Lec 03 - Control flow, list comprehensions and functions

Statistical Computing and Computation

Sta 663 | Spring 2022

Control Flow

Conditionals

Python supports tradition if / else style conditional expressions,

```
x = 42

if x < 0:
    print("X is negative")
elif x > 0:
    print("X is positive")
else:
    print("X is zero")
```

```
## X is positive
```

```
x = 0

if x < 0:
    print("X is negative")
elif x > 0:
    print("X is positive")
else:
    print("X is zero")
```

```
## X is zero
```

Significant whitespace

This is a fairly unique feature of Python - expressions are grouped together via indenting. This is relevant for control flow (`if`, `for`, `while`, etc.) as well as function and class definitions and many other aspects of the language.

Indenting should be 2 or more spaces (4 is the preferred based on PEP 8) or tab characters - generally your IDE will handle this for you.

If there are not multple expression then indenting is optional, e.g.

```python
if x == 0: print("X is zero")
```

```
## X is zero
```

Conditional scope

Conditional expressions do not have their own scope, so variables defined within will be accessible outside of the conditional. This is also true for other control flow constructs (e.g. `for`, `while`, etc.)

```python
s = 0
if True:
    s = 3

s
```

```
## 3
```

While loops

Repeat until the given condition evaluates to `False`,

```python
i = 17
seq = [i]

while i != 1:
    if i % 2 == 0:
        i /= 2
    else:
        i = 3*i + 1

    seq.append(i)

seq
```

```
## [17, 52, 26.0, 13.0, 40.0, 20.0, 10.0, 5.0, 16.0, 8.0, 4.0, 2.0, 1.0]
```

Anyone recognize what this is an example of?

For loops

Iterates over the elements of a sequence

```python
for w in ["Hello", "world!"]:
    print(w, len(w))

## Hello 5
## world! 6
```

```python
sum = 0
for v in (1,2,3,4):
    sum += v
sum

## 10
```

```python
res = []
for c in "abc123def567":
    if (c.isnumeric()):
        res.append(int(c))
res

## [1, 2, 3, 5, 6, 7]
```

```python
res = []
for i in range(0,10):
    res += [i]
res

## [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

break **and** continue

Allow early loop exit or step to next iteration respectively,

```python
for i in range(10):
    if i == 5:
        break
    print(i, end=" ")
```

```
## 0 1 2 3 4
```

```python
print()
```

```python
for i in range(10):
    if i % 2 == 0:
        continue

    print(i, end=" ")
```

```
## 1 3 5 7 9
```

```python
print()
```

loops and `else`?

Both `for` and `while` loops can also have `else` clauses which execute when the loop is terminated by fully iterating (`for`) or meetings the `while` condition, i.e. when `break` does not execute.

```python
# From python tutorial - Section 4.4
for n in range(2, 10):
    for x in range(2, n):
        if n % x == 0:
            print(n, 'equals', x, '*', n//x)
            break
    else:
        print(n, 'is a prime number')
```

```
## 2 is a prime number
## 3 is a prime number
## 4 equals 2 * 2
## 5 is a prime number
## 6 equals 2 * 3
## 7 is a prime number
## 8 equals 2 * 4
## 9 equals 3 * 3
```

pass

This is a expression that does nothing, it can be used when an expression is needed syntaxtically.

```python
x = -3

if x < 0:
    pass
elif x % 2 == 0:
    print("x is even")
elif x % 2 == 1:
    print("x is odd")
```

List comprehensions

Basics

List comprehensions provides a concise syntax for generating lists

```
res = []
for x in range(10):
    res.append(x**2)
```

```
[x**2 for x in range(10)]
```

```
## [0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

Since it uses the for loop syntax, any sequence is fair game:

```
[x**2 for x in [1,2,3]]
```

```
## [1, 4, 9]
```

```
[x**2 for x in (1,2,3)]
```

```
## [1, 4, 9]
```

```
[c.lower() for c in "Hello World!"]
```

```
## ['h', 'e', 'l', 'l', 'o', ' ', 'w', 'o', 'r', 'l', 'd', '!']
```

Using `if`

List comprehensions can include a conditional clause,

```
[x**2 for x in range(10) if x % 2 == 0]
```

[0, 4, 16, 36, 64]

```
[x**2 for x in range(10) if x % 2 == 1]
```

[1, 9, 25, 49, 81]

The comprehension can include multiple `if` statements,

```
[x**2 for x in range(10) if x % 2 == 0 if x % 3 ==0]
```

[0, 36]

```
[x**2 for x in range(10) if x % 2 == 0 and x % 3 ==0]
```

[0, 36]

Multiple `for`s

Similarly, the comprehension can also contain multiple `for` statements,

```
[(x, y) for x in range(3) for y in range(3)]
```

```
## [(0, 0), (0, 1), (0, 2), (1, 0), (1, 1), (1, 2)
```

```
res = []
for x in range(3):
    for y in range(3):
        res.append((x,y))
res
```

```
## [(0, 0), (0, 1), (0, 2), (1, 0), (1, 1), (1, 2), (2,
```

zip

This is a useful function for "joining" elements of a sequence,

```
x = [1,2,3]
y = [3,2,1]
```

```
z = zip(x, y)
z
```

<zip object at 0x1085ee400>

```
list(z)
```

[(1, 3), (2, 2), (3, 1)]

```
[a**b for a,b in zip(x,y)]
```

[1, 4, 3]

```
[b**a for a,b in zip(x,y)]
```

[3, 4, 1]

`zip` and length mismatches

If the length of the shortest sequence will be used, additional elements will be ignored (silently)

```
x = [1,2,3,4]
y = range(3)
z = "ABCDE"

list(zip(x,y))
```

```
## [(1, 0), (2, 1), (3, 2)]
```

```
list(zip(x,z))
```

```
## [(1, 'A'), (2, 'B'), (3, 'C'), (4, 'D')]
```

```
list(zip(x,y,z))
```

```
## [(1, 0, 'A'), (2, 1, 'B'), (3, 2, 'C')]
```

Exercise 1

Using list comprehensions, complete the following tasks:

- Create a list containing tuples of x and y coordinates of all points of a regular grid for $x \in [0, 10]$ and $y \in [0, 10]$.

