61A Lecture 14
Announcements
Object-Oriented Programming
Object-Oriented Programming
Object-Oriented Programming

A method for organizing programs
Object-Oriented Programming

A method for organizing programs

• Data abstraction
Object-Oriented Programming

A method for organizing programs

- Data abstraction
- Bundling together information and related behavior
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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 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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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('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')
```
**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 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'
```
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

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
```

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

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

```python
>>> a.deposit(15)
15
```
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

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

>>> a.deposit(15)
15
>>> a.withdraw(10)
5

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

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

```python
>>> a.holder
'Jim'
```

```python
>>> a.balance
0
```

```python
>>> a.deposit(15)
```

```python
>>> a.withdraw(10)
```

```python
>>> a.balance
5
```

**Better idea:** All bank accounts share a *withdraw* method and a *deposit* method

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

```python
>>> a.holder
'Jim'
```

```python
>>> a.balance
0
```

```python
>>> a.deposit(15)
```

```python
>>> a.withdraw(10)
```

```python
>>> a.balance
5
```

```python
>>> a.withdraw(10)
'Insufficient funds'
```
Class Statements
The Class Statement
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class <name>:
    <suite>
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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)
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```python
>>> class Clown:
...    nose = 'big and red'
...    def dance():
...        return 'No thanks'
...```
The Class Statement

A class statement creates a new class and binds that class to `<name>` in the first frame of the current environment. Assignment & def statements in `<suite>` create attributes of the class (not names in frames).

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

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'big and red'
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'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')
```
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

```python
>>> a = Account('Jim')
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When a class is called:

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

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An account instance
Object Construction

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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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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

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

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

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

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.

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

**__init__** is called a constructor.
Object Identity
Object Identity

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

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

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

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

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

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Object Identity

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

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

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

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Object Identity

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

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
```

Every call to `Account` creates a new `Account` instance. There is only one `Account` class.
Every object that is an instance of a user-defined class has a unique identity:

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

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

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

```python
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:

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

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
```

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

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

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

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

Methods are functions defined in the suite of a class statement

```python
class Account:
```
Methods

Methods are functions defined in the suite of a class statement

```python
def __init__(self, account_holder):
```

Methods

Methods are functions defined in the suite of a class statement

```python
self.balance = 0
```
Methods

Methods are functions defined in the suite of a class statement

```python
self.holder = account_holder
```
Methods

Methods are functions defined in the suite of a class statement

```python
def deposit(self, amount):
```
Methods

Methods are functions defined in the suite of a class statement

```python
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

Methods are functions defined in the suite of a class statement

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

self.balance = self.balance + 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.balance = self.balance + amount
        return self.balance

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

return self.balance
```
Methods

Methods are functions defined in the suite of a class statement

```python
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
```

```python
    def withdraw(self, amount):
```
Methods

Methods are functions defined in the suite of a class statement

```
if amount > 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
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
```

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

return 'Insufficient funds'
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

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class Account:
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        if amount > self.balance:
            return 'Insufficient funds'
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self should always be bound to an instance of the Account class
```

```
return 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
        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.

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

These `def` statements create function objects as always, but their names are bound as attributes of the class.

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

Defined with two parameters
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
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

class Account:
    ...
    def deposit(self, amount):
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Dot notation automatically supplies the first argument to a method

>>> tom_account = Account('Tom')
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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.

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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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Objects receive messages via dot notation

Dot notation accesses attributes of the instance or its class
Dot Expressions

Objects receive messages via dot notation

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<expression> . <name>
Dot Expressions

Objects receive messages via dot notation

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Dot Expressions

Objects receive messages via dot notation

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(Demo)

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Attributes

(Demo)
Accessing Attributes
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Using `getattr`, we can look up an attribute using a string.
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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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`getattr` and dot expressions look up a name in the same way

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

Using `getattr`, we can look up an attribute using a string:

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

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

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>>> type(Account.deposit)
```
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<class 'function'>
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*Function*: all arguments within parentheses
Methods and Functions

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

*Function*: all arguments within parentheses

```python
>>> tom_account.deposit(1004)
2015
```

*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:
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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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```python
class Account:
    interest = 0.02  # A class attribute

    def __init__(self, account_holder):
        self.balance = 0
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    # Additional methods would be defined here
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The interest attribute is not part of the instance; it's part of the class!
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