

Chapter 32

Sets



32.1 Introduction

In the last chapter we looked at Tuples and Lists; in this chapter we will look at a further container (or collection) types; the Set type. A Set is an unordered (un indexed) collection of *immutable* objects that does not allow duplicates.

32.2 Creating a Set

A Set is defined using curly brackets (e.g. '{}').

For example,

```
basket = {'apple', 'orange', 'apple', 'pear',  
          'orange', 'banana'}  
print(basket)
```

When run this code will show that *apple* is only added once to the set:

```
{'banana', 'orange', 'pear', 'apple'}
```

Note that because a Set is unordered it is not possible to refer to elements of the set using an index.

32.3 The Set() Constructor Function

As with tuples and lists Python provides a predefined function that can convert any iterable type into a Set. The function signature is:

```
set(iterable)
```

Given an iterable object, this function returns a new Set based on the values obtained from the iterable. This means that a Set can be easily created from a List, Tuple or Dictionary as well as any other data type that implements the iterable protocol. For example, the following code snippet converts a Tuple into a Set:

```
set1 = set((1, 2, 3))
print(set1)
```

which prints out

```
{1, 2, 3}
```

32.4 Accessing Elements in a Set

Unlike Lists it is not possible to access elements from a Set via an index; this is because they are unordered containers and thus there are no indexes available. However, they are Iterable containers.

Elements of a Set can be iterated over using the `for` statement:

```
for item in basket:
    print(item)
```

This applies the `print` function to each item in the list in turn.

32.5 Working with Sets

32.5.1 Checking for Presence of an Element

You can check for the presence of an element in a set using the `in` keyword, for example:

```
print('apple' in basket)
```

This will print True if ‘apple’ is a member of the set basket.

32.5.2 *Adding Items to a Set*

It is possible to add items to a set using the `add()` method:

```
basket = {'apple', 'orange', 'banana'}  
basket.add('apricot')  
print(basket)
```

This generates:

```
{'orange', 'apple', 'banana', 'apricot', 'pear'}
```

If you want to add more than one item to a Set you can use the `update()` method:

```
basket = {'apple', 'orange', 'banana'}  
basket.update(['apricot', 'mango', 'grapefruit'])  
print(basket)
```

Generating

```
{'orange', 'apple', 'mango', 'banana', 'apricot', 'grapefruit'}
```

The argument to `update` can be a set, a list, a tuple or a dictionary. The method automatically converts the parameter into a set if it is not a set already and then adds the value to the original set.

32.5.3 *Changing Items in a Set*

It is not possible to change the items already in a Set.

32.5.4 *Obtaining the Length of a Set*

As with other collection/container classes; you can find out the length of a Set using the `len()` function.

```
basket = {'apple', 'orange', 'apple', 'pear', 'orange',
          'banana'}
print(len(basket)) # generates 4
```

32.5.5 *Obtaining the Max and Min Values in a Set*

You can also obtain the maximum or minimum values in a set using the `max()` and `min()` functions:

```
print(max(a_set))
print(min(a_set))
```

32.5.6 *Removing an Item*

To remove an item from a set, use the `remove()` or `discard()` functions. The `remove()` function removes a single item from a Set but generates an error if that item was not initialising the set. The `remove()` function also removes a single item from a set but does not throw an error if it was not initially present in the set.

```
basket = {'apple', 'orange', 'apple', 'pear', 'orange',
          'banana'}
print(basket)
basket.remove('apple')
basket.discard('apricot')
print(basket)
```

This generates:

```
{'pear', 'banana', 'orange', 'apple'}
{'pear', 'banana', 'orange'}
```

There is also a method `pop()` that can be used to remove an item (and return that item as a result of running the method); however it removes the last item in the Set (although as a set is unordered you will not know which item that will be).

The method `clear()` is used to remove all elements from a Set:

```
basket = {'apple', 'orange', 'banana'}  
basket.clear()  
print(basket)
```

which prints out

```
set()
```

Which is used to represent an empty set.

