25. Inheritance and Related OOP* Ideas

Topics:
- The classes **Card**, **Deck** and **Hand**
- Subclasses
- Inheritance
- Method Overriding

*OOP = Object Oriented Programming

Will Cover These Topics With a Single Example

It will involve operations with playing cards.

Closely follows Chapter 18 in Think Python

We Are Going to Define Three Classes

```
class Card:
  """ Represents a single playing card."""

class Deck:
  """ Represents a deck of cards"""

class Hand:
  """ Represents a hand of cards"""
```

Decks and Hands

Things to do with a deck of cards:
1. Shuffle
2. Sort*
3. Add a card
4. Remove a card

Things to do with a hand of cards:
1. Compare
2. Sort*
3. Add a card
4. Remove a card

*Maybe sort in different ways

Representing a Card

A card has a suit and a rank.

There are 4 possible suits.

There are 13 possible ranks.

Anticipate a class with two attributes

Representing a Card

A card has a suit and a rank.
There are 4 possible suits.
There are 13 possible ranks

```
['Clubs','Diamonds','Hearts','Spades']

['Ace','Two','Three', 'Four','Five','Six',
    'Seven','Eight','Nine','Ten',
          'Jack', 'Queen','King']
```

The Class Card

```
class Card:
      suit_names =
      rank_names =
      def __init__(self,suit,rank):

      def __str__(self):

      def __cmp__(self,other):
```

The Class Card

```
class Card:
      suit_names =                    Class Variable
      rank_names =                    Class Variable
      def __init__(self,suit,rank):   Constructor

      def __str__(self):              For pretty printing

      def __cmp__(self,other):        For comparing one
                                      card to another
```

Class Variables

```
suit_names = ['Clubs', 'Diamonds',
              'Hearts','Spades'   ]

rank_names = [None,  'Ace', 'Two', 'Three',
             'Four', 'Five','Six', 'Seven',
             'Eight','Nine','Ten', 'Jack',
             'Queen','King']
```

Class Variables

```
suit_names = ['Clubs', 'Diamonds',
              'Hearts','Spades'   ]

rank_names = [None,  'Ace', 'Two', 'Three',
             'Four', 'Five','Six', 'Seven',
             'Eight','Nine','Ten', 'Jack',
             'Queen','King']
```

Putting `None` in the 0th entry makes for more intuitive subscripting: `rank_names[7]` is `'Seven'`

Suits are "Indexed"

```
suit_names = ['Clubs', 'Diamonds',
              'Hearts','Spades'   ]
```

0 ←→ Clubs
1 ←→ Diamonds
2 ←→ Hearts
3 ←→ Spades

An ordering: Clubs < Diamonds < Hearts < Spades

Class Variables

```
suit_names = ['Clubs', 'Diamonds',
              'Hearts','Spades'   ]

rank_names = [None,  'Ace', 'Two', 'Three',
             'Four', 'Five','Six', 'Seven',
             'Eight','Nine','Ten', 'Jack',
             'Queen','King']
```

The Class Card

```
class Card(object):
    suit_names =
    rank_names =
    def __init__(self,suit,rank):      Constructor

    def __str__(self):

    def __cmp__(self,other):
```

Let's look at the constructor…

The Constructor: Basic Idea

```
def __init__(self,suit,rank):
    """ suit and rank are ints """
    self.suit = suit
    self.rank = rank
```

```
c = Card(2,8)
```

Says:

Create a card object that represents the eight-of-hearts

The Constructor With a Convenient no-Argument Option

We'd like

```
c = Card()
```

to generate a random Card.

```
def __init__(self,suit=None,rank=None):
    if suit==None and rank==None:
        self.suit = randi(0,3)    # random suit
        self.rank = randi(1,13)   # random rank
    else:
        self.suit = suit
        self.rank = rank
```

Using the Optional Argument Idea

The Class Card

```
class Card(object):
    suit_names =
    rank_names =
    def __init__(self,suit,rank):

    def __str__(self):              For pretty printing

    def __cmp__(self,other):
```

Let's look at the __str__ method…

def __str__(self)

