Chapter 16: Loops

Parameter	Details
boolean expression	expression that can be evaluated in a boolean context, e.g. `x < 10`
variable	variable name for the current element from the `iterable`
iterable	anything that implements iterations

As one of the most basic functions in programming, loops are an important piece to nearly every programming language. Loops enable developers to set certain portions of their code to repeat through a number of loops which are referred to as iterations. This topic covers using multiple types of loops and applications of loops in Python.

Section 16.1: Break and Continue in Loops

`break` statement

When a `break` statement executes inside a loop, control flow "breaks" out of the loop immediately:

```
i = 0
while i < 7:
    print(i)
    if i == 4:
        print("Breaking from loop")
        break
    i += 1
```

The loop conditional will not be evaluated after the `break` statement is executed. Note that `break` statements are only allowed *inside loops*, syntactically. A `break` statement inside a function cannot be used to terminate loops that called that function.

Executing the following prints every digit until number `4` when the `break` statement is met and the loop stops:

```
0
1
2
3
4
Breaking from loop
```

`break` statements can also be used inside `for` loops, the other looping construct provided by Python:

```
for i in (0, 1, 2, 3, 4):
    print(i)
    if i == 2:
        break
```

Executing this loop now prints:

```
0
1
2
```

Note that 3 and 4 are not printed since the loop has ended.

If a loop has an `else` clause, it does not execute when the loop is terminated through a `break` statement.

`continue` statement

A `continue` statement will skip to the next iteration of the loop bypassing the rest of the current block but continuing the loop. As with `break`, `continue` can only appear inside loops:

```
for i in (0, 1, 2, 3, 4, 5):
    if i == 2 or i == 4:
        continue
    print(i)

0
1
3
5
```

Note that `2` and `4` aren't printed, this is because `continue` goes to the next iteration instead of continuing on to `print(i)` when `i == 2` or `i == 4`.

Nested Loops

`break` and `continue` only operate on a single level of loop. The following example will only break out of the inner `for` loop, not the outer `while` loop:

```
while True:
    for i in range(1,5):
        if i == 2:
            break    # Will only break out of the inner loop!
```

Python doesn't have the ability to break out of multiple levels of loop at once -- if this behavior is desired, refactoring one or more loops into a function and replacing `break` with `return` may be the way to go.

Use `return` from within a function as a `break`

The `return` statement exits from a function, without executing the code that comes after it.

If you have a loop inside a function, using `return` from inside that loop is equivalent to having a `break` as the rest of the code of the loop is not executed (*note that any code after the loop is not executed either*):

```
def break_loop():
    for i in range(1, 5):
        if (i == 2):
            return(i)
        print(i)
    return(5)
```

If you have nested loops, the `return` statement will break all loops:

```
def break_all():
    for j in range(1, 5):
        for i in range(1,4):
            if i*j == 6:
                return(i)
            print(i*j)
```

will output:

```
1 # 1*1
2 # 1*2
3 # 1*3
4 # 1*4
2 # 2*1
4 # 2*2
# return because 2*3 = 6, the remaining iterations of both loops are not executed
```

Section 16.2: For loops

`for` loops iterate over a collection of items, such as `list` or `dict`, and run a block of code with each element from the collection.

```
for i in [0, 1, 2, 3, 4]:
    print(i)
```

The above `for` loop iterates over a list of numbers.

Each iteration sets the value of `i` to the next element of the list. So first it will be `0`, then `1`, then `2`, etc. The output will be as follow:

```
0
1
2
3
4
```

`range` is a function that returns a series of numbers under an iterable form, thus it can be used in `for` loops:

```
for i in range(5):
    print(i)
```

gives the exact same result as the first `for` loop. Note that `5` is not printed as the range here is the first five numbers counting from `0`.

Iterable objects and iterators

`for` loop can iterate on any iterable object which is an object which defines a `__getitem__` or a `__iter__` function. The `__iter__` function returns an iterator, which is an object with a `next` function that is used to access the next element of the iterable.

