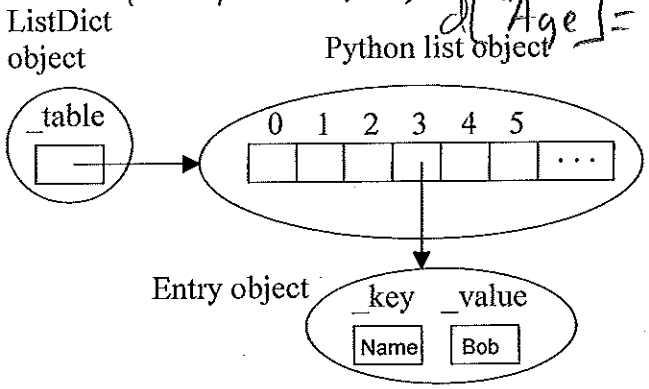
Data Structures Lecture 15 Name:____________________

1. The Map/Dictionary abstract data type (ADT) stores key-value pairs. The key is used to look up the data value.

Method call	Class Name	Description
`d = ListDict()`	`__init__(self)`	Constructs an empty dictionary
`d["Name"] = "Bob"`	`__setitem__(self,key,value)`	Inserts a key-value entry if `key` does not exist or replaces the old value with `value` if `key` exists.
`temp = d["Name"]`	`__getitem__(self,key)`	Given a `key` return it value or `None` if `key` is not in the dictionary
`del d["Name"]`	`__delitem__(self,key)`	Removes the entry associated with `key`
`if "Name" in d:` process	`__contains__(self,key)`	Return `True` if `key` is in the dictionary; return `False` otherwise
`for k in d:`	`__iter__(self)`	Iterates over the keys in the dictionary
`len(d)`	`__len__(self)`	Returns the number of items in the dictionary
`str(d)`	`__str__(self)`	Returns a string representation of the dictionary

{k:v, k2:v2, ...}

d["Age"] = 10



```
class Entry(object):
    """A key/value pair."""

    def __init__(self, key, value):
        self._key = key
        self._value = value

    def getKey(self):
        return self._key

    def getValue(self):
        return self._value

    def setValue(self, newValue):
        self._value = newValue

    def __eq__(self, other):
        if not isinstance(other, Entry):
            return False
        return self._key == other._key

    def __str__(self):
        return str(self._key) + ":" + str(self._value)
```

```
from entry import Entry

class ListDict(object):
    """Dictionary implemented with a Python list."""

    def __init__(self):
        self._table = []

    def __getitem__(self, key):
        """Returns the value associated with key or
        returns None if key does not exist."""
        entry = Entry(key, None)
        try:    # NOTE: Python list index method
                # errors on unsuccessful search
            index = self._table.index(entry)
            return self._table[index].getValue()
                                      O(n)
        except:
            return None

    def __delitem__(self, key):
        """Removes the entry associated with key."""
        entry = Entry(key, None)
        try:    # NOTE: Python list index method
                # errors on unsuccessful search
            index = self._table.index(entry)
            self._table.pop(index)
        except:
            return

    def __str__(self):
        """Returns string repr. of the dictionary"""
        resultStr = "{"
        for item in self._table:
            resultStr = resultStr + " " + str(item)
        return resultStr + " }"

    def __iter__(self):
        """Iterates over keys of the dictionary"""
        for item in self._table:
            yield item.getKey()
        ~~raise StopIteration~~
```

a) Complete the code for the `__contains__` method.

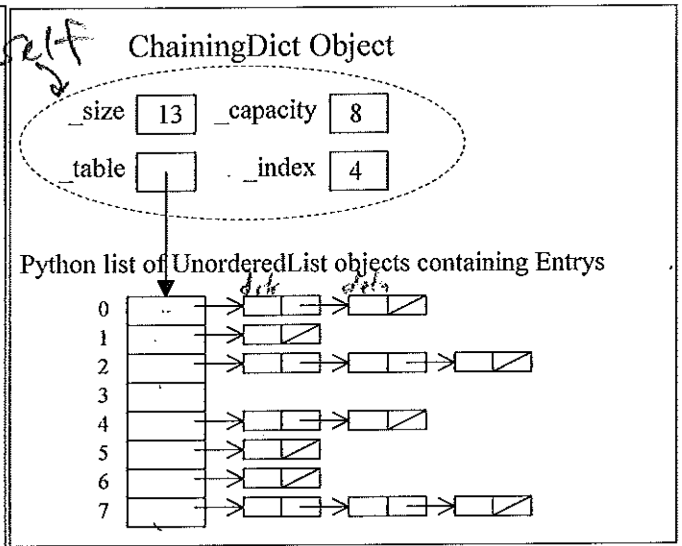
```
def __contains__(self, key):
    entry = Entry(key, None)
    try:
        index = self._table.index(entry)
        return True
    except:
        return False
```

b) Complete the code for the `__setitem__` method.

```
def __setitem__(self, key, value):
    entry = Entry(key, value)
    for entryItem in self._table:
        if entry == entryItem:
            entryItem.setValue(value)
            return
    self._table.append(entry)
```

