CHAPTER 6

Python Lists and Dictionaries

6.0. Introduction

In Chapter 5, we looked at the basics of the Python language. In this chapter, we look at two key Python data structures, lists and dictionaries.

6.1. Creating a List

Problem

You want to use a variable to hold a series of values rather than just one value.

Solution

Use a list. In Python, a list is a collection of values stored in order so that you can access them by position.

You create a list using [and] to contain its initial contents:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>>
```

Unlike more rigid arrays in languages like C, you don't need to specify the size of a list in Python when you declare it. You can also change the number of elements in the list any time you like.

Discussion

As this example illustrates, the items in a list do not have to be all of the same type, although they often are.

If you want to create an empty list that you can add items to later, you can write:

```
>>> a = []
>>>
```

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.2. Accessing Elements of a List

Problem

You want to find individual elements of a list or change them.

Solution

Use the [] notation to access elements of a list by their position in the list. For example:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> a[1]
'Fred'
```

Discussion

The list positions (indices) start at 0 for the first element.

As well as using the [] notation to read values out of a list, you can also use it to change values at a certain position. For example:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> a[1] = 777
>>> a
[34, 777, 12, False, 72.3]
```

If you try to change (or, for that matter, read) an element of a list using an index that is too large, you will get an “Index out of range” error:

```
>>> a[50] = 777
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: list assignment index out of range
>>>
```

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.3. Find the Length of a List

Problem

You need to know how many elements there are in a list.

Solution

Use the `len` Python function. For example:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> len(a)
5
```

Discussion

The `len` command also works on strings (Recipe 5.13).

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.4. Adding Elements to a List

Problem

You need to add an item to a list.

Solution

Use the `append`, `insert`, or `extend` Python functions.

To add a single item to the end of a list, use `append`:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> a.append("new")
>>> a
[34, 'Fred', 12, False, 72.3, 'new']
```

Discussion

Sometimes you don't want to add the new elements to the end of a list, but rather you want to insert them at a certain position in the list. For this, use the `insert` command. The first argument is the index where the item should be inserted, and the second argument is the item to be inserted:

```
>>> a.insert(2, "new2")
>>> a
[34, 'Fred', 'new2', 12, False, 72.3]
```

Note how all the elements after the newly inserted element are shuffled up one position.

Both `append` and `insert` add only one element to a list. The `extend` function adds all the elements of one list to the end of another:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> b = [74, 75]
>>> a.extend(b)
>>> a
[34, 'Fred', 12, False, 72.3, 74, 75]
```

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.5. Removing Elements from a List

Problem

You need to remove an item from a list.

Solution

Use the `pop` Python function.

The command `pop` with no parameters removes the last element of a list:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> a.pop()
72.3
>>> a
[34, 'Fred', 12, False]
```

Discussion

Notice that `pop` returns the value removed from the list.

To remove an item in a position rather than the last element, use `pop` with a parameter of the position from which the item will be removed:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> a.pop(0)
34
```

If you use an index position that is beyond the end of the list, you will get an "Index out of range" exception.

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.6. Creating a List by Parsing a String

Problem

You need to convert a string of words separated by some character into an array of strings with each string in the array being one of the words.

Solution

Use the `split` Python string function.

The command `split` with no parameters separates the words out of a string into individual elements of an array:

```
>>> "abc def ghi".split()
['abc', 'def', 'ghi']
```

If you supply `split` with a parameter, then it will split the string using the parameter as a separator. For example:

```
>>> "abc--de--ghi".split('--')
['abc', 'de', 'ghi']
```

Discussion

This command can be very useful when you are, say, importing data from a file. The `split` command can optionally take an argument that is the string to use as a delimiter when you are splitting the string. So, if you were to use commas as a separator, you could split the string as follows:

```
>>> "abc,def,ghi".split(',')
['abc', 'def', 'ghi']
```

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.7. Iterating over a List

Problem

You need to apply some lines of code to each item in a list in turn.

