Objects
Announcements
Object-Oriented Programming
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A method for organizing programs
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A method for organizing programs

- Data abstraction
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- Data abstraction
- Bundling together information and related behavior
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• Data abstraction
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A metaphor for computation using distributed state
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• Each object has its own local state
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• Each object has its own local state

• Each object also knows how to manage its own local state, based on method calls
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Specialized syntax & vocabulary to support this metaphor
Classes
A class describes the general behavior of 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
A class describes the general behavior of 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('John')
```
Classes

A class describes the general behavior of its instances

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Classes

A class describes the general behavior of 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('John')
>>> a.holder
'John'
```
A class describes the general behavior of 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('John')
>>> a.holder
'John'
>>> a.balance
0
```
Classes

A class describes the general behavior of 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

>>> a = Account('John')
>>> a.holder
'John'
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0

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

A class describes the general behavior of 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('John')
>>> a.holder
'John'
>>> a.balance
0
```

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

```python
>>> a.deposit(15)
15
```
A class describes the general behavior of 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('John')
>>> a.holder
'John'
>>> a.balance
0
>>> a.deposit(15)
15
>>> a.withdraw(10)
5
```
Classes

A class describes the general behavior of 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('John')
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'John'
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0

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```

**Idea:** All bank accounts should have withdraw and deposit behaviors that all work in the same way.
A class describes the general behavior of 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

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>>> a = Account('John')
>>> a.holder
'John'
>>> a.balance
0
>>> a.deposit(15)
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>>> a.withdraw(10)
5
>>> a.balance
5
>>> a.withdraw(10)
'Insufficient funds'
```

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

A class describes the general behavior of 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

>>> a = Account('John')
>>> a.holder
'John'
>>> a.balance
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'Insufficient funds'

Better idea: All bank accounts share a withdraw method and a deposit method
Class Statements
The Class Statement
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class <name>:
    <suite>
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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Assignment & def statements in `<suite>` create attributes of the class (not names in frames).
The Class Statement

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The suite is executed when the class statement is executed.

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The Class Statement

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```
>>> class Clown:
...    nose = 'big and red'
...    def dance():
...        return 'No thanks'
...```
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```python
>>> class Clown:
...     nose = 'big and red'
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...     
>>> Clown.nose
'big and red'
```
The Class Statement

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>>> class Clown:
...    nose = 'big and red'
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...
>>> Clown.nose
'big and red'
>>> Clown.dance()
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'bigs and red'
>>> Clown.dance()
'No thanks'
>>> Clown
<class '__main__.Clown'>
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Object Construction
Object Construction

**Idea:** All bank accounts have a *balance* and an account *holder*; the `Account` class should add those attributes to each of its instances

```python
>>> a = Account('Jim')
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Object Construction

**Idea:** All bank accounts have a *balance* and an account *holder*; the *Account* class should add those attributes to each of its instances

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When a class is called:
Object Construction

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each of its instances

>>> a = Account('Jim')

When a class is called:

1. A new instance of that class is created:
Object Construction

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When a class is called:

1. A new instance of that class is created: An account instance
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When a class is called:

1. A new instance of that class is created:

2. The `__init__` method of the class is called with the new object as its first argument (named `self`), along with any additional arguments provided in the call expression
**Object Construction**

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class Account:
    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder
```
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1. A new instance of that class is created:

2. The `__init__` method of the class is called with the new object as its first argument (named `self`), along with any additional arguments provided in the call expression.

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

- `__init__` is called a constructor.
When a class is called:

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        self.balance = 0
        self.holder = account_holder
```

An account instance

Object Construction

**Idea:** All bank accounts have a balance and an account holder; the `Account` class should add those attributes to each of its instances

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

Idea: All bank accounts have a balance and an account holder; the Account class should add those attributes to each of its instances

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

When a class is called:

1. A new instance of that class is created:

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class Account:
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__init__ is called a constructor.

An account instance
Object Identity
Object Identity

Every object that is an instance of a user-defined class has a unique identity:
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```python
>>> a = Account('John')
>>> b = Account('Jack')
```
Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```python
>>> a = Account('John')
>>> b = Account('Jack')
```

Every call to `Account` creates a new `Account` instance. There is only one `Account` class.
Object Identity

Every object that is an instance of a user-defined class has a unique identity:

```python
>>> a = Account('John')
>>> b = Account('Jack')
>>> a.balance
0
>>> b.holder
'Jack'
```

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Object Identity

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>>> a.balance
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>>> b.holder
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```

Identity operators "is" and "is not" test if two expressions evaluate to the same object:

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0
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```

Identity operators "is" and "is not" test if two expressions evaluate to the same object:

```python
>>> a is a
True
>>> a is not b
True
```

