OBJECT-ORIENTATION & CLASS INHERITANCE

LECTURE 08-1

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COURSE INFO

- **Project 2** is due next Monday
- The **1st Midterm Exam** is Wednesday
- **Today:** we continue looking at object-orientation in Python
  - a few more examples, including Rational
  - special methods
  - class inheritance
- **Reading:** Python object-orientation
  - ➡ TP**2e** Ch 15-18
    - ✦ at https://greenteapress.com/thinkpython2/thinkpython2.pdf
  - ➡ CP Ch 2.5-2.8

SYNTAX: CLASS DEFINITION

Below is a template for most class definitions:

```
class class-name:
    def __init__(self,parameter-list):
        statements that set each of self's attributes
        ...
    def method-name (self,parameter-list):
        statements that access self's attributes
        ...
    ...
```

SYNTAX: CLASS DEFINITION

Below is a template for most class definitions:

```
class class-name:
    def __init__(self,parameter-list):
        statements that set each of self's attributes
        ...
    def method-name (self,parameter-list):
        ...self.attribute... # attribute access
        ...
    ...
```

SYNTAX: CLASS DEFINITION

Below is a template for most class definitions:

```
class class-name:
    def __init__(self,parameter-list):
        statements that set each of self's attributes
        ...
    def method-name(self,parameter-list):
        ...
        # method invocation
        self.method(parameters)
        ...
    ...
```

SYNTAX: CLASS DEFINITION

Below is a template for most class definitions:

```
class class-name:
    def __init__(self,parameter-list):
        ...
    def method-name(self,parameter-list):
        ...
    ...
```

Here is client code for creating a new object instance:

```
thing = class-name(parameters)
thing.method-name(parameters)
```

EXAMPLE: A FIBONACCI GENERATOR CLASS

Here is a class for an object that produces the Fibonacci sequence:

```
class Fib:
    def __init__(self):
        self.prev = 0
        self.current = 1
    def advance(self):
        next = self.prev + self.current
        self.prev = self.current
        self.current = next
    def get(self):
        return self.current
    def output(self):
        print(self.get())
        self.advance()
```

EXAMPLE: A FIBONACCI GENERATOR CLASS

Here is a class for an object that produces the Fibonacci sequence:

```
class Fib:
    def __init__(self):
        self.reset()
    def advance(self):
        next = self.prev + self.current
        self.prev = self.current
        self.current = next
    def get(self):
        return self.current
    def output(self):
        print(self.get())
        self.advance()
    def reset(self):
        self.prev = 0
        self.current = 1
```

EXAMPLE: A TWO-DIGIT NUMBER OBJECT

Here is a class for an object that stores a two-digit number:

```
class TwoDigit:
    def __init__(self,d2,d1):
        self.tens = d2
        self.ones = d1
    def changeTensTo(self,d):
        self.tens = d
    def changeOnesTo(self,d):
        self.ones = d
    def get(self):
        return self.tens*10 + self.ones
```

EXAMPLE: A TWO-DIGIT NUMBER OBJECT V2.0

Here is a different implementation of the two-digit number class:

```
class TwoDigit:
    def __init__(self,d2,d1):
        self.number = d2*10 + d1
    def changeTensTo(self,d):
        self.number = d*10 + (self.number%10)
    def changeOnesTo(self,d):
        self.number = (self.number//10)*10 + d
    def get(self):
        return self.number
```

- Any client code that uses `TwoDigit` can be the same for either, so long as it uses only its methods.

EXAMPLE: RATIONAL NUMBER CLASS

Here is our rational number data structure as an object class

```
class Rational:
    def __init__(self,n,d):
        if d < 0:
            n *= -1
            d *= -1
        g = GCD(n,d)
        self.numerator = n // g
        self.denominator = d // g

    def getNumerator(self):
        return self.numerator

    def getDenominator(self):
        return self.denominator
```

EXAMPLE: RATIONAL NUMBER ADDITION METHOD

We can define multiplication of rational numbers as we did before:

```
class Rational:
    def __init__(self,n,d): ...
    def getNumerator(self): ...
    def getDenominator(self): ...

    def times(self,other):
        sn = self.getNumerator()
        sd = self.getDenominator()
        on = other.getNumerator()
        od = other.getDenominator()
        return Rational(sn*on, sd*od)
```

