Dispatch Dictionaries
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The Story So Far About Data
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**Data abstraction:** Enforce a separation between how data values are represented and how they are used.
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**Dispatch functions/dictionaries:** A single object can include many different (but related) behaviors that all manipulate the same local state.

(All of these techniques can be implemented using only functions and assignment.)
Object-Oriented Programming
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A method for organizing modular programs
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- Abstraction barriers
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• Each object has its own local state.
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- Each object has its own local state.
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Object-Oriented Programming

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A metaphor for computation using distributed state

• Each object has its own local state.
• Each object also knows how to manage its own local state, based on the messages it receives.
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Object-Oriented Programming

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Specialized syntax & vocabulary to support this metaphor
Classes
A class serves as a template for its instances.
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**Idea:** All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.
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```python
>>> a = Account('Jim')
```
Classes

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**Idea:** All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```python
>>> a = Account('Jim')
>>> a.holder
'Jim'
```
Classes

A class serves as a template for its instances.

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each newly created instance.

```python
>>> a = Account('Jim')
>>> a.holder
'Jim'
>>> a.balance
0
```
Classes

A class serves as a template for its instances.

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```python
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>>> a.balance
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```

**Idea:** All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.
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**Idea:** All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```python
>>> a.deposit(15)
15
```
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```python
>>> a = Account('Jim')
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'Jim'
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0
```

**Idea:** All bank accounts should have "withdraw" and "deposit" behaviors that all work in the same way.

```python
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
```
Classes

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```python
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
>>> a.balance
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'Insufficient funds'
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'Jim'
>>> a.balance
0
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```python
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15
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>>> a.balance
5
>>> a.withdraw(10)
'Insufficient funds'
```

**Better idea:** All bank accounts share a "withdraw" method.
The Class Statement
The Class Statement

```python
class <name>(<base class>):
    <suite>
```
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class <name>(<base class>):
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Next lecture
The Class Statement

A class statement **creates** a new class and **binds** that class to `<name>` in the first frame of the current environment.
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class Account(object):
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class Account(object):
    def __init__(self, account_holder):
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class Account(object):
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        self.balance = 0
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class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
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Initialization
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**Idea:** All bank accounts have a balance and an account holder; the Account class should add those attributes.

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When a class is called:
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class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```
Object Identity
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Every object that is an instance of a user-defined class has a unique identity:
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Every object that is an instance of a user-defined class has a unique identity:

```python
>>> a = Account('Jim')
>>> b = Account('Jack')
```
Object Identity

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Identity testing is performed by "is" and "is not" operators:
Object Identity

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```python
>>> a is a
True
>>> a is not b
True
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True
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True
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Binding an object to a new name using assignment **does not** create a new object:
Object Identity

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True
```

Binding an object to a new name using assignment does not create a new object:

```python
>>> c = a
>>> c is a
True
```
Methods
Methods

Methods are defined in the suite of a class statement
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```python
class Account(object):
```
Methods

Methods are defined in the suite of a class statement

class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
Methods

Methods are defined in the suite of a class statement

class Account(object):
    
def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
Methods

Methods are defined in the suite of a class statement

class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance

    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance
Methods

Methods are defined in the suite of a class statement

class Account(object):
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance

    def withdraw(self, amount):
        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance

These def statements create function objects as always, but their names are bound as attributes of the class.
Invoking Methods
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All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.
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All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.

```python
class Account(object):
    ...

    def deposit(self, amount):
        self.balance = self.balance + amount
    return self.balance
```
All invoked methods have access to the object via the self parameter, and so they can all access and manipulate the object's state.

class Account(object):
    ...

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All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.

```python
class Account(object):
    ...

    def deposit(self, amount):
        self.balance = self.balance + amount
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```

Dot notation automatically supplies the first argument to a method.
Invoking Methods

All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.

class Account(object):
    ...

