

# 61A Lecture 16

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Wednesday, October 5

# Policy Changes Based on the Survey

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- Deferred: Questions about related topics, extensions, etc.



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- I'll print out the code on code-intensive days

# Implementing an Object System

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**Today's topics:**



# Implementing an Object System

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- Dispatch dictionaries

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## **Tools we'll use:**

- Dispatch dictionaries
- Higher-order functions

# The OOP Abstraction Barrier (a.k.a. the Line)

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Below the Line:

- Objects have **mutable dictionaries** of attributes



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- Object **instantiation** is another function

# Implementing the Object Abstraction

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**Fundamental OOP concepts:**

# Implementing the Object Abstraction

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## **Fundamental OOP concepts:**

- Object instantiation and initialization

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- Dot expression syntax

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## **Fundamental OOP concepts:**

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- Multiple inheritance

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- Object instantiation and initialization
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- Dot expression syntax
- Multiple inheritance
- Introspection (e.g., what class does this object have?)

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## **Fundamental OOP concepts:**

- Object instantiation and initialization
- Attribute look-up and assignment
- Method invocation
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## **Not-so-fundamental issues (that we'll skip):**

- Dot expression syntax
- Multiple inheritance
- Introspection (e.g., what class does this object have?)

Dot expressions are equivalent to getattr and setattr (Demo)

# Instances

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Dispatch dictionary with messages 'get' and 'set'



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Attributes stored in a local dictionary "attributes"

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The class of the instance

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def make_instance(cls):  
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    def get_value(name):  
        if name in attributes:  
            return attributes[name]  
        else:  
            value = cls['get'](name)  
            return bind_method(value, instance)
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# Instances

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```
def make_instance(cls):
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```
    """Return a new object instance."""
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```
def get_value(name):
```

Match name against instance attributes

```
    if name in attributes:
```

```
        return attributes[name]
```

```
    else:
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```
        value = cls['get'](name)
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        return bind_method(value, instance)
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Match name against instance attributes

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        if name in attributes:
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```
            return attributes[name]
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        else:
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Look up the name in the class

```
            value = cls['get'](name)
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            return bind_method(value, instance)
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            value = cls['get'](name)
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```
    def set_value(name, value):
        attributes[name] = value
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    def set_value(name, value):
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        attributes[name] = value
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Assignment always creates/modifies instance attributes



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            value = cls['get'](name)  
            return bind_method(value, instance)  
  
    def set_value(name, value):  
        attributes[name] = value  
  
    attributes = {}  
    instance = {'get': get_value, 'set': set_value}  
    return instance
```

The class of the instance

Match name against  
instance attributes

Look up the name  
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Assignment always  
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        elif base_class is not None:  
            return base_class['get'](name)
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def set_value(name, value):  
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def set_value(name, value):  
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```
def new(*args):  
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            return base_class['get'](name)  
  
    def set_value(name, value):  
        attributes[name] = value  
  
    def new(*args):  
        return init_instance(cls, *args)  
  
    cls = {'get': get_value, 'set': set_value, 'new': new}  
    return cls
```

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    def set_value(name, value):  
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Common dispatch  
dictionary pattern

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    def new(*args):  
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def init_instance(cls, *args):
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    ...  
  
def init_instance(cls, *args):  
    """Return a new instance of cls, initialized with args."""
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First makes a new instance, then invokes the `__init__` method

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    ...
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    ...

def init_instance(cls, *args):
    """Return a new instance of cls, initialized with args."""
    instance = make_instance(cls)
```

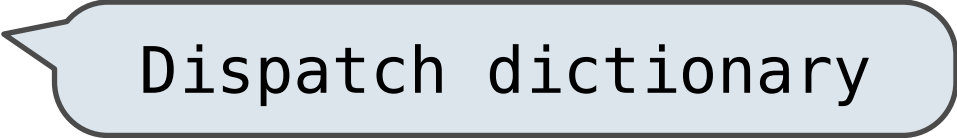
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Dispatch dictionary

# Instantiation and Initialization

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    init = cls['get']('__init__')
```



Dispatch dictionary

# Instantiation and Initialization

---

First makes a new instance, then invokes the `__init__` method

```
def make_class(attributes={}, base_class=None):  
    ...  
    def new(*args):  
        return init_instance(cls, *args)  
    ...
```

```
def init_instance(cls, *args):  
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    instance = make_instance(cls)  
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    if init:  
        init(instance, *args)  
    return instance
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# Example: Defining an Account Class

---

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---

```
def make_account_class():  
    """Return the Account class."""
```

## Example: Defining an Account Class

---

```
def make_account_class():  
    """Return the Account class."""  
  
    def __init__(self, account_holder):  
        self['set']('holder', account_holder)  
        self['set']('balance', 0)
```