Section 16.3: Iterating over lists

To iterate through a list you can use `for`:

```
for x in ['one', 'two', 'three', 'four']:
    print(x)
```

This will print out the elements of the list:

```
one
two
three
four
```

The `range` function generates numbers which are also often used in a for loop.

```
for x in range(1, 6):
    print(x)
```

The result will be a special range sequence type in python >=3 and a list in python <=2. Both can be looped through using the for loop.

```
1
2
3
4
5
```

If you want to loop though both the elements of a list *and* have an index for the elements as well, you can use Python's `enumerate` function:

```
for index, item in enumerate(['one', 'two', 'three', 'four']):
    print(index, '::', item)
```

`enumerate` will generate tuples, which are unpacked into `index` (an integer) and `item` (the actual value from the list). The above loop will print

```
(0, '::', 'one')
(1, '::', 'two')
(2, '::', 'three')
(3, '::', 'four')
```

Iterate over a list with value manipulation using `map` and `lambda`, i.e. apply lambda function on each element in the list:

```
x = map(lambda e :  e.upper(), ['one', 'two', 'three', 'four'])
print(x)
```

Output:

```
['ONE', 'TWO', 'THREE', 'FOUR'] # Python 2.x
```

NB: in Python 3.x `map` returns an iterator instead of a list so you in case you need a list you have to cast the result `print(list(x))`

Section 16.4: Loops with an "else" clause

The `for` and `while` compound statements (loops) can optionally have an `else` clause (in practice, this usage is fairly rare).

The `else` clause only executes after a `for` loop terminates by iterating to completion, or after a `while` loop terminates by its conditional expression becoming false.

```
for i in range(3):
    print(i)
else:
    print('done')

i = 0
```

```
while i < 3:
    print(i)
    i += 1
else:
    print('done')
```

output:

```
0
1
2
done
```

The `else` clause does *not* execute if the loop terminates some other way (through a `break` statement or by raising an exception):

```
for i in range(2):
    print(i)
    if i == 1:
        break
else:
    print('done')
```

output:

```
0
1
```

Most other programming languages lack this optional `else` clause of loops. The use of the keyword `else` in particular is often considered confusing.

The original concept for such a clause dates back to Donald Knuth and the meaning of the `else` keyword becomes clear if we rewrite a loop in terms of `if` statements and `goto` statements from earlier days before structured programming or from a lower-level assembly language.

For example:

```
while loop_condition():
    ...
    if break_condition():
        break
    ...
```

is equivalent to:

```
# pseudocode

<<start>>:
if loop_condition():
    ...
    if break_condition():
        goto <<end>>
    ...
    goto <<start>>
```

```
<<end>>:
```

These remain equivalent if we attach an `else` clause to each of them.

For example:

```
while loop_condition():
    ...
    if break_condition():
        break
    ...
else:
    print('done')
```

is equivalent to:

```
# pseudocode

<<start>>:
if loop_condition():
    ...
    if break_condition():
        goto <<end>>
    ...
    goto <<start>>
else:
    print('done')

<<end>>:
```

A `for` loop with an `else` clause can be understood the same way. Conceptually, there is a loop condition that remains True as long as the iterable object or sequence still has some remaining elements.

Why would one use this strange construct?

The main use case for the `for...else` construct is a concise implementation of search as for instance:

```
a = [1, 2, 3, 4]
for i in a:
    if type(i) is not int:
        print(i)
        break
else:
    print("no exception")
```

To make the `else` in this construct less confusing one can think of it as "*if not break*" or "*if not found*".

Some discussions on this can be found in [Python-ideas] Summary of for...else threads, Why does python use 'else' after for and while loops? , and Else Clauses on Loop Statements

Section 16.5: The Pass Statement

`pass` is a null statement for when a statement is required by Python syntax (such as within the body of a `for` or `while` loop), but no action is required or desired by the programmer. This can be useful as a placeholder for code that is yet to be written.

```
for x in range(10):
```

```
    pass #we don't want to do anything, or are not ready to do anything here, so we'll pass
```

In this example, nothing will happen. The `for` loop will complete without error, but no commands or code will be actioned. `pass` allows us to run our code successfully without having all commands and action fully implemented.

Similarly, `pass` can be used in `while` loops, as well as in selections and function definitions etc.

```
while x == y:
    pass
```

Section 16.6: Iterating over dictionaries

Considering the following dictionary:

```
d = {"a": 1, "b": 2, "c": 3}
```

To iterate through its keys, you can use:

```
for key in d:
    print(key)
```

Output:

```
"a"
"b"
"c"
```

This is equivalent to:

```
for key in d.keys():
    print(key)
```

or in Python 2:

```
for key in d.iterkeys():
    print(key)
```

To iterate through its values, use:

```
for value in d.values():
    print(value)
```

Output:

```
1
2
3
```

To iterate through its keys and values, use:

```
for key, value in d.items():
    print(key, "::", value)
```

Output:

```
a :: 1
b :: 2
c :: 3
```

Note that in Python 2, `.keys()`, `.values()` and `.items()` return a `list` object. If you simply need to iterate through the result, you can use the equivalent `.iterkeys()`, `.itervalues()` and `.iteritems()`.

