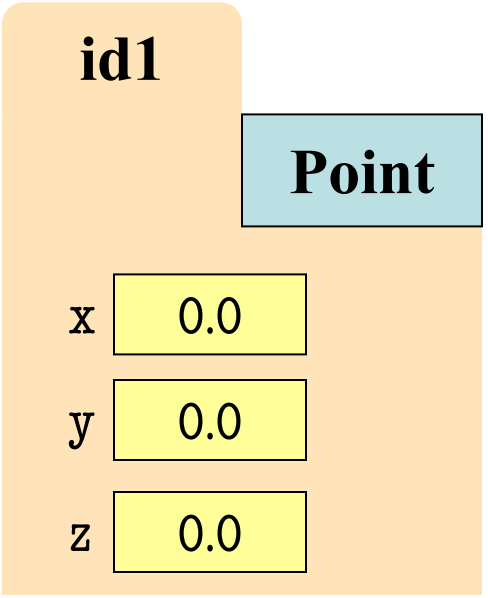
- Draw a line from subclass to the parent class
- Do not duplicate inherited methods and attributes
- Include initializer and operators with methods
- Method parameters are always optional
- Class attributes are a box with (current) value

Example: Class Point



Example: Class Point





Because it is always there, typically omit the object folder

Two Example Classes

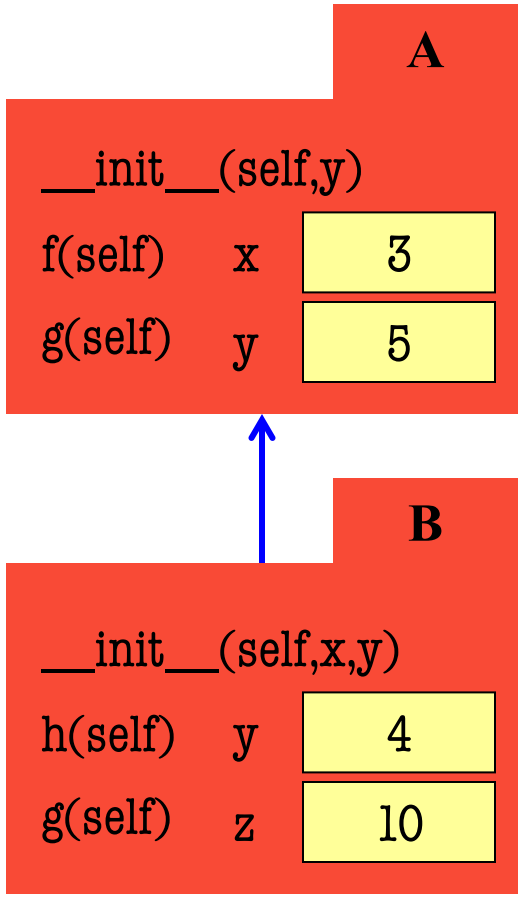
```
class A(object):
    x=3
    y=5
    def __init__(self,y):
        self.y = y

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

    def g(self):
        return self.x+self.y
```

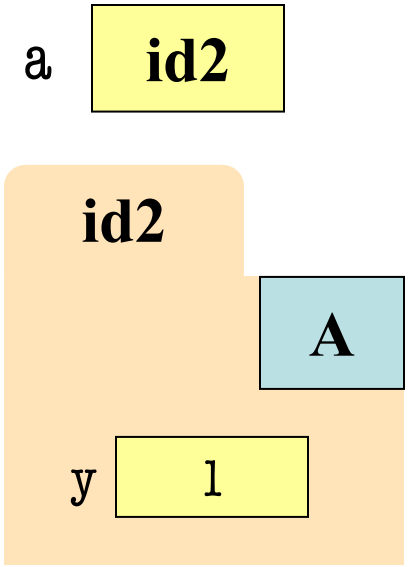
```
class B(A):
    y=4
    z=10
    def __init__(self,x,y):
        self.x = x
        self.y = y

    def g(self):
        return self.x+self.z

    def h(self):
        return 42
```