## Example: Defining an Account Class

---

```
def make_account_class():
    """Return the Account class."""

    def __init__(self, account_holder):
        self['set']('holder', account_holder)
        self['set']('balance', 0)

    def deposit(self, amount):
        """Increase the account balance by amount."""
        new_balance = self['get']('balance') + amount
        self['set']('balance', new_balance)
        return self['get']('balance')
```

## Example: Defining an Account Class

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```
def make_account_class():
    """Return the Account class."""

    def __init__(self, account_holder):
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        new_balance = self['get']('balance') + amount
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    def withdraw(self, amount):
        """Decrease the account balance by amount."""
        ...
```

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        self['set']('balance', 0)

    def deposit(self, amount):
        """Increase the account balance by amount."""
        new_balance = self['get']('balance') + amount
        self['set']('balance', new_balance)
        return self['get']('balance')

    def withdraw(self, amount):
        """Decrease the account balance by amount."""
        ...

    return make_class({'__init__': __init__,
                       'deposit': deposit,
                       'withdraw': withdraw,
                       'interest': 0.02})
```



## Example: Using the Account Class

---

The Account class is instantiated and stored, then messaged

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>>> Account = make_account_class()
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The Account class is instantiated and stored, then messaged

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>>> Account = make_account_class()
>>> jim_acct = Account['new']('Jim')
>>> jim_acct['get']('holder')
'Jim'
```

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'Jim'
>>> jim_acct['get']('interest')
0.02
>>> jim_acct['get']('deposit')(20)
20
```

## Example: Using the Account Class

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The Account class is instantiated and stored, then messaged

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>>> Account = make_account_class()
>>> jim_acct = Account['new']('Jim')
>>> jim_acct['get']('holder')
'Jim'
>>> jim_acct['get']('interest')
0.02
>>> jim_acct['get']('deposit')(20)
20
>>> jim_acct['get']('withdraw')(5)
15
```

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>>> jim_acct = Account['new']('Jim')
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'Jim'
>>> jim_acct['get']('interest')
0.02
>>> jim_acct['get']('deposit')(20)
20
>>> jim_acct['get']('withdraw')(5)
15
```

How can we also use getattr and setattr style syntax?



# Class and Instance Attributes

---

Instance attributes and class attributes can still share names

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---

Instance attributes and class attributes can still share names

```
>>> Account = make_account_class()
>>> jim_acct = Account['new']('Jim')
>>> jim_acct['set']('interest', 0.04)
```

# Class and Instance Attributes

---

Instance attributes and class attributes can still share names

```
>>> Account = make_account_class()
>>> jim_acct = Account['new']('Jim')
>>> jim_acct['set']('interest', 0.04)
>>> Account['get']('interest')
0.02
```

# Class and Instance Attributes

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Instance attributes and class attributes can still share names

```
>>> Account = make_account_class()
>>> jim_acct = Account['new']('Jim')
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>>> Account['get']('interest')
0.02
```

Demo

## Example: Using Inheritance

---

CheckingAccount is a special case of Account

## Example: Using Inheritance

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```
def make_checking_account_class():
```



## Example: Using Inheritance

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```
def make_checking_account_class():  
    """Return the CheckingAccount class."""
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## Example: Using Inheritance

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CheckingAccount is a special case of Account

```
def make_checking_account_class():  
    """Return the CheckingAccount class."""  
    def withdraw(self, amount):
```

## Example: Using Inheritance

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CheckingAccount is a special case of Account

```
def make_checking_account_class():  
    """Return the CheckingAccount class."""  
    def withdraw(self, amount):  
        return Account['get']('withdraw')(self, amount + 1)
```

## Example: Using Inheritance

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CheckingAccount is a special case of Account

```
def make_checking_account_class():
    """Return the CheckingAccount class."""
    def withdraw(self, amount):
        return Account['get']('withdraw')(self, amount + 1)
    return make_class({'withdraw': withdraw,
```

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CheckingAccount is a special case of Account

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def make_checking_account_class():
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    return make_class({'withdraw': withdraw,
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def make_checking_account_class():
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Class attributes for  
CheckingAccount

## Example: Using Inheritance

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def make_checking_account_class():  
    """Return the CheckingAccount class."""  
    def withdraw(self, amount):  
        return Account['get']('withdraw')(self, amount + 1)  
    return make_class({'withdraw': withdraw,  
                      'interest': 0.01},  
                      Account)
```

Class attributes for  
CheckingAccount

Demo



## Relationship to the Python Object System

---

Object attributes are stored as dictionaries

Some "magic" names, `__<name>__`, require special handling

An object has an "attribute" called `__dict__` that is a dictionary of its instance attributes

### Demo

In Python, classes have classes too

The equivalent of `init_instance` can be customized (metaclass)