A special method that "pretty prints" a card when we use `print`

```
>>> c = Card(2,13)
>>> print c
  King of Hearts
```

def __str__(self)

```
suit_names = ['Clubs', 'Diamonds',
                'Hearts','Spades'   ]
```

```
def __str__(self):
    i = self.suit    # suit index
    theSuit = self.suit_names[i]
    j = self.rank    # rank index
    theRank = self.rank_names[j]
    return theRank + ' ' + theSuit
```

Shows how to access class variables

The Class Card

```
class Card(object):
    suit_names =
    rank_names =
    def __init__(self,suit,rank):

    def __str__(self):

    def __cmp__(self,other):
```

For comparing one card to another

Let's look at the __cmp__ method…

Comparing Cards

What we'd like to do:

```
>>> C1 = Card(2,13)   # King of Hearts
>>> C2 = Card(0,5)    # Five of Clubs
>>> C1 > C2
True
```

The __cmp__ method makes this possible

Comparing Cards

What we'd like to do if L is a list of references to Card objects:

```
L.sort()
for c in L:
    print c
```

Sorting requires comparisons between the things that are being sorted

The __cmp__ method makes this possible

How Do We Compare 2 Cards?

First compare their suits:

Spades > Hearts > Diamonds > Clubs

If there is a tie, then compare their ranks:

K > Q > J > 10 > … > 2 > Ace

How It Works

```
def __cmp__(self,other):
    if self.suit > other.suit:
        return 1
    if self.suit < other.suit:
        return -1
    if self.rank > other.rank:
        return 1
    if self.rank < other.rank:
        return -1
    return 0
```

Returning +1 means that the Card `self` is greater than the Card `other`.

How It Works

```
def __cmp__(self,other):
    if self.suit > other.suit:
        return 1
    if self.suit < other.suit:
        return -1
    if self.rank > other.rank:
        return 1
    if self.rank < other.rank:
        return -1
    return 0
```

Returning -1 means that the Card `self` is less than the Card `other`.

How It Works

```
def __cmp__(self,other):
    if self.suit > other.suit:
        return 1
    if self.suit < other.suit:
        return -1
    if self.rank > other.rank:
        return 1
    if self.rank < other.rank:
        return -1
    return 0
```

Returning 0 means that the Card `self` is the same as the Card `other`.

Example

```
for k in range(7):
    YourCard = Card()
    MyCard   = Card()
    if YourCard > MyCard:
        Winner = 'You'
    elif MyCard > YourCard:
        Winner = 'Me'
    else:
        Winner =  'Tie'

    print YourCard, MyCard, Winner
```

Two random cards

Yours is "higher"

Mine is "higher"

If we get here, the two cards are the same.

Sample Output

Your Card	My Card	Winner
Six of Hearts	Six of Spades	Me
Eight of Spades	Queen of Hearts	You
Five of Diamonds	Queen of Clubs	You
Queen of Clubs	Eight of Diamonds	Me
Two of Clubs	Five of Spades	Me
Six of Clubs	Four of Spades	Me
Nine of Clubs	Seven of Spades	Me

This Completes the Discussion of the Class `Card`

```
class Card(object):
    suit_names =
    rank_names =
    def __init__(self,suit,rank):

    def __str__(self):

    def __cmp__(self,other):
```

Next Up : The Class `Deck`

```
class Deck(object):
    def __init__(self,suit,rank):

    def __str__(self):

    def pop_card(self):

    def add_card(self,card):

    def shuffle(self):

    def sort(self):
```

Constructor

Pretty Print

Remove a card from the deck

Add a card to the deck

Shuffle the Deck

Sort the Deck

The Attributes

`DeckOfCards`: list of Card objects
`n`: int

`n` is the number of cards in the deck.

The "top" of the deck is
`self.DeckOfCards[0]`

The "bottom" of the deck is
`self.DeckOfCards[self.n]`

The Constructor

It will build a length-52 list of cards:

```
def __init__(self):
    self.n = 52
    self.DeckOfCards = []
    for suit in range(4):
        for rank  in range(1,14):
            card = Card(suit,rank)
            self.DeckOfCards.append(card)
```

The Constructor

```
def __init__(self):
    self.n = 52
    self.DeckOfCards = []
    for suit in range(4):
        for rank  in range(1,14):
            card = Card(suit,rank)
            self.DeckOfCards.append(card)
```

Nested loops are used to cover all possible suits and ranks.