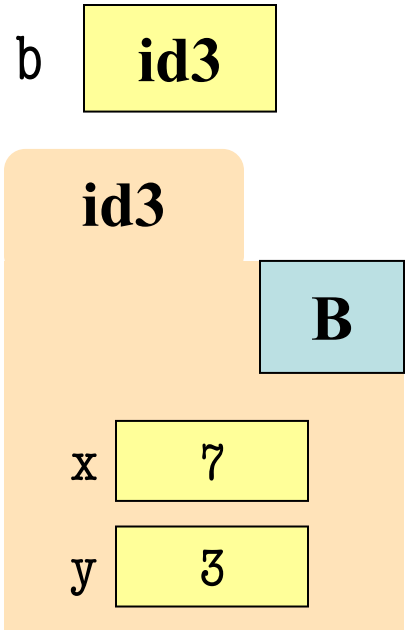
Execute:

```
>>> a = A(1)
>>> b = B(7,3)
```

Example from Fall 2013



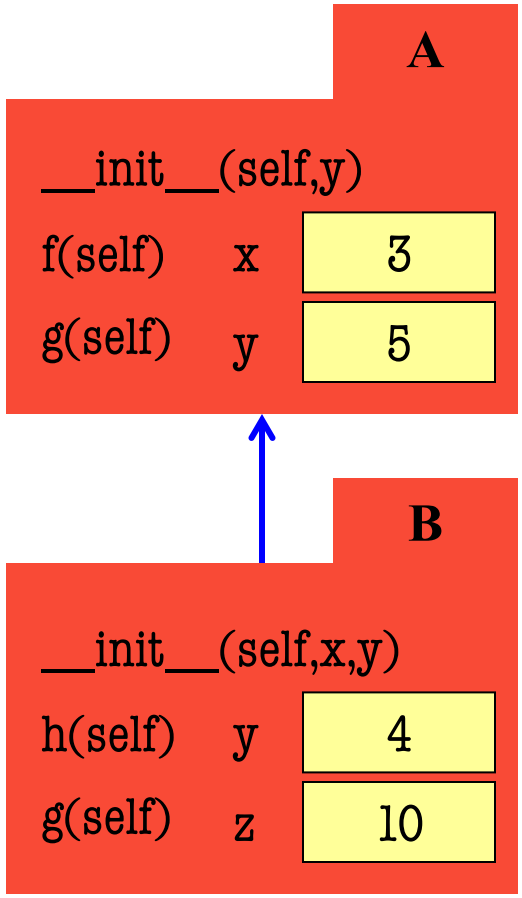


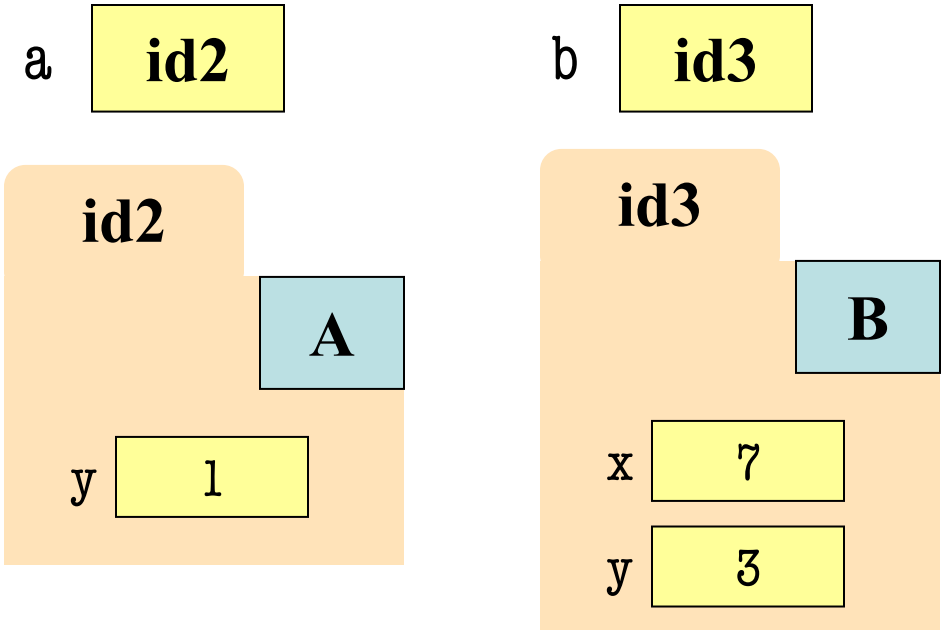