Solution

Use the `for` Python language command:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> for x in a:
...     print(x)
...
34
Fred
12
False
72.3
>>>
```

Discussion

The `for` keyword is immediately followed by a variable name (in this case, *x*). This is called the loop variable and will be set to each of the elements of the list specified after *in*.

The indented lines that follow will be executed one time for each element in the list. Each time around the loop, *x* will be given the value of the element in the list at that position. You can then use *x* to print out the value, as shown in the previous example.

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.8. Enumerating a List

Problem

You need to run some lines of code to each item in a list in turn, but you also need to know the index position of each item.

Solution

Use the `for` Python language command along with the `enumerate` command.

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> for (i, x) in enumerate(a):
...     print(i, x)
...
(0, 34)
(1, 'Fred')
(2, 12)
(3, False)
```

```
(4, 72.3)
>>>
```

Discussion

It's quite common to need to know the position of something in the list while enumerating each of the values. An alternative method is to simply count with an index variable and then access the value using the [] syntax:

```
>>> a = [34, 'Fred', 12, False, 72.3]
>>> for i in range(len(a)):
...     print(i, a[i])
...
(0, 34)
(1, 'Fred')
(2, 12)
(3, False)
(4, 72.3)
>>>
```

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

See Recipe 6.7 to iterate over a list without needing to know each item's index position.

6.9. Sorting a List

Problem

You need to sort the elements of a list.

Solution

Use the `sort` Python language command:

```
>>> a = ["it", "was", "the", "best", "of", "times"]
>>> a.sort()
>>> a
['best', 'it', 'of', 'the', 'times', 'was']
```

Discussion

When you sort a list, you'll actually be modifying it rather than returning a sorted copy of the original list. This means that if you also need the original list, you need to use the `copy` command in the standard library to make a copy of the original list before sorting it:

```
>>> import copy
>>> a = ["it", "was", "the", "best", "of", "times"]
>>> b = copy.copy(a)
>>> b.sort()
>>> a
['it', 'was', 'the', 'best', 'of', 'times']
>>> b
['best', 'it', 'of', 'the', 'times', 'was']
>>>
```

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.10. Cutting Up a List

Problem

You need to make a sublist of a list using a range of the original list's elements.

Solution

Use the `[:]` Python language construction. The following example returns a list containing the elements of the original list from index position 1 to index position 2 (the number after the `:` is exclusive):

```
>>> l = ["a", "b", "c", "d"]
>>> l[1:3]
['b', 'c']
```

Note that the character positions start at 0, so a position of 1 means the second character in the string and 5 means the sixth, but the character range is exclusive at the high end, so the letter *d* is not included in this example.

Discussion

The [:] notation is actually quite powerful. You can omit either argument, in which case the start or end of the list is assumed as appropriate. For example:

```
>>> l = ["a", "b", "c", "d"]
>>> l[:3]
['a', 'b', 'c']
>>> l[3:]
['d']
>>>
```

You can also use negative indices to count back from the end of the list. The following example returns the last two elements in the list:

```
>>> l[-2:]
['c', 'd']
```

Incidentally, `l[:-2]` returns `['a', 'b']` in the preceding example.

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

See Recipe 5.15 where the same syntax is used for strings.

6.11. Applying a Function to a List

Problem

You need to apply a function to each element of a list and collect the results.

Solution

Use the Python language feature called *comprehensions*.

The following example will convert each string element of the list to uppercase and return a new list the same length as the old one, but with all the strings in uppercase:

```
>>> l = ["abc", "def", "ghi", "ijk"]
>>> [x.upper() for x in l]
['ABC', 'DEF', 'GHI', 'IJK']
```

Although it can get confusing, there is no reason why you can't combine these kinds of statements, nesting one comprehension inside another.

Discussion

This is a very concise way of doing comprehensions. The whole expression has to be enclosed in brackets ([]). The first element of the comprehension is the code to be evaluated for each element of the list. The rest of the comprehension looks rather like a normal list iteration command (Recipe 6.7). The loop variable follows the `for` keyword and then after the `in` keyword is the list to be used.

See Also

All the recipes between Recipes 6.1 and 6.11 involve the use of lists.

6.12. Creating a Dictionary

Problem

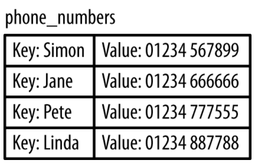
You need to create a lookup table where you associate values with keys.

Solution

Use a Python dictionary.

Arrays are great when you need to access a list of items in order, or you always know the index of the element that you want to use. Dictionaries are an alternative to lists for storing collections of data, but they are organized very differently.

Figure 6-1 shows how a dictionary is organized.



phone_numbers

Key: Simon	Value: 01234 567899
Key: Jane	Value: 01234 666666
Key: Pete	Value: 01234 777555
Key: Linda	Value: 01234 887788

Figure 6-1. A Python dictionary

A dictionary stores key/value pairs in such a way that you can use the key to retrieve that value very efficiently and without having to search the whole dictionary.