EXAMPLE: RATIONAL NUMBER ADDITION METHOD

We can define addition of rational numbers as we did before:

```
class Rational:
    def __init__(self,n,d): ...
    def getNumerator(self): ...
    def getDenominator(self): ...
    def times(self,other): ...
    def plus(self,other):
        sn = self.getNumerator()
        sd = self.getDenominator()
        on = other.getNumerator()
        od = other.getDenominator()
        return Rational(sn*od + on*sd, sd*od)
```

OUR RATIONAL NUMBER OBJECT IN ACTION

- With these defined, here is an interaction:

```
>>> a = Rational(1, 3)
>>> a.asString()
'1 / 3'
>>> b = Rational(1, 2)
>>> ba = b.times(a)
>>> ba.asString()
'1 / 6'
>>> c = a.plus(ba)
>>> c.asString()
'1 / 2'
```

OUR RATIONAL NUMBER OBJECT IN ACTION

- Wouldn't this be great to see instead?

```
>>> a = Rational(1, 3)
>>> a
1 / 3
>>> b = Rational(1, 2)
>>> b * a
1 / 6
>>> a + b * a
1 / 2
```

EXAMPLE: DEFINING THE TIMES OPERATION

Python has "special methods" that provide hooks to using operator syntax:

```
class Rational:
    def __init__(self,n,d): …
    …

    # defines r1 * r2
    def __mul__(self,other):
        sn = self.getNumerator()
        sd = self.getDenominator()
        on = other.getNumerator()
        od = other.getDenominator()
        return Rational(sn*on, sd*od)
```

EXAMPLE: DEFINING THE PLUS OPERATION

```
class Rational:
    def __init__(self,n,d): …
    def getNumerator(self): …
    def getDenominator(self): …
    def __mul__(self,other): …

    # defines r1 + r2
    def __add__(self,other):
        sn = self.getNumerator()
        sd = self.getDenominator()
        on = other.getNumerator()
        od = other.getDenominator()
        return Rational(sn*od + on*sd, sd*od)
```

SPECIAL METHODS

Python has "special methods" for lots of built-in syntax.

- They are surrounded by a double underscore (_)
- Documented at this technical page:
  - https://docs.python.org/3/reference/datamodel.html#special-method-names
- Nice overview here:
  - https://www.pythonlikeyoumeanit.com/Module4_OOP/Special_Methods.html

Example:

```
def __mul__(self,other):
    ...
```

- Defines `x * y` to mean `x.__mul__(y)`

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Example:

```
def __eq__(self,other):
    ...
```

- Defines `x == y` to mean `x.__eq__(y)`

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Example:

```
def __getitem__(self,index):
    ...
```

- Defines `x[i]` to mean `x.__getitem__(i)`

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Example:

```
def __str__(self):
    ...
```

- Defines `str(x)` to mean `x.__str__()`
- Also used for `print(x)`. It means `print(x.__str__())`

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Example:

```
def __repr__(self):
    ...
```

- Defines the string "representation" of an object.

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Example:

```
def __repr__(self):
    ...
```

- Used by the interpreter to display the object's value, like so:

```
>>> Rational(27, 33)
9 / 11
```

RECALL: ACCOUNT CLASS

- Here is the class definition of a new **`Account`** type:

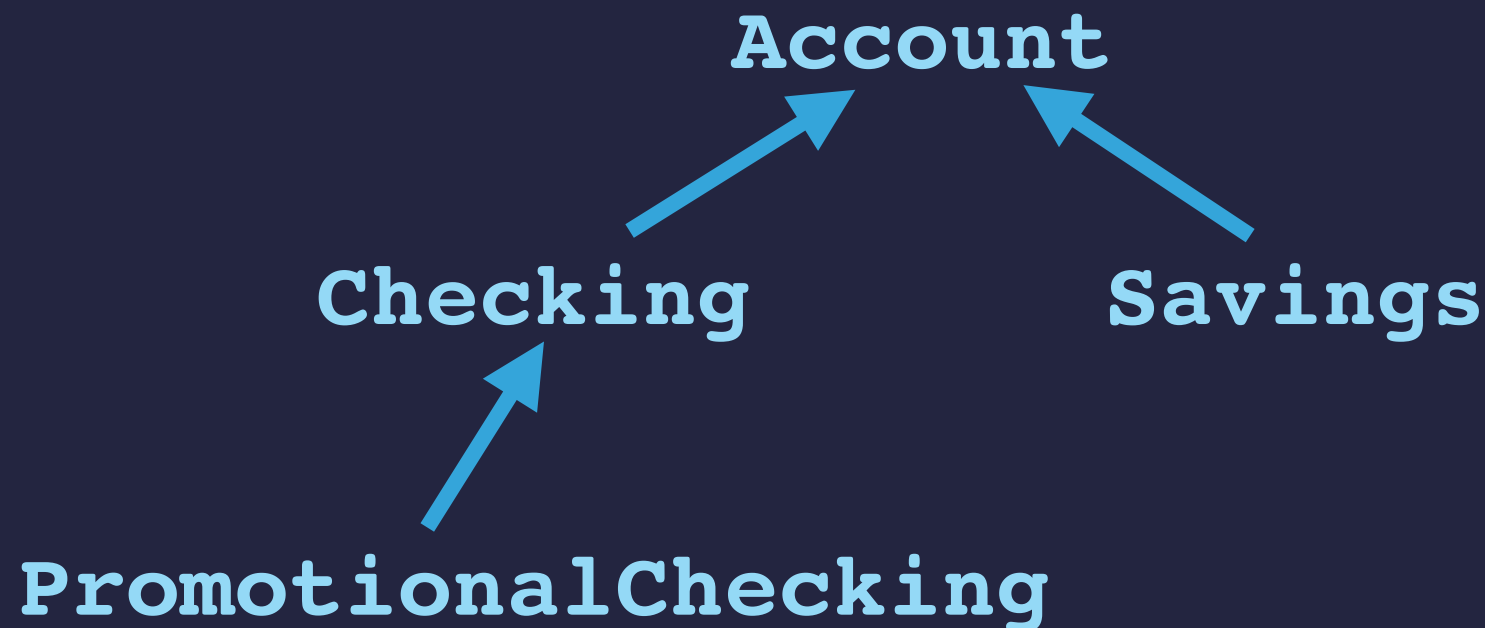
```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate
    def getBalance(self):
        return self.balance
```

- Here is **`Account`** in use:

```
>>> a = Account(150)
>>> a.deposit(50)
>>> a.payInterest()
>>> a.getBalance()
204.0
```

AN ACCOUNT CLASS HIERARCHY

- We can build ***hierarchies*** of different accounts:



- We make ***subclasses*** that ***inherit*** the attributes of their "***superclasses***"
  - A `Savings` account has all the info and operations of an `Account`.
  - But it has features and behavior more specific to checking accounts
    - This is called subclass ***specialization***.
    - We ***extend*** the superclass with additional attributes.
  - It also ***overrides*** some of the behavior it inherits from `Account`.

INHERITANCE EXAMPLE: A SAVINGS ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Savings(Account):
    interest_rate = 0.04
    withdraw_fee = 1.0
    def withdraw(self, amount):
        Account.withdraw(self, amount + self.withdraw_fee)
```

INHERITANCE EXAMPLE: A SAVINGS ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Savings(Account):  # inherit the methods and class variables of Account
    interest_rate = 0.04
    withdraw_fee = 1.0
    def withdraw(self, amount):
        Account.withdraw(self, amount + self.withdraw_fee)
```

INHERITANCE EXAMPLE: A SAVINGS ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Savings(Account):
    interest_rate = 0.04  # overrides the class variable inherited from Account
    withdraw_fee = 1.0
    def withdraw(self, amount):
        Account.withdraw(self, amount + self.withdraw_fee)
```

INHERITANCE EXAMPLE: A SAVINGS ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Savings(Account):
    interest_rate = 0.04
    withdraw_fee = 1.0  # extends with a specializing class variable
    def withdraw(self, amount):
        Account.withdraw(self, amount + self.withdraw_fee)
```