The Constructor

```
def __init__(self):
    self.n = 52
    self.DeckOfCards = []
        for suit in range(4):
        for rank  in range(1,14):
            card = Card(suit,rank)
            self.DeckOfCards.append(card)
```

The list is built via repeated appending

The Constructor

```
def __init__(self):
    self.n = 52
    self.DeckOfCards = []
    for suit in range(4):
        for rank  in range(1,14):
            card = Card(suit,rank)
            self.DeckOfCards.append(card)
```

Reminder: one constructor can call another constructor.

Create and Print a Deck

```
D = Deck()
print D
```

The __str__ method is invoked and produces 52 lines of output ---------->

```
  Ace of Clubs
  Two of Clubs
Three of Clubs
 Four of Clubs
 Five of Clubs
  Six of Clubs
Seven of Clubs
Eight of Clubs
 Nine of Clubs
  Ten of Clubs
 Jack of Clubs
Queen of Clubs
 King of Clubs
  Ace of Diamonds
  Two of Diamonds

    etc
```

Randomly Shuffle a Card Deck

```
def shuffleDeck(self):
    shuffle(self.DeckOfCards)
```

Makes use of the list method **shuffle**.

The list function `shuffle`

```
>>> a = [1,2,3,4,5,6,7,8,9,10]
>>> shuffle(a)
>>> a
[10, 1, 3, 9, 2, 5, 7, 4, 8, 6]
>>> shuffle(a)
>>> a
[4, 9, 1, 3, 7, 10, 5, 6, 8, 2]
```

This function can be applied to any list. A random permutation.
NOT THE PERFECT SHUFFLE

Create, Shuffle, and Print a Deck

```
D = Deck()
D.shuffle()
print D
```

```
Jack of Spades
Four of Hearts
Seven of Diamonds
Three of Spades
Eight of Diamonds
Seven of Clubs
Ace of Hearts
Six of Spades
Ace of Diamonds
Five of Diamonds
Eight of Clubs
Eight of Hearts
Queen of Diamonds
Six of Diamonds
Six of Hearts

etc
```

Remove a Card

```
def pop_card(self,Where):
    return self.cards.pop()
```

Recall how to pop an entry in a list:

```
>>> x = [10,20,30,40]
>>> x.pop(2)
30
>>> x
[10, 20, 40]
```

Remove a Card

```
def pop_card(self,Where):
    if Where=='Top':
        c = self.DeckOfCards.pop(0)
    elif Where=='Bot':
        c = self.DeckOfCards.pop()
    elif Where==None:
        k = randi(0,self.n-1)
        c = self.DeckOfCards.pop(k)
    self.n -= 1
    return c
```

Three alternatives. The selected card can come off the top or bottom of the deck or it can be selected randomly.

Add a Card to a Deck

```
def add_card(self,card):
    self.DeckOfCards.append(card)
```

`self.DeckOfCcards` is a list of cards

Sort a Deck

```
def sort(self):
    self.DeckOfCards.sort()
```

This is possible because we defined a

`__cmp__`

method in the Card class.

An Example

```
D = Deck()
D.shuffle()
for k in range(5):
    c = D.pop_card('Top')
    print c
    D.add_card(c)
```

Create and shuffle a deck. Then repeatedly select a card off the top of the Deck, display it, and put it back in the deck at the bottom.

This Completes the Discussion of the `Deck` Class

```
class Deck(object):
    def __init__(self,suit,rank):

    def __str__(self):

    def pop_card(self):

    def add_card(self,card):

    def shuffle(self):

    def sort(self):
```

Next Up: The `Hand` Class

```
class Hand(Deck):
    def __init__(self,suit,rank):

    def __str__(self):

    def sort(self):
```

The `Hand` Class

```
class Hand(Deck):
    def __init__(self,suit,rank):

    def __str__(self):

    def sort(self):
```

Usually we would write `Hand(object)`

The Hand Class inherits all the methods from the Deck class.