2. Dictionary implementation using hashing with chaining -- an UnorderedList object at each slot in the hash table.

```
from entry import Entry
from unordered_linked_list import UnorderedList

class ChainingDict(object):
    """Dictionary implemented using hashing with chaining."""

    def __init__(self, capacity = 8):
        self._capacity = capacity
        self._table = []
        for index in range(self._capacity):
            self._table.append(UnorderedList())
        self._size = 0
        self._index = None

    def __contains__(self, key):
        """Returns True if key is in the dictionary or
        False otherwise."""
        self._index = abs(hash(key)) % self._capacity
        entry = Entry(key, None)

        return self._table[self._index].search(entry)

    def __getitem__(self, key):
        """Returns the value associated with key or
        returns None if key does not exist."""
        if key in self:
            entry = Entry(key, None)
            entry = self._table[self._index].remove(entry)
            self._table[self._index].add(entry)
            return entry.getValue()
        else:
            return None

    def __delitem__(self, key):
        """Removes the entry associated with key."""
        if key in self:
            entry = Entry(key, None)
            entry = self._table[self._index].remove(entry)
            self._size -= 1

    def __setitem__(self, key, value):
        """Inserts an entry with key/value if key
        does not exist or replaces the existing value
        with value if key exists."""
        entry = Entry(key, value)
        if key in self:
            entry = self._table[self._index].remove(entry)
            entry.setValue(value)
        else:
            self._size += 1
        self._table[self._index].add(entry)

    def __len__(self):
        return self._size

    def __str__(self):
        result = "HashDict: capacity = " +  \
                 str(self._capacity) + ", load factor = " + \
                 str(len(self) / self._capacity)
        for i in range(self._capacity):
            result += "\nRow " + str(i)+": "+str(self._table[i])
        return result

    def __iter__(self):
        """Iterates over the keys of the dictionary"""
        for myList in self._table:
            for entry in myList:
                yield entry.getKey()
```



a) In `__getitem__`, why is the `entry = Entry(key, None)` object created?

So we can compare it to the Entry objects in the Unordered list.

b) In `__getitem__`, where does `self._index` receive its value?

The "if key in self:" calls the `__contains__` method to set self._index

c) What single modification was needed to the `UnorderedList`'s `remove` method?

I had remove return and remove the item.

d) Complete the `__iter__` method.

1. The Dictionary implementation using open-address hashing was the `OpenAddrHashDict` class in `lab7.zip`.

```
from entry import Entry

class OpenAddrHashDict(object):
    EMPTY = None  # class variables shared by all objects of the class
    DELETED = True

    def __init__(self, capacity = 8, hashFunction = hash,
                 linear = True):
        self._table = [OpenAddrHashDict.EMPTY] * capacity
        self._size = 0
        self._hash = hashFunction
        self._homeIndex = -1
        self._actualIndex = -1
        self._linear = linear
        self._probeCount = 0

    def __getitem__(self, key):
        """Returns the value associated with key or
        returns None if key does not exist."""
        if key in self:
            return self._table[self._actualIndex].getValue()
        else:
            return None

    def __delitem__(self, key):
        """Removes the entry associated with key."""
        if key in self:
            self._table[self._actualIndex] = OpenAddrHashDict.DELETED
            self._size -= 1

    def __setitem__(self, key, value):
        """Inserts an entry with key/value if key does not exist or
           replaces the existing value with value if key exists."""
        entry = Entry(key, value)
        if key in self:
            self._table[self._actualIndex] = entry
        else:
            self._table[self._actualIndex] = entry
            self._size += 1

    def __contains__(self, key):
        """Return True if key is in the dictionary; return False otherwise"""
        entry = Entry(key, None)
        self._probeCount = 0
        # Get the home index
        self._homeIndex = abs(self._hash(key)) % len(self._table)
        rehashAttempt = 0
        index = self._homeIndex

        # Stop searching when an empty cell is encountered
        while rehashAttempt < len(self._table):
            self._probeCount += 1
            if self._table[index] == OpenAddrHashDict.EMPTY:
                self._actualIndex = index
                return False # An empty cell is found, so key not found
            elif self._table[index] == entry:
                self._actualIndex = index
                return True

            # Calculate the index and wrap around to first position if necessary
            rehashAttempt += 1
            if self._linear:
                index = (self._homeIndex + rehashAttempt) % len(self._table)
            else:  # Quadratic probing
                index = (self._homeIndex + (rehashAttempt ** 2+ rehashAttempt) // 2) % len(self._table)

       return False   # tried all the slots in the hash table and did not find key

    def __len__(self):
        return self._size

    def __str__(self):
        resultStr = "{"
        for item in self._table:
            if not item in (OpenAddrHashDict.EMPTY,OpenAddrHashDict.DELETED):
                resultStr = resultStr + " " + str(item)
        return resultStr + " }"

    def __iter__(self):
        """Iterates over the keys of the dictionary"""
```

a) Complete the `__iter__` method.