# Lecture #14: Classes

# Data Abstraction vs. Function Abstraction

- Functions perform *computations*; their specifications abstract from possible implementations of a particular computation.
- In the old days, programs tended to be organized around functions or modules comprising related functions.
- The data were just the operands.
- Now we tend to organize instead around *objects* or types (*classes*) of objects.
- Objects have *state*, which is accessed and manipulated by means of *attributes*.
- The set of attributes and their behavior is analogous to the syntactic and semantic specification of a function.
- In the last lecture, we saw one way to get objects using functions and non-local variables.
- This is not the usual way it's done, however.

# Extending the Mutable Objects: Classes

- In languages such as Python, Java, and C++, an object is an *instance* of a class.
- The Python **class** statement defines new classes or types, creating new, vaguely dictionary-like varieties of object.

# Simple Classes: Bank Account

```
      # type name
class Account:
    # constructor method
    def __init__(self, initial_balance):
        self._balance = initial_balance

    def balance(self): # instance method
        # instance variable:
        return self._balance

    def deposit(self, amount):
        if amount < 0: raise ValueError("negative deposit")
        self._balance += amount

    def withdraw(self, amount):
        if 0 <= amount <= self._balance:
            self._balance -= amount
        else: raise ValueError("bad withdrawal")
```

```
>>> mine = Account(1000)
>>> mine.deposit(100)
>>> mine.balance()
1100
>>> mine.withdraw(200)
>>> mine.balance()
900
```

# Class Concepts

- Just as **def** defines functions and allows us to extend Python with new operations, **class** defines types and allows us to extend Python with new kinds of data.
- What do we want out of a class?
  - A way of defining named *new types* of data.
  - A means of defining and accessing *state* for these objects.
  - A means of defining and using *operations* specific to these objects.
  - In particular, an operation for *initializing* the state of an object.
  - A means of *creating* new objects.

# Class Machinery

- The Account type illustrated how we do each of these

```
class Account:                          Define named new type

    def __init__(self, initial_balance):  How to initialize
        self._balance = initial_balance  Create/modify state

    def balance(self):                   Define new operation on Accounts
        return self._balance   Access state of an Account

    ...

myAccount = Account(1000)          Create a new Account object,
print(myAccount.balance())         Operate on an Account object.
```

# Class Attributes

- Sometimes, a quantity applies to a type as a whole, not a specific instance.
- For example, with Accounts, you might want to keep track of the total amount deposited from all Accounts.
- This is an example of a *class attribute.*

# Class Attributes in Python

```
class Account:
    _total_deposits = 0      Define/initialize a class attribute
    def __init__(self, initial_balance):
        self._balance = initial_balance
        Account._total_deposits += initial_balance
    def deposit(self, amount):
        self._balance += amount
        Account._total_deposits += amount

    @staticmethod
    def total_deposits():     Define a class method.
        return Account._total_deposits
```

```
>>> acct1 = Account(1000)
>>> acct2 = Account(10000)
>>> acct1.deposit(300)
>>> Account.total_deposits()
11300
>>> acct1.total_deposits()
11300
```