    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance

Dot notation automatically supplies the first argument to a method.

```python
>>> tom_account = Account('Tom')
>>> tom_account.deposit(100)
100
```
Invoking Methods

All invoked methods have access to the object via the `self` parameter, and so they can all access and manipulate the object's state.

```python
class Account(object):
    ...  
    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance
```

Dot notation automatically supplies the first argument to a method.

```python
>>> tom_account = Account('Tom')
>>> tom_account.deposit(100)
100
```
Dot Expressions
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Objects receive messages via dot notation
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<expression> . <name>
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Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

\(<expression> \ . \ <name>\)

The \(<expression>\) can be any valid Python expression

The \(<name>\) must be a simple name
Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

<expression> . <name>

The <expression> can be any valid Python expression

The <name> must be a simple name

Evaluates to the value of the attribute looked up by <name> in the object that is the value of the <expression>
Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

\(<expression> . <name>\)

The <expression> can be any valid Python expression

The <name> must be a simple name

Evaluates to the value of the attribute looked up by <name> in the object that is the value of the <expression>

\(\text{tom_account.deposit(10)}\)
Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

\(<\text{expression}>\ . \ <\text{name}>\)

The \(<\text{expression}>\) can be any valid Python expression

The \(<\text{name}>\) must be a simple name

Evaluates to the value of the attribute looked up by \(<\text{name}>\) in the object that is the value of the \(<\text{expression}>\)

```
{\text{tom_account.deposit}(10)}
```

Dot expression
Dot Expressions

Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class

<expression> . <name>

The <expression> can be any valid Python expression

The <name> must be a simple name

Evaluates to the value of the attribute looked up by <name> in the object that is the value of the <expression>

( tom_account.deposit(10) )

Dot expression

Call expression
Accessing Attributes
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Using `getattr`, we can look up an attribute using a string, just as we did with a dispatch function/dictionary.
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Using `getattr`, we can look up an attribute using a string, just as we did with a dispatch function/dictionary.

```python
>>> getattr(tom_account, 'balance')
10
```
Accessing Attributes

Using getattr, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```python
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```
Accessing Attributes

Using getattr, we can look up an attribute using a string, just as we did with a dispatch function/dictionary.

```python
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

ggetattr and dot expressions look up a name in the same way.
Accessing Attributes

Using `getattr`, we can look up an attribute using a string, just as we did with a dispatch function/dictionary.

```python
>>> setattr(tom_account, 'balance', 10)
10

>>> hasattr(tom_account, 'deposit')
True
```

`getattr` and dot expressions look up a name in the same way.

Looking up an attribute name in an object may return:
Accessing Attributes

Using getattr, we can look up an attribute using a string, just as we did with a dispatch function/dictionary

```python
>>> getattr(tom_account, 'balance')
10
```

```python
>>> hasattr(tom_account, 'deposit')
True
```

getattr and dot expressions look up a name in the same way

Looking up an attribute name in an object may return:

- One of its instance attributes, or
Accessing Attributes

Using `getattr`, we can look up an attribute using a string, just as we did with a dispatch function/dictionary.

```python
>>> getattr(tom_account, 'balance')
10

>>> hasattr(tom_account, 'deposit')
True
```

global `getattr` and dot expressions look up a name in the same way.

Looking up an attribute name in an object may return:

- One of its instance attributes, or
- One of the attributes of its class
Methods and Functions
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Python distinguishes between:
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- *Functions*, which we have been creating since the beginning of the course, and
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Python distinguishes between:

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\[
\text{Object } + \text{ Function } = \text{ Bound Method}
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Python distinguishes between:

- *Functions*, which we have been creating since the beginning of the course, and

- *Bound methods*, which couple together a function and the object on which that method will be invoked.

Object + Function = Bound Method

```python
>>> type(Account.deposit)
```
Methods and Functions

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```python
>>> type(Account.deposit)
<class 'function'>
```
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```python
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
```
Methods and Functions

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\text{Object} + \text{ Function} = \text{Bound Method}
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```python
g>>> type(Account.deposit)
<class 'function'>
g>>> type(tom_account.deposit)
<class 'method'>
```
Methods and Functions

Python distinguishes between:

- Functions, which we have been creating since the beginning of the course, and

- Bound methods, which couple together a function and the object on which that method will be invoked.

```
>>> type(Account.deposit)
<class 'function'>
>>> type(tom_account.deposit)
<class 'method'>

>>> Account.deposit(tom_account, 1001)
1011
```
Methods and Functions

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```python
>>> type(Account.deposit)
<class 'function'>
```

```python
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<class 'method'>
```

```python
>>> Account.deposit(tom_account, 1001)
1011
```

```python
>>> tom_account.deposit(1000)
2011
```
Looking Up Attributes by Name

<expression> . <name>
Looking Up Attributes by Name

<expression> . <name>

To evaluate a dot expression:
Looking Up Attributes by Name

<expression> . <name>

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1. Evaluate the <expression> to the left of the dot, which yields the object of the dot expression.
Looking Up Attributes by Name

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Looking Up Attributes by Name

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2. <name> is matched against the instance attributes of that object; if an attribute with that name exists, its value is returned.

3. If not, <name> is looked up in the class, which yields a class attribute value.

4. That value is returned unless it is a function, in which case a bound method is returned instead.
Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.
Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

class Account(object):
    interest = 0.02    # A class attribute

    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    # Additional methods would be defined here
Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