To create a dictionary, you use the {} notation:

```
>>> phone_numbers = {'Simon':'01234 567899', 'Jane':'01234 666666'}
```

Discussion

In this example, the keys of the dictionary are strings, but they do not have to be; they could be numbers or in fact any data type, although strings are most commonly used.

The values can also be of any data type, including other dictionaries or lists. The following example creates one dictionary (a) and then uses it as a value in a second dictionary (b):

```
>>> a = {'key1':'value1', 'key2':2}
>>> a
{'key2': 2, 'key1': 'value1'}
>>> b = {'b_key1':a}
>>> b
{'b_key1': {'key2': 2, 'key1': 'value1'}}
```

When you display the contents of a dictionary, you will notice that the order of the items in the dictionary may not match the order in which they were specified when the dictionary was created and initialized with some contents:

```
>>> phone_numbers = {'Simon':'01234 567899', 'Jane':'01234 666666'}
>>> phone_numbers
{'Jane': '01234 666666', 'Simon': '01234 567899'}
```

Unlike lists, dictionaries have no concept of keeping items in order. Because of the way they are represented internally, the order of a dictionary's contents will be—for all intents and purposes—random.

The reason the order appears to be random is that the underlying data structure that is a *hash table*. Hash tables use a *hashing function* to decide where to store the value; the hashing function calculates a numeric equivalent to any object.

You can find out more about hash tables at Wikipedia.

See Also

All the recipes between Recipes 6.12 and 6.15 involve the use of dictionaries.

6.13. Accessing a Dictionary

Problem

You need to find and change entries in a dictionary.

Solution

Use the Python [] notation. Use the key of the entry to which you need access inside the brackets:

```
>>> phone_numbers = {'Simon':'01234 567899', 'Jane':'01234 666666'}
>>> phone_numbers['Simon']
'01234 567899'
>>> phone_numbers['Jane']
'01234 666666'
```

Discussion

If you use a key that is not present in the dictionary, you will get a *key error*. For example:

```
{'b_key1': {'key2': 2, 'key1': 'value1'}}
>>> phone_numbers = {'Simon':'01234 567899', 'Jane':'01234 666666'}
>>> phone_numbers['Phil']
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
```

```
KeyError: 'Phil'
>>>
```

As well as using the [] notation to read values from a dictionary, you can also use it to add new values or overwrite existing ones.

The following example adds a new entry to the dictionary with a key of `Pete` and a value of `01234 777555`:

```
>>> phone_numbers['Pete'] = '01234 777555'
>>> phone_numbers['Pete']
'01234 777555'
```

If the key is not in use in the dictionary, a new entry is automatically added. If the key is already present, then whatever value was there before will be overwritten by the new value.

This is in contrast to trying to read a value from the dictionary, where an unknown key will cause an error.

See Also

All the recipes between Recipes 6.12 and 6.15 involve the use of dictionaries.

For information on handling errors, see Recipe 7.10.

6.14. Removing Things from a Dictionary

Problem

You need to remove an item from a dictionary.

Solution

Use the `pop` command, specifying the key for the item that you want to remove:

```
>>> phone_numbers = {'Simon':'01234 567899', 'Jane':'01234 666666'}
>>> phone_numbers.pop('Jane')
'01234 666666'
>>> phone_numbers
{'Simon': '01234 567899'}
```

Discussion

The `pop` command returns the value of the item removed from the dictionary.

See Also

All the recipes between Recipes 6.12 and 6.15 involve the use of dictionaries.

6.15. Iterating over Dictionaries

Problem

You need to do something to each of the items in the dictionary in turn.

Solution

Use the `for` command to iterate over the keys of the dictionary:

```
>>> phone_numbers = {'Simon':'01234 567899', 'Jane':'01234 666666'}
>>> for name in phone_numbers:
...     print(name)
...
Jane
Simon
```

Discussion

There are a couple of other techniques that you can use to iterate over a dictionary. The following form can be useful if you need access to the values as well as the keys:

```
>>> phone_numbers = {'Simon':'01234 567899', 'Jane':'01234 666666'}
>>> for name, num in phone_numbers.items():
...     print(name + " " + num)
...
Jane 01234 666666
Simon 01234 567899
```

See Also

All the recipes between Recipes 6.12 and 6.15 involve the use of dictionaries.

See the `for` command used elsewhere in Recipes 5.3, 5.21, 6.7, and 6.11.