What Does this Mean?

The `Hand` Class

```
class Hand(Deck):
    def __init__(self,suit,rank):

    def __str__(self):

    def sort(self):
```

Constructor

For pretty printing

For sorting the cards in a hand

Hand Class methods override the methods from the **Deck** class that have the same name. The **Deck** class also has methods called **__str__** and **sort**.

What does "overriding" mean?

Create a Deck. Shuffle It. Extract 10 Cards. Make a Hand. Print it.

```
D = Deck()
D.shuffle()
H = Hand('CVL')
for k in range(10):
    c = D.pop_card()
    H.add_card(c)
print H
```

```
CVL:
      Ace of Hearts
    Three of Clubs
     Four of Spades
     Four of Diamonds
     Five of Hearts
      Six of Hearts
    Seven of Spades
    Eight of Spades
    Queen of Clubs
    Queen of Spades
```

Create a Deck. Shuffle It. Extract 10 Cards. Make a Hand. Print it.

```
D = Deck()
D.shuffle()
H = Hand('CVL')
for k in range(10):
    c = D.pop_card()
    H.add_card(c)
print H
```

The add_card method is inherited from the Deck class

```
CVL:
    Queen of Clubs
    Three of Clubs
    Eight of Spades
      Six of Hearts
    Queen of Spades
      Ace of Hearts
     Five of Hearts
     Four of Spades
    Seven of Spades
     Four of Diamonds
```

Create a Deck. Shuffle It. Extract 10 Cards. Make a Hand. Print it.

```
D = Deck()
D.shuffle()
H = Hand('CVL')
for k in range(10):
    C = D.pop_card()
    H.add_card(C)
print H
```

The print function from the Hand class overrides the print function from the Deck Class

```
CVL:
    Queen of Clubs
    Three of Clubs
    Eight of Spades
      Six of Hearts
    Queen of Spades
      Ace of Hearts
     Five of Hearts
     Four of Spades
    Seven of Spades
     Four of Diamonds
```

Inheritance Chit Chat

The existing class **Deck** is the parent

The new class **Hand** is the child

Hand is a subclass of **Deck**

Inheritance is a very important mechanism when it comes to maintaining and updating software.

Decks and Hands

Things to do with a deck of cards:

1. Shuffle
2. Sort*
3. Add a card
4. Remove a card

Things to do with a hand of cards:

1. Compare
2. Sort*
3. Add a card
4. Remove a card

*Maybe sort in different ways

Another Example of Overriding

As written, when a Deck is sorted, it is sorted by suit first and then by rank.

To be different, when a Hand is sorted, let's sort by rank first and then by suit.

```
Seven of Clubs
  Ten of Diamonds
  Six of Hearts
Eight of Hearts
  Ace of Spades
```

vs

```
  Ace of Spades
  Six of Hearts
Seven of Clubs
Eight of Hearts
  Ten of Diamonds
```

The sort Method in the Hand Class

```
def sort(self):
    self.cards.sort(MyCompare)
```

```
def MyCompare(H1,H2):
    if H1.rank > H2.rank:
        return 1
    if H1.rank < H2.rank:
        return -1
    if H1.suit > H2.suit:
        return 1
    if H1.suit < H2.suit:
        return -1
    return 0
```

Sorts by rank first, then suit.

This sort Method overrides the sort method in Deck, which sorts by suit first, then rank.

Since **D** is a **Deck** object, Python invokes the **sort** method defined in the **Deck** class.

A random 10-card deck D

```
Three of Hearts
 Four of Spades
Seven of Diamonds
 Five of Spades
Queen of Diamonds
 Four of Hearts
  Ten of Diamonds
Queen of Hearts
  Two of Spades
  Ace of Clubs
```

D.sort()

```
  Ace of Clubs
Seven of Diamonds
  Ten of Diamonds
Queen of Diamonds
Three of Hearts
  Four of Hearts
Queen of Hearts
  Two of Spades
  Four of Spades
  Five of Spades
```

Sorts by suit first, then rank.

Since **H** is a **Hand** object, Python invokes the **sort** method defined in the **Hand** class.