INHERITANCE EXAMPLE: A SAVINGS ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Savings(Account):
    interest_rate = 0.04
    withdraw_fee = 1.0
    def withdraw(self, amount):  # overrides a method inherited from Account
        Account.withdraw(self, amount + self.withdraw_fee)
```

INHERITANCE EXAMPLE: A SAVINGS ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Savings(Account):
    interest_rate = 0.04
    withdraw_fee = 1.0
    def withdraw(self, amount):  # overrides a method inherited from Account
        Account.withdraw(self, amount + self.withdraw_fee)
        # explicitly invokes the method of its superclass
```

INHERITANCE EXAMPLE: A SAVINGS ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Savings(Account):
    interest_rate = 0.04
    withdraw_fee = 1.0
    def withdraw(self, amount):  # overrides a method inherited from Account
        Account.withdraw(self, amount + self.withdraw_fee)
        # explicitly invokes the method of its superclass
```

ACCOUNT VERSUS SAVINGS

- Here is `Account` in use:

```
>>> a = Account(100)
>>> a.balance
100.0
>>> a.payInterest()
>>> a.balance
102.0
>>> a.withdraw(20)
>>> a.balance
82.0
```

- Here is `Savings` in use:

```
>>> a = Savings(100)
>>> a.balance
100.0
>>> a.payInterest()
>>> a.balance
104.0
>>> a.withdraw(20)
>>> a.balance
83.0
```

INHERITANCE EXAMPLE: A CHECKING ACCOUNT

```
class Account:
    interest_rate = .02
    def __init__(self, amount):
        self.balance = amount
    def deposit(self, amount):
        self.balance += amount
    def withdraw(self, amount):
        self.balance -= amount
    def payInterest(self):
        self.balance *= 1.0 + self.interest_rate

class Checking(Account):

    min_balance = 1000.0

    def payInterest(self):
        if self.balance >= self.min_balance:
            Account.payInterest(self)
```

CHECKING ACCOUNT INTERACTION

- Here is `Checking` in use:

```
>>> a = Checking(1000.0)
>>> a.balance
1000.0
>>> a.payInterest()
>>> a.balance
1040.0
>>> a.withdraw(50.0)
>>> a.balance
990.0
>>> a.payInterest()
>>> a.balance
990.0
```

INHERITANCE EXAMPLE: A PROMOTIONAL CHECKING ACCOUNT

```
class Checking(Account):

    min_balance = 1000.0

    def payInterest(self):
        if self.balance >= self.min_balance:
            Account.payInterest(self)

class PromotionalChecking(Checking):

    reward = 50

    def __init__(self,amount):
        Checking.__init__(self,amount+self.reward)
        # The code above explicitly uses the initializer code from Checking
```

INHERITANCE EXAMPLE: A PROMOTIONAL CHECKING ACCOUNT

```
class Checking(Account):

    min_balance = 1000.0

    def payInterest(self):
        if self.balance >= self.min_balance:
            Account.payInterest(self)

class PromotionalChecking(Checking):

    reward = 50

    def __init__(self,amount):
        super().__init__(amount+self.reward)
        # The code above explicitly uses the initializer code from Checking
```

INHERITANCE EXAMPLE: A PROMOTIONAL CHECKING ACCOUNT

```
class Checking(Account):

    min_balance = 1000.0

    def payInterest(self):
        if self.balance >= self.min_balance:
            Account.payInterest(self)

class PromotionalChecking(Checking):

    reward = 50

    def __init__(self,amount):
        super().__init__(amount+self.reward)
        # The code above uses the initializer code from Checking that was inherited from Account
        # Using super() references self as though it is an instance of its superclass
```

OBJECT TAKEAWAYS

- New object types are defined with class.
- Within the class you define these things:
  - `__init__`
  - other methods
  - (maybe) class attributes
- Method parameters are `self` followed by the others.
- Object dot notation:
  - Methods are called using `receiver.method(...)`
  - Instance variables are accessed by `receiver.variable`
  - We use self. notation inside a method to access these things too.
- New instances are built with `class-name(...)`

INHERITANCE TAKEAWAYS

- A class inherits from its superclass with
  - `class class-name(super-class-name):`
- You can call the superclass initializer with the syntax:
  - `super-class-name.__init__(self,...)`
- You can call the superclass methods with the syntax:
  - `super-class-name.method(self,...)`
- Subclasses inherit the methods of their superclass.
- They can be ***specialized*** in two ways:
  - You can add additional attributes and methods.
  - You can override super-class methods.