```python
class Account(object):
    interest = 0.02  # A class attribute
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>>> tom_account = Account('Tom')
```
Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

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class Account(object):
    interest = 0.02  # A class attribute
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        self.balance = 0
        self.holder = account_holder

    # Additional methods would be defined here

>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
```
Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

```python
class Account(object):
    interest = 0.02  # A class attribute

    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    # Additional methods would be defined here

>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
>>> tom_account.interest
0.02
```
Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

class Account(object):
    interest = 0.02  # A class attribute
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    # Additional methods would be defined here

>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

```python
class Account(object):
    interest = 0.02  # A class attribute

    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

    # Additional methods would be defined here

>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
```

*interest* is not part of the instance that was somehow copied from the class!
Assignment Statements and Attributes
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression.
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

• If the object is an instance, then assignment sets an instance attribute
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Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

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Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression:

- If the object is an instance, then assignment sets an instance attribute.
- If the object is a class, then assignment sets a class attribute.

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

• If the object is an instance, then assignment sets an instance attribute

• If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest
0.02
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

• If the object is an instance, then assignment sets an instance attribute

• If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest = 0.02
>>> jim_account.interest = 0.02
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest = 0.02
>>> jim_account.interest = 0.02
>>> tom_account.interest
```

0.02
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest = 0.02
>>> jim_account.interest = 0.02
>>> tom_account.interest = 0.02
>>> Account.interest = 0.04
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

• If the object is an instance, then assignment sets an instance attribute

• If the object is a class, then assignment sets a class attribute

>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest = 0.02
>>> jim_account.interest = 0.02
>>> tom_account.interest = 0.02
>>> Account.interest = 0.04
>>> tom_account.interest
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest = 0.02
>>> jim_account.interest = 0.02
>>> tom_account.interest = 0.02
>>> Account.interest = 0.04
>>> tom_account.interest = 0.04
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest = 0.02
0.02
>>> jim_account.interest = 0.02
0.02
>>> tom_account.interest = 0.02
0.02
>>> Account.interest = 0.04
>>> tom_account.interest = 0.04
0.04
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

• If the object is an instance, then assignment sets an instance attribute

• If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest = 0.02
>>> jim_account.interest = 0.02
>>> tom_account.interest = 0.02
>>> Account.interest = 0.04
>>> tom_account.interest = 0.04
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
>>> tom_account.interest
0.02
>>> Account.interest = 0.04
>>> tom_account.interest
0.04
>>> jim_account.interest = 0.08
>>> jim_account.interest
0.08
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
>>> tom_account.interest
0.02
>>> Account.interest = 0.04
>>> tom_account.interest
0.04
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression.

- If the object is an instance, then assignment sets an instance attribute.
- If the object is a class, then assignment sets a class attribute.

```python
class Account:
    interest = 0.02

jim_account = Account('Jim')
tom_account = Account('Tom')
tom_account.interest = 0.02
jim_account.interest = 0.08
tom_account.interest = 0.04
Account.interest = 0.04
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

• If the object is an instance, then assignment sets an instance attribute

• If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest 0.02
>>> jim_account.interest 0.02
>>> tom_account.interest 0.02
>>> Account.interest = 0.04
>>> tom_account.interest 0.04
>>> jim_account.interest = 0.08
>>> jim_account.interest 0.08
>>> tom_account.interest 0.04
>>> Account.interest = 0.05
>>> tom_account.interest 0.05
```
Assignment Statements and Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression

• If the object is an instance, then assignment sets an instance attribute

• If the object is a class, then assignment sets a class attribute

```python
>>> jim_account = Account('Jim')
>>> tom_account = Account('Tom')
>>> tom_account.interest 0.02
>>> jim_account.interest 0.02
>>> tom_account.interest 0.02
>>> Account.interest = 0.04
>>> tom_account.interest 0.04
>>> Account.interest = 0.05
>>> tom_account.interest 0.05
>>> jim_account.interest 0.08
>>> jim_account.interest = 0.08
>>> jim_account.interest 0.08
>>> tom_account.interest 0.04
>>> Account.interest = 0.05
>>> tom_account.interest 0.05
>>> jim_account.interest 0.08
```