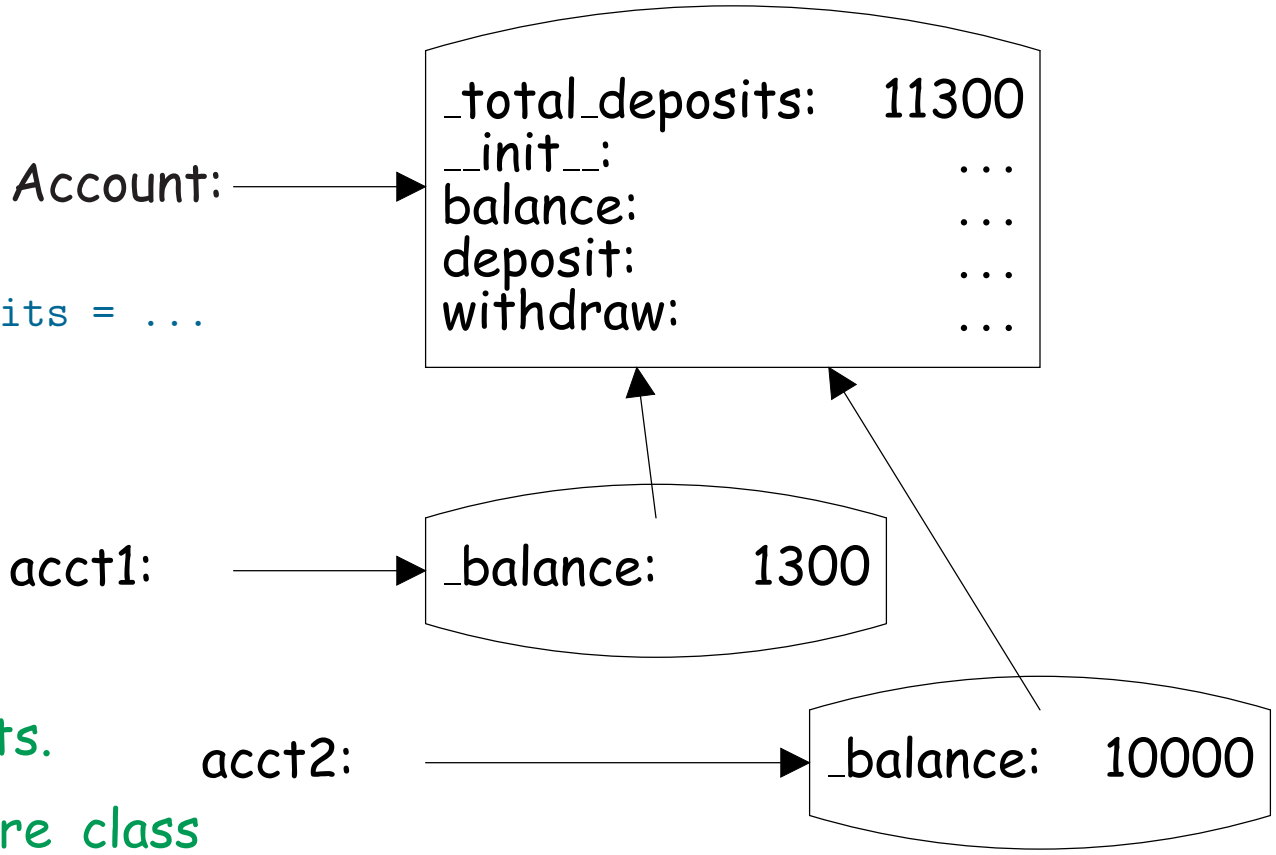
# Modeling Attributes in Python

- Unlike C++ or Java, Python takes a very dynamic approach.
- Classes and class instances behave rather like environment frames.

```
class Account:
    _total_deposits = 0

    def __init__(...):
        self._balance = ...
        Account._total_deposits = ...
```

```
acct1 = Account(1000)
acct2 = Account(10000)
acct1.deposit(300)
```

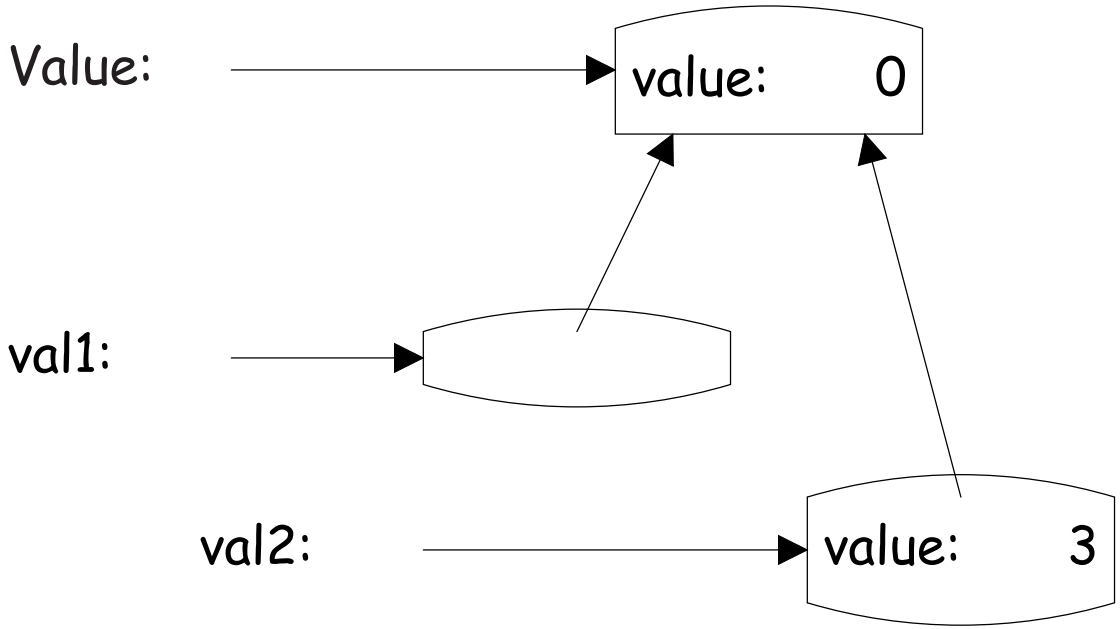



- Curved boxes are objects.
- Flat-bottomed boxes are class objects.
- 'x.y': look for 'y' starting at 'x'

# Assigning to Attributes

- Assigning to an attribute of an object (including a class) is like assigning to a local variable: it creates a new binding for that attribute in the object selected from (i.e., referenced by the expression on the left of the dot).

```
>>> class Value:
...     value = 0
...
>>> val1 = Value()
>>> val2 = Value()
>>> val2.value = 3
>>> val1.value
0
>>> Value.value
0
>>> val2.value
3
```



# Methods

- Consider

```
>>> class Foo:
...     def set(self, x):
...         self.value = x
>>> aFoo = Foo()
>>> aFoo.set(13)  # The first parameter of set is aFoo.
>>> aFoo.value
13
>>> aFoo.set
<bound method Foo.set of ...>
```

- Selection of function-valued attributes from objects (other than classes) creates *bound methods*: first parameter is *bound to* the selected-from object, leaving one fewer parameters.
- Effect of selecting `aFoo.set` is like calling `partial_bind(aFoo, Foo.set)`, where

```
def partial_bind(obj, func): return lambda x: func(obj, x)
```

# Class Machinery: Summary

- Classes have *attributes*, created by assignment statements and **defs** in the class body.
- Function-values attributes of classes are called *methods*.
- Classes beget objects called *instances*, created by "calling" the class: `Account(1000)`.
- Each such `Account` object inititally shares the attributes of its class.
- Attributes can be accessed using `object.attribute` notation.
- A method call `mine.deposit(100)` is essentially the same as `Account.deposit(mine, 100)`.
- By convention, we call the first argument of a method `self` to indicate that it is the object from which we got the method.
- When an object is created, the special `__init__` method is called on it first.
- Assigning to an attribute of an object (`a.b = v`) gives that object its own attribute (not shared with the class), if it doesn't have it already.