A random 10-card **Hand H**

```
Three of Hearts
 Four of Spades
Seven of Diamonds
 Five of Spades
Queen of Diamonds
 Four of Hearts
  Ten of Diamonds
Queen of Hearts
  Two of Spades
  Ace of Clubs
```

H.sort()

```
  Ace of Clubs
  Two of Spades
Three of Hearts
  Four of Hearts
  Four of Spades
  Five of Spades
Seven of Diamonds
  Ten of Diamonds
Queen of Diamonds
Queen of Hearts
```

Sorts by rank first, then suit.

A Couple of Examples

Dealing 4 Bridge Hands

```
D = Deck(); D.shuffle()
L = []
for k in range(4):
   L.append(Hand(str(k))
for k in range(52):
   L[k%4].add_card(D.pop_card())
for k in range(4):
   print L[k].sort()
```

Set up and shuffle the deck

Dealing 4 Bridge Hands

```
D = Deck(); D.shuffle()
L = []
for k in range(4):
   L.append(Hand(str(k))
for k in range(52):
   L[k%4].add_card(D.pop_card())
for k in range(4):
   print L[k].sort()
```

Set Up a length-4 list of Hands

Dealing 4 Bridge Hands

```
D = Deck(); D.shuffle()
L = []
for k in range(4):
   L.append(Hand(str(k))
for k in range(52):
   L[k%4].add_card( D.pop_card() )
for k in range(4):
   print L[k].sort()
```

Get a card from the Deck

Dealing 4 Bridge Hands

```
D = Deck(); D.shuffle()
L = []
for k in range(4):
   L.append(Hand(str(k))
for k in range(52):
   L[k%4].add_card(D.pop_card())
for k in range(4):
   print L[k].sort()
```

Add to every 4th hand

Dealing 4 Bridge Hands

```
D = Deck(); D.shuffle()
L = []
for k in range(4):
   L.append(Hand(str(k))
for k in range(52):
   L[k%4].add_card(D.pop_card())
for k in range(4):
   print L[k].sort()
```

Sort and print each Hand

Next Example from Poker

Probability of a Full House

Core Problem: When does a 5-card hand consist of two of one rank and three of another?

```
Seven of Spades
Seven of Diamonds
  Ten of Clubs
  Ten of Spades
  Ten of Diamonds
```

```
Four of Spades
Four of Diamonds
Jack of Hearts
Jack of Clubs
Jack of Spades
```

Is a Hand H a Full House?

```
H.sort()
r = []
for c in H.cards:
     r.append(c.rank)
B1 = (r[0]==r[1]==r[2]) and (r[3]==r[4])
B2 = (r[0]==r[1]) and (r[2]==r[3]==r[4])
If B1 or B2:
    print 'Full House'
```

Is a Hand H a Full House?

```
H.sort()
r = []
for c in H.cards:
     r.append(c.rank)
B1 = (r[0]==r[1]==r[2]) and (r[3]==r[4])
B2 = (r[0]==r[1]) and (r[2]==r[3]==r[4])
if B1 or B2:
    print 'Full House'
```

Sort the Hand by rank

Three Hands

Yes:

```
Seven of Spades
Seven of Diamonds
Seven of Clubs
  Ten of Spades
  Ten of Diamonds
```

Yes:

```
Four of Spades
Four of Diamonds
Jack of Hearts
Jack of Clubs
Jack of Spades
```

No:

```
Four of Spades
Four of Diamonds
Five of Hearts
Jack of Clubs
Jack of Spades
```

Is a Hand H a Full House?

```
H.sort()
r = []
for c in H.cards:
     r.append(c.rank)
B1 = (r[0]==r[1]==r[2]) and (r[3]==r[4])
B2 = (r[0]==r[1]) and (r[2]==r[3]==r[4])
If B1 or B2:
    print 'Full House'
```

Form a list of the ranks

Is a Hand H a Full House?

```
H.sort()
r = []
for c in H.cards:
     r.append(c.rank)
B1 = (r[0]==r[1]==r[2]) and (r[3]==r[4])
B2 = (r[0]==r[1]) and (r[2]==r[3]==r[4])
if B1 or B2:
    print 'Full House'
```

Boolean Business