32.5.7 Nesting Sets

It is possible to hold any *immutable* object within a set. This means that a set can contain a reference to a `Tuple` (as that is immutable). We can thus write:

```
s1 = { (1, 2, 3) }  
print(s1)
```

This prints out:

```
{ (1, 2, 3) }
```

However, we cannot nest Lists or other Sets within a Set as these are not immutable types. The following would both generate a runtime error in Python:

```
# Can't have the following  
s2 = { {1, 2, 3} }  
print(s2)  
  
s3 = { [1, 2, 3] }  
print(s3)
```

However we can use `Frozensets` and nest these within sets. A `Frozenset` is exactly like a `Set` except that it is immutable (it cannot be modified) and thus it can be nested within a `Set`. For example:

```
# Need to convert sets and lists into frozensets
s2 = { frozenset{1, 2, 3}}
print(s2)

s3 = { frozenset([1, 2, 3]) }
print(s3)
```

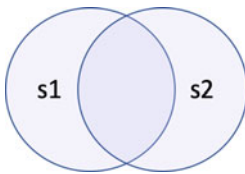
This generates:

```
{frozenset({1, 2, 3})}
{frozenset({1, 2, 3})}
```

32.6 Set Operations

The Set container also supports *set like* operations such as (`|`), intersection (`&`), difference (`-`) and symmetric difference (`^`). These are based on simple Set theory.

Given the two sets:



```
print('Union:', s1 | s2)
```

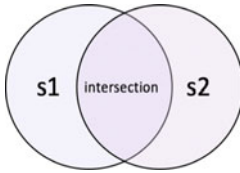
For example, the Union of two sets represents the combination of all the values in the two sets:

```
s1 = {'apple', 'orange', 'banana'}
s2 = {'grapefruit', 'lime', 'banana'}
```

This would print out:

```
Union: {'apple', 'lime', 'banana', 'grapefruit', 'orange'}
```

The intersection of two sets represents the common values between two sets:



```
print('Intersection:', s1 & s2)
```

This generates

```
Intersection: {'banana'}
```

The difference between two sets is the set of values in the first set that are not in the second set:

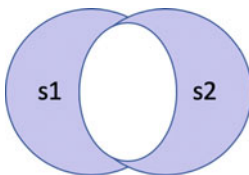


```
print('Difference:', s1 - s2)
```

which produces the output

```
Difference: {'apple', 'orange'}
```

The symmetric difference represents all the unique values in the two sets (that is it is the inverse of the intersection):



```
print('Symmetric Difference:', s1 ^ s2)
```

The output from this final operation is

```
Symmetric Difference: {'orange', 'apple', 'lime', 'grapefruit'}
```

In addition to the operators there are also method versions:

- `s1.union(s2)` is the equivalent of $s1 \mid s2$
- `s1.intersection(s2)` is the equivalent of $s1 \& s2$
- `s1.difference(s2)` is the equivalent of $s1 - s2$
- `s1.symmetric_difference(s2)` is the equivalent of $s1 \wedge s2$

32.7 Set Methods

Python has a set of built-in methods that you can use on sets.

Method	Description
<code>add()</code>	Adds an element to the set
<code>clear()</code>	Removes all the elements from the set
<code>copy()</code>	Returns a copy of the set
<code>difference()</code>	Returns a set containing the difference between two or more sets
<code>difference_update()</code>	Removes the items in this set that are also included in another, specified set
<code>discard()</code>	Remove the specified item
<code>intersection()</code>	Returns a set, that is the intersection of two other sets
<code>intersection_update()</code>	Removes the items in this set that are not present in other, specified set(s)
<code>isdisjoint()</code>	Returns whether two sets have a intersection or not
<code>issubset()</code>	Returns whether another set contains this set or not
<code>issuperset()</code>	Returns whether this set contains another set or not
<code>pop()</code>	Removes an element from the set
<code>remove()</code>	Removes the specified element
<code>symmetric_difference()</code>	Returns a set with the symmetric differences of two sets
<code>symmetric_difference_update()</code>	inserts the symmetric differences from this set and another
<code>union()</code>	Return a set containing the union of sets
<code>update()</code>	Update the set with the union of this set and others

32.8 Online Resources

Online resources on sets are listed below:

- <https://docs.python.org/3/tutorial/datastructures.html> Python Tutorial on data structures.
- <https://docs.python.org/3/tutorial/datastructures.html#sets> the online Set tutorial.

- https://www.python-course.eu/python3_sets_frozensets.php A tutorial on sets and frozen sets.
- <https://docs.python.org/3/library/stdtypes.html#set-types-set-frozenset> for sets

32.9 Exercises

The aim of this exercise is to use a Set.

Create two sets of students, one for those who took an exam and one for those that submitted a project. You can use simple strings to represent the students, for example:

```
# Set up sets
exam = {'Andrew', 'Kirsty', 'Beth', 'Emily', 'Sue'}
project = {'Kirsty', 'Emily', 'Ian', 'Stuart'}

# Output the basic sets
print('exam:', exam)
print('project:', project)
```

Using these sets answer the following questions:

- Which students took both the exam and submitted a project?
- Which students only took the exam?
- Which students only submitted the project?
- List all students who took either (or both) of the exam and the project.
- List all students who took either (but *not* both) of the exam and the project.