- Count the number of points where $y > x$.

- Count the number of points x or y is prime.

Functions

Basic functions

Functions are defined using `def`, arguments can be defined with out without default values.

```python
def f(x, y=2, z=3):
    print(f"x={x}, y={y}, z={z}")
```

```python
f(1)
```

```
## x=1, y=2, z=3
```

```python
f(1,z=-1)
```

```
## x=1, y=2, z=-1
```

```python
f("abc", y=True)
```

```
## x=abc, y=True, z=3
```

```python
f(z=-1, x=0)
```

```
## x=0, y=2, z=-1
```

```python
f()
```

```
## Error in py_call_impl(callable, dots$args, dots$keyw
##
## Detailed traceback:
##    File "<string>", line 1, in <module>
```

return **statements**

Functions must explicitly include a `return` statement to return a value.

```
def f(x):
    x**2
```

```
f(2)
```

```
type(f(2))
```

<class 'NoneType'>

```
def g(x):
    return x**2
```

```
g(2)
```

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```
type(g(2))
```

<class 'int'>

Functions can contain multiple `return` statements

```
def is_odd(x):
    if x % 2 == 0: return False
    else:          return True

is_odd(2)
```

False

Multiple return values

Functions can return multiple values using a tuple or list,

```python
def f():
    return (1,2,3)

f()
```

```
## (1, 2, 3)
```

```python
def g():
    return [1,2,3]

g()
```

```
## [1, 2, 3]
```

If multiple values are present and not in a sequence, then it will default to a tuple,

```python
def h():
    return 1,2,3

h()
```

```
## (1, 2, 3)
```

Doc strings

A common practice in Python is to document a function (and other objects) using a doc string - this is a short concise summary of the objects purpose. Doc strings are specified by supplying a string as the very line in the function definition.

```python
def f():
    "Hello."

    pass

f.__doc__
```

'Hello.'

```python
def g():
    """This function does
    absolutely nothing.
    """

    pass

g.__doc__
```

'This function does\n   absolutely nothing.\n   '

Variadic arguments

If the number of arguments is unknown it is possible to define to define variadic functions

```python
def paste(*args, sep=" "):
    return sep.join(args)
```

```python
paste("A")
```

```
## 'A'
```

```python
paste("A","B","C")
```

```
## 'A B C'
```

```python
paste("1","2","3",sep=",")
```

```
## '1,2,3'
```

Positional and/or keyword arguments

```
def f(pos1, pos2, /, pos_or_kwd, *, kwd1, kwd2):
      -----------    ----------      ----------
          |             |                |
          |          Positional or keyword |
          |                        - Keyword only
       -- Positional only
```

For the following function x can only be passed by position and z only by name

```python
def f(x, /, y, *, z):
    print(f"x={x}, y={y}, z={z}")
```

```python
f(1,1,1)
```

```
## Error in py_call_impl(callable, dots$args, dots$keywords): TypeError: f() takes 2 positional arguments but 3 were given
##
## Detailed traceback:
##    File "<string>", line 1, in <module>
```

```python
f(x=1,y=1,z=1)
```

```
## Error in py_call_impl(callable, dots$args, dots$keywords): TypeError: f() got some positional-only arguments passed as keyword arguments: 'x
##
## Detailed traceback:
##    File "<string>", line 1, in <module>
```

```python
f(1,1,z=1)
```

Based on Python tutorial Sec 4.8.3
x=1, y=1, z=1

Anonymous functions

Can be defined using the `lambda` keyword, they are intended to be used for very short functions (syntactically limited to a single expression, and not return statement)

```python
def f(x,y):
    return x**2 + y**2

f(2,3)
```

```
## 13
```

```python
type(f)
```

```
## <class 'function'>
```

```python
g = lambda x, y: x**2 + y**2


g(2,3)
```

```
## 13
```

```python
type(g)
```

```
## <class 'function'>
```

Function annotations (type hinting)

Python nows supports syntax for providing metadata around the expected type of arguments and the return value of a function.

```python
def f(x: str, y: str, z: str) -> str:
    return x + y + z
```

These annotations are stored in the `__annotations__` attribute

```python
f.__annotations__
```

{'x': <class 'str'>, 'y': <class 'str'>, 'z': <class 'str'>, 'return': <class 'str'>}

But doesn't actually do anything at runtime:

```python
f("A","B","C")
```

'ABC'

```python
f(1,2,3)
```

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Exercise 2

1. Write a function, `kg_to_lb`, that converts a list of weights in kilograms to a list of weights in pounds (there a 1 kg = 2.20462 lbs). Include a doc string and function annotations.

2. Write a second function, `total_lb`, that calculates the total weight in pounds of an order, the input arguments should be a list of item weights in kilograms and a list of the number of each item ordered.