Execute:

```
>>> a = A(1)
>>> b = B(7,3)
```

Example from Fall 2013





What is…

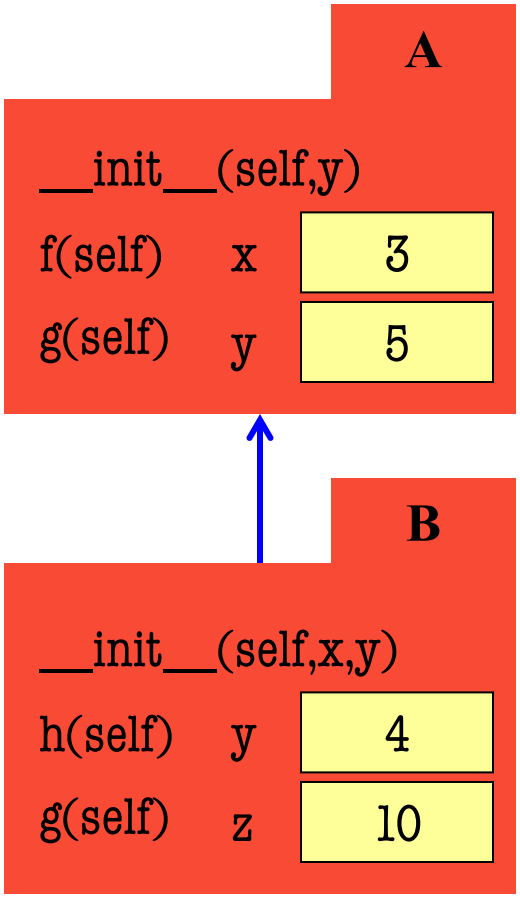
(1) a.y

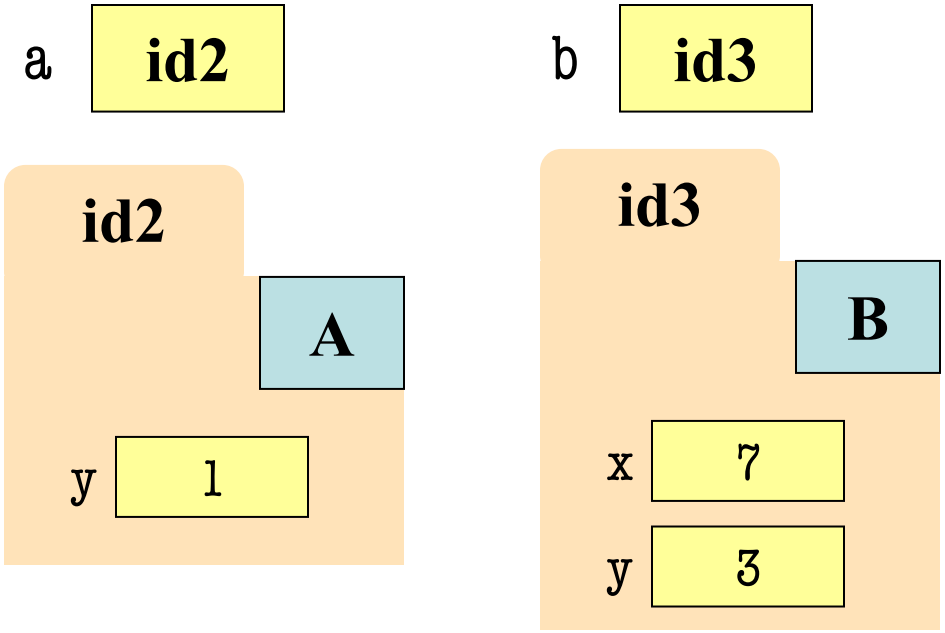
(2) a.z