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>>> a = Account('John')
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0
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Identity operators "is" and "is not" test if two expressions evaluate to the same object:

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

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Identity operators "is" and "is not" test if two expressions evaluate to the same object:

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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:

```python
>>> c = a
>>> c is a
True
```
Methods
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Methods are functions defined in the suite of a class statement
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```python
class Account:
```
Methods

Methods are functions defined in the suite of a class statement

```python
class Account:
    def __init__(self, account_holder):
```
Methods are functions defined in the suite of a class statement:

```python
class Account:
    def __init__(self, account_holder):
        self.balance = 0
```
Methods

Methods are functions defined in the suite of a class statement

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

Methods are functions defined in the suite of a class statement

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

    def deposit(self, amount):
Methods

Methods are functions defined in the suite of a class statement.

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

    def deposit(self, amount):
```

*Self should always be bound to an instance of the Account class.*
Methods are functions defined in the suite of a class statement

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

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

self should always be bound to an instance of the Account class.
Methods

Methods are functions defined in the suite of a class statement.

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

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

self should always be bound to an instance of the Account class.
Methods

Methods are functions defined in the suite of a class statement.

```python
class Account:
    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):
```

- `self` should always be bound to an instance of the Account class.
Methods

Methods are functions defined in the suite of a class statement

class Account:
    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:
Methods

Methods are functions defined in the suite of a class statement

```python
class Account:
    def __init__(self, account_holder):
        self.balance = 0
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    def deposit(self, amount):
        self.balance = self.balance + amount
        return self.balance

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

self should always be bound to an instance of the Account class
Methods

Methods are functions defined in the suite of a class statement:

```python
class Account:
    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
```

- `self` should always be bound to an instance of the `Account` class.
Methods

Methods are functions defined in the suite of a class statement

class Account:
    def __init__(self, account_holder):
        self.balance = 0
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        self.balance = self.balance + amount
        return self.balance

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        if amount > self.balance:
            return 'Insufficient funds'
        self.balance = self.balance - amount
        return self.balance

self should always be bound to an instance of the Account class
Methods

Methods are functions defined in the suite of a class statement

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class Account:
    def __init__(self, account_holder):
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        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
Methods

Methods are functions defined in the suite of a class statement

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

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

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self should always be bound to an instance of the Account 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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class Account:
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    def deposit(self, amount):
        self.balance = self.balance + amount
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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:
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        self.balance = self.balance + amount
    return self.balance
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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:
    ...
    def deposit(self, amount):
        self.balance = self.balance + amount
    return self.balance
```

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

```python
class Account:
    ...
    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:
    ...  # Defined with two parameters
    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  # Invoked with one argument
```
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:
    ...
    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
```

Defined with two parameters

Bound to self

Invoked with one argument
Dot Expressions
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Objects receive messages via dot notation
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Dot notation accesses attributes of the instance or its class
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<expression> . <name>
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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>
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tom_account.deposit(10)
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Dot expression

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(Demo)
Attributes

(Demo)
Accessing Attributes
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Using `getattr`, we can look up an attribute using a string
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```python
>>> getattr(tom_account, 'balance')
10
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>>> getattr(tom_account, 'balance')
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>>> hasattr(tom_account, 'deposit')
True
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`getattr` and `dot` expressions look up a name in the same way
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Looking up an attribute name in an object may return:
Accessing Attributes

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Looking up an attribute name in an object may return:

- One of its instance attributes, or
**Accessing Attributes**

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Looking up an attribute name in an object may return:

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Methods and Functions
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Object + Function = Bound Method

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

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

```python
>>> Account.deposit(tom_account, 1001)
1011
```
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>>> tom_account.deposit(1007)
2018
```
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Object + Function = Bound Method

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>>> type(Account.deposit)
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Function: all arguments within parentheses
>>> tom_account.deposit(1007)
2018
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Methods and Functions

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

```python
>>> Account.deposit(tom_account, 1001)
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>>> tom_account.deposit(1007)
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```

**Function:** all arguments within parentheses

**Method:** One object before the dot and other arguments within parentheses
Looking Up Attributes by Name

<expression> . <name>
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To evaluate a dot expression:
Looking UpAttributes by 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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2. <name> is matched against the instance attributes of that object; if an attribute with that name exists, its value is returned
Looking Up Attributes by Name

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3. If not, <name> is looked up in the class, which yields a class attribute value
Looking Up Attributes by Name

To evaluate a dot expression:

1. Evaluate the `<expression>` to the left of the dot, which yields the object of the dot expression

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
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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:

    interest = 0.02  # A class attribute

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

    # Additional methods would be defined here
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>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
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0.02
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The `interest` attribute is not part of the instance; it's part of the class!
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Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance.

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0.02
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