The difference between `.keys()` and `.iterkeys()`, `.values()` and `.itervalues()`, `.items()` and `.iteritems()` is that the `iter*` methods are generators. Thus, the elements within the dictionary are yielded one by one as they are evaluated. When a `list` object is returned, all of the elements are packed into a list and then returned for further evaluation.

> Note also that in Python 3, Order of items printed in the above manner does not follow any order.

Section 16.7: The "half loop" do-while

Unlike other languages, Python doesn't have a do-until or a do-while construct (this will allow code to be executed once before the condition is tested). However, you can combine a `while True` with a `break` to achieve the same purpose.

```
a = 10
while True:
    a = a-1
    print(a)
    if a<7:
        break
print('Done.')
```

This will print:

```
9
8
7
6
Done.
```

Section 16.8: Looping and Unpacking

If you want to loop over a list of tuples for example:

```
collection = [('a', 'b', 'c'), ('x', 'y', 'z'), ('1', '2', '3')]
```

instead of doing something like this:

```
for item in collection:
    i1 = item[0]
    i2 = item[1]
    i3 = item[2]
    # logic
```

or something like this:

```
for item in collection:
```

```
    i1, i2, i3 = item
    # logic
```

You can simply do this:

```
for i1, i2, i3 in collection:
    # logic
```

This will also work for *most* types of iterables, not just tuples.

Section 16.9: Iterating different portion of a list with different step size

Suppose you have a long list of elements and you are only interested in every other element of the list. Perhaps you only want to examine the first or last elements, or a specific range of entries in your list. Python has strong indexing built-in capabilities. Here are some examples of how to achieve these scenarios.

Here's a simple list that will be used throughout the examples:

```
lst = ['alpha', 'bravo', 'charlie', 'delta', 'echo']
```

Iteration over the whole list

To iterate over each element in the list, a `for` loop like below can be used:

```
for s in lst:
    print s[:1] # print the first letter
```

The `for` loop assigns s for each element of `lst`. This will print:

```
a
b
c
d
e
```

Often you need both the element and the index of that element. The `enumerate` keyword performs that task.

```
for idx, s in enumerate(lst):
    print("%s has an index of %d" % (s, idx))
```

The index `idx` will start with zero and increment for each iteration, while the `s` will contain the element being processed. The previous snippet will output:

```
alpha has an index of 0
bravo has an index of 1
charlie has an index of 2
delta has an index of 3
echo has an index of 4
```

Iterate over sub-list

If we want to iterate over a range (remembering that Python uses zero-based indexing), use the `range` keyword.

```
for i in range(2,4):
    print("lst at %d contains %s" % (i, lst[i]))
```

This would output:

```
lst at 2 contains charlie
lst at 3 contains delta
```

The list may also be sliced. The following slice notation goes from element at index 1 to the end with a step of 2. The two `for` loops give the same result.

```
for s in lst[1::2]:
    print(s)

for i in range(1, len(lst), 2):
    print(lst[i])
```

The above snippet outputs:

```
bravo
delta
```

Indexing and slicing is a topic of its own.

Section 16.10: While Loop

A `while` loop will cause the loop statements to be executed until the loop condition is falsey. The following code will execute the loop statements a total of 4 times.

```
i = 0
while i < 4:
    #loop statements
    i = i + 1
```

While the above loop can easily be translated into a more elegant `for` loop, `while` loops are useful for checking if some condition has been met. The following loop will continue to execute until `myObject` is ready.

```
myObject = anObject()
while myObject.isNotReady():
    myObject.tryToGetReady()
```

`while` loops can also run without a condition by using numbers (complex or real) or `True`:

```
import cmath

complex_num = cmath.sqrt(-1)
while complex_num:      # You can also replace complex_num with any number, True or a value of any
type
    print(complex_num)   # Prints 1j forever
```

If the condition is always true the while loop will run forever (infinite loop) if it is not terminated by a break or return statement or an exception.

```
while True:
    print "Infinite loop"
```

```
# Infinite loop
# Infinite loop
# Infinite loop
# ...
```