(3) b.x

(4) B.x

Example from Fall 2013





What is…

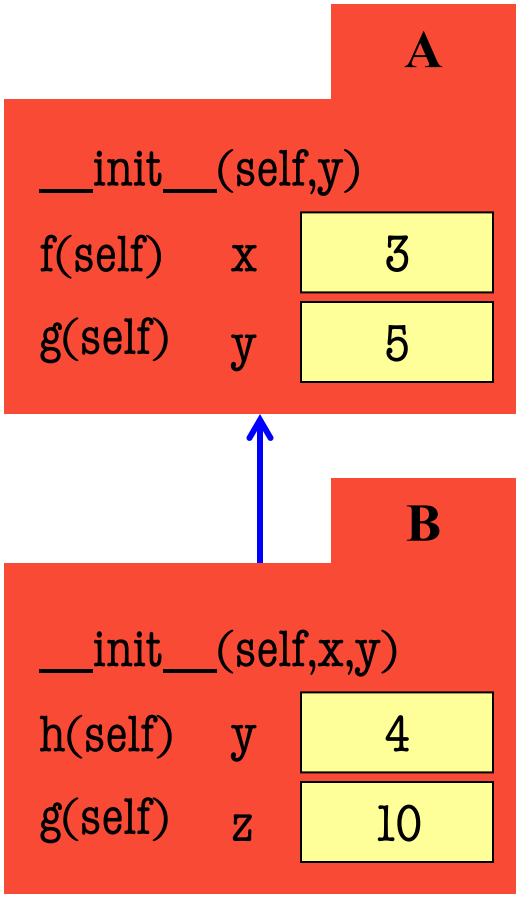
(1) a.y 1

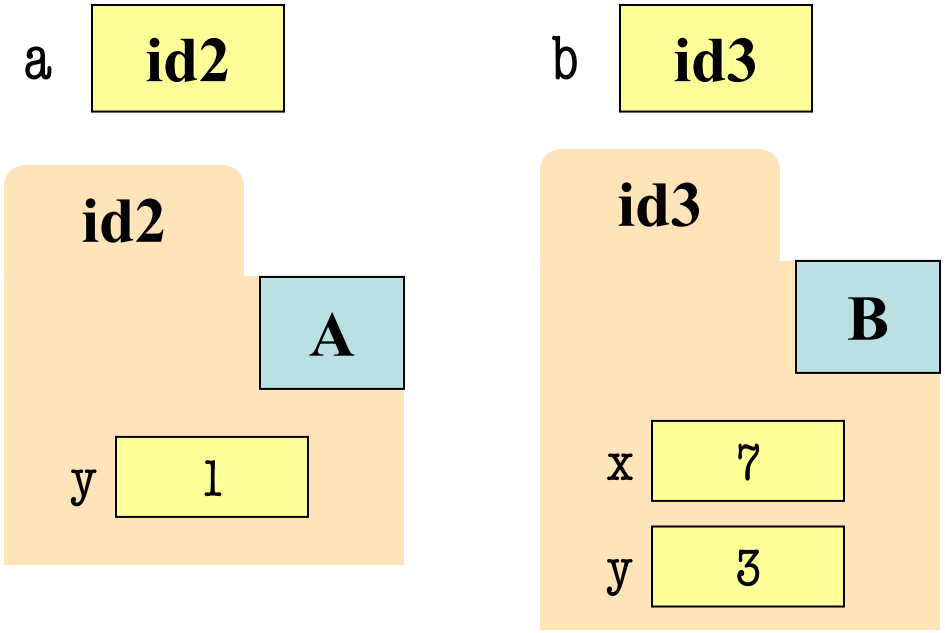
(2) a.z ERROR

(3) b.x 7

(4) B.x 3

Example from Fall 2013





What is…

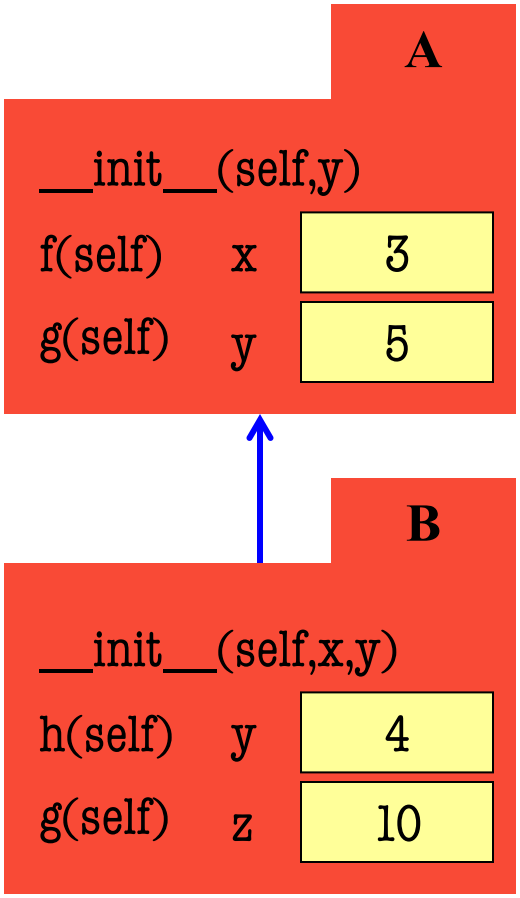
(1) a.f()

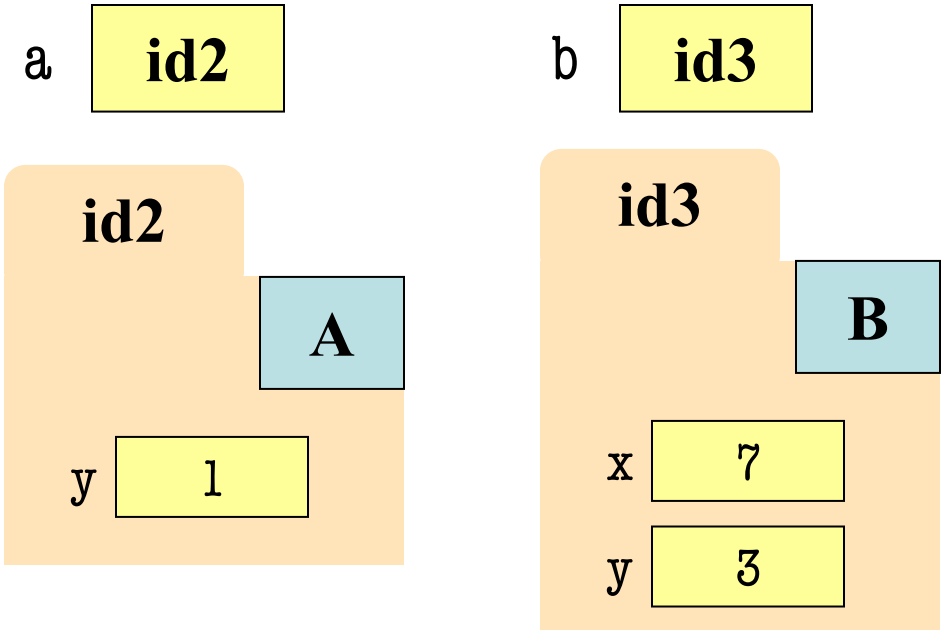
(2) a.h()

(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